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Environmental Assessment

DOI-BLM-CO-0000-2023-0003-EA

Low-Tech, Process-Based Lotic and Lentic Restoration for Colorado BLM

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U.S. Department of the Interior
Bureau of Land Management
Colorado State Office
Denver Federal Center
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1 Introduction

1.1 Identifying Information

Project Title: Low-Tech, Process-Based Lotic and Lentic Restoration for Colorado BLM

Legal Description: BLM Colorado

NEPA Document Number: DOI-BLM-CO-0000-2023-0003-EA

1.2 General Setting

Colorado is described as a semi-arid landscape where lotic and lentic habitat occupy only a small portion of the landscape (3-5%), yet have a disproportionately important influence on wildlife, riparian vegetation, and water resources (Naiman et al. 2010). Restoration of aquatic habitat is critical to meeting Colorado public land health standards 2 – 5 (see Table 1-A in Appendix A), meeting State water quality standards, and BLM's obligation under FLPMA. Most of the aquatic habitat restoration would occur primarily west of the Continental Divide, along perennial water bodies, and varying topography, elevation, and Ecoregions. Fostering internal and external partnerships, as well as securing funding through BLM is important in implementing restorative actions.

1.3 Background

Lotic and wetland ecosystems are highly sensitive to land management and climatic variability (Schlesinger et al.1990) and impacts associated with previous anthropogenic disturbances will continue to impair the health of many systems for decades or longer.

The historic and systematic removal of structural elements like wood accumulations and beaver dams from streams and rivers has occurred, causing streams to be disconnected from the floodplain, or less frequent in both time and space. Loss of wood accumulations and beaver dam structures has exacerbated erosion, incision, surface and groundwater interactions, nutrient cycling, and reduction in baseflow.

Lotic and lentic systems can be more vulnerable to disturbances of increasing frequency and severity (i.e., droughts, floods, and fires), depending on stream type, location in a watershed, aspect, stream morphology, and other watershed variables. Restoration of these areas is often a high priority to the BLM, the public, and agency partners to sustain terrestrial and aquatic species for future generations. There is also an economic benefit to citizens who implement projects on BLM lands as well as local communities.

Traditional restoration approaches are often intensive and costly, and applying more cost-effective, scalable restoration approaches to address these challenges is needed, especially with funding being a major concern. As highlighted in the Fourth National Climate Assessment (U.S. Global Change Research Program USGCRP (2018)), investing in proactive adaptation like low-tech process-based restoration produces benefits that far exceed the costs of such restoration efforts. Low-tech restoration is critical to rangeland health and productivity (Donnelly et al., 2016), the viability of rural communities, the stewardship and sustainability of working lands, water security, and resiliency to extreme events like floods, droughts, and fires. BLM field offices will need to determine areas in need of restoration, based upon factors such as 303(d) and M&E listed streams, fish distribution, historic presence of beavers and other aquatic species, acres of BLM in a watershed, land health determinations, cost-effectiveness, partners, access, and other factors.

Riverscape restoration is prioritized in this Programmatic Environmental Assessment (PEA) because many lotic systems have been adversely impacted by historical practices, yet still offer ample opportunities to measurably improve the ecological health of BLM administered resources with relatively simple, cost-effective techniques. Specifically, the Proposed Action prioritizes the restoration of perennial wadable streams that require floodplains and riparian vegetation to function properly.

The BLM has a backlog of aquatic restoration opportunities essential to the protection and recovery of aquatic species, and improvements in stream function and water quality, but has limited resources (both personnel time and funding) to address the need in a timely fashion. There is a need to increase efficiency of project planning to accelerate the pace of aquatic restoration project implementation. Currently, a substantial portion of personnel, time, and funding is spent on National Environmental Policy Act (NEPA) planning and analysis for individual aquatic restoration projects. The time and funding dedicated to such planning and analysis is particularly important since there are existing tools in place that enable streamlined implementation of projects under the Endangered Species Act and the Clean Water Act.

If approved, this programmatic EA would streamline the NEPA process across BLM Colorado, enabling field offices to improve the health of lotic and lentic habitat as necessary to achieve several goals and objectives, including:

- water quality
- water availability
- stream and floodplain connectivity
- surface and groundwater interactions
- riparian-wetland health
- improve degraded aquatic habitat
- habitat for aquatic and terrestrial species
- recreation, fishing, and hunting opportunities
- floodwater retention
- ecosystem resilience to climate change, drought, and flood
- wildland fire management

While the specific goals and objectives vary among individual field offices, watersheds, and stream reaches, all treatments would be used to restore the biophysical processes that maintain or improve the health of riparian-wetland and aquatic ecosystems. These projects would help the bureau meet or exceed the associated goals and objectives in our resource management plans (RMPs), Standards for public land health in Colorado, as well as the Fundamentals of Rangeland Health (43 CFR 4180.1).

Fundamentals of Rangeland Health:

(a) Watersheds are in, or are making significant progress toward, properly functioning physical condition, including their upland, riparian-wetland, and aquatic components; soil and plant conditions support infiltration, soil moisture storage, and the release of water that are in balance with climate and landform and maintain or improve water quality, water quantity, and timing and duration of flow.

(b) Ecological processes, including the hydrologic cycle, nutrient cycle, and energy flow, are maintained, or there is significant progress toward their attainment, to support healthy biotic populations and communities.

(c) Water quality complies with State water quality standards and achieves, or is making significant progress toward achieving, established BLM management objectives such as meeting wildlife needs.

(d) Habitats are, or are making significant progress toward being, restored or maintained for Federal threatened and endangered species, Federal proposed or candidate threatened and endangered species, and other special status species.

Senate Bill 23-270 passed on June 5th, 2023, and discusses activities that "*restore the environmental health of natural stream systems without administration*." Section 1 of the Act declares that functioning natural streams are beneficial to all Coloradans and the State should facilitate and encourage projects that restore environmental health of natural streams. BLM recognizes SB 23-270 and will coordinate with the Department of Natural Resources, where permitting is necessary for stream restoration projects not deemed a "minor stream restoration activity."

1.4 Purpose and Need for Action

The need for the action is to address legacy impacts to aquatic and riparian habitat. The purpose for the action is to restore or improve the condition of lotic and lentic systems and habitat to restore federally listed fish populations, improve water quality and quantity, improve floodwater retention, improve stream function, manage for biodiversity and to increase resilience to drought and climate change.

1.5 Decision to be Made

Based on the analysis contained in this PEA, the BLM will decide whether to approve or deny the proposed stream and aquatic habitat restoration and if approved, under what terms and conditions. Under the NEPA, the BLM must determine if there are any significant environmental impacts associated with the Proposed Action warranting further analysis in an Environmental Impact Statement (EIS). The BLM Colorado State Director is the responsible officer who will decide one of the following:

- To approve the Proposed Action with design features.
- To approve the Proposed Action, with additional mitigation added.
- To analyze the effects of the Proposed Action in an EIS; or
- To deny the programmatic EA for restoration.

The decision to be made is to determine whether the BLM should programmatically utilize a suite of "low tech restoration" techniques within each BLM District and Field Office in Colorado.

1.6 Overview of the Proposed Action

The Proposed Action is described in section 2.1. Initial projects will likely address wadable perennial streams that are moderately incised, slopes less than 3%, bankfull widths less than 10 meters, in an unconfined valley, and a ratio of valley width/stream greater than 4. There are a number of tools available to inform aquatic habitat improvements, such as the Colorado Beaver Restoration Assessment Tool (BRAT) by Scamardo, Marshall and Wohl (2021). Restoration actions would be used to address separate, but inter-related issues that currently limit the BLM's progress towards the attainment of resource objectives.

Techniques proposed by Natural Resources Conservation Service (NRCS), Army Corps of Engineers, Rosgen 1996, Zeedyk 2014, Castro et al 2018, and Utah State University Restoration Consortium 2019 (Wheaton et al), are <u>examples</u> of structures and techniques that could be applied to achieve stream restoration objectives (Appendix A).

The Proposed Action would be implemented programmatically to restore as many lotic miles and lentic acres as necessary to meet or exceed the BLM's goals and objectives for riverscape health. Due to the programmatic nature of the Proposed Action, the PEA does not include site specific projects; however, the PEA describes the types of projects to be implemented.

The BLM would utilize a suite of relatively simple, scientifically based, and cost-effective techniques to restore lotic and lentic habitat that have been impacted by historical practices (i.e., removal of beaver dams and woody debris) in Colorado. These techniques would address specific issues that limit the BLM's progress towards land health, floodplain inundation, surface and groundwater interactions, and aquatic restoration goals and objectives. These are summarized in Table 1.

Ten guiding principles would be considered in the design and implementation of all projects (*Utah State University, 2019*). They are broken into: (1) aquatic habitat principles and (2) restoration principles, both of which are described in Appendix A. A reference or expected condition would be determined to inform where and how structures would be implemented.

Project design and objectives should strive for self-sustaining (Restoration Principal 10) ecosystem, where minimal maintenance is required. The BLM may implement vegetation management actions where necessary to promote the growth of native riparian and wetland species (see Table 1). Where beaver dam activity potentially affects private land, the BLM would consult with Colorado Parks and Wildlife and other stakeholders to identify the most appropriate solution. Beaver mitigation strategies, such as beaver deceivers or re-location would be implemented if flooding of private land were an issue. Headcut control strategies would be used to compliment processes-based restoration where: (a) the BLM lacks sufficient control of the watershed processes causing the vertical instability (i.e., limited ownership), or (b) the issues that originally caused the erosional feature to develop have been addressed, but the threat of further incision into otherwise healthy stream segments persists. BLM would review the amount of BLM administered lands upstream, periodicity of flow, riparian and floodplain habitat, fish species diversity, irrigation return flows and other factors that help inform headcut control strategies.

Projects would be designed to restore physical, chemical, and biologic functions of lotic and lentic habitat processes that historically created and maintained the attributes and resource values of the site.

1.7 Conformance with the Land Use Plan

The Proposed Action is subject to and is in conformance (43 CFR 1610.5-3) with the following land use plans:

Land Use Plan: Record of Decision and Approved Resource Management Plans (ROD/ARMPs), as amended, for all Colorado field offices.

- Canyons of the Ancients Resource Management Plan
- Colorado River Valley Field Office Resource Management Plan and Roan Plateau RMP Amendment
- Dominguez-Escalante NCA Resource Management Plan
- Grand Junction Field Office Resource Management Plan
- Gunnison Resource Management Plan
- Gunnison Gorge NCA Resource Management Plan
- Kremmling Field Office Resource Management Plan
- Little Snake Field Office Resource Management Plan
- McInnis Canyons NCA Resource Management Plan

- Northwest Colorado Greater Sage-Grouse Resource Management Plan Amendment
- Royal Gorge Field Office Resource Management Plan (including Northeast Resource Area RMP)
- San Luis Resource Area Resource Management Plan
- Tres Rios Field Office Resource Management Plan
- Browns Canyon National Monument Resource Management Plan
- White River Resource Management Plan
- Uncompahgre Field Office Resource Management Plan

1.8 Relationship to Statutes, Regulations, Other NEPA Documents

The Proposed Action is in conformance with the following laws, statutes, Regulations, Other Plans, and NEPA:

- Laws and Statutes
    - National Historic Preservation Act (NHPA) of 1966, as amended
    - National Environmental Policy Act of 2020 (NEPA)
    - Endangered Species Act of 1973
    - Migratory Bird Treaty Act of 1918
    - Federal Noxious Weed Act of 1974, as amended in 1988, 1994
    - Federal Land Policy and Management Act of 1976 (FLPMA)
    - Fishery Conservation and Management Act of 1976
    - Clean Water Act of 1977 and subsequent amendments
    - Paleontological Resources Preservation Act (PRPA) of 2009
- Regulations and Manuals
    - Title 43 Code of Federal Regulation, Part 4100
    - BLM Water Quality Manual
    - BLM Water Rights Manual
    - Executive Order 11988 (Protection of Floodplain)
    - Executive Order 11990 (Protection of Wetlands)
- Other Plans and NEPA
    - Vegetation Treatments Using Herbicides on BLM Lands in 17 Western States Programmatic EIS- September 2007
    - Sage grouse Habitat Assessment Framework- 2015
    - Vegetation Treatments Using Aminopyralid, Fluroxypyr, and Rimsulfuron on BLM land in 17 Western States Programmatic EIS-August 2016
    - State of Colorado and BLM Nonpoint source Memorandum of Understanding
    - Executive Order 13175 Consultation and Coordination with Indian Tribal Governments.

1.9 Public Involvement

The BLM uses a scoping process to identify potential significant issues in preparation for impact analysis. The principal goals of scoping are to identify issues, concerns, and potential impacts that require detailed analysis. Scoping is both an internal and external process. Internal scoping was initiated when the project was presented to the Colorado State Office (COSO) interdisciplinary team. An announcement for public review of this EA was posted on the BLM's on-line National Environmental Policy Act (NEPA) register (ePlanning) on April 26, 2023. https://eplanning.blm.gov/eplanning-ui/project/2024463/510

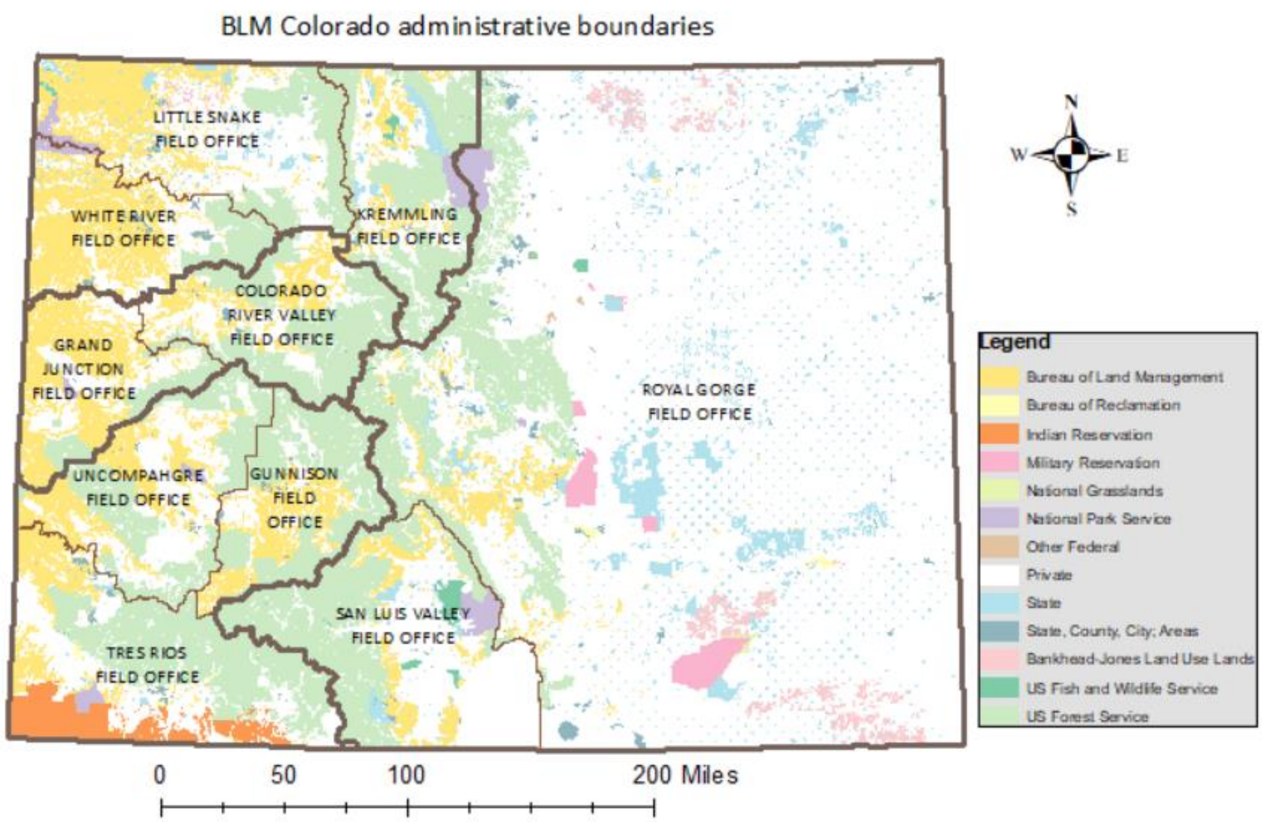
The EA was open for public comment from August 22 through September 22, 2023. There were five separate comments. One comment included technical recommendations in the specific actions to include Zeedyk structures and in the Design Features to include consultation with specialists regarding nesting wildlife and temporary fencing to manage grazing during restoration and post-restoration. In addition, there were edits to Appendix A, Principles and Practices of Low-Tech process-based restoration and natural channel design (i.e., addition of principles 6-10).

2. Proposed Action and Alternatives

2.1 Proposed Action (Alternative A)

The Bureau of Land Management (BLM) Colorado State Office proposes to utilize a suite of relatively simple, cost-effective restoration methods (commonly referred to as "low-tech, process-based restoration") to improve the condition of lotic and lentic systems and habitat (streams, rivers, wetlands, and the surrounding valley bottoms) on BLM managed lands in Colorado (Figure 1).

Figure 1. BLM lands administered by Colorado district and field offices.



Project locations and corresponding restoration actions would be prioritized by each BLM field manager as resources and funding allow and include those systems that are unlikely to make acceptable progress towards the achievement of land health standards or associated resource management plan (RMP) objectives through natural processes, alone. A restoration project may have a single goal or multiple goals to achieve a desired objective. Example goals include:

- Restore beaver populations,
- Increase water storage on floodplain, raise water tables, and surface/groundwater interactions,
- Restore wetland habitat,
- Restore mountain (i.e., wet) meadow habitat,
- Restore riparian habitat,
- Increase floodplain connectivity,
- Restore incised streams,
- Peak flow attenuation, increase fine grained sediment and organic matter storage, and more stable channels,
- Increase lateral and vertical exchange of water.

Beaver Dam Analog (BDAs) and Post Assisted Log Structure (PALS) Zeedyk 2014, Rosgen 1996, and other natural channel design structures would be implemented on predominately small wadable perennial streams on BLM administered lands. They would be implemented in accordance with scientific methods, publications and manuals produced by such researchers and institutions as Dave Rosgen, Bill Zeedyk, Utah State University, USFWS, USGS, USFS, Ellen Wohl, Emily Fairfax, Polluck, and others. These publications and manuals would assist field practitioners with developing a clear restoration objective, the proper location of projects, as well as a process to implement the proper techniques in a particular location. The use of hydraulic models, such as HEC RAS may be employed to further define stream morphology, flow events, size and character of sediment moving through a watershed. Permits that are needed would be secured from the Army Corps of Engineers prior to implementation. In addition to RMP objectives, other more specific examples of goals, objectives and treatment techniques are shown in Table 1. Table 1 summarizes the types of actions and techniques that may be used for a particular project.

Table 1. Example goals, objectives, and techniques of lotic and lentic habitat restoration.

Goal	Objective	Action	Techniques
Lotic and Lentic Habitat -restore or sustain processes that historically maintained the health of perennial streams	Restore the composition and distribution of structural elements that historically altered local hydraulics to produce diverse and complex physical habitat, as well as healthy, resilient, and self-sustaining aquatic habitat.	**Beaver Dam Analog (BDA)**	• Post less BDA • Post-Assisted BDA • Post-Line Wicker Weave
		Post Assisted Log Structure (PALS)	• Bank-Attached PALS • Mid-Channel PALS • Channel-Spanning PALS
	Maintain the health of lotic and lentic systems that are at risk of incision from headcut advancement. <u>Note</u>: Used where we lack control over the root causes for incision, or protection of	**Headcut Control**	• Zeedyk structures • Zuni Bowl Log Step Falls • Rosgen structures

	upstream lotic or lentic habitat is necessary.		
	Restore or maintain the composition and distribution of woody vegetation necessary to sustain the processes of wood accumulation and beaver dam building activity.	**Vegetation Management**	• Protection Fencing • Native Shrub/Tree Plantings
	Mitigate flooding impacts or damage from undesirable harvest of trees, while allowing the beaver to remain in place.	**Beaver Mitigation Strategies**	• Breach Dam • Install beaver deceiver • Install Fish Friendly Pond Leveler to Control Stage • Install Culvert Barrier to Prevent Culvert Clogging • Install Fencing Around Sensitive Trees • Use Abrasive Paint to Protect Sensitive Trees • Re-locate beaver

Structures would be installed in complexes (typically 3-50 structures) to create or improve aquatic habitat for beaver and other aquatic species. For example, the BLM could install these structures to reconnect streams with their floodplains, capture sediment, reduce stream power, enhance the storage of water in the streambed/banks, and raise water tables that have declined due to channel incision. The expected results would be to accelerate the development of structures and concomitant improvements in aquatic habitat features such as beaver dams. Like the physical characteristics of natural beaver dams and wood accumulations, the BLM would adapt the design of BDAs and PALS to influence specific hydraulic, hydrologic, and geomorphic processes (Table 2). Structures that move are expected to hang up at a stream "nick point," or be deposited on the adjacent floodplain, thereby creating additional habitat and mitigation for another future flood event.

These options are summarized succinctly by Castro, Polluck and Jordan, 2017 in The Beaver Restoration Guidebook. The "Specific Actions", below, summarize each of the proposed 'living with beaver' actions that BLM would utilize where site specific reviews indicate that they are viable or even likely to be more successful than lethal removal.

Structures would typically be installed with manual labor, pneumatic post pounder, hand tools, and occasionally an excavator to increase efficiency and productivity (i.e., to transport materials or drive posts at difficult locations) or where such equipment is necessary to complete a project. Field offices would follow all requisite Best Management Practices (BMPs) associated with the specific details of an individual project, including those for weed prevention, the protection of sensitive soils, water quality, and fish/wildlife. Whenever practicable, the BLM would utilize native materials that are near the riparian-wetland area (Restoration Principal 7).

Table 2. Summary of hydraulic, hydrologic, and geomorphic effects of PALs and BDAs.

Type	Hydraulic	Hydrologic	Geomorphic
PALS Channel-spanning	create upstream backwater or pond, and plunge hydraulics downstream	increase frequency and magnitude of overbank flow, increase hyporheic flows	channel aggradation, channel avulsion, bank erosion, dam and plunge pool formation, bar formation
PALS Bank-attached	force convergent flow (deeper and faster), create eddy behind structure	force overbank flows*	bank erosion, scour pool formation, bar formation, sediment sorting, channel avulsion
PALS Mid-channel	force flow separation, create eddy in lee of structure	force overbank flows*	bank erosion, scour pool formation, bar formation, sediment sorting, channel avulsion
Primary BDA	create deep slow water	increase frequency and magnitude of overbank flow, increase hyporheic flows	channel aggradation upstream, bar formation, bank erosion (if breached on ends), sediment sorting
Secondary BDA	create deep slow water	increase frequency and magnitude of overbank flow, increase hyporheic flows	channel aggradation, channel avulsion, bank erosion, dam pool formation, bar formation

Number and Occurrence of Projects, Monitoring

The proposed action covers up to 100 projects over a 20-year period, with an average of 5 projects/year being implemented using a BLM cooperative agreement, partnerships, or internal BLM staff. The actual outputs and outcomes would ultimately be limited by resources that are available to do watershed restoration work in the future. Under the proposed action, process efficiencies have been created that will enable greater amounts of work to be accomplished under similar funding levels (up to the limits of work which is described in the action alternative). Moreover, with environmental analysis complete, BLM expects streamlined project planning and implementation, and thus greater efficiency in producing results given available resources.

Field offices would prioritize project locations and include lotic and lentic areas that are unlikely to make acceptable progress towards the achievement of land health standards or RMP objectives through natural processes, alone. Individual projects would ideally be implemented over a subset of an entire drainage network and represent the intersection of priorities and practical opportunities (e.g., partnerships, willing landowners adjacent to public land, etc.). Projects would tend to be organized around these discrete locations, a collaboration of project organizers and stakeholders, and tied to a specific set of conservation and/or restoration actions. They would also be implemented on a reach-by-reach basis to ensure that the selected treatments account for the unique, site-specific characteristics. Although the site-specific project objectives would vary according to the desired outcomes, site potential, and current conditions; the target for most projects would include a state in which the processes of wood accumulation and/or beaver dam activity are self-sustaining.

Implementation and effectiveness monitoring would be conducted for all projects to facilitate adaptive management and ensure progress towards meeting land health standards, as well as those identified resource management plans. This could include the installation of hydrologic monitoring sensors such as piezometers, thermistors, soil moisture sensors and stream gauges, as well as the establishment of monitoring transects (permanent or temporary) and biological sampling. All equipment would be removed once sufficient data has been collected to answer the management question, which could be short and/or long-term. The installation and maintenance of monitoring equipment is not expected to have short- or long-term impacts to water quality, sediment delivery processes, macroinvertebrates, fisheries, or stream morphology.

Specific Actions

The BLM would utilize a suite of relatively simple, scientifically based, and cost-effective techniques to restore lotic and lentic habitat that have been impacted by historical practices (i.e., removal of beaver dams and woody debris) in Colorado. These techniques would address specific issues that limit the BLM's progress towards land health, floodplain inundation, surface and groundwater interactions, and aquatic restoration goals and objectives. The Proposed Action includes the following restoration action categories:

- *Adding Structural Elements*: (i.e., artificial beaver dams and wood accumulations) to improve biologic, hydrologic, or geomorphic processes that historically maintained the health of these systems. Moreover, install in-channel structures to aggrade streams and/or encourage beavers to build dams in incised channels and across floodplain surfaces. Structural elements may be used to address "headcuts," excessive downcutting and erosion, improve fish habitat, and biologic processes that are expected to be present. Implement Zeedyk structures to address "headcuts" on ephemeral, intermittent or perennial lotic systems to reduce sedimentation, as well as maintain water quality, fish and aquatic habitat.

- *Channel Reconstruction and Relocation*: in rare situations, it may be necessary to reconstruct or re-locate a stream to return it to an expected or reference condition. Reconstruction must mimic natural gradient, bankfull width and depth, substrate, entrenchment ratio, and sinuosity, as compared to an appropriate reference reach. Stage zero projects within an accessible floodplain may be necessary to create additional habitat for beaver or fish rearing.

- *Side-channels*: re-activate and restore relic side channels by removing manufactured fill and plugs to improve fish and aquatic habitat.

- *Streambank Restoration*: Restore streambanks that have been artificially altered to more natural conditions.

- *Vegetation Management*: actions that will promote the composition, diversity and density of riparian and floodplain native vegetation. Vegetation may be removed within the floodplain, as well as upslope areas to build beaver dam analogs and other low-tech structures to promote improvement of beaver and aquatic habitat.

- *Beaver Mitigation Strategies*: to mitigate potential flooding or affects to downstream private landowners.

- *Fish passage restoration*: Improve or replace culverts (at road crossings) that may be barriers to fish passage, causing excessive erosion, or undersized for the upstream watershed and debris movement. Aquatic organism passage and instream, side-channel, and floodplain aquatic restoration activities may require trees to be brought in from outside of the floodplain and riparian area when trees are not available on site.

- *Small Dam Removal*: Remove unauthorized, abandoned, or agency small dams that are *non-jurisdictional*, and would be less than a "minor dam," which does not exceed 20 feet in vertical height and 100-acre feet in capacity. Remove channel-spanning weirs and abandoned diversion and other water retention structures. Third-party dams can also be removed when coordination has occurred, and agreement has been reached with the landowner.

In addition to in-stream and floodplain considerations, District and Field Offices must conduct cultural resource surveys, determine consistency with biological opinions, review threatened and endangered species concerns, and consultation with the appropriate State and Federal agencies as projects are implemented. If projects are in proximity to private land, there may be water rights concerns that need to be addressed prior to project implementation. It will be important to include water rights specialist or hydrologist in these discussions.

Cultural Resource Surveys: Internal discussions or meetings must include an archeologist to check the project area prior to construction.

Water Rights: The proposed action would not *injure* valid existing water rights or other property rights that may be associated with existing structures. Specifically, design criteria have been added **that require** identification and evaluation of potential effects on existing valid water rights and implement projects in a manner that does not injure those rights. It's expected that BDA's, PALS, and other lotic and lentic projects would increase water availability and not affect existing water rights.

Projects would adhere to the following principles of process-based restoration in Table 3.

Table 3. Summary of process-based restoration principles (Low Tech Process-Based Restoration Manual, Utah State University (2019); adapted from Beechie et al. (2010).

Principle	Description
1. Target root causes of habitat and ecosystem change	Restoration actions are designed to address the human alterations to processes that are degrading habitat conditions
2. Tailor restoration actions to local potential	A given reach in a river network operates within specific constraints based on its location within the watershed and climatic and physiographic setting. Understanding the types and magnitudes of processes within a given reach helps design restoration actions.
3. Match the scale of restoration to the scale of the problem	When disrupted processes causing degradation occur at the reach scale, restoration actions at individual sites can effectively address root causes. When causes of degradation occur at the watershed scale, many individual site-scale actions are required.
4. Be explicit about expected outcomes	Process-based restoration is a long-term endeavor and there are often long lag times between implementation and recovery and biota may not improve dramatically with any single action. Articulating restoration goals and pathways is critical to setting appropriate expectations.

Beaver Dam Analogs and Post Assisted Log Structures

Beaver dam analogues (BDAs) and post-assisted log structures (PALS) are artificial structures that mimic the functions of natural beaver and aquatic habitat (Figure 2). They are permeable, temporary, and typically built by hand using natural materials to "kick start" processes that historically maintained the health and ecosystem services of many low gradient, wadable streams within the region. The BLM would install PALS to mimic and promote the processes of wood accumulation (Figure 3) and BDAs to mimic the effects of beaver dams (Figure 4).

Structures would be installed in complexes (typically 3-50 structures) to create or improve aquatic habitat for beaver and other aquatic species, as described under Number and Occurrence of Projects, above. For an overview of the typical design and application of the PALS and BDAs, refer to Appendix A.

Figure 1. Naturally occurring beaver dam on Reeder Creek near Kremmling, CO.

Figure 2. PALS on Reeder Creek near Kremmling, CO (Photo courtesy of Paula Belcher).

Figure 3. BDA. Use of woody vegetation on-site for structures without posts.

The BLM and/or contractors would review historic and current satellite imagery, modeling, geomorphology, streamflow characteristics, diversions, climate, and/or other watershed information in an office setting, prior to designing structures in the field. Structures would typically be designed in the field, built with locally available materials, and expected to withstand bankfull and lower flows and last until the structure(s) is compromised. Structures could withstand flows greater than bankfull, but would depend on channel characteristics, sediment delivery, and debris transported downstream. Structures that move are expected to hang up at a stream "nick point," or be deposited on the adjacent floodplain, thereby creating additional habitat and mitigation for another future flood event.

Low tech stream restoration would typically occur in partially confined or unconfined valley settings, characterized by relatively low gradient alluvial systems, with the potential to re-connect the floodplain and stream. They would generally not be used in highly confined or high gradient streams. Prior to implementing a project, the BLM would evaluate the risk of flooding and potential for impacting downstream uses, stream crossings and bridges. Additional details regarding design considerations and maintenance of BDAs and PALs are described in Table 4.

Although it may be possible to achieve project goals with one treatment, the BLM would implement additional structures or treatments along a stream, or within a watershed when the desired objective was not achieved by the original structure(s). When designing each project, the BLM would estimate the number of structures/treatments by evaluating the range of flows, as well as the flow at the bankfull and floodplain elevations for each treatment, relative to the width of the available valley bottom. Prior to implementing a project, it may be necessary to collect geomorphic data at a reference and project reach, to better understand the dimension, pattern, and profile of the affected reach to ensure objectives are met or implement adaptive management in response to new information. There may be instances where an excavator is needed to move materials, such as rock, posts, trees, and other vegetation to achieve the desired objectives and can't be moved by people.

Table 2. Overview of the types of BDAs and their typical applications

Low-Tech Structure	Design Variations	Purpose of Structure
Beaver Dam Analog (BDA): permeable, channel-spanning structure with a constant crest elevation, constructed with a mixture of woody debris and fill material to form a pond and mimic a natural beaver dam.	Post less BDA	• Increase dynamism and ecological benefits associated with dam formation, maintenance, breaching/blow-out, and infilling. • Increase water depths so that nearby beaver can overtake restoration. • Enable BDA installation where the transport of post-pounders may not be feasible
	Post Assisted BDA	• Prolong ecological benefits associated with dam building activity • enable the installation of BDAs in streams with flashy, high magnitude floods (i.e., streams that have incised)
	Post-Line Wicker Weave	• Mimic beaver dam activity where material that is suitable for wicker weaving is readily available

Type and Source of Materials for BDAs and PALS:

The BLM would prioritize the use of materials that can be found on-site or an adjacent area (Restoration Principle 7). This could include wood removed as part of conifer or fuels reduction projects. However, if building structures to support beaver and desirable woody species (i.e., those that can be used by beaver as food source and building material) are in short supply, the BLM will use fewer desirable species (e.g., conifers), more abundant species, or cuttings from locations where such concerns do not exist (i.e., artificial or abandoned reservoirs, nearby riverscapes where cuttings can be sustainably sourced, etc.). Typical ingredients include:

<u>PAL Ingredients:</u>

- **Branches, limbs, small logs, brushy fill:** generally < 6-15' long and 6-16" diameter (i.e., can be carried by 1-3 people and constructed by crew of 2-4)
- **Untreated wooden posts:** 6 - 8' long and 2-4" diameter; can sometimes be built on site with small diameter trees and/or branches, but may not be practical for building hundreds of structures

<u>BDA Ingredients:</u>

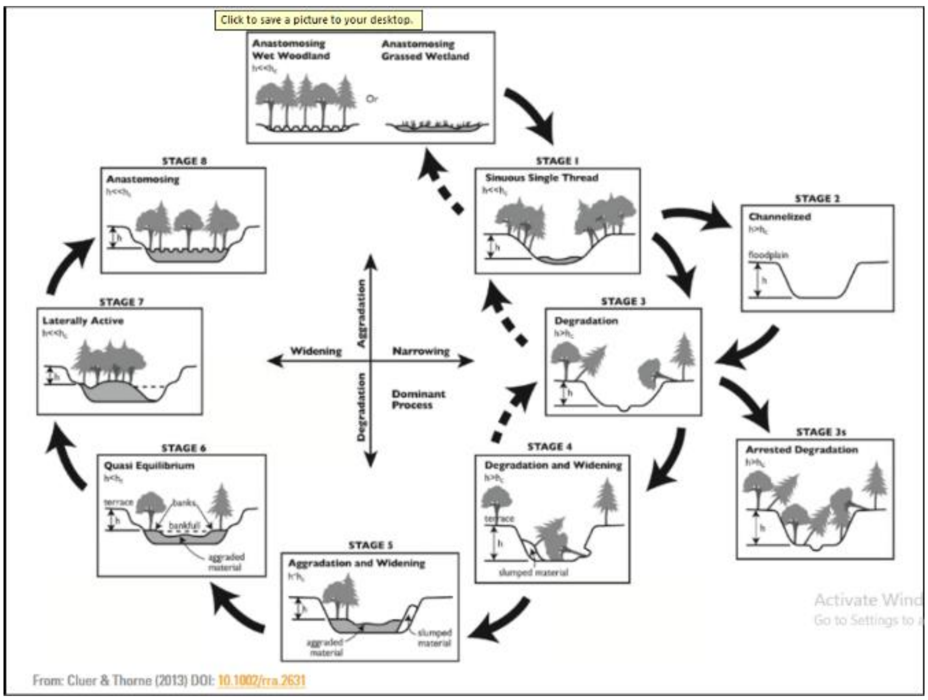
- **Woody fill material:** branches, limbs, small logs, brushy fill
- **Finer fill material (organic)**: e.g., turf mats, roots, leaves, conifer needles, grass, etc.
- **Finer fill material (inorganic)**: e.g., fine bed sediment, silt, clay, soil, gravel

- Optional if available onsite: key pieces: logs, cobbles, or small boulders
- Optional: untreated wooden posts if post-assisted

Vegetation and Other Approaches for Restoring Aquatic Habitat

Although it may be possible to achieve project goals with one project, multiple treatments may be required. For example, riverscape restoration projects would incrementally improve form and function by accelerating stream evolution during successive floods (Figure 5). Depending on the zone of influence of a treatment and the type of structures to be installed, it might take several bankfull flow events (over an extended period) to shift the channel laterally and re-connect the floodplain. The BLM may add structural elements to expand the lateral zone of influence in accordance with project objectives.

Figure 4. Stream evolution model proposed Cleur and Thorne 2013.



Vegetation Management:
Vegetation management actions would be implemented only where necessary to achieve restoration objectives. Vegetation management may be implemented to ensure that sufficient vegetation re-colonizes and expands across the treatment area. The BLM may install small fences (exclosures) around the riparian zone where woody browse by livestock, horses and/or other wildlife is likely to prevent sufficient regrowth of woody plant communities, as well as plant trees/shrubs, where necessary to accelerate recovery.

Project Protection Fences:
Where beaver historically occupied a stream and future dam building activity is desired, fences would typically extend at least 300 feet from the centerline of the stream, as this represents the distance that most beaver will travel when foraging for dam building material. Once sufficient woody vegetation exists to sustain the processes of wood accumulation and/or beaver dam activity, while supporting utilization by wildlife and livestock, the BLM would remove the fencing. The installation of fences is expected to occur on rare occasions, primarily due to cost and potential issue with migrating wildlife.

Shrub & Tree Plantings:
In some stream reaches, historical anthropogenic impacts have reduced or eliminated the types and amounts of woody riparian plant communities necessary for maintenance and recovery of the stream and floodplain, the BLM will plant native species to improve riparian function, if necessary.

Headcut Control:
Headcuts are highly mobile erosional features characterized by dramatic slope breaks (like a small waterfall) with the potential to migrate upstream during successive flow events. They are often symptoms of an imbalance between the driving and resisting forces that historically supported the maintenance of a dynamically stable dimension, pattern, and profile within the riverscape, but may also occur where the base level of a receiving stream or river has changed. The BLM would stabilize small headcuts (less than 5 feet) with hand-built structures to slow or stop the migration of the headcut and preserve the habitat upstream (Table 5). For larger headcuts, an excavator may be used because of the large diameter rock needed to stabilize the headcut. An interdisciplinary team will need to decide if stabilizing the headcut is necessary, given the position in the watershed and the amount of habitat to be preserved upstream.

Zeedyk techniques generally seek to slow and disperse water, dissipate energy, capture sediment, and increase soil moisture retention thereby promoting vegetation and channel recovery. The following are some principles to follow when treating headcuts and gullies from Zeedyk and Jansens (2009):

Table 3. Considerations when remediating headcuts and gullies.

Considerations for the Treatment of Headcuts	**Considerations for the Treatment of Gullies**
Lower the height of the falls to reduce the force of falling water, i.e., stepping down water.	Disperse surface flow, prevent concentration, increase infiltration and percolation.
Conserve soil moisture to enhance plant growth and root densities.	Retain soil moisture to improve environment for colonization and growth of plants.
Harden the base of the falls and plunge pool to protect substrates from erosion.	Increase channel roughness.
Consider structures above and below, such as a one-rock dam.	Widen channel bottom to lessen erosion force.
Top rocks of the wall must match the existing elevation of this pour-over.	Reduce channel slope to reduce runoff velocities to reduce available energy.

Additional information on channel incision, gullies and headcuts can be found in Bill Zeedyk publications and NRCS Range Technical note 40, *Hand-Built Structures for Restoring Degraded Meadows in Sagebrush Rangelands*. Two examples can be found in Table 6 and Appendix A.

Table 4. Objective, techniques, and purpose for headcut control.

Objective	**Headcut Control Technique**	**Purpose**
Headcut Control: Maintain the health of riparian-wetland systems that are at risk of incision by limiting the size and progression of small headcuts (< 3 feet)	**Zuni Bowl**	Halt incision from in-channel headcuts (1.5 – 3 ft tall)
	Rock Run Down	Halt incision from low energy headcuts (<1.5 ft tall) in small catchments and off-channel return sites.

The BLM would typically use headcut control techniques to ensure the success of other restoration efforts located upstream, as well as protect stream segments that contain high resource values (i.e., habitat for sensitive status, candidate, threatened, or endangered species), and/or where the headcuts are still small and easily stabilized. The following two Zeedyk *example structures* are used to dissipate stream power, trap sediment, and encourage the colonization of vegetation to stabilize a stream and improve surface and groundwater interactions.

Zuni Bowl:
The Zuni bowl is a rock-lined, step falls with plunge pools used to dissipate the energy of falling water and stabilize a headcut (Figure A-3, Appendix A). These structures stabilize the progression of a headcut by both stepping down the water in a way that minimizes the erosive and scour potential of falling water, and by protecting and maintaining moisture and vegetation at the pour-over. The BLM would install hand-built Zuni bowls to treat in-channel headcuts. For further information, including the construction guidelines that the BLM would typically follow when implementing this action, see *Range Technical Note No. 40, U.S. Department of Agriculture, Colorado Natural Resource Conservation Service, May 2018; pages 11-12 and Appendix A.*

Rock Run Down:
The BLM would install rock rundown structures to stabilize low energy headcuts in small catchments and off-channel return sites (Fig.7). This would typically involve laying back the headcut by shaping it to a stable angle, and then armoring the slope with rock. For further information, including the Construction Specifications that BLM would follow, see *Range Technical Note No. 40, U.S. Department of Agriculture, Colorado Natural Resource Conservation Service, May 2018; page 13 and Appendix A.*

Install Fish-Friendly Pond Leveler to Control Stage: In situations where beaver are active and causing flooding problems, fish-friendly pond levelers or "beaver deceivers" would be used to control pond stage heights and flooding, while allowing beaver to continue to build their dams and fish to pass through the structure. These installations would be checked regularly during spring runoff and/or periods of intense rainfall and maintained accordingly. The potential for each project to adversely affect fish passage would be evaluated prior to installation and reviewed in coordination with FWP biologists. BMPs to allow sufficient passage would be incorporated into every project. This would include the placement of the leveler pipe in a pool, with the outlet close to the face of the dam, as well as two-slot fishways (Snohomish Pond Leveler). This technique would not be used where adverse impacts to aquatic species would be expected and not easily mitigated. See https://www.beaversolutions.com/get-beaver-control-products/fish-passage-at-beaver-dams/ for more information.

2.1.1 Design Features Specific to the Proposed Action

In addition to features described above, the design features below would be considered for each project and incorporated into project design and implementation where necessary.

1. All applicable State and Federal Permits would be obtained, and all permit conditions would be followed. Any design features included in permits (e.g., timing restrictions) would be adopted and followed.
2. Depending on the action proposed, review of project design and construction oversight would be provided by journey-level agency resource specialists or qualified contractor. Examples of the specialists needed are, hydrologist, riparian specialist, fisheries biologist, wildlife biologist, botanist, or range specialist. An interdisciplinary team is preferable.

3. Journey-level aquatic field or district staff would coordinate the timing of these projects (seasonally) to minimize conflicts with wildlife and complete applicable surveys, if needed for special status species. If warranted, seasonal timing restrictions may be specified in treatment contracts.
4. Site specific BMPs from scientifically available information should be referenced and incorporated into project design, and may come from a field offices' RMP, State, watershed group, or another federal agency, such as the USFS.
5. Archeological, paleontological, and sensitive species surveys must be completed prior to implementation of any project. Results of the surveys would be incorporated into project design to mitigate potential impacts to those resources. Authorizations for site specific projects would be done in accordance with all applicable cultural and paleontological resource laws, regulations, policies, and guidance.
6. Consultation with Native American Tribes would be completed prior to project authorization, when applicable.
7. Where fill is to be placed or removed in riparian or uplands, topsoil would be stripped and stockpiled for subsequent spreading during final reclamation. Stockpiles are anticipated to be relatively small (less than 10 cubic yards) and short term (less than two days) as final reclamation would happen as each site is completed. The following BMPs would also be followed:
    a. Topsoil stockpiles would be kept away from stream channels and concentrated flow paths.
    b. Topsoil from riparian areas would be kept separate from other stockpiles to retain maximum volume and quality.
    c. If topsoil is to be stored for more than 10 days, diversion ditches and or berms would be constructed to divert storm runoff around the piles as necessary to prevent loss of topsoil. If topsoil is to be stored for longer than 30 days, the pile would be seeded with a native seed mix.
8. Where streambanks or streambeds are disturbed to key in a structure, the excavated material would be used as backfill around the structure. Key trenches would be backfilled and graded to match upstream and downstream bank elevations and desired streambed elevations.
9. Design would incorporate scientifically acceptable low tech stream restoration and natural channel design to achieve project objectives, such as natural meander frequencies and/or riffle pool sequences expected given the valley slope and channel type. When available, a reference reach of the same channel type and relative potential would be identified and surveyed to provide an example to guide design.
10. Where woody debris is to be utilized for restoration or enhancement, live trees, dead trees, and/brush would be utilized from the surrounding uplands or riparian area. The cutting of live trees would be limited to conifers or other species that can be sustainably harvested.
    a. Dead or dying trees and existing slash would be targeted for a source of woody debris before taking live trees where available (e.g., slash from previous conifer treatments).
11. Biodegradable erosion control blanket would be used to cover exposed soils, where necessary. Wattles, silt fence, and/or slash would be used to trap sediment or break up concentrated flow paths over exposed soils related to project activities.

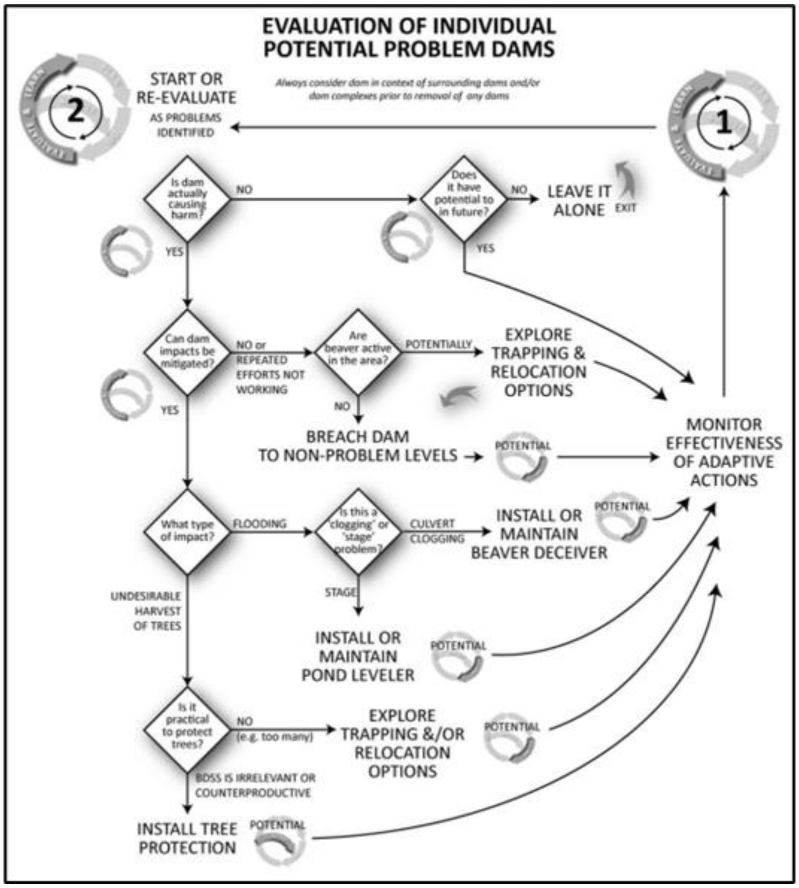
12. Equipment storage, maintenance and re-fueling within 150 feet of flowing water would be prohibited. Equipment, primarily a pneumatic post pounder, would be inspected frequently for leaks and spill contingency materials would be always kept on site.
13. Instream work would take place during periods of low flow and avoid fish spawning areas. Work with wildlife and riparian specialists to consider bird nesting periods to avoid disturbance to nesting birds.
14. For stream restoration actions, disturbance that may cause turbidity and suspended sediment at a given site would be a maximum of 5 contiguous days of activity.
15. Where temporary equipment access trails pass through riparian areas, trails would run on hard alluvium and avoid soft soils. Only the minimum amount of vegetation would be removed for access. If access across soft soils is needed, vegetation mats made of slash or other woody debris would be used to track over to minimize disturbance and create a physical buffer to the resource. Temporary trails would be reclaimed by restoring elevations as needed, spreading seed, and scattering slash over the footprint.
16. Temporary fencing to exclude livestock may be required to allow site stabilization or browse protection following a project. The project proponent would consult with the appropriate BLM Range Specialist during the planning phase of a project to ensure permittee/lessee input or concerns are included prior to project implementation. An interdisciplinary team and other invested parties should discuss livestock grazing management options early in the restoration planning process when the proposed meadow is currently grazed or may be grazed post-restoration.
17. The proposed action will not *injure* valid existing water rights or other property rights that may be associated with existing structures. Specifically, design criteria have been added that require identification and evaluation of potential effects on existing valid water rights and implement projects in a manner that does not injure those rights.
18. Beaver Mitigation Strategies
    To mitigate flooding impacts or damage from undesirable harvest of trees by beaver dam building activity, the BLM would coordinate with watershed partners and/or implement the use of "Beaver Mitigation Strategies" (Table 7), where such techniques are suitable and necessary to mitigate potential flooding impacts or damage from undesirable harvest of trees, while allowing them to remain in place for ecological purposes. Transport of beavers to a different watershed or installation of "beaver deceivers" may be necessary to mitigate flooding impacts on private land. These options are summarized by Castro, Polluck and Jordan, 2017 in The Beaver Restoration Guidebook. Depending on the complexity of the beaver activity and associated habitat, Figure 6 should be followed to evaluate best course of action and mitigation.

Table 5. Beaver mitigation strategies to reduce damage from beavers

Objective	Action	Purpose
Beaver Mitigation Strategies: Mitigate flooding impacts or damage from undesirable harvest of trees, while allowing the beaver to remain	**Re-locate beavers**	Mitigate potential flooding impacts by working with private landowners, CO Parks and Wildlife and interested stakeholders to re-locate beavers to a suitable location
	Install Pond Leveler to Control Stage	Control pond stage heights and flooding, while allowing beaver to continue to build their dams higher and inhabit the area

in place. Balance both the ecological needs of beaver and benefits to public lands users, while protecting public and private property	**Breach inactive beaver dams**	Install a notch (or multiple notches) in the dam to allow water flow. The number of notches depends on the width of the dam.
	Right-Sizing Culverts to Prevent Clogging	Minimize the probability that beaver will clog culverts

Figure 5. Flow chart diagramming monitoring evaluation of potential problem beaver activity



2.2 No Action Alternative (Alternative B)

In Colorado, the BLM implements approximately three aquatic habitat improvement projects annually, which entail riparian vegetation treatments, low tech process-based restoration, natural channel design and stream improvements to address the functionality of diversion structures. Individual projects tend to be very localized and small in scope, and typically address several hundred meters.

Completing an EA for each aquatic habitat restoration project requires assembling an interdisciplinary team, staff time for each EA, and prioritized along with other projects within a District or Field Office. Since much of this work is below the “average high-water mark of a water body, an Army Corps 404 permit would be necessary for each project, and these take significant time and effort by an interdisciplinary team for each individual project. From a statewide perspective, scattered, individual aquatic restoration projects would not be conducted on a geographic or watershed scale.

There's significant interest by non-government organizations to partner with BLM Colorado implementing restoration work on broader landscape or 8-digit HUC scale, such as the upper Colorado River basin. Implementing this work at a broader scale would not be possible without a Statewide programmatic EA, and hamper BLM's ability to expand partnerships and leverage money to improve water quality and aquatic habitat, ameliorate drought, fire, and climate change, as well as improve habitat for species that depend on functioning aquatic habitat, such as Gunnison Sage Grouse. The BLM nationally is moving towards identifying "focal areas" and priority watershed areas to implement restoration. The programmatic EA would allow BLM Colorado to implement restoration goals and objectives set forth by the Administration, DOI and BLM Headquarters.

2.3. Alternatives Considered but Eliminated

There were no additional internally or externally generated alternatives, e.g., using modified stream restoration techniques, or an expanded or limited scope or range of activities to enhance stream restoration.

2.4 Issues

The CEQ Regulations state that environmental assessments (EA)s should "briefly provide sufficient evidence and analysis" for determining whether to prepare an environmental impact statement (EIS) or a finding of no significant impact (FONSI) (40 CFR 1501.5) and that agencies should only briefly discuss issues other than significant ones (40 CFR 1500.4(e)). While many issues may arise during scoping, not all of the issues raised warrant analysis in an EA. Issues will be analyzed if: 1) an analysis of the issue is necessary to make a reasoned choice between alternatives, or 2) if the issue is associated with a significant impact, or where analysis is necessary to determine the significance of the impact. The following sections list the resources considered and the determination as to whether they require additional analysis.

2.4.1 Issues Analyzed

The following issues are analyzed in detail in this EA (Section 3): Riparian, threatened and endangered species, fish habitat, erosion, and water quality. The issue statements are listed below.

Issues by Resource

Resource	Issue Statement
Riparian	How would implementation of the alternative impact riverscape health and the corresponding ecosystem services?
Threatened or Endangered Species	How would implementation of the alternatives affect sensitive status, candidate, threatened, or endangered species that depend on riverscapes to meet their lifecycle needs (start broad, then refine the focus on the species for which it really could be a "significant" issue and/or benefit)?

Fisheries	How would implementation of the alternatives affect fish migration and aquatic habitat?
Soils	How would implementation of the alternatives affect erosion?
Drought, fire, and climate change	How would implementation affect drought, fire, and climate change?

2.4.2 Issues Considered but not Analyzed in Detail

Recreation, cultural resources, special designations, air quality, travel management and wildfire risk were also considered for detailed analysis. However, BLM subject matter experts determined that the proposed action would not result in issues associated with these resources and uses.

3. Affected Environment and Environmental Consequences

3.1 Assumptions for Analysis

Nationwide 404 permits from the Army Corps of Engineers will be required for each project. Currently, the Army Corps has issued permits/authorization for several projects in Colorado. Cultural clearances by field office archeologists will be conducted prior to implementation. Project implementation will increase habitat for threatened and endangered species and be consistent with sage grouse plans. The BLM will coordinate with the State of Colorado Department of Natural Resources Water Resources Division and other interested parties to comply with provisions described in SB 23-270.

3.2 Affected Environment

Background

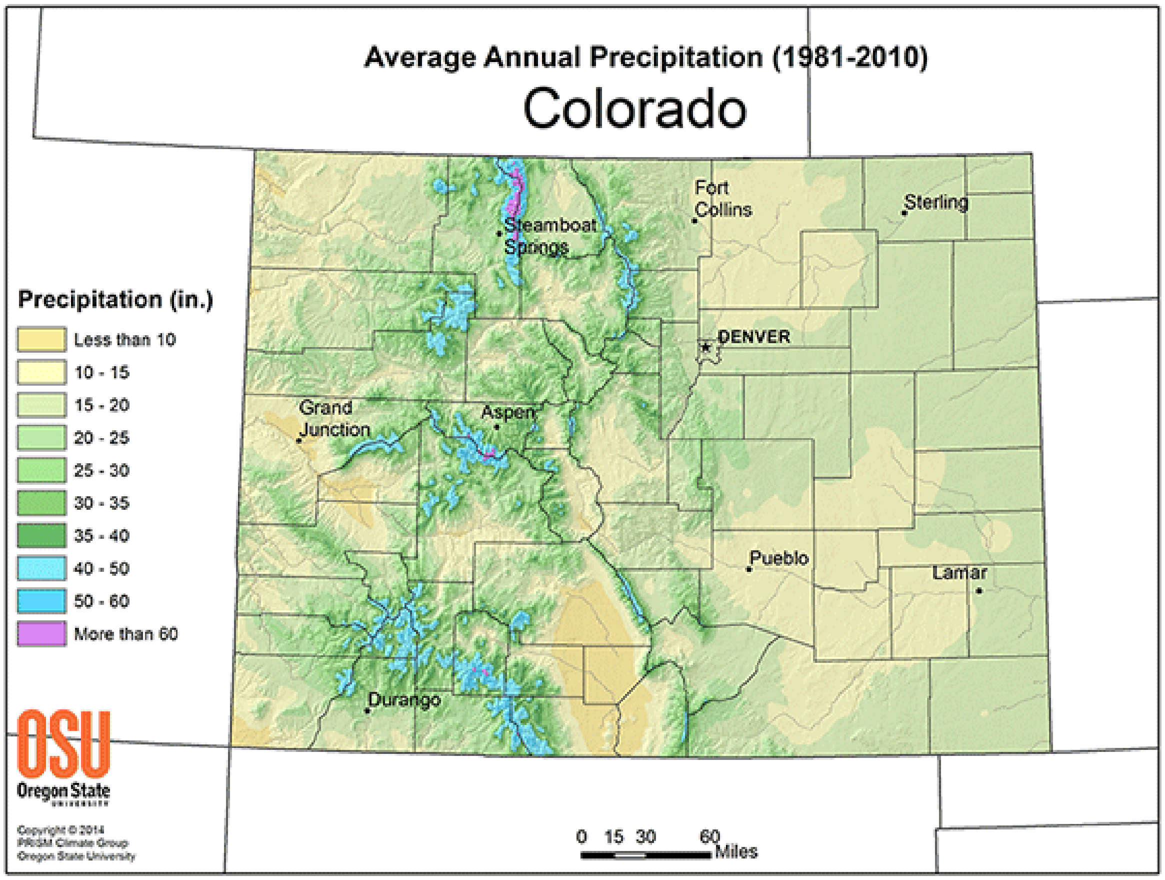
1. General Setting:

Treatments would predominately occur on BLM administered water bodies within Colorado, although treatments may occur on private lands, where a partnership exists, and the Wyden Amendment is invoked. Water bodies include perennial streams, rivers, wetlands, and springs where objectives can be met using low tech process-based restoration. Most restoration work will occur west of the Continental Divide, but some will occur within the Arkansas, North Platte, and South Platte River basins.

2. Topography and Climate:

Colorado's topography has a strong influence on local and regional climate. The Rocky Mountains in Colorado have 59 mountains exceeding 14,000 feet and 830 mountains between 11,000-14,000 feet. Colorado has a continental, semi-arid climate, that experiences large temperature and precipitation variation. The average annual precipitation is approximately 17 inches. There is a large range in the average annual precipitation across the state due to topographic features. For example, the San Luis Valley and parts of south-central Colorado receive an average of less than 7 inches of precipitation each year, while many mountainous regions receive 25-40” climbing to a maximum of near 60 inches per year just east of Steamboat Springs in north central Colorado. Precipitation falls in various forms (rain, snow, hail, etc.) and the amount varies seasonally, annually and by location (Figure 7).

Figure 6. Average Annual Precipitation in Colorado.



3. Stream and River Morphology

Colorado is a headwater state. All rivers in Colorado rise within its borders and flow out of the State, except for the Green River, which flows diagonally across the extreme northwestern corner of the State. Four of the Nation's major rivers have their source in Colorado: the Colorado, the Rio Grande, the Arkansas, and the Platte. The BLM manages approximately 2,700 miles of perennial streams, 19,000 acres of wetland/lentic habitat, 70 miles of Colorado Cutthroat Trout habitat, and 4,300 miles of riparian habitat.

Restoration activities will focus on perennial streams where beaver activity occurred historically or where improvements may entice beaver colonization. Work may also occur in fish bearing streams, as well as Sage Grouse habitat. The primary focus areas are streams with lower gradients, because these reaches tend to have wider valley bottoms and a more defined floodplain that facilitate greater spatial extent of backwaters, organic matter retention, sediment deposition, dissolved materials deposition, and habitat for a variety of species. These stream reaches typically exhibit slopes $\leq$ 0.05 m/m, although this will vary widely between watersheds, especially in western Colorado (Wohl, Scott and Yochum 2019). Table 8 shows BLM perennial streams by slope category and may be useful as a screening tool in determining treatment watersheds, or potential channel classification of a stream reach. Moreover, Table 8 shows miles of perennial streams by slope category for each Field Office, National Conservation Area, and

National Monument, with approximately 15% of the perennial stream miles on less than 4% slope. A statewide GIS layer file was also created to more effectively “drill-down” into stream slope categories in specific watersheds using ArcMap **(**Appendix A). Other layers may be added in ArcMap to describe watershed and channel characteristics more adequately. Appendix B contains additional background information on streams and river morphology. In addition to slope, factors considered in determining restoration potential are the degree of incision, the supply, character and transport of sediment, flow, valley confinement, bankfull width, and position of a waterbody within a stream evolution model, such as those proposed by Cluer and Thorne, Polluck (2014) and others. Other considerations include historical photos, GIS layers, areas of BLM where the fundamentals of land health are not meeting standards, Riparian/Wetland and Lotic AIM data, as well as the experience and knowledge of contractors, Field and District Office staff, and local stakeholders.

Table 6. Stream slope categories for BLM Colorado streams.

OFC_NAME	Stream Slope (<2%)	Stream Slope (2-4%)	Stream Slope (4-10%)	Stream Slope (>10%)
Browns Canyon National Monument	0.26	0.43	2.59	6.49
Canyons of the Ancients National Monument	6.09	5.07	7.61	9.77
Colorado River Valley Field Office	7.93	9.39	40.01	231.23
Dominguez/Escalante National Conservation Area - Grand Ju	5.94	5.69	12.86	21.85
Dominguez/Escalante National Conservation Area - Uncomp	3.58	4.49	8.36	34.70
Grand Junction Field Office	21.85	20.97	45.66	114.69
Gunnison Field Office	12.53	20.12	70.31	378.69
Gunnison Gorge National Conservation Area	3.43	2.38	4.89	19.01
Kremmling Field Office	12.86	16.96	45.53	113.38
Little Snake Field Office	31.22	32.89	57.88	76.49
McInnis Canyons National Conservation Area	6.35	5.39	7.08	7.15
Royal Gorge Field Office	19.22	21.51	62.34	193.23
San Luis Valley Field Office	13.68	11.70	27.19	41.21
Tres Rios Field Office	9.88	8.24	17.06	60.01
Uncompahgre Field Office	17.24	22.01	59.57	227.13
White River Field Office	19.12	21.16	52.19	126.48

4. Water Rights and Instream Flows

In Colorado, water is considered a public resource. A water right is a limited right to use a portion of the state’s water resources. Colorado water law is based upon the doctrine of prior appropriation, often stated as "first in time, first in right." All water that is part of a natural surface stream, including tributary groundwater, is subject to appropriation. The appropriator must have a plan to divert, store, or otherwise capture, possess, and control the water for a beneficial use. Priority is established by the order in which a user first puts water to a beneficial use, or the “date on which the appropriation was initiated if the appropriation was completed with reasonable diligence.” Please see Appendix B for additional information.

Status of Resources by Issue

Sediment and Erosion

Since much of the restoration work will occur on the floodplain and lotic waterbodies, short episodic pulses of sediment will be delivered downstream during construction but will subside once a structure is completed. Manual labor and hand tools will be utilized predominately to install structures, while an excavator may be utilized where stream conditions, access, and size of material necessitates its use. Native woody material from the floodplain and uplands, as well as large cobble and boulder – sized substrate will be utilized to create instream structures.

The State of Colorado has a narrative sediment standard for complying with the Clean Water Act, referred to as Policy 98-1 (Regulation 31, Section 31.11(1)(a)(i)). Policy 98-1 provides guidance in implementing the narrative standard for bottom deposits in all state surface waters (except wetlands). Different methods and thresholds are appropriate for different geographic settings and different beneficial uses. Only human-caused discharges of sediment in amounts, concentrations, or combinations which can settle to form bottom deposits detrimental to beneficial uses are considered in this guidance. There are 3 central components to Policy 98-1; beneficial uses vs classified uses, expected condition as a concept, and a general framework for attainment decisions. Moreover, the Water Quality Control Commission (WQCC) supports the notion of comparing the actual condition vs the expected condition, and that impairment occurs when there's a significant departure from expected condition.

To increase the value of the sediment assessment tool in Policy 98-1, the state was divided or stratified into regions with similar erosion/deposition rates. Approximately half of the state has been included in Sediment Regions 1, 2, and 3 (**Appendix B**). This represents the limits of the existing data and reference sites which formed the basis for assessment tool development. As more data are collected, this approach may be extended, and more Sediment Regions established. Table 9 shows the numeric criteria for lotic waterbodies within each region.

Table 7. Numeric thresholds for sediment <2mm by Sediment Region

Threshold for Percent Fines (<2 mm)	
Sediment Region 1	27.5%
Sediment Region 2	29.3%
Sediment Region 3	41.0%

As part of the assessment process, CDPHE uses biological indicators to help determine impairment by identifying sediment tolerance indicator values (Table 10). Sediment Tolerance Indicator Values (TIV_{SED}) for macroinvertebrates were developed as the biological indicator of impacts by excess fine sediments. The TIVSED reflects both the reduction in relative abundance of sediment-sensitive taxa and the increase in relative abundance of sediment-tolerant taxa. The method for calculating TIV_{SED} was developed using recommended methods from the National Water Quality Assessment Program (Carlisle et al. 2007). The calculated TIV_{SED} score from the site should be compared to the threshold for the Sediment Region. If the TIV_{SED} score from the site is below the threshold, the site is attaining the narrative standard (even if the sediment threshold is exceeded). If both the measured percent fines and the TIV_{SED} score for a site are above the thresholds, then the next step is to complete a watershed review. More detailed information on Policy 98-1 and the assessment tools can be found here.

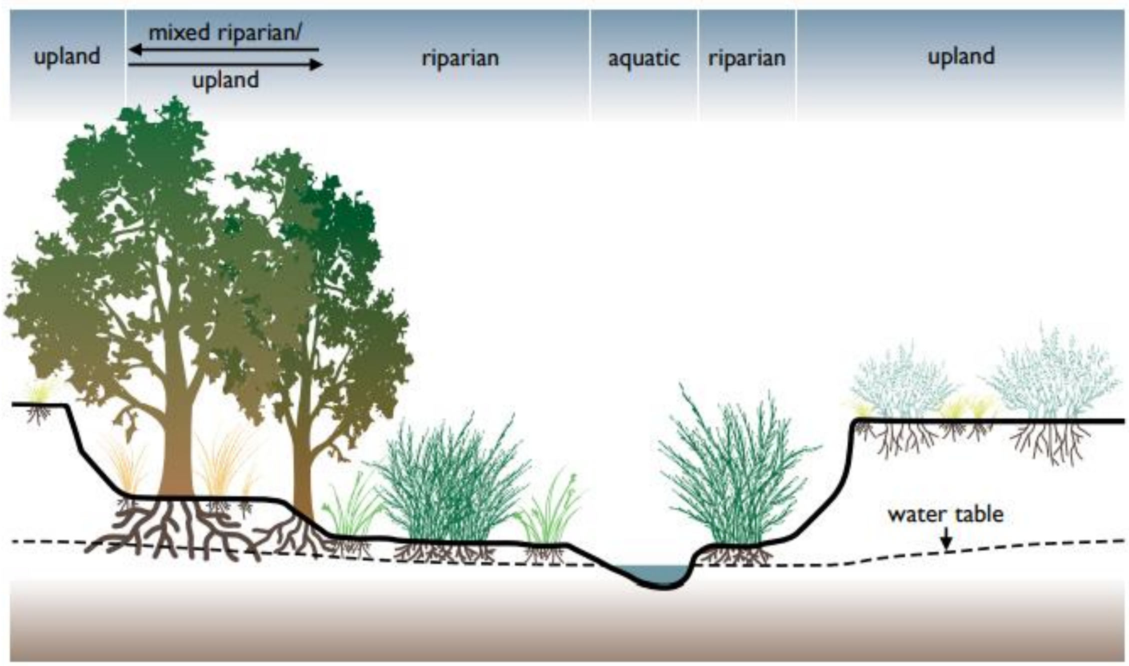
Table 8. Numeric thresholds for biological indicators

Threshold for TIV_{SED}	
Sediment Region 1	6.1
Sediment Region 2	7.0
Sediment Region 3	6.3

There are several sediment impairments on BLM administered lands that are listed on the State's 303(d) list, as well as the Monitoring and Evaluation list, where sediment impairments are suspected. Where a sediment listing occurs within a BLM stream segment or immediately downstream of the restoration, BLM would implement best management practices as well as design features to minimize sediment delivery downstream. The objective of the structures (long-term) is to minimize sediment deposition and increase habitat for aquatic life. Monitoring of the structures and stream morphology will occur to inform adaptive management strategies, where applicable. Aquatic, Riparian and Wetland Assessment, Inventory and Monitoring (AIM) sites will be established, also.

Riparian:
A riparian area is the transition between the aquatic area and adjacent upland areas (see example in Figure 8). These areas exhibit vegetation or physical characteristics reflective of permanent surface- or subsurface-water influence. A riparian area is the transition from the aquatic area to the upland area. Vegetation is expected to change from species adapted to wetter sites near the channel to species adapted to drier sites in the upland, with a mixture of species occurring in between. In this example, an assessment of riparian function would consider the riparian areas, mixed riparian/upland areas, and aquatic area in the reach. Not all riparian areas have all of these features.

Figure 7. Upland, riparian, and aquatic zones (courtesy BLM Tech Ref. 1737-15).



Aquatic habitat restoration through the installation of BDAs, PALS, Zeedyk and other structures is intended to dissipate stream energy during high flows, capture sediment, spread water across the floodplain, aid in floodplain development and connectivity with the channel, improve hyporheic exchanges, as well as improve resiliency, and interactions between the stream channel, floodplain and riparian zone. For riparian areas to function properly in various stream types, there must be certain vegetation attributes and processes occurring. Factors such as type, proportion and amount (cover and density) of vegetation are necessary for maintaining streambanks, cover for fish, shade, hyporheic exchanges, moderation of flooding, detritus, nutrient cycling, and a source of large wood for functioning aquatic habitat.

Threatened and Endangered Species
Colorado has several Threatened and Endangered species (TES) will likely benefit from low tech process-based restoration of aquatic habitat, such as Greater and Gunnison sage grouse, Southwestern willow flycatcher, Colorado Pikeminnow, bonytail chub, greenback cutthroat trout, and razorback sucker.

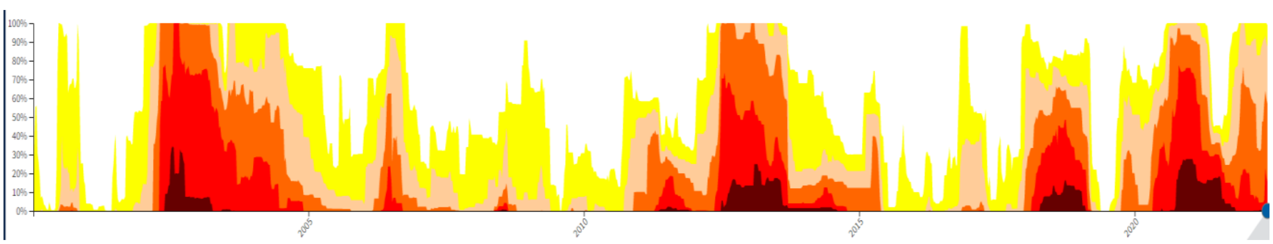
Projects are likely to increase water surface area across the floodplain and attenuate flood impacts. Streams and riparian areas provide cover, water, food, and brood rearing habitat for these species.

<u>Fish Habitat</u>
It is likely that projects will involve the installation of structures along fish bearing reaches, although the percentage of work on fish bearing vs. non fish bearing reaches is not known. Structures implemented on perennial fish bearing streams will likely improve habitat and not impair upstream or downstream migration of fish. Habitat for TES of fish will be improved; and increase fish populations and survival. Structures will likely create pool habitat, temperature variations, water storage and increased release of water during base flow periods, as well as side channels important for fish rearing and holding and not be a barrier to fish migration. The structures are expected to trap sediment or moderate its delivery downstream, which could potentially reduce sediment covering spawning gravels.

<u>Erosion</u>
Erosion and sediment delivery naturally occurs within a stream channel, and the degree of erosion that occurs depends on channel type, bankfull or greater flows, size and type of sediment produced by the upstream watershed, channel stability, and vagaries of nature that deposit a boulder and/or large wood in channel. The objective(s) of projects are likely muti-faceted and will likely address erosion and sediment in areas where there's excessive channel incision, headcuts, bank sloughing, lack of instream structure, or where a channel does not access the floodplain.

<u>Drought, Fire and Climate Change</u>
Drought, fire and climate change affect Colorado landscapes costing millions to address annually. The magnitude and severity of drought appears to be more pervasive in Colorado since 2000 (see Figure 9). Darker shading indicates more severe drought, with maroon color being "exceptional drought" and worst category. Drought can be a contributing factor to fire.

Figure 8. Drought severity between 2000-present.



The timing, intensity, and frequency of drought events have divergent impacts on fuel ignition and fire behavior. Rapidly drying abundant fuels, due to prolonged heat and wind, in forest understories, shrubs and grasslands after a wet spring can feed larger fires. Prolonged drought can limit fire occurrence as the availability of fuels (e.g., grasses) is reduced due to lack of precipitation. Soil moisture content is affected by drought, which can affect vegetative growth, fire intensity, and spread.

Colorado's climate has warmed over the last 50 years and future climate modeling indicates the climate is expected to warm 1.5-5 degrees Fahrenheit by 2050. With increasing temperatures, shifts in snowmelt runoff and timing, water quality and quantity concerns, stressed ecosystems and extreme weather events are expected to continue. A history of Colorado climate and water availability studies can be found on the *350Colorado* and *CWCB sites*.

3.3 Environmental Effects

3.3.1 Effects of Alternative A (Proposed Action)

Beneficial impacts to riparian and fish habitat, protection from erosion, and a reduction of impacts from drought, fire, and climate change are expected as projects are implemented in priority watersheds on BLM administered lands in Colorado. Short term localized and minor increases to erosion and sediment during construction are expected to not affect downstream beneficial uses of water or lands. Implemented projects are expected to significantly reduce erosion and sediment delivery downstream, as well as improve attributes of ecosystem health, resiliency to fire and drought, floodplain connectivity, beaver and aquatic habitat.

Riparian

Increased connectivity to the floodplain is expected to increase vegetation re-growth and vigor with increased water availability, storage, and water surface area from ever-changing snowmelt and rain runoff timing and magnitude. Many streams are devoid of structure, which has exacerbated instream erosion, stream channel incision, excessive aggradation in areas, loss of riparian vegetation, and streamside shade. Structures are likely to attenuate peak flows, improve hyporheic flow, moderate sedimentation, improve fish and wildlife habitat, water quality, improved resilience to drought and wildfire. These beneficial impacts are likely to maintain or improve riparian habitat. It is expected that late season downstream (from the project area) flows will be increased, which will likely maintain or improve riparian vegetation and habitat. BLM and partners hope to document these improvements through pre- and post-project monitoring. Stream temperature is a concern within many watersheds in Colorado. Restoring the native riparian vegetation community will help decrease water temperatures as well as overbank cover that's important to fish, amphibians, and other aquatic species. Riparian plantings may occur in areas devoid of riparian vegetation or increased root masses are necessary to further stabilize a streambank. Only native seed and/or cuttings will be used.

Threatened and Endangered Species

Beneficial impacts to TES are expected where projects are implemented in areas where they exist. Projects are likely to increase water surface area across the floodplain and attenuate flood impacts. Streams and riparian areas provide cover, shade, water, food, and brood rearing habitat for these species. No habitat loss will occur.

Fish Habitat

Most of the data and literature on the positive and negative effects to fish is in the Pacific Northwest and salmonids. There has been extensive research on both the positive and negative effects of beaver modifications on fish species. Kemp et al. (2012) thoroughly reviewed the primary literature on this topic, focusing on North America, and completed a meta-analysis. They reported the most cited positive and negative impacts to fish as shown in Table 11.

Table 9. Potential Impacts of Beaver Modifications on Fish Species

Beneficial Impacts	**Potential Negative Impacts**
Improved production of invertebrates	Altered temperature regime
Enhanced growth rates Providing flow refuge	Low oxygen levels in beaver ponds
Increased rearing and overwintering habitat	Siltation of spawning habitat

Increased habitat and habitat heterogeneity (which promotes biodiversity) (Smith and Mather 2013))	Barriers to fish movement
Increased fish productivity/abundance	

Kemp et al. noted that many of the positive effects cited (51.5 percent) were supported by data, while many more of the negative impacts (71.4 percent) were speculative and not supported by data collected in the field. Furthermore, the most cited negative impact of beaver dams—as barriers to fish movement—was highly speculative, as 78.4 percent of the studies did not support this claim with data. The authors report that 49 North American and European experts consider beaver to have an overall positive impact on fish populations, through their influence on abundance and productivity. During summer, beaver ponds are important rearing grounds for juvenile coho salmon (Leidholt-Bruner et al. 1992).

In addition to summer rearing grounds is the use of beaver ponds and slow-water habitat as overwintering grounds. Pollock et al. (2004) found that in the Stillaguamish River basin in Washington, the decline in beaver populations and subsequent loss of their dams resulted in a 61 percent reduction of summer coho habitat capacity and an 86 percent reduction in overwintering capacity. The authors conclude that the production bottleneck of coho salmon in this watershed was from a lack of overwintering habitat and that increasing beaver populations could be a simple and effective means of mitigating this loss of productivity.

Pollock et al. (unpublished data) found that juvenile steelhead in eastern Oregon had higher densities and survival rates in beaver ponds than did juveniles in similar reaches without dams. In the Sacramento River system of California, juvenile Chinook show more growth and higher survival in floodplain habitats than do fish in mainstem habitats (Sommer et al. 2001, Sommer et al. 2005).

The BDAs and PALS installed are not likely to be a barrier to fish migration or movement, due to their high porosity and concomitant flow through the structures. It's possible there could be altered thermal regime because of slower ponded water potentially retaining heat, versus faster water found in riffles or runs. This may be offset by improved by stream and floodplain interactions, as well as cooler hyporheic flow to the stream channel. The possibility and risk of silting in spawning areas appears very low. The structures interact with the bankfull stage at its highest elevation and are designed to pass most flow and sediment to downstream areas. An interdisciplinary team that includes a fisheries biologist will assess potential localized affects to fish and amphibian habitat.

<u>Erosion</u>

Sediment is the primary pollutant of concern while structures are being built, primarily due to instream erosion causing sediment to be dislodged from the stream bed and banks. Very short term and minor increases in turbidity and suspended sediment are expected to occur while the structures are being built, and then return to pre-disturbance levels within several hours, depending on stream type. The sediment produced during construction of structures or channel re-location is expected to be within the range of natural variability of sediment produced by the range of flows and sediment produced by the upstream watershed. Moreover, it's expected that completed structures will store significantly more sediment than is routed downstream during construction activities. Projects are likely to significantly reduce erosion shortly after construction and over the long-term, where structures are still interacting with the stream channel. Erosion is likely to be further reduced where beaver re-colonize back into project areas. Any dislodging or movement of benthic macroinvertebrates is expected to be negligible, as well as impacts to fish and aquatic life downstream, due to short-term localized work. No net increase in road density would occur.

Drought, Fire and Climate Change

Implementing aquatic habitat restoration, and project goals and objectives would improve resiliency against drought, fire, and climate change. Structures that cause flowing water to pond and spread water across a valley (channels) gives beavers the unique potential to attenuate environmental extremes such as flood and drought (Hood and Bayley 2008, Pilliod et al. 2017, Fairfax and Small 2018, Westbrook et al. 2020). Vegetation near beaver ponds does not experience as much reduced water availability, because vegetation is greener and lusher than other drought-stricken areas. One could conclude that vegetation around beaver ponds is less likely to burn. Research conducted by Fairfax and Whittle (2020) concludes that beaver dams play a significant role in protecting riparian vegetation during wildfires and is consistently observable across western landscapes under varying burn severities. Their data suggest that beaver dammed riparian areas are moist and less likely to burn, as well as providing refugia for fish, amphibians, reptiles, small mammals, wild and domestic ungulates, and birds that are unable to escape a fire.

3.3.2 Effects of Alternative B (No Action Alternative)

In Colorado, the BLM implements approximately three aquatic habitat improvement projects annually. This would probably continue without the programmatic EA. The continuation of this program of work would result in fewer short-term adverse impacts and fewer lotic and lentic habitat improvement projects compared to the proposed action. Completing an EA for each aquatic habitat restoration project requires assembling an interdisciplinary team, staff time for each EA, and prioritized along with other projects within a District or FO. From a statewide perspective, scattered, individual aquatic restoration projects may not be conducted on a watershed scale, or consider other ancillary factors.

Riparian

If there is no action, relatively few stream restoration projects would occur, and these would be on a limited case-by-case basis. Traditional restoration approaches are often intensive and costly, and applying more cost-effective, scalable restoration approaches to address these challenges is needed, especially with funding being a major concern. The trends of less functional connection of streams and floodplain, increased erosion, poorer surface and groundwater interactions, degraded nutrient cycling, and reduction in baseflow would continue to a greater extent compared to the proposed action. As a result, lotic and lentic systems on BLM lands would be increasingly vulnerable to disturbances such as droughts, floods, and fires.

Threatened and Endangered Species

If the no action alternative is taken, habitat degradation for threatened and endangered species would continue and the amount of damaged habitat would increase. In addition, there would be less water surface on floodplains, and greater overall floodplain impacts.

Fish Habitat

Under the no action alternative, the temperature regime of streams would be altered (e.g., warmer waters during the summer), there would be lower oxygen levels in beaver ponds, increased siltation of fish spawning habitat, there would be more barriers to fish movement.

Erosion

Erosion would increase if the no action alternative were selected. Flooding would be more frequent and sever, there would be increased bankside and soil loss, and damage to riparian vegetation.

Drought, Fire and Climate Change

There would be fewer habitat restoration projects with the no action alternative, and structures that result in ponding and channeling (such as real or simulated beaver dams) would have greener vegetation that is less likely to burn in a wildfire. With fewer ponding structures the impacts of fires would be worse and there would be a greater loss of green vegetation and subsequent increases in erosion. Such ponding areas also provide refugia in the event of a fire, so wildlife mortality from fires could be higher under the no action alternative.

3.3.3. Other Past and Present Disturbances

Impacts from past and present disturbances include the construction of roads, fires, dispersed recreation, grazing, and other multiple uses occurring on BLM lands. Past and present actions continue to contribute sediment to stream channels, where there's a nexus between a road and stream. Each Field Office's Resource Management Plan and NEPA guide multiple use decisions on BLM lands.

Design features, conditions of approval, and Best Management Practices (BMPs) associated with federally regulated projects would reduce impacts to floodplains by minimizing erosion and surface runoff to lotic waterbodies.

The proposed action to construct wood and rock structures in the stream channel would disturb approximately 5 miles of floodplains annually, which represents less than 1 percent of the perennial streams and rivers on BLM lands. This comprises a small addition to the past, present, and reasonably foreseeable disturbance in the short-term. Long term beneficial impacts of this restoration will likely reduce sediment, increase surface and groundwater interactions, hyporheic flow, increased channel length and aquatic habitat, floodplain connectivity, and reduced erosion from headcuts or downcutting.

4. Supporting Information

4.1 List of Preparers and Reviewers

Name	Title	Area of Responsibility
Ed Rumbold	Hydrologist	Water, riparian, fish and aquatic resources, (soils)
Roger Sayre	Planning & Environmental Coordinator	NEPA compliance
Tom Fresques	Fisheries Biologist	Fisheries and fish habitat
Robin Sell	Wildlife Biologist	T&E species
Natalie Clark	Cultural Resources Specialist	Cultural resources
Roy Smith	Water Rights Specialist	Water resources
Gwenan Poirier	Fire Specialist	Fire management
James Miller	Physical Scientist	Climate change and drought

4.2 Tribes, Individuals, Organizations, or Agencies Consulted

Tribal Section 106 Consultation

The BLM initiated review for cultural resources impacts for actions described this EA through a letter sent to 39 tribes in 10 western and southwestern states.

Government-to-Government consultation will continue as projects and actions described in this EA implemented to ensure that tribal groups' concerns are considered and addressed.

The Final EA will be provided to the tribes concurrently with its release to the public.

Colorado State Historic Preservation Officer Consultation

Cultural resource consultation with the Colorado State Historic Preservation Officer (SHPO) was completed through an informational letter signed June 6, 2023. The letter notified the SHPO of the proposed project scoping period and clarified that this programmatic NEPA process is a nondestructive planning activity that will not restrict the subsequent consideration of alternatives to avoid, minimize, or mitigate the undertaking's adverse effects on historic properties (36 CFR 800.1(c)). When implementation level projects are proposed under this programmatic EA, BLM will undergo the full Section 106 process.

The EA and FONSI will be provided to the SHPO concurrently with their release to the public.

Endangered Species Act Section 7 Consultation

To comply with Section 7(c) of the Endangered Species Act (ESA), at the Field Office level the BLM will consult the US Fish and Wildlife Service (USFWS) during the planning for any specific projects. Impacts to threatened and endangered species are expected to minimal, since designated critical habitats would be avoided and the Proposed Action contains several design features that would reduce impacts to special status species.

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Appendix A

Principles and Practices of Low-Tech process-based restoration and natural channel design

10 Guiding Principles; including Riverscape and Restoration principles (Utah State University Restoration Consortium 2019).

Riverscape Principles – would inform planning and design through an understanding of what constitutes healthy, functioning riverscapes and therefore what are appropriate targets and analogues to aim for. They include:

1. Streams need space. Healthy streams are dynamic, regularly shifting position within their valley bottom, re-working and interacting with their floodplain. Allowing streams to adjust within their valley bottom is essential for maintaining functioning riverscapes.

2. Structure forces complexity and builds resilience. Structural elements, such as beaver dams and large woody debris, force changes in flow patterns that produce physically diverse habitats. Physically diverse habitats are more resilient to disturbances than simplified, homogeneous habitats.

3. The importance of structure varies. The relative importance and abundance of structural elements varies based on reach type, valley setting, flow regime and watershed context. Recognizing stream type and comparing it to a reference condition helps with proper design and location decisions.

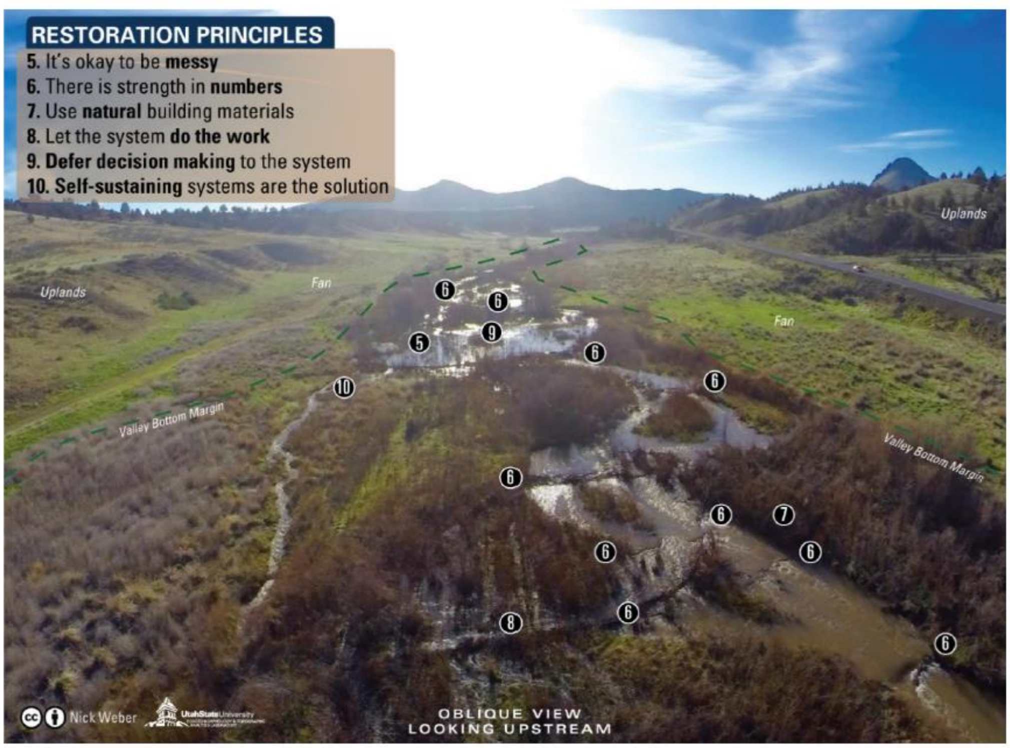
4. Inefficient conveyance of water is often healthy; whereby water is slowed and spread across the floodplain. More diverse residence times for water can attenuate potentially damaging floods, fill up valley bottom sponges, and slowly release that water later elevating baseflow and producing critical ecosystem services.

Restoration Principles – Restoration Principles relate to our specific restoration actions and give us clues as to how to develop designs to promote processes that lead to recovery and resilience. The low-tech Restoration Principles elaborated below and illustrated in Figure A-1 help place our restoration actions in the right context to maximize our effectiveness in promoting better riverscape health.

5. *It's okay to be messy*. Structure added back to streams is meant to mimic and promote the processes of wood accumulation and beaver dam activity. Structures should resemble natural structures (log jams, beaver dams, fallen trees) in naturally 'messy' systems. Structures do not have to be perfectly built to yield desirable outcomes but should focus on areas that improve aquatic/beaver habitat and improve stream, hyporheic flow and floodplain interactions.
6. *There is strength in numbers*. Many smaller structures working in concert with each other can achieve much more than a few isolated, over-built, highly secured structures. Using a lot of smaller structures provides redundancy and reduces the importance of any one structure. It generally takes many structures, designed in a complex (see Chapter 5: Shahverdian et al., 2019c), to promote the processes of wood accumulation and beaver dam activity for the desired outcomes. Structures may also fail over time and multiple structures are needed.

7. *Use natural building materials*. Natural materials should be used because structures are simply intended to initiate process recovery and degrade over time. Locally sourced materials are preferable because they simplify logistics and keep costs down. Structure failures may occur over time; however, they provide roughness to the floodplain, deposit with other debris, and may attenuate peak flows.
8. *Let the system do the work.* Giving the riverscape and/or beaver the tools (structure) to promote natural processes to heal itself with stream power and ecosystem engineering, it promotes efficiency that allows restoration to scale to the scope of degradation.
9. *Defer decision making to the system*. Wherever possible, let the system make critical design decisions by simply providing the tools and space it needs to adjust. Deferring decision making to the system downplays the significance of uncertainty due to limited knowledge. For example, choosing a floodplain elevation to grade based on limited hydrology information can be a complex and uncertain endeavor, but deferring to the hydrology of that system to build its own floodplain grade reduces the importance of uncertainty due to limited knowledge.
10. *Self-sustaining systems are the solution*. Low-tech restoration actions in and of themselves are not the solution. Rather they are just intended to initiate processes and nudge the system towards the goal of building a resilient, self-sustaining riverscape.

Figure A-1: Example of a healthy riverscape and the corresponding Restoration Principles that are incorporated into the Proposed Action (Courtesy of Nick Weber and Utah State University, 2019).



1. Use natural building materials. Natural materials adjacent to the site(s) will be used to accomplish aquatic habitat restoration goals and objectives. Locally sourced materials are preferable because

they simplify logistics and keep costs down. Moreover, the risk of damaging downstream habitat, private property, or structures is expected to be very low.

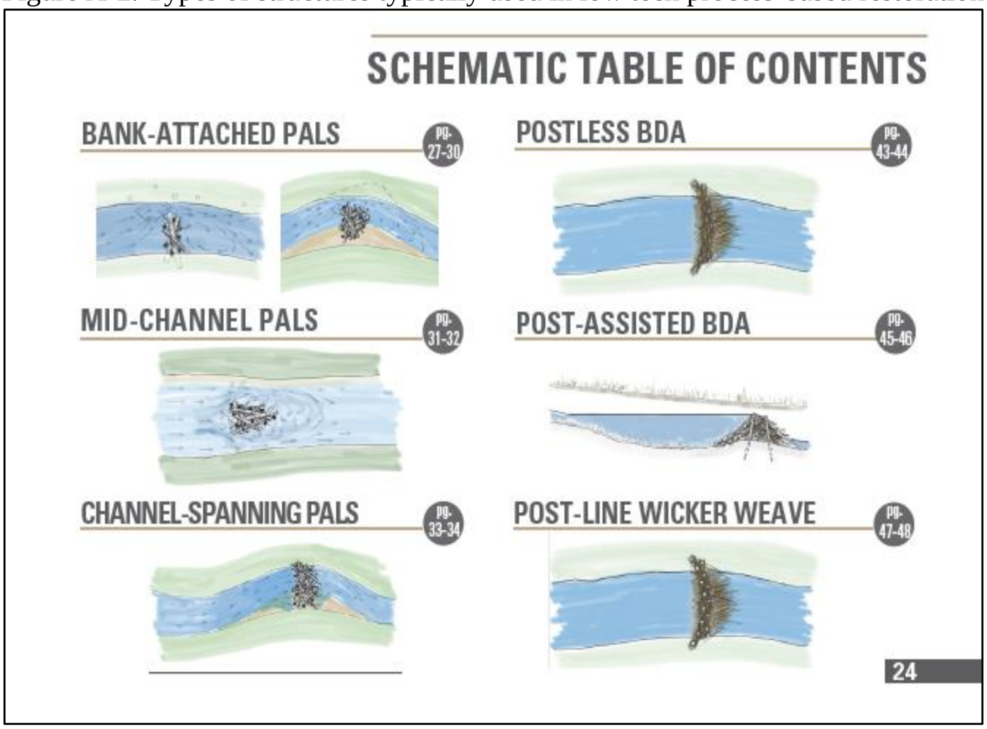
2. Let the system do the work. Giving the riverscape and/or beaver the tools (structure) to promote natural processes to heal itself with stream power and ecosystem engineering, as opposed to diesel power, promotes efficiency that allows restoration to scale to the scope of degradation.

3. Defer decision making to the system. Wherever possible, let the system make critical design decisions by simply providing the tools and space it needs to adjust. Deferring decision making to the system downplays the significance of uncertainty due to limited knowledge. For example, choosing a floodplain elevation based on limited hydrology information can be a complex and uncertain endeavor, but deferring to the hydrology of that system to build its own floodplain grade reduces the importance of uncertainty due to limited knowledge.

4. Self-sustaining systems are the solution. Low-tech restoration actions in and of themselves are not the solution. Rather they are just intended to initiate processes and nudge the system towards the goal of building a resilient, self-sustaining riverscape.

Figure A-2 below shows a schematic of different types of BDAs and PALS (Page 24 in the Low-Tech Process-Based Restoration of Riverscapes, Utah State University Restoration Consortium, 2019).

Figure A-2. Types of structures typically used in low tech process-based restoration.

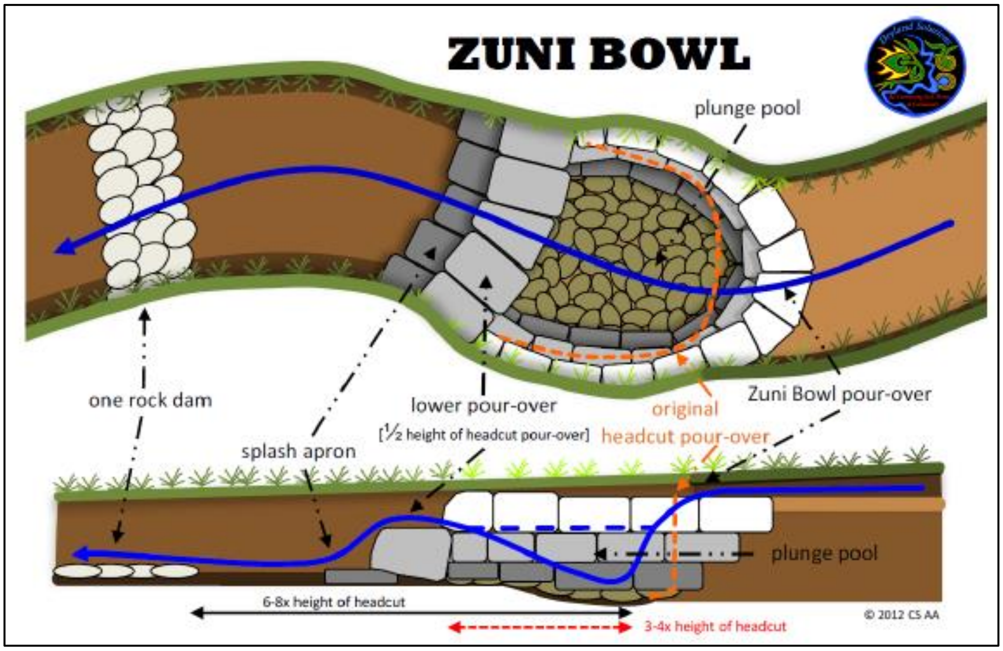


Zeedyk Structures:

Zuni Bowl:

The Zuni bowl is a rock-lined, step falls with plunge pools used to dissipate the energy of falling water and stabilize a headcut (Figure A-3). These structures stabilize the progression of a headcut by both stepping down the water in a way that minimizes the erosive and scour potential of falling water, and by protecting and maintaining moisture and vegetation at the pour-over.

Figure A-3. Zeedyk Zuni bowl.



Key Design Features:

- Top rocks of the headcut pour-over would match the existing elevation so that water freely flows over the structure (Fig. 7). Trim the headcut back to expose live roots as the maintenance of healthy vegetation at this spot is key to stopping the progression of the headcut.
- When building the back wall up the face of the headcut, the BLM would offset the layers of rock for stability and lean them back to form a sloping wall around the headcut instead of trying to build a vertical wall.
- Armor the plunge pool with tightly placed rock of sufficient size to avoid scouring.
- Construct a one rock dam or BDA downstream of the Zuni bowl to create another pool. Place the upstream edge of the ORD 4-6 times the height of the headcut away from the bottom of the Zuni bowl.

Rock Run Down:

The BLM would install rock rundown structures to stabilize low energy headcuts (< 1.5 ft tall) in small catchments and off-channel return sites (Figure A-4). This would typically involve laying back the headcut by shaping it to a stable angle (~3:1 slope), and then armoring the slope with rock.

Figure A-4. The center of a rock rundown should be the lowest, so water runs down the middle and not around the structure. Photo by: Nathan Seward

Key Design Features:

- Emplace rocks at the pour-over lip are at the same elevation of the headcut, so that water flows freely over it. Trim the headcut back until live plant material and roots are exposed.
- The center of the rundown should be the lowest, so water runs down the middle and not around the structure.
- Install rocks tightly to reduce gaps between rocks.

Figures A-5 and A-6. Example of Rosgen structures courtesy of Dave Rosgen:

Figure A-6. Cross vane grade control structure

Figure A-5. "J" hook grade control structure

Figures A-7 and A-8. Adding a rifle to improve aquatic habitat by Robert Newbury (Newbury Hydraulics, Ltd)

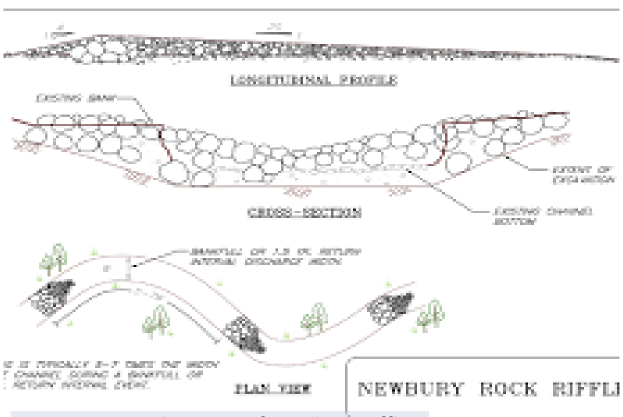


Figure A-7. Schematic of Newbury riffle

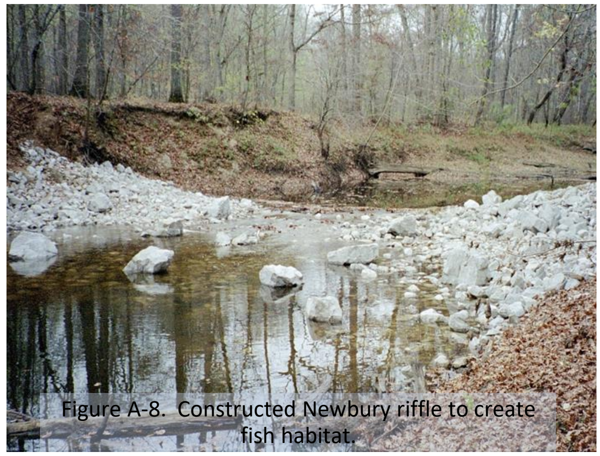


Figure A-8. Constructed Newbury riffle to create fish habitat.

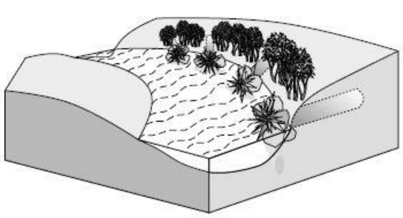
NRCS - Part 654 Stream Restoration Design National Engineering Handbook and NEH 653

The following figures are additional examples of stream and aquatic habitat restoration found in Stream Corridor Restoration; principles, processes and practices (NEH 653). This list is by no means extensive, but merely offers a few examples to consider. These publications should be reviewed for proper design, location, placement, timing, and fluvial geomorphology.

The US Army Corps of Engineers also produces stream restoration guidance, such as the Hydraulic Design of Stream Restoration Projects. This is a great reference for a systematic approach that involves developing an objective, proper design, analysis and monitoring.

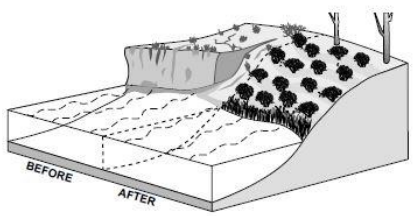
Figures A-9 and A-10. Revetments and bank shaping techniques.

Log, Rootwad, and Boulder Revetments



Boulders and logs with root masses attached placed in and on streambanks to provide streambank erosion, trap sediment, and improve habitat diversity.

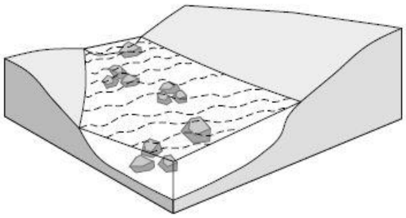
Bank Shaping and Planting



Regrading streambanks to a stable slope, placing topsoil and other materials needed for sustaining plant growth, and selecting, installing and establishing appropriate plant species.

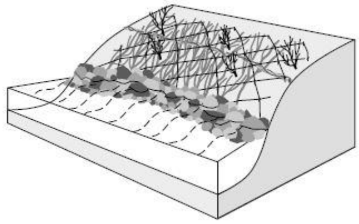
Figures A-11 and A-12. Boulder clusters and brush mattresses.

Boulder Clusters



Groups of boulders placed in the base flow channel to provide cover, create scour holes, or areas of reduced velocity.

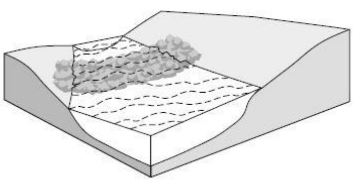
Brush Mattresses



Combination of live stakes, live facines, and branch cuttings installed to cover and physically protect streambanks; eventually to sprout and establish numerous individual plants.

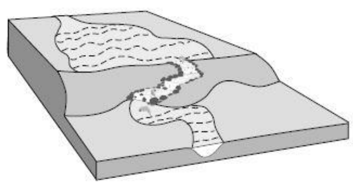
Figures A-13 and A-14, Fish passage and grade control techniques.

Grade Control Measures



Rock, wood, earth, and other material structures placed across the channel and anchored in the streambanks to provide a "hard point" in the streambed that resists the erosion forces of the degradational zone, and/or to reduce the upstream energy slope to prevent bed scour.

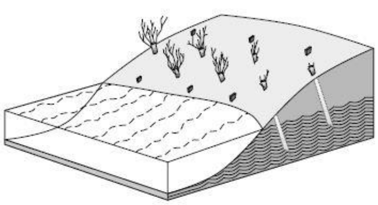
Fish Passages



Any one of a number of instream changes which enhance the opportunity for target fish species to freely move to upstream areas for spawning, habitat utilization, and other life functions.

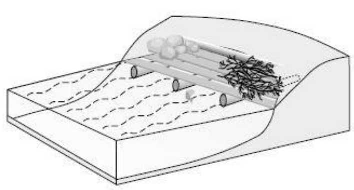
Figures A-15 and A-16. Planting live stakes and shelters.

Live Stakes



Live, woody cuttings which are tamped into the soil to root, grow and create a living root mat that stabilizes the soil by reinforcing and binding soil particles together, and by extracting excess soil moisture.

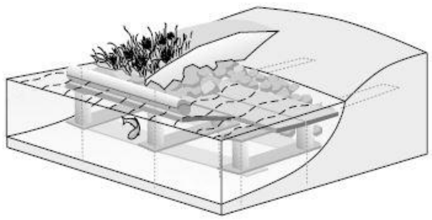
Log/Brush/Rock Shelters



Logs, brush, and rock structures installed in the lower portion of streambanks to enhance fish habitat, encourage food web dynamics, prevent streambank erosion, and provide shading.

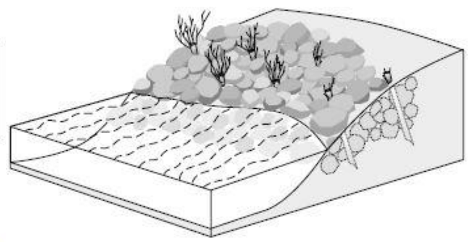
Figures A-17 and A-18. Lunker and joint plantings

Lunker Structures



Cells constructed of heavy wooden planks and blocks which are imbedded into the toe of streambanks at channel bed level to provide covered compartments for fish shelter, habitat, and prevention of streambank erosion.

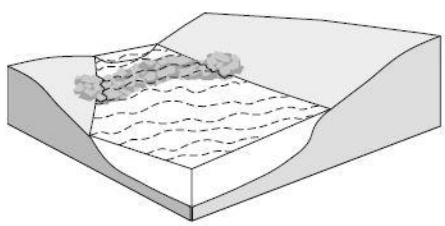
Joint Plantings



Live stakes tamped into joints or openings between rock which have previously been installed on a slope or while rock is being placed on the slope face.

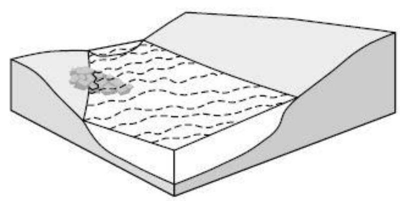
Figures A-19 and A-20. Weirs, sills, and wing deflectors.

Weirs or Sills



Log, boulder, or quarrystone structures placed across the channel and anchored to the streambank and/or bed to create pool habitat, control bed erosion, or collect and retain gravel.

Wing Deflectors



Structures that protrude from either streambank but do not extend entirely across a channel. They deflect flows away from the bank, and scour pools by constricting the channel and accelerating flow.

Figure A-21. Slope categories determined using ArcGIS.

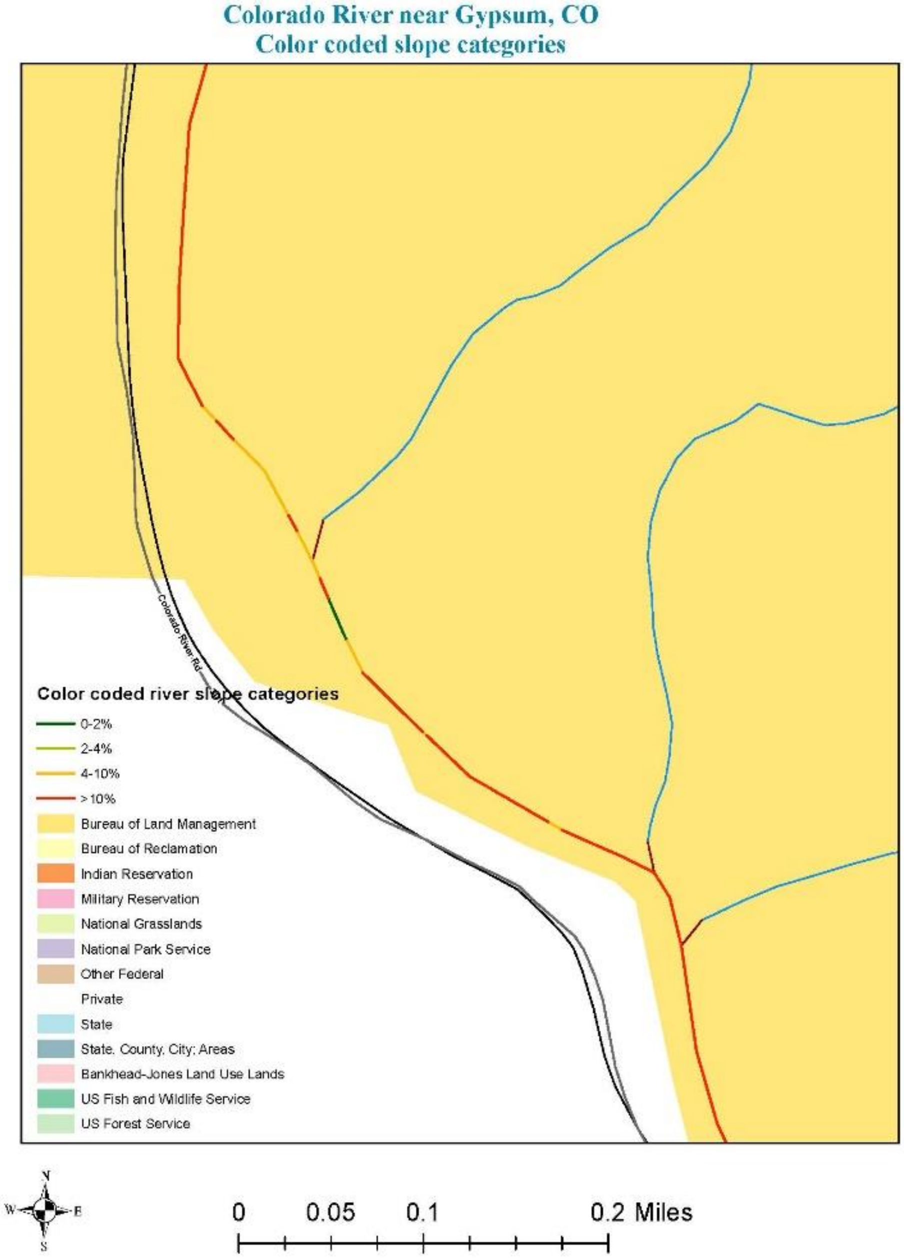


Table A-1 Colorado Public Land Health Standards - Summarized

Standard	Narrative	Indicators
2 (Riparian)	Riparian systems associated with both running and standing water, function properly and can recover from major disturbance such as fire, severe grazing, or 100-year floods. Riparian vegetation captures sediment, improves water quality, provides forage, habitat, and biodiversity.	• Vegetation is dominated by an appropriate mix of native or desirable introduced species, diverse age class structure, appropriate vertical structure, and adequate composition, cover, and density. Plant species present indicate maintenance of riparian moisture characteristics. • Streambank vegetation is present and have root systems capable of withstanding high streamflow events. • Stream is in balance with the water and sediment being supplied by the watershed (e.g., no head cutting, no excessive erosion or deposition). • Vegetation and free water indicate high water tables, colonizes point bars with a range of age classes and successional stages. • An active floodplain is present, and vegetation is available to capture and retain sediment and dissipate flood energies. • Stream channels with size and meander pattern appropriate for the stream's position in the landscape, and parent materials. • Woody debris contributes to the character of the stream channel morphology.
3 (Plant and Animal Communities)	Healthy, productive plant and animal communities of native and other desirable species are maintained at viable population levels commensurate with the species and habitat's potential. Plants and animals are productive, resilient, diverse, vigorous, and able to reproduce and sustain natural fluctuations, and ecological processes.	• Noxious weeds and undesirable species are minimal. • Native plant and animal communities are spatially distributed with a density, composition, and frequency of species suitable to ensure reproductive capability and sustainability. Plants and animals are present in mixed age classes. • Landscapes exhibit connectivity. • Diversity and density of plant and animal species are in balance with habitat/landscape potential. • Appropriate plant litter accumulates and is evenly distributed across the landscape.
4 (Special Status Species)	Special status threatened and endangered species (federal and state), and other plants and animals officially designated by the BLM, and their habitats are maintained or enhanced.	• There are stable and increasing populations of endemic and protected species in suitable habitat. Suitable habitat is available for recovery of endemic and protected species.
5 (Water Quality)	The water quality of all water bodies, including ground water, will achieve or exceed State Water Quality Standards, which include designated beneficial uses, numeric criteria, narrative criteria, and antidegradation requirements set forth under State law and Clean Water Act.	• Appropriate populations of macroinvertabrates, vertebrates, and algae are present. • Surface and ground waters only contain substances (e.g. sediment, scum, floating debris, odor, heavy metal precipitates on channel substrate) attributable to humans within the amounts, concentrations, or combinations as directed by the Water Quality Standards established by the State of Colorado (5 CCR 1002-8).

Appendix B

Additional background information on climate, streams, water rights, topography, and climate

The winter delivers moisture from the prevailing westerlies flowing in from the Pacific Ocean. Mountains block the western flowing moisture and gain most of the available moisture as snow, the eastern portion of the state is left with very little precipitation, which some would call a “rain shadow.” Average precipitation slightly decreases moving from the eastern border with Kansas into the Colorado plains and tends to significantly increase westward into the higher elevations of the foothills and mountain ranges.

The mountains and areas west of the Divide receive most of their annual precipitation as snow during the winter months, while most lower elevation precipitation falls as rain during the late spring and summer months (Table B -1). Convective thunderstorm processes significantly contribute precipitation statewide, as temperatures continue to increase into summer. Moreover, while mountainous areas capture much of the snow during the winter months, they produce thunderstorms moving into the spring and summer months. Topography also influences precipitation patterns at adjacent lower areas depending upon their proximity to mountainous areas; if the lower elevation areas are close to the mountains, precipitation that doesn’t fall in the mountain’s regions will fall in adjacent lower areas. If the lower areas are farther from the mountains, less precipitation will fall, as is the case in North Park, South Park, and the San Luis Valley.

Table B-1. Western Colorado climate station

GLENWOOD SPGS #2, COLORADO (053359)													
Period of Record Monthly Climate Summary Period of Record: 06/08/1988 to 05/31/2016													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	36.9	42.5	51.5	61.5	72	82.3	88.5	86.1	78.4	66.2	49.9	38.1	62.8
Average Min. Temperature (F)	11.7	16.7	24.5	31.3	38.4	44.2	50.9	49.7	42	32.1	22.4	13.6	31.5
Average Total Precipitation (in.)	1.46	1.25	1.41	1.59	1.41	1.1	1.23	1.48	1.59	1.46	1.14	1.29	16.4
Average Total Snowfall (in.)	17.9	11.2	6.6	1.8	0.3	0	0	0	0	1.1	5.3	14.9	59.3
Average Snow Depth (in.)	6	5	0	0	0	0	0	0	0	0	0	2	1
Percent of possible observations for period of record. Max. Temp.: 90.5% Min. Temp.: 90.3% Precipitation: 91.7% Snowfall: 87.7% Snow Depth: 41.6% Check Station Metadata or Metadata graphics for more detail about data completeness.													

Slow-moving storms carry moisture from the Gulf of Mexico into the eastern portion of the state from the south and southeast. Weak monsoon-like circulation can move subtropical moisture from the Pacific Ocean up into Colorado, resulting in frequent summer thunderstorms in the southern portion of the State. Convective thunderstorms contribute “significant” precipitation east of the Rockies (compared to west of the Divide), whereby rapid and high surface heating forces warm air to rise, expand and cool (**Table 7**). The high plains of Colorado (east of the Continental Divide) slope gently upward for some 200 miles from the eastern border to the base of the foothills of the Rocky Mountains. The eastern part of the State is generally level to rolling prairie interspersed by occasional hills and bluffs. Two major river valleys dissect eastern Colorado - the South Platte River in northeastern Colorado and the Arkansas River to the southeast. Elevations along the eastern border of Colorado range from about 3,350 feet at the lowest point in the State where the Arkansas River crosses into Kansas to near 4,000 feet. Elevations increase towards the west to between 5,000 and 6,500 feet where the plains meet the Front Range of the Rocky Mountain chain. Here elevations rise abruptly to 7,000 to 9,000 feet.

Table B-2. Eastern Colorado climate station.

RUSH 1N, COLORADO (057287)

Period of Record: 09/01/1916 to 04/30/2014

Period of Record Monthly Climate Summary

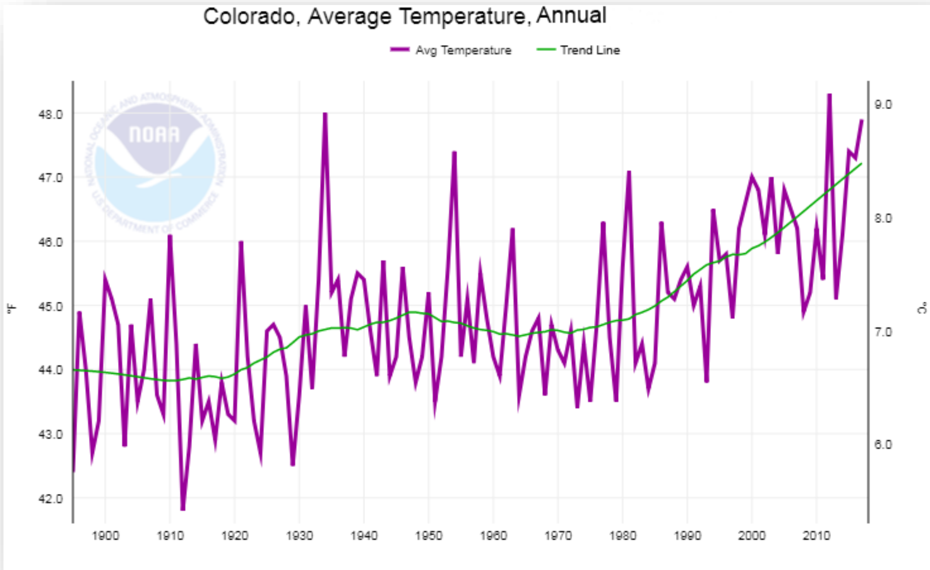
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	42.2	44.4	51	60.3	69.2	79.4	85.5	82.6	75.2	64.1	51.1	42.6	62.3
Average Min. Temperature (F)	13.1	15.7	21.8	29.7	39.3	48.4	54.2	52.5	43.8	32.6	21.8	14.5	32.3
Average Total Precipitation (in.)	0.24	0.25	0.65	1.26	2.18	1.87	2.37	2.54	1.11	0.64	0.35	0.25	13.7
Average Total Snowfall (in.)	3.6	3.5	4.7	3.2	0.4	0	0	0	0.6	1.5	3.4	3.6	24.5
Average Snow Depth (in.)	0	1	0	0	0	0	0	0	0	0	0	0	0

Percent of possible observations for period of record.

Max. Temp.: 48.5% Min. Temp.: 48.5% Precipitation: 92.4% Snowfall: 87.2% Snow Depth: 50.6%

Colorado’s rugged topography and high elevations create highly variable seasonal and daily temperatures throughout the state (Figure B-1). January tends to be the coldest month across the state while July and August are usually the warmest, with a 40 – 55* F variation in average temperature between the warmest and coldest months. Daily temperature variations of 30*F or more throughout much of the state can occur, with daily maximums being reached by late afternoon. Large temperature fluctuations occur due primarily to low humidity and less solar energy is absorbed by the air throughout the day. Differences in elevation, slope, and aspect result in varying amounts of solar heating in the mountains and surrounding terrain. South facing slopes receive more sunlight than north facing slopes, and as a result, are usually warmer and drier. Steep slopes may cast shadows, which may result in cooler temperatures.

Figure B-1. Average annual air temperature.



East of the Rockies annual temperature variations are generally controlled by the exchange among Pacific, subtropical and Polar air masses, while in the mountains, annual temperature variations are dictated more by atmospheric ridges and troughs moving through the state. Temperature variations are less significant west of the mountains, with snow presence or absence being the main influencing factor on annual variations.

Stream and River morphology

Streams and rivers are dynamic systems that interact with other surface and subsurface environments over time, which includes the riparian zone, floodplain, and hyporheic zone. The hyporheic zone is defined as the portion of unconfined, near stream aquifers where stream water exists (Wohl, Scott and Yochum 2019). The hyporheic zone is critical in that subsurface interactions with a channel, such as the downwelling of water and solutes from the channel into the hyporheic zone, as well as upwelling of water and solutes into the channel facilitates exchanges of material beneficial to water quality and macroinvertebrates.

Interactions between the channel, floodplain and riparian zone are generally most noticeable during high streamflow events, such as the bankfull discharge and greater flows that inundate the floodplain and deposit sediment and organic material. The riparian zone benefits from higher flows, sediment, and organic matter deposition by improving existing vegetation growth and facilitate the development of new sprouts (that aren’t scoured downstream). The riparian zone also provides roughness that ameliorates impacts from higher flow events while maintaining long term storage and retention of sediment and organic material.

Prior to implementing stream restoration activities, it's important to understand past land use, determine current conditions, and predict likely responses to future disturbance, including land management and restoration activities (Kondoff 2011). Channel classification, as well as knowing a stream's current condition within a stream evolution model are important tools in better identifying, locating, determining restoration objectives for a particular waterbody, and ultimately determining if treatments are needed. Synthesizing and articulating the voluminous research completed in these two areas and fluvial geomorphology is unrealistic and would likely diminish the importance and not provide adequate context. In the literature, there appears to be two types of classifications; descriptive and process based. Descriptive classifications are commonly quantitative, and involves measuring various physical parameters, whereas process-based classifications may be conceptual (i.e.,, qualitative). Both types may be useful in better understanding of stream hydraulics and the physical processes associated with channel morphology. Moreover, descriptive classifications lack quantitative assessment, it could be useful in informing further process-based classification and data collection. Stream order (descriptive), channel pattern (descriptive and process), channel and floodplain interactions, substrate and mobility, channel units, hierarchical classifications, and process domains (Buffington and Montgomery 2013). Researchers such as Stan Schumm divided rivers into sediment production, transfer, and deposition zones, which provides a process-based foundation for how sediment moves through a stream network through time. Montgomery and Buffington (1997) classified mountain rivers into source, transport, and response reaches. It's expected that most work will occur in *response* reaches.

Water Rights

The CWCB oversees conservation and development in the state and is responsible for the state's instream flow program. The CWCB is responsible for decisions regarding the protection, management, and development of Colorado's water resources, based on interstate compacts, state legislation, Colorado Revised Statutes, rules, policies, guidelines, and governmental agreements. The CWCB is responsible for the appropriation, acquisition, protection and monitoring of instream flow (ISF) and natural lake level water rights to preserve and improve the natural environment to a reasonable degree. ISF water rights are non-consumptive, in-channel or in-lake uses of water made exclusively by the CWCB for minimum flows between specific points on a stream or levels in natural lakes. These rights are administered within the state's water right priority system to preserve or improve the natural environment to a reasonable degree. The BLM works cooperatively with the CO Division of Water Resources and Colorado Water Conservation Board (CWCB) on water rights issues and securing instream flow protection. BLM CO routinely applies for this type of water right. Some examples of habitat protected are: Coldwater and warm water fisheries (various streams and lakes), waterfowl habitat (Gageby Creek), unique glacial ponds and habitat for neotenic salamanders, riparian vegetation, unique hydrologic and geologic features, and critical habitat for threatened or endangered native fish.