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EPA Superfund Record of Decision:

Silver Bow/Butte Creek, Streamside Tailings O.U., MT 11/29/1995

RECORD OF DECISION

STREAMSIDE TAILINGS OPERABLE UNIT
SILVER BOW CREEK/BUTTE AREA
(original portion)
NATIONAL PRIORITIES LIST SITE

SILVER BOW AND DEER LODGE
COUNTIES, MONTANA

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November 1995

RECORD OF DECISION

STREAMSIDE TAILINGS OPERABLE UNIT OF THE SILVER BOW CREEK/BUTTE AREA (original portion) NATIONAL PRIORITY LIST SITE

INTRODUCTION

The Montana Department of Environmental Quality (MDEQ)[1] and the U.S. Environmental Protection Agency (EPA) present the record of decision for the Streamside Tailings Operable Unit (the SST OU) of the Silver Bow Creek/Butte Area (original portion) National Priorities List (NPL) Site, Butte, Montana. The record of decision is based on the administrative record, remedial investigation/feasibility study, the proposed plan (MDEQ, 1995a), the public comments received, including those from the potentially responsible party, EPA comments, and other pertinent information. The record of decision presents a brief outline of the remedial investigation/feasibility study, actual and potential risks to human health and the environment, and the selected remedy. MDEQ followed the Comprehensive Environmental, Response, Compensation and Liability Act (CERCLA), the National Contingency Plan (NCP), and EPA guidance in preparation of the record of decision. The record of decision has the following three purposes:

1. To certify that the remedy selection process was carried out in accordance with the requirements of the CERCLA, 42 U.S.C. 9601 *et seq.*, as amended by the Superfund Amendments and Reauthorization Act (SARA), and, to the extent practicable, the National Contingency Plan (NCP);

2. To outline the remedial components and goals of the selected remedy; and

3. To provide the public with a consolidated source of information about the history, characteristics, and risks posed by the conditions at the OU, as well as a summary of the cleanup alternatives considered, their evaluation, the rationale behind the selected remedy, and the agencies' consideration of and responses to the comments received.

The record of decision is organized into three distinct sections:

- The **Declaration** functions as an abstract for the key information contained in the record of decision and is the section of the record of decision signed by the Director of the Montana Department of Environmental Quality and the Assistant Regional Administrator for Ecosystems Protection and Remediation,

[1] The Montana Department of Environmental Quality was created on July 1, 1995, by consolidating environmental programs from the Departments of Health and Environmental Sciences, Natural Resources and Conservation, and State Lands. The majority of the SST OU investigation was conducted under the authorities of the predecessor Montana Department of Health and Environmental Sciences (MDHES).

EPA Region VIII;

- The **Decision Summary** provides an overview of the OU characteristics, the alternatives evaluated, and the analysis of those options. The Decision Summary also identifies the selected remedy and explains how the remedy fulfills statutory requirements; and

- The **Responsiveness Summary** addresses public comments received on the proposed plan (MDEQ, 1995a), the remedial investigation/feasibility study and other information in the administrative record.

DECLARATION

OPERABLE UNIT NAME AND LOCATION

Streamside Tailings OU of the Silver Bow Creek/Butte Area (original portion) National Priority List Site in Silver Bow and Deer Lodge Counties, Montana.

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedy for the Streamside Tailings Operable Unit (the SST OU) of the Silver Bow Creek/Butte Area National Priorities List (NPL) Site. The Montana Department of Environmental Quality (MDEQ), in consultation with the United States Environmental Protection Agency (EPA), selected the remedy in accordance with CERCLA, as amended by SARA, and, to the extent practicable, the NCP. The EPA concurs in and adopts the selected remedy. The attached index identifies categories of documents or records that comprise the administrative record upon which the selection of the remedial action is based (Appendix B).

ASSESSMENT OF THE OU

Actual or threatened releases of hazardous substances from this OU, if not addressed by implementing the response action selected in this record of decision, may present an imminent and substantial endangerment to public health, welfare, or the environment.

DESCRIPTION OF THE SELECTED REMEDY

This is the final remedial action for the SST OU. This remedial action addresses the principal threats and provides for treatment and appropriate disposal of contaminated tailings/impacted soils, instream sediments, and railroad materials. Much of the treated materials will remain in the OU. Consequently, the OU will require long-term management and monitoring.

The principal contaminants of concern at the SST OU are arsenic, cadmium, copper, lead, mercury, and zinc. This remedial action is generally described as ***Alternative 5*** in the Feasibility Study (ARCO, 1995b) and the proposed plan (MDEQ, 1995a). Some refinements to Alternative 5 have been made to clarify the criteria used to require excavation of tailings/impacted soils, to more precisely identify excavation of contaminated railroad bed materials, and to specify an institutional controls/maintenance program that will be used to manage the Silver Bow Creek corridor in the future. This record of decision establishes cleanup levels or physical criteria for these and all other contaminants of concern at the SST OU. The major components of the selected remedy include:

Tailings/Impacted Soils

1. Excavation of contaminated tailings/impacted soils from most areas within the present 100-year floodplain as delineated in the CH2M Hill (1989) Flood Modeling Study ("floodplain"). The removed volume will include all tailings/impacted soils continuously or seasonally saturated by groundwater together with the tailings/impacted soils overlying these saturated tailings (collectively, "saturated tailings"), tailings/impacted soils located where in-situ Streambank Tailings and Revegetation Study (STARS) treatment cannot reliably immobilize the contaminants, and tailings/impacted soils subject to erosion and re-entrainment into the stream. These criteria, together with the other details on the selected remedy, are more fully described in the Decision Summary below. The total volume of saturated and overlying tailings/impacted soils to be removed is presently estimated at approximately 700,000 cy. The total volume of tailings/impacted soils subject to erosion and therefore to be excavated is estimated at approximately 850,000 cy (1,550,000 cy collectively). Specific locations and volumes of excavated materials will be determined by the agencies during remedial design/remedial action.

2. To meet the established OU remedial objectives, tailings/impacted soils will be removed from the floodplain where: (1) tailings/impacted soils are saturated by groundwater during any part of the year, (2) in-situ Streambank Tailings and Revegetation Study (STARS) treatment cannot reliably immobilize the contaminants, for example, due to the thickness of the tailings/impacted soils, proximity of the tailings/impacted soils to groundwater, or lack of appropriate buffer materials between the treated tailings/impacted soils and the groundwater, or (3) the treated tailings/impacted soils could be eroded back into the stream by natural lateral stream migration, channel avulsion, overbank flow, or flood events. A detailed discussion of this topic is presented in Section IX (Selected Remedy) of the Decision Summary.

3. All remaining tailings/impacted soils (approximately 950,000 cy) within the OU will be treated in-situ with the STARS technology and appropriately protected from washout or erosion from lateral stream migration and flood flows. In-situ and adjacent repository STARS treated areas will not be placed or left where they can be eroded back into Silver Bow Creek.

4. Excavated tailings/impacted soils will be relocated to safe, local repositories clearly outside of the present 100-year floodplain as defined by CH2M Hill (1989) provided that appropriate locations can be identified and delineated for repository use and that an appropriate institutional controls/maintenance

program can be implemented. Tailings/impacted soils placed in the relocation repositories will be fully treated with lime amendments in 2-foot lifts and will be revegetated in accordance with the STARS technology. If appropriate locations and an appropriate institutional control/monitoring and maintenance program cannot be implemented, excavated tailings/impacted soils and other wastes would be removed to centralized dry repositories and appropriately handled and disposed of there.

5. Replacement fill will be required in most locations where tailings/impacted soils are removed. Replacement fill and streambank reconstruction with suitable growth media having an appropriate texture and particle size distribution will be required. A key to long-term streambank stabilization will be establishment of mature riparian vegetation. Grass, forb, willow, and tree species will be specified based on local climatic conditions, proximity to stream channel, and ability to produce dense root systems at maturity. The overall topography of the replacement fill material will be appropriately sloped toward the stream channel, with the goal of creating geomorphic stability.

6. Because numerous repositories, which will be treated with the STARS technology, will be located near the floodplain in several areas along the length of the stream, and because in Subareas 2 and 4 a substantial amount of tailings will be treated with the STARS technology on the edges or just outside of the floodplain, a permanent monitoring, management, and maintenance program is an integral part of the remedy. Monitoring, management and maintenance will address vegetative performance on both STARS treatment areas and remediated streambanks, streambank stability and channel meander. This remedy will also ensure that the metals are immobilized at all in-situ remediated areas and removal repositories through vadose zone, saturated zone, and overland flow monitoring.

Instream Sediments

7. Fine-grained instream sediments (less than or equal to one millimeter in size [$\leq$ 1mm]) located in every depositional areas will be removed and placed in repositories with the excavated tailings/impacted soils and railroad materials. This size fraction was identified because it corresponds with the size of the tailings/impacted soils and contains the bulk of instream contamination. Specific volumes and locations to be excavated will be determined by the agencies during remedial design/remedial action. This sediment volume is presently estimated at 73,000 cy as presented in the RI report (ARCO, 1995a).

8. After removal of contaminated sediments, the channel bed and streambank will be reconstructed to an appropriate slope and other critical dimensions with materials of appropriate size, shape and composition. This reconfigured bed will contain suitable bedform morphology (riffles, bars, pools, etc.) for aquatic habitat. Streambanks will require adequate growth media to allow for immediate establishment of a healthy riparian vegetative system to protect the remedy from high flows.

9. Instream sediment monitoring will be performed during and after the response action to ensure that contaminated instream sediments have been adequately remediated. Monitoring will include sampling of instream sediment for sediment contaminant concentrations as well as macroinvertibrate abundance and diversity. Maintenance to deal with continuing sediment contamination over time may be necessary, depending on the results of long-term monitoring.

Railroad Materials

10. The remedy will excavate, treat and/or cover all contaminated railroad bed materials that pose a risk to human health or the environment. All concentrate spills, which are the primary human health concern for the railroad beds, will be removed and disposed in an appropriate and secure disposal facility in accordance with any applicable RCRA requirements. Railroad materials which directly impact the stream either at bridge abutments or along the streambank will be excavated and disposed in repositories along with the tailings/impacted soils and instream sediments. The actual amount and methods of excavation and/or treatment will be determined during remedial design. The estimated volume of excavated materials is presently 71,000 cy. The in-situ STARS technology or soil capping is expected to be appropriate for all other areas of the inactive grade presenting environmental risk.

11. Monitoring and maintenance of the remediated railroad materials will be required to ensure that contaminant sources are not exposed as a result of erosion and do not cause future contaminant loading to the stream.

Ground and Surface Water

12. While Silver Bow Creek ground and surface water are primary receptors of SST OU contamination, no separate remedial action is being prescribed for these media. Remedial activities for other SST OU media under this record of

decision and for sources of contaminants upstream/offsite under other cleanup actions will limit further releases to ground and surface water with the goal of ultimately attaining ground and surface water standards within the OU. Removing the source of groundwater contamination by addressing the tailings/impacted soils and railroad materials, will allow contaminants in groundwater to attenuate over time through dilution, adsorption, precipitation, and dispersion.

13. Removal of the tailings/impacted soils, fine-grained instream sediments, and railroad materials will allow for the attainment of instream sediment and surface water objectives, over time. Removing the sources and interrupting the pathways for surface water contamination by addressing all the contaminated materials should permit eventual attainment of the surface water objectives.

14. Long-term monitoring of ground and surface water is a critical element of the remedy. Surface water will be monitored for compliance at a number of points in the OU to ascertain possible surface water contaminant loading from onsite/nearsite contaminant sources. Groundwater will be monitored at locations of documented or suspected groundwater contamination, all relocation areas, and other locations where STARS treatment has been applied.

Coordination and Schedule

15. An institutional controls program, which must be funded on a permanent basis as part of the remedy, will be coordinated through a joint effort of the Butte-Silver Bow and Anaconda-Deer Lodge local governments. Institutional controls, monitoring, and maintenance will be integrated into a Silver Bow Creek corridor management program. The program will be established and maintained in a manner that will ensure that all aspects of the OU remedial action, both within and outside of the floodplain, are maintained for the long-term, and ensure that the future land use in the area is consistent with the scenarios upon which cleanup decisions for this action have been based.

16. Construction of the proposed remedy will be coordinated with other cleanup activities along Silver Bow Creek. Releases of contaminated instream sediments and surface waters prior to, during, and following remedial action, which might re-contaminate Silver Bow Creek, will be suitably controlled and treated. The design and schedule of the OU remedy will be coordinated with the design and installation of upstream sediment control basins. If adequate

upstream control facilities are not in service at the time of initiation of construction of this remedy, then additional sediment control and treatment facilities will be provided as a part of this remedy or other scheduling adjustments will be made. The implementation of the remedy will also be coordinated to the maximum extent possible with the possible implementation of the State's natural resource damage restoration plan in order to avoid duplication of effort and unnecessary costs and to maximize the benefits to the area.

17. Butte-Silver Bow County and ARCO are initiating research on constructed wetlands as a potential treatment technology for waste water nutrient discharge and stormwater metals contamination. To coordinate with this research, the end land use in Subarea 1 has been delineated as wetlands. After removal of all the above mentioned contaminant sources, reconstruction of the Subarea will be designed to incorporate use of the area as wetlands. Constructed wetlands in this area may be used as a treatment system for nutrients and/or metals from upstream, if such treatment is ultimately determined to be appropriate in this area.

STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with federal and state requirements that are legally applicable or relevant and appropriate to the remedial action except where a waiver of such requirements has been determined to be appropriate, and is cost-effective. This remedy uses permanent solutions and alternative treatment technologies to the maximum extent practicable and satisfies the preference for remedies that employ treatment that reduces toxicity, mobility, or volume as a principal element. Because this remedy will result in hazardous substances remaining in the OU above health or environmental based risk levels, periodic five-year reviews of the remedial action shall be conducted, beginning within five years after initiation of remedial action, to ensure that the remedy continues to provide adequate protection to human health and the environment.

Mr. Mark A. Simonich
Director
Montana Department of Environmental Quality

11/28/95
Date

Mr. William Yellowtail
Regional Administrator
Environmental Protection Agency, Region VIII

11/29/95
Date

DECISION SUMMARY

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ACRONYMS

ADL	Anaconda-Deer Lodge County
AMC	Anaconda Copper Mining Company
AOC	Administrative Order of Consent
ARARs	Applicable or Relevant and Appropriate Requirements
ARCO	Atlantic Richfield Company
AWQC	Ambient Water Quality Criteria
ARM	Administrative Rules of Montana
BA&P	Butte, Anaconda and Pacific Railroad
bgs	below ground surface
BRA	Baseline Risk Assessment
BSB	Butte-Silver Bow County
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CMSP	Chicago, Milwaukee, St. Paul and Pacific Railroad
COC	contaminants of concern
cy	cubic yards
DNRC	Department of Natural Resources and Conservation
DPS	Development Permit System
EPA	U.S. Environmental Protection Agency
FS	Feasibility Study
ft/ft	foot per foot
ICPD	Institutional Controls Planning Document
ICs	Institutional Controls
ICMM	Institutional Controls, Monitoring, and Maintenance
LAO	Lower Area One
MCLs	Maximum Contaminant Levels
MCLGs	Maximum Contaminant Level Goals
MCA	Montana Code Annotated
MDEQ	Montana Department of Environmental Quality
mg/kg	milligram per kilogram
mm	millimeter
MU	Montana Union
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NP	Northern Pacific
NPL	National Priorities List
OU	Operable Unit
O&M	Operation and Maintenance
PAH	Polycyclic Aromatic Hydrocarbons
PCP	Pentachlorophenol
PRAOs	Preliminary Remedial Action Objectives
PRAOR	Remedial Action Objectives Report

PRGs	Preliminary Remediation Goals
PRP	Potential Responsible Party
RAOs	Remedial Action Objectives
RI	Remedial Investigation
Rocker	Rocker Timber Framing and Treating Plant
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SBC	Silver Bow Creek
SPAOD	Superfund Planning Area Overlay District
SST	Streamside Tailings
STARS	Streambank Tailings and Revegetation Studies
su	Standard Units
TES	Threatened, Endangered and Sensitive (Species)
TTSD	Treatment Technology Screening Document
$\mu g/l$	micrograms per liter
UP	Union Pacific
WSP	Warm Springs Ponds
WQB-7	Montana Water Quality Circular 7

GLOSSARY

Administrative record: The files containing all documents relied upon by the agencies in selecting a remedy at a Superfund site.

Applicable or Relevant and Appropriate Requirements (ARARs): Legal requirements, criteria, or limitations which are set forth in federal and state environmental and facility siting laws and regulations.

Backfill: Clean soil used to replace contaminated material which was removed.

Baseline human health and ecological risk assessments: Studies conducted as part of the remedial investigation describing the risks posed to public health and the environment at a Superfund site.

Ground water: The water contained in interconnected pores located below the water table.

Impacted soils: Soils mixed with tailings or which tailings have leached inorganics into.

In-situ: Activity occurring in-place or without removing the contaminated material.

Institutional controls (ICs): Laws, regulations, or covenants that restrict certain activities or uses to ensure the effectiveness of remedy, such as zoning restrictions, deed restrictions, well bans, etc.

Maximum Contaminant Levels (MCLs): Federal drinking water standards which represent the maximum permissible level of a contaminant in a public water system.

Maximum Contaminant Level Goals (MCLGs): Non-enforceable drinking water standards that represent the levels of contaminants that are fully protective of human health and allow an adequate margin of safety.

National Contingency Plan (NCP): The federal regulations implementing Superfund, found at 40 CFR Part 300.

Operable Unit (OU): A term used to describe a designated portion of a Superfund site. An operable unit may be established based on a particular type of contamination, contaminated media (e.g., soils, water), source of contamination, and/or geographical location.

Operation and maintenance costs: The costs of activities conducted to maintain the effectiveness of the remedy, after physical construction and initial implementation of the remedy.

Potentially responsible party (PRP): Individual, organization or business who may be liable to implement or pay for a cleanup under Superfund law.

Remedy: The response action that addresses potential or actual threats to public health, welfare and/or the environment at a Superfund site.

Record of decision **(ROD)**: A public document that selects and describes the remedy that will be used at a Superfund site. The record of decision includes the explanation of the agency's rationale for choosing a remedy.

Relocation: Excavation of tailings/impacted soils from the 100-year floodplain, placement of those wastes in a nearby, local repository, and treatment of those wastes using STARS treatment.

Remedial investigation/feasibility study **(RI/FS)**: During the remedial investigation, the types, amounts and locations of contamination at a site are identified. In the feasibility study, alternatives for site remedy are identified, screened and evaluated.

Removal: Excavation of tailings/impacted soils located in the floodplain and placement in a regional dry repository. The two potential repository locations identified in the SST OU Feasibility Study were Browns Gulch and the Opportunity Ponds.

Streambank Tailings and Revegetation Studies **(STARS)**: Chemically amending floodplain tailings *in-situ*. Lab, greenhouse, and field studies, commonly referred to as STARS, developed a technology specifically for consideration at the Streamside Tailings OU.

Tailings: A sand to silt sized by-product of ore milling operations.

Vadose Zone: The zone between land surface and the water table. Pore spaces in this zone contain disconnected water.

WQB-7: A promulgated list of State water quality standards specifying concentrations of contaminants which, if not exceeded, should be protective of human health and should support a healthy ecosystem. Concentrations of contaminants which are toxic to aquatic life are usually expressed in terms of acute (short term) or chronic (long-term) effects. Acute toxicity is usually expressed as a lethal concentration while chronic toxicity refers to effects over an extended time period.

I. OPERABLE UNIT NAME, LOCATION AND DESCRIPTION

Streamside Tailings (SST) Operable Unit (OU) of the
Silver Bow Creek/Butte Area (original portion)
National Priority List (NPL) Site
Butte, Montana

The SST OU is located along Silver Bow Creek in Butte-Silver Bow and Anaconda-Deer Lodge Counties, Montana. Figure 1 displays the general location of the OU. Figure 2 illustrates the SST OU. Silver Bow Creek is the main drainage within the SST OU and is the headwaters of the Clark Fork River. Silver Bow Creek originates in Butte at the confluence of the Metro Storm Drain and Blacktail Creek.

The OU boundary has been defined in the Administrative Order on Consent (AOC) (MDHES, 1991) as the extent of fluvially deposited tailings along Silver Bow Creek, including adjacent railroad beds. The upstream boundary of SST OU is the Lower Area One (LAO) portion of the Priority Soils OU, and the downstream boundary is the Warm Springs Pond (WSP) OU. For the purposes of the remedial action, the operable unit boundary will also include any additional areas in close proximity to the contamination that are necessary for implementation of the remedial action.

The area containing and surrounding the previous location of the Rocker Timber Framing and Treating Plant (Rocker OU) adjacent to Silver Bow Creek in Rocker, Montana, is a separate and distinct OU. The Rocker OU is being investigated and evaluated separately with regard to contaminants associated with historical wood treating activities and mining wastes mixed with such wastes at the Rocker operation. Remediation of the streamside tailings and railroad materials containing contaminants of concern within the Rocker OU will be coordinated with the SST OU.

II. OU HISTORY

The first recorded disturbance of the Silver Bow Creek channel occurred in 1864 when placer mining techniques were used to extract gold along the stream and its tributaries (Freeman, 1900 and Smith, 1952). The gold recovered by placer mining was relatively pure, in the form of dust, flakes, or nuggets. Mercury was sometimes used to "attract" small pieces of gold. This phase of mining activity was short-lived; most placer operations in the area had ceased by 1869, although minor activity continued on a few local streams (Reclamation Research Unit and Schafer and Associates [RRU and Schafer], 1993).

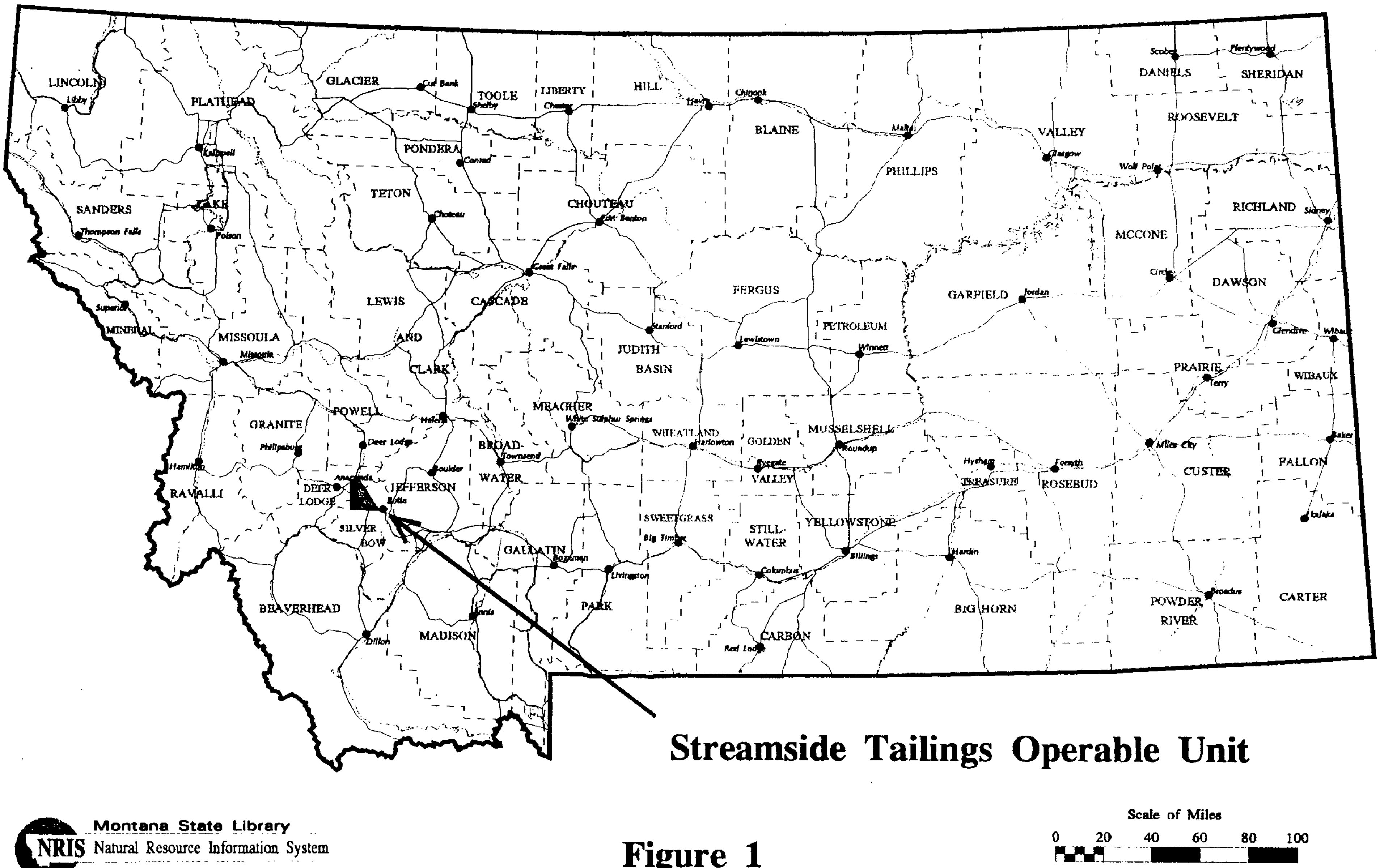
Some evidence of early placer mining along upper portions of Silver Bow Creek is still evident in the form of waterways required to convey water for hydraulic mining and spoils piles (Historical Research Associates [HRA], 1983). The waterways are in disrepair and no longer convey water. As Butte's placer deposits played out during the 1870s, miners turned their attention to the area of hardrock mining. There is no clear record of the amount of mining wastes produced and disposed of by placer miner operations.

Concomitant with placer mining along Silver Bow Creek, hard rock mining started on mineralized vein outcroppings on Butte Hill, north of Silver Bow Creek (Smith, 1952). Some mining claims on the Butte Hill were re-staked in the 1870s because of favorable assays of silver ore found in the area (Smith, 1952). Silver mill construction during the mid-1870s ushered in the era of industrial mining in Butte. This rejuvenated mining activity in Butte and, by 1878, several small mills were operating in the area. A combination of factors contributed to a boom in Butte's silver production during the early 1880s. Completion of railroads to Butte in 1881 along with favorable silver prices led to a drastic increase in mine production. Most existing mills increased their production.

Between 1879 and 1885, at least six major mills were built along Silver Bow Creek from Meaderville to Williamsburg. These mills were operated more or less continuously until 1910 (Freeman, 1900; Smith, 1952; HRA, 1983). The early mills were steam-powered stamp mills (5-10 stamps) designed to crush, concentrate, and amalgamate silver ore. Mills constructed during this time were the: Centennial, Dexter, Davis, Young and Roudebush, Walker Brothers, Clipper, Silver Bow, Grove Gulch, and Thornton (Gagnon)(HRA, 1983). By 1886 five new mills appeared in the vicinity of Butte's Missoula Gulch and along Silver Bow Creek: the Alice, the Moulton, the Lexington, the Marget Ann, and the Blue Bird (HRA, 1983). The Blue Bird mill was located on Silver Bow Creek east of the town of Rocker (Figure 2) and contained 90 stamps which was unusually large at the time. Production capacities from these new mills were many orders of magnitude greater than previous mills. Butte's silver era ended with the repeal of the Sherman Silver Act in 1893. These mills produced tailings and other mining wastes, which were disposed of near the mills. Some of that waste material was disposed directly into or washed into Silver Bow Creek.

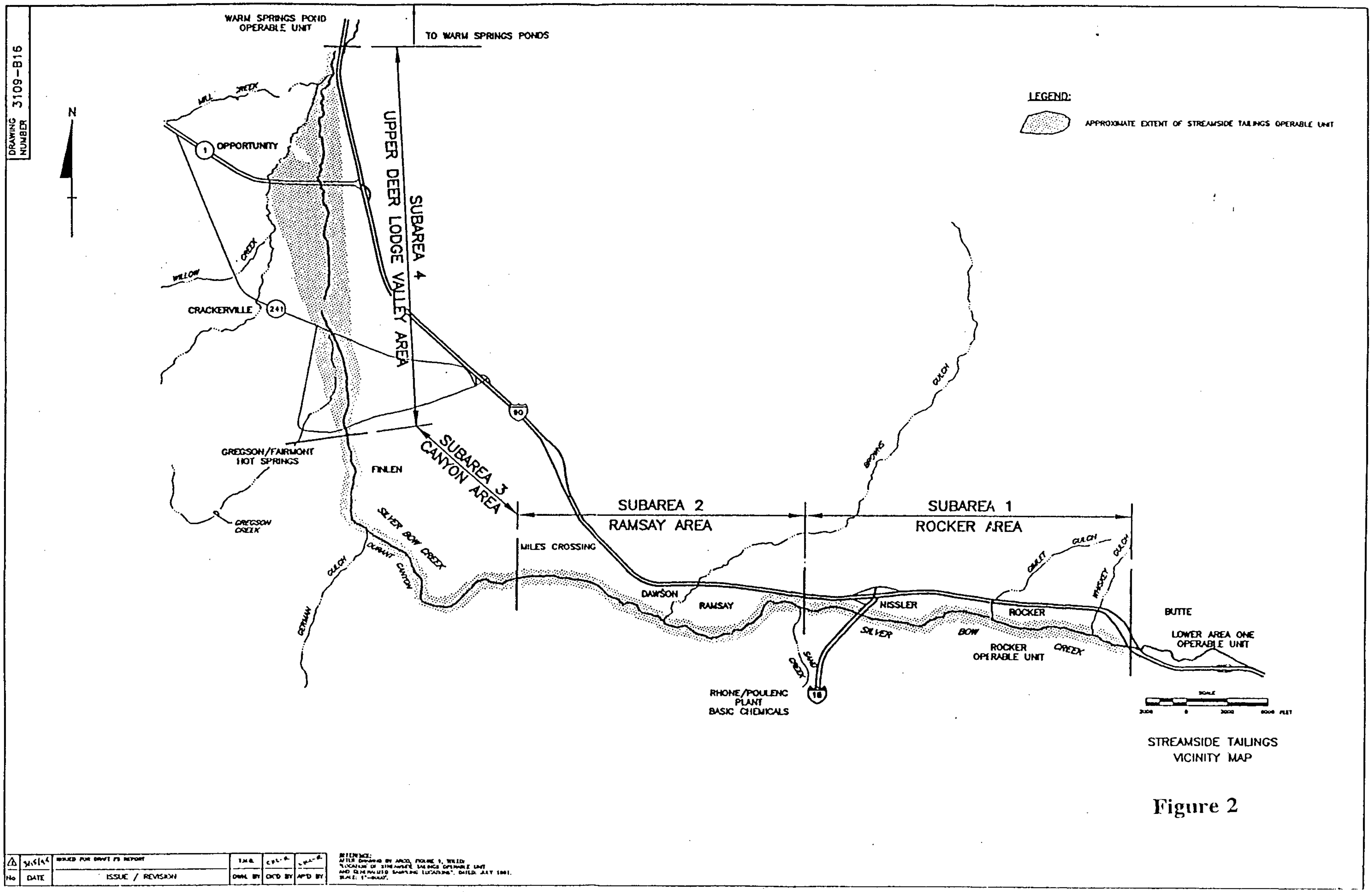
By the late 1880s copper mining had become more important, and Butte became one of the nation's prominent copper mining centers. Many of the previously described mills and smelters were used for copper production, and more mills and smelters were added. Five such facilities located along Silver Bow Creek were especially significant. They are the Colorado Smelter, the Butte Reduction Works facility, the Parrott Smelter, the Montana Ore and Purchasing Company Smelter, and the Butte and Boston Smelter. All of the described facilities along Silver Bow Creek discharged wastes alongside or directly into Silver Bow Creek.

Montana



Montana State Library
NRIS Natural Resource Information System
Map #96epaa4c - 9/14/95

Figure 1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WARM SPRINGS POND OPERABLE UNIT
TO WARM SPRINGS PONDS
LEGEND:
APPROXIMATE EXTENT OF STREAMSIDE TAILINGS OPERABLE UNIT
OPPORTUNITY
CRACKERVILLE
UPPER DEER LODGE VALLEY AREA
SUBAREA 4
GREGSON/FAIRMONT HOT SPRINGS
GREGSON CREEK
FINLEN
SUBAREA 3
CANYON AREA
SILVER BOW CREEK
DURANT CANYON
GERMAN GULCH
MILES CROSSING
SUBAREA 2
RAMSAY AREA
DAWSON
RAMSAY
SUBAREA 1
ROCKER AREA
NISSLER
ROCKER
ROCKER OPERABLE UNIT
SILVER BOW CREEK
BUTTE
LOWER AREA ONE OPERABLE UNIT
RHONE/POULENC PLANT BASIC CHEMICALS
STREAMSIDE TAILINGS VICINITY MAP
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Figure 2

These facilities operated large concentrators and smelters and disposed of very large volumes of waste directly into or near Silver Bow Creek.

A copper smelter (Old Works) was constructed near the mouth of Warm Springs Creek at the new town of Anaconda, 27 miles west of Butte, in 1884 (Smith, 1952; RRU and Schafer, 1993). The new Washoe Smelter was constructed and began operations on Smelter Hill, directly east of Anaconda, in 1903. The major smelters erected along Silver Bow Creek in the Butte vicinity continued to operate until approximately 1910 (HRA, 1983). The Amalgamated Copper Company and the Anaconda Copper Mining Company took possession and control of almost all other companies and facilities in the Butte area. These companies ultimately combined into the Anaconda Copper Mining Company. After 1910, most of the ore mined in Butte was then shipped via the Butte, Anaconda and Pacific Railway (BA&P) to the Anaconda Copper Mining Company's (AMC) Washoe Smelter for processing (RRU and Schafer, 1993).

By 1917, approximately 150 mines were located in and near Butte. These mines, which were controlled by AMC or its predecessors, produced a total of approximately 934 million pounds of copper (Techlaw, 1985). This corresponds to a maximum of approximately 4.2 million cubic yards of ore assuming a 5 percent copper content and an ore density of 163 pounds per cubic foot (Techlaw, 1985). Water pumped from these mines contributed to the contamination of Silver Bow Creek.

AMC constructed three treatment ponds, the Warm Springs Ponds (WSP), at the headwaters of the Clark Fork River near Warm Springs, Montana, in 1911, 1916, and between 1954 and 1959, respectively. The purposes of the ponds were to settle out mining wastes from Silver Bow Creek and to improve the quality of water released to the Clark Fork River (RRU and Schafer, 1993). The inlet to the WSP represents the downstream extent of the SST OU (Figure 2).

AMC commenced surface mining of low-grade copper ore with the opening of the Berkley Pit in 1955 and built the Weed Concentrator in 1963 to process this ore. These operations contributed contamination to Silver Bow Creek.

In 1977, the assets of AMC were purchased by the Atlantic Richfield Company (ARCO) which expressly assumed liability for AMC. ARCO closed all underground mines in 1980 and continued active mining only in the Berkley Pit. ARCO closed the Berkley Pit in 1982 and the East Berkley Pit in 1983. The Washoe Smelter in Anaconda, the last active smelting facility in the area, was closed in 1980 and subsequently dismantled (RRU and Schafer, 1993).

Waste Transport

Although floods and storm events contributed to the transport of waste into and within the SST OU, they were not the exclusive cause of contamination. As noted, upstream facilities discharged waste directly into or along Silver Bow Creek, and did not exercise due care in anticipating flood events or storm events and taking precautions to avoid waste movement. Waste was transported from these operations downstream via overland flow and surface water transport.

In June of 1908, the largest flood in recorded history in the Silver Bow Creek basin occurred, contributing to the extent of fluvially-deposited tailings found today. Heavy rains (8.12 inches) fell in late May and early June, melting the snow pack and causing extensive flooding (CH2M Hill, 1989a). Flood waters transported tailings from smelting facilities in Butte and along Silver Bow Creek and deposited them downstream as flood waters waned. Flood flows and fluvial deposits were physically constrained by railroad grades constructed parallel to Silver Bow Creek, limiting the areal extent of flood deposited tailings.

Other recorded significant storm events occurred in 1892, 1894, 1938, 1948, 1975 and 1980 (CH2M Hill, 1989a). All of these events occurred during the spring and early summer when precipitation and melting snow combined to produce large runoffs. These events also contributed to the movement of mine wastes from their sources into the Silver Bow Creek floodplain.

Railroad History

The Utah & Northern, a subsidiary of the Union Pacific Railroad (UP) and the first railroad in Montana, reached Butte in December of 1881. It linked the towns of Anaconda and Butte to the UP line from Utah in 1884 when it completed a narrow gage rail line between the mines in Butte and the smelter in Anaconda (GCM, 1991). This was the first railroad constructed within the SST OU.

Immediately following the Utah & Northern advancement into Montana, track laying crews of the Northern Pacific (NP), a predecessor to Burlington Northern Railroad, entered eastern and western Montana to complete a northern transcontinental rail line. By September 1883, construction was complete. The UP and NP then pooled their resources and formed the Montana Union Railroad which ran from Butte to Garrison (GCM, 1991).

Marcus Daly, owner and founder of the AMC, after disagreement with the Montana Union (MU) Railroad over freight rates charged to ship ore from mines in Butte to smelting facilities, suspended mining and smelting operations and announced that the AMC would construct its own railroad. On September 30, 1892, Daly and a group of investors incorporated the BA&P, with close subsidiary links to Anaconda, to construct and operate a separate rail line to transport ore from Butte to the smelter in Anaconda. This was the second rail line construction adjacent to Silver Bow Creek. Additionally, AMC used the BA&P to transport copper concentrate from Butte to Anaconda after construction of the Weed Concentrator in 1964. Today the BA&P track is occupied and operated by the Rarus rail line (Butte Archives, 1994; GCM, 1991).

In 1905, the Chicago, Milwaukee, St. Paul and Pacific Railroad (CMSP) began construction of another railroad line (the third) to run along Silver Bow Creek. Until 1913, the CMSP used the BA&P rails along Silver Bow Creek from Butte to Finlen. At that time, the CMSP constructed its own grade (popularly known as the Milwaukee Road) along Silver Bow Creek (GCM, 1991). In 1980, the CMSP abandoned its rail line. The tracks were removed shortly afterward (GCM, 1991).

In the early twentieth century, the Union Pacific Railroad leased the track near the Fairmont/Gregson area east into Butte under a long-term lease to the Great Northern Railroad. The Great Northern Railroad eventually became the Burlington Northern Railroad. The lease was subsequently transferred to the Montana Western Railroad in 1986, which operates on this line today (GCM, 1991).

Presently, there are three rail lines adjacent to the SST OU area: 1) Rarus (BA&P) from Anaconda to Butte, 2) Montana Western Railroad (leased from UP), and 3) the UP Railroad. Rarus (BA&P) and Montana Western have existing tracks adjacent to Silver Bow Creek. The UP line terminates at its northern extent at the switching yards of Port of Montana near Silver Bow, Montana. The abandoned CMSP grade parallels Silver Bow Creek within the SST OU although the rails and ballast have been removed.

Parts of all three rail lines were constructed with waste materials. The lines which transported concentrate materials for the smelter in Anaconda were additionally contaminated by spillage from this concentrate transportation.

Enforcement Actions

Environmental investigations in the vicinity of the SST OU were initiated by the EPA in 1982 to address mining impacts along Silver Bow Creek. The Silver Bow Creek/Butte Area Site (original portion) was listed on the NPL in 1983 by EPA under the CERCLA and site investigations began in 1984 with the Phase I Remedial Investigation (RI) prepared by MultiTech Services under contract to the MDEQ. A supplemental RI report was prepared by CH2M Hill (1987). The Phase II RI described in the Draft RI Report (ARCO, 1995a) was conducted by ARCO and describes investigation activities, characterizations and interpretations performed since 1991. All pre-1991 studies or data that were determined by ARCO and the MDEQ to be applicable or pertinent to current OU conditions were incorporated in the OU characterization in the Draft RI Report (Phase II). The Draft RI Report complied with Superfund law, defined the nature and extent of the contamination to the extent necessary to determine remedial action and provided information to complete the baseline human health and ecological risk assessments (ARCO, 1995a). The baseline risk assessment was released by MDEQ in December of 1994 (MDEQ, 1994a). The feasibility study, released by ARCO in June 1995, included the development, screening and evaluation of potential OU remedies (ARCO, 1995b). The proposed plan was also released in June 1995 and delineated the preferred alternative (MDEQ, 1995).

III. HIGHLIGHTS OF COMMUNITY PARTICIPATION

CERCLA sections 113 and 117 provide for public participation in the development of the administrative record upon which the remedy selection is based. These sections require that, before adoption of any plan for remedial action, the lead agency shall:

1. Publish a notice and brief analysis of the proposed plan and make such plan available to the public; and

2. Provide a reasonable opportunity for submission of written and oral comments and an opportunity for a public meeting at or near the OU regarding the proposed plan and any proposed findings relating to cleanup standards. The lead agency shall keep a transcript of the meeting and make such transcript available to the public. The notice and analysis published under item #1 shall include sufficient information to provide a reasonable explanation of the proposed plan and alternative proposals considered.

Additionally, notice of the final remedial action plan (record of decision) adopted shall be published and the plan shall be made available to the public before commencing any remedial action. Such a final plan shall be accompanied by a discussion of any significant changes to the preferred remedy presented in the proposed plan along with the reasons for the changes and a response (Responsiveness Summary) to each of the significant comments, criticisms, and new data submitted in written or oral presentations during the public comment period.

MDEQ has conducted extensive community participation activities beyond what is required under the National contingency Plan. Public participation began prior to initiation of the site investigation with the issuance of the draft RI/FS Administrative Order on Consent and draft RI/FS Work Plan. Three public informational meetings (in Missoula, Anaconda, and Butte) and a formal public hearing (in Ramsay) were held in 1991 to gather public input on the proposed study. Comments were incorporated into the final RI/FS AOC and Work Plan, and a responsiveness summary addressing those comments was published. Additional public meetings were held to provide progress updates on the investigation and to gather public comments on the SST OU demonstration projects, as well as the work plan for the draft Baseline Risk Assessment. In addition, ARCO and MDEQ held a series of meetings, moderated by the Headwaters Resource Conservation and Development District, with SST OU landowners during 1992 and 1993 to provide information about alternatives under consideration and to gather input from local landowners. During late 1994 and 1995, as the SST OU investigation was concluding and the major RI/FS reports were prepared and published, community participation activities included the following: nine (9) public "roundtable" meetings, numerous OU tours, two meetings to discuss the Remedial Investigation, three informational meetings on the Baseline Risk Assessment, three Proposed Plan informational meetings, a 60 day public comment period, a public hearing, and presentation of the selected remedy in the Record of Decision. The Record of Decision documents changes to the preferred remedy as a result of public comments.

The proposed plan (MDEQ, 1995a) for the OU was released for public comment on June 9, 1995, and mailed to over 1,300 citizens on various Montana Superfund mailing lists. The proposed plan was made available to the public at the Environmental Protection Agency (EPA) offices in Helena, MT, and information repositories maintained at: MDEQ Superfund office, State Library, EPA Office, and the Montana Historical Society in Helena; Hearst Free Library in Anaconda; Montana State University in Bozeman; Silver Bow Library, Montana Tech Library, Butte Public Library, EPA Office and the Citizens Technical Environmental Committee Office in Butte; Missoula Public Library, University of Montana Mansfield Library, and the Clark Fork Pend-Oreille Coalition Office in Missoula. The notice of availability of the proposed plan (MDEQ, 1995a) was published in the Butte-Montana Standard, the Missoulian, and the Anaconda Leader newspapers on June 9, 1995. The full administrative record is maintained by EPA in Helena. Microfilm copies of the administrative record are also made available to the public at several of the information repositories listed above.

During the 60-day public comment period (June 9 through August 7, 1995) public informational meetings were held at: Fairmont Hot Springs on June 20; Butte Community Center on June 21; and, Missoula Courthouse Annex on June 22, 1995. At these meetings, representatives from MDEQ answered questions about contamination issues, the remedial alternatives under consideration, and the preferred remedy. A public meeting/hearing was held on July 10, 1995, at Fairmont Hot Springs at which MDEQ accepted formal oral comments from the public. A court reporter transcribed the entire meeting/hearing and MDEQ made the transcript available by placing it in the administrative record. A response to the comments received during the public comment period is included in the Responsiveness Summary (Appendix D). Also, community acceptance of the selected remedy is discussed in Section VIII of the Decision Summary, Summary of Comparative Analysis of Alternatives.

MDEQ considered public comments and revised the selected alternative as a result (see Section XI).

IV. SCOPE AND ROLE OF RESPONSE ACTION

The primary focus of the SST OU RI/FS was to evaluate findings of previous investigations, to collect additional data to assist in characterizing current and future risks, and to develop and evaluate remedial action alternatives. The RI/FS was performed in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR Part 300, and CERCLA Section 104, 42 U.S.C. § 9604.

The overall objectives of the RI/FS were:

- To collect data on the types, concentrations, extent and movement of contaminants present in tailings, subsurface soils, railroad materials, surface water, groundwater, and instream sediment at the OU;
- To provide information for estimating volume, location, transport and fate of contaminated media and materials;
- To provide information on OU physical characteristics and contaminants for use in the risk assessment and the feasibility study;
- To assess the present and potential future risks to human health and the environment at the OU;
- To identify applicable or relevant and appropriate legal requirements (ARARs) for the remedial action; and
- To identify and evaluate remedial alternatives to address human health and environmental risks.

Based on these evaluations, findings of previous investigations and the results of the RI field investigation, the sources and the areas of environmental contamination at the Streamside Tailings Operable Unit have been delineated sufficiently to allow the agencies to evaluate and select an appropriate remedy for the OU contamination.

The remedy outlined in this record of decision represents the final remedial action at the OU and will address the principal threats to human health and the environment which are posed by the contaminated media and materials.

V. SUMMARY OF OU CHARACTERISTICS

This section presents a summary of RI conclusions for each of the four OU geographic subareas and for OU-wide aquatic and terrestrial resources (ARCO, 1995a). Detailed information is presented in Sections 4.3 through 4.8 of the Draft RI Report (ARCO, 1995a). Contamination was found in all media (soil, groundwater, surface water, railroad beds and instream sediments) throughout most of the SST OU. Table 1 enumerates contaminant concentrations found in tailings/impacted soils.

The OU has been divided into four subareas based upon geologic and topographic features that control the soil, hydrogeologic, geomorphic, surface water, ecologic, demographic and land use characteristics of the OU (Figure 2). Additionally, Silver Bow Creek was further divided into stream reaches for more detailed evaluation and characterization of OU information. A total of 12 reaches were defined with one to several reaches located in each subarea.

Table 1
Streamside Tailings OU
Median Concentrations - Tailings/Impacted Soil
(mg/kg)

Analyte	Reference[1]	Subarea 1	Subarea 2	Subarea 3	Subarea 4
$pH_{(su)}$	5.6	4.3	4.3	4.0	4.5
Arsenic	39	278	563	215	249
Cadmium	3.2	7.8	16.2	5.5	6.3
Copper	99	739	2,710	1,290	1,315
Lead	55	540	1,510	316	638
Mercury	0.13	2.1	11.0	1.2	2.7
Zinc	126	2,400	5,400	1,445	1,805

REF: SST OU RI (ARCO, 1995a), mg/kg = milligrams per kilogram. su = standard units. 1-"Reference" soils are considered to be outside the influence of flood deposited tailings but could be impacted by other contaminant sources.

General Description of Subareas

As shown on Figure 2, the SST OU consists of Silver Bow Creek and areas in and near its floodplain from the downstream extent of LAO west of Butte to the I-90 bridge directly upstream of the WSP OU northeast of Opportunity.

Subarea 1 - Rocker

The Rocker Subarea extends from the west end of LAO to approximately 1,000 feet upstream of the confluence of Sand Creek and Silver Bow Creek (Figure 2). Sand Creek is approximately 400 feet west of the bridge adjacent to the community of Silver Bow. During the development of the initial stages of the current RI, Subarea 1 was originally defined at the downstream end by the Rocker Fault, located near the town of Rocker. Subarea 1 was extended to its current boundary because of the nature of the stream and the tailings rather than the bedrock and alluvial geology.

Intermittent tributaries within this subarea include Whiskey Gulch and Gimlet Gulch. The subarea encompasses approximately 5.2 miles of Silver Bow Creek and loses approximately 88 feet in elevation over the subarea. Tailings/impacted soils within the subarea are continuous and confined to a narrow floodplain.

The communities of Rocker, Fredricksburg, and Nissler are adjacent to the SST OU within this subarea. The Rocker OU, ARCO's Demonstration Project I, and the Rocker Streambank Tailings and Revegetation Study (STARS) plots are also located within this subarea.

Subarea 2 - Ramsay

The Ramsay Subarea extends from 1,000 feet upstream of the confluence of Sand Creek and Silver Bow Creek to approximately 700 feet west of Miles Crossing (Figure 2). The communities of Silver Bow, Ramsay, Dawson and Miles Crossing are adjacent to the OU within this subarea. Industries adjacent to the OU include the Rhone-Poulenc Basic Chemicals Plant, the Port of Montana and the Union Pacific switching yards.

The subarea encompasses the Ramsay Flats, a tailings deposit of approximately 160 acres. Tailings/impacted soils within the subarea are continuous along a floodplain wider than that of Subarea 1. Tributaries within the subarea include the intermittent Sand Creek and perennial Browns Gulch. Average flow in Browns Gulch is approximately 0.5 to 5 cubic feet per second (cfs). Other inflows within the subarea include the Silver Lake Pipeline discharge, with an approximate flow of 5 to 20 cfs, and a seep near Rhone-Poulenc, with an approximate flow of 0 to 0.25 cfs. The subarea encompasses approximately 5.6 miles of Silver Bow Creek losing approximately 68 feet in elevation over the length of the subarea.

Subarea 3 - Canyon

The Canyon Subarea extends the length of Durant Canyon from slightly above the mouth of the canyon near Miles Crossing to Fairmont Bridge over Silver Bow Creek near the Fairmont Resort (Figure 2). The small community of Finlen is adjacent to the OU within this subarea.

German Gulch is the main tributary within the subarea with an average flow of 5 to 20 cfs. During summer months, most of German Gulch's flow is diverted just above its mouth for irrigation purposes and does not enter Silver Bow Creek. The subarea encompasses approximately 5.0 miles of Silver Bow Creek losing approximately 174 feet in elevation over the length of the subarea. Tailings/impacted soils within the subarea are discontinuous along the narrow canyon. A limited number of abandoned meander scars and sloughs containing tailings deposits exist on the opposite side of the railroad embankments from Silver Bow Creek.

Subarea 4 - Upper Deer Lodge Valley

The Upper Deer Lodge Valley Subarea extends from the Gregson Bridge to the I-90 bridge just south of the WSP (Figure 2). The communities of Fairmont, Crackerville and Opportunity are adjacent to the SST OU within this subarea.

Gregson Creek is the only notable intermittent tributary within the subarea. Perennial Mill and Willow Creeks are separated from Silver Bow Creek by a diversion dike and diverted away from Silver Bow Creek. The subarea encompasses approximately 6.8 miles of Silver Bow Creek losing approximately 194 feet in elevation over the length of the subarea. Tailings deposits within the subarea are continuous along a wide floodplain, interspersed with some vegetation. Tailings within the subarea were initially deposited along a system of overflow channels. More recently, the stream has been channelized with dikes along the upper portions of this subarea which somewhat limit overbank flow and flow to the overflow channels.

Railroad Materials and Instream Sediments

Two other media are also present throughout the OU but are not necessarily related to the subarea divisions. These media include the railroads and instream sediments. Four types of railroad materials, including bed and ballast construction materials and spilled materials, all contain contaminants of concern. The four material types include waste rock or low grade ore, concentrate spills, impacted material consisting of non-vegetated soil, and slag. Native alluvium, native rock and imported crushed rock were also used to construct the railroad bed and as ballast.

Instream sediments (i.e. sediment within the present active channel of Silver Bow Creek) contain contaminants of concern extending throughout the entire length of the SST OU stream channel. Instream sediments consist of tailings, soil and rock particles that have been deposited instream or are carried through the OU as a result of surface water transport.

Conceptual Model of Contaminant Transport

Data collected during the remedial investigation revealed five primary sources of contamination to Silver Bow Creek:

1) upstream;
2) tailings/impacted soils;
3) groundwater;
4) instream sediments; and
5) railroad embankments

Contaminants move through the area and between environmental media in response to a variety of processes. Some of the primary means by which contaminants move within the SST OU are listed below.

1) Upstream

Upstream sources include, but are not limited to, mine wastes in and near the City of Butte, mine/mill tailings in the Colorado Tailings and Butte Reduction Works areas, and the Butte storm and waste water systems and Butte Operations areas. Contaminants from these source areas enter the SST OU primarily in Silver Bow Creek surface water and instream sediments. Off-OU contaminants also enter via groundwater from the Colorado Tailings area and the Rocker Timber Framing and Treating Plant OU.

Surface water entering (inflow) the SST OU from upstream areas is highly contaminated (Table 2). Water quality data indicate that contaminants are added to Silver Bow Creek in the upper portion of the OU during most flow conditions (Table 2). However, control of upstream contamination is outside of the scope of this operable unit, but will be addressed in other operable unit or site cleanups, or permit activities under other environmental laws.

2) Tailings/Impacted Soils

Persistent and widespread expanses of tailings/impacted soils are present along nearly the entire 24-mile reach of Silver Bow Creek. Impacted soils are defined here as soils which have been mixed with the tailings or where the tailings have leached inorganics into the soils. Tailings/impacted soils are the primary source of contamination for the SST OU. Some tailings/impacted soils are mixed with native soils, which makes visual identification of contaminated materials difficult. The lateral and vertical extent of tailings/impacted soils was determined by analysis of 764 samples. The volume of these materials was estimated at 2.4 to 2.8 million cubic yards lying within 1,270 acres of the historic Silver Bow Creek floodplain with measured thickness ranging from a few inches to greater than seven feet. Most of these tailings/impacted soils contain elevated concentrations of arsenic, cadmium, copper, lead, mercury, and zinc.

Erosion and runoff are the most obvious and damaging contaminant transport mechanisms for the SST OU. Erosion, as it is discussed here, encompasses three major processes: channel migration or avulsion, bank/mass wasting, and surface or overland flow. The channel has and is expected to continue to migrate through many parts of the Silver Bow Creek floodplain (Schumm, 1995). This constant and sometimes dramatic migration re-entrains substantial volumes of tailings/impacted soils back into the Silver Bow Creek ecosystem (CH2M Hill, 1989a). Surface water elevation changes in Silver Bow Creek itself can cause bank storage which causes mechanical failure, high flows which cause tractive force failure, and undercutting of banks, all of which cause direct erosion of metals-laden streambank tailings/impacted soils into the stream. In addition, ice buildup in the stream during winter and spring months can cause streambank erosion and stream avulsion. Precipitation or snowmelt runoff moves metals-bearing materials through erosion and carries the contaminants to Silver Bow Creek. Metallic salts are sometimes wicked to the surface of tailings through capillary action, and are encrusted on the tailings surface as the water evaporates, and are subsequently dissolved or directly eroded by water into the stream during precipitation or runoff events. People and animals can also cause streamside tailings to directly enter the stream by disturbing the tailings/impacted materials on the bank (Figures 3, 4, 5 and 6).

Table 2
Silver Bow Creek Surface Water Quality
Geometric Mean Low Flow Concentrations
(μg/l)

Analyte	WQB - 7[1]		SS-07	SS-10	SS-14	SS-16	SS-17
	Chronic	Acute	inflow	Silver Bow	Mile Crossing	Fairmont	Opportunity[2]
$pH_{(su)}$	NA	NA	7.3	8.0	7.9	8.2	9.6
Arsenic	190	360	8.7	14.5	11.7	15.4	18
Cadmium	1.1	3.9	1.6	2.5	1.1	1.1	0.7
Copper	12	18	178	322	163	140	140
Lead	3.2	82	5.3	15.2	5.4	4.6	1.9
Zinc	110	120	662	860	532	455	366

NA = not applicable; su = standard units; SS-7 monitoring station on SBC; values in "total recoverable" concentrations, (μg/l).
1 - WQB-7 generally corresponds to "Gold Book" aquatic standards at a total hardness of 100 mg/l $CaCO_3$.
2 - Parameters for station SS-17 represent July 1985 event only. A geometric mean for this station was not calculated.

Contaminants not carried into Silver Bow Creek may also be adsorbed to the soil. These metals will remain in this semi-stable form until geochemical conditions alter the chemical stability of the soil system to re-release the metals. Contaminant transport by the many erosive processes described previously is the most significant method of metals introduction into the Silver Bow Creek aquatic and riparian system.

3) Groundwater

The main objectives of the groundwater investigation were to determine if groundwater was contaminated and to define where the contaminated groundwater was located (ARCO, 1991a). A third objective was to quantify the interaction between groundwater and Silver Bow Creek surface water and instream sediments.

A total of 30 wells were installed in the OU and monitored. Because of the limited number of wells and their spatial distribution throughout the OU's 24-mile length, groundwater characterization is discussed in terms of general OU conditions and does not fully characterize the range of contaminant concentrations or contaminant locations within the OU.

The 30 wells installed in the alluvium were screened at two different depths, within 20 feet of the ground surface (upper alluvial) and greater than 20 feet below the ground surface (lower alluvial). The designation between these two units (upper and lower alluvial) was intended only for SST RI data analysis. Both of these units are hydrogeologicly interconnected and should be considered as a single alluvial aquifer.

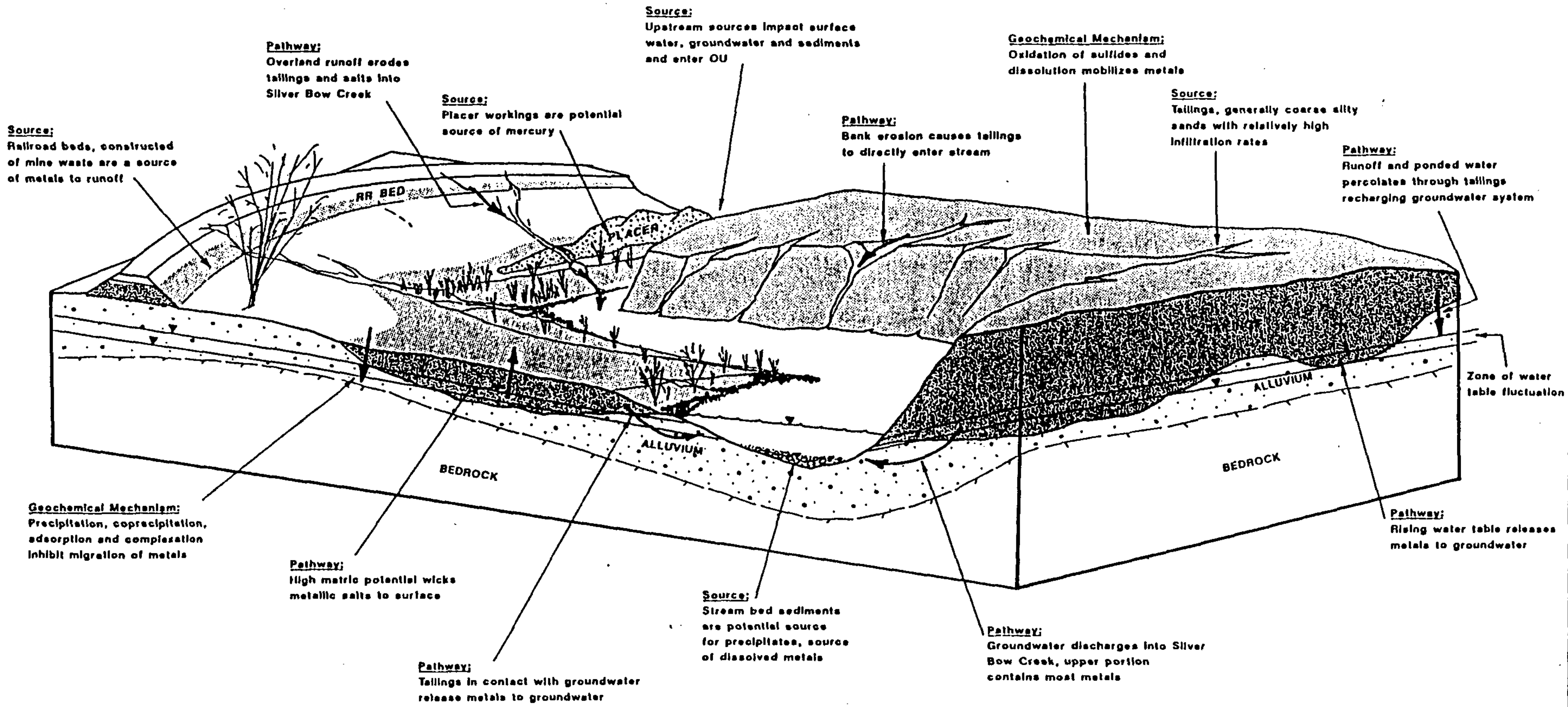
Generally, groundwater flows toward and into the stream except in several reaches (the most significant being the outlet of Durant Canyon) where surface water flows into groundwater. Elevated concentrations of copper and zinc and exceedances of drinking water standards (Maximum Contaminant Levels [MCLs], or Montana Water Quality Standards (WQB-7), Table 3) for arsenic and cadmium were found in many of the shallow monitoring wells.

In many areas, groundwater is in direct contact with tailings/impacted soils for at least part of a typical year (Figure 3). In the RI/FS documents and in the ROD these materials are designated the term "saturated tailings". The seasonal groundwater level fluctuation averages two feet (Table 4). This direct contact with metals enriched tailings/impacted soil mobilizes metals which in turn contaminate groundwater. The volume of tailings/impacted soils saturated with groundwater for a portion of the year and tailings which overlie them are listed in Table 4. This is a principal mechanism for groundwater contamination at the OU (ARCO, 1995a and Benner et al., 1995).

Movement of water from the tailings on the surface through the unsaturated (vadose) zone and into the saturated (groundwater) zone also causes transport of contaminants into underlying soils and groundwater. This is most likely to happen during longer precipitation or snowmelt events. Metals weakly held to tailings are leached by the infiltrating water and eventually can be carried into the underlying native soils and groundwater. Profiles of many soils in the SST OU show evidence of metals migration from the tailings into underlying native materials.

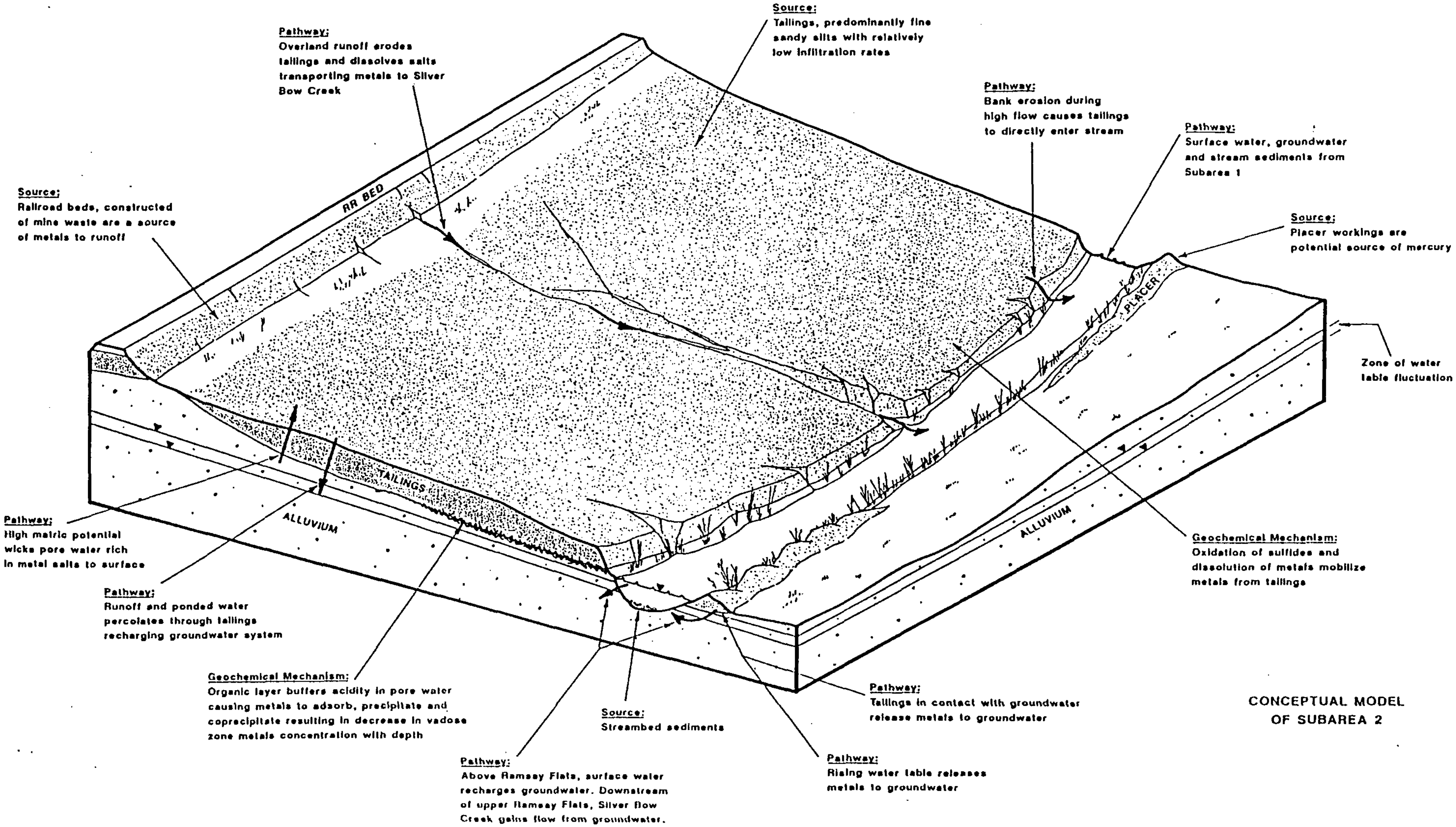
Contaminated groundwater flows into Silver Bow Creek along the majority of stream reaches. This is most likely to happen in areas where the stream gains flow from the groundwater and results in the greatest site related impact to Silver Bow Creek water quality during low-flow conditions. This mechanism is the likely cause for increases in most surface water contaminant concentrations in Subareas 1 and 2 during low or base-flow conditions because many of the other possible pathways, except for instream sediments potential for contaminate release, for contaminant movement are inactive during low-flow (e.g., runoff and infiltration)(Table 2). The opposite of this is true during high-flow conditions in portions of the stream when surface water may flow into and contaminate groundwater.

Silver Bow Creek surface water and instream sediments are the primary recipients of contaminants from the streamside tailings as well as from off-OU sources.



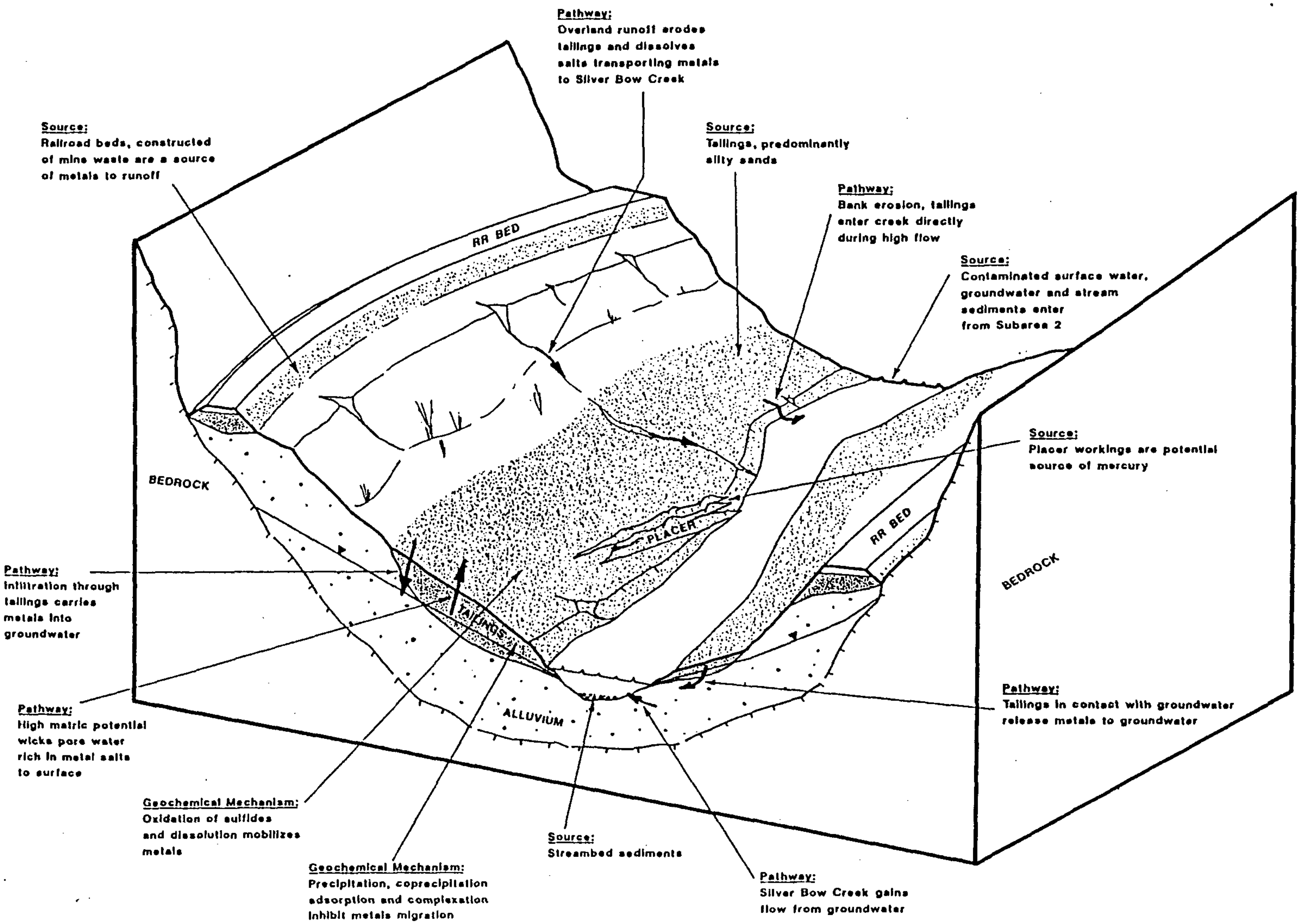
CONCEPTUAL MODEL
OF SUBAREA 1

FIGURE 3



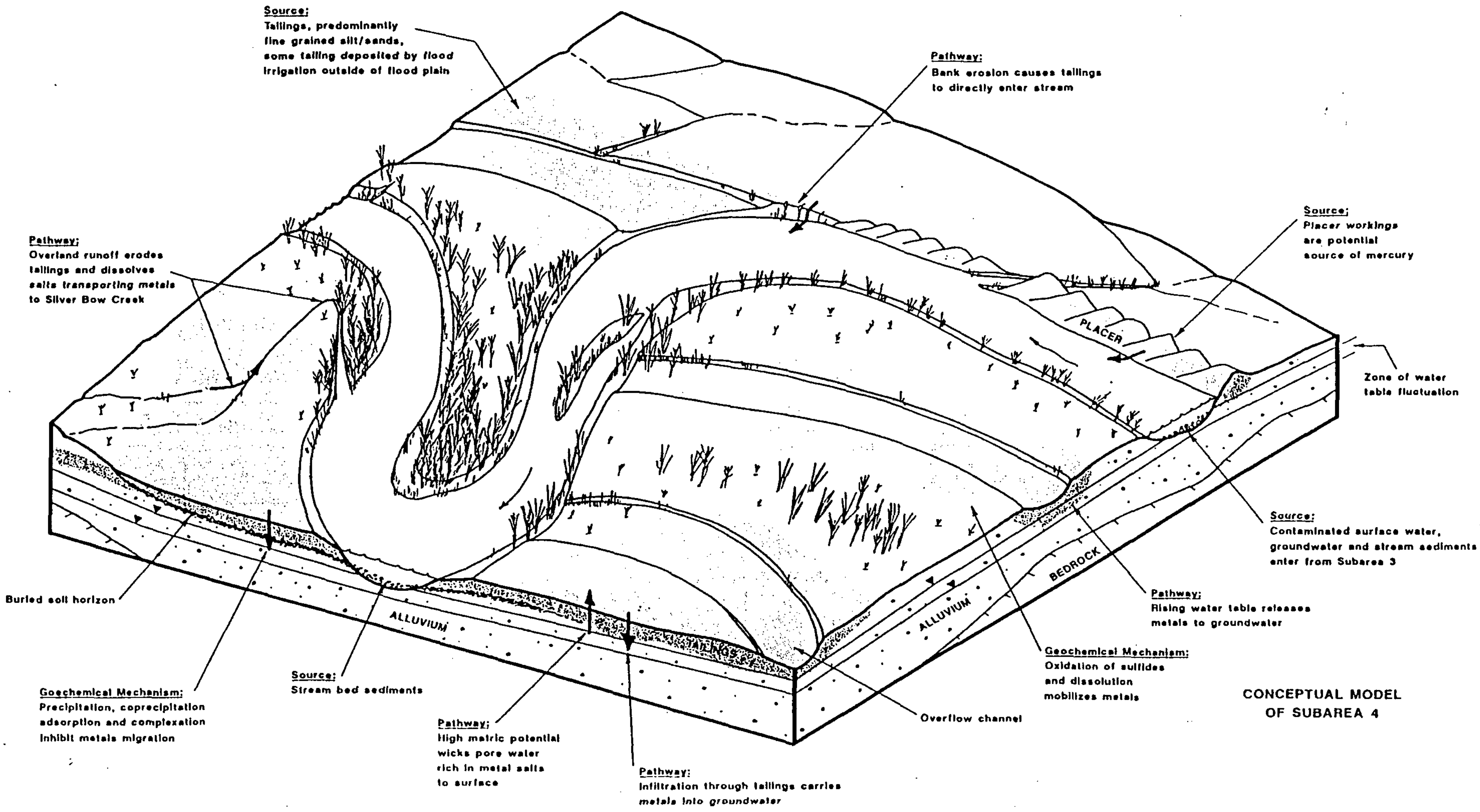
CONCEPTUAL MODEL OF SUBAREA 2

FIGURE 4



CONCEPTUAL MODEL
OF SUBAREA 3

FIGURE 5



CONCEPTUAL MODEL
OF SUBAREA 4

FIGURE 6

Table 3
SST OU WQB-7 Human Health Groundwater Exceedances [1]

Well No.[2]	Sample Interval (feet)	Date	DTW[3] (feet)	Arsenic (µg/L)	Cadmium (µg/L)	Mercury (µg/L)
C-1	19-24	08/19/93	3.55	3.2	0.0	0.19
C-14	15-20	08/19/93	8.46	6.0	0.04 U	0.15
C-16	2.8-7.1	10/27/92	2.56	11.5	6.2	0.16 U
C-18	3-7	10/27/92	3.25	13.0	12.1	0.16 U
		03/10/93	3.34	5.5	6.8	0.12
		06/07/93	3.80	5.8	R	0.29
		08/19/93	3.70	11.8	6.1	0.30
C-21	5-9.7	10/27/92	5.28	76.8	0.6	*
		03/10/93	4.88	48.3	0.1	*
		06/07/93	4.69	41.7	0.2	*
		08/19/93	4.54	53.1	0.2	*
C-22	4.5-8.9	10/27/92	5.15	72.2	0.8	*
		03/10/93	4.64	28.0	0.3	*
		06/07/93	4.71	20.7	0.2	*
		08/19/93	4.87	18.9	0.2	*
C-23	4.5-8.9	10/27/92	4.40	27.5	0.5	*
		03/10/93	4.82	25.4	0.2	*
		06/07/93	4.88	24.6	0.2	*
		08/19/93	5.06	31.3	0.2	0.12
C-24	4-8.7	03/10/93	4.22	1.9	5.8	0.10 U
		06/07/93	3.60	4.1	9.0	0.13
C-25	4.5-8.9	03/10/93	4.94	3.5	29.8	0.10 U
		06/07/93	4.95	2.3	9.6	0.10
C-26	11.4-16.1	08/19/93	5.53	6.2	0.63 U	0.23
C-3	13-18	11/23/91	6.81	1.6 U	10.4	0.2 U
		10/27/92	6.72	1.9	9.2	0.16 U
		03/10/93	5.30	4.4	10.9	0.10 U
		06/07/93	5.36	1.0	8.8	0.14

(1) WQB-7 - Montana Water Quality Bureau Standards Numeric Water Quality Standards (Arsenic 18 µg/L; Cadmium 5 µg/L; Mercury 0.14 µg/L); Shading indicates an exceedance; U - Below method detection limit; R - Rejected data.

(2) RH-/DP- - Well and drive points installed in the Rocker Operable Unit; wells represent ground water concentrations at shallow, intermediate, and deep depths; not inclusive of all wells with exceedances. DW - Domestic wells - 200 series wells are located in Rocker, Nissler, and Miles Crossing areas; 300 series wells are located in the upper Deer Lodge Valley.

(3) DTW - Depth to water below ground surface ! - Unknown * - Not analyzed + - Data not available

Table 3
SST OU WQB-7 Human Health Groundwater Exceedances [1]

Well No.[2]	Sample Interval (feet)	Date	DTW[3] (feet)	Arsenic (µg/L)	Cadmium (µg/L)	Mercury (µg/L)
		08/19/93	5.75	1.2 U	8.9	*
C-4	7.5-13	11/25/91	4.86	6.1	25.7	*
C-4	7.5-13	10/27/92	4.34	8.3	29.2	0.16 U
		03/10/93	3.09	5.8	41.1	0.10 U
		06/07/93	3.41	4.1	41.9	0.19
		08/19/93	3.70	3.6	44.2	0.47
C-4S	7.5-9.5	03/10/93	3.21	11.9	0.6	0.15
		06/07/93	3.54	9.1	0.3	0.16
		08/19/93	3.87	12.0	0.5	0.23
C-5	24-29	08/19/93	7.97	3.9	R	0.15
C-6	13-18	08/19/93	4.40	5.2	0.16 U	0.26
C-7	6.8-8.8	03/10/93	7.62	8.8	6.0	*
		08/19/93	7.97	3.5	5.8	*
DP-2	+	09/22/92	+	68.7	*	*
DP-3	+	09/22/92	+	1830.0	*	*
DP-4	+	09/29/92	+	16000.0	*	*
DP-5	5-8.1	09/30/92	2.56	131.0	*	*
DW-203	93-98	01/07/85	+	20.0	0.70 U	*
DW-206	< 30	01/07/85	!	33.0	0.70 U	*
		04/24/85	!	26.0	0.50 U	*
		12/13/85	!	29.0	1.1	*
DW-207	38-43	01/07/85	+	21.0	0.70 U	*
		02/28/85	+	24.0	1.1 U	*
		04/24/85	+	18.0	0.50 U	*
DW-212	30-?	01/07/85	!	23.0	0.70 U	*
		04/24/85	!	22.0	0.50 U	*
		12/12/85	!	19.0	1.0	*

(1) WQB-7 - Montana Water Quality Bureau Standards Numeric Water Quality Standards (Arsenic 18 µg/L; Cadmium 5 µg/L; Mercury 0.14 µg/L); Shading indicates an exceedance; U - Below method detection limit; R - Rejected data.

(2) RH-/DP- - Well and drive points installed in the Rocker Operable Unit; wells represent ground water concentrations at shallow, intermediate, and deep depths; not inclusive of all wells with exceedances. DW - Domestic wells - 200 series wells are located in Rocker, Nissler, and Miles Crossing areas; 300 series wells are located in the upper Deer Lodge Valley.

(3) DTW - Depth to water below ground surface ! - Unknown * - Not analyzed + - Data not available

Table 3
SST OU WQB-7 Human Health Groundwater Exceedances (1)

Well No.(2)	Sample Interval (feet)	Date	DTW(3) (feet)	Arsenic (μg/L)	Cadmium (μg/L)	Mercury (μg/L)
DW-215	!	01/08/85	11.50	22.0	0.60 U	*
		03/10/93	!	22.1	0.2	*
DW-230	< 40	01/08/85	!	38.0	0.60 U	*
		04/24/85	!	73.0	0.50 U	*
		07/25/85	!	36.0	0.20 U	*
DW-230	< 40	12/12/85	!	35.0	1.0	*
		03/10/93	!	38.1	0.1	*
DW-313	< 25	03/10/93	+	99.6	0.2	*
GS-04	3-8	01/16/85	+	41.0	6.9	*
		02/28/85	+	29.0	7.4	*
		03/28/85	+	26.0	6.1	*
		06/11/85	+	27.0	5.0	*
		03/10/93	+	21.0	1.1	0.10 U
		06/07/93	+	26.7	0.7	0.19
		08/19/93	+	R	R	0.18
GS-06	19-29	12/12/85	8.20	17.0	11.0	*
		08/19/88	+	13.0	5.9	*
RH-1	3-13	08/20/87	8.42	10.0	88.0	*
		09/14/88	9.58	16.0	30.0	*
		11/12/91	+	2 U	24.6	*
		09/23/92	+	3.0 U	37.1	*
RH-10	7-17	08/21/87	ND	3100.0	30.0	*
		09/13/88	10.47	5020.0	*	*
		11/07/91	+	1210.0	6.2	*
		09/29/92	+	3000.0	8.5	*
RH-14	29-39	09/13/88	10.25	4940.0	5.00 U	*
		11/08/91	+	1300.0	2 U	*
RH-14	29-39	09/28/92	+	6060.0	2.0 U	*

(1) WQB-7 – *Montana Water Quality Bureau Standards Numeric Water Quality Standards (Arsenic 18 μg/L; Cadmium 5 μg/L; Mercury 0.14 μg/L);* Shading indicates an exceedance; U – Below method detection limit; R – Rejected data.

(2) RH-/DP- – Well and drive points installed in the Rocker Operable Unit; wells represent ground water concentrations at shallow, intermediate, and deep depths; not inclusive of all wells with exceedances. DW – Domestic wells - 200 series wells are located in Rocker, Nissler, and Miles Crossing areas; 300 series wells are located in the upper Deer Lodge Valley.

(3) DTW – Depth to water below ground surface ! – Unknown * – Not analyzed + – Data not available

Table 3
SST OU WQB-7 Human Health Groundwater Exceedances [1]

Well No.[2]	Sample Interval (feet)	Date	DTW[3] (feet)	Arsenic (µg/L)	Cadmium (µg/L)	Mercury (µg/L)
RH-15	+	11/07/91	+	360.0	2.4	*
RH-15	+	09/24/92	+	955.0	2.0 U	*
RH-18	+	11/07/91	+	35.1 U	2 U	*
RH-3	5-15	11/12/91	+	2.1	5.6	*
RH-33	+	11/07/91	+	24700.0	46.1	*
		09/28/92	+	25700.0	2.0 U	*
RH-4	5-15	08/21/87	5.10	23.0	5.00 U	*
		09/14/88	5.08	34.0	*	*
		11/12/91	+	38.4	2 U	*
		09/24/92	+	53.9	2.0 U	*
RH-47	+	09/23/92	+	9.2	91.8	*
RH-5	8-18	08/20/87	10.81	490.0	78.0	*
		06/03/88	10.79	700.0	90.0	*
		09/13/88	11.23	1270.0	82.0	*
		11/07/91	+	1660.0	42.8	*
		09/28/92	+	2210.0	46.5	*
RH-6	29-39	08/20/87	11.69	1600.0	17.0	*
		06/03/88	10.94	780.0	14.0	*
		09/13/88	12.33	180.0	5.00 U	*
		11/07/91	+	875.0	2 U	*
		09/28/92	+	658.0	2.0 U	*
RH-8	30-40	09/14/88	9.28	19.0	5.00 U	*
		09/23/92	+	18.2	2.0 U	*
RH-9	6-16	08/20/87	8.81	21.0	5.00 U	*

(1) WQB-7 – Montana Water Quality Bureau Standards Numeric Water Quality Standards (Arsenic 18 µg/L; Cadmium 5 µg/L; Mercury 0.14 µg/L); Shading indicates an exceedance; U – Below method detection limit; R – Rejected data.

(2) RH-/DP- – Well and drive points installed in the Rocker Operable Unit; wells represent ground water concentrations at shallow, intermediate, and deep depths; not inclusive of all wells with exceedances. DW – Domestic wells - 200 series wells are located in Rocker, Nissler, and Miles Crossing areas; 300 series wells are located in the upper Deer Lodge Valley.

(3) DTW – Depth to water below ground surface ! – Unknown * – Not analyzed + – Data not available

Because the majority of inorganic compounds are typically most soluble at low (acidic) pH, metals carried with acidic groundwater entering the relatively higher pH water of Silver Bow Creek precipitate out of the water and adsorb onto instream sediments. Researchers working on Silver Bow Creek have documented that instream sediments accumulate the majority of contaminant load from groundwater (Benner et al., 1995; Smart, 1995). Under conditions of extremely acidic (pH = 1.0 to 4.5), low dissolved oxygen (less than 1,000 μg/l), and metal-rich groundwater (avg. Cu = 20,000 μg/l and Zn = 60,000 μg/l) discharging to a neutral to basic (pH = 7.9 to 9.1), oxidized (8,000 μg/l) stream with relatively lower contaminant concentrations (avg. Cu = 100 μg/l and Zn = 1,000 μg/l), the vast bulk of contaminant loading from groundwater to surface water is attenuated in the instream sediments (Benner et al., 1995 and Smart, 1995). The attenuation mechanisms are most likely adsorption and/or precipitation. Contaminated groundwater is doubtless a source of additional contamination to instream sediments and surface water of Silver Bow Creek.

4) Instream Sediments

Instream sediments (i.e. sediment within the active channel of Silver Bow Creek) are severely contaminated with metals arsenic, cadmium, copper, lead, mercury and zinc extending throughout the entire length of the SST OU stream channel (Table 4). Instream sediment concentrations of Silver Bow Creek are similar to the concentrations found in the tailings/impacted soils, so, for conceptual purposes, they can be considered "tailings in the stream". The SST OU risk assessment determined that arsenic, cadmium, copper, lead, mercury and zinc are, individually, major contributors to the impairment of the aquatic community of Silver Bow Creek (MDEQ, 1994a).

Essig and Moore (1992) described concentrations of Silver Bow Creek instream sediments as between 10 and 65 times higher for arsenic, cadmium, lead, and zinc, and 400 times higher for copper than are found in other area streams which drain highly mineralized geologic areas. Like tailings themselves, the majority of contaminated sediments vary in size from a coarse sand (1 mm) to a very fine silt or clay (Table 4).

While in the stream, these sediments are presently toxic to most macroinvertibrates (Besser et al., 1995a,b), serve as a potential future source of metals contamination to the surface water system, and could potentially impact future fish populations by biologic up-take from contaminated benthic invertebrates (Woodward et al., 1994).

Besser et al., (1995a,b) and Kubitz et al. (1995) tested instream sediments in the fall of 1993 from analogous locations to samples tested in the fall of 1991 by Kembel et al. (1994) and Ingersoll et al. (1994).

Table 4
Silver Bow Creek
Mean Instream Sediment Concentrations
(mg/kg)

Analyte	Background[1] (<63 μm)	Sand Fraction[2] (2,000-62 μm)	Clay/Silt Fraction[2] (<62 μm)
Arsenic	7	92	378
Cadmium	0.2	3.8	76
Copper	20	694	10,459
Lead	15	225	6,702
Mercury[3]	NA	0.8	--
Zinc	57	1,357	12,782

NA = not analyzed. 1 - Clark Fork Damage Assessment Bed Sediment Sampling And Chemical Analysis Report, University of Montana - Oct. 1992. 2 - sediment contaminant concentration analysis, data used PTI, ARCO, Essig & Moore, and CH2M Hill - Oct. 1995. 3 - As reported in Titan Oct. 12, 1994 submittal, not analyzed by size fraction. μm = micrometers. mg/kg = milligrams per kilogram.

Kubitz et al. (1995) tested the amphipod *Hyalella azteca* and Besser et al. (1995a,b) tested the midge *Chrionomus tentans*. These studies were conducted in accordance to both USEPA and ASTM standard sediment toxicity and bioaccumulation test methods with the standard test organisms (Ingersoll 1991, Ingersoll et al., 1995a, USEPA 1994, ASTM 1995a,b).

Instream sediment chemistry, toxicity, and bioaccumulation was similar between the 1991 and 1993 sampling dates. The sediments from Silver Bow Creek were consistently the most toxic of the samples collected in the Clark Fork basin and resulted in the highest bioaccumulation of metals by both amphipods and midges (Ingersoll per com. September 27, 1995). Moreover, concentrations of metals in these sediment samples consistently exceeded a variety of sediment quality guideline concentrations (Ingersoll et al. 1995b,c; MacDonald et al. 1995; Smith et al. 1995).

5) Railroad Materials

Certain portions of several historic and existing railroad embankments along Silver Bow Creek were constructed or contaminated with mine waste rock and/or mine and mill tailings.

This material represents a source of metals to groundwater or to Silver Bow Creek via runoff.

Estimated Volumes of Contaminated Materials By Subarea

Contaminated tailings/impacted soils volume estimates are presented in Table 4. These volumes were originally presented in the Draft RI as generated by the Natural Resource Information System (NRIS) Geographic Information System (GIS) database. A more detailed description of the various methods and measures used to calculate these quantities is presented in the Draft RI (ARCO, 1995a).

Subarea 1

There are approximately 285,000 cubic yards (cy) of tailings/impacted soils impacting approximately 154 acres within Subarea 1 (Table 4). Tailings/impacted soils are generally coarse textured, comprised primarily of sand and silt size materials. The coarse nature of these tailings increases the potential for movement of water through the tailings and transport of contaminants into the ground and surface water. Tailings deposits are primarily fluvial bar type deposits. The maximum lateral width of tailings/impacted soils is approximately 1,200 feet and the measured thickness of tailings/impacted soils ranges up to approximately four feet. These deposits are generally narrow and lie close to the stream.

Metals-elevated railroad bed and ballast materials identified in Subarea 1 include approximately 203,000 cy of waste rock, 74,500 cy of slag, and a single small (1.3 cy) concentrate spill. Approximately 95,000 cy (47%) of this total quantity of waste rock are present along the CMSP rail line outside the floodplain, relatively far away from the stream. The only significant means of migration of railroad materials is erosion and transport by runoff from near-stream areas and infiltration through contaminated materials. There are several locations within Subarea 1 where railroad materials are likely to be eroded and transported directly to the stream: at two railroad bridges above and below the Rocker siding; and, near Whiskey Gulch and Nissler where the railroad bed forms one of the streambanks of Silver Bow Creek. Approximately 55,000 cy of waste rock are present in locations proximal to the streambanks or bridge abutments at two stream crossings. About 24,000 cy of this total are located in areas proximal to the stream along the northern and eastern sides of the Rocker Siding, a large multi-track siding used by both the Montana Western and Rarus railroad companies. The volume of slag used as ballast material in these same locations proximal to the stream is approximately 15,000 cy.

Surface water flows into the OU from the LAO OU containing concentrations of cadmium, copper, lead and zinc above chronic and acute aquatic surface water quality standards (Table

2). Generally, Silver Bow Creek gains flow from groundwater inflow throughout Subarea 1 (groundwater recharges the stream), indicating that this is a pathway for contaminated groundwater to move into the stream. Evidence that this pathway exists is the presence of some contaminants measured in groundwater in Subarea 1 at concentrations much greater than those measured in Silver Bow Creek during low flow conditions and the notable increase in all dissolved contaminants in the surface water between Subareas 1 & 2 (Table 2). Runoff from areas of overbank tailings to Silver Bow Creek is considerable in Subarea 1 based on high flow water quality data. The confined nature of the floodplain which slopes toward the stream results in transport of both particulate and metal salts to the stream during runoff events.

The alluvial aquifer system is generally close to the ground surface within Subarea 1, ranging between zero to eight feet below ground surface (bgs) in the floodplain. Groundwater levels within the floodplain were found to have a maximum seasonal fluctuation of up to two feet in monitoring wells further from the stream but within the floodplain during the three year monitoring period. Because of groundwater fluctuation in combination with the near-surface groundwater levels, Subarea 1 contains the second largest quantity of tailings/impacted soils considered to be saturated tailings (Table 5).

Infiltration of water through the vadose zone in tailings deposits and into the saturated zone is another method by which contaminants move into groundwater. This is most likely to occur during longer duration precipitation or snowmelt events or in those locations where groundwater is located close to the ground surface and tailings/impacted soils are of a coarse texture.

MCL exceedances for arsenic in groundwater were measured in wells located proximal to and within the Rocker OU. These exceedances may be partially attributed to sources within the Rocker OU. Exceedances of cadmium MCLs in groundwater appear to be related to the presence of fluvially-deposited streamside tailings and/or railroad materials composed of mining wastes or other industrial sources. Such exceedances appear to be confined to samples obtained from monitoring wells completed in the upper portion of the alluvial aquifer in source areas within the floodplain.

The volume of metals-impacted stream sediment in Subarea 1 is 15,000 cy, as defined in the RI. A recent stream survey identified that 20 percent of the stream channel is classified as riffles, 70 percent is runs, and 9 percent is pools. Runs and riffles contain the bulk of contaminated instream sediments (Maxim, 1995).

Table 5
Streamside Tailings OU
Volumes of Saturated Tailings and Relevant Groundwater Information

Subarea	Max. Observed G.W. Fluctuation (ft)	Total Volume Tailings (cy)	Volume Saturated and Overlying (cy)	Volume Residual Tailings (cy)
1	1.98	285,000	187,500	97,500
2	2.09	808,000	112,600	695,400
3	1.68	160,400	78,400	82,000
4	3.06	1,292,000	321,400	970,600
Total		**2,545,400**	**699,900**	**1,845,500**

Note: GW = groundwater, All volumes given in cubic yards (cy). This table represents 50,000 cy which has been removed from Demonstration Projects II.

Subarea 2

There are approximately 808,000 cy of tailings/impacted soils covering over approximately 320 acres within Subarea 2 (Table 5). Tailings/impacted soil deposits range from the larger deposits on the Ramsay Flats (approximately 160 acres) to the limited deposits in the Miles Crossing region (about 34 acres) (ARCO, 1995a). Of this quantity, only 112,600 cy are considered to be saturated and overlying saturated tailings. The percentage of the total volume of tailings/impacted soils proximal to groundwater is smaller in this subarea than in any other subarea. A sizeable portion of the Ramsay Flats tailings deposit (approximately 280,000 cy) is located outside of the present floodplain boundary.

Tailings in the upper and lower portions of Subarea 2 (near Silver Bow Siding, and Miles Crossing) are primarily linear or impoundment style deposits, close to the stream with surfaces sloping towards the stream. In the central portion of Subarea 2 (Ramsay Flats and Browns Gulch), tailings deposits are primarily wide, flat overbank and channel fill deposits on flat streambanks with very little slope. An internal drainage system has developed in the Ramsay Flats that drains to the west to Browns Gulch, which in turn enters Silver Bow

Creek. Tailings are predominantly composed of fine sandy silts with some tailings underlain by a buried organic layer and a clay-silt laminated layer. Tailings/impacted soils generally range in measured thickness from one to four feet although tailings/impacted soils up to five feet thick were measured in several areas.

Tailings/impacted soil samples from Subarea 2 contain most of the highest median concentrations of contaminants of concern for the SST OU (Table 1). The tailings/impacted soils in this reach reflect relatively low-energy overbank deposition of medium to fine grained tailings. A buried soil horizon was penetrated in many of the borings in this subarea, especially in the vicinity of Ramsay Flats. This buried soil horizon provides some protection to groundwater where it is present, since the organic material present in the soil geochemically binds the metals in contaminated pore water moving through the vadose zone.

Railroad materials containing arsenic and metals that were identified in Subarea 2 include approximately 187,000 cy of waste rock, 48,000 cy of slag, and approximately 1,000 cy of impacted material. There are several railroad bridges within Subarea 2 where railroad materials are likely to be eroded and transported directly to Silver Bow Creek or a tributary: at the Silver Bow and Miles Crossing bridges and where the stream crosses Browns Gulch. At these locations, there are about 60,000 cy of waste rock and 5,000 cy of slag out of the total volumes presented above.

Surface water flows into the subarea containing concentrations of cadmium, copper, lead, and zinc above acute and chronic aquatic water quality standards (Table 2). During low flow periods, metals levels in surface water are generally higher at the upstream end of the subarea compared to the downstream end of the subarea. Contaminants of concern in runoff impact Silver Bow Creek substantially during high flows as evidenced by trends of increasing total and dissolved zinc and total copper. Silver Bow Creek appears to slightly gain flow from groundwater inflow in Subarea 2 in the reach of stream adjacent to Ramsay Flats where there is evidence of groundwater impacts to surface water. Silver Bow Creek is less armored within Subarea 2 than any other portion of the OU. Therefore, considerable streambank erosion in many areas is evident. The degree to which surface water is impacted by the groundwater pathway could not be quantified with the data ARCO collected for RI purposes. Data collected on SBC by other researchers quantified the effects of saturated tailings on groundwater and the subsequent impact of contaminated groundwater on instream sediments and surface water (Benner et al., 1995; Smart, 1995).

The alluvial aquifer in Subarea 2 is generally near the surface as in Subarea 1, ranging from approximately zero to eleven feet bgs in the floodplain. In Ramsay Flats, depth to water is approximately five feet below ground surface. Groundwater levels within the floodplain exhibited an observed fluctuation of over two feet in wells further from the streambank. In the larger areas of tailings such as Ramsay Flats, the groundwater elevation is far enough below the surface that a relatively small percentage of tailings are considered saturated. Because of this and the finer grained texture of the tailings/impacted soils deposits, precipitation and adsorption mechanisms may, to a greater extent than in Subarea 1, potentially retard contaminants of concern in the soil. Vadose zone transport of contaminants of concern are limited and less significant within Subarea 2 than anywhere else in the OU. For instance, on Ramsay Flats, the largest single area of tailings with limited data points (monitoring wells), no drinking water MCL exceedances were observed over the Phase II RI monitoring period.

Groundwater MCL exceedances have been detected in several other locations within Subarea 2, primarily where groundwater is close to the surface. Exceedances of the cadmium MCL have been measured in wells in the Silver Bow Siding area. Groundwater samples collected from wells located near the mouth of Browns Gulch and near Miles Crossing have periodically exceeded the arsenic MCL.

The volume of metals-impacted stream sediment in Subarea 2 is 22,700 cy, as defined in the RI. A recent stream survey identified that 21 percent of the stream channel is classified as riffles, 65 percent is runs, and 14 percent is pools. As with Subarea 1 runs and riffles contain the bulk of contaminated instream sediments (Maxim, 1995).

Subarea 3

Subarea 3 is almost wholly contained within Durant Canyon, the canyon setting constituting the main difference between this subarea and the other three subareas. There are no improved roads in the subarea although access can be gained along an unimproved inactive railroad bed which parallels the stream. Within the narrow canyon, the stream channel is generally confined to a narrow floodplain between the railroad embankments.

There are approximately 160,400 cy of tailings and impacted soils covering over approximately 92 acres within Subarea 3 (Table 5). Of this quantity, approximately 78,400 cy of tailings/impacted soils are considered saturated and above. The texture of tailings in this subarea is primarily very fine grained silty sands. Tailing deposits in Subarea 3 are primarily channel bar and impoundment deposits, with minor overbank and channel fill. The maximum lateral width of tailings/impacted soils is approximately 620 feet; tailings deposits are discontinuous through the narrow canyon. Tailings/impacted soils are generally less than two feet thick, averaging 0.5 feet thick. The maximum measured thickness of this material is approximately 4 feet.

Railroad materials containing contaminants of concern identified in Subarea 1 include approximately 60,000 cy of waste rock and approximately 35,000 cy of slag with about

24,000 cy present in areas proximal to the stream. These materials were present in the bed and ballast at five locations within Subarea 3 where railroads cross Silver Bow Creek or where the railroad bed makes up one of the streambanks. Additionally, the confined nature of the canyon and location of the railroads adjacent to Silver Bow Creek increase the area where materials containing contaminants of concern are likely to be eroded and transported directly to Silver Bow Creek. Erosion and transport of these railroad materials is potentially more significant in Subarea 3 than elsewhere in the SST OU.

As in Subarea 2, surface water flows into the subarea at levels above chronic and acute aquatic water quality standards for most metal parameters (Table 2, SS-14). At low flow, contaminant levels in surface water are generally higher at the upstream end of the subarea than at the downstream end of the subarea. This decrease probably occurs primarily from dilution of the input of relatively higher quality German Gulch water to the system. Silver Bow Creek is armored in Subarea 3, more than any other portion of the OU.

Runoff from areas of overbank tailings to Silver Bow Creek is potentially significant. The confined nature and relatively steep slopes of the floodplain near the stream within the canyon may result in transport of both particulate and dissolved salts to the stream during precipitation runoff events.

Based on data from the five monitoring wells located in Subarea 3, the alluvial aquifer is relatively near-surface, ranging from approximately zero to nine feet bgs. Groundwater levels were found to fluctuate between approximately 0 and 1.7 feet. Vadose zone transport of contaminants of concern may be considerable as a result of the fine grained sandy texture, the shallow depth to groundwater and the fluctuation of the water table.

Groundwater MCL exceedances measured in Subarea 3 were from a near-stream well completed in coarse tailings. Samples from this well have exceeded the cadmium MCL three out of five times that it has been sampled. Stream stage and groundwater level data indicate that the surface water is gaining with varying stream stage in the upper end of the subarea near Miles Crossing.

The volume of metals-impacted stream sediment in Subarea 3 is 5,600 cy, as defined in the RI. A recent stream survey identified that 49 percent of the stream channel is classified as riffles, 40 percent is runs, and 11 percent is pools. Runs contain the bulk of contaminated instream sediments for this subarea (Maxim, 1995).

Subarea 4

The character of Subarea 4 is quite different from the other three upstream subareas in that the floodplain is wide and contains numerous overflow channels. These overflow channels are active during various high flow events and contain some of the thicker deposits of tailings/impacted soils and generally contain the majority of off-stream saturated tailings. In the upper half of Subarea 4, Silver Bow Creek flows through a relatively straight man-made channel which limits to some extent potential overbank flows which would normally enter the overflow channels. Below the town of Stuart, the channel is characterized as meandering.

Subarea 4 contains the largest quantity of tailings and impacted soil of all four subareas, approximately 1,300,000 cy over approximately 700 acres (Table 4)(ARCO, 1995a). 50,000 cy has been removed from Demonstration Project II. Of the 1,250,000 cy, approximately 321,400 cy are considered saturated or overlying saturated tailings. Subarea 4 contains about 52% of the volume of tailings/impacted soils within the SST OU. The texture of tailings materials in Subarea 4 is primarily very fine, silty sands. Tailings deposits are discontinuous along a wide floodplain and are sparsely vegetated. Measured tailings/impacted soils thicknesses range from a few inches to over 4.5 feet.

Subarea 4 contains the smallest quantity of railroad materials containing metals and arsenic, including only approximately 8,300 cy of waste rock and approximately 23,000 cy of impacted material. Railroad materials are proximal to Silver Bow Creek at a single location on an abandoned railroad grade at Stuart, which contains approximately 5,000 cy of waste rock. Because the limited quantity of railroad materials containing contaminants of concern is located in the floodplain in a single location in Subarea 4, erosion and transport of railroad materials to Silver Bow Creek is not significant.

Surface water flows into Subarea 4 at levels above chronic and acute aquatic water quality standards for most metal parameters (Table 2, SS-16). With the exception of arsenic, metals levels in surface water are generally higher at the upstream end of the subarea than at the downstream end during low flow with most of the decrease occurring below the Stewart Street Bridge. Conversely, during high flow events, concentrations of both total and dissolved fractions of most contaminants of concern increase by up to an order of magnitude between the upper and lower ends of the subarea.

As Silver Bow Creek flows through the subarea, the upper (southern) part of the subarea loses flow to groundwater and the lower (northern) portion of the OU gains flow from groundwater during low flow. Surface water does not appear to impact groundwater quality in the losing reaches of the subarea.

Runoff of precipitation and snowmelt from the overbank tailings occurs along portions of Subarea 4, primarily through the various overflow channels that meander through the floodplain. Because runoff quality and quantity were not directly measured during the RI, the magnitude of runoff inflow in Subarea 4 could not be quantified.

The alluvial aquifer system is relatively near-surface within Subarea 4, ranging from zero to seven feet bgs in areas away from the active channel. Groundwater levels within the floodplain were found to fluctuate between approximately 0.5 to 3.0 feet. Drinking water MCL exceedances of cadmium in groundwater were detected in two areas, near Crackerville and Stuart. Copper and zinc concentrations where found to be many orders of magnitude greater than surface water standards in near stream wells. This groundwater would be expected to discharge into the creek in gaining sections. These cadmium exceedances were measured along with relatively high concentrations of other metals in the same wells. One of the wells in Subarea 4 that exhibited relatively high metals concentrations was installed in saturated tailings, indicating that the exceedances may be related to the presence of tailings/impacted soils in the saturated interval.

The volume of metals-impacted stream sediment in Subarea 4 is 30,000 cy, as defined in the RI. A recent stream survey identified that 37 percent of the stream channel is classified as riffles, 45 percent is runs, 10 percent is pools, and 8% is dewatered. In this subarea, runs contain the bulk of contaminated instream sediments (Maxim, 1995).

Terrestrial and Aquatic Resources

The Terrestrial and Aquatic Resources Investigations characterized the representative plant communities and the benthic macroinvertebrate community within the SST OU. The Terrestrial Investigation focused on vegetation mapping and vegetation uptake of contaminants of concern. The aquatic investigation focused on benthic macroinvertebrate communities and density of species.

Terrestrial Resources

The general objectives of the Terrestrial Investigation were to characterize representative plant communities within the operable unit in relation to soil conditions and to determine the existence and extent of bioaccumulation of contaminants of concern in tissues of selected plant species. Riparian plant communities were surveyed at stations representing a gradient of contaminant concentrations in soil. The results provide information for assessing potential effects of elevated concentrations of contaminants of concern on plant communities and wildlife that depend on vegetation for habitat and food.

The following conclusions were made on the bases of the limited data collected for the RI:

- Riparian meadow communities within the SST OU consist mainly of stands dominated by tufted hairgrass or redtop, with species of forbs and other grasses occurring in less abundance.

- Concentrations of contaminants of concern in soil and pH levels are the significant variables that affect riparian meadow community characteristics. In some areas of tailings with elevated contaminant concentrations, plant biomass and cover can reach levels characteristic of unimpacted reference areas because soil pH is relatively high (>6.0).

- Willows displayed leaf tip burn, general chlorosis, curling of leaves, and brown margins and brown necrotic spots on leaves that could be attributable to trace metal toxicity. However, it is possible that some of the effects observed are attributable to nutrient deficiency due to localized soil conditions.

Benthic Macroinvertebrate Resources

Since 1986, benthic macroinvertebrate assemblages have been studied at four sampling stations in Silver Bow Creek by the MDEQ (McGuire, 1995). The macroinvertebrate data are analyzed using a series of 10 community metrics that are combined into a single index of biological integrity. Such a measure indicates the severity of mining impacts to Silver Bow Creek. Selected metrics are also combined to develop separate indices of biological integrity for metals and organic effects at each station. The interpretation of the macroinvertebrate data is dependent upon many subjective factors associated with the validity of individual metrics, the combination of metrics used for cumulative assessments, and the impact categorizations based on index scores. Notwithstanding these limitations, the data provide an indication of the current status of macroinvertebrate communities, the degree of recovery over past conditions, and some insight into potential causative agents.

Four macroinvertebrate sampling stations were located along Silver Bow Creek. Two of these stations were located upstream of the SST OU boundary, one below the waste water treatment plant and one below the Colorado Tailings. The other two stations were located at Miles Crossing and at the lower end of the operable unit above the Warm Springs Ponds. The results and conclusions for this reach of stream indicated that biological integrity was severely impaired by metals and organic pollution and that metals remained the primary cause of impacts to macroinvertebrates above the Warm Springs Ponds (McGuire, 1995). Metals toxicity depressed biological integrity and restricted the benthic fauna to a few tolerant species. Biological responses to nutrient and organic inputs were limited in the metals-dominated environment.

Results from these stations also indicated that there was a slight improvement in biological integrity from below the Colorado Tailings to the Warm Springs Ponds. This condition was hypothesized to reflect the buffering effect of organics from the waste water treatment plant effluent and/or the distance from potential sources of contamination.

Algae are useful biomonitors of water quality because they have known environmental requirements and pollution tolerances. The results of this study for the Miles Crossing station and the station upstream of the Warm Springs Ponds indicated that the biological integrity at both stations was poor and the overall impairment at both stations was severe. For comparison, just below the ponds at a station on the Clark Fork River below the mouth of Warm Springs Creek, biological integrity was good and the overall impairment was minor.

VI. SUMMARY OF OU RISKS

The Draft Baseline Risk Assessment for the SST OU was issued by MDEQ for public comment in January 1995 (MDHES, 1994a). The U.S. EPA and MDEQ have defined carcinogenic potential risk in excess of 1 in 10,000 and hazard indices in excess of 1.0 as unacceptable. This definition of unacceptable risk to human health has been incorporated into the Draft Baseline Risk Assessment for the SST OU and the SST OU Preliminary Remediation Goals (PRGs). The BRA Executive Summary is located in Appendix C.

Human Health Conclusions

The Streamside Tailings Baseline Human Health Risk Assessment evaluated three exposure scenarios to determine the health risks related to OU use by residents, workers (occupational), and recreationists. Both existing and reasonably anticipated future exposure scenarios were evaluated. Risks were divided into those which may cause cancer and those which cause adverse health effects other than cancer (non-carcinogenic risks).

Residents

To evaluate potential residential exposure to floodplain contaminants, MDEQ considered a house located outside, but adjacent to, the floodplain with a yard leading down to Silver Bow Creek. Under this scenario, children and adults could be exposed to contaminated soils located outside and inside the floodplain and within the residential yard. Exposure to stream water and instream sediments was evaluated under the recreational scenario. The vast majority of residents in Rocker, Silver Bow, Ramsay, and Opportunity live outside the area of greatest impact from tailings and their exposure to contaminants is expected to be limited.

The primary carcinogenic risk to people living in or near the OU comes entirely from potential exposure to arsenic in soil and groundwater (Table 6). Elevated concentrations of arsenic can be found in tailings areas such as the Ramsay Flats and in upper alluvial (less than 20-feet below ground surface), near-stream groundwater.

Noncarcinogenic risks exceeded acceptable levels for arsenic in soils under the residential scenario (Table 7). As with the carcinogenic risks, the noncarcinogenic risks vary depending on the amount of contamination a person contacts. Noncarcinogenic risks related to arsenic, cadmium, copper and zinc in groundwater were found only in upper alluvial, near-stream groundwater within and directly adjacent to the floodplain. The risks posed by lead contamination in soil are generally within the acceptable range based on the risk model used in Butte.

Limited groundwater data demonstrate that the upper alluvial groundwater exceeds drinking water standards in some areas and also suggest that lower alluvial groundwater does not presently exceed drinking water standards except in Subarea 4. Most, if not all, water supply wells are located in lower alluvial groundwater but could potentially draw water from the upper alluvial system.

Occupational

The occupational scenario evaluates the risk to workers within the OU and focuses on agricultural workers in areas outside the floodplain. The risk assessment indicates that carcinogenic risk falls within an acceptable range (Table 8). Noncarcinogenic risks to agricultural workers are mostly related to arsenic and are also generally acceptable (Table 9). If workers were to equally divide their work time between areas inside and outside the floodplain their risks might be higher by a factor of three and could exceed acceptable levels.

Recreationists

Both carcinogenic and noncarcinogenic risks to OU visitors are posed by future use of the railroad beds which exceed the acceptable EPA risk range (Tables 10 and 11). This could become a concern if present plans for use of railroad beds as a trail system are developed. Elevated levels of arsenic where past ore concentrate spills occurred on the railroad beds create a hazard to recreational users and would therefore require cleanup. As in the residential scenario, using the Butte model, the risks posed by lead are within the acceptable range.

<u>Ecological Conclusions</u>

The Ecological Risk Assessment was conducted in a manner similar to, although less quantitative than, the human health risk assessment. The conclusions generally focus on whether the environment (plant and animal life) is or may be adversely impacted. A summation of the risks is presented in Table 12.

In Silver Bow Creek, which is devoid of fish and most other aquatic life forms, the presence of mine waste contamination is the primary factor limiting the health of the aquatic environment. These contaminants affect both the water quality and instream sediments in Silver Bow Creek and create a toxic environment for fish and most benthic macroinvertebrates. Other physical conditions which may adversely affect the health of Silver Bow Creek include siltation of the stream bottom, channelization, and disturbance of adjacent land and streamside (riparian) habitat.

TABLE 6

Carcinogenic Risks for the Residential Scenario[a]

Pathway	Chemical	RME Risk	Average Risk
Ingestion of Soil/Sediment	Arsenic	2.5×10^{-4}	4.4×10^{-5}
	Cadmium	NC	NC
	Copper	NC	NC
	Lead	NC	NC
	Mercury	NC	NC
	Zinc	NC	NC
Ingestion of Groundwater	Arsenic	3.11×10^{-4}	6.7×10^{-5}
	Cadmium	NC	NC
	Copper	NC	NC
	Lead	NC	NC
	Mercury	NC	NC
	Zinc	NC	NC
Dermal Contact with Groundwater	Arsenic	2.99×10^{-9}	NA
Inhalation of Dust	Arsenic	3.17×10^{-5}	9.51×10^{-7}
Total Carcinogenic Risk		5.6×10^{-4}	1.1×10^{-4}

[a] Total carcinogenic risks have been rounded to the nearest tenth.

NC = Not calculated, chemicals are not carcinogens for this exposure pathway, or carcinogenic slope factors are not available.

NA = Only RME exposure is assessed for this pathway.

TABLE 7

Noncarcinogenic Hazard Quotients and Hazard Indices for the Residential Scenario[a]

Pathway	Chemical	RME HQ	Average Risk
Ingestion of Soil/Sediment	Arsenic	1.05×10^{1}	3.03×10^{0}
	Cadmium	8.97×10^{-2}	2.44×10^{-2}
	Copper	5.26×10^{-1}	1.5×10^{-1}
	Lead	NC	NC
	Mercury	NC	NC
	Zinc	7.11×10^{-2}	2.28×10^{-2}
Pathway HI		**1.1×10^{1}**	**3.2×10^{0}**
Ingestion of Groundwater	Arsenic	3.10×10^{0}	2.22×10^{0}
	Cadmium	1.6×10^{0}	7.30×10^{-1}
	Copper	2.73×10^{0}	1.69×10^{0}
	Lead	NC	NC
	Mercury	NC	NC
	Zinc	4.00×10^{0}	4.75×10^{-1}
Pathway HI		**1.2×10^{1}**	**5.1×10^{0}**
Dermal Contact with Groundwater	Arsenic	2.23×10^{-5}	NA
Inhalation of Dust	Arsenic	NC	NC
Total HI		**2.3×10^{1}**	**8.4×10^{0}**

[a] Pathway HIs and total HIs have been rounded to the nearest tenth.
NC = Not calculated, data are insufficient for quantitative analysis.
NA = Only RME exposure is assessed for this pathway.
HQ = Hazard Quotient
HI = Hazard Index

TABLE 8

Carcinogenic Risks for the Occupational Scenario[a]

Pathway	Chemical	RME Risk	Average Risk
Ingestion of Soil/Sediment	Arsenic	5.4×10^{-5}	3.4×10^{-6}
	Cadmium	NC	NC
	Copper	NC	NC
	Lead	NC	NC
	Mercury	NC	NC
	Zinc	NC	NC
Inhalation of Dust	Arsenic	8.5×10^{-6}	5.1×10^{-6}
Total Carcinogenic Risk		**6.2×10^{-5}**	8.5×10^{-6}

[a] Total carcinogenic risks have been rounded to the nearest tenth.

NC = Not calculated, chemicals are not carcinogens for this exposure pathway, or carcinogenic slope factors are not available.

TABLE 9

Noncarcinogenic Hazard Quotients and Hazard Indices for the Occupational Scenario[a]

Pathway	Chemical	RME Risk	Average Risk
Ingestion of Soil/Sediment	Arsenic	8.05×10^{0}	4.99×10^{-2}
	Cadmium	8.0×10^{-3}	6.07×10^{-4}
	Copper	3.29×10^{-2}	2.39×10^{-3}
	Lead	NC	NC
	Mercury	NC	NC
	Zinc	3.64×10^{-3}	2.90×10^{-4}
Pathway HI		**8.5×10^{-1}**	**5.3×10^{-2}**
Inhalation of Dust	Arsenic	NC	NC
Total HI		**8.5×10^{-1}**	**5.3×10^{-2}**

[a] Pathway HIs and Total HIs have been rounded to the nearest tenth.
NC = Not calculated, data are insufficient for quantitative analysis.

TABLE 10

Carcinogenic Risks for the Recreational Scenario[a]

Pathway	Chemical	RME Risk	Average Risk
Ingestion of Soil/Sediment	Arsenic	6.2×10^{-5}	9.0×10^{-5}
	Cadmium	NC	NC
	Copper	NC	NC
	Lead	NC	NC
	Mercury	NC	NC
	Zinc	NC	NC
Pathway Risk		**6.2×10^{-5}**	**9.0×10^{-5}**
Ingestion of Surface Water	Arsenic	3.4×10^{-8}	7.8×10^{-9}
	Cadmium	NC	NC
	Copper	NC	NC
	Lead	NC	NC
	Mercury	NC	NC
	Zinc	NC	NC
Pathway Risk		**3.4×10^{-8}**	**7.8×10^{-9}**
Dermal Contact with Surface Water	Arsenic	3.2×10^{-9}	7.3×10^{-10}
Ingestion of Rail Road Bed Materials	Arsenic	1.2×10^{-3}	1.4×10^{-4}
	Cadmium	NC	NC
	Copper	NC	NC
	Lead	NC	NC
	Mercury	NC	NC
	Zinc	NC	NC
Pathway Risk		**1.2×10^{-3}**	**1.4×10^{-4}**
Inhalation of Rail Road Bed Materials	Arsenic	1.8×10^{-5}	9.2×10^{-6}
	Cadmium	NC	NC
	Copper	NC	NC
	Lead	NC	NC
	Mercury	NC	NC
	Zinc	NC	NC
Pathway Risk		**1.8×10^{-5}**	**9.2×10^{-6}**

[a] Total carcinogenic risks have been rounded to the nearest tenth.

NC = Not calculated, chemicals are not carcinogens for this exposure pathway, or carcinogenic slope factors are not available.

TABLE 11

Noncarcinogenic Hazard Quotients and Hazard Indices for the Recreational Scenario[a]

Pathway	Chemical	4-12 Year Old Child		1-3 Year Old Child	
		RME HQ	Average HQ	RME HQ	Average HQ
Ingestion of Soil/Sediment	Arsenic	8.95×10^{-1}	1.03×10^{-1}	4.17×10^{0}	2.91×10^{-1}
	Cadmium	6.34×10^{-3}	8.14×10^{-4}	3.47×10^{-2}	2.05×10^{-3}
	Copper	3.97×10^{-2}	5.15×10^{-3}	2.18×10^{-1}	1.52×10^{-2}
	Lead	NC	NC	NC	NC
	Mercury	NC	NC	NC	NC
	Zinc	6.28×10^{-3}	8.89×10^{-4}	3.02×10^{-2}	2.31×10^{-3}
Pathway HI		**9.5×10^{-1}**	**1.1×10^{-1}**	**4.5×10^{0}**	**3.1×10^{-1}**
Ingestion of Surface Water	Arsenic	3.89×10^{-4}	9.0×10^{-5}	8.75×10^{-4}	2.02×10^{-4}
	Cadmium	2.25×10^{-5}	5.22×10^{-6}	5.05×10^{-5}	1.17×10^{-5}
	Copper	3.26×10^{-6}	6.94×10^{-6}	7.33×10^{-5}	1.56×10^{-5}
	Lead	NC	NC	NC	NC
	Mercury	NC	NC	NC	NC
	Zinc	1.35×10^{-5}	2.23×10^{-6}	3.04×10^{-5}	5.02×10^{-6}
Pathway HI		**4.6×10^{-4}**	**1.0×10^{-4}**	**1.3×10^{-3}**	**2.3×10^{-4}**
Dermal Contact with Surface Water	Arsenic	1.96×10^{-5}	4.57×10^{-6}	3.06×10^{-5}	7.12×10^{-6}
Ingestion of Rail Road Bed Materials	Arsenic	1.65×10^{1}	2.02×10^{0}	7.44×10^{1}	4.55×10^{0}
	Cadmium	7.42×10^{-2}	1.08×10^{-2}	3.34×10^{-1}	2.43×10^{-2}
	Copper	1.91×10^{0}	1.8×10^{-1}	8.58×10^{0}	4.06×10^{-1}
	Lead	NC	NC	NC	NC
	Mercury	NC	NC	NC	NC
	Zinc	1.56×10^{-1}	8.07×10^{-3}	7.02×10^{-1}	1.82×10^{-2}
Pathway HI		**1.9×10^{1}**	**2.2×10^{0}**	**8.4×10^{1}**	5.0×10^{0}
Inhalation of Rail Road Bed Materials	Arsenic	NC	NC	NC	NC
	Cadmium	NC	NC	NC	NC
	Copper	NC	NC	NC	NC
	Lead	NC	NC	NC	NC
	Mercury	NC	NC	NC	NC
	Zinc	NC	NC	NC	NC
Pathway HI		**NC**	**NC**	**NC**	**NC**
Total HI		**2.0×10^{1}**	**2.4×10^{0}**	9.0×10^{1}	5.4×10^{0}

[a] Pathway HIs and Total HIs have been rounded to the nearest tenth.
NC = Not calculated, data are insufficient for quantitative analysis.
HQ = Hazard Quotient
HI = Hazard Index

TABLE 12

Simplified Summary of Ecological Risks from Chemical Stressors

Media (units)	Chemical	Arith. Mean Conc/ U95 Conc	Effects Conc [1]	Risk Potential
Surface Water				
mg/L	Ammonia	3.11 / NC	0.53-2.7	Mod to High (location/timing dependent)
µg/L	Arsenic (D)	15.56 / 24.1	48-850	Low
µg/L	Cadmium (D)	1.66 / 2.26	0.47-5.0	Mod
µg/L	Copper (D)	50.74 / 59.56	3.9-54	High
mg/L	Dissolved Oxygen	~9.5 / NC	4.0	Low to High (location/timing dependent)
µg/L	Lead (D)	3.0 / 6.57	0.8-500	Mod
µg/L	Mercury (D)	0.16 / 0.16	0.012-4.0	Low to Mod
mg/L	Nitrogen (total soluble)	1.75-9.19/NC	0.03-1.0	Mod to high (location/timing dependent)
µg/L	PAHs (individual)	0.02 / NC	0.1-5.0	Low
µg/L	PCP	8.01/NC	3.5-14.5	Mod
µg/L	Zinc (D)	336.19 / 585.99	40-277	High
Sediment				
mg/kg	Arsenic	75.16 / 113.11	23.8-24.8	High
mg/kg	Cadmium	4.66 / 7.01	3.9	High
mg/kg	Copper	828 / 1,579.89	325-354	High
mg/kg	Lead	250.5 / 318.66	62.4	High
mg/kg	Mercury	3.49 / 6.7	0.2-2.0	High
mg/kg	PAHs (individual)	0.054-1.563 / NC	4-100	Low
mg/kg	PCP	0.367 / 0.634	4.2-21	Low
mg/kg	Zinc	1,380.13 / 2,120.27	1,064	High

TABLE 12 (continued)

Simplified Summary of Ecological Risks from Chemical Stressors

Media (units)	Chemical	Arith. Mean Conc/ U95 Conc	Effects Conc [1]	Risk Potential
Surface Soil				
mg/kg	Arsenic	303.1 / 514.9	25-100	High
mg/kg	Cadmium	6.45 / 11.95	4-50	Mod
mg/kg	Copper	1,470.4 / 2,484.9	60-100	High
mg/kg	Lead	723.63 / 1,241.4	250-1,000	High
mg/kg	Mercury	1.82 / 5.7	2-10	Low to mod
mg/kg	PAHs (individual)	Not Analyzed	1-10	Unknown/ Probably low
mg/kg	PCP	Not Analyzed	0.5-5.0	Unknown/ Probably low
mg/kg	Zinc	1,835.6 / 2,920.7	200-500	High

[1] Description and source listed in Table 5-17

NC: not Calculated
D: dissolved

In addition to the metals associated with mining waste, the risk assessment also evaluated the risk to the environment from pentachlorophenol (PCP) and polycyclic aromatic hydrocarbons (PAH), both of which originated from the Montana Pole Superfund site, as well as from dissolved ammonia and nitrogen related to the Butte public treatment works.PCP and PAH were not considered significant for instream sediment. Ammonia, nitrogen, and low dissolved oxygen content are important to water quality in some areas of Silver Bow Creek which are affected by these parameters. These contaminants are expected ultimately to be addressed in connection with the sewage treatment operations.

Soil

Many near-stream surface soil areas are critically impacted by tailings deposits and devoid of vegetation. Surface soil risk is evaluated in terms of the toxicity of contaminants to plants (phytotoxicity). The contaminants posing the greatest threat in surface soils include arsenic, copper, lead, and zinc. Moderate threats are posed by cadmium and mercury because of uptake into plants.

Surface Water

Surface water has been severely impacted throughout the length of Silver Bow Creek and serves as a contaminant pathway to the aquatic environment. In Silver Bow Creek, populations of trout and other fish have been eliminated entirely. Risks from surface water relate to how the contaminants may adversely affect aquatic plants, fish and other stream life. Surface water contaminants which pose the greatest risk to the health of the stream include copper and zinc (Figures 7 and 8). Copper is a significant risk throughout the OU. Zinc is a significant threat in upstream sections of Silver Bow Creek but its concentration and potential risk decrease somewhat downstream of Miles Crossing. Cadmium, lead, mercury, and pentachlorophenol are considered moderate threats. Ammonia, nitrogen, and to a lesser extent, low dissolved oxygen are other significant limiting factors in certain reaches of Silver Bow Creek.

Sediment

The contaminated instream sediments of Silver Bow Creek are a critical contaminant pathway to impacted surface water and aquatic biota, particularly benthic macroinvertebrates. Contaminants in sediment posing a high risk to the environment are arsenic, cadmium, copper, lead, mercury, and zinc (Figures 9 - 14). Mercury is a contaminant which bioaccumulates and can potentially biomagnify. Mercury poses a small current threat because there are no fish in the stream. However, fish and other biota exposed to the levels of mercury currently in the stream sediment could be at risk.

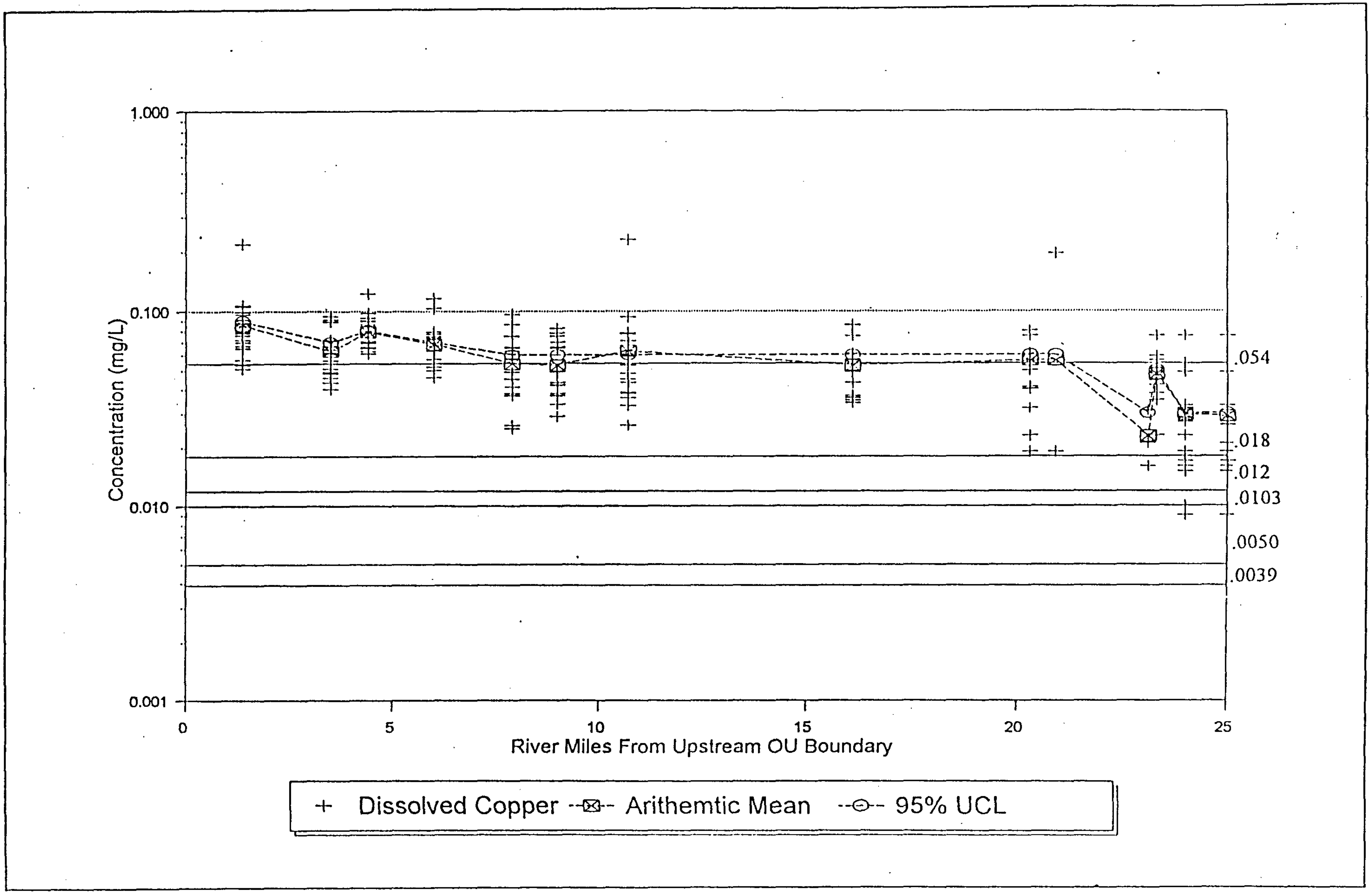


FIGURE 7
Dissolved Copper
SST Surface Water

Effects Concentration (ug/L)	Basis for Effects Concentration
3.9	LOAEC (growth & reproduction), freshwater invertebrates and salmonids (EPA 1985c)
5.0	LOAEC (growth), freshwater plants (EPA 1985c)
10.3	Chronic AWQC (dissolved), hardness = 100 mg $CaCO_3$/L (EPA 1985c)
12	Chronic AWQC, hardness = 100 mg Ca CO_3/L (EPA 1985c)
18	Acute AWQC, hardness = 100 mg Ca CO_3/L (EPA 1985c)
54	Mean 96 hr LC_{50}, Rainbow trout, CFR -- similar water quality (USFWS & VW 1992)

Copper Effects Concentrations
in Surface Water

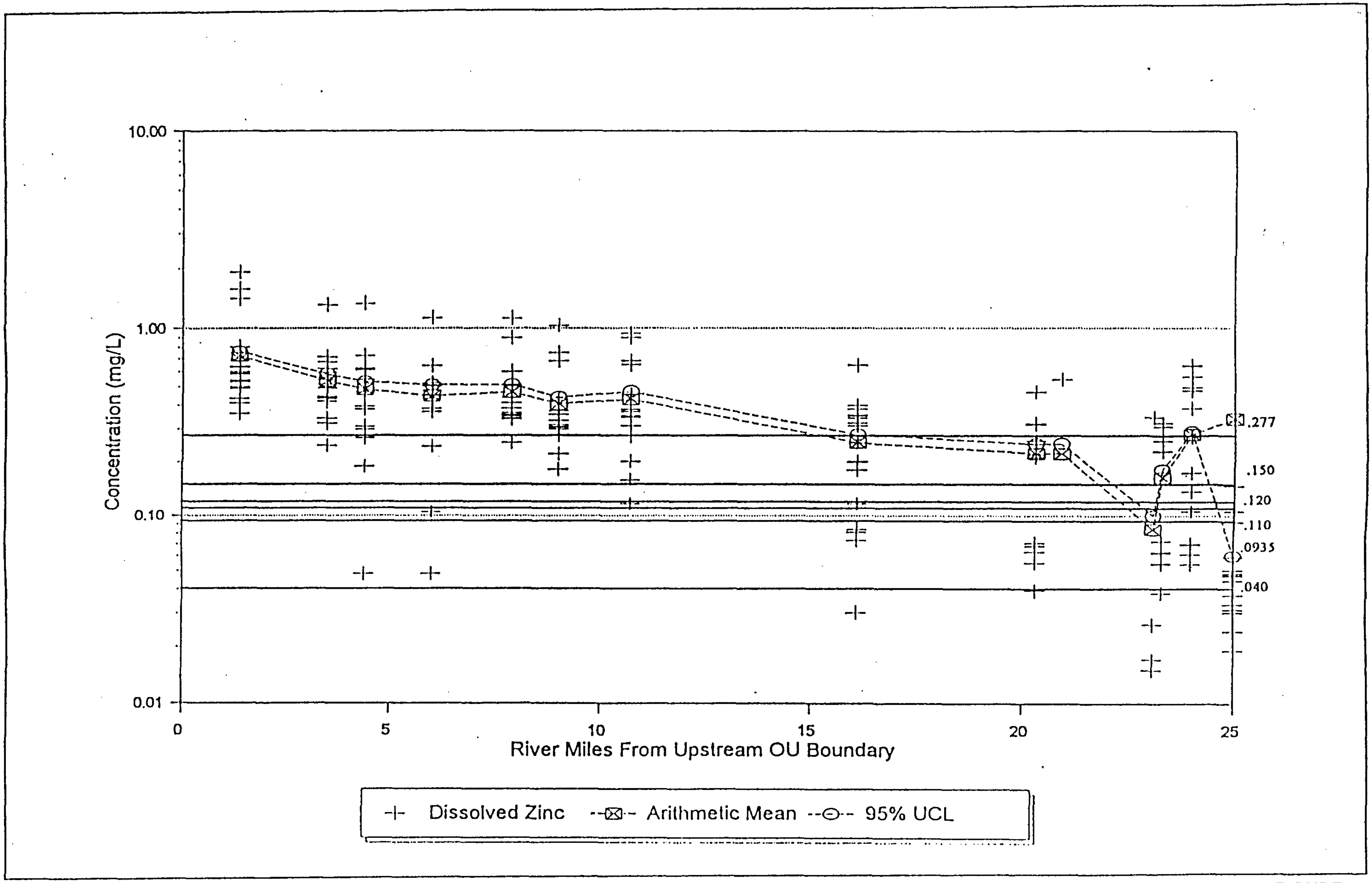


FIGURE 8
Dissolved Zinc
SST Surface Water

Effects Concentration (ug/L)	Basis for Effects Concentration
40	LOAEC (growth), freshwater plants (EPA 1987)
93.5	Chronic AWQC (dissolved), hardness = 100 mg $CaCO_3$/L (EPA 1987)
110	Chronic AWQC, hardness = 100 mg $CaCO_3$/L (EPA 1987)
120	Acute AWQC, hardness = 100 mg Ca CO_3/L (EPA 1987)
150	Mean 96 hr LC_{50}, Rainbow trout, CFR -- similar water quality (USFWS & VW 1992)
277	LOAEC (growth & reproduction), freshwater invertebrates and salmonids

Zinc Effects Concentrations
in Surface Water

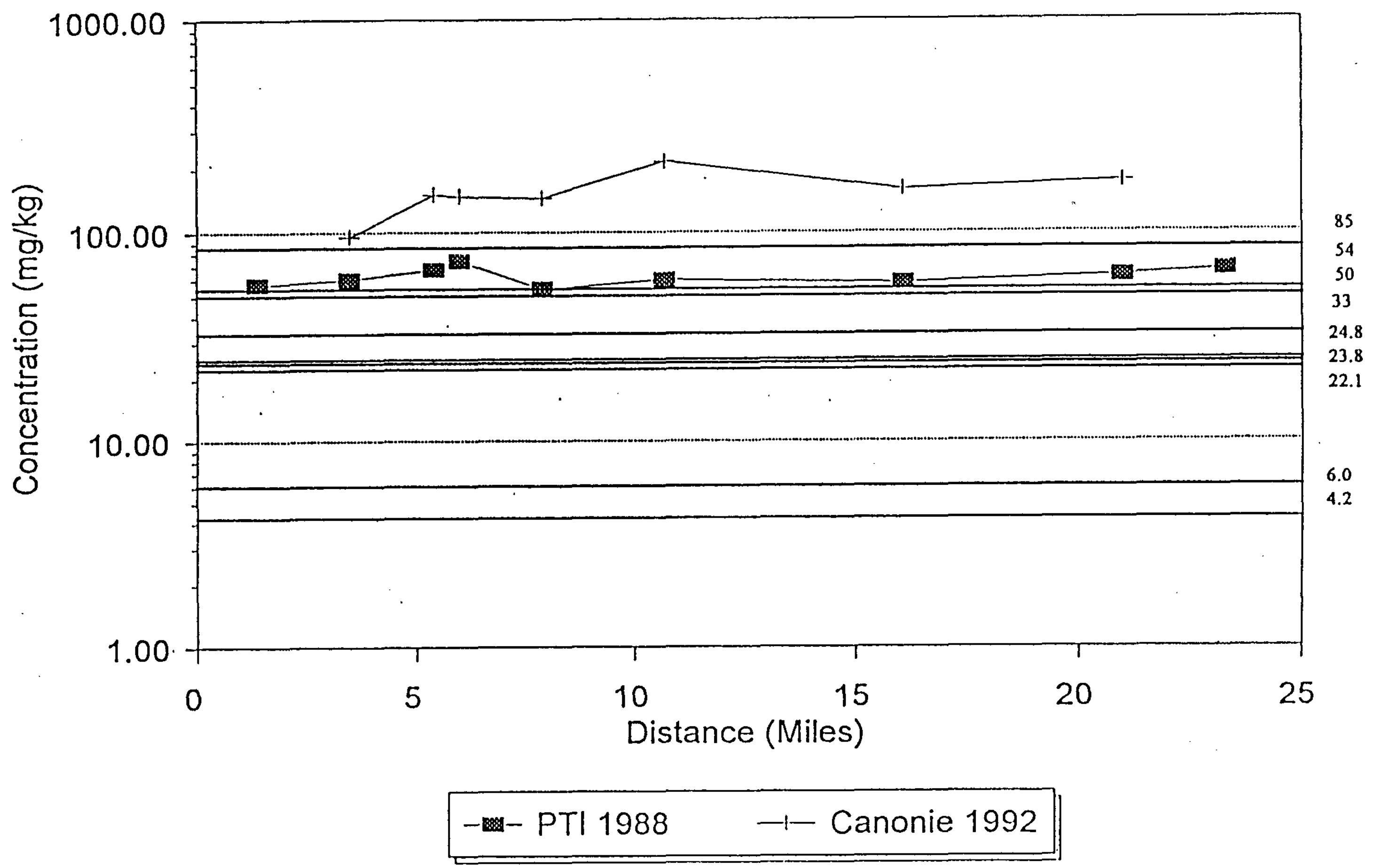


FIGURE 9
Total Arsenic
SST Sediment

Effects Concentration (mg/kg)	Basis for Effects Concentration
4.2	Background concentrations, uncontaminated sediment, Great Lakes precolonial horizon (Persaud . 1993)
6.0	Lowest Effect Level, benthic organisms, Ontario (Persaud *et al.* 1993)
22.1	Low range of bioassay effects concentrations, co-occurrence analyses (COA), multiple species (Long & Morgan 1990)
23.8	No Effect Concentration (NEC), length, *Hyalella azteca (FWS & UW* 1992)
24.8	NEC, maturation, *Hyalella azteca, (FWS & UW* 1992)
33	Severe Effect Level, benthic organisms, Ontario (Persaud *et al.* 1993)
50	Concentration at which adverse effects are always observed (Long & Morgan 1990)
54	Low range of apparent effects concentrations (AET), multiple species (Long & Morgan 1990)
85	Effects Range -- Median (ER-M) (Long & Morgan 1990)

Arsenic Effects Concentrations in Sediment

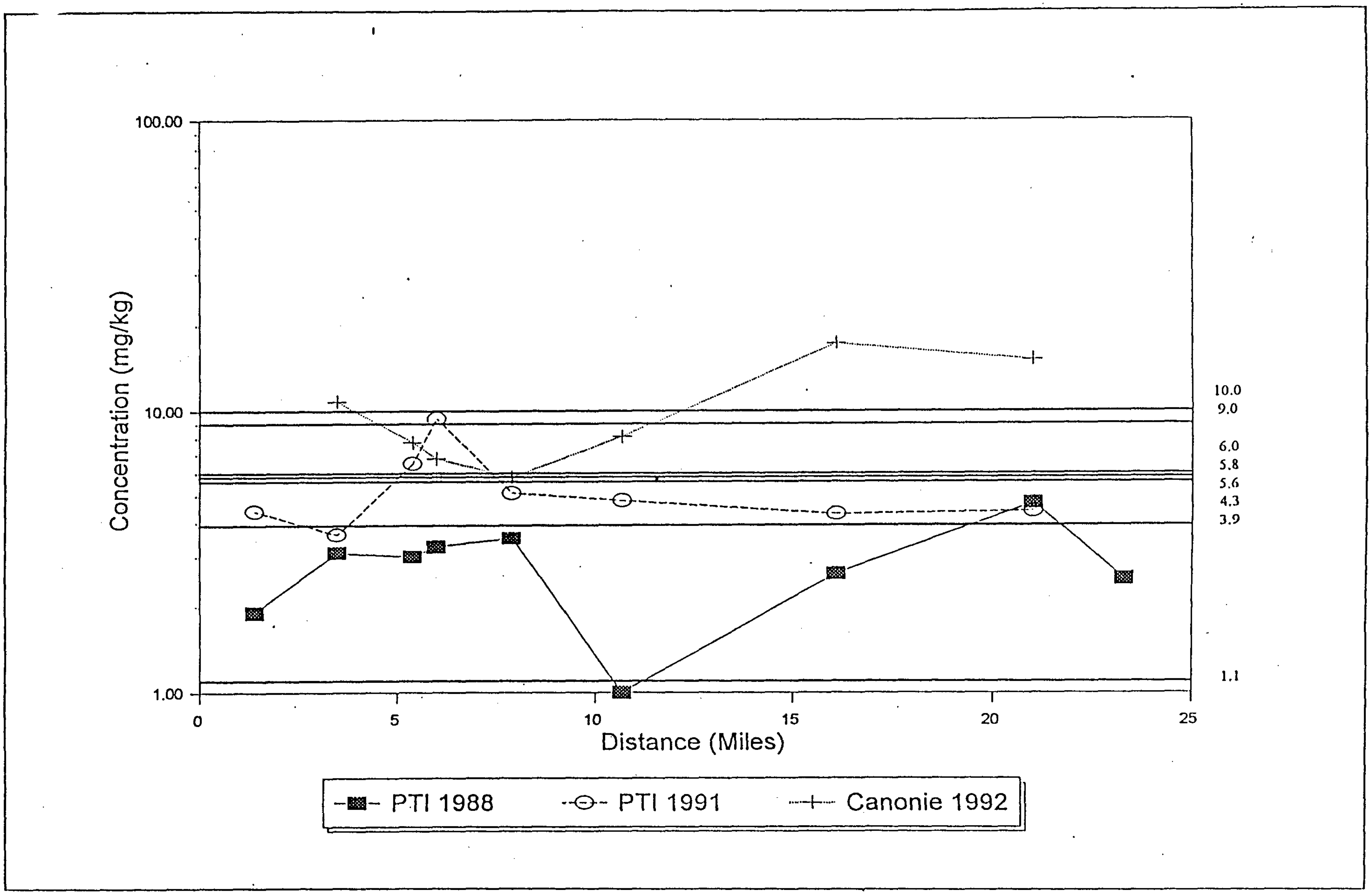


FIGURE 10
Total Cadmium
SST Sediment

Effects Concentration (mg/kg)	Basis for Effects Concentration
1.1	Background concentrations, uncontaminated sediment, Great Lakes precolonial horizon (Persaud . 1993)
3.9	No Effect Concentration (NEC), length and maturation, *Hyalella azteca (FWS & UW* 1992)
4.3	Low range of bioassay effects concentrations, co-occurrence analyses (COA), multiple species (Long & Morgan 1990)
5.6	Low range of spiked sediment bioassay (SSB), multiple species (Long & Morgan 1990)
5.8	Low range of apparent effects concentrations (AET), multiple species (Long & Morgan 1990)
6.0	Lowest Effect Level, benthic organisms, Ontario (Persaud *et al.* 1993)
9.0	Effects Range -- Median (ER-M) and concentration always associated with adverse effects (Long & Morgan 1990)
10.0	Severe Effect Level, benthic organisms, Ontario (Persaud *et al.* 1993)

Cadmium Effects Concentrations in Sediment

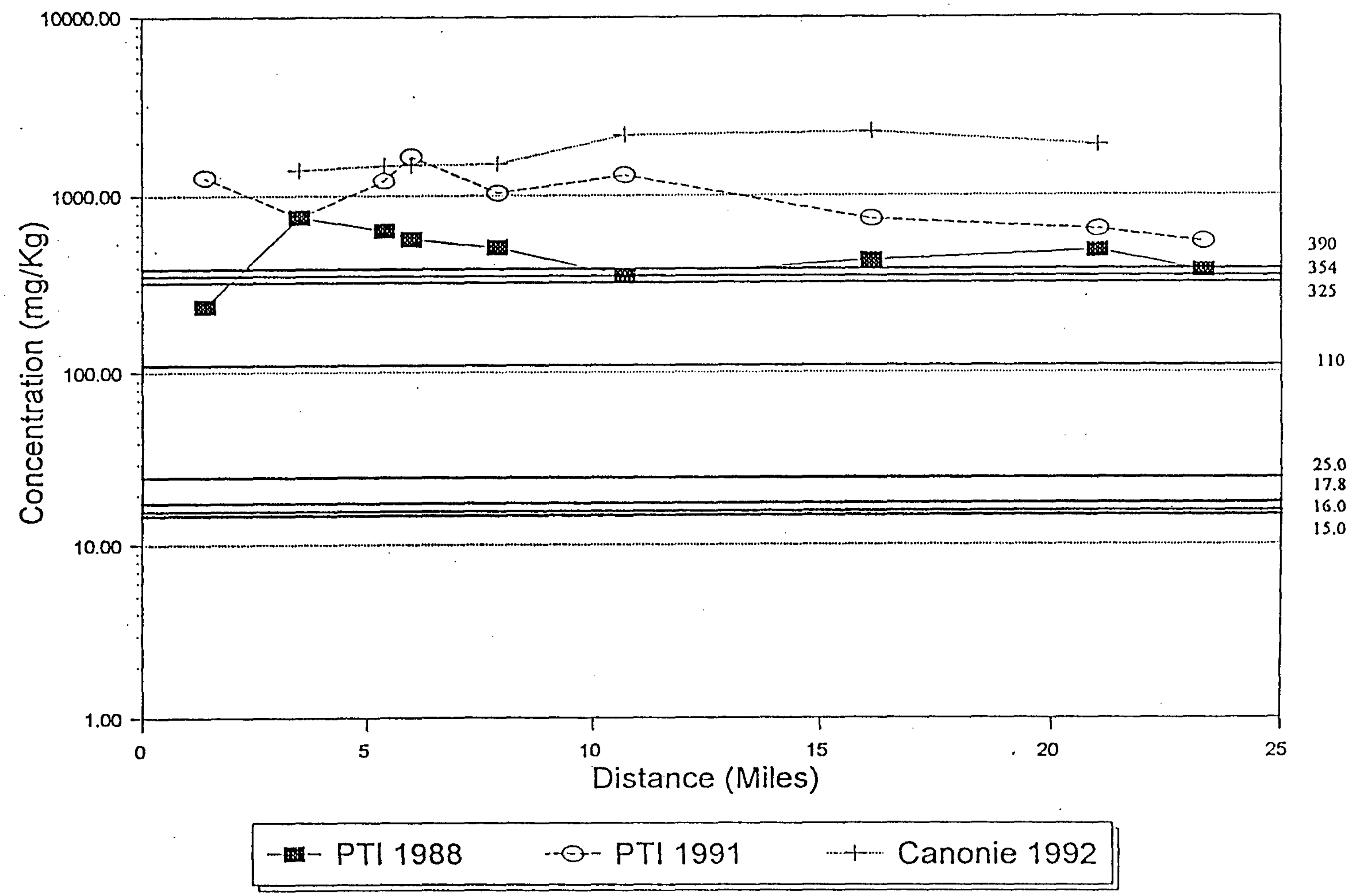


FIGURE 11
Total Copper
SST Sediment

Effects Concentration (mg/kg)	Basis for Effects Concentration
15.0	Low range of bioassay effects concentrations, co-occurrence analyses (COA), multiple species (Long & Morgan 1990)
16.0	Lowest Effect Level, benthic organisms, Ontario (Persaud *et al*. 1993)
17.8	Low range of spiked sediment bioassay (SSB), multiple species (Long & Morgan 1990)
25.0	Background concentrations, uncontaminated sediment, Great Lakes precolonial horizon (Persaud . 1993)
110	Low range of apparent effects concentrations (AET), multiple species (Long & Morgan 1990) and Severe Effect Level, benthic organisms, Ontario (Persaud *et al.* 1993)
325	No Effect Concentration (NEC), length, *Hyalella azteca (FWS & UW* 1992)
354	No Effect Concentration (NEC), maturation, *Hyalella azteca (FWS & UW* 1992)
390	Effects Range -- Median (ER-M) and concentration always associated with adverse effects (Long & Morgan 1990)

Copper Effects Concentrations in Sediment

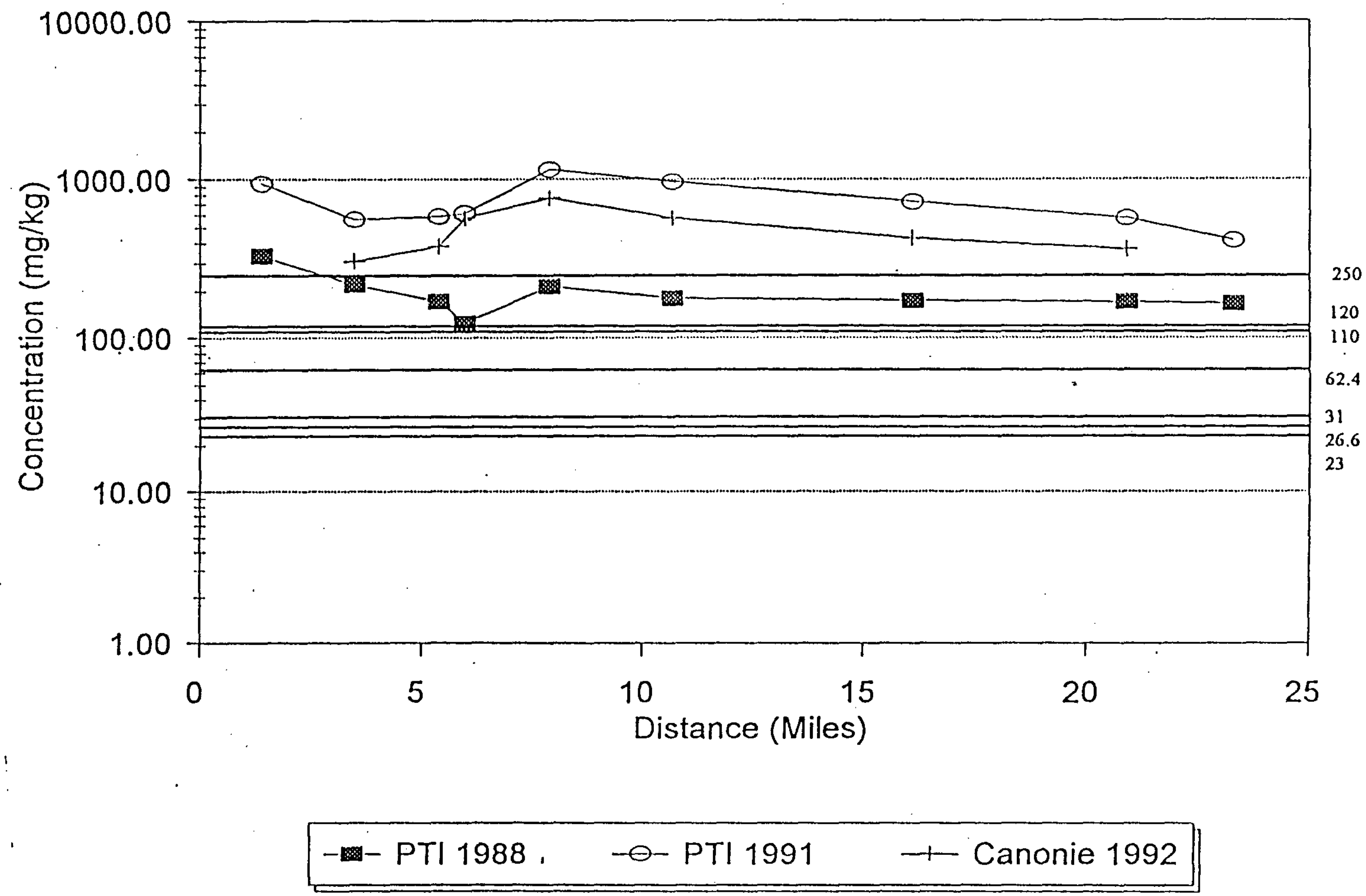


FIGURE 12
Total Lead
SST Sediment

Effects Concentration (mg/kg)	Basis for Effects Concentration
23	Background concentrations, uncontaminated sediment, Great Lakes precolonial horizon (Persaud . 1993)
26.6	Low range of bioassay effects concentrations, co-occurrence analyses (COA), multiple species (Long & Morgan 1990)
31	Lowest Effect Level, benthic organisms, Ontario (Persaud *et al.* 1993)
62.4	No Effect Concentration (NEC), length and maturation, *Hyalella azteca (FWS & UW* 1992)
110	Effects Range-Median (ER-M)
120	Low range of apparent effects concentrations (AET), multiple species (Long & Morgan 1990)
250	Severe Effect Level, benthic organisms, Ontario (Persaud *et al.* 1993)

Lead Effects Concentration
in Sediment

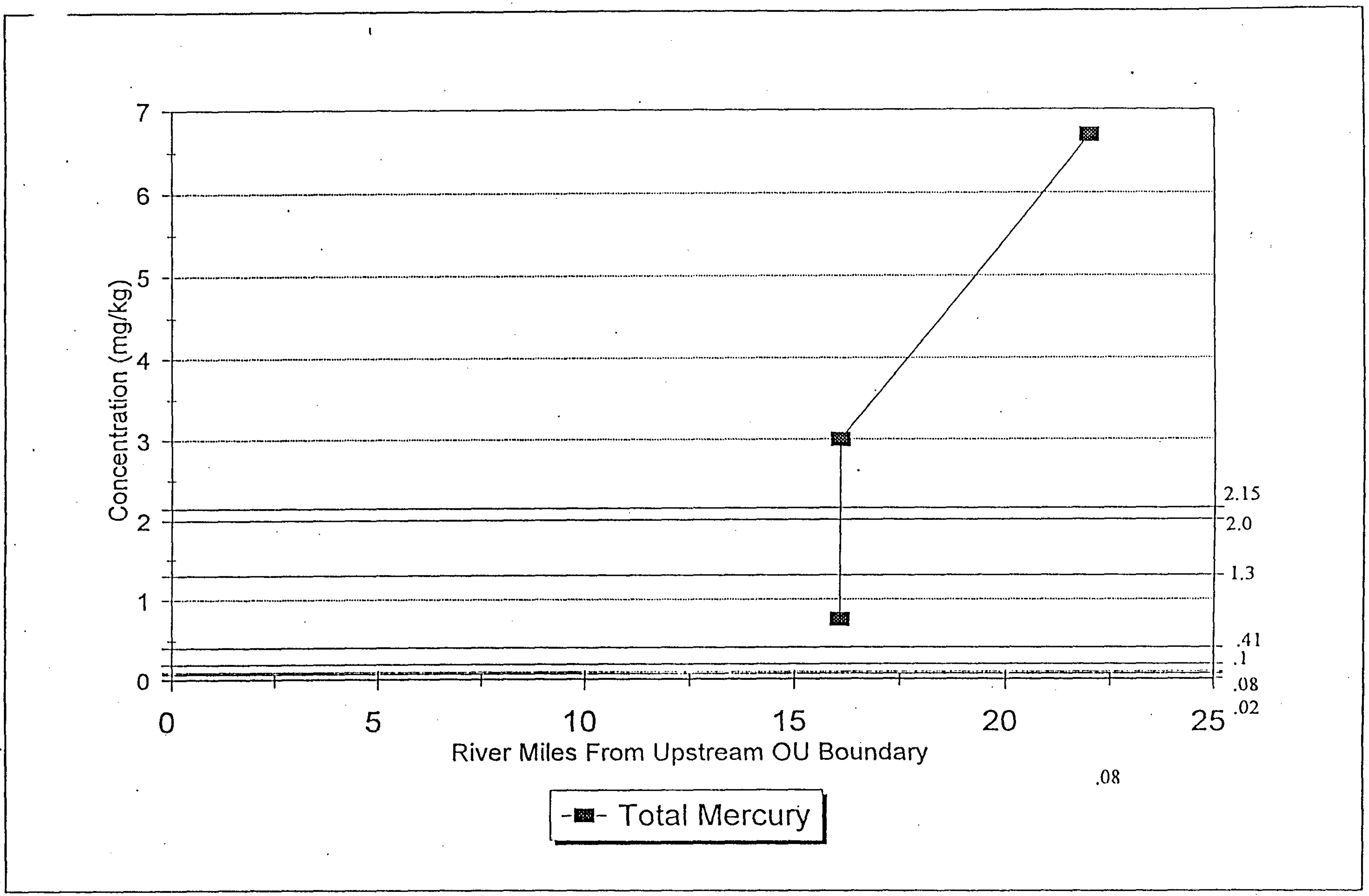


FIGURE 13
Total Mercury
SST Sediment

Effects Concentration (mg/Kg)	Basis for Effects Concentration (EPA 1985e)
0.02	Background concentrations, uncontaminated sediments, South Dakota (Eisler 1987a)
0.08	Range of bioassay effects concentrations, co-occurrence analyses (COA), multiple species (Long & Morgan 1990)
0.1	Background concentration, uncontaminated sediments, Great Lakes pre-colonial horizon (Persaud et. al 1993)
0.2	Lowest Effect Level, benthic organisms, Ontario (Persaud et. al 1993)
0.41	Range of apparent effects concentrations(AET), multiple species (Long & Morgan 1990)
1.3	Effects Range-Median (ER-M) (Long & Morgan 1990)
2.0	Severe Effect Level, benthic organisms, Ontario (Persaud et. al 1993)
2.15	Range of spiked sediment bioassay(SSB), multiple species (Long & Morgan 1990)

Mercury Effects Concentrations in Sediment

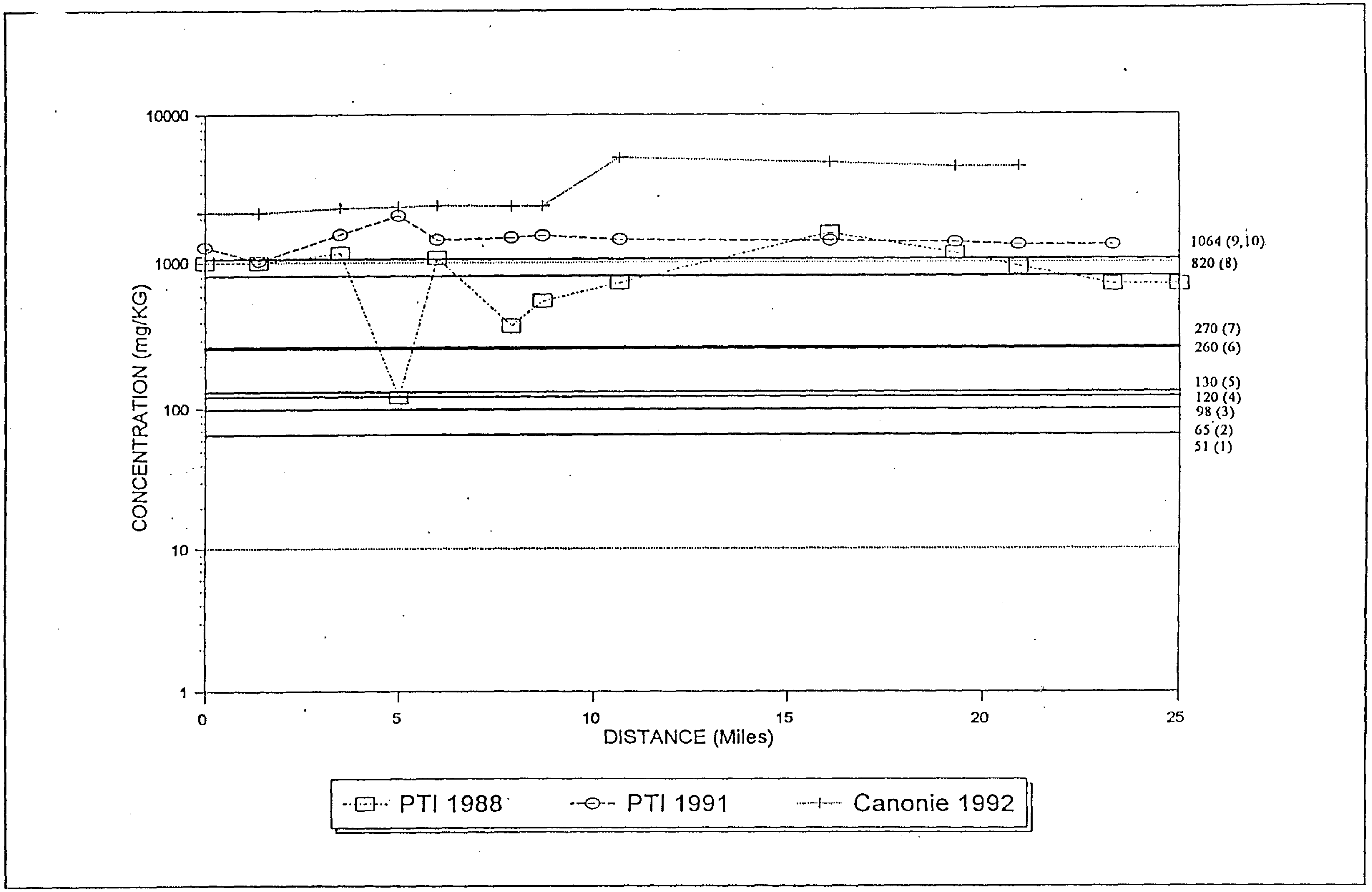


FIGURE 14
Total Zinc
SST Sediment

Effects Concentration (mg/kg)	Basis for Effects Concentration
51	Low range of spiked sediment bioassay (SSB), multiple species (Long & Morgan 1990)
65	Background concentrations, uncontaminated sediment, Great Lakes precolonial horizon (Persaud . 1993)
98	Low range of bioassay effects concentrations, co-occurrence analyses (COA), multiple species (Long & Morgan 1990)
120	Lowest Effect Level, benthic organisms, Ontario (Persaud *et al.* 1993)
130	Low range of apparent effects concentrations (AET), multiple species (Long & Morgan 1990)
260	Concentration at which adverse effects are always observed (Long & Morgan 1990)
270	Effects Range -- Median (ER-M) (Long & Morgan 1990)
820	Severe Effect Level, benthic organisms, Ontario (Persaud *et al.*1993)
1064	No Effect Concentration (NEC), length and maturation, *Hyalella azteca (FWS & UW* 1992)

Zinc Effects Concentrations in Sediment

VII. DESCRIPTION OF ALTERNATIVES

A brief description of the OU cleanup alternatives the agencies considered in the Feasibility Study (FS) report follows. The estimated present worth cost of each alternative includes capital cost and annual operation and maintenance cost. In calculating costs, remedial action time frames are limited to 30 years, even for those alternatives requiring perpetual operation and maintenance.

The development and evaluation of remediation alternatives under consideration for the SST OU is more fully documented in the FS (ARCO, 1995b). Initial screening was reported in the *Preliminary Remedial Action Objectives Report/Treatment Technology Scoping Document* (ARCO, 1993d). Subsequent development and refinement of the alternatives was documented in the FS. A full range of alternatives from no action through total removal of all contaminants was carried through the detailed analysis of the FS. Alternatives were considered for each of the four contaminated media and were evaluated, utilizing the NCP's remedy selection criteria, on a subarea basis in the FS. Those alternatives which were significantly deficient in meeting remedial action objectives in certain subareas for specified media were dropped from further consideration after the detailed analysis. Alternatives carried forward were then subjected to comparative analysis in the FS, again on a media-specific and subarea basis. Finally, representative groupings of the media-specific and subarea alternatives were assembled into comprehensive OU-wide alternative packages to enable MDEQ to evaluate the interaction of alternatives for the different media and to conduct a reasonable comparison of the costs of various alternatives.

The detailed and comparative analyses of the separate media alternatives formed the basis for the assembly of the OU-wide alternatives. The media-specific and subarea-specific analyses identified several alternatives that were not capable of providing adequate levels of performance, either for the OU as a whole, for some subareas, or for certain conditions within a subarea. Those alternatives were eliminated from consideration for use where they were deemed inappropriate.

Of the seven tailings/impacted soils alternatives, Surface Water Controls and Near-stream STARS were determined to be wholly inadequate in meeting OU remediation objectives and were eliminated from consideration for use anywhere in the operable unit. The remaining five site-wide alternatives were used in the OU-wide combinations.

The tailings/impacted soils elements of the four site-wide alternatives include four possible components: STARS, *partial relocation, partial removal, total relocation* or *total removal.* STARS is the application of lime amendments to the tailings/impacted soils and revegetation to treat and stabilize the tailings in place. *Relocation* and *removal* differ only in the location of the repository for excavated materials (numerous local repositories vs. one or two regional repositories, respectively). The difference between *partial relocation/removal* and *total relocation/removal* is how much tailings/impacted soils are excavated. *Total relocation/removal* of materials for the entire OU would excavate all 2.5 million cy of tailings/impacted soils. *Partial relocation/removal* alternatives would excavate only portions of the tailings/impacted soils, as described in each alternative.

Of the railroad alternatives, two active alternatives, Limited Removal and In-situ Amendment, were used in addition to no action.

In addition to no action, two groundwater remediation alternatives, Source Control and Pump and Treat, were considered in the FS. The pump and treat alternative was eliminated from further consideration because the cost of active treatment was not commensurate with benefits gained in actively treating the potentially widespread, but relatively low level, of groundwater contamination found at the OU. Therefore, except for the No Action combined alternative, only Source Control was included in the OU-wide alternatives.

Three alternatives for remediating instream sediments were considered: No Action, Limited Removal, and Total Removal. For either removal option, both on-OU and regional repository locations were evaluated.

The OU-wide alternatives were assembled by building on the No Action alternative, which was used to provide a baseline for comparing the other alternatives. As was the case for the comparative analysis, subarea characteristics pertinent to a specific alternative were considered during the assembly process so that, generally, alternatives that were determined not to be applicable to certain subareas were not used in an OU-wide alternative. One exception to this condition is the STARS alternative which, although determined to have limited applicability in Subareas 1 and 3 and not carried forward through the comparative analysis for these subareas, was used as an OU-wide alternative to provide an option lying between total in-situ treatment and total removal for the entire OU.

Although there were many different combinations possible for OU-wide alternatives due to both the number of alternatives considered and the number of subareas in the SST OU, the progression from simpler and less costly alternatives to more complex and more costly alternatives could be accomplished using only a relatively few combinations. This was done by combining media alternatives that added a clear benefit toward achieving maximum attainment of the evaluation criteria, thereby noticeably improving each progressive combination. Consequently, only a limited number of OU-wide alternatives were assembled for further consideration.

During the process of developing the OU-wide alternatives, MDEQ recognized that overall protection of human health and the environment and long-term effectiveness and permanence could be enhanced in certain subareas by modifying the quantity of material that would be excavated under the partial removal/STARS or partial relocation/STARS alternatives. The partial removal/STARS and partial relocation/STARS options evaluated in the detailed and comparative analyses removed only saturated tailings/impacted soils and overlying tailings, leaving substantial areas of tailings that were to be STARS treated in floodplain. The STARS treated areas would be subject to erosion and re-entrainment of tailings into the stream during stream meander and high-flow events. The considerable residual risk and the need for waiver of the floodplain and solid waste disposal ARARs associated with those alternatives led MDEQ to develop and consider modified partial removal/STARS and partial relocation/STARS alternatives as potential OU-wide alternatives that could provide better protectiveness and better compliance with ARARs. Details of the modified partial removal/STARS and modified partial relocation/STARS alternatives are provided in the FS (ARCO, 1995b) and the proposed plan (MDEQ, 1995).

Alternative No. 1 - No Action

Estimated present worth cost: $700,000 to $1,400,000
Implementation time: 3 - 5 years

This alternative includes the No Action Alternative for tailings/impacted soils, railroad materials, groundwater and instream sediments. The No Action Alternative is included primarily to satisfy NCP requirements and provide a baseline by which to compare other site-wide alternatives.

Under Alternative No. 1, no further action would be taken. Contaminated tailings/impacted soils, instream sediments, railroad materials, and groundwater would remain in the OU and would continue to migrate and impact groundwater, Silver Bow Creek, and instream sediments. The costs for the no-action alternative are those associated with continued administration of monitoring and institutional controls for a period of 30 years. Actual costs and efforts associated with the no action alternative would be incurred indefinitely beyond the 30-year period.

Alternative No. 2 - STARS Treatment of Tailings/Impacted Soils, No Action for Instream Sediments, and In-situ Treatment of Railroad Materials

Estimated present worth cost: $13,000,000 to $24,000,000
Implementation time: 3 - 5 years

The primary component of this alternative is STARS, which was developed as a potential low-cost alternative to the removal and controlled disposal of the tailings/impacted soils that comprise the primary source of contamination at the OU. Although STARS treatment of tailings/impacted soils was not evaluated in the comparative analysis for Subareas 1 and 3 because of potential effects of erosion of STARS treated areas due to stream meander and overbank flows, this alternative was included in the OU-wide analysis so that total in-situ treatment could be compared with the other OU-wide removal alternatives.

Under this alternative, approximately 1,950,000 cy of tailings/impacted soils would be treated in-situ with the STARS technology. An estimated 550,000 cy of tailings underlying the treated materials would remain untreated. This treatment would enable establishment of vegetation thereby reducing overland flow and wind erosion. Instream sediments and groundwater would receive no action and a limited amount of impacted railroad materials posing a risk to human health and the environment would be treated in-situ with lime amendments. In areas of expected residential development (i.e. outside the floodplain) this alternative would use a soil cover where the contaminants pose significant human health risk. Considerable long-term maintenance and monitoring would be required. Restrictions on OU access and use would be necessary.

Alternative No. 3 - Partial Relocation and Partial STARS Treatment for Tailings/Impacted Soils, Limited Removal for Instream Sediments, and In-situ Treatment of Railroad Materials

Estimated present worth cost: $21,000,000 to $40,000,000
Implementation time: 3 - 5 years

This alternative was developed to address one of the primary sources of contaminated groundwater, saturated tailings. Under this alternative, a total of approximately 480,000 cy of tailings/impacted soils and an additional 220,000 cy of tailings/impacted soils which overlie the saturated tailings/impacted soils would be excavated, relocated outside the floodplain, and treated with STARS amendments. Fill material would be brought in to replace a portion of the excavated soils. The remaining approximately 1,800,000 cy of tailings/impacted soils not considered to be saturated would be treated in place with STARS amendments and revegetated.

Instream sediments would be removed and relocated out of the floodplain with the relocated tailings. The volume of instream sediments defined for limited removal represents all fine-grained ($\leq$1mm) instream sediments, which account for the majority of highly contaminated instream sediments. Only limited data exist to estimate the volumes of instream sediments by size fraction. Based on quantities of instream sediments estimated during the RI, about 73,000 cy of fine-grained instream sediments would be removed.

Railroad materials would receive in-situ treatment under this alternative by applying STARS amendments to the impacted railroad grade materials. As part of the STARS treatment, limited soil cover is also considered where recreational users might come into contact with high concentrations of contaminated railroad material.

Alternative No. 4 - Partial Removal and Partial STARS Treatment of Tailings/Impacted Soils, Limited Removal of Instream Sediments, and Limited Removal of Railroad Materials

Estimated present worth cost: $27,000,000 to $47,000,000
Implementation time: 3 - 5 years

This alternative is nearly the same as Alternative No. 3 except that the saturated tailings/impacted soils and instream sediments would be transported to a regional repository at Opportunity Ponds or a location along Browns Gulch. In addition, railroad materials containing contaminants that pose a risk to human health or the environment would be removed and disposed along with the tailings/impacted soils and instream sediments.

Alternative No. 5 - Total Relocation of Tailings/Impacted Soils in Subareas 1 and 3, Partial Relocation and Partial STARS Treatment in Subareas 2 and 4, Limited Instream Sediment Removal, and Limited Removal of Railroad Materials

Estimated present worth cost: $32,000,000 to $55,000,000
Implementation time: 4 - 6 years

This alternative has been developed to address the limitations of STARS in effectively meeting the SST OU's threshold protectiveness standards and ARARs. Under this alternative, an estimated total of 1.76 million cy of tailings/impacted soils which are saturated by groundwater, potentially eroded by natural stream migration and/or flood events would be relocated to dry closure areas located adjacent to the OU but outside of the floodplain. Total excavation of all tailings/impacted soils within the floodplain would be required in Subareas 1 and 3 because those in-situ treatment areas could not be adequately protected from erosion. This alternative modifies partial relocation to include excavation and relocation of all tailings/impacted soils within the floodplain in Subarea 2 and excavation and relocation of additional near-stream tailings in Subarea 4. In Subarea 2, about 280,000 cy of tailings/impacted soils in the Ramsay Flats area located outside of the floodplain would be consolidated and treated with STARS, with a portion covered with top soil if residentially used. In Subarea 4, approximately 540,000 cy out of the 1,300,000 cy identified in the subarea would be relocated and the remainder treated with STARS. Excavated tailings/impacted soils would be fully treated with lime amendments prior to placement in the relocation areas.

As in Alternative No. 3, fine-grained ($\leq$1mm) instream sediments would be excavated and placed in the relocation areas with the relocated tailings. The volume of instream sediments defined for limited removal includes all fine-grained instream sediments, which represent those posing the most significant risk to health and the environment. As in OU-wide Alternative. No. 4, selected contaminated railroad materials would be excavated and placed into local relocation repositories.

Alternative No. 6 - Total Removal of Tailings/Impacted Soils in Subareas 1 and 3, Partial Removal and Partial STARS Treatment in Subareas 2 and 4, Limited Instream Sediment Removal, and Limited Removal of Railroad Materials

Estimated present worth cost: $39,000,000 to $66,000,000
Implementation time: 4 - 6 years

Alternative No. 6 was the alternative proposed by the agencies in the proposed plan. This alternative is similar to Alternative No. 5, with the exception that tailings/impacted soils, instream sediments, and railroad materials removed would be transported and deposited in a regional dry closure repository instead of adjacent relocation areas. Under this alternative, an estimated total of 1.76 million cubic yards of tailings/impacted soils would be removed to regional repositories located in Browns Gulch and/or at Opportunity Ponds. Total removal of all tailings/impacted soils within the floodplain would be required under this alternative in Subareas 1 and 3. In Subarea 2, about 280,000 cy of tailings/impacted soils in the Ramsay Flats area located outside of the floodplain would be consolidated and treated with STARS and a portion covered with top soil. In Subarea 4, approximately 540,000 cy out of the approximately 1,300,000 cy identified in the subarea would be removed and the remainder treated with STARS.

The same amounts of instream sediments and railroad materials would be removed as under Alternative No. 5, but they also would be hauled to the regional repository.

Alternative No. 7 - Total Removal of Tailings/Impacted Soils, Total Removal of Instream Sediments, and Limited Removal of Railroad Materials

Estimated present worth cost: $48,000,000 to $79,000,000
Implementation time: 4 - 7 years

This OU-wide alternative requires the most rigorous action and essentially removes all identified materials containing contaminants in tailings/soils and instream sediments. Removal of railroad materials would be limited to those areas where they pose a potential risk to human health and the environment. This alternative differs from Alternatives 5 and 6 in that it includes removal of all waste sources in and out of the floodplain to a regional dry repository. A total of approximately 2.55 million cy of tailings/impacted soils would be removed from the OU. In addition, instream sediment removal would address all instream sediments, not just the fine-grained fraction. Sediment volumes for total removal would be approximately 236,000 cy, which would include instream sediments to a depth of about 2.5 feet below the present stream bed. There would be a minor level of long-term maintenance and monitoring associated with this alternative.

VIII. SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

Section 300.430(e)(9) of the NCP requires that the agencies evaluate and compare the remedial cleanup alternatives based on the nine criteria listed below. The first two criteria - overall protection of human health and the environment and compliance with ARARs, are threshold criteria and must be met. The selected remedy must represent the best balance of the selection criteria.

Evaluation and Comparison Criteria

Threshold Criteria

1. Overall protection of human health and environment addresses whether or not a remedy provides adequate protection and describes how potential risks posed through each pathway are eliminated, reduced or controlled through treatment, engineering controls or institutional controls.

2. Compliance with applicable or relevant and appropriate requirements (ARARS) addresses whether or not a remedy will comply with federal and state environmental laws or provides grounds for invoking a waiver.

Primary Balancing Criteria

3. Long-term effectiveness and permanence refers to the ability of a remedy to maintain reliable protection of human health and the environment over time once cleanup goals have been met.

4. Reduction of toxicity, mobility and volume through treatment refers to the degree that the remedy reduces toxicity, mobility and volume of the contamination.

5. Short-term effectiveness addresses the period of time needed to complete the remedy, and any adverse impact on human health and the environment that may be posed during the construction and implementation period until cleanup goals are achieved.

6. Implementability refers to the technical and administrative feasibility of a remedy, including the availability of materials and services needed to carry out a particular option.

7. Cost evaluates the estimated capital costs and operation and maintenance costs, calculated at present value, for each alternative.

Modifying Criteria

8. State agency acceptance indicates whether, based on its review of the information, the state (MDEQ) concurs with, opposes or has no comment on the preferred alternative. However, for this OU, MDEQ is the lead management agency and EPA is the support agency. As such, the State has identified the selected remedy and EPA has concurred with and adopted that identification.

9. Community acceptance is based on whether community concerns are addressed by the selected remedy and whether or not the community has a preference for a remedy. Although public comment is an important part of the final decision, MDEQ and EPA are compelled by law to balance community concerns with all of the other criteria.

In assessing cleanup options, MDEQ and EPA evaluated a wide range of media-specific alternatives for each of the four subareas of the SST OU. After detailed analysis and comparative evaluation of the media-specific alternatives, seven comprehensive alternatives addressing all media in the entire OU were developed and evaluated. The seven alternatives were described and key elements of the evaluation were presented in the preceding section. Following is a brief summary of the agencies' comparative evaluation of the seven alternatives. Additional detail regarding the entire development and evaluation of the SST remediation alternatives is presented in the Feasibility Study (ARCO, 1995b), and additional analysis is presented in the Responsiveness Summary (Appendix D) in response to specific comments regarding the evaluation of alternatives.

1) Overall Protection of Human Health and the Environment: OU-wide Alternatives 1 (No Action) and 2 (STARS) were determined to not meet the threshold criterion of overall protection of human health and the environment. Alternatives 3 (Limited Relocation/STARS) and 4 (Limited Removal/STARS) provided significant improvements in overall protectiveness, but were found deficient in demonstrating long-term protectiveness because of reliance on STARS technology at extensive locations within the floodplain that would be subject to erosion and failure during natural stream meander and high-flow events. Alternatives 5 (Modified Relocation/STARS) and 6 (Modified Removal/STARS) were evaluated to provide acceptable overall protectiveness in the short and long-term. Alternatives 3 through 6 all included limited removal of instream sediments. Limited removal of instream sediments was determined to be adequately protective of human health and the environment, assuming that successful tailings/impacted soils remediation was also completed. Alternative 7 (Total Removal) would provide the greatest overall protection of human health and the environment.

2) Compliance with ARARs: OU-wide Alternative 1 would comply with very few of the ARARs established for the OU. Alternative 2 would not comply with major surface water, groundwater, floodplain, or solid waste disposal ARARs. Alternatives 3 and 4 would be expected to improve surface water quality in the near term, but would likely be a factor in the inability of Silver Bow Creek to meet surface water ARARs in the long-term. This is because MDEQ reasonably expects that STARS applied on a large scale in the floodplain will fail to some degree over time, causing future contaminant loading to the stream. In addition, the application of STARS within the floodplain does not meet the floodplain and solid waste ARARs. Alternatives 5 and 6 comply with all ARARs with the exception of the floodplain and solid waste management ARARs for the areas in which STARS would be applied in the floodplain under these alternatives. As discussed in Section X below, the agencies have determined that, under certain conditions, an ARAR waiver may be invoked for the limited use of in-situ STARS treatment, leaving treated wastes in certain areas of the floodplain, as contemplated under Alternatives 5 and 6. The more extensive use of STARS in the floodplain under Alternatives 3 and 4 would not meet the criteria for invoking the ARAR waiver, which are detailed in Sections IX and X below. Alternative 7 would meet all ARARs without waiver.

3) Long-term Effectiveness and Permanence: OU-wide Alternative 1 provides no long-term effectiveness. Alternative 2 would provide no improvement in groundwater quality where tailings and groundwater are in contact and would have severe limitations in effectiveness and permanence where STARS is applied to near-stream and floodplain locations. Alternatives 3 and 4 are roughly equivalent in terms of long-term effectiveness. Both offer major improvements over Alternative 2 by removing many of the tailings causing groundwater contamination and much of the overland flow sediment loading to the stream. Also, these alternatives remove contaminated fine-grained instream sediments. However, the over-reliance on STARS technology in the floodplain reduces substantially any expectation of long-term effectiveness and permanence of the remedy and the remedy would be expected to unravel over time. Alternative 3 is somewhat downgraded in long-term effectiveness to the extent it would rely on in-situ treatment of impacted railroad materials, which is considered less effective than limited removal. Alternatives 5 and 6 greatly increase the expected long-term effectiveness and permanence by removing most contaminant sources from the floodplain so that any chance of re-entrainment of contaminated materials into the stream is effectively eliminated. Contaminants would be left in the floodplain only in those locations where they could be determined to be safe from future erosion and re-entrainment. Contaminated fine-grained instream sediments would be removed under Alternatives 5 and 6, providing adequate long-term effectiveness for that media. Alternative 7 provides the greatest level of long-term effectiveness and permanence.

4) Reduction of Toxicity, Mobility or Volume Through Treatment: OU-wide Alternative 1 provides no reduction of toxicity, mobility, or volume. Alternative 2 provides for in-situ lime treatment of nearly 2 million cubic yards of tailings/impacted soils that would reduce mobility and therefore phytotoxicity of certain metals in the soil. However, the preference established in CERCLA is for treatment which "permanently and significantly reduces" volume, toxicity or mobility of the contaminants. 42 U.S.C. § 9621(b)(1). The treatment involved here could not be expected to be permanent if the lime amendments are physically separated from the contaminants through erosion or other processes. Alternative 3 provides reduced levels of in-situ treatment in comparison with Alternative 2, but provides more permanent reduction in mobility by placing some treated contaminants into dry repositories not subject to erosion by stream forces. Alternative 3 would treat contaminated railroad materials by lime amendment and therefore further reduce the mobility and toxicity of those contaminants. However, erosion of the amended materials, which would reverse the treatment, is considered possible and even likely in certain locations. Alternative 4 has considerably reduced use of treatment, but would achieve a reduction in mobility by placing the materials in a dry repository. Alternative 5 has the maximum permanent reduction in mobility through treatment because all materials would be treated, either in protected in--situ locations or in the relocation areas. Alternative 6 would provide reduced levels of treatment, but substantial permanent reduction in mobility by removing most contaminants from the floodplain environment. The degree of reduction in toxicity, mobility, or volume through treatment of contaminated instream sediments would depend entirely on whether excavated instream sediments were treated during disposal. This would be possible under Alternatives 3 and 5. However, Alternatives 4 and 6 would attain permanent reduction of mobility by placing the materials in secure repositories. Alternative 7 would provide no treatment, but would accomplish permanent reduction in mobility by placing all materials in a secure repository.

5) Short-term Effectiveness: Alternative 1 has no risks associated with implementation since no action is taken, although future actions would be required because no remedial action objectives would be met. Alternative 2 requires the least construction of any action alternative and therefore provides greater short-term effectiveness, although this again would be offset by the probability that a future action would be required. Alternatives 3 and 4 would have greater short-term impact on both nearby residents and the environment because substantial excavation, haulage, and disposal would be required. Of the two, impact on the local communities would be greater with Alternative 4 because considerably more truck traffic would be necessary to transport excavated materials to regional disposal areas. Alternatives 5 and 6, by requiring excavation of about twice as much tailings/impacted soils as Alternatives 3 and 4, would exhibit even greater short-term impacts during construction of the remedy. Alternatives 3 through 6 are all considered relatively equal with respect to short-term impact on the environment during construction. Alternative 7 would have the greatest risk to local communities and the environment during construction.

6) **Implementability**: All alternatives are considered implementable using standard construction technologies. Alternative 2 is the most easily implemented action alternative since it involves lime application and revegetation using standard construction and agricultural equipment with very little work in areas of shallow groundwater. Alternatives 3 and 4 present greater difficulties because excavation of saturated tailings is required, although standard construction dewatering techniques are expected to be adequate to facilitate excavation. Alternatives 5 and 6 require more substantial excavation, although generally no greater excavation under saturated conditions than for Alternatives 3 and 4. Alternatives 3 through 6 would all require some removal of instream sediments, which presents construction difficulties but should not be substantially different than removal of near-stream tailings saturated in the groundwater. In fact, excavation of saturated tailings and re-routing of the stream into the excavated area will be the likely approach for dewatering the stream so that excavation of instream sediments can proceed. Alternative 7 would require total removal of instream sediments, which would present significantly greater difficulties than any of the alternatives requiring limited removal of fine-grained instream sediments only. Alternatives that require limited removal of railroad material would present implementation difficulties in terms of coordinating construction during use of the active rail lines. Alternatives requiring in-situ treatment of railroad beds could be more easily implemented. If rail haul of excavated materials were used under Alternatives 6 or 7, difficulties in terms of coordinating loading and haul operations with active railroad use would be encountered.

7) **Cost**: The combination of the media-alternatives into OU-wide alternatives presents the range of total costs that could be expected if all four media (tailings/soils, groundwater, railroad materials, and instream sediments) were remediated concurrently. The presentation of costs in this manner eliminates duplicative cost elements, such as road building, monitoring, and operation and maintenance (O&M), between the media.

Total costs include anticipated capital costs to construct the remedy and anticipated operation, maintenance, and monitoring costs over a 30-year period (Table 13). The annual operation, maintenance and monitoring costs have been discounted at a 7 percent annual capitalization rate to obtain a present worth for those costs.

8) **State Agency Acceptance**: The State of Montana has been the lead agency for the development of this record of decision and has selected an amended Alternative 5 as the remedy contained herein. EPA has participated in the remedy selection process as the support agency and has concurred with and adopted the remedy selection.

Table 13
Total Volumes of Contaminated Materials Removed or Relocated and Cost

Site-Wide Alternative Number	Volume Relocated to Near Site Repository (cy)	Volume Removed to Regional Repository (cy)	Estimated Cost (millions)
1	0	0	$0.7 - $1.4
2	0	0	$13 - $24
3	773,000	0	$21 - $40
4	0	943,800	$27 - $47
5	1,716,940	0	$32 - $55
6	0	1,936,940	$39 - $66
7	0	2740,300	$48 - $79

NOTE: Cost of the remedy described in this ROD are different from those listed in the FS. The main reasons are (1) 50,000 cy has already been removed from ARCO's Demonstration Project II in Subarea 4, (2) in Subarea 4 an additional 170,000 cy of additional tailings/impacted soils would be treated in-situ, (3) use of a soils cover to protect human health in impacted areas outside the floodplain, (4) the volumes of railroad materials to be removed or treated was better delineated, and (5) Ramsay Flats has an additional 40,000 cy outside of the 100-year floodplain.

9) Community Acceptance: Public comment on the Remedial Investigation, Risk Assessment, Feasibility Study, proposed plan (MDEQ, 1995a) and all other pertinent documents was solicited during the formal public comment period extending from June 9, 1995, to August 7, 1995. An analysis of and responses to community comments are found in the Responsiveness Summary (Appendix D).

During the public comment period, MDEQ and EPA received extensive comments from ARCO, the potentially responsible party which conducted the RI/FS under an Administrative Order on Consent issued by MDEQ. Comments received from ARCO indicate its opposition to the preferred alternative No. 6 in the proposed plan (MDEQ, 1995a) and the selected remedy, Alternative 5. In its initial comments, ARCO preferred the approach of a combination of site-wide Alternatives 2 and 3; ARCO's proposed action consists primarily of in-situ STARS treatment with removal of approximately 50% of the saturated tailings.

ARCO comments with MDEQ and EPA responses are also found in the Responsiveness Summary.

As is clear in the summary text and tables of Appendix D - Responsiveness Summary, the majority of people and entities who commented on the proposed plan (MDEQ, 1995a) supported the proposed alternative, Alternative 6, or preferred a more protective cleanup (Alternative 7). Many people who commented believed that the 100-year floodplain was an unsafe place to store tailings and that STARS technology long-term effectiveness was extremely questionable.

However, comments submitted by ARCO, as well as representatives of local government and various business entities in the area, vehemently objected to certain cost elements of the proposed Alternative 6. Since cost is a primary concern and was a clear focus of certain of the public comments received, the agencies have modified their proposal to substantially reduce the costs of implementing the remedy, still allowing for the design and implementation of a remedy that will protect human health and the environment and attain ARARs, except as appropriately waived.

IX. SELECTED REMEDY

MDEQ and the EPA have selected a remedy that is intended to be the final remedial action for the SST OU. This action addresses the principal threats and provides for treatment and appropriate long-term management of contaminated tailings/impacted soils, instream sediments, and railroad materials. Much of the treated materials will remain in the OU. Consequently, the OU will require long-term management and monitoring.

Based upon consideration of CERCLA requirements, the detailed analysis of alternatives, and public comments, MDEQ and EPA have determined that ***OU-wide Alternative 5***, as generally described in the Feasibility Study (ARCO, 1995b) and the proposed plan (MDEQ, 1995a), with certain clarifications, represents the best balance of considerations using the selection criteria and is the appropriate remedy for the OU. As presented here, this alternative will protect human health and the environment by removing or treating sources of contamination to soils, surface water, groundwater, and instream sediments. The long-term effectiveness and degree of permanence of the selected remedy are high. MDEQ does not expect any unmanageable short-term risks associated with this alternative. This remedy will comply with all applicable or relevant and appropriate requirements, except where a waiver of such requirements has been determined to be appropriate. This remedy is cost-effective because the estimated costs are proportional to its overall effectiveness. This remedy uses permanent solutions and treatment technologies to the maximum extent practicable. All contaminated OU materials will be treated, therefore the selected remedy will also satisfy the preferences for treatment as a principal element of the remedy and for on-site remedies established in CERCLA. While certain other alternatives may better satisfy certain individual selection criteria, the selected remedy best meets the entire range of the selection criteria and achieves, in the determination of both EPA and MDEQ, the appropriate balance, considering OU specific conditions and the criteria identified in CERCLA and the NCP. The criteria described above are discussed in more detail in Section X, Statutory Determinations.

Components of Selected Remedy

Some refinements to OU-wide Alternative 5 have been made to clarify the criteria used to require excavation of tailings/impacted soils, to more precisely identify excavation of contaminated railroad bed materials, to delineate an end land use for Subarea 1, and to specify institutional controls, monitoring, and maintenance requirements that will be used to manage the Silver Bow Creek corridor in the future. This record of decision establishes cleanup levels or physical criteria for the contaminants of concern. The principal contaminants of concern at the SST OU are arsenic, cadmium, copper, lead, mercury, and zinc.

Tailings/Impacted Soils

Tailings/impacted soils are the primary contaminant source for the SST OU (Figure 15). There are three predominant ways in which tailings/impacted soils contaminate other Silver Bow Creek media: tailings in direct contact with groundwater; infiltration of precipitation through tailings; and erosion of tailings into Silver Bow Creek (Figures 3 - 6).

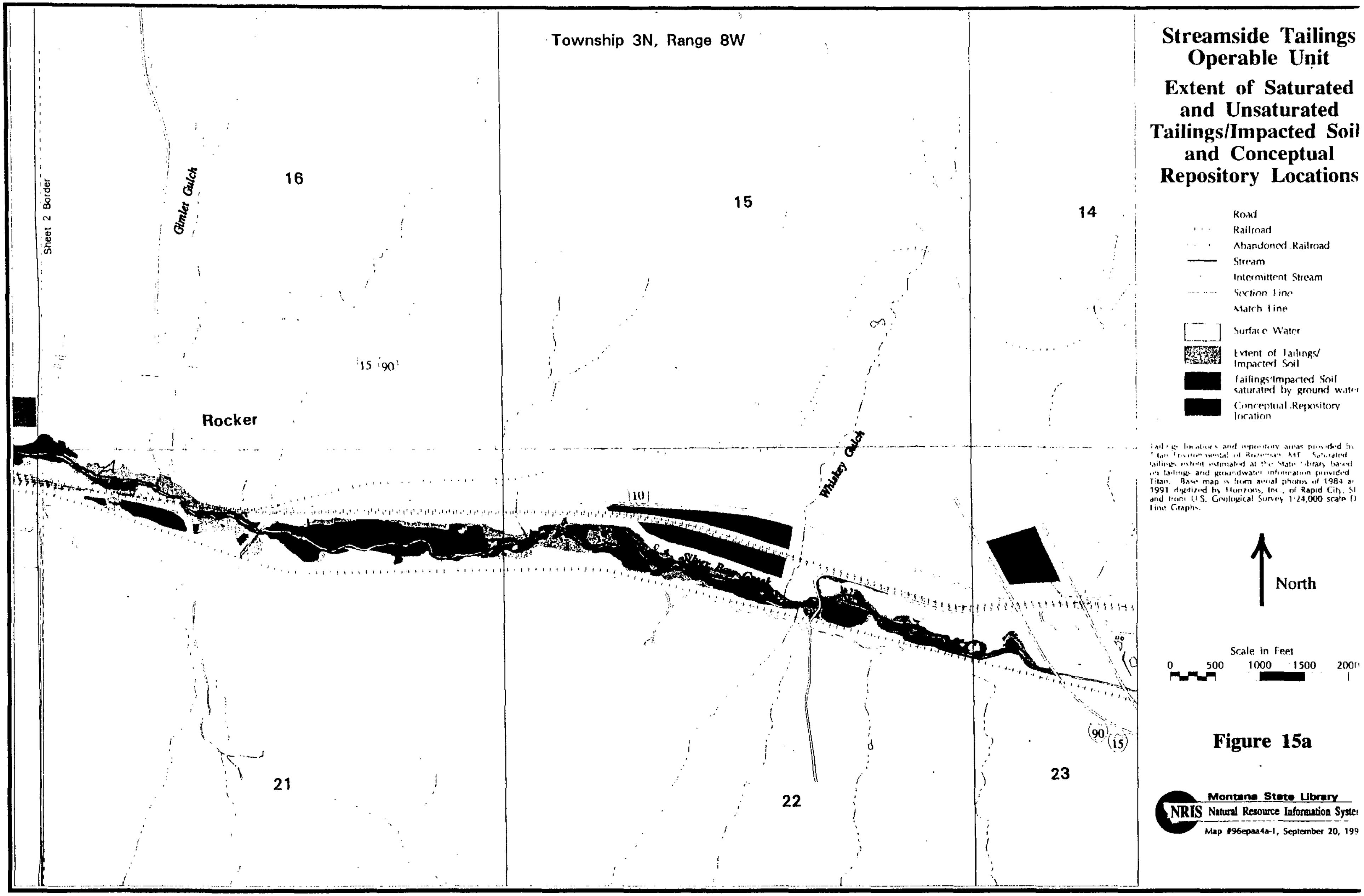
To meet the established OU remedial action objectives, tailings/impacted soils will be removed from the 100-year floodplain, as defined in the CH2M Hill (1989a) report, where: (1) tailings/impacted soils are saturated by groundwater during any part of the year, (2) in-situ Streambank Tailings and Revegetation Study (STARS) treatment cannot reliably immobilize the contaminants, for example, due to the thickness of the tailings/impacted soils, proximity of the tailings/impacted soils to groundwater, or lack of appropriate buffer materials between the treated tailings/impacted soils and the groundwater, or (3) the treated tailings/impacted soils could be eroded back into the stream by natural lateral stream migration, avulsion, overbank flow or flood events and subsequent erosion.

Excavation of contaminated tailings/impacted soils from most areas within the floodplain is required. The specific depth of excavation and the amount of excavated materials will be determined by the agencies during remedial design/remedial action. The removed volume will include all tailings/impacted soils continuously or seasonally saturated by groundwater together with the tailings/impacted soils overlying these saturated tailings (collectively, "saturated tailings"), as well as tailings/impacted soils subject to erosion and reentrainment into the stream over time as determined by the agencies. These two criteria relate primarily to the location of the particular tailings deposit; the agencies having determined that it is not appropriate to leave treated tailings in place in such locations. In addition, in determining whether other tailings must be removed, the agencies are to consider, for the particular tailings deposit, such factors as the depth and thickness of the tailings deposit, the proximity of the tailings to groundwater and the nature of any buffer materials/native soils between the tailings and the groundwater. The basis for and the manner in which all of these criteria are to be applied is further explained later in this section. Tailings that are not in a saturated or threatened location and that are situated so that STARS treatment can reliably immobilize the contaminants will be treated in-situ.

The total volume of saturated and overlying tailings/impacted soils to be removed is presently estimated at approximately 700,000 cy. The total volume of tailings/impacted soils subject to erosion and therefore to be excavated is estimated at approximately 850,000 cy. All remaining tailings/impacted soils (approximately 950,000 cy) within the OU will be treated in-situ with the STARS technology and will include appropriate monitoring, maintenance and protection from washout or erosion from lateral stream migration and flood flows.

Streamside Tailings Operable Unit

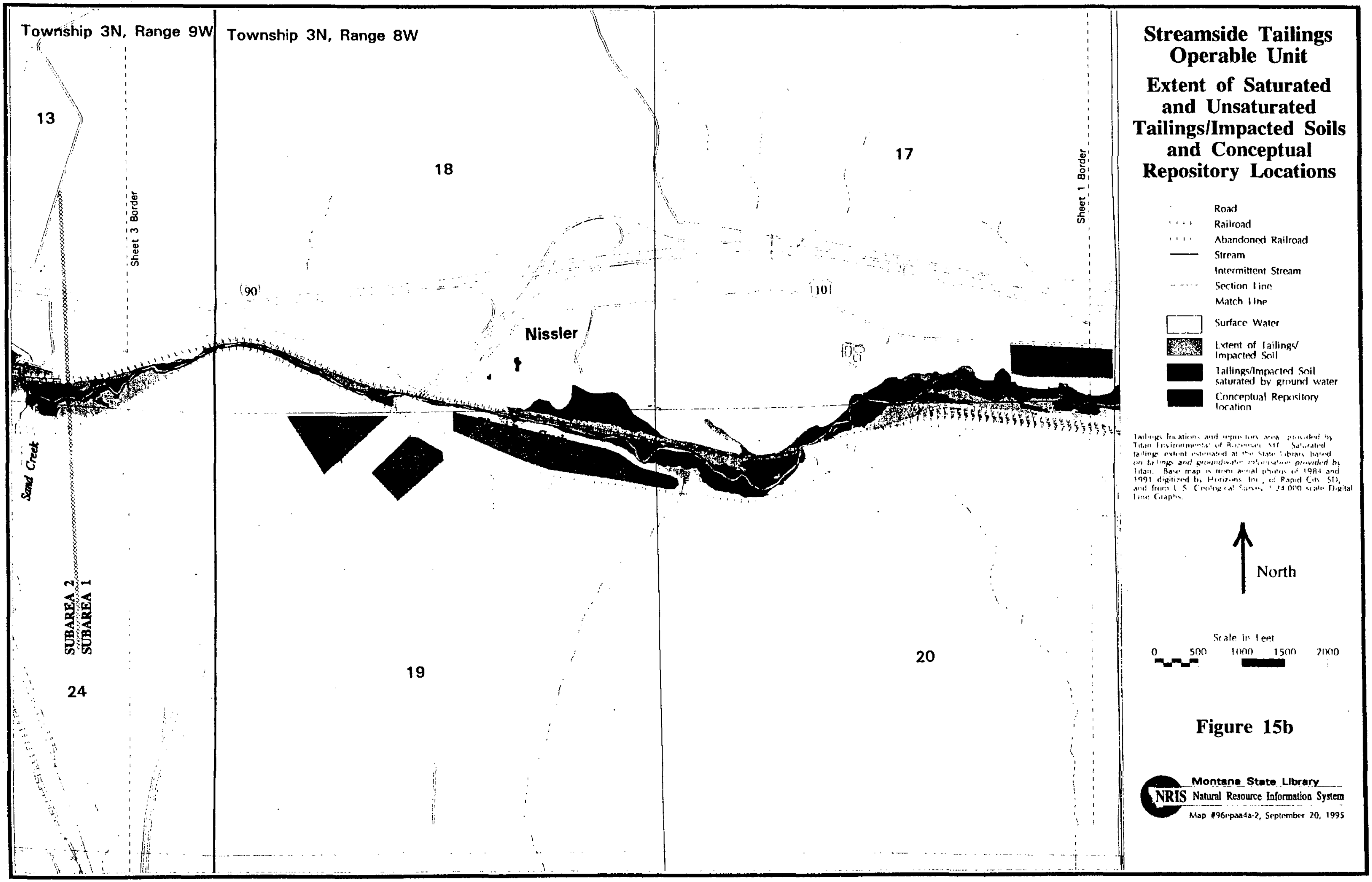
Extent of Saturated and Unsaturated Tailings/Impacted Soil and Conceptual Repository Locations

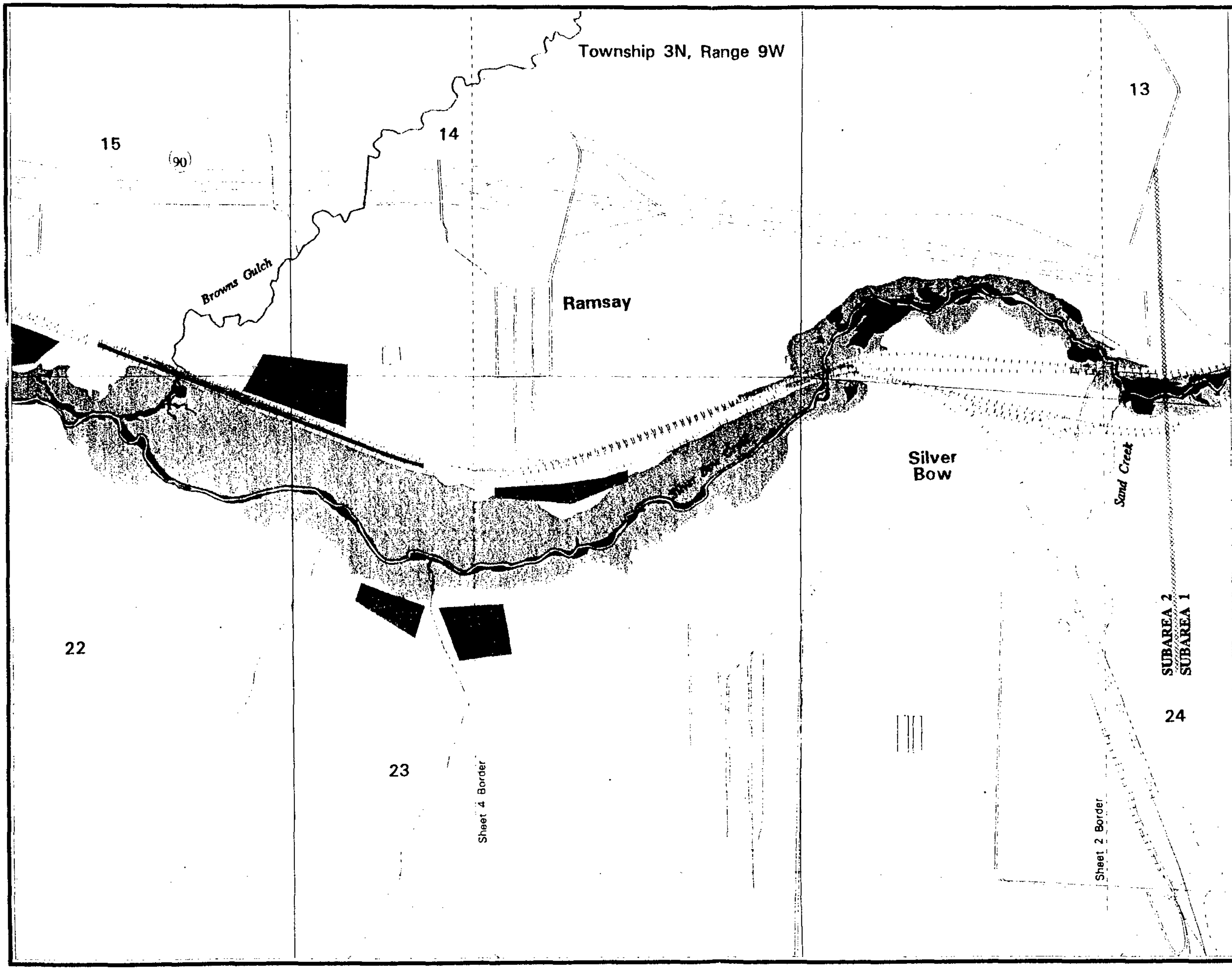


Titan. Base map is from aerial photos of 1984 a 1991 digitized by Horizons, Inc., of Rapid City, SI and from U.S. Geological Survey 1:24,000 scale D Line Graphs.

Figure 15a

Montana State Library
NRIS Natural Resource Information Syste
Map #96epaa4a-1, September 20, 199


Township 3N, Range 9W
Township 3N, Range 8W
13
18
17
Sheet 3 Border
Sheet 1 Border
90
101
Nissler
Sand Creek
SUBAREA 2
SUBAREA 1
24
19
20
Streamside Tailings Operable Unit
Extent of Saturated and Unsaturated Tailings/Impacted Soils and Conceptual Repository Locations
Road
Railroad
Abandoned Railroad
Stream
Intermittent Stream
Section Line
Match Line
Surface Water
Extent of Tailings/ Impacted Soil
Tailings/Impacted Soil saturated by ground water
Conceptual Repository location
North
Scale in Feet
0
500
1000
1500
2000
Montana State Library
NRIS Natural Resource Information System
Map #96epaa4a-2, September 20, 1995
Figure 15b



Streamside Tailings Operable Unit

Extent of Saturated and Unsaturated Tailings/Impacted Soils and Conceptual Repository Locations

Road
Railroad
Abandoned Railroad
Stream
Intermittent Stream
Section Line
Match Line
Surface Water
Extent of Tailings/ Impacted Soil
Tailings/Impacted Soil saturated by ground water
Conceptual Repository location

Tailings locations and repository areas provided by Titan Environmental of Bozeman, MT. Saturated tailings extent estimated at the State Library based on tailings and groundwater information provided by Titan. Base map is from aerial photos of 1981 and 1991 digitized by Horizons, Inc., of Rapid City, SD, and from U.S. Geological Survey 1:24,000 scale Digital Line Graphs.

North

Scale in Feet
0 500 1000 1500 2000

Figure 15c

Montana State Library
NRIS Natural Resource Information System
Map #96epaa4a-3, September 20, 1995

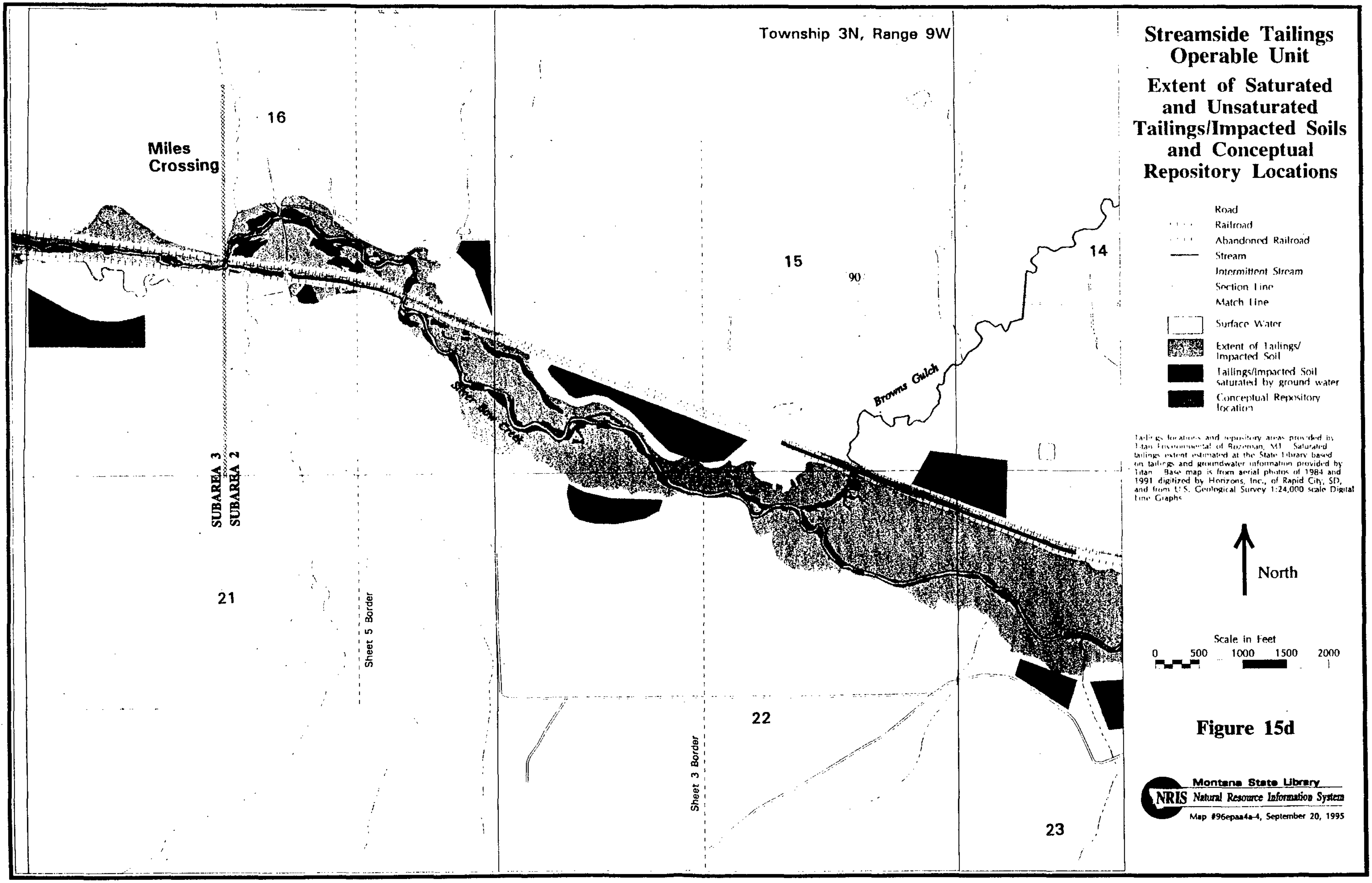
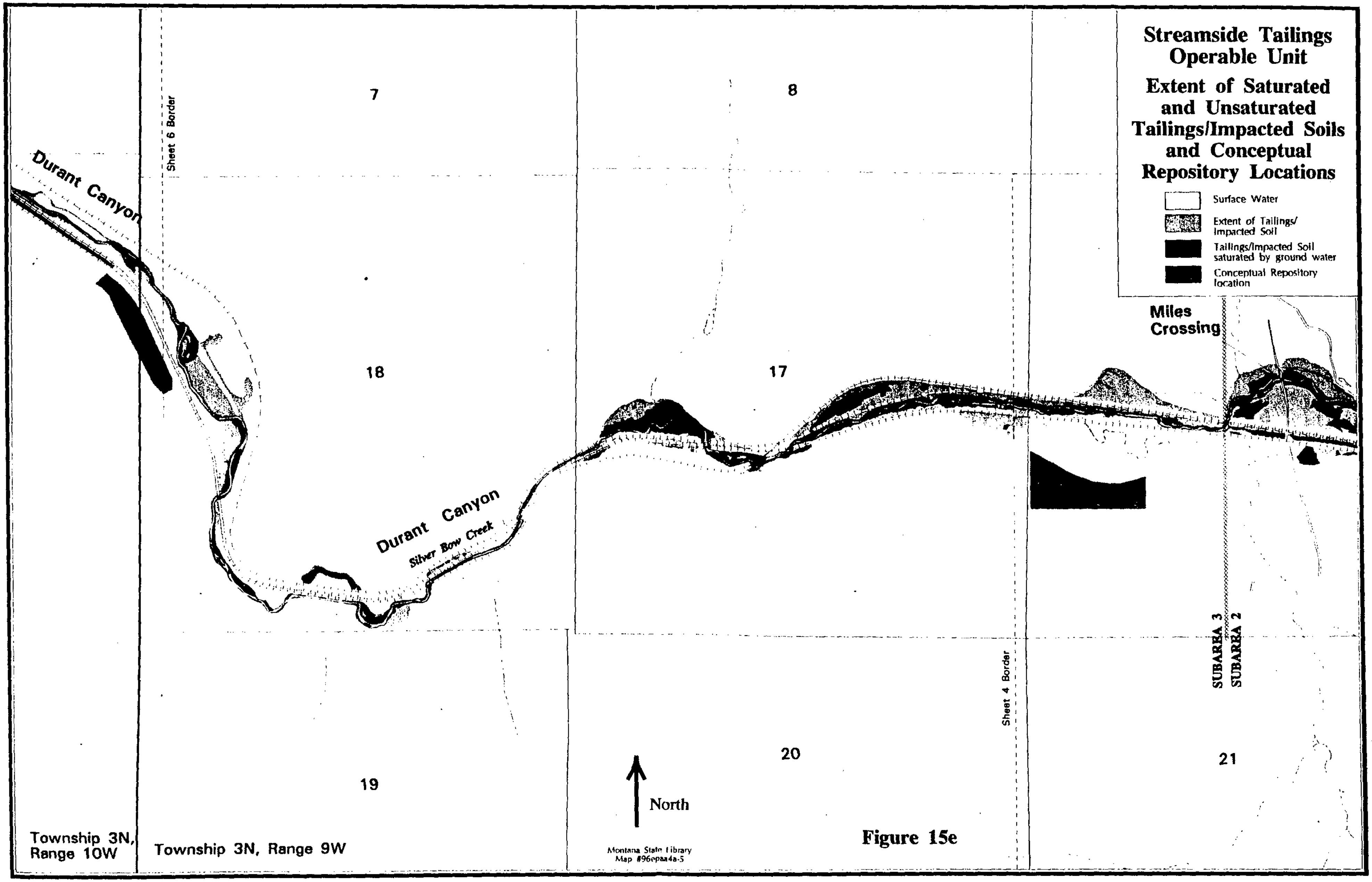

Streamside Tailings Operable Unit
Extent of Saturated and Unsaturated Tailings/Impacted Soils and Conceptual Repository Locations
Township 3N, Range 9W
Miles Crossing
16
15
14
21
22
23
90
Browns Gulch
SUBAREA 3
SUBAREA 2
Sheet 5 Border
Sheet 3 Border
Road
Railroad
Abandoned Railroad
Stream
Intermittent Stream
Section Line
Match Line
Surface Water
Extent of Tailings/ Impacted Soil
Tailings/Impacted Soil saturated by ground water
Conceptual Repository location
Tailings locations and repository areas provided by Titan Environmental of Bozeman, MT. Saturated tailings extent estimated at the State Library based on tailings and groundwater information provided by Titan. Base map is from aerial photos of 1984 and 1991 digitized by Horizons, Inc., of Rapid City, SD, and from U.S. Geological Survey 1:24,000 scale Digital Line Graphs.
North
Scale in Feet
0 500 1000 1500 2000
Montana State Library
NRIS Natural Resource Information System
Map #96epaa4a-4, September 20, 1995

Figure 15d

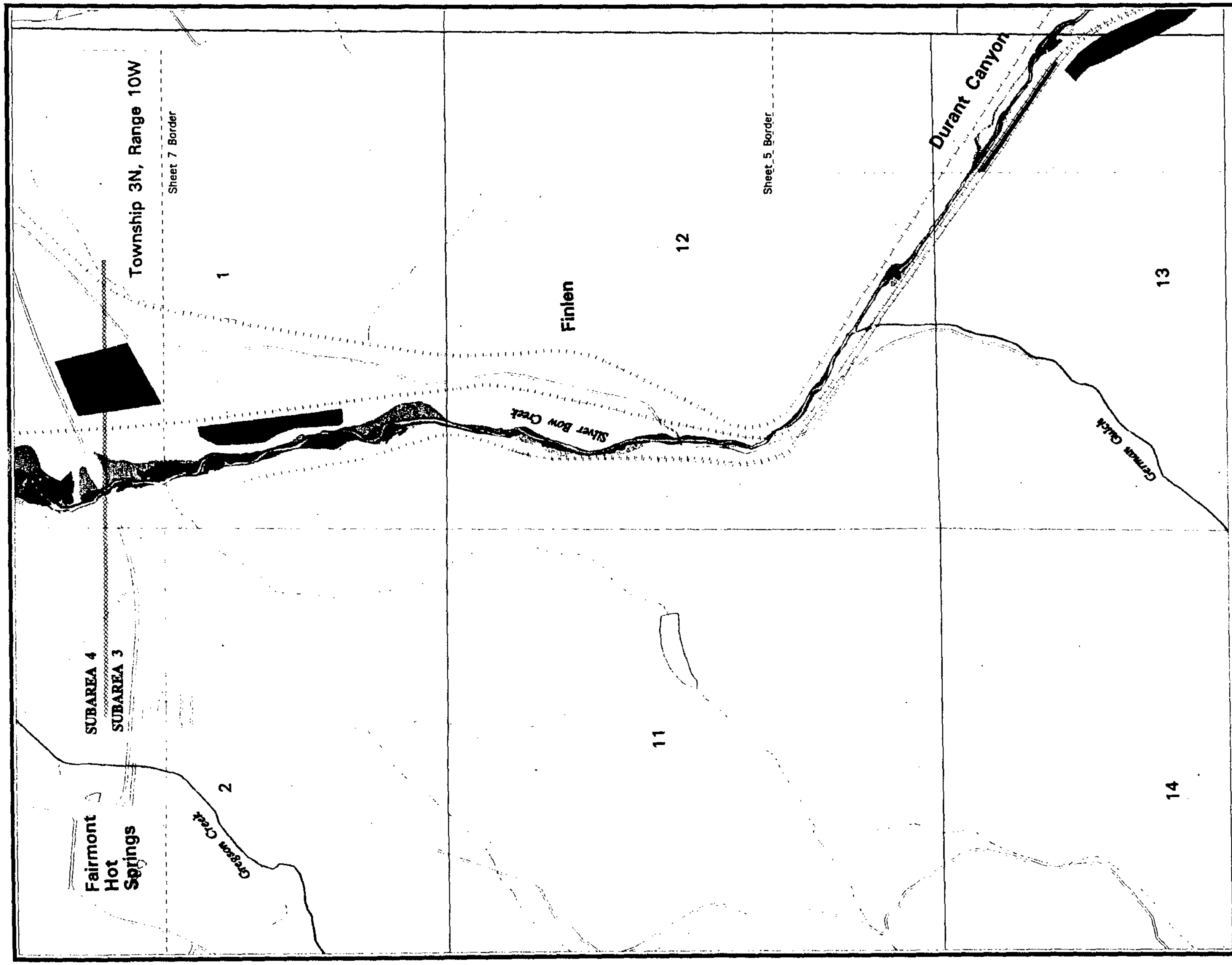


Streamside Tailings Operable Unit
Extent of Saturated and Unsaturated Tailings/Impacted Soils and Conceptual Repository Locations
Surface Water
Extent of Tailings/ Impacted Soil
Tailings/Impacted Soil saturated by ground water
Conceptual Repository location
7
8
Sheet 6 Border
Durant Canyon
18
17
Miles Crossing
Durant Canyon
Silver Bow Creek
SUBAREA 3
SUBAREA 2
Sheet 4 Border
20
21
19
North
Township 3N, Range 10W
Township 3N, Range 9W
Montana State Library Map #96epaa4a-5

Figure 15e

Streamside Tailings Operable Unit

Extent of Saturated and Unsaturated Tailings/Impacted Soils and Conceptual Repository Locations



- Road
- Railroad
- Abandoned Railroad
- Stream
- Intermittent Stream
- Section Line
- Match Line
- Surface Water
- Extent of Tailings/ Impacted Soil
- Tailings/Impacted Soil saturated by ground water
- Conceptual Repository location

Tailings locations and repository areas provided by Titan Environmental of Bozeman, MT. Saturated tailings extent estimated at the State Library based on tailings and groundwater information provided by Titan. Base map is from aerial photos of 1984 and 1991 digitized by Horizons, Inc., of Rapid City, SD, and from U.S. Geological Survey 1:24,000 scale Digital Line Graphs.

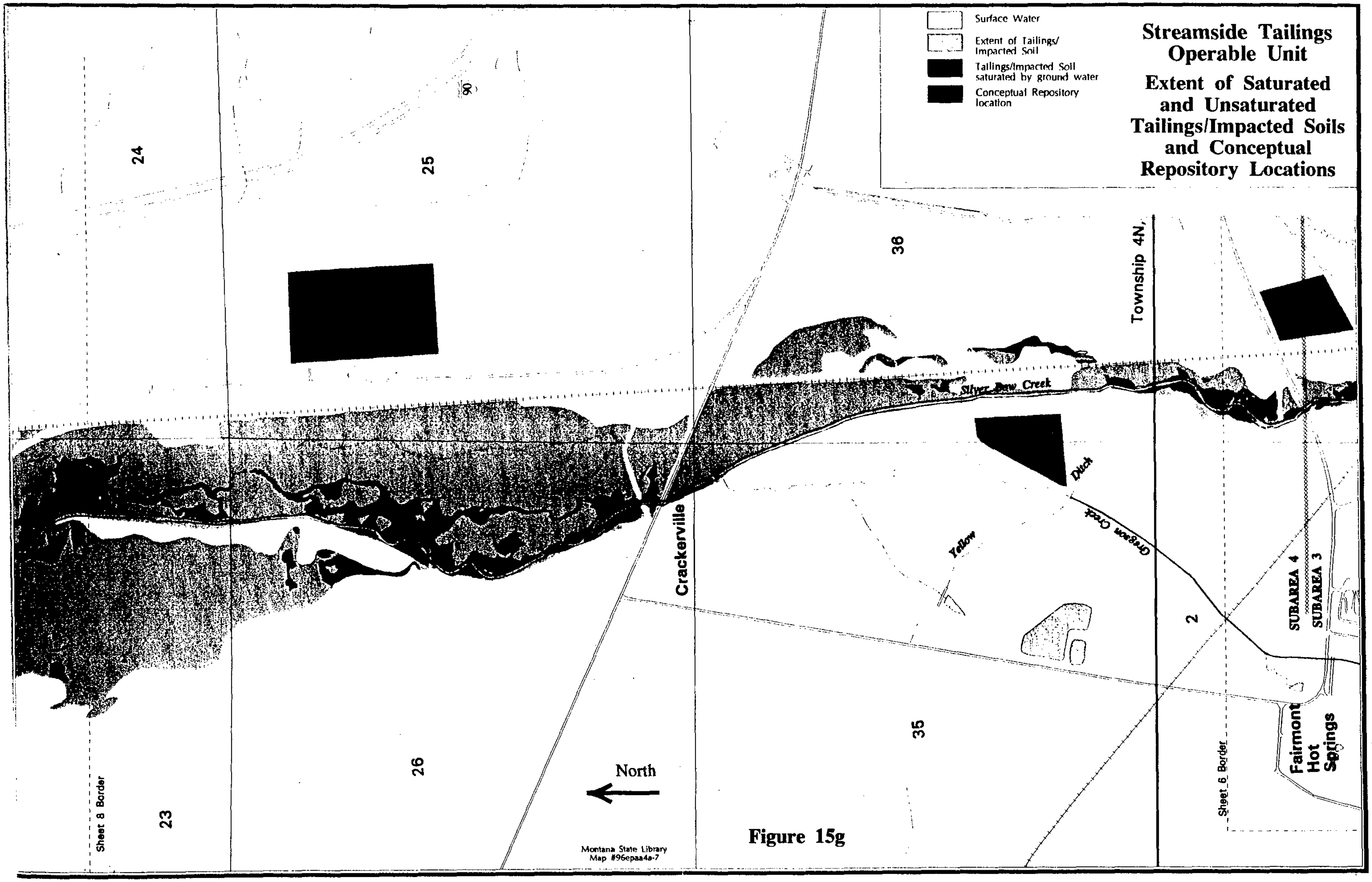
North

Scale in Feet

0 500 1000 1500 2000

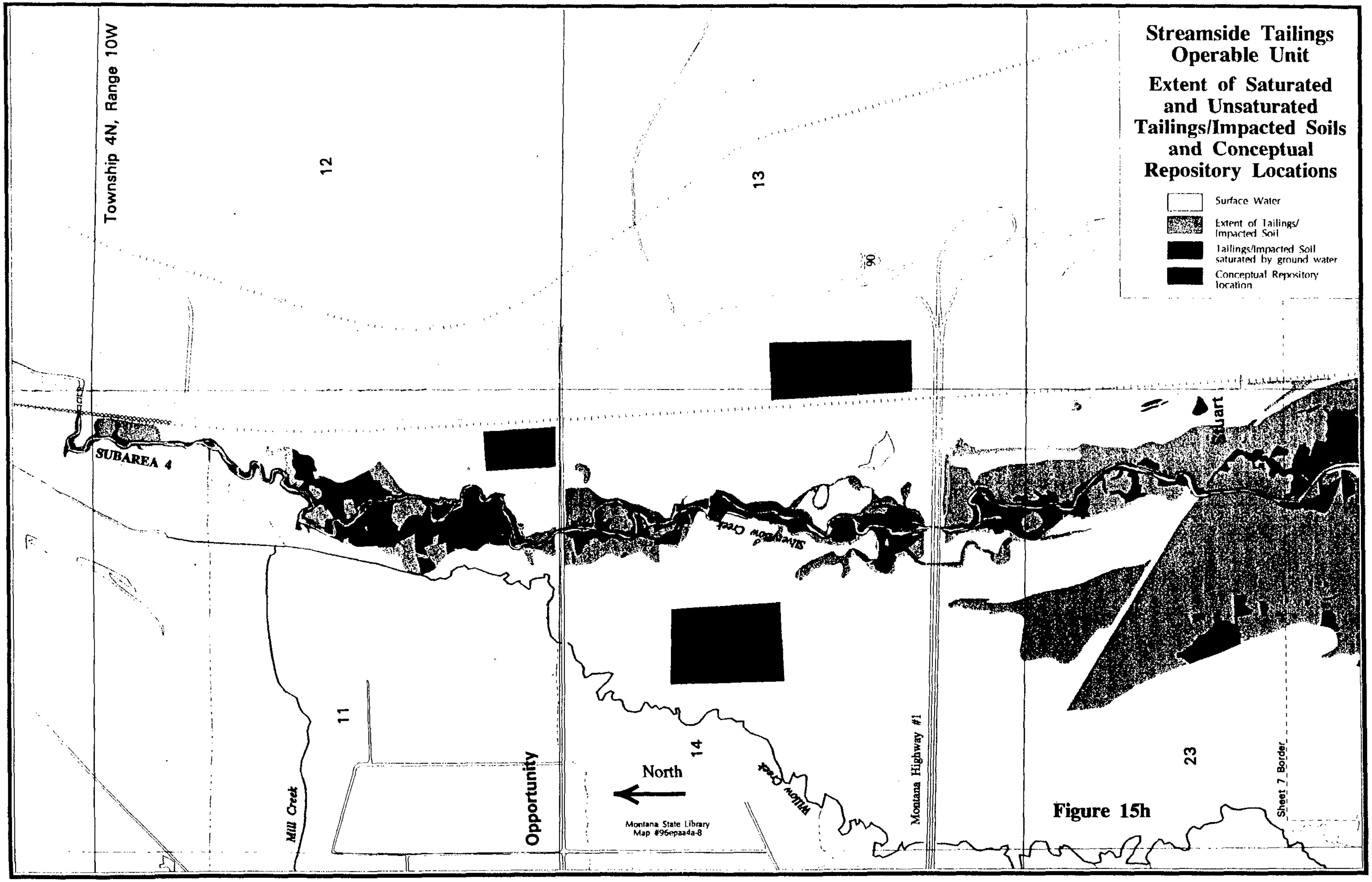
Figure 15f

Montana State Library
NRIS Natural Resource Information System
Map #96epaa4a-6, September 20, 1995



Surface Water
Extent of Tailings/ Impacted Soil
Tailings/Impacted Soil saturated by ground water
Conceptual Repository location
Streamside Tailings Operable Unit
Extent of Saturated and Unsaturated Tailings/Impacted Soils and Conceptual Repository Locations
24
25
36
Township 4N,
Silver Bow Creek
Ditch
Gregson Creek
Yellow
Crackerville
2
SUBAREA 4
SUBAREA 3
Fairmont Hot Springs
35
26
23
Sheet 8 Border
Sheet 6 Border
North
Montana State Library Map #96epaa4a-7

Figure 15g



Streamside Tailings Operable Unit

Extent of Saturated and Unsaturated Tailings/Impacted Soils and Conceptual Repository Locations

Figure 15h

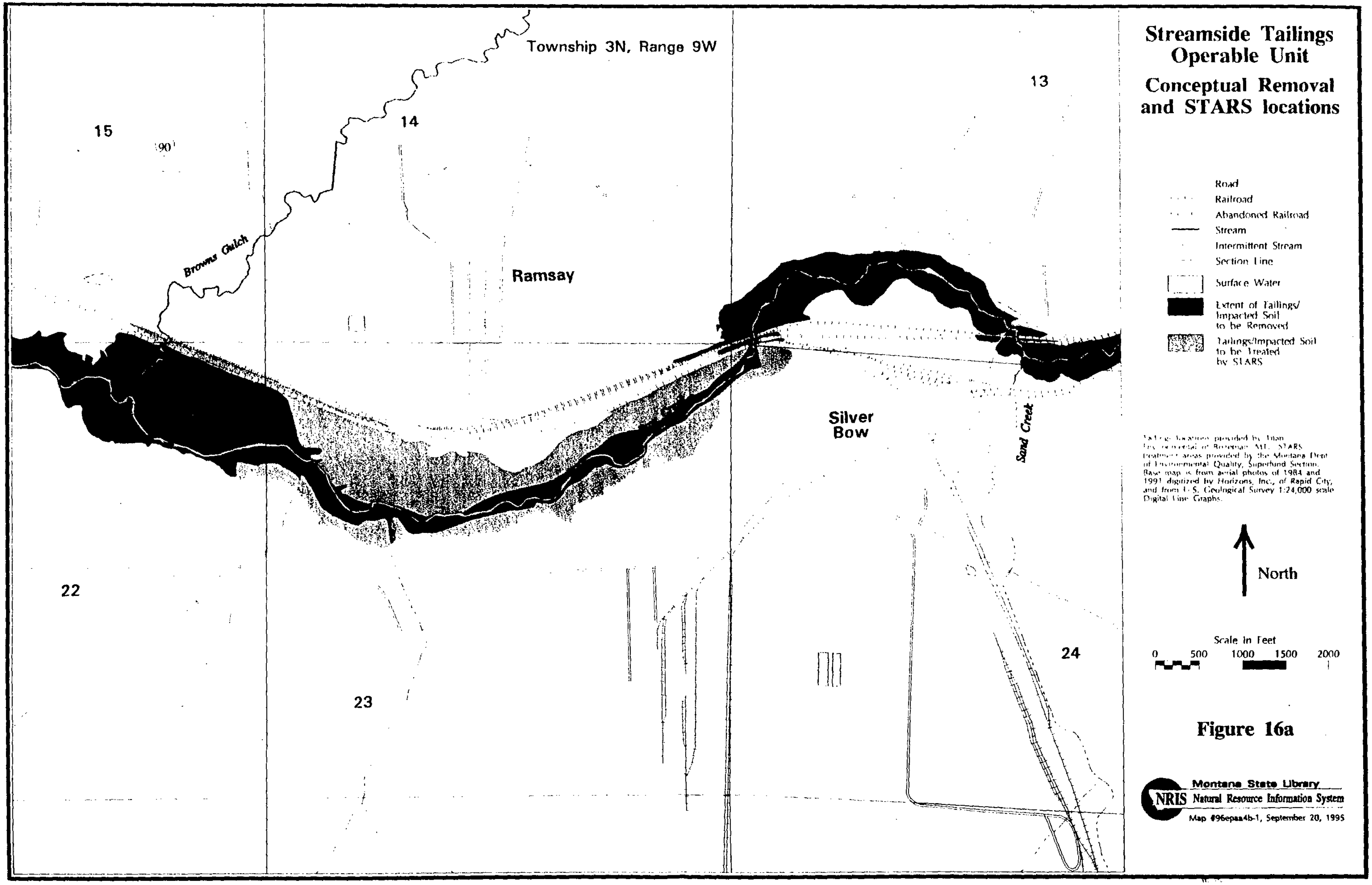

Streamside Tailings Operable Unit
Conceptual Removal and STARS locations
Township 3N, Range 9W
15
14
13
22
23
24
Browns Gulch
Ramsay
Silver Bow
Sand Creek
Road
Railroad
Abandoned Railroad
Stream
Intermittent Stream
Section Line
Surface Water
Extent of Tailings/ Impacted Soil to be Removed
Tailings/Impacted Soil to be Treated by STARS
of Environmental Quality, Superfund Section.
Base map is from aerial photos of 1984 and 1991 digitized by Horizons, Inc., of Rapid City, and from U.S. Geological Survey 1:24,000 scale Digital Line Graphs.
North
Scale in Feet
0 500 1000 1500 2000
Montana State Library
NRIS Natural Resource Information System
Map #96epaa4b-1, September 20, 1995

Figure 16a

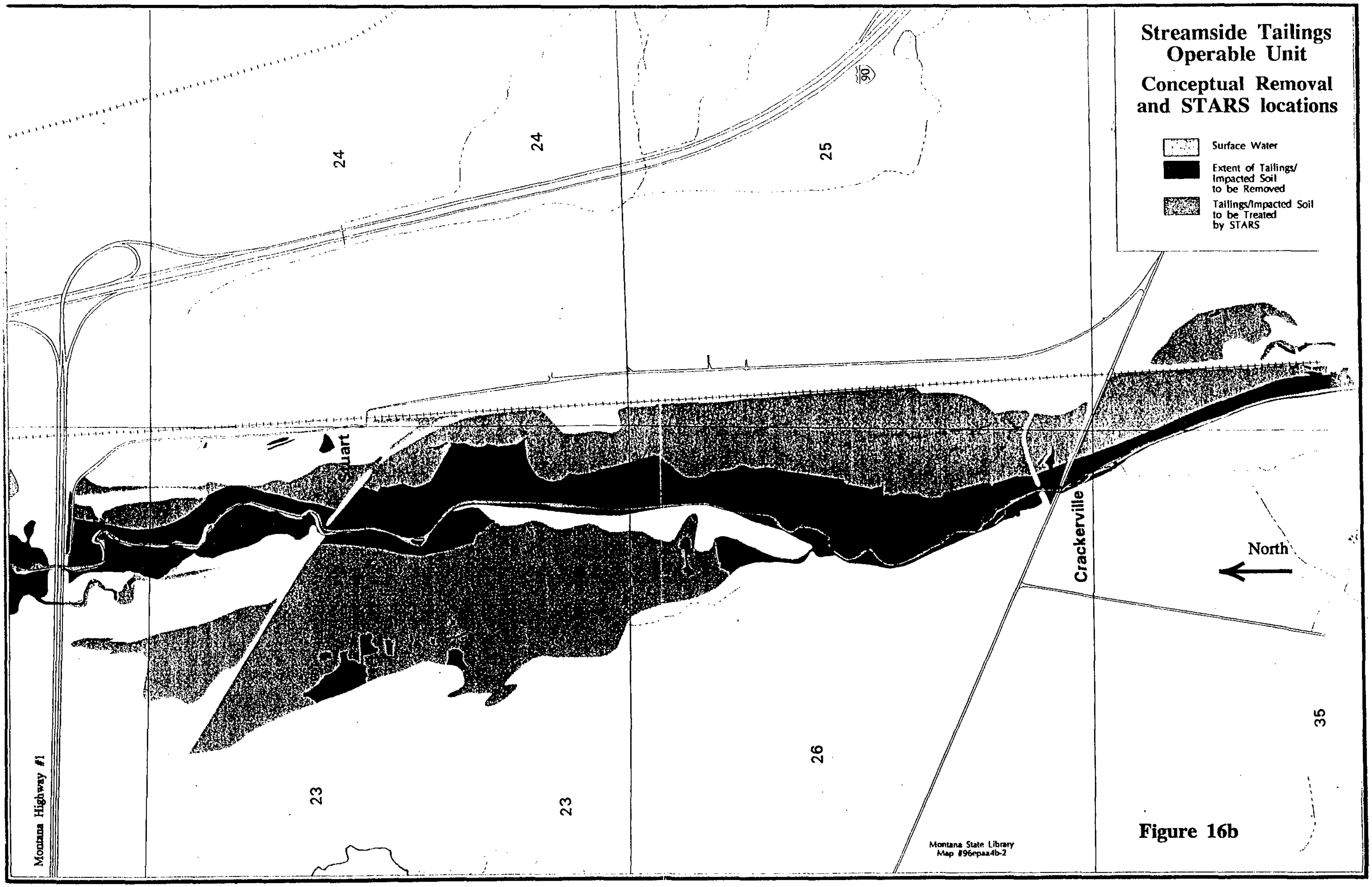

Streamside Tailings Operable Unit
Conceptual Removal and STARS locations
Surface Water
Extent of Tailings/ Impacted Soil to be Removed
Tailings/Impacted Soil to be Treated by STARS
90
24
24
25
23
23
26
35
Stuart
Crackerville
North
Montana Highway #1
Montana State Library Map #96epaa4b-2
Figure 16b

Table 14 presents the estimated volumes to be removed by subarea. Figure 15 portrays examples of possible relocation repositories and saturated tailings, while Figure 16 illustrates potential removal and in-situ STARS treatment locations.

Table 14
Summary of Estimated Media Specific Removal Volumes for SST Remedial Action
(cy)

Subarea	Tailings/Impacted Soil (total volume of tailings/impacted soil)	Instream Sediments	Railroad Materials
1	285,000 (285,000)	15,000	17,000
2	529,000 (808,000)	27,000	25,000
3	160,000 (160,000)	5,600	30,000
4	576,000 (1,300,000)	29,700	0
Total	**1,550,000 (2,550,000)[1]**	**73,000**	**72,000**

1 The site contains approximately 2.5 mcy of tailings/impacted soils of which 2,220,000 cy are in the current 100-year floodplain. 280,000 are located within Ramsay Flats and out of the present 100-year floodplain. Approximately 50,000 cy was removed from ARCO's Demonstration Project II in Subarea 4. All volumes are in cubic yards (cy).

Excavated tailings/impacted soils will be relocated to safe, local repositories clearly outside of the 100-year floodplain as defined by CH2M Hill (1989a), provided that appropriate locations can be obtained and an appropriate institutional controls/maintenance program can be implemented (see Contingency Measures at the end of this section). Tailings/impacted soils placed in the relocation repositories will be fully treated with lime amendments in lifts and will be revegetated in accordance with the STARS technology.

Instream Sediments

A portion of the tailings/impacted soil eventually becomes incorporated with instream sediments at the bottom of Silver Bow Creek. These sediments are highly contaminated. Concentrations are between 10 and 65 times higher for arsenic, cadmium, lead, zinc, and 400 times higher for copper than are found in other area streams which drain highly mineralized geologic areas (Essig and Moore, 1992). Numerous researchers have demonstrated that while in the stream, these sediments severely limit the number and types of benthic macroinvertebrates which live in the stream sediments, and these sediments could act as a source of contamination to future cleaner surface water (Ingersoll et al., 1995b,c; MacDonald et al., 1995; Smith et al., 1995; Woodward et al., 1995). Like tailings themselves, the majority of contaminated sediments vary in size from a coarse sand to a very fine silt or clay (PTI, 1989).

To meet the remedial objectives for the SST OU, MDEQ and EPA have determined that all contaminated fine-grained sediments will be removed. Fine-grained (defined here as all instream sediments equal to or less than one millimeter) instream sediments located in all depositional areas will be removed and placed in repositories outside the floodplain with the tailings/impacted soils and railroad materials. This size fraction was identified because it corresponds with the size of the tailings/impacted soils and contains the bulk of instream contamination. Specific volumes and locations to be excavated will be determined by the agencies during remedial design. This sediment volume is presently estimated at 73,000 cy (Table 14), although recent mapping performed by ARCO (Maxim, 1995) has indicated that a lesser volume may be present (approximately 25,000 cy).

After removal of contaminated instream sediments, the channel bed and streambank will be reconstructed to an appropriate slope and other critical dimensions with materials of appropriate size, shape and composition. This reconfigured streambed will contain suitable bedform morphology (riffles, bars, pools, etc.) for aquatic habitat.

Instream sediment monitoring will be performed during and after the response action to verify the locations and concentrations of contaminated instream sediments, and macroinvertebrate abundance and diversity, as well as appropriate geomorphic bed configuration. Maintenance to address continuing sediment contamination over time may be necessary, depending on the results of long-term monitoring. Streambanks will require adequate growth media to allow for immediate establishment of a healthy riparian vegetative system to protect the remedy from high flows.

Railroad Materials

Certain portions of one abandoned historic railroad embankment and two operating railroads along Silver Bow Creek were constructed with mine and mill wastes from the Anaconda Company operations such as waste rock and slag. This material represents a source of contaminants to Silver Bow Creek via runoff, to groundwater via infiltration, and to recreationists who might use the abandoned embankment as a trail for walking or biking. The remedy will excavate, treat and/or cover all contaminated railroad bed materials that pose a risk to human health or the environment. All concentrate spills, which are the primary human health concern, will be removed and disposed in an appropriate and secure disposal facility in accordance with any applicable RCRA requirements. The in-situ STARS technology or soil capping is expected to be appropriate for all other areas of the inactive grade presenting human health risk and not likely to be eroded by the stream. Railroad materials that directly impact the stream either at bridge abutments or where these materials form a streambank will be excavated and disposed in repositories outside the floodplain along with the tailings/impacted soils and instream sediments. The actual amount and methods of excavation and/or treatment will be determined during remedial design. The estimated volumes designated for removal have been refined since the release of the proposed plan (MDEQ, 1995a). The estimated volume of excavated railroad materials is 72,000 cy (Table 14).

Monitoring and maintenance of the remediated railroad areas and materials will be required to ensure that contaminant sources are not exposed from erosion and do not cause contaminant loading to the stream.

Ground and Surface Water

Generally, groundwater within the OU flows towards and into Silver Bow Creek. Elevated concentrations of copper and zinc and exceedances of drinking water standards for arsenic and cadmium are present in groundwater (ARCO, 1995a). Surface water and instream sediment quality is impacted by discharging contaminated groundwater (Benner et al., 1995). While Silver Bow Creek ground and surface water are primary receptors of SST OU contamination, no separate remedial action is being prescribed for these media. Remedial activities for other SST OU media under this record of decision and for sources of contaminants upstream/offsite under other cleanup actions will limit further releases to ground and surface water with the goal of ultimately attaining ground and surface water standards within the OU. The prescribed removal of tailings/impacted soils, fine-grained instream sediments, and railroad materials will allow for the attainment of instream sediment and surface water objectives and standards, over time. Removing the source of groundwater contamination by addressing the tailings/impacted soils and railroad materials, will allow contaminants in groundwater to attenuate over time through dilution, adsorption, precipitation, dispersion, and should allow eventual attainment of groundwater standards.

Long-term monitoring of surface water and groundwater is a critical element of the remedy. Surface water will be monitored for compliance at numerous points in the OU to ascertain possible contaminant loading from onsite/nearsite contaminant sources. Groundwater will be monitored at locations of documented or reasonably suspected groundwater contamination, all relocation areas, and other locations where STARS treatment has been applied.

Monitoring, Coordination, and Schedule

An institutional controls program, which must be funded on a permanent basis as part of the remedy, will be coordinated through a joint effort of the Butte-Silver Bow and Anaconda-Deer Lodge local governments. Institutional controls, monitoring, and maintenance will be integrated into a Silver Bow Creek corridor management program. The program will be established and maintained in a manner to be approved by the agencies that will ensure that all aspects of the OU remedial action, both within and outside of the floodplain, are maintained for the long term, that future land uses in the area are consistent with the scenarios upon which cleanup level decisions for this action have been based (recreational), and that institutional control, monitoring and maintenance mechanisms will be adequate to ensure protectiveness over the long term.

Butte-Silver Bow County and ARCO are initiating research on constructed wetlands as a potential treatment technology for waste water nutrient discharge and stormwater metals contamination. To coordinate with this research, the end land use in Subarea 1 has been delineated as wetlands. After removal of all identified contaminant sources (tailings/impacted soils, instream sediments, railroad materials, etc.), in Subarea 1, reconstruction of the Subarea will be designed to incorporate use of the area as wetlands. Constructed wetlands may be used as a treatment system for nutrient and/or metals treatment, if use of such wetlands treatment in this area is ultimately determined to be appropriate.

Construction of the proposed remedy will be coordinated with other cleanup activities along Silver Bow Creek. Releases of contaminated sediments and surface waters prior to, during, and following remedial action, which might re-contaminate Silver Bow Creek, will be suitably controlled and treated. The design and schedule of the OU remedy will be coordinated with the design and installation of upstream sediment control basins and other cleanup activities. If adequate upstream control facilities are not in service at the time of initiation of construction of this remedy, then additional sediment control and treatment facilities will be provided as a part of this remedy.

The State of Montana and ARCO are engaged in litigation, brought under CERCLA, involving natural resource damages in the Upper Clark Fork River Basin (State of Montana v. Atlantic Richfield Company, U.S.D.C. Case No. CV-83-317-H). That litigation includes claims for damages for injuries to natural resources within the SST OU. As a result of that litigation, the State has developed a restoration plan which would provide for certain actions to restore the injured resources in the OU. (See "Restoration Determination Plan, Upper Clark Fork River Basin," October 1995). As provided by CERCLA and applicable regulations, the restoration plan seeks to accomplish more extensive goals than the remedial action, and would do so by addressing the same contaminated areas. The implementation of the final remedial action plan for the SST OU will be coordinated to the maximum extent possible with any implementation of the State's restoration plan for Silver Bow Creek, in order to maximize the benefits of both efforts and to avoid duplication of effort. Such coordination could include, for example, adjustment of schedules for specific portions of the actions, the combination or coordination of specific actions under the two plans, or allowing a more extensive restoration action to be implemented in certain areas, as long as the restoration action would accomplish all of the goals of the remedial action in those areas.

Description and Limitations of the Streambank Tailings and Revegetation Studies (STARS) Technology

In 1986, the Montana Department of Health and Environmental Sciences (now MDEQ) initiated the Streambank Tailings and Revegetation Studies (STARS) to determine the feasibility of chemically amending tailings materials in-situ adjacent to Silver Bow Creek. The purpose was to attempt to develop an effective alternative less costly than removal.

The purpose of the study was three-fold:

1) Buffer the acid produced by metal sulfides present in the tailings materials.

2) Reduce the mobility of metals that leach through the tailings.

3) Provide a suitable growth medium that will support a vegetative cover consisting of grasses and forbs. Woody species such as willows were not investigated in the STARS study. The vegetative cover would act to reduce the amount of moisture that could percolate through the amended tailings, reduce erosion from surface runoff, and reduce wind blown dust.

The study was conducted by Montana State University's Reclamation Research Unit and Schafer and Associates in three phases. Phase I was designed to test a variety of chemical amendments on tailings in the laboratory and to determine the combination of amendments that best reduced the concentration of metals measured in water leached through the amended tailings. In conjunction with the chemical testing, greenhouse studies were undertaken to determine the mixture of plant species that would grow best in amended tailings. Phase II consisted of field trials to test the most effective chemical amendments determined in Phase I. Several different amendment mixing techniques were tested during this phase to maximize the depth to which the amendments could be incorporated. Several different seed mixtures were also tested based on the results of the greenhouse trials. Phase III consisted of collecting various types of soil, water, and vegetative data over the course of three years and evaluating each of the treatments applied.

The agencies determined that the application of STARS amendments were effective: in reducing runoff production from treated tailings; for reducing (but not eliminating) the acid produced by metal sulfides present in the tailings materials, reducing the toxicity or mobility of most metals that leach through the tailings; providing a favorable growth medium that will support a vegetative cover; reducing the amount of moisture that could percolate through the amended tailings through vegetative management of the annual soil water budget; and reducing wind blown dust.

The agencies discuss below specific concerns which limit the implementation of the STARS technology in the SST OU. The STARS treatability study itself was a scientific, quantitative study which was limited in its scope. However, in evaluating the use of the technology as part of this remedy, the agencies have to consider the full range of issues involving implementation of STARS in the floodplain.

1. STARS amendments do not appear to completely eliminate contaminant movement in porewater.

Data collected during the study demonstrated that soil pore water quality was highly variable from treatment to treatment and year to year. General trends in soil pore water chemistry indicated that amended plots generally showed an increase in pore water pH and a decrease in the concentrations of most metals. Due to funding limitations, porewater data was limited to three sampling events without the benefit of replicated instrumentation. Because of this, as well as difficulties in appropriately mixing amendments deeper in the profile, only the 40 cm depth increment (the shallowest depth monitored) conclusively demonstrated effective reductions in porewater metals concentrations. Arsenic concentrations were observed to increase at depth in the amended plots at some of the monitored sites, which may be attributed to the greater solubility of arsenic with increasing pH. The metals aluminum, iron, and copper were substantially less soluble in soil pore water as pH increased while manganese, cadmium, and zinc concentrations did not have a clear correlation with increasing pH until pore water pH could be raised to levels greater than 7.0. Much higher amendment rates may be needed to substantially reduce concentrations of cadmium, manganese and zinc. Because of these findings, there is some uncertainty in the effectiveness of STARS to prevent the movement of some contaminants through the vadose zone.

2. STARS amendments do not mitigate the migration of metals from tailings/impacted soils saturated by groundwater.

Two principal hydrologic processes govern the migration of metals from tailings to groundwater: first, downward movement of precipitation (infiltration) through tailings to the saturated zone; and second, the inundation of tailings by groundwater.

The STARS technology was never intended to remediate groundwater. The STARS study was developed to reduce the mobility of metals in the amended tailings and enhance water use within the rootzone, with the intent of limiting vertical movement of vadose zone water and contaminants. There is still much debate as to the ability of the STARS technology to effectively manage the soil water budget resulting in a substantial reduction in infiltration to groundwater. One associated condition of considerable concern is implementing STARS in riparian areas of shallow groundwater (12 to 18 inches below ground surface) because plant roots may tap the groundwater table, rather than use vadose zone moisture. Reestablishment of a vegetative cover, even if it successfully eliminates infiltration to groundwater, is not capable of addressing metals mobilized by the saturation of tailings/impacted soils by groundwater. OU groundwater was found to fluctuate approximately two feet. In many areas a large volume of tailings/impacted soils are permanently saturated by groundwater or within this two foot fluctuation and are therefore seasonally saturated by groundwater. Saturation of tailings/impacted soils by groundwater releases metals weakly bound to these materials as well as metals associated with acidic vadose zone water.

In addition, it has never been determined if lime amendments can be successfully incorporated into saturated soils. Neither STARS nor any other demonstration studies in the Clark Fork basin investigated this issue or the types of plant species that might be used in saturated conditions. The STARS test plot at the Manganese Stockpile site failed, at least partly because of the saturated conditions at the site during long periods. Also, in MDEQ's analysis of the STARS treatment in saturated tailings conditions, two critical factors concerning STARS implementation indicate that STARS will not be effective: 1) The equipment designed to mix lime amendments into tailings is not likely to be able to adequately mix below the water table; and, 2) Because the highly soluble calcium oxide or calcium hydroxide is used to make up 40% of the STARS amendment, it is likely to be removed from the amended profile in ground water in those amended tailings that are seasonally saturated, primarily during the first year after amendment.

To expand on the first critical factor, mixing STARS amendments below the water table was not demonstrated at any of the ARCO demonstration projects (Demonstration Projects I, II, and III), nor was lime mixed below the water table during Phase II of the STARS investigation at the Manganese Stockpile. MDEQ believes that adequate mixing of lime amendments in ground water would not occur due to the inherent problems of plowing saturated materials and the physical process used to deliver the lime to the tailings to be mixed. Whether saturated tailings were amended during implementation of the Governor's Project could not be confirmed in the published documentation of the project.

The second critical factor is based on the solubility of calcium oxide or calcium hydroxide amendment. When mixed with soil, the pH generally rapidly rises to 9 to 10 standard units after mixing and tends to elevate soil pH for several months. As ground water rises into recently amended tailings, some quantity of the soluble calcium amendments are likely to be solubilized and removed from the soil as the water table lowers, even where ground water has a near neutral pH and is slightly alkaline. While no data is available to quantify the amount of amendment that could be removed, MDEQ believes that the uncertainty associated with this issue, at the very least, limits the application of STARS to tailings located greater than two feet above the 1992 low water table elevation.

Contaminated groundwater results in continuing, long-term contamination of Silver Bow Creek's surface water and instream sediments. Where contaminated groundwater has the potential to discharge to the stream, metals have been shown to precipitate/adsorb on the stream substrate (instream sediments) and potentially remain a source of contamination to surface water. The STARS study was never designed to investigate this contaminant migration pathway.

3. Contaminants could continue to be transported to Silver Bow Creek from a treated floodplain by various hydrologic processes.

Overbank flows and channel migration could be expected to re-entrain amended tailings into the stream and instream sediments, thereby subjecting the tailings to oxidation. This is especially true in the areas immediately adjacent to the active stream channel where channel migration and streambank erosion processes are most prevalent. In addition, under flood conditions, the stream channel is at the greatest risk of making major changes in channel location by avulsion or "jumping" into abandoned channels or migrating into areas susceptible to erosion. Once a STARS treated area is eroded, the amendment is likely to separate from the treated tailings and basic geochemistry suggests that, over-time, these tailings would produce acid and re-mobilize the metals which would be expected to become bioavailable. The impacts of these bioavailable metals would severely limit the ability for remedial actions to meet specified ecologic and possibly surface water quality objectives.

4. Long-term effectiveness

There is substantial debate regarding the long-term effectiveness and permanence of STARS treatment. The STARS study was designed to compare treatments against untreated tailings conditions and to measure relative differences between treatments. Data collected during the three year monitoring period reasonably represents the short-term effects of the treatments. However, it is conceivable that actual long-term effects may be different than trends evident in the three years of data presented in the STARS reports (MDOJ, 1995).

In any event, no single treatment proved to ameliorate metals contamination for all environmental matrices or for the range of environmental conditions represented in the study. Consequently, it is apparent that the STARS treatment is not suited for all the conditions present at the SST OU. The agencies believe that STARS is best suited and has the fewest limitations in tailings locations well away from the active stream channel and well above the seasonal high ground water elevation.

<u>Criteria For Application of the Streambank Tailings and Revegetation Study (STARS) Technology</u>

A critical element of the remedy selection is the determination of which tailings may be left in place and treated with the STARS technology and which tailings must be removed from the floodplain before being treated with STARS. After evaluating STARS fully and considering the limitations inherent in such treatment, MDEQ and EPA have identified certain criteria which define where within the floodplain STARS may effectively and reliably be implemented.

The STARS study was designed to compare treatments against untreated tailings conditions and to measure relative differences between treatments. Data collected during the three year monitoring period reasonably represents the short term effects of the treatments. Because of the extreme heterogeneity encountered at the study sites, however, many statistical comparisons between treatments can not be supported at this time. It is possible that actual long-term effects may be different than trends evident in the three years of data presented in this report. Also, no one single treatment proved to ameliorate metals contamination for all environmental matrices or for the range of environmental conditions represented in the study.

The criteria for determining that specific tailings/impacted soils may be STARS treated in-situ in the floodplain are:

1) <u>The tailings/impacted soils involved cannot be saturated in groundwater during any part of the year.</u> The SST OU Remedial Investigation delineated the location and volumes of saturated tailings/impacted soils (ARCO, 1995a). Generally, groundwater seasonally fluctuates slightly over two feet in the OU.

Groundwater movement into and out of tailings, even in STARS treated tailings, will cause continued contaminant migration to groundwater.

2) <u>STARS treatment must effectively immobilize the contaminants in the tailings/impacted soils.</u> The STARS study identified the ability of the technology to successfully immobilize most contaminants of concern in the short term where the amendments can be adequately mixed into the tailings and soils. The depth to which the necessary soil amendments have been demonstrated to be effectively incorporated is limited to two feet. Future techniques may prove capable of effectively incorporating amendments to a greater depth. Moreover, because the STARS technology may not completely immobilize cadmium and zinc and may potentially increase the mobility of arsenic, a minimum thickness of native soils material between STARS treated tailings and groundwater is needed to act as a protective buffer. The nature and chemistry of the buffer materials must be considered in determining how much of a buffer constitutes adequate separation to prevent migration of contaminants into the groundwater. Tailings deposits that are thin enough that underlying native soils can also be tilled into the tailings is a positive consideration under this criterion.

3) <u>The tailings/impacted soils cannot be located where they may be eroded and re-entrained into the stream system through normal stream processes or major flood events.</u> STARS treated tailings could be transported into the stream system if eroded during natural stream channel migration, avulsion or as a result of overbank flows. Erosion and inundation from bank-full and flood events can be estimated based on a number of sources including CH2M Hill's Silver Bow Creek - Flood Modeling Study, which analyzes the lateral extent and water velocity of various flood events from regular bank-full to greater flood events. Another uncomplicated method of determining where the stream might meander to is to examine where the stream has been in the recent past.

Where the STARS technology is applied, regression or failure of a well-established vegetation could occur in the future. Failure could be due to one or more of the following: (1) weathering of pyritic wastes producing acidity, which in turn alters the availability of plant nutrients and toxic metals; (2) depletion of nutrients required for growth; (3) extreme weather or surface water flow conditions; and, (4) upward migration of acidity, metals, or salts into the amended zone (MDOJ, 1995). Because numerous repositories, which will be treated with the STARS technology, will be located near the floodplain in several areas along the length of the stream, and because in Subareas 2 and 4 large areas of tailings will be treated in-situ with the STARS technology at the edges of or outside of the floodplain, a permanent monitoring, management, and maintenance program will be an integral part of this remedy. Monitoring, management and maintenance will address vegetative performance on both STARS treatment areas and remediated streambanks, streambank stability and channel meander, and ensure that metals are immobilized at in-situ remediated areas. Each repository will be monitored through vegetative performance, vadose zone, saturated zone, and overland flow monitoring. The ultimate number and locations of relocation repositories will be determined and approved by the agencies during remedial design.

Replacement fill will be required in most locations where tailings/impacted soils are removed. Replacement fill and streambank reconstruction with suitable growth media having an appropriate texture and particle size distribution will be required. To the extent practicable, clean material excavated from nearby repositories will be used for replacement fill. A key to long-term streambank stabilization will be establishment of mature riparian vegetation. Grass, forb, willow, and tree species will be specified based on local climatic conditions, proximity to stream channel, and ability to produce dense root systems at maturity. The overall topography of the replacement fill material will be appropriately sloped toward the stream channel, with the goal of creating geomorphic stability.

While the exact delineation of STARS-treated areas will be established during remedial design/action, these three criteria were used in analyzing each subarea to preliminarily determine where STARS can be expected to effectively achieve protection of human health and the environment.

In Subarea 1, 67% of tailings/impacted soils are saturated by groundwater. The confined nature of the floodplain and the steeper stream gradient in Subarea 1 increase the probability of adverse flood impacts on STARS treated areas. The negative effects from saturated tailings, streambank erosion, and likely future overbank deposition of sediment on treated areas precludes implementing STARS in this subarea. Reconstruction of excavated areas in Subarea 1 will be designated to accommodate wetlands. These constructed wetlands will be designed in such a manner that they will have the potential for use as organic or inorganic contaminant treatment, if appropriate.

The evaluation of overall protection for Subarea 2 is the same as for Subarea 1 except for a considerable quantity of tailings/impacted soils which lie outside the floodplain. In the Ramsay Flats area, an estimated 280,000 cubic yards of tailings/impacted soils lie outside this demarcation. Because these tailings/impacted soils are located outside the floodplain, are generally unsaturated by groundwater, are finer grained in size, and are located, in areas, above a rich organic soil horizon which helps attenuate metals movement, the application of STARS treatment in this defined area should meet remedial action objectives (RAOs). However, the STARS treatment technology is presently only effective in tailings 2 feet thick and less. With present technology tailings thicker than 24-inches will need to be removed or relocated. These in-situ STARS treated areas will by required to be completely protected from erosion. An estimated 529,000 cy of tailings/impacted soils will be removed from this subarea (Table 14).

Because of the confined nature of the floodplain in Subarea 3 (a relatively steep, narrow canyon), the analysis of these criteria is much the same as for Subarea 1. Overall protectiveness would be compromised by saturated tailings, streambank erosion, and likely future overbank deposition of sediment on treated areas, precluding implementation of STARS in this subarea. An estimated 160,400 cy of tailings/impacted soils will be removed from this subarea (Table 14).

In Subarea 4, the potential for flood impacts to STARS treated tailings at the edge of the floodplain is smaller as a result of the wide floodplain, which allows dispersion of stream energy to a much greater degree than in the upper three subareas. In the near-stream areas there is ample evidence of stream migration in the recent past. Some of the channels are activated during spring snowmelt on an annual basis (MDOJ, 1995). The presence of buried soils and, in many places, the separation of tailings from groundwater is adequate to minimize the movement of metals through the vadose zone. Thus the potential effectiveness of STARS treatment appears to be greater in this subarea than the other three subareas. In Subarea 4 an estimated 724,000 will be treated in-situ with the STARS technology while 576,000 will be removed to a relocation repository (Table 14).

Estimated Costs of the Remedy

The total present worth cost of Alternative 5 was estimated in the feasibility study in the range of $32 million to $55 million (ARCO, 1995b). The estimated cost of the agencies' selected remedy, a modified Alternative 5, is estimated to be $24 to $46 million. These costs are substantially less than originally estimated because of the near stream repositories, the estimated removal volumes of tailings/impacted soils are somewhat lower due to better defined removal criteria, a more accurate quantification of railroad materials that will be treated or removed, and the determination that soil cover materials will not be needed for potential residential areas outside the floodplain. The cost uncertainties that are associated with this revised estimate are listed in Tables 15, 16, amd 17.

Cost Uncertainties

The agencies believe that the estimate of costs for this alternative as presented by ARCO in the Draft FS report are accurate for decision making purposes. Although the agencies believe that several important line item costs are significantly over-stated in the FS, considering the magnitude of this remedial action and the complexity of OU conditions, the cost for this remedial action has been reasonably delineated (Table 14).

The operation and maintenance costs beyond the thirty year time frame used in the FS, and the discount rate used to evaluate the present worth of operation and maintenance costs are important considerations. MDEQ recognizes that the 7 percent annual discount rate used in the FS and calculation of present worth costs without inclusion of inflation, as required by the NCP, tends to underestimate future costs. Discounting makes the costs of remedies that rely more heavily on future actions such as operations and maintenance, appear less costly than capital intensive remedies.

Some elements of the remedy will be further refined during remedial design. Listed below are cost elements on which ARCO and MDEQ differed when developing the SST OU Feasibility Study. The cost range estimated in Tables 15 - 17 is based on MDEQ's determinations regarding these issues.

- *Quantities of Tailings/Impacted Soils* - Quantities of tailings/impacted soils as calculated by NRIS were used to develop the cost estimates for removal. The quantities of saturated tailings include both the saturated tailings and the tailings that overlie the saturated tailings. This quantity was also calculated by NRIS. The accuracy of locations and amounts of tailings/impacted soils is restricted by limited data points (Table 15).

Table 15
Remedial Alternative Cost Summary - Tailings/Impacted Soils
Streamside Tailings Operable Unit

Activity	Quantity	Unit	Minimum Cost Unit Price	Maximum Cost Unit Price	Minimum Cost Extended Price	Maximum Cost Extended Price	Quantity	Unit	Minimum Cost Unit Price	Maximum Cost Unit Price	Minimum Cost Extended Price	Maximum Cost Extended Price
	Subarea 1: Partial Relocation, Partial STARS Treatment and ICs						**Subarea 3: Partial Relocation, Partial STARS Treatment and ICs**					
Roadbuilding (internal)	5.2	mile	$23,800	$31,200	$123,760	$162,240	5	mile	$23,800	$31,200	$119,000	$156,000
Roadbuilding (external)	5.2	mile	$8,200	$20,200	$42,640	$105,040	5	mile	$8,200	$20,200	$41,000	$101,000
Clear/Grub (site)	153.6	acre	$600	$1,300	$92,160	$199,680	92	acre	$600	$1,300	$55,200	$119,600
Grading (site)	153.6	acre	$350	$750	$53,760	$115,200	92	acre	$350	$750	$32,200	$69,000
Clear/Grub (relocation area)	69	acre	$600	$1,300	$41,419	$89,740	38.8	acre	$600	$1,300	$23,253	$50,381
Grading (relocation area)	69	acre	$350	$750	$24,161	$51,773	38.8	acre	$350	$750	$13,564	$29,066
Soil Cover (relocation area)	0.0	cy	$6.30	$8.27	$0	$0	0.0	cy	$6.30	$8.27	$0	$0
Dozer/Loader/Trackhoe	285,000	cy	$2.90	$4.20	$826,500	$1,197,000	160,000	cy	$2.90	$4.20	$464,000	$672,000
Haul (on-site, excavated T/S)	285,000	cy	$0.83	$1.11	$236,550	$316,350	160,000	cy	$0.83	$1.11	$132,800	$177,600
STARS	0.0	acre	$4,000	$7,100	$0	$0	0.0	acre	$4,000	$7,100	$0	$0
Clean Fill Streambank Replacement	85,500	cy	$0.83	$1.11	$70,965	$94,905	48,000	cy	$0.83	$1.11	$39,840	$53,280
Clean Fill Streambank Placement (Dozer)	85,500	cy	$2.90	$4.20	$247,950	$359,100	48,000	cy	$2.90	$4.20	$139,200	$201,600
Riprap (includes placement)	395	cy	$25	$30	$9,875	$11,850	1,978	cy	$25	$30	$49,450	$59,340
Reveg (relocation area)	69	acre	$4,000	$7,100	$276,125	$490,121	92	acre	$500	$1,000	$46,000	$92,000
Revegetation (site)	153.6	acre	$500	$1,000	$76,800	$153,600	38.8	acre	$4,000	$7,100	$155,017	$275,156
				Subtotal	$2,122,664	$3,346,600				*Subtotal*	$1,310,524	$2,056,022
Engineering Design/Construction Oversite	1	ls	13%	18%	$275,946	$602,388	1	ls	13%	18%	$170,368	$370,084
Mob/Demobilization	1	ls	1%	6%	$21,227	$200,796	1	ls	1%	6%	$13,105	$123,361
Construction Overhead	1	ls	8%	15%	$169,813	$501,990	1	ls	8%	15%	$104,842	$308,403
Institutional Controls	1	ls	$38,500	$82,500	$38,500	$82,500	1	ls	$21,000	$45,000	$21,000	$45,000
Operation and Maintenance	11%	ls	2,110,796	2,110,796	$232,188	$232,188	6%	ls	2,110,796	2,110,796	$126,648	$126,648
				Subtotal	$737,674	$1,619,862				*Subtotal*	$435,963	$973,496
				Total	$2,860,338	$4,966,461				*Total*	$1,746,487	$3,029,518

Activity	Quantity	Unit	Minimum Cost Unit Price	Maximum Cost Unit Price	Minimum Cost Extended Price	Maximum Cost Extended Price	Quantity	Unit	Minimum Cost Unit Price	Maximum Cost Unit Price	Minimum Cost Extended Price	Maximum Cost Extended Price
	Subarea 2: Partial Relocation, Partial STARS Treatment and ICs						**Subarea 4: Partial Relocation, Partial STARS Treatment and ICs**					
Roadbuilding (internal)	5.6	mile	$23,800	$31,200	$133,280	$174,720	6.8	mile	$23,800	$31,200	$161,840	$212,160
Roadbuilding (external)	5.6	mile	$8,200	$20,200	$45,920	$113,120	6.8	mile	$8,200	$20,200	$55,760	$137,360
Clear/Grub (site)	320	acre	$600	$1,300	$192,000	$416,000	700	acre	$600	$1,300	$420,000	$910,000
Grading (site)	320	acre	$350	$750	$112,000	$240,000	700	acre	$350	$750	$245,000	$525,000
Clear/Grub (relocation areas)	128.1	acre	$600	$1,300	$76,879	$166,571	139.5	acre	$600	$1,300	$83,709	$181,370
Grading (relocation areas)	128.1	acre	$350	$750	$44,846	$96,099	139.5	acre	$350	$750	$48,830	$104,637
Soil Cover (relocation area)	0.0	cy	$6.30	$8.27	$0	$0	0.0	cy	$6.30	$8.27	$0	$0
Dozer/Loader/Trackhoe	529,000	cy	$2.90	$4.20	$1,534,100	$2,221,800	576,000	cy	$2.90	$4.20	$1,670,400	$2,419,200
Haul Unit Cost (on-site)	529,000	cy	$0.83	$1.11	$439,070	$587,190	576,000	cy	$0.83	$1.11	$478,080	$639,360
STARS	175	acre	$4,000	$7,100	$700,000	$1,785,269	450	acre	$4,000	$7,100	$1,800,000	$3,549,581
Clean Fill Streambank Replacement	158,700	cy	$0.83	$1.11	$131,721	$176,157	172,800	cy	$0.83	$1.11	$143,424	$191,808
Clean Fill Streambank Placement (Dozer)	158,700	cy	$2.90	$4.20	$460,230	$666,540	172,800	cy	$2.90	$4.20	$501,120	$725,760
Riprap (includes placement)	0.0	cy	$25	$30	$0	$0	791	cy	$25	$30	$19,775	$23,730
Reveg (site)	320	acre	$500	$1,000	$160,000	$320,000	700	acre	$500	$1,000	$350,000	$700,000
Revegetation (relocation areas)	128.1	acre	$4,000	$7,100	$512,526	$909,734	139.5	acre	$4,000	$7,100	$558,062	$990,561
				Subtotal	$4,542,572	$7,873,199				*Subtotal*	$6,536,801	$11,310,526
Engineering Design/Construction Oversite	1	ls	13%	18%	$590,534	$1,417,176	1	ls	13%	18%	$849,680	$2,035,895
Mob/Demobilization	1	ls	1%	6%	$45,426	$472,392	1	ls	1%	6%	$65,360	$678,632
Construction Overhead	1	ls	8%	15%	$363,406	$1,180,980	1	ls	8%	15%	$522,880	$1,696,579
Institutional Controls	1	ls	$112,000	$240,000	$112,000	$240,000	1	ls	$178,500	$382,500	$178,500	$382,500
Operation and Maintenance	32%	ls	2,110,796	2,110,796	$675,455	$675,455	51%	ls	2,110,796	2,110,796	$1,071,403	$1,071,403
				Subtotal	$1,786,821	$3,986,002				*Subtotal*	$2,687,823	$5,865,008
				Total	$6,329,392	$11,859,201				*Total*	$9,223,824	$17,175,534

OPERABLE UNIT TOTAL - TAILINGS AND SOILS: $19,422,367 $35,410,854

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Table 16
Remedial Alternative Cost Summary - In-Stream Sediments
Streamside Tailings Operable Unit

Activity	Minimum Quantity	Maximum Quantity	Unit	Minimum Cost Unit Price	Maximum Cost Unit Price	Minimum Cost Extended Price	Maximum Cost Extended Price
	Subarea 1: Limited Removal, On-Site STARS Treatment						
Trackhoe (wet excavation)	15,000	15,000	bcy	$4.35	$6.30	$65,250	$94,500
Sediment Pond (construction)	1,144	3,661	bcy	$2.90	$4.20	$3,318	$15,375
Sediment Pond (loader excavate)	15,000	15,000	bcy	$2.90	$4.20	$43,500	$63,000
Truck Haul (on site)	15,000	15,000	bcy	$0.83	$1.11	$12,450	$16,650
Silt Fence	0.3	0.3	mile	$52,800	$73,920	$13,728	$19,219
Streambank Replacement	5.2	5.2	mile	$84,500	$211,000	$439,400	$1,097,200
Final Grading	1.4	4.5	acre	$350	$750	$496	$3,404
STARS	1.4	4.5	acre	$4,000	$7,100	$5,673	$32,221
Revegetation	1.7	5.4	acre	$500	$1,000	$851	$5,446
					Subtotal	$584,666	$1,347,015
Mob/Demobilization	1		ls	1%	6%	$5,847	$80,821
Construction Overhead	1		ls	8%	15%	$46,773	$202,052
Engineering Design/Construction Oversit	1		ls	8%	13%	$46,773	$175,112
Operation and Maintenance (30 years)	21%		%	$478,358	$478,358	$100,455	$100,455
					Subtotal	$199,848	$558,440
					Total	$784,514	$1,905,455
	Subarea 2: Limited Removal, On-Site STARS Treatment						
Trackhoe (wet excavation)	22,700	22,700	bcy	$4.35	$6.30	$98,745	$143,010
Sediment Pond (construction)	1,711	5,476	bcy	$2.90	$4.20	$4,962	$22,997
Sediment Pond (loader excavate)	22,700	22,700	bcy	$2.90	$4.20	$65,830	$95,340
Truck Haul (on site)	22,700	22,700	bcy	$0.83	$1.11	$18,841	$25,197
Silt Fence	0.3	0.3	mile	$52,800	$73,920	$14,784	$20,698
Streambank Replacement	5.6	5.6	mile	$84,500	$211,000	$473,200	$1,181,600
Final Grading	2.1	6.8	acre	$350	$750	$742	$5,091
STARS	2.1	6.8	acre	$4,000	$7,100	$8,485	$48,194
Revegetation	2.5	8.1	acre	$500	$1,000	$1,273	$8,145
					Subtotal	$686,862	$1,550,272
Mob/Demobilization	1		ls	1%	6%	$6,869	$93,016
Construction Overhead	1		ls	8%	15%	$54,949	$232,541
Engineering Design/Construction Oversit	1		ls	8%	13%	$54,949	$201,535
Operation and Maintenance (30 years)	31%		%	$478,358	$478,358	$148,291	$148,291
					Subtotal	$265,058	$675,384
					Total	$951,920	$2,225,656

Minimum Quantity	Maximum Quantity	Unit	Minimum Cost Unit Price	Maximum Cost Unit Price	Minimum Cost Extended Price	Maximum Cost Extended Price
Subarea 3: Limited Removal, On-Site STARS Treatment						
5,000	5,000	bcy	$4.35	$6.30	$21,750	$31,500
1,000	3,000	bcy	$2.90	$4.20	$2,900	$12,600
5,000	5,000	bcy	$2.90	$4.20	$14,500	$21,000
5,000	5,000	bcy	$0.83	$1.11	$4,150	$5,550
0.3	0.3	mile	$52,800	$73,920	$15,840	$22,176
5.0	5.0	mile	$84,500	$211,000	$422,500	$1,055,000
0	0	acre	$350	$750	$0	$0
0	0	acre	$4,000	$7,100	$0	$0
0	0	acre	$500	$1,000	$0	$0
				Subtotal	$481,640	$1,147,826
1		ls	1%	6%	$4,816	$68,870
1		ls	8%	15%	$38,531	$172,174
1		ls	8%	13%	$38,531	$149,217
7%		%	$478,358	$478,358	$33,485	$33,485
				Subtotal	$115,364	$423,746
				Total	$597,004	$1,571,572
Subarea 4: Limited Removal, On-Site STARS Treatment						
29,700	29,700	bcy	$4.35	$6.30	$129,195	$187,110
997	3,191	bcy	$2.90	$4.20	$2,892	$13,404
29,700	29,700	bcy	$2.90	$4.20	$86,130	$124,740
29,700	29,700	bcy	$0.83	$1.11	$24,651	$32,967
0.1	0.1	mile	$52,800	$73,920	$7,181	$10,053
6.8	6.8	mile	$84,500	$211,000	$574,600	$1,434,800
1.2	4.0	acre	$350	$750	$433	$2,967
1.2	4.0	acre	$4,000	$7,100	$4,945	$28,090
1.5	4.7	acre	$500	$1,000	$742	$4,748
				Subtotal	$830,769	$1,838,879
1		ls	1%	6%	$8,308	$110,333
1		ls	8%	15%	$66,462	$275,832
1		ls	8%	13%	$66,462	$239,054
41%		%	$478,358	$478,358	$196,127	$196,127
				Subtotal	$337,358	$821,346
				Total	$1,168,127	$2,660,225
OPERABLE UNIT TOTAL - IN-STREAM SEDIMENTS:					$3,501,564	$8,362,908

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Table 17
Remedial Alternative Cost Summary - Railroad Materials
Streamside Tailings Operable Unit

Activity	Minimum Quantity	Maximum Quantity	Unit	Minimum Cost Unit Price	Maximum Cost Unit Price	Minimum Cost Extended Price	Maximum Cost Extended Price
Subarea 1: Replacement of Railroad Materials							
Excavation of Materials (dozer/loader/trackhoe)	11,010	16,515	cy	$2.90	$4.20	$31,929	$69,363
Haul Cost	11,010	16,515	cy	$2.65	$3.84	$29,177	$63,418
Land Acquisition	0.55	0.57	acre	$1,000.00	$7,000.00	$551	$4,000
Clear/Grub (dry closure area)	0.55	0.57	acre	$600.00	$1,300.00	$330	$743
Grade (dry closure area)	0.55	0.57	acre	$350.00	$750.00	$193	$429
Scraper (dry closure area)	3,108	3,227	cy	$4.64	$5.04	$14,423	$16,263
Dozer/Loader/Trackhoe (dry closure area)	11,010	16,515	cy	$1.25	$2.70	$13,763	$44,591
Roller (dry closure area)	11,010	16,515	cy	$0.75	$1.25	$8,258	$20,644
Low Permeability Cover	23,980	24,893	ft^2	$0.60	$1.60	$14,388	$39,828
Revegetation (repository)	0.55	0.57	acre	$500.00	$1,000.00	$275	$571
Haul Unit Cost (SA 1, import soil)	11,010	11,010	cy	$6.30	$8.27	$69,363	$91,053
Excavate/Remove ore concentrate spill	8	10	hr	$43.50	$43.50	$348	$435
Revegetation (replaced materials)	1.0	3.3	acre	$500.00	$1,000.00	$500	$3,300
					Subtotal:	$183,496	$354,637
Mob/Demobilization	1		ls	1.00%	6.00%	$1,835	$21,278
Construction Overhead	1		ls	8.00%	15.00%	$14,680	$53,196
Engineering Design/Construction Oversite	1		ls	8.00%	13.00%	$14,680	$46,103
Operation and Maintenance (30 yr)	33.0%	33.0%	ls	$124,090	$124,090	$40,950	$40,950
					Subtotal:	$72,144	$161,526
					Total	$255,641	$516,163

Activity	Minimum Quantity	Maximum Quantity	Unit	Minimum Cost Unit Price	Maximum Cost Unit Price	Minimum Cost Extended Price	Maximum Cost Extended Price
Subarea 2: Replacement of Railroad Materials							
Excavation of Materials (dozer/loader/trackhoe)	16,651	24,977	cy	$2.90	$4.20	$48,288	$104,901
Haul Cost	16,651	24,977	cy	$2.65	$3.84	$44,125	$95,910
Land Acquisition	0.83	0.86	acre	$1,000.00	$7,000.00	$833	$6,050
Clear/Grub (dry closure area)	0.83	0.86	acre	$600.00	$1,300.00	$500	$1,124
Grade (dry closure area)	0.83	0.86	acre	$350.00	$750.00	$291	$648
Scraper (dry closure area)	4,701	4,880	cy	$4.64	$5.04	$21,813	$24,596
Dozer/Loader/Trackhoe (dry closure area)	16,651	16,651	cy	$1.25	$2.70	$20,814	$44,958
Roller (dry closure area)	16,651	16,651	cy	$0.75	$1.25	$12,488	$20,814
Low Permeability Cover	36,265.88	37,646.24	ft^2	$0.60	$1.60	$21,760	$60,234
Revegetation (repository)	0.83	0.86	acre	$500.00	$1,000.00	$416	$864
Haul Unit Cost (SA 1, import soil)	16,651	16,651	cy	$5.50	$7.48	$91,581	$124,549
Revegetation (replaced materials)	1.0	2.0	acre	$500.00	$1,000.00	$500	$2,000
					Subtotal:	$263,408	$484,647
Mob/Demobilization	1		ls	1.00%	6.00%	$2,634	$29,199
Construction Overhead	1		ls	8.00%	15.00%	$21,073	$72,997
Engineering Design/Construction Oversite	1		ls	8.00%	13.00%	$21,073	$63,264
Operation and Maintenance (30 yr)	33.0%	33.0%	ls	$124,090	$124,090	$40,950	$40,950
					Subtotal:	$85,729	$206,410
					Total:	$349,137	$693,057

	Minimum Quantity	Maximum Quantity	Unit	Minimum Cost Unit Price	Maximum Cost Unit Price	Minimum Cost Extended Price	Maximum Cost Extended Price
Subarea 3: Replacement of Railroad Materials							
	19,704	29,556	cy	$2.90	$4.20	$57,142	$124,135
	19,704	29,556	cy	$2.65	$3.84	$52,216	$113,495
	0.99	1.02	acre	$1,000.00	$7,000.00	$985	$7,159
	0.99	1.02	acre	$600.00	$1,300.00	$591	$1,330
	0.99	1.02	acre	$350.00	$750.00	$345	$767
	5,563	5,775	cy	$4.64	$5.04	$25,813	$29,105
	19,704	29,556	cy	$1.25	$2.70	$24,630	$79,801
	19,704	29,556	cy	$0.75	$1.25	$14,778	$36,945
	42,915	44,549	ft^2	$0.60	$1.60	$25,749	$71,278
	0.99	1.02	acre	$500.00	$1,000.00	$493	$1,023
	19,704	19,704	cy	$6.30	$8.27	$124,135	$162,952
	0	0	hr	$0	$0	$0	$0
	0.7	0.7	acre	$500.00	$1,000.00	$350	$700
					Subtotal:	$327,226	$628,690
	1		ls	1.00%	6.00%	$3,272	$37,721
	1		ls	8.00%	15.00%	$26,178	$94,303
	1		ls	8.00%	13.00%	$26,178	$81,730
	34.0%	34.0%	ls	$124,090	$124,090	$42,191	$42,191
					Subtotal:	$97,819	$255,945
					Total:	$425,045	$884,635

	Minimum Quantity	Maximum Quantity	Unit	Minimum Cost Unit Price	Maximum Cost Unit Price	Minimum Cost Extended Price	Maximum Cost Extended Price
Subarea 4: Replacement of Railroad Materials							
	0	0	cy	$2.90	$4.20	$0	$0
	0	0	cy	$2.65	$7.40	$0	$0
	0.00	0.00	acre	$1,000.00	$0.00	$0	$0
	0.00	0.00	acre	$600.00	$0.00	$0	$0
	0.00	0.00	acre	$350.00	$0.00	$0	$0
	0	0	cy	$4.64	$5.04	$0	$0
	0	0	cy	$2.90	$4.20	$0	$0
	0	0	cy	$0.75	$1.25	$0	$0
	0	0	ft^2	$0.60	$1.60	$0	$0
	0.00	0.00	acre	$500.00	$1,000.00	$0	$0
	0	0	cy	$6.30	$8.27	$0	$0
	0.0	0.0	acre	$500.00	$1,000.00	$0	$0
					Subtotal:	$0	$0
	1		ls	1.00%	6.00%	$0	$0
	1		ls	8.00%	15.00%	$0	$0
	1		ls	8.00%	13.00%	$0	$0
	0.0%	0.0%	ls	$124,090	$124,090	$0	$0
					Subtotal:	$0	$0
					Total:	$0	$0

OPERABLE UNIT TOTAL - RAILROAD MATERIALS: $1,029,823 $2,093,855

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- *Truck Haul* - Truck haul costs were not altered from those presented in the original cost estimate (ARCO, 1995b). While MDEQ believes that the bulking factor used in ARCO's unit cost calculation is high and the travel speeds used are low, the combination of these two factors provide some conservatism to the quantity estimates and allow for overage that might be expected during tailings removal (Table 15).

- *Clean Fill for Streambank Replacement* - The quantity of clean fill used for streambank replacement was increased from ARCO's draft FS submittal to account for a 4-inch lift of coversoil placed over these areas. This material is expected to be used where necessary to provide an adequate seedbed for germination. Costs associated with truck haulage were used to estimate costs to transport this material from local sources (Table 16).

- *Roadbuilding* - Roadbuilding was broken into two categories, internal and external, along with the minimum and maximum costs developed from the demonstration projects for each category. For each of the alternatives except TS3, one times (1X) the stream length was used for internal roads and one times (1X) the stream length was used for external roads (Table 15).

- *Revegetation (relocation area)* - The costs associated with STARS treatment in the relocation areas were increased to reflect the cost of applying STARS to multiple lifts of relocated tailings. ARCO's original estimate provided only for treating one 12-inch lift without treatment of the remaining 14 lifts of tailings placed in the relocation areas. Unit costs for this item were changed to the STARS unit costs and the acreage of the relocation areas adjusted to reflect applying STARS in seven, 2-foot lifts (Table 15).

- *Operations and Maintenance* - These costs were recalculated to reflect a percent failure expected for each alternative rather than the man hour and equipment hour method used in ARCO's original cost estimate. These costs were also discounted to net present value at an annual discount rate of 7% in accordance with EPA guidance (EPA, 1993) (Table 15).

- *Instream Sediments* - Costs were included to replace the streambank in addition to the backfill placed for the tailings/soils alternatives. Replacement costs were based on the lineal foot of streambank replaced using a minimum and maximum range of $16 to $40, respectively (Table 16).

Final Remediation Goals, Cleanup\Performance Standards, and Points of Compliance

Preliminary remedial action objectives and preliminary remediation goals were identified in the Preliminary Remedial Action Objectives Report/Treatment Technology Scoping Document (PRAOR/TTSD) (ARCO, 1993d). This section clarifies the final remediation objectives, goals, levels, specific cleanup standards, and points of compliance for each of the media addressed under the SST OU record of decision. Not all of the preliminary remediation goals identified in the PRAOR/TTSD are carried forward into the final remediation standards. Where separate preliminary goals are addressed by the same final standard, only a single goal has been identified, and although preliminary goals were established for organic parameters, final standards for organics have not been established because site characterization has determined that separate remedial action under this operable unit is not necessary to address organics.

Surface Water and Instream Sediments

The final remedial action objectives and final remediation standards for surface water are:

1. Meet the more restrictive of the aquatic life or human health standards for surface water identified in MDEQ Circular WQB-7, through application of I-classification requirements.

2. Prevent exposure of humans and aquatic species to instream sediments having concentrations of inorganic contamination in excess of risk-based standards. A physical criterion is used to define those sediments posing the greatest risk to receptor species. A contingency is established to develop metal-specific concentrations which would be risk-based, and allow sediment cleanup standards if the physical criterion standard cannot be employed appropriately.

3. Provided that upstream sources of Silver Bow Creek contaminants are eliminated, meeting the two remediation standards identified above should attain the remedial action objective to improve the quality of Silver Bow Creek's surface water and instream sediments to the point that Silver Bow Creek could support the growth and propagation of fishes and associated aquatic life, one of the designated goals for an I-class stream, including a self-sustaining population of trout species.

Within a reasonable time frame after implementation of the selected remedy, and contingent upon adequate cleanup of upstream sources, ambient surface water quality standards, ultimately including the WQB-7 standards described above, must be attained at all points in Silver Bow Creek within the OU. I-classification procedures allow for a gradual attainment of the standards by permitting point source discharges at the higher concentration of (1) the applicable Circular WQB-7 standard, (2) an adopted site-specific standard, or (3) one-half of the mean monthly instream concentration immediately upstream of the discharge. Since no site-specific standards have been developed as of the issuance of this record of decision, any point source discharges under this remedial action must meet one-half the mean monthly concentration in the stream immediately upstream of the discharge point, eventually reducing, as upstream water quality improves, down to the WQB-7 levels.

As effective ambient water quality standards for the stream, the WQB-7 levels also set the contaminant specific goal for the remediation of non-point sources. The remediation is to be designed and implemented to ensure that non-point sources, specifically those contaminant sources identified in this record of decision, do not contribute a contaminant loading to the stream that causes an exceedance of these standards. While upstream water quality continues to exceed these standards, the applicable I-class limitation for these non-point sources is that no discharge from such sources may commence or continue which lowers or is likely to lower the overall quality of the stream waters. Thus discharges from the non-point sources in excess of WQB-7 levels will not actually be in violation of the standards until the water coming into the stream from upstream sources is of a better quality. Therefore the implementation of the remedy and initial monitoring of non-point sources should serve to identify any continuing contaminant loadings from non-point sources, so that these sources can be effectively remediated prior to the improvement of upstream water quality.

Accordingly, monitoring should be designed to identify and locate any continuing contaminant source. For this purpose the stream may be divided into reaches, which could be modified or narrowed, as appropriate, to identify and locate contaminant sources. Potential stream reaches for which performance could be initially measured are the following:

- LAO to the Silver Lake Pipeline discharge point
- Silver Lake Pipeline discharge point to Browns Gulch
- Browns Gulch to head of Durant Canyon
- Head of Durant Canyon to German Gulch
- German Gulch to Fairmont Road bridge
- Fairmont Road bridge to Highway 1 bridge
- Highway 1 bridge to Warm Springs Pond inlet

Where perennial tributaries enter the SST OU (Silver Lake Pipeline, Browns Gulch, and German Gulch), the downstream sampling point for the upper reach will be immediately upstream of the tributary and the upstream sampling point for the downstream reach will be sufficiently downstream of the tributary to allow for mixing of the SBC and tributary flows. Specific stream reaches for monitoring will be delineated during the remedial design and adjusted as necessary to identify continuing contaminant sources.

The intent of the surface water performance standard is to allow determination of whether remedial actions taken at the OU are successful in providing for the improvement of Silver Bow Creek water quality over time in accordance with the I-classification requirements. As remedial action performance data is collected, revisions may be made to the stream reaches used for compliance and monitoring requirements as appropriate. Additional details of the performance standards may be included in any implementing order.

No metals concentration cleanup goal is established for instream sediments by this action. Cleanup performance standards are based on physical size criteria applied to all depositional areas. Specific standards may be identified in any implementing order, and the specific locations requiring instream sediment excavation will be determined prior to or during remedial design, based on more precise sampling and mapping of instream sediment grain size and depositional areas.

The compliance requirements for instream sediments, including locations of compliance, will be specified during remedial design but will entail, at a minimum, multiple locations along Silver Bow Creek. During implementation of the remedial action, compliance will require that sediments mapped for excavation are removed in accordance with design requirements. Instream sediment sampling will be performed during the response action to verify the locations and concentrations of contaminated instream sediments.

The specific performance standards for instream sediments will be removal of the sand sized fraction and less ($\leq$1mm) from all depositional stream locations, regardless of size, as delineated by MDEQ and the EPA. The objective of this standard is to remove the majority of tailings (which also range in size from $\leq$1mm and less) from the stream, which constitute the bulk of the instream sediment contamination. The objectives for instream sediments remedial actions is two fold, (1) remove all tailings and the majority of the contaminant load from the streambed and (2) is to prevent exposure of aquatic species to instream sediments having concentrations of contaminants in excess of published (in peer reviewed journals) risk-based concentrations. The ultimate goal is to improve Silver Bow Creek over time to a condition that supports a self-reproducing fishery for trout species.

Following sediment, tailings/impacted soils, and railroad bed remediation, monitoring of sediment characteristics in specified locations in all pertinent stream reaches will be required. If recontamination of the instream sediments is found to occur, then additional work to address the sources of the recontamination, as well as additional excavation of recontaminated sediments, will be required.

Tailings/Impacted Soils

The final remedial action objectives and final remediation standards for tailings/impacted soils are:

1. Prevent human exposure to tailings/impacted soils from residential or occupational activity within the SST OU. This will be accomplished, in part, through institutional controls that will require the entire OU to be developed into a recreational corridor.

2. Prevent erosion or migration of inorganic contaminants of concern in tailings/impacted soils into Silver Bow Creek or into groundwater that would prevent attainment of groundwater, surface water, and sediment remediation levels.

3. Protect all solid waste within the SST OU from flood displacement, washout, or erosion in accordance with ARARs.

4. Prevent the saturation of tailings/impacted soils by groundwater during any period of the hydrologic year or by bank storage of high-flow stream discharge.

5. Prevent migration of contaminants of concern in tailings/impacted soils that would cause phytotoxicity in terrestrial vegetation.

Because the remediation of tailings/impacted soils is based primarily upon the need to reduce risks to environmental receptors at the SST OU and because adopted soil cleanup levels to address the contaminants of concern are not available, no chemical action level is defined for tailings/impacted soils. Instead, an "order of magnitude definition" as defined in the Draft RI report (ARCO, 1994a) of contaminated tailings/impacted soils is utilized to identify those soils requiring remediation. This methodology is expected to provide for an easily defined performance standard for field implementation, while also yielding a degree of cleanup of tailings/impacted soils that will provide adequate protectiveness for receptor species without setting specific chemical action levels. Specific locations and depths of excavation or in-situ treatment of tailings/impacted soils to be required will be defined during remedial design.

Numerous (possibly hundreds) additional borings will be required to ascertain the base of tailings for the purposes of: (1) the concentration with depth, (2) determining if the tailings/impacted soils are saturated by groundwater, and (3) how much and what tailings will be removed or treated in-situ.

Performance will be monitored by agency oversight during construction to ensure that excavation, backfill, and in-situ treatment and revegetation are conducted in accordance with specifications developed during remedial design. Compliance with remedial design will be required at all locations of remedial action for tailings/impacted soils. During long-term maintenance of the remedy, vegetation and soil monitoring will be required at a representative number of locations within the SST OU. Vegetation will be monitored for cover and density, as well as for signs of chemical stress from contaminants of concern. Soils will be measured for pH while soil pore-water will be monitored for pH and all appropriate analytes, which will include all major cations and anions. The specific locations and requirements for the long-term monitoring program will be developed as part of the remedial design and remedial action at the OU.

An important element of the selected remedy is the establishment of several local repositories for treated, excavated tailings/impacted soils. Although it is expected that these repositories will be designed and constructed to prevent any migration of contaminants to underlying groundwater, it will be important to monitor the vadose zone water of each individual repository to confirm that the technology is performing as designed. Vadose zone pore-water will be monitored for pH and all appropriate analytes which will include all major cations and anions. Vegetation will also be monitored for cover and density, as well as for signs of chemical stress from contaminants of concern. The specific locations of lysimeters and sampling regimen will be determined during remedial design and remedial action (Table 18).

Methodology to Determine the Base of Tailings/Impacted Soil

Soil samples were collected within and adjacent to the SST OU to determine both the nature of tailings/impacted soils ("tailings") and native soil and to provide a frame of reference against which to assess the impact of tailings on the environment. The method used for delineating tailings/impacted soil from "nonimpacted" soils within the SST OU is described below.

To some extent, contaminants of concern mobilized by the chemical reactions have moved out of the tailings and into the underlying soils. This results in a gradual decrease in concentration of contaminants of concern with depth, with no distinct base. In addition, although several of the contaminants of concern behave in a similar manner, the exact mobility of each is unique. These conditions combine to make the determination of the base of the tailings/impacted soils somewhat problematic.

Graphs of data for distinct boreholes showing lithologic, chemical and physical parameters versus depth in the soil reveal that often the point at which the change in each of these parameters is greatest is approximately the same for several parameters. At some depth most metals concentrations decreased an approximate "order of magnitude," or factor of ten, from concentrations measured in the surface to near-surface depth intervals. This order of magnitude decrease in metals concentrations generally coincided with an increase in soil pH and a decrease in electrical conductivity. In other words, although there is no unique base of tailings with an abrupt, step-like change in chemical and physical parameters, the point that most closely approaches that distinct change can be quantitatively chosen by examination of multiple parameters. While this decrease in metals concentrations was not equal to a specific value for any metal, this observation provided a good "rule of thumb" to semi-quantitatively determine the base of tailings impacts for volume determinations.

Using this method, the data for each borehole was examined and the base of tailings was determined. The term "tailings/impacted soils" is used to describe those soils that lie above the order of magnitude change in chemical and physical parameters and the term "nonimpacted" soil is used to describe those soils that lie below the order of magnitude decrease. This definition is used to calculate volumes of tailings/impacted soils and to draw isopach maps of tailings/impacted soils. The phrase "non-impacted soils" is a working phrase, used here to indicate that the soils, as a whole, have lower concentrations of contaminants of concern than tailings/impacted soils.

To determine if this, semi-quantitative manner of determining the base of tailings/impacted soils was applied consistently and if there was a real and distinct difference between the materials that were above and below the point chosen as the base of tailings/impacted soils, a statistical analysis of the two groups was done. Details of this statistical analysis are provided in Appendix C of the Draft Remedial Investigation Report (ARCO, 1995a). This statistical analysis showed there was a distinct difference between the materials in the two categories, "tailings/impacted materials" and "nonimpacted materials." This performance standard will be applied in determination of tailings/impacted soils and nonimpacted soils.

Sampling will be performed during the response action to verify that all tailings/impacted soils contaminated above the order of magnitude cleanup criteria are appropriately addressed. The sampling program shall be developed by the agencies during remedial design.

Railroad Materials

The final remedial action objectives and final remediation levels for railroad materials are:

1. Prevent exposure by recreational users of the railroad beds in excess of acceptable cancer and noncancer risks from arsenic. Risks will be adequately reduced by removal of ore concentrate spills and other impacted railroad materials exhibiting arsenic concentrations in excess of 2,000 mg/kg (MDEQ, 1995b).

2. Prevent erosion of contaminated railroad bed materials into Silver Bow Creek to the degree that surface water standards would be exceeded, or instream sediments would be contaminated, or vegetation on adjacent relocation or STARS treated areas would be adversely impacted.

The SST OU Baseline Risk Assessment determined that the OU posed unacceptable health risk to recreational users of the railroad beds, but that those risks were primarily related to the existence of a limited number of highly contaminated spills of ore concentrate or fine-grained slag material. The selected remedy for the site requires removal and appropriate disposal of those materials. Specific procedures for sampling and designation of materials to be removed will be developed during remedial design. Compliance will be determined by confirmation sampling of locations where highly-contaminated materials were removed.

The selected remedy requires excavation of contaminated railroad bed materials that form the streambank of Silver Bow Creek. These materials are found primarily at bridge abutments and along certain stream reaches. During implementation of the remedial action, compliance with the construction specifications will be required. During long-term maintenance, repair of eroded materials will be required to ensure structural integrity of the railroad bed.

All concentrate spills will be removed and disposed in an appropriate secure repository in compliance with applicable RCRA requirements. Concentrate spill material will not be placed in relocation repositories. The STARS technology or soil capping is expected for all other areas of the inactive grade. Railroad materials which directly impact the stream either at bridge abutments or along the streambank will be excavated and disposed in the adjacent relocation repositories. The actual amount and methods of excavation and/or treatment will be determined during remedial design.

Groundwater

The final remedial action objectives and final remediation standards for groundwater are:

1. Attain compliance with applicable MDEQ Circular WQB-7 standards, federal MCL's, and federal nonzero maximum contaminant level goals (MCLGs) for all OU groundwater.

2. Prevent discharge of groundwater that would prevent attainment of Silver Bow Creek ambient Circular WQB-7 standards or instream sediment remediation goals.

A primary element of the selected remedy is to excavate and relocate tailings/impacted soils that act as sources of groundwater contamination at the SST OU because the tailings are in contact with groundwater either continually or seasonally. The purpose of these source removals is two fold. First, removal of the sources will allow natural attenuation to restore groundwater to compliance with Circular WQB-7 standards in a reasonable time frame. Second, as groundwater quality improves, contaminant loading to Silver Bow Creek in areas where near-stream groundwater discharges to the stream will be dramatically reduced. Over time, groundwater should not adversely impact water quality or instream sediment quality of the stream. To delineate the potentiometric surface to the degree necessary for saturated tailings quantification, numerous piezometers (possibly hundreds) will need to be installed with accurate horizontal/vertical survey control and monthly groundwater level measurements.

After construction of the remedy, at areas of suspected or known historic exceedances of groundwater standards, monitoring wells will be installed. These wells will be constructed so that the well screen is located in the appropriate hydrostratigraphic zone and monitored at proper time intervals to confirm that the source removals and natural attenuation are working to improve groundwater quality. The specific locations and number of wells required and the necessary sampling regimen will be determined during remedial design and remedial action.

Another element of the selected remedy is the establishment of several local repositories for treated, excavated tailings/impacted soils. Although it is expected that these repositories will be designed and constructed to prevent any migration of contaminants to underlying groundwater, it will be important to monitor the groundwater beneath each individual repository to confirm that they are performing as designed. The specific locations of monitoring wells and sampling regimen will be determined during remedial design and remedial action.

The groundwater levels to be attained consist of the more stringent of the MCL, any non-zero MCLG, or the WQB-7 human health standard for each parameter. More detail on the legal requirements that establish these levels is set forth in Appendix A, which identifies and discusses the ARARs for this remedial action.

Groundwater sampling will be performed during the response action to verify the locations of contaminated groundwater (Table 18). It is anticipated that the treatment prescribed for sources of contamination at the OU will effectively reduce the locations and levels of contamination and shrink the contaminant plumes within a reasonable period of time.

Air Resources

The final remediation standard for air resources is:

1. Compliance with air ARARs within and adjacent to the SST OU during implementation of the remedial action.

During construction of the remedy, dust-suppression measures will be required. In addition, provisions will be specified during remedial design to limit wind-borne dispersion of lime amendments used as part of the in-situ treatment of tailings/impacted soils. Monitoring of particulate matter will be required initially and on an as-needed basis for the duration of construction activities at the OU. The intensity of the monitoring may be reduced over time depending on the results of the initial sampling.

Compliance Monitoring Program

A sampling program for monitoring the remedial action and determining compliance with the performance standards shall be implemented during the remedial action. Table 18 lists minimum monitoring requirements. In addition, to ensure that performance standards are maintained, it is expected that there will be monitoring at least quarterly for a period of at least ten years following completion of remediation construction. Continued monitoring after that period may be conducted less frequently if MDEQ and EPA determine that a reduced frequency is appropriate. These monitoring programs will be developed during remedial design and shall include, at a minimum, the following parameters to evaluate success of the remedial action. Physical parameters of geomorphologic stability, macroinvertebrates (diversity and abundance) and aquatic health, riparian vegetation and analytical parameters (focusing on the contaminants of concern including mercury, but analyzing other contaminants, if any, that are not contaminants of concern and are determined to be occurring at levels exceeding performance standards), sampling points, sampling frequency and duration, and statistical methods for evaluating data. Specific performance monitoring points shall be specified and approved by EPA and MDEQ during remedial design and remedial action.

Because residual hazardous substances will be left in the OU and the cleanup is expected to take several years, the selected remedy will require five year reviews under Section 121(c) of CERCLA, Section 300.430(f)(4)(ii) of the NCP, and applicable guidance to ensure the long-term protectiveness of the remedy.

Engineering and Institutional Controls

These controls are required to maintain the protectiveness of the remedy. Since attainment of RAOs for all media are not likely to be met in less than 10 years, measures must be instituted to control risks during implementation of the remedy.

Because all OU contamination will remain on-site, a creative and secure institutional controls, monitoring, and maintenance (ICMM) program will be required. This ICMM program must: (1) ensure adequate land use/access restrictions to safeguard the waste materials treated in-situ and/or relocated to adjacent repositories, (2) be managed,

maintained, and monitored in perpetuity, and (3) ensure that shallow contaminated groundwater use is controlled.

Table 18
Minimum Post-Remedy Monitoring Requirements[1]

Media	Locations/Physical Parameters	Analytical Parameters
Surface Water	SS-07, SS-10, SS-13, SS-14, SS-15, SS-16, SS-17, SS-19	Metals: Total recoverable and dissolved: As, Cd, Cu, Pb, Hg, Zn Commons: Ca, Mg, Na, K, Cl^-, $SO4^{2-}$ Nutrients: Nitrate+Nitrite Nitrogen, Phosphorous Physical: Temperature, pH, Eh, conductance, dissolved O2
Instream Sediments, Geomorphology, Aquatic Biologic Resources	Surface water locations and at each depositional areas. Physical stream parameters such as geomorphologic stability (erosion rates and locations) and bedform morphologic features. Macroinvertebrate diversity, abundance and aquatic health.	Metals: Total As, Cd, Cu, Pb, Hg, Zn. To be analyzed by three size fractions: 1mm and greater, between 1mm and 63 μm, and less then 63 μm.
Groundwater	Upstream end near Colorado Tailings, Rocker, Silver Bow, Nissler, Ramsay Flats, Miles Crossing, Fairmont, Crackerville, Stuart, Opportunity, STARS in-situ treatment areas and every repository location	Metals: Dissolved As, Cd, Cu, Pb, Hg, Zn Commons: Ca, Mg, Na, K, Cl^-, $SO4^{2-}$ Physical: Temperature, pH, Eh, conductance, dissolved O2
Soil	Minimum one (1) sample per 10 acres and three (3) sample per repository	Neutralization potential, sulfur fractionation, conductance, pH
Vegetation	In conjunction with soil sample locations	Percent cover (total and by species), production (total and by species)
Vadose Zone	In conjunction with groundwater sampling locations; three (3) per repository location	Metals: Dissolved As, Cd, Cu, Pb, Hg, Zn Commons: Ca, Mg, Na, K, Cl^-, $SO4^{2-}$ Physical: Temperature, pH, Eh, conductance

[1] - Monitoring will focus on principal contaminants of concern As, Cd, Cu, Pb, and Zn including mercury (Hg), but analyzing other contaminants, if any, that are not principal contaminants of concern and are determined to be occurring at levels exceeding performance standards. The level of monitoring effort described in this table should be considered as minimal requirements. The necessity to meet remediation goals, cleanup/performance standards, and points of compliance might dictate a more substantial effort. The agencies will determine the final level of monitoring which includes sampling locations, frequency and duration, as well as statistical methods for evaluating the data, as needed, during remedial design.

An important component will be provisions to physically protect areas of in-situ STARS treatment from stream erosion and to provide for any necessary re-treatment of in-situ or repository STARS treated areas. If necessary, additional work, including engineering controls (e.g., riprap or removal of STARS treated areas) to prevent erosion of STARS treated areas, will be required. A critical component to this ICMM program will be provisions, to be approved by the agencies, which will ensure sufficient arrangements for financial resources to support the entities who will manage, operate, and maintain the institutional controls program.

Stream erosion would be significantly reduced from its present condition by establishment of woody vegetation (i.e., willows and cottonwoods) and backfill to maintain channel geomorphic stability.

The remedial action plan will incorporate the removal of tailings/impacted soils, contaminated instream sediments and certain railroad bed materials from the floodplain, except in those specific locations where such materials can be adequately protected in place and treated with the STARS technology to prevent further migration of the contaminants. The agencies believe that the selected remedy can be implemented in a manner that provides protection of the public health, safety, welfare and the environment and attains legally applicable or relevant and appropriate requirements.

Remedial Design/Remedial Action Process

The evaluation, selection, and description of the remedy identified in the record of decision were conducted at a feasibility study level of detail. The effectiveness and cost evaluations relied on a relatively limited amount of information collected during the remedial investigation. Although the RI/FS information is sufficient to support the setting of cleanup criteria and standards and the selection and conceptual design of the remedy, additional data will be necessary to complete the detailed design and implementation of the remedy.

The conceptual design of the remedy presented in this record of decision provides MDEQ's current best estimates of (1) the volumes and locations of contaminated media to be excavated or STARS-treated in place, (2) potential locations of the repositories for excavated materials, and (3) construction techniques to be employed. These estimates are based on the existing remedial investigation and feasibility study information. Remedy design details and construction specifications will be finalized during the remedial design phase of the cleanup. The actual volumes of excavated materials and in-situ treated materials, lime application rates, stream stabilization features, construction techniques, monitoring and maintenance requirements, etc. ultimately required under the remedy will be determined by the agencies during design, based on the criteria identified in this record of decision. Actual volumes to be excavated or treated in-situ may be either higher or lower than the current estimate. Likewise, the actual locations of excavated areas, in-situ treated areas, and relocation areas may vary from what is presently assumed in the record of decision. The final remedy design, however, must be approved by the agencies and must be able to attain the final remediation goals and compliance and performance standards specified in this record of decision in order to ensure protection of human health and the environment and attainment of ARARs, except where appropriately waived.

Remedial design typically involves primarily the potentially responsible parties and the overseeing agencies, along with their respective technical contractors. Consistent with recent EPA Superfund Administrative Reforms, MDEQ and EPA intend to conduct an open remedial design process that will include, in a consultative role, other parties that have an interest in the Streamside Tailings OU. These parties include Butte-Silver Bow, Anaconda-Deer Lodge, and Missoula county governments, interested state and local environmental permitting agencies, local environmental groups, the Silver Bow Creek/Butte area technical assistance grantee, natural resource trustees, and other interested individuals. As provided by CERCLA and the NCP, the agencies are ultimately responsible for making final determinations regarding remedial design.

Given the disparity of opinions regarding the ability of engineered stream stabilization features to control the hydraulic forces of Silver Bow Creek and offer long-term effectiveness in preventing erosion of STARS-treated areas over time and therefor compliance with performance standards, MDEQ and EPA will make earnest efforts to procure supplemental technical expertise in stream mechanics and stream geomorphology to assist in the design process. The focus of the remedial design process will be to identify and develop detailed specifications of the most cost-effective selected remedy design that will attain the cleanup criteria and performance standards set forth in this record of decision.

Provided that the final design of the SST OU remedy can attain the SST OU cleanup criteria and performance standards, it should to the degree possible incorporate components consistent with the following environmental and community improvement actions in the project area:

- A Silver Bow Creek recreational corridor land uses as designated and adopted by Butte-Silver Bow and Anaconda-Deer Lodge county governments;
- The use of wetlands treatment for Butte wastewater nutrient loadings and/or Butte area storm water runoff metals loadings, if appropriate;
- Preservation and enhancement of significant historical and prehistorical resources in accordance with the Regional Historic Preservation Plan; and

- Coordination with pertinent restoration actions implemented as part of the Upper Clark Fork River Basin natural resource damage restoration plan.

EPA and MDEQ will make concerted efforts to assist Butte-Silver Bow and Anaconda-Deer Lodge counties in obtaining EPA Brownfields redevelopment grants and Montana Resource Development Grants to enhance reclamation projects within the Silver Bow Creek corridor.

Contingency Measures

The decisions to invoke any or all of these contingency measures may be made by the agencies at any time during remedial design or implementation of the remedial action, as appropriate.

Repository Locations

As noted in the description of the selected remedy, the use of numerous near-stream repositories for the treated tailings/impacted soils and other materials is contingent upon obtaining adequate space at suitable locations for such repositories, securing adequate control over land use, access, and management of those sites, and the successful establishment of an adequately funded institutional controls/maintenance program as part of this remedy. In the event these requirements are not met, the remedial action shall incorporate instead the use of centralized repositories as determined appropriate by the agencies.

The use of centralized repositories would substantially reduce the need for land acquisition within the Silver Bow Creek corridor and the need for institutional controls and continued land use restrictions within the stream corridor, as well as the amount of maintenance required for such repositories. In such event, the agencies may also need to determine that a greater amount of tailings/impacted soils needs to be removed from the OU in order to ensure protection of the stream from reentrainment of tailings/impacted soils from STARS treated areas in the absence of a permanent management, monitoring, and maintenance program.

The locations of the centralized repositories would be determined by the agencies based upon the availability of appropriate locations at that time. For some tailings/impacted soils and other contaminated materials, the Opportunity Ponds could still be considered an appropriate location. Although there was some concern expressed during the public comment period regarding the use of the Opportunity Ponds as a disposal area, primarily by local government representatives from Deer Lodge County, the majority of comments addressing this issue recognized the Opportunity Ponds as an appropriate repository for such wastes. Possibly limiting the wastes disposed in this area to those wastes from the lower portion of the OU would address some of the concerns raised by those who objected to the use of the Opportunity Ponds.

- By the time that this decision would be made, there may be additional information from studies for other operable units within the site that would assist in identifying additional appropriate repositories. The agencies recognize that there was also substantial opposition during the public comment period to the siting of a repository in the Browns Gulch area. That location could also be avoided, if possible.

Instream Sediments

The use of the ≤1mm grain size standard is intended as an indicator that will allow for ease of field implementation, enabling reasonably reliable visual identification of the material to be removed in the field without the need for continued sampling and expensive, slow analytical analysis of instream sediments. MDEQ and EPA believe that this particle size fraction will reasonably identify the tailings/impacted soils located in the active streambed of Silver Bow Creek, particularly that fraction of the instream sediments that poses the greatest threat as a contaminant source, and therefore will serve as a reliable indicator for implementation in the field.

However, if it is demonstrated from design studies or initial field work that this size fraction standard is not a reliable indicator of the contaminated sediments that must be removed in order to eliminate the threat to aquatic life in the stream, sampling and chemical analysis may be used to identify the materials that must be excavated or another appropriate indicator may be selected. In any event, sampling and analysis may be used in coordination with the use of this indicator to establish that a specific deposit of sediments within this particle size are in fact natural, uncontaminated sand or silt size instream sediment and not tailings/impacted soils or contaminated instream sediments that require removal. For example, demonstration that specific materials contain concentrations similar to instream sediment concentrations found in like Montana streams that are located in similar geologic/hydrologic environments, that are relatively unimpacted by mining activity, and that contain a reproducing trout fishery would establish that such instream sediments need not be removed.

X. STATUTORY DETERMINATIONS

While the large majority of the comments received from the community supported the selection of Alternative 6, the alternative initially proposed by the agencies, comments submitted by the primary PRP, with support from both Butte/Silver Bow and Anaconda/Deer Lodge local governments, as well as numerous local business interests promoted implementation of a less extensive and less expensive remedy. After considering all the comments fully, as detailed in the Responsiveness Summary, the agencies have determined that certain changes to the proposed plan (MDEQ, 1995a) can accomplish substantial cost savings and still satisfy the statutory requirements for remedies under CERCLA. MDEQ and EPA have determined that, considering all appropriate factors, including OU specific conditions and the remedy selection criteria specified in CERCLA and the NCP, the remedy presented in this record of decision is the proper remedy for the OU and meets the statutory requirements for remedies under CERCLA, as described below.

Under CERCLA Section 121, MDEQ and EPA must select a remedy that is protective of human health and the environment, complies with applicable or relevant and appropriate requirements (unless a statutory waiver is justified), is cost-effective, and utilizes permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA provides a preference for remedies that include treatment which permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as a principal element. The following sections discuss how the selected remedy meets these statutory requirements.

Protection of Human Health and the Environment

The selected remedy will protect human health and the environment through actions designed to address all identified sources of contamination in the OU, including tailings/impacted soil, instream sediments, and railroad materials, together with permanent monitoring and maintenance (including retreatment or replacement, if necessary) of the remediated areas through a comprehensive institutional controls, monitoring, and maintenance program.

This remedial action will reduce much of the potential risk to human health and terrestrial and aquatic flora/fauna by establishing vegetation throughout the entire OU and relocating much of the contaminated materials outside of the 100-year floodplain. Contaminated materials to be relocated will include all tailings deposits that are saturated or within the observed groundwater fluctuation of two feet and all near stream tailings which may reasonably be expected to be eroded through natural stream processes.

Groundwater quality will improve significantly in many areas after the removal of source tailings. Tailings/impacted soils close to or saturated by groundwater and tailings in those areas that may be subject to erosion into the stream will be relocated safely outside of the 100-year floodplain and treated, significantly reducing the potential for impacts to groundwater or re-entrainment of tailings/impacted soils into the stream. Runoff and transport of total and dissolved metals and arsenic to the stream will be significantly reduced or eliminated. In those areas to be treated in-situ with STARS, the treatment will somewhat reduce pore water acidity and mobility of certain contaminants. An institutional controls program will monitor and maintain the integrity of all STARS treated areas, and, if necessary, additional work, including engineering controls to protect STARS treated areas from erosion or retreatment or removal of the STARS treated areas, will be required. Stream erosion would be significantly reduced from its present condition by establishment of woody vegetation (i.e., willows and cottonwoods) and backfill to maintain channel geomorphic stability.

All railroad materials which affect human health or the environment will be removed or treated in-situ. All concentrate spills will be removed and disposed in an appropriate, secure landfill. The STARS technology or soil capping is expected for all other areas of the inactive grade. Railroad materials which directly impact the stream either at bridge abutments or along the streambank will be excavated and disposed in the local relocation repositories.

Instream sediment quality and recovery time will improve dramatically through removal of all depositional areas of fine ($\leq$1mm) grained instream sediments.

After the sources of continuing contamination are addressed, groundwater quality will improve slowly by attenuation and dilution in areas where it is currently impacted. Institutional controls restricting use of and exposure to contaminated groundwater will be necessary until the standards are attained.

After the sources of contamination are addressed as provided for in the selected remedy, (and after upstream sources are addressed by actions in other operable units) protection of affected surface waters will be achieved. Once source control is achieved, flushing and dilution will restore the stream to acceptable and protective levels for contaminants of concern for this OU.

There are no short term threats associated with the selected remedy that cannot be readily controlled. A variety of institutional controls and access restrictions will be implemented with the remedy to ensure protectiveness while the remedy is being implemented.

Accordingly, the agencies have determined that the combination of actions, controls, and contingencies designated in this record of decision for the remedial action at this OU will provide protection of human health and the environment.

Compliance with Applicable or Relevant and Appropriate Requirements

The final determination of ARARs by MDEQ and EPA is set forth in Appendix A attached to this record of decision. The selected remedy will attain most applicable or relevant and appropriate requirements (ARARs). A waiver of certain solid waste and floodplain management ARARs is necessary where the STARS technology will be implemented in the 100-year floodplain. Some significant ARARs compliance issues are discussed below.

Contaminant-specific ARARs

Contaminant-specific ARARs typically set levels or concentrations of chemicals that may be allowed in or discharged to the environment. For groundwater, the contaminant-specific ARARs for this remedial action include the maximum contaminant levels (MCLs) and non-zero maximum contaminant level goals (MCLGs) established under the federal Safe Drinking Water Act, and the human health standards specified in MDEQ Circular WQB-7. The selected remedy is to be designed to address source areas of contamination to groundwater sufficiently to allow natural attenuation and dilution of groundwater to eventually attain these standards in the groundwater throughout the OU.

In addition the remedy will attain the surface water quality standards for OU contaminants in Silver Bow Creek, as designated under Montana law. ARM 16.20.623 specifies the standards for the "I" classification applicable to Silver Bow Creek and, for each contaminant, requires eventual attainment of the more restrictive of the aquatic life standard or the human health standard set forth in MDEQ Circular WQB-7.

Location-specific ARARs

Location-specific ARARs establish requirements or limitations based on the physical or geographic setting of the OU or the existence of protected resources in the OU.

The SST OU lies almost entirely within the 100-year floodplain of Silver Bow Creek. Several different ARARs limit or prohibit storing or disposing the SST mine tailings in the floodplain. The Montana Solid Waste Regulations prohibit placing any facility for the treatment, storage, or disposal of solid wastes in a 100-year floodplain. The Montana Floodplain Management Regulations prohibit solid and hazardous waste disposal or storage of toxic or hazardous materials within the 100-year floodplain.

The remedial action plan provides for the use of STARS treatment of tailings in place in the floodplain in a portion of Subarea 4. Because this will constitute disposal of solid waste in the floodplain, this action will not comply with these location-specific ARARs, and an ARAR waiver is necessary.

MDEQ and EPA have determined that, in those locations satisfying the technical criteria identified in this ROD for where STARS treatment may appropriately be implemented within the floodplain (Section IX), and when consistently and permanently monitored and maintained by an appropriate institutional controls, monitoring, and maintenance program to be established and funded as part of this remedy, the use of STARS treatment, together with any necessary maintenance or replacement actions, will attain a standard of performance that is equivalent to that required by these floodplain and solid waste regulations through use of another method or approach. Accordingly, the agencies invoke the ARAR waiver provided by CERCLA Section 121(d)(4)(D), 42 U.S.C. § 9621(d)(4)(D). In determining that this ARAR waiver may properly be invoked in this limited context, MDEQ and EPA have considered that the purpose behind the solid waste and floodplain regulations is to ensure that such wastes do not contaminate the stream or adjacent groundwater and to prevent the washout of solid waste disposal areas by the stream or floodwaters. The criteria used by the agencies to determine where tailings may be left in place within the floodplain, together with an institutional controls program to monitor the effectiveness of STARS and ensure the integrity of STARS treated areas (including the additional use of engineering controls, such as riprap, or re-treatment or removal of STARS treated areas, if necessary) can attain these specific goals at an equivalent level of performance.

Design of the remedy will have to ensure that treated tailings/impacted soils are protected by their location, placement or sufficient engineering controls to ensure that such materials will not be subject to any level of washout or erosion. Appropriately ensuring against any level of washout or erosion is a required condition for the application of this ARAR waiver. All other ARARs identified in Appendix A, including those specifically requiring the protection of solid wastes or toxic or hazardous materials in the floodplain from washout or erosion, remain applicable or relevant and appropriate and must be met by appropriate design and implementation of the remedy.

During design and implementation of the remedy, several other location-specific ARARs must continue to be observed. Several of these, including the Fish and Wildlife Coordination Act, the Endangered Species Act, the Migratory Bird Treaty Act and the Bald Eagle Protection Act, require continued consultation with the U.S. Fish and Wildlife Service. Other location-specific ARARs require consideration of historical resources and continued consultation with the State Historic Preservation Officer. ARCO, EPA, MDEQ, the State Historic Preservation Officer, the National Council on Historic Preservation, and both local governments in the area have entered into a Programmatic Agreement to ensure the appropriate consideration of cultural and historic resources in the Clark Fork Basin, including those within the SST OU.

Action-specific ARARs

Action-specific ARARs generally provide guidelines for the manner in which specific activities must be implemented. Thus, compliance with many action-specific requirements must be ensured through appropriate design and implementation of the remedy.

The remedy is to be designed and implemented in accordance with dust suppression and air quality regulations, certain reclamation requirements which have been determined to be relevant and appropriate to this action, and other action-specific ARARs identified in Appendix A.

Cost-Effectiveness

MDEQ and EPA have determined that the selected remedy is cost-effective in mitigating the principal risks posed by the tailings/impacted soils, instream sediments, railroad materials and contaminated groundwater. Section 300.430(f)(ii)(D) of the NCP requires evaluation of cost-effectiveness. The remedy must provide overall effectiveness proportional to its costs. Overall effectiveness is determined by the following three balancing criteria: long-term effectiveness and permanence; reduction of toxicity, mobility or volume through treatment; and short-term effectiveness.

The estimated costs of the selected remedy, as well as the costs of the other alternatives considered, are described in Tables 15, 16, and 17 of this record of decision. To the extent that the estimated cost of the selected remedy exceeds the costs of other alternatives, the additional cost is reasonably related to the additional benefits in long-term effectiveness and permanence and reduction of toxicity and mobility of the contaminants through the relocation and treatment to be used.

With respect to the short-term effectiveness of the remedy, including consideration of the risks involved to workers and the community as the remedy is being implemented, the agencies have revised the remedy from the preferred alternative identified in the proposed plan (MDEQ, 1995a). The change from Alternative 6, using one or two centralized repositories, to Alternative 5, using numerous local relocation repositories, will reduce concerns regarding the short-term effectiveness of the remedy. The use of numerous local repositories will dramatically reduce the length of trips travelled by trucks hauling the contaminated materials, and consequently will reduce the risk of traffic accidents and the risks/inconvenience to local communities that would be affected by such construction traffic. The remaining risks posed during implementation can be adequately addressed by proper safety precautions in the implementation of the remedy.

The selected remedy, fully addressing the sources of contamination, and provides the best overall effectiveness of all alternatives proportional to its cost. The tailings/impacted soils and railroad remediation are believed necessary in order to adequately protect Silver Bow Creek and the alluvial aquifers, in addition to providing a realistic opportunity to fully stabilize and achieve cleanup goals at the OU in the future. The agencies have determined that, if the tailings/impacted soils designated for relocation were not removed from the floodplain prior to treatment, the reduction in toxicity and mobility resulting from such treatment could well be only temporary. Thus the agencies have determined that such relocation is appropriate and cost-effective. The tailings that will remain in the floodplain are those that the agencies believe can be adequately protected by long-term maintenance activities or the addition of engineering controls, if necessary. In addition, the actions prescribed for sediments are necessary and cost-effective to address threats to and adverse impacts on the environment, including toxicity to aquatic organisms, ranging from macroinvertebrates to fish, as well as to prevent recontamination of the water in the stream.

As detailed above, the agencies have determined that the costs of this remedy are proportional to the overall effectiveness that will be achieved by the selected remedy.

Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

MDEQ and EPA have determined that the selected remedy represents the maximum extent to which an alternative treatment technology, STARS, can be used within the OU consistent with the need to provide a permanent solution. The specific nature of the STARS treatment technology must be considered in evaluating the appropriate use of STARS. STARS was developed by the State as a low cost, in-situ, alternative treatment technology. Considering the limitations on the effectiveness of the technology, it has been included in the remedy to the maximum extent practicable. Removal of the material from the floodplain prior to using STARS effects a permanent solution, as well as utilizes an alternative treatment technology, since outside the floodplain, the STARS treated areas can be expected to remain intact. Thus by this combination of removal of certain vulnerable tailings/impacted soils from the floodplain along with STARS treatment of all tailings/impacted soils both within and outside the floodplain, the selected remedy attempts to maximize the use of both permanent solutions and alternative treatment technologies.

Of those alternatives that are protective of human health and the environment and comply with ARARs or have an adequate bases for an ARAR waiver, MDEQ and EPA have determined that this selected remedy provides the best balance of trade-offs in terms of long-term effectiveness and permanence, reduction in toxicity, mobility, or volume achieved through treatment, short-term effectiveness, implementability and cost, while also considering the statutory preference for treatment as a principal element and considering state and community acceptance. The detailed evaluation of the balance of these criteria among the alternatives considered is set forth in the FS Report and is summarized in Section VIII, Summary of Comparative Analysis of Alternatives, of this record of decision.

The selected remedy includes removal and treatment of contaminated media which will permanently and significantly reduce the principal threats posed by the tailings/impacted soils, instream sediments and railroad materials. The other alternative considered which could achieve similar or more substantial reductions, Alternative #6, would do so at significant additional expense, although there was, overall, widespread support for OU-wide Alternative 6 from communities in the basin. Other alternatives considered, including containment, capping and partial excavation, did not offer similar prospects for protectiveness, effectiveness or permanence.

Preference for Treatment as a Principal Element

As discussed in the section on utilization of alternative treatment technologies above, the selected remedy incorporates the use of STARS treatment of practically all contaminated materials. Such treatment will be used for all the tailings left in the floodplain and will be used extensively in construction of the tailings repositories located outside the floodplain. Thus, by utilizing treatment as a significant portion of the remedy, the statutory preference for remedies that employ treatment as a principal element is satisfied.

XI. DOCUMENTATION OF SIGNIFICANT CHANGES

In the proposed plan (MDEQ, 1995a), MDEQ and EPA submitted as the preferred remedy for the OU the combination of actions set out as OU-wide Alternative 6 in Draft Feasibility Study Report (ARCO, 1995b). This remedy was detailed in a proposed plan which was submitted for public comment for 60 days from June 9 through August 7, 1995. Over 580 comments were received from local government entities, a potentially responsible party, environmental groups, business organizations, and numerous individual citizens. Comments were received from the Butte area, the Anaconda area, the Missoula area, and several other areas of Montana, as well as out of state.

The vast majority of the comments supported the preferred remedy as delineated in the proposed plan (MDEQ, 1995a), and most strongly supported full and effective cleanup of the Silver Bow Creek corridor. One distinct group of comments, which included support from local government entities in both the Butte and Anaconda areas, promoted a remedy which would incorporate a "greenway" or recreational corridor conceptual land use proposal. In addition, some comments, including government representatives in the Butte and Anaconda area, strongly objected to use of the two proposed repositories.

After considering the public comments received, especially the concerns expressed by local government representatives, MDEQ and EPA have included certain modifications to the proposed remedy. This record of decision will achieve substantial cost savings by avoiding transport of the excavated materials to a single repository, and by instead allowing the use of several local repositories which would be maintained over the long-term by an institutional controls plan such as a recreational corridor or similar designated recreational use plan.

The agencies' initial proposal for one or two central repositories was founded upon certain advantages including: (1) the wastes would be removed from the stream corridor where the relocation repositories might be incompatible with future residential or other land uses; (2) significantly less restriction on residential, agricultural (grazing, irrigating, etc.) land uses; (3) the amount of presently undisturbed land used for waste repositories would be significantly reduced or eliminated; (4) substantially reduced long-term monitoring and maintenance requirements; and (5) reduced lime requirements for the remedy. The agencies acknowledge the comments by ARCO and other supporters of a designated recreational use plan that a recreational corridor concept allows an implementable means of ensuring long-term monitoring and maintenance of numerous local repositories, thus addressing many of those concerns which led the agencies to propose a central repository. In light of the cost savings that can be achieved if the appropriate maintenance program can be established, as well as reduced short-term risk impacts on local communities during construction, the agencies believe use of numerous local repositories will be more cost effective.

Consequently, the agencies are including in the f… al remedial action plan the use of local relocation repositories rather than a central repos… ory, if it can be demonstrated that adequate space for such repositories is available outside of … he CH2M Hill (1989a) floodplain and that the long-term maintenance and monitoring of suc… repositories can be ensured through a properly designed and adequately funded institutional controls program.

The cost savings which could be obtained by the changes from the proposed plan (MDEQ, 1995a) remedy is estimated at $15,000,000 - $20,000,000. The savings achieved by this remedial action plan, will allow full funding of the institutional controls/management and monitoring plan, through establishment of a designated recreational use plan, and still provide substantial cost savings in the implementation of the remedy.

The remedial action plan will still incorporate the removal of tailings/impacted soils, contaminated instream sediments and certain railroad bed materials from the floodplain, except in those specific locations where such materials can be adequately protected in place and treated with the STARS technology to prevent further migration of the contaminants. The agencies believe that the final remedial action plan, as described, including the utilization of several local repositories, if appropriate, can be implemented in a manner that provides protection of the public health, safety, welfare and the environment and attains legally applicable or relevant and appropriate requirements. This change also takes into account the Butte-Silver Bow and Anaconda-Deer Lodge Counties' desire for a recreational land use plan for the Silver Bow Creek corridor.

Based on these concerns the agencies have revised the preferred remedy to a **modified Alternative 5** as delineated in the Feasibility Study and proposed plan (MDEQ, 1995a). This change in repository locations does not substantially reduce the protectiveness of the remedy. When implemented correctly, the modified Alternative 5 will be protective of human health and the environment. The differences between the final remedial action plan and the proposed plan are as follows:

- All removed materials will be placed in local relocation repositories and fully treated by the STARS technology in two foot lifts. These repositories will be located safely outside of the 100-year floodplain as delineated by CH2M Hill (1989a), and will be monitored and maintained as part of an institutional controls, monitoring and maintenance program for the Silver Bow Creek corridor.

- Although the specific volumes of tailings/impacted soils to meet the protectiveness criteria will be determined by the agencies during remedial design re-evaluation of the site data have indicated that less excavation than that proposed will be necessary. The approximate volumes have been slightly adjusted to take into account the 50,000 cy removed at the Demonstration Projects in Subarea 4 and to allow for implementation of in-situ STARS treatment for an additional 170,000 cy in Subarea 4.

- Constructed wetlands are designated as the end land use for Subarea 1. After removal of all identified contaminant sources, reconstruction of the Subarea will be designed to incorporate use of the area as wetlands. Constructed wetlands in this area may be used as a treatment system for nutrients and/or metals from upstream, if such treatment is ultimately determined to be appropriate in this area.

- The requirements for removal of instream sediments has been specified that fine-grained ($\leq$1mm) sediments in all depositional areas (regardless of size) will be removed.

- The volume of railroad bed materials to be excavated or treated has been estimated more precisely to include only those materials directly impacting Silver Bow Creek at bridge abutments or along the stream bank.

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APPENDIX A

IDENTIFICATION AND DESCRIPTION OF
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

STREAMSIDE TAILINGS OPERABLE UNIT
SILVER BOW CREEK/BUTTE ADDITION NPL SITE

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November 1995

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LIST OF ACRONYMS

ARAR	Applicable or Relevant and Appropriate Requirements
ATSDR	Agency of Toxic Substances and Disease Registry
BAT	Best Available Technology Economically Achievable
BCT	Best Conventional Pollutant Control Technology
BPCTCA	Best Practicable Control Technology Currently Available
BPJ	Best Professional Judgment
BTCA	Best Technology Currently Available
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
DNRC	Department of Natural Resources and Conservation (Montana)
DSL	Department of State Lands (Montana)
EPA	U.S. Environmental Protection Agency
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
HWM	Hazardous Waste Management
LNAPL	Light Non-aqueous Phase Liquid
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDEQ	Montana Department of Environmental Quality
MGWPCS	Montana Groundwater Pollution Control System
MPDES	Montana Pollutant Discharge Elimination System
NCP	National Contingency Plan
NESHAPS	National Emissions Standards for Hazardous Air Pollutants
NPL	National Priorities List
NPDES	National Pollutant Discharge Elimination System
PAH	Polynuclear Aromatic Hydrocarbon
PCP	Pentachlorophenol
POHC	Principal Organic Hazardous Constituents
POTW	Public Owned Treatment Works
PSD	Prevention of Significant Deterioration
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SHPO	State Historic Preservation Officer (Montana)
SIP	State Implementation Plan
TBC	To Be Considered
TU	Turbidity Unit
UIC	Underground Injection Control

INTRODUCTION

Section 121(d) of CERCLA, 42 U.S.C. § 9621(d), certain provisions of the current National Contingency Plan (the NCP), 40 CFR Part 300 (1990), and guidance and policy issued by the Environmental Protection Agency (EPA) require that remedial actions taken pursuant to Superfund authority shall require or achieve compliance with substantive provisions of applicable or relevant and appropriate standards, requirements, criteria, or limitations from state environmental and facility siting laws, and from federal environmental laws at the completion of the remedial action, and/or during the implementation of the remedial action, unless a waiver is granted. These requirements are threshold standards that any selected remedy must meet. See Section 121(d)(4) of CERCLA, 42 U.S.C. § 9621(d)(4); 40 CFR § 300.430(f)(1). EPA calls standards, requirements, criteria, or limitations identified pursuant to section 121(d) "ARARs," or applicable or relevant and appropriate requirements.

ARARs are either applicable or relevant and appropriate. Applicable requirements are those standards, requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, or contaminant, remedial action, location, or other circumstance found at a CERCLA site. Relevant and appropriate requirements are those standards, requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to hazardous substances, pollutants, contaminants, remedial actions, locations, or other circumstances found at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site such that their use is well suited to the particular site. Factors which may be considered in making this determination are presented in 40 CFR § 300.400(g)(2). Compliance with both applicable and relevant and appropriate requirements is mandatory.[1]

Each ARAR or group of related ARARs is identified by a specific statutory or regulatory citation, a classification describing whether the ARAR is applicable or relevant and appropriate, and a description which summarizes the requirements, and addresses how and when compliance with the ARAR will be measured (some ARARs will govern the conduct of the remedial action, some will define the measure of success of the remedial action, and some will do both).[2] The descriptions given here are provided to allow the reader a reasonable understanding of each requirement without having to refer constantly to the statute or regulation itself and to provide an explanation of how the requirement is to be applied in the specific circumstances involved at this operable unit.

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1 See CERCLA Section 121(d)(2)(A), 42 U.S.C. Section 9621(d)(2)(A).

2 40 CFR Section 300.435(b)(2); Preamble to the Proposed NCP, 53 Fed. Reg. 51440 (December 21, 1988); Preamble to the Final NCP, 55 Fed. Reg. 8755-8757 (March 8, 1990). The Atlantic Richfield Company (ARCO), an identified potentially responsible party for this operable unit, argues that the NCP's application of ARARs during the remedial action is not consistent with the CERCLA statute. However, ARCO did not challenge the NCP in the District of Columbia Court of Appeals in a timely manner, and therefore has waived the right to assert this argument. See Section 113(a) of CERCLA, 42 U.S.C. Section 9613(a).

Also contained in this list are policies, guidance and other sources of information which are "to be considered" in the selection of the remedy and implementation of the record of decision (ROD). Although not enforceable requirements, these documents are important sources of information which EPA and the State of Montana Department of Environmental Quality (MDEQ) may consider during selection of the remedy, especially in regard to the evaluation of public health and environmental risks; or which will be referred to, as appropriate, in selecting and developing cleanup actions.[3]

Finally, this list contains a non-exhaustive list of other legal provisions or requirements which should be complied with during the implementation of the ROD.

ARARs are divided into contaminant specific, location specific, and action specific requirements, as described in the NCP and EPA guidance. Contaminant specific ARARs are listed according to specific media and govern the release to the environment of specific chemical compounds or materials possessing certain chemical or physical characteristics. Contaminant specific ARARs generally set health or risk based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment.

Location specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of cleanup activities because they are in specific locations. Location specific ARARs generally relate to the geographic location or physical characteristics or setting of the site, rather than to the nature of the site contaminants.

Action specific ARARs are usually technology or activity based requirements or limitations on actions taken with respect to hazardous substances.

Only the substantive portions of the requirements are ARARs.[4] Administrative requirements are not ARARs and thus do not apply to actions conducted entirely on-site. Administrative requirements are those which involve consultation, issuance of permits, documentation, reporting, recordkeeping, and enforcement. The CERCLA program has its own set of administrative procedures which assure proper implementation of CERCLA. The application of additional or conflicting administrative requirements could result in delay or confusion.[5] Provisions of statutes or regulations which contain general goals that merely express legislative intent about desired outcomes or conditions but are non-binding are not ARARs.[6]

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3 40 CFR Section 300.400(g)(3); 40 CFR Section 300.415(i); Preamble to the Final NCP, 55 Fed. Reg. 8744-8746 (March 8, 1990).

4 40 CFR Section 300.5. See also Preamble to the Final NCP, 55 Fed. Reg. 8756-8757 (March 8, 1990).

5 Preamble to the Final NCP, 55 Fed. Reg. 8756-8757 (March 8, 1990); Compliance with Other Laws Manual, Vol. I, pp. 1-11 through 1-12.

6 Preamble to the Final NCP, 55 Fed. Reg. 8746 (March 8, 1990).

Many requirements listed here are promulgated as identical or nearly identical requirements in both federal and state law, usually pursuant to delegated environmental programs administered by EPA and the states, such as the requirements of the federal Clean Water Act and the Montana Water Quality Act. The preamble to the new NCP states that such a situation results in citation to the state provision as the appropriate standard, but treatment of the provision as a federal requirement. ARARs and other laws which are unique to state law are identified separately by the State of Montana.

This document constitutes MDEQ's and EPA's formal identification and detailed description of ARARs for remedial action at the Streamside Tailings Operable Unit. This ARARs analysis is based on section 121(d) of CERCLA, 42 U.S.C. § 9621(d); CERCLA Compliance with Other Laws Manual, Volumes I and II, OSWER Dirs. 9234.1-01 and-02 (August 1988 and August 1989 respectively); various CERCLA ARARs Fact Sheets issued as OSWER Directives; the Preamble to the Proposed NCP, 53 Fed. Reg. 51394 et seq. (December 21, 1988); the Preamble to the Final NCP, 55 Fed. Reg. 8666-8813 (March 8, 1990); the Final NCP, 40 CFR Part 300 (55 Fed. Reg. 8813-8865, March 8, 1990), and the substantive provisions of law discussed in this document.

FEDERAL ARARS

I. FEDERAL CONTAMINANT SPECIFIC REQUIREMENTS

A. Groundwater Standards - Safe Drinking Water Act (Relevant and Appropriate)[7]

The National Primary Drinking Water Standards (40 CFR Part 141), better known as maximum contaminant levels and maximum contaminant level goals (MCLs and MCLGs), are not applicable to the Streamside Tailings Operable Unit area because the aquifer underlying the area is not a current public water system, as defined in the Safe Drinking Water Act, 42 U.S.C. § 300f(4). These standards are relevant and appropriate standards, however, because the groundwater in the area is a potential source of drinking water. Groundwater use through private wells occurs in the area, and some of the groundwater in the area is a current source of drinking water. In addition, the aquifer discharges to Silver Bow Creek, which is designated as a potential drinking water source. Since Silver Bow Creek is also a potential source of drinking water, these standards are relevant and appropriate for that surface water as well.

Use of these standards for this action is fully supported by EPA regulations and guidance. The Preamble to the NCP clearly states that MCLs are relevant and appropriate for groundwater that is a current or potential source of drinking water (55 Fed. Reg. 8750, March 8, 1990), and this determination is further supported by requirements in the regulations governing conduct of RI/FS studies found at 40 CFR § 300.430(e)(2)(i)(B). EPA's guidance on Remedial Action for Contaminated Groundwater at Superfund Sites states that "MCLs developed under the Safe Drinking Water Act generally are ARARs for current

[7] 42 U.S.C. Sections 300f et seq.

or potential drinking water sources." MCLGs which are above zero are relevant and appropriate under the same conditions (55 Fed. Reg. 8750-8752, March 8, 1990). See also, State of Ohio v. EPA, 997 F.2d 1520 (D.C. Cir. 1993), which upholds EPA's application of MCLs and non-zero MCLGs as ARAR standards for groundwater which is a potential drinking water source.

As noted above, standards such as the MCL and MCLG standards are promulgated pursuant to both federal and state law. Currently, none of the State MCL's is more stringent than the corresponding federal MCL.

Chemical	MCLG	MCL
Arsenic	N.A.[8]	0.05 milligrams per liter (mg/l)[9]
Cadmium	0.005 mg/l[10]	0.005 mg/l[11]
Copper	1.3 mg/l[12]	1.3 mg/l[13]
Lead	N.A.[14]	0.015 mg/l[15]
Mercury	0.002 mg/l[16]	0.002 mg/l[17]

These standards incorporate applicable Resource Conversation and Recovery Act (RCRA) standards for groundwater found at 40 CFR Part 264, Subpart F, which is incorporated pursuant to state law at ARM 16.44.702. The RCRA standards are the same or less stringent than the MCLs or MCLGs identified above.

B. Surface Water - Ambient Standards and Point Source Discharges.

CERCLA and the NCP provide that federal water pollution criteria that match designated or anticipated surface water uses are the usual surface water standards to be used at Superfund cleanups, as relevant and appropriate standards, unless the state has promulgated surface water quality standards pursuant to the delegated state water quality act. The State of

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8 The MCLG for arsenic is zero, which is not considered appropriate for Superfund site cleanups.

9 40 CFR § 141.11, 60 Fed. Reg. 33926 (June 29, 1995).

10 40 CFR § 141.51

11 40 CFR § 141.62.

12 40 CFR § 141.51

13 40 CFR § 141.80(c). The requirement is an action level rather than a simple numerical standard.

14 The MCLG for lead is zero, which is not considered appropriate for Superfund site cleanups.

15 40 CFR § 141.80(c), which establishes an action level rather than a pure numerical standard.

16 40 CFR § 141.51.

17 40 CFR § 141.62.

Montana has designated uses for Silver Bow Creek and the Clark Fork River, and has promulgated specific standards accordingly. Those standards and their application to the Streamside Tailings Operable Unit, as well as other surface water standards, are included in the state ARARs identified below. These standards will be applied to all contaminants of concern identified in the Streamside Tailings Operable Unit remedial investigation, both to point sources retained or created by the Streamside Tailings cleanup and to ambient water in the Streamside Tailings Operable Unit.

C. Air Standards - Clean Air Act (Applicable)

Limitations on air emissions resulting from cleanup activities or emissions resulting from wind erosion of exposed hazardous substances are set forth in the action specific requirements, below.

II. FEDERAL LOCATION SPECIFIC REQUIREMENTS

A. Fish and Wildlife Coordination Act (Applicable)

These standards are found at 16 U.S.C. §§ 661 et seq. and 40 CFR § 6.302(g). They require that federally funded or authorized projects ensure that any modification of any stream or other water body affected by a funded or authorized action provide for adequate protection of fish and wildlife resources. Compliance with this ARAR necessitates consultation with the U.S. Fish and Wildlife Service (USFWS) and the State of Montana Department of Fish, Wildlife, and Parks. Further consultation with these agencies will occur during cleanup selection and implementation, and specific mitigative or other measures may be identified to achieve compliance with this ARAR.

B. Floodplain Management Order (Applicable)

This requirement (40 CFR Part 6, Appendix A, Executive Order No. 11,988) mandates that federally funded or authorized actions within the 100 year flood plain avoid, to the maximum extent possible, adverse impacts associated with development of a floodplain. Compliance with this requirement is detailed in EPA's August 6, 1985 "Policy on Floodplains and Wetlands Assessments for CERCLA Actions." Specific measures to minimize adverse impacts may be identified following consultation with the appropriate agencies.

If the remedial action selected for the Streamside Tailings Operable Unit is found to potentially affect the floodplain, the following information will be produced: a Statement of Findings which will set forth the reasons why the proposed action must be located in or affect the floodplain; a description of significant facts considered in making the decisions to locate in or affect the floodplain or wetlands including alternative sites or actions; a statement indicating whether the selected action conforms to applicable state or local floodplain protection standards; a description of the steps to be taken to design or modify the proposed action to minimize the potential harm to or within the floodplain; and a statement indicating how the proposed action affects the natural or beneficial values of the floodplain.

C. Protection of Wetlands Order (Applicable)

This requirement (40 CFR Part 6, Appendix A, Executive Order No. 11,990) mandates that federal agencies and potentially responsible parties (PRPs) avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists. Section 404(b)(1), 33 U.S.C. § 1344(b)(1), also prohibits the discharge of dredged or fill material into waters of the United States. (See also section III.D below.) Together, these requirements create a "no net loss" of wetlands standard.

Compliance with this ARAR will be achieved through consultation with the U.S. Fish and Wildlife Service and the U.S. Corp of Engineers, to determine the existence and category of wetlands present at the site, and any avoidance or mitigation and replacement which may be necessary. ARCO, USFWS, and EPA have established a protocol for addressing these issues during the RI/FS process.

D. The Endangered Species Act (Applicable)

This statute and implementing regulations (16 U.S.C. §§ 1531 - 1543, 50 CFR Part 402, and 40 CFR § 6.302(h)) require that any federal activity or federally authorized activity may not jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify a critical habitat.

Compliance with this requirement involves consultation with USFWS, and a determination of whether there are listed or proposed species or critical habitats present in the Streamside Tailings Operable Unit, and, if so, whether any proposed activities will impact such wildlife or habitat.

E. The National Historic Preservation Act (Applicable)

This statute and implementing regulations (16 U.S.C. § 470, 40 CFR § 6.310(b), 36 CFR Part 800) require federal agencies or federal projects to take into account the effect of any federally assisted undertaking or licensing on any district, site building, structure, or object that is included in, or eligible for, the Register of Historic Places. If effects cannot be avoided reasonably, measures should be implemented to minimize or mitigate the potential effect. In addition, Indian cultural and historical resources must be evaluated, and effects avoided, minimized, or mitigated.

In order to comply with this ARAR, EPA, MDEQ, and the PRP may consult with the State Historic Preservation Officer (SHPO), who can assist in identifying listed or eligible resources, and in assessing whether proposed cleanup actions will impact the resources and any appropriate mitigative measures. Additionally, in April 1992, ARCO, EPA, MDEQ, SHPO, the National Council on Historic Preservation, and local governments entered into a Programmatic Agreement to ensure the appropriate consideration of cultural and historical resources in a systematic and comprehensive manner throughout the Clark Fork Basin, in connection with response actions at the four Clark Fork Basin Superfund sites. A Second Programmatic Agreement was agreed upon in September 1994. The results of the

Programmatic Agreements may provide additional consideration of the factors to be addressed under this ARAR, and the two historical ARARs described below.

F. Archaeological and Historic Preservation Act (Applicable)

The statute and implementing regulations (16 U.S.C. § 469, 40 CFR § 6.301(c)) establish requirements for evaluation and preservation of historical and archaeological data, including Indian cultural and historical resources, which may be destroyed through alteration of terrain as a result of federal construction projects or a federally licensed activity or program. If eligible scientific, prehistorical, or archaeological data are discovered during site activities, they must be preserved in accordance with these requirements.

G. Historic Sites, Buildings, and Antiquities Act (Applicable)

Th' uirement states that "in conducting an environmental review of a proposed EPA act. he responsible official shall consider the existence and location of natural landmarks using information provided by the National Park Service pursuant to 36 CFR § 62.6(d) to avoid undesirable impacts upon such landmarks. The Programmatic Agreement activities described above should aid all parties in compliance with this ARAR.

H. Migratory Bird Treaty Act (Applicable)

This requirement (16 U.S.C. §§ 703 et seq.) establishes a federal responsibility for the protection of the international migratory bird resource and requires continued consultation with the USFWS during remedial design and remedial construction to ensure that the cleanup of the site does not unnecessarily impact migratory birds. Specific mitigative measures may be identified for compliance with this requirement.

I. Bald Eagle Protection Act (Applicable)

This requirement (16 U.S.C. §§ 668 et seq.) establishes a federal responsibility for protection of bald and golden eagles, and requires continued consultation with the USFWS during remedial design and remedial construction to ensure that any cleanup of the site does not unnecessarily adversely affect the bald and golden eagle. Specific mitigative measures may be identified for compliance with this requirement.

J. Resource Conservation and Recovery Act (Relevant and Appropriate)

Any discrete waste units created or retained by the Streamside Tailings site cleanup must comply with the siting restrictions and conditions found at 40 CFR § 264.18(a) and (b). These sections require management units to be designed, constructed, operated, and maintained to avoid washout, because they are within or near the 100 year flood plain.

III. FEDERAL ACTION SPECIFIC REQUIREMENTS

A. Solid Waste (Applicable), Surface Mining Control and Reclamation (Relevant and Appropriate), and RCRA (Relevant and Appropriate) Requirements

The contamination at the Streamside Tailings Operable Unit is primarily mining waste from various man-made sources. For the purposes of this record of decision, EPA and the State have determined that these wastes are not RCRA hazardous waste, in accordance with 40 CFR § 261.4(b)(7) (the Bevill exemption), although certain RCRA hazardous waste requirements have been determined to be relevant and appropriate in the handling of these wastes. For any management (i.e., treatment, storage, or disposal) or removal or retention of that contamination, the following requirements are ARARs.

1. Requirements described at 40 CFR §§ 257.3-1(a), 257.3-3, and 257.3-4, governing waste handling, storage, and disposal, including retention of the waste, in general, and 40 CFR §§ 257.3-5, relating to precautions necessary to ensure that cadmium is not taken up into crops, including pasture grasses, that may enter the food chain.[18]

2. For any discrete waste units which are addressed by the Streamside Tailings cleanup, reclamation and closure regulations found at 30 CFR Parts 816 and 784, governing coal and to a lesser extent, non-coal mining, are relevant and appropriate requirements.[19]

3. RCRA regulations found at 40 CFR §§ 264.116 and .119 (governing notice and deed restrictions), 264.228(a)(2)(i) (addressing de-watering of wastes prior to disposal), and 264.228(a)(2)(iii)(B), (C), and (D) and .251(c), (d), and (f) (regarding run-on and run-off controls), are relevant and appropriate requirements for the waste management units created or retained at the Streamside Tailings Operable Unit.[20]

B. Air Standards - Clean Air Act (Applicable)

These standards, promulgated pursuant to section 109 of the Clean Air Act,[21] are applicable to releases into the air from any Streamside Tailings Operable Unit cleanup activities.

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[18] Solid Waste regulations are promulgated pursuant to the federal Solid Waste Disposal Act, as amended by the Resource Conversation and Recovery Act, 42 U.S.C. 6901 et seq. They are applicable regulations, although the State of Montana has the lead role in regulating solid waste disposal in the State of Montana.

[19] The Surface Mining Control and Reclamation Act is promulgated at 30 U.S.C. Sections 1201 - 1326.

[20] As noted earlier, federal RCRA regulations are incorporated by reference into applicable State Hazardous Waste Management Act regulations. See ARM 17.54.702. Use of select RCRA regulations to mining waste is appropriate when discrete units are addressed by a cleanup and site conditions are distinguishable from EPA's generic determination of low toxicity/high volume status for mining waste. See Preamble to the Final NCP, 55 Fed. Reg. 8763 - 8764 (March 8, 1990), CERCLA Compliance with Other Laws Manual, Volume II (August 1989 OSWER Dir. 9234.1-02) p. 6-4; Preamble to Proposed NCP, 53 Fed. Reg. 51447 (Dec. 21, 1988), and guidance entitled "Consideration of RCRA Requirements in Performing CERCLA Responses at Mining Wastes Sites," August 19, 1986 (OSWER).

[21] 42 U.S.C. §§ 7401 et seq.

1. Lead: No person shall cause or contribute to concentrations of lead in the ambient air which exceed 1.5 micrograms per cubic meter ($\mu g/m^3$) of air, measured over a 90-day average.

These standards are promulgated at ARM 16.8.815 as part of a federally approved State Implementation Plan (SIP), pursuant to the Clean Air Act of Montana, §§ 75-2-101 et seq., MCA. Corresponding federal regulations are found at 40 CFR § 50.12.[22]

2. Particulate matter that is 10 microns in diameter or smaller (PM-10):
No person shall cause or contribute to concentrations of PM-10 in the ambient air which exceed:

- 150 $\mu g/m^3$ of air, 24 hour average, no more than one expected exceedence per calendar year;

- 50 $\mu g/m^3$ of air, annual average.

These regulations are promulgated at ARM 16.8.821 as part of a federally approved SIP, pursuant to the Clean Air Act of Montana, §§ 75-2-101 et seq., MCA. Corresponding federal regulations are found at 40 CFR § 50.6.

Ambient air standards under section 109 of the Clean Air Act are also promulgated for carbon monoxide, hydrogen sulfide, nitrogen dioxide, sulfur dioxide, and ozone. If emissions of these compounds were to occur at the site in connection with any cleanup action, these standards would also be applicable. See ARM 16.8.811 and 40 CFR Part 50.

C. Point Source Controls - Clean Water Act (Applicable)

If point sources of water contamination are retained or created by any Streamside Tailings Operable Unit remediation activity, applicable Clean Water Act standards would apply to those discharges. The regulations are discussed in the contaminant specific ARAR section, above, and in the State of Montana identification of ARARs. These regulations would include storm water runoff regulations found at 40 CFR Parts 121, 122, and 125 (general conditions and industrial activity conditions). These would also include requirements for best management practices and monitoring found at 40 CFR §§ 122.44(i) and 440.148, for point source discharges.

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[22] The ambient air standards established as part of Montana's approved State Implementation Plan in many cases provide more stringent or additional standards. The federal standards by themselves apply only to "major sources", while the State standards are fully applicable throughout the state and are not limited to "major sources". See ARM 16.8.808 and 16.8.811-.821. As part of an EPA-approved State Implementation Plan, the state standards are also federally enforceable. Thus, the state standards which are equivalent to the federal standards are identified in this section together. A more detailed list of State standards, which include standards which are not duplicated in federal regulations, is contained in the State ARAR identification section.

D. Dredge and Fill Requirements (Applicable)

Regulations found at 40 CFR Part 230 address conditions or prohibitions against depositing dredge and fill material into water of the United States. If remediation activities would result in an activity subject to these regulations, they would be applicable.

E. Underground Injection Control (Applicable)

Requirements found at 40 CFR Part 144, promulgated pursuant to the Safe Drinking Water Act, allow the re-injection of treated groundwater into the same formation from which it was withdrawn for aquifers such as the aquifer beneath the Streamside Tailings Operable Unit, and addresses injection well construction, operation, maintenance, and capping/closure. These regulations would be applicable to any reinjection of treated groundwater.

F. Transportation of Hazardous or Contaminated Waste (Relevant and Appropriate)

40 CFR Part 263 establishes regulations for the transportation of hazardous waste. These regulations would govern any on-site transportation of material. Any off-site transportation would be subject to applicable regulations.

STATE OF MONTANA ARARS

As provided by Section 121 of CERCLA, 42 U.S.C. § 9621, only those state standards that are more stringent than any federal standard and that have been identified by the state in a timely manner are appropriately included as ARARs. To be an ARAR, a state standard must be "promulgated," which means that the standards are of general applicability and are legally enforceable.

IV. MONTANA CONTAMINANT SPECIFIC REQUIREMENTS

A. Water Quality

1. Surface Water Quality Standards (Applicable)

Under the state Water Quality Act, §§ 75-5-101 et seq., MCA, the state has promulgated regulations to protect, maintain, and improve the quality of surface waters in the state. The requirements listed below are applicable water quality standards with which any remedial action must comply.

ARM 16.20.604(1)(b)(Applicable) provides that Silver Bow Creek (mainstem) from the confluence of Blacktail Deer Creek to Warm Springs Creek is classified "I" for water use.

The "I" classification standards are contained in ARM 16.20.623 (Applicable) of the Montana water quality regulations. This section states:

> [T]he goal of the state of Montana is to have these waters fully support the following uses: drinking, culinary, and food processing purposes after conventional treatment; bathing, swimming, and recreation; growth and propagation of fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply.

These beneficial uses are considered supported when the concentrations of toxic, carcinogenic, or harmful parameters in these waters do not exceed the applicable standards specified in department Circular WQB-7 when stream flows equal or exceed the stream flows specified in ARM 16.20.631(4)(10-year 7-day low flow, i.e., minimum consecutive 7-day average flow which may be expected to occur on the average of once in 10 years). Alternatively, site-specific criteria may be developed using the procedures given in the Water Quality Standards Handbook (US EPA, Dec. 1983), provided that other routes of exposure to toxic parameters by aquatic life are addressed.[23] These standards set the contaminant specific requirement for ambient water quality in the stream.

To allow a gradual attainment of these requirements in already impacted streams, the I classification allows point source discharges to be permitted at the higher concentration of (1)

[23] Such other routes of exposure in this operable unit would include, for example, contaminated sediment/food chain routes of exposure. In any event, no site specific standards have been developed for Silver Bow Creek, as of the issuance of the record of decision, and consequently the applicable numeric standards are those set forth in WQB-7.

the applicable standards specified in department Circular WQB-7, (2) the site-specific standards, or (3) one-half of the mean instream concentrations[24] immediately upstream of the discharge point. This effectively requires eventual attainment of the Circular WQB-7 levels in the stream, while allowing consideration of the current, impacted stream quality (a graduated reduction of point source discharge concentrations based on the mean instream concentration where the stream is substantially degraded). As the quality of the stream improves due to control of other sources, including cleanup of non-point source areas, point source dischargers must improve the quality of their discharges down to the instream standards (either WQB-7 or, for aquatic life only, site specific standards).

With respect to the remediation of non-point sources, the WQB-7 standards effectively set the ambient water quality standards that are to be attained by the remedial action. As an ambient standard, the point of compliance for these standards would be throughout the stream, and compliance should be measured by monitoring at several different points within the stream, as determined by any significant point sources or significant reaches of non-point sources.

For the primary contaminants of concern, the WQB-7 levels are listed below. WQB-7 provides that "whenever both Aquatic Life Standards and Human Health Standards exist for the same analyte, the more restrictive of these values will be used as the numeric Surface Water Quality Standard."

Chemical	WQB-7 Standard
Arsenic	18 μg/l[25]
Cadmium	1.1 μg/l[26]
Copper	12 μg/l[27]
Lead	3.2 μg/l[28]
Mercury	0.012 μg/l[29]

I classification standards also include the following criteria:

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24 Mean instream concentration is the monthly mean instream concentration, as defined by the MDHES Water Quality Bureau.

25 Human Health Standard. The acute and chronic Aquatic Life Standards are 360 μg/l and 190 μg/l, respectively.

26 Chronic Aquatic Life Standard based on 100 mg/l hardness ($CaCO_3$). The method for adjusting the standard for water hardness is provided in WQB-7. See Detailed Note of Explanation 12 in Circular WQB-7. In no event can the level for cadmium exceed the human health standard of 5 μg/l.

27 Chronic Aquatic Life Standard based on 100 mg/l hardness. See Detailed Note of Explanation 12 in Circular WQB-7.

28 Chronic Aquatic Life Standard based on 100 mg/l hardness. See Detailed Note of Explanation 12 in Circular WQB-7. In no event can the level for lead exceed the human health standard at 15 μg/l.

29 Chronic Aquatic Life Standard. The human health standard for mercury is 0.14 μg/l.

1. Dissolved oxygen concentration must not be reduced below 3.0 milligrams per liter.

2. Hydrogen ion concentration (Ph) must be maintained within the range of 6.5 to 9.5.

3. No increase in naturally occurring turbidity, temperature, concentrations of sediment and settleable solids, oils, floating solids, or true color is allowed which will or is likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish or other wildlife.

4. No discharges of toxic, carcinogenic, or harmful parameters may commence or continue which lower or are likely to lower the overall water quality of these waters.

Additional restrictions on any discharge to surface waters are included in:

ARM 16.20.633 (Applicable), which prohibits discharges containing substances that will:

(a) settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines;
(b) create floating debris, scum, a visible oil film (or be present in concentrations at or in excess of 10 milligrams per liter) or globules of grease or other floating materials;
(c) produce odors, colors or other conditions which create a nuisance or render undesirable tastes to fish flesh or make fish inedible;
(d) create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life;
(e) create conditions which produce undesirable aquatic life.

ARM 16.20.925 (Applicable), which adopts and incorporates the provisions of 40 C.F.R. Part 125 for criteria and standards for the imposition of technology-based treatment requirements in MPDES permits. Although the permit requirement would not apply to on-site discharges, the substantive requirements of Part 125 are applicable, i.e., for toxic and nonconventional pollutants treatment must apply the best available technology economically achievable (BAT); for conventional pollutants, application of the best conventional pollutant control technology (BCT) is required. Where effluent limitations are not specified for the particular industry or industrial category at issue, BCT/BAT technology-based treatment requirements are determined on a case by case basis using best professional judgment (BPJ). See CERCLA Compliance with Other Laws Manual, Vol. I, August 1988, p. 3-4 and 3-7.

Applicable for both surface water and ground water, § 75-5-605, MCA, provides that it is unlawful to cause pollution as defined in 75-5-103 of any state waters or to place or cause to be placed any wastes where they will cause pollution of any state waters.

Section 75-5-308, MCA, allows DEQ to grant short-term exemptions from the water quality standards or short-term use that exceeds the water quality standards for the purpose of allowing certain construction or emergency environmental remediation activities. Such exemptions typically extend for a period of 30-60 days. However, any exemption must include conditions that minimize to the extent possible the magnitude of the violation and the length of time the violation occurs. In addition, the conditions must maximize the protection of state waters by ensuring the maintenance of beneficial uses immediately after termination of the exemption. Water quality and quantity monitoring and reporting may also be included as conditions.

2. Groundwater Pollution Control System (Applicable)

In addition to the standards set forth below, relevant and appropriate MCLs and MCLGs are included in the federal ARARs identified above.

ARM 16.20.1002 (Applicable) classifies groundwater into Classes I through IV based on the present and future most beneficial uses of the groundwater, and states that groundwater is to be classified according to actual quality or actual use, whichever places the groundwater in a higher class. Class I is the highest quality class; class IV the lowest. Based upon its specific conductance, the great majority of the groundwater in the Streamside Tailings Operable Unit should be considered Class I groundwater, with the remainder of the groundwater Class II.[30]

ARM 16.20.1003 (Applicable) establishes the groundwater quality standards applicable with respect to each groundwater classification. Concentrations of dissolved substances in Class I or II groundwater (or Class III groundwater which is used as a drinking water source) may not exceed the human health standards listed in department Circular WQB-7. For the primary contaminants of concern these levels are listed below. Levels that are more stringent than the MCL or MCLG identified in the federal portion of the ARARs are set out in **boldface** type.

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[30] ARM 16.20.1002 provides that Class I groundwaters have a specific conductance of less than 1000 micromhos per centimeter at 25° C; Class II groundwaters: 1000 to 2500; Class III groundwaters: 2500 to 15,000; and Class IV groundwaters: over 15,000. The groundwater in the operable unit generally ranges from 298 to 3245 micromhos/cm, with the majority of the wells testing well below 1000. See 1991 Remedial Investigation Activities Data Summary Report, Table 11 (ARCO, August 1993); Final 1992 Data Summary Report, Table 15 (ARCO, September 1994)(showing a range of 331-2092 μmhos/cm).

At the uppermost level of the aquifer, in those locations where the groundwater is in contact with a contaminant source, there are areas that have specific conductance greater than 2500 μmhos/cm. However, the groundwater in this aquifer generally is of Class I quality, with the areas of greater specific conductance constituting discrete areas of contamination. For purposes of applying these standards in this action, the classification of the groundwater in the area should be based on the quality of the groundwater generally, rather than the specific areas of contamination.

In addition, classification of the groundwater is based on actual quality or actual use as of October 29, 1982. See ARM 16.20.1002(3). Considering the history of contamination at the site, there is no reason to assume that the quality of this ground water in 1982 would have been other than Class I or II.

Chemical	WQB-7 Human Health Standard
Arsenic	**18 μg/l**
Cadmium	5 μg/l
Copper	**1000 μg/l**
Lead	15 μg/l
Mercury	**0.14 μg/l**

Concentrations of other dissolved or suspended substances must not exceed levels that render the waters harmful, detrimental or injurious to public health. Maximum allowable concentration of these substances also must not exceed acute or chronic problem levels that would adversely affect existing or designated beneficial uses of groundwater of that classification. ARM 16.20.1003 specifies certain references that may be used as a guide in determining problem levels unless local conditions make these values inappropriate.

An additional concern with respect to ARARs for groundwater is the impact of groundwater upon the surface water. If significant loadings of contaminants from groundwater sources to Silver Bow Creek contribute to the inability of the stream to meet the I class standards (i.e., the WQB-7 levels described in the Surface Water section above), then alternatives to alleviate such groundwater loading must be evaluated and, if appropriate, implemented. Groundwater in certain areas may need to be remediated to levels more stringent than the groundwater classification standards for certain parameters in order to achieve the standards for affected surface water. See Compliance with Federal Water Quality Criteria, OSWER Publication 9234.2-09/FS (June 1990)("Where the ground water flows naturally into the surface water, the ground-water remediation should be designed so that the receiving surface-water body will be able to meet any ambient water-quality standards (such as State WQSs or FWQC) that may be ARARs for the surface water.")

The 1995 Montana Legislature enacted several revisions to the Montana Water Quality Statutes. Except as reflected in the analysis above, none of these changes has altered the application of these water quality requirements to the Streamside Tailings Operable Unit. One bill exempted from the permit requirements certain discharges from a water conveyance structure or certain groundwater discharged to surface water, but these exemptions do not apply if the discharged water contains "industrial waste." See § 75-5-401, MCA, as amended. "Industrial waste" means a waste substance from the process of business or industry or from the development of any natural resource..." § 75-5-103(10), MCA. Since the contamination found in the water in this operable unit is industrial waste, these new exemptions would not apply here.

B. Air Quality

In addition to the standards identified in the federal action specific ARARs above, the State of Montana has identified certain air quality standards in the action specific section of the State ARARs below.

V. MONTANA LOCATION SPECIFIC REQUIREMENTS

A. Floodplain and Floodway Management Act and Regulations (Applicable)

The Floodplain and Floodway Management Act and regulations specify types of uses and structures that are allowed or prohibited in the designated 100-year floodway[31] and floodplain.[32] Since the SST Operable Unit lies primarily within the 100-year floodplain of Silver Bow Creek, these standards are applicable to all actions contemplated for this operable unit.

1. Allowed uses

The law recognizes certain uses as allowable in the floodway and a broader range of uses as allowed in the floodplain. Residential use is among the possible allowed uses expressly recognized in both the floodway and floodplain. "Residential uses such as lawns, gardens, parking areas, and play areas," as well as certain agricultural, industrial-commercial, recreational and other uses are permissible within the designated floodway, provided they do not require structures other than portable structures, fill or permanent storage of materials or equipment. § 76-5-401, MCA; ARM 36.15.601 (Applicable). In addition, in the flood fringe (i.e., within the floodplain but outside the floodway), residential, commercial, industrial, and other structures may be permitted subject to certain conditions relating to placement of fill, roads, floodproofing, etc. § 76-5-402, MCA; ARM 36.15.701 (Applicable). Domestic water supply wells may be permitted, even within the floodway, provided the well casing is watertight to a depth of 25 feet and the well meets certain conditions for floodproofing, sealing, and positive drainage away from the well head. ARM 36.15.602(6).

2. Prohibited uses

Uses prohibited anywhere in either the floodway or the floodplain are:

1. solid and hazardous waste disposal; and
2. storage of toxic, flammable, hazardous, or explosive materials.

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31 The "floodway" is the channel of a watercourse or drainway and those portions of the floodplain adjoining the channel which are reasonably required to carry and discharge the floodwater of the watercourse or drainway. ARM 36.15.101(13).

32 The "floodplain" is the area adjoining the watercourse or drainway which would be covered by the floodwater of a base (100-year) flood except for sheetflood areas that receive less than one foot of water per occurrence. The floodplain consists of the floodway and flood fringe.

ARM 36.15.605(2) and 36.15.703 (Applicable[33]); see also ARM 36.15.602(5)(b) (Applicable).

In the floodway, additional prohibitions apply, including prohibition of:

1. a building for living purposes or place of assembly or permanent use by human beings;

2. any structure or excavation that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway; and

3. the construction or permanent storage of an object subject to flotation or movement during flood level periods.

§ 76-5-402, MCA (Applicable).

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[33] One commenter asserted that these regulations are not applicable to the SST OU. MDEQ has evaluated these arguments and has still determined that these are applicable requirements. Under the NCP, 40 CFR § 300.400(g)(1), MDEQ must make an "objective determination of whether the requirement specifically addresses a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found" at the site. MDEQ has made the determination here that these requirements specifically address the hazardous substances and location involved and are applicable legal requirements. While these prohibitions are applicable requirements, exactly how these prohibitions apply to specific mining wastes being addressed in this operable unit and the manner in which these prohibitions apply to specific actions requires some analysis. The floodplain management regulations include a version of this prohibition in three different provisions. ARM 36.15.605(2) and 36.15.703, applicable to the floodway and the flood fringe, respectively, state this prohibition generally as noted above. ARM 36.15.602(5)(b), applicable to the floodway, allows storage of materials and equipment under certain conditions, but provides "Storage of flammable, toxic, or explosive materials shall not be permitted."

Neither the regulations nor the Floodplain Management Act defines the terms disposal, storage, solid waste, hazardous waste, toxic materials or hazardous materials. In most contexts, the regulations are clear enough, by their plain meaning, to be easily implementable. As applied to the specific circumstances at this operable unit, however, these terms require some interpretation. This interpretation is further complicated by the fact that at least a substantial part of the tailings deposited along Silver Bow Creek can be assumed to have been deposited before the effective date of the regulations here. Thus the initial disposal of these materials does not constitute a violation of the regulations. However, as discussed in footnote 36, below, actions taken to actively manage these materials as part of the remedial action effectively trigger applicability of such requirements in certain circumstances.

These issues are discussed more fully in the responsiveness summary portion of the record of decision, in response to comments submitted by the Atlantic Richfield Company regarding ARARs issues. Summarized here, the department's analysis has determined that the tailings and mining wastes in the SST OU are included in the term solid wastes, as well as the terms toxic materials or hazardous materials, and that the prohibition on the disposal or storage of those wastes/materials within the floodplain applies to actions which constitute the active management/disposal of those wastes as part of the remedial action. The agencies further note that, if there were some jurisdictional prerequisite which were technically not met for applicability, the requirements identified here would be relevant and appropriate requirements as described for this remedial action. In such case, the agencies would apply these requirements as relevant and appropriate considering the factors set forth at 40 CFR § 300.400(g)(2)(i) through (viii).

Finally, in the record of decision, MDEQ and EPA invoke a waiver of this requirement under section 121(d)(4)(D) of CERCLA, 42 USC § 9621(d)(4)(D), to allow the remedial action, under certain conditions, to incorporate certain actions that will attain a standard of performance that is equivalent to that required under the prohibitions described above. The analysis of the ARAR waiver and the conditions on which the agencies have determined that equivalent standard of performance can be attained are set out in the Decision Summary portion of the record of decision.

3. Applicable considerations in use of floodplain or floodway

Applicable regulations also specify factors that must be considered in allowing diversions of the stream, changes in place of diversion of the stream, flood control works, new construction or alteration of artificial obstructions, or any other nonconforming use within the floodplain or floodway. Many of these requirements are set forth as factors that must be considered in determining whether a permit can be issued for certain obstructions or uses. While permit requirements are not directly applicable to remedial actions conducted entirely on site, the substantive criteria used to determine whether a proposed obstruction or use is permissible within the floodway or floodplain are applicable standards. Factors which must be considered in addressing any obstruction or use within the floodway or floodplain include:

1. the danger to life and property from backwater or diverted flow caused by the obstruction or use;

2. the danger that the obstruction or use will be swept downstream to the injury of others;

3. the availability of alternate locations;

4. the construction or alteration of the obstruction or use in such a manner as to lessen the danger;

5. the permanence of the obstruction or use; and

6. the anticipated development in the foreseeable future of the area which may be affected by the obstruction or use.

See § 76-5-406, MCA; ARM 36.15.216 (Applicable, substantive provisions only). Conditions or restrictions that generally apply to specific activities within the floodway or floodplain are:

1. the proposed activity, construction, or use cannot increase the upstream elevation of the 100-year flood a significant amount (½ foot or as otherwise determined by the permit issuing authority) or significantly increase flood velocities, ARM 36.15.604 (Applicable, substantive provisions only); and

2. the proposed activity, construction, or use must be designed and constructed to minimize potential erosion.

For the substantive conditions and restrictions applicable to specific obstructions or uses, see the following applicable regulations:

Excavation of material from pits or pools - ARM 36.15.602(1).

Water diversions or changes in place of diversion - ARM 36.15.603.

Flood control works (levees, floodwalls, and riprap must comply with specified safety standards) - ARM 36.15.606.

Roads, streets, highways and rail lines (must be designed to minimize increases in flood heights) - ARM 36.15.701(3)(c).

Structures and facilities for liquid or solid waste treatment and disposal (must be floodproofed to ensure that no pollutants enter flood waters and may be allowed and approved only in accordance with MDEQ regulations, which include certain additional prohibitions on such disposal) - ARM 36.15.701(3)(d).

Residential structures - ARM 36.15.702(1).

Commercial or industrial structures - ARM 36.15.702(2).

B. Solid Waste Management Regulations (Applicable)

Regulations promulgated under the Solid Waste Management Act, §§ 75-10-201 et seq., MCA, specify requirements that apply to the location of any solid waste management facility.[34] Under ARM 17.50.505 (formerly 16.14.505)(Applicable), a facility for the treatment, storage or disposal of solid wastes:[35]

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34 These requirements apply, inter alia, to the treatment, storage, or disposal of solid waste. See ARM 16.14.502(17).

35 The solid waste regulations are applicable to the wastes at issue in this operable unit, which consist of mining wastes, primarily tailings, which have been washed downstream and deposited along Silver Bow Creek for many years. Section 75-10-203(11) provides:

> (a) "Solid waste" means all putrescible and nonputrescible wastes, including but not limited to garbage; rubbish; refuse; ...
>
> (b) Solid waste does not mean municipal sewage, industrial wastewater effluents, mining wastes regulated under the mining and reclamation laws administered by the department of environmental quality, slash and forest debris regulated under laws administered by the department of natural resources and conservation, or marketable byproducts."

As noted, "solid waste" does not include "mining wastes regulated under the mining and reclamation laws administered by the Department of Environmental Quality," see § 75-10-203(11), MCA, as amended by Chapter 418, Laws of Montana 1995. However, the mining wastes found in the Streamside Tailings Operable Unit are not regulated under the mining and reclamation laws administered by the Department of Environmental Quality, because they are not part of any current mining permit or mine reclamation plan.

One commenter argued that "mining wastes are specifically excluded from the definition of 'solid waste.'" This argument may be read as an assertion that the exemption of "mining wastes regulated under the mining and reclamation laws" is broad enough to cover all mining wastes. However, both the plain meaning of the language and other principles of statutory construction weigh against such an interpretation. The words "regulated under the mining and reclamation laws" suggest actual regulation rather than a categorical exclusion of all mining wastes whether specific wastes are actually regulated or not. Where this statute provides a categorical exclusion, it does so in clear categorical language, without the qualification "regulated under ...". For example, the statute categorically exempts "municipal sewage" and "industrial wastewater effluents" without any such qualification.

(a) must be located where a sufficient acreage of suitable land is available for solid waste management;

(b) may not be located in a 100-year floodplain;[36]

The commenter's interpretation of the statute would render the words "regulated under ..." superfluous, in contravention of accepted principles of statutory construction. Moreover, an apparent purpose for the exemption is to avoid duplicative or conflicting regulation of the wastes, which would occur only in the event the wastes were actually subject to both sets of regulations. The language of the statute is not ambiguous, and under the plain meaning of the provision the exemption of mining wastes should be viewed as limited to those wastes which are actually regulated under the mining and reclamation laws. The mining wastes being addressed in this operable unit are not so regulated, and thus are not within this exemption from solid waste regulations.

36 The application of this requirement to certain alternatives considered in the SST OU remedy selection requires some clarification. This regulation was promulgated in the 1970's, and for purposes of this determination, the initial "disposal" of these wastes in the SSTOU can be assumed to have occurred before promulgation of the regulation. Thus as these wastes lie in the ground, no one would be required to remove them in order to comply with the solid waste regulations. However, compliance with such regulations is required if any action taken with respect to such wastes constitutes "active management" of those wastes. EPA has interpreted "active management" as "physically disturbing accumulated wastes within a management unit ..." See, e.g., 57 Fed. Reg. 37298 (August 18, 1992), 54 Fed. Reg. 36597 (September 1, 1989).

Effectively, any "active management" is to be regarded as constituting a new "disposal" of these solid wastes, triggering applicability of the state solid waste regulations, including the prohibition on disposing solid wastes in the floodplain. As applied to the alternatives being considered for the SSTOU, either excavating and placing the wastes in a repository or applying STARS treatment in situ, which consists of tilling lime-based amendments into the tailings in place, would constitute "active management" of the wastes. Thus treating floodplain wastes in place in this manner would not comply with the prohibition on storage or disposal of these wastes within the floodplain, and an ARAR waiver would be required for this alternative.

One commenter has asserted that disposal does not occur where waste is consolidated within a unit, waste is capped in place, including grading prior to capping, or waste is treated in situ. This argument derives from discussion in the CERCLA Compliance with Other Laws Manual: Interim Final (August 1988), p. 2-16. However, this discussion in the manual relates to "land disposal" or "placement" of wastes under RCRA Subtitle C (hazardous waste) and land ban rules, referred to in the manual as "placement/disposal."

A distinction must be made between RCRA's broad jurisdictional definition of "disposal," which is virtually identical to the state's broad definition of disposal, and the specific type of disposal triggering certain RCRA Subtitle C and land ban requirements, referred to as "land disposal." The term "disposal" is often used as shorthand in discussing RCRA's Subtitle C hazardous waste requirements, when technically referring to "land disposal." Thus in some instances the language in the manual and other sources seems to address the definition of disposal generally, rather than placement/disposal for land ban purposes.

However, an analysis of other sources makes clear that the activities addressed in this section of the manual relate only to RCRA's definition of land ban placement or "land disposal," and not to the broader definition of "disposal" under RCRA. The preamble to the final NCP notes the "Congressional choice to define 'land disposal' more narrowly ... than the already existing term 'disposal,'" which has a much broader meaning under RCRA. The Preamble continues:

> Under RCRA section 1004(3), the term "disposal" is very broadly defined and includes any "discharge, deposit, injection, dumping, spilling, leaking, or placing" of waste into or on any land or water. Thus "disposal" [in a statutory, rather than the regulatory subtitle C meaning of the term] would include virtually any movement of waste, whether within a unit or across a unit boundary.... However, Congress did not use the term "disposal" as its trigger for the RCRA land disposal restrictions, but instead specifically defined the new, and more narrow, term "land disposal" in section 3004(k). **The broader "disposal" language continues to be applicable to RCRA provisions other than those in subtitle C,** such as section 7003. (Emphasis added.)

(c) may be located only in areas which will prevent the pollution of ground and surface waters and public and private water supply systems;

(d) must be located to allow for reclamation and reuse of the land;

(e) drainage structures must be installed where necessary to prevent surface runoff from entering waste management areas; and

(f) where underlying geological formations contain rock fractures or fissures which may lead to pollution of the ground water or areas in which springs exist that are hydraulically connected to a proposed disposal facility, only Class III disposal facilities may be approved.[37]

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55 Fed. Reg. 8759 (March 8, 1990). The state's definition of "disposal" in the Montana Solid Waste Management Act is identical to the broader definition of disposal under RCRA. See § 75-10-203(3), MCA. Thus what constitutes a new disposal triggering applicability of the solid waste requirements should be based on the broader "disposal" test, rather than the narrower "land disposal" test proffered by the commenter.

Such an interpretation of "disposal" is also supported by judicial interpretations of the definition of "disposal" under CERCLA, which also is identical to the definition appearing in the state's Solid Waste Management Act and regulations. *See, e.g.,* Kaiser Aluminum & Chemical Corporation v. Catellus Development Corporation, 976 F.2d 1338 (9th Cir. 1992)("the term *'disposal' should not be limited solely to the initial introduction of hazardous substances* onto property. Rather, consistent with the overall remedial purpose of CERCLA, "disposal" should be read broadly to include the subsequent [movement, dispersal, or release] of such substances during landfill excavations and fillings.") (quoting Tanglewood East Homeowners v. Charles-Thomas, Inc., 849 F.2d 1568 (5th Cir. 1988)).

Finally, § 75-10-214(1)(b), MCA, provides that the Solid Waste Management Act does not apply to the operation of a mine, mill, or smelter. This provision exempts any disposal of wastes as part of the operation of a mine, mill, or smelter from the requirements of the Solid Waste Management Act and corresponding regulations. The agencies must still determine, however, whether these requirements are applicable to actions taken as part of a remedial action under CERCLA rather than as part of the operation of a mine, mill, or smelter or whether these requirements should be considered relevant and appropriate requirements for this remedial action.

The agencies have determined that for certain actions that are to be conducted as part of the remedial action for the operable unit, the regulations should be considered applicable legal requirements. As noted above, those actions that constitute "active management," or a new disposal, of the wastes trigger applicability of the regulations to such actions. The exemption for the operation of a mine, mill or smelter does not exempt such an action since the new disposal cannot be regarded as part of the operation of a mine, mill or smelter.

Moreover, if any of the exemptions noted above or any jurisdictional basis for exempting these wastes from the Solid Waste Management Act were justified, the agencies would find, using the criteria specified in the NCP, 40 CFR § 300.400(g)(2)(i) through (viii), that the solid waste management regulations specifically identified in this ARARs analysis are relevant and appropriate requirements for this remedial action. The identified requirements address problems or situations sufficiently similar and are well-suited to the circumstances involved here so that they should be considered relevant and appropriate requirements for this action. Specifically, the identified requirements are intended to address the type and location of wastes and the remedial actions contemplated here. They were developed for the purpose of preventing future problems resulting from the inappropriate storage or disposal of solid wastes, particularly those wastes containing hazardous substances that pose a threat to human health or the environment, such as the tailings and other materials involved here, and particularly those problems that result from inappropriate selection of a disposal site or location, such as areas that are in contact with groundwater or streams.

37 Group III wastes consist of primarily inert wastes, including "industrial mineral wastes which are essentially inert and non-water soluble and do not contain hazardous waste constituents." ARM 16.14.503(1)(b). The tailings and similar wastes found in the SSTOU do not fall within this category and are at least Group II wastes.

C. Natural Streambed and Land Preservation Standards (Applicable)

Sections 87-5-502 and 504, MCA, (Applicable -- substantive provisions only) provide that a state agency or subdivision shall not construct, modify, operate, maintain or fail to maintain any construction project or hydraulic project which may or will obstruct, damage, diminish, destroy, change, modify, or vary the natural existing shape and form of any stream or its banks or tributaries in a manner that will adversely affect any fish or game habitat. The requirement that any such project must eliminate or diminish any adverse effect on fish or game habitat is applicable to the state in approving remedial actions to be conducted. The Natural Streambed and Land Preservation Act of 1975, §§ 75-7-101 et seq., MCA, (Applicable -- substantive provisions only) includes similar requirements and is applicable to private parties as well as government agencies.

ARM 36.2.404 (Applicable) establishes minimum standards which would be applicable if a remedial action alters or affects a streambed, including any channel change, new diversion, riprap or other streambank protection project, jetty, new dam or reservoir or other commercial, industrial or residential development. No such project may be approved unless reasonable efforts will be made consistent with the purpose of the project to minimize the amount of stream channel alteration, insure that the project will be as permanent a solution as possible and will create a reasonably permanent and stable situation, insure that the project will pass anticipated water flows without creating harmful erosion upstream or downstream, minimize turbidity, effects on fish and aquatic habitat, and adverse effects on the natural beauty of the area and insure that streambed gravels will not be used in the project unless there is no reasonable alternative. Soils erosion and sedimentation must be kept to a minimum. Such projects must also protect the use of water for any useful or beneficial purpose. See § 75-7-102, MCA.

While the administrative/procedural requirements, including the consent and approval requirements, set forth in these statutes and regulations are not ARARs, the party designing and implementing the remedial action for the Streamside Tailings Operable Unit is encouraged to continue to consult with the Montana Department of Fish, Wildlife and Parks, and any conservation district or board of county commissioners (or consolidated city/county government) as provided in the referenced statutes, to assist in the evaluation of factors discussed above.

VI. MONTANA ACTION SPECIFIC REQUIREMENTS

In the following action-specific ARARs, the nature of the action triggering applicability of the requirement is stated in parentheses as part of the heading for each requirement.

A. Water Quality

1. Groundwater Act (Applicable) (Construction and maintenance of groundwater wells)

Section 85-2-505, MCA, (Applicable) precludes the wasting of groundwater. Any well producing waters that contaminate other waters must be plugged or capped, and wells must be constructed and maintained so as to prevent waste, contamination, or pollution of groundwater.

2. Public Water Supply Regulations (Applicable) (Reconstruction or modification of public water or sewer lines on the site)

If remedial action at the site requires any reconstruction or modification of any public water supply line or sewer line, the construction standards specified in ARM 16.20.401(3) (Applicable) must be observed.

B. Air Quality

1. Air Quality Regulations (Applicable) (Excavation/earth-moving; transportation)

Dust suppression and control of certain substances likely to be released into the air as a result of earth moving, transportation and similar actions may be necessary to meet air quality requirements. Certain ambient air standards for specific contaminants and particulates are set forth in the federal action specific section above. Additional air quality regulations under the state Clean Air Act, §§ 75-2-101 et seq., MCA, are discussed below.

ARM 16.8.1302 (Applicable) lists certain wastes that may not be disposed of by open burning[38], including oil or petroleum products, RCRA hazardous wastes, chemicals, and treated lumber and timbers. Any waste which is moved from the premises where it was generated and any trade waste (material resulting from construction or operation of any business, trade, industry or demolition project) may be open burned only in accordance with the substantive requirements of 16.8.1307 or 1308.

ARM 16.8.1401(1) and (2) (Applicable) provides that no person shall cause or authorize the production, handling, transportation or storage of any material; or cause or authorize the use of any street, road, or parking lot; or operate a construction site or demolition project, unless reasonable precautions to control emissions of airborne particulate matter are taken. Emissions of airborne particulate matter must be controlled so that they do not "exhibit an opacity of twenty percent (20%) or greater averaged over six consecutive minutes." ARM 16.8.1401(1) and (2) (Applicable) and ARM 16.8.1404 (Applicable).

In addition, state law provides an ambient air quality standard for settled particulate matter. Particulate matter concentrations in the ambient air shall not exceed the following 30-day average: 10 grams per square meter. ARM § 16.8.818 (Applicable).

The Butte area has been designated by EPA as non-attainment for total suspended particulates, as well as PM-10. 40 CFR § 81.327. ARM 16.8.1401(4) (Applicable) requires that any new source of airborne particulate matter that has the potential to emit less than 100 tons per year of particulates shall apply best available control technology (BACT); any new

[38] "'Open burning' means combustion of any material directly in the open air without a receptacle, or in a receptacle other than a furnace, multiple chambered incinerator or wood waste burner ..." ARM 16.8.1301(5).

source of airborne particulate matter that has the potential to emit more than 100 tons per year of particulates shall apply lowest achievable emission rate (LAER). The BACT and LAER standards are defined in ARM 16.8.1430. A significant source of the non-attainment for particulates and PM-10 in the Butte area is road dust. Accordingly, special precautions should be taken in this area to limit dust emissions from remedial activities.

ARM 26.4.761 (Relevant and Appropriate) specifies a range of measures for controlling fugitive dust emissions during mining and reclamation activities. Some of these measures could be considered relevant and appropriate to control fugitive dust emissions in connection with excavation, earth moving and transportation activities conducted as part of the remedy at the site. Such measures include, for example, paving, watering, chemically stabilizing, or frequently compacting and scraping roads, promptly removing rock, soil or other dust-forming debris from roads, restricting vehicle speeds, revegetating, mulching, or otherwise stabilizing the surface of areas adjoining roads, restricting unauthorized vehicle travel, minimizing the area of disturbed land, and promptly revegetating regraded lands.

C. Solid Waste Regulations

As noted in Section V.B above, the state Solid Waste Management Regulations are applicable to the disposal/active management of the tailings and similar wastes within this operable unit. Certain location specific requirements are identified in Section V.B above. Action specific solid waste regulations are discussed below.

ARM 17.50.505(2) (formerly 16.14.505(2))(Applicable) specifies standards for solid waste management facilities, including the requirements that:

1. if there is the potential for leachate migration, it must be demonstrated that leachate will only migrate to underlying formations which have no hydraulic continuity with any state waters;

2. adequate separation of such wastes from underlying or adjacent water must be provided, considering terrain, type of underlying soil formations, and facility design (the Waste Management Division of MDEQ has generally construed this to require a minimum separation of 10-20 feet); and

3. no new disposal units or lateral expansions may be located in wetlands.

ARM 17.50.523 (formerly 16.14.523)(Relevant and Appropriate) requires that such waste must be transported in such a manner as to prevent its discharge, dumping, spilling, or leaking from the transport vehicle.

Section 75-10-206, MCA, allows variances to be granted from solid waste regulations if failure to comply with the rules does not result in a danger to public health or safety or compliance with specific rules would produce hardship without producing benefits to the health and safety of the public that outweigh the hardship. In light of the nature of the wastes at issue and the likelihood that any repository would contain only a single type of waste, i.e. tailings and related materials, considering the volume of wastes involved (1.5 to

2.5 million cubic yards) and the cost of full compliance with all solid waste requirements, and considering available Superfund procedures for the maintenance of remedies and the ability of the agencies, within the Superfund process, to consider the characteristics of the particular wastes at issue in appropriately determining and designing repositories, certain of the Solid Waste Regulations regarding design of landfills, ARM 17.50.506, operational and maintenance requirements, ARM 17.50.520-521, and landfill closure requirements and post-closure care, ARM 17.50.530-531, may appropriately be subject to variance in implementing the remedy at this operable unit. The scope and manner of applying the variance can be determined in finalizing and approving of the remedial design by the agencies. For example, the barrier layer (liner) and leachate collection and removal system requirements of ARM 17.50.506 (Design Criteria for Landfills) may be subject to variance as long as the design approved by MDEQ ensures that the concentration values listed in Table 1, ARM 17.50.506, will not be exceeded in the uppermost aquifer. Similarly, the groundwater monitoring requirements of ARM 17.50.701 et seq. can be considered and coordinated with any other monitoring requirements under CERCLA.

D. Reclamation Requirements

The Strip and Underground Mine Reclamation Act, §§ 82-4-201 et seq., MCA, technically applies to coal and uranium mining, but that statute and the regulations promulgated under that statute and discussed in this section, set out the standards that mine reclamation should attain. Those requirements identified here have been determined to be relevant and appropriate requirements for this action. Section 82-4-231 (Relevant and Appropriate) requires the reclamation and revegetation of the land as rapidly, completely, and effectively as the most modern technology and the most advanced state of the art will allow. In developing a method of operation and plans of backfilling, water control, grading, topsoiling and reclamation, all measures shall be taken to eliminate damages to landowners and members of the public, their real and personal property, public roads, streams, and all other public property from soil erosion, subsidence, landslides, water pollution, and hazards dangerous to life and property. Sections 82-4-231(10)(j) and (i) and ARM 26.4.751 (Relevant and Appropriate) provide that reclamation of mine waste materials shall, to the extent possible using the best technology currently available, minimize disturbances and adverse impacts of the operation on fish, wildlife, and related environmental values and achieve enhancement of such resources where practicable, and shall avoid acid or other toxic mine drainage by such measures as preventing or removing water from contact with toxic-producing deposits. ARM 26.4.641 (Relevant and Appropriate) also provides that drainage from acid-forming or toxic-forming spoil into ground and surface water must be avoided by preventing water from coming into contact with such spoil. ARM 26.4.505 (Relevant and Appropriate) similarly provides that acid, acid-forming, toxic, toxic-forming or other deleterious materials must not be buried or stored in proximity to a drainage course so as to cause or pose a threat of water pollution.

1. Reclamation Activities - Hydrology Regulations (Relevant and Appropriate)
(Excavation, earth moving, altering drainage patterns)

The hydrology regulations provide detailed guidelines for addressing the hydrologic impacts of mine reclamation activities and earth moving projects and are relevant and appropriate for addressing these impacts in the Streamside Tailings Operable Unit.

ARM 26.4.631 (Relevant and Appropriate) provides that long-term adverse changes in the hydrologic balance from mining and reclamation activities, such as changes in water quality and quantity, and location of surface water drainage channels shall be minimized. Water pollution must be minimized and, where necessary, treatment methods utilized. Diversions of drainages to avoid contamination must be used in preference to the use of water treatment facilities. Other pollution minimization devices must be used if appropriate, including stabilizing disturbed areas through land shaping, diverting runoff, planting quickly germinating and growing stands of temporary vegetation, regulating channel velocity of water, lining drainage channels with rock or vegetation, mulching, and control of acid-forming, and toxic-forming waste materials.

ARM 26.4.633 (Relevant and Appropriate) provides water quality performance standards that may be invoked in the event that runoff from the treated areas threatens the water quality or sediments in the stream, including the requirement that all surface drainage from a disturbed area must be treated by the best technology currently available (BTCA). Treatment must continue until the area is stabilized.

ARM 26.4.634 (Relevant and Appropriate) provides that, in reclamation of drainages, drainage design must emphasize channel and floodplain dimensions that approximate the premining configuration and that will blend with the undisturbed drainage above and below the area to be reclaimed. The average stream gradient must be maintained with a concave longitudinal profile, and the channel and floodplain must be designed and constructed to:

1. establish or restore the drainage channel to its natural habit or characteristic pattern with a geomorphically acceptable gradient. The habits or characteristics of individual streams include their particular reactions to general laws related to stream work, whether or not the stream has attained the conditions of equilibrium, and the stream channel morphology and stability;
2. remain in dynamic equilibrium with the system;
3. improve unstable premining conditions;
4. provide for floods; and
5. establish a premining diversity of aquatic habitats and riparian vegetation.

ARM 26.4.635 through 26.4.637 (Relevant and Appropriate) set forth requirements for temporary and permanent diversions.

ARM 26.4.638 (Relevant and Appropriate) specifies sediment control measures to be implemented during operations.

ARM 26.4.640 (Relevant and Appropriate) provides that discharge from sedimentation ponds, permanent and temporary impoundments, and diversions shall be controlled by energy dissipaters, riprap channels, and other devices, where necessary, to reduce erosion, prevent deepening or enlargement of stream channels, and to minimize disturbance of the hydrologic balance.

2. Reclamation and Revegetation Requirements (Relevant and Appropriate) (Excavation)

ARM 26.4.501 and 501A (Relevant and Appropriate) give general backfilling and final grading requirements.

ARM 26.4.514 (Relevant and Appropriate) sets out contouring requirements.

ARM 26.4.519 (Relevant and Appropriate) provides that an operator may be required to monitor settling of regraded areas.

ARM 26.4.702 (Relevant and Appropriate) requires that during the redistributing and stockpiling of soil (for reclamation):

1. regraded areas must be prepared to eliminate any possible slippage potential, to relieve compaction, and to promote root penetration and permeability of the underlying layer; this preparation must be done on the contour whenever possible and to a minimum depth of 12 inches;

2. redistribution must be done in a manner that achieves approximate uniform thicknesses consistent with soil resource availability and appropriate for the postmining vegetation, land uses, contours, and surface water drainage systems; and

3. redistributed soil must be reconditioned by subsoiling or other appropriate methods.

ARM 26.4.703 (Relevant and Appropriate) When using materials other than, or along with, soil for final surfacing in reclamation, the operator must demonstrate that the material (1) is at least as capable as the soil of supporting the approved vegetation and subsequent land use, and (2) the medium must be the best available in the area to support vegetation. Such substitutes must be used in a manner consistent with the requirements for redistribution of soil in ARM 26.4.701 and 702.

ARM 26.4.711 (Relevant and Appropriate) requires that a diverse, effective, and permanent vegetative cover of the same seasonal variety and utility as the vegetation native to the area of land to be affected shall be established except on road surfaces and below the low-water line of permanent impoundments. The vegetative cover must also be capable of meeting the criteria set forth in § 82-4-233, MCA. Vegetative cover is considered of the same seasonal variety if it consists of a mixture of species of equal or superior utility when compared with the natural vegetation during each season of the year. (See also ARM 26.4.716 below regarding substitution of introduced species for native species.)

ARM 26.4.713 (Relevant and Appropriate) provides that seeding and planting of disturbed areas must be conducted during the first appropriate period for favorable planting after final seedbed preparation but may not be more than 90 days after soil has been replaced.

ARM 26.4.714 (Relevant and Appropriate) requires use of a mulch or cover crop or both until an adequate permanent cover can be established. Use of mulching and temporary cover may be suspended under certain conditions.

ARM 26.4.716 (Relevant and Appropriate) establishes the required method of revegetation, and provides that introduced species may be substituted for native species as part of an approved plan.

ARM 26.4.717 (Relevant and Appropriate) relates to the planting of trees and other woody species if necessary, as provided in § 82-4-233, MCA, to establish a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the affected area and capable of self-regeneration and plant succession at least equal in extent of cover to the natural vegetation of the area, except that introduced species may be used in the revegetation process were desirable and necessary to achieve the approved intended land use plan.

ARM 26.4.718 (Relevant and Appropriate) requires the use of soil amendments and other means such as irrigation, management, fencing, or other measures, if necessary to establish a diverse and permanent vegetative cover.

ARM 26.4.728 (Relevant and Appropriate) sets forth requirements for the composition of vegetation on reclaimed areas.

VII. TO BE CONSIDERED DOCUMENTS (TBCS)

The use of documents identified as TBCs is addressed on page 2 of the Introduction, above. A list of TBC documents is included in the Preamble to the NCP, 55 Fed. Reg. 8765 (March 8, 1990). Those documents, plus any additional similar or related documents issued since that time, will be considered by EPA and MDEQ in implementation of the remedy.

VIII. OTHER LAWS (NON-EXCLUSIVE LIST)

CERCLA defines as ARARs only federal environmental and state environmental and facility siting laws. Remedial design, implementation, and operation and maintenance must nevertheless comply with all other applicable laws, both state and federal, if the remediation work is done by parties other than the federal government or its contractors.

The following "other laws" are included here to provide a reminder of other legally applicable requirements for actions being conducted at the Streamside Tailings Operable Unit. They do not purport to be an exhaustive list of such legal requirements, but are included because they set out related concerns that must be addressed and, in some cases, may require some advance planning. They are not included as ARARs because they are not "environmental or facility siting laws." As applicable laws other than ARARs, they are not subject to ARAR waiver provisions.

Section 121(e) of CERCLA exempts removal or remedial actions conducted entirely on-site from federal, state, or local permits. This exemption is not limited to environmental or facility siting laws, but applies to other permit requirements as well.

A. Other Federal Laws

1. Occupational Safety and Health Regulations

The federal Occupational Safety and Health Act regulations found at 29 CFR § 1910 are applicable to worker protection during conduct of RI/FS or remedial activities.

B. Other Montana Laws

1. Groundwater Act

Section 85-2-516, MCA, states that within 60 days after any well is completed a well log report must be filed by the driller with the DNRC and the appropriate county clerk and recorder.

2. Water Rights

Section 85-2-101, MCA, declares that all waters within the state are the state's property, and may be appropriated for beneficial uses. The wise use of water resources is encouraged for the maximum benefit to the people and with minimum degradation of natural aquatic ecosystems.

Parts 3 and 4 of Title 85, MCA, set out requirements for obtaining water rights and appropriating and utilizing water. All requirements of these parts are laws which must be complied with in any action using or affecting waters of the state. Some of the specific requirements are set forth below.

Section 85-2-301, MCA, of Montana law provides that a person may only appropriate water for a beneficial use.

Section 85-2-302, MCA, specifies that a person may not appropriate water or commence construction of diversion, impoundment, withdrawal or distribution works therefor except by applying for and receiving a permit from the Montana Department of Natural Resources and Conservation. While CERCLA exempts the portion of a remedial action conducted entirely on site from permit requirements, appropriate notification and submission of an application should be performed and a permit should be obtained for all appropriations of water in order to establish a priority date in the prior appropriation system.

Section 85-2-306, MCA, specifies the conditions on which groundwater may be appropriated, and, at a minimum, requires notice of completion and appropriation within 60 days of well completion.

Section 85-2-311, MCA, specifies the criteria which must be met in order to appropriate water and includes requirements that:

1. there are unappropriated waters in the source of supply;

2. the proposed use of water is a beneficial use; and

3. the proposed use will not interfere unreasonably with other planned uses or developments.

Section 85-2-336, MCA, closes the Upper Clark Fork River Basin to further appropriations of surface water, with certain exceptions, including under certain conditions, appropriations for water to conduct CERCLA response actions.

Section 85-2-402, MCA, specifies that an appropriator may not change an appropriated right except as provided in this section with the approval of the DNRC.

Section 85-2-412, MCA, provides that, where a person has diverted all of the water of a stream by virtue of prior appropriation and there is a surplus of water, over and above what is actually and necessarily used, such surplus must be returned to the stream.

3. Controlled Ground Water Areas

Pursuant to § 85-2-507, MCA, the Montana Department of Natural Resources and Conservation may grant either a permanent or a temporary controlled ground water area. The maximum allowable time for a temporary area is four years.[39]

Pursuant to § 85-2-506, MCA, designation of a controlled groundwater area may be proposed if: (i) excessive groundwater withdrawals would cause contaminant migration; (ii) groundwater withdrawals adversely affecting groundwater quality within the groundwater area are occurring or are likely to occur; or (iii) groundwater quality within the groundwater area is not suited for a specific beneficial use.

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39 If a temporary controlled ground water area is granted, the statute requires DNRC to commence studies to determine the designation or modification of a permanent controlled ground water area.

4. Occupational Health Act, §§ 50-70-101 et seq., MCA.

ARM § 16.42.101 addresses occupational noise. In accordance with this section, no worker shall be exposed to noise levels in excess of the levels specified in this regulation. This regulation is applicable only to limited categories of workers and for most workers the similar federal standard in 29 CFR § 1910.95 applies.

ARM § 16.42.102 addresses occupational air contaminants. The purpose of this rule is to establish maximum threshold limit values for air contaminants under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. In accordance with this rule, no worker shall be exposed to air contaminant levels in excess of the threshold limit values listed in the regulation. This regulation is applicable only to limited categories of workers and for most workers the similar federal standard in 29 CFR § 1910.1000 applies.

5. Montana Safety Act

Sections 50-71-201, 202 and 203, MCA, state that every employer must provide and maintain a safe place of employment, provide and require use of safety devices and safeguards, and ensure that operations and processes are reasonably adequate to render the place of employment safe. The employer must also do every other thing reasonably necessary to protect the life and safety of its employees. Employees are prohibited from refusing to use or interfering with the use of safety devices.

6. Employee and Community Hazardous Chemical Information Act

Sections 50-78-201, 202, and 204, MCA, state that each employer must post notice of employee rights, maintain at the work place a list of chemical names of each chemical in the work place, and indicate the work area where the chemical is stored or used. Employees must be informed of the chemicals at the work place and trained in the proper handling of the chemicals.

THE ADMINISTRATIVE RECORD FOR THE
SILVER BOW CREEK/BUTTE AREA (ORIGINAL PORTION) SITE

This index lists the documents which comprise the administrative record for the Silver Bow Creek/Butte Area (Original Portion) Superfund Site (abbreviated as SBCO Superfund Site). Each record is identified by date, author, addressee, and type (when known), and a short abstract of the document.

The Silver Bow Creek/Butte Area Superfund Site comprises one of the largest Superfund Sites in the nation. Because of the size and complexity of the Site, EPA has divided the site into a Butte Portion and an Original Portion. The Butte Portion, or SBCB, addresses the contamination in and around the city of Butte away from the Silver Bow Creek streambed. The Original Portion, or SBCO, addresses the stream contamination found from the headwaters of Silver Bow Creek through the Warm Springs Ponds area. As stated, this index contains record abstracts for the SBCO Superfund Site.

The SBCO Superfund Site is divided into eight operable units. The name and location of administrative record indexes or locations for these operable units is as follows:

Lower Area One (once known as Area One) ERA operable unit - File numbers 5.02.00.00 through 5.02.37.00

Rocker Timber Framing and Treating Plant operable unit - File numbers 5.03.00.00 through 5.03.18.11

Streamside Tailings operable unit - File numbers 5.04.00.00 through 5.04.19.01

Warm Springs Ponds Active Area operable unit - File numbers 5.05.00.00 through 5.05.06.06 and 5.05.07.00 through 5.05.18.11

Mill Willow Bypass ERA operable unit - File number 5.05.06.07

Warm Springs Ponds Inactive Area operable unit - File number 5.05.06.08

Warm Springs Ponds Final Decision - File numbers 5.05.00.00 through 5.05.18.11

Manganese Stockpile Removal - Because this action was conducted by EPA's Emergency Removal Branch, records are indexed and maintained separately in EPA offices in Denver and Montana. Some duplicated and related documents for this action are found in file number 5.02.35.00.

The index also contains a section on site-wide material, designated under the file numbers 5.01.01.00 through 5.01.29.06. That section contains document or records which provide more general information about the SBCO Superfund Site. Each operable unit specific administrative record listed above incorporates the administrative record documents identified for the "site-wide" section of the SBCO record files.

In addition, each operable unit specific administrative record incorporates the administrative record designated for the Clark Fork Basin General system of records, which are listed in a separate index. In other words, the administrative record for each operable unit includes the administrative records for the specific SBCO Superfund Site operable unit, the administrative records for the SBCO site-wide component, and the administrative records for the Clark Fork Basin General component.

Guidance documents referred to or relied upon by the Environmental Protection Agency are also part of the administrative record, and, although not specifically listed, are incorporated into each operable unit specific administrative record. Those documents are available through EPA's Montana Superfund Records Center, located in Helena, Montana 59626, 301 South Park, Drawer 10096, Federal Building, (406) 449-5728.

Chain of custody documents and other supporting documents for sample collection and data analysis pertaining to a particular operable unit are incorporated into the administrative record of each operable unit, or are specifically listed in the index and contained in the physical files for the site. Those documents are located in one of the following places:

EPA Helena offices, 301 South Park St., Drawer 10096, Helena, Montana 59626
ARCO offices
State of Montana offices
Contractor offices for ARCO, EPA, or State of Montana contractors

Further review of those documents can be obtained by contacting EPA's Montana Superfund Records Center at the above address or telephone number.

A number of the documents contained in the administrative record contain references to primary sources. Those sources are incorporated by reference into each operable unit specific administrative record in which the document which references the material appears. Most of these references are publicly available through libraries or other document repositories. Those primary reference documents that are not publicly available are specifically contained in this record index. Further review of those documents can also be obtained by contacting EPA's Montana Superfund Records Center at the above address or telephone number.

The administrative record index contains some confidential records. Those documents are listed separately, and are abstracted in a manner similar to publicly available documents.

A short summary of the contents of those documents is contained in the abstract entry. Those documents are not available for public review.

This administrative record index, including incorporated documents, is established pursuant to section 113(k) of CERCLA, 42 U.S.C. Section 9613(k). These documents form the basis for EPA's decision concerning response actions taken or to be taken at the SBCO Superfund Site, and also indicate the involvement of the potentially responsible parties and the public in the decision making process. The index will be routinely updated, as additional records or documents are obtained by EPA in relation to each operable unit, unless that operable unit is closed. Administrative record files for the following operable units are closed, as response action was decided upon and taken by EPA for those units.

Manganese Stockpile
Lower Area One ERA
Warm Springs Ponds Active Area
Warm Springs Ponds Inactive Area
Mill Willow Bypass ERA

5.04.00.00 STREAM SIDE TAILINGS OPERABLE UNIT

- 5.04.01.00 Operable Unit Overview
  - 5.04.01.01 Summaries/Meetings
  - 5.04.01.02 Briefing Materials
  - 5.04.01.03 Operable Unit Management Plans
  - 5.04.01.04 Background/Information
- 5.04.02.00 PRP Information
  - 5.04.02.01 Financial Status
  - 5.04.02.02 PRP Searches
  - 5.04.02.03 AMC
- 5.04.03.00 Information Requests
  - 5.04.03.01 FOIA's
  - 5.04.03.02 Congressional Inquiries
  - 5.04.03.03 Other
- 5.04.04.00 RI/FS Planning
  - 5.04.04.01 Work Plans/Comments/Guidance
  - 5.04.04.02 Quality Assurance Project Plan (QAPP)
  - 5.04.04.03 Laboratory Analytical Protocol (LAP)
  - 5.04.04.04 Sampling Analysis Plan (SAP)/Field Operations Plan (FOP)
  - 5.04.04.05 Standard Operating Procedures (SOP)
  - 5.04.04.06 Remedial Action Master Plan (RAMP)
  - 5.04.04.07 General
  - 5.04.04.08 Health/Environmental Assessment/Comments
  - 5.04.04.09 AO/Consent
  - 5.04.04.10 Special Notice Letters
  - 5.04.04.11 Negotiations
- 5.04.05.00 ARAR's
- 5.04.06.00 RI/FS Reports
  - 5.04.06.01 Sampling Data
  - 5.04.06.02 Preliminary Reports
  - 5.04.06.03 Final Reports
  - 5.04.06.04 Screening Studies
  - 5.04.06.05 Photos/Aerial
  - 5.04.06.06 Comments/Responses/Summaries
  - 5.04.06.07 Meetings/Agendas/Minutes
  - 5.04.06.08 Risk Assessments
  - 5.04.06.09 Historical
  - 5.04.06.10 Proposed Plan
- 5.04.07.00 ROD
- 5.04.08.00 RD/RA
- 5.04.09.00 O/M

5.04.10.00 Accounting and Cost Recovery

5.04.11.00 Community Relations
- 5.04.11.01 Mailing Lists
- 5.04.11.02 Press Releases
- 5.04.11.03 Press Clippings
- 5.04.11.04 Technical Assistance Grants
- 5.04.11.05 Repository Index
- 5.04.11.06 Fact Sheets
- 5.04.11.07 Public Comments
- 5.04.11.08 Administrative Record Index
- 5.04.11.09 Plans
- 5.04.11.10 Correspondence

5.04.12.00 SCAP

5.04.13.00 References
- 5.04.13.01 Miscellaneous Studies
- 5.04.13.02 Journal Articles
- 5.04.13.03 Other Operable Unit Information

5.04.14.00 State and Other Agency Coordination
- 5.04.14.01 Interagency Agreements (IAG's)
- 5.04.14.02 Fish and Wildlife Service (FWS)
- 5.04.14.03 U. S. Geological Survey (USGS)
- 5.04.14.04 Corp of Engineers (COE)
- 5.04.14.05 Bureau of Mines (BOM)
- 5.04.14.06 Office of Surface Mining (OSM)
- 5.04.14.07 Agency for Toxic Substances Disease Registry (ATSDR)
- 5.04.14.08 Federal Emergency Management Agency (FEMA)
- 5.04.14.09 Historical/Cultural Preservation
- 5.04.14.10 Bureau of Reclamation (BOR)

5.04.15.00 Natural Resource Damage Claims

5.04.16.00 Local Governments
- 5.04.16.01 General
- 5.04.16.02 Institutional Controls

5.04.17.00 Demonstration Projects
- 5.04.17.01 Demonstration Project I
- 5.04.17.02 Demonstration Project II
- 5.04.17.03 Demonstration Project III

5.04.18.00 Correspondence
- 5.04.18.01 Pre-1983/No Dates/Partial Dates
- 5.04.18.02 1983
- 5.04.18.03 1984

5.04.18.04 1985
5.04.18.05 1986
5.04.18.06 1987
5.04.18.07 1988
5.04.18.08 1989
5.04.18.09 1990
5.04.18.10 1991
5.04.18.11 1992
5.04.18.12 1993
5.04.18.13 1994

5.04.19.00 Treatability Projects
5.04.19.01 Proposals
5.04.19.02 Correspondence
5.04.19.03 Studies
5.04.19.04 Comments
5.04.19.05 Reports

Executive Summary

Introduction

The Streamside Tailings (SST) Operable Unit (OU) is one of seven operable units of the Silver Bow Creek/Butte Area (original portion) NPL site. Silver Bow Creek was listed as a Superfund site by the EPA in 1982 pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). CERCLA, as amended by the Superfund Amendment and Reauthorization Act, stipulates that remedial actions at Superfund sites must be protective of both human and ecological receptors. To evaluate the degree to which remedial alternatives are protective, it is necessary to assess both existing environmental and human health risks and potential risks. The baseline Risk Assessment (RA) developed for the Streamside Tailings operable unit of the Silver Bow Creek/Butte Area National Priorities List (NPL) site. The RA uses site-related chemical concentrations, exposure potential, and toxicity information to characterize potential human health and ecological risks which may exist at the site as a result of former mining activities. The RA estimates current and potential future exposure and risk in the absence of future remedial actions. The results of the baseline RA are used to help determine the need for remediation of the site, to establish health-based remediation goals for contaminated media, and to assist in the selection of remedial alternatives.

Site Description

The Streamside Tailings (SST) Operable Unit (OU) is located along Silver Bow Creek in Silver Bow and Deer Lodge Counties, Montana. The SST OU includes approximately 25 miles of Silver Bow Creek from below the Lower Area One portion of the Priority Soils Operable Unit in Butte, Montana to the Warm Springs Ponds Active Area Operable Unit near Opportunity, Montana. The site generally encompasses the 100-year floodplain and areas impacted by fluvially deposited mine, mill, and smelter wastes within and adjacent to Silver Bow Creek. The OU also includes adjacent railroad beds, because mine, mill, and/or smelter wastes were often used as base materials for these beds. Since at least some of these beds may be converted to hiking, biking, and/or riding trails, future human exposure is possible.

The site was divided into four subareas for the purposes of risk assessment, based upon geologic and topographic features that control the soil, hydrogeologic, groundwater, surface water, ecologic, demographic, and land use characteristics. Subarea 1, the Rocker subarea, extends from Colorado Tailings to Nissler at the I-15 bridge over Silver Bow Creek. Subarea 2, the Ramsay subarea, extends from the I-15 bridge to Miles Crossing. Subarea 3, the Canyon subarea, extends from Miles Crossing to the 441 bridge. Subarea 4, the Opportunity subarea, extends from highway 441 to Warm Springs Ponds.

The history of over 100 years of continuous mining and related activities greatly affected the natural environment in and around Silver Bow Creek. Between 2.4 and 2.8 million cubic yards of mill tailings and other mining wastes have been estimated to be present within the SST OU. These mine wastes in and near the creek have contributed to substantial downstream contamination, particularly by the potentially toxic elements arsenic, cadmium, copper, lead, mercury and zinc. Organic pollution in Silver Bow Creek is contributed by municipalities via discharge from the Butte sewage plant, and from other sources, such as wood treating operations, which were located close to the creek. However, compared to the mining impacts such pollution appears to be a minor factor.

There are no cities within the SST OU. Butte, with a population of approximately 30,000, is located just east of the SST OU. Located within or near the SST OU are the small communities of Rocker, Nissler, Silver Bow, Ramsay, Miles Crossing, Finlen, Crackerville, and Opportunity, as well as unnamed communities consisting of several houses scattered throughout the site. A detailed overview of population, land use, economy, and related topics for Deer Lodge County is provided in a 1990 Anaconda/Deer Lodge County comprehensive master plan.

Land use near and within the SST OU also includes industrial activities (railroad, Rhone-Poulenc), mining (gravel), agriculture (grazing), and recreation (dirt biking, hiking, wading, etc.). Occasional irrigated croplands are present on the alluvial plain next to Silver Bow Creek in some areas.

Human Health Risk Assessment

Chemicals of Potential Concerns (COPCs)

The principal contaminants of concern at the SST OU are metals associated with mining activities. Those of particular concern for the HHRA are arsenic, cadmium, copper, lead, mercury, and zinc. All of these materials, except for mercury, have been considered COPCs for OUs upstream and downstream of SST. Mercury data for the site are very limited, but are consistent with elevated levels in sediments and possibly in surface water within the OU. Mercury is therefore discussed qualitatively in the assessment.

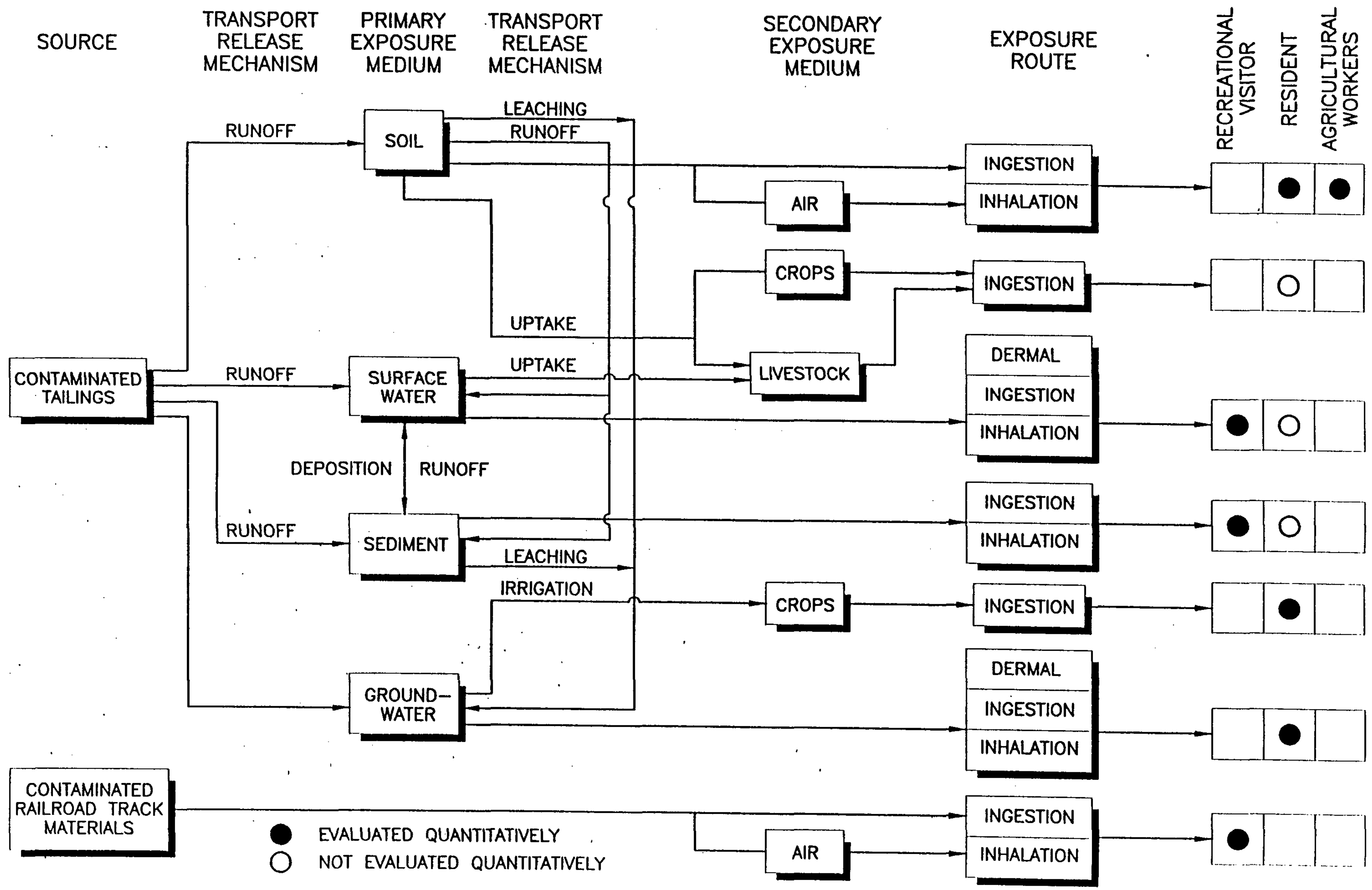
Organic chemicals (pentachlorophenol (PCP) and polycyclic aromatic hydrocarbons (PAH)) have been released from wood treating sites upstream of and within the SST OU. The sources of these contaminants are being addressed by actions at the Rocker Operable Unit and the Montana Pole NPL site.

Exposure Point Concentrations

Two types of exposure estimates are required for Superfund human health RAs, a reasonable maximum exposure (RME), and an average exposure. The RME is defined as an exposure well above the average but still within the range of those that could reasonably be expected to occur for a given exposure pathway at a site. The upper 95 percent confidence limit (UCL) on the arithmetic mean of contaminant concentrations within an exposure area is used to evaluate potential RME exposures. Arithmetic average exposure point concentrations are used to estimate potential average exposures. UCL and average values are also useful for many comparisons made in the ecological risk assessment. Exposure point concentrations for various media are provided in Table ES-1.

Exposure Assessment

This assessment addresses potential pathways by which human receptors could be exposed to contamination within the SST OU in accordance with EPA guidance. This guidance recommends that exposure assumptions were selected so that estimates fall near the reasonable maximum (RME) for that pathway. For most pathways evaluated in this assessment, an average exposure was also calculated to provide a range of exposures and some semi-quantitative information on uncertainties in the assessment. Inclusion of average exposures is intended to provide the risk manager with a range of exposures which encompasses both the typical and upper-range of exposures.



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STREAMSIDE TAILINGS OPERABLE UNIT
SITE CONCEPTUAL EXPOSURE MODEL - HUMAN EXPOSURE

FIGURE
ES-1

Combinations of exposure pathways and associated human receptors make up exposure scenarios. There are three general exposure scenarios which are considered in this risk assessment, and these are shown in schematic form in the site conceptual exposure model in Figure ES-1.

Residential Scenario

Residents might be exposed to contaminated soils and sediments while working or playing in their yards, might inhale contaminated dust originating from soils in their yards and in neighboring areas, might consume contaminated groundwater and be exposed dermally during bathing to contaminated groundwater from a residential well, and might consume vegetables and/or animal products grown/raised in/on contaminated soils and/or watered with contaminated surface water or groundwater. Where residential properties might extend down to the stream bank, residents might also be exposed to contaminated surface water, sediments and tailings on a regular basis during activities such as wading. In addition, residential exposures might vary significantly over the length of the OU, and residents in one area could potentially receive much higher or lower exposures than their counterparts in other areas of the OU. Evaluation of the residential scenario, then, considers both significant exposures by pathway and the distribution of exposures along the OU.

Occupational Scenario

Workers might be exposed to contaminants while working outdoors within the OU. This could occur, for example, in a lumber or brick yard, while moving cattle, or during planting, working and harvesting crops on agricultural land impacted by the tailings. Likely exposure pathways are incidental ingestion of contaminated soils/sediments, inhalation of contaminated dust suspended in air by wind or other disturbances, and dermal contact with contaminated soils and sediments. An agricultural worker is assumed to be representative for possible occupational exposures.

Recreational Scenario

People recreating in the SST OU may come into contact with contaminated surface water and sediment from Silver Bow Creek and contaminated materials in railroad beds in the SST OU . Recreational activities at the creek most likely include picnicking, swimming, wading, hunting, and dirt-bike riding. During these activities, incidental ingestion of and dermal contact with contaminants in surface water and sediments may occur. In addition, recreational visitors to the site may also be exposed to contaminated materials in railroad beds. The county may consider converting stretches of some railroad beds to recreational trails, and individuals and families who use the trails for jogging, bicycling and hiking in the future may be exposed. Contaminants in railroad bed materials may be incidentally ingested, and/or resuspended in air by wind or other disturbances and inhaled.

Toxicity Assessment

The purpose of the toxicity assessment is to examine the potential for each contaminant of concern (COC) to cause adverse effects in exposed individuals and to describe the relationship between the extent of exposure to a particular contaminant and adverse effects. Adverse effects include both noncarcinogenic (systemic) and carcinogenic health effects in humans.

Toxicity Criteria

Toxicity criteria for carcinogens are slope factors in units of risk per milligram of chemical exposure per kilogram body weight per day ($(mg/kg\text{-}day)^{-1}$). These cancer slope factors (CSFs) are based on the assumption that no threshold for carcinogenic effects exists and any dose, no matter how small, is associated with a finite cancer risk. Toxicity values for noncarcinogens, or for significant noncarcinogenic effects caused by carcinogens, are reference doses (RfDs) in units of milligrams of chemical exposure per kilogram body weight per day (mg/kg-day). RfDs are estimates of thresholds; exposures less than the RfD are not expected to cause adverse effects even in the most sensitive populations. Toxicity criteria for COPCs are presented in Tables ES-2 and ES-3.

Risk Characterization

Residential Scenario

Carcinogenic risks associated with residential exposures (Table ES-4) to COPCs within the SST OU are due entirely to potential exposures to arsenic in soil/sediment and in groundwater. Risks based on average exposure assumptions are estimated at the upper edge of the EPA risk range of 10^{-4} to 10^{-6}, and risks based on RME are greater by a factor of about 6. These risks could vary by a factor of 50 percent based on the variability of arsenic soil concentrations found within the OU. Higher concentrations of arsenic in soil occur in the Ramsay subarea of the site; this area is the most likely location where residents might be exposed to generally higher arsenic concentrations. Arsenic in groundwater is found in higher concentrations in both the Rocker and Ramsay areas. However, all higher concentrations in these locations were found in shallow groundwater. Since any future domestic drinking water well is likely to be installed much deeper than the near-surface monitoring wells, potential for consumption of shallow groundwater is limited. It is, therefore, unlikely that cancer risks are underestimated by a significant factor for exposure via ingestion of groundwater.

Noncancer risks associated with the residential scenario (Table ES-5) exceed the target level (a hazard index of one) for both average and RME. More importantly, individual target levels (hazard quotients) are exceeded for arsenic, cadmium, copper and zinc estimates based on average and/or RME. Noncancer health risk may be unacceptable for exposure to each of these COPCs. Noncancer risks from exposure to arsenic may vary by as much as 50 percent based on variability of arsenic soil concentrations found within the OU. It is unlikely that high concentrations of arsenic in groundwater in subareas would have significant effect on risk estimates. Cadmium, copper and zinc are of potential importance only through ingestion of contaminated groundwater.

Lead exposures within the OU are difficult to interpret. Based on bioavailability assumptions for lead in soil used in nearby Butte, MT, lead risks may generally be in the acceptable range in the OU. Based on the IEUBK model default for bioavailability, however, lead exposures may be excessive in many areas of the OU. A clear determination of bioavailability may be necessary in order to fully evaluate lead exposures. Moreover, in some areas of the site, lead concentrations reach very high levels (up to 9000 mg/kg and greater). If some exposure situations were to be dominated by soils with such high concentrations, lead risks could be significantly underestimated by use of site-wide averages. Specific land-use evaluation on a much smaller scale than those considered in this assessment may be necessary to determine if there are any small subareas of the OU which may present a human exposure hazard above that presented in the risk assessment.

Table ES-2
Carcinogenic Reference Concentrations for COCs
at the Streamside Tailings Site

COC	Carcinogen Classification	Oral Slope Factor $(mg/kg\text{-}day)^{-1}$	Inhalation Slope Factor $(mg/kg\text{-}day)^{-1}$	Source
Pentachlorophenol	B2	1.2×10^{-1}	NA	EPA 1994[a]
Benzo(a)pyrene	B2	$7.3 \times 10^{+0}$	$6.1 \times 10^{+0}$	EPA 1994[a]
Arsenic	A	$1.75 \times 10^{+0}$	$1.5 \times 10^{+1}$	EPA 1994[a]
Cadmium	B1	NA	6.3	EPA 1994[a]
Copper	D	NA	NA	EPA 1994[a]
Lead	B2	NA	NA	EPA 1994[a]
Mercury	D	NA	NA	EPA 1994[a]
Zinc	D	NA	NA	EPA 1994[b]

[a] EPA (U.S. Environmental Protection Agency). 1994. Integrated Risk Information System (IRIS).
[b] EPA (U.S. Environmental Protection Agency). 1994. Health Effects Assessment Summary Tables (HEAST).

Table ES-3
Reference Doses for COCs at the Streamside Tailings Site

COC	Oral RfD (mg/kg-day)	Inhalation RfD (mg/kg-day)	Source
Pentachlorophenol	3×10^{-2}	NA	EPA 1994[a]
Benzo(a)pyrene	NA	NA	—
Arsenic	3×10^{-4}	NA	EPA 1994[a]
Cadmium			
Water	5×10^{-4}	NA	EPA 1994[a]
Food	1×10^{-3}	NA	EPA 1994[a]
Copper	0.0356[c]	NA	EPA 1994[b]
Lead	NA	NA	—
Mercury			
Inorganic	3×10^{-4}	3×10^{-4}	EPA 1994[a]
Methyl Hg	3×10^{-4}	NA	EPA 1994[a]
Zinc	3×10^{-1}	NA	EPA 1994[b]

[a] EPA (U.S. Environmental Protection Agency). 1994. Integrated Risk Information System (IRIS).
[b] EPA (U.S. Environmental Protection Agency). 1994. Health Effects Assessment Summary Tables (HEAST).
[c] As suggested in HEAST, the oral RfD was calculated from maximum Contaminant Level Goal (MCLG).
NA = Not available.

Table ES-4
Carcinogenic Risks for the Residential Scenario[a]

Pathway	Chemical	RME Risk	Average Risk
Ingestion of Soil/Sediment	Arsenic	2.5×10^{-4}	4.4×10^{-5}
	Cadmium	NC	NC
	Copper	NC	NC
	Lead	NC	NC
	Mercury	NC	NC
	Zinc	NC	NC
Ingestion of Groundwater	Arsenic	3.11×10^{-4}	6.7×10^{-5}
	Cadmium	NC	NC
	Copper	NC	NC
	Lead	NC	NC
	Mercury	NC	NC
	Zinc	NC	NC
Dermal Contact with Groundwater	Arsenic	2.99×10^{-9}	NA
Inhalation of Dust	Arsenic	3.17×10^{-6}	9.51×10^{-7}
Total Carcinogenic Risk		**5.6×10^{-4}**	**1.1×10^{-4}**

[a] Total carcinogenic risks have been rounded to the nearest tenth.
NC = Not calculated, chemicals are not carcinogens for this exposure pathway, or carcinogenic slope factors are not available.
NA = Only RME exposure is assessed for this pathway.

Table ES-5
Noncarcinogenic Hazard Quotients and Hazard Indices for the Residential Scenario[a]

Pathway	Chemical	RME HQ	Average Risk
Ingestion of Soil/Sediment	Arsenic	1.05×10^{1}	3.03×10^{0}
	Cadmium	8.97×10^{-2}	2.44×10^{-2}
	Copper	5.26×10^{-1}	1.5×10^{-1}
	Lead	NC	NC
	Mercury	NC	NC
	Zinc	7.11×10^{-2}	2.28×10^{-2}
Pathway HI		**1.1×10^{1}**	**3.2×10^{0}**
Ingestion of Groundwater	Arsenic	3.10×10^{0}	2.22×10^{0}
	Cadmium	1.6×10^{0}	7.30×10^{-1}
	Copper	2.73×10^{0}	1.69×10^{0}
	Lead	NC	NC
	Mercury	NC	NC
	Zinc	4.00×10^{0}	4.75×10^{-1}
Pathway HI		**1.2×10^{1}**	**5.1×10^{0}**
Dermal Contact with Groundwater	Arsenic	2.23×10^{-5}	NA
Inhalation of Dust	Arsenic	NC	NC
Total HI		**2.3×10^{1}**	**8.4×10^{0}**

[a] Pathway HIs and total HIs have been rounded to the nearest tenth.
NC = Not calculated, data are insufficient for quantitative analysis.
NA = Only RME exposure is assessed for this pathway.
HQ = Hazard Quotient
HI = Hazard Index

Occupational Scenario

Potential cancer risks for the occupational scenario (Table ES-6), based on potential exposure to agricultural workers, fall within the EPA acceptable risk range. However, risks to agricultural workers are estimated assuming exposures in areas outside the 100-year floodplain only. If workers were to equally divided their work time between areas inside and outside the floodplain, risks could be as much as three times higher than those calculated. This would place worker risks at slightly more than 10^{-4}.

Potential noncancer risks (Table ES-7) are due almost entirely to arsenic and fall near the target HI of one, with arsenic risks based on RME essentially equal to the RfD, or "safe" dose. Upper-range risk estimates are thus at, but do not exceed, an exposure generally recognized as safe, even for lifetime exposure. In general, it does not appear that arsenic concentrations in the SST OU are sufficiently high under the occupational scenario to represent human health risks that exceed common EPA regulatory targets.

Recreational Scenario

Cancer risks for visitors (Table ES-8) to the SST OU are potentially large, with average and RME-based risk estimates exceeding the upper edge of the EPA risk range. Little of this risk is, however, contributed by exposures to visitors to the creek itself. Based on RME, it is future users of railroad beds converted to trails that may suffer the highest risks calculated for the site (over 10^{-3}). These risks are almost totally due to exposure to arsenic. Further, very high arsenic concentrations appear to be associated with areas of past concentrate spills. The methods used in this assessment essentially assume that future trail users will contact railroad bed materials with relatively low concentrations of arsenic much of the time, but will occasionally encounter areas where arsenic concentrations are greatly elevated ("hotspots").

Noncancer risks (Table ES-9) follow a pattern similar to noncancer risks. HIs based on both average and RME exposures exceed unity, suggesting a potential for adverse noncancer effects. Nearly all risk is contributed by arsenic, and, overall, noncancer risks in this scenario are the highest encountered for the site. Arsenic in railroad bed materials again contributes the bulk of the exposure.

Lead exposures within the OU are difficult to interpret. Based on bioavailability assumptions for lead in soil used in nearby Butte, MT, lead risks may generally be in the acceptable range in the OU. Based on the IEUBK model default for bioavailability, however, lead exposures may be excessive in the OU, particularly for the rails-to-trails exposure scenario. A clear determination of bioavailability may be necessary in order to fully evaluate lead exposures. Moreover, in some areas of the site, lead concentrations reach very high levels (up to 11,500 mg/kg in one sample of railroad bed materials). If some exposure situations were to be dominated by soils with such high concentrations, lead risks could be significantly underestimated by use of site-wide averages. Though very small scale variability is high, it is possible that some preferential recreational areas within the site could have average exposure concentrations in excess of those used to estimate lead exposures in this assessment.

In addition, the use of the IEUBK model for assessing lead exposures in non-residential settings is very uncertain. Lead exposures based on occasional exposure in a recreational setting may not be adequately estimated by the IEUBK model, and may, in fact be substantially, overestimated.

ES-6
Carcinogenic Risks for the Occupational Scenario[a]

Pathway	Chemical	RME Risk	Average Risk
Ingestion of Soil/Sediment	Arsenic	5.4×10^{-5}	3.4×10^{-6}
	Cadmium	NC	NC
	Copper	NC	NC
	Lead	NC	NC
	Mercury	NC	NC
	Zinc	NC	NC
Inhalation of Dust	Arsenic	8.5×10^{-6}	5.1×10^{-6}
Total Carcinogenic Risk		**6.2×10^{-5}**	**8.5×10^{-6}**

[a] Total carcinogenic risks have been rounded to the nearest tenth.
NC = Not calculated, chemicals are not carcinogens for this exposure pathway, or carcinogenic slope factors are not available.

Table ES-7
Noncarcinogenic Hazard Quotients and Hazard Indices for the Occupational Scenario[a]

Pathway	Chemical	RME Risk	Average Risk
Ingestion of Soil/Sediment	Arsenic	8.05×10^{0}	4.99×10^{-2}
	Cadmium	8.0×10^{-3}	6.07×10^{-4}
	Copper	3.29×10^{-2}	2.39×10^{-3}
	Lead	NC	NC
	Mercury	NC	NC
	Zinc	3.64×10^{-3}	2.90×10^{-4}
Pathway HI		**8.5×10^{-1}**	**5.3×10^{-2}**
Inhalation of Dust	Arsenic	NC	NC
Total HI		**8.5×10^{-1}**	**5.3×10^{-2}**

[a] Pathway HIs and Total HIs have been rounded to the nearest tenth.
NC = Not calculated, data are insufficient for quantitative analysis.

Table ES-8
Carcinogenic Risks for the Recreational Scenario[a]

Pathway	Chemical	RME Risk	Average Risk
Ingestion of Soil/Sediment	Arsenic	6.2×10^{-5}	9.0×10^{-6}
	Cadmium	NC	NC
	Copper	NC	NC
	Lead	NC	NC
	Mercury	NC	NC
	Zinc	NC	NC
Pathway Risk		**6.2×10^{-5}**	**9.0×10^{-5}**
Ingestion of Surface Water	Arsenic	3.4×10^{-8}	7.8×10^{-9}
	Cadmium	NC	NC
	Copper	NC	NC
	Lead	NC	NC
	Mercury	NC	NC
	Zinc	NC	NC
Pathway Risk		**3.4×10^{-8}**	**7.8×10^{-9}**
Dermal Contact with Surface Water	Arsenic	3.2×10^{-9}	7.3×10^{-10}
Ingestion of Rail Road Bed Materials	Arsenic	1.2×10^{-3}	1.4×10^{-4}
	Cadmium	NC	NC
	Copper	NC	NC
	Lead	NC	NC
	Mercury	NC	NC
	Zinc	NC	NC
Pathway Risk		**1.2×10^{-3}**	**1.4×10^{-4}**
Inhalation of Rail Road Bed Materials	Arsenic	1.8×10^{-5}	9.2×10^{-6}
	Cadmium	NC	NC
	Copper	NC	NC
	Lead	NC	NC
	Mercury	NC	NC
	Zinc	NC	NC
Pathway Risk		**1.8×10^{-5}**	**9.2×10^{-6}**

[a] Total carcinogenic risks have been rounded to the nearest tenth.
NC = Not calculated, chemicals are not carcinogens for this exposure pathway, or carcinogenic slope factors are not available.

Table ES-9
Noncarcinogenic Hazard Quotients and Hazard Indices for the Recreational Scenario[a]

Pathway	Chemical	4-12 Year Old Child		1-3 Year Old Child	
		RME HQ	Average HQ	RME HQ	Average HQ
Ingestion of Soil/Sediment	Arsenic	8.95×10^{-1}	1.03×10^{-1}	4.17×10^{0}	2.91×10^{-1}
	Cadmium	6.34×10^{-3}	8.14×10^{-4}	3.47×10^{-2}	2.05×10^{-3}
	Copper	3.97×10^{-2}	5.15×10^{-3}	2.18×10^{-1}	1.52×10^{-2}
	Lead	NC	NC	NC	NC
	Mercury	NC	NC	NC	NC
	Zinc	6.28×10^{-3}	8.89×10^{-4}	3.02×10^{-2}	2.31×10^{-3}
Pathway HI		**9.5×10^{-1}**	**1.1×10^{-1}**	**4.5×10^{0}**	**3.1×10^{-1}**
Ingestion of Surface Water	Arsenic	3.89×10^{-4}	9.0×10^{-5}	8.75×10^{-4}	2.02×10^{-4}
	Cadmium	2.25×10^{-5}	5.22×10^{-6}	5.05×10^{-5}	1.17×10^{-5}
	Copper	3.26×10^{-6}	6.94×10^{-6}	7.33×10^{-5}	1.56×10^{-5}
	Lead	NC	NC	NC	NC
	Mercury	NC	NC	NC	NC
	Zinc	1.35×10^{-5}	2.23×10^{-6}	3.04×10^{-5}	5.02×10^{-6}
Pathway HI		**4.6×10^{-4}**	**1.0×10^{-4}**	**1.3×10^{-3}**	**2.3×10^{-4}**
Dermal Contact with Surface Water	Arsenic	1.96×10^{-5}	4.57×10^{-6}	3.06×10^{-5}	7.12×10^{-6}
Ingestion of Rail Road Bed Materials	Arsenic	1.65×10^{1}	2.02×10^{0}	7.44×10^{1}	4.55×10^{0}
	Cadmium	7.42×10^{-2}	1.08×10^{-2}	3.34×10^{-1}	2.43×10^{-2}
	Copper	1.91×10^{0}	1.8×10^{-1}	8.58×10^{0}	4.06×10^{-1}
	Lead	NC	NC	NC	NC
	Mercury	NC	NC	NC	NC
	Zinc	1.56×10^{-1}	8.07×10^{-3}	7.02×10^{-1}	1.82×10^{-2}
Pathway HI		**1.9×10^{1}**	**2.2×10^{0}**	**8.4×10^{1}**	**5.0×10^{0}**
Inhalation of Rail Road Bed Materials	Arsenic	NC	NC	NC	NC
	Cadmium	NC	NC	NC	NC
	Copper	NC	NC	NC	NC
	Lead	NC	NC	NC	NC
	Mercury	NC	NC	NC	NC
	Zinc	NC	NC	NC	NC
Pathway HI		**NC**	**NC**	**NC**	**NC**
Total HI		**2.0×10^{1}**	**2.4×10^{0}**	**9.0×10^{1}**	**5.4×10^{0}**

[a] Pathway HIs and Total HIs have been rounded to the nearest tenth.
NC = Not calculated, data are insufficient for quantitative analysis.
HQ = Hazard Quotient
HI = Hazard Index

Results of IEUBK modeling for site visitors, and rails-to-trails users should be considered screening level only. Such modeling would provide little scientific support for risk management decisions. Once again, hotspots of lead dominate potential exposures and risks.

Uncertainties Associated with Risk Characterization

There is a degree of uncertainty associated with every step of the assessment process. Several important uncertainties were identified in the SST OU risk assessment.

Some exposure parameters, especially those for recreational exposure scenarios are often poorly characterized and may be based solely on professional judgement. Such exposure parameters introduce potentially significant, but substantially unknown amounts of uncertainty, into the assessment process. Generally, exposure parameters based on professional judgement are conservative (i.e., they tend to err on the side of protection of human health). Thus, these exposure parameters are generally more likely to cause overestimation of exposures than underestimation.

Land use in the SST OU is mixed and is likely to remain so in the future. However, it is difficult to predict which areas might be developed for which land uses in the future. This risk assessment does not make specific land use assumptions for specific areas. Instead, risk estimates are developed on a site-wide basis and evaluated for representativeness for different subareas within the OU. These risk estimates, with appropriate consideration given to subarea differences, can thus be applied as needed to different specific areas within the OU.

The relative bioavailability of arsenic in all media is assumed to be high (80 or 100 percent). Because arsenic in soil and sediments in the SST OU is largely derived from mining and milling wastes, and the relative bioavailability of arsenic associated with such wastes may actually be lower, potential risks from arsenic in soil and sediment may have been overestimated.

Several recent studies indicate current toxicity criteria for arsenic could overestimate risks. Metabolic detoxification of arsenic at low doses may lessen the impact of arsenic exposure predicted by linear extrapolation of results from higher exposures. In addition, new studies indicate that background inorganic arsenic intake and skin cancer risks may have been underestimated in the Taiwanese population on which current toxicity criteria are based. These new studies have not been peer-reviewed, however, and current toxicity criteria are therefore not modified for this RA.

The bioavailability of lead used in the RA is based in part on studies conducted for the Butte Priority Soils OU, and on the assumption that mineral species present in Silver Bow Creek would be similar to those found in Butte, since their source was Butte. There is some uncertainty associated with this approach. For example, the geochemistry of tailings deposited as stream sediments may not be identical to those from waste deposits not subject to constant or periodic inundation. Such uncertainties may lead to either over or underestimation of risks associated with lead depending on bioavailability assumptions made.

Quantitative assessment of exposures due to consumption of vegetables grown in contaminated soils, or irrigated with contaminated water, was not carried out even though screening calculations suggested that exposures via this pathway could be significant. It is possible, therefore, that significant exposures and associated risks at the site were omitted from the final estimates.

However, toxicity to plants is likely to restrict gardening within the SST OU to less contaminated soils and/or to soils that have been extensively amended. Baker and Bower (1988) concluded, on the basis of their study in Palmerton soils, that toxicity would limit cadmium exposure to a fraction of current estimates of daily cadmium intake from diet and other "background" sources. It seems likely that similar consideration might apply to gardens in the SST OU. It appears that any underestimation of risk due to elimination of consumption of home-grown vegetables from the quantitative risk assessment does not constitute a significant underestimation of total potential risks in the OU.

The risk assessment assumed that exposures to metals and arsenic from consumption of animals grazed on contaminated pastures and/or watered with contaminated surface or groundwater are not significant contributors to overall exposures. Conservative, though generic, calculations suggest that metal uptake into beef following ingestion of contaminated plants or soils will not be significant in the SST OU. A possible exception is zinc. Uptake of zinc into plants in the more heavily contaminated soils in the SST OU could raise concentrations of zinc in plants to a level that could approach levels toxic to cattle that use the plants as forage. Zinc, however, is expected to be toxic to the plants themselves at the higher concentrations found in the OU. Thus, the theoretical potential for toxic effects to livestock is probably not actually realized at the site.

Arsenic appears to represent the major risk "driver" for the site when considering potential human health impacts. However, arsenic background reference soil samples were collected very near areas of contamination; the higher values could reflect some degree of contamination. Reference concentrations for arsenic ranged from 5.7 to 142 mg/kg. RME and average exposure point concentrations for arsenic are 511 and 296 mg/kg respectively (Table ES-1). Background may thus contribute somewhat to total exposures and risks.

Thus, the high estimate for background contribution (based on comparison of maximum background to the average exposure point concentration) may well overestimate actual background contribution. The low background estimate is very unlikely to have received significant contamination, but could be below the average background for the area. Actual contributions from background for arsenic are likely to be greater than one percent, but may be significantly less than 50 percent.

Ecological Risk Assessment

Introduction

Ecological Risk Assessments (ERAs) evaluate the likelihood that adverse ecological effects may occur or are occurring at a site as a result of exposure to chemical or physical stressors. Risks result from contact between ecological receptors and stressors that are of sufficiently long duration and of sufficient intensity to elicit adverse effects. The primary purpose of this ERA is to identify and describe actual or potential onsite conditions that can result in adverse effects to present or future ecological receptors. These conditions are identified by comparing observed or likely effects with actual or predicted exposures to physical and, primarily, chemical stressors. Another important objective of this ERA is to provide information that can help establish remedial priorities and serve as a scientific basis for regulatory and remedial actions for the Streamside Tailings Operable Unit (SST OU).

The approach used to conduct this ERA is based on site-specific information and on recent EPA guidance, primarily The Framework for Ecological Risk Assessment. The primary components of this ERA are Problem Formulation, Analysis and Risk Characterization. Stressors identified for this ERA are based on their potential to cause adverse ecological effects, especially effects due to chemical contamination of surface water, sediment, and surface soil. This focus is based on the potential for onsite contaminated media to currently preclude the existence of healthy and diverse aquatic and riparian ecosystems in and adjacent to Silver Bow Creek. In addition, mining-related and other activities have caused considerable physical damage to aquatic and terrestrial habitats onsite.

The primary chemical stressors identified for the site include the following:

- Arsenic (surface water, sediment, surface soil)
- Cadmium (surface water, sediment, surface soil)
- Copper (surface water, sediment, surface soil)
- Lead (surface water, sediment, surface soil)
- Zinc (surface water, sediment, surface soil)
- Mercury (surface water, sediment, surface soil)

The following chemicals, are also considered COPCs and are therefore evaluated in this ERA:

- PCP (sediment, surface soil)
- PAHs (surface water, sediment, surface soil)
- Dissolved oxygen (surface water)
- Ammonia (surface water)
- Nitrogen (surface water)

In addition to chemical stressors, ecological receptors that inhabit or use the SST OU may also be exposed to physical or non-chemical stressors. Important physical stressors, related primarily to past mining activities at this site, include the following:

- Degradation of instream substrates
- Channelization of Silver Bow Creek
- Degradation or disturbance of terrestrial and riparian habitats

The major habitats that have potential to be affected by chemical and physical stressors include aquatic habitats, riparian habitats, and terrestrial habitats. The types of organisms that may be exposed to the chemical and physical stressors identified at this site include aquatic and terrestrial plants and animals (i.e., macroinvertebrates, fish, amphibians, reptiles, birds, and mammals) that inhabit or use, or have the potential to inhabit or use, aquatic, streamside/wetland or terrestrial habitats of the SST OU. No threatened, endangered, or sensitive species have been reported within the SST OU.

The primary exposure pathway evaluated in this ERA is the direct contact of ecological receptors with chemical and physical stressors. Although of lesser importance for this ERA, effects due to contaminant transfer through food chains are also evaluated.

Risk Characterization

Potential risks to ecological receptors are evaluated by comparing current or predicted conditions and chemical concentrations in exposure media (exposure assessment) with similar data correlated with potential to cause adverse effects (effects assessment). The risk characterization phase of the ERA integrates exposure assessment and effects assessment to estimate risk potential for ecological receptors, and considers the ecological significance of predicted effects. A weight-of-evidence approach, utilizing various measures of potential adverse effects instead of a single effects value, is employed in this assessment.

A simplified summary of SST-OU wide potential risks to ecological receptors is presented on a media-specific and chemical-specific basis in Table ES-10. Risk potentials (low, moderate, high) are estimated by evaluating the difference or magnitude between average (arithmetic mean) and U95 values and relevant effects concentrations. Risk potential is estimated to be high where average or U95 values greatly exceed relevant effects concentrations.

Surface Water

The assessment of potential risks to aquatic receptors is based on a comparison of dissolved COCs in surface water to relevant effects concentrations. Measurements of total metals concentrations in surface water may overestimate risks to aquatic receptors because only a portion of the total metals measured is bioavailable and toxic.

Ammonia has potential to cause adverse effects on aquatic biota in Silver Bow Creek because of elevated concentrations in some areas. Adverse effects are more likely, and probably more severe, immediately below the Butte wastewater treatment plant (WWTP), which has been identified as the only known point source of ammonia in Silver Bow Creek. Ammonia concentrations in the lower reaches of Silver Bow Creek only rarely exceed site-adjusted (for pH and temperature) chronic ambient water quality criteria (AWQC) for ammonia.

Recent measurements of dissolved arsenic in Silver Bow Creek have remained below important effects concentrations. These effects concentrations range from 0.048 to 0.850 mg/L, and include concentrations expected to protect freshwater plants and sensitive freshwater animals. Ambient concentrations of dissolved arsenic in Silver Bow Creek range from approximately 0.01 to 0.04 mg/L, indicating low potential for risks to aquatic life from arsenic.

Unlike arsenic, dissolved cadmium concentrations in Silver Bow Creek commonly exceed critical effects concentrations. Arithmetic mean values of dissolved cadmium for all sampled reaches of Silver Bow Creek exceed the lowest effects concentrations but remain below the higher, less protective effects concentrations but remain below the higher, less protective effects concentrations. Cadmium appears to be an important and probably moderate contributor to overall toxicity of Silver Bow Creek surface water. Dissolved copper in Silver Bow Creek is elevated throughout the entire OU, with slightly lower concentrations measured in the most downstream reaches. All recent samples of dissolved copper exceed the lowest effects concentrations for freshwater plants, invertebrates, and fish. Site specific acute effects concentrations for rainbow trout are exceeded in about half the samples measured. Dissolved copper is a major contributor to the toxicity of Silver Bow Creek, and ambient concentrations commonly exceed safe levels for aquatic plants, invertebrates, and fish.

Table ES-10
Simplified Summary of Ecological Risks from Chemical Stressors

Media (units)	Chemical	Arith. Mean Conc/ U95 Conc	Effects Conc [1]	Risk Potential
Surface Water				
mg/L	Ammonia	3.11 / NC	0.53-2.7	Mod to High (location/timing dependent)
µg/L	Arsenic (D)	15.56 / 24.1	48-850	Low
µg/L	Cadmium (D)	1.66 / 2.26	0.47-5.0	Mod
µg/L	Copper (D)	50.74 / 59.56	3.9-54	High
mg/L	Dissolved Oxygen	~9.5 / NC	4.0	Low to High (location/timing dependent)
µg/L	Lead (D)	3.0 / 6.57	0.8-500	Mod
µg/L	Mercury (D)	0.16 / 0.16	0.012-4.0	Low to Mod
mg/L	Nitrogen (total soluble)	1.75-9.19/NC	0.03-1.0	Mod to high (location/timing dependent)
µg/L	PAHs (individual)	0.02 / NC	0.1-5.0	Low
µg/L	PCP	8.01/NC	3.5-14.5	Mod
µg/L	Zinc (D)	336.19 / 585.99	40-277	High
Sediment				
mg/kg	Arsenic	75.16 / 113.11	23.8-24.8	High
mg/kg	Cadmium	4.66 / 7.01	3.9	High
mg/kg	Copper	828 / 1,579.89	325-354	High
mg/kg	Lead	250.5 / 318.66	62.4	High
mg/kg	Mercury	3.49 / 6.7	0.2-2.0	High
mg/kg	PAHs (individual)	0.054-1.563 / NC	4-100	Low
mg/kg	PCP	0.367 / 0.634	4.2-21	Low
mg/kg	Zinc	1,380.13 / 2,120.27	1,064	High

Table ES-10 (Cont.)
Simplified Summary of Ecological Risks from Chemical Stressors

Media (units)	Chemical	Arith. Mean Conc/ U95 Conc	Effects Conc [1]	Risk Potential
Surface Soil				
mg/kg	Arsenic	303.1 / 514.9	25-100	High
mg/kg	Cadmium	6.45 / 11.95	4-50	Mod
mg/kg	Copper	1,470.4 / 2,484.9	60-100	High
mg/kg	Lead	723.63 / 1,241.4	250-1,000	High
mg/kg	Mercury	1.82 / 5.7	2-10	Low to mod
mg/kg	PAHs (individual)	Not Analyzed	1-10	Unknown/ Probably low
mg/kg	PCP	Not Analyzed	0.5-5.0	Unknown/ Probably low
mg/kg	Zinc	1,835.6 / 2,920.7	200-500	High

[1] Description and source listed in Table 5-17

NC: not Calculated
D: dissolved

Dissolved oxygen (D.O.) concentrations in Silver Bow Creek are below minimum national coldwater criteria at some times and in some areas of Silver Bow Creek. For the most part, however, D.O. concentrations remain above minimum criteria levels except in the reach immediately below the Butte WWTP. Observed low D.O. concentrations in this and in other reaches are probably the result of excess nutrient inputs and high biological oxygen demand (BOD) discharges from the Butte WWTP. In the upper reaches, low D.O., along with elevated ammonia and dissolved metals, contribute to the biological impairment of Silver Bow Creek.

Dissolved lead appears to be a minimal to moderate contributor to the toxicity of Silver Bow Creek surface water. Although mean and U95 values generally exceed the lowest effects concentrations, they never exceed the highest (least protective) effects concentrations. Dissolved lead in Silver Bow Creek may add to the overall toxicity of the creek but is unlikely to be a major contributor, especially compared to copper and zinc.

Dissolved mercury was only rarely detected in Silver Bow Creek surface water (one sample, 11 percent frequency of detection). Detection limits for mercury commonly exceed critical effects concentrations or established criteria. Therefore, any detection of mercury in surface water can be important. Because dissolved mercury was detected in only one sample, and because of increased uncertainty associated with concentrations in the low µg/L range, dissolved mercury is not expected to be critically important to environmental conditions in Silver Bow Creek.

Nitrogen compounds were detected in all surface water samples, as expected. Elevated nitrogen compounds, measured as total soluble nitrogen or TSN can promote growth of nuisance algae. Excessive algal growth can indirectly cause depletions in dissolved oxygen and can also impair aquatic habitats. Excess nitrogen in Silver Bow Creek can be important and potentially serious problem in some reaches (especially below the Butte WWTP and in areas of uncontrolled cattle grazing).

PCP has moderate potential to cause adverse effects in surface water because it was detected in all of the few surface water samples for which it was analyzed at concentrations similar to national chronic ambient water criteria. The only known Silver Bow Creek PCP source is currently being addressed by remedial actions at the Montana Pole site.

Only one PAH, benzo(b)fluoranthene, was detected in Silver Bow Creek surface water, with all detections (4 of 4 samples) 02 µg/L. Although only limited toxicity data are available for individual PAHs in surface water, 0.02 µg/L is not expected to be acutely toxic to aquatic biota. PAHs in surface water are not likely to be a significant contributor to the biological impairment of Silver Bow Creek within the SST OU.

Elevated zinc concentrations are found throughout Silver Bow Creek, especially within the most upstream 10 miles of the creek. The spatial distribution of dissolved zinc in Silver Bow Creek indicates a general and consistent decrease in dissolved zinc as samples are taken further downstream. However, even the most downstream samples are associated with exceedances of critical effects concentrations. These data indicate that dissolved zinc is a major contributor to toxicity in the upstream reaches of Silver Bow Creek. In the lower reaches, dissolved zinc is at least a moderate contributor to Silver Bow Creek toxicity.

Sediment

There is less confidence (more uncertainty) in effects concentrations used to evaluate sediment toxicity compared to concentrations used for surface water evaluation. For this reason, the list of effects concentrations for assessing sediment toxicity include a greater variety of data, including site specific toxicity data (lowest degree of uncertainty); non-site specific toxicity data (moderate degree of uncertainty); background data; and other data based on co-occurrence of effects and sediments contaminated with a mixture of chemicals (highest uncertainty). The greatest uncertainty is with data that are statistically rather than toxicologically derived, such as Effects Range-Median (ER-M) values of Long and Morgan. ER-M values represent the median value of ranked concentrations associated with observed effects, and are based on sediments contaminated with a mixture of chemicals. These values are therefore not entirely appropriate for comparison to ambient sediments that are contaminated with a single or a few chemicals. ER-M values are included in this risk characterization because they are commonly used by regulatory agencies and others as a screening level tool in assessing potential sediment toxicity. For the most part, site specific sediment toxicity data are preferred over all other effects data and, where available, these serve as the primary effects data for comparison to recently collected sediment chemistry data.

The total arsenic concentrations of Silver Bow Creek sediments change little from upstream to downstream stations. Both PTI and Canonie sampling events confirm the relative consistent distribution of arsenic throughout the OU. The effects concentrations with the greatest confidence and the least uncertainty (No Effect Concentration, sublethal effects, *Hyallela*), are exceeded by the concentrations of all sediment samples taken. Depending on the data source (PTI or Canonie), ambient concentrations of total arsenic in Silver Bow Creek sediments exceed site-specific effects concentrations by a factor of approximately 2 to 8. Total arsenic is a major contributor to the potential toxicity of Silver Bow Creek sediments.

Unlike arsenic, the concentration of total cadmium in Silver Bow Creek sediments appears to vary both spatially and temporally, and may be increasing over time. Based on the 1991 and 1992 data, total cadmium in Silver Bow Creek sediments nearly always exceeds the site specific no adverse effect concentration (NEC) for sensitive benthic invertebrates (3.9 mg/kg, *Hyallela*). Other effects concentrations, including those based on spiked sediment bioassays (SSB) and apparent effects concentrations (AET) are similar in magnitude to the site specific NEC. These data and others indicate that total cadmium in Silver Bow Creek sediments have a high potential to adversely impact sensitive benthic invertebrates and possibly salmonids.

Copper concentrations in Silver Bow Creek sediments remain consistently elevated from the most upstream to the most downstream reaches of the creek.Copper concentrations in Silver Bow Creek sediments remain consistently elevated from the most upstream to the most downstream reaches of the creek. Studies from 1988, 1991, and 1992 reveal increasingly higher concentrations over time. Copper concentrations in Silver Bow Creek sediments are nearly always in excess of most of the relevant effects concentrations used for comparison, even though the effects concentrations are quite high. For example, all sediment samples collected in 1992 reveal copper concentrations in excess of 1000 mg/kg, much higher than relevant effects concentrations of 325-350 mg/kg. Copper in Silver Bow Creek sediments is a major contributor to the impairment of the aquatic community of Silver Bow Creek.

Total lead in Silver Bow Creek sediments changes little with respect to location with the exception of apparent increases approximately 1 and 8 miles downstream of the upstream border of the OU. Lead concentrations measured in Silver Bow Creek sediments always exceed 100 mg/kg. All 1991 and 1992 samples reveal total lead in sediments in excess of 250 mg/kg. For comparison, the most appropriate (i.e., those with the least uncertainty) effects concentrations are within the range of about 30 to 120 mg/kg. Values in excess of 250 mg/kg are likely to result in severe, acute effects to sensitive benthic biota, thereby potentially affecting organisms at several food chain levels, especially upper level consumers of mercury-contaminated prey. This pathway is not a primary concern at this time because it is incomplete in most cases due to limited numbers and types of potential receptors. The toxicity of inorganic mercury can be increased by bacterial methylation in aerobic and especially anaerobic sediments. Methylmercury concentrations in Silver Bow Creek sediments are expected to remain quite low, however, because anaerobic conditions are not expected to predominate.

PCP concentrations in Silver Bow Creek sediments within the SST OU ranged from 0.256 to 0.980 mg/kg. Relevant toxicity data for PCP in sediment are lacking. However, calculation of predicted sediment pore water concentrations, based on the equilibrium partitioning approach, indicate that Silver Bow Creek sediments within the SST OU have little potential to cause adverse ecological effects. PCP is not considered to be a concern in Silver Bow Creek sediments.

Concentrations of individual PAHs in Silver Bow Creek sediments range from 0.0084 to 3.015 mg/kg within the SST OU. The most commonly detected PAHs include benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzanthracene, and pyrene. The maximum mean value for any particular PAH (1.563 mg/kg, chrysene), only slightly exceeds the low threshold value (1.0 mg/kg) that serves as a conservative guideline for evaluating surface soil contamination. Based on available data, PAHs are not considered to be significant contributors of biological impairment of Silver Bow Creek within the SST OU.

064 mg/kg is a No Effect Concentration (NEC), The probability and the severity of such adverse effects increase with greater exceedances of the NEC. Therefore, while ambient concentrations around 1,000 mg/kg may or may not cause adverse effects to resident species, depending on the sensitivity of exposed organisms and on zinc bioavailability, values greatly in excess of 1,000 mg/kg are likely to be harmful. Since so many recent measurements of zinc in Silver Bow Creek sediments exceed 1,000 and even 2,000 mg/kg, sediment zinc is likely to adversely impact Silver Bow Creek.

Surface Soil

The primary data source for evaluating surface soil phytotoxicity is CH2M Hill (1987), in which the toxicities of arsenic, cadmium, lead, and zinc on soil, plants, and livestock in the Helena Valley of Montana were assessed. Although not site specific, This document summarizes available phytotoxicity data for most of the metals of concern and derives various threshold values for evaluating phytotoxicity. These threshold values include Tolerable Level (maximum concentration at which no phytotoxicity has been observed), Hazard Level (suggested hazard level based on State, provincial, and national regulatory guidelines), and Phytotoxic Level (toxic level for various crop species and soil parameters found in the Helena Valley). Of these, the Phytotoxic Level is most useful because it provides a reasonable threshold (not to exceed) level based on sensitive crop species found in the Helena Valley. Phytotoxic values are based on near-site (regional) data and they therefore are the best available data for assessing potential phytotoxicity of As, Cd, Pb, and Zn at the SST OU. , Threshold Contamination, Contaminated, and Background Pollution are also used for assessing the ecological risk potential for other chemicals of concern. Several of these values are based on multiple soil uses and are not specifically intended to be used as surface soil criteria for protecting ecological receptors. These values do, however, give a general indication of potential for risks from surface soil contamination within the SST OU. The basis for and limitations of this approach are discussed fully in the ERA.

Arsenic in SST surface soil is probably a major contributor to phytotoxicity within the SST OU because all relevant phytotoxicity effects concentrations, including those based on regional (near-site) studies, are greatly exceeded by site-wide mean, U95, and maximum concentrations measured in SST surface soils.

Cadmium, although elevated in SST surface soils, appears to be less likely to result in phytotoxic effects on local plants compared to arsenic. Site-wide mean, U95, and maximum concentrations of cadmium in SST surface soils remain below phytotoxic concentrations derived for sensitive crop species and regional soils. Site-wide mean, U95, and maximum values do, however, exceed regional baseline, suggested hazard, non-regional phytotoxic, and tolerable levels. There is less confidence in the ability of these values to predict or estimate potential phytotoxicity. Because regional phytotoxicity values are not exceeded in any samples, along with the finding that non-regional phytotoxic levels are exceeded in most samples, cadmium in surface soil is considered to have moderate potential for risk.

Copper in SST surface soil is also expected to be a major contributor to phytotoxicity within the SST OU because all relevant phytotoxicity effects concentrations are exceeded by site-wide mean, U95, and maximum concentrations measured in SST surface soils. There is less certainty in using non-regional or non-site specific effects data to estimate risk potential compared to using site specific data. Selected non-site specific data presented in the ERA clearly reveal a high potential for phytotoxicity. Although site- or regional-specific phytotoxicity data are lacking, it is unlikely that the greatly elevated copper concentrations commonly measured in SST surface soil are conducive to survival, growth, reproduction of sensitive native plant species.

Lead concentrations in SST surface soil are approximately half those of copper.. Comparisons of site-wide mean, U95, and maximum exposure concentrations and regional phytotoxic levels reveal a high potential for phytotoxicity. Site-wide mean (724 mg/kg) and U95 (1,241 mg/kg) values approximate the regional phytotoxic level (1,000 mg/kg), while the maximum detected value (9,130 mg/kg) greatly exceeds the 1,000 mg/kg regional phytotoxic concentration. The risk potential for lead in SST surface soil, based on phytotoxicity, is high.

Recommended threshold concentrations (2.0 mg/kg) are exceeded by U95 and maximum SST surface soil mercury concentrations. On the other hand, levels considered contaminated (10 mg/kg) are not exceeded by any surface soil sample. Because the effects concentrations used in this evaluation are not specifically derived to protect ecological receptors, there is substantial uncertainty in the conclusions reached. Mercury in surface soil is considered to have low to moderate potential for ecological risk within the SST OU compared to other surface soil contaminants (e.g., copper, lead, and zinc).

Site-wide exposure concentrations (average, U95, and maximum) of zinc in Silver Bow Creek surface soil greatly exceed selected comparative data for regional baseline, non-regional phytotoxic level, suggested hazard level, tolerable level, and regional phytotoxic level.

Non-chemical Stressors

The major non-chemical stressors contributing to biological impairment of Silver Bow Creek and adjacent areas are disturbed aquatic and terrestrial habitats. Disturbances of aquatic habitat appear to be primarily caused by sediment inputs from upstream sources and from streambank erosion. Where such sedimentation includes deposition of fine grained materials, preferred habitat is lost for most desirable benthic macroinvertebrates. Future spawning areas for salmonid fish would also be similarly affected where deposition of fine grained sediments predominates. Adult salmonids would also be affected by conditions that impair the colonization, survival, growth, and reproduction of prey species, including benthic macroinvertebrates. Finally, fine grained sediments are expected to be more toxic to aquatic life than large grained sediments because of increased metals sorption on fine grained materials. Sedimentation in Silver Bow Creek is therefore a source of both physical (habitat disturbance) and chemical (metals toxicity) stress on resident or future resident biota.

Terrestrial habitats are disturbed by the physical presence of mine waste and the toxic conditions associated with mine waste and surface soil that precludes the establishment of a diverse and healthy plant community. This in turn adversely affects animals that require sufficient food (herbivorous species) and cover (most all species) for survival and reproduction. Soil-dwelling animals, along with sensitive plant species, are not present where mine waste overlies native soils. This result is due to both physical (displacement or covering of native soil) and chemical (toxicity) causes. Streambank tailings and other mine wastes also contribute to impairment of Silver Bow Creek through erosion and runoff.