RECLAMATION

Managing Water in the West

BDA Pilot Project Description

Middle Rio Grande Project, NM

Upper Colorado Region

U.S. Department of the Interior
Bureau of Reclamation

December 2017

Mission Statements

The mission of the Department of the Interior is to protect and manage the Nation's natural resources and cultural heritage; provide scientific and other information about those resources; and honor 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.

BDA Pilot Project Description

Middle Rio Grande Project, NM

Upper Colorado Region

Report Prepared by:

Jonathan AuBuchon, PE., Sr. Hydraulic Engineer, Technical Service Division
Aubrey Harris, PE, Hydraulic Engineer, Technical Service Division

Cover Photograph. Rio Grande through the Bosque del Apache National Wildlife Refuge near RM 81 (2012 river mile demarcation) by Aubrey Harris on May 16, 2016

U.S. Department of the Interior
Bureau of Reclamation

December 2017

Contents

Page

Acknowledgments ..... **vii**
Executive Summary **1**
1.0 Project Background and Purpose **3**
2.0 Project Components **5**
2.1 Realignment Corridor Vegetation Destabilization 5
2.2 Inlet/Outlet Excavation 7
2.3 Vegetation Removal outside the Realignment Corridor 11
2.4 Existing Channel Floodplain Conversion 13
2.4.1 Channel Diversion 13
2.4.2 Channel Fill with Vegetation Stabilization 15
2.4.3 Upstream Bank Stabilization 19
3.0 Access **22**
3.1 Primary Access 23
3.2 Secondary Access 24
4.0 Staging **25**
5.0 Dust Abatement **28**
6.0 Impact Area **28**
7.0 Construction Operations **30**
8.0 Material Quantities **39**
9.0 Document Revision History **39**
10.0 References **41**

Figures

Page
Figure 1. BDA Pilot Project and PLSS delineations..... 2
Figure 2. BDA pilot project centerline, 300 foot offset, and proposed temporary stockpile area. The background imagery is a combination of the 2016 and 2012 aerial photography (Reclamation)..... 6
Figure 3. BDA pilot project realignment centerline showing existing and design surfaces. Stationing is from the upstream end of the pilot project. All elevation and distances are approximate. 9
Figure 4. BDA pilot project typical excavation cross section at inlet and outlet. All dimensions are approximate. Second and third tiers are constructed as needed. 10
Figure 5. BDA pilot project centerline and 300 foot offset alignment with vegetation removal areas. The background imagery is a combination of the 2016 and 2012 aerial photography (Reclamation)..... 12
Figure 6. BDA pilot project centerline and 300 foot offset alignment with existing channel fill area. The background imagery is a combination of the 2016 and 2012 aerial photography (Reclamation)..... 14
Figure 7. BDA pilot project existing channel floodplain conversion area showing existing and finished ground surfaces. Stationing is from the transition between the existing and realigned channels. All elevation, distances, and dimensions are approximate..... 16
Figure 8. BDA pilot project typical fill cross section at upstream end of existing river channel..... 17
Figure 9. BDA pilot project planview of coyote willow grids as part of the channel fill with vegetation stabilization. Coyote willow grids are shown at the upstream and downstream end of existing channel floodplain conversion area. The background imagery is the 2016 aerial photography (Reclamation)..... 18
Figure 10. BDA pilot project planview of coyote willow grids on upstream end of existing channel floodplain conversion area. The coyote willow grids are part of the channel fill with vegetation stabilization. All dimensions are approximate... 19
Figure 11. BDA pilot project typical cross section of an ELJ at upstream end of existing channel floodplain conversion area. All dimensions are approximate.... 20
Figure 12. BDA pilot project planview of ELJ at upstream end of existing channel floodplain conversion area. The background imagery is the 2016 aerial photography (Reclamation). 21
Figure 13. BDA pilot project planview of typical woody structure of ELJ anchored into permanent diversion berm at upstream end of existing channel floodplain conversion area. All dimensions are approximate..... 22
Figure 14. Primary access routes and temporary stockpile and equipment staging areas for the BDA pilot project. The background imagery is a terrain map generated by ESRI (accessed May 9, 2017). 26
Figure 15. BDA pilot project centerline and 300 foot offset alignment with temporary stockpile and equipment staging areas. The background imagery is a combination of the 2016 aerial photography (Reclamation) and aerial imagery available from ESRI..... 27

Figure 16. BDA pilot project features and maximum project area. The background imagery is a combination of the 2012 and 2016 aerial photography (Reclamation). 29
Figure 17. BDA pilot project centerline and realignment corridor and potential locations for facilitating project drainage, if needed. The background imagery is the 2012 and 2016 aerial photography (Reclamation). 32

Tables

Page
Table 1: Expected and Maximum Material Quantities for BDA pilot project 39

Acknowledgments

Much of the information contained in this document was obtained directly from designs and reports developed by Nathan Holste with the Bureau of Reclamation Technical Service Center, Sedimentation and River Hydraulics Group. Nathan Holste has developed the design for the Bosque del Apache National Wildlife Refuge east realignment and so this document owes considerably to his work.

Executive Summary

The Rio Grande between San Antonio and San Marcial, NM has perched channel conditions where the floodplain is lower than the channel. Concerns associated with the perched river system include: difficulty maintaining continuous low flows during drought, loss of native riparian woody plant species resulting in declining habitat, sediment transport imbalance leading to sediment plug formation, overbanking flows that are disconnected from the main channel during flood events, stranding of aquatic species during high flows, and threats to existing infrastructure from an uncontrolled channel avulsion. The latter is of particular concern due to potential damage to the spoil levee and adjacent Bosque del Apache National Wildlife Refuge lands. The risk to the Low Flow Conveyance Channel (LFCC) drain and spoil levee was the reason the Bosque del Apache (BDA) sediment plug is currently classified as a Class 2 river maintenance site (Maestas et al., 2014).

An eastern realignment of the existing river channel with some form of an excavated channel was chosen during an alternative analysis process that involved a multi-agency and interdisciplinary team. A pilot project on the lower three miles of the realignment will be used to observe the actual channel response and apply "'lessons learned' … to inform compliance and construction of larger, upper realignment" (Reclamation, 2016, p.2).

The purpose of this pilot project is to promote long-term effective conveyance of water and sediment through the reach while minimizing the potential for spoil levee and LFCC failure. It is also expected that this project will create and improve aquatic, wetland, and native riparian habitat that would benefit listed species such as the Rio Grande Silvery Minnow (minnow), Southwestern Willow Flycatcher (flycatcher), and Yellow-billed Cuckoo (cuckoo). The completion of this project would meet requirements specified in the 2016 Biological Opinion addressing Reclamation's river maintenance activities (U.S. Fish and Wildlife Service, 2016).

The BDA pilot project consists of a three mile long channel relocation of the Rio Grande channel between River Miles (RM) 79 and 82 (2012 channel demarcations). Channel excavation and vegetation clearing/removal along the new alignment, plus filling and stabilizing the existing river channel are all components of this project. The expected disturbance area is about 360 acres, with a maximum project area of 1,110 acres. Roughly 175,000 cubic yards (CY) of material will be used to fill in a portion of the existing river channel. Of this volume about 45,000 CY are from excavation at the inlet and outlet and 130,000 are from grubbing throughout the entire realignment corridor.

Figure 1 shows the approximate project area with underlying land ownership.

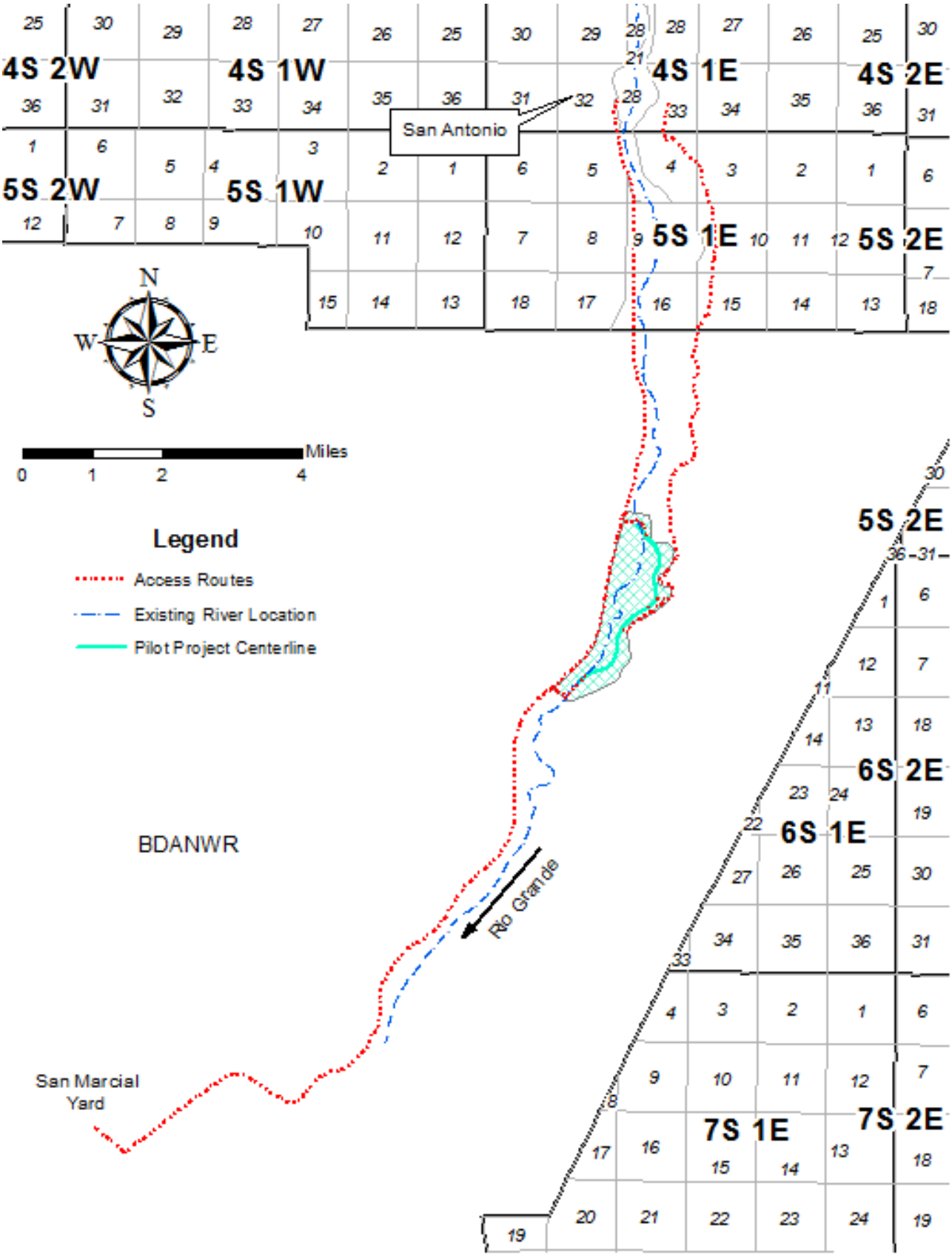

Figure 1. BDA Pilot Project and PLSS delineations

1.0 Project Background and Purpose

The Rio Grande between San Antonio and San Marcial, NM has perched channel conditions where the floodplain is lower than the channel. Concerns associated with the perched river system include: difficulty maintaining continuous low flows during drought, sediment transport imbalance leading to sediment plug formation, overbanking flows that are disconnected from the main channel during flood events, and threats to existing infrastructure from an uncontrolled channel avulsion. The latter is of particular concern due to potential damage to the spoil levee and adjacent Bosque del Apache National Wildlife Refuge lands.

Sediment plugs have occurred five times since 1991 between San Antonio and San Marcial. Three of the five times have been in the vicinity of San Marcial, NM. In recent years the decreasing water level in Elephant Butte has degraded the channel bed around San Marcial below the adjacent floodplain, decreasing the risk of sediment plug formation. However, the Rio Grande channel through the Bosque del Apache National Wildlife Refuge is still perched above the adjacent floodplain and was the site of the most recent sediment plugs in 2008 and 2017 during the spring snow-melt runoff. (Makar and AuBuchon, 2012; Julien and Rainwater, 2014; AuBuchon et al., 2017). The BDA sediment plug caused channel capacity and levee stability concerns, but also created ideal habitat for certain species. The risk to the LFCC drain and spoil levee was the reason the BDA sediment plug is currently classified as a Class 2 river maintenance site (Maestas et al., 2014). This classification status implies that a future project is required to effectively convey water and sediment downstream and/or protect riverside infrastructure.

An interagency and interdisciplinary team was formed and led by Reclamation to evaluate potential options for addressing river maintenance and water depletion concerns. During this process six different alternative types were considered, totaling 17 different alternatives. The various alternative types are listed below with a brief explanation (Holste, 2014a).

- Ongoing maintenance without a pilot channel – One alternative that considered ongoing maintenance, but no action to remove the sediment plug once formed.
- Pilot channels – Three alternatives that considered a narrow channel excavation through the sediment plug. Alternatives looked at different channel excavation and spoiling options.
- Pilot channel with grade control – One alternative that considered placement of deformable riffles in the channel bed and also considered excavation of a pilot channel through the sediment plug, if and when it occurs.
- Levee improvements – Four alternatives that considered methods of reducing the hydraulic pressure against the spoil levee. One alternative considered changes to the spoil levee width and slope. The other three alternatives considered placement of bendway weirs separately or in

conjunction with floodplain modifications such as vegetation clearing or excavation of small channels to route water away from the spoil levee toe.

- River realignments – Five alternatives that considered relocation of the river channel. Four alternatives were specific realignment locations to the east. These considered relocations around River Mile (RM) 83 and RM 81 (2012 channel demarcations) respectively. Each eastern location considered excavation at the inlet and outlet and also continuous channel excavation. The final alternative considered options of relocating the channel to the west.
- Preemptive channel work – Three alternatives that considered potential channel/floodplain work that may minimize the formation of sediment plugs. Potential work included widening the river channel and removing/destabilizing vegetation on islands and banks, breaking up of mud layers and smoothing out abrupt bends, and excavating the channel thalweg.

The alternative evaluation team considered engineering effectiveness related to levee integrity and water delivery, geomorphic response, environmental compliance ease, ecosystem function, constructability, and cost in the evaluation of alternatives. The RM 81 eastern river realignment alternative (RM 82/81 to RM 79) with some form of an excavated channel was the chosen alternative (Holste, 2014a).

During the initial design of the RM 81 river realignment, analysis of newly collected data (2012 LiDAR and 2013 hydrographic data) indicated that extension of a river realignment to the east further north would be possible. Two additional realignment starting locations were proposed for consideration of the interagency and interdisciplinary team that evaluated the initial list of alternatives. These proposals extended the starting location to the Bosque del Apache National Wildlife Refuge's northern boundary (~ RM 84, 2012 channel demarcations) and about one mile south of the U.S. 380 Bridge (~RM 86, 2012 channel demarcations). The team opted to pursue design work for the option that starts at ~ RM 86 (Holste, 2014b). Additional design modifications also occurred as the specific alignment of the relocated channel was addressed (Holste, 2015). An additional adjustment was made to this project in October 2016 to facilitate the initial construction of a pilot project (the last 3 miles of the proposed realignment, which is approximately the extent of the initial preferred alternative). The pilot project will be used to observe the actual channel response and apply "'lessons learned' … to inform compliance and construction of larger, upper realignment" (Reclamation, 2016, p.2).

The purpose of this pilot project is to promote long term effective conveyance of water and sediment through the reach while minimizing the potential for spoil levee and LFCC failure. It is expected that this project would reduce the potential for levee failure and may minimize depletions that result from a plug, although upstream reaches may overbank and allow water to travel along the toe of the

spoil levee. Benefits of the project also include the reestablishment of the surface water-floodplain connection which provides minnow nursery habitat and supports the development of flycatcher and/or cuckoo habitat. Completion of this project would meet requirements specified in the Biological Opinion addressing Reclamation's river maintenance activities (U.S. Fish and Wildlife Service, 2016).

2.0 Project Components

The BDA pilot project consists of relocating the Rio Grande from its current location to the east, as shown in Figure 2. The realigned channel is approximately three miles in length and would address the area where the 2008 and 2017 sediment plugs occurred. The work will involve the following project elements, described in more detail in the sections that follow.

- Vegetation destabilization for the length of the realignment corridor,
- Excavation at the inlet and outlet of the realignment corridor,
- Vegetation removal and destabilization, primarily of monotypic and exotic species, outside of the realignment corridor, and
- Conversion of the existing river channel into a floodplain, which consists of the following elements:
    - Diverting the river into the realignment corridor,
    - Filling and stabilizing the existing channel, and
    - Providing bank stabilization along the upstream end, if needed.

2.1 Realignment Corridor Vegetation Destabilization

The BDA pilot project consists of an approximately three mile long channel realignment, measured along the centerline. The realignment centerline will have a 300 foot wide swath, 150 feet on either side of the centerline. Both the centerline and the 300 foot swath are shown in Figure 2. All existing vegetation within this 300 foot swath will be removed by mulching or through tree extraction. The estimated area for the vegetation removal and destabilization is about 100 acres.

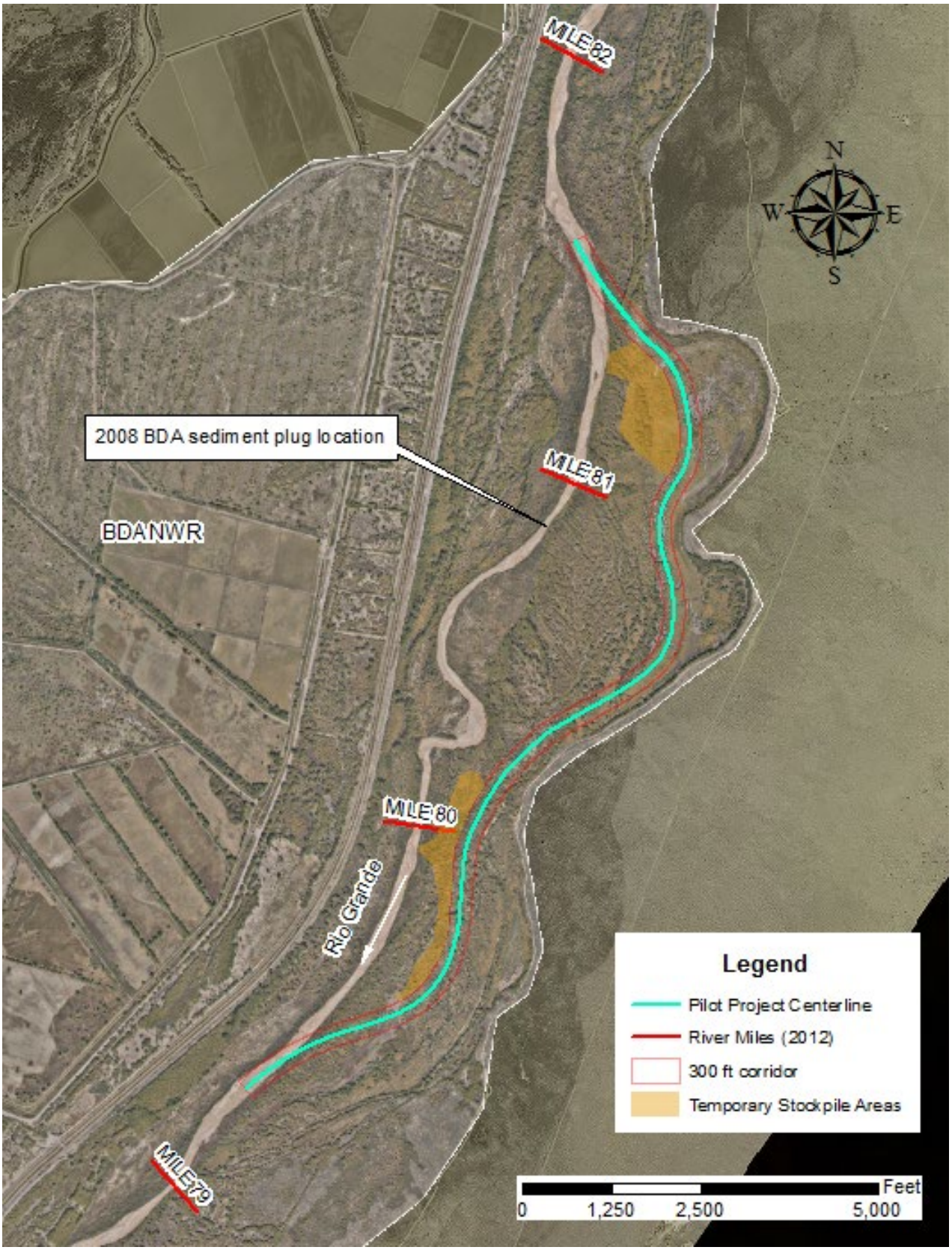

Figure 2. BDA pilot project centerline, 300 foot offset, and proposed temporary stockpile area. The background imagery is a combination of the 2012 and 2016 aerial photography (Reclamation).

Some existing stands of native vegetation may be left intact at the exterior fringes of the 300 foot realignment corridor. This will be at the discretion of the project team with agreement by the project engineer. Large native tree species (greater than 40 feet in height) that are within the realignment corridor and slated to be removed will be stockpiled in the temporary stockpile area. These trees may be used to help stabilize the bankline along the existing river channel if it is needed to help transition the flow into the realigned channel (see 2.4.3 Upstream Bank Stabilization). Native trees removed as part of this project will be replaced at a ratio of 10 new plants for each mature native tree removed, in accordance with the 2016 Biological Opinion (U.S. Fish and Wildlife Service, 2016). Replacement may occur through planned native tree plantings or natural recruitment.

Once the vegetation is removed, the soil will be loosened using a single or multi shank ripper to dislodge roots and tree trunks within the first few feet of the existing ground elevation. This grubbing and clearing of vegetation will cover a 300 foot width down the entire length of the realignment channel. It is estimated that the grubbing depth will be an average of 1 foot and will provide a volume of around 130,000 CY, 70% of which is expected to be organic. Woody material from the vegetation removal operations, except as discussed below, will be placed along the realignment centerline or in the temporary stockpile area (see Figure 2) and burned. Burning of cleared vegetation will be conducted by the Bosque del Apache National Wildlife Refuge fire crews. Once the piles are burned, Reclamation crews will transfer the ashes, expected to be about 65% of the original organic volume component (Misra et al., 1993), and any remaining inorganic material to the temporary stockpile area. This remaining ash and inorganic material will then be mixed with sediment to fill the existing channel, providing nutrients for planted material (see 2.4.2 Channel Fill with Vegetation Stabilization).

2.2 Inlet/Outlet Excavation

The proposed location of the BDA pilot project realignment (see Figure 2) is at a lower elevation than the adjacent floodplain and current bank elevation, adjacent and to the east of the current river location. To facilitate a connection with the existing channel, both the inlet and outlet realignment locations will be excavated, as shown in Figure 3. The elevation profile, shown along the proposed realignment centerline in Figure 3, illustrates the inlet and outlet excavation areas as well as the design invert slope (~ 0.0007 ft/ft). Excavation, other than grubbing activities, will not occur in areas outside of the inlet and outlet areas. In these areas (roughly between stations[1] 24+00 to 66+00, see Figure 3) the design invert slope will follow the natural topography. A 50 foot wide section will be smoothed along the BDA pilot project corridor outside of the inlet and outlet excavation

[1] Station designation denotes the linear distance along a line, from upstream to downstream. The distance is cumulative and provides a means of discussing specific locations within a long, linear feature.

areas. This will facilitate the conveyance of flows at lower discharges. The rest of the corridor width would be left rough.

About 2,400 feet at the inlet and 9,000 feet at the outlet will need to be excavated at a width of up to 300 feet. The excavation top width ranges between 50 and 300 feet. Part of the excavation may require work in the existing channel, such as through existing river bars or other depositional features to facilitate the river realignment. Part of the excavation may also be in the wet, especially as the inlet and outlet realignment locations are connected to the existing channel or the existing channel is excavated to help guide flows into the realigned channel. The average excavation depth within the inlet and outlet excavation areas is 2 feet, with a range between 0 and 7 feet. The inlet/outlet excavation cross section is designed to help provide variable depths for the initial baseline conditions (N. Holste, oral commun., 2016). The excavated cross section will be trapezoidal in shape with a minimum bottom width of 50 feet. The sides are graded to the existing ground at a minimum slope of 10 horizontal: 1 vertical (10H: 1V). Where the excavation depth is greater than 1.5 feet, a tiered channel, with up to three tiers, will be excavated with varying elevations and widths, as shown in Figure 4. Each tier is about 1.5 feet higher in elevation than the previous, with a variable terrace width. The last tier will daylight to match existing ground.

The expected excavation volume, less grubbing, is about 13,000 CY at the inlet (max of 16,000 CY) and roughly 32,000 CY at the outlet (max of 38,000 CY). The total excavation volume, with grubbing, of the realignment corridor is 175,000 CY (max of 215,000 CY). Most of this material is expected to be excavated in the dry, but a fraction (estimated at about 15,000 CY), may need to be excavated in the wet. While this is the expected condition, higher groundwater or river conditions during construction may require most of the excavation to be in the wet. Excavated material, both wet and dry, will be temporarily stockpiled at the designated temporary stockpile locations (see Figure 2) and discussed in section 4.0 Staging. All excavated material will be placed as fill in the existing channel (see 2.4.2 Channel Fill with Vegetation Stabilization).

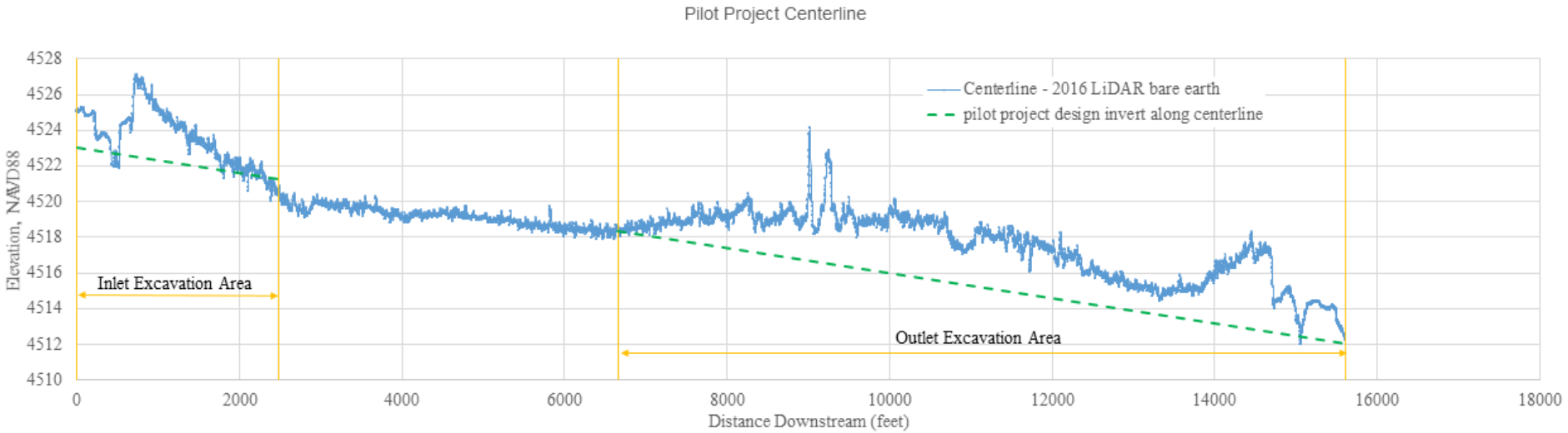

Figure 3. BDA pilot project realignment centerline showing existing and design surfaces. Stationing is from the upstream end of the pilot project. All elevation and distances are approximate.

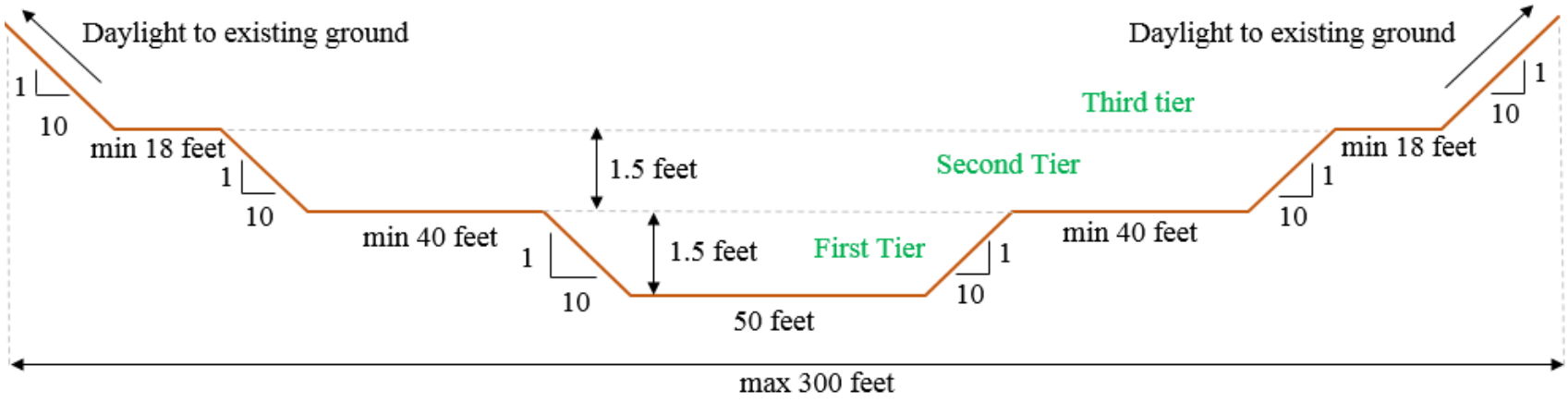

Figure 4. BDA pilot project typical excavation cross section at inlet and outlet. All dimensions are approximate. Second and third tiers are constructed as needed.

2.3 Vegetation Removal outside the Realignment Corridor

It is desirable to remove other vegetation, in addition to the vegetation clearing within the pilot project realignment corridor (see 2.1 Realignment Corridor Vegetation Destabilization). The additional vegetation removal will focus on monotypic stands of non-native and noxious plant species that are adjacent to and outside the 300 foot realignment corridor. Figure 5 shows the proposed locations for additional vegetation removal. The additional vegetation removal locations total about 170 acres. By removing established vegetation outside of the 300 foot realignment corridor additional freedom is given to the river to adjust its morphology and encourage the development of a wide range of future active channel widths (Holste, 2016). The preferential removal of non-native and noxious plant species also provides greater opportunity for natural recruitment of native vegetation.

Large native vegetation, such as cottonwoods and Goodding's willows, will be left intact to the extent possible. Some removal of large native vegetation, however, may be required in order to facilitate access to the existing channel at both stockpile locations. Large native tree species (greater than 40 feet in height) that are within the realignment corridor and slated to be removed will be stockpiled in the northern, temporary stockpile area (see Figure 2). These trees may be used to help stabilize the bankline and/or to help transition flow into the realigned channel (see 2.4.3 Upstream Bank Stabilization). Native trees removed as part of this project will be replaced at a ratio of 10 new trees for each mature native tree removed in accordance with the 2016 Biological Opinion (U.S. Fish and Wildlife Service, 2016). Replacement may occur through planned native tree plantings or natural recruitment.

Vegetation will be removed through extraction of woody material or mastication, followed by burning. Once the vegetation is removed, the soil will be loosened using a single or multi shank ripper to dislodge roots and tree trunks within the first few feet of the existing ground elevation. No grubbing, however, of this material would occur. Extracted woody material accumulated outside of the 300 foot pilot project corridor will be placed along the proposed realignment centerline or in the temporary stockpile area. Burning of cleared vegetation will be conducted by the Bosque del Apache National Wildlife Refuge fire crews. Once the piles are burned, Reclamation crews will transfer the ashes, expected to be about 65% of the original organic volume component (Misra et al., 1993), and any remaining inorganic material to the temporary stockpile area. This remaining ash and inorganic material will then be mixed with sediment used to fill the existing channel, providing nutrients for planted material (see 2.4.2 Channel Fill with Vegetation Stabilization).

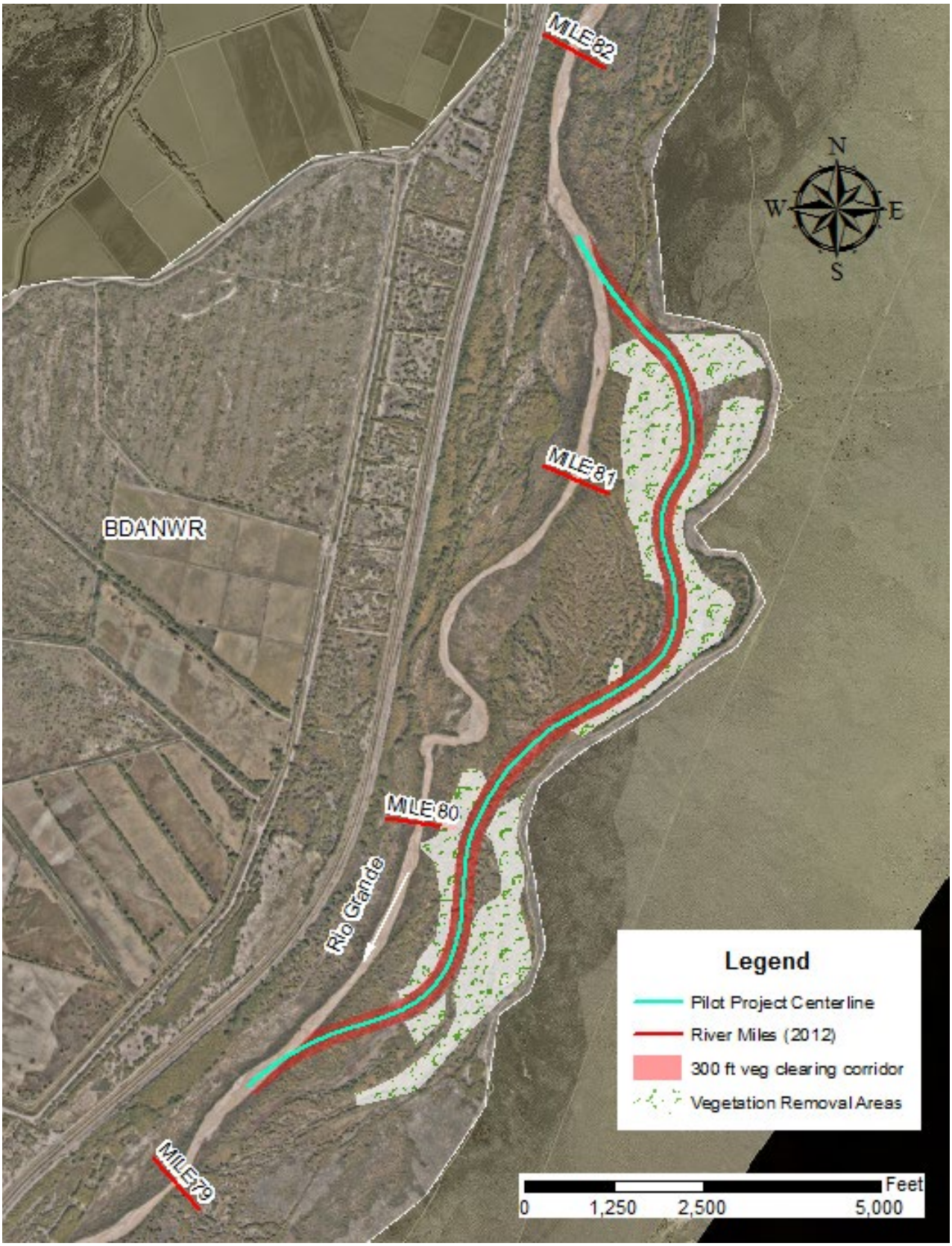

Figure 5. BDA pilot project centerline and 300 foot offset alignment with vegetation removal areas. The background imagery is a combination of the 2012 and 2016 aerial photography (Reclamation).

2.4 Existing Channel Floodplain Conversion

To successfully relocate the Rio Grande into the BDA pilot project realignment the existing channel will be converted into a floodplain throughout the area as shown in Figure 6. The following components will be required to facilitate the existing channel floodplain conversion.

- Diverting the existing channel into the realignment channel,
- Filling and stabilizing the existing channel corridor, and
- Stabilizing the "new river bankline," if needed.

2.4.1 Channel Diversion

A permanent earthen diversion berm will be used to redirect river flows from the existing channel into the realignment channel. The permanent diversion will be an earthen berm located about 930 feet downstream of the inlet transition area between the existing and realigned channels. The permanent diversion berm location was chosen to avoid removing riparian vegetation along the existing banks through the inlet transition area and to avoid higher energy areas along the transition to the realigned channel. This provides an established stand of vegetation that can provide additional bank stability (Pollen, 2007; Pollen-Bankhead and Simon, 2008) and minimizes the extent of bank stabilization required for the existing channel floodplain conversion area. The permanent diversion berm will be placed when river flows are at a discharge of 1,000 cfs or less.

The permanent berm will be part of the earthen channel fill (see 2.4.2 Channel Fill with Vegetation Stabilization) and may have additional bank stabilization across the upstream end of the existing channel floodplain conversion area, if needed. The bank stabilization, described in more detail in section 2.4.3 Upstream Bank Stabilization, consists of an engineered log jam. If the river is dry, the permanent diversion berm may be placed in conjunction with the engineered log jam.

The permanent diversion berm will have a trapezoidal shape and be constructed to have a height slightly above the tops of the existing river banks. The crest width will be 20 feet, with a minimum of a 2:1 (H:V) side slope on each side. About 2,000 CY of material will be required to construct the permanent diversion berm. The permanent diversion berm is located adjacent to the northwest edge of the northern temporary stockpile location, as shown in Figure 6. The northern temporary stockpile area provides the space to store the material and facilitates the relatively rapid movement of the earthen material into the existing channel. The northern temporary stockpile location is part of the vegetation removal locations described in more detail in section 2.3 Vegetation Removal outside the Realignment Corridor.

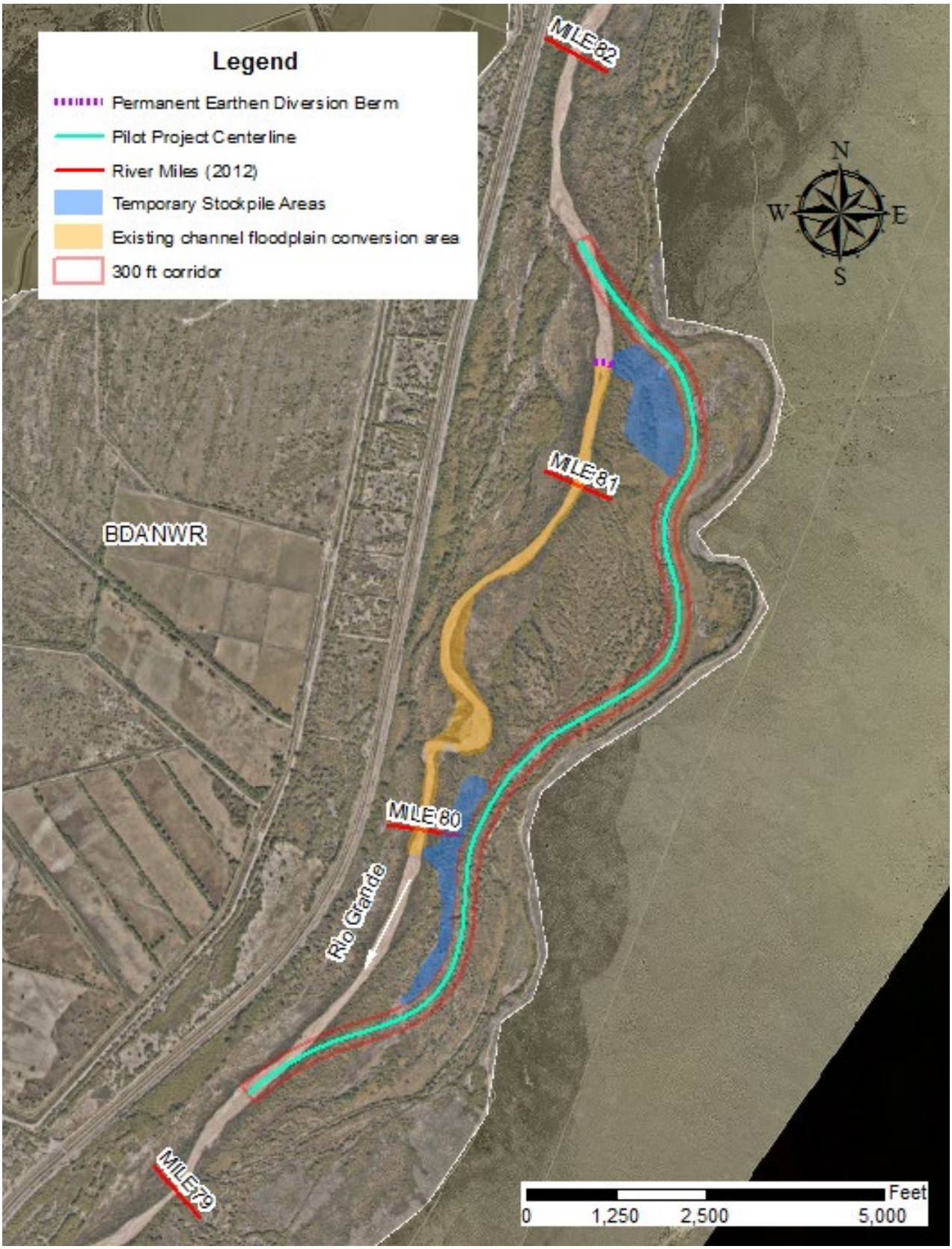

Figure 6. BDA pilot project centerline and 300 foot offset alignment with existing channel fill area. The background imagery is a combination of the 2012 and 2016 aerial photography (Reclamation)

2.4.2 Channel Fill with Vegetation Stabilization

The existing channel will be filled in and converted into a floodplain for almost 1.6 miles as shown in Figure 6. The stabilized channel fill will help ensure that the river flows transition into the realignment channel rather than returning to the existing channel. In addition, the fill provides a location to help manage material from the realignment excavation and vegetation clearing.

The extents and depths of the sediment deposition from the 2008 BDA sediment plug (Rolland, 2008; USFWS, 2008) were used as a guide for the planned existing channel fill. The longitudinal extents, however, were increased to match the expected excavated material volume. Fill placement elevations were also increased at the upstream transition between the existing and realigned channels to ensure overbanking occurs through the established riparian vegetation on the upstream end of the existing channel floodplain conversion area first, rather than over the top of the placed fill material.

Approximately 45 acres of the existing river channel will be filled. The expected fill volume is about 175,000 CY (max of 215,000 CY). The fill depth ranges from 0 to 7 feet. The fill will generally be placed to the current bankline elevations, but final fill elevations may vary to help preserve or create variable topography elevations through the channel fill area, creating an opportunity for a diversity of habitat communities. A typical elevation profile from north to south through the channel fill area is shown in Figure 7. A typical fill cross section is shown in Figure 8.

To encourage long term stability of the placed fill within the existing channel floodplain conversion area, vegetation planting will occur at the upstream and downstream longitudinal extents, as shown in Figure 9. The vegetation planting will consist of a grid of coyote willows (*Salix exigua spp.*) at a minimum density of 1 plant every couple of feet. The coyote willow grid will be tied into the existing vegetation on either bankline. The grid formation provides additional resistance to overbanking flows in both the longitudinal and transverse directions, encouraging a natural velocity reduction which helps to stabilize the channel fill. The longitudinal length of the coyote willow grid at both the upstream and downstream locations will be approximately 300 feet, or twice the channel width. The coyote willow grid spacing will be about ¼ of the channel width, or approximately 45 to 50 feet on center, as shown in Figure 10.

Additional geotechnical stability in the existing channel fill corridor will be obtained by planting other native riparian species appropriate for the topography and climate at the project site, such as Goodding's willow (*Salix gooddingii*) or Rio Grande cottonwoods (*Populus deltoides* var. *wislizenii*). Use of these plants would also encourage habitat diversity. All plants will be installed using revegetation techniques specified under the General Best Management Practices (BMP's). If whips are used, lengths will be specified to ensure contact with the water table is made.

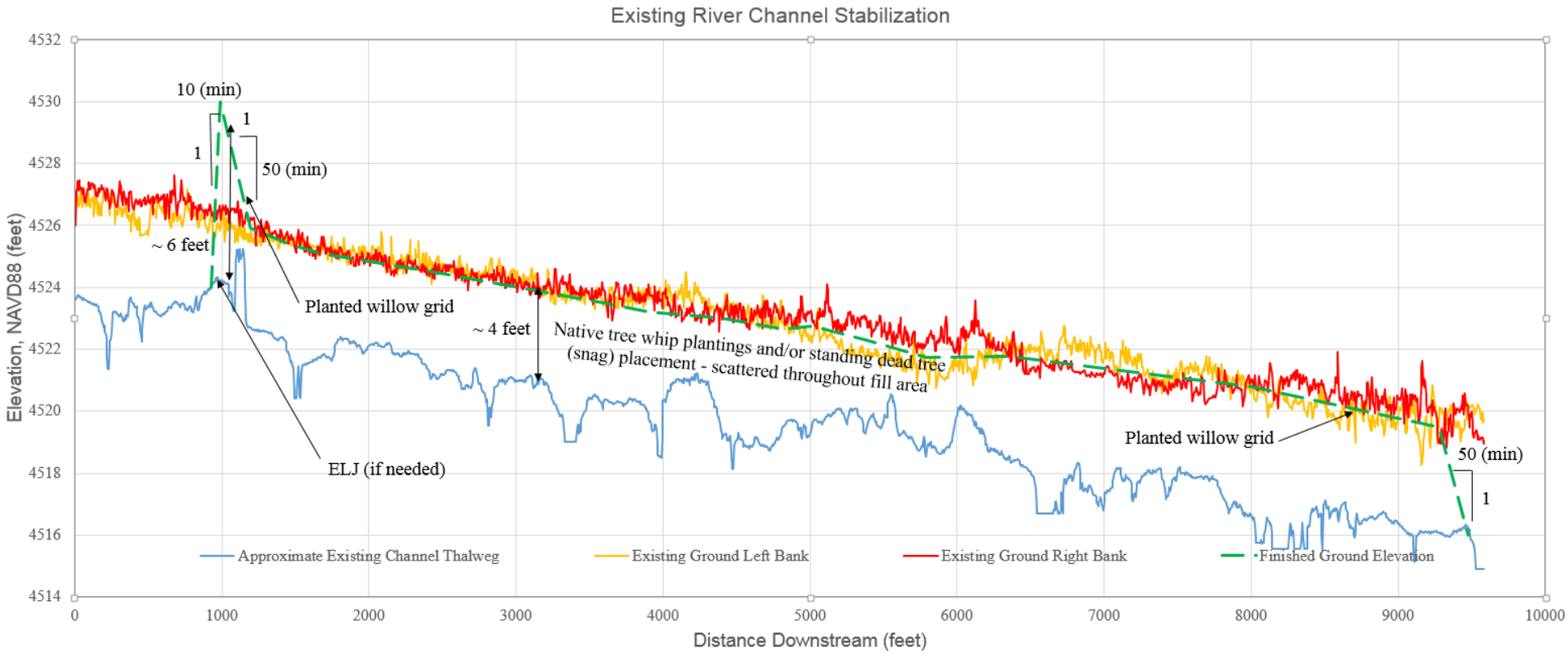

Figure 7. BDA pilot project existing channel floodplain conversion area showing existing and finished ground surfaces. Stationing is from the transition between the existing and realigned channels. All elevation, distances, and dimensions are approximate.

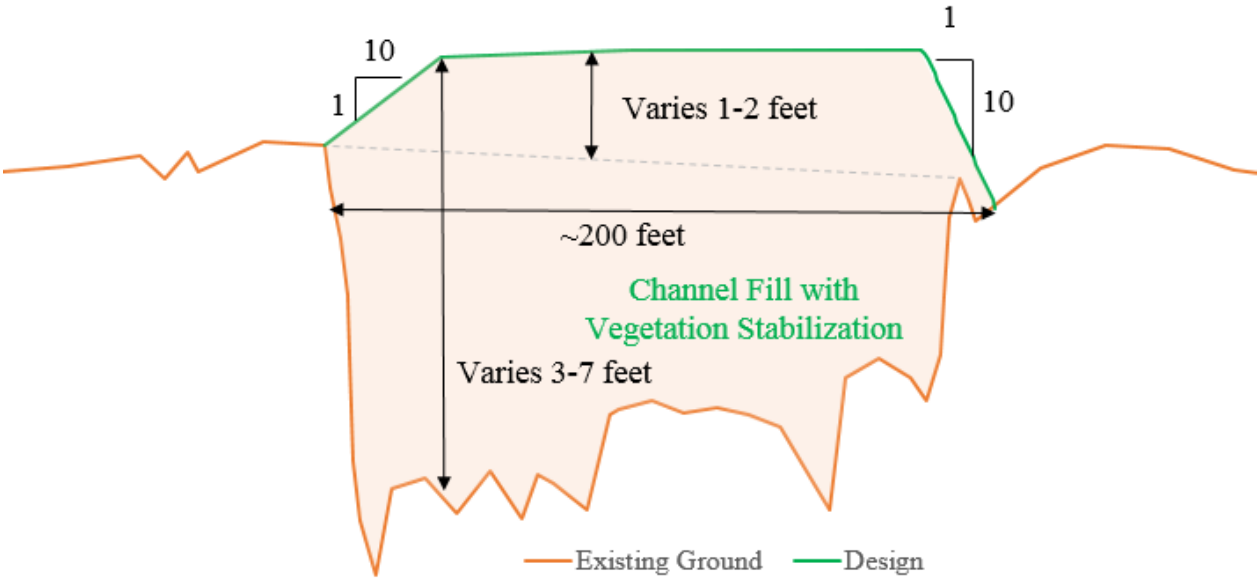

Figure 8. BDA pilot project typical fill cross section at upstream end of existing river channel stabilization. All dimensions are approximate.

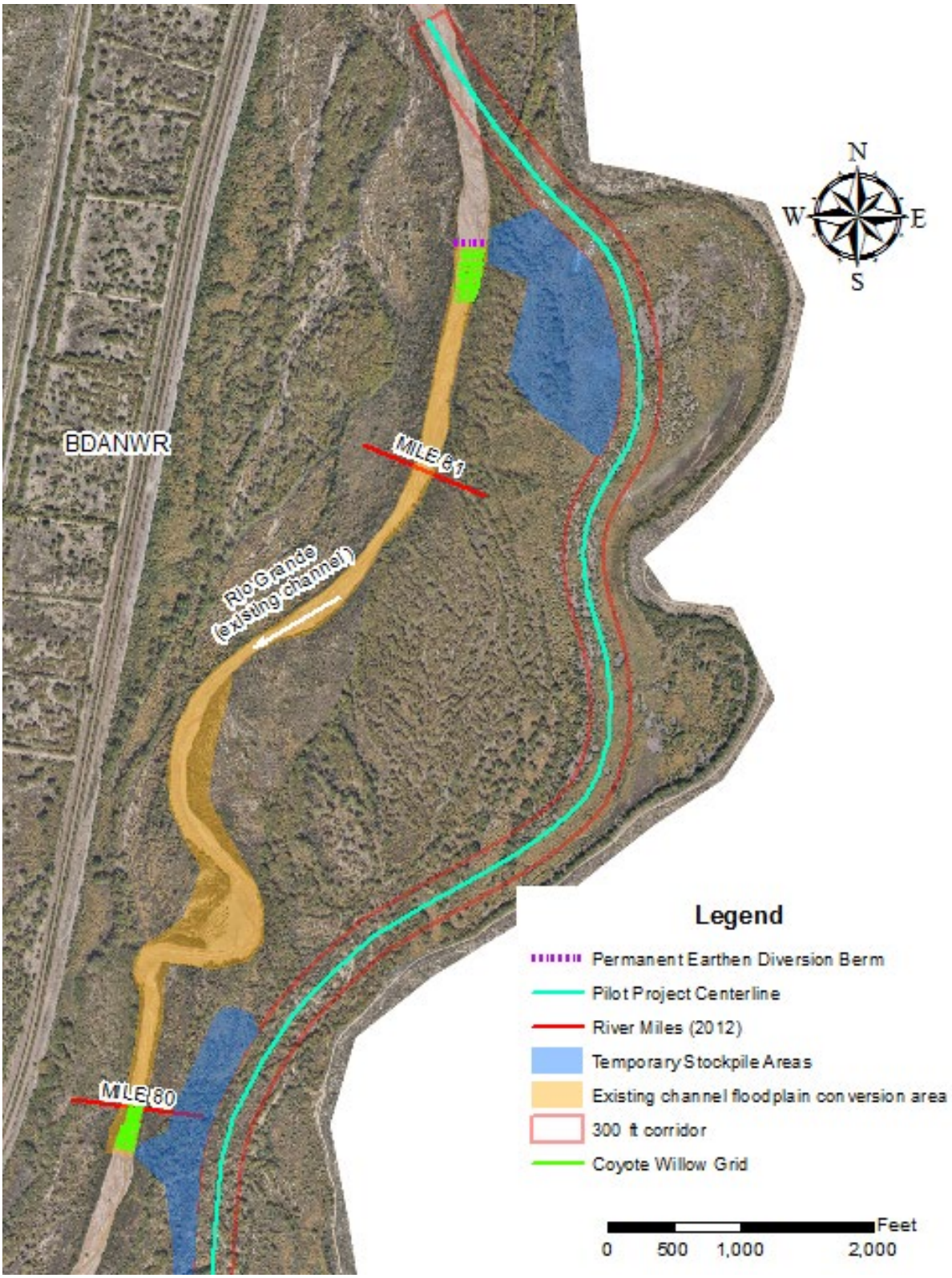

Figure 9. BDA pilot project planview of coyote willow grids as part of the channel fill with vegetation stabilization. Coyote willow grids are shown at the upstream and downstream end of existing channel floodplain conversion area. The background imagery is the 2016 aerial photography (Reclamation).

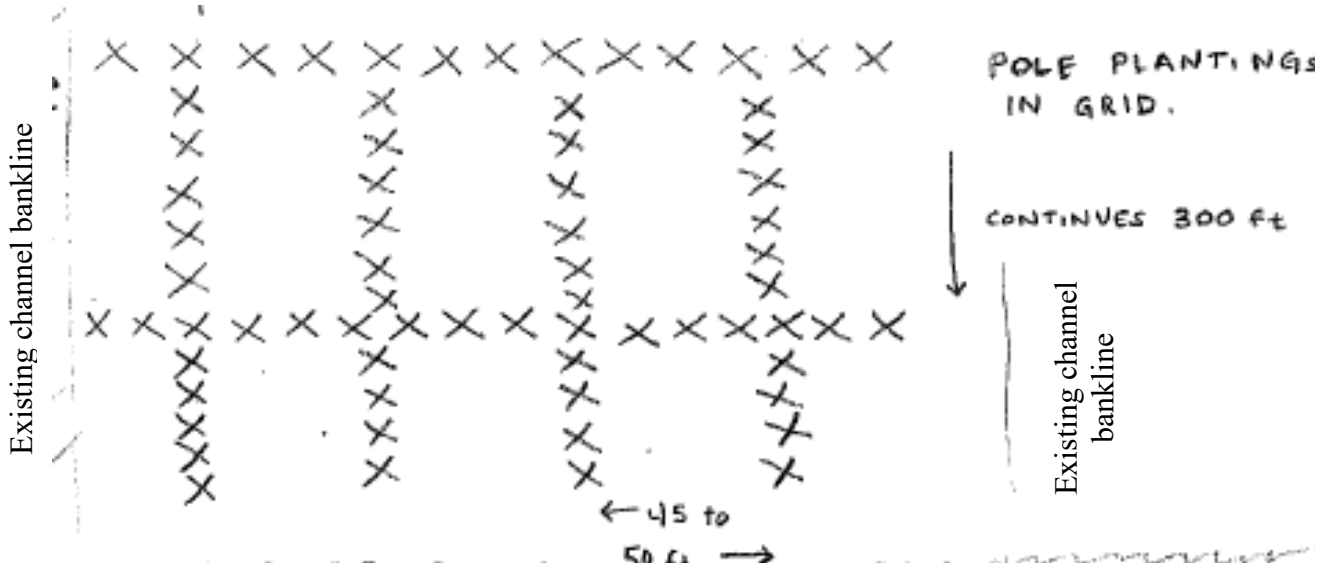

Figure 10. BDA pilot project planview of coyote willow grids on upstream end of existing channel floodplain conversion area. The coyote willow grids are part of the channel fill with vegetation stabilization. All dimensions are approximate.

2.4.3 Upstream Bank Stabilization

Bank stabilization may be required at the upstream edge of the existing channel floodplain conversion area. The channel floodplain conversion area is being setback from the transition area between the existing and realignment channel. Additional bank stabilization may be needed initially to help facilitate sediment deposition upstream and reduce hydraulic forces against the upstream face of the permanent diversion dam. Additional bank stabilization, if needed, will be comprised of an Engineered Log Jam (ELJ), consisting of 5 woody structures, as described below.

The ELJ will be constructed using mature native trees removed as part of the vegetation stabilization along the realignment corridor or the additional vegetation removal areas. It is anticipated that the native trees used in the ELJ will include both the tree trunk and its root wad, although reference hereafter is made only to root wads or logs. The tree trunk will be a minimum of 40 feet in length with a minimum tree trunk diameter of 1-2 feet. The tree trunk length is in addition to the root wad length, estimated to be around 10 feet with an estimated diameter around 10-15 feet. The ELJ will be placed in the existing river channel at the upstream end of the existing channel floodplain conversion area while the river is dry or almost dry (< 100 cfs). The ELJ will be comprised of about 5 groupings of woody structures, spaced about 40 feet apart as shown in Figure 12.

The woody structures will be placed along the upstream edge of the existing channel floodplain conversion area, providing additional erosion resistance while encouraging sediment deposition upstream of the existing channel floodplain conversion area. Each of these structures will consist of approximately 4-5 root wads with a minimum of one root wad buried beneath the existing channel bed with its root wad facing upstream. A minimum of two root wads in each woody

structure will be anchored into permanent diversion berm. Of these anchored root wads, the root wad end will extend out perpendicular to the river flow with a maximum of 15 feet beyond the "new river bank." At least one log in each woody structure will be placed parallel to the flow with the root wad facing upstream. A typical cross section of these woody structures is shown in Figure 11. A planform view of a single woody structure is shown in Figure 13.

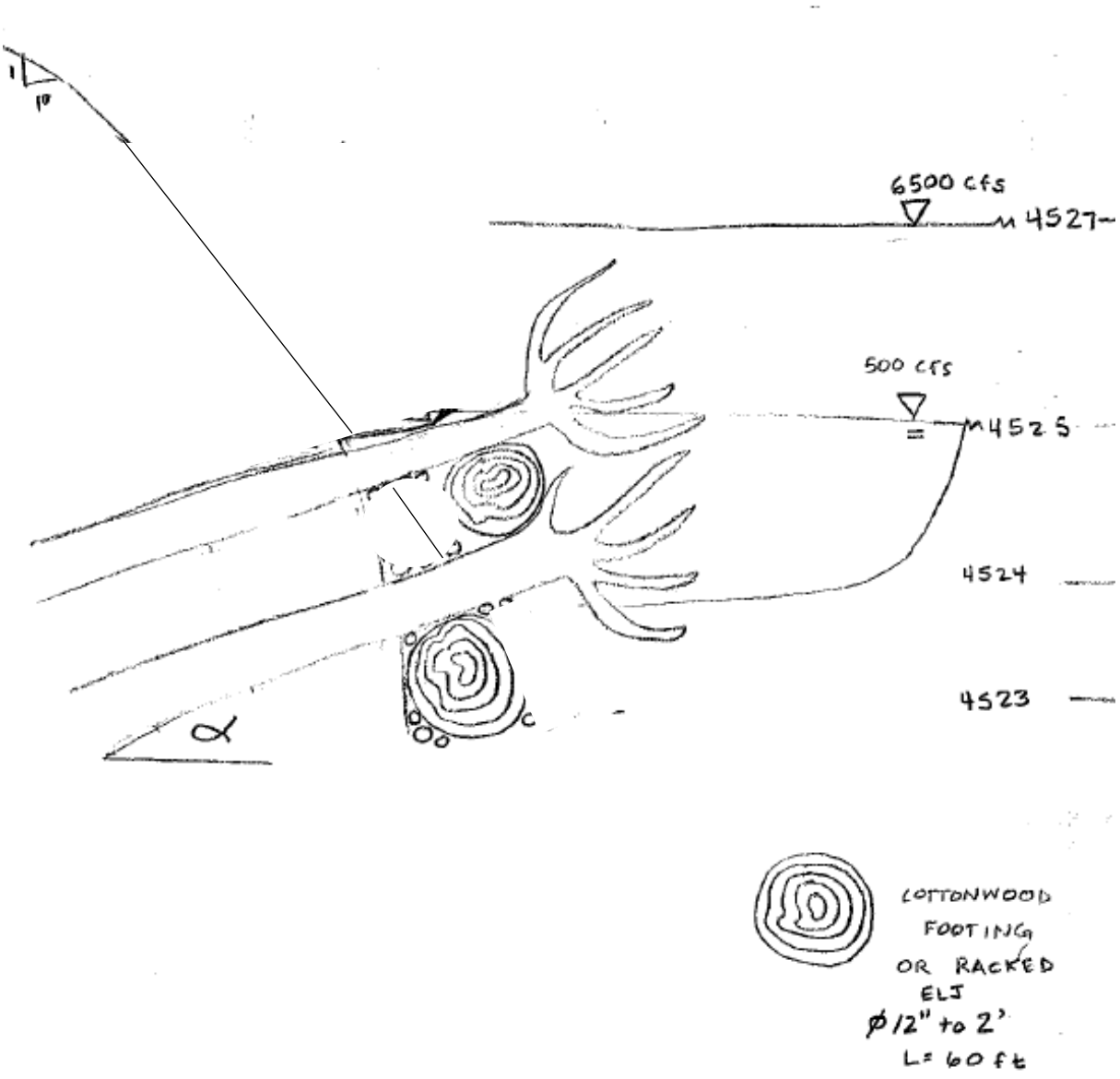

Figure 11. BDA pilot project typical cross section of an ELJ at upstream end of existing channel floodplain conversion area. All dimensions are approximate.

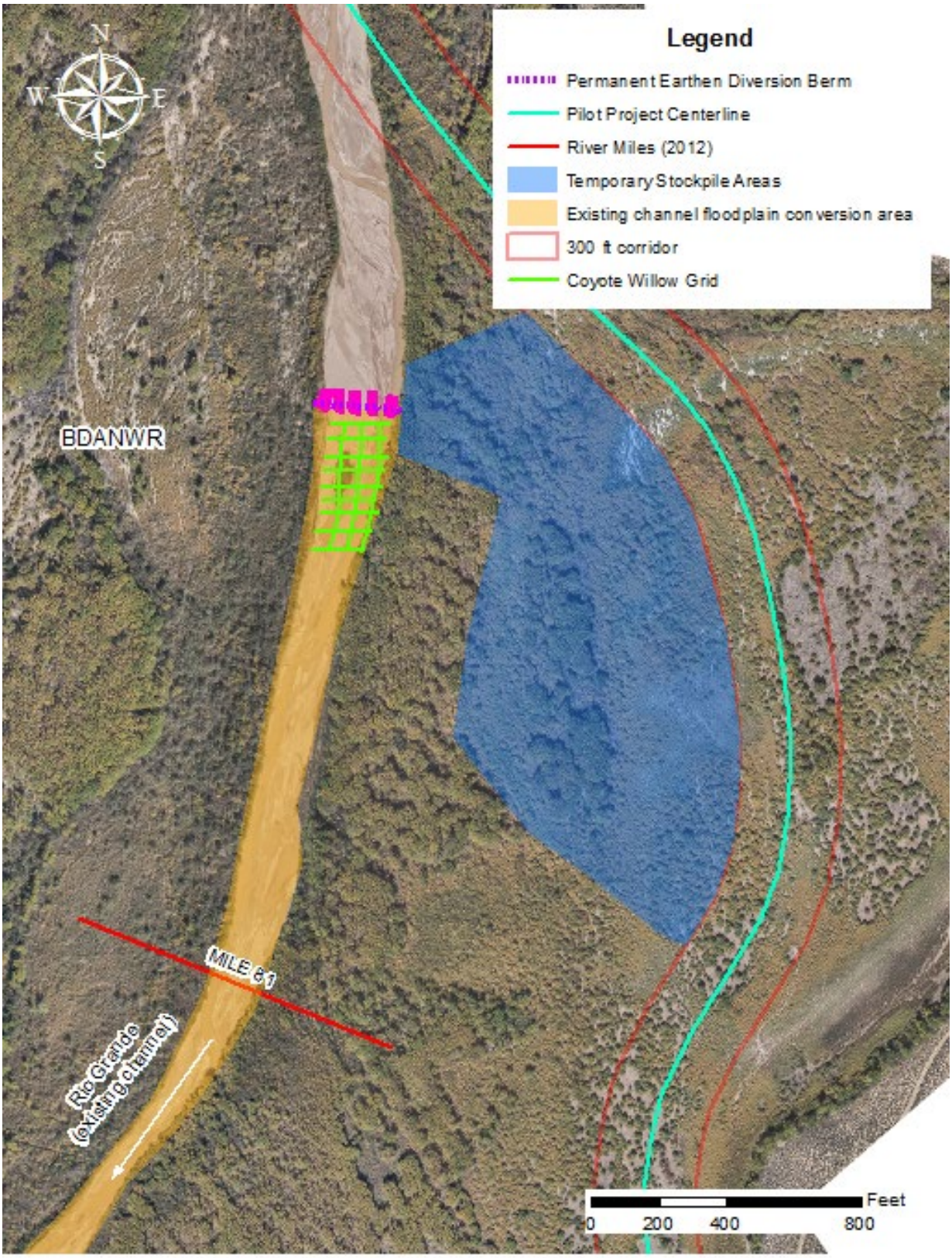

Figure 12. BDA pilot project planview of ELJ at upstream end of existing channel floodplain conversion area. The background imagery is the 2016 aerial photography (Reclamation).

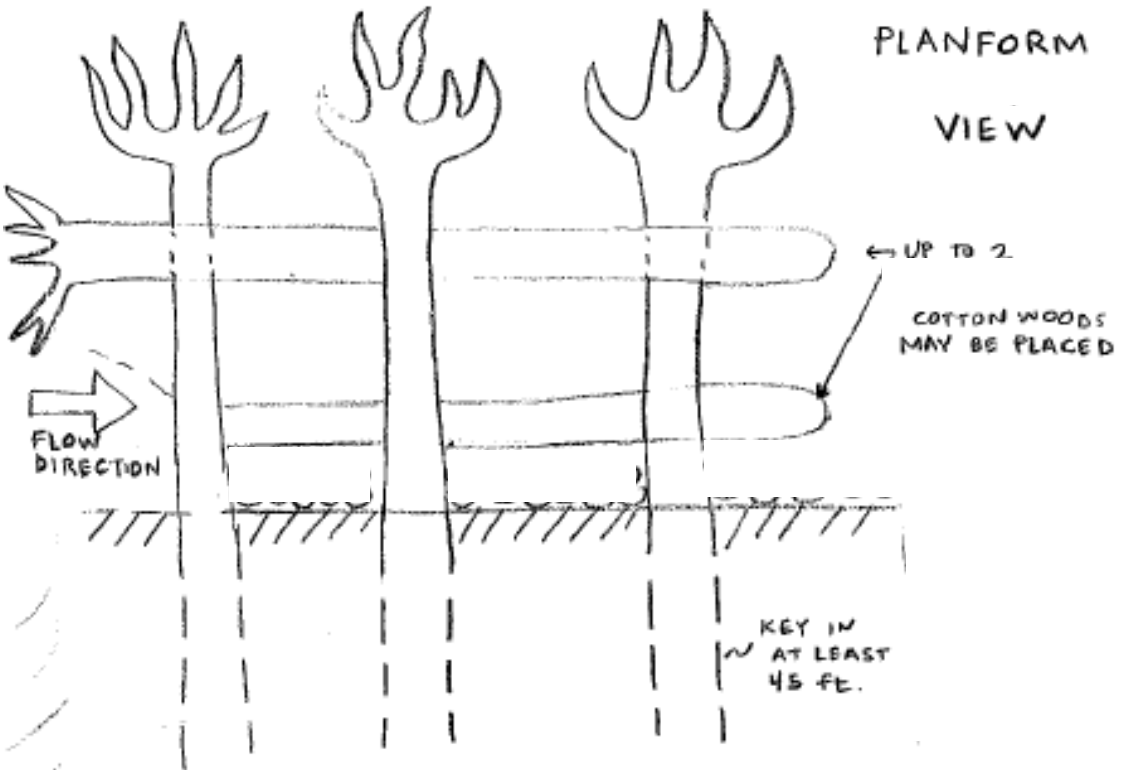

Figure 13. BDA pilot project planview of typical woody structure of ELJ anchored into permanent diversion berm at upstream end of existing channel floodplain conversion area. All dimensions are approximate.

3.0 Access

In order to perform construction of the project components, access is needed to the site. Access to the BDA pilot project will be via existing roads on the east and west side of Bosque del Apache National Wildlife Refuge as shown in Figure 14. All access roads are only shown to major transportation corridors, like U.S. Highway 380, since necessary construction traffic will follow these established routes to the identified access routes. Two classes of access roads, primary and secondary, will be utilized for the BDA pilot project. The designation of primary and secondary access routes are illustrated in Figure 14 and explained in more detail in the following sections. Airboats, accessing the river from the North Boundary BDANWR, may also be used to transport personnel to the project site and to refuel amphibious excavators if these are required for construction of the project features.

If necessary to ensure safe and convenient access, road improvements (e.g. clearing, mowing and trimming, blading, widening, gravel cap placement, etc.) may be made to the dirt roads designated as primary or secondary access routes. If water is present within the San Pedro Drain area (eastern portion of the realignment project area) culverts may be installed to facilitate downstream

movement of water while facilitating construction equipment access. Culverts would utilize 1-2 corrugated metal pipes (CMP) arranged in parallel with about 3 feet of dirt filled on top of the CMPs. Culverts would primarily be used to facilitate construction equipment access from the staging area to the project area via the secondary access routes. CMPs will be removed at the conclusion of construction activities.

Clearing involves the removal of vegetation within the roadway with some amount of subsurface disturbances to the vegetation roots. This is typically undertaken with new or minimally used access routes. A typical impact range for clearing is 20 to 30 feet per lineal foot of access road. Mowing is the process of cutting vegetation in and to the sides of the access route to provide line-of-sight and safe conditions for access, including increasing the reaction time to respond to wildlife and livestock within the access road corridor. Horizontal clearance also provides the ability for equipment to drive without hitting and damaging equipment. Trimming involves the selective cutting of tree branches in the vertical direction that will restrict vehicular access along the route. This is especially relevant when large trees are near the access routes that have a few branches that extend into the access route, making vehicular access difficult. The height from the road surface to be cleared varies with the type of equipment, with a range of 10 to 20 feet.

3.1 Primary Access

The primary access routes designated in the maps reflect those routes which will likely see the heaviest vehicle use. These are associated with transporting equipment into the project site. The primary access routes include the Operation and Maintenance (O&M) and spoil levee roads for the LFCC and access routes to the project site. One of the primary access routes follows the LFCC O&M road north from the San Marcial Yard and is approximately 13.8 miles in length. This access route would be utilized by transport trucks bringing amphibious excavators, if they are required to complete the project. The other primary access route, following the LFCC O&M road from the Highway 380 Bridge is approximately 6.7 miles in length, and would be utilized to transport most of the expected project's construction equipment. This length consists of 6.2 miles along existing roads.

The upstream temporary access route, about 0.5 miles in length, follows a previously cleared path on the western side of the river that was used to facilitate the equipment access for the 2008 and 2017 BDA sediment plug projects (Rolland, 2008; USFWS, 2008; Harris, 2017). On the eastern side if the river the upstream temporary access road will be constructed to take advantage of areas designated for vegetation clearing, minimizing additional impacts to the existing vegetation. The downstream temporary access route, about 0.3 miles in length, facilitates access from the LFCC spoil levee road to the river for the amphibious excavators. This access would only be used to facilitate access for the amphibious

excavators, if needed. This downstream temporary access route follows an existing two-track road from the spoil levee through the majority of the bosque.

Access along the primary route will require temporary river crossings to facilitate mobilization/ demobilization of the tracked construction equipment across the Rio Grande. The primary river crossing for this project will be located between RM 82 and 81 (2012 channel demarcations). The banks at the crossing location will be sloped to create ramps into the river. The wetted river channel crossing will be placed, where possible, in a riffle. Riffle crossings are preferable to the narrower sections, which may have deeper water. Crossing locations will be located to minimize impacts to existing bank vegetation and avoid areas of vertical slopes. The ramps will be approximately 20 feet wide. The crossing distance of the channel at the primary crossing is approximately 100 – 250 feet in the wet (river flows). The exact width is dependent on the amount of water in the Rio Grande disregarding a snow-melt runoff or monsoonal event. The expected number of trips for the project duration is 20 up to a maximum of 40. A secondary river crossing will be required if amphibious excavators are needed. This river crossing will be around RM 79 (2012 channel demarcations). The banks at the crossing location will be sloped to create ramps into the river, if needed. The ramps will be approximately 20 feet wide. Amphibious excavators would be walked up the active channel to minimize disturbance of vegetation and wear and tear on the vehicles. The expected wetted length of the secondary river crossing is about 0.5 miles. The expected number of trips for the project duration is 2 up to a maximum of 8. If amphibious excavators are used during construction this secondary river crossing would only be used for mobilization to the project site. The primary river crossing between RM 82 and 81 (2012 channel demarcation) would be used to de-mobilize the amphibious excavators from the project site.

3.2 Secondary Access

The secondary access routes will be used for project site access other than tracked construction equipment. This will include pickup trucks, repair vehicles, and fuel trucks. This access will be on the east side of the Rio Grande, using the U.S. Highway 380 Bridge to cross the river. This route is approximately 9.2 miles along existing dirt roads. The last 0.3 miles will be new temporary road construction to access the BDA pilot project 300 foot corridor. Three options for the new temporary road construction into the BDA pilot project 300 foot corridor are presented, as shown in Figure 15, with the northern path being preferred. The middle and southern one will be used in an emergency or in the event that construction site conditions favor the southern access path. These access paths will be constructed to take advantage of areas designated for vegetation clearing, minimizing additional impacts to the existing vegetation.

All secondary access routes may require some grading work to facilitate access to the project site. About 15-20 trips per day are expected for the secondary access roads.

4.0 Staging

Temporary staging and stockpile areas will be used to store equipment and materials, respectively (see Figure 15). The temporary stockpile site areas will be used to store material for the existing channel floodplain conversion area. There are two areas, totaling about 50 acres in size, located on the west side of the 300 foot pilot project corridor near RM 81. The temporary stockpile areas are placed in areas also slated for vegetation removal (see Vegetation Removal section). To the extent possible, native canopy vegetation will be left intact within the temporary stockpile areas. The one notable exception is where access is needed to the existing river channel. The northern temporary stockpile area will be used for stockpiling the material needed for the permanent diversion berm. This will require a wider access width to facilitate moving the material into the river. Additional vegetation planting may be added in temporary stockpile areas adjacent to the 300 ft realignment corridor to help stabilize the new channel banks and avoid avulsions at these locations. Similarly, vegetation planting may be added to river access locations along the banks of the existing channel. This would be a similar type of vegetation grid (preferably coyote willows) as shown in Figure 10.

An equipment staging area, around 1.0 acre in size, is located adjacent to the eastern secondary access route. This location will provide higher ground for storing the equipment during weekends and periods where equipment is not utilized. During the work week equipment will be staged throughout the construction site unless there is an expectation of flooding. There is some vegetation that will need to be removed to provide adequate space for equipment staging, these will be shrub or herbaceous vegetation, not mature, native trees.

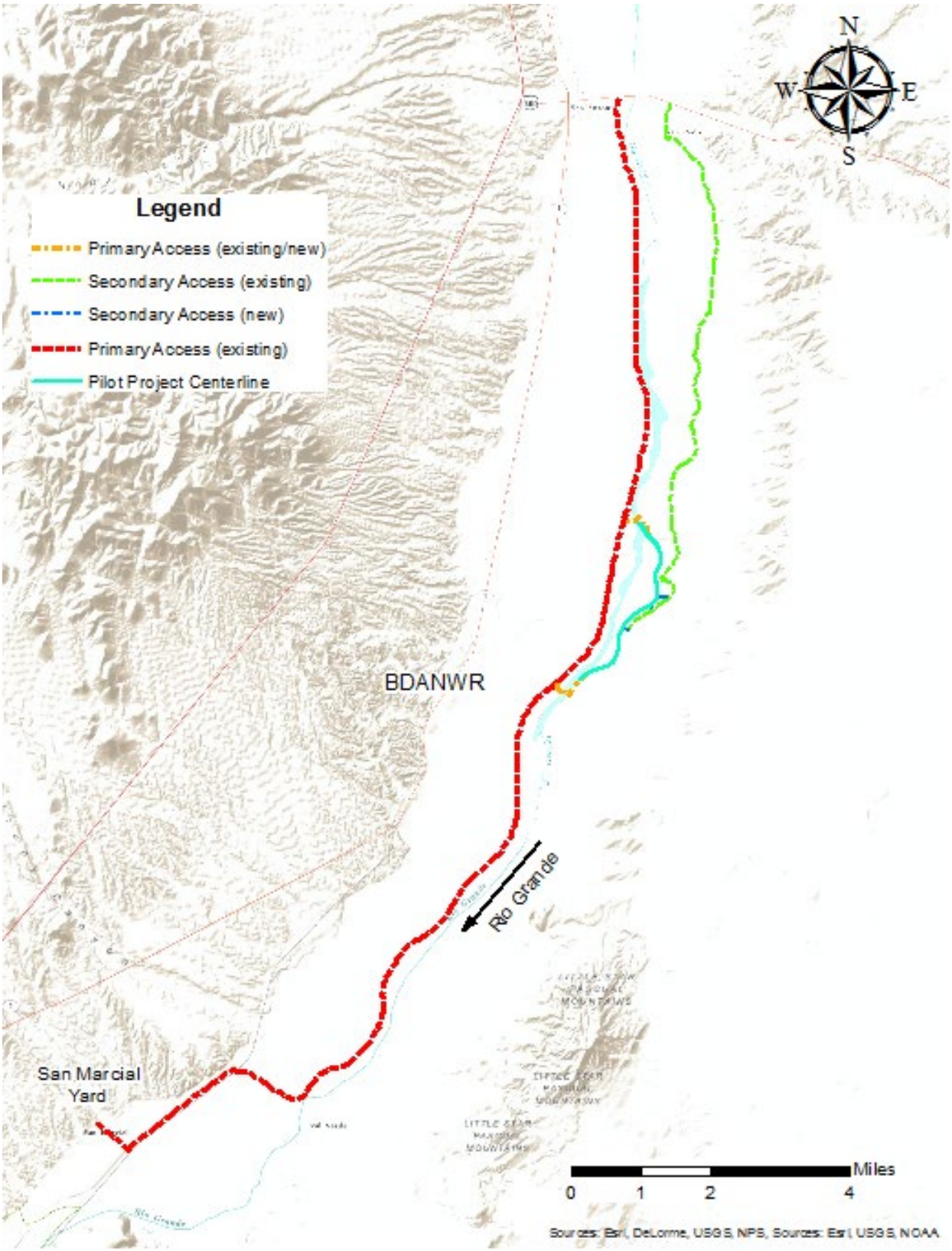

Figure 14. Primary access routes and temporary stockpile and equipment staging areas for the BDA pilot project. The background imagery is a terrain map generated by ESRI (accessed December 11, 2017).

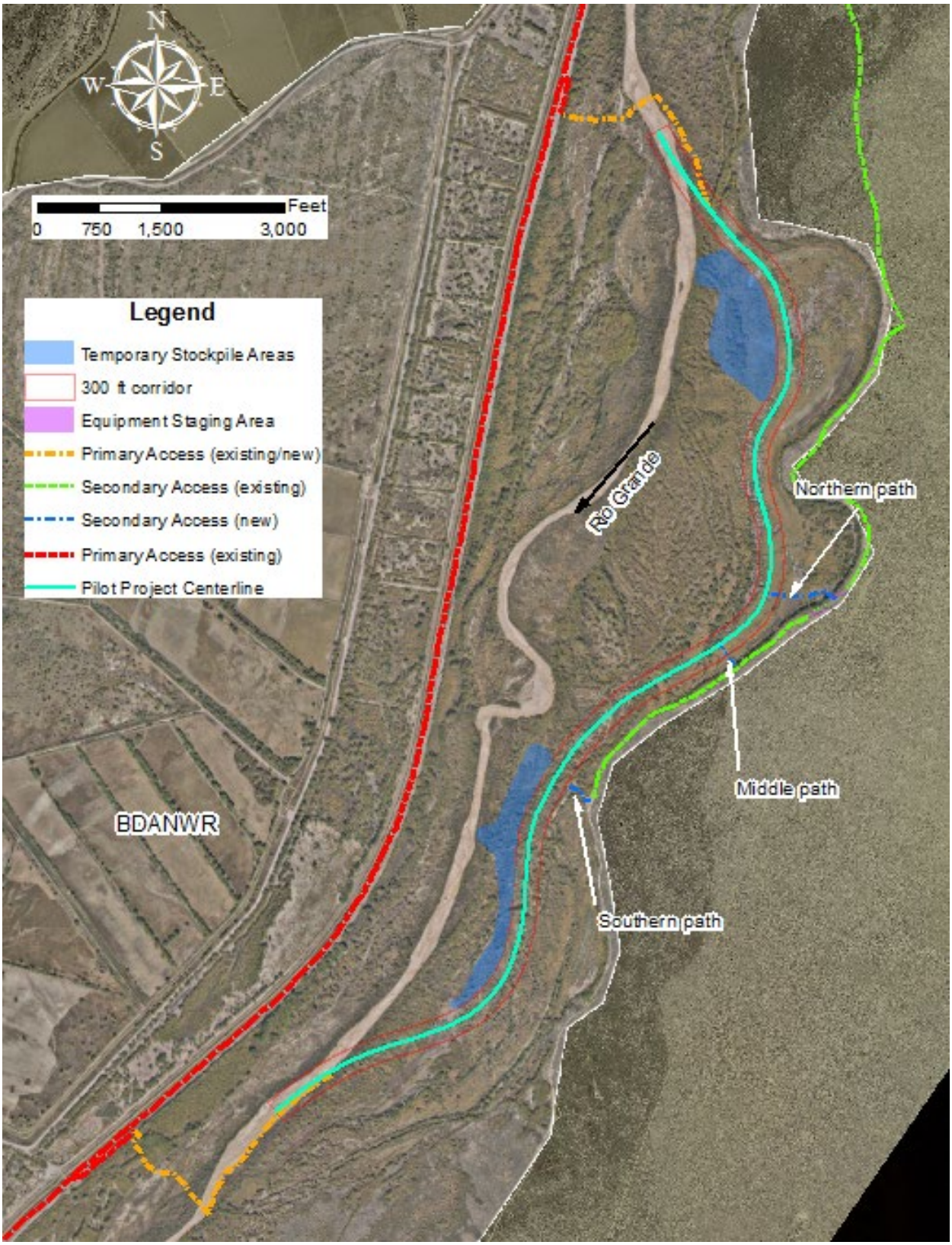

Figure 15. BDA pilot project centerline and 300 foot offset alignment with temporary stockpile and equipment staging areas. The background imagery is a combination of the 2012 and 2016 aerial photography (Reclamation).

5.0 Dust Abatement

Dust abatement typically occurs on access routes and in project areas during implementation when there is not sufficient moisture in the soil to inhibit the formation of dust. Dust abatement involves the distribution of water onto an earthen surface. If dust becomes a safety concern at the site, or while hauling cobble from the temporary stockpile areas to the priority site area, roads will be wetted with water pumped from the Rio Grande or from the LFCC. The Rio Grande will be the primary pumping source since work activities are primarily on the eastern side of the Rio Grande away from the LFCC.

When pumping from the Rio Grande, the pump setup will utilize a 0.25 inch mesh screen at the opening to the intake hose to minimize entrainment of aquatic organisms. For areas where the depth to a water surface is too much for the pump setup, an intermediate area will be leveled to create a temporary surface for the pump. Water is typically distributed using a truck-based water unit that allows for a controlled and uniform spraying of the desired surface.

6.0 Impact Area

The total maximum project area is 1,110 acres as shown in Figure 16. This area is delineated larger than necessary to allow for field adjustments due to changes in conditions. The expected area of disturbance (BDA pilot project 300 foot realignment corridor, vegetation removal areas, existing channel floodplain conversion area, and new access roads) is approximately 360 acres (max of 430 acres). The expected disturbance area will be within the total maximum project area. This larger delineation allows flexibility in the field to make adjustments to specific locations. Although field adjustments are likely, the disturbance acreage will be equal to or less than the maximum disturbance acreage of 430 acres.

The project will also avoid damage to any archaeological sites that have been identified near the access road on the eastern side of the project area.

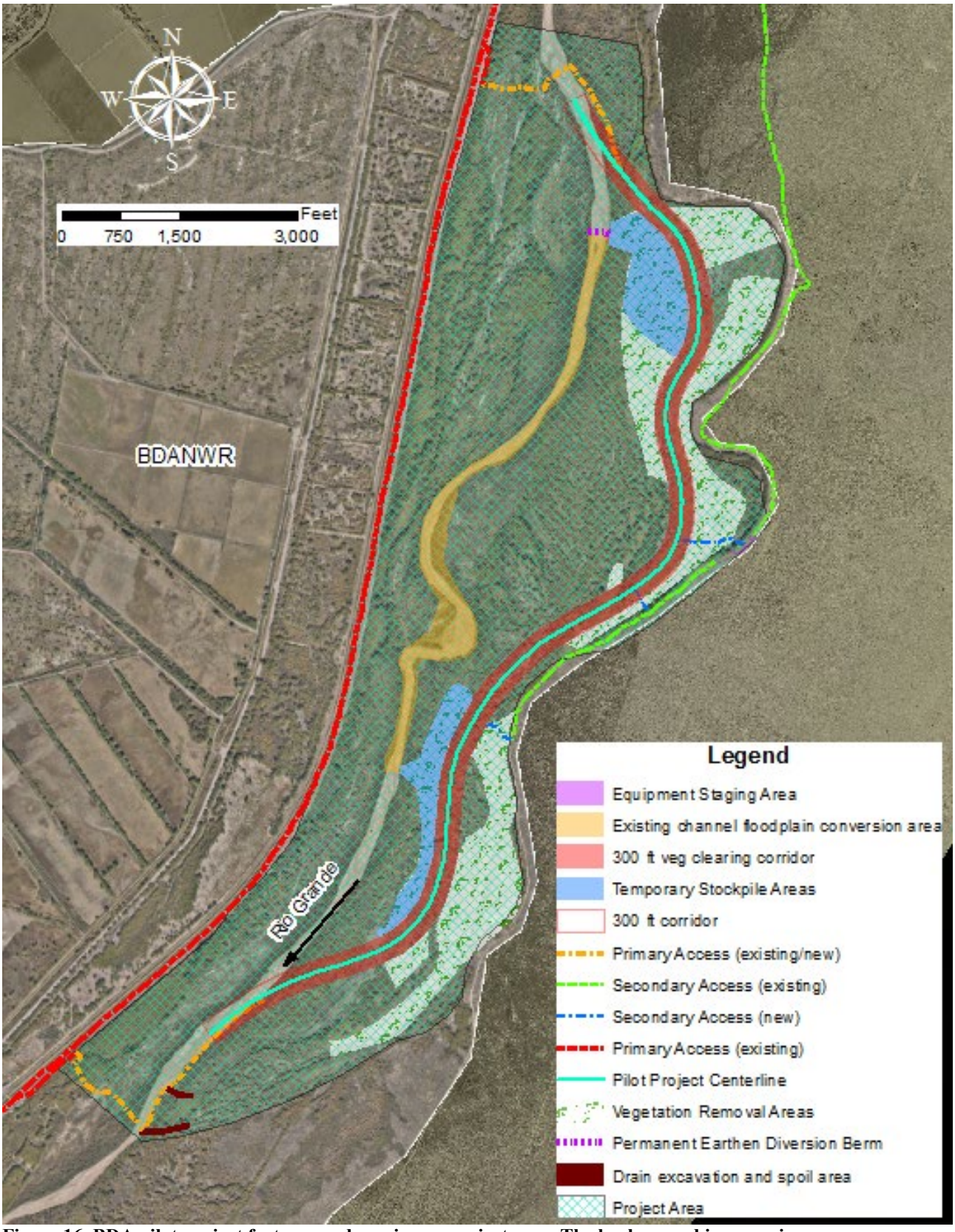

Figure 16. BDA pilot project features and maximum project area. The background imagery is a combination of the 2012 and 2016 aerial photography (Reclamation).

7.0 Construction Operations

To facilitate construction at this site, the following steps are expected, although not in the exact sequence as provided. Work is expected to be completed within a one to five year time frame. The anticipated construction start date is January 2018.

1. Prep both primary and secondary access roads.
2. Prep ramp from the LFCC eastern O&M road to the spoil levee and from the LFCC spoil levee to the floodplain west of the Rio Grande.
3. Prep ramp from the eastern mesa road to the floodplain east of the Rio Grande.
4. Brush vegetation from access route to the Rio Grande (primary new/existing access).
5. Create ramp into the river channel on the west and east banks for construction equipment to access the east side of the BDA pilot project.

Steps 6-14 may be done concurrently:

6. Drain project site, if needed to facilitate construction. Drainage would consist of those locations shown in Figure 17. The San Pedro Drain should be the first drain excavated, and it would be advisable for the project biologist to make the call on excavating the Meadow Drain, as its location has the potential to adversely affect listed bird species protected under the ESA which would be desirable to avoid. Excavation of identified outlet areas involves about 2,500 CY of material. Excavated material would be spread out adjacent to the excavated outlet area. Excavation would require the use of amphibious excavators. Amphibious excavators would access the identified outlet areas following the secondary river access shown in Figure 17.
7. Remove exotic/invasive vegetation in the temporary stockpile area and along project centerline between the new primary and secondary access routes, facilitating vehicular access to the construction site.
8. Remove all vegetation within the 300 foot pilot project corridor. Grub, mulch, rip, and temporarily place woody material along pilot project centerline or at temporary stockpile area for burning by Bosque del Apache National Wildlife Refuge Fire Crews.
9. Remove exotic/invasive vegetation in vegetation removal areas. Mulch and temporarily place woody material along pilot project centerline or at temporary stockpile area for burning by Bosque del Apache National Wildlife Refuge Fire Crews.
10. Transfer of ashes and any inorganic material from grubbing and/or vegetation clearing activities, if material is burned along the pilot project centerline, to the temporary stockpile area.
11. Excavate outlet connection to Rio Grande. Temporarily stockpile material in the temporary stockpile area.

12. Partially excavate inlet connection to the Rio Grande. Temporarily stockpile material in the temporary stockpile area.
13. Smooth a 50 foot section of the 300 foot pilot project corridor outside of the inlet and outlet excavation areas.
14. Complete inlet connection excavation and place temporary diversion structure.

Steps 15-19 may be done concurrently:

15. Mix excavated sediment with remaining ash/inorganic material from grubbing and vegetation clearance.
16. Complete channel fill for existing channel floodplain conversion.
17. Complete bioengineering bankline with deformable toe and ELJ for existing channel floodplain conversion. This would include use of coyote willow whips.
18. Add in vegetation stabilization (coyote willow grids), if needed, at temporary stockpile areas and river access locations.
19. Roughen temporary stockpile and equipment staging areas to loosen compacted material.

Step 20 may be constructed by Force Account crews or a contractor:

20. Complete vegetation planting associated with the Channel with Vegetation Stabilization.

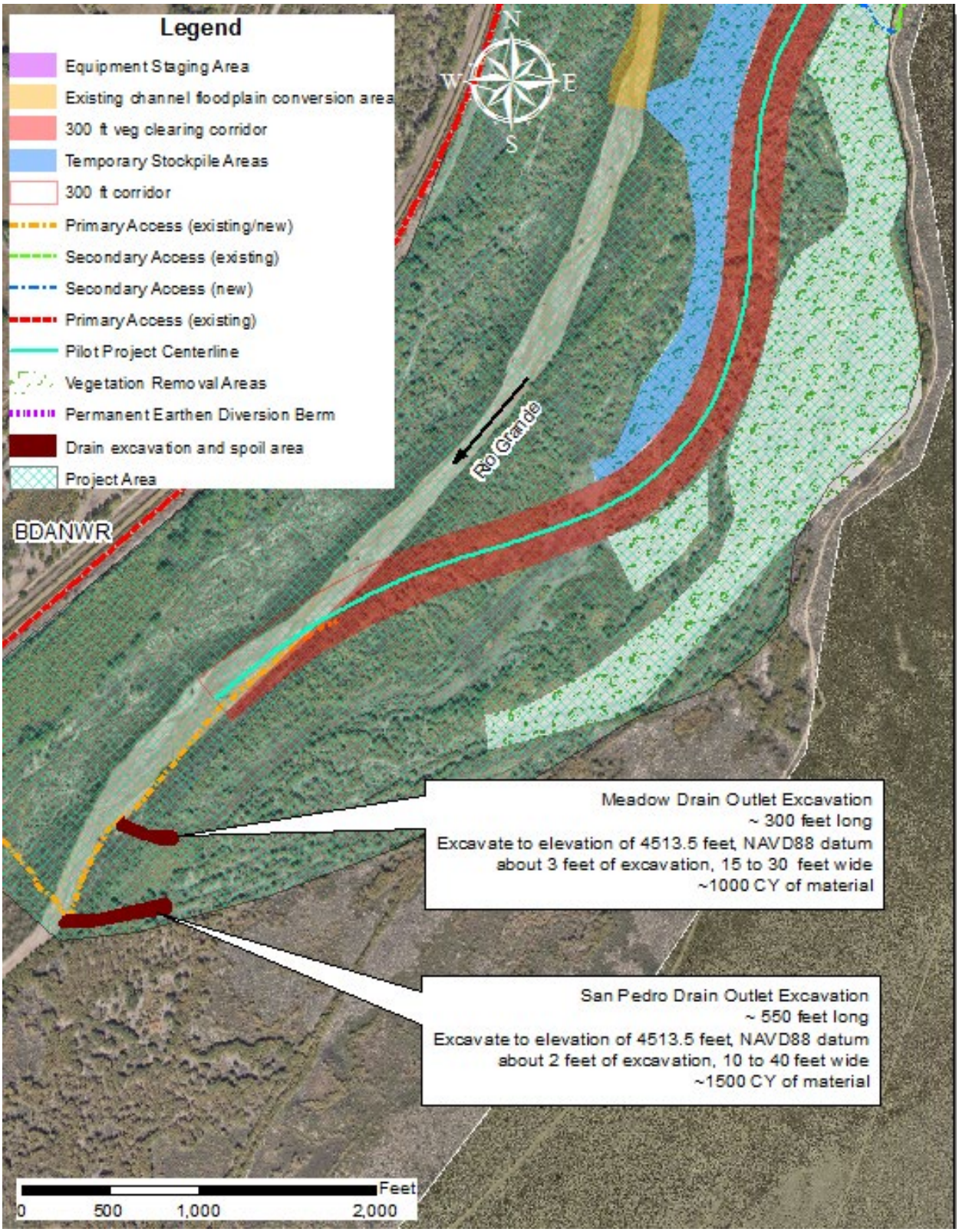

Figure 17. BDA pilot project centerline and realignment corridor and potential locations for facilitating project drainage, if needed. The background imagery is the 2012 and 2016 aerial photography (Reclamation).

The following Best Management Practices (BMPs) will be used at the site to minimize the risk of effects from the BDA pilot project.

General BMPs:
Timing of the Proposed Action

1. Reclamation will seek to avoid impacts to birds protected by the Migratory Bird Treaty Act (16 United States Code [U.S.C.] 703; MBTA), including the flycatcher and cuckoo, 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 bird habitat will be avoided during the construction activities as much as possible, utilizing the most current annual 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 Service will occur prior to such work activities.

    1.2. Reseeding or revegetation may be accomplished by hand or by mechanized means, such as using a Truax imprinter followed by hand or tractor broadcast seeding (see section Vegetation Planting and Control below). 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 Clean Water Act permits (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 work day. 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 in order to ensure compliance.

5. Reclamation will excavate an area as few times as possible to minimize disturbance of sediments. When excavating 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 when not excavating.

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 work day. 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 fairly continuous during work days, 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 (Los Lunas Plant Materials Center, 2007b); long stem transplants (Los Lunas Plant Materials Center, 2007a); 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. 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 breeding 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, native woody vegetation (primarily cottonwood), needs to be trimmed or 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 also 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.

Method Category BMPs:

1. *River diversion* – This implementation technique places a berm across the entire river channel to re-divert the river flow away from existing location into the new constructed location. This technique will be done for the BDA pilot project work in conjunction with the river reconnection technique. The diversion berm is placed after the desired channel relocation had been completed and is placed from one side of the river to the other to minimize the formation of isolated pools. Typically, this is done with a dozer or other similar tracked construction equipment. The initial BDA pilot project diversion berm will be temporary with more permanent diversion berm constructed with bank protection during lower discharges.
2. *River reconnection* – This implementation technique provides the excavation to reconnect sections of the river. This technique minimizes the amount of time construction equipment needs to work in the wet. Excavation typically proceeds from downstream to upstream, allowing the existing separation to act as a diversion berm for the project. The last phase of this implementation technique is to remove this diversion berm. The majority of this technique is performed in the dry, with only the last removal phase requiring equipment to potentially be in the wet. Typically, this technique requires less than 1 week for work in the wet.
3. *River crossings* – This implementation technique facilitates moving construction materials and equipment from the side of the river opposite of the project site. This technique is employed at the BDA Pilot Project to facilitate an initial construction equipment mobilization to the project site as access for transport equipment is not possible from the eastern secondary access route. This technique minimizes disturbance acreage in the wet by defining a set path for the construction equipment to follow. Equipment moves slowly across the river and crossings are typically performed as part of an equipment caravan. In areas with finer bed material, crossing platforms may be placed to facilitate the crossing of equipment, where possible, in a riffle. Crossing platforms in areas of finer bed material may consist of areas hardened with larger sized bed material, like gravels or cobbles, or constructed mats that can be placed on the bed and driven over. Constructed mats likely would consist of cabled wooden beams but may also consist of cabled articulated, concrete blocks. Riffle crossings are preferable to the shortest distance across the river, which may have deeper water. Crossing locations also typically are located to minimize impacts of existing bank vegetation and to avoid areas of vertical slopes. The river crossing length for the

BDA pilot project is about 250 feet in length. The typical crossing width is around 20 feet. River crossings for mobilization of amphibious excavators are about 0.5 miles in length.

4. *Amphibious construction* – This implementation technique requires construction equipment to operate in the river flows. For the BDA pilot project this technique will only be used if needed to establish channel connection at the inlet and outlet locations. This technique minimizes the disturbance to bank riparian areas. Material placement or removal follows the descriptions listed for those techniques. This technique would only be utilized for a portion of the project duration, unless site conditions dictate otherwise.
5. *Material removal* – This technique prescribes that materials, such as sediment, jetty jacks, woody debris, riprap, or other material, will be removed in a consistent manner to help avoid the formation of isolated pools or channels, which could trap fish or other species. If stranding occurs, Reclamation will coordinate with the Service to rescue stranded fish.

8.0 Material Quantities

Expected and maximum quantities for the BDA pilot project are shown in Table 1.

Table 1: Expected and Maximum Material Quantities for BDA pilot project

Description	Unit	Expected Quantity	Maximum Quantity
Excavation in dry	cubic yard	160,000	195,000
Excavation in wet	cubic yard	18,000	23,000
Channel Fill	cubic yard	175,000	215,000
Access Roads	miles	30	35
Access Roads	acre	110	140
Estimated areas of disturbance	acre	360	430
Temporary staging/stockpile areas	acre	50	60
Max project area	acre	---	1,110
Vegetation removal area	acre	270	300
Large trees for ELD	each	25	40
Coyote willow tree whips	each	2,500	12,000
Other native tree whips	each	1,000	3,000

9.0 Document Revision History

December 7, 2016: Initial draft version completed

February 2, 2017: Updated with revised access locations and vegetation clearance footprint based on site visit conducted on 23 January 2017. Clarification of starter channel configuration and burning of brush material as discussed in meetings at BDANWR on 11 January 2017 and at the AAO on 5 January 2017. Updated references to reflect the 2012 channel demarcation for river miles.

March 31, 2017: Design quantities and descriptions placed in document. Vegetation clearance areas revised. Edits made based on feedback reviews to increase clarity. Final draft version completed and distributed to internal Reclamation team.

April 21, 2017: Edits made from team review, peer review, and administrative review to increase clarity. Updated project component descriptions and maps. ELD tree quantities and wetland impacts adjusted.

May 10, 2017: Clarifying edits and update on impact area to include access from San Marcial Yard.

June 15, 2017: Increased max project area to include entire Bosque area between the LFCC spoil levee and the eastern access road. Also adjusted vegetation clearing areas to create regular polygonal shapes, added yellow-billed cuckoo to endangered species, and adjusted terminology on evaluated alternatives to better align with NEPA processes.

June 30, 2017: Added second stockpile location in southern area of realignment project and eliminated bank protection at upper end of channel fill with vegetation stabilization, except for ELJ. This also required extension of the channel fill with vegetation stabilization to the south. Also amended description of vegetation removal areas outside the realignment corridor to include ripping the roots. Two draining locations are added downstream of the realignment corridor to facilitate draining ponded water (this would only be done if needed). Also amended language on construction duration to 1-5 years, since 1 year is an ideal scenario. Revised material quantities and figures accordingly. Minor edits from review by ELD also added.

September 21, 2017 – Updated Figure 16 to show full project extents.

October 3, 2017 – Edits made in Executive Summary and Introduction to clarify project goals.

December 1, 2017 – Edits made to include 2017 BDA sediment plug reference and add contingency for vegetation planting at temporary stockpile areas. Added acreage associated with wetlands and rephrased impact terminology. Added additional descriptions of activities to account for construction activities to occur in the wet. This includes the use of amphibious excavators, longer access routes in the wet, fueling and access of site from the air boats, and ability to excavate drain outlets. The max project area has also been increased to accommodate this change. Figures 1, 14, 16, and 17 have been updated. Table 1 has also been updated.

December 11, 2017 – Added new secondary access route on the eastern side to facilitate construction access. Figures 1, 14, 15, 16, and 17 have been updated. No changes to Table 1, since length is small and within rounding estimate of previous version.

10.0 References

AuBuchon, J., Harris, A., Lawlis, B., Holste, N. 2017. BDA Pilot Project May 26, 2017 Site Visit – Trip Report. U.S. Department of the Interior, Bureau of Reclamation, Upper Colorado Region, Albuquerque, NM. 24 pp.

Dreesen, David R. 2008. Basic Guideline for Seeding Native Grasses in Arid and Semi-Arid Ecoregions. USDA-NRC Plant Materials Center. Los Lunas, NM 4p.

Harris, A. 2017. BDA Plug Pilot Project Description. U.S. Department of the Interior, Bureau of Reclamation, Upper Colorado Region, Albuquerque, NM. 20 pp.

Holste, N. 2014a. BDANWR Sediment Plug and River Restoration Project: Alternatives Analysis Synthesis Report. U.S. Department of the Interior, Bureau of Reclamation, Upper Colorado Region, Albuquerque, NM. 121 pp.

Holste, N. 2014b. BDANWR East Realignment Preliminary Design Status Report: May 30, 2014. U.S. Department of the Interior, Bureau of Reclamation, Upper Colorado Region, Albuquerque, NM. 20 pp.

Holste, N. 2015. BDANWR Sediment Plug and Habitat Restoration: Design Status Report. U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Denver, CO. 38 pp.

Holste, N. 2016. Restoring Natural River Processes through Channel Realignment. Poster presented at the Confluence, an Interdisciplinary Riverside Technical Gathering, Albuquerque, NM 1 pp.

Julien, P.Y. and Rainwater, J.S. 2014. Review of Sediment Plug Factors Middle Rio Grande, NM. Colorado State University, Fort Collins, CO. 66 pp.

Los Lunas Plant Material Center. 2007a. Guidelines for Planting Longstem Transplants for Riparian Restoration in the Southwest: Deep Planting – The Ground Water Connection. U.S. Department of Agriculture, Natural Resources Conservation Service, Los Lunas Plant Material Program, Los Lunas, NM, 2 p.

Los Lunas Plant Material Center. 2007b. Guidelines for Planting Dormant Whip Cuttings to Revegetate and Stabilize Streambanks: Deep Planting – The Ground Water Connection. U.S. Department of Agriculture, Natural Resources Conservation Service, Los Lunas Plant Material Program, Los Lunas, NM, 2 p.

Maestas, J., Padilla, R., Nemeth, M., AuBuchon, J., Casuga, J., Makar, P., and Varyu, D. 2014. Determination of River Maintenance Need at Individual Sites and Reaches on the Middle Rio Grande, NM. U.S. Department of the Interior, Bureau of Reclamation, Upper Colorado Region, Albuquerque, NM. 32 pp.

Makar, P. and AuBuchon, J. 2012. Channel Conditions and Dynamics of the Middle Rio Grande. U.S. Department of the Interior, Bureau of Reclamation, Albuquerque, NM. 109 PP.

Misra, M., Ragland, K., Baker, A. 1993. Wood Ash Composition as a Function of Furnace Temperature. Biomass and Bioenergy, Vol 4., No. 2, pp. 103-116.

Pollen, N. 2007. Temporal and spatial variability in root reinforcement of streambanks: accounting for soil shear strength and moisture. Catena 69: 197-2005.

Pollen-Bankhead, N. and A. Simon. 2008. Enhanced application of root-reinforcement algorithms for bank-stability modeling. Earth Surface Processes and Landforms 34(4): 471-480. DOI: 10.1002/esp 1690.

Reclamation. 2015. Albuquerque Area Office Integrated Pest Management Plan and Pesticide General Permit. U.S. Department of the Interior, Bureau of Reclamation, Upper Colorado Region, Albuquerque, NM. 72 pp.

Reclamation. 2016. Decision and Documentation Paper No. 2016-1 – BDANWR Realignment. U.S. Department of the Interior, Bureau of Reclamation, Upper Colorado Region, Albuquerque, NM. 3 pp.

Rolland, C. 2008. Project Description: Bosque del Apache National Wildlife Refuge Sediment Plug Removal. U.S. Department of the Interior, Bureau of Reclamation, Albuquerque, NM. 15 pp.

US Fish and Wildlife Service. 2008. U.S. Fish and Wildlife Service's Biological Opinion on the Effects of Actions Associated with the Rio Grande Sediment Plug Removal Project at Bosque del Apache National Wildlife Refuge. U.S. Department of the Interior, Fish and Wildlife Service, Albuquerque, NM. 38 pp.

US Fish and Wildlife Service. 2016. 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. U.S. Department of the Interior, Fish and Wildlife Service, Albuquerque, NM. 266 pp.

White, J.A. 2007. Recommended Protection Measures for Pesticide Applications in Region 2 of the U.S. Fish and Wildlife Service, U.S. Department of the Interior, Fish and Wildlife Service, Austin, TX, 205 pp.