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TECHNICAL SERVICES, INC.

Technical Memorandum

To: Musselshell Watershed Coalition

From: Jon Jupka, P.E., CFM

CC: Karin Boyd and George Austiguy, P.E.

Date: 6/3/2022

Re: Rowton and Cushman Bridge Preliminary Engineering Report

This Memorandum provides preliminary design and cost opinions for (2) projects selected by The Musselshell River Watershed Coalition. Two alternatives are provided for each project. The (2) projects that were evaluated are:

- Rowton Property, and
- Cushman Bridge

Figure 1 shows the projects' locations. Each proposed project's objective, design criteria, method and cost estimate are discussed in this memo.

Rowton Property Bank Restoration

Rowton Property looking North

Background and Objective

In response to the 2011 Musselshell River flood event a meander bend stream bank on the Rowton property experienced significant erosion and migration. Additional high flow events since the 2011 event have continued to erode to the channel banks and the river has migrated to the west and the north. The erosion has resulted in loss of agricultural land and if it continues, may endanger multiple structures on the Rowton property. The project objective is to use vegetation to increase streambank and floodplain roughness. Flattening and vegetating the steep cut bank will help reduce channel migration and provide a more resilient floodplain and streambank. The Rowton property is not located in a regulatory mapped floodplain area of the Musselshell River.

Method

The proposed bank restoration method will involve building a brush matrix bank and grading the steep cut bank back to a milder slope (3 horizontal to 1 vertical [3:1]).

A brush matrix bank treatment consists of constructing a new channel bank with coarse alluvium, dormant willow cuttings and woody debris (branches, roots, or small trees not expected to grow). Once the willow cuttings have been established, they will increase roughness by providing riparian vegetation within the floodplain and streambank. This vegetation will improve bank stability and provide shade/cover, improving aquatic habitat. The woody debris adds roughness to the bank, reducing erosive forces until the willows are established. As part of the brush matrix bank treatment a bench 10-15 feet wide will be constructed at the floodplain elevation to provide additional floodplain conveyance capacity. This bench will be planted with willow cuttings to add floodplain roughness during out of bank flood events. Finally, grading the cut bank to a milder slope and vegetating will provide a more geotechnically stable slope that is easier for vegetation to become established and will help to reduce erosion during flood events.

The brush matrix bank treatment is designed to be constructed to bankfull flow elevation. The brush matrix and bench will be planted with locally harvested willows and the slope will be planted with native grasses. The proposed bank design was based on April 2022 GPS survey data, 2011 LiDAR, and site observations.

Results

Two alternatives were proposed for the Rowton Property Bank restoration project, as shown in Figure 2 and Figure 3. The first alternative would provide bank treatment for the more actively eroding reach of bank. This alternative would start at the meander bend's downstream end and continue ~1,000ft upstream. The second alternative would provide bank treatment for entire ~1,800 ft of eroding meander bend. Two brush matrix bank treatment variations are proposed. For areas that are expected to see higher erosive forces an erodible rock toe will be placed in the channel beneath the brush matrix. This rock toe is intended to withstand more frequent flood events but can be mobilized at less frequent flood events. This will provide a better chance for the new vegetation to establish, while still allowing the river the ability to adjust during large flood events. Figure 7 shows the typical brush matrix bank treatments. Additional detailed survey and engineering analysis will be required for final construction level design.

The brush matrix bank treatment is proposed as a bank restoration technique. Per the State of Montana Model Floodplain Ordinances Section 9.14 stream bank restoration is categorized as "*projects intended to reestablish the terrestrial and aquatic attributes of a natural stream and not for protection of a structure or development*". The Rowton bank restoration is not intended or designed to protect a structure but to reduce future erosion and improve aquatic and riparian habitat by promoting vegetation. The bank treatments are not designed to

withstand a specific flow but will be designed to "*not increase velocity or erosion upstream, downstream, across from or adjacent to the site;*" (ARM 36.15.606(1)(b)). A floodplain permit and approval will be required as part of the project permits.

A feasibility level cost opinion (+25%) was developed based on the preliminary design. The cost opinion assumes cut material will be disposed of locally, fill material will be available locally and willow cuttings can be harvested on or near the site. Due to the cut banks height a large volume of bank material will need to be excavated. Installing a narrower bench may save cost on the overall project. The total cost could be reduced by using volunteer labor to harvest and plant the willows.

Where available, local rates were used to calculate the expected costs. Where local data was not readily available costs from RS Means and other similar projects were used for the estimate. The cost opinion includes cost of construction and a 25% contingency.

Table 1 and Table 2 summarizes the itemized breakdown of the total feasibility cost opinion for Alternative 1 at $165,100 and Alternative 2 at $245,500, respectfully.

Cushman Bridge

Cushman Bridge Site Looking West

Background and Objective

When the Cushman Bridge was installed, the Musselshell River upstream of the crossing was relatively straight and streamflow traveled perpendicular to Cushman Road. Since the 2011 flood event, the south bank has started eroding as the river attempts to lengthen. The river has abandoned the old channel and now flows in a new channel to the south and has created a meander bend just west of Cushman Road (Figure 4). The erosion has resulted in loss of land and if continues, may endanger Cushman Road. The project objective is to reduce the erosion potential, improve aquatic and riparian habitat, and improve the hydraulic bridge approach. The Cushman Bridge site objective will be to have a less deformable toe than Rowton, the degree of protection will be determined by stake holders during final design. The Cushman Bridge is in a mapped Zone AE (no Floodway) reach of the Musselshell River.

Method

Two alternatives were analyzed for the Cushman Bridge site.

The first alternative consists of a similar brush matrix bank treatment as proposed for on the Rowton Property (Figure 6), new bank will be constructed with coarse alluvium, willow cuttings and woody debris. The treatment will also include a small bench (10'-15') with willow cuttings and grading the steep cut bank back to a milder slope (3 horizontal to 1 vertical [3:1]). The brush matrix bank treatment will be placed near bankfull flow elevation and planted with locally harvested willow cuttings (Figure 5).

The second alternative would realign the river back into the abandoned channel with the use of a large woody debris plug and new channel banks would be constructed using the brush matrix bank treatment (Figure 6).

A large woody debris plug is an embankment placed in the active river channel to divert the flow into a newly constructed or re-activated channel. Large logs and/or root wads will be partially embedded within the embankment with the root ball side exposed to the river (Figure 8). The roughness from the woody debris provides habitat and reduces the erosive forces on the plug to help establish the new channel.

Excess material from the re-activated channel excavation will be placed in the current active channel to create a floodplain and wetland areas. Locally harvested willow clumps (large, salvaged willow plants) will be placed in the new floodplain. The existing cut bank to the south will be graded back to a 3:1 slope and seeded to reduce the chance of additional erosion during large flood events. Both proposed alternatives were based on April 2022 GPS survey data, 2011 LiDAR, and site observations.

Results

The first alternative would provide bank treatment for approximately 475 feet. Figure 7 shows the typical brush matrix bank treatment. This alternative would not move the river from its current alignment. Additional detailed survey and engineering analysis will be required for final construction level design.

For the second alternative approximately 500 feet of channel will be re-constructed to realign the channel to the pre-2011 channel alignment. A brush matrix bank treatment will be installed on both relocated channel banks where erosive forces are expected to occur. The existing cut bank would be graded and seeded. Additional detailed survey and analysis will be required for final construction level design.

Both alternatives could be considered streambank restoration projects as discussed above for the Rowton Project or designed as bank stabilization protecting the bank for flows up to the 100-year storm event. Since the

Cushman Bridge site falls within a mapped Zone AE flood zone and encroachment analysis will be required along with the project permits. The first alternative may allow for a less expensive qualitative encroachment analysis (if treated as a bank restoration project).

The second alternative would require placing fill in the existing channel and construction within an effective Special Flood Hazard Area. The placement of fill and channel re-alignment will require a quantitative encroachment analysis to demonstrate the re-aligned channel will not raise the BFE water surface more than 0.5 feet during a 100-year storm event. In addition to the encroachment analysis, placing fill within the active channel will require approval from the Army Corps of Engineers. Both additional requirements will be addressed under the Joint Application permits but will require extra design effort and federal agency approval to proceed.

A feasibility level cost opinion (+25%) was developed based on the preliminary design. The cost opinion assumes cut material will be reused to fill in the channel and willow cuttings/clumps can be harvested on or near the site. The total cost may be reduced by using volunteer labor to harvest and plant the willows. Reinforcing the toe to withstand the 100-year storm event would add additional cost for the larger stone.

When available, local rates were used to calculate the expected costs. Where local data was not readily available costs from RS Means and other similar projects were used for the estimate. The cost opinion includes cost of construction and a 25% contingency.

Table 3 and Table 4 summarizes the itemized breakdown of the total feasibility cost opinion for Alternative 1 at $92,800 and Alternative 2 at $176,100 respectfully.

Tables

Table 1 - Rowton Property Alternative #1

Project: **Rowton Property**
Date: **6/1/2022**

Work Item	Desc.	Unit	Quantity	Unit Cost	Total Cost	Notes
	Alternative #1 - Construction Costs					
1	Mobilization	LS	1	$ 12,500	$ 12,500	Includes all prep work for transport and movement of personal, equipment, supplies and incidentals to/from the project site.
1a	Bonding	LS	1	$ 4,800	$ 4,800	Construction Bonding 5% of project total
2	Water Management	LS	1	$ 1,000	$ 1,000	Includes work area stormwater management and sediment control
3	Bank Treatment					Includes brush matrix bank construction, bank excavation, slope grading, fill materials, plantings, seeding and labor
3a	Type 1 Bank Treatment	LS	1	$ 17,000	$ 17,000	Brush matrix construction with native toe (490 lf, ~$34.75/ft)
3b	Type 2 Bank Treatment	LS	1	$ 20,000	$ 20,000	Brush matrix construction with cobble toe (510 lf, ~39.25/ft)
3c	Excavation, Grading, Miscellaneous	LS	1	$ 46,500	$ 46,500	Bank excavation, slope grading, fill materials, plantings, seeding
	Construction Subtotal				**$ 101,800**	
	Construction Contingency				**$ 25,450**	25% construction cost contingency
	Construction Total				**$ 127,250**	Total construction cost estimate with 20% contingency.
	Alternative #1 - Engineering Costs					
4	Final Design and Permitting	T&M			**$ 20,200**	Includes finalizing (100%) construction drawings and specifications, Bid package support, attendance at Pre-bid Meeting and issue clarifications\addenda to the bid documents as needed.
5	Construction Services	T&M			**$ 17,600**	Includes Design Engineer or Engineer Representative on-site inspections during river diversion, for milestone inspection and support ,(6 days total) substantial completion, submittal reviews, design clarifications\adjustments and pay request reviews.
				Rowton Alternative #1 Total[1]	**$ 165,100**	

1 Rounded up to the nearest $100

Table 2 - Rowton Property Alternative #2

Project: **Rowton Property**
Date: **6/1/2022**

Work Item	Desc.	Unit	Quantity	Unit Cost	Total Cost	Notes
	Alternative #2 - Construction Costs					
1	Mobilization	LS	1	$ 17,900	$ 17,900	Includes all prep work for transport and movement of personal, equipment, supplies and incidentals to/from the project site.
1a	Bonding	LS	1	$ 7,700	$ 7,700	Construction Bonding 5% of project total
2	Water Management	LS	1	$ 2,000	$ 2,000	Includes work area stormwater management and sediment control
3	Bank Treatment					Includes brush matrix bank construction, bank excavation, slope grading, fill materials, plantings, seeding and labor
3a	Type 1 Bank Treatment	LS	1	$ 35,400	$ 35,400	Brush matrix construction with native toe (1,020 lf, ~$34.75/ft)
3b	Type 2 Bank Treatment	LS	1	$ 30,600	$ 30,600	Brush matrix construction with cobble toe (780 lf, ~39.25/ft)
3c	Excavation, Grading, Miscellaneous	LS	1	$ 69,300	$ 69,300	Bank excavation, slope grading, fill materials, plantings, seeding
	Construction Subtotal				**$ 162,900**	
	Construction Contingency				**$ 40,725**	25% construction cost contingency
	Construction Total				**$ 203,625**	Total construction cost estimate with 20% contingency.
	Alternative #2 - Engineering Costs					
4	Final Design and Permitting	T&M			**$ 20,200**	Includes finalizing (100%) construction drawings and specifications, Bid package support, attendance at Pre-bid Meeting and issue clarifications\addenda to the bid documents as needed.
5	Construction Services	T&M			**$ 21,600**	Includes Design Engineer or Engineer Representative on-site inspections during river diversion, for milestone inspection and support ,(10 days total) substantial completion, submittal reviews, design clarifications\adjustments and pay request reviews.
				Rowton Alternative #2 Total[1]	**$ 245,500**	

1 Rounded up to the nearest $100

Table 3 - Cushman Bridge Alternative #1

Project: **Cushman Bridge**
Date: **6/1/2022**

Work Item	Desc.	Unit	Quantity	Unit Cost	Total Cost	Notes
	Alternative #1 - Construction Costs					
1	Mobilization	LS	1	$ 7,800	$ 7,800	Includes all prep work for transport and movement of personal, equipment, supplies and incidentals to/from the project site.
1a	Bonding	LS	1	$ 2,200	$ 2,200	Construction Bonding 5% of project total
2	Water Management	LS	1	$ 600	$ 600	Includes work area stormwater management and sediment control
3	Bank Treatment					Includes brush matrix bank construction, bank excavation, slope grading, fill materials, plantings, seedings and labor
3a	Type 1 Bank Treatment	LS	1	$ 9,600	$ 9,600	Brush matrix construction with native toe (275 lf, ~$34.75/ft)
3b	Type 2 Bank Treatment	LS	1	$ 7,900	$ 7,900	Brush matrix construction with cobble toe (200 lf, ~39.25/ft) [Type 2 bank treatment costed with cobbles, larger, less mobile stone will add cost to bank treatment]
3c	Excavation, Grading, Miscellaneous	LS	1	$ 19,400	$ 19,400	Bank excavation, slope grading, fill materials, plantings, seeding
	Construction Subtotal				**$ 47,500**	
	Construction Contingency				**$ 11,875**	25% construction cost contingency
	Construction Total				**$ 59,375**	Total construction cost estimate with 20% contingency.
	Alternative #1 - Engineering Costs					
4	Final Design and Permitting	T&M			**$ 17,800**	Includes finalizing (100%) construction drawings and specifications, Bid package support, attendance at Pre-bid Meeting and issue clarifications\addenda to the bid documents as needed.
5	Construction Services	T&M			**$ 15,600**	Includes Design Engineer or Engineer Representative on-site inspections during river diversion, for milestone inspection and support ,(4 days total) substantial completion, submittal reviews, design clarifications\adjustments and pay request reviews.
				Cushman Alternative #1 Total[1]	**$ 92,800**	

1 Rounded up to the nearest $100

Table 4 - Cushman Bridge Alternative #2

Project: **Cushman Bridge**
Date: **6/1/2022**

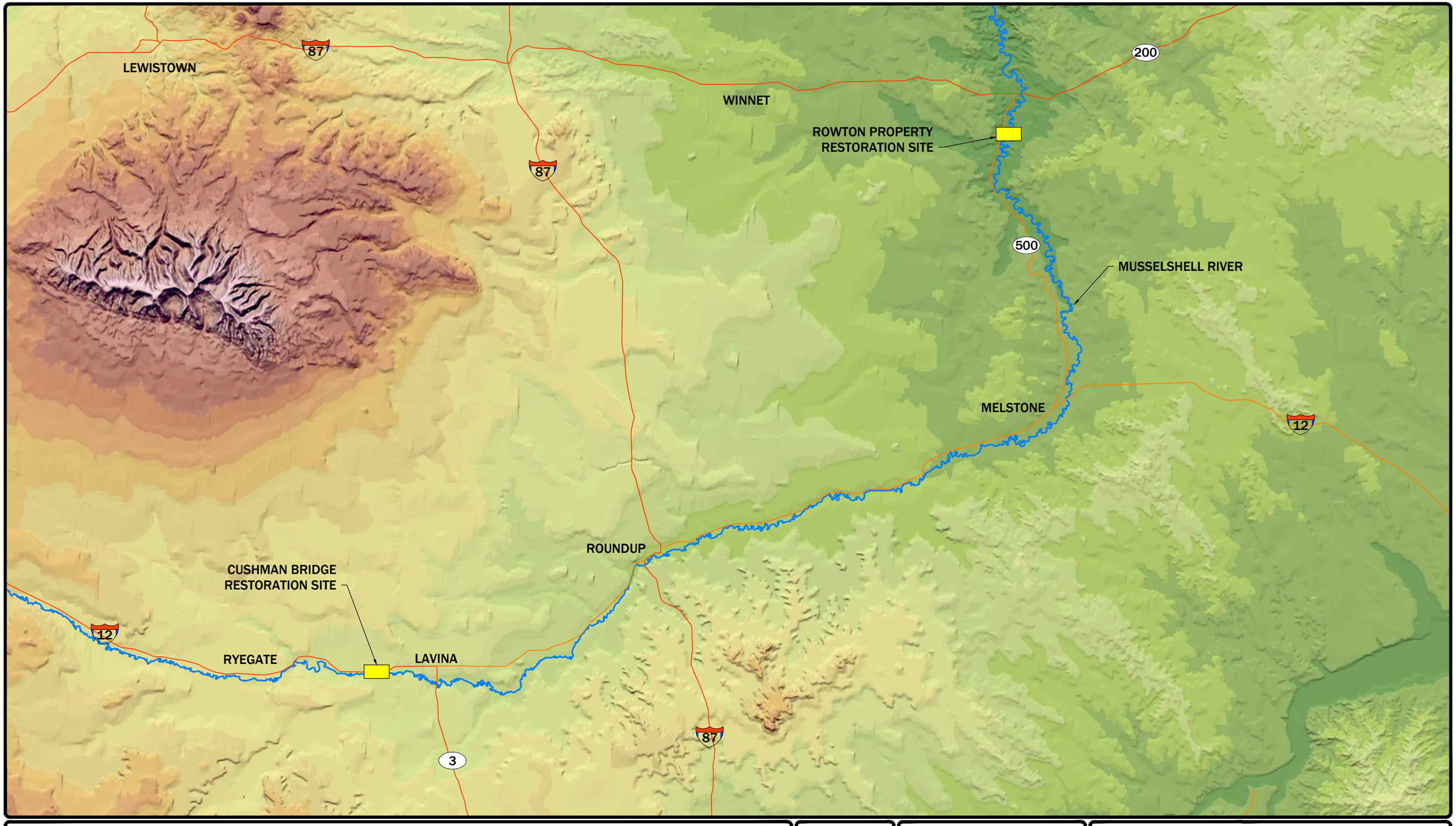
	Alternative #2 - Construction Costs					
Work Item	**Desc.**	**Unit**	**Quantity**	**Unit Cost**	**Total Cost**	**Notes**
1	Mobilization	LS	1	$ 9,400	$ 9,400	Includes all prep work for transport and movement of personal, equipment, supplies and incidentals to/from the project site.
1a	Bonding	LS	1	$ 4,800	$ 4,800	Construction Bonding 5% of project total
2	Water Management	LS	1	$ 3,600	$ 3,600	Includes work area dewatering, stormwater management and sediment control
3	Channel Construction					Includes channel excavation, brush matrix bank construction, and slope grading
3a	Type 1 Bank Treatment	LS	1	$ 5,200	$ 5,200	Brush matrix construction with native toe (185 lf, ~$28.00/ft)
3b	Type 2 Bank Treatment	LS	1	$ 10,300	$ 10,300	Brush matrix construction with cobble toe (320 lf, ~32.25/ft) [Type 2 bank treatment costed with cobbles, larger, less mobile stone will add cost to bank treatment]
3c	Excavation, Grading, Miscellaneous	LS	1	$ 27,900	$ 27,900	Channel excavation and slope grading
4	Active Channel Plug and Backfill	LS	1	$ 40,800	$ 40,800	Includes fill materials, constructing channel plug, backfill, habitat grading, plantings, seedings and labor
	Construction Subtotal				**$ 102,000**	
	Construction Contingency				**$ 25,500**	25% construction cost contingency
	Construction Total				**$ 127,500**	Total construction cost estimate with 20% contingency.

	Alternative #2 - Engineering Costs					
4	Final Design and Permitting	T&M			**$ 27,000**	Includes finalizing (100%) construction drawings and specifications, Bid package support, attendance at Pre-bid Meeting and issue clarifications\addenda to the bid documents as needed.
5	Construction Services	T&M			**$ 21,600**	Includes Design Engineer or Engineer Representative on-site inspections during river diversion, for milestone inspection and support ,(10 days total) substantial completion, submittal reviews, design clarifications\adjustments and pay request reviews.

1 Rounded up to the nearest $100

Cushman Alternative #2 Total[1] **$ 176,100**

Figures



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DATUM: NAD83/NAVD88
UNITS: INTL. FEET
SOURCE: PIONEER

SCALE IN FEET
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FIGURE 1

ROWTON AND CUSHMAN BRIDGE SITE LOCATION

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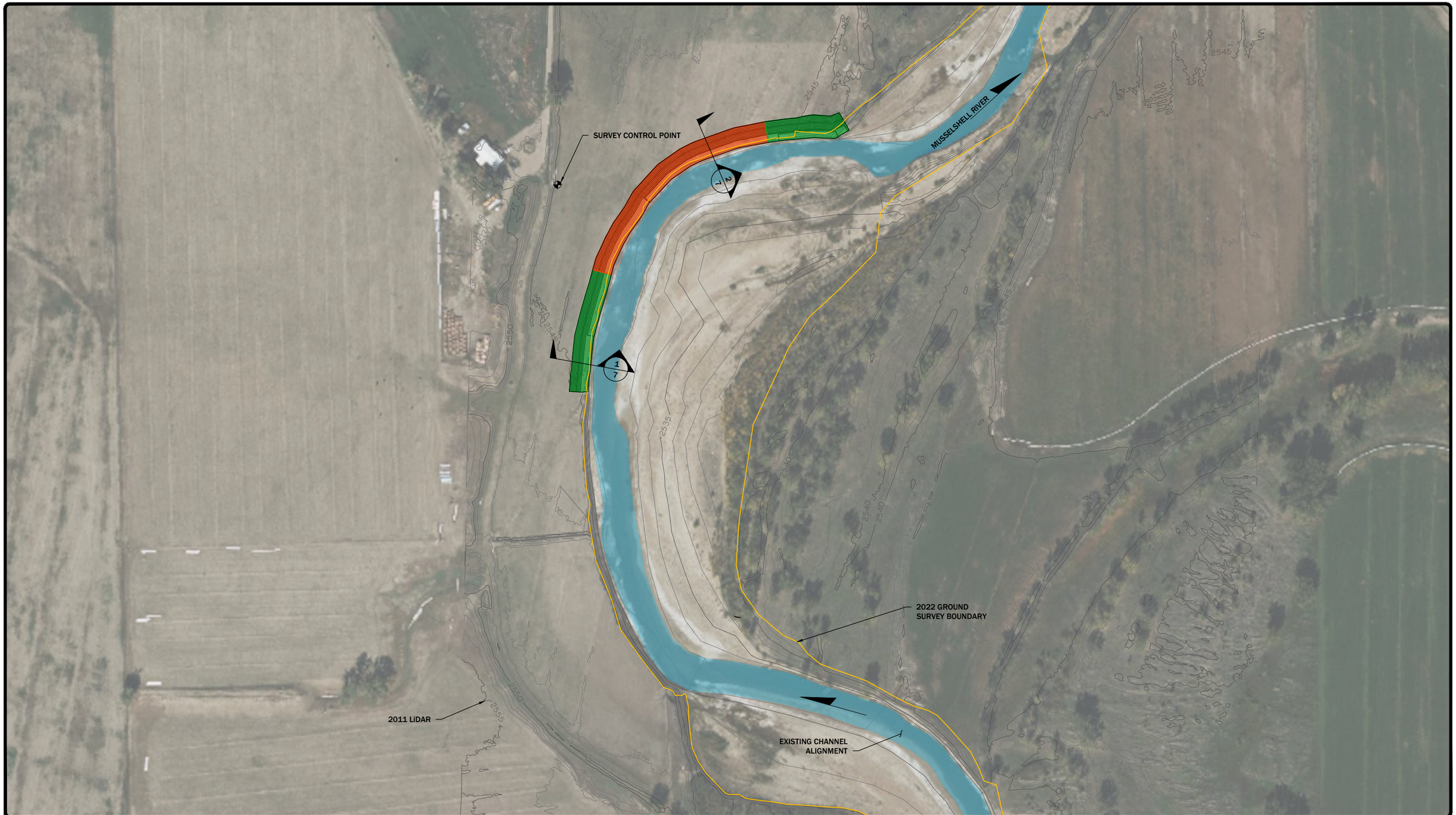

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FIGURE 2

ROWTON PROPERTY
BANK RESTORATION
ALTERNATIVE 1
PLAN VIEW

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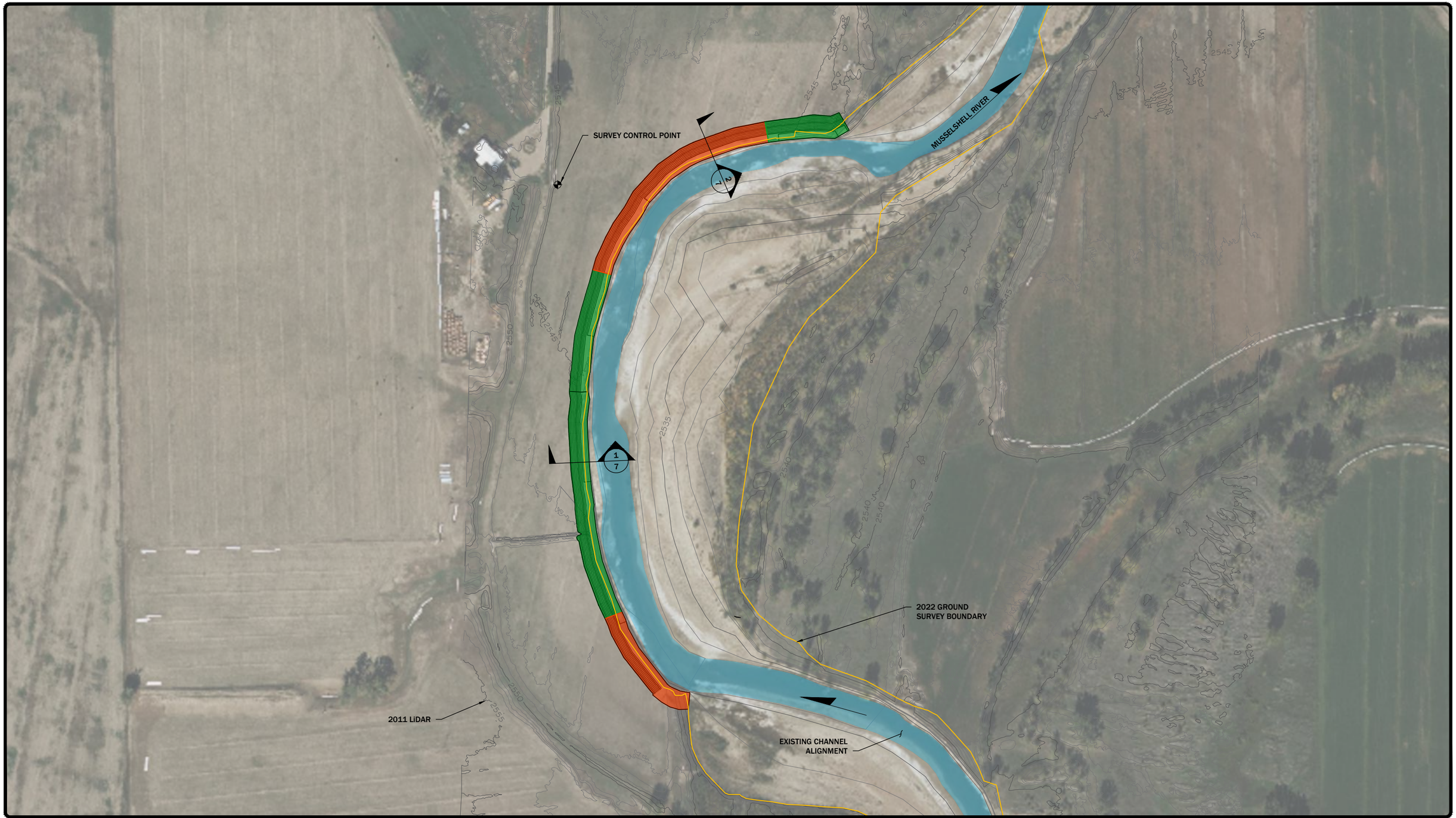

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FIGURE 3

ROWTON PROPERTY
BANK RESTORATION
ALTERNATIVE 2
PLAN VIEW

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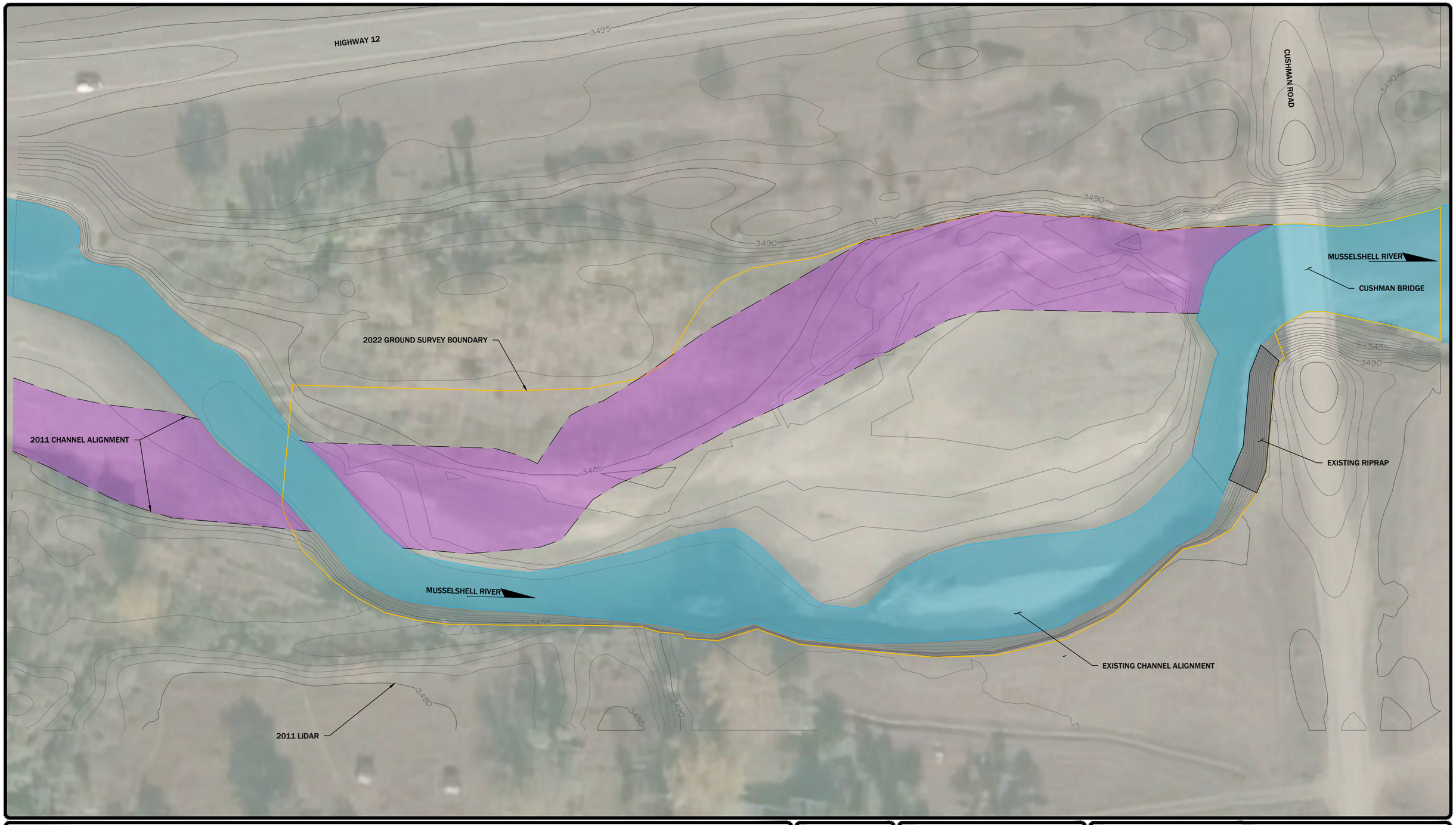

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FIGURE 4

CUSHMAN BRIDGE
SITE MAP
EXISTING
CONDITIONS

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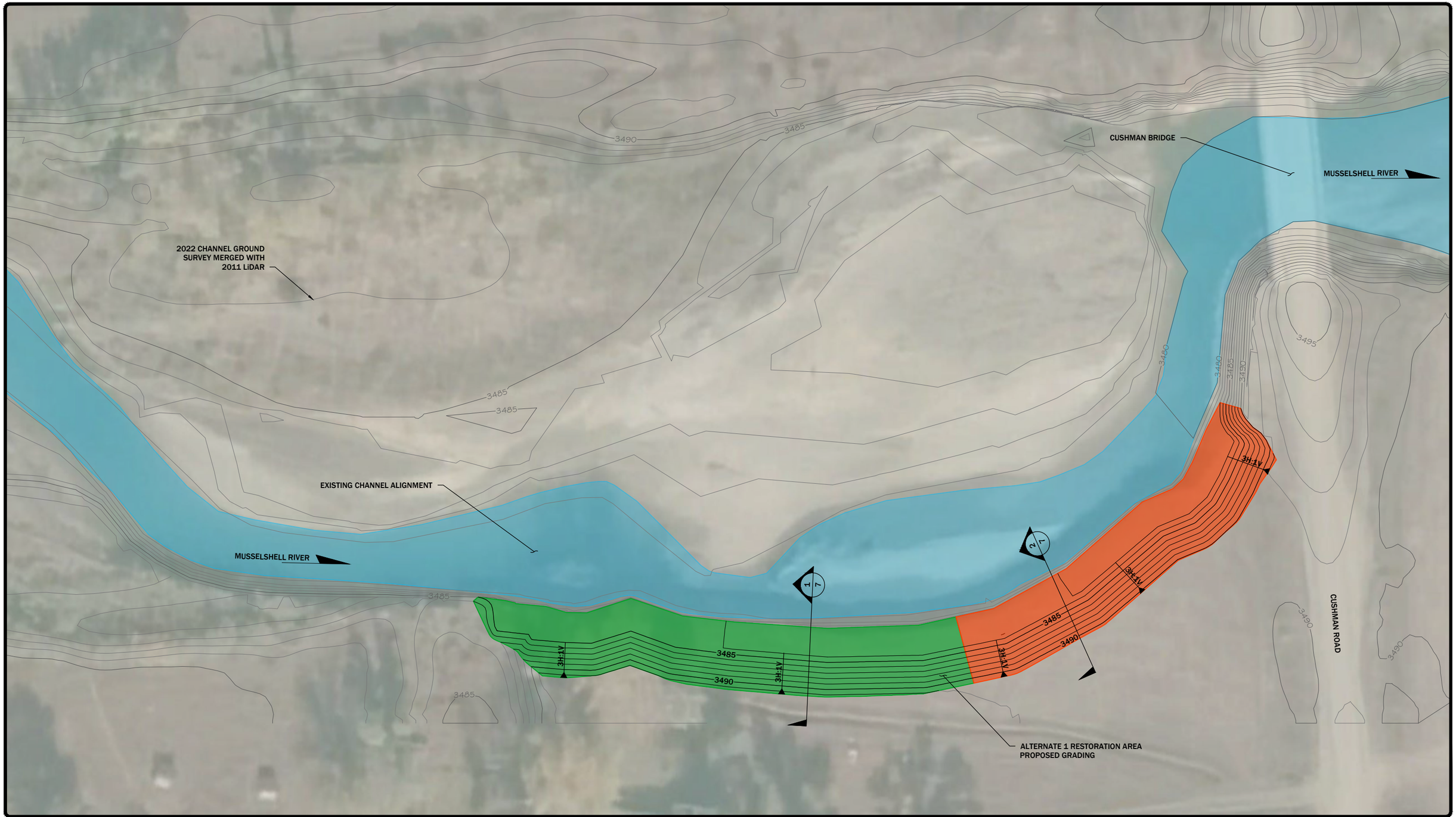

LEGEND:

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FIGURE 5

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CUSHMAN BRIDGE BANK RESTORATION ALTERNATIVE 1 PLAN VIEW

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HIGHWAY 12

CUSHMAN BRIDGE

MUSSELSHELL RIVER

RE-ALIGNED MUSSELSHELL RIVER

PROPOSED CHANNEL
RE-ALIGNMENT GRADING

WILLOW CLUMPS

LEAVE EXISTING
CHANNEL TO CREATE
BACKWATER AREA

2022 CHANNEL GROUND
SURVEY MERGED WITH
2011 LiDAR

MUSSELSHELL RIVER

LEAVE PORTION OF
EXISTING CHANNEL
TO CREATE WETLAND

CUSHMAN ROAD

LARGE WOODY DEBRIS/
VEGETATION ON FACE OF PLUG

PROPOSED LARGE
WOODY DEBRIS PLUG

LEGEND:

- TYPE 1 BANK TREATMENT
- TYPE 2 BANK TREATMENT
- ALTERNATIVE 2 RESTORATION AREA PROPOSED GRADING

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FIGURE 6

CUSHMAN BRIDGE
BANK RESTORATION
ALTERNATIVE 2
PLAN VIEW

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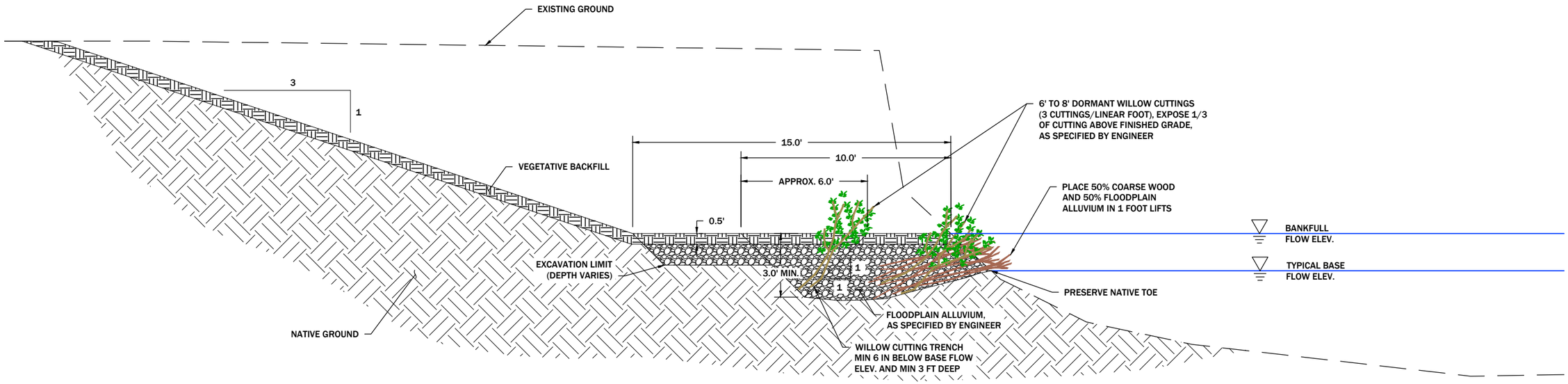

TYPE 1 BANK TREATMENT

1

TYPICAL SECTION
SHEETS: 2, 3, 5, 6
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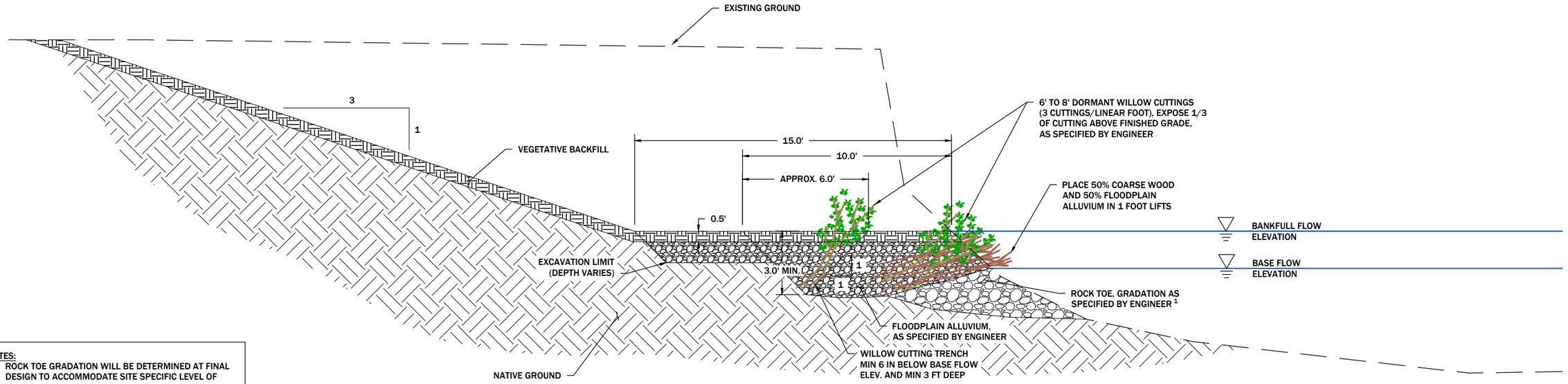

NOTES:
1. ROCK TOE GRADATION WILL BE DETERMINED AT FINAL DESIGN TO ACCOMMODATE SITE SPECIFIC LEVEL OF DEFORMABLILITY/PROTECTION.

TYPE 2 BANK TREATMENT

2

TYPICAL SECTION
SHEETS: 2, 3, 5, 6
N.T.S.

DISPLAYED AS:
COORD SYS/ZONE: NA
DATUM: NA
UNITS: FEET
SOURCE: PIONEER

SCALE IN FEET
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FIGURE 7

BRUSH MATRIX
BANK TREATMENT
TYPICAL SECTIONS

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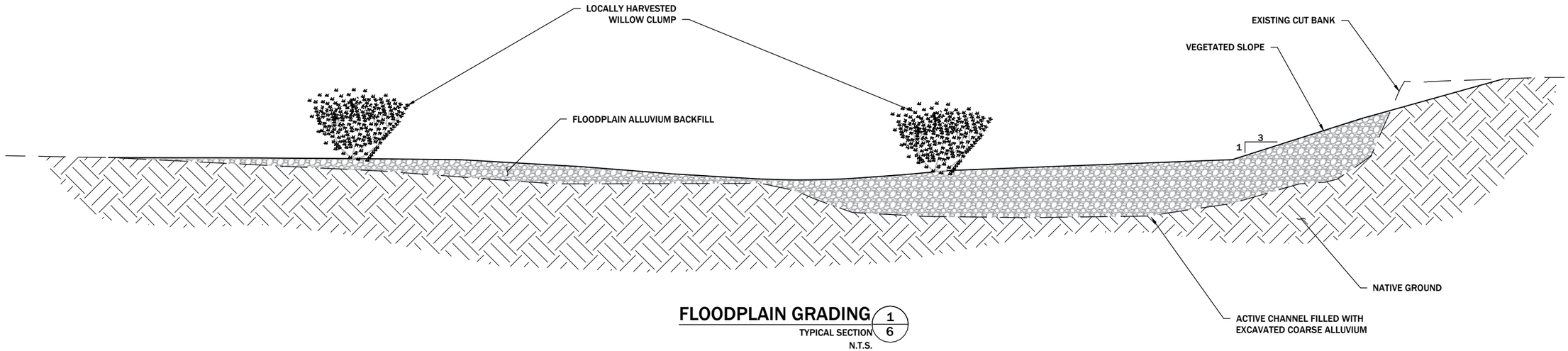

FLOODPLAIN GRADING 1/6

TYPICAL SECTION

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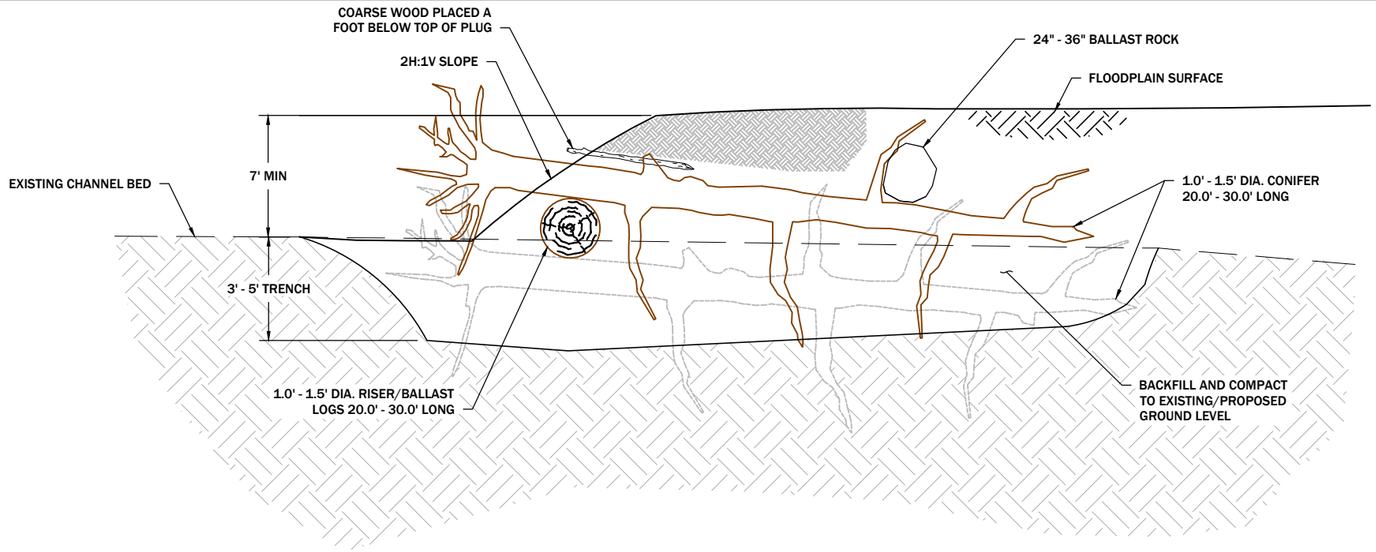

LARGE WOODY DEBRIS PLUG 2/6

TYPICAL SECTION

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FIGURE 8

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CUSHMAN BRIDGE FLOODPLAIN GRADING AND LWD PLUG TYPICAL SECTIONS

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