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Clark Fork River Operable Unit

of the Milltown Reservoir/Clark Fork River Superfund Site

Record of Decision

Appendix A:

Identification and Description of Applicable or Relevant and Appropriate Requirements

U.S. Environmental Protection Agency
Region 8

10 West 15th Street
Suite 3200
Helena, Montana 59626

April 2004

List of Acronyms

ARAR	Applicable or Relevant and Appropriate Requirements
ATSDR	Agency for Toxic Substances and Disease Registry
BAT	Best Available Technology Economically Achievable
BCT	Best Conventional Pollutant Control Technology
BPCTCA	Best Practicable Control Technology Currently Available
BPJ	Best Professional Judgment
BTCA	Best Technology Currently Available
CCC	Criterion Continuous Concentration
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended
CFROU	Clark Fork River Operable Unit
CMC	Criteria Maximum Concentration
DEQ	State of Montana Department of Environmental Quality
EPA	U.S. Environmental Protection Agency
GRKO	Grant-Kohrs Ranch National Historic Site
HWM	Hazardous Waste Management
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MGWPCS	Montana Groundwater Pollution Control System
MPDES	Montana Pollutant Discharge Elimination System
NCP	National Contingency Plan, as amended
NESHAPS	National Emissions Standards for Hazardous Air Pollutants
NPL	National Priorities List
NPDES	National Pollutant Discharge Elimination System
POTW	Public Owned Treatment Works
PSD	Prevention of Significant Deterioration
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
RD/RA	Remedial Design and Remedial Action
ROD	Record of Decision
SHPO	State Historic Preservation Officer (Montana)
SIP	State Implementation Plan
TBC	To Be Considered
TU	Turbidity Unit
UIC	Underground Injection Control
WQB-7	Circular WQB-7, Montana Numeric Water Quality Standards

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Introduction

Section 121(d) of CERCLA, 42 U.S.C. § 9621(d), certain provisions of the current National Contingency Plan (the NCP), 40 CFR Part 300, and guidance and policy issued by the Environmental Protection Agency (EPA) require that remedial actions taken pursuant to Superfund authority shall require or achieve compliance with substantive provisions of applicable or relevant and appropriate standards, requirements, criteria, or limitations from state environmental and facility siting laws, and from federal environmental laws, at the completion of the remedial action, during the implementation of the remedial action, or both, depending on the nature of the requirements, unless a waiver is granted[1]. If contaminant or location specific ARARs are not being met before the commencement of a remedial action, it is not necessary to invoke a waiver to justify their non-attainment during the action although they must be obtained (or appropriately waived) for remedial action to be complete and the remedy to be successful[2]. These requirements are threshold standards that any selected remedy must meet, unless adequate basis for a waiver is present. See Section 121(d)(4) of CERCLA, 42 U.S.C. § 9621(d)(4); 40 CFR § 300.430(f)(1). EPA calls standards, requirements, criteria, or limitations identified pursuant to section 121(d) "ARARs," or applicable or relevant and appropriate requirements.

ARARs are either applicable or relevant and appropriate. Applicable requirements are those standards, requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, or contaminant, remedial action, location, or other circumstance found at a CERCLA site. 40 CFR § 300.5. Relevant and appropriate requirements are those standards, requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to hazardous substances, pollutants, contaminants, remedial actions, locations, or other circumstances found at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site such that their use is well suited to the particular site. Id. Factors which may be considered in making this determination are presented in 40 CFR 300.400(g)(2). Compliance with both applicable and relevant and appropriate requirements is mandatory, unless compliance is waived. 42 U.S.C. § 121(d)(4); 40 CFR 300.430(f)(1)(ii)(B).

Each ARAR or group of related ARARs identified here is followed by a specific statutory or regulatory citation, a classification describing whether the ARAR is applicable or relevant and appropriate, and a description which summarizes the requirements and addresses how and when compliance with the ARAR will be measured (some ARARs will govern the conduct of the remedial action, some will define the measure of success of the remedial action, and some will do both)[3]. The descriptions given here are provided to allow the user

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[1] See 55 Fed.Reg. 8666, 8755 (March 8, 1990)

[2] EPA CERCLA Compliance with Other Laws Manual 1-8 (OSWER 9234.1-01, August 1988)

[3] 40 CFR § 300.435(b)(2); Preamble to the Proposed NCP, 53 Fed.Reg. 51440 (December 21, 1988); Preamble to the Final NCP, 55 Fed.Reg. 8755-8757 (March 8, 1990)

a reasonable understanding of the requirements without having to refer constantly to the statute or regulation itself. However in the event of any inconsistency between the law or regulations and the summary provided in this document, the applicable or relevant and appropriate requirement is ultimately the requirement as set out in the law or regulation, rather than any paraphrase of the law provided here.

Also contained in this list are policies, guidance or other sources of information which are "to be considered" in the implementation of the Record of Decision (ROD). Although not enforceable requirements, these documents are important sources of information which EPA and the State of Montana Department of Environmental Quality (DEQ) may consider during implementation of the remedy, especially in regard to the evaluation of the remedy's success in addressing public health and environmental risks.

Finally, this list contains a non-exhaustive list of other legal provisions or requirements which should be complied with during the implementation of the ROD[4].

ARARs are divided into contaminant specific, location specific, and action specific requirements, as described in the NCP and EPA guidance. For contaminant specific ARARs, ARARs are listed according to the appropriate media.

Contaminant specific ARARs include those laws and regulations governing the release to the environment of materials possessing certain chemical or physical characteristics or containing specific chemical compounds. Contaminant specific ARARs generally set health or risk based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment. Location specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of cleanup activities because they are in specific locations. Location specific ARARs relate to the geographic or physical position of the site, rather than to the nature of site contaminants. Action specific ARARs are usually technology or activity based requirements or limitations on actions taken with respect to hazardous substances.

Only the substantive portions of the requirements are ARARs[5]. Administrative requirements are not ARARs and thus do not apply to actions conducted entirely on-site. Administrative requirements are those which involve consultation, issuance of permits, documentation, reporting, record keeping, and enforcement. The CERCLA program has its own set of administrative procedures which assure proper implementation of CERCLA. The application of additional or conflicting administrative requirements could result in delay or confusion[6]1-12. Provision of statutes or regulations which contain general goals that merely express legislative intent about desired outcomes or conditions but are non-binding are not ARARs.[7]

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[4] 40 CFR § 300.400(g)(3); 40 CFR § 300.515(h)(2); Preamble to the Final NCP, 55 Fed.Reg. 8744-8746 (March 8, 1990)

[5] 40 CFR § 300.5. See also Preamble to the Final NCP, 55 Fed.Reg. 8756-8757 (March 8, 1990)

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

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

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

This list constitutes EPA's and DEQ's detailed description of ARARs for use in the implementation of the Milltown Reservoir/Clark Fork River Superfund Site, Clark Fork River operable unit, and resulting remedial design and remedial action decisions. The determination of the applicability of ARAR waivers to certain previously identified ARARs is also included here. ARARs waivers can be invoked after the ROD is issued if necessary and appropriate, and these waivers will be documented separately.

The ARAR analysis is based on section 121(d) of CERCLA, 42 U.S.C. § 9621(d); CERCLA Compliance with Other Laws Manual, Volumes I and II; OSWER Directives 9234.1-01 and -02 (August 1988 and August 1989 respectively; various CERCLA ARARs Fact Sheets issued as OSWER Directives; the Preamble to the Proposed NCP, 53 Fed. Reg. 51394 et seq. (December 21, 1988); the Preamble to the Final NCP, 55 Fed. Reg. 8666-8813 (March 8, 1990); and the NCP, 40 CFR Part 300; other applicable guidances; and the substantive provisions of law discussed in this document.

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Federal ARARs

I. Federal Contaminant Specific Requirements

A. Groundwater Standards—Safe Drinking Water Act (Relevant and Appropriate) [1]

The National Primary Drinking Water Standards (40 CFR Part 141), better known as maximum contaminant levels and maximum contaminant level goals (MCLs and MCLGs), are not applicable to the Clark Fork River Operable Unit (CFROU) because the aquifer underlying the area is not a current public water system, as defined in the Safe Drinking Water Act, 42 U.S.C. § 300f(4). These standards are relevant and appropriate standards, however, because the groundwater in the alluvial aquifer is a potential source of drinking water. Some domestic use of ground water occurs in the CFROU at various depths, and there are not specific laws or regulations which prevent the use of the CFROU aquifers. In addition, the aquifer discharges to the Clark Fork River which is designated as a potential source of drinking water. Since the Clark Fork River is also a potential source of drinking water, these standards are relevant and appropriate for that surface water as well.

Use of these standards for this action is fully supported by EPA regulations and guidance. The Preamble to the NCP clearly states that MCLs are relevant and appropriate for groundwater that is a current or potential source of drinking water (55 Fed.Reg. 8750, March 8, 1990), and this determination is further supported by requirements in the regulations governing conduct of the RI/FS studies found at 40 CFR § 300.430(e)(2)(i)(B). EPA's guidance on Remedial Action for Contaminated Groundwater at Superfund Sites states that "MCLs developed under the Safe Drinking Water Act generally are ARARs for current or potential drinking water sources." MCLGs which are above zero are relevant and appropriate under the same conditions (55 Fed.Reg. 8750-8752, March 8, 1990). See also, State of Ohio v. EPA, 997 F.2d 1520 (D.C. Cir. 1993), which upholds EPA's application of MCLs and non-zero MCLGs as ARAR standards for groundwater which is a potential drinking water source.

As noted earlier, standards such as the MCL and MCLG standards are promulgated pursuant to both federal and state law. Under the Safe Drinking Water Act, EPA has granted the State of Montana primacy in implementation of the Safe Drinking Water Act. The State has promulgated its own public water supply ground water standards through the Public Water Safety Act for most contaminants of concern, primarily through incorporation by reference of the federal standard. These standards, when the same or more stringent than federal standards, are also identified here.

[1] 42 U.S.C. §§ 300f et seq.

Chemical	MCLG	MCL
Arsenic	NA	10 ug/l[2]
Cadmium	5 ug/l[3]	5 ug/l[4]
Copper	1300 ug/l[5]	1300 ug/l[6]
Lead	NA [7]	15 ug/l[8]

All ground water standards are measured as dissolved constituents. All are identified as Performance Standards in the CFROU ROD.

These standards incorporate potentially relevant and appropriate Resource Conversation Act (RCRA) standards for groundwater found at 40 CFR Part 264, Subpart F, which is incorporated pursuant to state law at ARM 17.53.801. The RCRA standards are the same or less stringent than the MCLs or MCLGs identified above.

B. Surface Water—Ambient and Point Source Discharges—Clean Water Act (Applicable or Relevant and Appropriate)

CERCLA and the NCP provide that federal water pollution criteria that match designated or anticipated surface water uses are the usual surface water standards to be used at Superfund cleanups, as relevant and appropriate standards, unless the state has promulgated surface water quality standards pursuant to the delegated state water quality act. The State of Montana has designated uses for the Clark Fork River, and has promulgated specific numeric water quality standards accordingly. Those standards as well as other surface water standards are included in the State ARARs identified in section IV.A.1. below. These standards will be applied to all contaminants of concern identified in the CFROU ROD, both to point sources affected or created by the CFROU ROD cleanup and to ambient water in CFROU, except for the State copper standard, which is waived in the CFR ROD and replaced with the federal copper water quality criteria. The FWQC standards for CFROU ROD designated contaminants of concern are identified here.

[2] 40 CFR §§ 141.11(b) and 141.62.

[3] 40 CFR § 141.51

[4] 40 CFR § 141.62

[5] 40 CFR § 141.51

[6] 40 CFR § 141.80(c)(2) The requirement is an action level rather than a simple numerical standard.

[7] The MCLG for arsenic and lead is zero, which is not an appropriate standard for Superfund site cleanups.

[8] 40 CFR § 141.80(c)(1). The requirement is an action level rather than a simple numerical standard.

Chemical	FWQC[9] CMC (acute)	FWQC CCC (chronic)
Arsenic	340 ug/l	150 ug/l
Cadmium	2.0 ug/l	0.25 ug/l
Copper	**13 ug/l**	**9.0 ug/l**
Lead	65 ug/l	2.5 ug/l
Zinc	120 ug/l	120 ug/l

As noted, the **bolded** copper standard above is the replacement standard for the waived state water quality standard, and is a Performance Standard for the CFROU ROD. Federal Water Quality Criteria are measured as dissolved constituents. The criteria assume a hardness of 100 ug/l, and the standards will likely be modified as applied to the CFROU surface waters which have a different hardness value.

Additionally, since the Clark Fork River is a potential drinking water source, the MCLs are relevant and appropriate requirements. The federal arsenic level of 10 ug/l, measured as a dissolved standard, sets the performance standard for surface water for the ROD.

C. Surface Water—Point Source Discharges—Stormwater Regulations—Clean Water Act (Applicable)

If point sources of water contamination from identifiable metals contamination are retained or created by any CFROU remediation activity, applicable Clean Water Act standards would apply to those discharges. These include the general requirements and storm water regulations found at 40 CFR Parts 122 and 125 (general conditions and industrial activity conditions). The storm water regulations address non-agricultural sources of storm water discharges which adversely affect water quality. Generally, the permits require the permittee to implement Best Management Practices (BMP) and to take all reasonable steps to minimize or prevent any discharge which has a reasonable likelihood of adversely affecting human health or the environment.[10] At the CFROU, it is likely that the actions required by the remedy would meet these requirements. However, if there is evidence indicating potential or realized impacts on water quality due to any storm water discharge associated with the activity, substantive standards associated with an individual National Pollutant Discharge Elimination System (NPDES) permit or alternative general permit may

[9] Pursuant to Section 304(a) of the Clean Water Act. National Recommended Water Quality Criteria-2002. US EPA, EPA 822-R-02-047 November 2002.

[10] For further explanation of storm water applications, see the letter from EPA to Chuck Stilwell, ARCO, dated February 2, 1999, which describes that treatment, in addition to BMPs, may be necessary if in-stream standards are not met after implementation of BMPs. The letter addresses the nearby Butte Priority Soils operable unit of the Silver Bow Creek/Butte Area Site but similar reasoning would apply to the CFROU.

be required (or Montana Pollutant Discharge Elimination System (MPDES) permit or alternative general permit under the State program).

D. Air Standards—Clean Air Act (Applicable)

Federal air quality standards are not currently exceeded in the CFROU. Limitations on air emissions resulting from cleanup activities or emissions resulting from wind erosion of exposed hazardous substances are set forth-in the action specific requirements, below.

II. Federal Location Specific Requirements

A. Fish and Wildlife Coordination Act (Applicable)

These standards are found at 16 U.S.C. §§ 661 et seq. and 40 CFR § 6.302(g). They require that federally funded or authorized projects ensure that any modification of any stream or other water body affected by a federally funded or authorized action provide for adequate protection of fish and wildlife resources. Compliance with this ARAR necessitates EPA consultation with the U.S. Fish and Wildlife Service (USFWS) and the State of Montana Department of Fish, Wildlife, and Parks. Consultation occurred during the selection of the CFROU remedy, and further consultation with these agencies will occur during cleanup implementation, and specific mitigative or other measures may be identified to achieve compliance with this ARAR, as the streambank remediation measures are implemented. The purpose of consultation is to develop measures to prevent, mitigate, or compensate for project-related losses to fish and wildlife. Mitigative measures must be performed by the persons who implement any selected remedy.

B. Floodplain Management Order (Applicable)

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

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

C. Protection of Wetlands Order (Applicable)

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

Compliance with this ARAR will be achieved through EPA consultation with the U.S. Fish and Wildlife Service, to determine the existence and category of wetlands present at the site, and any avoidance or mitigation and replacement which may be necessary. Avoidance, mitigation, or replacement activities will be done by the persons who implement any selected remedy. Avoidance or mitigation and replacement of wetlands is a specific requirement of the CFROU Selected Remedy and will be further examined and detailed during remedy implementation. In December 1994, ARCO published a report titled "Determination of Functionally Effective Wetland Area with Threatened/Endangered Species inventory." EPA also approved ARCO's August 1992 Evaluation Form for Determining Wetland Functional Value and Effective Wetland Area in Upper Clark Fork River superfund Sites for use in wetland evaluations. Additional information regarding wetlands is found in Appendix G-1 of the CFROU Feasibility Study. These documents will form the basis for further action during remedial design and implementation to ensure compliance with this ARAR.

D. The Endangered Species Act (Applicable)

This statute and implementing regulations (16 U.S.C. §§ 1531—1544, 50 CFR Part 402, and 40 CFR § 6.302(h)) require that any federal activity or federally authorized activity may not jeopardize the continued existence of any threatened or endangered species known to live or to have lived in the affected environment or destroy or adversely modify a critical habitat. This ARAR requires EPA to ensure that the selected remedy is sufficiently protective of the environment containing the threatened or endangered species, with an emphasis on reducing the risks from the contaminants of concern to the listed species described in the EPA risk assessment to an acceptable level, with consideration given to the special status of the listed or threatened species—see 40 CFR Sections 300.430(d)(2)(vii) and (e)(2)(i)(G) and EPA Guidance Document OSWER Dir. No. 9285.7-28P, Ecological Risk Assessment and Risk Management principles for Superfund Sites (October, 1999) page 3; and to ensure that the selected remedy is implemented in a manner such that effects on any existing threatened or endangered species from the active remedy implementation activities are avoided or mitigated—see page 4-12 of the CERCLA Compliance with Other Laws Manual: Volume II (EPA August 1989).

In December 1994, ARCO published a report titled "Determination of Functionally Effective Wetland Area with Threatened/Endangered Species." The CFROU Feasibility Study contains additional information regarding threatened and endangered species at Appendix A-10. The bald eagle, the bull trout, the Canada lynx, and the gray wolf were identified as animals potentially frequenting or occurring at the CFROU.

Compliance with this ARAR has to date involved consultation with USFWS, and a determination of the presence of listed or proposed species or critical habitats present at the CFROU. Consultation has focused on the bull trout. The USFWS has indicated a strong interest in the CFROU remedial action and generally agrees with EPA that the Selected Remedy is adequately protective of the sensitive species found at the CFROU as reflected in the USFWS Biological Opinion.

EPA submitted a Biological Assessment (BA) for the CFROU to the US FWS in December 2002. The State of Montana submitted additional comments on the BA subsequent to EPA's submission. The decision by EPA to perform the BA itself, rather than require the PRP to perform the study, was a site specific decision related to the nature of ARCO's objections to EPA's risk assessments and the schedule associated with this project. The US FWS issued a Biological Opinion (BO) in response to these documents in April 2004. Continued consultation with the USFWS and the Montana Department of Fish, Wildlife and Parks will be required as remedial designs are completed. The measures identified in the BO must be implemented by the persons performing the CFROU Selected Remedy. The primary focus of the continued consultation are the best management practices to be undertaken during streambank construction work as the CFROU Selected Remedy is implemented.

E. The National Historic Preservation Act (Applicable)

This statute and implementing regulations (16 U.S.C. § 470 et seq, 40 CFR § 6.301(b), 36 CFR Part 800) require federal agencies or federal projects to take into account the effect of any federally assisted undertaking or licensing on any district, site building, structure, or object that is included in, or eligible for, the Register of Historic Places. If effects cannot be avoided reasonably, measures should be implemented to minimize or mitigate the potential effect. In addition, Indian cultural and historical resources must be evaluated, and effects avoided, minimized, or mitigated.

Compliance with this ARAR has been undertaken through a phase I summary of existing information about sites within the CFROU which may be eligible or are currently included in the National Registry of Historic Places. The results of this search are found in the Remedial Investigation Report, and are summarized in the CFROU Feasibility Study, page 2-23. In addition, the Salish and Kootenai Confederated Tribes are conducting a cultural resources survey of the CFROU. The most notable resource identified to date which may be impacted by the CFROU Selected Remedy is the Grant-Kohrs Ranch National Historic Site, a National Historic Landmark (December 19, 1960) and listed on the National Registry of Historic Places.

Compliance with this ARAR will require continued consultation with the State Historic Preservation Office and the Salish and Kootenai Tribes. Although not generally applicable to the CFROU site, consultation requirements with SHPO are described generally in the First and Second Programmatic Agreements (Programmatic Agreement, April 6, 1992 and Second Programmatic Agreement, December 14, 1994). The Second Programmatic Agreement in particular describes a notification and consultation process, which must be observed during remedial design and remedial action activities at CFROU. Consultation requirements for the Salish and Kootenai Confederated Tribe are described in an agreement between EPA and the Tribe dated July 2003. Consultation will focus on the further

identification of specific eligible or listed resources which may be impacted by remedy implementation, avoidance of harmful effects to those areas if possible, and mitigative activities if avoidance is not possible.

F. Archaeological and Historic Preservation Act (Applicable)

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

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

This statute and implementing regulations (16 U.S.C. § 461 et seq., 40 CFR § 6.310(a)) state that in conducting an environmental review of an EPA action, the responsible official shall consider the existence and location of natural landmarks using information provided by the National Park Service pursuant to 36 CFR § 62.6(d) to avoid undesirable impacts upon such landmarks. The persons responsible for implementing the CFROU Selected Remedy will utilize this information during remedial design to accomplish the requirements of this act.

H. Migratory Bird Treaty (Applicable)

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

I. Bald Eagle Protection Act (Applicable)

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

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

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

K. Native American Grave Protection and Repatriation Act, 25 U.S.C. § 3001; 43 CFR §§ 10.1—10.17 (Applicable or Relevant and Appropriate)

NAGPRA and its implementing regulations provide for the disposition of Native American remains and objects inadvertently discovered on federal or tribal lands after November, 1990. 25 U.S.C. Section 3002(d). If the response activities result in the discovery of Native American human remains or related objects, the activity must stop while the head of the federal land management agency (if federal lands are involved) and appropriate Indian tribes are notified of the discovery. After the discovery, the response activity must cease and a reasonable effort must be made to protect the Native American human remains or related objects. The response activity may later resume. 42 CFR Section 10.4. Accordingly, depending on the facts of the discovery and the location of the response action, NAGPRA could be applicable or relevant and appropriate to the response action.

L. Solid Waste Disposal in National Parks (Applicable)

Part of the CFROU contains portions of the Grant-Kohrs National Historic Site (GRKO), managed by the National Park Service. The substantive statutory provisions of this act, found at 16 U.S.C. §§ 4601 - 22(c) et seq., and its implementing regulations, found at 36 CFR Part 6, are applicable to the creation or expansion of new solid waste disposal units within the boundary of the GRKO.[11]

M. The National Park Service Organic Act, 16 U.S.C. §§ 1-3, certain implementing regulations at 36 CFR Parts 1-0 and P.L. 92-406, and the enabling legislation for the GRKO (Relevant and Appropriate)

The Organic Act and the park specific enabling legislation establish the purposes and uses of the Grant Kohrs Ranch National Historic Site, while the regulations proscribe certain conduct within the park. The statutes and regulations establish standards, requirements, criteria, or limitations for the GRKO, and the National Park Service and EPA have identified these as relevant and appropriate ARARs for remedial work done at the GRKO. EPA issued a more specific description of these ARARs and their application to the CFROU in a letter dated May 17, 2000, which is attached. The application of this ARAR to the GRKO site is described more completely in the ROD section 13.7. EPA and the National Park Service will work cooperatively in the oversight and approval of remedial design and remedial action at the GRKO. Specific Performance Standards related to this ARAR are described more fully in the ROD at Section 13.7.

[11] These regulations would not apply to, nor be relevant and appropriate to, the use of in situ treatment on wastes on site at the GRKO.

III. Federal Action Specific Requirements

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

The contamination at the CFROU is primarily mining waste from mining mills and smelters in Butte. This waste may not be RCRA hazardous waste, although EPA reserves its rights to make a more formal determination in this regard at a later date. For any active management (i.e., treatment, storage, disposal, grading, or in-situ treatment) or removal of tailings or mixed tailings and soils[12] contamination, the following requirements are ARARs.

1. Requirements described at 40 CFR §§ 257.3-1(a), 257.3-3, and 257.3-4, governing waste handling, storage, and disposal, including retention of the waste, in general[13], and 257.3-5, relating to precautions necessary to ensure that cadmium is not taken up into crops, including pasture grasses that may enter the food chain, at levels which may be a risk to human health.

2. For any discrete waste units which are created or actively managed by the CFROU cleanup, reclamation and closure regulations found at 30 CFR Parts 816 and 784, governing coal and to a lesser extent, non-coal mining, are relevant and appropriate requirements[14].

3. Portions of RCRA regulations found at 40 CFR §§ 264.116 and .119(a) and (b) (governing notice and deed restrictions)are relevant and appropriate requirements for any waste management units created or actively managed at the CFROU[15].

B. Air Standards—Clean Air Act (Applicable)

These standards, promulgated pursuant to section 109 of the Clean Air Act[16], are applicable to releases into the air from any CFROU cleanup activities.

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[12] Federal and State solid waste requirements may also be relevant and appropriate for contaminated soils in certain circumstances. Generally, if soils materials are determined by the agencies to be able to be used in conjunction with other removal or remedial measures such as deep plowing or capping, these requirements are not considered relevant and appropriate. At the CFROU, the solid waste waiver described in the Record of Decision applies to both mixed tailings and soils and contaminated soils at the site.

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

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

[15] As noted earlier, federal RCRA regulations are incorporated by reference into applicable State Hazardous Waste Management Act regulations. See ARM 17.53.801. Use of select RCRA regulations for mining waste cleanups is appropriate when discrete units are addressed by a cleanup and site conditions are distinguishable from EPA generic determination of low toxicity/high volume status for mining waste. See Preamble to the Final NCP, 55 Fed.Reg. 8763 - 8764 (March 8, 1990), CERCLA Compliance with Other Laws Manual, Volume II (August 1989 OSWER Directive #9234.1-02) p. 6-4; Preamble to the Proposed NCP, 53 Fed.Reg. 51447 (Dec. 21, 1988); and guidance entitled Consideration of RCRA Requirements in Performing CERCLA Responses at Mining Wastes Sites, August 19, 1986 (OSWER).

[16] 42 U.S.C. §§ 7401 et seq.

1. Lead: No person shall cause or contribute to concentrations of lead in the ambient air which 3 exceed 1.5 micrograms per cubic meter (ug/m) of air, measured over a 90-day average. These standards are promulgated at ARM 17.8.222 as part of a federally approved State Implementation Plan (SIP), pursuant to the Clean Air Act of Montana, §§ 75-2-101 et seq. MCA. Corresponding federal regulations are found at 40 CFR § 50.12[17].

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

   – 150 ug/m3 of air, 24 hour average, no more than one expected exceedence per calendar year;

   – 50 ug/m3 of air, annual average.

These regulations are promulgated at ARM 17.8.223 as part of a federally approved SIP, pursuant to the Clean Air Act of Montana, §§ 75-2-101 et seq. MCA. Corresponding federal regulations are found at 40 CFR § 50.6.

Ambient air standards under section 109 of the Clean Air Act are also promulgated for carbon monoxide, hydrogen sulfide, nitrogen dioxide, sulfur dioxide, and ozone. If emissions of these compounds were to occur at the site in connection with any cleanup action, these standards would also be applicable. See ARM 17.8.222 and .223, and 40 CFR Part 50.

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

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

D. Dredge and Fill Requirements (Applicable)

Regulations found at 40 CFR Part 230 address conditions or prohibitions against depositing dredge and fill material into water of the United States. If remediation activities would result in an activity subject to these regulations, they would be applicable. Compliance with this requirement will be achieved at the site of dredge and fill activity within the CFROU during construction activities through the use of construction best management practices.

[17] Ambient air standards established as part of Montana's approved State Implementation Plan in many cases provide more stringent or additional standards. The federal standards by themselves apply only to major sources, while the State standards are fully applicable throughout the state and are not limited to major sources. See ARM 17.8.205 and 17.8.212-223. As part of an EPA approved State Implementation Plan, the state standards are also federally enforceable. Thus, the state standards which are equivalent to the federal standards are identified in this section. A more detailed list of State standards, which include standards which are not duplicated in federal regulations, is contained in the State ARAR identification section.

E. Underground Injection Control (Applicable)

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

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

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

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State of Montana ARARs

As provided by Section 121 of CERCLA, 42 U.S.C. § 9621, only those state standards that are more stringent than any federal standard and that have been identified by the state in a timely manner are appropriately included as ARARs.

IV. Montana Contaminant Specific Requirements

A. Water Quality

Surface Water Quality Standards (Applicable)

Under the Montana Water Quality Act, §§ 75-5-101 et seq., MCA, the state has promulgated water quality standards to protect, maintain, and improve the quality and potability of the state's surface water for water supplies, wildlife, fish and aquatic life, agricultural, industry, recreation, and other beneficial uses. The requirements listed below are applicable water quality standards with which any remedial action must comply.

ARM 17.30.607 (1)(a)-(n) (Applicable) classifies the waters of the Clark Fork River as follows:

Newly constructed channel below Pond 2 outfall to the mainstem of Warm Springs Creek	B-1
Mainstem from Warm Springs Creek to Cottonwood Creek (Deer Lodge)	C-2
Mainstem from Cottonwood Creek to Little Blackfoot River	C-1
Little Blackfoot River to Milltown Reservoir	B-1

In addition, Mill and Willow Creeks flow into the Clark Fork River at the upstream end of the operable unit, and they are classified as B-1.

The B-1 classification standards are contained in ARM 17.30.623 (Applicable) of the Montana water quality regulations. This section states:

Waters classified B-1 are suitable for drinking, culinary and food processing purposes, after conventional treatment; bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply.

The B-1 classification standards at ARM 17.30.623 include the following criteria: 1) dissolved oxygen concentration must not be reduced below the levels given in department circular WQB-7; 2) the maximum allowable increase above naturally occurring turbidity is 5 nephelometric turbidity units; 3) temperature increases must be kept within prescribed limits; 4) no increases above naturally occurring concentrations of sediment or suspended sediment, settleable solids, oils, floating solids, which will or are likely to create a nuisance

or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife are allowed; 5) true color must be kept within specified limits; 6) induced variation of hydrogen ion cncentration (pH) within the range of 6.5 to 8.5 must be less than 0.5 pH unit. Natural pH outside this range must be maintained without change. Natural pH above 7.0 must be maintained above 7.0.

ARM 17.30.623 (applicable) also provides that concentrations of carcinogenic, bioconcentrating, toxic, or harmful parameters which would remain in the water after conventional water treatment may not exceed the applicable standards set forth in the current version of circular WQB-7. Discharges shall conform with ARM Title 16, Chapter 20, subchapter 7 (the nondegradation rules) and may not cause receiving water concentrations to exceed the applicable standards specified in WQB-7 when stream flows equal or exceed the design flows specified in ARM 17.30.635(4).

The C-1 classification standards are contained in ARM 17.30.626 (Applicable) of the Montana water quality regulations. This section states:

Waters classified C-1 are suitable for bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

The C-1 classification standards at ARM 17.30.626 include the following criteria: 1) dissolved oxygen concentration must not be reduced below the levels given in department circular WQB-7; 2) the maximum allowable increase above naturally occurring turbidity is 5 nephelometric turbidity units; 3) temperature increases must be kept within prescribed limits; 4) no increases above naturally occurring concentrations of sediment or suspended sediment, settleable solids, oils, floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife are allowed; 5) true color must be kept within specified limits; 6) induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 8.5 must be less than 0.5 pH unit. Natural pH outside this range must be maintained without change. Natural pH above 7.0 must be maintained above 7.0.

ARM 17.30.626 also provides that concentrations of carcinogenic, bioconcentrating, toxic or harmful parameters may not exceed levels which render the water harmful, detrimental, or injurious to public health. Concentrations of toxic parameters also may not exceed the applicable standards specified in WQB-7. Discharges shall conform with ARM Title 16, Chapter 20, subchapter 7 (the nondegradation rules) and may not cause receiving water concentrations to exceed the applicable standards specified in WQB-7 when stream flows equal or exceed the design flows specified in ARM 17.30.635(4).

C-2 classification standards are found in ARM 17.30.627 (applicable) of the Montana Water Quality Regulations. This section states:

> Waters classified C-2 are suitable for bathing, swimming, and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; agricultural and industrial water supply.

The C-2 classification standards at ARM 17.30.627 include the following criteria: 1) dissolved oxygen concentration must not be reduced below the levels given in department circular WQB-7; 2) the maximum allowable increase above naturally occurring turbidity is 10 nephelometric turbidity units; 3) temperature increases must be kept within prescribed limits; 4) non increases above naturally occurring concentrations of sediment or suspended sediment, settleable solids, oils, floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife are allowed; 5) true color must be kept within specified limits; 6) induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 8.5 must be less than 0.5 pH unit. Natural pH outside this range must be maintained without change. Natural pH above 7.0 must be maintained above 7.0.

ARM 17.30.627 provides that concentrations of carcinogenic, bioconcentrating, toxic or harmful parameters may not exceed levels which render the water harmful, detrimental, or injurious to public health. Concentrations of toxic parameters also may not exceed the applicable standards specified in WQB-7. Discharges shall conform with ARM Title 16, Chapter 20, subchapter 7 (the nondegradation rules) and may not cause receiving water concentrations to exceed the applicable standards specified in WQB-7 when stream flows equal or exceed the design flows specified in ARM 17.30.635(4).

If these standards are violated due to hazardous substances or Superfund response action, they must be complied with as part of any selected remedial action.

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

Chemical	WQB-7 Standard (total recoverable standards)	
Arsenic	**Acute**	**340 ug/l**
	Chronic	**150 ug/l**
	Human Health	**18 ug/l**
Cadmium	**Acute**	**2.1 ug/l @ 100 mg/l hardness**
	Chronic	**0.27 ug/l @ 100 mg/l hardness**
Copper	Acute	18 ug/l @ 100 mg/l hardness
	Chronic	12 ug/l @ 100 mg/l hardness
	Human Health	1,300 ug/l @ 100 mg/l hardness

The copper standard is waived in the CFROU ROD and replaced with the federal water quality criteria for copper.

Lead	**Acute**	**81 ug/l @ 100 mg/l hardness**
	Chronic	**3.2 ug/l @ 100 mg/l hardness**
	Human Health	**15 ug/l**

Zinc	**Acute**	**119 ug/l @ 100 mg/l hardness**
	Chronic	**119 ug/l @ 100 mg/l hardness**
	Human Health	**2,100 ug/l @ 100 mg/l hardness**

Bolded water quality standards are Performance Standards for the CFROU.

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

ARM 17.30.637 (Applicable) which prohibits discharges containing substances that will: (a) settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines; (b) create floating debris, scum, a visible oil film (or be present in concentrations at or in excess of 10 milligrams per liter) or globules of grease or other floating materials; (c) produce odors, colors or other conditions which create a nuisance or render undesirable tastes to fish flesh or make fish inedible; (d) create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life; (e) create conditions which produce undesirable aquatic life.

ARM 17.30.637 also states that no waste may be discharged and no activities conducted which, either along or in combination with other waste activities, will cause violation of surface water quality standards.

ARM 17.30.1203 (Applicable), adopts and incorporates the provisions of 40 CFR Part 125 for criteria and standards for the imposition of technology-based treatment requirements in MPDES permits. Although the permit requirement would not apply to on-site discharges, the substantive requirements of Part 125 are applicable, i.e., for toxic and nonconventional pollutants treatment must apply the best available technology economically achievable (BAT) ; for conventional pollutants, application of the best conventional pollutant control technology (BCT) is required. Where effluent limitations are not specified for the particular industry or industrial category at issue, BCT/BAT technology based treatment requirements are determined on a case by case basis using best professional judgment (BPJ). See CERCLA Compliance with Other Laws Manual, Vol. I, August 1988, p. 3-4 and 3-7. These State standards would apply to both point source discharges and ambient water quality within the CFROU.

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

Montana Pollutant Discharge Elimination System (MPDES)—stormwater and other point sources.

ARM 17.30.1342 - 1344 set forth the substantive requirements applicable to all MPDES permits. The substantive requirements, including the requirement to properly operate and maintain all facilities and systems of treatment and control are applicable requirements.

Under ARM 17.30.601, ARM 17.30.1101 et seq., and ARM 17.30.1301 et seq., the Montana Department of Environmental Quality has issued general stormwater permits for certain activities. The substantive requirements of the following permits are applicable for the following activities:

- For construction activities: General Permit for Storm Water Discharges Associated with Construction Activity, Permit No. MTR 100000 (June 8, 2002);
- For mining activities: General Permit for Storm Water Discharges Associated with Mining and with Oil and Gas Activities, Permit No. MTR300000 (November 17, 2002)[1];
- For industrial activities: General Permit for Storm Water Discharges Associated with Industrial Activity, Permit No. MTR000000 (October 1, 2001).

Generally, the permits listed above require the permittee to implement Best Management Practices (BMP) and to take all reasonable steps to minimize or prevent any discharge which has a reasonable likelihood of adversely affecting human health or the environment.[2] However, if there is evidence indicating potential or realized impacts on water quality due to any storm water discharge associated with the activity, the substantive standards associated with an individual MPDES permit or alternative general permit may be required.

A related mine reclamation requirement is set out in ARM 17.24.633 (relevant and appropriate), which requires that all surface drainage from disturbed areas that have been graded, seeded or planted must be treated by the best technology currently available (BTCA) before discharge. Sediment control through BTCA practices must be maintained until the disturbed area has been reclaimed, the revegetation requirements have been met, and the area meets state and federal requirements for the receiving stream.

2. Groundwater Quality Standards (Applicable)

ARM 17.30.1006 (Applicable) classifies groundwater into Classes I through IV based upon the its specific conductance and establishes the groundwater quality standards applicable with respect to each groundwater classification. Based upon its specific conductance, the majority of the groundwater in the CFROU is considered Class I groundwater, with the remainder of the groundwater Class II.[3]

Concentrations of dissolved substances in Class I or II groundwater (or Class III groundwater which is used as a drinking water source) may not exceed the human health standards listed in department Circular WQB-7. For the primary contaminants of concern these levels are listed below. Ground water is measured in dissolved form, according to WQB-7.

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[1] This permit covers point source discharges of storm water from mining and milling activities (including active, inactive, and abandoned mine and mill sites) including activities with Standard Industrial Code 14 (metal mining).

[2] For further explanation of storm water applications, see the letter from EPA to Chuck Stilwell, ARCO, dated February 2, 1999, which describes that treatment, in addition to BMPs, may be necessary if in-stream standards are not met after implementation of BMPs.

[3] ARM 17.30.1006 provides that Class I groundwaters are those with specific conductance of less than 1000 microSiemens per centimeter at 25B C; Class II groundwaters: 1000 to 2500; Class III groundwaters: 2500 to 15,000; and Class IV groundwaters: over 15,000.

Chemical	WQB-7 Human Health Standards (December 2002 edition)
Arsenic	20 ug/1
Cadmium	5 ug/1
Copper	1300 ug/1
Lead	15 ug/1
Zinc	**2000 ug/1**

Zinc is not addressed under federal groundwater standards. Therefore, the State zinc standard is a Performance Standard for the CFROU ROD. Other state standards listed above are not as stringent or are duplicative of federal standards previously identified as Performance Standards.

For concentrations of parameters for which human health standards are not listed in WQB-7, ARM 17.30.1006 allows no increase of a parameter to a level that renders the waters harmful, detrimental or injurious to listed beneficial uses.

For Class I and II groundwaters, 17.30.1006 allows no increase of a parameter that causes a violation of the nondegradation provisions of § 75-5-303, MCA.

ARM 17.30.1011 also provides that groundwater whose existing quality is higher than the standard for its classification must be maintained at that high quality unless degradation may be allowed under the principles established in § 75-5-303, MCA, and the nondegradation rules at ARM 17.30.701 et seq.

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

B. Air Quality

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

V. Montana Location Specific Requirements

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

The Floodplain and Floodway Management Act and regulations specify types of uses and structures that are allowed or prohibited in the designated 100-year floodway[4] and floodplain[5]. These standards are applicable to all actions contemplated for this site within the floodplain.

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

2. Prohibited Uses. Uses prohibited anywhere in either the floodway or the floodplain are:

   a. solid and hazardous waste disposal; and

   b. storage of toxic, flammable, hazardous, or explosive materials.

   ARM 36.15.605(2) and 36.15.703. These standards are waived in the CFROU ROD for areas designated for in-situ treatment.

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

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

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

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

[5] The floodplain is the area adjoining the water course or drainway which would be covered by the floodwater of a base (100 year) flood except for sheet flood areas that receive less than one foot of water per occurrence. The floodplain consists of the floodway and flood fringe. ARM 36.15.101

[6] However, see EPA's 1997 Human Health Risk Assessment for a determination of likely land use at the CFR OU, based on local zoning requirements and other factors.

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

Section 76-5-403, MCA.

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

    1. the danger to life and property from backwater or diverted flow caused by the obstruction or use;
    2. the danger that the obstruction or use will be swept downstream to the injury of others;
    3. the availability of alternate locations;
    4. the construction or alteration of the obstruction or use in such a manner as to lessen the danger;
    5. the permanence of the obstruction or use; and
    6. the anticipated development in the foreseeable future of the area which may be affected by the obstruction or use.

See 76-5-406, MCA; ARM 36.15.216 (substantive provisions only).

Conditions or restrictions that generally apply to specific activities within the floodway or floodplain are:

1. the proposed activity, construction, or use cannot increase the upstream elevation of the 100-year flood a significant amount (one-half foot or as otherwise determined by the permit issuing authority) or significantly increase flood velocities, ARM 36.15.604 (Applicable, substantive provisions only); and
2. the proposed activity, construction, or use must be designed and constructed to minimize potential erosion, see ARM 36.15.605.

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

- Excavation of material from pits or pools—ARM 36.15.602 (1).
- Water diversions or changes in place of diversion—ARM 36.15.603.

- Flood control works—ARM 36.15.606.
- Roads, streets, highways and rail lines (must be designed to minimize increases in flood heights)—ARM 36.15.701(3) (c).
- Structures and facilities for liquid or solid waste treatment and disposal (must be floodproofed to ensure that no pollutants enter flood waters and may be allowed and approved only in accordance with MDEQ regulations, which include certain additional prohibitions on such disposal)—ARM 36.15.701(3) (d).
- Residential structures—ARM 36.15.702(1).
- Commercial or industrial structures—ARM 36.15.702(2).

B. Solid Waste Management Regulations (Applicable)

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

- must be located where a sufficient acreage of suitable land is available for solid waste management;
- may not be located in a 100-year floodplain;
- may be located only in areas which will prevent the pollution of ground and surface waters and public and private water supply systems;
- must be located to allow for reclamation and reuse of the land;
- drainage structures must be installed where necessary to prevent surface runoff from entering waste management areas; and
- where underlying geological formations contain rock fractures or fissures which may lead to pollution of the ground water or areas in which springs exist that are hydraulically connected to a proposed disposal facility, only Class III disposal facilities may be approved[7].

Even Class III landfills may not be located on the banks of or in a live or intermittent stream or water saturated areas, such as marshes or deep gravel pits which contain exposed ground water. ARM 17.54.505(2)(j).

The above standards are waived in the CFROU ROD for those areas designated for in-situ treatment.

In addition, § 75-10-212 prohibits dumping or leaving any debris or refuse upon or within 200 yards of any highway, road, street, or alley of the State or other public property, or on privately owned property where hunting, fishing, or other recreation is permitted.

[7] Group III consist of primarily inert wastes, including industrial mineral wastes which are essentially inert and non-water soluble and do not contain hazardous waste constituents. ARM 17.50.503(1)(b)

However, the restriction relating to privately owned property does not apply to the owner, his agents, or those disposing of debris or refuse with the owner's consent.

C. Natural Streambed and Land Preservation Standards (Applicable)

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

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

ARM 36.2.410 establishes minimum standards which would be applicable if a remedial action alters or affects a streambed, including any channel change. Projects must be designed and constructed using methods that minimize adverse impacts to the stream (both upstream and downstream) and future disturbances to the stream. All disturbed areas must be managed during construction and reclaimed after construction to minimize erosion. Temporary structures used during construction must be designed to handle high flows reasonably anticipated during the construction period. Temporary structures must be completely removed from the stream channel at the conclusion of construction and the area must be restored to a natural or stable condition. Channel alternation must be designed to retain original stream length or otherwise provide hydrologic stability. Streambank vegetation must be protected except where removal of such vegetation is necessary for the completion of the project. When removal of vegetation is necessary, it must be kept to a minimum. Riprap, rock, and other material used in a project must be of adequate size, shape and density and must be properly placed to protect the streambank from erosion. The placement of road fill material in a stream, the placement of debris or other materials in a stream where it can erode or float into the stream, projects that permanently prevent fish migration, operation of construction equipment in a stream, and excavation of streambed gravels are prohibited unless specifically authorized by the district. Such projects must also protect the use of water for any useful or beneficial purpose. See 75-7-102, MCA.

VI. Montana Action Specific Requirements

A. Water Quality Statute and Regulations (Applicable)

Causing of pollution: Section 75-5-605 of the Montana Water Quality Act prohibits the causing of pollution of any state waters. Pollution is defined as contamination or other alteration of physical, chemical, or biological properties of state waters which exceeds that permitted by the water quality standards. Construction Best Management Practices described in the CFROU ROD are intended to meet this requirement during remedial action implementation.

Placement of Wastes: Section 75-5-605, MCA, states that it is unlawful to place or cause to be placed any wastes where they will cause pollution of any state waters. Placement of waste is not prohibited if the authorization for placement contains provisions for review of the placement of materials to ensure it will not cause pollution to state waters.

Nondegradation: Section 75-5-303, MCA, states that existing uses of state waters and the level of water quality necessary to protect the uses must be maintained and protected. Section 75-5-317, MCA, provides an exemption from nondegradation requirements which allows changes of existing water quality resulting from an emergency or remedial activity that is designed to protect the public health or the environment and that is approved, authorized, or required by the department. Changes determined to meet these requirements may be considered nonsignificant. In determining that remedial actions are protective of public health and the environment and in approving, authorizing, or requiring such remedial activities, no significant degradation should be approved, considering the criteria for a determination of non-significance set out in 75-5-301(5)(c), which (i) equate significance with the potential for harm to human health, a beneficial use or the environment, (ii) consider both the quantity and strength of the pollutant, (iii) consider the length of time the degradation will occur, and (iv) consider the character of the pollutant so that greater significance is associated with carcinogens and toxins that bioaccumulate or biomagnify and lesser significance is associated with substances that are less harmful or less persistent. Under ARM 17.30.715(1)(b), concentrations of carcinogenic parameters or parameters with a bioconcentration factor greater than 300 cannot exceed the concentration in the receiving water in order for a discharge to be considered nonsignificant and thus exempt from nondegradation requirements under § 75-5-317.

ARM 17.30.705 provides that for any surface water, existing and anticipated uses and the water quality necessary to protect these uses must be maintained and protected unless degradation is allowed under the nondegradation rules at ARM 17.30.701 et seq.

ARM 17.30.1011 provides that any groundwater whose existing quality is higher than the standard for its classification must be maintained at that high quality unless degradation may be allowed under the principles established in § 75-5-303, MCA, and the nondegradation rules at ARM 17.30.701 et seq.

B. Montana Pollutant Discharge Elimination System (MPDES)-stormwater and other point sources (Applicable or Relevant and Appropriate)

ARM 17.30.1342 - 1344 set forth the substantive requirements applicable to all MPDES permits. The substantive requirements, including the requirement to properly operate and maintain all facilities and systems of treatment and control are applicable requirements.

Under ARM 17.30.601, ARM 17.30.1101 et seq., and ARM 17.30.1301 et seq., the Montana Department of Environmental Quality has issued general stormwater permits for certain activities. The substantive requirements of the following permits are applicable for the following activities:

- For construction activities: General Permit for Storm Water Discharges Associated with Construction Activity, Permit No. MTR 100000 (June 8, 2002);
- For mining activities: General Permit for Storm Water Discharges Associated with Mining and with Oil and Gas Activities, Permit No. MTR300000 (November 17, 2002)[8];
- For industrial activities: General Permit for Storm Water Discharges Associated with Industrial Activity, Permit No. MTR000000 (October 1, 2001).

Generally, the permits listed above require the permittee to implement Best Management Practices (BMP) and to take all reasonable steps to minimize or prevent any discharge which has a reasonable likelihood of adversely affecting human health or the environment.[9] However, if there is evidence indicating potential or realized impacts on water quality due to any storm water discharge associated with the activity, the substantive standards associated with an individual MPDES permit or alternative general permit may be required.

A related mine reclamation requirement is set out in ARM 17.24.633 (relevant and appropriate), which requires that all surface drainage from disturbed areas that have been graded, seeded or planted must be treated by the best technology currently available (BTCA) before discharge. Sediment control through BTCA practices must be maintained until the disturbed area has been reclaimed, the revegetation requirements have been met, and the area meets state and federal requirements for the receiving stream.

C. Air Quality

Air Quality Regulations (Applicable)

Dust suppression and control of certain substances likely to be released into the air as a result of earth moving, transportation and similar actions related to remedial activity at the CFROU may be necessary to meet air quality requirements. Certain ambient air standards for specific contaminants and particulates are set forth in the federal action specific section

[8] This permit covers point source discharges of storm water from mining and milling activities (including active, inactive, and abandoned mine and mill sites) including activities with Standard Industrial Code 14 (metal mining).

[9] For further explanation of storm water applications, see the letter from EPA to Chuck Stilwell, ARCO, dated February 2, 1999, which describes that treatment, in addition to BMPs, may be necessary if in-stream standards are not met after implementation of BMPs. This letter was issued under the Butte Priority Soils operable unit, but similar reasoning applies to this site.

above. Additional air quality regulations under the state Clean Air Act, §§ 75-2-101 et seq., MCA, are discussed below.

ARM 17.8.604 (Applicable) lists certain wastes that may not be disposed of by open burning, including oil or petroleum products, RCRA hazardous wastes, chemicals, and treated lumber and timbers. Any waste which is moved from the premises where it was generated and any trade waste (material resulting from construction or operation of any business, trade, industry or demolition project) may be open burned only in accordance with the substantive requirements of 17.8.611 or 612.

ARM 17.8.308 (Applicable) provides that no person shall cause or authorize the production, handling, transportation or storage of any material, cause or authorize the use of any street, road, or parking lot, or operate a construction site or demolition project, unless reasonable precautions to control emissions of airborne particulate matter are taken. Normally, emissions of airborne particulate matter must be controlled so that they do not "exhibit an opacity of twenty percent (20%) or greater averaged over six consecutive minutes."

In addition, state law provides an ambient air quality standard for settled particulate matter. Particulate matter concentrations in the ambient air shall not exceed the following 30-day average: 10 grams per square meter. ARM 17.8.220 (Applicable). Whenever this standard is exceeded, the activity resulting in such exceedance shall be suspended until such time as conditions improve.

ARM 17.24.761 (Relevant and Appropriate) specifies a range of measures for controlling fugitive dust emissions during mining and reclamation activities. Some of these measures could be considered relevant and appropriate to control fugitive dust emissions in connection with excavation, earth moving and transportation activities conducted as part of the remedy at the site. Such measures include, for example, paving, watering, chemically stabilizing, or frequently compacting and scraping roads, promptly removing rock, soil or other dust-forming debris from roads, restricting vehicle speeds, revegetating, mulching, or otherwise stabilizing the surface of areas adjoining roads, restricting unauthorized vehicle travel, minimizing the area of disturbed land, and promptly revegetating regraded lands.

D. Solid Waste Management Regulations (Applicable)

As noted above, the Solid Waste Management Regulations are applicable to the disposal or active management of the tailings and similar wastes within the CFROU. Certain of these regulations are identified in the state location specific ARARs above. Action specific solid waste regulations are discussed below:

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

1. Class II[10] landfills must confine solid waste and leachate to the disposal facility. If there is the potential for leachate[11] migration, it must be demonstrated that leachate will only

[10] Generally Class II landfills are licensed to receive Group II and Group III waste, but not regulated hazardous waste. Class III landfills may only receive Group III waste.

[11] Leachate is defined as a liquid which has contacted passed through, or emerged from solid waste and contains soluble, suspended, or miscible materials removed from the waste. ARM 17.50.502(29).

migrate to underlying formations which have no hydraulic continuity with any state waters;

2. adequate separation of group II wastes from underlying or adjacent water must be provided[12]; and

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

ARM 17.50.506 specifies design requirements for landfills[13]. Landfills must either be designed to ensure that MCLs are not exceeded or the landfill must contain a composite liner and leachate collection system which comply with specified criteria.

ARM 17.50.511 sets forth general operational and maintenance and design requirements for solid waste management systems. Specific operational and maintenance requirements specified in ARM 17.50.511[14] that are relevant and appropriate are requirements for run-on and runoff control systems, requirements that sites be fenced to prevent unauthorized access, and prohibitions of point source and nonpoint source discharges which would violate Clean Water Act requirements.

ARM 17.50.523 specifies that solid waste must be transported in such a manner as to prevent its discharge, dumping, spilling or leaking from the transport vehicle.

ARM 17.50.530 sets forth the closure[15] requirements for landfills. Class II landfills must meet the following criteria:

1. install a cover that is designed to minimize infiltration and erosion;

2. design and construct the final cover system to minimize infiltration through the closed unit by the use of an infiltration layer that contains a minimum 18 inches of earthen material and has a permeability less than or equal to the permeability of any bottom liner, barrier layer, or natural subsoils or a permeability no greater than 1 X 10-5 cm/sec, whichever is less;

3. minimize erosion of the final cover by the use of a seed bed layer that contains a minimum of six inches of earthen material that is capable of sustaining native plant growth and protecting the infiltration layer from frost effects and rooting damage; and

4. revegetate the final cover with native plant growth within one year of placement of the final cover.

ARM 17.50.530(1)(b) allows an alternative final cover design if the infiltration layer achieves reduction in infiltration at least equivalent to the stated criteria and the erosion layer provides protection equivalent to the stated criteria.

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[12] The extent of separation shall be established on a case-by-case basis, considering terrain and the type of underlying soil formations, and facility design. The Waste Management Section of DEQ has generally construed this to require a 10 to 20 foot separation from groundwater.

[13] A landfill is defined as an area of land or an excavation where wastes are placed for permanent disposal, and that is not a land application unit, surface impoundment, injection well, or waste pile. ARM 17.50.502(27).

[14] ARM 17.50.511(1)(j), 17.50.511(l)(k) and 17.50.511(1)(l)

[15] Closure means the process by which the operator closes all or part of the facility.

ARM 17.50.531 sets forth post closure care requirements for Class II landfills. Post closure care must be conducted for a period sufficient to protect human health and the environment. Post closure care requires maintenance of the integrity and effectiveness of any final cover, including making repairs to the cover as necessary to correct the effects of settlement, subsidence, erosion, or other events, and preventing run-on and run-off from eroding or otherwise damaging the cover and comply with the groundwater monitoring requirements found at ARM Title 17, chapter 50, subchapter 7.

Section 75-10-206, MCA, allows variances[16] to be granted from solid waste regulations if failure to comply with the rules does not result in a danger to public health or safety or compliance with specific rules would produce hardship without producing benefits to the health and safety of the public that outweigh the hardship. In certain circumstances relating to waste nature and volume and the provisions of the Superfund law regarding ongoing maintenance and review, certain of the Solid Waste regulations regarding design of landfills, operational and maintenance requirements, and landfill closure and post-closure care may appropriately be subject to variance for the CFROU. Similarly, the ground water monitoring requirements of ARM 17.50.701 et seq. can be considered and coordinated with any other monitoring requirements under CERCLA. In general, the Solid Waste requirements listed in this section will not be used to require additional activities at the CFROU in situ treatment areas other than those activities described in the ROD—either through application of the previously invoked CERCLA waiver or through application of the variance described above.

E. Reclamation Requirements

The Strip and Underground Mine Reclamation Act, §§ 82-4-201 through 254, MCA, technically applies to coal and uranium mining, but that statute and the regulations promulgated under that statue and discussed in this section set out the standards that mine reclamation should attain. Those requirements identified here have been determined to be relevant and appropriate requirements for this action. Section 82-4-231 (Relevant and Appropriate) requires the reclamation and revegetation of the land as rapidly, completely, and effectively as the most modern technology and the most advanced state of the art will allow. In developing a method of operation and plans of backfilling, water control, grading, topsoiling and reclamation, all measures shall be taken to eliminate damages to landowners and members of the public, their real and personal property, public roads, streams, and all other public property from soil erosion, subsidence, landslides, water pollution, and hazards dangerous to life and property. Sections 82-4-231(10)(j) and (10)(k)(i) and ARM 17.24.751 (Relevant and Appropriate) provide that reclamation of mine waste materials shall, to the extent possible using the best technology currently available, minimize disturbances and adverse impacts of the operation on fish, wildlife, and related environmental values and achieve enhancement of such resources where practicable, and shall avoid acid or other toxic mine drainage by such measures as preventing or removing water from contact with toxic producing deposits. ARM 17.24.641 (Relevant and Appropriate) also provides that drainage from acid forming or toxic-forming spoil into ground and surface water must be avoided by preventing water from coming into contact

[16] See the letter from EPA to Chuck Stilwell, ARCO, dated May 21, 2002, which describes the application of variances to solid waste management rules for the Railroad Bed Time Critical Removal Action (TCRA) at the BPSOU.

with such spoil. ARM 17.24.505 (Relevant and Appropriate) similarly provides that acid, acid forming, toxic, toxic-forming or other deleterious materials must not be buried or stored in proximity to a drainage course so as to cause or pose a threat of water pollution.

Reclamation Activities—Hydrology Regulations (Relevant and Appropriate)

The hydrology regulations promulgated under the Strip and Underground Mine Reclamation Act, §§ 82-4-201 et seq., MCA, provide detailed guidelines for addressing the hydrologic impacts of mine reclamation activities and earth-moving projects and are relevant and appropriate for addressing these impacts in the CFROU.

ARM 17.24.631 (Relevant and Appropriate) provides that long-term adverse changes in the hydrologic balance from mining and reclamation activities, such as changes in water quality and quantity, and location of surface water drainage channels shall be minimized. Water pollution must be minimized and, where necessary, treatment methods utilized. Diversions of drainage to avoid contamination must be used in preference to the use of water treatment facilities. Other pollution minimization devices must be used if appropriate, including stabilizing disturbed areas through land shaping, diverting runoff, planting quickly germinating and growing stands of temporary vegetation, regulating channel velocity of water, lining drainage channels with rock or vegetation, mulching, and control of acid-forming, and toxic-forming waste materials.

ARM 17.24.633 (Relevant and Appropriate) provides water quality performance standards that may be invoked in the event that runoff from the treated areas threatens water quality or sediments in the stream, including the requirement that all surface drainage from a disturbed area must be treated by the best technology currently available (BTCA). Treatment must continue until the area is stabilized.

ARM 17.24.634 (Relevant and Appropriate) provides that, in reclamation of drainages, drainage design must emphasize channel and floodplain dimensions that approximate the pre-mining configuration and that will blend with the undisturbed drainage above and below the area to be reclaimed. The average stream gradient must be maintained with a concave longitudinal profile. This regulation provides specific requirements for designing the reclaimed drainage to:

1. approximate an appropriate geomorphic habit or characteristic pattern;
2. remain in dynamic equilibrium with the system without the use of artificial structural controls;
3. improve unstable premining conditions;
4. provide for floods and for the long-term stability of the landscape; and
5. establish a premining diversity of aquatic habitats and riparian vegetation.

ARM 17.24.635 through 26.4.637 (Relevant and Appropriate) set forth requirements for temporary and permanent diversions.

ARM 17.24.638 (Relevant and Appropriate) specifies sediment control measures to be implemented during operations.

ARM 17.24.639 (Relevant and Appropriate) sets forth requirements for temporary and permanent sedimentation ponds.

ARM 17.24.640 (Relevant and Appropriate) provides that discharge from sedimentation ponds, permanent and temporary impoundments, and diversions shall be controlled by energy dissipaters, riprap channels, and other devices, where necessary, to reduce erosion, prevent deepening or enlargement of stream channels, and to minimize disturbance of the hydrologic balance.

ARM 17.24.643 (Relevant and Appropriate) requires protection of groundwater resources.

ARM 17.24.645 (Relevant and Appropriate) sets forth requirements for groundwater monitoring.

ARM 17.24.646 (Relevant and Appropriate) sets forth requirements for surface water monitoring.

Reclamation and Revegetation Requirements (Relevant and Appropriate)

ARM 17.24.501 (Relevant and Appropriate) gives general backfilling and final grading requirements. Backfill must be placed so as to minimize sedimentation, erosion, and leaching of acid or toxic materials into waters, unless otherwise approved. Final grading must be to the approximate original contour of the land and final slopes must be graded to prevent slope failure, may not exceed the angle of repose, and must achieve a minimum long term static safety factor of 1:3. The disturbed area must be blended with surrounding and undisturbed ground to provide a smooth transition in topography.

ARM 17.24.519 (Relevant and Appropriate) provides that an operator may be required to monitor settling of regraded areas.

ARM 17.24.702(4), (5), and (6) (Relevant and Appropriate) requires that during the redistributing and stockpiling of soil (for reclamation):

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

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

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

ARM 17.24.703 (Relevant and Appropriate) requires that when using materials other than, or along with, soil for final surfacing in reclamation, the operator must demonstrate that the material (1) is at least as capable as the soil of supporting the approved vegetation and subsequent land use, and (2) the medium must be the best available in the area to support vegetation. Such substitutes must be used in a manner consistent with the requirements for redistribution of soil in ARM 17.24.701 and 702.

ARM 17.24.711 (Relevant and Appropriate) requires that a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area of land to be affected shall be established except on road surfaces and below the low-water line of permanent impoundments. See also § 82-4-233, MCA (Relevant and Appropriate). Vegetative cover is considered of the same seasonal variety if it consists of a mixture of species of equal or superior utility when compared with the natural vegetation during each season of the year (See also ARM 17.24.716 and 719 below regarding substitution of introduced species for native-species). This requirement may not be appropriate where other cover is more suitable for the particular land use or another cover is requested by the landowner.

ARM 17.24.713 (Relevant and Appropriate) provides that seeding and planting of disturbed areas must be conducted during the first appropriate period for favorable planting after final seedbed preparation.

ARM 17.24.714 (Relevant and Appropriate) requires use of a mulch or cover crop or both until an adequate permanent cover can be established. Use of mulching and temporary cover may be suspended under certain conditions.

ARM 17.24.716 (Relevant and Appropriate) establishes the required method of revegetation, and provides that introduced species may be substituted for native species as part of an approved plan.

ARM 17.24.717 (Relevant and Appropriate) relates to the planting of trees and other woody species if necessary, as provided in § 82-4-233, MCA, to establish a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the affected area and capable of self-regeneration and plant succession at least equal to the natural vegetation of the area, except that introduced species may be used in the revegetation process where desirable and necessary to achieve the approved land use plan.

ARM 17.24.718 (Relevant and Appropriate) requires the use of soil amendments and other means such as irrigation, management, fencing, or other measures, if necessary to establish a diverse and permanent vegetative cover.

ARM 17.24.719 (Relevant and Appropriate) sets forth requirements for livestock grazing on reclaimed land.

ARM 17.24.721 (Relevant and Appropriate) specifies that rills or gullies in reclaimed areas must be filled, graded or otherwise stabilized and the area reseeded or replanted if the rills and gullies are disrupting the reestablishment of the vegetative cover or causing or contributing to a violation of water quality standards for a receiving stream.

ARM 17.24.723 (Relevant and Appropriate) sets forth requirements for vegetation, soils, wildlife, and other monitoring.

ARM 17.24.724 (Relevant and Appropriate) specifies that revegetation success must be measured against approved unmined reference areas or by comparison with technical standards from historic data. More than one reference area or historic record must be established for vegetation types with significant variation due to a number of factors.

ARM 17.24.726 (Relevant and Appropriate) sets forth vegetation production, cover, diversity, density, and utility requirements.

ARM 17.24.728 (Relevant and Appropriate) sets forth performance standards for native species and introduced species in revegetated areas.

ARM 17.24.733 (Relevant and Appropriate) sets forth performance standards for composition and stocking of trees, shrubs, and half shrubs on the revegetated area and for measurement of revegetation success.

To Be Considered Documents (TBCs)

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

Other Laws (Non-Exclusive List)

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

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

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

Other Federal Laws

Occupational Safety and Health Regulations

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

Other Montana Laws

1. Groundwater Act

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

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

2. Public Water Supply Regulations

If remedial action at the site requires any reconstruction or modification of any public water supply line or sewer line, the construction standards specified in ARM 17.38.101 (Applicable) must be observed.

3. Water Rights

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

Parts 3 and 4 of Title 85, Chapter 2, MCA, set out requirements for obtaining water rights and appropriating and utilizing water. All requirements of these parts are laws which must be complied with in any action using or affecting waters of the state. Some of the specific requirements are set forth below.

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

Section 85-2-302, MCA, specifies that a person may not appropriate water or commence construction of diversion, impoundment, withdrawal or distribution works therefor except by applying for and receiving a permit from the Montana Department of Natural Resources and Conservation. While the permit itself may not be required under federal law, appropriate notification and submission of an application should be performed and a permit should be applied for in order to establish a priority date in the prior appropriation system.

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

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

1. there are unappropriated waters in the source of supply;
2. the proposed use of water is a beneficial use; and
3. the proposed use will not interfere unreasonably with other planned uses or developments.

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

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

4. Controlled Ground Water Areas

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

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

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

ARM § 17.74.101 addresses occupational noise. In accordance with this section, no worker shall be exposed to noise levels in excess of the levels specified in this regulation. This regulation is applicable only to limited categories of workers and for most workers the similar federal standard in 29 CFR 1910.95 applies.

ARM § 17.74.102 addresses occupational air contaminants. The purpose of this rule is to establish maximum threshold limit values for air contaminants under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. In accordance with this rule, no worker shall be exposed to air contaminant levels in excess of the threshold limit values listed in the regulation. This regulation is applicable only to limited categories of workers and for most workers the similar federal standard in 29 CFR § 1910.1000 applies.

6. Montana Safety Act

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

7. Employee and Community Hazardous Chemical Information

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

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Clark Fork River Operable Unit

of the Milltown Reservoir/Clark Fork River Superfund Site

Record of Decision

Appendix B:

Clark Fork River OU Streambank Stabilization Design Consideration and Examples

U.S. Environmental Protection Agency
Region 8

10 West 15th Street
Suite 3200
Helena, Montana 59626

April 2004

APPENDIX B

Clark Fork River OU Streambank Stabilization Design Consideration and Examples

Flood Hydrology on the Upper Clark Fork River

Because of the short periods of record for Clark Fork River gage stations within Reach A, a procedure to correlate the data with downstream stations having longer periods of record was conducted by R2 Resource Consultants (2000) to refine estimates of flood flows for various return periods. Two different calculations of peak flows at the Deer Lodge gage station (#12324200) are presented in Exhibit B-1 for several return flow periods. One calculation is based solely on the 21 years of actual gage data at the Deer Lodge station. The other calculation is correlated with a downstream gage having a longer period of record, which is used to extend the effective period of record at Deer Lodge to 48.4 years.

Bankfull flow of the Clark Fork River at Deer Lodge has been calculated to be about 1,900 cfs (Griffin and Smith 2001). At this stage, the flow begins to spill out of the channel and disperse onto the floodplain. When a river floodplain is broad relative to its channel width, as is the case for the upper Clark Fork, a flow stage above bankfull produces a large increase in overbank discharge. However, this occurs with a very small increase within the channel (Smith and Griffin 2002) because the increased flow is distributed over the floodplain at a shallow depth. Since both shear stress and velocity are functions of flow depth, these critical factors of erosion potential increase very slowly as total discharge increases beyond bankfull stage.

Referring to Exhibit B-1, a 25-year flood at 2,830 cfs is about 900 cfs above bankfull discharge. Throughout Reach A, the Clark Fork River has access to a floodplain in excess of one channel width wide on at least one side of the channel. Only in the town of Deer Lodge do high banks on both sides of the river confine the flows above bankfull stage causing an increase in flow depth instead of dispersing over the floodplain.

EXHIBIT B-1
Annual Peak Flow Calculations for the Clark Fork River at Deer Lodge USGS Gage No. 12324200

Return Period	Peak Flow (cfs) 21 Year Record	Peak Flow (cfs) 48.4 Year Record (Extrapolated)
2-year flood	987	1,090
5-year flood	1,610	1,750
10-year flood	2,050	2,220
20-year flood	2,490	2,680
25-year flood	2,630	2,830
50-year fllod	3,080	3,330
100-year flood	3,530	3,770

Streambank Stabilization Considerations

Designers of streambank stabilization projects must ensure that the materials placed within the channel or on the streambanks will remain stable over the full range of conditions expected during the design life of the project. Unfortunately, techniques to characterize stability thresholds are limited. Empirical data for shear stress or stream power are generally lacking, but the existing body of information is summarized here. The presence of dense, woody vegetation on streambanks can decrease erosion substantially by reducing the shear stress along the streambanks, and by increasing the cohesion of the soil comprising the streambanks (Griffin and Smith 2001).

The stability of a stream refers to how it accommodates itself to the inflowing water and sediment load. Erosion occurs when the hydraulic forces in the flow exceed the resisting forces of the channel boundary. The two traditional approaches for characterizing stream flow erosion potential use maximum permissible velocity or critical shear stress. Flow velocity can be measured directly, but shear stress cannot; however, shear stress is a better measure of the fluid force on the channel boundary than is velocity. Moreover, conventional guidelines, including ASTM standards, rely upon the shear stress as a means of assessing the stability of erosion control materials.

Vegetation has a profound effect on the stability of both cohesive and non-cohesive soils. It serves as an effective buffer between the water and the underlying soil. It increases the effective roughness height of the boundary, thereby increasing flow resistance and displacing the flow velocity upwards away from the soil. This reduces drag and lift acting on the soil surface. Since boundary shear stress is proportional to the square of the near-streambank velocity, a reduction in this velocity produces a much greater reduction in the forces causing erosion.

Vegetation armors the soil surface, but the roots and rhizomes of plants also bind the soil and introduce extra cohesion beyond any intrinsic cohesion of the streambank material. The presence of vegetation does not render underlying soils immune from erosion, but the threshold for erosion of a vegetated bank is usually the point of breakage or uprooting of the plants rather than the threshold for movement of the soil particles. Vegetation failure usually occurs at much greater flow intensity than does soil erosion.

The stability of a waterway or the suitability of various channel linings can be determined by first calculating actual mean velocity and shear stress. These values can then be compared with allowable velocity and shear stress for a particular treatment application.

Mechanics of Stabilizing Streambanks

Treatments are designed for streambanks where engineered safety needs to be combined with ecological function and aesthetics. This means they incorporate live, source-identified, site-adapted, vegetation with various applications of structural materials to protect the streambank from the erosive forces of the river water. The material is flexible (i.e. forgiving of grading mistakes), yet strong and easy to use. These materials are typically used in strong currents, high-energy sites, on steep slopes as erosion control material, and revegetation units for difficult sites where energy conditions require an instant solution of strength and stability and simultaneous re-establishment of vegetation. Another prime criteria for

inclusion in this approach is that the treatments all minimize disturbance to the aquatic and the terrestrial riparian system during installation.

Coconut fiber coir blankets, mats, and logs that can be pre-vegetated with native plants are widely accepted and used as appropriate materials to protect erodible streambanks. However, for protecting streambanks that are exposed to the most severe erosive forces, a heavier engineering approach may be required. In the United States, since the advent of heavy machinery for moving earth and large rock, the use of large rock has become the most frequently applied solution in these placations. However, there is a cost effective, functionally effective, and aesthetically pleasing alternative that uses smaller rock (4-to-6 inch) compatible to, and readily available in, most river systems. This material is used throughout Europe to stabilize rivers. Rock roll and chambered rock mattress are products consisting of heavy duty polypropylene (environmentally inert) net casings that are filled at the site with suitably sized rock native to the local area and placed at the toe of the most vulnerable streambanks. Heavy equipment is required for installation.

Typical applications in Europe of the chambered rock mattress are on steep embankments with high erosive forces where engineered safety has to be combined with ecological function and aesthetics. Typical uses include:

- Toe protection
- Steep bank slopes (1:1.5)
- Channel liners and bridge aprons
- Submerged dams and shelves
- Reservoir inlet and discharge channels
- Filling-in of scour holes
- Jetties and guide dams
- Breakwaters
- Drainage layers

A sediment filter screen within the net casing of the rock roll and chambered rock mattress may be included that will allow the enclosed rock to collect sediment and become integrated into the natural streambank as rooting medium for vegetation, while blocking sediment from entering the stream. A great advantage of this method of protecting the streambank toe is the reduced need to disturb either the streambank or the channel bottom. These net casings containing smaller rock do not require digging of keyways and will conform to subsurface contours.

In moderate shear stresses/water velocities, rock rolls are another treatment, and they act as small, flexible, and permanent gabions. In turbulent flows, rock rolls are used to provide a solid foundation on top of which pre-vegetation coir rolls can be installed. The roots of plants then quickly grow into the voids of the rock rolls giving long term erosion control and bank support. Rock rolls that are installed below coir units can also be used to support a filter fabric or biodegrading matting. This system retains the fines in the streambank while the roots of the plants from the pre-vegetated coir units establish themselves into the streambank and through the woven geotextile into the suitable fill.

Traditional Approach

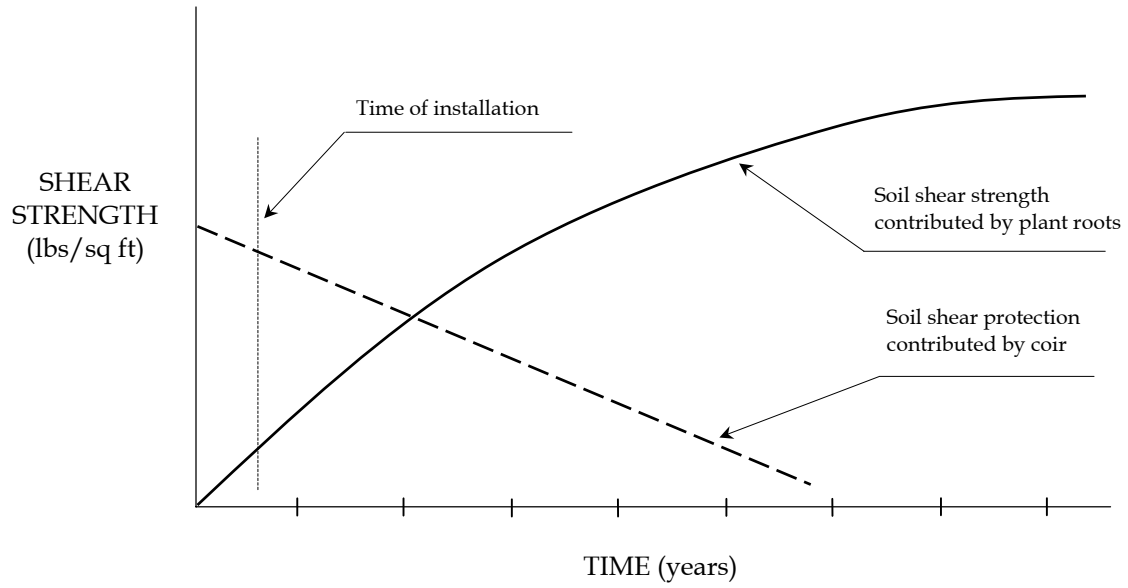
Traditional methods use a variety of methods for stabilizing various conditions of channel shear stress and flow velocity. Three typical levels of susceptibility to erosion and treatment types are:

1. Low to moderate (less than 3 to 4 feet per second velocity and less than 4 pounds per square feet shear stress), with treatment by revegetation
2. Moderate to high (less than 8 feet per second velocity and less than 6 pounds per square feet shear stress), with treatment by biotechnical methods (coir fabric, large rock toe protection, and revegetation)
3. High (exceeds 8 feet/sec velocity and exceeds 6 pounds per square feet shear stress), with hard structural treatment (rip-rap, with in-stream flow deflectors in some cases)

Bioengineering Approach

Commonly available bioengineered materials offer inherent resistance to shear stress on the order of 3 to 5 pounds per square foot. Several companies produce these materials in the form of logs in a variety of diameters for application along lines of high stress, and in mats for use on wider surfaces. These materials are available in several forms designed for particular applications in stabilizing disturbed sites with challenging potential for erosion. However, although these bioengineered materials (typically made of coir fiber from coconut husks) are very strong, they do biologically degrade over time, and are intended to supply stabilizing enforcement during the period necessary for live vegetation to become established and take over the mechanical soil stabilization duties (Exhibit B-2).

EXHIBIT B-2
Idealized relationship to show how over time the plant roots assume the entire role of reinforcing the soil strength to resist shear stress, as the coir biodegrades. Note that the actual strength is the sum of the two components, plus that of the soil's own cohesive strength.



Modern techniques have now been developed to grow the plants in the coir material in advance of application on site. In this way, the inherent strength of the coir is augmented from initial installation beyond the 3 to 5 pounds per square foot by whatever additional strength is also provided by the integrated roots of the live plants. These pre-vegetated coir products typically have the plants growing in the material for one growing season before installation on a project, so that the root systems of the plants are well developed and already providing substantial fiber strength and biomass to the coir product.

Unvegetated soil is generally strong in compression, but weak in tension. The fibrous roots of vegetation have the opposite characteristics; therefore, a composite of a soil permeated by plant roots has enhanced strength (Simon and Collison 2001). The amount by which plant roots augment soil strength varies immensely by species. According to Hoitsma and Payson (1998) vegetation resistance to shear stress is reported to vary from 0.35 to 8.50 pounds per square feet. Simon and Collison (2001), found that, even with the negative surcharge of the weight of trees, the net effect of adding riparian species to unvegetated banks was to double the effective strength when compared to unvegetated soil during a dry year (in Mississippi), using several species of riparian trees and grasses commonly used in revegetation projects in that region.

Goldsmith (1998) reports laboratory tests of strain resistance to shear stresses on blocks of riparian soil (medium sand texture) containing various kinds of plant root structures. These tests found that sedges increased resistance of the soil block to failure by a factor of 18.5 over a block of soil with no vegetation. Similar tests on a block with a single willow stem (0.6 inch diameter) and its associated sparse roots showed an increased resistance to failure by a factor of 3. A listing of ten studies measuring increases in soil cohesion due to the addition of roots of a variety of plant species shows universal increase that ranges from a factor of 2 to a factor of 17.5 (average increase = 5.7 times) (Coppin and Richards 1990). While we are less concerned with the load bearing strength of soils in the context of streambank stabilization and resistance to erosion, Goldsmith's comparison does reveal the magnitude of relative gains in soil strength contributed by the addition of plant roots. The following shear load to deform in pounds per square foot, according to Goldsmith, is as follows:

- Bare Soil (No Plant Roots): 64
- Soil with Sedge Roots: 1,184
- Soil with Willow Roots: 191

While every application is unique and all plant species differ in pertinent characteristics, we can be assured that integrating live plant roots into a coir product will significantly increase its inherent resistance to shear stresses. The intent is to transfer shear stress on the soil to tensile resistance of plant roots as a function of the interface friction along the root surfaces. This process can be greatly augmented and hastened by reinforcing a high-strength growth medium that comes with its own inherent resistance to shear stress. The tensile strength of plant roots also varies among species. Species of the genera *Salix* (willow), *Betula* (birch), and *Alnus* (alder) all have roots with tensile strengths in the range of 24.17 pounds per square feet to 27.92 pounds per square foot (Coppin and Richards 1990). Exhibit B-3 shows a comparison of properties of some of the different materials discussed above.

Pre-vegetated coir products described above can easily satisfy structural requirements for stabilizing streambanks in all but the most critical sites where public works infrastructure

installations have to be protected in place by absolutely rigid structures. These pre-vegetated coir products provide even further gains in protection of banks through the added friction to flowing water from roughness because the plants grow from the coir. This added roughness slows the water velocity at the critical surface boundary layer, and steadily increases in effectiveness over time.

EXHIBIT B-3
Comparison of Streambank Material Properties

Boundary Material	Critical Boundary Shear Stress (lb/ft^2)	Critical Water Velocity (ft/sec)	Reference
Bare Soils			
Sandy Loam	0.03 – 0.04	1.75	(Chang 1988)
Alluvial Silt	0.045 – 0.05	2	(Chang 1988)
Mixed Silt to Cobble	0.43	4	(Chang 1988)
Rock			
1-inch Gravel	0.33	2.5 – 5	(Chang 1988)
2-inch Gravel	0.67	3 – 6	(Chang 1988)
6-inch Gravel	2.0	4 – 7.5	(Chang 1988)
Large Rock (Rip-Rap) (D50 = 2 feet)	10.1	14 – 18	(Kouwen, Li, Simons 1980)
Gabion	10	14 – 19	(Goff 1999)
Rock Roll (16 – 20 in. diameter)	12 (estimate)	At Least 16	
Chamber Rock Mattress (1 feet thick by 5 feet wide)	15 (estimate)	At Least 16	
Vegetated Soil			
Long, Native Grasses	1.2 – 1.7	4 – 6	(Fischenich 2001)
Hardwood Trees	0.45 – 2.5	Unknown	(Fischenich 2001)
Bioengineering			
Coir Roll-Sod (Unvegetated)	5	15	(Santha 2003)
Coir Roll-Sod (Vegetated)	4 – 8	9.5	(Gray and Sotir 1996)
Coir Roll-Sod (Pre-vegetated)[a]	12+	At Least 15	(Di Pietro and Brunet 2002)
Coir Fiber Roll (Un-vegetated)	3 – 5	8 – 16	(Fischenich 2001, Santha 2003)
Coir Fiber Roll (Pre-vegetated)[a]	12+	At Least 16	(Di Pietro and Brunet 2002)

[a] Critical shear stress and water velocity are based upon values at installation. After installation, the roots of the plants grow into the streambank and the values increase greatly.

Anchoring the Critical Streambank Toe—Traditional methods typically offer a design utilizing large rock to anchor the streambank toe. The toe of the streambank slope is where shear stress is greatest against the streambank, and where streambank failure is most likely to happen. Angular rock is typically required for such applications to achieve stability. Most sources of such material are distant and expensive. A simpler solution utilizes smaller rounded rock, readily available within the floodplain, in rock rolls or rock mattresses. These are tubes of strong netting in various configurations that are filled with this smaller rock on site and laid in place to protect the streambank toe. The netting is typically made of an environmentally inert material that holds the rock in place 10 to 20 years, or until the banks are well protected by natural vegetation. Added benefits are that the rock used in the rock rolls is locally obtained in the valley and is round. This means that the rock is native to the floodplain and the round rock is similar to the rock in the streambed and that it will provide interstitial spaces for macroinvertebrate habitat, which are an indicator of water quality and

overall health. Large, angular rip-rap does not provide the same type and amount of such spaces.

Matching Streambank Stabilization Techniques and Materials to Site-Specific Criteria

The following paragraphs offer a general procedure for matching streambank stabilization techniques and materials to specific site applications in terms of actual erosion potential (Fischenich 2001).

Step 1: Estimate Mean Hydraulic Conditions

Flow of water in a channel is governed by the discharge, hydraulic gradient, channel geometry, and roughness coefficient. This functional relationship may be evaluated using normal depth computations that take into account principles of conservation of linear momentum, which take into account variations in momentum slope directly related to shear stress. Several models are available to aid in assessing hydraulic conditions. Notable examples include HEC-2, HEC-RAS, and WSP2. Channel cross sections, slopes, and Manning's coefficients should be determined based upon surveyed data and observed or predicted channel boundary conditions. Output from the model should be used to compute main channel velocity and shear stress at each cross section.

Step 2: Estimate Local/Instantaneous Flow Conditions

The computed values for velocity and shear stress may be adjusted to account for local variability and instantaneous values higher than mean. A number of procedures exist for this purpose. Most commonly applied are empirical methods based upon channel form and irregularity. Local maximum shear stress can be assumed from the following simple equations (Fischenich 2001):

$$\lambda_{max} = 1.5t \text{ (for straight channels)}$$
$$\lambda_{max} = 2.65(R_c/W)^{-0.5} \text{ (for sinuous channels)}$$

Where λ is the computed value of actual shear stress at a cross section, R_c is the radius of curvature, and W is the top width of the channel. These equations adjust for the spatial distribution of shear stress; however, temporal maximums in turbulent flows can be 10 to 20 percent higher. A further adjustment is needed to account for instantaneous maximums, and a factor of 1.15 is usually applied (Fischenich 2001).

Step 3: Determine Existing Stability

Existing stability should be assessed by comparing estimates of local and instantaneous shear and velocity to values for the materials available for use. Both the underlying soil and the soil/vegetation condition should be assessed. If the existing conditions are deemed stable and are in agreement with other project objectives, then no further action is required. Otherwise, proceed to Step 4.

Step 4: Select Channel Lining Material

If existing conditions are unstable, or if a different material is needed along the channel perimeter to meet project objectives, then the new material or stabilization measure should be selected by using the critical threshold values as a guideline. Only material with a threshold exceeding the predicted value plus safety factor should be selected.

Suggested Design Criteria for Clark Fork River Streambank Treatments

Exhibit B-4 shows the suggested maximum values of shear stress and flow velocity for the proposed streambank treatment designs for the Upper Clark Fork River.

EXHIBIT B-4
Allowable Maximum Values of Shear Stress and Flow Velocity for Bioengineered Streambank Treatment Designs

Treatment	Description	Maximum Allowable Shear Stress (lb/ft^2)	Maximum Allowable Flow Velocity (ft/sec)
Treatment 2	Pre-vegetated Coir	8[a]	9.5[a]
Treatment 3	Pre-vegetated Coir and Rock Roll	10[b]	15[b]
Treatment 4	Pre-vegetated Coir and Rock Mattress	12[b]	16[b]

[a] from Gray and Sotir (1996)
[b] from Di Pietro and Brunet (2002)

Examples of Streambank Treatments for Various Conditions

Once the data for various streambank reaches is completed and interpreted and the appropriate lengths of banks by classification is determined, appropriate streambank stabilization designs, depending on classification, can then can be determined. Components of the following designs includes a bio-engineering component for physically stabilizing the streambank and streambank toe if appropriate. Also included are revegetation plans for the riparian corridor that further serve to stabilize and protect the installed streambank erosion protection component but further serve to protect the riparian corridor from floodplain flow erosion as well. Over time, as these differing sizes of woody vegetation mature, both streambank and floodplain erosion protection will increase.

The following treatment designs are those designs developed as examples for the Upper Clark Fork River. Final decision on the actual design specifications will be made in the remedial design phase. As the streambank work progresses, site-specific designs or other designs will be necessary. The treatments are ordered from low shear stresses and flow velocities to high shear stresses and high velocities. The diagrams shown throughout this discussion are not drawn to scale.

1. **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.

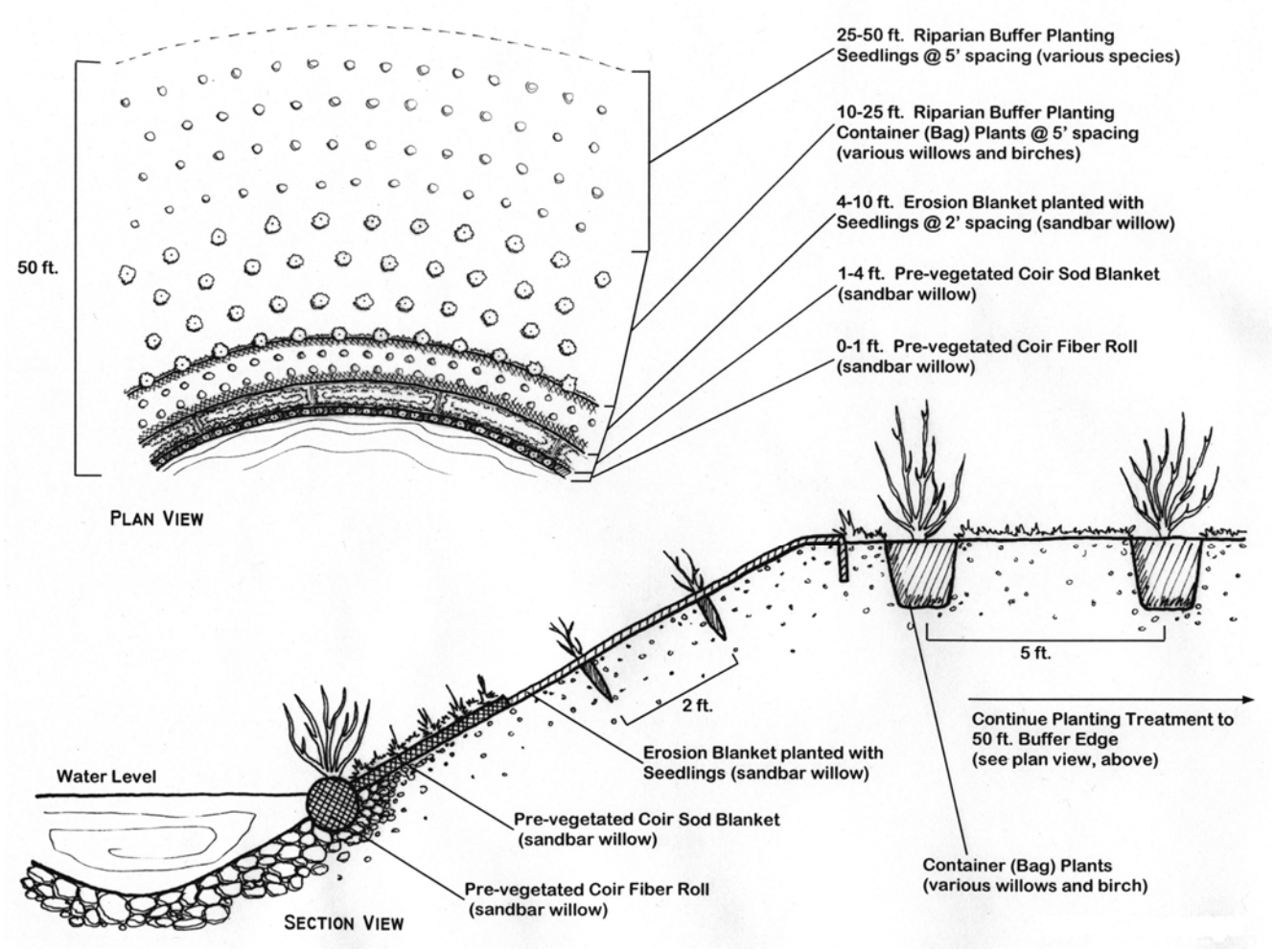
2. **Treatment 1 (vegetation augmentation)**—Augment existing vegetation with additional small-containerized plants. May require scalping and weed barriers for better survival. Assumption is that in this treatment, the average canopy cover of deep, binding woody vegetation is 50 percent. Therefore, the treatment will be the planting of 10 containerized plants at a level of 10 plants per 10 feet or 1 plant per linear feet of streambank. The mixture would be as follows:

- 25 percent *Salix exigua* (sandbar willow) wet areas
- 25 percent *Betula occidentalis* (water birch) wet areas
- 50 percent equal mixture of *Salix lutea* (yellow willow), wet areas; *Salix boothii* (Booth willow), wet areas; *Salix bebbiana* (Bebb willow), wet areas; *Alnus incana* (mountain alder), wet areas; *Cornus stolonifera* (red-osier dogwood), wet areas; *Prunus virginiana* (common chokecherry), dry areas; and *Amelanchier alnifolia* (western serviceberry), dry areas.

3. **Treatment 2 (low shear stresses/flow velocities)**—Pre-vegetated coir roll-sod with a toe protection of pre-vegetated fiber-rolls (comprised of sandbar willow [*Salix exigua*]) is considered Treatment 2 (see Exhibit B-5). Because of the sandy/gravelly streambank material (relatively unconsolidated in many places), the species mix for the roll-sods will be exclusively *Salix exigua* (sandbar willow). In other words, it is too sandy (therefore too droughty) for sedges to take hold. They need to have more silt/clay in the soil profile. Within the nominal 50-foot zone, the following will apply:

    a. 1-to-25 foot zone
        i. Pre-vegetated coir fiber-roll for toe protection (*Salix exigua* [sandbar willow]).
        ii. 3 feet of pre-vegetated coir roll-sod planted with *Salix exigua* (sandbar willow).
        iii. 6 feet of coir woven blanket (23 oz./square yard) planted with two rows of 10T containerized *Salix exigua* (sandbar willow) on a 2-foot spacing.
        iv. Three rows of bag plants of *Salix exigua* (sandbar willow) and *Betula occidentalis* (water birch) at a ratio of 2:1 (sandbar willow:water birch). The three rows will be on 5-foot spacing with the first plant at 10 feet and the last plant at 20 feet from the edge of the stream. These plants will be augered into the floodplain so that the roots are in constant contact with capillary fringe throughout the growing season.
        v. One row of bag plants of an equal mixture of *Salix lutea* (yellow willow), *Salix bebbiana* (Bebb willow), and *Salix boothii* (Booth willow).
    b. 25 to 50 foot zone
        i. Four rows of 10T containerized shrubs at a 5 foot spacing. The plants include *Salix lutea* (yellow willow) wet areas; *Salix boothii* (Booth willow) wet areas; *Salix bebbiana* (Bebb willow) wet areas; *Alnus incana* (mountain alder) wet areas; *Cornus stolonifera* (red-osier dogwood) wet areas; *Prunus virginiana* (common chokecherry) dry areas; and *Amelanchier alnifolia* (western serviceberry) dry areas.

EXHIBIT B-5
Streambank Treatment 2—Low Shear Stresses/Flow



4. **Treatment 3 (moderate shear stresses/flow velocities)—**Pre-vegetated coir roll-sod with a toe protection of pre-vegetated fiber-rolls comprised of *Salix exigua* (sandbar willow) on top of rock roll is considered Treatment 3 (see Exhibit B-6). Also included is tipped over mature willow on a spacing of 15 feet along the streambank to deflect and dissipate the energy of the stream. The design for the zone behind the immediate streambank work is the same as Type 2 Treatment.

   Exhibit B-7 illustrates the typical installation for the rock roll and pre-vegetated coir fiber roll.

EXHIBIT B-6
Streambank Treatment 3—Moderate Shear Stresses/Flow

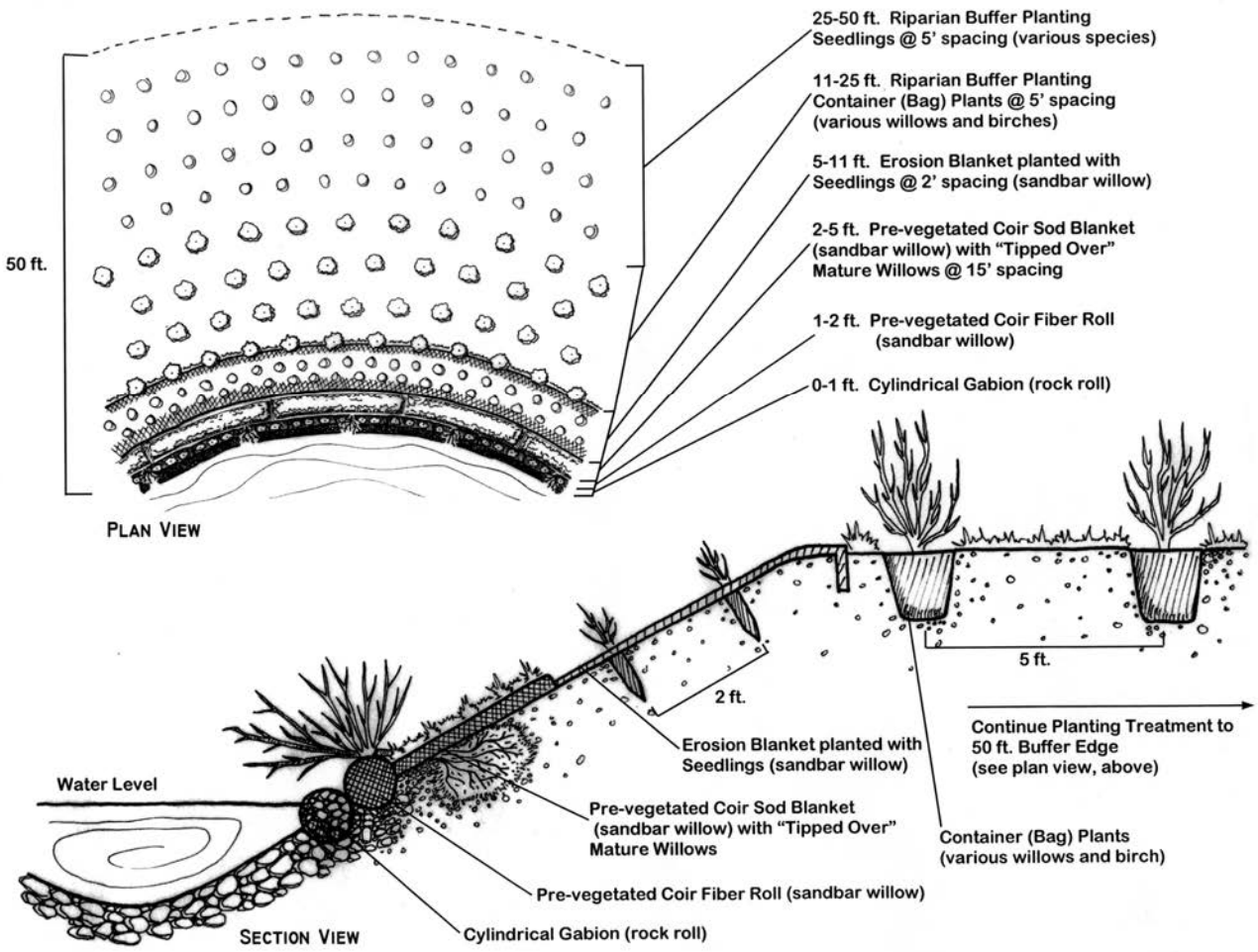
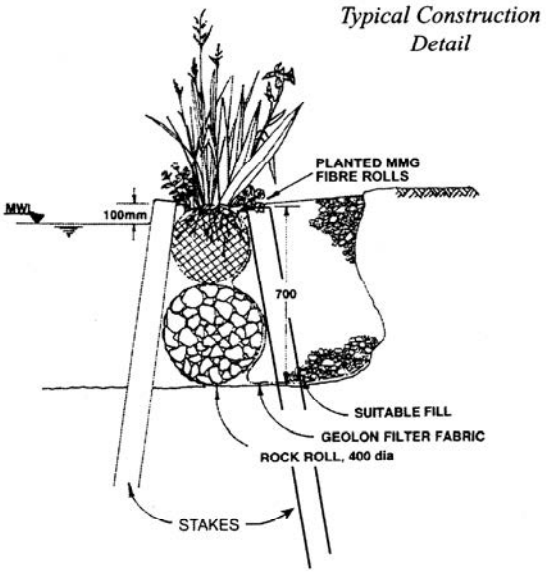
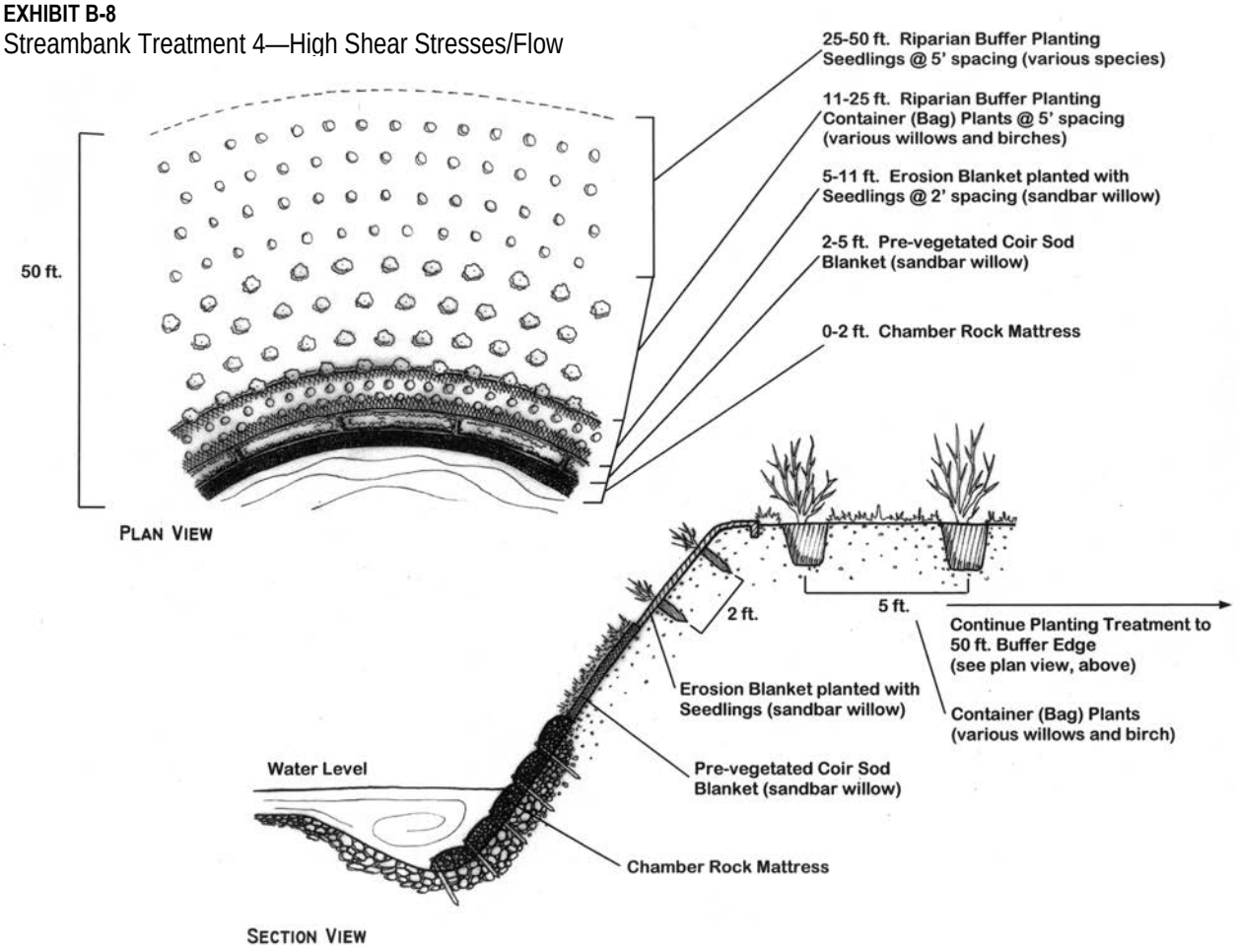


EXHIBIT B-7
Typical Construction Detail



5. **Treatment 4 (high shear stresses/flow velocities)**—Pre-vegetated coir roll-sod with a toe protection of rock mattress is considered Treatment 4 (see Exhibit B-8.) Also included is tipped over mature willow on a spacing of 15 feet along the streambank to deflect and dissipate the energy of the stream. The design for the zone behind the immediate streambank work is the same as Type 2 Treatment.

EXHIBIT B-8
Streambank Treatment 4—High Shear Stresses/Flow



Bio-Stabilization

As shown in the illustrations above, willow sprigs planted near the edge of the river and tipped-over willows (which deflect water flow away from the streambank) are to be the first structures to stabilize the banks of the river. Additional stabilization is achieved by planting "bagged" willows and mature willow transplants. These four types of bio-stabilization are implemented within the first 25 feet away from the river streambank. The second 25 feet away from the streambank is planted with additional bagged willows, and other woody vegetation including chokecherry, red dogwood, alder, serviceberry, water birch, and others. The intensity of woody plants is less for inside bends compared to outside bends of the river. Herbaceous communities are also to be established within this zone to provide riparian pastures for use by livestock and wildlife. This approach will provide herbaceous forage production for the landowner and maximum growth of woody vegetation to protect

against erosion, soil loss, and floodplain deformation. A key component in establishing successful woody and herbaceous vegetation within the riparian corridor buffer will be supplemental irrigation for 2 to 3 years following implementation. This will provide optimum growth of these stabilizing plants, thereby reducing the time to attain streambank stability, as well as overall floodplain stability. In addition, supplemental irrigation will hasten establishment of grasses and forbs, and retard the invasion of unwanted plant species, specifically weeds.

Salix exigua (sandbar willow) is considered either an obligate wetland species or a facultative wetland species. Therefore, *Salix exigua* (sandbar willow) needs to be close to the water table to survive. If supplemental watering is not available, planting depth of the root-control bags can be adjusted to compensate. The planting depth should be deep enough so that the plant is in constant contact with the capillary fringe throughout the growing season. Planting *Salix exigua* (sandbar willow) at this depth will not affect the health of the plant. *Salix exigua* (sandbar willow) evolved in an environment where sediment deposition of up to 1 to 2 meters after a single high flow event (e.g., flood) can occur. When this happens, the plant develops new roots along the entire length of the buried stems. Therefore, augering the holes deeper can be used to compensate for supplemental watering concerns.

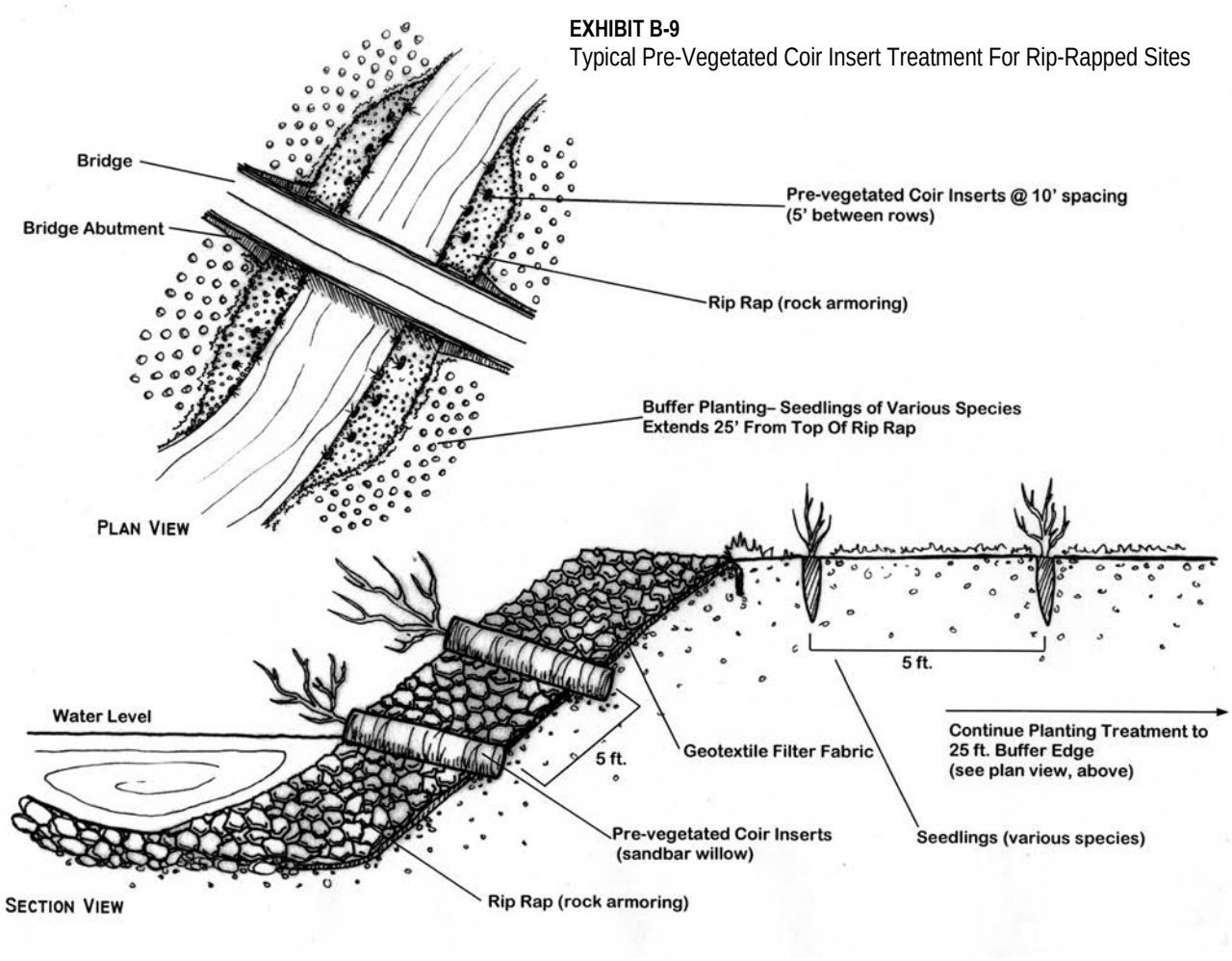
Additional Possible Streambank Treatments

The following examples are possible treatments for unique locations along the upper Clark Fork River. They have not been included in the cost analysis for the river.

1. **Modification of Existing Rip-Rap**—Existing rip-rap can be supplemented with pre-vegetated coir inserts (comprised of *Salix exigua* [sandbar willow]). Currently, rip-rap is associated with public infrastructure, such as bridges, irrigation diversion ditches, sewage lagoons, City of Deer Lodge, etc. The pre-vegetated coir inserts will be two rows, with the first row near the water level for the middle of the summer and another row 5 feet higher on the rock. The inserts will be spaced at 10 foot intervals. Behind the rip-rap, those areas outside an immediate transportation corridor right-of-way will include a buffer of 25 feet with four rows of 10T containerized shrubs at a 5 foot spacing. The plants include *Salix lutea* (yellow willow), wet areas; *Salix boothii* (Booth willow), wet areas; *Salix bebbiana* (Bebb willow), wet areas; *Alnus incana* (mountain alder), wet areas; *Cornus stolonifera* (red-osier dogwood), wet areas; *Prunus virginiana* (common chokecherry), dry areas; and *Amelanchier alnifolia* (western serviceberry) dry areas. See Exhibit B-9.

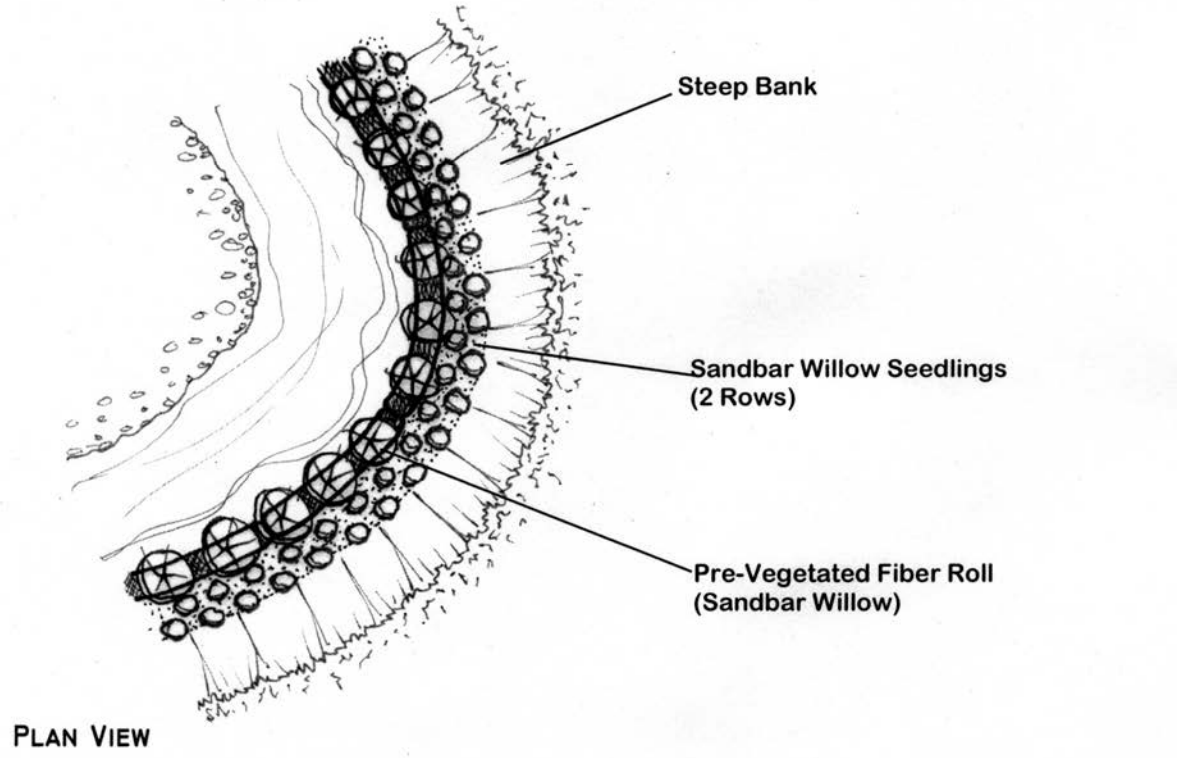
2. **In-stream Flow Deflectors or Low Rock Barbs**—See the Atlantic Richfield Company's Type 4 streambank stabilization option for a drawing of this type of structure (2002, *Feasibility Study,* Figure 5-12). (In the *Feasibility Study*, the Company does not include a cost estimate or a linear foot estimate.)

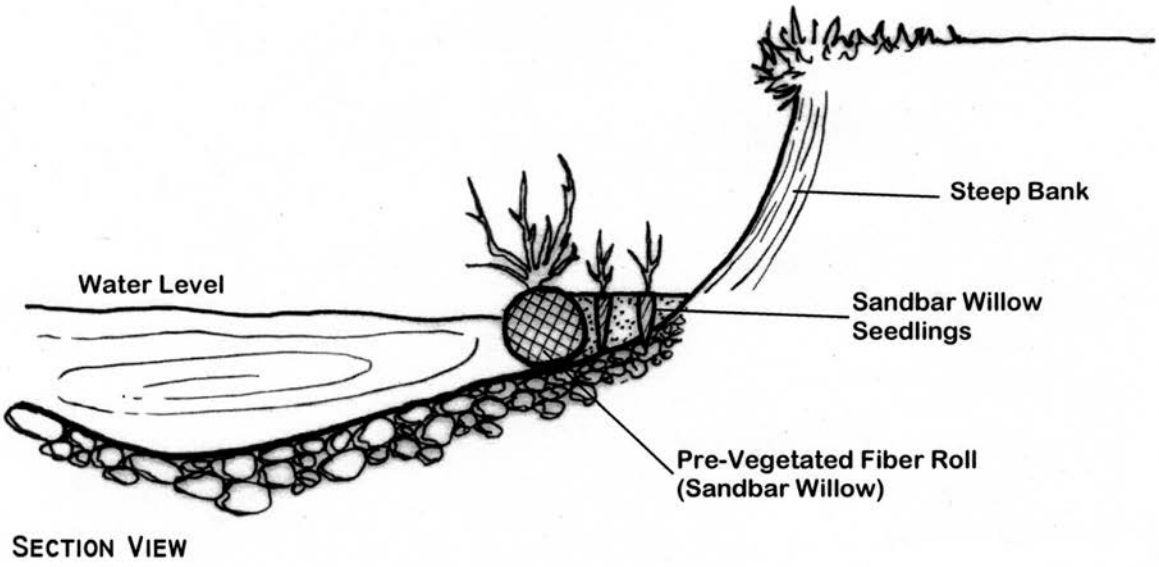
EXHIBIT B-9
Typical Pre-Vegetated Coir Insert Treatment For Rip-Rapped Sites



3. **Pre-vegetated Coir Fiber-rolls (comprised of *Salix exigua* [sandbar willow])**—Used along the base of high eroding banks. Immediately behind the fiber-rolls are two rows of small-containerized plants comprised of *Salix exigua* (sandbar willow). See Exhibit B-10.

EXHIBIT B-10
Typical Pre-Vegetated Coir Fiber Roll Treatment For Steep Banks





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Clark Fork River Operable Unit

of the Milltown Reservoir/Clark Fork River Superfund Site

Record of Decision

Appendix C:

Clark Fork River OU BMPs and Riparian Management Plan Considerations

U.S. Environmental Protection Agency
Region 8

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April 2004

APPENDIX C

Clark Fork River OU BMPs and Riparian Management Plan Considerations

Developing an Effective Riparian Grazing Management Plan

Benefits Of Proper Riparian Management To Ranchers

1. Water storage and availability
2. Increased vegetation
3. Better forage quantity and quality
4. Flood protection and reduction
5. Reduced streambank erosion
6. Increased water quality
7. Shelter for livestock
8. Acceptance and "security"

General Principles For Grazing Livestock In Riparian Zones

1. Tailor the approach to the specific situation and landowner objectives (have clearly defined goals and objectives).
2. Incorporate riparian management into an overall plan.
3. Select season of use so grazing occurs, as often as possible, during periods compatible with animal behavior, conditions in the riparian zone, and riparian objectives.
4. Determine *riparian* objectives.
5. *Monitor* change.
6. Limit livestock time in pastures with riparian areas.
7. Control (influence) distribution of livestock within a pasture.
8. Ensure adequate residual vegetation cover.
9. Provide adequate regrowth time and rest for plants.

Be actively involved by:

1. Determine an appropriate season for grazing a specific riparian zone.

2. Use various methods for reducing intensity and use in the riparian area through control and distribution of livestock within a pasture.

Techniques for Controlling Distribution of Livestock

1. Offstream water development
2. Stable access points
3. Salt and mineral block placement
4. Improve upland forage
5. Riding/herding
6. Drift fences
7. Turn-in location
8. Smaller pastures with a riparian area in each
9. Fencing: permanent or temporary

Early Season (Spring) Ranchers

Best Used When:

1. Succulent forage in the uplands that discourages livestock impacts in the riparian zone
2. Temperatures encourage livestock to stay out of the riparian zone
3. Wet soils discourage livestock use
4. Well-drained soils reduce soil compaction

Potential Advantages:

1. Less soil compaction and streambank shearing *if* livestock use is minimized
2. Provides time for regrowth of riparian and upland vegetation
3. Less browsing pressure on woody vegetation

Possible Drawbacks:

1. High potential for soil compaction, trampling, and erosion
2. Has potential for reducing plant vigor thereby changing plant community composition
3. Upland forage nutrition may be low
4. High potential to affect wildlife

Late Season (Fall) Grazing

Best Used When:

1. Mostly herbaceous plant communities rather than woody communities

2. Palatable cool season forage in uplands
3. Offstream water available or other conditions draw livestock out the riparian zone

Possible Benefits:

1. Drier conditions on the floodplain reduce soil compaction, streambank shearing, and erosion
2. Plants have a completed growth cycle (e.g., set seed)
3. Less impact on wildlife.

May be Detrimental When:

1. No regrowth due to soil moisture and temperature
2. No incentives to induce livestock to move out of the riparian zone
3. When woody species maintenance and regeneration objectives are not met

Hot Season (Mid-Summer) Grazing

Least Likely to be Negative When:

1. Conditions are closely monitored and grazing period is limited in duration and frequency
2. Actions taken to induce livestock to move out of the riparian zone
3. Opportunities are provided for regrowth based upon time of removal, climatic conditions, and frequency of use

Possible Disadvantages:

1. Greater tendency to hang in the riparian zone
2. More intense use may reduce plant vigor and change plant communities
3. Damage to trees and shrubs

Potential Advantages

1. Drier and more stable soils and streambanks
2. Potential for regrowth after hot season cessation of growth by plants
3. Palatability of riparian forage is greater than upland plants

Winter Grazing

Especially Beneficial When:

1. Pasture is large enough to feed away from the stream
2. Cold drainages or south-facing slopes reduce riparian use
3. Soil compaction, streambank shearing is more likely during other periods

Possible Advantages:

1. Minimal soil compaction and streambank damage—provided the livestock are removed before the soils/streambanks thaw
2. Livestock use will not affect plant development (plants are dormant)
3. Livestock distribution is easily influenced by location of feed and water

Possible Detrimental Impacts:

1. Grazing of dead material can reduce streambank protection and sediment trapping in the spring when run-off occurs
2. Browsing and physical damage to woody plants may be high

Conclusion of Good Riparian Management

1. What operators do to encourage livestock not to loiter in the riparian zone while they are in a pasture is more important than either season of use or length of time in the pasture per se.
2. Two common threads for good riparian management:
   a. Presence of offstream water developments; and
   b. Operator involvement.
3. Many useful techniques were not tied to any particular grazing "system."

Thus, riparian grazing might be incorporated into each of the traditional grazing systems, except season-long, ***as long as the condition of the riparian zone itself remains of primary concern.***

Management, not the system, is the key.

Developing a Riparian or Wetland Management Plan

An objective is defined as something toward which effort is directed; an aim or end of action. Objectives should contain the following five elements (e.g., five W's): 1) who, 2) what, 3) when, 4) where, and 5) why. For example, the John Doe Ranch (who) will provide for survival and recruitment of cottonwood trees from a frequency of 0 percent (what) in 2004 (when) to a frequency of 5 percent (what) in 2009 (when) along Big Creek in the Longhorn Pasture (where) to provide for future perching/resting sites for great blue herons (why). Do not confuse the management practice to achieve an objective (how) with the elements of the objective.

Once objectives have been clearly defined, the next step is to develop a management plan. The following discussion uses riparian or wetland areas as an example in how a management plan is developed and monitored.

Introduction and Development of a Plan

A management plan based only on objectives related to non-riparian (uplands) or wetland areas does not usually result in maintenance or improvement of riparian or wetland areas. Therefore, where maintenance or improvement of riparian or wetland areas is desired, the land use plan, activity plan objectives, and management prescriptions must be determined specifically for the riparian or wetland features while considering the needs of the entire watershed. The establishment of specific objectives, description of the desired plant community, and selection of key species should be an interdisciplinary effort. Management objectives need to be focused, achievable, measurable, repeatable, have a starting and ending point in time and location, be reasonable, clear, concise, and affordable. In short, management objectives need to have realistic and attainable goals. In addition, they should be dictated by the present condition and trend of the riparian or wetland habitat in relation to management goals, the resource potential for change, and the importance of other resource values. Major considerations in establishing management objectives in riparian or wetland areas should include the following:

1. Vegetation
    a. The potential of the site (that is, the riparian or wetland plant association).
    b. The desired plant community.
        i. If the potential of the site is woody vegetation, then the health and reproduction of woody vegetation should receive equal consideration as the herbaceous vegetation (depending on the riparian or wetland objectives). If one of the objectives for a riparian or wetland area is streambank stability, then woody vegetation vigor should be of utmost importance due to the vastly different streambank stability protection afforded by the woody vegetation when compared to the herbaceous vegetation.
        ii. The development and/or maintenance of different age classes (for example, seedlings, saplings, poles, and mature for trees; seedlings, saplings, and mature age classes for shrubs) of the key woody plant species on the site to maintain a viable plant community. (Once again, only if the potential of the site is for woody vegetation.)
        iii. The type of vegetation cover necessary to minimize the erosive effects of run-off events.
        iv. The vegetation structure necessary for wildlife cover diversity.
    c. The stabilization of streambanks.
    d. The value of the site for forage production.
    e. The amount of vegetation stubble required to trap and hold sediment deposits during run-off events to rebuild streambanks and restore/recharge aquifers. It is important to realize that on streams with high gradients and low silt loads, it is more difficult to improve them than those with low gradients and high silt loads (that is, mud management).

   f. The kind and amount of "weedy species" present. The more persistent and difficult the weedy species are to control, the more limited the management opportunities. Therefore, proper understanding of the ecology of weeds present will help the manager(s) make realistic and attainable goals.

2. Water Quality/Quantity Issues

   a. Raising the elevation of the present water table and expanding the sponge effect.

   b. The improvement or maintenance of water quality and quantity or change in the timing of the flow.

3. Streambank Stability

   a. The establishment of proper stream channels, streambanks, and floodplain conditions and functions.

   b. The maintenance of long term adjustment processes that may affect channel or wetland conditions. These processes include sediment deposition, streambank development, floodplain development, and stream dynamics (meandering).

4. Wildlife

   a. The improvement or maintenance of the fishery habitat.

   b. The importance of the riparian or wetland community to riparian or wetland dependent wildlife and to wildlife species that occur primarily on upland sites but are periodically attracted to riparian or wetland areas.

5. Other

   a. The aesthetic values of a healthy riparian or wetland zone.

   b. The period of time that is acceptable or necessary for riparian or wetland rehabilitation/restoration.

   c. The reduction of upland erosion and stream sediment load and the maintenance of soil productivity.

Implementation of the Plan

Once a management plan has been written, the following steps should be taken:

1. Implement the management plan.

2. Design a monitoring plan that will evaluate the effectiveness of the management plan and provide information for identifying the cause of any failures. Monitoring needs to be done at the initiation of management plan in order to establish a baseline or "starting point."

3. Monitor the site or the stream reach over time. Management must be flexible enough to accommodate changes based on experience. Mistakes need to be documented and not repeated elsewhere.

4. Once the management plan is in progress, the most important element is frequent supervision.
5. Determine the outcome of the management plan. If it is successful, then proceed with the existing management plan. If the plan was either a partial or complete failure, then modify the management objectives. *Remember, mistakes need to be documented and not repeated elsewhere.*

Developing the Monitoring Plan

Key Areas—As objectives are considered and developed for riparian or wetland areas, key areas for monitoring must be located in representative portions of the riparian or wetland areas as well as in the uplands. These key areas will indicate where appropriate monitoring will be conducted and will provide the basis for decisions as to whether management objectives are being met or not. Key areas must possess (or have the potential to produce) all the specific elements in the objective(s) because these will provide data for evaluation of management efforts. In many cases, it is appropriate to select the key areas first and then develop objectives specific to each.

Key Plant Species—Key plant species will vary with the potential of each individual site. Selected key plant species should be those that are necessary to the operation of the natural stream functions. The type of vegetation present will affect channel roughness and the dissipation of stream energy. Willows and other large woody vegetation (trees) filter large water-borne organic material, and their root systems provide streambank stabilization. Sedges, rushes, grasses, and forbs capture and filter out the finer materials while their root masses help stabilize streambanks and colonize captured sediments. On sites where the potential exists for both woody and herbaceous vegetation, the cumulative effect of plant diversity greatly enhances stream function. Finally, it is essential that the physiological and ecological requirements of the key woody species, along with key herbaceous species, be understood so that a proper management program can be designed. This includes determining the effects of grazing/browsing on the particular growth characteristics of the species involved.

Utilization Guidelines (if appropriate)—Utilization target guidelines are a tool that can be used to help ensure that long-term objectives are met. Utilization levels of browse or forage can be monitored annually, or more often; whereas progress in reaching long-term resource objectives (such as streambank stabilization, rebuilding of the streamside aquifer, and the re-establishment of beaver, fish, moose, or other big game habitat) can only be determined over a longer period of time. The accomplishment of these long-term objectives relates directly or indirectly to the need to leave a certain amount of vegetation available for other functions (soil stabilization, trapping sediment, wildlife cover, or forage). Utilization monitoring provides a means of insuring that the necessary amount of vegetation is left to protect the site and provide for reaching other vegetation-dependent objectives.

Summary

The establishment of utilization targets for riparian or wetland key plant species and the management of browsing/grazing to ensure these targets are met are critical factors involved in proper riparian or wetland area management. The establishment of utilization

targets requires that the manager know the growth habitats and characteristics of the important plant species for which they are managing and how the plant species respond to browsing and grazing. The manager must know the characteristics, preferences, and requirements of the grazing/browsing animals. Therefore, utilization targets should be developed for riparian or wetland areas that:

1. Will maintain both woody species and herbaceous species in a healthy and vigorous state and promote their ability to reproduce and maintain different age classes in the desired riparian or wetland plant community.
2. Will leave sufficient plant residue necessary to protect streambanks during run-off events and provide for adequate sediment filtering, and dissipation of flood water energy.
3. Are consistent with other resource values and objectives (such as aesthetics, water quality, water quantity, and wildlife populations).
4. Will limit streambank instability to acceptable levels.

In many instances, proper utilization guidelines can only be derived over time through trial and error by monitoring, analyzing, and evaluating the results. Initial results may be different than expected. The manager should not hesitate to make changes in key species or utilization guidelines where required to meet objectives.

When establishing utilization targets to ensure riparian or wetland area improvements, guidelines should be considered that will provide a margin of safety for those years when production is less than average. This could take the form of reduction in the utilization targets for both riparian or wetland areas and upland areas to provide additional carryover forage and vegetation necessary for streambank protection and sediment filtering. The importance of providing for adequate vegetation vigor and regeneration at the end of the growing season can not be emphasized enough.

Finally, because of the variation in riparian or wetland sites and management, one standard utilization target is not appropriate. However, utilization should be considered, together with regrowth potential, to ensure the presence of vegetation stubble necessary to the operation of natural stream functions or accomplishment of other land use objectives.

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Record of Decision

Appendix D:

Clark Fork River OU Weed Prevention and Management Planning Information and Weed Species Fact Sheets

U.S. Environmental Protection Agency
Region 8

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April 2004

APPENDIX D

Clark Fork River OU Weed Prevention and Management Planning Information

Invasive Plant Species Prevention

Invasive plants specialize in colonizing disturbed ground. They possess a number of physical traits that allow them to arrive at disturbed sites sooner and grow faster than other plants. With these advantages, they are able to out-compete native species, at least for a time. To counter this, EPA plans to avoid disturbing existing vegetation whenever possible. Such disturbance exposes the soil surface and reduces desirable vegetation, creating ideal opportunities for weed colonization. If disturbance cannot be avoided, all disturbed areas would be re-seeded or re-planted immediately. Native species or carefully chosen non-invasive introduced species will be used so that "vacant" or bare ground is quickly occupied by desirable plants.

Weeds also invade plant communities that have been degraded by land management practices that expose the soil surface and stress the desirable vegetation. Healthy native plant communities resist weed invasion. One of the best ways to avoid damaging plant communities is to manage livestock grazing to maintain good vigor of native perennial vegetation, especially grasses. Recreationists can also damage vegetation by overusing popular camping areas and creating trails. Dense, vigorous stands of perennial grasses are highly resistant to weed invasion. However, certain very aggressive weeds such as leafy spurge (*Euphorbia esula*), spotted knapweed (*Centaurea maculosa*), and Canada thistle (*Cirsium arvense*) can invade even well managed lands that have dense, vigorous vegetation.

All remedial activities on a property will follow strict guidelines for preventing the spread or introduction of invasive species to the site. Specific practices designed to avoid transporting weed materials and introducing weeds will be strictly followed and monitored. These will include the following:

- Educating all project personnel in weed identification and prevention. Local Weed Boards, such as the Powell County Weed Board can provide assistance in this process.
- Ascertaining that all equipment used in remediation (including all vehicles and digging tools) be thoroughly washed and inspected for plant matter before entering the OU, and before entering a new property or new site.
- Requiring adherence by all personnel on site to prescribed practices for prevention of weed dispersal.
- Minimizing movement of personnel and vehicles on the property, and limiting access to specifically identified necessary routes, parking, and staging points.
- Designing all work to minimize soil surface disturbance.

- Re-vegetating all disturbed soil surfaces with appropriate vegetation (e.g., native species, including agronomic varieties for rangelands, and appropriate species for croplands, such as alfalfa) to deny opportunity to invasive species.
- Identification and control of pre-existing weed populations on the site to remove nearby sources of invasive species.

Integrated Weed Management Monitoring and Evaluation Plan

Factors to Consider

If a monitoring program is simple and straightforward, it is more likely to be completed and to provide useful information. The effort you invest in monitoring depends on what could happen if your management actions are not working or are counter productive. A higher risk of failure means more effort should go toward monitoring. For example, using high densities of livestock to control weeds requires close and frequent attention to the forage available to avoid overgrazing. Also, eradicating high-priority weed species may require more monitoring than the suppression of low-priority species because eradication of high-priority species will be a much more important goal.

Monitoring, like weed control, is an ongoing process. Although the information gathered in the early days of a monitoring study is certainly valuable, its value is enhanced by comparison with every future piece of data. Even a simple monitoring program may not yield easily interpreted results with the first few repetitions. However, the likelihood of detecting useful trends increases with each year of monitoring.

One of the limitations of most monitoring programs is their inability to determine cause and effect. Although monitoring data can tell you if a weed species decreased in abundance, the data cannot definitely tell you if your weed control actions *caused* the decline. It is possible that a decline in weed abundance would have happened anyway, due to unfavorable weather or other factors. Determining cause and effect requires replicated, controlled experiments where all relevant factors are closely controlled except for one that is varied. Such experimentation is normally performed by university, government, and industry researchers, and is not usually practical for private landowners or public land managers. However, there are some places where land managers could conduct experiments; for example, testing whether two weed treatments differ in their ability to control a weed species.

Setting Monitoring Priorities

Using your previously identified high-priority weed species and infestations, decide which of the species and infestations you will monitor, based on the number of weed species and weed infestations and the resources at your disposal. In addition, you need to decide how intensively to monitor the species and infestations, that is, how much effort you are willing to devote to monitoring.

Establish a minimal level of monitoring for each high-priority weed species and high-priority weed infestation in each of your weed management units. In addition, you should establish a system of recording and tracking herbicide applications and bio-control releases.

We suggest that you monitor at least:

- Two sites where each high-priority weed species occurs
- One high-priority weed patch

There will probably be some overlap in the above categories that will reduce your monitoring work. For example, if one of your high-priority weed species is Canada thistle (*Cirsium arvense*) and two of your high-priority weed infestations are patches of Canada thistle (*Cirsium arvense*), monitoring those two patches would satisfy your minimal monitoring needs for Canada thistle (*Cirsium arvense*).

Designing Monitoring Actions

The challenge of monitoring is to find a balance between the time and money spent monitoring and the value of the information you expect to obtain from monitoring. There is a direct relationship in monitoring between the time required to collect information and your ability to determine if your weed control objectives are being met. If you spend less time collecting and analyzing monitoring data, you will be less able to evaluate your weed management actions. Conversely, if you spend more time and money monitoring, you will have a better idea if you are meeting weed management objectives.

The methods used to monitor the high-priority weed species and infestations depend on weed management objectives. Thus, the complexity of monitoring depends on what you need to know to determine if weed management objectives are being met. Examples of several weed management objectives and monitoring methodologies are presented below. Note that many of the monitoring actions are very simple and their "analysis" is largely self-evident. Keep monitoring actions as simple as possible to increase the likelihood that you will actually monitor your weeds and understand the results of the monitoring. Most private landowners will not need to conduct complicated monitoring programs involving formal statistical tests, and will not need to monitor as many plots.

Review your weed management objectives to see if you can re-word them so they can be evaluated with simple monitoring actions. Make sure your objectives specify time, numbers, and location.

Written Records

The most basic form of monitoring consists of taking careful notes of:

- Sizes of the high-priority infestations and the general abundance of the weeds in those infestations.
- General extent and abundance of the high-priority weed species that are not found in the high-priority infestations.

For weed management objectives that specify eradicating a patch of weeds, the only monitoring required it to note whether the patch is present or not. A few sentences in a field notebook will be sufficient documentation. Consider buying a field book of the type that surveyors use. These books are very sturdy and will last for years. A very simple way to monitor weeds is to use a tape recorder to record observations while you drive, ride, or

walk around your property. You can transcribe the tapes during the winter when you are not as busy.

Photographic Records

Photographs can be extremely useful in documenting changes in weeds over time, especially if they are taken from permanent locations (called photo points) each time. Photographs work best for monitoring weed species, which can be easily distinguished from other plants during flowering. Examples of these types of species include leafy spurge (*Euphorbia esula*), whitetop (*Cardaria draba*), Dalmatian toadflax (*Linaria dalmatica*), and spotted knapweed (*Centaurea maculosa*).

Photo points can be established adjacent to high-priority weed infestations since these sites are likely be relatively small. Carefully select the location of the photo point so that all or nearly all of the area can be seen from the photo point. Mark the location of the photo point with a permanent marker to enable it to be relocated for subsequent monitoring photographs. Sturdy red 18-inch plastic stakes (Plastake®) are also available from mail order outlets such as Ben Meadows or Forestry Suppliers.

Take photographs when the target weed is most visible, usually during the period of peak flowering. Try to include obvious background features such as fences, trees, cliffs, and distant mountains as an aid to repeating the photograph with the same scene every year. Carry prints of last year's photographs mounted in plastic sleeves in the field, to help you frame the scenes correctly and to provide instant visual comparisons of weed abundance. One or more photographs may be taken at each photo point depending on the place. Use a 35-mm camera with color film or a digital camera. Note the locations of the photo points on your weed map with an arrow showing the direction of the photograph, and give each point a unique number. Keep a log of pictures taken (possibly in the field notebook), matching the number of the exposure with the number of the photo point and the scene being photographed. Write the photo point number and the date on each developed photograph or slide as soon as you receive them otherwise you may forget to do it. Cameras that automatically include the date in the picture are handy for photo monitoring.

Test Monitoring Actions

Monitoring actions should be tested to see if they will really work in the field. Often ideas that seemed great in the office do not work very well in the field. Testing your monitoring methods before embarking on your monitoring program can save time and money in the end. It is much easier to redesign a monitoring protocol after a failed test than to redesign the program half way through the monitoring period. Questions to consider during the pilot phase of a monitoring program include:

- Will the data collection methods really work in the field? You may discover that it is not practical to count certain species to estimate density, or that thick vegetation prevents sampling plots from being laid out uniformly. Permanently marked plots may not be easy to relocate after all. Such problems need to be identified and corrected before you commit large amounts of time and resources to a monitoring program.
- Is the cost and time of performing monitoring acceptable? You may discover that it takes too long to collect the data called for in your original monitoring design, or that

monitoring actions are too expensive. It is important to design a monitoring program that you can afford to implement. A less ambitious program is better than none at all.

- Will the observations allow you to detect changes? Given the constraints of field methods, time and money, the bottom line is whether or not the monitoring will allow you to evaluate the effectiveness of weed control actions.

Keep in mind that the usefulness of monitoring arises from its repeated nature. You must continue to monitor to detect changes, which will affect your management decisions.

Implement the Monitoring Plan

The most critical step in any monitoring program is to begin doing it. If you do not do the monitoring, you will not be able to determine if you are meeting your weed management objectives. Monitoring will save you money by insuring that your control efforts are as effective as possible. After you begin monitoring, perform the following cycle of tasks:

1. Perform monitoring by collecting field data according to plan.
2. Analyze and evaluate monitoring results immediately after each data collection.
3. Determine whether weed management actions need to be revised, given the results of monitoring analysis.
4. Implement weed management actions again, revise as necessary.
5. Evaluate monitoring actions (analyze data), revise as necessary.
6. Begin the cycle again.

Whenever possible, share the results of your monitoring with other weed managers, and help to build a base of weed control knowledge that others can use in the fight against noxious weeds. Do not over-respond to your monitoring results. You may need to give a treatment method more than one year of trial. Check with other land managers in your area to see if it was a particularly "good" year for your weed species.

Do not forget to include repeated reconnaissance for new weed species and infestations in your monitoring program.

Information on monitoring and evaluation used is from a variety of sources including the Center for Invasive Plant Management (CIPM) at Montana State University (2003) and the Colorado Department of Agriculture (2000). Monitoring is an essential component of a weed control program. Monitoring is the repeated collection and analysis of information to evaluate progress in meeting resource management objectives. Periodic observation of weeds being managed is necessary to evaluate the effectiveness of a weed control program. Monitoring saves money by helping to determine what is working and what is not.

Integrated Weed Management Options

The *Record of Decision* for the Clark Fork River Operable Unit (OU) states that on each remedial site, a plan for management and control of invasive species will be written to address those weeds already present, as well as the potential for further invasion. Taken into account will be the unique set of physical site and managerial factors identified for the

property in consultation with the landowner and other involved parties. This plan will be designed as an Integrated Weed Management approach based on the invasive species identified. It will draw from individually prescribed practices for each weed species using such types of options as those described herein (CIPM 2003, Colorado Department of Agriculture 2000).

Cultural Control

Cultural control seeks to control weed problems by establishing desired plant species in healthy populations that will deny opportunity for weed establishment. Cultural techniques include manipulating the plant community through seeding desired species, planting of established containerized material, and cultivating areas previously invaded by weeds (cutting through and turning over the soil, re-seeding, fertilizing and irrigating).

Best suited for:

- Large construction projects. Cultivating is often necessary to reduce the number of weed seeds in the soil before planting desirable plant species. Cultivating for a year prior to reseeding kills weeds that have sprouted since the last cultivation and progressively reduces the bank of weed seeds.
- Re-establishing native plant communities on disturbed or depleted areas so desirable plants can prevent or reduce weed infestation.

Limitations include:

- Cultivating is appropriate only for restoration of drastically disturbed sites.
- Lack of seeds from locally adapted plants.
- Lack of seeds of certain native species, especially forbs and shrubs.

Pitfalls include:

- Seed mixes may be contaminated with weed seeds.
- Cultivation may result in wholesale germination and establishment of weed species if there is not adequate follow-up weed control.
- Temporary cover crops such as wheat, rye, or barley used to reduce soil erosion must be mowed or grazed to eliminate their seed production.
- Promoting weed growth by adding unneeded nitrogen fertilizers. Native plant species are generally adapted to low-nitrogen conditions, while weed species are adapted to high nitrogen conditions. Only add nitrogen fertilizer if tests show that soil nitrogen levels are insufficient to support native species.
- Common components of commercial seed mixes such as yellow sweet clover (*Melilotus officinalis*), smooth brome (*Bromus inermis*), and Kentucky bluegrass (*Poa pratensis*) are often considered weeds in the context of natural lands and natural areas.
- Importing weed seeds on borrowed or rented equipment. You can reduce this risk by inspecting equipment before it enters your property or you can insist that the equipment must be cleaned first.

Biological Control

Biological control is the use of insects or other natural predators to control the growth of a specific plant species. The insects usually come from the invasive plant's native habitat and all have been extensively tested to ensure that they will not attack plants other than the one they are targeting. Once insect populations are established, they can often support their own growth and expansion. Different insects attack different parts of plants at different times, but over time may decrease seed production and growth rate.

Best suited for:

- Reducing seed production or weakening plants.
- Large, dense infestations where other control methods are not cost-effective.
- Situations where a reduced but effectively permanent presence of a noxious weed species is acceptable.

Limitations include:

- Failing to eradicate the target plant species. Do not use bio-control agents where you seek to eradicate a weed population. Eradication of weeds with biological agents never occurs.
- Use of biological control is effectively an admission that a particular weed species is here to stay and that this is acceptable.
- Feasible for only a handful of weed species because of the high cost of finding, screening and testing potential control organisms. Biological controls have a mixed record with some tremendous successes but also with many failures.
- Rarely successful as the sole means of control of a weed species.
- Lack of effective biological control agents for most noxious weed species.
- Biological control agents may be unavailable when you want them.
- Necessity of having a reservoir of host weeds to support biological agents over the long term. Thus, it may be necessary to leave some weeds to support populations of control organisms. This may be unpopular with neighbors or the public.
- Degree of control is variable and will take several years to achieve.

Pitfalls include:

- Insects attacking beneficial, non-target plants. The weevil *Larinus planus*, introduced for control of Canada thistle (*Cirsium arvense*), has been reported to attack native thistle species as well. Insects that have been released to control St. Johnswort (*Hypericum perforatum*) also feed on native *Hypericum* species, and some insects released for controlling leafy spurge (*Euphorbia esula*) also attack native spurge species.
- Inability to establish populations of biological control organisms for reasons relating to climate, soils and so forth that are not well understood.

Grazing

Grazing is the use of sheep, goats, cattle, or horses to control weed growth. Sheep and goats are most commonly used in this function because they often eat plants rejected by cattle and horses. Animals will eat plants at specific stages of the plants' growth, so it is important to be informed about what animal is the best agent at different times of the year. It is also very important to make sure the land is not over-grazed and that the animals are moved before they start to eat the desired plants, which would eliminate the desired plant community competition with the invaders.

Best suited for:

- Weeds that are palatable (at least at some point during the year) and non-toxic to livestock. Weeds vary greatly in their palatability to types of livestock. Generally speaking, the preference for grasses declines from horses to cattle to sheep to goats. Furthermore, goats and sheep are more likely than horses or cattle to relish broadleaf weeds (forbs).
- Leafy spurge (*Euphorbia esula*) control. Goats and sheep are very effective control agents for all but the smallest infestations, especially in riparian areas.
- Low-level, widespread weed infestations where other control techniques are not cost-effective.

Limitations include:

- Lack of availability of goats and sheep or even cattle when and where you need them.
- Need for water and fencing or herding to control livestock movement.
- The need to manage the intensity and duration of livestock grazing carefully to avoid overgrazing, and allow desirable species to recover from grazing impacts.
- Areas where predators such as coyotes, mountain lions, and black bears may kill grazing animals, especially sheep and goats.
- Using the proper kind of animal to manage the weeds on your property.
- Need for someone with knowledge of animal husbandry to manage the animals.
- Palatability of weeds varying widely throughout the growing season. For example, young shoots of Canada thistle (*Cirsium arvense*) are very palatable to cattle, while old, mature stalks are not. However, palatability of many weeds can be greatly increased by spraying them with a dilute solution of molasses.

Pitfalls include:

- Expecting livestock to control weeds without close management. Simply turning animals into a pasture and expecting weed problems to vanish would likely be counterproductive.

- Failing to manage the intensity and duration of livestock grazing to prevent the animals from depleting the desirable plant species they are grazing, or creating disturbance, which favors the establishment of weeds.
- Spreading weed seeds in fur or in manure when animals are moved from one area to another. Grazing should be done before weeds set seed.
- Toxicity of weeds such as poison hemlock, halogeton, St. Johnswort (*Hypericum perforatum*), and Russian knapweed (*Centaurea repens*) to grazing animals; toxicity can vary greatly by type of animal.

Herbicide

Although herbicides must be used with extreme care and caution, they are one of the most effective ways of quickly managing weed populations for the short term. When considering what herbicide to use, look at what weeds are present, how close they are to water, and what time of year is best to apply the chemical. Herbicides often work best if applied more than once and in conjunction with other control methods.

Best suited for:

- Eradicating some weed species in certain places. Herbicides are most effective on pure stands of a single weed species where desirable non-target plants are scarce or absent. In this place, one often has the option of selecting from several different herbicides.
- Rhizomatous weed species that are unpalatable to livestock, require repeated pulling or cutting for control, or are located in remote areas where pulling or cutting are not feasible.
- Small patches of weeds where hand pulling or cutting is not effective or feasible.
- Use in combination with other control methods. For example, Canada thistle (*Cirsium arvense*) can be controlled by repeated cutting during the growing season followed by treatment with clopyralid herbicide in the fall. Russian olive (*Elaeagnus angustifolia*) can be controlled very effectively by cutting stems very close to the ground in the fall then immediately spraying or painting the cut stems with triclopyr herbicide.

Limitations include:

- Damaging or killing non-target plants. Herbicides are not completely selective in their toxicity to the target plant species. Effects on non-target plants can be minimized by selecting an appropriate herbicide and using a wick or a backpack sprayer. A wick is made from adsorbent material and saturated with herbicide. This wick is rubbed directly against the weeds so the herbicide is not applied to adjacent, desirable plants.
- Difficulty of using herbicides to control small weeds when they occur among taller desirable plant species.
- Toxicity to humans to varying degrees. Thus, their use is regulated by federal and state laws. People who use herbicides need to know these regulations. Certain herbicides are classified as “restricted use herbicides” whose application is limited by federal and state regulations.

- Restricted use herbicides are often available only at licensed outlets such as your local farm co-op or by ordering through reputable distributors.
- Property owners must possess a private applicator's license to apply a restricted use herbicide on their property.
- Herbicides must be applied in conformance with the label. With herbicides, the label is the law, and applying an herbicide beyond the bounds specified on the label is illegal.
- Certain herbicides may not be used around or on water. This is an important consideration for weeds that grow in wetlands or riparian areas.
- One must possess the proper equipment and requisite knowledge to apply chemicals safely. Proper clothing must be used, and materials to contain spills must be on hand when using herbicides.
- Herbicides can move beyond the area where they are applied and affect non-target plants and animals. This drift can be eliminated by using a wick or reduced by spraying under calm wind conditions and by adjusting the sprayer apparatus to produce large droplets.
- Populations of weeds may develop resistance to a particular herbicide over time.
- Opposition to the use of chemicals in the environment, especially in urban areas. Local opposition in some areas may pose challenges for the use of some or all herbicides.
- Like most other control methods, herbicides are short-term solutions that do not address reasons for weed problems in the first place. Therefore, spraying an herbicide treats a symptom of a problem. Even if an herbicide eradicates a weed infestation, another infestation may appear if the underlying cause of the infestation persists.

Pitfalls include:

- Simplifying diverse plant communities by suppressing certain plant species, although this effect may be temporary.
- Herbicide applicators who cannot distinguish noxious weeds from desirable plant species, resulting in accidental damage to the latter.

Hand Pulling

One of the most labor-intensive methods of weed management, hand pulling is a viable option for small infestations. Hand pulling does not work on plants with rhizomatous root systems because it will stimulate the plant's growth. Pulling is often best in the spring before the weeds have an extensive root system. Tools like the weed wrench greatly assist in pulling small bushes or plants with long taproots.

Best suited for:

- Small infestations where the entire patch can be pulled.
- Annual and biennial plants (although seed banks will remain for some time).

- Shallow-rooted species that do not resprout from any residual roots.
- Plants growing on sandy or gravelly soils. (If possible, concentrate on pulling when the soil is moist and soft, such as after a soaking rain.)
- Places where more effective methods cannot be used or are undesirable.

Limitations include:

- Pulling generally may not remove the entire root system of the plant. Thus, pulling is ineffective for rhizomatous species such as Canada thistle (*Cirsium arvense*) or leafy spurge (*Euphorbia esula*), even if used in conjunction with other techniques. *If pulled weeds contain seeds, they should be removed from the site and burned or disposed in a landfill. Do not compost this material!*
- Pulling will not reduce a soil seed bank, although it can keep a seed bank in the soil from increasing.
- Pulling is not cost effective for large infestations.
- Pulling may not be cost effective for small infestations, either; unless plants are easy to pull and a volunteer work force is available.

Pitfalls include:

- Volunteer burnout from endless hours of boring work.
- Soil disturbance which stimulates germination of weed seeds in soil.
- Creating bare soil spots as sites for weed seed germination and establishment.
- Some weeds produce chemicals causing allergic reactions in some people. Always wear gloves and a long-sleeved shirt for pulling plants. Wash your hands with soap and water afterwards.

Cutting and Mowing

Mowing can be effective in some places if it is done at the correct time of the weed's growth cycle. However, mowing can stimulate many plants' growth. Additionally, mowing damages as many native plants as invasive and usually requires multiple field entries over a span of years to kill all the weeds. Generally, after mowing the sites will need to be re-seeded, which is another step in a labor-intensive procedure. Nonetheless, used in conjunction with other methods, mowing can be an adequate option in a long-term plan.

Best suited for:

- Large, relatively flat and dry areas that can be mowed with few safety or equipment concerns.
- Preventing tall, erect biennial weed species, such as mullein, from setting seed when other control techniques are not feasible.
- Preventing the "tumbleweed" action of certain weed species such as kochia and Russian thistle that spreads seeds across wide areas.

- Weakening the plants by depleting root reserves through repeated mowing.
- Combining with other control methods, such as herbicide treatment. Cutting can be extremely effective for killing certain trees and shrubs if it is combined with herbicide treatment of the cut stumps. For example, cutting the stems as close to the ground as possible in the fall and immediately (within 30 seconds) painting the cut stumps with triclopyr herbicide kills Russian olive (*Elaeagnus angustifolia*).
- Small infestations of fleshy-stemmed biennial thistles are easy to cut with a sharp machete. These thistles include Scotch, musk, plumeless, and bull thistles.

Limitations include:

- Rarely killing weeds.
- Sites that are inaccessible or too rocky cannot be mowed, although weed whips and machetes can be effective in such places.
- Having to repeat mowing frequently for control to be effective.
- Cut plants re-sprouting to larger sizes than prior to cutting (Russian olive [*Elaeagnus angustifolia*]).
- Weakening rhizomatous plants only slightly, unless the frequency of cutting is very high.

Pitfalls include:

- Failing to remove and dispose of cut stems if they contain seeds.
- Dislodging rocks from the mower may be dangerous to the mower operator.

Weed seeds spread by mowing equipment to areas previously free of infestations. Clean equipment which has been used in weed infested areas before moving it to another area. Make sure that borrowed or rented equipment is free of weed seeds by inspecting equipment before it enters your property. Or, you can insist that the equipment must be cleaned first.

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Invasive Plant Species of the Clark Fork River OU

Several invasive plant species are already well established within the Clark Fork River OU, while several others have quite limited occurrence in Reach A. Some species are among the most commonly encountered plants in some areas, while others are rare thus far. Included below is a list of twelve species of invasive plants. Brief individual fact sheets are provided for each weed species. The information for this list came from a variety of sources, including CIPM at Montana State University (2003), and the Colorado Department of Agriculture (2000). The species include the following:

- Canada thistle (*Cirsium arvense*)
- Common tansy (*Tanacetum vulgare*)
- Dalmatian toadflax (*Linaria dalmatica*)
- Houndstongue (*Cynoglossum officinale*)
- Kochia (*Kochia scoparia*)
- Leafy spurge (*Euphorbia esula*)
- Perennial pepperweed (*Lepidium latifolium*)
- Russian olive (*Elaeagnus angustifolia*)
- Russian thistle (*Salsola iberica*)
- Spotted knapweed (*Centaurea maculosa*)
- Yellow toadflax (*Linaria vulgaris*)
- Whitetop (*Cardaria draba*)

Canada Thistle

Cirsium arvense (L.) Scop.

Family: *Asteraceae* (Sunflower)
Other Names: field thistle, Californian thistle
Six Letter Code: CIRARV
USDA Code: CIAR4

Keys to Identification:
- Purple flowers form in clusters of 1-5 per branch.
- The floral bracts of Canada thistle are spineless.
- Small heads, vanilla scent.

Identification

Growth form: Perennial forb.
Flower: Flower heads are white to purple and borne in clusters of 1-5 per branch, with a strong vanilla scent. Heads are only about 1 cm in diameter.
Seeds/Fruit: One-seeded fruits (achenes) are straw or light brown in color, straight or slightly curved (Moore 1975).
Leaves: Leaves are spiny, alternate, oblong or lance-shaped, with the base leaves stalkless and clasping, or extended down along the stem.
Stems: Mature plants range from 2-4 ft in height.
Roots: Canada thistle has two types of roots, horizontal and vertical. The horizontal roots produce numerous shoots, while vertical roots store water and nutrients in their many small branches.
Seedling: Early spring growth appears as rosettes with spiny-tipped, wavy leaves.
Other: The floral bracts of Canada thistle are spineless.

Similar Species

Exotics: Bull thistle (*Cirsium vulgare*); flower bracts are somewhat tapered and covered with spines. Musk thistle (*Carduus nutans*); floral bracts are broad with spiny tips. Russian knapweed and Canada thistle are often confused.
Natives: Wavyleaf thistle (*Cirsium undulatum*): flower bracts often have a prominent white glandular dorsal ridge (often sticky to touch) and minutely hairy margins (Whitson et al. 1996).

Impacts

Agricultural: Canada thistle is an aggressive, creeping, perennial weed. It infests crops, pastures, rangelands, roadsides, and riparian areas (Beck 1996).
Ecological: Canada thistle spreads rapidly through horizontal roots, which give rise to shoots (Moore 1975). Its root system can be extensive, growing horizontally as much as 18 ft in one season (Nuzzo 1998). Most Canada thistle patches spread at a rate of 3-6 ft/year, crowding out more desirable species and creating thistle monocultures.
Human: Spiny thickets of Canada thistle can restrict recreational access to infested areas.

Habitat and Distribution

General requirements: Canada thistle thrives in the Northern Temperature Zone due to its day length response and a high temperature limitation on growth (Haderlie et al. 1991). Although Canada thistle mainly invades disturbed areas, it does invade native plant communities, open meadows

(including wetlands), and ponderosa pine savanna (Rutledge and McLendon 1998). Canada thistle is adapted to a wide range of soil types and environmental conditions (FEIS 1996). It is best adapted to rich, heavy loam, clay loam, and sandy loam, with an optimum soil depth of 20 inches (FEIS 1996, Rutledge and McLendon 1998). Canada thistle can tolerate saline soils (up to 2 percent salt) and wet or dry soil (Rutledge and McLendon 1998). However, it does not tolerate waterlogged or poorly aerated soils. Canada thistle usually occurs in 17-35 inch annual precipitation zones or where supplemental soil moisture is available (Beck 1996). Canada thistle is also somewhat shade intolerant. It can grow along the edge of forested areas, but is rarely found within forests.
Distribution: Canada thistle is found throughout the northern half of the United States and lower portions of Canada. It is common found along roadsides, fields, pastures, meadows, and other disturbed areas statewide in Montana.
Historical: Canada thistle is a native of southeastern Eurasia. It was introduced to Canada as a contaminant of crop seed as early as the late 18th century. Since its introduction, it has spread throughout North America (Whitson et al. 1996).

Biology/Ecology

Life cycle: Over-wintering roots develop new underground roots and shoots in January and begin to elongate in February (Nuzzo 1998). Shoots emerge between March and May, when mean weekly temperatures reach 5° C, and form rosettes (Nuzzo 1998). Early in the spring, plants remain near the soil surface until long days (over 14 hours of light) trigger flowering and stem elongation (Haderlie et al. 1991, FEIS 1996). Canada thistle is dioecious (male and female flowers are produced on separate plants). Female flowers can be readily distinguished from male flowers by the absence of pollen (abundant in male flowers) and presence of a distinct vanilla-like fragrance. Flowering occurs from June to October (Rutledge and McLendon 1998). Seeds mature July to October.
Mode of reproduction: Canada thistle reproduces primarily vegetatively through creeping horizontal roots, and can quickly form dense stands. Every piece of the root system is capable of forming a new plant (Rutledge and McLendon 1998). This allows dense monocultures of Canada thistle to form even without seed production. Canada thistle growth is limited or stopped when temperatures exceed 30° C for extended periods of time.
Seed production: A female Canada thistle plant can produce up to 5,200 seeds in a season, but the average is about 1,500 seeds/plant (Rutledge and McLendon 1998).
Seed bank: Mature seeds germinate most readily in mid-spring. Seeds that do not germinate may remain dormant for several years but most studies indicate that the majority of seeds do not remain viable after three years of burial (Rutledge and McLendon 1998).
Dispersal: Seeds are distributed by wind.
Hybridization: No information available.

Control

Biocontrol: Currently, there is no single biological control agent that effectively controls Canada thistle. However, there are several agents that have been reported to provide very limited control. One species, *Urophora cardui* (a gall fly), may hold some promise.

Keys to Control:
- Eliminate seed production.
- Reduce the plant's nutrient reserves through persistent management.

Mechanical: Mowing pastures and hay meadows can be an effective control if it is repeated at about one-month intervals throughout the growing season. Combining mowing with herbicides will further enhance control of Canada thistle. However, a recent study (Beck and Sebastian 2000) found that mowing or mowing plus herbicide was only effective where the root system of Canada thistle is restricted by a high water table, such as near rivers or subirrigated meadows.

Fire: Prescribed burning in the spring has been proposed as a means of slowing the spread of Canada thistle. Such fires could reduce the number of mature plants, decrease seed production, and stimulate the growth of native grasses (FEIS 1996).
Herbicides: Chemical control of Canada thistle should be conducted in the spring or fall depending on local environmental conditions. In general, fall treatments are more effective as herbicide absorption is enhanced in the late summer and fall when shoot to root translocation is the greatest. However, translocation of the herbicide is dependent on moist soil conditions. If fall is a dry period in your area, a spring application around the flower bud stage (early June), when root carbohydrate reserves are at their lowest, is recommended. Clopyralid + 2,4-D (commonly sold as Curtail®) applied at a rate of 2-3 quarts/acre will effectively control Canada thistle. Curtail should either be applied in the late spring (when Canada thistle plants are entering the bud growth stage) or in the fall (October) when Canada thistle roots are actively growing. The performance of Curtail can be improved when proceeded by two or three mowings under conditions when the root systems are restricted (Beck 1996, Beck and Sebastian 2000). Begin mowing when Canada thistle is 12-15 inches tall and repeat at about one month intervals (Beck 1996). Apply Curtail in October or about one month after the last mowing. Clopyralid alone can be applied at a rate of 2/3 to 1 pint/acre in the spring or fall. Spring applications should be timed to the rosette to bud growth stages. 2,4-D or picloram are effective when applied at a rate of 1 lb active ingredient/acre in the spring when Canada thistle is in the pre-bud to early bud growth stages (about 10-15 inches tall). For increased control, retreat with dicamba (1 lb active ingredient/acre) in the fall to prevent regrowth of plants.
Cultural/Preventive: Reduce the spread of Canada thistle seeds by always purchasing "weed free" seeds. Quickly eliminate new seedlings before they have a chance to form a well-developed root system.

Integrated Management Summary

The tendency of this species to grow in wet areas may restrict the use of certain herbicides. Control efforts should target Canada thistle plants in high-quality areas first (typically areas that contain mostly native species and few undesirable species), and then work on controlling lower quality areas (areas that are already infested with undesirable species and have fewer desirable species present). Management strategies should be adjusted to reflect weather conditions (Nuzzo 1998). For example, drought stress reduces the effectiveness of most herbicides, but increases the effectiveness of mechanical controls (e.g., mowing or burning). It takes at least two years of control to determine whether a particular method is effective. Several studies have recorded a temporary decline in Canada thistle in the first year of control followed by a return to the pre-treatment conditions the second growing season (Nuzzo 1998). For one example of Canada thistle control, see page 60.

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Common Tansy

Tanacetum vulgare L.

Family: *Asteraceae* (Sunflower)
Other Names: garden tansy
Six Letter Code: TANVUL
USDA Code: TAVU

Keys to Identification:
- Flower heads contain button like flowers without ray flower "petals."
- Stems are often purplish-red in color.

Identification

Growth form: Perennial forb.
Flower: Yellow flowers are numerous in flat-topped dense clusters at the tops of the plants. Button like flower heads lack ray flowers.
Seeds/Fruit: Seeds are yellowish brown achenes with short, five-toothed crowns.
Leaves: Leaves are alternate, deeply divided into numerous narrow, individual leaflets.
Stems: Mature plants are 1.5 to 6 ft tall. Stems are often purplish-red in color.
Roots: Rhizomatous.
Seedling: No information available.
Other: Rank smelling foliage.

Similar Species

Exotics: None known.
Natives: None known.

Impacts

Agricultural: Common tansy is considered undesirable forage for livestock. Although it may be toxic, animals rarely ingest it.
Ecological: May displace native, more desirable species.
Human: Can be toxic if large quantities are consumed.

Habitat and Distribution

General requirements: Common tansy is commonly found along roadsides, stream banks, in waste places, and in pastures. It grows best in full sun and on fertile, well-drained soil.
Distribution: Found throughout the United States.
Historical: Common tansy is a native of Europe that was introduced into North America as an ornamental and medicinal herb (Whitson et al. 1996). It has been used for treating various ailments and as an insect repellent.

Biology/Ecology

Life cycle: Flowering typically occurs from July to September.
Mode of reproduction: Reproduces by both seed and creeping rootstocks.
Seed production: No information available.
Seed bank: No information available.
Dispersal: No information available.
Hybridization: No information available.

Control

Biocontrol: None known.
Mechanical: Common tansy can be mowed before flowering and seed set to eliminate seed production. This method may have to be repeated to eliminate regrowth from the rootstocks.
Fire: No information available.
Herbicides: Picloram or dicamba at 1 lb active ingredient/acre, or glyphosate at 1.5 lb active ingredient/acre can be used to control common tansy. The best time for treatment is between the early flower (bud) to bloom stage (Dow AgroSciences 1998).
Cultural/Preventive: Prevent the establishment of new infestations by minimizing disturbance and seed dispersal, eliminating seed production and maintaining healthy native communities.

Keys to Control:

- Eliminate seed production and vegetative reproduction from creeping rootstocks.
- Re-seed controlled areas with desirable species.

Integrated Management Summary

As with other rhizomatous perennials, mechanical controls such as mowing or hand cutting are most effective in combination with other methods. Plants can regrow from severed roots, and cut stems may still produce viable seed. Control the spread of common tansy by preventing seed production and dispersal, minimizing the spread of cut rootstocks, and establishing healthy stands of desirable species on controlled areas.

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Dalmatian Toadflax

Linaria dalmatica (L.) Miller

Family: *Scrophulariaceae* (Figwort)
Other Names: broad-leaved toadflax, wild snapdragon
Six Letter Code: LINDAL
USDA Code: LIDAM

Keys to Identification:

- Dalmatian toadflax can be easily identified by its bright-yellow, snapdragon-shaped flowers.
- Dalmatian toadflax can be distinguished from yellow toadflax by its larger flowers and more ovate leaves (rather than the linear, somewhat pointed leaves that are characteristic of yellow toadflax).

Identification

Growth form: Perennial forb.
Flower: Flowers are borne in loose, elongate, terminal racemes. Flowers are bright yellow and resemble snapdragons.
Seeds/Fruit: Fruits are egg-shaped to nearly round capsules. Seeds are sharply angular, and slightly winged.
Leaves: Leaves are broad, ovate to ovate-lanceolate, and are alternate, generally clasping but crowded.
Stems: Mature plants are up to three ft tall. A single toadflax plant contains from 1-25 vertical floral stems which are thick-walled and somewhat woody.
Roots: The taproot may penetrate one meter into the soil. Horizontal roots may grow to be several meters long, and can develop adventitious buds that may form independent plants.
Seedling: No information available.

Similar Species

Exotics: Yellow toadflax *(Linaria vulgaris)* is similar in appearance, but has more linear pointed leaves, and is generally a smaller plant.
Natives: None known.

Impacts

Agricultural: Low-till cultivation practices have contributed to the resurgence of toadflax populations on agricultural lands (McClay 1992). Dalmatian toadflax contains a glucoside, a quinoline alkaloid, and peganine, which make it toxic to livestock (Rees et al. 1996). However, dalmatian toadflax is generally considered unpalatable, and reports of livestock poisonings are rare.
Ecological: Dalmatian toadflax is a persistent, aggressive invader and capable of forming colonies through adventitious buds from creeping root systems. These colonies can push out native grasses and other perennials, thereby altering the species composition of natural communities. New infestations of dalmatian toadflax can occur in naturally occurring disturbances or in small openings in pristine or excellent-condition rangeland (Lajeunesse 1999). Dalmatian toadflax can rapidly colonize open sites. It is most commonly found along roadsides, fences, rangelands, croplands, clear cuts, and pastures. Disturbed or cultivated ground is a prime candidate for colonization. Toadflax can significantly reduce crop yields and stress native communities. In one study, toadflax-free plots produced 2.5 times more grass than plots where toadflax was present (Robocker 1974). The seedlings of toadflax are considered ineffective competitors for soil moisture with established perennials and winter annuals (Morishita 1991).

However, once established both species of toadflax suppress other vegetation mainly by intense competition for limited soil water. Mature plants are particularly competitive with winter annuals and shallow-rooted perennials (Robocker 1974).
Human: No information available.

Habitat and Distribution

General requirements: Dalmatian toadflax can adapt its growth to fit a wide range of environmental conditions, and is tolerant of low temperatures and coarse-textured soils.
Distribution: Dalmatian toadflax in Montana this weed has escaped from gardens to become a serious invader of rangeland, mountain meadows, and waste areas. Large infestations of it are found in Missoula and Lake Counties in western Montana.
Historical: Dalmatian toadflax is a native of the Mediterranean region from Yugoslavia to Iran (Robocker 1974).

Biology/Ecology

Life cycle: Spring emergence occurs about mid-April and depends primarily on temperature. During the first year the plant forms a rosette and develops a deep root system. Prostrate stems emerge in September and produce ovate leaves. Prostrate stems are tolerant to freezing and are associated with floral stem production the following year (Robocker 1974). The strong upright floral stems that characterize mature toadflax plants develop after a winter's dormancy, and emerge about the same time as new seedlings in mid-April. A single plant will produce from 1-25 floral stems. Flowering occurs from May-August and seeds mature from July-September. Dalmatian toadflax can also reproduce vegetatively. Stems develop from adventitious buds on primary and lateral roots. Vegetative reproduction from root buds can occur as early as 2-3 weeks after germination, and is possible from root fragments as short as 1 cm in length (Zimmerman 1996). These buds can grow their own root and shoot systems, and become independent plants the next year. In addition to promoting growth, the large, deep, root systems of dalmatian toadflax exploit water efficiently. The taproot may penetrate 3-4 ft into the soil and lateral roots may be 6-12 ft long.
Mode of reproduction: By seeds and vegetatively
Seed production: A mature dalmatian toadflax can produce up to 500,000 seeds annually (Morishita 1991).
Seed bank: Seeds may remain viable in the soil for up to ten years.
Dispersal: Seeds are winged, and wind-dispersed.
Hybridization: No information available.

Control

Keys to Control:
- Maintain a dense cover of vigorous perennial plants.
- Picloram, dicamba, and glyphosate are effective when applied during flowering.
- Hand pulling is effective for small areas, especially in sandy soils.

Biocontrol: The Division of Plant Industry's Biological Pest Control Section currently has one species, *Calophasia lunula*, that may be available for redistribution on dalmatian toadflax infestations. *C. lunula* larvae feed extensively on leaves and flowers of toadflax, severely damaging the plants.
Mechanical: Cutting or removal of the above ground portion of toadflax plants reduces the current year growth, but it will not kill the plant. Cutting toadflax stands in spring or early summer is an effective way to eliminate plant reproduction through seed production and dispersal. However, the long dormancy of toadflax seeds requires that the process be repeated annually for up to ten years. Hand pulling toadflax before seed set each year can be an effective control method. The hand pulling experiment on The Nature Conservancy's Magnusson Butte Preserve in Washington showed that toadflax can be significantly reduced by pulling once a year as long as new seed is eliminated. Again, this method must be repeated annually for up to ten years to completely

remove a stand. Sheep can help suppress dalmatian toadflax infestations and reduce seed production. The sheep showed no ill effects from eating toadflax and showed good weight gain (Lajeunesse 1999).

Fire: No information available.
Herbicides: Herbicides have highly variable effects on dalmatian toadflax, probably due to its high genetic variability. Fall applications of picloram 0.5-1.0 lb active ingredient/acre has provided excellent control for one year. However, the higher concentrations of picloram may be injurious to desirable plants, plus picloram has been ineffective on some sites. A tank mix of picloram + 2,4-D controlled over 90 percent of dalmatian toadflax when applied pre-bloom or in the fall. A six-year study found that phenoxypropionic herbicides such as diclorprop were more effective at controlling toadflax than phenoxyacetic herbicides such as 2,4-D (Robocker 1968). 2,4-D, MCPA, MCPB, and mecoprop used alone do not control toadflax.
Cultural/Preventive: Intensive clean cultivation techniques are recommended for successful toadflax control on agricultural land. Discing can be an effective method of toadflax control on agricultural lands. This method requires at least two years with eight to ten cultivations in the first year, and four to five cultivations the second year (Morishita 1991). Weed control should be accompanied by reseeding with a variety of plant species to occupy the site so as to prevent re-establishment of toadflax. An ideal mix of species would include cool- and warm-season plants as well as plants that root at a variety of depths. For example, shallow rooted, cool-season species such as Sandberg bluegrass (*Poa secunda*) compete with toadflax seedlings.

Integrated Management Summary

Management of dalmatian toadflax must focus on both reducing the rate of vegetative spread and reducing seed production (Lajeunesse 1999). Successful management requires integrating as many control tactics as possible. Dalmatian toadflax has high genetic variability, and local populations can respond differently to control actions, especially herbicide treatments. Successful control can be obtained by pulling, or killing the plants with herbicide before toadflax seed production begins (Carpenter and Murray 1998). Since the plant also spreads through vegetative propagation, and the seeds can remain dormant for up to ten years, this process must be repeated every year for at least ten years to completely remove a stand. Competitive perennial grasses and forbs should be planted to utilize water and nutrients that would otherwise be readily available to toadflax.

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Houndstongue

Cynoglossum officinale (L.)

Family: *Boraginaceae* (Borage)
Other Names: hound's tongue, dog bur, gypsy flower
Six Letter Code: CYNOFF
USDA Code: CYOF

Keys to Identification:
- Five-petaled reddish-purple flowers in panicles.
- Prickly nutlets are distinctive.

Identification

Growth form: Biennial or short-lived perennial forb.
Flower: Flowers are reddish-purple, with five petals, arranged in panicles in the upper leaf axils.
Seeds/Fruit: The fruit is composed of four prickly nutlets each about 1/3 inch long (Whitson et al. 1996).
Leaves: Leaves are alternate, 1-12 inches long, 1-3 inches wide, rough, hairy, and lacking teeth or lobes (Whitson et al. 1996). Leaves often appear dusty and insect-ridden. Basal leaves are elliptical to oblanceolate and tapered at the base.
Stems: Houndstongue produces a single flowering stem. The stem is erect, stout, heavy, 1.5 to 3 ft high and usually branched above.
Roots: Houndstongue has a thick, black, woody taproot.
Seedling: Houndstongue forms a rosette the first year of its life cycle.

Similar Species

Exotics: Rosettes may resemble burdock.
Natives: If not flowering, could be mistaken for members of the *Hackelia* or *Lappula* genus (stickseeds).

Impacts

Agricultural: Houndstongue contains toxic alkaloids that stop liver cells from reproducing. Therefore, houndstongue reduces livestock and wildlife forage and grazing animals should be kept away from houndstongue infested areas. Animals may live six or more months after eating a lethal dose of houndstongue. Sheep are more resistant to houndstongue poisoning that cattle or horses. The burs may reduce the value of wool.
Ecological: Houndstongue is an early successional species on recently disturbed sites.
Human: Due to its toxicity to grazing animals, houndstongue should not be eaten by humans.

Habitat and Distribution

General requirements: Houndstongue prefers areas with more than 10 percent bare ground (Butterfield et al. 1996), and is common on gravelly, alkaline soils (Stubbendieck et al. 1995).
Distribution: Houndstongue is found over much of North America. It grows on rangeland, pastures, abandoned cropland, roadsides, and waste places (Butterfield et al. 1996). Houndstongue is found on rangeland, pastures, and roadsides throughout Montana.

Historical: Houndstongue is a native of Eurasia that was introduced to North America as a contaminant in agricultural seed.

Biology/Ecology

Life cycle: Houndstongue is a biennial that produces a rosette the first year. During the second year a flowering stem bolts and produces fruit.
Mode of reproduction: Reproduces solely by seed.
Seed production: Mature plants can produce up to 2,000 seeds (Butterfield et al. 1996).
Seed bank: Seeds remaining on the parent plant may remain viable for 2-3 years. Buried seed rarely survive more than one year (Butterfield et al. 1996).
Dispersal: Seeds stick to clothing and animals and have the ability to be spread great distances.
Hybridization: No information available.

Control

Biocontrol: None known.
Mechanical: Mowing second year plants during flowering but before seed maturation reduces seed production and may kill the plant.
Fire: No information available.
Herbicides: Picloram at 0.25-0.5 lb, 2,4-D, or dicamba at 1.0 lb, or metsulfuron at 0.6 oz active ingredient/acre applied in spring provides control of houndstongue. Spring treatments with picloram, dicamba, or metsulfuron are more effective than fall treatments (Sebastian and Beck 1995). Chlorsulfuron applied 0.5 lb active ingredient/acre gave complete control when applied any time beginning with the rosette stage until the bolted plant had attained 10 inches in height (Butterfield et al. 1996).
Cultural/Preventive: Maintaining a healthy population of native perennials the best way to prevent the establishment and spread of houndstongue.

Keys to Control:
- Eliminate seed production.
- Re-seed controlled areas with desirable species.

Integrated Management Summary

Houndstongue is poor competitor with native perennials and requires disturbed or bare areas to establish. Once established, it quickly forms dense monocultures. Treat first year plants with herbicides. Mow bolted plants to eliminate seed production. Repeat this process for several years to exhaust the seed bank. It is imperative to establish a healthy population of native perennials on treated areas to prevent the re-establishment of houndstongue or other noxious weeds.

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Kochia

Kochia scoparia (L.) Schrad.

Family: *Chenopodiaceae* (Goosefoot)
Other Names: kochia, summer cypress
Six Letter Code: KOCSCO
USDA Code: KOSC

Keys to Identification:
- Flowers are inconspicuous forming dense spikes in leaf axils.
- Five-hook bassia (Bassia hyssopifolia) is distinguished from kochia by the five hooked structures on each seed.

Identification

Growth form: Annual forb.
Flower: Flowers are inconspicuous, stalkless in the axils of upper leaves and form short, dense, bracted spikes (Whitson et al. 1996).
Seeds/Fruit: Seeds are wedged shaped, dull brown, slightly ribbed.
Leaves: Leaves are 0.5-2 inches long, alternate, and lance-shaped. The upper surface of the leaf is usually smooth, while the lower surface is covered with soft hairs.
Stems: Mature plants are 1-6 ft tall with numerous branches. Stems are erect, simple to much-branched, and often form pyramidal or rounded tops. Stems are usually hairy, but are occasionally smooth.
Roots: Roots generally penetrate to depths of 6-8 ft.
Seedling: No information available.

Similar Species

Exotics: Five-hook bassia (*Bassia hyssopifolia*) is easily distinguished from kochia by the five hooked structures on each seed.
Natives: None known.

Impacts

Agricultural: Although kochia is readily grazed by livestock, it sometimes contains high nitrate levels and sulfate toxicity (Whitson et al. 1996).
Ecological: Kochia colonizes rapidly and may suppress other vegetation. It is an early successional plant on disturbed sites and can dominate vegetation for the first two years following disturbance (FEIS 1996). Kochia may spread into undisturbed sites when growing conditions are ideal.
Human: No information available.

Habitat and Distribution

General requirements: Kochia is most often found in open, sunny areas on disturbed sites. It grows on a variety of soil types, and is often found on saline/alkaline soils (FEIS 1996). Kochia can also be found in grasslands, mixed-grass prairie, shortgrass prairie, floodplains, riparian areas, sagebrush, and desert shrub communities. Other common associates include salt-cedar (*Tamarix* spp.), sand dropseed (*Sporobolus cryptandrus*), saltgrass (*Distichlis spicata*), and western wheatgrass (*Agropyron smithii*) (FEIS 1996).

Distribution: In Montana, kochia occurs on disturbed grasslands and desert shrub communities.
Historical: Kochia is a native of Eurasia that has become naturalized in the Great Plains and western states (FEIS 1996).

Biology/Ecology

Life cycle: Seedlings emerge very early in the spring. Flowering and seed production may occur from July to October. Kochia is very responsive to elevated soil nitrogen levels, either through some type of soil disturbance or due to fertilization. It will often grow rapidly for 1-2 years in abandoned fields or in badly overgrazed rangeland until the readily available nitrogen is depleted. Then kochia plants are often small, presumably due to the nitrogen limitation. Kochia is rarely a problem in areas where healthy stands of perennial grasses exist.
Mode of reproduction: Kochia reproduces exclusively by seed.
Seed production: Typically, a single plant will produce about 14,600 seeds per year.
Seed bank: Kochia seeds have little seed bank viability, as they either germinate or decay in one year (FEIS 1996).
Dispersal: The major means of seed dispersal is through a "tumbleweed" process.
Hybridization: No information available.

Control

Biocontrol: None known.
Mechanical: Grazing or mowing alone will not control kochia or stop seed production (FEIS 1996). Small infestations can be pulled by hand.
Fire: No information available.
Herbicides: Kochia is commonly controlled with herbicides but it is not by phenoxy herbicides at rates recommended for crops (FEIS 1996). Dicamba at 1 lb active ingredient/acre, or glyphosate at 1.5 lb active ingredient/acre will control it. Metsulfuron+dicamba is effective.
Herbicides should be applied in early spring after seedling emergence (Whitson et al. 1996).
Cultural/Preventive: Prevent the establishment of new infestations by minimizing disturbance and seed dispersal, eliminating seed production and maintaining healthy native communities.

Keys to Control:
- Exhaust the root system and eliminate seed production by mowing or treating with herbicides.
- Maintain a healthy cover of perennial plants to discourage the establishment and spread of hoary cress.

Integrated Management Summary

Even though kochia exhibits extreme reproductive plasticity (in that one plant can produce over 50,000 seeds under favorable conditions, but only 5 seeds under stressful conditions), the limited viability of kochia seeds increases the effectiveness of control methods. As with other plants which reproduce solely by seed, integrated management efforts should focus on the elimination of seed production and the depletion of the seed bank. Combine herbicide or mechanical removal of rosettes with removal of seed heads from any plants that have bolted.

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Leafy Spurge

Euphorbia esula L.

Family: *Euphorbiaceae* (Spurge)
Other Names: none widely accepted
Six Letter Code: EUPESU
USDA Code: EUES

Keys to Identification:

- Flowers are yellowish-green and have a pair of heart shaped yellow green bracts below each inconspicuous flower.
- The entire plant contains white, milky latex.

Identification

Growth form: Perennial forb.
Flower: Flowers are yellowish-green, small, arranged in numerous small clusters and subtended by paired heart-shaped yellow-green bracts.
Seeds/Fruit: Seeds are oblong, grayish to purple, contained in a 3- celled capsule.
Leaves: Leaves are alternate, narrow, 1-4 inches long.
Stems: Mature plants are up to 3 ft tall. Stems are thickly clustered.
Roots: Extensive lateral root system.
Seedling: Seed leaves (cotyledons) are linear to lanceolate, with entire margins.
Other: The entire plant contains white, milky latex. Foliage of the plant is smooth and hairless.

Similar Species

Exotics: None known.
Natives: Leafy spurge is distinguished from native spurges such as *Euphorbia brachycera* by its long linear leaves.

Impacts

Agricultural: Leafy spurge can invade rangeland that is in excellent condition, making it worthless for cattle and horse grazing and reducing land values (Lajeunesse et al. 1999).
Ecological: Leafy spurge is an aggressive, long-lived, perennial weed that can displace all other vegetation in rangeland, pasture, and native habitats (Biesboer 1998). Leafy spurge decreases rangeland diversity, threatens native plants and degrades wildlife habitat (Lajeunesse et al. 1999). It produces a large number of seeds and underground shoot buds. These two reproductive techniques allow it to rapidly displace native species, and form a monoculture. Rapid re-appearance of treated stands often follows an apparently successful eradication because of the large nutrient reserve in the roots. Leafy spurge produces an allelopathic compound that inhibits the growth of other plants (Butterfield et al. 1996).

Human: The milky latex sap of leafy spurge can cause irritation, blotching, blisters, and swelling in sensitive individuals.

Habitat and Distribution

General requirements: Leafy spurge grows in a wide range of habitats. It is most aggressive in semi-arid areas, but can be found in xeric to subhumid and subtropic to subarctic habitats (Butterfield et al. 1996). Leafy spurge occurs most commonly on untilled, non-crop areas such as rangeland, pastureland, woodland, prairies, roadsides, stream and ditches, and waste sites. It grows on all kinds of soils, but is most abundant in coarse-textured soils and least abundant on clayey soils (Butterfield et al. 1996).
Distribution: Leafy spurge is widely distributed in Montana and throughout the United States.
Historical: Leafy spurge is native to Eurasia. It was brought to northeastern United States in 1829 as an ornamental, and had spread to the west coast by the early 1900s.

Biology/Ecology

Life cycle: Leafy spurge is one of the earliest plants to emerge in the spring, usually in mid-April to late May (Butterfield et al. 1996). The development of terminal flower clusters begins 1 to 2 weeks after stem emergence. Flower clusters have 8 to 16 branches. Each branchlet forms a greenish yellow bract in May. Flowering generally ends in late June to mid-July as the plants do not usually flower, and growth is reduced, during the hotter portion of the summer. However, if conditions are favorable, leafy spurge may produce a few lateral flowers throughout the summer and in the fall. Thus, it is possible for the plant to produce seed until frost. Seeds mature about 30 days following pollination. Peak germination occurs from late-May to early June. If adequate moisture is present, germination can occur throughout the growing season.
Mode of reproduction: Despite being a successful seed producer, leafy spurge primarily reproduces vegetatively through its extensive lateral root system. Long roots have the capability to produce shoots and can reach nearly 15 ft laterally, and about 30 ft in depth. As many as 300 buds have been counted on these long roots (Butterfield et al. 1996).
Seed production: Each flowering stem produces from 10-50 capsules with a seed yield range of 200-250 seeds per flowering shoot (Best et al. 1980). A large plant may produce up to 130,000 seeds (Rutledge and McLendon 1998).
Seed bank: Seeds can remain viable in the soil for 5-8 years although 99 percent of the viable seeds will germinate in the first two years (Butterfield et al. 1996).
Dispersal: The three-sided capsules explode when ripe, sending the enclosed seeds up to 15 ft from the parent plant. Seeds float on water, and can be transported and deposited by floodwater.
Hybridization: No information available.

Control

Biocontrol: Currently, there is extensive research on biological control agents for leafy spurge with over 15 insects being studied (Biesboer 1998). However, control of leafy spurge by insects is often limited by the thick milky latex, which tends to clog the mouth or sucking parts of most insects (Butterfield et al. 1996). Successful biological control will most likely require a combination of insects and a long-term management program to establish them. The Division of Plant Industry's Biological Pest Control Section has released eight species in an effort to control leafy spurge. Three of these species, *Aphthona nigriscutis*, *A. cyparissiae*, and *A. czwalinae/lacertosa*, have become established and may be available for distribution from the Insectary. The most effective biological control agents seem to be six species of root- and foliage-feeding beetles in the genus *Aphthona*, and a stem- and root-boring beetle *Obera erythrocephala* (Lajeunesse et al. 1999).Grazing sheep on infested areas has been used successfully to control spurge on ranches in Montana, but ranchers agree that once the sheep were removed the spurge

Keys to Control:
- Develop a management scheme that uses several control methods that are compatible with your site.
- Persistently monitor your area and quickly control new infestations.

would quickly return (Biesboer 1998). Sheep grazing is likely to be most effective in the spring and summer when the spurge plants are succulent and when sheep tend to prefer forbs over grasses, rather than in fall when sheep forage more on grasses (Lajeunesse et al. 1999). Two grazing periods during the spring-summer with a recovery period (for the grasses) between are recommended rather than season-long grazing. Fall grazing by goats followed by application of picloram and 2,4-D (each 1 quart/acre) can provide good control (Lajeunesse et al. 1999). A recent study near Denver found that sheep grazing for a short period in early July every year for 5 years reduced leafy spurge density by 90 percent. This study also produce excellent results by combining sheep with *Apthona* beetles (Beck and Rittenhouse, 2000).

Mechanical: Tillage is not generally a practical control method for areas where leafy spurge grows. Mowing can actually increase the density of leafy spurge, and may not be effective even when combined with herbicide (K.G. Beck, personal comm.). Pulling leafy spurge is ineffective, even for small infestations because of the deep root system and the presence of numerous root buds.

Fire: Burning alone will not likely provide adequate control of leafy spurge due to regeneration from the root system. However, combinations of burning and herbicide application 5 weeks later might provide adequate control (Biesboer 1998). In one study, plots of leafy spurge were sprayed with a mix of 2,4-D and picloram in September and burned the following April. The plots were sprayed again in June and burned again in October (Biesboer 1998). This process is designed to exhaust the nutrient reserves in the root system of the plant and hinder its ability to compete with other species. Therefore, reseeding desirable species is also necessary.

Herbicides: Herbicides can provide some control of leafy spurge. However, due to its extensive root system and general hardiness, follow up applications are necessary for herbicides to be effective. Picloram is recommended for eradication of small infestations, with herbicide application extending for 10-15 ft beyond the leafy spurge patches (Lajeunesse et al. 1999). A combination of picloram and 2,4-D (1-1.5 pints of picloram with 1-1.5 quarts of 2,4-D) was shown to provide the best control when applied in the spring when flowers emerge (Beck 1996). Research in North Dakota has shown that a tank mix of picloram (1 pt./ac) and 2,4-D (1 quart/acre) (based on concentrate of 4 pounds active ingredient/gallon) applied 2 weeks after the yellow bracts appear and applied annually is a cost effective treatment for leafy spurge (Lym et al. 1993). Picloram at 1 quart/acre for 2-3 consecutive years is also effective, but more expensive. An annual combination of dicamba plus 2,4-D (4-8 oz + 0.5-1 quart/acre) also provided good control (Beck 1996). Glyphosate is most effective when applied sequentially at 1 quart/acre at one month intervals, coupled with fall grass seeding (Beck 1996).

Cultural/Preventive: Long-term control of leafy spurge requires, among other things, a competitive plant community dominated by desirable species. For reseeding, select a mixture of grass species with early-, mid-, and late-season growth, and with shallow-, intermediate-, and deep-rooting depths. The resulting plant community will maximize the use of water and nutrients by the desirable species and will effectively compete with leafy spurge. After reseeding, it is imperative to manage grazing animals carefully so as to invigorate and not harm perennial grasses. Consider grazing sheep or goats with cattle so the former can graze spurge plants.

Note of Caution: The milky latex associated with leafy spurge can cause irritation, blotching, blisters, and swelling in sensitive individuals. The eyes should never be rubbed until after the hands are thoroughly washed. Gloves should be worn while pulling or coming into contact with this plant.

Integrated Management Summary

Persistent monitoring of areas with known or potential infestations is crucial to managing leafy spurge. New infestations are much more easily controlled than established infestations. 100 percent eradication of leafy spurge is rarely achieved, but infestations can be reduced to manageable levels. Herbicides are most commonly used to control leafy spurge. However, damage to non-target species is always a concern. Sheep and goats can be used to control leafy spurge. Leafy spurge is extremely difficult to control by chemical means and is almost impossible to control by cultural or physical

methods. Therefore a management scheme that combines control methods over four to five years is recommended (Beck 1996). Lym (1998) recommends combinations of re-seeding with competitive grasses, biological control insects, sheep or goat grazing and herbicide (2,4-D + picloram) treatment. Grazing animals and biological agents are generally appropriate only for larger infestations. Although leafy spurge can be poisonous to cattle, sheep can be taught to feed on it and goats will seek it out.

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Perennial Pepperweed

***Lepidium latifolium* L.**

Family: ***Brassicaceae*** (Mustard)
Other Names: tall whitetop, broad-leaved peppergrass, Virginia pepperweed
Six Letter Code: LEPLAT
USDA Code: LELA2

Keys to Identification:
- Perennial pepperweed has dense clusters of white flowers that appear in early summer.
- The leaves and stem are covered with a waxy layer.

Identification

Growth form: Perennial forb.
Flower: White flowers are packed in dense clusters near the ends of branches. **Seeds/Fruit:** Fruits are nearly round, about 0.1 inch in diameter and usually sparsely hairy.
Leaves: Leaves are alternate, lance-shaped, entire to toothed, bright green to gray-green, and do not have clasping bases (whitetop leaves have clasping bases). The basal leaves are larger than the upper leaves.
Stems: Mature plants are 1-3 feet tall.
Roots: Perennial pepperweed roots grow deep into the soil.
Seedling: No information available.
Other: The leaves and stem are covered with a waxy layer (Whitson et al. 1996).

Single flower - enlarged

Similar Species

Exotics: Whitetop (*Cardaria draba*) leaves have clasping bases; perennial pepperweed can also be distinguished by its waxy appearance.
Natives: Many native members of the sunflower *(Asteraceae)* family resemble this species in the rosette stage.

Impacts

Agricultural: Perennial pepperweed invades irrigated pastures, cropland, and native meadows (FEIS 1996).
Ecological: Perennial pepperweed is an aggressive colonizer of riparian habitats. It establishes rapidly and can eliminate competing vegetation (FEIS 1996).
Human: No information available.

Habitat and Distribution

General requirements: Perennial pepperweed is most often found in open, unshaded areas on disturbed, and often saline soils.
Distribution: Perennial pepperweed is found in riparian habitats of the Intermountain region (FEIS 1996).
Historical: Perennial pepperweed was introduced from Eurasia.

Biology/Ecology

Life cycle: Dense flower clusters appear in early summer and continue through August.
Mode of reproduction: Perennial pepperweed reproduces mainly by spreading rhizomes, and can be an aggressive colonizer of disturbed areas (FEIS 1996).
Seed production: Perennial pepperweed produces an abundance of highly germinable seeds. Seed production is from June to August.
Seed bank: Seeds have no apparent dormancy.
Dispersal: Seeds drop from the plant or travel short distances by wind/water.
Hybridization: No information available.

Control

Biocontrol: None known.
Mechanical: Periodic mowing and spring burning have reduced perennial pepperweed density in Utah (FEIS 1996).
Fire: (See above)
Herbicides: Metsulfuron at the rate of 0.45 oz. active ingredient/acre is the most effective herbicide treatment. Dicamba at 1 lb. active ingredient/acre, glyphosate at 1.5 lb. active ingredient/acre or glyphosate+2,4-D at 54 fl. oz. product/acre will control perennial pepperweed. Other herbicides that proved to be effective include chlorsulfuron and imazapyr.

Keys to Control:
- Plants must not be allowed to produce seed if control is to be successful.
- Use a combination of mechanical techniques and herbicide applications to control

Cultural/Preventive: Treat new infestations of perennial pepperweed as soon as they are found.
Integrated Management Summary A combination of mechanical (cutting or pulling) and herbicide applications can provide effective control of perennial pepperweed. Plants should be cut or pulled during the flower bud stage. Herbicides should be applied to the recovering stems when they return to flower bud stage later the same year.

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Russian Olive

***Elaeagnus angustifolia* L.**

Family: *Elaeagnaceae* (Oleaster)
Other Names: Russian olive, oleaster
Six Letter Code: ELAANG
USDA Code: ELAN

Keys to Identification:
- Russian olive is known by its silvery-gray color, short tree stature, fragrant flowers, and small, silvery fruits.

Identification

Growth form: Russian olive is a large, spiny, perennial, deciduous shrub or small tree to 30 ft tall.
Flower: Highly aromatic, creamy yellow flowers appear in June and July.
Seeds/Fruit: Clusters of abundant silvery fruits, about 1/2 inch long, mature from August to October and stay on the tree through the winter.
Leaves: The dull green to gray, elliptical to lanceolate shaped leaves are alternate and simple, 1 to 3 inches long by about 1/2 inch wide, distinctly scaly above and silvery-scaly below.
Stems: The branches are silvery, scaly and thorny when young; and shiny, light brown when mature. The bark is at first smooth and gray, becoming unevenly rigid and wrinkled.

Similar Species

Exotics: None known
Natives: Silverberry *(Elaeagnus commutata)* is a smaller shrub of similar coloration that occurs on drier riparian and upland sites.

Impacts

Ecological: Russian olive, with its tendency to spread quickly, is a menace to riparian woodlands, threatening strong, native species like cottonwood and willows. Russian olive has out competed native vegetation, interfering with natural plant succession and nutrient cycling, and choking irrigation canals and marshlands, displacing native plants and critical wildlife habitats. Areas dominated by Russian olive do not have a high concentration of wildlife. Although Russian olive is a source of food and habitat for some wildlife, ecologists have found that bird species richness is actually greater in areas with a higher concentration of native vegetation.
Human: Russian olive was introduced by humans as an attractive landscape species. Its dense, silvery foliage forms a good hedge to screen out unwanted views. Until recently, it was planted for wildlife habitat and windbreaks by the USDA Natural Resource and Conservation Service.

Habitat and Distribution

General requirements: Russian olive can tolerate a variety of temperature, water, and soil conditions, including bare mineral substrates. The species is very adaptive and is an initial colonizer of disturbed sites. It grows along floodplains, riverbanks, streams and marshes. It can tolerate large amounts of

salinity and can grow well in a variety of soils from sand to heavy clay. It can survive temperatures from –50 to 115 degrees F. It is shade tolerant, allowing it to withstand competition from taller trees. It can absorb nitrogen into its roots, giving it the ability to grow on bare, mineral surfaces.
Distribution: Russian olive is found throughout North America, but mainly in the central and western portions of the United States. It has naturalized and been planted in 17 western states from the Dakotas, Nebraska, Kansas, Oklahoma, and Texas westward to the Pacific coast. It is most abundant in the Great Basin Desert region and the riparian zones of the Great Plains.

Biology/Ecology

Mode of reproduction: Seed primarily, but also resprout of cut stems
Seed production: Abundant
Seed bank: Seeds are persistent
Dispersal: Birds and small mammals foraging on the fruit scatter seeds widely.

Control

Russian olive is very difficult to control or eradicate, due to its capacity to produce root sprouts and "suckers." Although the species can thrive without water, it becomes stressed when there is a severe lack of water, often causing fungus to appear.

Keys to Control:

- Eradicate initial colonizer plants by cutting and applying herbicide to the stump or digging out the roots.

Biocontrol: Few animals and insects feed or bother Russian olive, so there tends to be no effective biological control. There are two kinds of fungus that can affect it: Verticillium wilt and Phomopsis canker. Verticillium wilt attacks and usually kills Russian olive in eastern areas that are very humid and wet or poorly drained, causing the leaves to wilt. Canker disease is a reddish-brown to black canker that appears on smaller branches, resulting in a kind of "bleeding" on the diseased areas. Once the fungus covers the branch, lack of water causes the leaves to wilt and the branches die off.
Mechanical: Cutting has little effect on it, as it resprouts heartily from the stump. Mowing Russian olive with a brush type mower, removing cut material, and then spraying is probably the most effective way to eradicate the species.
Fire: Russian olive is fire resistant and tends to colonize burned areas, yet burning with a combination of herbicide spraying on the stump may prevent it from resprouting.
Herbicides: Systemic herbicides, such as Roundup®, Glypro®, Garlon 3A®, and Garlon 4® can be effective when applied to cut stumps or when used as a foliar spray. A small amount of Tordon Kit in the mixture will control resprouting. Basal bark application of Garlon 4® with Penevator Basal Oil® can also be an effective control.

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Russian Thistle

Salsola iberica Sennen

Family: *Chenopodiaceae* (Goosefoot)
Other Names: tumbleweed
Six Letter Code: SALIBE
USDA Code: SAIB

Keys to Identification:
- Stems of Russian thistle have purple stripes.
- Inconspicuous flowers are borne in leaf axils.
- Seedling plants have long, fleshy leaves.

Identification

Growth form: Annual forb
Flower: Inconspicuous flowers are borne in axils of the upper leaves. Each flower is accompanied by a pair of spiny, floral bracts (Whitson et al. 1996).
Seeds/Fruit: Small one-seeded fruits with winged tips. Seeds are round, black, smooth and shiny.
Leaves: Leaves are alternate; the first leaves are long, string-like and soft. Later leaves are short, scale-like and tipped with a stiff spine (Whitson et al. 1996).
Stems: Mature plants are 0.5-3 ft tall and are rounded, bushy, and highly branched. Stems are red or purpled striped.
Roots: The root system consists of a taproot that can grow 3 ft or more in depth with extensive lateral roots
Seedling: Seedling plants have long, fleshy leaves.

Similar Species

Exotics: Young Russian thistle plants resemble young halogeton plants, although halogeton lacks spines.
Natives: None known.

Impacts

Agricultural: It is well adapted to cultivated dryland agriculture, but is also found on disturbed rangeland, and wasteland.
Ecological: Russian thistle colonizes barren desert areas that cannot support other flora, and invades many different disturbed plant communities. Since its introduction, it has become one of the most common and troublesome weeds in the drier regions of the United States (Whitson et al.1996). Russian thistle occurs in many communities. It is most common along disturbed grassland and desert communities. In disturbed big sagebrush communities, Russian thistle dominated for the first two years. After this time plants became overcrowded and stunted, and were replaced by mustards (FEIS 1996).
Human: No information available.

Habitat and Distribution

General requirements: Russian thistle grows in disturbed or unoccupied sites. (FEIS 1996). It grows on any type of well-drained, uncompacted soil with a sunny exposure. Russian thistle cannot tolerate saturated soil for extended periods.
Distribution: Found throughout central and western North America, up to 8,550 ft (FEIS 1996).
Historical: No information available.

Biology/Ecology

Life cycle: In spring, Russian thistle seeds will germinate at virtually any conceivable seedbed temperature (FEIS 1996). Plants typically flower from July through October. Seeds mature during August through November. Russian thistle seedlings are poor competitors, and do not establish well in crowded communities (FEIS 1996).
Mode of reproduction: Reproduces by seeds.
Seed production: One plant can produce up to about 250,000 seeds (FEIS 1996).
Seed bank: Seeds remain viable less than a year.
Dispersal: After seeds mature in the fall the plant stem separates from the root. The plant is then blown by wind. Seeds, held in the leaf axils, fall to the ground as the plant tumbles.
Hybridization: No information available.

Control

Biocontrol: The Division of Plant Industry's Biological Pest Control Section has two moth species, *Coleophora klimeschiella* and *C. parthenica*, that may be available for redistribution.
Mechanical: Mowing or pulling young plants can be used to control Russian thistle. However this process may have to be repeated for several years to be successful.
Fire: Prescribed burning is not recommended for control of Russian thistle, since it favors disturbed communities and readily recolonizes burned areas (FEIS 1996).
Herbicides: Dicamba at 0.5 lb, 2,4-D at 1 lb, or glyphosate at 1.5 lb active ingredient/acre, have been used to successfully control Russian thistle (Calweed 1997).
Cultural/Preventive: Prevent the establishment of new infestations by minimizing disturbance and seed dispersal, eliminating seed production and maintaining healthy native communities.

Keys to Control:

- Maintain vigorous stands of perennial plants.
- Herbicides should be applied at the seedling growth stage for best results.
- Small infestations can be controlled by mowing or pulling young plants.

Integrated Management Summary

For effective control of Russian thistle, control methods should be accompanied by a program to maintain or enhance the natural plant cover. As with other annual plants which reproduce by seeds, Russian thistle can eventually be controlled by eliminating seed production until the soil seed bank is depleted. Cut/pull or treat plants with herbicide prior to seed set.

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Spotted Knapweed

***Centaurea maculosa* L.**

Family: *Asteraceae* (Sunflower)
Other Names: none widely accepted
Six Letter Code: CENMAC
USDA Code: CEMA4

Keys to Identification:
- Spotted knapweed can be distinguished from other similar looking knapweeds by the dark tips and fringed margins of the floral bracts.

Identification

Growth form: Short-lived perennial forb (rarely biennial).
Flower: Flowering heads are solitary at the ends of branches. The floral bracts are stiff and tipped with a dark comb-like fringe. The flowers are pinkish-purple or rarely cream colored.
Seeds/Fruit: Seeds have a tuft of persistent bristles.
Leaves: Rosette leaves are up to 6 inches long, and deeply lobed. The principal stem leaves are pinnately divided, have smooth margins, and become smaller toward the top of the shoot. Leaves are alternate.
Stems: Mature plants are 1-3 ft tall with one or more stems.
Roots: Spotted knapweed has a stout taproot.
Seedling: Rosettes of spotted and diffuse knapweed are nearly indistinguishable. Leaves are narrow and 1-2 times pinnately divided (Stubbendieck et al. 1995).
Other: Closely related to diffuse knapweed (*Centaurea diffusa*).

Similar Species

Exotics: Other knapweeds include diffuse knapweed (*Centaurea diffusa*) which has a distinct terminal spine on the floral bracts, Russian knapweed *(Centaurea repens)* whose flowers are smaller than those of spotted knapweed and do not have black mottling on the flower bracts, squarrose *(Centaurea virgata)* and black *(Centaurea nigra)* knapweeds.
Natives: American star-thistle *(Centaurea americana).* Other native members of the sunflower family can resemble knapweed in the seedling/rosette stage.

Impacts

Agricultural: Spotted knapweed reduces or displaces desirable plant species, thereby reducing livestock and wildlife forage (Sheley et al. 1999).
Ecological: Spotted knapweed is a highly competitive weed that invades disturbed areas and degrades desirable plant communities. It forms near monocultures in some areas of western North America (FEIS 1996). There is evidence that spotted knapweed produces allelopathic chemicals that inhibit growth of other plants (Rutledge and McLendon, 1998). This allows it to form dense monocultures. However, Kelsey and Bedunah (1989) reported that resource capture was more important than allelopathy in spotted knapweed success. Although it is usually found in disturbed areas, once a colony is established, it may invade adjacent undisturbed areas (Rutledge and McLendon, 1998).

Human: The sap of spotted knapweed can cause skin irritation in some people. As a precaution, anyone working with spotted knapweed should wear protective gloves and avoid getting knapweed sap into open cuts or abrasions. Workers should wash hands and exposed skin with soap and water following contact with this plant.

Habitat and Distribution

General requirements: Spotted knapweed is adapted to well-drained, light to coarse-textured soils. It is not tolerant of shade. It tends to inhabit somewhat moister sites than diffuse knapweed, preferring areas that receive 12 to 30 inches mean annual precipitation.
Distribution: Spotted knapweed has heavily infested large areas of several states in the Pacific Northwest, with lesser infestations throughout much of the United States.
Historical: Native to central Europe and Asia.

Biology/Ecology

Life cycle: Spotted knapweed germinates in spring or fall (Beck 1997). Spotted knapweed seedlings develop into and remain as rosettes for at least one growing season while root growth occurs (FEIS 1996). It usually bolts for the first time in May of its second growing season and flowers August through September (Rutledge and McLendon, 1998). Individual flowers bloom for 2-6 days (FEIS 1996). Plants are self fertile and are also cross-pollinated by insects.
Mode of reproduction: Spotted knapweed reproduces entirely by seed and is a prolific seed producer.
Seed production: Plants may produce up to 140,000 seeds/m2 (Rutledge and McLendon, 1998). Most seeds are shed immediately after reaching maturity.
Seed bank: Spotted knapweed seeds exhibit three germination behaviors: dormant light-sensitive, dormant light insensitive, and non-dormant (FEIS 1996). Dormant seeds form a seed bank and may remain viable in the soil for over 8 years (Rutledge and McLendon, 1998).
Dispersal: Knapweed seeds are often spread in hay and on vehicle undercarriages.
Hybridization: No information available.

Control

Biocontrol: Currently, there is no single biological control agent that effectively controls knapweed populations. Some researchers believe that it will take a combination of up to twelve different insects to reduce knapweed infestations (Beck 1997). The Division of Plant Industry's Biological Pest Control Section has five species that may be available for redistribution. These five species are *Urophora affinis*, *U. quadrifasciata*, *Agapeta zoegana*, and *Sphenoptera jugoslavica*, *Cyphocleonus achates*. The seedhead flies *U. affinis* and *U. quadrifasciata* have been released in many Front Range communities (Beck 1997). These insects cause plants to produce fewer viable seeds and abort terminal or lateral flowers (Beck 1997). Biological control insects may help reduce knapweed plants in stands of desirable plant species. For this reason, insects may be beneficial in combination with other control methods. Cattle and sheep will both graze spotted knapweed, although sheep appear to be the more effective control animal. Olson et al. (1997) found that limited duration sheep grazing of spotted knapweed when associated grasses were dormant reduced knapweed seedlings and rosettes and reduced knapweed reproduction.

Keys to Control:
- The most effective method of control for spotted knapweed is to prevent its establishment. Areas should be monitored two to three times a year (spring, summer, and fall) and any new rosettes should be destroyed.
- Established plants or stands of spotted knapweed can be pulled or spot treated with picloram, or a combination of picloram and dicamba.
- Burning may be an effective means of controlling knapweed in areas where seasonal or occasional fires are part of the natural ecosystem.

Goats would also probably be effective in controlling spotted knapweed.

Mechanical: Cutting, mowing, or removing the above ground portion of the plant after flowering, but before seed set, may be an effective way to eliminate seed production. However, spotted knapweed seeds can remain dormant in the soil for nearly a decade, requiring any cutting program to be repeated annually to be effective. A long-term program with repeated cuts of bolted plants only for several years will strongly reduce numbers and cover of spotted knapweed. Pulling can control spotted knapweed in small areas. Pulling works best when the soil is wet so the entire plant crown and taproot can be removed.

Fire: Burning has either promoted or controlled spotted knapweed; this variability in effect probably reflects differences in environmental conditions before and after the burns occurred and differences in the competitiveness of the native plant communities that were burned. Burning has been shown an effective control of knapweed with strong grass re-growth occurring on burned sites (Watson and Renney 1974). However, herbicide efficacy may increase when applied on post-burn rangeland, possibly due to the removal of standing dead material that would otherwise intercept herbicide (Lacey et al. 1995). A low-severity fire may only top-kill knapweed, but a severe fire will probably kill the plant. Dry soil conditions associated with burns may discourage knapweed re-infestation as moisture is the limiting factor for knapweed seed germination. Re-seeding desirable species should be part of any burning program to deter a re-infestation of knapweed or other exotic species.

Herbicides: Several herbicides are relatively effective at controlling knapweed. Picloram at 1.0 lb active ingredient/acre is the most effective, but has a long soil life and can damage non-target species (Harris and Cranston 1979, Watson and Renney 1974). Davis (1990) found that picloram applied at 0.25 lb active ingredient/ac provided 100 percent spotted knapweed control for 3-5 years. Other effective herbicides include dicamba or 2,4-D at 1 lb active ingredient/acre, or glyphosate at 1.5 lb active ingredient/acre. To save money and reduce grass injury resulting from higher use rates of a single herbicide, several of these herbicides can be combined (Beck 1997). Tank-mixes of picloram and dicamba (0.25 to 0.5 lb/acre + 0.125 to 0.25 lb/acre), picloram plus 2,4-D (0.188 lb/acre + 1.0 lb/acre), and dicamba plus 2,4-D (0.5 lb/acre + 1.0 lb/acre) all control knapweed (Beck 1997). Clopyralid applied at 0.24 lb active ingredient/ac and at 0.2 lb active ingredient/ac + 2,4-D at 1.0 lb active ingredient/ac provide control comparable to picloram when applied at the bolt or bud growth stages (Sheley et al. 1999). A backpack sprayer or a wick is highly recommended in small areas to minimize damage to non-target plants. Herbicides should be applied before the mature plants set seed to maximize effectiveness.

Cultural/Preventive: Prevent the establishment of new infestations by minimizing disturbance and seed dispersal.

Integrated Management Summary

Spotted knapweed can spread readily by stems that are carried on vehicles or in infested hay or seed. Early detection and prompt control of small spotted knapweed infestations are by far the most economical ways to manage this weed. Spotted and diffuse knapweed can be managed similarly (Beck 1997). They are readily controlled with herbicides but will re-invade unless cultural techniques are used (Beck 1997). Sheley and Jacobs (1997) found that a ninety percent reduction in diffuse knapweed was necessary to shift the competitive relationship in favor of bluebunch wheatgrass. The sap of spotted knapweed can cause skin irritation in some people. As a precaution, anyone working with spotted knapweed should wear protective gloves and avoid getting knapweed sap into open cuts or abrasions. Workers should wash their hands and exposed skin with soap and water following contact with this plant.

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Whitetop

Cardaria draba (L.) Desv.

Family: *Brassicaceae* (Mustard)
Other Names: heart-podded whitetop, hoary cress, pepperweed
Six Letter Code: CARDRA
USDA Code: CADA

Keys to Identification:

- Whitetop can be easily identified by the clusters of numerous, four-petal, white flowers that give it a flat-topped appearance.

Identification

Growth form: Perennial forb.
Flower: Numerous white flowers with four petals, give the plant a white, flat-topped appearance.
Seeds/Fruit: Seed capsules are heart shaped, and contain two reddish brown seeds.
Leaves: Leaves are alternate, 1.6-4 inches long, blue green in color, and lance-shaped. Lower leaves are stalked, while the upper leaves have two lobes clasping the stem.
Stems: Mature whitetop plants are up to two ft tall with erect stems.
Roots: Roots are rhizomatous and usually occur at depth of 29-32 inches, but have been recorded to penetrate to a depth of 30 ft in the Pacific Northwest (FEIS 1996).
Seedling: No information available.

Similar Species

Exotics: Two other closely related species, *Cardaria pubescens* and *Cardaria chalapensis* are designated as noxious weeds in some states (Sheley and Stivers 1999).
Natives: Rosettes of gumweed *(Grindelia squarrosa)* are similar, and are found in similar habitat.

Impacts

Agricultural: Whitetop is generally considered unpalatable to livestock.
Ecological: Whitetop is invading rangelands throughout North America. It is highly competitive, once it becomes established, and spreads primarily by extremely persistent roots. Stands eventually eliminate desirable vegetation, becoming a monoculture.
Human: No information available.

Habitat and Distribution

General requirements: Whitetop is typically found on generally open, unshaded, disturbed ground. It grows well on alkaline soils that are wet in late spring and generally does better in areas with moderate amounts of rainfall. It is widespread in fields, waste places, meadows, pastures, croplands, and along roadsides (FEIS 1996).

Distribution: Whitetop is widespread in the United States except along the southern boundary of the western and southcentral states (USDA 1971). In Montana whitetop was first identified in Gallatin County in 1916. This weed has been introduced in all but two of Montana's 56 counties and infests about 32 thousand acres. It is predominantly found in alfalfa, pastures, rangeland and small grain.
Historical: Whitetop is a weed of Eurasian origin.

Biology/Ecology

Life cycle: The root system of whitetop consists of vertical and horizontal roots from which new rosettes and flowering shoots arise (Mulligan and Findlay 1974). Plants emerge in very early spring. The first leaves appear aboveground 5 to 6 weeks after planting (Mulligan and Findlay 1974, FEIS 1996). During this period, the first leaves emerge and form a loose rosette (Mulligan and Findlay 1974, FEIS 1996). Stems arise from the center of each rosette in late April (FEIS 1996). Plants flower from May to June, are self-incompatible, and are pollinated by insects. The plants set seed by mid-summer (Whitson et al. 1996). If conditions are favorable, a second crop of seeds can be produced in the fall (Sheley and Stivers 1999).
Mode of reproduction: Whitetop reproduces both by seeds and vegetatively. It spreads vigorously by creeping roots (FEIS 1996). Within three weeks of germination, a seedling root can begin producing buds (FEIS 1996). One plant can eventually result in a large colony and push out other vegetation to form a monoculture.
Seed production: One plant can produce from 1,200-4,800 seeds.
Seed bank: 84 percent of seed produced are viable the first season (Mulligan and Findlay 1974, FEIS 1996). Buried seeds can remain viable for three years in the soil (Sheley and Stivers 1999).
Dispersal: No information available.
Hybridization: No information available.

Control

Biocontrol: Currently, there is little information about biological controls that attack whitetop. Sheep grazing may control it, but evidence is limited. Managing the grazing is important so desirable species are not damaged.
Mechanical: Mowing 2-3 times a year for several years may slow the spread and reduce seed production. Mowing may increase the effectiveness of subsequent herbicide application (Sheley and Stivers 1999). Mowing should be conducted during the bud stage and repeated when the plants re-bud. The effectiveness of a mowing program can be increased by planting perennial grasses as competitors.

Keys to Control:
- Exhaust the root system and eliminate seed production by mowing or treating with herbicides.
- Maintain a healthy cover of perennial plants to discourage the establishment and spread of hoary cress.

Fire: Rapid growth rate may favor hoary cress after fires, which temporarily eliminate native vegetation. Plants may resprout from rhizomes or establish from seeds (FEIS 1996).
Herbicides: Whitetop is most commonly controlled with herbicides. However, multiple applications are usually needed to provide lasting control. The best time to apply herbicides is in May or June before flowering. The non-crop herbicides metsulfuron and chlorsulfuron are most effective herbicides while the plants still have green tissue (CSU 1998a). It is important to use a non-ionic surfactant with the herbicide (Sheley and Stivers 1999). 2,4- D + dicamba is very effective when applied during the early pre-bud stage (late May through early June) (CSU 1998a). Glyphosate at 1.5 lb active ingredient/acre applied during the flower stage will provide good control. Picloram does not control whitetop. Spraying followed by spring mowing can control whitetop by up to 90 percent (FEIS 1996).
Cultural/Preventive: Cultivation alone will control whitetop when tillage begins at flower bud stage and is repeated every ten days throughout the growing season (FEIS 1996). Reseeding of depleted areas with competitive grasses would probably be an effective complement to sheep grazing.

Nitrogen fertilization can increase the growth of grasses and slow the rate of whitetop invasion (Sheley and Stivers 1999).

Integrated Management Summary

Whitetop is an aggressive weed, reproducing from seed and vegetatively. It can crowd out desirable species and form a monoculture. In the absence of competition, a single plant can spread over an area 12 ft in diameter in a single year (FEIS 1996). Whitetop is commonly controlled with herbicides and less commonly controlled by mowing. Control is difficult because of the perennial root system, abundant seed production, and diverse habitats of the plant (FEIS 1996).

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Yellow Toadflax

Linaria vulgaris P. Miller

Family: *Scrophulariaceae* (Figwort)
Other Names: butter and eggs, wild snapdragon, common toadflax
Six Letter Code: LINVUL
USDA Code: LIVU2

Keys to Identification:

- Yellow toadflax can be identified by its yellow, snapdragon-like, flowers and disagreeable turpentine-like scent.
- It can be distinguished from dalmatian toadflax by its leaves. The leaves of yellow toadflax are narrow, lance-shaped, and pointed at both ends. The leaves of dalmatian toadflax are shorter, wider, and broad-based.

Identification

Growth form: Perennial forb
Flower: Flowers are bright yellow and resemble snapdragons. Flowers are arranged in a raceme at the ends of the branches.
Seeds/Fruit: Seed capsules are round-ovate, 0.3-0.5 inches long, and two-celled. Seeds are brown or black, circular, and surrounded by a notched wing.
Leaves: Leaves are soft, lance-shaped, and pale green. Leaves are mainly alternate but lower leaves appear to be opposite due to crowding.
Stems: Mature yellow toadflax plants are 1-3 feet tall with 1-25 smooth erect floral stems.
Roots: Taproots may be up to a meter in length. Horizontal roots may grow to be several meters long, and can develop adventitious buds that may form independent plants.
Seedling: No information available.
Other: Closely related to dalmatian toadflax *(Linaria dalmatica)*.

Similar Species

Exotics: Leaves of dalmatian toadflax *(Linaria dalmatica)* are shorter, wider, broad based, and clasping the stem.
Natives: None known.

Impacts

Agricultural: Yellow toadflax contains a poisonous glucoside that is reported to be mildly poisonous to cattle (Morishita 1991). However, the plant is considered unpalatable and reports of livestock poisonings are rare.
Ecological: Yellow toadflax is quick to establish in open sites and is capable of adapting growth to a wide range of environmental conditions. Yellow toadflax aggressively forms colonies through adventitious buds from creeping root systems. These colonies can push out native grasses and other perennials, thereby altering and simplifying the species composition of natural communities and reducing forage production for livestock and wildlife.
Human: No information available.

Habitat and Distribution

General requirements: Yellow toadflax has a highly variable habitat that depends on environmental factors such as shading, grazing, and soil type (Saner et al. 1995).
Distribution: Yellow toadflax now occurs throughout the continental United States and in every Canadian province and territory (Saner et al. 1995).
Historical: Yellow toadflax is native to the steppes of southeastern Europe and southwestern Asia. Yellow toadflax was introduced to New England in the late 1600s as an ornamental and medicinal plant and continues to be sold in nurseries and seed catalogs (FEIS 1996).

Biology/Ecology

Life cycle: Spring emergence occurs around mid-April and depends primarily on temperature. A smaller flush of seedlings can occur in the fall. Prostrate stems emerge in September and produce leaves that are ovate, 0.9-1.5 inches in size. Prostrate stems are tolerant to freezing and are associated with floral stem production the following year (Robocker 1974). The strong, upright floral stems that are characteristic of mature toadflax plants develop after a winter's dormancy, and emerge about the same time as seedlings in mid-April. Flowering occurs from May through August and seeds mature from July through October (Saner et al. 1995). Yellow toadflax is self-incompatible and relies on insects for pollination. The two most important pollinators are bumblebees and halictid bees (Zimmerman 1996).
Mode of reproduction: Yellow toadflax can reproduce both by seeds and vegetatively. Vegetative reproduction enables a stand of toadflax to spread rapidly. Stems develop from adventitious buds on primary and lateral roots. These buds can grow their own root and shoot system, and become independent plants the next year. Yellow toadflax colonies persist mostly via vegetation means while those of dalmatian toadflax persist both by vegetative and seed reproduction (Lajeunesse 1999).
Seed production: A mature plant can produce up to 30,000 seeds annually. A single stem has been reported to contain over 5,000 seeds (Saner et al. 1995).
Seed bank: Seeds can remain dormant for up to ten years.
Dispersal: Winged seeds aid wind dispersal. Seeds may also be dispersed by water and ants (Rutledge, 1998).
Hybridization: No information available.

Control

Biocontrol: The Division of Plant Industry's Biological Pest Control Section currently has one species, *Calophasia lunula*, that may be available for redistribution on yellow toadflax infestations. *C. lunula* larvae feed extensively on leaves and flowers of toadflax, severely damaging the plants.
Mechanical: Hand pulling toadflax before seed set each year can be an effective control method especially in coarse-textured soils where large portions of the roots can be pulled. However, this method must be repeated as long as there are viable seeds in the soil (up to 10 years). Cutting or mowing yellow toadflax reduces the current year growth and possibly seed dispersal, but will not kill the plant. These techniques are not recommended to control any toadflax species (Lajeunesse 1999).

Keys to Control:
- Limit vegetative spread of colonies.
- Destroy seedlings that emerge from the soil seed bank.
- Maintain a cover of native perennial plants to discourage infestation elsewhere.

Fire: Burning is not a recommended control method for yellow toadflax (Saner et al. 1995). The large, deep root system protects the plant from burning. In fact, areas that have been recently disturbed by fire are susceptible to increased toadflax infestation.
Herbicides: Effectiveness of herbicides on both toadflax species is highly variable, reflecting in part their high genetic variability (Lajeunesse 1999). Yellow toadflax is difficult to control with herbicides. Herbicides should be applied during flowering when carbohydrate reserves in the root of the plants

are at their lowest. Picloram or dicamba at 1 lb. active ingredient/acre, or glyphosate at 1.5 lb. active ingredient/acre, will kill yellow toadflax plants in some situations. 2,4-D, MCPA, 2,4-DB, MCPB and mecoprop are ineffective on yellow toadflax (Lajeunesse 1999). Picloram+2,4-D at 0.5+1.0 lb. active ingredient/acre (as Grazon P+D®) controlled 95-100% of yellow toadflax when applied for 1-3 consecutive years (Sebastian and Beck 1999).

Cultural/Preventive: In agricultural areas, minimum-till cultivation practices have contributed to the resurgence of toadflax populations (McClay 1992). By not tilling the soil, and subsequently damaging the root system of toadflax plants, toadflax colonies have been able to flourish. Intensive clean cultivation techniques are recommended for successful toadflax control on agricultural land. This requires at least two years with 8-10 cultivations in the first year and 4-5 cultivations in the second year (Morishita 1991).

Integrated Management Summary Yellow toadflax rapidly colonizes open sites. It is most commonly found along roadsides, fences, rangelands, croplands, clear cuts, and pastures. Disturbed or cultivated ground is a prime candidate for colonization. The seedlings of yellow toadflax are considered ineffective competitors for soil moisture with established perennials and winter annuals (Morishita 1991). However, once established, yellow toadflax suppresses other vegetation mainly by intense competition for limited soil water. Mature plants are particularly competitive with winter annuals and shallow-rooted perennials. The key to controlling yellow toadflax is to limit vegetative spread of established colonies (by cutting, pulling, or spraying seed stalks prior to seed set, or by using insects to destroy flowers, seeds, or damage plants). Once current seed production has been controlled, toadflax seedlings that emerge from the soil seed bank must be destroyed every year until the seed bank is diminished.

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Clark Fork River Operable Unit

of the Milltown Reservoir/Clark Fork River Superfund Site

Record of Decision

Appendix E:

Grant-Kohrs Ranch National Historic Site

E.1: List of Riparian Plant Communities

E.2: Planting Criteria and Vegetation Performance Standards After 10 years for Remediated Sites (for Individual Habitat Types and Community Types)

U.S. Environmental Protection Agency
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April 2004

APPENDIX E.1 – GRANT-KOHRS RANCH NATIONAL HISTORIC SITE

List of Riparian Plant Communities

Introduction

As discussed in Section 13.7 and elsewhere throughout the Record of Decision for the Clark Fork River Operable Unit (OU), remedial action within the Grant-Kohrs Ranch National Historic Site (GRKO) must attain location-specific Applicable or Relevant and Appropriate Requirements (ARARs) derived from the National Park Service Organic Act and the enabling legislation establishing GRKO. Attainment of these ARARs requires remedial measures that ensure the historic ranch landscape of the late nineteenth century is reestablished, preserved, and sustained for future generations in a condition unimpaired by hazardous substances. The "Grant-Kohrs Ranch National Historic Site Riparian Plant Communities" and "Planting Criteria and Vegetation Performance Standards after 10 years for Remediated Sites of the Grant-Kohrs Ranch National Historic Site" documents in this appendix (Appendix E.1 and E.2, respectively) define the performance standards by which attainment of these location-specific ARARs will be measured. These performance standards require that the selected remedial action reestablish self-producing native riparian vegetation communities as further described in this appendix.

To facilitate development of these performance standards, GRKO submitted to EPA a list of habitat types (HT) and community types (CT) (Rice 2003) that would be present within the riparian zone of GRKO but for the past and ongoing releases of hazardous substances from upstream mining activities. This list was derived from statistical analysis of a statewide wetland and riparian site classification (Hansen et al. 1995). In this appendix, the GRKO list is further refined to meet the site-specific physiographic conditions encountered within Reach A of the Clark Fork River OU.

Ecological Site Potential for Riparian and Wetland Types

The distribution of natural plant communities in an area, and the relative acres covered by each, depends on site potential and how it varies within the area, as well as on site disturbance. Within a relatively small area, such as the GRKO, the greatest determinant of vegetation potential is hydrology as modified by soil type. This parameter can vary greatly within short distances.

The remedial activities planned for contaminated areas within Reach A of the Clark Fork River OU, which includes the GRKO, include either in-place treatment with lime or removal. These activities may alter every treated site's vegetation potential.

Exotic (Non-native) Species

Non-native, or introduced exotic, species were not considered. However, they will invade remediated sites. Species such as Kentucky bluegrass (*Poa pratensis*), timothy (*Phleum pratense*), redtop (*Agrostis stolonifera*), common dandelion (*Taraxacum officinale*), and others will inevitably account for some of the understory canopy cover and species diversity. The most (perhaps only)

effective way to prevent their taking dominance of remediated sites is to cover the soil as quickly as possible with desired native species.

Required Types for GRKO

Table E.1-1 presents an estimate of the fractional breakdown of the GRKO floodplain area among the types that, in order to attain the site-specific ARAR, should occupy the remediated floodplain on the GRKO. This breakdown reflects our knowledge of riparian habitat type, community type, and riparian species distribution and relative abundance in the different regions of Montana.

TABLE E.1-1
Fifteen Required Habitat Types (HT) and Community Types (CT) Grouped by Overstory Lifeform Dominance (i.e., trees, shrubs, graminoids, and forbs) and Ranked by Estimated Percentage of Area Represented by the Type

Type	Deer Lodge Valley Distribution Category*	Estimated Percentage (%) of Total Area Represented	Typical Floodplain Position of the Type
Tree Dominated Types			
Black Cottonwood/Red-osier Dogwood (*Populus trichocarpa/Cornus stolonifera*) CT	Minor	8-12	Recent point bars and low floodplain terraces.
Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/Calamagrostis canadensis*) HT	Incidental	<1	Slightly moist to mesic floodplain sites
Shrub Dominated Types			
Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/Calamagrostis canadensis*) HT	Major	18-23	Drier areas in old oxbows, floodplain terraces.
Water Birch (*Betula occidentalis*) CT	Major	12-18	Moist areas, old oxbow banks, streambanks.
Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) HT	Major	12-18	Moist areas, old oxbow, streambanks.
Sandbar Willow (*Salix exigua*) CT	Minor	8-12	Recent point bars, streambanks.
Woods Rose (*Rosa woodsii*) CT	Minor	1-3	Drier areas on upper floodplain terraces.
Western Snowberry (*Symphoricarpos occidentalis*) CT	Minor	1-3	Drier areas on upper floodplain terraces.
Mountain Alder (*Alnus incana*) CT	Minor	1-3	Moist areas, old oxbow banks, streambanks.
Graminoid Dominated Types			
Beaked Sedge (*Carex rostrata*) HT	Minor	5-8	Wet sites, old oxbow, or slough bottoms.
Bluejoint Reedgrass (*Calamagrostis canadensis*) HT	Minor	3-6	Moist areas, old oxbow, and streambanks.
Western Wheatgrass (*Agropyron smithii*) HT	Minor	3-6	Drier open areas away from the river channel.
Water Sedge (*Carex aquatilis*) HT	Minor	2-4	Wet sites, old oxbow, or slough bottoms.
Common Spikesedge (*Eleocharis palustris*) HT	Incidental	<1	Ponded areas, water edges.

TABLE E.1-1
Fifteen Required Habitat Types (HT) and Community Types (CT) Grouped by Overstory Lifeform Dominance (i.e., trees, shrubs, graminoids, and forbs) and Ranked by Estimated Percentage of Area Represented by the Type

Type	Deer Lodge Valley Distribution Category*	Estimated Percentage (%) of Total Area Represented	Typical Floodplain Position of the Type
Forb Dominated Types			
Common Cattail (*Typha latifolia*) HT	Minor	2-4	Ponded areas, old oxbow, and slough bottoms.

*A ***major type*** occupies extensive acreages in at least some portion of the riparian or wetland zone; a ***minor type*** seldom occupies large acreages but may be common on smaller areas within the riparian or wetland zone; and an ***incidental type*** rarely occurs within the region, or is limited to narrow site conditions and/or very localized occurrence.

Species Composition of Required Habitat Types and Community Types

The ecological amplitude (the range of distribution across all site parameters—which translates to geographic range) of a habitat type or community type is never identical to that of all its constituent species. For this reason, when designing the species list for a given type, the geographic position of the particular site within the overall range of the type must be considered. Knowledge of the distribution and ecology of local natural vegetation is essential to correct prescriptions for "what and how much to plant where" in any installation of natural vegetation communities onto radically disturbed sites.

Not all species listed for any type can be expected to occur in any given stand of that type. The listed species are those deemed as appropriately adapted and reasonably likely to naturally occur in a stand of that type in the Deer Lodge Valley. Listed species are intended to constitute a design list, from which implementation design and performance standards can be drawn.

Tree Dominated Types

Black Cottonwood/Red-osier Dogwood (*Populus trichocarpa/Cornus stolonifera*) Community Type—Although very little of the Upper Clark Fork River Valley (Reach A) supports any tree types, GRKO does have several small stands of black cottonwood (*Populus trichocarpa*). Re-establishing young stands of black cottonwood (*Populus trichocarpa*) on suitable sites following remedial treatment will require selection of sites with dependable ground water contact, full sunlight, and little competition from other taller plants. This species may seed naturally on moist, suitably bare sites. The seed source is present, but success of this is dependent on flooding events. Competition from aggressive weeds and weedy herbaceous plants is the greatest obstacle to success of natural re-establishment of this type on sites free from excess grazing pressure. Table E.1-2 provides a list of native species that commonly occur in stands of the Black Cottonwood/Red-osier Dogwood (*Populus trichocarpa/Cornus stolonifera*) Community Type at this elevation and in this portion of its range. ***NOTE:*** Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-2
Native Plant Species that may be Present in a Mature Stand of the Black Cottonwood/Red-Osier Dogwood (*Populus trichocarpa/Cornus stolonifera*) Community Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) on a Typical Stand Having the Species Present
Trees	
black cottonwood (*Populus trichocarpa*)	40-70
Shrubs	
mountain alder (*Alnus incana*)	5-10
western serviceberry (*Amelanchier alnifolia*)	5-10
water birch (*Betula occidentalis*)	5-10
western virgins-bower (*Clematis ligusticifolia*)	1-3
red-osier dogwood (*Cornus stolonifera*)	20-40
common chokecherry (*Prunus virginiana*)	5-10
swamp current (*Ribes lacustre*)	1-3
Missouri gooseberry (*Ribes setosum*)	1-3
woods rose (*Rosa woodsii*)	2-5
common red raspberry (*Rubus idaeus*)	1-3
Bebb willow (*Salix bebbiana*)	5-10
Booth willow (*Salix boothii*)	5-10
sandbar willow (*Salix exigua*)	5-10
Geyer willow (*Salix geyeriana*)	5-10
yellow willow (*Salix lutea*)	2-5
western snowberry (*Symphoricarpos occidentalis*)	2-5
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	3-5
fringed brome (*Bromus ciliatus*)	1-3
bluejoint reedgrass (*Calamagrostis canadensis*)	30-60
Canada wildrye (*Elymus canadensis*)	1-3
fowl bluegrass (*Poa palustris*)	1-3
Forbs	
baneberry (*Actaea rubra*)	1-2
western aster (*Aster occidentalis*)	1-3
field horsetail (*Equisetum arvense*)	2-5
sweetscented bedstraw (*Galium triflorum*)	2-5
fringed loosestrife (*Lysimachia ciliata*)	1-2
field mint (*Mentha arvensis*)	1-2
mountain sweet-cicely (*Osmorhiza chilensis*)	1-3
starry Solomon-plume (*Smilacina stellata*)	1-3
streambank groundsel (*Senecio pseudaureus*)	1-2
Canada goldenrod (*Solidago canadensis*)	2-5
western meadowrue (*Thalictrum occidentalis*)	1-3
American vetch (*Vicia americana*)	1-2

Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/Calamagrostis canadensis*) Habitat Type— Although quaking aspen (*Populus tremuloides*) is not presently found on the GRKO, the species is recorded on several sites within the Upper Clark Fork River Valley (Reach A) on sites both upstream and downstream from GRKO. The Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/Calamagrostis canadensis*) Habitat Type occurs on higher floodplain terrace sites that are not frequently flooded. Table E.1-3 provides a list of native species that commonly occur in stands of the Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/Calamagrostis canadensis*) Habitat Type at this elevation and in this portion of its range. ***NOTE:*** Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-3
Native Plant Species that may be Present in a Mature Stand of the Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/Calamagrostis canadensis*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) on a Typical Stand Having the Species Present
Trees	
quaking aspen (*Populus tremuloides*)	40-70
Shrubs	
western serviceberry (*Amelanchier alnifolia*)	5-10
water birch (*Betula occidentalis*)	3-5
shrubby cinquefoil (*Potentilla fruticosa*)	1-3
Missouri gooseberry (*Ribes setosum*)	1-3
woods rose (*Rosa woodsii*)	3-5
common red raspberry (*Rubus idaeus*)	1-3
Bebb willow (*Salix bebbiana*)	3-5
western snowberry (*Symphoricarpos occidentalis*)	3-5
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	3-5
fringed brome (*Bromus ciliatus*)	1-2
bluejoint reedgrass (*Calamagrostis canadensis*)	50-80
Canada wildrye (Elymus canadensis)	1-3
Baltic rush (*Juncus balticus*)	1-3
fowl bluegrass (*Poa palustris*)	1-3
Forbs	
western aster (*Aster occidentalis*)	2-5
field horsetail (*Equisetum arvense*)	2-5
Virginia strawberry (*Fragaria virginiana*)	1-2
white geranium (*Geranium richardsonii*)	1-2
large leaved avens (*Geum macrophyllum*)	1-2
sweetscented bedstraw (*Galium triflorum*)	1-2
fringed loosestrife (*Lysimachia ciliata*)	1-2
field mint (*Mentha arvensis*)	1-2
mountain sweet-cicely (*Osmorhiza chilensis*)	1-2
streambank groundsel (*Senecio pseudaureus*)	1-2
starry Solomon-plume (*Smilacina stellata*)	1-2

TABLE E.1-3
Native Plant Species that may be Present in a Mature Stand of the Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/Calamagrostis canadensis*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) on a Typical Stand Having the Species Present
Canada goldenrod (*Solidago canadensis*)	1-2
western meadowrue (*Thalictrum occidentalis*)	1-2
American vetch (*Vicia americana*)	1-2
Canada violet (*Viola canadensis*)	1-2

Shrub Dominated Type

Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/Calamagrostis canadensis*) Habitat Type—The Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/Calamagrostis canadensis*) Habitat Type represents the potential of a large portion of the area within the floodplain in the Deer Lodge Valley on slightly drier sites than the Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) Habitat Type. Presently, as with the Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) Habitat Type, much of this area is disturbed to the extent of successional regression to various early seral community types and disclimaxes. Many of the stands still supporting willows have their understories converted to disturbance-induced exotic species. Table E.1-4 provides a list of native species that commonly occur in stands of the Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/Calamagrostis canadensis*) Habitat Type at this elevation and in this portion of its range. ***NOTE***: Each stand of this type will not contain all species in this list.

TABLE E.1-4
Native Plant Species That May be Present in a Mature Stand of the Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/ Calamagrostis canadensis*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Shrubs	
Geyer willow (*Salix geyeriana*)	30-60
Booth willow (*Salix boothii*)	20-40
water birch (*Betula occidentalis*)	5-10
red-osier dogwood (*Cornus stolonifera*)	5-10
sandbar willow (*Salix exigua*)	5-10
mountain alder (*Alnus incana*)	2-5
Bebb willow (*Salix bebbiana*)	2-5
swamp current (*Ribes lacustre*)	1-3
Missouri gooseberry (*Ribes setosum*)	1-3
woods rose (*Rosa woodsii*)	1-3
shrubby cinquefoil (*Potentilla fruticosa*)	1-2
Graminoids	
bluejoint reedgrass (*Calamagrostis canadensis*)	40-60
narrow-spiked reedgrass (*Calamagrostis stricta*)	5-10

TABLE E.1-4
Native Plant Species That May be Present in a Mature Stand of the Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/ Calamagrostis canadensis*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
tufted hairgrass (*Deschampsia cespitosa*)	1-2
bearded wheatgrass (*Agropyron caninum*)	3-5
fringed brome (*Bromus ciliatus*)	1-3
Baltic rush (*Juncus balticus*)	1-3
fowl bluegrass (*Poa palustris*)	1-3
fowl mannagrass (*Glyceria striata*)	1-2
Forbs	
fireweed (*Epilobium angustifolium*)	1-3
cow parsnip (*Heracleum lanatum*)	1-3
common yarrow (*Achillea millefolium*)	1-2
leafy aster (*Aster foliaceus*)	1-2
western aster (*Aster occidentalis*)	1-2
field horsetail (*Equisetum arvense*)	1-2
Virginia strawberry (*Fragaria virginiana*)	1-2
northern bedstraw (*Galium boreale*)	1-2
large leaved avens (*Geum macrophyllum*)	1-2
field mint (*Mentha arvensis*)	1-2
slender cinquefoil (*Potentilla gracilis*)	1-2
starry Solomon-plume (*Smilacina stellata*)	1-2
Canada goldenrod (*Solidago canadensis*)	1-2

Water Birch (*Betula occidentalis*) Community Type—The Water Birch (*Betula occidentalis*) Community Type is appropriate for a large fraction of the floodplain area on moist sites that are in early-to-mid seral successional stage in the Deer Lodge Valley. This type is well represented along the Clark Fork River by older, mature stands on slightly elevated floodplain terraces. Young stands that are to be established with seedling and small sapling nursery stock will need to be located on lower sites, having a shallow water table. Table E.1-5 provides a list of native species that commonly occur in stands of the Water Birch (*Betula occidentalis*) Community Type at this elevation and in this portion of its range. ***NOTE:*** Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-5
Native Plant Species That May be Present in a Mature Stand of the Water Birch (*Betula occidentalis*) Community Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Shrubs	
mountain alder (*Alnus incana*)	5-10
western serviceberry (*Amelanchier alnifolia*)	2-5
water birch (*Betula occidentalis*)	40-60
red-osier dogwood (*Cornus stolonifera*)	5-10
shrubby cinquefoil (*Potentilla fruticosa*)	1-2
common chokecherry (*Prunus virginiana*)	2-5
woods rose (*Rosa woodsii*)	1-3
Bebb willow (*Salix bebbiana*)	2-5
Booth willow (*Salix boothii*)	1-5
sandbar willow (*Salix exigua*)	5-10
Geyer willow (*Salix geyeriana*)	1-5
yellow willow (*Salix lutea*)	1-5
western snowberry (*Symphoricarpos occidentalis*)	1-3
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	3-5
bluejoint reedgrass (*Calamagrostis canadensis*)	30-50
Nebraska sedge (*Carex nebraskensis*)	3-5
Baltic rush (*Juncus balticus*)	1-3
fowl bluegrass (*Poa palustris*)	3-5
Forbs	
spreading dogbane (*Apocynum androsaemifolium*)	2-5
wartberry fairy-bell (*Disporum trachycarpum*)	1-2
common willow herb (*Epilobium ciliatum*)	1-2
field horsetail (*Equisetum arvense*)	1-2
smooth scouring rush (*Equisetum laevigatum*)	1-2
Virginia strawberry (*Fragaria virginiana*)	1-2
northern bedstraw (*Galium boreale*)	1-2
Nuttall's sunflower (*Helianthus nuttallii*)	1-2
starry Solomon-plume (*Smilacina stellata*)	1-2
Canada goldenrod (*Solidago canadensis*)	1-2

Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) Habitat Type—The Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) Habitat Type represents the potential of another large fraction of the floodplain in the Deer Lodge Valley. Presently much of this area is disturbed to the extent of successional regression to various early seral community types and disclimaxes. Many of the stands still support willow communities, but have understories converted to disturbance-induced exotic species. Table E.1-6 provides a list of native species that commonly occur in stands of the Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex*

rostrata) Habitat Type at this elevation and in this portion of its range. ***NOTE:*** Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-6
Native Plant Species That May be Present in a Mature Stand of the Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) Habitat Type Within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Shrubs	
mountain alder (*Alnus incana*)	2-5
water birch (*Betula occidentalis*)	2-5
shrubby cinquefoil (*Potentilla fruticosa*)	1-2
Bebb willow (*Salix bebbiana*)	2-5
Booth willow (*Salix boothii*)	20-40
sandbar willow (*Salix exigua*)	3-5
Geyer willow (*Salix geyeriana*)	30-60
yellow willow (*Salix lutea*)	1-2
Graminoids	
tickle grass (*Agrostis scabra*)	1-2
fringed brome (*Bromus ciliatus*)	1-2
narrow-spiked reedgrass (*Calamagrostis stricta*)	1-2
bluejoint reedgrass (*Calamagrostis canadensis*)	5-10
water sedge (*Carex aquatilis*)	10-30
soft-leaved sedge (*Carex disperma*)	2-5
wooly sedge (*Carex lanuginosa*)	2-5
beaked sedge (*Carex rostrata*)	40-70
inflated sedge (*Carex vesicaria*)	1-2
tufted hairgrass (*Deschampsia cespitosa*)	1-2
fowl mannagrass (*Glyceria striata*)	1-2
Baltic rush (*Juncus balticus*)	1-3
fowl bluegrass (*Poa palustris*)	1-2
Forbs	
leafy aster (*Aster foliaceus*)	1-2
western aster (*Aster occidentalis*)	1-2
large leaved avens (*Geum macrophyllum*)	1-3
common willow herb (*Epilobium ciliatum*)	1-2
field horsetail (*Equisetum arvense*)	1-2
Virginia strawberry (*Fragaria virginiana*)	1-2
small bedstraw (*Galium trifidum*)	1-2
field mint (*Mentha arvensis*)	1-2
starry Solomon-plume (*Smilacina stellata*)	1-2
Canada goldenrod (*Solidago canadensis*)	1-2
Canada violet (*Viola canadensis*)	1-2

Sandbar Willow (*Salix exigua*) Community Type—Sandbar willow (*Salix exigua*) is a major species throughout the Deer Lodge Valley. It is a pioneer of broad ecological amplitude, meaning it can grow on a wide array of site types. It is adapted for most sites of exposed, moist, mineral soil. The Sandbar Willow (*Salix exigua*) Community Type represents an early seral stage that will develop into one of several later seral stages, as late seral species assume dominance. Large amounts of sandbar willow (*Salix exigua*) may be planted throughout the Clark Fork River OU on or near the streambank for stabilization purposes. Most of these sites will proceed along this successional path through the sandbar willow (*Salix exigua*) to one of the other willow dominated habitat types over the coarse of 50 to 75 years. Table E.1-7 provides a list of native species that commonly occur in stands of the Sandbar Willow (*Salix exigua*) Community Type at this elevation and in this portion of its range. ***NOTE:*** Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-7
Native Plant Species That May be Present in a Mature Stand of the Sandbar Willow (*Salix exigua*) Community Type Within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Shrubs	
mountain alder (*Alnus incana*)	2-5
western serviceberry (*Amelanchier alnifolia*)	1-2
water birch (*Betula occidentalis*)	3-5
red-osier dogwood (*Cornus stolonifera*)	5-10
woods rose (*Rosa woodsii*)	2-5
Bebb willow (*Salix bebbiana*)	1-2
Booth willow (*Salix boothii*)	2-5
sandbar willow (*Salix exigua*)	80-100
Geyer willow (*Salix geyeriana*)	3-5
yellow willow (*Salix lutea*)	1-2
western snowberry (*Symphoricarpos occidentalis*)	2-5
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	3-5
western wheatgrass (*Agropyron smithii*)	1-2
bluejoint reedgrass (*Calamagrostis canadensis*)	30-60
narrow-spiked reedgrass (*Calamagrostis stricta*)	5-10
beaked sedge (*Carex rostrata*)	2-5
fowl bluegrass (*Poa palustris*)	1-2
Forbs	
hemp dogbane (*Apocynum cannabinum*)	1-2
field horsetail (*Equisetum arvense*)	1-2
wild licorice (*Glycyrrhiza lepidota*)	1-2
field mint (*Mentha arvensis*)	1-2
Canada goldenrod (*Solidago canadensis*)	1-2

Woods Rose (*Rosa woodsii*) Community Type—The Woods Rose (*Rosa woodsii*) Community Type is appropriate for a small areas on drier sites on upper terraces near the outer edges of the floodplain along the Clark Fork River in the Deer Lodge Valley. Table E.1-8 provides a list of native species that commonly occur in stands of the Woods Rose (*Rosa woodsii*) Community Type at this elevation and in this portion of its range. ***NOTE:*** Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-8
Native Plant Species That May be Present in a Mature Stand of the Woods Rose (*Rosa woodsii*) Community Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Shrubs	
woods rose (*Rosa woodsii*)	50-80
western snowberry (*Symphoricarpos occidentalis*)	10-30
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	5-10
western wheatgrass (*Agropyron smithii*)	20-40
Canada wildrye (*Elymus canadensis*)	1-3
Baltic rush (*Juncus balticus*)	1-3
satin-grass (*Muhlenbergia racemosa*)	1-2
fowl bluegrass (*Poa palustris*)	1-3
Forbs	
common yarrow (*Achillea millefolium*)	1-2
Virginia strawberry (*Fragaria virginiana*)	1-2
northern bedstraw (*Galium boreale*)	1-3
wild licorice (*Glycyrrhiza lepidota*)	3-5
Canada goldenrod (*Solidago canadensis*)	1-3

Western Snowberry (*Symphoricarpos occidentalis*) Community Type—Western snowberry (*Symphoricarpos occidentalis*) is common throughout the Deer Lodge Valley on dry-to-slightly moist sites. It is an early-to-mid seral species that is a common constituent of many other types, but it occasionally develops dominance of stands in open sites. Table E.1-9 provides a list of native species that commonly occur in stands of the Western Snowberry (*Symphoricarpos occidentalis*) Community Type at this elevation and in this portion of its range. ***NOTE:*** Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-9
Native Plant Species That May be Present in a Mature Stand of the Western Snowberry (*Symphoricarpos occidentalis*) Community Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Shrubs	
woods rose (*Rosa woodsii*)	10-20
western snowberry (*Symphoricarpos occidentalis*)	50-80
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	3-5
western wheatgrass (*Agropyron smithii*)	20-40
Canada wildrye (*Elymus canadensis*)	2-3
Forbs	
common yarrow (*Achillea millefolium*)	1-2
prairie sagewort (*Artemisia ludoviciana*)	1-2
northern bedstraw (*Galium boreale*)	1-2
wild licorice (*Glycyrrhiza lepidota*)	1-2
satin grass (*Muhlenbergia racemosa*)	1-2
Canada goldenrod (*Solidago canadensis*)	1-2

Mountain Alder (*Alnus incana*) Community Type—The Mountain Alder (*Alnus incana*) Community Type is appropriate for small areas on moist sites along streambanks and edges of sloughs along the Clark Fork River in the Deer Lodge Valley. This type is represented in the Deer Lodge Valley by small stands that are usually associated with entering tributary streams. Table E.1-10 provides a list of native species that commonly occur in stands of the Mountain Alder (*Alnus incana*) Community Type at this elevation and in this portion of its range. ***NOTE:*** Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-10
Native Plant Species That May be Present in a Mature Stand of the Mountain Alder (*Alnus incana*) Community Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Shrubs	
mountain alder (*Alnus incana*)	50-80
red-osier dogwood (*Cornus stolonifera*)	10-20
stinking current (*Ribes hudsonianum*)	1-3
woods rose (*Rosa woodsii*)	1-3
common red raspberry (*Rubus idaeus*)	3-5
Bebb willow (*Salix bebbiana*)	3-5
sandbar willow (*Salix exigua*)	3-5
yellow willow (*Salix lutea*)	3-5

TABLE E.1-10
Native Plant Species That May be Present in a Mature Stand of the Mountain Alder (*Alnus incana*) Community Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	3-5
bluejoint reedgrass (*Calamagrostis canadensis*)	30-50
beaked sedge (*Carex rostrata*)	5-10
drooping woodreed (*Cinna latifolia*)	1-3
tall mannagrass (*Glyceria elata*)	1-3
fowl bluegrass (*Poa palustris*)	1-3
Forbs	
western aster (*Aster occidentalis*)	1-3
ladyfern (*Athyrium filix-femina*)	1-2
common willow herb (*Epilobium ciliatum*)	1-2
field horsetail (*Equisetum arvense*)	1-2
meadow horsetail (*Equisetum pratense*)	1-2
sweetscented bedstraw (*Galium triflorum*)	2-5
large leaved avens (*Geum macrophyllum*)	1-2
cow parsnip (*Heracleum lanatum*)	1-3
field mint (*Mentha arvensis*)	1-2
starry Solomon-plume (*Smilacina stellata*)	1-2

Graminoid Dominated Types

Beaked Sedge (*Carex rostrata*) Habitat Type, Beaked Sedge (*Carex rostrata*) and Water Sedge (*Carex aquatilis*) Phases—Beaked sedge (*Carex rostrata*) is common throughout the Deer Lodge Valley on wet-to-very-wet sites. It is a late seral constituent species of many other types, but that occasionally develops stand dominance on open sites, such as in slough bottoms, along old channels, and around beaver ponds. The Beaked Sedge (*Carex rostrata*) Habitat Type typically forms dense stands that inhibit the invasion of other species, as long as the site remains undisturbed. Table E.1-11 provides a list of native species that commonly occur in stands of the Beaked Sedge (*Carex rostrata*) Habitat Type at this elevation and in this portion of its range. ***NOTE:*** Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-11
Native Plant Species That May be Present in a Mature Stand of the Beaked Sedge (*Carex rostrata*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Graminoids	
bluejoint reedgrass (*Calamagrostis canadensis*)	2-5
narrow spiked reedgrass (*Calamagrostis stricta*)	3-5

TABLE E.1-11
Native Plant Species That May be Present in a Mature Stand of the Beaked Sedge (*Carex rostrata*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
water sedge (*Carex aquatilis*)	10-20
awned sedge (*Carex atherodes*)	2-5
beaked sedge (*Carex rostrata*)	80-100
inflated sedge (*Carex vesicaria*)	10-20
tufted hairgrass (*Deschampsia cespitosa*)	1-2
common spikesedge (*Eleocharis palustris*)	3-5
Baltic rush (*Juncus balticus*)	1-3
Forbs	
common willow herb (*Epilobium ciliatum*)	2-5
water horsetail (*Equisetum fluviatile*)	1-2
small bedstraw (*Galium trifidum*)	1-2
large leaved avens (*Geum macrophyllum*)	1-3
field mint (*Mentha arvensis*)	1-2
water smartweed (*Polygonum amphibium*)	3-5
purple cinquefoil (*Potentilla palustris*)	1-2

Bluejoint Reedgrass (*Calamagrostis canadensis*) Habitat Type—The Bluejoint Reedgrass (*Calamagrostis canadensis*) Habitat Type represents the potential of certain positions on the floodplain of the Clark Fork River floodplain in the Deer Lodge Valley that are slightly drier than the requirements for beaked sedge (*Carex rostrata*), but that do usually receive short periods of springtime flooding. Table E.1-12 provides a list of native species that commonly occur in stands of the Bluejoint Reedgrass (*Calamagrostis canadensis*) Habitat Type at this elevation and in this portion of its range. ***NOTE:*** Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-12
Native Plant Species That May be Present in a Mature Stand of the Bluejoint Reedgrass (*Calamagrostis canadensis*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Graminoids	
tickle grass (*Agrostis scabra*)	1-2
bluejoint reedgrass (*Calamagrostis canadensis*)	80-100
narrow-spiked reedgrass (*Calamagrostis stricta*)	10-20
water sedge (*Carex aquatilis*)	2-5
tufted hairgrass (*Deschampsia cespitosa*)	1-2
Baltic rush (*Juncus balticus*)	1-3
fowl bluegrass (*Poa palustris*)	1-3

TABLE E.1-12
Native Plant Species That May be Present in a Mature Stand of the Bluejoint Reedgrass (*Calamagrostis canadensis*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Forbs	
sharptooth angelica (*Angelica arguta*)	2-5
leafy aster (*Aster foliaceus*)	1-2
western aster (*Aster occidentalis*)	2-5
common willowherb (*Epilobium ciliatum*)	1-3
cow parsnip (*Heracleum lanatum*)	2-3
slender leafed licorice root (*Ligusticum tenuifolium*)	1-2
field mint (*Mentha arvensis*)	1-2
elephant's head (*Pedicularis groenlandica*)	2-5
western groundsel (*Senecio integerrimus*)	2-5
arrowleaf groundsel (*Senecio triangularis*)	5-10
Canada violet (*Viola canadensis*)	1-2

Western Wheatgrass (*Agropyron smithii*) Habitat Type—The Western Wheatgrass (*Agropyron smithii*) Habitat Type represents the driest, open areas on the river floodplain that may be flooded for short periods during spring runoff, but that lack potential for natural succession to taller communities. These will be the highest terrace benches that lie within the floodplain. Table E.1-13 provides a list of native species that commonly occur in stands of the Western Wheatgrass (*Agropyron smithii*) Habitat Type, at this elevation, and in this portion of its range. ***NOTE:*** Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-13
Native Plant Species That May be Present in a Mature Stand of the Western Wheatgrass (*Agropyron smithii*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	3-5
western wheatgrass (*Agropyron smithii*)	90-100
Baltic rush (*Juncus balticus*)	1-5
green needlegrass (*Stipa viridula*)	2-5
Forbs	
common yarrow (*Achillea millefolium*)	1-2
prairie sagewort (*Artemisia ludoviciana*)	1-3
wild licorice (*Glycyrrhiza lepidota*)	1-2
American vetch (*Vicia americana*)	1-2

Water Sedge (*Carex aquatilis*) Habitat Type, Water Sedge (*Carex aquatilis*) Phase—Water sedge (*Carex aquatilis*) is common throughout the Deer Lodge Valley on moist-to-wet sites. It is a

late seral constituent species of many other types, but it occasionally develops stand dominance on sites such as sloughs, old channels, and around beaver ponds. The Water Sedge (*Carex aquatilis*) Habitat Type can form dense stands that inhibit the invasion of other species, as long as they remain undisturbed. Table E.1-14 provides a list of native species that commonly occur in stands of the Water Sedge (*Carex aquatilis*) Habitat Type at this elevation and in this portion of its range. ***NOTE:*** Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-14
Native Plant Species That May be Present in a Mature Stand of the Water Sedge (*Carex aquatilis*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Graminoids	
Columbia sedge (*Carex aperta*)	3-5
water sedge (*Carex aquatilis*)	80-100
lentil fruited sedge (*Carex lenticularis*)	3-5
Nebraska sedge (*Carex nebraskensis*)	2-5
beaked sedge (*Carex rostrata*)	10-20
short beaked sedge (*Carex simulata*)	3-5
inflated sedge (*Carex vesicaria*)	2-5
common spikesedge (*Eleocharis palustris*)	3-5
few flowered spikesedge (*Eleocharis pauciflora*)	3-5
Baltic rush (*Juncus balticus*)	2-3

Common Spikesedge (*Eleocharis palustris*) Habitat Type—Common spikesedge (*Eleocharis palustris*) occurs throughout the Deer Lodge Valley in very small, usually narrow, linear stands on sites of very specific hydrologic regime at the water's edge along sloughs, ponds, and borrow pits where the water is still or slow moving. Table E.1-15 provides a list of native species that commonly occur in stands of the Common Spikesedge (*Eleocharis palustris*) Habitat Type at this elevation and in this portion of its range. ***NOTE:*** Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-15
Native Plant Species That May be Present in a Mature Stand of the Common spikesedge (*Eleocharis palustris*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Graminoids	
western wheatgrass (*Agropyron smithii*)	1-5
short awn foxtail (*Alopecurus aequalis*)	1-2
American sloughgrass (*Beckmannia syzigachne*)	1-2
slender beaked sedge (*Carex athrostachya*)	1-2
needle spikesedge (*Eleocharis acicularis*)	5-10
common spikesedge (*Eleocharis palustris*)	80-100
foxtail barley (*Hordeum jubatum*)	3-5 (on more saline sites)
Nuttall's alkaligrass (*Puccinellia nuttalliana*)	1-2 (on more saline sites)

TABLE E.1-15
Native Plant Species That May be Present in a Mature Stand of the Common spikesedge (*Eleocharis palustris*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Forbs	
common willow herb (*Epilobium ciliatum*)	1-2
field mint (*Mentha arvensis*)	1-2
arumleaf arrowhead (*Sagittaria cuneata*)	1-2
alkali marsh butterweed (*Senecio hydrophilus*)	1-2
simplestem bur reed (*Sparganium emersum*)	1-5

Forb Dominated Types

Common Cattail (*Typha latifolia*) Habitat Type—Common cattail (*Typha latifolia*) occurs throughout the Deer Lodge Valley on sites with ponded surface water. It is a late seral species that develops dense stands on such sites as sloughs, old channels, and borrow pits. The Common Cattail (*Typha latifolia*) Habitat Type typically forms dense stands that inhibit the invasion of other species, as long as they remain undisturbed. Table E.1-16 provides a list of native species that commonly occur in stands of the Common Cattail (*Typha latifolia*) Habitat Type at this elevation and in this portion of its range. ***NOTE:*** Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-16
Native Plant Species That May be Present in a Mature Stand of the Common Cattail (*Typha latifolia*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Graminoids	
softstem bulrush (*Scirpus validus*)	5-10
Forbs	
common willow herb (*Epilobium ciliatum*)	3-5
field mint (*Mentha arvensis*)	1-2
water smartweed (*Polygonum amphibium*)	3-5
common cattail (*Typha latifolia*)	80-90

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APPENDIX E.2—GRANT-KOHRS RANCH NATIONAL HISTORIC SITE

Planting Criteria and Vegetation Performance Standards After 10 Years for Remediated Sites

(for Individual Habitat Types and Community Types)

Overall Planting Criteria and Vegetation Performance Standards

Remedial action will be implemented to achieve the GRKO-specific ARARs on the basis of habitat types (HT) and community types (CT). Therefore, planting criteria must be designed and performance assessed on the basis of those HTs and CTs. Each HT or CT must have individual planting criteria and standards of performance written in terms of species richness and species canopy cover that are to be met after a development period of 10 years after remedy implementation. Implementation of the remedy is understood to mean the first year of full scale on-site revegetation activities at GRKO. Success in achieving the performance standards defining the ARAR will be assessed on polygons drawn around stands of individual types, and will be based on whether or not:

- Prescribed amounts of key species are present;
- Minimum numbers of members from certain species groups or unions are present;
- Minimum canopy cover of members from certain species groups or unions are present;
- A maximum canopy cover by certain species is not surpassed in some types;
- A minimum total canopy cover by the aggregate of all preferred plant species is present;
- No human-caused unvegetated soil surface is present;
- A maximum canopy cover by undesirable herbaceous species (e.g., dandelions, plantains, Kentucky bluegrass, etc.) is not surpassed; and
- Invasive species (noxious weeds) are absent.

A union is defined as a subdivision of a plant association (Daubenmire 1968, 1978). It may be a single species of high abundance and distinctive ecology, or a rather well defined list of species, which are restricted to approximately the same narrow range of environmental variation in the vegetation mosaic. Commonly unions have physiognomic as well as taxonomic distinctiveness, i.e., they may consist of tall shrubs, or herbs, or of tree species, but this is not necessarily true. Therefore, union is a more flexible term than layer, emphasizing ecology as judged by similar patterns of distribution rather than height. The unions in a landscape typically occur in different combinations.

Canopy cover is defined as the percentage of ground covered by the gross outline of an individual plant's foliage; or collectively covered by all individuals of a species within a stand or sample plot (Daubenmire 1959).

Interim Vegetation Performance Standards—To assure that performance standards will be met after the 10 year time frame, interim criteria will need to be developed and evaluated after 1, 2, 4, and 7 years for stands of each HT and CT to provide a means for detecting deficiencies of stand development while there is still time for correcting any problems.

Individual Plant Species Importance—Very few species occur in all the stands that make up a particular habitat type or community type. In addition, not all species normally occurring within a given type are equal in the amount of information their presence conveys. The presence of some species is diagnostic, but others are merely incidental and/or opportunistic in their occurrence. Therefore, the species installed on a stand of a particular type must be carefully chosen using the following criteria:

- Include all overstory and understory diagnostic species (species named in the key);
- Include as many as possible of the species with constancy greater than 20 percent (frequency of occurrence in sampled stands—information available in *Classification and Management of Montana's Riparian and Wetland Sites* [Hansen and others 1995]);
- When using an index that averages abundance across all stands sampled for the type, be careful of species that have great abundance on few stands (i.e., high canopy cover, but low constancy [constancy is defined as the percentage of sampled stands in which a species occurs]);
- It is better to consider constancy (frequency) and average canopy cover (abundance) separately;
- Use the average canopy cover on those stands sampled that have the species present to prescribe the design amount for that species; and
- Consider the local setting with respect to the type's overall distribution range to further screen species selections for ecological appropriateness (look especially at elevation).

Levels of Species Importance—A multi-tier species list approach will be used for assessing performance. Each union represents a different level of species importance. This same list will also be used for planting criteria. The format will be as follows:

- Union A would list essential species and prescribe their required minimum percent canopy cover;
- Union B would list important, but non-essential, species—of which a minimum number must be present with a prescribed minimum total combined percent canopy cover; and
- Unions C, D, and E would list less important species from which a minimum number must be present with a smaller prescribed minimum total combined percent canopy cover.

Woody Types—More complex types, such as the Black Cottonwood/Red-Osier Dogwood (*Populus trichocarpa/ Cornus stolonifera*) CT, or any of the willow types could need as many as 4 or 5 different unions. Simpler types, such as herbaceous ones, might need only two (the required dominant and a few possible other species).

Each union of plant species has a prescribed minimum canopy cover for the group. The top union contains the species that are required to be present. Progressively lower unions tend to

have more species listed, but with a smaller fraction of them required to be present, and with a smaller total canopy cover prescribed.

Herbaceous Types—Some herbaceous types tend to form monospecific stands of a species under favorable conditions. These types may include varying amounts of several other species, depending of the degree of stand development or level of disturbance. For example, a well-developed and undisturbed stand of the Common Cattail (*Typha latifolia*) HT should have very little presence of other species. For this reason, these simpler types, lower unions are prescribed with a maximum total canopy cover (not to exceed), rather than a minimum that must be met.

Geographic Distribution of Plant Species

The *Classification and Management of Montana's Riparian and Wetland Sites* (Hansen and others 1995) was used as the basis for determining how much of each species to expect on a well developed, remediated site of a given type. However, since types described range over large regions, and GRKO is a localized area within a much broader range, the published type species lists were "customized" to more closely fit local conditions. The information contained in Hansen and others (1995) was modified based upon our understanding of the distribution limitations of individual plant species. For instance, the species list for the Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) HT in Hansen and others (1995) shows a strong presence of bog birch (*Betula glandulosa*). However, we know that this species normally occurs farther to the northwest at lower elevations in Montana, or at higher elevations in southwest Montana, and is not likely to occur in the Deer Lodge Valley. There are many other such examples of species recorded in sampled stands of a type that are unlikely to occur in the Deer Lodge Valley.

Special Considerations

Certain species, such as bluejoint reedgrass (*Calamagrostis canadensis*), are described below with greater canopy cover than is indicated in the documentation for the HT or CT. This is due to the fact that sampling also occurred on slightly to moderately disturbed stands that comprised a HT or CT.

Later seral shrub species, such as Geyer willow (*Salix geyeriana*) and Booth willow (*Salix boothii*) are prescribed for inclusion with the early seral CTs, such as the Sandbar Willow (*Salix exigua*) CT and the Water Birch (*Betula occidentalis*) CT, although these species may not have been recorded with high constancy in the documentation for the CT. This is necessary to provide for a normal seral progression on the GRKO where these willows represent the majority of the climax vegetation area of the floodplain.

Grant-Kohrs Ranch National Historic Site Types

We recommend 15 HTs and CTs that are adapted for this location and appropriate for installation onto remediated sites on GRKO. Table E.2-1 contains a rough estimate of the fractional breakdown of the area each of these types might occupy on the GRKO floodplain after remediation is completed. This breakdown reflects our knowledge of riparian habitat types, community types, and riparian species distribution and relative abundances in the different regions and ecological zones of Montana.

TABLE E.2-1
Fifteen Required Habitat Types (HT) and Community Types (CT) Grouped by Overstory Lifeform Dominance (i.e., Trees, Shrubs, Graminoids, and Forbs) and Ranked by Estimated Percentage of Area Represented by the Type

Type	Deer Lodge Valley Distribution Category*	Estimated Percentage of Total Area Represented	Typical Floodplain Position of the Type
Trees			
Black Cottonwood/Red-osier Dogwood (*Populus trichocarpa/Cornus stolonifera*) CT	Minor	8-12	Recent point bars and low floodplain terraces.
Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/Calamagrostis canadensis*) HT	Minor	<1	Drier areas in old oxbows, floodplain terraces.
Shrubs			
Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/Calamagrostis canadensis*) HT	Major	18-23	Drier areas in old oxbows, floodplain terraces.
Water Birch (*Betula occidentalis*) CT	Major	12-18	Moist areas, old oxbow banks, streambanks.
Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) HT	Major	12-18	Moist areas, old oxbow, streambanks.
Sandbar Willow (*Salix exigua*) CT	Minor	8-12	Recent point bars, streambanks.
Mountain Alder (*Alnus incana*) CT	Minor	2-4	Moist areas, old oxbow banks, streambanks.
Woods Rose (*Rosa woodsii*) CT	Minor	2-4	Drier areas on upper floodplain terraces.
Western Snowberry (*Symphoricarpos occidentalis*) CT	Minor	1-3	Drier areas on upper floodplain terraces.
Graminoids			
Beaked Sedge (*Carex rostrata*) HT	Minor	3-6	Wet sites, old oxbow, or slough bottoms.
Bluejoint Reedgrass (*Calamagrostis canadensis*) HT	Minor	3-6	Moist areas, old oxbow, and streambanks.
Western Wheatgrass (*Agropyron smithii*) HT	Minor	3-6	Drier open areas away from the river channel.
Water Sedge (*Carex aquatilis*) HT	Minor	2-4	Wet sites, old oxbow, or slough bottoms.
Common Spikesedge (*Eleocharis palustris*) HT	Incidental	<1	Ponded areas, water edges.
Forbs			
Common Cattail (*Typha latifolia*) HT	Minor	2-4	Ponded areas, old oxbow, and slough bottoms.

*A ***major type*** occupies extensive acreages in at least some portion of the riparian or wetland zone; a ***minor type*** seldom occupies large acreages but may be common on smaller areas within the riparian or wetland zone; and an ***incidental type*** rarely occurs within the region, or is limited to narrow site conditions and/or very localized occurrence.

Planting Criteria and Performance Standards

Planting criteria and performance standards are specified for each HT/CT individually in terms of species presence and abundance requirements. The required standards are written for the end point of the remedial action phase and/or the beginning point of the operation and maintenance phase of the project, which is set at a period of 10 years after the remedial action is implemented, as defined on page 1 of this document. Therefore, remedial design must be written to accomplish these requirements; and interim monitoring on a 1, 2, 4, and 7-year time frame must be done to detect community development that is not on a trajectory to meet the required performance standard at the end of 10 years. Therefore, additional or supplemental plantings may need to be done 1, 2, 4, and 7 years after initial installation. In the event such additional plantings do not result in attainment of performance standards, previously treated areas of contamination will require removal and revegetation as stipulated in the Record of Decision.

Individual Habitat Types and Community Types

Tree Dominated Types

Black Cottonwood/Red-osier Dogwood (*Populus trichocarpa/Cornus stolonifera*) CT—The Black Cottonwood/Red-osier Dogwood) (*Populus trichocarpa/Cornus stolonifera*) CT is a mid-seral successional type that is common along western Montana riverine floodplains. It is structurally complex, having multiple stories of tall trees over tall shrubs, over short shrubs, over an herbaceous layer. More than 140 species were recorded in 21 stands sampled of this type across its range (Hansen and others 1995). There are four unions described in Table E.2-2:

- Union A lists the type indicator dominants of both the upper and understory canopies, as well as a required grass species as an essential ground cover to reduce weedy species invasion.
- Union B lists a set of important shrubs that constitute most of the tall shrub structural layer and that represent the later successional stage to eventually replace the cottonwood trees as stand dominants.
- Union C contains a longer list of less important shrubs, of which several are typically present in healthy stands of the CT.
- Union D contains a list of herbaceous species that will not individually represent much canopy cover, but which are likely present in smaller amounts in healthy stands of the CT.

TABLE E.2-2
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Black Cottonwood/Red-osier Dogwood (*Populus trichocarpa/Cornus stolonifera*) CT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Trees	
black cottonwood (*Populus trichocarpa*)	MINIMUM CANOPY COVER = 40%
Shrubs	
red-osier dogwood (*Cornus stolonifera*)	MINIMUM CANOPY COVER = 20%
Graminoids	
bluejoint reedgrass (*Calamagrostis canadensis*)	MINIMUM CANOPY COVER = 60%
UNION B SPECIES (At least 4 of the following 5 species must be present with combined total canopy cover of at least 15 percent)	
Shrubs	
western serviceberry (*Amelanchier alnifolia*)	
water birch (*Betula occidentalis*)	
Booth willow (*Salix boothii*)	
sandbar willow (*Salix exigua*)	
Geyer willow (*Salix geyeriana*)	COMBINED MINIMUM CANOPY COVER = 15%
UNION C SPECIES (At least 5 of the following 10 species must be present with combined total canopy cover of at least 15 percent)	
Shrubs	
mountain alder (*Alnus incana*)	
western virgins-bower (*Clematis ligusticifolia*)	
common chokecherry (*Prunus virginiana*)	
swamp currant (*Ribes lacustre*)	
Missouri gooseberry (*Ribes setosum*)	
woods rose (*Rosa woodsii*)	
common red raspberry (*Rubus idaeus*)	
Bebb willow (*Salix bebbiana*)	
yellow willow (*Salix lutea*)	
western snowberry (*Symphoricarpos occidentalis*)	COMBINED MINIMUM CANOPY COVER = 15%
UNION D SPECIES (At least 6 [minimum of 2 graminoids and 4 forbs] of the following 15 species must be present with combined total canopy cover of at least 20 percent)	
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	
blue wildrye (*Elymus glaucus*)	
fowl bluegrass (*Poa palustris*)	
Forbs	
baneberry (*Actaea rubra*)	
western aster (*Aster occidentalis*)	
field horsetail (*Equisetum arvense*)	
sweetscented bedstraw (*Galium triflorum*)	
fringed loosestrife (*Lysimachia ciliata*)	
field mint (*Mentha arvensis*)	

TABLE E.2-2
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Black Cottonwood/Red-osier Dogwood (*Populus trichocarpa/Cornus stolonifera*) CT

Species	Percent Canopy Cover
mountain sweet-cicely (*Osmorhiza chilensis*)	
streambank groundsel (*Senecio pseudaureus*)	
starry Solomon-plume (*Smilacina stellata*)	
Canada goldenrod (*Solidago canadensis*)	
western meadowrue (*Thalictrum occidentalis*)	
American vetch (*Vicia americana*)	
Plus other unlisted native volunteer species	COMBINED MINIMUM CANOPY COVER = 20%

Additional requirements. In addition to the requirements specified in Table E.2-2, these conditions must be met at the end of 10 years:

- Minimum of 170 percent total canopy cover of individual species listed in Table E.2-2;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/Calamagrostis canadensis*) HT— The Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/Calamagrostis canadensis*) HT is a late-seral type that is common along western Montana riverine floodplains but less abundant than it historically was. The type has suffered decline in the past century across most of its range due to understory alteration and prevention of regenerative success of the aspen. The type is structurally complex, having multiple stories of tall trees over a few tall shrubs, over a few short shrubs, over a dense herbaceous layer of grass. There are three unions described in Table E.2-3:

- Union A lists the type indicator dominants of both the upper and understory canopies.
- Union B lists a set of important shrubs and herbaceous species.
- Union C contains a longer list of less important herbaceous species that will not individually represent much canopy cover, but which are likely present in smaller amounts in healthy stands of the type.

TABLE E.2-3
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/ Calamagrostis canadensis*) HT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Trees	
quaking aspen (*Populus tremuloides*)	MINIMUM CANOPY COVER = 40%
Graminoids	
bluejoint reedgrass (*Calamagrostis canadensis*)	MINIMUM CANOPY COVER = 60%

TABLE E.2-3
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/ Calamagrostis canadensis*) HT

Species	Percent Canopy Cover
UNION B SPECIES (At least 6 of the following 11 species must be present [minimum of 1 shrub, 2 graminoids, and 3 forb species] with a combined total canopy cover of at least 30 percent)	
Shrubs	
western serviceberry (*Amelanchier alnifolia*)	
water birch (*Betula occidentalis*)	
Bebb willow (*Salix bebbiana*)	
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	
narrow-spiked reedgrass (*Calamagrostis stricta*)	
fowl bluegrass (*Poa palustris*)	
Forbs	
western aster (*Aster occidentalis*)	
large leaved avens (*Geum macrophyllum*)	
mountain sweet-cicely (*Osmorhiza chilensis*)	
streambank groundsel (*Senecio pseudaureus*)	
Canada goldenrod (*Solidago canadensis*)	
western meadowrue (*Thalictrum occidentalis*)	COMBINED MINIMUM CANOPY COVER = 30%
UNION C SPECIES (At least 6 of the following 17 species must be present [minimum of 2 shrubs, 1 graminoid, and 3 forbs] and a combined total canopy cover of at least 20 percent)	
Shrubs	
shrubby cinquefoil (*Potentilla fruticosa*)	
Missouri gooseberry (*Ribes setosum*)	
woods rose (*Rosa woodsii*)	
common red raspberry (*Rubus idaeus*)	
western snowberry (*Symphoricarpos occidentalis*)	
Graminoids	
fringed brome (*Bromus ciliatus*)	
Canada wildrye (Elymus canadensis)	
Baltic rush (*Juncus balticus*)	
Forbs	
field horsetail (*Equisetum arvense*)	
Virginia strawberry (*Fragaria virginiana*)	
white geranium (*Geranium richardsonii*)	
sweetscented bedstraw (*Galium triflorum*)	
fringed loosestrife (*Lysimachia ciliata*)	
field mint (*Mentha arvensis*)	
starry Solomon-plume (*Smilacina stellata*)	
American vetch (*Vicia americana*)	
Canada violet (*Viola canadensis*)	
Plus other unlisted native volunteer species	COMBINED MINIMUM CANOPY COVER = 20%

Additional requirements. In addition to the requirements specified in Table E.2-3, these conditions must be met at the end of 10 years:

- Minimum of 150 percent total canopy cover of individual species listed in Table E.2-3;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Shrub Dominated Types

Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/Calamagrostis canadensis*) HT—The Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/Calamagrostis canadensis*) HT is a complex community with a core of key willow and grass species required. There are four unions described in Table E.2-4:

- Union A lists indicator dominants of both upper and understory canopies. Both of these layers may have either of two species in any combination totaling the shown minimum amount.
- Union B lists a set of important shrubs that are usually present in the tall shrub layer.
- Union C contains a list of shorter shrubs and other important herbaceous species, of which several should be present in healthy stands of the CT.
- Union D contains a list of herbaceous species that will not individually represent much canopy cover, but which are likely present in smaller amounts in healthy stands of the CT.

TABLE E.2-4
Plant Community Composition, Separated into Unions with Specified aMounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/Calamagrostis canadensis*) HT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Shrubs	
Booth willow (*Salix boothii*)	MINIMUM CANOPY COVER = 10%
Geyer willow (*Salix geyeriana*)	MINIMUM CANOPY COVER = 40%
Graminoids (One or both of these species must be present with total combined canopy cover of at least 60 percent)	
bluejoint reedgrass (*Calamagrostis canadensis*)	
narrow-spiked reedgrass (*Calamagrostis stricta*)	COMBINED MINIMUM CANOPY COVER = 60%
UNION B SPECIES (At least 3 of the following 5 species must be present with combined total canopy cover of at least 15 percent)	
Shrubs	
mountain alder (*Alnus incana*)	
water birch (*Betula occidentalis*)	
red-osier dogwood (*Cornus stolonifera*)	
Bebb willow (*Salix bebbiana*)	
sandbar willow (*Salix exigua*)	COMBINED MINIMUM CANOPY COVER = 15%

TABLE E.2-4
Plant Community Composition, Separated into Unions with Specified aMounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/Calamagrostis canadensis*) HT

Species	Percent Canopy Cover
UNION C SPECIES (At least 6 of the following 13 species must be present [minimum of 2 shrubs, 1 graminoid, and 3 forbs] with combined total canopy cover of at least 15 percent)	
Shrubs	
shrubby cinquefoil (*Potentilla fruticosa*)	
swamp currant (*Ribes lacustre*)	
Missouri gooseberry (*Ribes setosum*)	
woods rose (*Rosa woodsii*)	
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	
fringed brome (*Bromus ciliatus*)	
fowl mannagrass (*Glyceria striata*)	
Forbs	
leafy aster (*Aster foliaceus*)	
western aster (*Aster occidentalis*)	
large leaved avens (*Geum macrophyllum*)	
cow parsnip (*Heracleum lanatum*)	
purple cinquefoil (*Potentilla gracilis*)	
Canada goldenrod (*Solidago canadensis*)	COMBINED MINIMUM CANOPY COVER = 15%
UNION D SPECIES (At least 5 of the following 10 species must be present [minimum of 1 graminoid and 4 forbs] with combined total canopy cover of at least 15 percent)	
Graminoids	
tufted hairgrass (*Deschampsia cespitosa*)	
Baltic rush (*Juncus balticus*)	
fowl bluegrass (*Poa palustris*)	
Forbs	
common yarrow (*Achillea millefolium*)	
fireweed (*Epilobium angustifolium*)	
field horsetail (*Equisetum arvense*)	
Virginia strawberry (*Fragaria virginiana*)	
northern bedstraw (*Galium boreale*)	
field mint (*Mentha arvensis*)	
starry Solomon-plume (*Smilacina stellata*)	
Plus other unlisted native volunteer species	COMBINED MINIMUM CANOPY COVER = 15%

Additional requirements. In addition to the requirements specified in Table E.2-4, these conditions must be met at the end of 10 years:

- Minimum of 155 percent total canopy cover of individual species listed in Table E.2-4;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Water Birch (*Betula occidentalis*) CT—The Water Birch (*Betula occidentalis*) CT is a mid seral successional community with a minimum canopy of water birch required. There are three unions described in Table E.2-5:

- Union A lists the type indicator dominant species and a required grass species as an essential ground cover to preempt weedy species invasion with minimum canopy cover amounts.
- Union B lists a set of other important tall shrubs that are usually present and that may represent the later successional stage.
- Union C contains a list of other shrubs and herbaceous species, of which several should be present in smaller amounts in healthy stands of the CT.

TABLE E.2-5
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Water Birch (*Betula occidentalis*) CT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Shrubs	
water birch (*Betula occidentalis*)	MINIMUM CANOPY COVER = 50%
Graminoids	
bluejoint reedgrass (*Calamagrostis canadensis*)	MINIMUM CANOPY COVER = 60%
UNION B SPECIES (At least 4 of the following 6 species must be present with combined total canopy cover of at least 15 percent)	
Shrubs	
mountain alder (*Alnus incana*)	
western serviceberry (*Amelanchier alnifolia*)	
red-osier dogwood (*Cornus stolonifera*)	
Booth willow (*Salix boothii*)	
sandbar willow (*Salix exigua*)	
Geyer willow (*Salix geyeriana*)	COMBINED MINIMUM CANOPY COVER = 15%
UNION C SPECIES (At least 10 of the following 20 species must be present [minimum 3 shrubs, 2 graminoids, and 5 forbs] with combined total canopy cover of at least 20 percent)	
Shrubs	
shrubby cinquefoil (*Potentilla fruticosa*)	
common chokecherry (*Prunus virginiana*)	
woods rose (*Rosa woodsii*)	
Bebb willow (*Salix bebbiana*)	
yellow willow (*Salix lutea*)	
western snowberry (*Symphoricarpos occidentalis*)	
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	
Nebraska sedge (*Carex nebraskensis*)	
Baltic rush (*Juncus balticus*)	
fowl bluegrass (*Poa palustris*)	

TABLE E.2-5
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Water Birch (*Betula occidentalis*) CT

Species	Percent Canopy Cover
Forbs	
spreading dogbane (*Apocynum androsaemifolium*)	
common willow herb (*Epilobium ciliatum*)	
wartberry fairy-bell (*Disporum trachycarpum*)	
field horsetail (*Equisetum arvense*)	
smooth scouring-rush (*Equisetum laevigatum*)	
Virginia strawberry (*Fragaria virginiana*)	
northern bedstraw (*Galium boreale*)	
Nuttall's sunflower (*Helianthus nuttallii*)	
starry Solomon-plume (*Smilacina stellata*)	
Canada goldenrod (*Solidago canadensis*)	
Plus other unlisted native volunteer species	COMBINED MINIMUM CANOPY COVER = 20%

Additional requirements. In addition to the requirements specified in Table E.2-5, these conditions must be met at the end of 10 years:

- Minimum of 145 percent total canopy cover of individual species listed in Table E.2-5;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) HT—The Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) HT is a complex community with a core of key willow and sedge species required. There are four unions described in Table E.2-6:

- Union A lists type indicator overstory dominants. This layer may have either of these two species in any combination totaling the prescribed minimum amount.
- Union B lists the indicator herbaceous understory dominants. Any combination of one or more of these species totaling the prescribed minimum canopy cover amount must be present.
- Union C lists a set of important shrubs that are usually present in the tall shrub layer.
- Union D contains a list of other less important species, of which several should be present in healthy stands of the CT. These species will not individually represent much canopy cover, but are likely present in smaller amounts in healthy stands of the HT.

TABLE E.2-6
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) HT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Shrubs	
Booth willow (*Salix boothii*)	MINIMUM CANOPY COVER = 10%
Geyer willow (*Salix geyeriana*)	MINIMUM CANOPY COVER = 40%
UNION B SPECIES (At least 2 of the following 4 species must be present with combined total canopy cover of at least 60 percent)	
Graminoids	
water sedge (*Carex aquatilis*)	
lentil-fruit sedge (*Carex lenticularis*)	
beaked sedge (*Carex rostrata*)	
inflated sedge (*Carex vesicaria*)	COMBINED MINIMUM CANOPY COVER = 60%
UNION C SPECIES (At least 3 of the following 5 species must be present with combined total canopy cover of at least 20 percent)	
Shrubs	
mountain alder (*Alnus incana*)	
water birch (*Betula occidentalis*)	
Bebb willow (*Salix bebbiana*)	
sandbar willow (*Salix exigua*)	
yellow willow (*Salix lutea*)	COMBINED MINIMUM CANOPY COVER = 20%
UNION D SPECIES (At least 8 of the following 22 species must be present [minimum 4 graminoids and 4 forbs] with a combined total canopy cover of at least 20 percent)	
Shrubs	
shrubby cinquefoil (*Potentilla fruticosa*)	
Graminoids	
tickle grass (*Agrostis scabra*)	
fringed brome (*Bromus ciliatus*)	
bluejoint reedgrass (*Calamagrostis canadensis*)	
narrow-spiked reedgrass (*Calamagrostis stricta*)	
soft-leaved sedge (*Carex disperma*)	
wooly sedge (*Carex lanuginosa*)	
tufted hairgrass (*Deschampsia cespitosa*)	
Baltic rush (*Juncus balticus*)	
fowl bluegrass (*Poa palustris*)	
fowl mannagrass (*Glyceria striata*)	
Forbs	
leafy aster (*Aster foliaceus*)	
western aster (*Aster occidentalis*)	
common willow herb (*Epilobium ciliatum*)	
field horsetail (*Equisetum arvense*)	
Virginia strawberry (*Fragaria virginiana*)	
small bedstraw (*Galium trifidum*)	

TABLE E.2-6
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) HT

Species	Percent Canopy Cover
large leaved avens (*Geum macrophyllum*)	
field mint (*Mentha arvensis*)	
starry Solomon-plume (*Smilacina stellata*)	
Canada goldenrod (*Solidago canadensis*)	
Canada violet (*Viola canadensis*)	
Plus other unlisted native volunteer species	COMBINED MINIMUM CANOPY COVER = 20%

Additional requirements. In addition to the requirements specified in Table E.2-6, these conditions must be met at the end of 10 years:

- Minimum of 150 percent total canopy cover of individual species listed in Table E.2-6;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Sandbar Willow (*Salix exigua*) CT—Sandbar willow (*Salix exigua*) is an early seral, pioneering community type that naturally colonizes streamside sites and other bared, moist sites. There are three unions described in Table E.2-7:

- Union A lists the type indicator overstory dominant and a required grass species as an essential ground cover to preempt weedy species invasion.
- Union B lists a set of important shrubs that are usually present in the tall shrub layer.
- Union C contains a list of other less important shrubs and herbaceous species, of which several should be present in healthy stands of the CT.

TABLE E.2-7
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Sandbar Willow (*Salix exigua*) CT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Shrubs	
sandbar willow (*Salix exigua*)	MINIMUM CANOPY COVER = 60%
Graminoids	
bluejoint reedgrass (*Calamagrostis canadensis*)	MINIMUM CANOPY COVER = 50%
UNION B SPECIES (At least 4 of the following 6 species must be present with combined total canopy cover of at least 20 percent)	
Shrubs	
mountain alder (*Alnus incana*)	
western serviceberry (*Amelanchier alnifolia*)	
water birch (*Betula occidentalis*)	
red-osier dogwood (*Cornus stolonifera*)	
Booth willow (*Salix boothii*)	
Geyer willow (*Salix geyeriana*)	COMBINED MINIMUM CANOPY COVER = 20%

TABLE E.2-7
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Sandbar Willow (*Salix exigua*) CT

Species	Percent Canopy Cover
UNION C SPECIES (At least 6 of the following 14 species [minimum 1 shrub, 2 graminoids, and 3 forbs] must be present with combined total canopy cover of at least 20 percent)	
Shrubs	
woods rose (*Rosa woodsii*)	
Bebb willow (*Salix bebbiana*)	
yellow willow (*Salix lutea*)	
western snowberry (*Symphoricarpos occidentalis*)	
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	
western wheatgrass (*Agropyron smithii*)	
narrow-spiked reedgrass (*Calamagrostis stricta*)	
beaked sedge (*Carex rostrata*)	
fowl bluegrass (*Poa palustris*)	
Forbs	
hemp dogbane (*Apocynum cannabinum*)	
field horsetail (*Equisetum arvense*)	
wild licorice (*Glycyrrhiza lepidota*)	
field mint (*Mentha arvensis*)	
Canada goldenrod (*Solidago canadensis*)	
Plus other unlisted native volunteer species	COMBINED MINIMUM CANOPY COVER = 20%

Additional requirements. In addition to the requirements specified in Table E.2-7, these conditions must be met at the end of 10 years:

- Minimum of 150 percent total canopy cover of individual species listed in Table E.2-7;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Woods Rose (*Rosa woodsii*) CT—The Woods Rose (*Rosa woodsii*) CT is an early to mid seral community that occupies the drier edge of sites that can support woody types. This community usually occurs as small patches, unless some physical disturbance has extended it. Table E.2-8 shows two unions:

- Union A lists the type indicator overstory dominant.
- Union B lists other less important shrubs and herbaceous species, of which several should be present in healthy stands of the CT.

TABLE E.2-8
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Woods Rose (*Rosa woodsii*) CT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Shrubs	
woods rose (*Rosa woodsii*)	MINIMUM CANOPY COVER = 70%
UNION B SPECIES (At least 6 of the following 12 species must be present [minimum 3 graminoids and 2 forbs] with combined total canopy cover of at least 40 percent)	
Shrubs	
western snowberry (*Symphoricarpos occidentalis*)	
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	
western wheatgrass (*Agropyron smithii*)	
Canada wildrye (*Elymus canadensis*)	
Baltic rush (*Juncus balticus*)	
satin-grass (*Muhlenbergia racemosa*)	
fowl bluegrass (*Poa palustris*)	
Forbs	
common yarrow (*Achillea millefolium*)	
Virginia strawberry (*Fragaria virginiana*)	
northern bedstraw (*Galium boreale*)	
wild licorice (*Glycyrrhiza lepidota*)	
Canada goldenrod (*Solidago canadensis*)	
Plus other unlisted native volunteer species	COMBINED MINIMUM CANOPY COVER = 40%

Additional requirements. In addition to the requirements specified in Table E.2-8, these conditions must be met at the end of 10 years:

- Minimum of 110 percent total canopy cover of individual species listed in Table E.2-8;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Western Snowberry (*Symphoricarpos occidentalis*) CT—Western Snowberry (*Symphoricarpos occidentalis*) is an early to mid seral community that occupies the drier edge of sites that can support woody types. This community usually occurs as small patches, unless some physical disturbance has extended it. Table E.2-9 shows two unions:

- Union A lists the type indicator overstory dominant.
- Union B lists other less important shrubs and herbaceous species, of which several should be present in healthy stands of the CT.

TABLE E.2-9
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Western Snowberry (*Symphoricarpos occidentalis*) CT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Shrubs	
western snowberry (*Symphoricarpos occidentalis*)	MINIMUM CANOPY COVER = 70%
woods rose (*Rosa woodsii*)	MINIMUM CANOPY COVER = 10%
UNION B SPECIES (At least 5 of the following 10 species [minimum 2 graminoids and 3 forbs] must be present with combined total canopy cover of at least 20 percent)	
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	
western wheatgrass (*Agropyron smithii*)	
Canada wildrye (*Elymus canadensis*)	
satin grass (*Muhlenbergia racemosa*)	
Forbs	
common yarrow (*Achillea millefolium*)	
prairie sagewort (*Artemisia ludoviciana*)	
northern bedstraw (*Galium boreale*)	
wild licorice (*Glycyrrhiza lepidota*)	
starry Solomon-plume (*Smilacina stellata*)	
Canada goldenrod (*Solidago canadensis*)	
Plus other unlisted native volunteer species	COMBINED MINIMUM CANOPY COVER = 20%

Additional requirements. In addition to the requirements specified in Table E.2-9, these conditions must be met at the end of 10 years:

- Minimum of 110 percent total canopy cover of individual species listed in Table E.2-9;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Mountain Alder (*Alnus incana*) CT—The Mountain Alder (*Alnus incana*) CT is a mid-seral successional community with a minimum canopy of mountain alder required. There are three unions described in Table E.2-10. Union A contains the site indicator dominant and a grass species that is also required:

- Union A lists the type indicator overstory dominant and a required grass species as an essential ground cover to preempt weedy species invasion.
- Union B lists a set of important tall shrubs and herbaceous species that are usually present.
- Union C contains a list of other less important shrubs and herbaceous species, of which several should be present in healthy stands of the CT.

TABLE E.2-10
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Mountain Alder (*Alnus incana*) CT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Shrubs	
mountain alder (*Alnus incana*)	MINIMUM CANOPY COVER = 50%
Graminoids	
bluejoint reedgrass (*Calamagrostis canadensis*)	MINIMUM CANOPY COVER = 60%
UNION B SPECIES (At least 5 of the following 11 species must be present [minimum 2 shrubs, 1 graminoid, and 2 forbs] with combined total canopy cover of at least 15 percent)	
Shrubs	
red-osier dogwood (*Cornus stolonifera*)	
Bebb willow (*Salix bebbiana*)	
sandbar willow (*Salix exigua*)	
yellow willow (*Salix lutea*)	
Graminoids	
water sedge (*Carex aquatilis*)	
beaked sedge (*Carex rostrata*)	
fowl bluegrass (*Poa palustris*)	
Forbs	
western aster (*Aster occidentalis*)	
ladyfern (*Athyrium filix-femina*)	
large leaved avens (*Geum macrophyllum*)	
cow parsnip (*Heracleum lanatum*)	COMBINED MINIMUM CANOPY COVER = 15%
UNION C SPECIES (At least 6 of these 13 species [including at least 2 shrubs, 1 graminoid, and 3 forbs] must be present with combined total canopy cover of at least 20 percent)	
Shrubs	
red raspberry (*Rubus idaeus* common)	
stinking currant (*Ribes hudsonianum*)	
swamp currant (*Ribes lacustre*)	
woods rose (*Rosa woodsii*)	
Graminoids	
narrow-spiked reedgrass (*Calamagrostis stricta*)	
drooping woodreed (*Cinna latifolia*)	
tall mannagrass (*Glyceria elata*)	
Forbs	
common willow herb (*Epilobium ciliatum*)	
field horsetail (*Equisetum arvense*)	
meadow horsetail (*Equisetum pratense*)	
sweetscented bedstraw (*Galium triflorum*)	
field mint (*Mentha arvensis*)	
starry Solomon-plume (*Smilacina stellata*)	
Plus other unlisted native volunteer species	COMBINED MINIMUM CANOPY COVER = 20%

Additional requirements. In addition to the requirements specified in Table E.2-10, these conditions must be met at the end of 10 years:

- Minimum of 150 percent total canopy cover of individual species listed in Table E.2-10;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Graminoid Dominated Types

Beaked Sedge (*Carex rostrata*) HT—Beaked sedge is a late seral community that naturally dominates very wet sites that are slightly wetter than sites of the Water Sedge (*Carex rostrata*) HT. There are three unions described in Table E.2-11:

- Union A is the type indicator species required to be present.
- Union B species may also be present in large amounts up to an aggregate maximum.
- Union C species may be present, but much less if the stand is healthy and undisturbed.

TABLE E.2-11
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Beaked Sedge (*Carex rostrata*) HT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Graminoids	
beaked sedge (*Carex rostrata*)	MINIMUM CANOPY COVER = 80%
UNION B SPECIES (These species may be present with combined total ***maximum*** canopy cover of 40 percent)	
Graminoids	
water sedge (*Carex aquatilis*)	
awned sedge (*Carex atherodes*)	
lentil fruited sedge (*Carex lenticularis*)	
inflated sedge (*Carex vesicaria*)	***MAXIMUM*** COMBINED CANOPY COVER = 40%
UNION C SPECIES (These species may be present with combined total ***maximum*** canopy cover of 20 percent)	
Graminoids	
bluejoint reedgrass (*Calamagrostis canadensis*)	
narrow spiked reedgrass (*Calamagrostis stricta*)	
tufted hairgrass (*Deschampsia cespitosa*)	
common spikesedge (*Eleocharis palustris*)	
Baltic rush (*Juncus balticus*)	
Forbs	
common willow herb (*Epilobium ciliatum*)	
water horsetail (*Equisetum fluviatile*)	
small bedstraw (*Galium trifidum*)	
large leaved avens (*Geum macrophyllum*)	
field mint (*Mentha arvensis*)	
water smartweed (*Polygonum amphibium*)	
purple cinquefoil (*Potentilla palustris*)	
Plus other unlisted native volunteer species	***MAXIMUM*** COMBINED CANOPY COVER = 20%

Additional requirements. In addition to the requirements specified in Table E.2-11, these conditions must be met at the end of 10 years:

- Minimum of 90 percent total canopy cover of individual species listed in Table E.2-11;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Bluejoint Reedgrass (*Calamagrostis canadensis*) HT—The Bluejoint Reedgrass (*Calamagrostis canadensis*) HT is a late seral herbaceous community that establishes dense grass stands on moist site openings that do not become flooded for too long during the growing season. Normally, when the site is undisturbed, bluejoint reedgrass forms dense mono-specific stands. However, physical or hydrologic disturbance will promote the invasion of other plant species. Table E.2-12 has two unions for this type:

- Union A is the pair of reedgrass species that in combination dominate the site.
- Union B lists other species that may also be present in large or small amounts up to an aggregate maximum.

TABLE E.2-12
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Bluejoint Reedgrass (*Calamagrostis canadensis*) HT

Species	Percent Canopy Cover
UNION A SPECIES (Some combination of these species must be present with the specified minimum combined canopy cover)	
Graminoids	
bluejoint reedgrass (*Calamagrostis canadensis*)	
narrow-spiked reedgrass (*Calamagrostis stricta*)	COMBINED MINIMUM CANOPY COVER = 80%
UNION B SPECIES (These species may be present with combined total ***maximum*** canopy cover of 20 percent)	
Graminoids	
tickle grass (*Agrostis scabra*)	
water sedge (*Carex aquatilis*)	
tufted hairgrass (*Deschampsia cespitosa*)	
Baltic rush (*Juncus balticus*)	
fowl bluegrass (*Poa palustris*)	
Forbs	
sharptooth angelica (*Angelica arguta*)	
leafy aster (*Aster foliaceus*)	
western aster (*Aster occidentalis*)	
common willowherb (*Epilobium ciliatum*)	
cow parsnip (*Heracleum lanatum*)	
slender leafed licorice root (*Ligusticum tenuifolium*)	
field mint (*Mentha arvensis*)	
elephant's head (*Pedicularis groenlandica*)	
western groundsel (*Senecio integerrimus*)	
arrowleaf groundsel (*Senecio triangularis*)	
Canada violet (*Viola canadensis*)	
Plus other unlisted native volunteer species	***MAXIMUM*** COMBINED CANOPY COVER = 20%

Additional requirements. In addition to the requirements specified in Table E.2-12, these conditions must be met at the end of 10 years:

- Minimum of 90 percent total canopy cover of individual species listed in Table E.2-12;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Western Wheatgrass (*Agropyron smithii*) HT—The Western Wheatgrass (*Agropyron smithii*) HT represents drier, open sites that lack potential for woody types. This is one of the driest of functional wetland types, and not all sites dominated by western wheatgrass performs much wetland function. Sites of this type are often on clayey soils along alluvial fans at the outer edges of valley bottoms. Table E.2-13 shows two unions for this type. As with most of the herbaceous types, well developed, undisturbed stands are usually almost mono-specific. However, physical or hydrologic disturbance will promote the invasion of other plant species.

- Union A is the type indicator species required to be present.
- Union B lists other species that may also be present in large or small amounts up to an aggregate maximum.

TABLE E.2-13
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Western Wheatgrass (*Agropyron smithii*) HT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Graminoids	
western wheatgrass (*Agropyron smithii*)	MINIMUM CANOPY COVER = 80%
UNION B SPECIES (These species may be present with combined total ***maximum*** canopy cover of 30 percent)	
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	
tickle grass (*Agrostis scabra*)	
Baltic rush (*Juncus balticus*)	
green needlegrass (*Stipa viridula*)	
Forb	
common yarrow (*Achillea millefolium*)	
prairie sagewort (*Artemisia ludoviciana*)	
wild licorice (*Glycyrrhiza lepidota*)	
American vetch (*Vicia americana*)	
Plus other unlisted native volunteer species	***MAXIMUM*** COMBINED CANOPY COVER = 30%

Additional requirements. In addition to the requirements specified in Table E.2-13, these conditions must be met at the end of 10 years:

- Minimum of 90 percent total canopy cover of individual species listed in Table E.2-13;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Water Sedge (*Carex aquatilis*) HT—Water Sedge is a late seral community that naturally dominates very wet sites that are slightly drier than sites of the Beaked Sedge (*Carex aquatilis*) HT. There are three unions described in Table E.2-14:

- Union A is the type indicator species required to be present.
- Union B species may also be present in large amounts up to an aggregate maximum.
- Union C species may be present, but probably not if the stand is healthy and undisturbed.

TABLE E.2-14
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Water Sedge (*Carex aquatilis*) HT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Graminoids	
water sedge (*Carex aquatilis*)	MINIMUM CANOPY COVER = 70%
UNION B SPECIES (These species may be present with combined total maximum canopy cover of 20 percent)	
Graminoids	
Columbia sedge (*Carex aperta*)	
lentil fruited sedge (*Carex lenticularis*)	***MAXIMUM*** COMBINED CANOPY COVER = 30%
UNION C SPECIES (These species may be present with combined total maximum canopy cover of 20 percent)	
Graminoids	
bluejoint reedgrass (*Calamagrostis canadensis*)	
Nebraska sedge (*Carex nebraskensis*)	
beaked sedge (*Carex rostrata*)	
short beaked sedge (*Carex simulata*)	
inflated sedge (*Carex vesicaria*)	
common spikesedge (*Eleocharis palustris*)	
few flowered spikesedge (*Eleocharis pauciflora*)	
Baltic rush (*Juncus balticus*)	
Plus other unlisted native volunteer species	***MAXIMUM*** COMBINED CANOPY COVER = 20%

Additional requirements. In addition to the requirements specified in Table E.2-14, these conditions must be met at the end of 10 years:

- Minimum of 90 percent total canopy cover of individual species listed in Table E.2-14;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Common Spikesedge (*Eleocharis palustris*) HT—Common spikesedge (*Eleocharis palustris*) HT is a minor type that occurs commonly in very small stands on narrowly defined hydrologic conditions along the edges of ponded or slowly moving water. Although the Common Spikesedge (*Eleocharis palustris*) HT defines site potential, this community is adapted to quickly changing potential. A narrow band of common spikesedge can move up or down slope to follow changing water level rapidly. Table E.2-15 shows two unions for this type:

- Union A is the type indicator species required to be present.
- Union B lists other species that may also be present in large or small amounts up to an aggregate maximum.

TABLE E.2-15
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Common Spikesedge (*Eleocharis palustris*) HT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Graminoids	
needle spikesedge (*Eleocharis acicularis*)	
common spikesedge (*Eleocharis palustris*)	COMBINED MINIMUM CANOPY COVER = 70%
UNION B SPECIES (These species may be present with combined total maximum canopy cover of 40 percent)	
Graminoids	
western wheatgrass (*Agropyron smithii*)	
short awn foxtail (*Alopecurus aequalis*)	
American sloughgrass (*Beckmannia syzigachne*)	
slender beaked sedge (*Carex athrostachya*)	
foxtail barley (*Hordeum jubatum*)	
Nuttall's alkaligrass (*Puccinellia nuttalliana*)	
Forbs	
common willow herb (*Epilobium ciliatum*)	
field mint (*Mentha arvensis*)	
arum leaf arrowhead (*Sagittaria cuneata*)	
alkali marsh butterweed (*Senecio hydrophilus*)	
simplestem bur reed (*Sparganium emersum*)	
Plus other unlisted native volunteer species	***MAXIMUM*** COMBINED CANOPY COVER = 40%

Additional requirements. In addition to the requirements specified in Table E.2-15, these conditions must be met at the end of 10 years:

- Minimum of 90 percent total canopy cover of individual species listed in Table E.2-15;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Forb Dominated Types

Common Cattail (*Typha latifolia*) HT—The Common Cattail (*Typha latifolia*) HT is a late seral type that dominates very wet sites that retain standing ponded water for most of the growing season each year. Under normal hydrologic circumstances, and free of disturbance, this type forms a dense, mono specific stand. Table E.2-16 shows two unions for this type:

- Union A is the type indicator species required to be present.
- Union B lists other species that may also be present in large or small amounts up to an aggregate maximum.

TABLE E.2-16
Plant community composition, separated into unions with specified amounts of canopy cover, required 10 years after remediation for stands of the Common Cattail (*Typha latifolia*) HT (*NOTE: Exempt area of open water more than 2 ft deep from polygon area*)

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Forbs	
common cattail (*Typha latifolia*)	MINIMUM CANOPY COVER = 80%
UNION B SPECIES (These species may be present with combined total maximum canopy cover of 20 percent)	
Graminoids	
softstem bulrush (*Scirpus validus*)	
Forbs	
common willow herb (*Epilobium ciliatum*)	
field mint (*Mentha arvensis*)	
water smartweed (*Polygonum amphibium*)	
Plus other unlisted native volunteer species	*MAXIMUM* COMBINED CANOPY COVER = 20%

Additional requirements. In addition to the requirements specified in Table E.2-16, these conditions must be met at the end of 10 years (*NOTE: Exempt area of open water more than 2 feet deep*):

- Minimum of 90 percent total canopy cover of individual species listed in Table E.2-16;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

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Clark Fork River Operable Unit

of the Milltown Reservoir/Clark Fork River Superfund Site

Record of Decision

Appendix F:

Concurrence Letter from the State of Montana

U.S. Environmental Protection Agency
Region 8

10 West 15th Street
Suite 3200
Helena, Montana 59626

April 2004

Montana Department of
ENVIRONMENTAL QUALITY

Judy Martz, Governor

P.O. Box 200901 • Helena, MT 59620-0901 • (406) 444-2544 • www.deq.state.mt.us

April 22, 2004

Max H. Dodson
Assistant Regional Administrator
US EPA Region
One Denver Place
999 18th Street
Denver, CO 80202-2405

Re: The Montana Department of Environmental Quality's Concurrence in the Record of Decision for the Clark Fork River Operable Unit of the Milltown Reservoir NPL Site in Montana

Dear Mr. Dodson:

The Montana Department of Environmental Quality (DEQ) concurs in the Record of Decision (ROD) for the Clark Fork River Operable Unit of the Milltown Reservoir NPL Site in Montana. DEQ fully supports EPA's determination that there are present and potential human health and environmental risks in the Operable Unit that must be addressed pursuant to CERCLA and the NCP. In concurring, however, DEQ does not necessarily agree with all statements and opinions expressed in the ROD. While DEQ generally supports EPA's determination of the areas where these risks must be addressed, DEQ has reservations concerning certain issues, including those discussed below. In addition, the Department wishes to identify certain concerns that it believes should be addressed in designing and implementing the remedy and in evaluating the effectiveness and protectiveness of the remedy in EPA's five-year reviews.

Limitations on the Effectiveness of In-situ Treatment

DEQ has concerns about the extensive use of in-situ treatment within the floodplain. Specific limitations of in-situ treatment that DEQ commented on in the development of the remedy for the Clark Fork River included: the continued migration of metals into groundwater and surface water; increased mobility of arsenic and increased migration of arsenic into both surface water and groundwater; the inability of in-situ treatment to meet human health action levels in certain circumstances; the limitations of in-situ treatment where materials are too deep or too wet to be treated in place; the difficulty of calculating and applying the correct lime amendment amount; the lack of certainty as to the permanence of in-situ treatment; and the continued re-entrainment of contaminants into the river system.

These limitations have to a large extent been acknowledged in the ROD. However, DEQ believes these limitations will play an important role in the development of the remedial design and the implementation of the remedial action. In addition, these limitations should be explicitly addressed in each five-year review, although DEQ notes that additional removal of materials from the floodplain may occur as part of the State of Montana's Natural Resource Damage Program's (NRD) restoration efforts in the Clark Fork River Operable Unit.

Surface Water Arsenic Concentrations

DEQ is concerned with the arsenic concentrations that have been reported in the Clark Fork River from Warm Springs Ponds to Turah Bridge. Arsenic concentrations here often exceeded both the EPA Maximum Contaminant Level (MCL) of 10 μg/L and the State WQB-7 standard of 18 μg/L. These concentrations are a concern because of potential human health effects and because arsenic has been identified as a significant chronic stress risk to trout. These high levels of arsenic need to be recognized and addressed during the remedial design, in future monitoring, and in each five-year review.

Significance of Chronic Stress on Fish

In the Ecological Risk Assessment, EPA determined unacceptable acute risk to fish from pulse events causing the release of copper. Major fish kills have been attributable to sudden precipitation events that wash copper and other mining wastes into the river. EPA also found that metals and arsenic in the aquatic environment are also imposing a low-level chronic stress on trout and other fish and that the most likely manifestation of this stress is decreased growth.[1] The State of Montana believes that chronic stress is even a more important risk factor. Recently, Stratus Consultants conducted a trout feeding study for the NRD program that showed reduced growth in rainbow trout fed a diet of aquatic invertebrates that bioaccumulated arsenic and metals from Clark Fork River sediments.[2] Research scientists at EPA's Duluth office, as well as others, have documented similar growth effects in rainbow trout resulting from arsenic contamination in trout diets.[3]

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[1]Ecological Risk Assessment for the Clark Fork River Operable Unit, EPA December 1999.

[2]The Stratus study showed a diet of aquatic invertebrates containing 129 mg As/kg caused a 44% reduction in growth rate of rainbow trout. "Reduced Growth of Rainbow Trout Fed a Live Invertebrate Diet Pre-exposed to Metal Containated Sediments Collected from the Clark River Basin, Montana," Dec. 5, 2002, Hansen, James, et al. (accepted for publication).

[3]Drs. Dave Mount and Russ Erickson observed an average 40% reduction in growth in fish consuming 100 mg As/kg diet, and 10% reduction in growth (LOEC) in fish consuming 35 mg As/kg.

Cockell, Hilton, and Bettger, 1991, "Chronic Toxicity of Dietary Disodium Arsenate Heptahydrate to Juvenile Rainbow Trout," Arch. Environ. Contam. Toxicol., 21:518-527, (Found significant reduced growth [LOEC] at 33 mg As/kg in diet.)

Cockell, Hilton, and Bettger, 1992, "Hepatobillary and Hematological Effects of Dietary Disodium Arsenate Heptahydrate in Juvenile Rainbow Trout," Comp. Biochem. Physiol., 103C: 453-458, (Found significant growth reduction [LOEC] at 55 and 60 mg As/kg in diet.)

Scientists working for the NRD program determined that overall trout populations in the Upper Clark Fork River are approximately one-sixth of reference stream populations and found that this reduced population is not due to differences in available habitat or other non-contaminant-related factors.[4] These depressed trout populations can be explained, at least in part, by chronic stress and decreased growth resulting from metals and arsenic in the trout diet. The evidence also suggests avoidance of metals and arsenic may be responsible, in part, for the depressed trout populations, including the absence of bull trout, in the upper Clark Fork River. Therefore, post-remedy concentrations must be closely monitored.

Floodplain Stability, Streambank Stabilization and Width of the Riparian Buffer Zone

EPA, in the ROD and Responsiveness Summary, recognizes that floodplain stability is a significant issue. This is consistent with the State's finding that terrestrial resources in the river's riparian zone, including, soils, vegetation, wildlife and wildlife habitat, have suffered significant injuries.[5] In a substantial part of Reach A, vegetation, affected by soil phytotoxicity, is absent or very sparse in areas of exposed and nearly exposed tailings, and there is decreased abundance and diversity in other areas containing contaminated soils. EPA also determined that soil organisms are adversely affected, and wildlife is potentially affected by the contaminants of concern (COCs).[6] As EPA's and the State's scientists have recognized, this has resulted in an unstable floodplain which may be subject to unraveling during overbank floods.

As stated in the Responsiveness Summary, Dr. Dungan Smith indicated that the width of riparian buffer zone to be revegetated should be greater than 50 feet in order to adequately protect floodplain stability and prevent unraveling.[7] Also, a large number of public comments supported a wider riparian buffer zone. DEQ believes that the implementation of a wider buffer zone is feasible, and efforts should be made to increase the zone's width where practicable during remedy implementation.

DEQ also has reservations about certain aspects of the streambank component of the proposed remedy. The Department of Fish, Wildlife and Parks and other Montana streambank experts feel that some of the streambank stabilization techniques proposed in the ROD may not be sufficient to decrease erosion and stabilize the banks. However, this component can be evaluated in the remedial design and the best streambank stabilization techniques can be implemented during construction.

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[4]Aquatic Resources Injury Assessment Report, Upper Clark Fork River Basin, State of Montana, 1995.

[5]Terrestrial Resources Injury Assessment Report, Upper Clark Fork River Basin, State of Montana, 1995.

[6]Ecological Risk Assessment for the Clark Fork River Operable Unit, EPA, December 1999.

[7]Letter to Scott Brown from J. Dungan Smith dated October 29, 2001

Protection of Human Health

DEQ has concerns regarding the level of protectiveness of human health in the ROD. The arsenic cleanup levels selected are based on a 1.499×10^{-4} risk. The least stringent cleanup level considered acceptable under CERCLA and the NCP is 1×10^{-4}. More protective levels, using a 1×10^{-6} risk as the point of departure, are encouraged under the law. Although the cleanup levels selected by EPA represent a 1.499×10^{-4} risk, the 1.499 was rounded down to 1 for purposes of finding that the risk was within the acceptable risk range. No corresponding adjustment was made in the cleanup levels. Use of a true 1×10^{-4} risk level would have resulted in more protective cleanup levels.

Moreover, the cleanup levels chosen in the ROD are based on risks to the general population and are not necessarily protective of all sensitive subgroups. Under the NCP and EPA guidance, the levels should be set to be protective of all subgroups. EPA proposes to address the risk to pica children (defined as children with a medical condition that makes them prone to eat dirt) through an educational program, as part of the remedy. For arsenic, protective levels for pica children may represent levels below arsenic background concentrations. An aggressive educational program offers the best option for protecting this sensitive subgroup.

The Atlantic Richfield Company, in its comments on the Clark Fork River Proposed Plan, asserts that it cannot be required to fund such an educational program. In the event that educational programs are, for any reason, not successful in ensuring that all sensitive subgroups are protected, cleanup levels should be adjusted and additional action implemented to make the remedy more protective. This also can and should be evaluated as part of each five-year review.

The State of Montana looks forward to working closely with EPA, the responsible party, and landowners along the Clark Fork in designing and implementing this remedy and any related restoration actions to ensure a clean and healthful environment for the citizens of the State, especially for those who live or work along the Clark Fork River.

Sincerely,

Tom Livers

for Jan P. Sensibaugh
Director
Montana Department of Environmental Quality