Yampa River – Duquette Ditch Improvements – Phase 2

Hydraulic Design Report

DRAFT

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March 5, 2026

Project No. 21136.001

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1. Introduction

Identified in the 2020 Yampa River Basin Integrated Water Management Plan (IWMP; Diversion Infrastructure Assessment; Wilson Water Group and JUB Engineers, 2020), the Duquette Diversion presents a critical opportunity to improve irrigation efficiency, restore bank stability, and enhance river health. This section of the Yampa River has straightened significantly since 1983 and is currently constrained by bluffs and a railroad bridge.

The diversion owners—Three Quarter Circle Ranch, Steamboat II Metropolitan District, and Steamboat Golf Club—lack effective in-river infrastructure. During low flows, they currently rely on placing concrete road barriers in the channel. This temporary solution is inefficient for water delivery, detrimental to river ecology, and creates hazards that shift during high spring flows. Additionally, the site presents passage challenges for fish and significant safety risks for recreational boaters due to dangerous hydraulics near the downstream railroad bridge.

In 2024, the Community Agriculture Alliance (CAA) received a grant from the Yampa River Fund (with CAA providing match funding) to support the planning and design of diversion and bank stabilization improvements at the Duquette Ditch headgate on the Yampa River (Phase 1). As a result of this Phase 1 effort, a grouted boulder grade control diversion structure was recommended and developed into a 15% design (Otak, 2025). In 2025, a second grant was awarded to CAA from Yampa River Fund to complete hydraulic analysis of the design alternative selected at the 15% design level (Phase 2). The following memorandum outlines the hydraulic analysis completed for the selected design to determine an appropriate crest height and shape to meet the diversion needs of the water users.

1.1. Project Location

The Duquette Ditch headgate is located on the river right side of the Yampa River, approximately 3 miles downstream/west of downtown Steamboat Springs and approximately 950 feet (ft) upstream of a Union Pacific Railroad crossing (Figure 1). Land use adjacent to the project area is agricultural and residential. Additionally, the Steamboat Golf Club is located just west of the project area. Owners of the Duquette Ditch include the Three Quarter Circle Ranch, the Steamboat II Metropolitan District, and the Steamboat Golf Course.

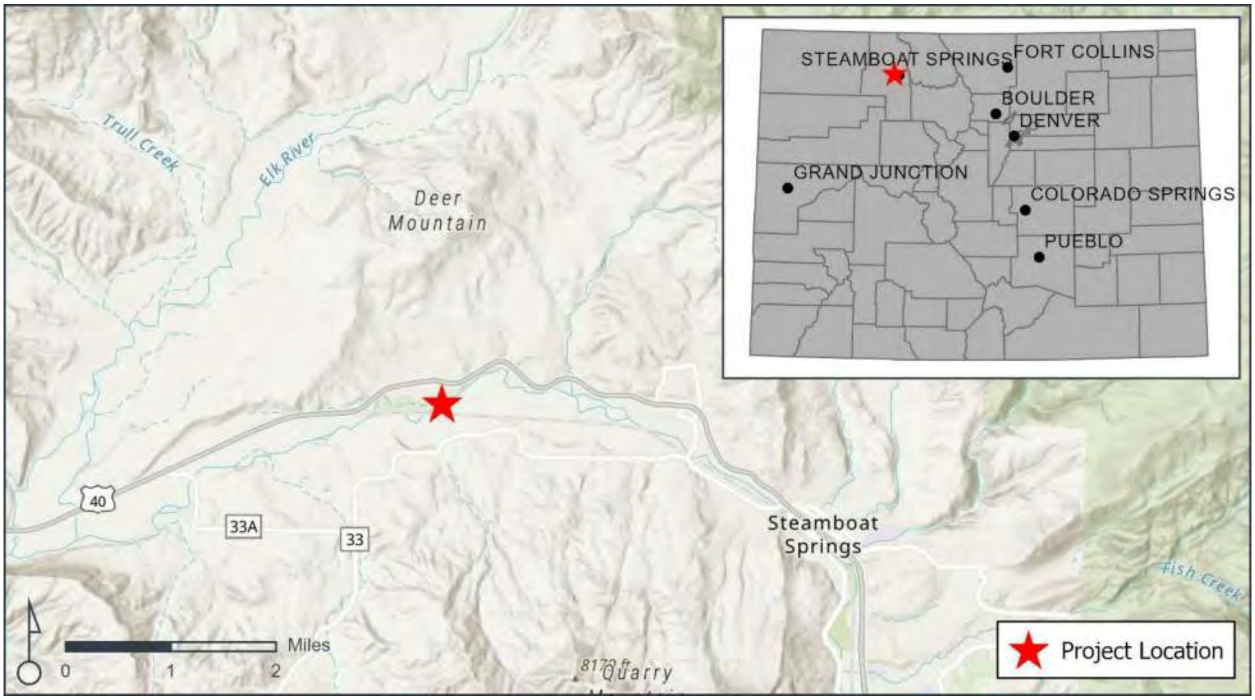

Figure 1: Vicinity Map

1.2. Goal and Objectives

Project goals and objectives were developed during Phase 1 in collaboration with the CAA and project stakeholders and are summarized in Table 1.

Table 1: Project Goals and Objectives

Goals	Objectives
Ensure reliable water delivery to Duquette and upstream infiltration gallery	• Improve ability to divert legally decreed water under a full range of river flow conditions. • Raise water surface elevation at the Duquette Ditch headgate (and upstream infiltration gallery) to improve diversion performance.
Stabilize river and reduce land loss	• Reduce bank erosion and stabilize failing, over-steepened banks on both sides of the river. • Reconnect the channel to the floodplain where possible to reduce energy of river flows and subsequent lateral erosion.
Maintain or enhance aquatic and riparian habitat	• Provide fish and sediment passage across the diversion structure. • Avoid disturbance to established riparian vegetation, including mature trees. • Use log and rock vanes to provide greater habitat diversity and reduce bank erosion.
Support a multi-benefit, stakeholder driven solution	• Incorporate feedback from agricultural, recreational, and environmental stakeholders throughout design

2. Background Information and Site Conditions

During Phase 1, assessments were completed to evaluate existing physical, hydrologic, and ecological conditions at the Duquette Ditch project site, based on field observations (site visit conducted September 5, 2024), survey data, and background research (Phase 1 Basis of Design Report; Otak, 2025). This section further expands on these assessments, to help inform the understanding of current site constraints and opportunities and provide the foundation for design development.

2.1. Site Infrastructure and Operations

The water users on the Duquette Ditch hold decreed water rights totaling up to 18.54 cubic feet per second (cfs) from the Yampa River (Table 2). Water flows through the Duquette Ditch headgate (north side of the river; Photo 1) towards the Steamboat Golf Club where water either flows through a headgate toward the golf club, or returns to the river (Photo 2, Photo 3). The headgate consists of two 2.5-ft diameter culvert pipes with a slight adverse slope, controlled by Waterman C-10 gates, which convey flow for 40 ft into the diversion canal. Immediately downstream of this return is the Union Pacific Railroad Bridge crossing (Photo 4). Upstream of the Duquette Ditch, landowners place rocks/concrete blocks by hand to create a weir to raise the water surface elevation for their infiltration gallery (Photo 5).

Table 2: Duquette Ditch Decreed Water Rights

Structure	Priority Admin No.	Diversion Rate (cfs)
DUQUETTE D - BAMBER HG (5802156)	19622.14750	1.67
DUQUETTE DITCH (5800618)	14722.00000	6
DUQUETTE DITCH (5800618)	33782.23892	9
DUQUETTE D - SAMPSON HG (5802160)	22186.17695	0.5
DUQUETTE D - SAMPSON HG (5802160)	45522.00000	1
DUQUETTE D - SAMPSON HG (5802160)	54299.00000	0.37
Total		**18.54**

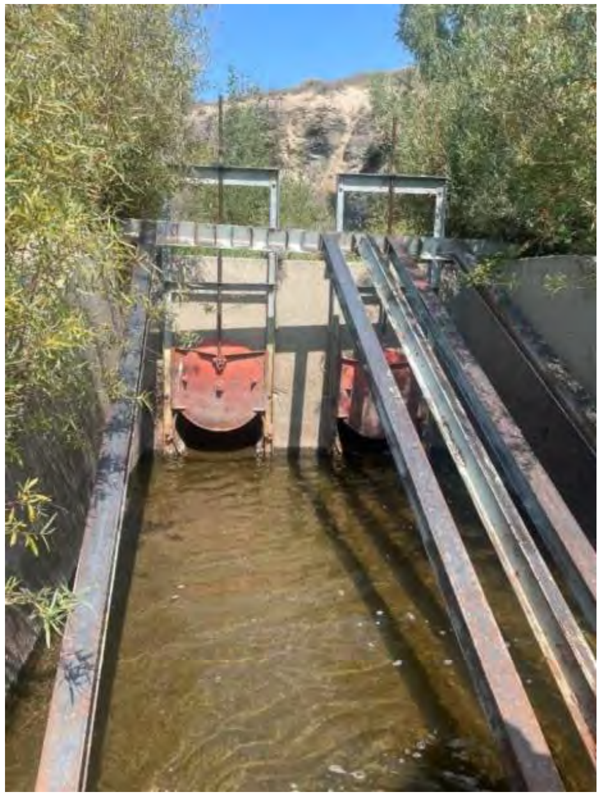

Photo 1: Duquette Ditch Headgate

Photo 2: Duquette Ditch Return Flow (looking downstream)

Photo 3: Control Gates for Water Delivery

Photo 4: Union Pacific Railroad Bridge (looking downstream)

Photo 5: Pushup Riffle for Infiltration Gallery

2.2. Topography

Topographic data was collected by Landmark Consultants, Inc. in September and November, 2024. The data collection included a full bathymetric survey of the channel bed and banks for a 290 ft segment of the Yampa River in the vicinity of Duquette Ditch (140 ft upstream and 150 ft downstream), as well as approximately 75 ft of the ditch starting at the headgate structure. Detailed survey of the existing double barrel 30” corrugated metal culverts was also collected. In addition, four cross sections were surveyed, two roughly 500 ft upstream of the diversion and two roughly 800 ft downstream of the diversion. The data was provided in Colorado State Plane, North Zone (NAD 83 (NSRS2011).

LiDAR data collected in 2016 for Routt County was downloaded from the Colorado Water Conservation Board Colorado Hazard Mapping and Risk MAP Portal. This LiDAR data was used to represent the topography outside of the channel.

Interpolation of the survey data was necessary to create a surface sufficiently large to support development of a two-dimensional (2D) hydraulic model. To represent the Yampa River channel, the cross sections and bathymetric surface were used to interpolate a channel bed surface between the surveyed cross sections upstream and downstream of the full bathymetric survey at the project area. Additional topography of the ditch downstream of the survey was also necessary to support 2D hydraulic modeling. To create additional topography for the ditch, the relative elevation of the LiDAR data and the surveyed portion of the ditch bottom was used to predict the depth below the LiDAR data and extrapolate a surface for the ditch bottom an additional 585 ft downstream. The topographic survey data was blended with 2016 LiDAR data, the interpolated Yampa River topography, and extrapolated ditch topography to create a complete topographic surface extending 1,300 ft to best represent the project area for purposes of hydraulic model development. The topographic surface is in Colorado State Plane, North Zone (NAD 83 (NSRS2011) (GRID) and the vertical datum is NAVD88.

3. Hydrologic Assessment

Design flows for the project reach were determined through analysis of available hydrologic data for the watershed, including daily flow gage records and diversion records. One-dimensional (1D) hydraulic modeling utilized larger peak discharges adopted from the Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) Report and are summarized in Section 3.4.

3.1. Gage Analysis

The design flows are based on mean daily flows developed using data from the Yampa at Steamboat gage (YAMSYECO and USGS 09239500, period of record 1904 to 2025), located approximately 4.6 miles upstream of the Duquette Diversion, as well as the Yampa below Soda Creek gage (YAMSODCO and USGS 09240020, period of record 2008 to 2025), located 4.0 miles upstream of the Duquette Diversion. The flow records from these two gages were scaled to the basin area at the Duquette project location. The Yampa at Steamboat gage and Yampa below Soda Creek gage have basin drainage areas of 567.4 and 598 square miles, respectively. The drainage basin area at Duquette Diversion is 612 square miles. A drainage basin scaling factor of 0.64 for northwest Colorado streams (Vaill, 2000) was utilized.

A flow duration curve was developed to understand the frequency of various low flows at the Duquette Diversion. Scaled mean daily discharges from the Yampa at Steamboat gage were utilized to develop the flow duration curve at Duquette Diversion on account of the longer period of record (Figure 2), with representative flow statistics summarized in Table 3.

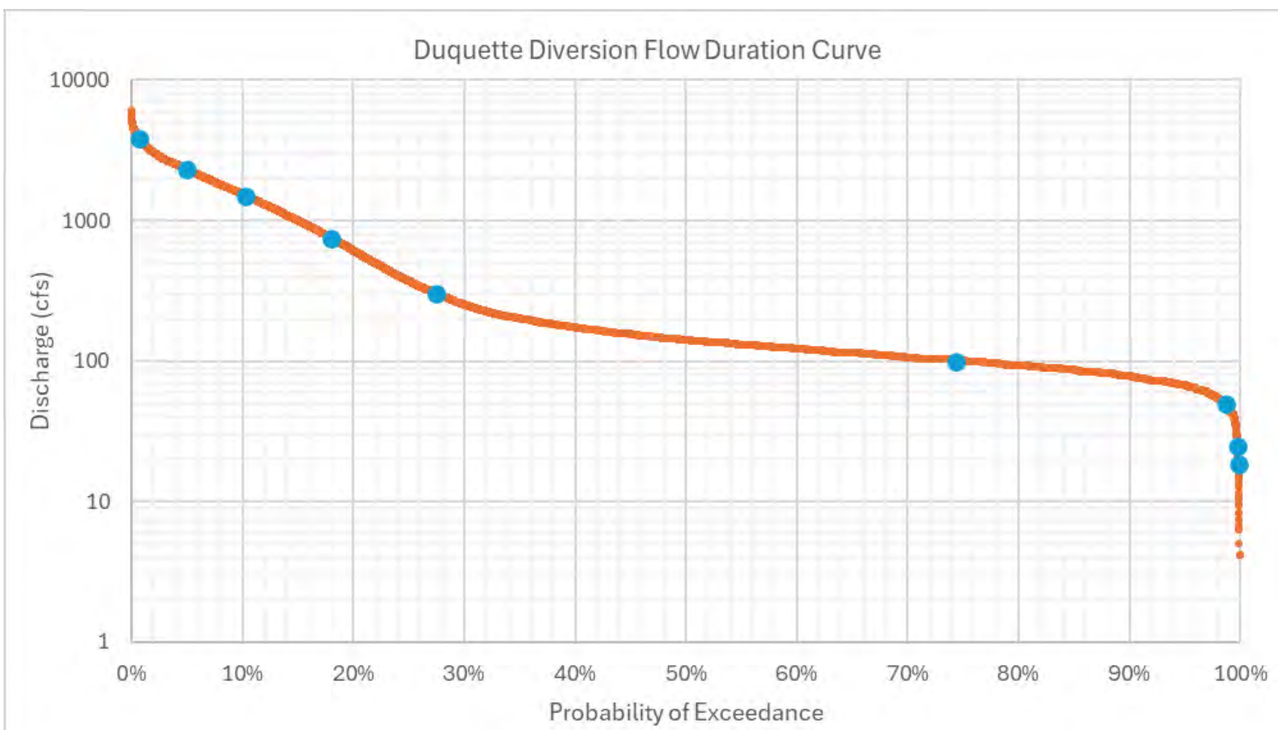

Figure 2: Flow Duration Curve for the Yampa River at Duquette Diversion (blue dots represent chosen design discharges)

Table 3: Representative Flow Statistics for Yampa at Duquette Diversion

Probability of Exceedance	Discharge (cfs)
95%	67
90%	78
70%	105
50%	140
30%	250
10%	1531

The scaled mean daily discharges were also used to develop an annualized hydrograph which shows the median, 90% exceedance and 10% exceedance discharges for each day through the year (Figure 3, Figure 4). These metrics, along with the flow duration curve, are important for understanding the range of discharges anticipated during the diversion period. The 90% exceedance/10th percentile flows which characterize some of the lowest flows anticipated on the Yampa River at Duquette Diversion are of particular interest for the hydraulic design of the diversion structure crest.

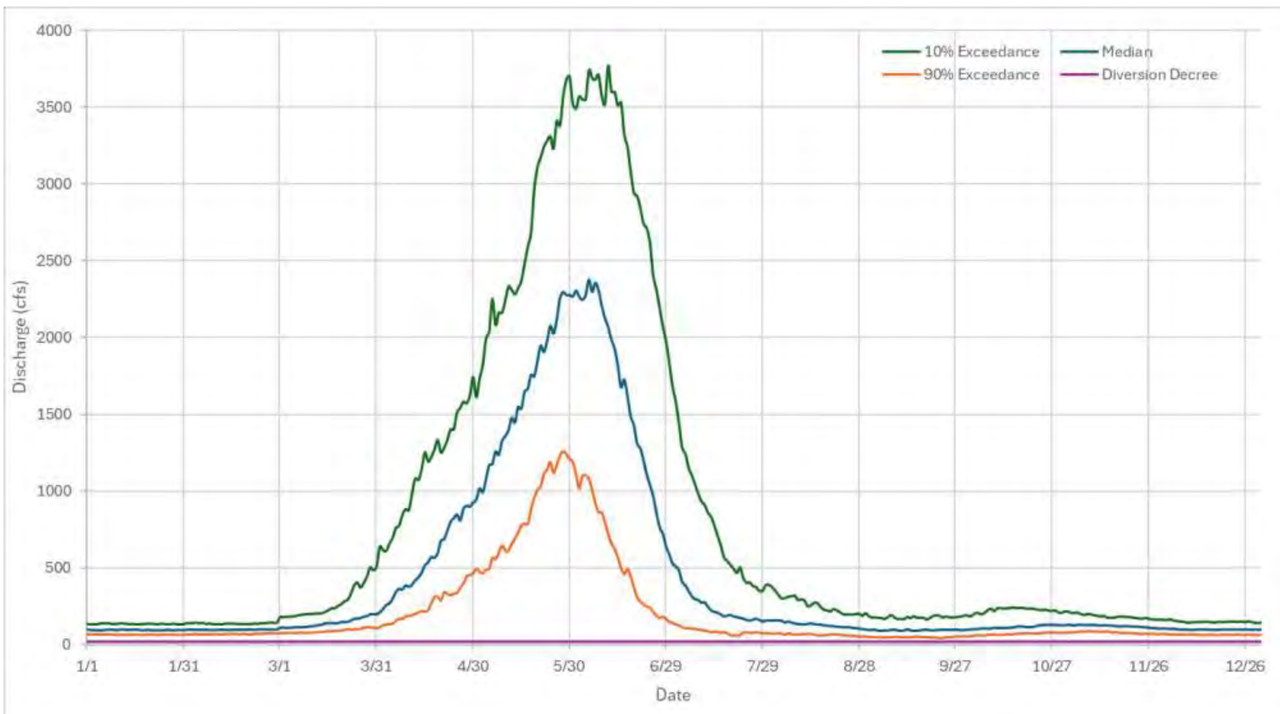

Figure 3: Annualized Hydrograph for the Yampa River at Duquette Diversion

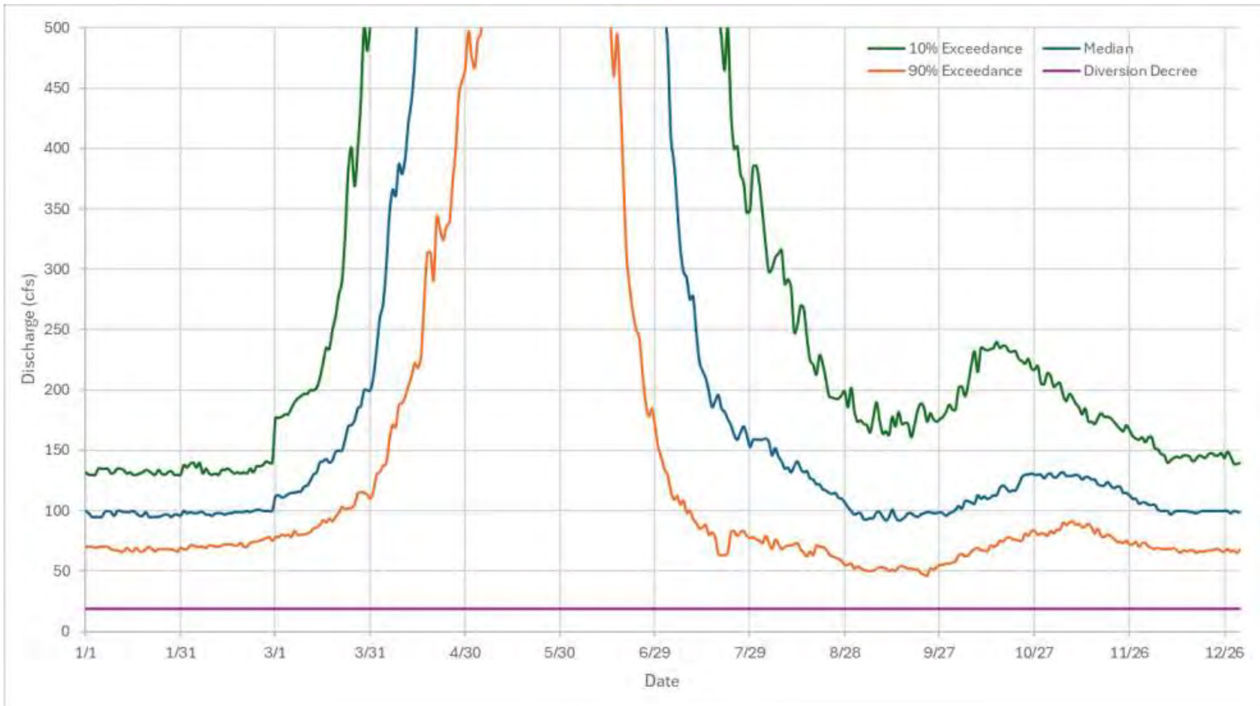

Figure 4: Low Flow Focus of Annualized Hydrograph for Yampa River at Duquette Diversion

3.2. Diversion Record Analysis

Historical diversion records for Duquette Diversion were downloaded from the Colorado Division of Water Resources. The diversion at Duquette is documented in three separate records which were combined for a full record:

- Duquette Diversion – 2024 to 1933
- Duquette Bamber – 2024 to 2003
- Duquette Sampson – 2025 to 2003

The combined diversion data was sorted by day of the year and then used to compute median daily diversions, and 10% and 90% exceedance diversion flow rates. These metrics help characterize both typical and extreme diversion conditions. The data are accumulated into an annualized hydrograph (Figure 5). Typically, the diversion period extends from May through October. Typical daily diversion rates are less than 12 cfs during peak runoff and less than 6 cfs during the low flow period of the summer months. The maximum diversion rate recorded was 25 cfs.

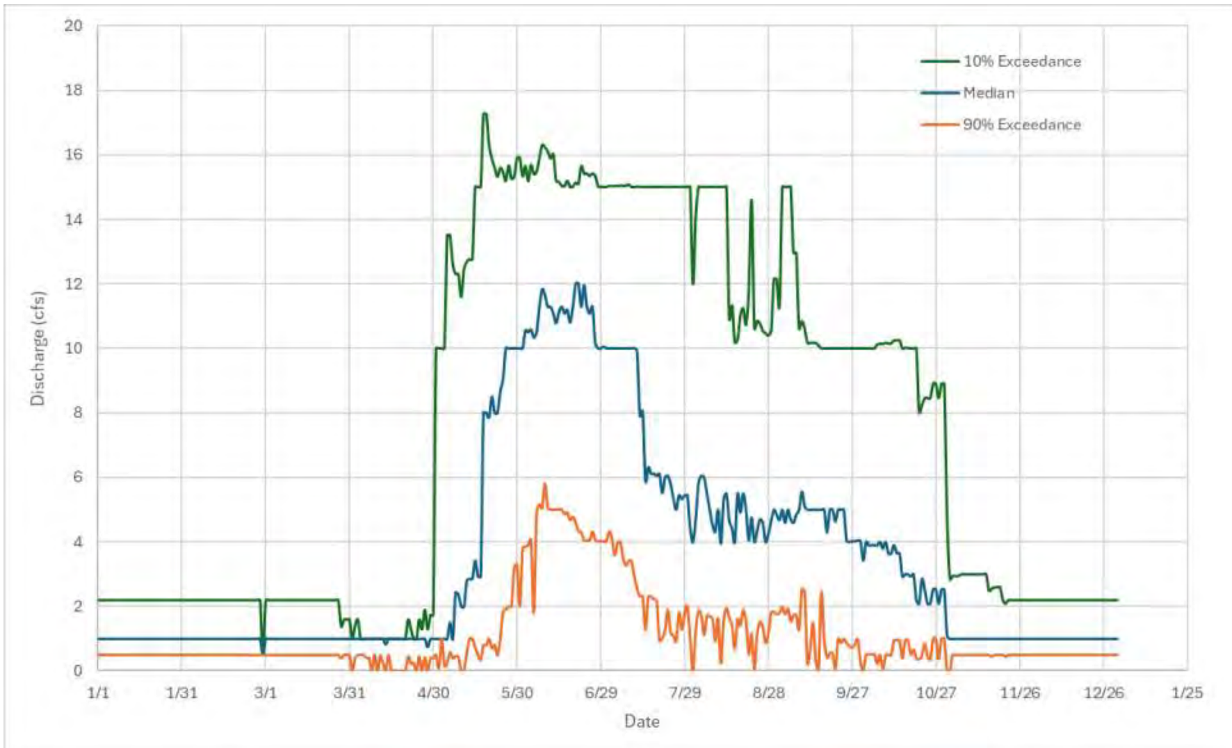

Figure 5: Duquette Diversion Annualized Hydrograph

3.3. Effective Discharge

The channel forming flow is one of the most geomorphically critical design flows to determine, and one method to determine the channel forming flow is effective discharge. The effective discharge calculations identify the flow responsible for moving the most sediment in the river, specifically the mean daily flow rate that moves the most sediment over the historic range of flows. Although the diversion crest will operate primarily under low-flow conditions, the effective discharge is relevant to long-term channel stability and grade control performance.

Effective discharge is conceptually represented in Figure 6. The bottom axis of the graph is flow rate and the vertical axis represents either frequency of occurrence for different flows (blue line) or magnitude of sediment discharge for different flows (yellow line). At very low flows there is no sediment transport occurring, but as flows increase, the threshold of motion is reached (where yellow line starts to climb). From that point on sediment transport increases rapidly and continuously with increasing discharge (Andrews and Nankervis, 1995). The most frequently occurring flows—represented by the peak of the flow-frequency curve—are generally above the threshold of motion and therefore transport some sediment. However, the volume moved during these events is relatively small and insufficient to drive long-term channel morphology (typically limited to finer fractions). In contrast, the largest flows transport substantial sediment volumes but occur infrequently. Effective discharge is the flow between these two extremes that can move enough sediment frequently enough to have the largest impact on channel morphology. Effective discharge (red line in Figure 6is the product of the flow frequency curve and the discharge rating curve. The maximum point on the red line represents the flow that moves the most sediment over time, which is the effective discharge.

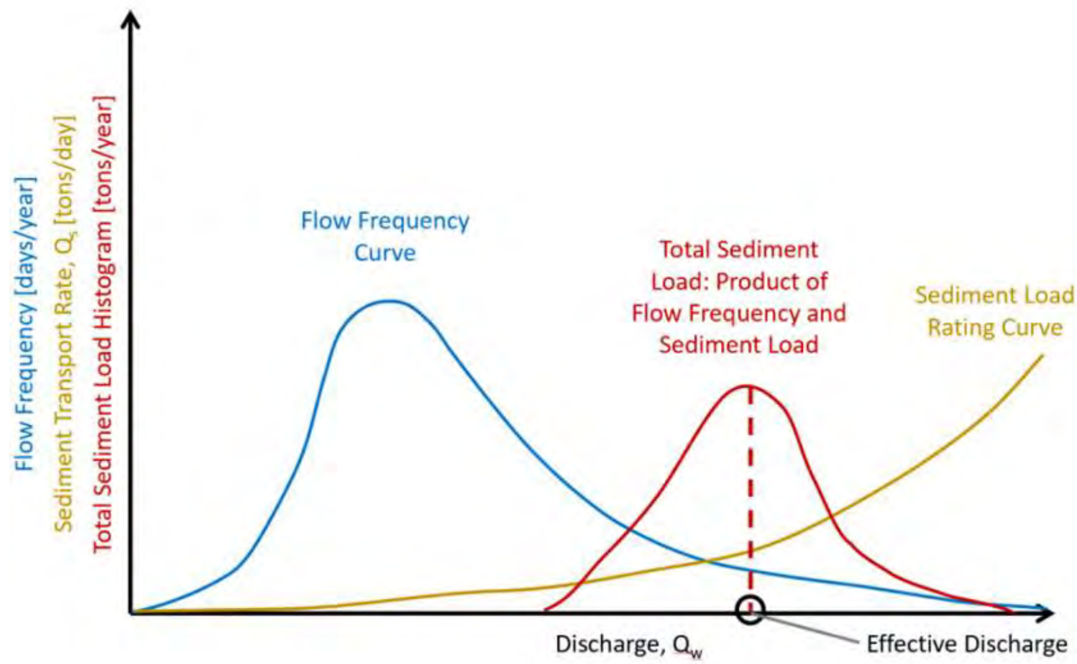

Figure 6: Conceptual Graphic of Determining Effective Discharge

The two inputs used to calculate the effective discharge are the flow duration curve (a cumulative frequency curve that shows the percent of time specific discharges were equaled or exceeded during a given period) and the sediment rating curve (which relates how much sediment is moved during certain flow events). To create the flow duration curve, mean daily flow data was obtained from the Yampa River at Steamboat Springs, CO gage (USGS 09239500) with a period of record from 1904 to 2025. The flow records from this gage were scaled to the basin area at the Duquette project location as described in Section3.1.

The second input for the determination of effective discharge is the development of sediment rating curves (calculation of how much sediment is moved for various flows). The Bedload Assessment in Gravel-bed Streams (BAGS) software was used to create sediment rating curves (Pitlick et al., 2009). The software utilizes a representative channel cross section (surveyed), Manning's roughness (values of 0.04 were used for within the bankfull channel and 0.05 for the overbank areas), longitudinal bed slope (0.58%), and a sediment gradation (determined from a pebble count taken in 2024 [Otak, 2025]) to create a sediment rating curve. The software is capable of using different bedload sediment transport equations, for purposes of this analysis Wilcock and Crowe (2003) and Parker (1990) were utilized.

A histogram of flows was created from the flow duration curve using three different quantities of bins (15, 20, and 25 bins) to evaluate the sensitivity of bin size. In a histogram, a bin is a range of values that groups data points together to better understand the frequency of those data and the bin size determines the width of that range. The frequency of occurrence of flows within each bin was then multiplied by the sediment transport rate for the median value of each bin (based on the output of each of the BAGS analyses). The results of these analyses are visualized using different colors reflecting different bin sizes, and solid lines and dashed lines representing results utilizing the Parker, and Wilcock and Crowe, respectively (Figure 7). The calculations utilizing two sediment transport equations and three bin quantities yielded six individual estimates of effective discharge ranging from 3,729 cfs to 4,378 cfs with an average value of 3,924 and a median value of 3,860 cfs (Table 4, black dots; Figure 7, black lines).

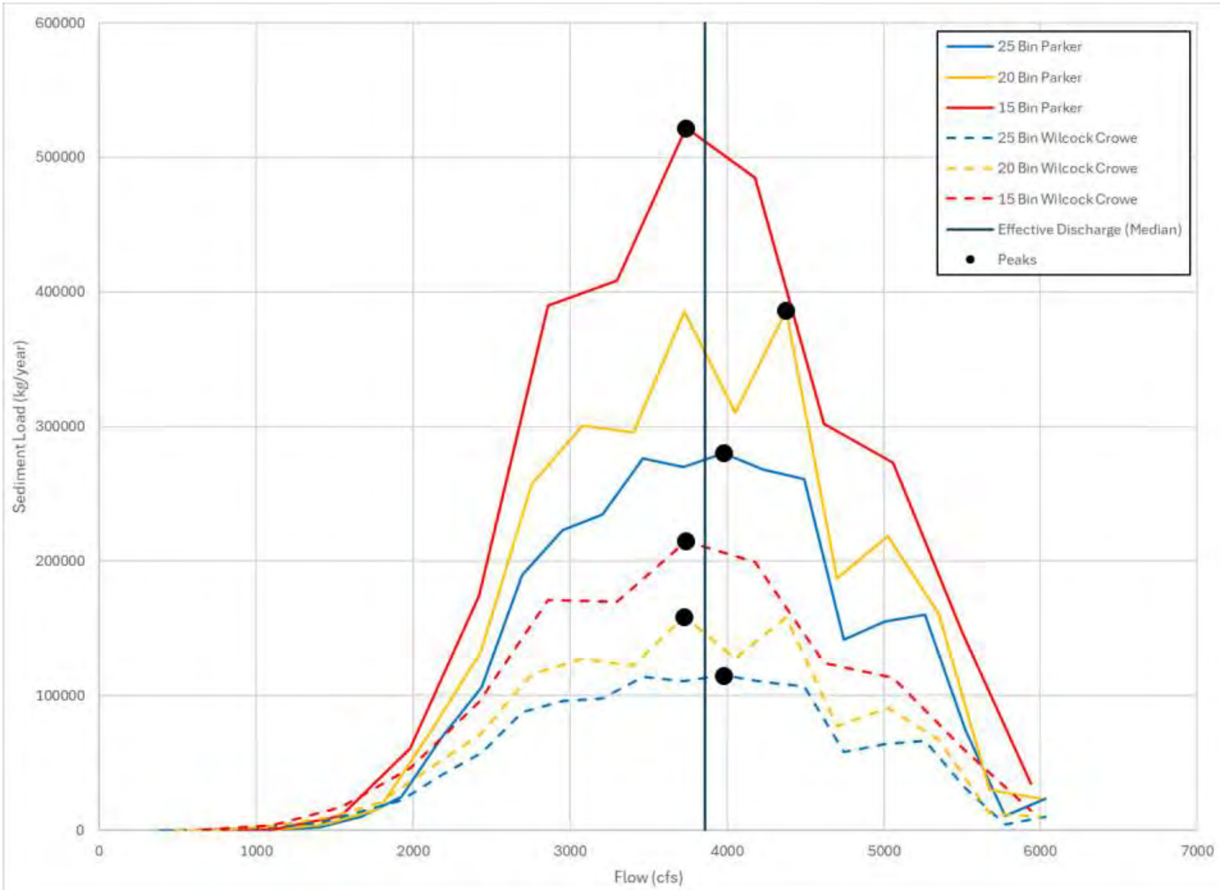

Figure 7: Graphical Results of Effective Discharge Analysis

Table 4: Summary of Effective Discharge Analysis

		Effective Discharge (cfs)	Sediment Load (kg/year)
Parker	25 Bin	3,979	280,252
	20 Bin	4,378	386,071
	15 Bin	3,741	522,025
Wilcock Crowe	25 Bin	3,979	115,237
	20 Bin	3,729	158,757
	15 Bin	3,741	214,859
Mean		3,924	
Median		3,860	
Median (round)		3,900	

An additional data point exists to corroborate the effective discharge analysis. Andrews, 1980 calculated an effective discharge of 6,074 cfs at the Yampa River downstream of the Duquette Diversion near the Hayden stream gage (USGS 09244300). Scaling this number down for basin area (from 1,429 square miles to 612 square miles) yields an effective discharge value of 3,531 cfs. Although basin scaling is best applied between basins with area ratios between 0.5 and 1.5 (Hayden to Steamboat is 2.3), the calculated effective discharge aligns with Andrews (1980); therefore, a rounded median of 3,900 cfs was utilized to represent the effective discharge for subsequent hydraulic modeling (described in Section 5).

In some cases, the 2-year recurrence flow event is also used to represent the channel forming flow, although it is considered less rigorous than effective discharge calculations. For comparison purposes, the 2-year flow at the project area was estimated to be approximately 3,700 cfs using the Bulletin 17C methodology (calculated in HEC-SSP using annual peak flow data from the Yampa at Steamboat gage; England, et al., 2018; HEC 2023) and scaled up to the basin area (with a scaling factor of 0.64 as explained in Section 3.1). The calculated effective discharge is slightly greater than the estimated 2-year flow event which further supports the effective discharge analysis results.

3.4. Design discharges

The discharges summarized in Table 5 were identified for utilization in the hydraulic design based on the hydrologic analysis (described in the subsequent sections) and discussion with CAA. Particular focus was put on the lowest discharges in the design process.

Table 5: Design Discharges for Hydraulic Design of Diversion Crest

Discharge (cfs)	Probability of Exceedance	Note
18.5	99.9%	Diversion Decree
25	99.8%	Maximum diversion recorded
50	98.8%	
100	74%	Representative Low Flow
300	27%	
750	18%	
1500	10%	90th Percentile Flow
2300	5%	Mean Annual High Flow
3800	1%	Effective Discharge

Notes:

- Probability of exceedance is the likelihood that a given flow will be equal or exceeded.
- Percentile indicates the percentage of measured flows that fall below a specific value.
- A 10% exceedance flow means there is a 10% chance the flow will be exceeded; likewise, the 90th percentile flow means 90% of measured flows are lower than this value.

The larger peak discharges utilized for the floodplain analysis were adopted from the FEMA Flood Insurance Study (FIS) report (FEMA, 2005) for the location described as ‘Yampa River near Steamboat Springs at the downstream limit of City of Steamboat Springs’ as summarized in Table 6.

Table 6: FIS Peak Discharges for Floodplain Analysis

Return Period	Peak Discharge (cfs)
10-yr	7,000
50-yr	8,450
100-yr	9,020
500-yr	10,220

4. Concept Summary and Design Criteria

During Phase 1 of the project, a concept alternative was identified to progress into a 30% design with additional hydraulic analysis. The alternative features a grouted boulder grade control utilizing a concrete cutoff wall at the crest, with grouted boulders placed upstream and downstream of the crest and a 10% downstream slope of the grouted boulders. The alternative also includes a sluice gate on river right to facilitate sediment management in front of the headgate. The cut off wall and grouted boulders would be anchored into the shale bedrock to ensure stability.

The headgate will be replaced with a new structure that is integral to the sluice gate and grade control structure. The concept identified the new headgate as two Waterman C-10 gates that control flow into the canal, similar to the existing configuration. However, after review and discussion with the client, a single 4x4 concrete box culvert with an overshot gate was evaluated as the new headgate in the hydraulic design. The overshot gate will allow water to be taken from the top of the water column during high flows, limiting the amount of bed load sediment that could be entrained into the canal. The overshot gate will remain completely flat during low flow operations, and therefore was not included in the hydraulic design, but additional details regarding the intake structure will be furthered in the next design phase.

Aside from the diversion infrastructure, the proposed project also includes localized bank grading within the larger project reach to improve stability and reconnect the floodplain. Large wood and boulder vanes are proposed along the river bank for stabilization, directing flow toward the headgate, and enhancing aquatic habitat. The large wood will be stabilized using ballast (e.g., buried in alluvium and boulders) and the vanes will be tied into bedrock to ensure stability. Riparian plantings (willow stakes, riparian, and wetland trees and shrubs) are proposed to support a healthy riparian corridor. The bank grading, large wood, and boulder vanes were not included in the Phase 2 hydraulic design but will be furthered in future design phases. There are also opportunities for additional floodplain and habitat improvements throughout the reach which will be identified and considered in future design phases.

Grading within the floodplain will most likely be necessary to achieve a no-rise condition for the 100-year flood Base Flood Elevation (BFE) as part of floodplain permitting. Floodplain grading is proposed in the adjacent pasture on river left, and the concept design identified and approximately 200-ft-wide by 500-ft-long floodplain area to be lowered between 1 and 3 ft. This grading also has the added benefit of lowering the root zone of the pasture closer to the groundwater table, which should improve sub-irrigation. The 1D hydraulic analysis was completed to evaluate if the proposed diversion structure causes a rise in the 100-year BFE and if floodplain grading can improve any rises that are identified.

This Phase 2 hydraulic design effort focused on advancing the design of the diversion structure crest elevation and shape over a range of flow conditions to meet design criteria using a 2D hydraulic model. Defining these components validates the viability of the concept, and allows for more accurate cost estimation of the proposed design, as well as an understanding of the floodplain impacts for future permitting. The 2D hydraulic analysis of the proposed conditions is also utilized to qualitatively evaluate sediment transport between the existing and proposed conditions to determine if modifications can be made that improve sediment transport around the design features.

Design criteria were determined in coordination with the client based on the results of the hydrology assessment and identification of needs for fish passage and recreational river use (Table 7).

Table 7: Phase 2 Yampa River Duquette Diversion Improvements Design Criteria

Objective	Hydraulic Design Criteria
Ensure reliable water delivery to water users and upstream infiltration gallery	Fully divert the diversion decree (18.54 cfs) at 18.54 cfs river flow.
	Divert the maximum diversion recorded (25 cfs) at 30 cfs and higher flows.
Maintain or enhance aquatic and riparian habitat	Maintain passage for larger-bodied fish species (e.g., trout) by providing minimum low flow depth of 0.5 to1 ft and maximum velocity of 3 to 4 cfs through the structure at all flow conditions.
Support a multi-benefit, stakeholder driven solution	Maintain navigable boat passage at flows as low as 200 cfs, by providing a designated notch with a minimum clear width of 8 ft and a minimum flow depth of 1 ft.
	Maintain tuber passage at flows as low as 100 cfs by providing a passage zone with a minimum clear width of 3 ft and minimum depth of 0.5 ft.

5. Hydraulic and Sediment Transport Analyses

5.1. 2D Hydraulic Modeling

A 2D hydraulic model was prepared to further the hydraulic design of the diversion structure crest, including determination of the crest height and shape to achieve the design criteria summarized in Section 4.

5.1.1. Existing Conditions Model Development

The 2D hydraulic model was developed for the project site using Hydraulic Engineering Center's River Analysis Software (HEC-RAS) version 6.3.1. Unlike 1D hydraulic models, 2D hydraulic models compute spatial variations in water surface elevation (WSE), velocity, and momentum across the channel. This approach captures not only the downstream hydraulics, but also the transverse patterns that influence flow distribution. Such detail is essential when evaluating complex flow patterns including multiple flow paths and localized hydraulic conditions created by diversion structures within the river channel. For this project, 2D modeling provides critical insight into the design of the Duquette Diversion structure and routing of flow into the ditch.

The topographic data outlined in Section 2.2 was utilized in the development of the 2D hydraulic model. A 2D model mesh was created to capture the topography defined in the digital surface terrain model and to delineate the model boundaries (Figure 8). Breaklines and spacing of mesh elements were defined to capture significant grade breaks and features in the terrain. The mesh was used in the model to calculate flow characteristics throughout the model domain. Figure 9 shows a close-up view of the mesh elements in the vicinity of the Duquette Ditch and demonstrates the use of cell size refinement to achieve accurate results.

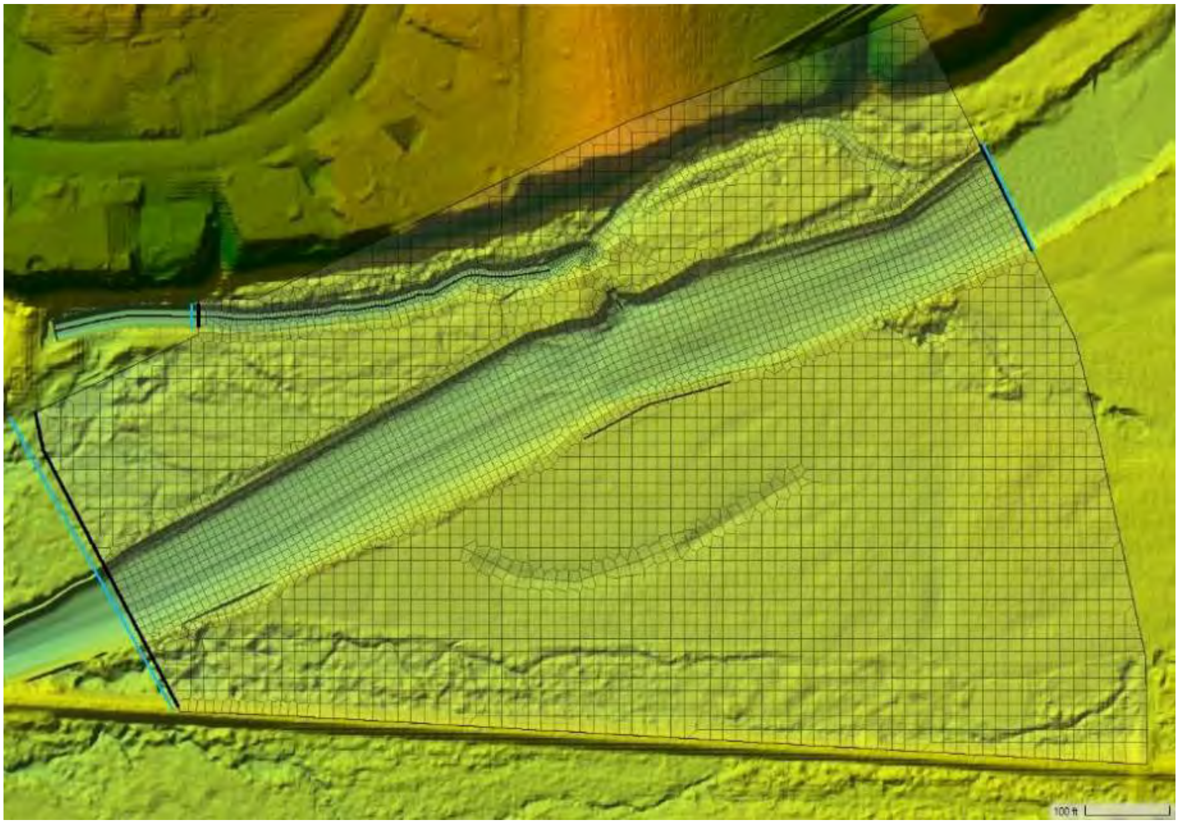

Figure 8: Extents of the 2D Model Mesh

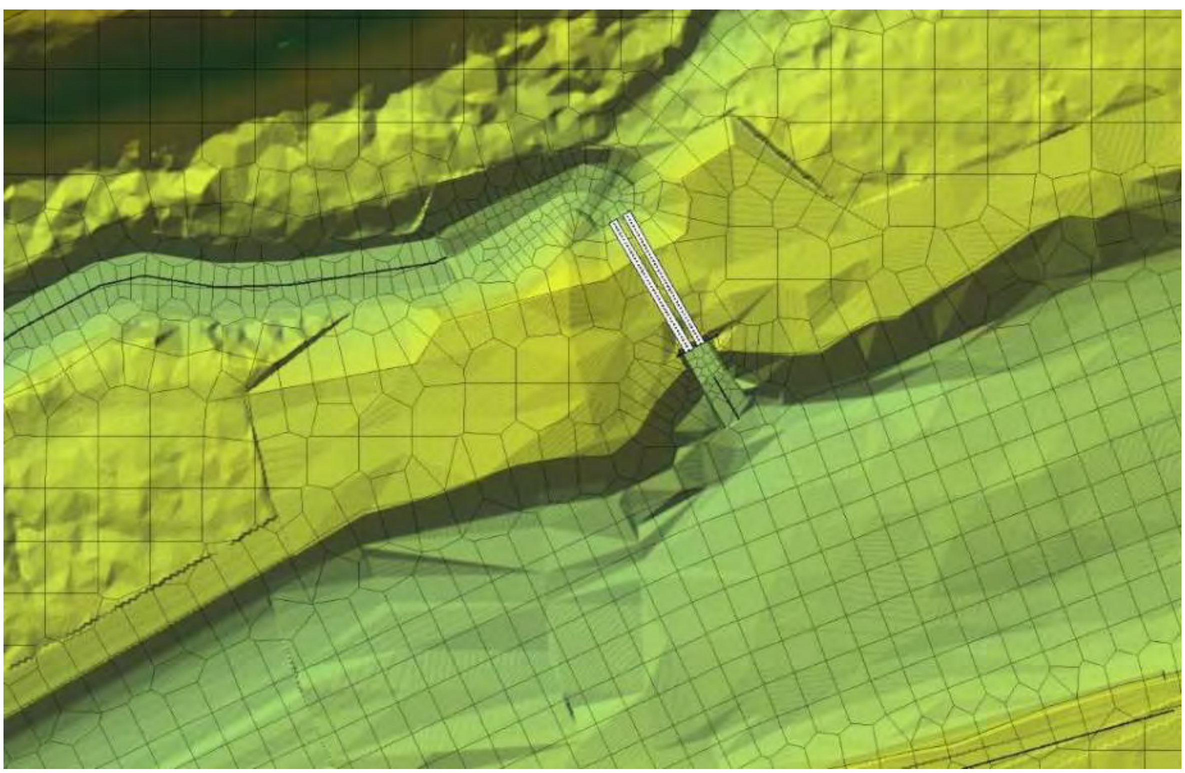

Figure 9: Close-up View of the 2D Model Mesh Surrounding the Existing Duquette Ditch Diversion Structure

Terrain modification tools were used in several regions of the existing surface to eliminate survey artifacts and refine the bottom and sides of the diversion ditch. The Channel Burn tool in HEC-RAS was used at the inlet of the culverts leading into the ditch, and along the un-surveyed length of the ditch itself, to better define the thalweg in these areas and match conditions observed in the field. Along the south bank of the main channel, just opposite of the ditch inlet, the High Ground tool was used to fill in a seam between the survey and LiDAR surface (Figure 10). The existing culvert that connects the main channel to the ditch is a dual 30" CMP barrel structure that features a slight adverse slope into the ditch. They are controlled by Waterman head gates on the upstream end.

Hydraulic roughness in the 2D model is represented by Manning's n roughness coefficients, which are defined spatially in hydraulic roughness areas. Within the model boundary, estimates of Manning's n value were defined based on aerial imagery and site photos, hydraulic modeling experience, and cross referenced using standard published Manning's n values (Chow, 1959, Barnes, 1967). The roughness zones and Manning's n roughness values used in the hydraulic model are illustrated in Figure 11.

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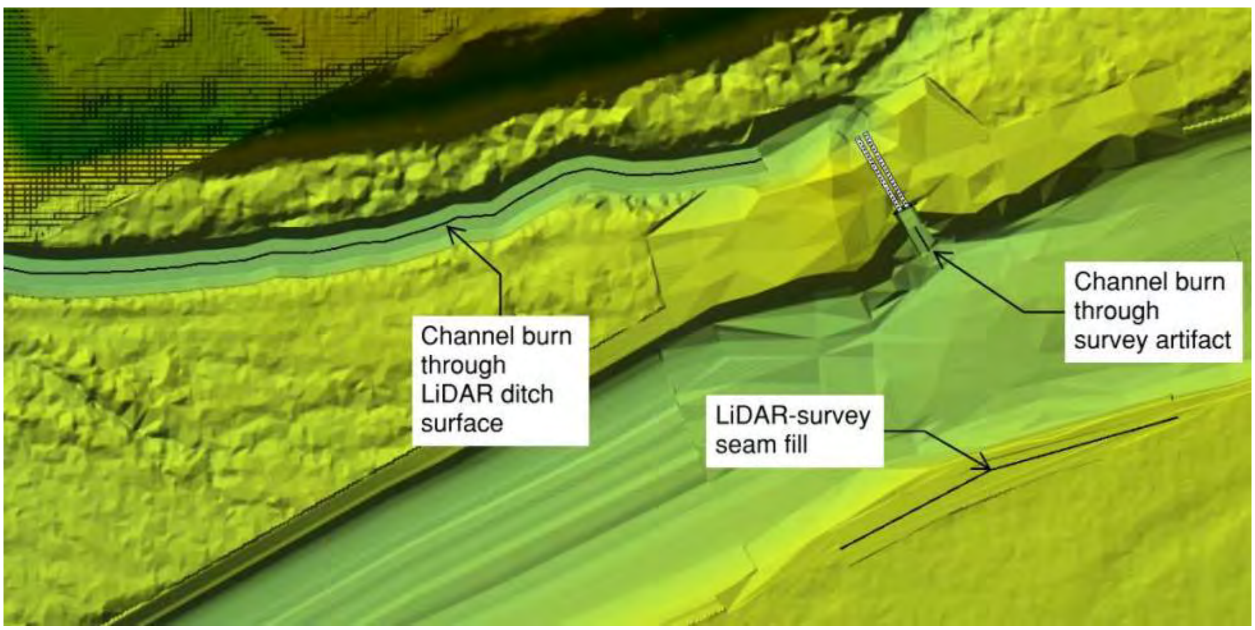


Figure 10: Terrain Modifications

Figure 11: Manning's n Roughness Zones and Values for the Existing Conditions 2D Model

5.1.2. Proposed Conditions Model Development

The existing conditions 2D hydraulic model was modified to incorporate the proposed design of the Duquette Ditch diversion structure. An iterative process was used to evaluate different crest configurations to balance the two design objectives: providing sufficient flow to the ditch and maintaining adequate water depth over structure for recreational use and fish passage.

The proposed diversion structure design is represented in the 2D model by a channel-spanning, smooth-crested weir with a mid-section perpendicular to flow and two sloped sections extending towards the bank at approximately a 30-degree angle to the direction of flow (Appendix A). The angled sections of the structure tie-in to the bank on river left, and a sediment sluice channel bisects the river-right section at the right bank.

Figure 12 shows the cross-sectional shape of the diversion structure crest. The lowest elevation is in the center of the crest, which includes two notches to facilitate low flow, recreational and fish passage, and the angled sections of the structure slope upwards towards the banks of the river. The elevation and dimensions of the notches were adjusted iteratively to achieve the design objectives. In addition, the proposed design iterations also evaluated the slope and roughness of the downstream face of the structure. For each iteration of the proposed crest, the steps outlined below were completed to update the 2D proposed conditions model to reflect the recent iteration of the design. Results of these model iterations are provided in Section 0.

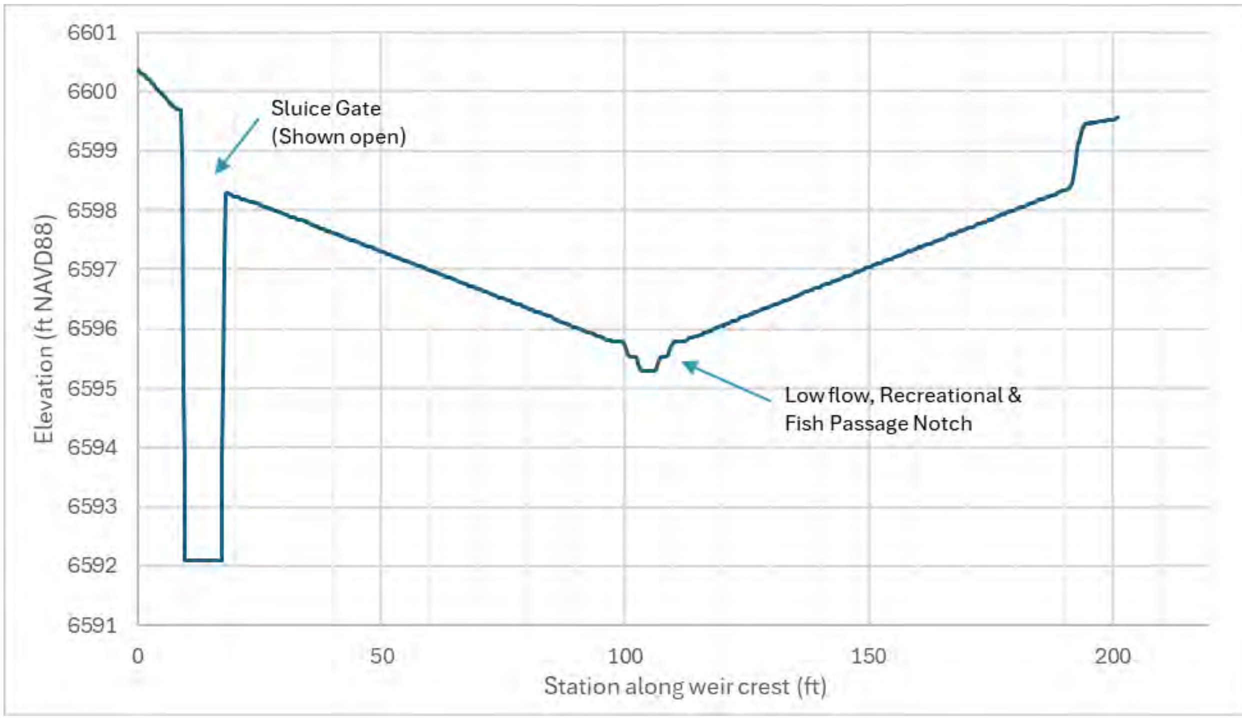


Figure 12: Cross-sectional View of Proposed Weir Crest Looking Upstream

Proposed conditions modifications included the following:

- A design surface reflecting the proposed diversion structure and sluice channel was overlayed onto the composite LiDAR-survey surface utilized in the existing conditions 2D hydraulic model (Figure 13). The projection and vertical datum were maintained from existing conditions.
- Breaklines were updated to represent the proposed terrain.
- Manning's n roughness zones were updated as described above to reflect the hydraulic roughness characteristics of the diversion structure. Figure 14 shows the changes that were made to the defined hydraulic roughness areas, and the updated Manning's n values that were utilized.
- The existing dual-barrel culvert that connects the ditch to the main channel was also replaced in the proposed conditions model, with a 4x4' concrete box culvert with a 0.2% slope, matching the inlet invert elevation of the existing culverts. An overshot gate will be included at the inlet to the ditch to control water and bedload into the channel, however for this analysis the gate is assumed to be open and is not included in the model.
- The sluice gate in the diversion crest on river right was modeled as a 1D/2D Connection so that the weir elevation could be used to represent the gate as open or closed. For all model runs besides the sediment transport analyses, the gate was modeled as closed.

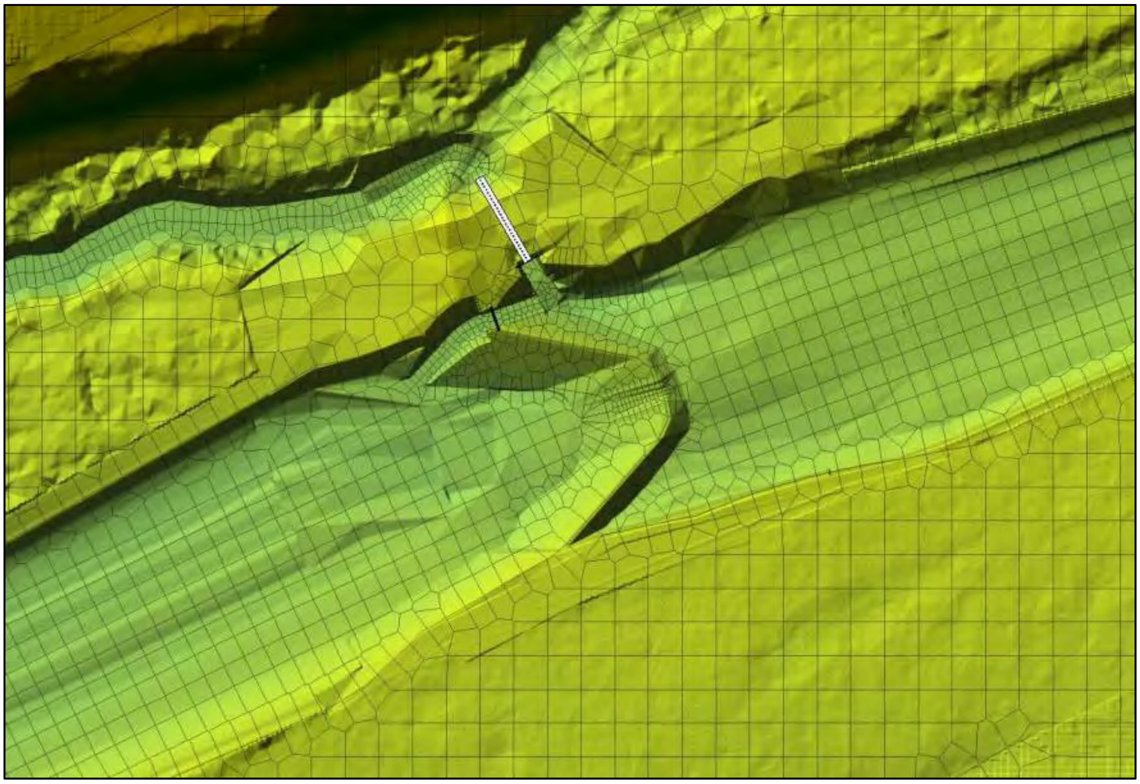
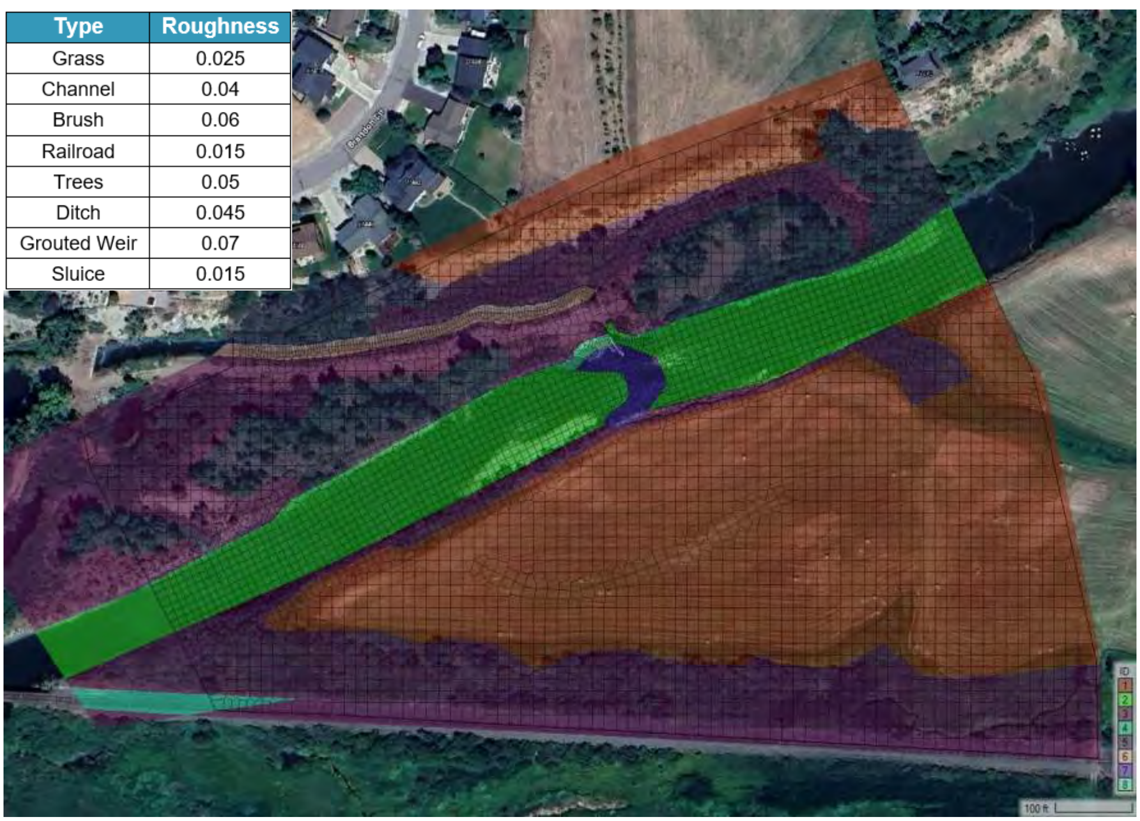


Figure 13: Close-up View of the 2D Model Mesh Surrounding the Proposed Whitney Ditch Diversion Structure



Type	Roughness
Grass	0.025
Channel	0.04
Brush	0.06
Railroad	0.015
Trees	0.05
Ditch	0.045
Grouted Weir	0.07
Sluice	0.015

Figure 14: Manning's n Roughness Zones and Values for the Proposed Conditions 2D Model

5.1.3. 2D Model Results

Results from the 2D hydraulic model developed during the iterative design process were used to assess whether the proposed diversion structure meets the design criteria (outlined in Section 4) and guides subsequent refinements to the crest geometry. Key outputs evaluated included water depth over the crest of the weir, velocity along the downstream face of the structure, and amount of flow directed into the ditch. These metrics were assessed primarily at discharges of 30, 50, and 100 cfs. An additional low-flow discharge of 18.5 cfs (corresponding to the ditch user's decreed water right) was incorporated into the final model run to confirm that the ditch can effectively sweep the river at very low flows. Appendix B includes a table summarizing each 2D model iteration and the resulting hydraulic results.

Initial iterations of the proposed design focused on an appropriate overall crest elevation without incorporation of a notch. Through this process, a crest elevation of 6595.78 ft at the center of the structure was determined to be suitable. Subsequent iterations introduced notch configurations to meet recreational and fish passage objectives. All but the final iteration used a single trapezoidal notch (6-ft wide) with invert elevations ranging from 0.1 to 1 ft above the crest of the weir. A model simulation was completed for each notch depth. These results demonstrated that the single-notch configuration could not reliably achieve the required diversion flows while also maintaining adequate passage conditions for recreation and fish.

After identifying the notch dimensions, additional iterations focused on reducing high velocities along the downstream face of the structure. The initial configuration, with a 4:1 downstream face slope and Manning's n of 0.06, produced velocities up to 12 ft/s at a relatively common summer flow of 300 cfs (27% probability of exceedance), which is too high for fish passage. To address this, roughness values n=0.06, 0.07, 0.08, and 0.09 were tested to represent varying degrees of surface roughness achievable with different boulder sizes and construction finishes. Increasing roughness reduced the peak velocity at 300 cfs to approximately 8.5 ft/s, but remained above acceptable thresholds for fish passage. The final design incorporates a roughness of 0.07, and a significantly flatter downstream face slope of 20:1 within the notch (with steeper slopes elsewhere), resulting in a reduced peak velocity of approximately 7.5 ft/s. Although this represents a marked improvement, it is still likely too high to fully support fish passage, indicating that further design refinement will be needed in future project phases. Further evaluation should also consider if a roughness of 0.07 or similar is achievable without creating a hazardous condition for recreational passage due to protruding rocks.

The final crest configuration (shown in Appendix A) utilized a double-notch design consisting of a 8-ft-wide bottom width primary notch (10-ft-wide top width, 0.25 ft deep), with a 3-ft-wide bottom width secondary notch inset (5-ft-wide top width) and additional 0.25 ft deep. The larger notch accommodates recreational boat passage during higher flows, while the smaller notch maintains tuber passage into lower flow ranges. Figure 16 shows the final configuration of the diversion structure design at 18.5 cfs (full sweep) and 30 cfs (partial sweep). Appendix B shows velocity and depth results from the final configuration across all modeled discharges.

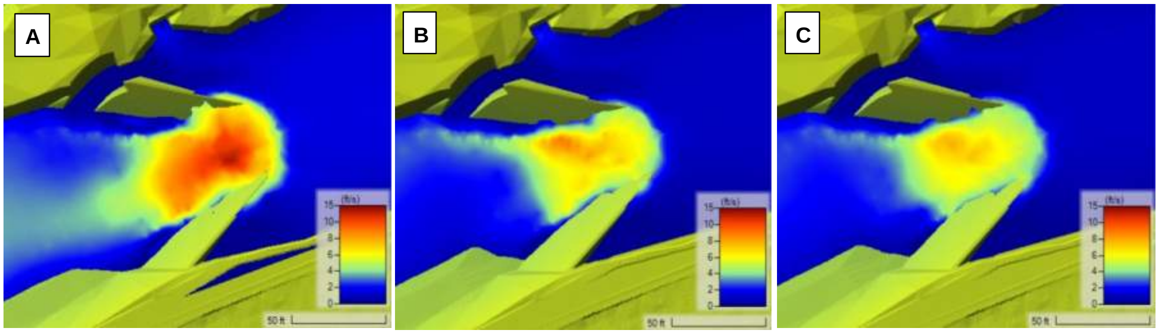


Figure 15: Velocity at the Proposed Diversion Structure for (A) Face Slope of 4:1 with Roughness of 0.06, (B) Face Slope of 4:1 With Roughness of 0.08, and (C) Face Slope of 20:1 with Roughness of 0.07 (Final Iteration)

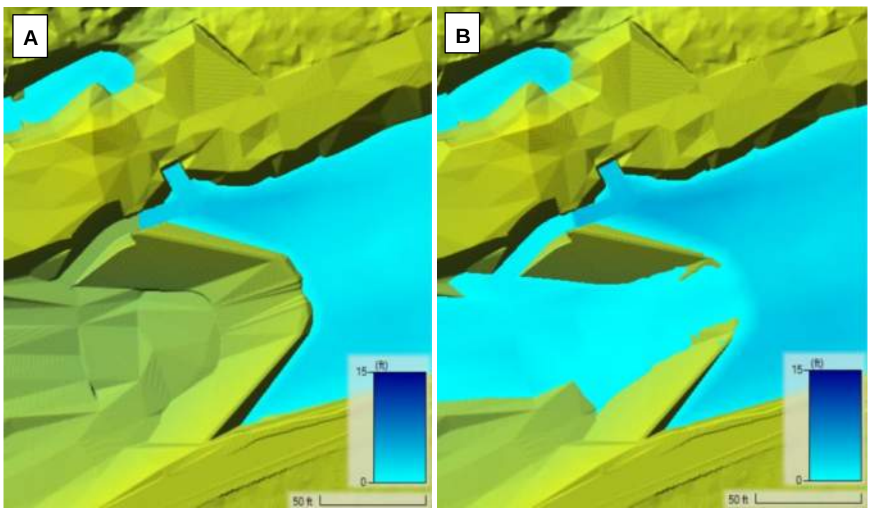


Figure 16: 2D Model Results for the Final Diversion Structure Configuration with (A) Full Sweep of the River at 18.5 cfs, and (B) Partial Sweep of the River at 30 cfs

5.2. 1D Hydraulic Modeling

Floodplain permitting will be necessary prior to construction of this project. The project area is located within a FEMA Special Flood Hazard Area Zone AE (Figure 17); panel 08107C0694D effective 2/4/2005. Otak contacted the Routt County floodplain administrator who confirmed that the effective model is a HEC-3 format, and is likely no longer available. To obtain a floodplain development permit, a project must either demonstrate compliance with no-rise requirements by not increasing the base flood elevation (BFE) in the project locations during the occurrence of a 1%-annual chance flood (100-year flood), or by preparing a Conditional Letter of Map Revision (CLOMR). This phase of the project evaluated if the proposed diversion structure is likely to meet a ‘no rise’ condition and if additional pasture lowering to the south improves the ‘no rise' condition.

5.2.1. Existing Conditions Model

To evaluate whether the proposed design can feasibly meet the ‘no rise’ requirements, 1D HEC-RAS models were developed for both existing and proposed conditions. The effective regulatory model was developed using HEC-3 and the Routt County Floodplain Administrator communicated that it is no longer available, and therefore could not serve as the basis for the model development. Instead, a new HEC-RAS Version 6.3 model (USACE, 2025) was developed using the project topography described in Section 2.2.

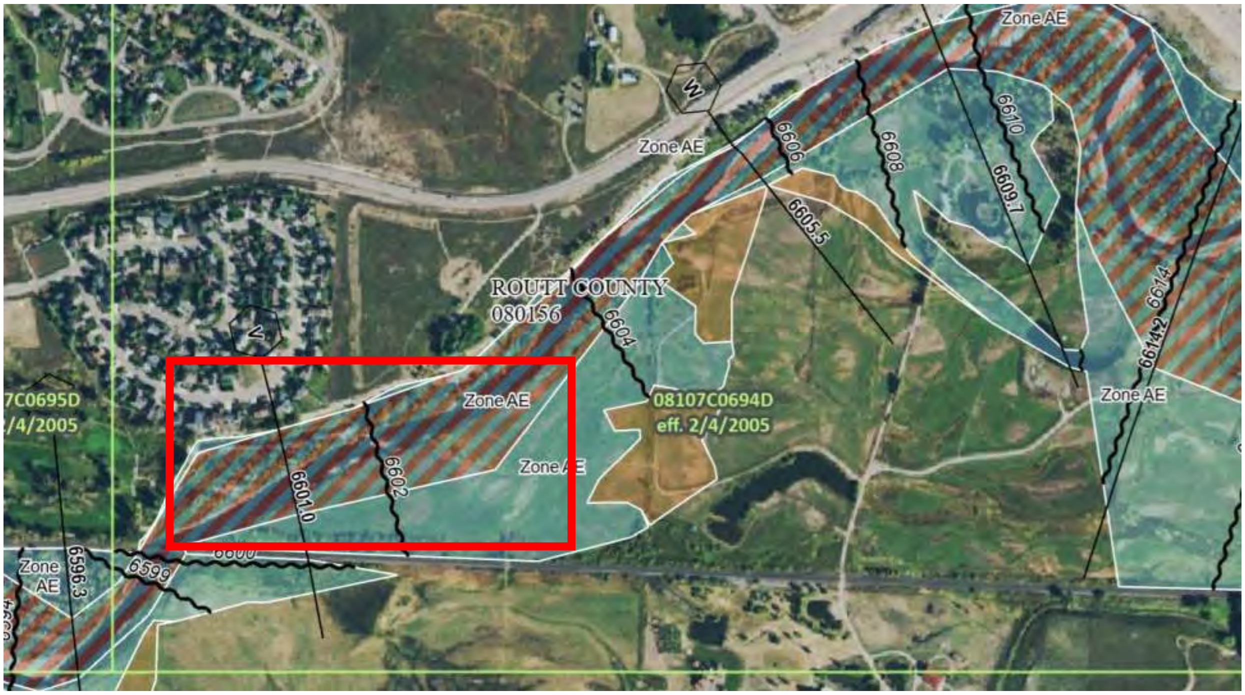


Figure 17: FEMA National Flood Hazard Layer Viewer at the Project Area (red box)

The existing conditions 1D model extends from just upstream of the Union Pacific railroad bridge west of Steamboat Springs, to approximately 4,170 ft upstream (Figure 18). Considering no survey data are available for the reach downstream of the railroad bridge, including the bridge structure itself, these features could not be incorporated into the model. Instead, the downstream boundary condition was defined using the water surface elevation at the upstream face of the railroad bridge, as shown in the FIS profiles for each discharge (FEMA, 2005). This approach captures the backwater influence of the railroad bridge and supports consistency between the model and the effective floodplain analysis.

The existing conditions model includes 14 cross sections. The geometry of cross sections 498 through 1601 is based on the topographic model described in Section 2.2. Cross sections 1900 through 4166 are outside of the bathymetric survey extents and are therefore based solely on the 2016 LiDAR. Manning's n values were assigned based on aerial imagery and assigned to match the values chosen in then 2D hydraulic analysis.

The southern edge of the floodplain is constrained by the Union Pacific railroad embankment from Cross Sections 498 through 1900, and narrows considerably as it approaches the railroad bridge acting as the downstream model boundary. Ineffective flow areas were used on river left from Cross Section 498 through 1601 to account for the portion of the floodplain adjacent to the embankment that does not convey water in due to the constriction in the floodplain created by the embankment (Figure 19).

As summarized in Section 3.4, discharges utilized for the floodplain analysis (Table **6**) were adopted from the FEMA FIS (FEMA, 2005) for the location described as 'Yampa River near Steamboat Springs at the downstream limit of City of Steamboat Springs'.

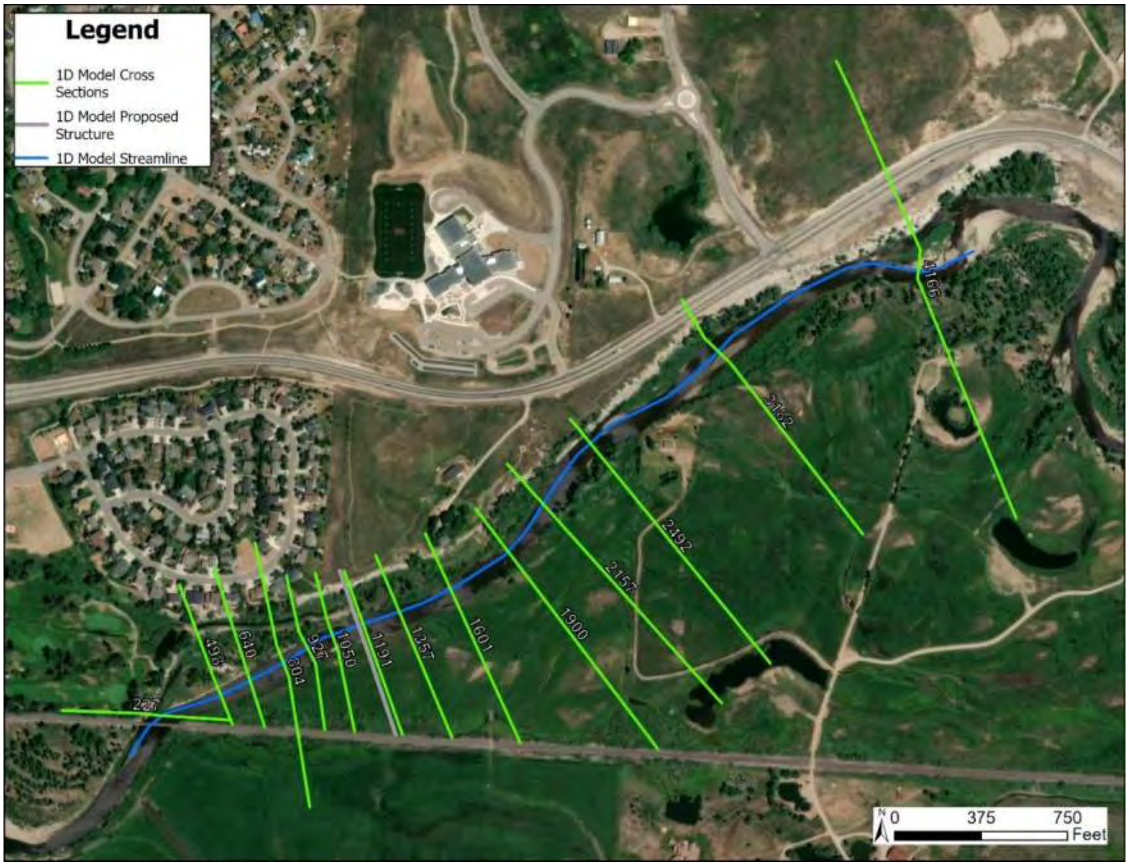


Figure 18: Existing Conditions 1D Model Extents

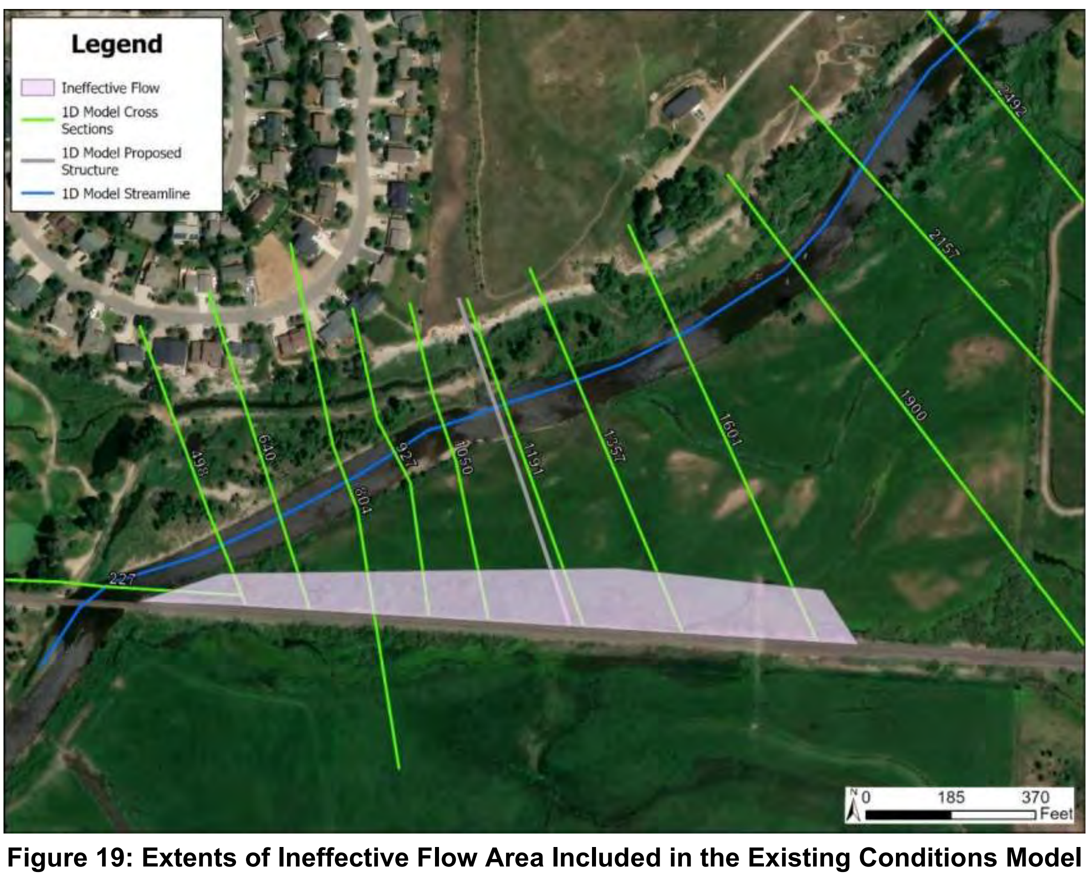


Figure 19: Extents of Ineffective Flow Area Included in the Existing Conditions Model

5.2.2. Proposed Conditions Analysis

The existing conditions model was used as a basis for the proposed conditions 1D hydraulic model. An inline structure was implemented at station 1170 to represent the proposed weir. The weir profile was manually entered, matching the elevations and profile of the proposed structure. While the lengths of weir connecting the low flow notch to the banks are angled downstream, in this analysis these portions of the structure are modeled perpendicular to flow. The sluice gate is also assumed to be closed during flood conditions; therefore, not included in the modeled weir profile.

Water surface elevation comparison results in Table 8Table 8 show the impact of the proposed Duquette Diversion on the 100-yr floodplain WSEs. The proposed project results in a decrease in WSE upstream of the structure, but a slight increase in WSE at one cross section downstream of the structure. The results also show that the WSEs converge within 500 ft upstream of the diversion structure, which informs the necessary extent for future additional survey data collection. Given the previous survey extends only 140 ft upstream of the diversion structure, and the effective regulatory model is not available, additional survey outside of the project area is necessary to show the extents of the impacts to the floodplain from the proposed project.

Table 8: Yampa River at Duquette Diversion Water Surface Elevation Comparison

River Station	WSE (feet)		Difference in WSE (feet)
	Existing Conditions (Ex.)	Proposed Conditions (Prop.)	Prop. – Ex.
4166	6609.84	6609.84	0
3182	6607.03	6607.03	0
2492	6605.28	6605.28	0
2157	6604.28	6604.28	0
1900	6602.92	6602.92	0
1601	6602.21	6602.18	-0.03
1357	6601.74	6601.68	-0.06
1191	6601.31	6601.21	-0.1
1170	Proposed Duquette Diversion - Inline Structure		
1050	6601.15	6601.18	0.03
927	6600.85	6600.85	0
804	6600.51	6600.51	0
640	6600.21	6600.21	0
498	6600.1	6600.1	0
227	6600	6600	0

A second iteration of the proposed conditions model was completed to evaluate the effect of lowering the adjacent river-left pasture on the 100-yr water surface elevations and the overall ‘no rise’ condition. In this scenario, the full width of the pasture between cross sections 804 and 1357 (approximately 700 ft length) was lowered by 1.5 to 2.5 ft, to an approximate elevation of 6597 ft. The resulting water surface elevations are shown in Table 9. Comparison of existing and proposed WSE indicates that the pasture lowering does not reduce the rise downstream of the diversion structure and generates additional rises at several cross sections both upstream and downstream. Further refinement of the proposed design within the 1D hydraulic model will be necessary in subsequent project phases to identify a configuration that meets the 'no rise' requirement; otherwise a pre-project CLOMR will be necessary.

Table 9: Yampa River at Duquette Diversion Water Surface Elevation Comparison with Pasture Lowering

River Station	WSE (feet)		Difference in WSE (feet)
	Existing Conditions (Ex.)	Proposed Conditions (Prop.)	Prop. – Ex.
4166	6609.84	6609.84	0
3182	6607.03	6607.03	0
2492	6605.28	6605.28	0
2157	6604.28	6604.29	0.01
1900	6602.92	6602.92	0
1601	6602.21	6601.34	-0.87
1357	6601.74	6601.51	-0.23
1191	6601.31	6601.33	0.02
1170	Proposed Duquette Diversion - Inline Structure		
1050	6601.15	6601.21	0.06
927	6600.85	6600.95	0.1
804	6600.51	6600.66	0.15
640	6600.21	6600.21	0
498	6600.1	6600.1	0
227	6600	6600	0

5.3. Incipient Motion Analysis

A high-level sediment transport analysis was completed to assess how the proposed project alters existing sediment dynamics within the reach. Specifically, the Shields parameter was utilized to calculate critical shear, or the shear stress at which a well-graded sediment distribution starts to mobilize for a given particle size. This analysis utilizes the median particle size (D_{50}), or a combination of the median particle size and the 84th percentile particle size (D_{84}). The Shields parameter equation can be simplified to the following equations when the density of sediment and water are assumed to be 165 lb/ft^3 and 62.4 lb/ft^3, respectively:

$$Equation\ 1:\ \tau_c = \tau^*(102.6 * D_{50})$$

$$Equation\ 2:\ \tau_c = \tau^*(102.6 * {D_{84}}^{0.3} * {D_{50}}^{0.7})$$

Where:
τ_c = critical shear stress in lb/ft^2
τ^* = dimensionless Shields parameter
D_{50} = median sediment size in ft
D_{84} = 84th percentile particle size in ft

Utilizing the D_{50} and D_{84} from the pebble count (81.6 mm or 0.27 ft, and 125.6 mm or 0.41 ft), and the appropriate dimensionless Shields parameter (0.052) yields a critical shear stress of 1.63 lb/ft^2 for Equation 1 and 1.43 lb/ft^2 for Equation 2. The average value of 1.53 lb/ft^2 was utilized for this analysis as the threshold for expected sediment movement. In other words, if shear stress in the channel (calculated in the 2D hydraulic model) exceeds 1.53 lb/ft^2, sediment is expected to mobilize, whereas if shear stress is less than 1.53 lb/ft^2, sediment is not expected to mobilize. It should be noted that the HEC-RAS 2D shear outputs are depth-averaged, not grain-resolved; therefore, this analysis does not account for local turbulence and macro-roughness effects at individual boulders.

Figure 20 through Figure 23 show the results of this analysis for existing and proposed conditions, for four flows (750 cfs, 1,500 cfs, 2,300 cfs, and 3,800 cfs), where red represents areas where sediment is not expected to mobilize and green represents areas where sediment is expected to mobilize. The range of flows evaluated in this analysis represent discharges that are anticipated to occur annually or semiannually.

Under existing conditions, the only notable area of expected sediment mobility occurs at the downstream end of the model, just upstream of the railroad bridge. This region is also predicted to be mobile in proposed conditions at similar extents. The results at the downstream extent of hydraulic models are generally considered to be less reliable since they are influenced by the downstream boundary. In this case the terrain is also based on extrapolation of survey data rather than full bathymetric survey and therefore this area of mobility may not represent accurate conditions, and should be considered further in future phases with additional survey.

Within existing conditions, there are no other areas of mobile sediment (green) observed at 750 cfs or 1,500 cfs. At 2,300 cfs a small mobile area is observed in the ditch, due to flow leaving the main channel upstream at an old ditch entrance and flows down into the existing ditch. At 3,800 cfs the mobile sediment areas in the ditch expand, and some minor mobile sediment areas are observed in the main channel.

Within proposed conditions, the quantity of mobile sediment areas is higher than existing conditions for every flow, specifically, on the downstream face of the diversion structure and in the ditch. There are mobile areas in the vicinity of the structure as well as in the ditch starting at 750 cfs, which increase as flow increases. This is because as water spills over the steep face of the grade control structure it concentrates energy and increases shear stress at the structure. The protection provided by the proposed grade control structure (grouted boulders) will prevent undesirable sediment mobility at the structure, and this analysis is helpful in identifying the necessary extents of that protection. Additionally, the backwater caused by the diversion structure crest leads to additional flow entering the ditch via the upstream entrance. This results in larger areas of predicted sediment mobility within the ditch. Future design phases can confirm these results with additional survey and modeling and propose appropriate protection measures. Opportunities to reduce shear stress for a given flow within the ditch and the main channel include adding floodplain lowering to the design, which will help to spread flow and decrease energy within the channel, as well as minimize flow entering the ditch further upstream of the headgate.

Figure 20: Incipient Motion Analysis - 750 cfs

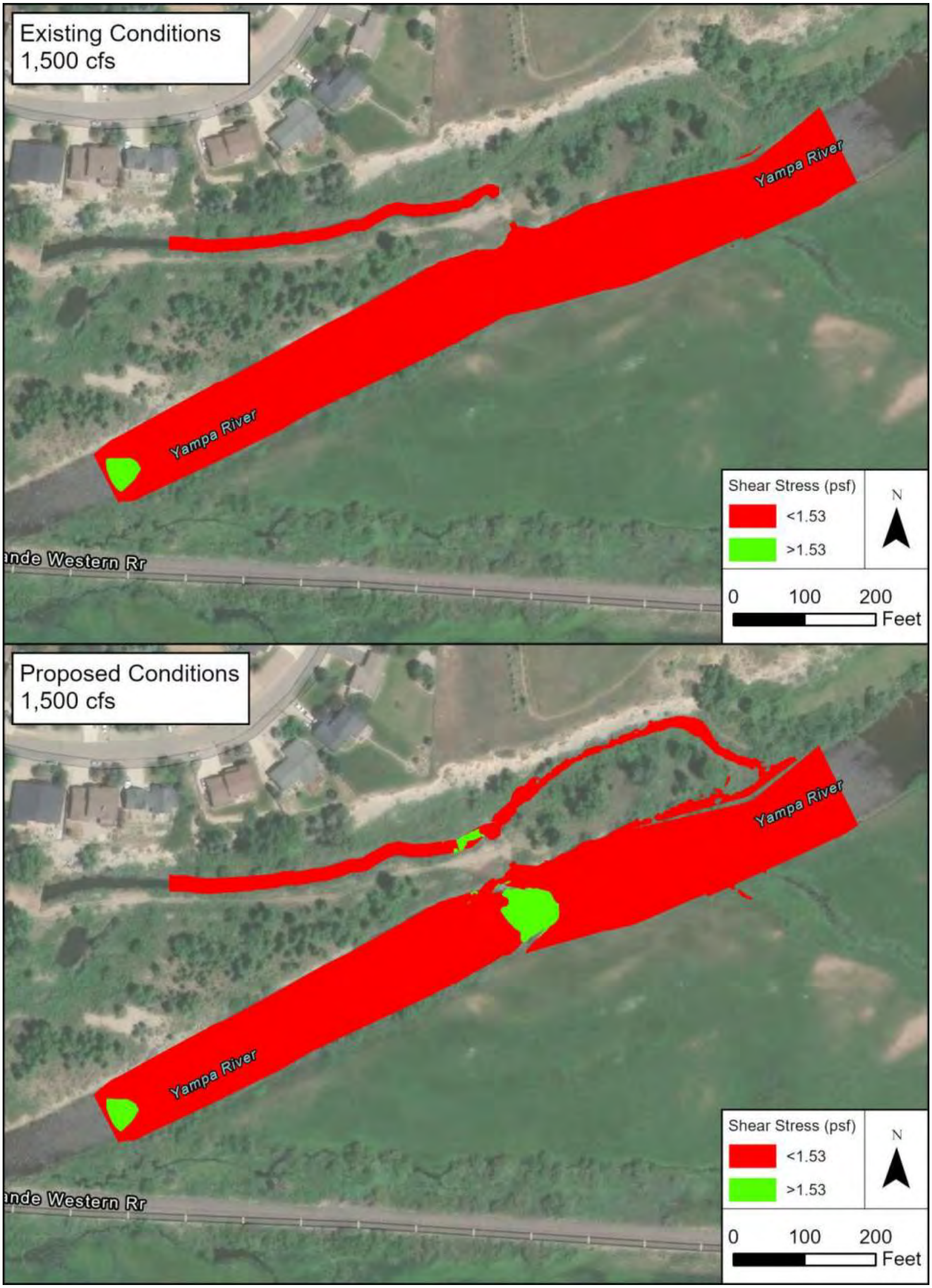


Figure 21: Incipient Motion Analysis - 1,500 cfs

Figure 22: Incipient Motion Analysis - 2,300 cfs

Figure 23: Incipient Motion Analysis - 3,800 cfs

6. Conclusions

The Phase 2 hydraulic design effort advanced the proposed Duquette Ditch diversion structure by refining the crest elevation, geometry, and hydraulic performance using 2D hydraulic modeling. The analysis confirms that the selected grouted-boulder grade control structure—with a double-notch configuration—can meet the project's diversion, recreational use, and low-flow fish passage objectives under the range of design discharges evaluated.

The 2D hydraulic modeling demonstrated that the recommended crest elevation (6595.78 ft at the center of the structure) and final notch configuration effectively diverts the full diversion decree (18.5 cfs), supports partial diversion at higher flows, and maintains sufficient low-flow depths for recreational and fish passage. Iterations of the downstream face geometry and roughness indicate that flatter slopes and increased surface roughness substantially reduce velocities, though additional refinement will be required in later phases to fully satisfy fish passage criteria while maintaining safe recreational conditions.

The 1D floodplain analysis showed that the proposed diversion structure does not increase the 100-year water surface elevation upstream but causes a small rise at one downstream cross section. A subsequent evaluation of river-left pasture lowering did not improve the downstream rise and resulted in additional increases at several upstream and downstream locations. Achieving a no-rise condition will therefore require further refinement of the proposed design or will necessitate preparation of a CLOMR during future phases.

The incipient motion (sediment mobility) analysis predicted increased sediment mobility at the downstream face of the proposed structure and within the existing ditch. These changes are driven by concentrated shear stresses on the downstream slope of the grouted-boulder crest and by additional flow deflected into the right overbank then routed through the ditch during higher discharges. While the proposed grade control structure will provide adequate protection against unwanted scour at the crest itself, the results highlight the need to develop appropriate scour protection at the ditch and potentially integrate floodplain grading concepts to diffuse the upstream overbank flow path that directs flow into the existing ditch from upstream.

Overall, the hydraulic analyses completed in Phase 2 validate the feasibility of the concept design, identify necessary refinements for subsequent design phases, and provide a clear path toward improving diversion performance, recreational safety, and maintaining fish passage.

7. Next Steps and Further Considerations

Advancing the Duquette Ditch diversion structure from concept to 30% design level will require additional data collection, model refinement and analysis, stakeholder engagement, and further development of additional project elements such as floodplain grading and habitat enhancements. The following tasks summarize the recommended next steps for future design phases.

7.1. Additional Data Collection

To support more detailed design, hydraulic model refinement, and floodplain permitting, the following field data collection are recommended:

- <u>Expanded bathymetric and topographic survey</u>: Bathymetric survey beyond the project area is necessary, extending from downstream of the Union Pacific railroad bridge to approximately 1,000 ft upstream of the project area. Survey may be collected using targeted cross sections if full bathymetry is not feasible. Additionally, ground survey of overbank areas where floodplain grading, habitat enhancements, or bank stabilization features may be incorporated.

- Survey of the Union Pacific railroad bridge: including low chord, high chord, railings, abutments, and roadway embankment geometry, to support more accurate hydraulic modeling and floodplain analysis.
- Hydraulic calibration data: including main channel and ditch water surface elevations paired with discharge measurements, to validate the existing conditions 2D hydraulic model.
- Geotechnical assessment: at the diversion structure to characterize bedrock depth and material properties required for structural design.
- Aquatic species assessment: including confirmation of native and non-native species of concern, behavioral swimming thresholds, and life stage requirements to support fish passage and habitat enhancement design, as well as minimize non-native species habitat.
- Floodplain assessment: field assessment of right-bank floodplain conditions to refine opportunities for habitat restoration and validate other design components.
- Wetland delineation: following U.S. Army Corps of Engineers (USACE) protocols to identify jurisdictional wetlands potentially affected by floodplain grading, bank work, or access routes, which will help inform and minimize project impacts and future permitting efforts.
- Cultural resources assessment: Class I and, if necessary, Class III survey to identify any historic or archaeological resources within the project footprint, supporting compliance with Section 106 and local permitting requirements.
- Groundwater assessment: to evaluate groundwater elevations within river-left agricultural fields. This information will support refinement of floodplain grading to both enhance agricultural productivity (via improved sub-irrigation) and promote floodplain flow dispersal during high-water events.

7.2. Stakeholder and Agency Coordination

The next design phase should include targeted coordination with key partners to ensure that the project meets operational, ecological, and permitting needs:

- Colorado Parks and Wildlife (CPW):
  - Confirm target species for fish passage design (native and non-native).
  - Review preliminary fish passage geometry and velocity/depth targets.
  - Discuss opportunities for improved riparian and aquatic habitat.
- Adjacent landowners and ditch users:
  - Clarify operational needs for the headgate and ditch system.
  - Review proposed floodplain grading or access considerations.
- Routt County Floodplain Administrator:
  - Confirm floodplain permitting pathway (no-rise vs. CLOMR).
  - Review updated 1D model geometry in future submittals.
  - Identify documentation needs and timelines for floodplain review.
- U.S. Army Corps of Engineers (USACE)
  - Coordinate early regarding potential Section 404 permitting requirements. If a federal permit is required, USACE will act as the lead federal agency and oversee Section 7 (US Fish and Wildlife Service) and Section 106 (State Historic Preservation Office) consultations.
- Union Pacific Railroad (if required):

- Determine whether coordination is needed based on survey approach, construction methods, or regulatory requirements. (*Coordination may be avoided if no work occurs on railroad property.*)

7.3. Further Design Development

Further refinement of the diversion structure and channel/floodplain enhancement design will be necessary to resolve outstanding performance, fish passage, and floodplain considerations, including:

- Refine fish passage geometry, focusing on downstream face slope and roughness needed to achieve acceptable velocities without creating hazardous protrusions for recreational users.
- Further channel and floodplain enhancement design, including floodplain grading and habitat features, riparian plantings, and in-channel features (e.g., wood or rock vanes), integrating both hydraulic and ecological objectives.
- Update the 2D hydraulic model using additional survey data and model calibration to confirm:
  - Diversion performance, velocity fields, and passage conditions
  - Performance of floodplain grading, bank stabilization features, and treatments to influence hydraulics upstream of railroad bridge (under low-flow, design, and flood conditions).
- Evaluate modifications to floodplain grading, particularly on river left, to:
  - Reduce backwater impacts and support no-rise compliance.
  - Decrease shear stress in the main channel and ditch.
  - Reduce unwanted sediment delivery to the ditch.
- Advance structure design, including:
  - Grouted boulder and concrete crest geometry.
  - Sluice gate configuration.
  - Box culvert design and headgate layout.
  - Sheet pile cutoff wall anchoring into bedrock.
- Update the 1D hydraulic model with refined topography and structure geometry to evaluate potential design adjustments to achieve a no-rise condition. If no-rise cannot be met, initiate CLOMR documentation requirements.
- Development of concept renderings to facilitate stakeholder communication/engagement around the vision of the project.
- Development of 30% design plans and engineer's opinion of probable construction cost for diversion infrastructure and channel/floodplain improvements project to facilitate stakeholder review and for inclusion in future funding applications.

8. References

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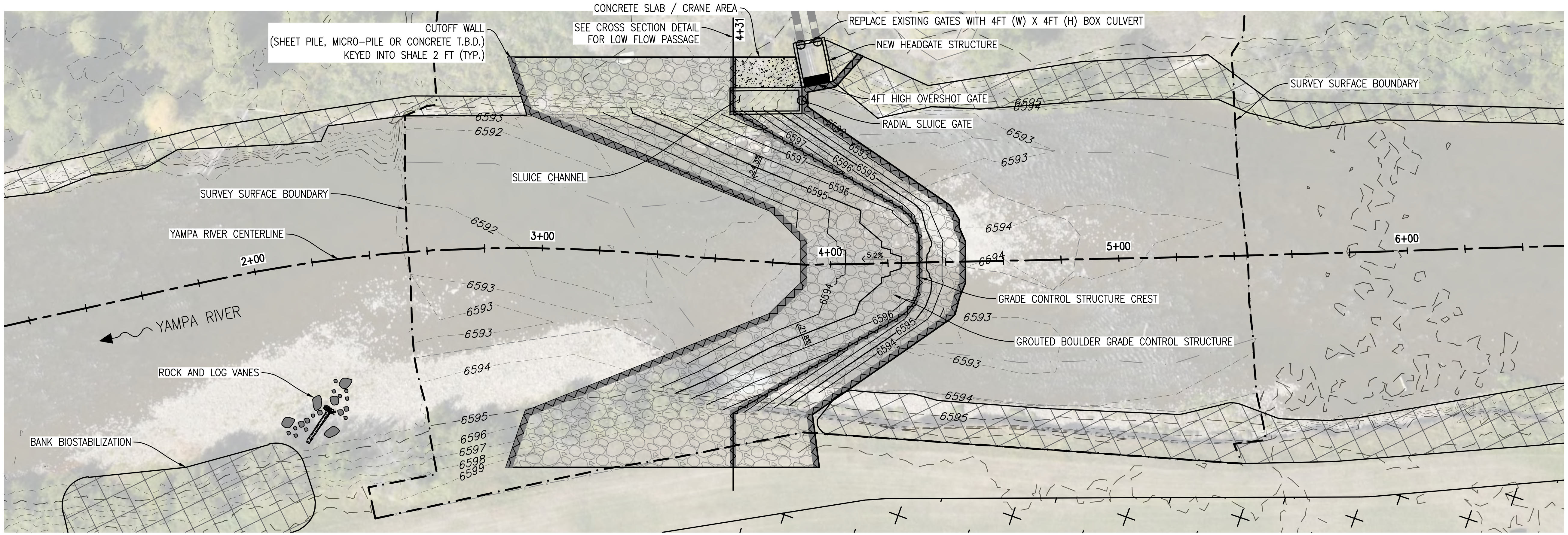
Appendix A

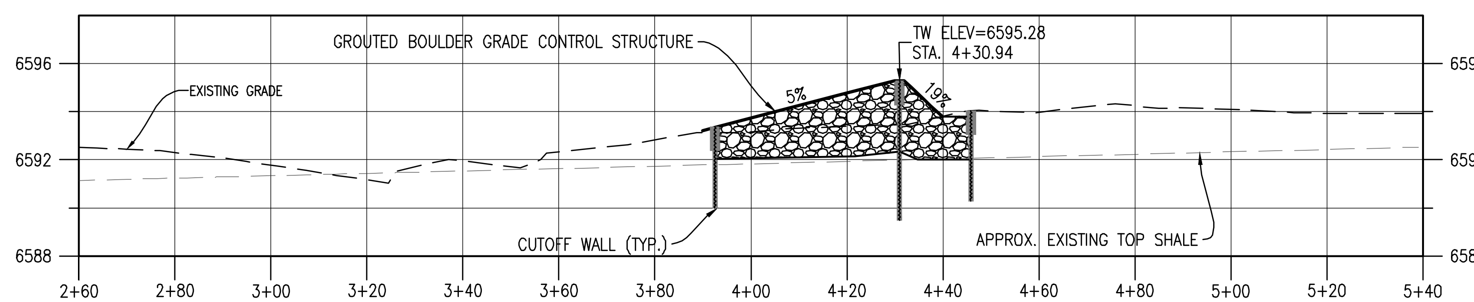
Grouted Boulder Grade Control Structure –

Design Plan, Profile and Section

NOTES:
1. –

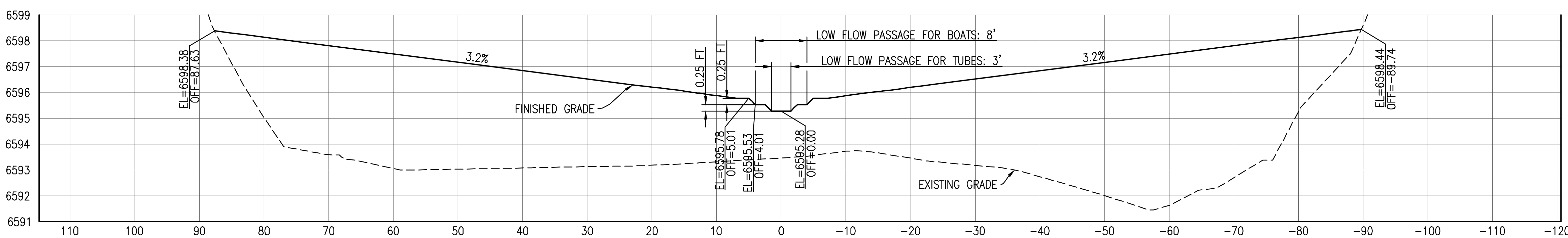


PLAN



PROFILE

(TAKEN ALONG HCL) HORIZ. SCALE 1"=40' VERT. SCALE 1"=2' 5X VERTICAL EXAGGERATION



4+31
SECTION

HORIZ. SCALE 1"=20' VERT. SCALE 1"=2.5' 4X VERTICAL EXAGGERATION VIEW LOOKING DOWNSTREAM

0' 10' 20' 40'
1 INCH = 40' (11 X 17)
1 INCH = 20' (22 X 37)

NOT FOR CONSTRUCTION - 15% DESIGN - MARCH 2026

Print Date: Mar 04, 2026
File Name: 21136-001-P&P Crest Exhibit.dwg
Horiz. Scale: As Noted Vert. Scale: As Noted

Otak

Sheet Revisions		
Date:	Comments	Init.

COMMUNITY · AGRICULTURE · ALLIANCE

No Revisions:
Revised:
Void:

YAMPA RIVER AT DUQUETTE DITCH PHASE 2
GROUTED BOULDER GRADE CONTROL
30% PLAN, PROFILE & SECTION

Designer:	RW	Structure Numbers	
Detailer:	MC2		
Sheet Subset:	P&P	Subset Sheets:	1 of 1

Project No./Code
21136
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Sheet Number C3

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Appendix B

2D Proposed Conditions Hydraulic Model Results

Summary of Results from 2D Model Iterations

Model Configuration	Flow down ditch at 100cfs	Flow down ditch at 50 cfs	Flow down ditch at 30cfs	Flow down ditch at 18.5 cfs	Depth over crest at 100cfs	Depth over crest at 50cfs	Depth over crest at 30cfs	Depth over crest at 18.5cfs
PC iteration 1, 4x4' box, sluice closed, culvert box raised 0.1'	51	41.7	30	Not modeled	0.75	0.41	0	Not modeled
PC iteration 2, 4x4' box, sluice closed, notch side slopes laid back 1'	53	43	30	Not modeled	0.75	0.37	0	Not modeled
PC iteration 3, 4x4' box, sluice closed, lowered weir midsection by 0.5' compared to Iteration 1	18.9	11.9	8.5	Not modeled	1	0.75	0.6	Not modeled
PC iteration 4, 4x4' box, sluice closed, lowered weir midsection by 0.25' compared to Iteration 1	27.2	20	15.5	Not modeled	0.9	0.7	0.55	Not modeled
PC iteration 5, 4x4' box, sluice closed, lowered weir midsection by 0.15' compared to Iteration 1	27.2	20	15.5	Not modeled	0.89	0.67	0.53	Not modeled
PC iteration 6, 4x4' box, sluice closed, lowered weir 0.05' compared to Iteration 1	29.8	22.2	17.5	Not modeled	0.87	0.65	0.5	Not modeled
PC Iteration 7, 4x4' box, sluice closed, lowered weir 0.00' compared to Iteration 1	31.5	23.3	18.5	Not modeled	0.85	0.63	0.47	Not modeled
PC Iteration 7, 4x4' box, sluice closed, lowered weir 0.00' compared to Iteration 1, weir roughness 0.092	35	25	19	Not modeled	0.97	0.71	0.53	Not modeled
PC Iteration 8, 4x4' box, sluice closed, lowered weir 0.00' compared to Iteration 1, weir roughness 0.09, widened notch to 6'	38	27	20.5	Not modeled	0.89	0.62	0.43	Not modeled
PC Iteration 8, 4x4' box, sluice closed, lowered weir 0.00' compared to Iteration 1, weir roughness 0.08, widened notch to 6'	36.6	26.7	20.4	Not modeled	0.86	0.6	0.43	Not modeled
PC Iteration 8, 4x4' box, sluice closed, lowered weir 0.00' compared to Iteration 1, weir roughness 0.07, widened notch to 6'	35.9	26.1	19.9	Not modeled	0.84	0.58	0.41	Not modeled
PC Iteration 8, 4x4' box, sluice closed, lowered weir 0.00' compared to Iteration 1, weir roughness 0.07, widened notch to 8'	27	19.7	15.6	Not modeled	0.44	0.25	0	Not modeled
PC Iteration 11, 4x4' box, sluice closed, double notch, reduced slope on D/S structure face	57	44.6	30	18.5	1	0.52	0	0

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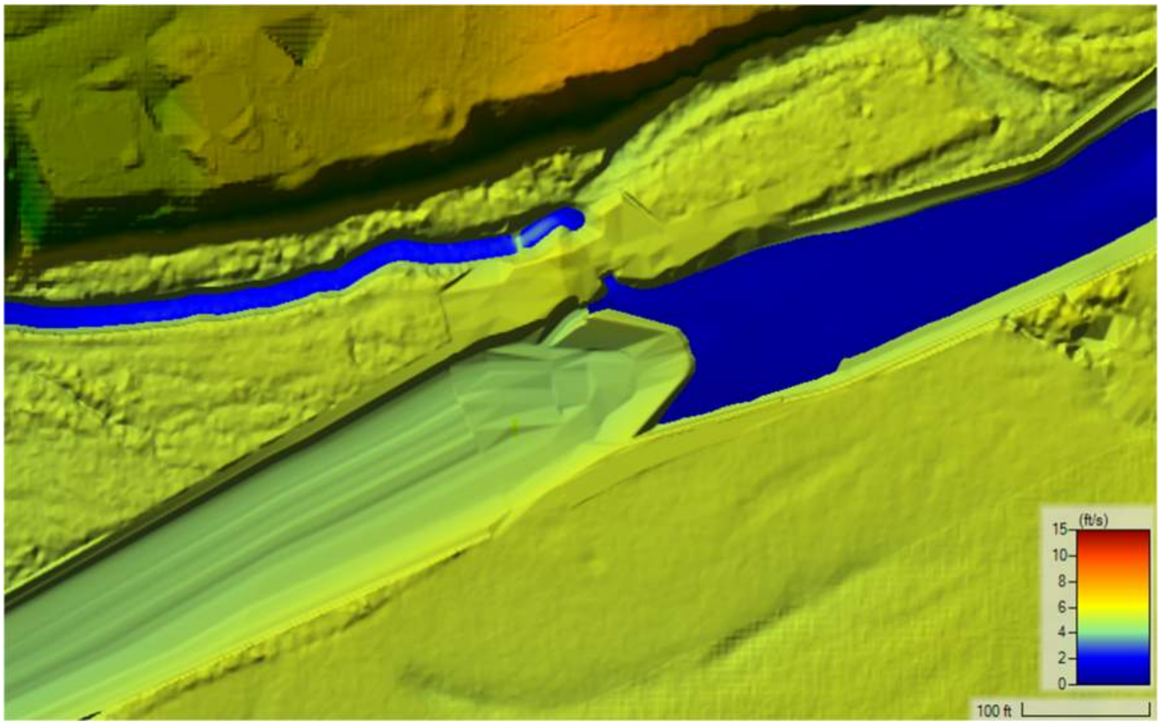

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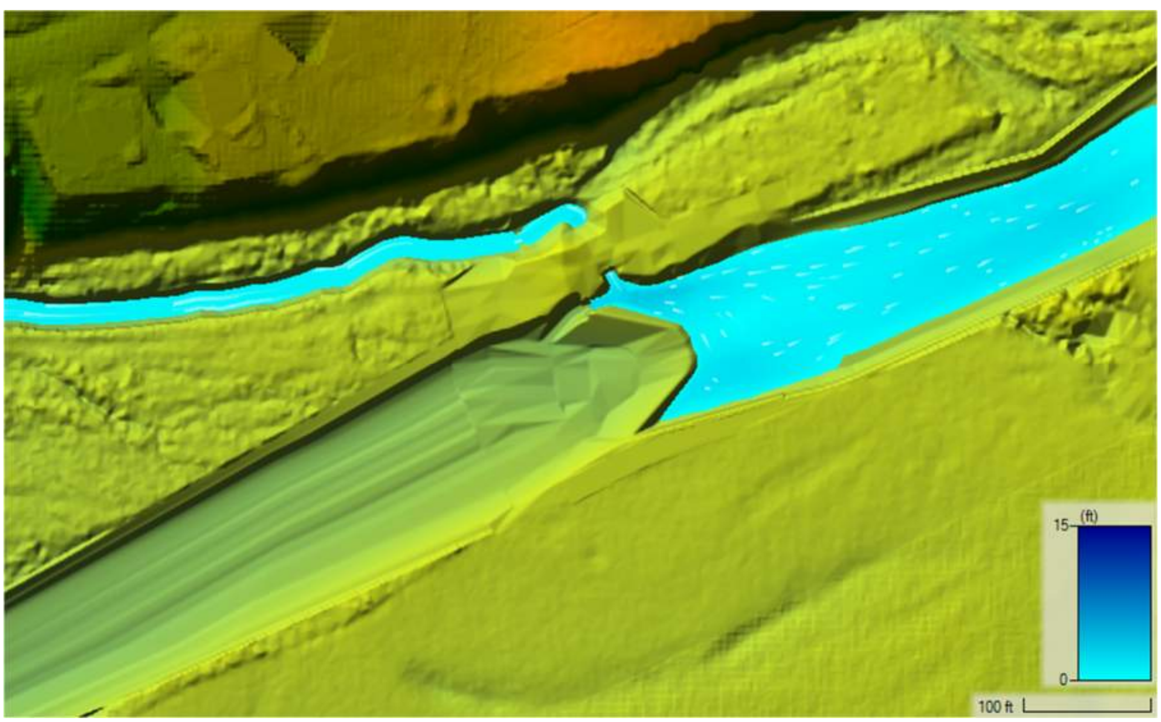

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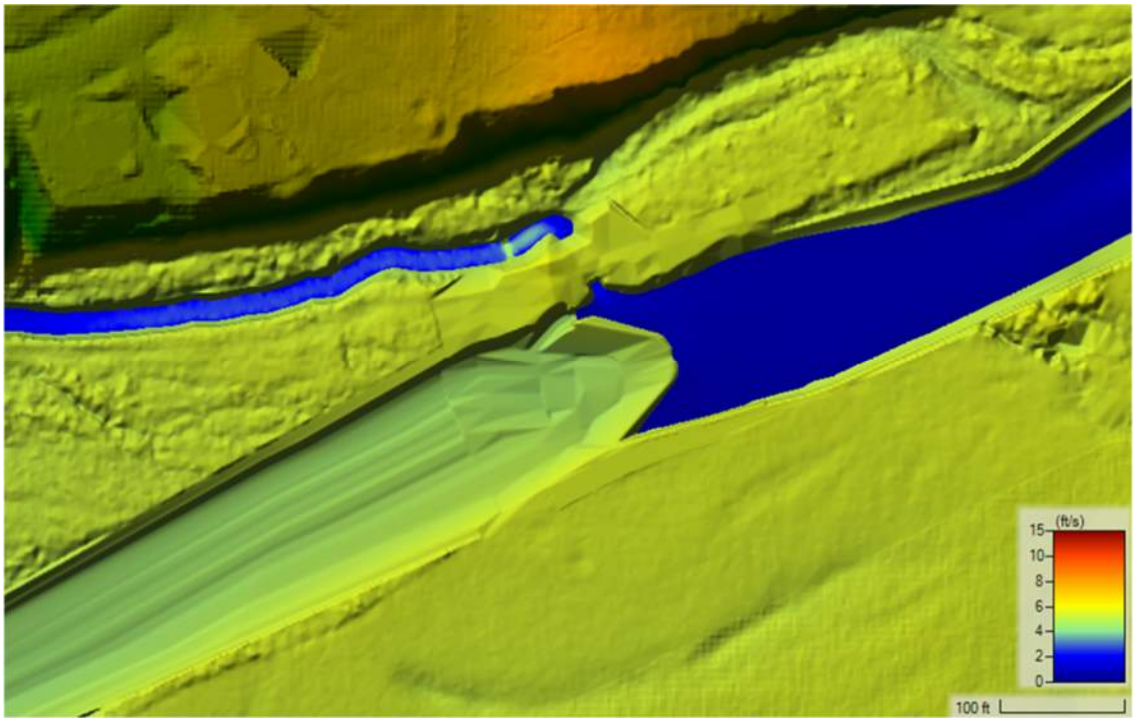

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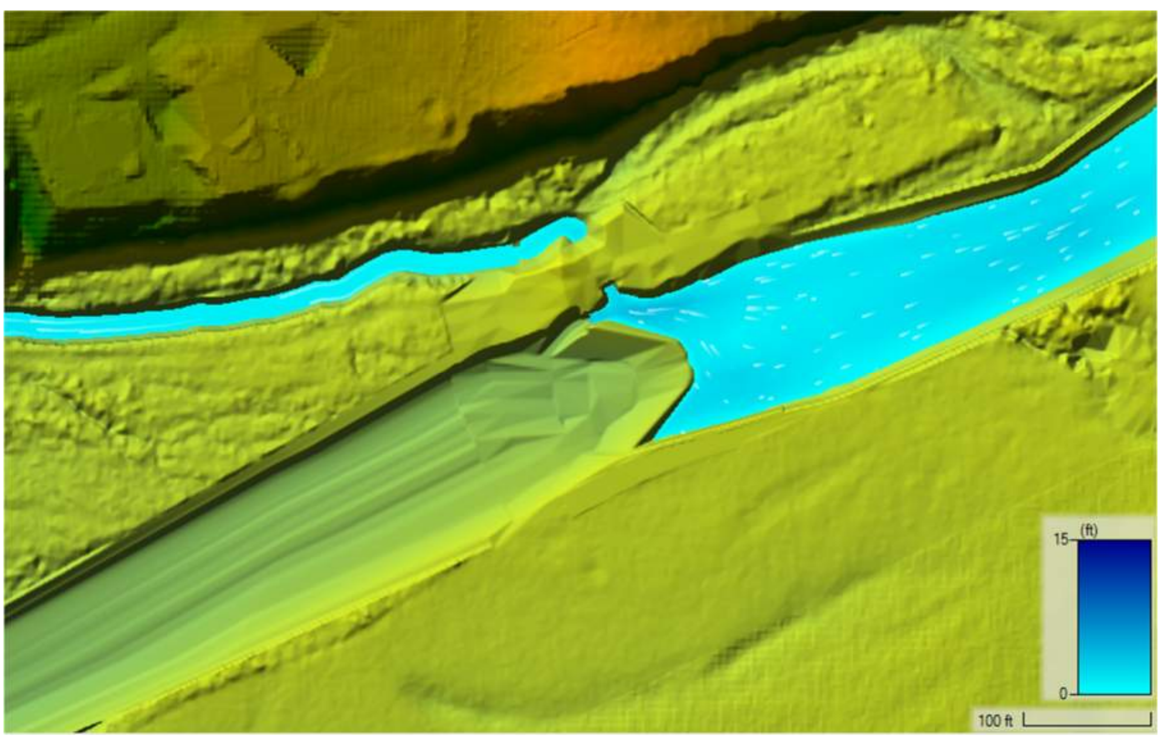

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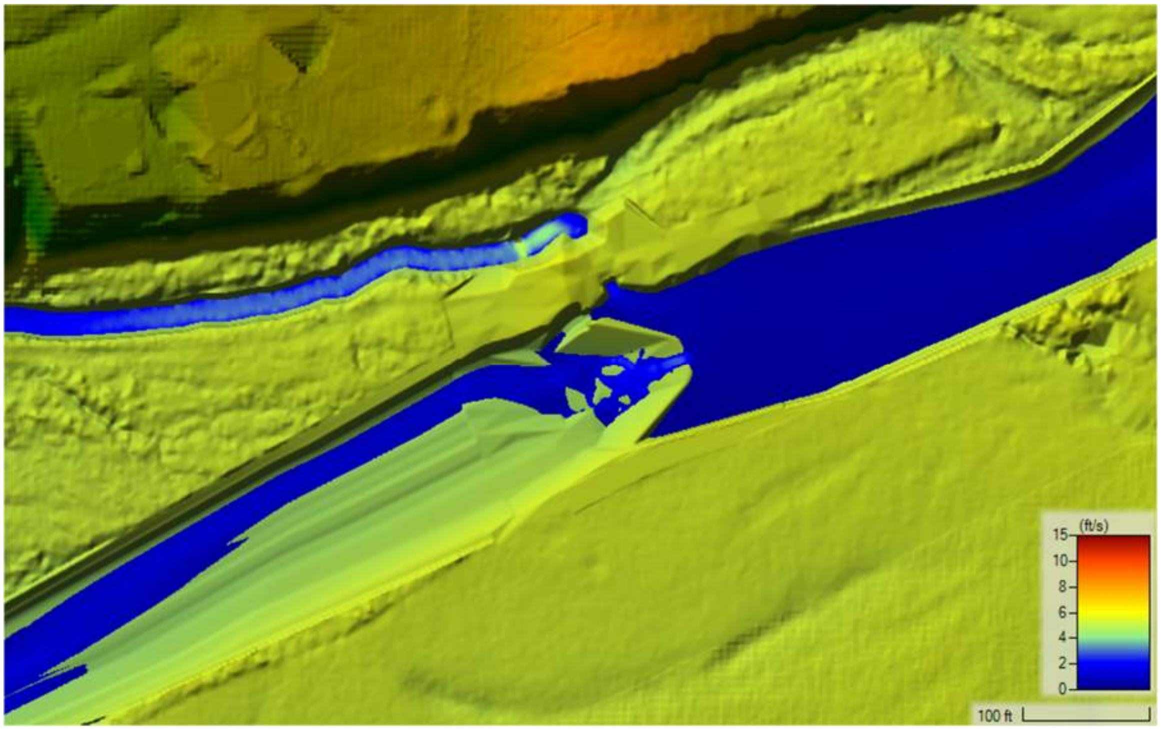

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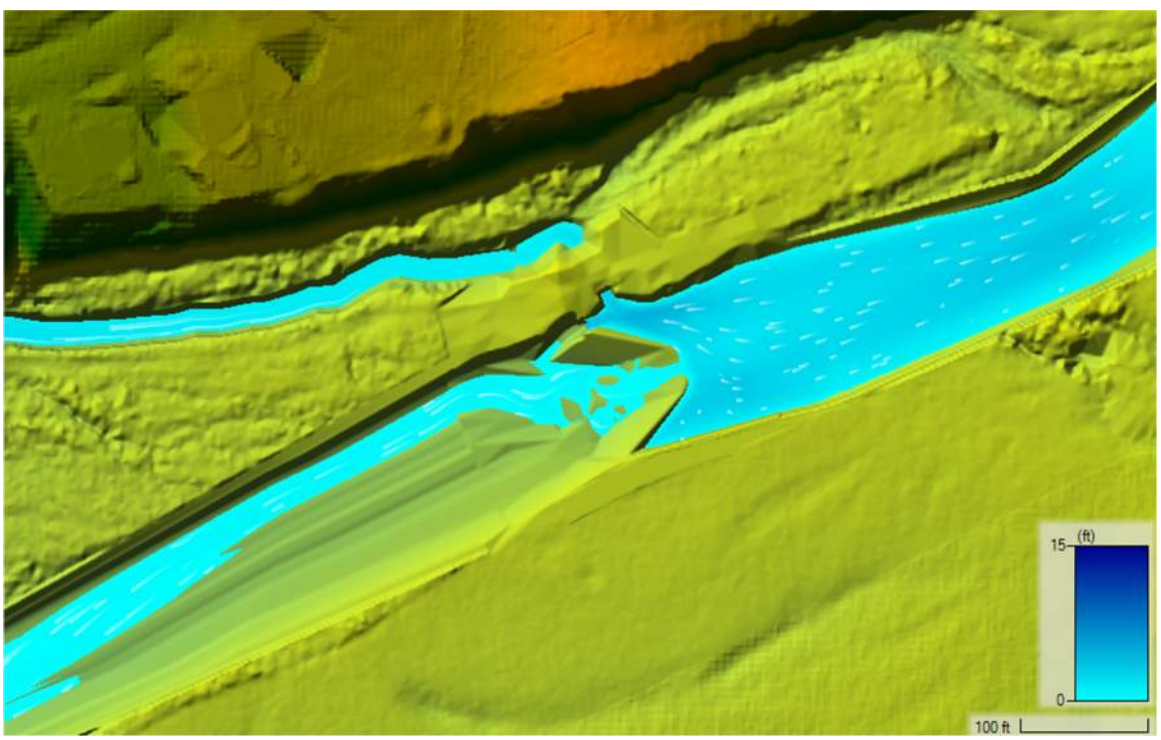

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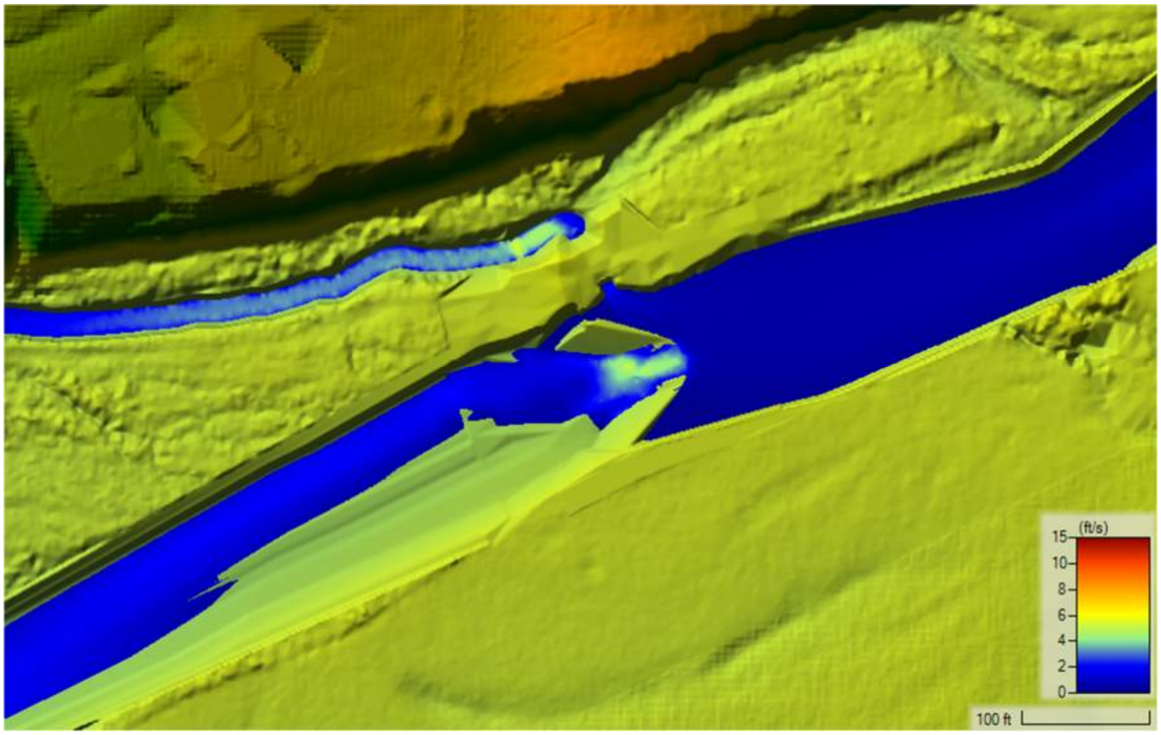

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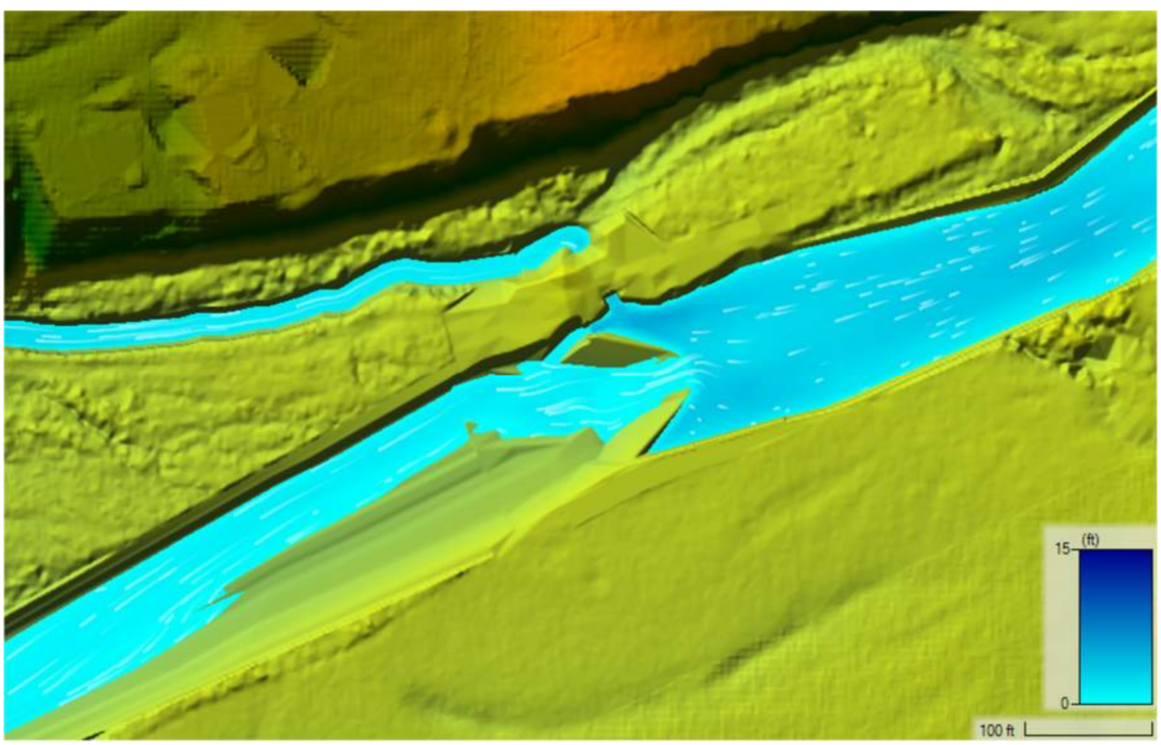

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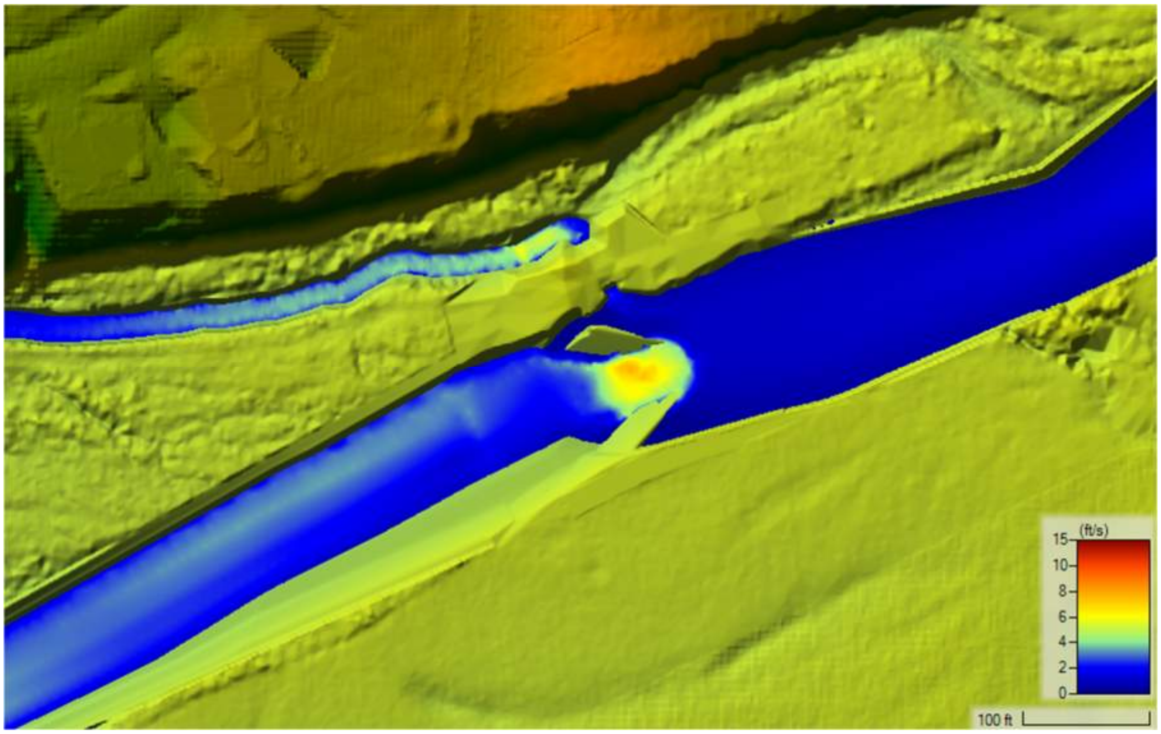

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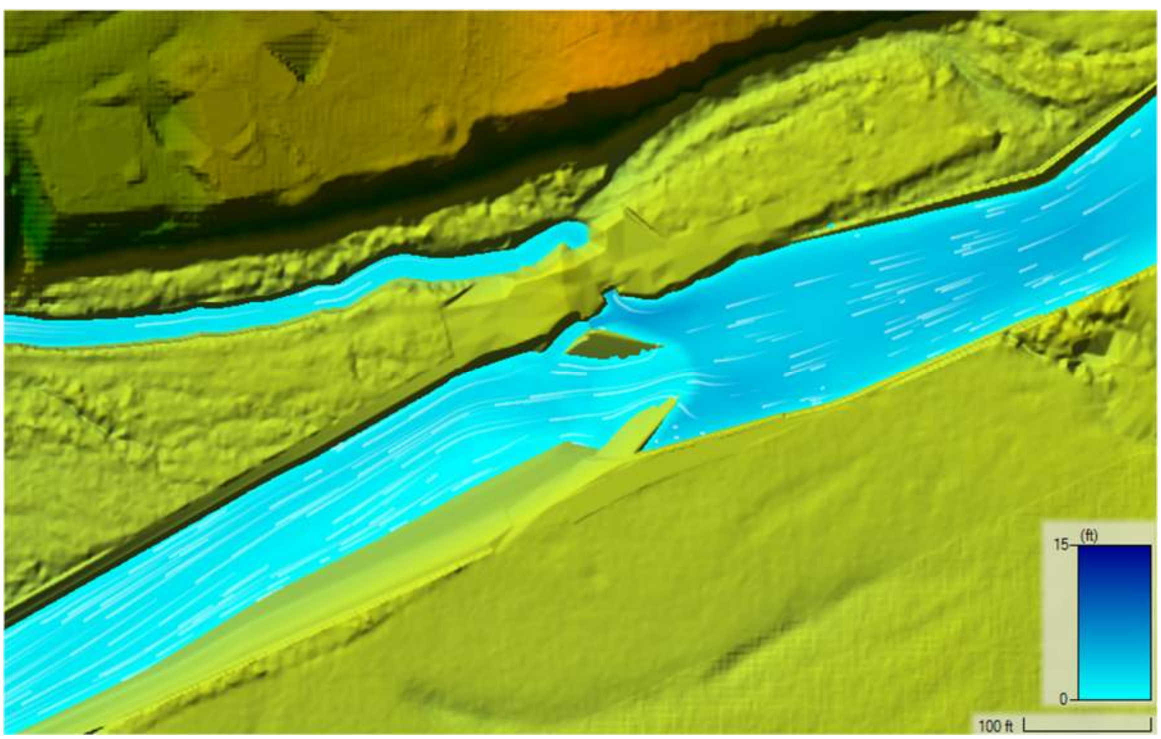

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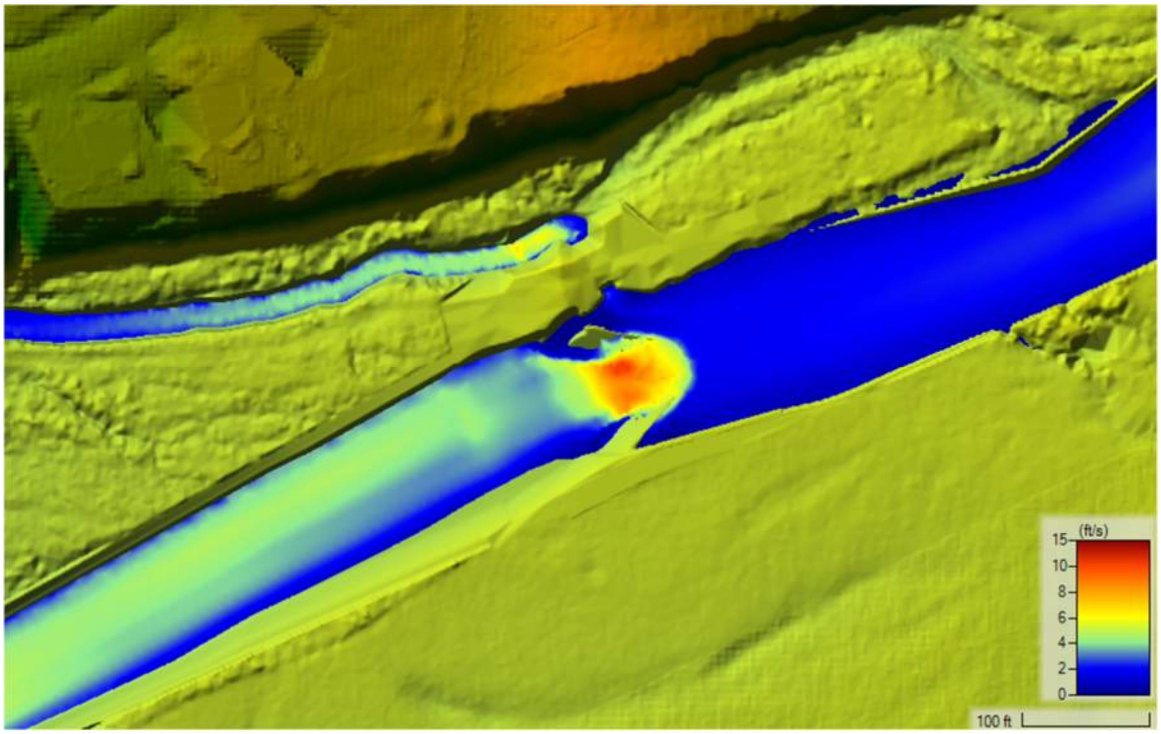

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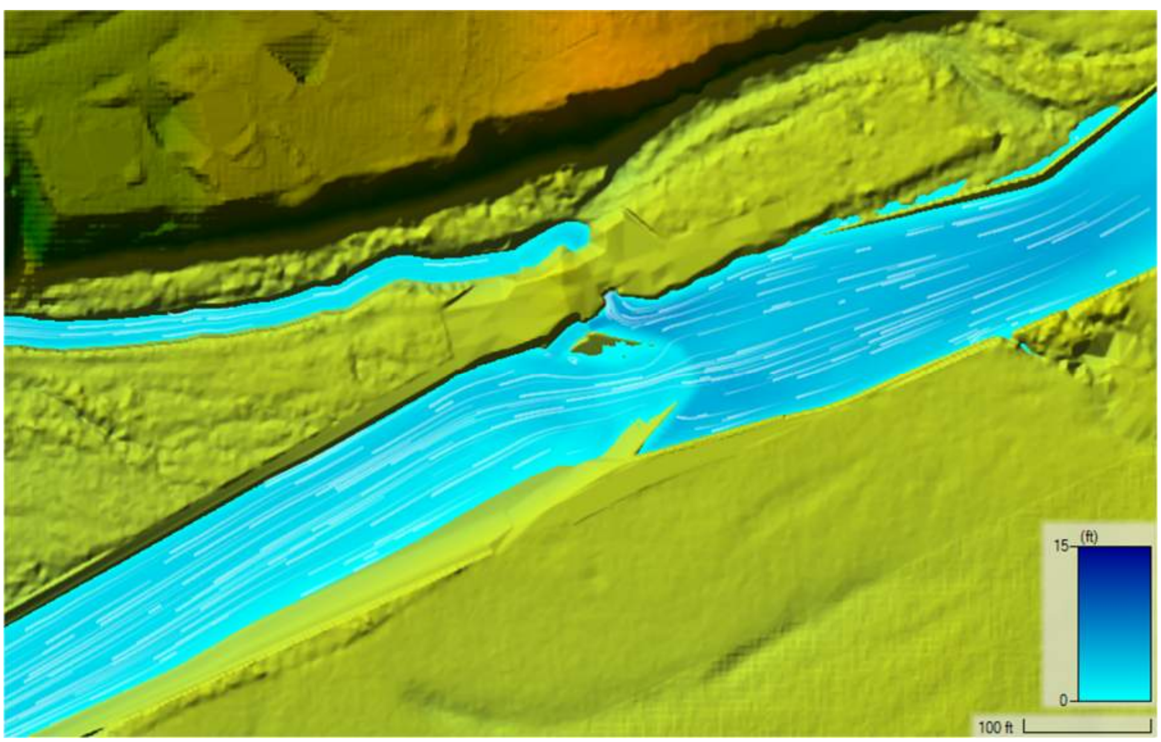

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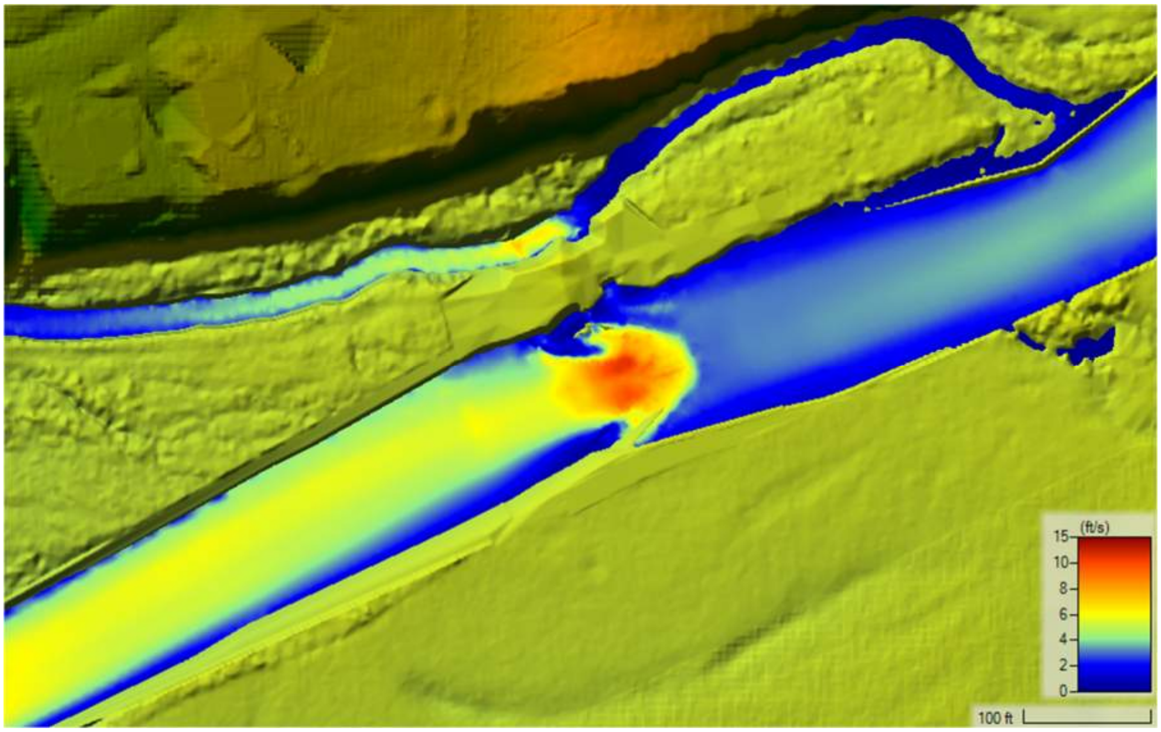

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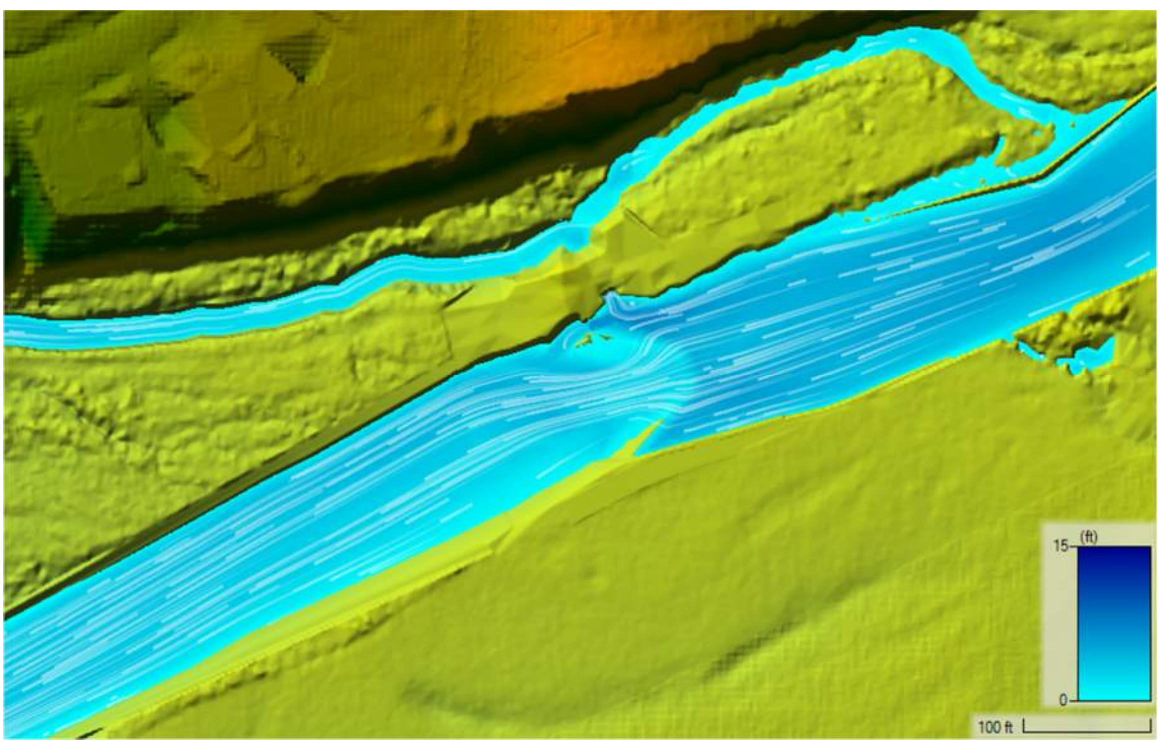

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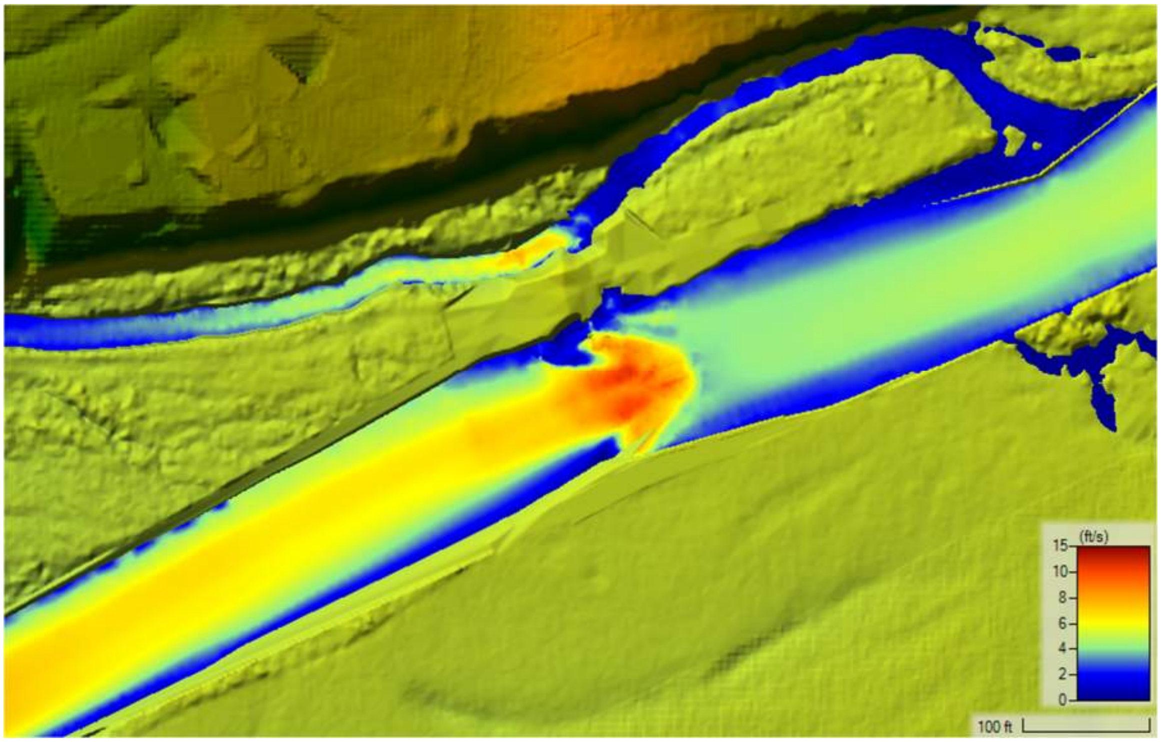

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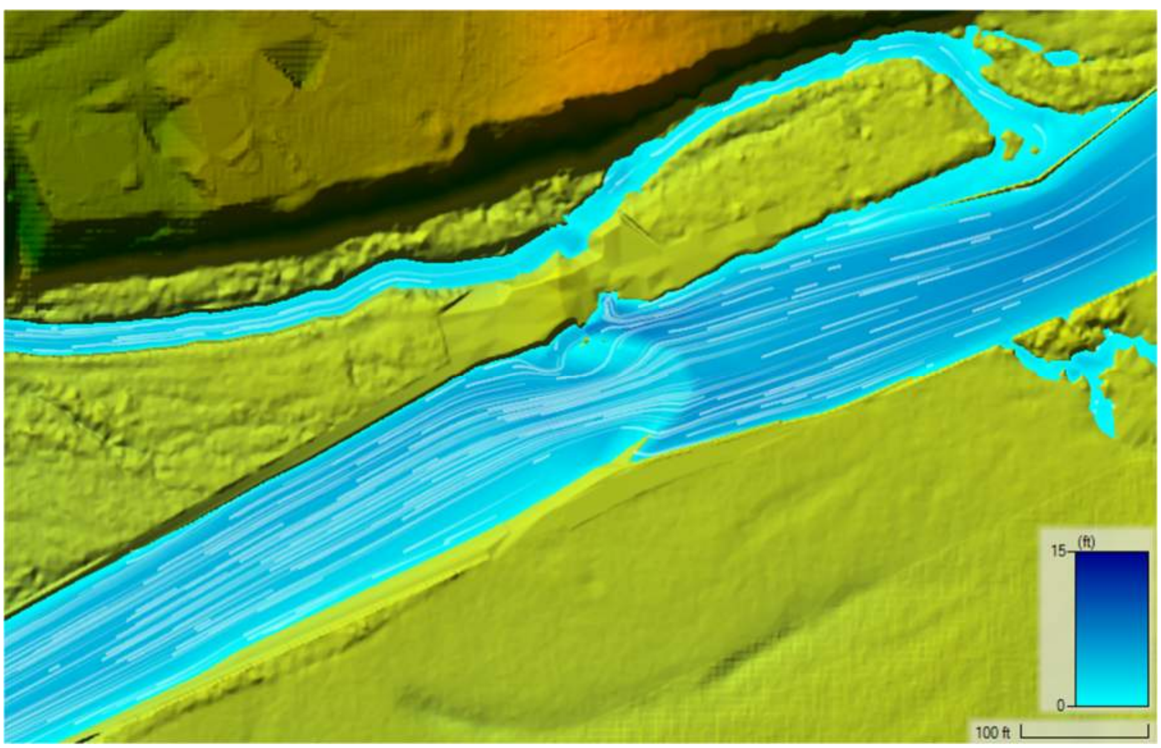

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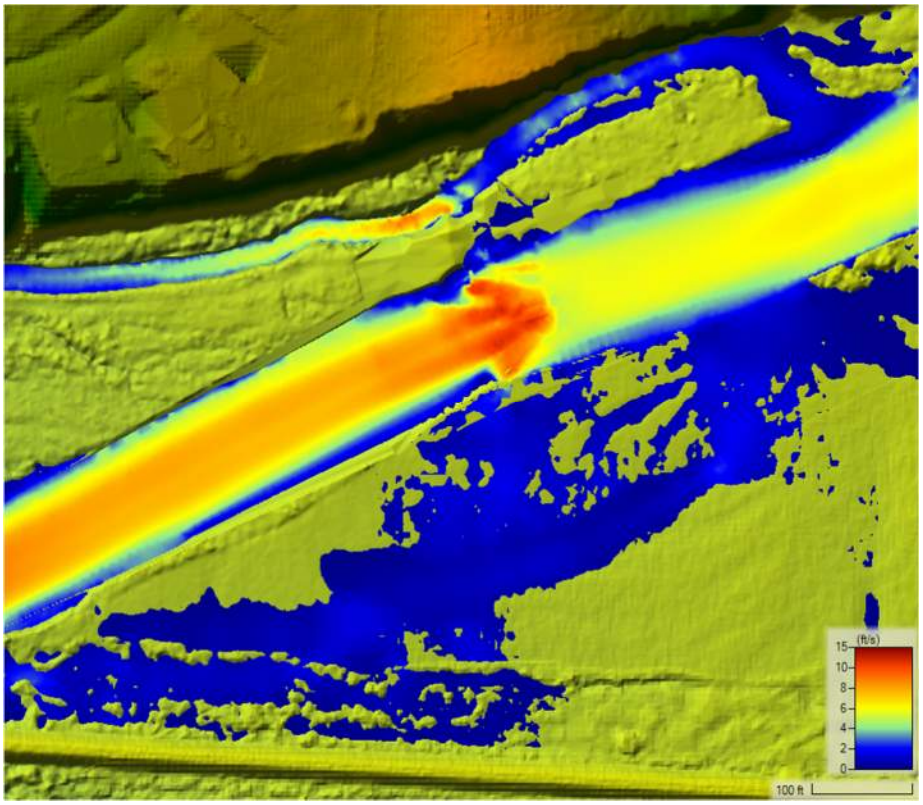

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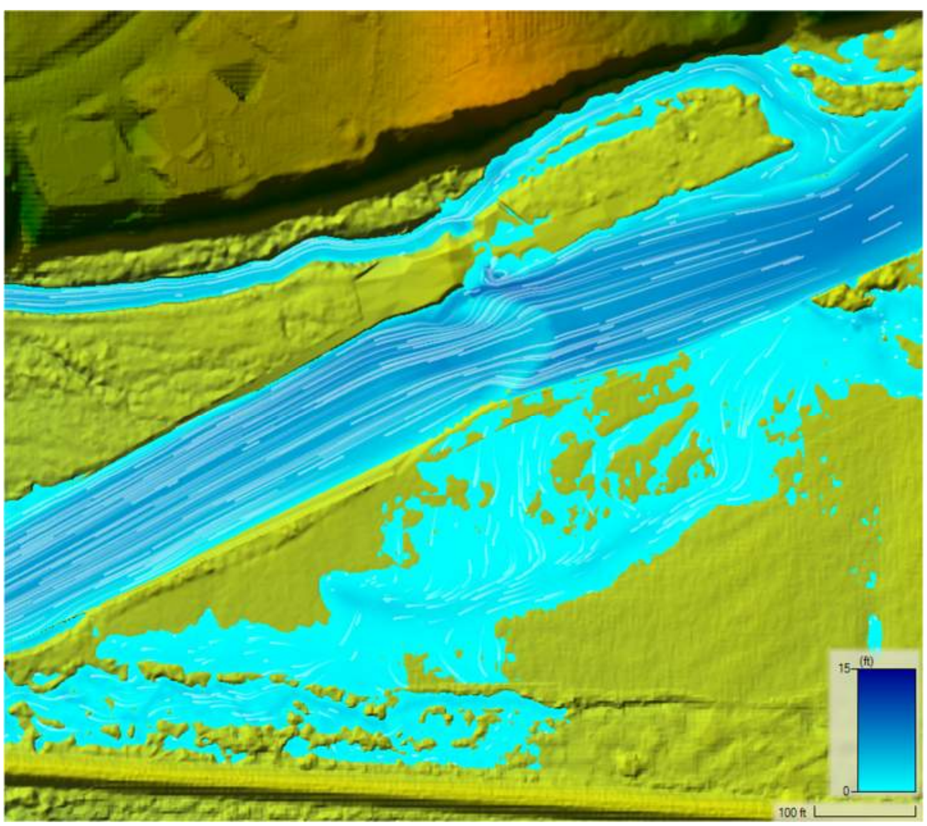

3800 cfs Depth Figure

Yampa River – Duquette Ditch Improvements

Basis of Design Report

Submitted to:

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May 16, 2025

Project No. 21136

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APPENDICES

1. Introduction

The Diversion Infrastructure Assessment, developed as part of the Yampa River Basin Integrated Water Management Plan (IWPM; Wilson Water Group and JUB Engineers, 2020), identified locations where infrastructure improvement could provide multiple benefits to the Yampa River and its users. As part of this assessment, the Duquette Ditch was identified as an opportunity to potentially improve operations during low flows and bank stability in the vicinity of the structure. Owners of the Duquette Ditch report problems with diversions at low flow due to a lack of in-river infrastructure. Additionally, localized channel degradation has resulted in erosion of the banks upstream and downstream of the Duquette diversion location.

The Community Agriculture Alliance (CAA) received a grant from the Yampa River Fund (with CAA providing match funding) to support the planning and design of diversion and bank stabilization improvements at the Duquette Ditch headgate on the Yampa River. The following memorandum outlines the process of developing a 15% design for improvements to the Duquette Diversion and the proximate reach of the Yampa River, including background assessments and an alternatives assessment of potential concepts.

1.1. Project Location

The Duquette Ditch headgate is located on the river right side of the Yampa River, approximately 3 miles west of downtown Steamboat Springs and approximately 950 feet upstream of a Union Pacific Railroad crossing (Figure 1). Land use adjacent to the project area is agricultural and residential. Additionally, the Steamboat Golf Club is located just west of the project area. Water from the Duquette Ditch is used by the Hogue Ranch, the Steamboat II Metropolitan District, and the Steamboat Golf Course.

1.2. Goals and Objectives

Project goals and objectives were developed in collaboration with the CAA and project stakeholders (Table 1).

Table 1: Project Goals and Objectives

Goals	Objectives
Ensure reliable water delivery to Duquette and upstream infiltration gallery	Improve ability to divert legally decreed water under a full range of river flow conditions. Raise water surface elevation at the Duquette Ditch headgate (and upstream infiltration gallery) to improve diversion performance.
Stabilize river and reduce land loss	Reduce bank erosion and stabilize failing, oversteepened banks on both sides of the river. Reconnect the channel to the floodplain where possible to reduce energy of river flows and subsequent lateral erosion.
Maintain or enhance aquatic and riparian habitat	Provide fish and sediment passage across the diversion structure. Avoid disturbance to established riparian vegetation, including mature trees. Use log and rock vanes to provide greater habitat diversity and reduce bank erosion.
Support a multi-benefit, stakeholder driven solution	Incorporate feedback from agricultural, recreational, and environmental stakeholders throughout design

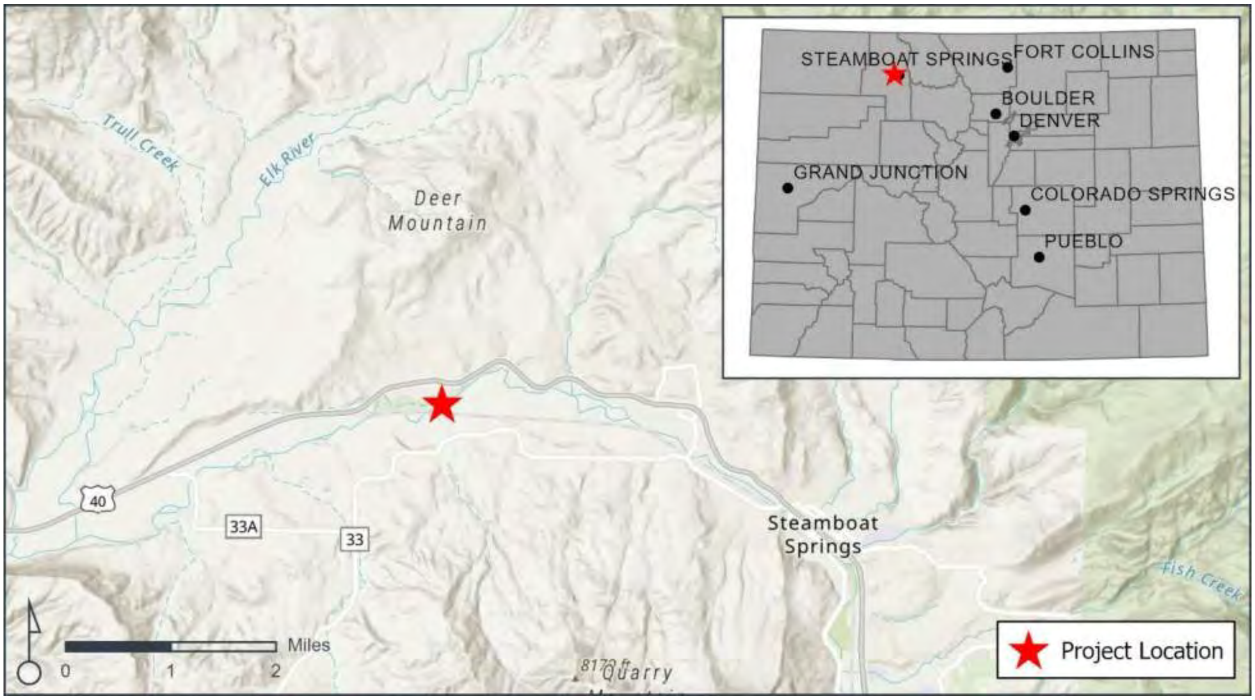

Figure 1: Vicinity Map

1.3. Stakeholder Engagement

Given the multi-objective goals of the Project, the stakeholder engagement process was a critical step to garner local support for, and collaboration on, the Project. The list of stakeholders associated with this project includes:

- Community Agricultural Alliance
- Stanko Ranch
- Hogue Ranch
- Friends of the Yampa
- Steamboat II Metropolitan District
- Steamboat Golf Course
- Trout Unlimited

The design team worked closely with Patrick Stanko (representing Stanko Ranch and the CAA), as well as other stakeholders throughout the development of the project alternatives and selection of the preferred solution. Multiple on-site meetings were held to discuss existing issues, concerns and potential solutions. A stakeholder meeting was held on January 9, 2025 during which three alternative diversion concepts were presented to the stakeholders and feedback was documented and incorporated into the design. The criteria, weighting, and structure of the Multiple-Criterion Decision Analysis (MCDA) were also discussed and updated based on stakeholder input (details of the MCDA process are presented in Section 4).

2. Background Information and Site Conditions

This section summarizes existing physical, hydrologic, and ecological conditions at the Duquette Ditch project site, based on field observations, survey data, and background research. These baseline conditions inform the understanding of current site constraints and opportunities, and provide the foundation for design development, hydraulic modeling, and permitting analysis in subsequent phases of the project.

2.1. Site Infrastructure and Operations

The Duquette Ditch has a water right to divert 18.4 cubic feet per second (cfs) from the Yampa River. Water flows through the Duquette Ditch headgate (north side of the river; Photo 1) towards the Steamboat Golf Club where water either flows through a headgate toward the golf club, or returns to the river (Photo 2, Photo 3). Immediately downstream of this return is the Union Pacific Railroad Bridge crossing (Photo 4). Upstream of the Duquette Ditch, landowners place rocks by hand to create a weir to raise the water surface elevation for their infiltration gallery (Photo 5).

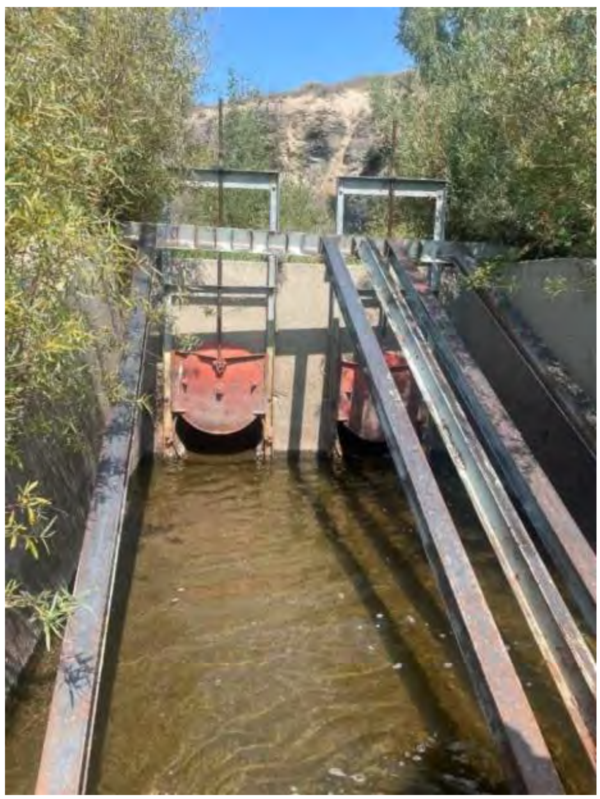

Photo 1: Duquette Ditch headgate

Photo 2: Duquette Ditch return flow (looking downstream)

Photo 3: Control gates for water delivery

Photo 4: Union Pacific Railroad Bridge (looking downstream)

Photo 5: Pushup riffle for infiltration gallery

2.2. Geomorphic Assessment

2.2.1. Watershed Characteristics

Upstream of the Duquette Ditch headgate, the Yampa has a drainage area of 612 square miles (the overall basin area at the confluence with the Green River is 7,660 square miles). The Yampa River generally flows east to west, and the project is located within the Foothill Shrublands Level IV Ecoregion within the Southern Rockies Level III Ecoregion. This ecoregion is characterized as a transition from higher elevation forests within the headwaters to the drier and lower Colorado Plateaus (Omernik and Griffith, 2014).

2.2.2. Site Geology

The Yampa flows through an approximate 2,000-foot-wide alluvial valley, which lies overtop and adjacent to Mancos Shale formation (Madole, 1991). The Mancos Shale can be seen in the bluffs north of the Yampa River and can be found in the channel bed throughout the site (Photo 6, Photo 7).

Photo 6: Duquette headgate with bluffs in the background (looking north)

Photo 7: Mancos shale bedrock exposed in channel

2.2.3. Site Characterization

Otak personnel conducted a site visit on September 5, 2024 to provide a high-level geomorphic characterization of the Yampa River within the vicinity of the Duquette Ditch project. Specifically, this assessment included field observations along approximately 1,000 feet upstream and downstream of the Duquette Ditch.

Within the assessment area, the Yampa is relatively straight, in contrast to the river as a whole, which is generally sinuous. The channel slope is approximately 0.46% and bankfull width within the project area is approximately 100-120 feet wide. Bed morphology is generally characterized as pool-riffle, although pools were infrequent. Lateral bars and one mid-channel bar were present within the reach.

Evidence of degradation was observed throughout the project reach (exposed tree roots, undercut bridge piers, narrow/deep channel). The channel is moderately entrenched with bank heights of 5 to 6 feet on river left, and 5 to 6 feet of degradation was observed at the railroad bridge piers immediately downstream of the project area (Photo 8). Notably, the presence of Mancos Shale bedrock in the channel limits the ability of the river to downcut. Therefore, as the river encounters the shale bedrock, the energy will instead be expended on the surrounding banks and the channel may tend to adjust laterally versus vertically. Outside of the bedrock, the bed material consists of gravel and cobble sediment; however, these deposits are likely only a few feet thick at most.

In addition to the larger scale anthropogenic impacts to the Yampa River Valley (e.g., railroad and road encroachment, levees) historical aerial imagery (Figure 2) suggests that channel degradation in this reach of the Yampa River may be linked or exacerbated to a localized channel adjustment between 1983 and 1999. In the 1967 image, a prominent point bar is visible on river left, just downstream of the Duquette Ditch and upstream of the railroad bridge. Following a series of high spring runoff events in 1983, 1984, and 1997, the river abandoned this meander, eroded through the point bar, and adopted a straighter, steeper alignment. This large alignment shift likely caused vertical incision and bank instability within the project reach.

Figure 2: Historical aerial imagery comparison

Observed banks consisted of noncohesive sands and gravels, with oversteepened, failing banks present on river left (Photo 9, Photo 10). However, vegetation has recruited and started to grow in some areas of previous bank failure (Photo 11). Minimal large wood was observed within the reach; however, Patrick Stanko, the property owner, noted that large wood often moves through the system, racks on the railroad bridge piers, and is subsequently removed and placed on river right (Photo 12).

Photo 8: Five feet of scour under railroad bridge piers

Photo 9: Bank material

Photo 10: River left bank (5-foot-tall)

Photo 11: Vegetation establishing at toe of previously failed bank

Photo 12: Large wood pulled from railroad bridge abutments

2.2.4. Sediment Gradation Analysis

One Wolman pebble count was performed on a riffle located approximately 850 feet upstream of the Duquette headgate. Based upon the pebble count results, bed material within the project area was approximately one third gravel, and two thirds cobble, with a D50 of 82 millimeters (Table 2 and Figure 1). Fractured shale bedrock was prevalent in the bed throughout the reach.

Table 2: Sediment Gradation Results

Percentile	Diameter (mm)
DMIN	8
D10	16.6
D16	26.3
D25	41.3
D50	81.6
D75	113
D84	125.6
D90	149.7
DMAX	362

Class	% Total
Sand	0%
Fine Gravel	2%
Coarse Gravel	34%
Cobble	63%
Boulder	2%
Bedrock	0%

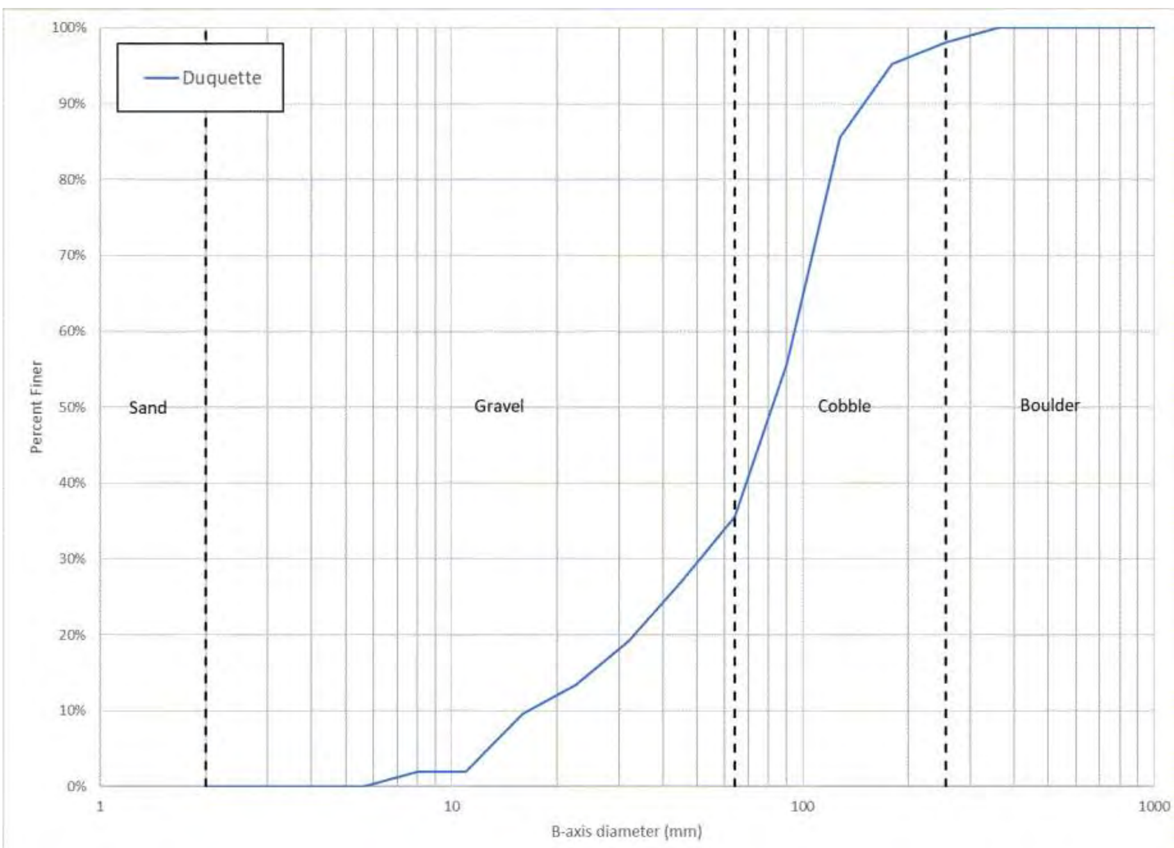

Figure 3: Sediment Gradation Results

2.3. Ecological Assessment

ERO completed an ecological assessment within the project reach in the fall of 2024. The assessment provides a review of ecological conditions and restoration opportunities along the Yampa River near Duquette Ditch. The assessment identifies riparian, wetland, and upland grassland communities, describing their vegetation and ecological roles. Key findings include areas of bank erosion, limited wetland and riparian habitats, and the presence of noxious weeds. ERO recommends planting native vegetation to enhance bank stability, ecological diversity, and wildlife habitat, with further stabilization focused on erosion along the southern bank. Detailed findings can be found in Appendix A.

2.4. Hydrologic Assessment

The US Geologic Service (USGS) gage 09239500 Yampa River at Steamboat Springs, Colorado has a record that spans from 1904 through the present day. The peak annual flows for this gage can be seen in Figure 4. The peak discharge plot includes a linear regression line, as well as bounding lines that represent plus/minus one standard deviation. This plot shows that there is a general trend of decreasing peak discharges over the period of record.

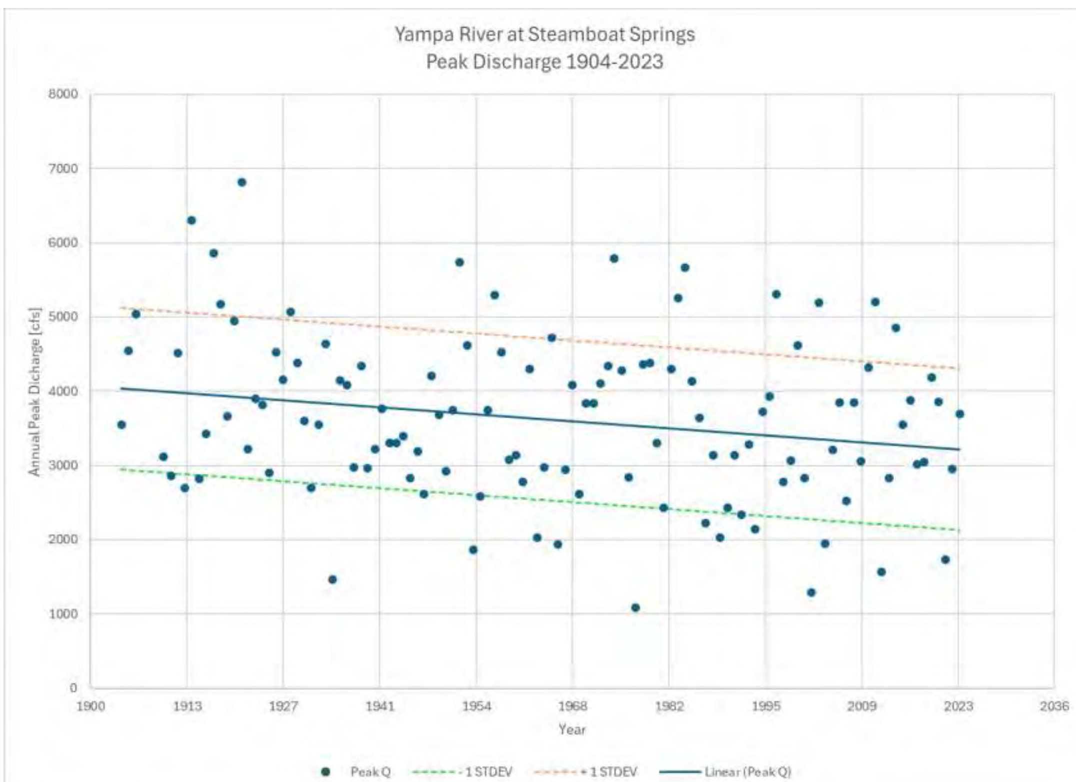

Figure 4: Peak annual flows for USGS Gage 09239500 Yampa River at Steamboat Springs, Colorado

3. Diversion Concept Alternative Development

The background information and data collection summarized in Section 2 informed the development of conceptual alternatives for the diversion structure. Three identified alternatives for this project are presented in Appendix B and outlined in the following subsections. For this assessment it is assumed that the invert of the structure would need to be elevated 3 feet above the existing channel bed. This assumption drives the assessment of cost for the alternatives. Future hydraulic analysis will be necessary to determine the most effective height of the structure.

3.1. Alternative 1 – Engineered Riffle with Concrete Cutoff Wall and Stabilizing Vanes

Alternative 1 features an engineered riffle grade control structure that utilizes a concrete cutoff wall at the crest. Boulders would be placed upstream and downstream of the cutoff wall to provide a smooth transition. On the downstream side, boulders and void filled riprap would be used to construct an engineered riffle sloped at approximately 3%. Considering the shale bed provides a sliding surface the engineered riffle would need to be stabilized to prevent the loss of the engineered riffle (using vanes constructed out of either concrete or grouted boulders). The cutoff wall and vanes would be anchored into the shale.

Benefits: Mimics natural stream morphology, providing smooth transitions for flow and habitat benefits with the engineered riffle slope at 3%. The concrete cutoff wall and anchored vanes stabilize the structure, helping to prevent sliding on the shale bedrock.

Considerations: The use of vanes for additional stabilization is effective for dynamic flow conditions but requires careful design to ensure anchoring in the shale bed and void-filled riprap to maintain the riffle integrity.

3.2. Alternative 2- Grouted Boulder Grade Control with Concrete Cutoff Wall and Sluice Gate

Alternative 2 features a grouted boulder grade control utilizing a concrete cutoff wall at the crest. Grouted boulders would be placed upstream and downstream of the crest, with the downstream slope being 10%. This alternative also includes a sluice gate on river right to facilitate sediment management in front of the headgate. The cut off wall and grouted boulders would be anchored into the shale bedrock to ensure stability.

Benefits: Grouted boulders provide a durable and natural appearance with a steeper downstream slope of 10%, which can help in higher-energy settings. The sluice gate offers active sediment management, keeping the headgate clear and managing sediment accumulation effectively.

Considerations: Anchoring grouted boulders into the shale is critical to avoid movement. The steeper slope will require careful design to prevent excessive energy dissipation or erosion downstream. The sluice gate improves operational flexibility but adds maintenance requirements.

3.3. Alternative 3- Concrete Grade Control with Obermeyer Gates, new headgate and Sediment Bypass Sluice

Alternative 3 features a concrete grade control structure that spans the channel close to existing grade with operable Obermeyer gates. This alternative would include the replacement of the existing headgate and the addition of a sediment bypass sluice. When the Obermeyer gates are in the up position they create a small low head dam; therefore, a bypass channel would be necessary to provide passage for aquatic life (and recreation).

Benefits: The Obermeyer gates provide adjustable flow control, functioning as a low-head dam when raised, which could enhance flow management options. The bypass channel accommodates aquatic life and potentially boat passage, enhancing ecological and recreational connectivity.

Considerations: While highly functional, this alternative is more engineered in appearance and may require additional maintenance, especially with moving parts like the Obermeyer gates. Anchoring into shale and ensuring a low-profile structure will be key for both stability and minimizing visual impact on the river landscape.

3.4. Bedrock Design Considerations

Anchoring a concrete wall into flat shale bedrock typically involves methods designed to create a strong mechanical bond between the concrete and the rock. Here are some common methods:

1. **Rock Dowels or Epoxy-Grouted Anchors**:
   - This method involves drilling holes into the shale bedrock at regular intervals along the base of the wall. Steel dowels, threaded rods, or reinforcing bars are then inserted into these holes and secured with high-strength grout or epoxy. The grout or epoxy provides a strong bond between the dowel and the bedrock, creating a stable mechanical connection. This approach is effective for anchoring the wall, especially in cases where additional bonding strength is needed due to bedrock conditions.
2. **Cast-in-Place Keyways and Bench Cuts**:
   - For enhanced stability, a trench (keyway) can be cut along the bedrock surface, allowing the concrete to fill and interlock with the groove when poured. Alternatively, bench cuts or stepped surfaces can be created on sloped or uneven bedrock to provide a stable base that resists sliding and movement. Both methods establish a strong mechanical lock between the concrete wall and the bedrock surface, adapting to different bedrock contours and increasing wall stability.
3. **Post-Tension Anchors**:
   - Post-tensioning involves drilling deeper holes in the shale bedrock, inserting high-strength steel tendons or cables, and grouting them in place. After the grout cures, the tendons are tensioned to create a compressive force between the wall and the bedrock, adding extra stability. This method is particularly effective for high-load applications, as it helps resist lateral and vertical forces by locking the wall tightly to the bedrock.

Each method's suitability depends on factors like the shale's condition, wall height, loading conditions, and groundwater presence. For instance, softer or fractured shale may require deeper or more frequent anchoring to ensure stability. These methods could be used to anchor a concrete cutoff wall as well as possible anchor individual rocks. It is assumed that the forces on the structure will not require Post-Tension Anchors, but this will be confirmed during later phases of design.

4. Alternatives Analyses/Multi-Criteria Decision Analysis

An MCDA was developed to assist with selection of a preferred alternative. The MCDA approach (Pomerol and Romero, 2000; Kiker et al., 2005) provides a flexible, rational, transparent, and defensible means to establish decision making criteria and prioritize alternatives. The MCDA works by assigning a weighting factor for each criterion based on relative importance and scores for each alternative for each criterion. The weighted scores of all criteria are summed to yield a total score for each alternative, and the highest total score corresponds to the preferred alternative.

The criteria and relative weights for the evaluation of the Duquette Ditch alternatives were developed in collaboration with CAA and key stakeholders to ensure it reflected their key interests and relative priorities. The framework was refined based on their input and then used to evaluate and rank the final design options.

The description of criteria and weighting, rationale for the scoring of each alternative, and the final results are presented in the following subsections.

4.1. Criteria and weighting

The following criteria have been identified to serve as a framework for the MCDA (Table 3). The weighting of each criterion can be seen in Table 4.

Table 3: MCDA Criterion

Criteria	Description	Reasoning
1. Effectiveness, Ease, and Flexibility of Operations	How effective is the structure at diverting water, how easy is it to operate, and how flexible is it for operators to adapt to varying conditions? A more effective, flexible structure (e.g., operable grade control) would ensure operators can divert across all river levels while improving management of sediment and improved control over diversion and bypass rates.	The current system is ineffective, requires ongoing maintenance to maintain diversion and provides little flexibility. It is critical that the selected structure resolve these issues.
2. Construction Costs	This criterion evaluates the initial cost of constructing the structure, including materials, labor, and equipment.	Construction costs are an important factor given budget constraints and/or feasibility for grant funding. Lower initial costs allow for a more feasible project, though higher costs may be a viable option if the structure offers considerable long-term benefits.
3. Sustainability, Maintenance Costs, and Life Span	This criterion combines durability, maintenance needs, and long-term sustainability, assessing how long the structure is expected to last, how much upkeep it will require, and whether it can withstand environmental wear over time, including extreme events.	Given the cost of design, permitting, construction, operation, and maintenance it is critical that full life cycle costs are considered when selecting a preferred alternative. While one alternative may cost less to design and construct, it may have higher maintenance costs and a shorter life span.
4. Fish Passage/Ecological Connectivity/Environmental impact	This criterion assesses how well the structure supports the passage of fish and other aquatic life, preserving ecological connectivity along the river. It also includes impacts to the surrounding area.	Stakeholders, including landowners, FOTY and TU, want to maintain ecological connectivity and enhance habitat conditions along the project reach. The current diversion structure does not significantly impact fish passage, but a new structure has the potential to be a fish barrier. Additionally, portions of the project reach, particularly along the south bank, have degraded with failing banks.
5. Sediment Transport Continuity	This criterion assesses the structure’s ability to allow natural sediment movement through the river system, which is vital for maintaining downstream habitats and river morphology.	Effective sediment transport prevents sediment buildup, supports downstream habitats, and maintains river health.

Table 4: Weighting of MCDA Criteria

Criteria	Weighting
1. Effectiveness, Ease, and Flexibility of Operations	25%
2. Construction Costs	25%
3. Sustainability, Maintenance Costs, and Life Span	25%
4. Fish Passage/Ecological Connectivity/Environmental impact	15%
5. Sediment Transport Continuity	10%
Total	100%

4.2. Scoring and Rationale

The results of the MCDA Assessment can be seen in Table 5. Additionally, the rationale for each rating can be seen in Table 6.

4.3. Assessment Results

Alternative 2, the Grouted Boulder Grade Control with Concrete Cutoff Wall and Sluice Gate, scored the highest and will move forward as the preferred alternative for the proposed 15% design described in Section 5.

Table 5: Results of the Multiple-Criteria Decision Analysis

				Duquette Ditch Diversion Structure			
				Alternative 0	**Alternative 1**	**Alternative 2**	**Alternative 3**
				Do Nothing	Engineered Riffle	Grouted Boulder Grade Control	Automated Overshot Gates
Criteria #	Weight (%)	Criteria	Description for Rating	Rating	Rating	Rating	Rating
1	25%	Effectiveness, Ease, and Flexibility of Operations	*4 = easy to operate with flexible options* *1 = difficult to operate with limited options*	1	3	3	4
2	25%	Construction Costs	*4 = low construction costs* *1 = high construction costs*	4	2	2	1
3	25%	Sustainability, Maintenance Costs, and Life Span	*4 = durable, low maintenance, sustainable* *1 = low durability, high maintenance, unsustainable*	1	3	4	3
4	15%	Fish Passage/Ecological Connectivity/Environmental impact	*4 = low impact on fish passage/ecological connectivity/environmental impact* *1 = high impact on fish passage/ecological connectivity/environmental impact*	4	3	2	1
5	10%	Sediment Transport Continuity	*4 = sediment can be easily transported downstream* *1 = structure halts sediment movement downstream*	4	2	2	4
			Alternative Total Score	2.5	2.7	2.8	2.6
			Final Rank	4	2	1	3

Table 6: MCDA Scoring Rationale

Criteria #	Weight (%)	Criteria	Description for Rating	Duquette Ditch Diversion Structure Rating Rationale
1	25%	Effectiveness, Ease, and Flexibility of Operations	*4 = easy to operate with flexible options* *1 = difficult to operate with limited options*	Alternative 3 ranks the highest since the operable gates are adjustable and can be controlled remotely. Alternative 2 and Alternative 3 are similar in their ease of operation; they both have fixed crests which will provide sufficient head to divert the full amount, but they are not adjustable. The headgates could be automated. The do-nothing option is difficult and provides no flexibility.
2	25%	Construction Costs	*4 = low construction costs* *1 = high construction costs*	Alternative 3 will be the most expensive alternative. Alternative 2 and Alternative 3 are similar in costs since the riffle requires some amount of grout stabilization to key into the shale bottom and the riffle has a very large footprint. No action has no construction costs.
3	25%	Sustainability, Maintenance Costs, and Life Span	*4 = durable, low maintenance, sustainable* *1 = low durability, high maintenance, unsustainable*	Alternative 2 has a slight advantage because it is fully grouted and/or concrete with no movable/operable components. Alternative 3, while very sturdy, does have some additional costs associated with maintenance of the mechanical components. Alternative 1 will likely require more maintenance than Alternative 2 because not all the rocks are locked in place, requiring maintenance after larger flows. Due to the increased maintenance these two alternative score lower. No Action scores the lowest since it requires ongoing work in the channel to ensure diversions.
4	15%	Fish Passage/Ecological Connectivity/Environmental impact	*4 = low impact on fish passage/ecological connectivity/environmental impact* *1 = high impact on fish passage/ecological connectivity/environmental impact*	Alternatives 1, 2 and 3 can all be designed to accommodate fish passage, however the operable gates in Alternative 3 do pose a barrier to fish passage when raised. The fish passage channel will provide sufficient access, but scores lower because it requires fish to find the entrance to the channel, making passage more difficult. Alternatives 2 and 3 both allow for fish passage straight over the structure, but Alternative 2 has a flatter slope so it scores better. Lastly the Do-Nothing option has no impact on fish passage.
5	10%	Sediment Transport Continuity	*4 = sediment can be easily transported downstream* *1 = structure halts sediment movement downstream*	The operable gates in Alternative 3 allow the operators to manage sediment build up behind the structure by lowering the gates during high flow, flushing out the channel. The effectively creates the same hydraulic/sediment transport conditions as No Action, therefore both Alternatives score the highest. Alternatives 2 and 3 will have a similar impact on sediment transport; they will both likely create a sediment wedge upstream. Additional sediment influx from upstream will likely pass over the structure without issue, but some sediment maintenance may be required for both alternatives.

5. 15% Concept Design

Alternative 2: grouted boulder grade control utilizing a concrete cutoff wall at the crest was selected to progress to a 15% design. The stakeholders requested that a replacement headgate was added to the design as well, to ensure the system is fully integrated. The grade control structure will feature a concrete cutoff wall at the crest, with grouted boulders upstream and downstream to direct flow toward the Duquette Ditch headgate and facilitate sediment transport. This structure will be anchored into the underlying shale bedrock. The design also includes a new sluice gate to improve operations by enhancing sediment management at the headgate. The 15% design plans are included in Appendix C.

The headgate will be replaced with a new structure that is integral to the sluice gate and grade control structure. The headgate will consist of two new Waterman C-10 gates that control flow into the canal, similar to the existing configuration. An additional overshot gate is proposed to control the flow to the two headgates. The overshot gate will allow water to be taken from the top of the water column during high flows, limiting the amount of bed load sediment that could be entrained into the canal. The overshot gate will remain completely flat during low flow operations.

The proposed design also includes localized bank grading within the larger project reach to improve stability and reconnect the floodplain. Large wood and boulder vanes are proposed along the river bank to protect the bank, guide flow toward the headgate, and enhance aquatic habitat. The large wood will be stabilized using ballast (e.g. buried in alluvium and boulders) and the vanes will be tied into bedrock to ensure stability. Riparian plantings (willow stakes, riparian, and wetland trees and shrubs) are proposed to support a healthy riparian corridor.

Grading within the floodplain will most likely be necessary to achieve a no-rise condition for the 100-year flood Base Flood Elevation (BFE) as part of floodplain permitting described in Section 6.7.2. Floodplain grading is proposed in the adjacent pasture on river left. In this phase we assumed that an area approximately 200 feet wide by 500 feet long will be lowered between 1 to 3 feet. Final grading extents and locations will be determined based on hydraulic modeling in the next project phase. This grading also has the added benefit of lowering the root zone of the pasture closer to the groundwater table, which should improve sub-irrigation and yield.

5.1. Preliminary Opinion of Probable Construction Costs

A preliminary opinion of probable construction cost (based on the 15% concept design), including contingency, escalation, and estimated design and permitting costs, is presented below in Table 7.

Table 7: Preliminary Opinion of Probable Cost

Item	Cost
Anticipated Construction Cost (+30% Contingency)	$3,150,000
+5-yr escalation (4%)	$4,416,000
Anticipated Design and Permitting	$500,000

The costs were based on the following assumptions:

1. Floodplain grading consisting of 200-foot by 500-foot area with an average depth of 1.5 feet.
2. Three acres of clearing and grubbing.
3. Additional pre-construction survey and as-built survey included.
4. Staging area stabilization assumed to be $30K.
5. Includes $100K to run electricity to site.
6. Includes two new headgates ($5,000 each).
7. Includes $180K for overshot gate.

6. Next Steps and Further Considerations

The following section outlines additional considerations as well as key technical, regulatory, and design tasks required to advance the Duquette Ditch project from 15% concept to final design and permitting.

6.1. Considerations

Key considerations that will influence final design and permitting include the presence of invasive aquatic species (northern pike, smallmouth bass, and walleye), as well as potential impacts to upstream properties, including an infiltration gallery and possibly insurable structures. Boater safety and recreational use (particularly at the railroad bridge downstream of the project area) must also be accounted for in the final layout and hydraulic performance of the structure. In addition, a framework for long-term monitoring and adaptive management should be developed to evaluate post-construction performance and guide potential future modifications.

6.2. Hydrologic Refinement

The next phase of work should include refinement of the hydrologic inputs to support final design. This includes determining the channel-forming (bankfull) discharge, confirming maximum and minimum diversion rates, assessing river low-flows, and potentially evaluating groundwater conditions in the adjacent pasture. If necessary, piezometers may be installed in the field to support design of the floodplain grading and riparian restoration.

6.3. Survey and Site Data Collection

While topographic survey was obtained in this phase of the project, additional survey work may be required to support modeling and design. This includes a bathymetric survey of the ditch behind the headgate (if needed to support hydraulic modeling) and topographic and bathymetric surveys in areas proposed for rock and log vane installation to inform design and constructability.

6.4. Geotechnical Investigation and Design

A geotechnical investigation should be conducted to support the next design phase. This includes evaluation of subsurface conditions and foundation requirements for the sluice gate and headgate, confirmation of tie-in methods to shale bedrock for grade control and assessment of stability and embedment for proposed rock and log vanes.

6.5. Hydraulic Modeling

Hydraulic modeling will play a central role in refining the design and ensuring regulatory compliance. Model results will inform final layout and elevation of the diversion structure, floodplain grading design, and sediment management strategies. Modeling will also support no-rise certification or Conditional Letter of Map Revision (CLOMR) and subsequent Letter of Map Revision (LOMR) preparation, evaluation of hydraulic stability of in-channel structures, and informing optimization of ecological restoration elements. Additionally, modeling will be used to assess the operational performance of the structure across a range of flow conditions.

6.6. Structure Design

As part of the next phase, design of the grade control structure, headgate, and sluice gate should incorporate geotechnical findings, hydraulic inputs, and constructability considerations to advance the project toward final design and permitting.

6.7. Preliminary Permitting

The proposed diversion structure and restoration plans will require acquisition of permits from several different regulatory agencies. The following outlines the likely permits required:

6.7.1. Clean Water Act Section 404 Permit

Projects that place fill below the ordinary high water are required to comply with the Clean Water Act Section 404 Permit, regulated by the US Army Corps of Engineers (USACE). However, if more than 50% of the water use is for irrigation, the project may qualify for a 404(f) exemption. If an irrigation exemption is provided, the additional bank stabilization work could likely be permitted under a Nationwide Permit 13. However, if an irrigation exemption is not feasible, the project may potentially be permitted under an Individual Permit. These are preliminary recommendations and coordination with USACE will be necessary during future phases of design to determine the applicability of the project to fall under these permitting mechanisms.

6.7.2. Floodplain Development Permit

The project area is located within FEMA Flood Insurance Rate Map (FIRM) Panel 0817C0694D (effective 2/4/2005). It lies within Zone AE and the regulatory floodway. As such, this project is subject to regulations administered by Routt County, Colorado Water Conservation District (CWCB), and FEMA. To comply with these regulations, the project must obtain a Routt County floodplain development permit. This can be accomplished in one of two ways:

- No-Rise Certification: If the project can demonstrate that it will not increase the BFE by more than 0.0049 feet then a no-rise certificate can be submitted to the County in lieu of further FEMA process or review.
- CLOMR/LOMR: If modeling indicates a rise in the BFE greater than 0.0049 feet, the project will be required to complete a Conditional Letter of Map Revision (CLOMR) and subsequent Letter of Map Revision (LOMR) through FEMA.

6.7.3. Migratory Bird Treaty Act and Bald and Golden Eagle Act

There is at least one Bald Eagle nesting site near the project location. To comply with the Migratory Bird Treaty Act (MBTA) and Bald and Golden Eagle Act (BGEA), ground-clearing activities should occur outside of the April 1 through July 31 migratory bird breeding season. If construction activities occur during the migratory bird breeding season, a nest survey should be conducted immediately prior to construction. Additionally, immediately prior to construction mobilization, survey for raptor nests is recommended.

6.7.4. Cultural Resources

It is likely that this project will be subject to regulation by the Colorado State Historic Preservation Office (SHPO) due to factors such as federal funding sources, federal permitting requirements (404), etc.

Coordination with SHPO should be completed in a future phase of design to determine potential requirements.

7. References

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APPENDIX A

ECOLOGICAL ASSESSMENT MEMO

ERO Resources Corporation

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October 10, 2024

TO: Chris Romeyn
Otak, Inc.
371 Centennial Parkway, Suite 210
Louisville, Colorado 80027

FROM: Anna Wistrom, Biologist

RE: Ecological Assessment Memorandum – Yampa River – Duquette Ditch Improvements, Steamboat Springs, Routt County, Colorado

Background

Otak, Inc. (Otak) retained ERO Resources Corporation (ERO) to provide an ecological assessment memorandum (memo) to document ecological resources and potential restoration opportunities for a portion of the Yampa River in Steamboat Springs, Colorado (project area; Figure 1, attached). The Community Agricultural Alliance is proposing stream channel improvements and bank stabilization activities along a portion of the Yampa River, upstream and downstream of the existing Duquette Ditch headgate. ERO is assisting Otak and the Community Agricultural Alliance with evaluating the current conditions of the Yampa River in the project area and opportunities for restoration or enhancement activities.

On September 5, 2024, Anna Wistrom and Isabel Mansour, biologists with ERO, assessed the project area for natural resources (2024 site visit). During the 2024 site visit, activities included a review of vegetation communities, an informal wetland delineation, and identification of potential areas for restoration and enhancement opportunities. This memo provides information on existing site conditions and resources as well as current regulatory guidelines related to those resources.

Project Area Location

The project area is in Section 3, Township 6 North, Range 85 West of the 6th Principal Meridian in Routt County, Colorado (Figure 1). The UTM coordinates for the approximate center of the project area are 338771mE, 4485269mN, Zone 13 North. The longitude/latitude of the project area is 106.90278°W/40.502475°N. The elevation of the project area is approximately 6,745 feet above sea level. Representative photos of the project area are included in the attached photo log, and photo points are shown on Figure 2, attached.

Ecological Setting

The U.S. Department of Agriculture (USDA) maps the project area within the Southern Rocky Mountains Major Land Resource Areas (MLRA), which consists of strongly sloping to precipitous mountain ranges with several basins and parks and some high mesas and plateaus. Many narrow stream valleys with steep gradients occur in this MLRA, and high plateaus and steep-walled canyons are fairly common (USDA, NRCS 2022). This MLRA is part of the Southern Rocky Mountains Province of the Rocky Mountain System and ranges in elevation from 6,500 to 14,400 feet. The climate of these areas is strongly dependent on elevation with greater precipitation and cooler temperatures at the higher elevations. The annual precipitation ranges from 7 to 73 inches, of which about half occurs as snow in the winter. The mean annual temperature is 23 degrees to 55 degrees Fahrenheit with the number of frost-free days ranging from 35 to 195.

The project area is further divided into the Foothill Shrublands ecoregion of Colorado (Chapman et al. 2006). The geology of the Foothill Shrublands ecoregion consists generally of quaternary glacial till with most of the region having rolling to irregular terrain of hills. Most of the ecoregion historically consisted of sagebrush and mountain mahogany shrublands and pinyon-juniper woodlands. Most of the land use consists of livestock grazing with occasional irrigated haylands near streams.

The project area is located in the Cow Creek - Yampa River watershed of northwest Colorado. The Yampa River continues generally to the west where it eventually flows into the Green River. The Green River converges with the Colorado River in Canyonlands National Park.

Existing Conditions

The project area consists of the Yampa River, located upstream and downstream of the existing Duquette Ditch headgate. The Yampa River is a perennial stream and a riverine feature, as identified on the U.S. Geological Survey (USGS) topographic map and the National Wetlands Inventory (USGS 2022; Service 2024). The project area is northwest of Steamboat Springs and is bounded by residential development to the north, agricultural fields to the east and south, and the Steamboat Golf Course to the west (Photo 1; Figure 2). The Yampa River flows from northeast to southwest in the project area in a 65- to 95-foot-wide channel with vegetated cobble bars (Photo 2). The southern bank of the Yampa River has substantial erosion, sparse wetland habitat, and contains limited riparian habitat (Photo 3).

The USDA Natural Resources Conservation Service Web Soil Survey maps Slocum loam, gravelly substratum, 0 to 3 percent slopes and Toponas loam, 0 to 3 percent slopes in the project area (USDA, NRCS 2024b). Three vegetation communities, riparian, wetland, and upland grassland, were identified and are described in further detail below.

Vegetation Communities

Wetland

The wetland community in the project area occurs in the cobble bars and along the banks of the Yampa River (Photo 2 and Photo 3). Additional wetlands are present along the banks of the irrigation ditch in the northwest portion of the project area. Trees and shrubs in the wetland community of the Yampa River include narrowleaf cottonwood (*Populus angustifolia*), coyote willow (*Salix exigua*), greenleaf willow (*Salix lasiandra*), red osier (*Cornus alba*), peachleaf willow (*Salix amygdaloides*), and gray alder (*Alnus incana*) (Photo 4). During the 2024 site visit, the understory was dominated by spikerush (*Eleocharis palustris*), reed canary grass (*Phalaris arundinacea*), wild mint (*Mentha arvensis*), Northwest territory sedge (*Carex utriculata*), panicled bulrush (*Scirpus microcarpus),* and Bebb's sedge (*Carex* *bebbii*). ERO did not conduct a wetland delineation of the project area during the 2024 site visit; an additional site visit would be needed to determine wetland boundaries in the project area (Table 1).

Riparian

Most of the riparian community in the project area is along the north bank of the Yampa River with small sections of riparian communities along the southern bank (Photo 1). Trees and shrubs in the riparian community include narrowleaf cottonwood, red osier, peachleaf willow, gray alder, coyote willow, greenleaf willow, twinberry (*Lonicera involucrata*), western snowberry (*Symphoricarpos occidentalis),* golden currant (*Ribes aureum*), and Woods' rose (*Rosa woodsii*) (Photo 1). During the 2024 site visit, the understory was dominated by smooth brome (*Bromus inermis*), Timothy (*Phleum pratense*), and redtop bent (*Agrostis gigantea*) with lesser occurrences of Canada goldenrod (*Solidago gigantea*), common yarrow (*Achillea millefolium*), scouringrush horsetail (*Equisetum hyemale*), fireweed (*Chamaenerion angustifolium*), and houndstongue (*Cynoglossum officinale)* (Table 1).

Upland Grassland

The upland grassland community in the project area is adjacent to the southern bank of the Yampa River. A small area of upland grasslands is present as the wetland and riparian community transitions to agricultural fields (Photo 3 and Photo 4). The upland grassland community consists of a mixture of native and nonnative species including smooth brome, western wheatgrass (*Pascopyrum smithii*), Canada thistle (*Cirsium arvense*), scouringrush horsetail with lesser occurrences of red clover (*Trifolium pratense*) and silvery lupine (*Lupinus argenteus*) (Photo 3; Table 1).

Table 1. List of prevalent species.

Common Name[1]	Scientific Name	Wetland Indicator[2]	Native Status	Noxious List
Trees				
Gray alder	*Alnus incana*	FACW	Native	
Narrowleaf cottonwood	*Populus angustifolia*	FACW	Native	
Peachleaf willow	*Salix amygdaloides*	FACW	Native	
Shrubs				
Coyote willow	*Salix exigua*	FACW	Native	
Golden currant	*Ribes aureum*	FAC	Native	
Greenleaf willow	*Salix lasiandra*	FACW	Native	
Red osier	*Cornus alba*	FACW	Native	
Twinberry	*Lonicera involucrata*	FAC	Native	
Western snowberry	*Symphoricarpos occidentalis*	FAC	Native	
Woods' rose	*Rosa woodsii*	FACU	Native	
Forbs				
Bebb's sedge	*Carex bebbii*	OBL	Native	
Canada goldenrod	*Solidago gigantea*	FACW	Native	
Canada thistle	*Cirsium arvense*	FAC	Nonnative	List B
Common spikerush	*Eleocharis palustris*	OBL	Native	
Common yarrow	*Achillea millefolium*	FACU	Native	
Fireweed	*Chamaenerion angustifolium*	FACU	Native	
Houndstongue	*Cynoglossum officinale*	FACU	Nonnative	List B
Northwewst Territory sedge	*Carex utriculata*	OBL	Native	
Panicled bulrush	*Scirpus microcarpus*	OBL	Native	
Red clover	*Trifolium pratense*	FACU	Nonnative	
Reed canarygrass	*Phalaris arundinacea*	FACW	Native	
Scouringrush horsetail	*Equisetum hyemale*	FACW	Native	
Silvery lupine	*Lupinus argenteus*	NI	Native	

Common Name[1]	Scientific Name	Wetland Indicator[2]	Native Status	Noxious List
Wild mint	*Mentha arvensis*	FACW	Native	
Grasses				
Redtop bent	*Agrostis gigantea*	FAC	Nonnative	
Reed canarygrass	*Phalaris arundinacea*	FACW	Nonnative	
Smooth brome	*Bromus inermis*	UPL	Nonnative	
Timothy	*Phleum pratense*	FAC	Nonnative	
Western-wheatgrass	*Pascopyrum smithii*	FACU	Native	

[1] Common names and wetland indicators are from the National Wetland Plant List (Corp 2020) and the Plants Database (USDA, NRCS 2024a), if names were not listed in the National Wetland Plant List.
[2] UPL – Upland, FACU – Facultative Upland, FAC – Facultative, FACW – Facultative Wetland, NI – No Indicator.

Noxious Weeds

During the 2024 site visit, ERO identified several small areas of noxious weeds in both the riparian and upland grassland communities. Two Colorado Department of Agriculture Noxious Weed List B species were identified in the project area, as described below. The observed weed populations in the project area were small compared with the size of the project area.

List B Species

- **Houndstongue** – Houndstongue was documented in the riparian community throughout the project area. The population was less than 10 individuals at each location identified.
- **Canada thistle** – Canada thistle was documented in the upland grassland community throughout the project area. The population was less than 10 individuals at each location identified.

Restoration and Enhancement Opportunities

Although riparian and wetland communities make up a small portion of the Colorado landscape, these areas play a key role in many ecological functions and services. Vegetation in riparian and wetland areas act as natural buffers that absorb surface water runoff and filter out pollutants, such as fertilizers, before entering our streams and drinking water sources. Vegetation in these areas also helps to contain and slow flowing water during storm events, resulting in less soil erosion and a reduction in flood damage. Riparian areas provide habitat for a variety of wildlife and a travel corridor linking other habitats. Riparian areas also play an important role in our social environment by enhancing our recreational experience and providing educational opportunities. ERO recommends including plant species native to Colorado in the project design that are adapted to the stream corridor that occurs in the project area. Site access, watering needs, and long-term maintenance should also be considered and incorporated into the project design.

Overall, the vegetative diversity throughout the northern portion of the project area is moderate with a wider terrace currently supporting wetland/riparian habitat and limited opportunities for enhancement. The vegetative diversity through the southern portion of the project area is low with several areas that have potential for wetland and riparian restoration and enhancement along the southern bank of the Yampa River in the project area. The riparian vegetation along the southern bank of the Yampa River is limited due to the encroachment of agricultural land. The banks are vertical in many locations and offer an opportunity for restoration and enhancement. At certain locations, it appears possible to lay back the banks to establish wetland shelves by planting native wetland vegetation in the form of live willow stakes, herbaceous wetland plugs, and wetland species seeds, which will help to increase the ecological function of the banks and increase wetland and riparian habitat. Additional locations along the banks should be stabilized to protect against erosion (Photo 3 and Photo 4).

The uplands in the project area have low-quality ecological functions; however, the uplands make up a small percent of the project area. ERO recommends controlling noxious weeds in the project area and replanting areas that have been treated for noxious weeds with a native upland grass seed mix. Additionally, ERO recommends enhancing the overstory along the southern banks of the Yampa River channel. Planting additional trees and shrubs, such as narrowleaf cottonwood, coyote willow, snowberry, golden currant, and Woods' rose, would help enhance the overstory and provide additional shade as well as create additional wildlife habitat along the channel. Any enhancement opportunities in the riparian corridor abutting the Yampa River would help support this area as a wildlife corridor for the larger surrounding ecosystem.

Sincerely,

Anna Wistrom

Anna Wistrom
Biologist

Attachments: Figure 1 and Figure 2; Photo Log

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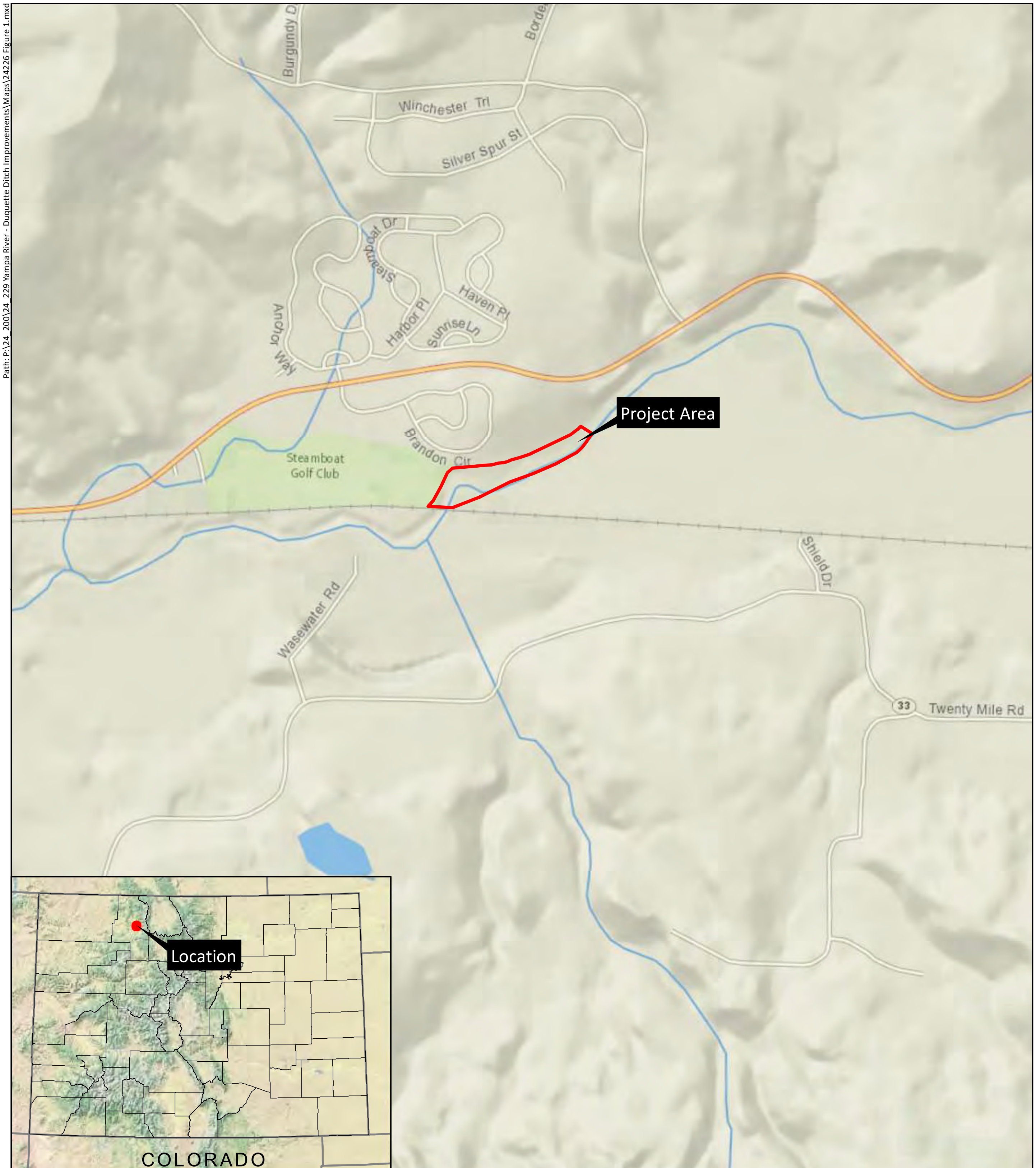
Path: P:\24_200\24_229 Yampa River - Duquette Ditch Improvements\Maps\24226 Figure 1.mxd



Yampa River – Duquette Ditch Improvements

Section 3, T6N, R85W; 6th PM

UTM NAD 83: Zone 13N; 338771mE, 4485269mN

Longitude 106.90278°W, Latitude 40.502475°N

USGS Mad Creek, CO Quadrangle

Routt County, Colorado

0 750 1,500 feet

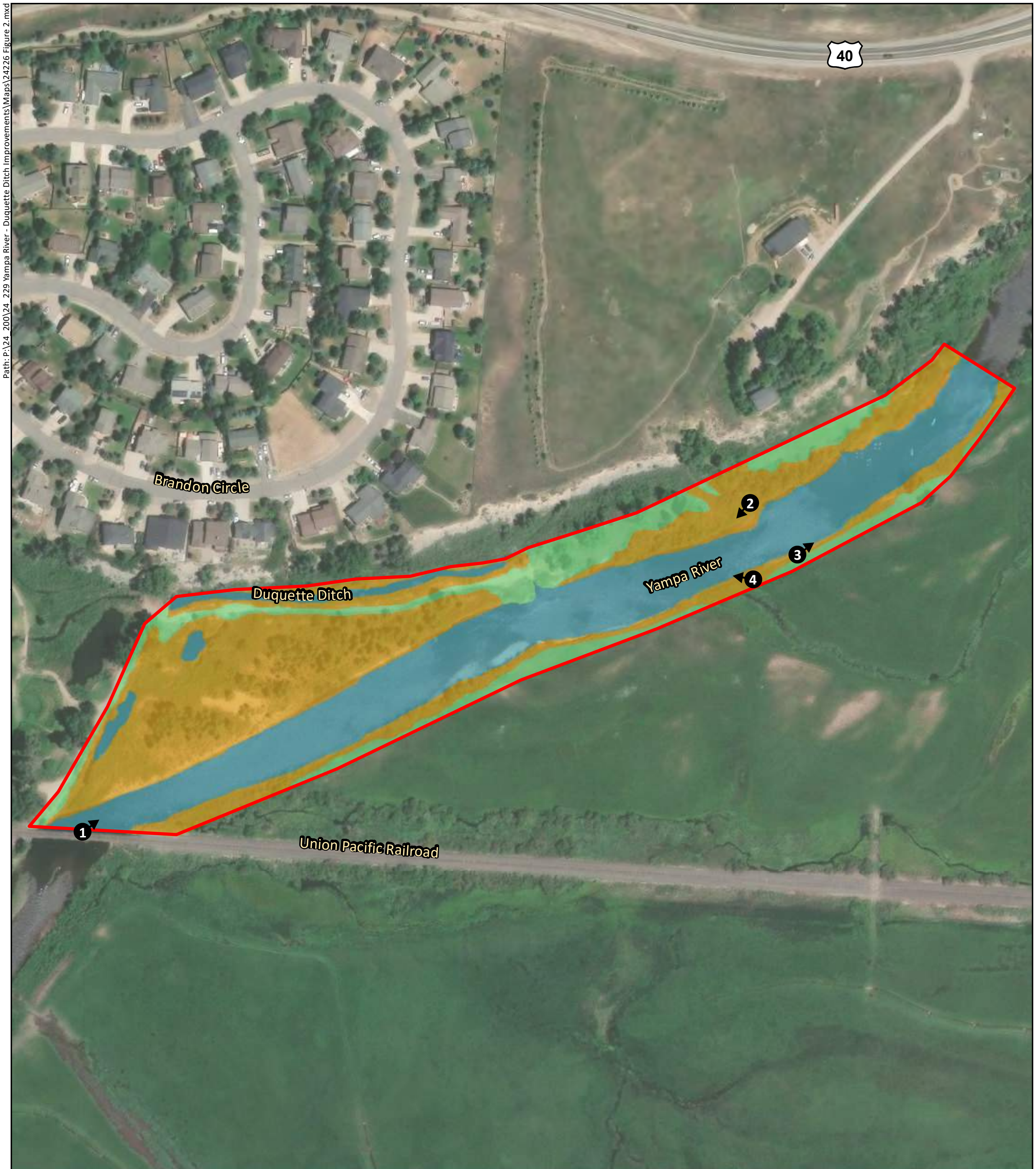
N

Figure 1
Vicinity Map

Prepared for: Otak, Inc.
File: 24226 Figure 1.mxd [dlH]
October 10, 2024

ERO Resources Corp.

Path: P:\24_200\24_229 Yampa River - Duquette Ditch Improvements\Maps\24226 Figure 2.mxd



Yampa River – Duquette Ditch Improvements

- Project Area
- Photo Point
- Open Water (4.04 ac)
- Riparian/Wetland (4.87 ac)
- Upland Grassand (1.63 ac)

0 125 250 feet

N

Figure 2
Existing Conditions

Prepared for: Otak, Inc.
File: 24226 Figure 2.mxd [dlH]
October 10, 2024

ERO Resources Corp.

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Photo 1 - The Yampa River in the southern portion of the project area. The riparian vegetation community can be observed on the northern bank of the river. View is to the northeast.

Photo 2 - Wetland vegetation community on cobble bar along the Yampa River. View is to the southwest.

Photo 3 - Prominent erosion and wetland vegetation along the Yampa River. View is to the northeast.

Photo 4 - Upland vegetation community and wetland vegetation community in the southern portion of the project area. View is to the northwest.

APPENDIX B

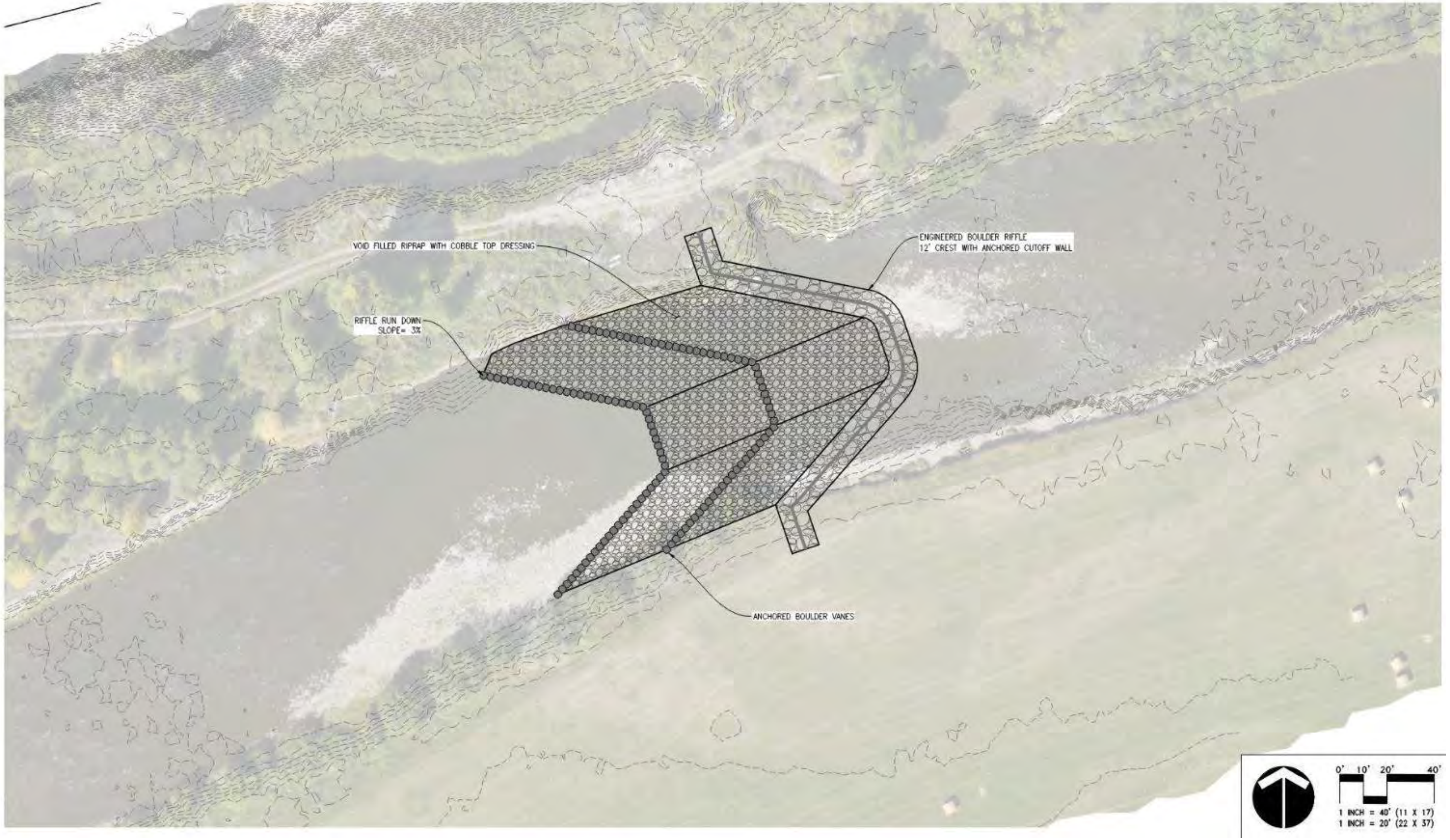
DUQUETTE DITCH CONCEPTS

Concepts Considered

- Alternative 1 – Engineered Riffle with Concrete Cutoff Wall and Stabilizing Vanes
- Alternative 2- Grouted Boulder Grade Control with Concrete Cutoff Wall and Sluice Gate
- Alternative 3- Concrete Grade Control with Obermeyer Gates, New Headgate and Sediment Bypass Sluice

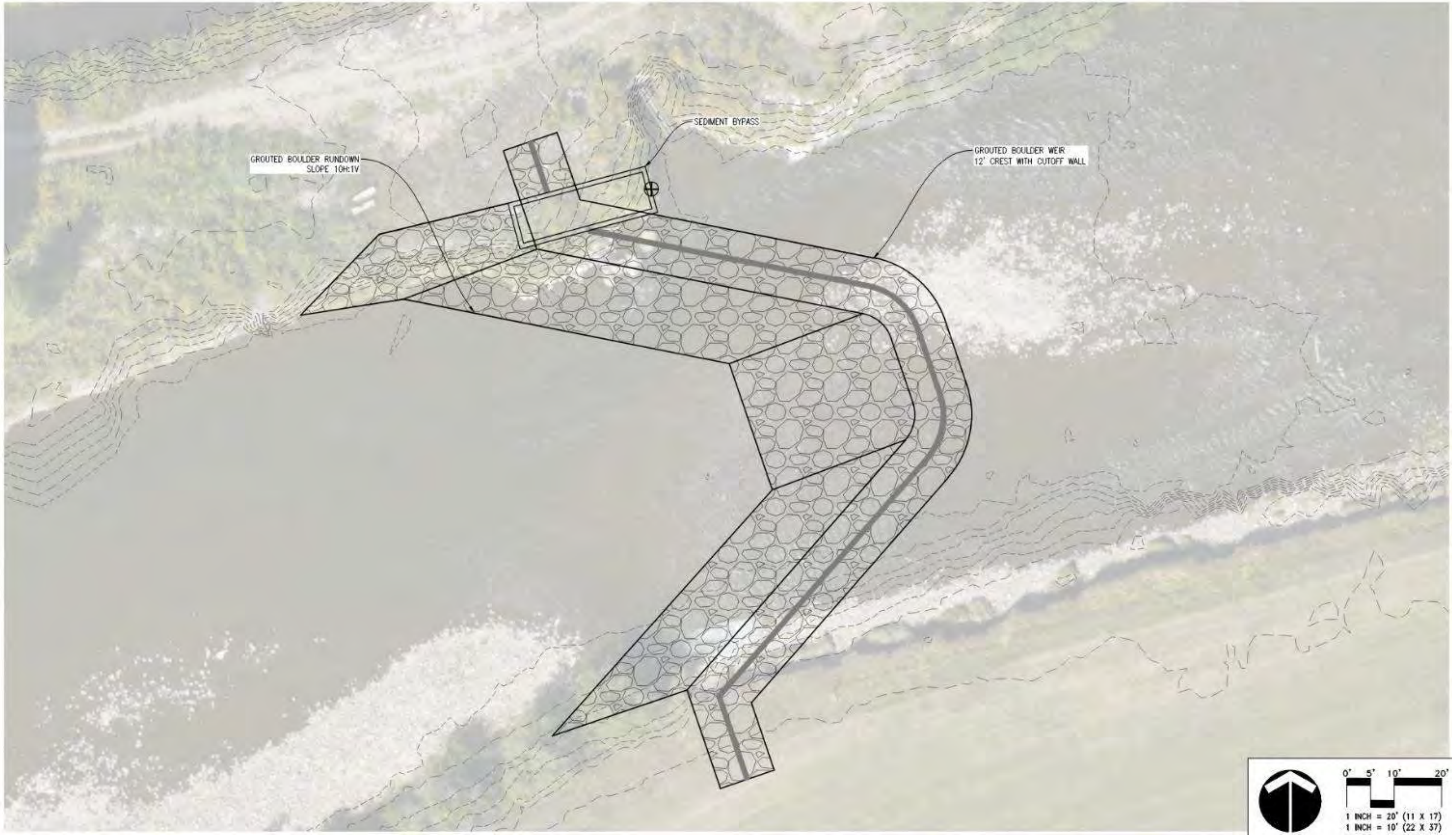
Note: New headgates and/or sediment by-pass structures can be included in any of the alternatives (a.k.a. “Mix-and-Match”).

Alternative 1 – Engineered Riffle with Concrete Cutoff Wall and Stabilizing Vanes



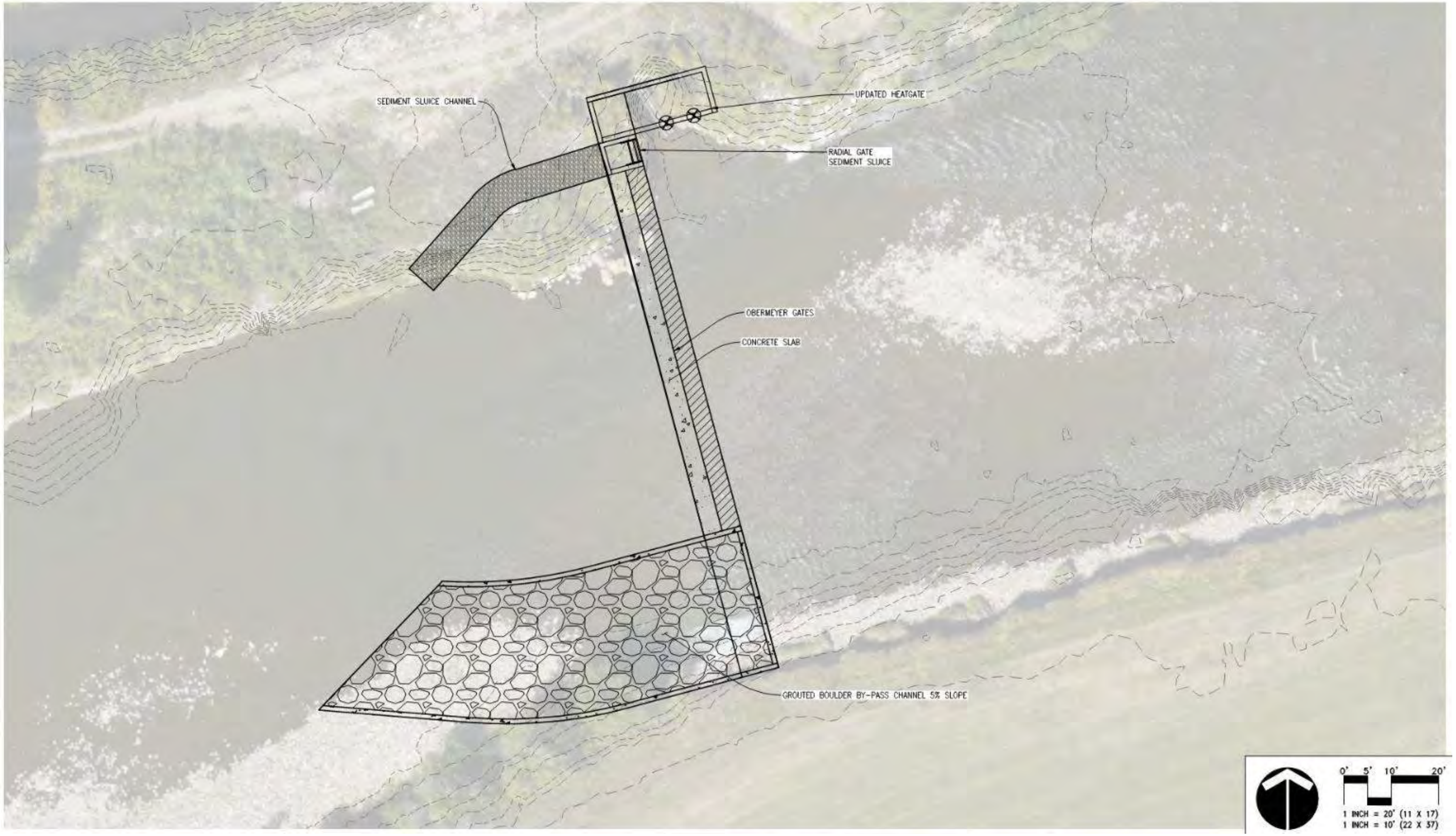
Alternative 1 – Engineered Riffle with Concrete Cutoff Wall and Stabilizing Vanes

Alternative 2- Grouted Boulder Grade Control with Concrete Cutoff Wall and Sluice Gate



Alternative 2- Grouted Boulder Grade Control with Concrete Cutoff Wall and Sluice Gate

Alternative 3- Concrete Grade Control with Obermeyer Gates, New Headgate and Sediment Bypass Sluice



Alternative 3- Concrete Grade Control with Obermeyer Gates, New Headgate and Sediment Bypass Sluice

APPENDIX C

15% DESIGN PLANS

YAMPA RIVER AT DUQUETTE DITCH

15% DESIGN
NOT FOR CONSTRUCTION
STEAMBOAT SPRINGS, COLORADO

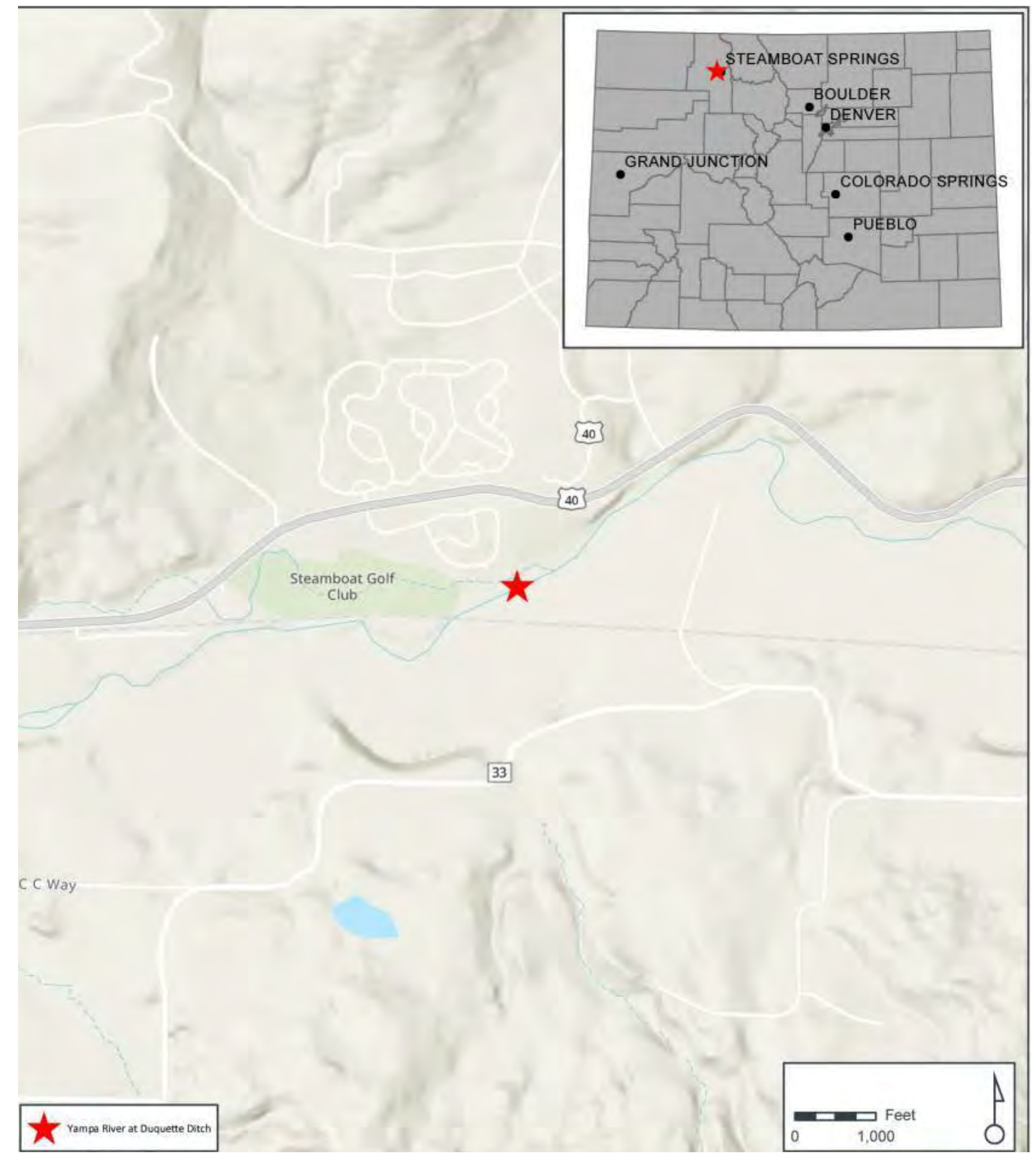
Know what's **below.**
Call before you dig.

CLIENT CONTACT:
COMMUNITY AGRICULTURE ALLIANCE
PO BOX 774134
STEAMBOAT SPRINGS, COLORADO 80477

PROJECT CONTACT:
OTAK, INC.
371 CENTENNIAL PARKWAY SUITE 210
LOUISVILLE, CO, 80027
TRACY EMMANUEL (PROJECT MANAGER)
TRACY.EMMANUEL@OTAK.COM
720.758.7723
CHRIS ROMEYN, PE (PROJECT ENGINEER)
CHRIS.ROMEYN@OTAK.COM
720.758.7751

INDEX OF SHEETS

REPRESENTATIVE PICTURE OF EXISTING CONDITIONS



NOT FOR CONSTRUCTION - 15% DESIGN - MAY 2025

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Print Date:
File Name:
Horiz. Scale: NA Vert. Scale: NA

Otak

Sheet Revisions		
Date:	Comments	Init.

COMMUNITY AGRICULTURE ALLIANCE

No Revisions:
Revised:
Void:

Contract Information
Contractor:
PROJECT STARTED: / / ACCEPTED: / /
Comments:

Project No./Code
21136
–
Sheet Number G1

NOTES:
1. –

0' 40' 80' 160'
1 INCH = 160' (11 X 17)
1 INCH = 80' (22 X 37)

NOT FOR CONSTRUCTION - 15% DESIGN - MAY 2025

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Horiz. Scale: NA Vert. Scale: NA

Otak

Sheet Revisions

Date:	Comments	Init.

COMMUNITY · AGRICULTURE · ALLIANCE

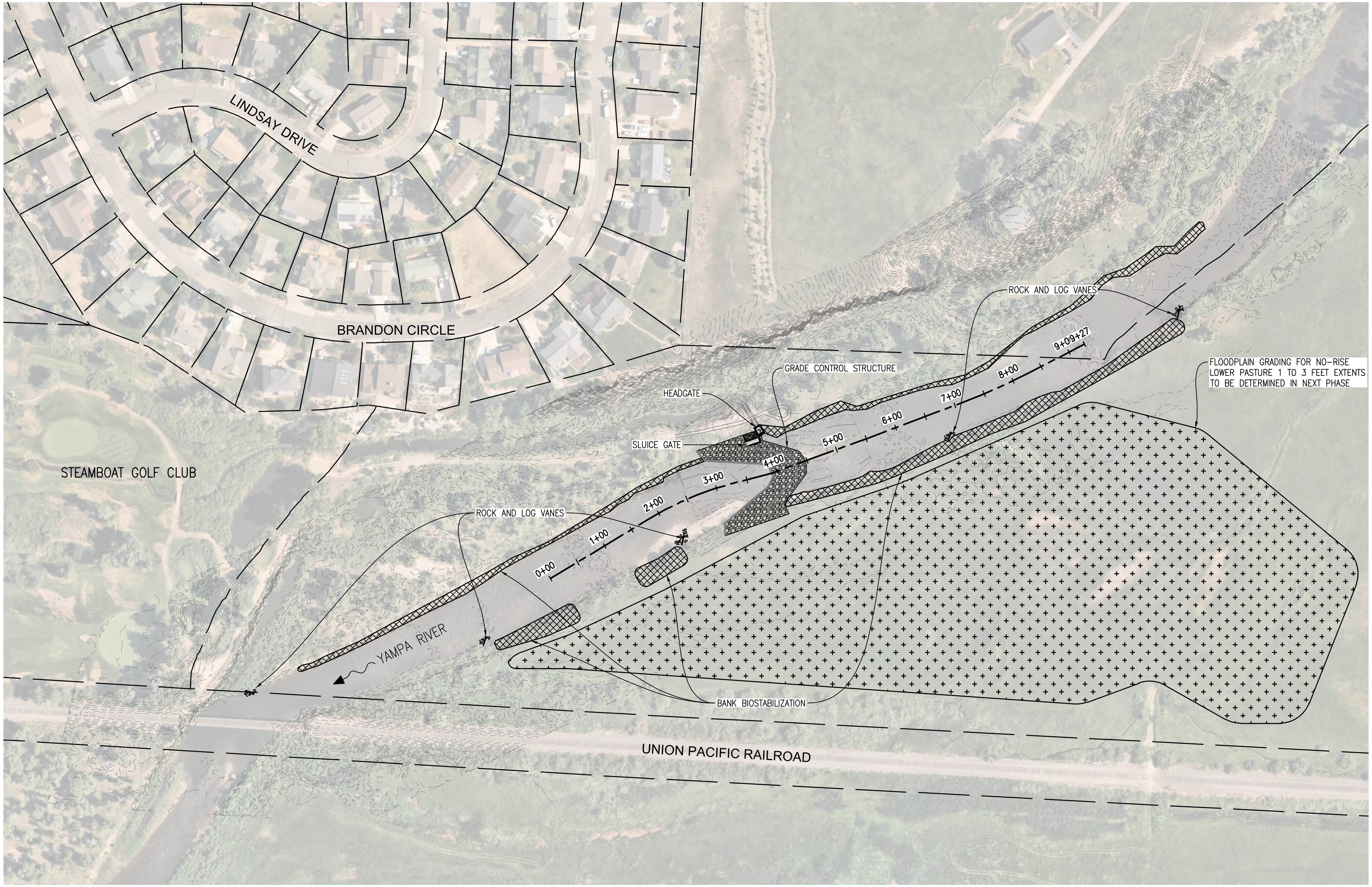
No Revisions:
Revised:
Void:

YAMPA RIVER AT DUQUETTE DITCH
EXISTING CONDITIONS PLAN

Designer:	CR	Structure Numbers	
Detailer:	MC2		
Sheet Subset:	EXPLN	Subset Sheets:	1 of 1

Project No./Code
21136
–
Sheet Number C1

NOTES:
1. –



0' 40' 80' 160'

1 INCH = 160' (11 X 17)
1 INCH = 80' (22 X 37)

NOT FOR CONSTRUCTION - 15% DESIGN - MAY 2025

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Print Date: May 15, 2025
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Horiz. Scale: As Noted Vert. Scale: As Noted

Otak

Sheet Revisions		
Date:	Comments	Init.

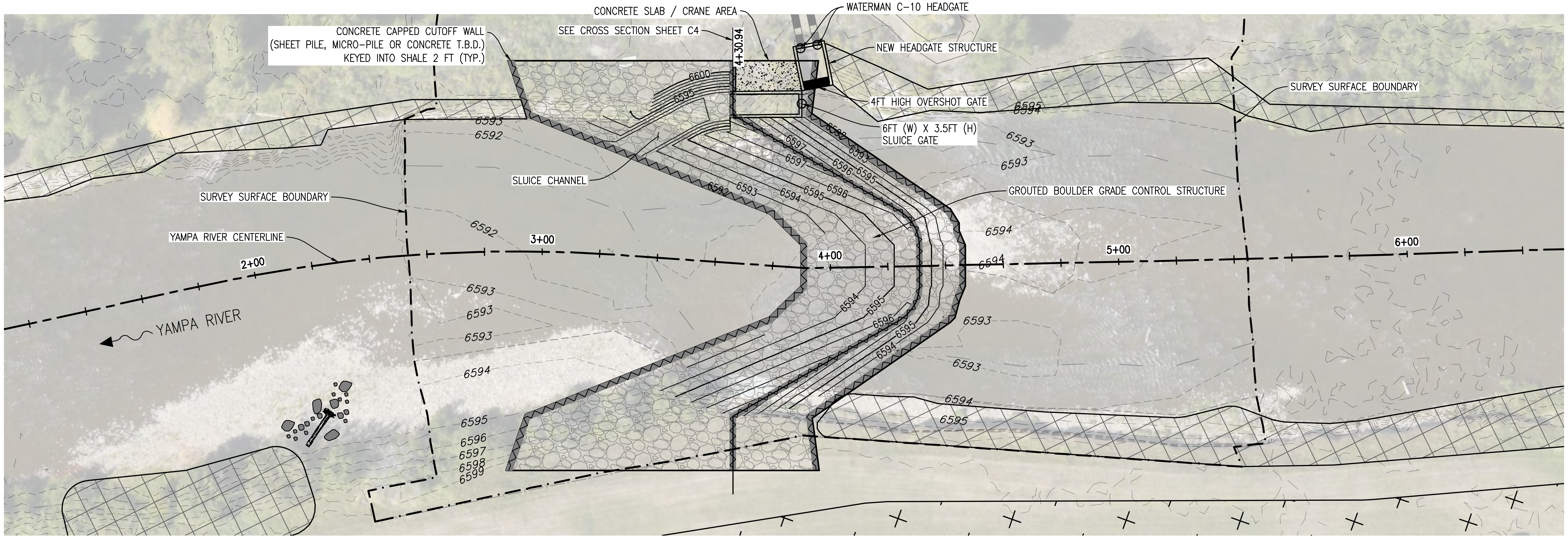
COMMUNITY · AGRICULTURE · ALLIANCE

No Revisions:
Revised:
Void:

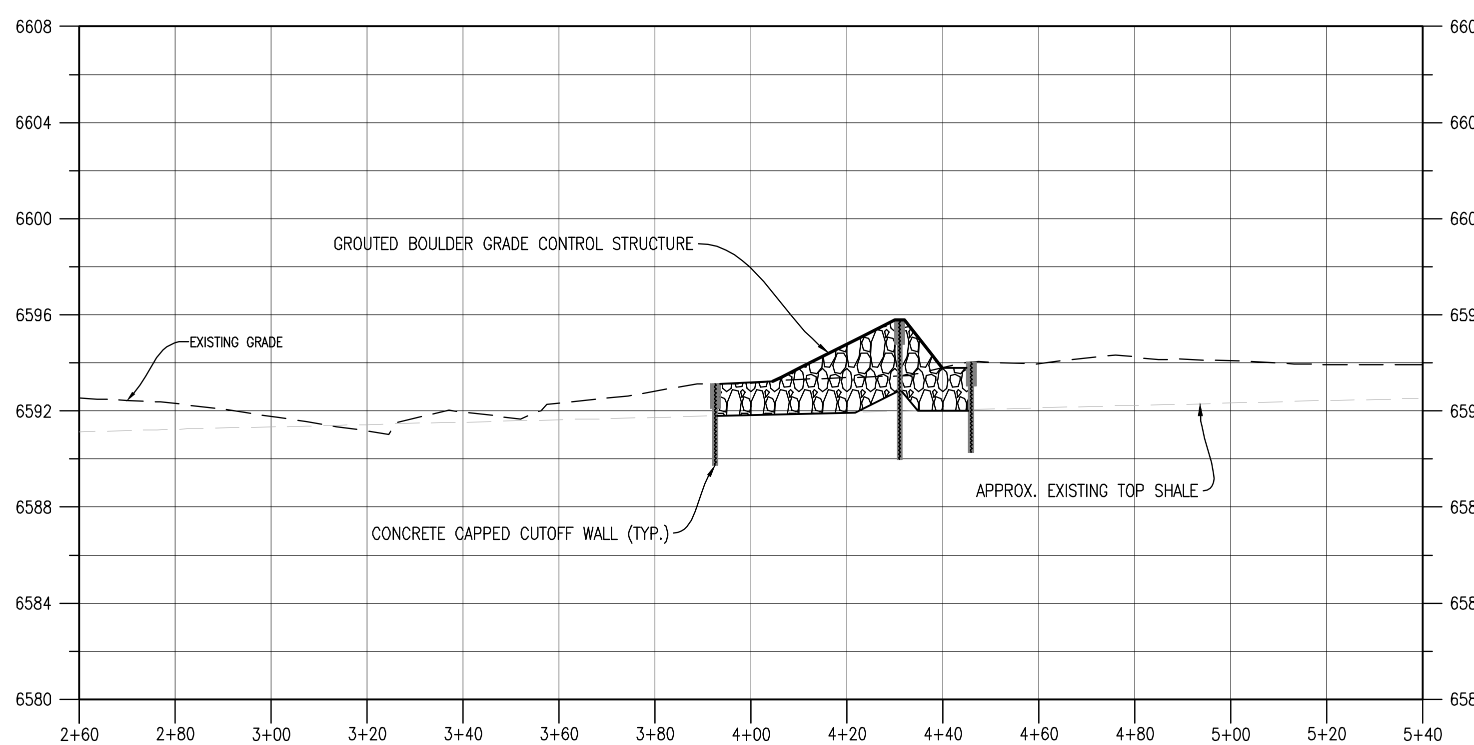
YAMPA RIVER AT DUQUETTE DITCH
PROPOSED CONDITIONS PLAN

Designer:	CR	Structure Numbers	
Detailer:	MC2		
Sheet Subset:	PRPLN	Subset Sheets:	1 of 1

Project No./Code
21136
–
Sheet Number C2



PLAN



PROFILE

(TAKEN ALONG HCL) HORIZ. SCALE 1"=40' VERT. SCALE 1"=2' 5X VERTICAL EXAGGERATION

NOTES:
1. -

NOT FOR CONSTRUCTION - 15% DESIGN - MAY 2025

0' 10' 20' 40'
1 INCH = 40' (11 X 17)
1 INCH = 20' (22 X 37)

O:\PROJECT\21100\21136\04 CAD\ACAD\Dwg\21136-007-P&P Drop Structure.dwg | SHT01 | Michael.Carlson | May 15, 2025 - 12:08pm

Print Date: May 15, 2025
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Horiz. Scale: As Noted Vert. Scale: As Noted

Otak

Sheet Revisions		
Date:	Comments	Init.

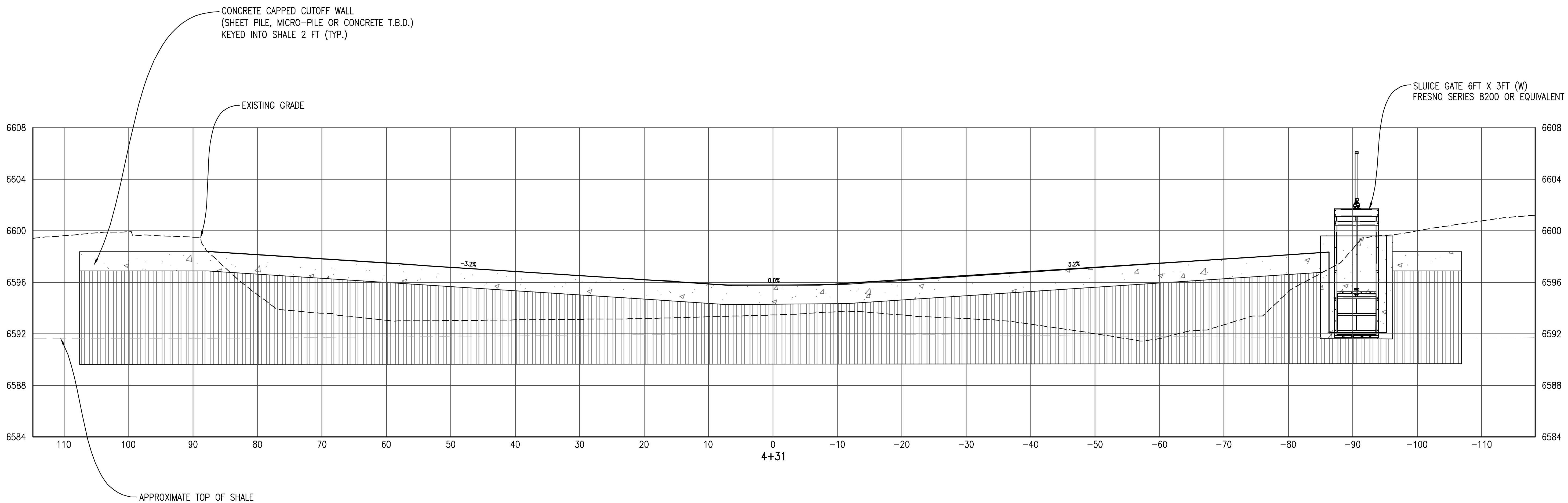
COMMUNITY · AGRICULTURE · ALLIANCE

No Revisions:
Revised:
Void:

YAMPA RIVER AT DUQUETTE DITCH GRADING PLAN AND PROFILE

Designer:	CR	Structure Numbers	
Detailer:	MC2		
Sheet Subset:	1 of 1	Subset Sheets:	GRDP&P

Project No./Code
21136
–
Sheet Number C3



CROSS SECTIONS – HORIZ. SCALE 1"=8' VERT. SCALE 1"=4' 2X VERTICAL EXAGGERATION

NOT FOR CONSTRUCTION - 15% DESIGN - MAY 2025

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Print Date: May 15, 2025
File Name: 21136-008-Channel XSEC.dwg
Horiz. Scale: As Noted Vert. Scale: As Noted

Otak

Sheet Revisions		
Date:	Comments	Init.

No Revisions:
Revised:
Void:

YAMPA RIVER AT DUQUETTE DITCH
CROSS SECTIONS
GRADE CONTROL STRUCTURE

Designer:	CR	Structure Numbers	
Detailer:	MC2		
Sheet Subset:	1 of 1	Subset Sheets:	XSEC

Project No./Code
21136
–
Sheet Number C4

LEGEND

PLANTING ZONE

NOTES:
1. PLANTING TO CONSIST OF WETLAND PLUGS, WILLOW STAKES, AND RIPARIAN TREES AND SHRUBS.
2. WETLAND PLUGS TO BE PLANTED NO MORE THAN 1 FOOT ABOVE THE CHANNEL INVERT. RIPARIAN TREES, SHRUBS, AND SEED MIX TO BE PLANTED ABOVE WETLANDS PLUGS AND WILLOW STAKES.

0' 15' 30' 60'

1 INCH = 60' (11 X 17)
1 INCH = 30' (22 X 37)

NOT FOR CONSTRUCTION - 15% DESIGN - MAY 2025

O:\PROJECT\21100\21136\04 CAD\ACAD\Dwg\21136-013-Planting Plan.dwg | SHT02 | Michael.Carlson | May 15, 2025 - 12:08pm

Print Date: May 15, 2025
File Name: 21136-013-Planting Plan.dwg
Horiz. Scale: NA Vert. Scale: NA

Otak

Sheet Revisions		
Date:	Comments	Init.

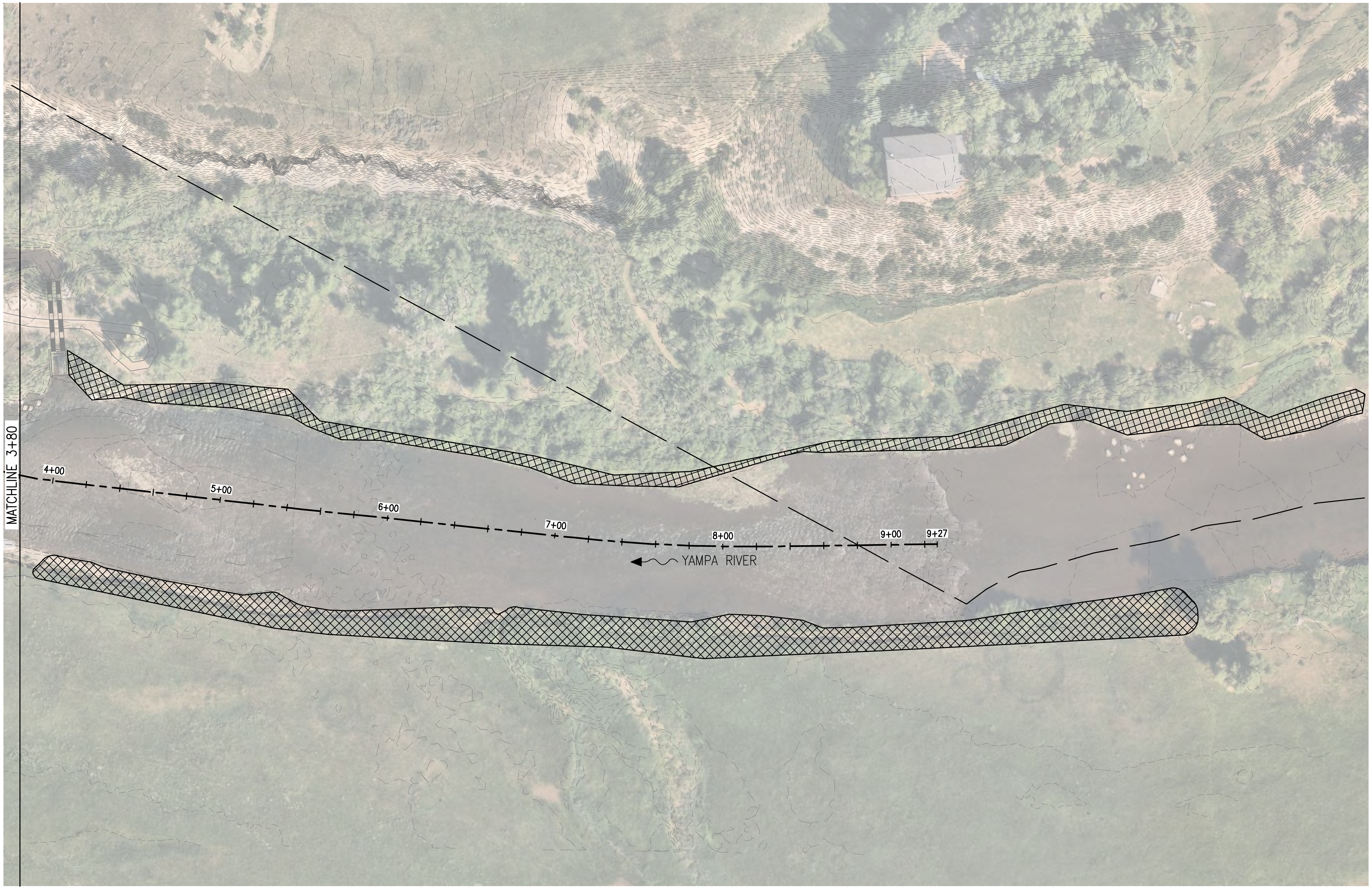
COMMUNITY · AGRICULTURE · ALLIANCE

No Revisions:
Revised:
Void:

YAMPA RIVER AT DUQUETTE DITCH
PLANTING PLAN

Designer: CR	Structure Numbers		
Detailer: MC2			
Sheet Subset: PLNTPLN	Subset Sheets:	1 of 2	

Project No./Code
21136
–
Sheet Number L1



LEGEND

PLANTING ZONE

NOTES:

1. PLANTING TO CONSIST OF WETLAND PLUGS, WILLOW STAKES, AND RIPARIAN TREES AND SHRUBS.
2. WETLAND PLUGS TO BE PLANTED NO MORE THAN 1 FOOT ABOVE THE CHANNEL INVERT. RIPARIAN TREES, SHRUBS, AND SEED MIX TO BE PLANTED ABOVE WETLANDS PLUGS AND WILLOW STAKES.

NOT FOR CONSTRUCTION - 15% DESIGN - MAY 2025

0' 15' 30' 60'

1 INCH = 60' (11 X 17)
1 INCH = 30' (22 X 37)

O:\PROJECT\21100\21136\04 CAD\ACAD\Dwg\21136-013-Planting Plan.dwg | SHT03 | Michael.Carlson | May 15, 2025 - 12:08pm

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Sheet Revisions		
Date:	Comments	Init.

COMMUNITY AGRICULTURE ALLIANCE

No Revisions:
Revised:
Void:

YAMPA RIVER AT DUQUETTE DITCH
PLANTING PLAN

Designer: CR
Detailer: MC2
Sheet Subset: PLNTPLN
Structure Numbers
Subset Sheets: 2 of 2

Project No./Code
21136
–
Sheet Number L2

March 30, 2026

Yampa-White-Green Basin Roundtable
Colorado Water Conservation Board
131 Sherman Street, Room 718
Denver, CO 80203

RE: Support for the Duquette Diversion Infrastructure Project (Phase 3)

To: Yampa-White-Green Basin Roundtable Members,

As a primary water right owner and diversion user on the Yampa River, I am writing to express my strongest personal support for the Duquette Diversion Infrastructure Project.

My operations depend directly on the ability to divert water at this location. However, since the channel changes in 1983, we have been forced to manage our water rights under increasingly difficult and unsustainable conditions.

The Challenges We Face

Currently, our lack of permanent in-river infrastructure means that during low-flow periods, we must resort to manually placing concrete road barriers in the channel just to meet our decreed water needs. This is not a viable long-term solution. It is:

- **Operationally Inefficient:** It makes precise water delivery nearly impossible and requires constant, labor-intensive adjustments.
- **Environmentally Damaging:** We recognize that these temporary measures are hard on the river ecology and create unnecessary hazards for the boating community.
- **A Risk to Water Security:** Without modern headworks and grade control, our legal access to water is at the mercy of shifting channel hydraulics and bedrock constraints.

Why Phase 3 is Critical

We have worked closely with the Community Agriculture Alliance and its partners on initial concepts, but we have reached a point where "guesswork" is no longer an option. The unique challenges of this site—specifically the shale bedrock and the influence of the railroad bridge—require the professional geotechnical and hydraulic data that **Phase 3** will provide.

For us, this project isn't just about "river health"—it's about **agricultural and operational resilience.** Refining the diversion infrastructure to a 30% design level will finally provide a roadmap toward:

- Reliable, modernized headworks that eliminate the need for temporary barriers.
- Improved floodplain connectivity that supports our land's productivity.
- A safer, more stable river reach that benefits both our neighbors and recreational users.

Conclusion

This project is a high priority in the 2020 Yampa River Basin IWMP for a reason: it balances the needs of water right holders like myself with the health of the river we all share. I urge you to provide the necessary funding for Phase 3 so we can move toward a permanent, professional solution for this critical diversion.

Sincerely,

Jeb Brewster

District Manager

Steamboat II Metropolitan District

March 27, 2026

Yampa-White-Green Basin Roundtable
Colorado Water Conservation Board
1313 Sherman Street, Room 718
Denver, CO 80203

RE: Support for the Duquette Diversion Infrastructure Project (Phase 3)

To: Yampa River Fund Steering Committee Members,

As a primary water right owner and diversion user on the Yampa River, I am writing to express my strongest personal support for the Duquette Diversion Infrastructure Project.

My operations depend directly on the ability to divert water at this location. However, since the channel changes in 1983, we have been forced to manage our water rights under increasingly difficult and unsustainable conditions.

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Sincerely,

Michael Hogue
Houge Family Ranch, LLC