ENGINEERING EVALUATION/COST ANALYSIS REPORT

SOUTHWEST JEFFERSON COUNTY MINING SITE, OPERABLE UNIT (OU) 4

JEFFERSON COUNTY, MISSOURI

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LIST OF ACRONYMS

ft	foot/feet
mg/kg	milligrams per kilogram
AMSL	above mean sea level
AR	Administrative Record
ARAR	applicable or relevant and appropriate requirement
BERA	Baseline Ecological Risk Assessment
BRMT	Big River Mine Tailings Superfund site
BRWP	Big River Watershed Project
CAD	confined aquatic disposal
CDF	confined disposal facility
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
CFR	Code of Federal Regulations
COC	contaminants of concern
CWA	*Clean Water Act*
CY	cubic yards
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
FS	Feasibility Study
GRA	General Response Action
HHRA	Human Health Risk Assessment
IC	institutional control
IEUBK	Integrated Exposure Uptake Biokinetic
MoDNR	Missouri Department of Natural Resources
MSU-OEWRI	Missouri State University – Ozarks Environmental and Water Resources Institute
NCP	*National Oil and Hazardous Substances Pollution Contingency Plan*
NTCRA	Non-Time-Critical Removal Action
O&M	Operation & Maintenance
OU	Operable Unit
PRP	potentially responsible party
PRSCP	Post Removal Site Control Plan
RAO	Removal Action Objectives
RI	Remedial Investigation

ROD	Record of Decision
SARA	*Superfund Amendments and Reauthorization Act*
SJCM	Southwest Jefferson County Mining
TCLP	Toxicity Characteristic Leaching Procedure
TCRA	Time-Critical Removal Action
USGS	United States Geological Survey

1.0 EXECUTIVE SUMMARY

This Engineering Evaluation/Cost Analysis was prepared by the U.S. Environmental Protection Agency to identify alternatives for a Non-Time-Critical Removal Action of sediment and floodplain soil at the Southwest Jefferson County Mining Superfund site, Operable Unit 4 in Jefferson County, Missouri. An EE/CA must be completed for all Non-Time-Critical Removal Actions in accordance with the *Comprehensive Environmental Response, Compensation, and Recovery Act*, as required by section 300.415(b)(4)(i) of the *National Oil and Hazardous Substances Pollution Contingency Plan*. The goals of the EE/CA are to identify the objectives of the NTCRA and to analyze the effectiveness, implementability and cost of various alternatives that may satisfy these objectives.

The EE/CA was developed in accordance with EPA/540/F-93/057 *Guidance on Conducting NTCRA Under CERCLA* (EPA, 1993). A Removal Action may be taken to abate, prevent, minimize, stabilize, mitigate or eliminate the release or threat of release to public health, welfare or the environment. The results of the EE/CA, along with the EPA's response decision, will be summarized in the Action Memorandum.

Early surface-mining in the Big River Watershed began in the 1700s followed by large-scale underground mining in the mid-1800s, producing more than 9 million tons of lead. The largest mining operations associated with the Big River Mine Tailings Superfund site OU2 were in St. Francois County near the Big River. An estimated 250 million tons of hazardous mining waste, such as lead mill waste tailings, and chat were produced in the Old Lead Belt. Mine wastes adjacent to the Big River and tributaries of Big River have contaminated sediment, floodplain soil, and surface water with heavy metals, including lead, cadmium and zinc.

Elevated levels of lead and other mining metals have impacted the Big River starting near the western edge of St. Francois County and extending approximately 113 miles downstream to the confluence with the Meramec River. The impacted area of the Big River is comprised of 40 upstream miles of the BRMT OU2 site, and 73 downstream miles of the SJCM OU4 site, collectively referred to as the Big River Watershed Project.

The focus area of the SJCM OU4 NTCRA includes the highest priority areas upstream of River Mile 31. This includes 42 miles of mining-contaminated river sediments and banks of the Big River which the EPA collectively defines as the secondary source areas within the watershed. During flood events, contaminated sediments within the watershed are mobilized and deposited downstream while unstable riverbanks release contaminated soil stored in the floodplain.

The EPA is proposing an iterative approach to address contaminated sediment, floodplain soil from eroding riverbanks and surface water in SJCM. The first phase will be to address priority areas using a NTCRA. Prioritization is determined by a combination of erosion rate, concentrations of contaminants of concern and accessibility. Lead, cadmium, barium, chromium, arsenic and zinc have been identified as the COCs for this response action.

The following Removal Action Objectives have been developed:

- Reduce the COC mass and downstream transport of riverbed sediments in priority locations through capture and removal, and

- Reduce the release and transport of COCs from unstable riverbanks to the watershed in priority locations through bank stabilization

The EE/CA considers the following response actions to achieve the RAOs.

1. No Action
2. Targeted Bank Stabilization
3. Sediment Traps, Targeted Excavation/Dredging
4. Targeted Bank Stabilization, Sediment Traps, Targeted Excavation/Dredging (the EPA's preferred alternative)

Alternative 4 is the recommended removal alternative. Alternative 4 reduces risks to human health and the environment by reducing inputs of secondary sources to the watershed through bank stabilization and sediment removal. The proposed actions would reduce the release, transport and mass of COCs. Alternative 4 also reduces risks, stabilizes banks of the river and reduces the potential for recontamination and is the only alternative that achieves the RAOs.

The EPA has developed this EE/CA and will use it to develop the Action Memorandum for the SJCM OU4 site. This NTCRA will be consistent with and support any future Remedial Action and information gained from this NTCRA will be used in development and support of a subsequent Record of Decision .

2.0 INTRODUCTION

Under the authority of *CERCLA* and the *Superfund Amendments and Reauthorization Act* , the EE/CA is meant to guide the recommended approach for a NTCRA to address historical, mining-related contamination in the SJCM portion of the Big River watershed. The impacted area of the watershed comprises SJCM OU4 and BRMT OU2, collectively referred to as the Big River Watershed Project. Because the proposed NTCRAs at SJCM and BRMT are interdependent, this document contains details pertaining to both sites. However, an EE/CA for the BRMT portion of the BRWP has been prepared separately. The SJCM OU4 site encompasses approximately 73 miles from the northern border of the St. Francois County portion of the BRWP from river mile 73 near Upper Blackwell Road to river mile 0 at the confluence of the Meramec River. This NTCRA focuses on the highest priority areas in the upper 42 miles of mining-contaminated river channel, associated tributaries and the adjacent 100-year floodplain.

The SJCM site is located within the Old Lead Belt, which was one of the world's largest lead mining districts. Early surface-mining began in the 1700s followed by large-scale underground mining in the mid-1800s, producing more than 9 million tons of lead (Figure 1.1). It has been estimated that some 250 million tons of mining waste (such as lead mill waste tailings and chat) was generated in the Old Lead Belt from processing lead.

Historical mining activities in BRWP resulted in the release of heavy metals to air, soil sediment, surface water and groundwater. COCs include lead, cadmium, barium, chromium, arsenic and zinc. Mine waste has been dispersed throughout the area from water and wind erosion, spread as residential fill material, used as treatment on icy roads and used as agricultural lime. Runoff from these applications, along with historic releases directly from the lead mill waste tailings and chat, has been transported downstream in the Big River, incorporated into channel sediments and deposited in the floodplain. Contaminated sediments and floodplain soils are secondary sources and are mobilized and released during flood events.

This EE/CA evaluates technologies and assesses proposed Removal Action alternatives for the removal of contaminated sediment and stabilization of eroding riverbanks in the BRWP.

The EPA proposes to cleanup locations posing the greatest and most immediate threats to human health and the environment. The NTCRA will include removal and stabilization of some of the most highly contaminated areas of the river and floodplain, while assessing any unintended impacts to the watershed. The NTCRA is intended to be followed by a Remedial Action that may expand on the scope.

2.1 PURPOSE AND SCOPE

The EPA is performing a NTCRA pursuant to *CERCLA* Section (§) 104, 42 *United States Code* (U.S.C) § 9604 and federal Executive Order Number (Exec. Order No.) 12580. The purpose of a NTCRA is to take action that reduces a threat to human health or the environment. This EE/CA develops, compares and evaluates Removal Action alternatives for a planned NTCRA within the BRWP in Jefferson County, Missouri. The EPA's decision to undertake this NTCRA and its selected Removal Action alternative will be documented in this EE/CA and in an Action Memorandum consistent with the *NCP*.

CERCLA § 101(23) and the *NCP* (Title 40 of the *Code of Federal Regulations* [CFR] Part 300.5) define remove or removal as:

"…The cleanup or removal of released hazardous substances from the environment; such actions as may be necessary taken in the event of the threat of release of hazardous substances into the environment; such action as may be necessary to monitor, assess and evaluate the release or threat of release of hazardous substances; the disposal of removed material; or the taking of such other actions as may be necessary to prevent, minimize, or mitigate damage to the public health or welfare of the United States or to the environment, which may otherwise result from a release or threat of release..."

Based on 40 CFR 300.415 of the *NCP*, the EPA has classified Removal Actions into three types, based on the circumstances surrounding the release or threat of release:

- An emergency Removal Action, where on-site cleanup is initiated within hours after a release or threat of a release has been verified;
- A Time-Critical Removal Action where, based on the site evaluation, a period of 6 months or less is available before on-site removal activities must be initiated; and
- A Non-Time Critical Removal Action, whenever a planning period of at least six months exists before on-site activities must be initiated.

Given the scope and scale of the SJCM OU4 response action, greater than six months planning time is necessary prior to beginning on-site activities. This EE/CA for a NTCRA at the SJCM OU4 site addresses the implementability, effectiveness and costs of the Removal Action alternatives, along with applicable or relevant and appropriate requirements. The EPA is the lead agency for Removal Actions at the site. As the lead agency, the EPA has the authority to select the alternative, after considering public and regulatory comments. The EPA is working in consultation with the Missouri Department of Natural Resources to plan and implement this Removal Action.

2.2 COMMUNITY INVOLVEMENT

CERCLA and the *NCP* define Removal Actions to include actions that may be necessary to prevent, minimize or mitigate damage to the public health or welfare or to the environment, which may otherwise result from a release or threat of release to public health, welfare or the environment. The *NCP* includes requirements for public participation during Removal Actions.

The EE/CA is maintained at the information repositories identified in the public notice and will be included in the Administrative Record published for the NTCRA. The supporting documents used to develop this EE/CA are contained within the AR.

3.0 SITE CHARACTERIZATION

3.1 SITE DESCRIPTION AND BACKGROUND

3.1.1 Site Location

The SJCM site is in Jefferson County, Missouri, and occupies the northern portion of a former mining region of Missouri known as the “Old Lead Belt.” Mining began in Jefferson County in the early 1800s, and facilities were generally located in the southwest portion of the county. By the mid-1800s, hundreds of mines and three smelters were operating in the county and produced over 3 million pounds of lead annually. The primary source areas are located within the BRMT site. The SJCM OU4 site is defined as the portion of the Big River Watershed that is in Jefferson County, from river mile 73 near Upper Blackwell Road to river mile 0 at the confluence of the Meramec River. This NTCRA focuses on the highest priority areas in the upper 42 miles of mining-contaminated river channel associated tributaries and the adjacent 100-year floodplain.

3.1.2 Site Background and Historical Operations

The site background information in this section was summarized from the EPA draft Remedial Investigation (RI) Report, submitted under a separate cover, for the BRWP (HGL, 2021a).

The 2019 Inventory of Mines Occurrences and Prospects database (MSDIS, 2021) lists 418 historical sites associated with mineral mining and production operations in Jefferson County (Figure 2.1). Of these, 222 of the mining operation sites were designated for lead or lead and other commodities, particularly zinc and tiff (a common slang term for barite). There are 75 tiff mines listed, and the remaining 121 sites include a few iron and copper mines along with numerous limestone, sand, gravel and clay mines.

Mining activities in Jefferson County began in the early 1800s in the southern portion of the county, where the Cambrian dolomite source rock is concentrated along Big River and other major streams (Tetra Tech, 2008). The first production operation was a lead shot tower erected in 1809 in the southern part of Herculaneum. Two mines were in operation as early as 1818. Gray’s Mine was located on the Big River and McKane’s Mine was located on Dry Creek. Many other mines were opened in the 1830s and 1840s for producing lead, zinc, and barium. By 1855, three smelters were operating in Jefferson County: Valles Mines, Mammoth Mines, and Sandy Mines. Historical records indicate that over 1,500 tons of lead were shipped out of Jefferson County annually during this period.

Only the Valles Mining Company still exists in the area; however, it no longer mines for lead. According to historical records, the company operated the lead mine and smelting operation at Valles Mines from about 1824 through the 1930s. The ruins of several ore milling structures, a former smelter, chat piles and mill wastes are still present in the vicinity of Valles Mines (Tetra Tech, 2007). The St. Joe Lead Company opened a smelting facility in Herculaneum in 1892. Smelting operations at the Doe Run facility in Herculaneum concluded in 2013. The Valles Mines is addressed as OU6 for SJCM while the Herculaneum Smelter is addressed as a separate site.

The Big River is used for recreational purposes such as fishing and canoeing as well as for commercial activities such as watering livestock. The Missouri Department of Health and Senior Services works with the Missouri Department of Conservation and other agencies to evaluate the amount of lead in Missouri sport fish. Sunfish, carp, and suckers are listed in the annual fish advisory as “Do not eat” in Big River and in Flat River downstream of the mining areas (MoDHSS, 2024). The following water body identification numbers 2074, 2080, 2166 (draft), 2168, 2170, 2171 (draft), 3282 (MoDNR, 2024) have a Total Maximum Daily Load listed for metals contamination in the BRWP (MoDNR, 2023).

3.1.3 Topography and Surface Water Hydrology

Topography varies considerably throughout Jefferson County. Much of the northern and southern parts of the county can be classified as rugged with more than 20% slopes that exhibit narrow ridges and deep ravines. The central one-third of the county, however, consists of wider/flatter crests and shallower valleys. The highest point in the county is Vinegar Hill at 1,060 ft above mean sea level and the lowest elevation is in the Mississippi River bottom at 385 ft AMSL. The landscape is controlled by various geologic units that vary in bedding thickness, depositional properties and weathering characteristics. According to the U.S. Department of Agriculture soil survey (USDA, 2004), there are seven distinct physiographic regions in Jefferson County:

- Dissected Till Plains – Adjacent to the lower Meramec and Mississippi rivers. Consists of rolling and partially dissected basins with low hills and broad ridges.
- River Hills – Bounded on the east by the Mississippi River and on the west by the Burlington Escarpment. Consists of a narrow band of uplands.
- Zell Platform – Bounded on the east by the River Hills and the west by the Crystal Escarpment. Consists of a small valley east of Selma with rolling topography.
- Burlington Escarpment – Borders the River Hills and Crystal Escarpment. Consists of a band of ridges, thinning from north to south, that are generally narrow with deeply incised side slopes.
- Crystal Escarpment – Borders the Burlington Escarpment to the east and the Salem Plateau to the south and west and follows the St. Peter Sandstone from the northwest corner of the county to the southeast. Consists of broad ridges with strongly sloping to moderately steep side slopes.
- Salem Plateau – Borders the Crystal Escarpment to the north and east and the Avon Escarpment to the south. Consists of narrow ridge tops that are the remnants of an extensive sedimentary plain that encompasses the entire Ozark region.
- Avon Escarpment – Located in the southwest corner of the County with the Salem Plateau to the north. Represents the highest area of the County.

Three major watersheds occur in Jefferson County and northern St. Francois County (Figure 2.2): the Cahokia-Joachim (USGS Hydrologic Unit 07140101) located in the eastern half of the counties; the Meramec River (USGS Hydrologic Unit 07140102) situated in the far north and northwest portions of Jefferson County; and the Big River (USGS Hydrologic Unit 07130104), which encompasses the western portion of Jefferson County and the northern half of St. Francois County.

3.1.4 Geology

A general geologic description for the SJCM OU4 is included below. As noted above, Jefferson County is divided into seven distinct regions. The landscape in these regions is controlled by various geologic units that vary in bedding thickness, depositional properties, and weathering characteristics.

Exposed bedrock units in Jefferson County range in geologic age from Cambrian to Pennsylvanian. The bedrock units consist of gently dipping to flat formations dominated by dolomite, sandstone, and limestone. The Cambrian rocks are composed mainly of massive dolomite from which zinc, lead, and barium ores were mined. These ore bodies occur along the larger creeks and Big River in southern Jefferson County.

Three quarters of the bedrock exposed in Jefferson County consist of Ordovician formations, including the St. Peter Sandstone, which is mined for glass. Ordovician limestone and dolomite are quarried for cement, building stones and aggregate. Devonian formations consist of a narrow band of sandstone, shale and limestone in the northern part of the County. Mississippian formations are predominantly limestone and cherty limestone. Pennsylvanian formations consist of sandstones and shales and can have karst features such as sinks and bedrock joints (USDA, 2004).

The surface geologic units in Jefferson County generally trend in a northwest-to-southeast direction. The younger geologic units are in the northeast corner of the county and the older units are found in the southwest corner of the county. The Big River cuts across most of the units found in Jefferson County (MoDNR, 2007).

3.1.5 Hydrogeology

Domestic wells in Jefferson County produce groundwater from either alluvial or bedrock aquifers. The alluvial aquifers typically have a high conductivity on the order of 0.01 centimeters per second (cm/sec). The Ozark aquifer is a bedrock aquifer that lies directly beneath the alluvium. Hydraulic conductivity in the Ozark aquifer is moderate, ranging between 0.1 cm/sec to 1×10^{-6} cm/sec. The Ozark aquifer is not considered to be a karst aquifer (Miller and Vandike, 1997).

The St. Francois Confining Unit is located below the Ozark aquifer and consists of an approximate 300-ft-thick layer of shales, fine-grained limestones and dolomites, with a hydraulic conductivity of 1×10^{-8} cm/sec. This Confining Unit serves as a barrier to downward groundwater movement. Beneath the St. Francois Confining Unit is the St. Francois aquifer, which can be 700 ft thick and consists of dolomite and sandstone formations. Hydraulic conductivity of the St. Francois aquifer varies locally and may be between 1×10^{-4} cm/sec and 1×10^{-7} cm/sec. In Jefferson County, 19% of the potable groundwater is stored in the St. Francois aquifer; however, most of the potable groundwater (81%) is stored in the Ozark aquifer (Miller and Vandike, 1997).

Groundwater is the principal source of public and private water supplies in the area. According to the Missouri Environmental Geology Atlas 2007 database, 142 active public water supply wells are in Jefferson County and range in depth from 90 ft to 1,528 ft. Domestic well depths recorded in the certified well file generated by MoDNR range from shallow (less than 50 ft deep) to 1,375 ft deep for the 6,274 listed wells (Tetra Tech, 2008).

3.1.6 Sensitive Ecosystems

The Big River is the largest tributary within the greater Meramec River basin. Freshwater mussel communities within the lower Big River include nine freshwater mussel species of conservation concern and five federally endangered species (*Lampsilis abrupta, Leptodea leptodon, Plethobasus cyphyus, Epioblasma triquetra* and *Cumberlandia monodonta*). Big River is known to support more than 100 fish species, 34 mussel species, eight crayfish species and 107 aquatic insect species (MoDC, 2002).

In general, impacted areas along Big River include the river sediments and adjacent floodplain soils. The habitats associated with floodplains are generally dominated by deciduous forest. In some areas there are industrial/commercial operations, including active mining and gravel pits, adjacent to the river. In other areas, there are agricultural activities (mostly pasture) encroaching up to the river's edge. Within and along the banks of the Big River there are numerous depositional areas (gravel and sand flats). Some of these areas contain visible deposits of chat and tailings.

A Baseline Ecological Risk Assessment was completed for the SJCM site by the EPA in 2020 and is included in Appendix A of the Draft RI Report (HGL, 2021a).. The media of concern are contaminated surface soil, surface water and sediment. The BERA evaluated terrestrial herbivore, vermivore, macroinvertebrate and piscivore communities.

3.2 HISTORY OF PREVIOUS REMEDIAL INVESTIGATIONS AND RESPONSE ACTIONS

3.2.1 Previous Investigations

The EPA has investigated mine waste contamination within the Big River watershed by collecting and analyzing thousands of sediment, floodplain soil, and surface water samples to characterize the nature and extent of contamination within the watershed. Risk to human and ecological receptors were compiled in a draft RI Report:

Draft Remedial Investigation Report, Big River Mine Tailings site OU 02 and Southwest Jefferson County Mining site OU 4, St. Francois and Jefferson Counties, Missouri. Dated: March 2021.https://usepa.sharepoint.com/_layouts/15/spappbar.aspx?workload=sites

3.2.2 Previous Response Actions

The EPA prioritizes cleanup by addressing the highest risks first. The response actions taken at the site are described below.

Residential Soils (OU1) and Groundwater (OU5)

The EPA's cleanup efforts to date have reduced risks posed by lead-contaminated soils at thousands of residential properties including yards, daycares, schools, playgrounds, and parks. Cleanup efforts at the SJCM site have included sampling of over 6,952 residential properties and remediation of over 1,760 properties as of 9/25/24. The EPA also provides water filtration and/or bottled water to private residential well owners with groundwater exceeding the lead Action Level.

BRWP Treatability Studies

The treatability studies completed to evaluate potential removal technologies within the watershed include the following:

- Bone Hole (Owl Creek Park) (2009) – Sediment dredging and gravel bar excavation
- Byrnes Mill (2013) – Floodplain soil remediation and sediment collection study
- Calico Creek (2022) – Bank stabilization of Big River floodplain soils
- Mammoth (2017) – Installation and maintenance of off channel sediment trap
- Mineral Fork (2017) – Bank stabilization of Big River floodplain soils
- Riffle 96 (2015) – Modified in-channel and overbank sediment collection
- Rockford Park (formerly Rockford Beach) (2016 stabilization) – 2020 Long-term dam impact study

3.3 SOURCE, NATURE AND EXTENT OF CONTAMINATION

The draft RI summarizes the nature and extent of metals contamination in SJCM OU4. Lead, cadmium, barium, chromium, arsenic, and zinc are the COCs for the site and are generally co-located. Mine waste such as chat, tailings, and fine-grained slime deposits are in direct contact with or were released to Big River in St. Francois County and migrated downstream into Jefferson County. COC-contaminated sediment and floodplain soil occurs along the entire length of the BRWP. The primary depositional areas in Jefferson County are the floodplains. These areas contain the highest COC concentrations in the SJCM OU4 site. These floodplain deposits are eroded and mobilized during high water events and redistributed downstream.

Soil and sediment lead concentration results that are summarized in subsequent sections are compared to a site-specific ecological risk-based level for lead of 205 milligrams/kilogram (mg/kg). This risk-based level was derived from the concentration response models developed from the mussel toxicity study data, specifically the 28-day *Lampsilis siliquoidea* test (HGL, 2021a).

3.3.1 Floodplain Soils

Lead contamination exceeding ecological screening levels for benthic biota (205 mg/kg) and residential cleanup levels for SJCM (400 mg/kg) is present in floodplain soils throughout the site area. Figure 2.3 plots average lead concentrations along the Big River from previous investigations for the RI.

The following provides a summary of the data on the source, nature and extent of mining related waste in floodplain soils:

- The lowest lead concentrations were observed upstream of the BRMT OU2 source areas and are considered background for the SJCM OU4 site. These concentrations were below 100 mg/kg.

- The highest cadmium and zinc concentrations were observed at locations near the source areas in St. Francois County.

- The primary source areas are mine waste piles within St. Francois County. Data shows that the main tributaries draining the Barite Mining District (Mill Creek and Mineral Fork) are a significant source of the barite found in Big River. Lead is also associated with the barite mining ores.

- Investigations confirmed that mining waste-related contamination generally extends across the floodplain.
- The depth of contamination generally extends 8 to 12 ft below ground surface, with a sharp decline below this depth. Floodplain soils were most heavily contaminated during the active mining period of over 150 years which contributed to the depth of contamination.

3.3.1.1 Floodplain Soil Concentration Sampling Details

Pavlowsky (2010) found that lead contamination extended from the Leadwood mine waste pile to the confluence of the Meramec River. The highest concentrations of floodplain soils measured during that study were in SJCM OU4 at Washington State Park (>8,000 mg/kg) with depths up to 13 feet. The report explains that mine tailings from St. Francois County have been selectively transported downstream according to grain size of the sediment. Larger size fractions tend to remain in sediments of St. Francois County while finer size fractions extend downstream and have deposited primarily in the floodplain of Jefferson County. Lead concentrations in floodplain soils of Jefferson County were generally higher than the adjacent channel sediments. The most heavily contaminated floodplain soils found in the study were in areas that frequently flooded.

Floodplain surface soils sampled in 2014 as part of the RI found lead above removal management concentrations at 32 of the 35 properties sampled along the Big River in Jefferson County. The highest floodplain surface soil detection was observed at property JC-12868 at 2,450 mg/kg lead. This property had the three highest lead X-Ray fluorescent spectrometer concentrations observed in the floodplain soil samples.

Subsurface floodplain soils sampled for the RI contained lead above the removal management concentrations at 19 of the 20 properties in Jefferson County at both the 0 to 6-inch and the 6 to 12-inch depths. The highest concentrations at both sample depths, which exceeded 3,000 mg/kg, were detected at property JC-12588 located in the upstream portion of the study area near Washington State Park. The lowest lead concentrations were clustered at the downstream portion of the combined site area, and concentrations at both depths generally increased in the upstream portion of the river. Generally, if the 0 to 6-inch sample contained lead above risk-based concentrations, then the lead concentration in the 6 to 12-inch sample also exceeded this value.

The Smith & Schumacher (2018) study focused on Big River tributaries draining the Washington County Barite District. The findings show the Barite District floodplain soils contain lesser concentrations of lead and zinc than that of the Big River floodplain soils. However, the floodplain soils in the Barite District were found to have elevated concentrations of barium.

Arsenic, cadmium, barium, and zinc have a widespread presence in the study area and were detected in most soil samples. In general, the spatial distribution of these metals corresponds with the spatial distribution of lead. However, highest barium concentrations were found downstream of the tributaries that drain the historical Barite Mining District.

Noerpel (2020) found lead concentrations in floodplain soil generally decrease from upstream source areas downstream and documented a lead isotopic signature consistent with the mine tailings sites in St. Francois County. This signature continued through Jefferson County to the mouth of Big River. This report also found higher bioaccessibility of lead, even at lower concentrations, in the downstream portions of Big River located in Jefferson County.

3.3.2 Sediment

Widespread lead contamination exists within the Big River and Flat River channel bank and bar sediments. Figure 2.4 shows average lead concentrations along Big River from previous investigations conducted by the PRPs, EPA, and other agencies in the Big River watershed (AMEC, 2014; NewFields, 2006; Noerpel, 2020; Pavlowsky, 2010; Smith & Schumacher, 2018).

The following provides a summary of the data on lead concentrations in sediment.

- Contaminant concentrations exceed ecological risk-based thresholds for sediment throughout most of the Big River beginning at source waste piles and extending downstream to the confluence with the Meramec River. Concentrations are below established thresholds upstream of source locations.
- Lead concentrations generally decrease gradually downstream of source locations.
- Sediments from tributaries in Washington County are only a small contributor of lead and zinc to the Big River system. Isotopic data shows that the source of the contamination is the piles in St. Francois County.
- Elvins Mine Tailings site, Federal Mine Tailings site, and National Mine Tailings site are adjacent to the Flat River making them a significant source of lead contamination into Big River.

The following provides a summary of the data on cadmium, arsenic, barium, and zinc concentrations in sediment.

- Cadmium and zinc concentrations generally decline from upstream to downstream in Big River, with the highest concentrations near the source area in St. Francois County.
- Arsenic is widespread within the sediments throughout the SJCM OU4 site area.
- Elevated barium concentrations in Big River sediment downstream of Mineral Fork and Mill Creek can be partially attributed to the high barium concentrations from these tributaries. Elevated barium concentrations were documented in streams flowing through the Barite Mining District in Washington County, most notably during the USGS study (Smith and Schumacher, 2018).
- Flat River is a significant source of zinc contamination into Big River.

3.3.2.1 <u>River Sediment Concentration Sampling Detail</u>

Sediment samples were collected for the RI from transects across the Big River in spring 2014, spring 2015 and summer 2015 and submitted for analysis to the EPA Laboratory for arsenic, barium, cadmium, lead, and zinc. The sample collection varied between the events as described in Section 3.2 of the RI report. In general, each transect consisted of east bank, west bank, and in-channel samples.

Lead was detected at all locations in each of the three sampling events. In spring 2014, lead concentrations ranged from 25.9 mg/kg to 19,900 mg/kg and were detected in one or more samples at 34 of 35 sample locations at concentrations exceeding the ecological risk-based concentrations for soil and sediment. Observed variability may be at least partially explained by hydraulic sorting of sediments. The spring 2015 results are consistent with those from spring 2014. In summer 2015, lead concentrations ranged from 19.1 mg/kg to 12,700 mg/kg. At all 30 locations sampled during this event, lead was detected in one or more samples at or above risk-based concentrations for soil and sediment.

3.3.3 Surface Water

Surface water in the Big River has been impacted by COCs, consistent with collocated sediment samples. Although a trend in lead concentrations from upstream to downstream generally was not evident, lead was detected at all 35 surface water sampling locations with concentrations ranging from 18.5 µg/L to 355 µg/L. Four arsenic and seven cadmium detections exceeded their respective RSLs. Cadmium was detected only in the most upstream locations in the study area, while arsenic was observed at locations in the central and downstream portions of the study area. Barium and zinc were present in almost all samples, but generally not at concentrations exceeding their RSLs.

Low and nondetect concentrations for COCs in background samples show that the source for high metals concentrations in the Big River and Flat River are attributable to the mining activities and waste piles in St. Francois County. Increased river heights were generally found to correspond to more suspended and contaminated sediments through the erosion of bed and bank material.

Additionally, portions of the Big River, Flat River, and associated tributaries have been listed by MoDNR as impaired waters under Section 303(d) of the *CWA* (MoDNR, 2024). Total Maximum Daily Load calculations have also been established in response to lead contamination in reaches of the Big River, Flat River Creek, Koen Creek, and Turkey Creek.

3.4 STREAMLINED RISK EVALUATION

The following risk assessment discussion was taken from the Draft RI Report (HGL, 2021a). The Human Health Risk Assessment and BERA for each site were performed for/by the EPA and are included in Appendix A of the Draft RI Report (HGL, 2021a). The risk assessments were conducted using data collected by the EPA and MoDNR from 2012 to 2019. Data collected include both whole body and fish fillet samples for the BRMT HHRA. The General Conceptual Site Model is provided in Figure 2.6.

3.4.1 Human Health Risk Assessment Summary

The EPA considers lead to be a special case because of the difficulty in identifying a level of exposure, or dose, below which adverse effects are unlikely, which is needed to develop a reference dose. For assessment of lead, the EPA recommends the use of the Integrated Exposure Uptake Biokinetic model to evaluate exposures to children from lead-contaminated media. The IEUBK model integrates exposures to lead from all media, including site-related media such as soil, sediment, groundwater used as drinking water and surface water (as applicable for a given exposure scenario).

The updated HHRA evaluated risks posed by lead in floodplain soil, groundwater, surface water, and sediment to people who live and/or recreate in SJCM OU4. The update also estimated risks posed by metals other than lead to OU4 residents. The HHRA found that lead in all environmental media poses an unacceptable risk to child residents, child recreational visitors, and child residential recreators. The EPA defines unacceptable risk as a greater than 5% probability of exceeding the target blood lead of 5 micrograms per deciliter (EPA, 2020a).

It is expected that decisions made by risk managers for the Big River and its floodplain that are based on protecting against risks associated with exposures to lead will also be protective of exposures to non-lead contaminants by evaluating both cancer and non-cancer health effects. The cancer risks estimated for the child recreational visitor are not greater than the EPA target risk range.

The draft Risk Assessment documents have identified lead as a primary COC and referenced arsenic, barium, cadmium, chromium, and zinc as historically significant secondary COCs for SWJC OU4.

3.4.2 Ecological Risk Assessment Summary

A BERA was completed for the SJCM site in 2020 (EPA, 2020). The media of concern were surface soil, pore water and sediment. Pore water was selected in lieu of surface water because benthic macroinvertebrates exposure to pore water is a significant exposure pathway. The BERA evaluated potential risks posed by cadmium, lead, and zinc in site soil, sediment, and pore water to wildlife including piscivores, aquatic macroinvertebrates, and freshwater mussels. These COCs are also found upstream of the SJCM site and were evaluated in previous risk assessments for the BRMT site.

The SJCM BERA included food chain modeling for upper trophic level receptors, soil testing, sediment testing, and pore water testing. The BERA identified cadmium and lead as primary risk drivers for terrestrial wildlife due to soil concentrations within the floodplain. Risk to piscivores were primarily due to ingestion of lead in aquatic prey. No clear association between metals in sediment and the health of the macroinvertebrate community was shown in the lower Big River. However, results from juvenile mussel toxicity tests indicate potential significant risk to mussels due to lead and cadmium concentrations in sediments throughout the river.

Multiple studies have demonstrated adverse impacts of heavy metals to the freshwater mussel communities in the BRWP (Roberts et al., 2023; Albers et al., 2016). Laboratory toxicity studies also confirmed adverse effects of contaminated sediments on mussel communities across a variety of endpoints including survival, growth, and biomass (Besser et al., 2009, HGL, 2021a).

Roberts et al. 2023 conducted a concentration-response model for the effects of sediment lead on freshwater mussel densities in Big River. Results using median sediment lead concentrations compared to densities from quantitative mussel surveys indicated the half maximal effective concentration (EC50) for mussel density to be 166 mg/kg in Big River. This concentration is consistent with MacDonald et al. (2000) established Probable Effects Concentrations (PEC) for benthic invertebrates (128 mg/kg) and is comparable to screening levels derived from the EPA's laboratory-based concentration-response models developed from 28-day *Lampsilis siliquoidea* toxicity tests (HGL, 2021a).

For purposes of the EE/CA, soil and sediment lead concentration results are compared to the EPA's ecological risk-based screening level for lead of 205 milligrams/kilogram (mg/kg) which was derived from the laboratory-based concentration-response models developed from 28-day *Lampsilis siliquoidea* toxicity tests (HGL, 2021a).

4.0 IDENTIFICATION OF REMOVAL ACTION SCOPE, GOALS, AND OBJECTIVES

Removal Action Objectives are site-specific qualitative or quantitative goals that define the extent of cleanup required for the NTCRA. The EPA has determined that a NTCRA is appropriate for the site, to achieve a reduction in the release, transport, and mass of COCs through secondary source control of floodplain soil and sediment while the follow-on phase for the site is being developed. The NTCRA will be consistent with any future Remedial Action. The RAOs are general statements of cleanup goals along with medium- or OU-specific goals to achieve response objectives and satisfy ARARs. The NTCRA approach is appropriate for the following reasons:

1. The approach allows for temporary/short-term measures to stabilize SJCM OU4 and/or reduce further migration of contaminants or further environmental degradation.
2. The EPA encourages the use of an iterative approach for optimizing decision-making due to potential uncertainties, especially at complex contaminated sediment sites.

The EPA will collect data demonstrating the effectiveness of each removal measure over an approximate 11-year period during the NTCRA. Monitoring will continue through the development of a follow-on action.

The determination of RAOs includes consideration of site-specific risks and ARARs in accordance with *CERCLA*. RAOs consist of medium-specific or Operable Unit-specific (or both) goals for protecting human health and the environment. RAOs are developed to identify and screen removal alternatives that achieve protection of human health and the environment consistent with a reasonably anticipated land use.

The following RAOs have been developed for this NTCRA:

- Reduce the COC mass and downstream transport of riverbed sediments in priority locations through capture and removal, and
- Reduce the release and transport of COCs from unstable riverbanks to the watershed in priority locations through bank stabilization.

The NTCRA would focus on reducing the release, transport, and mass of COCs through secondary source control of sediment and floodplain soil while any future Remedial Actions are being developed.

The EPA defines the secondary source areas as the riverbanks and sediment in the Big River Watershed that are the primary contributors of COC exposure and transport, as determined through floodplain and sediment sampling, channel migration analyses (Pavlowsky et al., 2010 and Pavlowsky et al., 2013), and river modeling. The geographically prioritized banks and depositional areas within the Big River Watershed are discussed in Section 6. Prioritization is determined by a combination of erosion rate, COC concentrations, and accessibility to the project locations.

Through this NTCRA, the EPA is proposing secondary source control through stabilizing contaminated eroding banks and removing mobile contaminated sediments. The locations identified as Priority 1 are the most active and unstable locations in the river. Priority 1 locations are the most significant contributors to the mass flux of COCs into the watershed. The Priority 1 locations are the primary focus of the NTCRA. Monitoring would be performed to evaluate the effectiveness of the project within one to 5 years after the implementation of the NTCRA.

4.1 STATUTORY LIMITS ON REMOVAL ACTIONS

This Removal Action is being taken pursuant to *CERCLA* and the *NCP*, under the delegated authority of the Office of the President of the United States, by Exec. Order No. 12580. This Executive Order authorizes the EPA to conduct Removal Actions.

The EPA is the lead agency for the Removal Action. This EE/CA complies with the requirements of *CERCLA*, *SARA,* and the *NCP* at 40 CFR Part 300. This EE/CA is being prepared under 40 CFR 300.415(b)(2).

40 CFR 300.415(b)(5) specifies that for fund-financed Removal Actions, a statutory limit of $2 million, and a 12-month duration for the Removal Action applies. The EPA anticipates this NTCRA to exceed both limits due to 42 miles of watershed within the SJCM OU4 site and the estimated cost detailed in this EE/CA. In the case of the SJCM OU4, a consistency waiver to the statutory limits will be requested in the Action Memorandum.

As the lead agency, the EPA has the authority to select the Removal Action methodology, while considering public and regulatory participation. The public comment period for this EE/CA will provide the opportunity for public input to the cleanup process.

4.2 DETERMINATION OF REMOVAL SCOPE

The NTCRA prioritizes actions and locations by weighing spatial concentrations of COCs, potential for erosion and migration, habitat sensitivity and accessibility to project locations. The strategy for prioritization is ultimately determined by a mass budget analysis that indicates the most effective reduction of COCs in the watershed. The focus of the NTCRA is the identification and ranked prioritization of locations within the extents of the Federal Emergency Management Agency 100-Year Flood Zone, but primarily in and adjacent to the mainstem of the Big River. The NTCRA is centered around the channel migration zone, an approximate 100-ft corridor on both sides of the Big River channel, where episodic flooding deposits sediment on the floodplain. The EPA is proposing secondary source control through stabilizing contaminated eroding banks and removing mobile contaminated sediments. The locations identified as Priority 1 are the most active and unstable locations in the river. Priority 1 locations are the most significant contributors to the mass flux of COCs into the watershed. The prioritization scheme is displayed in Figures 3.1 through 3.2b.

4.3 DETERMINATION OF REMOVAL SCHEDULE

The EPA anticipates the Removal Action to begin in 2027 and estimates that the Removal Action will occur over an 11-year duration.

4.4 PLANNED REMOVAL ACTIVITIES

Various Removal Alternatives are presented in Section 5.2 to address historic, mine-related contamination in the Big River watershed Removal Alternative 2 includes stabilization of approximately 7.5 miles of Priority 1 riverbank locations. Removal Alternative 3 includes the removal of approximately

198,000 cubic yards of sediment through sediment traps, targeted dredging, and sediment bar excavation in Priority 1 locations.

Removal Alternative 2 only addresses eroding banks (COC input). However, COC mass and downstream transport would continue by not addressing instream sediments. Removal Alternative 3 only addresses instream sediments through traps, targeted dredging and sediment bar excavation. However, release and transport of COCs from unstable riverbanks to the watershed would not be addressed. The Region determined that the most effective means of achieving the RAOs would be Alternative 4, which includes a combination of Alternatives 2 and 3.

Removal Alternative 4, the preferred removal alternative, includes all Priority 1 locations identified through visual inspection, sampling, review of historic channel change maps, analysis of the distribution, and deposits of sediment and floodplain soils within the watershed. Priority 1 locations include approximately 7.5 miles of bank stabilization and remediation of an estimated 198,000 CY of contaminated instream sediment from nine locations. These are locations where the river is actively eroding contaminated stream banks or depositing contaminated sediments.

Secondary source control is necessary to enhance natural recovery processes and would be accelerated by the removal technologies applied. Riverbank stabilization would be the most effective action to reduce contaminated sediment loading into the Big River. Sediment capture would also reduce downstream bedload transport into sensitive areas.

Work would generally start upstream and progress downstream. Locations with the highest concentration and mobilization potential would generally be prioritized first as access allows. The iterative process and monitoring plan would consider the hydrology, hydraulics and sediment transport to manage uncertainty associated with cleanup work in a dynamic river environment. Institutional controls (ICs) will be addressed in future Remedial Actions but will not be considered in the NTCRA. Post-removal site controls under the NTCRA may be required based on the selected technology and is discussed further below and Table 1.1.

5.0 IDENTIFICATION OF REMOVAL ACTION ALTERNATIVES

Development of Removal Action alternatives for the BRWP-contaminated sediments and soil began with identifying potential response actions based on the RAOs, ARARs, and EPA guidance. The selection of removal technologies and process options for initial screening is based on *Guidance for Conducting Non-Time-Critical Removal Actions Under CERCLA* (EPA, 1993). Process options refer to specific processes within each technology type. The screening is first conducted at a preliminary level to focus on relevant technologies and process options, and then at a more detailed level based on certain evaluation criteria. Finally, alternatives are selected from the technologies retained after the detailed evaluation and screening.

This section identifies the general response actions and then, more specifically, the removal technologies and process options that are potentially useful to address the preliminary RAOs identified in Section 3.0 for the contaminated media.

A larger inventory of site-applicable GRAs was preliminarily screened in the 2021 draft Feasibility Study (FS). A subset of those actions was retained following the preliminary screening process documented in the FS and listed below. The response actions considered in the alternatives in this document include only those retained from FS preliminary screening. Table 1.1 includes the full inventory of GRAs that were evaluated in the initial screening. In this assessment, a secondary screening of the selected response actions (retained from the FS) was performed to re-assess the applicability of each for the NTCRA proposed in this EE/CA.

The general design concepts presented in this section are provided to assess the feasibility of the alternatives as well as to develop cost estimates.

The identification and screening process consists of the following steps:

- Develop GRAs for the contaminated media that will satisfy the preliminary RAOs identified in Section 3.0.
- Compile a list of removal technologies and process options for each GRA that are potentially viable for remediation of the contaminated media.
- Screen the removal technologies and process options with respect to technical implementability for the contaminated media at the site. Technologies and process options that are not technically implementable relative to the contaminated media are eliminated from further consideration in this EE/CA.
- Evaluate and screen the retained removal technologies and process options with respect to effectiveness, implementability, and relative cost. Technologies and process options that have low effectiveness, low implementability or high-cost relative to the contaminated media are eliminated from further consideration in this EE/CA.
- Combine and assemble the retained technologies and process options for the contaminated media into sitewide removal alternatives as presented in Section 5.1.

The following GRAs were developed for sediment and soil.

- No action

- Hydraulic controls
- Containment
- Excavation/dredging
- Treatment
- Disposal

5.1 GENERAL RESPONSE ACTIONS

Descriptions of these GRAs are provided below.

No action leaves contaminated media in their existing condition with no control or cleanup planned. This action is considered to provide a baseline against which other options can be compared.

Hydraulic Controls are engineering controls that are established to modify the hydraulic characteristics of the waterbody, thereby controlling peak flows, reducing erosion potential, isolating areas of highly contaminated sediment, and/or improving habitat for ecological receptors. Examples of hydraulic controls include dams, streamflow diversion, channel realignment, and construction of traps to collect both instream (bedload) and overbank (suspended) sediment. Sediment would be removed periodically from these locations after construction is complete and then disposed of at on-site repositories.

Containment includes such actions as stabilization, capping, covering, armoring, and habitat modification. These actions are designed to reduce contaminant mobility and prevent human or ecological exposure by physical separation. Post-removal site controls may be required to protect the integrity of the technology.

Excavation/Dredging consists of the complete or partial extraction of contaminated media. These actions are designed to eliminate or reduce human or ecological exposure to site contaminants. This action would be coupled with ex situ treatment and/or disposal to address the contaminated media once they are removed.

Treatment involves biological, chemical, thermal, and/or physical measures applied to the contaminated media that reduce the toxicity, mobility, and/or volume of the contaminants present. Treatment can be applied either in situ to treat contaminated media in place or ex situ to treat contaminated media after it has been removed. Examples of treatment include separation, stabilization, chemical oxidation, phytoremediation, and constructed wetlands.

Disposal is transporting and ultimately discarding contaminated or treated media in a manner that will prevent or reduce its interaction with the public and the environment. Examples of disposal include off-site landfilling, on-site disposal into an existing soil repository, or construction of an on-site containment cell.

The removal technologies and process options to be considered as alternatives for the COC-contaminated sediment and soil at the site include the following:

- The no action alternative establishes a baseline for comparison with the other alternatives but doesn’t achieve RAOs because secondary sources are not addressed.

- The stabilization of eroding contaminated riverbanks provides partial secondary source control and reduces recontamination downstream by minimizing the release and transport of COCs stored in the floodplain.
- The capture and periodic removal of contaminated sediments from depositional areas with grade control (e.g., upstream of low-water crossings) and gravel bars or beach areas provides partial secondary source control. The removal and disposal at on-site repositories reduces the COC mass and downstream transport of mobile riverbed sediments stored in the river channel.

The evaluation criteria for detailed screening of technologies and process options that have been retained after the preliminary screening are effectiveness, implementability, and cost in accordance with 40 CFR 300.415. The following are descriptions of these evaluation criteria:

Effectiveness:

- Protectiveness
    - Protective of public health, community
    - Protective of workers during implementation
    - Protective of the environment
    - Compliance with ARARs and other criteria, advisories, and guidance
- Ability to Achieve Removal Objectives
    - Level of treatment/containment expected
    - No residual effect concerns
    - Will maintain control until long-term solution implemented.

Implementability:

- Technical feasibility
    - Construction and operational considerations
    - Demonstrated performance/useful life
    - Adaptable to environmental conditions
    - Contributes to remedial performance
    - Can be implemented in one year
- Availability
    - Equipment
    - Personnel and services
    - Outside laboratory testing capacity
    - Off-site treatment and disposal capacity
    - PRSC (Post Removal Site Control or Operation & Maintenance)

- Administrative feasibility
    - Permits required
    - Easements or rights-of-way required
    - Impact on adjoining property
    - Ability to impose institutional controls
    - Likelihood of obtaining an exemption from statutory limits (if needed)

Cost:

- Capital costs
- PRSC cost
- Present worth costs

These alternatives will reduce exposure and risk throughout the watershed through the remediation of sediment and containment of contaminated soil at the site. The technologies and process options identified here are evaluated against the criteria listed above in the following subsections.

5.2 IDENTIFICATION OF ARARS AND OTHER CRITERIA

Section 121(d) of *CERCLA* (42 U.S.C. § 9621[d]), as amended, requires that on-site Remedial Actions, and to the extent practical, Removal Actions, at *CERCLA* sites must attain (or the decision document must justify the waiver of) any federal or more stringent state environmental standards, requirements, criteria or limitations determined to be legally applicable or relevant and appropriate. Although *CERCLA* § 121 does not itself expressly require that *CERCLA* Removal Actions comply with ARARs, the EPA has promulgated a requirement in the *NCP* mandating that *CERCLA* Removal Actions "…shall, to the extent practicable considering the exigencies of the situation, attain applicable or relevant and appropriate requirements under federal environmental or state environmental or facility siting laws…" (40 CFR § 300.415[j]). Certain specified waivers may be used for Removal Actions, as is the case with Remedial Actions.

As the lead federal agency, the EPA has primary responsibility for identifying federal ARARs at the site. State agencies are responsible for identifying state ARARs. The EPA has sought input from the state agencies on this identification. ARARs were developed for the site as part of the draft FS (HGL, 2021b).

The final determination of ARARs will be made by the EPA in the Action Memorandum as part of the response action selection process.

5.2.1 Overview of Applicable or Relevant and Appropriate Requirements

ARARs are cleanup standards, standards of control and other substantive environmental protection requirements, criteria or limitations promulgated under federal or state law that specifically address the situation at a *CERCLA* site. The identification of ARARs is a site-specific determination and involves a two-part analysis. First, a determination is made about whether a given requirement is applicable. If it is not applicable, a determination is made about whether it is relevant and appropriate. If the requirement is not applicable, the requirement may nonetheless be relevant and appropriate if the site's circumstances are sufficiently similar to circumstances in which the law otherwise applies, and it is well suited to the conditions of the site.

Non-promulgated agency advisories, criteria and guidance issued by federal, or state governments are not ARARs but may have useful requirements that are to be considered (TBC). TBC requirements complement ARARs but do not override them. They are useful for guiding decisions regarding cleanup levels or methodologies when regulatory standards are not available.

5.2.2 Chemical-Specific ARARs

Chemical-specific ARARs are usually health or risk-based standards that limit the concentration of a chemical found in or discharged to the environment. They govern the extent of site remediation by providing either actual cleanup levels or the basis for calculating such levels. Chemical-specific ARARs may also be used to indicate acceptable rates of discharge in determining treatment and disposal requirements as well as to assess the effectiveness of future removal alternatives. Chemical-specific ARARs and TBC information were developed for each media affected and are presented in Table A.1 of Appendix A.

5.2.3 Location-Specific ARARs

Location-specific ARARs pertain to natural site features (e.g., wetlands, floodplains, and sensitive ecosystems) and manmade features (e.g., existing landfills, disposal areas, and places of historical or archeological significance). These ARARs generally restrict the concentration of hazardous substances, or the conduct of activities based on a site's characteristics or location. Location-specific ARARs were developed for the natural site features potentially affected and are presented in Table A.2 of Appendix A.

5.2.4 Potential Action-Specific

Action-specific ARARs, unlike location-specific and chemical-specific ARARs, are usually technology-based or activity-based limitations that direct how response actions are conducted. Action-specific ARARs are presented in Table A.3.

5.2.5 Other Guidance to Be Considered

No other guidance was identified as TBC for the contaminated sediment at the site.

6.0 COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES

The scale and volume of contamination within the approximate 42 miles of Big River and tributaries in SJCM OU4 makes remediation logistically and economically challenging. Current available repository capacity is estimated to be over 6 million cubic yards, which meets the needs of this NTCRA. The design for sediment removal will include segregating material to minimize the transportation and disposal of non-contaminated fractions. The EPA is evaluating and plans to open additional repositories, as necessary, to meet the needs of the watershed and the residential Operable Units.

For this EE/CA, the river was divided into segments to focus the NTCRA on Priority 1 locations. Segments 0 through 2 are addressed under the BRMT OU2 EE/CA. Segment 3 is the most upstream segment in SJCM OU4 with Segment 5 being at the confluence of the Big River and Meramec River (Figures 3.1 through 3.2b). Although Segment 5 is within the SJCM, the focus of this EE/CA will be on the 42-mile portion of the Big River that lies within Segments 3 and 4 in SJCM OU4. Early action in these upstream segments will reduce the COC mass, transport and further releases downstream. Work in Segment 5 may be included in a follow-on action.

Because the river ecosystem could be damaged by removal construction, the benefits of removal activities must be weighed versus their potential negative ecological impacts. The river is also heavily used by the public for recreation; therefore, the impacts of removal activities on public access and recreational uses must be considered.

6.1 DEVELOPMENT AND SCREENING OF REMOVAL ALTERNATIVES

Retained technologies are presented in Table 1.2. Implementing any one of these technologies alone would most likely not achieve the RAOs. However, combinations of technologies can remove and isolate contaminants sufficient to achieve RAOs. These combinations of technologies are referred to as removal alternatives.

The goal of developing removal alternatives is to present a range of cleanup options in sufficient detail so that the alternatives can be evaluated both individually and comparatively. Preference is also given to those technologies that permanently treat the contaminated media instead of simply containing contaminants or transferring them from one media to another.

A summary of the four removal alternatives evaluated as part of the EE/CA are presented below.

Removal Alternative	Title	Estimated Quantities
1	No Action	No Action is taken to address the contamination.
2	Targeted Bank Stabilization	Stabilization of 7.5 miles of Priority 1 riverbanks
3	Sediment Traps, Targeted Excavation/Dredging	Removal of 198,000 CY of sediment through sediment traps, targeted dredging, and sediment bar excavation.
4	Targeted Bank Stabilization, Sediment Traps, Targeted Excavation/Dredging	Stabilization of 7.5 miles of Priority 1 riverbanks and removal of 198,000 CY of sediment through sediment traps, targeted dredging, and sediment bar excavation **[EPA's Preferred Alternative]**

6.1.1 Alternative 1 – No Action

Under Alternative 1, no action would be taken to achieve the RAOs. The no action alternative has no capital or Operation & Maintenance costs. Alternative 1 would not have significant impacts on current and reasonably anticipated future land use, including recreational and residential uses within SJCM OU4. The no action alternative is evaluated to establish a baseline for comparison with the other alternatives.

RAOs would not be achieved because sources would remain uncontrolled. ARAR compliance would not be achieved in this alternative.

6.1.2 Alternative 2 – Targeted Bank Stabilization

Under Alternative 2, bank stabilization would be applied to approximately 7.5 miles of Priority 1 locations along the Big River. Priority 1 areas are portions of the river channel that are dynamic where the banks are subject to erosion (Missouri State University – Ozarks Environmental and Water Resources Institute [MSU-OEWRI], 2012). Bank stabilization installations will measurably decrease the volume of contaminated soils eroding directly into the river. Natural methods would be used, where possible, instead of conventional riprap for bank stabilization by integrating live plant material, boulders, logs, and natural fiber geotextiles. In high-energy locations (with high migration rates), flow will be projected away from the bank using bank toe structures such as engineered log jams, bendway weirs and/or groins. Streambanks may be sloped to a low angle promoting survival of riparian vegetation (trees and shrubs). The vegetation is a crucial component to build mature root mass networks that prolong bank stability. This alternative includes bank stabilization only; no sediment traps or excavation/dredging would be used.

Risks to human health and ecological receptors would be reduced through the stabilization of banks and control of the release of contaminated soils into the river system. Bank stabilization provides partial secondary source control and reduces recontamination downstream.

The residual risks (the risk remaining after implementation) would remain in the floodplain after Removal Actions are completed because contamination is not being removed. Post-removal site controls such as site use and access restrictions would be required to protect the integrity of the stabilized bank. Large areas of contaminated floodplain are prone to further erosion. Bank stabilization within the Priority 1 action areas would reduce ongoing release and recontamination of riverbed sediments after the action ceases.

ARAR compliance may be achieved by designing and implementing these technologies in accordance with the requirements of action and location specific ARARs. The Monitoring Plan is included as Appendix C and will be utilized throughout the NTCRA to determine the effectiveness of each specific action and will be used to modify future remedies to increase effectiveness and adjust to river conditions.

Bank stabilization has been successfully implemented and evaluated in treatability studies within the watershed and at similar sites in the region. While some of the contaminated floodplain soil would be stabilized in this alternative, the downstream transport of COCs in riverbed sediments in high priority areas would not be addressed; therefore, Alternative 2 does not achieve the RAOs.

Alternative 2 actions would be applied to approximately 7.5 miles of Big River. Cost is estimated to be $51.4 million. State acceptance and community acceptance of the alternatives will be fully determined after the public comment period closes for the EE/CA.

6.1.3 Alternative 3 – Sediment Traps, Targeted Excavation/Dredging

Alternative 3 includes maintaining one existing sediment trap and the construction of two new sediment traps for a total of 3 sediment traps within SJCM OU4. Approximately 198,000 CY of contaminated sediment collected in all traps will be removed over a period of 11 years by mechanical methods (dredging or excavation), dewatered and then transported to an approved soil repository. Sediment removal frequency would be determined by the estimated sediment transport rate and volume of each trap. Alternative 3 also includes targeted excavation of exposed channel bars containing sediment with high concentrations of contaminants.

Gravel and coarse sand tend to migrate as bedload sediment dragged or rolled along the riverbed slower than the average flow rate in the water column. Fine sand and silt tend to migrate as suspended sediment carried along suspended in the water column and moving at roughly the same rate as the flow. Gravel and coarse sand are commonly deposited in large gravel bars and bar complexes that correspond with more dynamic zones of the river where the channel is slightly steeper. Gravel bar excavation allows for dry material handling which reduces costs associated with water diversion or sediment dewatering prior to disposal.

Sediment traps may be positioned within the river channel (in-line sediment trap), or they may be positioned off to the side of the channel where flow can be diverted into the structure (off-line sediment trap). In-line sediment traps are constructed within the river channel and are designed to capture bedload sediment. Off-line sediment traps located outside of the river channel and are designed to divert flow into the trap where suspended sediment is removed and water exiting the trap is returned to the channel downstream. Off-line traps are better for extraction of finer sediments (suspended load) which tend to mobilize during flood events. In-line traps are more effective for bedload sediments, but their overall effectiveness decreases with higher peak flow.

The capture and removal of contaminants in the river system eliminates the potential of those materials to cause current or future COC exposure and risks to human health and ecological receptors. Continued actions such as excavation and dredging would be required to reduce the mobilization and redistribution of contaminated sediment. Sediment traps would intercept and remove contaminated sediments that have already been mobilized. This technology reduces the amount of contaminated sediment in the riverbed but does not reduce the ongoing input of contaminates to the river by stabilizing contaminated eroding banks. Large scale removal of contaminated sediment without bank stabilization could increase bank erosion and increase the mass of contaminated sediments entering the river. Therefore, Alternative 3 does not achieve the RAOs. The Monitoring Plan is included as Appendix C and will be utilized throughout the NTCRA to determine the effectiveness of each specific action and to modify future remedies to increase effectiveness and adjust to river conditions.

ARAR compliance would be achieved by designing and implementing these technologies in accordance with the substantive requirements of all action and location specific ARARs. However, long-term compliance would not be achieved due to eroding contaminated banks contributing COCs to the watershed.

Components of Alternative 3 have been evaluated in treatability studies within the watershed and at similar sites in the region. This alternative will support any future Remedial Actions in the SJCM OU4. Alternative 3 would remove a total of 198,000 CY from Big River. Cost is estimated to be $23.9 M.

6.1.4 Alternative 4 – Targeted Bank Stabilization, Sediment Traps, Targeted Excavation/ Dredging

Alternative 4 includes a combination of the response actions that complement each other with the potential to achieve RAOs.

Bank stabilization – Approximately 7.5 miles of Priority 1 riverbanks would be stabilized at targeted locations along the Big River as described in Alternative 2.

S*ediment traps, Dredging, Excavation* – The removal of approximately 198,000 CY of contaminated sediment from Big River through the technologies described in Alternative 3.

Under Alternative 4, risks to human health and ecological receptors would be mitigated by secondary source control in two ways: 1) through the stabilization of banks which reduces recontamination from eroding floodplain soils into the river system and 2) with traps and depositional areas to allow for removal of contaminated sediments in the river system. These combined actions would achieve the RAOs.

The risks to human health and the environment from exposure to COCs would be reduced while the Removal Actions are completed. Residual risks in the watershed would remain. Post-removal site controls such as site use and access restrictions would be required to protect the integrity of the stabilized bank. Contaminated floodplain soil would be kept in place by bank stabilization and recontamination of riverbed sediments would be reduced after the action ceases.

ARAR compliance may be achieved by designing and implementing these technologies in accordance with the substantive requirements of all action and location specific ARARs. While none of the technologies in this alternative treats the contaminated sediments, focused Removal Actions would reduce the amount and spatial extent of contamination, and bank stabilization would reduce the mobilization and redistribution of COCs.

The Monitoring Plan is included as Appendix C and will be utilized throughout the NTCRA to determine the effectiveness of each specific action and will be used to modify future remedies to increase effectiveness and adjust to river conditions.

Components of this alternative have been evaluated in treatability studies within the watershed and at similar sites in the region. The remedy would be implemented in a phased approach with the Monitoring Plan guiding actions to meet the RAOs. This alternative is anticipated to support follow-on actions in SJCM OU4.

Alternative 4 would stabilize a total of 7.5 miles of bank and remove 198,000 CY of sediment from Big River. Cost is estimated to be $75.3 million. State acceptance and community acceptance of the alternatives will be fully determined after the public comment period closes for the EE/CA.

6.2 EVALUATION OF ALTERNATIVES

The alternatives are evaluated against the three *CERCLA* evaluation criteria required by the *NCP*, 40 CFR Part 300: effectiveness, implementability and cost. For the EE/CA, these criteria are used to evaluate the removal alternatives individually and in comparison, to each other.

Alternative 1, the no action alternative, does not achieve threshold criteria; therefore, it cannot be recommended by the EPA. The following summarizes the detailed evaluation of the evaluation criteria applied to Alternatives 2, 3, and 4.

6.2.1 Effectiveness

6.2.1.1 Overall Protection of Human Health, Workers, and the Environment

This criterion considers whether an alternative eliminates, reduces or controls threats to human health and the environment through ICs, engineering controls, or treatment. The more specific findings of the baseline risk assessment and the ultimate removal goals (i.e., acceptable COC exposure levels) for the SJCM OU4 will be included in a subsequent ROD. Alternatives 2, 3, and 4, would reduce risk to human health and the environment by gradually reducing the release, transport, and mass of COCs in the watershed. Limited impacts to workers could be controlled through standard health and safety practices.

6.2.1.2 Compliance with ARARs and Other Criteria, Advisories and Guidance

This criterion evaluates whether the alternative meets federal and state environmental statutes, regulations and other requirements that pertain to the watershed or to whether a waiver is justified. An alternative that does not meet ARARs may be selected when the alternative is an interim measure and will become part of a final Remedial Action that attains ARARs.

ARAR compliance for Alternatives 2, 3, and 4 may be achieved by designing and implementing these technologies in accordance with the requirements of action- and location-specific ARARs.

6.2.1.3 Ability to Achieve Removal Objectives

This criterion considers the ability of an alternative to maintain protection of human health and the environment over time and whether the alternative, with monitoring, can achieve RAOs while supporting an interim or final RA.

Alternative 2 would stabilize some contaminated floodplain soils but would not reduce the amount of mobile contaminated sediment. Alternative 3 would not prevent erosion of contaminated riverbanks. Large scale removal of contaminated sediment without bank stabilization could increase bank erosion and increase the mass of contaminated sediments entering the river. Alternatives 2 and 3 would only partially reduce COC mass and transport within the scope of this action. Therefore, Alternatives 2 and 3 do not achieve the RAOs.

Alternative 4 would reduce the release of COCs from unstable riverbanks and reduce the mass and downstream transport of contaminated sediments. The bank stabilization and sediment removal in tandem are expected to sustain effectiveness after the NTCRA is complete. Alternative 4 would achieve the RAOs.

While this NTCRA does not address the large-scale quantities required to achieve risk-based levels of COCs throughout the BRWP, it will reduce COCs and the actions taken will be monitored to determine remedy effectiveness, system response, and model calibration to inform follow-on actions.

6.2.1.4 Reduction of Toxicity, Mobility or Volume Through Treatment

This criterion evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment and the amount of contamination present.

None of the alternatives would reduce contaminants through treatment. Emphasis on riverbank stabilization (Alternative 2) would reduce the release and transport of COCs entering the watershed more than sediment traps alone (Alternative 3). Sediment traps would reduce the downstream transport of COCs more than bank stabilization alone (Alternative 2). Alternative 4 provides the combination of reduction of release of COCs entering and moving within the watershed but does not utilize treatment to address the threats posed by the contaminated sediment and floodplain soil.

The residual waste found in the sediment and floodplain soil is considered a principal threat waste, which is defined as mobile source material, surface soil, or subsurface soil containing high concentrations of COCs that are (or potentially are) mobile due to wind entrainment, volatilization (e.g., volatile organic compounds), surface runoff, or subsurface transport (OSWER, Publication 9380.3-06FS, 1991). However, no treatment technologies were identified that have definitively demonstrated the ability to reliably provide short- and long-term effectiveness, permanence, and meet the other *NCP* criteria. The extraordinary volume of materials and their location within a dynamic fluvial environment would make treatment impracticable. Additionally, treatment technologies for metals in stream sediment are not readily available.

6.2.1.5 <u>Short-Term Effectiveness</u>

This criterion considers the length of time needed to implement an alternative and the risks the alternative poses to workers, residents and the environment during implementation.

Alternatives 2 and 3 would have a moderate level of construction-related impacts on the community and environment. Alternative 4 would have the greatest level of construction-related impacts on the community and environment.

Alternative 2 would stabilize some of the contaminated floodplain soils from entering the river but would not reduce the amount of mobile contaminated sediment. Alternative 3 may temporarily reduce COC mass in the Big River but does not address eroding banks from releasing COCs to the watershed. Alternative 4 would reduce the mass of contaminated sediment in the short-term and stabilize banks to minimize further recontamination, achieving a measurable reduction of COCs in the short-term.

6.2.2 Implementability

This criterion considers the technical and administrative feasibility of implementing the alternative, including factors such as the relative availability of goods and services. Overall, the administrative and technical requirements associated with each alternative could be challenging; however, each alternative is implementable.

All alternatives involve technologies that are technically feasible. Treatability studies, including bank stabilization and sediment traps (utilizing excavation), have been successfully designed and implemented in the Big River watershed. The biggest concerns regarding implementability are access to properties required for construction, transportation, and disposal of contaminated material removed during the NTCRA. Environmental conditions will be considered for equipment access and seasonal river levels. Impacts are possible through ecosystem disturbance and sediment resuspension but can be controlled by seasonal work and engineering measures.

The action alternatives will be consistent with and support any future Remedial Action and information gained from this NTCRA will be used in development and support of a subsequent ROD. Statutory exemptions are necessary to complete the NTCRA and are anticipated to be granted. The EPA will be seeking exemptions for the 12-month and $2 million statutory limit through an Action Memorandum. Services and materials for implementation are readily available from providers on a nation-wide basis.

Alternative 2 may require some transport and disposal of contaminated materials to an on-site repository; however, the quantity is anticipated to be much less than the other alternatives. Alternatives 3 and 4 require large-scale transport and disposal of contaminated materials at an on-site repository. Although on-site repositories can have limited capacity, the volumes proposed for disposal in Alternatives 3 and 4 should be manageable at current on-site repository locations.

A plan for the long-term care and maintenance of the action alternatives will need to be developed. This plan would include, but not be limited to, a long-term maintenance plan, an inspection plan, and the Monitoring Plan provided in Appendix B. This will be developed as part of the Post-Removal Site Control Plan following the completion of the Removal Action activities.

All alternatives require property owner access and may require adjoining property access depending on project locations and specific actions. The failure to receive access to required areas could impede removal efforts. Off-site permits will not be required for the completion of the Removal Action activities. Coordination with multiple partner agencies will be required and documented in a Memorandum of Understanding.

State acceptance and community acceptance of the alternatives will be fully determined after the public comment period closes for the EE/CA.

6.2.3 Cost

This criterion includes estimated capital and annual Operations & Maintenance costs, as well as present worth cost. Present worth cost is the total cost of an alternative over time in terms of today's dollar value. Tables 1.4 through 1.7 detail the cost of each technology and the recommended removal alternative total.

Alternative 2 cost is $51.4 M, Alternative 3 cost is $23.9 M, and Alternative 4 (a combination of Alternative 2 and 3) has the highest cost estimated at $75.3 M.

It is important to note that the uncertainties associated with the estimated cost of these alternatives increases with their complexity. These estimates are approximate and made without detailed engineering data. The actual cost of the NTCRA would depend on the final scope of the selected alternative, the time required to complete the actions, and other contingencies. It also is expected that design optimization during NTCRA could achieve significant cost savings not assumed or reflected in these preliminary planning level cost estimates.

7.0 RECOMMENDED REMOVAL ACTION ALTERNATIVE

Alternative 4 is the recommended Removal Action alternative. Work would generally start upstream and progress downstream, focusing on selected Priority 1 locations. An iterative process and a Monitoring Plan would be utilized throughout the NTCRA to determine the effectiveness of each specific action and to modify future remedies to increase effectiveness and adjust to river conditions.

The primary mechanisms for achieving RAOs will be to reduce the release and transport of COCs from unstable riverbanks and to reduce the mass and downstream transport of sediments through removal. Secondary source control is necessary to enhance natural recovery processes and would be accelerated by the removal technologies applied. Riverbank stabilization would be the most effective action to reduce COC loading into the Big River. Sediment capture would be the most effective action to reduce bedload and suspended sediment transport. Sediment capture would involve multiple technologies presented in Section 5 including excavation, dewatering, and disposal. Alternative 4 balances the technologies to provide a cost-effective solution that will support the long-term remedial goals.

Under Alternative 4, risks to human health and ecological receptors would be mitigated by secondary source control in two ways: first, through the stabilization of approximately 7.5 miles of riverbanks which reduces recontamination from eroding floodplain soils into the river system and second, with traps and depositional areas to allow for the removal of approximately 198,000 CY of contaminated sediments in the river system. The proposed actions would reduce the release, transport, and mass of COCs. Alternative 4 also reduces risks, reduces contaminant loading to the Big River and is the only alternative that achieves the RAOs. While these actions are intended to be consistent with a final ROD, they may not meet final risk-based levels for human and ecological receptors. Post-removal site controls under this alternative will be evaluated as ICs in the future remedial decision-making.

The Post Removal Site Control Plan will describe the activities that will be performed to maintain the effectiveness and integrity of the Removal Actions. This plan will provide for all inspections and maintenance activities. These activities will include the timing and details of the inspection processes, steps to develop corrective actions if needed, EPA notification process for non-routine issues, land-use development, addressing routine and unscheduled maintenance activities, and reporting requirements. Evaluation and development of ICs would be considered in follow-on actions with collaboration among local citizens along with local, county, state, and federal government officials.

Alternative 4 would include a Monitoring Plan, provided as Appendix B, providing a strategic framework that adjusts details (timing, types, extent, locations, etc.) of removal construction with other activities based on monitoring data. The Monitoring Plan would evaluate each phase of the cleanup work and apply new data and insights to improve the subsequent phases. This NTCRA will be consistent with and support any future Remedial Action and information gained from this NTCRA will be used in development and support of a subsequent ROD.

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TABLES

Table 1.1
Preliminary Screening of Removal Technologies for Sediment
Engineering Evaluation/Cost Analysis Report
BRMT Site OU2 and SJCM Site OU4, St. Francois and Jefferson Counties, MO

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
No Action	None	Not Applicable	No activities conducted to address site contamination. Natural processes may reduce concentrations of COCs over time, but this would not be verified.	**Required by law.** Retain for baseline comparison to other technologies.
Institutional Controls	Institutional Controls	Site Use Restrictions	Administrative action using property deeds, legal instruments, or other land use prohibitions to restrict future site activities.	**Retain** to be used as needed protect the integrity of other technologies. The Baseline Risk Assessment only found unacceptable risk to ecological receptors, and not humans, from exposure to COCs in sediment. Not effective for protecting ecological receptors from exposure, only humans.
		Access Restrictions	Municipal, county, state, or federal codes and deed restrictions to limit access to the site.	
		Informational Device	State registries, deed notices, signage or other methods that inform the public of site hazards.	
Hydraulic Controls	Discharge Controls	Dam Construction	Installation of dam(s) to provide a physical barrier for downstream sediment transport and reduce sediment transport by controlling peak flows and erosion.	*Eliminate* due to land acquisitions required for impoundment(s), multi-agency administrative approvals, and negative ecological consequences.
		Increased Flood Plain Storage	Provide storage of water to reduce sediment transport by controlling peak flows and erosion.	*Eliminate* due to land acquisitions required, limited extent of undeveloped floodplains, and potential negative environmental impacts to floodplain soils.
	River Realignment	New Channel Construction	Bypass contaminated reaches of river by construction of a new channel.	*Eliminate* due to land acquisitions required and multi-agency administrative approvals.
Containment	Sediment Capping	Conventional Cap	Layer of sand, gravel, or other material spread over contaminated sediment; may include additional layers to armor.	**Retain** to possibly be used in conjunction with other remedial technologies or as a standalone remedy.
		Amended Cap	Incorporates reactive media into the cap that binds contaminants and reduces their bioavailability.	**Retain** to possibly be used in conjunction with other remedial technologies or as a standalone remedy.
	Bank Stabilization	Vegetative Stabilization	Plant vegetation along banks to decrease erosion of contaminated bank material and provide riparian habitat.	**Retain** to possibly be used in conjunction with other remedial technologies.
		Armoring	Armor banks with rip-rap, stone, or manufactured materials to prevent erosion of contaminated bank material.	**Retain** to possibly be used in conjunction with other remedial technologies.
		Hydraulic Measures	Local hydraulic measures to re-direct flows and reduce erosion of contaminated bank material.	**Retain** to possibly be used in conjunction with other remedial technologies.

Table 1.1 (Continued)
Preliminary Screening of Removal Technologies for Sediment
Engineering Evaluation/Cost Analysis Report
BRMT Site OU2 and SJCM Site OU4, St. Francois and Jefferson Counties, MO

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
Removal	Mechanical Removal	Dredging	Remove contaminated sediment using a hydraulic or mechanical dredge.	**Retain** on a limited basis to potentially be used in conjunction with other remedial technologies; complete removal via dredging is *eliminated* due to excessive habitat disruption.
		Excavation	Remove contaminated sediment using traditional excavating equipment such as backhoes.	**Retain** on a limited basis to potentially be used in conjunction with other remedial technologies; complete removal via excavation is *eliminated* due to excessive habitat disruption.
	Engineered Sediment Capture	Sediment Traps	Low energy environments are created along the river to naturally collect deposits of contaminated sediments, which are removed periodically by mechanical means.	**Retain** to possibly be used in conjunction with other remedial technologies or as a standalone remedy.
		Rock Riffle Structures	Operate very similar to sediment traps; force water to slow and pool where sediment can settle out in a containment area.	**Retain** to possibly be used in conjunction with other remedial technologies.
Treatment	In Situ	Stabilization	Contaminated sediment is mixed in place with a stabilizer such as cement to reduce bioavailability and/or leachability.	*Eliminate* due to difficulty implementing in a river environment and the potential for negative ecological impacts.
		Chemical	A chemical binder or complexant is added to contaminated sediment in place to reduce bioavailability or leachability.	*Eliminate* due to difficulty implementing in a river environment and the potential for negative ecological impacts.
		Biological	Plants or microbes are used to remove or contain contamination through uptake, biological transformation or co-metabolization.	*Eliminate* due to difficulty implementing in a river environment; biological transformation or co-metabolization typically not effective for metals.
	Ex Situ (assuming removal)	Dewatering	The water content of removed sediment is reduced using presses, centrifuges, or filtration tubes to reduce the amount of material requiring disposal.	**Retain** to possibly be used in conjunction with other remedial technologies.
		Separation	Removed sediments are size separated to reduce the volume of material requiring disposal. Effective when a subset of the sediment size fraction is contaminated.	**Retain** to possibly be used in conjunction with other remedial technologies; previous studies have indicated that COC concentrations are higher in fine material and lower in coarse material.
		Stabilization	Removed sediment is mixed with a stabilizer such as cement to reduce bioavailability and/or leachability.	**Retain** to possibly be used in conjunction with other remedial technologies.

Table 1.1 (Continued)
Preliminary Screening of Removal Technologies for Sediment
Engineering Evaluation/Cost Analysis Report
BRMT Site OU2 and SJCM Site OU4, St. Francois and Jefferson Counties, MO

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
Disposal (assuming removal)	Off-Site Disposal	Landfilling	Dispose of removed sediment off-site at a permitted RCRA Subtitle C or RCRA Subtitle D facility, as applicable.	**Retain** to possibly be used in conjunction with other remedial technologies.
	On-Site Disposal	Containment Cell	Dispose of removed sediment in an existing or future on-site soil repository located at a former mine site. Disposal of removed sediment constructed on-site, or by the use of CAD or CDF..	**Retain** on-site containment using existing or new soil repositories. **Retain** CAD and CDF to possibly be used in conjunction with other remedial technologies.

usingNotes:
BRMT = Big River Mine Tailings
CAD = confined aquatic disposal
CDF = confined disposal facility
COC = contaminant of concern
OU = operable unit
RCRA = Resource Conservation and Recovery Act
SJCM = Southwest Jefferson County Mining

Table 1.2
Summary of Technologies Retained for Removal Alternative Development
Engineering Evaluation/Cost Analysis Report
BRMT Site OU2 and SJCM Site OU4, St. Francois and Jefferson Counties, MO

General Response Action	Remedial Technology	Process Options
No Action	None	Not Applicable
Containment	Bank Stabilization Sediment Capping	Vegetative Stabilization
		Armoring
		Hydraulic Measures
Removal	Mechanical Removal	Dredging
		Excavation
	Engineered Sediment Removal	Sediment Traps
		Rock Riffle Structures
Treatment	Ex Situ	Dewatering
		Separation
Disposal	Off-Site Disposal	Landfilling
	On-Site Disposal	Soil Repository, CAD, or CDF

Notes:
BRMT = Big River Mine Tailings
CAD = confined aquatic disposal
CDF = confined disposal facility
OU = operable unit
SJCM = Southwest Jefferson County Mining

Table 1.3 – Big River Watershed Locational Data

Site	Segment	Location ID	Bank Miles	Bank Feet	Bar Acres	Trap Install	Notes
BRMT	0	0.SB.01	0.29	1050	0.21	No	P2 bar at same location
BRMT	0	0.SB.02	0.38	2000	0.5	No	P1 bank
BRMT	0	0.S.03	0.00	0	0.14	No	Upstream of US Hwy 67
BRMT	0	0.SBT.04	0.14	740	0.5	Yes	Near waste water treatment plant
BRMT	0	0.S.05	0.00	0	1.5	No	Big River Confluence
BRMT	1	1.T.01	0.00	0	2	Existing	Bone Hole Access
BRMT	1	1.B.02	0.10	520	0	No	East of Desloge Pile
BRMT	1	1.SBT.03	0.09	500	1.36	Existing	Riffle 96 Pilot Location
BRMT	2	2.S.01	0.00	0	1.5	No	St. Francois State Park
BRMT	2	2.B.02	0.16	830	0	No	Turkey Creek Confluence
BRMT	2	2.SB.03	0.52	2723	2.55	No	Upstream of Highway E
BRMT	2	2.SB.04	0.27	1400	1.8	No	RM 82
BRMT	2	2.S.05	0.00	0	1.6	No	RM 77 at former Dickinson Rd. crossing
SJCM	3	3.B.01	0.14	760	0	No	Mineral Fork Confluence
SJCM	3	3.BT.02	0.17	900	0	Existing	Mammoth Road Pilot Location
SJCM	3	3.B.03	0.30	1600	0	No	Upstream of MO Hwy H near Merrill Horse Access
SJCM	4	4.B.01	0.27	1400	0	No	RM 50
SJCM	4	4.BT.02	1.67	8808	0	Yes	West of State Rd Y near RM39
SJCM	4	4.B.03	1.66	8785	0	No	RM 36
SJCM	4	4.B.04	1.68	8865	0	No	RM 35
SJCM	4	4.BT.05	1.48	7820	0	Yes	RM 31 Near Morse Mill

Location Identification codes are based on the following:

- First Digit = Segment Number (0, 1, 2, 3, 4)
- Letters = Type of Remediation (S = Sediment Bar Excavation; B = Bank Stabilization; T = Sediment Trap)
- Last Digit = Sequential number of projects within the river segment

Table 1.4 – Sediment Trap Cost Calculations

Site	Segment	Sediment Traps	CY Total	Unit Cost	O&M
BRMT	0	1	66,000	$2,640,000	$6,000,000
BRMT	1	2	132,000	$0	$13,200,000
BRMT	2	0	0	$0	$0
BRMT Totals:	**3**	**3**	**198,000**	**$21,840,000**	
SJCM	3	1	66,000	$0	$6,600,000
SJCM	4	2	132,000	$5,280,000	$12,000,000
SJCM Totals:	**2**	**3**	**198,000**	**$23,880,000**	
BRWP Totals:	**5**	**6**	**396,000**	**$45,720,000**	

Assumptions	
Planning/Design	$240,000
Years of O&M	11
CY per cleanout[2]	6,000
Total O&M CY per trap[3]	66,000
Cost per CY	$60
CY Cost per event	$360,000
Total O&M Cost per Trap[4]	$600,000

Notes:

1. $2,640,000 to construct a new trap (one-time construction cost)
2. Estimating 1 clean out event per year for 11 years at 6,000 CY per event
3. For new trap construction, O&M reduced by 1 year as construction includes first cleanout
4. $600,000 per cleanout event includes planning/design plus CY cost
5. Assumptions and cost based on Mammoth Road and Riffle 96 pilot projects

Representative Project Cost:

2017 Mammoth Road Trap Pilot Operation Cost			
CY Removed	**Cost**	**Cost/CY**	**Notes**
22,000	$ 964,000	$ 43.82	2017 Mammoth Rd Pilot Project Cost
22,000	$1,232,944	$ 56.04	Cost inflation based on 2017 past cost at Mammoth Rd and the inflation calculator below for 2024 cost
			https://data.bls.gov/cgi-bin/cpicalc.pl

Table 1.5 – Sediment Bar Excavation Cost Calculations

Site	Segment	Bar Acres	CY Total	Annual Cost	Total Cost
BRMT	0	2.85	151,734	$930,679	$10,237,468
BRMT	1	3.36	178,886	$1,097,221	$12,069,436
BRMT	2	7.45	396,638	$2,432,827	$26,761,100
BRMT Totals:	**3**	**13.66**	**727,258**	**$49,068,004**	
SJCM	3	0	0	$0	$0
SJCM	4	0	0	$0	$0
SJCM Totals:	**2**	**0**	**0**	**$0**	
BRWP Totals:	**5**	**13.66**	**727,258**	**$49,068,004**	

Assumptions	
Planning/Design	$27,000
Years of O&M	11
CY per bar-acre excavated[1]	4,840
Total CY per bar-acre[2]	53,240
Cost per bar-acre[3]	$ 326,554

Notes:

1. CY per bar-acre excavated estimated off 1 acre at 3 feet in depth for 4,840 CY per acre
2. A total of 53,240 CY per bar-acre would be excavated over 11 years (4,840 CY per acre X 11 years)
3. Estimating 1 clean out event per year for 11 years at 4,840 CY per event
4. Cost per bar-acre includes Planning and Design
5. Assumptions and cost based on 2018 FS with adjustments for cost inflation and EPA experience with pilot studies
6. No sediment bar excavations planned under this EE/CA for the SJCM Site

Representative Project Cost:

CY Removed Per Acre	Cost Per Acre	Cost/CY	Notes
9,680	$ 522,000	$ 53.93	2018 FS Sediment (Bar) Excavation Estimates
4,840	$ 261,000	$ 53.93	EPA assumes 3 feet excavation depth instead of 2018 FS assumption of 6 feet
4,840	$ 326,554	$ 67.47	Cost inflation based on 2018 FS estimate and the inflation calculator below for 2024 cost
			https://data.bls.gov/cgi-bin/cpicalc.pl

Table 1.6 – Bank Stabilization Cost Calculations

Site	Segment	Bank Miles	Banks	Unit Cost	O&M
BRMT	0	0.81	5	$5,452,918	$265,630
BRMT	1	0.19	2	$1,263,571	$106,252
BRMT	2	0.94	4	$6,283,051	$212,504
BRMT Totals:	**3**	**1.95**	**11**	**$13,583,927**	
SJCM	3	0.62	3	$4,074,554	$159,378
SJCM	4	6.76	8	$46,757,305	$425,008
SJCM Totals:	**2**	**7.37**	**11**	**$51,416,245**	
BRWP Totals:	**5**	**9.32**	**22**	**$65,000,172**	

Assumptions	
Planning/Design (Each)	$63,300
Years of O&M[1]	8
O&M Cost per Bank[2]	$53,126
Construction Cost per LF	$1,215
Construction Cost per Mile[3]	$6,414,239
Total Cost + O&M per Mile	**$6,530,665**

Notes:

1. O&M based on first year quarterly monitoring for plant establishment and annual monitoring 4 years after that for a total of 8 monitoring events.
2. O&M cost per bank is $53,126
3. $6,414,239 per mile to stabilize a bank ($1,215 per LF) plus $63,300 to plan and design each structure

Representative Project Cost:

2018 Calico Creek Pilot Project Cost			
Feet Stabilized	**Cost**	**Cost/Foot**	**Notes**
3,000	$ 2,878,000	$ 959.33	2018 Calico Creek Pilot Project Cost
3,000	$ 3,644,454	$1,214.82	Cost inflation based on 2018 past cost at Calico Creek and the inflation calculator below for 2024 cost
	$ 42,000		2018 FS O&M Cost Per Bank
	$ 53,126		2024 O&M Cost Per Bank using inflation calculator below
			https://data.bls.gov/cgi-bin/cpicalc.pl

Table 1.7 – Big River Watershed Total Cost Calculations

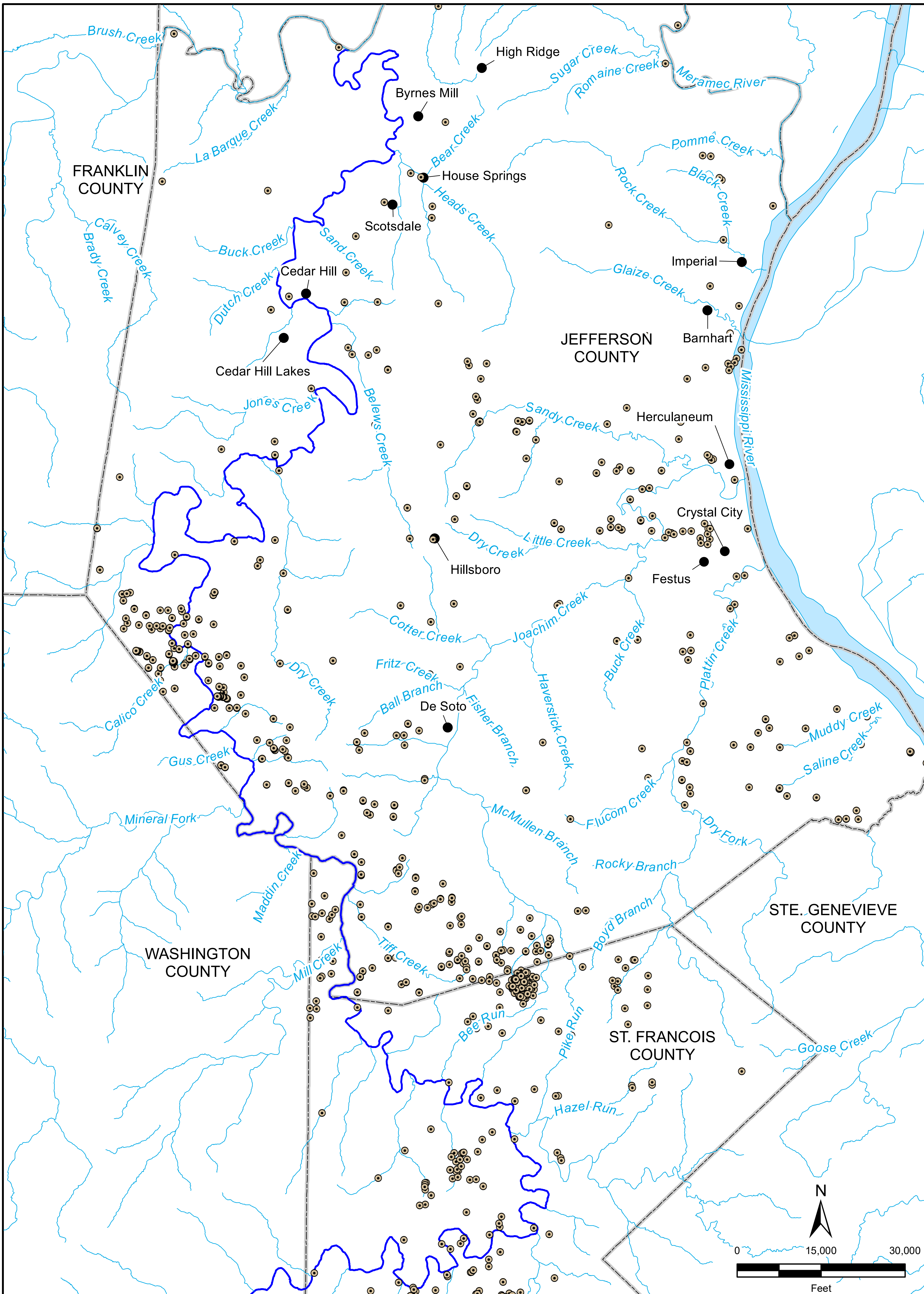
Site	Segment	Traps	CY	Trap Cost	Bar Acres	CY	Bar Cost	Banks	Bank	Bank Cost	Total CY	Total
BRMT	0	1	66,000	$ 8,640,000	2.85	151,734	$ 10,237,468	5	0.81	$ 5,718,548	217,734	$ 24,596,016
BRMT	1	2	132,000	$ 13,200,000	3.36	178,886	$ 12,069,436	2	0.19	$ 1,369,823	310,886	$ 26,639,259
BRMT	2	0	0	$ -	7.45	396,638	$ 26,761,100	4	0.94	$ 6,495,555	396,638	$ 33,256,655
BRMT Totals:	**3**	**3**	**198,000**	**$ 21,840,000**	**13.66**	**727,258**	**$ 49,068,004**	**11**	**1.95**	**$ 13,583,927**	**925,258**	**$ 84,491,931**
SJCM	3	1	66,000	$ 6,600,000	0	0	$ -	3	0.62	$ 4,233,932	66,000	$ 10,833,932
SJCM	4	2	132,000	$ 17,280,000	0	0	$ -	8	6.76	$ 47,182,313	132,000	$ 64,462,313
SJCM Totals:	**2**	**3**	**198,000**	**$ 23,880,000**	**0**	**0**	**$ -**	**11**	**7.37**	**$ 51,416,245**	**198,000**	**$ 75,296,245**
BRWP Totals:	**5**	**6**	**396,000**	**$ 45,720,000**	**13.66**	**727,258**	**$ 49,068,004**	**22**	**9.32**	**$ 65,000,172**	**1,123,258**	**$ 159,788,176**

FIGURES

Figure 1.1: Site Location Map

The Environmental Protection Agency does not guarantee the accuracy, completeness, or timeliness of the information shown, and shall not be liable for any injury or loss resulting from reliance upon the information shown.

- Select cities/towns
- Big River
- Southwest Jefferson County Mining Site, OU4
- Big River Mine Tailing Site, OU2
- Counties
- 2021 Washington County Ponds
- National Mine Ponds, St Francois, MO
- 2021 Washington County Mines
- National Mine Tailings, St Francois, MO



Legend

- Missouri Department of Natural Resources IMOP Location (2019)
- Town
- Surface Water Course
- Big River
- County Boundary

Note:
IMOP = Inventory of Mines, Occurrences and Prospects

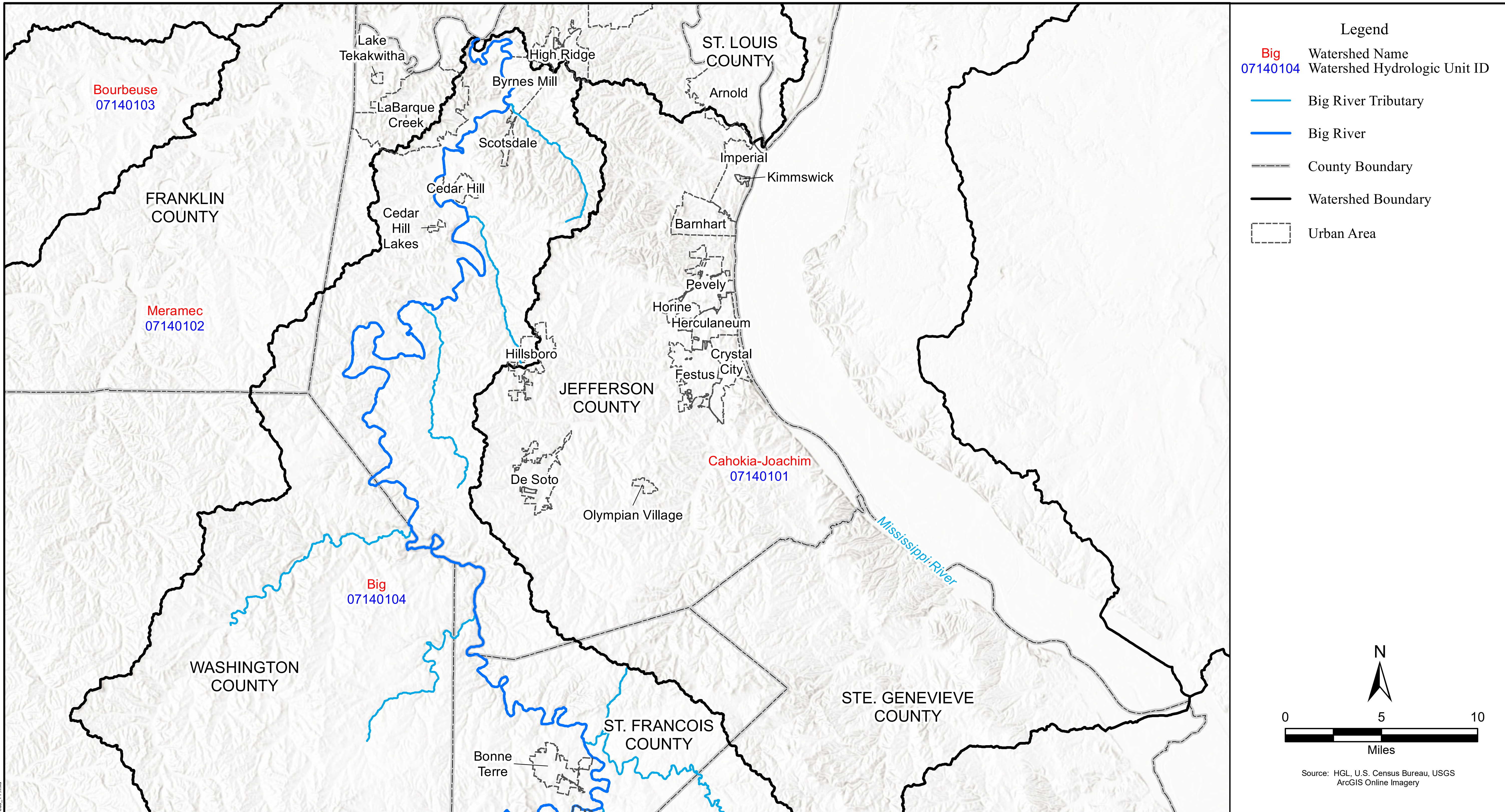
Source: HGL, NHD, MSDIS

Big River Watershed

Figure 2.1
Former Mine Locations

TETRA TECH

Date: 8/24/2022 Drawn By: Susmita Shrestha Project No: X903023F0142



Big River Watershed

Figure 2.2
Shaded Relief and Watershed Map

TETRA TECH

Date: 11/7/2023 Drawn By: Susmita Shrestha Project No: X903023F0142

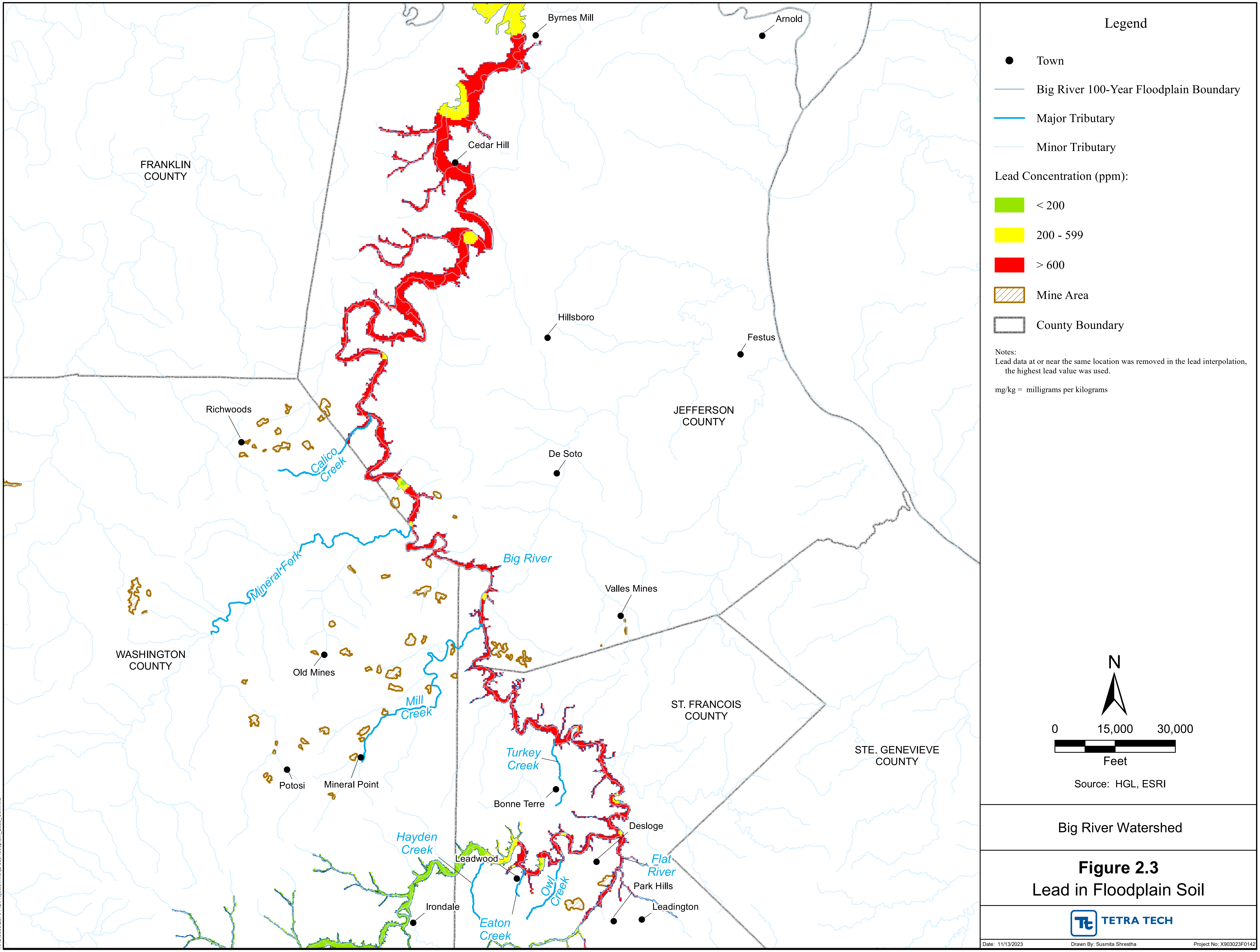


Figure 2.3
Lead in Floodplain Soil

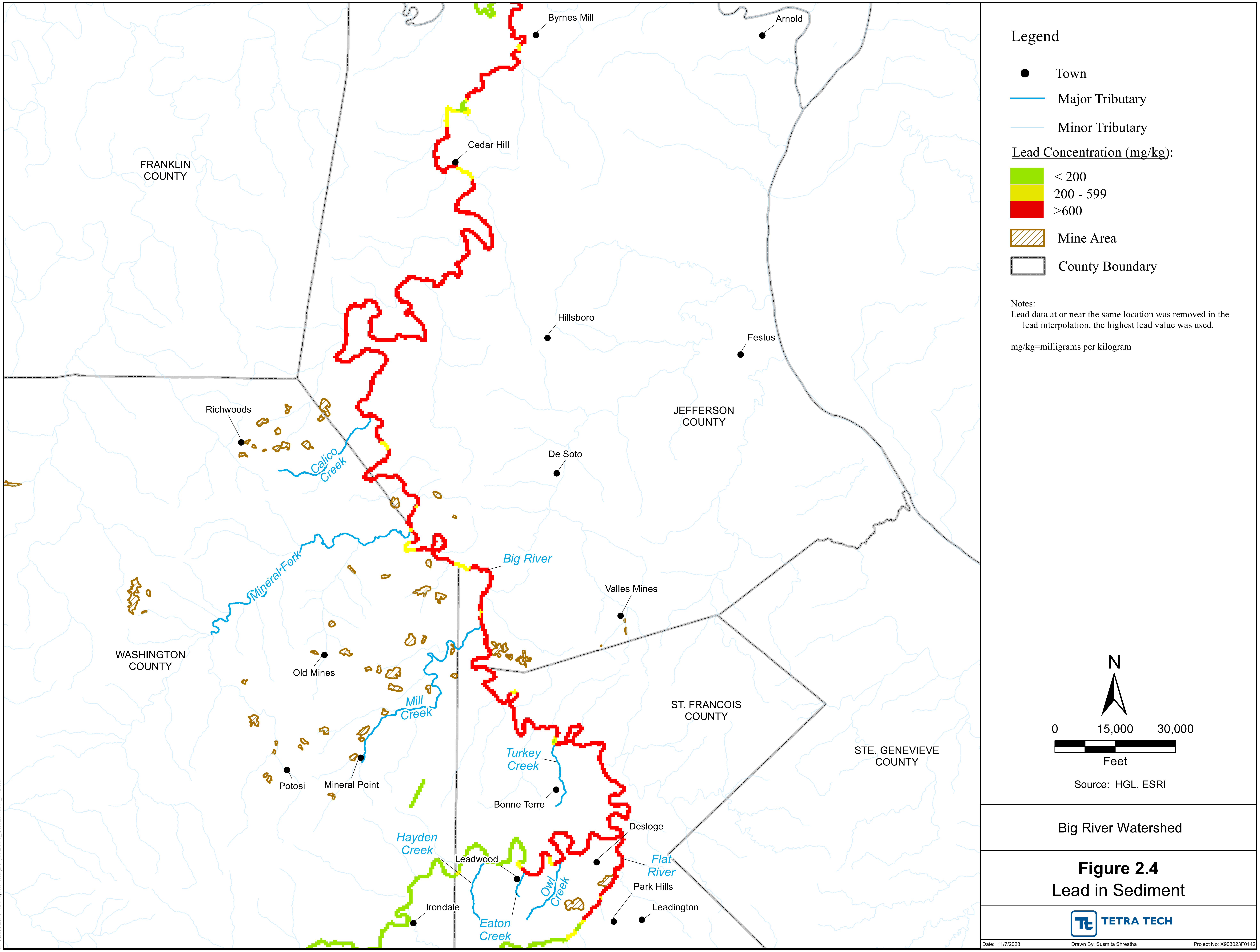
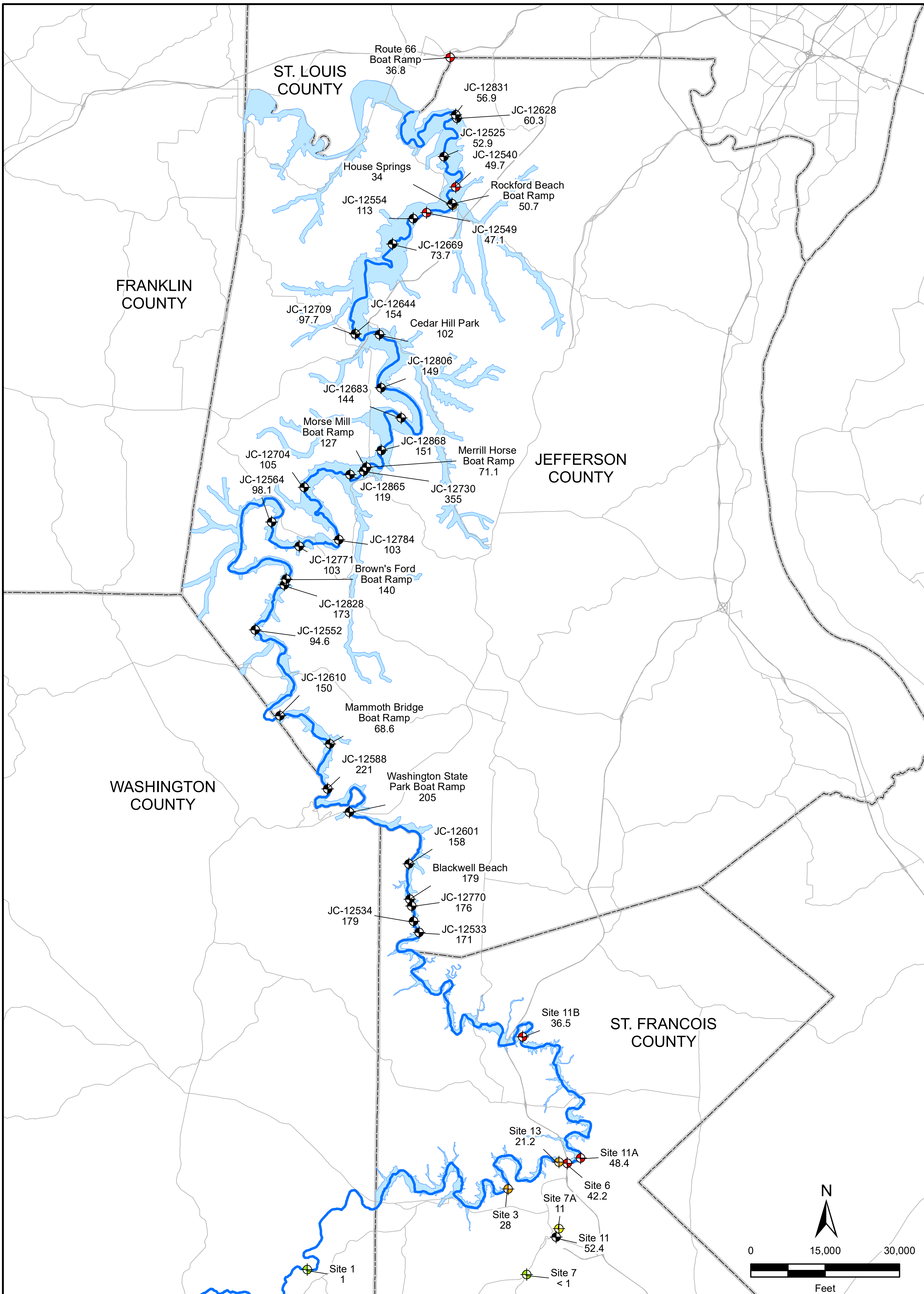


Figure 2.4
Lead in Sediment



Legend

- Lead Concentration < 5 µg/L
- Lead Concentration 5 to 20 µg/L
- Lead Concentration 20 to 35 µg/L
- Lead Concentration 35 to 50 µg/L
- Lead Concentration > 50 µg/L
- County Boundary
- Big River
- Big River 100-Year Floodplain Boundary

JC-12770 176 — Sample Location Lead Concentration (µg/L)

Notes:
µg/L=micrograms per liter

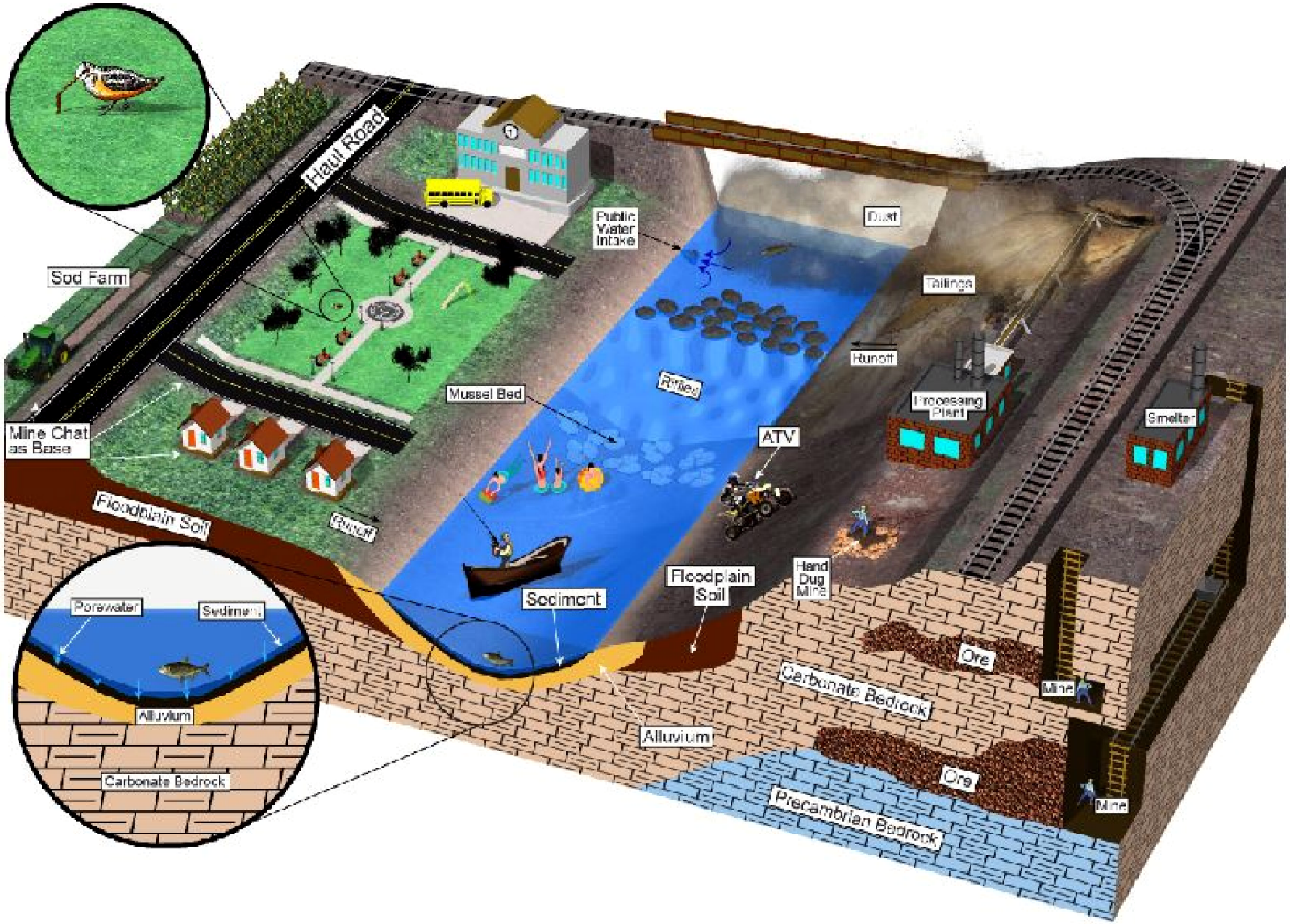
Source: HGL, MSDIS

Big River Watershed

Figure 2.5
Surface Water Lead Results

TETRA TECH

Date: 8/24/2022 Drawn By: Susmita Shrestha Project No: X903023F0142



Source: HGL

Big River Watershed

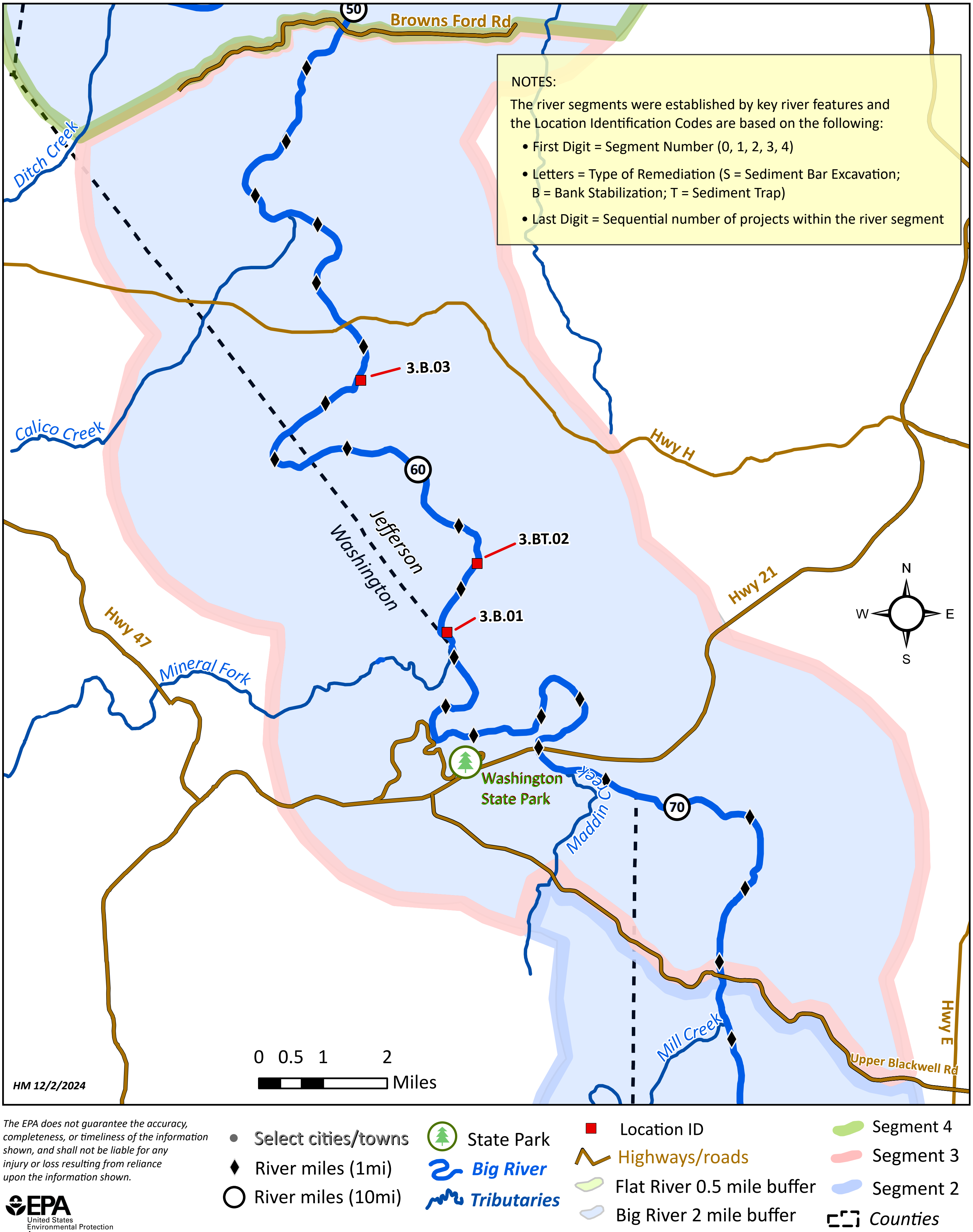
Figure 2.6
General Conceptual Site Model

TETRA TECH

Date: 11/7/2023 Drawn By: Susmita Shrestha Project No: X903023F0142

Figure 3.1: Big River All Segments

Figure 3.2a: Prioritized Location: Segment 3



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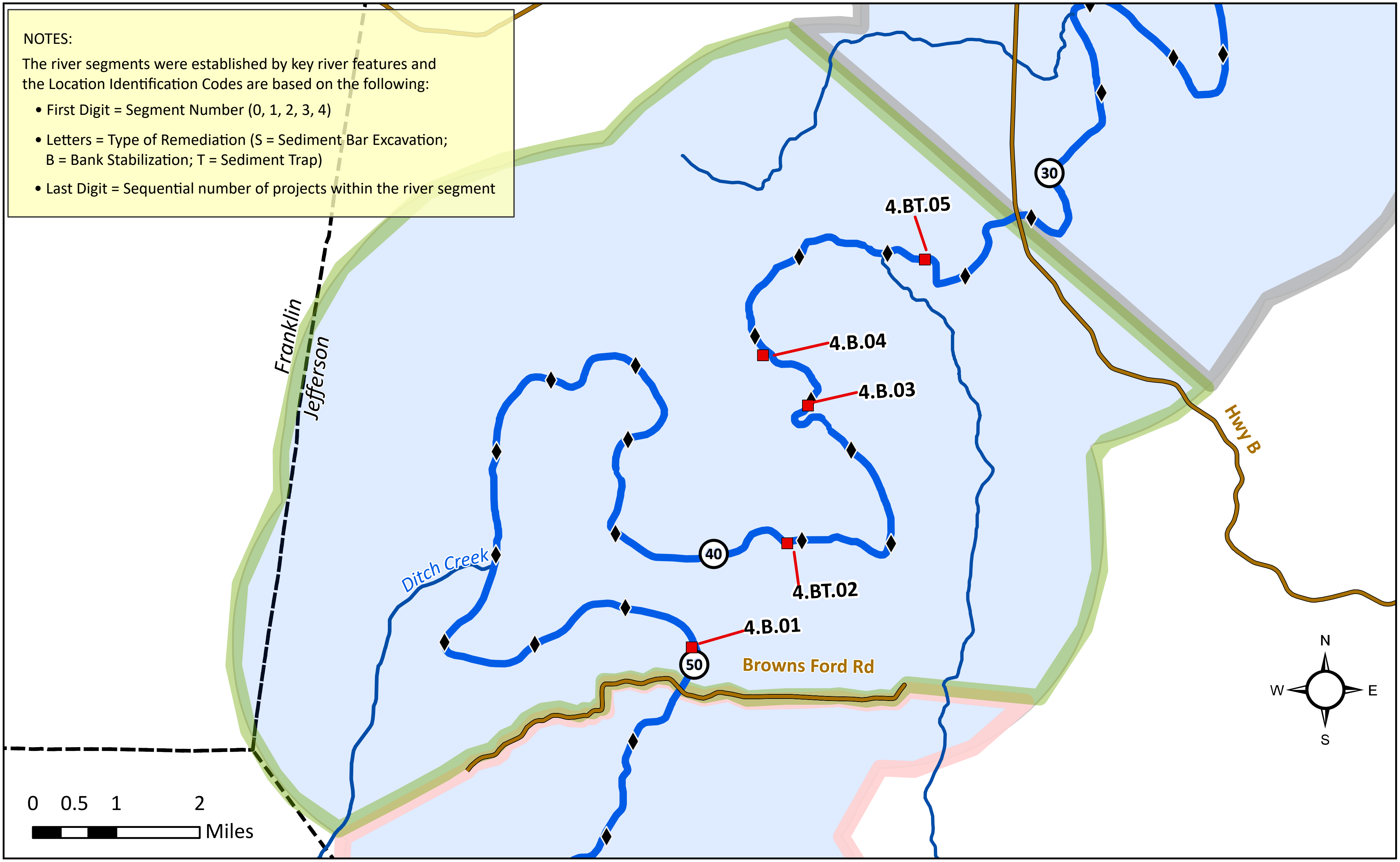
EPA United States Environmental Protection Agency

Figure 3.2b: Prioritized Location: Segment 4



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HM 5/7/2024

APPENDIX A

SUMMARY OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

(Appendix still being revised. Will be included in a future version of this report.)

- Table A.1 Chemical-Specific ARARs
- Table A.2 Location-Specific ARARs
- Table A.3 Action-Specific ARARs

TABLE A.1

CHEMICAL-SPECIFIC ARARS
ENGINEERING EVALUATION AND COST ANALYSIS REPORT
BIG RIVER WATERSHED PROJECT, ST. FRANCOIS AND JEFFERSON COUNTIES, MO

Action	Regulatory Authority	Citations	Description
ARARs			
1. Clean Water Act	Federal	Water Quality Criteria 40 CFR Part 131 Water Quality Standards	Establishes non-enforceable standards to protect aquatic life.
2. Clean Air Act	Federal	National Ambient Air Quality Standards/NESHAPs 42 USC 74112; 40 CFR 50.6 and 50.12	Emissions standards for particulate matter and lead.
3. Clean Water Act of 1977	Federal	33 USC § 1251et seq. as amended in 1987	Implements a system to impose effluent limitations on, or otherwise prevent, discharges of pollutants into any waters of the United States from any point source. Will be applicable if discharges to streams, rivers, or lakes occur from a site.
4. Safe Drinking Water Act of 1974	Federal	42 USC 300f–300j–9 et seq. as amended in 2002	Set national health-based standards for drinking water to protect against both naturally occurring and man-made contaminants that may be found in drinking water. EPA sets standards for drinking water quality and with its partners implements various technical and financial programs to ensure drinking water safety. Will be applicable at the distribution point (i.e., at the tap). Will be relevant and appropriate at sites where potential drinking water sources—rivers, lakes, reservoirs, springs, and ground water wells—are affected.
5. Missouri Clean Water Act	State	RSMo 644.006, 10 CSR 20-7.015	Establishes pollutant limits to various waters of the state.
		RSMo 644.006, 10 CSR 20-7.031(2)(3) (4)(5); Tables(A)(B)	Establishes criteria to protect uses of the waters of the state and defines anti degradation policy.
		RSMo 644.041, 10 CSR 20-7-031(5)(S)	Allows for the establishment of site-specific criteria.

TABLE A.1 (Continued)

CHEMICAL-SPECIFIC ARARS
ENGINEERING EVALUATION AND COST ANALYSIS REPORT
BIG RIVER WATERSHED PROJECT, ST. FRANCOIS AND JEFFERSON COUNTIES, MO

Action	Regulatory Authority	Citations	Description
To Be Considered			
1. Draft Soil Screening Guidance	Federal	OSWER Directive 9355.4-14FS, December 1994. EPA/540/R-94/101 and 106	Describes the soil screening process and its application at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites.
2. Revised Interim Soil Lead Guidance for CERCLA Sites	Federal	OSWER Directive No. 9355.4-12, August 1994	Guidance on site-specific Preliminary Remediation Goals and soil lead cleanup at CERCLA sites.
3. Baseline Human Health Risk Assessment for the BRMT Site OU2	Federal	Prepared for EPA Region 7 by SRC, Inc.; December 2020.	Evaluates baseline health risk due to current site exposures. The final risk assessment will establish contaminant levels in environmental media at the site for the protection of human health.
4. Baseline Human Health Risk Assessment for the SJCM Site OU4	Federal	Prepared for EPA Region 7 by SRC, Inc.; April 24, 2020.	Evaluates baseline health risk due to current site exposures. The final risk assessment will establish contaminant levels in environmental media at the site for the protection of human health.
5. Ecological Risk Assessment BRMT Site OU2	Federal	Prepared by EPA Region 7 and Black and Veatch Special Project Corps; July 2006.	Evaluates baseline ecological risk due to current site. The final risk assessment will establish contaminant levels in environmental media at the site for the protection of aquatic and terrestrial biological communities and ecosystems.
6. Ecological Risk Assessment SJCM Site OU4	Federal	Prepared by EPA Region 7; July 8, 2020.	Evaluates baseline ecological risk due to current site. The final risk assessment will establish contaminant levels in environmental media at the site for the protection of aquatic and terrestrial biological communities and ecosystems.

Notes:

Site-specific surface water clean-up goals will be based on an average hardness of 237 mg/L $CaCO_3$.

ARAR = applicable or relevant and appropriate requirement
BRMT = Big River Mine Tailings
CFR = Code of Federal Regulations
CSR = Code of State Regulations
EPA = U.S. Environmental Protection Agency
NESHAP = National Emission Standards for Hazardous Air Pollutants
OSWER = Office of Solid Waste and Emergency Response
OU = operable unit
RSMo = Revised Statutes of Missouri
SJCM = Southwest Jefferson County Mining
USC = U.S. Code

TABLE A.2

LOCATION-SPECIFIC ARARS
ENGINEERING EVALUATION AND COST ANALYSIS REPORT
BIG RIVER WATERSHED PROJECT, ST. FRANCOIS AND JEFFERSON COUNTIES, MO

Action	Regulatory Authority	Citations	Description
ARARs			
1. Historic project owned or controlled by a federal agency	Federal	National Historic Preservation Act: 16 USC 470, et. seq; 40 CFR § 6.301; 36 CFR Part 1	Property within areas of the site is included in or eligible for the National Register of Historic Places. The remedial alternatives will be designed to minimize the effect on historic landmarks.
2. Site within an area where action may cause irreparable harm, loss, or destruction of artifacts	Federal	Archeological and Historic Preservation Act; 16 USC 469, 40 CFR 6.30	Property within areas of the site may contain historical and archaeological data. The remedial alternative will be designed to minimize the effect on historical and archeological data.
3. Site located in area of critical habitat upon which endangered or threatened species depend	Federal	Endangered Species Act of 1973, 16 USC 1531-1543; 50 CFR Parts 17; 40 CFR 6.302. Federal Migratory Bird Act; 16 USC 703-712	Determination of the presence of endangered or threatened species. The remedial alternatives will be designed to conserve endangered or threatened species and their habitat; including consultation with the Department of Interior if such areas are affected.
4. Waters in and around the site	Federal	Clean Water Act, (Section 404 Permits) Dredge or Fill Substantive Requirements, 33 USC Parts 1251-1376; 40 CFR Parts 230, 231	Capping, dike stabilization, construction of berms and levees, and disposal of contaminated soil, waste material or dredged material are examples of activities that may involve a discharge of dredge or fill material. Five conditions must be satisfied before dredge and fill is an allowable alternative: 1. There must not be a practical alternative. 2. Discharge of dredged or fill material must not cause a violation of State water quality standards, violate applicable toxic effluent standards, jeopardize threatened or endangered species or injure a marine sanctuary. 3. No discharge shall be permitted that will cause or contribute to significant degradation of the water. 4. Appropriate steps to minimize adverse effects must be taken. 5. Determine long- and short-term effects on physical, chemical, and biological components of the aquatic ecosystem.

TABLE A.2 (Continued)

LOCATION-SPECIFIC ARARS
ENGINEERING EVALUATION AND COST ANALYSIS REPORT
BIG RIVER WATERSHED PROJECT, ST. FRANCOIS AND JEFFERSON COUNTIES, MO

Action	Regulatory Authority	Citations	Description
5. Areas containing fish and wildlife habitat	Federal	Fish and Wildlife Conservation Act of 1980, 16 USC Part 2901 et seq.; 50 CFR Part 83.9 and 16 USC Part 661, et seq.: Federal Migratory Bird Act, 16 USC Part 703	Regulates activity affecting wildlife and non-game fish. Remedial action will conserve and promote conservation of non-game fish and wildlife and their habitats.
6. Fish and Wildlife Coordination Act	Federal	16 USC Section 661 et seq.; 33 CFR Parts 320-330; 40 CFR 6.302	Requires consultation when a Federal department or agency proposes or authorizes any modification of any stream or other water body, and adequate provision for protection of fish and wildlife resources.
7. 100-year floodplain	Federal	Location Standard for Hazardous Waste Facilities - RCRA; 42 USC 6901; 40 CFR 264.18(b)	RCRA hazardous waste treatment and disposal. Facility located in a 100-year floodplain must be designed, constructed, operated, and maintained to prevent washout during any 100-year/24-hour flood.
8. Historic Site, Buildings, and Antiquities Act	Federal	16 USC Section 470 et seq., 40 CFR Section 301(a), and 36 CFR Part 1	Requires Federal agencies to consider the existence and location of landmarks on the National Registry of Natural Landmarks and to avoid undesirable impacts on such landmarks.
9. Archaeological and Historic Preservation Act of 1974	Federal	16 USC § 469 et seq.	Provides for the preservation of historical or archaeological data which might be destroyed or lost as the result of (1) flooding, building of access roads, relocation of railroads and highways, and other alterations of terrain caused by the construction of a dam by government or persons, or (2) alteration of terrain caused by Federal construction projects or federally licensed activity or program. Will be applicable if construction projects or alteration of terrain at a site have the potential to destroy historical or archaeological materials.
10. National Historic Preservation Act of 1966	Federal	16 USC § 470 et seq.	Establishes a national registry of historic sites. Provides for preservation of historic or prehistoric resources. Will be applicable if a site is listed on historic registry and if activities requiring permitting are initiated at a site.

LOCATION-SPECIFIC ARARS
ENGINEERING EVALUATION AND COST ANALYSIS REPORT
BIG RIVER WATERSHED PROJECT, ST. FRANCOIS AND JEFFERSON COUNTIES, MO

Action	Regulatory Authority	Citations	Description
11. Endangered Species Act of 1973	Federal	7 USC § 136; 16 USC § 460 et seq.	Provides a program for conservation of threatened and endangered plants and animals and the habitats in which they are found. Will be applicable if threatened or endangered species or their habitats are present at or near a site.
12. Clean Water Act of 1977 Wetlands Protection	Federal	40 CFR 22, 40 CFR 230 to 233, and 33 CFR 320 to 330	Allows for permitting of discharge of dredged or fill material to the waters of the United States if no practicable alternatives exist that are less damaging to the aquatic environment. Applicants must demonstrate that the impact to wetlands is minimized. Will be applicable if designated wetlands are affected by a remedy.
13. Flood Control Act of 1944	Federal	16 USC § 460	Provides the public with knowledge of flood hazards and promotes prudent use and management of floodplains. Will be applicable if a site is located on a designated floodplain.
14. Rivers and Harbors Appropriation Act of 1899	Federal	33 USC 401; 33 USC 403; and related regulations 33 CFR 320	Prohibits building of structures (Section 9) and the disposal of dredged and fill material into waters of the United States without a permit by a designated federal agency. Will be applicable if structures are constructed or a discharge of dredged or fill material occurs in waters of the United States.
15. Executive Order 11988 – Floodplain Management	Federal	40 CFR Part 6	Requires federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. Will be applicable if a site is located on a designated floodplain.
16. Executive Order 11990 – Protection of Wetlands	Federal	40 CFR Part 6	Requires federal agencies to avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative. Will be applicable if designated wetlands are affected by a remedy.

TABLE A.2 (Continued)

LOCATION-SPECIFIC ARARS
ENGINEERING EVALUATION AND COST ANALYSIS REPORT
BIG RIVER WATERSHED PROJECT, ST. FRANCOIS AND JEFFERSON COUNTIES, MO

Action	Regulatory Authority	Citations	Description
17. Fish and Wildlife Conservation Act	Federal	16 USC § 2901 to 2911	Action to conserve fish and wildlife, particularly those species that are indigenous to the state. Will be applicable if significant populations are present at a site or they are affected by site activities.
18. Fish and Wildlife Coordination Act	Federal	16 USC § 661-667e	Allows the Departments of Agriculture and Commerce to assist Federal and State agencies to study the effects of domestic sewage, trade wastes, and other polluting substances on wildlife. Will be applicable if significant populations are present at a site or they are affected by site activities.
19. Missouri Wildlife Code: Endangered Species	State	3 CSR 10-4:111	Determination of the presence or absence of endangered or threatened species and provides for regulation of non-game wildlife. Places restrictions on actions affecting protected species.

Notes:

ARAR = applicable or relevant and appropriate requirement
CFR = Code of Federal Regulations
OU = operable unit
RCRA = Resource Conservation and Recovery Act
USC = U.S. Code

TABLE A.3

ACTION-SPECIFIC ARARS
ENGINEERING EVALUATION AND COST ANALYSIS REPORT
BIG RIVER WATERSHED PROJECT, ST. FRANCOIS AND JEFFERSON COUNTIES, MO

Action	Regulatory Authority	Citations	Description
ARARs			
1. Offsite Land Disposal	Federal	RCRA, Subtitle C, 40 CFR 260-268 RCRA, Subtitle D, 40 CFR 257-258 USDOT Requirements for the Transport of Hazardous Materials, 40 CFR 172	Soil or sediment that is excavated/dredged for offsite disposal and constitutes a hazardous waste must be managed in accordance with the requirements of RCRA. 40 CFR 258, Criteria for Municipal Solid Waste Landfills, establishes requirements for the operation of landfills accepting non-hazardous solid waste. These requirements would be applicable to facilities used for the disposal of non-hazardous soil and/or sediment. Transportation of hazardous materials on public roadways must comply with the requirements of 49 CFR 172.
2. Onsite Staging of Remedial Waste	Federal	40 CFR 264.554	Regulates storage of remediation waste in a staging pile including; design, duration, performance criteria, and closure
3. Remedial Activities in Navigable Waterway	Federal	Rivers and Harbors Act, Section 10, 33 CFR 320-323	Activities that could impede navigation and commerce are prohibited. Prohibits unauthorized obstruction or alteration of any navigable waterway.
4. Impounded, Diverted, Controlled, or Modified Stream Drainage	Federal	16 USC 662(a)	Whenever the waters of any stream or other body of water are proposed or authorized to be impounded, diverted, the channel deepened, or the stream or other body of water otherwise controlled or modified for any purpose whatever, including navigation and drainage, by any department or agency of the U.S., or by any public or private agency under federal permit or license, such department or agency first shall consult with the U.S. Fish and Wildlife Service, Department of Interior, and the head of the agency exercising administration over the wildlife resources of the particular State wherein the impoundment, diversion, or other control facility is to be constructed, with a view to the conservation of wildlife resources by preventing loss of and damage to such resources as well as providing for the development and improvement thereof in connection with such water resource development.

ACTION-SPECIFIC ARARS
ENGINEERING EVALUATION AND COST ANALYSIS REPORT
BIG RIVER WATERSHED PROJECT, ST. FRANCOIS AND JEFFERSON COUNTIES, MO

Action	Regulatory Authority	Citations	Description
5. Discharge to Surface Water	Federal	Clean Water Act (CWA), 33 CFR 1342 40 CFR Part 125	Regulates discharges of pollutants to surface water. Implementation has been delegated to the State of Missouri. EPA publishes national recommended Ambient Water Quality Criteria for the protection of aquatic life and human health.
6. Dredging or Filling	Federal	CWA, 33 USC 1344, Section 404 permits, Dredge or Fill Substantive Requirements, 40 CFR 230-231	Five conditions must be met before dredging and/or filling is allowed: 1. There must not be a practical alternative. 2. No discharge of dredged or fill material may cause a violation of state water quality standards, jeopardize threatened or endangered species, injure a marine sanctuary, or violate applicable toxic effluent standards. 3. Appropriate steps must be taken to minimize adverse effects. 4. Determine long- and short-term effects on chemical, physical, and biological components of the aquatic ecosystem. 5. No discharge shall be permitted that will cause or contribute to significant degradation of the water.
7. Land Disturbing Activities	Federal State	CWA, 33 USC 1342, 40 CFR 122, Discharge of Stormwater 10 CSR 20-6.200 10 CSR 10-6.170	Regulates point and non-point stormwater discharge associated with construction activities disturbing one acre or more of land: includes requirements for Best Management Practices and for pollution prevention plans. Requires persons that emit fugitive particulates to minimize emissions through use of all reasonable precautions. In addition, no visible fugitive dust transport is allowed beyond the lot line of the property where the emissions originate.
8. Management of Hazardous Soil/Sediment	State	Hazardous Waste Management Law, 10 CSR 25-4.261	Defines solid waste subject to regulation as hazardous waste under 10 CSR 25.
9. Transportation of Waste	State	Missouri Solid Waste, Regulation 10 CSR 25-6.263	Rules regarding transportation of hazardous substances.
10. Discharge to Surface Water – TMDL Requirements	State	Missouri Clean Water Act – RSMo 644.006, 10 CSR 20-7.031 (4)(B)1, Tables (A) and (B)	Establishes pollutant limits for various waters of the state and effluent standards that protect waters of the state. Designates beneficial uses for waters of the state and takes steps to determine if uses are attainable and what TMDLs should be used to protect the designated uses.

TABLE A.3 (Continued)

ACTION-SPECIFIC ARARS
ENGINEERING EVALUATION AND COST ANALYSIS REPORT
BIG RIVER WATERSHED PROJECT, ST. FRANCOIS AND JEFFERSON COUNTIES, MO

Action	Regulatory Authority	Citations	Description
To Be Considered			
1. Transportation and Handling of Contaminated Sediments	Federal	USACE Directive ERDC\EL TR-08-29	Dredged or filled wastes generated in the remedial process for disposal offsite as defined by the USACE Directive.
	Federal	EPA-540-R-05-012, OSWER 9355.0-85	Guidance designed to assist EPA staff managing sediment sites by providing a thorough overview of methods that can be used to reduce risk caused by contaminated sediment.
2. Bank Stabilization	Federal	USACE NWP 13 – Bank Stabilization Substantive Requirements, 82 FR 1860	Provides general conditions for performing bank stabilization activities that require a permit under Section 404 of the CWA and/or Section 10 of the Rivers and Harbors Act.
3. Cleanup of Hazardous and Toxic Waste	Federal	USACE NWP 38 – Cleanup of Hazardous and Toxic Waste Substantive Requirements, 82 FR 1860	Provides general conditions for activities required to effect the containment, stabilization, or removal of hazardous or toxic waste materials that are performed, ordered, or sponsored by a government agency that require a permit under Section 404 of the CWA and/or Section 10 of the Rivers and Harbors Act.

Notes:

ARAR = applicable or relevant and appropriate requirement
CFR = Code of Federal Regulations
CSR = Code of State Regulations
EPA = U.S. Environmental Protection Agency
FR = Federal Register
NWP = Nationwide Permit
OSWER = Office of Solid Waste and Emergency Response
OU = operable unit
RCRA = Resource Conservation and Recovery Act
RSMo = Revised Statutes of Missouri
TMDL = total maximum daily load
USC = U.S. Code
USACE = U.S. Army Corps of Engineers
USDOT = U.S. Department of Transportation

APPENDIX B

BIG RIVER WATERSHED PROJECT REMOVAL AND REMEDIAL ACTION MONITORING PLAN

(Appendix still being revised. Will be included in a future version of this report.)

BIG RIVER WATERSHED PROJECT
REMOVAL AND REMEDIAL ACTION MONITORING PLAN
March 2024

EPA R7
SEMD/LMSE/SES

Contents

I. Introduction

The following sections include the monitoring plan for all cleanup actions, including the (Non-Time Critical Removal Actions [NTCRAs] and Interim Actions. Please note that the cleanup actions are collectively referred to as the remedial action (or RA) at the following Superfund Sites:

- Big River Mine Tailings (BRMT) Operable Unit 2 (OU2) - Off-Source Areas; and,
- Southwest Jefferson County Mining (SJCM) OU4 -Unconsolidated Mine Waste: Big River and Floodplain

Big River Mine Tailings OU2 and Southwest Jefferson County OU4 are collectively referred to as the Big River Watershed Project (BRWP). Remediation in the Big River Watershed (BRW) presents several unique challenges. With approximately 107 miles of the Big River and 10 miles of tributaries, the project presents logistic, construction, and financial challenges. Constraints on private and public access, and recreational uses of the river, must also be considered. Because of these challenges, United States Environmental Protection Agency, Region 7 (EPA) is proposing an incremental cleanup strategy utilizing an iterative approach. EPA encourages the use of an iterative approach, especially at complex contaminated sediment sites (OSWER Directive 9285.6-08, February 12, 2002). As used here, an iterative approach is defined broadly to include approaches which incorporate testing of hypotheses and conclusions, and foster re-evaluation of site assumptions as new information is gathered.

This monitoring plan will be used to identify uncertainty, promote efficiency, and determine the effectiveness of the remedy. This approach will inform the process for addressing remaining exposures in a final remedy. The RA must be flexible to enhance the remedial technologies applied and adapt to physical changes in the river over time.

An iterative approach may also incorporate the use of phased, early, or interim actions. Monitoring data collected during each construction phase will be used to modify and optimize the approach for the subsequent phase. This incremental approach minimizes temporary impacts to both recreational uses and ecological processes by focusing annual remediation on a limited channel segment. This approach also maximizes the potential for successful integration of natural riverine processes and long-term natural recovery of the BRWP. The ongoing data collection and refinement of remedial techniques will also directly support the development of a final remedy.

The remedial action objective (RAO) for the BRWP is to reduce the mass flux of COCs through stabilization of priority banks and removal of sediment from high priority depositional areas. This monitoring plan will be used to measure Contaminant of Concern (COC) concentrations during RA implementation to determine RA effectiveness. COCs for the BRWP include Cadmium (Cd), Lead (Pb), Zinc (Zn), Barium (Ba), Arsenic (As), and Chromium (Cr).

The remedial strategy includes reducing contaminated sediment discharge to the channel through bank stabilization; removing the highest concentration sediment in the channel; and reducing bedload migration of sediment to sensitive locations. Development of the RA strategy incorporates a sediment mass budget model for calculating and monitoring contaminant flux, in addition to the use of intensive monitoring to inform, improve, and refine both the RA strategy and model.

This monitoring plan is considered a living document, with necessary adjustments expected during the RA. The EPA is the lead agency that will be responsible for implementing the monitoring plan. The Missouri Department of Natural Resources (MoDNR) is the state support agency. The monitoring plan provides the following:

- Background information about the BRWP; and,
- Monitoring approach within the BRWP

II. Background

The BRWP spans multiple Superfund Sites (Appendix B, Figure 1) and is being addressed as a combined project under the two sites, the Big River Mine Tailings Site and the Southwest Jefferson County Mining Site.

The sites are in St. Francois and Jefferson counties of southeastern Missouri and lie within the Old Lead Belt, which was once one of the world's largest lead mining districts. Mining began in the early 1700s producing lead, zinc, and barium. By the mid-1800s, hundreds of mines and several smelters were operating and producing millions of pounds of lead annually. The last active smelter on the BRWP was destroyed by a fire in 1883.

As compiled from Bureau of Mining annual reports of Mineral Resources of the U.S. and the Mineral Yearbook, mining discharged approximately 291 million tons of mine tailings wastes to nearby streams, flat land areas, or constructed ponds from 1866 to 1972 in the Big River watershed (Pavlowsky et al., 2017). There are two main types of mining wastes: chat, and tailings. Chat waste consists of sand to gravel-sized material resulting from the crushing, grinding, and dry separation of the ore material. Tailings include sand and silt-sized material resulting from the wet washing or flotation separation of the ore material.

The mines were primarily concentrated in the BRW with the mining operations that produced the most lead located in St. Francois County, resulting in the largest volume of surface deposits of mine waste (source areas). These large mine waste areas in St. Francois County were located immediately adjacent to the Big River and along major contributing streams including Hayden Creek and Flat River. The BRMT site includes all of St. Francois County and the SJCM site includes the impacted portions of Jefferson County. The large mine waste areas that impact the BRWP are listed below by site and illustrated in Appendix B, Figure 1**.**

Big River Mine Tailings

- Bonne Terre
- Desloge

Southwest Jefferson County Mining

- Dresser Mine No. 10
- Dresser Mine No. 11

- Elvins/Rivermines
- Federal/St. Joe State Park
- Hayden Creek (not depicted on Figure 1)
- Leadwood
- National
- Lee
- Mammoth
- Valles

Mining waste was released to the BRWP primarily through erosion and the collapse of the piles directly into the stream and river drainage channels (see Appendix B, Figure 2). The releases over 100+ years have contaminated sediment, floodplain soil, and surface water in the BRWP with elevated levels of heavy metals, primarily lead. Other less significant releases have occurred from wind erosion and hauling of material by truck throughout the region.

Studies conducted by the Missouri Department of Health (MDOH, predecessor to the Missouri Department of Health and Senior Services [MDHSS]), including a Preliminary Public Health Assessment in 1994 and a lead exposure study in 1997, determined that children living in the Big River lead mining area had average blood lead levels twice as high as children living in a non-mining area, 6.52 micrograms per deciliter (µg/dL) verses 3.43 µg/dL, and that 17% of the study children were lead poisoned as defined by the Centers for Disease Control and Prevention guidelines in 1991 compared to three percent in the control community (MDOH, 1998). The MDOH followed the exposure study with the St. Francois and Jasper Counties Lead Intervention Study in 2000 as an effort to reduce the percentage of elevated blood lead levels in children.

EPA and Missouri state agencies have been addressing lead-contamination throughout southeastern Missouri for decades. The BRMT and SJCM Superfund sites were listed on the National Priorities List in 1992 and 2009, respectively.

The BRMT site is divided into five OUs as listed in Appendix A, Table 1, along with a brief description of the OU and the cleanup status.

The SJCM site addresses all mining related contamination in Jefferson County, except for the former Herculaneum Smelter, and has been divided into eight OUs. A brief description of the OUs and the cleanup status is described in Appendix A, Table 2.

Cleanup efforts to date have reduced significant risks posed by lead contamination at thousands of residential properties, including yards, daycare facilities, schools, playgrounds, and parks, by excavation and removal of contaminated soil. In addition, EPA has taken many response actions to contain the mine waste piles and minimize the movement of contaminants from the piles into the surrounding environment. The RAO for the BRWP is to reduce the mass flux of COCs through stabilization of priority banks and removal of sediment from high priority depositional areas. The upcoming work within the BRWP presents the first EPA-recommended cleanup to address risks posed by lead-contaminated sediment, floodplain soil, and surface water in the sites.

EPA is proposing an iterative approach to address contaminated sediment, floodplain soil, and surface water (See Outline in Appendix A, Table 3). The first phase will be to address high priority areas using NTCRAs. Prioritization is determined by a combination of erosion rate, COC concentrations, and accessibility. EPA plans to develop Engineering Evaluations/Cost Analyses (EE/CAs) for each Superfund site and will use the EE/CAs to develop the Action Memorandums for each site. The EE/CAs may include the following remedial approaches in the BRWP:

- Contaminated sediment removal from existing depositional areas. Sediment would be removed periodically from these locations and disposed at on-site repositories.
- Contaminated sediment removal from gravel bars or beach areas that are typically above the water level. Sediment would be removed periodically from these locations and disposed at on-site repositories.
- Contaminated sediment removal from depositional areas with existing grade control (e.g., upstream of low-water crossings). Sediment would be removed periodically from these locations and disposed at on-site repositories.
- Construction of traps or grade control structures to collect both instream (bedload) and overbank (suspended) sediment. Sediment would be removed periodically from these locations after construction is complete and disposed at on-site repositories.
- Stabilization of eroding contaminated riverbanks.
- Establishment of Institutional Controls with property owners to help preserve remedial measures.

The current plan includes NTCRAs followed by an Interim Action under an Interim Record of Decision (ROD). The Interim ROD may follow a similar approach as the NTCRAs, with emphasis on additional critical areas. It is anticipated that these actions will be followed with a Final ROD, which will establish final RAOs for the BRWP.

III. Monitoring Approach

A key element of the RA is monitoring and assessment before and after each construction activity. Monitoring and assessment are critical to measuring RA effectiveness. Monitoring data will be included in either Pollution Reports (POLREPs) under NTCRA or Five-Year Reviews during the remedial action phases. Data are evaluated against established baselines and anticipated outcomes to inform future actions. Please note that the Mass Budget Model predicts that it will take a considerable amount of work and time to reveal significant progress towards achieving reductions to lead concentrations throughout the BRWP.

Three tiers of performance monitoring will be outlined in the BRWP Long-Term Monitoring Plan (LTMP):

1. Baseline conditions,

2. RA Effectiveness Monitoring, and
3. Area-Wide Monitoring.

Baseline conditions evaluate the chemical, biological, and physical conditions at a project prior to implementation of the RA. RA Effectiveness Monitoring evaluates the chemical conditions at a project within one to five years after implementation of the RA. Area-wide monitoring expands the monitoring to include ecological and habitat recovery and encompasses a broader area (e.g., watershed or river reach area). Decreasing trends in contaminant flux and ambient water quality criteria ratios (AWQCR) are used to represent RA effectiveness. Decreasing trends in contaminant concentrations will be evaluated using surface weighted average concentrations (SWAC) of the TRZs defined in the design documents. An additional component of the design will include the approaches used to estimate bedload. The LTMP will be used to monitor and assess the progress of the remedial actions within the BRWP.

Each selected action will include some level of monitoring and assessment. RA

Effectiveness Monitoring Plans (EMPs) will be prepared and reviewed/approved by EPA and MoDNR. For basic projects, such as simple recreational areas, the need for monitoring and assessment plans will be considered on a project-by-project basis. In all cases, the types of monitoring and assessment activities and plans will be included in the Project Execution Plan (PEP).

Reference areas shall be established if possible. Reference areas would be located within the same Ecological Drainage Unit (EDU) as the potentially impacted stream, and is considered to be unimpaired by anthropogenic activities, or close to natural conditions. An EDU is developed empirically using an extensive biological sampling database and multivariate statistical techniques. Reference areas should be comparable to the potentially impacted stream in fauna, flora, and physical characteristics (wetted width, order, and overall habitat quality). Reference areas are used as a tool of comparison. EPA will work with the EPA R7 Applied Science Branch and partners to determine the appropriate location(s) to use as reference areas for comparison purposes.

A. SAMPLING ACTIVITIES AND OBJECTIVES TO SUPPORT ACTIONS

Sampling and monitoring activities have been performed to support the RI/FS. Sampling and monitoring are under way to characterize baseline conditions and would be performed as part of the development of the Removal Action Workplans (RAWP) under the NTCRA and later during the remedial design (RD) under the Interim Remedy (IR). Recovery assessment monitoring would be conducted to provide key information to support the implementation of actions in the BRWP. The draft RI/FS for the BRWP provided the foundational data and system understanding to support an action.

Additional data from several ongoing and anticipated sampling activities would supplement the existing data in the RI:

- A baseline monitoring program was initiated to provide information on pre-IR baseline site conditions. The NTCRA will use these baseline conditions for RA effectiveness measures. EPA will evaluate this dataset to identify data gaps that should be addressed prior to RA implementation.
- Construction performance monitoring will be performed during the implementation of the RA to verify the attainment of construction performance criteria and confirm that construction best management practices (BMPs) are effective in meeting project criteria for minimizing bank erosion and controlling sediment resuspension and contaminant release.
- Prior to RA implementation under the Interim ROD, a pre-design investigation (PDI) would be implemented as needed before the RD is conducted to define the final IR footprint and support other data needs to complete the RD. EPA would also use data collected from the NTCRA phase to help develop the RD.
- Construction completion sampling would be undertaken shortly after RA construction to support an evaluation of RA effectiveness.
- A recovery assessment monitoring program would be implemented following construction completion to evaluate system recovery, assess whether final cleanup goals would be met within a reasonable time frame, and inform decisions regarding the need for and scope of any additional remedial actions.
- Long-term monitoring would be implemented to verify attainment of cleanup goals both at a project specific and an area-wide level. Timeframe of monitoring is estimated to be at least 30 years after the start of RA implementation.

An overview of these additional sampling activities, which are anticipated to meet the data needs and objectives for the adaptive elements, is presented in Appendix A, Table 3, and described below.

1.1 Baseline Monitoring

The baseline monitoring program is intended to provide a thorough characterization of pre-IR physical, biological, and chemical baseline conditions in the BRWP. This will include sampling in areas of concern as well as locations where remediation is not anticipated. In addition to characterizing baseline conditions, these data would provide a basis for comparison with results of the future recovery assessment monitoring program.

The baseline sampling program is composed of the following components:

- Bathymetry and sediment texture survey in the Targeted Remediation Zones (TRZs).
- Biota tissue chemistry (Target Analyte Metals in Suckers [redhorse sp.]).

- Chemical and physical water column sampling (Target Analyte List Metals in suspended sediment, total suspended solids, hardness, stream stage, turbidity, and temperature).
- Chemical sediment and composition sampling (Target Analyte Metals and Particle Size Distribution).
- Physical habitat assessment, stream channel and bank morphology at and near the TRZs.
- Aerial surveillance of the length of the project along the channel migration zone (CMZ), an approximate 100-ft corridor on both sides of the Big River channel, where episodic flooding erodes contaminated banks and deposits sediment on the floodplain. The baseline aerial surveillance (including imagery and LiDAR) was completed in 2020.

Each of these components is described below. Additional details will be provided in the Removal Action Workplan (under NTCRA) along with the Remedial Design (under the Interim ROD).

1.1.1 Bathymetric Survey

These surveys will be performed as a baseline for site conditions in the TRZs. This information may be needed in some of the TRZs before the NTRCA. The purpose of the survey is to obtain high-resolution bathymetry from bank to bank. A combination of multibeam bathymetry and LiDAR may be used for the bathymetric evaluation. Sediment texture will be evaluated using side-scan sonar as well as sediment probing. Bathymetric survey(s) are anticipated prior to implementation of remediation for comparison with the baseline survey to support identification of erosional and depositional areas in the TRZs and following high flow events as needed. These data would be used in the Removal Action Workplan (RAWP) and the RD and in the evaluation and modeling of system hydrodynamics. Bathymetric data would support evaluation of erosional and depositional patterns for delineation of the remedial footprint.

1.1.2 Biota Chemistry

Biota sampling is a multiyear program to characterize COC concentrations in fish. The sampling would be primarily performed through cooperation with the Missouri Department of Conservation (MDC) and MDHSS. MDC and MDHSS have established sampling stations throughout Big River (Appendix B, Figure 3). Fish are collected periodically and analyzed for lead in fillets. Suckers (redhorse species) will be targeted for analysis. Fillets and whole body will be analyzed for COC concentrations. Additionally, Corbicula and crayfish will be analyzed for whole body COC concentrations. These organisms are benthic in that they spend most of their lives on or near the bottom and come into frequent contact with sediments. These data will be reviewed to enable the comparison of pre- and post-RA biota lead concentrations in fish. Please note that EPA may add sampling stations in the future if needed. EPA plans to use existing data from the MDC for baseline. Since it is unlikely the RA will have an immediate impact on biota tissue concentrations, tissue will be evaluated within 10 years after the start of construction. Results of the first round of sampling will be used to adapt and optimize the scope of the sampling in the subsequent years.

EPA will evaluate and, as necessary, refine the food web model (FWM) to better represent the relationship (i.e., transfer of contaminants) between sediment and fish. EPA will also identify and refine specific characteristics of biota in the FWM (e.g., species abundance, COC concentrations, and required sample size) within the BRWP to support refinement of the baseline monitoring program for year 10 of the program and development of the recovery assessment monitoring program.

1.1.3 Water Column Sampling

The water column sampling will generate data to support the design, implementation, and evaluation of the RA.

The baseline water column data has been continuously collected since 2011. The water column sampling program includes continuous collection of stream stage, turbidity, and water temperature from stream gages located downstream of the historical mining area in St. Francois County, and further downstream in Jefferson County. Also collected from the same area are periodic water column samples for the purpose of analyzing suspended sediment for TAL metals. EPA has worked continuously with USGS to measure lead concentration flux during flood events within collected suspended sediment. USGS developed a regression model for the computation of suspended-sediment concentrations and loads using continuous turbidity and streamflow. The model was validated and calibrated annually and will be applied to future efforts in monitoring sediment at the Highway E gage (07017610) and further downstream at the Byrnesville gage (07019500). Please see Appendix B, Figure 4 for more information on gage locations.

In addition to the continuous monitoring, a sampling network will be established for the purpose of collecting surface water samples above and below each TRZ and within each river segment as shown in Appendix B, Figure 5. Surface water samples will be analyzed for dissolved and total metals, as well as hardness.

The physical and chemical water column sampling programs will achieve the following objectives:

1. Establish the current key physical characteristics (flow velocity, turbidity, suspended solids, and temperature), including their spatial and temporal variation, within the historical mining area of the BRWP. These data would support the design and implementation of an IR, including the types of resuspension controls that could be used.

2. Characterize the relationship between hydrodynamic conditions and concentrations of suspended sediment and COCs, including spatial and temporal variation, in the water column within the historical mining area of the BRWP. These data would be used to refine numerical

models and will be compared to recovery assessment monitoring data to evaluate the success of an IR in reducing COC water column concentrations.

3. Support the calibration and refinement of the Sediment Mass Budget Model and the HEC-RAS hydraulic and sediment transport model. These data will be used to predict post-RA recovery trajectories.

1.1.4 Sediment Sampling (Target Analyte Metals and Particle Size Distribution)

The sediment sampling program will generate data to support the design, implementation, and evaluation of the RA. This data has already been collected; however, more focused sampling in the TRZs may be required. The objective for the baseline monitoring network sampling is to further characterize the existing conditions of the TRZs, and to assess and monitor the baseline and future sediment concentrations throughout the BRWP. Establishing a baseline sampling network allows for assessment of existing conditions and future conditions (presumably recovery) that is driven by past and on-going source control and in-river remedial actions. This monitoring network can be used to inform the management approach for the BRWP.

Sediment samples will be collected from targeted areas within each river segment, which is shown in Appendix B, Figure 5. It is anticipated that the first phase would include surface sediment samples (0-4 inches depth) collected on a standardized grid pattern within the TRZs to calculate the Surface Weighted Average Concentration (SWAC) of lead (and other co-located COCs as needed). Additionally, sediment will be analyzed for particle size distribution. Samples will also be collected from established sampling stations throughout the watershed. Details on the sampling plan will be included in the design documents.

This approach will be applied to each TRZ for sediment removal. In addition to the surface sediment collection, depth samples will be collected from each TRZ. These would be collected at defined cross sections from the surface down to refusal for estimating volume of sediment to be removed.

The baseline sediment sampling program will achieve the following objectives:

1. Establish the baseline sediment lead concentration within the TRZs and in the depositional zones downstream of the TRZs. These data would support the design of an IR by determining the concentration and volume of sediment to be removed.

2. Characterize the relationship between hydrodynamic conditions and concentrations of sediment and COCs, including spatial and temporal variation, in the depositional areas within the historical mining area of the BRWP. These data would be used to refine numerical models and will be compared to recovery assessment monitoring data to evaluate the success of an IR in

reducing bed load sediment concentrations. Frequency of sampling will be determined after further discussion with external partners and will also be dependent on the pace of remediation.

3. Support the calibration and refinement of the Sediment Mass Budget Model and the HEC-RAS hydraulic and sediment transport model. These data will be used to predict post-IR recovery trajectories during the RA.

1.1.5 Floodplain Sampling

The objective for the floodplain sampling is, in general, to identify the contributing sources of contaminated floodplain sediments to the Big River. This would be performed as needed, since many of the TRZs have already been characterized. The floodplain sampling will focus on the CMZ of Flat River and the Big River. CMZ soils that are elevated with lead and are unstable will be targeted for sampling, since these are the areas that may be targeted for remediation. Prioritization will be documented in the RAWP and further refined in the RD.

1.1.6 Physical Habitat Assessments, Stream Channel and Bank Morphology at and near Target Remediation Zones

Physical habitat assessments, including stream channel and bank morphology upstream, within, and downstream of each TRZ will be conducted prior to the NTCRAs. Each area will be assessed consistent with current EPA guidance. The habitat characterization found in the Rapid Bioassessment Protocols provides an effective means of evaluating and documenting habitat quality at each biosurvey station.

1.1.7 Aerial Surveillance of the BRWP

The baseline aerial surveillance has already been completed throughout the BRWP and can be used for comparison purposes. EPA will repeat this effort at least every five years throughout the BRWP. EPA will review the baseline aerial surveillance report and may supplement this by including an on-site evaluation as needed in the TRZs and other areas of concern (e.g., new areas of bank instability).

2.1 RA Effectiveness Monitoring

Remedial measures and monitoring are necessary to determine both the effectiveness and efficiency of the remedial action. The following sections describe the proposed actions to be taken to measure RA effectiveness.

2.1.1 Construction Performance Monitoring

Construction performance monitoring will be conducted within 45 days after RA construction to support an evaluation of RA effectiveness. Contractor estimates will be captured in As-Built reports for each construction project. Construction performance monitoring would include the following measures under each type of activity:

- *TRZs focused on sediment removal from existing pools/areas with grade control*
    - Bathymetric surveys (as needed) to assess excavation cut lines and post-removal conditions.
    - Residual sediment sampling to evaluate the post construction conditions and residual management measures being employed. Sampling methodology would be identical to baseline sampling methodology.
    - Sediment and concentration removal volume and/or mass based on contractor estimates.
- *TRZs focused on construction of grade control structures/traps*
    - Bathymetric surveys (as needed) to assess post-construction conditions
    - Sediment sampling to evaluate post-construction conditions
    - Sediment and concentration removal volume and/or mass based on contractor estimates.

- *TRZs focused on gravel bar removals*
    - Surveys to evaluate post-removal elevations potentially using LiDAR
    - Bathymetric surveys (as needed) to assess post-construction conditions within the TRZ and in the adjacent reach to be defined during design.
    - Sediment sampling to evaluate post-construction conditions.
    - Sediment and concentration removal volume and/or mass based on contractor estimates.
- *TRZs focused on bank stabilization*
    - Physical habitat assessments, including stream channel and bank morphology upstream, within, and downstream of each TRZ will be conducted within 30-days after implementation of bank stabilization, and vegetated areas will be evaluated.
    - Approximate area of bank stabilization will be calculated and recorded in contractor as-builts. LiDAR may also be used to help calculate area.
- *Aerial Surveillance throughout the BRWP*
    - These would be conducted throughout the BRWP at least every 5 years to assess conditions of the watershed as a response to the RA.
    - Surveillance will include photo/video documentation and LiDAR.
    - Any deficiencies and/or observations could be used to modify the RA in the following years.

2.1.2 Short-term Recovery Assessment Monitoring

Recovery assessment monitoring of contaminant concentrations would provide data needed to evaluate key metrics for the overall system recovery in response to the NTCRA, to assess

whether the Conceptual Site Model (CSM) and quantitative models accurately represent system behavior and certainty to support the RAO. While models would be used to predict recovery rates over time, the actual recovery amounts will be determined by sampling performed after the completion of the first sediment removal season, targeting newly deposited sediment within TRZs. Please note that sampling methodology will be consistent with baseline and completion monitoring. The following short-term (1-10 years) recovery assessment monitoring may be included:

- *TRZs focused on sediment removal from existing pools/areas with grade control*
  - Bathymetric surveys (as needed) to assess recovery conditions.
  - Sediment sampling for COCs and particle size distribution in newly deposited material.
  - Sediment and concentration volume and/or mass.
- *TRZs focused on construction of grade control structures/traps*
  - Bathymetric surveys (as needed) to assess recovery conditions.
  - Sediment sampling for COCs and particle size distribution in newly deposited material.
  - Sediment and concentration removal volume and/or mass.
- *TRZs focused on gravel bar removals*
  - Surveys to evaluate recovery elevations.
  - Sediment sampling for COCs and particle size distribution in newly deposited material.
  - Sediment and concentration volume and/or mass.
  - Physical habitat assessments, including stream channel and bank morphology upstream, within, and downstream of each TRZ, as needed.
- *TRZs focused on bank stabilization*
  - Physical habitat assessments, including stream channel and bank morphology upstream, within, and downstream of each TRZ will be conducted biannually until vegetation is fully established. Assessments may be reduced to annually thereafter.
  - Approximate area of bank stabilization will be compared to completion monitoring results.

Please note that this process may be repeated numerous times throughout the NTCRA. Samples would be analyzed for COCs along with volume estimates, and the quantity of COCs (mass or volume) along with the volume of material removed will be calculated annually. Sampling frequency may depend on river flow, with the first sampling event to occur after bank full river flow. It is expected, based on treatability study results, that trap and depositional areas could refill quickly after bank full events.

Sediment sampling would be conducted and evaluated before and after each removal event. If the COC concentrations of newly deposited materials are consistent with or lower than risk-based levels, sediment sampling may be reduced or discontinued in that TRZ, especially in the upper portion of the BRWP, where redeposition of contaminated sediment may be less likely.

Sediment and surface water will be collected and analyzed for COCs throughout the life of the project at established sampling stations outside of the TRZs.

3.1 Area-Wide Monitoring

Area-Wide Monitoring expands on the RA Effectiveness Monitoring to include a much broader area over a longer period of time. Area-wide monitoring would be performed in two phases: 1) Mid-Term Recovery Assessment (MTRA), and 2) Long-Term Recovery Assessment (LTRA). Each phase is described in more detail in the following sections.

3.1.1 Mid-Term Recovery Assessment Monitoring

The MTRA expands on the RA Effectiveness monitoring to include ecological and habitat recovery and encompasses a broader area (e.g., watershed or river reach area) over a longer period (≥10 years after NTCRA implementation). Decreasing trends in contaminant flux and ambient water quality criteria ratios (AWQCR) are used to represent RA effectiveness. The MTRA will be used to monitor and assess the overall progress of the NTCRA and Interim Actions within the BRWP. These data will be used in the development of the Final ROD for the BRWP.

The MTRA would be used to assess system recovery in accordance with expectations for the response of the system to the RA. Recovery assessment monitoring would include five primary components: Fish tissue, water column COC concentrations, sediment COC concentrations, physical habitat assessments, and macroinvertebrate community data. Each of these components is described briefly below and details would be developed during the RD, taking into consideration the results of the baseline and short-term RA conditions. The MTRA would be performed 10 years after the NTCRA start and would continue until issuance of the Final ROD, which would include provisions for continued long-term monitoring.

3.1.1 Biota Tissue Monitoring

The monitoring of biota recovery is anticipated to include periodic collection of fish, crayfish, and corbicula tissue, with selection of target species, numbers, size ranges, and locations based on the results of baseline monitoring to best support assessment of tissue concentration and system response. The final data collection approach would be established during the RD.

Tissue data would be analyzed for trends and compared to model projections to assess the adequacy of the CSM and the models to represent system response. Tissue data may also be used to monitor and evaluate attainment of interim risk-based thresholds for tissue concentrations and/or provide consumption guidance, to communicate risk reduction expectations and progress to stakeholders over the course of the MTRA.

3.1.2 Water Column Monitoring

Water column monitoring is anticipated to include continuous and flow event-based physical water column monitoring, small-volume chemical water column monitoring, and passive sampling. Water column sampling would be performed continuously at the stream gage locations and annually or periodically at established grab stations during the MTRA. The final scope and approach for recovery assessment monitoring would be established during the RD. Physical water column data would be used to support CSM and model refinement. Chemical water column data would be analyzed for trends to assess the effectiveness of an IR in reducing water column concentrations and compared to model projections to assess the adequacy of the CSM and the models to represent system response.

3.1.3 Sediment Monitoring

Sediment sampling would be conducted to evaluate system response to the RA and support a diagnostic assessment if needed. It is anticipated that sediment sampling would be performed periodically during the MTRA, following construction of the RA. Sediment would be collected periodically from the grab stations (co-located with the water column samples), as well as from the TRZs (until TRZ concentrations are below the action level) using methodologies consistent with baseline and construction monitoring.

3.1.4 Physical Habitat/Geomorphology Assessments

The physical habitat assessments may include the following measures during the MTRA:

- Aerial surveillance of the BRWP. Results would be reviewed and compared with baseline surveillance results. Any areas of concern would be subject to on-site visual surveys to assess any potential issues. A corrective action plan would be developed for areas of concern. Follow up actions to the aerial surveillance may include the following:
    - Bathymetric surveys within the area of concern for more detailed evaluation.
    - Physical habitat assessments, including stream channel and bank morphology upstream, within, and downstream of each area of concern, as needed.

3.1.5 Macroinvertebrate Community Assessments

EPA has collected baseline macroinvertebrate data throughout the BRWP. Advantages of monitoring of macroinvertebrates are:

- They are good indicators of localized conditions because many species have limited migration patterns.
- They integrate the effects of short-term environmental variations. Most have a complex life cycle of approximately one year or more. Sensitive life stages will respond quickly to stress; the overall community will respond more slowly.

- Degraded conditions can be detected by an experienced biologist with only a cursory examination of the benthic macroinvertebrate assemblage.
- Macroinvertebrates are relatively easy to identify to family; many "sensitive" taxa can be identified to lower taxonomic levels.
- Benthic macroinvertebrate assemblages consist of species that constitute a broad range of trophic levels and pollution tolerances.
- Sampling is relatively easy, requires few people and inexpensive gear.
- Benthic macroinvertebrates serve as a primary food source for many species of fish, including recreationally and commercially important species.
- Benthic macroinvertebrates are abundant in most streams.

The BRWP includes five species of endangered mussels: the Pink Mucket, Scaleshell, Sheepnose, Snuffbox, and Spectaclecase. These are generally located in the lower 30 miles of the BRWP. Periodic monitoring of the established mussel beds could be compared to baseline conditions as part of the macroinvertebrate assessment. EPA may explore options to working in collaboration with the with other partners (MDC, USACE, USGS, USFWS, etc.) to collect relevant mussel data in the future.

3.1.6 Floodplain Monitoring

Floodplain soil samples would be collected from locations within the CMZ. The objective of the CMZ sampling is to monitor the CMZ downstream of TRZs after remediation. Sampling would be focused on areas where suspended sediment deposits onto the floodplain. These areas would be sampled after post-remediation flood events. Results would be compared to pre-remediation concentrations. The floodplain sampling will focus on the CMZ of Flat River and the Big River. Floodplain monitoring would be performed to monitor the effects of the RA.

3.2 Long-Term Recovery Assessment Monitoring

The LTRA expands the monitoring to include ecological and habitat recovery and encompasses a broader area (entire BRWP Site) over a longer period (≥10 years after Interim Action implementation). Decreasing trends in contaminant flux and ambient water quality criteria ratios (AWQCR) are used to represent RA effectiveness. LTRA will include everything listed under MTRA but will expand the monitoring across the entire BRWP. The LTRA will be used to monitor and assess RA effectiveness after the Final ROD is issued.

IV. Summary

Monitoring during removal and remedial actions is critical to the implementation and effectiveness of the anticipated remedy in the BRWP. Information collected during the RA will be used to inform, develop, and modify the remedy throughout each step of the removal and remedial processes. This monitoring plan provides the general guidelines that shall be followed. Each specific project will include additional details regarding monitoring methodology, locations, timeframe, etc.

The LTMP is based on the traditional "weight of evidence" approach, assessing bedload and suspended sediment, surface water, physical habitat, fish tissue, and aquatic communities. The monitoring plan is a living document and may be modified periodically as additional information is gathered throughout the RA. The Big River is a dynamic system and EPA expects the river to change as the RA is implemented. The LTMP provides EPA with a useful tool to help adapt to changes in the watershed as more projects are implemented. The LTMP is a component of the final action.

EPA intends to administer this monitoring plan throughout the life of the RA.

Appendix A - Tables

Table 1- Big River Mine Tailings Site OUs

OU1	Residential properties and source control: Consists of the stabilization of the Desloge Pile, and remediation of residential properties and high child exposure areas exceeding a soil cleanup level of 400 milligrams per kilogram (mg/kg). Cleanup work ongoing.
OU2	**Off-Source areas: Includes the upcoming cleanup to address sediment and floodplain soil impacted with lead-contaminated mine waste. (Focus of this plan; the BRWP)**
OU3	Interim Program and Halo Removal Action: Consists of the removal action to address elevated blood lead levels at the site. OU3 was considered complete upon the effective date of the Consent Decree (CD) for OU1. The CD addresses any of the remaining obligations for OU3. Work complete.
OU4	Abandoned Rail Lines: Future Remedial Investigation (RI)/Feasibility Study (FS).
OU5	Doe Run Pile: RI/FS in St. Francois River Watershed to begin in Spring/Summer 2023.

Appendix A - Tables

Table 2- Southwest Jefferson County Site OUs

OU1	Residential Soils: Historic soils, properties with soil from mining operations and unidentified soil transporters. Cleanup ongoing.
OU2	Residential Soils: Luebbers, properties with soil transported to the site by Luebbers Trucking Company. Cleanup complete.
OU3	Residential Soil: Stewart, properties that obtained soil from the Stewart property on the Big River. Cleanup complete.
OU4	**Unconsolidated Mine Waste: Big River and floodplain. Included as part of Big River Watershed Project. (Focus of this plan; the BRWP)**
OU5	Groundwater: Encompasses contaminated groundwater in private residential wells impacted by mining-related activities. RI/FS in progress.
OU6	Valles Mines: Involves distinct areas within the Valles Mines Lead Mining site located in southern Jefferson County. RI/FS in progress.
OU7	Rail Lines: Includes abandoned and historic railroads used to transport lead concentrate and other milled metals. Future RI/FS planned.
OU8	Mine Waste Piles: Encompasses the remaining mining waste and tailings piles found sporadically throughout the southwest portion of Jefferson County. RI/FS in progress.

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TABLE 3. Monitoring Plan Outline

Monitoring Activity/ Component	Stream Section/ IR RA Location	Monitoring Location Media Monitored	Monitoring Frequency	Corrective Actions and Adaptive Elements	Success Metrics
A Stream Bank Stabilization at Target Remediation Zones (TRZs)	Selected based on prioritization scheme (to be developed in the EE/CA) giving preference to areas with highest COC concentrations and erodibility. Locations will also be determined based on access.	Big River RM 109 – RM 96 (3 locations in upper) Big River RM (lower river in Jeff Co (3 locations) Flat River RM 5 – 0 (1-2 locations within impacted reach). All areas monitored for: 1- Cap stability 2- Vegetation density (if soft technology) 3- Stream above/below feature/geomorphology changes.	1- Baseline Collection before construction. 2- Within 45 days of construction. 3- Biannually until vegetation is established. 4- Annual monitoring after vegetation is established. 5- After 500-year floods.	1- Cap instability – evaluate and implement stability improvements. 2- Sparse vegetation – evaluate, replant and/or change seed variety. 3- Stream morphology – If changes are causing excessive channel sediment degradation/aggradation, review findings and work with site team to implement corrective action.	**RA Effectiveness:** Contaminated floodplain soils are no longer entering the river from stabilized bank locations. **Area Wide Effectiveness:** Contaminated floodplain soils are no longer entering the river within a defined reach.
In-Stream Sediment Removal at TRZs	Selected based on decision tree	Area of removal 1- SWAC (0–4-inch composite of sediment)	1- Pre-removal 2- Post-removal 3- Annually or after 100-year flood events (or higher)	If TRZ is elevated with COCs per the annual monitoring, removal will be	**RA Effectiveness:** Contaminated sediments are removed from the project

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		2- Sediment and contaminant volume (estimate from concentration and volume of removed material and potentially surveys.		performed (annually).	location and no longer available to transport downstream. **Area Wide Effectiveness:** Removal of contaminated sediment will reduce COC concentrations
Gravel Bar Removal at TRZs	Selected based on decision tree	Area of removal 1- SWAC (0–4-inch composite) 2- Gravel and contaminant volume (estimate from concentration and volume of removed material).	1- Pre-removal 2- Post-removal 3- Annually or after 100-year flood events (or higher)	If TRZ is elevated with COCs per the annual monitoring, removal will be performed (annually or as needed).	**RA Effectiveness:** Contaminated gravel bars are removed from the project location and no longer available to transport sediment downstream. **Area Wide Effectiveness:** Removal of contaminated gravel bars will reduce COC concentrations
Sediment Removal from Sediment Traps at TRZs	Trap location, sections/subsections immediately above and below trap	1- SWAC in sediment collection area (0–4-inch composite in depositional area)	1-Pre-removal 2-Post-removal 3-Annually or after 100-year flood events (or higher)	1- Remove elevated sediment. 2- Plan necessary repairs	**RA Effectiveness:** Contaminated sediments are removed from the project

Appendix A - Tables

		2- Structural integrity of grade control structure and adjacent banks 3-Stream feature/geomorphology changes upstream, within, and downstream of structure.		3- Modify to address adverse conditions.	location and no longer available to transport downstream. **Area Wide Effectiveness:** Removal of contaminated sediment will reduce COC concentrations
Suspended Sediment	USGS gage stations; in-channel passive samplers; floodplain (sediment cups)	Turbidity (channel, backwater Suspended sediment Streamflow volume/velocity	Pre-and Post-removal. Continuous monitoring below the piles in St. Francois County.	Identify other upstream sources; evaluate remediated stream sections/subsections; ensure goals are met in downstream locations.	**Baseline:** Determine current suspended sediment COC concentrations for future comparison **Area Wide Effectiveness:** Decrease in suspended sediment COC concentrations beginning 10 years after RA project start
Eco-Receptors	IR RA location; section/subsections above and below IR RA	Fish tissue (sucker sp.)	Starting 10 years after construction begins with periodic sampling occuring in consultation with	This will be modeled over a long period of time, with expected improvements after overall river lead	**Baseline:** Determine current tissue concentrations

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			MDC, FWS, and MoDNR.	concentrations decrease.	for future comparison **Area Wide Effectiveness:** Decrease in tissue concentrations beginning 10 years after RA project start
Human Health (as related to OU1 Residential Properties)	Residences/recreation/other high use areas	Residential properties within the floodplain. Recreational areas within the floodplain.	Ongoing for new properties and every 5-years after remediation.	1- Remove soil if COCs are above residential action level. 2- Plan necessary repairs on eroded areas from flood impacts as needed. 3- Modify property to address adverse conditions, if possible.	**Baseline:** Determine current soil COC concentrations for future comparison **RA Effectiveness:** Contaminated soil removed from residential areas at time of project. **Area Wide Effectiveness:** Decrease in soil COC concentrations beginning 5 years after RA project start

Appendix A - Tables

RA LOCATION SELECTION DECISION TREE (TBD in the EE/CA and RD)

APPENDIX B

FIGURES

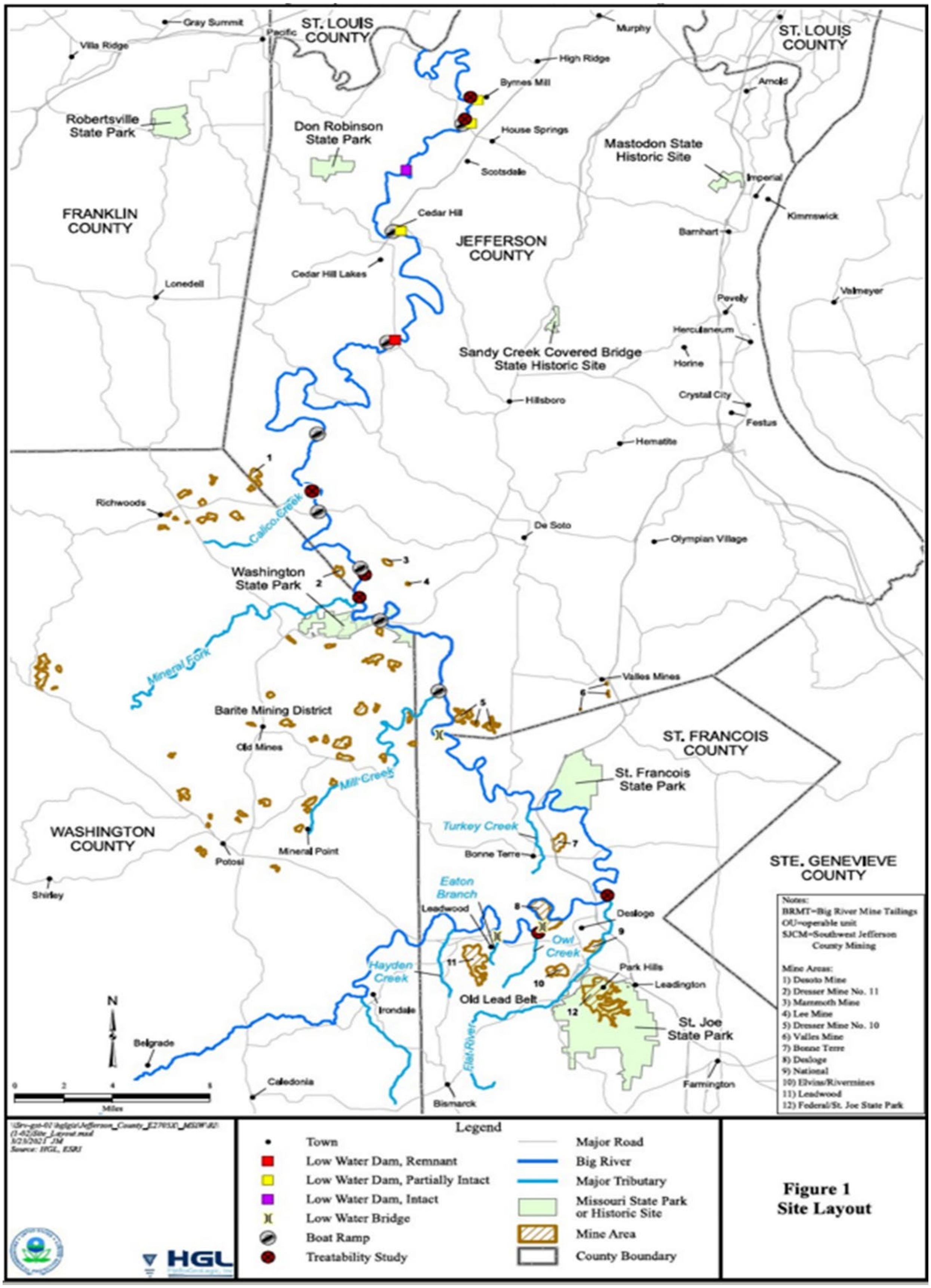

Figure 1
Site Layout

<u>Figure 2</u>: Historical photograph of the Elvins Mine Tailings Pile facing southeast (Whitton and Wixson, 1981). The photograph illustrates a partial pile collapse and drainage exiting the pile.

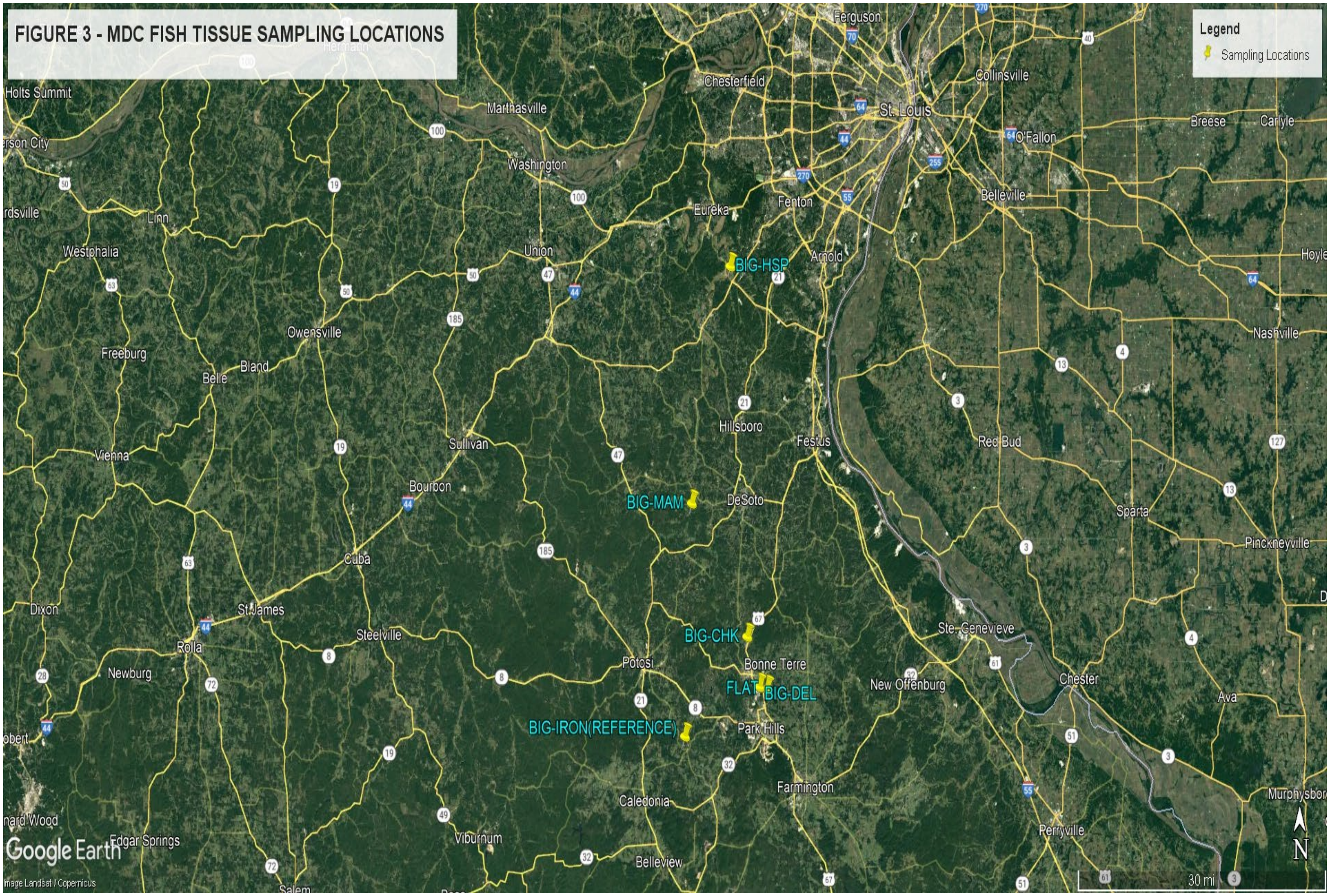
FIGURE 3 - MDC FISH TISSUE SAMPLING LOCATIONS
Legend
Sampling Locations
BIG-HSP
BIG-MAM
BIG-CHK
FLAT
BIG-DEL
BIG-IRON(REFERENCE)
St. Louis
Ferguson
Chesterfield
Collinsville
Marthasville
Washington
Eureka
Fenton
Belleville
O'Fallon
Breese
Carlyle
Holts Summit
Linn
Westphalia
Union
Arnold
Owensville
Freeburg
Bland
Belle
Hillsboro
Festus
Red Bud
Nashville
Sullivan
Vienna
Bourbon
DeSoto
Sparta
Pinckneyville
Cuba
St. James
Dixon
Rolla
Steelville
Potosi
Bonne Terre
Ste. Genevieve
Chester
Newburg
New Offenburg
Park Hills
Ava
Farmington
Caledonia
Viburnum
Edgar Springs
Belleview
Perryville
30 mi
N
Google Earth
Image Landsat / Copernicus

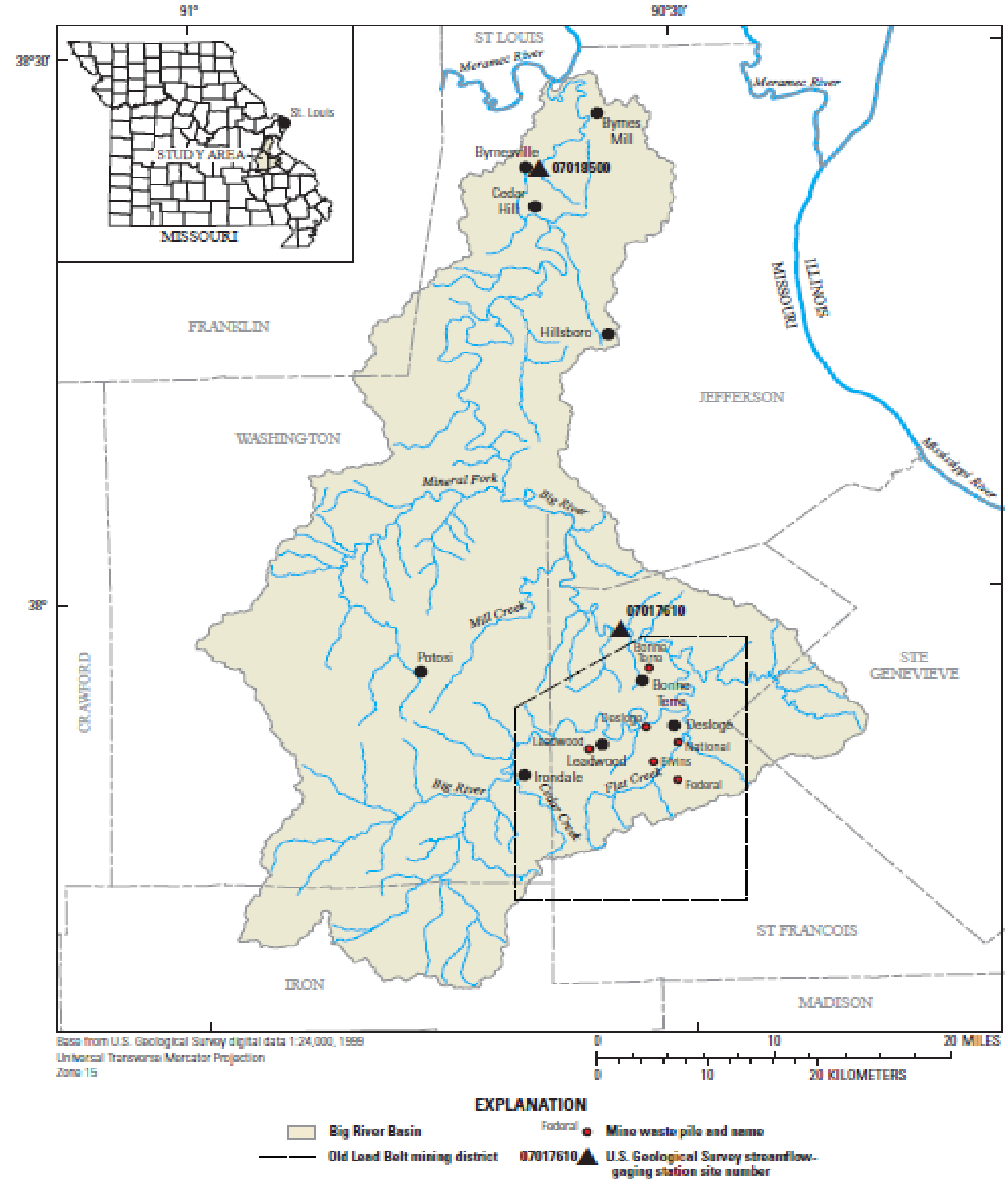

Figure 4. Gage Locations in the BRWP

Big River Watershed Project

Figure 5.1 Big River All Segments

APPENDIX C

ACRONYM LIST

As	Arsenic
AWQCR	Ambient Water Quality Criteria Ratios
Ba	Barium
BMP	Best Management Practices
BRMT	Big River Mine Tailings
BRW	Big River Watershed
BRWP	Big River Watershed Project
CA	Cost Analysis
CD	Consent Decree
Cd	Cadmium
CMZ	Channel Migration Zone
Cr	Chromium
COC	Contaminant of Concern
CSM	Conceptual Site Model
EDU	Ecological Drainage Unit
EE	Engineering Evaluations
EMP	Effectiveness Monitoring Plan
EPA	United States Environmental Protection Agency
FS	Feasibility Study
FWM	Food Web Model
HEC-RAS	Hydrologic Engineering Center’s River Analysis System
IC	Institutional Controls
IR	Interim Remedy
LIDAR	Light Detection & Ranging
LMSE	Lead Mining & Special Emphasis Branch
LTMP	Long-Term Monitoring Plan
LTRA	Long-Term Recovery Assessment
MDC	Missouri Department of Conservation
MDHSS	Missouri Department of Health and Senior Services
MDOH	Missouri Department of Health
MoDNR	Missouri Department of Natural Resources
MTRA	Mid-Term Recovery Assessment
NTCRA	Non-Time Critical Removal Action
OU	Operable Unit
Pb	Lead
PDI	Pre-Design Investigation
PEP	Project Execution Plan
POLREPs	Pollution Reporting System
RA	Remedial Action

RAO	Remedial Action Objective
RAWP	Removal Action Workplan
RD	Remedial Design
RI	Remedial Investigation
ROD	Record of Decision
SEMD	Superfund & Emergency Management Division
SES	Special Emphasis Section
SJCM	Southwest Jefferson County Mining
SWAC	Surface Weighted Average Concentrations
TAL	Target Analyte List
TRZ	Targeted Remediation Zones
USACE	United States Army Corps of Engineers
USFWS	United States Fish & Wildlife Service
USGS	United States Geological Survey
Zn	Zinc