Finding of No Significant Impact and Environmental Assessment for the Corrales River Mile 199 Project

Middle Rio Grande Project
Upper Colorado Basin Region, Albuquerque Area Office

U.S. Department of the Interior July 2025

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The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Prepared for the Bureau of Reclamation by
Vernadero Group Inc.

July 2025

Cover Photo: Aerial photograph taken at approximately 500 feet above ground level looking south toward the RM 199 River Maintenance project area in May 2024. The riprap line at the Corrales Siphon and the interim bank protections windrow just downstream of the siphon are visible in the center of the photograph. Rio Grande flows were roughly 2,450 cubic feet per second at the time of the photograph as measured at the USGS Alameda Gage (USGS 08329918).

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FINDING OF NO SIGNIFICANT IMPACT

Corrales River Mile (RM) 199 Project
United States Department of the Interior
Bureau of Reclamation
Upper Colorado Basin
Albuquerque Area Office
Albuquerque, New Mexico

Introduction

In compliance with the National Environmental Policy Act of 1969, as amended (NEPA), the Bureau of Reclamation (Reclamation) has completed an environmental assessment (EA) for the Proposed Action of authorizing the use of federal funds to implement the Corrales RM 199 Reclamation Project, New Mexico. The EA was prepared by Reclamation to address the potential impacts on the human and natural environment due to implementation of the Proposed Action. The EA is attached to this Finding of No Significant Impact (FONSI) and is incorporated by reference.

Alternatives

The EA analyzes the No Action Alternative and the Proposed Action Alternative to implement the Corrales RM 199 Project. The Proposed Action Alternative would be implemented to reduce the risk of levee failure due to bank erosion and lateral migration of the Rio Grande in the project reach. In addition, the Proposed Action Alternative would improve ecological conditions, avoid negative community impacts, be suitable given the geomorphic trends, and be cost effective. To reduce erosion towards the levee, the bank would be stabilized at locations of immediate threat, and the river's energy would be dissipated before it can cause erosion in other areas of the reach. Under the Proposed Action Alternative, Reclamation would construct three 2-tiered longitudinal stone toe protection (LSTP) features along the eroding bank and three floodplain benches adjacent to the LSTP features, construct three side channels, raise the riverbed by 1 to 3 feet; install six bed control features to reduce the risk of levee failure due to bank erosion and lateral migration; improve connectivity of the river to the floodplain; and improve habitat from RM 199.8 to RM 199.2 of the Middle Rio Grande.

Summary of Impacts

A total of 12 resources were identified by Reclamation for detailed analysis in the EA. The following summarizes the impacts of the Proposed Action on these 12 resources.

Water Resources: The Proposed Action would have short-term, minor, adverse impacts on water quality from sediment transport during construction and potential for the discharge of petroleum, oils, and lubricants during construction. There would be long-term, minor beneficial impacts on water quality from channel stabilization and revegetation. Proposed project features would have potential impacts on waters of the United States (U.S.). These impacts are assessed and included in the Clean Water Section 404 and 401 applications to the U.S. Army Corps of Engineers and New Mexico Environment Department, and resulting guidance and requirements from these agencies for this project will be adhered to in the construction phase.

Access, Transportation, and Safety: There would be short-term, minor, adverse impacts on access and transportation from additional vehicles and equipment commuting to the project area during construction. The Proposed Action would have short-term, negligible, adverse impacts on safety inherent to construction activities.

Air Quality: The Proposed Action would have short-term, minor, adverse air quality impacts from fugitive dust and combustion emissions during construction activities. Because the Air Quality Control Region is in attainment for all criteria pollutants, there would be no significant air quality impacts from the short-term increase in combustion emissions.

Noise: The Proposed Action would have short-term, negligible, adverse impacts on noise from construction equipment and construction worker vehicles during commutes. Construction noise would be limited to the proposed project area within the floodplain of the Rio Grande.

Visual Resources: There would be short-term, adverse impacts on visual resources as a result of the removal of vegetation, establishment of staging areas, use of heavy construction equipment, parking of construction worker vehicles, and channel protection features; these would all decrease the visual appeal of the Rio Grande riparian area. The Proposed Action would have long-term, adverse impact on visual resources from the removal of mature cottonwood trees.

Public Recreation: The Proposed Action would have short-term, adverse impacts on recreation as construction activities would limit recreational opportunities within the Rio Grande floodplain due to restrictions on public access.

Vegetation: The Proposed Action would have short-term, minor, adverse impacts from the removal of vegetation in staging areas on both sides of the Rio Grande. There would be long-term minor, adverse impacts from the removal of mature cottonwood trees, and long-term, minor beneficial impacts on vegetation from the revegetation of disturbed area with native vegetation, likely replacing some invasive vegetation with native vegetation.

Invasive Species: The Proposed Action would have long-term, negligible, beneficial impacts on invasive species as some invasive plant species would be removed during construction and those removal areas revegetated with native plant species.

Wildlife: The Proposed Action would have short-term, minor, adverse impacts on wildlife as construction activities, including equipment noise and equipment movement, have the potential to directly injure or kill wildlife, or cause stress to wildlife as species flee the movement and noise from equipment.

Threatened and Endangered Species: The Proposed Action is not anticipated to affect the New Mexico meadow jumping mouse, southwestern willow flycatcher, Mexican spotted owl, or yellow-billed cuckoo. The Proposed Action may affect and is likely to adversely affect the Rio Grande silvery minnow. The Proposed Action would adversely affect 2.4 acres of moderately suitable habitat for the southwestern willow flycatcher. Incidental take of the Rio Grande silvery minnow and loss of moderately suitable southwestern willow flycatcher habitat are included in Reclamation's annual accounting and reporting procedures to the U.S. Fish and Wildlife Service for the 2016 Biological Opinion, which will include post-project refined areas across these types of covered projects.

Cultural Resources: The Proposed Action would have no effect on historic properties. Because of the degradation and loss of integrity that has already occurred for both the Corrales Acequia Madre and Corrales Main Siphon sites within the area of potential effects, on 25 March 2025 the New Mexico State Historic Preservation Office concurred with Reclamation's determination that the proposed undertaking would have no effect on historic properties.

Soils: The Proposed Action would have short-term, adverse impacts on soils from disturbance during the clearing of vegetation for staging areas, side channel construction, and the recontouring of the banks to stabilize the river bends.

Environmental Commitments

The best management practices located in Section 2.1.9 of the Final EA will be implemented to further reduce effects of the Proposed Action. All permits and authorizations listed in Section 2.1.10 of the Final EA will be completed prior to the implementation of the Proposed Action.

Decision and Finding of No Significant Impact

Reclamation's decision is to implement the Proposed Action Alternative. Based on the EA, which analyzes potential impacts of the Proposed Action, Reclamation has determined that implementing the Proposed Action does not constitute a major federal action that will significantly affect the quality of the human or natural environment. Therefore, an environmental impact statement is not required for this proposed action. This finding is based on consideration of the degree of effects of the Proposed Action on the potentially affected environment, as analyzed in the EA.

Approved by:

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FONSI Number: AAO-EA-25-006

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List of Abbreviations and Acronyms

APE	Area of Potential Effects
AQCR	Air Quality Control Region
BISON-M	Biota Information System of New Mexico
BMP	Best Management Practice
CFR	Code of Federal Regulations
cfs	cubic feet per second
CWA	Clean Water Act
dB	decibel
dBA	A-weighted decibel
EA	Environmental Assessment
ESA	Endangered Species Act
FONSI	Finding of No Significant Impact
GRF	gradient-restoration facilities
LSTP	longitudinal stone toe protection
MBTA	Migratory Bird Treaty Act
MRG	Middle Rio Grande
MRGCD	Middle Rio Grande Conservancy District
MSO	Mexican spotted owl
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NMMJM	New Mexico meadow jumping mouse
OHV	off-highway vehicle
OHWM	ordinary high water mark
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl
POLs	petroleum, oils, and lubricants
PL	Public Law
Preserve	Corrales Bosque Preserve
Reclamation	Bureau of Reclamation

RGSM	Rio Grande silvery minnow
RM	river mile
SCBB	Suckley's cuckoo bumble bee
SHPO	State Historic Preservation Office
SSCAFCA	Southern Sandoval County Flood Control Authority
SWFL	Southwestern willow flycatcher
THPO	Tribal Historical Preservation Office
TMDL	Total Maximum Daily Load
USACE	U.S. Army Corps of Engineers
USC	United States Code
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
WOTUS	Waters of the U.S.
WSE	water surface elevation
YBCU	Yellow-billed cuckoo

CHAPTER 1 - INTRODUCTION

This Environmental Assessment (EA) documents the Bureau of Reclamation's (Reclamation's) review of the implementation of the Corrales River Mile (RM) 199 Project (project) to protect riverside infrastructure from erosion along the Rio Grande north of Albuquerque, New Mexico (Figure 1). Reclamation is authorized under the Flood Control Acts of 1948 and 1950 to maintain the Rio Grande channel in the Middle Rio Grande (MRG) to pass the 2-year return peak flow[1]. In accordance with this authorization, Reclamation has initiated the project to protect the riverside levee system at three points where river meandering is currently threatening the levee. The project has a primary goal of protecting the riverside levees at three meander bend locations where the river is currently on a trajectory to threaten the levee systems and secondary goals of rehabilitating the river planform and enhancing native riparian habitat. Overall the project purpose is to stabilize the outer banks and restore the reach energy grade to a point at which the levees are not under threat.

Reclamation prepared this EA in compliance with the National Environmental Policy Act (NEPA). Reclamation provided a Draft EA public review period from 22 June through 7 July 2025 (Appendix A). No public comments were received. Reclamation determined that a Finding of No Significant Impact (FONSI) for the Proposed Action is warranted as there would be no significant impacts on the natural or human environment.

The project area was identified as needing rehabilitation during regular aerial reconnaissance and Reclamation's Albuquerque Area Office 2018 report detailing the trends and conditions in the reach between Angostura and Montano Bridge (Harris, Klein, and Bui, 2018), due to lateral development of the river bends toward the levees bounding the floodplain. Current geomorphic trends in this reach of the Rio Grande include river incision and narrowing, vegetation encroachment, and reduced geomorphic complexity due to flow regulation. The proposed project design features to address the potential threats to the Rio Grande levee include riprap stone toe protection, side channels through the vegetated channel bars, and construction of deformable bed controls. These design features would directly stabilize eroding bends, dissipate erosive energy, and raise the channel bed elevation.

1.1 Project Location and Legal Description

The Corrales RM 199 project site is within the Corrales sub-reach of the MRG, extending from Arroyo de la Barranca RM 199.8 (35°16'58.0" N; 106°35'51.15" W) to RM 199.2 (35°16'13.82" N; 106°35'52.01" W) in New Mexico. This reach of the Rio Grande is closely bounded by the Village of Corrales on the west and the Pueblo of Sandia to the east (see Figure 1), both of which are separated from the Rio Grande floodplain by riverside flood risk reduction levees. The land on the eastern bank belongs to the Pueblo of Sandia. The western floodplain is jointly owned and maintained by Reclamation and the MRG Conservancy District (MRGCD).

[1] The 2-year return peak flow is the maximum amount of runoff that occurs in a given area within a 2-year period (or a 50 percent chance of the peak flow occurring in any given year).

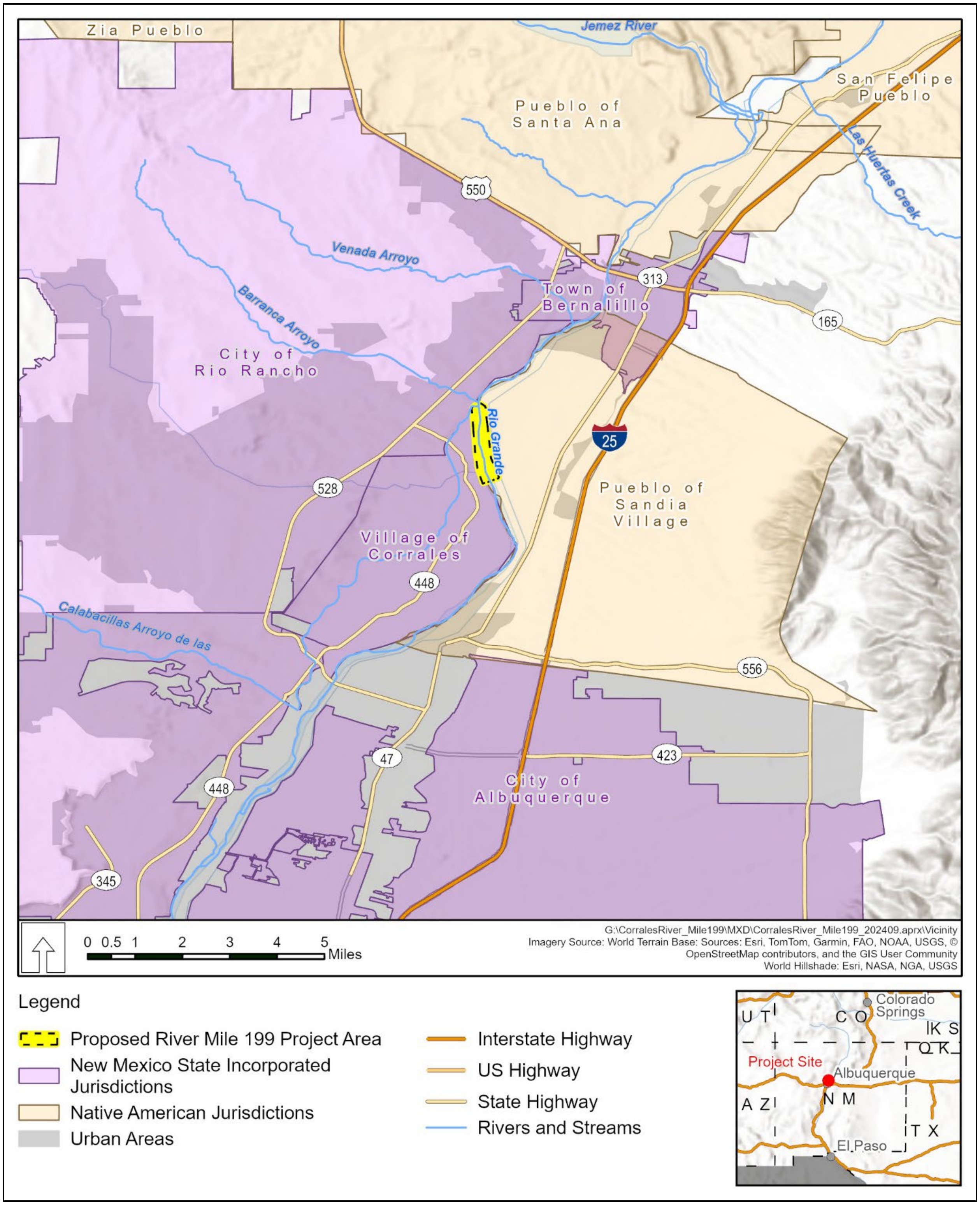

Figure 1. Location of the Corrales River Mile 199 Project

1.2 Need for and Purpose of the Proposed Action

The need for the Proposed Action is to protect the riverside levees, rehabilitate the Rio Grande planform, and enhance native riparian habitat of this reach at three points where river meandering is currently on a trajectory to threaten the levee toes. The purpose of the Proposed Action is to pass the 2-year return flow in accordance with the Flood Control Acts of 1948 and 1950 (Public Laws 858 and 516), which were created to authorize projects implemented by Reclamation to rectify and maintain the river channel throughout the MRG.

1.3 Decision to Be Made

Reclamation will decide to 1) prepare and execute a FONSI and implement the proposed project, 2) prepare and execute a FONSI and implement the proposed project with mitigation measures to reduce any potentially significant impacts if identified, 3) further evaluate the proposed project through an Environmental Impact Statement if significant impacts are identified that cannot be reduced to a less-than-significant level through proposed mitigation measures, or 4) take no action.

1.4 Background

The Corrales RM 199 project area was identified as needing rehabilitation due to lateral development of the river bends toward the levees bounding the Rio Grande floodplain. Current geomorphic trends on this reach include river incision and narrowing because of sediment cutoff and flow regulation due to Cochiti Dam (Reclamation 2012; Massong 2005), which is upstream of the project area. Interruption of sediment transport at Cochiti Dam has resulted in high-energy flows exiting the dam and armoring of the channel downstream of Cochiti Dam, as river sediments are evacuated by the high-energy flows. As the bed of the Rio Grande becomes incised, flows eventually destabilize the riverbanks. Destabilized riverbanks result in distribution of energy along the channel and lead to channel meander development. Flow regulation has led to decreased peak flows and extended base flows, which have enabled vegetation to become established on low terraces in the reach. As vegetation matures, the active channel becomes confined to a narrower path. Detriments of a narrow and incised channel include lateral erosion, formation of cut banks, low floodplain connectivity, poor habitat quality, and poor river conveyance.

1.4.1 River Mile 199 Land Ownership

The RM 199 project area has a mix of federal government, MRGCD, and Pueblo of Sandia ownership. The eastern floodplain between the levees and the river is owned and actively managed by the Pueblo of Sandia. The western floodplain between the levee and the river is owned by Reclamation and jointly managed by Reclamation and MRGCD. Portions of the western floodplain are also managed by the Village of Corrales as the Corrales Bosque Preserve, with a mission to protect and preserve the bosque (i.e., riparian forested area) (Corrales Bosque Advisory Commission 2009). The Village of Corrales has a Bosque Commission to make decisions for bosque actions. The Village of Corrales Fire Department is active in fuel reduction and recreational safety in the bosque.

MRGCD has responsibility for maintenance of the engineered levees on the west side of the river, the levees on the east side of the river, the riverside drains, and the irrigation infrastructure including Corrales Siphon. The Southern Sandoval County Arroyo Flood Control Authority has maintenance responsibility for the Arroyo de la Barranca and the Harvey Jones Channel, both on the west side of the Rio Grande.

1.5 Scoping and Issues

Scoping for this EA was completed by Reclamation to identify the potential natural and human environment issues and concerns associated with implementation of the Proposed Action and No Action Alternatives. Reclamation coordinated with the following agencies and organizations during the planning stages of the project:

- U.S. Army Corps of Engineers (USACE)
- U.S. Department of the Interior
- U.S. Geological Survey
- U.S. Fish and Wildlife Service
- Village of Corrales, New Mexico
- Pueblo of Sandia, New Mexico
- MRGCD
- Southern Sandoval County Flood Control Authority (SSCAFCA)
- New Mexico Environment Department (NMED) Surface Water Quality Bureau

Two public scoping meetings were held on 26 and 27 March 2025 to provide the public an opportunity to learn about the proposed Corrales RM 199 project and to provide comments on the project’s purpose and need, the proposed action, and alternatives for implementing the proposed action (Appendix A). The public scoping period extended from 26 March to 26 April 2025. No comments were received during the public scoping period.

CHAPTER 2 - PROPOSED ACTION AND ALTERNATIVES

Alternatives evaluated in this EA include the No Action Alternative and the Proposed Action Alternative. The Proposed Action would be implemented to reduce the risk of levee failure due to bank erosion and lateral migration of the Rio Grande in this reach. In addition, the Proposed Action would improve ecological conditions, avoid negative community impacts, be suitable given the geomorphic trends, and be cost effective. To reduce erosion towards the levee, the bank would be stabilized at locations of immediate threat, and the river's energy would be dissipated before it can cause erosion in other areas of the reach.

2.1 Proposed Action

Under the Proposed Action, Reclamation would construct three 2-tiered longitudinal stone toe protection (LSTP) features along the eroding bank and three floodplain benches adjacent to the LSTP features, construct three side channels, raise the riverbed by 1 to 3 feet; install six bed control features to reduce the risk of levee failure due to bank erosion and lateral migration; improve connectivity of the river to the floodplain; and improve habitat from RM 199.8 to RM 199.2 of the MRG (Figure 2). A detailed Project Information Report for the proposed Corrales RM 199 Project is in Appendix B.

2.1.1 Longitudinal Stone Toe Protection and Bench

Reclamation would construct three 2-tiered LSTP features to protect the outer bends from bank erosion at three locations: the Corrales Siphon bend, the BB-343 bend, and the RM 199 bend (see Figure 2). The total length of these LSTP features would be approximately 4,700 feet.

Each LSTP would be constructed using riprap (i.e., engineered rock) sized appropriately to withstand the erosive force and scour expected to result from a 10-year flood flow (i.e., a 10 percent probability that the flood flow would occur in any given year) event (Figure 3). Approximately 17,000 cubic yards of riprap would be used for the construction of the three LSTP features. The lower tier of each LSTP feature would be constructed with 16- to 24-inch median diameter riprap, and the upper tier would be constructed with 12-inch median diameter riprap. The two LSTP tiers would be separated by a low terrace. The three low terraces would be constructed using fill from the excavated side channels (Figure 3). Additionally, Reclamation would construct three floodplain benches on the outer bends adjacent to the LSTP features, at elevations below the abandoned terraces (see Figure 2).

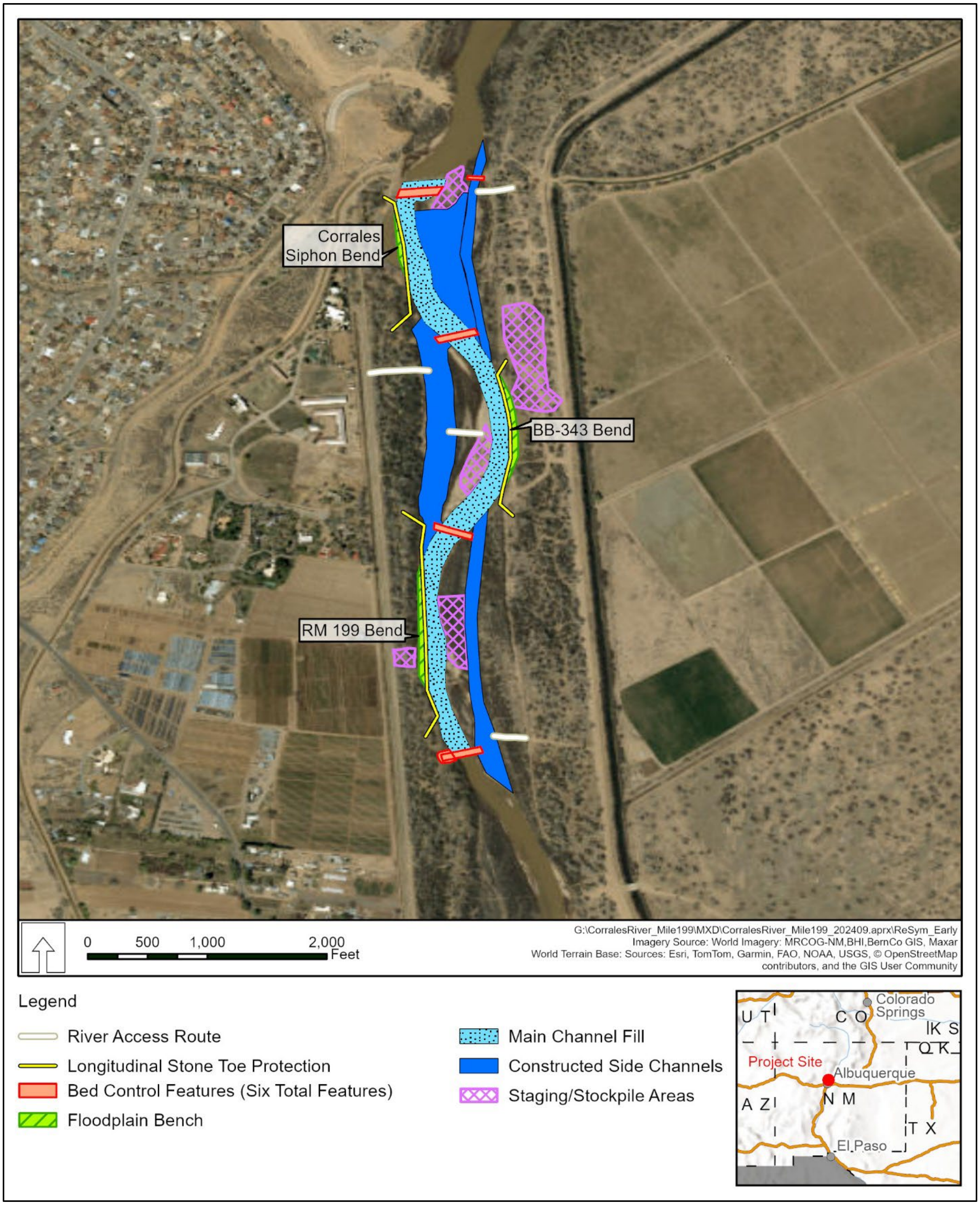

Figure 2. Corrales River Mile 199 Proposed Project Features

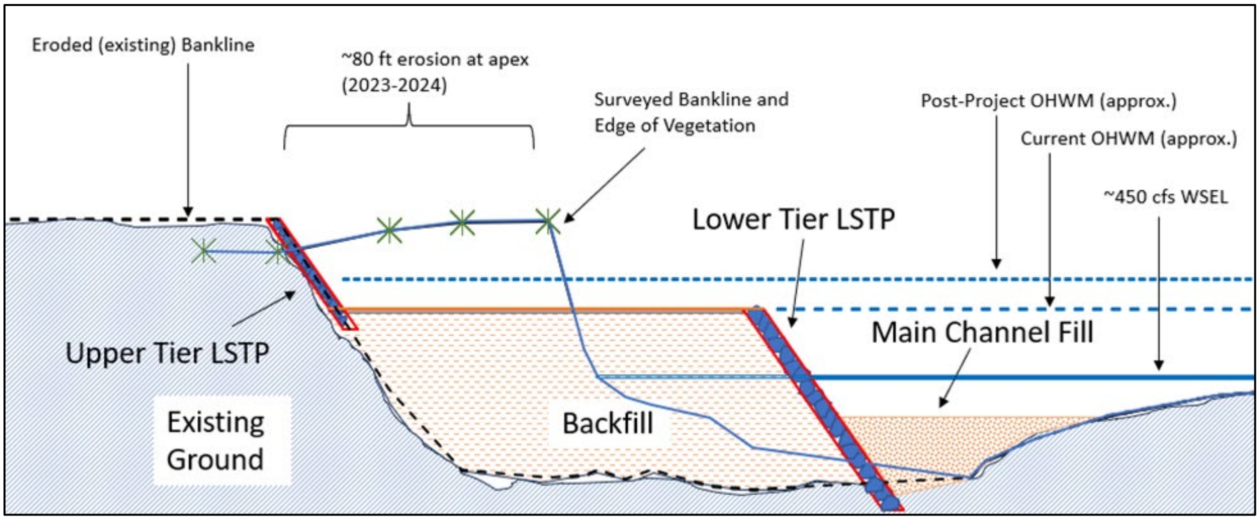

Figure 3. Schematic of the 2-Tiered Longitudinal Stone Toe Protection Feature at BB-343 Bend. (Includes the area of floodplain bench and main channel backfill [not to scale]. The erosion at the apex of the bend was roughly 80 feet between the survey conducted in July 2023 and April 2024.)

The elevation of the top of the lower stage riprap for each LSTP feature would align with the water surface elevation (WSE) where vegetation does not grow, which corresponds to a flow of 4,000 cubic feet per second (cfs) (Baird et al. 2015). At the Corrales Siphon Bend cross-section, the 4,000 cfs flow rate corresponds to a WSE of 5,032 feet. At the BB-343 Bend cross-section, the 4,000 cfs flow rate corresponds to a WSE of 5,030.5 feet, and at the RM 199 Bend cross-section, the 4,000 cfs flow rate corresponds to a WSE of 5,029 feet. Reclamation's design model for the floodplain benches is based on the elevations at the three cross sections. The floodplain benches would be constructed to increase and/or decrease elevations surrounding the three cross sections to provide consistent inundation values from river flows for the entire floodplain at these cross sections. Because Reclamation's design-model channel would be raised with fill material from the side channels, the inundation level of the floodplain benches in the design model varied from 2,000 cfs to 3,500 cfs, not 4,000 cfs as expected with the existing terrain. The lower inundation values would provide relief of hydraulic pressures, riparian habitat, and Rio Grande silvery minnow (*Hybognathus amarus*; RGSM) nursery habitat. The slope of the lower stage riprap revetment would be 2:1 (height to vertical), and the thickness would depend on the scour calculations shown in the design report.

The upper stage riprap revetment for each LTSP feature would be further protected from river flows higher than 4,000 cfs, by installing pole plantings (i.e., vegetation plantings) on the floodplain bench. The width of each floodplain bench, or the distances between the two stages of the riprap revetment, would vary based on specific bankline features, but would be a minimum of 15 feet with additional width for creating a smooth flow alignment on these three banks. The lower stage riprap revetment for each of the three LSTP features would be placed below the ordinary high-water mark (OHWM), and the upper stage riprap revetment would be placed entirely above the OHWM.

2.1.2 Constructed Side Channels

Reclamation would excavate a total of 5,280 linear feet of side channels along the accreted sand bars to dissipate erosive forces above average flow rates and create habitat complexity in the river floodplain. The three side channels would be excavated opposite each of the three channel bends (see Figure 2) and would include constructed terraces located 1 foot above the side channel bottom elevation, except for the northernmost side channel (opposite the Corrales Siphon Bend), which would not have a terrace feature. Side channels would activate at above average flows, with the outlets inundating at approximately 1,000 cfs and the inlets inundating at approximately 2,000 cfs. The side channels would have average slopes of 0.002 foot per foot. For comparison the river channel in this reach has a slope of roughly 0.001 ft/ft in the area below the rock at the Corrales Siphon.

The constructed side channels would also be used to temporarily convey river flows past the work area during construction of the LSTP features, the deformable grade controls and the main channel fill. Rock berms would first be constructed at the upstream and downstream ends of the work area to redirect river flows into the constructed side channels. The side channels would be designed to contain the 25 percent exceedance of daily flows for the winter construction period. Each side channel would contain the river base flows while the LSTP feature is constructed along the opposite bank.

2.1.3 Main Channel Fill

Reclamation would fill the main Rio Grande channel from just downstream of the Corrales Siphon Bend to immediately downstream of the RM 199 Bend (see Figure 2). The fill would raise the riverbed by 1 to 3 feet and increase the connectivity between the main channel and the inset floodplain. The material excavated from the three side channels would be used to fill the main Rio Grande channel. All main channel fill would be placed below the OHWM.

2.1.4 Bed Control Features

Reclamation would construct deformable bed control features composed of riprap in the channel bed at the upstream and downstream ends of the project, between the side channels, below the OHWM, and laterally from bank-to-bank with each bed control feature extending between 5 and 10 feet into the riverbank for stability. The bed control structures would protect the main channel fill from degradation from the sediment-starved waters and protect against downstream head-cutting (Figure 4). The total volume of riprap for the bed control features would be approximately 9,600 cubic yards; 12-inch median diameter riprap would be used to trench the bed control features into the riverbed, and 6-inch median diameter riprap would be used for the low-profile surface along the channel bed (Figure 4). The rock size and structural design of the bed control features would withstand the 5-year peak flow for the bed condition.

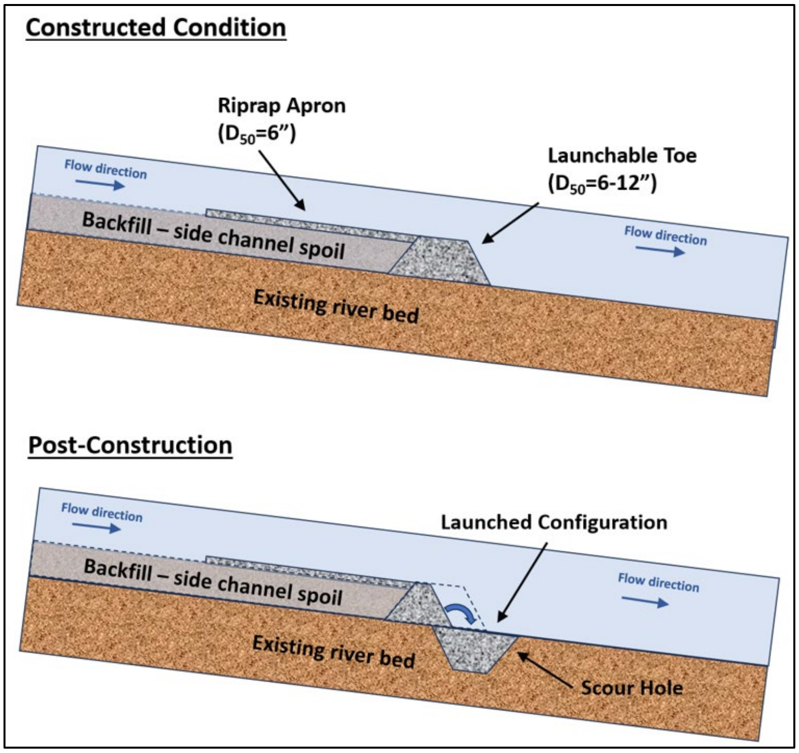

Figure 4. Schematic of a Typical Trenched Bed Control Feature with Upstream Rock Sill. (Schematic [not to scale] shows both the constructed condition and the post-construction condition including the launch of the stone toe.)

Reclamation would initially construct the bed control features as cofferdams to divert water through the side channels while filling the main channel. After diverting the Rio Grande flows, dredged material stockpiled from the side channel construction would be placed in the riverbed primarily in dry conditions, although a few pools could remain. The 1 to 3 feet of main channel fill material would be placed against the cofferdams, leaving the lower 3 feet of the cofferdams acting as the trenched bed control feature (Figure 5). The top 1 to 2 feet of the cofferdam would be removed to a low-profile surface on the upstream side of the trenched riprap (thereby creating the surface bed control feature). However, because the Corrales Siphon already has a riprap dike that acts as grade control structure, Reclamation would place additional riprap at the siphon to divert water during construction and not for grade control purposes. After construction, Reclamation would smooth the cofferdam riprap downstream at the siphon to lessen the existing riprap slope to facilitate fish passage. Reclamation would return the top of the riprap at the siphon to its preconstruction elevation of 5,031.5 feet. If the existing riprap dike would be removed by the MRGCD before or during the RM 199 project construction, the cofferdam at the siphon would be modified to serve as another bed control feature at this location.

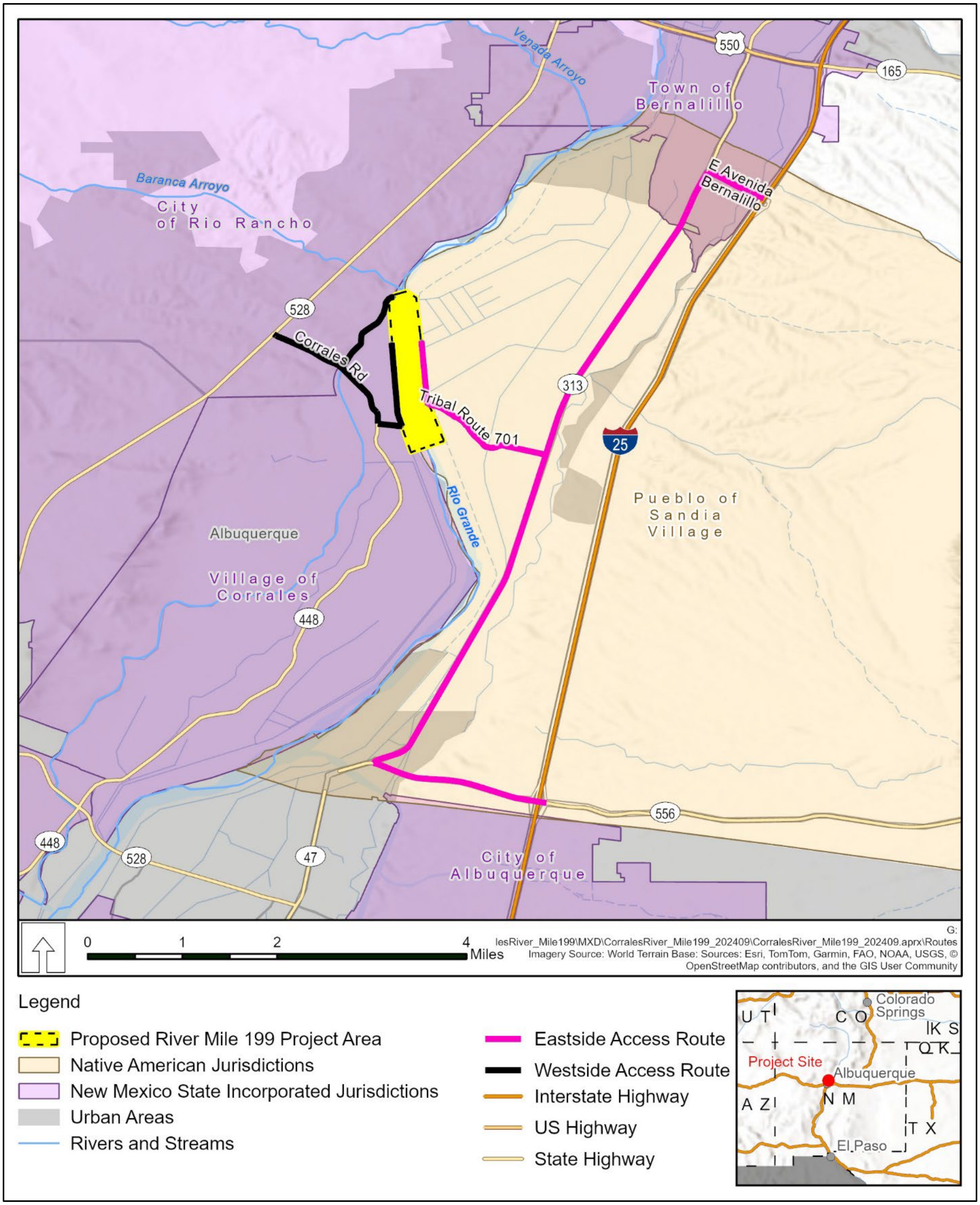

Figure 5. Corrales River Mile 199 Proposed Construction Access Routes

2.1.5 Site Access and Staging

Construction equipment would access the project site on both the east and west sides of the Rio Grande at specified access routes (see Figure 2). Additionally, 4.5-acre and 7.0-acre staging and material stockpile areas would be located on both the west and east sides of the Rio Grande, respectively (see Figure 2). Riprap would only be delivered on the east side of the river; construction mobilization would occur after riprap delivery to the east-side staging areas. The west-side staging areas would only be used for temporary storage of construction equipment.

The access route to the east-side staging area at the BB-343 Bend would follow from Interstate 25 through State Route 313 to Tribal Route 701 towards the Sandia Pueblo Canal Road (see Figure 5). To haul material and equipment from the east to the west side, Reclamation would occasionally cross the river. Crossing could sometimes occur in the wet or could occur in the dry after the river has been diverted in the constructed side channels.

The access route to the west-side staging area at the RM 199 Bend would follow State Route 448 towards the Corrales Siphon Road near Paseo Cesar Chavez and then follow the levee road towards the RM 199 Bend (see Figure 5), just upstream of the Harvey Jones Channel. Alternatively, Reclamation would take the Corrales Road to the Harvey Jones Channel and then travel north along the levee road to access the west-side staging area. This route is owned by the Southern Sandoval County Flood Control Authority (SSCAFCA); Reclamation would obtain a right-of-entry from SSCAFCA if this route would be used. Additional access routes would be created through the bosque from the staging and stockpile areas both on the west and east side for river access (see Figure 2).

2.1.6 Construction Sequencing

Reclamation would sequence the various Corrales RM 199 project construction activities proceeding from downstream at the RM 199 Bend protection feature to upstream at the Corrales Siphon Bend bed control feature and side channels. Table 1 provides the anticipated construction sequencing for the project; however, the exact sequence may vary in the field. If approved, Reclamation anticipates that construction would be completed in an eight-month construction season between 15 August 2025 and 15 April 2026; however, work could extend into the next construction season depending on complexity and workload for the construction crew.

Table 1. Corrales River Mile 199 Anticipated Construction Sequencing

Construction Sequence Step	Location	Construction Sequence Description
1	RM 199 Bend	Excavate the side channel on the RM 199 point bar, leaving the entrance and exit plugs in place. Stockpile excavated material on the inside of the RM 199 point bar. Remove entrance and exit plugs to allow flow through the side channel.
2	RM 199 Bend	Build temporary riprap cofferdam diversions immediately downstream and upstream of the RM 199 side channel entrance and exit, respectively, within the main channel. All flows would be temporarily diverted to the side channel, and the RM 199 bend would be temporarily dry. On the RM 199 outer bend, construct the LSTP. Place excavated material from the side channel in the (dry) main channel and fill in behind the LSTP for the floodplain bench.
3	RM 199 Bend	Smooth the riprap from the downstream temporary diversion cofferdam (immediately upstream the RM 199 side channel exit) onto the material placed in the main channel. Leave the upstream temporary riprap diversion cofferdam at the RM 199 side channel entrance in place.

Construction Sequence Step	Location	Construction Sequence Description
4	BB 343 Bend	Excavate the side channel along the BB-343 Bend point bar, leaving the entrance and exit plugs in place. Stockpile excavated material on the inside of the point bar. Remove the entrance and exit plugs to allow flow through the excavated side channel.
5	BB-343 Bend	Build a temporary riprap diversion cofferdam immediately downstream of the BB-343 Bend side channel entrance, temporarily diverting flows. The side channel and the BB-343 Bend would be temporarily dry. On the BB-343 outer bend, construct the LSTP. Place the side channel's spoil material in the (dry) main channel and fill in behind the LSTP for the floodplain bench.
6	Between the RM-199 and BB-343 Bends	At the temporary riprap diversion cofferdam between the BB-343 and RM 199 Bends, smooth the riprap onto the spoiled/fill material now placed upstream and downstream of the temporary riprap diversion cofferdam. This feature would act as a grade control for the channel bed to prevent the erosion of fill material.
7	Corrales Siphon Bend	Excavate the side channel on the Corrales Siphon point bar, leaving the entrance and exit plugs in place. Stockpile the excavated material on the inside of the Corrales Siphon point bar. Place a small layer of riprap immediately downstream of the siphon's alignment and inside the side channel to minimize potential downcutting to the siphon. Remove the entrance and exit plugs to allow flow through the side channel.
8	Corrales Siphon Bend	Build a temporary riprap diversion cofferdam on top of the Corrales Siphon's downstream riprap protection installed by MRGCD. If MRGCD is opposed to a temporary riprap diversion cofferdam on top of the siphon's riprap protection, the cofferdam could also be placed closer to the upstream entrance of the side channel. However, this configuration would require a much longer cofferdam. All flows would be temporarily diverted to the side channel, and the Corrales Siphon Bend would be temporarily dry. On the Corrales Siphon Bend, construct the LSTP. Place the side channel's excavated material in the (dry) main channel and fill in behind the LSTP for the floodplain bench.
9	Between the BB-343 and Corrales Siphon Bends	At the temporary riprap diversion cofferdam between the Corrales Siphon and BB-343 Bends, smooth the riprap onto the fill material in the main channel, now placed upstream and downstream of the cofferdam. This feature would act as grade control for the channel bed to prevent erosion of the fill material. At the temporary riprap diversion cofferdam at the Corrales Siphon, smooth the extra riprap in the downstream direction to create a smooth slope with a downstream apron for extra scour protection.

RM – river mile; **LSTP** – longitudinal stone toe protection; **MRGCD** – Middle Rio Grande Conservation District

2.1.7 Construction Quantities

Table 2 provides a summary of the anticipated construction quantities for the three LSTP features, excavation of the three side channels, fill volumes in the main channel, and deformable bed control features. The estimated surface areas associated with the proposed construction components that would be disturbed are:

- LSTP: 2.25 acres
- Side Channel Excavation: 21.10 acres
- Main Channel Fill: 17.48 acres
- Bed Control Features: 1.72 acres

Table 2. Summary of Anticipated Quantities and Areas of Impact for the Corrales River Mile 199 Project

Proposed Project Construction Component	Anticipated Quantity (cubic yards)
Longitudinal Stone Toe Protection	
Volume of Riprap for Corrales Siphon Bend (Volume of the total riprap below OHWM)	3,140 (2,020)
Volume of Riprap for BB-343 Bend (Volume of the total riprap below OHWM)	4,480 (2,880)

Proposed Project Construction Component	Anticipated Quantity (cubic yards)
Volume of Riprap for RM-199 Bend (Volume of the total riprap below OHWM)	5,550 (3,570)
Total Volume of Riprap (Volume of Total Riprap below OHWM)	***13,170 (8,470)***
Side Channel Excavation	
Volume of Excavated Material at the Corrales Siphon Side Channel	10,810
Volume of Excavated Material at the BB-343 Bend Side Channel	18,200
Volume of Excavated Material at the RM-199 Bend Side Channel	21,014
Total Volume of Excavated Material	***50,024***
Main Channel Fill	
Corrales Siphon Bend Main Channel Fill Volume	12,174
BB-343 Bend Main Channel Fill Volume	22,839
RM-199 Bend Main Channel Fill Volume	14,957
Total Volume of Channel Fill	***49,970***
Bed Control Features	
Trenched Bed Control below Corrales Siphon Bend Rock Volume	254
Surface Bed Control below Corrales Siphon Bend Rock Volume	2,026
Trenched Bed Control below BB-343 Bend Rock Volume	133
Surface Bed Control below BB-343 Bend Rock Volume	1,601
Trenched Bed Control below RM-199 Bend Rock Volume	97
Surface Bed Control below RM-199 Bend Rock Volume	2,525
Rock Volume of Tie-ins	404
Total Volume of Bed Control Features	***7,040***

OHWM – ordinary high water mark

2.1.8 Monitoring and Adaptive Management

The Corrales RM 199 project area has been actively monitored by Reclamation since it was first identified as a river maintenance concern in 2019. The current monitoring effort includes at a minimum 1) regular site visits to the project site and both riverbanks, 2) aerial photography collection during high flow, springtime runoff events, 3) regular use of ground-level photographs to record site changes, and 4) estimations of the rate of bankline retreat. Most recently, Reclamation completed a short-term bank protection project on the west bank of the Rio Grande at the Corrales Siphon Bend due to the high runoff season observed in 2023 and the resulting lateral migration of the bend towards the Corrales levee (approximately 150 feet from the Corrales levee). The Proposed Action would include regular, ongoing technical monitoring and adaptive management, as monitoring the natural response of the river channel following the proposed construction activities at the project site is integral to understanding project success. Additionally, Reclamation would monitor channel bank conditions in the near-term, which would consist of field monitoring of rock launching from the LSTP and estimating bankline recession following significant flow events exceeding the 2-year flood return period. The frequency of these measurements would be coordinated with Pueblo of Sandia staff (for the east bank) and MRGCD and the Village of Corrales (for the west bank).

After project completion, Reclamation would also conduct regular field inspections of the side channel features on all sides of the river to ensure that the channel continues to maintain its design capacity following the Clean Water Act (CWA) regulation from the USACE and the NMED. Following planted vegetation establishment, the LSTP would provide adequate foundational stability to the bank slope while the rooted vegetation would add slope support to the upper two-thirds of the bankline. After this, the capacity of the side channels would be of less importance. The side channels would be allowed to become riparian habitat unless leaving the channels open was determined as vital to the overall project's success by the Pueblo of Sandia staff, MRGCD, or by the Reclamation Project Engineer. Actions that could trigger maintenance include launching of the LSTP features and/or substantial erosion threatening any new sections of the levee. Overall, the side channels would be expected to fill in over time as sediment deposits and vegetation become established. Rehabilitation of the side channel features could be needed over time to restore function at the desired flow range. The bed features would eventually fail over time as a function of mobilization by peak flows. As needed, these features may be maintained for up to 5 years and the impacts would be similar or less than the initial construction, including access, vegetation removal, and sediment removal and disposal. Remedial action on the deformable bed control features would not be expected unless the features become damaged or rendered ineffective somehow in the early years of the project.

Monitoring for environmental compliance would include photograph points to monitor vegetation establishment, topographic surveys documenting any geomorphic development, and targeted hydrographic monitoring to identify benefits to aquatic habitat for the RGSM.

2.1.9 Best Management Practices

Table 3 provides the Best Management Practices (BMPs) that would be implemented as part of the Proposed Action to minimize the risk of effects to the human and natural environment from the RM 199 project.

Table 3. Best Management Practices to Be Implemented with the Proposed Action

Best Management Practice	Implementation Description
RGSM - 1	To reduce impacts on the RGSM, seining will be conducted in standing water after main channel flows are diverted to side channels or when side channel flows are diverted back to the main channel. USFWS and Reclamation biologists, or a contractor will conduct this work and return any stranded RGSM back to the flowing water outside of the construction area's footprint.
Implementation Timing - 1	Reclamation would seek to avoid impacts on neotropical migratory nesting birds protected by the MBTA, including the federally endangered SWFL (*Empidonax traillii extimus*; flycatcher), protected under the ESA, by conducting work activities outside of the normal breeding and nesting season (15 April to 1 September).
Implementation Timing - 2	If work is necessary between 15 April and 1 September, suitable/occupied migratory and listed bird species habitat will be avoided during the construction activities as much as possible, utilizing the most currently available survey results in conjunction with habitat suitability. Reclamation will establish appropriate work avoidance zones for any nesting birds observed during surveys in the project area. Coordination and consultation with the USFWS will occur prior to such work activities.
Implementation Timing - 3	Reseeding or revegetation would be accomplished by hand or by mechanized means. Planting via mechanized means would use a hand-held or tractor-mounted auger. If Reclamation implements mechanized means for either reseeding or replanting in the 15 April to 1 September timeframe, migratory bird surveys will be conducted immediately prior to the work to determine if any breeding birds are present. If birds are detected, Reclamation will coordinate with the USFWS to determine appropriate next steps.
Water Quality - 1	Reclamation will obtain all applicable permits prior to implementation of the project, including authorizations and certifications required under various sections of the CWA. Reclamation will comply with the requirements of the CWA and other permits associated with the project, including required reporting to the appropriate authorities as needed. Reclamation will not begin work until all required permits are obtained.

Best Management Practice	Implementation Description
Equipment and Operations - 1	Reclamation will visually monitor for water quality in the areas below locations of river work before and during the workday. Water quality will be monitored during construction and after equipment operates in the river channel. Monitoring will include visual observations and may include direct sampling, as appropriate.
Equipment and Operations – 2	If direct sampling would be needed, water-quality parameters to be tested include pH, temperature, dissolved oxygen, and turbidity. Parameters will be measured both upstream and downstream of the work area.
Equipment and Operations – 3	Responses to changes in water-quality measures exceeding the applicable standards will include reporting the measurements to the NMED Surface Water Quality Bureau and moving construction activities away from the shore Equipment and Operations.
Equipment and Operations – 4	Reclamation-led work activities that have the potential for adverse impacts will be monitored by properly trained Reclamation personnel to ensure compliance.
Equipment and Operations – 5	Reclamation will excavate an area as few times as possible to minimize disturbance of sediments. When placing fill within the wetted channel, Reclamation will minimize the movement of excavator trucks and minimize excavator bucket contact with the riverbed to reduce disturbance of sediments.
Equipment and Operations – 6	Each individual operator will be briefed on local environmental considerations specific to the project tasks.
Equipment and Operations – 7	To minimize potential for spills into or contamination of aquatic habitat the following will be implemented. 1) Hydraulic lines will be checked each morning for leaks and periodically throughout each workday. Any leaky or damaged hydraulic hoses will be replaced. 2) All fueling will take place outside the active floodplain, where possible. All fueling will occur with a spill kit ready. If amphibious excavators are used, fueling will occur at the Rio Grande using airboats equipped with lined fuel containment. Fuel, hydraulic fluids, and other hazardous materials may be stored on-site overnight, but outside the normal floodplain, not near the Rio Grande or any location where a spill could affect the river. 3) All equipment will undergo high-pressure spray cleaning and inspection prior to initial operation in the project area. 4) All equipment will be parked on pre-determined locations on high ground away from the Rio Grande overnight, on weekends, and holidays. 5) Spill protection kits will be on-site, and operators will be trained in the correct deployment of the kits. 6) When there is increased risk of puncture of external hydraulic lines, such as during mastication while removing vegetation, external hydraulic lines will be covered with additional puncture resistant material (i.e., steel mesh guards, Kevlar, etc.) to offer additional protection.
Equipment and Operations – 8	Equipment will be removed from the channel in the event of high storm surges.
Equipment and Operations – 9	To allow fish time to leave the area before in-water work begins, equipment will initially enter the water slowly. In-water work will be continuous during workdays, so that fish are less likely to return to the area once work has begun.
Equipment and Operations – 10	Riprap to be placed in the water will be reasonably clean to the extent possible. If there are large clumps of soil bigger than 1 foot within the riprap, those clumps will be set aside during the loading or placing operations.
Access and Staging - 1	Impacts on terrestrial habitats will be minimized by using existing roads whenever possible. In general, equipment operation will take place in the most open area available, and all efforts will be made to minimize damage to native vegetation and wetlands (also see BMP titled Vegetation Replanting and Control).
Access and Staging - 2	All necessary permits for access points, staging areas, and study sites will be acquired prior to construction activity.
Vegetation Replanting and Control - 1	A variety of revegetation strategies could be used such as stem and pole cuttings, long stem transplants, and upland planting with and without a polymer, zeolite, or similar compound to maximize soil water retention. Planting techniques could vary from site to site, and consist of buckets, augers, stingers, and/or water jets mounted on construction equipment. In some areas, a trench could be constructed to facilitate the placement of a significant number of plants, specifically stem and pole cuttings. Seeding would be accomplished using a native seed drill, where feasible, and spread with a protective covering, which would provide moisture to the seeds.

Best Management Practice	Implementation Description
Vegetation Replanting and Control – 2	Vegetation control may consist of mechanical removal, burning, mowing, and/or herbicide treatment. Herbicides will be used when non-chemical methods are unsuccessful or are not economically feasible (see BMP titled Herbicide and Pesticide Use).
Vegetation Replanting and Control – 3	Vegetation control will be completed between 15 August and 1 September to avoid adverse impacts on migratory nesting birds and their associated habitats. Any need for deviations from this work window will be considered on a project-specific basis and coordinated with the USFWS. If work is planned between 15 April and 15 August, Reclamation will conduct surveys for nesting birds to determine the presence of migratory birds. Reclamation and/or the appropriate project partner will coordinate monitoring and work activities with the USFWS, as appropriate, if bird nests are found.
Vegetation Replanting and Control – 4	Native vegetation at work sites will be avoided to the extent possible. If large, native woody vegetation (primarily cottonwoods [*Populus* spp.]), need to be trimmed or removed, they will be replaced at a ratio of 10:1 (replantings:removed vegetation). When and where possible, small, native woody vegetation will be removed or harvested at the appropriate season to use for revegetation work at another location in the project area or at another project site. Native vegetation that cannot be replanted may be mulched (mulch will be removed or spread on-site at a depth of three inches or less) or temporarily stockpiled and used to create dead tree snags or brush piles in the project area upon completion.
Vegetation Replanting and Control – 5	Nonnative vegetation that is removed at work sites will be mulched, burned, or removed offsite to an approved location. Mulched vegetation may also be spread on-site at a depth of three inches or less.
Herbicide and Pesticide Use - 1	The use of chemical pesticides may be necessary to control undesirable plant species around stockpile sites and storage yards and to prevent the spread of invasive species in areas cleared for maintenance activities. Because the application of herbicides and chemical spraying is regulated, Reclamation will follow all state and federal laws and regulations applicable to herbicide application, including guidelines described by White (2007). Pesticides will not be directly applied to or near water unless they are labeled for aquatic use and appropriate buffers will be observed. Communication with the USFWS will occur prior to any application to sites with threatened or endangered wildlife species.
Herbicide and Pesticide Use - 2	Reclamation will follow the Albuquerque Area Office Integrated Pest Management Plan and Pesticide General Permit when applying pesticides. The Reclamation project partners will follow their agencies' pesticide guidance, if they have pesticide use guidance. Pesticides may be applied using low pressure spray rigs mounted OHVs, trucks and trailers with spray bars, or backpack sprayers (for spot applications). Treatments will be conducted by trained and approved personnel observing appropriate buffer distances and label directions. Treatment will not take place when winds exceed 10 miles per hour or when rain is forecasted for the local area within 48 hours of application. Care will be taken when mixing or applying any pesticides to avoid runoff onto the ground or into the water. Surfactants may also be added to certain herbicides to maximize performance and minimize retreatments.
Dust Abatement - 1	If water is needed for dust abatement or to facilitate grading of roads, water may be pumped from the Rio Grande, irrigation drains, sumps, or secondary channels adjacent to the river. During irrigation season (1 March to 31 October), water will not be pumped from the river but will be pumped from the irrigation drains if possible. Pumping from the river is not expected to be needed between 15 April and 15 August. However, if pumping is needed between 1 May and 1 July (emergencies only), Reclamation and/or the appropriate project partner(s) will coordinate with the USFWS to avoid impacts on minnow eggs and larvae. Outside of the irrigation season, an amount not to exceed 5 percent of river flows at the time of pumping may be drawn from the Rio Grande. Pumping is short duration (minutes) for filling whatever water transport equipment is used. Sumps or secondary channels adjacent to the river will be used, whenever feasible. Pump intake pipes will use a 0.25-inch (0.64-centimeter) mesh screen at the opening of the intake hose to minimize entrainment of aquatic organisms.

Best Management Practice	Implementation Description
Monitoring - 1	All treatment and control areas will be monitored for three years following construction to determine the effectiveness of the methods implemented and identify project-related hydrologic and geomorphic alterations. The monitoring will consist of biological, vegetation, geomorphic, and hydrologic monitoring, as appropriate to the project design and purpose.
Spoil and Waste Disposal - 1	All project spoils and waste will be disposed of offsite at approved locations or may be used on-site as appropriate to the project purpose, consistent with applicable environmental requirements.
Portable Restrooms - 1	All work projects will have a contract in place for the rental of portable restroom facilities for the duration of the project.

RGSM – Rio Grande Silvery Minnow; **MBTA** – Migratory Bird Treaty Act; **SWFL** – southwestern willow flycatcher; **ESA** – Endangered Species Act; **USFWS** – U.S. Fish and Wildlife Service; **CWA** – Clean Water Act; **NMED** - New Mexico Environment Department; **BMP** – Best Management Practice; **OHV** – off-highway vehicle

2.1.10 Agreements, Authorizations, and Consultations

The Proposed Action, if approved, would require the following permits and/or authorizations prior to implementation:

- Authorization under the CWA Section 404 from the USACE
- Authorization under the CWA, Section 401 from NMED and the Pueblo of Sandia
- Endangered Species Act (ESA) Section 7 memo to the U.S. Fish and Wildlife Service (USFWS) for inclusion under the 2016 Biological Opinion
- National Historic Preservation Act (NHPA) Section 106 concurrence has been received from the New Mexico State Historic Preservation Office (SHPO)
- Dust abatement using water from Rio Grande outside irrigation season; during irrigation season take water from irrigation drains

Reclamation would comply with all applicable federal, state, and local laws and regulations, as well as obtain the necessary permits for the implementation of the proposed action. These laws and regulations include, but are not limited to, the following:

- Antiquities Act of 1906, as amended (Public Law [PL] 52-209; 16 United States Code [USC] 431-433)
- American Indian Religious Freedom Act of 1978 (PL 95-431; 92 Stat. 469; 42 USC 1996)
- Archaeological Resources Protection Act of 1979 (PL 96-95; 93 Stat. 721; 16 USC 470aa et seq.), as amended (PL 100-555; PL 100-588)
- Clean Water Act, as amended (PL 107-303; 33 USC 1251 et seq.)
- Endangered Species Act of 1973, as amended (PL 93-205; 16 USC 1531 et seq.)
- Migratory Bird Treaty Act of 1918, as amended (16 USC 703-712; 50 Code of Federal Regulations (CFR) 21)
- Native American Graves Protection and Repatriation Act of 1990 (PL 101-601; 104 Stat. 3048; 25 USC 3001; 43 CFR 10)
- Section 106 of the National Historic Preservation Act of 1966 (PL 89-665; 80 Stat. 915; 16 USC 470 et seq.), as amended (implemented under regulations of the Advisory Council on Historic Preservation, 36 CFR 800)
- State Water Law, Chapter 72

2.2 No Action Alternative

Under the No Action Alternative, Reclamation would not implement design features to address the adverse river channel conditions in RM 199. Reclamation would not construct LSTP features, would not construct side channels, would not place fill in the Rio Grande channel, and would not construct deformable bed controls. Under the No Action Alternative, the Rio Grande at RM 199 would continue widening its meander belt width and possibly continue incising/disconnecting from the floodplain (while simultaneously building new floodplain on the meanders' inner point bars). This widening would threaten the levee system and post-flooding risk due to levee failure.

The No Action Alternative would not meet the project's purpose and need but is being described in this EA, as the analysis of the No Action Alternative provides a benchmark, enabling decision makers to compare the magnitude of the potential environmental effects of the Proposed Action. Further, NEPA requires an EA to analyze the No Action Alternative.

2.3 Alternatives Considered and Dismissed from Detailed Analysis

Multiple alternatives for meeting this project purpose were evaluated including bank stabilization options (e.g., longitudinal riprap protection, longitudinal woody protection) and energy dissipation options (e.g., gradient-restoration facilities [GRF]s, side channels, limited side channels, bed control features). The descriptions of the alternatives and the results of the analysis were presented to a multi-disciplinary Reclamation team to score and rank, as well as to the Pueblo of Sandia Department of Natural Resources (Appendix C). The scoring exercise found that implementation of longitudinal riprap stabilization and side channels, in combination with bed control, would best meet the goals of the project. Therefore, these combined LSTP and bed control features, and side channels compose the Proposed Action. The following five alternatives were considered but were determined to not be feasible for meeting the project's purpose and need.

2.3.1 Gradient-Restoration Facilities Alternative

This alternative would construct four two-foot to three-foot tall GRFs within the Corrales RM 199 project area. The proposed number of structures within the project area was determined using the anticipated equilibrium slope upstream of the structures (Reclamation 1987) and using the GRF spacing recommendations found in *Design Considerations for Siting Grade Control Structures* (Biedenharn and Hubbard 2001). Three GRF structures would allow the entire 2.5 mile stretch to be influenced by the GRF structures, but a fourth GRF placed at the upstream end of the reach would be needed to protect Corrales Siphon. This upstream GRF would benefit not only the siphon, but would add some stability to the degradational Arroyo de la Barranca. While GRFs would provide excellent incision protection, the incision criterion would be only one component of the overall bank protection goal. It was determined that the combined bed control and side channels would provide comparable incision protection as the GRFs but for a lower 50-year cost. Therefore, the GRFs alternative was determined to not meet the project's purpose and need and was eliminated from detailed analysis.

2.3.2 Bed Control Alternative

Additional incision is anticipated in the Proposed Action area until an armor layer is formed on the riverbed. The Bed Control Alternative would construct deformable riffles, rock sills, or riprap grade control to prevent further incision throughout the reach. These bed control features would be placed at the same slope as the existing bed. These bed control features can prevent scour and bed degradation from progressing upstream by launching riprap into the knickpoint (see Figure 4). Bed control features can also prevent degradation from sediment transport imbalances from progressing downstream (such as the incision that has progressed downstream from Cochiti Dam) by stabilizing the steepened sections, and by reducing sediment transport immediately upstream of the feature similar to GRFs. However, bed control features alone would not rehabilitate the Rio Grande planform and enhance native riparian habitat; therefore, bed control features alone were determined to not meet the project's purpose and need and would not achieve channel stabilization. Because this alternative alone would not meet the project's purpose and need, it was not carried forward for detailed analysis, but was included as a component of the Proposed Action.

2.3.3 Side Channels Alternative

This alternative would raise the riverbed by one to three feet and widen the active channel by roughly 90 feet. This would be accomplished by creating side channels through each meander's inner bend and placing the excavated materials in the main channel to raise the main channel. The side channels would be excavated such that they would flow year-round. This alternative would increase floodplain connection, reduce incision, reduce outer bank erosion, and improve habitat. These goals would be achieved by widening the river's flow area to slow velocities and decrease depths. Also, the cutoff geometry would attempt to disrupt the meandering flow path to further decrease outer bend bank erosion. Side channels would be built at all five inner bends from Corrales Siphon to the RM 198 bend. Each side channel would be built one at a time, and the cut material would be temporarily stockpiled until side channel construction is finished. First the entire river would be temporarily diverted into the side channel alignment with a temporary cofferdam near the upstream inlet of the side channel. Materials excavated from the side channel would then be placed into the existing channel along the outer bank and used to raise the existing channel bed. Lastly, the temporary cofferdam diversion would be removed, and the river would be allowed to split flows between the existing river channel and the new side channel.

It was determined that implementing the side channels alternative without riprap stabilization could successfully protect the bank for a time. However, the amount of protection provided would be uncertain, and longevity of the side channels would be much shorter than with the longitudinal riprap stabilization. Therefore, this alternative does not meet the project's purpose and need and was not carried forward for detailed evaluation. Side channel creation was, however, incorporated as a component of the Proposed Action.

2.3.4 Limited Side Channels Alternative

This alternative would create side channels through each of the meander's inner bends. The limited side channels would reduce incision, reduce bank erosion, and improve habitat by widening the river's flow area to slow velocities and decrease depths. The dimensions of the side channels would be limited by the availability of opportunities to dispose of the excavated material. The eastern side could reasonably accept 39,000 cubic yards of excavated material against the levee, while the western side could reasonably accept 10,000 to 15,000 cubic yards of excavated material to the river. The side slopes would be 4:1, which is based on Reclamation's typical MRG habitat restoration projects designed to provide good habitat for the RGSM. Flow area under this alternative would be less than the flow area under the Side Channels Alternative. The limited side channels would have greater hydraulic diversity than the side channels with multiple threads and varying inundation rates. The limited side channels would inundate at medium and high flows. However, the limited side channels would only last approximately five to ten years and would not achieve the project goals. Therefore, the Limited Side Channels Alternative does not meet the project's purpose and need and was not carried forward for detailed analysis.

2.3.5 Vegetation Destabilization

This alternative would root-plow vegetation on point bars in the early spring during a higher snowpack winter, so that the high runoff could destabilize and rework the channel in those areas. The areas for destabilization would be selected by a multidisciplinary team based on biological factors such as presence of nonnative exotic vegetation and diversification of the vegetation age classes and on engineering factors such as hydraulics and bank stability. A best-case scenario would result in the root-raked areas being scoured down to a more easily accessible elevation for future flood flows. The ground elevation would have to be low enough that a high-flow year would have deep enough flows in that area to scour away the material. The Vegetation Destabilization Alternative was determined to not provide appropriate channel incision, meandering, and narrowing control. Therefore, this alternative does not meet the project's purpose and need and was not carried forward for detailed analysis.

2.4 Comparison of Alternatives

Table 4 provides a comparison of alternatives analyzed in detail. Resource impacts are outlined for the No Action and Proposed Action Alternatives.

Table 4. Summary of Impacts for the Proposed Action and No Action Alternatives

Resource	No Action Alternative	Proposed Action Alternative
Water	No direct impacts on water quality or WOTUS. Potential indirect impacts on water resources from continued migration of the Rio Grande channel, causing increased soil erosion into surface waters, and potential erosion of and damage to levees.	Short-term minor adverse impacts on water quality from sediment transport during construction and potential for the discharge of POLs during construction. Long-term minor beneficial impacts on water quality from channel stabilization and revegetation. Proposed project features would have potential impacts on WOTUS. These impacts are assessed and included in the CWA Section 404 and 401 applications to the USACE and NMED, and resulting guidance and requirements from these agencies for this project will be adhered to in the construction phase.
Access, Transportation, and Safety	No impacts on access and transportation. Potential for moderate, indirect adverse impacts on safety as the Rio Grande levees would be at risk of damage due to Rio Grande channel migration.	Short-term minor adverse impacts on access and transportation from additional vehicles and equipment commuting to the project area during construction. Short-term, negligible, adverse impacts on safety inherent to construction activities.

Resource	No Action Alternative	Proposed Action Alternative
Air Quality	No impacts on air quality. Continued channel migration and potential damage to the flood risk reduction levee could cause short-term increased air emissions from construction equipment in the process of emergency levee repairs.	Short-term, minor, adverse air quality impacts from fugitive dust and combustion emissions during construction activities. Because the AQCR is in attainment for all criteria pollutants, there would be no significant air quality impacts from the short-term increase in combustion emissions.
Noise	No impacts on noise. Potential levee damage from continued channel migration could cause short-term noise from construction equipment in the process of emergency levee repairs.	Short-term, negligible, adverse impacts on noise from construction equipment and construction worker vehicles during commutes. Construction noise would be limited to the proposed project area within the floodplain of the Rio Grande.
Visual Resources	No direct impacts on visual resources because the project would not be constructed. Potential future levee damage from the encroachment of the Rio Grande channel on the levee toe could cause short-term impacts on visual resources as the flood risk reduction levee is repaired.	Short-term, adverse impacts on visual resources as a result of the removal of vegetation, establishment of staging areas, use of heavy construction equipment, parking of construction worker vehicles, and channel protection features would all decrease the visual appeal of the Rio Grande riparian area. Long-term adverse impact on visual resources from the removal of mature cottonwood trees.
Public Recreation	No direct impacts on public recreation. The continued channel incision and migration of the Rio Grande towards the flood risk reduction levees could place the integrity of the levees at risk, which would require limitations on public access to those levees and the Rio Grande floodplain.	Short-term adverse impacts on recreation as construction activities would limit recreational opportunities within the Rio Grande floodplain due to restrictions on public access.
Vegetation	No direct impacts on vegetation. Continued channel migration and potential damage to the flood risk reduction levee could damage native riparian plant species in the Rio Grande floodplain and cause vegetation removal in the process of emergency levee repairs.	Short-term, minor, adverse impacts from the removal of vegetation in staging areas on both sides of the Rio Grande. Long-term minor, adverse impacts from the removal of mature cottonwood trees. Long-term minor beneficial impacts on vegetation from the revegetation of disturbed area with native vegetation, likely replacing some invasive vegetation with native vegetation.
Invasive Species	Invasive plant species would continue to persist and potentially spread as the migrating channel would disturb soils leading to increased areas for colonization of invasive species.	Long-term, negligible, beneficial impacts on invasive species as some invasive plant species would be removed during construction and in those areas revegetated with native plant species.
Wildlife	There would be no impacts on wildlife.	Short-term, minor, adverse impacts on wildlife as construction activities, including equipment noise and equipment movement, have the potential to directly injure or kill wildlife, or cause stress to wildlife as species flee the movement and noise from equipment.
Threatened and Endangered Species	There would be no effects on any listed species.	The project is not anticipated to affect the NMMJM, SWFL, MSO, or YBCU. May affect and is likely to adversely affect the RGSM. Would adversely affect 2.4 acres of moderately suitable habitat for the SWFL. There is no critical habitat for RGSM, SWFL, or YBCU in the project area. Incidental take of the RGSM and loss of moderately suitable SWFL habitat are included in Reclamation's annual accounting and reporting procedures to the USFWS for the 2016 BO, which will include post-project refined areas across these types of covered projects.

Resource	No Action Alternative	Proposed Action Alternative
Cultural Resources	No direct effects to historic properties. Ongoing erosion in the project area could damage known and unknown cultural resources resulting in indirect impacts.	Because of the degradation and loss of integrity that has already occurred for both the Corrales Acequia Madre and Corrales Main Siphon sites within the APE, on 25 March 2025 the New Mexico SHPO concurred with Reclamation's determination that the proposed undertaking would have no effect on historic properties.
Soils	No impacts on soils.	Short-term adverse impacts on soils from disturbance during the clearing of vegetation for staging areas, side channel construction, and the recontouring of the banks to stabilize the river bends.

WOTUS – waters of the U.S.; **CWA** – Clean Water Act; **USACE** – U.S. Army Corps of Engineers; **NMED** – New Mexico Environment Department; **POL** – petroleum, oils, and lubricants; **AQCR** – Air Quality Control Region; **RGSM** – Rio Grande silvery minnow; **NMMJM** – New Mexico meadow jumping mouse; **SWFL** – southwestern willow flycatcher; **MSO** – Mexican spotted owl; **YBCU** – yellow-billed cuckoo; **BO** – Biological Opinion; **USFWS** – U.S. Fish and Wildlife Service; **APE** – Area of Potential Effects; **SHPO** – State Historic Preservation Office

CHAPTER 3 - AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

3.1 Introduction

This chapter discusses resources that would be affected by the Proposed Action Alternative and the No Action Alternative. For each resource, the affected area and/or interests are identified, and the existing conditions and impacts are described under the No Action and Proposed Action Alternatives. This section concludes with a summary of impacts.

3.2 Water Resources

Water resources include surface waters, groundwater, and floodplains. Surface waters include all lakes, ponds, rivers, streams, impoundments, and wetlands within a defined area or watershed. Wetlands are transitional areas between terrestrial and aquatic systems with land covered by shallow surface water. Groundwater resources include water contained in soils, permeable and porous rock, or unconsolidated substrate. Floodplains are areas that are flooded periodically by the lateral overflow of surface water bodies.

3.2.1 Water Quality

3.2.1.1 *Affected Environment*

Section 303(d) of the Clean Water Act (CWA) authorizes the U.S. Environmental Protection Agency (USEPA) to assist states, territories, and authorized tribes in listing impaired waters and developing Total Maximum Daily Loads (TMDLs) for these waterbodies. Section 303(d) requires that states review, make necessary changes, and submit the 303(d) list to the USEPA. That 303(d) list describes surface waters not meeting water quality standards. State of New Mexico water quality standards are published in Title 20, Chapter 6, Part 4 of the New Mexico Administrative Code (NMAC), *Standards for Interstate and Intrastate Surface Waters*, as amended by the New Mexico Water Quality Control Commission and approved by the USEPA on 12 September 2018. The designated uses for this portion of the MRG, as defined by the water quality standards, are irrigation, marginal warmwater aquatic life, livestock watering, wildlife habitat, and secondary contact. Criteria for this reach include:

1) In any single sample, pH within the range of 6.6 to 9.0 and temperature 32.2 degrees Celsius (90 degrees Fahrenheit) or less. The use-specific numeric criteria set forth in 20.6.4.900 NMAC are applicable to the designated uses listed above in Subsection A of this section.

2) The monthly geometric mean of Escherichia coli (E. coli) bacteria 126 cfu/100 mL or less; single sample 410 cfu/100 mL or less (see Subsection B of 20.6.4.14 NMAC).

3) At mean monthly flows above 100 cfs, the monthly average concentration for: TDS l,500 mg/L or less, sulfate 500 mg/L or less and chloride 250 mg/L or less. [20.6.4.105 NMAC - Rp 20 NMAC 6.1.2105, 10-12-00; A, 05-23-05.

The Rio Grande in Assessment Unit ID: NM-2105.1_00 is an impaired water in Section 303(d) list. This segment of the Rio Grande is listed as being impaired for livestock watering, marginal warmwater aquatic life, primary contact, and wildlife habitat. Impairments come from parameters that do not meet state or tribal-specific water quality standards such as mercury and polychlorinated biphenyls (PCBs) for fish consumption, and E. coli for primary contact (USEPA 2025). The USEPA has approved a plan prepared by the Surface Water Quality Bureau to address the TMDL for E. coli in the MRG (Surface Water Quality Bureau 2010).

3.2.1.2 *Environmental Consequences*

No Action Alternative:

Under the No Action Alternative, there would be no impacts on water quality because there would be neither ground-disturbing activities nor alterations to surface waters from construction. There would be no equipment use, and therefore, no risk of petroleum, oils, and lubricants (POLs) from construction equipment entering surface waters in the project area.

Proposed Action Alternative:

There would be short-term, minor adverse impacts and long-term, minor beneficial impacts on water quality from the implementation of the Proposed Action Alternative. During construction, excavation and grading activities have the potential to distribute sediments into the Rio Grande. However, all BMPs listed in Section 2.1.9 would be implemented to reduce erosion to the maximum extent possible. Work in the river channel would be performed in the dry as much as is reasonably achievable. However, unpredictable weather conditions and the placement of fill to raise the riverbed would cause short-term soil erosion and sediment deposition into the Rio Grande, which would be minimized through the use of BMPs.

The quantity of POLs used in vehicles and equipment would increase in the RM 199 project area during construction. However, all hazardous materials required for construction operations would be properly tracked and maintained, and only the smallest quantities necessary to support the construction would be used. Further, all hazardous waste generated as a result of construction activities would be disposed of properly and in accordance with federal, state, and local regulations. Following the BMPs described in Section 2.1.9 during construction activities would ensure the proper handling of hazardous materials such as POLs and disposal of hazardous wastes, greatly reducing the risk of soil and water contamination.

One of the primary drivers of the proposed RM 199 project is to protect the levee system from degradation, and thus sediment load into the river due to bank erosion. The Proposed Action Alternative would stabilize the riverbanks and levee system thus reducing long-term erosion. Further, proposed post-construction restoration would reduce long-term erosion, providing a beneficial impact on water quality.

Reclamation will obtain all applicable permits prior to implementation of the project, including authorizations and certifications required under various sections of the CWA (33 U.S.C 1251–1387; CWA). Reclamation will comply with the requirements of the CWA and other permits associated with the project, including required reporting to the appropriate authorities as needed and will not begin work until all required permits are obtained.

3.2.2 Waters of the U.S.

Waters of the U.S. (WOTUS) is a threshold term in the CWA and can include rivers, streams, and wetlands as well as other jurisdictional waterways. Rivers and streams are defined by the presence of an ordinary highwater mark (OHWM) and the presence of a defined bed and bank. An OHWM is a line on the bank/shore established by the fluctuations of water and indicated by physical characteristics, or by other appropriate means that consider the characteristics of the surrounding areas (see 33 CFR 328.3(e)). The stream bank is the part of the stream channel between the bed's lateral margins when normally wetted at baseflow and at bankfull height, where flood flows begin to spread laterally over the floodplain (Florsheim et al. 2008).

Inland/non-tidal wetlands are most common on floodplains along rivers and streams (riparian wetlands), in isolated depressions surrounded by dry land (for example, playas, basins and "potholes"), along the margins of lakes and ponds, and in other low-lying areas where the groundwater intercepts the soil surface or where precipitation sufficiently saturates the soil (vernal pools and bogs). According to the USACE (1987), for an area to be considered a jurisdictional wetland, it must contain the following three parameters under normal circumstances: 1) the presence of wetland hydrology showing regular inundation, 2) a predominance of hydrophytic (water-loving) vegetation, and 3) soils characteristic of frequent saturation (i.e., hydric soils). The presence or absence of wetlands was identified in the field using routine on-site delineation methods outlined in the *Corps of Engineers Wetlands Delineation Manual* (USACE 1987) and the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region* (Version 2.0) (USACE 2008).

3.2.2.1 *Affected Environment*

Reclamation conducted a survey of WOTUS, including the potential for wetlands within the proposed project area. There are no jurisdictional wetlands in the proposed RM 199 project area. Potentially jurisdictional WOTUS in the project area are defined by the Rio Grande channel below the OHWM. A CWA Section 404 permit application package for proposed dredge and fill activities in WOTUS in the project area was submitted to the USACE, while a CWA Section 401 permit application package for proposed dredge and fill activities in the WOTUS was sent to the NMED.

3.2.2.2 *Environmental Consequences*

No Action Alternative:

Under the No Action Alternative, there would be no direct impacts on WOTUS because the project would not be constructed. However, continued channel migration and potential damage to floodplain levees could cause filling of the Rio Grande channel with eroded sediments and loss of the total area of WOTUS from bank narrowing and continued encroachment of vegetation in the proposed project area.

Proposed Action Alternative:

Proposed project features would have potential impacts on WOTUS. These impacts are assessed and included in the CWA Section 404 and 401 applications to the USACE and NMED. The resulting guidance and requirements from these agencies following issuance of CWA permits for this project will be adhered to in the construction phase. However, these features would not permanently alter the surface area of potentially jurisdictional WOTUS in the project area.

Following the completion of the proposed RM 199 project, approximately 5.4 acres of the floodplain between the LSTP and the existing riverbank would be converted to wetlands. Pole plantings would be incorporated into the wetland conversion areas. Therefore, although there would be temporary impacts on WOTUS from the Proposed Action Alternative, long-term benefits would be achieved from the stabilization of the Rio Grande channel and the creation of approximately 5.4 acres of additional wetlands. A CWA Section 404/401 permit application has been submitted to the USACE Albuquerque District Regulatory Division and to NMED for permission to fill jurisdictional WOTUS in support of the RM 199 project.

3.3 Access, Transportation, and Safety

Transportation is defined as the system of roadways, highways, and transit services that are in the vicinity of the installation and could be reasonably expected to be potentially affected by the Proposed Action.

A safe environment is necessary to prevent or reduce the potential for death, serious injury and illness, or property damage. Safety and human health issues address workers' safety and health during construction, as well as employee safety during the daily operations of the facilities. The Occupational Safety and Health Administration's (OSHA's) program's purpose is to protect personnel from occupational deaths, injuries, or illnesses; OSHA safety guidance published in the Department of Labor 29 series CFR governs general safety requirements relating to general industry practices (Section 1910), construction (Section 1926), and elements for federal employees (Section 1960). These standards include guidance for entry into areas in which a hazard may exist.

3.3.1 Affected Environment

Public roads, especially state and county roads, and even private roads generally provide ingress and egress through the areas and mobility for residents proximate to the proposed project area. The Village of Corrales on the west side of the Rio Grande maintains a moderate public road infrastructure. The east side of the Rio Grande is relatively sparsely developed and on land owned by the Pueblo of Sandia. Interstate 25, located east of the Rio Grande and the project area, crosses the Pueblo of Sandia and is the main north-south access road in metropolitan Albuquerque (see Figure 6). Other main public roads in the area are State Highway 313, which provides access to the project area from east, State Highway 448/Corrales Road and State Highway 528, which provide access to the project area from the west.

The average annual weekday traffic count in 2023 (Mid-Region Council of Governments 2024a) for the major roads proximate to the project area were:

- Interstate-25 at Alameda Boulevard (State Highway 528): 87,900
- State Highway 313 at Santa Fe Trail Road: 4,500
- Corrales Road (State Highway 448) at State Highway 528: 5,900
- State Highway 528 at Corrales Road (State Highway 448): 25,500

The intersection of Westside Boulevard and State Highway 528 in the Village of Corrales was ranked in 2023 as the eleventh highest approach volume intersection in the Albuquerque Metropolitan Planning Area (Mid-Region Council of Governments 2024b). No other intersections proximate to the project area had high volume rankings in 2023.

Channel widening and migration pose safety risks to the flood risk reduction levees and associated protected infrastructure. As channel migration occurs, there is a continued risk of levee damage and even failure, which during a flood or in a post-flood situation, could also damage residential and commercial structures and reduce the safety to people and property provided by the flood risk reduction levee system.

The Corrales Siphon crosses the project area and is currently exposed from its originally buried condition due to riverbed incision. This siphon delivers irrigation water to the Village of Corrales underneath the river from an eastern irrigation canal. In 2016, emergency repairs were undertaken which placed a riprap pad in the scour hole downstream of the siphon for the western 75 feet of the approximately 200-foot-wide channel. These emergency repairs also included continuous riprap protection along the western bank. After 2016, the thalweg moved from the west side of the channel to the middle of the channel along the edge of the riprap pad. In fall 2020 MRGCD extended the riprap protection across the entire river.

3.3.1.1 *No Action Alternative:*

Under the No Action Alternative, there would be no impacts on access and transportation because the proposed RM 199 project would not be constructed. There would be no direct impacts on safety, as there would be no construction activities and there would be no associated safety risks to construction personnel. However, there could be moderate, indirect adverse impacts on safety as the Rio Grande levees would be at risk of damage due to Rio Grande channel migration. Potential levee damage would likely require emergency repair measures in response to increased flood risk to ensure public safety.

The No Action Alternative would also cause continued safety risks to the MRGCD-operated Corrales Siphon and its ability to be used to distribute water. The MRGCD would likely need to extend additional protection to the siphon as the channel further incised and migrated, and would potentially expose new areas of the Corrales Siphon to river flows.

3.3.1.2 *Proposed Action Alternative:*

There would be short-term, minor adverse impacts on access and transportation as a result of the Proposed Action Alternative. Construction access on both the east and west sides of the proposed RM 199 project would require construction equipment transport and construction workers' personal vehicles to transit to the project's staging areas and into the project area. This would increase vehicular traffic in the Village of Corrales and proximate to the Pueblo of Sandia during the project construction activities. This increased vehicle traffic, especially along highly traveled roads such as State Highway 528 and at the intersection of Westside Boulevard and State Highway 528, would be short-term and coordinated with authorities to minimize traffic disruptions at project ingress and egress points. Upon project construction completion, impacts on access and transportation would cease.

There would be short-term, negligible, adverse impacts on safety as a result of the construction of the proposed RM 199 project. Construction activities inherently pose increased health and safety risks to workers and the public. However, all construction personnel would be responsible for following federal and state safety regulations and OSHA safety standards and would be required to conduct construction activities in a manner that does not increase risk to workers, Reclamation personnel, or the public.

There would be long-term, minor, beneficial impacts on transportation and safety from the Proposed Action Alternative. The implementation of the proposed RM 199 project would reduce local and regional flood risk by managing the Rio Grande channel and preventing damage to the Rio Grande levees from likely future channel migration.

3.4 Air Quality

As mandated under the Clean Air Act, the USEPA set the National Ambient Air Quality Standards (NAAQS) (40 CFR Part 50) for select pollutants that are known to affect human health and the environment: ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, respirable particulate matter, lead, nitrogen oxides, and volatile organic compounds emitted from various sources are primarily responsible for ozone formation and are also referred to as “ozone precursors.” Regulatory agencies typically limit atmospheric ozone concentrations by controlling these pollutant emissions.

The USEPA has established Air Quality Control Regions (AQCRs) to evaluate compliance with the NAAQS. Each AQCR has regulatory areas that are designated as an attainment or nonattainment area for each of the criteria pollutants depending on whether it meets or exceeds the NAAQS. Attainment areas that were reclassified from a previous nonattainment status to attainment are called maintenance areas and require the preparation of a maintenance plan for air quality.

3.4.1 Affected Environment

The project area is in the Albuquerque-Mid Rio Grande Intrastate AQCR, and it is composed of portions of Sandoval and Valencia Counties and Bernalillo County in its entirety. The total area of the AQCR is about 5,000 square miles. The topography varies from mesas and arroyos to mountains. Along the eastern border of the region are the Sandia and Manzano Mountains and in the north are the Jemez and Sierra Nacimiento Mountains. Elevations range from 4,800 feet at the Rio Grande to 10,678 feet at Sandia Peak. All areas within the Albuquerque-Mid Rio Grande Intrastate AQCR are in attainment with the NAAQS.

The NMED documents that certain exceedances of particulate matter air quality standards were caused by dust storms generated by high winds, rather than man-made sources. Without these demonstrations, certain areas of the state would be in violation of the federal standards and subject to stricter air quality rules and requirements designed to meet and maintain the standard in the future (NMED 2025).

3.4.2 Environmental Consequences

3.4.2.1 *No Action Alternative:*

Under the No Action Alternative, there would be no impacts on air quality because the project would not be constructed, and there would be no emissions from construction vehicles or increased potential for fugitive dust during construction.

3.4.2.2 *Proposed Action Alternative:*

Under the Proposed Action Alternative, there would be short-term, minor, adverse air quality impacts from fugitive dust and combustion emissions. Dust can increase particulate matter that can be inhaled and irritate sensitive lung tissue and cause health problems, especially in vulnerable populations including infants, children, teens, the elderly and pregnant women; people with asthma, bronchitis, emphysema, or other respiratory conditions; and people with heart disease (NMED 2025). Combustion emissions from construction equipment and workers' vehicles from commuting to and from the project site would increase during construction activities. These emissions would return to ambient levels following the completion of construction. Because the AQCR is in attainment for all criteria pollutants, and the BMPs for dust suppression as described in Table 3 (Section 2.1.9) would be implemented during construction, there would be no significant air quality impacts from the short-term increase in combustion emissions.

3.5 Noise

Noise is often defined as unwanted sound that can interfere with normal activities or otherwise diminish the quality of the environment. Depending on the noise level, it has the potential to disrupt sleep, interfere with speech communication, or cause temporary or permanent changes in hearing sensitivity in humans and wildlife. Noise sources can be continuous (e.g., constant noise from traffic or air conditioning units) or transient (e.g., a jet overflight or an explosion) in nature. Noise sources also have a broad range of frequency content (pitch) and can be nondescript, such as noise from traffic, or be specific and readily definable, such as a whistle or a horn. The way the acoustic environment is perceived by a receptor (animal or person) is dependent on the hearing capabilities of the receptor at the frequency of the noise and the receptor's perception of the noise.

The amplitude of sound is described in a unit called the decibel (dB). Because the human ear hears a broad range of encountered sound pressures, dBs are measured on a quasi-logarithmic scale. The dB scale simplifies this range of sound pressures and allows the measurement of sound to be more easily understood. Typically, a commercial area with heavy traffic approximately 300 feet away has a noise level of approximately 60 to 70 dB, while a gas lawnmower at approximately 3 feet away has a noise level of 90 to 100 dB.

3.5.1 Affected Environment

The existing noise in the proposed RM 199 project area is primarily dominated by vehicle traffic on nearby levee roads and at bridge crossings on the Rio Grande. Generally, given the location of the proposed project area within the Rio Grande and Rio Grande floodplain and that it is separated by levees from developed areas, ambient noise levels in the proposed project area are relatively low, and likely less than 60 dB.

3.5.2 Environmental Consequences

3.5.2.1 *No Action Alternative:*

Under the No Action Alternative, there would be no impacts on noise because the project would not be constructed.

3.5.2.2 *Proposed Action Alternative:*

Under the Proposed Action Alternative, there would be short-term, negligible, adverse impacts on noise. There would be an increase in ambient noise levels within the RM 199 project area, as relatively continuous noise would be generated during construction. These continuous noise levels would be generated by equipment that has source levels (at distance of 3.28 feet from the source) ranging from approximately 70 to 110 A-weighted decibels (dBA). Typical noise levels of heavy construction equipment that would likely be involved in the Proposed Action Alternative are presented in Table 5.

Table 5. Noise Levels of Heavy Construction Equipment

Construction Category and Equipment	Predicted Noise Level at 50 Feet (dBA)
Front End Loader	79-80
Excavator	81-85
Crane	75–87
Dump Truck	76-84

Source: U.S. Department of Transportation 2017; USEPA 1971
dBA – A-weighted decibel

Sound levels decrease with greater distances from a sound source, which is called the attenuation rate. Attenuation rates are highly dependent on the terrain over which the sound is passing and the characteristics of the medium in which it is propagating. The rate used in these estimates represents a decrease in sound level of 4.5 dB per doubling of distance. This average rate has been shown to be an accurate estimate from field data on grassy surfaces (Harris 1998).

At a distance of approximately 500 feet from the construction activities, the predicted maximum noise levels would be at or below 65 dBA, a noise level that is equivalent to normal conversation or background music. The proposed RM 199 project area is not near any buildings or structures and a flood risk reduction levee separates the proposed project area from developed areas to the east and west; therefore, noise levels beyond the boundaries of the Rio Grande floodplain would remain at or below 65 dBA during construction. Further, construction activities would be limited to daytime hours, further reducing the potential for noise impacts from construction activities. Upon completion of construction, noise from these construction activities would cease.

Construction activities would temporarily increase traffic noise to and from the proposed construction location. Additional traffic noise from personal vehicles operated by construction workers and transport of construction equipment would be limited to existing roadways that approach the proposed project area. Traffic noise would be temporary and would cease at the end of construction activities. Noise from the increased traffic in support of the construction activities would not be perceptible and would not contribute to local or regional noise increases.

3.6 Visual Resources

Visual resources are defined as all objects (natural and man-made, stationary and moving) and structures (e.g., landforms and water bodies) visible on a landscape. These resources add to or detract from the scenic quality of the landscape. Any alteration in vegetation, water bodies, or landforms that either negatively or positively change the visual quality or composition of a landscape and the visual experience of persons viewing the landscape through the introduction of visual disturbance in the existing environment would impact visual resources. Also, any or any introduction of structures or other human-made visual elements that changes the visual landscape would alter visual resources.

3.6.1 Affected Environment

The study area for visual resources consists of foreground, middle ground, and background views of the proposed RM 199 project viewshed. A viewshed is the area that is visible from a particular location. Therefore, the proposed project viewshed includes areas where aboveground proposed project facilities would be visible, and where proposed project features would be visible.

The study area is comprised of multiple viewer groups, that have varying sensitivities to the visual character and quality of their surroundings. These viewers include recreationists using open space or natural areas; motorists experiencing views as they travel through the landscape on local roadways; and residents, agricultural workers, and industrial and commercial viewers that border areas where aboveground proposed project facilities would be built and where existing aboveground features (e.g., trees or structures) would be modified to accommodate aboveground and underground proposed project facilities. Visual preferences, or what people in the study area like and dislike about the area's visual character, define the study area's visual quality. Visual quality serves as the baseline for determining the degree of the Project's visual impacts.

Situated along the western side of the Rio Grande, between the channel and the levee and below the Corrales Siphon, is the Corrales Bosque Preserve (Preserve) in the Village of Corrales. The Preserve was annexed by the Village of Corrales in the late 1970s to halt wood cutting, livestock grazing, trash dumping, and other damaging activities. The bosque in the Preserve is predominantly woodlands (including a tall, cottonwood (*Populus deltoides*) gallery forest), shrubland, including coyote willow (*Salix exigua*), New Mexico olive (*Forestiera neomexicana*), invasive non-native Russian olive (*Elaeagnus angustifolia*), Siberian elm (*Ulmus pumila*), saltcedar (*Tamarix* spp.), and other species with occasional meadows or marshland. A mixture of agricultural, residential, commercial, and industrial land uses is located adjacent to the proposed RM 199 project area (Corrales Bosque Advisory Commission 2009).

On the eastern side, the Pueblo of Sandia has actively managed their bosque since 2000. Over 1,000 acres of nonnative vegetation have been removed through a variety of treatments (mechanical treatment, herbicide application, and other techniques) and restored to a cottonwood-willow native habitat. Additionally, aquatic habitat restoration treatments were included to create embayment, backwaters, channels, and a bankline bench. In 2012, a fire started in the Village of Corrales and burned 5 acres before spreading across the river to 400 acres of Bosque on Pueblo of Sandia. Various efforts to thin high fuel loads, improve access, and revegetate burned areas have occurred, and fire reduction strategies remain an important conservation issue.

3.6.2 Environmental Consequences

3.6.2.1 *No Action Alternative:*

Under the No Action Alternative, there would be no direct impacts on visual resources because the project would not be constructed. However, in the long term, there would be risk to levee damage from the encroachment of the Rio Grande channel on the levee toe. This would likely trigger an emergency repair response and would cause short-term impacts on visual resources as the flood risk reduction levee is repaired.

3.6.2.2 *Proposed Action Alternative:*

There would be negligible, short-term, adverse impacts on visual resources as a result of the Proposed Action Alternative. The removal of vegetation, establishment of staging areas, use of heavy construction equipment, parking of construction worker vehicles, and channel protection features would all decrease the visual appeal of the Rio Grande riparian area. The public, viewing the Rio Grande in the proposed project area from the levees or floodplain, would view the contrast between construction equipment and activities and the natural riparian habitat of the Rio Grande and floodplain. However, impacts on visual resources would only last as long as construction activities occur. Post-construction plantings in the floodplain of the proposed RM 199 project area would reestablish the visual characteristics of the Rio Grande riparian habitat within approximately 5 to 10 years.

3.7 Public Recreation

Recreational uses of an area may include any type of outdoor activity in which area residents, visitors, or tourists may participate. Recreational resources may include, but are not limited to, trails (for pedestrian hikes and mountain bike trails), historic and cultural attractions, parks, and fishing. Recreational opportunities and resources can be a very important component of an area's economy and the lifestyle of its residents. Recreational resources analyzed are activities that the public can participate in within project areas.

3.7.1 Affected Environment

Public recreation occurs with hiking, wildlife viewing, walking, and bicycling along the Rio Grande levees and within the Rio Grande floodplain in the Corrales RM 199 project area, including the Preserve. The Rio Grande and its floodplain between the flood risk reduction levees provides one of the few natural forested areas in the Corrales and Pueblo of Sandia regions.

3.7.2 Environmental Consequences

3.7.2.1 *No Action Alternative:*

Under the No Action Alternative, there would be no direct impacts on public recreation because the proposed RM 199 project would not be constructed. However, the continued channel incision and migration of the Rio Grande towards the flood risk reduction levees could place the integrity of the levees at risk, which would require limitations on public access to those levees and the Rio Grande floodplain. This would have an indirect adverse impact on recreational activities with the access disruption to the levees as a linear recreation feature.

3.7.2.2 *Proposed Action Alternative:*

The Proposed Action Alternative would have short-term adverse impacts on recreation. During construction activities, which are anticipated to take approximately eight months to complete, recreational opportunities within the Rio Grande floodplain the project area would be restricted, and there would be no public access allowed. These access restrictions on both sides of the Rio Grande would continue until all construction activities ceased. Recreation access along the levees would continue, but would experience temporary disruptions with vehicle and equipment traffic crossing the levees to reach staging areas and the construction areas within the Rio Grande floodplain.

3.8 Vegetation

Vegetation includes the native and invasive plants and sensitive floral species in a given area. Vegetation provides important components of wildlife habitats, such as wetlands, forests, and grasslands, in which they exist. Habitat can be defined as the resources and conditions in an area that support a defined suite of organisms.

3.8.1 Affected Environment

The bosque region of the Rio Grande provides a rich environment for many fauna and flora. This floodplain area supports a wide range of plant life, including trees, shrubs, and grasses. Historically, the bosque consisted mostly of willow (*Salix* spp.) and cottonwood trees. Other common trees and shrubs associated with the Rio Grande bosque included New Mexico olive, baccharis (*Baccharis wrightii*), false indigo bush (*Amorpha fruticosa*), wolfberry (*Lycium andersonii*), and, in southern reaches, mesquite (*Prosopis glandulosa*) (Scurlock 1998).

Cattail (*Typha* spp.) grow around wetlands or on areas of the floodplain with high water tables (Scurlock 1998), along with other common herbaceous plants, such as sedges (*Carex spp., Eleocharis spp*.) rush (*Juncus* spp.), scouring rush (*Equisetum hyemale*), buttercup (*Ranunculus cymbalaria*), pepperwort (*Marsilea vestita ssp. vestita*), mosquito fern (*Azolla mexicana*), giant cane (*Arundo donax*), common reed (*Phragmites* spp.), and yerba mansa (*Anemopsis californica*).

Reclamation biologists identified 76 mature Rio Grande cottonwood (*Populus deltoides wislizenii*) trees within the west side proposed constructed side channel and associated buffer zone. No other trees were identified within the west side proposed constructed side channel and associated buffer zone greater than 6 inches diameter at breast height. Cultural resource surveys conducted in 2024 noted hackberry (*Celtis occidentalis*), alder (*Alnus glutinosa*), ash (*Fraxinus* sp.), Chinese elm (*Ulmus parvifolia*), tree of heaven (*Ailanthus altissima*), Russian olive, salt cedar (*Tamarix sp.*), willow, cottonwood, Russian thistle (*Salsola tragus*), sacaton (*Sporobolus wrightii*), mullen (*Verbascum thapsus*), snakeweed (*Gutierrezia sarothrae*), mallow (*Malva sylvestris*), amaranth (*Amaranthus*), sunflower (*Helianthus annuus*), currant (*Ribes spp.*), and prickly pear cactus (*Opuntia littoralis*) (University of New Mexico Office of Contract Archeology 2025).

3.8.2 Environmental Consequences

3.8.2.1 *No Action Alternative:*

Under the No Action Alternative, there would be no direct impacts on vegetation because the proposed RM 199 project would not be constructed. However, continued channel migration and potential damage to the flood risk reduction levee could damage native riparian plant species in the Rio Grande floodplain, and cause vegetation removal in the process of any emergency repairs needed to protect the levee toe from erosion.

3.8.2.2 *Proposed Action Alternative:*

The Proposed Action Alternative would have short-term, minor, adverse impacts and long-term minor beneficial impacts on vegetation. The proposed RM 199 project would remove vegetation in staging areas on both sides of the Rio Grande. Some vegetation would be removed for the construction of the side channels. This would cause the direct loss of vegetation in the project area, including native riparian vegetation. However, the staging areas as well as all areas disturbed by construction activities within the floodplain would be revegetated with native vegetation upon completion, likely replacing some invasive vegetation, such as saltcedar, with native vegetation.

3.9 Invasive Species

Invasive species include both plants and animals that can substantially disrupt native ecosystems. For invasive plants, which are of concern for much of New Mexico, these invasions result in decreased forage availability for livestock and wildlife. Invasive weeds refer to nonnative species that show a tendency to spread out of control. Noxious weeds refer to a weed that is considered to be harmful to the environment or animals. Weeds pose a serious and increasing threat to New Mexico’s environment and economy.

Invasive plant species are tough competitors and can spread rapidly, creating large stands that can persevere for many years in the environment. Unique to each species, invasives have been documented to cause the following impacts: supplanting of native plants, enhanced fire risk, increased soil erosion potential, higher risk to flooding and flood damage, increased soil salinity, and potentially harmful to water quality.

3.9.1 Affected Environment

Invasive plant species have been documented in the proposed RM 199 project area, and include saltcedar, Chinese elm, Russian olive, and tree of heaven. There is also giant cane and common reed known to occur along the Rio Grande. Invasive species present in the proposed RM 199 project area pose a threat to nearby lands managed for native species and riparian habitat such as the Bosque Preserve and the Pueblo of Sandia lands.

3.9.2 Environmental Consequences

3.9.2.1 *No Action Alternative:*

Under the No Action Alternative, invasive plant species would continue to persist and potentially spread. The migrating channel would disturb soils leading to increased areas for colonization of invasive species, which often rapidly invade highly disturbed areas.

3.9.2.2 *Proposed Action Alternative:*

While the Proposed Action Alternative would result in a small reduction in invasive plant species in the Rio Grande floodplain, the benefits provided to the habitat of the bosque would be negligible in comparison to the overall habitat known to occur along the Rio Grande. The proposed RM 199 project would remove some invasive plant species such as salt cedar, Russian olive, and tree of heaven during construction. Following the completion of construction activities, disturbed areas, including the staging areas, would be replanted with native riparian plant species. The small reduction in invasive plant species in the Rio Grande floodplain would provide a benefit to the habitat of the bosque.

3.10 Wildlife

Wildlife includes the birds, mammals, reptiles, amphibians, and invertebrates potentially present in the habitats, both seasonally and perennially, of the proposed project area.

3.10.1 Affected Environment

A query of the Biota Information System of New Mexico reports 934 species or taxa of wildlife in Sandoval County (BISON-M 2025) many of which could potentially occur in the proposed RM 199 project area. This estimate includes 12 amphibians, 31 fishes, 49 reptiles, 99 mammals, 285 birds, and 429 invertebrate taxa (e.g. spiders, insects, crayfish, ants, snails, etc.). Amphibians include frogs, toads, and spadefoot. Fishes include sucker, carp, chub, shiner, minnow, and bullhead. Reptiles include lizards, turtles, whiptails, and snakes. Common mammals include rodents, muskrat (*Ondatra zibethicus*), beaver (*Castor canadensis*), raccoon (*Procyon lotor*), ground squirrel (Family Sciuridae), rabbit (*Lepus* spp.), striped skunk (*Mephitis mephitis*), coyote (*Canis latrans*), gopher (Family Geomyidae), and bats, along with some feral dogs, cats, and livestock. A variety of waterfowl, shorebirds, wading birds, and raptors utilize the Rio Grande, bosque, and riverside drains, including ducks, Canada geese (*Branta canadensis*), sandhill crane (*Grus canadensis*), great blue (*Area herodias*) and black-crowned night (*Nycticorax nycticorax*) herons, snowy (*Egretta thula*) and great (*Ardea alba*) egrets, killdeer (*Charadrius vociferus*), blackbirds, hummingbirds, hawks, owls, swallows, and a variety of songbirds. The MRG provides excellent avian habitat, and the Corrales bosque provides some of the highest avian density and richness within the entire MRG (Hawks Aloft, Inc 2017).

3.10.2 Environmental Consequences

3.10.2.1 *No Action Alternative:*

There would be no direct impacts on wildlife under the No Action Alternative, because there would be no construction activities. It is unlikely that potential future erosion caused by the migrating Rio Grande channel and associated risk to the flood risk reduction levee toe would impact wildlife, as wildlife are typically mobile and capable of moving away from eroding channel banks.

3.10.2.2 *Proposed Action Alternative:*

There would be short-term, minor, adverse impacts on wildlife from the Proposed Action Alternative. Construction activities, including equipment noise and equipment movement, have the potential to directly injure or kill wildlife, or cause stress to wildlife as species flee the movement and noise from equipment. Vegetation removal would cause a reduction in avian use of the project area, as vegetation structure is important for bird foraging and nesting behaviors. However, Reclamation will implement BMPs listed in Section 2.1.9 to reduce the potential for construction-related impacts on wildlife, including avoiding any actively nesting migratory birds. When construction activities would cease, the potential to impact wildlife species from project activities would also end.

3.11 Threatened and Endangered Species

3.11.1 Affected Environment

The USFWS Information for Planning and Consultation database (USFWS 2025a) and the *Final Biological and Conference Opinion for Bureau of Reclamation, Bureau of Indian Affairs, and Non-Federal Water Management and Maintenance Activities on the Middle Rio Grande, New Mexico* (USFWS 2016) describe the potential federally listed species that could occur in the proposed RM 199 Corrales project area. Five federally listed species and two species proposed for listing have been recorded as potentially occurring within or near the proposed project area (Table 6). The federally listed species includes one mammal, three birds, and one fish. Additionally, two insect species that are proposed for listing also have the potential to occur in the area. There is no designed critical habitat for any listed species in the proposed project area.

Table 6. Federally Listed and Proposed Listed Species with Potential to Occur in the Project Area

Species Common Name	Species Scientific Name	Federal Listing Status	Designated Critical Habitat	Potential to Occur in the Proposed Project Area
Mammals				
New Mexico Meadow Jumping Mouse	*Zapus hudsonius luteus*	Endangered	None	No suitable habitat is present
Birds				
Mexican Spotted Owl	*Strix occidentalis lucida*	Threatened	None	No suitable habitat is present
Southwestern Willow Flycatcher	*Empidonax traillii extimus*	Endangered	None	Moderately suitable habitat is present
Yellow-billed Cuckoo	*Coccyzus americanus occidentalis*	Threatened	None	No suitable habitat is present
Fish				
Rio Grande Silvery Minnow	*Hybognathus amarus*	Endangered	None	Suitable habitat is present
Insects				
Monarch Butterfly	*Danaus plexippus*	Proposed Threatened	None	Suitable habitat is present for nectaring by adult monarchs

Species Common Name	Species Scientific Name	Federal Listing Status	Designated Critical Habitat	Potential to Occur in the Proposed Project Area
Suckley's Cuckoo Bumble Bee	*Bombus suckleyi*	Proposed Endangered	None	No suitable habitat is present

New Mexico Meadow Jumping Mouse (*Zapus hudsonius luteus*)

The New Mexico meadow jumping mouse (NMMJM), a subspecies of the meadow jumping mouse, was listed as endangered by the USFWS in 1983, and is also listed as endangered by the State of New Mexico. It is a habitat specialist that nests in dry soils but also uses moist streamside and dense riparian vegetation up to an elevation of about 8,000 feet. The NMMJM appears to only utilize two riparian community types: 1) persistent emergent herbaceous wetlands (i.e., beaked sedge and reed canarygrass alliances); and 2) scrub-shrub wetlands (i.e., riparian areas along perennial streams that are composed of willows and alders). It especially uses microhabitats of patches or stringers of tall dense sedges on moist soil along the edge of permanent water. Home ranges vary between 0.37 and 2.7 acres and may overlap. The jumping mouse is generally nocturnal, but occasionally diurnal. It is active only during the growing season of the grasses and forbs on which it depends (USFWS 2025b).

Mexican Spotted Owl *(Strix occidentalis lucida*)

The Mexican spotted owl (MSO) occurs in forested mountains and canyonlands throughout the southwestern U.S. and Mexico. It ranges from Utah, Colorado, Arizona, New Mexico and the western portions of Texas south into several states of Mexico.

In 1993, the USFWS listed the MSO as threatened under the ESA and in 2004, the USFWS designated critical habitat for the MSO. One of the primary reasons for the original listing of the MSO in 1993 was the historical alteration of the owl's habitat as the result of timber-management practices. The other primary reason for listing of the MSO was the threat that these practices continued to have on the species, as evidenced in existing National Forest plans. At the time of listing, the danger of stand-replacing wildland fire was also recognized as a threat. Currently, the primary threat to the MSO in the U.S. is the increased risk of landscape scale stand-replacing wildland fire (USFWS 2025c).

The MSO is found only in isolated canyon lands and mountain ranges throughout a five-state region of the southwestern U.S. The MSO’s distribution is limited by suitable nesting locations, whereas not all isolated forests and canyon systems provide suitable nesting habitat. Nests are caves and cliff ledges in the canyons and mistle toe conglomerates most often found in Douglas fir (*Pseudotsuga menziesii*) in the forest habitats. Generally, in the northern portion of their range, MSO utilize mostly canyon systems, and in the southern areas, MSO utilize isolated mix-conifer forested mountains. The patterns of habitat use by foraging MSOs are not well known, but MSOs generally forage in a broader array of habitats that they use for nesting and/or roosting.

Southwestern Willow Flycatcher (*Empidonax traillii extimus*)

The USFWS listed the Southwestern willow flycatcher (SWFL) as endangered on 27 February 1995 (USFWS 1995). The SWFL is a subspecies of the willow flycatcher family. The SWFL is a summer breeder within its range in the U.S. It migrates to wintering areas in Central America by the end of September. Nest territories are set up for breeding, and there is some site loyalty to nest territories.

For nesting, the SWFL requires dense riparian habitats with cottonwood, willow, and tamarisk vegetation. Spring-fed wetlands containing saturated soils, standing water or nearby streams, are a component of nesting habitat. Habitat not suitable for nesting may be used for migration and foraging. The SWFL is typically found below 8,500 feet of elevation.

Loss and degradation of dense riparian habitats are the primary habitat threat to the SWFL. Water developments that altered flows in the rivers and streams are one of the primary threats to habitat. Human disturbances at nesting sites may result in nest abandonment (USFWS 1995).

Yellow-billed Cuckoo (*Coccyzus americanus occidentalis*)

The USFWS listed the western distinct population segment of the yellow-billed cuckoo (YBCU) as threatened on 3 October 2014 (USFWS 2014). YBCUs use wooded habitat with dense cover and water nearby, including woodlands with low, scrubby, vegetation, overgrown orchards, abandoned farmland and dense thickets along streams and marshes. In the western U.S., YBCUs typically nest in willows along streams and rivers, with nearby cottonwoods serving as foraging sites (USFWS 2014).

Rio Grande Silvery Minnow (*Hybognathus amarus*)

On 19 August 1994, the USFWS listed the Rio Grande Silvery Minnow (RGSM) as endangered (USFWS 1994). The RGSM's current distribution is limited to a 174-mile stretch of the MRG (USFWS 2021a), from Cochiti Dam to the headwaters of Elephant Butte Reservoir, which is approximately 5 percent of its historical 3,000-mile range (USFWS 1994).

RGSM live for approximately two to three years. The species spawns during spring runoff which typically occurs April to June. Larvae are most commonly found in slow velocity habitats such as backwaters, shoreline pools, and inundated floodplain areas. Recruitment for the species is highest when spring runoff is prolonged and the flow volume is high. RGSM experience rapid larval and juvenile growth, reaching the first juvenile stage in approximately 50 days. Adults occupy large streams with slow to moderate current flowing over silt or silt/sand substrate, where water depths are typically less than 15.75 inches. (USFWS 2023).

Monarch Butterfly (*Danaus plexippus*)

The monarch butterfly is proposed for listing under the ESA as threatened. The species is globally distributed throughout 90 counties, islands, and island groups with the two largest migratory populations located east and west of the Rocky Mountain chain in North America (USFWS 2020a).

In both the eastern and western North American populations, monarchs begin migrating in the fall to their respective overwintering sites, flying south to the mountainous regions of central Mexico or to groves along the California coast and northern Baja California (USFWS 2020b). In early spring (February to

March), monarchs begin the breeding season by mating at the overwintering sites and beginning the generational migration northward over the course of three to five generations (USFWS 2020b). Adult monarch butterflies require a diversity of blooming nectar resources on which they feed throughout their migration routes and in breeding grounds from spring to fall (USFWS 2020b). Monarchs require milkweed (*Asclepias* spp.) embedded within diverse nectary habitat for egg laying and larval feeding (USFWS 2020b). The correct phenology of monarchs, nectar plants, and milkweeds, as well as the position of these resources on the landscape, are important to monarch survival (USFWS 2020b).

Suckley's Cuckoo Bumble Bee (*Bombus suckleyi*)

The Suckley's cuckoo bumble bee (SCBB) is proposed for listing as endangered under the ESA. The SCBB depends on other bumble bee hosts for its survival and raising of young. It has been found in various habitat types including prairies, grasslands, meadows, woodlands and agricultural and urban areas. The bee has a broad historical distribution across North America and has been documented in Arizona, California, Colorado, Idaho, Minnesota, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, Wyoming, and 11 Canadian territories and provinces. The last confirmed sighting in the U.S. was in 2016 in Oregon (USFWS 2025d).

SCBB is an important indicator species for the health of pollinators and native floral communities. In addition, this species' parasitic nature is very unique among bees, with social parasites making up less than 1 percent of all bee species. They are different from brood parasites, which only attack the brood of their host, because social parasites rely on the entire colony. Female SCBBs invade host bumble bee nests where they will often eliminate the host queen, destroy host eggs, and eject host larvae from the nest (USFWS 2025).

The viability of this bee is highly dependent on its host bumble bee species, many of which have declined historically, and are expected to continue to do so in the near term. Other major threats include pesticides, habitat fragmentation and conversion, and global environmental change (USFWS 2025).

3.11.2 Environmental Consequences

3.11.2.1 *No Action Alternative:*

Under the No Action Alternative, there would be no impacts on federally listed species because there would be no construction or ground-disturbing activities. Some indirect habitat disturbance that supports federally listed species could occur from continued channel migration and associated erosion; however, this would be unlikely to have an adverse effect on any listed species.

3.11.2.2 *Proposed Action Alternative:*

Reclamation and its consulting partners have completed Section 7 consultation under the ESA for federally listed species that could be affected by the MRG management and maintenance activities (Appendix D). These activities include those described by the Proposed Action Alternative. To reduce the effects on RGSM and SWFL, BMPs described in Table 3 (Section 2.1.9) would be implemented. This would ensure that RGSM would not be stranded in standing water after the main channel flows would be diverted and that work would be conducted outside the SWFL nesting season. The constructed side channels would provide low velocity habitat at a variety of flow levels for the endangered RGSM. However, the vegetation removal that would occur as part of the proposed project construction would remove 2.4 acres of moderately suitable SWFL habitat. Therefore, Reclamation determined that the activities in the Proposed Action Alternative may affect and are likely to adversely affect the RGSM and would adversely affect 2.4 acres of moderately suitable habitat for the SWFL. There is no critical habitat for RGSM, SWFL, or YBCU in the project area. Reclamation determined that the activities in the Proposed Action Alternative would have no effect on the SWFL, as project activities would not occur during the SWFL nesting and breeding season. There is no suitable habitat in the proposed project area for the NMMJM, MSO or the YBCU; therefore, the Proposed Action Alternative would have no effect on the NMMJM, MSO, or the YBCU.

Under the Proposed Action Alternative, plants utilized by adult monarch butterflies could be disturbed or removed during construction activities. This would be a potential short-term loss of nectaring habitat for adult monarchs that could visit the proposed project area during migration. It is unlikely that construction activities would take individual monarch butterflies as individuals would readily relocate in advance of noise and movement from equipment and construction personnel. Revegetation activities following the completion of construction, including the planting of native riparian plant species, would reestablish any habitat lost from construction. Therefore, the Proposed Action Alternative would not jeopardize the continued existence of the monarch butterfly.

The SCBB is not anticipated to be present at the proposed project area, and there would be no effect from the Proposed Action Alternative on the SCBB.

3.12 Cultural Resources

Cultural resources are defined as physical or other expressions of human activity or occupation. Such resources include culturally significant landscapes, prehistoric and historic archaeological sites, isolated artifacts or features, traditional cultural properties, Native American and other sacred places, and artifacts and documents of cultural and historical significance.

The prehistory of the southwestern U.S. is commonly discussed in three basic chronological periods: Paleoindian, Archaic, and Puebloan. Each of these represents a different cultural adaptation established for a specific time period. Scholars have continually revised understandings of this history and provided important overviews, particularly for the region as a whole, but these are also relevant for smaller areas.

3.12.1 Affected Environment

The Area of Potential Effects (APE) for the proposed Corrales RM 199 project includes 18 acres within the Rio Grande floodplain. A Class III cultural resources survey of the APE was completed on 31 October and 5 November 2024. The survey effort focused on recording all cultural resources with the proposed project area. Two previously recorded sites, LA 132552 (Corrales Acequia Madre) and LA 146163 (Corrales Main Canal Siphon), were redocumented and updated. The Corrales Acequia Madre is a system of irrigation canals used before 1926 and includes levee features within the proposed project area. The Corrales Main Canal Siphon is a historic wooden siphon built in 1933 to route the Corrales Main Canal beneath the Rio Grande. Features within both sites were noted to be suffering from alluvial and vegetative damage. The Corrales Main Canal Siphon, in particular, has experienced a sinkhole that disrupted the flow of water. However, that site and the Corrales Acequia are considered eligible for listing in the

National Register of Historic Places under criteria “a,” “c,” and “d.” A single isolated occurrence, a possible historic doll, was noted (University of New Mexico Office of Contract Archaeology 2025).

3.12.2 Environmental Consequences

3.12.2.1 *No Action Alternative:*

Under the No Action Alternative, there would be no direct impacts on cultural resources because proposed project would not be implemented, and there would be no ground-disturbing activities. However, erosion from the Rio Grande in the project area could damage known and unknown cultural resources, as soils are disturbed from river migration, having indirect impacts on cultural resources.

3.12.2.2 *Proposed Action Alternative:*

Under Section 106 of the NHPA, Reclamation consulted with the New Mexico State Historic Preservation Office (SHPO) on the potential effects to historic properties from the proposed Corrales RM 199 project. The SHPO concurred with Reclamation’s determination that parts of the Corrales Acequia Madre site within the APE do not retain integrity; however, the site remains eligible for listing in the National Register of Historic Places. The SHPO concurred with Reclamation’s determination that the Corrales Main Siphon is unevaluated, but that the site is eligible under criteria a and c. Because of the degradation and loss of integrity of both sites within the APE, Reclamation determined that the proposed undertaking would have no effect on historic properties. The SHPO concurred with Reclamation’s determination on 25 March 2025 (Appendix D).

If cultural resources are encountered during site construction, work would be halted immediately, and the Reclamation Area Archaeologist will be notified immediately. Work would recommence only after the necessary cultural resource clearance had been received.

3.13 Soils

Soils are the unconsolidated materials overlying bedrock or other parent material. Soils typically are described in terms of their complex type, slope, and physical characteristics. Differences among soil types in terms of their structure, elasticity, strength, shrink-swell potential, and erosion potential affect their abilities to support certain applications or uses. In appropriate cases, soil properties must be examined for their compatibility with particular construction activities or types of land use.

3.13.1 Affected Environment

The project area is within an active alluvial floodplain. Under such conditions, the floodplain will experience variable periods of accretion and erosion. This unstable environment is characterized by sandy and loam soils with some parts containing vegetation that protects these soils from erosion (Figure 6). Due to the frequent flooding followed by subsequent drying, high salinity can occur. Peralta loam, with 1 to 3 percent slopes, is the predominant soil type present in the project area (Table 7).

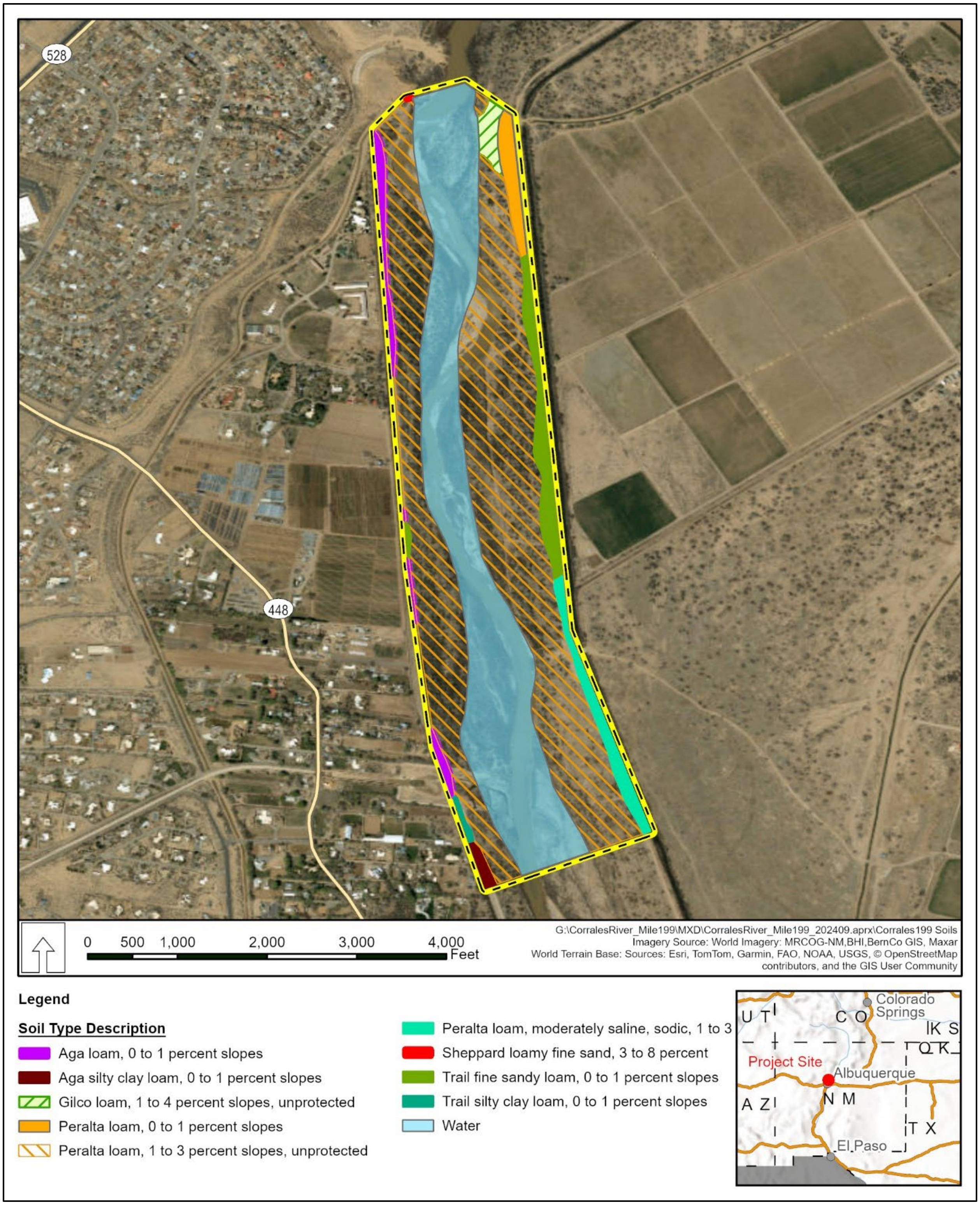

Figure 6. Soil Types within the Corrales River Mile 199 Project Area

Table 7. Soil Types in the Corrales River Mile 199 Project Area

Soil Type	Area (acres)	Soil Type Description
Aga Loam (0 to 1 percent slopes)	2.6	Floodplain soil of stream alluvium derived from igneous and sedimentary rock. Soils are moderately well drained.
Aga Silty Clay Loam (0 to 1 percent slopes)	1.1	Floodplain soil of stream alluvium derived from igneous and sedimentary rock. Soils are moderately well drained.
Gilco Loam (1 to 4 percent slopes)	2.8	Floodplain soil with loam to a depth of 14 inches. Stream alluvium derived from igneous and sedimentary rock. Soils are moderately well drained.
Peralta Loam (0 to 1 percent slopes)	4.5	Floodplain soils derived from stream alluvium originating from various geological formations. Slightly to moderately saline and somewhat poorly drained.
Peralta Loam (1 to 3 percent slopes)	150.4	Stream alluvium in floodplain deposits whose original geological outcrops were highly varied. Such soils are typically somewhat poorly drained with salinity ranging from slight to moderate.
Peralta Loam, moderately saline, sodic (1 to 3 percent slopes)	5.4	Floodplain soil with loam to a depth of 4 inches and stratified loam to fine sandy loam to loamy sand below 4 inches. Stream alluvium derived from igneous and sedimentary rock. Soils are somewhat poorly drained.
Sheppard Loamy Fine Sand (3 to 8 percent slopes)	0.1	Soils found on stream terraces, alluvial fans, benches, dunes, and structural benches. Eolian deposits derived from sandstone. Soils are somewhat excessively drained.
Trail fine sandy loam (0 to 1 percent slopes)	7.3	Principally eolian deposits originating from eroding sandstone that are found overlaying stream alluvium. Moderately well drained with low saline concentrations.
Trail silty clay loam (0 to 1 percent slopes)	0.4	Soil type found on alluvial fans, floodplains, valley-floor remnants, and channels. Eolian deposits over stream alluvium derived from sandstone. Soils are moderately well drained.

Source: Web Soil Survey 2025

3.13.1 Environmental Consequences

3.13.1.1 *No Action Alternative:*

Under the No Action Alternative, there would be no direct impacts on soils because the project would not be constructed. However, there would continue to be channel degradation and lateral migration of the channel banks, leading to increase sediment loss and subsequent exposure of the underlaying bedrock. Therefore, under the No Action Alternative there would be an increase in the loss of sediment in the RM 199 project area, and continuous erosion of the outer channel banks.

3.13.1.2 *Proposed Action Alternative:*

There would be short-term adverse impacts on soils from the Proposed Action Alternative. Surface soils would be disturbed in the RM 199 project area during the clearing of vegetation for staging areas, side channel construction, and the recontouring of the banks to stabilize the river bends. Excavated soils would be used in the project area to raise the riverbed and promote expedited connection to the adjacent floodplain, promoting better habitat for the RGSM and other aquatic and riparian-dependent species. All BMPs listed in Table 3 (Section 2.1.9) to minimize soil erosion during and after construction would be implemented by Reclamation. In the long-term, disturbed areas would be revegetated, the Rio Grande channel stabilized, and soils protected from erosion through these measures.

3.14 Reasonably Foreseeable Impacts

Reasonably foreseeable effects under NEPA are direct and indirect impacts on the resources affected by the Project which result from the incremental impact of the proposed project when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (federal or non-federal) or person undertakes such actions. Reasonably foreseeable impacts can result from individually minor but collectively significant actions taking place over a period of time. Reasonably foreseeable impacts can also be characterized as additive or interactive. An additive impact emerges from persistent additions from one kind of source, whether through time or space. An interactive—or synergistic—impact results from more than one kind of source.

No other reasonably foreseeable future actions were identified during the scoping process. Overall, Reclamation is responsible for maintenance and management of the MRG Project, which includes channel realignments and management projects elsewhere along the MRG. However, these projects would not have any reasonably foreseeable effects when combined with the impacts of the proposed RM 199 project, and Reclamation would implement BMPs similar to those described in Section 2.1.9 to greatly reduce impacts on sensitive resources of the MRG. Therefore, there would be no reasonably foreseeable impacts from the implementation of the Proposed Action Alternative.

CHAPTER 4 - CONSULTATION AND COORDINATION

Reclamation has consulted with the New Mexico SHPO and the Tribal Historical Preservation Office (THPO) for the Sandia Pueblo regarding the Proposed Action Alternative and received concurrence from both SHPO and THPO on Reclamation's determination of no effects on historic properties. Reclamation has coordinated with the Village of Corrales and the New Mexico Interstate Stream Commission as well as local agencies including the MRGCD, USACE Hydraulic Engineering Division, and the Albuquerque Bernalillo County Water Utility Authority.

Reclamation has consulted with the USFWS regarding potential effects on federally listed species under Section 7 of the ESA. Incidental take of the RGSM and marginally suitable SWFL habitat that could result from the Proposed Action Alternative is included in Reclamation's annual accounting and reporting procedures to the USFWS for the 2016 BO, which will include post-project refined areas across these types of covered projects (USFWS 2016).

Reclamation has submitted a CWA Section 404/401 permit to the USACE and NMED to receive approval for impacts in WOTUS for the Proposed Action Alternative.

Reclamation held two open house public meetings on 26 and 27 March 2025. Notification of the public meetings was published in the *Albuquerque Journal* and made available on the Village of Corrales website.

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CHAPTER 5 - PREPARERS

Table 8 lists the individuals who participated in the preparation of this EA.

Table 8. List of Preparers

Name	Title	Organization
Jancoba Dorley, PhD	Middle Rio Grande River Maintenance Project Manager	Bureau of Reclamation
Dan Becker, GISP	GIS Specialist	Vernadero Group Inc.
Brian Grasman	Biologist	Vernadero Group Inc.
Katharine Hewlings	GIS Analyst	Vernadero Group Inc.
Carey Lynn Perry	NEPA Specialist	Vernadero Group Inc.
Crystal Ramey	Document Production Specialist	Vernadero Group Inc.
Jennifer Ritter	Technical Editor	Vernadero Group Inc.
Ralph Tharp, AICP	Planner	Vernadero Group Inc.
Eric Webb, PhD	NEPA Project Manager	Vernadero Group Inc.

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CHAPTER 6 - REFERENCES

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APPENDIX A. PUBLIC INVOLVEMENT

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Affidavit of Publication

STATE OF NEW MEXICO } SS
COUNTY OF BERNALILLO }

Ad Cost:	$848.03
Ad Number:	194580
Account Number:	1112735
Classification:	NON-GOVERNMENT LEGALS

I, Bernadette Gonzales, the undersigned, Legal Representative of the Albuquerque Journal, on oath, state that this newspaper is duly qualified to publish legal notices or advertisements within the meaning of Section 3, chapter 167, Session Laws of 1937, and payment of fees has been made of assessed and a copy of which is hereto attached, was published in said publication in the daily edition, 1 times(s) on the following date(s):

March 9, 2025

That said newspaper was regularly issued and circulated on those dates.
SIGNED:

Legal Representative

Subscribed to and sworn to me this 10th day of March 2025.

David Lindsey Montoya
Notary Public
County Bernalillo
ID#: 1140229
My commission expires: 04-26-2027

STATE OF NEW MEXICO
NOTARY PUBLIC
DAVID LINDSEY MONTOYA
COMMISSION NUMBER 1140229
EXPIRATION DATE 04-26-2027

VERNADERO GROUP INCORPORATED
4833 CONTI ST
SUITE 103
New Orleans, LA 70119

NOTICE OF PUBLIC SCOPING MEETINGS, PROPOSED CORRALES RIVER MILE 199 PROJECT, MIDDLE RIO GRANDE PROJECT, NEW MEXICO

The Bureau of Reclamation (Reclamation) is preparing a draft Environmental Assessment (EA) in accordance with the National Environmental Policy Act to assess the potential environmental consequences associated with the proposed Rio Grande channel rehabilitation project to protect riverside infrastructure from erosion along the Rio Grande north of Albuquerque, New Mexico. Reclamation is authorized under the Flood Control Acts of 1948 and 1950 to maintain the Rio Grande channel in the Middle Rio Grande to pass the 2-year return peak flow. In accordance with this authorization, Reclamation has developed the Proposed Action to protect the riverside levee system at three points where river meandering is currently threatening the levee. The Proposed Action has secondary goals of rehabilitating the river planform (i.e., the shape of the river and how it flows) and enhancing aquatic and riparian habitat.

Reclamation will host two public scoping meetings at the Village of Corrales Council/ Municipal Court Chambers at 4324 Corrales Road, Corrales, NM 87048. Meetings will be held from 5:30-7:30 p.m. on Wednesday, March 26 and Thursday, March 27. Meetings will be conducted in an open house format. Meeting attendees will have an opportunity to review exhibits, speak with Reclamation representatives, and provide comments on Reclamation's proposal. No presentation and no formal question and answer session will be provided.

Please submit your written comments concerning the Proposed Action to the Project Manager, Dr. Jancoba Dorley, 555 Broadway NE, Suite 100, Albuquerque, NM, 87102, to jdorley@usbr.gov, and/or attend a public scoping meeting. Although comments can be submitted to Reclamation any time during the EA process, scoping comments are requested by 27 April 2025, to ensure full consideration in the draft EA. If you have any questions or would like more information on this project, please reach out to Dr. Dorley at (505) 859-1746.

UPPER COLORADO BASIN

Upper Colorado News

About Us

Area Offices

Albuquerque Area Office

About Us

Albuquerque Water Operations

Programs & Activities

Document Library

Environmental Documents

Water Operations

Contact Us

Albuquerque Area Office

The Albuquerque Area Office is one of the largest in Reclamation reaching from the Alamosa area of southern Colorado through most of New Mexico and into west Texas. Staff here manage delivery of water on the Rio Grande, Rio Chama, Pecos, and Canadian rivers from the main office in Albuquerque and six field offices in Alamosa, Colorado; Alamogordo, Chama, Elephant Butte, and Socorro, New Mexico; and El Paso, Texas. This office is also responsible for overseeing the management of nine major dams with a combined reservoir storage capacity of more than 3.5 million acre-feet that supply water for more than 439,000 acres of irrigated land and several municipal drinking water projects. They also oversee hydropower production at Elephant Butte Dam, and research and testing at the Brackish Groundwater National Desalination and Research Facility.

News and Highlights

NEWS RELEASE – JANUARY 16, 2025

Environmental Planning

Current Focus

NOTICE OF PUBLIC SCOPING MEETINGS, PROPOSED CORRALES RIVER MILE 199 PROJECT, MIDDLE RIO GRANDE PROJECT, NEW MEXICO

Public Meeting for River Mile 199 Project

News Release Date:03-13-2025

Back to News

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Community

Upcoming Events

Public Meeting - River Mile 199 Project
Wed, Mar 26 2025, 5:30 - 7:30pm

Clone of Public Meeting - River Mile 199 Project
Thu, Mar 27 2025, 5:30 - 7:30pm

Town Hall with Representative Cates
Sat, Apr 5 2025, 3 - 4pm

View the Community Calendar

Contact Information

Phone Number

505-897-0502

Fax Number

505-897-7217

Office Hours

8:00 am - 5:00 pm

Address

4324 Corrales Rd
Corrales, NM 87048

Extreme wind, fire danger and possible power outages Click for more information

Search

Mayor's Message for March 14th, 2025

"The older I get, the more I realize how little I know"

The Earth might seem like it has **abundant water**, but in fact **less than 1 percent** is available for **human use**. The rest is either **salt water** found in oceans, fresh water **frozen** in the polar ice caps, or **too inaccessible** for practical usage. While population and demand for freshwater resources are increasing, **supply will always remain constant**. Although it's true that the **water cycle** continuously returns water to Earth, it is not always returned to the same place, or in the same quantity and quality. All the fresh water that is here on Earth now is **all that we will ever have**.

Water plays a big role in **supporting our communities**. Without water there would be no local business or industry. Fire-fighting, municipal parks, and public swimming pools all need lots of water. An array of pipes, canals, and pumping stations managed by our **public water systems** are needed to bring a reliable supply of water to our taps each day. In the Village most of us have our **individual wells**. Where does all this water come from? It starts out as **rain or snow** and flows into our local lakes, rivers, and streams or into underground aquifers.

In the US, we are **lucky** to have **easy access** to some of the **safest** treated water in the world—just by **turning on the tap**. We wake up in the morning, take a shower, brush our teeth, grab a cup of coffee, and head out for the day. Water is an **important part** of our **daily lives,** and we use it for a wide variety of purposes, but do we really understand **how much we use**? It's easy to forget that we also use water in ways we don't see every day. Water is used to **grow our food**, **manufacture** our favorite **goods,** and keep our businesses running smoothly.

New Mexico faces a **serious water crisis** due to a combination of **drought, climate change,** and increasing **water demand**, particularly from agriculture, with **71% of the state under drought conditions** as of March 4, 2025. That is why the Village has put **emphasis** on our **water availability**, not just for the farmers, but for the communities **long term survival**. The surface water (irrigation) is important, but the ground water (wells) is what we drink. We need to keep it **clean and safe.** Hence, the need eventually for a **conventional sewer system**.

NOTICE OF PUBLIC SCOPING MEETINGS, PROPOSED CORRALES RIVER MILE 199 PROJECT, MIDDLE RIO GRANDE PROJECT, NEW MEXICO

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Reclamation will host **two public scoping meetings** at the **Village of Corrales Council/Municipal Court Chambers at 4324 Corrales Road**, Corrales, NM 87048. Meetings will be held from **5:30-7:30 p.m.** on **Wednesday, March 26 and Thursday, March 27.** Meetings will be conducted in an open house format. Meeting attendees will have an opportunity to review exhibits, speak with Reclamation representatives, and provide comments on Reclamation's proposal. No presentation and no formal question and answer session will be provided.

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The **old boy scout bridge**, which allows passage across the **clear ditch** (riverside drain) from the **lateral** to the **levee**, located about mid-way between **E. Ella and E. La Entrada,** is in the process of being **replaced.** The current bridge is about 40 years old. The **new bridge** will be placed **north** of the current location at a spot that aligns with a levee ramp, which should improve equestrian access. The **MRGCD** is **assisting** the Village with the placement of the new bridge and the project is **on schedule** to be completed in the next few weeks. Keep an eye out here for an announcement of the **ribbon-cutting** and opening of the new bridge in the next few weeks. You can see **photos and a map** of the location on the Village website here: https://www.corrales-nm.org/community/page/boy-scout-bridge-replacement.

HEALTH AND SAFETY UPDATE

Measles cases in New Mexico have risen to **33**. Lea county has 32 and Eddy has one case. If you do not know your **vaccination status**, reach out to your physician to see if you should **get vaccinated** or have blood work to check your immunity.

If you are **65 or over** it may be time to **boost your immunity to COVID.** If your last vaccination was **at least 6-months ago**, you can receive a booster.

To lookup **vaccination status** for vaccines given in New Mexico, visit the Public Portal: https://vaxview.doh.nm.gov/.

UPCOMING EVENTS

TODAY – Happy Pi day (3.14)

TODAY – Lunch Bunch with Corrales MainStreet at Sandia Bar **12 PM**

SATURDAY – CBAC and Corrales Fire will host a Bosque wood removal event from **9 – 11 AM** at the east end of Andrews Ln. at the levee.

SATURDAY - Music in Corrales Concert, Maire Ni Chathasaigh & Chris Newman, at the Historic Old San Ysidro Church **7:30 PM.** This event is SOLD OUT but tickets may be available at the door. Sign-ups for the waiting list will start at 6:30 PM and tickets at the door will be $30 each.

TUESDAY – Library Board meeting, Corrales Library **6 PM**

WEDNESDAY – Story Time at the library **10 AM**

THURSDAY – Conversational Spanish at the library **6 PM**

THURSDAY – Corrales Compadres gathering for a wine tasting, **4 – 6 PM.** Please email Eric Neuwrith at neuwy55@gmail.com to RSVP and for more details. Space is limited but all adult Village residents are welcome.

MARK YOUR CALENDAR

3/21 Farmland Preservation and Agricultural Commission meeting, Corrales Library **9 AM**

3/22 Spring Planting day for the Storybook Garden, Corrales Library **10 AM**

3/22 Kite craft for kids, Corrales library **10 AM**

3/22 Artists reception for Natasa Vretenar, Corrales Library **10 AM**

3/23 Historical Society Speaker Series "18 Years in the Village" by Dennis Chamerlain, **2 PM** at the Historic Old San Ysidro Church. This event is Free but space is limited to 150 people.

3/28 Daffodil Days – pick up your daffodils and gift a donation to the Robert Wertheim Hospice House, **1 – 5 PM** at Sandia Bar and the Grower's Market Lot

If you are looking for the **latest information** on what's happening in the Village, please visit the Village website at www.corrales-nm.org and click on the **"News"** tab or the **"Calendar"** tab. We work to make sure the website is updated frequently to keep residents informed.

Remember, we are **all neighbors** in the Village. We share this community, and we have to **work together** to assure its longevity and success. We are all more alike than different. Be kind, thoughtful, and considerate of your fellow Corraleños. **Be courteous, drive the posted speed limit, and yield to equestrians, pedestrians, and bicyclists.**

By the way, I have decided to **run for another term as Mayor.** I will appreciate your support.

Jim Fahey

Mayor of Corrales

Community

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4324 Corrales Rd
Corrales, NM 87048

BUREAU OF RECLAMATION

26 March 2025 | Bureau of Reclamation, Upper Colorado Region, Albuquerque Area Office
Public Scoping Meeting, Village of Corrales, New Mexico

Name	Organization	Address	Email	Check Here to Be Added to Distribution List
Joan Hashimoto	Corrales Bosque Advisory Commission	[redacted]	[redacted]	✓
Lee Traynhan	BOR	[redacted]	[redacted]	

27 March 2025 | Bureau of Reclamation, Upper Colorado Region, Albuquerque Area Office
Public Scoping Meeting, Village of Corrales, New Mexico

Name	Organization	Address	Email	Check Here to Be Added to Distribution List
JOE ABELÉ	CORRALES BOSQUE COMMISSION		[redacted]	✓
Keith Julian	NM Desalination Association	[redacted]		

— BUREAU OF —
RECLAMATION

Public Scoping Meeting
Registration Card

Bureau of Reclamation

Corrales River Mile 199 Project

Name: Joan Hashimoto

Mailing Address: [redacted]
(Street, City, State, Zip)

Email Address: [redacted]

- ☐ I am an elected official.
- ☐ I represent a federal, state, or local agency: ______ (Name of Agency)
- ☑ I represent an organization: Corrales Bosque Advisory Commission (Name of Organization)
- ☑ I am a private citizen.

The Draft EA will be made publicly available on the Bureau of Reclamation website.

Privacy Act Statement: The information you furnish above will be used to provide you with a copy of the Draft EA, if so desired; to compile mailing lists for sending brochures and other data concerning this project as well as other projects in which you might have an interest; and to establish an official record for this EA that will be published in project reports and made available to the public. Your disclosure of the requested information is voluntary. Failure to provide the requested information will prevent the delivery of documents and notification of further developments.

— BUREAU OF —
RECLAMATION

Public Scoping Meeting
Registration Card

Bureau of Reclamation

Corrales River Mile 199 Project

Name: Nancy Julian

Mailing Address: [redacted]
(Street, City, State, Zip)

Email Address: ______

- ☐ I am an elected official.
- ☐ I represent a federal, state, or local agency: ______ (Name of Agency)
- ☐ I represent an organization: ______ (Name of Organization)
- ☒ I am a private citizen.

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BUREAU OF RECLAMATION

Public Scoping Meeting
Registration Card

Bureau of Reclamation

Corrales River Mile 199 Project

Name: Keith Julian

Mailing Address: [redacted]

Email Address: [redacted]

☐ I am an elected official.

☐ I represent a federal, state, or local agency: ________________ (Name of Agency)

☐ I represent an organization: ________________ (Name of Organization)

☒ I am a private citizen.

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Albuquerque Bernalillo County
Water Utility Authority

PO Box 568
Albuquerque, NM 87103
www.abcwua.org

April 29, 2025

Jancoba Dorley, Ph.D.
Middle Rio Grande River Maintenance Project Manager
U.S. Department of The Interior, Bureau of Reclamation
Upper Colorado Basin Region 7, Albuquerque Area Office
555 Broadway NE, Suite 100
Albuquerque, NM, 87102

Re: Letter of Support for River Mile 199 Maintenance Project

Dear Dr. Dorley:

The Albuquerque Bernalillo County Water Utility Authority (Water Authority) is providing this letter of acknowledgement and support for the U.S. Bureau of Reclamation (Reclamation) proposed River Mile (RM) 199 River Maintenance Project. The Water Authority is familiar with the joint responsibilities of the U.S Army Corps of Engineers, the Middle Rio Grande Conservancy District, and Reclamation under the Middle Rio Grande Project associated with flood mitigation risk, irrigation and drainage, and downstream water delivery for this important semi-urbanized reach. Also, the importance of Interstate Rio Grande Compact Agreement for downstream water delivery between the States of Colorado, New Mexico, and Texas between the Otowi gauge and Elephant Butte Reservoir associated with the State of New Mexico's delivery requirements.

Reclamation staff consulted with the Water Authority in the fall of 2024 regarding the purpose, scope, and downstream effects of their upcoming project. The project is intended to protect riverside infrastructure that include the levee, drain, and canal systems from erosion along the Rio Grande north of Albuquerque, New Mexico. In addition, this project will provide for future reliable downstream water delivery through this reach by minimizing the risk of a levee breach into the adjoining riverside drains, canals, and lands. This reach of the Rio Grande is closely bounded by the Village of Corrales on the west and the Pueblo of Sandia to the east, both of which are protected by riverside levees. Moreover, this project includes elements to help reduce some of the erosive energies in this reach and reconnect portions of the floodplain that no longer experience overbank flows. Current geomorphic trends on this reach include riverbed incision, increased velocities and depths, lowering of the alluvial groundwater table, and narrowing as a result of sediment supply cutoff and flow regulation due to Cochiti Dam. This project as proposed will also provide localized ecological benefits to both aquatic and riparian habitats.

The Water Authority has its San Juan-Chama Surface Water Treatment Plant, intake/collection, and distribution systems located immediately downstream of this reach near the Alameda Bridge. Effective conveyance of San Juan-Chama water deliveries through this reach is important to the residents of Bernalillo County for their water supply. The Water Authority understands this project is currently undergoing environmental review related to the National Environmental Policy Act, Clean Water Act, and the Endangered Species Act and this letter is intended to demonstrate that we have been consulted with as part of those review processes. We appreciate the coordination from Reclamation on this project and have no objections to the proposed upstream reach work. Please continue to keep our office updated with any additional information for the RM 199 River Maintenance Project which may potentially affect downstream water delivery, the ABCWUA dam downstream and its associated works involving the upcoming proposed project.

If you have any questions, please contact me at mkelly@abcwua.org

Best regards,

Mark Kelly, PE
Water Resources Division Manager

Affidavit of Publication

STATE OF NEW MEXICO } SS
COUNTY OF BERNALILLO }

Ad Cost:	$1,194.76
Ad Number:	248590
Account Number:	1112735
Classification:	NON-GOVERNMENT LEGALS

I, Bernadette Gonzales, the undersigned, Legal Representative of the Albuquerque Journal, on oath, state that this newspaper is duly qualified to publish legal notices or advertisements within the meaning of Section 3, chapter 167, Session Laws of 1937, and payment of fees has been made of assessed and a copy of which is hereto attached, was published in said publication in the daily edition, 2 times on the following dates:

June 22, 2025
June 23, 2025

That said newspaper was regularly issued and circulated on those dates.
SIGNED:

Legal Representative

Subscribed to and sworn to me this 23rd day of June 2025.

STATE OF NEW MEXICO
NOTARY PUBLIC
Karen Marie Schoepke
Commission No.2003018
Expires: April 24, 2028

Subscribed to and sworn to me this 23rd day of June 2025.

Karen Marie Sc
Notary Public

Bernal County

ID#: 2003018

My commission expires: 4-24-2028

VERNADERO GROUP INCORPORATED
4833 CONTI ST
SUITE 103
New Orleans, LA 70119

NOTICE OF AVAILABILITY

DRAFT ENVIRONMENTAL ASSESSMENT FOR THE CORRALES RIVER MILE 199 PROJECT, NEW MEXICO

The Bureau of Reclamation (Reclamation) has prepared a draft Environmental Assessment (DEA) in accordance with the National Environmental Policy Act to assess the potential environmental impacts associated with a proposed Rio Grande channel rehabilitation project. The proposed Corrales River Mile 199 project would protect riverside infrastructure from erosion along the Rio Grande north of Albuquerque, New Mexico. Reclamation is authorized under the Flood Control Acts of 1948 and 1950 to maintain the river channel in the Middle Rio Grande to pass the 2-year return peak flow. In accordance with this authorization, Reclamation has developed a DEA describing the potential environmental impacts of the Proposed Action to protect the riverside levee system at three points where river meandering is currently threatening the integrity of the levee. The Proposed Action has secondary goals of rehabilitating the river planform (i.e., the shape of the river and how it flows) and enhancing aquatic and riparian habitat.

An electronic copy of the DEA is available at: https://www.usbr.gov/uc/DocLibrary/ea.html.

Reclamation is soliciting comments from interested local, state, and federal elected officials and agencies, as well as interested members of the public. Please submit your written comments concerning the DEA to the Project Manager, Dr. Jancoba Dorley, 555 Broadway NE, Suite 100, Albuquerque, NM, 87102, or to jdorley@usbr.gov by 7 July 2025. If you have any questions or would like more information on this project, please contact Dr. Dorley at (505) 859-1746.

APPENDIX B. CORRALES RM 199 PROJECT INFORMATION REPORT

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Corrales River Mile (RM) 199 Project Description

Middle Rio Grande, NM
Upper Colorado Region

U.S. Department of the Interior **5/12/2025**

Mission Statements

The U.S. Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated Island Communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Corrales River Mile (RM) 199 Project Description

Middle Rio Grande, NM
Upper Colorado Region

prepared by

Technical Services Division
James Fluke, Senior Civil Engineer, PE
Tammy Huynh, Civil Engineer, EIT

Cover Photo: Aerial photograph taken at ~500 feet above ground level looking south toward the RM 199 River Maintenance project area in May 2024. The riprap line at the Corrales Siphon and the interim bank protection windrow just downstream of the siphon are visible in the center of the photograph. Rio Grande flows were roughly 2,450 cfs at the time of the photograph as measured at the USGS Alameda Gage (USGS 08329918).

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Executive Summary

The Bureau of Reclamation is authorized under the Flood Control Acts of 1948 and 1950 to maintain the Rio Grande channel in the Middle Rio Grande to pass the 2-year return peak flow. In accordance with this authorization Reclamation has initiated a project to protect riverside infrastructure from erosion along the Rio Grande north of Albuquerque, New Mexico. The project has a primary goal of protecting the riverside levee system at three locations where river meander bends are currently threatening the levee. The project has secondary goals of rehabilitating the river planform and enhancing aquatic and riparian habitat.

The project area was identified both during regular aerial reconnaissance and on-the-ground monitoring as needing rehabilitation due to lateral development of the river bends toward the east and west riverside levees bounding the floodplain. Current geomorphic trends at play in this reach include river incision and narrowing, river bed material coarsening, vegetation encroachment, and reduced geomorphic complexity due to flow regulation.

The design features to address these adverse conditions include longitudinal riprap stone toe protection features to directly stabilize the eroding bend banklines, side channels through the vegetated point bars to improve habitat and alleviate hydraulic pressure at high flows, and construction of deformable rock bed controls to reduce local slope and raise groundwater levels. These will accomplish the project goals by 1) directly stabilizing the eroding bends, 2) dissipating erosive energy and 3) raising the channel bed elevation and slowing bed incision locally. The design features were selected for the conditions of this reach following Reclamation's 2012 Comprehensive Plan and Guide for the Middle Rio Grande (USBR, 2012).

1.0 Project Background and Purpose

The Bureau of Reclamation is authorized under the Flood Control Acts of 1948 and 1950 to maintain the Rio Grande channel in the Middle Rio Grande to pass the 2-year return peak flow. In accordance with this authorization Reclamation has initiated a project to protect riverside infrastructure from erosion along the Rio Grande north of Albuquerque, New Mexico. This reach of the Rio Grande is closely bounded by the Village of Corrales on the west and the Pueblo of Sandia to the east, both of which are protected by riverside levees. The project has a primary goal of protecting the riverside levees at three meander bend locations where the river is currently on a trajectory to threaten the levee systems and secondary goals of rehabilitating the river planform and enhancing native riparian habitat. Overall, the project purpose is to stabilize the outer banks and restore the reach energy grade to a point at which the levees are not at risk.

The project area was identified as needing rehabilitation due to lateral migration and bank erosion along river bends toward the existing east and west levees. Current geomorphic trends on this reach include river bed incision and narrowing as a result of sediment supply cutoff and flow regulation due to Cochiti Dam (USBR, 2012; Massong, 2005). Upstream reach sediment supply cutoff at

Cochiti Dam results in clear water scouring flows exiting the dam and armoring of the channel bed downstream of Cochiti Dam with cobbles and gravels as river sand sized sediments are evacuated by the high energy flows. As the river bed becomes incised the flows eventually destabilize the river banks and floodplain terraces (comprised on finer sands and silts) leading to meander development resulting from the distribution of energy along the channel. Up to 6 feet of bed lowering between 2001 and 2019 has been documented by Reclamation-contracted point survey crews in the project area (Klein et al., 2021). Flow regulation has led to decreased peak flows and extended base flows enabling vegetation to colonize and become established on the lower bars and terraces in the channel. As the vegetation matures the active channel becomes confined to a narrower and deeper path. The river bed elevation is also lower than the rootzone of the adjacent cottonwood and willow vegetation. This vegetation is no longer stabilizing the existing bankline. Detriments of a narrow and incised channel include lateral erosion from higher in-channel velocities and depths, formation of cut banks, low floodplain connectivity, poor habitat quality due to lack of complexity, and poor flood flow conveyance.

The design features will accomplish the project goals by 1) directly stabilizing the eroding banks, 2) dissipating erosive energy and 3) raising the channel bed elevation. The design features were selected for the conditions of this reach following Reclamation's 2012 Comprehensive Plan and Guide for the Middle Rio Grande (USBR, 2012). These will be implemented using riprap stone toe protection features to directly stabilize the eroding banks, side channels through the vegetated bars to improve habitat and alleviate hydraulic pressure at high flows, and construction of deformable bed controls to reduce local slope and raise locally both surface and groundwater levels.

2.0 Project Components

The primary project components are described in the sections below and shown in Figure 1 below.

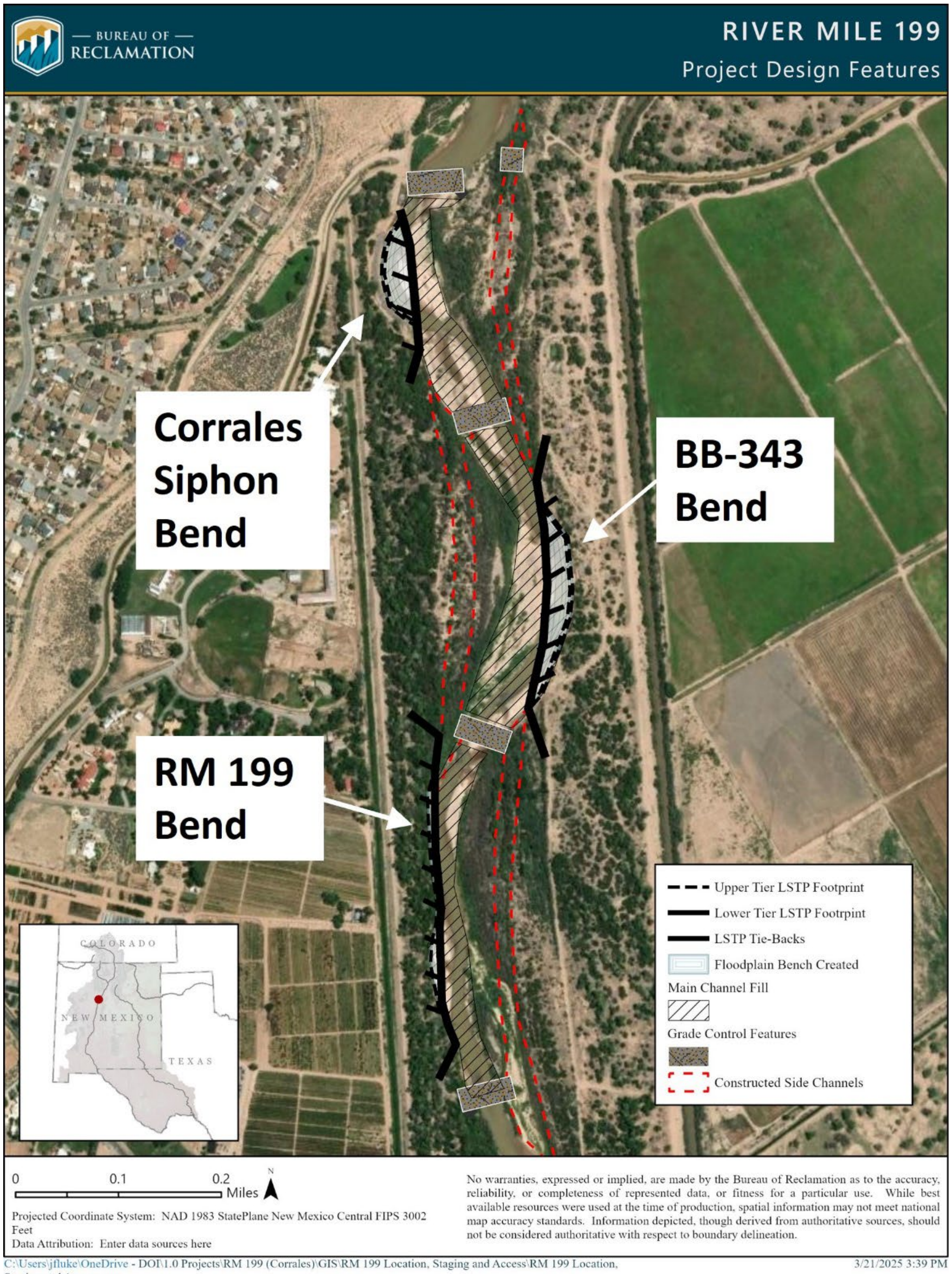


Figure 1: Corrales RM 199 River Maintenance project layout and features.

2.1 Longitudinal Stone Toe Protection (LSTP)

The eroding meander bend outer banks will be protected with a 2-tiered Longitudinal Stone Toe Protection (LSTP) and intermediate floodplain bench. The tiers of stone toe protection will be separated by a low terrace to be constructed using fill from the excavated side channels. The LSTP features will be constructed using rock sizing and constructed dimensions required to withstand the erosive force and scour expected to result from the 10-year flood flow event of approximately 7,900 cfs (Clarkin, 2023). Scour depths at the outer bends range from 3 to 5 feet in the design condition assuming no armor layer halts the toe erosion. The stone toe is designed to be overtopped at roughly the 2-year return flow of 4000 cfs (Clarkin, 2023) which roughly corresponds to the flow associated with the Ordinary High Water Mark (OHWM) or channel forming flow.

The LSTP features will be installed along roughly 4,700 feet of existing bankline at the 3 identified bends in the project area. Tie-backs and structural keys into the bank will ensure longevity of the lower LSTP tier by preventing flanking of the LSTP feature at the upstream or downstream ends, or due to flows overtopping the stone toe. The total estimated volume of riprap to construct the tiered LSTP features will be roughly 12,000 cu yd of 16 to 24-inch rock and 5,000 cu yd of 12-inch rock. The volume of floodplain bench backfill material will be roughly 25,000 cu yd (See Section 9.2, Table 9 for the fill quantities tabulated by bend). The lower tier of the LSTP features will be constructed using 16 to 24-inch median diameter rock. The upper tier will be constructed using 12-inch median diameter rock. These rock sizings correspond to the ranges of rock sizes recommended for side slopes based on hydraulic parameters (depth and velocity) simulated at the 10-year peak flow rate.

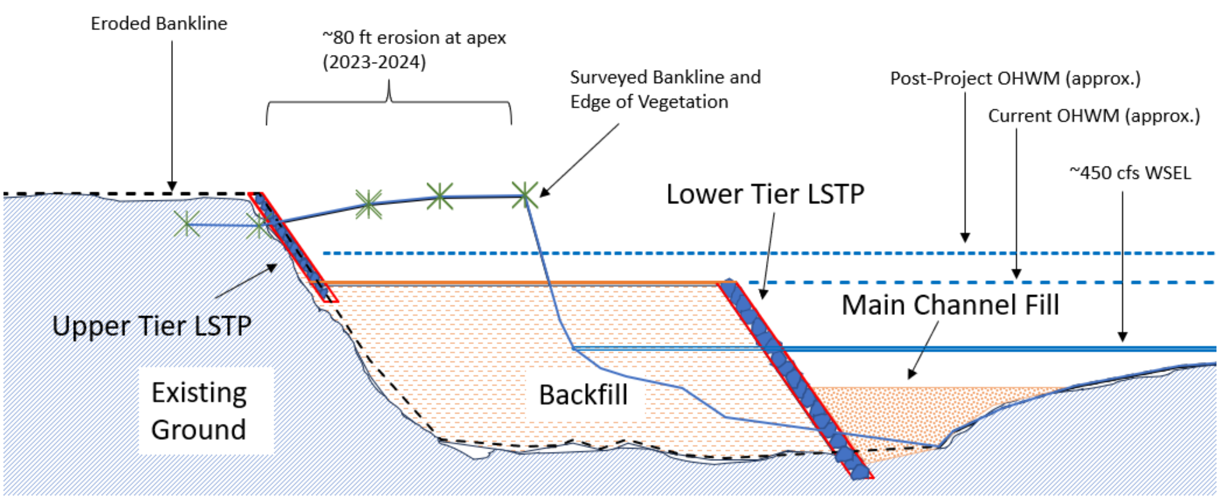


Figure 2: Schematic of the 2-tiered Longitudinal Stone Toe Protection (LSTP) feature at the BB-343 bend including the area of floodplain bench and main channel backfill (not to scale). The erosion at the apex of the bend was roughly 80 feet between the survey conducted in July, 2023 and April, 2024.

Table 1: Design geometry and quantities for the Longitudinal Stone Toe Protection (LSTP) bank protection features including tie-backs, structural keys, and backfill floodplain bench.

LSTP Feature	Length of Application (ft)	Riprap Nominal Median Diameter (in)	Riprap Placement Thickness (ft)	Linear Application Rate (cu yd/ft)	Total Volume of Riprap (cu yd)
Corrales Siphon Bend Lower Revetment	1,480	16–24″	3-4	1.8	2,700
Corrales Siphon Bend Upper Revetment	1,120	12″	2	1	1,200
BB-343 Bend Lower Revetment	2,320	16–24″	3-4	1.8	4,200
BB-343 Bend Upper Revetment	1600	12″	2	1	1,600
RM 199 Bend Lower Revetment	2,700	16–24″	3-4	1.8	4,900
RM 199 Bend Upper Revetment	1980	12″	2	1	2,000
Total					
Lower Revetment and Tie-backs	6,500	16–24″	3-4	1.8	11,800
Upper Revetment	4,700	12″	2	1	4,800

+

2.2 Constructed Side Channels

Side channels will be excavated along the accreted sand bars opposite of each of the three meander bend bank stabilization locations to help dissipate erosive force and flows at above average flow rates. These side channels will also provide additional geomorphic and habitat complexity. A total length of 5,280 feet of side channel will be excavated with an estimated total volume of 55,400 cu yd. The side channels will include constructed inner terraces at 1 foot above the side channel bottom elevation save for the northernmost side channel which will not feature terraces. The side channels will have a 20 foot bottom width and 1-foot terraces at a 4:1 (h:v) slope above the channel bottom for an inner compound channel with a 28-foot top width.

The side channels are designed to activate at above average flows, with the outlets inundating at roughly 1,000 cfs and the inlets inundating at roughly 2,000 cfs in the design condition. This flow rate to fully activate the side channels is just below the estimated 2-year return peak flow rate for summer conditions (Clarkin, 2023), ensuring the side channels will receive sufficient river flow to be sustainable and effective. The side channels will have average slopes of 0.002 ft/ft. For comparison the river channel in this reach has a slope of roughly 0.001 ft/ft in the area below the rock at the Corrales Siphon.

The side channels will also function to convey river flows around the work area during construction of the bank protection features, grade control, and raising of the stream bed. This will be accomplished by constructing rock lined trapezoidal earthen berms at the upstream and downstream ends of the work area to redirect river flows into the constructed side channels. The rock lining will only face the river flows at these temporary diversion features with earthen material behind the rock. The side channels will initially be constructed to contain the 25% exceedance of daily flows for the winter construction period. This is roughly 660 cfs based on gage analysis of the most recent 10-years of daily flow data recorded at the USGS Alameda Bridge Gage (USGS 08329918). Each side channel will contain the river base flows while the LSTP feature is constructed along the opposite bank. The construction of the features will proceed from south to north as described in the "Construction Sequencing" section. The side-channels will be monitored during construction to identify any headcutting or adverse channel development. Field engineering will be employed to address any developments that could adversely affect the final constructed project.

The spoil material generated from the construction of the side channels will be used to backfill the lower tier bench of the LSTP features and as fill material to be added to the existing main channel upstream of each bed control feature.

Table 2: Side channel design geometry, flow capacity, and quantities.

Side Channel	Length (ft)	Bottom Width (ft)	Hydraulic Capacity (cfs)	Inlet Elevation (ft)	Outlet Elevation (ft)	Total Excavated Volume (cu yd)
Corrales Siphon Side Channel	1730	20	660	5033.9	5029.3	11,400
BB-343 Side Channel	2000	20	660	5031.8	5027.7	21,000
RM 199 Side Channel	1520	20	660	5029.2	5026.1	23,000
Total	5,250					55,400

2.3 Bed Control Features

To locally reduce river slope and upstream erosive velocities deformable grade control features will be constructed in the river channel. The deformable grade control features will be constructed using stone sized to be stable at the 5-year return flow of 6,500 cfs (Clarkin, 2023) for the in-stream shear and velocity conditions and will be installed at the three inflection points of the meander bends as shown in Figure 1 where natural riffles would typically form. The stone features will be installed as a rock sill with a key into the bed at the downstream end as shown in Figure 4. The rock sill will be similar in concept and function to the deformable rock sill and gradient restoration facilities (GRFs) along the Rio Grande in the upstream Bernalillo/Santa Ana reach. Lastly, an additional deformable rock sill will be installed downstream of the existing wooden box for the Corrales Siphon for its localized protection from construction of a side channel over it at the most upstream bend.

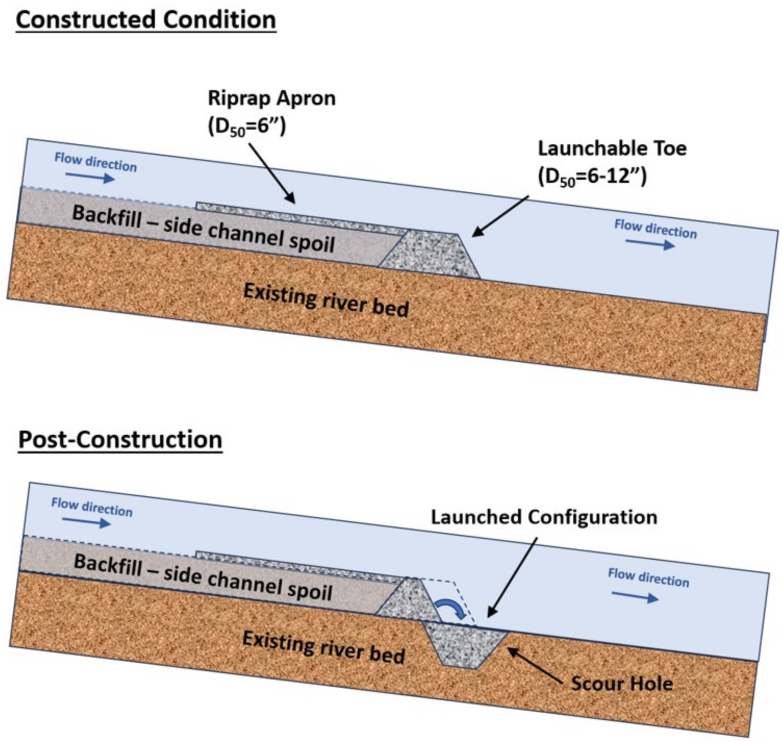


Figure 3: Schematic of a typical trenched bed control feature with upstream rock sill (not to scale) and showing both the constructed condition and the post-construction condition including the launch of the stone toe.

The total estimated volume of cobble sized material (256mm -64mm) to be placed in the channel bed is roughly 9,720 cu yd including the aprons and the keys at the downstream ends (total for all bed control features). The cobble used for the sill along the channel bed (8,920 cu yd) will be of a 6-inch median diameter corresponding to a stable rock size under the 5-year return peak flow rate of 6,500 cfs. The rock used to key the bed control features into the bed (the toe, or trenched portion) should be larger involving 6 to 12-inch median diameter (800 cu yd, total for all bed control features). The stone key is sized to fill the scour hole expected to develop below the rock sill once flows begin to scour at the downstream end of the constructed features.

In addition to serving as grade control in the final design condition, the material used to construct the grade control will firstly be used for the upstream and downstream coffer dams and access points for equipment across the river (Figure 4). To do this a coffer dam will be constructed using the future grade control material and side channel spoil as needed to redirect upstream flows into the aforementioned side channels. The coffer dams will be 20 feet wide at their crest to allow equipment crossing and will have heights of 5-8 feet from the channel bottom with side slopes of at least 2:1 (h:v). The upstream side of the coffer dam that comes in contact with flows shall be rock-lined at a minimum thickness of 2*D50 or 1 foot.

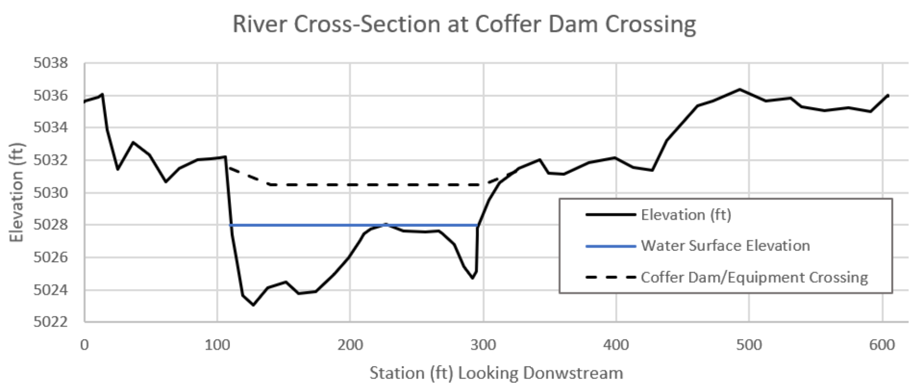


Figure 4: Cross-section schematic showing the elevation of the coffer dams to be constructed across the river channel.

If the existing placed cross-channel rock at the Corrales Siphon crossing can be used for this project the quantity of rock needed for the grade control can be reduced. As of early 2025 this project assumes the rock at the Corrales Siphon cannot be used for this project due to issues involving ownership of lands along the siphon alignment and timing of the planned replacement project.

Table 3: Design geometry and quantities for the deformable bed control features.

Bed Control Feature	Longitudinal Length of Cobble Placement (ft)	Width of Cobble Placement (ft)	Thickness of Cobble Placement (ft)	Nominal Rock Size (in)	Total Volume (cu yd)
Trenched Bed Control below Corrales Siphon	8	450	2.5	12	300
Surface Bed Control below Corrales Siphon	125	450	1	6	2500
Trenched Bed Control below Corrales Siphon Bend	8	450	2.5	12	260
Surface Bed Control below Corrales Siphon Bend	125	450	1	6	2100
Trenched Bed Control below BB-343 Bend	6	350	2.5	12	140
Surface Bed Control below BB-343 Bend	125	350	1	6	1600
Trenched Bed Control below RM 199 Bend	7	270	2.5	12	100
Surface Bed Control below RM 199 Bend	250	270	1	6	2600
Protection for Corrales Siphon Box	80	40	1	6	120
Total	500				9720

2.4 Main Channel Fill

The spoil material from the excavation of the side channels will be used to fill the incised main channel and backfill the LSTP features. The main channel will be raised locally about 1.5-2.5 feet at each bed control feature crest or starting point with the placed fill being held in place by the deformable grade control features. Roughly 25,000 cu yd will be placed in the main channel between the 4 grade control features in the main channel.

Most (about 15,000cy) of this material will be placed along the two upstream bed controls and channel lengths at the Corrales Siphon Siphon and BB-343 bends where the where the river bed is the most incised and bank height is significant from recent years. The remaining 10,000 cy of the anticipated spoil will be placed at the RM 199 bend. See in Section 9.0 Construction Quantities for the quantities of fill in each feature location for the project.

3.0 Environmental Effects

Approximately 20 acres of floodplain will actively be disturbed as part of the planned construction activities for this project for its construction duration. Additionally, the river will be temporarily re-routed via earthern berm coffer dams into identified the project side channels to dewater the existing channel for the construction the LSTP bankline along the cut banks and the in-stream bed control features.

3.1 Work Activities Below OHWM (Ordinary High Water Mark)

The OHWM in this reach of the Rio Grande is typically considered to be at the edge of woody vegetation. Locally in this reach, the determination of the OHWM is affected by the flow regulation at Cochiti Dam, the recent channel incision and existence of cut banks, and the effect of the Corrales Siphon box and placed riprap functioning as bed elevation control. Notably, erosion is observed below the Corrales Siphon rock protection which provides roughly 3 feet of vertical drop over a short distance.

Figure 5: Plan view of project area showing the Ordinary High Water Mark (OHWM) based on field assessment and showing the most recently available aerial imagery.

Work below the OHWM will include installation of the LSTP features, placing of the bed fill, and construction of the deformable bed control features. This work will be caried out by tracked equipment used to excavate and construct the project features and haul trucks to move the rock and earthen fill. At least one temporary ramp from the floodplain to the river bed elevation will need to be constructed in order to access the main channel for construction of the in-channel features.

The lower tier of the LSTP features will be below the OHWM and will be inundated during average and above-average flows. The estimated volume of riprap to be placed below the OHWM is 8,500 cu yd. This quantity includes the exposed rock face of the LSTP feature and does not include the tie-backs which will be covered with spoil material. The area below the OHWM affected by the placement of these features is approximately 0.3 acres corresponding to the top width of the design features.

The bed fill placed in the channel will be the material excavated from the side channels that is not required to backfill the tiered LSTP features. Overall the total volume to be placed in the river channel including the bed fill and backfill for the LSTP features is roughly 55,400 cu yd and will be spread over an area of roughly 18.9 acres of active river channel. Roughly 25,200 cu yd will be placed as backfill behind the LSTP features (5.4), and the remainder (roughly 25,300) cu yd will be placed in the main channel bed (13.5 ac).

Lastly, the deformable bed control features will be completely below the OHWM and will be inundated during average flows. The estimated volume of the deformable bed control features is 9,600 cu yd.

Table 4: Areas of floodplain bench created at current Ordinary High Water Mark

Feature	Floodplain Bench Area roughly at current OHWM (ac)
Corrales Siphon Bend	1.6
BB-343	2.6
RM 199 Bend	1.2
total (ac)	5.4

Main Channel section	Main channel bed fill (ac)
Corrales Siphon Bend	3.7
BB-343	3.5
RM 199 Bend	6.3
total (ac)	13.5

Table 5: Top area of longitudinal stone toe protection placement below the Ordinary High Water Mark

Feature	Top area of stone placement (ac)
Corrales Siphon Bend	0.06
BB-343	0.11
RM 199 Bend	0.12
total (ac)	0.3

4.0 Access

Site access from I-25 will be via the Bosque road through Sandia Pueblo via US Hwy 313 as shown in Figure 6 below. From Bosque road cross the riverside canal at the concrete fire bridge and from there drive along the levee road. Alternate site access to the east side is from Bernalillo going south along US Hwy 313.

Access to the project area from the west side is along Corrales Siphon Road off of US Hwy 448. Take US Hwy 528 to US 448 (Corrales Road) and turn north onto Corrales Siphon Road. Alternately, take Corrales Road to the Harvey Jones Channel and drive North along the levee road. This route is owned by the Southern Sandoval County Flood Control Authority (SSCAFCA).

Figure 6: RM 199 River Maintenance Site access routes accessible from US Interstate 25 and US Hwy 528.

5.0 Construction Staging Areas

The staging areas for the construction equipment and temporary riprap and/or fill material storage needed during the construction operations will be mainly along the eastern side of the river along the BB-343 bend.

Figure 7: Plan view of project area showing the planned access routes and staging areas.

6.0 Excavation Spoils Management

Spoils material will be created as a result of excavation of the side-channels. The spoil material will be placed in mounds along the inner sand bars as described in section 7.0 Construction Sequencing. The spoil material will ultimately be used to backfill the tiered LSTP features and as fill in the main channel upstream of each bed control feature with the exception at the siphon crossing as earlier described. The spoil material will be composed of river floodplain sand and gravels with some cobble sized materials as is typical of the accreted sand bars in this area.

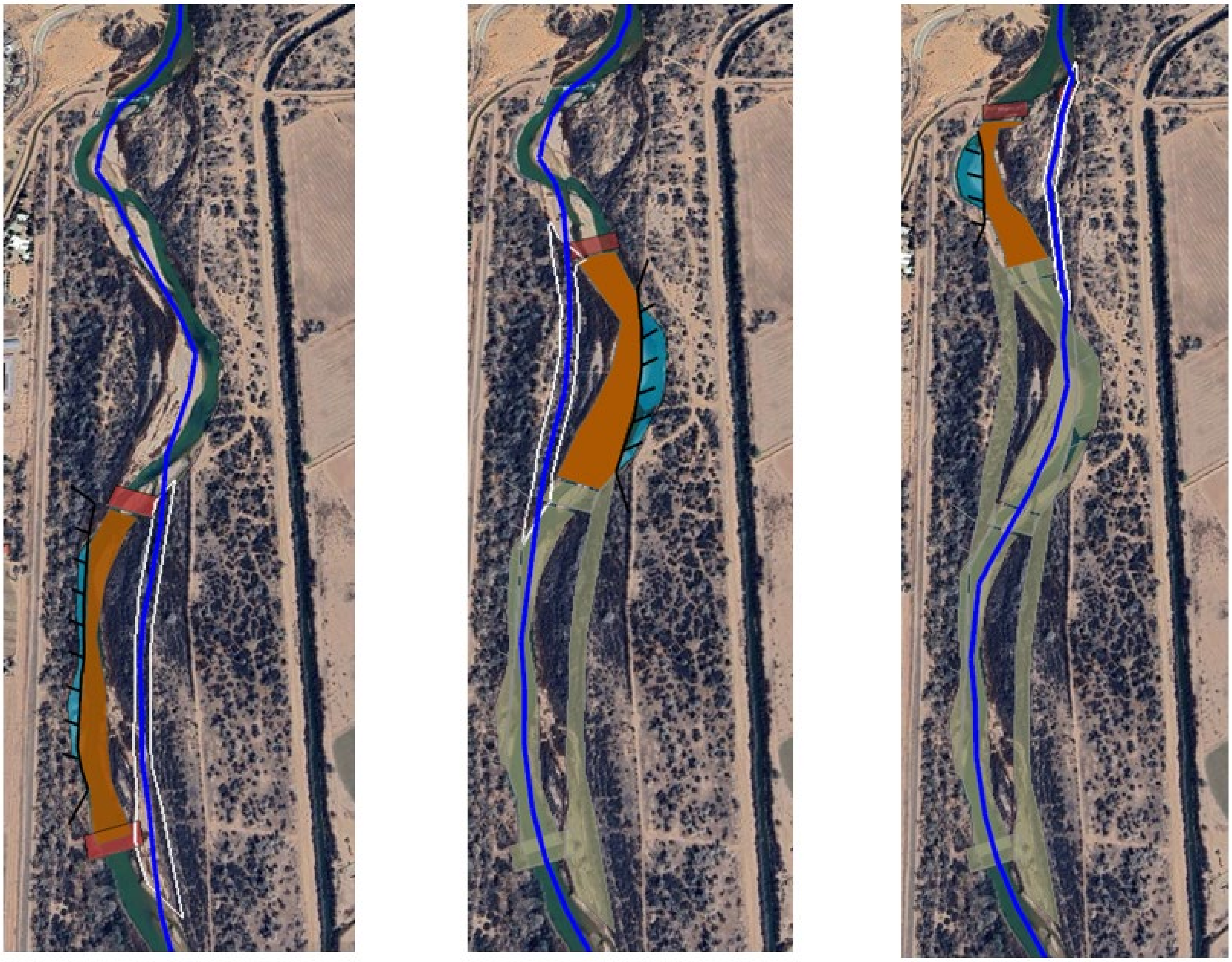
The spoil material used to backfill the LSTP features will be planted with cottonwood and willow poles following construction and at a time of year that will ensure the best chance of success of planting. In the event that there is more spoil material available onsite than anticipated; the additional material will be used to ensure slope continuity downstream of the grade control features as required. If even more space is needed for spoil material it may be used to raise the levee and/or repair any roads damaged by the hauling.

7.0 Construction Sequencing

To facilitate construction at the project site, the following steps will be taken proceeding from downstream at the RM 199 bend protection feature to upstream at the Corrales Siphon bed control feature and cutoff channels. The exact sequence may vary in the field with the sequencing defined here intended to not be prescriptive to allow for field adjustments.

Overall, the sequencing of the project will be dependent on how the main channel is dewatered for the installation of the LSTP's, the bed control features, and the main channel fill. It is proposed to divert the river flow during base flows into the constructed side channels opposite of each respective bend (Figure 8). Diverting river flows for construction at one bend at a time will allow for close monitoring of river flows and groundwater levels affecting the work area. The proposed sequencing begins at the southern end of the project area in order to establish the downstream grade for the project area and since the outer bend at RM 199 is closest to the levee and presents the greatest risk should erosion occur at this bend as it has in the two upstream bends within the project as a result of recent runoff events.

The construction is expected to be completed in the eight-month construction season between 15 August 2025 to 15 April 2026. If cuckoos are present, construction will not begin until 1 September.



Phase I

- RM 199 Bend LSTP and backfill
- Side Channel (Sandia side)
- Main channel fill
- Bed Control features (x2)

Phase II

- BB-343 Bend LSTP and backfill
- Side Channel (Corrales side)
- Main channel fill
- Bed Control feature

Phase III

- Corrales Siphon Bend LSTP and backfill
- Side Channel (Sandia side)
- Main channel fill
- Bed Control feature x2 (main channel and side channel)

Figure 8: Overall proposed construction phasing for the RM 199 project features.

Step 1:

Excavate the cutoff/side channel on the RM 199 point bar, leaving the entrance and exit plugs in place. Stockpile spoil material on the inside of the RM 199-point bar (see Figure 7). Remove entrance and exit plugs to allow flow through the newly excavated cutoff/side channel.

Step 2:

Build temporary riprap diversion cofferdam/berm immediately downstream and upstream of the RM 199 cutoff channel entrance and exit, respectively. All flows would temporarily be in the cutoff/side channel and the RM 199 bend would be temporarily dry. Any remaining pools of stranded water in the main channel would then be surveyed for Rio Grande silvery minnow (minnow) by approved Reclamation biologists or contractors approved by the U.S. Fish and Wildlife Service. Any minnows found would be returned to flowing water in the river channel.

Step 3:

On the RM 199 outer bend, install the Longitudinal Stone Toe Protection (LSTP). Place cutoff/side channel's spoil material in the (dry) main channel, install bed control rock lining and trench, and fill in behind the LSTP for the floodplain bench. During this time monitor flows through the side channel and identify any headcutting that may require stabilizing of the grade.

Step 4:

Smooth out the riprap from the downstream temporary riprap diversion cofferdam onto the spoiled material filling the main channel. This will stabilize the slope going from spoil material grade to main channel grade. Leave the upstream temporary riprap diversion cofferdam in place.

Step 5:

Excavate the cutoff channel on the BB-343-point bar, leaving the entrance and exit plugs in place. Stockpile spoil material on the inside of the point bar. Remove entrance and exit plugs to allow flow through the cutoff channel.

Step 5:

Build temporary riprap diversion cofferdam immediately downstream of the BB-343 cutoff channel entrance. All flows would temporarily be in the cutoff channel and the BB-343 bend would be temporarily dry. Any pools of stranded water in the main channel would then be surveyed for minnows by approved Reclamation biologists or contractors approved by the U.S. Fish and Wildlife Service. Any minnows found would be returned to flowing water in the river channel. On the BB-343 outer bend, construct the LSTP. Place the cutoff channel's spoil material in the (dry) main channel and fill in behind the LSTP for the floodplain bench. Monitor flows through the side channel and identify any headcutting that may require stabilizing of the grade.

Step 6:

At the temporary riprap diversion cofferdam between BB-343 and RM 199, smooth out the riprap onto the spoiled/fill material now placed upstream and downstream of the temporary riprap diversion cofferdam. This feature will now act as grade control to prevent erosion of fill material.

Step 7

Excavate the cutoff channel on the Corrales Siphon point bar, leaving the entrance and exit plugs in place. Stockpile spoil material on the inside of the Corrales Siphon point bar. Place a small layer of riprap immediately downstream of the siphon's alignment inside the cutoff channel to minimize potential downcutting to the siphon. Remove entrance and exit plugs to allow flow through the cutoff channel.

Step 8

Build a temporary riprap diversion cofferdam on top of the siphon's downstream riprap protection installed by MRGCD. If MRGCD is opposed to a temporary riprap diversion cofferdam on top of the siphon's riprap protection, the cofferdam could also be placed closer to the upstream entrance of the cutoff channel. However, this configuration would require a much longer cofferdam. All flows would temporarily be in the cutoff channel and the Corrales Siphon bend would be temporarily dry. On the Corrales Siphon bend, construct the LSTP. Place the cutoff channel's spoil material in the (dry) main channel and fill in behind the LSTP for the floodplain bench. Monitor flows through the side channel and identify any headcutting that may require stabilizing of the grade.

Step 9

At the temporary riprap diversion cofferdam between Corrales Siphon bend and BB-343 bend, smooth out the riprap onto the spoiled/fill material now placed upstream and downstream of the cofferdam. This feature will now act as grade control to prevent erosion of fill material. At the temporary riprap diversion cofferdam at the siphon, smooth the extra riprap in the downstream direction to create a smooth slope with a downstream apron for extra scour protection.

Step 10

Within 2 years of construction plant willow and cottonwood poles on the floodplain benches created behind the LSTP features. The poles should be within 3-6 feet of groundwater to ensure the best chance of success for the plantings.

8.0 Best Management Practices

The following Best Management Practices (BMPs) will be used at the site to minimize the risk of effects from the RM 199 project on the river and the surrounding areas.

General BMPs:

Timing of the Proposed Action

1. Reclamation will seek to avoid impacts to neotropical migratory nesting birds protected by the Migratory Bird Treaty Act (16 United States Code [U.S.C.] 703; MBTA), including the federally endangered Southwestern willow flycatcher (Empidonax traillii extimus; flycatcher) and the federally threatened Western yellow-billed cuckoo (Coccyzus americanus; cuckoo) protected under the Endangered Species Act (16 U.S.C. 1531; ESA), by conducting work activities outside of the normal breeding and nesting season (April 15 to August 15, or September 1 for work in suitable cuckoo habitat).

    1.1. If work is necessary between April 15 and August 15 (or September 1 for work in suitable cuckoo habitat), suitable/occupied migratory and listed bird species habitat will be avoided during the construction activities as much as possible, utilizing the most currently available survey results in conjunction with habitat suitability. Reclamation will use current flycatcher and cuckoo monitoring data to avoid work within 0.25 miles of an active nest as much as possible. Coordination and consultation with the U.S Fish and Wildlife Service (Service) will occur prior to such work activities.

1.2. Reseeding or revegetation may be accomplished by hand or by mechanized means. Planting via mechanized means includes using a hand-held or tractor-mounted auger. If mechanized means are used for either reseeding or replanting in the April 15 to August 15 timeframe (or September 1 for work in suitable cuckoo habitat), migratory bird surveys will be conducted immediately prior to the work to determine if any breeding birds are present. If birds are detected, Reclamation will coordinate with the Service to determine appropriate next steps.

Water Quality

2. Reclamation will obtain all applicable permits prior to implementation of the project, including authorizations and certifications required under various sections of the Clean Water Act (33 U.S.C 1251–1387; CWA). Reclamation will comply with the requirements of the CWA and other permits associated with the project, including required reporting to the appropriate authorities as needed and will not begin work until all required permits are obtained.

3. Reclamation will visually monitor for water quality in the areas below areas of river work before and during the workday. Water quality will be monitored during construction and after equipment operates in the river channel. Monitoring will include visual observations and may include direct sampling, as appropriate.

   3.1. If direct sampling is needed, water-quality parameters to be tested include pH, temperature, dissolved oxygen, and turbidity. Parameters will be measured both upstream and downstream of the work area.

   3.2. Responses to changes in water-quality measures exceeding the applicable standards would include reporting the measurements to the New Mexico Environment Department Surface Water Quality Bureau and moving construction activities away from the shore.

Equipment and Operations

4. Reclamation-led work activities that have the potential for adverse impacts will be monitored by properly trained Reclamation personnel to ensure compliance.

5. Reclamation will excavate an area as few times as possible to minimize disturbance of sediments. When placing fill within the wetted channel, the following practices will be used to minimize disturbance of sediments:

   5.1. Minimize movement of excavator tracks.

   5.2. Minimize excavator bucket contact with riverbed.

6. Each individual operator will be briefed on local environmental considerations specific to the project tasks.

7. Minimize impact of hydrocarbons: To minimize potential for spills into or contamination of aquatic habitat:

7.1. Hydraulic lines will be checked each morning for leaks and periodically throughout each workday. Any leaky or damaged hydraulic hoses will be replaced.

7.2. All fueling will take place outside the active floodplain, where possible. All fueling will occur with a spill kit ready. If amphibious excavators are used, fueling will occur at the Rio Grande using airboats equipped with lined fuel containment. Fuel, hydraulic fluids, and other hazardous materials may be stored on site overnight, but outside the normal floodplain, not near the river or any location where a spill could affect the river.

7.3. All equipment will undergo high-pressure spray cleaning and inspection prior to initial operation in the project area.

7.4. Equipment will be parked on pre-determined locations on high ground away from the river overnight, on weekends, and holidays.

7.5. Spill protection kits will be onsite, and operators will be trained in the correct deployment of the kits.

7.6. External hydraulic lines are composed of braided steel covered with rubber. When there is increased risk of puncture such as during mastication while removing vegetation, external hydraulic lines will be covered with additional puncture-resistant material, such as steel-mesh guards, Kevlar, etc. to offer additional protection.

8. Equipment will be removed from the channel in the event of high storm surges.

9. To allow fish time to leave the area before in-water work begins, equipment will initially enter the water slowly. In-water work will be continuous during workdays, so that fish are less likely to return to the area once work has begun.

10. Riprap to be placed in the water will be reasonably clean to the extent possible. If there are large clumps of soil bigger than 1 foot within the riprap, those clumps will be set aside during the loading or placing operations.

Access and Staging

11. Impacts to terrestrial habitats will be minimized by using existing roads whenever possible. In general, equipment operation will take place in the most open area available, and all efforts will be made to minimize damage to native vegetation and wetlands (also see BMP titled Vegetation Replanting and Control below).

12. All necessary permits for access points, staging areas, and study sites will be acquired prior to construction activity.

Vegetation Replanting and Control

13. A variety of revegetation strategies may be used: stem and pole cuttings long stem transplants and upland planting with and without a polymer, zeolite, or similar compound to maximize soil water retention (Dreesen, 2008). Planting techniques may vary from site to site, and may consist of buckets, augers, stingers, and/or water jets mounted on construction equipment. In some

areas, a trench may be constructed to facilitate the placement of a significant number of plants, specifically stem and pole cuttings. Seeding would be accomplished using a native seed drill, where feasible, and spread with a protective covering which would provide moisture to the seeds.

14. Vegetation control may consist of mechanical removal, burning, mowing, and/or herbicide treatment. Herbicides will be used when non-chemical methods are unsuccessful or are not economically feasible (see section Herbicide and Pesticide Use below).

    14.1. Vegetation control will be completed between August 15 (or September 1 for work in suitable cuckoo habitat) and April 15 to avoid adverse impacts to migratory nesting birds and their associated habitats. Any need for deviations from this work window will be considered on a project-specific basis and coordinated with the Service. If work is planned within two weeks before April 15 or after August 15 (or September 1 for work in suitable cuckoo habitat), Reclamation will conduct additional surveys, if warranted, to determine the presence of breeding flycatchers, cuckoos, or other migratory birds. Reclamation and/or the appropriate project partner will coordinate monitoring and work activities with the Service, as appropriate, if bird nests are found.

15. Native vegetation at work sites will be avoided to the extent possible. If large, healthy native woody vegetation (primarily cottonwood, above 6" diameter at breast height), needs to be removed, they will be replaced at a ratio of 10:1. When and where possible, small, native woody vegetation will be removed or harvested at the appropriate season to use for revegetation work at another location in the project area or at another project site. Native vegetation that cannot be replanted may be mulched (mulch will be removed or spread on site at a depth of three inches or less) or temporarily stockpiled and used to create dead tree snags or brush piles in the project area upon completion.

16. Nonnative vegetation that is removed at work sites will be mulched, burned, or removed offsite to an approved location. Mulched vegetation may also be spread on site at a depth of three inches or less.

Herbicide and Pesticide Use

17. The use of chemical herbicides or pesticides may be necessary to control undesirable plant species around stockpile sites and storage yards and to prevent the spread of invasive species in areas cleared for maintenance activities. It also may be necessary to spray or control arthropods (spiders, ants, cockroaches, and crickets) that pose a safety problem or are a nuisance in buildings and facilities; birds (pigeons and swallows) roosting in building structures that are considered a nuisance; and mice that get into structures and/or equipment. Since the application of herbicides and chemical spraying is tightly controlled by State and Federal agencies, Reclamation will follow all State and Federal laws and regulations applicable to the application of herbicides, including guidelines described by White (2007). Herbicides or pesticides will not be directly applied to or near water unless they are labeled for aquatic use and appropriate buffers will be observed. Communication with the Service will occur prior to any application to sites with threatened or endangered wildlife species. Reclamation will follow the Albuquerque Area Office Integrated Pest Management Plan and Pesticide General Permit (Reclamation, 2015) when applying herbicides or pesticides. The non-Reclamation project partners will follow their

agencies' herbicide/pesticide guidance, if applicable. Herbicides or pesticides may be applied using low pressure spray rigs mounted to OHVs, trucks and trailers with spray bars, or backpack sprayers (for spot applications). Treatments will be conducted by trained and approved personnel observing appropriate buffer distances and label directions. Treatment will not take place when winds exceed 10 miles per hour or when rain is forecasted for the local area within 48 hours of application. Care will be taken when mixing or applying any herbicide to avoid runoff onto the ground or into the water. Surfactants may also be added to certain herbicides to maximize herbicide/pesticide performance and minimize retreatments.

Dust Abatement

18. If water is needed for dust abatement or to facilitate grading of roads, water may be pumped from the Rio Grande, irrigation drains, sumps, or secondary channels adjacent to the river. During irrigation season (March 1 to October 31), water will not be pumped from the river but will be pumped from the irrigation drains if possible. Pumping from the river is not expected to be needed between April 15 and August 15 (or September 1 in suitable cuckoo habitat); however, if pumping is needed between May 1 and July 1 (emergencies only), Reclamation and/or the appropriate project partner(s) will coordinate with the Service to avoid impacts to minnow eggs and larvae. Outside of the irrigation season, an amount not to exceed 5% of river flows at the time of pumping may be drawn from the Rio Grande. Pumping is short duration (minutes) for filling whatever water transport equipment is used. Sumps or secondary channels adjacent to the river will be used, whenever feasible. Pump intake pipes will use a 0.25 in (0.64 cm) mesh screen at the opening of the intake hose to minimize entrainment of aquatic organisms.

Other Measures

19. All treatment and control areas will be monitored for three years following construction to determine the effectiveness of the methods implemented and identify project-related hydrologic and geomorphic alterations. The monitoring will consist of biological, vegetation, geomorphic, and hydrologic monitoring, as appropriate to the project design and purpose.

20. All project spoils and waste will be disposed of offsite at approved locations or may be used on site as appropriate to the project purpose, consistent with applicable environmental requirements.

21. All work projects will have a contract in place for the rental of portable restroom facilities during the duration of the project.

9.0 Construction Quantities

Expected and maximum construction quantities estimated at the 90% design level including riprap quantity and sizing and earthwork are tabulated in the sections below.

9.1 Riprap Quantities

Table 6: Estimated and maximum overall riprap quantities of Longitudinal Stone Toe Protection (LSTP) design features including keyways and tie-backs.

	Corrales Siphon	BB343	RM 199	Total
Lower Terrace and Tie-backs (16–24")	2,800 (maximum: 3,400)	4,300 (maximum: 5,200)	4,900 (maximum: 5,900)	12,000 (maximum: 14,500)
Upper Terrace (12")	1,200 (maximum: 1,450)	1,600 (maximum: 1,900)	2,000 (maximum: 2,400)	4,800 (maximum: 5,800)

Table 7: Expected and maximum overall riprap quantities for the adjustable bed control features upstream (U/s) and downstream (D/s) of each bend.

	Corrales Siphon U/s	Corrales Siphon D/s	BB 343 D/s	RM 199 D/s	Total
Trenched (6", or 6–12”)	300 (maximum: 360)	260 (maximum: 320)	140 (maximum: 170)	100 (maximum: 120)	800 (maximum: 960)
Surface (6")	2,500 (maximum: 3,000)	2,100 (maximum: 2,600)	1,600 (maximum: 2,000)	2,600 (maximum: 3,200)	8,800 (maximum: 10,600)
Total					9,600 (maximum: 11,600)

9.2 Earthwork Quantities

Table 8: Expected and maximum earthwork cut quantities for the side channel features

	Corrales Siphon	BB343	RM 199	Total
Side Channel Cut (cy)	11,400 (maximum: 13,700)	21,000 (maximum: 25,200)	23,000 (maximum: 27,600)	55,400 (maximum: 66,500)

Table 9: Expected and maximum earthwork quantities for backfill behind the Longitudinal Stone Toe Protection features and bed fill to raise the main channel.

	Corrales Siphon	BB343	RM 199	Total
LSTP Backfill (cy)	12,170 (maximum: 14,600)	10,600 (maximum: 12,800)	2,410 (maximum: 2,900)	25,180 (maximum: 30,300)
River Bed Fill (cy)	9,500 (maximum: 11,400)	10,500 (maximum: 12,600)	5,400 (maximum: 6,500)	25,400* (maximum: 30,500)

*Volume required to reach design grade.

10.0 Technical Monitoring and Adaptive Maintenance

Typical monitoring of the site overall includes aerial reconnaissance, cross-section surveys, and longitudinal thalweg profiles conducted every few years or after a significant spring runoff event. Monitoring of the project features will be conducted regularly to ensure efficacy of the constructed features. The tiered LSTP features will be inspected visually at a minimum annually and after significant runoff and rainfall events. The side channels will be inspected visually during runoff periods to assess performance and during low-flow periods as needed to assess elevation change. The bed control features will be inspected visually during low-flow periods as flows permit.

Actions that may trigger maintenance include launching of the LSTP features and/or significant erosion threatening any new sections of the levee. Overall the side channels can be expected to fill in over time as sediment deposits and vegetation become established. Rehabilitation of the side channel features may be needed over time to restore function at the desired flow range. The deformable bed control features are expected to eventually discontinue functioning as local bed elevation control and energy reduction over time due to hydraulic sorting and eventual material displacement by the continuous fluvial processes. Remedial action on the deformable bed control features is not expected unless the features become damaged or rendered ineffective somehow in the early years of the project.

Monitoring for environmental compliance will likely include photo points to monitor vegetation establishment, topographic surveys documenting any geomorphic development, and targeted hydrographic monitoring to identify benefits to aquatic habitat for Rio Grande Silvery Minnow.

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APPENDIX C. CORRALES RM 199 RIVER MAINTENANCE SITE ALTERNATIVE ANALYSIS REPORT

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Corrales RM 199 River Maintenance Site Alternative Analysis

Middle Rio Grande Project, New Mexico
Upper Colorado Region

U.S. Department of the Interior May 2021

Mission Statements

The Department of the Interior (DOI) conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Corrales RM 199 River Maintenance Site Alternative Analysis

Middle Rio Grande Project, New Mexico
Upper Colorado Region

prepared by

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Cover Photo: Bank erosion below Corrales Siphon on July 18th, 2019. (Reclamation/Robert Padilla)

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1.0 Executive Summary

The Corrales River Mile (RM) 199 project encompasses an actively meandering sinuous reach in northern Corrales, NM which is narrowly confined on both sides by spoil levees. The project purpose at RM 199 is to reduce the risk of levee failure due to bank erosion and lateral migration of the Rio Grande. Additional goals include improving ecological conditions, avoiding negative community impacts, being suitable given the geomorphic trends, and being cost effective.

Multiple alternatives for meeting this project purpose were evaluated in this report including bank stabilization options (longitudinal riprap protection, longitudinal woody protection) and energy dissipation options (GRFs, cutoff channels, limited side channels, bed control features) and no-action alternatives. The descriptions of the alternatives and the results of the analysis were presented to a multi-disciplinary Reclamation team to score and rank the alternatives, as well as to the Pueblo of Sandia Department of Natural Resources.

The scoring exercise found that the top two ranking alternatives are longitudinal riprap stabilization and an experimental alternative named "cutoff channels plus bed control." The longitudinal riprap stabilization will take the form of a longitudinal stone toe protection. This design method focuses the stone protection at the toe while incorporating willow plantings on a floodplain bench for additional bank stability and habitat improvement. The "cutoff channels plus bed control" is an alternative which raises the main channel and widens the flow area. The alternative includes large side channels through the meanders' inner point bars. The spoil material from these channels are placed in the existing river channel (while flows are diverted) which significantly improves floodplain connection in this severely incised reach. To minimize erosion of the newly placed spoil material, riprap bed control is strategically placed throughout the reach.

These two alternatives best meet the goals of the project when they are used in combination; thus, a new proposed alternative was generated that applies the tools at the appropriate locations based on risk and opportunity. This proposed alternative implements longitudinal stone toe protection with floodplain benches, channel raising, side channels, and bed control at the Corrales Siphon bend, the BB-343 bend, and the RM 199 bend.

2.0 Background

2.1 Purpose

The project purpose at River Mile 199 is to reduce the risk of levee failure due to bank erosion and lateral migration of the Rio Grande. Additional goals include improving ecological conditions, avoiding negative community impacts, being suitable given the geomorphic trends, and being cost effective.

The purpose of this Alternative Analysis Report is to assess current conditions and to develop, assess, and recommend a preferred alternative(s) to achieve the project purpose.

2.2 Site Selection

In 2018, the Bureau of Reclamation's Albuquerque Area Office published a report detailing the trends and conditions in the reach between Angostura and Montano Bridge (Harris, Klein, and Bui, 2018). Reclamation used the information from that report to publish a follow-on report in 2019 identifying potential sites that could benefit from river maintenance and habitat restoration actions (Harris, Grosso, Klein, and Gonzales, 2019). One of the sites that scored high on both river maintenance and habitat restoration was the stretch of river between River Mile (RM) 199 to 201, which encompasses one mile upstream of Arroyo de la Barranca and downstream to Harvey Jones Channel.

Reclamation has decided to move forward with implementing a project in the identified stretch of river but is modifying the project area boundaries. The upstream portion of the reach (RM 200 to RM 201) will be excluded since the New Mexico Interstate Stream Commission (NMISC) has recently completed habitat restoration work in the area, and because this area does not have any river maintenance concerns. Also, the downstream lower boundary will expand to RM 197.5 to include an additional meander bend downstream of the original extents due to the meander bend's proximity to the riverside levee. No additional meander bends downstream were included due to the bends being relatively far from the riverside levees. Also, the US Army Corps of Engineers constructed habitat restoration sites immediately downstream of RM 197.5, making it less desirable to build over their past projects. The final project area boundaries are from RM 200 (Arroyo de la Barranca) to RM 197.5. For shorthand, we refer to this as the RM 199 Project area.

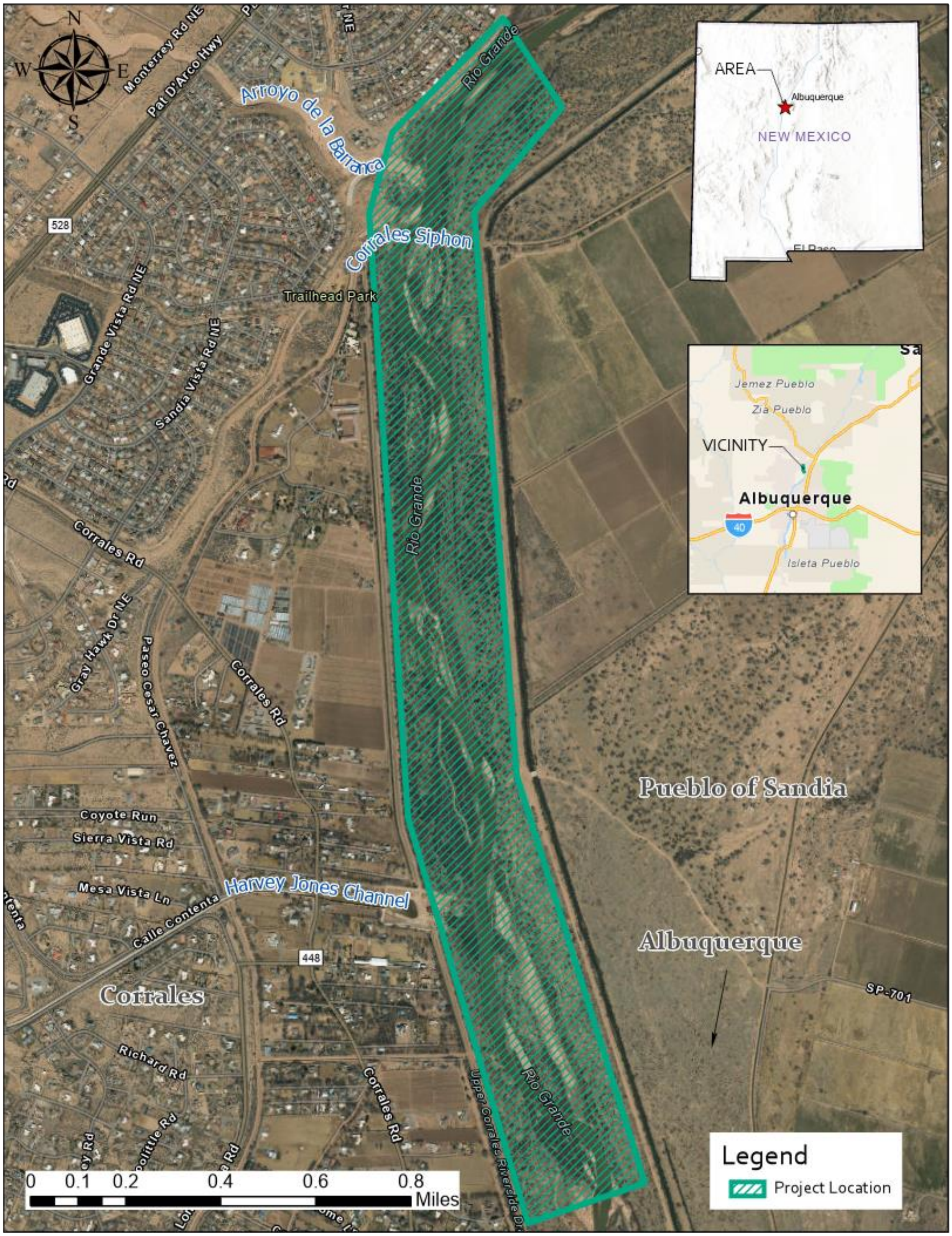


Figure 1: RM 199 Project Area

2.3 Reach Background

The project reach is an incised reach that has a sinuous planform and is actively meandering. This reach's floodplain is also narrowly confined by the eastern and western riverside levee system(s). This reach is located near the community of Corrales on its west side and involves floodplain lands belonging to Sandia Pueblo on its east side. The reach trends include bed incision, increasing bank height, channel narrowing, lateral migration, increasing channel velocities and floodplain disconnection.

Immediately downstream of Arroyo de la Barranca is where the MRGCD facility Corrales Siphon crosses, which is currently exposed from its originally buried condition due to river bed incision. This siphon delivers irrigation water to the community of Corrales underneath the river from an eastern irrigation canal. In 2016, emergency repairs were undertaken which placed a riprap pad in the scour hole downstream of the siphon for the western 75 feet of the approximately 200-foot-wide channel. These emergency repairs also included continuous riprap protection along the western bank. After 2016, the thalweg moved from the west side of the channel to the middle of the channel along the edge of the riprap pad. In fall 2020 MRGCD extended the riprap protection across the entire river.

Some of the bends in this meandering reach are stable while others are actively eroding; some are close to the levee (less than 200 feet) while others are much further from the levee (as much as 400 feet away). Further information on these bends is discussed in Section 3.0 Bank Protection Methods.

The bend located closest to the levee is on the western side and is referred to as the Corrales RM 199 site, and it has been determined to be a river maintenance class 2 site (Padilla, 2019). The bend has some minor erosion (five or ten feet laterally per large runoff event) with a twelve-foot tall undercut bank and is, at its closest, approximately 130 feet from the levee. An island is present in the channel next to the bend, which in this reach is often a catalyst for erosion in the bank adjacent to the island.

2.4 Geomorphic and Hydraulic Trends

A few recent reports have studied the geomorphic and hydraulic trends covering the Corrales RM 199 Priority Site, including Harris et al. (2018), and Tetra Tech (2013a). The discussion below draws on their findings and in some instances expands on the findings.

In summary, the reach has experienced decreased variability and magnitude of the hydrologic regime that has enabled vegetation encroachment, leading to a decreased channel width. The reduction in sediment loads due to upstream controls (dams, urban watersheds, etc.) has led to an incised condition which further disconnects the river from its floodplain (Reclamation, 2012). The reduction in sediment load and the increased channel incision has also led to increased bed material size. The channel substrate has transitioned from sand to gravelly sand.

2.4.1 Hydraulic parameters

The 2018 Geomorphic and Hydraulic Analysis (Harris et al., 2018) identified hydraulic trends for the reach between Angostura Dam and Montano Bridge and for the period between 2004 and 2017. In general, the reach has transitioned to deeper, narrower flows with increased velocities.

Table 1: Hydraulic parameter trends for the Angostura to Montano reach, 2004-2017 (Harris et al., 2018).

Hydraulic Parameter	Trend
Top Width	Decrease
Hydraulic Depth	Increase
Width/Depth Ratio	Decrease
Energy Slope	Increase
Wetted Perimeter	Decrease
Flow Area	Stable
Channel Velocity	Increase

2.4.2 Longitudinal profile

The longitudinal profile for the reach (Figure 2) shows that the minimum channel elevation of the river has incised approximately one foot upstream of Corrales Siphon between 2001 and 2018, while downstream project areas have incised two to five feet in the same time frame. The longitudinal profile suggests that Corrales Siphon has a significant role in controlling the localized bed elevation and acts as a grade control. Analysis of the siphon's grade control effect is in Appendix B (section 9.2.7).

The longitudinal profile does not indicate an acceleration or deceleration of incision. The increase in channel bed variability over time may be explained more by an increase in data points than an actual increase in channel bed variability.

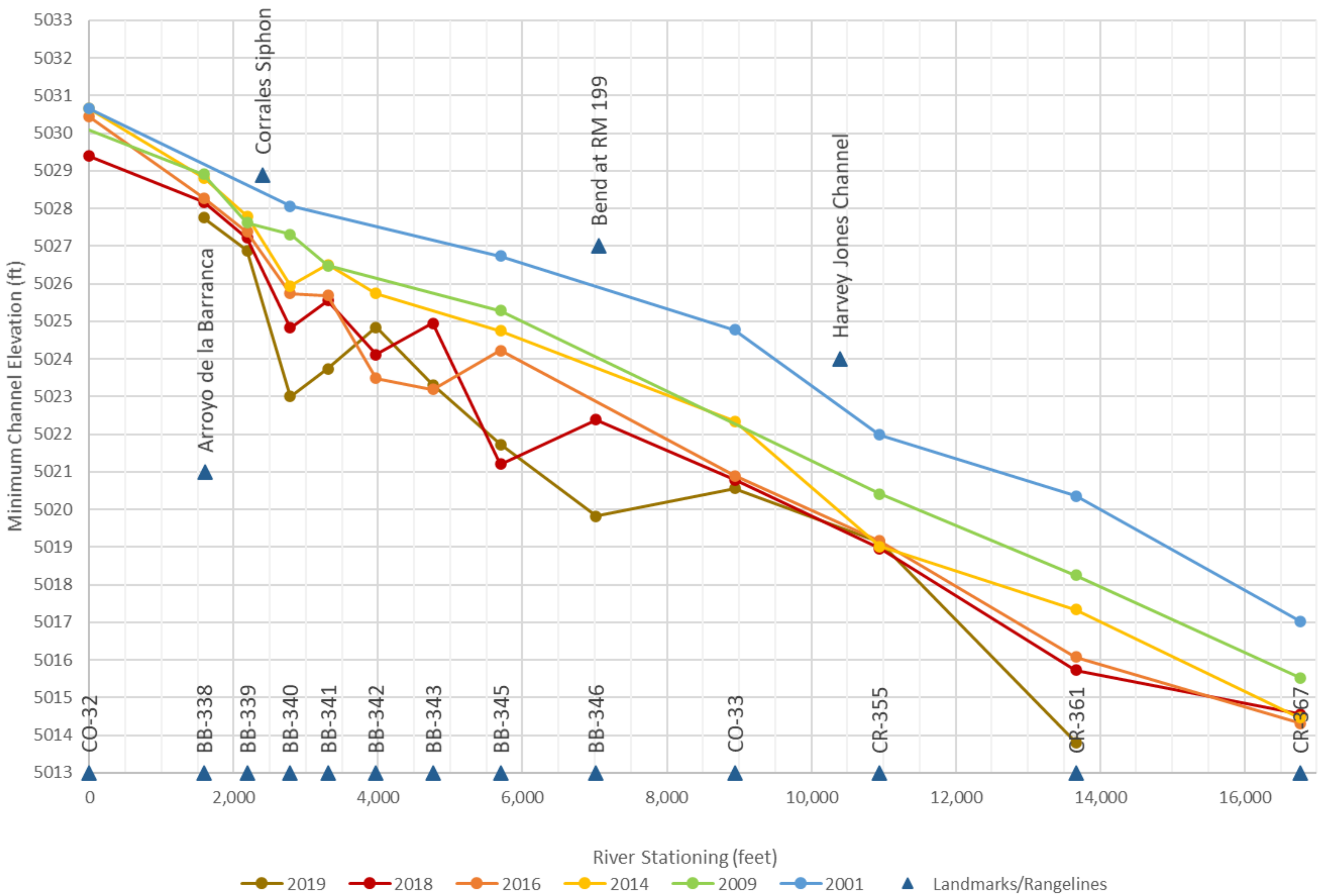


Figure 2: Current and historical longitudinal profile of the Corrales RM 199 Project area

2.4.3 Cross section geometry

An analysis of the cross-section geometry shows significant changes with eroding banks, deepening channels at most cross sections, and deposition on point bars and on side channels.

Figure 3: Plan view of cross section lines in the vicinity of the Corrales RM 199 Project area

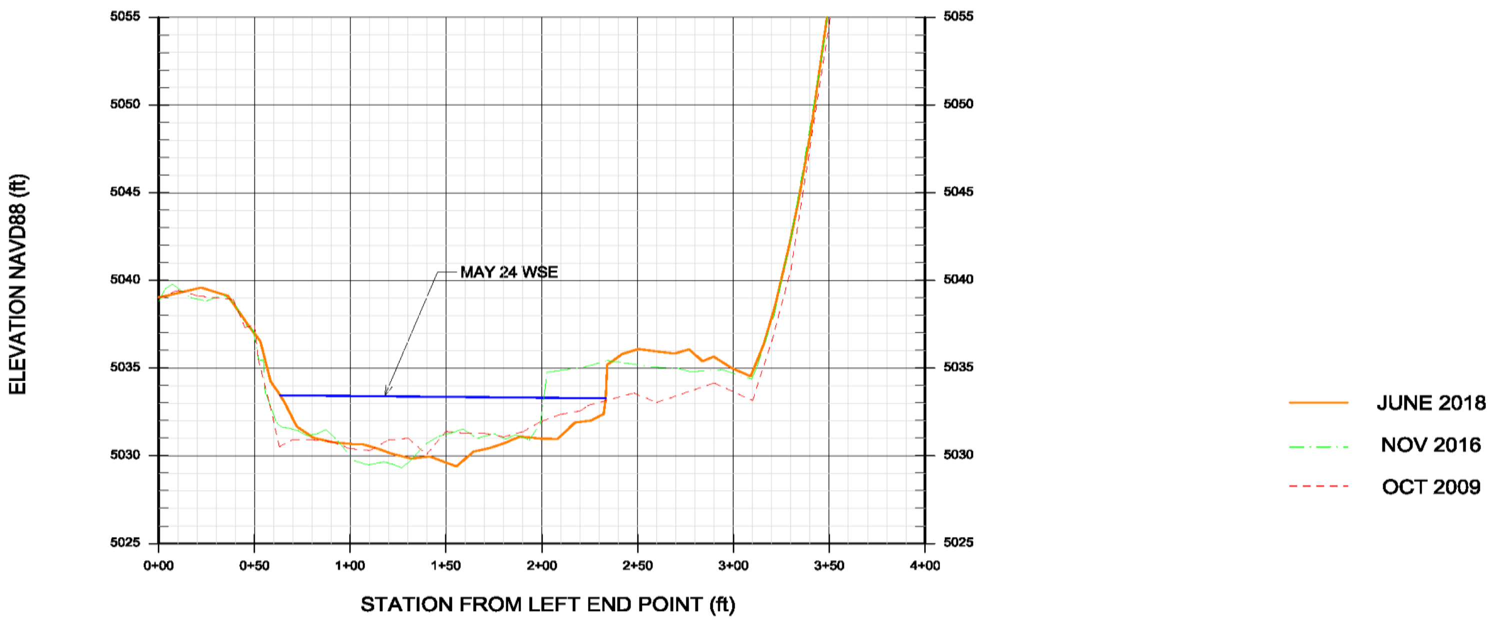


Figure 4: Cross section at CO-32 (approximately 1,650 feet upstream of Arroyo de la Barranca) depicted looking downstream

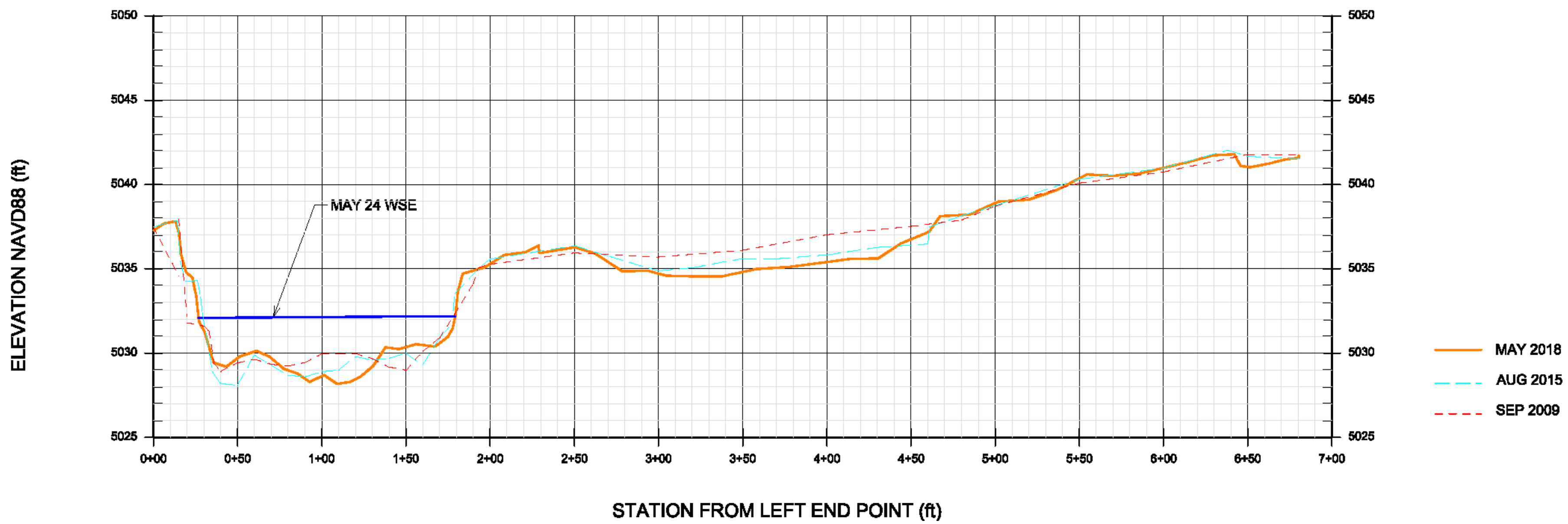


Figure 5: Cross section at BB-338 (at Arroyo de la Barranca) depicted looking downstream

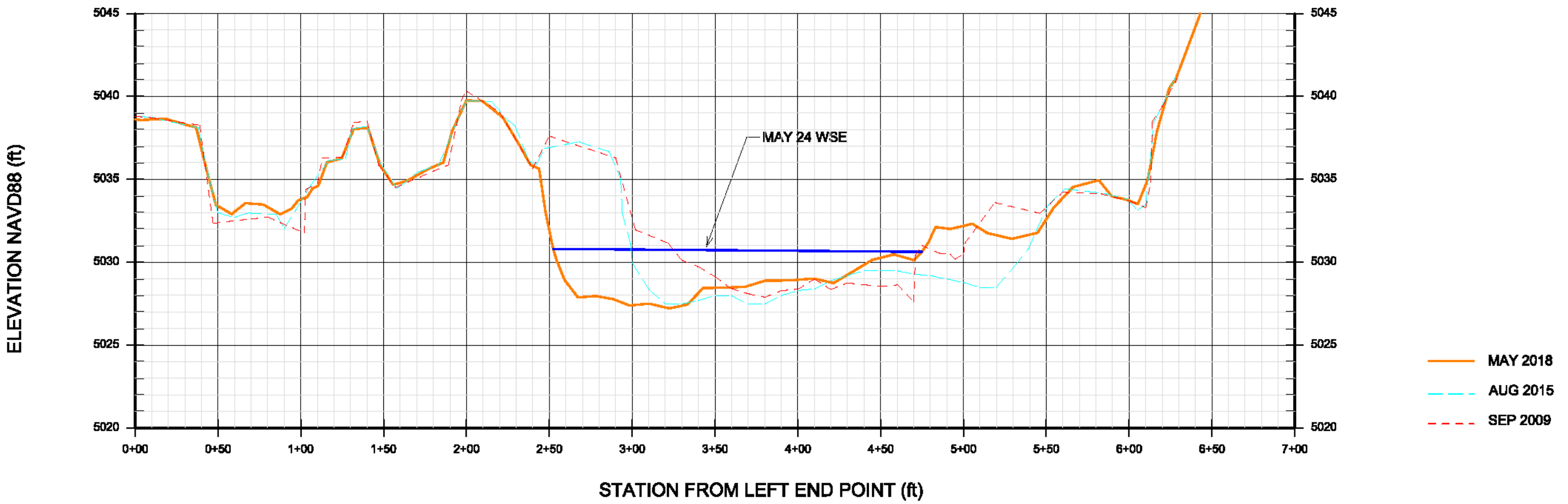


Figure 6: Cross section at BB-339 (approximately 200 feet upstream of Corrales Siphon) depicted looking downstream

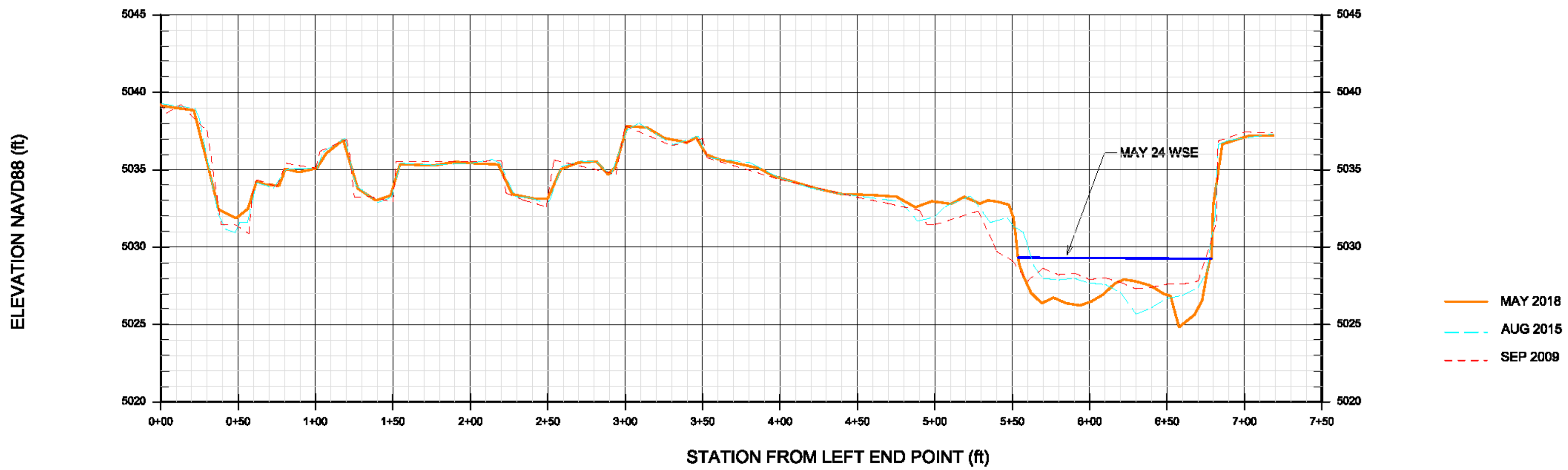


Figure 7: Cross section at BB-340 (approximately 350 feet downstream of Corrales Siphon) depicted looking downstream

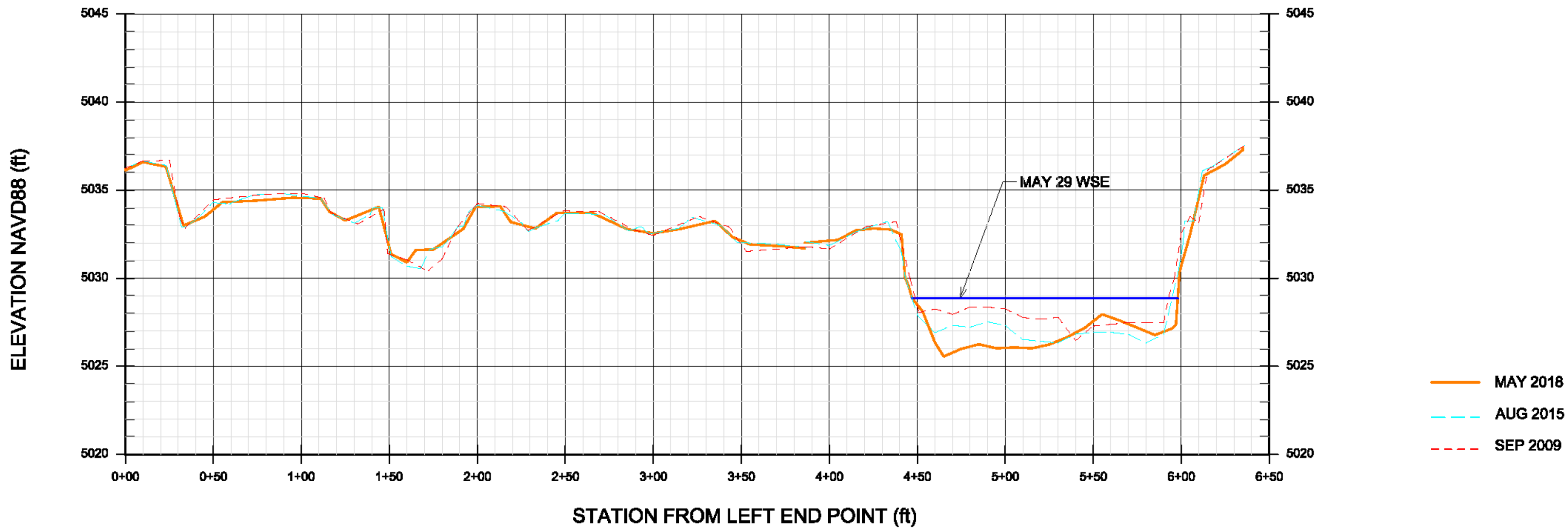


Figure 8: Cross section at BB-341 (approximately 900 feet downstream of Corrales Siphon, on outer bend) depicted looking downstream

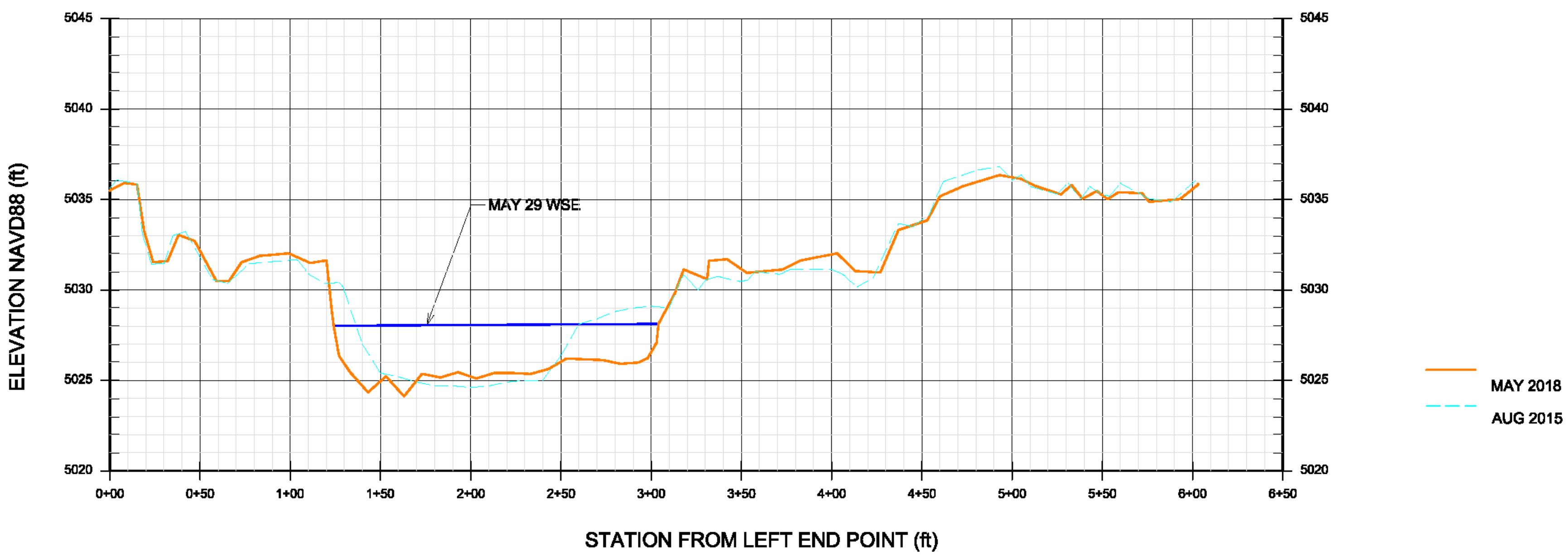


Figure 9: Cross section at BB-342 (approximately 1,550 feet downstream of Corrales Siphon, on run) depicted looking downstream

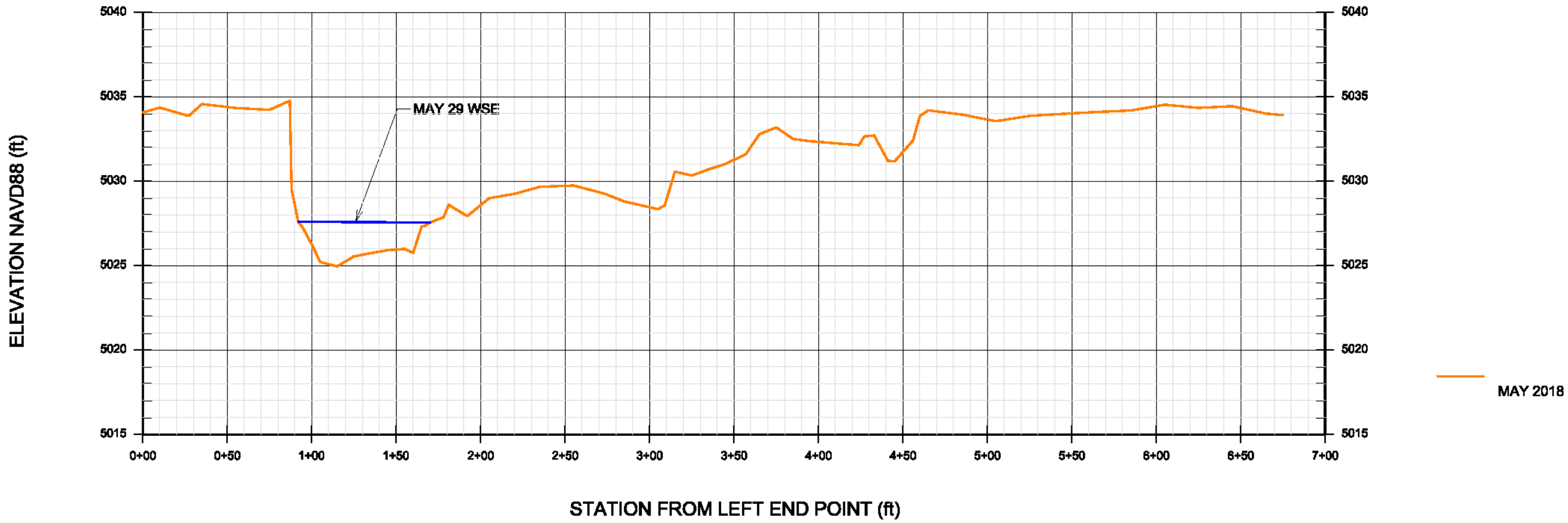


Figure 10: Cross section at BB-343 (highly erosional bend) depicted looking downstream

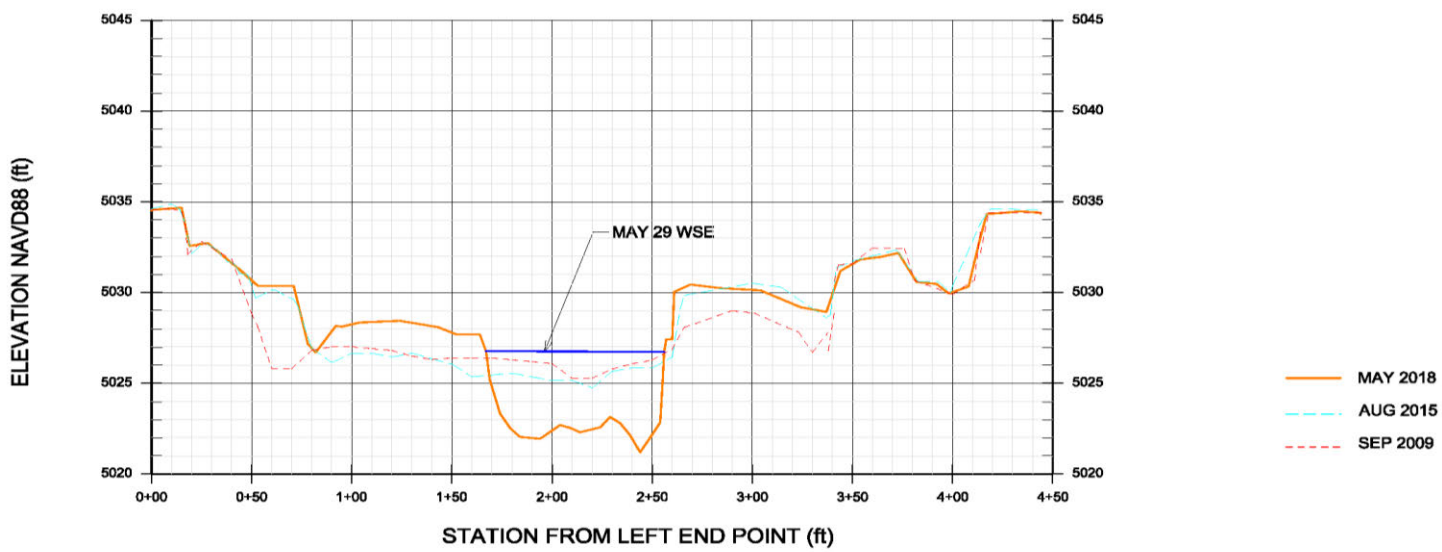


Figure 11: Cross section at BB-345 (on run upstream of RM 199 bend) depicted looking downstream

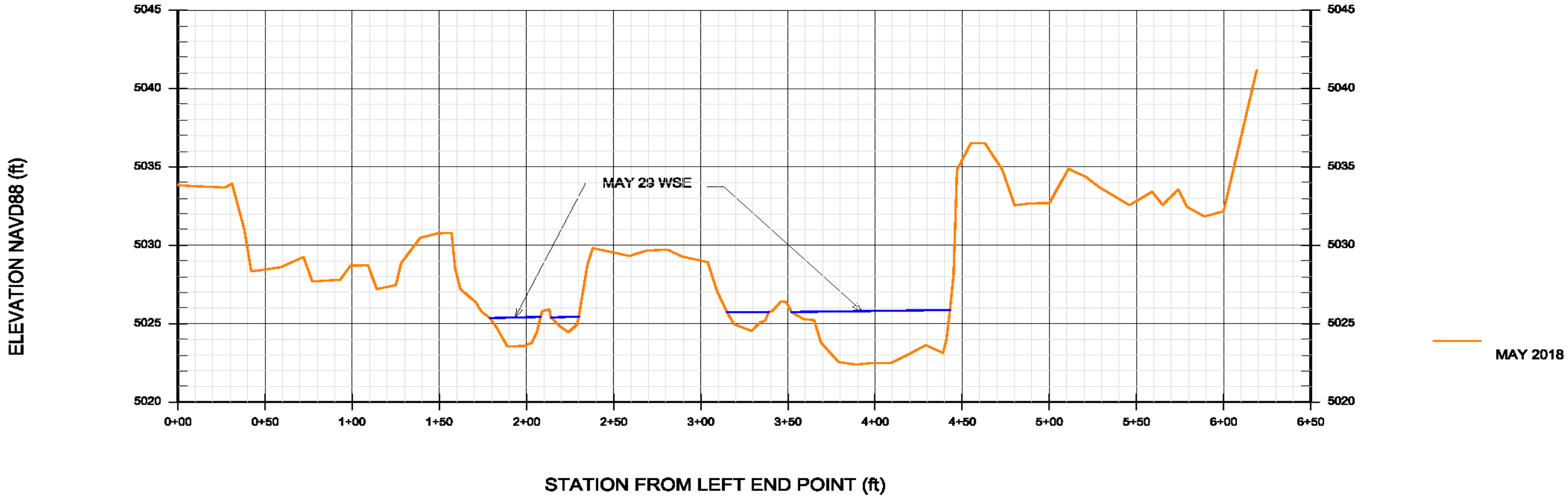


Figure 12: Cross section at BB-346 (at RM 199 bend apex) depicted looking downstream

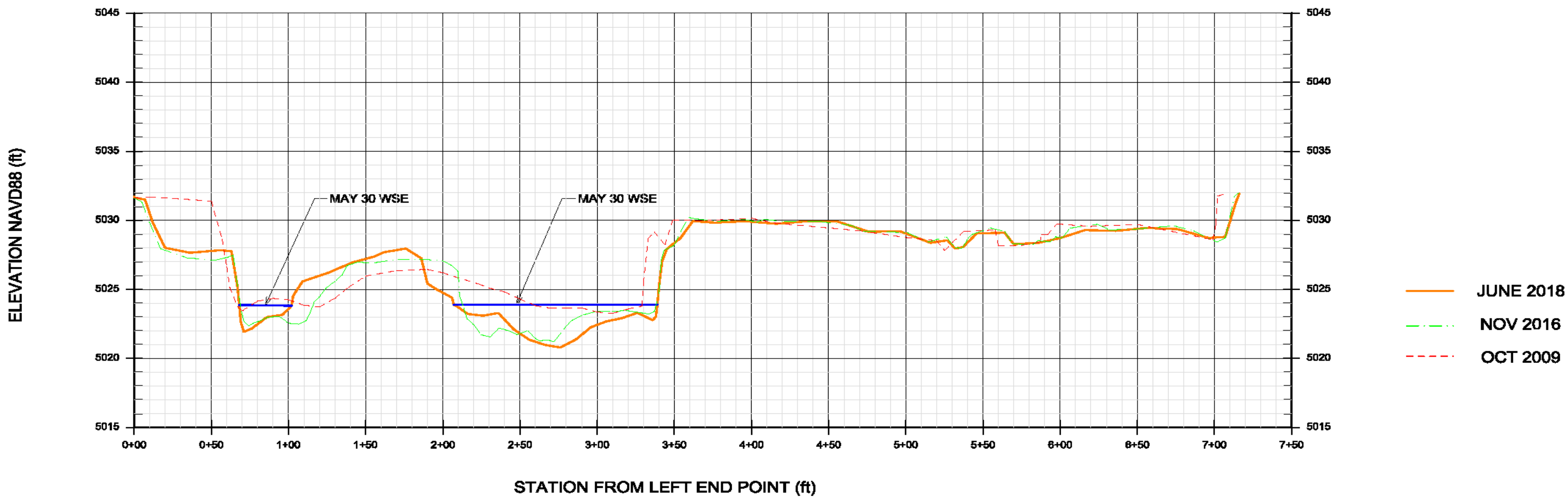


Figure 13: Cross section at CO-33 (at Sandia Pueblo river access site bend apex) depicted looking downstream

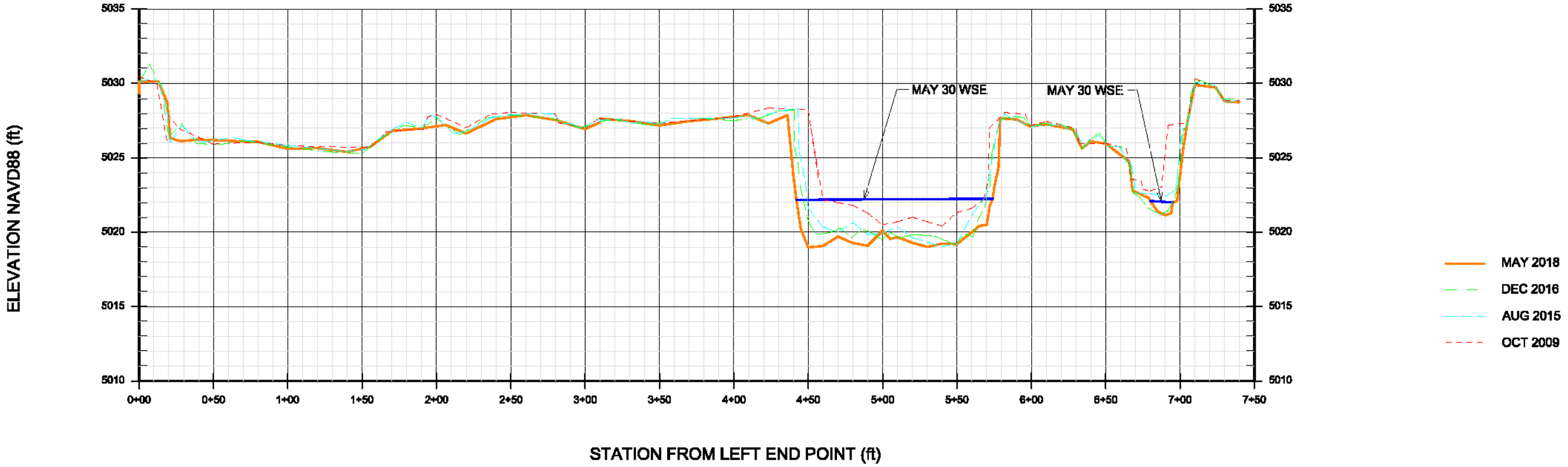


Figure 14: Cross section at CR-355 (approximately 450 feet downstream of Harvey Jones channel outlet, near the Rio Rancho wastewater outfall, on run) depicted looking downstream

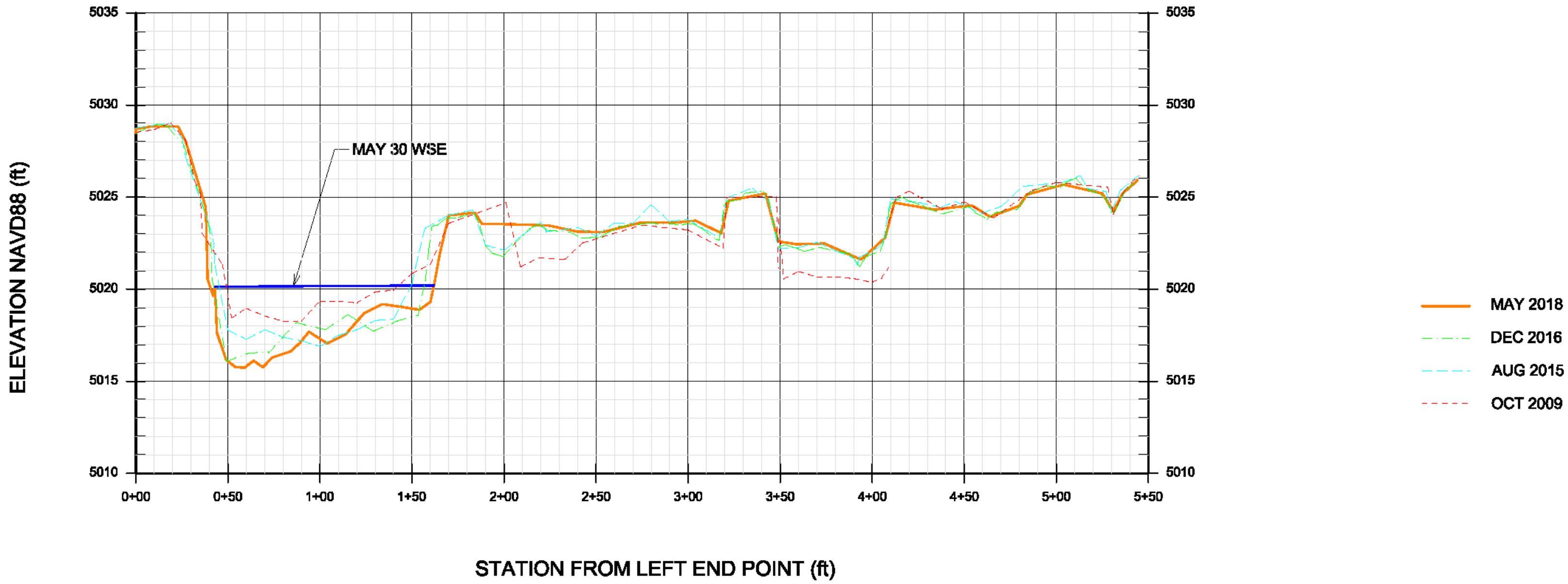


Figure 15: Cross section at CR-361 (downstream end of project, on an outer bend apex) depicted looking downstream

2.4.4 Planform

The planform figures below show planform changes at two of the five bends in the project area.

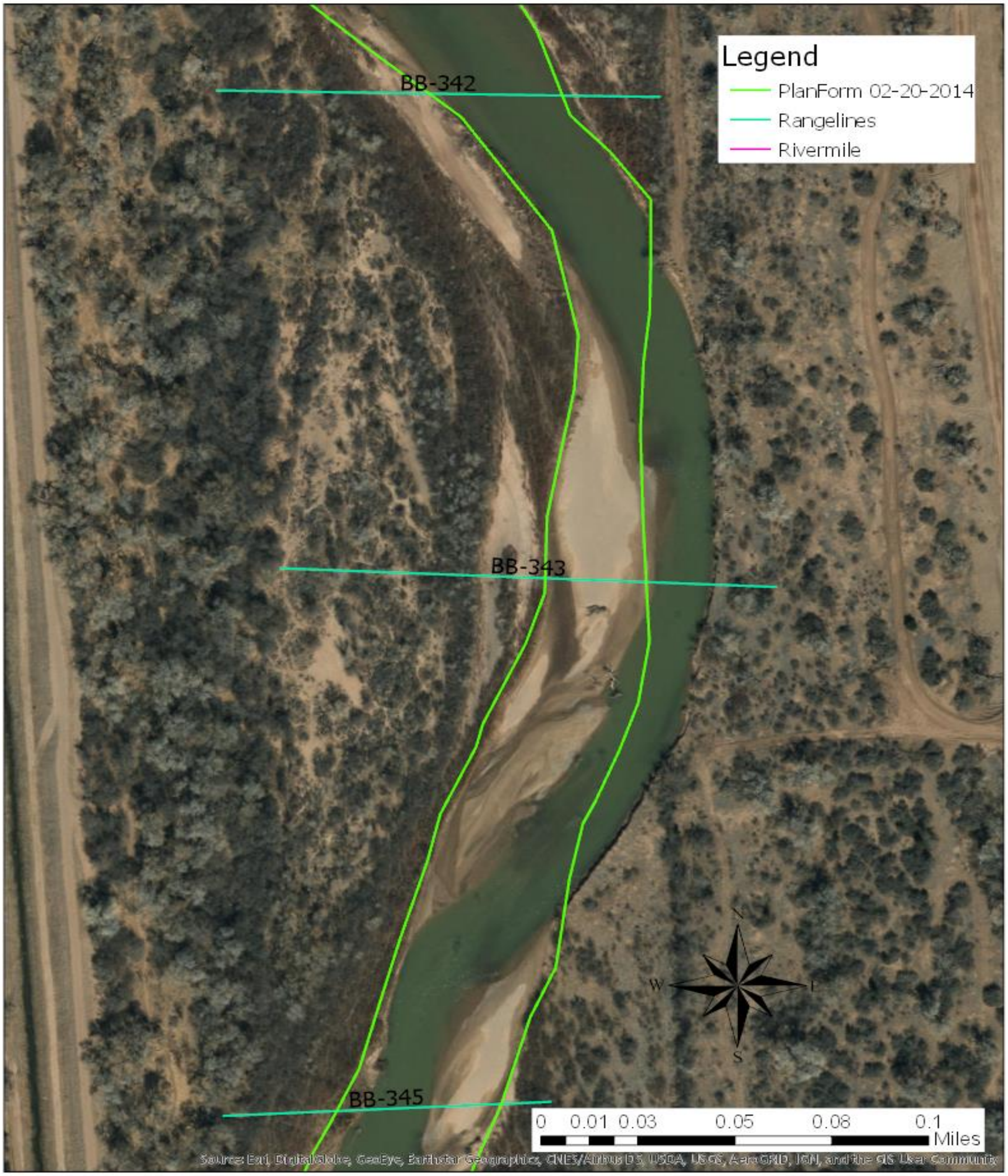


Figure 16: 2014 Rio Grande planform outline on 2018 aerial imagery (Esri GIS) at the BB-343 bend

Figure 17: 2014 Rio Grande planform outline on 2018 aerial imagery (Esri GIS) at the RM 199 bend

2.4.5 Bed material (Substrata)

Bed material has been coarsening over time within the project area. The D_{50} values shown in Figure 18 are derived from bed material composited over the width of the cross section. Actual median bed material sizes (D_{50}) vary greatly over the cross section. During a recent bed material survey (River Restoration, 2019) there were two bars found to be armored with very coarse gravel (D_{50} around 50 mm), numerous sand and gravel bars (D_{50} around 10 mm), and some areas of fine sand (D_{50} around 0.15 mm).

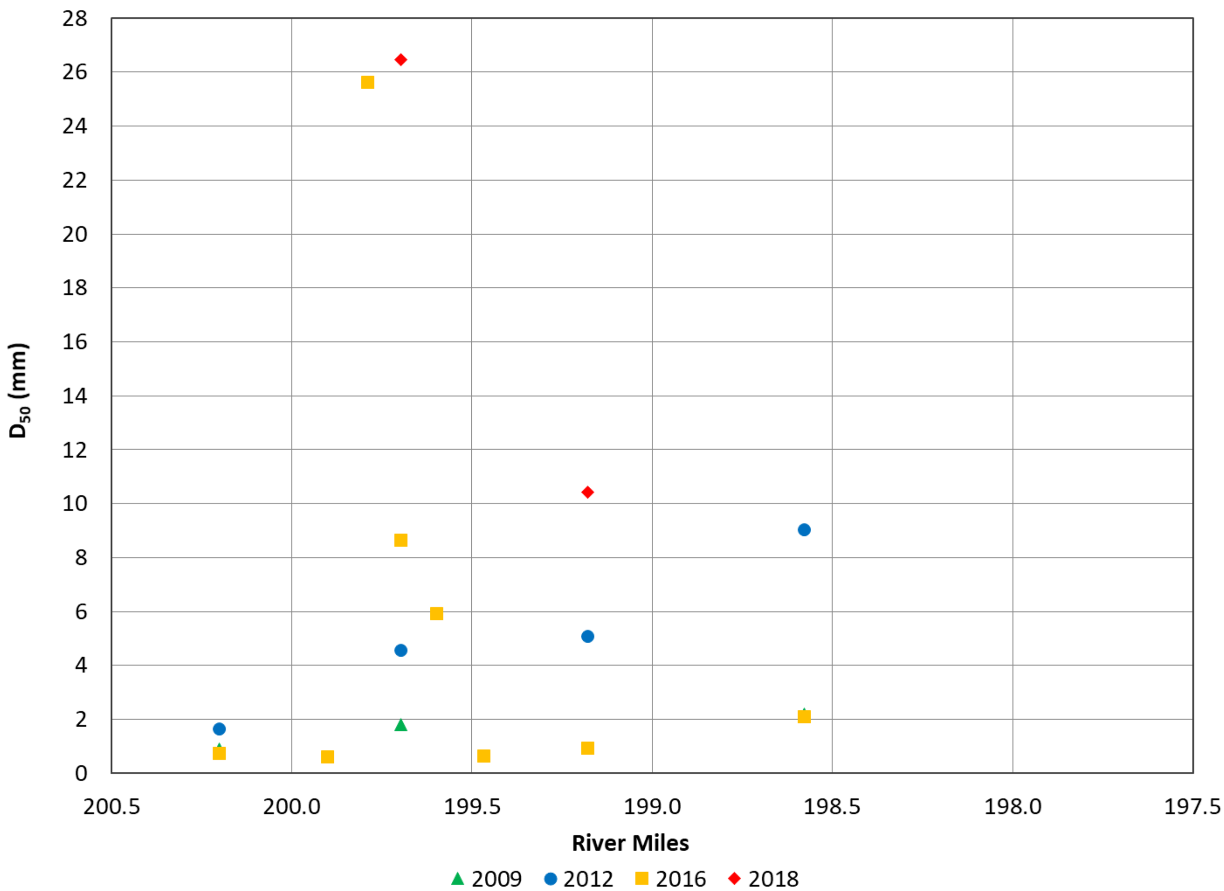


Figure 18: Historic D_{50} Bed Material Sizes between RM 200.5 and RM 197.5. Arroyo de la Barranca is at RM 199.9, the RM 199 bend apex is at RM 198.9, the Harvey Jones channel is at 198.2, and the project area ends at RM 197.7.

2.5 Site Information

The following sections describe features of the site which may affect the feasibility of the proposed alternatives.

2.5.1 Land Ownership and Other Stakeholders

The eastern floodplain between the levees and the river is owned and actively managed by the Pueblo of Sandia. The western floodplain between the levee and the river originally belonged to MRGCD but was annexed by the Village of Corrales in the 1970s. The RM 199 Project area has a mix of federal government, MRGCD, and Pueblo ownership. Portions of the western floodplain are now managed by the Village of Corrales as a Wildlife Preserve, with a mission "to preserve and protect the natural and native conditions, habitat, and wildlife in the Preserve…" ("Metropolitan Open Space," 2019). The Village of Corrales uses a Bosque Commission to make decisions for bosque actions. The Corrales Fire Department is active in fuel reduction and recreational safety in the bosque.

MRGCD has responsibility for maintenance of the engineered levees on the west side of the river, the spoil levees on the east side of the river, the riverside drains, and the irrigation infrastructure including Corrales Siphon.

The Southern Sandoval County Arroyo Flood Control Authority (SSCAFCA) has maintenance responsibility for the Arroyo de la Barranca and the Harvey Jones Channel, both on the west side of the river.

2.5.2 Utilities

Infrastructure that runs under the river in this area includes a gas line and the Corrales Siphon (Figure 19).

Figure 19: Utilities buried in the floodplain and under the river.

2.5.3 Recreational, Ceremonial, and Other Land Uses

The Pueblo of Sandia is a federally recognized Indian tribe situated between the Middle Rio Grande Valley and the crest of the Sandia Mountains, located 15 miles north of Albuquerque, New Mexico. The people of Pueblo of Sandia have variously used the Rio Grande and bosque for recreational or other uses (fishing, grazing, hunting, gathering of clam shells). Over the years the Pueblo of Sandia has actively restored the eastern side of the bosque to a more nature condition by removing non-native species, planting native vegetation, and adding aquatic features. The Rio Grande is also used by the tribe for ceremonial or traditional purposes.

On the western side of the river, there are two recreational parking lots in the project area including one at the eastern end of Romero Street (near the outer bend of RM 198) and one at the Corrales Siphon outlet (Figure 20). Another parking lot is located just outside of the project area and is on the upstream side of the Arroyo de la Barranca confluence. This parking lot is a Rio Rancho Open Space facility.

These recreational parking lots lead to a network of trails throughout the bosque. The parking lot above Arroyo de la Barranca and the parking lot at Corrales Siphon both provide undeveloped river access for small watercraft carried by hand. Recreation that takes place in the bosque or river includes walking, jogging, bicycling, horseback riding, fishing, wading, and wildlife observation.

The levee road is closed and gated to public vehicles.

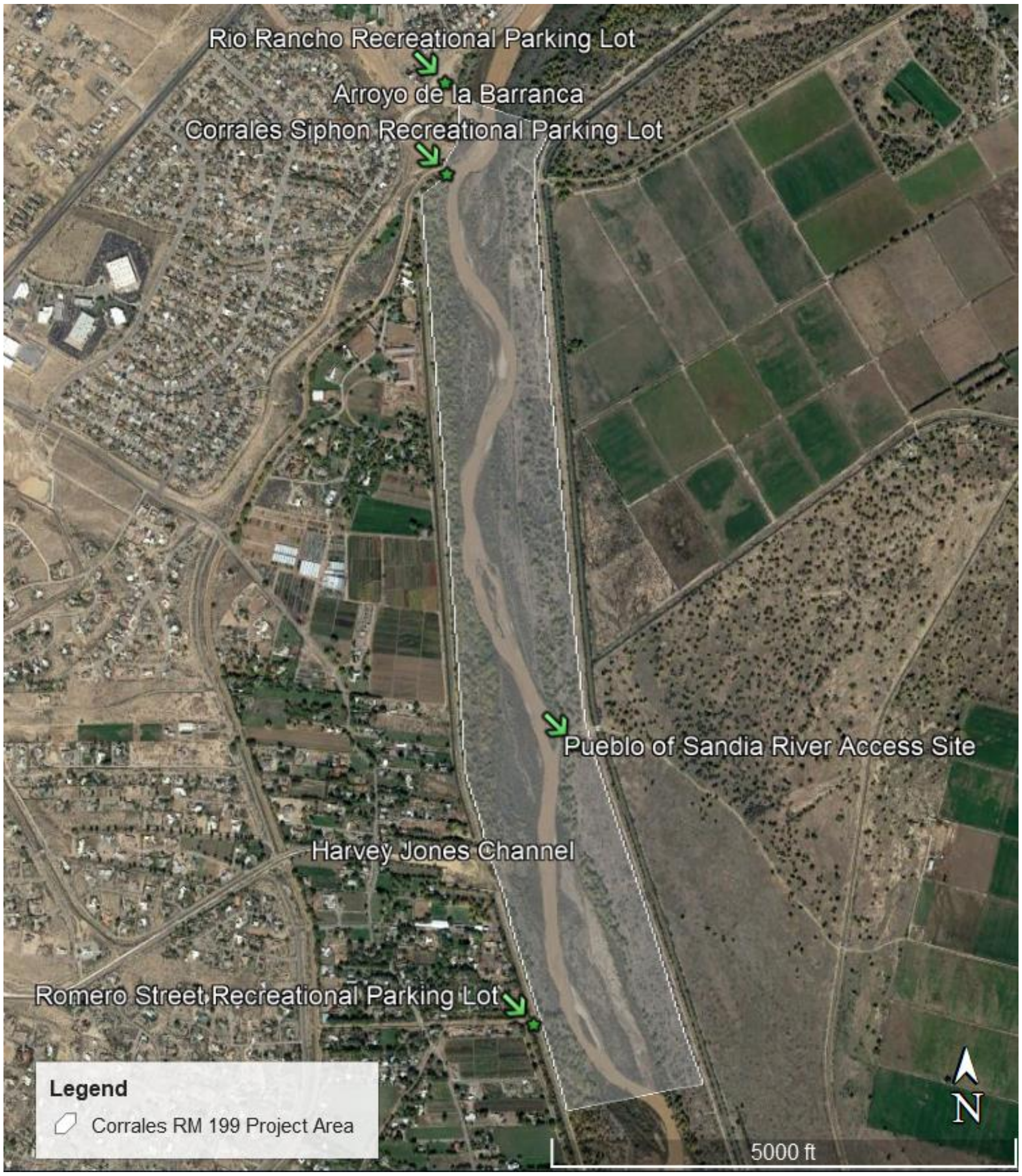


Figure 20: Recreational and other areas of interest within the RM 199 Project area

2.5.4 Arroyos

Harvey Jones Channel consists of a concrete-lined channel that extends from the Rio Grande to very near the Rio Rancho City limits. Because it is concrete, this arroyo is neither aggrading nor degrading. The outfall to the river is extremely flat, often after major runoff events, sediment must be removed in the arroyo east of Corrales Road down to the river. Harvey Jones Channel's 100-year 24-hour peak discharge at the Rio Grande is approximately 9,120 cfs (Sanchez, 2019).

Arroyo de la Barranca is generally degrading in the reach between NM 528 and the river. The arroyo's 100-year 24-hour peak discharge at the Rio Grande is approximately 3,840 cfs (Sanchez, 2019).

Two jetty jacks are visible south of River Mile 199 (Figure 21). Most jetty jacks have been removed, but it is possible more jetty jacks are present in the project area. Removal of jetty jacks may be necessary as part of the selected alternative.

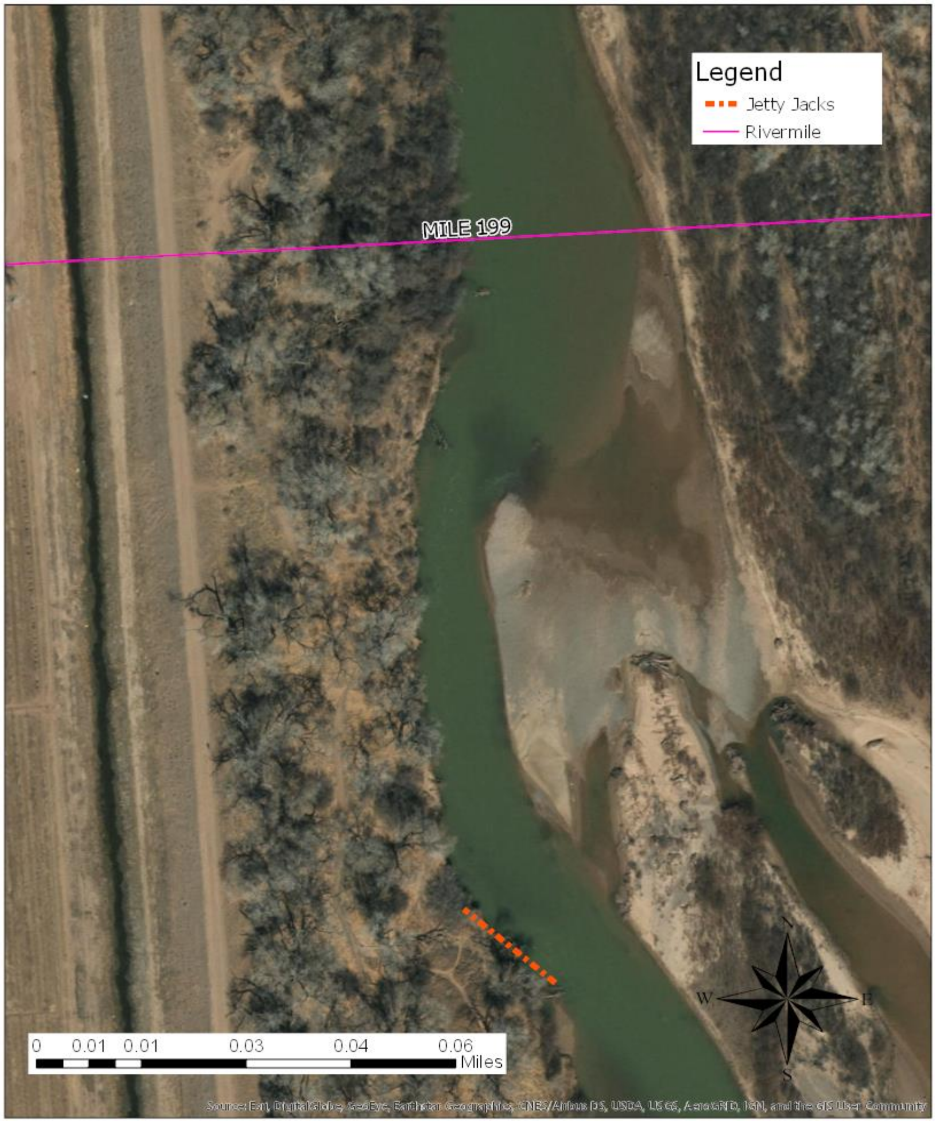


Figure 21: Jetty jacks within the project area.

2.5.6 Previous Habitat Restoration Work

Previous habitat restoration work in the area includes the Management of Exotics for the Recovery of Endangered Species (MERES) Habitat Restoration Project and the U.S. Army Corps of Engineers (USACE) project.

The MERES project, constructed in 2009, is located immediately downstream of the Corrales Siphon on the eastern floodplain. There is a network of side channels in this area that inundate at high flows. The Pueblo of Sandia Bosque Manager would support a construction that would open up the side channel entrances and exits to encourage inundation at lower flows, and/or the addition of an additional connector channel at the upstream end.

The USACE project is mostly outside of the current RM 199 project extents, but one component within the extents is a backwater in the western floodplain adjacent to the Romero Street recreational area parking lot.

2.5.7 Environmental Setting

Various construction, river maintenance, or habitat restoration projects have been conducted by several agencies that have described the environmental setting in or near the RM 199 Project area (Crawford et al. 1993; Feldhahn 2018; Reclamation 2015, 2020; SWCA Environmental Consultants 2011; USACE 2019). These documents were incorporated and summarized below.

Situated along the western side of the Rio Grande between the channel and the levee and below the Corrales Siphon is the Corrales Bosque Preserve (Preserve) in the Village of Corrales. The Preserve was annexed by the Village of Corrales in the late 1970s to halt wood cutting, livestock grazing, trash dumping, and other damaging activities. The bosque in the Preserve is predominantly woodlands (including a tall, cottonwood (*Populus deltoides*) gallery forest), shrubland (including coyote willow (*Salix exigua*), New Mexico olive (*Forestiera neomexicana*), and invasive non-native Russian olive (*Elaeagnus angustifolia*), Siberian elm (*Ulmus pumila*), saltcedar (*Tamarix spp.*) and other species with occasional meadows or marshland (Feldhahn 2018). A mixture of agricultural, residential, commercial, and industrial land uses is located adjacent to the RM 199 Project area.

On the eastern side, the Pueblo of Sandia has actively managed their bosque since 2000. Over 1,000 acres of non-native vegetation have been removed through a variety of treatments (mechanical treatment, herbicide application, and other techniques) and restored it to a cottonwood-willow native habitat. Additionally, aquatic habitat restoration treatments were included to create embayment, backwaters, channels, and a bankline bench. In 2012, a fire started in the Village of Corrales and burned five acres before spreading across the river to 400 acres of bosque on Pueblo of Sandia. Various efforts to thin high fuel loads, improve access, and revegetate burned areas have occurred and fire reduction strategies remain an important conservation issue. The Pueblo of Sandia's Bosque Manager has identified the floodplain point bar across from the RM 199 bend as being dominantly Russian olives and is agreeable to having the entire area cleared.

Within the RM 199 Project area there is approximately 2.2 miles of river channel and 290 acres of bosque. A query of the Biota Information System of New Mexico reports 852 species or taxa of wildlife in Sandoval County (BISONM accessed July 2020). This estimate includes 12 amphibians, 30 fishes, 49 reptiles, 93 mammals, 250 birds, and 418 invertebrate taxa (e.g. spiders, insects, crayfish, ants, snails, etc.). Amphibians include frogs, toads, and spadefoot. Fishes include sucker, carp, chub, shiner, minnow, and bullhead. Reptiles include lizards, turtles, whiptails, and snakes. Rodents, muskrat, beaver, raccoon, squirrel, rabbit, striped skunk, coyote, gopher and bats are common mammals along with some feral dogs, cats, and livestock. A variety of waterfowl, shorebirds, wading birds, and raptors utilize the river, bosque, riverside drains including ducks, Canada geese, sandhill crane, great blue and black-crowned night herons, snowy and common egrets, killdeer, blackbirds, hummingbirds, hawks, owls, swallows, and a variety of songbirds. Based on the mean densities of birds reported by Hawks Aloft (2011; up to ~850 birds per 100 acres), the average number of birds in the RM 199 Project area would be approximately 2,500.

Special Status Species in the RM 199 Project Area

There are no designated critical habitats for the endangered Rio Grande Silvery Minnow (*Hybognathus amarus*; RGSM or silvery minnow) or for the endangered Southwestern Willow Flycatcher (*Empidonax traillii extimus*; flycatcher) in the RM 199 Project area (USFWS 2003, 2013). Critical habitat for the threatened, western, distinct population segment of the Yellow-Billed Cuckoo (*Coccyzus americanus*; cuckoo) was initially proposed by the Service (USFWS 2014) but was subsequently removed in a subsequent proposal (USFWS 2020).

Silvery minnows are a small-bodied (adults range up to 90 mm standard length), short-lived (lifespan is typically less than two years) minnow of the cyprinid family (Horwitz et al. 2018). Silvery minnow spawn during spring runoff and produce numerous, non-adhesive, semi-buoyant eggs (that hatch into larvae), which can be dispersed into shallow, slow-velocity habitats (Platania and Altenbach 1998; Worthington et al. 2018). Silvery minnows exhibit rapid growth and mature within 12 months. The interaction of flow, channel morphology, and habitat conditions are strongly related to the population dynamics of this species (Mortensen et al. 2019). When elevated and long duration spring runoff occurs it newly inundates channel and floodplain areas that provide essential nursery habitats (Medley et al. 2013), which can result in substantial population increases within a year (Archdeacon et al. 2016; Dudley et al. 2020). Juvenile and adult silvery minnows typically inhabit shallow, low velocity habitats with find-grained substrates (Dudley et al. 1997). Silvery minnows are capable of briefly swimming in higher velocities and moving long distances (Bestgen et al. 2010; Archdeacon et al. 2012; Platania et al. 2020). Major threats of persistence of silvery minnow include reduction of flow, hydrologic alteration, habitat degradation, fragmentation, diminished water quality, and non-native species (USFWS 2010). Silvery minnow now occupies seven percent of its historical range and persists in the MRG including in the RM 199 Project area.

The flycatcher was listed as endangered by the USFWS effective March 29, 1995. This subspecies has a grayish-green back and wings, whitish throat, light gray-olive breast, and pale yellowish belly. The flycatcher is an insectivore and forages within and above dense riparian vegetation. The flycatcher is present in breeding territories by mid-May. It builds nests and lays eggs in late May and early June (average clutch size is 2 to 5 eggs) and fledges young in early to mid-July. One of the primary reasons for their decline is the loss and degradation of dense, native riparian habitat used for nesting. Since 2004, the Corps (USACE 2019) had contracted Hawks Aloft to conduct nesting flycatcher surveys in the RM 199 Project area and none were detected. However, many other flycatchers have been reported using the Preserve (ebird.org, Cornell Lab of Ornithology) indicating the RM 199 Project area is likely being used as a migratory corridor for feeding and resting flycatchers. The Pueblo of Sandia's Bosque Manager (Scialdone, written comm., 2020) stated that although flycatchers have passed through on the east side of the Rio Grande near RM 199, none have been recorded nesting there for over 10 years and the habitat conditions were not good.

The cuckoo was listed as a threatened species by the USFWS in October of 2014. The cuckoo is a medium-sized bird with grayish-brown plumage above and white below and tail feathers boldly patterned with black and white below. Their short legs are bluish gray with two toes that point forward and two point backwards. Cuckoos eat large insects and use a variety of riparian habitats. Cuckoos appear to require large blocks of riparian habitat for nesting. In New Mexico, nesting activities typically begin in mid-June and end in late-August (Hughes 1999). Fall migration from its breeding grounds in New Mexico generally occurs from late-August through mid-September (Williams et al. 2005). Cuckoos have been detected migrating through the RM 199 Project area (ebird.org, Cornell Lab of Ornithology) but surveys contracted by Corps (USACE 2019) did not detect them nesting. Habitat potentially suitable for nesting is limited and based on the surveys it is highly unlikely that nesting cuckoos occupy the RM 199 Project area. Additionally, no cuckoos have been recorded nesting on the Pueblo of Sandia near RM 199 and the habitat is of poor quality (Scialdone, written comm., 2020). Cuckoos are in decline due to loss and degradation of native riparian habitat throughout their range.

2.5.8 600-foot Depletions Corridor

New Mexico Interstate Stream Commission (NMISC) requires that all habitat restoration projects which have the potential to cause water evaporation or infiltration losses be within a 600-foot corridor of the center of the channel, or within a 600-foot corridor of the closest levee if the river centerline is closer to the levee than 300 feet. These rules were used to create a figure showing the 600-foot corridor for the RM 199 project area, shown in Figure 22. While useful to be aware of, it is unlikely that this corridor will apply to the current project since the primary purpose of this project is bank stabilization.

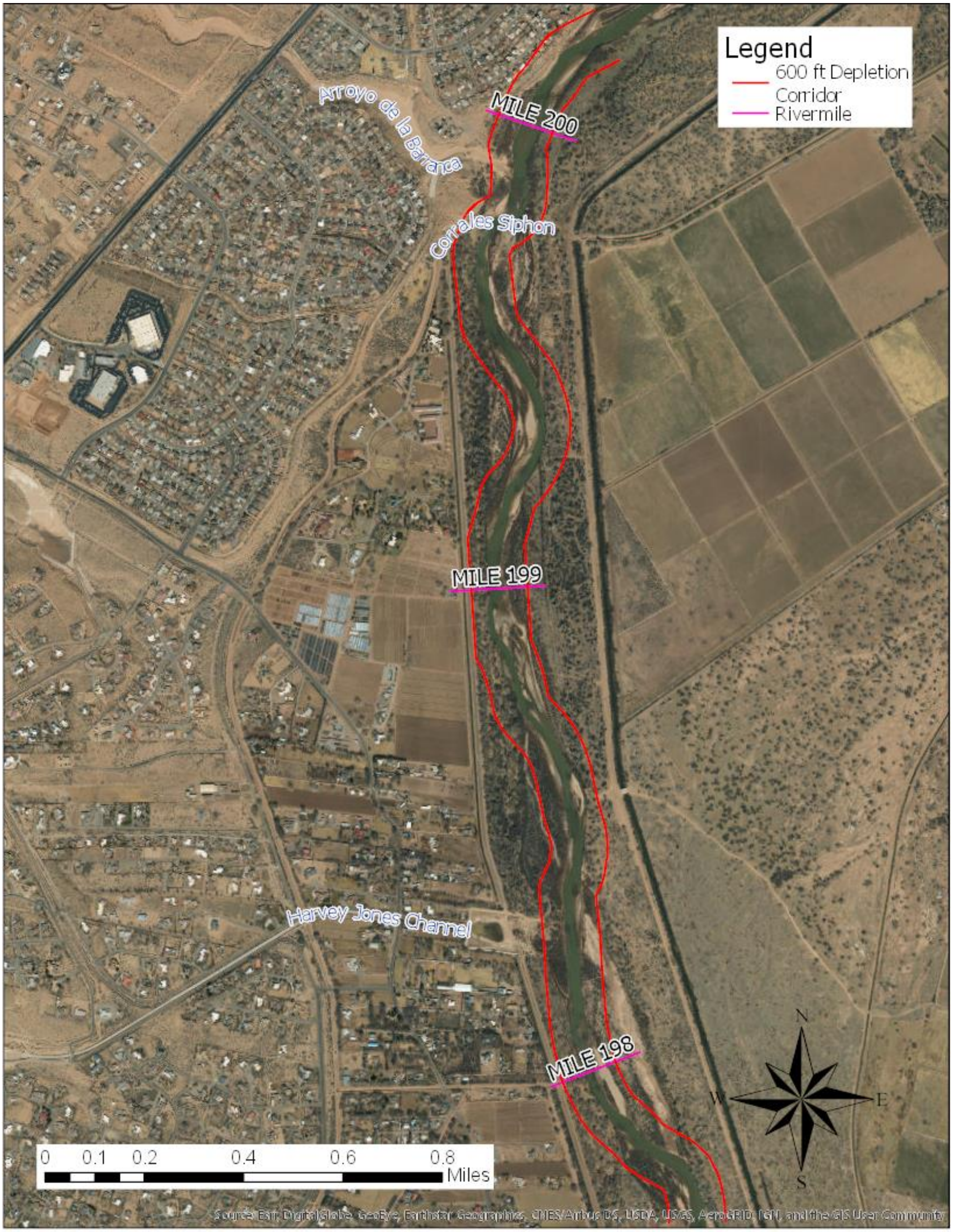


Figure 22: 600-foot depletions corridor

2.5.9 Construction Access Routes

In general, construction access throughout the project area is very good with minimal environmental disturbance required for access.

Construction equipment could access the western levee from the following public locations:

- Rio Rancho recreational area parking lot
- Corrales Siphon recreational parking lot
- Romero Street recreational area parking lot

From the western levee, there are numerous turnoffs (ramps) that drop down into the bosque, or a new turnoff can be built temporarily and removed after project completion. There are no roads in the western bosque, only recreational trails, and any construction roads built through the bosque will be recontoured to match the topography and reseeded.

On the eastern side of the river, the riverside drain can be crossed at the western end of Tribal Route 701 or at the irrigation entrance to Corrales Siphon. There are numerous turnoffs from the eastern levee that drop down into the bosque. If new construction roads are built through the bosque, the Pueblo will determine the permanence of any constructed ramps or roads.

2.5.10 Spoil Material Opportunities

Options to spoil construction material include spoiling against the levee and spoiling to the river. Other spoil locations outside of the levees would have significant hauling costs.

The levee on the western side of the river is an engineered levee through the RM 199 project area. It is discouraged to spoil against engineered levees, although allowable with engineering controls.

The eastern spoil levee in this area is around two miles long and approximately 9 to 11 feet tall. If spoil was placed against the entire length of the levee 10 feet wide and maintaining the existing slope, it would total approximately 39,000 cubic yards of spoil material. However, it should be noted that the Pueblo of Sandia Environmental Division would strongly prefer material to be spoiled into the river instead of on the levee for the habitat benefits given that the river channel in this reach has a reduced sediment supply compared to historical conditions, owing to construction of dams and other land use changes.

Habitat restoration projects in this area have set a precedent in spoiling their construction materials to the river. At the Pueblo of Sandia's "Riverine Constructed Habitat Features Creation and Modification" project, 8,857 cubic yards of material were spoiled to the river through the section 404 permit. The Pueblo of Sandia Environmental Division strongly supports spoiling to the river for the habitat benefits.

The only area within the project extents that is not close to a levee for spoils would be the Arroyo de la Barranca delta. If a project component was constructed in this area, spoils would have to go to the river or hauled off site. It is a possibility that SSCAFCA would allow spoiling within the Arroyo channel or floodplain considering it's generally a degrading arroyo (Sanchez, 2019) although this possibility has not been discussed with SSCAFCA.

2.5.11 Hydrology and Design Flows

Reclamation has authority for river maintenance in this reach for the two-year flood. According to Wright (2010), the regulated two-year flood at San Felipe and Albuquerque gages are 5,600 cfs and 4,000 cfs, respectively. The regulated 10-year flood at San Felipe and Albuquerque gages are 10,000 cfs and 7,500 cfs, respectively.

As described in Section 2.5.4, the Arroyo de la Barranca's 100-year 24-hour peak discharge at the Rio Grande is approximately 3,840 cfs, and Harvey Jones Channel's 100-year 24-hour peak discharge at the Rio Grande is approximately 9,120 cfs (Sanchez, 2019).

Bankfull flow in a healthy reach occurs when the water surface elevation matches the bank elevation, and typically occurs around a 1.5-year return interval (Leopold, Wolman, and Miller, 1964). The 1.5-year return interval flow at the USGS Albuquerque gage is 3,128 cfs based on a Log Pearson III analysis of peak flows between 1998 and 2019.

Reclamation will restore or enhance those riparian or aquatic habitats impacted by river maintenance activities in the RM 199 Project area. Where feasible and appropriate, aquatic habitat restoration will be designed to increase areas that provide shallow depths and slow water necessary for RGSM egg, larvae, or juvenile habitat for a variety of flows. In recent years, the average flow during the two peak weeks of spring runoff is 2,640 cfs. The lowest two-week spring runoff average flow was 660 cfs (in 2018) and the highest two-week spring runoff average flow was 4,950 cfs (in 2017). These flow scenarios were calculated from all spring flowrates between 2004 and 2018 at the Alameda gage (USGS 08329918). For this analysis, spring flows were defined as flows between February 15 until June 30.

These hydrologic data will be used in helping design bank protection and habitat features in the Corrales RM 199 Project area.

2.6 Alternative Analysis Goal and Strategy

In Reclamation's 2012 Comprehensive Plan and Guide (CP&G) four large scale strategies are deemed suitable for the Angostura to Isleta reach. These include Promote Elevation Stability (PES), Promote Alignment Stability (PAS), Rehabilitate Channel and Floodplain (RCF), and Manage Sediment (SED).

The project purpose at River Mile 199 is to reduce the risk of levee failure due to bank erosion and lateral migration of the Rio Grande. Additional goals include improving ecological conditions, avoiding negative community impacts, being suitable given the geomorphic trends, and being cost effective. To reduce erosion towards the levee, the bank needs to be stabilized at locations of immediate threat (PAS), and the river's energy needs to be dissipated before it can cause erosion in other areas of the reach (PES, RCF, and SED). Thus, the alternatives will be grouped into bank protection methods and energy dissipation methods, and these two groups will be evaluated separately.

Figure 23: Decision tree considering strategies to achieve the project goal

3.0 Bank Protection Methods

The RM 199 project area encompasses 6 outer bends, shown and named in Figure 24 below. Table 2 provides information on each bend's distance from the riverside levee and relative erosion rate. For some of the bends, including the RM 199 bend, strong bank stabilization with a low risk of failure is necessary to protect the riverside levee. For other bends, the risk to the levee is lower and other softer bank treatments may be appropriate.

Although we anticipate applying bank protection methods to multiple bends, this section will only compare bank protection methods at the RM 199 bend (a higher risk bend) in order to simplify method comparison. This section also briefly discusses bioengineering methods that could be implemented at lower risk bends as appropriate for the purpose of improving habitat.

At RM 199, which is the bend closest to the levee, the goal is to safely pass the 2-year flood (between 5,600 and 4,000 cfs; see Section 2.5.11) without incurring further erosion towards the levee. At this time, it is proposed to stabilize approximately 1,300 feet of bankline at the RM 199 site (not including the structural keys and tie backs). See Figure 25 for the aerial extents of this proposed bankline protection (not including structural keys and tie backs).

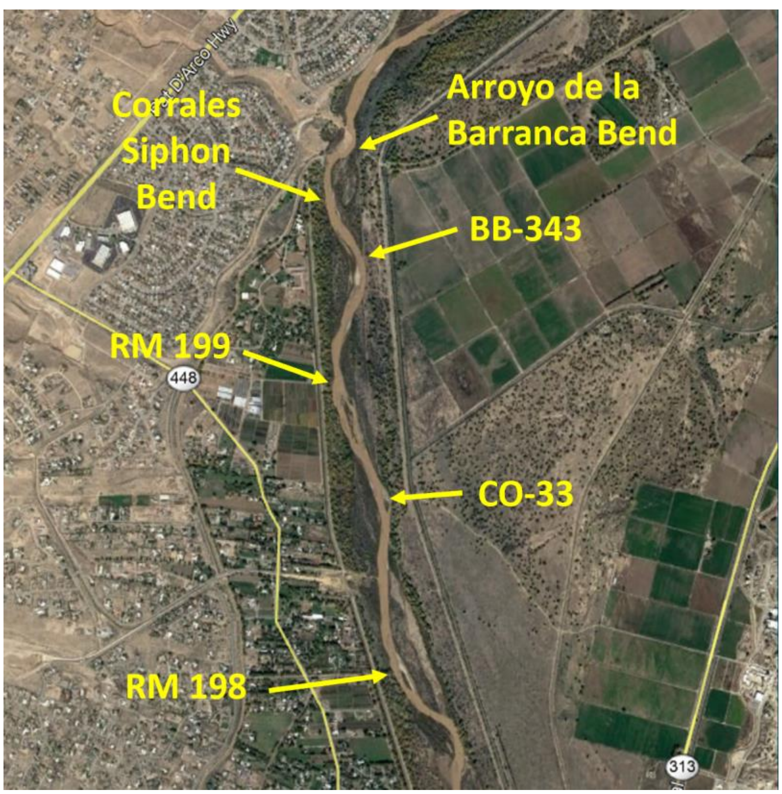


Figure 24: Map showing the naming convention for each of the six bends in the RM 199 project area

Table 2: Description of the six bends in the RM 199 project area

Arroyo de la Barranca	430	High
Corrales Siphon	230	Medium
BB-343	290	High
RM 199	120	Low
CO-33	250	None
RM 198	220	Low

Figure 25: Extents of proposed bankline protection at the RM 199 bend, not including the structural keys and tie backs

3.1 Initial Screening

Table 3 contains a list of bank stabilization methods from Bank Stabilization Design Guidelines (Baird, Fotherby, Klumpp, and Scurlock, 2015) and the Large Wood Manual (USBR and ERDC, 2016). Table 34 and Table 35 in Appendix A include a more complete list of bank stabilization options as well as additional details on the advantages and disadvantages. Table 3 discusses the suitability of each option for the RM 199 outer bend based on the particulars of the reach and site.

Table 3: Bank stabilization methods from Baird et al., 2015; McCullah and Gray, 2005; NRCS, 2007a; and USBR and ERDC, 2016.

Method	Description	Suitability
Transverse Features or Flow Deflection Techniques		
Bendway Weirs, Trench Filled Bendway Weirs, Spur Dikes, Vanes or Barbs, J-Hook	Rock features that protrude laterally into the channel to redirect flow away from the bank	Unsuitable - Long-term stability uncertain due to upstream channel migration potential, incision potential, and bend radius (see Appendix A Section 9.1.4)
Longitudinal Features using Riprap		
Riprap Revetment	Riprap placed along the bankline	Unsuitable – Although this option could provide adequate bankline stabilization, it would hamper critical bankline vegetation establishment and it would be aesthetically unappealing in an area of high recreational use
Longitudinal Stone Toe with Bioengineering	Riprap placed at the bank toe with coir fabric, willow poles, and/or similar vegetation incorporated into the bank	Suitable – This option could provide adequate bankline stabilization and would increase likelihood of vegetation establishment. In-channel construction would be likely.
Trench Filled Riprap	Riprap buried in a trench set back a small distance from the bankline	Suitable - This option could provide adequate bankline stabilization and would not require in-channel construction. Unfortunately, this option would likely require mature tree removal regardless of placement due to the frequency of trees in the RM 199 area.

Method	Description	Suitability
Longitudinal Features using Woody Materials		
ELJs or flow deflection jams	Intermittent structures built into eroding banks by stacking whole trees and logs with rootwads in crisscross arrangements	Semi-suitable – the bank protection needs to be continuous, not intermittent, but the principle of stacking trees in crisscross arrangements may be a useful anchoring mechanism in sandy banks.
Rootwads or Meander Jams	Logs buried in bank with rootwads protruding into channel	Semi-suitable – May experience erosion between the features due to upstream channel migration, but may be acceptable if the design is closer spaced with additional crisscrossed logs for stability
Tree revetments or roughness logs or bench jams	Whole trees placed along bank parallel to current. Trees are overlapped (shingled) and securely anchored or lodged into bedrock outcrops, boulders, etc.	Unsuitable – The protrusion into the current would create a large force requiring a lot of additional anchoring considering the erodible sandy banks, and the extent of the protrusion into the river may be a recreational hazard
Toe logs	One or two rows of logs or whole trees running parallel to current and secured to bank toe	Unsuitable – The anchoring would prove difficult in the erodible sandy banks
Live cribwall	A hollow box-like interlocking arrangement of structural logs, with willows protruding between the logs and backfilled with soil	Semi-suitable – The design would need to be a sloped bank instead of a vertical wall, but otherwise may provide adequate stability in the erodible sandy banks

Method	Description	Suitability
Bank Treatments		
Terraced or sloped cut bank	The cut bank would be terraced or sloped to allow vegetation to establish and create edge habitat. (A terraced configuration is preferred over a sloped configuration).	Suitable for non-eroding bends as a habitat improvement method
Pole plantings at cut bank	At a cut bank location, willow or cottonwood poles would be planted (after terracing/sloping) to jump-start vegetation establishment to promote stability at the banks and create edge habitat.	Suitable for non-eroding bends as a habitat improvement method
Woody debris at toe of terraced banks	When terracing the cut banks, old trees can be buried into the bank with their root wads exposed at the toes of the banks. This will add extra assurance against toe erosion. The root wads may degrade over time, but the goal is to establish mature vegetation on the banks by the time of degradation.	Suitable for non-eroding bends as a habitat improvement method

Based on the initial screening discussed in the table above, the remaining bank stabilization methods have been grouped into "Longitudinal Riprap Features" and "Longitudinal Woody Features" which will move forward to the evaluation phase. These alternatives are described below. In addition, a "No Action Alternative" will be evaluated which will provide a baseline for conditions.

The bank treatments discussed above can be applied at any of the bends as a habitat restoration method and not as a bank stabilization method. These bank treatments will be scored alongside the other methods for their habitat and community benefits even though they offer little bank protection.

3.2 Longitudinal Riprap Feature Description

The first alternative, a longitudinal riprap feature, would most likely resemble the "longitudinal stone toe with bioengineering" design discussed in the initial screening table (Table 3), although this is subject to change during the design phase based on design-level considerations or stakeholder and community feedback. In that case the design could resemble the "riprap filled trench" design discussed in the initial screening table to minimize impacts and permitting requirements while continuing to provide high certainty of strong bank protection (Table 3).

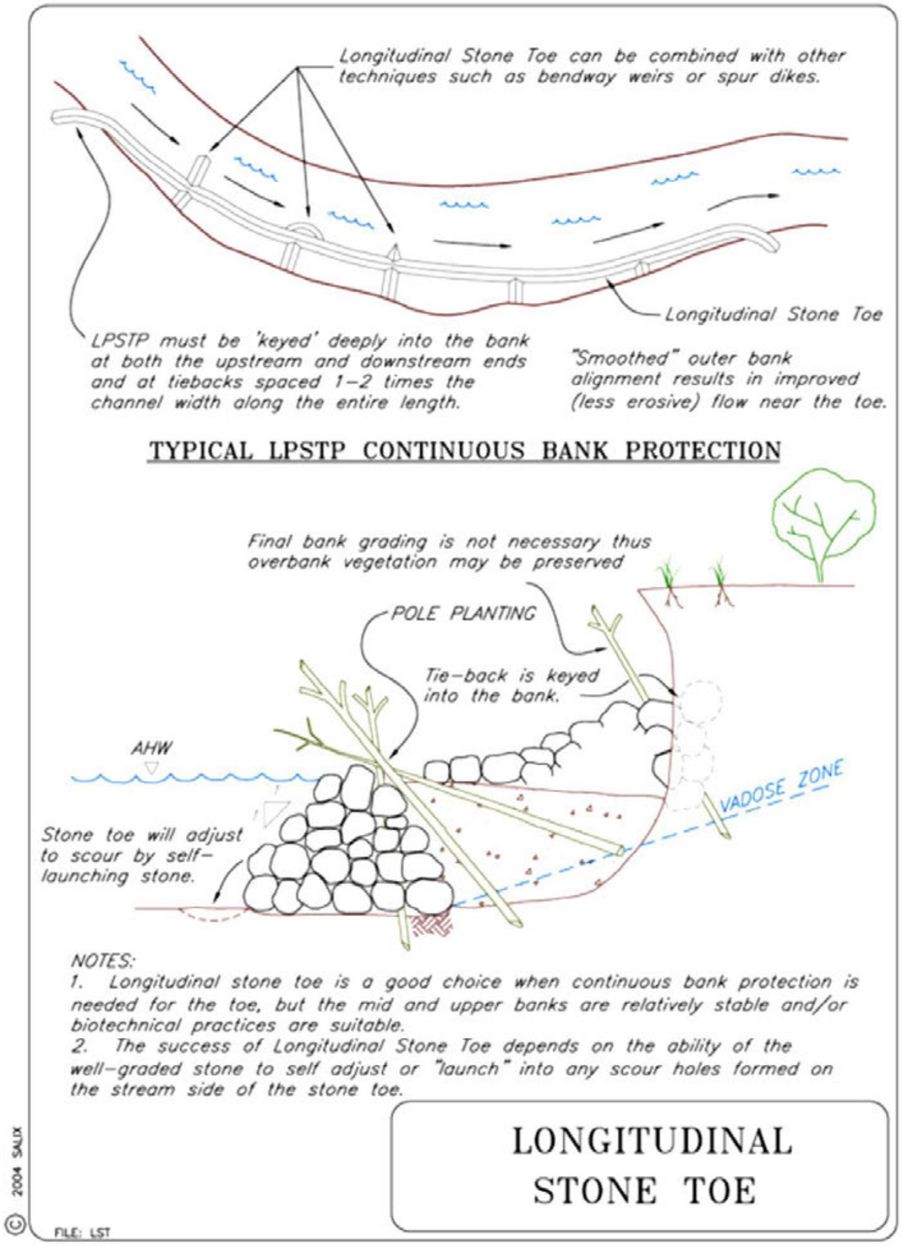


Figure 26: Typical longitudinal peak stone toe design (Baird et al., 2015)

Similar completed designs nearby on the MRG include the San Felipe RM 211.3 site. San Felipe has similar conditions as the Corrales area, although the hydrology at the San Felipe site has slightly greater flows due to being upstream of Angostura Diversion Dam. The San Felipe site also had an eroding bend, and the designed solution was a 1,200 linear foot longitudinal fill stone toe protection (similar to the 1,300 feet at RM 199), with a floodplain bench and willow plantings. This feature was designed to withstand the 25-year flood at San Felipe, which has a flow of approximately 10,000 cfs. The San Felipe bank was approximately 12 feet high, which is the same bank height at RM 199 (Tetra Tech, 2012 and 2013b). Thus, for the purposes of an alternative analysis, the design quantities and riprap sizing at San Felipe will be used to guide the alternative cost estimate, with some appropriate changes.

Table 4: Estimated material quantities and cost for the longitudinal riprap feature alternative

Item Description	Unit	Quantity	Unit Price	Cost
Clearing and grubbing	acre	1.6	$1,000	$1,600
Excavation for tie-backs and keys	cubic yard	2,800	$7	$19,600
Fill behind LFSTP	cubic yard	2,600	$7	$18,200
Riprap: D_{50}=12 inch (LFSTP and launch)	cubic yard	2,500	$110	$275,000
Riprap: D_{50}=12 inch (tie-backs and key)	cubic yard	2,300	$110	$253,000
Erosion control fabric	square yard	4,200	$2	$8,400
Willow pole plantings	linear foot	2,600	$8	$20,800
Revegetation seed mix	acre	1.1	$1,000	$1,100
			Subtotal	$597,700
Mob/Demob	%	3	$597,700	$17,931
Site Staking/Survey	%	2	$597,700	$11,954
Contingency	%	25	$597,700	$149,425
			Total Cost	$777,010

3.3 Longitudinal Woody Feature Description

The second alternative, a longitudinal woody feature, would most closely resemble the "Live Cribwall" design discussed in Table 3, but would be modified to provide a sloped bank. Figure 27 and Figure 28 provides examples of live cribwall designs. The design at RM 199 would include crooked logs, rootwads, some attached branches, and pole plantings or live cuttings would be placed between the logs.

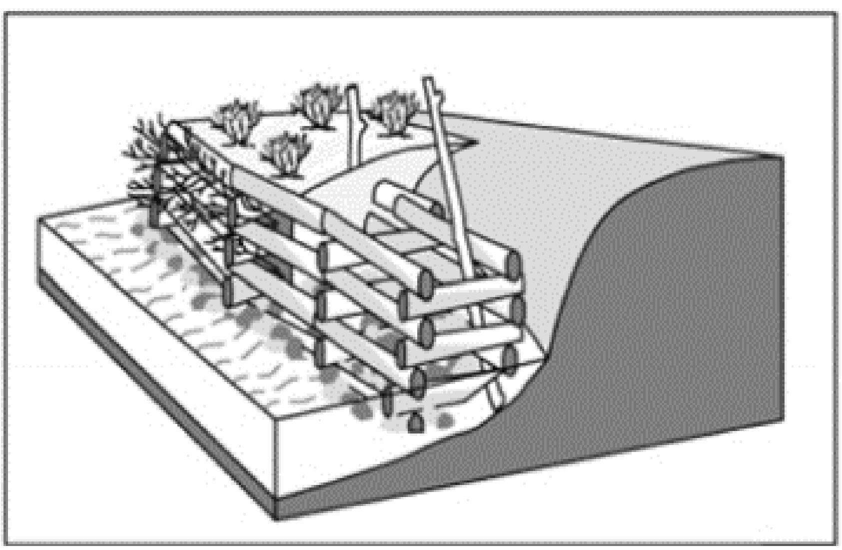


Figure 27: Live cribwall example (Transportation Research Board, 2005)

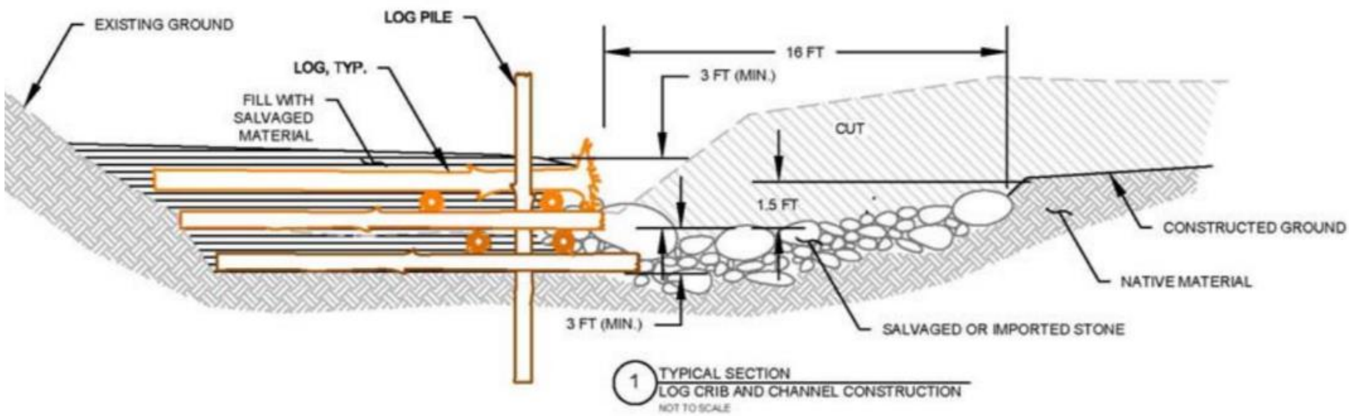


Figure 28: Example cribwall design with rootwads (Lee, Melchior, Selle, and Swanson, 2015)

For cost estimating purposes, the following assumptions have been made, although the final design may vary. The cribwall would have three tiers of logs perpendicular to the flow, two tiers of logs parallel to the flow, and a vertical log pole. The perpendicular logs would be spaced roughly every 8 feet, and the vertical log poles would also be spaced roughly every 8 feet, between each perpendicular log. This alternative's protection would extend 1,300 feet, similar to the longitudinal riprap feature, as shown in Figure 25. In this cost estimate, riprap has not been included in the assumed design, but riprap could be used in a final design to add extra stability depending on the needs of the bend where the method is being applied.

The logs would be harvested from the nearby burn area on Sandia Pueblo, as well as any downed cottonwoods in the nearby bosque. From aerial imagery, most logs in the burn area are between 15 and 30 feet long.

Table 5: Estimated material quantities and cost for the longitudinal woody feature alternative

Item Description	Unit	Quantity	Unit Price	Cost
Clearing and grubbing	acre	1.6	$500	$800
Fill behind and inside cribwall	cubic yard	8,100	$7	$56,700
Log preparation, transport, and placement	log	900	$200	$180,000
Specialized log equipment rental	month	3	$45,000	$135,000
Willow pole plantings	linear foot	3,900	$8	$31,200
Revegetation seed mix	Acre	1.1	$1,000	$1,100
Mob/Demob	%	3		$12,144
Site Staking/Survey	%	2		$8,096
Contingency	%	25		$101,200

3.4 Bank Treatments as Habitat Restoration

For this analysis, bank treatments are defined as creating terraced or sloped banks with plantings and coir fabric. These treatments are not intended to be a stabilization method, but a habitat restoration method. Bank treatments provide minimal bank protection immediately upon construction; however, as vegetation grows over time, bank protection increases. Additionally, these methods provide edge habitat for the minnow. This method is appropriate for lower risk bends. They are being included in this Bank Protection Methods section since they are applied to the bank and not to the point bars or channel.

Bank treatments have particular value in this reach due to the eroding cut bank nature of the outer bends. These cut banks are roughly 12 feet from the thalweg to the top of the bank. The cut bank would be terraced or sloped to allow vegetation to establish and create edge habitat. (A terraced configuration is preferred over a sloped configuration). Willow or cottonwood poles would be planted to jump-start vegetation establishment to promote stability at the banks and create edge habitat. Coir fabric would be used to encapsulate soil lifts to add stability.

Although these methods are best at bends with no erosion, bank treatments could be applied to bends with small amounts of erosion if some toe protection is included. One potential toe protection option is to bury old trees into the bank when terracing. Their root wads would be exposed at the toes of the banks. The root wads may degrade over time, but the goal is to establish mature vegetation on the banks by the time of degradation.

The bank treatments are estimated to cost around $200,000 assuming dimensions of 600 feet long, 75 feet wide, and 6 feet deep terraces. Depending on the other alternatives implemented and future narrowing, incision, and meandering trends, they could last anywhere from 2 years to 50 years. The fifty-year lifecycle cost is $3,000,000 and assumes bank treatments at five bends rebuilt three times in fifty years.

Table 6: Cost estimate for an example one-acre bank treatment area

Item Description	Unit	Quantity	Unit Price	Cost
Clearing and grubbing	acre	1	$1,000	$1,000
Excavation for terraces	cubic yard	9,000	$5	$45,000
Disposal, nearby site	cubic yard	6,000	$2	$12,000
Cottonwood poles, 8-12'	acre	1	$2,150	$2,150
Willow pole plantings	linear foot	3,600	$8	$28,800
Fabric encapsulated terrace protection	square yard	30,000	$2	$60,000
Revegetation seed mix	acre	2	$1,000	$2,000
			Subtotal	$150,950
Mob/Demob	%	3	$150,950	$4,529
Site Staking/Survey	%	2	$150,950	$3,019
Contingency	%	25	$150,950	$37,738
			Total Cost	$196,235

Since this alternative is purely for habitat restoration, it will not be compared with the bank stabilization alternatives below.

3.5 Comparison of Alternatives

The project purpose at River Mile 199 is to reduce the risk of levee failure due to bank erosion and lateral migration of the Rio Grande. Additional goals include improving ecological conditions, avoiding negative community impacts, being suitable given the geomorphic trends, and being cost effective. These criteria are used below to compare the alternatives to each other.

3.5.1 Bank Protection

Both the riprap and the woody features alternatives can be scaled to provide the required protection for the 10,000 cfs design flood. There is a lot of literature on riprap protection, and if the riprap feature alternative is chosen, the bank will be protected with a high level of certainty. On the other hand, woody features are less commonly used for bank protection and have less certainty in their ability to provide adequate bank protection.

A significant uncertainty with the adequacy of the bank protection is because woody features placed in banks with >85% sand are subject to flanking (NRCS, 2007c). Although the sand content at the RM 199 site is unknown, an estimate can be made based on a comparable floodplain area located roughly four miles away from the RM 199 bend which generally has 78 to 96% sand content (Daniel B. Stephens, 2019). Woody features placed in banks of uniform sand require stabilizing with riprap or burying the logs for a long distance. Also, the bed elevation and slope need to be stable (Baird et al., 2015) but in the RM 199 area the bed has not be stable historically. Due to the MRG's high sand content and bed instability, the live cribwall design would be the sturdiest design of the woody stabilization options for the conditions, but the uncertainty is high.

The no action alternative does not provide any bank protection. The RM 199 bend has only had minor erosion (<10 feet) between 1996 and 2018, according to Google Earth aerial imagery (a rangeline at this cross section was only recently established in 2018). However, the two bends immediately upstream from the RM 199 bend have been eroding and changing geometries, and thus accelerated erosion at the RM 199 bend is a likely possibility in the near future. The bend is as little as 120 feet from the western levee.

For both the riprap and woody alternatives, the project could fail by river flows flanking or undercutting around these erosion resistant materials.

Flanking failure has the same likelihood for both alternatives and the neither alternative would perform well in a flanking situation (thus, adequate keys at the upstream and downstream end of the riprap or woody protection will be designed to prevent flanking failure).

If a riprap feature experiences undercutting (scour), the riprap will launch into the scour hole and will continue to provide bank toe protection, assuming the riprap volume is adequate for the scour.

If a woody feature fails through undercutting, the logs may not fall neatly into the scour hole, leaving the bank toe unprotected. Also, without the backfill and other logs stacked on top of each other, the logs are likely to be washed downstream, potentially clogging up bridges or the ABCWUA diversion dam. Also, logs in the river are often hazardous to recreationalists.

3.5.2 Suitability Given Trends

The trends in this reach show that the channel bed is incising and its planform is meandering and migrating laterally over time. In addition, the riverbed material is coarsening or becoming more gravel dominated.

If the channel continues to incise, the toe of the riprap or woody feature may be undercut. As discussed in the previous section, the riprap could launch and continue to protect the bankline, but the woody feature may fail and no longer protect the bankline.

If the channel continues to meander, the meander bend apex may move downstream of the RM 199 bank protection site. If this process happens rapidly, it would be prudent to avoid overspending on a long-life feature (e.g. riprap) that will outlive its usefulness. However, this will likely not be the case at the RM 199 site, where the bend apex has moved so little that a migration rate over time cannot be established. (Although it could be noted that the bend apex immediately upstream from RM 199 has migrated laterally and downstream at a rate of 70 feet per year over the last four years).

3.5.3 Longevity

Riprap is a durable material, especially the absence of freeze-thaw cycles, and it is anticipated to still be intact by the time the river meander moves downstream of the site.

The durability of woody material can be estimated from other woody material implementation sites on the MRG. Immediately downstream of the Sandia Priority Site, the cottonwood woody debris installed in 2008 endured the 2019 high runoff eleven years later without breaking apart. These logs are out of the water in low flows and submerged in high flows. However, literature shows that large logs subjected to wetting and drying cycles in hot climates may only last a few years. Cottonwood is listed as a species that is known to have particularly poor durability (USBR and ERDC, 2016).

Considering the uncertainties of longevity with woody features, they should not be relied on for long term stabilization. Large wood placement should be viewed as a transitional rehabilitation technique which is dependent on sediment retention and woody-plant colonization for its long-term success (USBR and ERDC, 2016). Adaptive management planning can be used to ensure woody colonization is successful, but there is still some uncertainty and risk as to the degree of woody colonization establishment by the time of wood failure.

3.5.4 Costs

As shown in section 3.2, the cost of the riprap alternative will likely be around $700,000 to $800,000. As shown in section 3.3, the cost of the woody alternative will likely be around $500,000 to $600,000. The woody alternative is approximately four fifths the cost of the riprap alternative, which may be within the range of error of these feasibility level estimates. The riprap alternative's major cost component is obtaining and hauling the riprap. The woody alternative's major cost component is hauling as well as labor installing the wood.

The no-action alternative will have no immediate costs. However, if bank stabilization is not performed, the potential costs to repair a failed levee could cost $300,000 to $900,000 depending on the length of the levee area requiring repair (see section 9.1.5 in Appendix A), plus the costs of the water losses and any additional infrastructure damages if the water were to flood onto the surrounding residential and agricultural areas.

A long-term cost analysis was completed assuming a fifty-year lifecycle. It is assumed that the riprap bank stabilization will last fifty years, assuming the possibility of some minor adaptive management repairs during those 50 years such as localized riprap supplementation that costs about $200,000. The likelihood of adaptive maintenance is based on the hydrologic probability of the design flow being exceeded.

It is assumed that the woody stabilization will last ten years before the materials have decayed and are unsuitable, and after that a complete rebuild would be required. The likelihood of woody stabilization failure is mostly based on material durability although a failure due to high flows is also a possibility.

It is assumed that if no action is taken, the levee will fail within 10 to 20 years and then fail every 8 years thereafter (assuming no additional bank protection is provided other than at the immediate location of failure).

Table 7: Long term cost analysis for the bank stabilization alternatives

Alternative	**Initial Cost**	**Assumed Longevity**	**Fifty-Year Lifecycle Cost (RM 199 only)**	**Fifty-Year Lifecycle Cost (5 bends)**
Longitudinal Riprap Stabilization	$750,000	50 years (when including $200,000 adaptive maintenance)	$950,000	$4,750,000
Longitudinal Woody Stabilization	$525,000	10 years (build five times in fifty years)	$2,625,000	$13,125,000
No Action	$600,000*	15 years with subsequent failures every 8 years (five repairs in fifty years)	$3,000,000	$3,000,000

*The No Action cost is the assumed cost of repairing a failed levee due to river meander erosion

3.5.5 Material Availability

The Middle Rio Grande Program has a system in place for regularly obtaining riprap of the required volume and sizing via material supply contracts. Any riprap needed for this project would most likely be used and hauled from Reclamation's Bernalillo stockpile located approximately 13 miles away.

Woody debris could be obtained from the nearby Sandia burn area. The wood is already de-limbed by the fire. The estimate of the number of logs in the burn area is between 1,000 and 1,300, but it's possible that only half of that is useable. Also, salvaging fallen trees throughout the bosque is a possibility. (Scialdone, 2019)

3.5.6 Community Impact

Both the riprap or woody feature alternatives will have a positive impact on the community by reducing erosion, improving bank slope, and improving bankline vegetation.

However, there will also be a negative impact during construction since the increased construction traffic and increased risk of accidents will require the bosque to be at least partially closed to the public.

The construction duration for a riprap feature is estimated to be around 5 months, while the construction duration for a woody feature is estimated to be around 6 months.

The most direct way to haul the riprap would be from the Bernalillo stockpile, crossing the river on Highway 550, to the Corrales Siphon and down the levee road to the bank protection site. This may require a full bosque closure from the Corrales Siphon to the bank protection site.

Another option may be to haul the riprap through the Pueblo of Sandia to the eastern bank, and depending on the energy dissipation alternative selected, the riprap may be stockpiled on the eastern bank until the river is dewatered or it may be directly hauled across the river to the western bank. The number of river crossings would be roughly between 260 and 1,050, depending on the size of the trucks and the final design. While this option minimizes the required bosque closure in Corrales, the increased truck traffic will be undesirable to the Pueblo.

Hauling wood from the Pueblo's bosque to the river would not interfere with the populated areas of the Pueblo and thus would have a much smaller community impact. There would still be a partial bosque closure on the Corrales side around the construction site.

3.5.7 Impact on Habitat

A discussion of the bank protection methods' impacts on the habitat has been combined with the energy dissipation alternatives (as introduced in Section 4.2) and has been included in Section 4.4.6.

3.5.8 Level of Effort for Environmental Permitting

Riprap and woody barriers would likely require similar levels of permits such as an Environmental Assessment (EA) for NEPA, a Clean Water Act (CWA) Section 404 permit authorization, and a CWA Section 401 water quality certification. If the bank stabilization feature fails, this may be a CWA permit violation and the permit terms may dictate how Reclamation responds to the failure. Permits for bank stabilization will likely be a minor effort compared to any grade control and/or bank lowering permitting that may be required for the energy dissipation alternatives in the reach.

4.0 Energy Dissipation Methods

Energy is dissipated by increasing channel roughness, increasing wetted perimeter, decreasing slope, and decreasing the channel depth. These energy dissipation methods can be accomplished by reconnecting the river to its floodplain. The river has disconnected from its floodplain due to decreases in water and sediment discharge and subsequent vegetation encroachment on the active channel, resulting in channel narrowing and incision. This incision is so substantial that in this subreach the river is disconnected from its inset floodplain consisting of meander bend point bars developed in the last 20-30 years.

4.1 Initial Screening

Table 8 describes energy dissipation and habitat restoration methods and performs an initial screening for infeasible or impractical methods. Appendix B contains information on the investigations which led to these decisions.

Table 8: Initial screening of energy dissipation methods

Method	Description	Keep? (Yes/No)
Channel bed elevation alteration options	Raising the channel bed will create a wider floodplain at lower discharges, altering the channel bed slope will affect the river velocity, and grade control can decrease bed incision.	
Raise bed 7 feet to re-engage root zone	To re-engage the root zone of the eroding abandoned terraces, the channel bed would have to be raised approximately 7 feet. At the downstream end of the project, the bed would have to return to existing grade, and the resulting 7-foot drop would be too steep for fish to maneuver even if the drop was spread out over a reasonable distance.	No – This option would fragment the river and create a barrier to fish movement.
Gradient Restoration Facility (GRF)	A GRF would raise the bed by one to three feet, stopping incision and decreasing the channel slope upstream of the GRF. Although not ideal, fish can migrate past a GRF with swimming bursts.	Yes
Raise bed at upstream end of project reach and slope to existing grade by the downstream end of the project	This option would raise the bed at the upstream end of the project at most by 4 feet to protect the Corrales Siphon. After passing the Corrales Siphon the longitudinal profile would be a constant slope down to where it meets existing grade at the end of the project. The raise would create overbanking at lower discharges. The new slope over the length of the project would be approximately 0.0012, compared to the existing project slope of 0.0009.	No – This option is not optimal since the increase in slope will increase energy instead of dissipating energy.

Method	Description	Keep? (Yes/No)
Bed/grade control	Deformable riffles, rock sills, and riprap grade control can help reduce or stop bed incision, ensuring the floodplain does not become further disconnected. Depending on the design needs, bed/grade control can come in various sizes and may or may not be keyed into the bank which affects likelihood of bank erosion flanking the features.	Yes
Raise the bed 1–3 feet with spoil materials	Spoil materials from side channels or bank lowering could be placed in the river to help reconnect the river to the floodplain. To prevent these spoil materials from washing downstream soon after placement, bed/grade control features would protect the spoil materials by launching riprap into scour holes that progress from downstream to upstream, and by slowing particle movement that causes incision from upstream to downstream.	Yes – This option will be combined with a floodplain lowering option described below named "Widen the channel with cutoff channels."
Upstream Sediment Management (Increasing sediment supply to the reach)	Managing sediment upstream of the project area would involve influencing USACE dam operations (Cochiti, Galisteo, Jemez), influencing ESCAFCA or SSCAFCA arroyo management practices, or influencing landowners' management practices.	No – These are worthwhile activities to engage these groups, but outside the scope of this project.
Local Sediment Source Management (Increasing sediment supply to the reach)	The two arroyo sources in the project area include Arroyo de la Barranca and Harvey Jones Channel, both managed by SSCAFCA. Arroyo de la Barranca is an incising channel and thus any efforts to increase its sediment load to the river would be detrimental to upstream infrastructure. Harvey Jones Channel is a concrete channel with a sedimentation basin approximately 700 feet before reaching the river.	No – A partnership of stakeholders including Reclamation is currently considering a potential project at the Harvey Jones confluence. To avoid overlap, this analysis will not further pursue Harvey Jones Channel reconnection, but Reclamation will advocate for the benefits of sediment continuity within the partnership.
Floodplain lowering options	Floodplain lowering options will provide more floodplain access at lower flows, increase wetted perimeter, increase roughness, and decrease depth.	

Method	Description	Keep? (Yes/No)
Widen the channel with longitudinal bank lowering	A design width analysis (see Appendix B) recommends an active channel design width of 260 feet. The 2018 average active channel width was 176 feet. Channel widening with longitudinal bank lowering would widen the channel by roughly 85 feet.	No – The bank lowering should not be implemented on the outer banks of a bend to avoid bringing the channel erosion closer to the protected levees. Channel widening on the inner bend would not last long since inner bends are extremely depositional by nature. This option is not recommended and an improved channel widening method is presented next.
Widen the channel with cutoff channels	This method would widen the channel by roughly 85 feet by creating a flow-through cutoff channel through each of the meander bends. These cutoff channels can be used as temporary diversion channels to allow any type of stabilization treatments to be constructed in the dry at the erosional outer banks.	Yes – Note: This method combines well with the method "Raise the bed 1–3 feet with spoil materials" described above. The two methods will be combined as an additional alternative.
Widen the channel with a network of side channels on the inner bend	A network of side channels that can flow during low and/or high flows would allow a wider floodplain. This option would create even more edge habitat than the cutoff channels option.	Yes
Vegetation destabilization	This option would root-plow vegetation on lower point bars during the early spring of a high-snowpack runoff year. During spring runoff, the high flows would scour out the destabilized floodplain. This method essentially mimics an extreme flood event.	Yes – This option would be a good adaptive management tool but may not be useful immediately if a high snowpack year does not present itself.

From this initial screening, six alternatives progressed to the evaluation phase. These six alternatives are not mutually exclusive and multiple alternatives could be selected and combined as appropriate (except the no-action alternative).

- GRFs
- Bed control
- Widening the channel with cutoff channels (hereafter named "Cutoff Channels")
- Widening the channel with a network of side channels on the inner bend (hereafter named "Limited Side Channels")
- Vegetation destabilization
- A no-action alternative

Out of these six alternatives, four of them were hydraulically modeled to further understand their impacts. The two alternatives that were not modeled were 1) bed control, since the two-dimensional hydraulic model only minimally shows this alternative's impact on hydraulics and cannot show this alternative's impact on sediment transport, and 2) vegetation de-stabilization, since the post-implementation terrain is too unpredictable to hydraulically model.

4.2 Description of Alternatives

The following sections describe how the alternatives might be applied in the RM 199 project area. The descriptions are a basic overview, and most of the design details will be determined during the design phase.

4.2.1 Gradient Restoration Facilities

This alternative would construct four two-feet to three-feet tall Gradient Restoration Facilities (GRFs) within the two-and-a-half-mile project area. The number of structures within the project area was determined using the anticipated equilibrium slope upstream of the structures (Reclamation, 1987) and using the GRF spacing recommendations found in "Design Considerations for Siting Grade Control Structures" (Biedenharn and Hubbard, 2001). Three GRF structures would allow the entire 2.5 mile stretch to be influenced by the GRF structures, but the fourth GRF has been added at the upstream end of the reach to protect Corrales Siphon. This upstream GRF will benefit not only the siphon, but also add some stability to the degradational Arroyo de la Barranca (see Section 2.5.4).

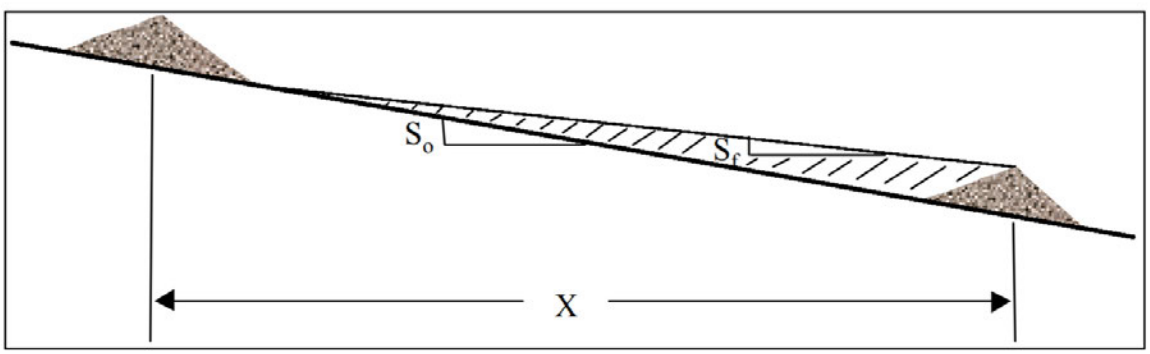


Figure 29: General longitudinal configuration of GRFs showing the conceptual initial and final slopes (from Biedenharn and Hubbard, 2001)

The GRFs would have a sheetpile wall that crosses the entire width of the river and into both banks. The sheetpile wall fixes the riverbed elevation and is usually set 1–3 feet above the existing bed elevation. A downstream rock apron (approximately 500 feet long) is needed to protect the sheetpile and allow for a sloped transition for upstream fish movement (see Figure 30 for an example GRF near RM 205). The structures would tie into the abandoned upper floodplain with structural keys to prevent the river from flanking the structure. The apron's riprap material would increase the roughness of the river at these sections. Two case scenarios of the GRFs will be evaluated with hydraulic modeling: 1) right after construction (assuming no sedimentation), and 2) assuming anticipated equilibrium slope upstream has been achieved (following sedimentation).

Figure 30: Example of a GRF near RM 205

In 1998, for a similar structure on Pueblo of Santa Ana lands, a GRF was estimated to cost $1.6 million, which in 2020 dollars is $2.6 million. The GRFs for this project would likely have more robust structural keys than at Santa Ana due to the lessons learned from that project. It can be assumed that each GRF would be in the ballpark of $2.5–3 million, for a total of $10–12 million for all four GRFs. The GRFs are assumed to last fifty years with an anticipated total adaptive management cost of $800,000 during that time.

4.2.2 Bed Control

Additional incision is anticipated in this reach until an armor layer is formed on the river bed. This alternative would place deformable riffles, rock sills, or riprap grade control to prevent further incision throughout the reach. These bed control options would be placed at the same slope as the existing bed.

These bed control options can prevent scour and bed degradation from progressing upstream by launching riprap into the knickpoint as seen in Figure 31. These bed control options also prevent degradation from sediment transport imbalances from progressing downstream (such as the incision that has progressed downstream from Cochiti dam) by stabilizing the steepened sections as seen in Figure 32, and by reducing sediment transport immediately upstream of the feature similar to GRFs (see Figure 29).

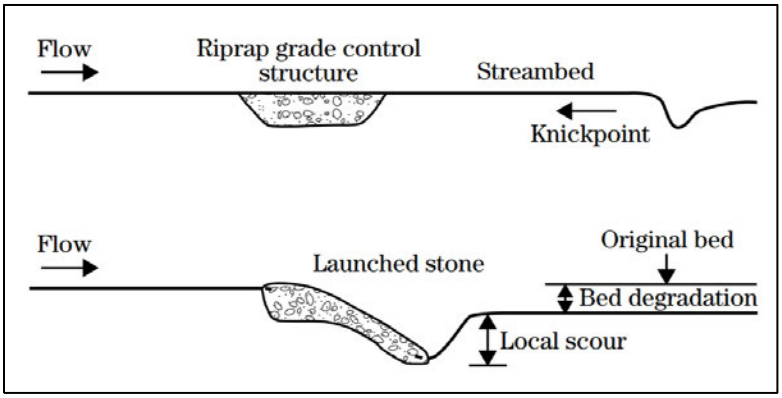


Figure 31: Typical riprap grade control structure (NRCS, 2007b)

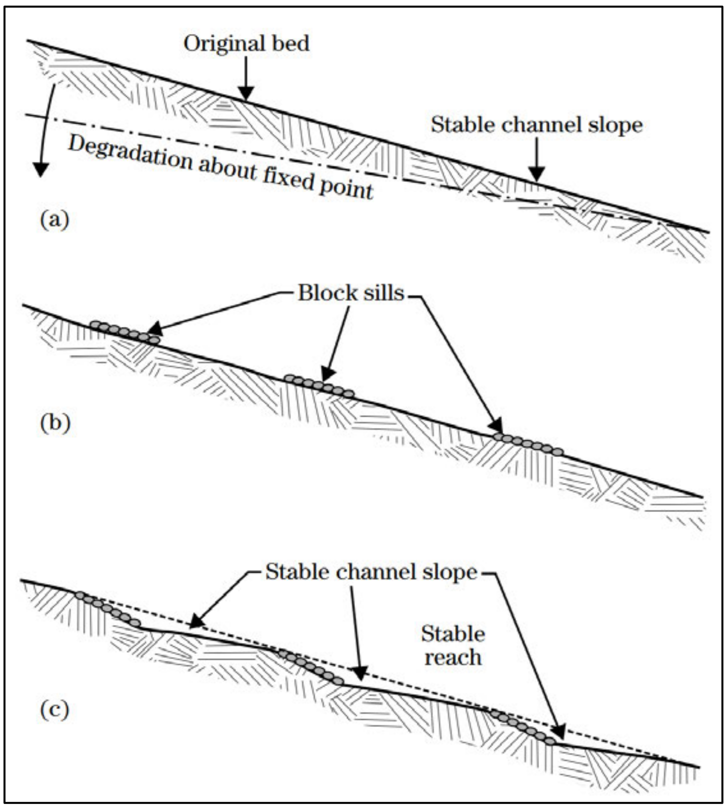


Figure 32: Typical rock sills structure (NRCS, 2007b)

The number of bed control structures needed in this subreach is based on Biedenharn and Hubbard's (2001) guidance.

- Deformable riffles would consist of a rock-filled trench spanning the river. The rock would be sized to move during the 5- to 10-year flood. There would be eight one-foot-tall (above the existing river bed elevation) riffles throughout the reach and each riffle would extend downstream 20 feet (subject to change based on design calculations).
- Rock sills would be rock spanning the river, placed directly on the streambed, with larger rock designed to resist movement or further bed incision. There would be eight one-foot tall sills throughout the reach and each sill would extend downstream 10 feet (subject to change

based on design calculations). Rock sills would be keyed into the banks to prevent bank erosion from flanking the feature.

- Riprap grade control would place larger rock designed to resist movement in a trench spanning the river, and the rock volume would be designed to launch in the event of scour or headcutting. There would be four 2-foot-deep riprap grade control trenches throughout the reach and each trench would extend downstream 10 feet (subject to change based on design calculations). Riprap grade control would be keyed into the banks to prevent bank erosion from flanking the feature.

Advantages of the deformable riffle is that it can supplement the current sediment regime with some additional bedload. The bed sill has the advantage of sitting on the streambed so no diversion channel and dewatering is required, unlike the options that are placed in trenches. However, sitting on the streambed also means that the rock will have to be sized even larger since the rock is protruding into the flow. The riprap grade control structures have the advantage of being the sturdiest against large flows and thus having the longest life. In a rapidly changing reach, a structure appropriate for the current river conditions might not be appropriate in future river conditions, and thus a structure with a long life (and its additional costs) is not necessary.

The cost of this alternative would vary based on option implemented (see Table 9; for full cost estimate see Appendix B). The majority of the cost of bed control is the temporary diversion channels required to install the bed control features. If the Cutoff Channels alternative is selected concurrently with the Bed Control Alternative, the bed control feature can be constructed while the cutoff channels diversion channel is in place, sharing that cost feature. Rock Sills can be constructed without a diversion channel since the rock is placed directly on the streambed instead of in a trench.

A large part of the cost are the long riprap keys required to prevent flanking in a rapidly changing reach. Deformable riffles don't require riprap keys since they are intended to deform over time, and thus they are the cheapest of the options, assuming they are built concurrently with the Cutoff Channels alternative.

Table 9: Cost estimate for bed control features (full cost estimate in Appendix B)

Feature	Cost for 1 Feature	Recommended # of Features	Total Cost
Deformable Riffle - with diversion channel	$143,217	8	$1.1 mil
Deformable Riffle – w/o diversion channel*	$27,040	8	$216,320
Rock Sill	$58,741	8	$469,926
Riprap Grade Control - with diversion channel	$206,917	4	$827,667
Riprap Grade Control – w/o diversion channel*	$84,240	4	$336,960

*If the Cutoff Channels alternative is concurrently selected, the bed control will be constructed while the Cutoff Channels' diversion channel is in place

4.2.3 Cutoff Channels

This alternative would raise the river bed by one to three feet and widen the active channel by roughly 90 feet. This would be accomplished by creating a cutoff channel through each meander's inner bend, and placing the excavated materials in the main channel to raise the main channel (see Figure 33 for a conceptual plan view of these components). The cutoff channel would be excavated such that it would flow year-round. The purpose of this alternative is to increase floodplain connection, reduce incision, reduce outer bank erosion, and improve habitat. These goals are achieved by widening the river's flow area to slow velocities and decrease depths. Also, the cutoff geometry would attempt to disrupt the meandering flow path to further decrease outer bend bank erosion.

For this alternative evaluation, cutoff channels would be built at all five inner bends from Corrales Siphon to the RM 198 bend. Each cutoff channel would be built one at a time, from downstream to upstream. The cut material from each channel will be temporarily stockpiled until the cutoff channel is finished. Then the entire river will be temporarily diverted into the cutoff channel alignment with a temporary cofferdam near the upstream inlet of the cutoff channel. Then the excavated cutoff channel spoil materials will be moved into the existing channel along the outer bank and used to raise the existing channel bed. Then the temporary cofferdam diversion would be removed, and the river would be allowed to split flows between the existing river channel and the new cutoff channel.

Figure 33: Cutoff channel alternative components, zooming in on the three upper bends to better demonstrate details

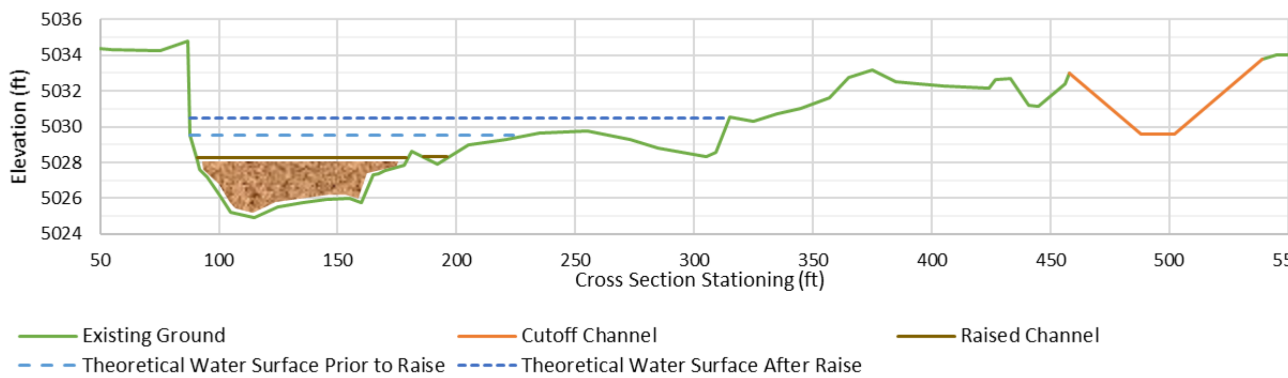


Figure 34: Example of the raised channel and raised WSE that would occur from placement of the cutoff channel's spoils in the main channel

The cutoff channel width would be finalized in the design phase based on competing needs of maximizing desired hydraulic conditions, optimizing longevity, and providing RGSM habitat. For conceptual designs, the cutoff channel's width is 90 feet wide. This width was selected because the recommended design width for this stretch of river is 265 feet (see Appendix B), and the existing average active channel width is 175 feet. Adding a 90-foot-wide cutoff channel will widen the top width for the total flow area (main channel plus cutoff channel) to the recommended design width. Immediately after construction it is anticipated that around two thirds of the flow will go through the main channel and one third of the flow will go through the cutoff channels. The side slopes would be 4:1, which is based on typical Reclamation's MRG habitat restoration projects, designed to provide good habitat for the RGSM. The channels' longitudinal slopes would follow existing topography. The cutoff channel dimensions will be able to accommodate the baseflow during construction which is anticipated to be between 500 and 1,000 cfs (the cutoff channels can hold approximately 1,300 cfs).

This alternative with five cutoff channels is estimated to cost $1.2 million (see Table 10). In the past, Socorro Field Division has constructed rock cofferdams with riprap and some fill material, and this method is anticipated to be used for the Cutoff Channels alternative. Dewatering will not be necessary as the fill in the existing channels can be placed in the active channel outer bank areas or "wet" areas after fish rescue.

Table 10: Cost estimate for cutoff channels alternative

Cutoff Channels Alternative	Unit	Quantity	Unit Price	Cost
New channels - clearing and grubbing	acres	27	$1,000	$27,000
New channel excavation & existing channel fill	cubic yard	110,000	$7	$770,000
Existing channels - rock cofferdam	cubic yard	1,400	$110	$154,000
			Subtotal	$951,000
Mob/Demob	%	3		$28,530
Site Staking/Survey	%	2		$19,020
Contingency	%	25		$237,750
			Total Cost	$1,236,300

The cutoff channel represents stage M7 in Massong's 2010 planform evolution model (see Figure 35). In a reach with excess transport capacity, a migrating bend channel (stage M6) evolves into a migrating channel with cutoff channel (stage M7). According to Massong's model, the RM 199 subreach is currently a stage M6 channel. With the addition of cutoff channels, the river would be assisted in converting to stage M7. It is uncertain if some time after construction the river would convert back to a stage M6 through sedimentation in the cutoff channels, or if it would progress forward into a stage M8 with the preferential flow path being the cutoff channels (contingency planning for this scenario is provided in Section 6.3).

Given this uncertainty in this alternative's planform adjustment to either stage M8 or back to the current M6 stage, this type of project would be considered a pilot-project. In addition, the ability of the river to remain in the form of a cutoff channel remaining in stage M7 or M8 is also an unknown. Therefore, the design life and the future need for adaptive management to realize the project's objective of being a long-term cutoff channel are also uncertain compared to other river realignment or partial realignment methods employed elsewhere (e.g. Sandia Pueblo Bendway Weirs and Bosque Del Apache Realignment). The use of cutoff channels to widen the river, disrupt meander flows along the outer bank, and split flows is a new method on the Middle Rio Grande; therefore, this alternative is designated as a pilot-project or experimental.

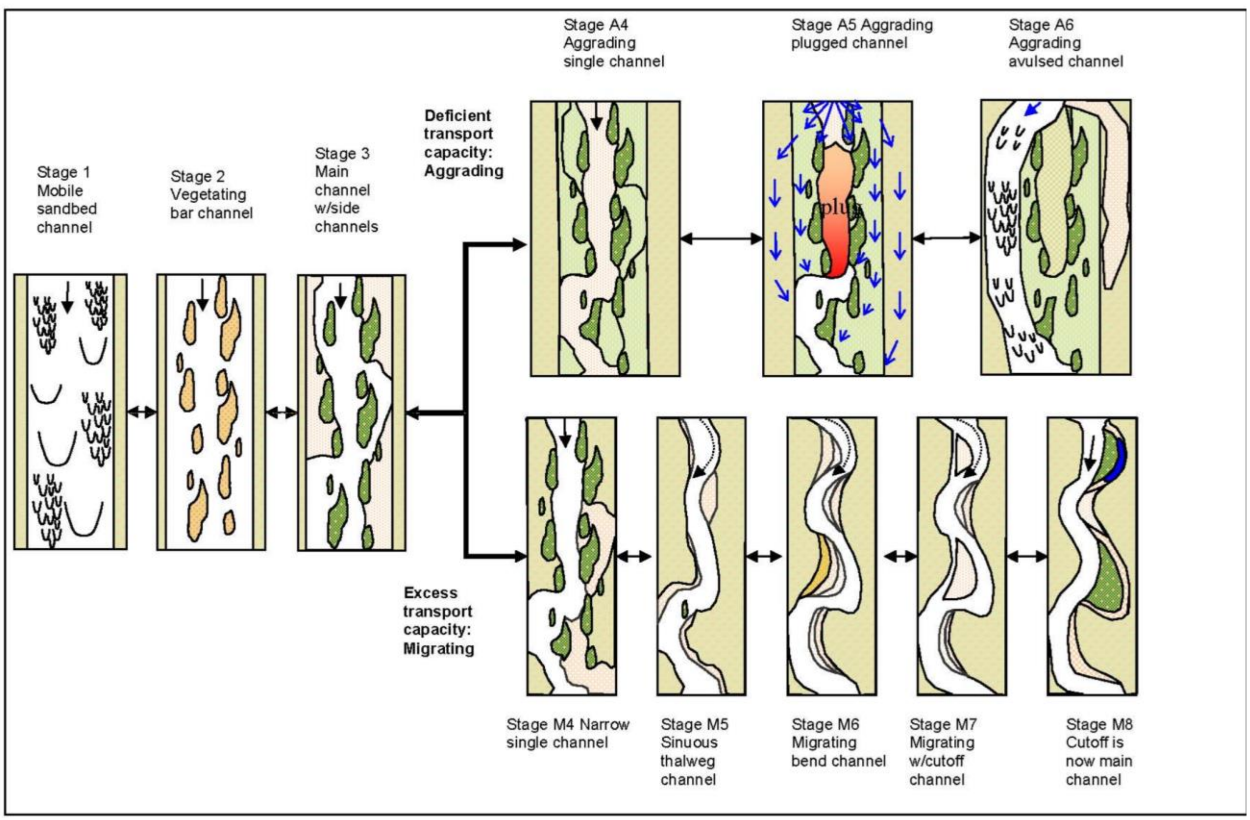


Figure 35: Middle Rio Grande planform cycle model (Massong et al., 2010)

By introducing cutoff channels at existing bend locations, the river will be widened with split flows going down the cutoff channel and the existing channel. Flows are expected to slow down and possibly settle out deposits in the widened areas. The areas of greatest deposition are expected to be at the cutoff channel inlet where the channel first widens, and at the cutoff channel outlet just before the channel returns to the existing channel and a narrower form. It is estimated that this alternative will last around five to ten years and possibly longer, based on analysis of the MERES HR side channels located within the RM 199 project boundaries. At that site, the high-flow side channels experienced zero to one feet of deposition over a 10-year period (although measurements were not taken at the entrances and exits of the side channels, which are typically the areas of highest deposition). During this same period, the main channel incised 1–4.5 feet, somewhat disconnecting the side channels from the main channel flow.

4.2.4 Limited Side Channels

This alternative would create traditional side channels through each of the meander's inner bends. The purpose of this alternative is to reduce incision, reduce bank erosion, and improve habitat by widening the river's flow area to slow velocities and decrease depths.

The dimensions of the side channels would be limited by the availability of opportunities to spoil the excavated material. As discussed in Section 2.5.10 (Spoil Material Opportunities), the eastern side could reasonably accept 39,000 cubic yards of excavated material against the levee while the western side could reasonably spoil 10,000 to 15,000 cubic yards of excavated material to the river. The side slopes would be 4:1, which is based on typical Reclamation's MRG habitat restoration projects, designed to provide good habitat for the RGSM.

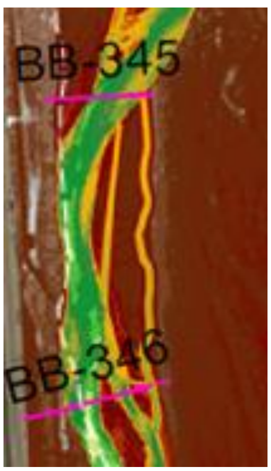


Figure 36: Topography map showing example design of limited side channels (orange) on the RM 199 point bar (red)

Since the dimensions of the side channels are limited by spoil material opportunities, the increase in flow area is less than the cutoff channels alternative's increase in flow area. The limited side channels will have greater hydraulic diversity than the cutoff channels with multiple threads and varying inundation rates. The cutoff channels are intended to inundate year-round, while the limited side channels would inundate at medium and high flows. The limited side channels are also anticipated to last approximately five to ten years (see Section 4.2.3 for information on this determination).

This alternative is estimated to excavate approximately 51,000 cubic yards of material and spoil the material to nearby locations. The cost of this alternative is approximately $480,000 (see Table 11).

Table 11: Cost estimate for limited side channels alternative

Limited Side Channels Alternative	Unit	Quantity	Unit Price	Cost
Side channels - clearing and grubbing	acres	12	$1,000	$12,000
Side channels excavation and spoiling	cubic yard	51,000	$7	$357,000
			Subtotal	$369,000
Mob/Demob	%	3		$11,070
Site Staking/Survey	%	2		$7,380
Contingency	%	25		$92,250
			Total Cost	$479,700

4.2.5 Vegetation Destabilization

This alternative would root-plow point bar vegetation in the early spring during a higher snowpack winter, so that the high runoff could destabilize and rework the channel in those areas. The areas for destabilization would be selected by a multi-disciplinary team based on biological factors such as presence of exotics and diversifying the vegetation age classes and based on engineering factors such as hydraulics and bank stability.

A best-case scenario would result in the root-raked areas being scoured down to a more easily accessible elevation for future flood flows. The ground elevation would have to be low enough that a high flow year would have deep enough flows in that area to scour away the material.

For cost estimate purposes, it is assumed that 11 acres of vegetation will be root plowed, based on an initial selection of bank destabilization areas including a 2-acre area across from the Corrales Siphon outer bend (within the MERES site), a 3-acre area across from the BB-343 outer bend, and a 6-acre area of Russian Olives across from the RM 199 outer bend.

Table 12: Cost estimate for the vegetation destabilization alternative

Vegetation Destabilization Alternative	Unit	Quantity	Unit Price	Cost
Vegetation mastication and root-plow	acres	11	$1,500	$16,500
			Subtotal	$16,500
Mob/Demob	%	3		$495
Site Staking/Survey	%	2		$330
Contingency	%	25		$4,125
			Total Cost	$21,450

4.2.6 No-action Alternative

The no-action alternative is also being included for comparison purposes. With no action, the river is anticipated to continue widening its meander belt width and possibly continue incising/disconnecting from the floodplain (while simultaneously building new floodplain on the meanders' inner point bars).

To predict outcomes of the no-action alternative, past erosion rates, bend apex movements, and point bar formations were analyzed at both the RM 199 area and upstream at the nearby Sandia Bendway weir site and then projected into the future. Sections 9.2.5 and 9.2.6 in Appendix B shows some of the data used in this analysis. The highest total bankline erosion was 160 feet at BB-343, and the highest bend apex movement was 574 feet in the downstream direction at BB-343 for the time period between 2013 and 2020. The downstream portions of the Corrales Siphon bend and the RM 199 bend showed no significant change, as well as the CO-33 bend. It is worth noting that nearby at the Sandia Bendway Weir Site the four bends experienced 42 to 219 feet of bankline erosion between 2013 and 2020.

This bend movement analysis was used to predict a planform for year 2030 (shown in Figure 37). However, it should be noted that as seen in the past in this reach, some areas may unexpectedly start eroding while other stop eroding, so the level of certainty in future planform predictions is very low. To model this no-action alternative in HEC-RAS, the current geometry of the river (October 2019 LiDAR and bathymetry data) was used since the predicted future terrain has low certainty.

In 2018, Reclamation's Technical Service Center (TSC) used an SRH-1D sediment model with dry, average, and wet hydrologic scenarios to predict that between 2012 and 2032 the channel bed elevation will likely be relatively stable in the RM 199 project area. The model predicted localized changes between 1.5 feet of degradation and 1.5 feet of aggradation in the project area, with a net change for the subreach of 0 to 0.5 feet of aggradation (Varyu, 2018). Despite these modeling results, it is likely there will be some additional incision in this reach considering that the bed is not fully armored (see Section 2.4.5).

While this alternative has no immediate cost, the future costs may include additional bank stabilization locations and additional excavation costs to lower abandoned terraces to floodplain levels.

Figure 37: Predicted planform for year 2030 based on erosion rate and direction between 2013 and 2020

4.3 Modeling Effort

Hydraulic models were built for the four alternatives (GRFs, Cutoff Channels, Limited Side Channels, and No-Action) to evaluate the effects different actions would have on the channel hydraulics. Two-dimensional HEC-RAS was used to build the four models using October 2019 LiDAR and bathymetry data (River Restoration, 2019). The total length of about 2 miles of the reach modeled was consistent between all models, spanning from immediately upstream of Arroyo de la Barranca down to immediately below CR-361/RM 197.5. The modeling mesh size of 75 x 75 feet (in total 3084 cells) over an area of about 344 acres was used. An unsteady flow data was used for upstream boundary conditions while normal depth with a slope of 0.0009 derived from the terrain was used for downstream boundary condition for all models, so that the only difference between the four models was the terrain geometry and manning's boundary roughness values. In ArcGIS, the current terrain was modified to simulate the following four model alternative scenarios. A more complete description of these alternatives is provided in Section 4.2 Description of Alternatives.

1. No-Change alternative (current terrain) – no changes were made to the October 2019 LiDAR and underwater bathymetry data so that a baseline could be established.
2. GRFs – Starting with the current terrain, four GRFs approximately two to three feet tall each were added throughout the project area. The rock ramp downstream from the GRF was sloped to existing grade over approximately 500 feet for a resulting slope around 0.004 (more or less to fit each unique location). For the scenario that assumed sedimentation as described in Section 4.2, the river upstream of the GRFs was raised to be level from the GRF upstream to the existing channel bed to closely match Figure 29. Figure 40 shows a plan view of the model.
3. Cutoff Channels – Starting with the current terrain, channels were created to cutoff each of the existing meander bends, and the existing channel was raised 1–3 feet to an approximately equal elevation as the cutoff channels to balance cut and fill volumes. The channels were designed to be approximately 90 feet wide with a 14-foot base width and a 4:1 side slope. The width was based on a design channel width analysis shown in Appendix B. The side slopes are based on typical Reclamation's MRG habitat restoration projects, designed to provide good habitat for the RGSM. The channels' longitudinal slopes follow existing topography as shown in Figure 41.
4. Limited Side Channels – Starting with the current terrain, side channels of varying width and inundation levels were created in each of the existing meander bends. The side channel depths and widths were limited by the spoil volumes that may be reasonably disposed of on Pueblo land and in the river. Figure 42 shows a plan view of the model.

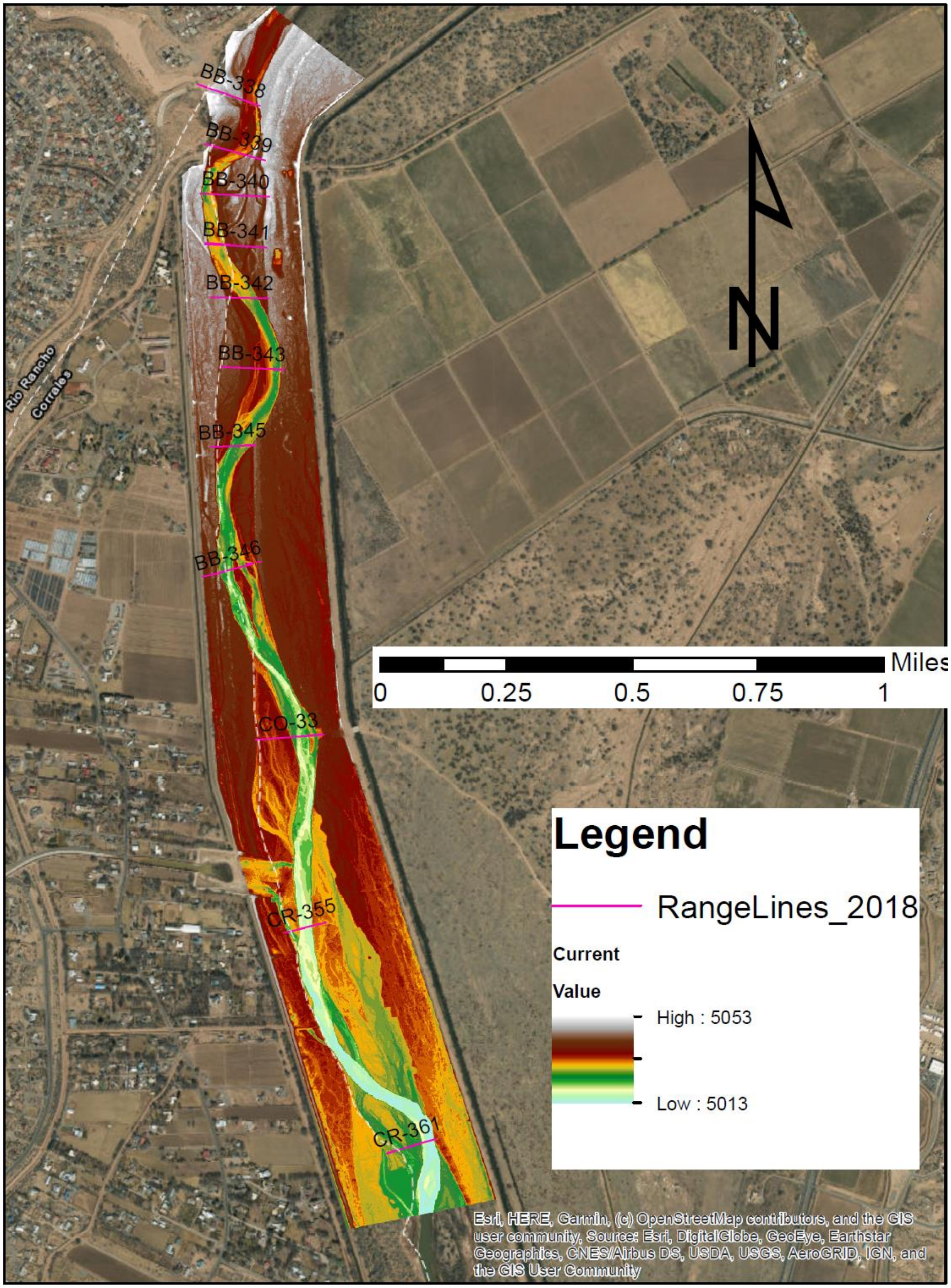


Figure 38: Digital Elevation Model of current topography

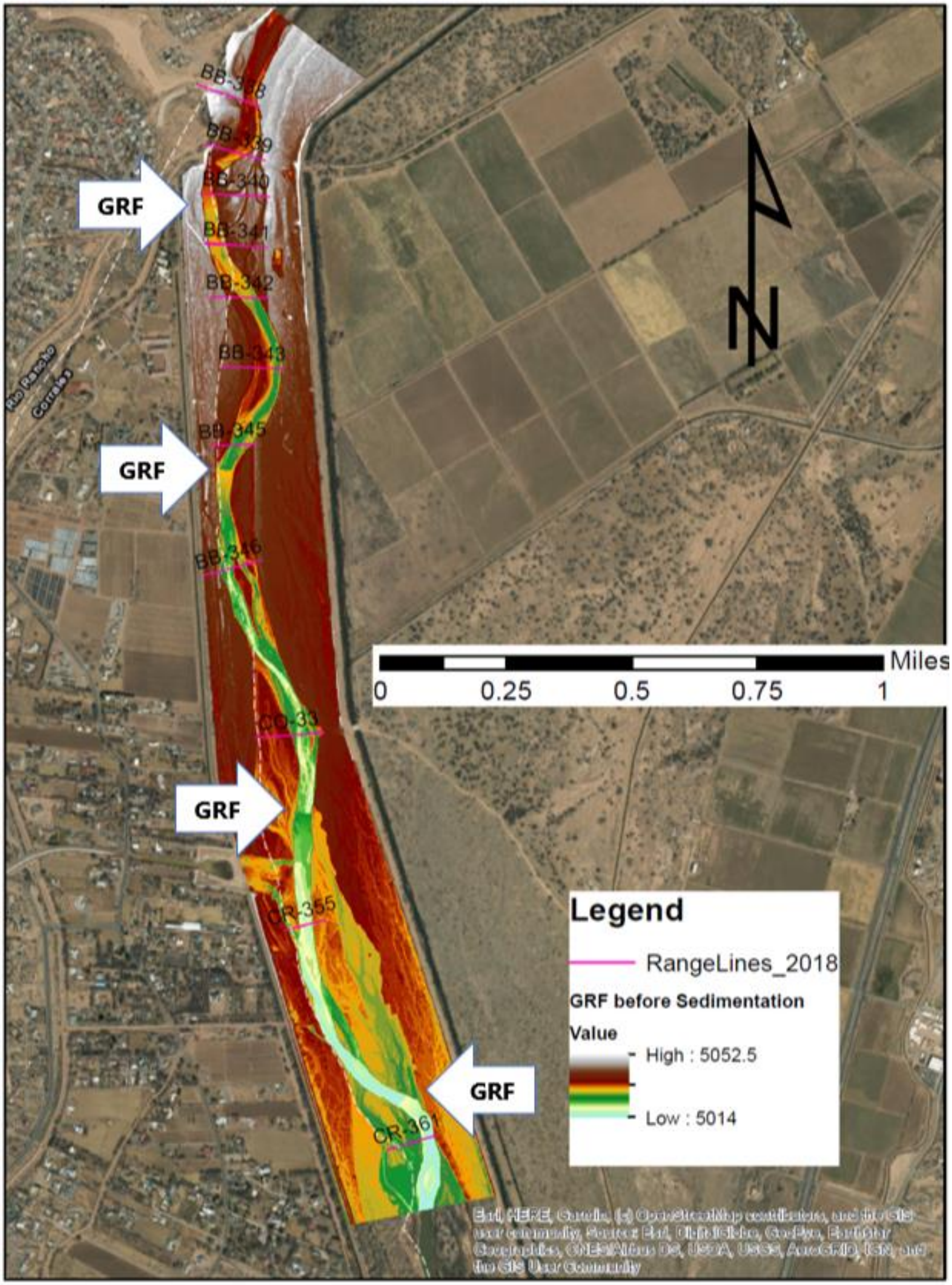


Figure 39: Digital Elevation Model of GRF before sedimentation alternative

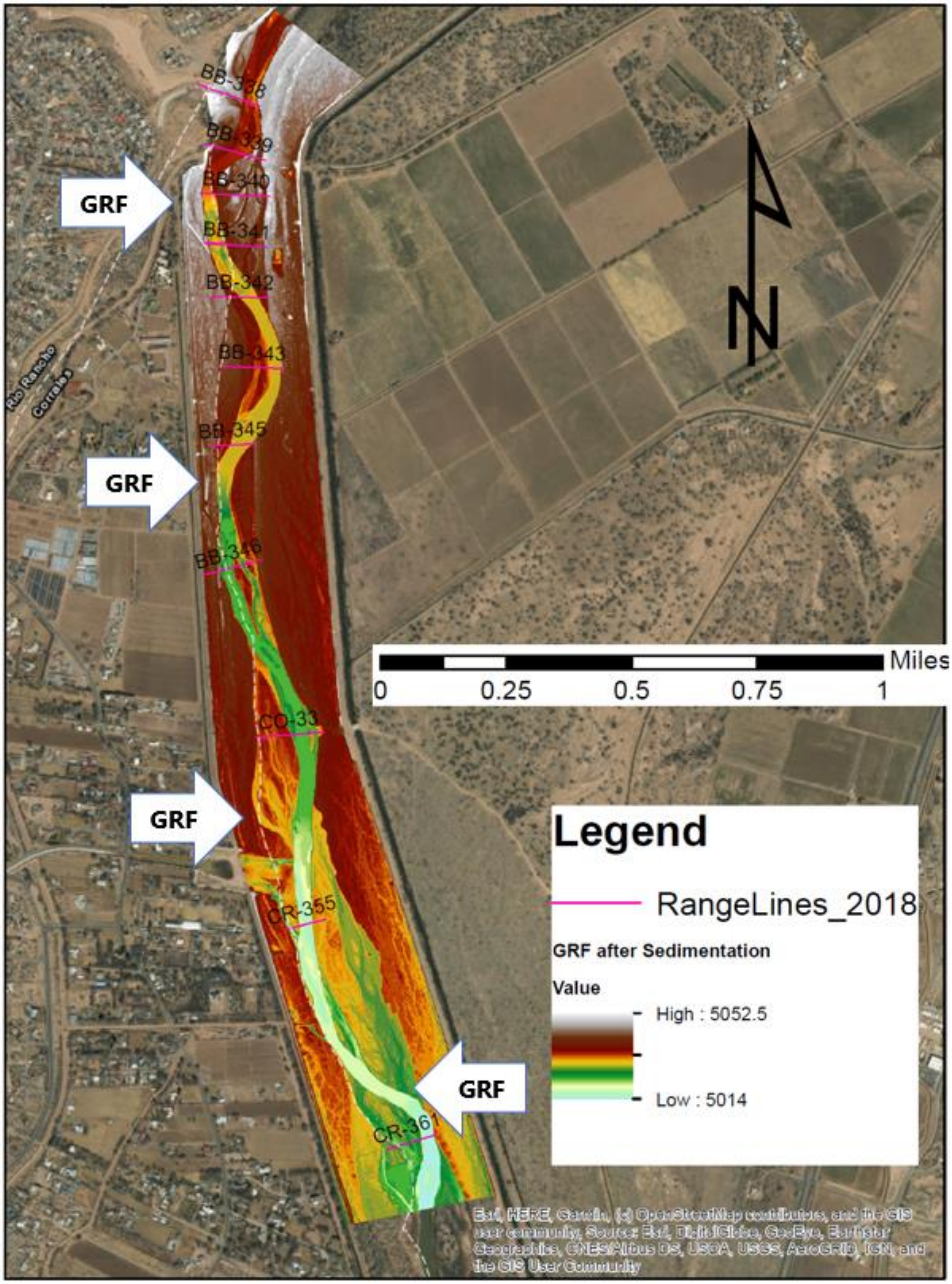


Figure 40: Digital Elevation Model of GRF after sedimentation alternative

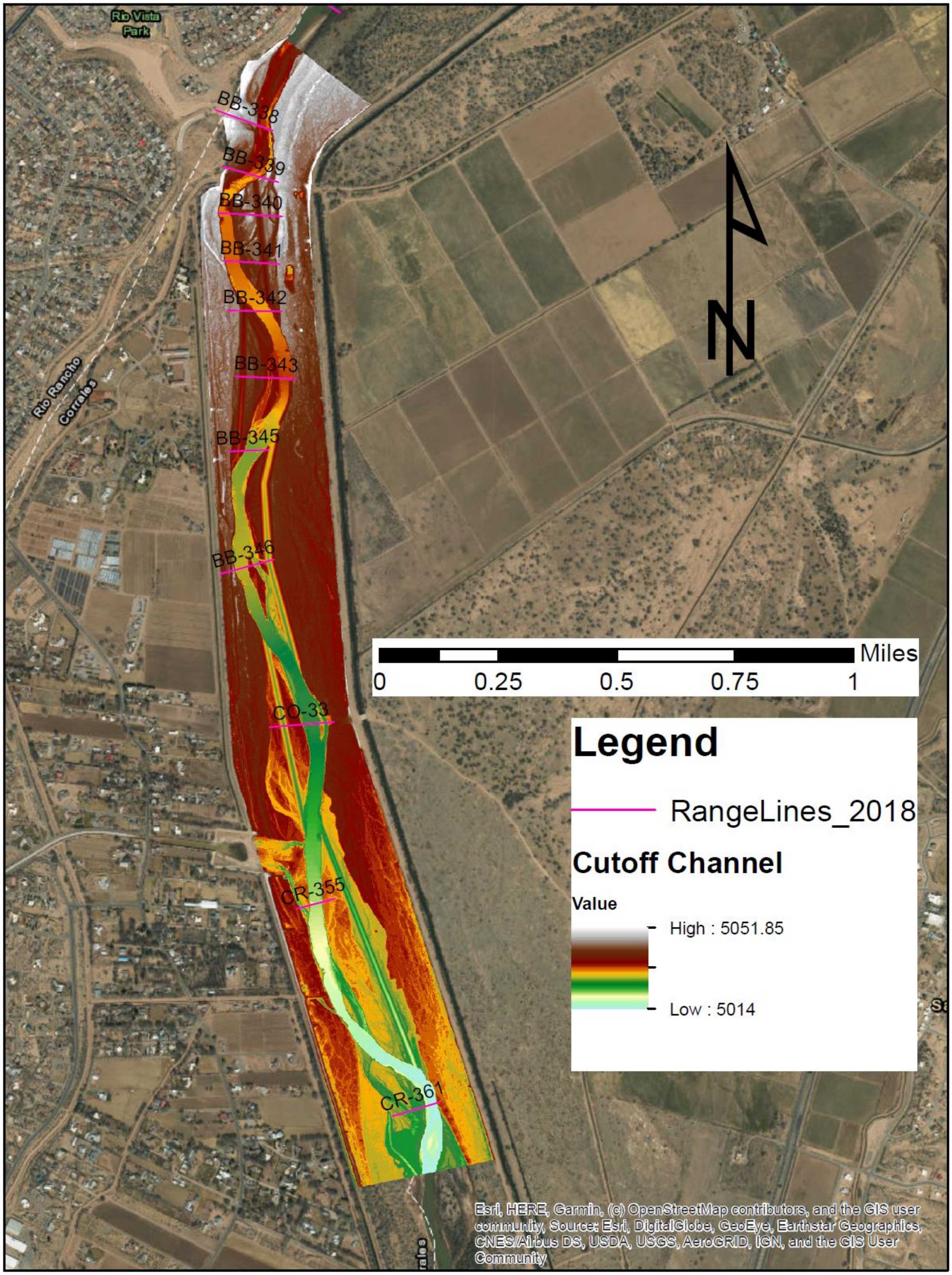


Figure 41: Digital Elevation Model of Cutoff Channels at each of the five point bars

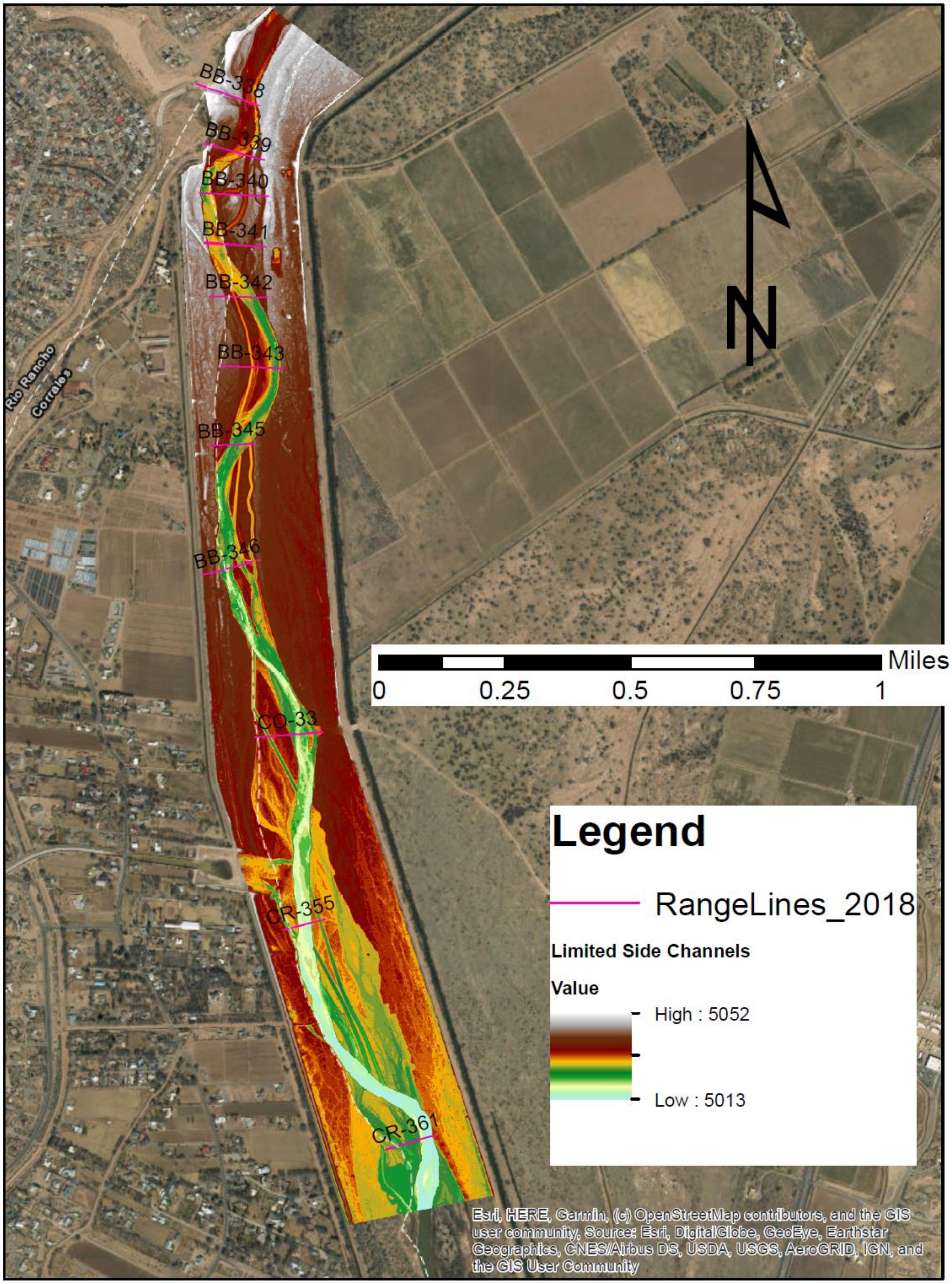


Figure 42: Digital Elevation Model of Limited Side Channels at each of the five point bars

4.3.1 Manning's n Calibration

The current terrain was used for the calibration of the model channel roughness. Since Manning's n values change based on the magnitude of flow, a single Manning's channel n value was assessed for the entire model for two discharge scenarios: one value was determined for flows < 4,000 cfs and one value was determined for flows > 4,000 cfs. The goal of the calibration was to provide a best fit between the model's computed water surface elevation and the observed water surface elevation at established rangeline locations. Profile lines drawn in HEC-RAS mapper at the locations of the established rangelines were used to show the modeled water surface elevations. The channel Manning's n value for the current terrain model was then adjusted until the root mean square error (RMSE) as defined in Equation 1 of the water surface elevations (WSEL) was minimized.

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(WSEL_{i-model} - WSEL_{i-measured})^2} \quad \text{Equation 1 (ASPRS, 2015).}$$

Where RMSE = the root mean square error,

n = the number of analyzed cross sections,

i = the i^{th} location of the analyzed cross sections,

$WSEL_{i\text{-model}}$ = the HEC-RAS modeled water surface elevation (NAVD88 datum, feet) at the i^{th} location, and

$WSEL_{i\text{-measured}}$ = the field measured water surface elevation (NAVD88 datum, feet) at the i^{th} location.

For high flows (>4, 000 cfs), water surface elevation data was collected for four rangelines in the study reach on May 24, 2019 while for low flows (<4,000 cfs) the water surface elevations were collected on 11 rangelines on 16–18 December 2019. The corresponding flow data on these dates was pulled from USGS gage 08329918 "Rio Grande at Alameda Bridge, NM." This gage was selected because it is located immediately downstream of the study reach. The flow data is shown in Table 13. The flows for each of the dates were entered as a hydrograph in the unsteady file of HEC-RAS. For each of the flows, the 2D models were run for 4–8 hours until a 'dynamic steady state', when the WSE at the observation profiles was not changing, was reached. The resulting channel manning's n was 0.027 for low flows and 0.023 for high flows. The overbank or floodplain roughness was assumed to be 0.12 (Chow, 1959).

Using these Manning's n values, the four models underwent an unsteady flow run for various flows between 100 cfs to 10,000 cfs with appropriate ramping but making sure to include 500, 2,000, and 4,000 cfs with each discharge level held until dynamic steady state was reached before increasing to the next higher discharge. A 5-second time step was used, and these three discharges were held for a minimum of 4 hours in order to achieve the dynamic steady state. The models were analyzed for the creation of habitat, impact on bed and bank stability, and impact on flood levels.

Table 13: Flow data used for model calibration

Rangeline	Date of Survey for low flow	Low flow Discharge (cfs)	Date of Survey for high flow	High flow Discharge (cfs)
BB-338	December 16, 2019	834		
BB-339	December 16, 2019	834	May 24, 2019	4,550
BB-340	December 17, 2019	832		
BB-341	December 17, 2019	832		
BB-342	December 17, 2019	832	May 24, 2019	4,550
BB-343	December 17, 2019	832		
BB-345	December 17, 2019	832	May 24, 2019	4,550
BB-346	December 18, 2019	819		
CO-33	December 18, 2019	819	May 24, 2019	4,550
CR-355	December 18, 2019	819		
CR-361	December 18, 2019	819		

4.3.2 Habitat Creation

The same method for evaluating habitat creation was used for each of the four alternatives. In previous Reclamation projects, three categories have been used to define Rio Grande Silvery Minnow (RGSM) habitat: ideal habitat, suitable habitat, and unsuitable habitat. These category definitions were verified in a conversation with Eric Gonzales on 6/29/2017. They are defined in the bullets below and in Table 14.

- Ideal Habitat meets the depth and velocity criteria identified by Bachus and Gonzales (2017)
- Suitable Habitat meets only the velocity criteria
- Unsuitable Habitat meets neither the depth nor velocity criteria

Table 14: Ideal, Suitable, and Unsuitable RGSM Habitat Depths and Velocities (Bachus et al., 2017)

	Ideal		**Suitable**	**Unsuitable**
Life Stage	*Depth*	*Velocity*	*Velocity*	
Egg/drifting Larvae	>0 and <30 cm	≥9.29 mm/s	≥9.29 mm/s	All other wetted areas
Larvae/Juvenile	5-50 cm	1-30 cm/s	1-30 cm/s	All other wetted areas
Adults	5-50 cm	1-40 cm/s	1-40 cm/s	All other wetted areas

From the 2-D HEC-RAS analysis, the results of the 500, 2,000 and 4,000 cfs depth and velocities were saved as raster files. In ArcMap 10.4.1, raster calculator was used to determine areas where ideal, suitable and unsuitable were met for each of the RGSM life stage using the definitions provided in Table 14 for each the raster files saved. The results of this analysis are shown in Table 15 to Table 17 and Figure 43 to Figure 48.

Table 15: Egg stage Habitat Acreage for all alternatives

Flow (cfs)	Current Ideal	Current Suitable	CC Ideal	CC Suitable	LSC Ideal	LSC Suitable	GRF Ideal	GRF Suitable	GRF with Sediment. Ideal	GRF with Sediment. Suitable
500	9.59	37.82	14.66	60.29	9.64	37.84	7.40	44.38	6.76	47.82
2000	4.82	50.53	11.07	79.15	5.91	54.51	5.23	55.41	5.98	60.07
4000	4.53	57.19	18.22	99.37	6.86	64.24	15.79	75.45	20.76	86.78

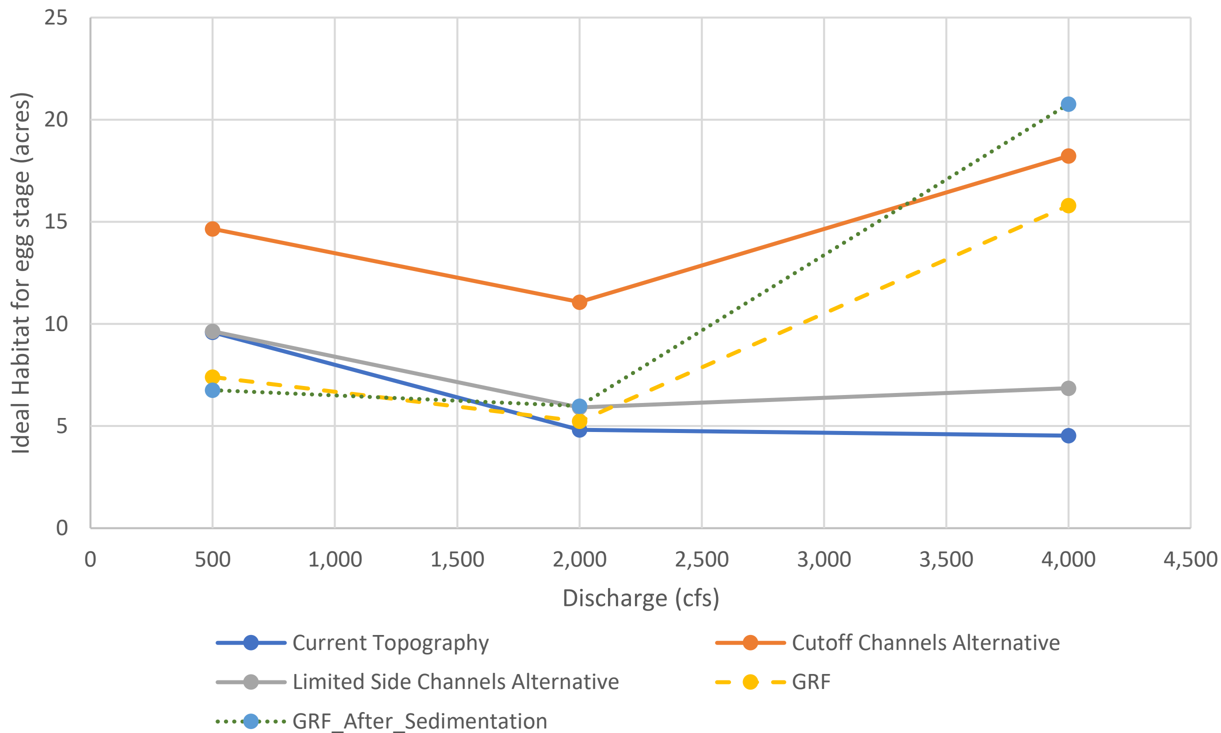


Figure 43: Ideal Habitat Acreage for egg stage

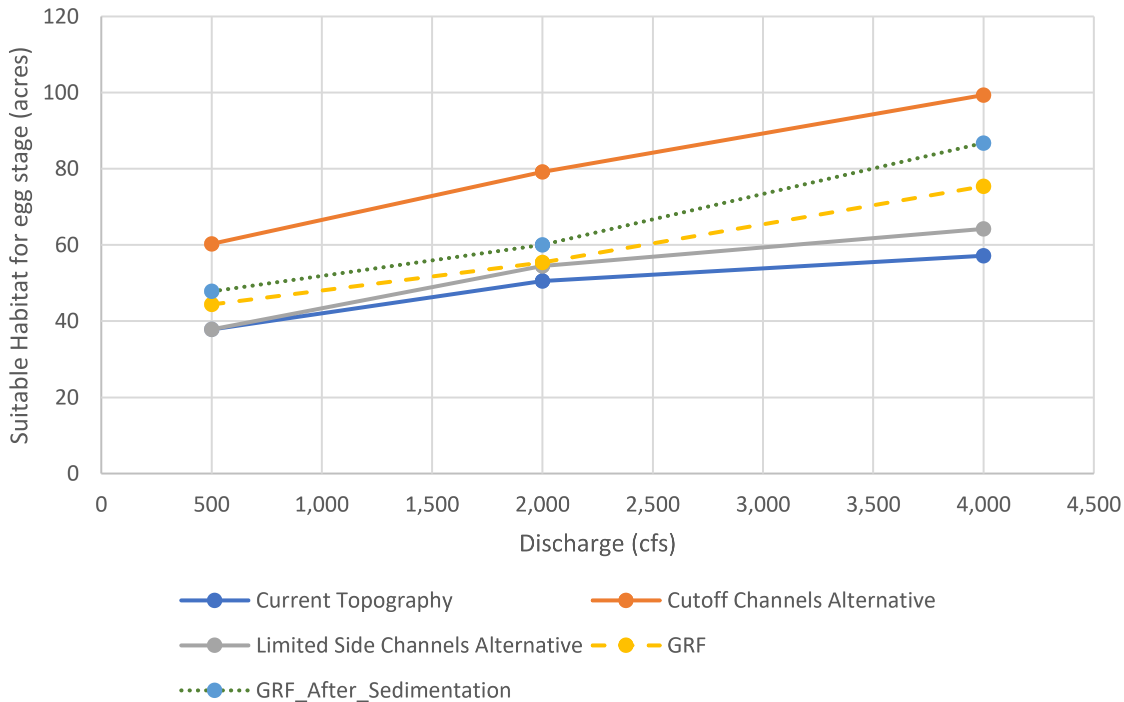


Figure 44: Suitable Habitat Acreage for egg stage

Table 16: Larvae/Juvenile stage Habitat Acreage for all alternatives

Flow (cfs)	Current Ideal	Current Suitable	CC Ideal	CC Suitable	LSC Ideal	LSC Suitable	GRF Ideal	GRF Suitable	GRF with Sediment. Ideal	GRF with Sediment. Suitable
500	1.72	2.23	10.94	15.21	1.75	2.25	4.37	10.58	4.00	7.91
2000	2.26	3.27	5.67	9.32	3.62	5.77	4.24	7.37	5.88	9.52
4000	3.13	5.60	11.33	16.01	4.50	7.10	13.15	21.46	17.79	25.98

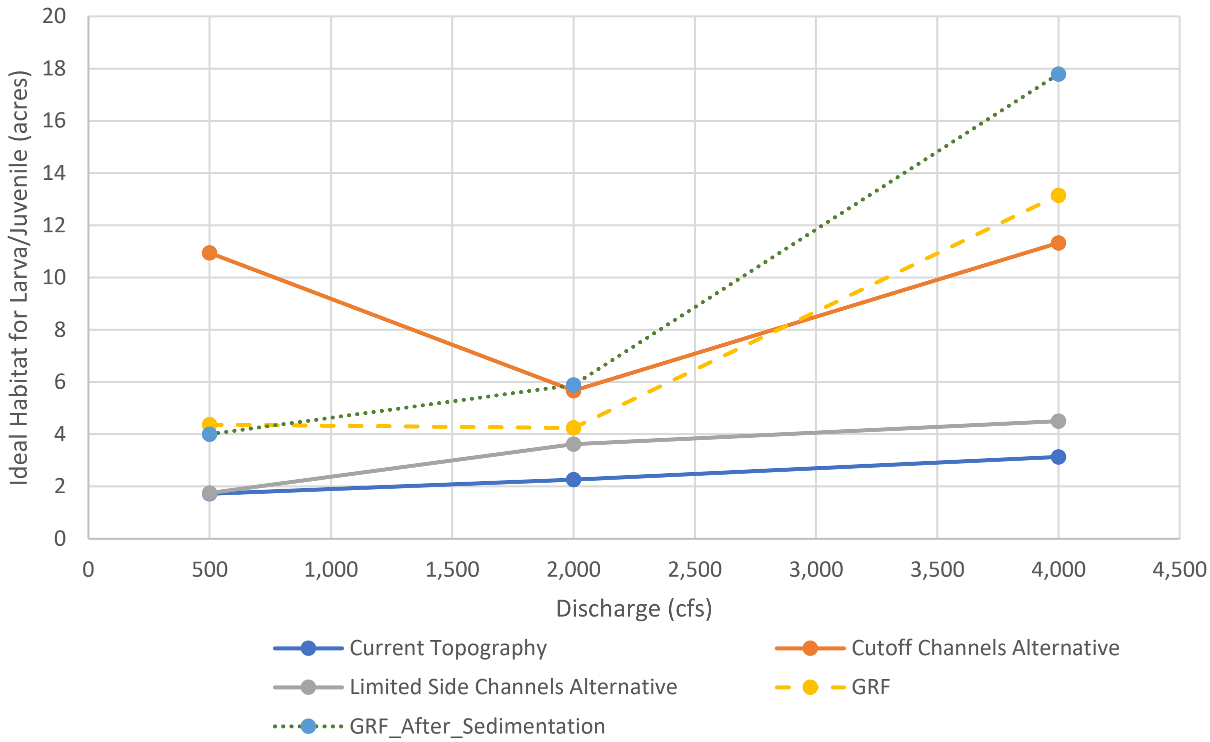


Figure 45: Ideal Habitat Acreage for Larva/Juvenile

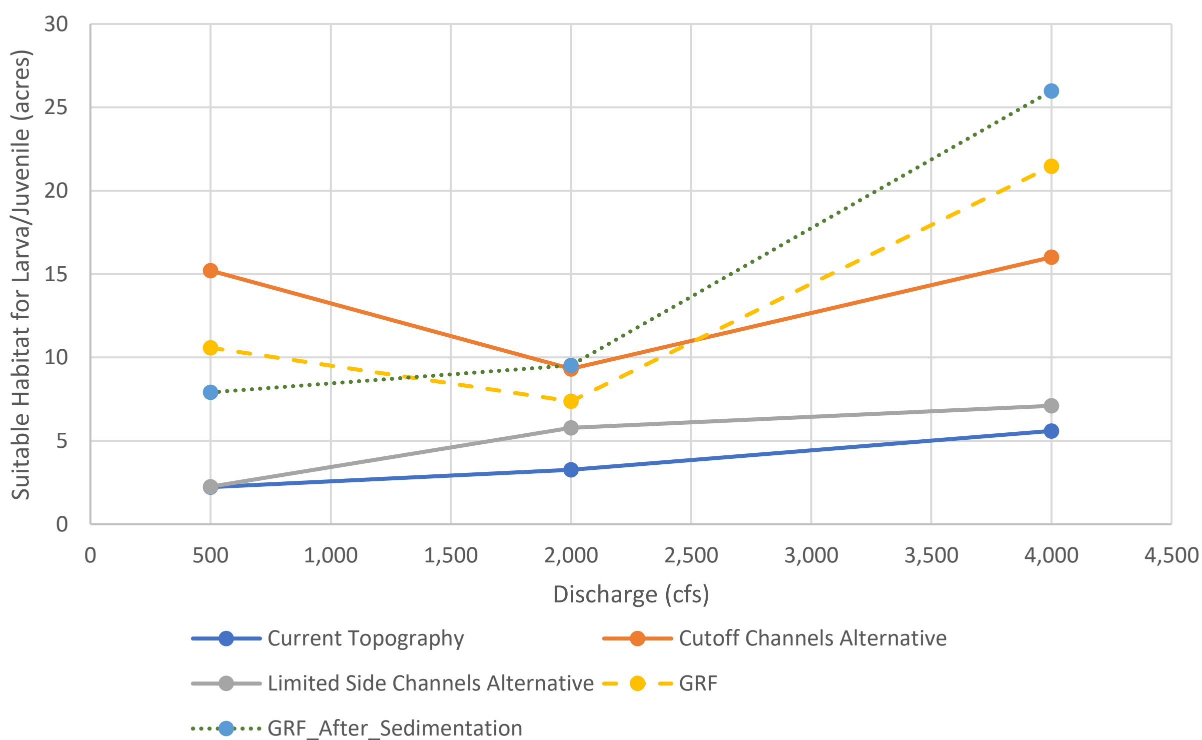


Figure 46: Suitable Habitat Acreage for Larva/Juvenile

Table 17: Adult Stage Habitat Acreage for all alternatives

Flow (cfs)	Ideal	Suitable	CC Ideal	CC Suitable	Ideal	Suitable	GRF Ideal	GRF Suitable	Ideal	Suitable
500	3.69	5.20	15.25	23.05	3.73	5.25	6.80	21.36	6.53	18.04
2000	2.88	4.43	8.56	16.56	4.85	7.61	4.92	9.25	6.46	11.98
4000	3.71	7.30	13.86	22.17	6.21	11.36	13.81	23.88	19.15	31.46

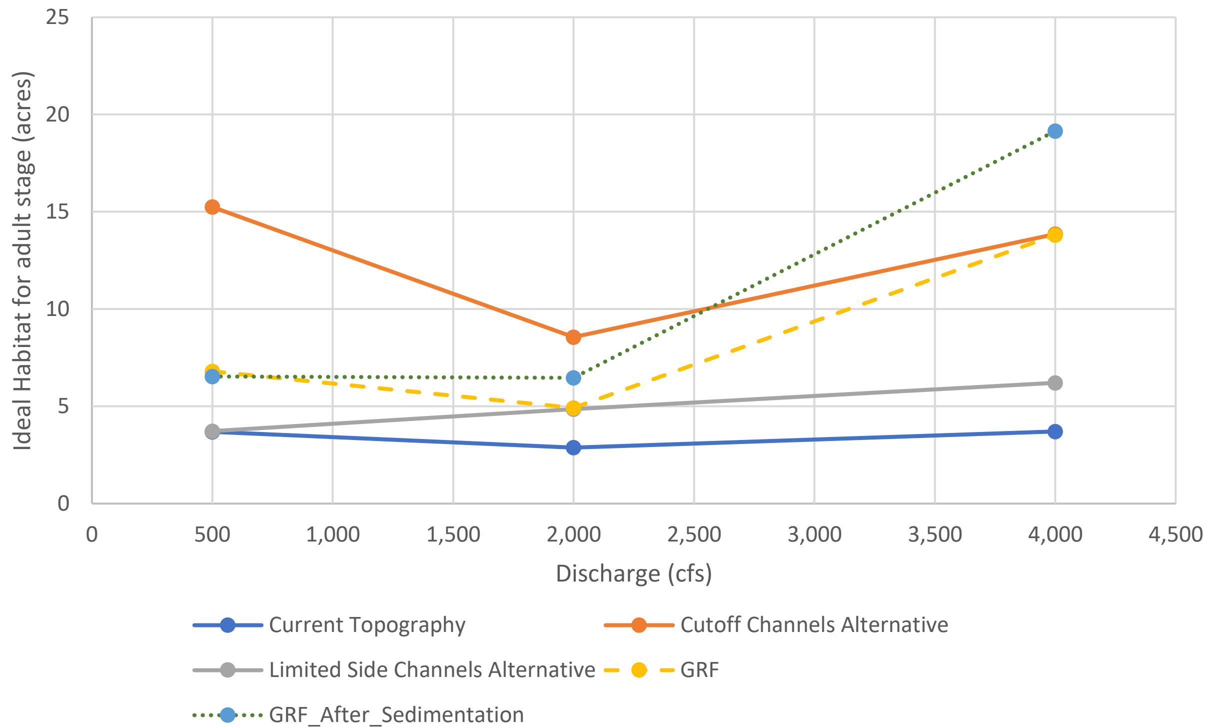


Figure 47: Ideal Habitat Acreage for adult stage

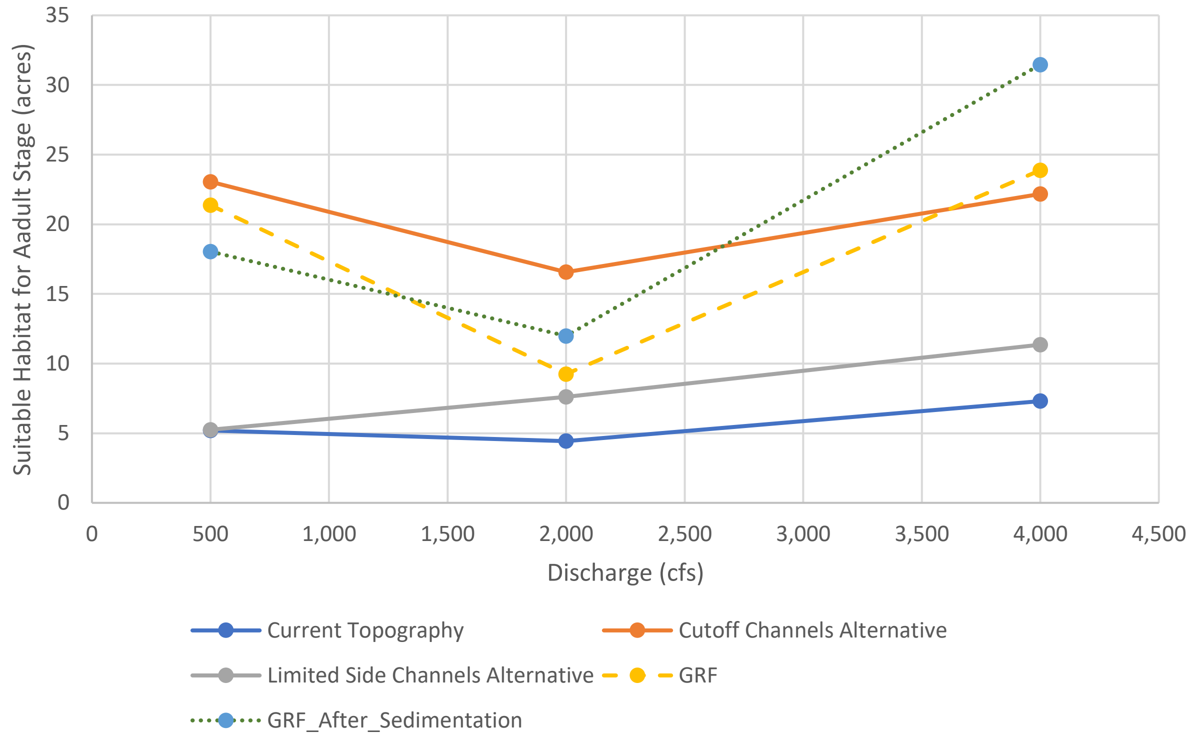


Figure 48: Suitable Habitat Acreage for Adult Stage

In all cases, the cut-off channels and the GRFs after sedimentation appears to generate most RGSM habitat at different stages and flows.

4.3.3 Bed and Bank Stability

Section 2.4 presented the geomorphic characteristics of the study reach. In summary, the reach trends include bed incision, increasing bank height, channel narrowing, lateral migration, increasing channel velocities and floodplain disconnection. The reduction in sediment load and the increased channel incision has also led to increased bed material size. The channel substrate has transitioned from sand to gravelly sand. In general, the reach has transitioned to deeper, narrower flows with increased velocities.

According to Baird et al. (2015), small width to depth ratio are not desirable for some rivers such as the Rio Grande because the low friction loss translates to larger erosive forces acting on the bed and banks of the channel. Larger width/depth ratios can help balance the available energy in the system by increasing friction loss and losses from secondary flow currents and turbulence. Therefore, alternatives selected for dissipating energy in this reach were aimed at increasing the wetted perimeter and thus increase the width/depth ratio of the river channel while ensuring reconnection with the floodplain.

Since any bank protection measures may fail due to bed stability, an assessment of bed stability is also critical for any bank stabilization project (NRCS 654.1301). The incipient movement of sediments on the riverbed is usually expressed in terms of critical shear stress derived from the Shields parameter given in Equation 2.

$$\tau_{*c} = \frac{\tau_c}{(\gamma_s - \gamma)D} \quad \text{Equation 1}$$

Where τ_{*c} = critical Shields parameter
τ_c= critical shear stress
γs = specific weight of sediment
γ = specific weight of water
D= diameter of sediment

For a fluid to begin transporting sediment that is currently at rest on a surface, the bed shear stress (τ_b) exerted by the fluid must exceed the critical shear stress, τ_c. Thus, any alternative that reduces the τ_b can reduce sediment movement especially if the τ_c is known.

The bed shear stress is calculated within HEC-RAS as shown in Equation 3.

$$\tau_b = \gamma R S_f \quad \text{Equation 2}$$

Where τ_b = bed shear stress
γ = specific weight of water
R = hydraulic radius or flow cross sectional area divided by wetted perimeter
S_f = energy slope

Stream power may also be used to evaluate the bed stability across different alternatives. Stream power is a geomorphology concept that is a measure of the available energy a stream has for moving sediment, rock, or woody material. River slope and flow rate define the level of stream power available with steeper slopes and larger flow rates imparting more energy (Leopold and Wolman, 1957).

$$\Omega = \gamma Q S_f \quad \text{Equation 3}$$

where: γ = unit weight of water (lb/ft3)
Q = discharge (ft3 /s)
S_f = energy slope (ft/ft)

For a cross section, the total stream power per unit width of channel may be formulated as:

$$\omega = \frac{\Omega}{w} \quad \text{Equation 4}$$

where: w = channel width (ft).

Unlike shear stress, stream power also incorporates the flow velocity in the computations thus the effects of changed velocity across different alternatives are also evaluated concurrently. In the main body of this report, we will use shear stress to evaluate how the different models perform in ensuring bed stability because there exists a method (Shields Diagram, 1936) that can be used to evaluate how close a method is to the initiation of particle movement. However, the results of stream power analysis at various cross sections made at the same location as the shear stress analysis are presented in Appendix C.

Bed stability analysis in the reach was performed at 4,000 cfs. Cross sections for evaluating bed stability were made in HEC-RAS mapper from left to right facing downstream at locations along the existing rangelines. The cross sections were widened beyond the rangeline to capture the full wetted width of each alternative. See Figure 49 for more details.

Shear stress results at each of these cross sections are provided in Figure 50 through Figure 60. As stated previously, bed particle movement will initiate when the bed shear stress exceeds the critical shear stress. For context, critical shear stress for particles of varying sizes are provided in Table 18.

Table 18: Critical shear stress for various particle classifications and diameters (condensed from Berenbrock and Tranmer, 2008)

Particle Classification Name	**Ranges of particle diameters (mm)**	**Critical bed shear stress (τ_c) (N/m^2)**
Coarse cobble	128–256	112–223
Fine cobble	64–128	53.8–112
Very coarse gravel	32–64	25.9–53.8
Coarse gravel	16–32	12.2–25.9
Medium gravel	8–16	5.7–12.2
Fine gravel	4–8	2.7–5.7
Very fine gravel	2–4	1.3–2.7
Very coarse sand	1–2	0.47–1.3
Coarse sand	0.5–1	0.27–0.47
Medium sand	0.25–0.5	0.194–0.27
Fine sand	0.125–0.25	0.145–0.194
Very fine sand	0.0625–0.125	0.110–0.145
Coarse silt	0.0310–0.0625	0.0826–0.110
Medium silt	0.0156–0.0310	0.0630–0.0826
Fine silt	0.0078–0.0156	0.0378–0.0630

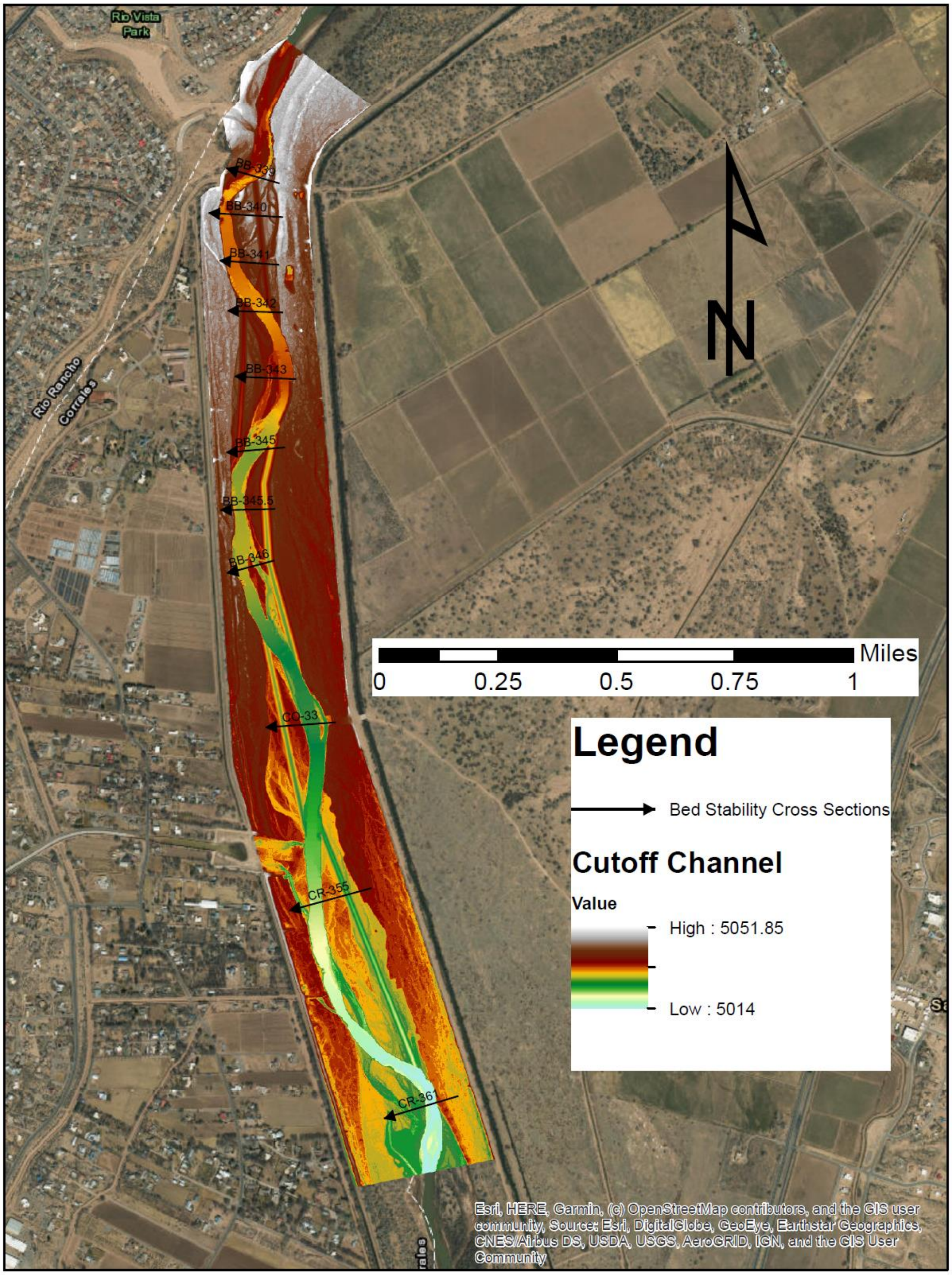


Figure 49: Bed Stability Cross Sections overlaid on the Cutoff Channels model terrain

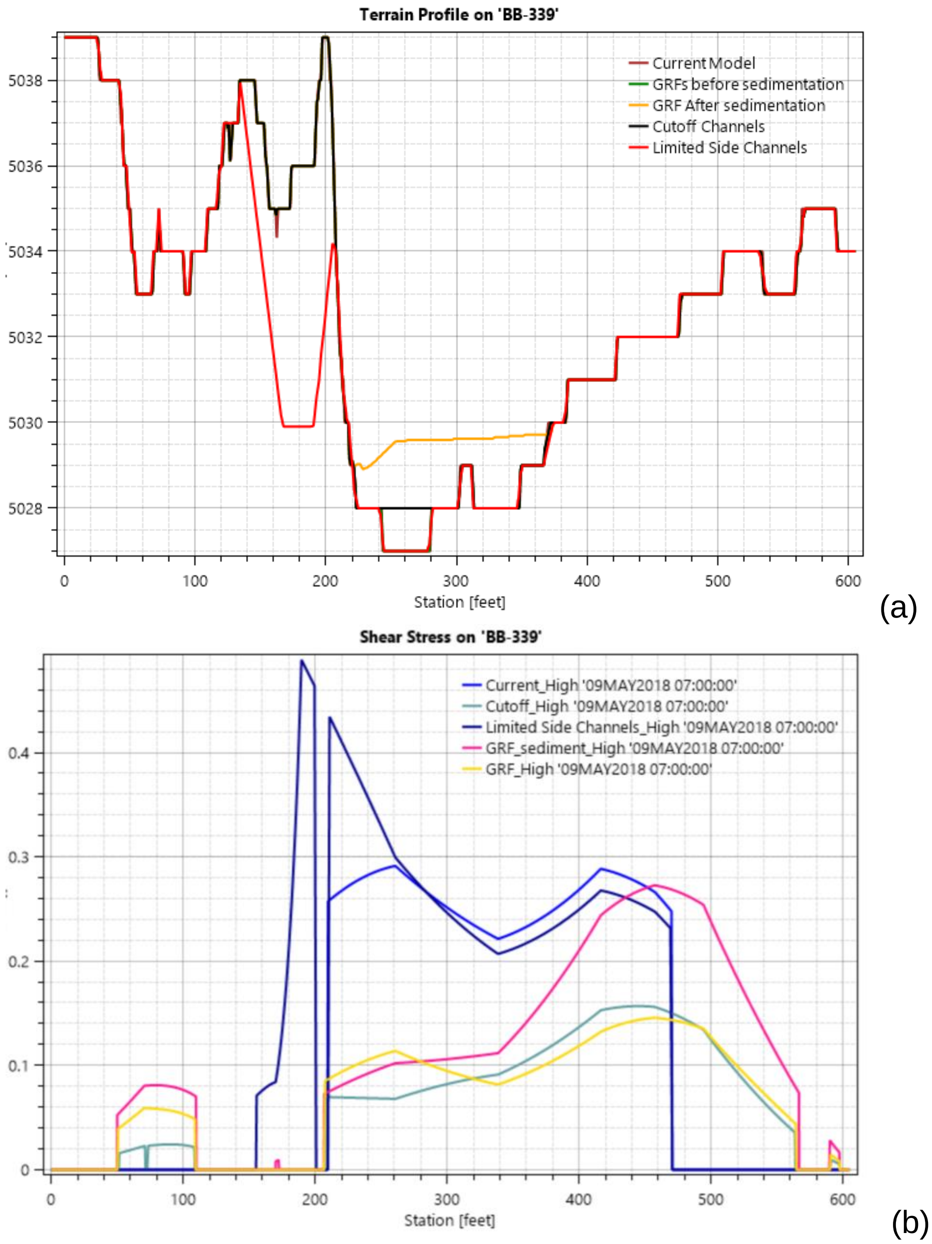
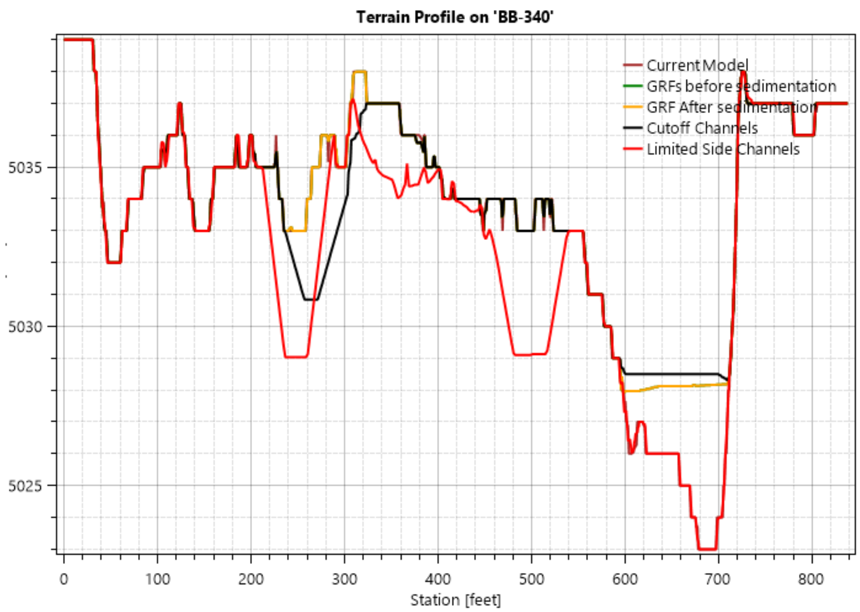


Figure 50: a) Cross section of terrain for all four models on BB- 339 and, b) Shear Stress at BB-339

Figure 50 a & b shows river cross section and shear stress along the cross section at BB-339. The shear stress plots show that the GRFs before sedimentation and cutoff channels result in reduced channel shear stress at the eroding bank (approx. Sta. 210). There is also a shift of the shear stress to the west away from the eroding bank and towards the depositional area above Corrales Siphon.

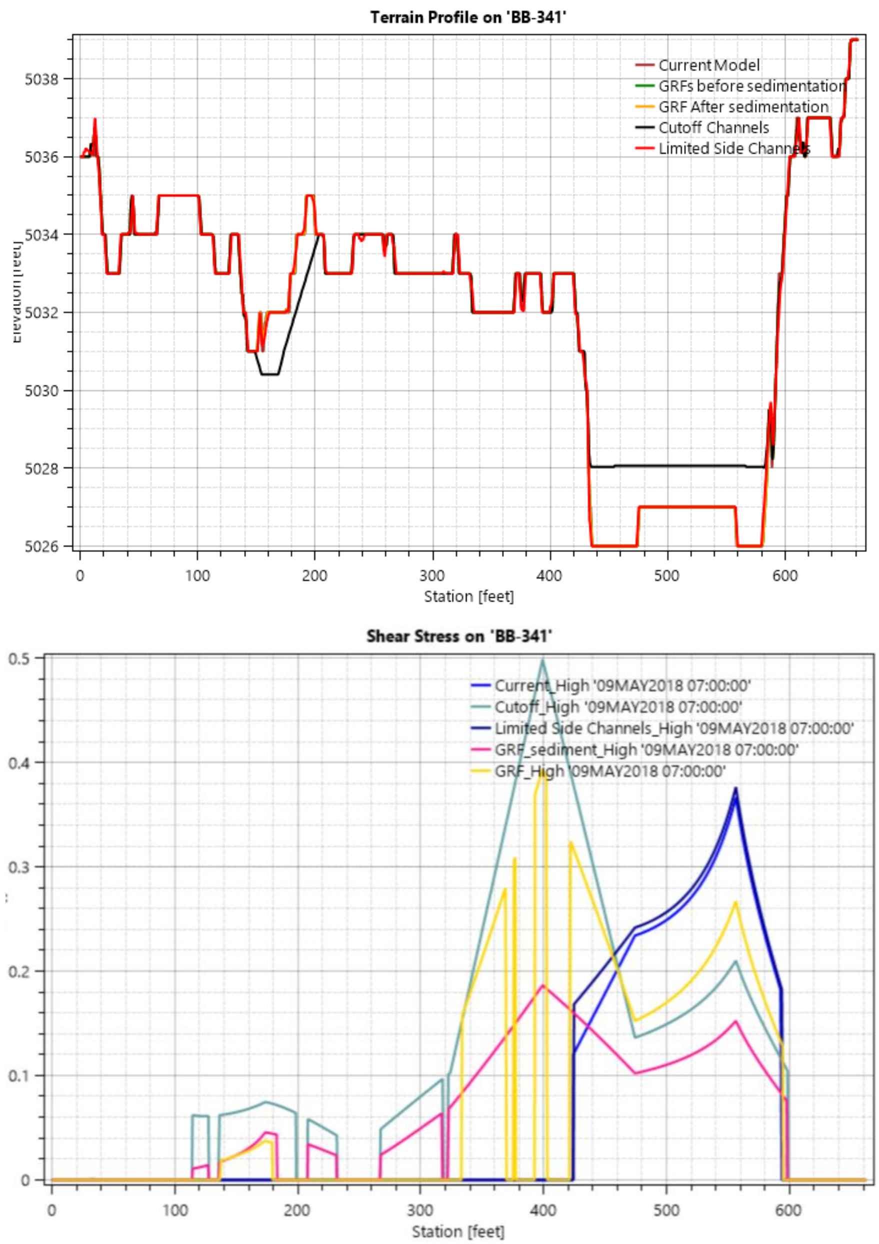


(a)

(b)

Figure 51: a) Cross section of terrain for all four models on BB-340 and, b) Shear Stress at BB-340

Figure 51 a & b shows the river cross section and shear stress at BB-340. At this cross section, even though the cutoff channels have higher shear stress than the current model, it is the alternative with the lowest shear stress at the eroding bank (approx. Sta. 720), along with limited side channels. These alternatives have helped to transfer some of the shear stress from the channel bed to the floodplain.

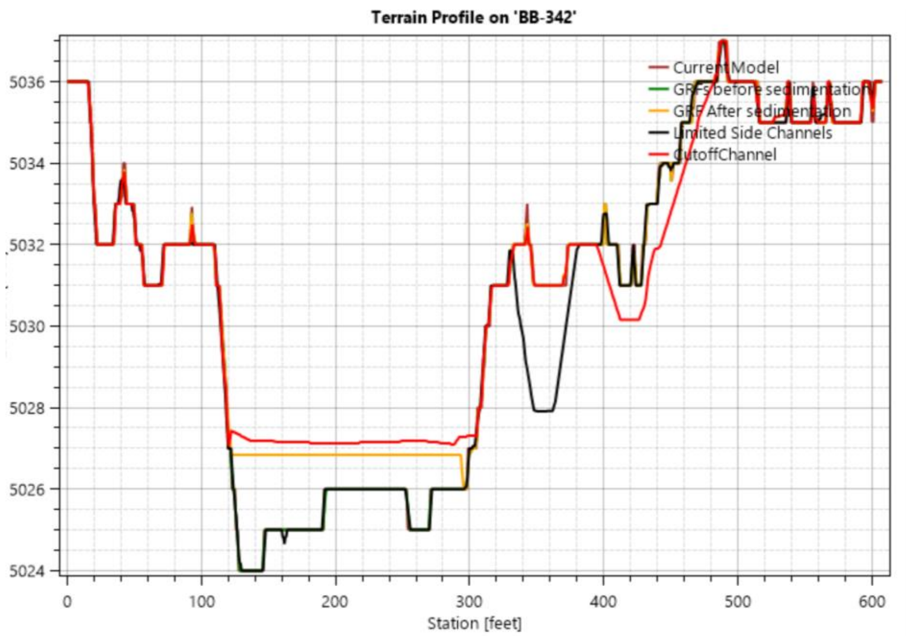


(a)

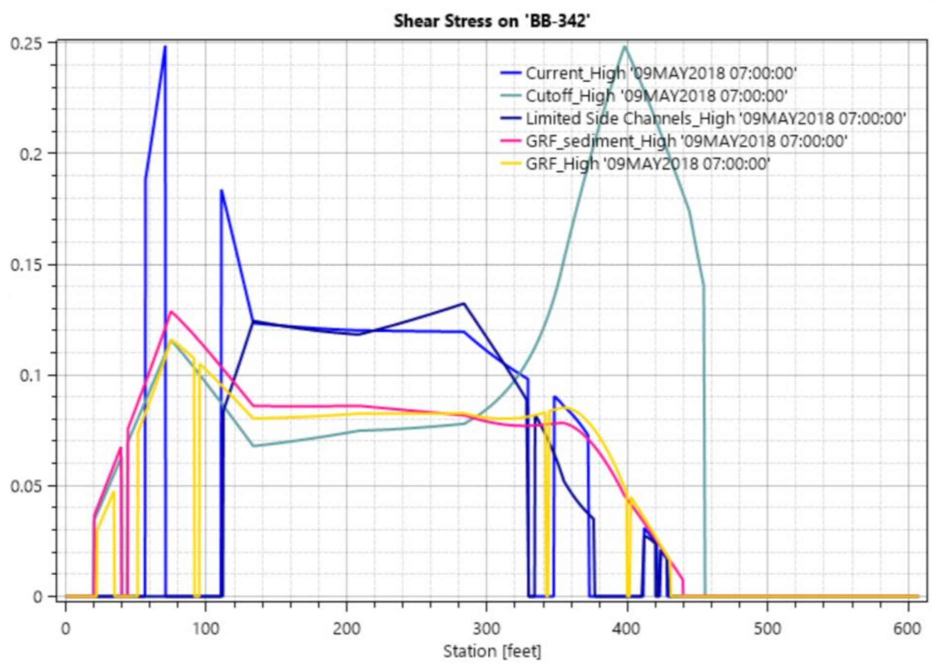
(b)

Figure 52: a) Cross section of terrain for all four models on BB- 341 and, b) Shear Stress at BB-341

Figure 52 a & b shows river cross section and shear stress along the cross section at BB-341. The GRF after sedimentation shows the least shear stress at the cut bank (approx. Sta. 600). This alternative has also helped to shift the shear stress to the west floodplain, away from the cut bank. This GRF is located downstream, close to BB-345.



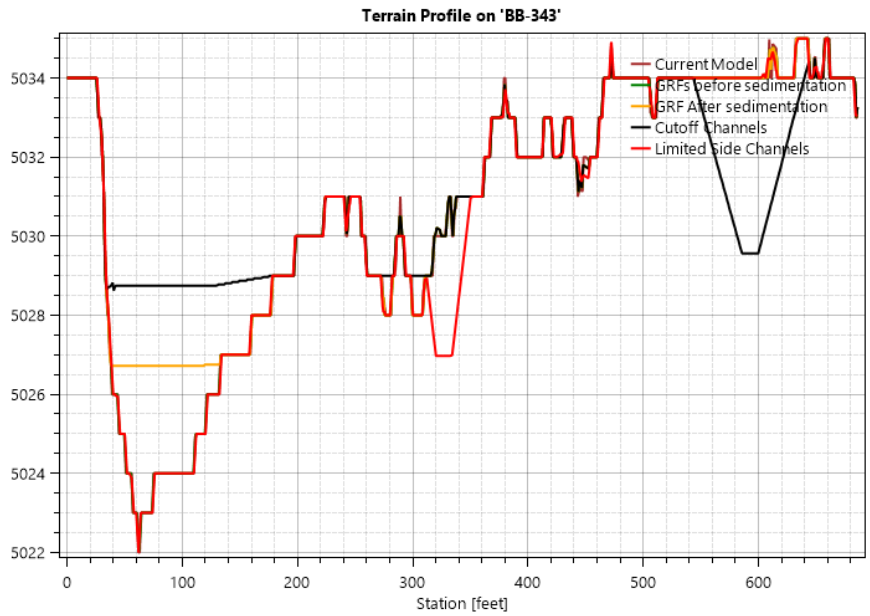
(a)



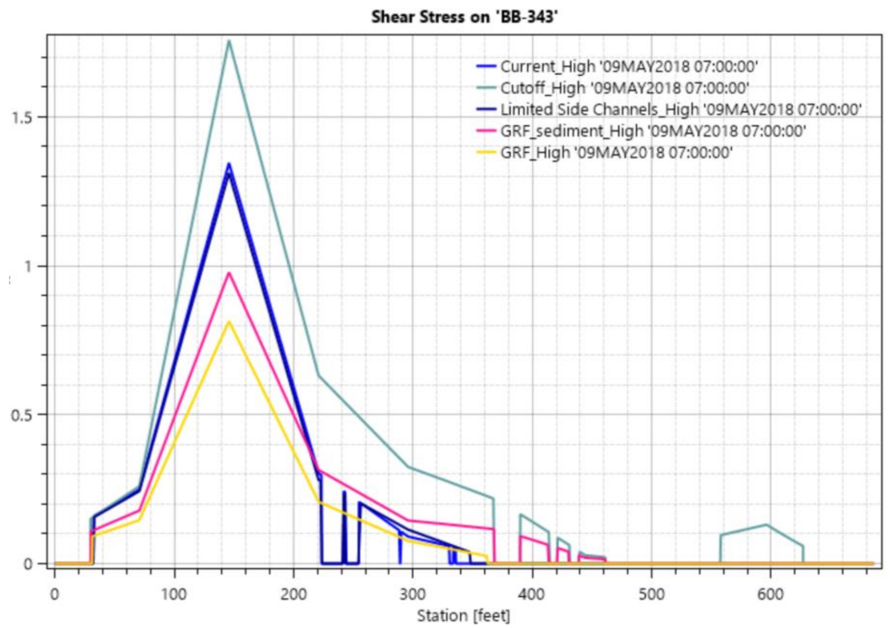
(b)

Figure 53: a) Cross section of terrain for all four models on BB- 342 and, b) Shear Stress at BB-342

Figure 53 a & b shows the river cross section and shear stress along the cross section at BB-342 which is between two bends and thus has no distinct erosional bank. At this location the cutoff channels alternative has the least shear stress in the river channel between Sta. 120 and 300 and has also resulted in shifting of the shear stress to the west floodplain.



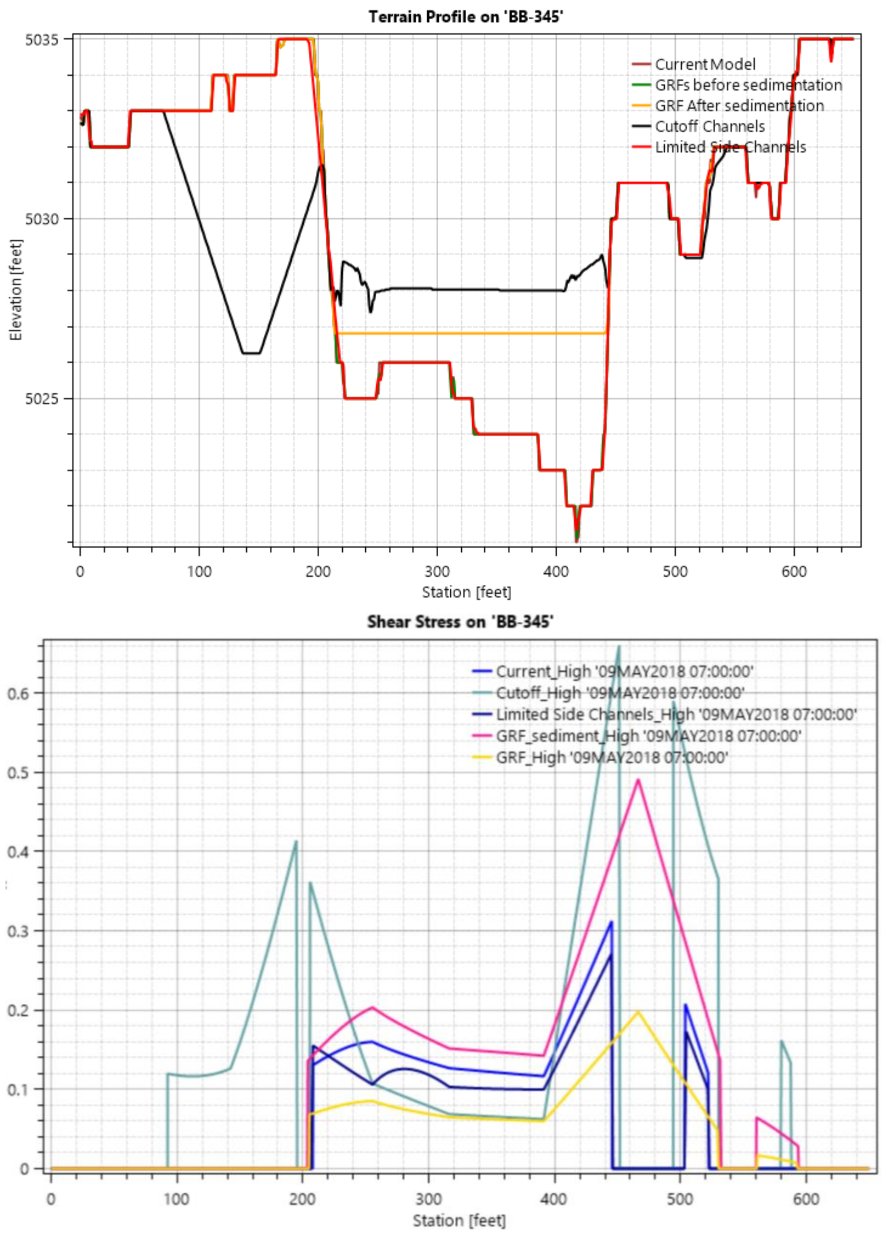
(a)



(b)

Figure 54: a) Cross section of terrain for all four models on BB-343 and, b) Shear Stress at BB-343

Figure 54 a & b shows the river cross section and shear stress along BB-343. At this location, the GRF shows the least shear stress at the cut bank (approx. Sta. 30). This alternative also has the least shear stress in the river channel and has shifted some shear stress to the east side floodplain.

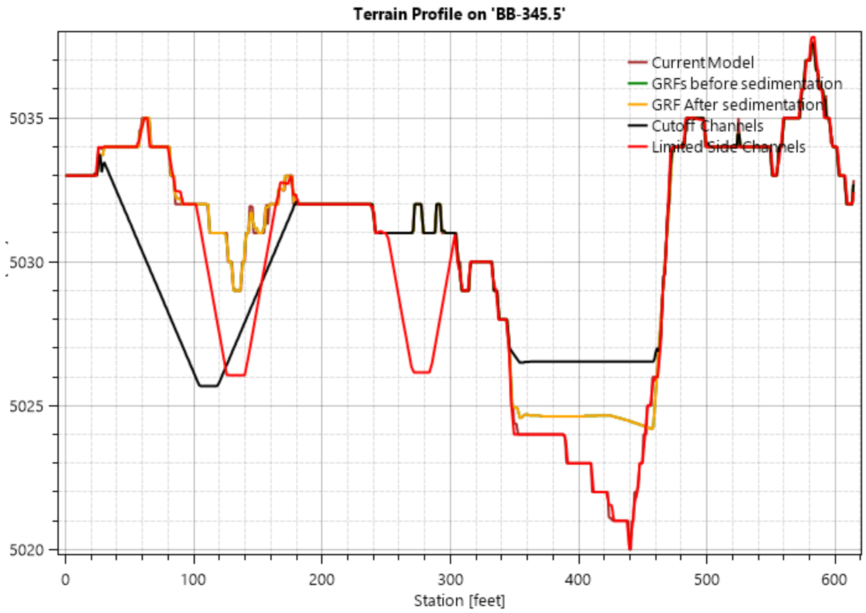


(a)

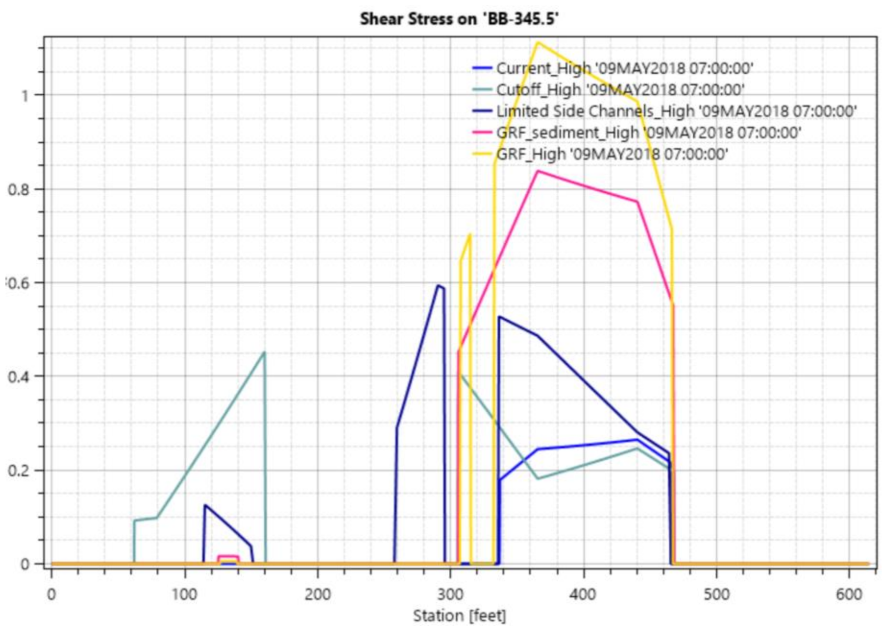
(b)

Figure 55: a) Cross section of terrain for all four models on BB-345 and, b) Shear Stress at BB-345

Figure 55 a & b shows river cross section and shear stress along the cross section at BB-345. This cross section is about 0.1 miles above RM 199 where erosion is a concern, and it's between bends so there is no distinct eroding outer bank. Compared to the current model, there is a great increase in shear stress along the outer bank at this cross section when cutoff channels are used. There is also an increase in shear stress for the GRF after sedimentation. These two alternatives have a higher channel bed elevation as shown in the terrain cross section Figure 55 (a). This is the likely reason for high stress at the outer bank due to increased flow onto the river banks. Cutoff channels and GRFs without sedimentation alternatives have the least shear stress in the channel (at approx. Sta. 300-400) and thus would be more appropriate at this location



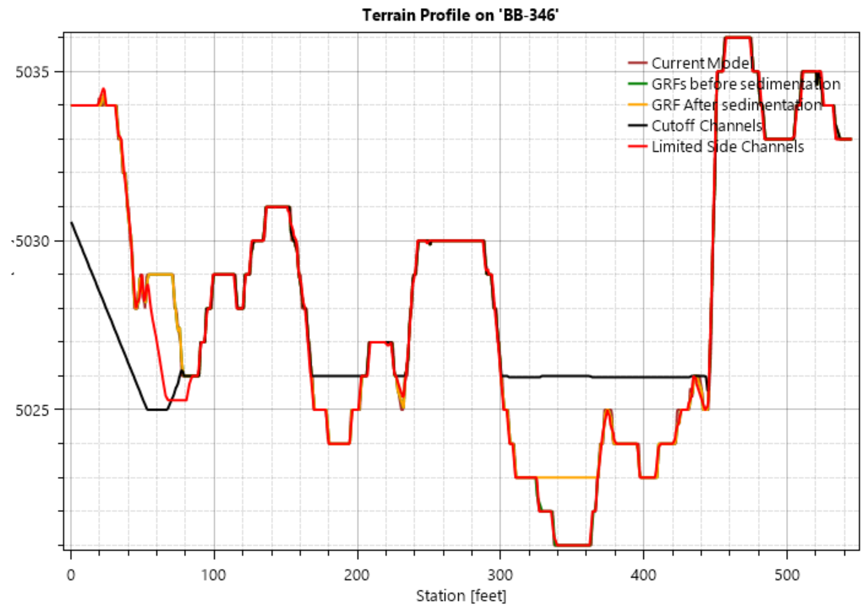
(a)



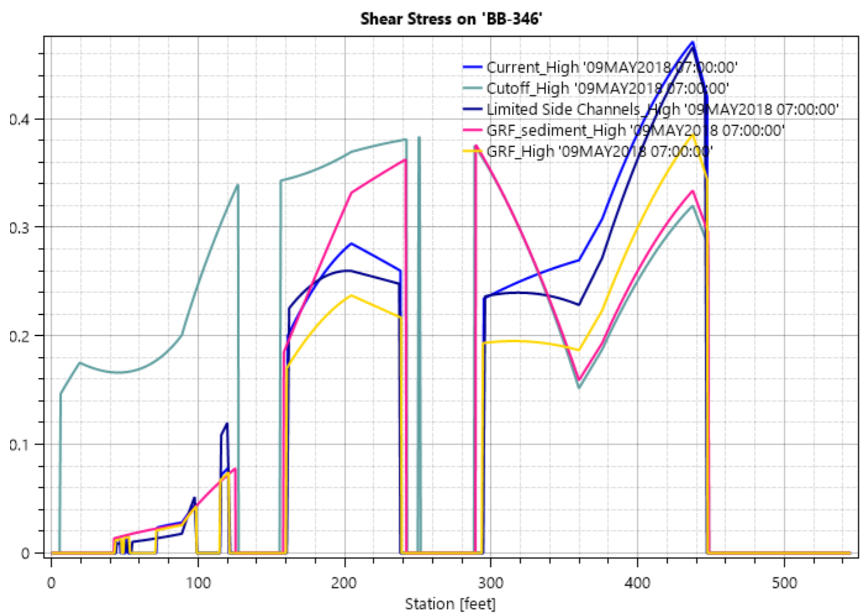
(b)

Figure 56: a) Cross section of terrain for all four models on BB- 345.5 and, b) Shear Stress at BB-345.5

Figure 56 a & b shows river cross section and shear stress along the cross section BB-345.5. This is at the upstream side of the RM 199 bend where the river is only 200 feet from the levee, and where the changed angle of attack from the upstream side created new erosion in 2019. At this location, the cutoff channels have really shifted the shear stress onto the east floodplain, away from the eroding bank (approx. Sta. 460) and have also reduced the shear stress along the river channel.



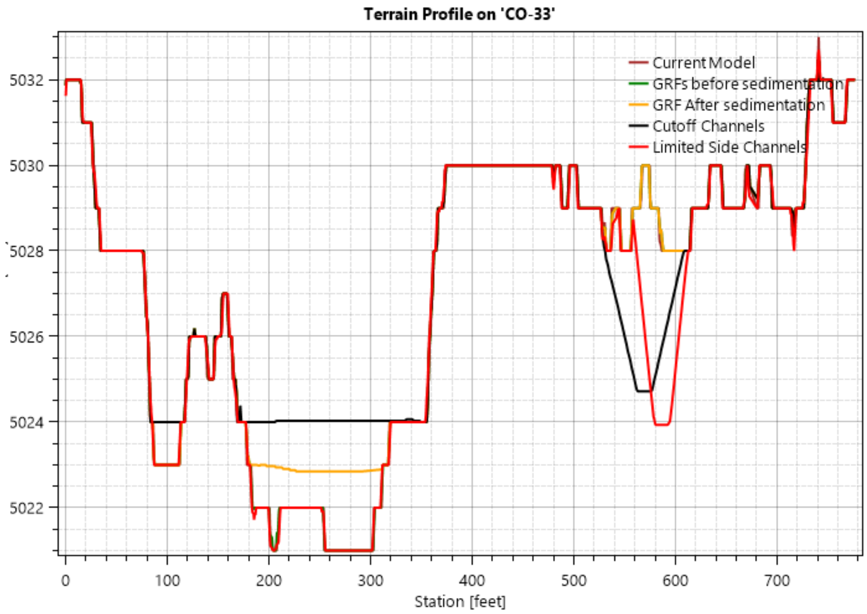
(a)



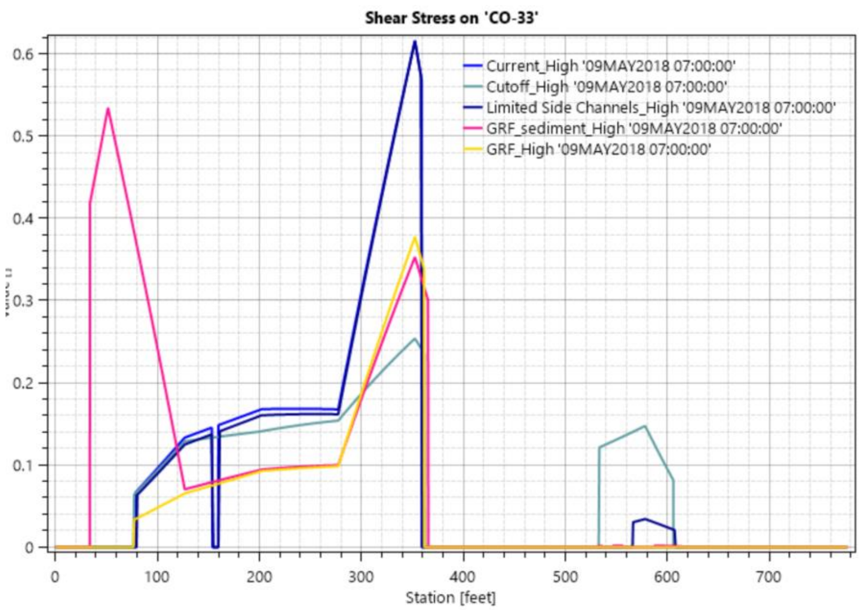
(b)

Figure 57: a) Cross section of terrain for all four models on BB-346 and, b) Shear Stress at BB-346

Figure 57 a & b shows cross section and shear stress along BB-346 which is around the middle of the RM 199 bend, and only 120 feet from the levee. At this location all alternatives, especially cutoff channels, have helped to shift a good amount of shear stress from the cut bank (approx. Sta. 440) onto east side of the floodplain as well as reduce the river channel shear stress.



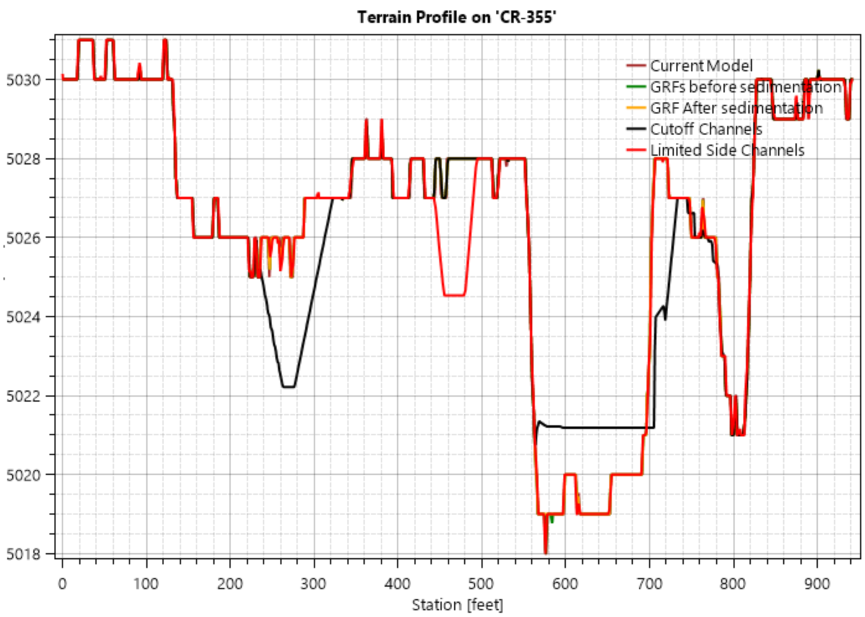
(a)



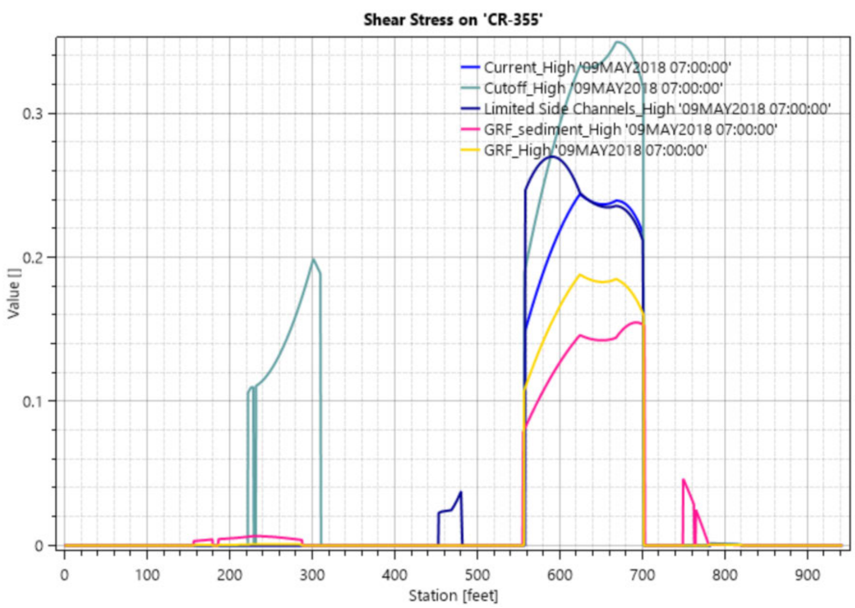
(b)

Figure 58: a) Cross section of terrain for all four models on CO-33 and, b) Shear Stress at CO-33

Figure 58 a & b shows cross section and shear stress along CO-33. This is near the Pueblo's river access site, which is located at the outside of the bend, but is not actively eroding. The cutoff channels and GRFs have resulted in reduced shear stress in the channel (Sta. 80 to 350). The GRFs have increased shear stress at the outer bank (approx. Sta. 80). The increase in shear stress in the floodplain is a result of the spoil materials increasing the elevation of the river channel, raising the flow out onto the floodplain.



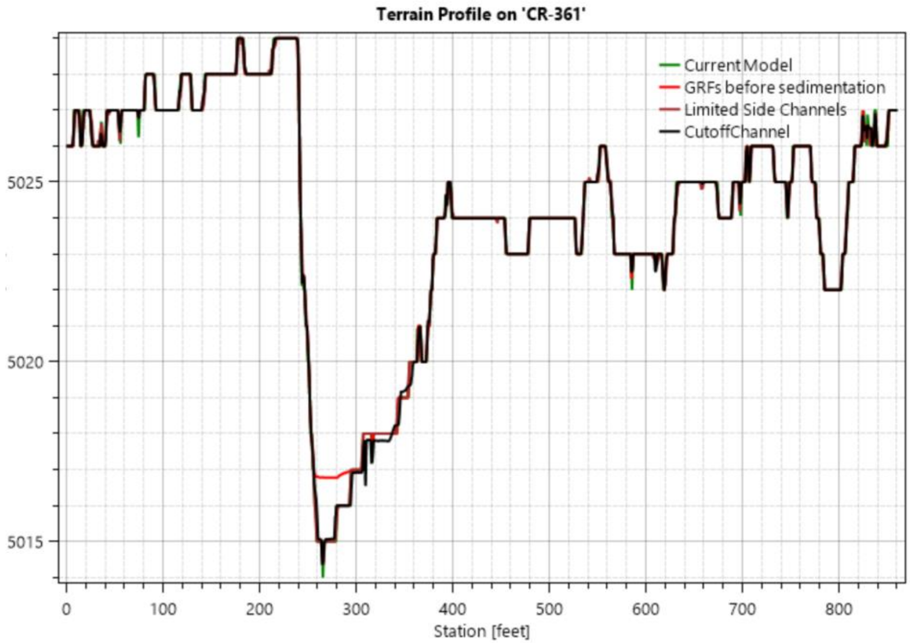
(a)



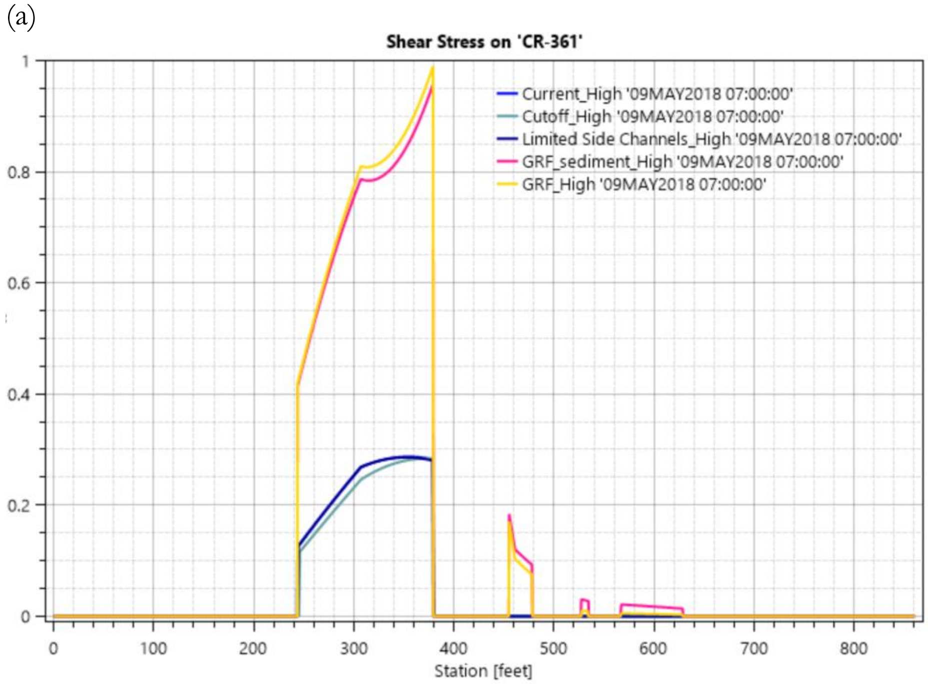
(b)

Figure 59: a) Cross section of terrain for all four models on CR-355 and, b) Shear Stress at CR-355

Figure 59 a & b shows river cross section and shear stress along CR-355 which is on the upstream side of the RM 198 bend. At this section the GRF shows the least shear stress along the river channel. The cutoff channels have the highest shear stress at this cross section because as the alternative's raised channel bed returns to the existing bed elevation, the steep bed slope increases the WSE slope, which increases shear stress.



(a)



(b)

Figure 60 a) Cross section of terrain for all four models on CR-361 and, b) Shear Stress at CR-361

Figure 58 a & b shows river cross section and shear stress along CR-361. This marks the end of the study reach and shows how the shear stresses change along the channel for all the alternatives.

This analysis shows which alternative is suitable at different bends along the river. In summary, it appears that cutoff channels result in more favorable results in most locations while side channels and GRF are suitable in just a few. This analysis has been carried out only along the river cross sections. The distribution of the shear stress throughout the study reach is presented in Appendix C.

Figure 61 below shows the velocity distribution at 4,000 cfs for four scenarios from Arroyo de la Barranca to the bottom of the BB-343 bend and generally represents the velocity changes for the entire project area.

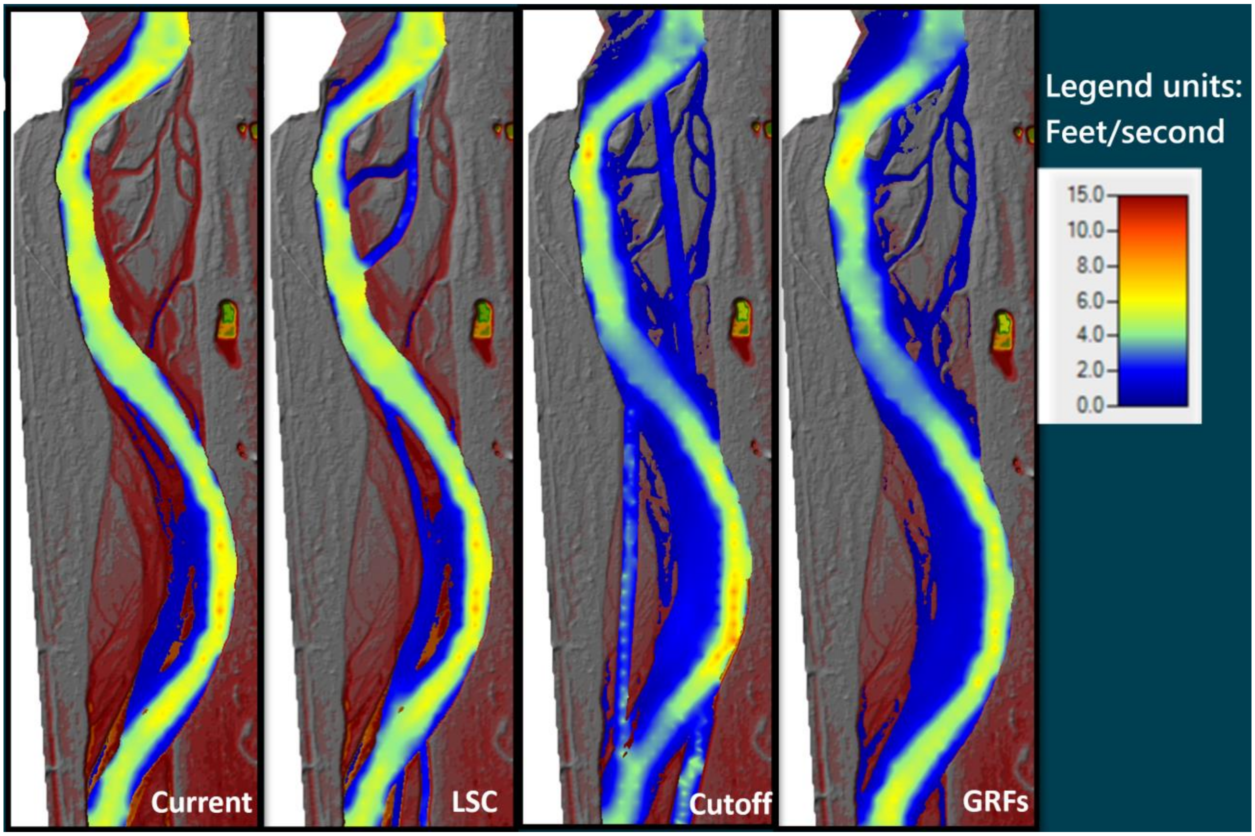


Figure 61: Modeled velocity results at 4,000 cfs for Arroyo de la Barranca through the BB-343 bend (existing MERES channels are visible in the terrain of the Corrales Siphon point bar)

4.3.4 Impact on Flood Levels

The four models were run at 500 cfs increments up to 10,000 cfs to evaluate when the levee toes become inundated and increase the risk of levee failure. Table 19 shows the flow at which levee toe inundation first occurs and the general area where this occurs.

Table 19: Alternatives' impact on flood levels

Model/Alternative	Initial Levee Toe Inundation Flow	Location
Current Terrain	9,500 cfs	BB-343 East
GRF After Sedimentation	6,500 cfs	BB-343 East
Cutoff Channels	7,500 cfs	BB-343 East
Limited Side Channels	10,000 cfs	BB-343 East

It is logical that GRFs after sedimentation would increase the risk since the channel bottom elevation is increasing due to the bed raise due to sediments from outside the model boundaries. With the cutoff channels alternative, the cut and fill volumes will be balanced so that whatever material is excavated from the floodplain will be spoiled in the channel. Therefore, in theory the flood level change from the current terrain should not be significant other than a small increase in WSE from increased wetted perimeter and increased roughness. The hydraulic model terrain may not have balanced cut and fill volumes as they would be in the actual construction of this alternative, and thus the flood impact may appear worse than in the actual implementation of this alternative.

4.4 Comparison of Alternatives

The project purpose at River Mile 199 is to reduce the risk of levee failure due to bank erosion and lateral migration of the Rio Grande. Additional goals include improving ecological conditions, avoiding negative community impacts, being suitable given the geomorphic trends, and being cost effective. These criteria are used below to compare the alternatives to each other.

4.4.1 Bank Protection

To reduce the risk of levee failure, bank erosion near the levees should be minimized. As described in Section 4.3.3, shear stress is a useful metric for evaluating likelihood of sediment particle movement and resulting bed and bank erosion. The 2D HEC-RAS model averages the shear stress for a column of water which doesn't allow examination of shear stress at just the bank toe, but the shear stress data is useful nonetheless.

In theory, the shear stress will decrease with reductions in channel depths and slope (see Section 4.3.3), which will manifest itself in reduced velocities. The GRFs improve bank stability by decreasing the slope upstream of the GRF. The decreased slope reduces velocities and shear stresses and reduces the extent that failed bank material washes away. Also, the banks are protected through reducing bank heights (through sediment deposition) (Biedenharn and Hubbard, 2001). The cutoff channels improve bank stability by increasing flow area which reduces water depth. Also, the cutoff channel decrease bank heights by placing fill material in the main channel. The cutoff channels bank protection effectiveness could be improved by widening them so that they capture a higher percentage of the main channel flows. The limited side channels improve bank stability by reducing water depth.

The modeling results show that the alternatives generally reduce shear stress in the channel while increasing shear stress in the floodplain. There are localized spots within the models where an alternative significantly increased shear stress; however, lessons learned from examining the modeling results can be used to fine-tune the final design of any alternative to ensure maximum bank and bed protection. For example, there is increased shear stress when flow transitions from the main channel to a sharply angled side channel. Using this information, side channels can be designed to have gentle transitions to decrease bank shear stress.

Table 20 and Table 21 show an evaluation of the alternative's bank protection at each eroding bend in the project area.

Table 20: Ranking of alternatives' bank protection performance at each eroding bend

Eroding Bend	Current Rank*	GRF Rank*	CC Rank*	LSC Rank*
Arroyo de la Barranca (BB-339)	3	2	1	4
Corrales Siphon (BB-340)	3	4	2	1
Corrales Siphon (BB-341)	3	1	2	3
BB-343	3	1	2	3
Upstream eroding side of RM 199 bend (BB-345.5)	2	4	1	3
RM 199 bend (BB-346) (not eroding, but 120' from levee)	4	2	1	3
CO-33 (not eroding, but worth protecting)	3	4	2	1
CR-355 (minor erosion recently on west bank)	3	1	4	2
Average rank	3	2.4	1.9	2.5

*rankings range from 1 as the lowest shear stress to 4 which is the highest shear stress

Table 21: Alternatives' shear stress divided by current terrain model shear stress (percentage) at each eroding bend

Eroding Bend	GRF % of Current	CC % of Current	LSC % of Current
Arroyo de la Barranca (BB-339)	27%	27%	165%
Corrales Siphon (BB-340)	350%	100%	100%
Corrales Siphon (BB-341)	44%	56%	100%
BB-343	63%	100%	100%
Upstream eroding side of RM 199 bend (BB-345.5)	250%	95%	109%
RM 199 bend (BB-346) (not eroding, but 120' from levee)	74%	71%	100%
CO-33 (not eroding, but worth protecting)	757%	100%	100%
CR-355 (minor erosion recently on west bank)	68%	145%	100%
Average rank	204%	87%	109%

The GRFs perform well at some locations and poorly at other locations. The limited side channels usually perform about the same as the current terrain. The cutoff channels usually either reduce the shear stress at the eroding bends, or they at least keep it the same as the current terrain, with the one exception being the downstream-most cross section where the main channel bed's return to existing elevation creates a steeper WSE slope which increases shear stress.

4.4.2 Incision Reduction

Incision has been a continuing trend in this reach which has contributed to the severity of the meander bend erosion and migration which threatens the levees. The extent of incision in this reach can be seen in Figure 2. From 2001 to 2019, the RM 199 bend (BB-346) has incised 6 feet. The incision is much less significant upstream near Corrales Siphon since it behaves as a sort of grade control. Nonetheless, incision has a negative impact at Corrales Siphon as the top of the siphon is now exposed to flow.

Reduction of incision is important for this reach to protect Corrales Siphon, to reduce meandering which will reduce the risk to the levees, and to improve habitat by slowing the floodplain disconnection. Previously constructed habitat restoration projects will continue to be less effective over time as incision continues.

The GRFs and bed control alternatives would perform best at reducing incision. Knick points and scour holes that attempt to travel upstream would be stopped as the rock from the structures launches into the incising areas. GRFs particularly slow down the flow and reduce the shear stresses that would initiate bed particle movement. An analysis of the bed control effects of Corrales Siphon has been included in Appendix B and it shows that incision upstream of the siphon is on average less than half of the incision downstream of the siphon (see Section 9.2.7).

The cutoff channels, limited side channels, and vegetation destabilization alternatives would also reduce incision by widening flow area, reducing velocities, and reducing the shear stresses that would initiate bed particle movement. However, these alternatives do not have hard rock to stop bed particle movement at regular intervals as the first two alternatives have.

The modeling results show that all three modeled alternatives reduce shear stress overall in the model, which means it is likely that incision in the channel would be reduced by each of the modeled alternatives.

Table 22: Average wetted area shear stress for each model at 4,000 cfs

Model	Average Shear Stress (lb/sq. ft)
Current Terrain	0.249
GRF after sedimentation	0.216
Cutoff Channels	0.233
Limited Side Channels	0.242

4.4.3 Suitability Given Trends

The prominent trends in this reach which may affect the effectiveness of the alternatives are narrowing, incision, and meander bend erosion and migration.

Channel narrowing is characterized by sediment depositing along banks and side channels, and vegetation establishes before flows are high enough to scour out the new vegetation. This would not pose a detriment to the alternatives of GRFs and bed control. However, sediment deposition in the cutoff channels, limited side channels, and vegetation destabilization areas would significantly reduce the effectiveness of the alternative at dissipating energy, protecting the banks and bed from erosion and incision, and providing habitat.

The trends of incision would not impact the GRFs and bed control since these alternatives can launch riprap into scour holes and continue to serve their purpose of protecting against incision. Incision would affect cutoff channels, limited side channels, and vegetation destabilization by increasing the flow required to access the channels. Incision might occur most rapidly in the cutoff channels alternative where the spoils materials were placed in the existing channel; thus, bed control is recommended to be combined with this alternative to prevent rapid incision following construction. The bed control would be placed on top of the fill material at the downstream end of the project area and at the straight segments between bends so that the riprap is available to launch into nick points or scour holes and slow the incision. Also, the bed control would limit the sediment transport capacity in the main channel and limit incision of the fill material as described in Section 4.2.2. The spacing and frequency of bed control is expected to adequately prevent incision according to guidance from Biedenharn and Hubbard (2001) and according to observable de facto grade control elsewhere in the reach (specifically, Corrales Siphon; see Section 9.2.7 in Appendix B).

The meander bend erosion and migration trends would affect the GRFs and bed control alternatives as the meander bends move away from the structures' alignments. Wing walls would help to prevent flanking of the structures but in the long term may not be enough to protect against meander bend migration. Biedenharn and Hubbard (2001) state that a stable upstream alignment that provides a straight approach into the structure is critical. If the channel is very sinuous, it may be necessary to realign the channel to provide an adequate approach, and the realigned channel may require bank stabilization to ensure the longevity of the realigned channel.

Meander bend erosion and migration may slightly change the lengths of the cutoff channels, side channels, and vegetation destabilization areas, and the changing angle of attack may result in changes in incision and aggradation in these alternatives, but overall the impact will be minimal.

Considering the cutoff channels' low inundation flow rate and increased slope, it is possible that the cutoff channels become the primary flow channel. This possibility would be minimized in the design phase with hydraulic and sediment modeling used to identify widths, depths, side slopes, entrance angles, bed control elevations, etc. to minimize the chance of unintentional channel realignment. Further details on contingency planning is provided in Section 6.3.

All these trends will have significant negative impacts on the no-action alternative. Without action, the river will continue to incise, further disconnecting itself from its floodplain. The hydraulic depths will increase, the velocities will increase, and the bank erosion will increase. The meander bends will continue to migrate and increasingly threaten the levees. See Figure 37 for the predicted planform based on current erosion rates for year 2030 if the no-action alternative is selected.

4.4.4 Long Term Cost Analysis

The estimated initial construction costs described in Section 4.2 are compared in **Error! Reference source not found.**. Another important consideration when analyzing costs is the alternatives' longevity and lifecycle costs.

An analysis of the MERES HR site's high flow side channels suggests that high flow side channels in this area have an effective life of around five to ten years. Since cutoff channels are lower, wider, and designed to flow year-round, the effective life is less certain, but ten years is an acceptable assumption. Side channels and/or cutoff channels become ineffective either due to disconnection as a result of main channel incision or due to cutoff channel sedimentation. Disconnection from the main channel through incision can be delayed or prevented by supplementing the design with bed control. Bed control will be designed to last about 25 years by selecting the appropriate riprap sizing for the expected flow and incision conditions.

Vegetation destabilization, if initially successful, is expected to also last approximately 10 years; however, this method is experimental and may not result in lowered floodplain if the high flows fail to significantly scour down the destabilized floodplain.

Assuming the cutoff channels, side channels, and vegetation destabilization need to be re-constructed every 10 years, the anticipated fifty year cost of the alternatives has been calculated and is shown in Table 23. An additional option of cutoff channels supplemented with rock sill bed control has been included to see how this combination impacts longevity and fifty-year costs. It is assumed that the combination alternative will require some moderate excavation to keep the channels open (around $300,000 during 25 years) and a complete rebuild at the 25-year mark. Also, GRF are included with a longevity of fifty years, assuming $800,000 in adaptive maintenance during those fifty years.

It is important to note that these costs are being extrapolated to fifty years for comparison purposes only. Whether or not Reclamation would choose to extend the life of the project for that duration would be on a case-by-case basis.

Table 23: Comparison of alternatives' initial construction cost, assumed longevity, and anticipated fifty-year lifecycle cost

Alternative	Initial Cost	Assumed Longevity	Fifty-Year Lifecycle Cost
GRFs	$11 million	50 years (when including $800,000 adaptive maintenance)	$11.8 million
Bed Control	$216k–$1.1 million	25 years (build two times in fifty years)	$940,000*
Cutoff Channels	$1.24 million	10 years (build five times in fifty years)	$6.2 million
Cutoff Channels with Bed Control*	$1.7 million	25 years (including $300,000 of adaptive maintenance)	$4.0 million
Limited Side Channels	$480,000	10 years (build five times in fifty years)	$2.4 million
Vegetation Destabilization	$22,000	10 years (build five times in fifty years)	$110,000

*assumes the rock sill as the bed control type

GRFs and cutoff channels offer similar levels of bank protection and acres of habitat created, but cutoff channels are approximately half the cost, or a third of the cost when bed control is included. Limited side channels and vegetation destabilization offer lower levels of bank protection and acres of habitat created than the other two alternatives, but they cost much less than those alternatives. The limited side channels and vegetation destabilization seem to offer best value for cost, but those alternatives may not achieve the level of bank protection and acres of created habitat that is desired to meet project goals.

4.4.5 Community Impact

Community impacts of these alternatives include short-term construction impacts, changes to the way recreationists access the bosque, a potential for perceived and/or real changes to the Pueblo's western boundary, and long-term impacts to the health of the bosque for the community's enjoyment.

The Pueblo of Sandia and the Corrales recreationalists would be impacted by construction traffic during mobilization and demobilization, hauling of riprap and other materials to the site, and hauling excavated soils around the site. The GRFs would require the most hauling traffic through the Pueblo and/or Corrales recreation areas, followed by the bed control alternative. To avoid closing large sections of the Corrales bosque to recreationists, the majority of the hauling could take place through the Pueblo's side of the bosque; however, although the Pueblo has less traffic than the Corrales side, the hauling traffic will still have a negative impact on the community. Also, even with hauling on the Pueblo side, small sections of the Corrales bosque would still be closed for diversion channel construction.

The cutoff channels would also have a large amount of traffic hauling excavated materials, but this traffic would be contained within a smaller area and would only require closing isolated sections of the Corrales bosque. The limited side channels would have less than half the excavated volume to haul, although the acreage closed would be the same amount as the cutoff channels. The vegetation destabilization would close small sections of bosque for a much shorter time than the other alternatives since there would be vegetation destabilization only and no excavation.

Cutoff channels would create a channel with year-round flows on each of the meanders' point bars, cutting off recreationists' access to these point bars. Arguably, these are the least-accessed portions of the bosque since they are typically dense with willows. GRFs, bed control, limited side channels, and vegetation destabilization would likely not significantly impact the area accessible to recreationists.

Reclamation's understanding is that the Pueblo of Sandia's official western boundary is legally undetermined, although various boundaries are suggested and in use. The most common western boundary used is the centerline of the Rio Grande. If the Rio Grande channel's centerline is moved to east, this could be a perceived and/or real change to the Pueblo's land area, which is highly undesirable to the Pueblo. The centerline could be moved through a variety of ways, including no action, which would allow the river to erode further east; implementing GRFs, which may realign the river somewhat to provide a straight segment through the GRFs; and implementing cutoff channels, which may eventually turn into the main channel if they provide a preferred flow path.

The community will benefit from the long-term impacts of creating a healthier bosque, including recreationists' enjoyment of vegetation and bird life. The alternatives that are likely to create the healthiest bosque are the cutoff channels and limited side channels. The channels created would increase the areas colonized by native vegetation and the diversity of topography will vary the proximity to alluvial groundwater. The increased connection and proximity to water will increase the diversity, abundance, and richness of riparian and wetland vegetation. Open water habitat improvements will also improve the recreational and aesthetic experience as the view over a wetland or open water is more pleasing than a view obstructed by thick brush. Energy dissipation and crib wall bank protection methods will provide a variety of high-quality habitats that will benefit fish and wildlife. Habitat improvements also increase the opportunities to catch fish and view wildlife.

Recreationists will also enjoy a safer river. This stretch has a high number of incidents requiring fire department dispatch during high flows due to the fast waters, numerous strainers (trees fallen in the river), and lack of boaters' egress on the high cut banks (Fluke and Klein, 2019, unpub.). The GRFs and cutoff channels alternatives will create slower flows at all flow rates, while the limited side channels and vegetation destabilization will only influence higher flows. The cutoff channels, limited side channels, and vegetation destabilization alternatives will offer the best egress for boaters and swimmers in distress.

Flood Level Impacts
The US Army Corps of Engineers (Corps) maximum safe channel capacity at Albuquerque is 7,000 cfs (WildEarth Guardians v. US Army Corps of Engineers, 2018). This means the Corps will manage their releases from Cochiti and Jemez dam to attempt to prevent more flow than 7,000 cfs in the river at Albuquerque. Also, the regional hydrology and managing for infrastructure bottlenecks elsewhere on the MRG (such as the Los Lunas area) limit the maximum flows this area usually experiences to around 5,500 cfs. Relating this information to the flow at which the levee toes may become inundated (see Table 19), the risk of levee toe inundation for the cutoff channels (7,500 cfs) and limited side channels (10,000 cfs) is acceptable, while the GRFs after sedimentation (6,500 cfs) is somewhat more likely to experience inundated levee toes.

4.4.6 Impact on Habitat

General Impacts
We evaluated the two Bank Protection Methods (i.e., Longitudinal Woody Features and Longitudinal Riprap Features), five alternatives for energy dissipation (GRFs, Bed Control, Cutoff Channels, Limited Side Channels, Vegetation Destabilization) and the No Action alternative for their general impacts and benefits to fish, wildlife, and their habitats. We refer to these two methods and six alternatives collectively as the alternatives.

Impacts of Channel Narrowing: When viewed in isolation, several of the alternatives (Bank Protection Methods, No Action Alternative) could result in a narrower river channel and change duration or extent of aquatic habitats. Narrower channels can contain less aquatic habitat (temporarily) or reduce habitat complexity and availability. Narrow channels, especially when accompanied by channel incision, can result in less floodplain connectivity, less floodplain habitat, and reduced food resource availability (through scour or reduced floodplain connectivity). Channel narrowing in the bosque would create additional surface area that would be colonized by vegetation.

Impacts of Coarse Substrate: Several of the alternatives propose to introduce hardened substrates (boulders, cobble, launchable riprap, stone toes, etc.) into aquatic or riparian habitats. These substrates can contribute to armoring or bed coarsening in aquatic habitats. Aquatic life can both increase (attached algal and insect communities) and decrease (plants and animals that prefer sand or silt substrates). A mix of substrates is associated with many stormwater or snowmelt runoff events, but the reduction of upstream fine sediment sources can contribute to the predominance of coarse substrates and bed armoring. In terrestrial environments the increase in areas of soil colonizable by vegetation is initially reduced by coarse substrates. However, these coarse substrates will be covered by soils or soils become entrained over time which contribute to vegetation colonization. Installation of large woody debris and crib walls, can increase the carbon content of soils, reduce velocities and increase depths in aquatic habitat, and increase aquatic food web productivity.

Impacts of heavy equipment and noise: During construction and associated activities, equipment such as handheld tools, chainsaws, or heavy equipment such as chippers, mulchers, compactors, construction equipment, heavy trucks, pumps, water trucks, and other vehicles may be used will generate noise and vibrations. Additional disturbances, noise, and vibrations will affect fish, wildlife and their habitats temporarily during mobilization, demobilization, travel, and construction of heavy equipment and associated activities. Depending on the frequency, intensity, and proximity, noise and vibrations can result in heightened physiological stress, fleeing behaviors, disruption of schooling or movement patterns, changes in distribution, masking of biologically important sound (e.g. during spawning, predator/prey detection), auditory injury, decreased population fitness, and in extreme cases, direct or indirect mortality and reductions in survival in certain fish and wildlife species (Fernandez-Juricic et al. 2009; Goodwin et al. 2010; Popper et al. 2014; Faulkner et al. 2018). Equipment and associated activities have potential to physically displace, entrap, crush, or harass fish and wildlife or modify habitat conditions (by both potential impacts and realized benefits).

Vegetation removal impacts and planting benefits: Clearing and grubbing, blading, excavation, root plowing, will result in vegetation community changes. Both immediately, and with management over time, the number and extent of non-native species will be reduced, and extent of native species will increase and may favor native species of fish and wildlife. Vegetation changes affect fish, wildlife, and their habitats in a variety of ways including changing cover, food, community structure, and local microclimate or temperature regimes. Increases in native riparian, wetland, or terrestrial vegetation, depending on the type, density, and eventual structure, will likely create conditions favorable to flycatchers, cuckoos, migratory birds, and other wildlife species. Increased native vegetation may also contribute to reduced velocities, reduced local temperatures, increased food availability, and increased habitat for aquatic species during inundation.

Pumping, diversion of flow, and water quality impacts: To protect equipment, staff, and aquatic species below the ordinary high water mark or in areas of inundation, it may be necessary to temporarily reduce the local ground water or temporarily divert surface water away from or around areas of construction and travel. Aquatic habitats may be impacted by changes in water quality or quantity and cause aquatic species displacement. Riparian vegetation may also become stressed.

Benefits of energy dissipation, bank protection, and best management practices: Excavation of energy dissipation alternatives and bank protection provide opportunities to widen the channel features, and increase, enhance, or create new aquatic, riparian, and terrestrial habitats. Bank protection measures offer opportunities for areas of improved riparian habitat or recreation and access. Cutoff channels and Limited Side Channels also increase the aquatic and riparian habitat complexity, extent, and floodplain connectivity. These features will increase the availability and persistence of spawning, nursery, and slack water habitats for aquatic life and riparian or wetland conditions for wildlife. In the process of conducting these river maintenance activities, Reclamation (2015) also employs several Best Management Practices (BMPs) and Standard Operating Procedures (SOPs) that will likely benefit fish, wildlife, or their habitats and that include the following:

- Construction would be accomplished during periods of least resource impact;
- Where possible, construction will avoid the vast majority of migratory bird nesting season;
- Surveys of special status species, geographic, or temporal avoidance prior to disturbances;
- Employment of silt curtains, cofferdams, dikes, straw bales, bubble barriers, and other suitable erosion control or wildlife exclusion measures prior to or during construction;
- Storage and dispensing of fuels, lubricants, hydraulic fluids, and other petrochemicals safely;

- Cleaning and inspection of construction equipment daily for petrochemical leaks;
- Containing and removing of any petrochemical spills and disposing of these materials safely;
- Planned and physical minimization of work, staging, and traffic areas;
- Use of uncontaminated earth or alluvium suitable for native vegetation as fill, where needed;
- Scarification of compacted soils or replacement of topsoil, as necessary;
- Revegetation or reseeding of disturbed sites with mixture of native grasses, forbs, or shrubs;
- Protection of mature cottonwood trees from damage during vegetation removal activities;
- Strict control of site access, using fencing, or other appropriate materials;
- Community outreach, public participation, review, and stakeholder involvement;
- Implementation of monitoring and minimization measures for the special status species;
- As necessary, conduct bald eagle surveys to determine areas of eagle use with avoidance;
- Address discharges, fills, or mitigation of jurisdictional wetlands under the Clean Water Act;
- Obtaining water quality certifications from Pueblo of Sandia and State of New Mexico, and;
- Measures to address air quality, noise, fire risks, aesthetics, and cultural or historic resources.

Wetted Impacts

Wetted impacts for each of the alternatives were quantified and are shown in Table 24. The longitudinal riprap bank stabilization could be constructed either by placing the riprap directly on the river on the edge of the bank, or it can be constructed in the dry utilizing a cofferdam. The longitudinal woody stabilization would need to be constructed in the dry, requiring cofferdams. A cofferdam would be constructed by placing riprap, gravel, and sand in the channel while it was wet. The area impacted would be about 0.3 acres per cofferdam, and two cofferdams would be needed per construction area for a total of 0.6 acres of wetted impact per bank stabilization area. For the riprap bank stabilization, if the riprap is placed directly in the river, the wetted impact depends on the length of bank being protected. For a typical bend approximately 1,200 feet long, the wetted impact would be around 0.3 acres. Bank treatments for habitat improvements could be constructed entirely in the dry, with zero wetted impacts, assuming construction occurs during low river flows.

The four GRFs are anticipated to be constructed in a dry channel after diversion channels and cofferdams have been built. The diversion channels would be excavated with channel entrance and exit plugs left in place until the diversion channel was complete. The removal of the entrance and exit plugs would be clean excavation but may have some in-channel impacts. The placement of the cofferdams would impact about 0.3 acres per cofferdam. With two cofferdams per GRF and four GRFs, the total wetted impact would be about 2.4 acres. Once the cofferdam redirected flow into the diversion channels, the GRFs could be constructed in the dry channel.

The bed control could be constructed with diversion channels if they are trenched, or they could be placed on top of the river bed which would not require diversion channels. If they are trenched, their wetted impact would be similar to the GRFs considering their cofferdam impacts. If they are placed directly on the river bed, their wetted impact would be the bed area that riprap is placed on, which would be about 0.1 acre per bed control feature. If eight bed control features are constructed as recommended, this would be approximately 0.8 acres of wetted impact.

The cutoff channels would be constructed one at a time, from upstream to downstream, with channel entrance and exit plugs left in place until the cutoff channel was complete. The removal of the entrance and exit plugs would be clean excavation but may have some in-channel impacts. Then cofferdams would be placed to divert the river through the cutoff channels, and the stockpiled spoils from the cutoff channels would be pushed into the now (mostly) dry main channel. The wetted impacts would consist of the construction of the cofferdams, which similar to the GRFs would impact about 0.3 acres per cofferdam. Assuming cutoff channels are placed at all five bends, the total wetted impact would be about 3 acres.

The limited side channels would be constructed with entrance and exit plugs left in place until the channels were complete, and the plug removals would be clean excavation. The spoils from the western floodplain would need to be placed in the river, and assuming 12,000 cubic yards of spoils are placed in the river, that spoiling process would cause an anticipated wetted impact of around 0.1 acres occurring nearly continuously during the workday, 4 days per week, over approximately 8 weeks. If the river does not wash away all the material, the leftovers would be distributed evenly across the river causing an additional 0.2 acres of wetted impact.

The vegetation destabilization would take place entirely in the dry on the vegetated point bars and would have no wetted impact.

Table 24: Anticipated wetted impacts of each alternative

Alternative	Approximate Wetted impacts
Longitudinal riprap stabilization	0.3 acres (per bend)
Longitudinal woody stabilization	0.6 acres (per bend)
Bank treatments for habitat improvement	0 acres
GRFs	2.4 acres
Bed Control	0.8 acres
Cutoff Channels	3 acres
Limited Side Channels	0.3 acres
Vegetation Destabilization	0 acres

Riparian Impacts

The RM 199 Project area consists of upland terrace areas consisting of mature and senescent cottonwood trees, and lower point bar areas that are dense with willows and young cottonwoods. If any wetlands are present in this area, they would be on the lower point bars, although these bars tend to be approximately six feet above the minimum channel elevation and are not frequently inundated.

The bank stabilization alternatives would impact a small margin of the upland terrace along the river edge. For 1,200 linear feet of bank stabilization, there would be approximately 2.5 acres of upland terrace disturbed. This number would be slightly smaller for bank treatments for habitat improvement which do not require structural tie backs and keys.

The GRFs riparian impacts would be limited to the diversion channels which would impact around one acre per GRF, or four acres total. The most economical location for these channels would be through the lower point bars. The bed control's riparian impacts would be approximately two acres if diversion channels are used, plus an additional one acre of impact for structural keys (if used). This would go through both upper terraces and lower point bars depending on the exact location of the eight bed control features. Most likely the bed control would not use diversion channels or keys and would have practically zero impact except for construction staging. The cutoff channels would disturb approximately 25 to 30 acres almost entirely on lower point bars, but after construction that area would turn into improved aquatic and riparian areas. The limited side channels would disturb a similar amount of surface area on the lower point bars, but the side channels would be shallower and create less aquatic habitat but more riparian habitat. The vegetation destabilization could disturb any amount of area selected for destabilization, and it would likely result in improved aquatic and riparian areas, but this result is not certain. This analysis has been using 11 acres as a probable project size for vegetation destabilization, and these would likely be located on lower point bars.

Below shows the approximate disturbed areas and direct benefit areas of each of the alternatives. Some of the alternatives may have indirect benefits to riparian and aquatic habitat, such as the GRFs slowing the water and improving floodplain connection in the area generally, but it doesn't have a direct impact such as the cutoff channels which lower the floodplain in specific locations that can be quantified.

Table 25: Anticipated number of acres impacted and floodplain acres improved for each alternative

Alternative	Approximate Riparian impacts	Probable Riparian impact location	Floodplain Improved for Aquatic/Riparian Habitat
Longitudinal stabilization	2.5 acres per bend	Upper terraces	0 acres
Bank treatments for habitat improvement	2 acres per bend	Upper terraces	2 acres
GRFs	4 acres	Lower point bars	0 acres
Bed Control	0–3 acres	Both	0 acres
Cutoff Channels	25–30 acres	Lower point bars	25–30 acres
Limited Side Channels	25–30 acres	Lower point bars	25–30 acres
Vegetation Destabilization	11 acres	Lower point bars	11 acres potential

Table 26: Anticipated number of acres of improved channel habitat for the modeled alternatives

	Acres of Suitable* Larval Habitat at 1,500 cfs	Acres of Suitable* Larval Habitat at 2,500 cfs	Acres of Suitable* Adult Habitat at 500 cfs
Current Terrain	3.0	4.0	5.3
GRFs	9.0	13.7	18.0
Cutoff Channels	11.3	11.0	23.0
Limited Side Channels	4.6	6.0	5.3

*For definition of suitable, see section 4.3.2

Impacts or benefits to fish, wildlife, and their habitats

We evaluated the remaining alternatives according to their relative impacts and benefits (Table 27). We reviewed the types of impacts and consolidated them to evaluate them better. The impacts of hard or coarse substrates was greatest with the GRF alternative. The Limited Side Channels would likely have the highest impacts due noise and construction based on the number and extent of construction areas that would occur in or near the river channel. The heterogeneity of topography and increased surface areas of both the Limited Side Channel and Cutoff Channel alternatives would benefit native vegetation the most. We selected summer flows of 500 cfs and spring runoff flows of 1,500 cfs and 2,500 cfs as those that would most likely represent the inundated channel and floodplain surfaces that represent adult and nursery habitat for silvery minnows, respectively. Then, based on the analyses depicted in Figure 45 and Figure 47, we found that the acres of habitat associated with GRF and Cutoff Channel alternatives were the highest, with Cutoff Channels providing a bit more habitat than GRF. Based on this qualitative evaluation of the relative impacts and benefits of the different alternatives, the Cutoff Channel alternative would likely provide both the least impacts and the most habitat benefits for both aquatic and riparian wildlife.

Table 27: Qualitative assessment of the alternatives' habitat impacts and benefits

Alternative	Substrate Impact	Noise/Heavy Equipment Impact	Native Vegetation Benefit	Aquatic Habitat Benefit
No Action	Low	Low	Low	Low
Limited Side Channels	Low	High	High	Medium
GRF after sedimentation	High	Medium	Medium	High
Cutoff Channels	Low	Medium	High	High
Bank Protection	Medium	Medium	Medium	Low

4.4.7 Level of Effort for Environmental Permitting

Section 404 of the CWA requires analysis if Reclamation were to propose to discharge fill material into water or wetlands of the United States. A wetland delineation and evaluation would be necessary to quantify the extent of wetlands affected by the various alternatives. Reclamation would seek authorization for such discharges either under one or more nationwide (general) permits or an individual permit. In either case, all conditions under permits would be adhered to during construction and monitoring after construction. Additionally, a water quality certification under Section 401 of the CWA would also be required from both the State of New Mexico and the Pueblo of Sandia. For CWA compliance, the GRFs, bed control, cutoff channels, and those activities that take place on Pueblo of Sandia lands would likely require an individual permit, while the limited side channels and vegetation destabilization that would occur off of Pueblo of Sandia could be authorized under various nationwide permits.

During a fifty-year period, the GRFs would likely only require one time of environmental permitting, but for the cutoff channels and limited side channels which are expected to need rehabilitation after approximately 10 years, the environmental permitting effort may be repeated five times over a fifty-year period.

5.0 Alternative Scoring

5.1 Evaluation Criteria

The alternatives were presented to an internal interdisciplinary team who evaluated the alternatives according to evaluation criteria which were based on the project's primary and secondary purposes: 1. reduce the risk of levee failure due to bank erosion and lateral river migration, and 2. improve ecological conditions, avoid negative community impacts, be suitable given the geomorphic trends, and be cost effective.

An engineering team evaluated the criteria as shown in Table 28, and an environment and lands team evaluated the criteria as shown in Table 29, and the results were discussed and agreed to by the entire group. Also, the Pueblo of Sandia participated in alternative scoring by evaluating the criteria shown in Table 30.

The evaluation criteria supporting the primary purpose were weighted highest, and the criteria supporting secondary purposes were weighted appropriately lower. The anticipated fifty-year costs were also included in the scoring to capture both economics and longevity. The anticipated fifty-year costs assumed bank stabilization methods were applied to five bends in the reach over the next fifty years. This provides a more adequate comparison to the reach-wide energy dissipation alternatives.

Table 28: Engineering and geomorphic suitability evaluation criteria

Evaluation Criteria	Description	Scoring Guide
Bank Protection	What is the conservative most likely level of bank protection offered, given the certainty?	Strong protection = 10 pts Medium protection = 5 pts No protection = 1 pts
Incision Protection	What is the conservative most likely level of incision protection offered, given the certainty?	Strong protection = 10 pts Medium protection = 5 pts Low protection = 1 pts
Suitability considering incision	Will the trends of incision inhibit the alternative from performing its levee protection purpose?	No = 10 pts Yes, but after 10 years = 5 pts Likely before 10 years = 1 pts
Suitability considering meandering	Will the trends of meandering inhibit the alternative from performing its levee protection purpose?	No = 10 pts Yes, but after 10 years = 5 pts Likely before 10 years = 1 pts
Suitability considering narrowing	Will the trends of narrowing inhibit the alternative from performing its levee protection purpose?	No = 10 pts Yes, but after 10 years = 5 pts Likely before 10 years = 1 pts
Likelihood of construction errors (Constructability)	Does the alternative require construction methods which the crew is unfamiliar with and which may increase the chances of failure due to incorrect construction?	No = 10 pts Some detriment = 5 pts Major detriment = 1 pts
Adaptability	How much monitoring and adaptive management resources would this alternative most likely need?	Low resources = 10 pts Medium Resources = 5 pts High resources = 1 pts

Table 29: Environmental evaluation criteria

Evaluation Criteria	Description	Scoring Guide
Aquatic Impact	Considers noise, disturbance, substrates, and increased flow velocities.	Low impact = 8 to 10 pts Medium impact = 5 to 7 pts
Riparian Impact	Considers disturbance, non-native vegetation or monotypic communities, and distance to water.	

Evaluation Criteria	Description	Scoring Guide
Community Concerns	Considers aesthetics, recreational or traditional uses, and loss of land or access.	High impact = 1 to 4 pts
Aquatic Habitat Benefit	Considers wetted area, areas with reduced flow velocities, and vegetation.	High benefit = 8 to 10 pts Medium benefit = 5 to 7 pts Low benefit = 1 to 4 pts
Riparian Benefit	Considers inundation areas, vegetation density or structure, and distance to water.	
Community Benefit	Considers aesthetics, recreational or traditional uses, and gain of land or access.	

Table 30: Tribal evaluation criteria

Score	Short Description	Full Description
10	Highly support	Provides good benefits relative to Pueblo management goals for the Bosque and Rio Grande; likely to succeed
7 to 9	Supportive	Provides good benefits relative to Pueblo management goals for the Bosque and Rio Grande; likely to succeed
4 to 6	Uncertain or ambivalent	Likely need more information before becoming fully supportive or non-supportive
1 to 3	Do not support	--

5.2 Results

Numerous scoring and ranking methods exist as engineering and decision-making tools. These scoring and ranking activities are useful in illuminating new considerations and eliminating biases, but they should not be substituted for engineering judgment.

Rankings for each group of evaluation criteria were calculated by totaling the weighted scores within each group of evaluation criteria and are shown in Table 31. Economics scoring was based on scaling the anticipated lifecycle fifty-year cost to values appropriately weighted compared to the other evaluation criteria categories. An overall ranking was calculated by totaling the weighted scores for all evaluation criteria. Complete scoring details are shown in Appendix D.

Table 31: Alternatives' final ranking on ability to meet objectives

Alternative	Engr. Rank	Environ. Rank	Tribal Rank	Econ. Rank	Overall Score	Overall Rank
Criteria Category Weighting	*3.6 (41%)*	*2.1 (24%)*	*2 (23%)*	*1 (11%)*	-	-
Longitudinal Riprap Stabilization	1	9	1*	8	*53.6*	1
Longitudinal Woody Stabilization	3	5	6*	11	*34.2*	7
Bank Treatments	8	4	1*	4*	*41.6*	4
No Bank Stabilization	10*	8	10*	4*	*11.1*	10
GRFs	4	7	6*	10	*32.4*	8
Bed Control	7	10	1*	2	*41.4*	5
Cutoff Channels	5	1	5	9	*47.2*	3
Bed Control + Cutoff Channels	2	2	4	7	*52.0*	2
Limited Side Channels	6	3	9	3	*37.8*	6
Vegetation Destabilization	9	6	8	1	*30.6*	9
No Energy Dissipation	10*	11	10*	4*	*8.0*	11

*tied rankings

Longitudinal riprap stabilization has been deemed to be the most effective tool overall in protecting the levees while considering secondary goals (habitat, community impacts, geomorphic suitability, and economics). The second most effective tool is the combination of cutoff channels and bed control, although there is some uncertainty about the effectiveness of this tool.

A sensitivity analysis was performed on these results by altering variables within a reasonable range such as the criteria weighting and the anticipated 50-year costs. It was found that these two alternatives consistently ranked at the top.

Rather than implementing only one of the top two alternatives, both alternatives used in combination would significantly improve the project's success in achieving the primary and secondary goals. Implementing longitudinal riprap stabilization without energy dissipation methods would only have a minor positive effect on habitat, and it would likely have high costs as the eroding bends migrate downstream and require continuous riprapping of the banks. On the other hand, implementing cutoff channels without riprap stabilization may be successful at protecting the bank for a time but the amount of protection provided is uncertain, and the cutoff channels' longevity is much shorter than the longitudinal riprap stabilization. Thus, it is recommended that these two tools be used in combination – longitudinal riprap stabilization for long-term bank protection, and cutoff channels plus bed control for delaying the need for additional bank protection and for habitat improvement.

While GRFs have excellent scores on incision protection, the incision criterion is only one component of the overall bank protection goal. The combined bed control and cutoff channels alternative provides comparable incision protection as the GRFs but for a lower fifty-year cost.

6.0 Proposed Alternative

Since the longitudinal riprap stabilization and the combination of bed control and cutoff channels are the highest rated alternatives, these tools will be used as appropriate considering the opportunities and constraints of each bend and point bar within the project area. The recommended placement of these alternatives at various bends is described below along with anticipated costs and proposed construction sequencing. The siting of the longitudinal riprap stabilization, bed control, and cutoff channels presented hereafter is based on the most suitable locations where they will provide the desired function to protect the levees and improve habitat. However, if further design-level analysis or stakeholder feedback identify the need for additional project modifications or deletions to the design, these potential modifications or deletions would need to be consistent within the findings of the alternative analysis and scoring exercise.

6.1 Design Components

The recommended conceptual design is shown in Figure 62. It includes longitudinal stone toe protection (LSTP) at the upstream three bends, floodplain benches behind these LSTP features, and cutoff channels on the upstream three point bars. Refer to Appendix E for suggested construction sequencing of these features.

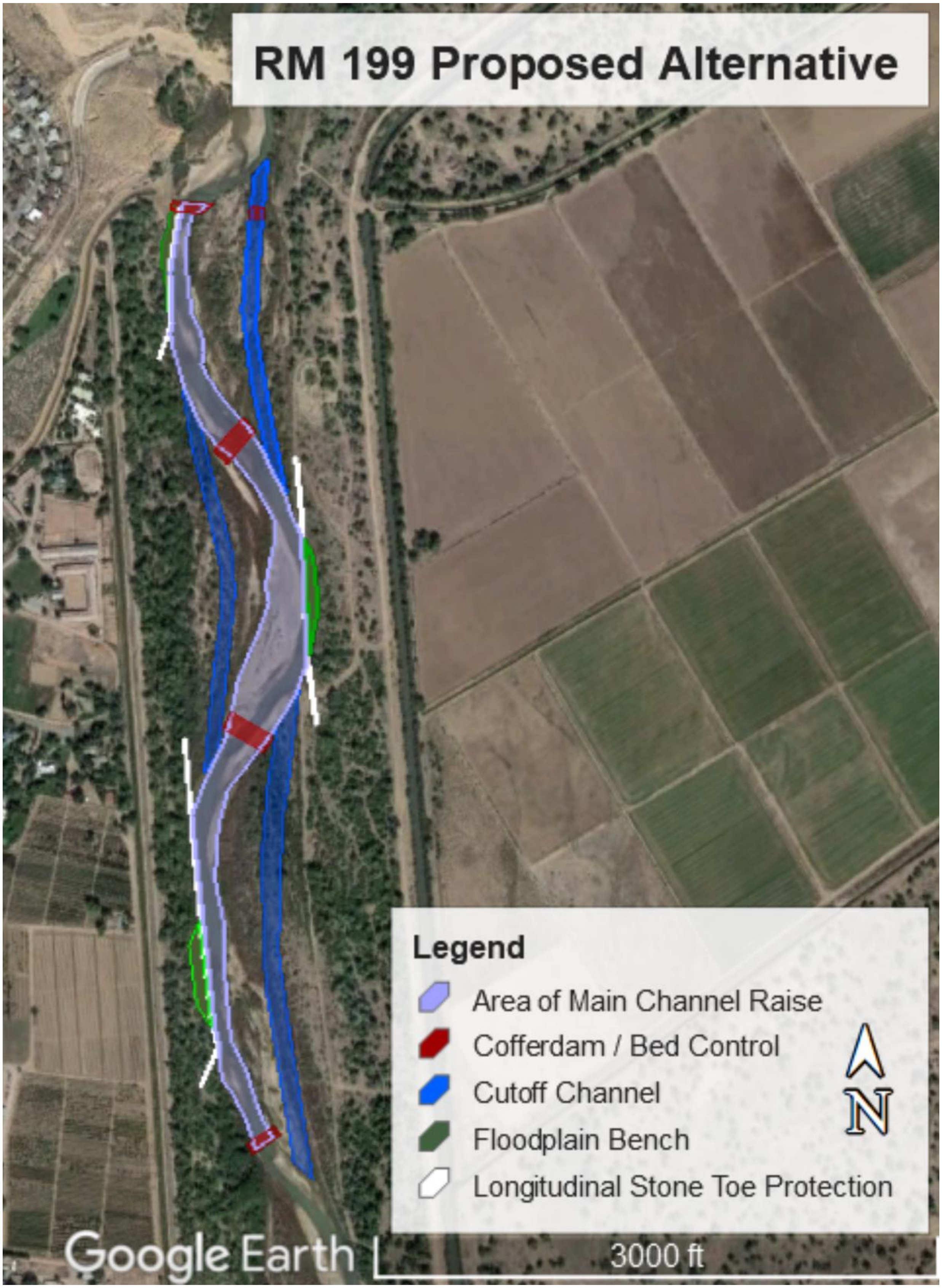


Figure 62: Proposed alternative design components

6.1.1 LSTP

The two bends with the highest risk of bank erosion into the levee are the Corrales Siphon bend and the RM 199 bend. Accordingly, LSTP will be placed at these bends. The rapidly migrating BB-343 bend has the ability to change the upstream approach angle into the RM 199 bend and thus will also be stabilized to avoid future flanking at the RM 199 bend. There is also benefit to the eastern levee at this location (BB-343 bend) by reducing the future threat of erosion towards the levee. The bends at CO-33 and at RM 198 currently do not need any stabilization, although RM 198 should be closely monitored for further erosion. Modeling results showing shear stress at these bends is shown in Figure 69 and provides further justification for these decisions.

6.1.2 Floodplain Benches

The three locations with LSTP will have tie backs and keys as extra safety measures to prevent erosion from progressing behind the toe protection. To minimize these features' impact on the community's highly valued mature cottonwoods, the LSTP will be placed out into the channel a small distance and backfilled with a floodplain bench and cottonwood and willow plantings. This reduction in channel width will be mitigated by including cutoff channels on the inner point bars. Also, the cutoff channels will provide the fill material necessary to create the floodplain bench. A potential configuration for the LSTP and floodplain bench is illustrated in Figure 63. This figure is from a Reclamation drawing set for a nearby river maintenance site (San Felipe RM 214.4).

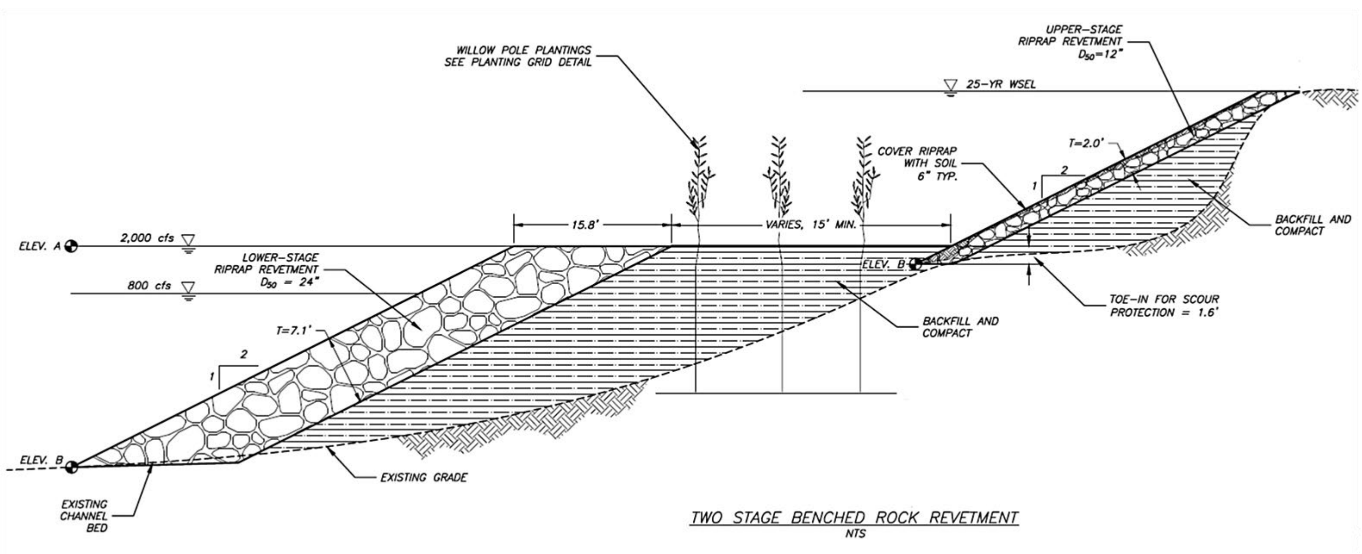


Figure 63: Example of a LSTP and floodplain bench

6.1.3 Channel Raise and Cutoff Channels

Not only are cutoff channels being used to support the floodplain benches, but the main channel raise from the cutoff channels' spoils is anticipated to raise groundwater levels which improves the health of the bosque and reduces the erosive forces along the banks (see Figure 34). The cutoff channels will be implemented on the three upstream point bars – the Corrales Siphon point bar, BB-343 point bar, and RM 199 point bar. Within the Corrales Siphon cutoff channel, a small layer of riprap will be placed immediately downstream of the siphon alignment to prevent potential downcutting to the elevation of the siphon by the cutoff channel work.

The CO-33 point bar will not have a cutoff channel since it is undesirable to alter the Pueblo's river access site characteristics. The RM 198 point bar will not have a cutoff channel since installation of a cutoff channel here would significantly affect the hydraulics upstream at the Pueblo's river access site. Also, these downstream two bends are the least incised in the project area and thus would receive the least benefit from the increased floodplain connection resulting from the cutoff channel.

6.1.4 Bed Control Features

The construction of the cutoff channels will require temporary riprap cofferdams (a rough conceptual diagram is shown in item (a) in

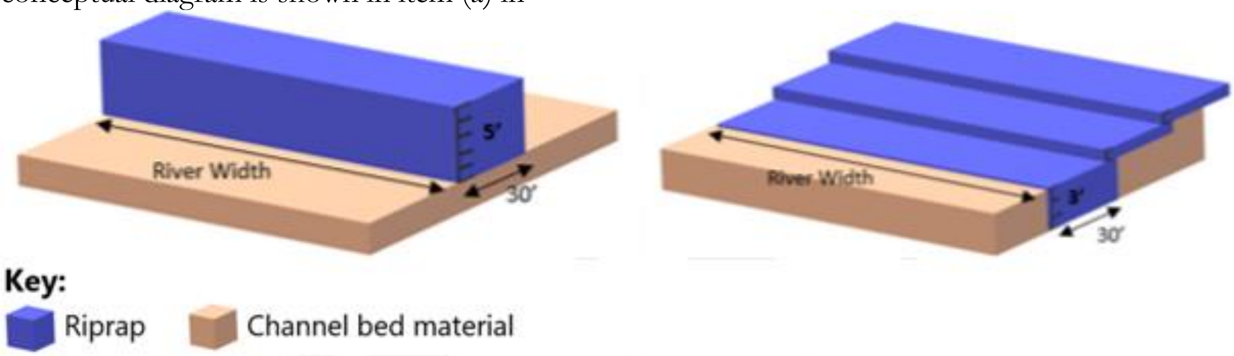


Figure 64). These cofferdams will extend across the existing channel at the natural riffle to divert flows into the cutoff channel. While the main channel is dry, spoil from the cutoff channels will be placed into the main channel. After three feet of spoil material has been placed upstream and/or downstream of the cofferdam (depending on cofferdam location), the top two feet of the cofferdam are smoothed out on top of the fill material to create a trenched bed control feature (Item (b) in

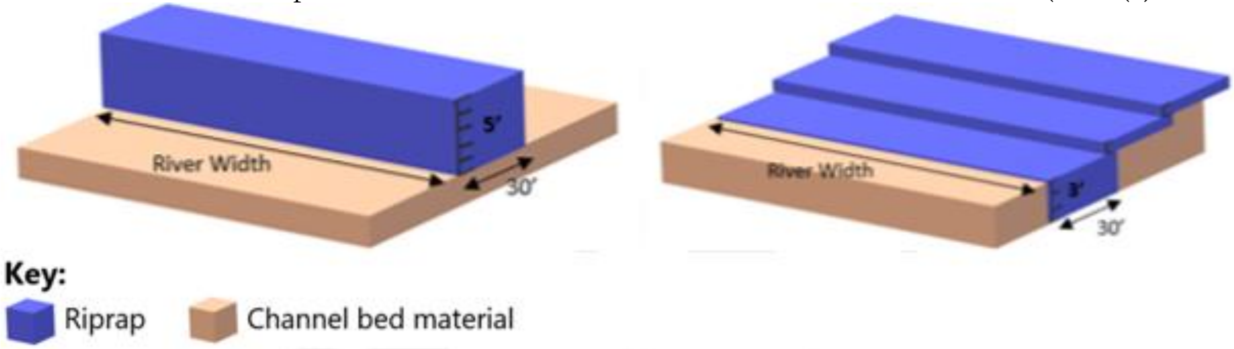


Figure 64). The goal of bed control feature is to reduce erosion of the spoil material. More details on this construction process and final dimensions are shown in Appendix F.

(a) (b)

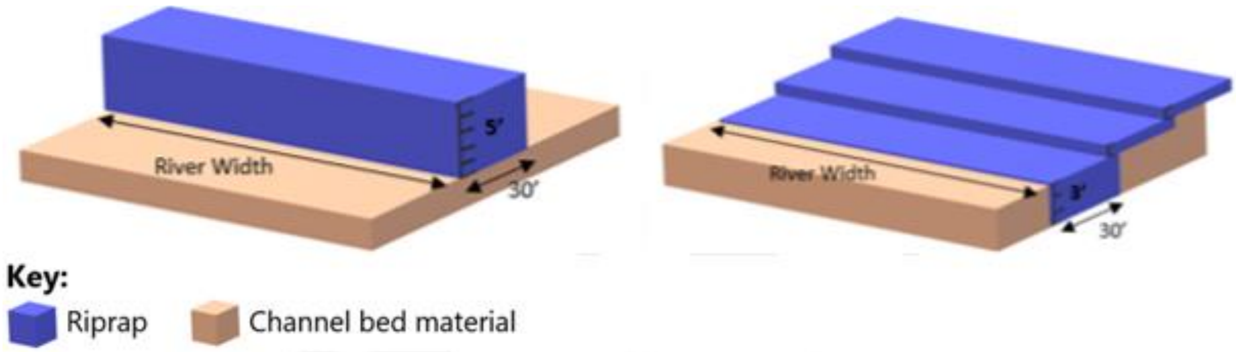


Figure 64: Rough conceptual diagram of the riprap cofferdam (a) and bed control feature (b)

The locations of the bed control are consistent with typical bed control siting between bends at the natural riffle. The bed control will include structural keys to tie the feature into the bank and prevent erosion laterally around the feature.

Bed control will also be included within the cutoff channel at Corrales Siphon to prevent incision from uncovering the siphon. Bed control may be included elsewhere within the cutoff channels as adaptive management if incision becomes problematic (see Section 6.3 for additional contingency planning).

6.1.5 Additional Habitat Features

Additional habitat features will likely be included in the final design including willow plantings along the cutoff channels and woody debris strategically placed as aquatic shelter.

6.2 Cost Estimate

The anticipated cost of this proposed alternative is $2.7 million. The breakdown of this estimate is shown in Table 32.

Table 32: Cost estimate of proposed alternative

Feature	Cost
Cutoff Channels (3 channels)	$600,000
Bed Control (4 structures at 3 bends)	$740,000
LSTP and Floodplain Bench at Corrales Siphon	$210,000
LSTP and Floodplain Bench at BB-343	$320,000
LSTP and Floodplain Bench at RM 199	$860,000
Total	**$2,730,000**

6.3 Contingency Planning

This section describes the type and likelihood of potential deterioration of the proposed alternative along with suggested preventions and, if necessary, the appropriate adaptive maintenance response.

While some of the proposed alternative components have been proven effective through many past applications such as LSTP, other components such as the combination of bed control and cutoff channels are a new application of proven river maintenance techniques. Widening the river and installing riprap transverse features have both been completed recently, and the basic engineering concepts have proven equations to appropriately size the features for the conditions; however, the river is likely to respond differently to the unique combination of features.

6.3.1 Longitudinal Stone Toe Protection

The most likely method of LSTP deterioration is from a hydrologic event larger than the design event. The hydraulic forces would create scour larger than the available riprap launch volume and there would not be enough riprap leftover to protect the bank. This would allow bank erosion around the scour, and depending on the size of the hydrologic event, the erosion could continue back behind other areas of the LSTP. It is highly unlikely that the hydrologic event would be large enough for the erosion to reach the levee after getting past the LSTP.

To prevent this kind of bank erosion, the volume of the LSTP riprap will be appropriately sized for a reasonable hydrologic event. Also, structural tie backs and keys will be implemented to prevent erosion behind the riprap material, as is standard in industry.

If a large hydrologic event caused riprap bank protection failure, fill material and additional riprap would be brought in to restore the bankline to its original alignment and the riprap to its original dimensions. The launched riprap would remain in place.

Another potential method of LSTP deterioration is if the LSTP becomes buried in sediment deposition as the thalweg shifts to another area of the channel. This would be an acceptable outcome and no adaptive maintenance would be necessary.

6.3.2 Cutoff Channels and Bed Control Features

Multiple types of deterioration could occur in the combination cutoff channels and bed control features. These are grouped by potential outcomes and discussed in Table 33 below.

Table 33: Cutoff Channels and Bed Control potential outcomes, potential causes, preventative actions, and potential corrective actions

Main Channel Degrades to Current Elevations	
Potential Future Condition	The raised main channel degrades to its current elevation and disconnects from the cutoff channels
Potential Causes	• Bed control failure during a hydrologic event based on riprap being sized too small for the hydraulic forces • Bed control failure if incision from downstream progresses upstream and the volume of launchable riprap in the bed control feature is inadequate to cover the drop The likelihood of these failures is based on hydrologic probabilities (if the flood event exceeds the design flood) and may occur in ten to thirty years.
Preventative (Design) Actions	• Size the bed control riprap diameter and volume adequately for a reasonable hydrologic event

	• Design the channel slopes adequately to degradation • Design the bed control feature spacing and frequency adequately to address long reach degradation • Design the bed control keys adequate to prevent flanking which can accelerate incision • Select appropriate factors of safety considering any uncertainties in the field data and engineering equations
Potential Corrective Actions	Since the cutoff channels were not intended to be permanent, but rather a temporary habitat and energy dissipation feature, no actions will be needed assuming at least a few years of beneficial use was experienced. If the main channel degrades to current elevations in the first year or two, action may be taken to repair the bed control if the benefits outweigh the costs. The total volume of fill material that will likely be placed in the channel is 42,000 CY or approximately 47,000 tons. The average annual suspended sediment load (not including bed load) past the USGS Albuquerque Central gage is 968,000 tons/year based on 2000 to 2019 data. If all the fill material were to erode within one year (which is unlikely), it would increase the total load by less than 5%. Compared to a suspended sediment load that was 57% higher between 1970 and 1997 than from 2000 to 2019, this is a minor increase and no corrective action would be needed.

Cutoff Channels Fill In	
Potential Future Condition	The cutoff channels fill in with sediment, redirecting most flows to the (raised) main channel. This reduces the overall channel capacity and flood flows will spread out more on the point bar floodplains at lower flow rates, which is beneficial to habitat. However, infrastructure may be at increased flood risk.
Potential Causes	Channel expansion and contraction, increased manning's roughness, and decreased hydraulic radius are some of the factors contributing to the sedimentation of side channels that frequently occurs on the Middle Rio Grande. This outcome is highly likely given enough time (possibly in five to ten years) and based on hydrologic probabilities with incoming water and sediment volumes.
Preventative (Design) Actions	• Avoid adding unnecessary expansion and contraction zones (such as complex multi-thread channels) • Maximize slope by reducing cutoff channel sinuosity • Optimize hydraulic radius for sediment transport while maintaining side slopes that are beneficial to habitat
Potential Corrective Actions	The infrastructure flooding risk should be analyzed based on the level of aggradation, and if the risk is deemed too high, the sedimented cutoff

	channels may be partially or fully excavated. If the infrastructure flooding risk is acceptable, no action is needed.

Unintentional Channel Realignment	
Potential Future Condition	The existing main channel fills in with sediment and one or more of the cutoff channels become the main flow path. This may be accompanied with incision and bank erosion along the cutoff channel(s).
Potential Causes	• The lack of bed control within the cutoff channels may cause the cutoff channels to incise. As the cutoff channel incises, more of the flow goes into this channel, further increasing the flow depth and thus incision. Although this is a possibility, it is more likely that the cutoff channels will aggrade since typical behavior on the MRG is to aggrade within the smaller flow path while the larger flow path remains open. • It is possible that the flow prefers the cutoff channels due to the alignment. Meandering flow paths are a complex science and even with three-dimensional flow modeling software, it would be difficult to predict the likelihood of the flow preferring the cutoff channels based on the alignment.
Preventative (Design) Actions	The cutoff channels will be designed to allow a maximum of one third of the total flow, and the channel will be designed with shallower side slopes than the main channel. This flow limitation and reduced

	hydraulic radius will make it more likely that the cutoff channels will experience more sedimentation than the main channel.
Potential Corrective Actions	Cross section monitoring will occur during the first few years following construction. If rapid incision is found in the cutoff channels (greater than around a half foot) a small amount of riprap bed control could be placed in an appropriate location. MRGCD has expressed concerns about cutoff channel incision at Corrales Siphon and this location will be closely monitored. If a realignment occurs, this would benefit channel and floodplain habitat diversity; however, community members may find a realignment unfavorable due to perceived land loss considerations. If a realignment occurs and the community requests correction, fill material or riprap could be placed at the cutoff channel's entrance to redirect more flows back to the main channel. If necessary, a pilot channel could be excavated in the main channel to encourage a new flow path.

Significant Channel Aggradation	
	The channel aggrades significantly and poses an infrastructure flooding risk.
Potential Causes	The widening of the channel will slow flow and cause sediment to drop out. Typical narrowing trends for the MRG suggest that the sediment will drop out on the edges, become vegetated, and leave a single thread channel which will not aggrade but rather would incise if not for the presence of bed control. Thus, this potential future condition is extremely unlikely but worth discussing.
Preventative (Design) Actions	No design actions are needed; activities which would make this scenario more likely will be avoided such as large-scale bank vegetation removal and large-scale woody debris placement.
Potential Corrective Actions	If analysis reveals the infrastructure flooding risk requires action, pilot channels can be dug to encourage concentration of flows and subsequent degradation.
Erosion Laterally Around Bed Control (Flanking)	
Potential Future Condition	The channel would erode laterally around the bed control feature(s) and likely incise in its new alignment.

Potential Causes	If the bank erodes near the bed control structural keys and the riprap sizing or volume in the structural keys is inadequate for the hydraulic forces and/or volume of erosion, then the keys could fail, allowing bank erosion to circumvent the bed control feature.
Preventative (Design) Actions	• Size the bed control structural keys' riprap diameter and volume adequately for a reasonable hydrologic event • Select appropriate factors of safety considering any uncertainties in the field data and engineering equations
Potential Corrective Actions	While bank erosion benefits channel and floodplain habitat diversity, it would potentially allow channel incision and it looks negative to the public. Reclamation would remove any trees that fell into the river as a result of the bank erosion (assuming the bed control feature exacerbated the bank erosion), and as appropriate riprap would be brought in to repair the failed bed control structural keys.

The most likely outcomes from this table is that the cutoff channels will fill with sediment (as side channels typically do on the MRG). This is an acceptable outcome, as side channels are considered to be temporary features providing habitat and energy dissipation benefits for only five or ten years. The raised main channel will likely continue to provide habitat and energy dissipation benefits for a slightly longer period before that feature also naturally deteriorates, which is again an acceptable outcome.

7.0 Summary and Recommendations

The project purpose at River Mile 199 is to reduce the risk of levee failure due to bank erosion and lateral migration of the Rio Grande. Additional goals include improving ecological conditions, avoiding negative community impacts, being suitable given the geomorphic trends, and being cost effective.

Multiple alternatives for meeting this project purpose were evaluated in this report including bank stabilization options (longitudinal riprap protection, longitudinal woody protection) and energy dissipation options (GRFs, cutoff channels, limited side channels, bed control features) and no-action alternatives. The descriptions of the alternatives and the results of the analysis were presented to a multi-disciplinary Reclamation team to score and rank the alternatives, as well as to the Pueblo of Sandia Department of Natural Resources.

The scoring exercise found that the top two ranking alternatives are longitudinal riprap stabilization and cutoff channels plus bed control. The longitudinal riprap stabilization will take the form of a longitudinal stone toe protection. This design method focuses the stone protection at the toe while incorporating willow plantings on a floodplain bench for additional bank stability and habitat improvement. The "cutoff channels plus bed control" is an alternative which raises the main channel and widens the flow area. The alternative includes large side channels through the meanders' inner point bars. The spoil material from these channels are placed in the existing river channel (while flows are diverted) which significantly improves floodplain connection in this severely incised reach. To minimize erosion of the newly placed spoil material, riprap bed control is strategically placed throughout the reach.

These two alternatives best meet the goals of the project when they are used in combination; thus, a new proposed alternative was generated that applies the tools at the appropriate locations based on risk and opportunity. This proposed alternative implements longitudinal stone toe protection with floodplain benches, channel raising, side channels, and bed control at the Corrales Siphon bend, the BB-343 bend, and the RM 199 bend.

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9.0 Appendices

Appendices A and B demonstrate the investigations undertaken in formulating the alternatives analyzed in this report. Appendix C provides supplemental information on the results of modeling the alternatives. Appendix D provides supplemental information on the scoring used in selecting the proposed alternative. Appendices E and F provide clarification of specific details of the proposed alternative.

9.1 Appendix A: Bank Stabilization Alternative Formulation Investigations

9.1.1 Bank Stabilization Method Tables

Longitudinal Features

Table 34: Longitudinal Features

Method	Level of Confidence	Advantages	Disadvantages	Geomorphic Effects	Habitat Effects
Riprap Revetment	Level 3	Thoroughly tested and used for a wide range of conditions and can be designed with a high degree of precision and confidence. Provides maximum protection for riverside infrastructure.	Decreased channel width and increased depth. Creates a local static bank line. In some cases, riprap revetments can lead to accelerated bank erosion of downstream bends.	Eliminates local bank erosion; causes local scour and channel deepening. Studies about longer reach response are contradictory. Can be susceptible to flanking if upstream channel migration occurs. Prevents local bend migration and the establishment of new depositional zones. Eliminates sediment supplied from bank erosion. The point bar can remain connected to the main channel. The flow velocity, depth, and bank angle would be greater than typically found in natural channels along the outside bank of a river bend. Interstices within the riprap could host low-energy "pockets" along the bank.	Prevents bend migration and the establishment of new depositional zones where vegetation could become established. Eliminates sediment supplied from local bank erosion. The steep bank angle on the outside of the bend limits fish cover, except for the riprap interstitial spaces. The point bar remains connected to the main channel and remains static. The flow velocity and depth are greater than typically found in natural channels along the outside bank of a river bend.
Other Type of Revetments	Level 2	In general, these methods are widely tested and used, while deformable bank lines are less well understood.		Effects are essentially the same as riprap revetments.	Effects are essentially the same as riprap revetments.
Longitudinal Stone Toe with Bioengineering				Similar to riprap revetment.	Same as riprap revetment. Bioengineering provides very minimal benefits to riparian community.
Trench Filled Riprap	Level 2.				Same as riprap revetment.

Method	Level of Confidence	Advantages	Disadvantages	Geomorphic Effects	Habitat Effects
Deformable Stone Toe/Bioengineering and bank lowering	Level 2 (Riprap Sizing) and Level 1 (Lack of Design Guidelines and Postproject Studies)	The design is intended to allow bend migration at a slower rate than without protection. Bank line vegetation is established.	River maintenance still may be required in the future. Water surface elevations could be lower with bank lowering. After installation, and before the toe of the riprap becomes mobile, the channel bed may scour along the deformable bank line.	The design is intended to allow bend m1grat1on at a slower rate than without protection. River maintenance still may be required in the future. Water surface elevations could be lower with bank lowering After installation, and before the toe of scour along the deformable bank line. Bank erosion occurs during peak-flow events, which mobilize the small-sized riprap along the bank toe. Future bank migration would allow new depositional surfaces to be established	If flood plain is created behind the stone toe and vegetation becomes established before the toe is lost, an expanded riparian area could develop. Future bank migration would allow new depositional surfaces to establish, which would become new riparian areas
Bioengineering Riparian Vegetation Establishment	Level 2	Restores flood plain riparian areas.	Plantings can have a large mortality rate unless planted at the specific elevation to receive water but not too shallow to be excessively inundated.	Can cause sediment deposition in overbank areas due to increased flow resistance. Sediment deposition in the overbank can increase main channel sediment transport capacity by raising the bank height.	Directly adds to the amount of riparian vegetation. Increased growth of riparian vegetation in overbank areas can enhance habitat conditions for both the flycatcher and the silvery minnow. Encroachment of mature vegetation eventually may lead to a narrower and more confined channel that is negative for silvery minnow habitat.

Transverse Features

Table 35: Transverse Features or Flow Deflection Techniques

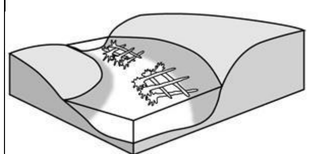
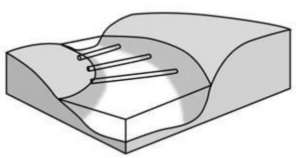
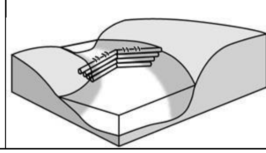
Method	Level of Confidence	Advantages	Disadvantages	Geomorphic Effects	Habitat Effects
Bendway Weirs	Level 2 (Limited Design Guidelines Available) and Level 1 (Lack of Quantitative Design Guidelines and Post-project Studies)	Flows are redirected throughout the flow field. The outer bank toe can become a zone of low velocity and a zone of sediment deposition. Aquatic habitat is improved because bendway weirs create variable depth and velocity habitat.	Weir fields must have sufficient spacing to protect the banks and weir roots so that if bank scalloping occurs, the weirs riverside infrastructure remains protected. Regular monitoring and maintenance are required. Velocity over the weirs along the bank accelerates which can cause a bank shelf to develop in addition to scalloping.	The location of the thalweg is shifted away from the outer bank line. Local scour at the tip occurs because of the three-dimensional flow patterns. Secondary currents are interrupted, and flows are redirected away from the bank. The outer bank can become a zone of lower velocity. The combined effect of the tip scour and lower velocity along the bank line creates a flow condition of variable depth and velocity. Scalloping also can occur along the bank line or sediment deposition between structures, depending upon local conditions and bendway weir geometry. Can reduce local sediment supplied from bank erosion because the current river alignment is maintained.	Sediment deposition between structures may allow establishment of riparian vegetation and backwater areas. Channel deepening and tip scour could occur locally. Depending on site specific details, bendway weirs would allow for overbank flooding conditions for flycatchers. Local scour could provide habitat diversity and deep habitat during low-flow conditions.

Method	Level of Confidence	Advantages	Disadvantages	Geomorphic Effects	Habitat Effects
Spur Dikes		Spur dikes modify channel alignment and provide erosion protection for riverside structures. Provides variable velocity and depth habitat. Can induce sediment deposition.	The bank line between spur dikes can erode when the spur dike spacing is too large. Over time, the channel deepens, increasing flow capacity. Local channel narrowing can occur. The extent of channel deepening and narrowing cannot be predicted with great reliability. The bank line is fixed, thus interrupting fluvial processes.	Spur dikes block the flow up to bank height, thus shifting the thalweg alignment to the dike tips. Peak flow capacity can be reduced initially until the channel adjusts. The channel adjusts to the presence of spur dikes by forming a deeper, narrower cross section with additional scour downstream from each spur dike Sediment deposition can occur between spur dikes. There is a greater tendency for sediment deposition between spur dikes than the other transverse features.	Same as bendway weirs above. There is a greater tendency for sediment deposition between spur dikes than the other transverse features.
Vanes or Barbs	Level 2 (Limited Design Criteria) and Level 1 (Very Little Design Test Data)	Reduces streambank erosion, modifies flow direction, creates local scour, and gains environmental benefits. Vegetation can grow on sediment deposits between vanes where sufficient supply exists for sediment to deposit between vanes. Vanes generally require less rock than other structures for a similar length of bank line.	The low volume of rock near the tip of the vane often launches into the scour hole, requiring regular maintenance. Bank scalloping between vanes is common and can lead to vane failure. Long-term bank protection is usually only achieved when sediment deposition occurs between vanes.	These structures redirect flow from the bank toward the channel center and reduce local bank erosion while providing a downstream scour hole. Sediment deposition or bank scalloping can occur along the outer bank, depending upon spacing.	Same as bendway weirs above.
J Hook	Level 2 (Limited Design Criteria) and Level 1 (Does not Have a Documentable Track Record and Very Little Design Test Data)	Same as vanes with a "J" hook added. The "J" tip creates a scour pool in the channel bed, which increases the amount of pool habitat. The rest of the vane provides variable depth and velocity habitat.	"J" hook at the center of the channel is subject to scour erosion. This structure requires more riprap and more in channel construction than vanes. The "J" tip can fill with sediment in sand and fine gravel bedded channels. The remainder of the disadvantages is the same as for	Redirects flow away from eroding banks, the same as vanes or barbs, with an added downstream-pointing "J" configuration. The J-hook creates an additional scour hole pool and can produce a local downstream riffle. Remainder of the geomorphic response is the same as for vanes.	Same as bendway weirs described above. Additional pool habitat is created by the J-hook.
Trench Filled Bendway Weirs	Level 1	Work is away from the bankline. Same as Bendway Weirs.	Same as Bendway Weirs.	Once the bank erosion reaches the bendway weir tips, the flow is redirected away from the eroding bank. The location of the thalweg is shifted away from the outer bank line. Local scour at the tip occurs because of the three-dimensional flow patterns. Secondary currents are interrupted. The outer bank can become a zone of lower velocity.	Provided the bendway weirs constructed in a trench remain intact, the habitat characteristics will be about the same as bendway weirs constructed in the channel.
Boulder Groupings	Level 2 Cross Channel Because Constructed Out into the Channel	Adds local roughness elements, local areas of variable depth and velocity, and is simple and natural looking in many contexts.	Can often become mobile and lose the shape of the cluster. Do not provide benefits in depositional zones.	Creates a zone of local scour immediately downstream from the boulders. Creates areas of variable depth and velocity. Creates velocity shear zones. Effects are localized to the immediate vicinity of the boulders. Increases channel roughness at high flows. Adds complexity to the	Can provide structure and habitat for fish.

Method	Level of Confidence	Advantages	Disadvantages	Geomorphic Effects	Habitat Effects
Rootwads	Level 2 Bank Stab Bank Line Feature	Can create in stream cover, pool formation, deflect flows, retain gravels, and create complex hydraulics.	Length of benefit is usually between 5 and 15 years depending upon the durability of the available tree species.	Creates local scour pools and areas of variable velocity. Increases flow resistance along the bank line, which dissipates energy, traps and retains sediments, and creates turbulence that can move the main current away from the bank line. Adds complexity to the system. Variable depth and velocity conditions can be created. Some potential for creating areas of sediment deposition (depending on specific placement). Cottonwood tree rootwads have a design span of about 5 years; therefore, this method has been used with many other methods to create habitat	Adds complexity to the system. Variable depth and velocity conditions can be created. Some potential for creating areas of sediment deposition (depending on specific placement), which is generally beneficial to the establishment and development of riparian vegetation. Can provide structure and habitat for silvery minnow. Isolated pools often are maintained in scour pools caused by debris, including rootwads. This can serve as refugia habitat for silvery minnow during low-flow periods. Similar to LWD. Could trap sediment and encourage new native vegetative growth.
Large Woody Debris	Level 2	Can create in stream cover, pool formation, deflect flows, retain gravels, and create complex hydraulics. LWD is a natural material.	Length of benefit is usually between 5 and 15 years depending upon the durability of the available tree species.	LWD can provide local stream cover and scour pool formations, can deflect flows and increase depth and velocity complexity. Can promote side channel formation and maintenance. LWD in the Middle Rio Grande can lead to sediment deposition, including formation of islands, in reaches with large sand material loads. Could establish new sediment deposition areas. LWD constructed from cottonwood trees last about 3-5 years.	Adds complexity to the system. Sediment deposition can create areas where new riparian vegetation becomes established Can create variable depth and velocity habitat. Can provide structure and habitat for fish. May provide for habitat diversity in areas with monotypic flow patterns and refugia habitat during low flows. These habitats also may provide refuge for predatory fishes. Increased areas of moist or flooded soil conditions could assist in flycatcher territory establishment and native vegetation recruitment.

Wood Instream Structures

Table 36: Classification of large wood instream structures (from USBR and ERDC, 2016)

Configuration	Sketch	Description	Functional Role and Strengths and Weaknesses	References
ELJs or flow deflection jams		Intermittent structures built into eroding banks by stacking whole trees and logs with rootwads in crisscross arrangements. Often filled with gravel or cobble as ballast. Large quantities of smaller wood (*racked debris*) may be added to upstream face.	Emulates natural formations if dimensions and spacing vary. Creates diverse physical conditions, traps additional debris. Suitable for banks subject to mass failure.	Abbe et al. 1997; Drury et al. 1999; Drury 1999; Shields et al. 2004; Brooks 2006; Brooks et al. 2006
Log vanes/step jams		Single logs or small bundles of logs secured to bed. Also called log bendway weirs (if partially spanning channel and angling upstream) or log steps (if fully spanning channel, and usually placed perpendicular to channel). Ends of logs held in place by burying in sediment or in bank, or secured against trees, boulders, or bedrock.	Low-cost, minimally intrusive. Generally limited to channels with low banks not subject to mass failure. May be used to retard bed erosion (fully spanning logs) or divert flow away from concave bank (log bendway weirs). High failure rates due to undermining by downstream scour hole.	Derrick 1997; ODFW 2010 provides nine configurations.
Log weirs/valley jams		Weir-like accumulations built around one or more large logs (key members).	Creates pool habitat. Prone to failure by flanking or undermining.	D'Aoust and Millar 2000

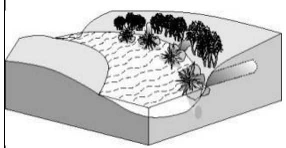
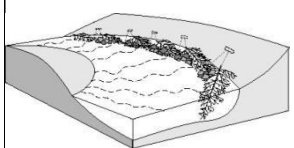
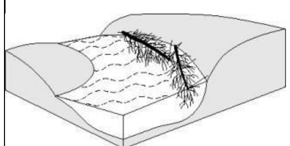
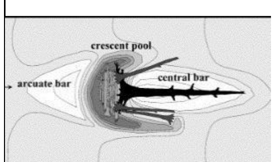
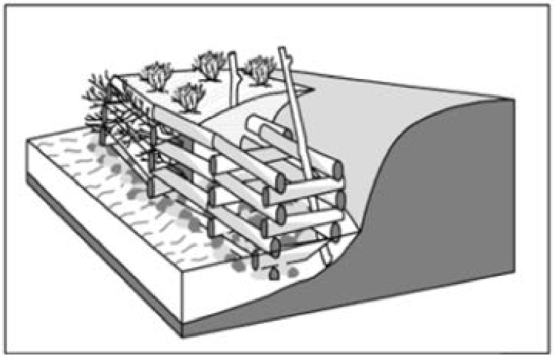
Configuration	Sketch	Description	Functional Role and Strengths and Weaknesses	References
Rootwads or meander jams		Logs buried in bank with rootwads protruding into channel. Usually placed on outside of bends.	Protects low banks by reducing shear stress acting on bank toe, provides scour pools with woody cover Accumulates fluvially transported wood. Does not emulate natural features.	Wood and Jarrett 2004
Tree revetments or roughness logs or bench jams		Whole trees placed along bank parallel to current. Trees are overlapped (shingled) and securely anchored or lodged into bedrock outcrops, boulders, or other obstructions.	Deflects high flows and shear from outer banks; may induce sediment deposition and halt erosion. Provides complex cover until smaller branches decay or break away.	Cramer et al. 2002
Toe logs		One or two rows of logs or whole trees running parallel to current and secured to bank toe. Gravel fill may be placed immediately behind logs.	Temporary toe protection. Generally only for low banks because banks above toe remain unprotected and therefore allow toe logs to be flanked if banks are high and erodible.	Cramer et al. 2002; Brooks 2006
Bar apex jam		Wood structure composed of 10– 30 logs placed in the middle of the channel to initiate bar formation or placed on the upstream end of an existing bar or island.	Readily accumulates fluvially transported wood. Designed to emulate a commonly occurring natural large wood formation.	Abbe and Montgomery 1996; Cramer 2012; Brooks 2006

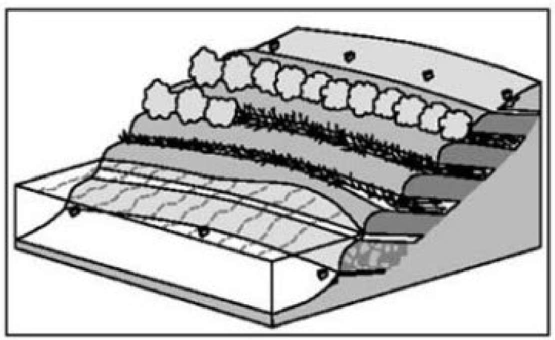
Table 37: Descriptive List of Channel and Bank Protection Techniques (abbreviated from McCullah and Gray, 2005)

LIVE CRIBWALLS



A cribwall is a gravity retaining structure consisting of a hollow, box-like interlocking arrangement of structural beams (for example, logs). The interior of the cribwall is filled with rock or soil. In conventional cribwalls, the structural members are fabricated from concrete, wood logs, and dimensioned timbers (usually treated wood). In live cribwalls, the structural members are usually untreated log or timber members. The structure is filled with a suitable backfill material, and live branch cuttings are inserted through openings between logs at the front of the structure and imbedded in the crib fill. These cuttings eventually root inside the fill and the growing roots gradually permeate and reinforce the fill within the structure.

VEGETATED MECHANICALLY STABILIZED EARTH



This technique consists of live cut branches (live brushlayering) interspersed between lifts of soil wrapped in natural fabric, for example, coir, synthetic geotextiles (turf reinforcement mats [TRMs] or erosion control blankets [ECBs]), or geogrids. The fabric, branches and optional geogrids provide the primary geotechnical reinforcement, similar to that of conventional mechanically stabilized earth, allowing relatively steep, stable slopes. The fabric wrap over the face of the soil lift prevents erosion until vegetation takes over. The live, cut branches eventually root and leaf out, providing vegetative cover and secondary reinforcement as well. This technique is recommended for use above the annual high water stage.

9.1.2 Crib Wall Designs

The typical section of a log crib wall used on a small stream is shown below. This design could be implemented at the RM 199 outer bend assuming larger dimensions since larger wood would be used.

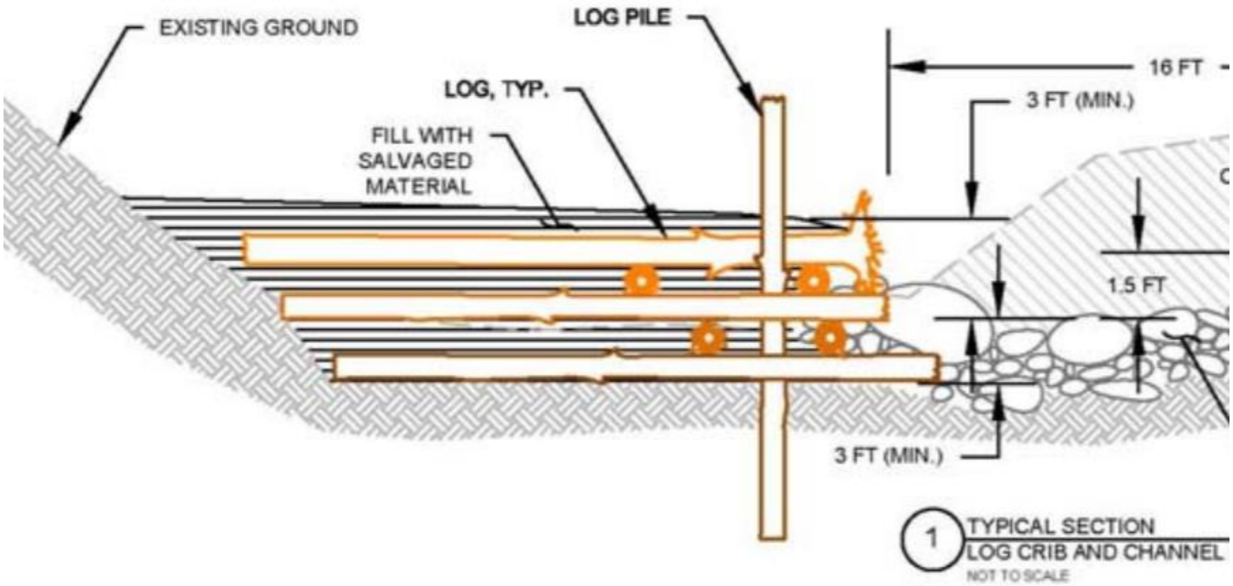


Figure 65: Typical section of a log crib wall design (Lee et al., 2015)

The incline of the crib wall can be adjusted to allow a more gradual slope for better habitat. In one study of 12 cribwalls in Ontario, the cribwall inclines varied between 25 and 55 degrees, and the data suggested the incline did not affect structural stability (Krymer and Robert, 2013).

9.1.3 Stone Toe with Bioengineering Design

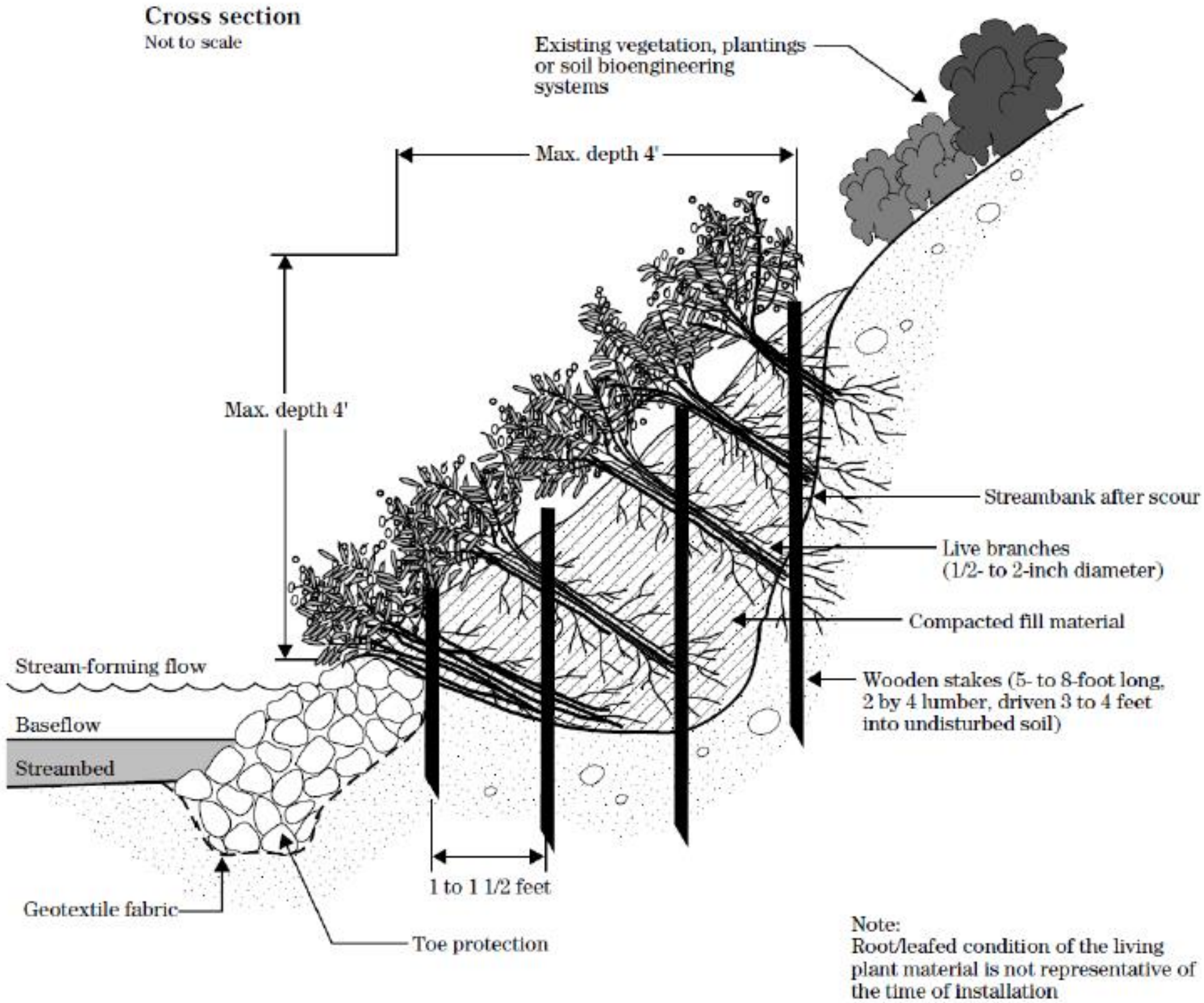


Figure 66: Longitudinal stone toe with bioengineering (Baird et al., 2015)

9.1.4 Bend Curvature

For re-directive flow techniques (such as bendway weirs and rock vanes), the migration rate, incision trends, and bend curvature may impact the effectiveness of the features. Baird et al. (2015) state that if the angle of attack changes due to upstream channel migration, the re-directive flow features and bank can erode. NRCS (2007a) states that re-directive flow techniques are not suitable when the foundation around the feature may incise or aggrade. Many literature sources do not place restrictions on the bend curvature of re-directive flow techniques (Baird et al., 2015; McCullah and Gray, 2005); however, NRCS (2007a) states that there are often problems with erosion below a re-directive flow feature for bends with a radius of curvature over top width (Rc/W) of less than 3. This information suggests a low level of risk present with re-directive flow techniques on small-radius actively meandering bends.

In 2018, the only bend in the RM 199 project area which had a Rc/W less than 3 was the bend at the Arroyo de la Barranca. After the 2019 runoff the Corrales Siphon bend transitioned from a simple bend to a compound bend with two radii of curvature which both had Rc/W of approximately 3. Table 38 provides data on bend curvature in the reach and demonstrates the rapidly changing geometry of this stretch of river.

Table 38: RM 199 bend curvature based on 2018 and 2020 aerial imagery

Bend	Radius of Curvature (Rc)	Top Width (W) (feet)	Rc/W
Arroyo de la Barranca	~340	~170-240	~1.4-2
Corrales Siphon (measured as a simple bend, 2018)	~1700	~120-170	~10-14
Corrales Siphon upstream (measured as a compound bend, 2020)	~430	~120-170	~2.5-3.6
Corrales Siphon downstream (measured as a compound bend, 2020)	~410	~120-170	~2.4-3.4
BB-343 (2018)	~1050	~115-220	~5-9
BB-343 (2020)	~970	~170	~5.7
RM 199	~2500	~115-270	~9-22
RM 199 upstream (measured as a compound bend, 2020)	~870	~120	~7
RM 199 downstream (measured as a compound bend, 2020)	~1240	~140	~9
CO-33	~1000	~150-240	~4-7
RM 198	~2000	~115-225	~9-17

9.1.5 Levee Failure Cost Estimate

Based on estimates from San Felipe bankline stabilization projects, riprap bank stabilization costs approximately $600/LF of bank stabilized. This includes all construction costs and additional engineering and environmental features such as tie backs and keys.

If the river meandered into the levee, the levee may need anywhere from 500 to 1,500 feet of linear repairs. This repair cost would have an estimated range of $300,000 to $900,000. Also, if the levee breached there would be repair and replacement costs associated with damages to the riverside irrigation canals, roads, adjacent infrastructure, and private property. This value is highly variable depending on if the breach is adjacent to Corrales homes, businesses, agricultural fields, or Pueblo agricultural fields.

9.2 Appendix B: Energy Dissipation Alternative Formulation Investigations

9.2.1 Considerations for a potential river bed raise

One of the detrimental conditions in this area is a disconnection of the floodplain from the river. One method to improve floodplain connection is to raise the river bed. A river bed raise will have varying impacts depending on the height of the raise. The impact of a shorter raise is that the river will have greater access to the floodplain which subsequently dissipates flow energy. A higher raise will not only increase floodplain access, but also re-engage the root zone from the abandoned terrace. Engaging the root zone can have a significant impact on slowing erosion. Currently, there is minimal protection against bank erosion in this area since the bank toes are located well below the root zone in non-cohesive sand.

This section will investigate the required height of a river bed raise to re-engage the root zone, and it will demonstrate the increasing floodplain access for varying heights of river bed raises.

Considerations to re-engage root zone of abandoned terrace

A cursory review for this report showed that the maximum distance from channel bed to top of bank (hereafter "bank height") in non-eroding areas in the Albuquerque reach is around five feet.

This value was then applied to the RM 199 project area as a maximum bank height goal. To make the maximum bank height to the abandoned terrace less than 5 feet in this reach, the river bed would have to be raised between approximately seven feet. A channel bed raise of seven feet would be difficult to achieve due to the required 7-foot drop at the end of the project area. Even if the 7-foot drop was spread out over a long distance, this would still be a very steep slope unless it was spread out for multiple miles (see Section 9.2.1 "**Error! Reference source not found.**" for further discussion on slopes).

Another consideration is that the abandoned terrace in this reach may be artificially high. The abandoned terrace elevation was likely established during the aggradational years in the first half of the 20th century, when channel incision was intentionally pursued to protect infrastructure and agriculture from the rising channel (U.S. House of Representatives, 1949). Thus, although most of the bank erosion is due to the lack of root structure on the abandoned terrace, the abandoned terrace may too high to reasonably reconnect hydrologically.

In conclusion, rather than raising the river to reconnect to the abandoned terrace, a better goal is to lower the abandoned terrace to a level that is hydrologically connected and can provide natural vegetative bankline stability.

Corrales Siphon considerations

Although Corrales Siphon's maintenance is the responsibility of MRGCD, it is useful to be aware of the potential impact of a river bed raise on the siphon.

Table 39: Elevations around the Corrales Siphon

Location	Elevation	Data Source
BB-339 (cross section immediately upstream of Corrales Siphon)	5027.2 feet (Thalweg)	May 2018 Survey
Corrales Siphon Top of Pipe	5028.9 feet	As-built construction drawings (Nemeth and Donnelly, 2007)
BB-340 (cross section immediately downstream of Corrales Siphon)	5024.8 feet (Thalweg)	May 2018 Survey

The elevation difference between the siphon's top of pipe and the thalweg at BB-340 (which is 340 feet downstream) is 4.1 feet.

Slope investigation

At the downstream end of the project, any channel raise implemented will have to be returned to existing grade, which would be steeper than the existing slope. Table 40 shows the amount the existing slope would potentially be increased for a one, two, or three foot drop over varying distances.

In the Highway 550 to Montano reach, natural and man-made features have created localized zones of steep slopes. Table 41 shows the slopes at these features, as well as the normal slopes for the subreaches.

Table 40: Potential increase in slope for the drop feature

Drop Distance (feet)	Potential Slope Increase (feet/feet)		
	One-foot drop	Two-foot drop	Three-foot drop
500 feet	0.0020	0.0040	0.0060
1,000 feet	0.0010	0.0020	0.0030
3,000 feet	0.0003	0.0007	0.0010
5,000 feet	0.0002	0.0004	0.0006

Table 41: Slopes for local features and subreaches using May 2018 cross section data

Feature or Subreach	Slope (feet/feet)	Bounding Cross Sections
Features		
Arroyo de la Barranca	0.0016	BB-338 to BB-339
Corrales Siphon	0.0042	BB-339 to BB-340
North Diversion Channel	+0.0001 (upward gradient)	CR-394 to CR-400
ABCWUA Diversion Dam	0.0044	CA-2 to CA-3
Calabacillas Arroyo Delta (flat zone)	0.0001	CA-3 to CA-11
Drop downstream of Calabacillas flat zone	0.0015	CA-11 to CR-438

Feature or Subreach	Slope (feet/feet)	Bounding Cross Sections
Subreaches		
HWY 550 to Arroyo de la Barranca	0.0006	BB-301 to BB-338
RM 199 project area	0.0010	BB-338 to CR-361
RM 199 project area not incl. drop features	0.0008	BB-340 to CR-361
CR-361 to North Diversion Channel	0.0008	CR-361 to CR-394
North Diversion Channel to ABCWUA	0.0008	CR-400 to CA-2
ABCWUA to Calabacillas Arroyo	0.0003	CA-3 to CA-7
Downstream end of RM 199 Project Area		
Second-to-last set of cross sections in project area	0.0009	CO-33 to CR-355
Last set of cross sections in project area	0.0012	CR-355 to CR-361
Immediately downstream of project area	0.0004	CR-361 to CR-367

As listed in Table 40, a 3-foot drop for 5,000 feet at the end of the project area would increase the existing slope by 0.0006, which is an increase of around 50 or 100 % in slope depending on the exact area.

Steep zones may present recreational hazards or fish passage difficulties. Fish can swim in bursts to get past areas of high velocity flow, but these areas cannot be too long.

Also, stabilizing this drop would require increasing the bed material size to cobble or riprap. The RGSM tends to be found in areas of sand and silt. It is uncertain if they prefer sand and silt substrate, or if their presence near sand and silt is the result of preferring slow areas, where sand and silt settle out of the water column. Thus it is uncertain if the impacts of increasing the bed material size would be detrimental, neutral, or beneficial.

Another way of looking at the steepness of the bed raise and subsequent drop is to examine the longitudinal profile, as shown in Figure 67. If the bed is raised at the upstream end to cover the Corrales Siphon top of pipe, and the bed is evenly sloped from there to the end of the project area at CR-361, then the resulting slope is 0.0012.

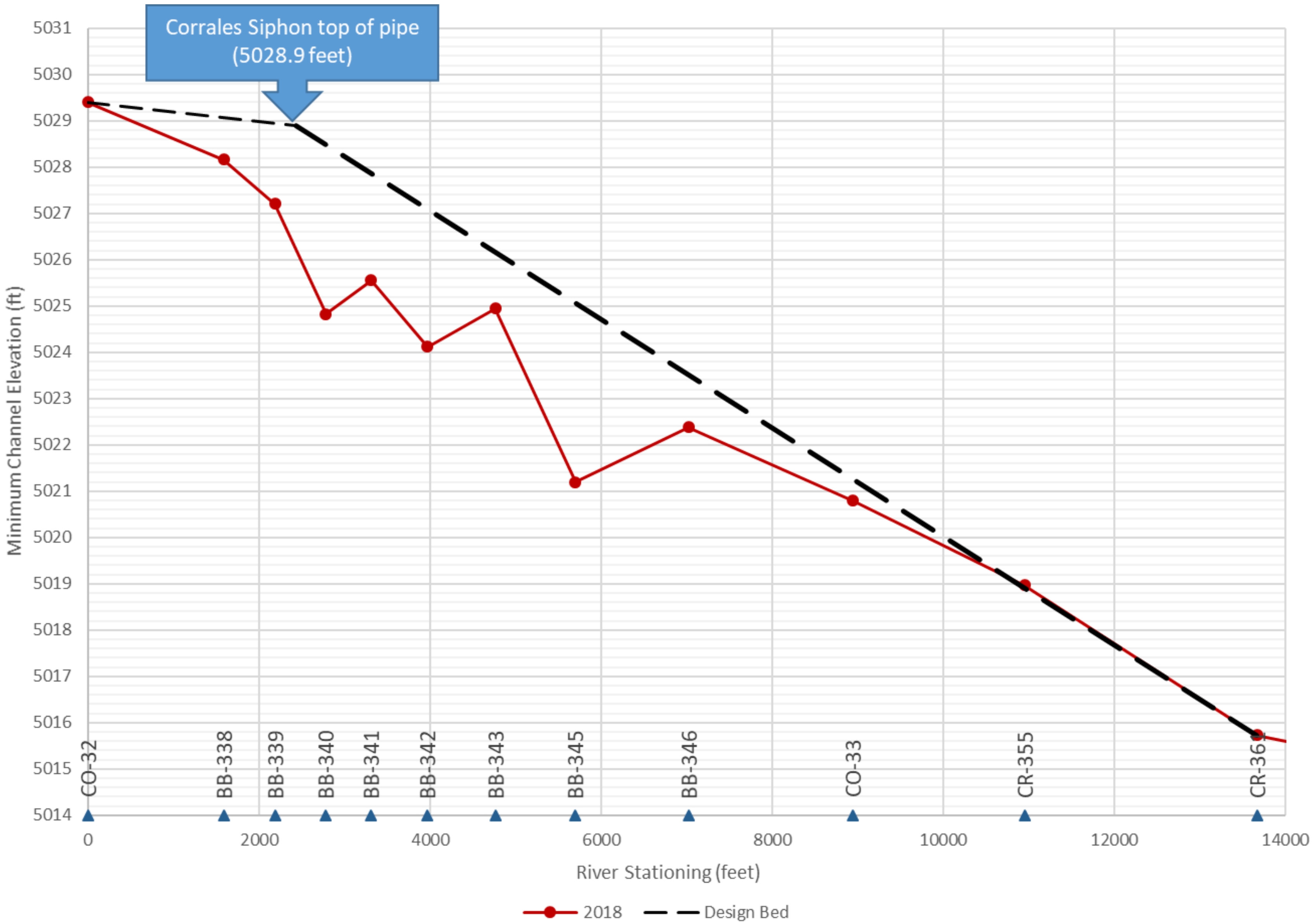


Figure 67: Potential design longitudinal profile with a slope of 0.0012 compared with 2018 longitudinal profile

To mitigate the increased energy created by a steep slope, the channel would be the widest at the location of the drop feature.

9.2.2 Potential methods for raising the river bed

Various methods could be used to raise the river bed. A gradient restoration facility (GRF) would place a small riprap dam in-stream in the range of one to three feet high and sediment would fill in behind this structure over time. The upstream impact of the GRF would depend on the height of the GRF and the existing slope upstream of the installation. A 3-foot GRF installed in a channel with an upstream slope of 0.0008 may fill in upstream for 3,750 feet to establish a flat slope upstream of the GRF. Other upstream distances are shown in Table 42. The entire project area is approximately two miles long so at least two GRFs, if not more, would be needed to impact the entire project area.

Table 42: Possible distance of upstream impacts from a GRF of varying heights

	Distance of Upstream Impacts (feet)		
Upstream Slope	1-foot GRF	2-foot GRF	3-foot GRF
0.0007	1,429	2,857	4,286
0.0008	1,250	2,500	3,750
0.0009	1,111	2,222	3,333
0.001	1,000	2,000	3,000
0.0011	909	1,818	2,727

GRFs have a high cost due to the sourcing and hauling of a large quantity of riprap. A cheaper option is to use spoils from floodplain lowering activities to raise the bed. This may save costs on hauling excavation materials to other spoil locations, but it may have a negative impact on fish during construction depending on the construction method and use of a diversion channel.

Potential methods for stabilizing the bed drop

Downstream of the river bed raise, the river bed will be returned to existing grade with a steepened zone. This steepened zone will have increased channel velocities and an increased potential for channel incision. Protection against channel incision in this steepened zone could come in a few different forms.

The entire length and width of the steepened zone could be stabilized or armored with a layer of riprap sitting on the channel bed, or a channel-spanning trench (bed control structure) filled with riprap could be placed at the steepened zone at the best place for stopping incision. Due to the possibility that the steepened zone may erode and undercut the bed control structure, more than one trench through the steepened zone may be required.

The size of the stabilizing or armoring material would range in size from cobbles to riprap depending on the steepness of the drop and the acceptability of feature deformation. Riprap would need to be hauled in from Reclamation’s Bernallilo stockpile (approximately 13 miles away) and the costs would be high. Cobble could be harvested from the existing channel and then replaced on top of the bed raise fill material, but this also may have high costs due to the necessity of a diversion channel and the amount of material handling required.

Another option is to not stabilize the downstream end and let the river morph naturally into a slope and grade that it prefers. If the channel is designed to be significantly wider through this steepened zone, there may only be minimal changes. However, if the channel narrows over time, the incision in the steep slope area may be significant and the entire project area could return to its pre-project condition. This risk may be too great to move forward with this option.

Potential fill material sources

If it is decided to raise the bed with floodplain material, the material could come from a variety of sources between the levees.

As described in section 2.5.8, a 600-foot buffer limits the habitat restoration excavation activities if the excavation will connect to the main channel during flood flows. The 600-foot buffer in this reach has abandoned terraces on the river's outer bends and lower floodplain on the river's inner bends.

The abandoned terraces on the erosional outer bends could be lowered and their spoils pushed into the river. Since the tree roots in this area are not providing stabilization to the bank due to incision, there is no loss of stability by removing the bankline trees on the abandoned terraces. Also, future erosion will likely cause the trees to fall in the river, which is a significant recreational hazard in this reach. The abandoned terraces would be lowered to a level where the new vegetative roots could provide stabilization against future erosion. As discussed in section 9.2.1, the recommended bank height is five feet above the river bed. Native poles would be planted to jump start the vegetation growth, and woody debris would be installed on the lowered area to protect against erosion during flood flows.

Inner bend point bars could be lowered and their spoils pushed into the river. Recreational use is higher on the abandoned terraces than the inner point bars, and so lowering the inner point bars would have less impact on recreational use.

Material could be brought in from areas outside of the 600-foot buffer if it will not connect hydrologically to the main channel during flood flows. For example, burn areas on the abandoned terrace on the Sandia side could be lowered to improve access to groundwater, and the fill material could be used in raising the river. However, this fill material source would likely have to be hauled in trucks to the river as opposed to other options which may only be moved by dozer. The Pueblo of Sandia may strongly prefer this option over the option of lowering their bankline and causing even the perception of land loss.

When pushing material into the river, it may be best for aquatic impacts to redirect the river flows through a diversion channel during construction. This diversion channel would ideally be located within the 600-foot buffer so that the diversion channel could remain in place to create additional floodplain widening after construction is over. It would most logically be placed as a cut-off channel through the river's inner point bars.

It is recommended that the area of inner point bar between the diversion channel and the main channel not be removed entirely to leave behind one or more vegetated islands. The most biologically valued channels are often complex and multi-threaded (Greimann and Holste, 2018).

9.2.3 Design Width Analysis

To determine optimum active channel widths for channel widening projects, Greimann and Holste's 2018 "Analysis and Design Recommendations of Rio Grande Width" was applied. Their paper provides guidance on predicting Middle Rio Grande (MRG) active channel widths with three different regression equations based on flow rate (Q), bank height (H), bed material size (D_{50}), and bed slope (S). Those three equations are provided below.

$$W = 7.4 \times 10^{-4} Q^{1.56} \qquad \text{Eqn. 14}$$

$$W = 0.011 Q^{1.37} H^{-0.67} \qquad \text{Eqn. 15}$$

$$W = 6.9 Q^{1.1} D_{50}^{-0.12} S^{0.74} \qquad \text{Eqn. 16}$$

Flow Rate

Greimann and Holste recommend using the 8-year average of each year's maximum daily average flow as the Q (flow rate) in each of their three equations. For 2013-2020 at the USGS Alameda gage, that value is 3,595 cfs. The design flow rate was the average of two flow rates including the 8-year average maximum daily flow (3,595 cfs) and the average two-week peak spring runoff flow of 2,640 cfs (see Section 2.5.11). These were chosen since there is merit in designing to a width appropriate for the recent hydrology and there is merit in designing a narrower river to have the floodplain inundated more frequently for the RGSM spawning period.

Bank Height

As it is desirable to have the floodplain inundated more frequently for the RGSM, and since wider and shallower channels are slower and better for the RGSM, the design bank height chosen was 4 feet. This is at the upper end of Greimann and Holste's recommendation of 2–4 feet for designed channels. Current bank heights in this subreach are 8.8 feet tall.

Bed Material

Bed material sampling conducted in 2019 by River Restoration found that the channel ranges from fine sands to gravel and cobble bars. Overall, the average D_{50} for the reach was 7.9 mm. If a channel widening project is implemented, the influence of the sandy floodplain material would likely decrease the D_{50} significantly. For the purposes of a design channel, a D_{50} of 1.7 mm was used, which represents the average of the 2019 non-armored bed material samples.

Slope

The slope chosen was 0.0009, which is the valley slope of the project area downstream of Corrales Siphon. The valley slope was used because it is likely that the selected alternative will include side channels which will cut off the meanders and make the bed slope more closely resemble the valley slope.

Table 43: Existing bed slopes compared to valley slopes using May 2018 cross section data

Feature or Subreach	Slope (feet/feet)	Bounding Cross Sections
Existing Bed Slopes		
RM 199 project area	0.0010	BB-338 to CR-361
RM 199 project area downstream of Corrales Siphon	0.0008	BB-340 to CR-361

Feature or Subreach	Slope (feet/feet)	Bounding Cross Sections
Valley Slopes		
RM 199 project area	0.0011	BB-338 to CR-361
RM 199 project area downstream of Corrales Siphon	0.0009	BB-340 to CR-361

Results
To check applicability of the equations for this reach, the current condition parameters were input into the three equations. The three resulting values were 260 feet, 191 feet, and 245 feet for Equations 14, 15, and 16, respectively. Greimann and Holste's average width value for Angostura to the North Diversion Channel for 2012 was 310 feet. The active channel width for the project area (as calculated with Google Earth October 2018 aerial imagery) is approximately 175 feet. (The maximum top width was roughly 270 feet immediately upstream of the island at BB-346, and the minimum top width was roughly 100 feet at RM marker 199). This shows that the equations predict a little higher than the actual average top width, although it is apparent that the subreach is trying to widen itself by meander bend erosion. The most accurate of the three equations was Equation 15 (which was also found to be true in Greimann and Holste's analysis).

Next, design parameters were entered into the three equations to find the recommended design width. The results were 209 feet, 266 feet, and 251 feet for Equations 14, 15, and 16, respectively. Since Equation 15 has been yielding the most accurate results, a width of 265 feet is being recommended as the average channel top width for the RM 199 project reach. Considering that the current average width in this subreach is approximately 175 feet, it is recommended to widen the channel by approximately 90 feet. However, site conditions and final design considerations will refine the final top widths.

9.2.4 Bed Control Alternative Cost Estimate
The following bed control concepts are more fully described in Section 4.2.2, including the reasoning behind the inclusion or exclusion of diversion channels in the cost estimate.

For the purpose of creating a rough cost estimate, the riprap grade control feature is assumed to be a two-foot-deep trench spanning the river (typically 240 feet wide at the riffles) with 200-foot-long keys extending into the bank on both sides of the river. The longitudinal length of the feature was estimated at 10 feet.

Riprap grade control w/ div. channel	Unit	Quantity	Unit Price	Cost
temporary diversion channel - clearing and grubbing	acres	1.5	$1,000	$1,500
temporary diversion channel - excavation	cubic yard	7,100	$7	$49,700
temporary diversion channel - rock cofferdam	cubic yard	667	$55	$36,667
Excavation for rock trench	cubic yard	178	$7	$1,244
Excavation for keys	cubic yard	1,630	$7	$11,407
Dewatering rock trench	lump sum	1	$5,000	$5,000
Riprap: D_{50}=12 inch (trench fill)	cubic yard	178	$110	$19,556
Riprap: D_{50}=12 inch (keys)	cubic yard	296	$110	$32,593

Riprap grade control w/ div. channel	Unit	Quantity	Unit Price	Cost
Revegetation seed mix	acre	1.5	$1,000	$1,500
			Subtotal	$159,167
Mob/Demob	%	3	$159,167	$4,775
Site Staking/Survey	%	2	$159,167	$3,183
Contingency	%	25	$159,167	$39,792
			Total Cost	$206,917

Riprap grade control w/o div. channel	Unit	Quantity	Unit Price	Cost
Excavation for rock trench	cubic yard	178	$7	$1,244
Excavation for keys	cubic yard	1,630	$7	$11,407
Riprap: D_{50}=12 inch (trench fill)	cubic yard	178	$110	$19,556
Riprap: D_{50}=12 inch (keys)	cubic yard	296	$110	$32,593
			Subtotal	$64,800
Mob/Demob	%	3	$64,800	$1,944
Site Staking/Survey	%	2	$64,800	$1,296
Contingency	%	25	$64,800	$16,200
			Total Cost	$84,240

For the purpose of creating a rough cost estimate, the rock sill is assumed to be a one-foot-thick layer of rock on top of the channel bed. Since the rock sill is not trenched, the rock sill does not require a diversion channel. The rock sill would span the entire river width (typically 240-feet wide) and would have 200-foot-long keys extending into the bank on both sides of the river. The longitudinal length of the feature was estimated at 10 feet.

Rock Sill	Unit	Quantity	Unit Price	Cost
Excavation for keys	cubic yard	1,333	$7	$9,333
Riprap: D_{50}=12 inch (bed sill)	cubic yard	178	$110	$19,556
Riprap: D_{50}=12 inch (keys)	cubic yard	148	$110	$16,296
			Subtotal	$45,185
Mob/Demob	%	3	$45,185	$1,356
Site Staking/Survey	%	2	$45,185	$904
Contingency	%	25	$45,185	$11,296
			Total Cost	$58,741

For the purpose of creating a rough cost estimate, the deformable riffle is assumed to be a one-foot-deep trench spanning the river (typically 240 feet wide). Keys were not required since the intent is that the riffle will deform before the river avulses around the feature. The longitudinal length of the feature was estimated at 20 feet.

Deformable Riffle w/ diversion channel	Unit	Quantity	Unit Price	Cost
temporary diversion channel - clearing and grubbing	acres	1.5	$1,000	$1,500
temporary diversion channel - excavation	cubic yard	7,100	$7	$49,700
temporary diversion channel - rock cofferdam	cubic yard	667	$55	$36,667
Excavation for rock trench	cubic yard	178	$7	$1,244
Riprap: D_{50}=6 inch (trench fill)	cubic yard	178	$110	$19,556
Revegetation seed mix	acre	1.5	$1,000	$1,500
			Subtotal	$110,167
Mob/Demob	%	3	$110,167	$3,305
Site Staking/Survey	%	2	$110,167	$2,203
Contingency	%	25	$110,167	$27,542
			Total Cost	$143,217

Deformable Riffle w/o diversion channel	Unit	Quantity	Unit Price	Cost
Excavation for rock trench	cubic yard	178	$7	$1,244
Riprap: D_{50}=6 inch (trench fill)	cubic yard	178	$110	$19,556
			Subtotal	$20,800
Mob/Demob	%	3	$20,800	$624
Site Staking/Survey	%	2	$20,800	$416
Contingency	%	25	$20,800	$5,200
			Total Cost	$27,040

9.2.5 Bend Apex Movement Analysis

The bends in the RM 199 project area were formed when a narrowing trend caused vegetated sandbars to attach to the banks around the 1990s. They have not existed long enough for the river to smooth all of them into geometric arcs with constant radii and well-defined bend apexes (although BB-343 is very close to a geometric arc). This limitation should be considered when reviewing the bend apex movement values. These values were measured from Google Earth imagery.

It is worth noting that although these bend apex movement values and erosion values (Section 9.2.6) make RM 198 look like a highly active bend, it does not currently need maintenance. The outer bend bankline is jagged and non-geometric, making the bend's apex difficult to ascertain (similar to most of the bends). As the jagged points eroded away during some of the measurement periods, the selected apex location shifted around to new locations. This consideration was included in the engineering judgement that went into developing the predicted planform for 2030 (Figure 37).

Table 44: Analysis of recent bend apex movement and projected bend apex movement

Bend	1/2013 to 11/2015	11/2015 to 4/2017	4/2017 to 10/2018	10/2018 to 4/2020	*Rate of Movement (feet/month)*	Predicted 4/2020 to 1/2030
	Bend Apex Lateral Movement (feet)					
Arr. de las Barrancas	5	11	21	15	*0.7*	82
Corrales Siphon[1]	0	0	0	0	*0*	0
Corrales Siphon[2]	7	6	-130[5]	20	*0.6*	65
Corrales Siphon[3]	0	0	0	0	*0*	0
BB-343	32	0	18	25	*0.8*	97
RM 199[1]	0	0	0	10	*0.3*	33
RM 199[2]	0	0	0	0	*0*	0
RM 199[3]	0	0	0	0	*0*	0
CO-33	0	0	0	0	*0*	0
RM 198	17	16	0	16	*0.6*	68
CR-361	0	0	0	46	*0.5*	62
	Bend Apex Longitudinal Movement[4] (feet)					
Arr. de las Barrancas	-54	33	58	-79	*-0.2*	-24
Corrales Siphon[1]	0	0	0	0	*0*	0
Corrales Siphon[2]	-4	1	0	315[5]	*0*	0
Corrales Siphon[3]	0	0	0	0	*0*	0
BB-343	170	105	78	221	*6.9*	813
RM 199[1]	0	0	0	0	*0*	0
RM 199[2]	0	0	0	166	*1.9*	223
RM 199[3]	0	0	0	0	*0*	0
CO-33	0	0	0	0	*0*	0
RM 198	167	15	57	-8	*2.1*	249
CR-361	0	0	0	0	*0*	0

[1] Measured as a simple bend
[2] Measured as a compound bend: the upstream bend
[3] Measured as a compound bend: the downstream bend

[4] Longitudinal movement is measured as positive in the downstream direction
[5] Due to the construction of a riprap pad on the western downstream side of Corrales Siphon, subsequent large sediment deposits shifted the bend apex significantly. This movement was not included in the calculations of the predicted future rate of movement for this bend.

9.2.6 Bend Erosion Analysis

Table 45 below shows the total erosion distance between January 2013 and April 2020 at the location on the bend experiencing the highest erosion. These values were measured from Google Earth imagery.

Table 45: Maximum erosion distance, erosion rate, and predicted erosion for RM 199 project area bends and nearby bends

Bend	Total lateral erosion Jan 2013 to Apr 2020 (feet)	Erosion rate (feet/month)	Predicted erosion Apr 2020 to Jan 2030 (feet)
Arr. de las Barrancas	84	1.0	113
Corrales Siphon[1]	26	0.3	35
BB-343	160	1.8	215
RM 199[1]	17	0.2	23
RM 199[2]	21	0.2	28
CO-33	0	0	0
RM 198	42	0.5	56
CR-361	53	0.6	71
U/S of Sandia Bendway Weirs	*145*	*1.7*	-
Sandia Bendway Weir Site	*126*	*1.4*	-
Willow Creek Open Space	*219*	*2.5*	-
D/S of Willow Creek Open Space	*42*	*0.5*	-

[1] This erosion occurred on the upstream side of the bend
[2] This erosion occurred near the middle of the bend

9.2.7 Historical Effect of Bed Control in Subreach

In the RM 199 project area, the Corrales Siphon and the Arroyo de la Barranca somewhat function as bed control. The arroyo is a flexible bed control, in some years supplying sediment to increase the channel grade but washing away in other years. The Corrales Siphon top of box is at elevation 5028.9 and limits upstream channel's low point to this elevation. (Downstream of the siphon there is a scour hole that is much lower than the siphon). The top of Corrales Siphon was exposed and acting as a grade control as far back as Reclamation's electronic records show in 2001.

Figure 68 shows average annual incision values at each rangeline calculated with the longest data available between 2001 and 2019. Table 46 shows the distance-weighted average of the data points upstream and downstream of the siphon calculated with the longest data available between 2001 and 2019. The data shows that above the siphon the incision is on average 0.10 feet per year, while the incision below the siphon is generally around 0.26 feet per year. It's difficult to determine how far upstream the effective bed control protection is extending. Rangelines continuing upstream to Highway 550 were also found to have incision of around 0.1 feet per year or less for the same time period. There are potentially two reasons for why this upstream area, located up to 20,000 feet upstream, had incision levels more similar to the area above the siphon than below the siphon. One, it could reflect that the Corrales Siphon bed control effects are extending at least 20,000 feet upstream. On the other hand, it could reflect that distance to bed armoring was much closer in the upstream reach than the downstream reach when the data set begins in 2001, and so incision rates have slowed much faster in the upstream reach. More data on bed incision over the years can be found in the longitudinal profile shown in Figure 2.

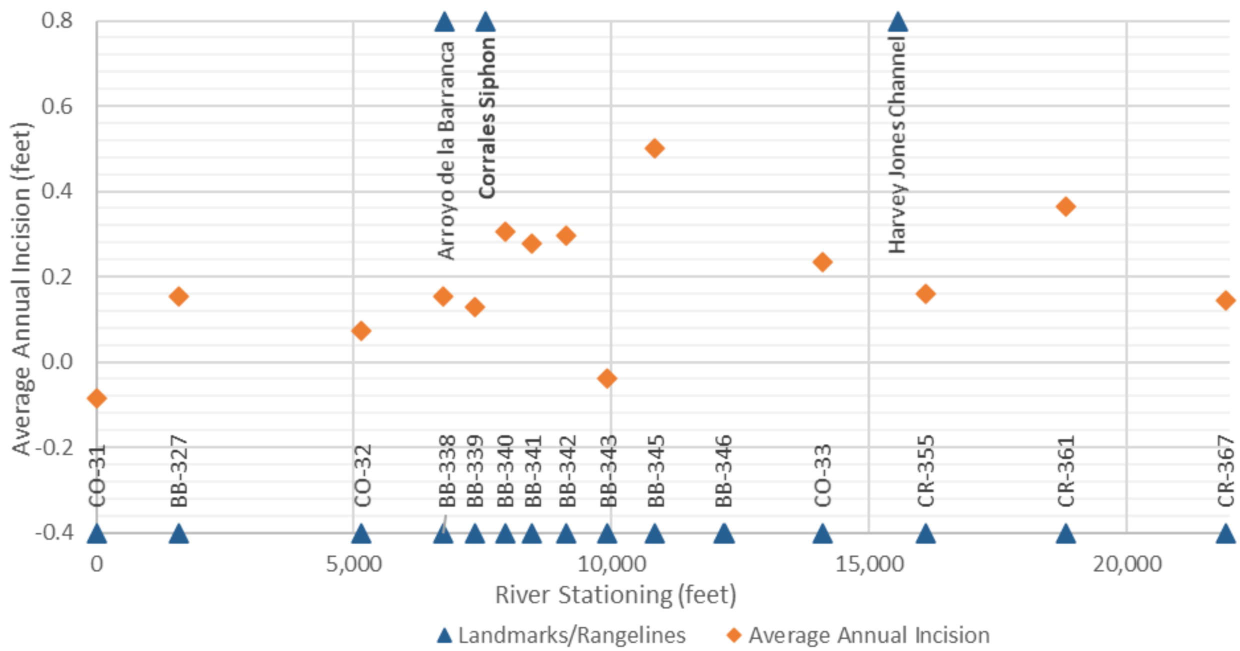


Figure 68: Average annual incision at rangelines around Corrales Siphon using available data between 2001 and 2019

Table 46: Average annual incision (distance-weighted) upstream and downstream of Corrales Siphon using available data between 2001 and 2019

Location	Average Annual Incision (feet)	Distance Included in Average (feet)
Above Corrales Siphon	0.10	7,638
Below Corrales Siphon	0.26	14,286

9.3 Appendix C: Bed and Bank Stability Analysis

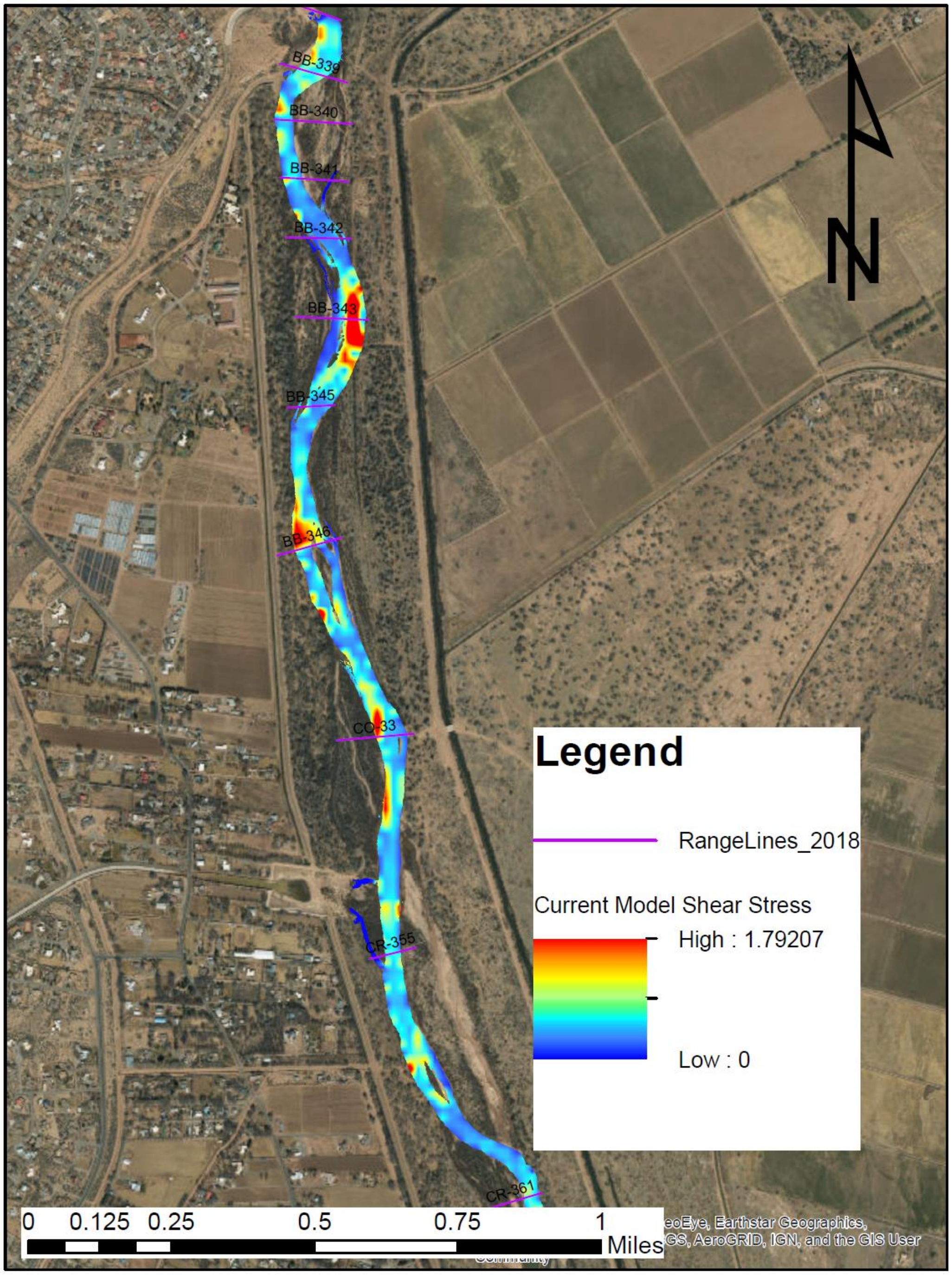


Figure 69: Plan view of shear stress for Current Model at 4,000 cfs

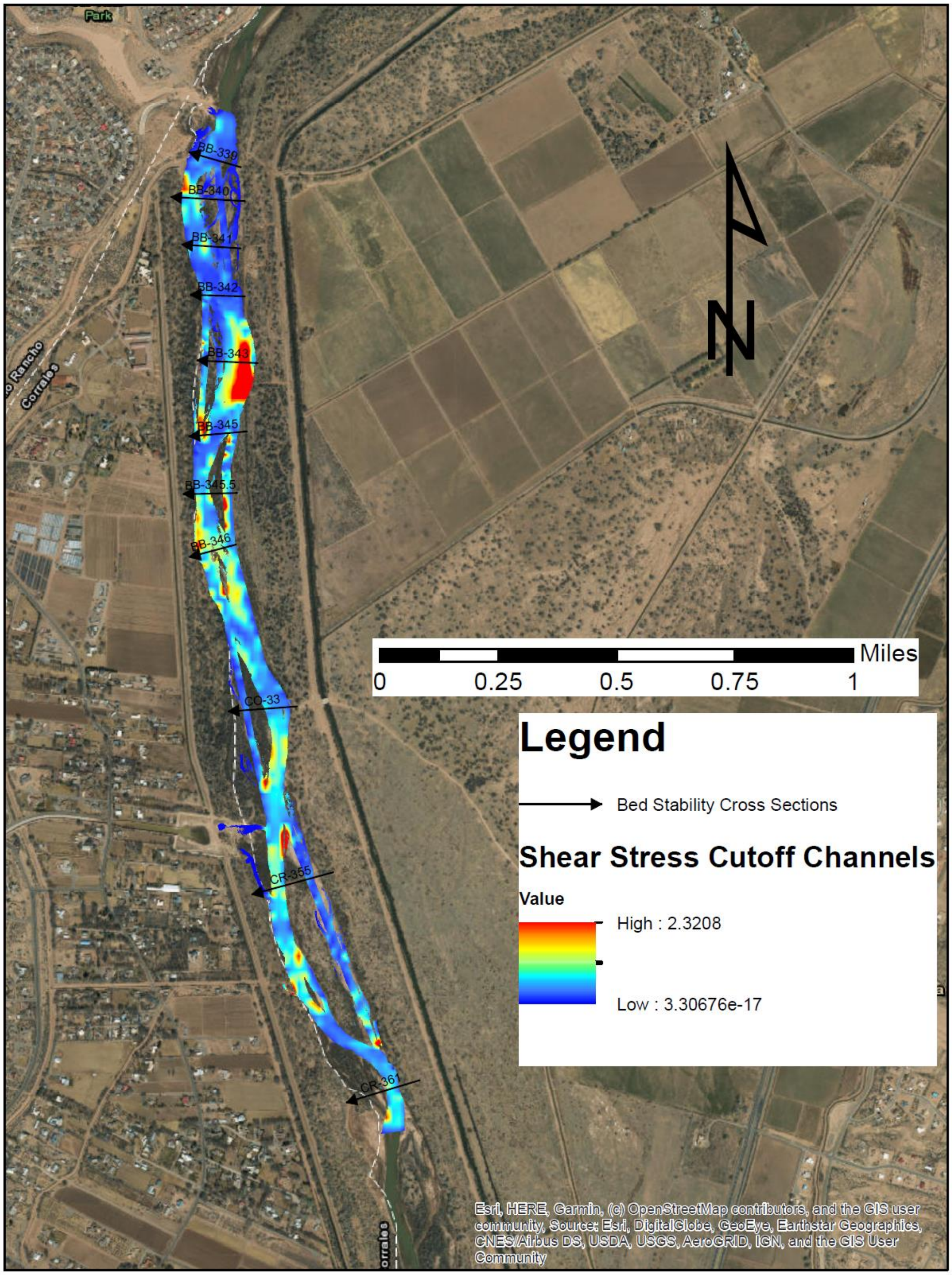


Figure 70: Plan view of shear stress for Cutoff Channels at 4,000 cfs

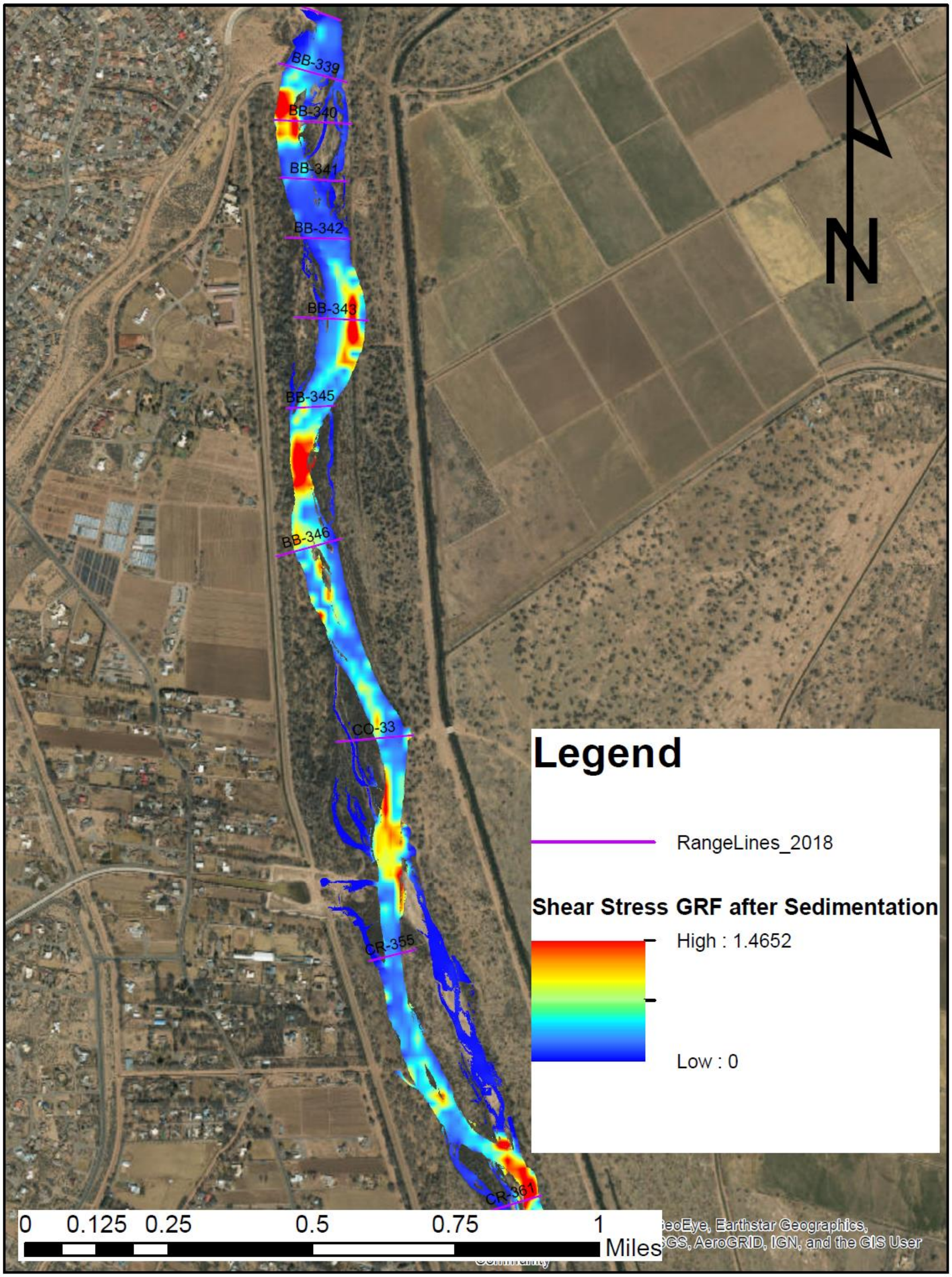


Figure 71: Plan view of shear stress for GRF after sedimentation at 4,000 cfs

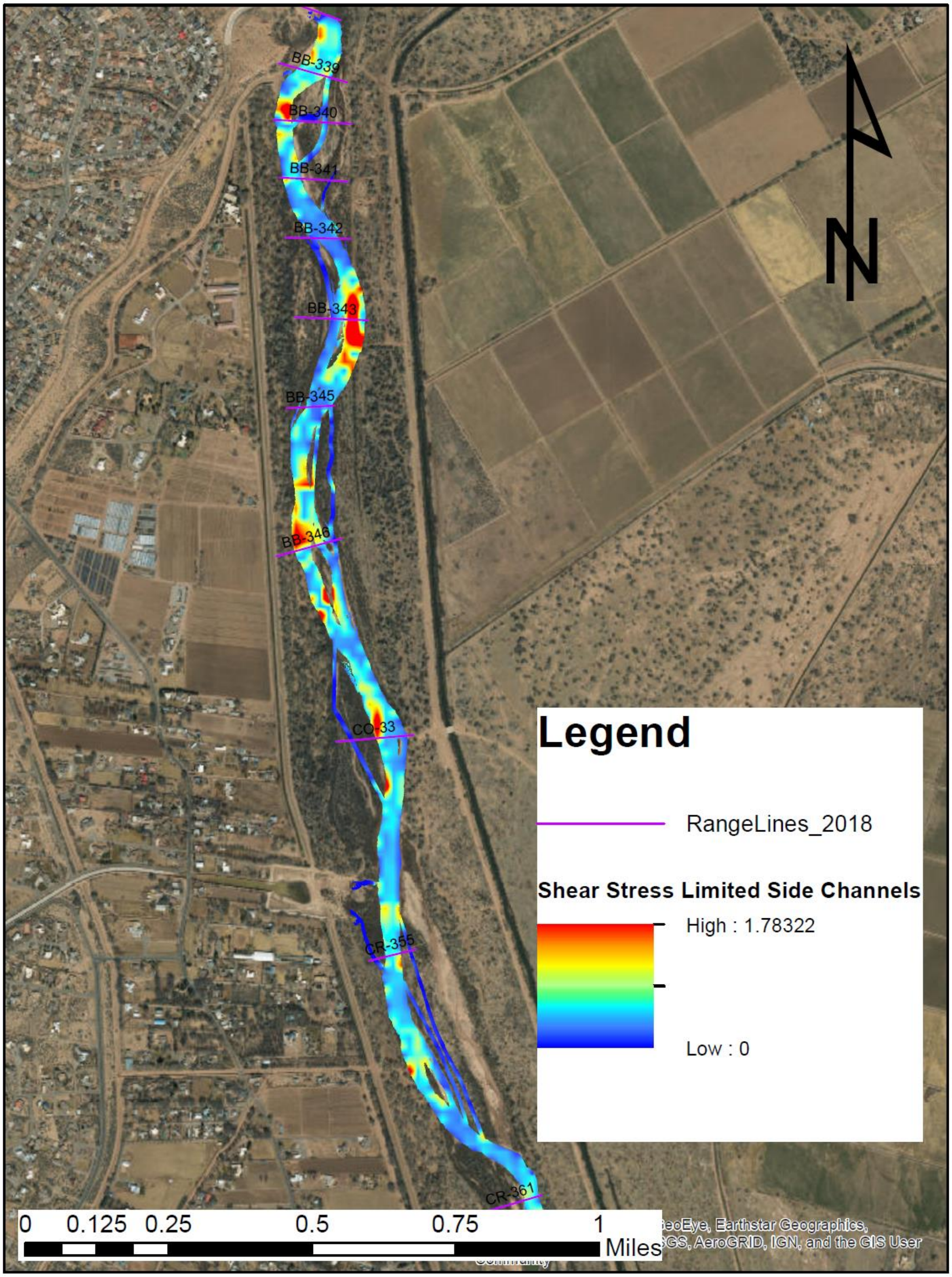


Figure 72: Plan view of shear stress for Limited Side Channels Model at 4,000 cfs

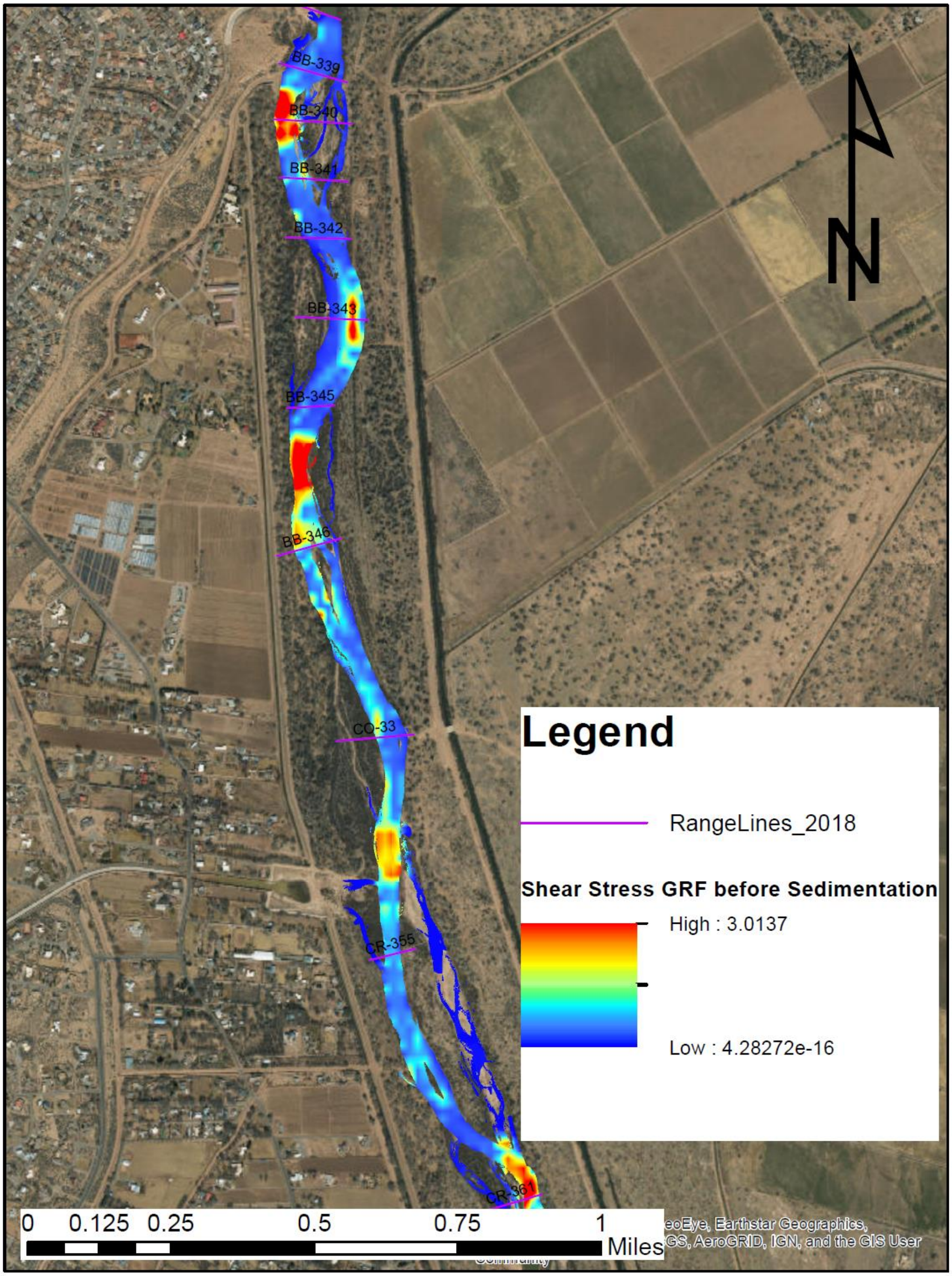
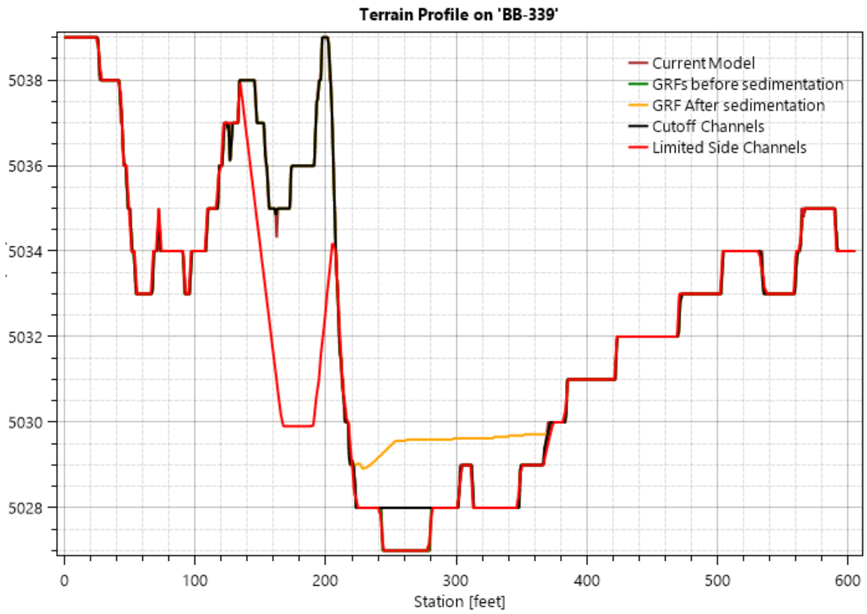
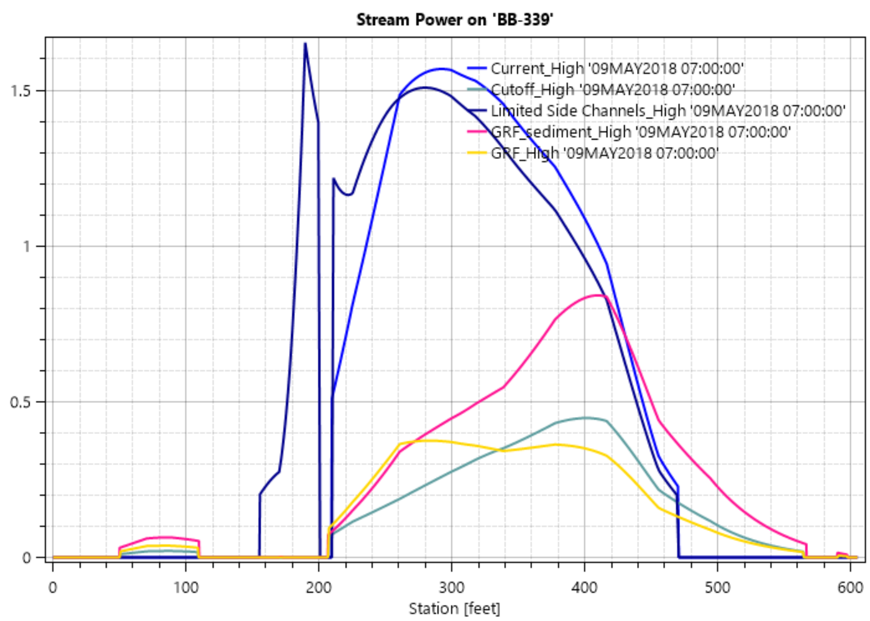


Figure 73: Plan view of shear stress for GRF before sedimentation at 4,000 cfs

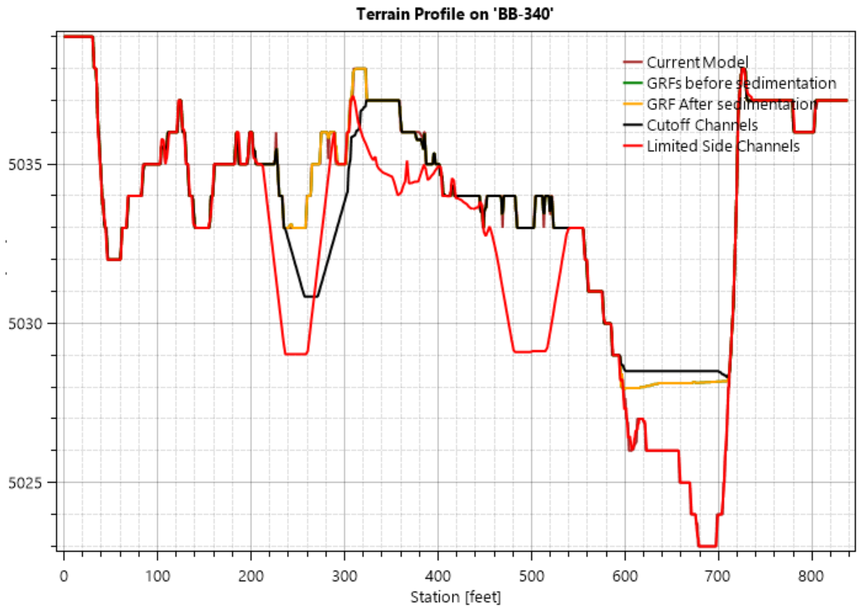


(a)

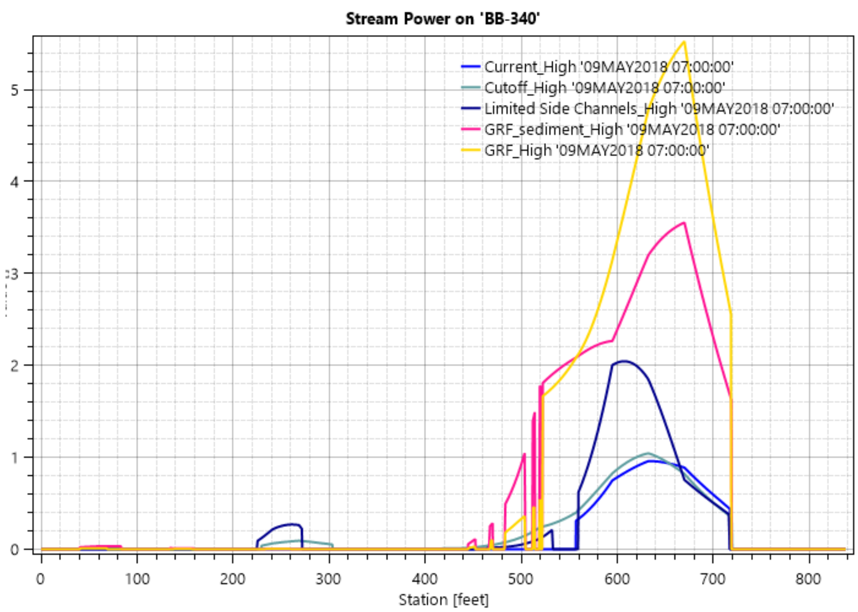


(b)

Figure 74: a) Cross section of terrain for all four models on BB-339 and, b) Stream power at BB-339



(a)



(b)

Figure 75: a) Cross section of terrain for all four models on BB-340 and, b) Stream Power at BB-340

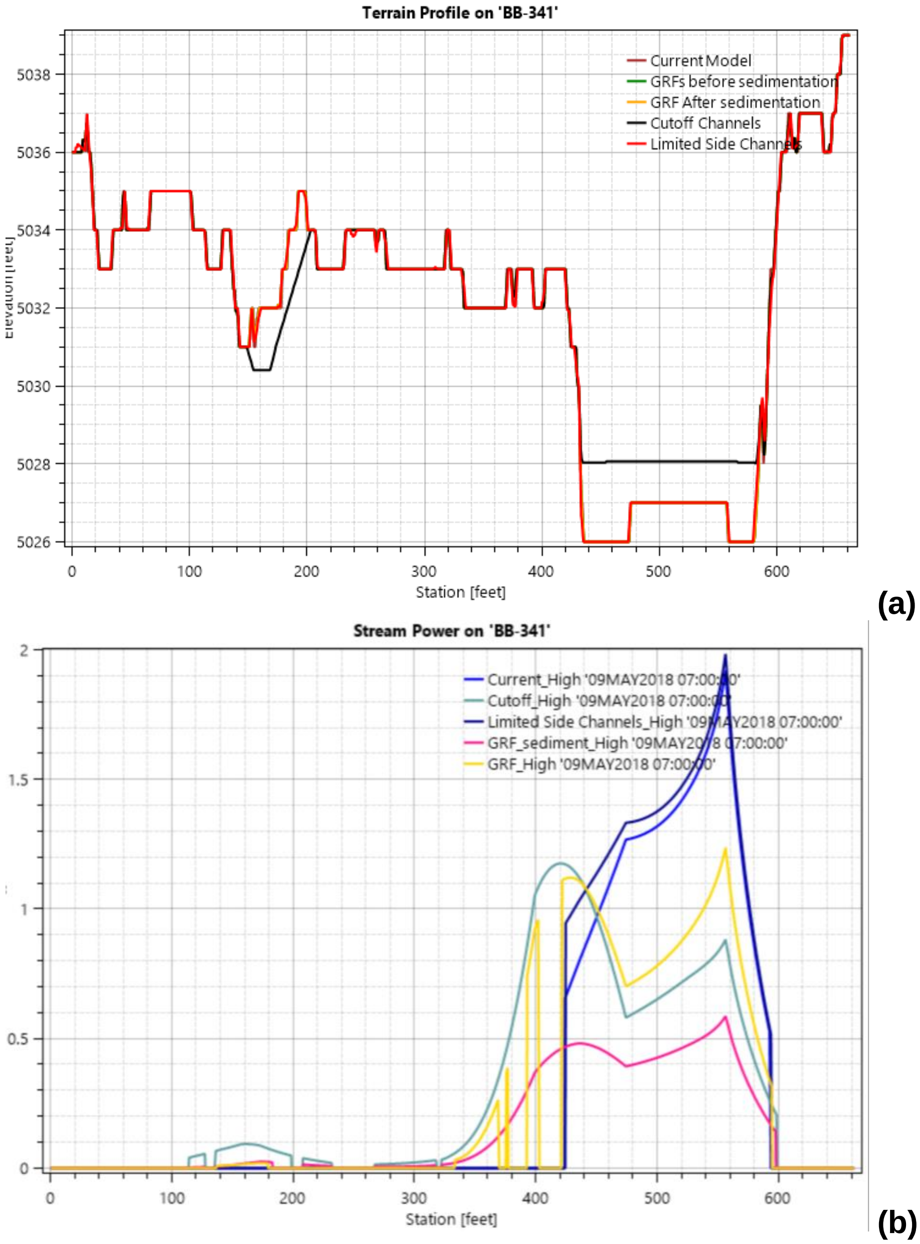


Figure 76: a) Cross section of terrain for all four models on BB-341 and, b) Stream power at BB-341

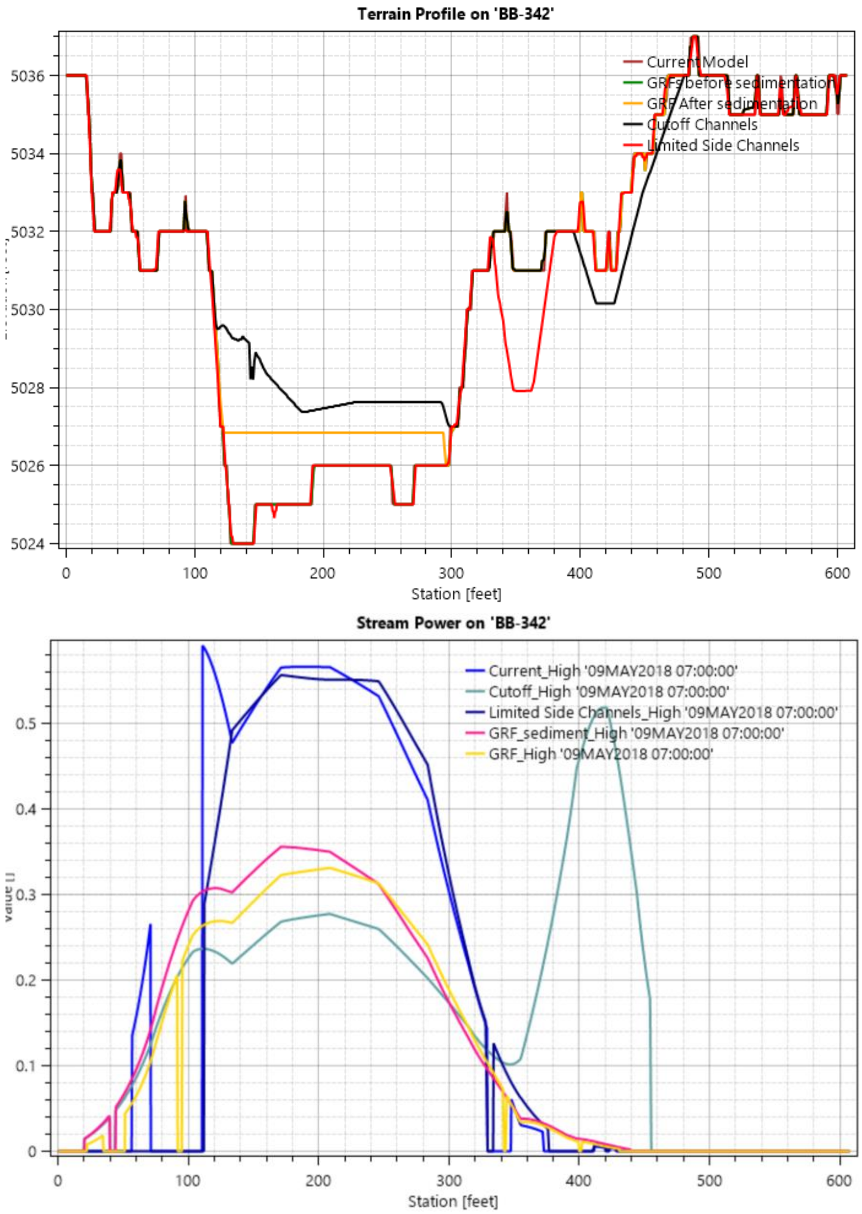
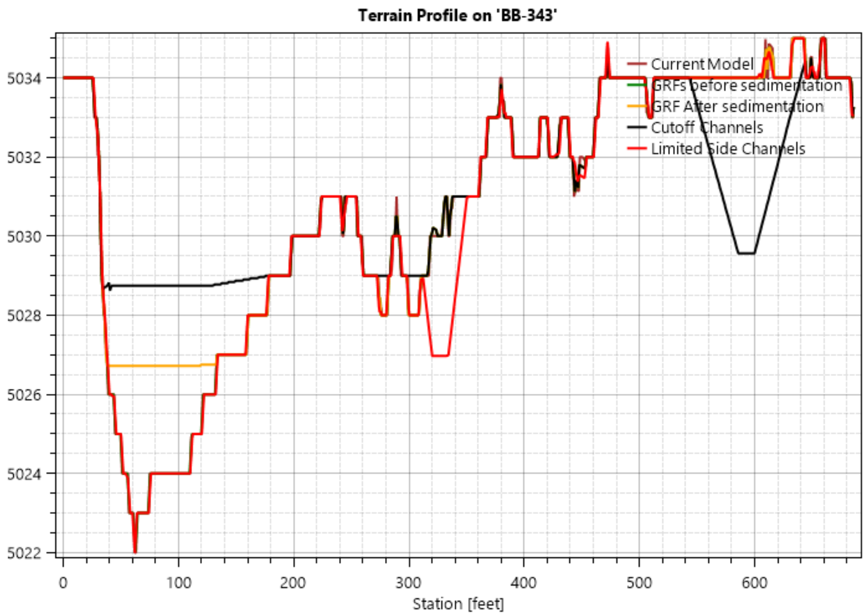
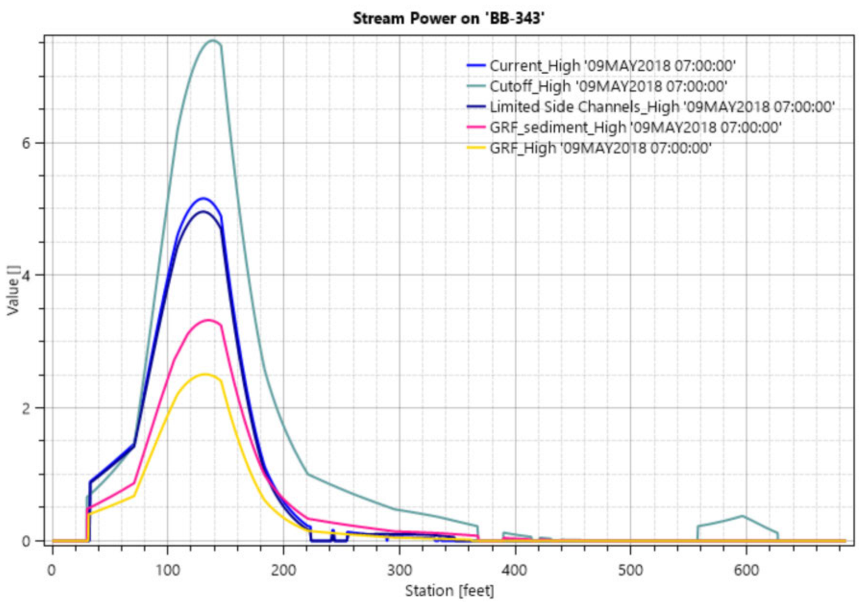


Figure 77: a) Cross section of terrain for all four models on BB-342 and, b) Stream Power at BB-342

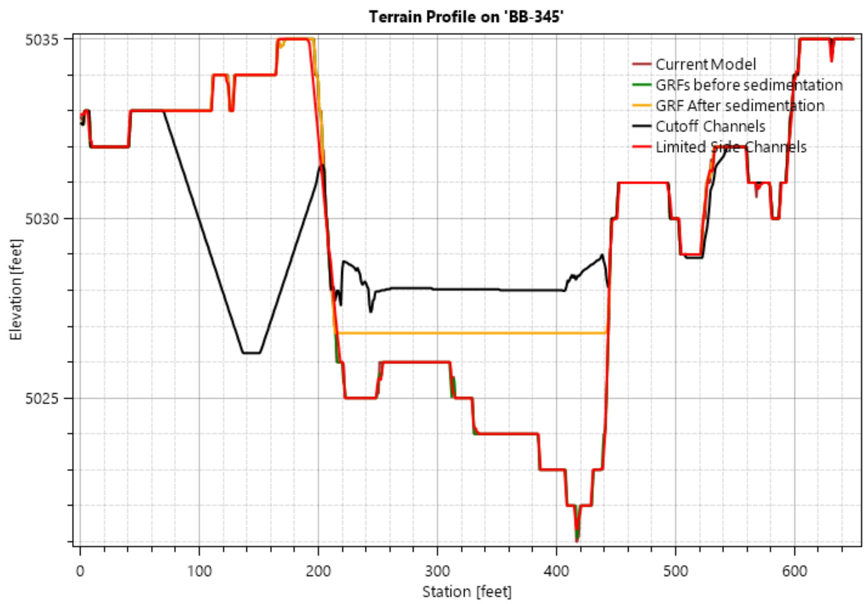


(a)

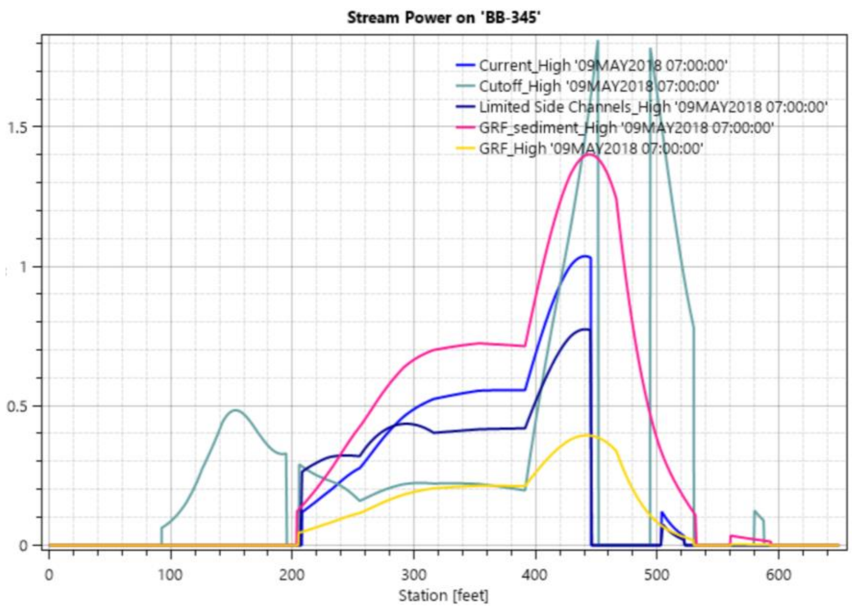


(b)

Figure 78: a) Cross section of terrain for all four models on BB-343 and, b) Stream power at BB-343

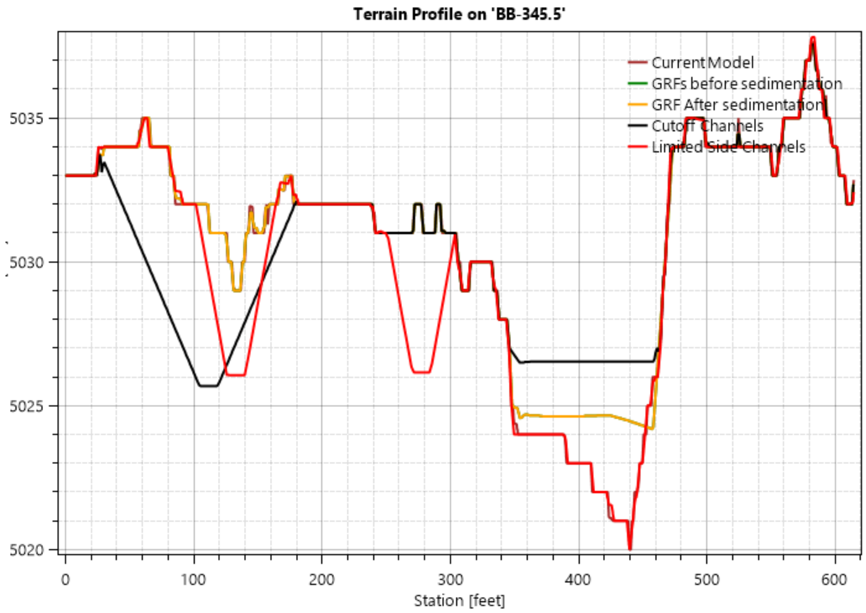


(a)



(b)

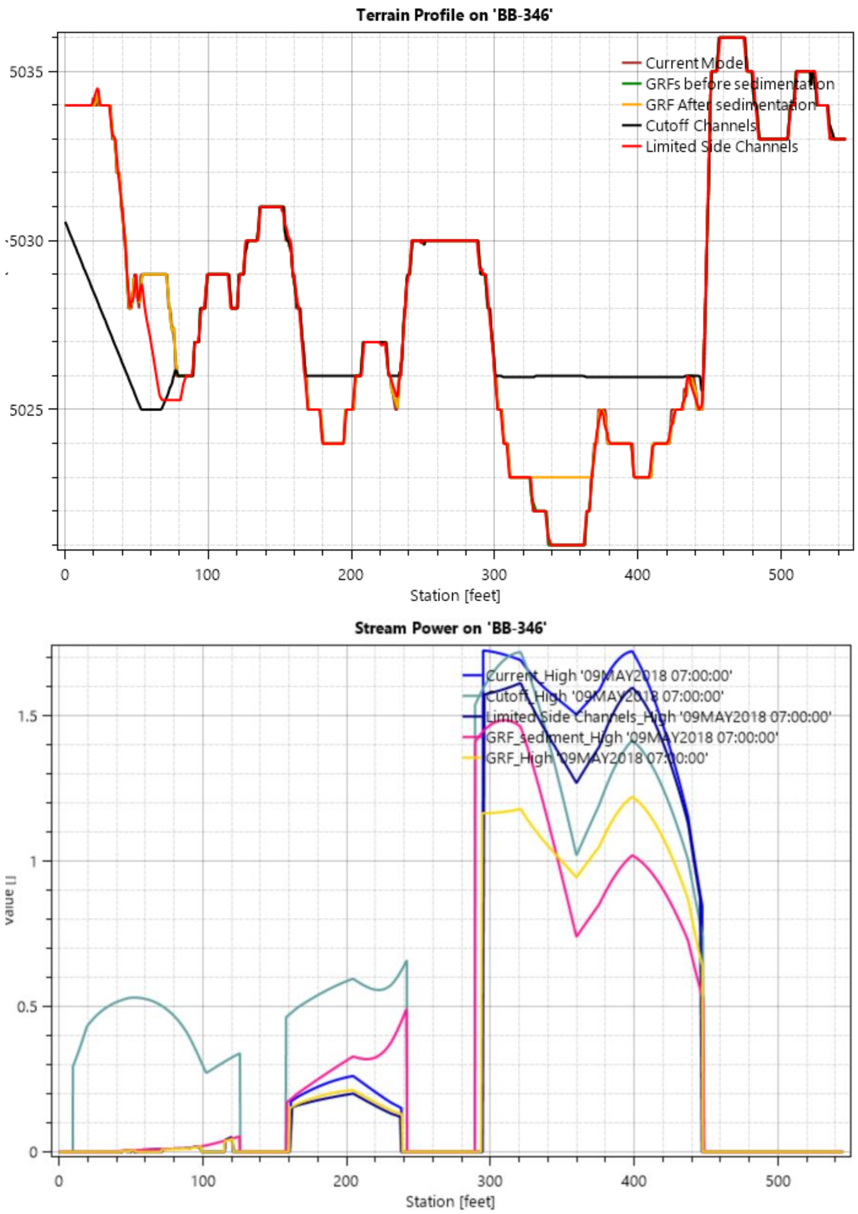
Figure 79: a) Cross section of terrain for all four models on BB-345 and, b) Stream Power at BB-345



(a)

(b)

Figure 80: a) Cross section of terrain for all four models on BB-345.5 and, b) Stream Power at BB-345.5



(a)

(b)

Figure 81: a) Cross section of terrain for all four models on BB-346 and, b) Stream Power at BB-346

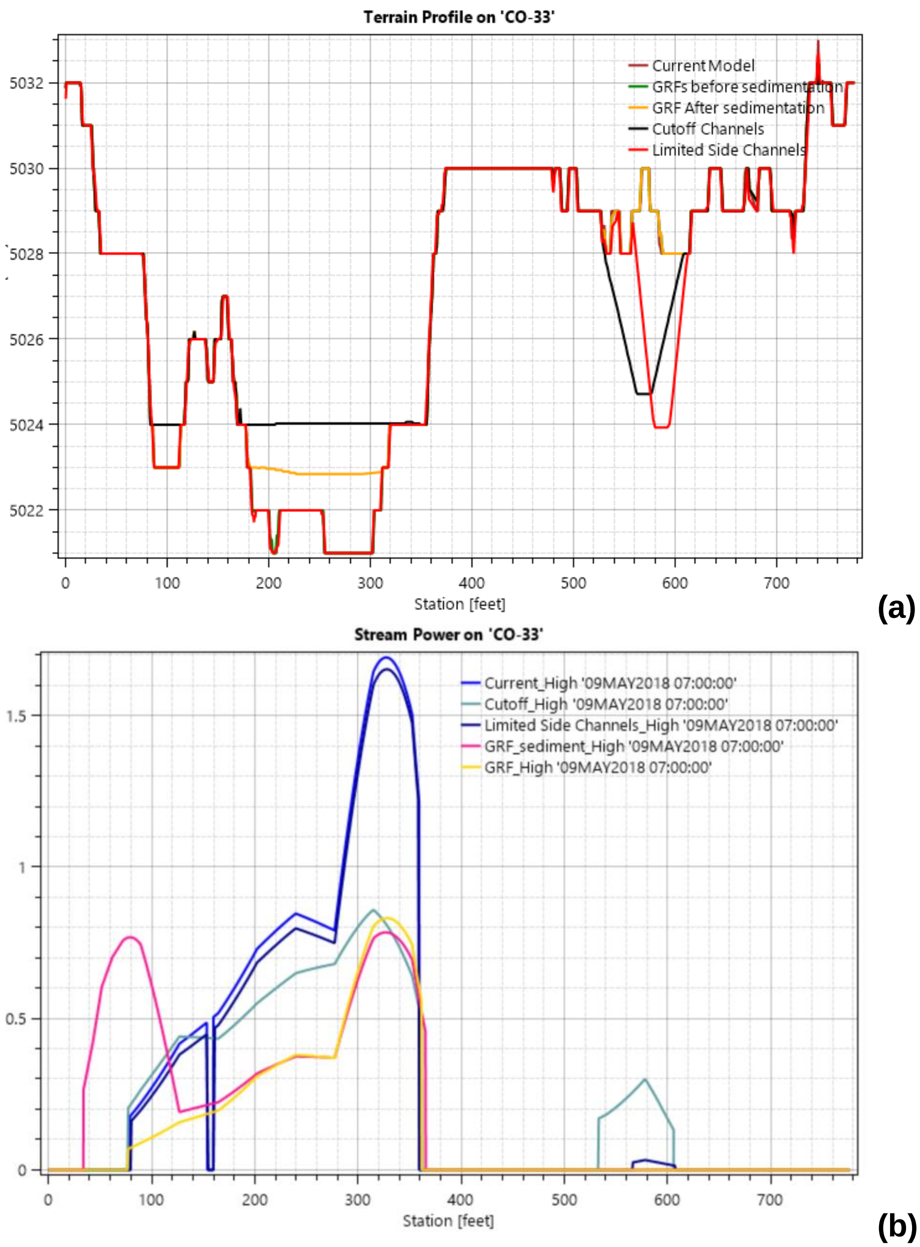
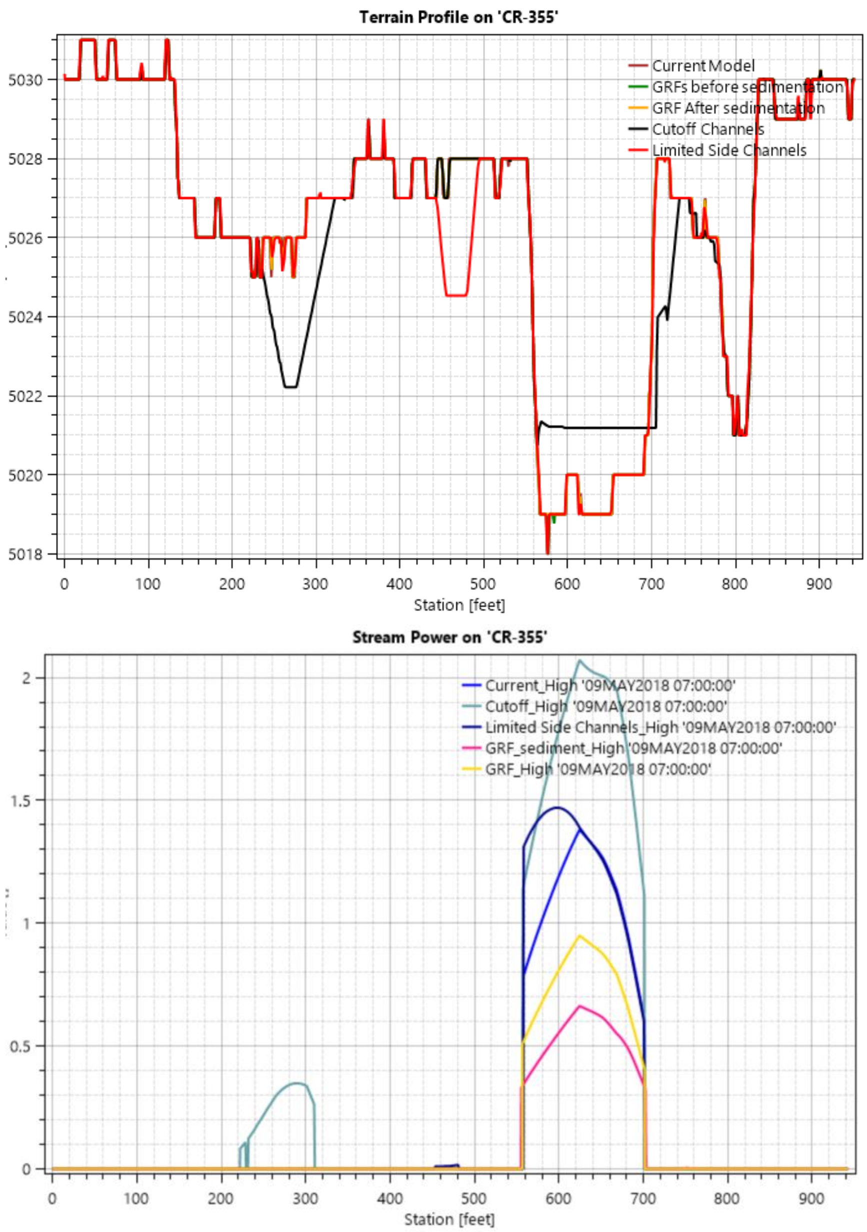


Figure 82: a) Cross section of terrain for all four models on CO-33 and, b) Stream Power at CO-33



(a)

(b)

Figure 83: a) Cross section of terrain for all four models on CR-355 and, b) Stream Power at CR-355

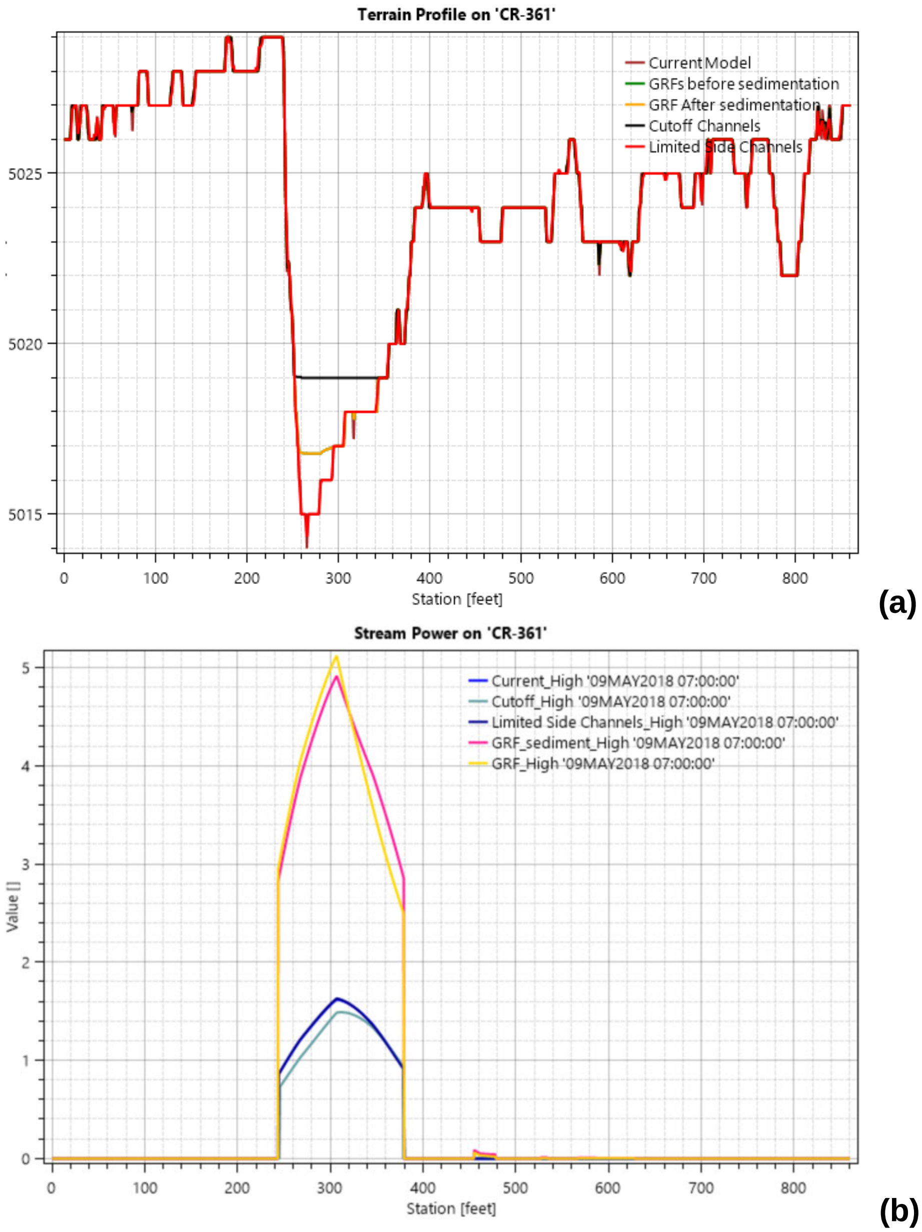


Figure 84: a) Cross section of terrain for all four models on CR-361 and, b) Stream Power at CR-361

9.4 Appendix D: Alternative Scoring Results

Table 47: Engineering effectiveness scoring table

Alternatives	Bank Protection	Incision Protection	Suitability considering incision	Suitability considering meandering	Suitability considering narrowing	Constructability	Adaptability	Total Engineering Effectiveness	Engr. Rank
Weighting	2	0.20	0.33	0.33	0.33	0.2	0.2	(Total 3.6)	
Longitudinal Riprap Stabilization	9.0	2.5	8.5	7.8	8.0	10.0	6.8	29.9	1
Longitudinal Woody Stabilization	5.8	1.3	3.5	5.5	6.3	5.0	6.0	19.0	3
Bank Treatments	2.8	1.0	2.0	2.0	3.0	8.8	6.8	11.1	8
No Bank Stabilization	1.0	1.0	1.0	1.0	1.0	10.0	1.0	5.4	10
GRFs	3.0	10.0	8.8	3.3	9.8	7.0	4.5	17.6	4
Bed Control	1.8	7.8	6.3	4.3	9.5	8.0	5.0	14.3	7
Cutoff Channels	4.3	5.0	3.8	4.5	3.5	9.0	4.5	16.1	5
Bed Control + Cutoff Channels	4.6	7.4	6.6	5.2	6.0	8.0	4.6	19.1	2
Limited Side Channels	4.0	2.5	2.8	4.3	3.5	9.3	6.8	15.2	6
Vegetation Destabilization	2.3	2.3	2.5	3.3	2.8	9.0	7.3	11.0	9
No Energy Dissipation	1.0	1.0	1.0	1.0	1.0	10.0	1.0	5.4	10

Table 48: Habitat, community, and permits scoring table

Alternatives	Aquatic Impact	Riparian Impact	Community Concerns	Aquatic Habitat Benefit	Riparian Benefit	Community Benefit	Total Environment	Env. Rank
Weighting	0.2	0.2	0.5	0.5	0.5	0.2	(Total 2.1)	
Longitudinal Riprap Stabilization	1	8	5	3	4	4	8.5	9
Longitudinal Woody Stabilization	5	7	6	5	4	6	11.3	5
Bank Treatments	8	10	8	5	3	9	13.4	4
No Bank Stabilization	9	6	7	1	1	5	8.7	8
GRFs	2	4	5	7	4	2	9.6	7
Bed Control	2	8	7	1	2	5	8.0	10
Cutoff Channels	7	10	10	10	9	7	19.3	1
Bed Control + Cutoff Channels	4.5	9	8.5	10	9	7	17.9	2
Limited Side Channels	7	10	7	8	9	8	17.0	3
Vegetation Destabilization	7	5	7	2	4	4	9.7	6
No Energy Dissipation	5	7	4	1	1	1	5.6	11

Table 49: Overall scores table including summary of engineering and environmental, tribal preferences, and anticipated fifty-year costs

Alternatives	Total Engineering Effectiveness	Total Environment	Tribal Preference Score	Construction Cost	50-year Cost	Econ. Rank	Total Score	Rank
Weighting	(Total 3.6)	(Total 2.1)	2		1			
Longitudinal Riprap Stabilization	29.9	8.5	10	$ 3,750,000	$ 4,7500,000	8	53.6	1
Longitudinal Woody Stabilization	19.0	11.3	8.5	$ 2,625,000	$ 13,125,000	11	34.2	7
Bank Treatments	11.1	13.4	10	$ 1,000,000	$ 3,000,000	4*	41.6	4
No Bank Stabilization	5.4	8.7	0	$ -	$ 3,000,000	4*	11.1	10
GRFs	17.6	9.6	8.5	$11,000,000	$ 11,800,000	10	32.4	8
Bed Control	14.3	8.0	10	$ 470,000	$ 940,000	2	41.4	5
Cutoff Channels	16.1	19.3	9	$ 1,236,300	$ 6,181,500	9	47.2	3
Bed Control + Cutoff Channels	19.1	17.9	9.5	$ 1,706,300	$ 4,012,600	7	52.0	2
Limited Side Channels	15.2	17.0	4	$ 480,000	$ 2,400,000	3	37.8	6
Vegetation Destabilization	11.0	9.7	5	$ 22,000	$ 110,000	1	30.6	9
No Energy Dissipation	5.4	5.6	0	$ -	$ 3,000,000	4*	8.0	11

*tied ranking

9.5 Appendix E: Proposed Alternative Construction Sequencing

The construction sequencing would likely occur in the order described below. For more details on the construction phases and dimensions of the temporary riprap diversion cofferdams, see Appendix F.

Table 50: Construction sequencing of proposed alternative

Step	Actions	Features Completed (flow path shown in yellow)
1	Excavate the cutoff channel on the RM 199 point bar, leaving the entrance and exit plugs in place. Stockpile spoil material on the inside of the RM 199 point bar. Remove entrance and exit plugs to allow flow through the cutoff channel.	

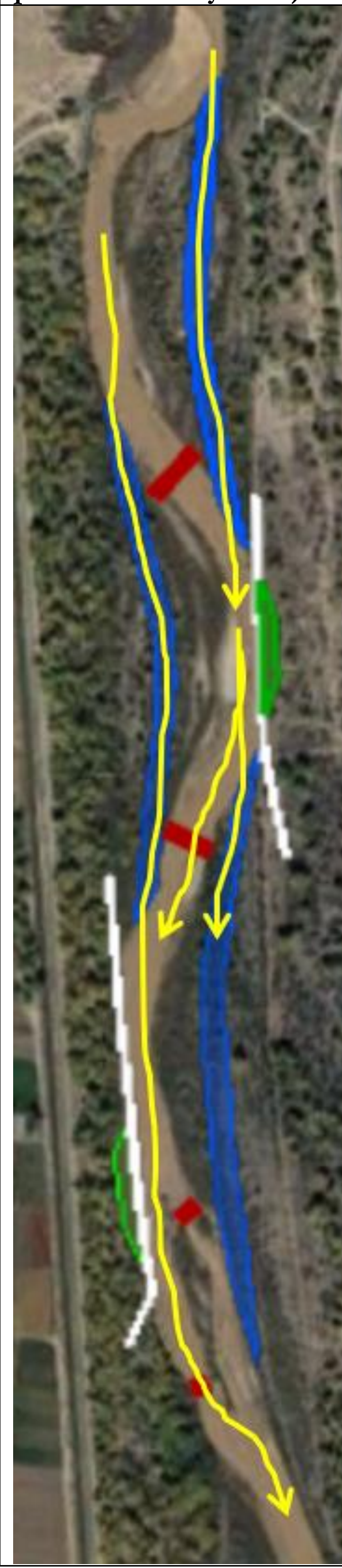
Step	Actions	Features Completed (flow path shown in yellow)
2	Build temporary riprap diversion cofferdam immediately downstream and upstream of the RM 199 cutoff channel entrance and exit, respectively. All flows would temporarily be in the cutoff channel and the RM 199 bend would be temporarily dry. On the RM 199 outer bend, construct the LSTP. Place cutoff channel's spoil material in the (dry) main channel and fill in behind the LSTP for the floodplain bench.	

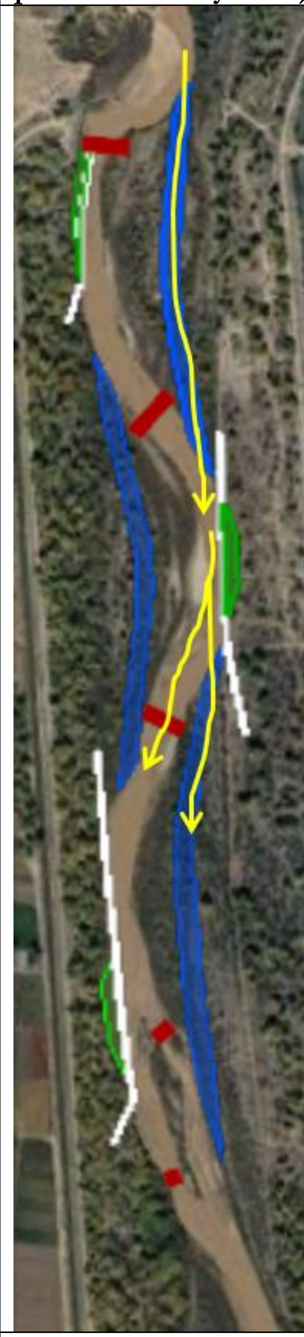
Step	Actions	Features Completed (flow path shown in yellow)
3	Smooth out the riprap from the downstream temporary riprap diversion cofferdam onto the spoiled material filling the main channel. This will stabilize the slope going from spoil material grade to main channel grade. Leave the upstream temporary riprap diversion cofferdam in place.	

Step	Actions	Features Completed (flow path shown in yellow)
4	Excavate the cutoff channel on the BB-343 point bar, leaving the entrance and exit plugs in place. Stockpile spoil material on the inside of the point bar. Remove entrance and exit plugs to allow flow through the cutoff channel.	

Step	Actions	Features Completed (flow path shown in yellow)
5	Build temporary riprap diversion cofferdam immediately downstream of the BB-343 cutoff channel entrance. All flows would temporarily be in the cutoff channel and the BB-343 bend would be temporarily dry. On the BB-343 outer bend, construct the LSTP. Place the cutoff channel's spoil material in the (dry) main channel and fill in behind the LSTP for the floodplain bench.	

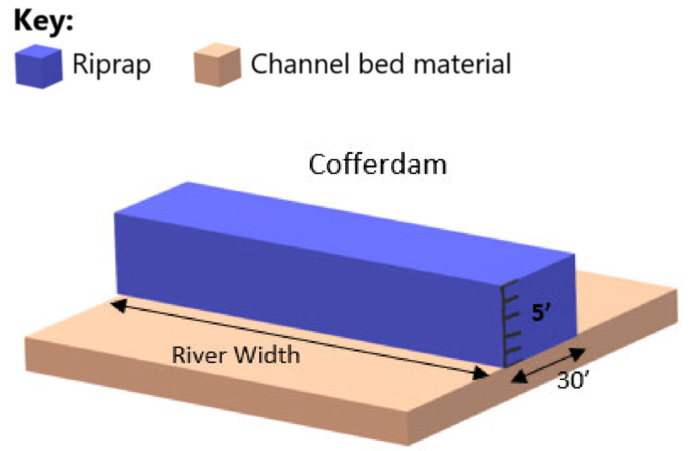
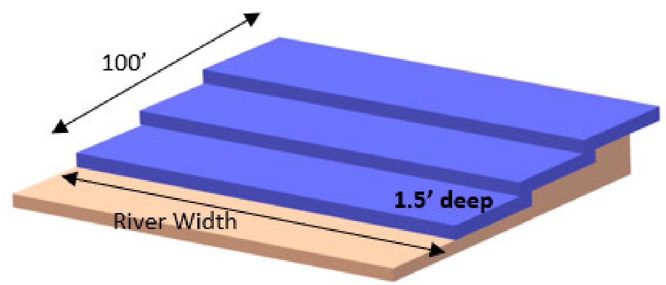
Step	Actions	Features Completed (flow path shown in yellow)
6	At the temporary riprap diversion cofferdam between BB-343 and RM 199, smooth out the riprap onto the spoiled/fill material now placed upstream and downstream of the temporary riprap diversion cofferdam. This feature will now act as grade control to prevent erosion of fill material.	

Step	Actions	Features Completed (flow path shown in yellow)
7	Excavate the cutoff channel on the Corrales Siphon point bar, leaving the entrance and exit plugs in place. Stockpile spoil material on the inside of the Corrales Siphon point bar. Place a small layer of riprap immediately downstream of the siphon's alignment inside the cutoff channel to minimize potential downcutting to the siphon. Remove entrance and exit plugs to allow flow through the cutoff channel.	

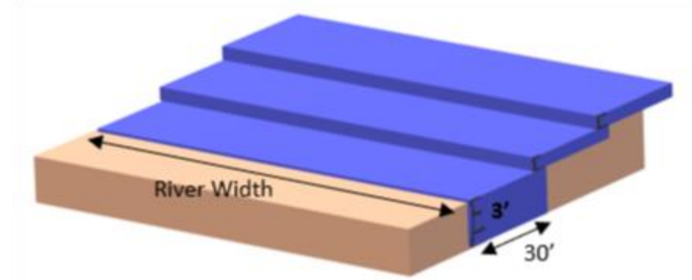
Step	Actions	Features Completed (flow path shown in yellow)
8	Build a temporary riprap diversion cofferdam on top of the siphon's downstream riprap protection installed by MRGCD. (If MRGCD is opposed to a temporary riprap diversion cofferdam on top of the siphon's riprap protection, the cofferdam could also be placed closer to the upstream entrance of the cutoff channel. However, this configuration would require a much longer cofferdam). All flows would temporarily be in the cutoff channel and the Corrales Siphon bend would be temporarily dry. On the Corrales Siphon bend, construct the LSTP. Place the cutoff channel's spoil material in the (dry) main channel and fill in behind the LSTP for the floodplain bench.	
9	At the temporary riprap diversion cofferdam between Corrales Siphon bend and BB-343 bend, smooth out the riprap onto the spoiled/fill material now placed upstream and downstream of the cofferdam. This feature will now act as grade control to prevent erosion of fill material. At the temporary riprap diversion cofferdam at the siphon, smooth the extra riprap in the downstream direction to create a smooth slope with a downstream apron for extra scour protection.	Flow can now travel the entire length of the main channel or in any of the cutoff channels.

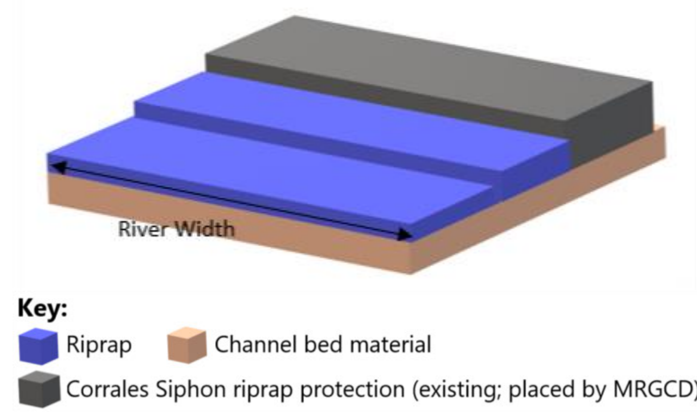
9.6 Appendix F: Proposed Alternative: Bed Control Dimensions

Table 51: Proposed temporary riprap diversion cofferdam and bed control feature diagrams and descriptions

Feature	Description	Rough Conceptual Diagram
Temporary riprap diversion cofferdam (during construction)	Riprap placed on riverbed Roughly 5' tall x 30' long x river width	
Bed control downstream of RM 199 bend (final configuration after material is spoiled)	Approx. 1-2 feet of fill placed on upstream side of cofferdam Then the cofferdam is smoothed in the upstream direction over the new fill material with the resulting riprap layer being approx. 1.5' thick, 100' long, and no greater than 0.002 slope	

<table>
<tr><th>Feature</th><th>Description</th><th>Rough Conceptual Diagram</th></tr>
<tr><td>Two intermediate bed control features (final configuration)</td><td>Approx. 3 feet of fill placed on both sides of cofferdam

Then the top 2’ of cofferdam riprap is smoothed in the upstream direction at approx. 1’ thick, 60’ long, and approx. 0.001 slope</td><td>
</td></tr>
<tr><td>Bed control at Corrales Siphon -- additional bed control is unnecessary at Corrales Siphon since there is already riprap protection present (installed by MRGCD); thus, cofferdam riprap will be used to improve the slope of the existing (MRGCD’s) riprap protection</td><td>The cofferdam at Corrales Siphon would consist of approx. 1-2’ of riprap on top of the existing riprap protection to ensure water is blocked from flowing downstream.

After approx. 3 feet of fill placed on the downstream side of cofferdam, the excess riprap on top of the existing Corrales Siphon riprap would be smoothed in the downstream direction to improve the slope of the existing riprap and add an apron (scour protection).</td><td>
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APPENDIX D. AGENCY CONSULTATIONS AND PERMITS

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NEW MEXICO HISTORIC PRESERVATION DIVISION

New Mexico Historic Preservation Division
407 Galisteo Street, Suite 236
Santa Fe, NM 87501
Telephone: (505) 827.6320
Email: nm.shpo@dca.nm.gov

March 25, 2025

Jennifer Faler, P.E.
Area Manager
Bureau of Reclamation
Albuquerque Area Office
555 Broadway NE, Suite 100
Albuquerque, NM 87102-2352

SENT VIA EMAIL
Re: Section 106 Consultation for the Corrales River Mile 199 (RM-199) River Maintenance Project, Sandoval County, New Mexico

Dear Ms. Faler:

Thank you for providing the cultural resources survey report prepared by the Office of Contract Archeology (OCA) (NMCRIS 157205). I have several comments on the determinations of eligibility and the documentation, but I concur that the proposed undertaking will have No Effect on Historic Properties.

<u>LA 132552.</u> I concur that the parts of this site within the APE do not retain integrity; however, the site remains eligible for listing in the National Register. The report and site documentation show the current boundaries of the site, but OCA (and previous) contractors have not uploaded the shapefiles to the GIS portion of NMCRIS. As it stands now, LA 132552 is shown as a point outside of the APE and it is very confusing to figure out the relationship between that location and its location with the APE. With the upgrades to NMCRIS it should be much easier to document linear features. Please have OCA provide an updated shapefile ASAP.

<u>LA 146163.</u> I concur with Reclamation that this site is unevaluated, but it is our opinion that the site is eligible under criteria A and C.

In addition to the above comments, it would be helpful if Reclamation could enter their determinations of eligibility in NMCRIS and confirm that the contractor has uploaded the survey and historic property shapefiles, completed the forms online, and uploaded the report. For this project, I noticed that the report has not been uploaded to NMCRIS but all of the forms and survey shapefiles were entered.

Please do not hesitate to contact me if you have any questions. I can be reached be telephone at [redacted] or by email at [redacted]

Sincerely,

Michelle M. Ensey
Director, Historic Preservation Division
State Historic Preservation Officer