

CLARK FORK RIVER RIPARIAN EVALUATION SYSTEM

A REMEDIAL DESIGN TOOL

Clark Fork River Operable Unit Milltown Reservoir Sediments NPL Site

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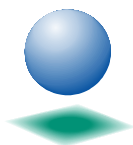


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PREFACE

The Clark Fork River Riparian Evaluation System (CFR RipES) is a decision-making tool, that allows the *Record of Decision* requirements to be implemented on a site-specific, refined, and definitive basis. The purpose of CFR RipES is to provide a data predicated design tool to identify and categorize polygons (delineated areas of land) based on landscape stability, contamination severity, and plant community attributes within the Clark Fork River OU.

CFR RipES was first described in a draft document in December of 2000 (RRU and RWRP). At the time of writing, several remedial alternatives were under consideration as eventually described in the *Feasibility Study* (ARCO 2002) for the CFR OU. Since December of 2000, the *Feasibility Study* was completed, the *Proposed Plan* (EPA 2002) describing the preferred cleanup strategy has been distributed for public comment.

An iterative process of successive drafts since 2000 of CFR RipES have been made by the authors as they gained more understanding of the nuances of questions that it needed to answer, and of the physical complexities of contaminant distribution on the floodplain and the different ways these are ecologically expressed. Additional fieldwork was conducted in the fall of 2002, and in the spring of 2003, the CFR RipES was applied to multiple locations within the CFR OU to calibrate and validate the system. In late August of 2003, the CFR RipES system was field demonstrated to a group of people representing landowners, state and federal agencies, and representatives of environmental advocacy organizations. This document describes CFR RipES that is congruent with remedial action goals, objectives, and requirements specified in the *Record of Decision*.

This document integrates the streambank and riparian corridor buffer concept, sets standards for classification of streambanks (Class 1, 2, or 3) as a function of physical stability and phytotoxicity, defines slickens (exposed tailings), defines impacted soils and vegetation areas, and defines slightly impacted soils and vegetation areas. This document also integrates data and information generated during fieldwork in 2002 and 2003, as well as comments received from the people during the August 2003 field demonstrations. It is noted that scoring categories, point allocations, and discriminatory thresholds have been greatly modified from the December 2000 document. New decision matrices have also been developed to reflect the remedy as described in the CFR OU *Record of Decision*.

INTRODUCTION

Brief Site Background

Mining for gold, silver, and especially copper began in the late 19th Century in the Butte-Silver Bow Creek area. Milling and smelting of these ores produced vast wealth and concurrently a variety of wastes including mine and process waters and contaminated tailings that were released into Silver Bow Creek. These wastes contained elevated levels of several metals and arsenic, as well as the acid producing mineral pyrite. These wastes were fluvially transported downstream and into the Clark Fork River. Transport rates varied depending on flow conditions caused by precipitation patterns. Large flood events, particularly in 1908, distributed the metal bearing wastes along the entire Upper Clark Fork River floodplain. Sedimentation ponds constructed at Warm Springs in 1918 and 1959 altered the amount and type of wastes reaching the Upper Clark Fork River. Contaminated tailings and sediments reaching the river after construction of the ponds were due to fluvial redistribution of deposited wastes in the river, contributions from other tributaries, and from occasional overflows and failures at the ponds. Mining wastes from the Old Works Smelters in Anaconda were also transported via Warm Springs Creek and other creeks into the Upper Clark Fork River.

In addition to fluvial deposition of contaminated tailings within the historic 100-year floodplain, agricultural fields were irrigated with water from the Clark Fork River that at times contained enriched concentrations of metals in the dissolved form and as suspended sediment. In some instances irrigation ditches overflowed or were breached, flooding fields down gradient of the ditches with river water. Soils in these irrigated fields now contain elevated concentrations of metals and arsenic resulting from these historic irrigation practices. The irrigated fields are located on terraces above the influence of metals and arsenic impacts associated with flood deposition, thus the mechanism of contaminant transport is fundamentally different for irrigated fields compared to impacted areas within the floodplain.

Brief Site History

The Clark Fork River Operable Unit (CFR OU) of the Milltown Reservoir/Clark Fork River Superfund Site was placed on the National Priorities List in 1984. The CFR OU is defined as “surface water, bed sediments, tailings, impacted soils, ground water, aquatic resources, terrestrial resources, irrigation ditches and related tailings deposits, and air located within and adjacent to the historic 100-year floodplain of the Clark Fork River” (EPA 1995). The CFR OU extends from the confluence of the old Silver Bow Creek channel and the re-constructed Mill-Willow Bypass some 120 miles to the upstream end of the Milltown Reservoir Operable Unit. A Remedial Investigation defining the nature and extent of contamination was completed (ARCO 1998). This investigation summarized the results of numerous existing environmental studies of impacted media and collected additional data to evaluate risk to human health and the environment and to develop and evaluate remedial alternatives. The Remedial Investigation process also included Treatability Studies designed to evaluate some potential alternatives, and both Human (EPA 1998a, addendum by Syracuse [2001]) and Ecological (EPA 1999, EPA 2001a) Risk Assessments to quantify threats to human health and environmental receptors. Studies addressing geomorphic stability and mass balance loading were also done (ARCO 2000a). A *Feasibility Study* (ARCO 2002) describing and evaluating remedial alternatives was prepared, and EPA issued a *Proposed Plan* describing the preferred alternative in August 2002. A *Record of Decision* defining the selected remedy for the CFR OU is being published by EPA, which this CFR RipES document accompanies.

Remedial Investigation

The EPA released for general distribution the Clark Fork River *Remedial Investigation* Final Draft Report in August 1998 (ARCO). This report characterized the nature and extent of contamination within the OU. The *Remedial Investigation* contains a description of the site conceptual model; characterization of soil/tailings, groundwater and surface water, streambed sediments, and biological resources; and fate and transport of contaminants from sources to receptors.

Feasibility Study

The Public Review Draft *Feasibility Study* Report was prepared by ARCO Environmental Remediation Limited (AERL) and submitted to EPA in March 2002. This document used data and information from the *Remedial Investigation* and the *Human Health Risk Assessment* and the *Ecological Risk Assessment* to identify, screen, and evaluate remedial alternatives that will reduce or eliminate environmental and human health risks. Eight primary alternatives and ancillary sub-alternatives were evaluated in detail. These analyses addressed how each alternative meets the following CERCLA criteria: overall protection of human health and the environment; compliance with applicable or relevant and appropriate requirements; long term effectiveness and permanence; short term effectiveness; cost; reduction of toxicity, mobility and volume through treatment; implementability; State (Montana) acceptance; and community acceptance.

Record of Decision for the Clark Fork River Operable Unit

The *Record of Decision* (EPA 2004) presents the selected remedy, which is described there in Part 2, Sections 13.2 and 13.3. The role and function of this CFR RipES tool, which is being issued as a companion document to the *Record of Decision*, is described in Section 13.6.1 of Part 2 the *Record of Decision*. The *Record of Decision* recognizes CFR RipES as the design tool for identifying and categorizing areas for remedial action.

The *Record of Decision* identifies five main categories of area for remedial action and the general priority and preference for the type of action to be implemented in each. A sixth category called “slightly impacted soils and vegetation areas” is added; thereby accounting for all of the land within the historic 100-year floodplain, since tailings contamination is found throughout the historic 100-year floodplain.

These areas (defined in the *Record of Decision* and later in the document) are:

Streambank and Riparian Corridor Buffer

- Class 1 Streambanks
- Class 2 Streambanks
- Class 3 Streambanks

Historic 100-Year Floodplain Contaminated Soils

- Slickens (exposed tailings)
- Impacted Soils and Vegetation Areas
- Slightly Impacted Soils and Vegetation Areas

CLARK FORK RIVER RIPARIAN EVALUATION SYSTEM (CFR RipES)

Purpose

Scientists from the Riparian and Wetland Research Program (University of Montana) and the Reclamation Research Unit (Montana State University) initially developed a riparian evaluation system (RipES) for the CFR OU (RRU and RWRP 2000).

CFR RipES is a tool that allows the *Record of Decision* requirements to be implemented on a site specific, refined, and definitive basis. The purpose of CFR RipES is to provide a data predicated decision tool to identify and categorize polygons (delineated areas of land) based on landscape stability, contamination severity, and plant community attributes within the CFR OU. CFR RipES will make classifications and determine actions consistent with the standards set forth in the *Record of Decision*. The system contains the following elements:

- Definitions and scoring for three types of soils polygons and three types of streambank and riparian corridor buffer polygons;
- A 100 percent accounting of all areas in the historic 100-year floodplain within the CFR OU among the three types of soil polygons in Reach A and portions of Reach B;
- Numerical components with threshold scores that distinguish the severity of contamination of the floodplain soils, and thresholds that separate streambank riparian corridor buffer polygons into three classes; and
- A process for identification of data and information required to complete remedial designs for each polygon.

The numerical portion of the system is based upon the Land Reclamation Evaluation System (LRES) developed for the Anaconda Smelter NPL Site (EPA 1998b, CDM and RRU 1999, and ARCO 2000b), and the Riparian and Wetland Health Assessment protocols (Hansen and others 2000), which are used extensively in the western United States and Canada. The health assessment protocols (Hansen and others 2000), upon which the numerical evaluation of the ecological aspect of CFR RipES is based, were initiated in 1986 in a series of iterative steps wherein inter-disciplinary teams of natural resource professionals and scientists collaborated using the Delphi Method or Expert Opinion Method (Delbecq and others 1975, Schuster and others 1985) to write, field-test, and refine the protocols.

After the CFR RipES concept and initial format was officially accepted, a formalized and systematic field test and statistical analysis of it was conducted to finalize the design and prove the effectiveness and utility in practice. The authors wrote and received EPA approval of a Sampling and Analysis Plan in early 2003 (RRU and BRI 2003a) and conducted field sampling and testing during the summer of 2003. This further sampling and testing allowed adjustment of the formats, question item weighting, and discriminatory thresholds to achieve optimum differentiation among the pertinent types of streambank and soil polygon. Subsequent statistical analysis shows the tool to be useful and effective, as intended (RRU and BRI 2003b).

This document describes the CFR RipES system in relation to the CERCLA RD/RA process and the CERCLA RD/RA process. It builds on the initial RipES document (RRU and RWRP 2000) and integrates the thinking and rationale supporting the selected remedy as stated in the *Record of Decision*. CFR RipES will also be used to evaluate land reclamation designs, evaluate post-action effectiveness, and in monitoring and maintenance programs for reclaimed areas.

Data Quality Objectives

A Sampling and Analysis Plan was prepared to guide the validation of the CFR RipES system (RRU and BRI 2003a). As part of the Plan, the Data Quality Objectives process was integrated. This process provides a systematic planning tool based on the scientific method (APHA 1998). The process documents the criteria for defensible decision-making before an environmental data collection activity begins. The DQO process specifies project decisions, the data quality required to support those decisions, specific data types needed, data collection requirements, and analytical techniques necessary to generate the specified data quality. The process also ensures that the resources required to generate

the data are justified. The DQO process (EPA 1994) consists of seven steps of which the output from each step influences the choices that will be made later in the process. These steps include:

- State the problem;
- Identify decisions and actions;
- Identify inputs;
- Identify spatial and temporal limits;
- Develop a decision rule;
- Specify limits on decision errors; and
- Optimize design for collection.

Step 1. State the Problem—The problem was to devise a systematic way to identify areas (polygons) within Reach A and limited portions of Reach B of the CFR OU that require remediation to address effects of contamination from mining and smelting wastes, and to place these areas (polygons) into categories that determine appropriate remedial action(s), all in a manner consistent with the CFR OU *Record of Decision*.

Step 2. Identify the Decision—During development of the CFR RipES several questions were identified that are to be answered in order to classify streambank polygons, exposed tailings areas, and impacted and slightly impacted soils and vegetation areas. These questions included:

- What information and data are required to characterize streambanks as Class 1, 2, or 3?
- What characteristics (chemical, physical, and biological) define slickens (exposed tailings)?
- What characteristics (chemical, physical, and biological) define impacted soils and vegetation areas?
- What characteristics (chemical, physical, and biological) define slightly impacted soils and vegetation areas?
- How should streambank stability and contamination severity be evaluated for streambank polygons?
- How should ecological dysfunction and contamination severity be evaluated for floodplain contaminated tailings/soils polygons?
- How will the system be calibrated so that categorization and classification effectively separate polygons with different levels of dysfunction?
- How are the CFR RipES threshold scores developed?
- How are data gaps identified for a site or polygon?
- What data and information are required on a polygon-by-polygon basis to support remedial design?

Step 3. Identify the Inputs to the Decision—Informational variables required to answer the major questions posed above are:

- **Streambank and riparian corridor buffer polygon**—In order to categorize streambanks the following information and data are required for a polygon: (1) percent of the polygon with live plant canopy cover other than tufted hairgrass, (2) the completeness of the canopy of live, deep-binding, woody species in the polygon, and (3) the percent of the streambank length in the polygon that exhibits active lateral cutting. The minimum mapping unit of these polygons is 20 linear feet of streambank with a maximum length of 500 ft. These parameters are assessed using the CFR RipES Field Form for Streambank and Riparian Corridor Buffer Polygons. Threshold scores discriminate streambanks into three categories (e.g., Class 1, 2, or 3 streambank).
- **Slickens (exposed tailings) polygon**—In order to identify an area as a slickens, the following information and data are required for a polygon: (1) percent of the polygon with live plant

canopy cover, (2) whether there is tufted hairgrass (*Deschampsia cespitosa*) present, (3) whether efflorescent metal salts are visible on the soil surface during dry periods. The minimum mapping unit for slickens polygons is 400 square feet. Areas smaller than 400 square feet that have slickens characteristics are included within impacted soils and vegetation area polygons.

- **Impacted soils and vegetation area and slightly impacted soils and vegetation area polygons**—In order to distinguish between an impacted soils and vegetation area and a slightly impacted soils and vegetation area, the following information and data are required for a polygon: (1) percent of the polygon with live plant canopy cover other than tufted hairgrass, (2) the amount of any tufted hairgrass present, (3) the percent of the area that is bare ground caused by tailings, (4) the depth and concentration of contamination, (5) the depth integrated soil pH, and (6) whether efflorescent metal salts are visible on the soil surface during dry periods. These parameters are assessed using the CFR RipES Data Form for Impacted Soils Area Polygons and for Slightly Impacted Soils Area Polygons. A threshold score discriminates polygons into the two categories. The minimum mapping unit for these polygons is 400 square feet.
- **Additional quantitative environmental data**—Additional data on a polygon-by-polygon basis will be required. One of the main data gaps identified is the lack of contamination severity information, specifically concentrations of the COCs (copper is used as a surrogate for all COCs), depth of contamination, depth to groundwater, and pH of the materials. Filling these data gaps will be necessary so that preliminary remedial actions can be assigned to a polygon. Additional data to support remedial design include acid base account, nutrient status of the newly constructed root zone, quality and quantity of imported materials, and others. See Part 2, Section 13.6, 13.7, and 13.8 of the *Record of Decision*.

Step 4. Define the Study Boundaries—Spatial boundaries of the CFR RipES evaluation encompass Reach A and limited portions of Reach B of the CFR OU. The temporal boundaries of the CFR RipES process begin with field use of the system and end when remedial designs are approved by the agencies.

Step 5. Develop a Decision Rule—The parameters of interest are those parameters scored during the field data collection. CFR RipES threshold levels were determined during the late 2002 field season and the summer of 2003, as the system was validated and calibrated. Validation of the threshold levels was made during the summer of 2003 and adjustments were made. Threshold scores are used to distinguish streambank categories or classes, and to identify impacted soils and vegetation sites that require remedial action and slightly impacted soils and vegetation areas that receive no action (or only monitoring). Areas with extensive exposed tailings (e.g., slickens) will all require remedial action, and therefore are not further categorized by a threshold score.

The scoring protocols will be used to categorize each polygon. In general, the lower the site score, the higher the intensity of action that may be required. There will be target levels (cutoffs) for different remedial action intensities, but the type of remedial action required on a specific polygon will ultimately be determined during the remedial design phase of the CERCLA process. Field and analytical information collected during the CFR RipES process will be vital in making design decisions. The CFR RipES score and supplemental descriptive information will be used during design, in concert with other design considerations (refer to Section 13.6.1.1 of the *Record of Decision*).

Step 6. Specify Tolerable Limits on Decision Errors—Tolerable limits on decision errors are built into the CFR RipES system. Most parameters scored on the field scoring system forms include a range for the parameter measured. For example, less than 25 percent canopy cover, or a range of contamination

levels in the soil profile. These ranges are meant to envelop the limits on the decision errors made by field personnel and specify the tolerable limits on field decision errors.

The point system was designed with a lack of flexibility in order to increase scoring precision (i.e. repeatability) by limiting the effect of variability among observers. Although there is a range of values for each category of some parameters, the field observer must assign that range only one score. Intermediate values within the ranges do not translate to an intermediate score. This limitation of choices minimizes inter-observer variability.

Spatial heterogeneity in terms of contamination levels as well as the expressions of phytotoxicity within vegetation communities is apparent along the Clark Fork River. It is the goal of the CFR RipES system to be able to precisely and accurately score polygons in Reach A of the Clark Fork River. Precision is the ability of trained and experienced field personnel to repeatedly score a polygon with a variation in the overall score of less than ± 5 percent at the threshold value(s). The goal for bias is also ± 5 percent at the threshold value(s). Accuracy of arsenic and copper determinations will be determined by analyzing standard reference materials, field replicates, and field blanks inserted into the sample queue at a five percent rate.

Step 7. Optimize the Design – The data collection design specified in the field scoring was optimized during the field validation and calibration portion of this work in the late fall of 2002 and summer of 2003. One aspect of CFR RipES that optimizes the design is its capability for incorporating new analytical data into the scoring system as such data become available. The system utilizes previously collected data in the evaluation process to eliminate redundancy of data collection. Finally, the system increases field worker efficiency with the pre-assessment preparation. This preparation part of the system gives field personnel available information, pertinent to the field survey, on and attached to aerial photographs of sites for CFR RipES evaluation (refer to Section 13.6.1.1 of the *Record of Decision*).

Data Measurement Objectives

The field Quality Assurance program was designed in accordance with EPA's Guidance for the Data Quality Objectives Process (EPA 1994, 1998c).

Precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters are indicators of data quality. PARCC goals were established for the calibration and validation of the CFR RipES system as part of the Sampling and Analysis Plan (RRU and BRI 2003a). The Data Summary Report (RRU and BRI 2003b) provides detailed results of the following QA/QC assessments:

Precision – Field duplicate samples, for the determination of pH and total copper and arsenic, were collected to provide a measure of the contribution to overall variability of field-related sources. Contribution of laboratory-related sources to overall variability is measured through various laboratory Quality Control samples, specifically XRF laboratory duplicates and laboratory splits. The acceptable RPD limits for field duplicates are less than 35 percent for soil. Chemical analytical data were validated for precision using field duplicates, and laboratory duplicates and splits. Acceptance windows for XRF precision are functions of both the analyte and the concentration. These are defined in the XRF LAP document (Ashe 1995). See Data Summary Report (RRU and BRI 2003b) for results.

Accuracy – Accuracy is the degree of agreement of a measurement with an accepted reference or true value, and is a measure of the bias in a system. Accuracy of this program was based on the results of National Institute of Standards and Technology Standard Reference Material samples inserted into the sample stream at the rate of 5 percent. Laboratory accuracy was based on the results of LCS analysis.

The detection limits specified in the XRF LAP (Ashe 1995) were sufficient to meet the needs of this project for each element (copper and arsenic) of interest. Refer to the Sampling and Analysis Plan and the Data Summary Report (RRU and BRI 2003a, 2003b).

Representativeness— This parameter was achieved through: a) careful, informed selection of sampling sites within each polygon, b) selection of testing parameters and methods that adequately define and characterize the extent of possible contamination and meet the required parameter reporting limits, c) proper gathering and handling of samples to avoid interference and prevent contamination and loss, and d) collection of a sufficient number of samples to allow for polygon characterization. It is acknowledged that defining the spatial distribution of the contaminants within a CFR RipES polygon is a very difficult task. The intent of the CFR RipES system validation sampling and analysis effort was to gain some additional conceptual understanding of the depth of contamination and the horizontal variation. These data will be most useful in determining sampling schemes that might be used during full-scale remedial design.

Completeness— Completeness is a measure of the amount of usable data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. Those data that are validated and need no qualification (CFR Enforcement Quality Data), or are qualified as estimated data (CFR Screening Quality Data), are considered usable. Rejected data are not considered usable. Completeness was calculated following data evaluation (refer to Data Summary Report (RRU and BRI 2003b)). For the validation of CFR RipES, the completeness goal of 90 percent was exceeded for total copper and arsenic, as well as field pH determinations. The goal for XRF copper and arsenic data is enforcement quality data was also met (RRU and BRI 2003b).

Comparability— Consistency in the acquisition, handling, and analysis of samples is necessary for comparing results. Where appropriate, the results of analyses obtained can be compared with the results obtained in previous CFR *Remedial Investigation* studies. Standard US EPA analytical methods and QC, as well as those specified in the CFR SSI documents were used to ensure comparability of results with other analyses performed in a similar manner.

The Data Quality Assessments process (EPA 1998c) was used to evaluate the generated data in terms of meeting the stated Data Quality Objectives and in terms of meeting the measurement goals for accuracy, precision, representativeness, completeness, and comparability (refer to Data Summary Report).

CFR RipES Structure

Areas within the Upper Clark Fork River floodplain are classified for purposes of determining specific remedial actions based on landscape stability, contamination, and plant community dysfunction. Of first concern are those areas most in jeopardy of being eroded into the river channel. The CFR OU is divided into smaller units of land, called *polygons*, delineated and classified as candidates for the various kinds of remediation as described in the *Record of Decision*.

Four major types of site are defined below for the purpose of identifying areas for the various remedial actions:

1. Streambank and riparian corridor buffer;
2. Slicken areas (exposed tailings);
3. Impacted soils and vegetation areas; and
4. Slightly impacted soils and vegetation areas.

Other miscellaneous site types are also identified (i.e., irrigation ditches, contaminated upland areas, tributary streams, etc.). Remedial actions for these miscellaneous site types are discussed in Part 2, Section 13.6.1 of the *Record of Decision*. Characteristics of the major types of sites and remedial actions for each type are provided below.

Streambank and Riparian Corridor Buffer

The streambank and riparian corridor buffer is a zone of approximately 50 feet in width on each side of the river that may vary in width, depending on site specific conditions. For example, a severely eroding outer streambank may require more than 50 feet while on inside banks with point bars and along straight reaches of the stream where the erosive forces are minimal, the corridor may be less.

The streambank and riparian corridor buffer is delineated by measuring from the “bankfull” stage on each side of the stream out a flexible or variable distance (see preceding paragraph) **OR** where the historic 100-year floodplain elevation is reached. In other words, areas outside the historic 100-year floodplain are not included in the streambank and riparian corridor buffer. In cases where high banks are reached, the buffer will be narrower. Bankfull flow for the Clark Fork River at Deer Lodge has been calculated to be about 1,900 cfs (Griffin and Smith 2001). This equates to approximately a 7-year flood event. At this stage, the flow begins to spill out of the channel and disperse onto the floodplain.

The approximate 50 foot streambank and riparian corridor buffer zone on each side of the river will be broken into preliminary polygons based on live vegetative canopy cover, canopy cover of deep, binding, woody vegetation, and/or lengths of streambank erosion. The minimum mapping unit of these polygons is 20 linear feet of streambank with a maximum length of 500 feet. Polygon units will not cross land-ownership boundaries. These polygon units will be scored using the CFR RipES Field Form for Streambank and Riparian Corridor Buffer Polygons, thereby classifying streambanks into one of three categories designated as Class 1, 2, or 3 streambanks.

Streambank Categories

Class 1 streambanks – Phytotoxic conditions exist as demonstrated by an inability of the active channel areas to support and sustain significant amounts of woody and herbaceous vegetation. Streambanks are actively eroding and are significant contributors of contaminant release to the river (Fig. 1 and 2). Remedial actions for this class include removal of phytotoxic materials and revegetation with deep, binding, woody vegetation. These actions will be implemented from a line at the lateral extent of inundation at bankfull stage out to approximately 50 feet from that line. Specific actions at a Class 1 Streambank will be determined in accordance with *Record of Decision* specifications and after consideration of design factors. Design factors include: depth of removal (this is not necessarily the same as depth of contamination), depth to the water surface, depth to groundwater, current streambank stability, current vegetation status, infrastructure (bridges, culverts, etc.), surface drainage, future land use, BMPs, and others.

Class 2 streambanks – These streambanks demonstrate some current woody and herbaceous vegetation, but are contaminated, unstable, and eroding (Fig. 3 and 4). Remedial actions for this class include supplemental revegetation and planting of deep, binding, woody vegetation. Reconfiguration of the streambanks may require minor removal or *in-situ* treatment. Design factors include current streambank stability, current vegetation status, infrastructure, surface drainage, future land use, BMPs, and others.

Class 3 streambanks – These streambanks are contaminated but they may have varying amounts of deep, binding, woody vegetation holding the streambank in place (Fig. 5 and 6). Remedial actions

possible for these areas include no action or minor actions to enhance woody vegetation within the buffer corridor and/or BMPs. Design factors are: current vegetation status, current streambank stability, knowledge of underlying contamination, and current and future land use.



Figure 1. Typical Clark Fork River Class 1 streambank

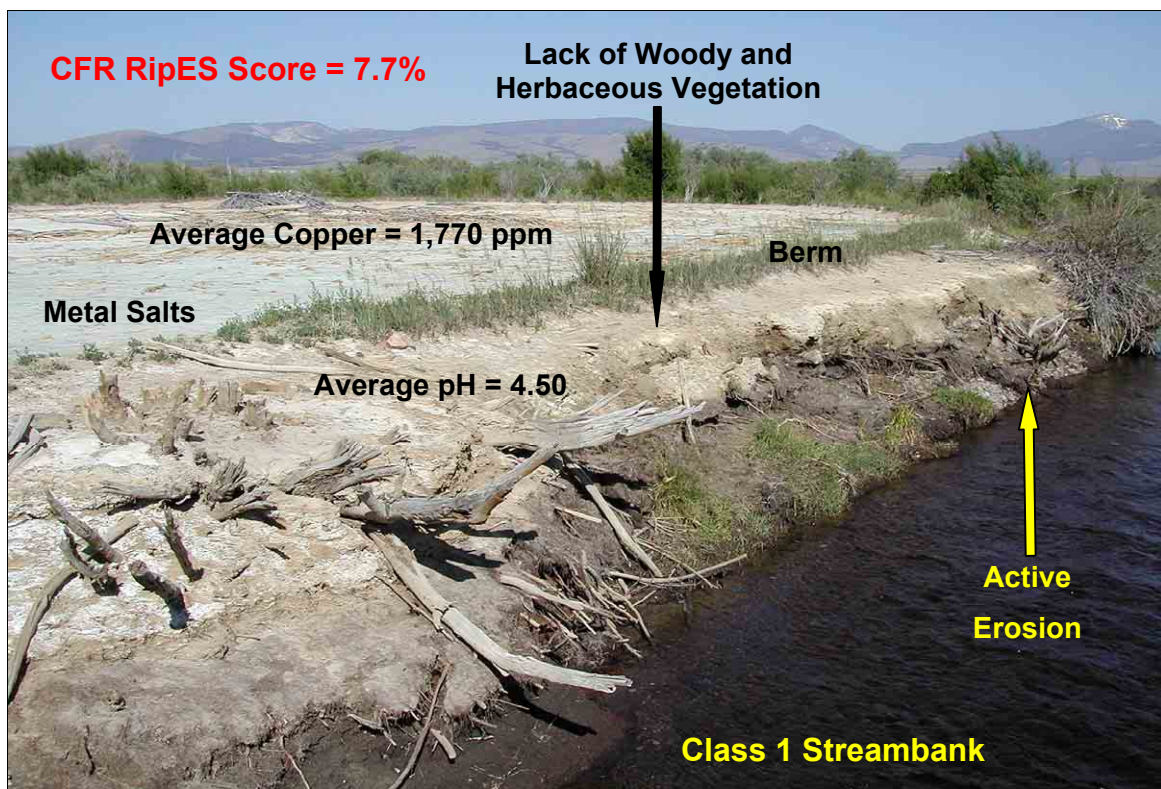


Figure 2. Clark Fork River Class 1 streambank adjacent to a slickens area (exposed tailings)



Figure 3. Typical Clark Fork River Class 2 streambank

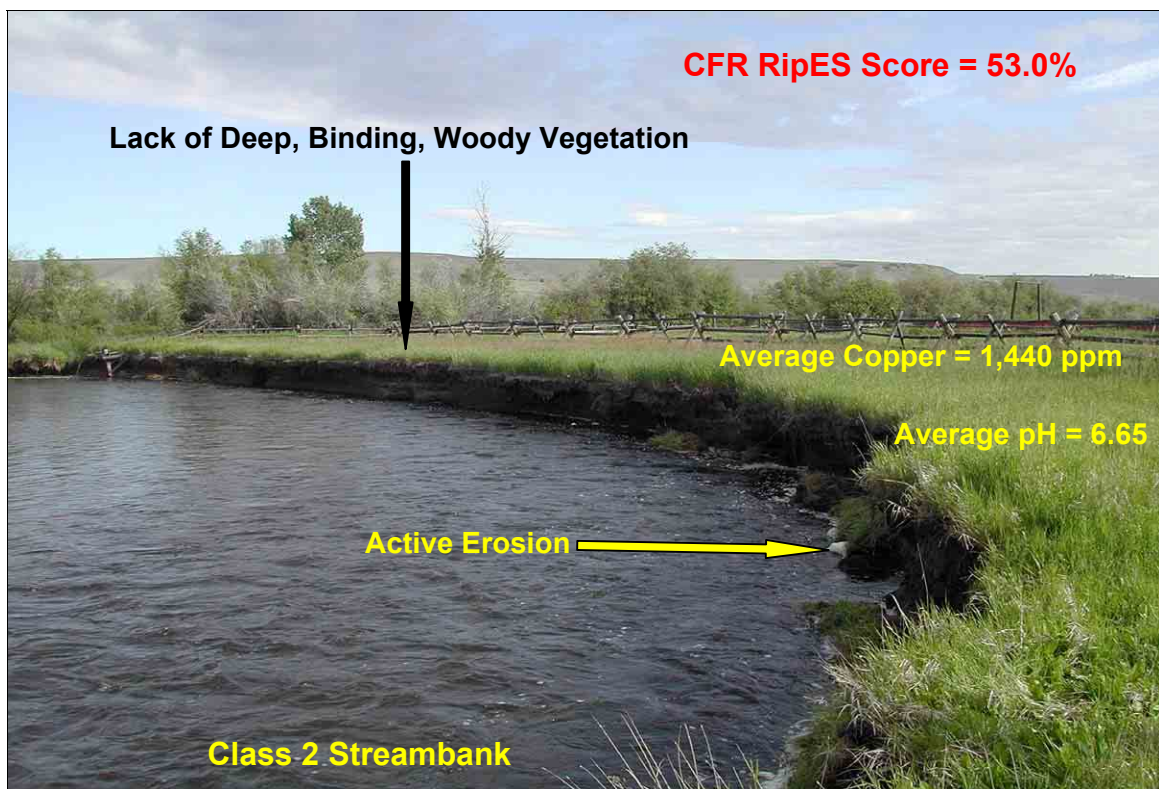


Figure 4. Highly eroding Clark Fork River Class 2 streambank



Figure 5. Well-vegetated, stable Clark Fork River Class 3 streambanks

CFR RipES Score = 100%

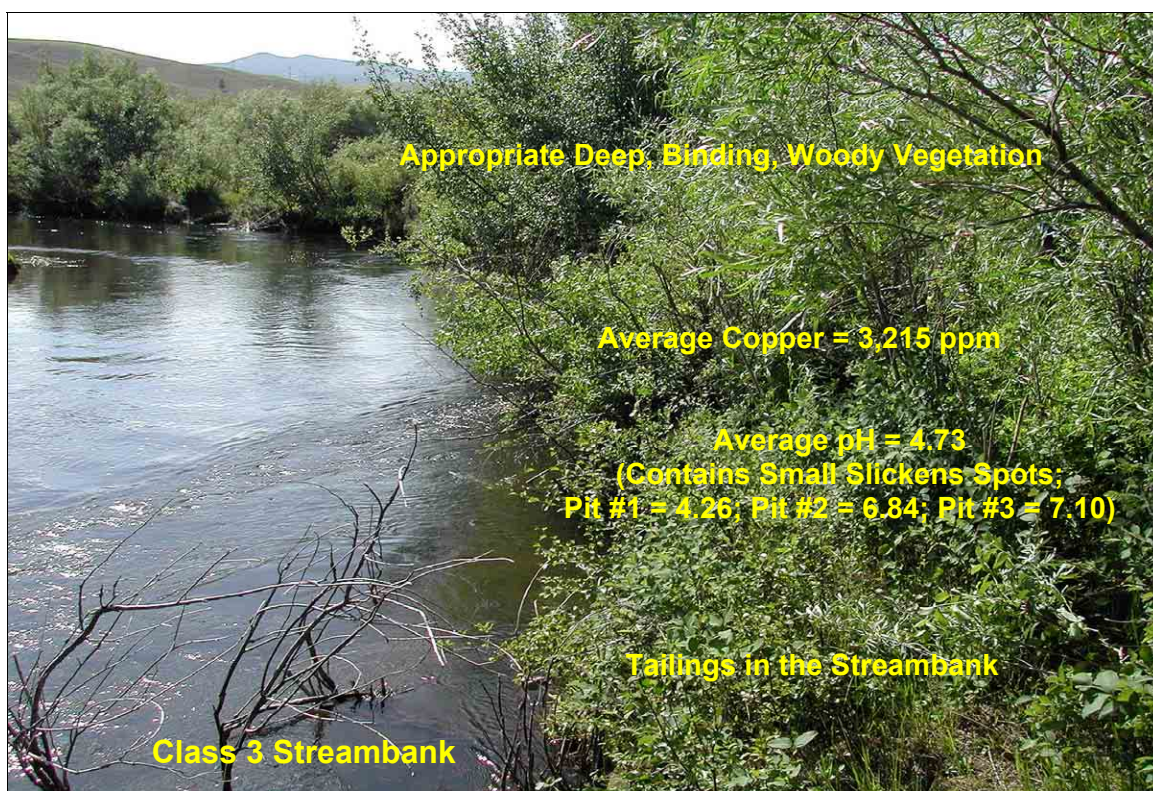


Figure 6. Clark Fork River Class 3 streambank with visible tailings and appropriate deep, binding, woody vegetation

Special Cases

Streambank and riparian corridor buffer polygons will be delineated for evaluation and classification for appropriate remedial actions on sites beyond the main channel of the Clark Fork River within the OU. These are tributary streams and secondary channels of the Clark Fork River.

Tributary streams – Tributaries within the CFR OU (e.g., Lost Creek, Warm Springs Creek, Dutchman Creek, Racetrack Creek, Cottonwood Creek, and others) may have transported contaminants from other NPL sites in the basin, or may have been contaminated during depositional flood events from the Clark Fork River. Tributaries having perennial flow will be protected with a streambank buffer 25 feet wide within the CFR OU, unless this width extends outside the historic 100-year floodplain of the Clark Fork River.

Secondary channels of the Clark Fork River – Also of concern are secondary channels forming islands on the Clark Fork River floodplain. Secondary channels with perennial flow throughout their length and having connection to the main channel of the river at both ends will also be protected with a flexible or variable streambank and riparian corridor buffer of 25 ft, unless this width extends outside the historic 100-year floodplain of the Clark Fork River.

Historic 100-Year Floodplain Contaminated Soils

Contaminated soils within the historic 100-year floodplain may consist of:

- Slickens (exposed tailings);
- Impacted soils and vegetation; and
- Slightly impacted soils and vegetation.

Slickens (exposed tailings) – These areas generally lack vegetation and present a principal waste in the Clark Fork River OU, along with Class 1 Streambanks. Estimated in the RI/FS at about 167 acres, but possibly up to 250 acres, in Reach A. These slickens areas are contamination-caused, mostly-bare ground. Scattered throughout Reach A, the areas number in the hundreds, are usually a fraction of an acre in size, and are too toxic to support most vegetation or soil organisms. These areas are usually easy to recognize. Remedial action for most of these areas is removal, except as described below. Removal of slickens areas adjacent to an active channel is part of the streambank remedial action.

Slickens (exposed tailings) (Fig. 7, 8, 9, 10, and 11), are characterized as follows:

1. Because of phytotoxic condition, these areas are generally devoid of vegetation, supporting less than 25 percent live plant canopy cover.
2. Tufted hairgrass (*Deschampsia cespitosa*) is present, if there is any live vegetation (See Appendix A for a discussion of the special indicator value of this species).
3. Efflorescent metal salts are visible on the soil surface during dry periods.

Slickens (exposed tailings) and underlying contaminated soil which meet these criteria will be removed, with a limited exception. For the exception to occur, all of the following criteria as defined by CFR RipES must be met:

- The slickens area is small - less than 400 square feet;
- The contamination is less than 2 feet deep;
- The contamination is widely dispersed or separated by vegetation;
- The contamination is contiguous with impacted soils and vegetation areas that will be treated in place; and
- The area is not too wet or otherwise unable to be treated effectively.

Slickens that are less than 400 square feet and less than 2 feet in depth and not too wet will be treated *in-situ* if they are next to or contained within an impacted soils and vegetation area that is designated to be treated *in-situ*. These small slickens within or next to areas to be treated *in-situ* will be removed if they are thicker than 2 feet or too wet to treat.

Isolated, small slickens areas (less than 400 square feet) that are not contiguous with impacted soils and vegetation areas will not be removed in most cases. These areas are too small to bring in removal equipment without significant destruction of the surrounding unimpacted areas. *In-situ* treatment will be done in these areas where practicable. These areas will also not be mapped under the CFR RipES protocols.

Often there will be areas of slickens interspersed with areas of woody vegetation. On sites that will receive remedial treatment by removal of contaminated soil or of *in-situ* treatment, some woody plants will necessarily be affected. The desired option is to leave as many as possible of certain “preferred woody plant species” in place that are already growing on the floodplain within the CFR OU. This will be accomplished by working around them whenever practicable and whenever the overall goals of the project can still be achieved by doing so. Woody vegetation patches within a large general area of slickens area can often be separated as smaller polygons of more healthy vegetation from the more severe slickens area polygons.

When a decision must be made whether to remove or keep a particular shrub or patch of shrubs in question, the dichotomous key provided in Appendix B will serve as the logical matrix.



Figure 7. Clark Fork River slickens area (exposed tailings)

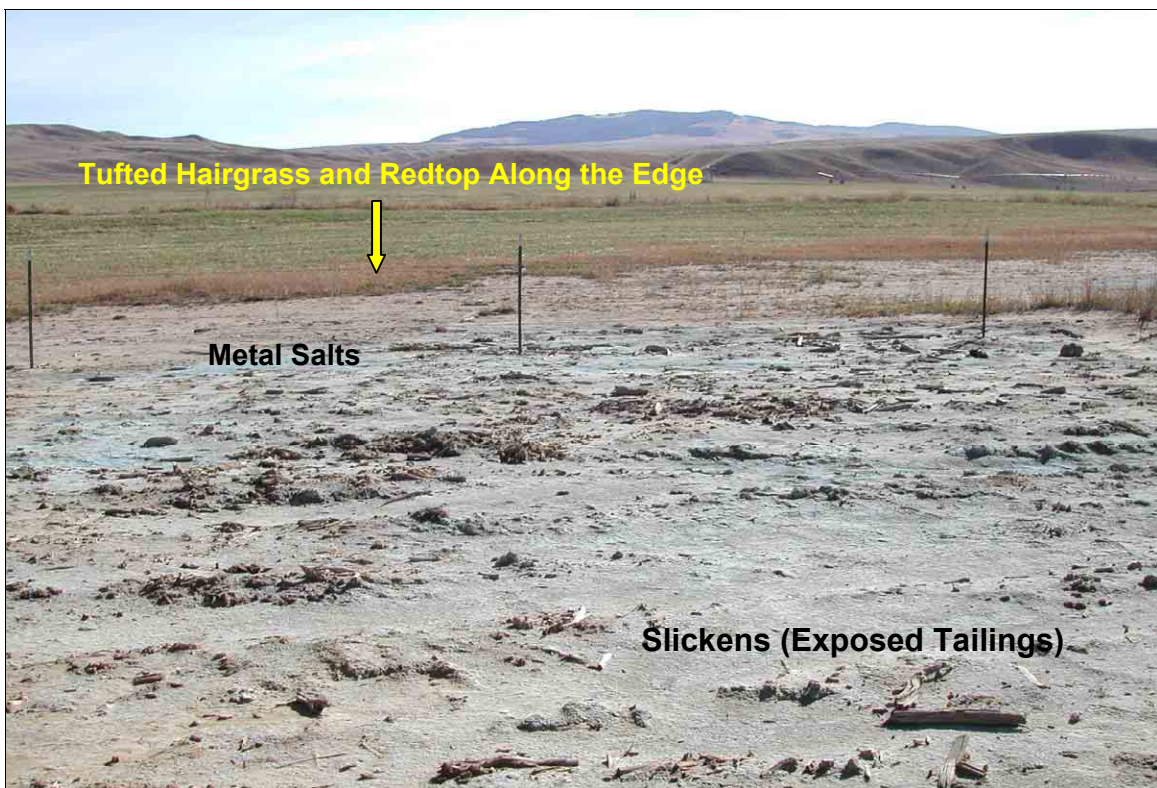


Figure 8. Clark Fork River slickens (exposed tailings) surrounded by pioneer species such as tufted hairgrass (*Deschampsia cespitosa*) and redtop (*Agrostis stolonifera*)



Figure 9. Clark Fork River slickens (exposed tailings) showing metal salts on the soil surface following a dry period

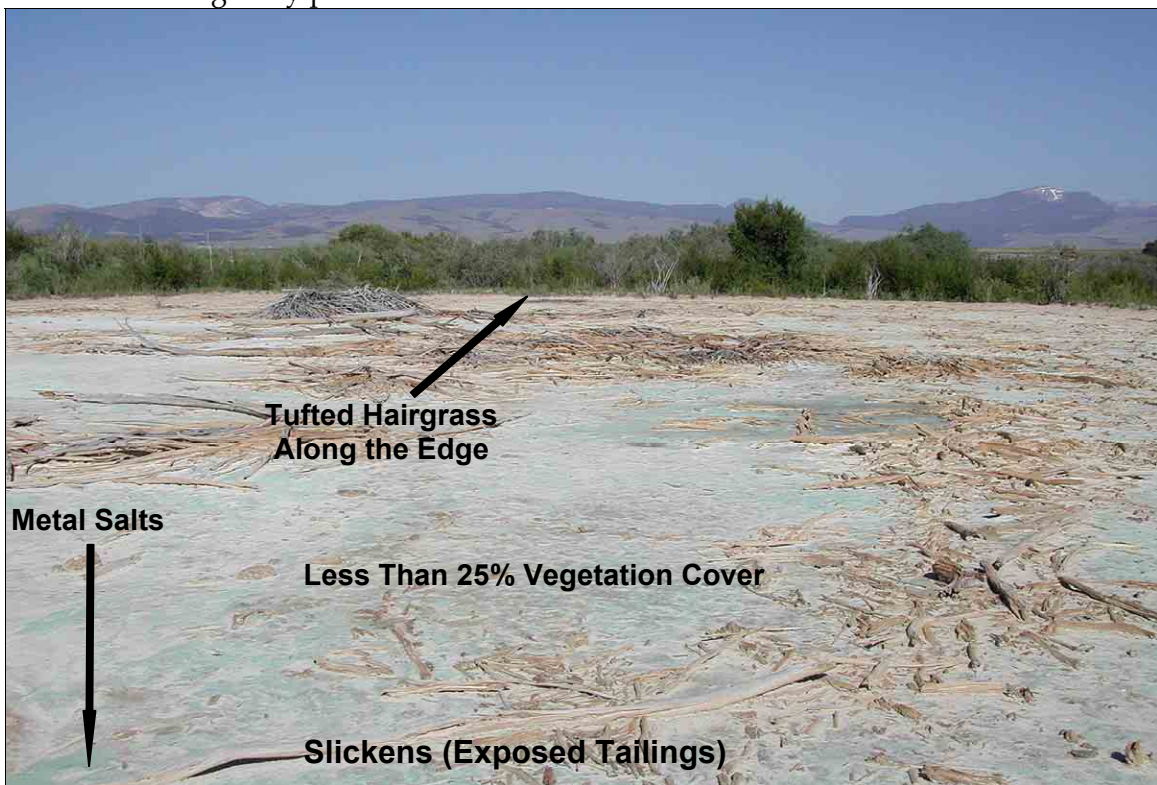


Figure 10. Clark Fork River slickens area (exposed tailings) showing extensive areas of metal salts along with less than 25 percent vegetative canopy cover

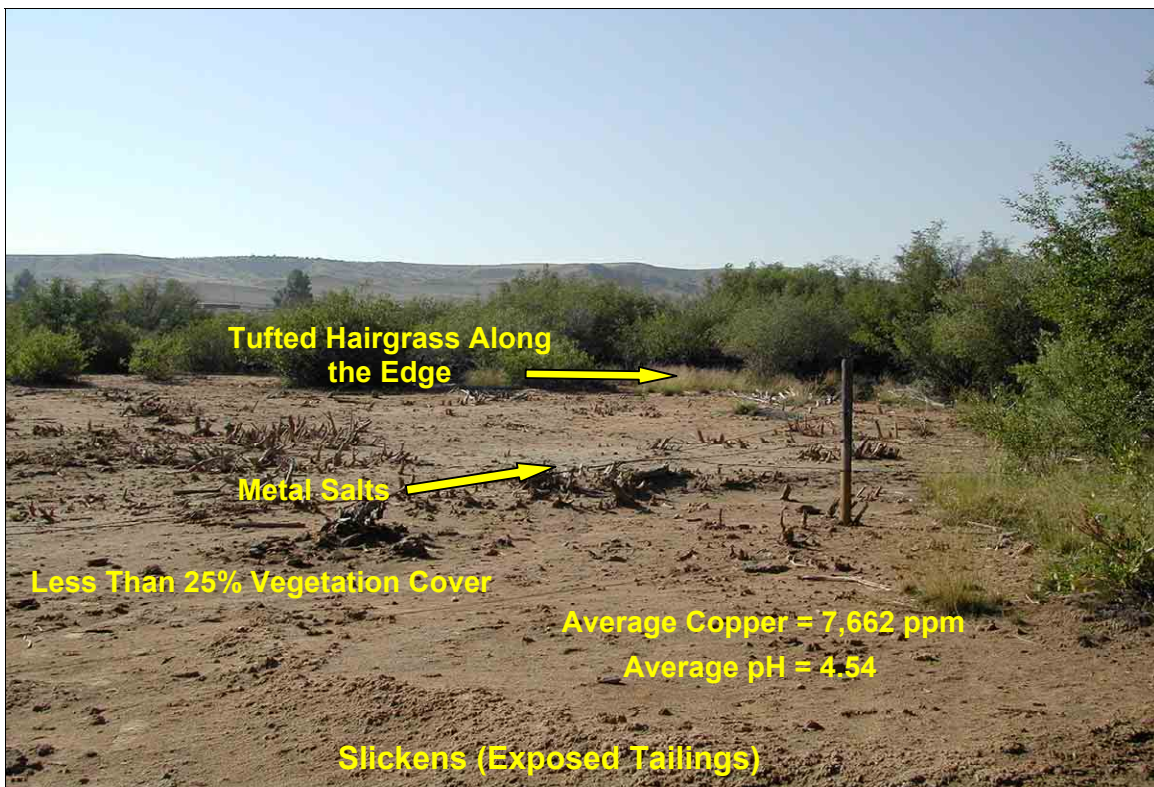


Figure 11. Clark Fork River slickens area (exposed tailings) showing some metal salts, less than 25 percent vegetative canopy cover, and tufted hairgrass (*Deschampsia cespitosa*) along the perimeter

Impacted soils and vegetation areas— These sparsely vegetated areas amount to everything between slickens and slightly impacted soils and vegetation areas (Fig. 12 and 13). Impacted soils and vegetation areas will generally be treated *in-situ*, unless the tailings and impacted soils in a given area extend more than 2 feet below ground surface. In that case, the tailings and impacted soils will be removed. Other impacted soils and vegetation areas that are too wet for implementation of *in-situ* treatment techniques will also be removed. Old river channels (oxbows) and wetlands will be evaluated using CFR RipES. If they have high quality vegetation and score 75 percent or more on CFR RipES, they will not be remediated. If they have impacted vegetation and soils, and the contaminated tailings and soils are deeper than 2 feet, or the soil is too wet; they will be removed and replaced in a manner that re-establishes a productive and healthy wetland. If the tailings and contaminated soils are less than 2 feet deep in an old oxbow channel, and it is not too wet, the area will be treated *in-situ*.

Impacted soils and vegetation areas are characterized as follows:

1. The degree of phytotoxicity in these areas is quite variable, but they do sustain at least 25 percent live plant canopy cover.
2. Tufted hairgrass (*Deschampsia cespitosa*) has greater than 1 percent canopy cover.
3. Efflorescent metal salts may be visible on the soil surface during dry periods.
4. Small, individual areas of exposed tailings (that appear as small slickens) may be present.
5. Concentrations of COCs within the soil profile exceed the geometric mean values for unimpacted soils for Reach A of the CFR OU. Copper is used as a surrogate for the COCs; soils with copper concentrations exceeding 300 ppm within the profile are considered impacted by mining-related activities.
6. The minimum polygon size is 400 square feet.

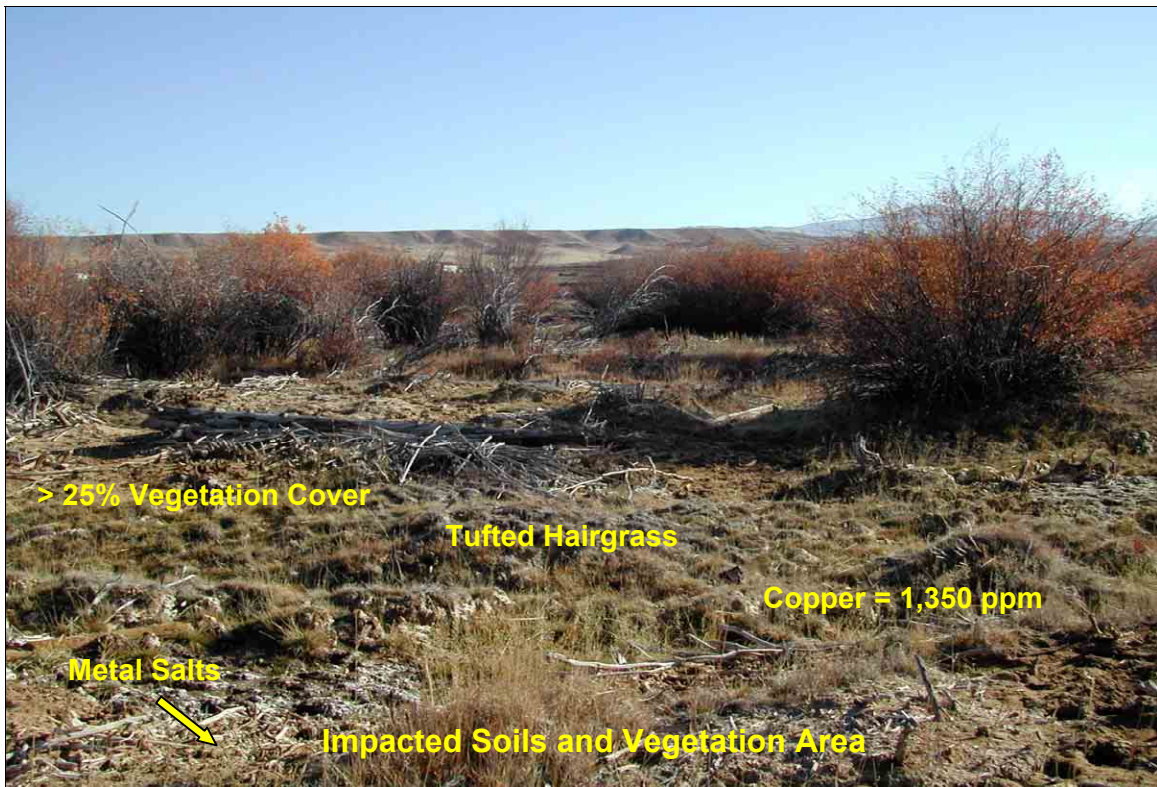


Figure 12. Example of a Clark Fork River impacted soils and vegetation area

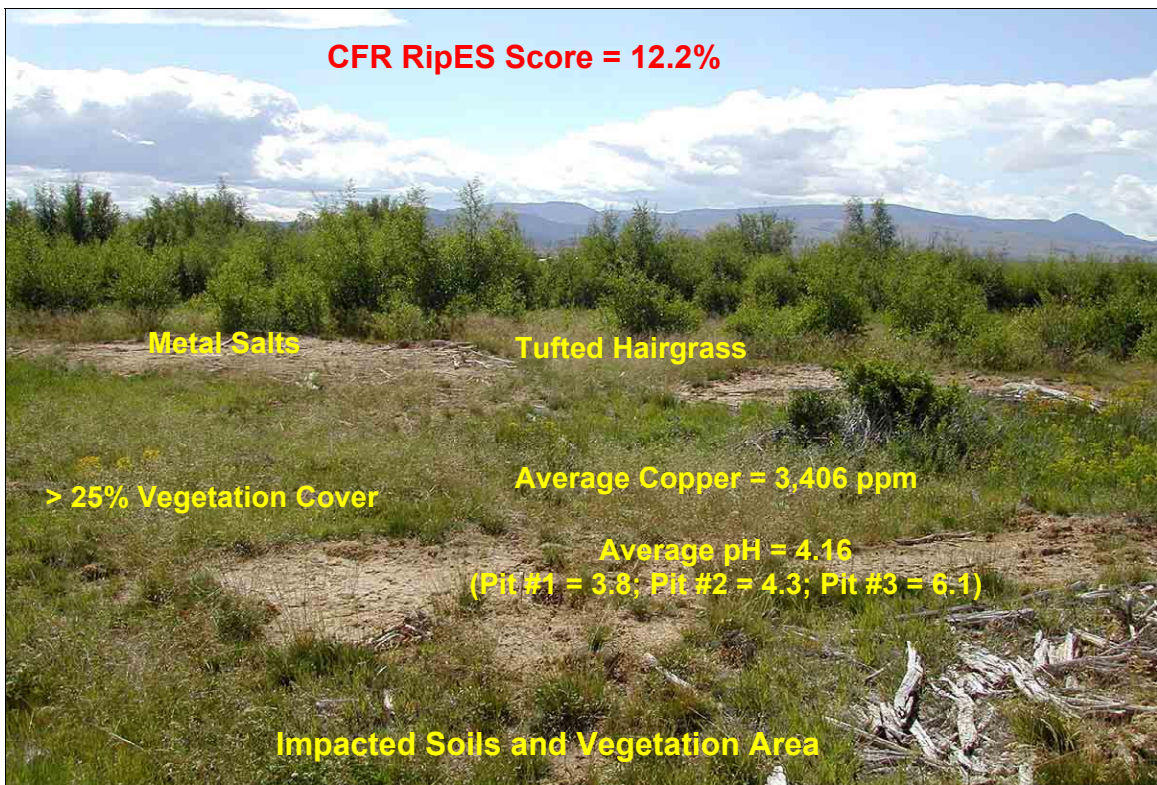


Figure 13. Example of a Clark Fork River impacted soils and vegetation area in foreground surrounded by a stand of water birch (*Betula occidentalis*) and willows

Slightly impacted soils and vegetation areas— These areas do not meet the characteristics or definitions of streambank and riparian corridor buffer, slickens (exposed tailings), or impacted soils and vegetation area. They are generally well vegetated and display no visible evidence of contamination from tailings, although the soil may contain copper contamination above 300 ppm (Fig. 14 and 15). Remedial actions for these areas are no action, or BMPs and ICs.

Slightly impacted soils and vegetation areas characterized as follows:

1. The area expresses no evidence of phytotoxicity and has less than 1 percent bare ground caused by contaminated tailings.
2. Tufted hairgrass (*Deschampsia cespitosa*) has less than 1 percent canopy cover.
3. No efflorescent metal salts are visible on the soil surface during dry periods.
4. Concentrations of COCs within the soil profile exceed the geometric mean values for unimpacted soils for Reach A of the CFR OU. Copper is used as a surrogate for the COCs; soils with copper concentrations exceeding 300 ppm within the profile are considered impacted by mining-related activities.

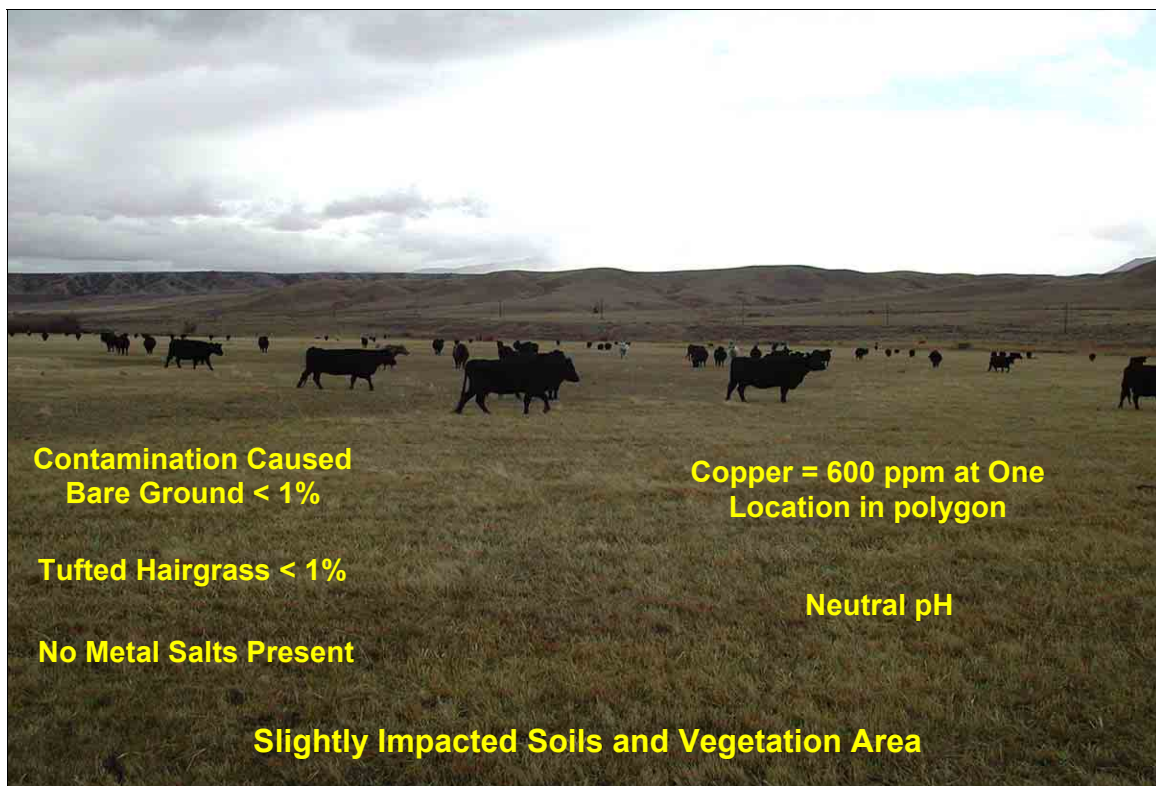


Figure 14. Example of a Clark Fork River slightly impacted soils and vegetation area used as a cattle pasture

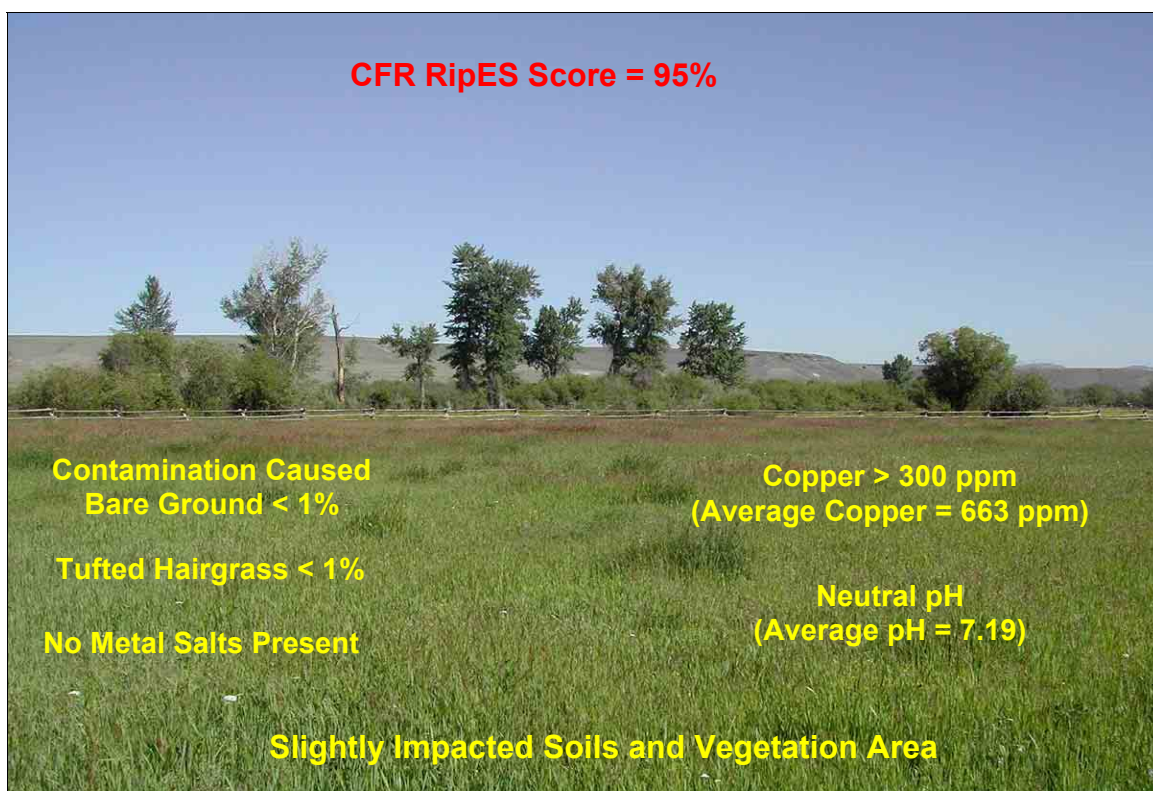


Figure 15. Hay meadow containing a Clark Fork River slightly impacted soils and vegetation area

CFR RipES Application

The characterizations of contaminated soils above will account for the majority of land within the CFR OU that is to be considered for remedy. (CFR RipES is not applicable to the historically irrigated upland areas. Historically irrigated lands will be evaluated for human health risks and remediated if necessary.) After a polygon has been delineated using the delineation criteria described above, application of the flow-chart keys in Figures 16, 17, and 18 will provide the correct classification, and Table 1 will indicate the correct subset of remedial actions from which to draw the remedial design. Also refer to Part 2 Section 13.6 of the *Record of Decision*.

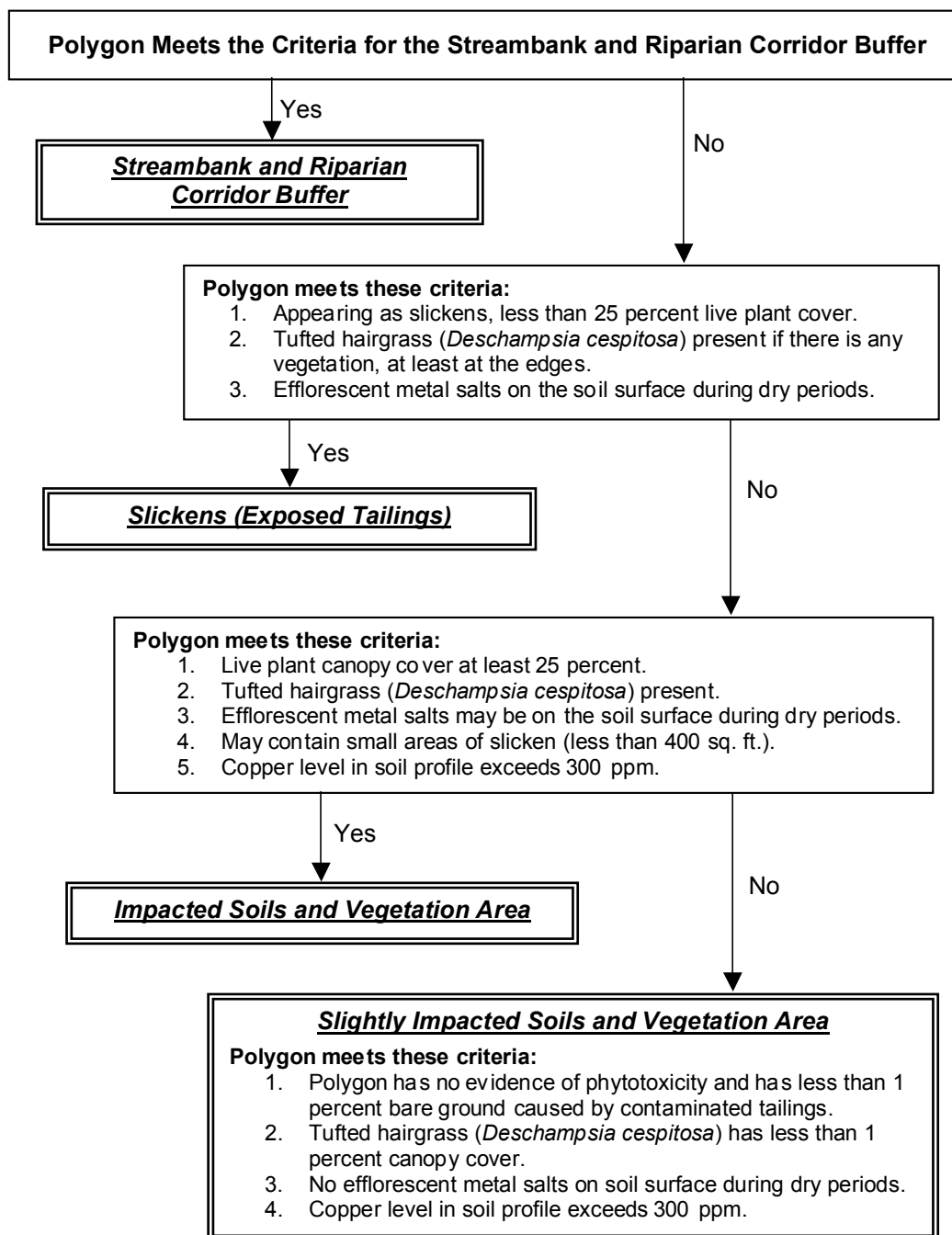


Figure 16. Generalized key for categorizing CFR RipES polygons

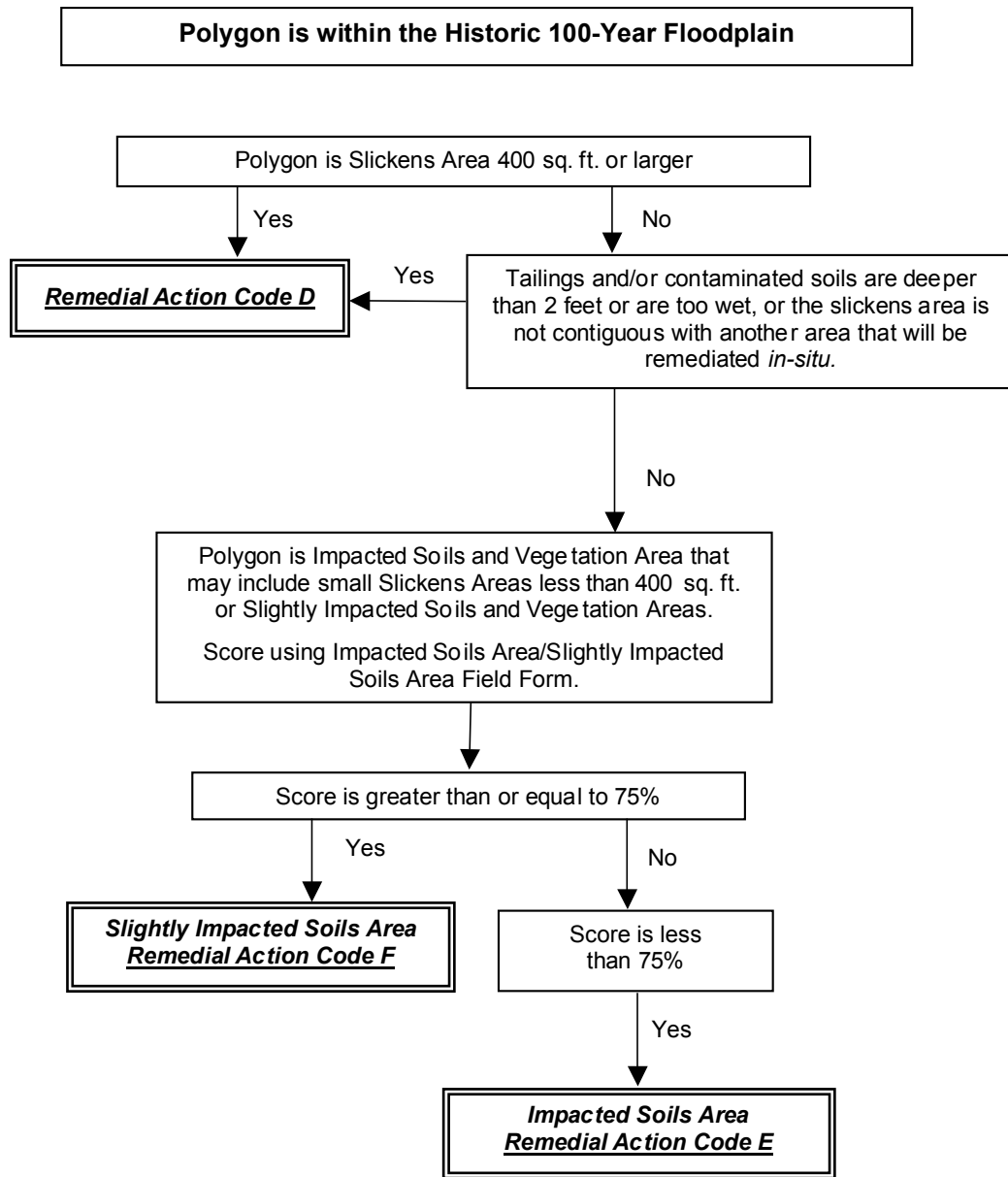


Figure 17. Polygon characterization within the historic 100-year floodplain

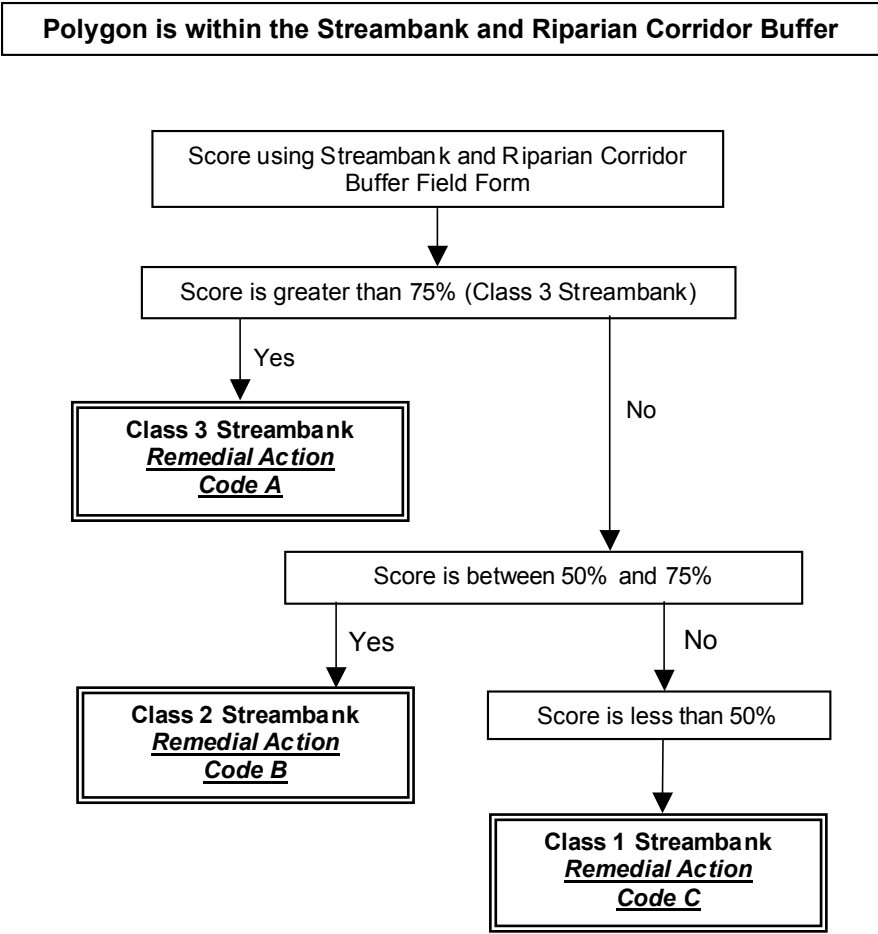


Figure 18. CFR RipES polygon characterization for streambank and riparian corridor buffer polygons

Table 1. Preliminary remedial action (RA) codes for major CFR RipES polygon categories

CFR RipES Polygon Category	RA Code	Preliminary Remedial Action Recommendations ¹
Class 3 Streambank	A	Remedial actions include no action or minor actions to enhance vegetation within the buffer corridor and/or BMPs.
Class 2 Streambank	B	Polygons with Class 2 streambanks will receive remedial actions intended to secure streambank stability through establishment of appropriate deep, binding, woody vegetation. Remedial actions may include reconfiguration of the banks, minor removal/ replacement and/or in-place treatment of contaminated materials, followed by supplemental planting of deep, binding, woody vegetation and revegetation with appropriate herbaceous species and BMPs.
Class 1 Streambank	C	Class 1 streambanks will receive treatment(s) chosen from a set of remedial actions depending upon site-specific characteristics. Remedial actions for this class include removal of phytotoxic materials and revegetation with deep, binding, woody vegetation and an understory of appropriate herbaceous species. BMPs.
Slickens (Exposed Tailings)	D	Remedial action for most of these areas is removal, with the exception as noted previously. Removal of slickens areas adjacent to active channel are part of the streambank remedial actions. BMPs and ICs.
Impacted Soils and Vegetation Areas	E	Impacted soils and vegetation areas will generally be treated <i>in-situ</i> , with two exceptions: 1) when the tailings and contaminated soils in a given area extend more than 2 feet below ground surface (In which case, all of the material will be removed.), and 2) when the tailings and contaminated soils are in a saturated condition which makes <i>in-situ</i> treatment impracticable (In which case, the contaminated material will be excavated). Old river channels in the floodplain will be addresses as described previously. BMPs and ICs.
Slightly Impacted Soils and Vegetation Areas	F	Remedial actions are no action, or BMPs.

¹Data gaps need to be identified in order to define remedial action(s) and to satisfy initial remedial design specifications. These may include pH, concentrations of COCs in the soil profile, depth to permanent groundwater level, thickness of contaminated materials, acid-base account, organic matter level, and others.

Miscellaneous Site Types

There are several landscape areas or features that may contain contaminated materials by having one of the following:

1. Conveyed contaminated waters, i.e., drainage ditches;
2. Contaminated through historical irrigation, i.e., current or abandoned ditches; and
3. Subsequent separation of the historic 100-year floodplain from the present FEMA 100-year floodplain by human structures such as highways and railroads.

These areas, with the exception of historically irrigated fields (which will be evaluated under the human health component), are to be considered in the remedial design. If this consideration shows soil contamination above action levels or impacted soils and vegetation communities, appropriate remediation will be designed for these areas.

These miscellaneous site types are further defined as:

1. Old river channels and oxbows that may be well vegetated, but may have thick deposits of buried contaminated tailings in contact with ground water. (These sites do not meet the criteria for slickens or impacted soils and vegetation areas as defined in this document.)
2. Irrigation ditches, drainage ditches, and canals that may have conveyed contaminated waters and sediment. Irrigation ditches that conveyed historically contaminated water will be sampled through a representative sampling program to be developed to ensure that contaminate concentrations do not cause unacceptable risks to human health or the environment, as further described in Part 2, Section 13.8.3 of the *Record of Decision*.
3. Perennially or seasonally flooded wetlands that may contain contaminated sediment with hydrologic connectivity to groundwater and surface waters.
4. Contaminated areas that may be located within the historic floodplain, but outside the current Federal Emergency Management Agency (FEMA) defined floodplain. Some of these areas are separated from the main part of the floodplain by the Interstate 90, railroad berms, and other cultural structures.

These minor site types may contain much higher levels of contamination than adjacent areas because of particular historic circumstances. Removal, if feasible, will often be required. Therefore, these areas will be delineated as separate CFR RipES polygons, and evaluated accordingly for their potential need for remediation.

CFR RipES Process and Integration with Remedial Design

The CFR RipES process is to be applied to all lands within the historic 100-year floodplain of the Clark Fork River. The CFR RipES process is a critical detail design component which, for a specific landowner, involves a series of steps beginning with delineation of land ownership boundaries and noting areas having similar ecological attributes on aerial photographs, and ends by delineating specific locations of slickens, impacted soils and vegetation, slightly impacted soils and vegetation and classification of Class 1, 2, and 3 streambanks. While at the property, additional design data and information will also be collected necessary to complete remedial design. It is envisioned that during remedial design, coordinated teams of ecologists and engineers will work together, with the ecologists scoring polygons and engineers surveying the polygons and both working to produce GIS maps of the landscape, and collecting samples and other required design data and information for analyses. The general remedial design data gathering process is as follows:

1. Delineate existing land ownership boundaries, irrigation ditches, and fence lines on aerial photographs.
2. Delineate preliminary polygons on aerial photography for the following soil categories (minimum mapping unit size is 400 ft²) (Note: this must account for 100 percent of the property that lies within the historic 100-year floodplain.):
 - a) Slickens (exposed tailings);
 - b) Impacted soils and vegetation areas; and
 - c) Slightly impacted soils and vegetation areas.
3. Delineate a preliminary approximately 50 foot streambank and riparian corridor buffer zone on aerial photographs along both sides of the streambank. The buffer zone extends back

approximately 50 foot from the bankfull stage on each side of the river. The actual width of the approximately 50 foot buffer zone is a function of the geomorphic characteristics of the river. For example, in those instances where the river abuts a high bank that is considered upland, the buffer zone width is reduced.

4. Conduct initial consultation with landowner about present and future management desires (e.g., grazing pasture versus alfalfa field) and any limitations to remedial design such as locations of temporary haul roads.
5. Obtain landowner approval to conduct CFR RipES of his/her property.
6. Conduct CFR RipES field reconnaissance, adjust preliminary polygon boundaries, and sample and collect data for scoring and classifying the following polygons:
 - a) Soils polygons (slickens, impacted soils and vegetation areas, and slightly impacted soils and vegetation areas); and
 - b) Streambank polygons (Class 1 Streambanks, Class 2 Streambanks, and Class 3 Streambanks).
7. Delineate the approximately 50 foot streambank and riparian corridor buffer zone into preliminary polygons based on live vegetative canopy cover and/or canopy cover of deep, binding, woody vegetation. There is a strong bias to leaving deep, binding, woody vegetation undisturbed. The minimum mapping unit of these polygons is 20 linear feet of streambank with a maximum length of 500 feet.
8. Delineate areas of deep, binding, woody vegetation outside the approximate 50 foot streambank and riparian corridor buffer zone. These represent areas where mature woody vegetation may be obtained and utilized as tipped over willows in streambank treatment types 3 and 4. There is a strong bias to leaving deep, binding, woody vegetation undisturbed.
9. Further subdivide (categorize) the streambank based on actively laterally cutting streambanks/critical shear stress areas. Assign a streambank treatment type to each subdivision. The minimum mapping unit length for this purpose is 10 linear feet of streambank. Data will be collected to determine the critical shear stresses associated with each streambank.
10. Conceptual streambank treatment designs were developed as examples for the Upper Clark Fork River and are described in Appendix B to the *Record of Decision*. The conceptual treatments are as follows:
 - a) No treatment necessary – This applies to streambanks where there is adequate deep, binding, woody vegetation already in place, and no additional work on the site is necessary.
 - b) Treatment 1 (vegetation augmentation) – This treatment requires augmenting existing deep, binding, woody vegetation with additional woody vegetation.
 - c) Treatment 2 – This treatment is for streambanks where low critical shear stresses are acting on the immediate streambank. This treatment involves the use of pre-vegetated coir roll-sod with a toe protection of fiber-rolls pre-vegetated with sandbar willow (*Salix exigua*).
 - d) Treatment 3 – This treatment is for streambanks where moderate critical shear stresses are acting on the immediate streambank. This treatment involves the use of pre-vegetated coir roll-sod with a toe protection of fiber-rolls pre-vegetated with sandbar willow (*Salix exigua*) on top of a rock roll. Also included is tipped over mature willow on a spacing that will depend on river morphology along the streambank to deflect and dissipate the energy of the stream.
 - e) Treatment 4 – This treatment is for streambanks where high critical shear stresses are acting on the immediate streambank. This treatment involves the use of pre-vegetated coir roll-sod with a toe protection of rock mattress. Also included is tipped over mature

willow on a spacing that will depend on river morphology along the streambank to deflect and dissipate the energy of the stream.

Other site-specific conditions may dictate design modifications.

11. Identify data needs to be filled to define remedial action(s) and to satisfy initial remedial design specifications. These may include pH, concentrations of COCs in the soil profile, depth to permanent groundwater level, thickness of contaminated materials, acid-base account, soil organic matter level, and others identified. Sampling will be conducted on the polygons to fulfill these gaps using a Sampling and Analysis Plan developed for the CFR OU. The intent is to sequence the CFR RipES scoring and sampling concurrently so that data are collected in an efficient manner and landowners disturbance is minimized.
12. Develop a preliminary design for the property. Components of Phase 1 preliminary design include the following:
 - Base map with layer displaying 1 foot contours;
 - Location of CFR RipES defined polygons for streambanks, slickens, impacted soils and vegetation areas, and slightly impacted soils and vegetation areas
 - Transportation corridors and existing roads;
 - Locations of temporary fences;
 - Locations of potential staging areas;
 - Locations of wetlands and irrigation and drainage ditches;
 - Locations of water access points for livestock;
 - Locations of temporary bridges;
 - Locations of vegetation that is to be removed during clearing and grubbing, and locations of salvageable vegetation that can be used during remediation; and
 - Other appropriate data and information.
13. Present preliminary remedial design and preliminary construction schedule for the property to the landowner including weed management plan, preliminary grazing management plan, BMPs, and ICs. Obtain landowner feedback.
14. Prepare revised design and preliminary construction schedule based on landowner feedback.
15. Submit to appropriate Agencies for review. Obtain agency's approval and then obtain landowner access for implementation.