NORTH PLATTE RIVER CHOKEPOINT
EVALUATION OF ALTERNATIVES

Prepared in Support of the
Platte River Recovery Implementation Program

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RIVER WORKS

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EXECUTIVE SUMMARY

Releases from the Lake McConaughy Environmental Account (EA) for specific scientific or species-related purposes have been identified as critical to achieving Program goals in the Associated Habitat Reach (AHR) on the central Platte River. Conveyance of EA water is constrained by the flow capacity in the lower 10 miles of the North Platte River, referred to as the "Chokepoint."

Reduced hydraulic capacity at the Chokepoint is a significant problem that has spanned more than two decades. Several studies have been undertaken to develop a solution to increase and maintain hydraulic capacity. The current study was conducted to provide a review of previous work, a comprehensive geomorphic and sediment transport assessment of the Chokepoint reach, and a screening and evaluation of alternatives to increase hydraulic capacity to a target flow of 3,000 cfs at or below minor flood stage (6.0 feet) as defined by the NWS.

GEOMORPHOLOGY AND SEDIMENT TRANSPORT

A comprehensive geomorphic and sediment transport assessment of the Chokepoint was conducted to identify and describe the physical processes that have contributed to the geomorphic evolution of the North Platte River Between Lake McConaughy and the Tri-County Canal Diversion over the last century with focus on the Chokepoint. A key conclusion from the geomorphology and sediment transport study is Lake McConaughy and the TCCD have altered flow and sediment regimes in the Chokepoint and appear to be the primary drivers of channel aggradation and the long-term reduction in hydraulic capacity at Highway 83. The geomorphic assessment showed that tailwater conditions at the TCCD to facilitate diversions have slowed and/or blocked movement of bed sediments through the system, resulting in the formation of the "sediment wedge" as far upstream as HWY 83. The accumulation of sediment in the channel has increased water levels, flattened the channel gradient, lowered shear stress and ultimately reduced hydraulic capacity.

The assessment also concluded that the North Platte River Chokepoint reach has been in a quasi-equilibrium state for roughly 20 years. Assuming that there are no significant changes in upstream reservoir operations, vegetation control, diversions and dredging at the TCCD, or climate shifts, the Chokepoint reach is expected to remain in a quasi-equilibrium state into the future. Currently, the average hydraulic capacity at minor flood stage is expected to remain at about 1,700 cfs, with a range between 1,550 and 2,150 cfs, depending on flow conditions.

PHASE I ALTERNATIVE SCREENING

Phase I Alternatives Screening included a review of all prior studies, documents, and previously developed alternatives related to the North Platte River Chokepoint. A list of 62 alternatives that have been considered in the previous 20 years was compiled and reviewed. Alternatives were grouped into eight categories including: implemented projects, sediment management, channel modification/construction, flow bypass, vegetation control, flood control, flood easements/property buyouts, and new alternatives. After review and discussion by the EDO and ACE project team a short list of alternatives proposed for Phase II screening was developed.

PHASE II ALTERNATIVES SCREENING

Phase II alternative screening included investigation of the short-listed items identified in Phase I which included: 1) no-action, 2) South Platte reservoir storage, 3) reduction of upstream sediment sources, 4) purchase of existing irrigation infrastructure for bypass, 5) construction of a bypass canal, and 6) channel modification/sediment removal. Additional concepts that could enhance standalone alternatives also considered included modification of the Tri-County Canal Diversion (TCCD). An initial screening and review of the shortlisted alternatives was developed to provide information to the EDO and Chokepoint Planning Workgroup to decide which alternatives should be studied in more detail as part of the final phase of the project.

The shortlist of alternatives was further reduced based on discussions between the EDO and ACE team and feedback from the workgroup. Alternatives retained for further evaluation in Phase III of the project included the no-action, bypass canal, and channel modification/sediment removal alternative. Modification of the TCCD was also moved on to Phase III.

South Platte Storage

Note that the additional information related to the South Platte reservoir storage alternative was included in this report as part of Phase II. Given the Program's "good neighbor" policy and lack of condemnation authority, past experience (e.g., the J-2 Regulating Reservoirs project) demonstrates that the Program would be unable to accomplish a reservoir storage project at an effective scale without stakeholder or other outside sponsorship. Lacking this authority, further evaluation of the South Platte Storage alternative was not pursued for this study.

PHASE III ALTERNATIVE EVALUATIONS

Phase III evaluations included further investigation of the sediment removal, modification of the TCCD, and bypass canal alternatives.

No Action Alternative

The no-action alternative is a continuation of existing river management at the Chokepoint including vegetation control and CNPPID dredging at the Tri-County Canal Diversion (TCCD). Evaluation of the no-action alternative was based on results of the geomorphic assessment and additional sediment transport modeling. Results indicate that the Chokepoint reach is likely to remain in quasi-equilibrium assuming that flow characteristics, sediment supply trends, and diversion and dredging operations at the TCCD are consistent with those of the past 20 years. Under the no-action alternative average hydraulic capacity at minor flood stage is expected to remain at about 1,700 cfs, with a range between 1,500 and 2,150 cfs.

Note that a sustained flow event, probably greater than the peak flow and duration of the most recent flood in 2011, would likely disrupt the quasi-equilibrium state.

Even though existing hydraulic capacity is expected to continue with no-action, it should be noted that the no-action alternative does not allow the Program to convey and maintain 1,500 cfs when irrigation demand is highest. In periods of drought and heat, when both irrigation and EA flows (usually for germination suppression) are most urgently needed, EA releases and irrigation demand are in direct competition with each other. At present, the demand for irrigation takes precedence over EA releases.

Sediment Removal Alternative

The primary barrier to increasing hydraulic capacity through the Chokepoint is the presence of accumulated sediment or the "sediment wedge" that has formed between HWY 83 and the TCCD. Removing sediment from the channel is the most effective way to increase hydraulic capacity. Assuming existing diversion and dredging operations continue at the TCCD, and upstream sediment sources remain unchanged, sediment will undoubtedly redeposit in removal areas over time.

The concept design of the sediment removal alternative includes excavation of a 150 wide channel beginning at the TCCD and extending upstream for 6.2 miles. The channel slope restores the historic bed profile and slope. The total volume of excavation, determined from design grading, is 1,170,000 CY. The sediment removal alternative can achieve and sustain hydraulic capacity at HWY 83 of 3,000 cfs under minor flood stage for roughly 2 to 3 decades without additional sediment removal. This would allow reduced flooding and conveyance of flows of 3,000 cfs, and potentially as high as 5,000 cfs, to be conveyed through the North Platte without exceeding minor flood stage. This assumes that hydrologic conditions, sediment supply trends, and diversion and dredging operations at the TCCD of the previous 20 years continue without drastic change. Sediment removal of this magnitude would require a significant capital investment. Due to uncertainty in the modeling it would be reasonable to provide additional hydraulic capacity above the target to minimize the risk of loosing hydrualic capacity in the future. A smaller extent of excavation could be conducted but would require an additional round of sediment removal within the same time frame of 2 to 3 decades and would not be likely to reduce long term costs.

Although this alternative can meet and exceed the hydraulic capacity targets there are several issues associated with implementation, as listed below.

- **Permitting:** This alternative would require an Individual CWA Section 404 Permit, environmental assessment (EA), and potentially an environmental impact statement (EIS). Securing a permit would be difficult given the impacts to riparian wetlands, wetland mitigation requirements, and the potential for other less environmentally damaging alternatives (e.g. a bypass canal).

- **Private Land Parcels:** The sediment removal alternative is located on a total of 49 privately owned parcels. Given the Program's "good neighbor" policy and lack of condemnation authority landowner approval and participation would be required. Agreements with all private landowners for construction would be necessary for consistent sediment removal.

- **Staging and Disposal of Sediment:** The sediment removal alternative requires removal of roughly 1 million CY of material. Identification of staging areas and material disposal sites within a reasonable distance is a significant challenge. CNPPID has experienced difficulties finding locations to store or dispose of material dredged at the TCCD. They currently have roughly 300,000 CY of dredged sediments for which disposal has been problematic. This issue could drive costs up significantly.

- **Constructability:** The logistics of effectively removing sediment from the project reach using heavy equipment in wet conditions is possible but would be challenging. Unknowns related to logistics of construction, including but not limited to access, staging, re-routing of flow, use of heavy equipment, and material disposal could increase costs.

- **Capital Cost:** The estimated capital cost for this alternative is approximately 37 million dollars. Due to uncertainties, the estimated cost is considered to be at the lower end of the range of possibilities.

Modification of the Tri-County Canal Diversion

Modification of the Tri-County Canal Diversion (TCCD) for more efficient sediment passage was considered as an alternative to increase hydraulic capacity at HWY 83 or as an enhancement to the sediment removal alternative. Without disrupting current operations and diversion practices modification of the TCCD structure would not likely improve existing conditions or enhance performance of sediment removal alternatives.

It is our opinion that modification to the TCCD is not a practical alternative largely due to the lack of flows high enough to sufficiently pass sediment downstream and limitations associated with year-round diversions that require roughly 9 to 10 feet of headwater. Under current operations modification of existing gates would not provide added benefit given that existing gates are sufficient to sluice large flows and sediment. In addition, modification of the structure could create potential difficulties related to upstream migration of invasive aquatic species. Modification of the TCCD structure was estimated in Phase II of this study at $21 million, which is a large investment for an alternative that has not yet been proven beneficial under current limitations.

Bypass Canal Alternative

A dedicated bypass canal would provide diversion of 1,500 cfs around the Chokepoint. This combined with hydraulic capacity through the Chokepoint of 1,500 cfs would meet the 3,000 cfs targe flow without exceeding minor flood stage at HWY 83. This would reduce, but not eliminate, conflict between conveyance of 1,500 cfs in the North Platte of EA flows and irrigation demand during hot/dry conditions. There is also potential for the bypass canal to be utilized for other diversion purposes and/or groundwater recharge.

The bypass canal alternative has an estimated capital cost of $31 million and long-term annual maintenance costs of roughly $400,000. Construction of the bypass canal would require acquisition of private land and easements that would impact a total of 23 privately owned parcels. Given the Program's "good neighbor" policy and lack of condemnation authority landowner approval and participation would be key to successful implementation.

1 INTRODUCTION

The Platte River Recovery Implementation Program (PRRIP or Program) was established on January 1, 2007 by Nebraska, Wyoming, Colorado and the Department of the Interior to address endangered species issues in the central and lower Platte River Basin. Program "target species" include the whooping crane, piping plover, least tern (now delisted) and pallid sturgeon. Species recovery through habitat creation and maintenance within the Platte River Basin has been the focus of the Program.

Releases from the Lake McConaughy Environmental Account (EA) for specific scientific or species-related purposes have been identified as critical to achieving Program goals in the Associated Habitat Reach (AHR) on the central Platte River. Conveyance of EA water is constrained by the flow capacity in the lower 10 miles of the North Platte River, referred to as the "Chokepoint." With the Chokepoint geographically located between the Lake McConaughy EA (upstream) and the AHR (downstream), this can limit the Program's ability to deliver water under certain hydrologic conditions (e.g., dry) and operational scenarios (e.g., high irrigation demand).

Reduced hydraulic capacity at the Chokepoint is a significant problem that has spanned more than two decades. Several studies have been conducted to develop a solution to increase and maintain hydraulic capacity. Although the Program has successfully implemented two flood control projects that have proven beneficial, a comprehensive and practical alternative solution that increases and maintains hydraulic capacity, makes economic sense, is widely accepted by local landowners, and has been demonstrated to be effective with a very high degree of confidence has yet to be found.

As directed in the Program Document as modified for the First Increment Extension, the Program continues its efforts to achieve and maintain hydraulic capacity of 3,000 cfs on the North Platte River at the Chokepoint below minor flood stage, which is defined by the National Weather Service (NWS) as 6.0 ft at the North Platte River at North Platte (06693000) gage adjacent to the Highway 83 bridge. Since the late 1980s, hydraulic capacity through the Chokepoint has been significantly reduced and is now on the order of 1,750 cfs.

The Program selected Anderson Consulting Engineers Inc. (ACE) to perform the current North Platte River Chokepoint Engineering Service Project (project) in May 2023. The ACE team's work includes review of previously developed alternatives and studies, a geomorphic and sediment transport assessment, hydraulic and sediment transport modeling, and development and evaluation of alternatives. This report summarizes the identification, screening, and development of alternative solutions to meet Program goals related to the Chokepoint.

1.1 Study Reach

The Chokepoint study area is located along the lower 10 miles of the North Platte River and extends from the Tri-County Canal Diversion (TCCD) on the Platte River to approximately 5.5 miles upstream of State Highway 83 (HWY 83), see Figure 1-1. This section of the North Platte River runs along the northern boundary of the City of North Platte, Nebraska. Notable locations within the study reach include the Buffalo Bill Campground, Rivers Edge Golf Course, HWY 83 Bridge, HWY 83 Gage, Cody Park, the Union Pacific Railroad Bridge, the Highway 30 Bridge (HWY 30), and the Tri-County Diversion Structure (TCCD).

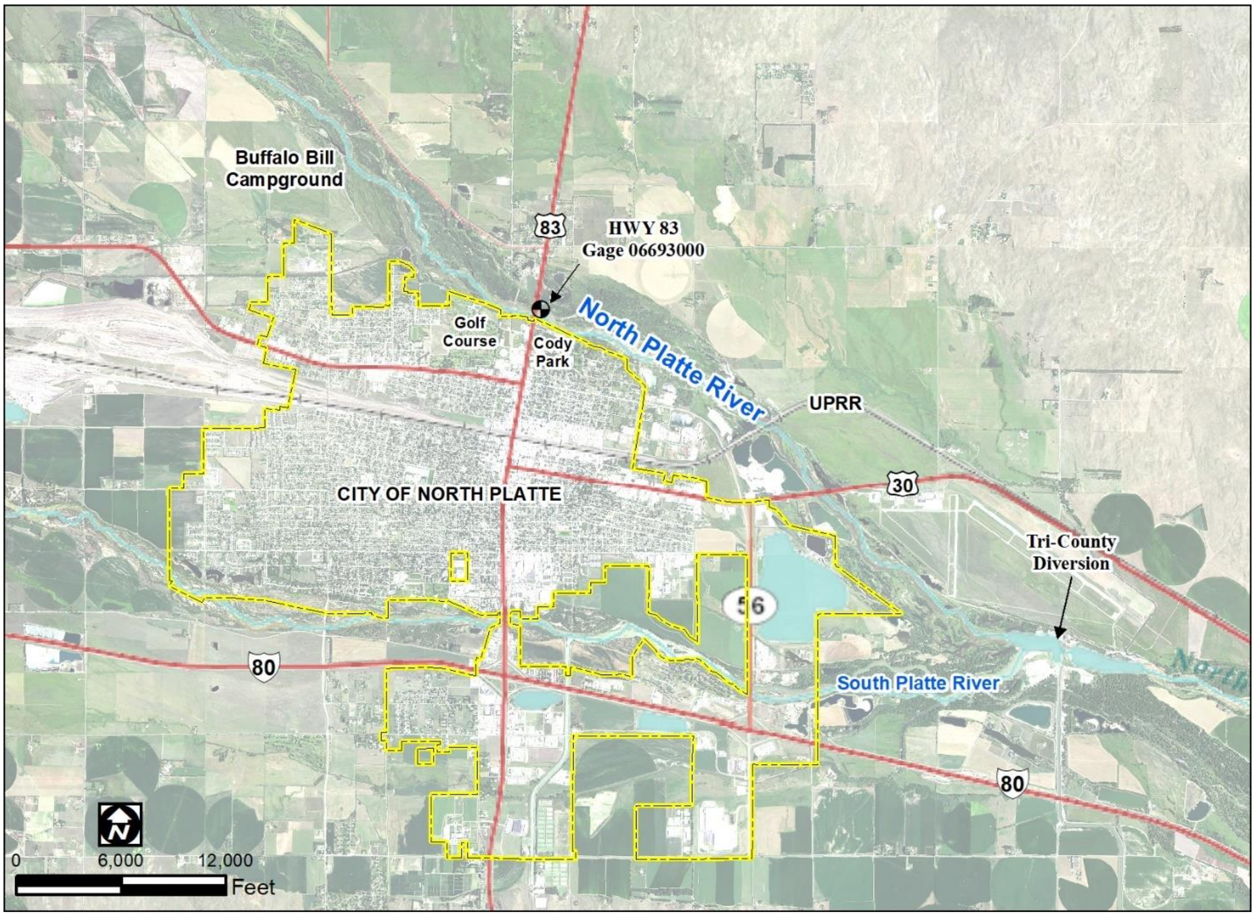


Figure 1-1 North Platte River Chokepoint Study Reach

1.2 Project Goal and Constraints

In August 2023, a project charter was prepared by the Program Executive Director's Office (EDO) and the Anderson Consulting Engineers (ACE) team. The charter, which can be found in Appendix A, summarizes and defines the project goals, objectives, strategies, and constraints. The EDO defined the project goal as identifying and screening alternative solutions to increase the hydraulic capacity of the Chokepoint and/or provide delivery of EA water downstream of the Chokepoint through other systems. Alternatives are to be developed to maintain delivery of a total peak flow of 3,000 cfs to the Program's AHR on the central

Platte River without exceeding the minor flood stage of 6.0 feet on the North Platte River as defined by and measured at the HWY 83 gage.

Alternatives presented in this report were developed and evaluated within the constraints set out in the project charter, see Appendix A. Key constraints are as follows.

- Alternative solutions will not exceed NWS minor flood stage of 6.0 feet at the North Platte River at North Platte Gage (06693000) at the State Highway 83 bridge.
- Alternatives will not seek modification of minor flood stage as currently defined by the NWS.
- Alternatives will not adversely impact or disrupt any irrigation and/or hydro-power generation operations. This applies particularly, but not exclusively, to the current operation of the Tri-County Canal Diversion.
- Alternatives shall not adversely impact private properties. If unavoidable impacts to private properties are identified, mitigation will be included as part of alternative development.
- Long-term O&M costs will be considered.
- Alternatives will not exceed a capital cost of $15 million.

1.3 Definition of Minor Flood at Highway 83 Gage

The North Platte River at North Platte gage (06693000), also referred to as the HWY 83 gage, is located on the downstream face of the HWY 83 bridge near the Cody Park boat ramp, see Figure 1-1. Following the July 2020 flow test conducted by the Program, the NWS redefined flood impacts at minor flood stage of 6.0 feet, as described below (https://water.noaa.gov/gauges/nptn1).

> *"Minor flood stage. Minor flooding begins in low lying and agricultural areas along the south bank of the North Platte River. Flooding of yards between the golf course and Buffalo Bill Campground are possible. Minor water intrusions into low lying areas of Cody Park in North Platte begin. People should use caution in the water and along the banks of the river, especially near Cody Park."*

More detailed information related to minor flooding observed during the 2020 flow test is available in "North Platte River Chokepoint Test Flow Release" report (PPRIP EDO, 2020).

1.4 Geomorphic and Sediment Transport Study

The ACE team conducted a detailed geomorphic and sediment transport assessment of the Chokepoint, which is documented in a separate report titled "North Platte River Chokepoint Geomorphology and Sediment Transport Study" (ACE 2024). The assessment identified and described the physical processes that have contributed to the geomorphic evolution of the North Platte River between Lake McConaughy and the Tri-County Canal Diversion structure over the last century with a specific focus on the Chokepoint segment. The assessment also analyzed the changes to the flow and sediment regimes that ultimately led to loss of hydraulic capacity at the Highway 83 Bridge in the Chokepoint segment over the last 20 years. Results of the study were used to predict trends in the future trajectory of the river and inform development of stream modification alternatives. A summary of conclusions from the study is discussed below.

The team's hydrologic analysis indicates that the changing trend in flow variables seem to have reached a general status of equilibrium over the past 20 years. Further, median flows after 1942 do not show remarkable differences to present day. This is not surprising given that median flows reflect baseflows. Average flows after 1942 range from 573 to 601 cfs except during the 1970s and 1980s when average flow was 1,007 cfs. The 1.5-year discharge (1,642 cfs) is also relatively stable between 2000-2022. Minor flood stage for the North Platte River is 6.0 feet, as currently defined by the National Weather Service (NWS), at the North Platte Gage at Highway 83. Capacity is estimated at 5,420 during the late 1980s. Capacity between 1998 and 2023 has fluctuated between 1,570 and 2,165 cfs, with current capacity estimated in 2023 at 1,764 cfs.

We also performed hydraulic modeling and inundation mapping on the North Platte River through the Chokepoint segment. The velocity and shear stress results suggest limited fluctuation in average values between reaches but reveal a decreasing trend in the downstream direction. This indicates minimal if any conveyance problems, such as blockages or constrictions. Incipient motion analysis indicates that bed material is mobilized for all flow conditions including baseflows (~400 cfs) and greater.

Sediment continuity was evaluated to estimate sediment supplied to a reach and sediment exported out of the reach. Measured mass bed changes from 2009 to 2017 and 2017 to 2023 were compared with estimated annual transport and dredging volume. Results do not indicate a strong trend in either aggradation of degradation during either period apart from the depositional zone immediately upstream of the TCCD where dredging is required. It is noted that minimal change in the channel between 2009 and 2023 indicates that the river is generally able to balance sediment supply and transport, even after the 2011 flood event. This is consistent with the stabilization in hydraulic capacity, with some natural fluctuation, as shown by results of hydraulic analyses and specific gage evaluation. This finding is consistent with a quasi-equilibrium condition.

Identifying the geomorphic characteristics and trends through the Chokepoint segment were based on pattern and planform, profile, and geometry. Interpreting the results from those analyses, the ACE team did not find substantial changes in overall geomorphic characteristics over the past twenty years. For example, active channel widths and channel area are stable based on comparison of surveyed cross-sections and hydraulic analyses, which in combination with slowly changing vegetation patterns supports relatively consistent hydraulic conveyance between 1999 and 2020. Further, since 2011, the average bed slope of the Chokepoint segment has remained within the historical range of 0.11% and 0.12%, except for the area between HWY 30 and the TCCD. Depositional impacts related to the TCCD extend much further upstream than backwater, likely due to a slowing and/or blocking of sand bed movement related to backwater conditions and the presence of the structure. This is evident through evaluation and comparison of 1940 and 2009 bed profiles that shows a "sediment wedge" extending from the TCCD upstream to HWY 83 has formed. Comparison of more contemporary bed profile information after 2009 indicates relatively consistent channel bed slopes suggesting that the river profile along the Chokepoint segment will remain within the 0.11 to 0.12% range if present-day flow characteristics and sediment supply relationships remain consistent.

A key conclusion from the geomorphology and sediment transport study is Lake McConaughy and the TCCD have altered flow and sediment regimes in the Chokepoint segment and appear to be the primary drivers of channel aggradation and the long-term reduction in hydraulic capacity at Highway 83. While this conclusion is based in part on a comparison of estimated 1940 and 2009 bed profiles that show the formation of the "sediment wedge" extending upstream from the TCCD to roughly HWY 83 (see Figure 1-2), our quantitative analyses provide multiple lines of evidence to support this conclusion. Further, the analyses demonstrate dramatic changes in processes (low and high flows, sediment transport, etc.) that directly affect form i.e., decreased slope, narrower pattern (braided evolving to single thread), reduced flow area, and increased vegetation, which together lead to reduced shear stress.

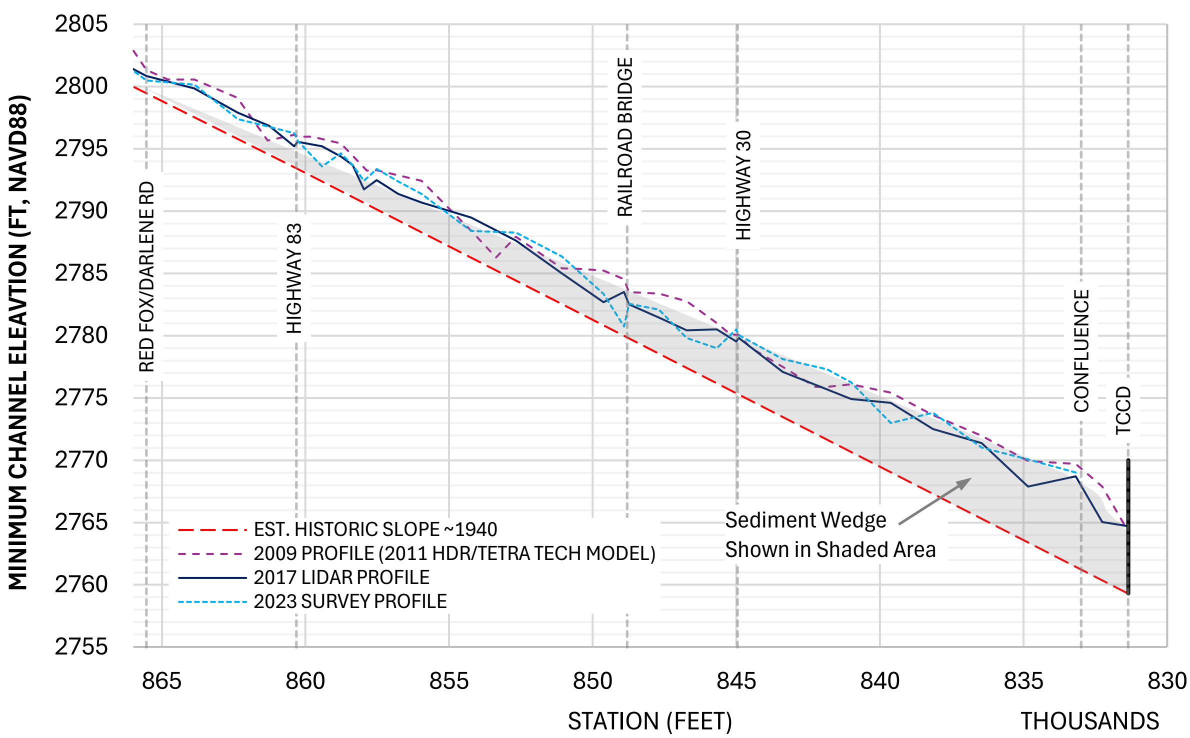


Figure 1-2 North Platte River Historic and Contemporary Profile

The various analyses in the "North Platte River Chokepoint Geomorphology and Sediment Transport Study" suggest the evolution of the North Platte River through the Chokepoint over the past approximately 20 years has reached a state of quasi-equilibrium. The conclusion that the Chokepoint segment has reached a general state of quasi-equilibrium is supported by the balance between active channel area and vegetated cover area, which for most reaches, has changed little since the 1980s. Further, the bankfull hydraulic capacity, which tends to correlate with the minor flood stage, appears to have settled into a range between approximately 1,200 and 1,700 cfs upstream of Highway 83 and 1,700 cfs downstream to the TCCD structure. The relatively stable average bed slopes in the Chokepoint segment are also expected to remain in a quasi-equilibrium state assuming flow characteristics and sediment supply trends are consistent with those over the previous 20 years, and dredging operations continue at the TCCD structure. Also, a large, sustained flow event, probably greater than the peak flow and duration of the most recent flood event in 2011, would likely disrupt the quasi-equilibrium state.

1.5 Alternative Analyses

The current study divided the screening and assessment of alternatives into three phases. This report summarizes the results of Phase I and Phase II of the alternatives screening in Section 2. The remaining sections of this report describe Phase III work which include development of modeling tools used to evaluate channel alternatives (Section 3), results of the no-action and channel alternatives modeling (Sections 4 and 5), and conceptual design information related to the sediment removal and bypass canal alternatives (Sections 6 and 7). A full summary of the project is provided in Section 8.

2 ALTERNATIVE SCREENING

This section provides a summary of Phase I and II Alternative screening.

2.1 Phase I Alternatives Screening

The loss of hydraulic capacity at the Chokepoint and alternative solutions developed prior to the current study (2021) are summarized in a memo written by the EDO titled “North Platte Chokepoint Alternatives Memo”, which is provided in Appendix B.1 for reference.

Phase I Alternatives Screening included a review of all prior studies, documents, and previously developed alternatives related to the North Platte River Chokepoint. This effort was conducted by the ACE team and documented in a memo titled “North Platte River Chokepoint Review of Documents and Previous Alternatives” (ACE 2023), see Appendix B.2. The memo includes a listing of all previous studies and an inventory of all alternatives that have been considered over the last 20 years. Listed alternatives were grouped into eight categories including: implemented projects, sediment management, channel modification/construction, flow bypass, vegetation control, flood control, flood easements/property buyouts, and new alternatives. The initial list was reviewed and discussed by the EDO and ACE project team resulting in the development of a short list of alternatives that were proposed for further investigation as part of the current project. The lists were developed as a starting point for identifying and screening alternatives. Information provided in the memo was presented to the Chokepoint Planning Work Group on August 28, 2023.

2.2 Phase II Alternatives Screening

Based on feedback from the EDO and Chokepoint Planning Work Group a short list of alternatives was developed for Phase II Alternatives Screening, including: 1) no-action, 2) South Platte reservoir storage, 3) reduction of upstream sediment sources, 4) purchase of existing irrigation infrastructure for bypass, 5) construction of a bypass canal, and 6) channel modification/sediment removal. Additional concepts that could enhance standalone alternatives also discussed include modification of the Tri-County Canal Diversion (TCCD).

An initial screening and review of the shortlisted alternatives was developed to provide information to the EDO and Chokepoint Planning Workgroup to decide which alternatives are worthy of more detailed study as part of the final phase of the project. The Phase II Alternatives Screening generally assumed an existing capacity at HWY 83 of 1,700 cfs at the 6.0 ft minor flood stage and the need for an additional 1,300 cfs to meet a target of 3,000 cfs. A summary of the initial assessment of each shortlisted alternative was provided to the EDO on February 7, 2024, in a memo titled “North Platte Chokepoint Phase II Alternative Screening.” The memo is provided for reference in Appendix B.3. The ACE team presented their findings to the Chokepoint Planning Workgroup at a meeting on February 13, 2024.

The shortlist of alternatives was further reduced based on discussions between the EDO and ACE team and feedback from the workgroup, as discussed below.

- No-Action Alternative: Retained for additional detailed evaluation and to provide a baseline for alternative comparisons, see Section 4.
- South Platte Storage: Discussion of the alternative was expanded to provide additional context, see Section 2.3, but the alternative was not retained for detailed model evaluation.
- Upstream Sediment Sources: No specific source of sediment supply that could reasonably be reduced, controlled, or stabilized was identified. This alternative was considered infeasible and therefore additional evaluation was not pursued.
- Purchase of Existing Irrigation Infrastructure for Bypass: This alternative offers a very small gain in hydraulic capacity (less than 300 cfs) relative to the capital costs. In addition, acquisition of existing infrastructure, conversion of users from surface to groundwater, and long-term maintenance of the canal(s) would be difficult for the Program without local stakeholder support and sponsorship. Further evaluation of this alternative was not pursued.
- Bypass Canal: The 1,500 cfs bypass canal concept was advanced to a higher level of design and evaluation, which is provided in Section 7.
- Channel Modification/Sediment Removal: This alternative includes Channel Modification concepts (ACE 2016 Construction Alternative and Modifications to the Tri-County Canal Diversion) and a Sediment Removal Concept (VESPR/RDG 2023). These were retained for additional concept development and refinement as well as hydraulic and sediment transport modeling, see Sections 5 and 6.

Section 3 of the report provides a brief description of the hydraulic and sediment transport models used to evaluate channel alternatives. As noted, No-Action (Section 4), Channel Modification (Section 5), Sediment Removal (Section 6), and Bypass Canal (Section 7) were the alternatives retained for more detailed model analyses and/or design refinements.

2.3 South Platte Storage

The purpose of this alternative is to estimate storage volume required from the South Platte River to bypass the Chokepoint and meet flow targets on the central Platte. Use of reservoir storage within the Nebraska Public Power District (NPPD) Sutherland Project system as a means to facilitate bypass of the North Platte Chokepoint was previously investigated by the Program. The original long list of potential Chokepoint solutions developed by the Anderson Consulting Engineers (ACE) team and presented to the North Platte Chokepoint Planning Workgroup included two potential storage opportunities within the NPPD system: (1) additional storage in the existing Sutherland Reservoir and (2) construction of a new Sutherland East Reservoir (ACE and River Works 2023). These storage concepts were originally contemplated by Harza Engineering Company (Harza) and NPPD in 1993 and were considered by the Program in 2012 (EDO 2012a-e). To provide context for the current evaluation of South Platte Reservoir Storage, it is worth briefly revisiting these alternatives.

Originally constructed in the 1930s, Sutherland Reservoir was designed to have a maximum water elevation of 3,084 ft but is operationally limited to 3,055 ft because of seepage and stability issues. This maximum operational elevation is reflected in the terms of NPPD's license for FERC Project No. 1835 (Sutherland Project) and was the basis for design and construction of the adjacent Gerald Gentleman Station power plant in the 1970s.

Working on behalf of NPPD, Harza (1993) developed potential alternatives to increase storage capacity in Sutherland Reservoir by 18,000 AF to 78,750 AF, all of which were predicated on prior implementation of solutions to curb the excessive seepage losses. A soilcrete seepage cutoff was recommended, and in combination with additional facility modifications necessary to increase the maximum operational water level, cost estimates for expanded storage capacity ranged from $101 million to $146 million in 1993 dollars. Notably, while the seepage cutoff would allow for additional storage capacity in Sutherland Reservoir, modeling indicated it would also have the effect of reducing South Platte River flows by about 50-60 cfs. A partially lined Sutherland East Reservoir with a storage capacity of 7,500 AF or 12,500 AF was also evaluated. Located approximately 2.5 miles east of the existing Sutherland Reservoir, costs for this facility were estimated to range from $20 million to $25 million, again in 1993 dollars.

For Program purposes to bypass the Chokepoint, both storage options in the NPPD system would require construction of an outlet back to the South Platte River, either directly or potentially via Fremont Slough. These options were considered by the Program in a series of memos and meetings in mid-2012. With the North Platte having a conveyance capacity of about 1,600 cfs at minor flood stage (6.0 ft) at that time, it was determined that 1,400 cfs would need to be returned to the South Platte River to achieve the Program's 3,000 cfs objective. For a 3-day short-duration high flow (SDHF) release, this would mean staging about 9,000 AF of water from the Lake McConaughy EA in a storage facility within the NPPD system. Given that this volume of required storage is comparable to the proposed capacity options for Sutherland East Reservoir, costs were updated to range from $45 million (7,500 AF) to $54.3 million (12,500 AF) in 2012 dollars. An outlet from Sutherland East Reservoir to the South Platte River was estimated to cost $10 million at the time. Table 2-1 summarizes 1993 and 2012 cost estimates for these alternatives along with new estimates for 2024.

Table 2-1 Cost Comparison for Reservoir Storage in the NPPD Sutherland Project System

Alternative	Capacity	1993 $million[1]	2012 $million[2]	2024 $million[3]
Sutherland Reservoir with Seepage Cutoff or Other Lining	18,000 AF	$101	$200-$300	$300-$600
	37,000 AF	$104		
	78,750 AF	$146		
Sutherland East Reservoir	7,500 AF	$20	$45	$67
	12,500 AF	$25	$54.3	$82
Outlet to South Platte River via Fremont Slough	1,400 cfs	N/A	$10	$15

[1] From Harza (1993), Table IV-4.

[2] From EDO (2012c), Table 2 and Table 3. Based on U.S. Bureau of Reclamation (USBR) Construction Cost Indices for April 2012.

[3] Based on USBR Construction Cost Indices for July 2024.

A tentative proposal for the Program and NPPD to pursue a feasibility study for the Sutherland East Reservoir project in late 2012 was never advanced, likely due to the prohibitive costs, extensive permitting hurdles, and extended construction timelines relative to the duration of the Program's First Increment (2007-2019). The Program instead spent the next several years focused on the design and construction of far less expensive flood proofing projects at the North Platte Chokepoint in an ultimately unsuccessful attempt to increase available conveyance capacity by raising minor flood stage from 6.0 ft to 6.5 ft.

To be clear, neither the expansion of storage in the existing Sutherland Reservoir nor construction of a new Sutherland East Reservoir is considered to be a viable South Platte Reservoir Storage alternative for the Program at this time. Their inclusion in this discussion is merely to illustrate the magnitude of costs for such projects in this area. NPPD itself has deemed the Sutherland East project infeasible to due cost (estimated at $83 million for a 20,000 AF reservoir in 2017) but has said it would be open to studying an outlet from Sutherland Reservoir to the South Platte River (Jeff Shafer, personal email communications, October 19, 2020, and October 2, 2024).

With SDHF releases no longer a priority for the Program the South Platte Reservoir Storage concept was reframed for the current study. Specifically, South Platte Reservoir Storage would be used to supplement existing North Platte Chokepoint conveyance capacity to achieve desired releases of water from the Lake McConaughy EA to achieve a flow of 1,500 cfs at Grand Island for the purpose of germination suppression between late May and early July.

The South Platte Reservoir Storage alternative concept evaluated for the current study would be a new reservoir constructed along the South Platte River between the Colorado-Nebraska state line and the city of North Platte. The volume of reservoir storage required to stage EA flows on the South Platte to meet flow targets on the central Platte was estimated to inform discussion. Volume estimates were developed for a range of flow rates and durations to supplement existing capacity through the North Platte Chokepoint up to a total flow of 3,000 cfs at the confluence of the North Platte and South Platte rivers. Specific locations for a staging reservoir and diversion logistics were not included in the current scope of work.

Volume estimates assume a release of up to 1,500 cfs would be required from the staging reservoir to supplement 1,500 cfs that can be passed through the North Platte Chokepoint below minor flood stage. This would allow for a 1,500 cfs release for germination suppression even if the entirety of existing capacity at the North Platte Chokepoint is being utilized to meet downstream irrigation demands. Volume estimates assume an average annual evaporation rate of 43 inches/year (per NOAA Technical Report NWS 34) and average annual precipitation of 20 inches/year (High Plains Regional Climate Center, Average Annual Precip 1990-2020) for a net total evaporative loss of 23 inches/year.

Volumetric losses associated with transport to the Program's habitat reach on the central Platte were also included and based on data computed by NDNR during the Spring 2013 short duration medium flow (SDMF) release. The percentage loss of water between Kingsley Dam and Grand Island has been estimated to be as much as 50% during flow releases between 2007 and 2013 (EDO 2014) but ranged from 23% to 29% during the 2013 SDMF release. Assuming a net evaporative loss of 23 inches/year and a conservative transport loss of 50% the required storage volume was estimated for a range of flows (250 cfs to 1,500 cfs) and durations (10 to 30 days), see Table 2-2. The storage required to provide 1,500 cfs for a duration of 30 days is approximately 135,600 acre-feet, which would be the upper bound of storage requirement.

Table 2-2 Estimated South Platte Reservoir Volumes

Q (cfs)	Reservoir Volume (acre-feet)	
Duration	10 Days	30 days
250	7,500	22,600
500	15,100	45,200
1,000	30,200	90,400
1,500	45,200	135,600

Given the Program's "good neighbor" policy and lack of condemnation authority, past experience (e.g., the J-2 Regulating Reservoirs project) demonstrates that the Program would be unable to accomplish a reservoir storage project at this scale without stakeholder or other outside sponsorship. Lacking this authority, further evaluation of the South Platte Storage alternative was not pursued for this study.

3 HYDRAULIC AND SEDIMENT TRANSPORT MODELING

This section describes the hydraulic and sediment transport models that were developed to evaluate the existing conditions (no-action) and performance of channel alternatives.

3.1 1D Sediment Transport Model

The 1D hydraulic model updated and calibrated for the geomorphic and sediment transport assessment was used to develop a 1D sediment transport model of the Chokepoint study reach. The model was developed and run using HEC-RAS Version 6.5.

3.1.1 Model Reach and Geometry

The 1D sediment transport model uses LiDAR data from 2017 for cross sectional geometry. The model reach includes the lower 10.5 miles of the North Platte River, the lower 0.5 miles of the South Platte River, and about 2 miles of the Central Platte below the confluence, see Figure 3-1. Model geometry includes the HWY 83 bridge, railroad bridge, HWY 30 bridge, and Tri-County Canal Diversion structure.

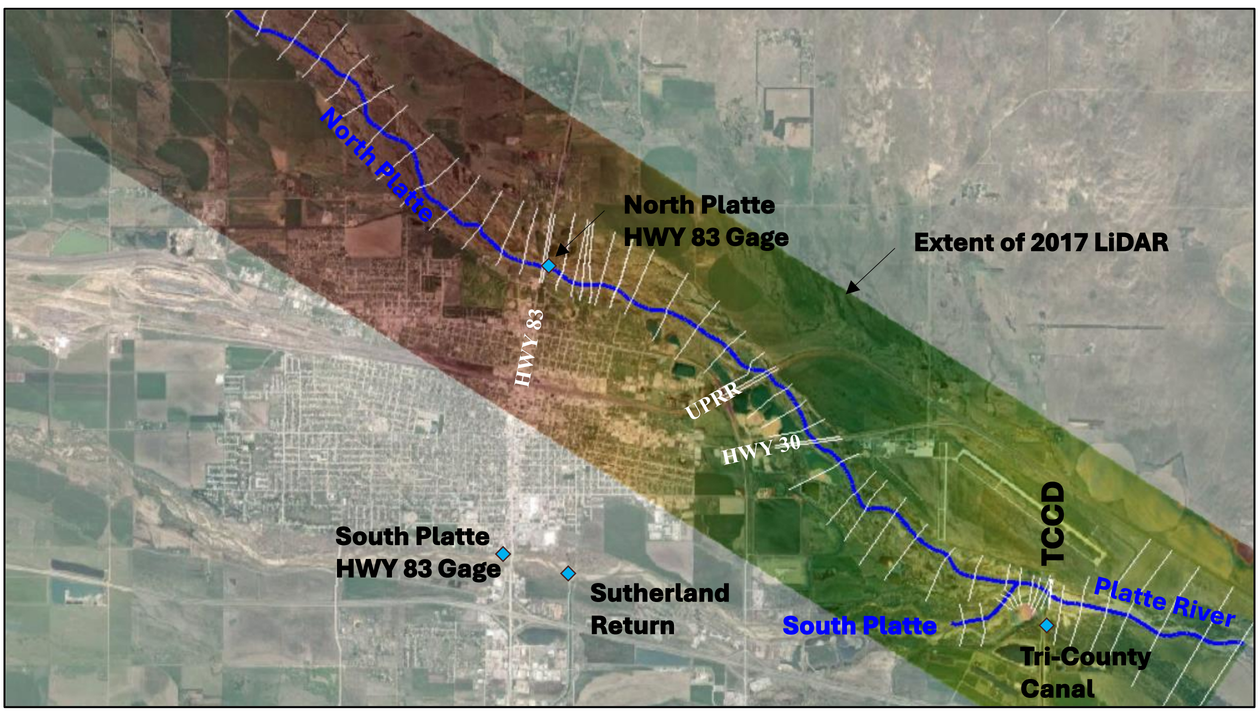


Figure 3-1 1D Hydraulic and Sediment Transport Model Reaches

3.1.1 Hydrology and Boundary Conditions

Hydrologic input to the North Platte includes average daily flow data from the North Platte River at North Platte Gage (06693000) at HWY 83. South Platte flow input at the upstream boundary of the model utilizes average daily flow data from the South Platte River at North Platte Gage (06765500) located at HWY 83 plus daily flow data at the Sutherland Power Return Gage (00140003). Gage data utilized for calibration references the period of record between 2017 and 2023. The period of record between 2009 and 2022 was applied to long term forecast modeling as discussed in Section 3.1.4. The location of gages is shown in Figure 3-1. Flow diversions to the Tri-County Canal are extracted from the model just upstream of the TCCD using daily diversion records.

A normal depth boundary condition is applied at both the upstream and downstream limits of the model. To simulate conditions at the TCCD, an internal boundary condition was applied for operation of gates to maintain a headwater elevation of 2770 feet, which is necessary to support hydraulic dredging operations and facilitate diversion of flow into the Tri-County Canal.

3.1.2 Sediment Input Parameters and Dredging

The sediment transport model requires specification of a bed material gradation and selection of a transport function and fall velocity method. Bed material samples collected in October of 2023 were used to approximate input gradations. Four sediment transport functions developed for use in sand bed rivers were considered for use including Ackers White, Enelund-Hansen, Yang, and Laursen Copeland. The Yang equation was selected for use based on results of model calibration runs.

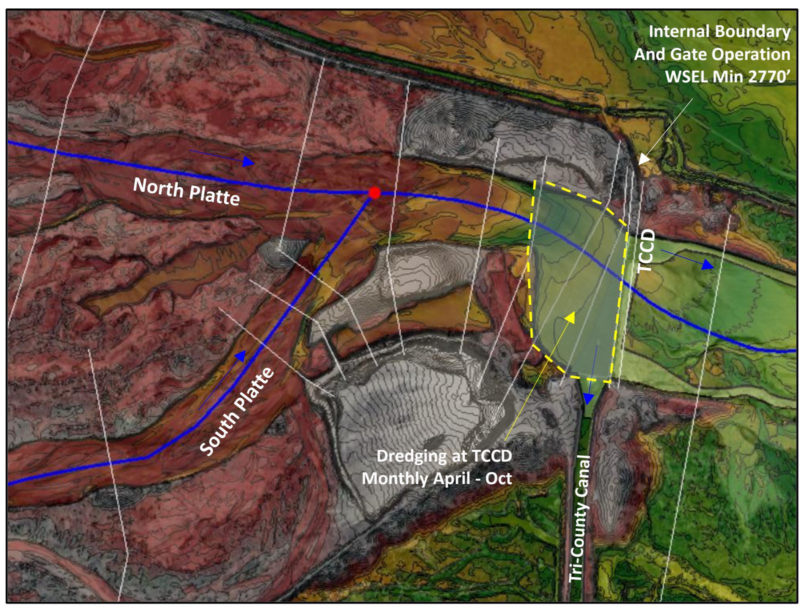


Figure 3-2 Area of Model Dredging at TCCD

Simulation of dredging operations at the TCCD was also included in the model. During model runs sediment that accumulates upstream of the TCCD is extracted between the months of April and October in the specified area shown in Figure 3-2.

3.1.4 Model Calibration

Model calibration and validation was performed to optimize model input parameters such that results reproduce the measured data with an acceptable degree of accuracy. The calibration model simulates the period between the date of 2017 LiDAR, used to define model geometry, and 2023 channel cross sectional survey. Key model parameters tested during calibration that carry a high level of uncertainty include transport function, fall velocity method, bed material gradations, and erosion/depositional methods.

The model results were compared to measured data sets, including the stage-discharge curve and time series of water surface elevation at the HWY 83 gage, the annual dredging volumes at the TCCD, and the change in channel geometry and profile based on survey data. Final model parameters include the Yang transport function, Soulsby fall velocity method, and a bed material gradation sample collected in 2023 that was coarser than other samples. Comparison of HWY 83 gage data and model results are shown in Figure 3-3 and Figure 3-4. The stage-discharge relationship and plot of water surface elevation through time show that the model reasonably predicts water surface elevation within 0.25 feet over the 6-year calibration period.

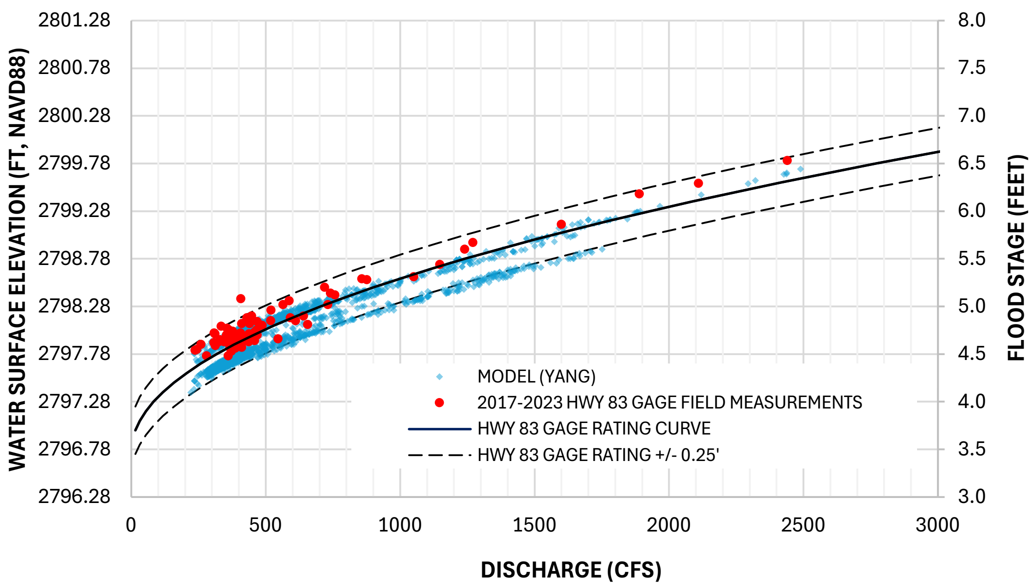


Figure 3-3 Stage-Discharge Curve at HWY 83 Gage – Gage Data vs Model 2017-2023

CNPPID dredges approximately 150,000 CY/year of sediment at the TCCD. The calibration model computed an average annual dredging volume of 128,000 CY/year, with a range of annual volumes shown over the calibration period in Figure 3-5. Variations in dredging volumes are directly related to variation in flow conditions occurring in the North and South Platte in a given year. (Note that over the six-year simulation period the model predicted a total dredging volume of 760,000 CY.)

The channel profile at the end of the model period was compared with the 2023 survey profile in Figure 3-6. The average difference in minimum channel elevation along the length of the model is +/-0.8 feet,

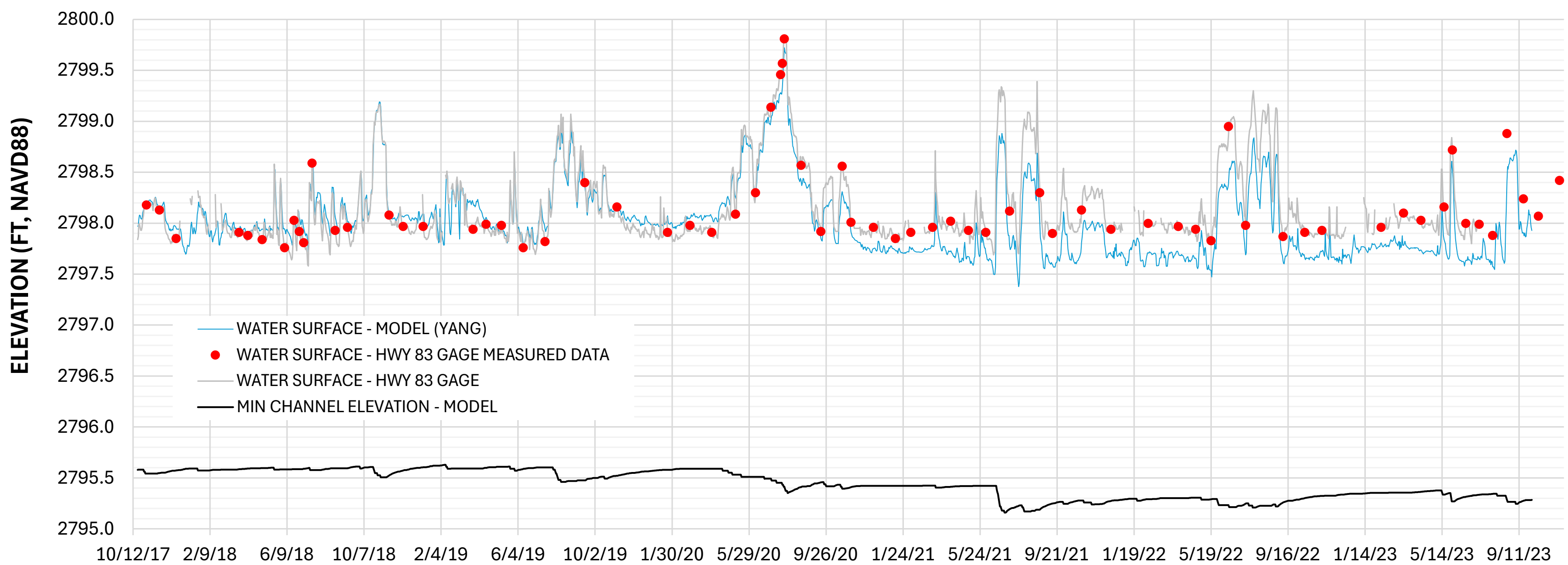


Figure 3-4 Comparison of Water Surface Elevation HWY 83 Gage vs Model 2017 - 2023

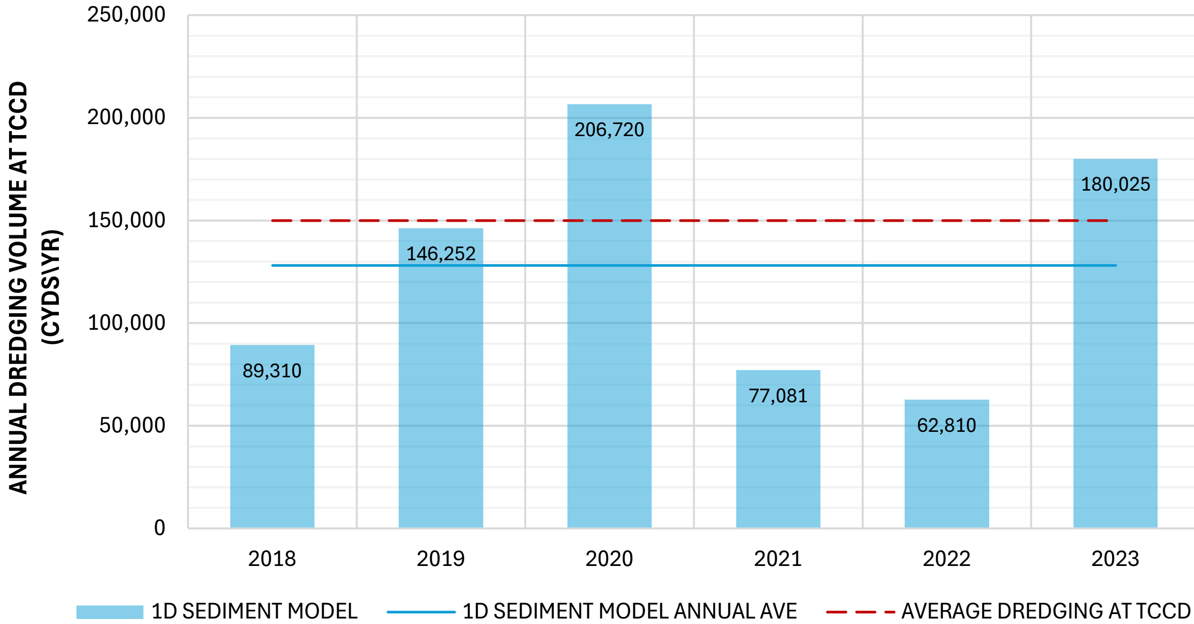


Figure 3-5 Comparison of Annual Dredging Volume at TCCD

and within the natural variation of channel change. The mass bed change occurring within the channel is compared in Figure 3-7. Examination of mass bed change is often used to identify trends in degradation or aggradation. The magnitude of mass bed change shown in Figure 3-7 is much smaller (an order of magnitude smaller) relative to the volume of sediment being transported to and dredged at the TCCD. Mass bed change measured from survey data does not indicate a trend in either aggradation or degradation and is similar in magnitude to model results. Overall review of the calibration results indicates that the model can reasonably simulate transport dynamics through the Chokepoint reach and dredging operations at the TCCD.

Caution should be exercised when interpreting results from other modeling conducted using the calibrated sediment transport model. Sediment transport models, even when calibrated, still include inherent uncertainty. The model and its results are not intended to provide deterministic information but are instead a tool to identify gross trends and provide relative comparisons of various scenarios.

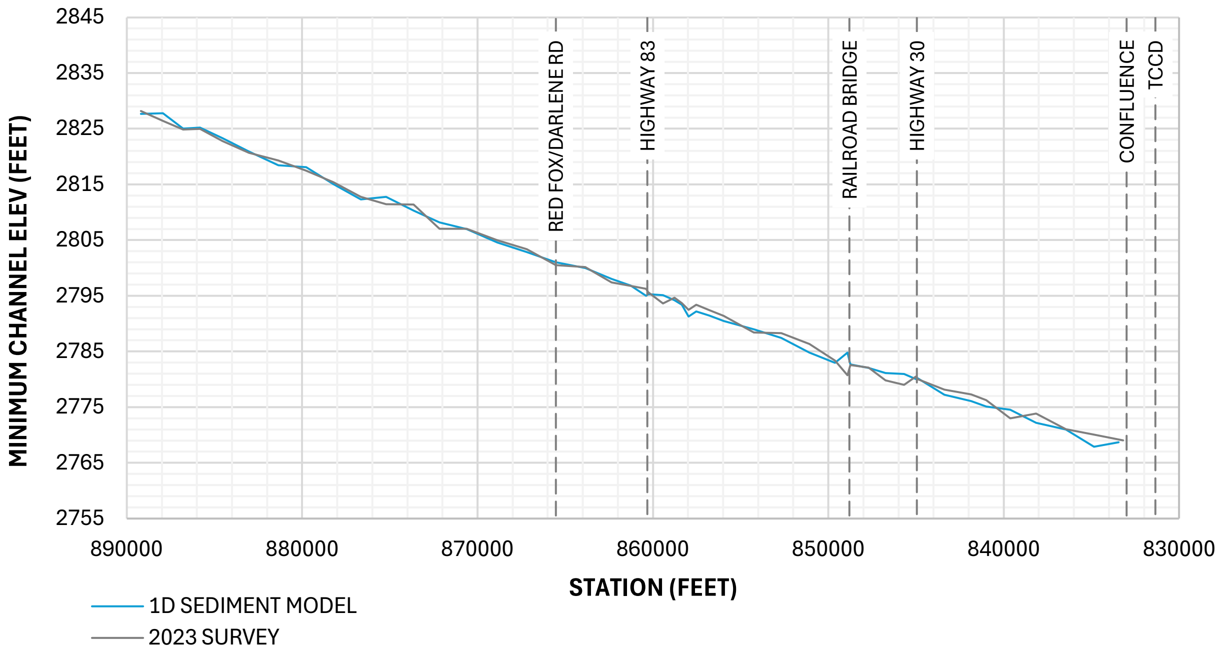


Figure 3-6 Channel Profile Comparison – Model vs 2023 Survey

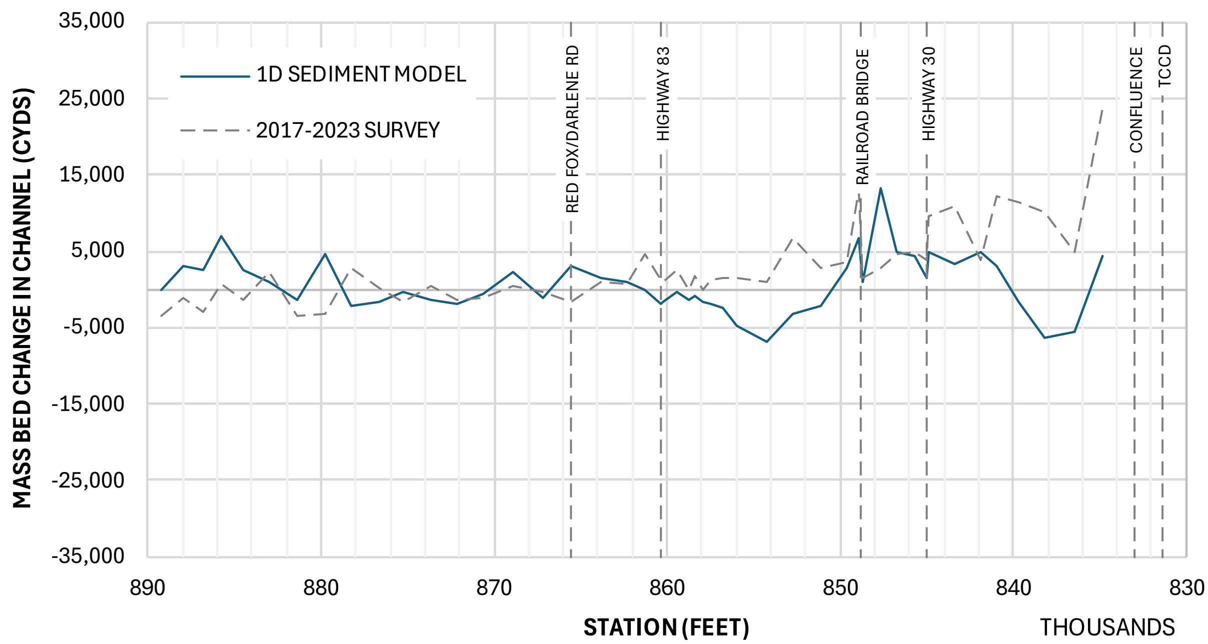


Figure 3-7 Mass Bed Change in Channel – Model vs Survey Data

3.1.5 25 Year Forecast Model

The calibrated 1D sediment transport model was used to run a 25-year forecast of no-action and channel modification/sediment removal alternatives. The model was used to provide insight into long term river response. All forecast modeling includes continuation of diversion and dredging operations at the TCCD.

Three 25-year hydrographs were developed using historic gage data and diversion records between 2009 and 2022 in the following combinations:

1. H1 Hydrograph: 2009 – 2022, 2009 – 2019, both occurrences of the 2011 flood (in year 3 and 17) were removed and replaced with 2019, see Figure 3-8.
2. H2 Hydrograph: 2009 – 2022, 2009 – 2019, both occurrences of the 2011 flood were removed and replaced with 2019, a 3-day annual peak of 3,000 cfs was added to each year in early April to simulate EA releases, See Figure 3-9. The 2011 flood was replaced with 2019 because 2019 is representative of an average hydrologic year.
3. H3 Hydrograph: 2009 – 2022, 2009 – 2019, the 2011 flood is included in year 3, the 2011 flood was removed and replaced with 2019 in year 17, a 3-day annual peak of 3,000 cfs was added to each year in early April to simulate EA releases, see Figure 3-10.

The hydrology that occurred between 2009 and 2022 has a reasonable range of flow conditions on both the North Platte and South Platte that are representative of the previous 20 years. Notable occurrences include the 2011 flood with a peak flow of approximately 6,000 cfs (roughly a 10-year flood event based on USACE 2013 hydrologic study), the 2016 event with a peak flow of 3,500 cfs on the North Fork (roughly between a 2- and 5-year event based on USACE 2013 hydrologic study), and 2020 with a peak flow of 2,500 cfs that occurred during the 2020 flow test. Modeling does not consider large flood events on the North Platte that exceed a 10-year return period. High flow events on the South Platte are noted within the dataset and include the 2013 and 2015 floods, both with a peak flow of nearly 20,000 cfs, which is estimated to be larger than a 25-year event.

Results of 1D sediment transport forecast modeling for the no-action and channel alternatives are discussed in Sections 4 and 5.

Figure 3-8 25-Year Hydrograph for Sediment Transport Modeling – H1 Hydrograph

H1 Hydrograph: 2009 – 2022, 2009 – 2019, both occurrences of the 2011 flood (in year 3 and 17) were removed and replaced with 2019.

Figure 3-9 25-Year Hydrograph for Sediment Transport Modeling – H2 Hydrograph

H2 Hydrograph: 2009 – 2022, 2009 – 2019, both occurrences of the 2011 flood were removed and replaced with 2019, a 3-day annual peak of 3,000 cfs was added to each year in early April to simulate EA releases.

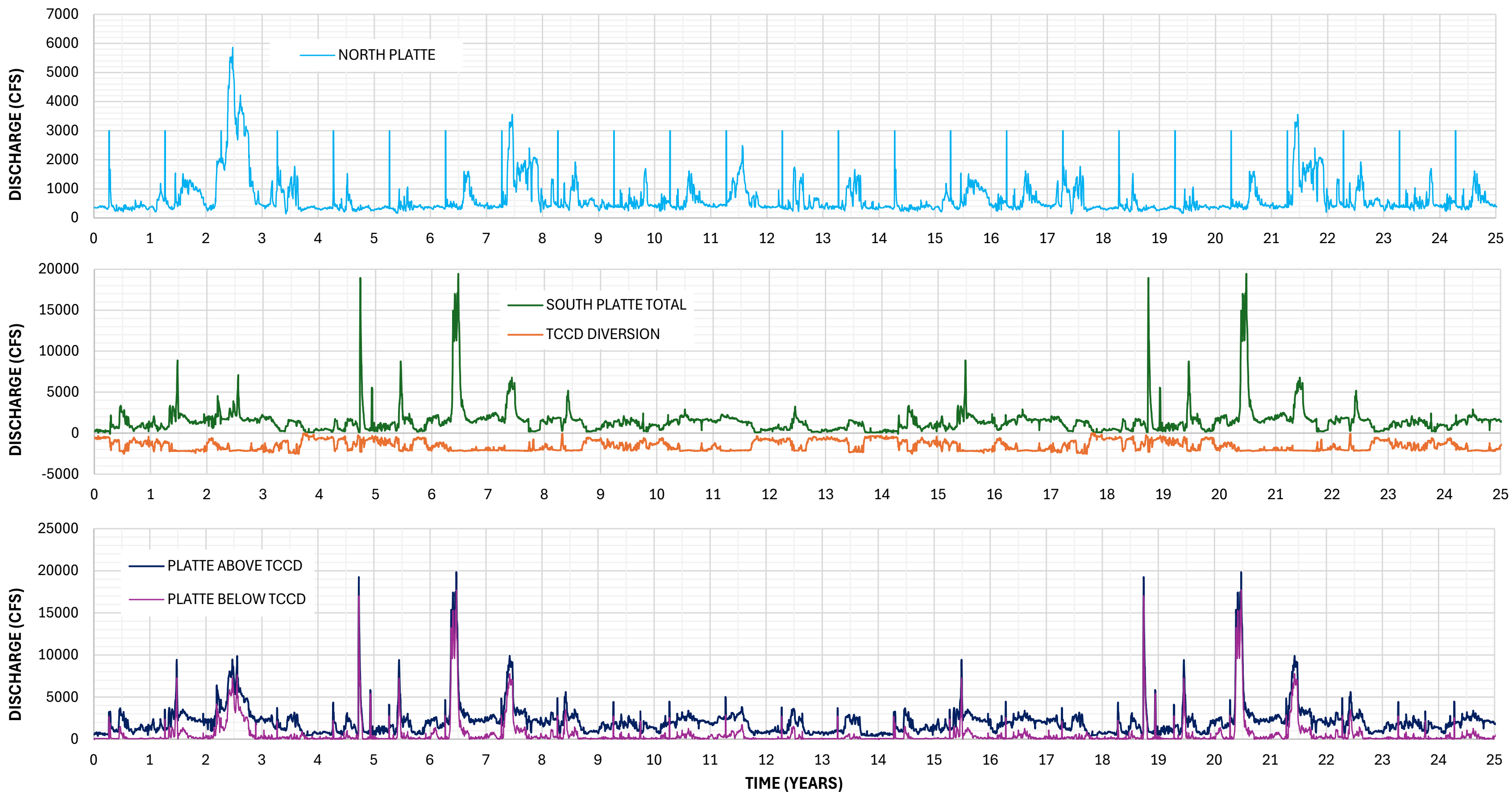


Figure 3-10 25-Year Hydrograph for Sediment Transport Modeling – H3 Hydrograph

H3 Hydrograph: 2009 – 2022, 2009 – 2019, the 2011 flood is included in year 3, the 2011 flood was removed and replaced with 2019 in year 17, a 3-day annual peak of 3,000 cfs was added to each year in early April to simulate EA releases.

3.2 2D Hydraulic Modeling

A 2D hydraulic model of the entire 11 miles of the study reach was developed in HEC-RAS 6.5 using the 2017 LiDAR terrain. This model was used in the assessment of geomorphology and sediment transport and was also used to evaluate selected alternatives presented in this report. Hydraulic structures (HWY 83, UPRR, and HWY 30 bridges, state channel berm, and TCCD) are included as well as a short portion of the South Platte River at the confluence. North Platte flow inputs range from 400 cfs up to 6,000 cfs. Flow input from the South Platte was assumed to be half of the North Platte (e.g., North Platte Q = 6,000 cfs and South Platte Q = 3,000 cfs). The model includes two downstream boundary conditions to allow for flow to exit the model through the Tri-County Canal and downstream of the diversion structure in the Central Platte. The TCCD includes the northern outlet which is open enough for each flow event to maintain a headwater elevation of 2770 to facilitate flow diversion without overtopping the ogee spillway. The 2017 LiDAR just upstream of the TCCD was modified to account for dredging needed to pass flow through the outlet gates. Model calibration was conducted using HWY 83 gage data. 2D model results were used in this study to provide inundation mapping related to alternatives.

3.3 2D Sediment Transport Modeling

The 2D hydraulic model was used to develop a 2D sediment transport model, also using HEC-RAS 6.5. 2D sediment transport modeling is computationally intensive. The 2D sediment transport model was limited to the study reach downstream of HWY 30 and reserved for evaluation of the TCCD modification alternative and Sediment Removal Alternative A, both discussed in Section 5. The sediment transport model parameters used in the 1D model were applied to the 2D model.

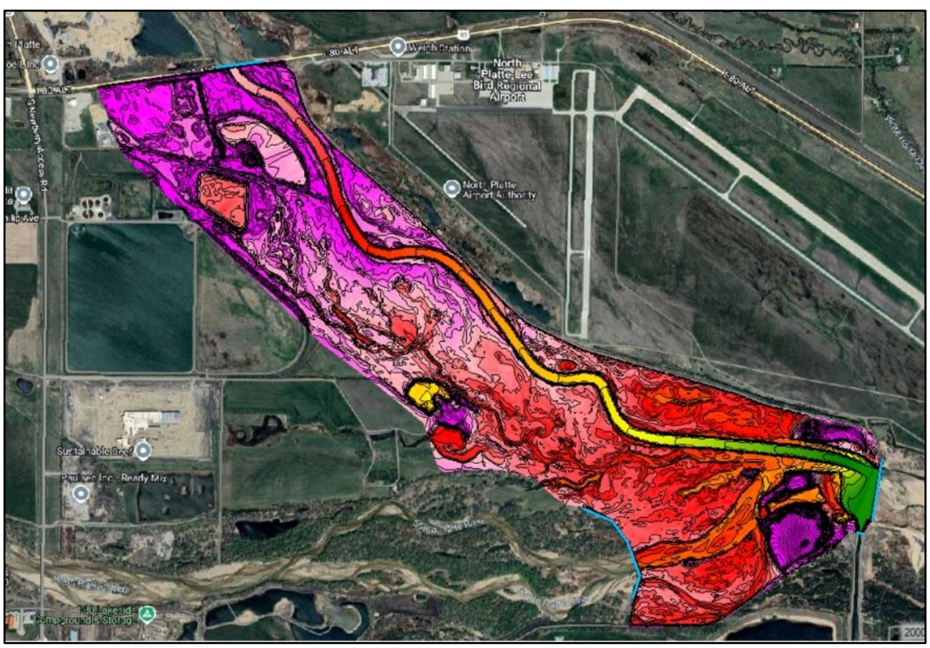


Figure 3-11 Extent of 2D Sediment Transport Model

4 NO-ACTION ALTERNATIVE

The no-action alternative is a continuation of existing river management at the Chokepoint including vegetation control and CNPPID dredging at the Tri-County Canal Diversion (TCCD).

The geomorphic and sediment transport assessment concluded that the North Platte River Chokepoint reach has been in a quasi-equilibrium state for roughly 20 years. Assuming that there are no significant changes in upstream reservoir operations, vegetation control, diversions and dredging at the TCCD, or climate shifts, the Chokepoint reach is expected to remain in a quasi-equilibrium state into the future. Currently, the average hydraulic capacity at minor flood stage is expected to remain at about 1,700 cfs, with a range between 1,550 and 2,150 cfs, depending on flow conditions. At the target flow of 3,000 cfs flood stage at the HWY 83 gage is between 6.5 and 7.0 feet (0.5 to 1.0 feet above minor flood stage).

Additional hydraulic and sediment transport modeling of the no action alternative was conducted to establish a baseline for comparison with other alternatives. The existing hydraulic conditions were defined based on the results of the 2D hydraulic model. The 2D hydraulic model was run for a range of selected flows including 400 (baseflow), 1,000, 1,500, 2,000, 3,000 and 6,000 cfs. The 1D sediment transport model with a 25-year forecast was used to estimate future river trajectory and trends in hydraulic capacity. Note that sediment transport modeling is not intended to provide deterministic results. The results should be carefully interpreted within the context of the geomorphic assessment and consider uncertainties associated with sediment transport modeling.

Both the 2D hydraulic and 1D sediment transport models span the full 11 miles of the Chokepoint study reach. Presentation of model results is focused on areas impacted at minor flood stage as identified by the NWS during the 2020 flow test (PPRIP 2020). Two specific locations include the HWY 83 gage and the south bank of the river near Red Fox Lane and Darlene Road (Red Fox/Darlene Rd).

4.1 Existing Condition Hydraulics at 3,000 cfs

Inundation mapping at 3,000 cfs developed from 2D hydraulic model results are shown in Figure 4-1. The location of Red Fox/Darlene Rd area and HWY 83 gage are noted on the figure. A graphical water surface profile at 3,000 cfs is shown for the study reach below Red Fox/Darlene Rd in Figure 4-2.

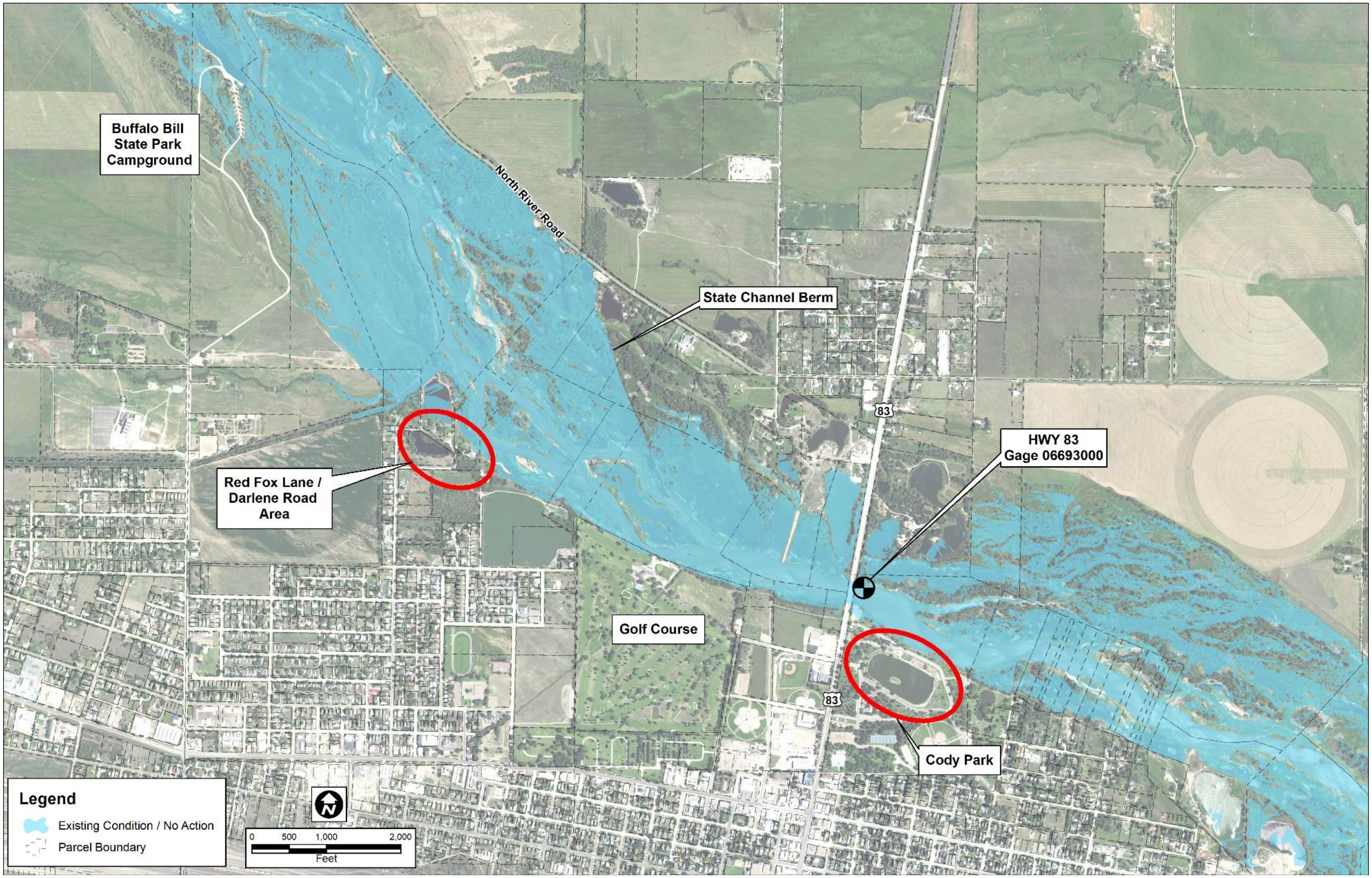


Figure 4-1 North Platte Chokepoint Existing Conditions/No-Action - Inundation Mapping at 3,000 cfs

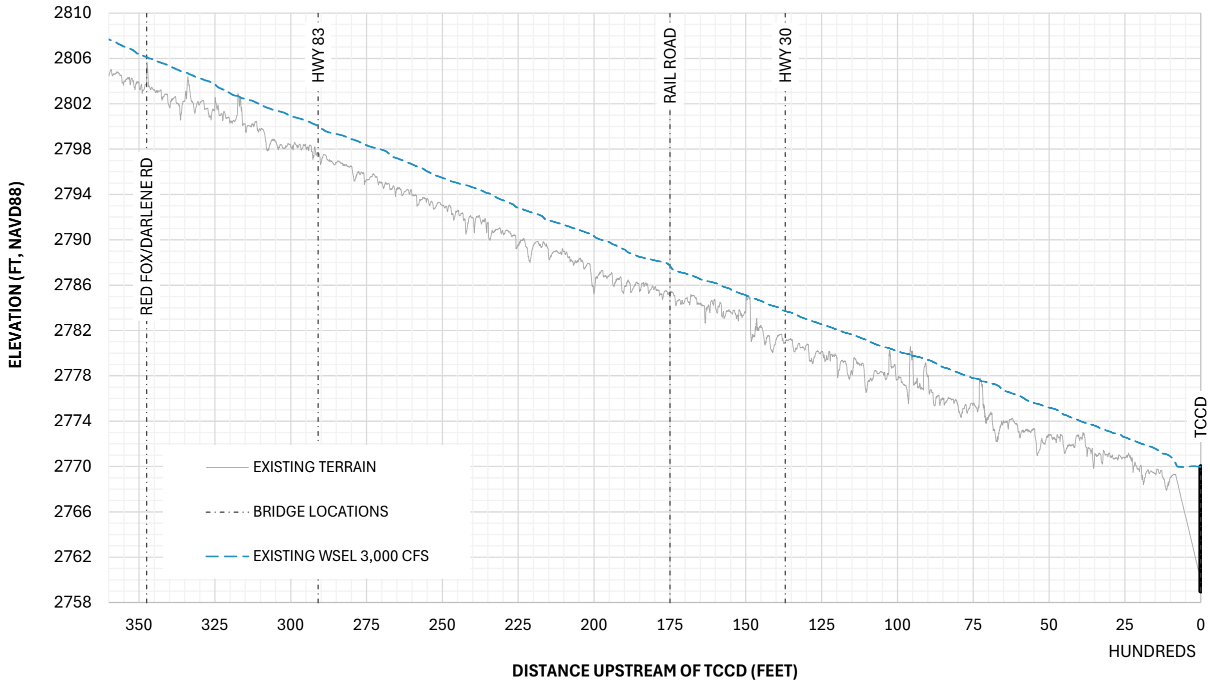


Figure 4-2 3,000 cfs Water Surface Profile - Existing Condition

4.2 1D Sediment Transport 25-Year Forecast Results

Results from the 1D sediment transport forecast modeling for all three hydrographs (see Section 3.1.1) were reviewed. Figure 4-3 and Figure 4-4 show changes in water surface elevation and channel invert over the 25-year forecast period at HWY 83 and Red Fox/Darlene Rd, respectively. The grey shaded area in the figures indicates the range of channel invert elevations surveyed in 2009, 2017, and 2023 plus and minus 0.25 feet, which is considered representative of the natural fluctuation of bed elevation observed during the past 20 years. At both HWY 83 and Red Fox/Darlene Rd change in channel invert elevation over the forecast period does not consistently deviate from the shaded area. This indicates that there is not a signal of degradation or aggradation. A slight increase in water surface elevation (less than 0.4ft) is noted after 15 to 20 years, however the magnitude also does not suggest a strong signal of aggradation. Both water surface and channel invert elevation remain within 0.4 feet over the 25 years for all three runs, indicating a generally stable condition into the foreseeable future, even with the occurrence of a 2011 flood (shown in the bottom graph of the figure). This is consistent with and further supports the findings of the geomorphologic assessment that the river will continue in a state of quasi-equilibrium. It also indicates resiliency of the system to withstand an event like 2011, which had a peak discharge of approximately 6,000 cfs.

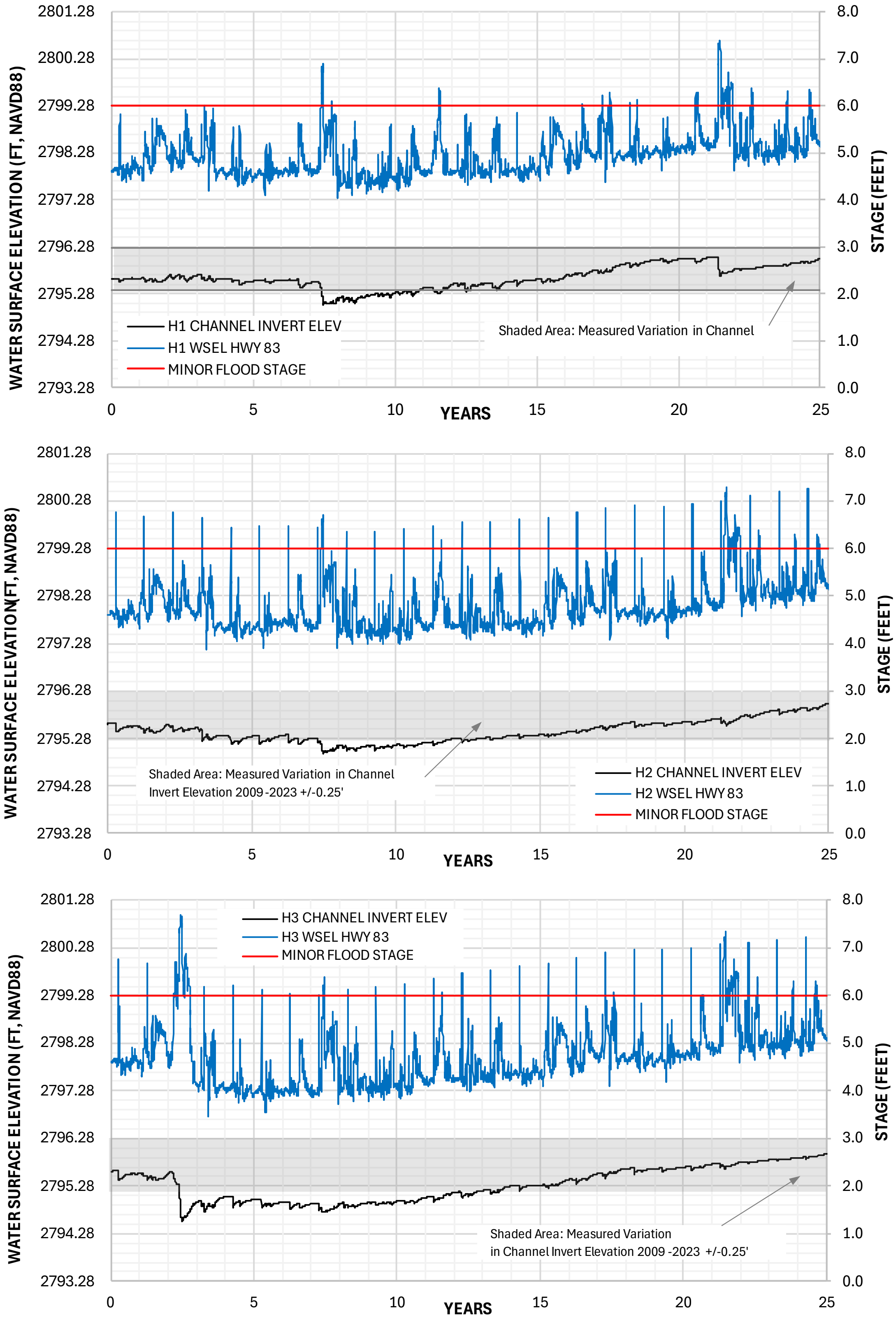
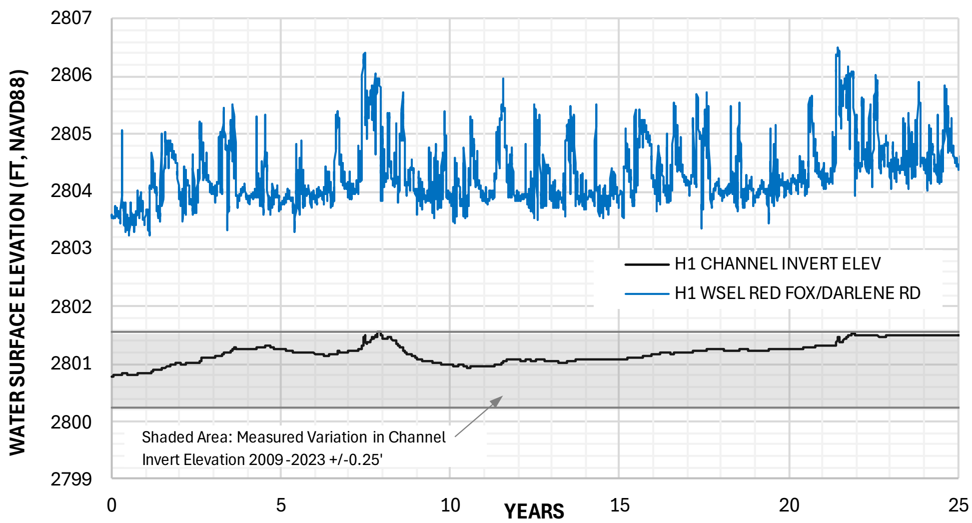
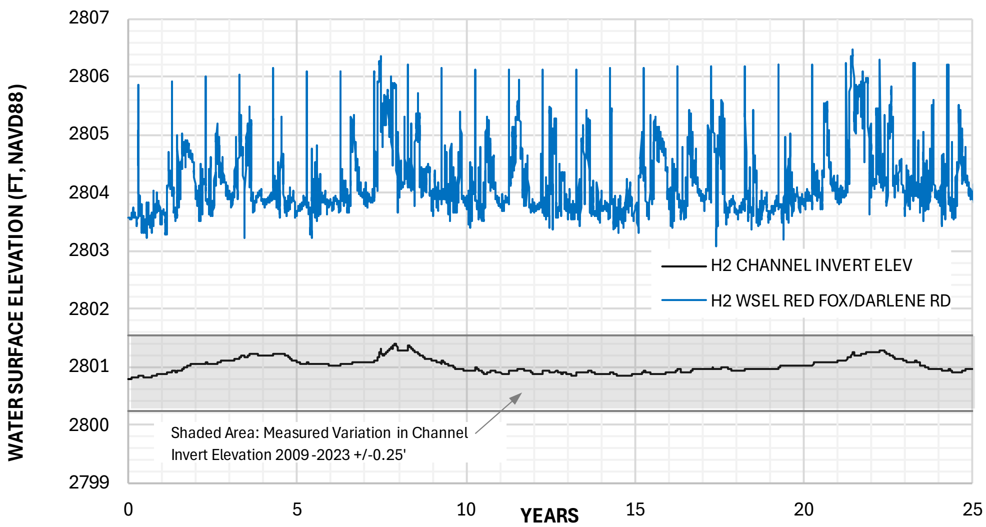


Figure 4-3 No-Action 25-Year Forecast for - Water Surface and Channel Elevation at HWY 83

H1 (top), H2 (middle) and H3 (bottom)





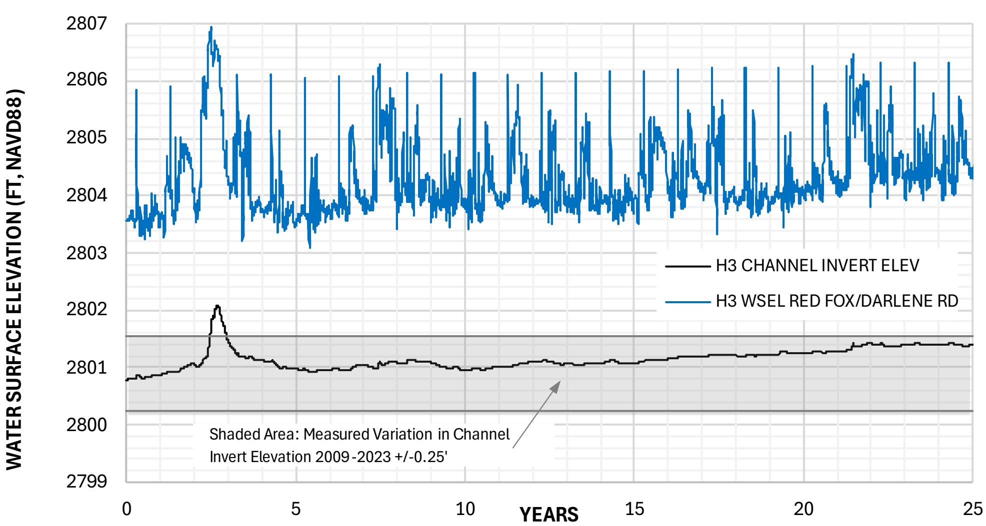


Figure 4-4 No-Action 25-Year Forecast - Water Surface and Channel Elevation at Red Fox/Darlene Rd

H1 (top), H2 (middle) and H3 (bottom)

The estimated water surface elevation and stage at HWY 83 at the 3,000 cfs target flow is shown for H2 and H3 hydrographs (which both include 3-day annual occurrence of 3,000 cfs) in Figure 4-5. Model results are shown as solid lines, with a shaded area that identifies the range in stage measured between 2003 and 2022 plus and minus 0.25 feet. Over the forecast period stage at 3,000 cfs does not consistently fall outside estimated variation noted in the previous 20 years. As previously noted, the no-action model results will be used to compare against other alternatives.

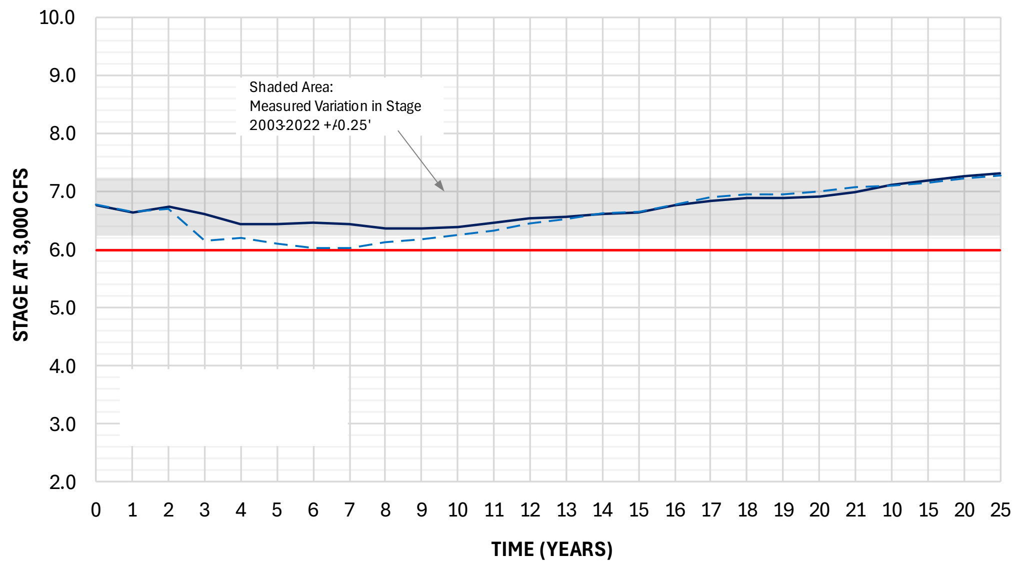


Figure 4-5 No-Action H2 and H3 25-Year Forecast - Stage at 3,000 cfs through Time

4.3 Summary

The main purpose of the no-action analysis is to develop baseline conditions for comparison with other alternatives. In addition, the results of the no-action analysis described above are consistent with the results of the geomorphic assessment, which indicate that the Chokepoint reach is likely to remain in quasi-equilibrium assuming that flow characteristics, sediment supply trends, and diversion and dredging operations at the TCCD are consistent with those of the past 20 years. Under the no-action alternative average hydraulic capacity at minor flood stage is expected to remain at about 1,700 cfs, with a range between 1,500 and 2,150 cfs. Note that a sustained flow event, probably greater than the peak flow and duration of the most recent flood in 2011, would likely disrupt the quasi-equilibrium state.

Even though existing hydraulic capacity is expected to continue with no-action, it should be noted that the no-action alternative does not allow the Program to convey and maintain 1,500 cfs when irrigation demand is highest. In periods of drought and heat, when both irrigation and EA flows (usually for germination suppression) are most urgently needed, EA releases and irrigation demand are in direct competition with each other. At present, the demand for irrigation takes precedence over EA releases.

5 EVALUATION OF SEDIMENT REMOVAL ALTERNATIVES

Closer evaluations of channel modification/sediment removal alternatives were conducted by reviewing, refining, and analyzing the concepts presented in Phase II of the study (see ACE Feb 2024 Memo provided in Appendix B.3). Refinement of channel alternatives was first informed by results of the geomorphic assessment. Performance of each alternative was evaluated by conducting hydraulic and sediment transport modeling. The modeling results for three sediment removal alternatives and a revised version of the ACE 2016 alternative are discussed below. Modeling and discussion of modification of the TCCD is also included. Results presented below were then used to select one alternative for which conceptual design and costs was developed.

5.1 Sediment Removal

The primary barrier to increasing hydraulic capacity through the Chokepoint is the presence of accumulated sediment or the “sediment wedge” that has formed between HWY 83 and the TCCD. The geomorphic assessment revealed that tailwater conditions at the TCCD to facilitate diversions have slowed and/or blocked movement of bed sediments through the system, resulting in the formation of the “sediment wedge” as far upstream as HWY 83. The accumulation of sediment in the channel has increased water levels, flattened the channel gradient, lowered shear stress and ultimately reduced hydraulic capacity. Removing sediment that has accumulated in the channel is the most effective way to increase hydraulic capacity. However, assuming existing diversion and dredging operations continue at the TCCD, and upstream sediment sources remain unchanged, sediment will undoubtedly redeposit in removal areas over time. 1D sediment transport modeling was conducted to determine what extent of sediment removal can effectively increase and sustain hydraulic capacity. The sediment removal alternatives discussed below were developed with the intent of reaching and sustaining target capacity under minor flood stage over a period of 2 to 3 decades.

5.1.1 Sediment Removal Alt A – TCCD to 1.4 Miles Upstream of HWY 83

Sediment Removal Alternative A (Alt A) includes channel excavation of roughly 6.6 miles from the TCCD to just upstream of the Red Fox/Darlene Rd area, see Figure 5-1. The excavated channel would restore the historic channel profile and slope of 0.125% as shown in Figure 5-2. Channel widths of 150 and 200 feet were evaluated, with 150 feet providing slightly more efficient sediment movement. All modeling results discussed assume a 150 wide channel. Total excavation volume for Alt A (150 ft wide channel) is significant and estimated at 1,170,000 CY. The depth of channel excavation would be variable and increase in the downstream direction to cut into the sediment wedge. This is similar to the sediment removal concept originally proposed in the VESPR Report (RDG 2023), but with excavation extended upstream an additional 1.4 miles from HWY 83 to effectively reduce water surface elevations in the Red Fox/Darlene Rd area that were problematic during the 2020 flow test.

Sediment removal Alt A increases hydraulic capacity at minor flood stage to approximately 6,000 cfs. This is similar to historic hydraulic capacity measured at the HWY 83 gage in the 1980s. Figure 5-2 shows the water surface profile at 3,000 cfs for Alt A compared with existing conditions. Inundation mapping at 3,000 cfs for Alt A is compared with existing conditions in Figure 5-3. Water surface profiles and inundation mapping for other flow rates are provided in Appendix C.2.

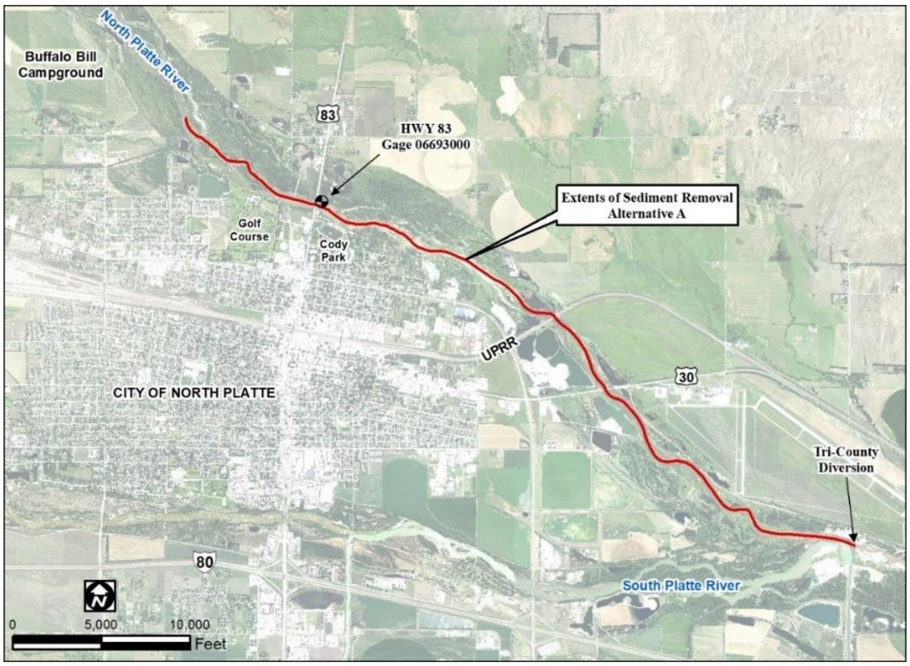


Figure 5-1 Extents of Sediment Removal Alternative A

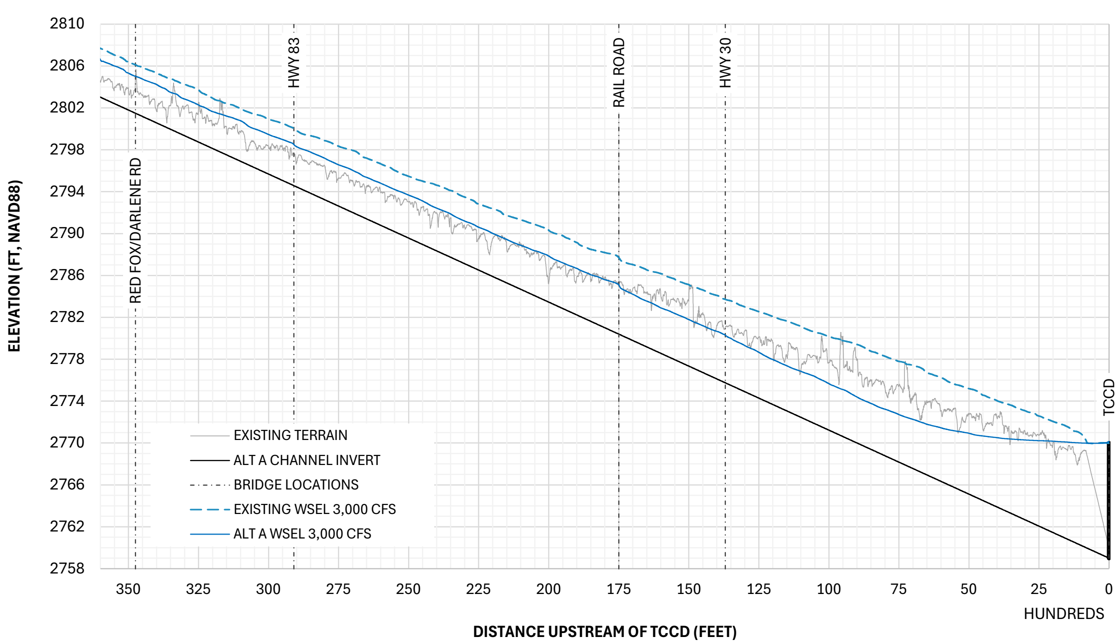


Figure 5-2 3,000 cfs Water Surface Profile - Existing Condition and Alt A

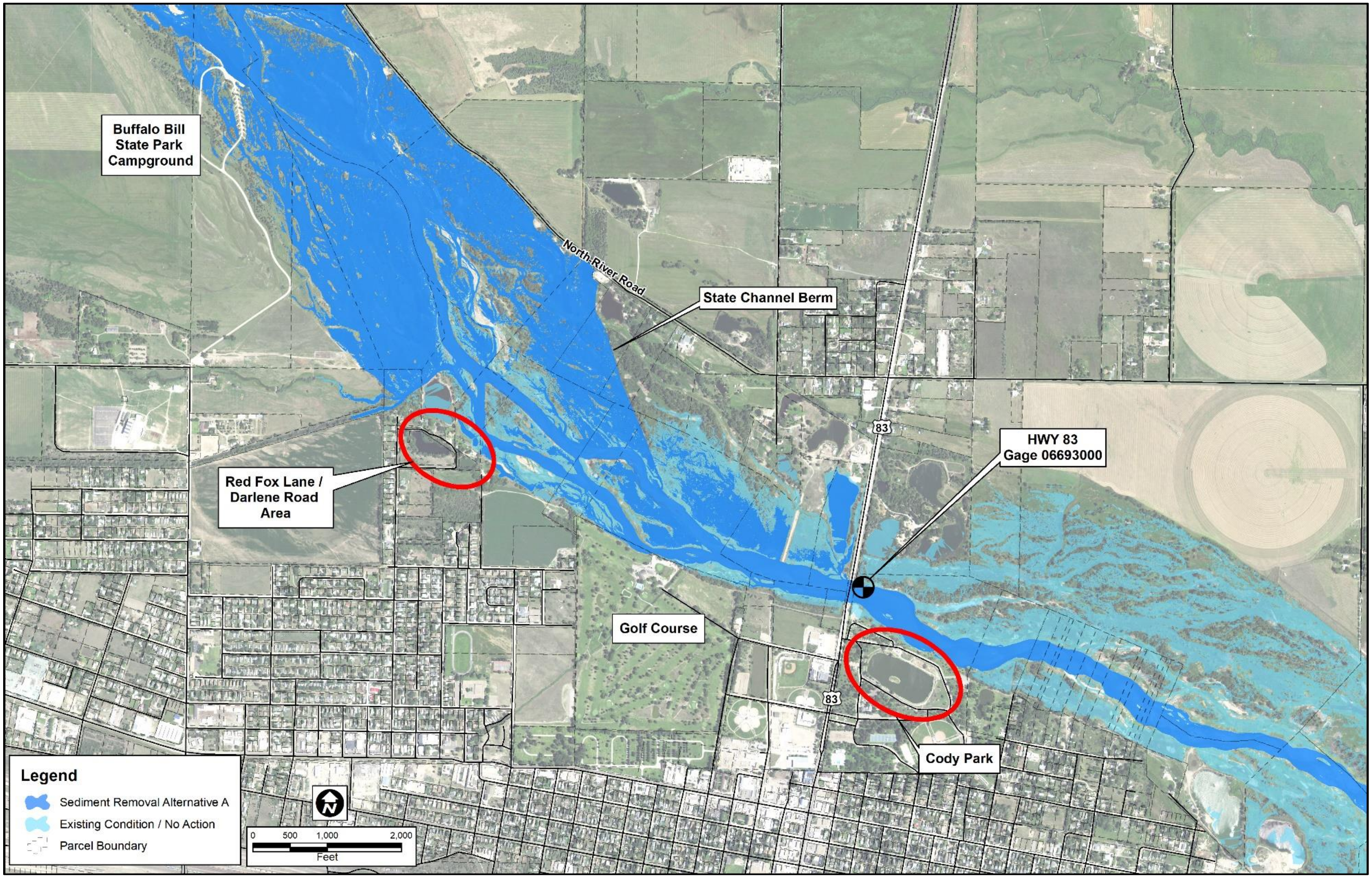


Figure 5-3 North Platte Chokepoint Inundation Mapping at 3,000 cfs – Existing Conditions/No Action and Alt A

Results at HWY 83 and Red Fox/Darlene Rd from the 1D sediment transport forecast for all three hydrographs are shown graphically in Figure 5-4 and Figure 5-5, respectively. Water surface elevation are reduced by approximately 1.6 feet at HWY 83 and 1.2 feet at Red Fox/Darlene Road. Comparison to the no action alternative shows that Alt A reduces water surface elevations, increases hydraulic capacity, and can likely sustain flood stage below 6.0 feet at 3,000 cfs for roughly 2 to 3 decades.

Figure 5-6 shows the profile of the channel along the study reach at 5 year intervals during the 25-year simulation. Note that sediment wedge is re-established within the TCCD backwater area downstream of HWY 30 within the first 5 years. Progression of channel deposition moves upstream reaching present day channel elevations at the railroad bridge by year 25. HWY 83 stage at 3,000 cfs is shown in Figure 5-7 for H2 and H3 hydrographs. An estimated error bound of +/-0.5 feet is shown after year 3 for H2 results. Model results for Alt A show an initial stage at 3,000 cfs of 5.2 ft which is then reduced during the first 5 to 10 years likely due to increased channel slope, velocity, and transport capacity. Modeled stage is then stabilized as sediment accumulation in the channel begins to migrate upstream.

It should be noted that Alt A exceeds the target hydraulic capacity of 3,000 cfs at a minor flood of 6 feet and provides a capacity of approximately 6,000 cfs at 6.0 feet (or 3,000 cfs at a stage of 5.2 feet). Refinement of this alternative is possible to more closely meet the target capacity. However, this would not substantially reduce the volume of sediment removal because much (approximately 60-70%) of the excavated volume is located between the railroad and the TCCD, where the sediment wedge is deepest. In addition, a refined version of this alternative to minimize hydraulic capacity beyond the target would reduce the amount of time that capacity can be maintained. Sediment removal on this scale would require a significant capital investment. Due to the uncertainties in the modeling, it would be prudent to provide additional hydraulic capacity beyond the target to minimize the risk of future loss of hydraulic capacity.

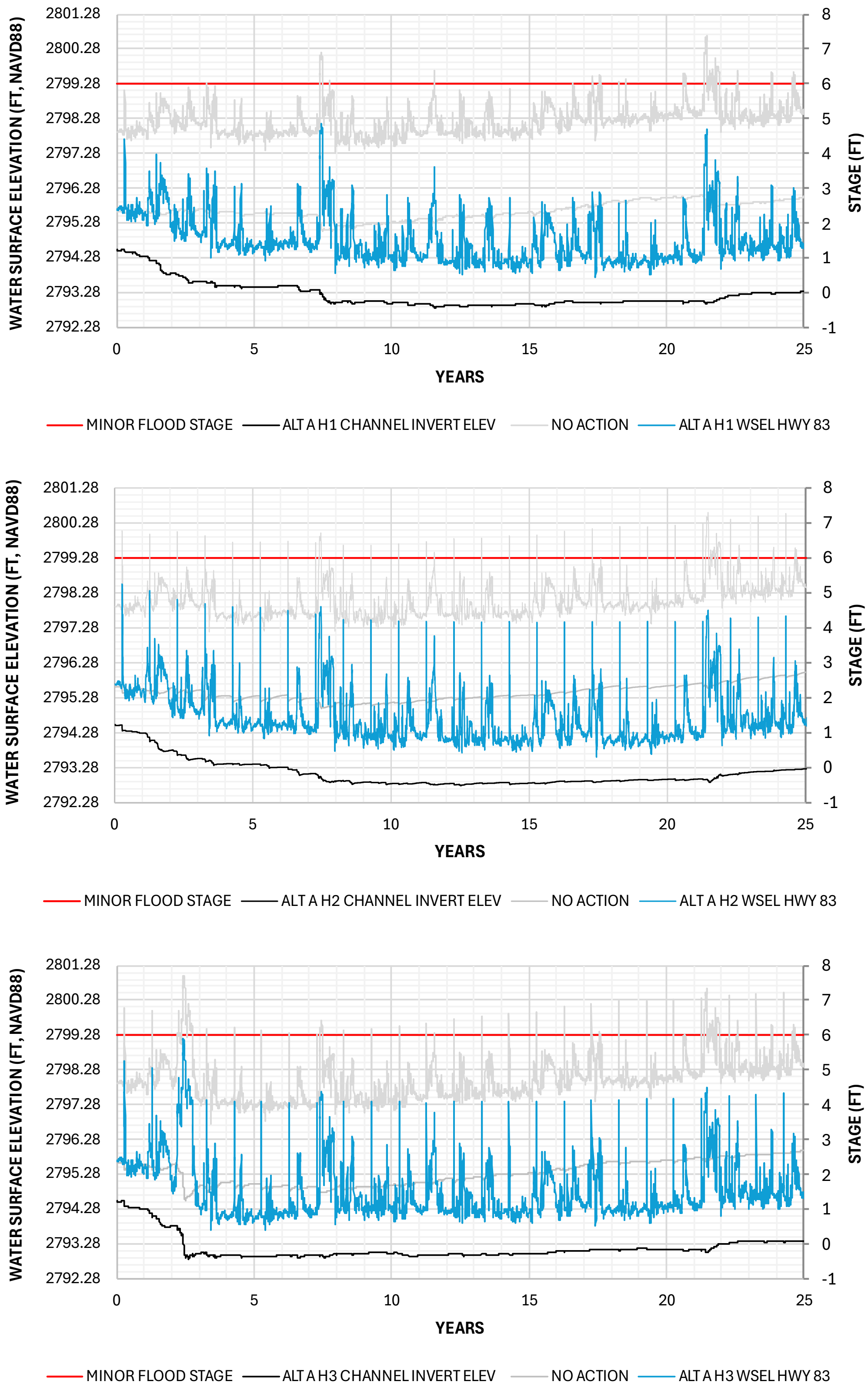
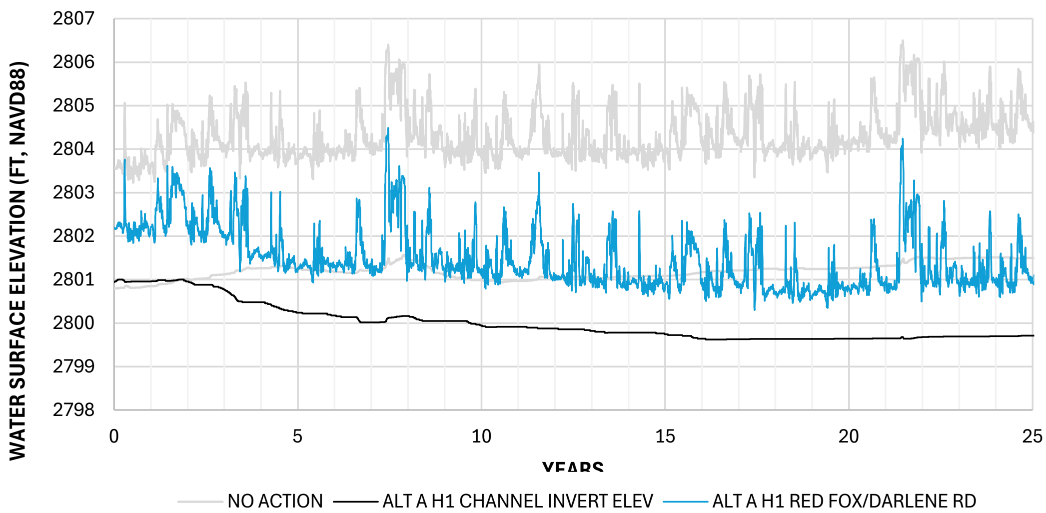
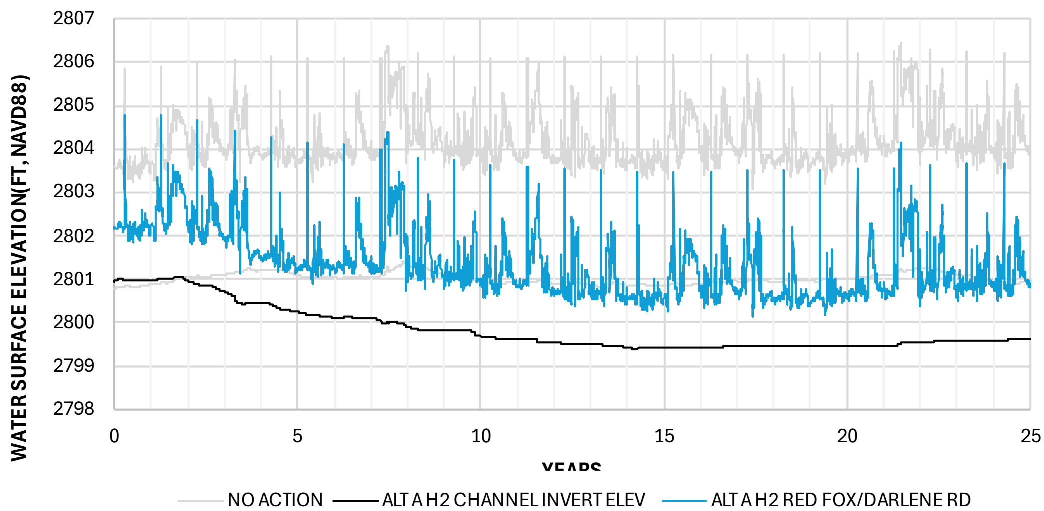


Figure 5-4 Alt A 25-Year Forecast - Water Surface and Channel Elevation at HWY 83

H1 (top), H2 (middle) and H3 (bottom)





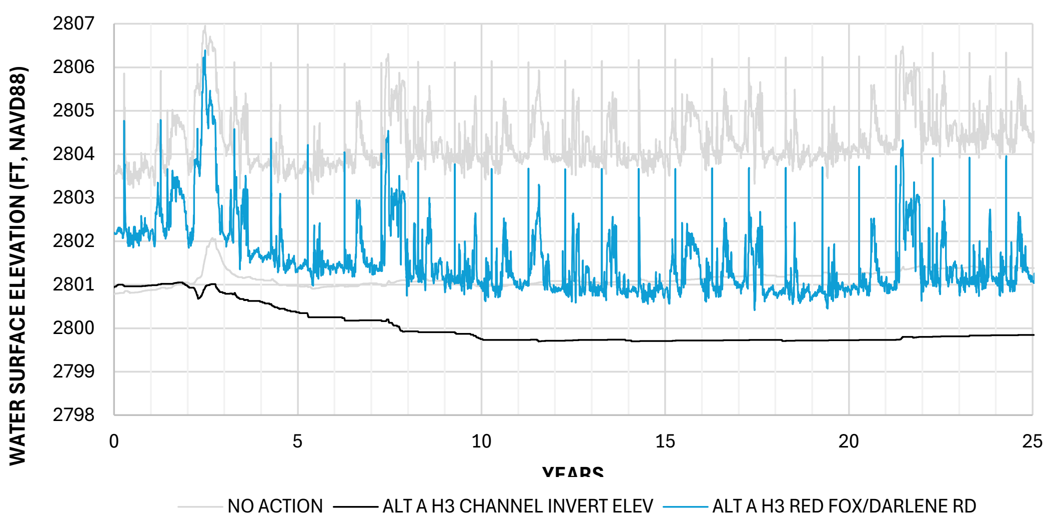


Figure 5-5 Alt A 25-Year Forecast - Water Surface and Channel Elevation at Red Fox/Darlene Rd

H1 (top), H2 (middle) and H3 (bottom)

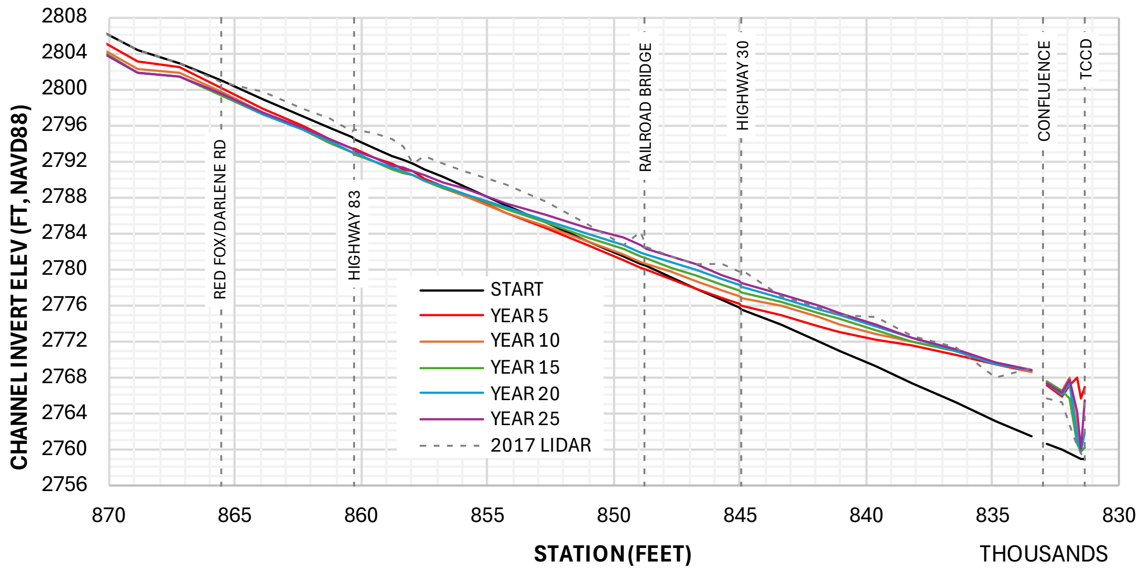


Figure 5-6 Alt A Progression of Channel Profile

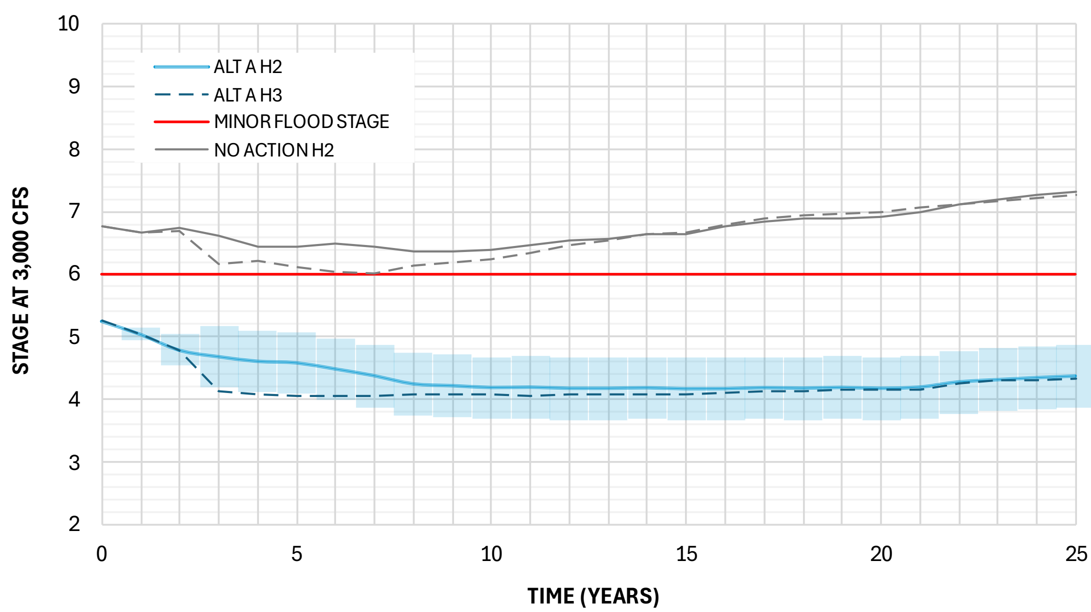


Figure 5-7 Alt A and No Action H2 and H3 25-Year Forecast - Stage at 3,000 cfs through Time

2D sediment transport modeling of Alt A was conducted to seek additional information related to the rate of sediment aggradation within the excavated channel downstream of HWY 30 relative to 1D model results. The 2D model simulates the first 5 years of the H2 hydrology used in the 1D model. Figure 5-8 shows a map of bed change at the end of the 5-year 2D model simulation. Figure 5-9 shows the 2D model results along the channel profile at 1-year increments. For reference the existing channel profile based on 2017 Lidar is included on the plot.

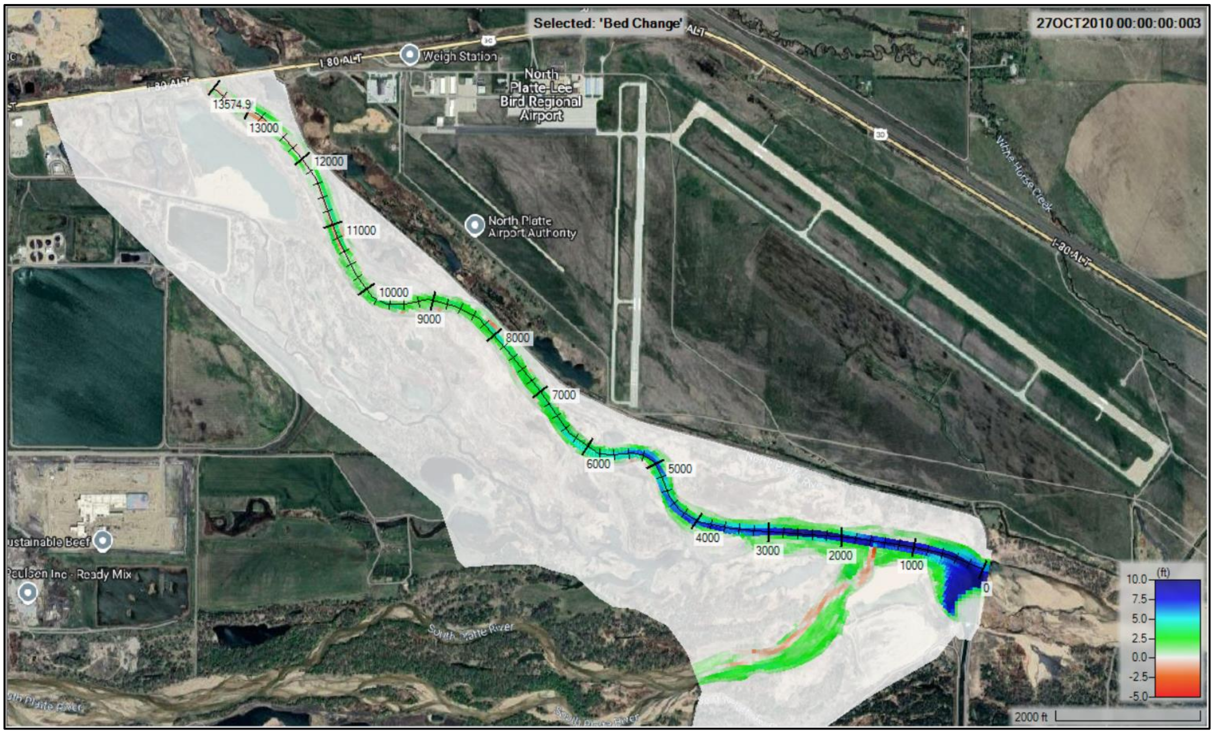


Figure 5-8 Alt A 2D Model Results – Bed Change at Year 5
Deposition shown in green and blue, erosion shown in orange and red.

The 2D model results indicate that deposition within the excavated channel up to the TCCD backwater elevation of 2770 within the first 3 years, with a continuation of deposition occurring through year 5. Figure 5-10 compares the channel profile after 5-years computed by the 1D and 2D sediment transport models. Results from both models are consistent and support the conclusion that the sediment wedge will re-establish within the first 5-years and progressively migrate in the upstream direction thereafter.

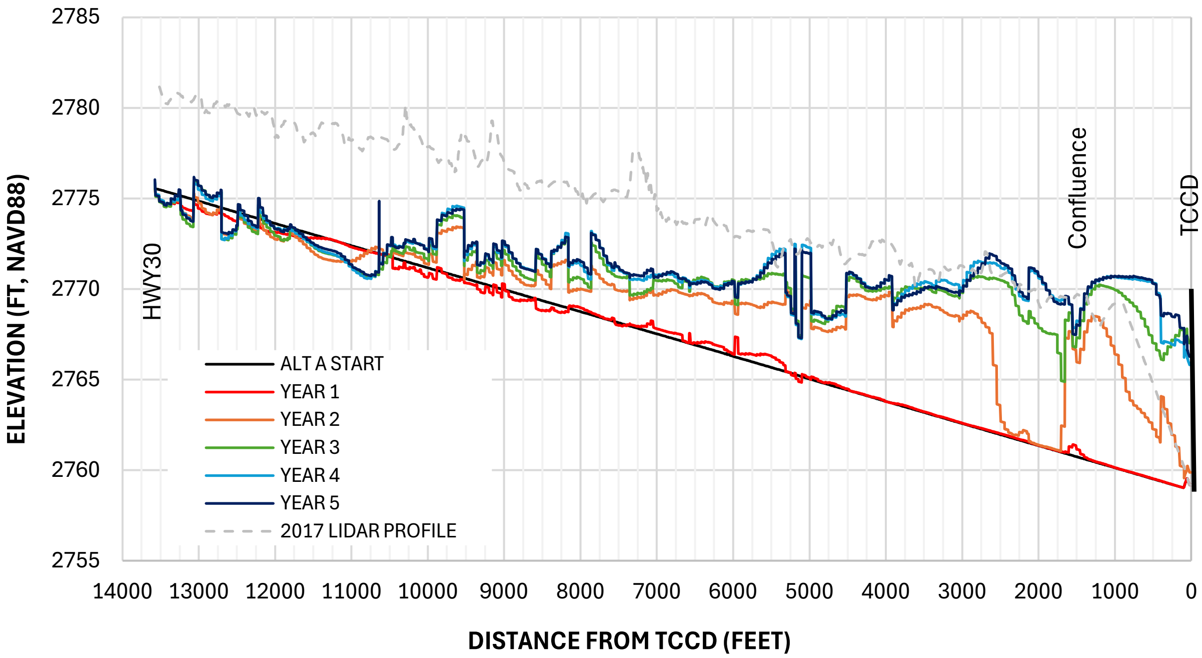


Figure 5-9 Alt A 2D Sediment Model Results – Channel Profile Year 1 through 5.

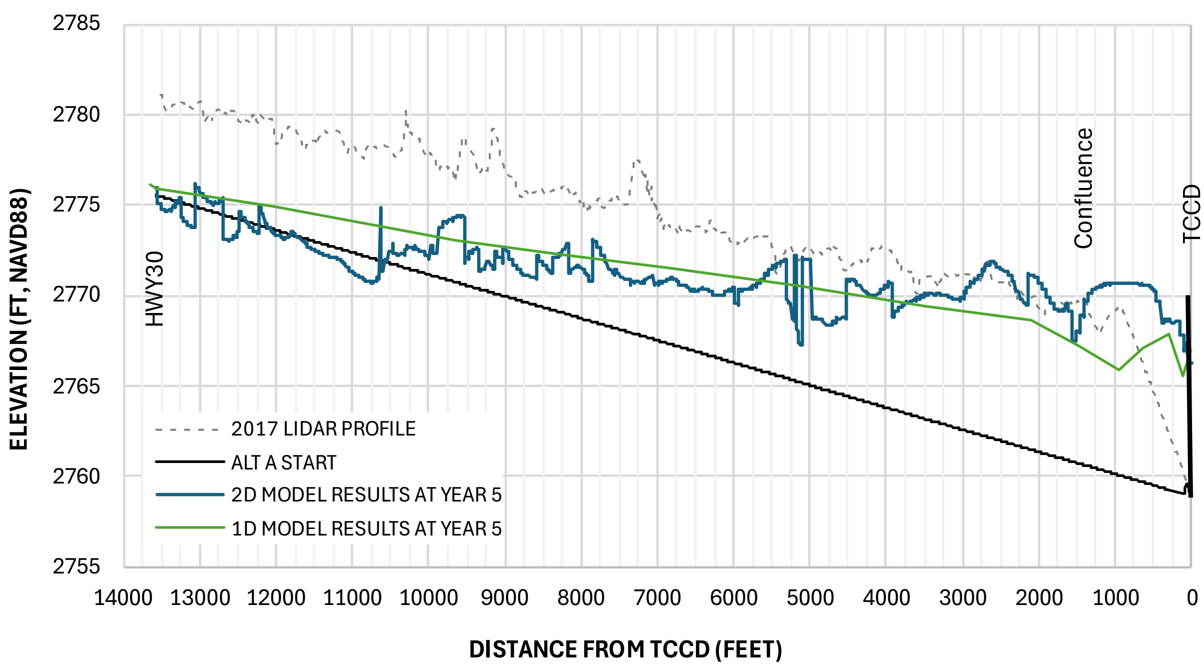


Figure 5-10 Comparison of Alt A 1D and 2D Sediment Model Results – Channel Profile at Start and Year 5.

5.1.2 Sediment Removal Alt B – Below HWY 30 to 1.4 Miles Upstream of HWY 83

Evaluation of Alt A indicates that sediment will fill in the excavated channel downstream of HWY 30 in roughly 5 years. Sediment Removal Alternative B (Alt B) includes a smaller extent of excavation by moving the downstream limit to one mile below HWY 30, Figure 5-11. This reduces the length of sediment removal to 4.8 miles and total excavation volume to 330,000 CY, which is roughly 30% of what is required in Alt A. Figure 5-12 shows a graphical profile at 3,000 cfs. The slope of the excavated channel is 0.115%, which is flatter than the historic and Alt A slope. Channel hydraulics and sediment transport are highly sensitive to slope changes. Achieving the target hydraulic capacity and a reasonable slope along the length of the excavated channel requires a flatter area at the downstream tie-in to the existing channel. This is not ideal but a limitation of the existing slope.

Results of the 1D sediment model 25-year forecast are shown in Figure 5-13 through Figure 5-15. Given that results are generally the same for all three hydrographs, the model output shown below is limited to H2. Stage at HWY 83 for 3,000 cfs is just below 6.0 feet at the beginning of the simulation. Additional hydraulic capacity above the target at the onset was not achievable given slope limitations. The forecast model results show stage at 3,000 cfs under 6 feet sustained for the first 5 to 10 years with an increase above 6 feet starting around year 15. The lower water surface elevations with Alt B at HWY 83 roughly follow the same trend as the no-action, which could indicate that it is sustainable for roughly for 5 to 15 years. However, the uncertainty related to sustainability of hydraulic capacity over the estimated time is higher than Alt A. Additionally, the simulation failed around year 20 due to excessive deposition occurring at the downstream limit of excavation. This is a result of the flattened slope at the downstream tie-in, which is problematic. Additional modification and a longer model simulation was not pursued.

Alt B requires a significantly smaller amount of sediment removal relative to Alt A which could reduce initial construction costs, However, reducing the volume of sediment removal decreases the amount of time hydraulic capacity is sustainable (on the order of 3 to 15 years). Within a 25-year window Alt B would require annual monitoring and likely repeated sediment removal to maintain target capacity. An additional round of sediment removal within a 25-year period would likely increase long term costs to be similar in magnitude to Alt A.

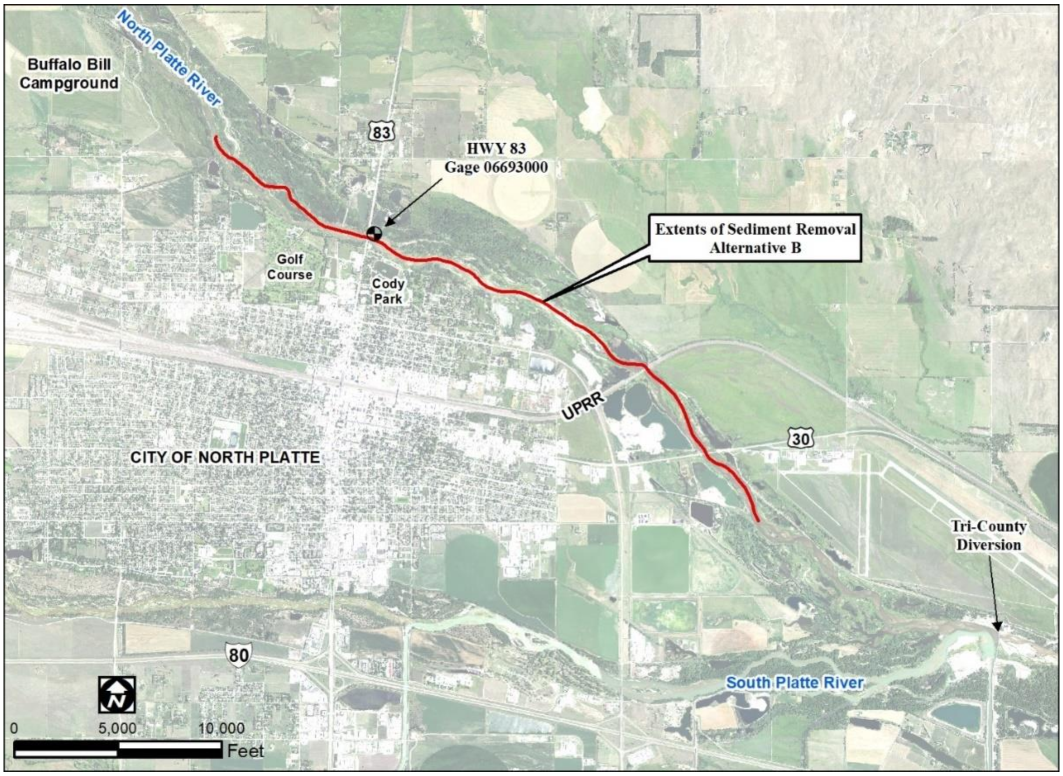


Figure 5-11 Extents of Sediment Removal Alternative B

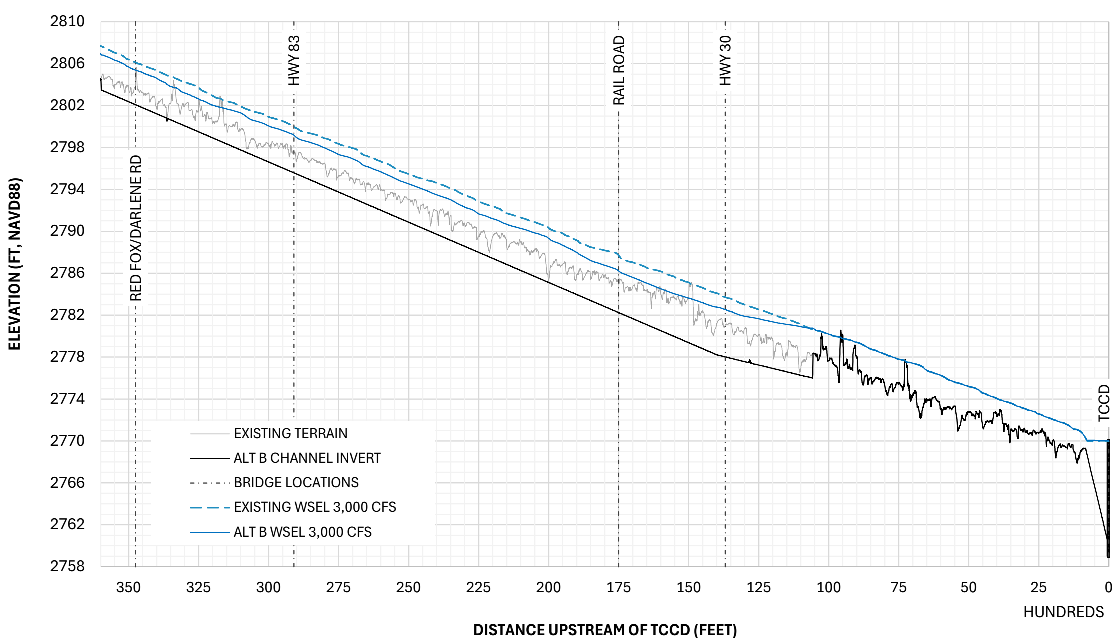


Figure 5-12 3,000 cfs Water Surface Profile - Existing Condition and Alt B

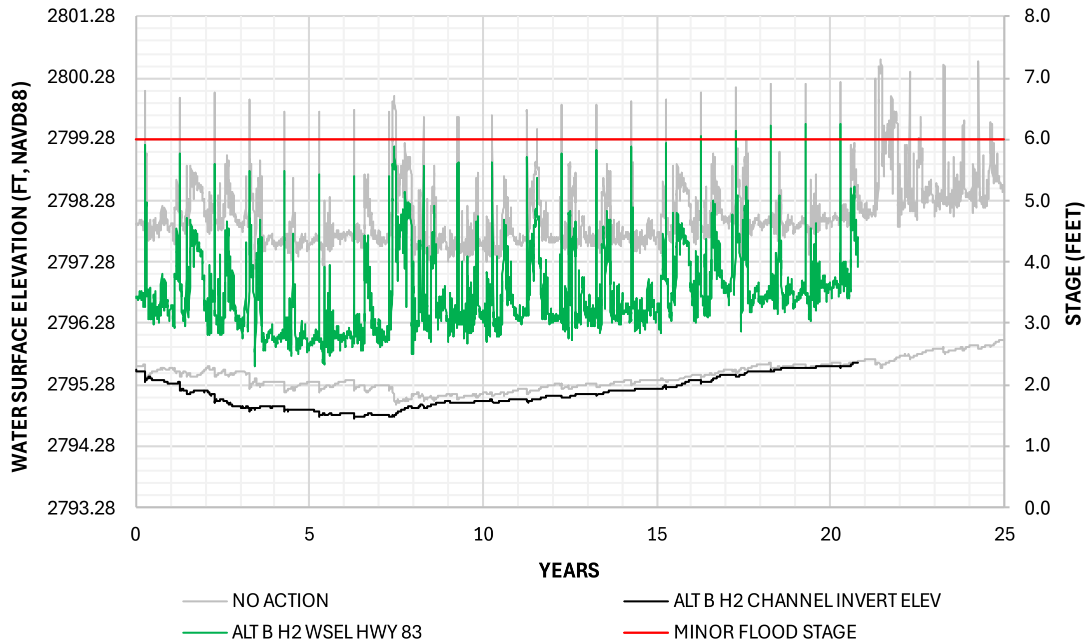


Figure 5-13 Alt B 25-Year Forecast - Water Surface and Channel Elevation at HWY 83

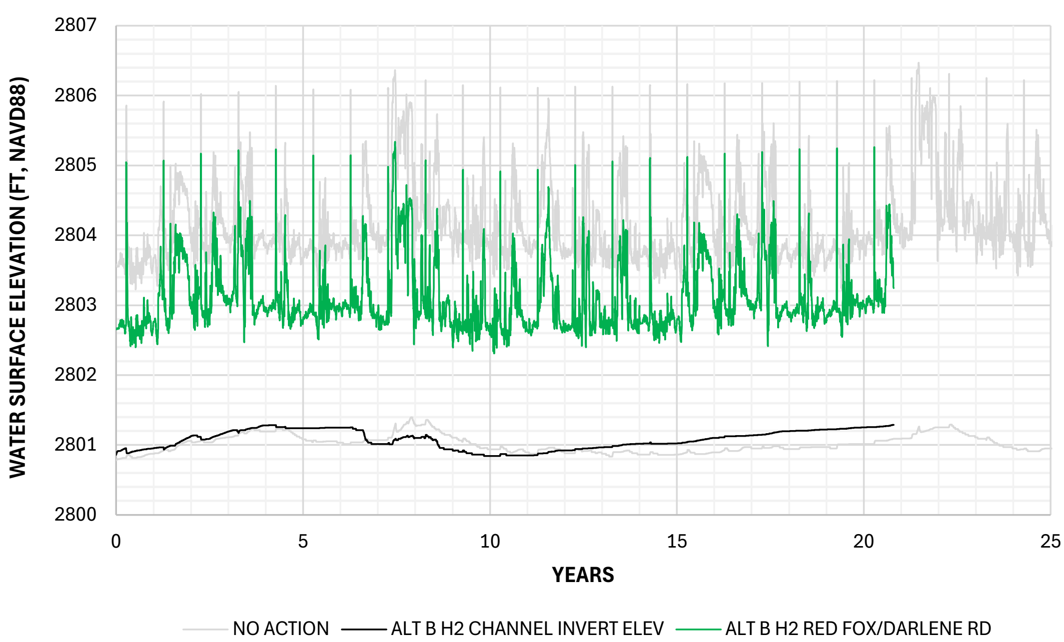


Figure 5-14 Alt B 25-Year Forecast - Water Surface and Channel Elevation at Red Fox/Darlene Rd

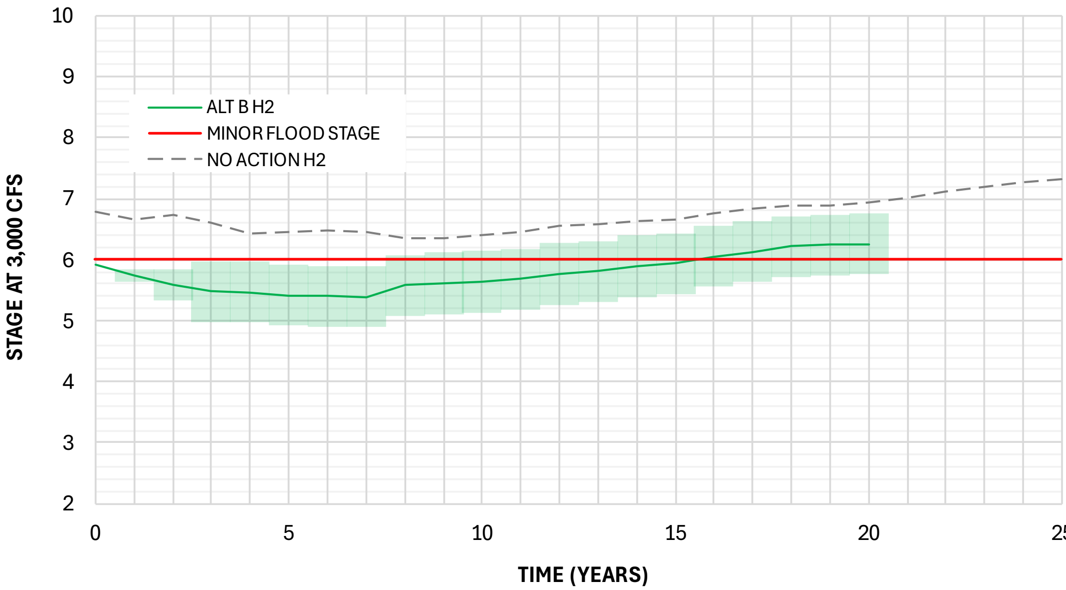


Figure 5-15 Alt B H2 25-Year Forecast - Stage at 3,000 cfs through Time

5.1.3 Sediment Removal Alt C – Railroad to 1.4 Miles Upstream of HWY 83

Sediment Removal Alternative C (Alt C) includes an even more limited extent of excavation, with the downstream boundary located upstream of the railroad, see Figure 5-16. This alternative requires excavation of roughly 233,000 CY of sediment along 3.3 miles of the river. Alt C channel slope is 0.115% and is shown in profile in Figure 5-17. As noted with Alt B, achieving a reasonable slope along the length of the excavated channel and meeting the target hydraulic capacity requires a flatter slope at the downstream tie-in to the existing channel, which is problematic.

Results of the 1D sediment model 25-year forecast are shown in Figure 5-18 through Figure 5-20. Stage at HWY 83 is just below 6.0 feet at the beginning of the simulation until roughly year 7 when stage begins to increase to levels that are similar to the no-action, see Figure 5-16 and 5-18. Reduction in water surface elevations at Red Fox/Darlene Rd are roughly 1 foot but begin to diminish to 0.5 feet by year 25, see Figure 5-19. It is likely that target capacity would not be sustained for more than 3 to 10 years, with a high degree of uncertainty.

Alt C requires roughly 30% less excavation relative to Alt B and 80% less than Alt A but is even less sustainable over time than both alternatives. Within a 25-year window Alt C would require annual monitoring and likely repeated sediment removal to maintain target capacity.

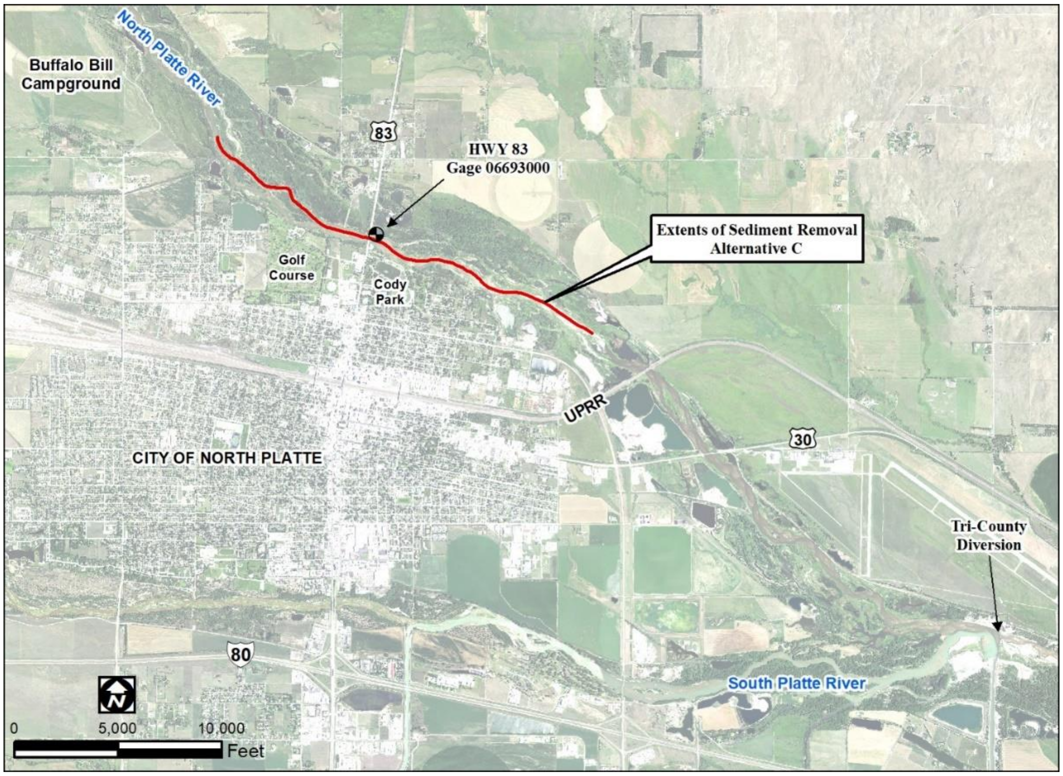


Figure 5-16 Extents of Sediment Removal Alternative C

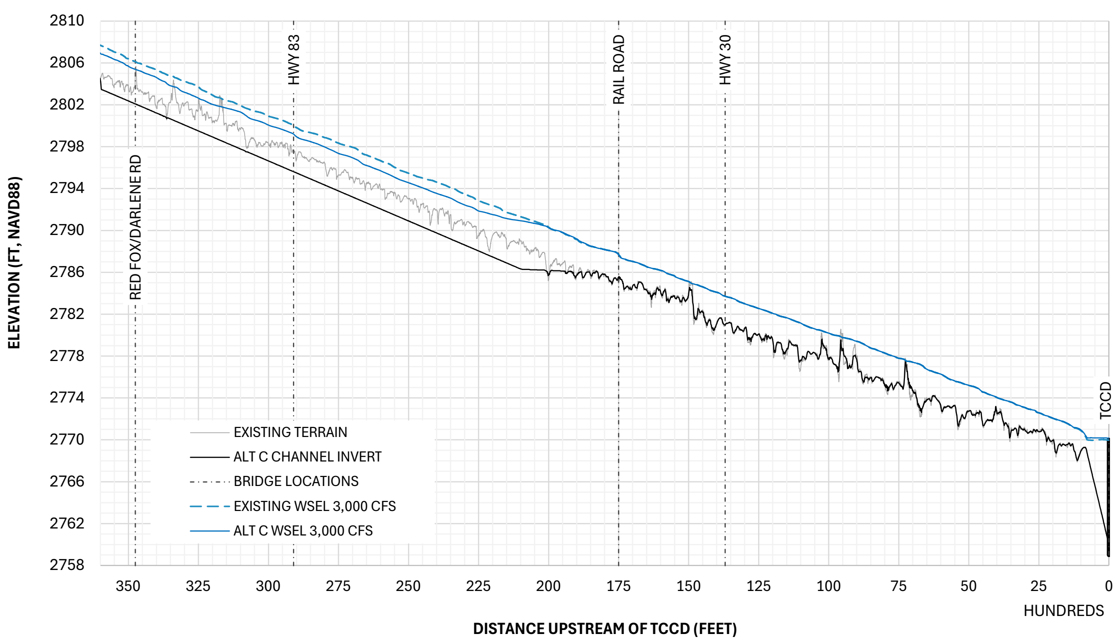


Figure 5-17 3,000 cfs Water Surface Profile - Existing Condition and Alt C

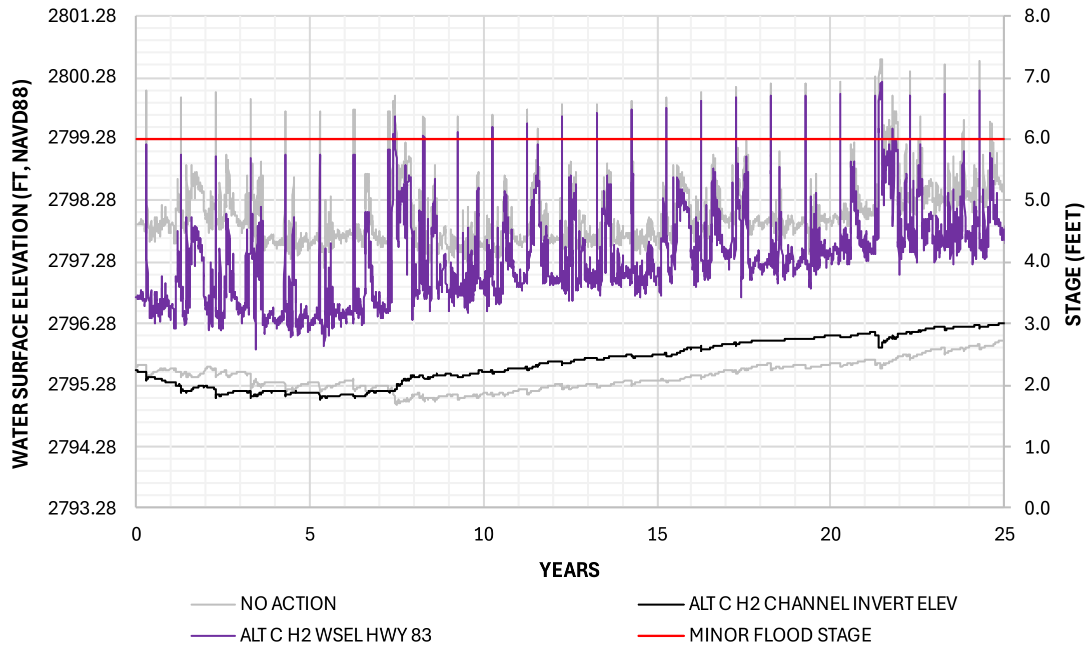


Figure 5-18 Alt C 25-Year Forecast - Water Surface and Channel Elevation at HWY 83

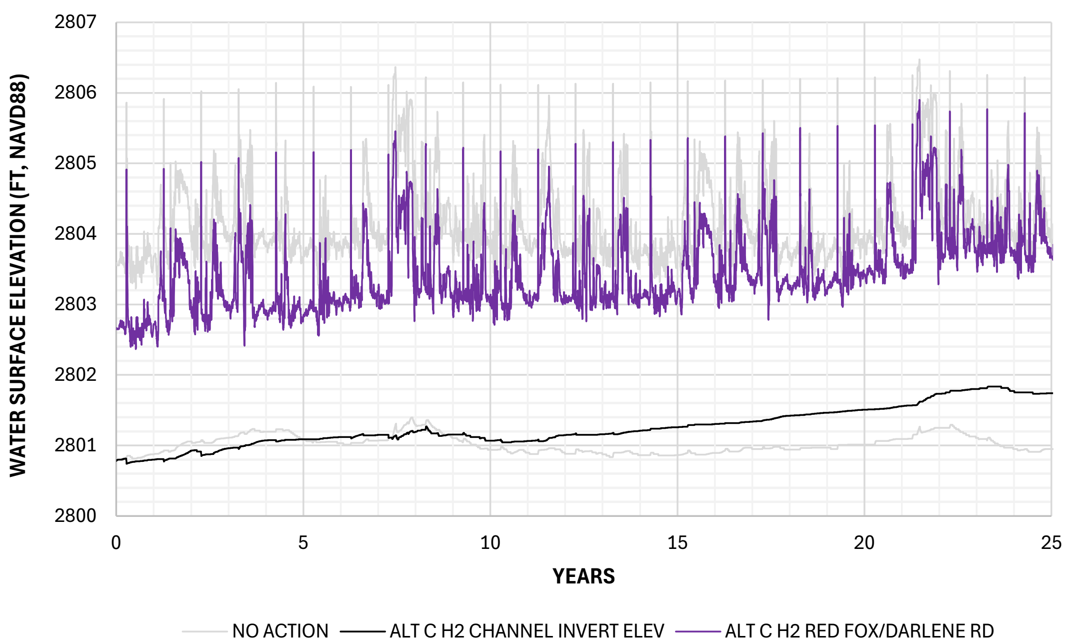


Figure 5-19 Alt C 25-Year Forecast - Water Surface and Channel Elevation at Red Fox/Darlene Rd

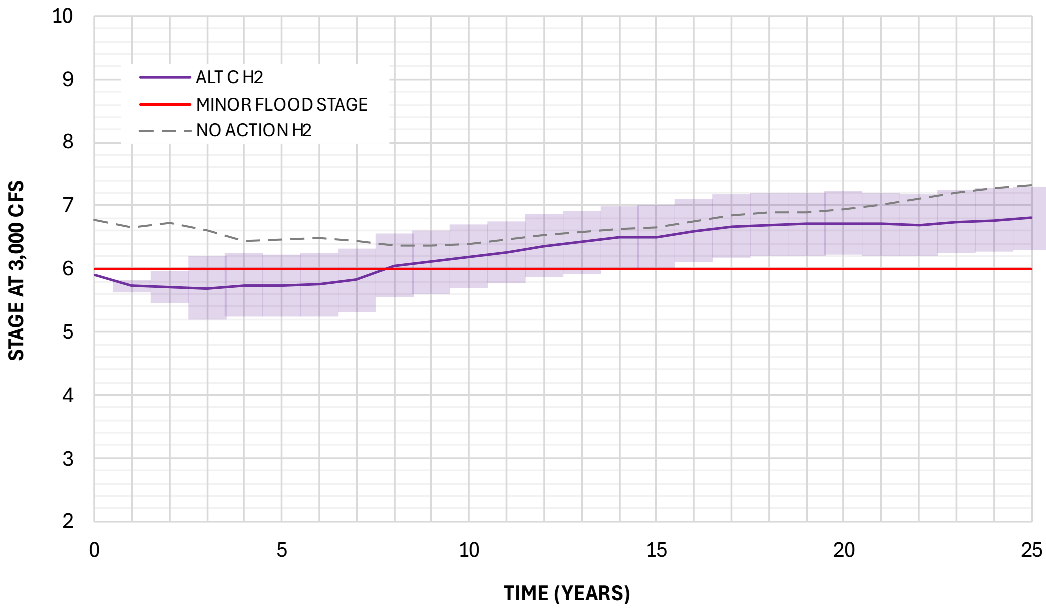


Figure 5-20 Alt C H2 25-Year Forecast - Stage at 3,000 cfs through Time

5.1.4 ACE 2016 Channel Modification/Sediment Removal

The ACE 2016 channel modification/sediment removal alternative identified in Phase II was slightly modified and modeled. This alternative was originally developed in 2016 with the goal of achieving more consistent sediment transport capacity through the Chokepoint upstream of the railroad. A modified version (Mod ACE 2016 Alt) of the concept was developed and includes widening of the channel upstream of HWY 83 to 300 feet in combination with the same channel excavation as Alt C downstream of HWY 83. The upstream and downstream extents are the same as Alt C. A total of 203,000 CY of sediment removal would be required for the Mod ACE 2016 Alt. This concept is intended to promote sediment continuity and reduce deposition near HWY 83.

Results of the 1D sediment model 25-year forecast are shown in Figure 5-21 through Figure 5-25. Water surface elevation at HWY 83 is reduced and remains stable over the 25 years, see Figure 5-22. Water surface elevations at Red Fox/Darlene Rd are also reduced but steadily increase until roughly year 12, as shown in Figure 5-23. The forecast modeling shows stage at 3,000 cfs just below 6.0 feet at HWY 83 through the 25-year run, see Figure 5-25. Widening of the channel upstream of HWY 83 results in more rapid deposition occurring upstream of HWY 83, which in turn results in a sustained capacity at HWY 83. Deposition occurring due to channel widening is shown at Red Fox/Darlene Rd on the graphical profile provided in Figure 5-24. Channel widening essentially distributes sediment deposition first to the area around Red Fox/Darlene Rd while a slower filling of the channel downstream of HWY 83 progresses (as compared to Alt C). While the modeling indicates a stable capacity through time there is a high degree of uncertainty related to sustainability and an additional risk of mobilizing sediments deposited in the widened area.

It is estimated that the ACE 2016 Alterative could provide hydraulic capacity for roughly 3 to 25 years, but with a higher degree of uncertainty when compared with Alts B and C. Within a 25-year window this alternative would require annual monitoring and likely repeated sediment removal to maintain target capacity.

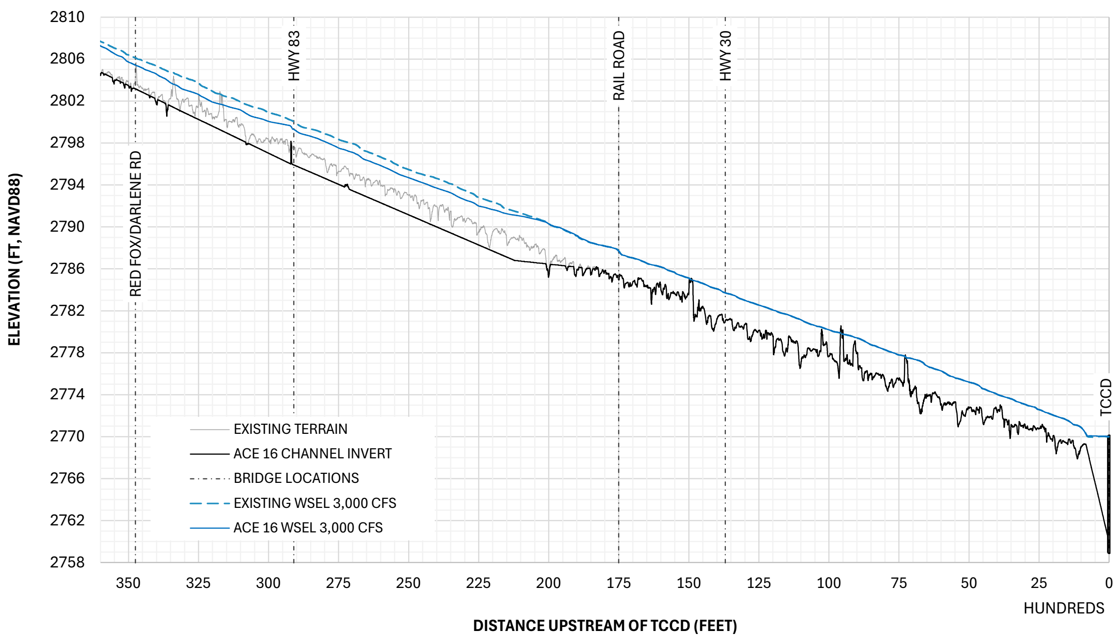


Figure 5-21 3,000 cfs Water Surface Profile - Existing Condition and Modified ACE 2016 Alt

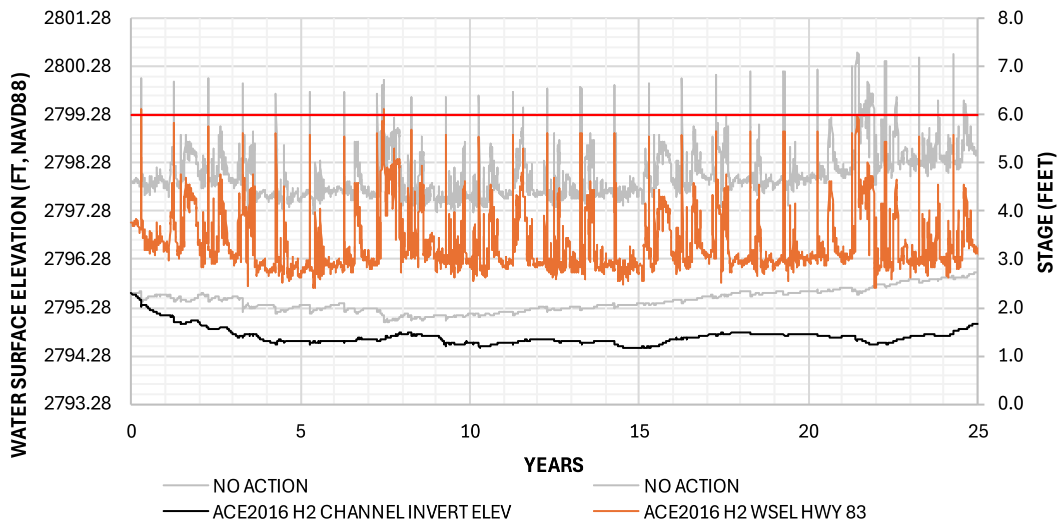


Figure 5-22 Mod ACE 2016 Alt 25-Year Forecast - Water Surface and Channel Elevation at HWY 83

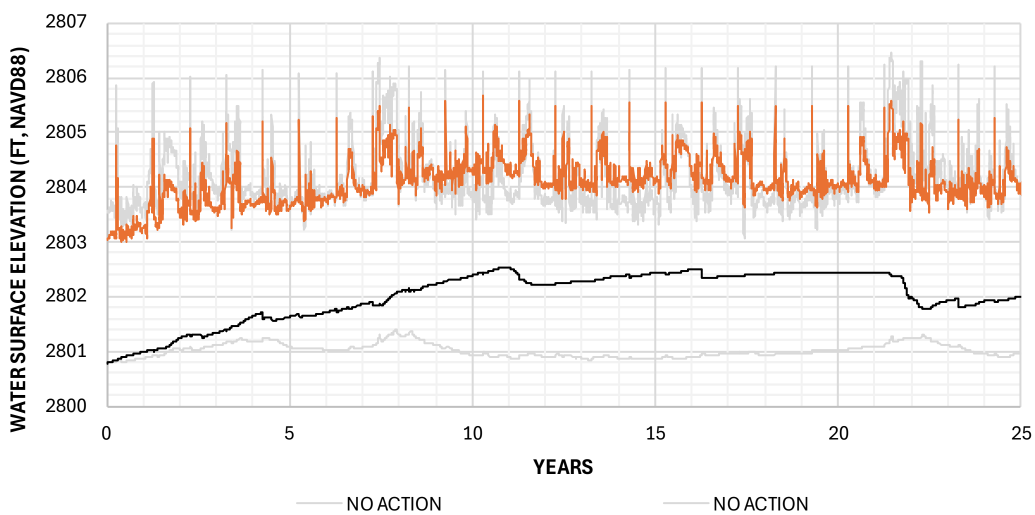


Figure 5-23 Mod ACE 2016 Alt 25-Year Forecast - Water Surface and Channel Elevation at Red Fox/Darlene Rd

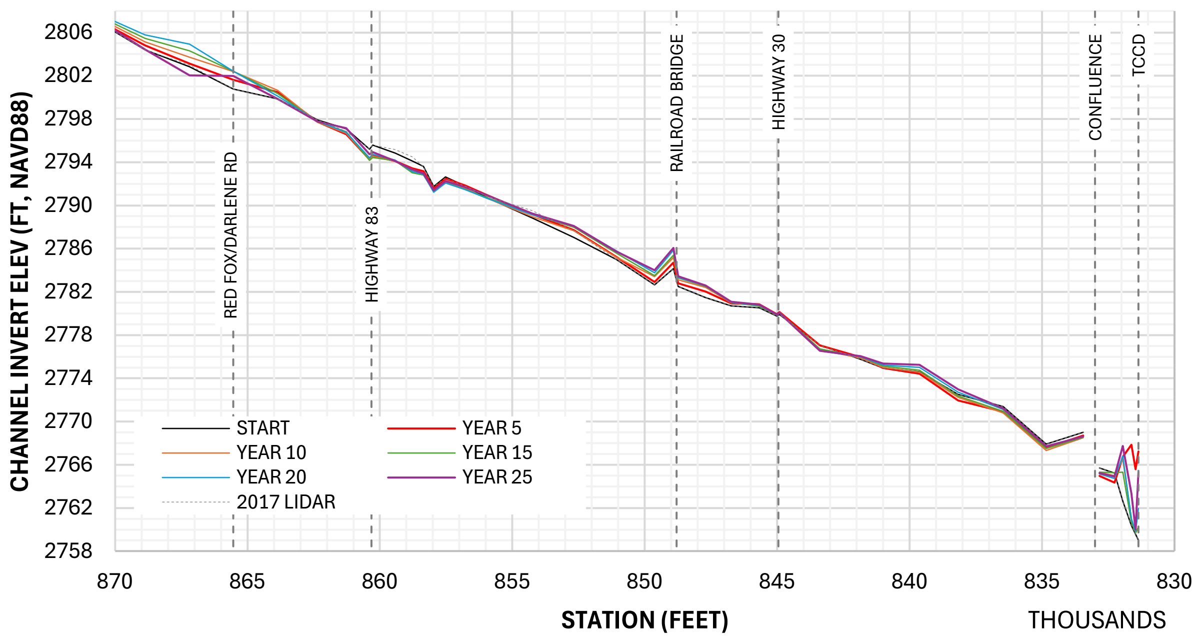


Figure 5-24 Mod ACE 2016 Alt Progression of Channel Profile

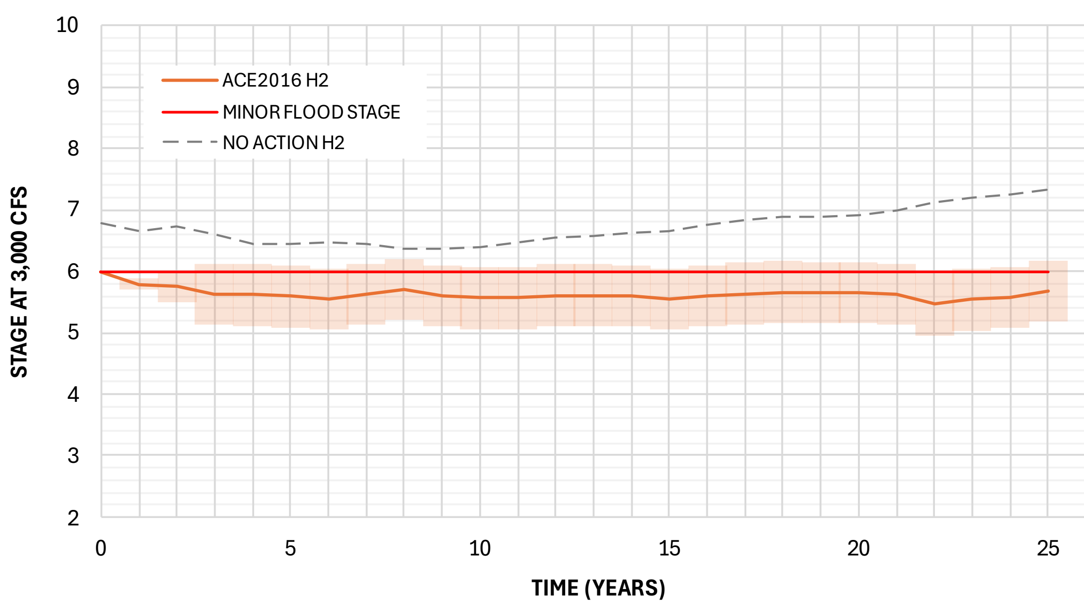


Figure 5-25 Mod ACE 2016 H2 25-Year Forecast - Stage at 3,000 cfs through Time

5.1.5 Comparison of Alternatives

A key conclusion from evaluation of sediment removal alternatives is that sustainability of target hydraulic capacity is directly related to the volume of sediment removal. Stage at 3,000 cfs estimated by the sediment transport model over the 25-year forecast period is shown for the No-Action and all Sediment Removal Alternatives in Figure 5-26. Table 5-1 compares the removal volume, channel slope, estimated sustainability, and long-term monitoring and maintenance.

Over a 25-year period Alt A provides the most sustainable solution with the least amount of uncertainty or risk relative to other sediment removal options. A conceptual design, identification of permitting requirements, and a cost estimate for Alt A is provided in Section 6. Alternatives B, C, and the ACE 2016 Alternative would initially provide target capacity at a lower cost but would require annual monitoring and likely an additional round of sediment removal within a 25-year time frame.

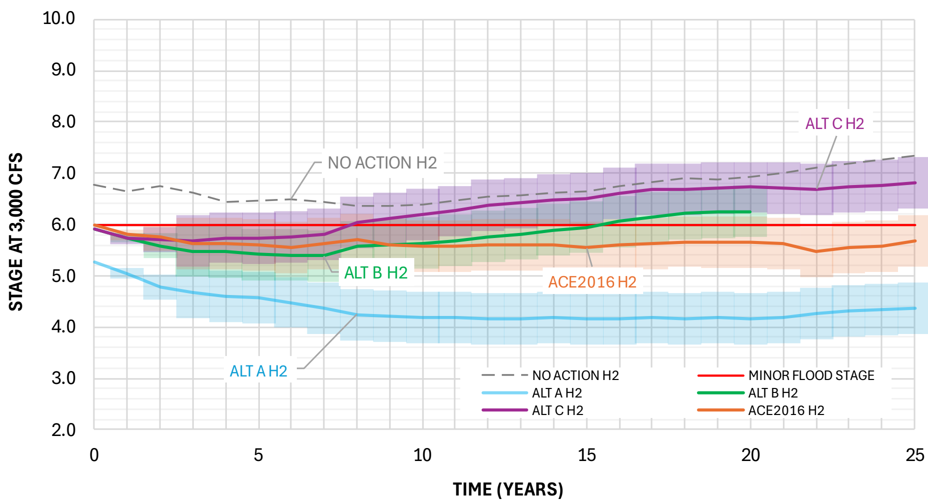


Figure 5-26 Alternative Comparisons - Stage at 3,000 cfs through Time

Table 5-1 Comparison of Sediment Removal Alternatives

	Sediment Removal Volume (CY)	**Channel Slope**	**Sustainability***	**Long Term Monitoring and Maintenance 25 Years**
Alt A	1,170,000	0.125%	20 - 30 yrs	Periodic Monitoring
Alt B	330,000	0.115%	3 - 15 yrs	Annual Monitoring, Additional Sediment Removal Likely
Alt C	233,000	0.115%	3 - 10 yrs	Annual Monitoring, Additional Sediment Removal Likely
ACE 2016 Alt	203,000	0.115%	3 - 25 yrs	Annual Monitoring, Additional Sediment Removal Likely

* Estimated range of time capacity of 3,000 cfs at or below minor flood stage of 6 feet is sustained. Estimates assume hydrologic conditions similar to the previous 20 years and do not account for effects and risks related to large flood events.

5.2 Modification of Tri-County Canal Diversion

The TCCD is an 870-foot-wide concrete structure that spans the width of the Platte River just downstream of the North and South Platte confluence. The structure consists of two sets of outflow gates located at the northern and southern ends. Between them is a 375-foot-wide ogee spillway. The height of the structure is 10.7 feet, measured from the bottom of the lowest river gate (2759.3 ft, NAVD88) and the top of the spillway crest (2770 ft, NAVD88). The Tri-County Canal has a diversion capacity of 2,250 cfs and diverts flow year-round for irrigation and hydropower operations. To facilitate diversions the gates are adjusted so that headwater is consistently held between an elevation of 2769 and 2770. The existing structure is currently capable of sluicing large flows and sediment through the outlet gates, as demonstrated during the 2013 flood when approximately 18,000 cfs was passed without overtopping the spillway.

There have been several diversion modification projects successfully implemented in the Platte River Basin with the purpose of promoting sediment passage, reducing maintenance and sedimentation in canals and ditches, removing barriers to fish passage, improving safety for river recreation, and improving overall river health. This is usually accomplished by replacing gates and spillways that continually obstruct flow with overshot gates (e.g. Obermeyer gates) that can be raised for diversions and lowered to lay flat across the bottom of river allowing for passage of flow and sediment along the natural channel bed. Typically, these projects have been implemented for structures that divert water during the irrigation season and allow flow and sediment passage during the remainder of the year.

Modification of the Tri-County Canal Diversion (TCCD) for more efficient sediment passage was considered as an alternative to increase hydraulic capacity at HWY 83 or as an enhancement to the sediment removal alternative. Without disrupting current operations and diversion practices modification of the TCCD structure would not likely improve existing conditions or enhance performance of sediment removal alternatives. Diversions at the TCCD occur nearly year-round, instead of seasonally. The passage of flow and sediment through a fully open overshot gate along the bed of the river would conflict with headwater necessary for diversions. Sediment passage through a modified structure would be limited to very short periods of time. Further, the existing gates are capable of flushing sediments when there is excess flow above diversion demands as observed during the 2013 flood. Even though existing gates can handle large amounts of flow and sediment, benefits of sediment passage have not been realized due to lack of water availability. Peak flows, or flushing flows, required to transport sediments through the structure and downstream are limited by irrigation demands and hydraulic capacity. Modification of the structure to pass sediment would not be beneficial without sufficient flows. In addition, invasive aquatic species have been detected downstream of the TCCD, which currently acts as a barrier. While fish passage is usually a benefit of structure modification in this case it would be problematic. While there are some acoustic solutions it would be difficult to simultaneously pass sediment downstream and limit fish from migrating upstream.

Sediment transport modeling was used to demonstrate if a modified structure could pass sediment and induce a headcut in the North Platte upstream of the TCCD. Both 1D and 2D models with a constant flow of 3,000 cfs were run to determine how long it would take for a headcut to migrate upstream as far as HWY 83. Modeling assumes that the northern gates of the TCCD are replaced with an overshot gate and a 200 ft wide pilot channel is initially excavated between the TCCD and confluence to start a headcut. Modeling also assumes that no diversions are occurring, and all flow is passed downstream.

Figure 5-27 shows channel profiles computed by the 1D sediment model at 30-day increments of constant flow of 3,000 cfs. The water surface elevation computed at HWY 83 by the 1D model is shown in Figure 5-28. This figure shows that a headcut could migrate upstream and reduce stage at HWY 83, but it takes nearly 600 days (2 years) of continual flow of 3,000 cfs to occur. The 2D sediment transport model, which was run for a total of 30 days, shows similar results. Migration of the headcut only extends roughly 3,500 feet upstream over the 30-day simulation period as shown in Figure 5-29. Bed change at the end of 30 days is shown in Figure 5-30.

This modeling exercise demonstrates that a significant volume of water is required to flush sediments through the North Platte. Much larger flows on the North Platte, on the order of 10,000 cfs or greater, would be necessary to transport an effective amount of sediment downstream through a modified structure. This would only be possible if headwater and diversions are interrupted. Passage of sediment downstream during times of diversion would be in conflict. It should also be noted that modeling does not account for large contributions of sediment originating in the South Platte which would also require passage downstream.

It is our opinion that modification to the TCCD is not a practical alternative largely due to the lack of flows high enough to sufficiently pass sediment downstream and limitations associated with year-round diversions that require roughly 9 to 10 feet of headwater. Under current operations modification of existing gates would not provide added benefit given that existing gates are sufficient to sluice large flows and sediment. In addition, modification of the structure could create potential difficulties related to upstream migration of invasive aquatic species. Modification of the TCCD structure was estimated in Phase II of this study at $21 million, which is a large investment for an alternative that has not yet been proven beneficial under current limitations.

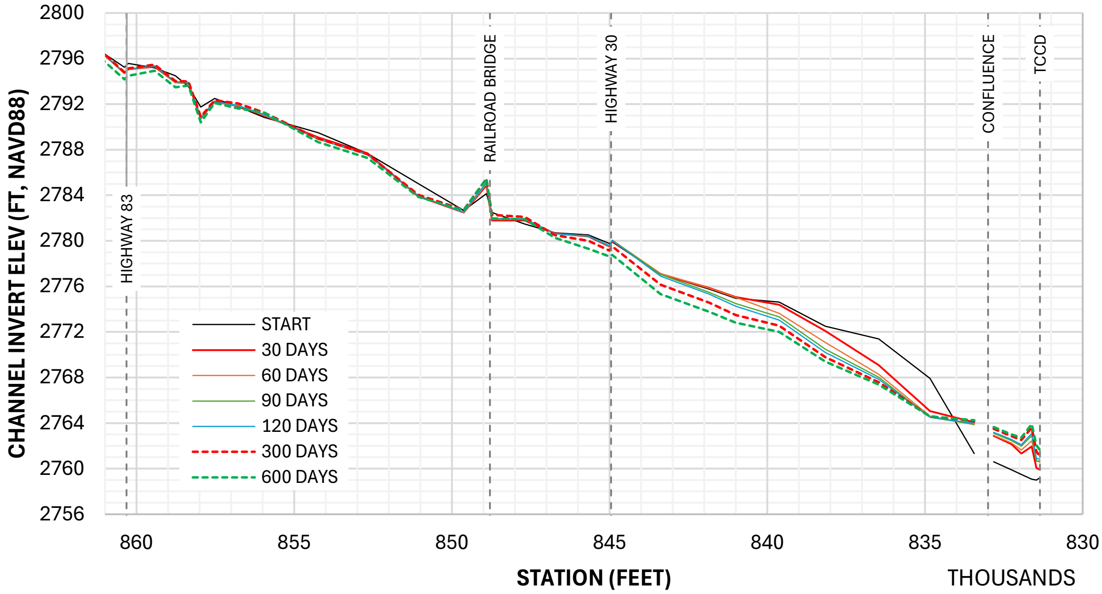


Figure 5-27 Headcut Progression of Channel Profile

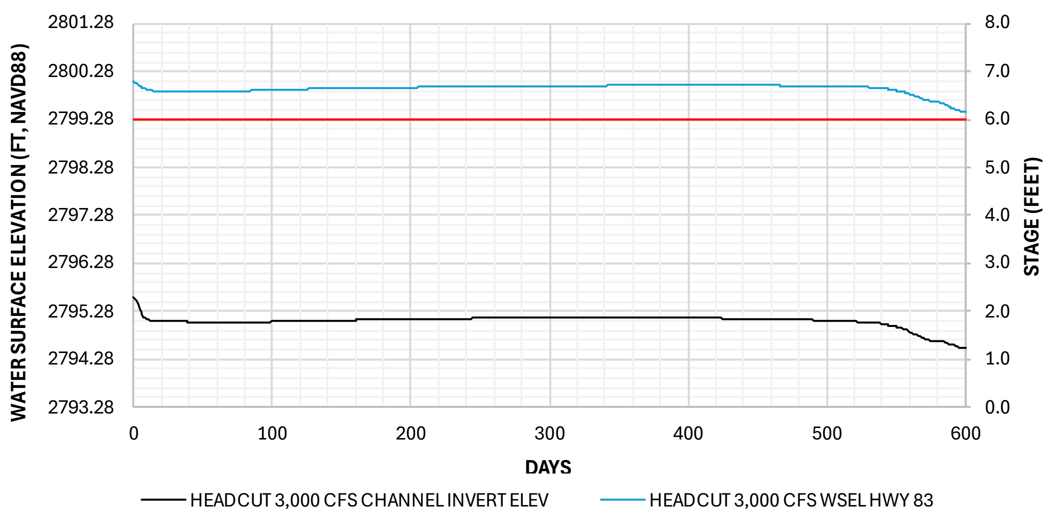


Figure 5-28 Headcut - Water Surface and Channel Elevation at HWY 83

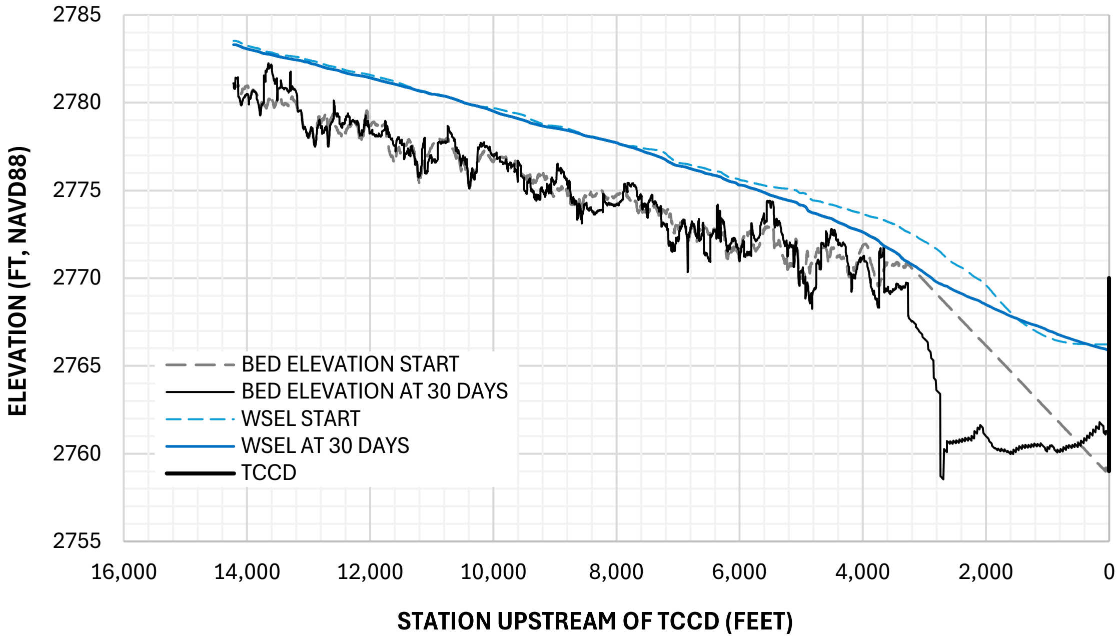


Figure 5-29 Headcut - 2D Sediment Transport Model Channel Profile

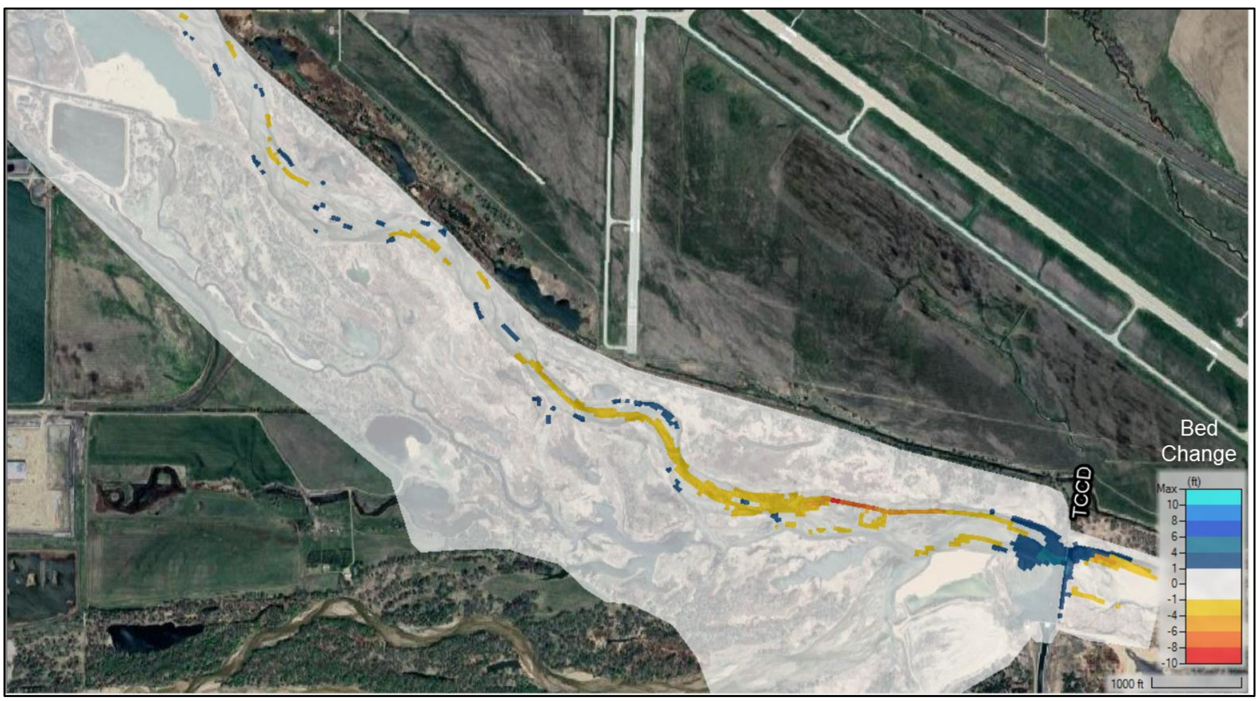


Figure 5-30 Headcut - 2D Sediment Transport Model Bed Change

6 SEDIMENT REMOVAL ALTERNATIVE A

Conceptual design, evaluation of impacts to wetlands, determination of permitting requirements, and a cost estimate for sediment removal alternative A was developed.

6.1 Conceptual Design

Conceptual design drawings of the sediment removal alternative A are provided in Appendix C.1. Design drawings include channel grading, plan and profile, and cross-sectional information. The concept design includes excavation of a 150 wide channel beginning at the TCCD and extending upstream for 6.2 miles. The channel slope restores the historic bed profile and slope back to 0.125%. The total volume of excavation, determined from design grading, is 1,170,000 CY. Sediment removal would be conducted one time only and is anticipated to provide hydraulic capacity at HWY 83 of 3,000 cfs below minor flood stage for roughly 2 to 3 decades.

6.2 Project Impacts to Wetlands

As part of the ACE team, ERO evaluated the study reach for potential wetlands that may be affected by the sediment removal alternative. ERO reviewed U.S. Geological Survey topographic quadrangle maps (U.S. Geological Survey 2024), the U.S. Fish and Wildlife Service National Wetland Inventory (Service 2024), and aerial photography to identify potential areas of wetlands that may be regulated by the U.S. Army Corps of Engineers (Corps) under the CWA. In addition, ACE provided ERO with inundation maps based on hydraulic modeling and potential groundwater depths. In general, wetlands have groundwater support within 12 to 18 inches of the ground surface for at least two weeks during the growing season. Though the study reach may not be interpreted as highly disturbed or problematic, the Corps provides a technical standard for problematic wetlands to monitor hydrology with a requirement of 14 or more consecutive days of flooding or ponding, or a water table 12 inches (30 centimeters) or less below the soil surface, during the growing season at a minimum frequency of 5 years in 10 (50 percent or higher probability) (Corps 2005; National Research Council 1995).

The North Platte River through the study reach has an extensive wetland/riparian corridor with limited encroachment. In addition, the accumulated sediment in the river has allowed for increased wetland/riparian development and wider floodplain connectivity. In total, ERO mapped 1,703 acres of potential wetlands within the entire 11 miles of the Chokepoint study reach using the methods described above. The actual amount of wetlands, including their connectivity and regulatory status, would need to be determined with a full wetland delineation. However, the evaluation method for mapped wetlands provides a good indication of the extent of potential wetland habitat based on the hydraulic modeling and database review.

Groundwater was evaluated using 2D hydraulic modeling and GIS. Water surface profiles for flows contained within the channel were projected to the adjacent riparian and wetland areas to estimate groundwater levels with and without the project. Based on groundwater modeling, it is assumed that up to 339 acres of potential wetlands would no longer have groundwater support (within 12 to 18 inches below the surface) at a base flow of 400 cfs. At 1,000 cfs the acreage of wetlands that would lose groundwater support is reduced to 205 acres.

Anderson also completed an analysis of changes to surface inundation at various flow rates and the acreage of potential wetlands mapped in the existing and proposed inundation areas. Based on that analysis, 231 acres of wetlands would no longer be inundated at 1,500 cfs, which is roughly the existing bankfull flow. At 3,000 cfs approximately 556 acres of potential wetlands would no longer be inundated.

Inundation mapping, estimated wetland delineations, and groundwater mapping is provided in Appendix C.2.

In summary, the proposed alternative has the potential to adversely affect up to 556 acres of wetlands in the study reach, with a likelihood of drying up at least 205 acres of potential wetlands.

6.3 Permitting

The sediment removal alternative would require a CWA Section 404 Permit. Due to the acreage and volume of direct and indirect impacts along the river, the Corps would likely require an Individual Permit and completion of an environmental assessment (EA) following the requirements defined in the National Environmental Policy Act (NEPA). If the EA confirmed the project would have significant impacts, then an environmental impact statement (EIS) analysis could be required. The cost and time frame for completing an EIS can be significant, with EIS projects taking 2 to 20 years depending on the complexity of the project, and several hundred thousand to millions of dollars.

Although the purpose of the alternative is to deliver water to benefit federally threatened and endangered species on the Central Platte, the Corps must evaluate the project impacts on waters of the U.S. compared to other possible alternatives that meet the purpose and need for the project. Per CWA Section 404(b)(1) Guidelines, the Corps must only permit the Least Environmentally Damaging Practicable Alternative (LEDPA). The Corps' EA and EIS processes under NEPA would require an alternatives analysis to determine if there are other practicable alternatives (i.e., alternatives that meet the project purpose and need such as the bypass alternative discussed in Section 7). A permit cannot be issued if a practicable alternative exists that would have less adverse impacts on the aquatic ecosystem, provided that the LEDPA does not have other significant adverse environmental consequences to other resources. This analysis may demonstrate that other practicable alternatives are feasible, and the sediment removal alternative is not the LEDPA.

In addition to permitting difficulties, the amount of mitigation required for the project would be significant, with potentially hundreds of acres of wetland mitigation required. The project could try to incorporate wetland mitigation by lowering the entire river corridor and reestablishing wetlands in the corridor; however, it is likely the Corps would have concerns with sediment reestablishing in the project area and filling in where mitigation is proposed. Currently, wetland mitigation bank credits are approximately $200,000 per acre, which could result in a significant cost if mitigation of hundreds of acres of banking is required. It also would likely be difficult to find banks with the amount of credits required.

A memo submitted by ERO in connection with the above discussion can be found in Appendix C.3.

Additional permits required include a CLOMR and LOMR FEMA submittal, floodplain development permit, and right of way easement permits with NDOT and the UPRR.

6.4 Cost Estimate

A cost estimate for construction of the Sediment Removal Alternative based on the conceptual drawings in Appendix C.1 is presented in Table 5-1. The estimated cost for Sediment Removal Alternative A is $37 million.

Table 6-1 Cost Estimate for Sediment Removal Alternative A

Item Number	*Description*	*Unit*	*Estimated Quantity*	*Unit Cost ($)*	*Item Cost ($)*
1	Channel Excavation (Note 1)	CY	1,070,000	$23.75	$25,412,500
	Subtotal				$25,412,500
2	Mobilization/Demobilization	LS	1		$5,082,500
	Cost of Project Components				$30,495,000
	Engineering Costs	LS	1		$1,270,625
	Subtotal				$31,765,625
	Contingency (15%)	LS	1		$4,764,844
	Total Project Construction Costs				$36,530,469
	Permitting (See Note 2)	LS	1	$600,000	$600,000
	Easements (See Note 3)	EA	49	$5,500	$269,500
	TOTAL PROJECT COSTS				**$37,399,969**
Note 1	Excavation/dredging volume per conceptual plan and profile				
Note 2	Assumes Individual Permit/EA, CLOMR/LOMR floodplain permits, and 401 permit, UPRR, NDOT				
Note 3	Assumes Temporary easment reimbursement, boundary survey, legal services				

The quantities used for the cost estimate were developed from the North Platte River Sediment Removal Alternative conceptual design drawings provided in Appendix C.1.

Costs for the sediment removal alternative are based on data from the 2024 National Construction Estimator 72nd Edition. Geographic adjustments to cost data were made based on the NCE. Inflation-related adjustments to the cost data were made using information from the ENR Construction Cost Indices.

Channel excavation unit cost was estimated based on mass excavation using a 24 cubic-yard scraper-haulers assisted by D-9 bulldozers. Excavated material would be deposited at a designated stockpile site for loading and hauling off-site. Material deposited at the stockpile site would be loaded with a 5 cubic-yard loader into side-dump trailers, assuming 20 cubic-yards maximum per load. Hauling unit costs were estimated based on a 24-mile haul to a disposal site (one-way distance). This does not reflect the identification of any specific disposal site. Mobilization costs anticipate the development of several stockpile sites with truck access and identification of multiple disposal sites for dredged material and are estimated at 15% of project component costs. Engineering includes design and resident services and is estimated at 5% of project component costs.

In addition to project construction costs, total project costs include permitting and easements. Regulatory costs include requirement for an individual CWA Section 401 and 404 permits, related environmental assessment (EA), FEMA floodplain permitting (CLOMR/LOMR) and crossing review by Union Pacific Railroad (UPRR), Nebraska Department of Transportation (NDOT). Cost for an EIS and/or wetland mitigation is not included. The project intersects 49 private properties, and it is expected that 49 individual temporary construction easements will be required to support construction. The easement estimates include a $2,000 payment to each landowner, a boundary survey for each easement and legal services to prepare easement documents.

The cost estimate for the sediment removal alternative should be considered on the lower end of the scale of possible cost. Uncertainty is partially accounted for by the 15% contingency applied to the project construction costs, but aspects of the proposed project are difficult to quantify. Although there may be efficiencies to be gained in the excavation and loading of soils, most of the unit cost is due to transportation to the disposal sites. It is uncertain if enough disposal sites can be identified within 24 miles of the dredging reach, which is the distance assumed in the cost estimate. This will be a significant challenge given that excavated material likely cannot be utilized for other purposes. CNPPIDs recent difficulties disposing of sand dredged at the TCCD is an example. Easement costs assume that a payment of $2,000 will be sufficient to induce property owners to sign temporary easement agreements. Easement payments are a negotiated amount. Given that the extent of the work in each easement and the personalities involved will vary, the easement payments to individual landowners could be significantly higher.

6.5 Summary

The sediment removal alternative can achieve and sustain hydraulic capacity at HWY 83 of 3,000 cfs under minor flood stage for roughly 2 to 3 decades without additional sediment removal. This assumes that hydrologic conditions, sediment supply trends, and diversion and dredging operations at the TCCD of the previous 20 years continue without drastic change. This would allow reduced flooding and conveyance of flows of 3,000 cfs, and potentially as high as 5,000 cfs, to be conveyed through the North Platte without exceeding minor flood stage.

Although this alternative can meet and exceed the hydraulic capacity targets there are several issues associated with implementation, as listed below.

- **Permitting:** This alternative would require an Individual CWA Section 404 Permit, environmental assessment (EA), and potentially an environmental impact statement (EIS). Securing a permit would be difficult given the impacts to riparian wetlands, wetland mitigation requirements, and the potential for other less environmentally damaging alternatives (e.g. a bypass canal).

- **Private Land Parcels:** The sediment removal alternative is located on a total of 49 privately owned parcels. Given the Program's "good neighbor" policy and lack of condemnation authority landowner approval and participation would be required. Agreements with all private landowners for construction would be necessary for consistent sediment removal.

- **Staging and Disposal of Sediment:** The sediment removal alternative requires removal of roughly 1 million CY of material. Identification of staging areas and material disposal sites within a reasonable distance is a significant challenge. CNPPID has experienced difficulties finding locations to store or dispose of material dredged at the TCCD. They currently have roughly 300,000 CY of dredged sediments for which disposal has been problematic. This issue could drive costs up significantly.

- **Constructability:** The logistics of effectively removing sediment from the project reach using heavy equipment in wet conditions is possible but would be challenging. Unknowns related to logistics of construction, including but not limited to access, staging, re-routing of flow, use of heavy equipment, and material disposal could increase costs.

- **Capital Cost:** The estimated capital cost for this alternative is approximately 37 million dollars. Due to uncertainties, the estimated cost is considered to be at the lower end of the range of possibilities.

7 BYPASS CANAL ALTERNATIVE

A conceptual design of a bypass canal to route EA flows around the Chokepoint, as discussed in the Phase II memo provided in Appendix B.3, was developed. The concept design allows for up to 1,500 cfs to be diverted into a dedicated bypass canal from the North Platte River, just upstream of the North Platte Canal, and conveyed to the South Platte, bypassing the Chokepoint. Discussion of the conceptual design and associated cost estimate is provided below.

7.1 Conceptual Design

Conceptual design drawings of a bypass canal with a capacity of 1,500 cfs can be found in Appendix D. The drawings include a plan and profile of the canal developed using 2021 LiDAR data. The canal has a total length of approximately 6.3 miles and is aligned adjacent to the existing North Platte Canal, except for the lower 1-mile where the canal turns toward the South Platte, see Figure 7-1. Note that canal alignment to the south of the UPRR currently bisects an irrigated field with a center pivot. This alignment is not ideal and would need to be resolved with further design.

The geometry of the earthen canal is trapezoidal with a bottom width of 60 feet, a total depth of 6 feet, and 3:1 side slopes. A rectangular concrete canal section 90 feet wide is provided at points where the canal makes a moderate or sharp change in direction or approaches a crossing structure. The slope of the canal ranges from 0.0004 to 0.001 ft/ft. Design details for the diversion structure and headgate on the North Platte were not developed due to the absence of bathymetric survey in the river. (Note that general cost estimates of similarly sized structures were included.) Similarly, details of an outfall structures to the South Platte were not included at this level of conceptual design.

The canal alignment requires three siphons, five large structures at road crossings, eight bridges to cross local access roads, and two lateral ditch crossings. The location of all intersecting structures is indicated in the plan and profile drawings. Siphons and road crossing structures were sized based on capacity and local topography. All three siphons include 4 20’W x 6’H concrete boxes. The N Prairie Trace Road, W Platte Valley Road, N O’Fallon’s Road, and Union Pacific Railroad crossings include 8 - 10’W x 6’H box culverts. The Highway 30 crossing includes 12 – 10’W x 4’H box culverts.

7.2 Cost Estimate

A cost estimate for construction of the bypass canal based on the conceptual design drawings is shown in Table 7-1. The estimated capital cost of the bypass canal is just under $31 million, with an estimated annual maintenance cost of $390,000/year.

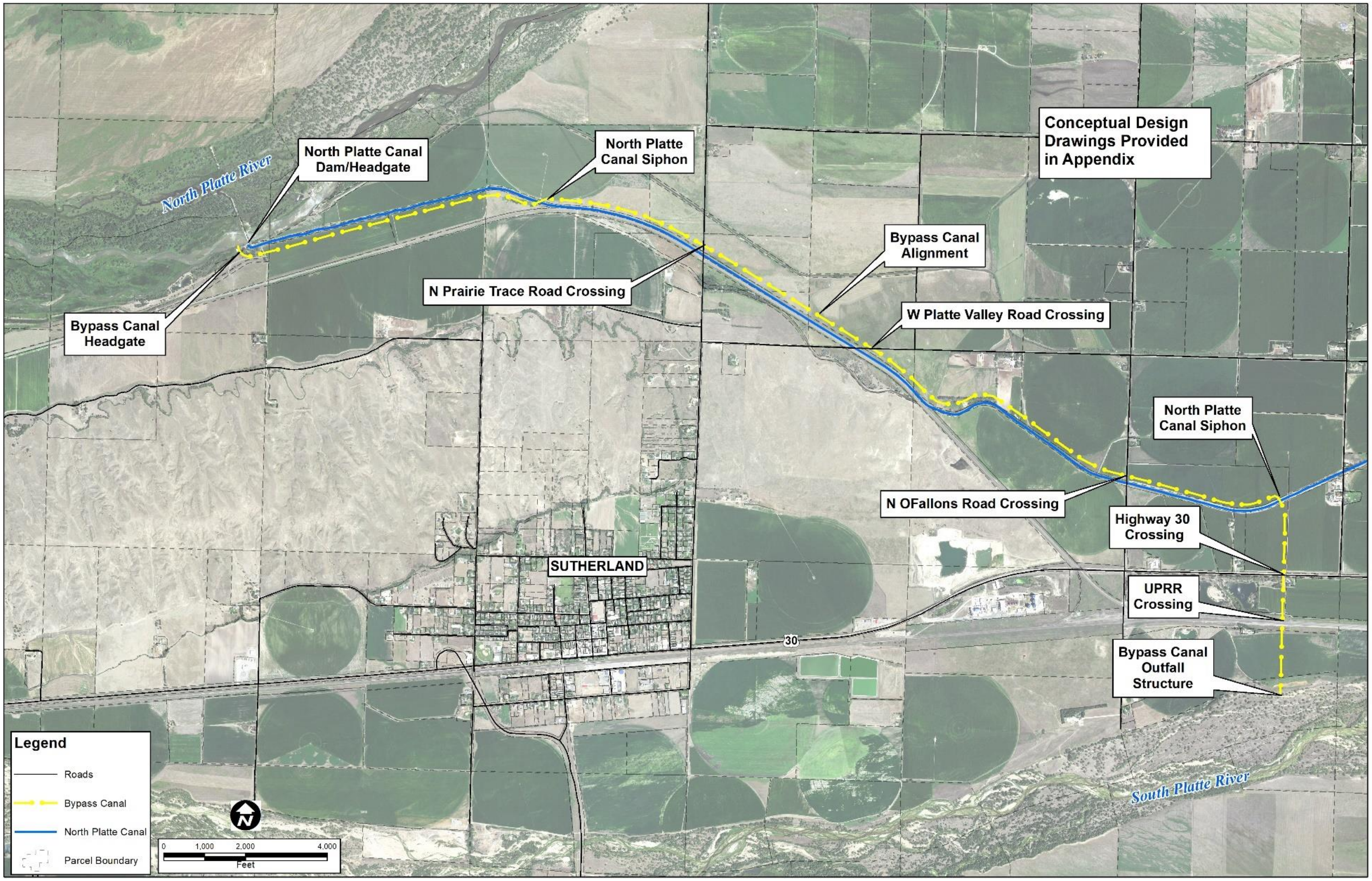


Figure 7-1 Bypass Canal Alignment

Table 7-1 Cost Estimate 1,500 cfs Bypass Canal Alternative

Item Number	*Description*	*Unit*	*Estimated Quantity*	*Unit Cost ($)*	*Item Cost ($)*
1	Diversion Headgate Structure (see Note 1)	LS	1	$1,378,560	$1,378,560
2	Excavation (see Note 2)	CY	568,515	$4.10	$2,330,912
3	Road Crossing, North Prairie Trace (see Note 3)	LS	1	$1,566,900	$1,566,900
4	Road Crossing, West Platte Valley (see Note 4)	LS	1	$2,814,900	$2,814,900
5	Road Crossing, North O Fallon (see Note 5)	LS	1	$1,086,900	$1,086,900
6	Road Crossing, Highway 30 (see Note 6)	LS	1	$1,098,900	$1,098,900
7	Siphon Crossing, North Platte Canal #1 (see Note 7)	LS	1	$2,622,900	$2,622,900
8	Siphon Crossing, North Platte Canal #2 (see Note 8)	LS	1	$1,125,300	$1,125,300
9	Siphon Crossing, North Platte Canal Lateral (see Note 9)	LS	1	$990,900	$990,900
10	Railroad Crossing, UPRR (see Note 10)	LS	1	$1,566,900	$1,566,900
11	Local Access Crossing Bridge (see Note 11)	EA	8	$422,400	$3,379,200
12	North Platte Canal Lateral Crossing (see Note 12)	EA	2	$80,700	$161,400
13	Concrete Lined Ditch (see Note 13)	LF	591	$5,640	$3,333,240
14	Diversion Outfall (see Note 14)	LS	1	$350,000	$350,000
	Land Acquisition				
15	Irrigation (sprinkler)	AC	16	$9,000	$144,000
16	Irrigation (flood)	AC	22	$6,000	$132,000
17	Dry land	AC	34	$2,000	$68,000
	Subtotal				$24,150,912
18	Mobilization/Demobilization	LS	1		$1,207,546
	Cost of Project Components				$25,358,457
	Engineering Costs	LS	1		$1,207,546
	Subtotal				$26,566,003
	Contingency (15%)	LS	1		$3,984,900
	Total Project Construction Costs				$30,550,903
	Permitting (see Note 15)	LS	1	$300,000.00	$300,000
	Easements	EA	23	$5,500.00	$126,500
	TOTAL PROJECT COSTS				**$30,977,403**
	Annual Operations and Maintenance Costs (see Note 16)				**$387,218**

Note 1 8-6'Hx8'W gates, concrete headwall, wingwalls, apron
Note 2 Canal, 60' BW/96'TW, 6' high, 3:1 SS
Note 3 150 ft xsing, 1,200 ft of 6'Hx10W RCBC, headwall/wingwalls
Note 4 280 ft xsing, 2,240 ft of 6'Hx10W RCBC, headwall/wingwalls
Note 5 100 ft xsing, 800 ft of 6'Hx10W RCBC, headwall/wingwalls
Note 6 100 ft xsing, 1,200 ft of 4'Hx10W RCBC, headwall/wingwalls
Note 7 260 ft xsing, 1040 ft of 6'Hx20'W RCBC, concrete inlet/outlet
Note 8 104 ft xsing, 416 ft of 6'Hx20'W RCBC, concrete inlet/outlet
Note 9 90 ft xsing, 360 ft of 6'Hx20'W RCBC, headwall/wingwalls
Note 10 150 ft xsing, 1,200 ft of 6'Hx10W RCBC, headwall/wingwalls
Note 11 96 ft xsing, bridge, steel and concrete
Note 12 150 ft xsing, 150 ft of 4' concrete pipe, headwall/wingwalls
Note 13 Conc. canal 90' wide x 6' high x 1' th, 4CY/LF
Note 14 24" d50 riprap outfall installation
Note 15 Assumes nationwide CWA Section 404 permit, UPRR permit, NDOT permits, and CWA Section 401 permit
Note 16 O&M costs estimated at 1.25% of total project costs, annually

Unit costs for the bypass canal are based on actual cost data from completed construction projects familiar to ACE as well as data from the 2024 National Construction Estimator 72nd Edition (NCE) and other sources. Geographic adjustments to cost data were based on the NCE. Inflationary adjustments to cost data were made using information from the ENR Construction Cost Indices (CCI).

Quantities utilized in the cost estimate were developed from the North Platte River Chokepoint 1,500 CFS Bypass Canal Conceptual Design drawings provided in Appendix D.

Project components included in the proposed conceptual design are a diversion headgate structure, outfall structure, channel excavation, eight in-line culvert/siphon structures, eight bridges and two lateral siphon crossings. The excavation cost estimates reflect a blended unit cost for excavation and grading. In-line structure cost estimates are a lump sum cost based on the quantity of reinforced concrete box culvert and installation per 2024 NCE. The same method was applied to lateral crossing pipelines. Local access bridge costs are taken from a 2009 US Forest Service construction cost bulletin adjusted to 2024 dollars using the ENR CCI. Structural concrete unit costs are based on construction projects with similar quantities completed in Colorado and Wyoming in 2022 and 2023, inflation adjusted. Riprap costs were also based on actual unit costs from a 2023 construction project in Colorado, geographically adjusted to account for transportation costs. The estimated cost of project components is rounded out with land acquisition costs. Land acquisition costs are divided up between sprinkler irrigation, flood irrigation and dryland. Unit cost estimates for each classification of land are based on data published by the University of Nebraska Center for Agricultural Profitability: Nebraska Farm Real Estate Highlights for 2022-2023.

Total project construction costs are estimated by adding mobilization, engineering, and contingency to project component costs. Mobilization and engineering are estimated at 5% of project components each. A contingency of 15% is added to estimate the project construction cost.

In addition to project construction costs, total project costs include permitting and easements. Regulatory costs include requirement for CWA Section 401 and nationwide 404 permits and crossing review by Union Pacific Railroad (UPRR) and Nebraska Department of Transportation (NDOT). It is expected that 23 individual temporary construction easements will be required to support construction. The easement estimates include a $2,000 payment to each landowner, a boundary survey for each easement and legal services to prepare easement documents. Easements assume the footprint of the excavated channel with a 50-foot buffer on each side.

Annual operations and maintenance costs for the completed bypass canal are included in the project cost estimate. The Nebraska Resources Development Fund guidelines recommend budgeting 1.25% of the capital construction costs for ongoing annual maintenance.

Uncertainty in the project cost is partially accounted for by the 15% contingency applied to the project construction costs, but aspects of the proposed project are difficult to quantify. Easement costs assume that a payment of $2,000 will be sufficient to induce property owners to sign temporary easement agreements. Easement payments are a negotiated amount. Given that the extent of the work in each easement and the personalities involved will vary, the easement payments to individual landowners could be significantly higher.

7.3 Summary

A dedicated bypass canal would provide diversion of 1,500 cfs around the Chokepoint. This combined with hydraulic capacity through the Chokepoint of 1,500 cfs would meet the 3,000 cfs targe flow without exceeding minor flood stage at HWY 83. This would reduce, but not eliminate, conflict between EA flows and irrigation demand during hot/dry conditions. There is also potential for the bypass canal to be utilized for other diversion purposes and/or groundwater recharge.

The bypass canal alternative has an estimated capital cost of $31 million and long-term annual maintenance costs of roughly $400,000. Construction of the bypass canal would require acquisition of private land and easements that would impact a total of 23 privately owned parcels. Given the Program's "good neighbor" policy and lack of condemnation authority landowner approval and participation would be key to successful implementation.

8 SUMMARY CONCLUSIONS

Phase III evaluations included further investigation of the sediment removal, modification of the TCCD, and bypass canal alternatives.

8.1 No Action Alternative

The no-action alternative is a continuation of existing river management at the Chokepoint including vegetation control and CNPPID dredging at the Tri-County Canal Diversion (TCCD). Evaluation of the no-action alternative was based on results of the geomorphic assessment and additional sediment transport modeling. Results indicate that the Chokepoint reach is likely to remain in quasi-equilibrium assuming that flow characteristics, sediment supply trends, and diversion and dredging operations at the TCCD are consistent with those of the past 20 years. Under the no-action alternative average hydraulic capacity at minor flood stage is expected to remain at about 1,700 cfs, with a range between 1,500 and 2,150 cfs. Note that a sustained flow event, probably greater than the peak flow and duration of the most recent flood in 2011, would likely disrupt the quasi-equilibrium state.

Even though existing hydraulic capacity is expected to continue with no-action, it should be noted that the no-action alternative does not allow the Program to convey and maintain 1,500 cfs when irrigation demand is highest. In periods of drought and heat, when both irrigation and EA flows (usually for germination suppression) are most urgently needed, EA releases and irrigation demand are in direct competition with each other. At present, the demand for irrigation takes precedence over EA releases.

8.2 Sediment Removal Alternative

The primary barrier to increasing hydraulic capacity through the Chokepoint is the presence of accumulated sediment or the “sediment wedge” that has formed between HWY 83 and the TCCD. Removing sediment from the channel is the most effective way to increase hydraulic capacity. Assuming existing diversion and dredging operations continue at the TCCD, and upstream sediment sources remain unchanged, sediment will undoubtedly redeposit in removal areas over time.

The concept design of the sediment removal alternative includes excavation of a 150 wide channel beginning at the TCCD and extending upstream for 6.2 miles. The channel slope restores the historic bed profile and slope. The total volume of excavation, determined from design grading, is 1,170,000 CY. The sediment removal alternative can achieve and sustain hydraulic capacity at HWY 83 of 3,000 cfs under minor flood stage for roughly 2 to 3 decades without additional sediment removal. This would allow reduced flooding and conveyance of flows of 3,000 cfs, and potentially as high as 5,000 cfs, to be conveyed through the North Platte without exceeding minor flood stage. This assumes that hydrologic conditions, sediment supply trends, and diversion and dredging operations at the TCCD of the previous 20 years continue without drastic change. Sediment removal of this magnitude would require a significant capital investment. Due to uncertainty in the modeling it would be reasonable to provide additional hydraulic capacity above the target to minimize the risk of loosing hydrualic capacity in the future. A smaller extent of excavation could be conducted but would require an additional round of sediment removal within the same time frame of 2 to 3 decades and would not be likely to reduce long term costs.

Although this alternative can meet and exceed the hydraulic capacity targets there are several issues associated with implementation, as listed below.

- **Permitting:** This alternative would require an Individual CWA Section 404 Permit, environmental assessment (EA), and potentially an environmental impact statement (EIS). Securing a permit would be difficult given the impacts to riparian wetlands, wetland mitigation requirements, and the potential for other less environmentally damaging alternatives (e.g. a bypass canal).

- **Private Land Parcels:** The sediment removal alternative is located on a total of 49 privately owned parcels. Given the Program's "good neighbor" policy and lack of condemnation authority landowner approval and participation would be required. Agreements with all private landowners for construction would be necessary for consistent sediment removal.

- **Staging and Disposal of Sediment:** The sediment removal alternative requires removal of roughly 1 million CY of material. Identification of staging areas and material disposal sites within a reasonable distance is a significant challenge. CNPPID has experienced difficulties finding locations to store or dispose of material dredged at the TCCD. They currently have roughly 300,000 CY of dredged sediments for which disposal has been problematic. This issue could drive costs up significantly.

- **Constructability:** The logistics of effectively removing sediment from the project reach using heavy equipment in wet conditions is possible but would be challenging. Unknowns related to logistics of construction, including but not limited to access, staging, re-routing of flow, use of heavy equipment, and material disposal could increase costs.

- **Capital Cost:** The estimated capital cost for this alternative is approximately 37 million dollars. Due to uncertainties, the estimated cost is considered to be at the lower end of the range of possibilities.

8.3 Modification of the Tri-County Canal Diversion

Modification of the Tri-County Canal Diversion (TCCD) for more efficient sediment passage was considered as an alternative to increase hydraulic capacity at HWY 83 or as an enhancement to the sediment removal alternative. Without disrupting current operations and diversion practices modification of the TCCD structure would not likely improve existing conditions or enhance performance of sediment removal alternatives.

It is our opinion that modification to the TCCD is not a practical alternative largely due to the lack of flows high enough to sufficiently pass sediment downstream and limitations associated with year-round diversions that require roughly 9 to 10 feet of headwater. Under current operations modification of existing gates would not provide added benefit given that existing gates are sufficient to sluice large flows and sediment. In addition, modification of the structure could create potential difficulties related to upstream migration of invasive aquatic species. Modification of the TCCD structure was estimated in Phase II of this study at $21 million, which is a large investment for an alternative that has not yet been proven beneficial under current limitations.

8.4 Bypass Canal Alternative

A dedicated bypass canal would provide diversion of 1,500 cfs around the Chokepoint. This combined with hydraulic capacity through the Chokepoint of 1,500 cfs would meet the 3,000 cfs targe flow without exceeding minor flood stage at HWY 83. This would reduce, but not eliminate, conflict between conveyance of 1,500 cfs in the North Platte of EA flows and irrigation demand during hot/dry conditions. There is also potential for the bypass canal to be utilized for other diversion purposes and/or groundwater recharge.

The bypass canal alternative has an estimated capital cost of $31 million and long-term annual maintenance costs of roughly $400,000. Construction of the bypass canal would require acquisition of private land and easements that would impact a total of 23 privately owned parcels. Given the Program's "good neighbor" policy and lack of condemnation authority landowner approval and participation would be key to successful implementation.

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APPENDIX A. PROJECT CHARTER

PRRIP CHOKEPOINT PROJECT MEMORANDUM

DATE:	August 18, 2023	**ACE PROJECT NO.:** NEHW05.01
TO:	Seth Turner, PPRIP Executive Director's Office	
FROM:	Michelle Martin, PE, Anderson Consulting Engineers, Inc.	
	Brian Murphy, PhD, PE, River Works Ltd	
SUBJECT:	North Platte Chokepoint Project Charter	

This memorandum describes the North Platte chokepoint project charter. The charter summarizes the PPRIP North Platte chokepoint Project goals, objectives, strategies, and constraints as developed by the PRRIP Executive Director's Office (EDO) and the Anderson Consulting Engineers (ACE) team. It also provides clarity to everyone involved in the project about what will be accomplished and sets expectations for all stakeholders so that everyone is working towards meeting the project goal.

Background

The Platte River Recovery Implementation Program (Program) initiated on January 1, 2007 between the states of Nebraska, Wyoming, and Colorado and the Department of the Interior to address endangered species issues in the central and lower Platte River basin. Program "target species" include the whooping crane, piping plover, interior least tern (now de-listed), and pallid sturgeon.

Project Reach

The project reach includes the lower 10 miles of the North Platte River extending from the Tri-County Canal Diversion on the Platte River to approximately 5.5 miles upstream of State Highway 83.

Platte River Recovery Implementation Program Objective

The Addendum to the Program Document for the First Increment Extension specifies the following water management objectives related to the North Platte chokepoint:

- Aggressively continue to implement channel conveyance improvements at North Platte chokepoint through efforts directed toward achieving and maintaining at least 3,000 cfs conveyance capacity while remaining below flood stage, with additional capacity developed as practicably achievable with available resources.
- Implement water releases including short-duration high flows (SDHF) and target flows once Program water projects are operational and chokepoint conveyance issues are resolved.
- The Program will continue to evaluate the efficacy of available Program water and chokepoint capacity through time to ensure Program water meets its intended purposes.

Problem Statement

Minor flood stage for the North Platte chokepoint, as defined by the National Weather Service (NWS) for the North Platte River at North Platte gage (06693000), is 6.0 feet. Average discharge capacity at this minor flood stage is estimated to be about 1,760 cfs based on the current Nebraska Department of Natural

Resources rating curve and shift measurements since July 2020. Limited hydraulic capacity through the chokepoint is a constraint on the ability to deliver water from the Lake McConaughy EA to the Program's Associated Habitat Reach (AHR) on the central Platte River downstream between Lexington and Chapman, Nebraska.

Project Goal

The EDO defined the project goal as identifying and screening alternative solutions to increase hydraulic capacity through the chokepoint and/or provide delivery of flows downstream of the chokepoint through other systems. Any new alternatives the ACE team develops will maintain delivery of a total peak flow of 3,000 cfs to the Program's AHR on the central Platte River without exceeding minor flood stage of 6.0 feet on the North Platte River as defined by and measured at the gage at the State Highway 83 bridge.

Project Objectives and Strategies

1. Identify, screen, and rank past and potential new alternatives to improve conveyance capacity and reduce flood risk through the North Platte chokepoint reach.
2. Update and calibrate baseline models.
3. Conduct detailed hydraulic and/or sediment transport modeling as needed to evaluate the effectiveness of selected alternatives at achieving and maintaining gains in conveyance capacity through the North Platte chokepoint.
4. Complete assessment of permitting requirements, estimated costs, and implementation timeline for selected alternatives.

Objective	Strategy
1. Identify, screen, and rank past and potential new alternatives to improve conveyance capacity and reduce flood risk through the North Platte chokepoint reach.	Review all previous studies and alternatives provided by the EDO.
	Develop a listing and brief description of all previous alternatives, refinement of pervious alternatives, and new alternatives.
	Collaborate with the EDO and Chokepoint Planning Workgroup to review and screen alternatives list. The list will be reduced to the most feasible alternatives identified for further evaluation.
	Develop decision criteria for alternative selection (e.g. performance, cost, permitting, long term O&M, timeline, social impacts, etc.)
	Utilize a multi criteria decision analysis (MCDA) process to rank and select alternatives.
2. Update and calibrate baseline models.	Utilize best available topography (2020 LiDAR) to update the existing HEC-RAS 1D hydraulic model of the study reach.
	Utilize best available topography (2017/2020 LiDAR) to develop an existing 2D hydraulic model of the entire study reach using SRH-2D. Information from the previously developed 2D HEC-RAS model will be leveraged.
3. Conduct detailed hydraulic and/or sediment transport modeling as needed to evaluate the effectiveness of selected alternatives at achieving and maintaining gains in conveyance capacity through the North Platte chokepoint.	Perform a robust geomorphic assessment that clearly identifies the physical processes of river function and response.
	Develop a 2D hydraulic model using SRH-2D, leveraging the baseline data and models, to determine hydraulic capacity and floodplain inundation for each alternative.
	Use the SRH 2D model to characterize the depth and velocity fields across a range of expected flows, and to predict the location and magnitude of changes in channel morphology for each recommended alternative.
	Improve the calibration/validation process by comparing model output to high-resolution surface velocities computed from UAV imagery using large-scale particle image velocimetry techniques
4. Complete assessment of permitting requirements, estimated costs, and implementation timeline for selected alternatives.	Build upon previous vegetation studies and data collected though the Program's vegetation monitoring program to evaluate each alternative, permitting implications and permitting strategies
	Develop rough order of magnitude (ROM) planning-level capital cost estimates and O&M costs for new alternatives and update cost estimates (capital, O&M) for previous alternatives (if available).
	Prepare a milestone schedule for the top three ranked alternatives that considers current permitting and procurement timelines.

Project Considerations/Constraints

- Alternative solutions will not exceed NWS minor flood stage of 6.0 feet at the North Platte River at North Platte Gage (06693000) at the State Highway 83 bridge.
- Alternatives will not include modification to minor flood stage as defined by the NWS.
- Alternatives shall not adversely impact private properties. If unavoidable impacts to private properties are identified, mitigation will be included as part of alternative development.
- Alternatives will not adversely impact or disrupt any irrigation and/or hydro-power generation operations.
- Long-term O&M costs will be considered for all alternatives.
- Alternatives will not exceed a capital cost of $15 million.

APPENDIX B. NORTH PLATTE CHOKEPOINT SUMMARY OF PREVIOUS STUDIES

APPENDIX B.1.   2021 EDO CHOKEPOINT MEMO

TO: NORTH PLATTE CHOKEPOINT PLANNING WORKGROUP
FROM: PRRIP EXECUTIVE DIRECTOR'S OFFICE
SUBJECT: NORTH PLATTE CHOKEPOINT ALTERNATIVES
DATE: APRIL 6, 2021

I. INTRODUCTION

The Platte River Recovery Implementation Program (PRRIP or Program) continues to have a goal of achieving and maintaining a flow capacity of 3,000 cfs at the gage on the North Platte River at North Platte, Nebraska. The gage is located adjacent to the downstream side of the Highway 83 bridge, and the reach of the river extending a few miles upstream and downstream of the bridge is referred to as the "North Platte Chokepoint" because of diminished flow capacity in recent decades. Critically, flows of 3,000 cfs for Program purposes are to occur while remaining below minor flood stage, which the National Weather Service (NWS) has currently set at a stage of 6.0 feet. Based on the gage rating curve developed by the Nebraska Department of Natural Resources, discharge at that stage is presently estimated to be about 1,930 cfs.[1] Flows of 3,000 cfs occur at a stage of about 6.63 feet.

Starting in the late 1990s, significant flooding of residential areas on the north side of the river in the vicinity of North River Road and North Washboard Road began to occur at or around the 6.0-foot stage. Since the early 2000s, NWS had defined flood stage impacts based on observations in that area and low-lying areas of Cody Park. In an effort to reduce the north bank flooding impacts, the Program implemented two flood-proofing projects, the Whitehorse Creek drainage project (2014) and the State Channel Berm rehabilitation (2018). As early as 2012, the Program was having discussions with NWS about the possibility of increasing minor flood stage to 6.5 feet after completion of the flood-proofing projects. The flood stage increase would gain additional flow capacity for the Program (about 800 cfs) but would not achieve the full 3,000 cfs. Due to permitting issues, the need for mitigation wetlands, and other factors, completion of the flood-proofing projects took years longer than originally anticipated. Concurrently and somewhat intermittently, the Program continued to evaluate other solutions to close the gap in flow capacity below flood stage.

In July 2020, the Program, in coordination with stakeholder organizations and local, state, and federal government agencies, completed a flow test to observe the impacts of river flows up to and exceeding a stage of 6.5 feet. The flow test was a success in terms of demonstrating the benefits of the flood-proofing projects, as no floodwaters were observed anywhere in the neighborhood along the north bank of the river. However, impacts were observed at properties along the south bank in the Darlene Road-Red Fox Lane area (e.g., encroachment near a house foundation, septic system issues, a flooded storm cellar, and inaccessibility of an outbuilding) that the NWS determined were threats to property. As a result, NWS declared that minor flood

[1] Discharge at 6.0 feet generally ranged between 1,500 and 2,000 cfs during the Program's First Increment from 2007-2019.

stage would remain at 6.0 feet, and flood impacts definitions were revised to reflect observations during the flow test.

Absent the flood stage increase, the Program would need to find alternative means of increasing capacity below 6.0 ft by more than 1,000 cfs or find ways to bypass the North Platte chokepoint altogether. The North Platte Chokepoint Planning Workgroup has been reconvened to consider potential next steps towards resolving this issue. **The objective of this memo is to summarize the many previous efforts by the Program to identify and implement solutions to increase North Platte chokepoint capacity during the First Increment.**

The underlying premise of all of this work at the North Platte chokepoint is outlined in Section III.E.2.d of the Program Document, which among other things calls for delivering 5,000 cfs pulse flows of Program water for three days to the upper end of the associated habitat reach (AHR) at the Overton gage. It was eventually determined that this could be accomplished by EA releases passing up to 3,000 cfs through the North Platte chokepoint, supplemented by a Central Platte regulating reservoir at the upper end of the AHR. The J-2 Regulating Reservoirs Project progressed well into the design phase and would have had an outlet capacity of 2,000 cfs, but the project was derailed by significant cost increases and land acquisition issues. The Program has not identified any viable replacement projects that would have remotely comparable capacity to release water to the Platte River. Additionally, the 2019 State of Platte Report conclusively and negatively answered the question of whether implementation of short-duration high flows (SDHF) would produce suitable target species habitat.

Despite these setbacks, any capacity improvements that could be achieved at the North Platte chokepoint would still be beneficial to the Program. Ongoing and future Adaptive Management Plan activities and experimental flow tests can help determine how much increased flow capacity is actually necessary to achieve the Program's target species management objectives. An example of such a flow test is the germination suppression event planned for June 2021. For now, it is worthwhile to undertake the present review of previous alternatives considered for the North Platte chokepoint to determine if any projects still remain feasible or studies warrant updating and to potentially identify new alternatives that were not previously evaluated.

II. NORTH PLATTE CHOKEPOINT ALTERNATIVES

The following sections summarize chokepoint-related documents that were reviewed by the EDO and made available to the North Platte Chokepoint Planning Workgroup on the PRRIP website.

<u>Parsons (2003). Preliminary Evaluation of Channel Capacity in the North Platte River at North Platte, Nebraska. Prepared for Central Nebraska Public Power and Irrigation District</u>.

This study predates the Program by several years but was an attempt to understand channel capacity changes in the North Platte chokepoint following a decision by NWS in 2002 to lower minor flood stage from 6.0 feet to 5.7 feet. Flooding in the North River Road and North Washboard Road area was reported to be a relatively new phenomenon, having only started occurring a few years earlier in the late 1990s.

Parsons concurred with previous studies by the USGS and Corps of Engineers in the 1980s that determined the main channel capacity (different from the flood stage or carrying capacity) to be consistently on the order of 1,700-2,000 cfs. They stated that "Expecting, or trying to create, a channel capacity greater than this 1,700 cfs rate would be contrary to principles of dynamic equilibrium and therefore ill-advised."

Around 1991 a sudden and significant decline in the hydraulic properties of the North Platte chokepoint was observed. Parsons hypothesized that this was primarily due to changes in the overbank areas, including the rapid and extensive growth of phragmites ("This is the most dramatic change documented for this period, and it alone could account for the changes and associated problems."); the intentional blockage of a drain channel adjacent to residential properties on North River Road (and leading to a box culvert under Highway 83); and the State Channel, which was built around 1970 but was overgrown and basically non-functional for redirecting high flows towards the main channel by the 1990s.

<u>Program Document, Attachment 5, Section 2. Includes J.F. Sato and Associates (2005). Final Report, North Platte Channel Capacity Study for the Water Management Committee, North Platte Cooperative Agreement</u>.

J.F. Sato and Associates completed a report in December 2005 that included a series of possible alternatives for short-term improvements to channel capacity at the North Platte chokepoint. Attachment 5, Section 2 of the Program Document called for the implementation of the Base Case, Alternative 1, and Alternative 2, with proposed completion of the project by October 1, 2009. Elements of the proposed project were as follows:

Base Case

1. Open State Channel.
2. Extend State Channel north to existing ponds/North River Road.
3. Construct road ditch along west side of Washboard Road.
4. Open southern channel from road ditch to abandoned detour road.
5. Remove abandoned detour road and construct ditch to main channel of the North Platte.
6. Remove phragmites along opened drainages.

Alternative 1: All elements of the Base Case PLUS

1. Improve and open the channel to connect existing culverts in Washboard Road to the existing concrete box culvert under Highway 83.
2. Improve conveyance through the ponds to the main channel and provide overflow structure.

Alternative 2: All elements of Alternative 1 PLUS

1. Remove sand bar that is blocking the northern channel about 1,500 feet above Highway 83 and improve the channel downstream of this point.

J.F. Sato and Associates also proposed additional studies to identify long-term solutions, but the Governance Committee did not approve that proposal.

Short Elliott Hendrickson, Inc. (SEH, 2008). Project Update Report, Platte River Restoration and Enhancement Project.

SEH was hired in April 2007 to complete plans and specifications for the project outlined by J.F. Sato and Associates. They met with the property owners who would be impacted by the proposed project components and found that there had been little or no prior contact with these property owners. Based on objections from the property owners and/or permitting issues, nearly all of the construction elements of the project were eliminated. SEH then proposed a modified project that included the following:

- Island (sand bar) removal per the J.F. Sato and Associates report, but with a significantly reduced excavation component to minimize permitting requirements.
- Phragmites removal.
- Installation of staff gages at affected properties.
- Monitoring program to read staff gages from fall 2007 through fall 2008.
- Monitoring of controlled pulse flow release planned for spring 2008.
- Develop a calibrated HEC-RAS model to help with flow forecasting.
- Revise flood stage elevation.

Extensive phragmites treatment was conducted over the next few years. Spraying included the island or sand bar removal area, but no mechanical work was ever done there. SEH developed a HEC-RAS model and completed various analyses that were documented in this report. The pulse flow release occurred, but not until April 2009.

The report also documents a July 2007 meeting involving SEH, the Program, and staff from the NWS North Platte office. NWS stated the following:

> The gage station at Highway 83 is not located in the ideal spot since it is downstream of the bridge. The ideal location would have been upstream of the bridge. If the gage station was upstream of the bridge there would be more of a direct correlation between the gage station elevation and the [affected] properties without the influences of downstream structures.

In 2008, NWS increased minor flood stage from 5.7 feet to 6.0 feet, where it remains today; discharge at this minor flood stage has ranged from 1,500 to 2,000 cfs at different times since then.

PRRIP Executive Director's Office (EDO) and U.S. Fish and Wildlife Service (2009). 2009 Platte River Flow Routing Test: Results, Information Gleaned, Lessons Learned.

The Program and its partners conducted a flow routing test in April 2009, reportedly reaching a peak of 1,747 cfs at a stage of 6.08 feet. The report stated these "key take-home points" regarding the North Platte chokepoint:

- The North Platte River at North Platte chokepoint remains a serious constraint on the ability of the Program to use the Environmental Account to help achieve short duration high flows of the desired magnitude. The NWS flood-stage capacity of this reach appears to be in the neighborhood of 1,700 to 1,800 cfs, based on the published flood stage of 6.0 feet at the North Platte gage. The Program has further work to do to achieve the 3,000 cfs capacity it has committed to at this location.

- Phragmites infestation of the Platte River remains a serious problem. These invasive weeds contribute to chokepoint problems around North Platte. Infestations may aggravate localized flooding problems in the mainstem Platte channel between North Platte and Lexington, and they appear to result in slower travel times, high transit losses, and greater peak flow attenuation as augmented flow moves down the Platte River system.

SEH (2009). Memorandum, Current Conclusions and Recommendations from the April 2009 Short Duration High Flows summary report and follow-up discussions.

SEH (2010). April 2009 High Flow Event, Project Update Report: Platte River Restoration and Enhancement Project.

These two documents are grouped together in one PDF file. SEH stated that "Based on the information gathered over the last two years, all indications are that the goal of allowing for increased flow through the reach can be achieved with a combination of vegetation removal and hopefully through the purchase of flow easements."

SEH reported that velocity measurements in areas of phragmites were half or less than in the free-flowing sections of river "which means that flow capacity in a reach can be more than doubled by just removing the phragmites." During the April 2009 flow routing test, it was also observed that previously-sprayed vegetation in the island/sand bar removal area was washed away and opened that channel. Based on these observations, SEH concluded that spraying and/or shredding of phragmites, followed by repeated annual pulse flows to wash away dead vegetation, should be enough to achieve the desired flow capacity through the North Platte chokepoint. SEH also recommended working with property owners to purchase flood easements during high flow events, and if needed, providing temporary protection of non-critical structures.

At the time, it appeared that gage stage had increased by about 1 foot for the 3,000 cfs flow rate since 1994. Despite the observations and conclusions described above, SEH also noted that modeling indicated that phragmites were only responsible for part of that increase. They suggested that sedimentation downstream of the Highway 83 bridge, possibly caused by a flow constriction at the east end of Cody Park, was also a contributing factor.

HDR and Tetra Tech (2011). Final Technical Memorandum, Evaluation of Alternatives for Improvements in Carrying Capacity of the North Platte River at North Platte.

At the time of this study, capacity at 6.0 feet was reportedly only about 1,500 cfs. HDR and Tetra Tech completed work based on the premise that sedimentation downstream of the Highway

83 bridge was the primary problem, and that the objective was to reduce the 3,000 cfs stage by 0.8 feet. They developed and screened six alternatives (two hydraulic improvement options and four sediment management options), and "the three alternatives with the highest rank…were evaluated for their effectiveness to increase the carrying capacity from the current discharge of 1,500 cfs to 3,000 cfs without increasing stage." Those top three alternatives were as follows:

1. Construct an approximately 0.5-mile long levee along the south bank downstream from Highway 83 and reconnect the overbank channel along the north bank in the vicinity of Cody Park.
2. Widen the channel through the UPRR bridge and set back the bank and sandpit levees upstream and downstream of the bridge along an alignment that matches the main channel approaches to this existing channel constriction.
3. Reactivation of the north bank channel between the Highway 83 bridge and the restriction at the east end of Cody Park.

HDR and Tetra Tech completed both hydraulic and sediment transport modeling for these alternatives and a baseline condition. Results indicated that none of the alternatives would be successful in achieving successful in achieving the desired reduction in stage for a flow of 3,000 cfs, with the best being a reduction of 0.1 foot at the gage (compared to the 0.8 feet needed) and the worst actually increasing the stage at 3,000 cfs. Another notable conclusion in the HDR and Tetra Tech report was as follows:

> Since the evaluated alternatives only include elements located below Highway 83, it is likely that implementing upstream measures that would reduce the sediment supply to the bridge (i.e., reactivation of overbank channels in the reach above the bridge) would be necessary to significantly reduce flood stages at the gage and possibly downstream near the Cody Park restriction. Based on the model results from the evaluated alternatives, reactivating overbank channels could result in increased sediment storage in the overbanks, thereby reducing the sediment supply to and associated aggradation in downstream reaches.

HDR and Tetra Tech thus recommended "that an evaluation of additional alternatives that include variations of these measures be carried out to assess the potential benefits on flood stage and carrying capacity."

EDO (2012). Memorandum, Choke Point Options (June 10) and Choke Point Workgroup Conference Call Meeting Notes (June 20).

EDO (2012). Memorandum, Further Detail on Institutional and Engineering Options (July 19) and Choke Point Workgroup Conference Call Meeting Notes (July 26).

At the May 2012 WAC meeting, the EDO presented two options for increasing capacity at flood stage towards the 3,000 cfs objective:

1. Institutional options that may provide a basis for NWS to increase flood stage from the existing 6.0 feet (capacity of approximately 1,560 cfs) to 6.5 feet (capacity of approximately 2,400 cfs).
2. Engineering the river to increase capacity at flood stages.

The WAC supported an expenditure of $150,000 to implement some of the institutional options and formed a new workgroup to study engineering options.

Institutional options included implementation of flood-proofing projects or buying out potentially affected properties. In fall 2011, the EDO met with representatives from the City of North Platte and Lincoln County to discuss possible flood-proofing projects. In May 2012, the EDO met with NWS North Platte to discuss those projects as a possible basis for increasing flood stage. NWS identified the developed area along North River Road west of Highway 83 as the primary area of concern for potential flood impacts to structures. NWS also explained that "Flood stage is equal to the stage where flow initially overtops the channel banks, but is not based on stage when high ground water levels cause flooding."

The three proposed flood-proofing projects were as follows:

1. Reactivation of the State Channel
2. Construction of a new outlet from a gravel pit pond on the east side of Highway 83 to make more effective use of natural drainage near North River Road west of Highway 83.
3. Installation of driveway culverts in the road ditch on the north side of North River Road to improve drainage to Whitehorse Creek.

The Whitehorse Creek drainage project was completed in 2014, and the State Channel berm rehabilitation was finally completed in 2018. The gravel pond outlet was determined to be an inefficient and comparatively costly solution and was not implemented.

Potentially affected properties to be targeted for buyouts were identified based on flood inundation modeling by the EDO and anecdotal information from the summer 2011 flooding. The total cost of buyouts was estimated to be about $3.4 million. The EDO noted that "In addition to the high cost, property buyouts are likely politically unacceptable until all other options have been exercised, and SDHFs are deemed essential for successful Program implementation." Based on feedback from the workgroup, the EDO completed additional analyses to reflect the benefits of flood-proofing projects and evaluated combinations of buyouts and flood easements. Estimated costs still ranged from $1.9 to $4.3 million depending on the alternative. The EDO said "There is a low likelihood of all owners willing to sell or enter into easements, and as a result this alternative should not be considered further." However, the workgroup requested that the option be retained for further consideration.

Four engineering options were presented to the workgroup for discussion:

1. Existing or new infrastructure to divert water from North Platte River to South Platte River to circumvent the North Platte chokepoint issue (e.g., additional capacity through NPPD's system).
    a. In the NPPD system, a combination of Sutherland East Reservoir and a new South Platte River outlet was identified as the most feasible option but was considered a long-term solution at best given the high cost and lengthy timeline to develop. The outlet alone (via Fremont Slough) was estimated to cost $10 million in 2012. In an October 2020 email, Jeff Shafer said "NPPD believes the Sutherland East concept is not feasible due to the estimated costs. We are still interested in an additional outlet from Sutherland Reservoir and would be open to studying the concept."
    b. A concept involving an 18-inch pipeline from the North Platte River to the South Platte River with a capacity of 22 cfs and a cost of $1.5 million was briefly considered but not pursued further.
    c. Improvements to existing canals that divert from the North Platte River and return to the South Platte River were considered to be a low-cost solution that should be explored further.
2. Additional storage in existing canals/reservoirs in CNPPID's system available for releases to the central Platte River.
    a. Any potential regulating storage in CNPPID's system was very limited, and this concept was eliminated.
3. Dredge material from the North Platte River to provide additional capacity and potentially modify North Platte River channel dimensions to maximize sediment transport capacity.
    a. Dredging options were focused on lowering the channel bed in the reach between the Highway 83 bridge and the UPRR bridge, with the anticipated result being a comparable reduction in the stage for 3,000 cfs. However, dredging would need to be repeated periodically to maintain hydraulic capacity.
    b. The workgroup suggested the use of jetties or bendway weirs as a means of inducing scour and reducing the need for repeat dredging. Initial analyses indicated that such structures would not be appropriate in this reach of the river and would not achieve the intended objectives.
4. Install sediment collector(s) on the North Platte River to reduce sediment input and potentially induce "natural" dredging.
    a. With costs similar to dredging but the outcome more uncertain, these were not pursued further.

Out of all of these engineering options, only improvements to existing canals and various dredging options were considered in future evaluations.

EDO (2014). Memorandum, Spring 2013 SDMF Release Hydrologic Summary.

In April 2013, the Program conducted a pulse flow release that created short-duration medium flow (SDMF) conditions at the associated habitat reach. The Keith-Lincoln, North Platte, and Suburban canals were used to route water from the North Platte River to the South Platte River, bypassing the North Platte chokepoint. Of 588 cfs collectively diverted into the canals from the North Platte River, only 265 cfs (45 percent) was returned to the South Platte River. The Keith-Lincoln Canal was the least effective and was eliminated from consideration for future flow routing activities. The North Platte and Suburban canals were to be retained for further evaluation, and it was noted that improvements could be made to increase conveyance efficiency. However, no specific improvements to the existing canals were ever pursued.

Anderson Consulting Engineers, Inc. (ACE, 2015). Memorandum, North Platte Choke Point: Investigation of Channel Modifications Upstream of Highway 83 (January 21).

ACE (2015). Memorandum, North Platte Choke Point: Feasibility Assessment of Recommended Alternatives (May 5).

ACE (2016). Memorandum, North Platte Chokepoint: Feasibility Assessment of Recommended Alternatives.

ACE (2018). Memorandum, North Platte Chokepoint: Updated Modeling and Inundation Mapping.

Overall, this series of memos by ACE presents refinements to concept evaluations that began at the time of the June-July 2012 EDO memos discussed above. Initial analyses showed that dredging the river channel could achieve the desired flow capacity at the North Platte chokepoint, but that it would be lost within 3-5 years. It was also found that the addition of jetties or bendway weirs did not improve the longevity of dredging improvements, and thus recurring maintenance would still be necessary.

In a discussion of an “existing conditions” model run, the January 2015 ACE memo describes fairly rapid changes in the hydraulic capacity at the North Platte chokepoint during and just after a major flood event:

> Historic field observations and measurements indicate that the hydraulic capacity at Highway 83 at 6.0 foot flood stage was approximately 1,500 to 1,600 cfs prior to the 2011 flood event. Just after the 2011 flood event, capacity at flood stage increased to approximately 2,600 cfs. However, within a few months of the 2011 flood, hydraulic capacity at the Highway 83 gage was diminished to 1,500 to 1,600 cfs.

With regard to modeling of this event, ACE concluded the following:

> The 1D sediment transport model is capable of recreating observed trends in hydraulic capacity before and after the 2011 flood event. However, the temporal rate at which the model predicts changes in hydraulic capacity is slower than what has been observed in

the field. Channel response likely occurs quicker than the sediment transport model is predicting.

Based on a series of model analyses, ACE found that a combination of upstream channel improvements (e.g., channel widening), dredging downstream of Highway 83, and installation of jetties or bendway weirs downstream of Highway 83 appeared capable of maintaining the long-term hydraulic capacity target for the entire 16-year model period. This became the Recommended Construction Alternative, but the potential longevity of the project should be viewed with some caution given the observations about the temporal rate of modeled flow capacity changes.

The May 2015 ACE memo further developed the details and feasibility assessment of the Recommended Construction Alternative. Total cost to implement the alternative was estimated at about $3.3 million, plus annual O&M costs of $30,500 per year assuming vegetation treatment every three years and dredging every five years. Given anticipated permitting requirements, it was expected that the Recommended Construction Alternative would take a minimum of 4 years to implement.

This was compared to a Property Inundation Compensation Alternative (flood easements), which incorporated 28 parcels totaling 87 acres, and two secondary buildings, and was estimated to cost about $374,000. These costs did not assume any acquisition of the impacted land or structures. Rather, "this information represents a reasonably conservative estimate to initiate the negotiation and development of inundation compensation agreements with each individual parcel owner," which in turn assumes that property owners are actually willing to enter into such an agreement.

The September 2016 ACE memo retained the same information about the Recommended Construction Alternative and the Property Inundation Compensation Alternative but added a new alternative to bypass the chokepoint by diverting 1,500 cfs from the North Platte River to the South Platte River via existing diversion structures and conveyance facilities. Improvements to the Keith-Lincoln, North Platte (Platte Valley Irrigation District or PVID), and Suburban canals had not been pursued further after the 2013 SDMF release, which had shown relatively little capacity to route water through these canals and around the North Platte chokepoint. This new alternative proposed the construction of entirely new parallel canals with much larger capacities. Several alignments were investigated, with the most feasible being a new canal running parallel to the PVID canal. In addition to excavation, this new canal would require land acquisition and numerous road, rail, and siphon crossings. Costs were estimated to be more than $13 million plus $10,000 for annual O&M.

The June 2018 ACE memo documented updated modeling using 2017 LiDAR data (previous modeling used 2009 LiDAR data) to demonstrate the benefits of the State Channel Berm and also updated the mapping and costs associated with the Property Inundation Compensation Alternative. The revised cost estimates for this alternative ranged from $92,400 to $320,400 depending on the extent of the area that is considered to be impacted by inundation. This would still require the negotiation of flood easements with the owners of 29 individual parcels. No formal action has been taken in pursuit of this alternative, and numerous issues would need to be resolved in order to do so (e.g., what if not all property owners agree to participate? are the estimated fees to be paid for every flood event? etc.). Additionally, the Program Document would need to be revised to allow flows above flood stage.

III. CONCLUSIONS

During the First Increment, the Program put considerable effort into solving the issue of flow capacity limitations at the North Platte chokepoint, but with limited success. Phragmites were treated periodically by both chemical and mechanical (e.g., disking, shredding) means, but the invasive vegetation continues to persist. Two flood-proofing projects were completed to mitigate flooding issues along the north bank with the hope of gaining capacity by raising minor flood stage. This process took nearly nine years and culminated in a test flow release in July 2020. While the flood-proofing projects performed as intended (if not better), flood impacts were instead observed on the south bank, and the NWS declined to raise the minor flood stage.

The many other alternatives considered for increasing flow capacity at the North Platte chokepoint were met with numerous obstacles: objections from affected property owners, lengthy permitting and construction times, insufficient capacity to be useful, high costs, model results indicating the opposite of what was intended, and so forth. Low-cost improvements to existing canals were considered to bypass the chokepoint by diverting water from the North Platte River to the South Platte River, but the potential capacity gained was too small to make much difference. Construction of a new canal to do the same was prohibitively expensive. The Recommended Construction Alternative evaluated by ACE was estimated to take four years to implement, but given the time it took to successfully design, permit, construct, and test the flood-proofing projects, this is surely underestimating the time required for a project that involves dredging and construction activities in the river channel and on private land. These are but a few of the problems faced. However, if any viable new solutions emerge from North Platte Chokepoint Planning Workgroup discussions, the EDO is prepared to evaluate them as needed.

APPENDIX B.2. 2023 ACE MEMO - NORTH PLATTE CHOKEPOINT REVIEW OF DOCUMENTS AND PREVIOUS ALTERNATIVES

PRRIP CHOKEPOINT PROJECT MEMORANDUM

DATE: August 21, 2023 **ACE PROJECT NO.:** NEHW05.01

TO: Seth Turner, PPRIP Executive Director's Office (EDO)
Chokepoint Planning Workgroup

FROM: Michelle Martin, PE, Anderson Consulting Engineers, Inc.
Brian Murphy, PhD, PE, River Works Ltd

SUBJECT: North Platte River Chokepoint Review of Documents and Previous Alternatives

The Platte River Recovery Implementation Program (PRRIP or Program) continues efforts to achieve and maintain hydraulic capacity of 3,000 cfs on the North Platte River below minor flood stage of 6.0 feet as defined by the national Weather Service (NWS) at the North Platte River at North Platte (06693000) gage adjacent to the Highway 83 bridge. The Program selected Anderson Consulting Engineers Inc. (ACE) to conduct the current North Platte River Chokepoint Engineering Service Project in May of 2023. The EDO has defined the project goal as identifying and screening alternative solutions to increase hydraulic capacity through the Chokepoint and/or provide delivery of flows downstream of the Chokepoint through other systems.

The purpose of this memo is to provide the EDO and the Chokepoint Planning Workgroup with a summary of initial efforts completed by the ACE team as part of the first project task order. This memo also includes an initial listing of alternatives previously considered to address limited hydraulic capacity at the Chokepoint as well as a short list of alternatives that are proposed for further investigation. The lists were developed as a starting point for identifying and screening alternatives.

As part of the first task order the ACE team developed a project charter, conducted a comprehensive review of previous studies and documents related to the North Platte River Chokepoint, and formulated a listing of all alternatives previously considered. The project charter summarizes the North Platte Chokepoint Project goals, objectives, strategies, and constraints as developed by the PRRIP Executive Director's Office (EDO) and the Anderson Consulting Engineers (ACE) team. A copy of the project charter is included in Attachment A. All available documents related to the North Platte River Chokepoint, as referenced in Attachment B, were reviewed by the ACE team. The purpose of the document review was to familiarize team members with the North Platte River, previous Program studies and documents related to the Chokepoint, and the history of alternative development.

A complete listing of alternatives that appear in previous studies was compiled and is shown in Table 1. Information provided for each alternative in Table 1 includes a brief description, noted benefits to capacity and/or flood control, reasons for elimination, and the reference study. Alternatives were grouped into eight categories including: implemented project, sediment management, channel modification/ construction, flow bypass, vegetation control, flood control, flood easements/property buyouts, and new alternatives. For each alternative the table also notes a scaled level of evaluation (from 0 to 4), if the alternative is not feasible, if the solution is independent of other alternatives, if there is an increase in hydraulic capacity, and if flooding is improved. More detailed information related to most alternatives can be found in the North Platte Choke Point Summary Memo (PPRIP EDO September 2012), and North Platte Chokepoint Alternatives Memo (PPRIP EDO 2021).

The full listing provided in Table 1 was reviewed and discussed by the EDO and ACE project team resulting in the development of a short list of alternatives that are proposed for further investigation as part of the current project. The short list identifies a total of nine alternatives as shown in Table 2. Note that none of the alternatives listed under the flood control or flood easements/property buyouts categories were moved to the short list. Alternatives in both these categories were not advanced because increased conveyance capacity could only be achieved by raising minor flood stage or intentionally exceeding minor flood stage. The former was already pursued by the Program without success and the latter would violate Program policy. Bridge widening alternatives, which could include widening of the bridge itself or just the channel underneath, were also eliminated. Prior analyses indicate that bridge widening would provide a limited and unsustainable increase in conveyance capacity through the Chokepoint reach and may actually increase sediment deposition due to reduced velocity and sediment transport capacity associated with wider channel cross sections.

The lists provided in Table 1 and 2 are intended to facilitate initial discussions with the Chokepoint Planning Workgroup regarding alternative identification and screening. Workgroup input on the full alternatives list shown in Table 1 is requested relative to its completeness. Additional input regarding alternatives identified (or not identified) on the short list in Table 2 is also requested to help scope and guide the next phase of the project.

Table 1 North Platte River Chokepoint Alternatives 2005 - 2023

Line No.	Alternative	Description	Capacity and/or Flood Control Benefit	Reason for Elimination	Reference	Prior Level of Evaluation (0-4)*	Feasible?	Stand Alone Solution?	Increases Hydraulic Capacity?	Improves Flooding?	Short List Alt No. **
Implemented Projects											
1	Re-activation of State Channel	Re-activation of the "State Channel" upstream of primary flooding area, restored berm	-Successful at flood proofing to the north		EDO 2012	4				Yes	
2	North River Road / Whitehorse Creek Drainage	Install culverts along N River Rd to improve drainage	- Successful flood proofing project		EDO 2012	4				Yes	
3	Revise Flood Stage	Request that NWS revise flood stage after flood control improvements.* (This was explored after the 2020 flow test, NWS did not agree to modify and redefined flooding at 6.0 feet)	- Raising flood stage from 6.0 ft to 6.5 ft would increase available conveyance capacity below flood stage by about 800 cfs	- Unsuccessful implementation per decision of NWS	SEH 2008/EDO 2020	4	No				
4	Chemical Phragmites Treatment	Annual spraying from Lake McConaughy to Columbus coordinated by Platte Valley Weed Management Area	- Prevents further propagation of vegetation and reduction in hydraulic capacity	- Required annually - Minimal increase in hydraulic capacity, because root balls remain in place	EDO 2012	4					
5	Chemical/Mechanical Phragmites Treatment	Spraying of all vegetation along 50-100 ft swaths of riverbanks and island perimeters Fall 2021. Attempted to follow with disking in Spring 2022, but were unable to secure landowner permissions to facilitate adequate site access.	- Prevents further propagation of vegetation and reduction in hydraulic capacity - Does not required USACE permit	- Property access - Required annually	WAC Meeting Minutes Oct 2021, Feb 2022, May 2022	4					
Category: Sediment Management											
6	Dredging	No description / evaluation	Unknown	Unknown	J.F Sato 2005	1					Alt 1
7		Periodic dredging in main channel 5 miles up and downstream of HWY 83.	- High likelihood of increased capacity - Best alternative modeled provides ~5 years of hydraulic capacity - Known results of lowered channel bottom and water surface elevation	- High cost (best alternative ~$1.6M) - Repeated maintenance required - Permitting difficulty (e.g., 404 permit) - Sediment disposal issues	EDO 2012	2		Yes	Yes	Yes	
8		Dredging downstream of HWY 83	- High likelihood of increased capacity	- Permitting - Repeated maintenance required - Sediment disposal issues	ACE 2015	3		Yes	Yes	Yes	
9		Dredging from just upstream of HWY 83 to Tri-County to excavate pilot channel down to pre-Tri County Div Dam profile.	- Increase hydraulic capacity/ sed transport capacity - Restores equilibrium slope - Reduces dredging at TCCDD	- Permitting - Sustainability - Cost - Sediment disposal issues	River Design Group, Inc. 2023	2		Yes	Yes	Yes	
10	Install Sediment Collectors	Sediment collection system (Streamside Systems) - Fountain Creek demonstration project in Pueblo, CO is an example.	- Potentially sustainable	- Unknown results for untested technology / scale - High cost (~$800k for demonstration project) - Permitting difficulty (e.g., 404 permit) - Sediment disposal issues	EDO 2012	2	No				
11	Induce Headcut at Tri-County Diversion	Induce a headcut by opening TCD gates to sluice sediments or by increasing dredging upstream of diversion. Also dredging plus bypass of sediment. (Mentioned but never advanced)	- Increase hydraulic capacity/ sed transport capacity - Increase time between dredging	- Unknown results and uncertainty of impacts - Permitting - Repeated maintenance required - Sediment disposal issues	HDR/Tetra Tech 2011	1					
12	Modification to Tri County Diversion	Modification to Dam to allow for sediment passage.	- Potential to promote sediment transport - Sediment passage could provide downstream benefit - Potential to reduce time between dredging upstream	- Impacts to diversion operations - Permitting - Sediment passage could have impacts downstream - Sediment disposal issues	River Design Group, Inc. 2023	2					Alt 2

* 0 = New Alternative, 1 = Named and Eliminated with no Discussion/Evaluation, 2 = Conceptual Evaluation, 3 = Hydraulic/Sediment Model Evaluation, 4 = Pursued/Implemented
** See Table 2

Line No.	Alternative	Description	Capacity and/or Flood Control Benefit	Reason for Elimination	Reference	Prior Level of Evaluation (0-4)*	Feasible?	Stand Alone Solution?	Increases Hydraulic Capacity?	Improves Flooding?	Short List Alt No. **
Category: Channel Modification / Construction											
13	Sand Bar/Island Removal above HWY 83	Remove sand bar located ~1.5 miles upstream of HWY 83.	- Removal would widen channel - would keep more flow in main channel and reduce overbank flooding	- Island could reform - Not stand alone solution - Local impacts	J.F Sato 2005	2					Alt 3
14		Refinement of JF Sato Alt			SEH 2008	2					
15		Removal of Vegetation and Widening at Sand Bar / Island			ACE 2015	3					
16	Wetland enhancement project to connect State Channel to Dishman property	No description / evaluation	Unknown	Unknown	SEH 2009/2010	1					
17	Spur Dikes / Jetties / Bendway Weirs	Natural spur dikes to increase flow to underutilized channels around island to keep channels open (No evaluation)	- Aid in removal of sand bars	- Permitting - Require maintenance and can lose effectiveness over time	SEH 2009/2010	1					Alt 4
18		Narrowing channel width throughout, using jetties or weirs, to a uniform width equivalent to width at current restrictions	- Sustainable option to achieve uniform sediment transport and minimize deposition	- Can increase resistance to flow and water levels - No increase in hydraulic capacity	EDO 2012	2					
19		Low profile bendway weirs placed downstream of HWY 83 to increase transport capacity during low flows.	- Sustainable option to increase sediment transport capacity - Creates compound channel geometry to promote transport during moderate flows - 1D Sediment modeling indicated potential for effectiveness - Could be adaptively managed for performance/longevity	- Periodic dredging may be necessary to maintain hydraulic capacity - Can raise water surface elevations if not designed correctly - Permitting	ACE 2015	3					
20	Channel Widening	Widening channel at current restrictions to make channel width uniform	- Increase in hydraulic capacity	- Prevents further decreases in capacity, but may not increase capacity - Landowner access required to modify channel width - Permitting difficulty (e.g., 404 permit)	EDO 2012	2					Alt 3
21		Widening of channel to 350 feet upstream of HWY 83 w/ channel excavation to create uniform channel slope.	- Has potential to be effective when included with other alternatives (e.g. dredging, jetties)	- Increase in hydraulic capacity not sustainable without other measures - Not effective as stand alone alternative	ACE 2015	3					
22		Increase channel width to improve hydraulic capacity	- Increase in hydraulic capacity	- Not sustainable without other measures - Not effective as stand alone alternative	River Design Group, Inc. 2023	2					
23	Widen Bridge Crossings	Remove South Bank Deposition at UPRR and Sandpit. Removal of sediment deposition on south bank just upstream of UPRR Bridge towards sand pit lakes.	-Increases capacity at UPRR bridge and upstream approx. 3,800 feet.	- No impact at HWY 83 - Coordination with UPRR and sand pit pond owners - Sediment disposal issues	HDR/Tetra Tech 2011	2	No				
24		Widening bridges at Hwy 83, UPRR, Hwy 30 to increase hydraulic capacity	- Reduce local backwater areas at constrictions	- Net overall increase in deposition - Not sustainable	EDO 2012	2	No				
25	Widen at HWY 83	Widening at HWY83 Bridge to increase hydraulic capacity (evaluation assumed removal of bridge)	- Lower water surface elevations	- 1D Sediment modeling indicated little to no increase in hydraulic capacity with bridge removal - Decreases sediment transport capacity	ACE 2015	3	No				
26	Widen Bridge Crossings	Widen bridge crossings to increase hydraulic capacity	- Localized increase in hydraulic capacity	- Increase in hydraulic capacity not sustainable without other measures - Not effective as stand alone alternative - Expensive	River Design Group, Inc. 2023	2	No				

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** See Table 2

Line No.	Alternative	Description	Capacity and/or Flood Control Benefit	Reason for Elimination	Reference	Prior Level of Evaluation (0-4)*	Feasible?	Stand Alone Solution?	Increases Hydraulic Capacity?	Improves Flooding?	Short List Alt No. **
Category: Flow Bypass											
27	Revise diversion operations	No description / evaluation	Unknown	Unknown	J.F Sato 2005	1					
28	Interconnect NPPDs Sutherland Canal and Central's Main Supply Canal (aka Tri-County Canal).	No description / evaluation	- Existing infrastructure and low cost (yet to be determined)	- Low capacity - High seepage loss - Limited operation outside of irrigation season	J.F Sato 2005	1	No				
29	Canal Modification between NPPD and TCCDD	Consolidation of CNPPID diversions and construction of canal connections.	- Avoids flood stage concerns	- Not feasible due to interference w/ NPPID hydro power operations '- requires modification to irrigation/hydropower ops	River Design Group, Inc. 2023	2	No				
30	Flow Bypass using existing facilities	North Platte to South Platte Diversion.	- Existing infrastructure and low cost - Relatively low cost (yet to be determined) - Higher capacity than option without canal improvements	- Low capacity (<200 cfs) - High seepage loss (~40% of NPR diversion) - Limited operation outside of irrigation season	EDO 2012 (June)	2	No				
31	Flow Bypass using existing facilities	Keith-Lincoln Canal (KLC), Suburban Irrigation Canal (SID), and Platte Valley Canal (PVID).	- Existing infrastructure and low cost (yet to be determined)	- Low capacity (<100 cfs) - High seepage loss - Limited operation outside of irrigation season	ACE 2016	2	No				
32	Construct New Canal for Bypass	Construct new canals parallel to or upside PPVID/North Platte Canal or SID/Suburban Canal	- Flexibility in return timing/capacities to NPR - Avoids flood stage concerns - Avoids modifications to existing water supply infrastructure	- Land acquisition and easements - Expensive - Excavation costs - Requires land acquisition and numerous road, rail, and siphon crossings.	ACE 2016	2		Yes	Yes	Yes	Alt 5
33	Existing Storage in CNPPIDs System	Storage in Jeffery and Johnson Lakes. Additional program water storage in CNPPID system, with SDHF release to make up for capacity shortfall in North Platte.	- Flexibility in reservoir and return capacities - Benefits to CNPPID and PRRIP	- Additional storage volume may be needed to avoid adverse impacts of rapid drawdown on Jeffrey and Johnson lakes. - Initially determined to be undesirable by CNPPID.	EDO 2012 (June)	2	No		Yes		
34	Sutherland East Reservoir	New Sutherland East Reservoir	- Flexibility in reservoir and return capacities - Benefits to TPNRD, PRRIP, and NPPD	- High cost - Delayed project completion (>5 years) - Permitting	EDO 2012 (Sept.)	2	No				
35	Storage in Existing Sutherland Reservoir	Divert water using Korty or Keystone Diversions, with new return to South Platte.	- Existing infrastructure and low cost - Higher capacity than option without canal improvements	- Concerns with system losses / timing - Not reasonable for NPPD	EDO 2012	2	No				
36	NPPD siphon bypass at South Platte River	Bypass using NPPD's Keystone Diversion, with the addition of a bypass just before or after the Paxton Siphon to the SPR. There is approximately 40 feet of head at this location (NPPD 2012), which could be used to gravity feed water to the South Platte River via a pipeline installed immediately above or below the Paxton Siphon.	- Up to ~1,700 cfs capacity at South Platte River	- Would require hydro-bypass agreement - Capacity constraints on delivering water to this point on the Sutherland Canal, i.e., unreliable surplus capacity (years when chokepoint capacity is actually a constraint on EA water delivery, Sutherland Canal is already going to be full due to preferential routing)	EDO 2012	2	No				
37	Pipeline from NPR to South Platte River	Small-diameter pipeline to carry water along north-south alignment from NPR to SPR	- No limits on operating schedule	- Limited capacity (<25 cfs) - High cost - Infeasible based on number of headgate diversion wells needed to divert from NPR, and pump water over divide from SPR to NPR.	EDO 2012	2	No				

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** See Table 2

Line No.	Alternative	Description	Capacity and/or Flood Control Benefit	Reason for Elimination	Reference	Prior Level of Evaluation (0-4)*	Feasible?	Stand Alone Solution?	Increases Hydraulic Capacity?	Improves Flooding?	Short List Alt No. **
Category: Vegetation Control											
38	Chemical Phragmites Treatment	Annual spraying	- Prevents further propagation of vegetation and reduction in hydraulic capacity	- Required annually - Minimal increase in hydraulic capacity, because root balls remain in place	J.F Sato 2005	2					Alt 6
39		Refinement of JF Sato Alt			SEH 2008	2					
40	Chemical/Mechanical Phragmites Treatment	Spraying in the fall with shredding only in areas with immediate need for flow improvement. Spraying upstream and downstream of HWY 83.	- Prevents further propagation of vegetation and reduction in hydraulic capacity - Does not required USACE permit	- Property access - Required annually	SEH 2009/2010	4					
41	Mechanical Phragmites Treatment	Chopping and disking	- May break up existing root balls, and facilitate sediment flushing - Relatively inexpensive - Slows rate hydraulic capacity reduction - Does not required USACE permit	- Higher cost than spraying alone - Access issues for heavy machinery in the floodplain - Potential 404 permitting requirements - Annual maintenance required - Not a standalone fix - Does not increase capacity	EDO 2012	4					
42	Vegetation Removal	Overall vegetation removal concept	- Prevents further propagation of vegetation and reduction in hydraulic capacity - Does not required USACE permit	- Removal alone has marginal effects on water surface elevations	River Design Group, Inc. 2023	2					
Category: Flood Control											
43	Open and Extend State Channel	Open State Channel and extend to connect to main floodplain	- Provide local flood relief along North River Rd - Redirect flow back to main channel	- Minimal impact on overall hydraulic capacity - Would violate minor flood stage and conflict with Program policy	J.F Sato 2005	2	No			Yes	
44	Open South Channel	Open 800 feet of channel to connect road ditch along Washboard Road to another ditch to convey flow to main channel.	- Provide local flood relief - Redirect flow to main channel	- Minimal impact on overall hydraulic capacity - Would violate minor flood stage and conflict with Program policy	J.F Sato 2005	2	No			Yes	
45	Remove Abandoned detour road and construct ditch to main channel	Remove the old detour road upstream of HW83 and construct a ditch from the south channel to the main channel of the river.	- Remove constriction/obstruction in river - Provide connection of south ditch to main channel to promote flow conveyance	- Minimal impact on overall hydraulic capacity - Would violate minor flood stage and conflict with Program policy	J.F Sato 2005	2	No			Yes	
46	Box Culvert and Enlargement of Overbank Floodplain North of HWY83	Box culvert north of HWY 83 Bridge combined with vegetation removal and enlargement of overbank floodplain channels.	- Provide local flood relief - Redirect flow to main channel	- Minimal impact on overall hydraulic capacity - Would violate minor flood stage and conflict with Program policy	HDR/Tetra Tech 2011	2	No			Yes	
47	Re-activate North Bank Channel downstream of HWY 83	Restore channels connection to main channel and match river invert to create additional conveyance during low and high flows.	- Provide local flood relief - Redirect flow to main channel	- Minimal impact on overall hydraulic capacity - Would violate minor flood stage and conflict with Program policy	HDR/Tetra Tech 2011	2	No			Yes	
48	Construct Road Ditch along Washboard Road	Construct a road ditch along west side of Washboard Rd. Culvert/headwall installation under existing drives.	- Provide local flood relief - Redirect flow to main channel	- Minimal impact on overall hydraulic capacity - Would violate minor flood stage and conflict with Program policy	J.F Sato 2005	2	No			Yes	
49	Increase width of North Channel	Increase width of North Channel	- Provide local flood relief - Redirect flow to main channel	- Minimal impact on overall hydraulic capacity - Would violate minor flood stage and conflict with Program policy	SEH 2009/2010	2	No			Yes	
50	Gravel Pond Outlet Project	Construction of an outlet for gravel pond located just east of HWY83 to reduce flooding. Project includes an outlet and pump/lift station.	- Improve drainage of ground and surface water in primary flood area	- Cost benefit not feasible - Minimal impact to hydraulic capacity - Topography may limit ability to drain pond during NPR high flows	EDO 2012	2					
51	Levee/Berm	Floodproof-Type Berm at Cody Park. Earthen "levee" along the bank at Cody Park ~1/2mile in length.	- Would protect Cody Park at high flows	- Ineffective at reducing flood impacts up to 3,000 cfs	HDR/Tetra Tech 2011	2	No				
52		Construct dikes to protect properties (No description/eval)	Unknown	Unknown	J.F Sato 2005	1					
53		Levee along the south bank of the NPR to protect Cody Park, similar to that installed summer 2011 by FEMA	- Would protect Cody Park at high flows (i.e., greater than 6,000 cfs)	- No flood protection at Program flow of up to 3,000 cfs	EDO 2012	2	No			Yes	
54		Levee along the north bank of the NPR to protect area south of N River Road that is typically flooded at flows above minor flood stage	- Would minimize flooding related to surface flows overtopping channel banks	- Could increase ground water flooding as a result of increased river stage - Difficulty permitting levees within NPR floodway - High profile levee likely unacceptable to residents - Would violate minor flood stage and conflict with Program policy	EDO 2012	2	No			Yes	

* 0 = New Alternative, 1 = Named and Eliminated with no Discussion/Evaluation, 2 = Conceptual Evaluation, 3 = Hydraulic/Sediment Model Evaluation, 4 = Pursued/Implemented
** See Table 2

Line No.	Alternative	Description	Capacity and/or Flood Control Benefit	Reason for Elimination	Reference	Prior Level of Evaluation (0-4)*	Feasible?	Stand Alone Solution?	Increases Hydraulic Capacity?	Improves Flooding?	Short List Alt No. **
Category: Flood Easements / Property Buyouts											
55	Flood Easements	No description / evaluation	Unknown	Unknown	SEH 2009/2010	1					
56		Property Inundation Compensation Alternative (flood easements). Flood easement for properties impacted. 28 parcels identified, no insurable structures, two secondary building. Total area ~87 acres.	- May not require any additional alternatives - One time fee, no long term costs	- Intentional violation of flood stage conflicts with Program policy and CNPPID's FERC license requirements. - Most property owners unwilling to participate - Conflicts with Programs 'willing seller' policy - Impacted areas may change over time	ACE 2015/2016	2	No				
57	Property Buyouts	No description / evaluation	Unknown	Unknown	J.F Sato 2005	1					
58		Buyouts and easements with minimal impact of floodproofing projects		- Not enough willing seller area to justify increased flood stage - Likely politically unacceptable until other options exhausted and SDHF deemed essential - High cost with uncertain results	EDO 2012	2	No				
59		Buyout of affected properties based on flood inundation. Total assessed value in 2012 was ~$2.8M, with additional costs likely ~$3.4M.	- Smaller area needed because of flood-proofing - May justify an increase in minor flood stage to 6.5 feet (2,400 cfs)	- Not enough willing seller area to justify increased flood stage - High cost with uncertain results	EDO 2012	2	No				
New Alternatives											
60	South Platte Storage	Develop Storage on the South Platte River to Provide 3,000 cfs at Confluence. Exchange of flows from North Platte to South Platte at a ratio would be required.				0					Alt 7
61	Buyout Existing Irrigation District Infrastructure	Buyout of irrigation district canals - PVID/North Platte Canal or SID/Suburban Canal. Irrigation would be converted from surface to groundwater with groundwater recharge to mitigate impacts.				0					Alt 8
62	Reduce/Control Upstream Sediment Sources	Identify and reduce upstream sediment sources between Lake McConaughy and HWY 83.				0					Alt 9

* 0 = New Alternative, 1 = Named and Eliminated with no Discussion/Evaluation, 2 = Conceptual Evaluation, 3 = Hydraulic/Sediment Model Evaluation, 4 = Pursued/Implemented

** See Table 2

Table 2 North Platte River Chokepoint Alternatives Short List

Alt No.	Alt Type	Alternative	Description	Prior Level of Evaluation (0-4)*	Evaluation Tasks
Alternatives					
1	Sediment Management	Dredging	Dredging in main channel. Extents could be from upstream of HWY83 to Tri-County Canal Diversion.	3	- Geomorphic Evaluation - Hydraulic / Sediment Transport Modeling - Determine Dredging Extents, Volume, Frequency - Permitting Requirements - Disposal Plan - Engineering/Dredging Costs and Permitting
2	Sediment Management	Modification to Tri County Diversion	Modification to Dam to allow for sediment passage.	2	- Geomorphic Evaluation - Hydraulic / Sediment Transport Modeling - Identify Design Constraints Related to Tri-County Operations - Determine Benefit to Hydraulic Capacity at HWY 83 - Evaluate Downstream Impacts of Sediment Passage - Engineering/Construction Costs and Permitting
3	Channel Modification/ Construction	Channel Widening and/or Sand Bar/Island Removal	Widening of channel in strategic locations to increase hydraulic capacity. Removal of vegetation and widening at Sand Bar / Islands	3	- Geomorphic Evaluation - Identify Potential Locations - Hydraulic / Sediment Transport Modeling - Evaluate as Benefit to Other Alternatives - Engineering/Dredging Costs and Permitting
4	Channel Modification/ Construction	Spur Dikes/Jetties/ Bendway Weirs	Low profile bendway weirs placed downstream of HWY 83 to increase transport capacity during low flows.	3	- Geomorphic Evaluation - Determine Potential Locations - Hydraulic / Sediment Transport Modeling - Evaluate as Benefit to Other Alternatives - Engineering/Dredging Costs and Permitting
5	Flow Bypass	Construct New Canal for Bypass	Construct new canals parallel to or upside PPVID/North Platte Canal or SID/Suburban Canal	2	- Assess Feasibility of New Canal or Upsizing of Existing - Determine Required Canal Capacity to Bypass Chokepoint - Canal Sizing (new or upsized) - Evaluate Land Acquisition/Easements and Crossing Requirements - Engineering/Construction Costs
6	Vegetation Control	Chemical/Mechanical Phragmites Treatment	Spraying in the fall with shredding in areas with immediate need for flow improvement.	4	- Geomorphic Assessment - Evaluate Impact of Vegetation on Capacity and Transport - Hydraulic / Sediment Transport Modeling - Identify Benefits of Vegetation Control/Removal

* 0 = New Alternative, 1 = Named and Eliminated with no Discussion/Evaluation, 2 = Conceptual Evaluation, 3 = Hydraulic/Sediment Model Evaluation, 4 = Pursued/Implemented

Alt No.	Alt Type	Alternative	Description	Prior Level of Evaluation (0-4)*	Evaluation Tasks
New Alternatives					
7	Flow Bypass	South Platte Storage	Develop Storage on the South Platte River to Provide 3,000 cfs at Confluence. Exchange of flows from North Platte to South Platte at a ratio would be required.	0	- Determine Storage Volume Required to Deliver 3,000 cfs at Confluence - Assess and Account for Flow Exchange from NP to SP - Identify Potential Storage Locations (New or Existing) - Evaluate Land Acquisition/Easements - Engineering/Construction Costs
8	Flow Bypass	Buyout Existing Irrigation District Infrastructure	Buyout of irrigation district canals - PVID/North Platte Canal or SID/Suburban Canal. Irrigation would be converted from surface to groundwater with groundwater recharge to mitigate impacts.	0	- Determine Capacity of Existing Canals - Explore Potential for Buyout of Irrigation District Infrastructure - Evaluate Groundwater Recharge Requirements and Costs to Offset Conversion of Irrigation from Surface to Groundwater - Identify Long Term O&M Plan/Cost
9	Sediment Management	Reduce/Control Upstream Sediment Sources	Identify and reduce upstream sediment sources between Lake McConaughy and HWY 83.	0	- Geomorphic Assessment from Lake McConaughy to HWY 83 - Identify Sediment Sources / Develop Sediment Budget - Identify Locations Where Sediment Sources Might be Controlled - Determine Feasibility of Reduction in Upstream Sediment Sources

* 0 = New Alternative, 1 = Named and Eliminated with no Discussion/Evaluation, 2 = Conceptual Evaluation, 3 = Hydraulic/Sediment Model Evaluation, 4 = Pursued/Implemented

PRRIP CHOKEPOINT PROJECT MEMORANDUM

DATE:	August 18, 2023	**ACE PROJECT NO.:**	NEHW05.01
TO:	Seth Turner, PPRIP Executive Director's Office		
FROM:	Michelle Martin, PE, Anderson Consulting Engineers, Inc.		
	Brian Murphy, PhD, PE, River Works Ltd		
SUBJECT:	North Platte Chokepoint Project Charter		

This memorandum describes the North Platte chokepoint project charter. The charter summarizes the PPRIP North Platte chokepoint Project goals, objectives, strategies, and constraints as developed by the PRRIP Executive Director's Office (EDO) and the Anderson Consulting Engineers (ACE) team. It also provides clarity to everyone involved in the project about what will be accomplished and sets expectations for all stakeholders so that everyone is working towards meeting the project goal.

Background

The Platte River Recovery Implementation Program (Program) initiated on January 1, 2007 between the states of Nebraska, Wyoming, and Colorado and the Department of the Interior to address endangered species issues in the central and lower Platte River basin. Program "target species" include the whooping crane, piping plover, interior least tern (now de-listed), and pallid sturgeon.

Project Reach

The project reach includes the lower 10 miles of the North Platte River extending from the Tri-County Canal Diversion on the Platte River to approximately 5.5 miles upstream of State Highway 83.

Platte River Recovery Implementation Program Objective

The Addendum to the Program Document for the First Increment Extension specifies the following water management objectives related to the North Platte chokepoint:

- Aggressively continue to implement channel conveyance improvements at North Platte chokepoint through efforts directed toward achieving and maintaining at least 3,000 cfs conveyance capacity while remaining below flood stage, with additional capacity developed as practicably achievable with available resources.
- Implement water releases including short-duration high flows (SDHF) and target flows once Program water projects are operational and chokepoint conveyance issues are resolved.
- The Program will continue to evaluate the efficacy of available Program water and chokepoint capacity through time to ensure Program water meets its intended purposes.

Problem Statement

Minor flood stage for the North Platte chokepoint, as defined by the National Weather Service (NWS) for the North Platte River at North Platte gage (06693000), is 6.0 feet. Average discharge capacity at this minor flood stage is estimated to be about 1,760 cfs based on the current Nebraska Department of Natural

Resources rating curve and shift measurements since July 2020. Limited hydraulic capacity through the chokepoint is a constraint on the ability to deliver water from the Lake McConaughy EA to the Program's Associated Habitat Reach (AHR) on the central Platte River downstream between Lexington and Chapman, Nebraska.

Project Goal

The EDO defined the project goal as identifying and screening alternative solutions to increase hydraulic capacity through the chokepoint and/or provide delivery of flows downstream of the chokepoint through other systems. Any new alternatives the ACE team develops will maintain delivery of a total peak flow of 3,000 cfs to the Program's AHR on the central Platte River without exceeding minor flood stage of 6.0 feet on the North Platte River as defined by and measured at the gage at the State Highway 83 bridge.

Project Objectives and Strategies

1. Identify, screen, and rank past and potential new alternatives to improve conveyance capacity and reduce flood risk through the North Platte chokepoint reach.
2. Update and calibrate baseline models.
3. Conduct detailed hydraulic and/or sediment transport modeling as needed to evaluate the effectiveness of selected alternatives at achieving and maintaining gains in conveyance capacity through the North Platte chokepoint.
4. Complete assessment of permitting requirements, estimated costs, and implementation timeline for selected alternatives.

Objective	Strategy
1. Identify, screen, and rank past and potential new alternatives to improve conveyance capacity and reduce flood risk through the North Platte chokepoint reach.	Review all previous studies and alternatives provided by the EDO.
	Develop a listing and brief description of all previous alternatives, refinement of pervious alternatives, and new alternatives.
	Collaborate with the EDO and Chokepoint Planning Workgroup to review and screen alternatives list. The list will be reduced to the most feasible alternatives identified for further evaluation.
	Develop decision criteria for alternative selection (e.g. performance, cost, permitting, long term O&M, timeline, social impacts, etc.)
	Utilize a multi criteria decision analysis (MCDA) process to rank and select alternatives.
2. Update and calibrate baseline models.	Utilize best available topography (2020 LiDAR) to update the existing HEC-RAS 1D hydraulic model of the study reach.
	Utilize best available topography (2017/2020 LiDAR) to develop an existing 2D hydraulic model of the entire study reach using SRH-2D. Information from the previously developed 2D HEC-RAS model will be leveraged.
3. Conduct detailed hydraulic and/or sediment transport modeling as needed to evaluate the effectiveness of selected alternatives at achieving and maintaining gains in conveyance capacity through the North Platte chokepoint.	Perform a robust geomorphic assessment that clearly identifies the physical processes of river function and response.
	Develop a 2D hydraulic model using SRH-2D, leveraging the baseline data and models, to determine hydraulic capacity and floodplain inundation for each alternative.
	Use the SRH 2D model to characterize the depth and velocity fields across a range of expected flows, and to predict the location and magnitude of changes in channel morphology for each recommended alternative.
	Improve the calibration/validation process by comparing model output to high-resolution surface velocities computed from UAV imagery using large-scale particle image velocimetry techniques
4. Complete assessment of permitting requirements, estimated costs, and implementation timeline for selected alternatives.	Build upon previous vegetation studies and data collected though the Program's vegetation monitoring program to evaluate each alternative, permitting implications and permitting strategies
	Develop rough order of magnitude (ROM) planning-level capital cost estimates and O&M costs for new alternatives and update cost estimates (capital, O&M) for previous alternatives (if available).
	Prepare a milestone schedule for the top three ranked alternatives that considers current permitting and procurement timelines.

Project Considerations/Constraints

- Alternative solutions will not exceed NWS minor flood stage of 6.0 feet at the North Platte River at North Platte Gage (06693000) at the State Highway 83 bridge.
- Alternatives will not include modification to minor flood stage as defined by the NWS.
- Alternatives shall not adversely impact private properties. If unavoidable impacts to private properties are identified, mitigation will be included as part of alternative development.
- Alternatives will not adversely impact or disrupt any irrigation and/or hydro-power generation operations.
- Long-term O&M costs will be considered for all alternatives.
- Alternatives will not exceed a capital cost of $15 million.

Attachment B
North Platte River Chokepoint Reference List

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APPENDIX B.3. 2024 ACE MEMO - NORTH PLATTE CHOKEPOINT PHASE II ALTERNATIVE SCREENING

PRRIP CHOKEPOINT PROJECT MEMORANDUM

DATE:	February 7, 2024	**ACE PROJECT NO.:** NEHW05.03
TO:	Seth Turner, PPRIP Executive Director's Office	
FROM:	Michelle Martin, PE, Anderson Consulting Engineers, Inc. Brian Murphy, PhD, PE, River Works Ltd	DRAFT
SUBJECT:	North Platte Chokepoint Phase II Alternative Screening	

The Platte River Recovery Implementation Program (PRRIP or Program) continues efforts to achieve and maintain hydraulic capacity of 3,000 cfs on the North Platte River below minor flood stage, which is defined by the national Weather Service (NWS) as 6.0 ft at the North Platte River at North Platte (06693000) gage adjacent to the Highway 83 bridge. This gage represents a reach known as the North Platte Chokepoint that extends for several miles upstream and downstream of the Highway 83 bridge. Starting in the late 1980s, hydraulic capacity of the North Platte River through this reach was significantly reduced and is now on the order of 1,750 cfs. As a result, the North Platte Chokepoint limits the Program's ability to deliver water from the Lake McConaughy Environmental Account (EA) upstream to the Associated Habitat Reach (AHR) downstream for the benefit of threatened and endangered species.

The Program selected Anderson Consulting Engineers Inc. (ACE) to conduct the current North Platte River Chokepoint Engineering Service Project in May of 2023. The EDO has defined the project goal as identifying and screening alternative solutions to increase hydraulic capacity through the Chokepoint and/or provide delivery of flows downstream of the Chokepoint through other systems.

The purpose of this memo is to provide a summary of information reviewed, revised and/or developed for a short list of alternatives identified during the initial phase of the project and documented in a memo dated August 21st, 2023. The short-listed alternatives considered and discussed in this memo focus on standalone alternatives including: 1) no-action, 2) South Platte reservoir storage, 3) reduction of upstream sediment sources, 4) purchase of existing irrigation infrastructure for bypass, 5) construction of a bypass canal, and 6) channel modification/sediment removal. Additional concepts that could enhance standalone alternatives also discussed include modification of the Tri-County Canal Diversion (TCCD).

Initial Screening of Alternatives

An initial investigation and screening of the short-listed alternatives was developed to provide information to the EDO and Chokepoint Planning Workgroup to inform selection of which alternatives are worth pursuing in more detail as part of the final phase of the project.

Alternative screening assumes an existing capacity at HWY 83 below 6ft minor flood stage of 1,700 cfs and a need for an additional 1,300 cfs to meet a target of 3,000 cfs.

1. No-Action Alternative

Concept: The no-action alternative is a continuation of existing actions including vegetation control and CNPPID dredging at the Tri-County Canal Diversion (TCCD). Defining conditions under no-action provides a baseline for which alternatives can be compared.

The current hydraulic capacity at HWY 83 at minor flood stage of 6 feet is 1,760 cfs based on October 2023 survey data and hydraulic modeling. Review of rating curve data at the HWY 83 gage has shown a fluctuation in capacity at minor flood stage between 1,550 up to 2,150 cfs over a period of 20 years, see Figure 1. There is not a consistent trend in either direction. Preliminary findings of the geomorphic assessment being conducted as part of this study indicate that the project reach and hydraulic capacity has been in a general state of quasi-equilibrium with the flow and sediment regimes between 1998 and 2023. The single thread morphology is expected to be the channel form into the foreseeable future based on current hydrology, sediment sources and vegetation management practices that established and maintain a stable channel bed and vegetated banks and floodplain. Thus, average hydraulic capacity is anticipated to continue to be approximately 1,700 cfs with a range between 1,550 and 2,150 cfs depending upon flow conditions.

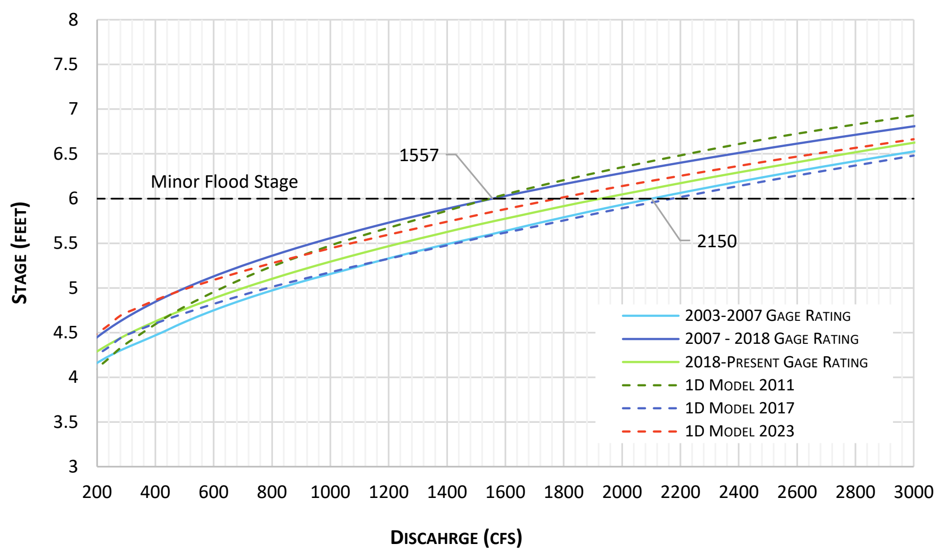

Figure 1. *Stage Discharge Rating Curves at HWY 83 Gage (Gage Data and 1D Hydraulic Model)*

For those reasons, the Program could decide to stay with the status quo, including continued spraying and treatment of invasive vegetation coupled with CNPPID's ongoing dredging at the TCCD and occasional flushing flows as a result of natural events or releases from the Lake McConaughy Environmental Account (EA). This approach would limit cost expenditures and likely maintain delivery of at least 1,500 cfs of EA water downstream of Highway 83 and TCCD.

Summary: No-Action Alternative

Flow Capacity at Confluence vs Flow Target (3,000 cfs): 1,700 cfs (56%)

Percent Increase to Flow Target: none

Est Cost: $0

2. Reduction of Upstream Sediment Sources

Concept: Investigate possibility of reducing upstream sediment sources. The intent of this concept is to minimize incoming sediment load to the Chokepoint in order to maintain and/or improve hydraulic capacity at HWY 83.

The sediment sources to the North Platte River near North Platte, NE are channel, bank, and land erosion from upstream reaches and tributaries, which are also receiving sediment from adjacent hillslopes. Sediment delivery from eroding hillslopes and adjacent upland sources as well as bank erosion is a natural occurring process that is often accelerated by human-induced changes to those natural processes. As discussed in the Geomorphic Assessment memorandum, the construction and operation of Lake McConaughy has cutoff sediment sources from the expansive North Platte River watershed. The watershed downstream of Lake McConaughy is much smaller (1,444 sq mi) and includes Birdwood Creek and several other smaller tributaries (see Figure 2). While some portion of sediment enters directly from adjacent lands, most of the sediment appears to enter the North Platte River as bedload and suspended load from eroding banks and Birdwood Creek and is transported by the river down to the Chokepoint segment and TCCD.

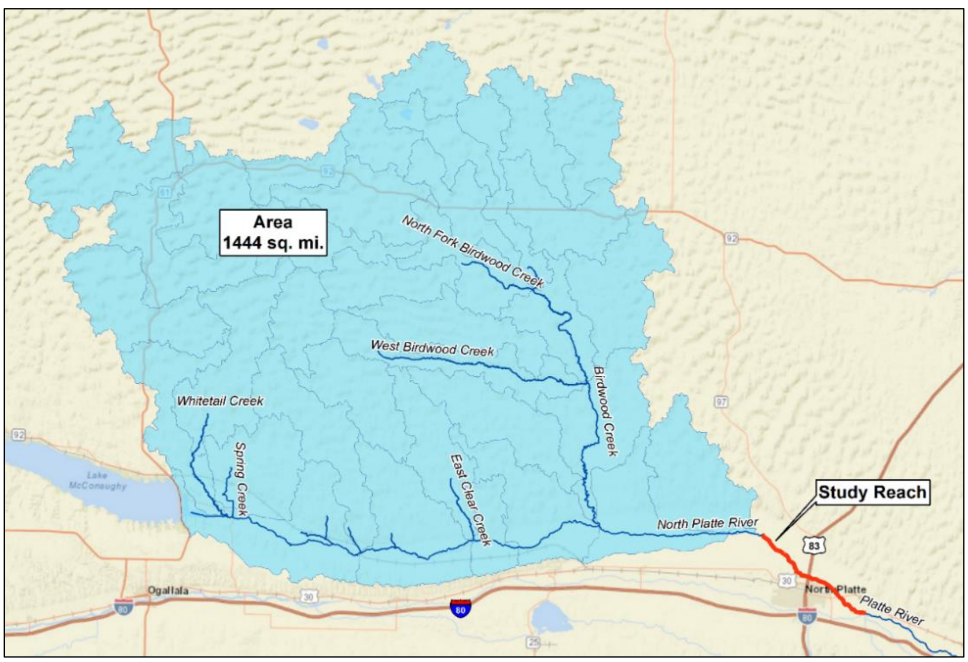

Figure 2. *North Platte River Watershed Downstream of Lake McConaughy*

During the 2023 field visit, we observed Birdwood Creek running sediment laden with no apparent explanation. On the North Platte we also noted acute active bank erosion upstream and downstream of road crossings, but the bank erosion did not appear to be systemic or chronic loading due to lateral migration. In-channel sediment storage in bars and other morphological features was apparent and those features appeared to be migrating downstream, albeit slowly due to bed armoring and dune formation. Further, the quasi-equilibrium state upstream and downstream of Highway 83 suggests that upstream sediment sources are in balance with the river's transport capacity. The EDO and Chokepoint Workgroup could consider performing a detailed sediment source study that would involve evaluating bed materials, geometry, and bed slopes from North Platte, NE up to Lake McConaughy as well as hillslope and tributary inputs from the North Platte River watershed. Tools such as Watershed Assessment of River Stability and Sediment Supply (WARSSS) or other watershed scale sediment source investigation could be included in that study to quantify the sediment source locations and volumes. That information would inform watershed-wide planning and identify best management practices to control sediment sources. However, because the river has shifted towards a stable form with limited reach-scale bed aggradation, and is generally inactive laterally, limiting bank derived sediment into the system, managing sediment sources across the watershed would likely not significantly change the rating curve or increase the flow passing through the Chokepoint at the minor flood stage.

Summary: Reduce Upstream Sediment Sources
Flow Capacity at Confluence vs Flow Target (3,000 cfs): Unknown
Percent Increase to Flow Target: n/a
Est Cost: Unknown

3. South Platte Reservoir Storage

Concept: Develop reservoir storage to stage EA flows on the South Platte. At this stage the purpose of this alternative is to estimate a storage volume required from the South Platte River to bypass the Chokepoint and meet flow targets on the Central Platte.

Use of reservoir storage within the NPPD and CNPPID systems to stage EA flows has been previously investigated. Storage in the NPPD's Sutherland Reservoir was deemed infeasible given the need for a costly outlet to the South Platte River and lengthy development time. Storage in CNPPID's system was determined to be limited and thus an infeasible solution.

The South Platte Reservoir Storage alternative concept evaluated for the current study would be a new reservoir constructed along the South Platte River between the Colorado-Nebraska state line and the city of North Platte. The volume of reservoir storage required to stage EA flows on the South Platte to meet flow targets on the Central Platte was estimated to inform discussion. Volume estimates were developed for a range of flow rates and durations to supplement existing capacity through the North Platte Chokepoint up to a total flow of 3,000 cfs at the confluence of the North Platte and South Platte rivers. Specific locations for a staging reservoir and diversion logistics were not included in the current scope of work.

Volume estimates assume a release of up to 1,500 cfs would be required from the staging reservoir to supplement 1,500 cfs that can be passed through the North Platte Chokepoint below minor flood stage. This would allow for a 1,500 cfs release for germination suppression even if the entirety of existing capacity at the North Platte Chokepoint is being utilized to meet downstream irrigation demands. Volume estimates assume an average annual evaporation rate of 43 inches/year (per NOAA Technical Report NWS 34) and average annual precipitation of 20 inches/year (High Plains Regional Climate Center, Average Annual Precip 1990-2020) for a net total evaporative loss of 23 inches/year. Volumetric losses associated with transport to the Program's habitat reach on the Central Platte were also included and based on data computed by NDNR during the Spring 2013 short duration medium flow (SDMF) release. The percentage loss of water between Kingsley Dam and Grand Island has been estimated to be as much as 50% during flow releases between 2007 and 2013 (EDO 2014) but ranged from 23% to 29% during the 2013 SDMF release. Assuming a net evaporative loss of 23 inches/year and a conservative transport loss of 50% the required storage volume was estimated for a range of flows (250 cfs to 1,500 cfs) and durations (10 to 30 days), see Table 1. The storage required to provide 1,500 cfs for a duration of 30 days is approximately 135,600 acre-feet, which would be the upper bound of storage requirement.

Table 1. *Estimated South Platte Reservoir Volumes*

Q (cfs)	Reservoir Volume (acre-feet)	
Duration	10 Days	30 days
250	7,500	22,600
500	15,100	45,200
1,000	30,200	90,400
1,500	45,200	135,600

Summary: South Platte Reservoir Storage
Range of Storage Volume Required: 45,200 – 135,600 acre-feet

Flow Capacity at Confluence vs Flow Target (3,000 cfs): 3,000 cfs (100 %)
Percent Increase to Flow Target: +44% (56% - 100%)
Est Cost: TBD

4. Purchase of Existing Irrigation Infrastructure for Bypass

Concept: Acquire existing irrigation infrastructure that can be used to divert EA flows from the North Platte to the South Platte, bypassing the Chokepoint. The purpose of this alternative is to utilize existing infrastructure to route a portion of EA flows around the Chokepoint. This concept includes conversion of existing surface water users of the canal to groundwater, allowing for the full capacity of the canal to be dedicated to EA water routing.

Upstream irrigation infrastructure capable of diverting flows from the North Platte to South Platte as a means of bypassing the Chokepoint has been previously explored by the Program. A test of EA flow routing through the Keith Lincoln, North Platte, and Suburban canals was conducted as part of the Spring 2013 SDMF release (EDO 2014). Data collected during the 2013 routing was used to determine potential routing capacity and canal losses. Over a 6-day period between April 4 and 10th a peak flow of 30 cfs, 61 cfs, and 28 cfs was diverted from the Keith Lincoln, Suburban, and North Platte canals, respectively. Based on volumes, an overall loss of 45% was measured between diversion points and spills back to the South Platte River. The Keith Lincoln canal had the largest losses of the three canals, likely due to its length. The North Platte had the least amount of loss, but also the smallest amount of diversion. In addition to losses, routing EA water such as that released in June for germination suppression through canal systems would be difficult due to available capacity during the irrigation season.

Additional investigation was conducted to determine the feasibility of purchasing existing irrigation canals that could then be dedicated to bypass. Purchase of the canal infrastructure would require conversion of existing surface water irrigation to groundwater. Available data was evaluated to identify which irrigation districts/canals might be candidates. The North Platte (Platte Valley Irrigation District) and Suburban (Suburban Irrigation District) canals were identified to have the highest potential based on previous study data, diversion routes, capacity, and loss rates. **These specific districts are identified only for purposes of a preliminary conceptual analysis; representatives of the districts have NOT been contacted to discuss actual feasibility of the alternative.** A map showing both irrigation district boundaries is provided in Figure 3. Active water rights for each canal are summarized in Table 2.

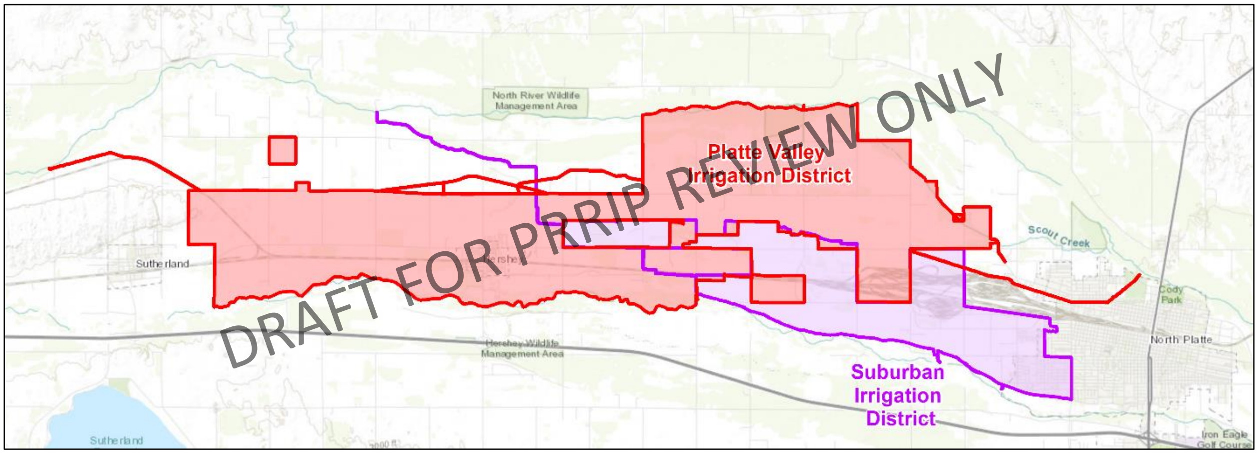

Figure 3. *North Platte and Suburban Canals and Irrigation Districts*

Table 2 Water Rights Summary

Use	Suburban Canal	North Platte Canal
Irrigation from Natural Streams	98 cfs	199.37 cfs
Incidental Underground Storage	15.8 cfs	8.99 cfs
Recharge	77.5 cfs (A-19905)	201 cfs (A-19904)

Source: State of Nebraska DNR – SurfaceWaterRightsSearchIndex

Figure 4 shows the alignment of the North Platte and Suburban Canals. The map also indicates the spill locations of flow diverted back to the South Platte during the 2013 flow test. The figure indicates that the North Platte Canal has its tailwater return to the North Platte River via the Lincoln County Drain No. 1 located just upstream of HWY 83. Use of the North Platte Canal for bypass requires spilling flow into the O'Fallons Lateral and then into the South Platte. This route was used during the 2013 flow test.

Diversion records dating back to 1940 were reviewed to determine the maximum flow discharge for each canal. The Suburban Canal has diverted a maximum of 170 cfs (in 1960) and the North Platte Canal 360 cfs (in 1989). The maximum diversions could potentially account for roughly 5% and 10% of the 3,000 cfs target conveyance through the North Platte Chokepoint. What is unknown at this time is the capacity of the O'Fallons Lateral, which may limit the amount of flow bypass on the North Platte Canal. Records of canal returns to the South Platte River during the 2013 flow test show maximum returns of 22.5 cfs at North Platte Spill No. 1 and 9.0 cfs at North Platte Spill No. 2; thus the capacity of the lateral may only be on the order of 30-35 cfs. To take advantage of the potential capacity of 360 cfs in the North Platte Canal improvements to the O'Fallons Lateral or construction of a new outlet to the South Platte would likely be required. This would include upsizing of the O'Fallons Lateral crossing under Highway 30 and the Railroad, which would be costly and roughly estimated to be between $1 and $2 million (see bypass canal alternative costs). It is also difficult to extrapolate losses from the 2013 data given the large difference in flows (2013 flow test flows were much smaller than the full capacities and bypass diversions were made into dry canals prior to the start of the irrigation season). However, losses will increase with increasing travel length. The Suburban canal is 13.8 miles in length. The diversion path along the North Platte includes 4.9 miles from the diversion to the O'Fallons Lateral, 2.7 miles to the first existing spill location on the South Platte, and another 5.7 miles to the second spill location on the South Platte. The total travel distance along the North Platte Canal route is 7.6 to 13.3 miles.

Processes and logistics for purchase of canal infrastructure are not clear at this time. The cost for just purchase of infrastructure would be difficult to estimate without a valuation study, which would need to involve the Irrigation Districts. If purchased, canal operations and long-term O&M costs would also need to be considered, as well as how staff and operations of the District would move forward. Both canals currently provide recharge for the Twin Platte Natural Resources District, as indicated by water rights listed in Table 2. Groundwater recharge operations would need to continue and likely be increased to offset conversion of surface users to groundwater. Instead of purchasing the infrastructure, another scenario would be for the Program to compensate districts for conversion of surface water users to groundwater and the districts would continue operation and maintenance of the canal for groundwater recharge.

The irrigated acreage for each canal was reviewed to estimate how many users are currently on center pivot irrigation systems and groundwater wells. A GIS analysis using water rights data from Nebraska Department of Natural Resources (NDNR) and inspection of aerial photography was conducted to provide a rough estimate of the acres that are not currently using a center pivot or sprinkler irrigation. Similarly, the irrigated acreage that currently operates a pivot system but does not draw from groundwater was also estimated based on GIS mapping from NDNR of groundwater well locations. These estimates were developed to quantify how much of the district would need to be converted from surface to groundwater use. Table 3 provides a summary of results, and Figure 5 and Figure 6 show the corresponding mapping. Of the acreage irrigated by the Suburban Canal roughly 2,353 acres (53%) would need to be converted. Roughly 5,754 acres (41%) irrigated by the North Platte Canal would need conversion. Note that these numbers are very rough estimates subject to future refinement.

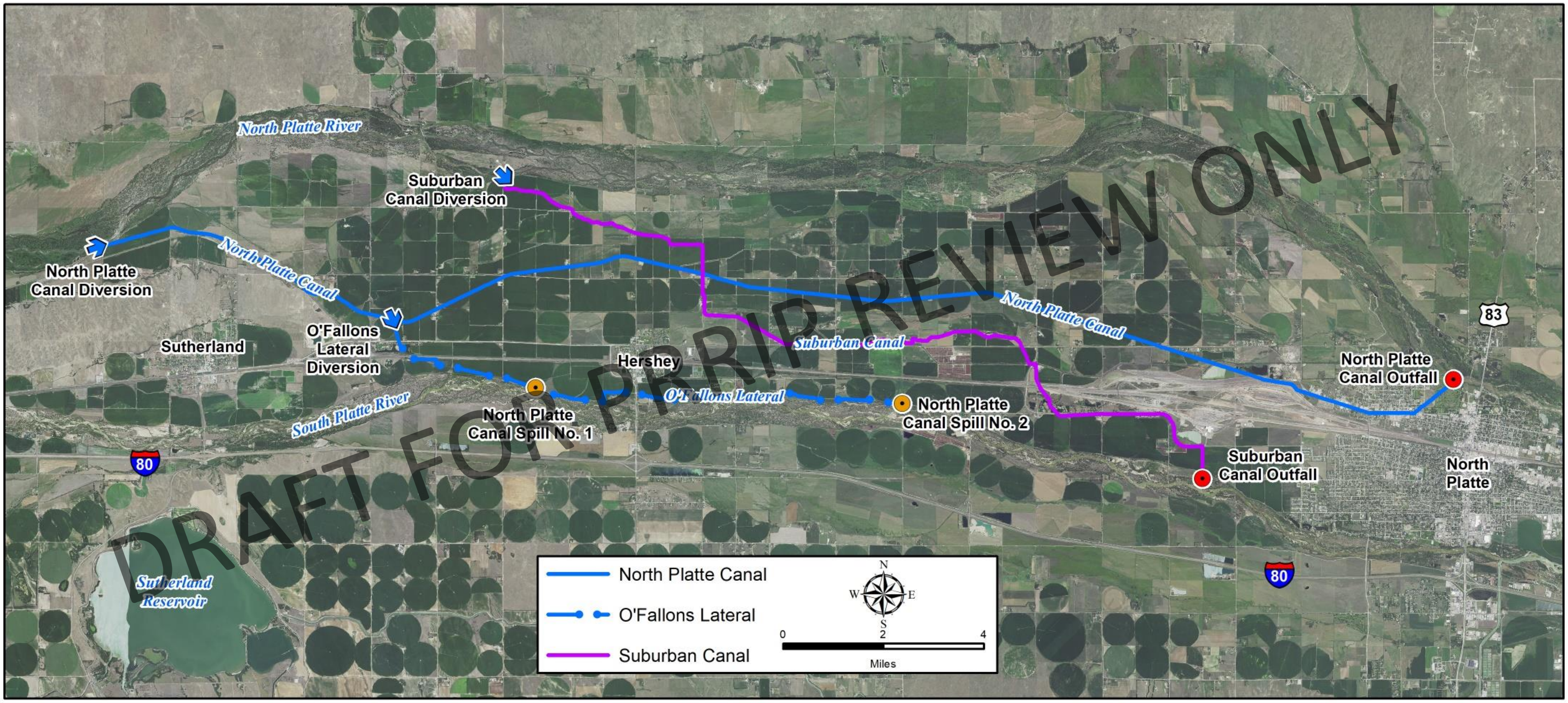

Figure 4. *Alignment and Spill Locations of the Suburban and North Platte Canals*

Table 3 Irrigated Acreage with and without Center Pivots

	Suburban Canal	North Platte Canal
Total Irrigated Acres	4,463 ac	14,105 ac
Irrigated Acres without Pivot Systems	2,353 ac (53%)	5,754 (41%)
Irrigated Acres w/ Pivot Systems	2,110 ac (47%)	8,351 (59%)
Irrigated Acres w/ Pivot Systems not using Groundwater Well	976 ac	726 ac

GIS Data Source: [SurfaceWaterRightsBoundaries40AcresExternal DNR | SurfaceWaterRightsBoundaries40AcresExternal DNR | NebraskaMAP]

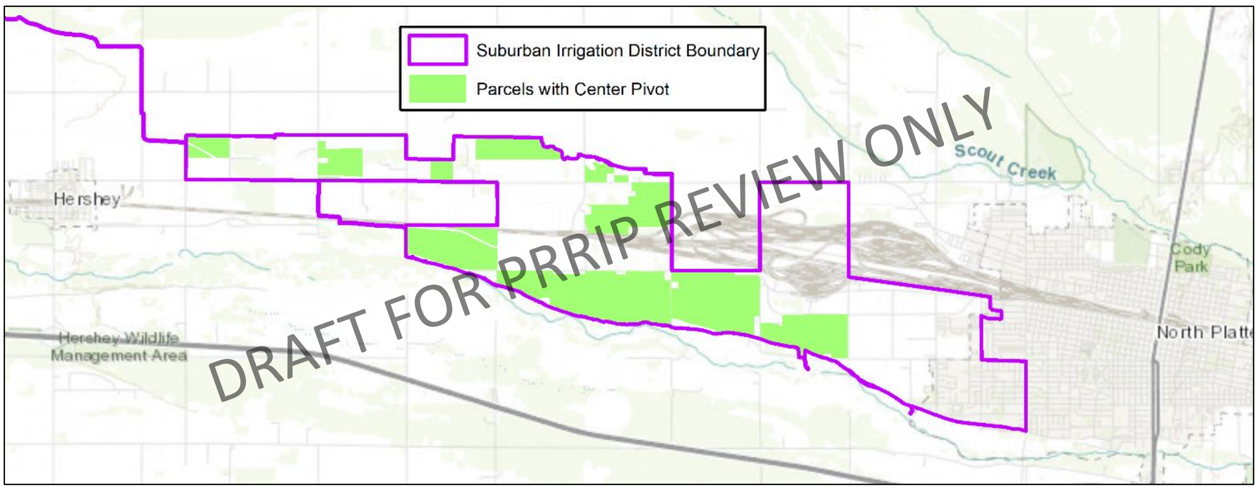

Figure 5. *Map of Suburban Canal Parcels with Center Pivots*

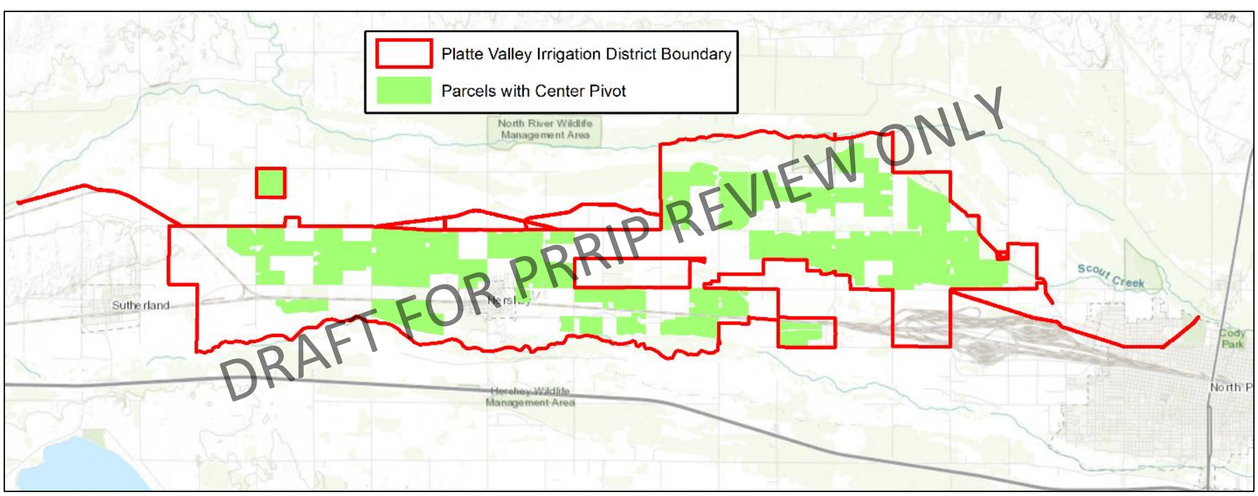

Figure 6. *Map of North Platte Canal Parcels with Center Pivots*

The average cost of a new quarter section center pivot (irrigating about 130 acres of a 160 acre parcel), set up in a field with a concrete pad, is about $90,000. The cost of the pump, well, pipeline, controls and power is estimated at $80,000 per well. The estimated costs to convert surface water users to groundwater for each irrigation district is shown in Table 4. Note that there is some uncertainty in the estimates of acres presented in Table 4 that could be refined with additional investigation.

__Table 4__ Estimated Cost to Convert Surface Water Users to Groundwater

	Acres	# of Irrigated Parcels to Convert [3]	Unit Cost	Cost	Total Cost
Suburban Canal					
Conversion of Surface Irrigation to Pivot/Groundwater Well	2,353	15	$170,000 [1,2]	$2,550,000	
Conversion of Surface Irrigation w Existing Pivot to Groundwater Well	976	6	$80,000 [2]	$480,000	
Total Cost for Conversion					$3,030,000
North Platte Canal					
Conversion of Surface Irrigation to Pivot/Groundwater Well	5,754	36	$170,000 [1,2]	$6,120,000	
Conversion of Surface Irrigation w Existing Pivot to Groundwater Well	726	5	$80,000 [2]	$400,000	
Total Cost for Conversion					$6,520,000

[1] Assumes $90,000 for installation of new center pivot with concrete pad.
[2] Assumes $80,000 for new installation, high capacity, agricultural well. 100 to 300 feet deep, pump included. Approx 6 gpm per acre capacity, ¼ mile center pivot. New electrical supply, overhead, 1,250 feet. Permitting included.
[3] Assumes 160 acre parcels.

The Suburban Canal has the least amount of acreage for conversion, but a smaller capacity for flow and longer travel length when compared with the North Platte Canal. Improvements to the North Platte Canal system would be required to make use of potential capacity. Both canals would require long-term O&M.

Summary: Purchase of Existing Irrigation Infrastructure for Bypass

Suburban Irrigation District and Platte Valley Irrigation District identified as preliminary candidates for evaluation of concept.

Suburban Irrigation District/Suburban Canal

Potential Canal Capacity: 170 cfs

Flow Capacity at Confluence vs Flow Target (3,000 cfs): 1,870 cfs (62%)
Percent Increase to Flow Target: +6% (from 56% - 62%)
Est Cost for Purchase of Infrastructure: TBD
Est Cost to Convert Surface Water Irrigators to Groundwater: $3.0 M
Long Tern O&M Costs: TBD
Permitting: Groundwater Well Permits

Platte Valley Irrigation District/North Platte Canal

Potential Canal Capacity: 360 cfs

Flow Capacity at Confluence vs Flow Target (3,000 cfs): 2,060 cfs (69%)
Percent Increase to Flow Target: +13% (from 56% - 69%)
Est Cost for Purchase of Infrastructure: TBD
Est Cost to Convert Surface Water Irrigators to Groundwater: $6.5 M
Est Capital Cost for Canal Improvements: $1-2 M
Long Tern O&M Costs: TBD
Permitting: Groundwater Well Permits, UPRR Permit

5. Construction of Bypass Canal

Concept: Construct a bypass canal dedicated to routing EA flows around the Chokepoint. The canal would divert flow from the North Platte to the South Platte, bypassing the Chokepoint.

The bypass canal concept and cost developed in 2016 was reviewed and refined. The 2016 concept included construction of a bypass canal aligned parallel to a portion of the North Platte Canal. The bypass canal was sized to convey a maximum flow of 1,500 cfs which requires a bottom width of 60 feet at a slope of 0.0005 ft/ft and total depth of 6 feet, see Figure 7. The 2016 alignment was refined at its downstream end to avoid crossing the railroad tracks twice. Figure 9 shows the refined alignment, location of major crossings that would need to be constructed, and parcel boundaries. There are a total of 23 parcels that intersect the bypass canal alignment. Figure 8 illustrates a typical plan view and cross section associated with the roadway and railroad crossings. Costs were re-evaluated and brought up to date, as shown in Table 5. The estimated capital cost for a 1,500 cfs bypass canal is $13.6 million, with a large portion of that cost related to road, railroad and siphon crossings. Long-term O&M costs are not included.

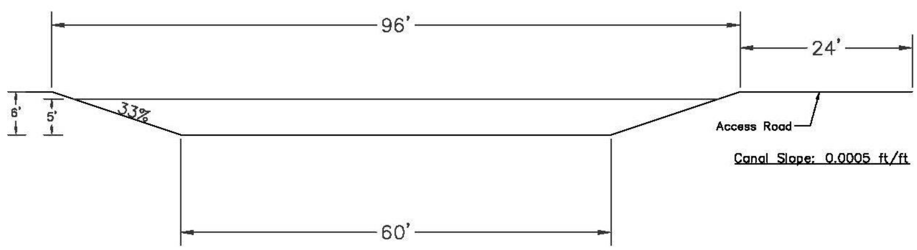

Figure 7. *Bypass Canal Section – 1,500 cfs Capacity*

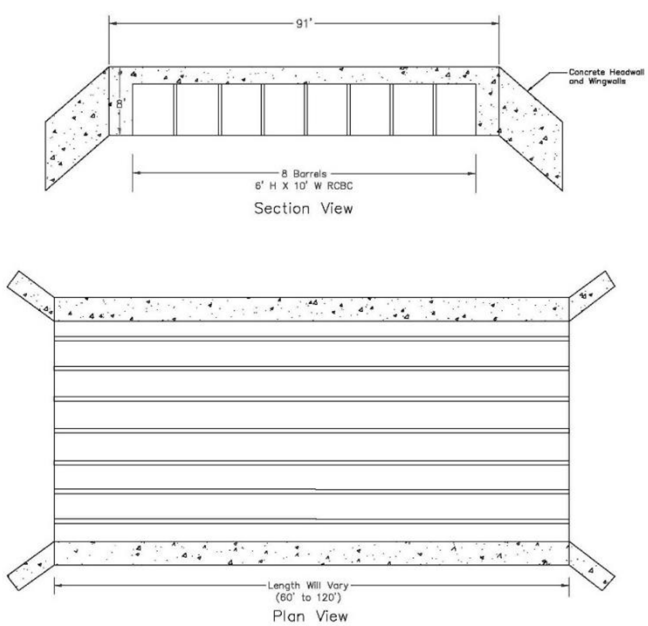

Figure 8. *Typical Canal Road Crossing Structure – 1,500 cfs Canal*

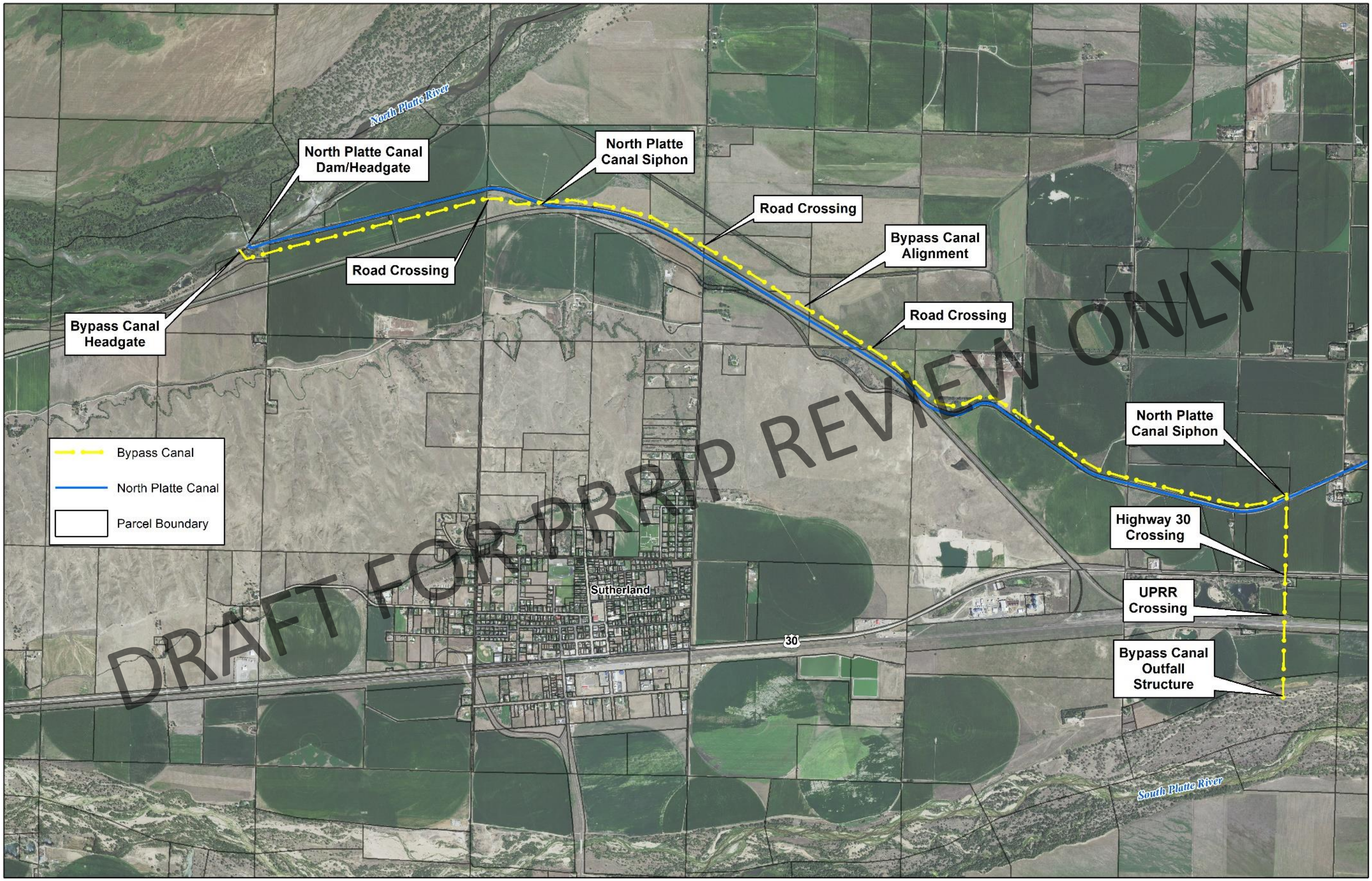

Figure 9. *Alignment of Bypass Canal and Location of Crossings*

Table 5. *1,500 cfs Bypass Canal Cost Estimate*

Item Number	Description	Unit	Estimated Quantity	Unit Cost ($)	Item Cost ($)
1	Diversion Headgate Structure (see Note 1)	LS	1	$1,400,000	$1,400,000
2	Excavation (see Note 2)	CY	573,800	$4.00	$2,295,200
3	Road Crossing #1 (see Note 3)	LS	1	$600,000	$600,000
4	Road Crossing #2 (see Note 4)	LS	1	$983,000	$983,000
5	Road Crossing #3 (see Note 5)	LS	1	$983,000	$983,000
6	Road Crossing #4 (see Note 6)	LS	1	$600,000	$600,000
7	PVID Siphon Crossing #1 (see Note 7)	LS	1	$207,000	$207,000
8	PVID Siphon Crossing #2 (see Note 8)	LS	1	$177,000	$177,000
9	Highway 30 Crossing (see Note 9)	LS	1	$983,000	$983,000
10	UPRR Crossing #1 (see Note 10)	LS	1	$1,600,000	$1,600,000
11	Diversion Outfall Structure	LS	1	$350,000	$350,000
	Land Acquisition				
12	Irrigation (sprinkler)	AC	16	$9,000	$144,000
13	Irrigation (flood)	AC	22	$6,000	$132,000
14	Dry land	AC	34	$2,000	$68,000
	Subtotal				$10,522,200
15	Mobilization/Demobilization	LS	1		$526,110
	Cost of Project Components				$11,048,310
	Engineering Costs	LS	1		$550,000
	Subtotal				$11,598,310
	Contingency (15%)	LS	1		$1,739,747
	Total Project Construction Costs				$13,338,057
	Permitting-Section 404/401 Certification/UPRR (See Note 11)	LS	1	$300,000.00	$300,000
	Easements/Management Agreements	LS	1	$0.00	$0
	TOTAL PROJECT COSTS				**$13,638,057**

Note 1 8-6'Hx8'W gates, concrete headwall, wingwalls, apron
Note 2 Canal, 60' BW/96'TW, 6' high, 3:1 SS
Note 3 50 ft xsing, 400 ft of 6'Hx10W RCBC, Headwall/wingwalls
Note 4 90 ft xsing, 720 ft of 6'Hx10W RCBC, Headwall/wingwalls
Note 5 90 ft xsing, 720 ft of 6'Hx10W RCBC, Headwall/wingwalls
Note 6 50 ft xsing, 400 ft of 6'Hx10W RCBC, Headwall/wingwalls
Note 7 120 ft xsing, 6'Hx10"W RCBC, concrete inlet/outlet
Note 8 100 ft xsing, 6'Hx10"W RCBC, concrete inlet/outlet
Note 9 90 ft xsing, 720 ft of 6'Hx10W RCBC, Headwall/wingwalls
Note 10 150 ft xsing, 1,200 ft of 6'Hx10W RCBC, Headwall/wingwalls
Note 11 Assumes Nationwide Permit, UPRR permit, and 401 permit

A smaller bypass canal with a maximum capacity of 500 cfs was also evaluated to provide a less expensive alternative. The canal cross section for a 500 cfs canal requires a 13-foot bottom width at a channel slope of 0.0005 ft/ft and total depth of 6 feet, see Figure 10. The typical road crossing structures would be reduced in size (see Figure 11). The estimated capital cost for a 500 cfs bypass canal is $7.4 million, as shown in Table 6. Long-term O&M costs were not estimated but would be similar to what would be required for a larger canal.

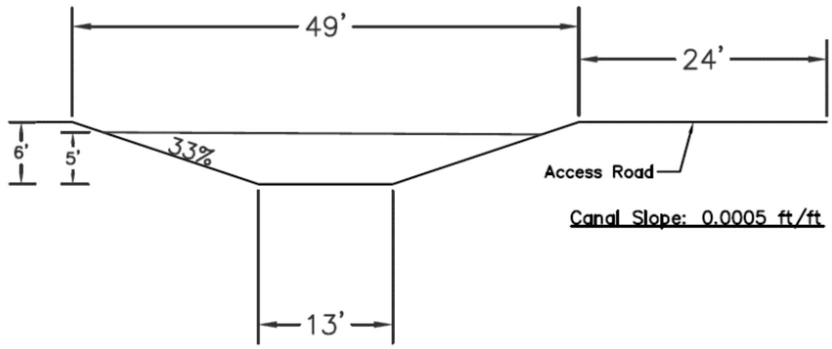

Figure 10. *Bypass Canal Cross Section – 500 cfs Capacity*

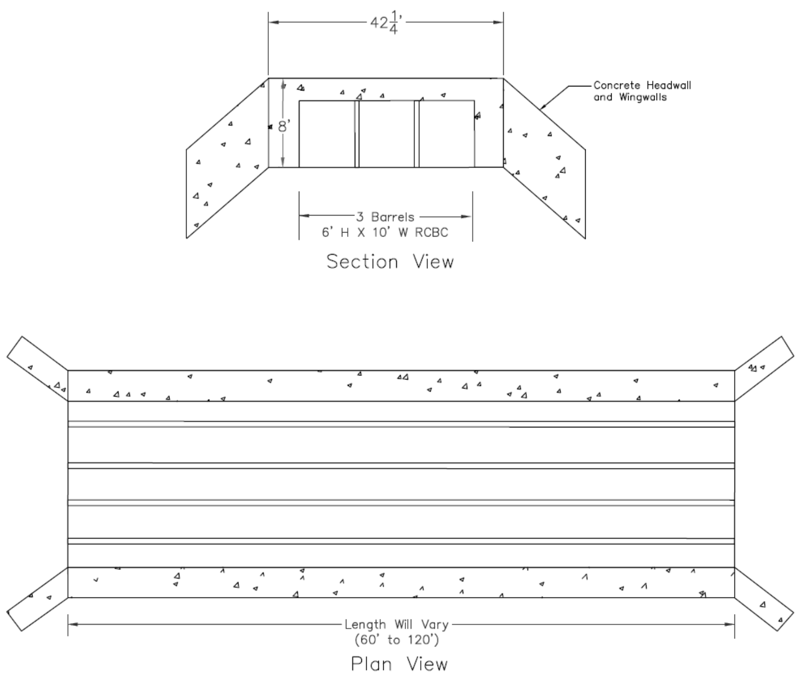

Figure 11. *Typical Canal Road Crossing Structure – 500 cfs Canal*

Table 6. *500 cfs Bypass Canal Cost Estimate*

Item Number	Description	Unit	Estimated Quantity	Unit Cost ($)	Item Cost ($)
1	Diversion Headgate Structure (see Note 1)	LS	1	$520,000	$520,000
2	Excavation (see Note 2)	CY	228,100	$5.00	$1,140,500
3	Road Crossing #1 (see Note 3)	LS	1	$249,000	$249,000
4	Road Crossing #2 (see Note 4)	LS	1	$393,000	$393,000
5	Road Crossing #3 (see Note 5)	LS	1	$393,000	$393,000
6	Road Crossing #4 (see Note 6)	LS	1	$249,000	$249,000
7	PVID Siphon Crossing #1 (see Note 7)	LS	1	$249,000	$249,000
8	PVID Siphon Crossing #2 (see Note 8)	LS	1	$219,000	$219,000
9	Highway 30 Crossing (see Note 9)	LS	1	$393,000	$393,000
10	UPRR Crossing #1 (see Note 10)	LS	1	$609,000	$609,000
11	Diversion Outfall Structure	LS	1	$350,000	$350,000
	Land Acquisition				
12	Irrigation (sprinkler)	AC	16	$9,000	$144,000
13	Irrigation (flood)	AC	22	$6,000	$132,000
14	Dry land	AC	34	$2,000	$68,000
	Subtotal				$5,108,500
7	Mobilization/Demobilization	LS	1		$510,850
	Cost of Project Components				$5,619,350
	Engineering Costs	LS	1		$560,000
	Subtotal				$6,179,350
	Contingency (15%)	LS	1		$926,903
	Total Project Construction Costs				$7,106,253
	Permitting-Section 404/401 Certification/UPRR (See Note 11)	LS	1	$300,000.00	$300,000
	Easements/Management Agreements	LS	1	$0.00	$0
	TOTAL PROJECT COSTS				**$7,406,253**

Note 1 3-6'Hx8'W gates, concrete headwall, wingwalls, apron
Note 2 Canal, 13' BW/49'TW, 6' high, 3:1 SS
Note 3 50 ft xsing, 150 ft of 6'Hx10W RCBC, Headwall/wingwalls
Note 4 90 ft xsing, 270 ft of 6'Hx10W RCBC, Headwall/wingwalls
Note 5 90 ft xsing, 270 ft of 6'Hx10W RCBC, Headwall/wingwalls
Note 6 50 ft xsing, 150 ft of 6'Hx10W RCBC, Headwall/wingwalls
Note 7 120 ft xsing, 6'Hx10"W RCBC, concrete inlet/outlet
Note 8 100 ft xsing, 6'Hx10"W RCBC, concrete inlet/outlet
Note 9 90 ft xsing, 270 ft of 6'Hx10W RCBC, Headwall/wingwalls
Note 10 150 ft xsing, 450 ft of 6'Hx10W RCBC, Headwall/wingwalls
Note 11 Assumes Nationwide Permit, UPRR permit, and 401 permit

Summary: Bypass Canal Alternatives

<u>1,500 cfs Capacity Bypass Canal</u>
Canal Capacity: 1,500 cfs

Flow Capacity at Confluence vs Flow Target (3,000 cfs): 3,000 cfs (100%)
Percent Increase to Flow Target: +44% (from 56% - 100%)
Est Capitol Cost: $13.6 M
Long Tern O&M Costs: TBD
Permitting: Nationwide 404, UPRR Permit, 401 Permit
Number of Private Parcels Impacted: 23

<u>500 cfs Capacity Bypass Canal</u>
Canal Capacity: 500 cfs

Flow Capacity at Confluence vs Flow Target (3,000 cfs): 2,200 cfs (73%)
Percent Increase to Flow Target: +17% (from 56% - 73%)
Est Capitol Cost: $7.4 M
Long Tern O&M Costs: TBD
Permitting: Nationwide 404, UPRR Permit, 401 Permit
Number of Private Parcels Impacted: 23

6. Channel Modification/Sediment Removal

Concept: Construct channel modifications and remove sediment along the North Platte River through the Chokepoint to increase and maintain hydraulic capacity at HWY 83.

Channel modification and sediment removal concepts to increase hydraulic capacity through the North Platte and previously developed by ACE in 2016 and the VESPR Report (River Design Group) in 2023 were reviewed. Both concepts meet or exceed the hydraulic capacity target at HWY 83 through different methods. A brief description of each concept and corresponding capital cost estimate is provided below. Additional discussion regarding development of a combined/refined alternative is also included.

Channel Modification (ACE 2016 Construction Alternative)

An overview of the channel modification ('Construction Alternative') developed in 2016 is shown in Figure 12. This alternative includes construction both upstream and downstream of Highway 83The construction upstream of Highway 83 is intended to achieve a braided channel condition to promote deposition of sediment within the limits of construction to promote sediment continuity. The details associated with the construction upstream of Highway 83 include the following:

- The limits of the channel construction encompass length and width of approximately 16,200 feet and 350 feet, respectively resulting in an area of approximately 130 acres.
- Treatment for vegetation removal of approximately 31 acres (reflects the area of the mid-channel bar)
- Channel widening, material movement and slope grading (130 acres).

Downstream of Highway 83, construction of the improvements is intended to: (a) create a wider channel to promote additional transport during the high flow events, and (b) integrate a constricted low-flow channel that increases the sediment transport during relatively low flows. The specific details of the proposed improvements are listed below:

- Limits of the channel improvements encompass a length of approximately 6,000 feet.
- Creation of a compound channel through channel widening/dredging and placement of jetties/bendway weirs.
- Channel widening to increase the average channel width from 270 feet to a minimum of 300 feet; channel dredging to lower the channel thalweg 1.25 feet to 3 feet.
- Placement of 19 jetties/bendway weirs to constrict the dredged channel to a width of 150 feet. Maximum height of the jetties/bendway weirs not to exceed 2 feet above the channel thalweg. Length varies from 50 feet to 215 feet.

An updated cost estimate is provided in Table 7. This alternative would require work on private land, most likely an individual 404 permit, and floodplain permitting through City of North Platte, Lincoln County and FEMA. The footprint of the project intersects an estimated 62 parcels with 50 individual landowners. It should be noted that no costs have been assumed for access easements or management agreements.

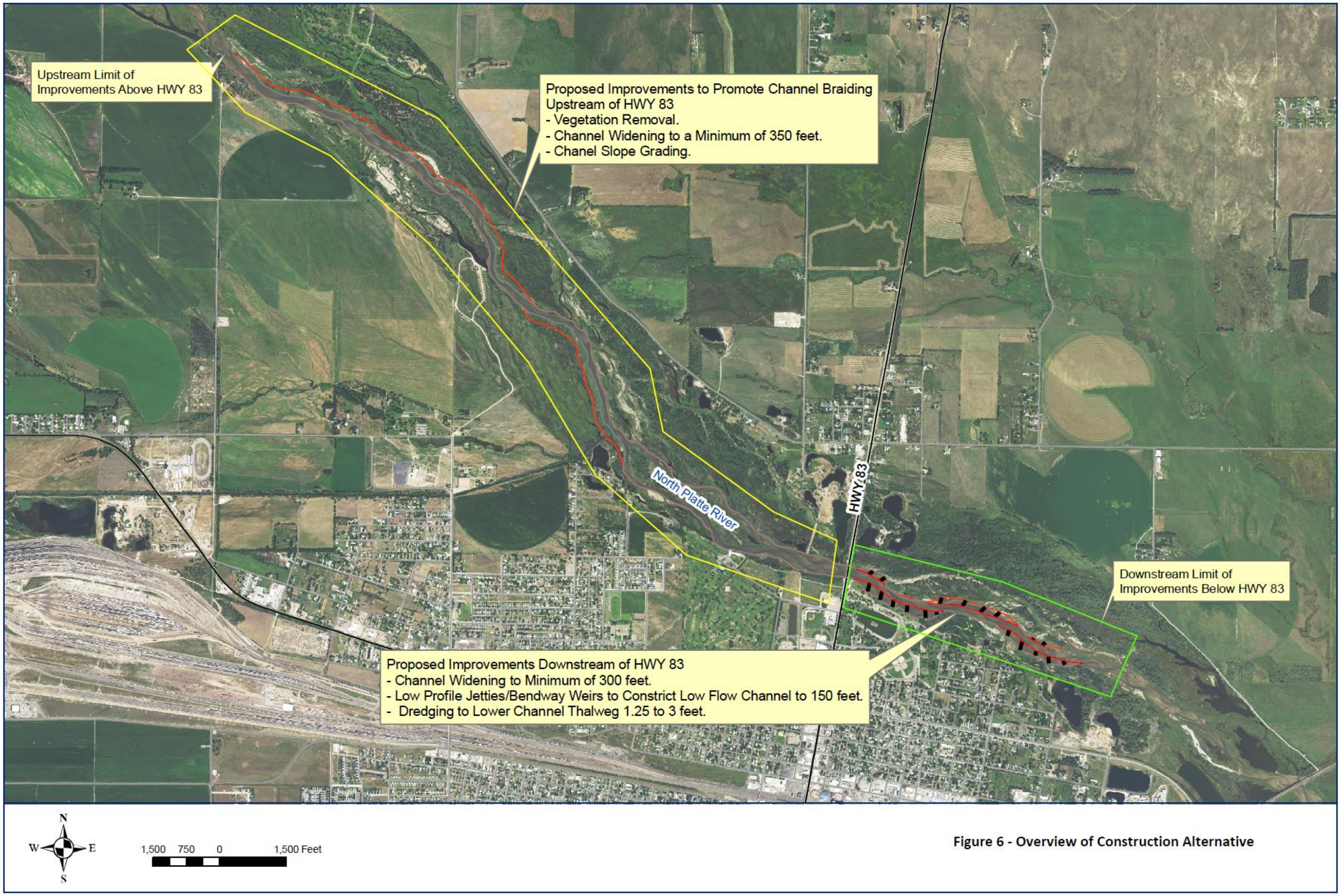

Figure 12. *2016 Construction Alternative (ACE 2016)*

Table 7. *Updated Construction Alternative Cost Estimate*

Item Number	Description	Unit	Estimated Quantity	Unit Cost ($)	Item Cost ($)
Upstream of HWY 83					
1	Vegetation Treatment (see Note 1)	AC	31	$5,500	$170,500
2	Channel Widening (see Note 2)	CY	315,000	$2.00	$630,000
	Subtotal				$800,500
Downstream of HWY 83					
4	Channel Widening/Dredging (See Note 3)	CY	134,000	$8.10	$1,085,400
5	Rock Riprap for 19 jetties/bendway weirs, haul and placement (See Note	CY	8,000	$210	$1,680,000
6	Excavation for Rock Riprap (See Note 5)	CY	11,500	$8.90	$102,350
	Subtotal				$2,867,750
7	Mobilization/Demobilization	LS	1		$366,825
	Cost of Project Components				$4,035,075
	Engineering Costs	LS	1		$200,000
	Subtotal				$4,235,075
	Contingency (15%)	LS	1		$635,261
	Total Project Construction Costs				$4,870,336
	Permitting-Section 404/401 Certification/Floodplain (See Note 6)	LS	1	$300,000	$300,000
	Easements/Management Agreements (See Note 7)	LS	1	$0.00	$0
	TOTAL PROJECT COSTS				**$5,170,336**
Note 1	Removal of vegetation/trees from mid-channel bar (unit cost reflects removal of large trees)				
Note 2	1.5 ft of depth, 130 acres, 350 ft wide; no haul off site required				
Note 3	Average depth of 2 ft, 300 ft wide; $5.10/CY for haul included				
Note 4	Rock quantities include jetty/dike, tie-back into bank, and toe; 2-ft height, 3-ft burial depth				
Note 5	Includes excavation for tie-back, jetty/dike section, toe protection; $5.10/CY for haul included				
Note 6	Assumes Individual Permit/EA, CLOMR/LOMR floodplain permits, and 401 permit				
Note 7	No costs assumed based on previous projects involving "No harm, channel improvements".				

One-dimensional hydraulic and sediment transport modeling of this alternative was conducted by ACE in 2016. Results estimated that hydraulic capacity could be maintained for 3-5 years, but that periodic sediment removal would likely be needed to maintain capacity. As with all sediment transport models there is a level of uncertainty associated with interpretation of results. More current morphodynamic modeling could be conducted to further assess sustainability.

The previous study conducted by ACE in 2016 estimated long term O&M costs of approximately $30,500/year, which assumed vegetation treatment of the large island upstream of HWY 83 every 3 years and removal of approximately 10,000 cy of sediment downstream of HWY 83 every 5 years. Current estimates under the same assumptions put long term O&M estimates at $35,000/year.

Sediment Removal Concept (VESPR 2023)

The 2023 VESPR study provided conceptual level recommendations, one of which included a sediment removal concept (RDG 2023). The concept included excavation of a 200 ft wide channel from upstream of HWY 83 downstream to the Tri-County Canal Diversion (TCCD) to promote an equilibrium slope, see Figure 13. This would increase estimated capacity at HWY 83 to more than 4,600 cfs, exceeding the PRRIP flow target by more than 50%. RDG (2023) estimated that dredging of this magnitude would produce about 1.5 million cubic yards (CY) of sediment requiring disposal, which ACE has refined to about 700,000 CY, see Table 8. Means and locations for disposal of this much sediment have not yet been identified but will be explored in the final phase of this study.

The concept as proposed in the VESPR study also includes modification of the TCCD structure for passage of sediment, which is discussed in the following section. A cost estimate for sediment removal was developed and is provided in Figure 13. The estimated cost for sediment removal without modification to the TCCD is roughly $7 million, see Table 8. This alternative would require work on private land (roughly 65 private land parcels and 44 individual landowners), most likely an individual 404 permit, and floodplain permitting through City of North Platte, Lincoln County and FEMA.

As noted in the VESPR report, hydraulic and sediment transport modeling of this concept would be needed to determine how sediment removal would impact channel erosion, private properties, sustainability, etc. Additional analyses will be conducted in the next phase of the study to determine what level of sediment removal is optimal.

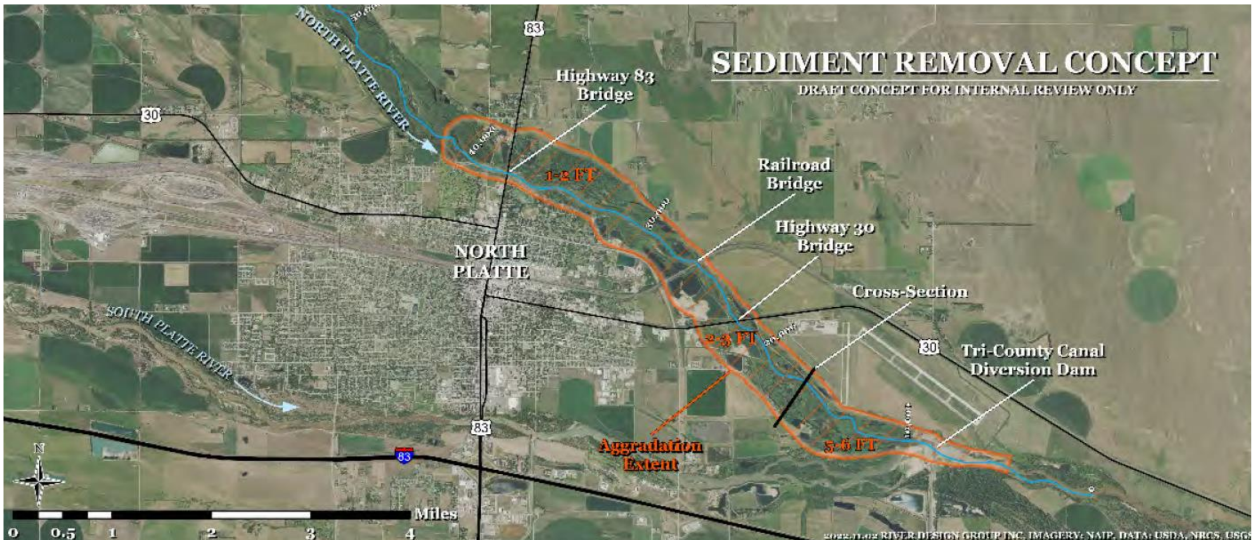

Figure 13. *Sediment Removal Concept – VESPR Report (RDG 2023)*

Table 8. *Sediment Removal Concept Cost Estimate*

Item Number	*Description*	*Unit*	*Estimated Quantity*	*Unit Cost ($)*	*Item Cost ($)*
1	Channel Excavation (Note 1)	CY	700,000	$8.10	$5,670,000
	Subtotal				$5,670,000
2	Mobilization/Demobilization	LS	1		$567,000
	Cost of Project Components				$6,237,000
	Engineering Costs	LS	1		$200,000
	Subtotal				$6,437,000
	Contingency (15%)	LS	1		$965,550
	Total Project Construction Costs				$7,402,550
	Permitting-Section 404/401 Certification/Floodplain (See Note 6)	LS	1	$300,000	$300,000
	Easements/Management Agreements (See Note 7)	LS	1	$0.00	$0
	TOTAL PROJECT COSTS				**$7,702,550**
Note 1	200' Wide Channel, 6' x 1.25 miles + 3' x 2.05 miles + 1.5' x 2.9 miles; $5.10/CY for haul included				
Note 2	Assumes Individual Permit/EA, CLOMR/LOMR floodplain permits, and 401 permit				
Note 3	No costs assumed based on previous projects involving "No harm, channel improvements".				

Channel Modification/Sediment Removal Refinement

Both the channel modification and sediment removal concepts discussed above pose a few key questions including:

- How long can increased hydraulic capacity be sustained?
- Would there be costs associated with long-term O&M?
- How can an alternative be developed to work with the river?
- Are there impacts to wetlands (positive or negative) associated with lowering the channel and water table or increasing channel width? Does this pose permitting issues?
- What are options for sediment disposal?
- What are the impacts to private properties?
- Are there other local enhancement opportunities or benefits (flood reduction, habitat, recreation, etc.)?

A refined alternative that would combine elements of both the channel modification and sediment removal concepts above will be developed in the next phase of the study by utilizing results of the geomorphic assessment and updated morphodynamic model (SRH-2D Sediment Modeling). A refined channel alternative can be formulated with the objective of meeting the target hydraulic capacity of 3,000 cfs while minimizing channel work/ sediment removal, maximizing sustainability, and minimizing long term O&M costs. This will require hydraulic and sediment transport/morphodynamic modeling of proposed conditions to inform development of an alternative. Additionally, more detailed information related to permitting requirements and implementation timelines will also be developed.

Summary: Channel Modification/Sediment Removal
Flow Capacity at Confluence vs Flow Target (3,000 cfs): 3,000 cfs (100%)
Percent Increase to Flow Target: +44% (from 56% - 100%)

ACE Channel Modification Concept
Est Capitol Cost: $5.2 M
Long Tern O&M Costs: $35,000/year
Permitting: Individual 404 Permit, FEMA CLOMR/LOMR, 401 Permit
Number of Private Property Parcels Impacted: ~62

VESPR Sediment Removal Concept
Est Capitol Cost: $7.7 M
(Est Capitol Cost w/ Modification to TCCD: $29 M)
Long Tern O&M Costs: TBD
Permitting: Individual 404 Permit, FEMA CLOMR/LOMR, 401 Permit
Number of Private Property Parcels Impacted: ~65

Refined Channel/Sediment Removal Alternative
Est Capitol Cost: TBD
Long Tern O&M Costs: TBD
Permitting: Individual 404 Permit, FEMA CLOMR/LOMR, 401 Permit
Number of Private Property Parcels Impacted: TBD

7. Modification of Tri-County Canal Diversion

Concept: Modify the Tri-County Canal Diversion to allow for sediment passage which has potential to enhance performance and sustainability of the channel modification and sediment removal alternative by promoting sediment continuity.

Modification of the Tri-County Canal Diversion (TCCD) for sediment passage was considered as a potential enhancement that might promote long term sustainability to the channel modification/sediment removal alternative previously described. Several studies have suggested that hydraulic capacity at HWY 83 could be improved through promotion of sediment passage through the TCCD (Parsons 2003, HDR 2011, and RDG 2022). However, previous studies have also stated that there is likely to be limited benefit to hydraulic capacity at the HWY 83 bridge associated with modification to the TCCD alone given the 5.5 miles and 25 feet vertical separation between the structures. Benefits would only be realized if this concept was combined with sediment removal and channel modification in the reach upstream between HWY 83 and the TCCD. Modification to the TCCD to pass additional sediment downstream would be beneficial to CNPPID operations, overall sediment continuity, and downstream river condition. However, it is currently unclear how much added benefit modification of the TCCD would provide to upstream channel improvements.

During a site visit in October of 2023 project staff met with CNPPID to tour the facility and discuss operations, permitting and issues associated with dredging. Under the original FERC license and USACE permitting CNPPID was authorized to dredge and has been doing so since 1965. Permitting also allowed for return of sediment back to the river downstream of the diversion when a minimum flow passed the structure. While this practice did not likely restore full sediment continuity downstream it did provide some level of sediment passage downstream. For the past three years changes to permitting requirements do not allow for return of sediment back to the river, creating significant challenges for CNPPID related to sediment disposal. Challenges associated with sediment disposal expressed by CNPPID would also be an issue for a channel modification/sediment removal project.

The estimated cost to modify the TCCD structure to accommodate sediment passage is $21 million, see Table 9. It should also be noted that invasive aquatic species have been detected downstream of the TCCD, which currently acts as a barrier. Simultaneously passing sediment downstream and restraining fish from migrating upstream is a difficult problem. One possible solution is a BioAcoustic Fish Fence (BAFF) system that could be installed across the dam, but at a significant additional cost. The cost estimate provided for structure modification does not include the BAFF system.

Note that the cost to modify the TCDD is roughly 2 to 4 times the cost estimated for the channel modification/sediment removal alternative. Further investigation (i.e. modeling) would be required to determine what added benefit modification of the TCCD would provide.

Table 9. *Modification of Tri-County Canal Diversion for Sediment Passage Cost Estimate*

Item Number	Description	Unit	Estimated Quantity	Unit Cost ($)	Item Cost ($)
1	Demolition and Clearing (see Note 2)	LS	1	$446,000	$446,000
2	Earthwork (see Note 3)	LS	1	$1,935,000	$1,935,000
3	Overshot Gates (See Note 4)	LS	1	$4,895,000	$4,895,000
4	Concrete/Sheet Piling/Sturctures (See Note 5)	LS	1	$4,866,000	$4,866,000
5	Erosion and Channel Protection Measures (See Note 6)	LS	1	$4,757,000	$4,757,000
	Subtotal				$16,899,000
6	Mobilization/Demobilization	LS	1		$844,950
	Cost of Project Components				$17,743,950
	Engineering Costs	LS	1		$530,000
	Subtotal				$18,273,950
	Contingency (15%)	LS	1		$2,741,093
	Total Project Construction Costs				$21,015,043
	Permitting-Section 404/401 Certification/Floodplain (See Note 7)	LS	1	$300,000	$300,000
	TOTAL PROJECT COSTS				**$21,315,043**
Note 1	Line item costs adjusted for inflation (+24%), location (-9%) and quantity from similar project on South Platte River near Evans, CO. in 2017.				
Note 2	Complete removal of existing river dam,foundations and debris. Canal headgates remain.				
Note 3	Structure excavation, fill, hauling and dewatering.				
Note 4	Fully controllable crest using Obermeyer type overshot gates. 870 ft span.				
Note 5	Concrete cap and apron over sheet piling. 870 ft span.				
Note 6	Erosion and sediment control during construction and channel protection measures.				
Note 7	Assumes Individual Permit/EA, CLOMR/LOMR floodplain permits, and 401 permit				

Summary: Modification to Tri-County Canal Diversion

This concept would be an add on to a channel modification/sediment removal alternative.

Flow Capacity at Confluence vs Flow Target (3,000 cfs): 1,700 cfs (100%)

Percent Increase to Flow Target: 0%

Est Capitol Cost: $21.3 M

(Est Capitol Cost VESPR Sediment Removal + Modification to TCCD: $29M)

Long Term O&M Costs: TBD

Permitting: Nationwide 404 Permit, FEMA CLOMR/LOMR, 401 Permit

Comparison of Alternatives

At HWY 83 the existing conveyance capacity at minor flood stage is about 1,700 cfs, , which accounts for 56% of the Program's 3,000 cfs capacity target. The goal of the alternatives considered herein is to increase hydraulic capacity through the North Platte Chokepoint to 3,000 cfs or provide a means of flow bypass that in combination with existing North Platte Chokepoint capacity will result in 3,000 cfs at the confluence of the North Platte and South Platte rivers.

The percent of the 3,000 cfs target that can be achieved by each alternative along with the corresponding capital cost is compared visually in Figure 14. Table 10 provides a summary comparison of flow capacity, capital costs, long term O&M, permitting, and number of properties impacted. The South Platte storage, 1,500 cfs bypass canal, channel modification, and sediment removal alternatives meet or exceed the 3,000 cfs flow target. Purchase of irrigation infrastructure and the 500 cfs bypass canal only provide a 10 to 15% increase towards the target but still fall short by roughly 30%. Of the alternatives that can achieve target flows, the channel modification and sediment removal have the lowest capitol cost. Long-term O&M costs are not included in the comparison. A storage reservoir and bypass canal will have long-term maintenance costs. Long-term maintenance of a channel solution has less potential for long-term maintenance. Additional study is required to determine how sustainable a channel solution could be in the long term.

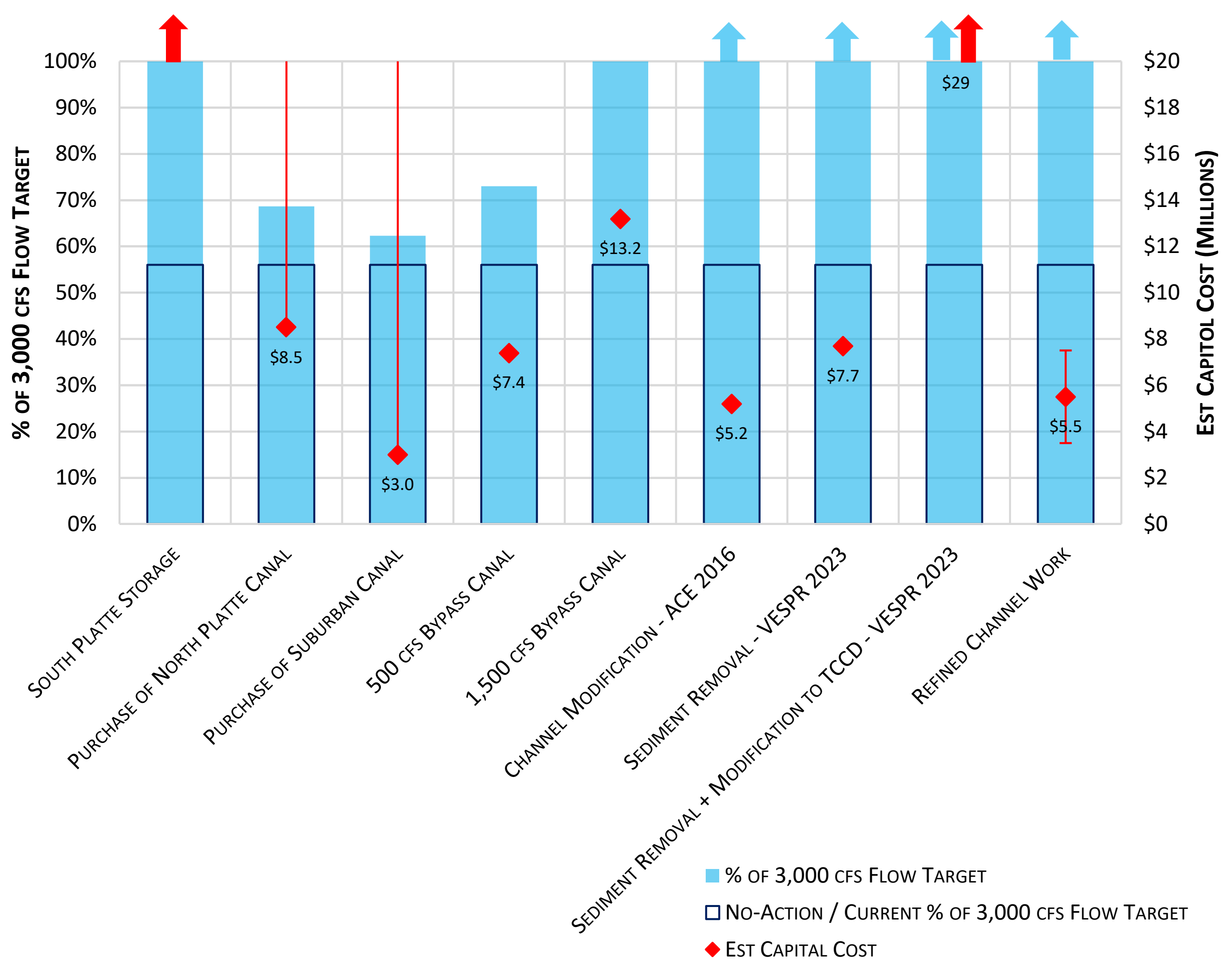

Figure 14. *Comparison of Alternative Benefit to Flow Target and Est Capital Cost*

Table 10. *Alternative Comparison*

Alternative	Flow Capacity at HWY 83 (cfs)	Bypass Flow (cfs)	Total Flow to Central Platte (cfs)	% of 3,000 cfs Flow Target	Estimated Capital Cost	Long Term O&M Required?	Long Term O&M Costs	Permitting	Number of Private Parcels Impacted
No-Action	1,700	--	1,700	56%	$0	No	none	none	n/a
South Platte Storage	1,700	1,500	3,200	100%	>> $20 M [2]	Yes	TBD		TBD
Purchase of Irrigation Infrastructure North Platte Canal	1,700	360 [1]	2,060	69%	Purchase: TBD [3] Conversion: $6.5M Improvements: $1-2M	Yes	TBD	Groundwater UPRR Permit	n/a
Purchase of Irrigation Infrastructure Suburban Canal	1,700	170	1,870	62%	Purchase: TBD [3] Conversion: $3.0 M	Yes	TBD	Groundwater	n/a
500 cfs Bypass Canal	1,700	500	2,200	73%	$7.4 M	Yes	TBD	Nationwide 404/401 UPRR Permit FEMA Floodplain	23
1,500 cfs Bypass Canal	1,700	1,500	3,200	100%	$13.2 M	Yes	TBD	Nationwide 404/401 UPRR Permit FEMA Floodplain	23
Channel Modification (ACE 2016)	3,000 +	--	3,000 +	100% +	$5.2 M	Yes	$35,000/yr	Individual 404/401 FEMA Floodplain	62
Sediment Removal (VESPR 2023)	3,000 +	--	3,000 +	100% +	$7.7 M	TBD	TBD	Individual 404/401 FEMA Floodplain	65
Sediment Removal (VESPR 2023) + Modification to TCCD	3,000 +	--	3,000 +	100% +	$29 M	TBD	TBD	Individual 404/401 FEMA Floodplain	65
Channel Mod/Sed Removal (TBD)	3,000 +	--	3,000 +	100% +	TBD	TBD	TBD	Individual 404/401 FEMA Floodplain	TBD

[1] 360 cfs is the best-case scenario using the North Platte River. Improvements to O'Fallons Lateral would be needed.
[2] Location, cost, and details of developing storage on the South Platte not included in evaluation.
[3] Details and costs related to purchase are difficult to estimate, currently not enough information to provide a full cost estimate.

References:

ACE (2023). Memorandum, North Platte Chokepoint Geomorphic Assessment (January 26).

ACE (2016). Memorandum, North Platte Chokepoint: Feasibility Assessment of Recommended Alternatives (September 2).

HDR and Tetra Tech (2011). Final Technical Memorandum, Evaluation of Alternatives for Improvements in Carrying Capacity of the North Platte River at North Platte.

PRRIP EDO (2014). Memorandum, Spring 2013 SDMF Release Hydrologic Summary.

River Design Group (2023). North Platte Chokepoint Investigation, Final Report (January).

APPENDIX C. SEDIMENT REMOVAL ALTERNATIVE A

APPENDIX C.1. SEDIMENT REMOVAL CONCEPTUAL DESIGN

NORTH PLATTE RIVER SEDIMENT REMOVAL ALTERNATIVE

CONCEPTUAL DESIGN

INDEX OF SHEETS		
SHEET NO.	INDEX NO.	DESCRIPTIONS
1	1	COVER SHEET
2	2	KEY MAP SITE LEGEND
3	C1	NORTH PLATTE CHANNEL PLAN & PROFILE (1 OF 16)
4	C2	NORTH PLATTE CHANNEL PLAN & PROFILE (2 OF 16)
5	C3	NORTH PLATTE CHANNEL PLAN & PROFILE (3 OF 16)
6	C4	NORTH PLATTE CHANNEL PLAN & PROFILE (4 OF 16)
7	C5	NORTH PLATTE CHANNEL PLAN & PROFILE (5 OF 16)
8	C6	NORTH PLATTE CHANNEL PLAN & PROFILE (6 OF 16)
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10	C8	NORTH PLATTE CHANNEL PLAN & PROFILE (8 OF 16)
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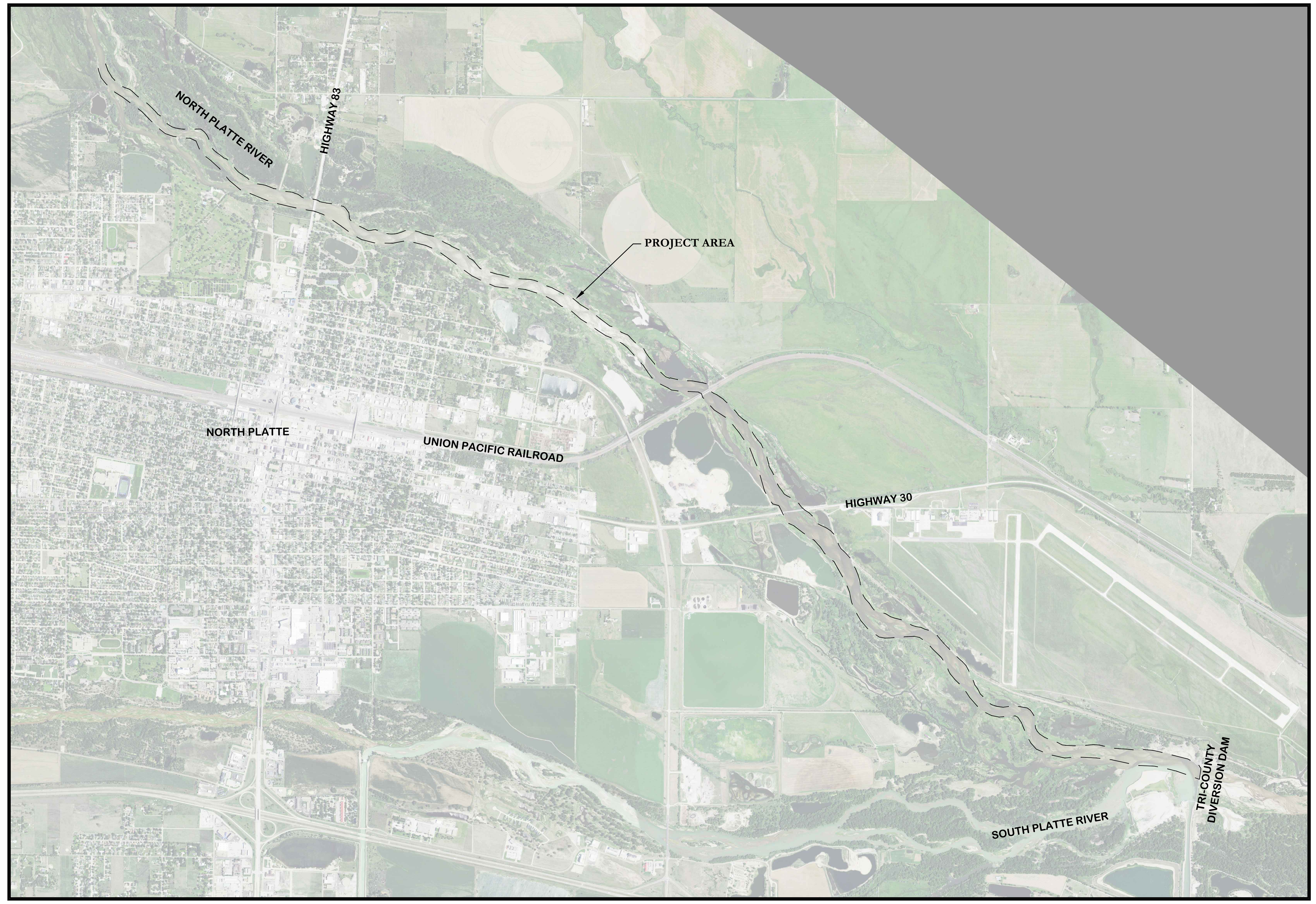
12	C10	NORTH PLATTE CHANNEL PLAN & PROFILE (10 OF 16)
13	C11	NORTH PLATTE CHANNEL PLAN & PROFILE (11 OF 16)
14	C12	NORTH PLATTE CHANNEL PLAN & PROFILE (12 OF 16)
15	C13	NORTH PLATTE CHANNEL PLAN & PROFILE (13 OF 16)
16	C14	NORTH PLATTE CHANNEL PLAN & PROFILE (14 OF 16)
17	C15	NORTH PLATTE CHANNEL PLAN & PROFILE (15 OF 16)
18	C16	NORTH PLATTE CHANNEL PLAN & PROFILE (16 OF 16)
19	C17	CHANNEL CROSS SECTIONS (1 OF 2)
20	C18	CHANNEL CROSS SECTIONS (2 OF 2)



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PROJECT DATUM: **NAVD88**

HORIZONTAL DATUM:

NORTH AMERICAN DATUM 1983 (NAD83)
NEBRASKA STATE PLANE

OWNER:

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM
4111 4TH AVE, SUITE 6
KEARNEY, NE 68845

GENERAL CIVIL ENGINEER:

ANDERSON CONSULTING ENGINEERS, INC.
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KEY MAP SITE LEGEND

NORTH PLATTE RIVER SEDIMENT REMOVAL ALTERNATIVE

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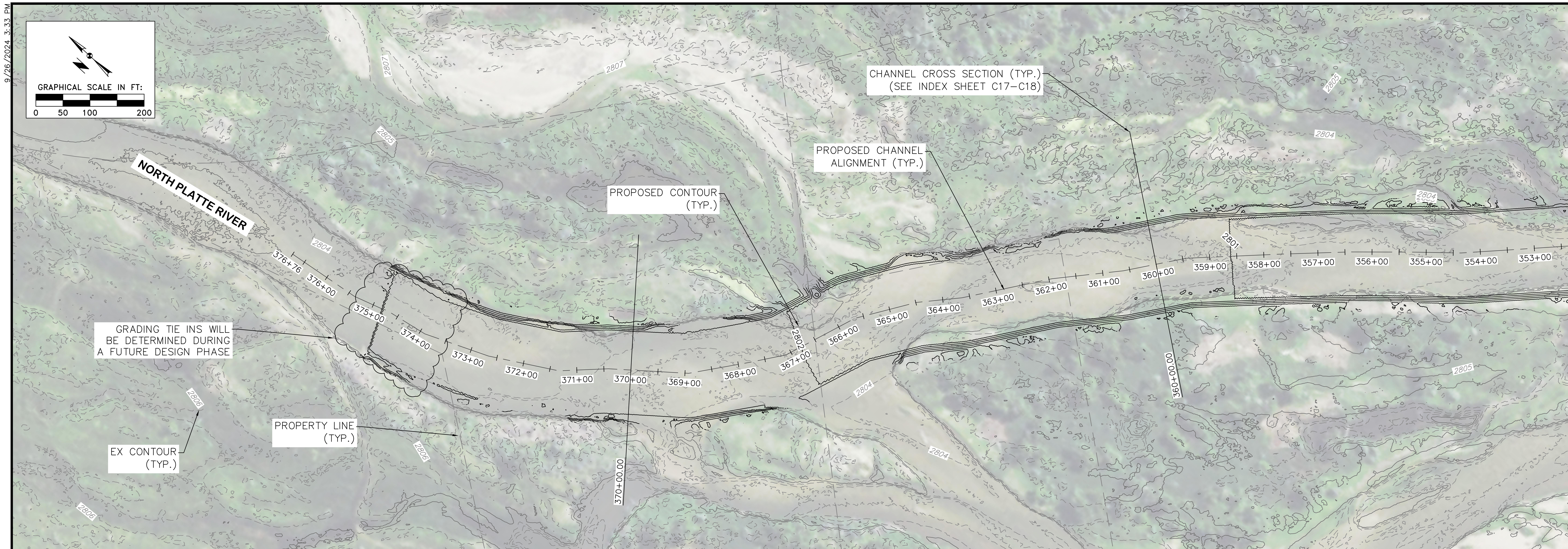

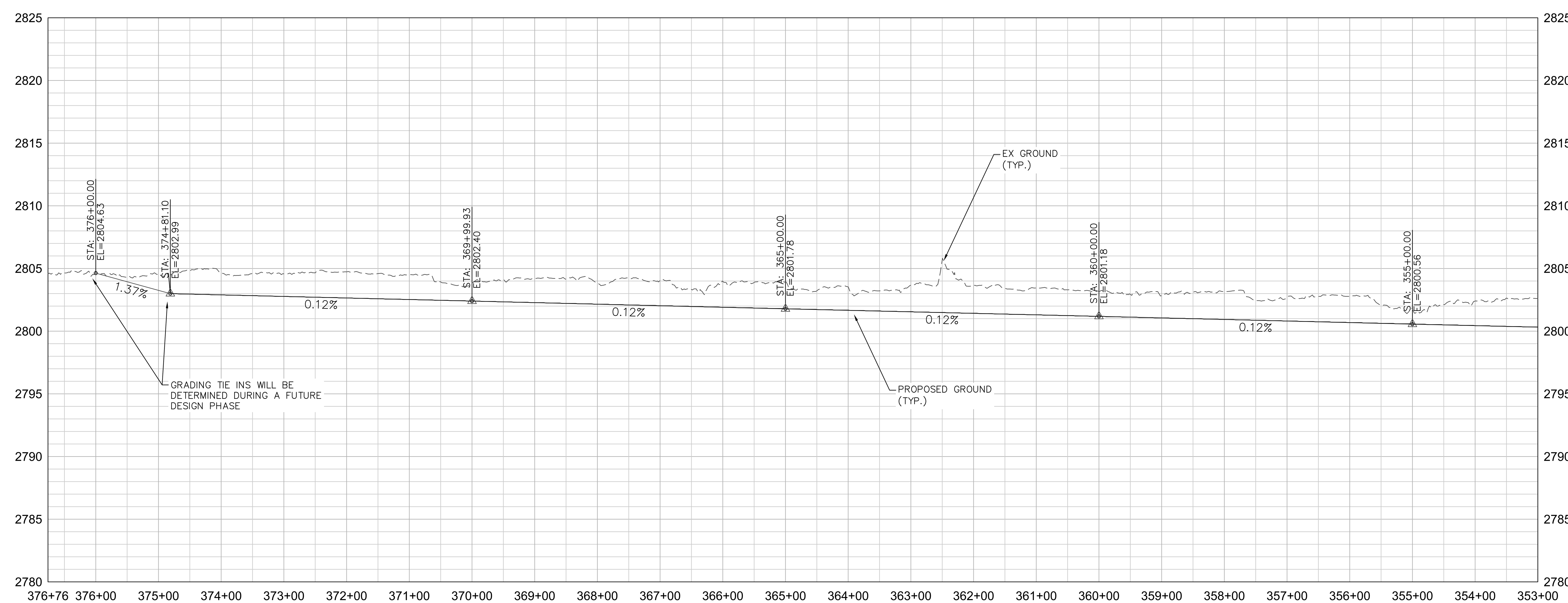

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NORTH PLATTE CHANNEL PLAN & PROFILE (1 OF 16)

NORTH PLATTE RIVER SEDIMENT REMOVAL ALTERNATIVE

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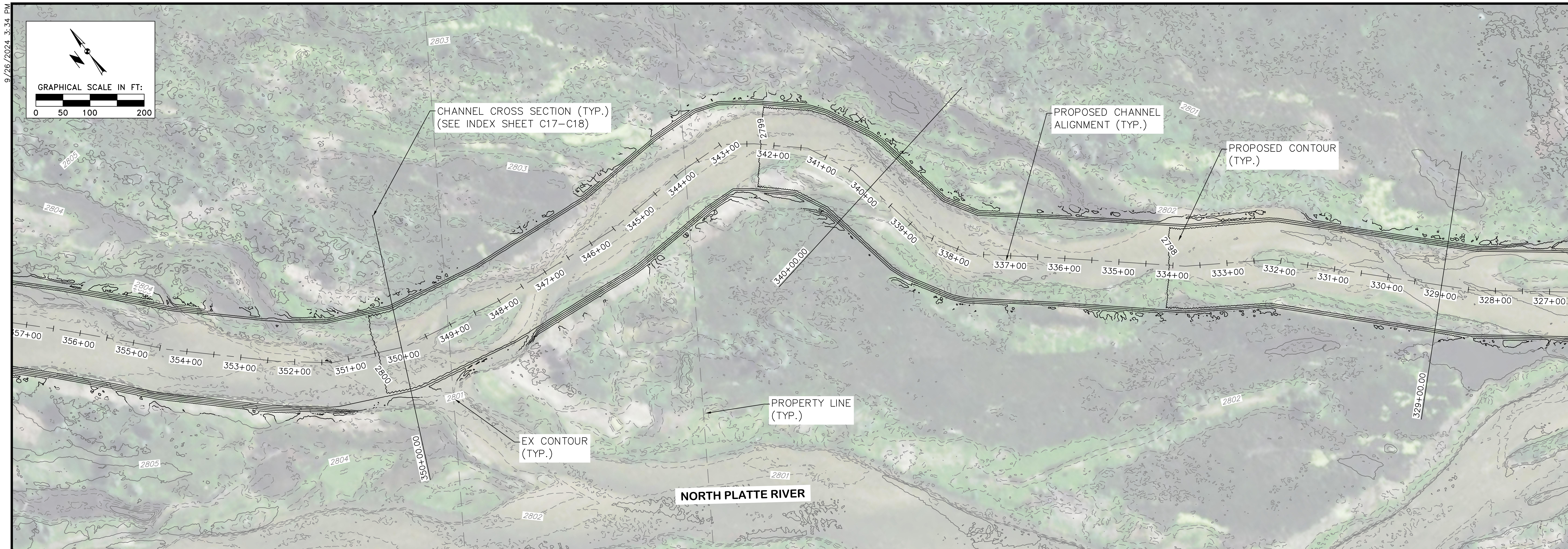

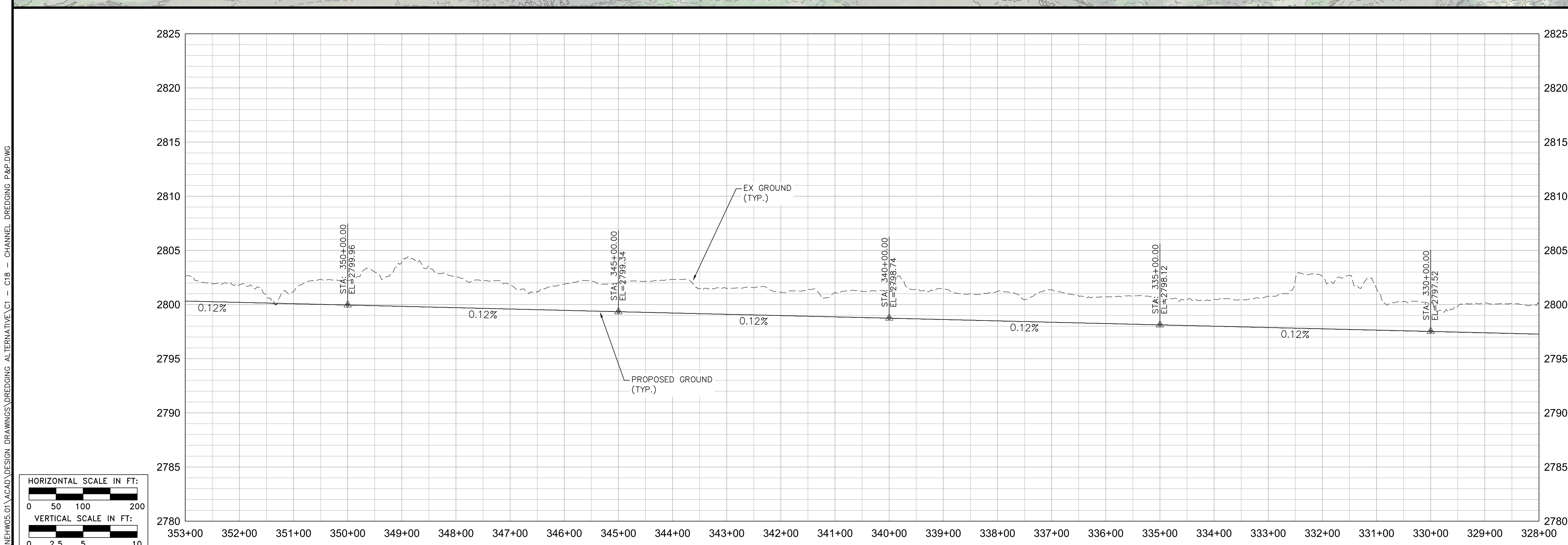

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NORTH PLATTE RIVER SEDIMENT REMOVAL ALTERNATIVE

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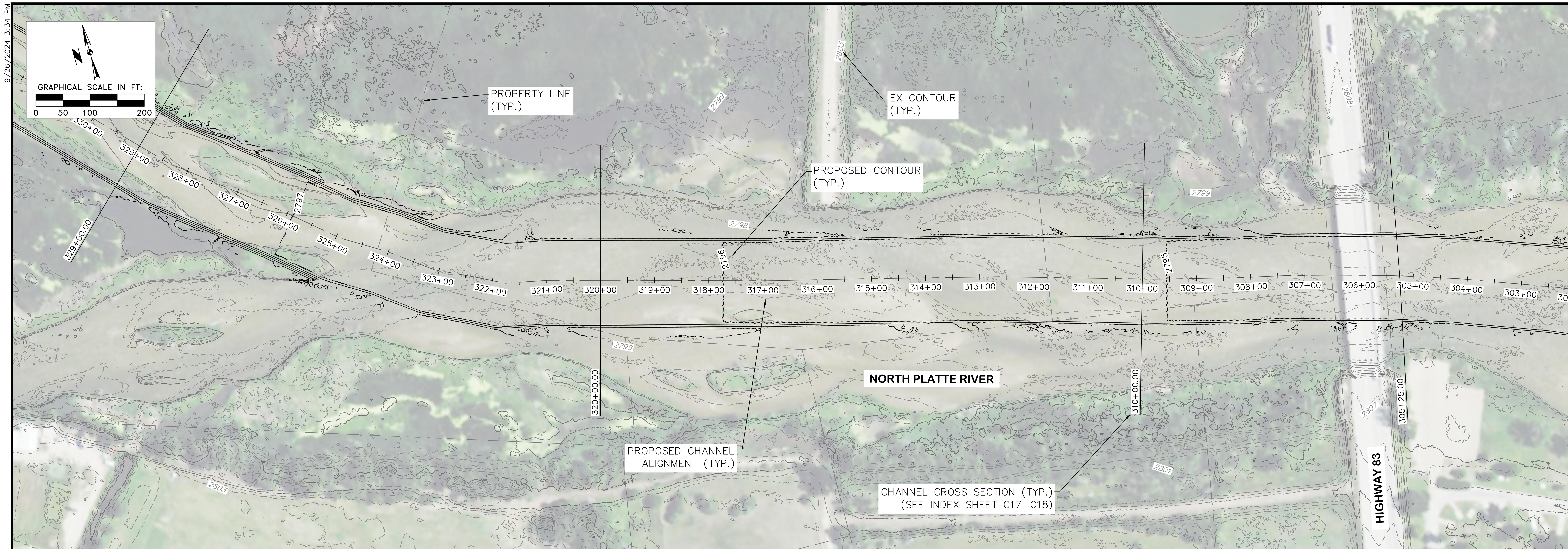

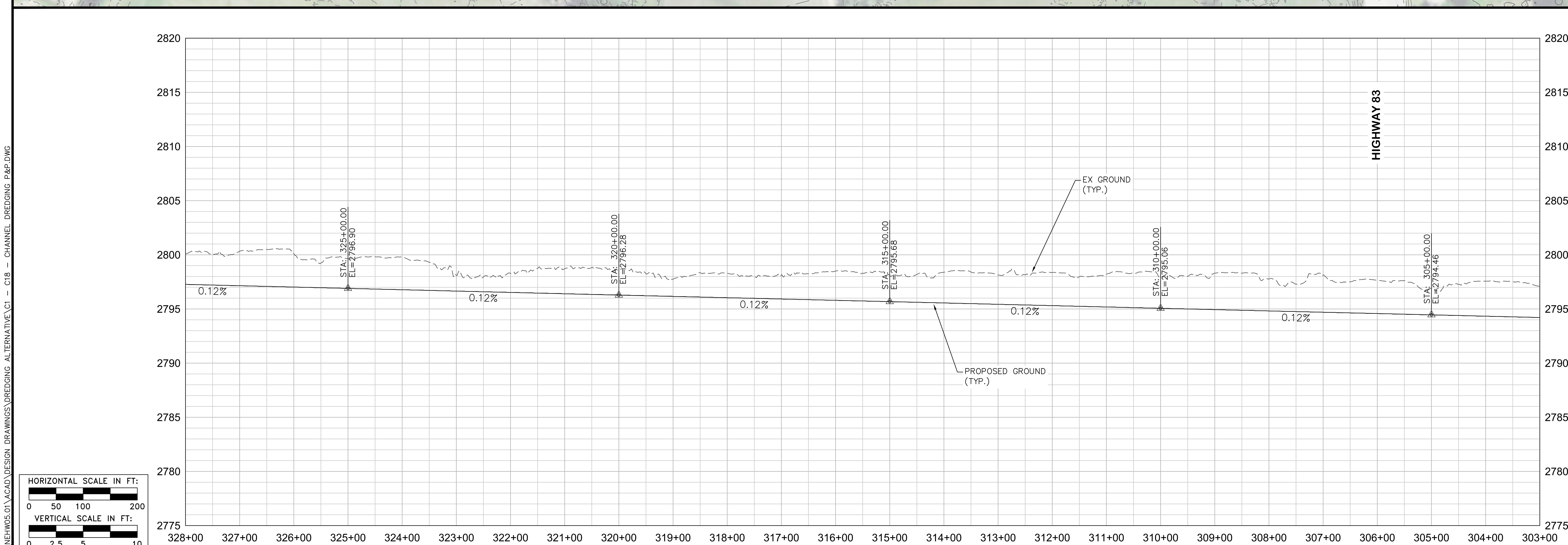

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NORTH PLATTE RIVER SEDIMENT REMOVAL ALTERNATIVE

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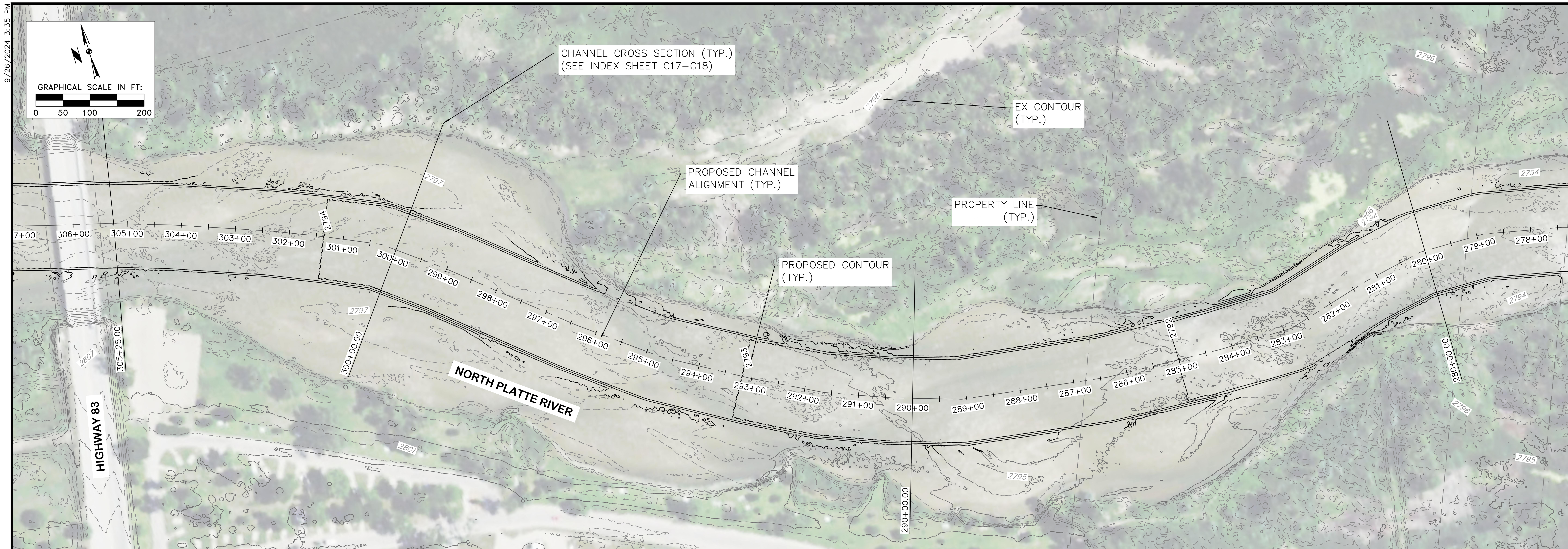

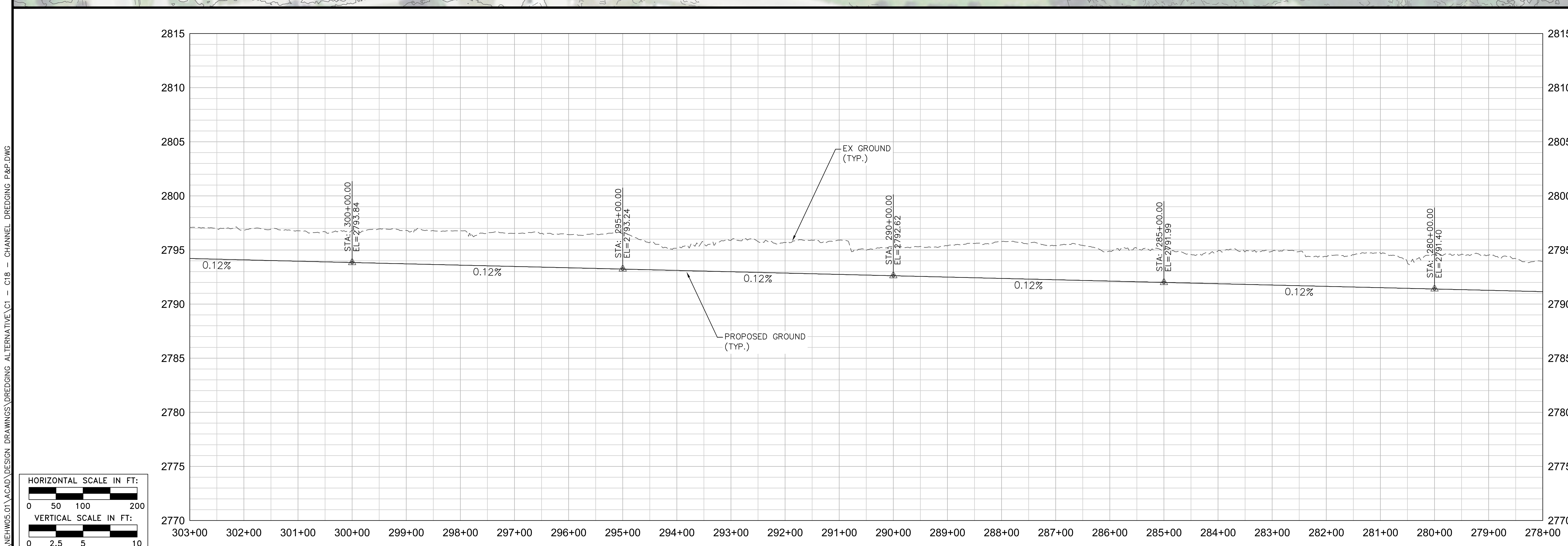

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NORTH PLATTE RIVER SEDIMENT REMOVAL ALTERNATIVE

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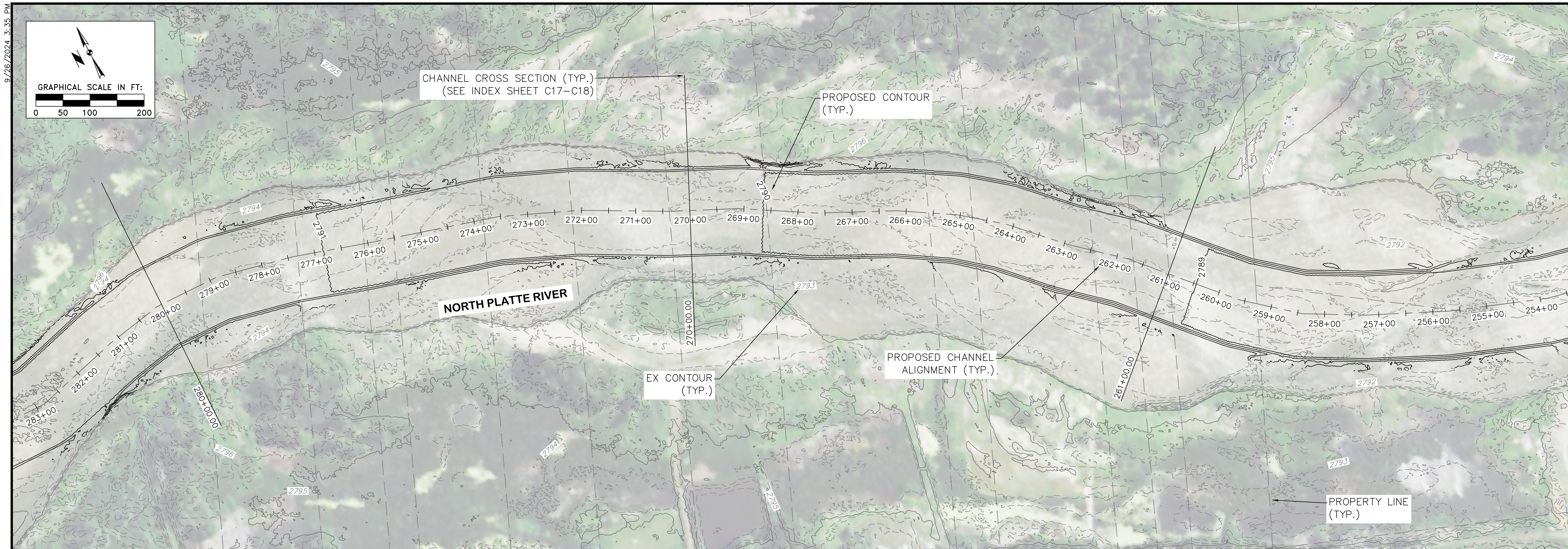

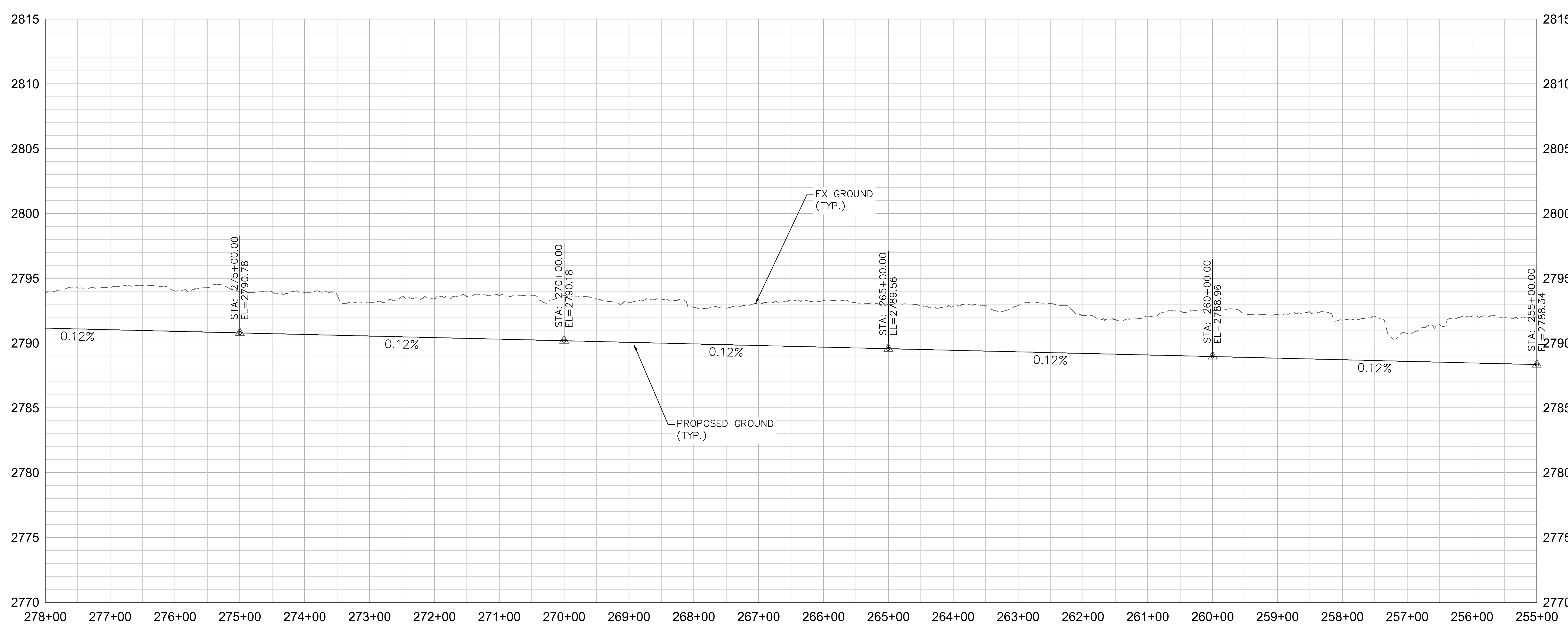

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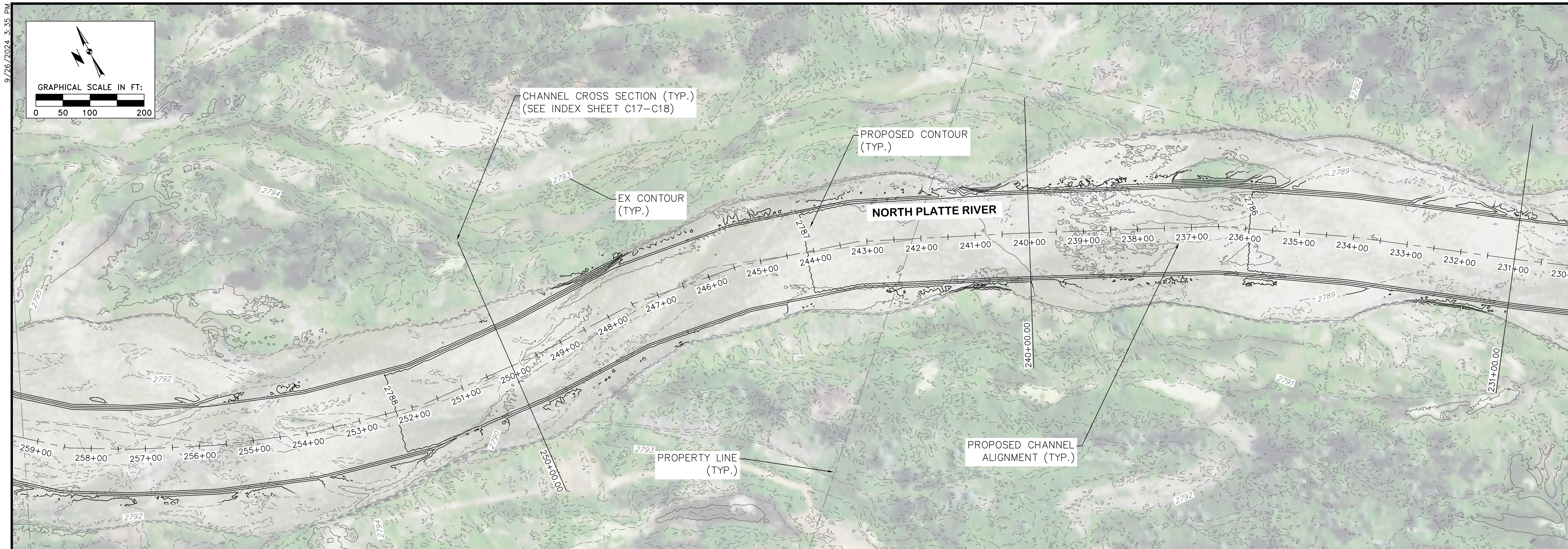

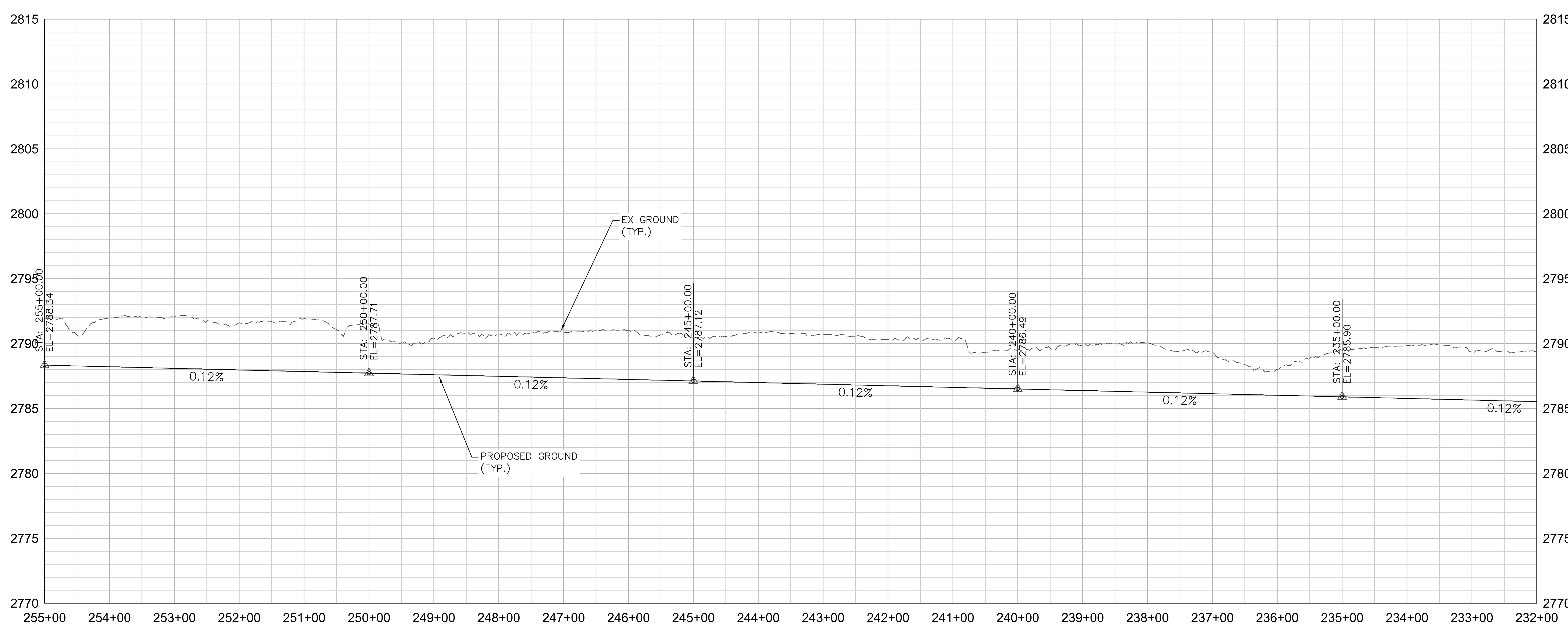

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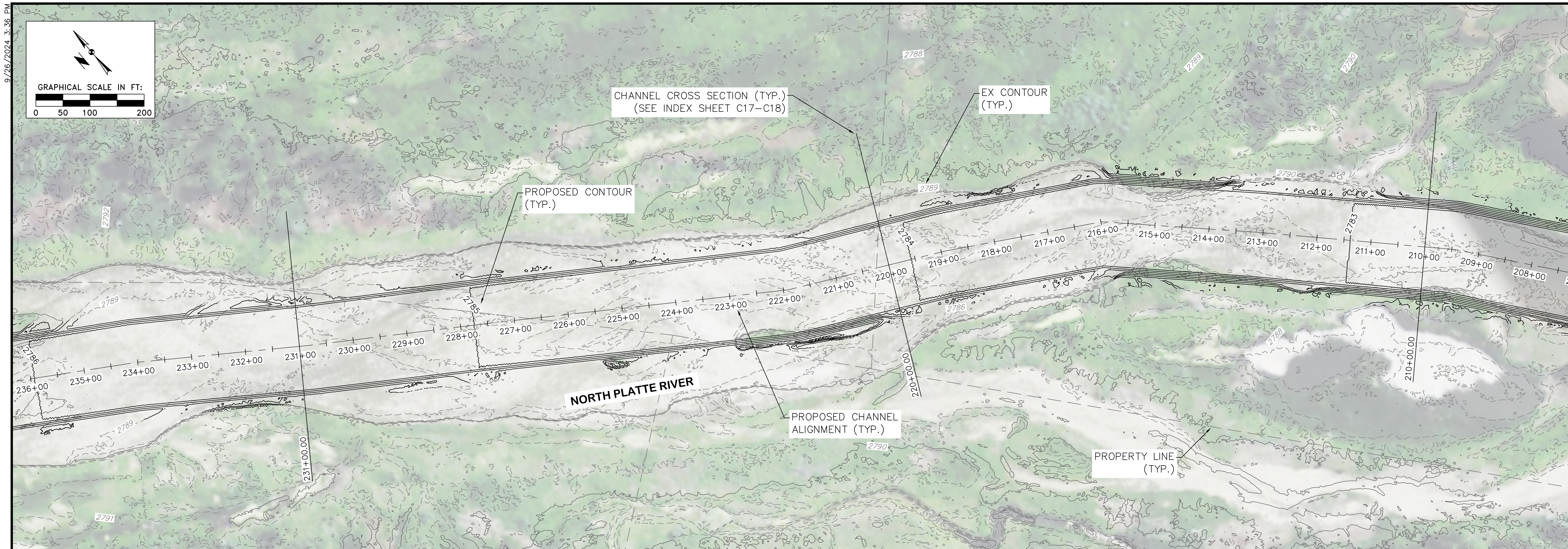

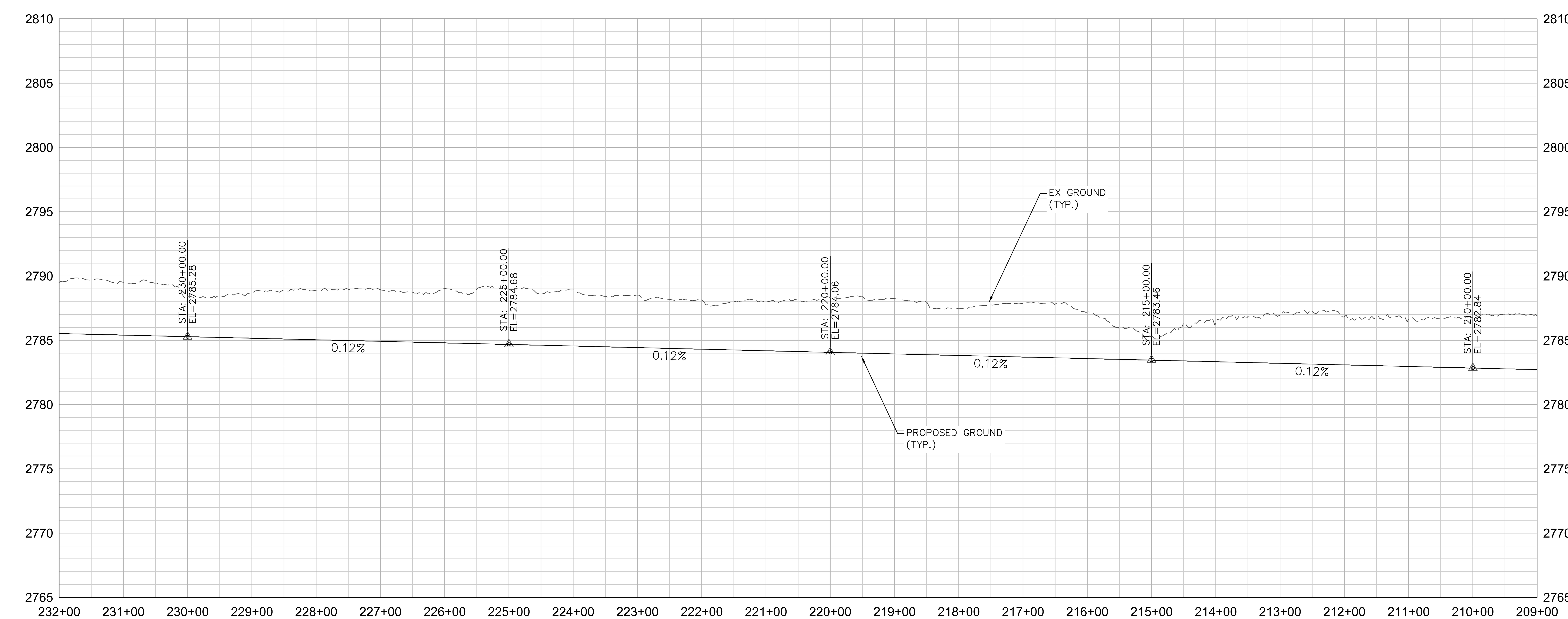

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NORTH PLATTE RIVER SEDIMENT REMOVAL ALTERNATIVE

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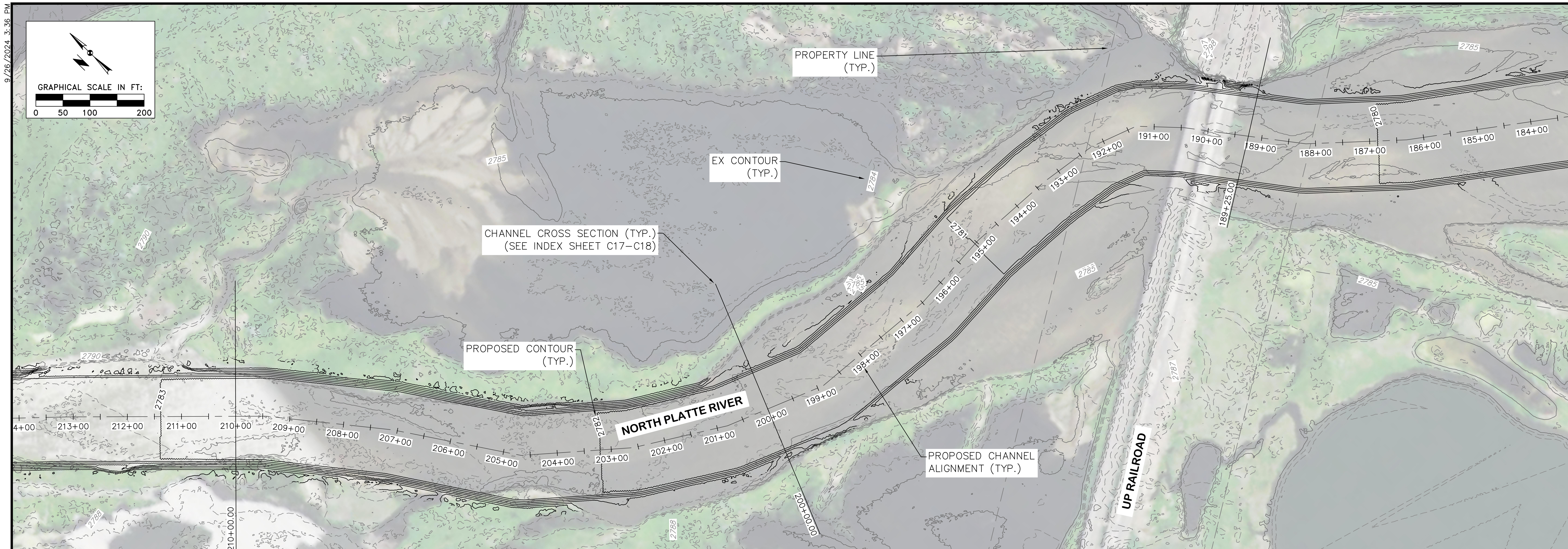

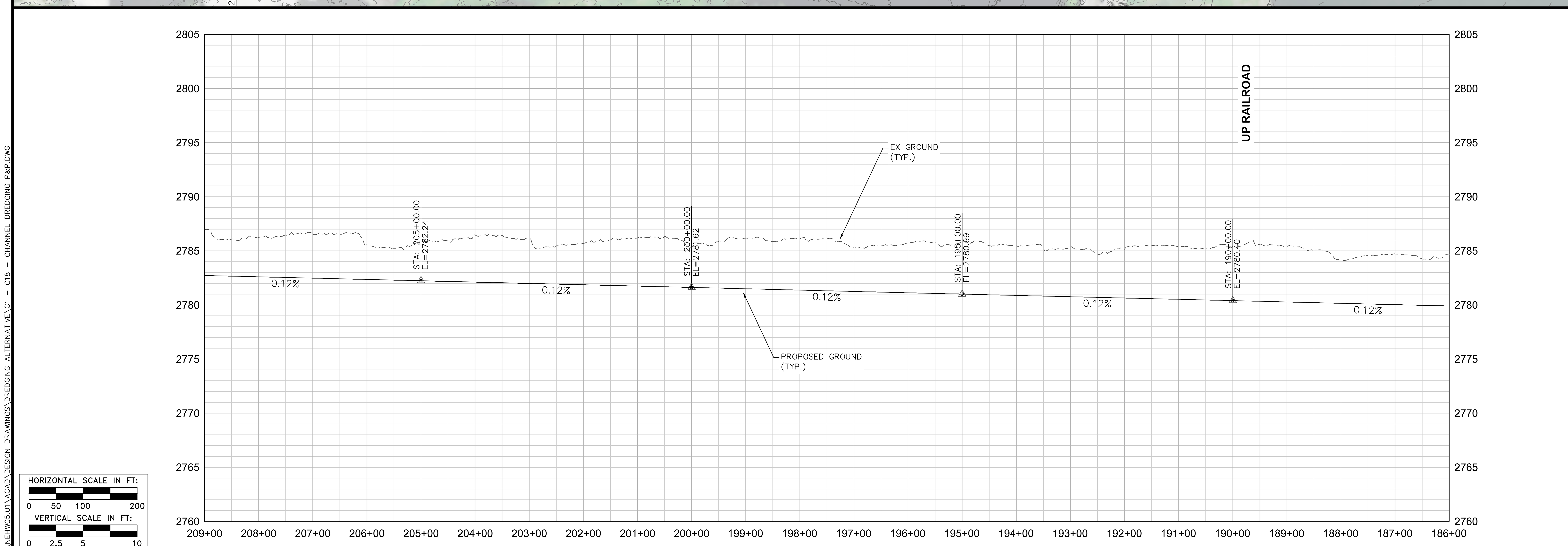

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NORTH PLATTE CHANNEL PLAN & PROFILE (8 OF 16)

NORTH PLATTE RIVER SEDIMENT REMOVAL ALTERNATIVE

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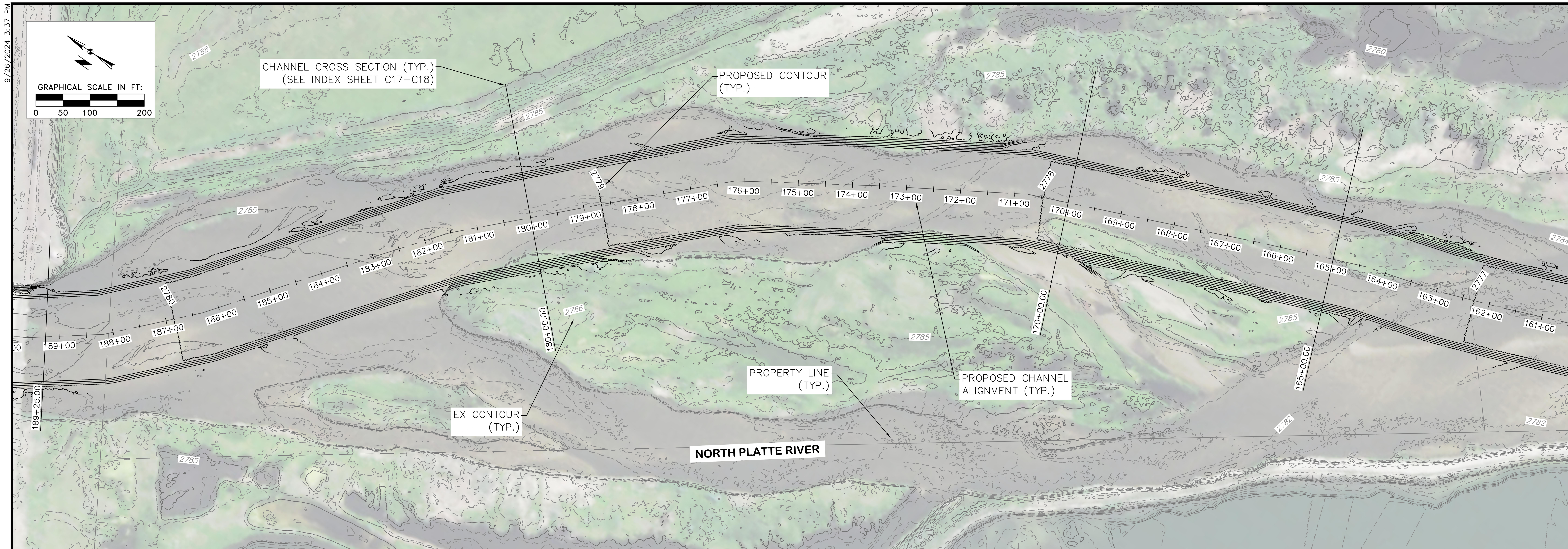

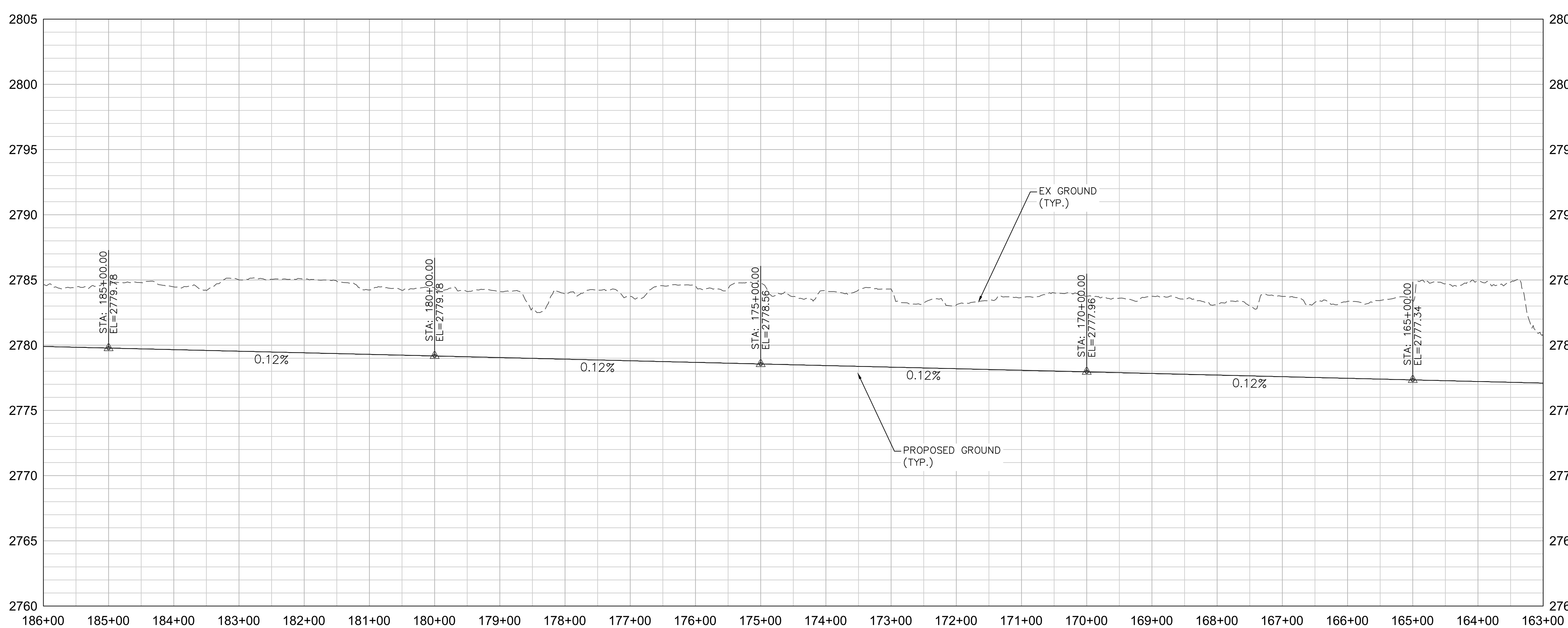

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NORTH PLATTE CHANNEL PLAN & PROFILE (9 OF 16)

NORTH PLATTE RIVER SEDIMENT REMOVAL ALTERNATIVE

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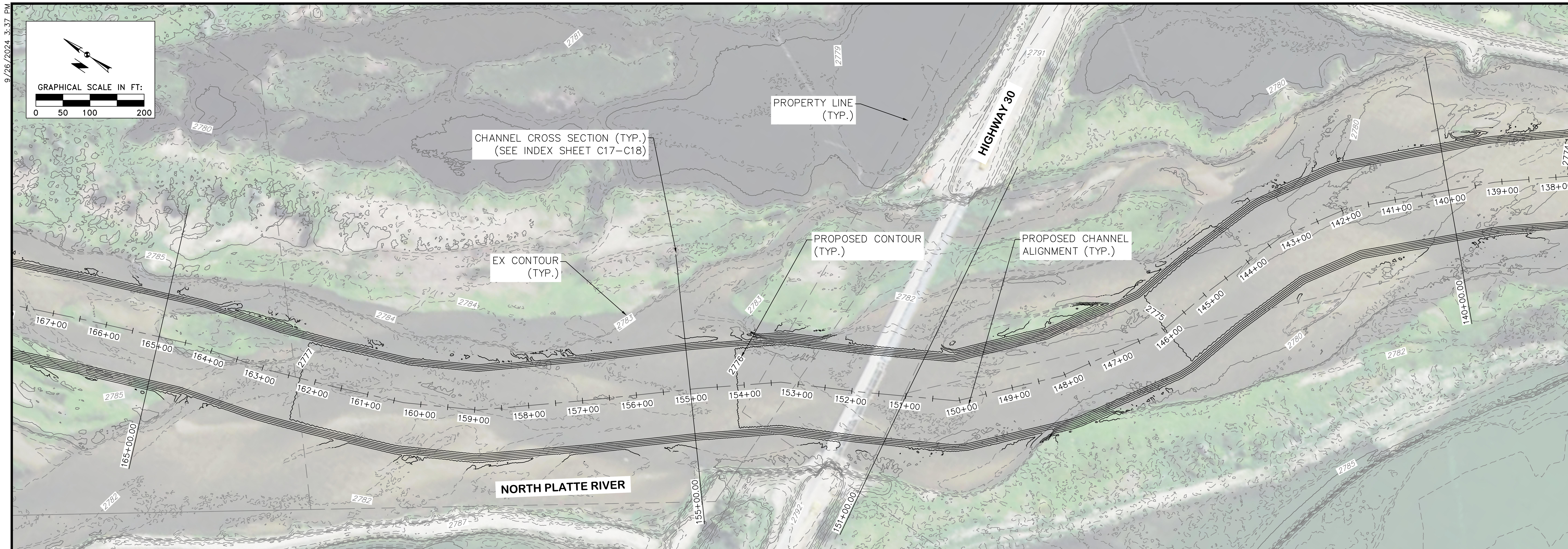

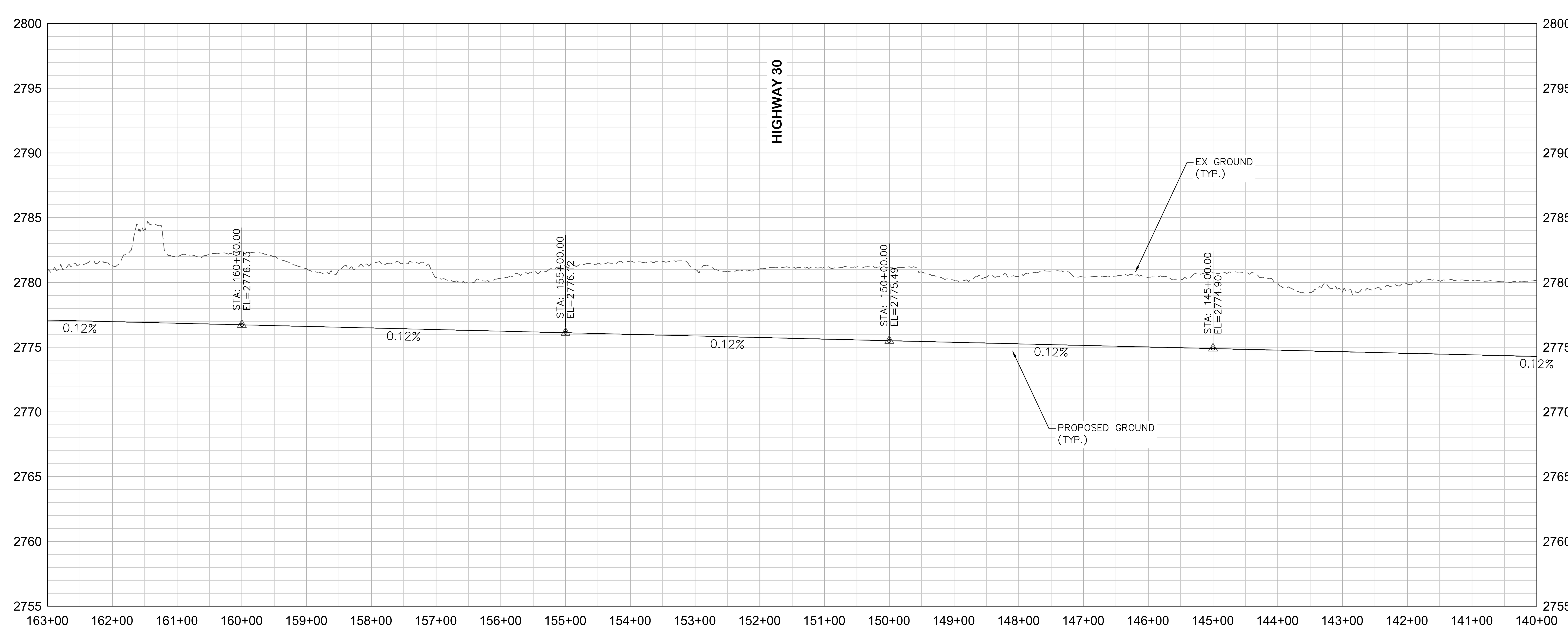

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NORTH PLATTE CHANNEL PLAN & PROFILE (10 OF 16)

NORTH PLATTE RIVER SEDIMENT REMOVAL ALTERNATIVE

CONCEPTUAL DESIGN

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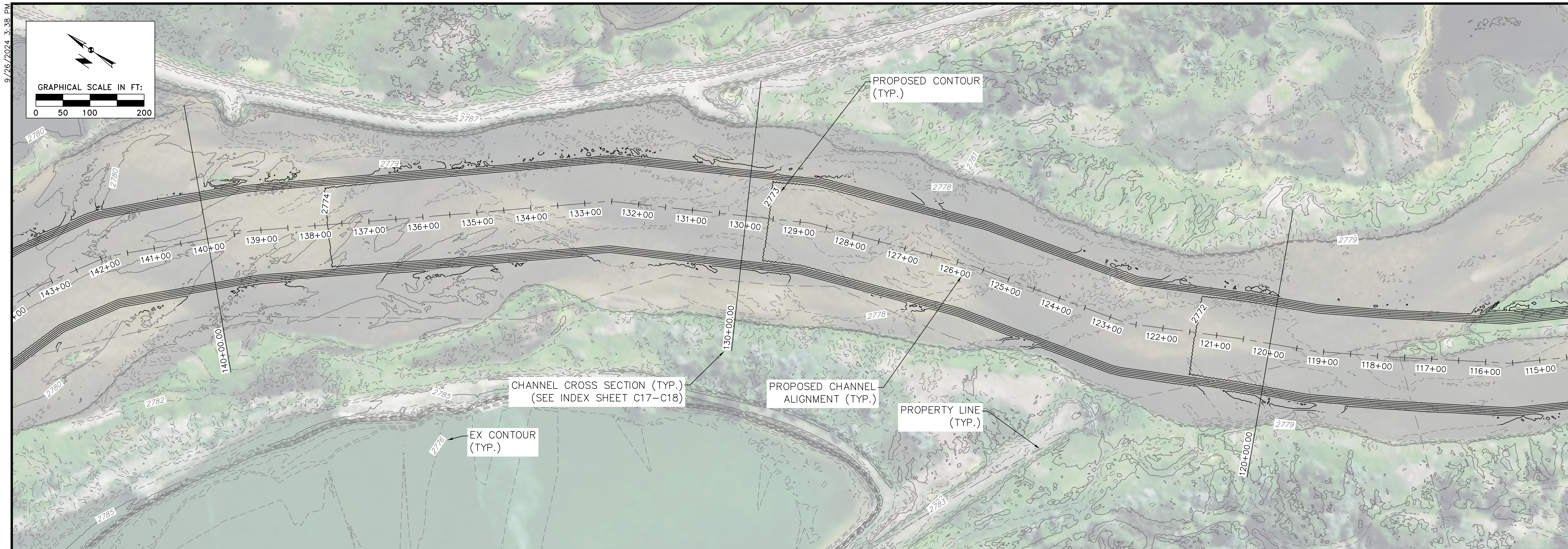
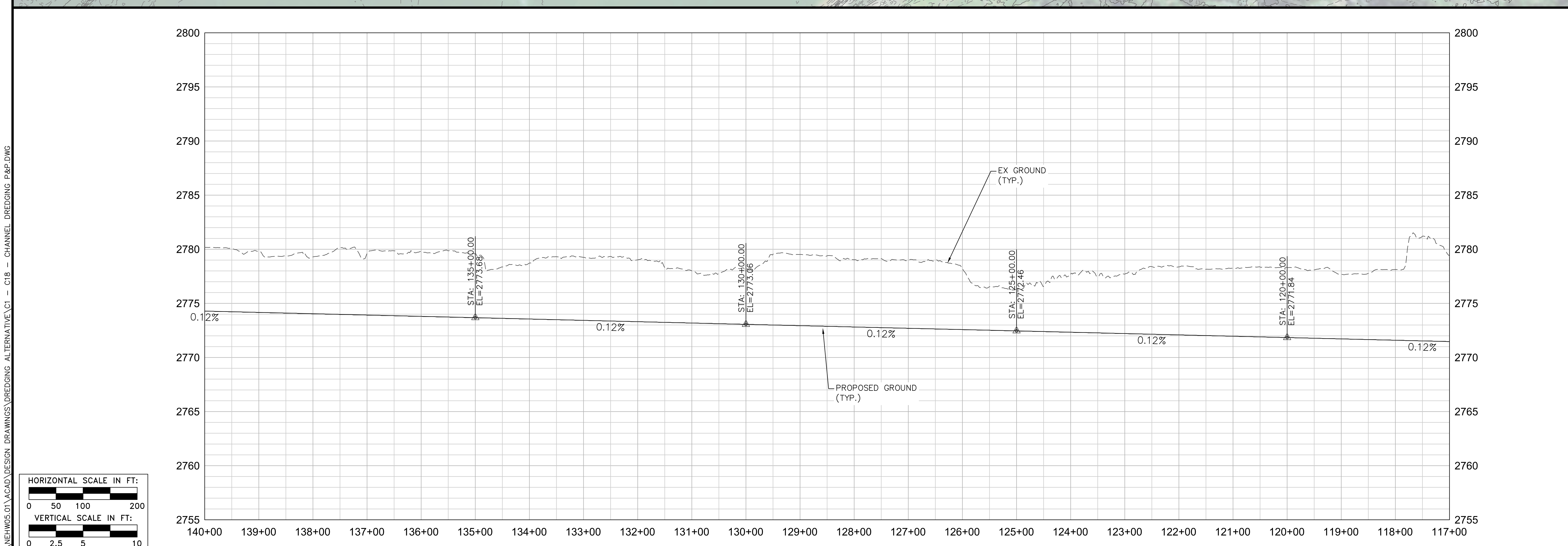
DATE:	9/25/2024
SHEET: 12	INDEX: C10





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NORTH PLATTE CHANNEL PLAN & PROFILE (11 OF 16)

NORTH PLATTE RIVER SEDIMENT REMOVAL ALTERNATIVE

CONCEPTUAL DESIGN

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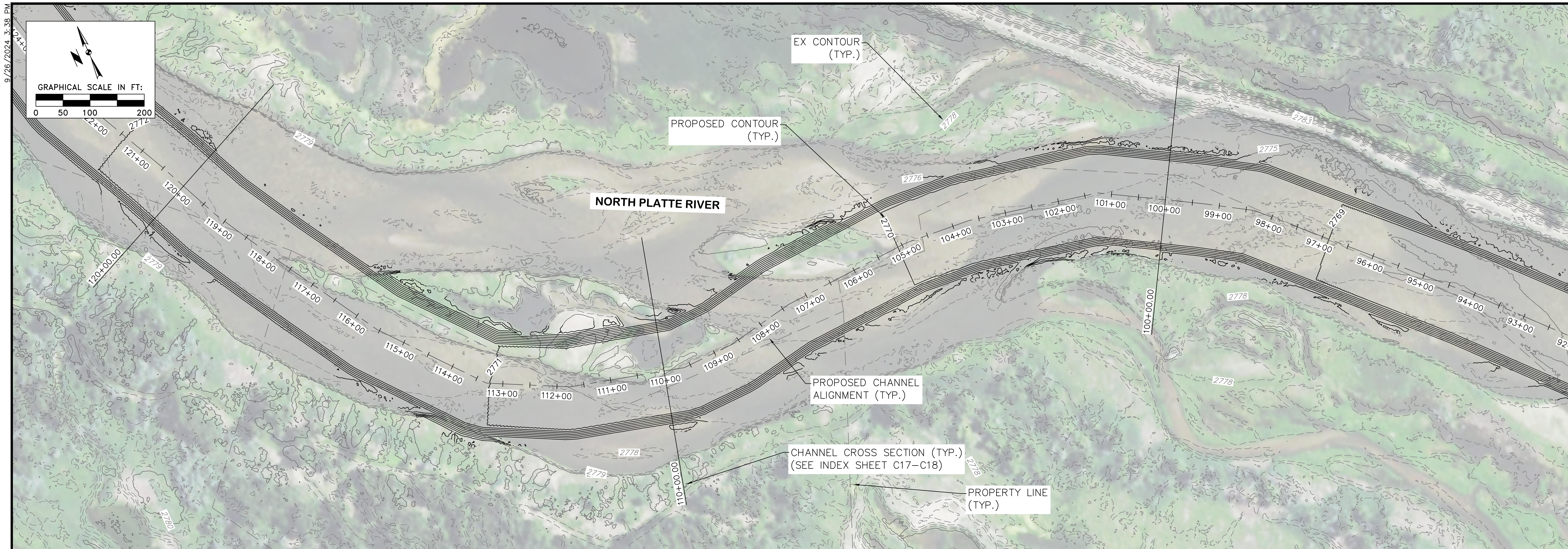

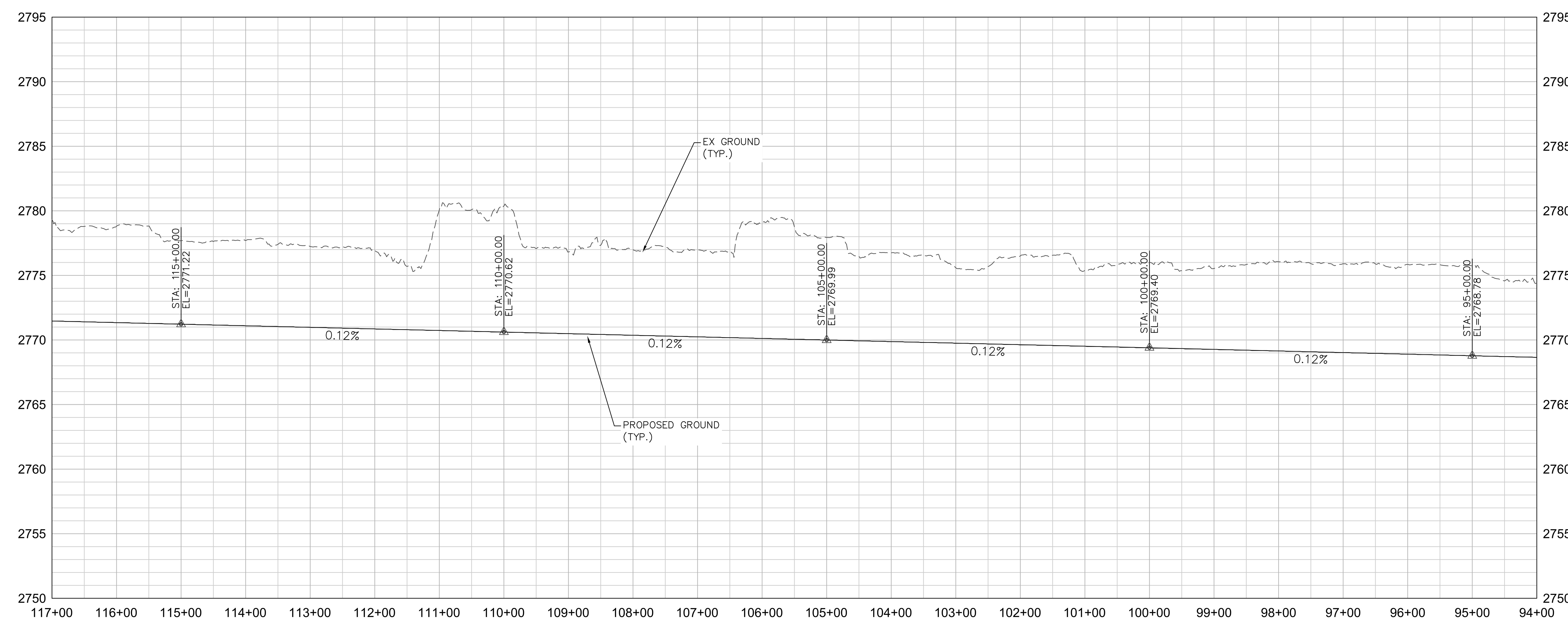

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NORTH PLATTE CHANNEL PLAN & PROFILE (12 OF 16)

NORTH PLATTE RIVER SEDIMENT REMOVAL ALTERNATIVE

CONCEPTUAL DESIGN

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DATE:	9/25/2024
SHEET: 14	INDEX: C12

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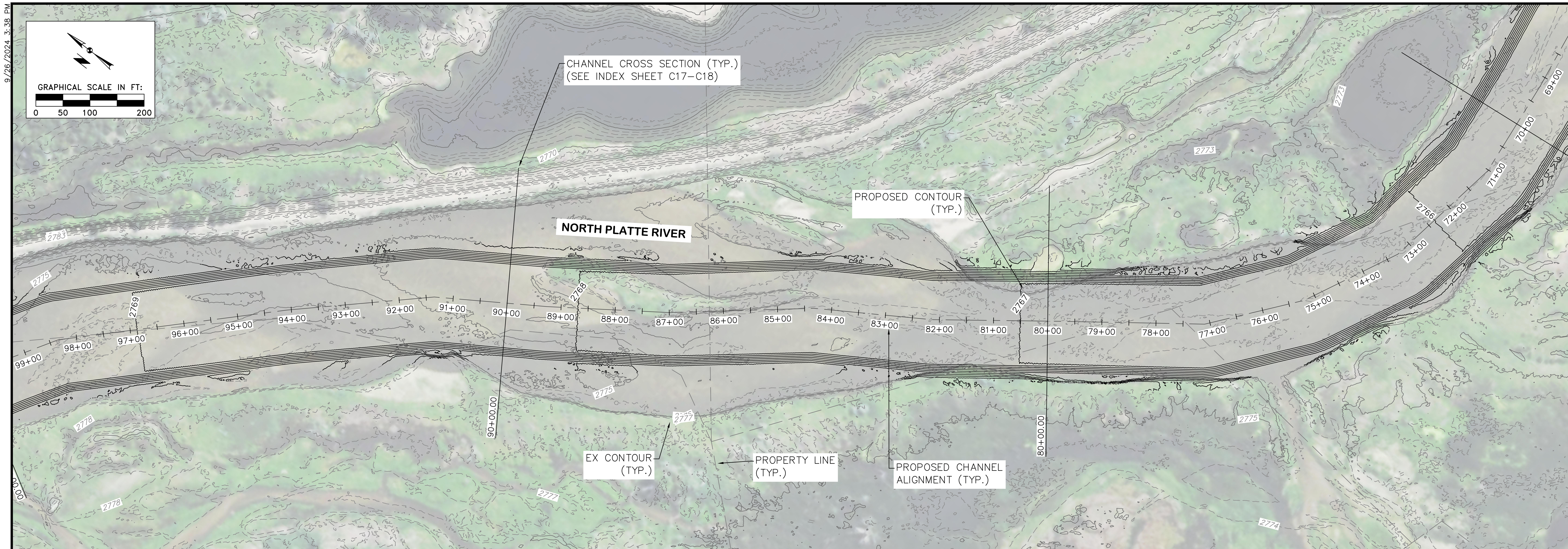

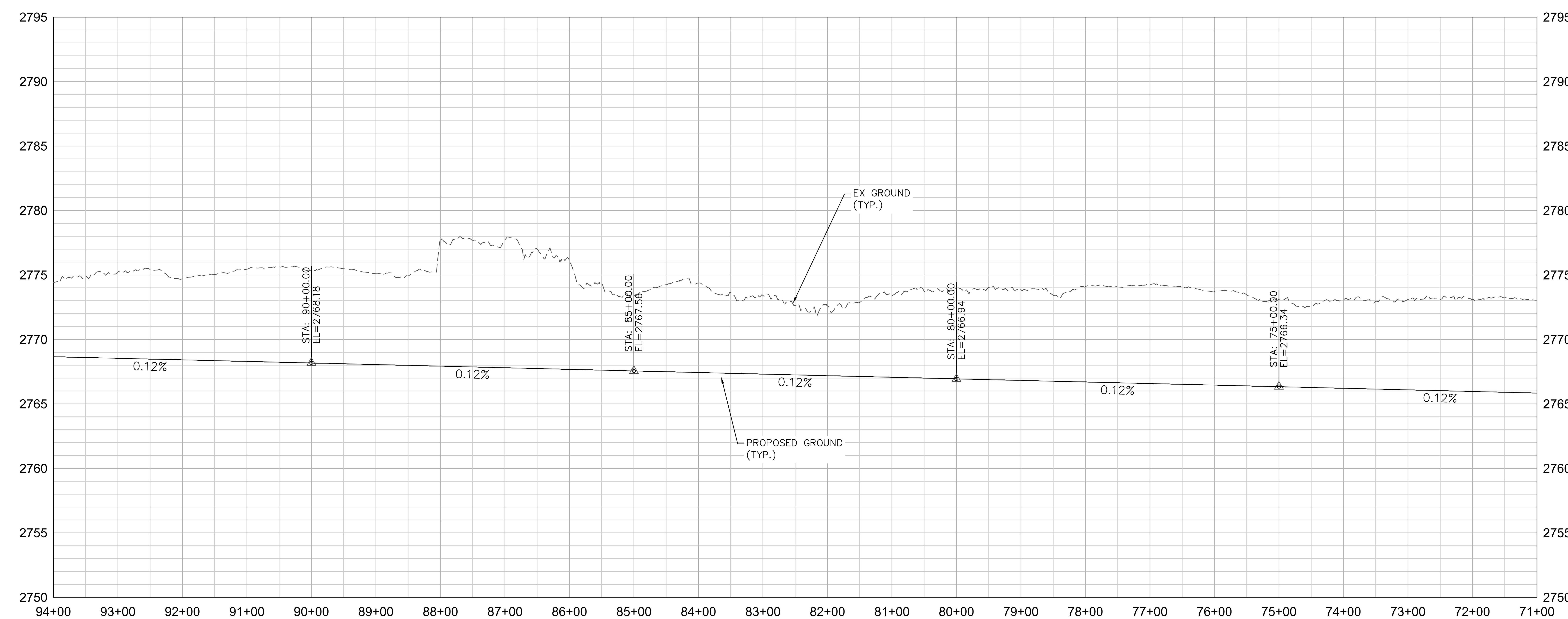

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NORTH PLATTE CHANNEL PLAN & PROFILE (13 OF 16)

NORTH PLATTE RIVER SEDIMENT REMOVAL ALTERNATIVE

CONCEPTUAL DESIGN

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DATE: 9/25/2024	
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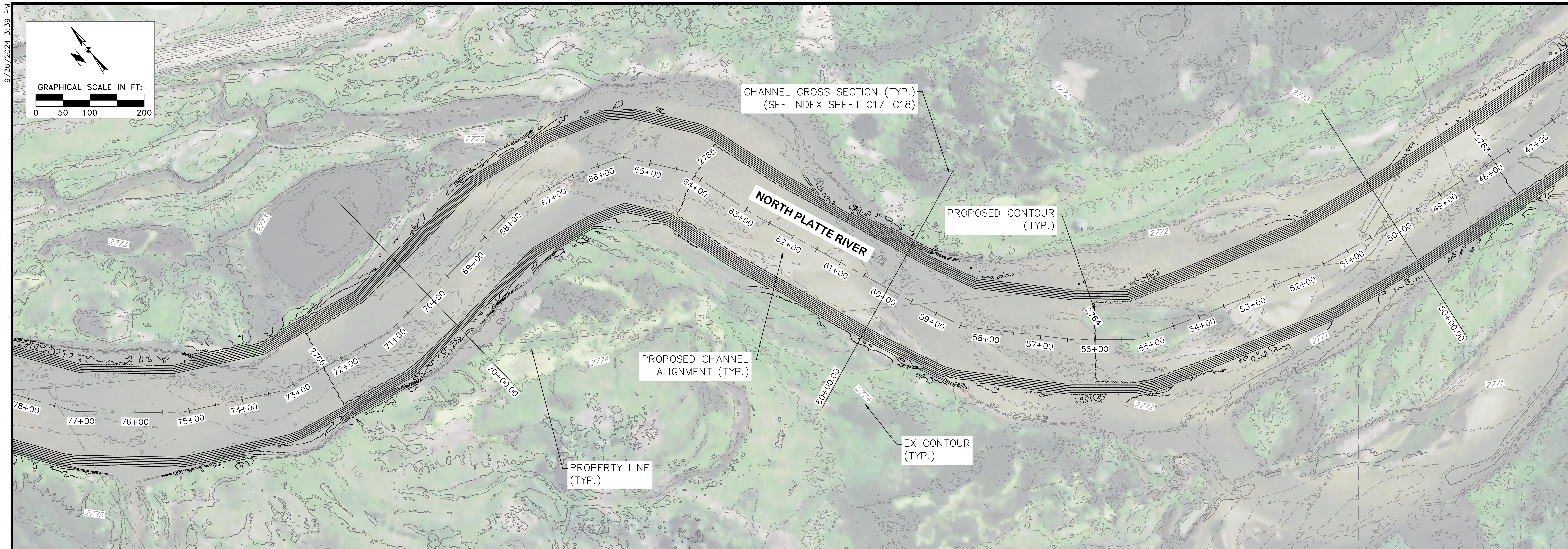

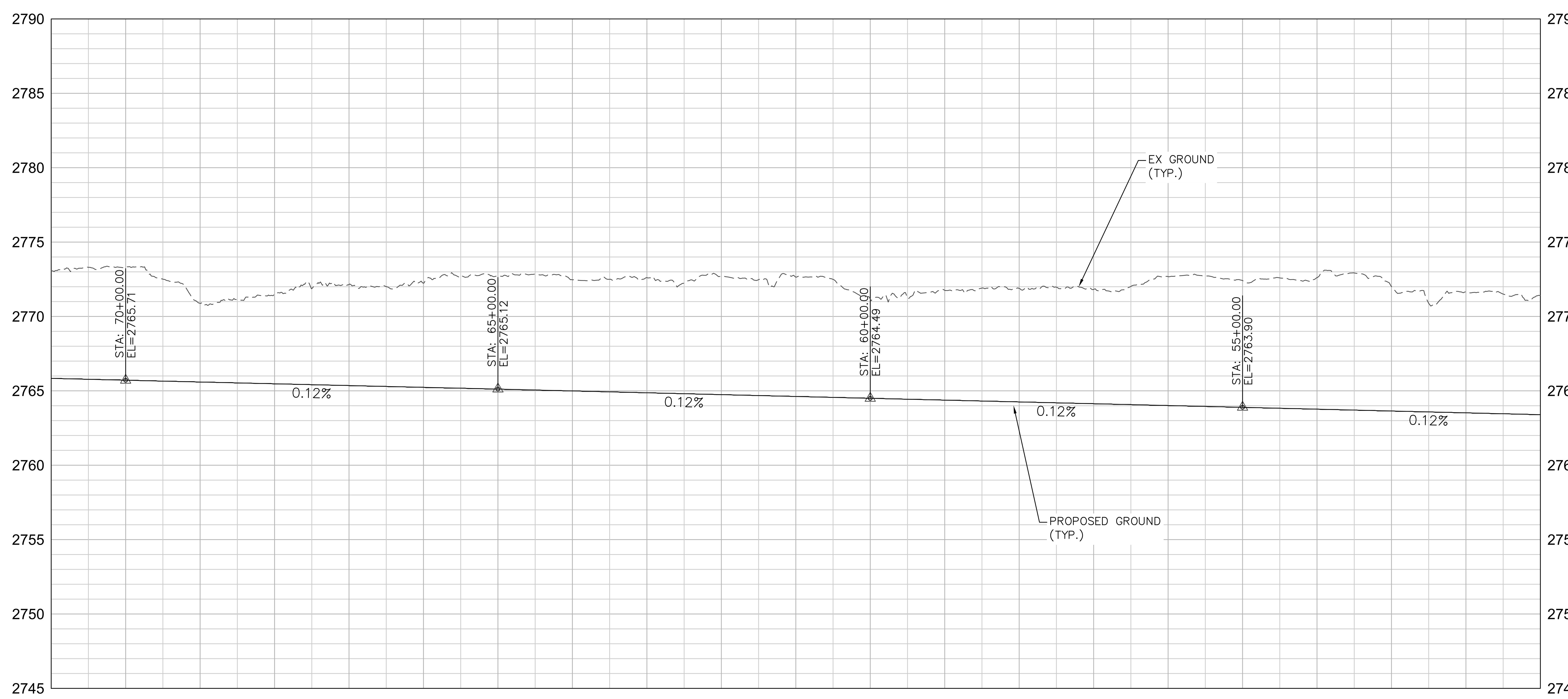

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NORTH PLATTE CHANNEL PLAN & PROFILE (14 OF 16)

NORTH PLATTE RIVER SEDIMENT REMOVAL ALTERNATIVE

CONCEPTUAL DESIGN

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PROJECT NUMBER: NEHW05.01	
DATE: 9/25/2024	
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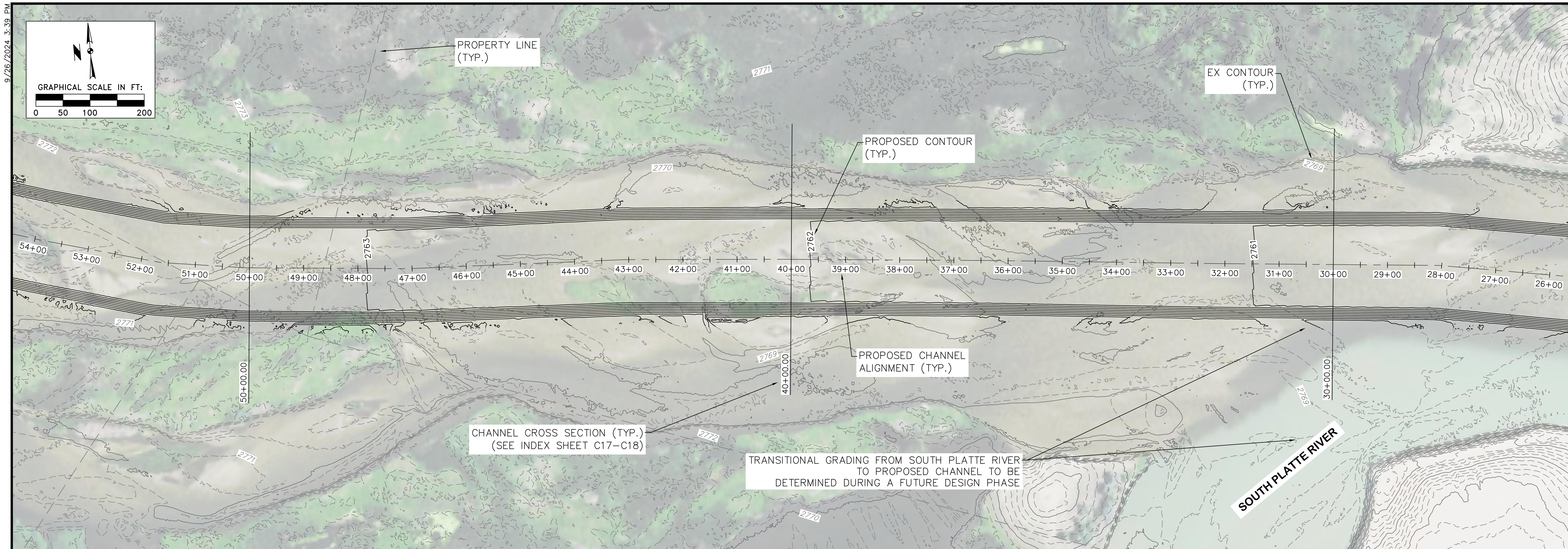

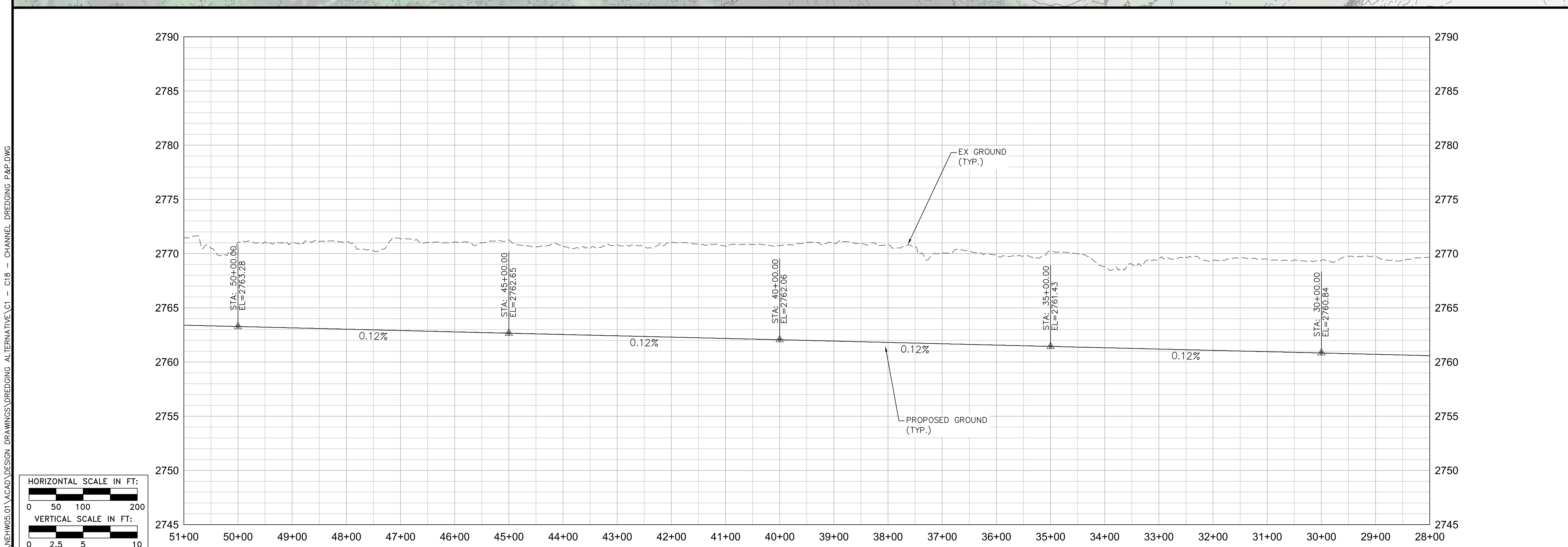

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NORTH PLATTE CHANNEL PLAN & PROFILE (15 OF 16)

NORTH PLATTE RIVER SEDIMENT REMOVAL ALTERNATIVE

CONCEPTUAL DESIGN

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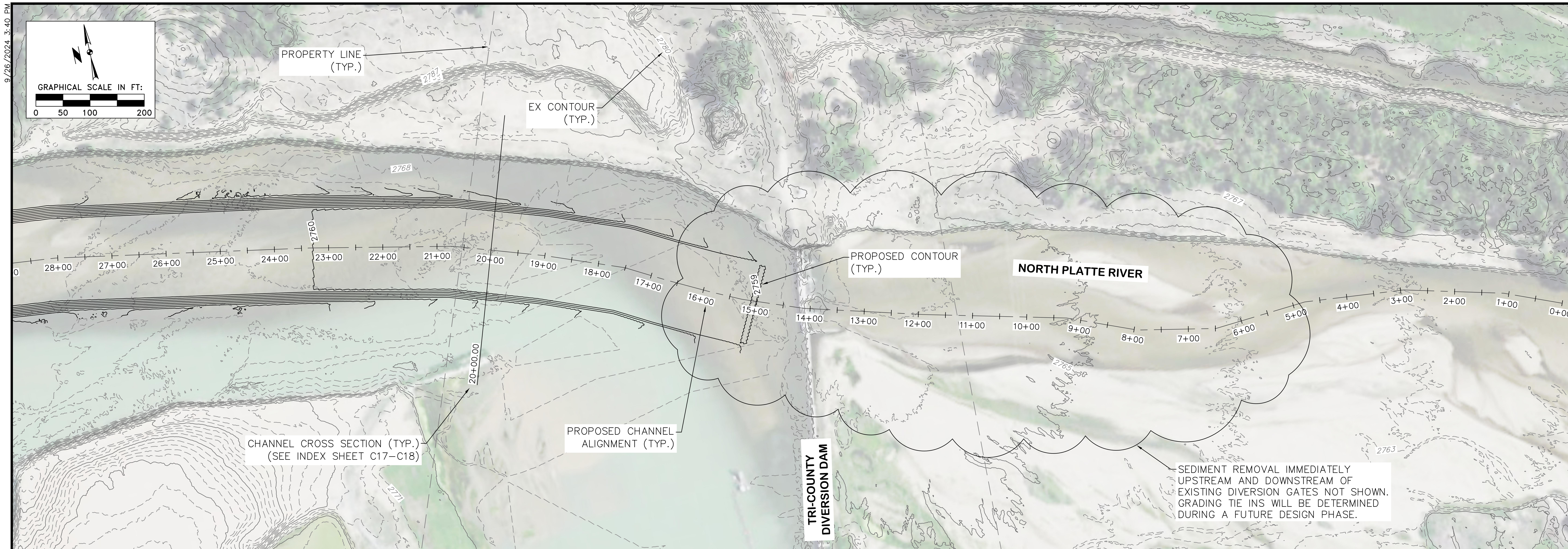
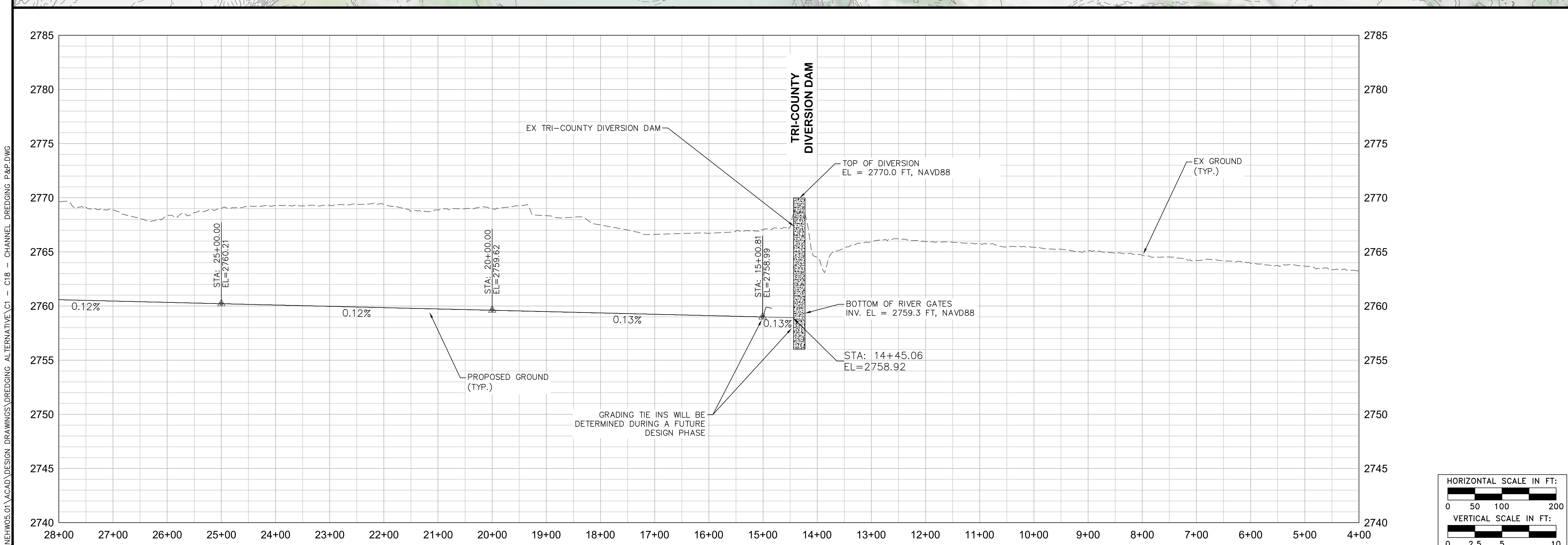
CHECKED BY:	MLM
PROJECT NUMBER:	NEHW05.01
DATE:	9/25/2024
SHEET: 17	INDEX: C15





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NORTH PLATTE CHANNEL PLAN & PROFILE (16 OF 16)

NORTH PLATTE RIVER SEDIMENT REMOVAL ALTERNATIVE

CONCEPTUAL DESIGN

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PROJECT NUMBER: NEHW05.01	
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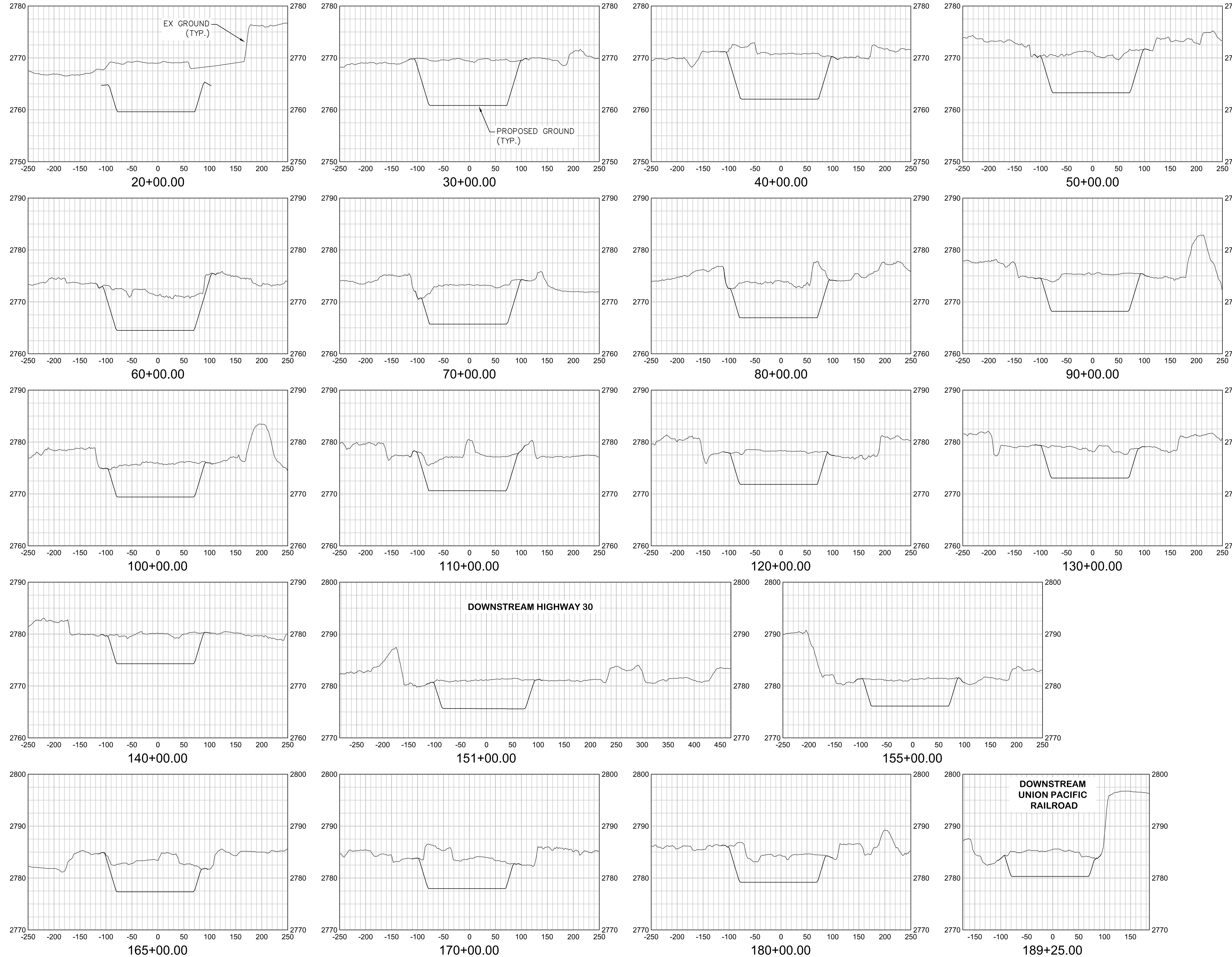

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CHANNEL CROSS SECTIONS (1 OF 2)

NORTH PLATTE RIVER SEDIMENT REMOVAL ALTERNATIVE

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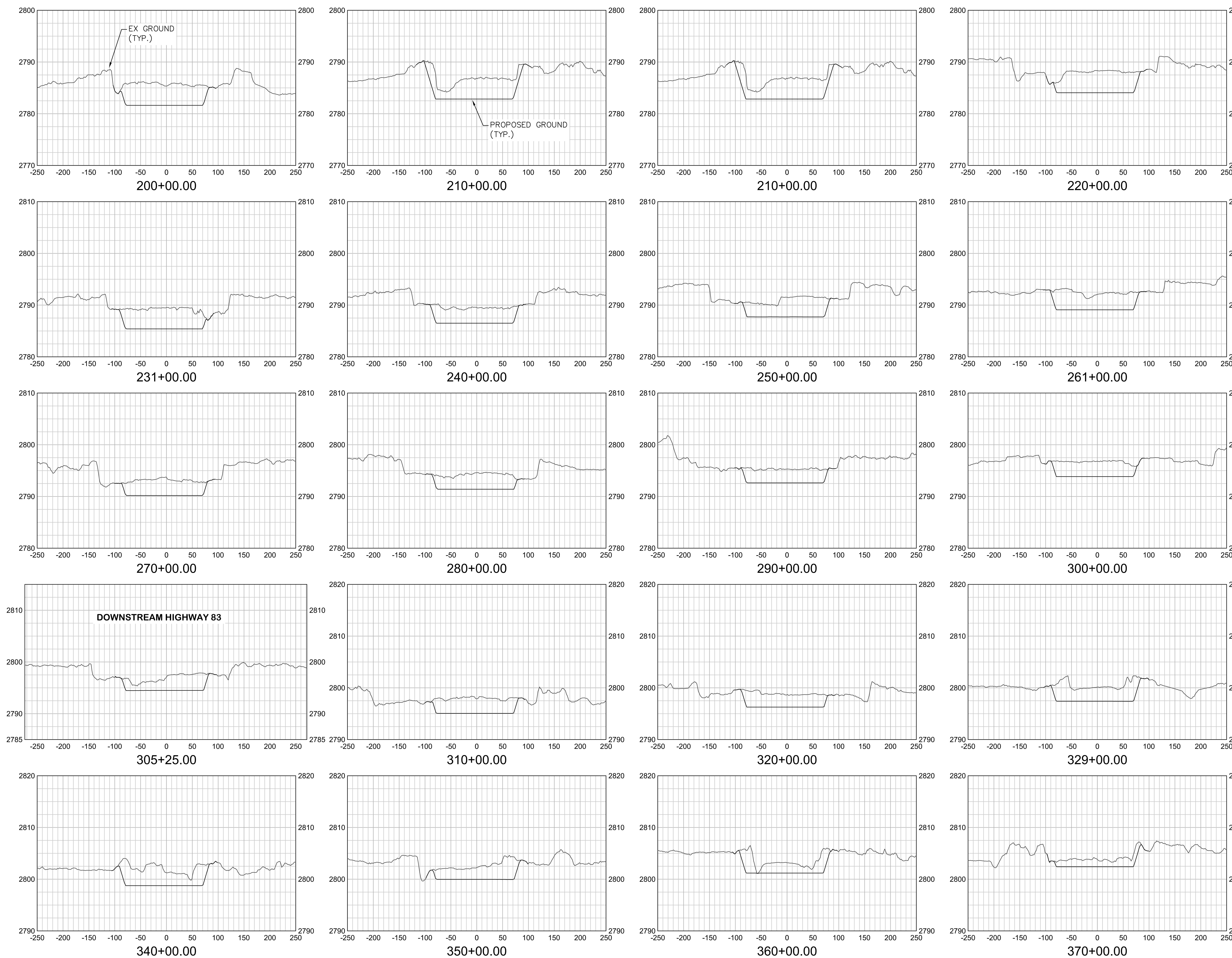

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CHANNEL CROSS SECTIONS (2 OF 2)

NORTH PLATTE RIVER SEDIMENT REMOVAL ALTERNATIVE

CONCEPTUAL DESIGN

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PROJECT NUMBER: NEHW05.01
DATE: 9/25/2024
SHEET: 20 INDEX: C18

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REVISIONS:----

APPENDIX C.2. INUNDATION, WETLANDS, AND GROUNDWATER MAPPING

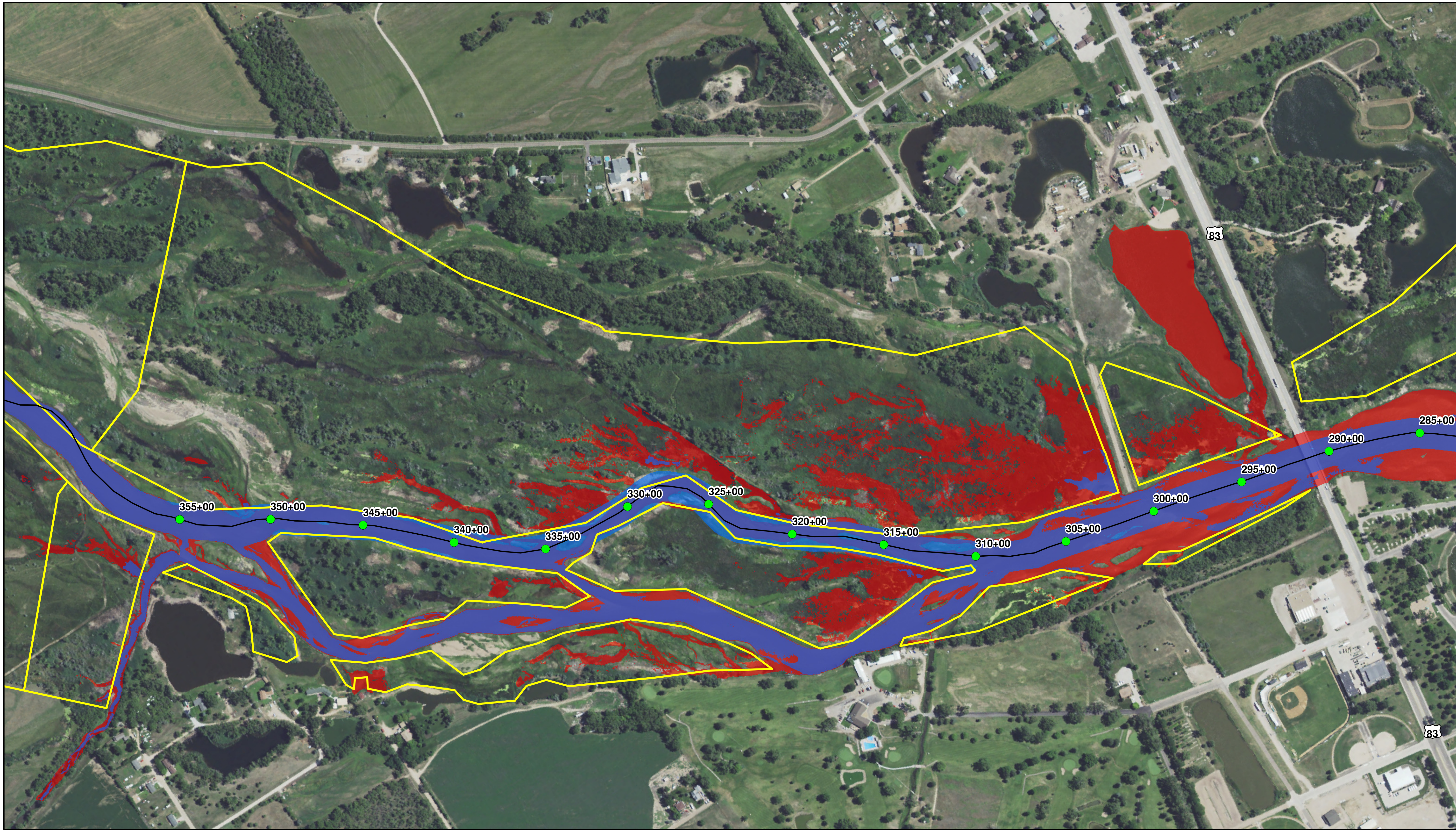
North Platte River 2D Hydraulic Modeling Results

Area of Inundation by Discharge

Flow	Existing	Sed Removal Alt A	Difference
	Area of Inundation (acres)		(acres)
400 CFS	469	293	176
1000 CFS	681	347	334
1500 CFS	919	456	463
2000 CFS	1296	669	627
3000 CFS	2157	1201	956
6000 CFS	3393	2365	1029

Flow	Existing	Sed Removal Alt A	Difference	
	Area of Wetland Inundation (acres) *		(acres)	
400 CFS	36	4	32	
1000 CFS	130	6	124	
1500 CFS	249	18	230	~ Existing Conditions Bankfull
2000 CFS	416	55	360	
3000 CFS	679	123	556	~ Proposed Condition Bankfull
6000 CFS	857	381	476	

* Inundation mapping intersected with delineation of potential wetlands.



N E W S

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Feet

SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 1000 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 1000 CFS

Existing Inundation 1000 CFS

Potential Wetland

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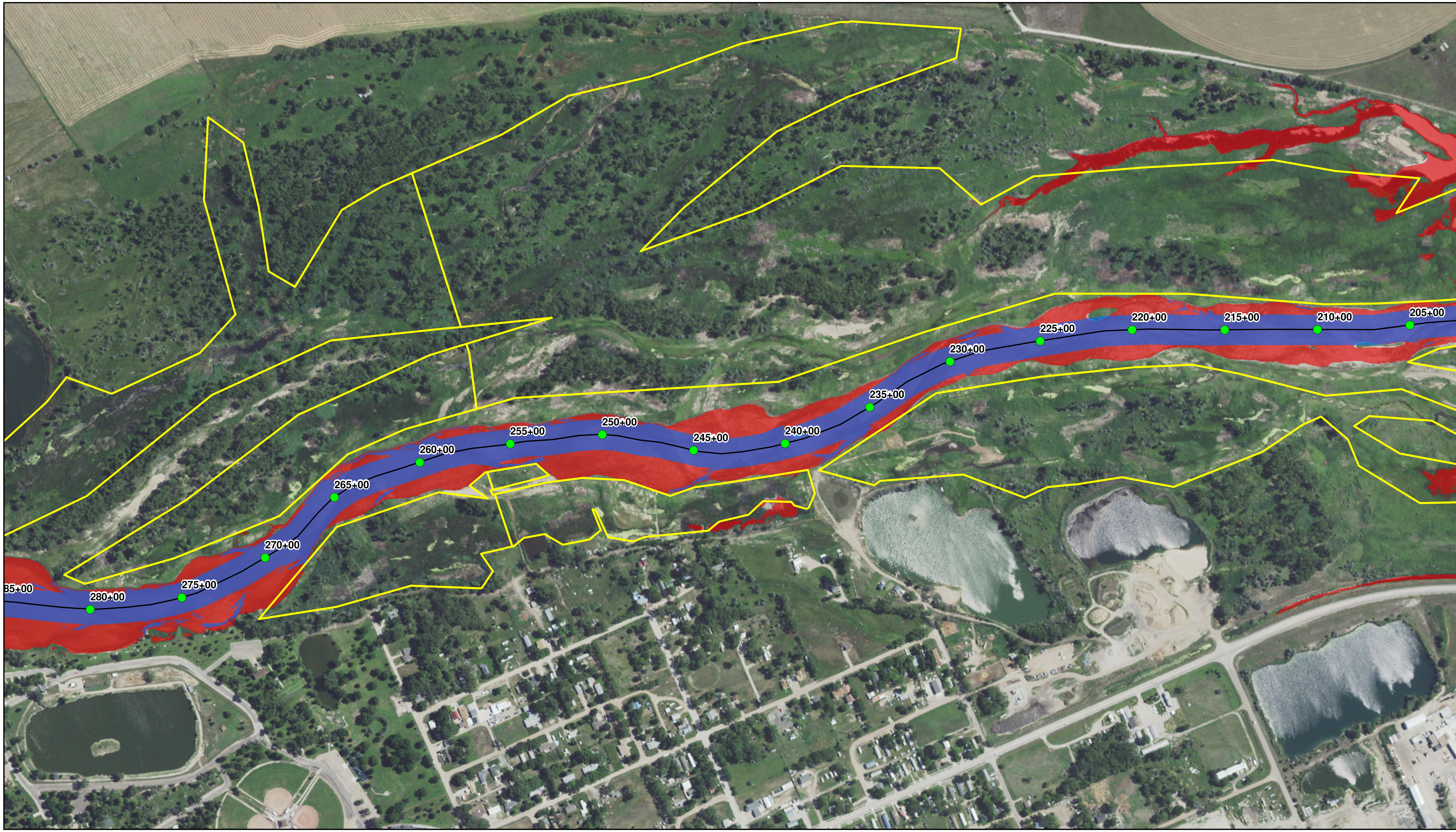

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SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 1000 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 1000 CFS

Existing Inundation 1000 CFS

Potential Wetland

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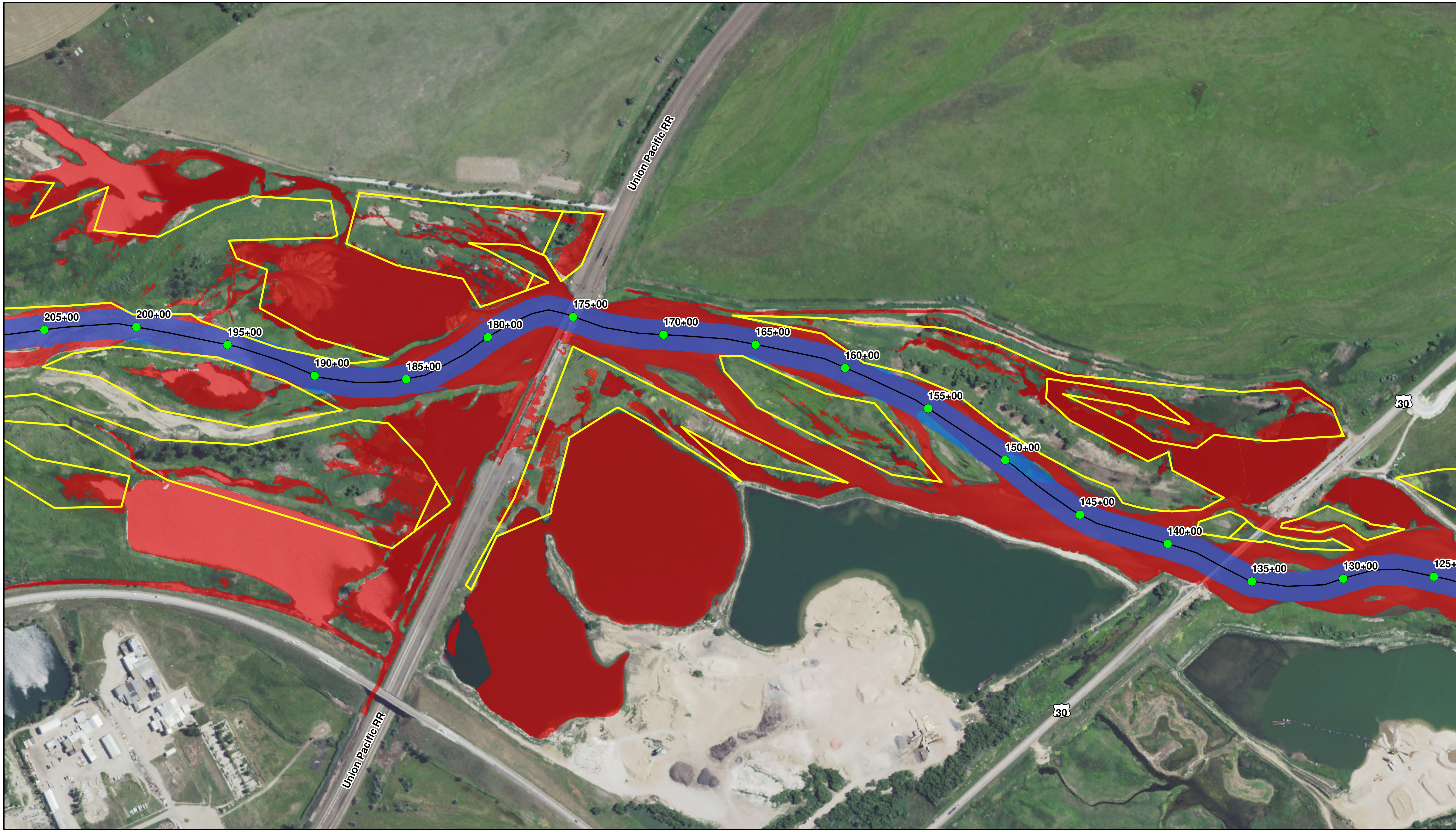

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SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 1000 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 1000 CFS

Existing Inundation 1000 CFS

Potential Wetland

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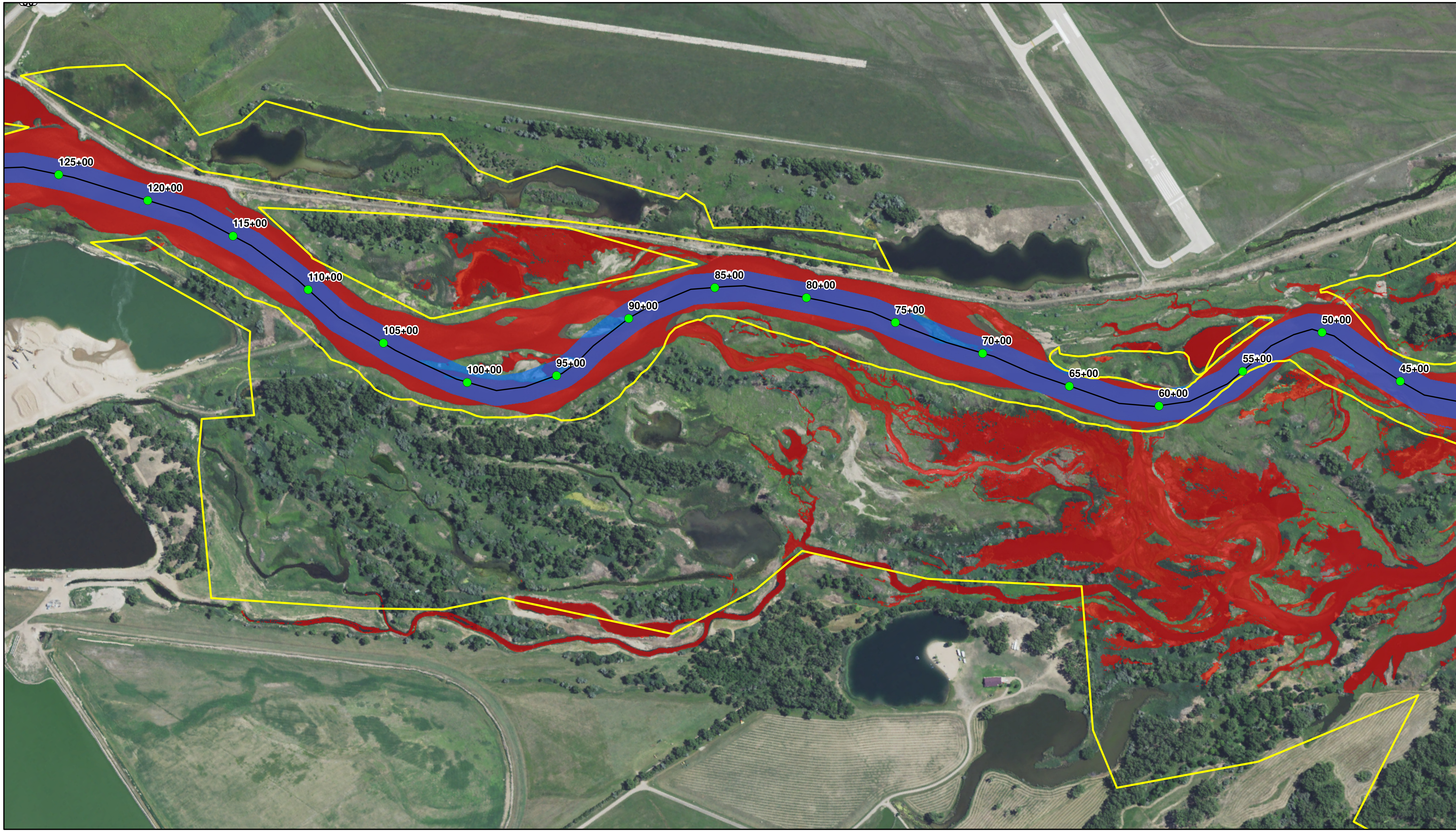

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SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 1000 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 1000 CFS

Existing Inundation 1000 CFS

Potential Wetland

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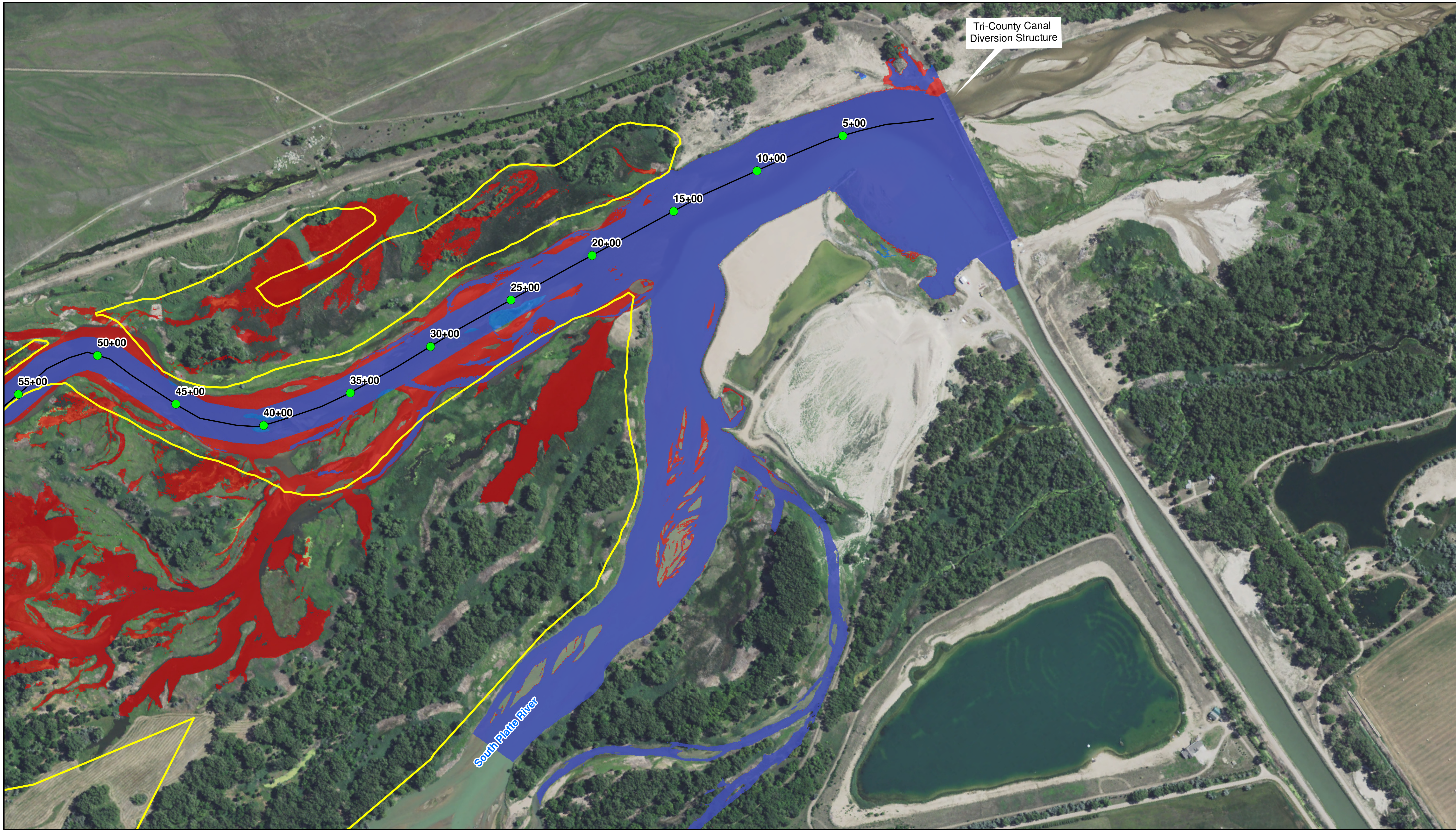

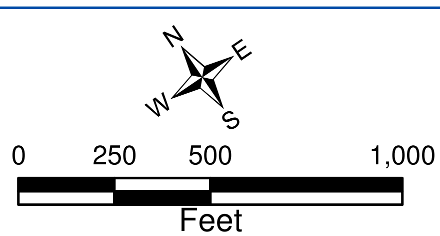

SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 1000 CFS

Legend

- Proposed Channel Centerline
- Proposed Inundation 1000 CFS
- Existing Inundation 1000 CFS
- Potential Wetland

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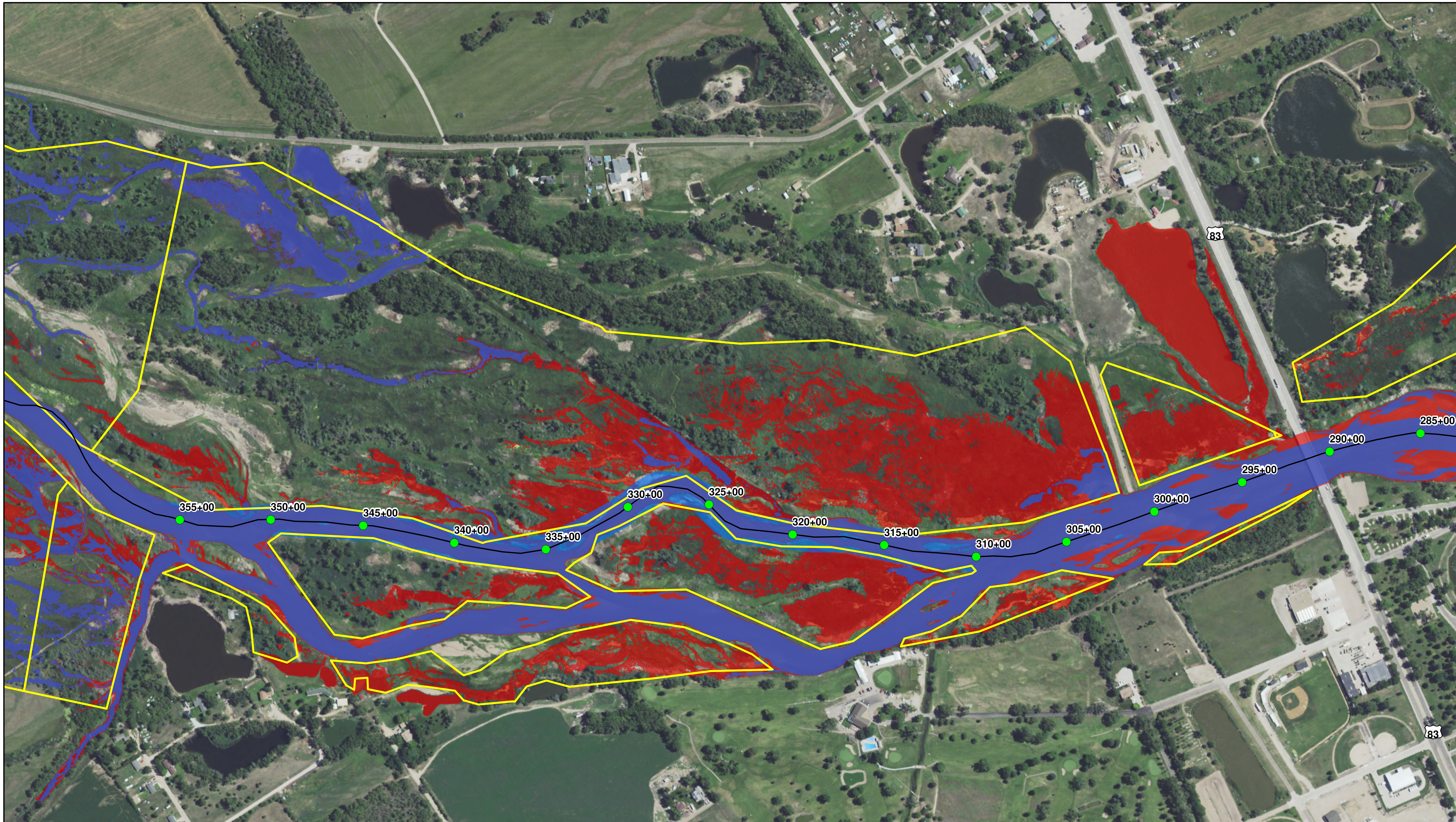

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Feet

SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 1500 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 1500 CFS

Existing Inundation 1500 CFS

Potential Wetland

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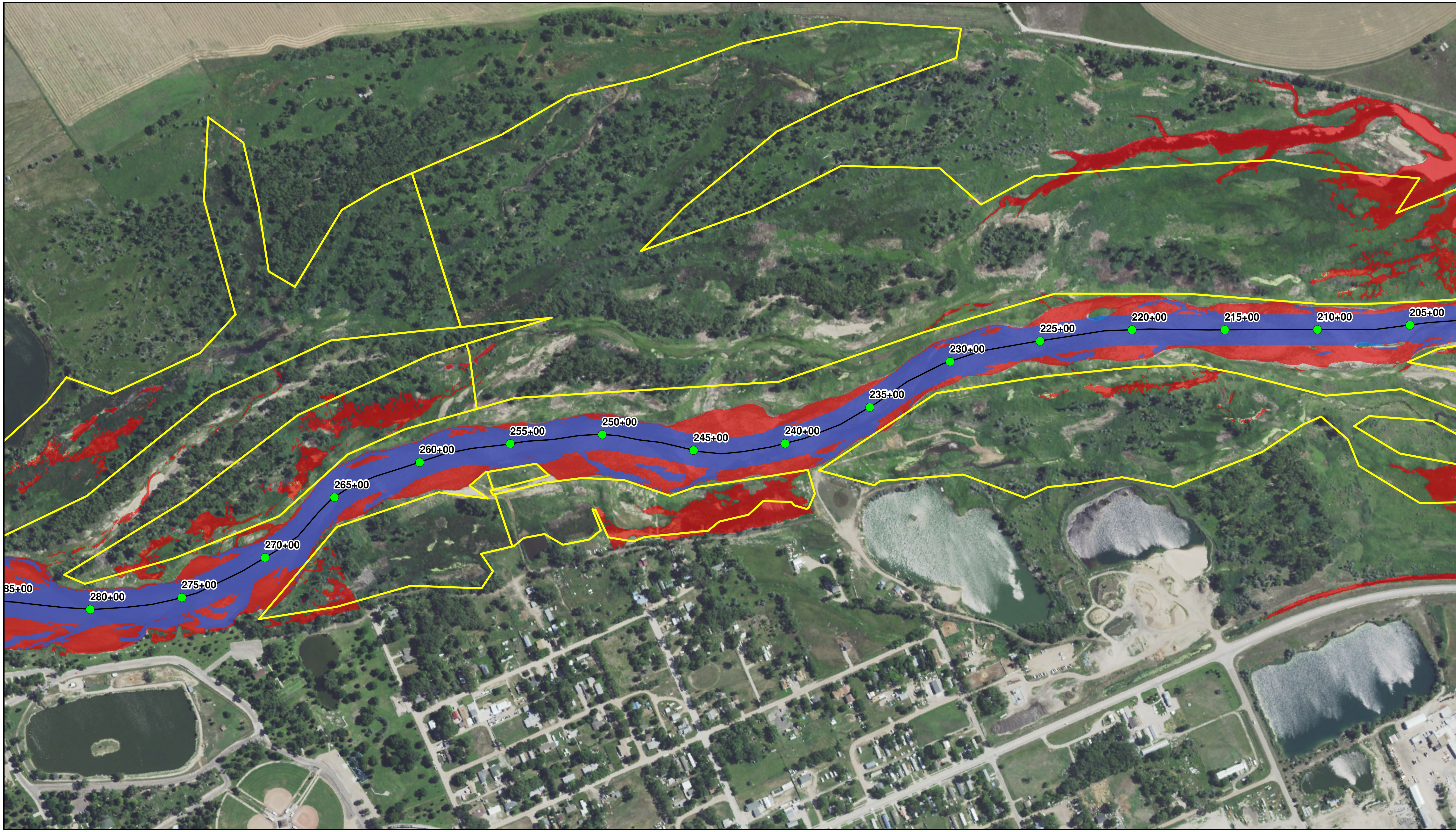

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Feet

SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 1500 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 1500 CFS

Existing Inundation 1500 CFS

Potential Wetland

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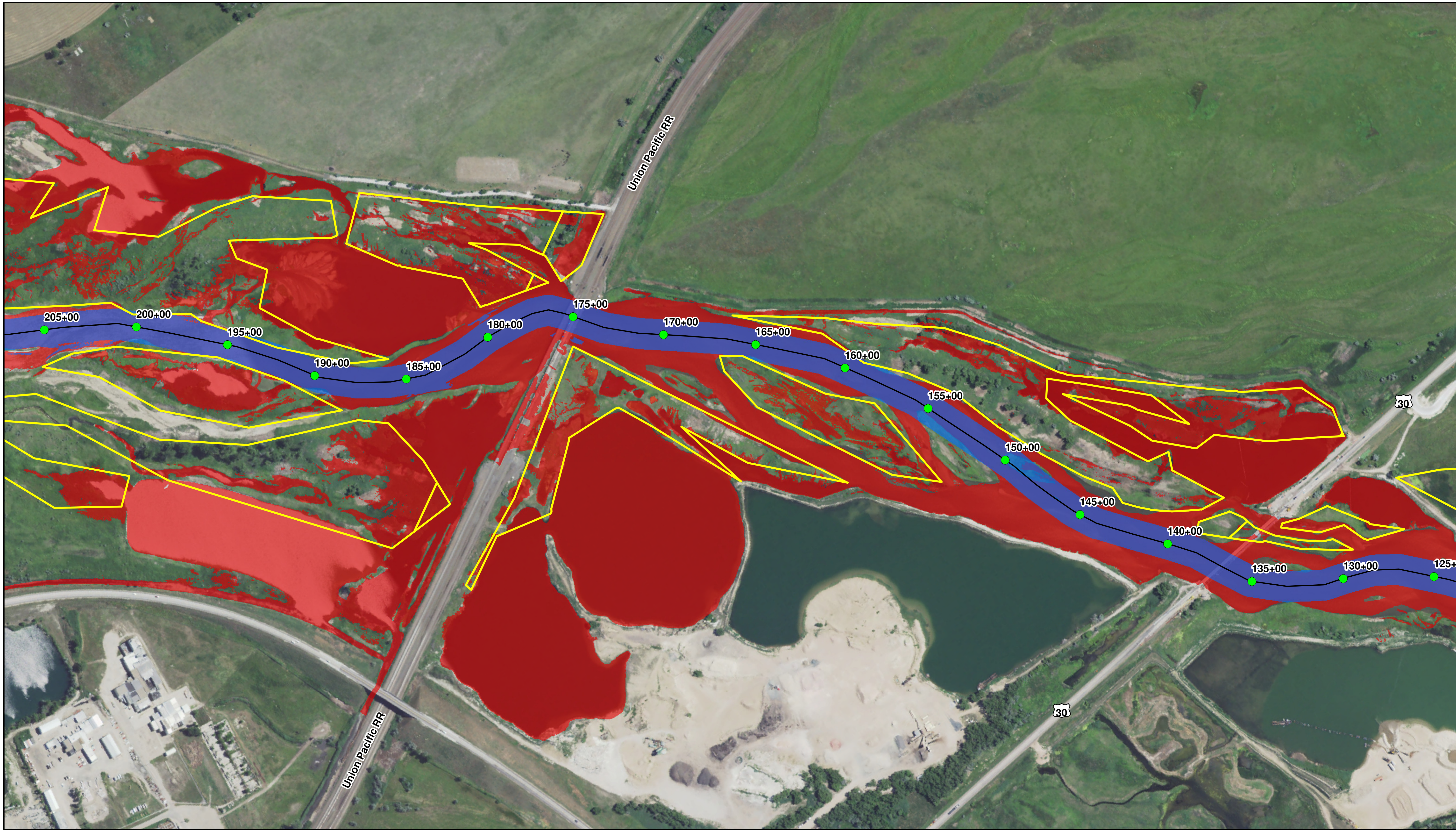

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SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 1500 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 1500 CFS

Existing Inundation 1500 CFS

Potential Wetland

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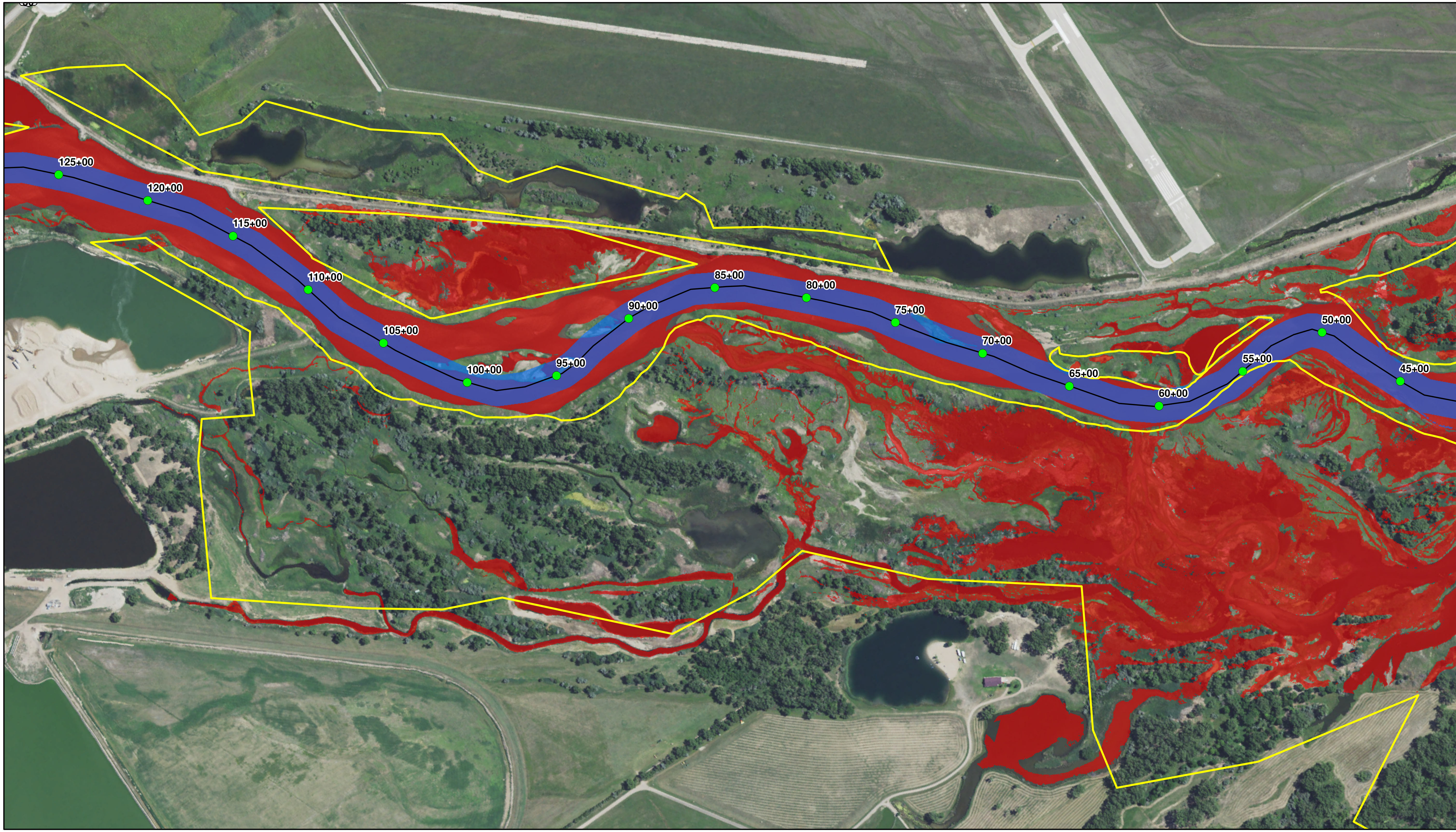

SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 1500 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 1500 CFS

Existing Inundation 1500 CFS

Potential Wetland

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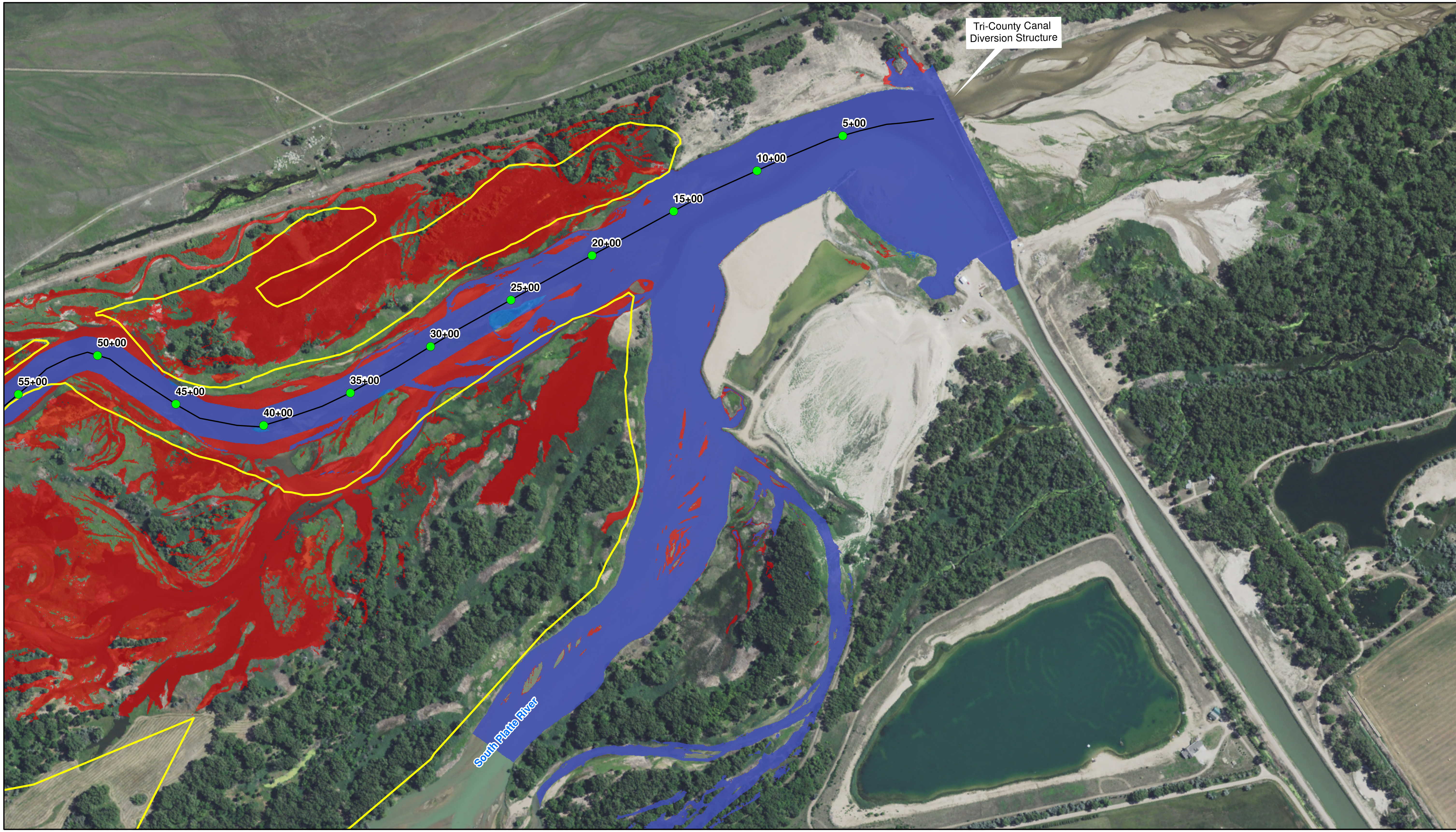

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Feet

SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 1500 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 1500 CFS

Existing Inundation 1500 CFS

Potential Wetland

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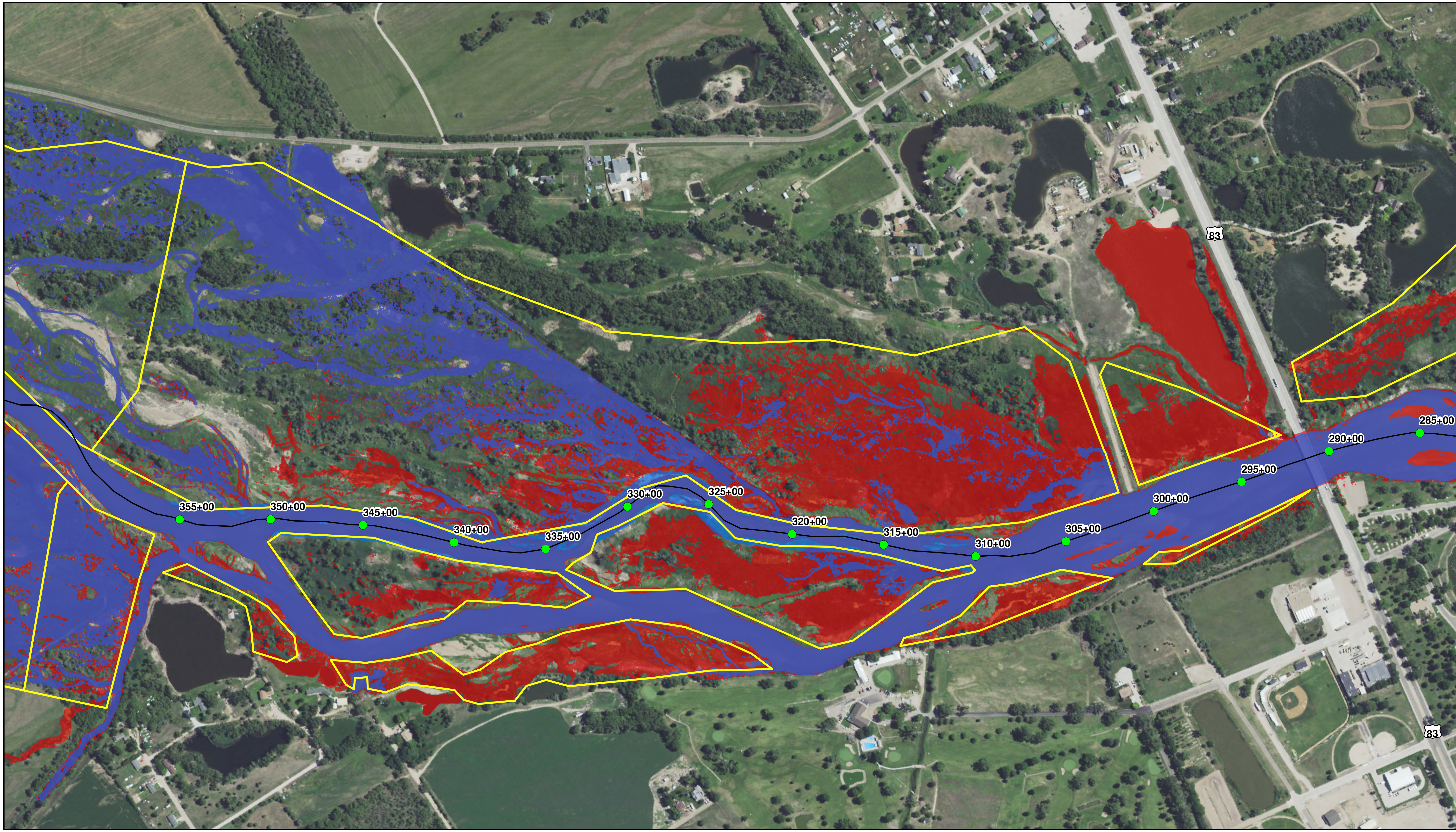

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Feet

SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 2000 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 2000 CFS

Existing Inundation 2000 CFS

Potential Wetland

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N E S W

0 250 500 1,000

Feet

SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 2000 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 2000 CFS

Existing Inundation 2000 CFS

Potential Wetland

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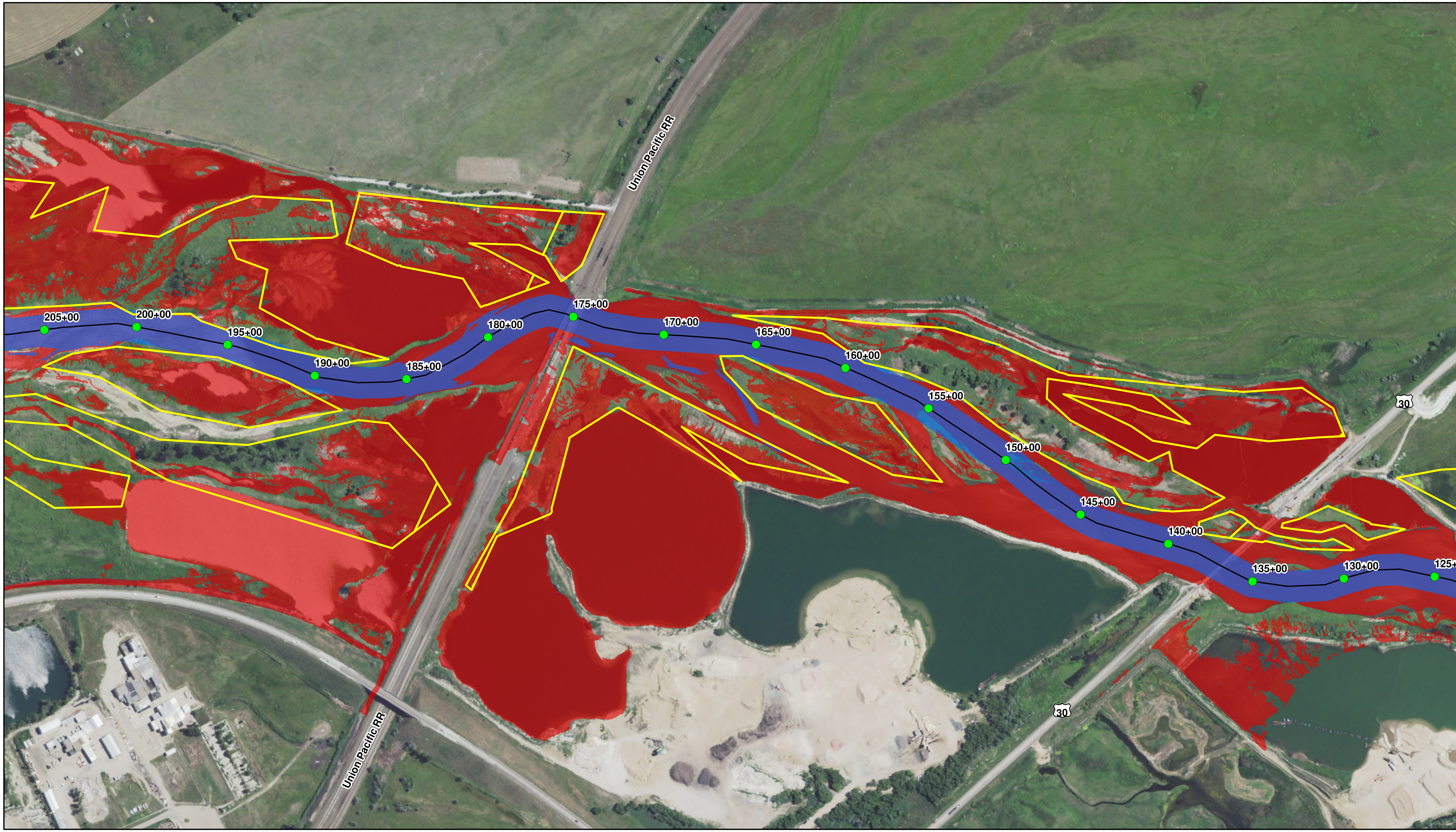

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Feet

SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 2000 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 2000 CFS

Existing Inundation 2000 CFS

Potential Wetland

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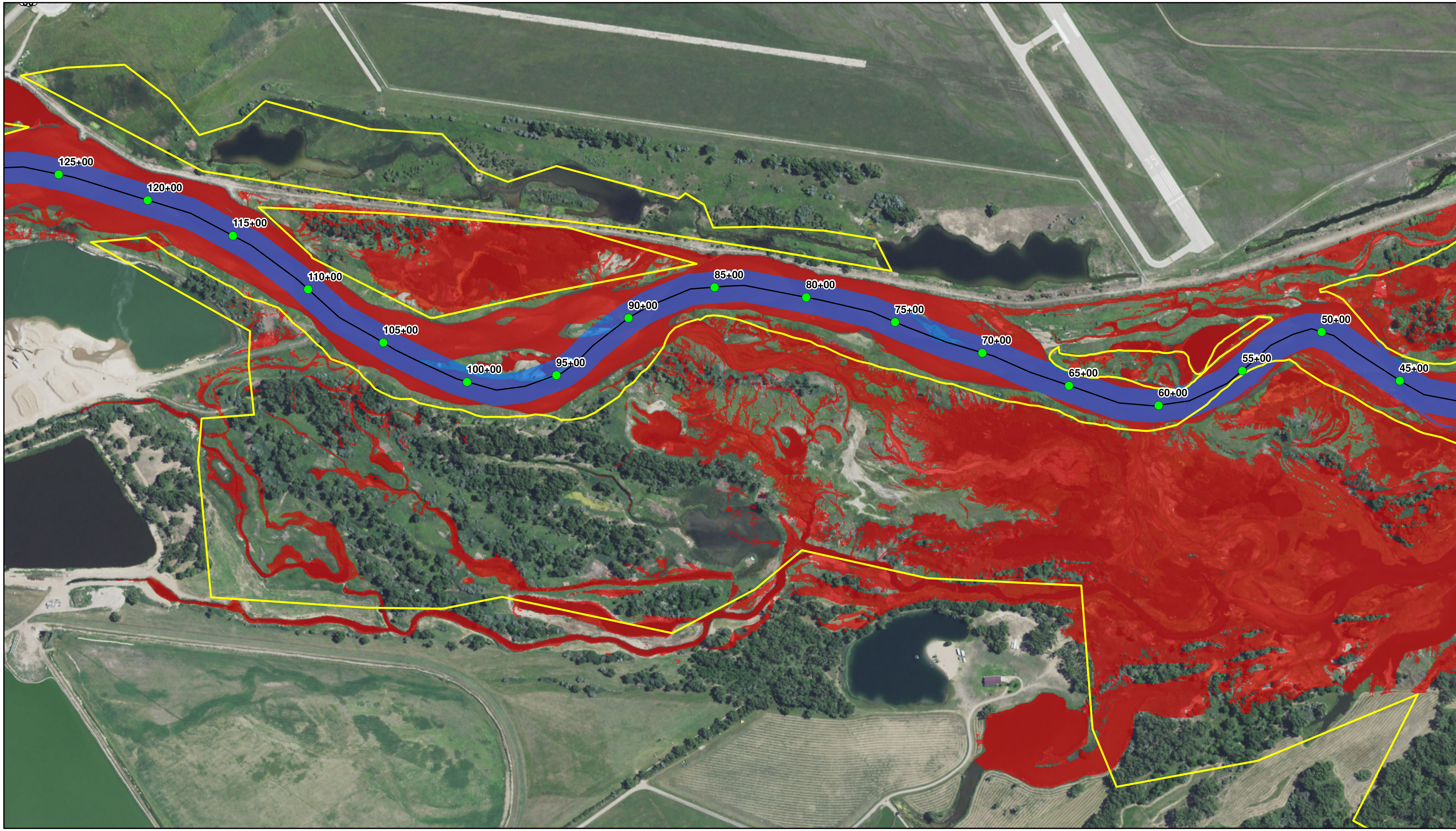

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Feet

SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 2000 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 2000 CFS

Existing Inundation 2000 CFS

Potential Wetland

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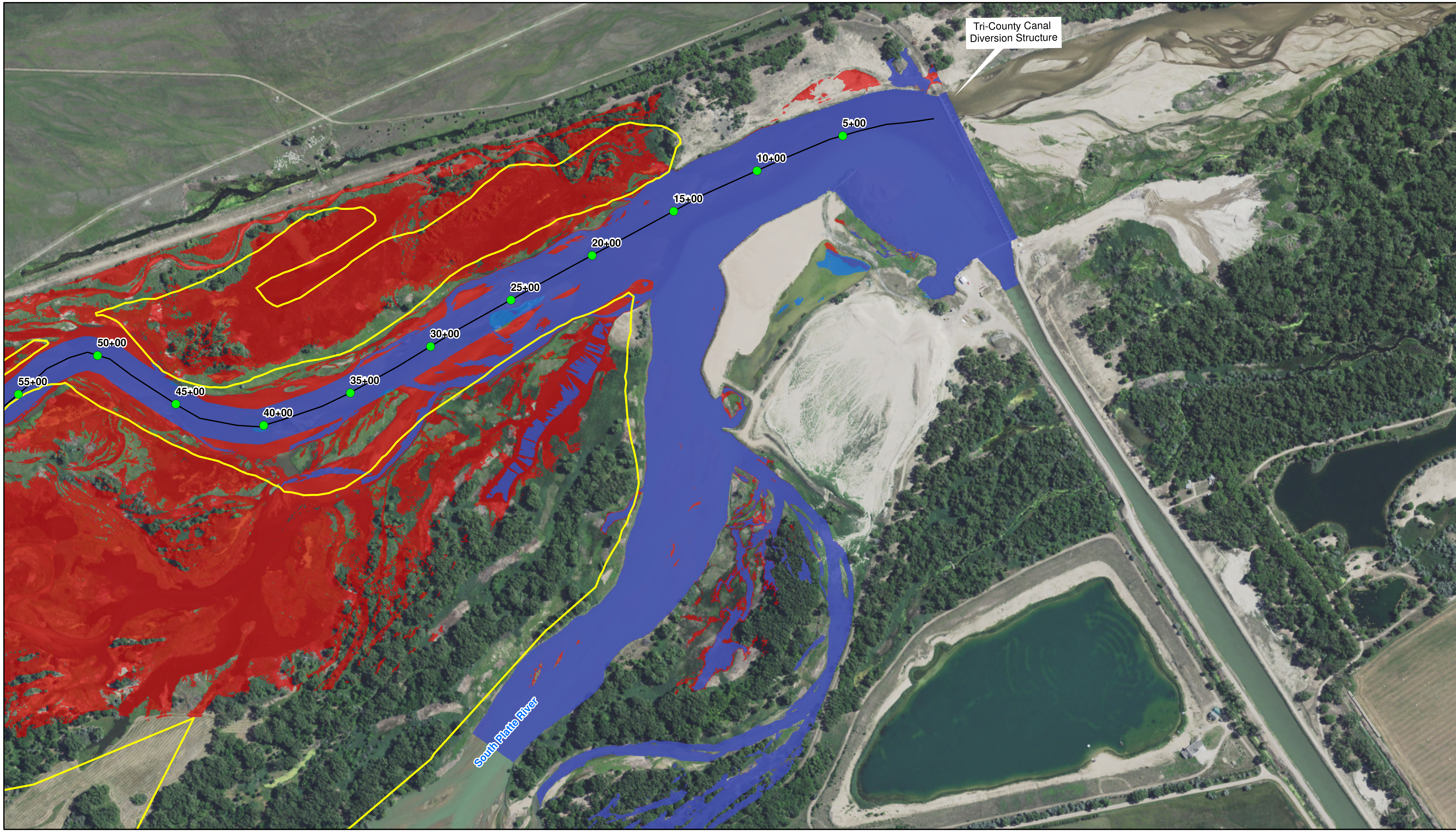

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Feet

SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 2000 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 2000 CFS

Existing Inundation 2000 CFS

Potential Wetland

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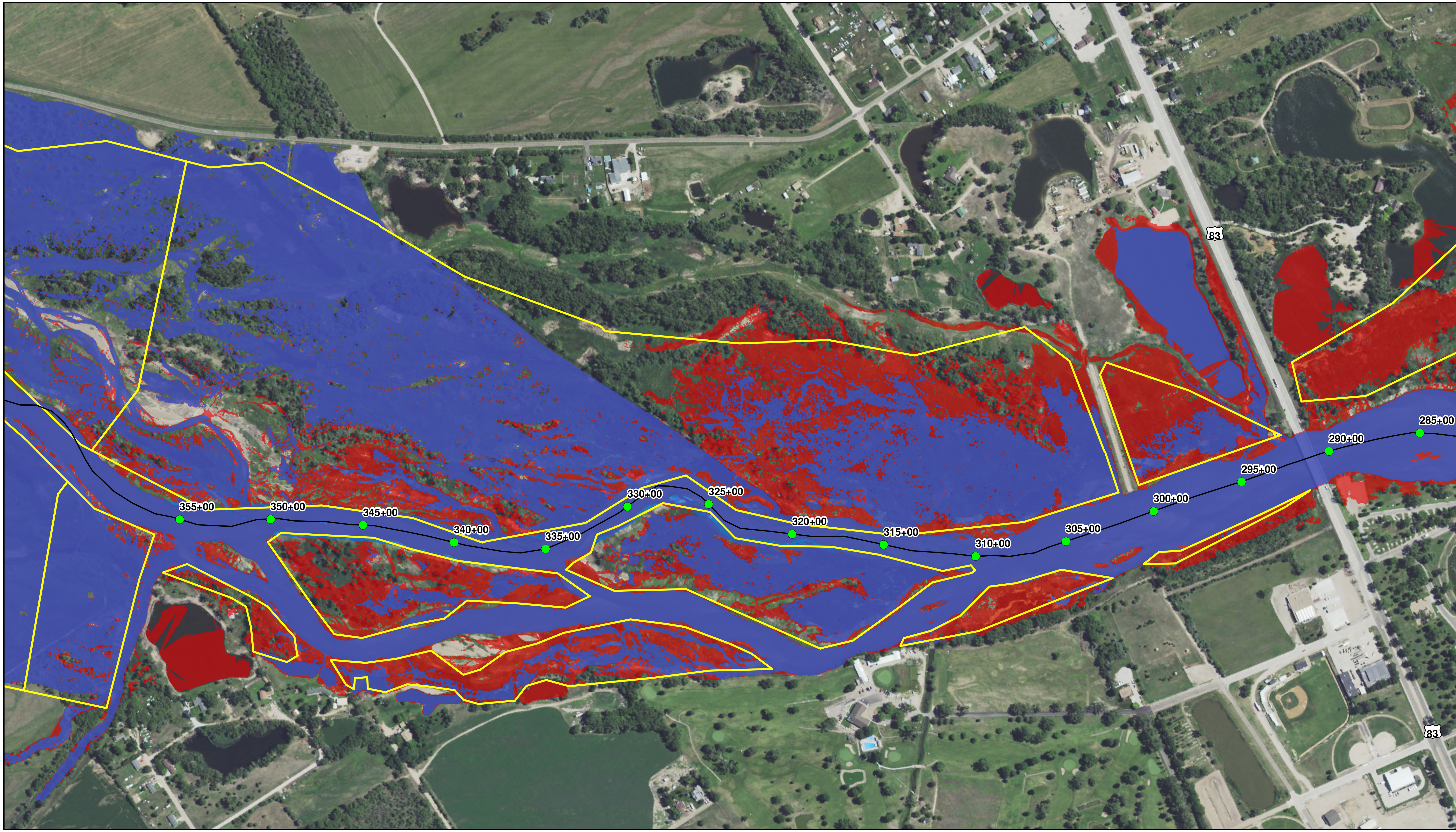

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Feet

SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 3000 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 3000 CFS

Existing Inundation 3000 CFS

Potential Wetland

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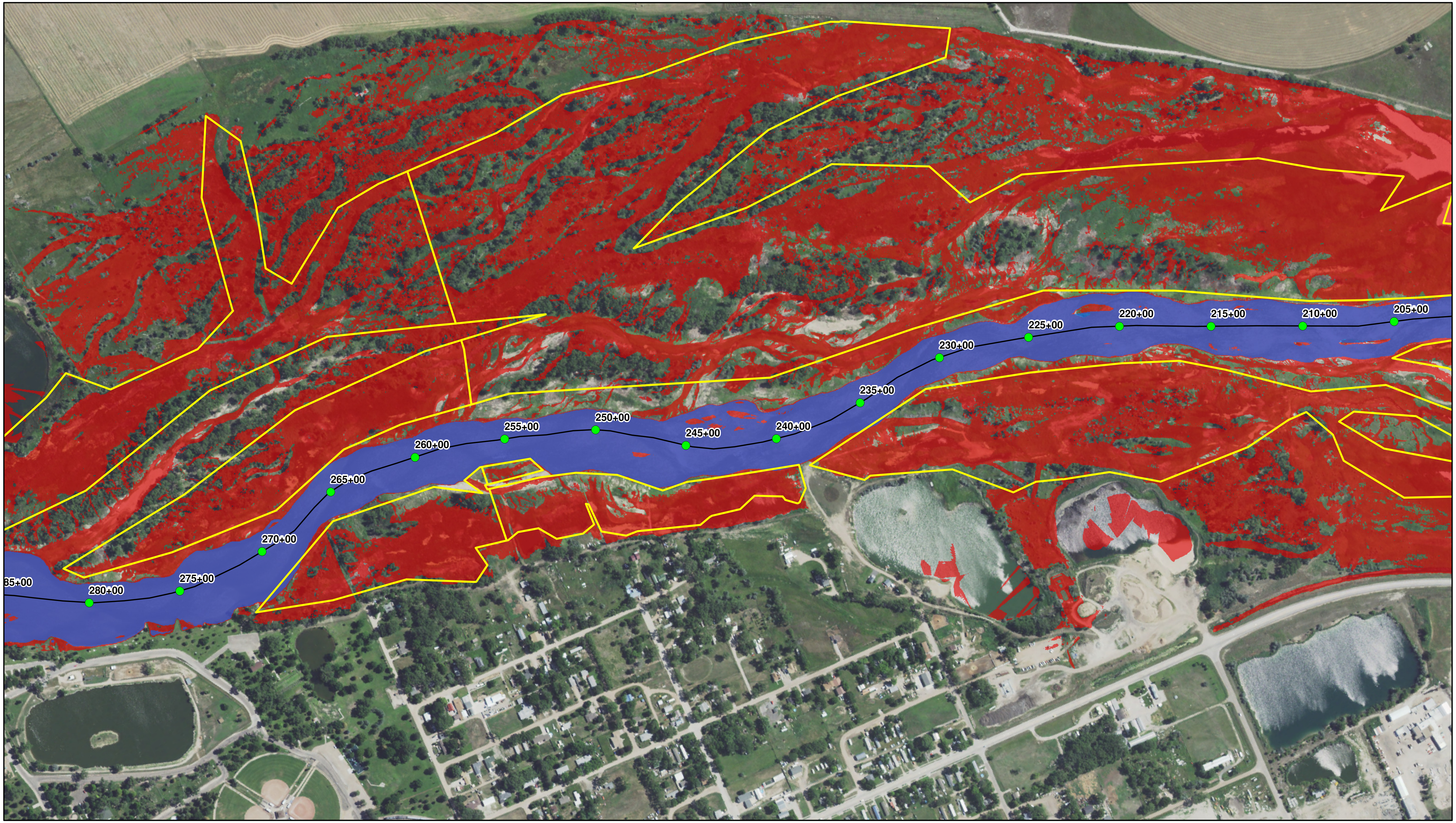

SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 3000 CFS

Legend

- Proposed Channel Centerline
- Proposed Inundation 3000 CFS
- Existing Inundation 3000 CFS
- Potential Wetland

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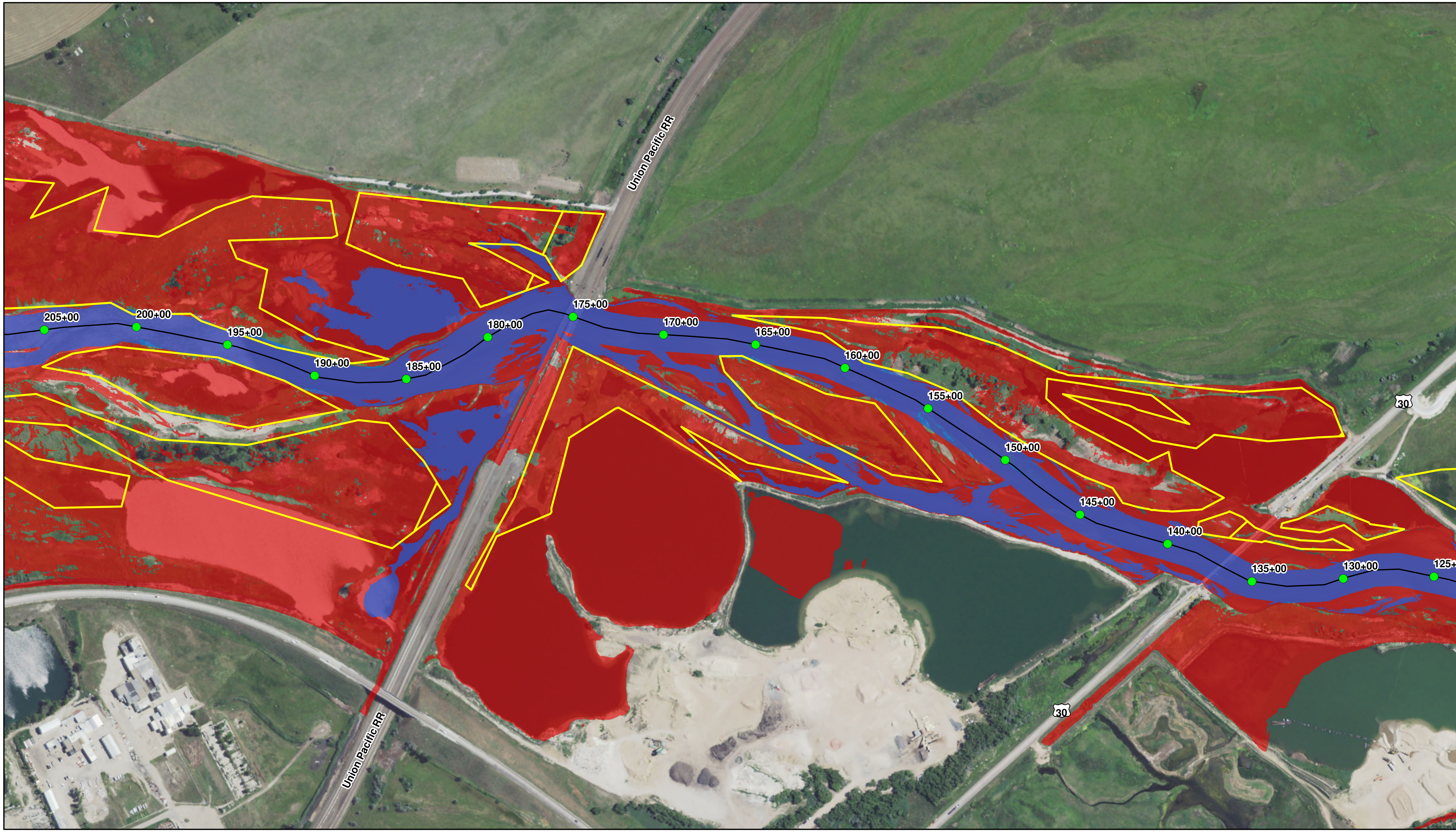

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Feet

SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 3000 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 3000 CFS

Existing Inundation 3000 CFS

Potential Wetland

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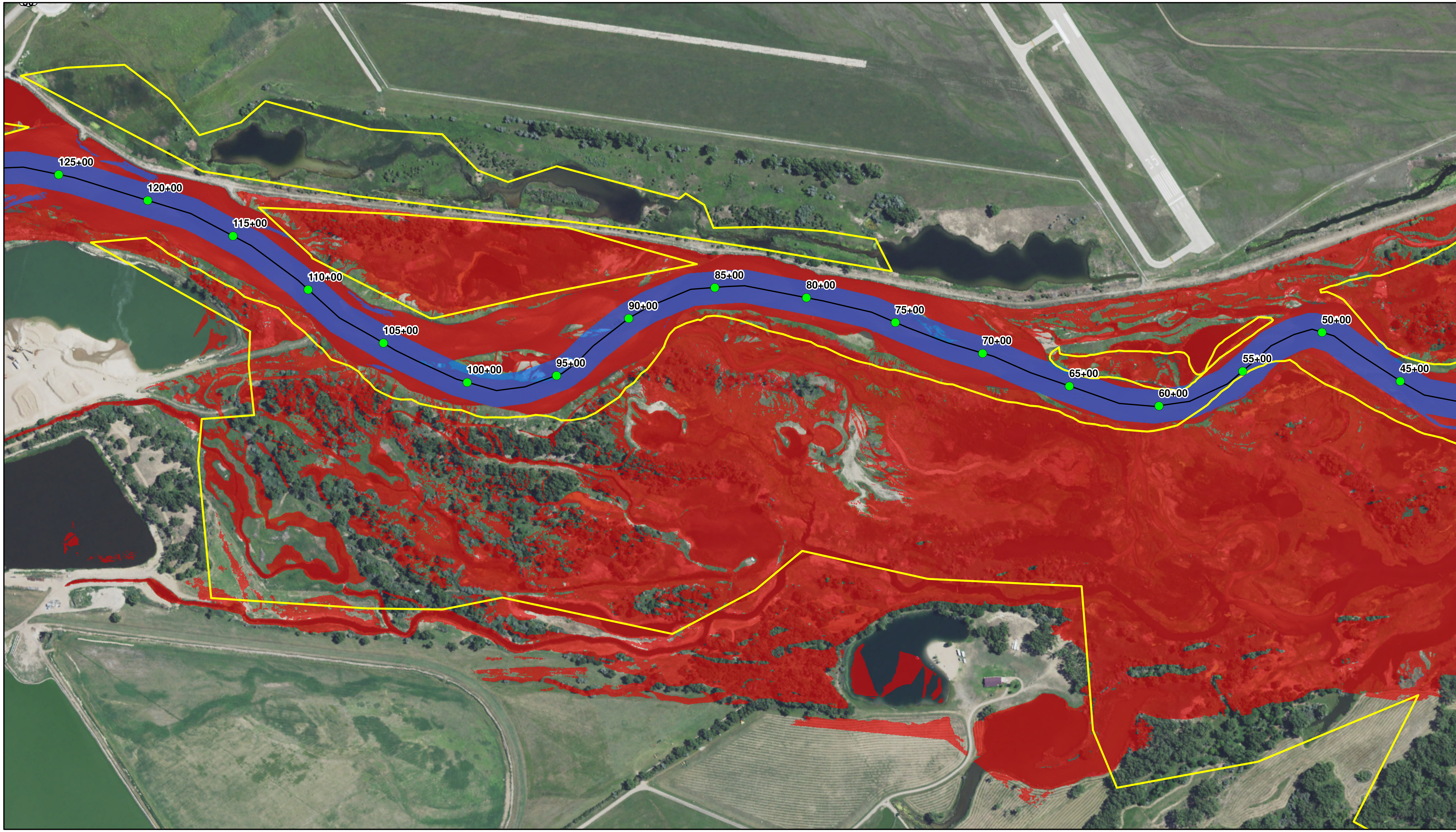

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Feet

SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 3000 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 3000 CFS

Existing Inundation 3000 CFS

Potential Wetland

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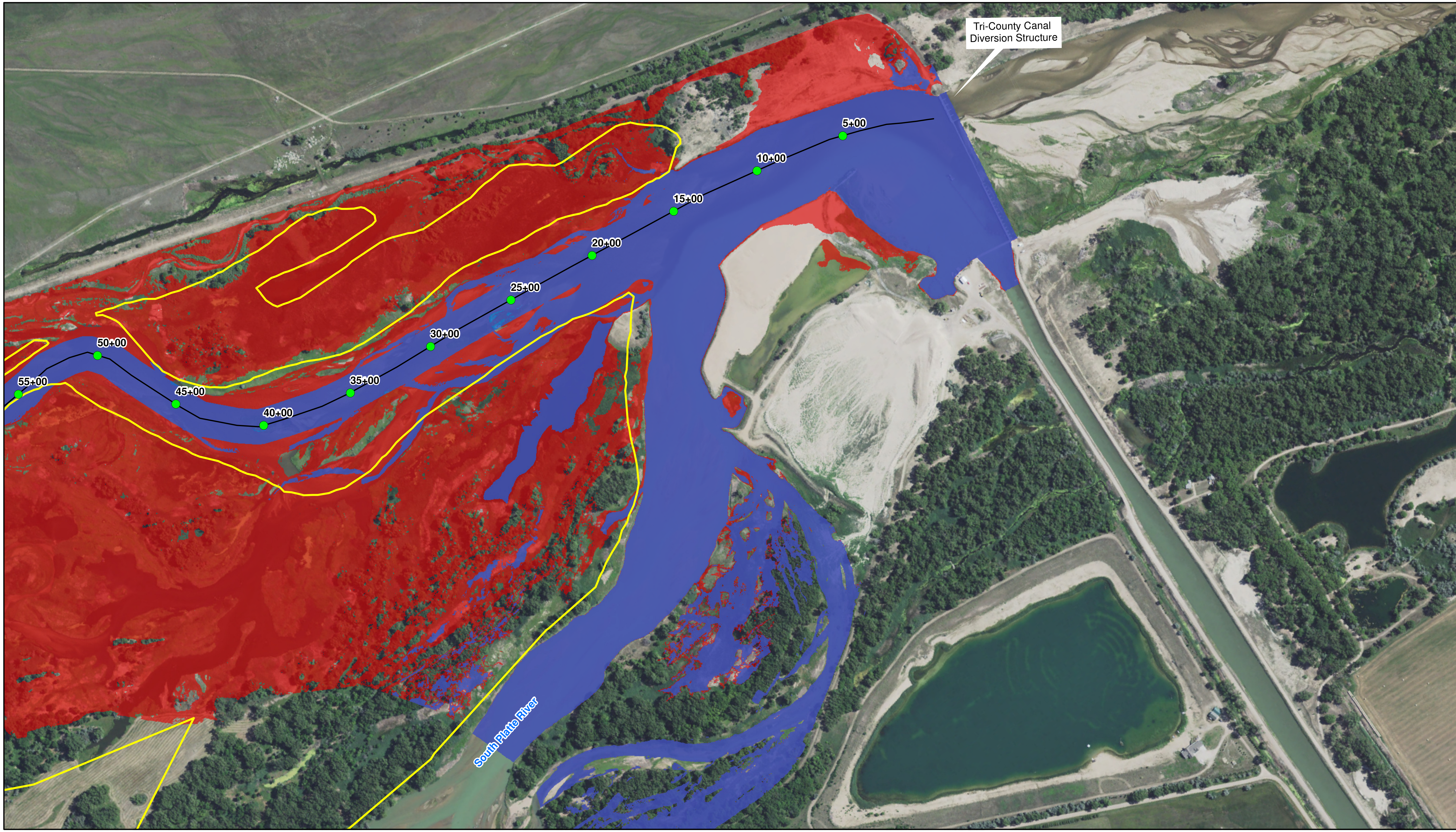

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SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 3000 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 3000 CFS

Existing Inundation 3000 CFS

Potential Wetland

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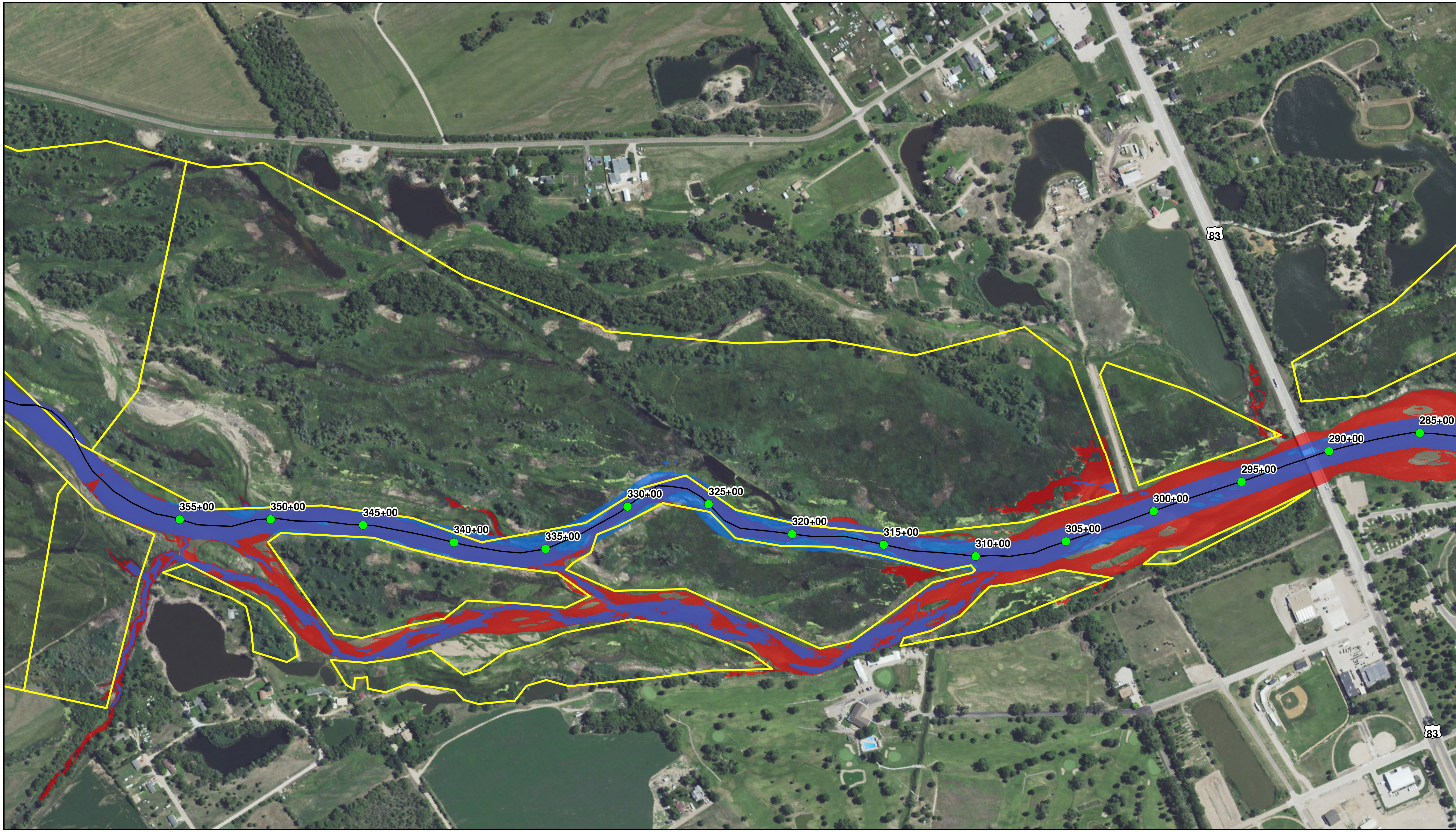

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Feet

SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 400 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 400 CFS

Existing Inundation 400 CFS

Potential Wetland

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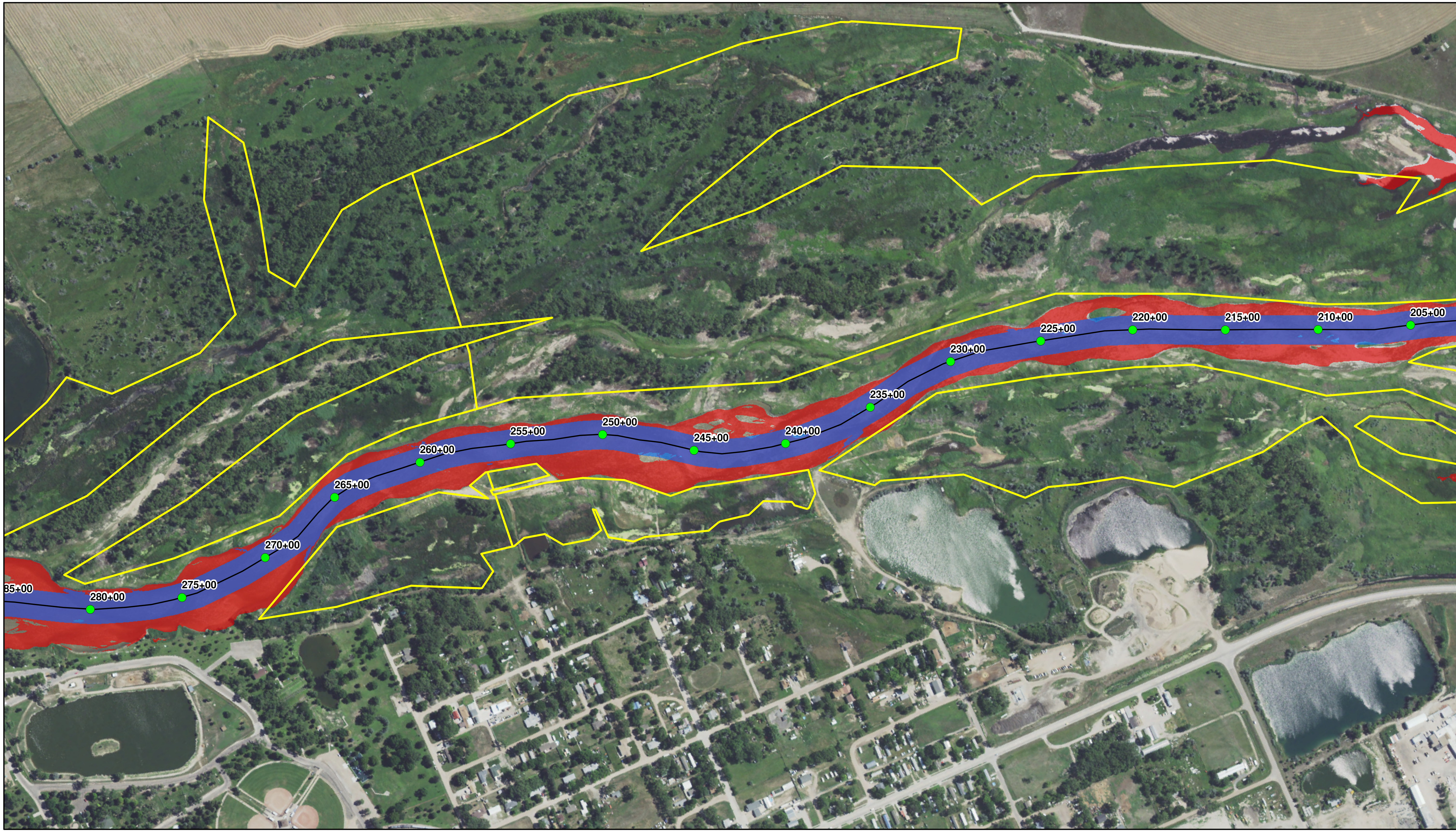

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SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 400 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 400 CFS

Existing Inundation 400 CFS

Potential Wetland

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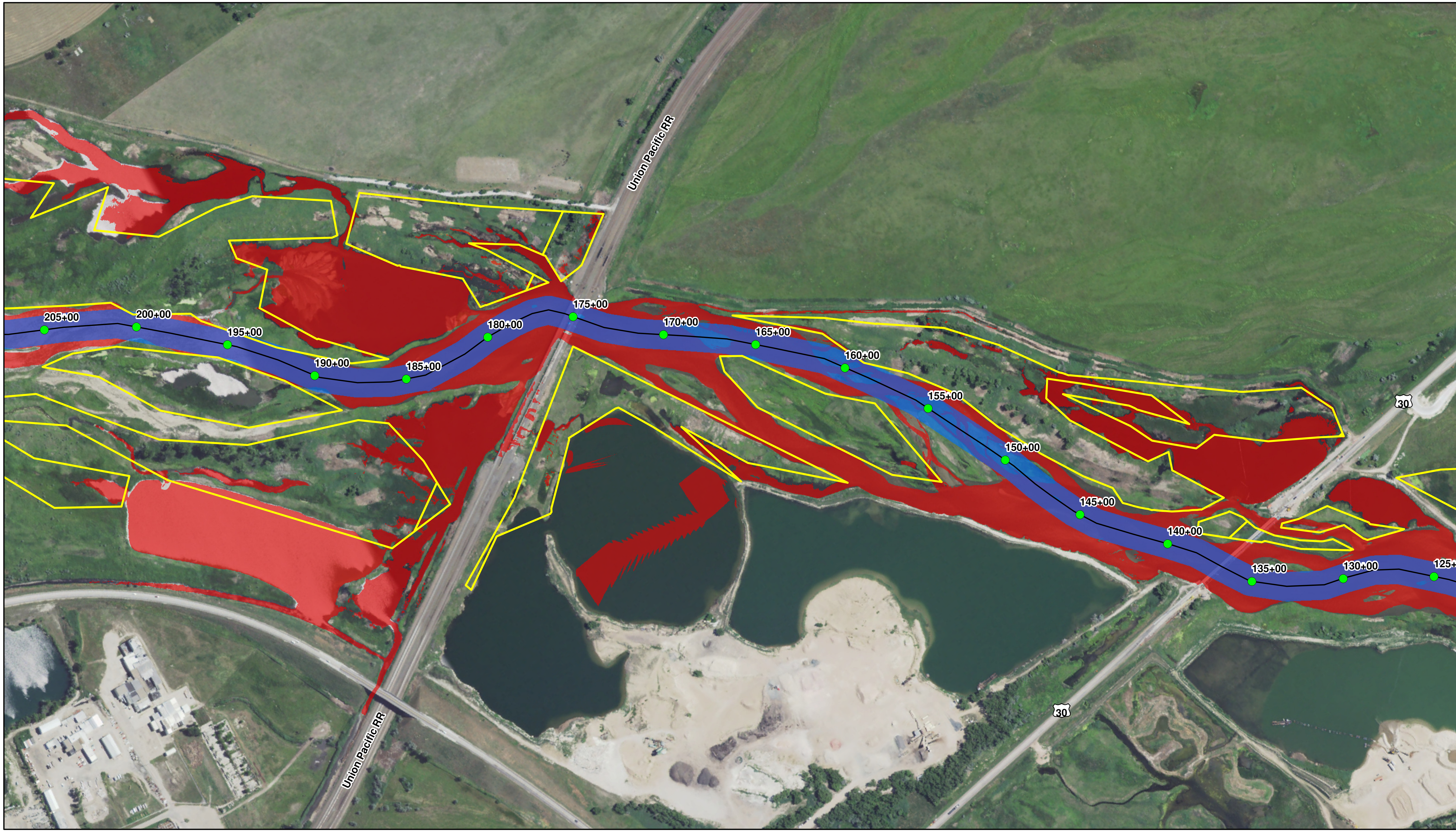

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SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 400 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 400 CFS

Existing Inundation 400 CFS

Potential Wetland

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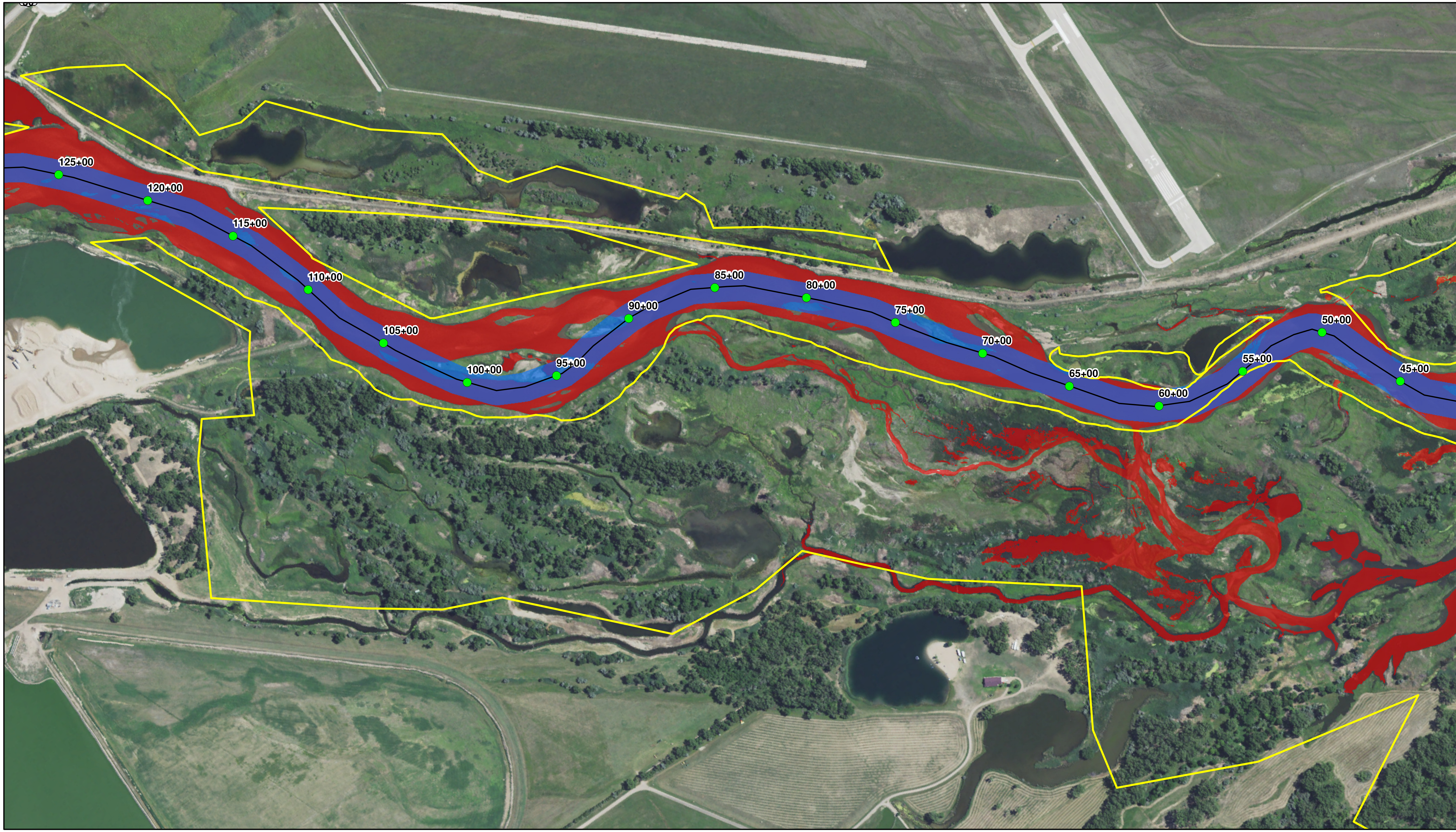

N E S W

0 250 500 1,000

Feet

SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 400 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 400 CFS

Existing Inundation 400 CFS

Potential Wetland

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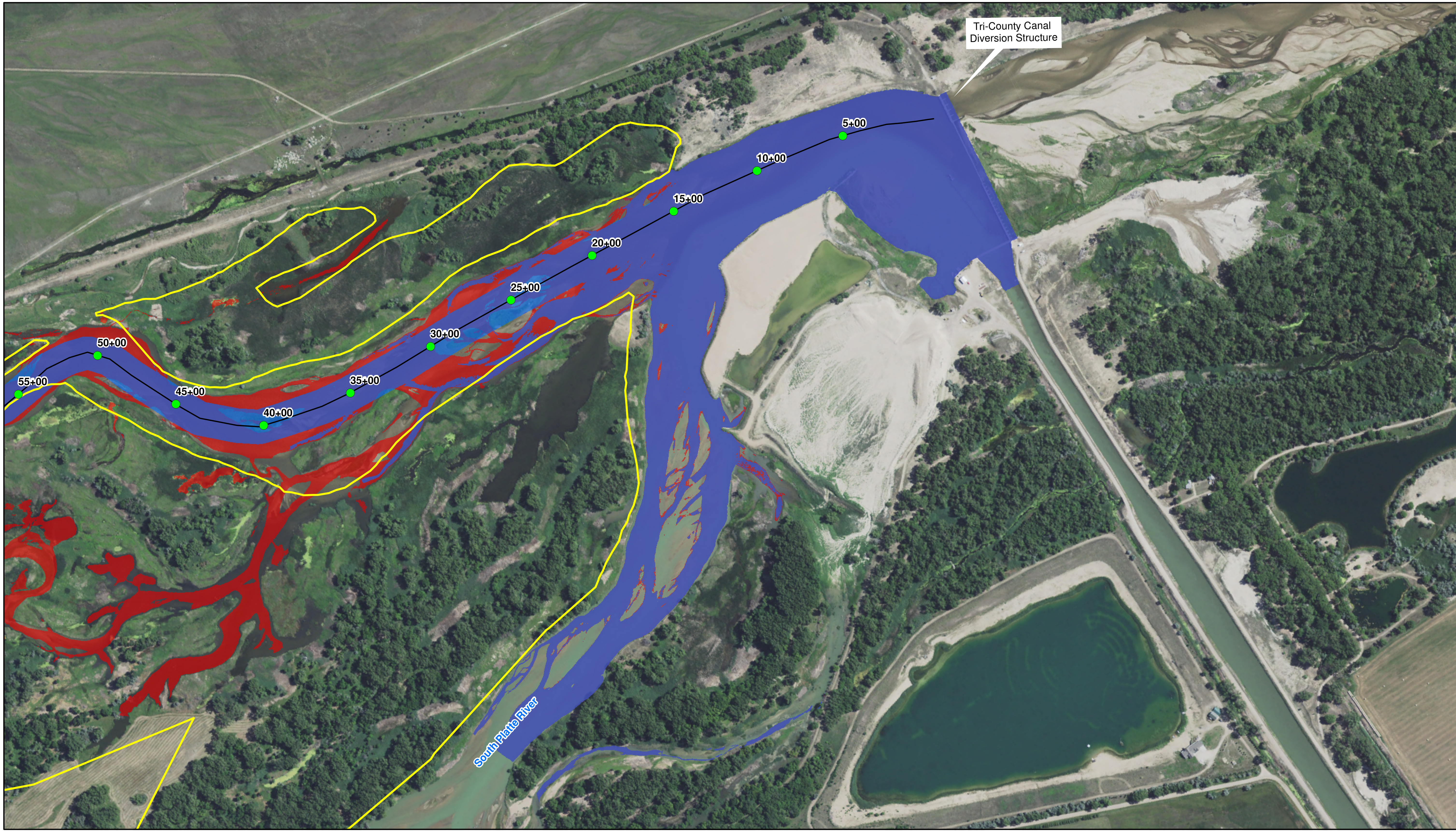

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SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 400 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 400 CFS

Existing Inundation 400 CFS

Potential Wetland

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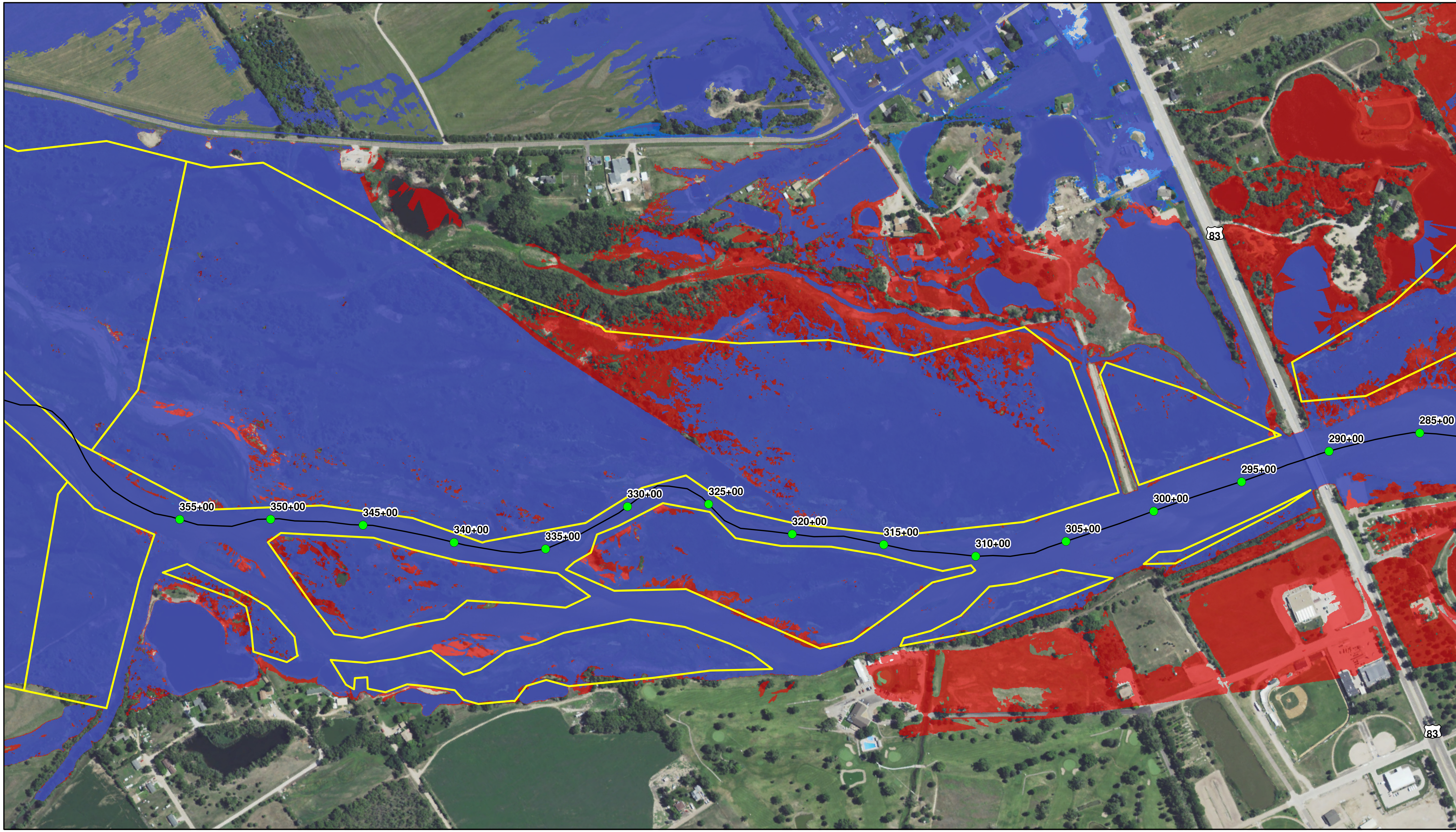

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Feet

SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 6000 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 6000 CFS

Existing Inundation 6000 CFS

Potential Wetland

Anderson Consulting Engineers, Inc.
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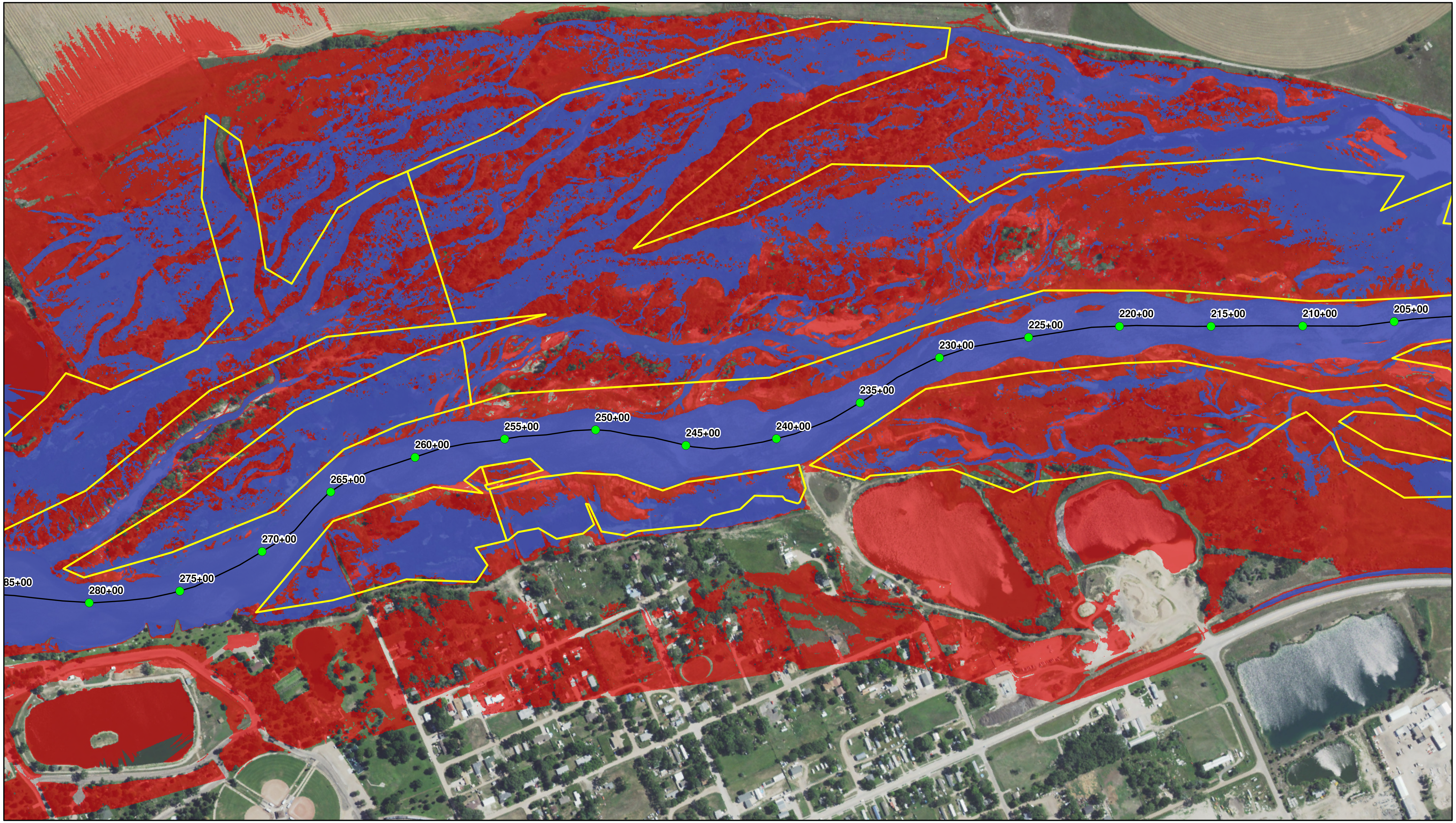

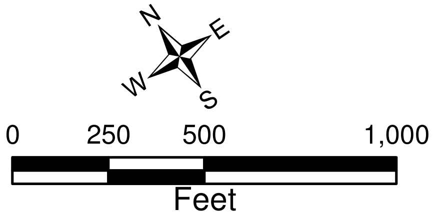

SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 6000 CFS

Legend

- Proposed Channel Centerline
- Proposed Inundation 6000 CFS
- Existing Inundation 6000 CFS
- Potential Wetland

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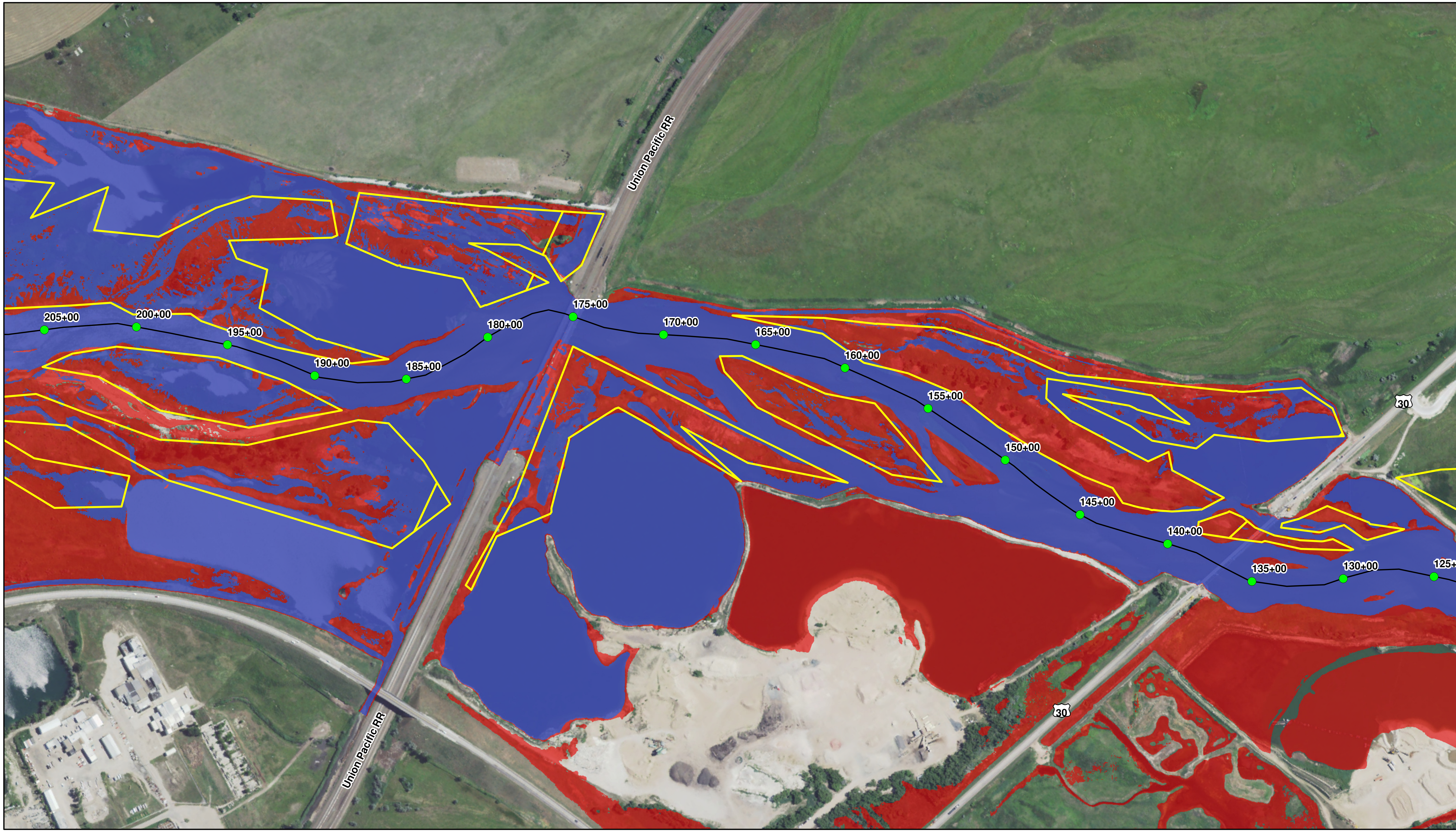

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SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 6000 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 6000 CFS

Existing Inundation 6000 CFS

Potential Wetland

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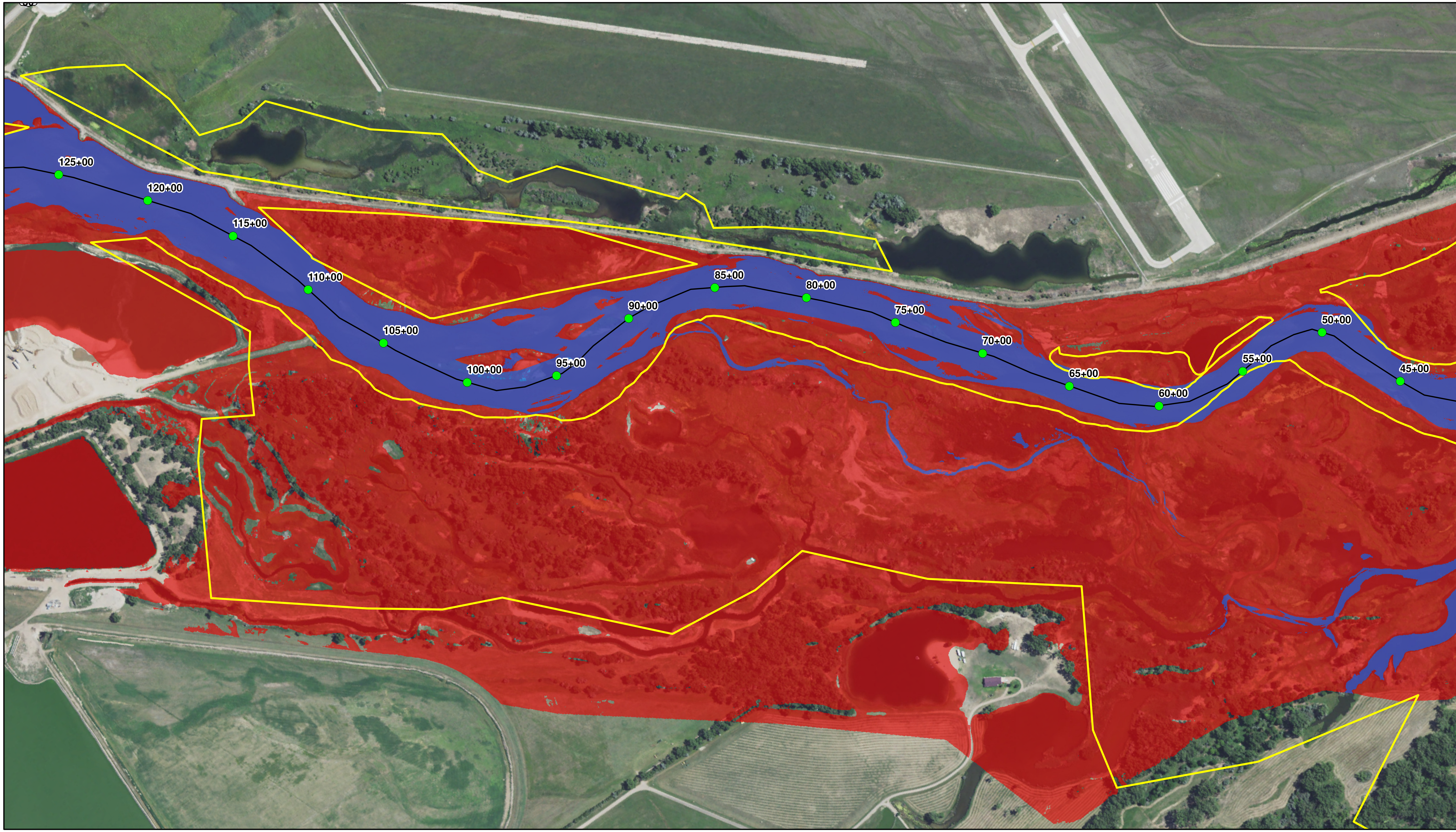

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SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 6000 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 6000 CFS

Existing Inundation 6000 CFS

Potential Wetland

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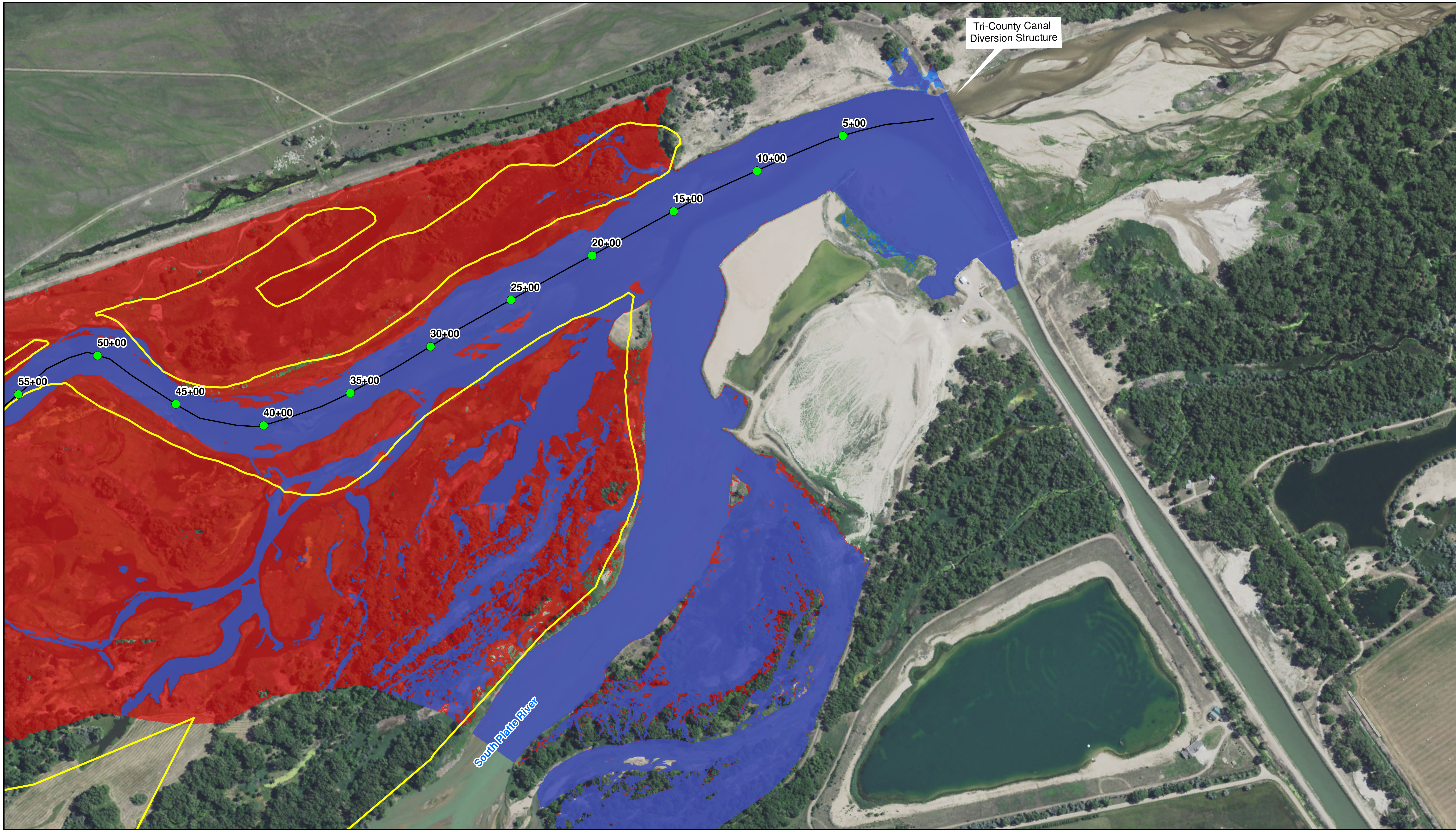

N E W S

0 250 500 1,000

Feet

SEDIMENT REMOVAL ALTERNATIVE
INUNDATION MAPPING 6000 CFS

Legend

Proposed Channel Centerline

Proposed Inundation 6000 CFS

Existing Inundation 6000 CFS

Potential Wetland

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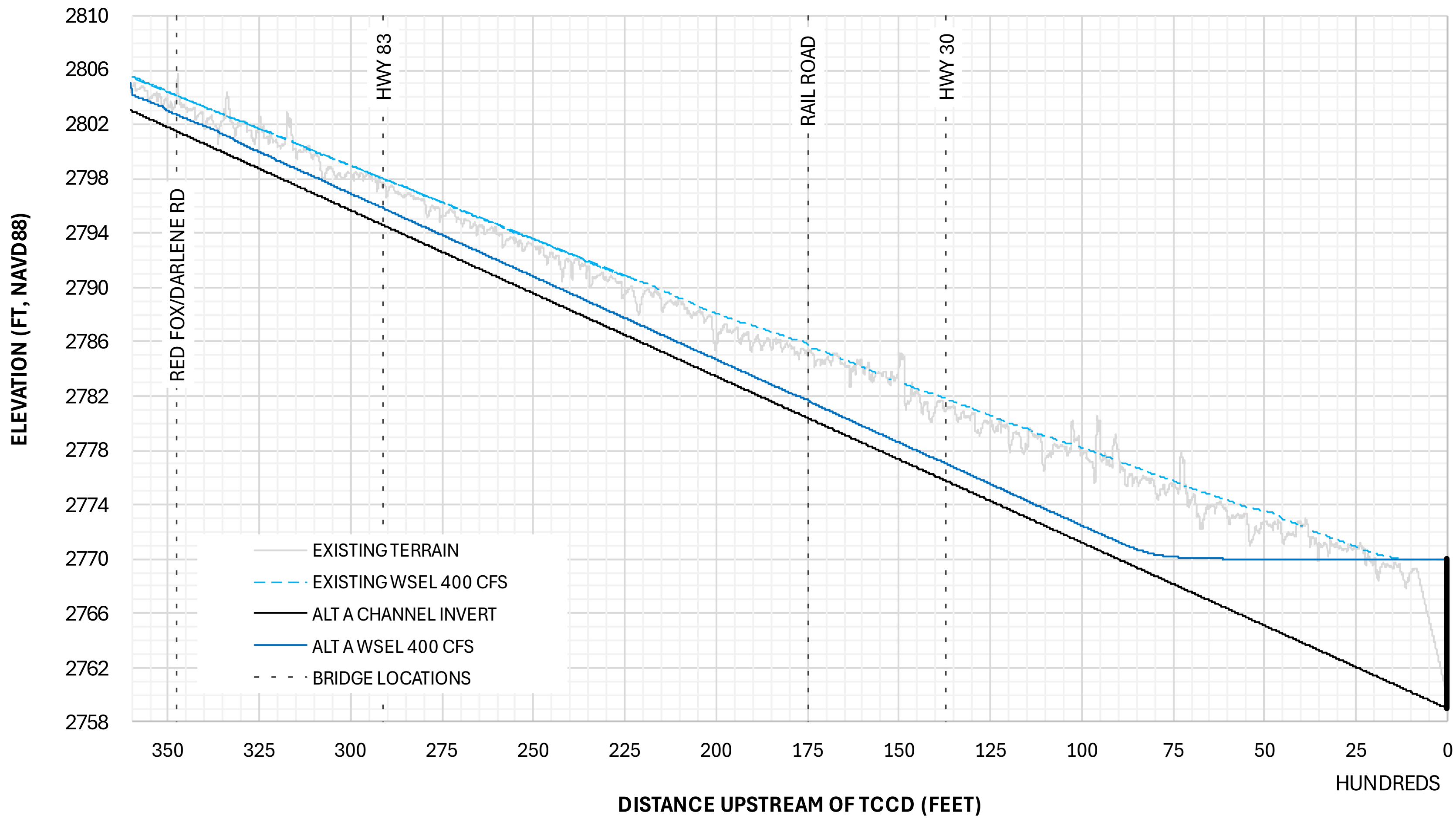


Figure 1 Existing and Sediment Removal Alt A Water Surface Profile 400 cfs (Baseflow)

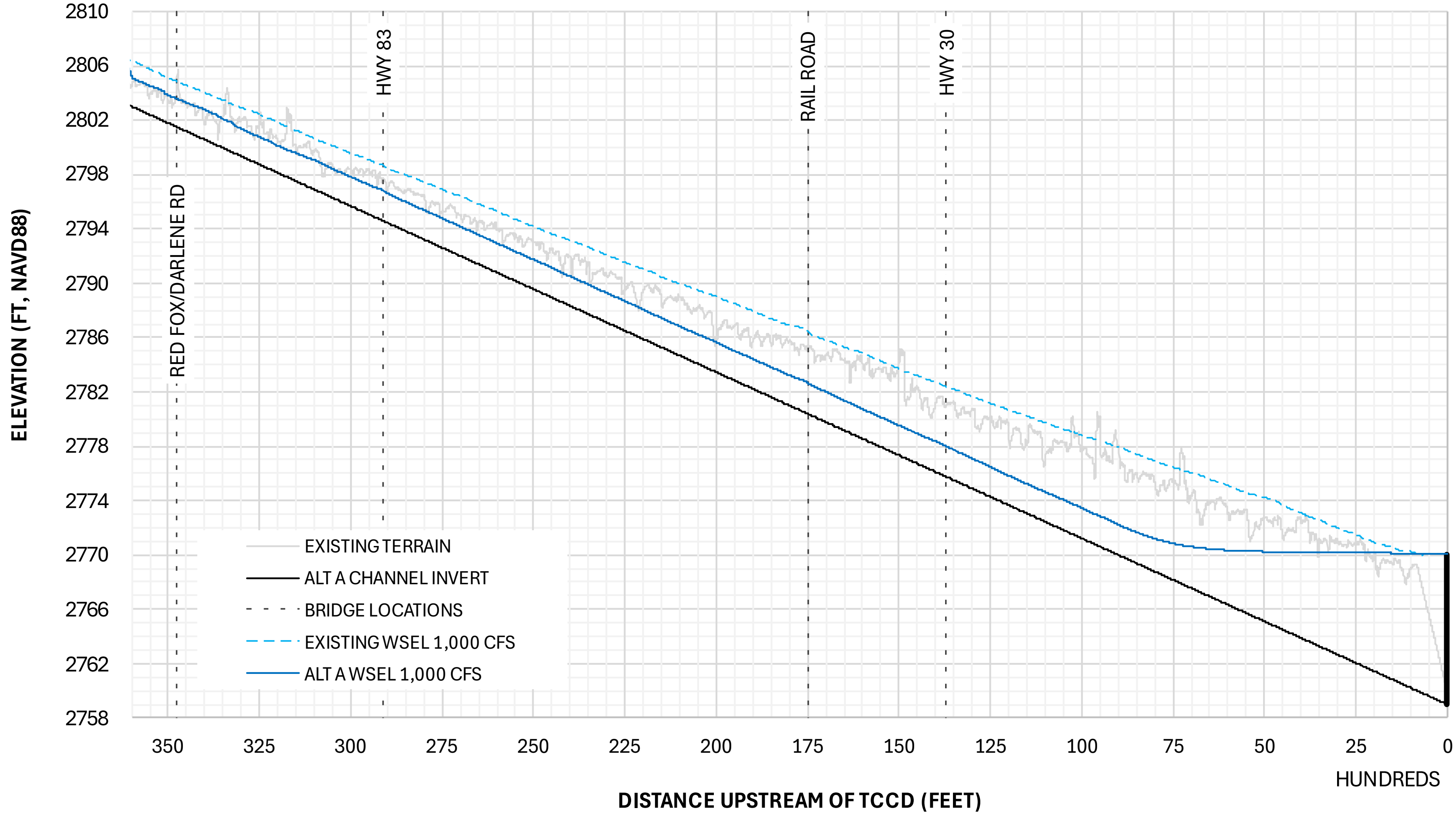


Figure 2 Existing and Sediment Removal Alt A Water Surface Profile 1,000 cfs

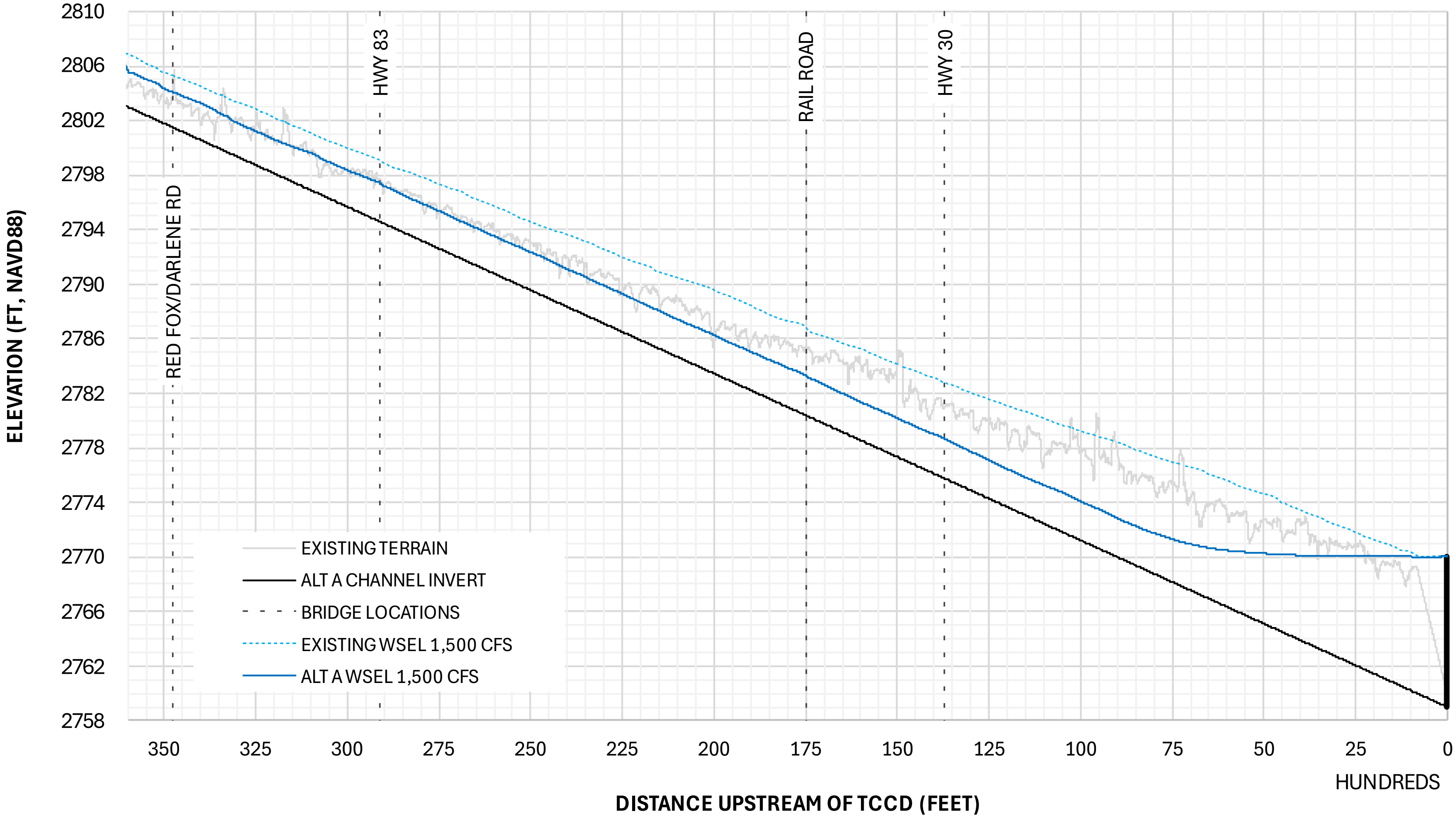


Figure 3 Existing and Sediment Removal Alt A Water Surface Profile 1.500 cfs

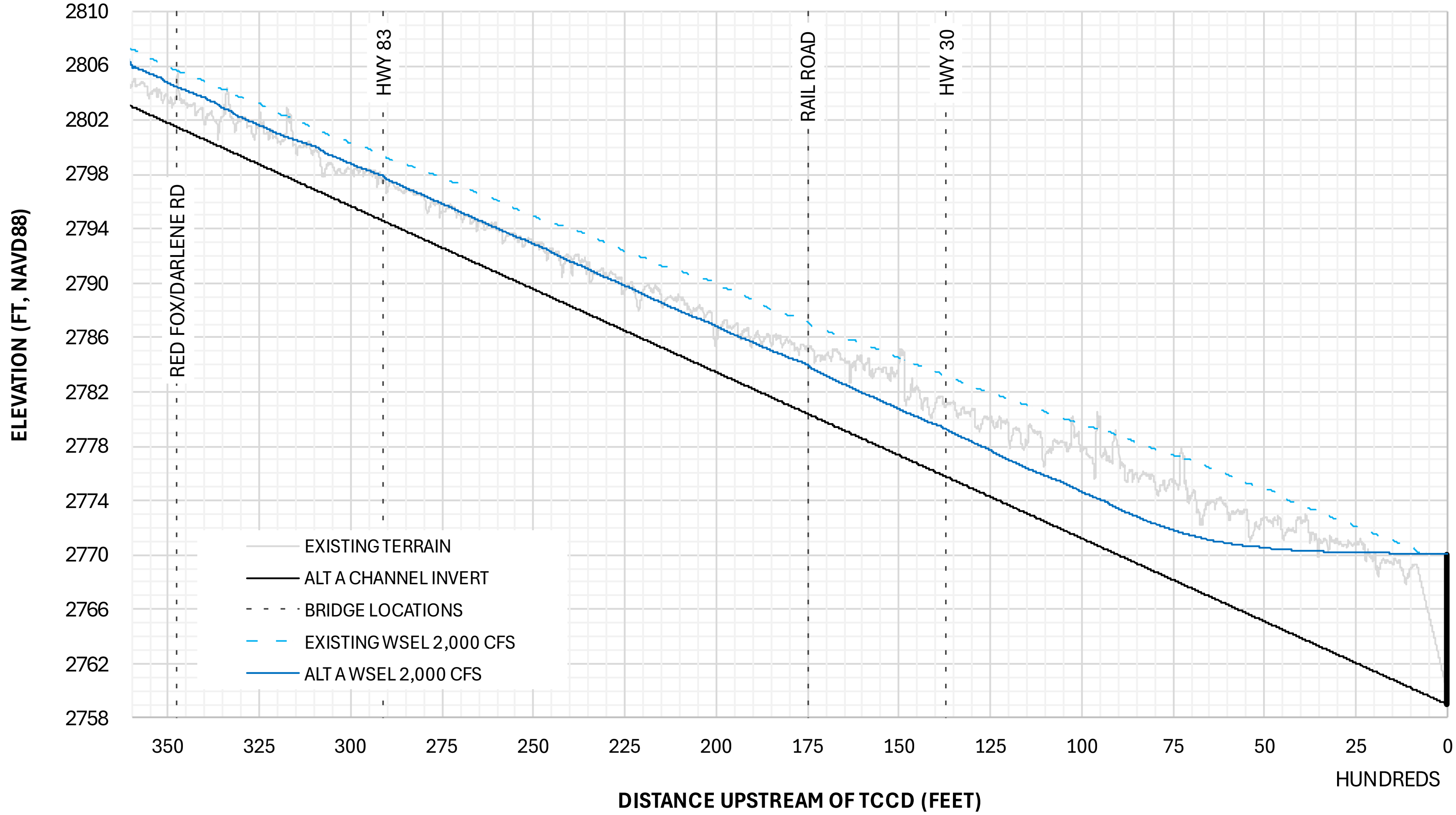


Figure 4 Existing and Sediment Removal Alt A Water Surface Profile 2,000 cfs

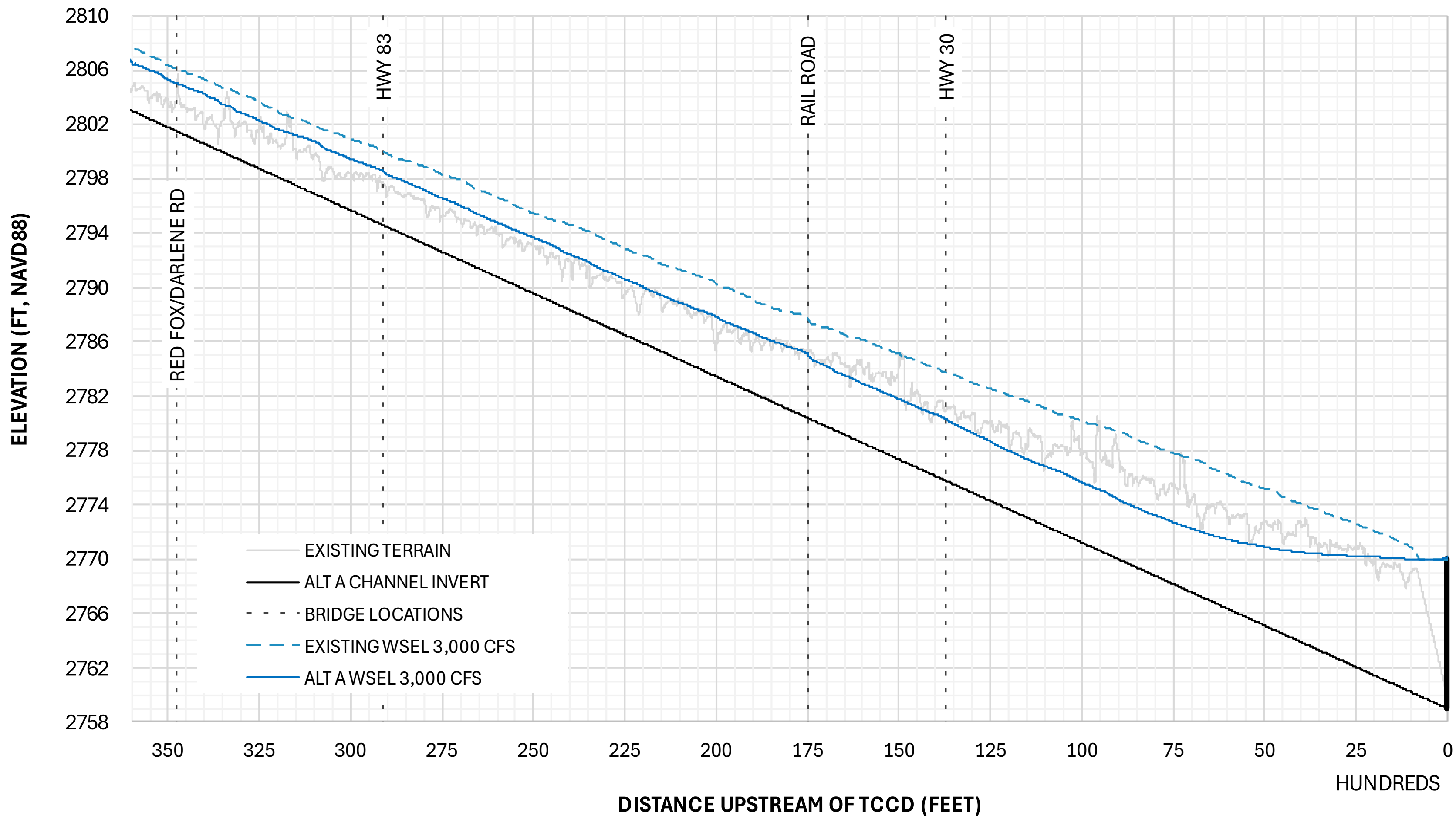


Figure 4 Existing and Sediment Removal Alt A Water Surface Profile 3,000 cfs

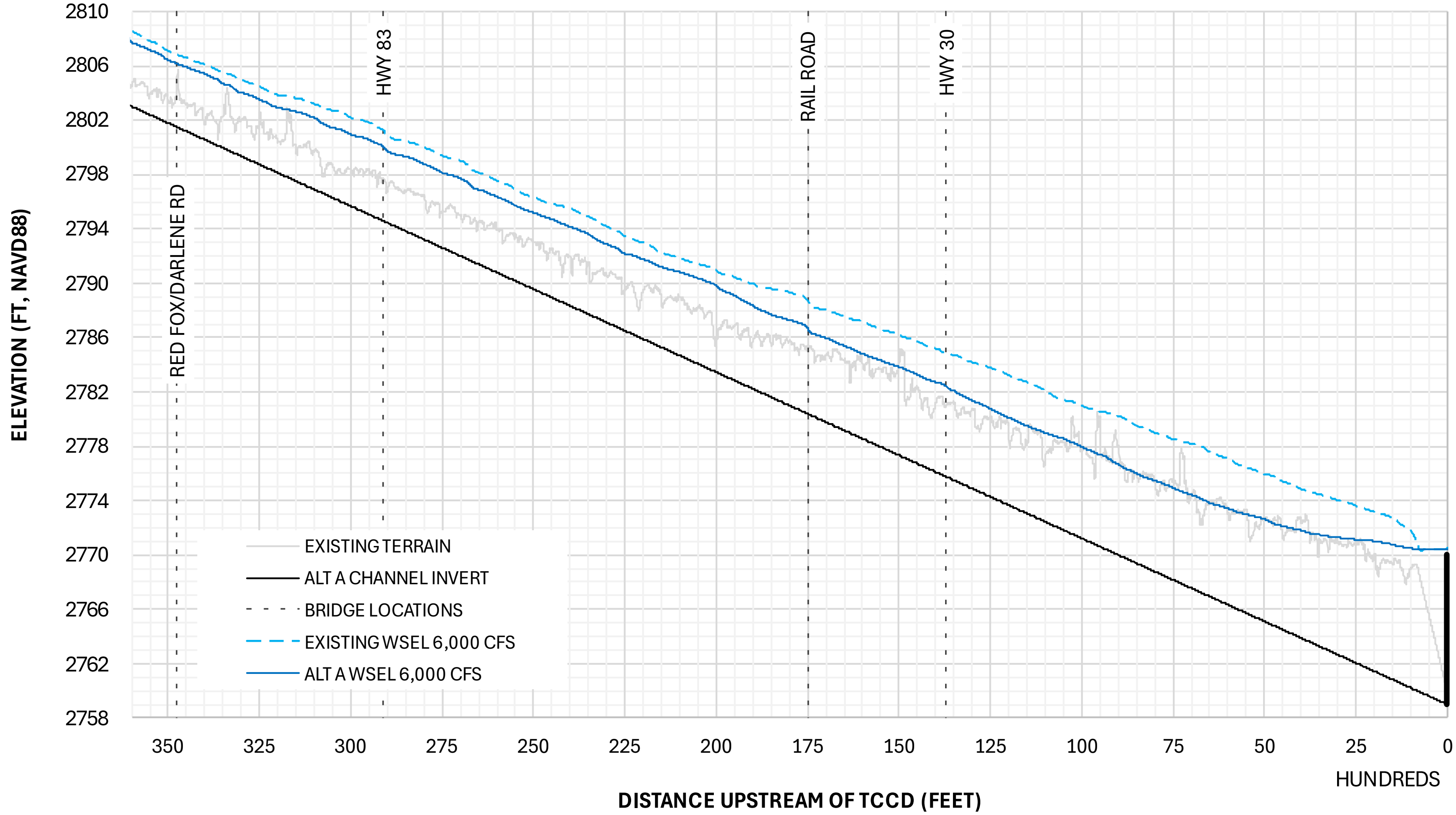


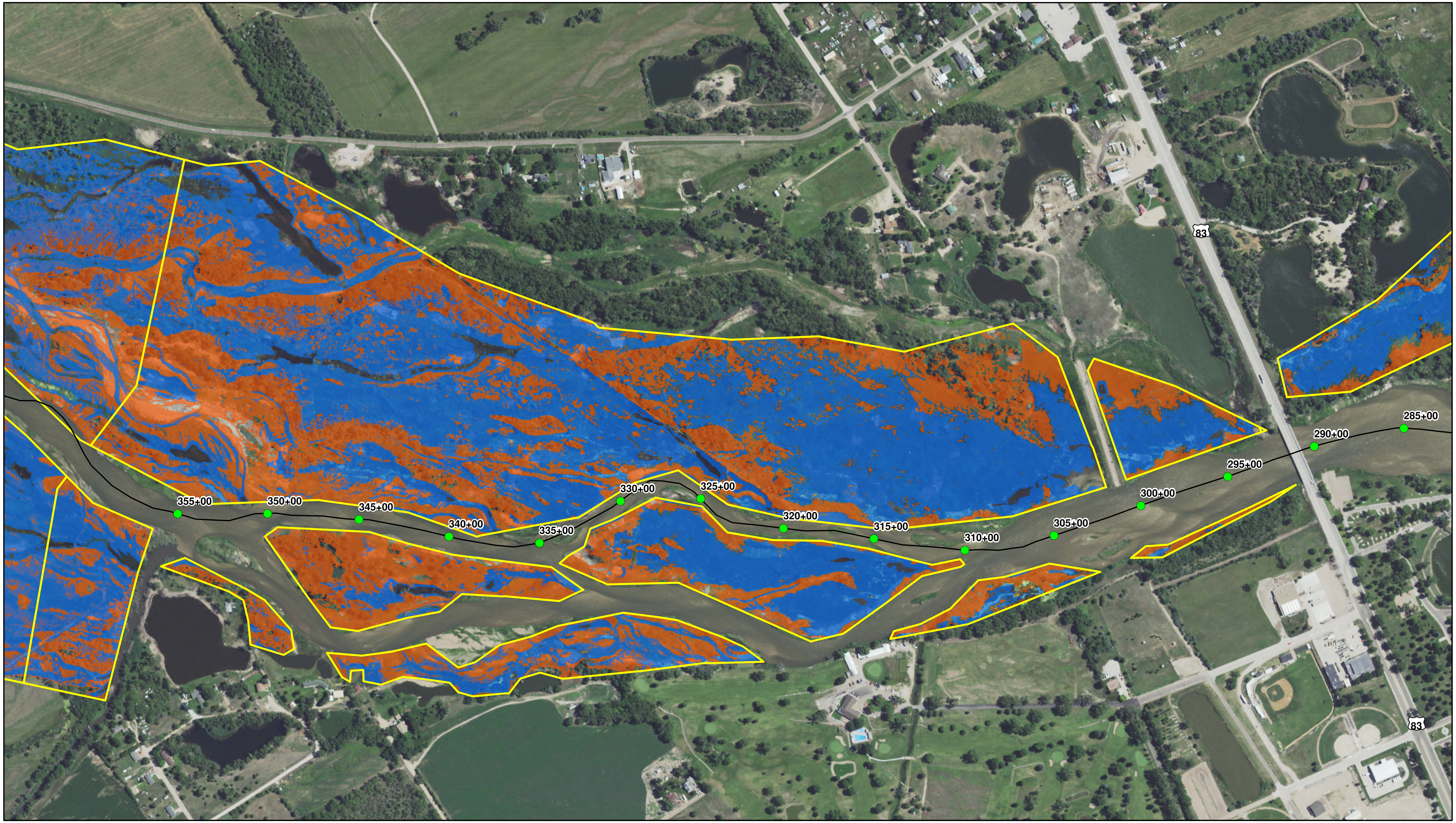
Figure 4 Existing and Sediment Removal Alt A Water Surface Profile 6,000 cfs

North Platte River - Estimated Change in Groundwater

Wetland areas with groundwater depth between 0 and 1.5 feet, based on compouted water surface elevation in

Flow	Existing	Sed Removal Alt A	Area of Wetlands with Groundwater Depth >1.5 feet (acres)	
	Area of Wetlands with Groundwater Depths < 1.5 feet (acres)			
400 CFS	401	62	339	Baseflow
1000 CFS	395	190	205	

North Platte channel.



N E W S

0 250 500 1,000

Feet

ESTIMATED GROUNDWATER
COMPARISON 1000 CFS

Legend

Proposed Channel Centerline

Proposed Groundwater Estimate

Existing Groundwater Estimate

Potential Wetland

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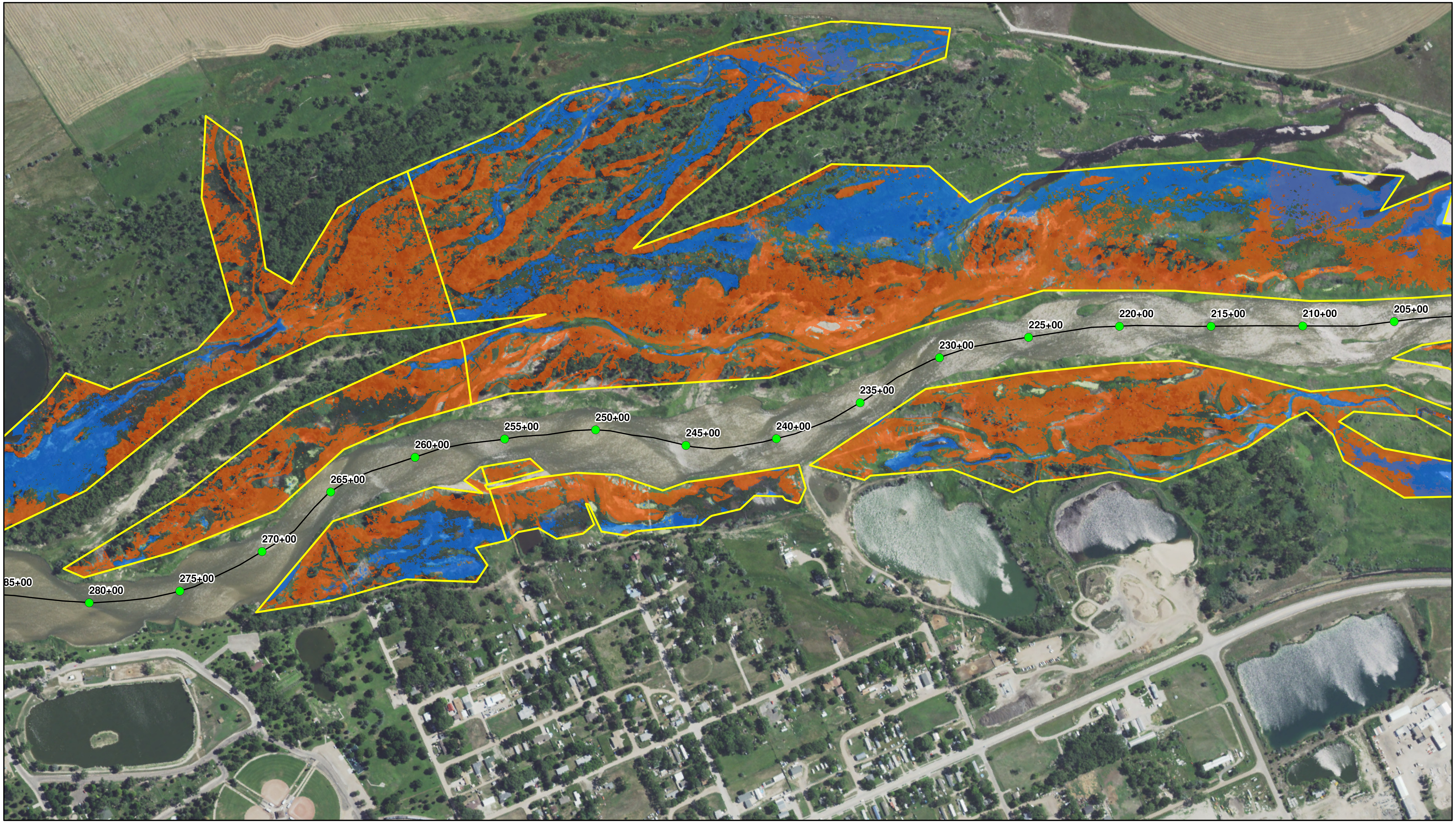

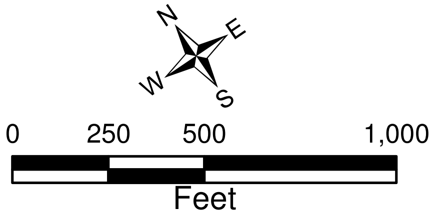

ESTIMATED GROUNDWATER
COMPARISON 1000 CFS

Legend

Proposed Channel Centerline

Proposed Groundwater Estimate

Existing Groundwater Estimate

Potential Wetland

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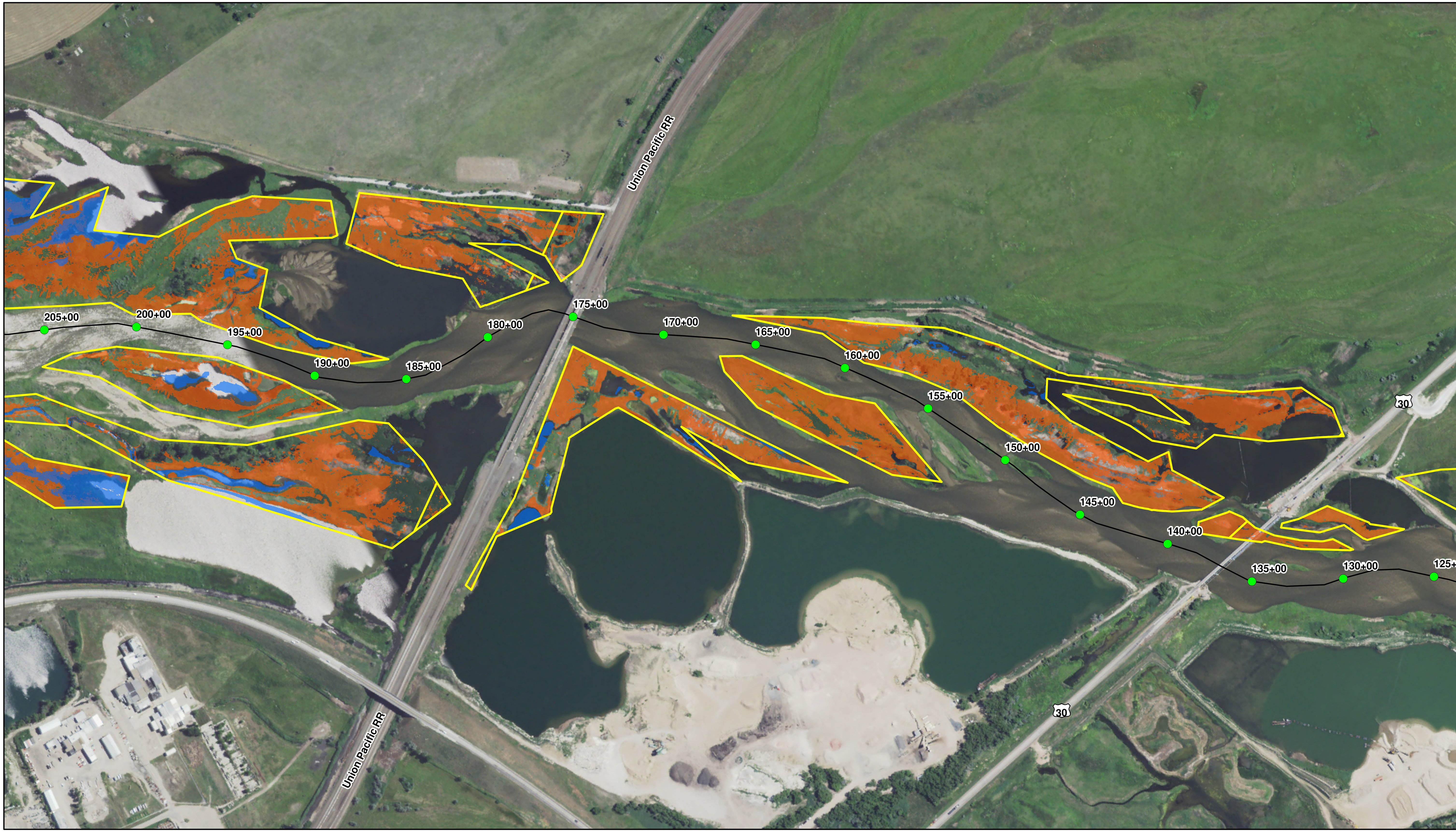

ESTIMATED GROUNDWATER COMPARISON 1000 CFS

Legend

Proposed Channel Centerline

Proposed Groundwater Estimate

Existing Groundwater Estimate

Potential Wetland

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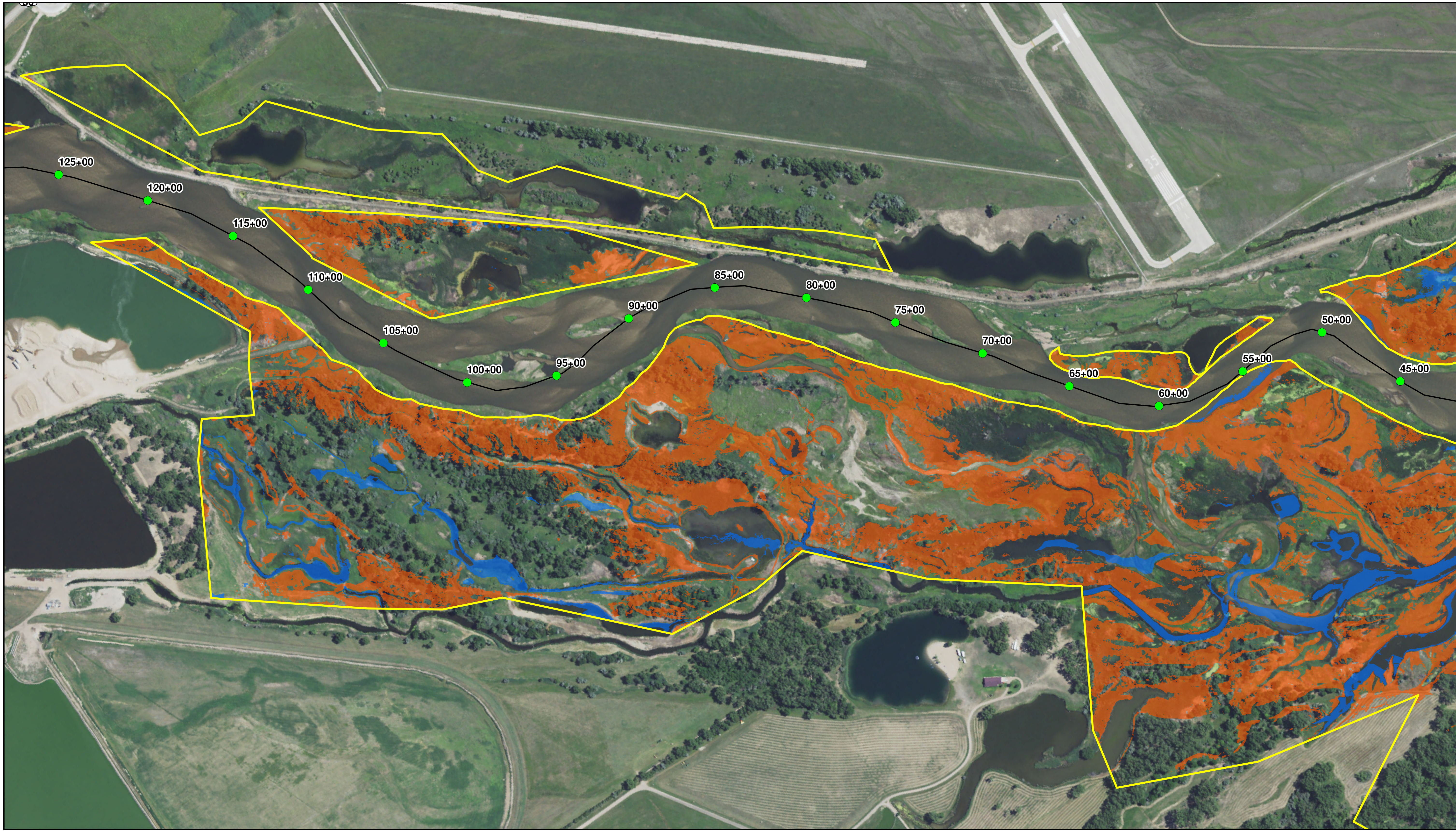

N E S W

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Feet

ESTIMATED GROUNDWATER
COMPARISON 1000 CFS

Legend

Proposed Channel Centerline

Proposed Groundwater Estimate

Existing Groundwater Estimate

Potential Wetland

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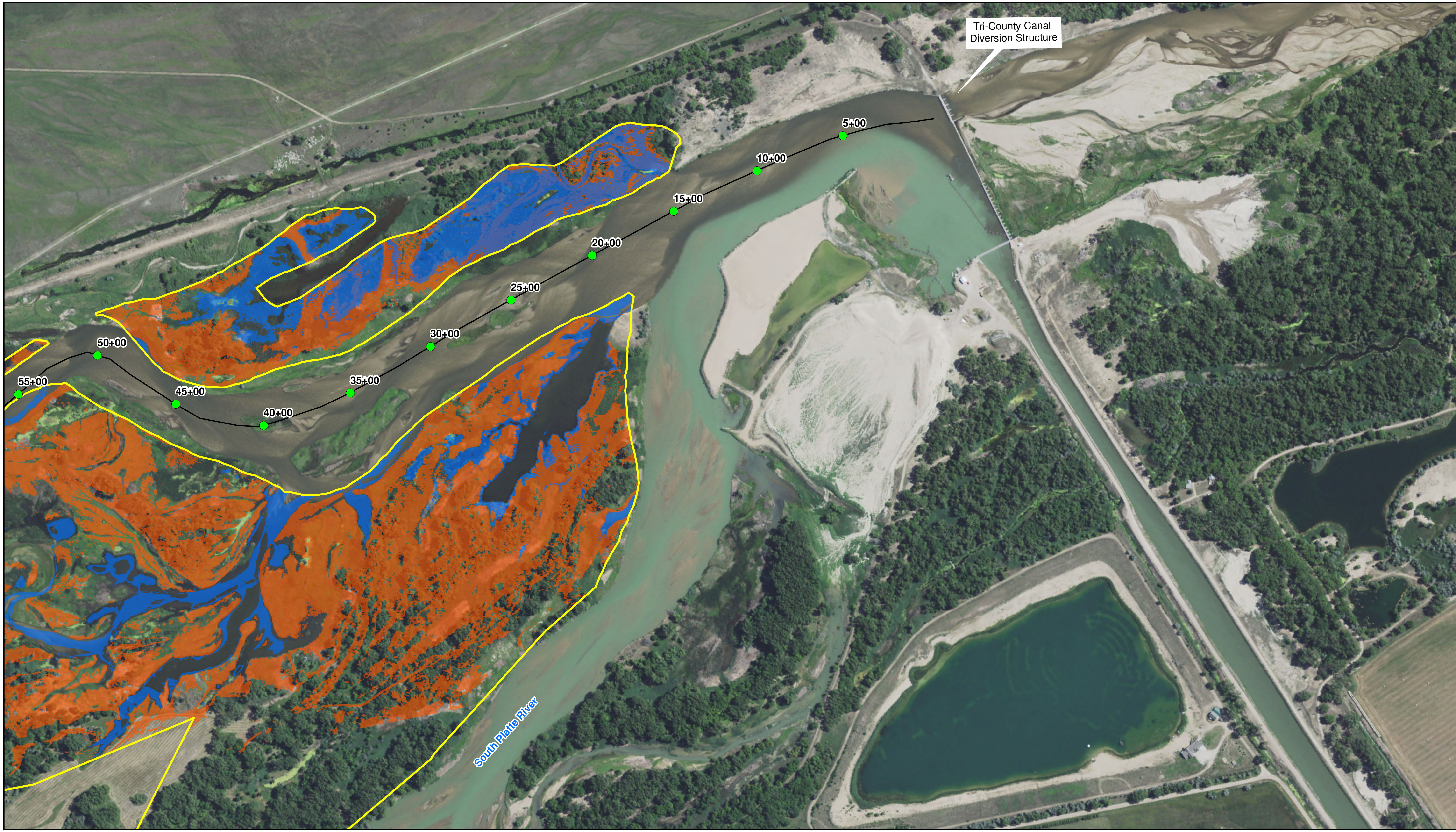

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Feet

ESTIMATED GROUNDWATER
COMPARISON 1000 CFS

Legend

Proposed Channel Centerline

Proposed Groundwater Estimate

Existing Groundwater Estimate

Potential Wetland

Anderson Consulting Engineers, Inc.
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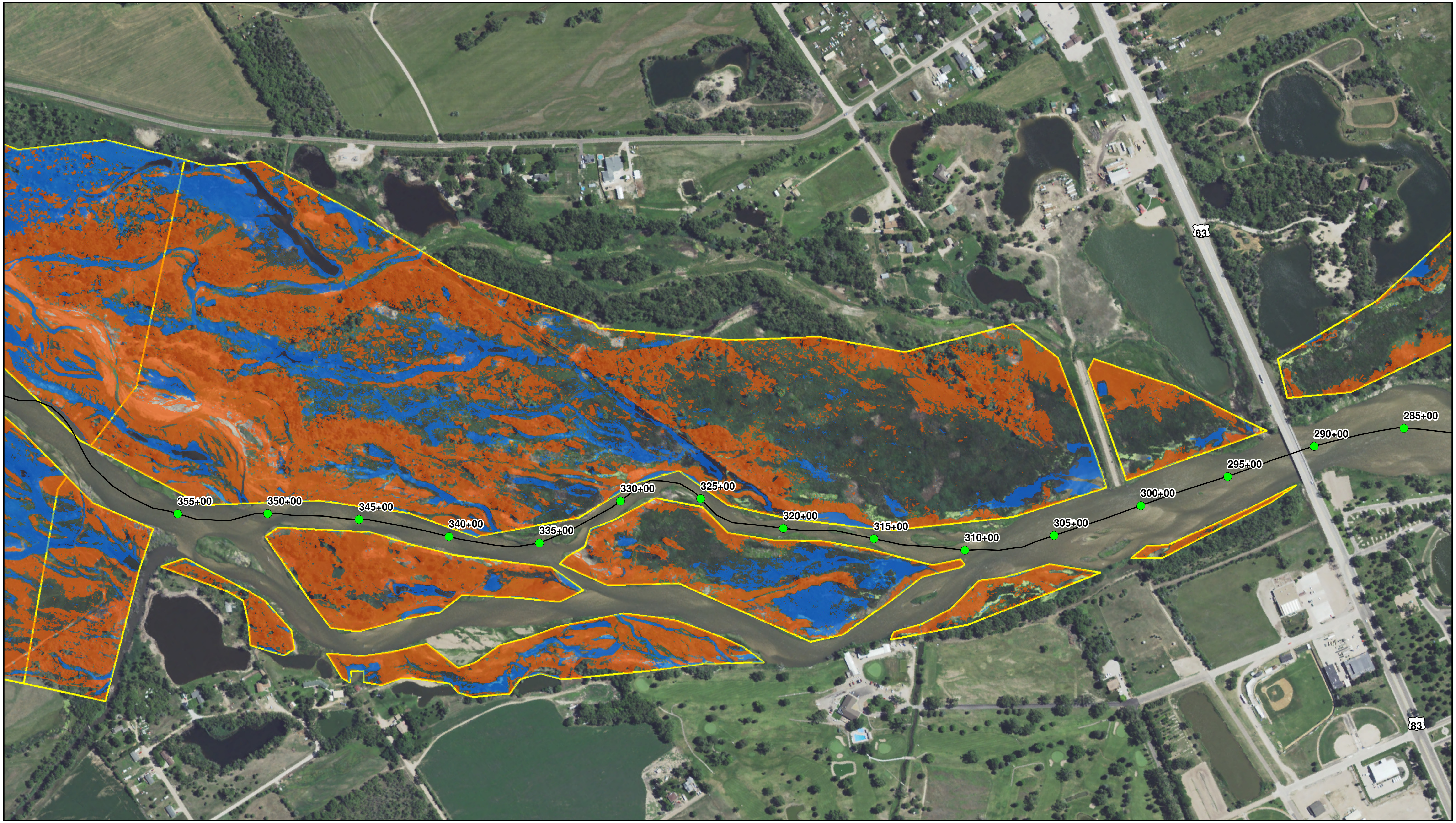

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Feet

ESTIMATED GROUNDWATER COMPARISON 400 CFS

Legend

Proposed Channel Centerline

Proposed Groundwater Estimate

Existing Groundwater Estimate

Potential Wetland

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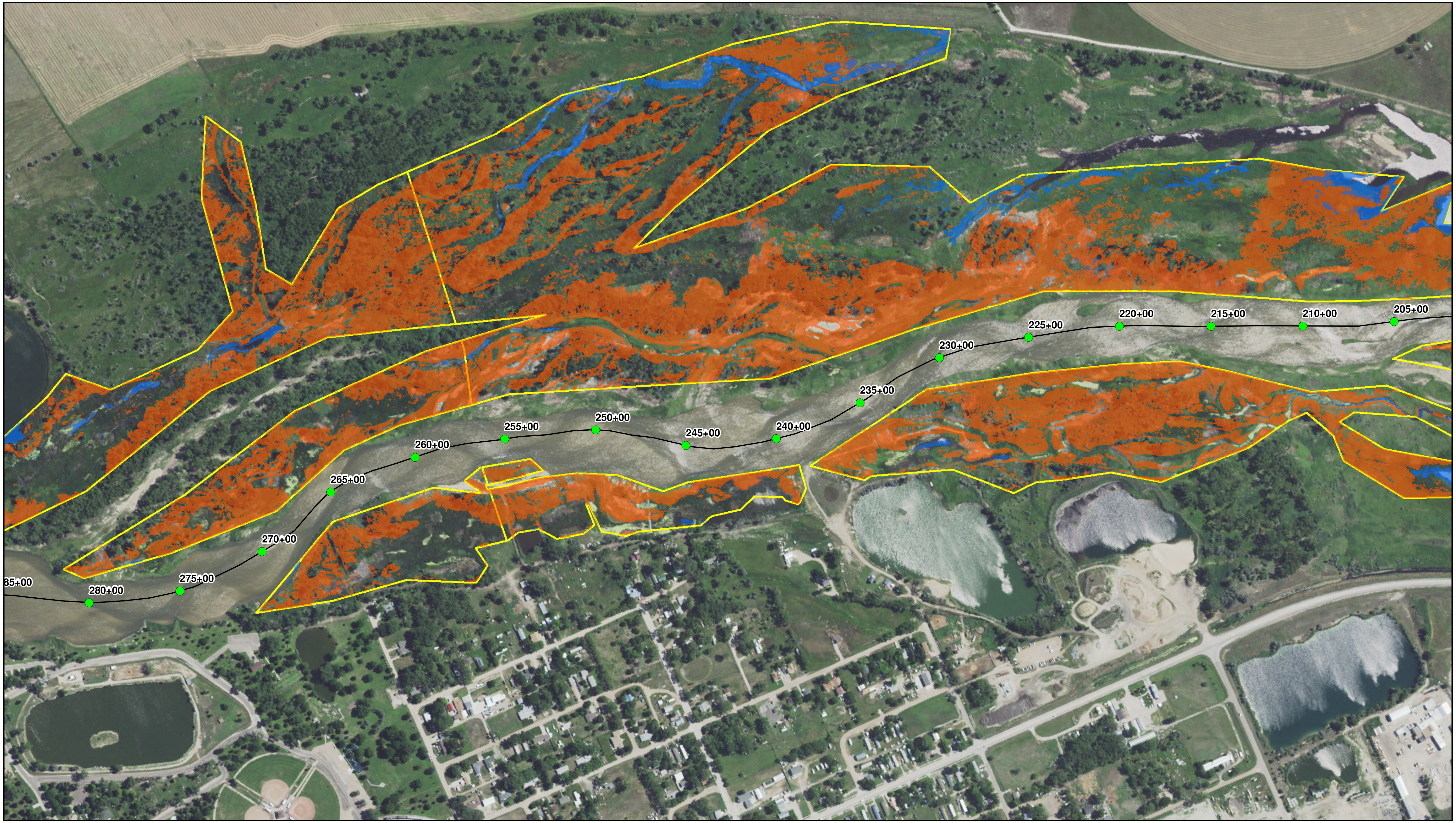

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Feet

ESTIMATED GROUNDWATER
COMPARISON 400 CFS

Legend

Proposed Channel Centerline

Proposed Groundwater Estimate

Existing Groundwater Estimate

Potential Wetland

Anderson Consulting Engineers, Inc.
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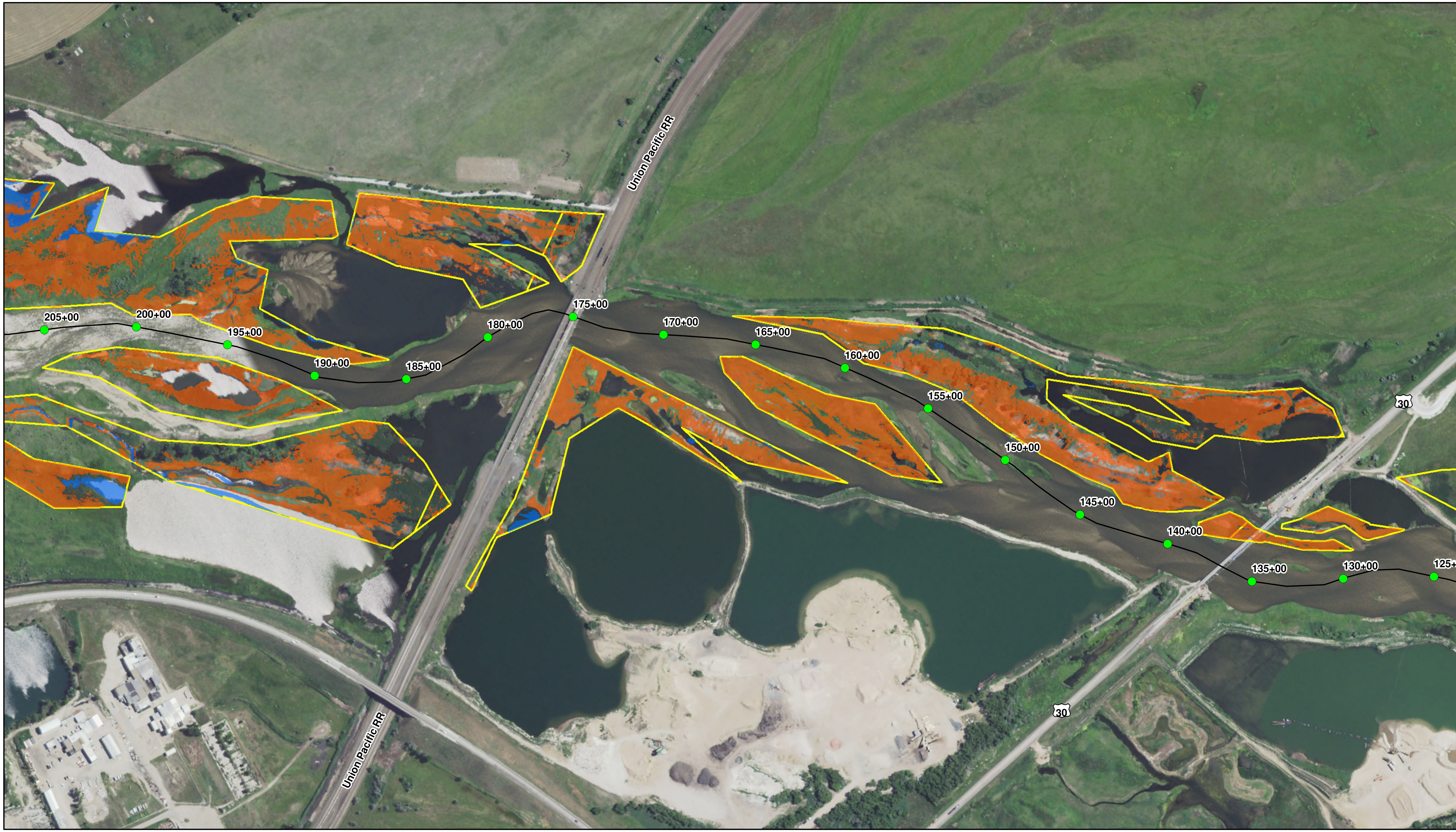

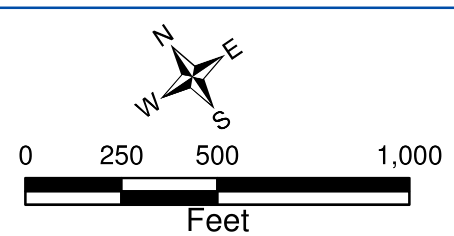

ESTIMATED GROUNDWATER
COMPARISON 400 CFS

Legend

Proposed Channel Centerline

Proposed Groundwater Estimate

Existing Groundwater Estimate

Potential Wetland

Anderson Consulting Engineers, Inc.
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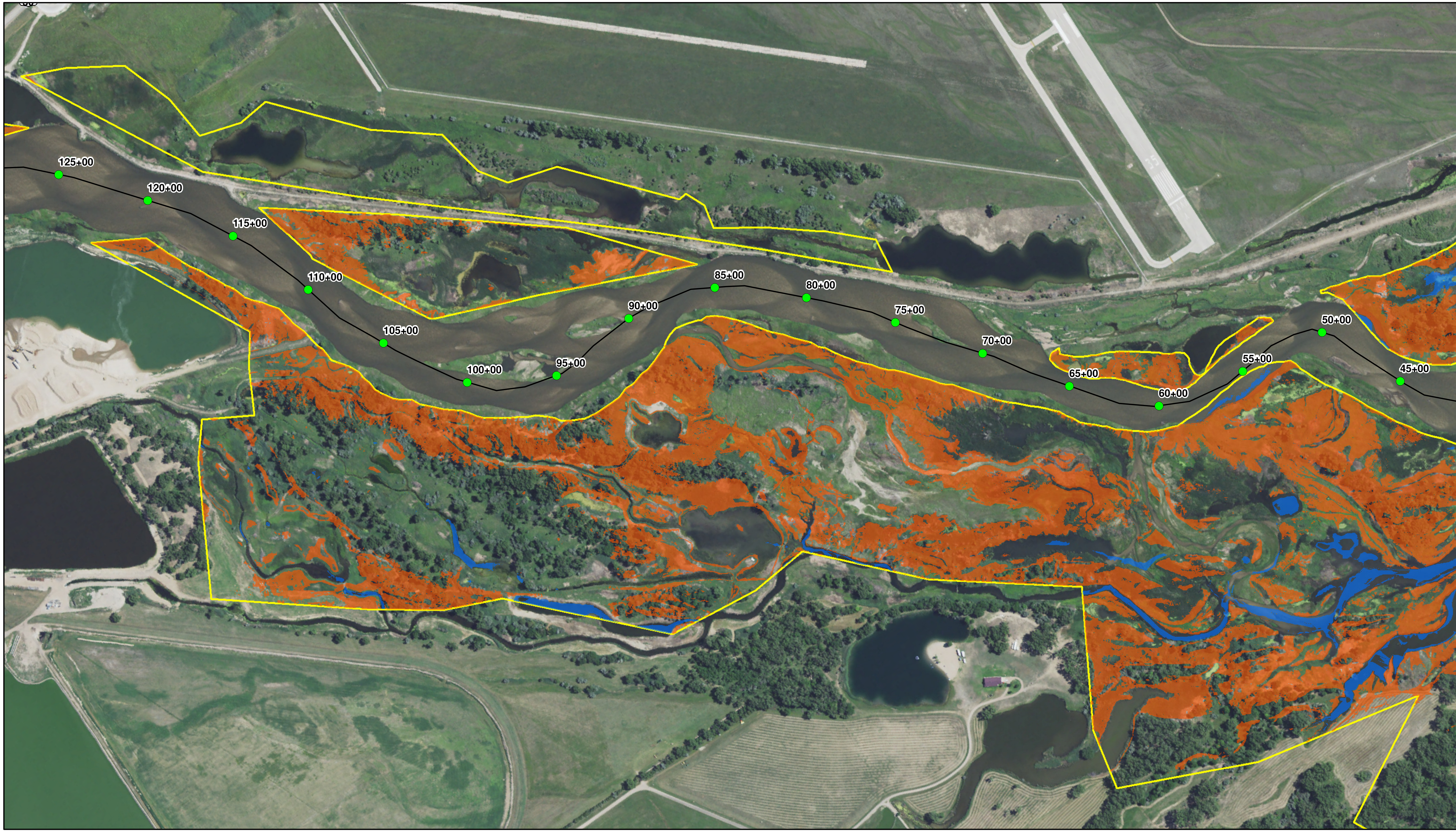

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Feet

ESTIMATED GROUNDWATER
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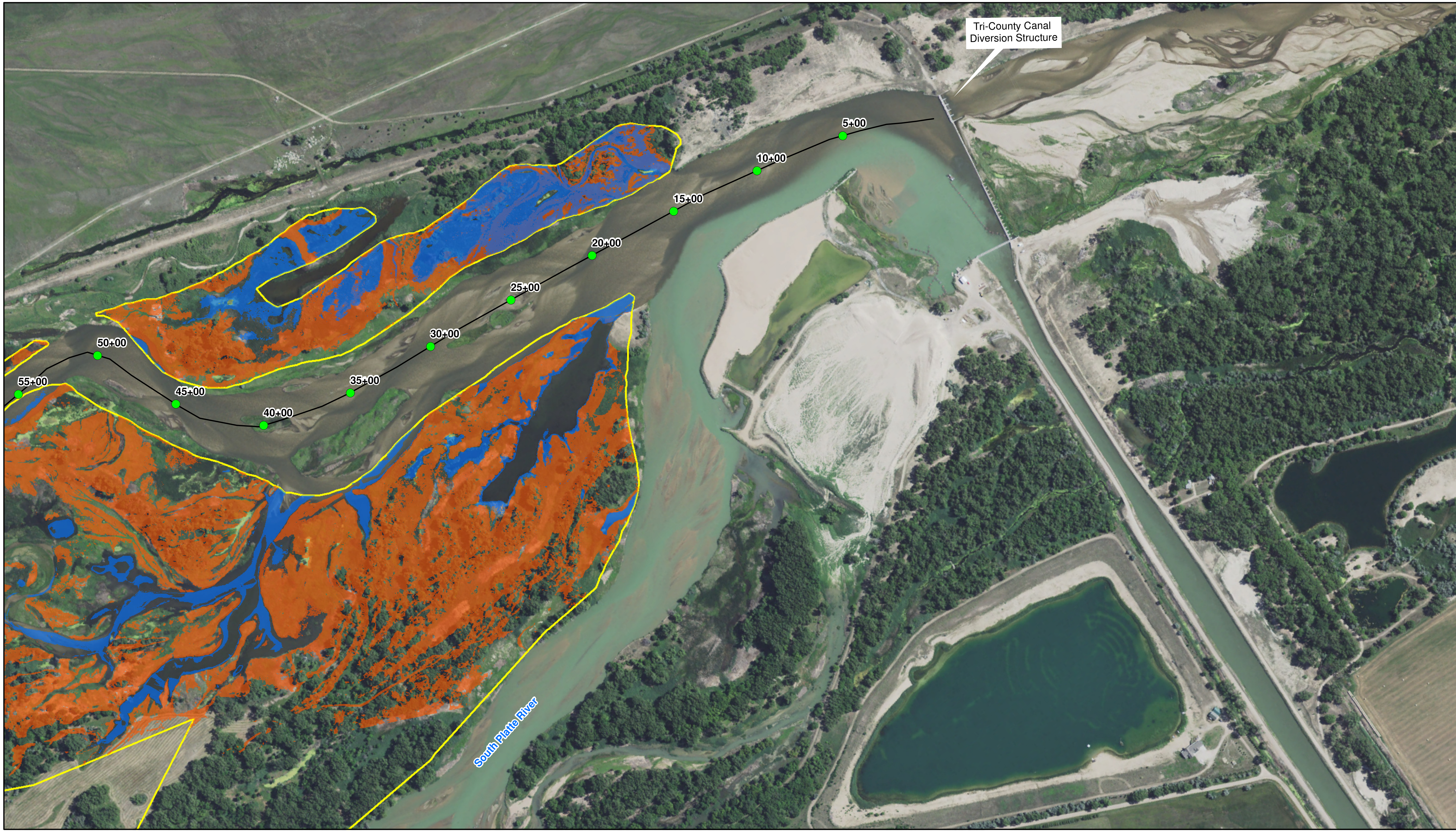

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Feet

ESTIMATED GROUNDWATER
COMPARISON 400 CFS

Legend

Proposed Channel Centerline

Proposed Groundwater Estimate

Existing Groundwater Estimate

Potential Wetland

Anderson Consulting Engineers, Inc.
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APPENDIX C.3. ERO PERMITTING MEMO

ERO Resources Corporation

Denver | 1626 Cole Boulevard, Suite 100, Lakewood, CO 80401
Durango | 835 East 2nd Avenue, Suite 400, Durango, CO 81301
Grand Junction | 715 Horizon Drive, Unit 301, Grand Junction, CO 81506
Idaho | 7154 West State Street, Suite 398, Boise, ID 83714

October 2, 2024

TO: Ms. Michelle Martin, Senior Engineer
Anderson Consulting Engineers
375 East Horsetooth Road, Building 5, Suite 100
Fort Collins, Colorado 80525

FROM: Moneka Worah, Natural Resource Specialist/President

RE: North Platte Chokepoint - Permitting Evaluation

Background

ERO Resources Corporation is assisting Anderson Consulting Engineers (Anderson) with evaluations of the North Platte River at North Platte, Nebraska as part of the Platte River Recovery Implementation Program (Program) evaluation to maintain hydraulic capacity of 3,000 cubic feet per second (cfs) below minor flood stage along the river. Limited hydraulic capacity through this reach, known as the chokepoint, is a constraint on the ability to deliver water from the Lake McConaughy Environmental Account to the Program's Associated Habitat Reach (AHR) on the central Platte River downstream between Lexington and Chapman, Nebraska. The project team has been evaluating alternatives to deliver 3,000 cfs to the AHR.

One alternative that is being evaluated (proposed alternative) is to dredge the North Platte River from its confluence with the South Platte River, upstream approximately 11 miles (study reach). The proposed alternative would increase channel capacity by removing large amounts of sediment that have accumulated in the river due to the Tri-County Canal Diversion, which is located immediately downstream of the confluence of the North and South Platte Rivers. This alternative would lower the bed of the North Platte River 2 to 6 feet in the study reach. Sediment removal activity would trigger the need for a Clean Water Act (CWA) Section 404 Permit and requires analysis of both direct and indirect impacts on regulated waters of the U.S., including wetlands.

Wetland Evaluation

ERO evaluated the study reach for potential wetlands that may be affected by the proposed alternative. ERO reviewed U.S. Geological Survey topographic quadrangle maps (U.S. Geological Survey 2024), the U.S. Fish and Wildlife Service National Wetland Inventory (Service 2024), and aerial photography to identify potential areas of wetlands that may be regulated by the U.S. Army Corps of Engineers (Corps) under the CWA. In addition, Anderson provided ERO with inundation maps based on hydraulic modeling and potential groundwater depths. In general, wetlands have groundwater support within 12 to 18 inches of the ground surface for at least two weeks during the growing season. Though the study reach may not be interpreted as highly disturbed or problematic, the Corps has provided a technical standard for problematic wetlands to monitor hydrology with a requirement of 14 or more consecutive days of flooding or ponding, or a water table 12 inches (30 centimeters) or less below the soil surface, during the growing season at a minimum frequency of 5 years in 10 (50 percent or higher probability) (Corps 2005; National Research Council 1995).

The North Platte River through the study reach has an extensive wetland/riparian corridor with limited encroachment. In addition, the accumulated sediment in the river has allowed for increased wetland/riparian development and wider floodplain connectivity. In total, ERO mapped 1,703 acres of potential wetlands in the study reach using the methods described above. The actual amount of wetlands, including their connectivity and regulatory status, would need to be determined with a full wetland delineation. However, the evaluation method for mapped wetlands provides a good indication of the extent of potential wetland habitat based on the hydraulic modeling and database review.

Based on the groundwater modeling, it is anticipated that up to 339 acres of potential wetlands would no longer have groundwater support (within 12 to 18 inches of the surface) at the baseflow rates of 400 cfs (Table 1). At 1,000 cfs flow rates, the acreage of wetlands that would lose groundwater support is reduced to 205 acres (Table 1).

Table 1. Estimated change in groundwater of potential wetlands.

Flow	Area of Wetlands with Groundwater Depths <1.5 Feet (acres)		Area of Wetlands with Groundwater Depth >1.5 Feet (acres) in Proposed Conditions
	Existing	Proposed	
400 cfs	401	62	339
1,000 cfs	395	190	205

Anderson also completed an analysis of changes to inundation at various flow rates and the acreage of potential wetlands mapped in the existing and proposed inundation areas. Based on that analysis, 231 acres of wetlands would no longer be inundated during the 1,500 cfs rate, which is the current bankfull elevation (Table 2). At the 3,000 cfs rate, which is the proposed condition bankfull elevation, approximately 556 acres of potential wetlands would no longer be inundated (Table 2).

Table 2. Estimated change in inundation of potential wetlands,

Flow	Existing	Proposed	Difference (acres)
	Area of Wetland Inundation (acres)*		
400 cfs	36	4	32
1,000 cfs	130	6	124
1,500 cfs	249	18	231
2,000 cfs	416	55	361
3,000 cfs	679	123	556
6,000 cfs	857	381	476

In summary, the proposed alternative has the potential to adversely affect up to 556 acres of wetlands in the study reach, with a likelihood of drying up at least 205 acres of potential wetlands.

Permitting Implications

The proposed alternative to dredge the North Platte River for up to 11 miles would require a CWA Section 404 Permit. Due to the acreage and volume of direct and indirect impacts along the river, the Corps would likely require an Individual Permit and completion of an environmental assessment (EA) following the requirements defined in the National Environmental Policy Act (NEPA). If the EA confirmed the project would have significant impacts, then an environmental impact statement (EIS) analysis could be required. The cost and time frame for completing an EIS can be significant, with EIS projects taking 2 to 20 years depending on the complexity of the project, and several hundred thousand to millions of dollars.

Although the purpose of the project is to deliver water to benefit federally threatened and endangered species, the Corps must evaluate the project impacts on waters of the U.S. compared to other possible alternatives that meet the purpose and need for the project. Per CWA Section 404(b)(1) Guidelines, the Corps must only permit the Least Environmentally Damaging Practicable Alternative (LEDPA). The Corps' EA and EIS processes under NEPA would require an alternatives analysis to determine if there are other practicable alternatives (i.e., alternatives that meet the project purpose and need). A permit cannot be issued if a practicable alternative exists that would have less adverse impacts on the aquatic ecosystem, provided that the LEDPA does not have other significant adverse environmental consequences to other resources. This analysis may demonstrate that other practicable alternatives are feasible and the proposed alternative to dredge up to 11 miles of the North Platte River is not the LEDPA.

In addition to the permitting difficulties, the amount of mitigation required for the project would be significant, with potentially hundreds of acres of wetland mitigation required. The project could try to incorporate wetland mitigation by lowering the entire river corridor and reestablishing wetlands in the corridor; however, it is likely the Corps would have concerns with sediment reestablishing in the project area and filling in where mitigation is proposed. Currently, wetland mitigation bank credits are approximately $200,000 per acre, which could result in a significant cost if mitigation banking is required. It also would likely be difficult to find banks with the amount of credits required.

SIGNED: Moneka Worah

Moneka Worah, Natural Resource Specialist/President

References

National Research Council. 1995. Wetlands: Characteristics and boundaries. Washington, DC: National Academy Press.

U.S. Army Corps of Engineers (Corps). 2005. Technical standard for water-table monitoring of potential wetland sites. Technical Note ERDC TN-WRAP-05-02. Vicksburg, MS: U.S. Army Engineer Research and Development Center. (http://el.erdc.usace.army.mil/wrap/pdf/tnwrap05-2.pdf).

U.S. Fish and Wildlife Service (Service). 2024. National Wetlands Inventory: Surface waters and wetlands. https://fwsprimary.wim.usgs.gov/wetlands/apps/wetlands-mapper/

U.S. Geological Survey. 2024. "National Hydrography Dataset." U.S. Department of the Interior, U.S. Geological Survey. https://apps.nationalmap.gov/viewer/.

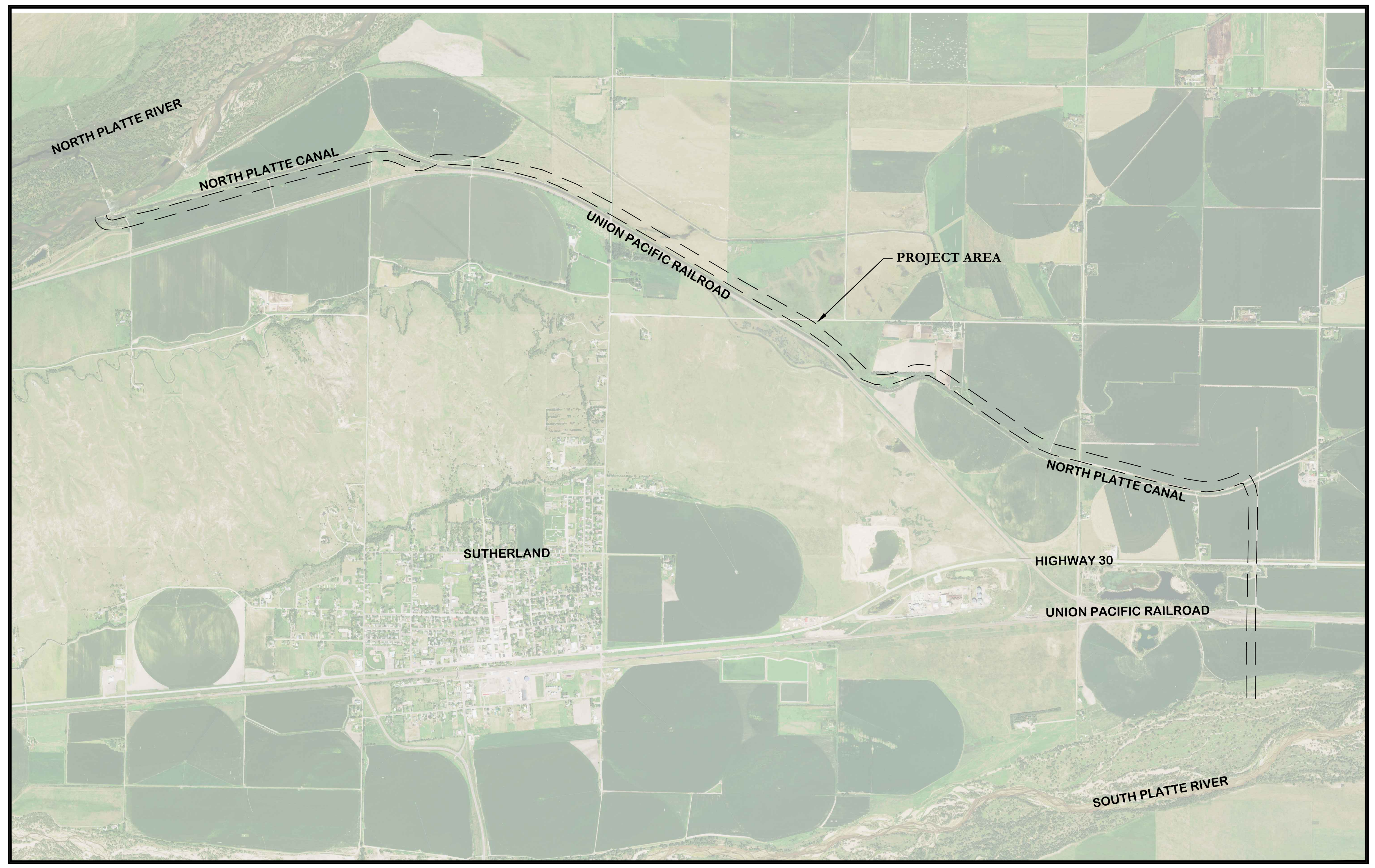
APPENDIX D. BYPASS CANAL CONCEPTUAL DESIGN

10/4/2024 9:27 AM

NORTH PLATTE RIVER CHOKEPOINT 1,500 CFS BYPASS CANAL CONCEPTUAL DESIGN

CONCEPTUAL DESIGN

INDEX OF SHEETS		
SHEET NO.	INDEX NO.	DESCRIPTIONS
1	1	COVER SHEET
2	2	KEYMAP SITE LEGEND
3	C1	BYPASS CANAL PLAN & PROFILE (1 OF 14)
4	C2	BYPASS CANAL PLAN & PROFILE (2 OF 14)
5	C3	BYPASS CANAL PLAN & PROFILE (3 OF 14)
6	C4	BYPASS CANAL PLAN & PROFILE (4 OF 14)
7	C5	BYPASS CANAL PLAN & PROFILE (5 OF 14)
8	C6	BYPASS CANAL PLAN & PROFILE (6 OF 14)
9	C7	BYPASS CANAL PLAN & PROFILE (7 OF 14)
10	C8	BYPASS CANAL PLAN & PROFILE (8 OF 14)
11	C9	BYPASS CANAL PLAN & PROFILE (9 OF 14)
12	C10	BYPASS CANAL PLAN & PROFILE (10 OF 14)
13	C11	BYPASS CANAL PLAN & PROFILE (11 OF 14)
14	C12	BYPASS CANAL PLAN & PROFILE (12 OF 14)
15	C13	BYPASS CANAL PLAN & PROFILE (13 OF 14)
16	C14	BYPASS CANAL PLAN & PROFILE (14 OF 14)
17	D1	DETAILS



VERTICAL DATUM:

PROJECT DATUM: **NAVD88**

HORIZONTAL DATUM:

NORTH AMERICAN DATUM 1983 (NAD83)
NEBRASKA STATE PLANE

OWNER:

PLATTE RIVER RECOVERY
IMPLEMENTATION PROGRAM
4111 4TH AVE, SUITE 6
KEARNEY, NE 68845

GENERAL CIVIL ENGINEER:

ANDERSON CONSULTING ENGINEERS, INC.
375 EAST HORSETOOTH ROAD, BUILDING 5
FORT COLLINS, CO 80525
PHONE (970) 226-0120

Know what's below.
Call before you dig.

CONCEPTUAL DESIGN

SHEET: 1 INDEX: 1

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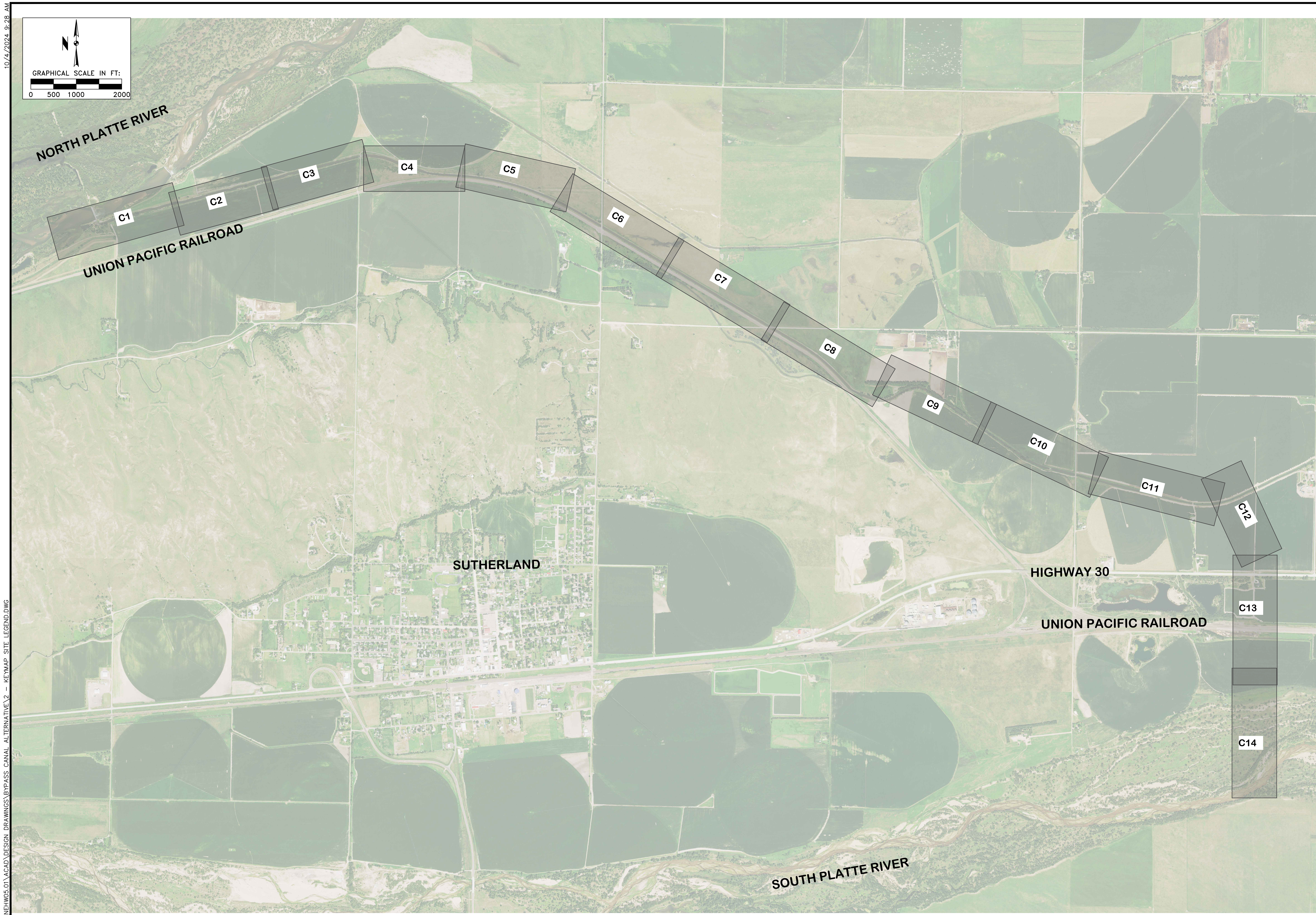

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Civil • Water Resources • Environmental
375 East Horsetooth Road, Building 5, Fort Collins, CO 80525
Phone (970) 226-0120 / Fax (970) 226-0121
www.acewater.com

KEYMAP SITE LEGEND

NORTH PLATTE RIVER
CHOKEPOINT 1,500 CFS
BYPASS CANAL
CONCEPTUAL DESIGN

CONCEPTUAL DESIGN

DRAWN BY:	CWK
DESIGNED BY:	CWK
CHECKED BY:	MLM
PROJECT NUMBER: NEHW05.01	
DATE: 09/24/2024	
SHEET: 2	INDEX: 2

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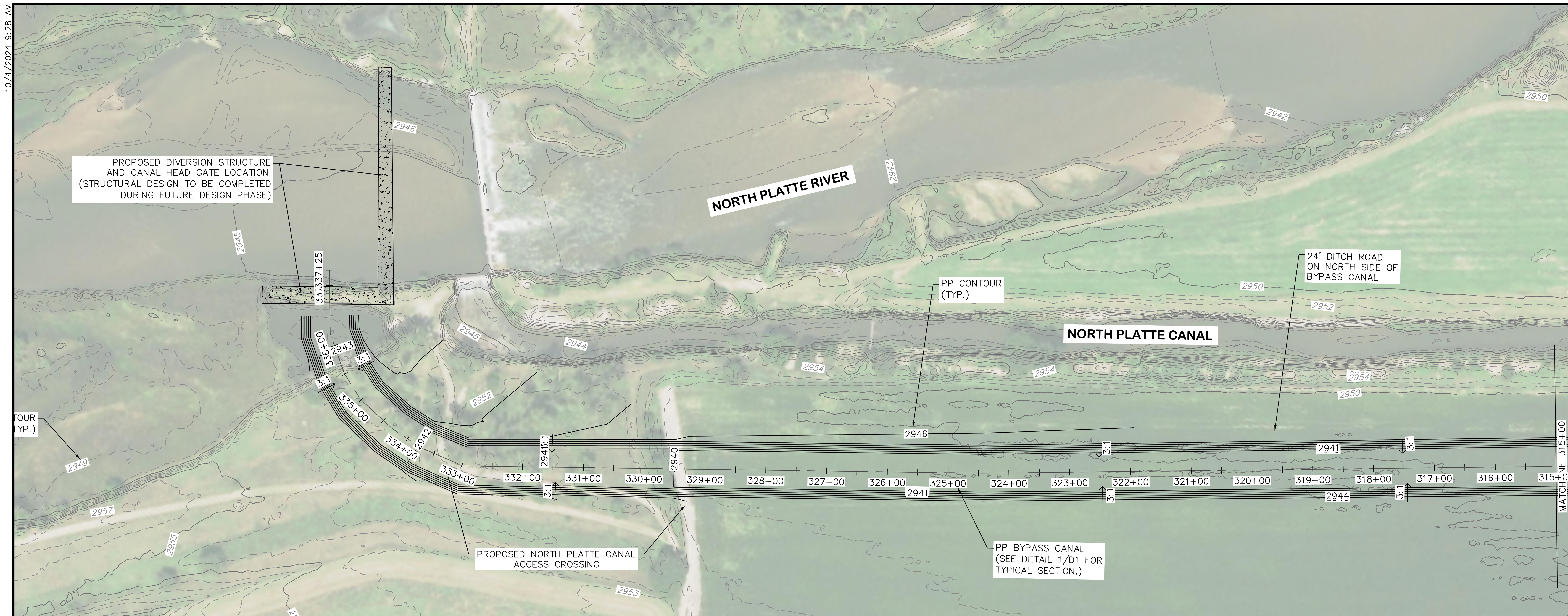

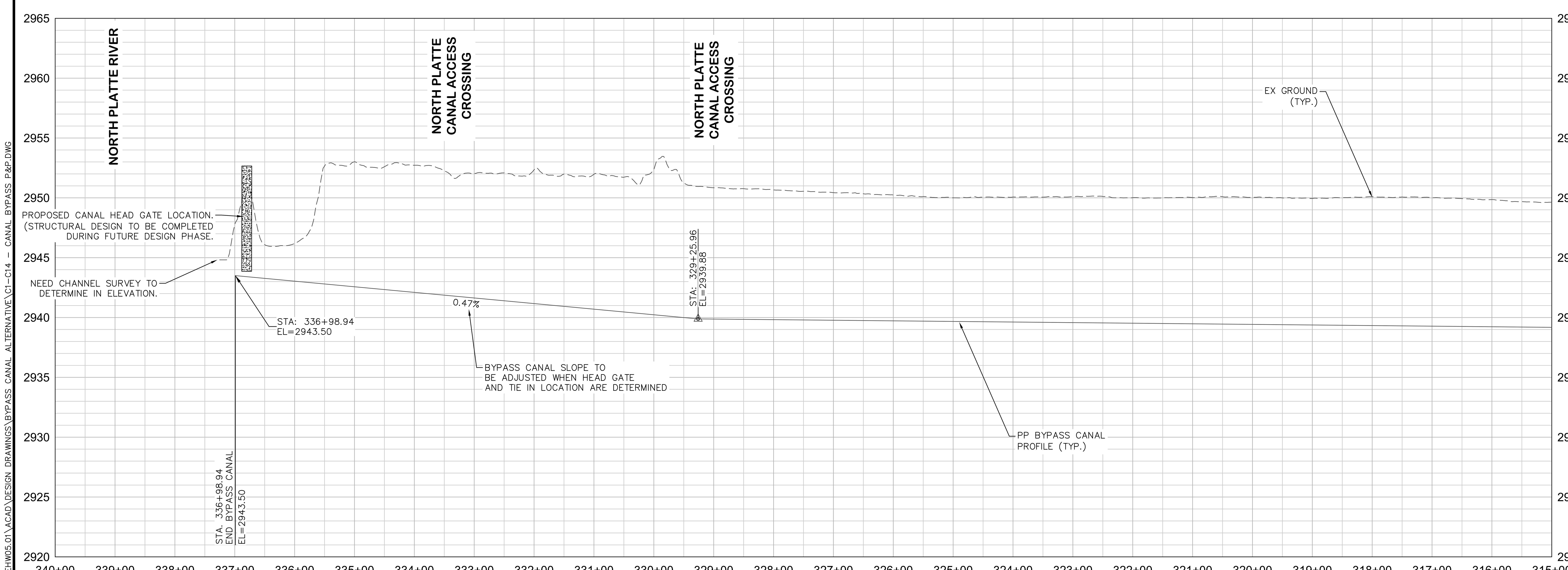

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REVISIONS:----

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BYPASS CANAL PLAN & PROFILE (1 OF 14)

NORTH PLATTE RIVER CHOKEPOINT 1,500 CFS BYPASS CANAL CONCEPTUAL DESIGN

CONCEPTUAL DESIGN

DRAWN BY:	CWK
DESIGNED BY:	CWK
CHECKED BY:	MLM
PROJECT NUMBER:	NEHW05.01
DATE:	09/24/2024
SHEET: 3	INDEX: C1

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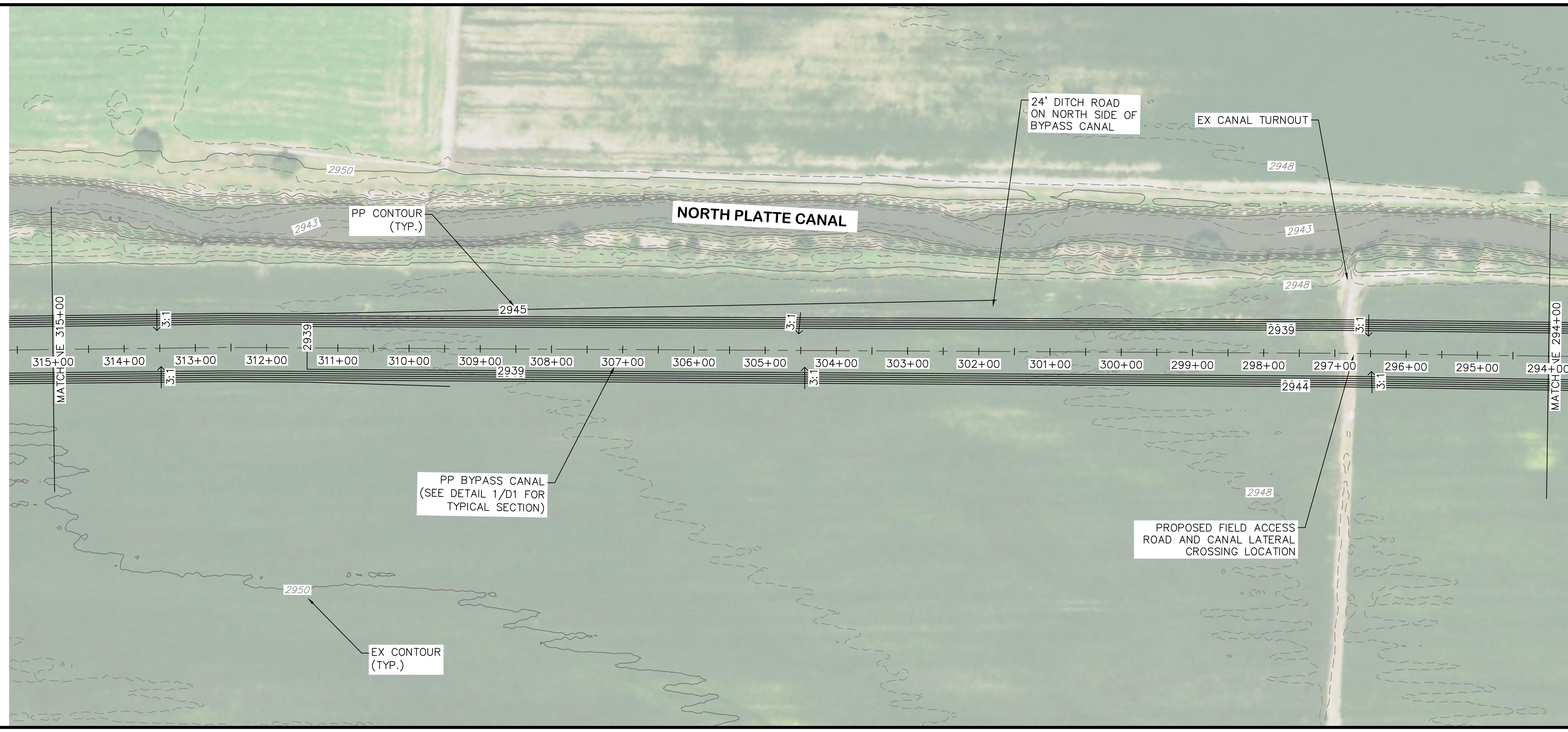

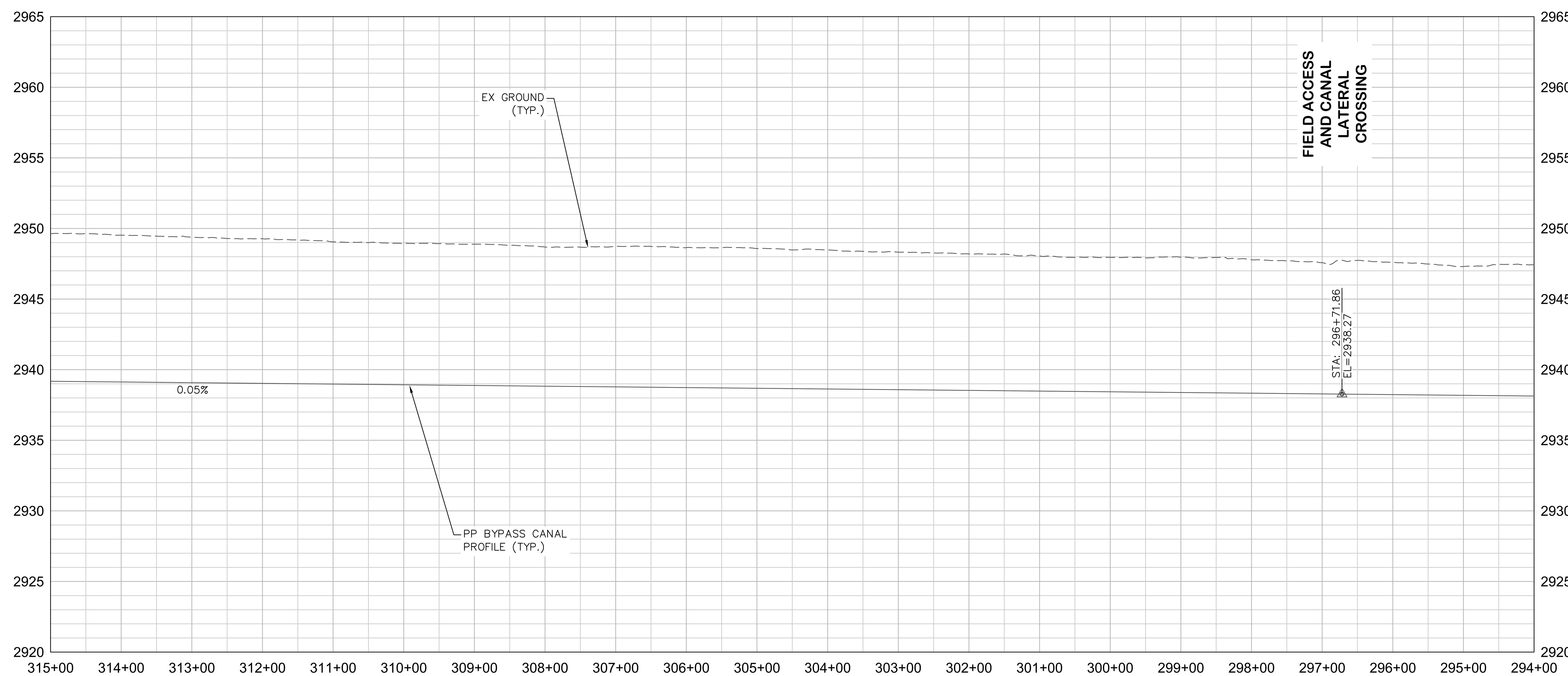

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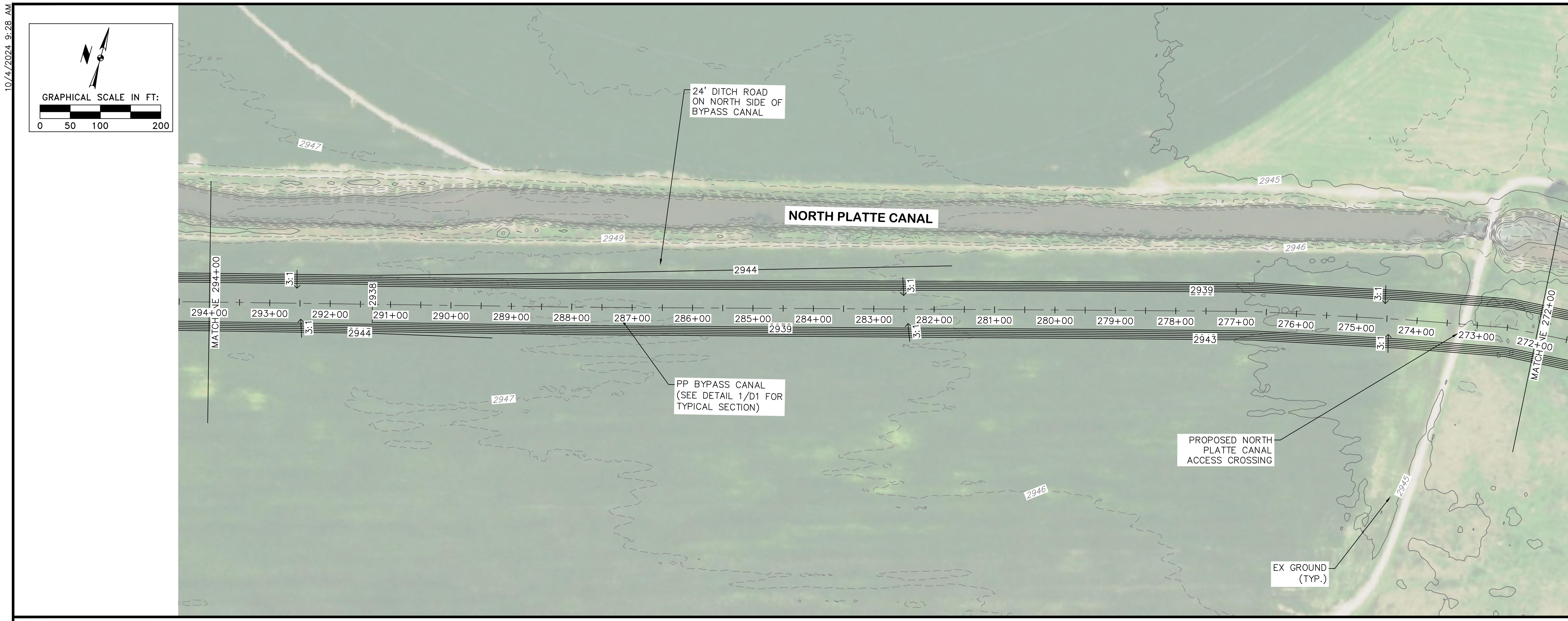

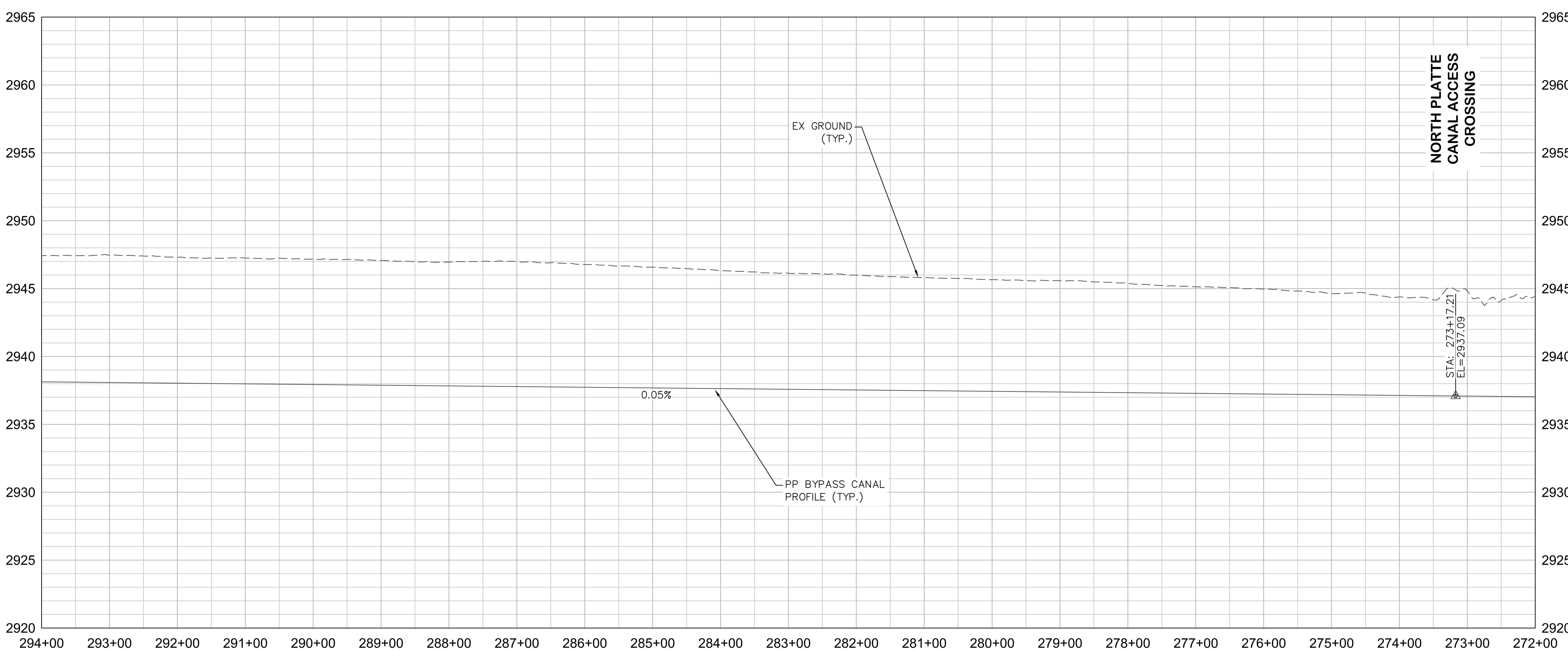

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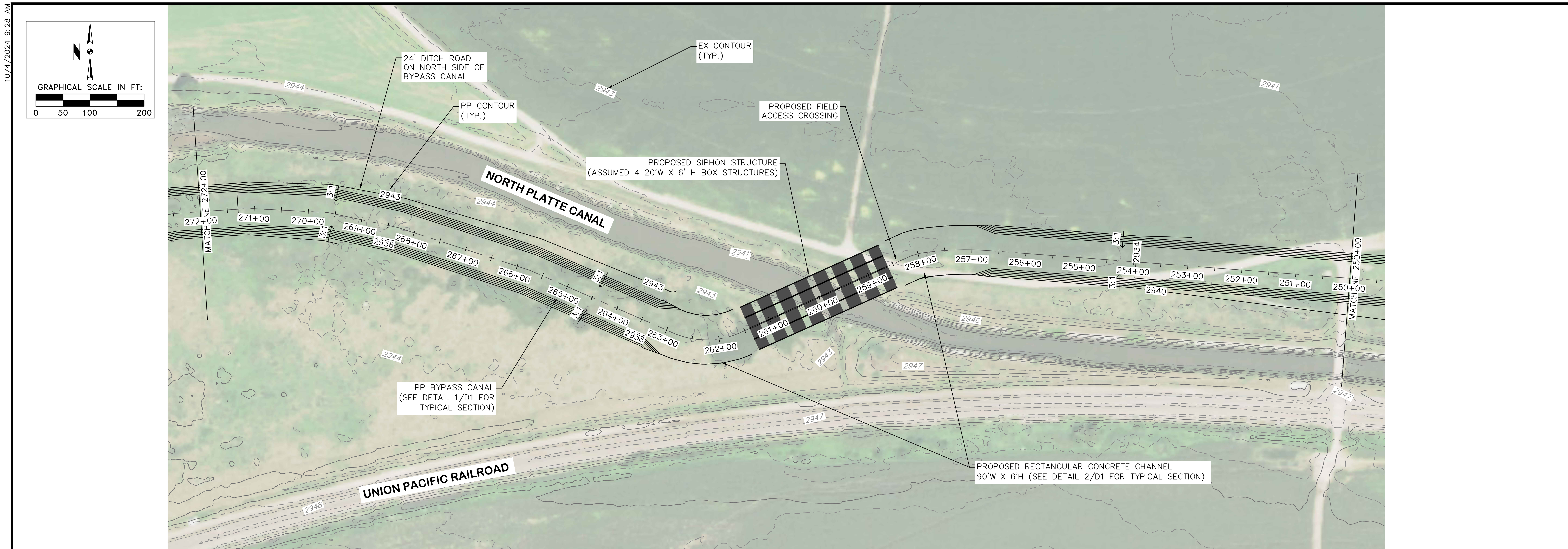

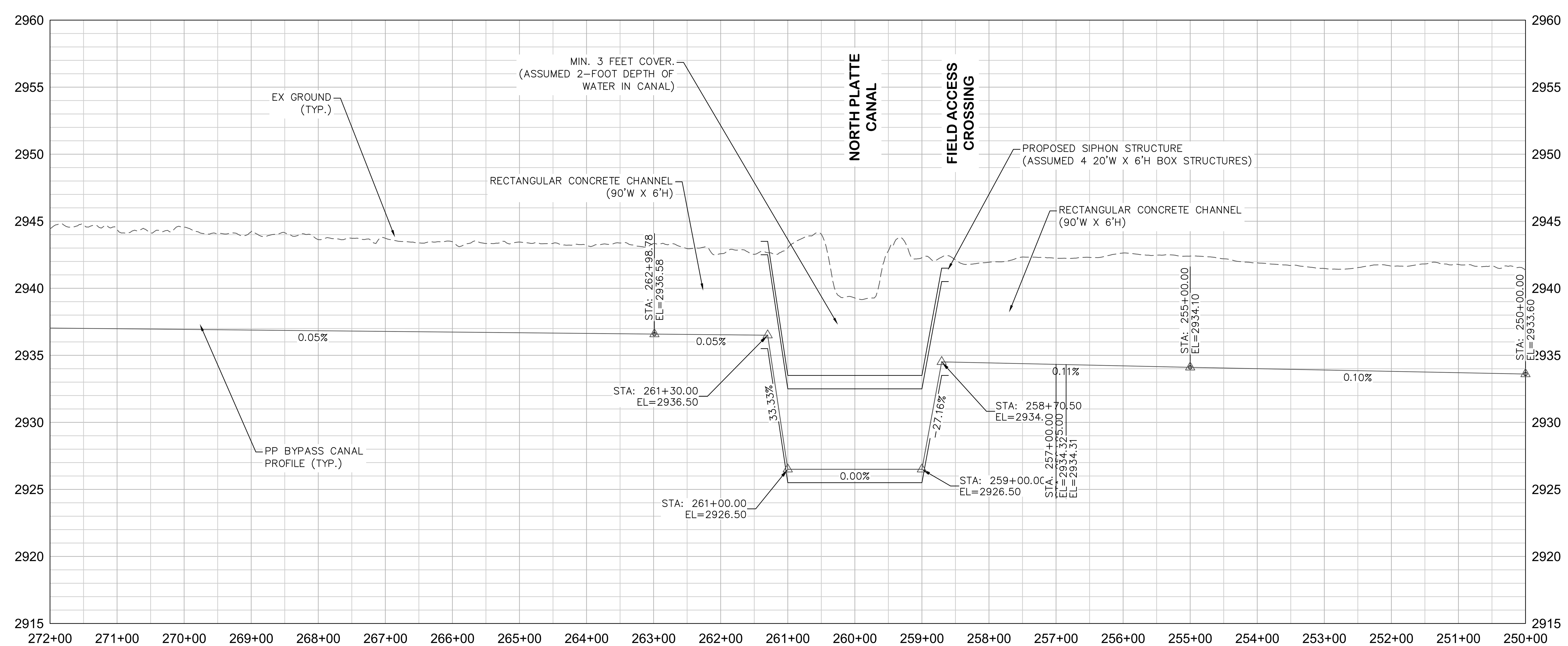

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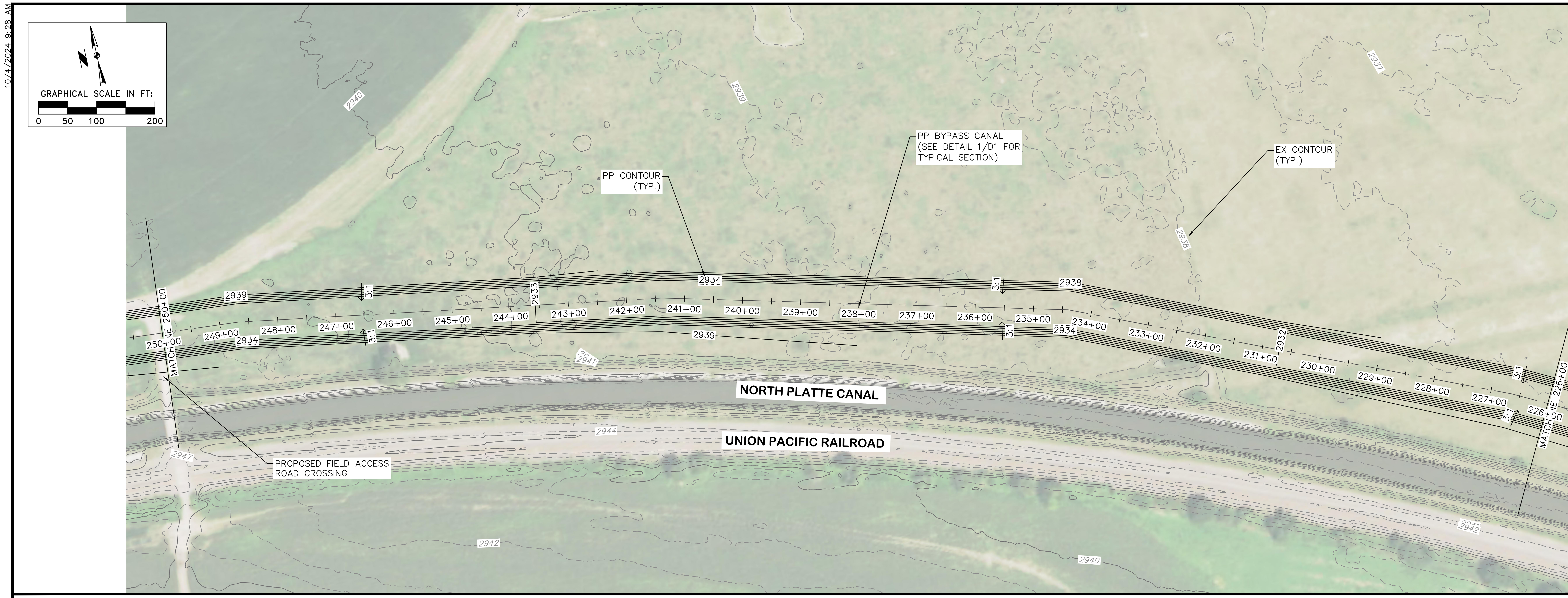

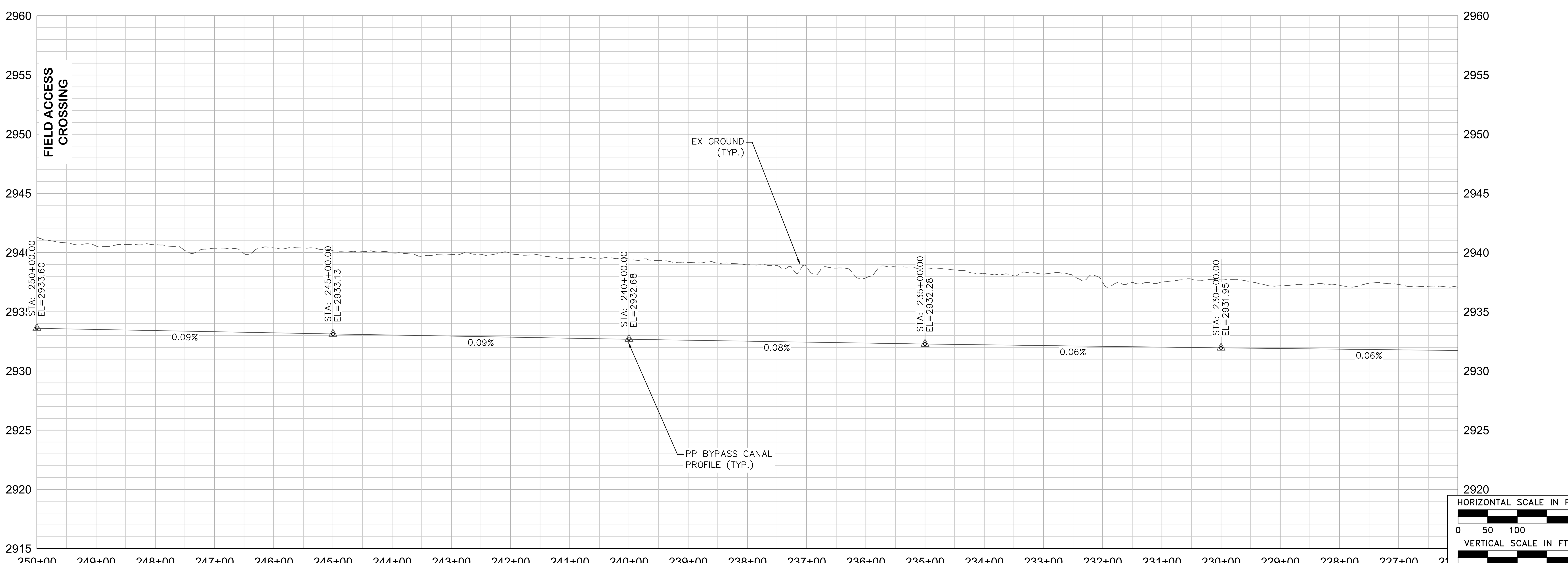

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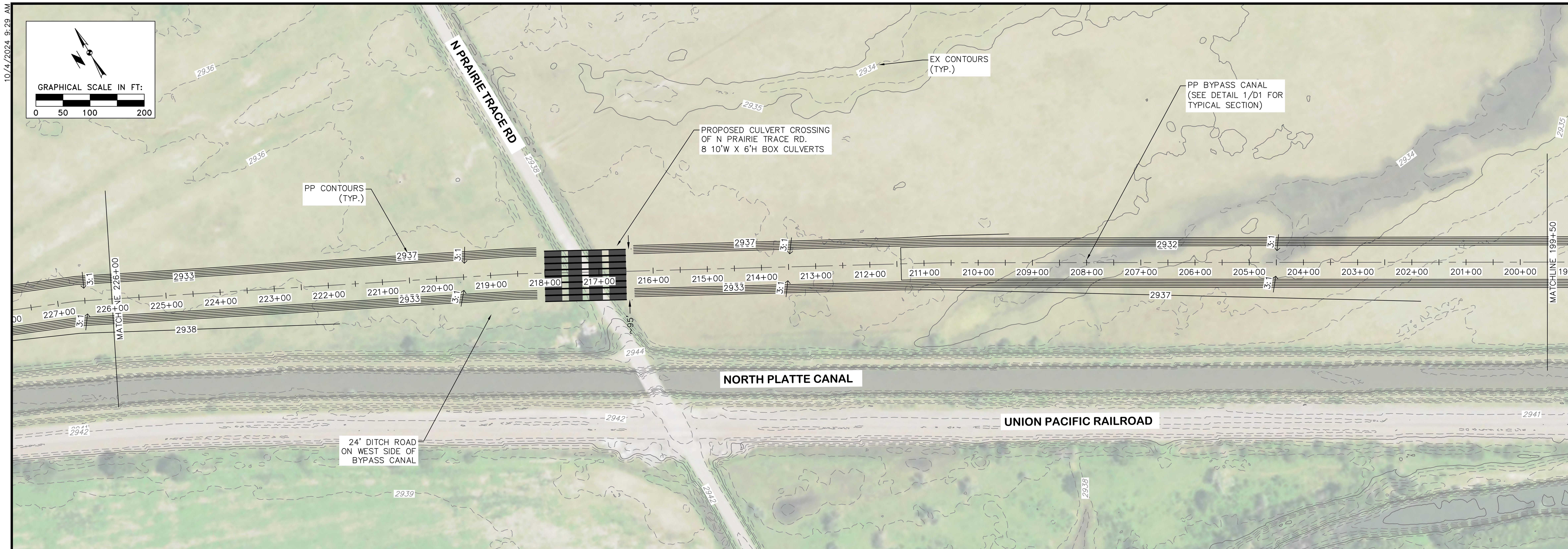

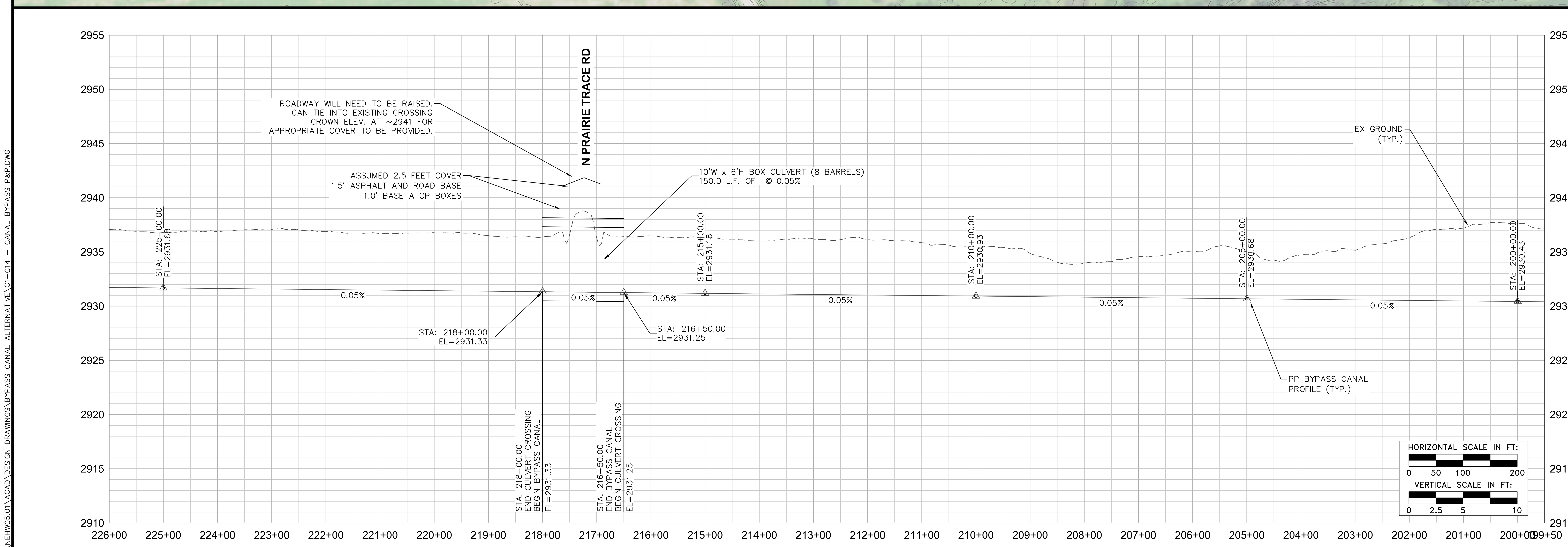

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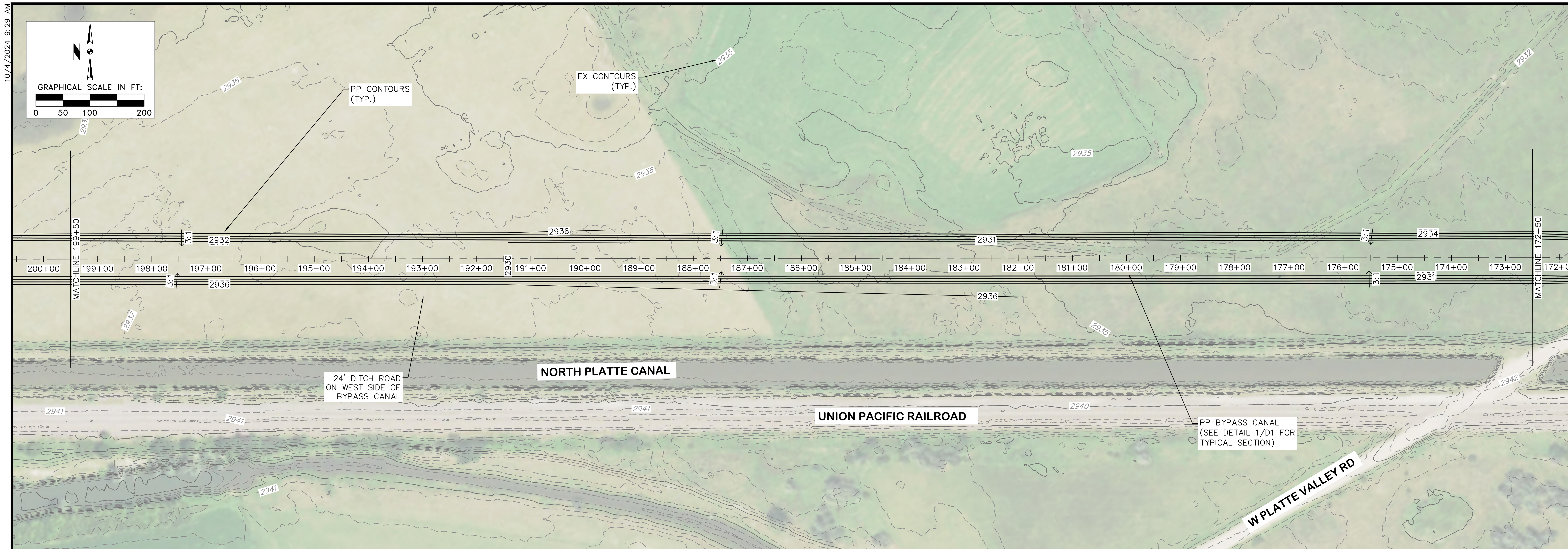

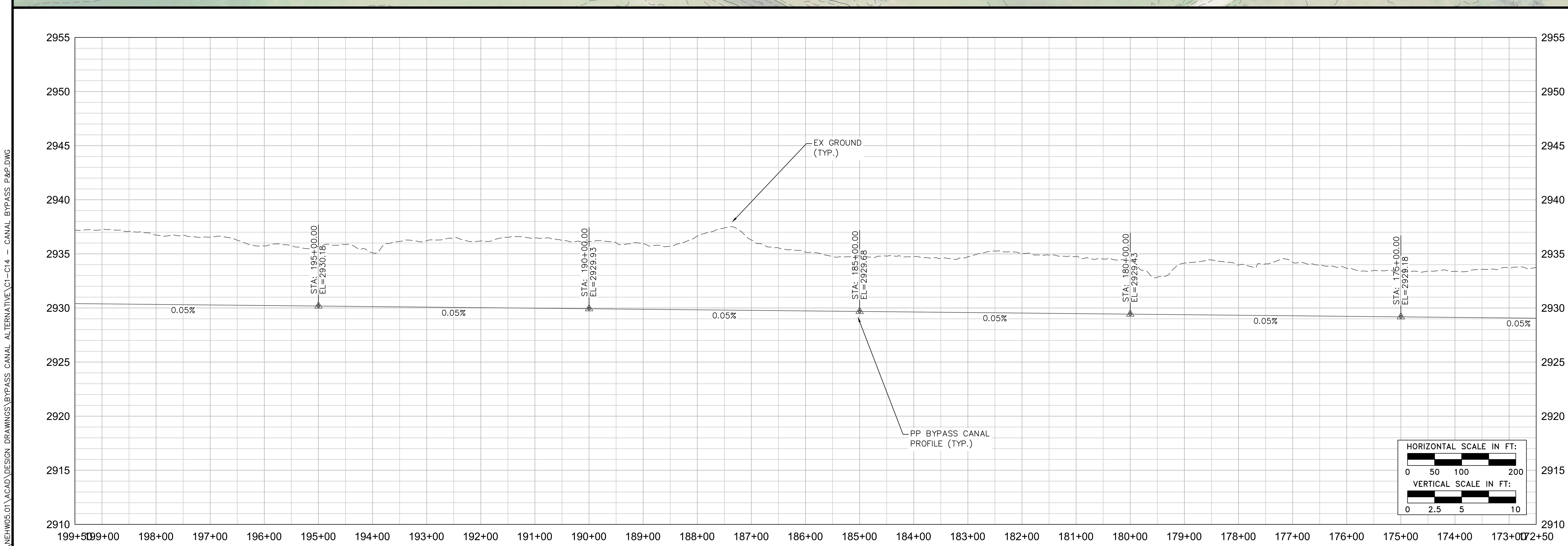

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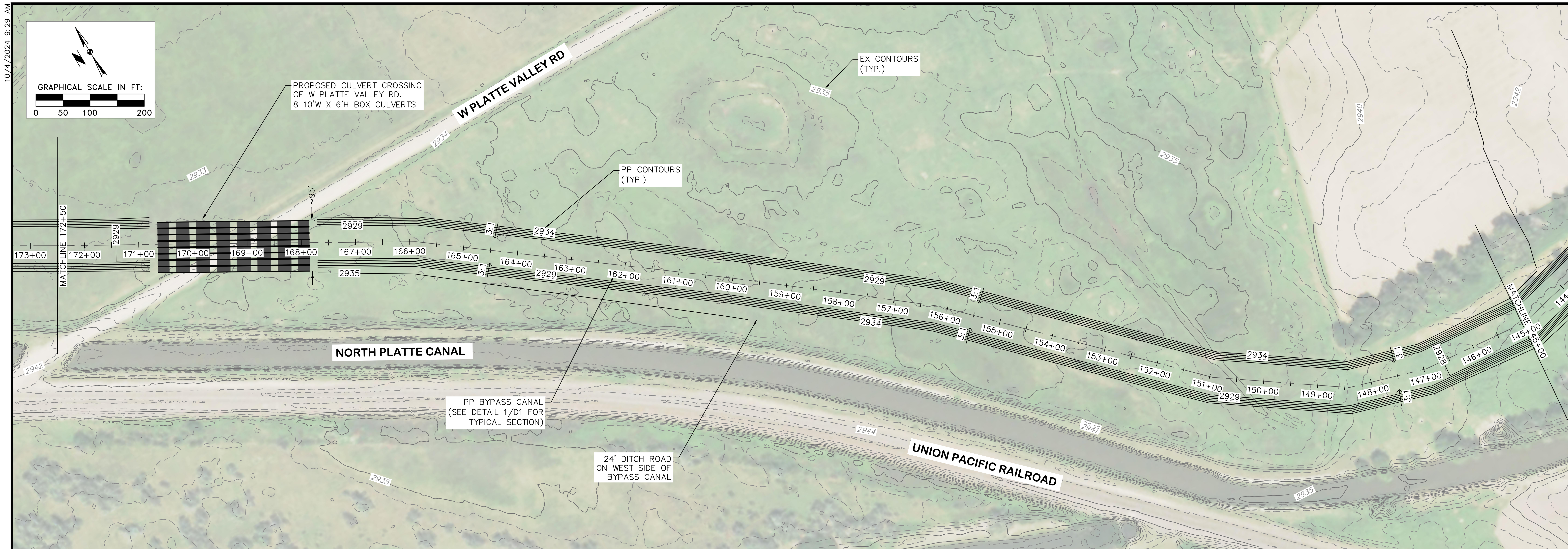

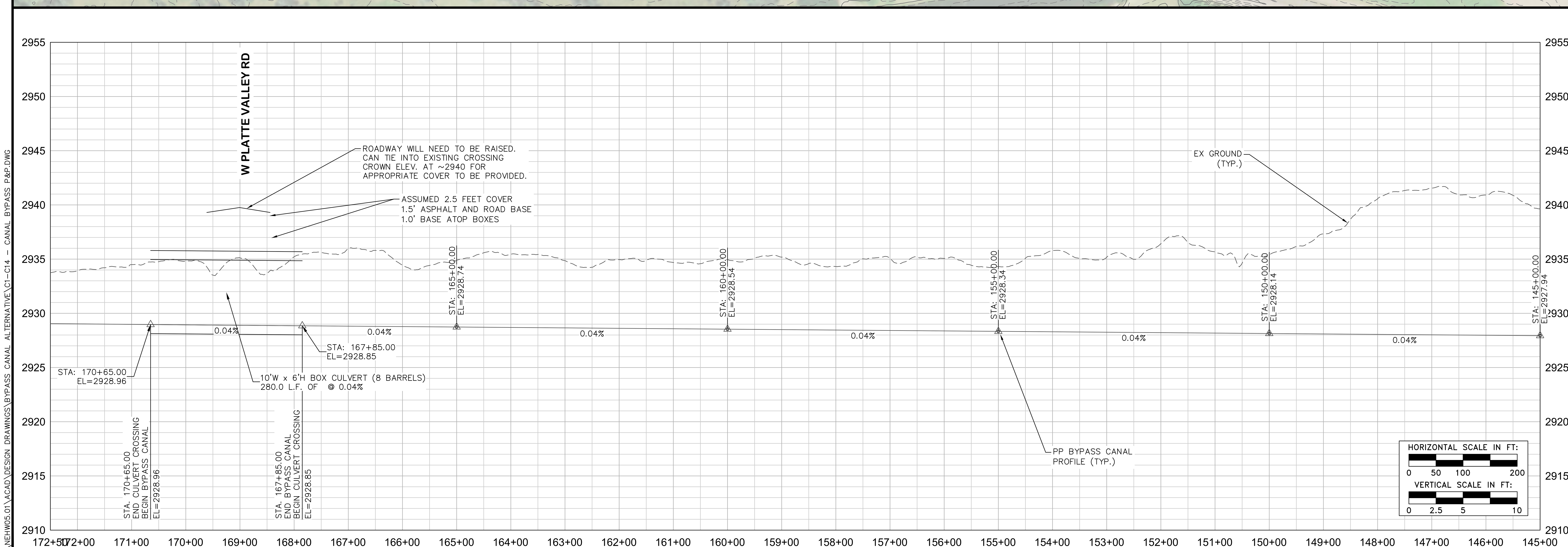

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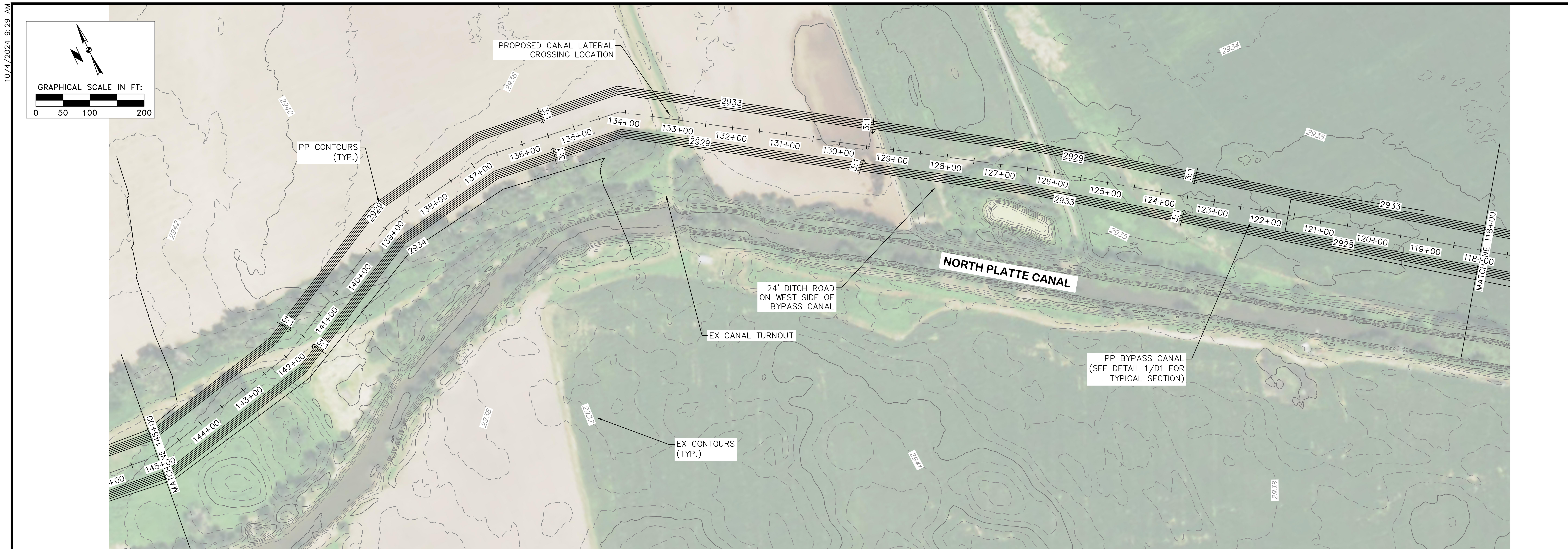

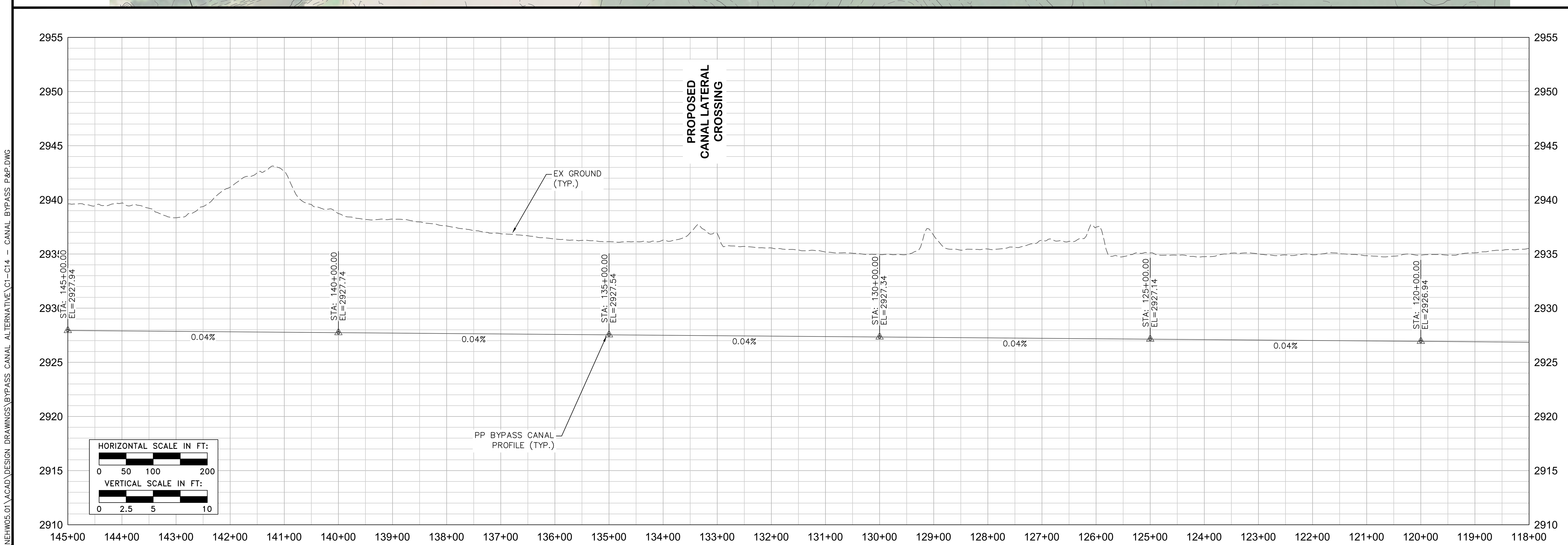

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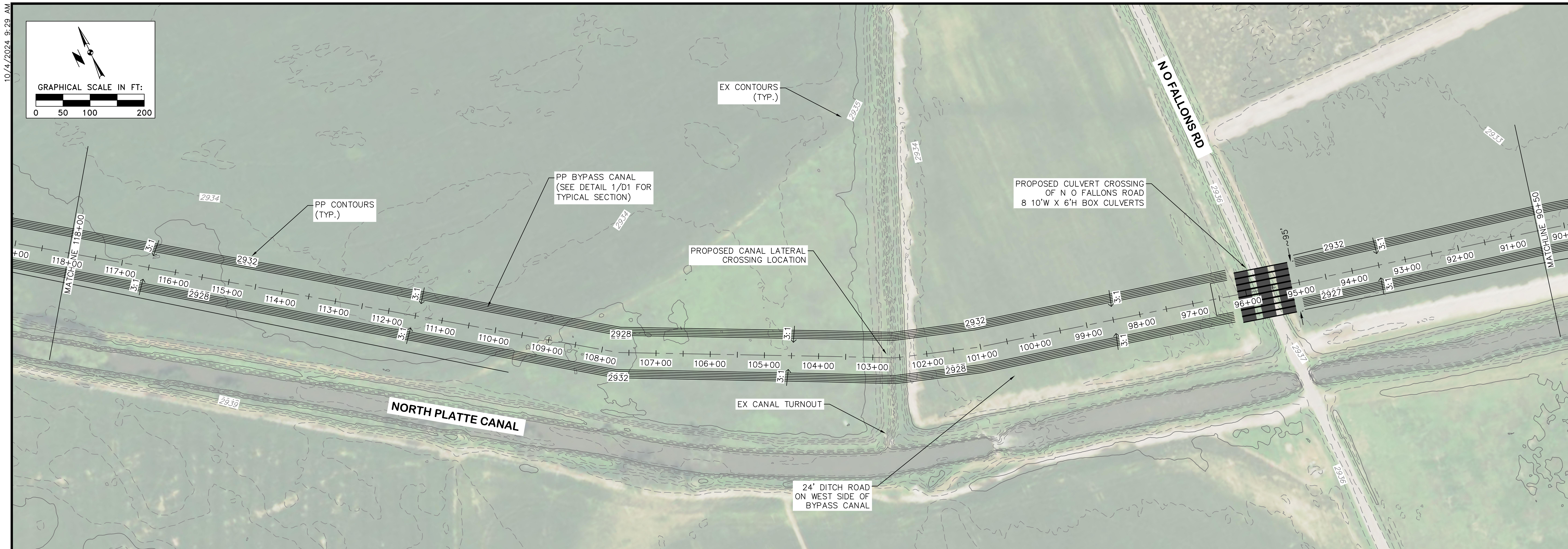

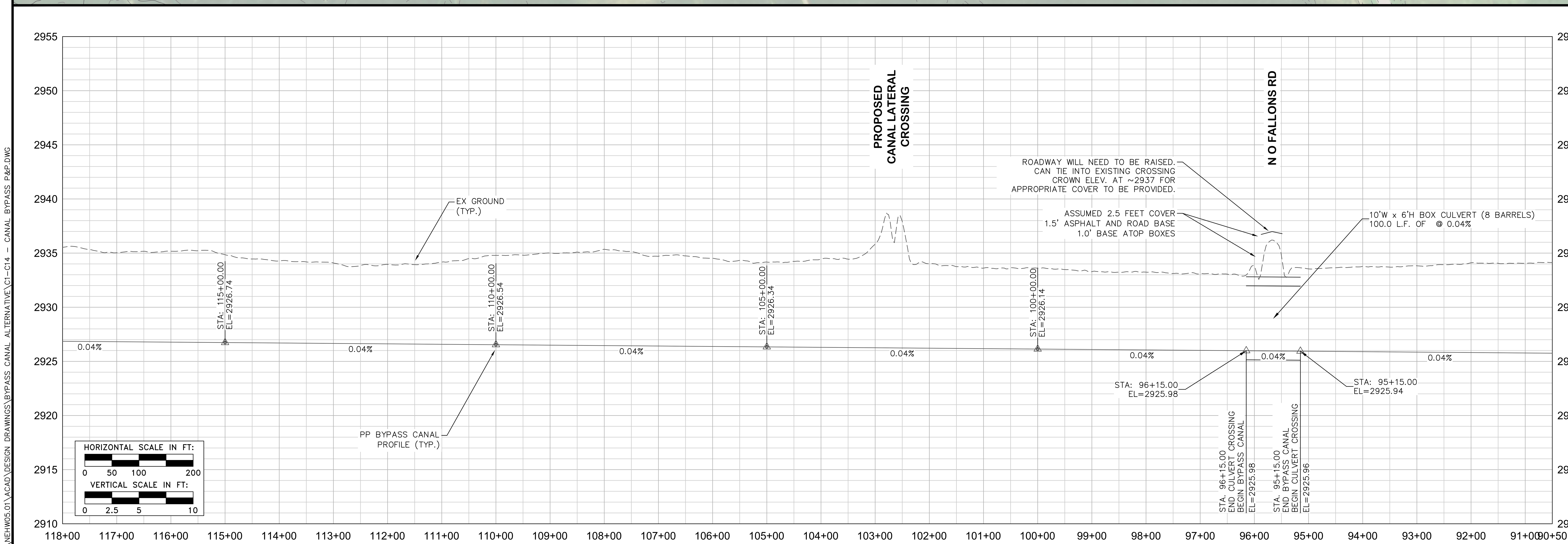

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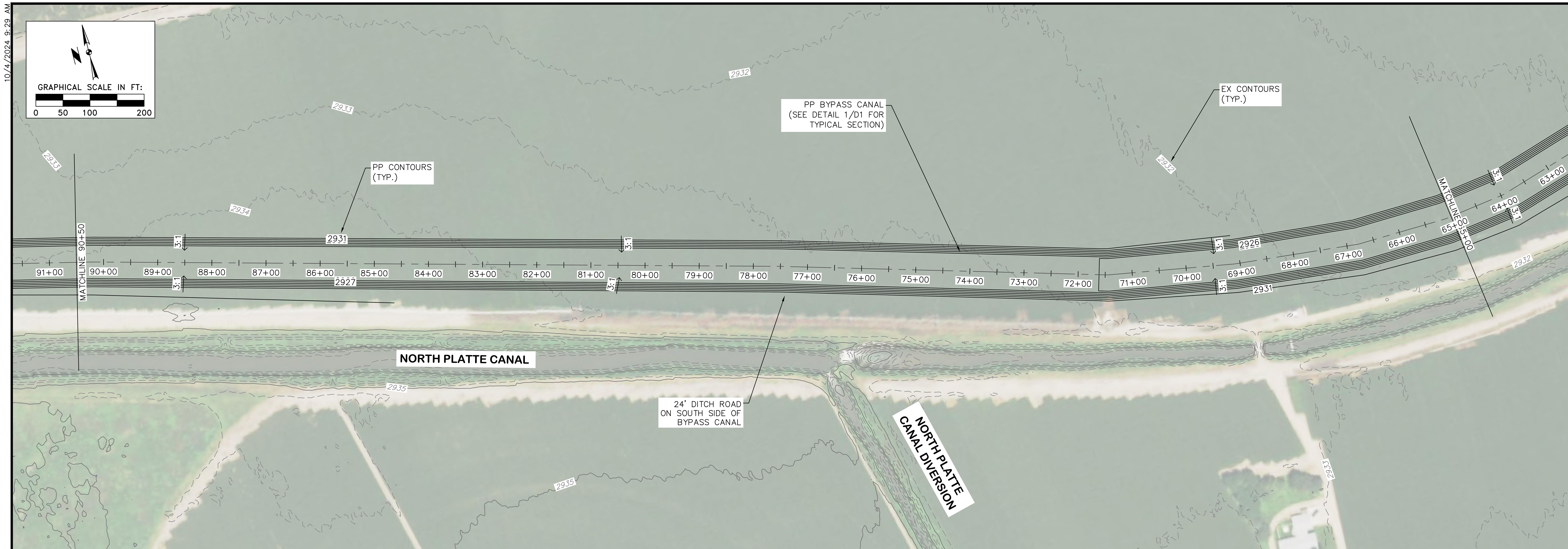

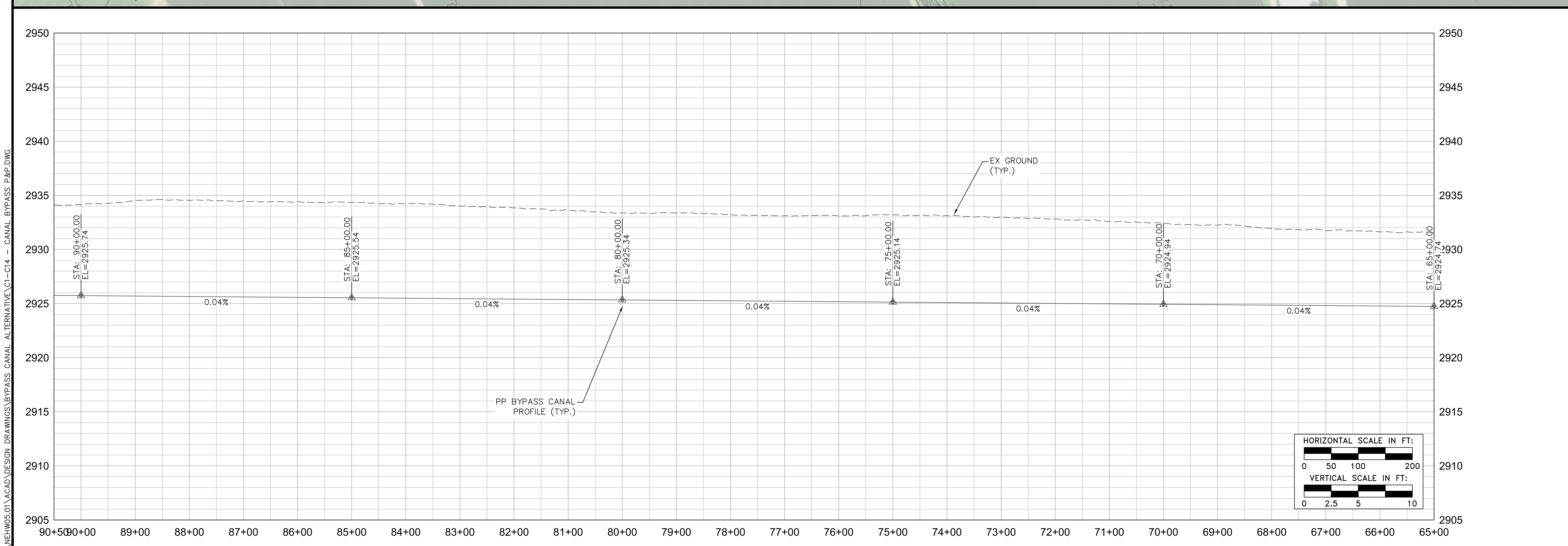

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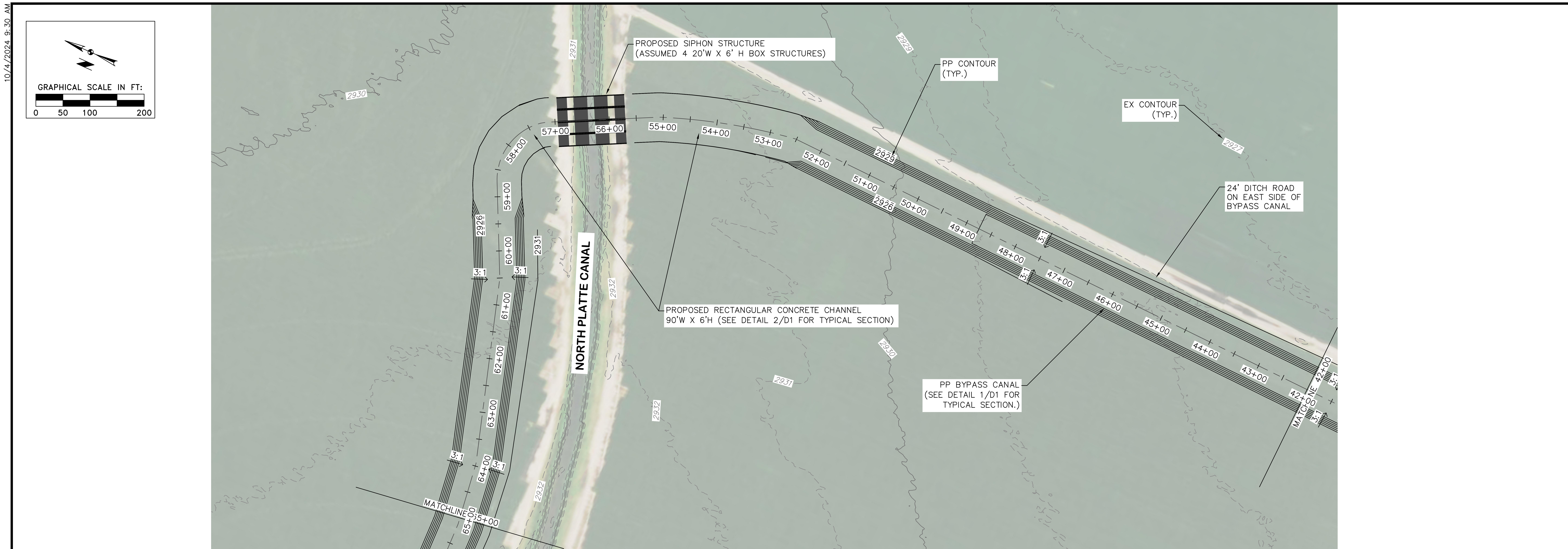

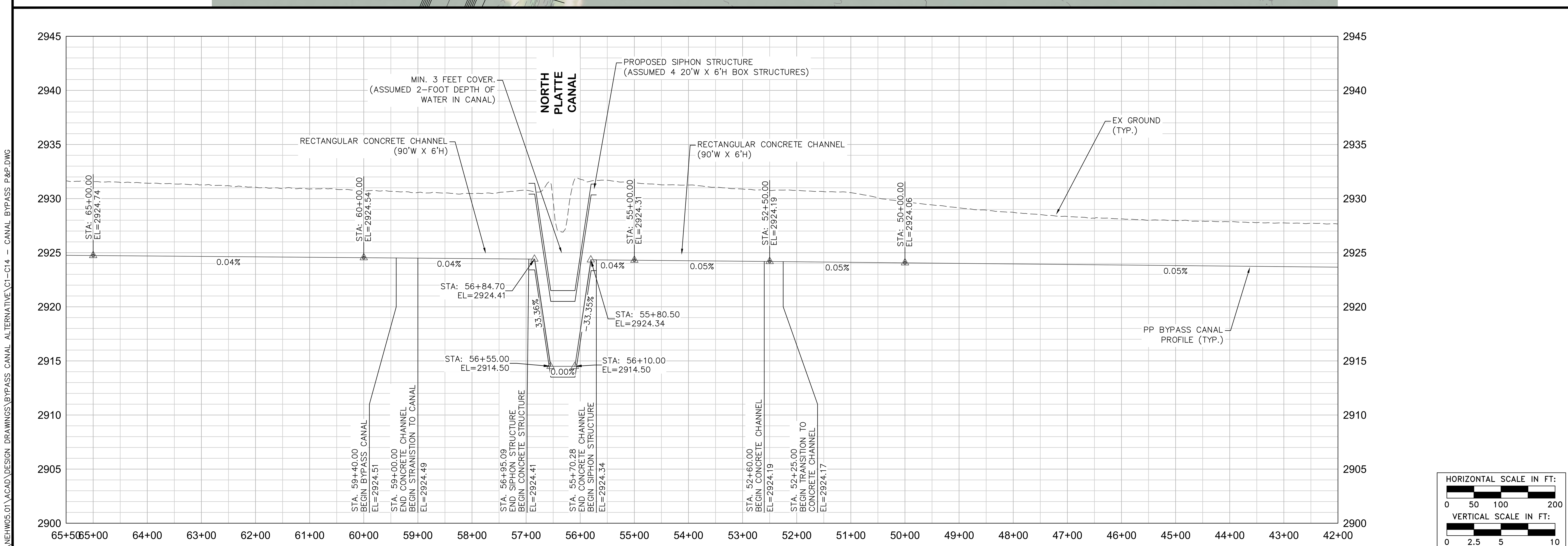

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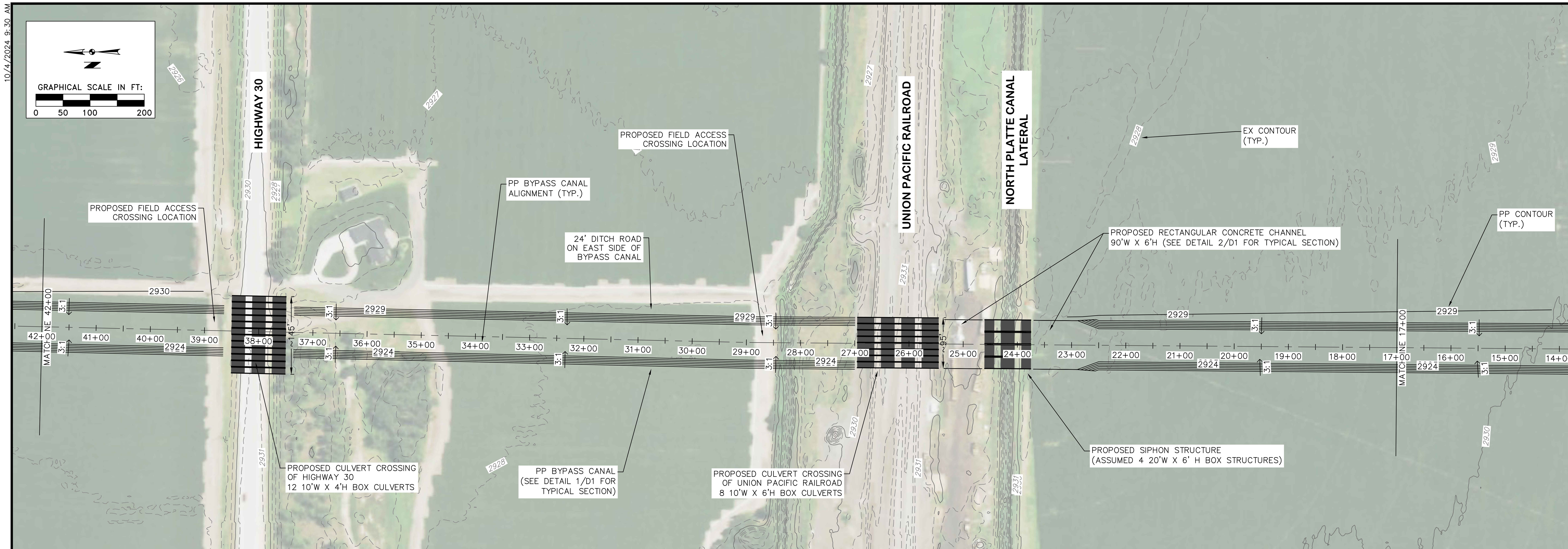

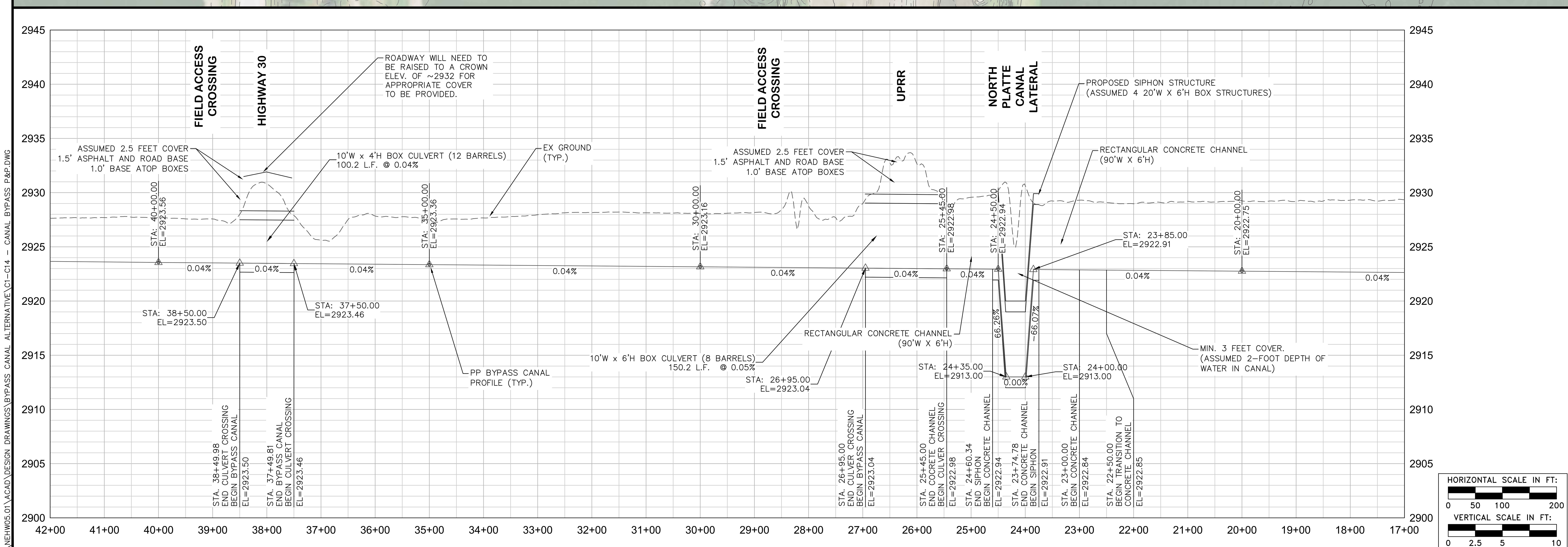

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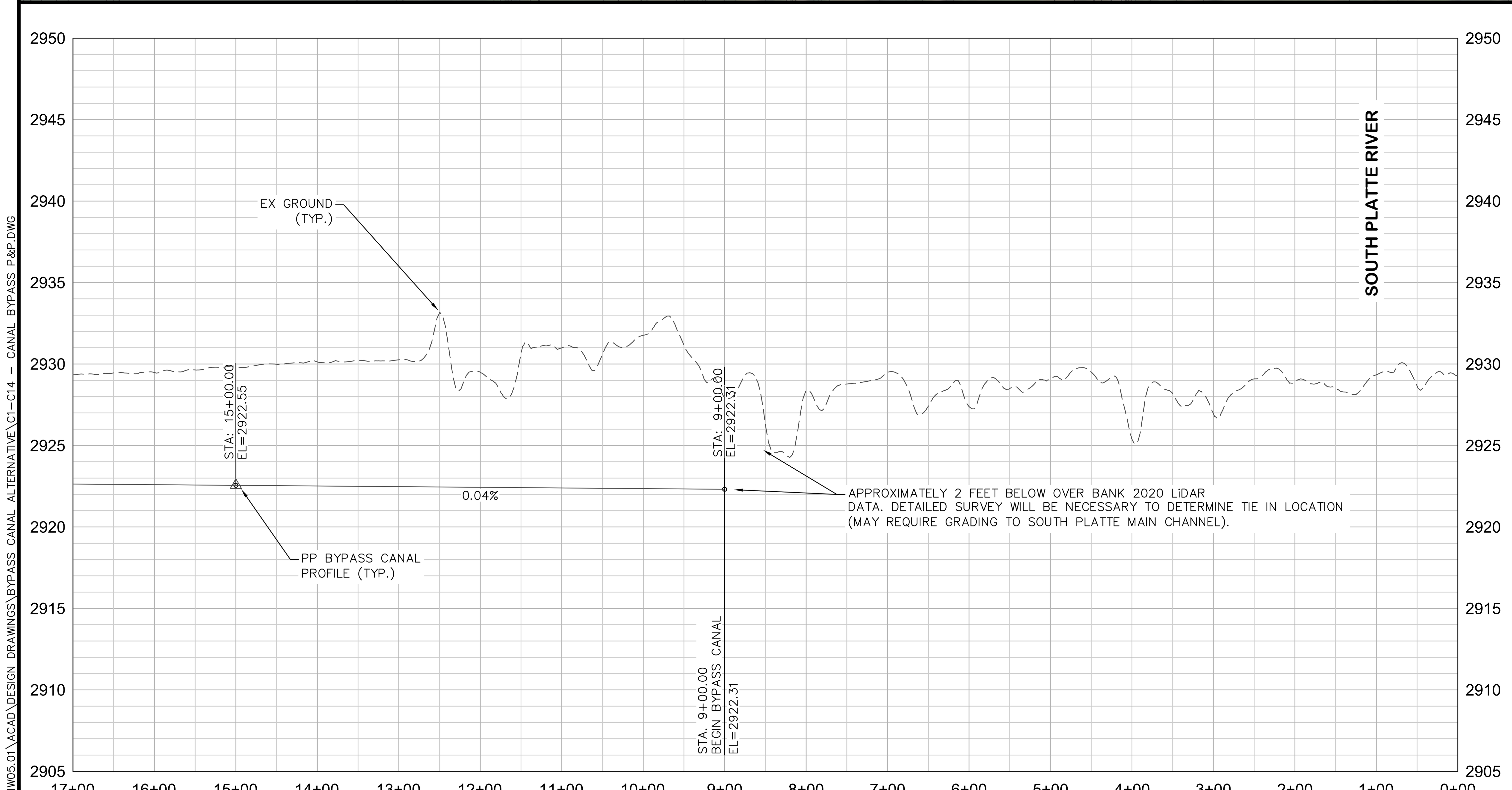

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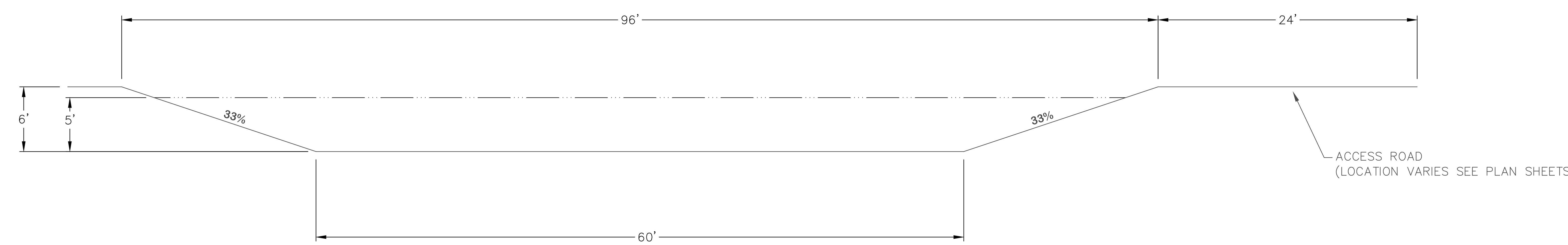

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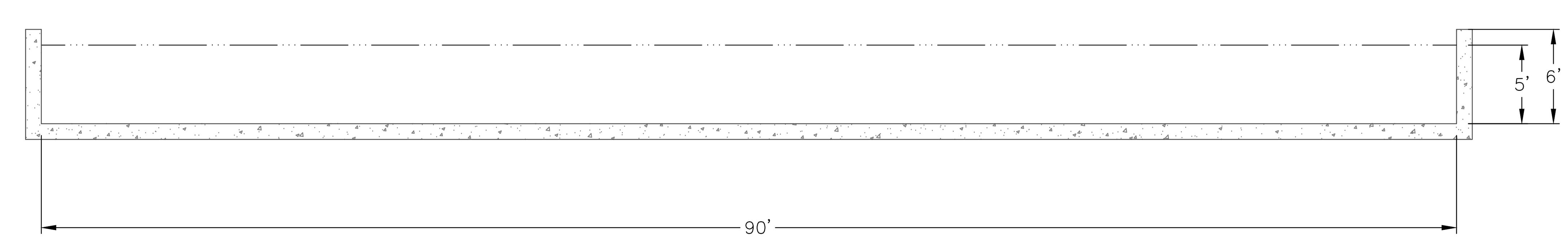

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DETAILS

NORTH PLATTE RIVER CHOKEPOINT 1,500 CFS BYPASS CANAL CONCEPTUAL DESIGN

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APPENDIX E. HYDRAULIC AND SEDIMENT TRANSPORT MODELING

MEMORANDUM

Anderson Consulting Engineers, Inc.
Civil • Water Resources • Environmental

DATE: November 25, 2024 **ACE PROJECT NO.:** NEHW05.04

TO: Seth Turner, PPRIP Executive Director's Office (EDO)

FROM: Michelle Martin, PE, Anderson Consulting Engineers, Inc.

SUBJECT: North Platte Chokepoint Hydraulic and Sediment Transport Modeling Technical Information

This memo provides information related to the 1D and 2D hydraulic and sediment transport modeling developed for evaluation of the North Platte River at the Chokepoint. Model development, calibration, simulation scenarios, and model results applicable to Chokepoint Alternative Evaluations are included. Interpretation of results is provided in the North Platte River Chokepoint Evaluation of Alternative Report (ACE 2024).

1D Hydraulic Model Development

A 1D hydraulic model was developed using HEC-RAS Version 6.5.0 to compute hydraulic conditions required for sediment transport modeling. The 1D hydraulic model of the Chokepoint includes roughly 11 miles of the lower North Fork River, 0.5 miles of the lower South Platte River, and roughly 1.5 miles of the upper Platte River. Model geometry includes 50 cross sections cut using 2017 Bathymetric LiDAR. The model includes the HWY 83, UPRR, and HWY 30 bridges and the Tri-County Canal Diversion (TCCD). Figure 1 shows a schematic of the model reaches and cross sections.

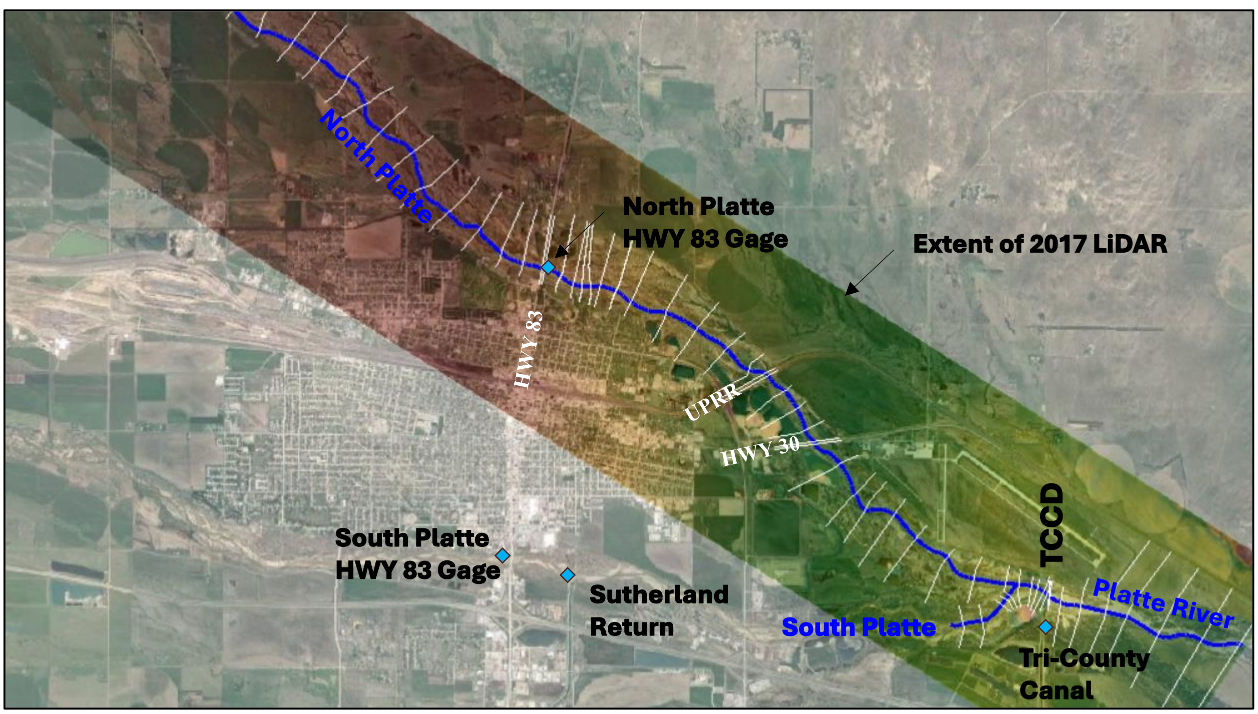

Figure 1 1D Hydraulic and Sediment Transport Model Reaches

Flow is input into the model at the upstream boundary of the North and South Plate reaches. Hydrologic input was determined using average daily flow data from the North Platte River at North Platte Gage (06693000) at HWY 83. South Platte flow input at the upstream boundary of the model utilizes average daily flow data from the South Platte River at North Platte Gage (06765500) located at HWY 83 plus daily flow data at the Sutherland Power Return Gage (00140003). Figure 1 shows the location of the gages. Flow diversions to the Tri-County Canal are extracted from the model just upstream of the TCCD using daily diversion records.

Normal depth boundary conditions are applied at both the upstream and downstream limits of the model. To simulate conditions at the TCCD, an internal boundary condition was applied for operation of gates to maintain a headwater elevation of 2770 feet, which is necessary to facilitate diversions to the Tri-County Canal and support hydraulic dredging operations.

1D Hydraulic Model Calibration

Steady state hydraulics computed by the 1D model were calibrated first using measured data at the North Fork HWY 83 Gage. Steady state hydraulics were computed for a range of flows up to 6,000 cfs and compared with measured gage data. Manning's n values were adjusted to achieve model calibration. Figure 2 shows the stage vs discharge rating curve at the HWY 83 gage from measured data compared with calibrated model results.

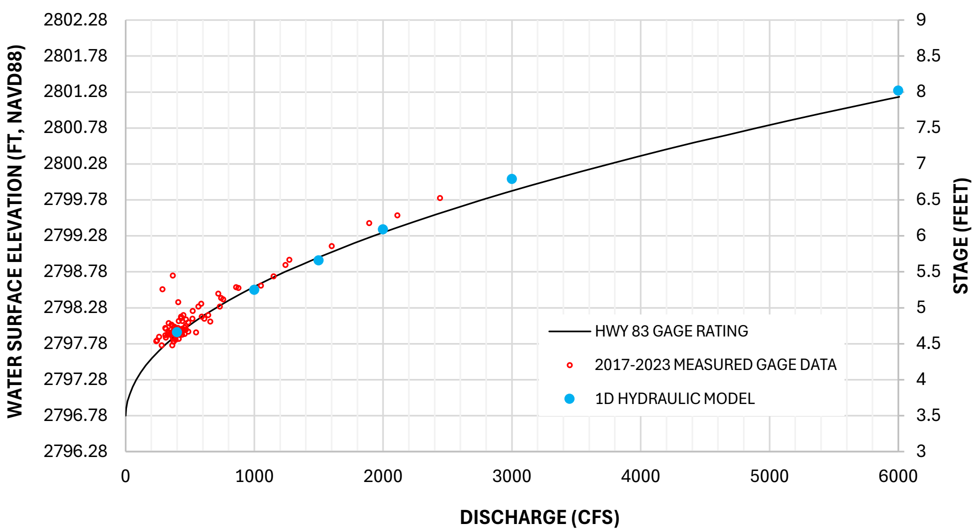

Figure 2 Measured Data vs 1D Hydraulic Model - Stage vs Discharge at HWY 83 Gage

1D Sediment Transport Model Development

The sediment transport model requires specification of a bed material gradation and selection of a transport function and fall velocity method. Bed material samples collected in October of 2023 were used to approximate input gradations. The Yang equation was selected for use based on results of model calibration runs, which are described in the following section on 1D sediment transport model calibration.

Simulation of dredging operations at the TCCD was also included in the model. During model runs sediment that accumulates upstream of the TCCD is extracted between the months of April and October in the specified area shown in Figure 3.

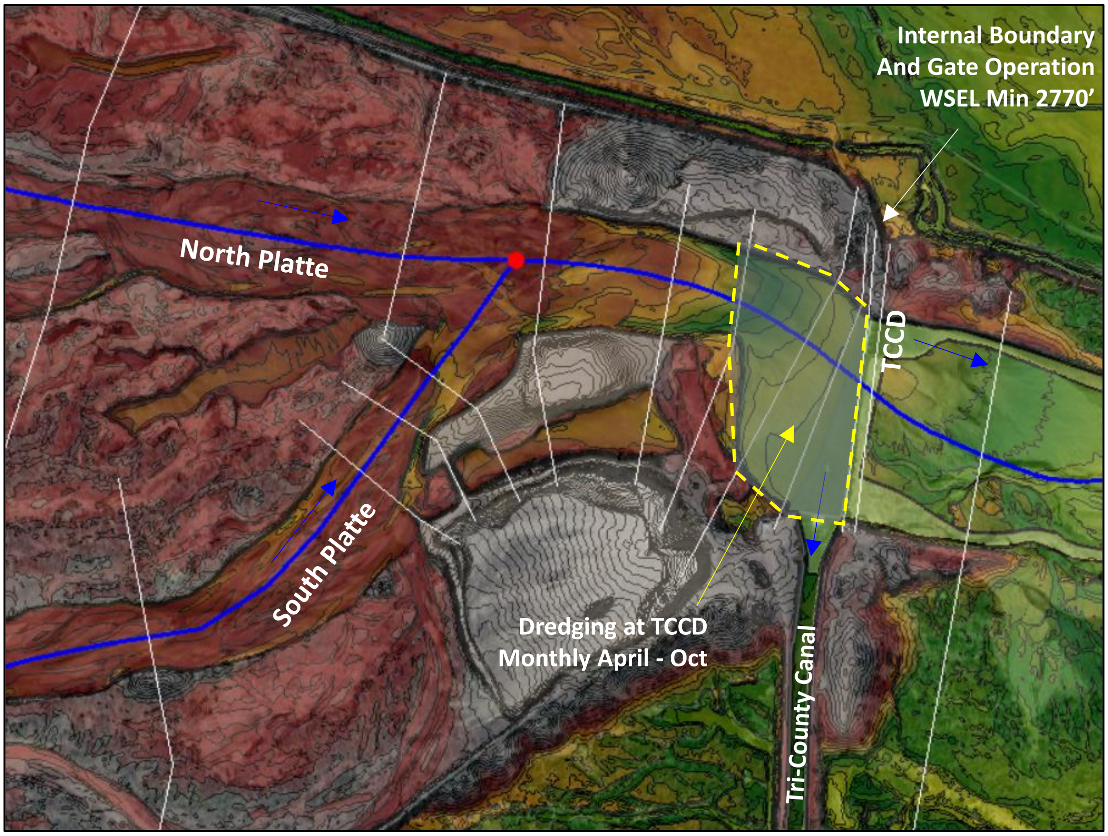

Figure 3 Area of Model Dredging at TCCD

1D Sediment Transport Model Calibration

Model calibration and validation was performed to optimize sediment model input parameters such that results reproduce the measured data with an acceptable degree of accuracy. The calibration model simulates the period between the date of 2017 LiDAR, used to define starting model geometry, and 2023 channel cross sectional survey. Daily flow hydrology for the calibration period is shown in Figure 4. Key model parameters tested during calibration that carry a high level of uncertainty include transport function, fall velocity method, bed material gradations, and erosion/depositional methods.

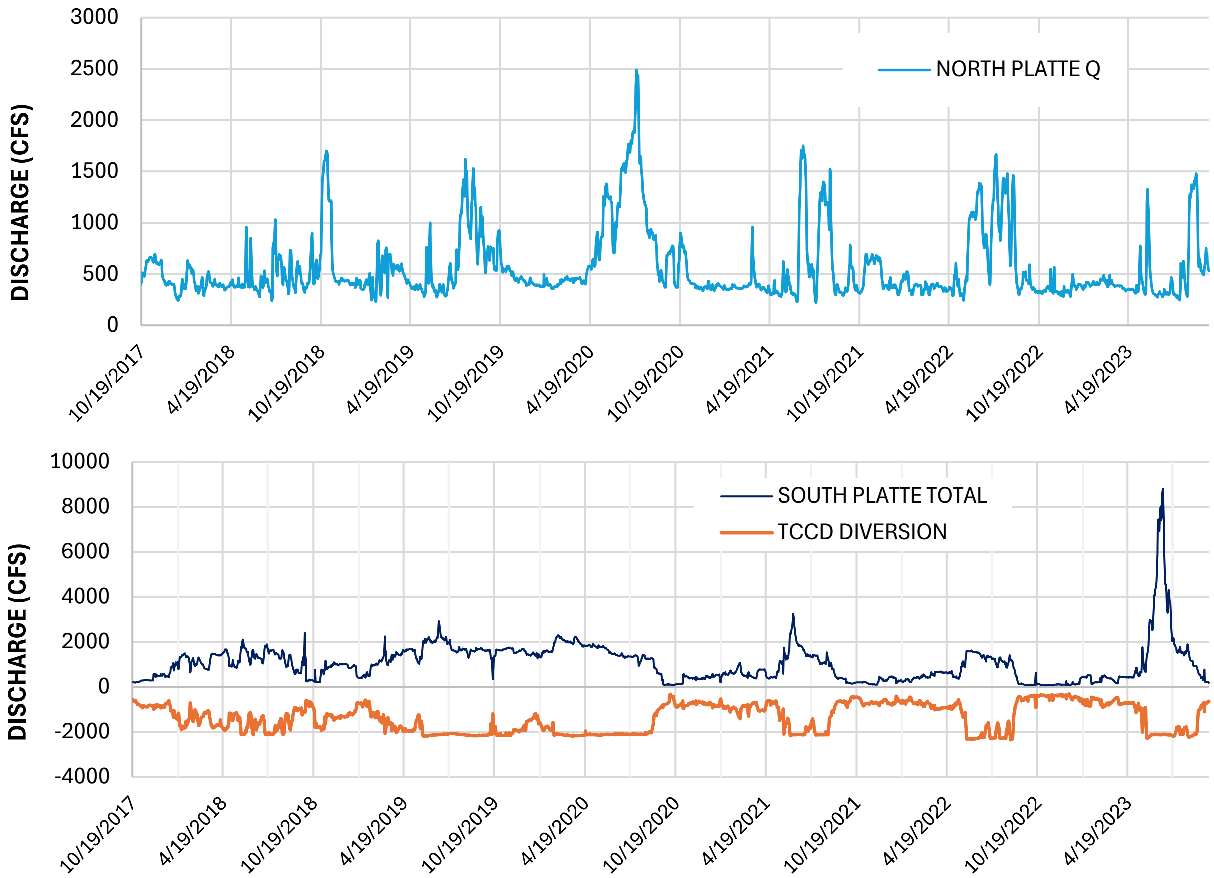

Figure 4 Daily Flow Hydrology for Calibration Period Oct 2017 – Oct 2023

Model results were compared to measured data sets, including the stage-discharge curve and time series of water surface elevation at the HWY 83 gage, the annual dredging volumes at the TCCD (CNPPID dredges an average annual volume of 150,000 cy/yr), and the change in channel geometry and profile based on survey data. Selection of a transport function was determined to have the largest impact on model results. Four sediment transport functions developed for use in sand bed rivers were considered for use including Ackers White, Enelund-Hansen, Yang, and Laursen Copeland. Results using all four equations are shown below. Table 1 shows the average and maximum water surface elevation difference between model results and measured data at HWY 83 over the calibration period and the average annual dredging volume computed by the model at the TCCD. Figures 5 through 8 show a time series comparing water surface elevation at the HWY 83 gage for each transport equation. Figure 9 shows model results using the four transport equations in the form of stage-discharge rating curves at HWY 83 for the full calibration period. Laursen Copeland had the poorest overall performance in both water surface at HWY 83 and dredging volume. Ackers White matched water surface elevations at HWY 83 the closest, however the computed dredging volume was 2.3 times higher than observed. Engelund Hansen and Yang both computed reasonable dredging volumes with Yang providing more accurate water surface elevations at HWY 83.

Table 1 Calibration Model Results

Transport Equation	Ave Error in Water Surface Elevation at HWY83 (ft)[1]	Max Error in Water Surface Elevation at HWY83(ft)[1]	Average Annual Dredging Volume at TCCD (cy/year)[2]
Laursen Copeland	-0.3	-0.9	455,000
Ackers White	0.1	0.4	347,000
Engelund Hansen	-0.3	-0.9	125,000
Yang	-0.1	-0.7	128,000

[1] Model water surface compared to measured water surface elevation at HWY 83 gage.

[2] Average annual dredging volume at TCCD is 150,000 cy/year.

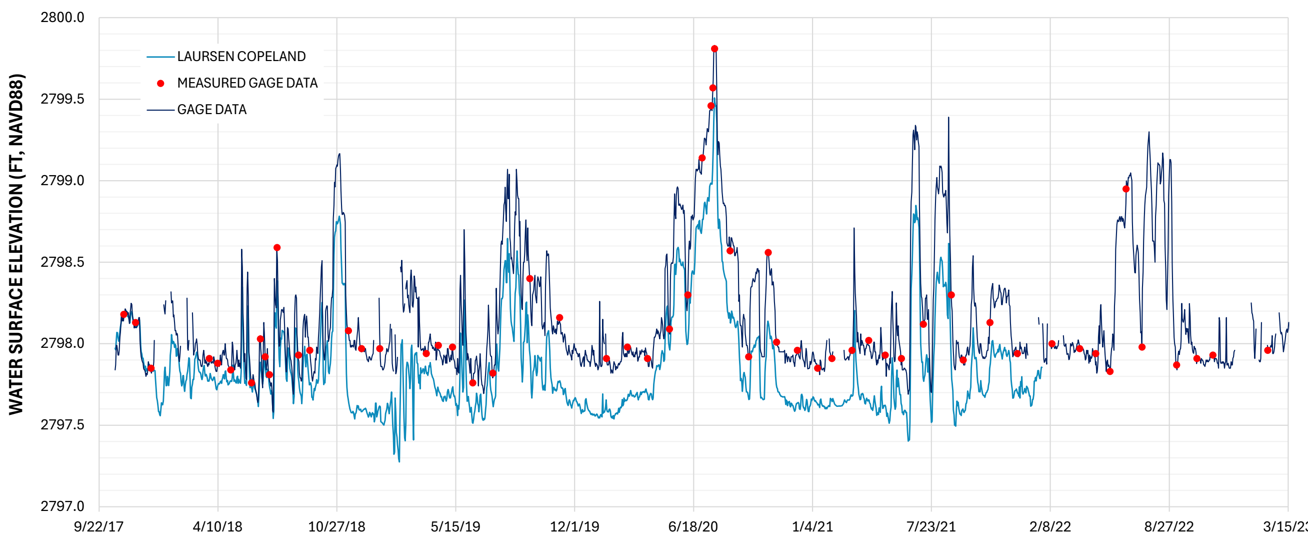

Figure 5 Model Results using Larsen Copeland vs HWY 83 Gage Data

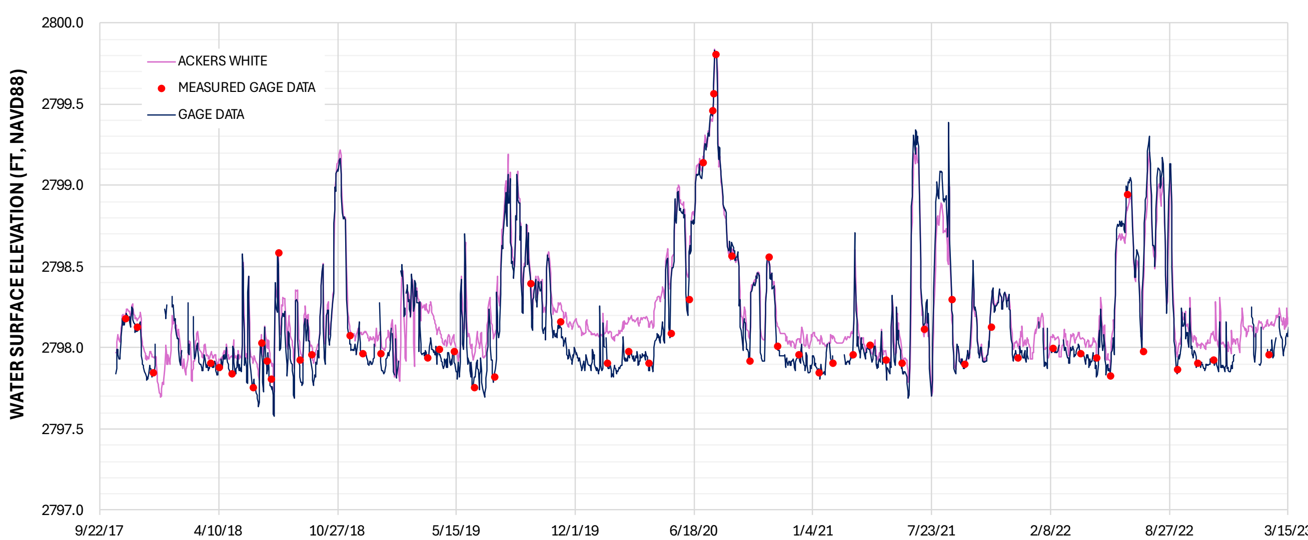

Figure 6 Model Results using Ackers White vs HWY 83 Gage Data

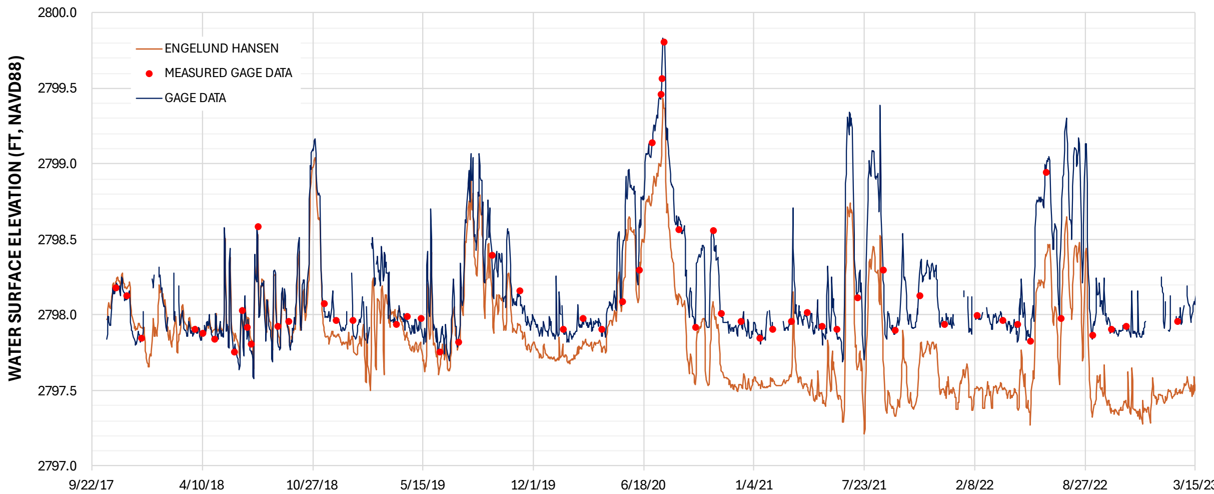

Figure 7 Model Results using Engelund Hansen vs HWY 83 Gage Data

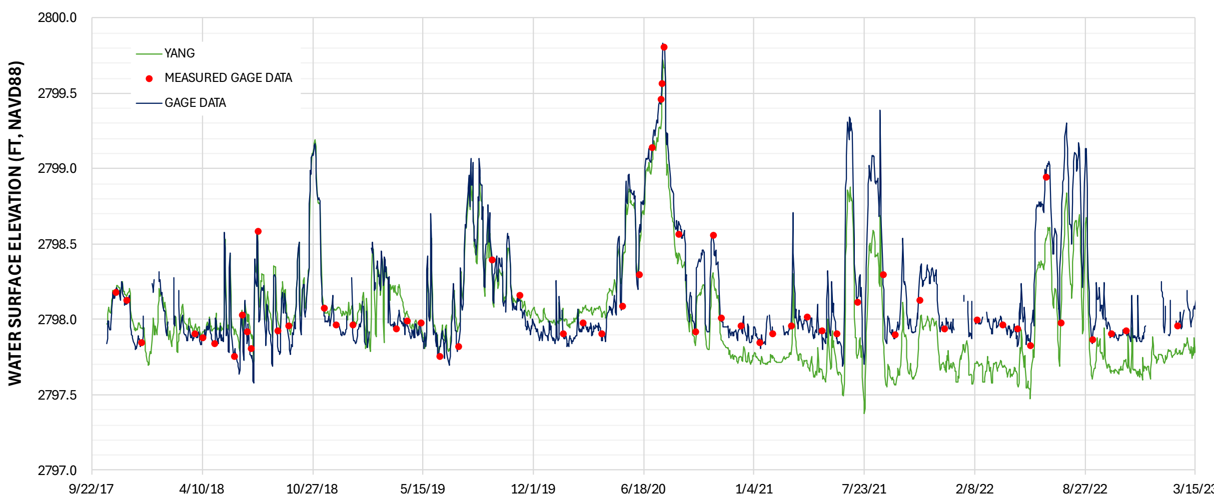

Figure 8 Model Results using Yang vs HWY 83 Gage Data

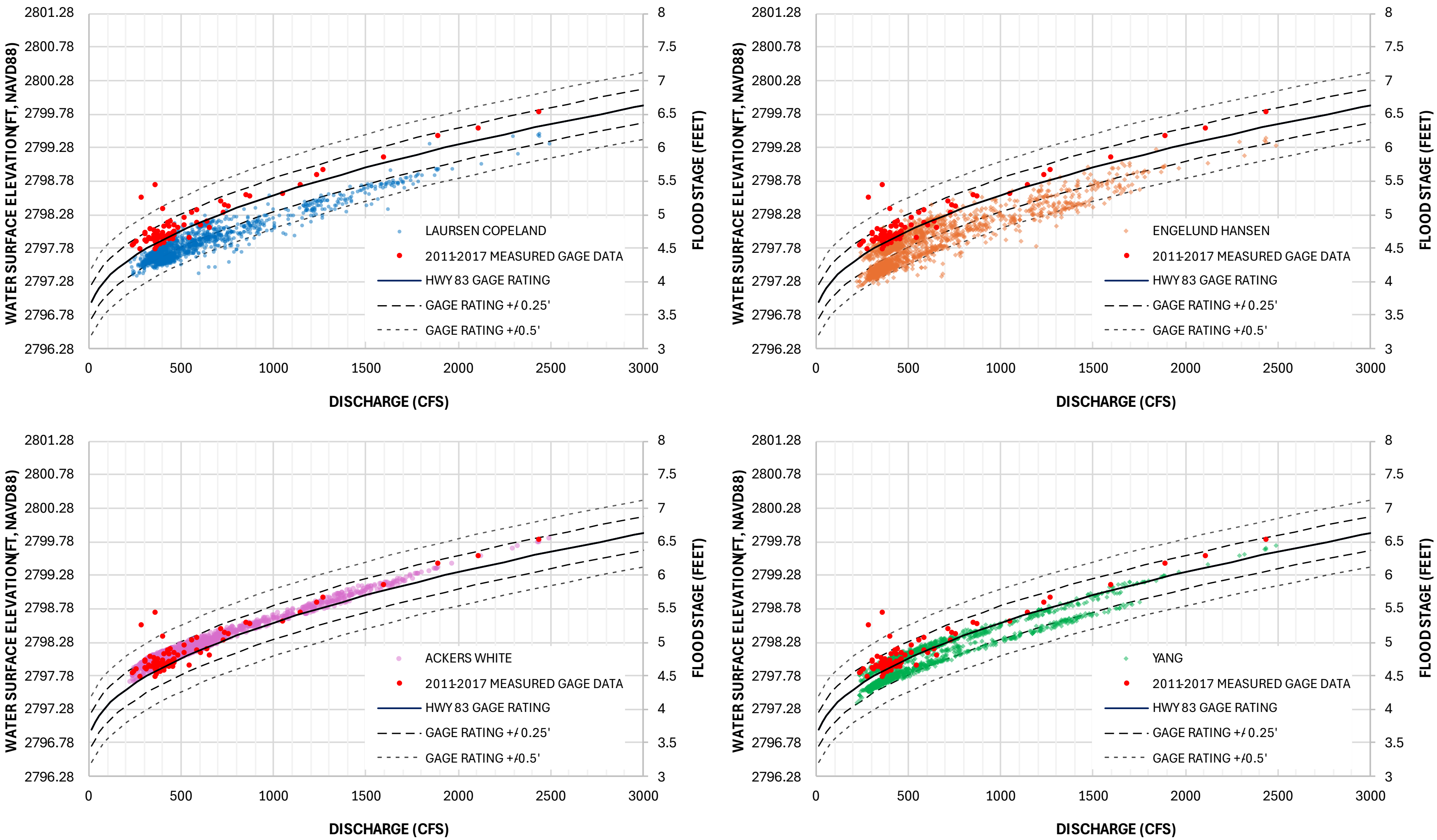

Figure 9 Stage Discharge Rating Curves at HWY 83 Gage – 1D Sediment Transport Model Results 2017-2023 using 4 Transport Equations

Upper Left: Larsen Copeland, Upper Right: Engelund Hansen, Lower Left: Ackers White, and Lower Right: Yang

Final model parameters include the Yang transport function, Soulsby fall velocity method, and a bed material gradation sample collected in 2023 that was coarser than other samples. The stage-discharge relationship and plot of water surface elevation through time show that the model reasonably predicts water surface elevation within 0.25 feet over the 6-year calibration period.

CNPPID dredges approximately 150,000 CY/year of sediment at the TCCD. The calibration model computed an average annual dredging volume of 128,000 CY/year, with a range of annual volumes shown over the calibration period in Figure 10. Variations in dredging volumes are directly related to variation in flow conditions occurring in the North and South Platte each year. (Note that over the six-year simulation period the model predicted a total dredging volume of 760,000 CY.)

The channel profile at the end of the model period was compared with the 2023 survey profile in Figure 11. The average difference in minimum channel elevation along the length of the model is +/-0.8 feet, and within the natural variation of channel change. The mass bed change occurring within the channel is compared in Figure 12. Examination of mass bed change is often used to identify trends in degradation or aggradation. The magnitude of mass bed change shown in Figure 12 is much smaller (an order of magnitude smaller) relative to the volume of sediment being transported to and dredged at the TCCD. Mass bed change measured from survey data does not indicate a trend in either aggradation or degradation and is similar in magnitude to model results. Overall review of the calibration results indicates that the model can reasonably simulate transport dynamics through the Chokepoint reach and dredging operations at the TCCD.

The percent of daily sediment load from the North Platte relative to the total from the North and South Platte is plotted through the calibration period in Figure 13. This value is highly variable from day to day. However, when averaged through time the model estimates that roughly 40% of sediment delivered to the TCCD during the calibration period originated from the North Platte.

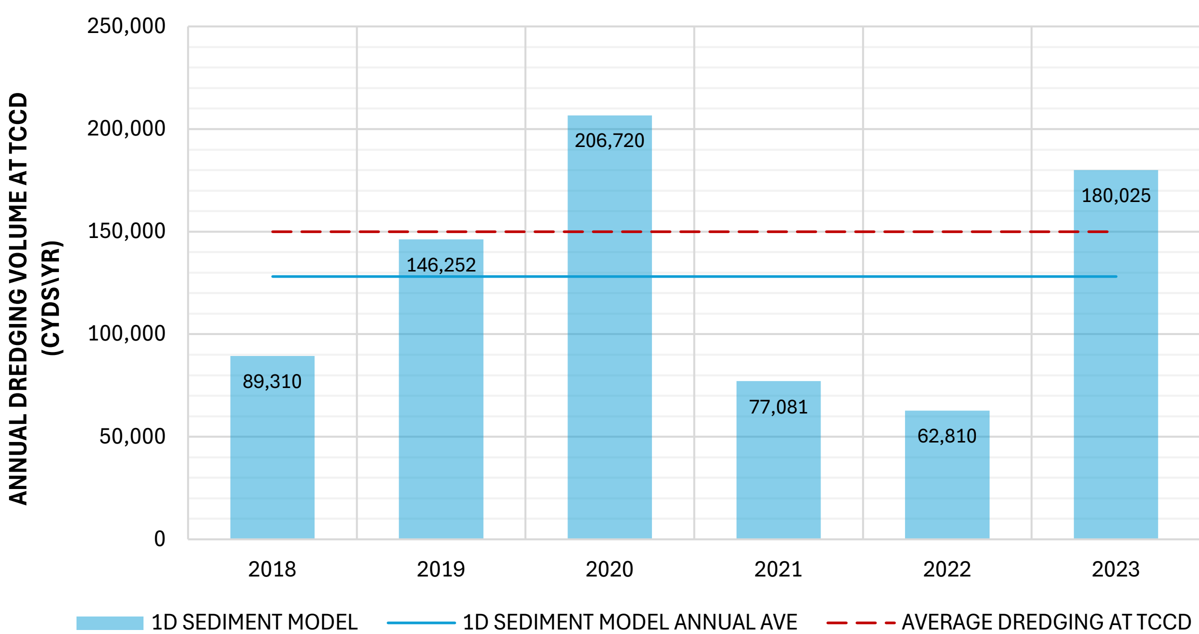

Figure 10 Comparison of Calibration Model Annual Dredging Volume at TCCD using Yang

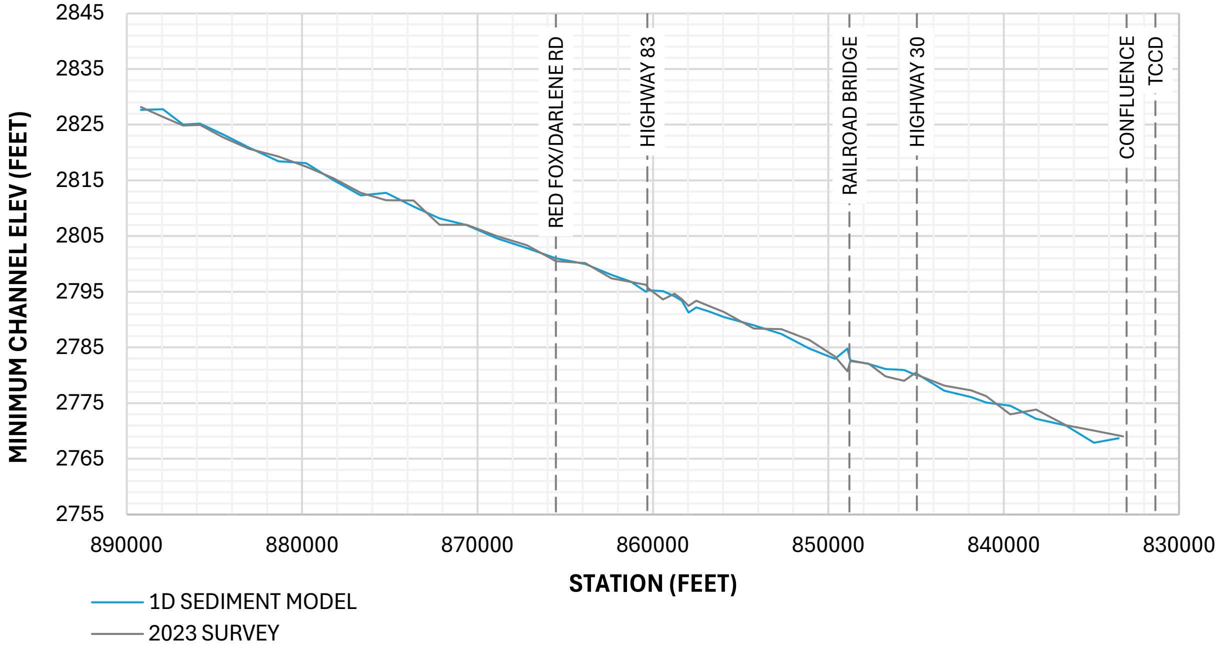

Figure 11 Channel Profile Comparison – Calibration Model vs 2023 Survey using Yang

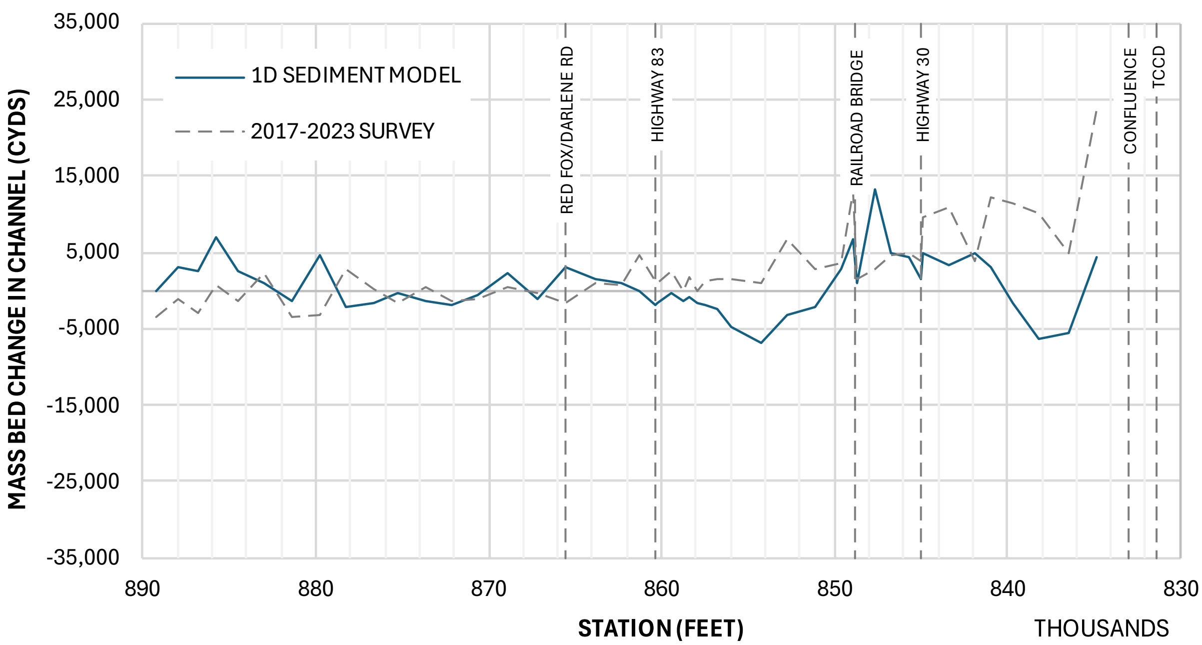

Figure 12 Mass Bed Change in Channel – Calibration Model vs Survey Data using Yang

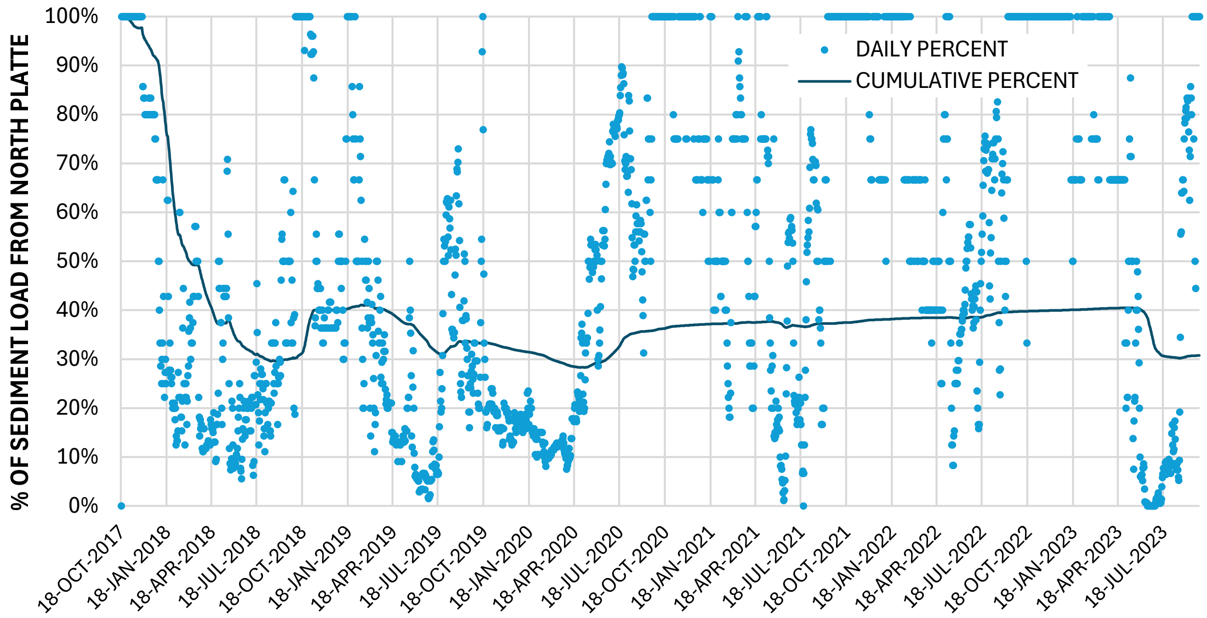

Figure 13 Percent of Sediment Load from North Platte over Calibration Period

1D Sediment Model – Long Term Forecasting

The calibrated 1D sediment transport model was used to run a 25-year forecast of no-action and channel modification/sediment removal alternatives. The model was used to provide insight into long term river response. All forecast modeling includes continuation of diversion and dredging operations at the TCCD.

Three 25-year hydrographs were developed using historic gage data and diversion records between 2009 and 2022 in the following combinations:

1. H1 Hydrograph: 2009 – 2022, 2009 – 2019, both occurrences of the 2011 flood (in year 3 and 17) were removed and replaced with 2019, see Figure 14.

2. H2 Hydrograph: 2009 – 2022, 2009 – 2019, both occurrences of the 2011 flood were removed and replaced with 2019, a 3-day annual peak of 3,000 cfs was added to each year in early April to simulate EA releases, see Figure 15. The 2011 flood was replaced with 2019 because 2019 is representative of an average hydrologic year.

3. H3 Hydrograph: 2009 – 2022, 2009 – 2019, the 2011 flood is included in year 3, the 2011 flood was removed and replaced with 2019 in year 17, a 3-day annual peak of 3,000 cfs was added to each year in early April to simulate EA releases, see Figure 16.

The hydrology that occurred between 2009 and 2022 has a reasonable range of flow conditions on both the North Platte and South Platte that are representative of the previous 20 years. Notable occurrences include the 2011 flood with a peak flow of approximately 6,000 cfs (roughly a 10-year flood event based on USACE 2013 hydrologic study), the 2016 event with a peak flow of 3,500 cfs on the North Fork (roughly between a 2- and 5-year event based on USACE 2013 hydrologic study), and 2020 with a peak flow of 2,500 cfs that occurred during the 2020 flow test. Modeling does not consider large flood events on the

North Platte that exceed a 10-year return period. High flow events on the South Platte are noted within the dataset and include the 2013 and 2015 floods, both with a peak flow of nearly 20,000 cfs, which is estimated to be larger than a 25-year event.

Results of 1D sediment transport forecast modeling for the no-action and channel alternatives are provided in Attachments A through E as listed below. Interpretation of results is provided in the North Platte River Chokepoint Evaluation of Alternatives Report.

Attachment A No-Action Model Results

Attachment B Sediment Removal Alternative A

Attachment C Sediment Removal Alternative B

Attachment D Sediment Removal Alternative C

Attachment E ACE1026 Channel Modification Alternative

Figure 14 25-Year Hydrograph for Sediment Transport Modeling – H1 Hydrograph

H1 Hydrograph: 2009 – 2022, 2009 – 2019, both occurrences of the 2011 flood (in year 3 and 17) were removed and replaced with 2019.

Figure 15 25-Year Hydrograph for Sediment Transport Modeling – H2 Hydrograph

H2 Hydrograph: 2009 – 2022, 2009 – 2019, both occurrences of the 2011 flood were removed and replaced with 2019, a 3-day annual peak of 3,000 cfs was added to each year in early April to simulate EA releases.

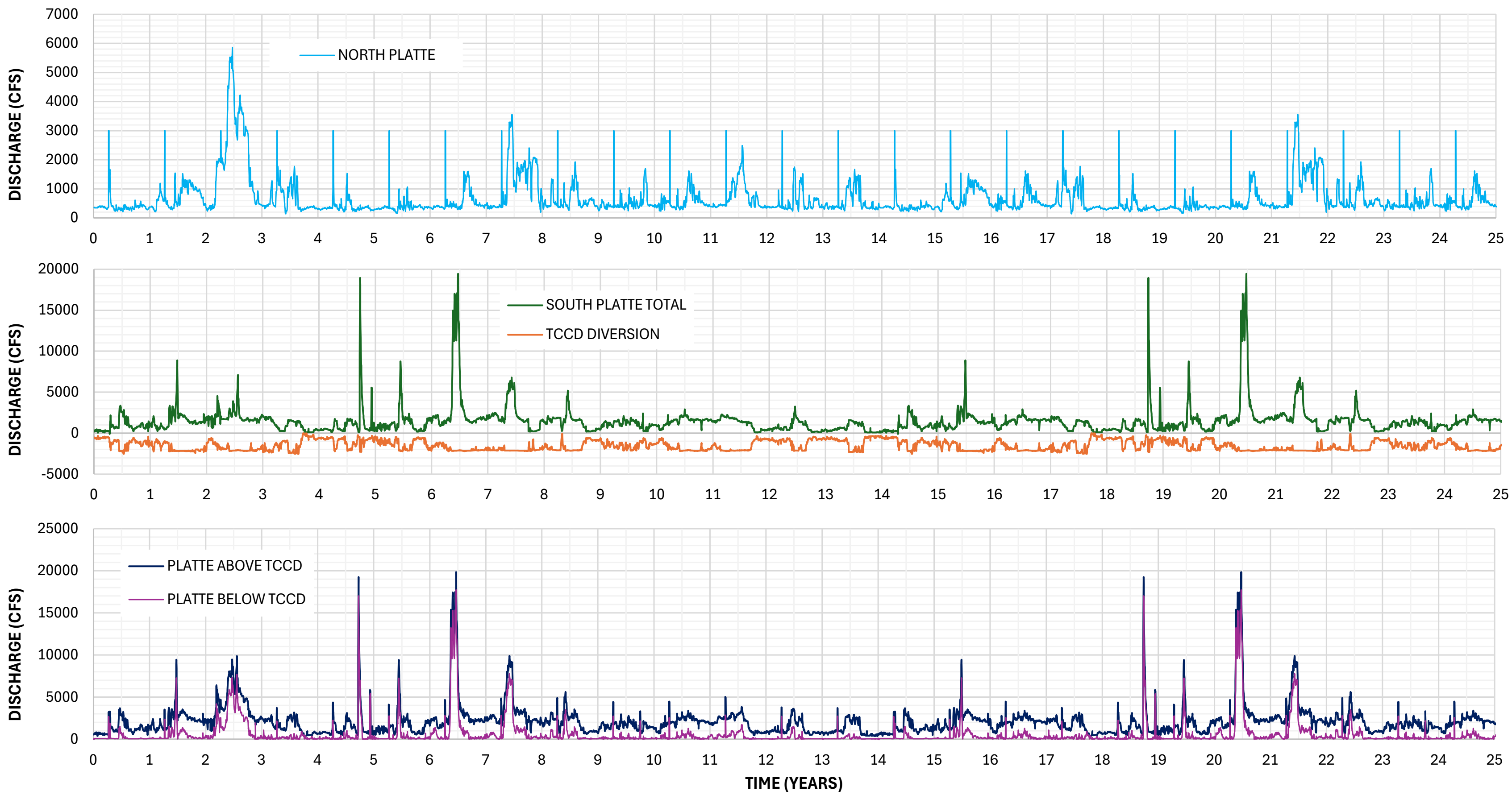

Figure 16 25-Year Hydrograph for Sediment Transport Modeling – H3 Hydrograph

H3 Hydrograph: 2009 – 2022, 2009 – 2019, the 2011 flood is included in year 3, the 2011 flood was removed and replaced with 2019 in year 17, a 3-day annual peak of 3,000 cfs was added to each year in early April to simulate EA releases.

Attachment A. No Action Alternative

The No Action alternative is a continuation of existing river management at the Chokepoint including vegetation control and CNPPID dredging at the Tri-County Canal Diversion (TCCD).

The geomorphic and sediment transport assessment concluded that the North Platte River Chokepoint reach has been in a quasi-equilibrium state for roughly 20 years. Assuming that there are no significant changes in upstream reservoir operations, vegetation control, diversions and dredging at the TCCD, or climate shifts, the Chokepoint reach is expected to remain in a quasi-equilibrium state into the future. Currently, the average hydraulic capacity at minor flood stage is expected to remain at about 1,700 cfs, with a range between 1,550 and 2,150 cfs, depending on flow conditions. At the target flow of 3,000 cfs flood stage at the HWY 83 gage is between 6.5 and 7.0 feet (0.5 to 1.0 feet above minor flood stage).

Additional hydraulic and sediment transport modeling of the No Action alternative was conducted to establish a baseline for comparison with other alternatives. The existing hydraulic conditions were defined based on the results of the 2D hydraulic model. The 2D hydraulic model was run for a range of selected flows including 400 (baseflow), 1,000, 1,500, 2,000, 3,000 and 6,000 cfs. The 1D sediment transport model with a 25-year forecast was used to estimate future river trajectory and trends in hydraulic capacity. Note that sediment transport modeling is not intended to provide deterministic results. The results should be carefully interpreted within the context of the geomorphic assessment and consider uncertainties associated with sediment transport modeling.

A graphical water surface profile at 3,000 cfs is shown for the study reach below Red Fox/Darlene Rd in Figure A-1. Inundation mapping at 3,000 cfs developed from 2D hydraulic model results are shown in Figure A-2. The location of Red Fox/Darlene Rd area and HWY 83 gage are noted on the figure.

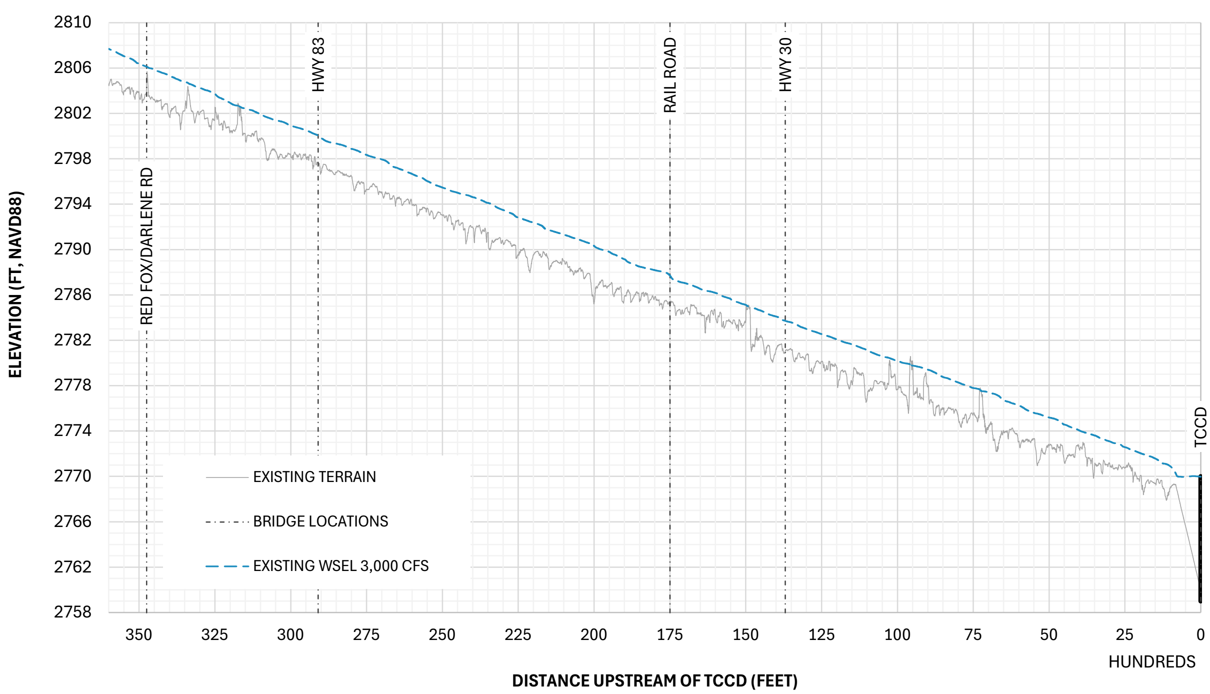

Figure A-1 3,000 cfs Water Surface Profile - Existing Condition/No Action

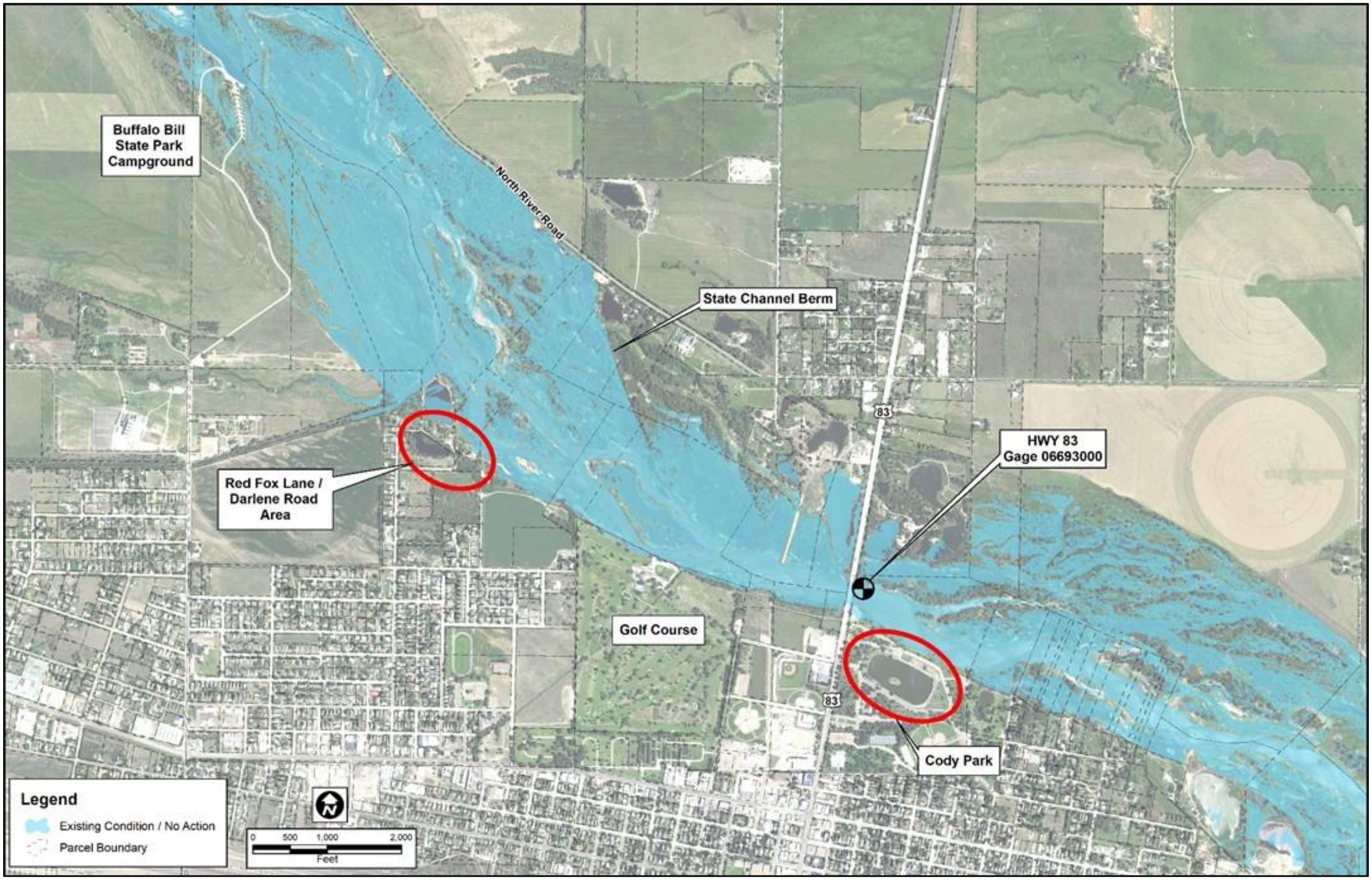

Figure A-2 North Platte Chokepoint Inundation Mapping at 3,000 cfs – Existing Conditions/No Action

A.1 No Action – H1 Hydrograph

Results for the No Action alternative 25-year forecast modeling using the H1 hydrograph is provided in Figure A-3 through Figure A-5.

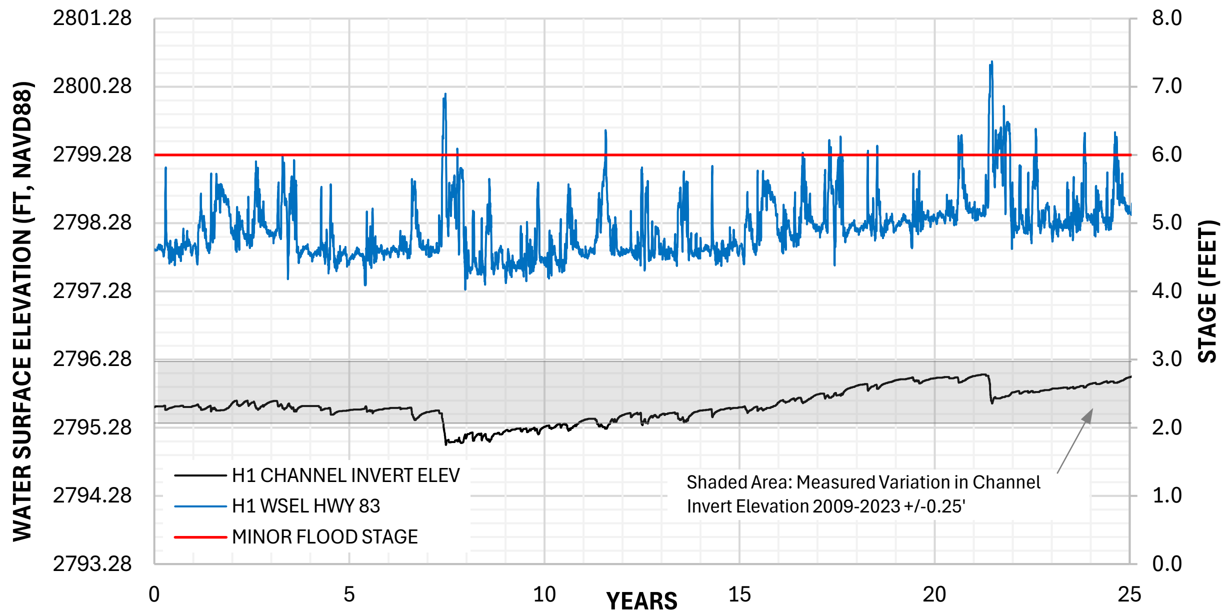

Figure A-3 Water Surface and Channel Elevation at HWY 83 – No Action H1

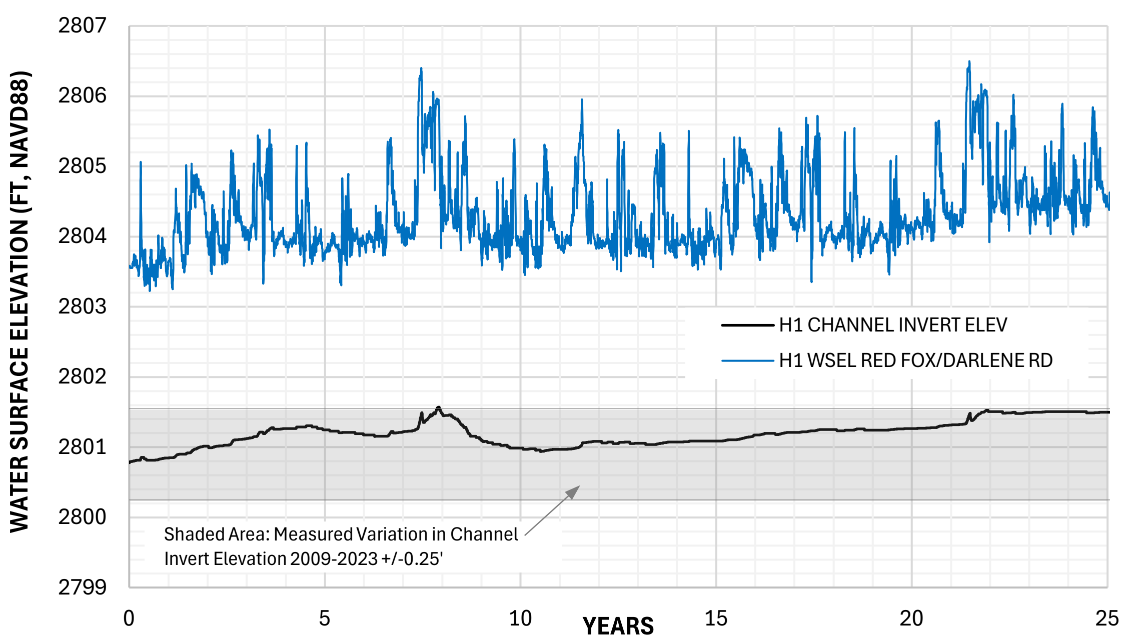

Figure A-4 Water Surface and Channel Elevation at Red Fox/Darlene Rd – No Action H1

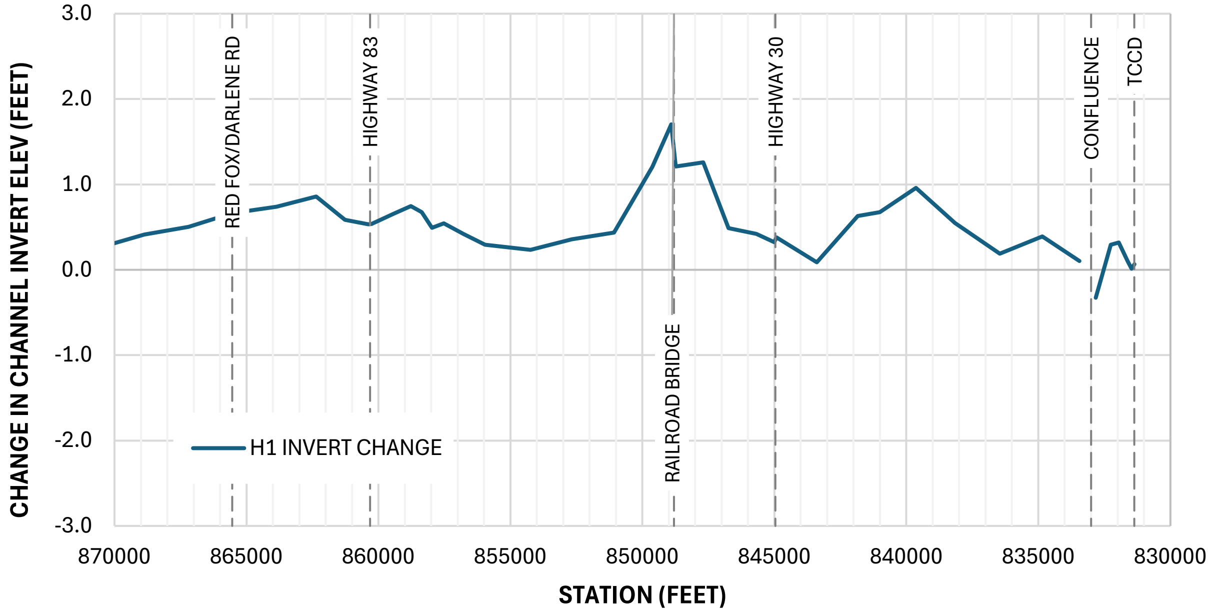

Figure A-5 Change in Channel Invert Elevation – No Action H1

Table A-1 Ave Annual Dredging Volume – No Action H1

Average Annual Dredging at TCCD	190,742 cyds/yr

A.3 No Action – H2 Hydrograph

Results for the No Action alternative 25-year forecast modeling using the H2 hydrograph is provided in Figure A-6 through Figure A-9.

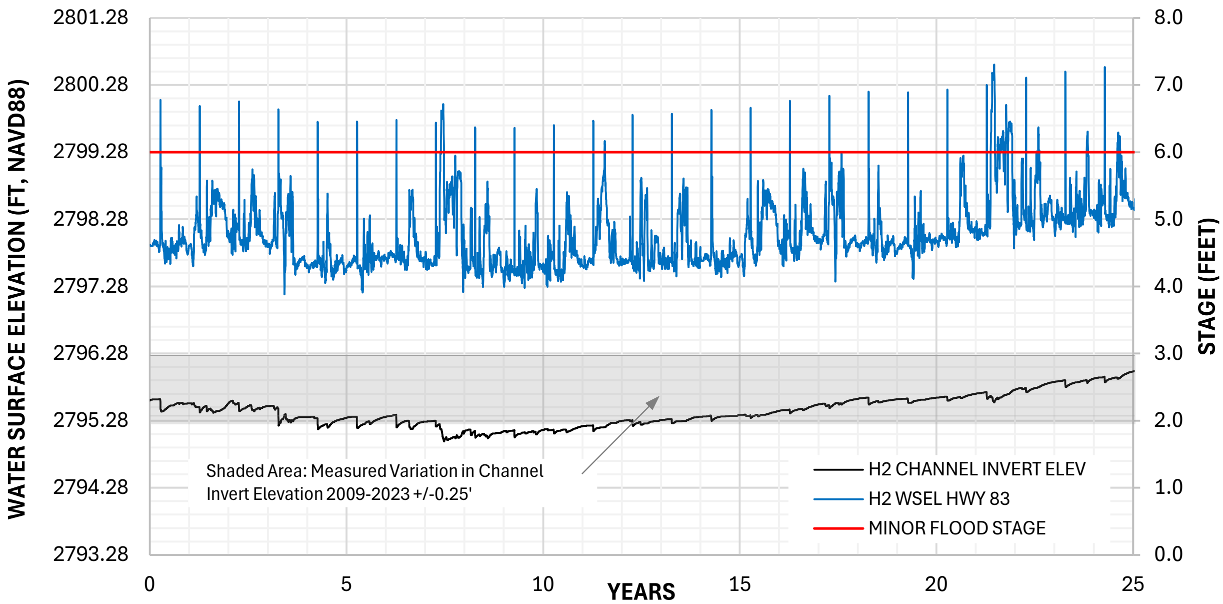

Figure A-6 Water Surface and Channel Elevation at HWY 83 – No Action H2

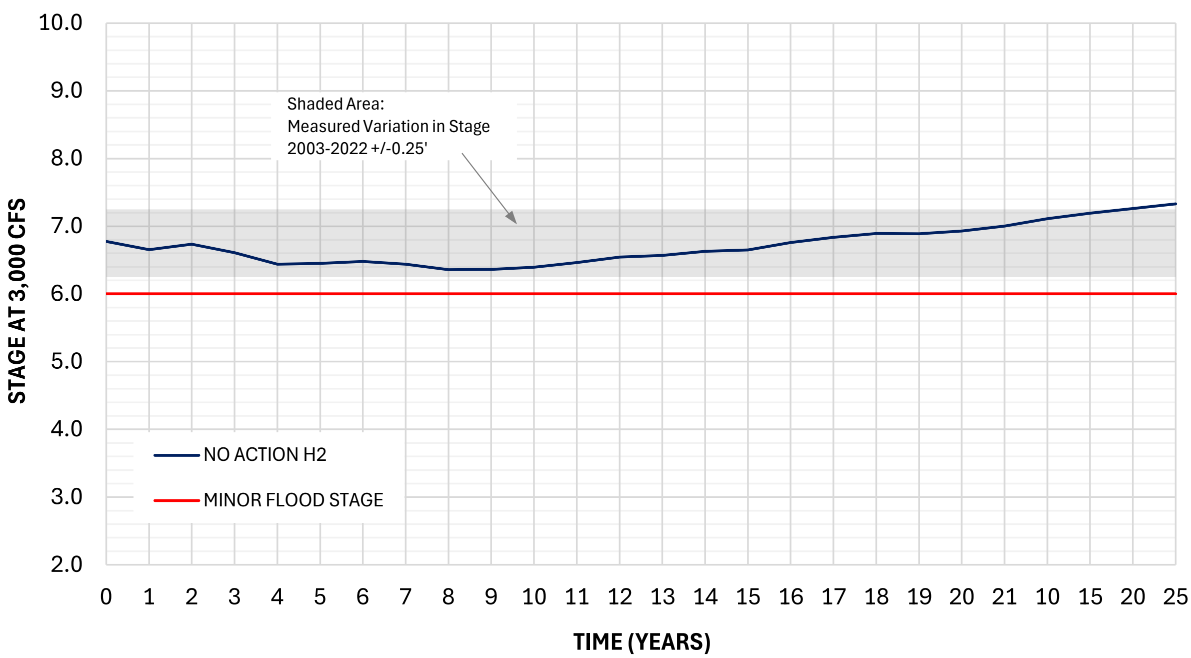

Figure A-7 Stage at HWY83 at 3,000 cfs through Time – No Action H2

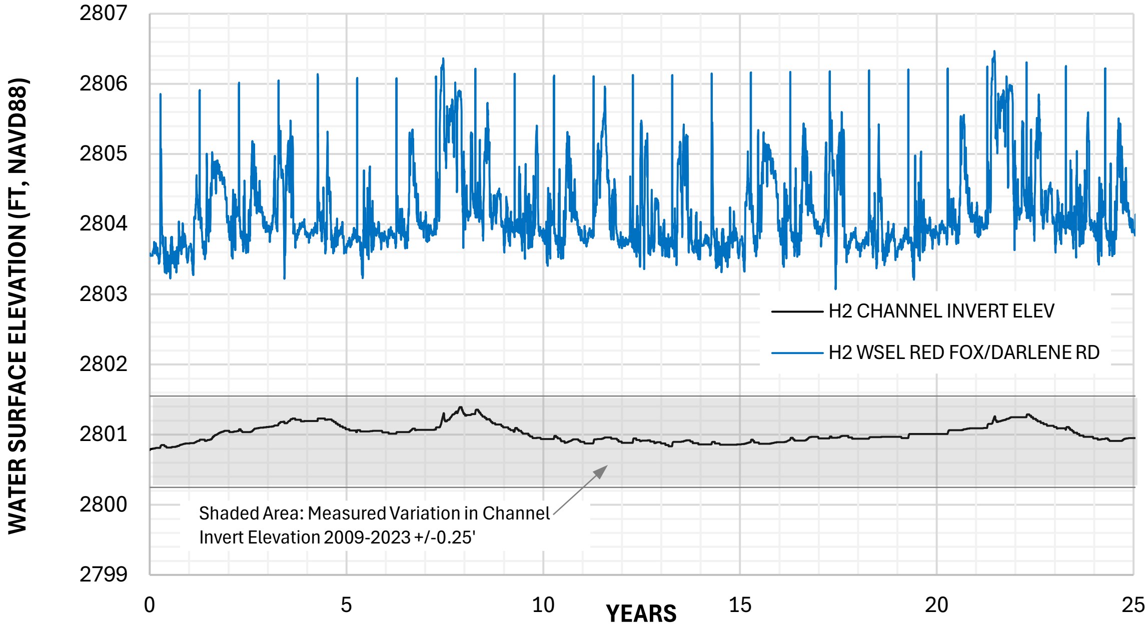

Figure A-8 Water Surface and Channel Elevation at Red Fox/Darlene Rd – No Action H2

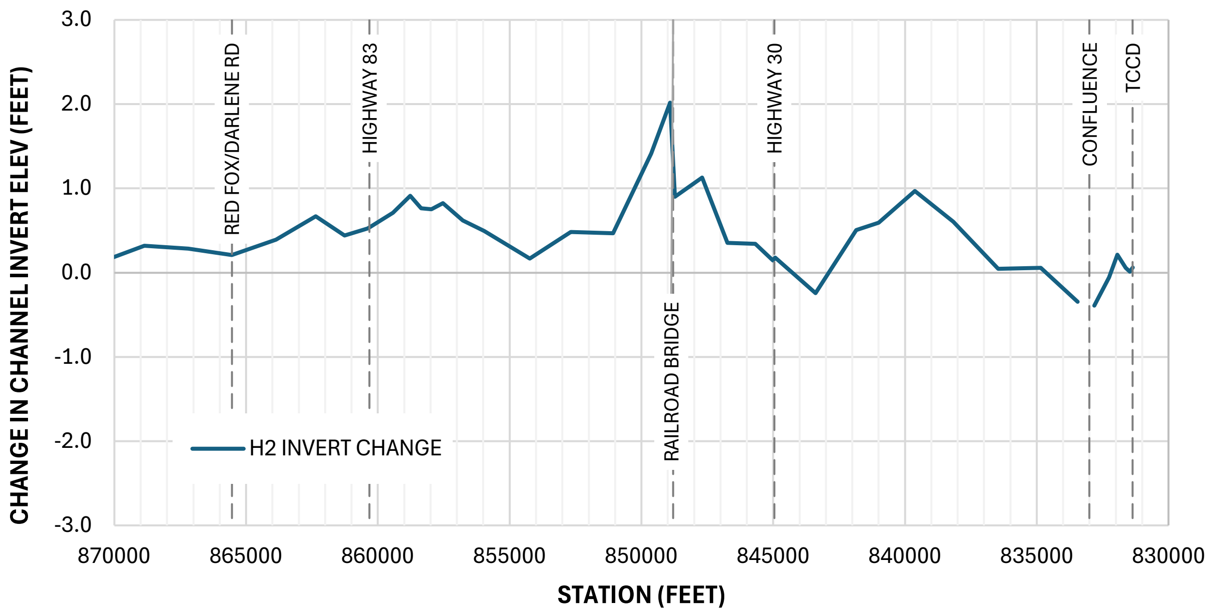

Figure A-9 Change in Channel Invert Elevation – No Action H2

Table A-2 Ave Annual Dredging Volume – No Action H2

Average Annual Dredging at TCCD	193,629 cyds/yr

A.4 No Action – H3 Hydrograph

Results for the No Action alternative 25-year forecast modeling using the H3 hydrograph is provided in Figure A-10 through Figure A-13.

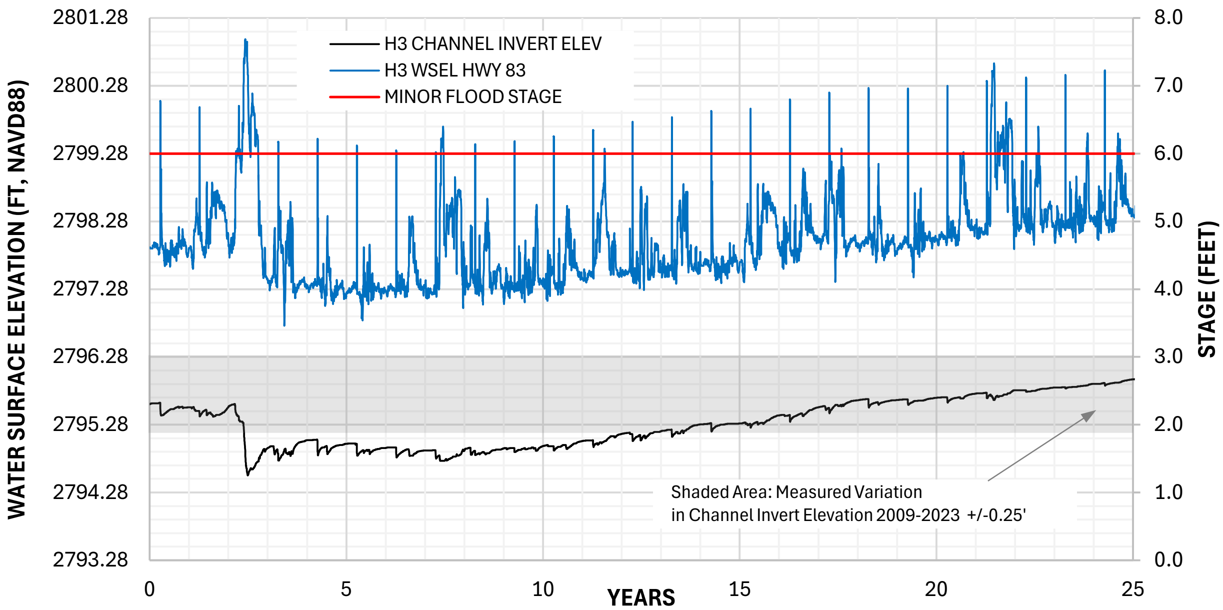

Figure A-10 Water Surface and Channel Elevation at HWY 83 – No Action H3

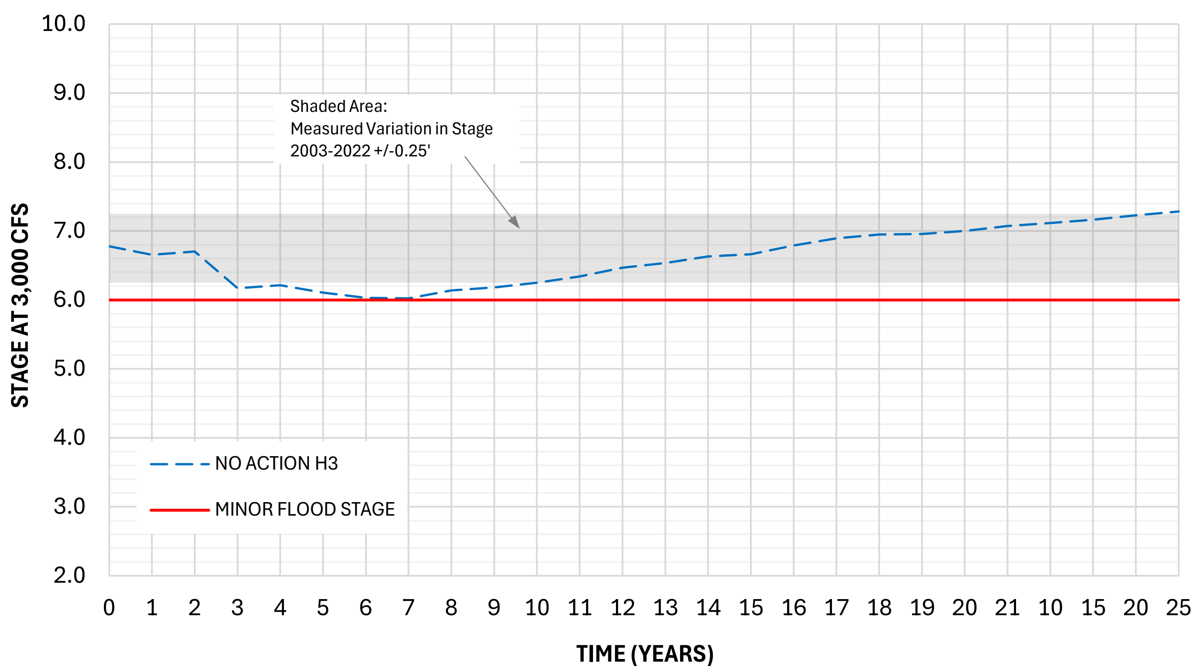

Figure A-11 Stage at HWY83 at 3,000 cfs through Time – No Action H3

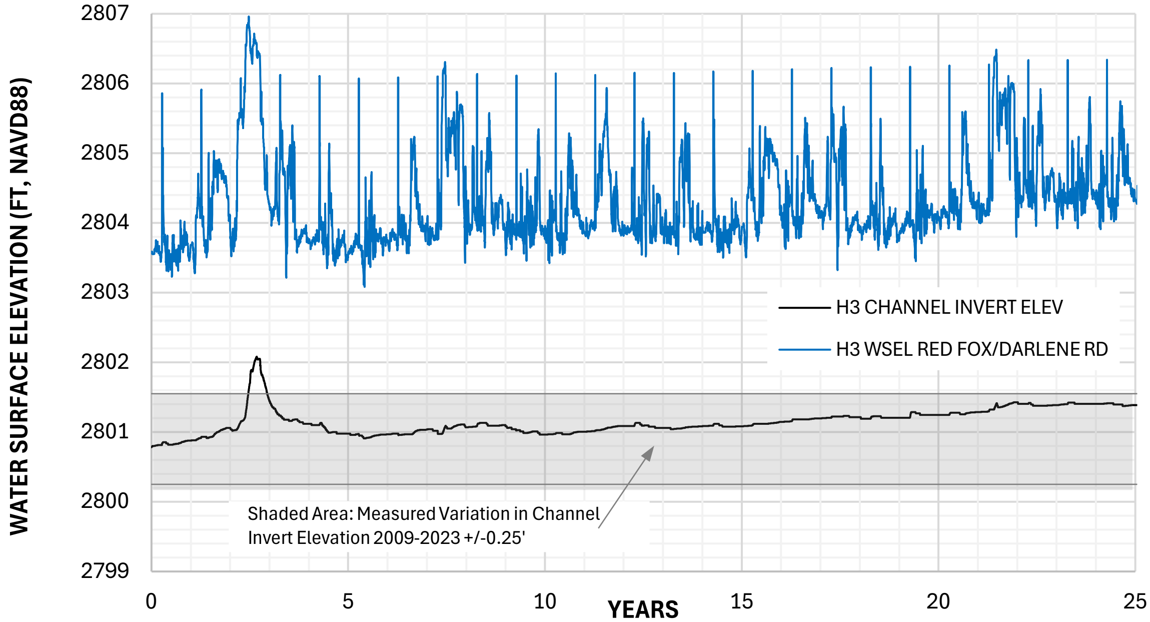

Figure A-12 Water Surface and Channel Elevation at Red Fox/Darlene Rd – No Action H3

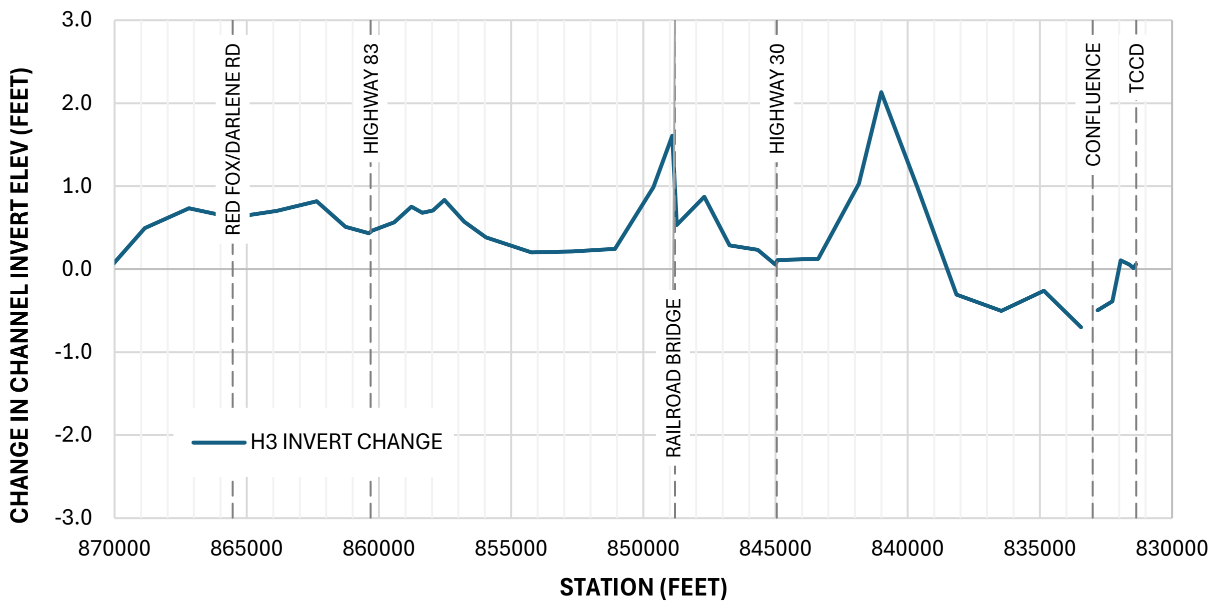

Figure A-13 Change in Channel Invert Elevation – No Action H3

Table A-3 Ave Annual Dredging Volume – No Action H3

Average Annual Dredging at TCCD	203,878 cyds/yr

Attachment B. Sediment Removal Alternative A

Sediment Removal Alternative A (Alt A) includes channel excavation of roughly 6.6 miles from the TCCD to just upstream of the Red Fox/Darlene Rd area, see Figure B-1. The excavated channel would restore the historic channel profile and slope of 0.125% as shown in Figure B-2. Channel widths of 150 and 200 feet were evaluated, with 150 feet providing slightly more efficient sediment movement. All modeling results discussed assume a 150 wide channel. Total excavation volume for Alt A (150 ft wide channel) is significant and estimated at 1,170,000 CY. The depth of channel excavation would be variable and increase in the downstream direction to cut into the sediment wedge. This is similar to the sediment removal concept originally proposed in the VESPR Report (RDG 2023), but with excavation extended upstream an additional 1.4 miles from HWY 83 to effectively reduce water surface elevations in the Red Fox/Darlene Rd area that were problematic during the 2020 flow test.

Sediment removal Alt A increases hydraulic capacity at minor flood stage to approximately 6,000 cfs. This is similar to historic hydraulic capacity measured at the HWY 83 gage in the 1980s. Figure B-2 shows the water surface profile at 3,000 cfs for Alt A compared with existing conditions. Inundation mapping at 3,000 cfs for Alt A is compared with existing conditions in Figure B-3. Water surface profiles and inundation mapping for other flow rates are provided in Appendix C.2.

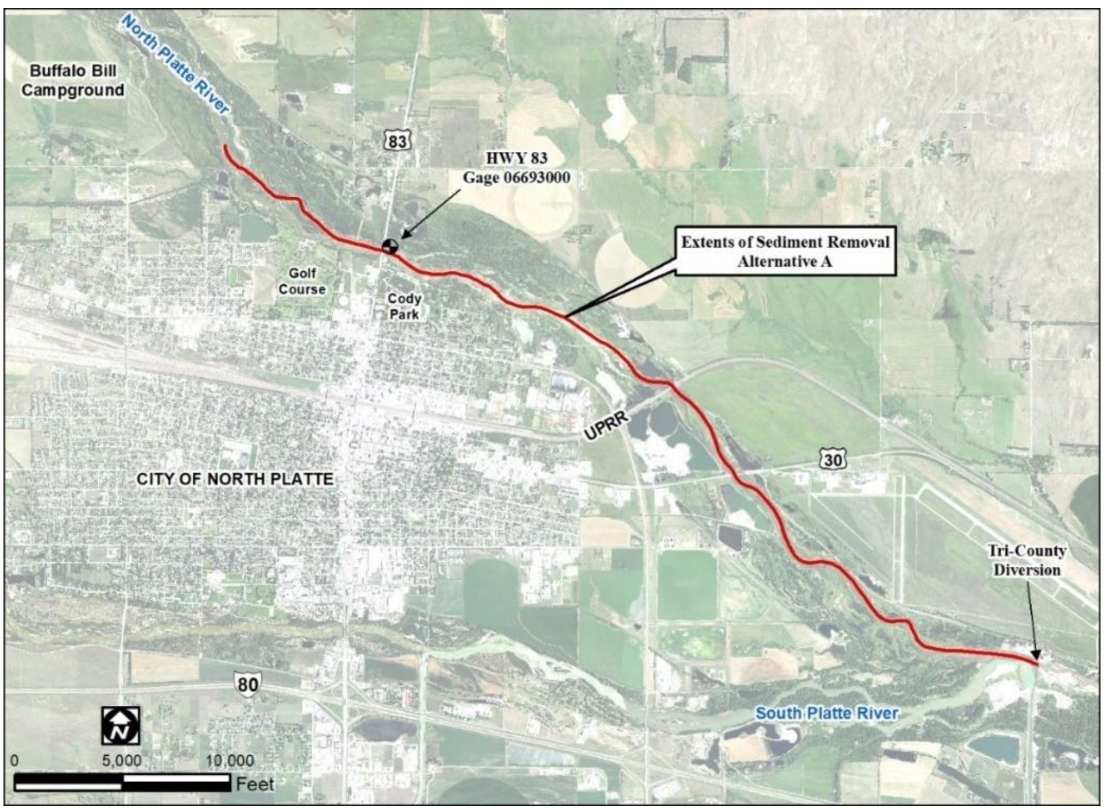

Figure B-1 Extents of Sediment Removal Alternative A

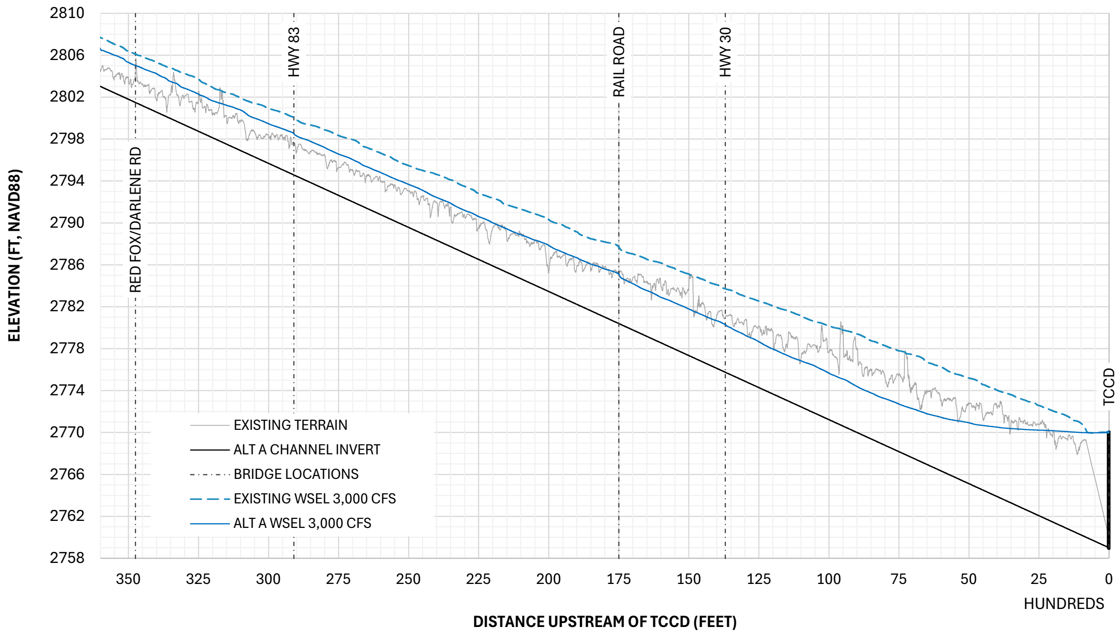

Figure B-2 3,000 cfs Water Surface Profile - Existing Condition/No Action and Alt A

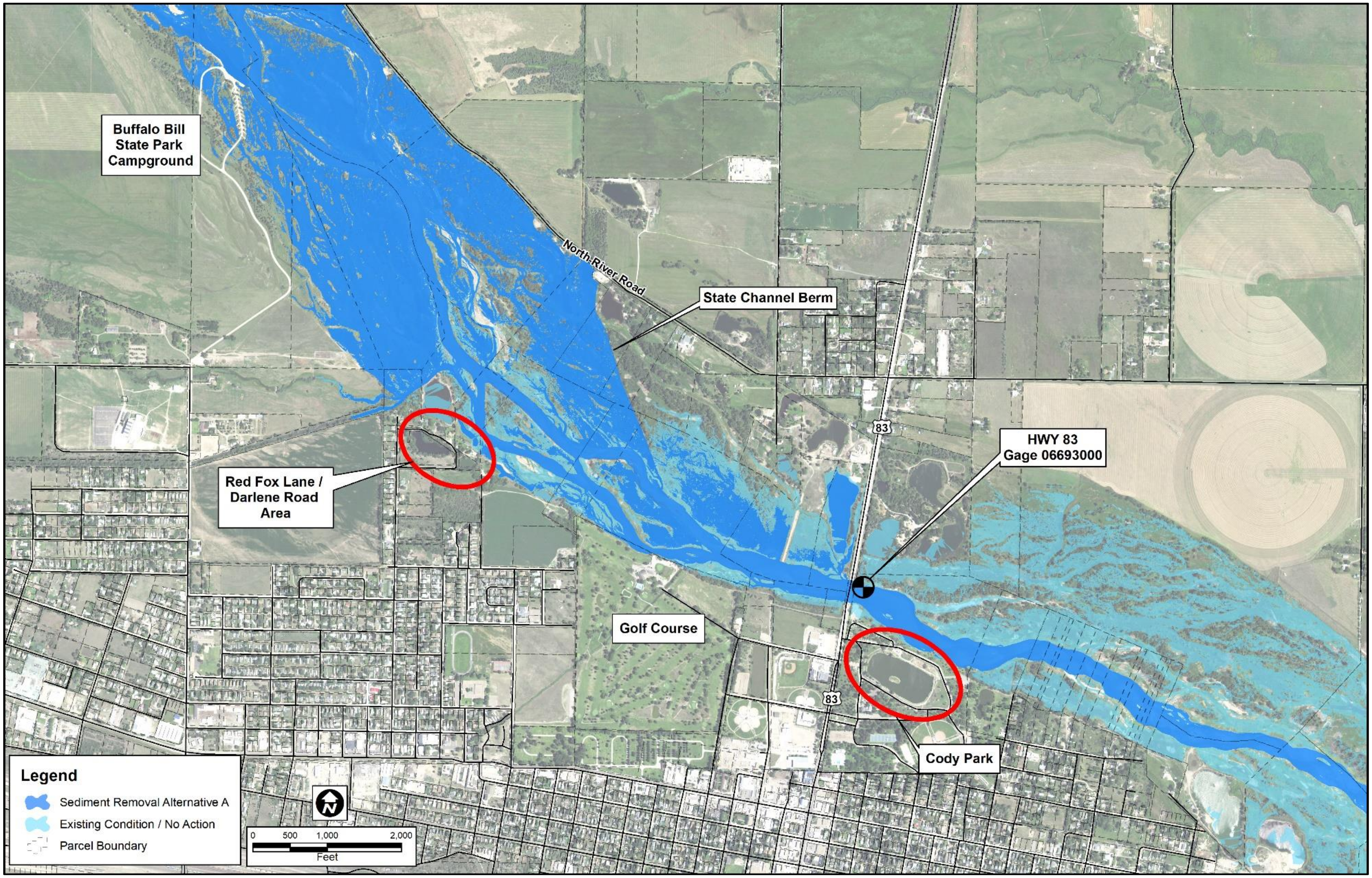

Figure B-3 North Platte Chokepoint Inundation Mapping at 3,000 cfs – Existing Conditions/No Action and Alt A

B.1 Alternative A – H1 Hydrograph

Results for Sediment Removal Alternative A 25-year forecast modeling using the H1 hydrograph is provided in Figure B-4 through Figure B-7.

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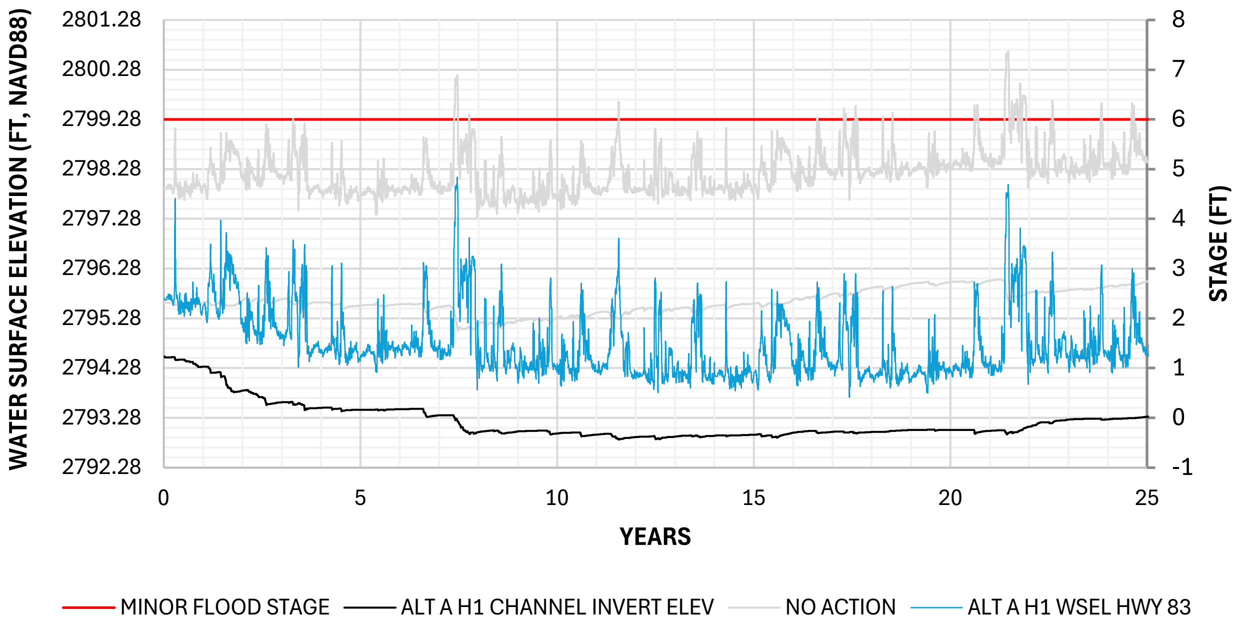

Figure B-4 Water Surface and Channel Elevation at HWY 83 – No Action and Alt A H1

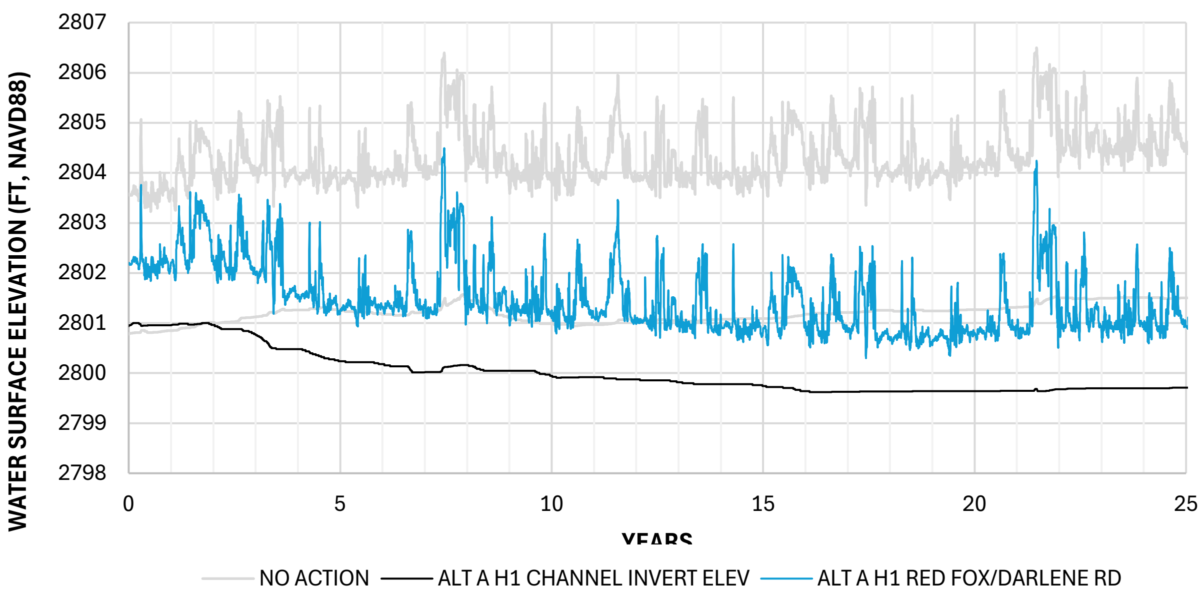

Figure B-5 Water Surface and Channel Elevation at Red Fox/Darlene Rd – No Action and Alt A H1

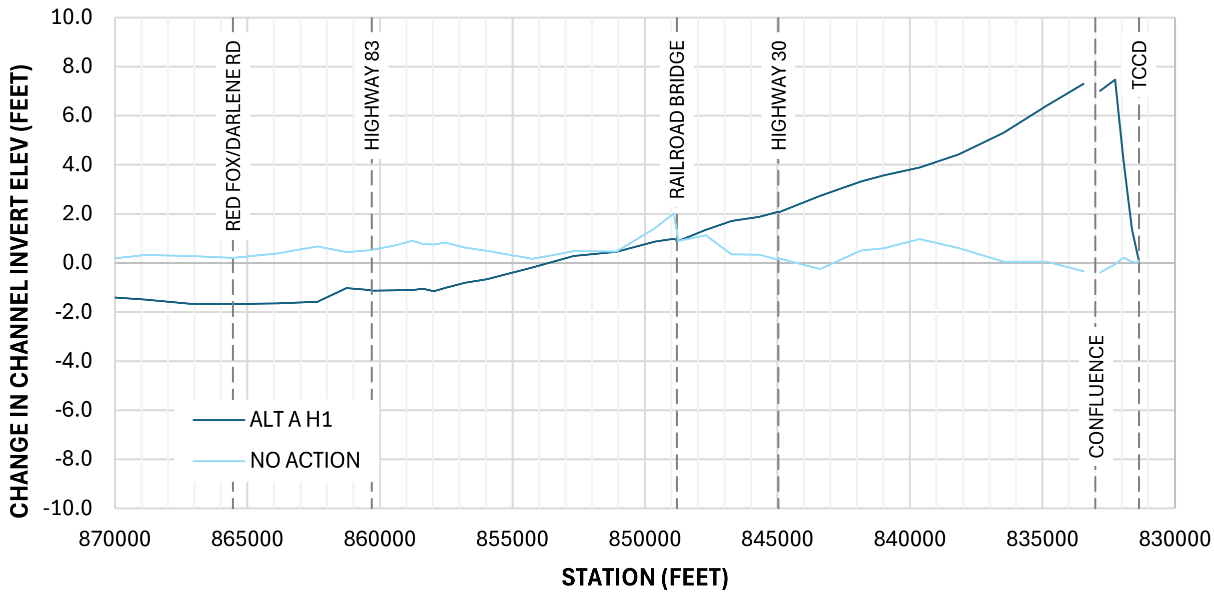

Figure B-6 Change in Channel Invert Elevation – No Action and Alt A H1

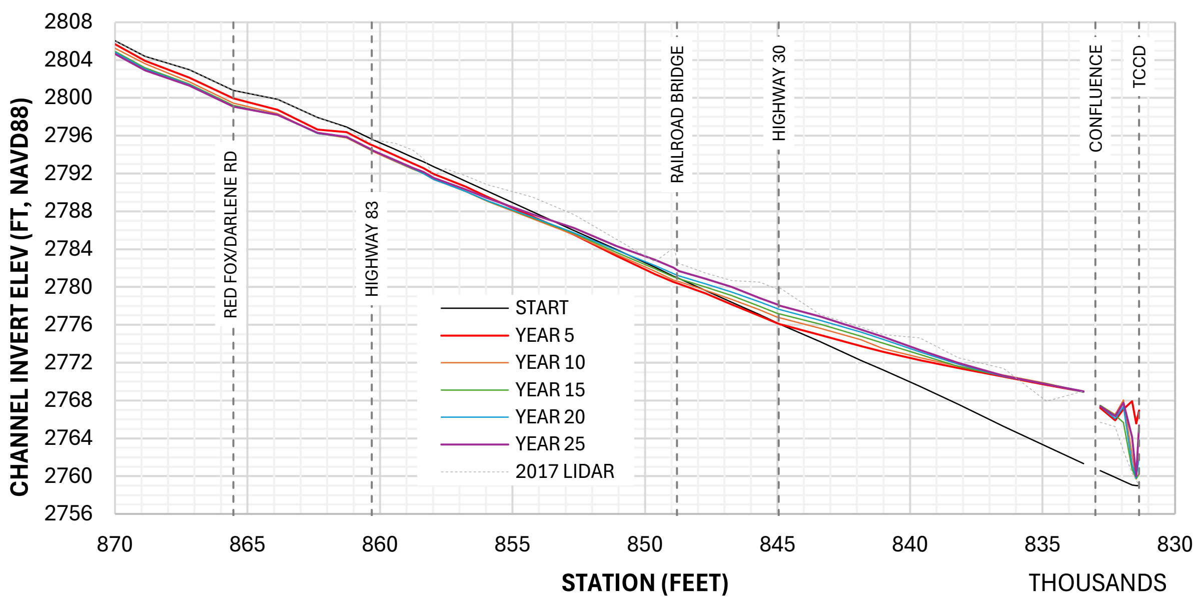

Figure B-7 Channel Profile through Time – Alt A H1

Table B-1 Ave Annual Dredging Volume – No Action and Alt A H1

Alternative	Average Annual Dredging at TCCD
Sediment Removal Alt A	217,453 cyds/yr
No Action	190,742 cyds/yr

B.2 Alternative A – H2 Hydrograph

Results for Sediment Removal Alternative A 25-year forecast modeling using the H2 hydrograph is provided in Figure B-8 through Figure B-12.

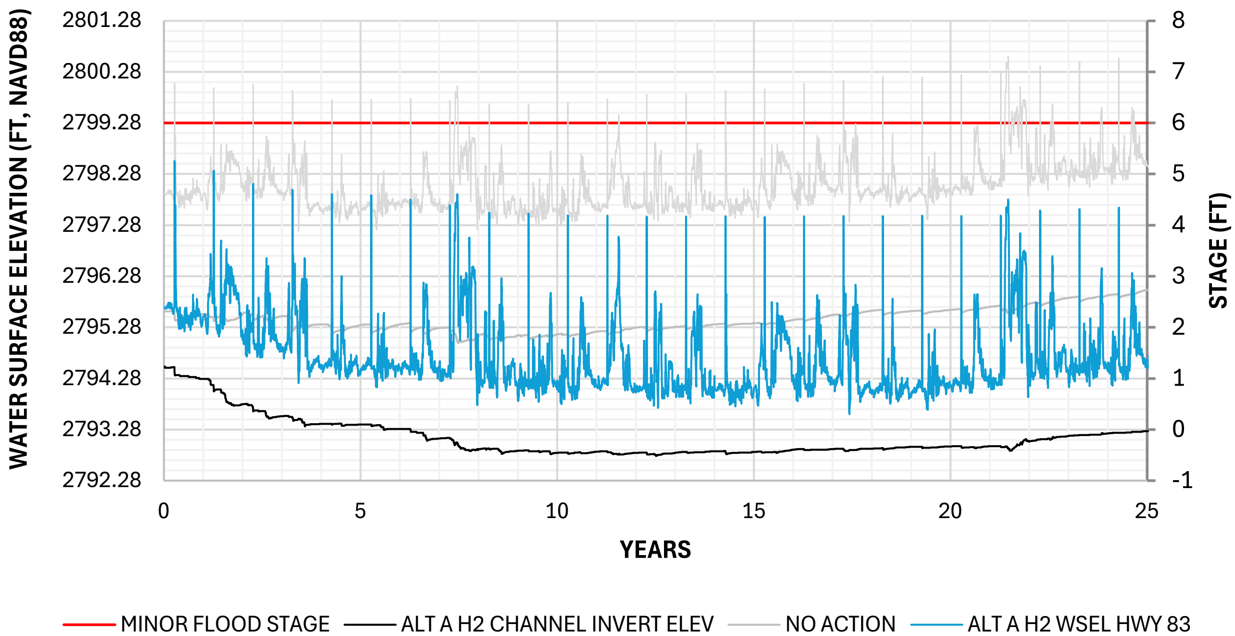

Figure B-8 Water Surface and Channel Elevation at HWY 83 – No Action and Alt A H2

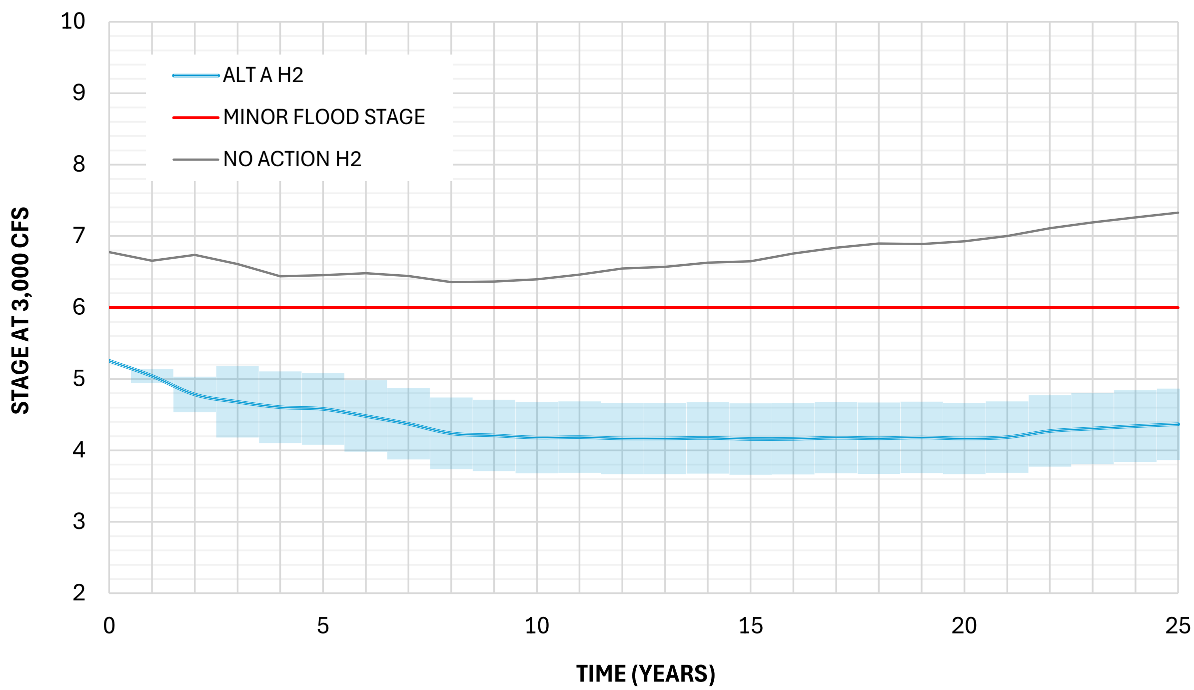

Figure B-9 Stage at HWY83 at 3,000 cfs through Time – No Action and Alt A H2

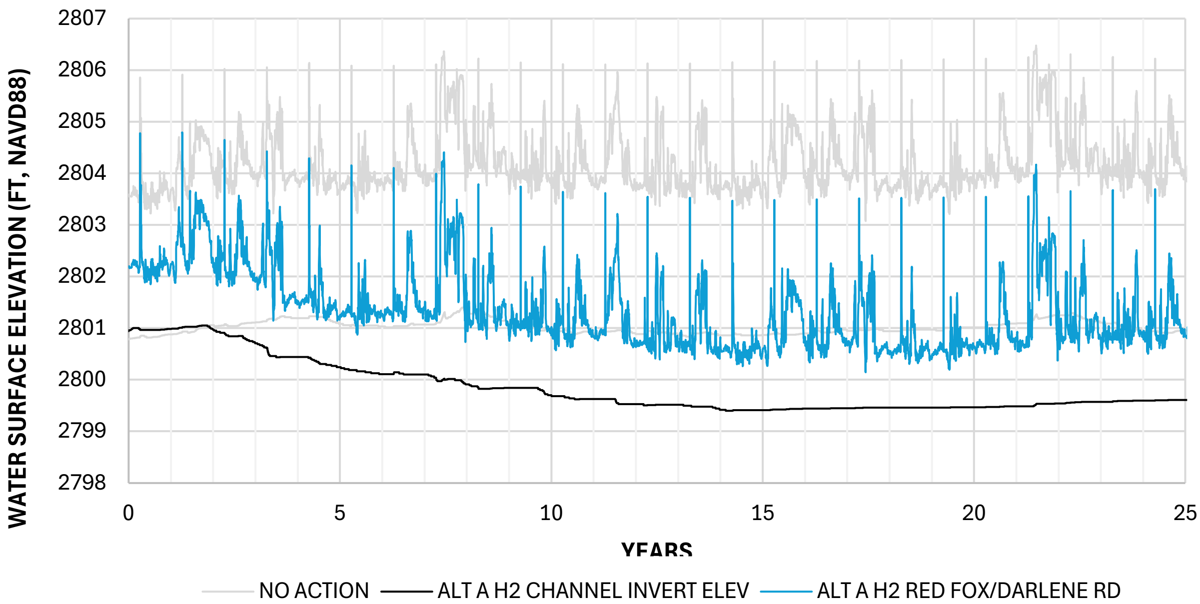

Figure B-10 Water Surface and Channel Elevation at Red Fox/Darlene Rd – No Action and Alt A H2

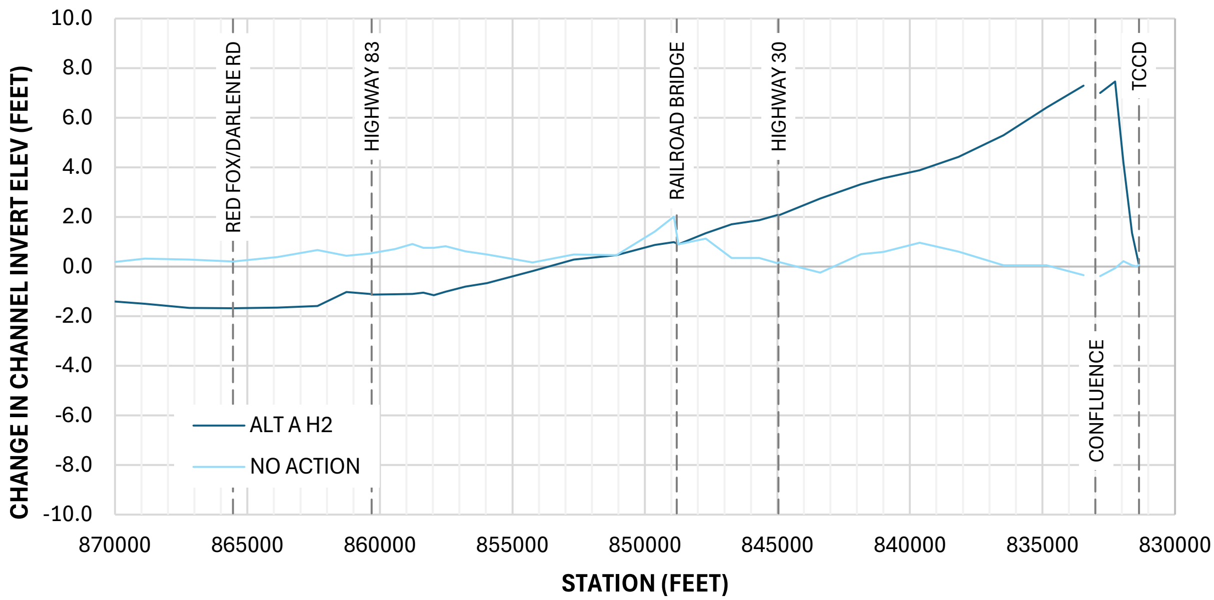

Figure B-11 Change in Channel Invert Elevation – No Action and Alt A H2

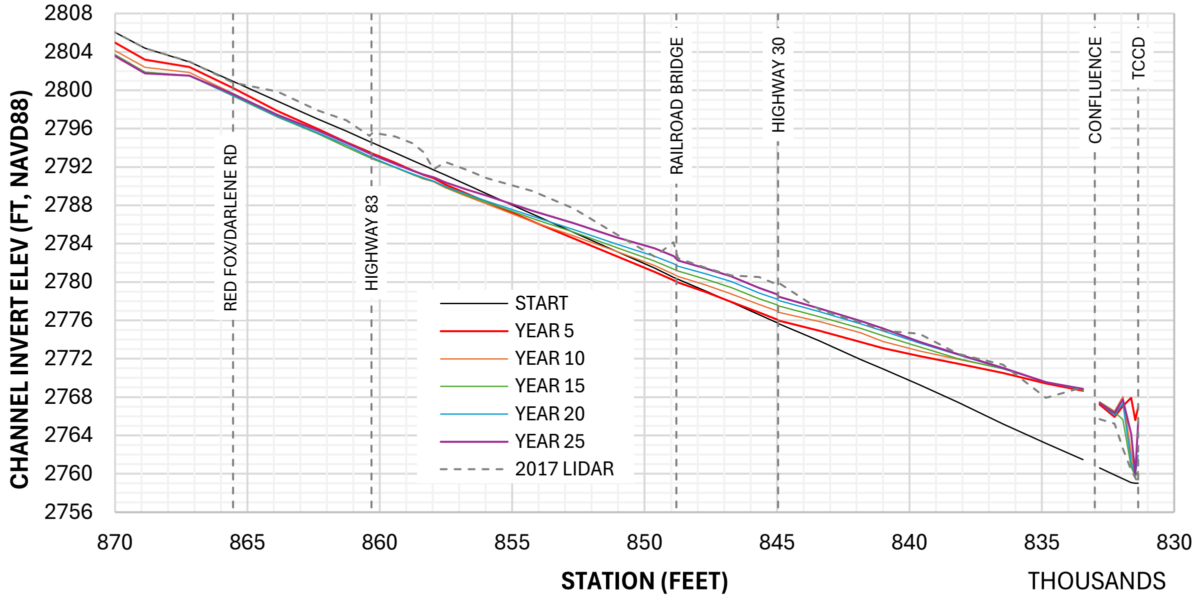

Figure B-12 Channel Profile through Time – Alt A H2

Table B-2 Ave Annual Dredging Volume – No Action and Alt A H2

Alternative	Average Annual Dredging at TCCD
Sediment Removal Alt A	222,306 cyds/yr
No Action	193,629 cyds/yr

B.4 Alternative A – H3 Hydrograph

Results for Sediment Removal Alternative A 25-year forecast modeling using the H3 hydrograph is provided in Figure B-13 through Figure B-17.

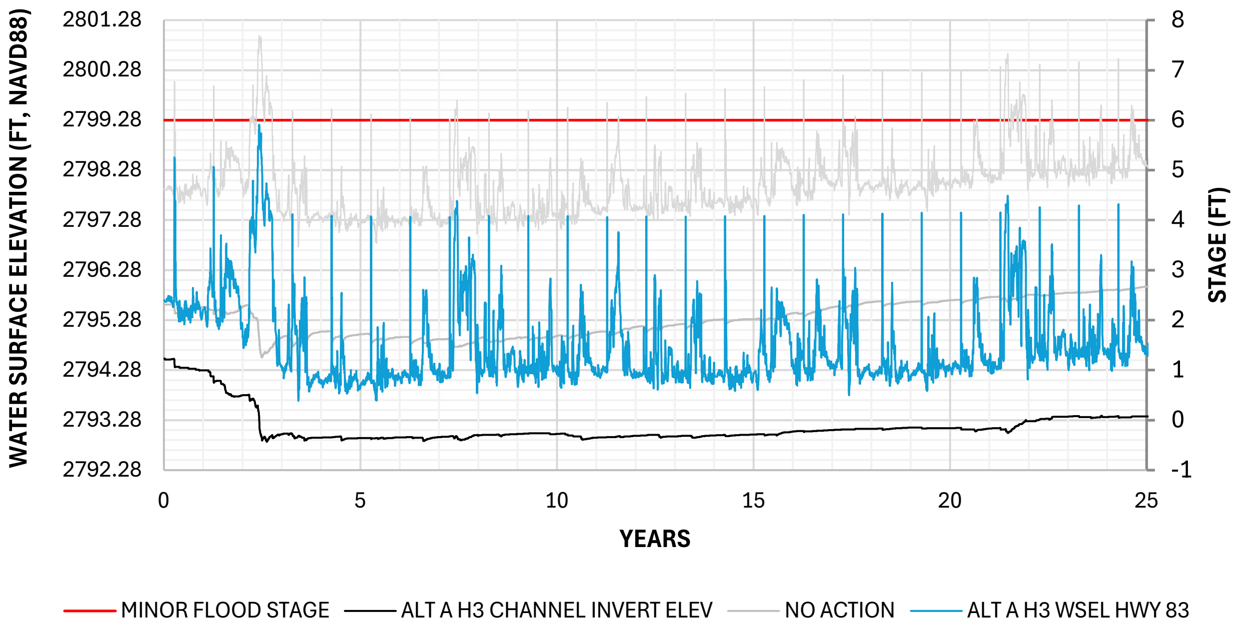

Figure B-13 Water Surface and Channel Elevation at HWY 83 – No Action and Alt A H3

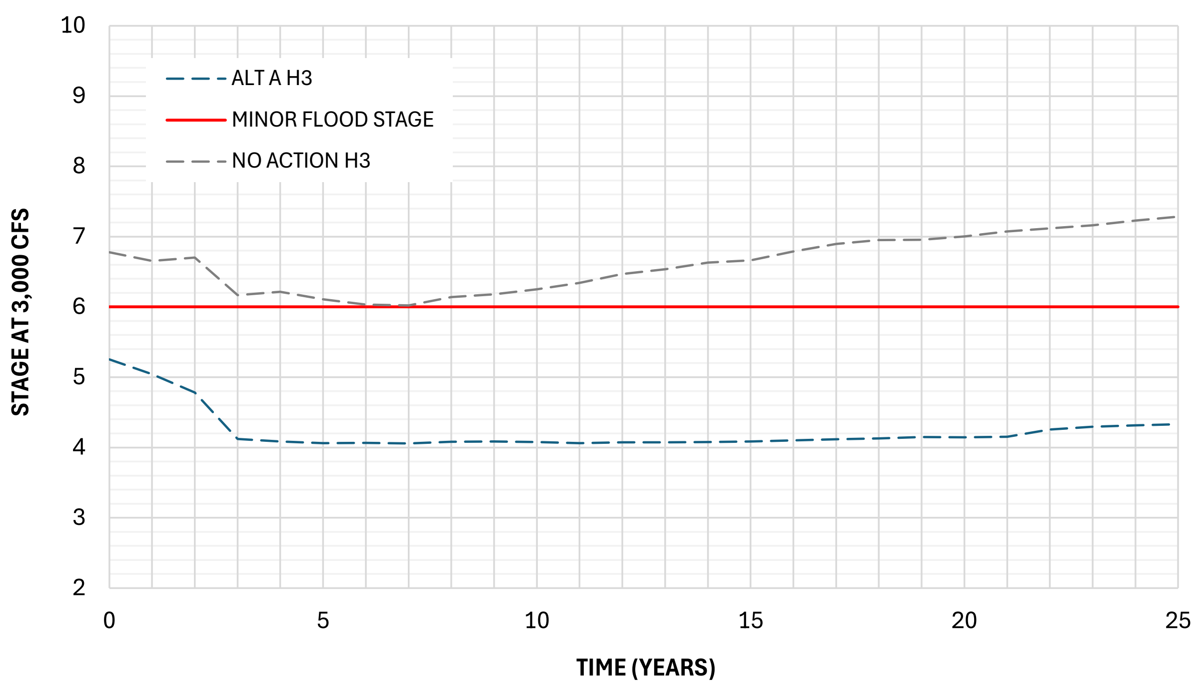

Figure B-14 Stage at HWY83 at 3,000 cfs through Time – No Action and Alt A H3

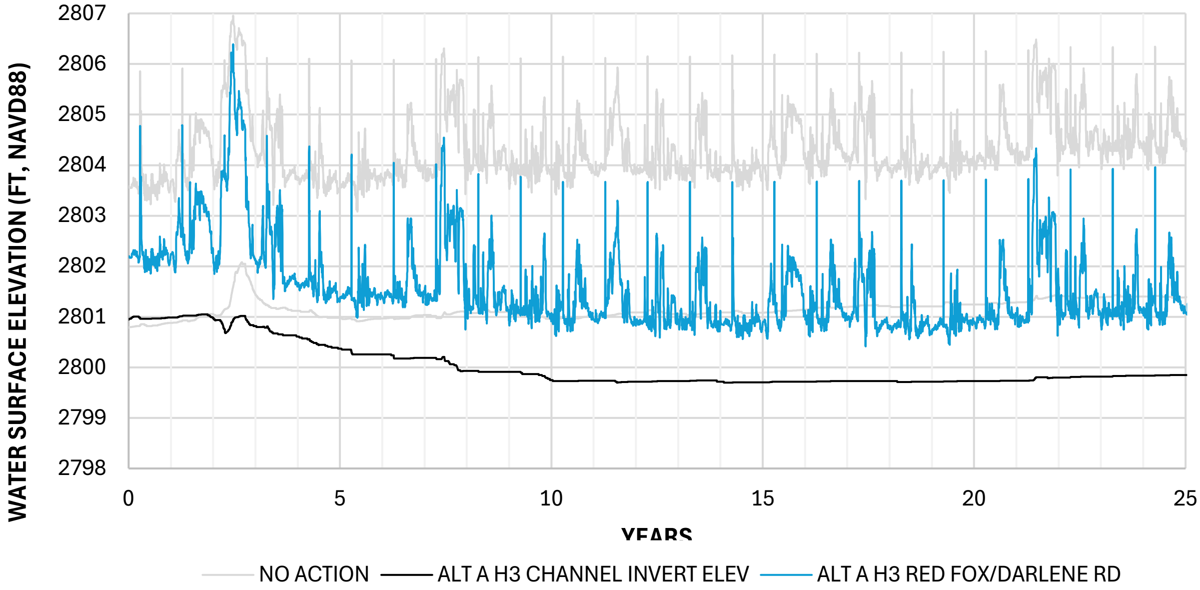

Figure B-15 Water Surface and Channel Elevation at Red Fox/Darlene Rd – No Action and Alt A H3

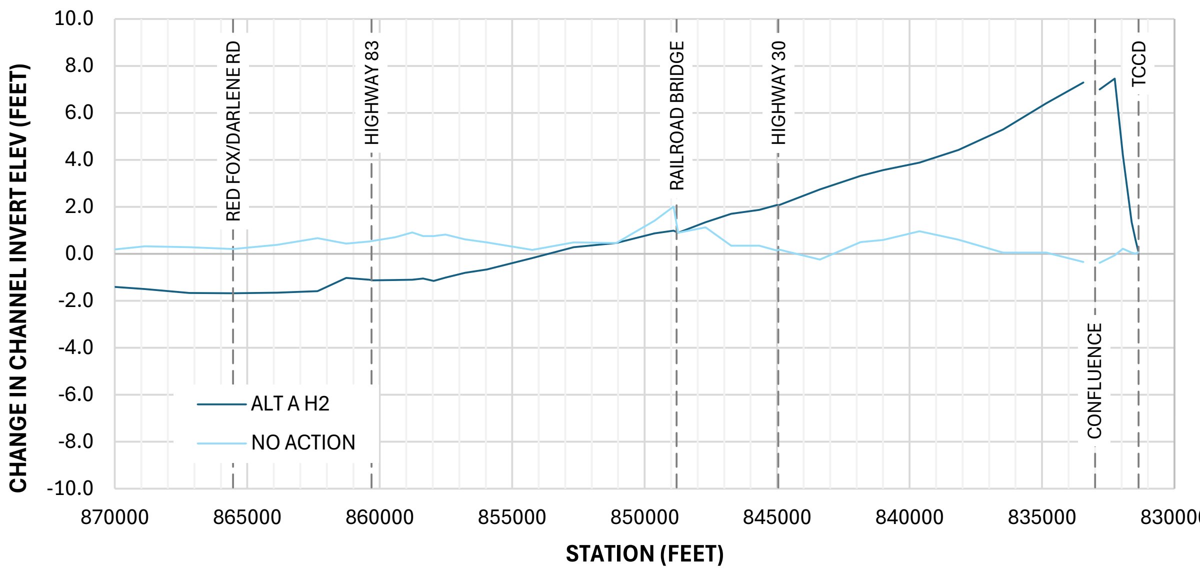

Figure B-16 Change in Channel Invert Elevation – No Action and Alt A H3

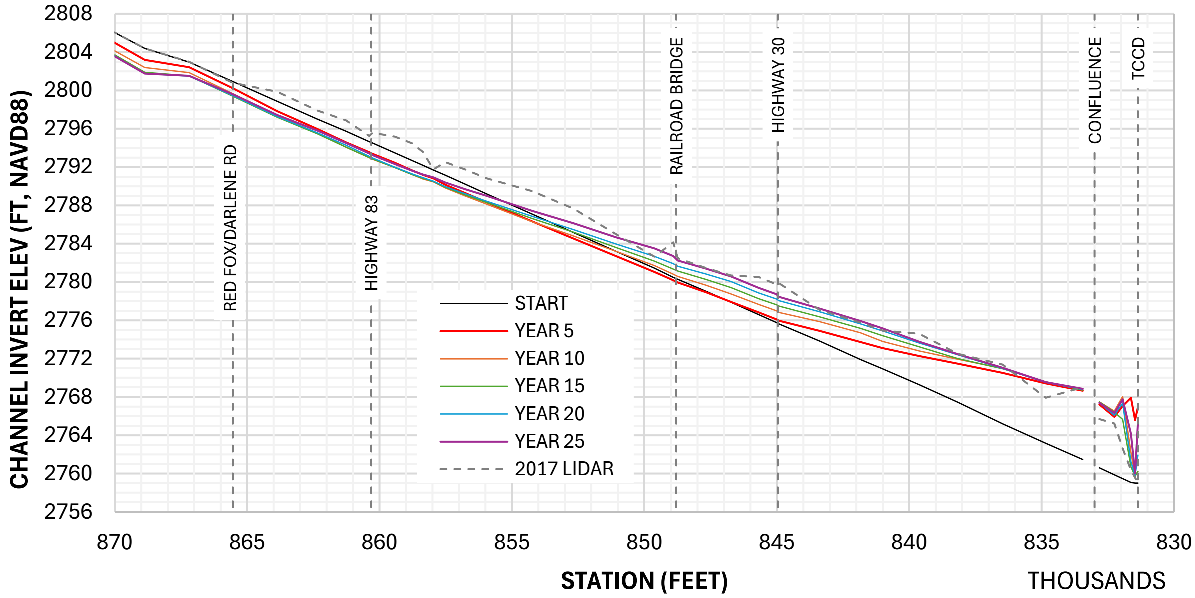

Figure B-17 Channel Profile through Time – Alt A H3

Table B-3 Ave Annual Dredging Volume – No Action and Alt A H3

Alternative	Average Annual Dredging at TCCD
Sediment Removal Alt A	234,025 cyds/yr
No Action	203,878 cyds/yr

Attachment C. Sediment Removal Alternative B

Evaluation of Alt A indicates that sediment will fill in the excavated channel downstream of HWY 30 in roughly 5 years. Sediment Removal Alternative B (Alt B) includes a smaller extent of excavation by moving the downstream limit to one mile below HWY 30, Figure C-1. This reduces the length of sediment removal to 4.8 miles and total excavation volume to 330,000 CY, which is roughly 30% of what is required in Alt A. Figure C-2 shows a graphical profile at 3,000 cfs. The slope of the excavated channel is 0.115%, which is flatter than the historic and Alt A slope. Channel hydraulics and sediment transport are highly sensitive to slope changes. Achieving the target hydraulic capacity and a reasonable slope along the length of the excavated channel requires a flatter area at the downstream tie-in to the existing channel. This is not ideal but a limitation of the existing slope.

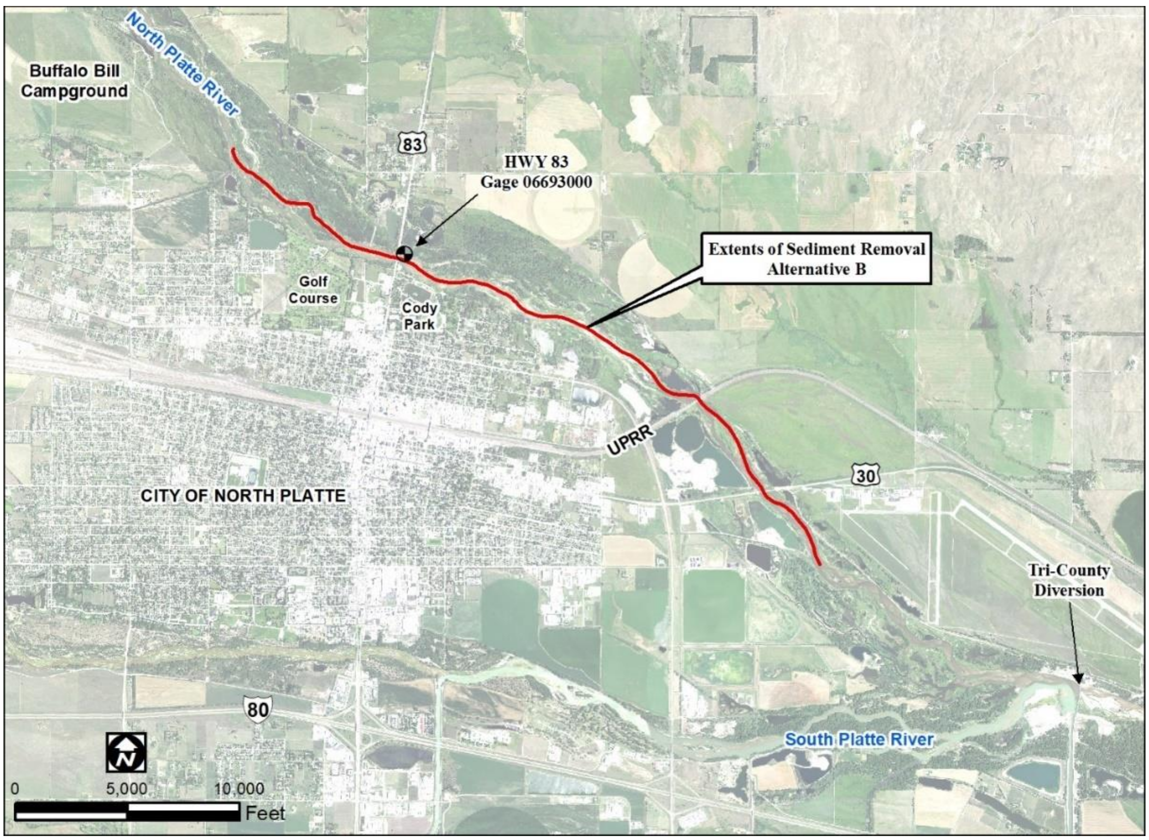

Figure C-1 Extents of Sediment Removal Alternative B

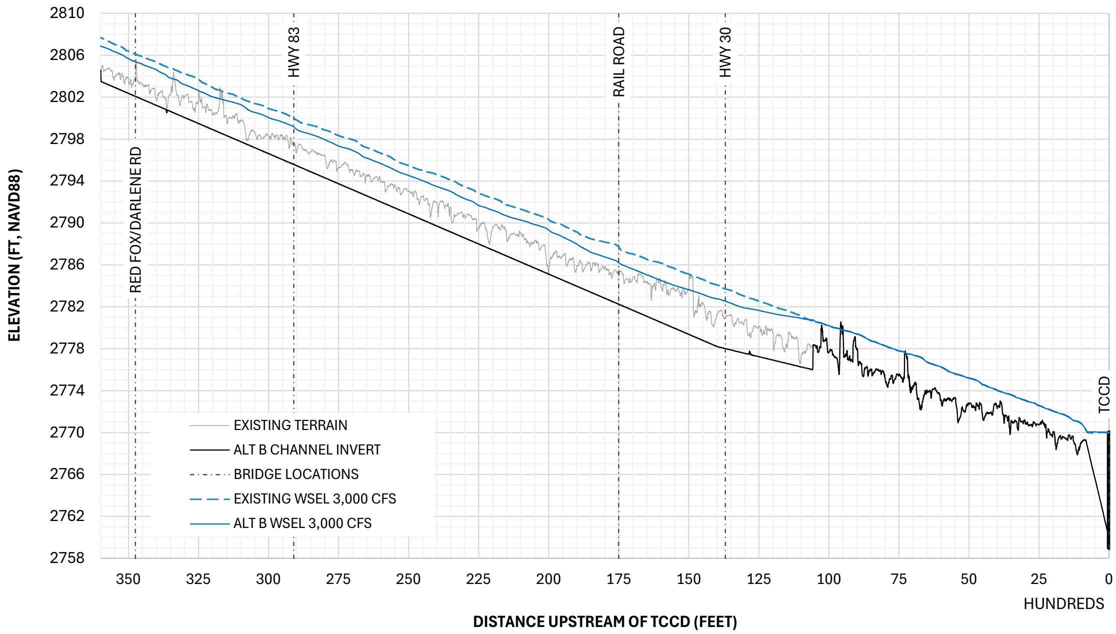

Figure C-2 3,000 cfs Water Surface Profile - Existing Condition and Alt B

C.2 Alternative B – H2 Hydrograph

Results for Sediment Removal Alternative B 25-year forecast modeling using the H2 hydrograph is provided in Figure C-3 through Figure C-7Figure B-12.

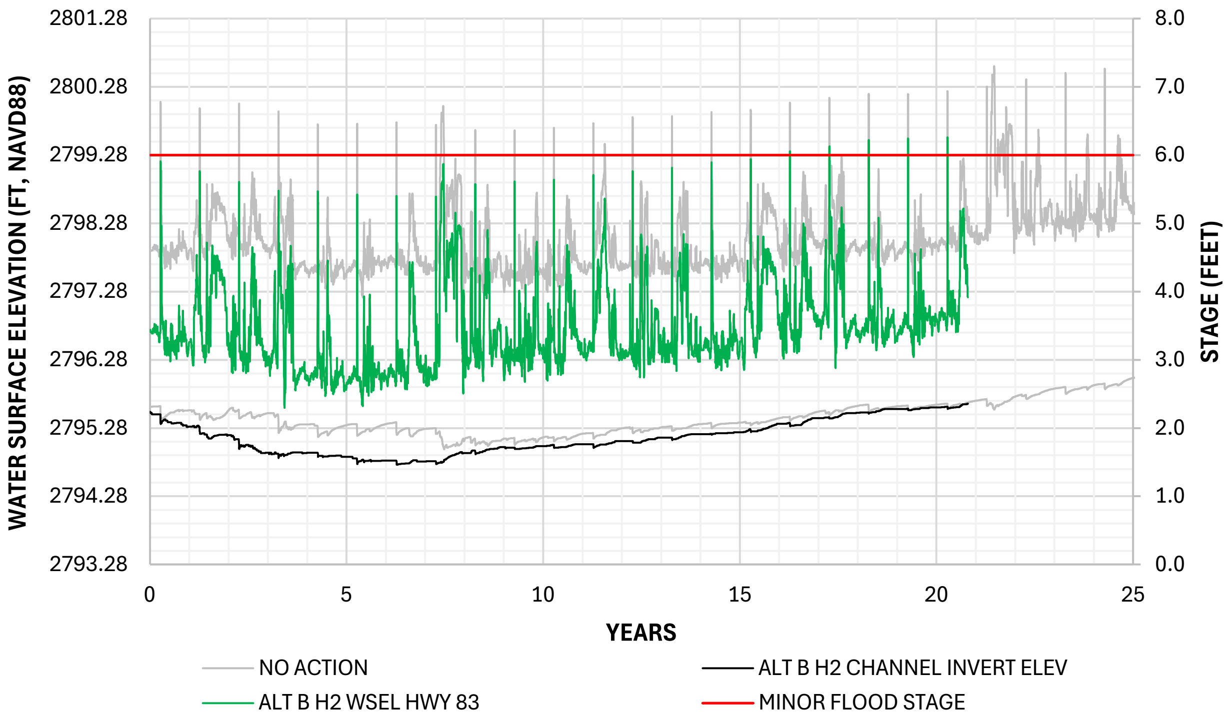

Figure C-3 Water Surface and Channel Elevation at HWY 83 – No Action and Alt B H2

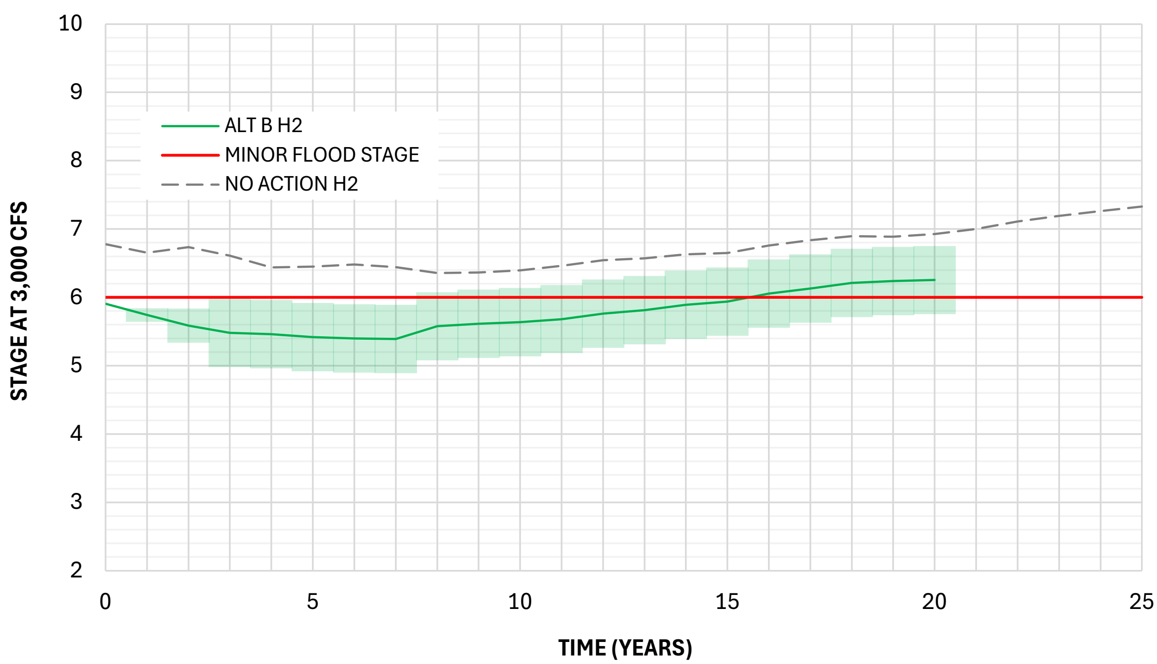

Figure C-4 Stage at HWY83 at 3,000 cfs through Time – No Action and Alt B H2

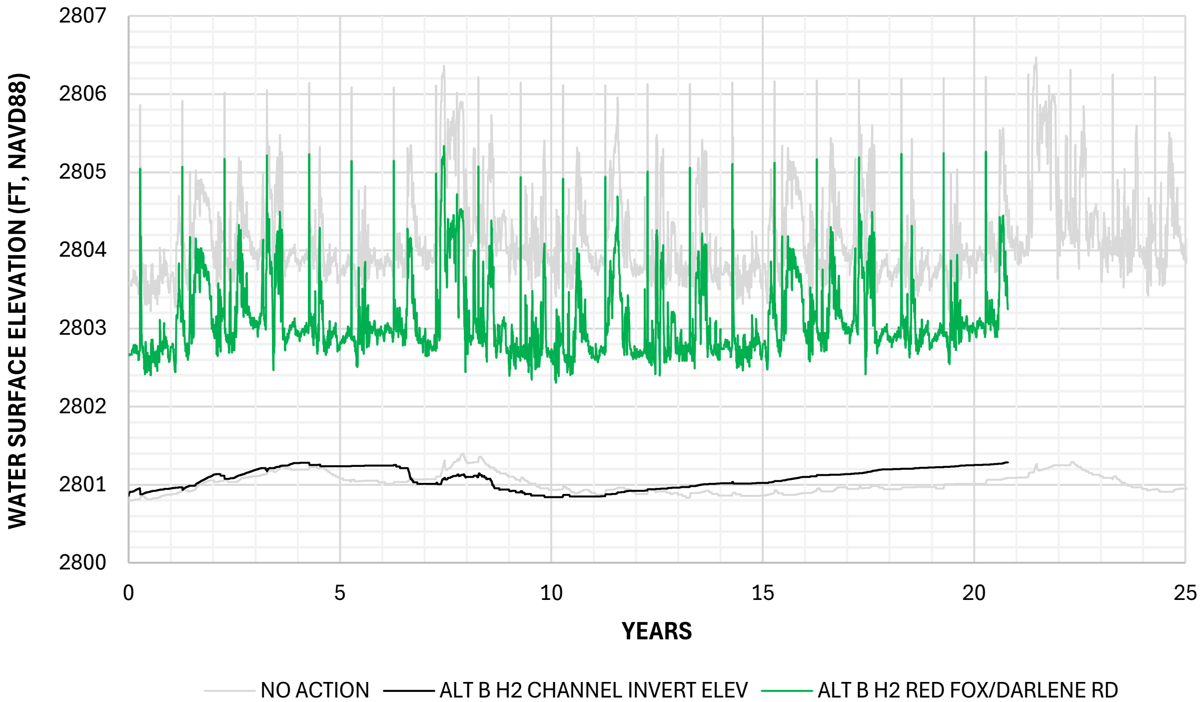

Figure C-5 Water Surface and Channel Elevation at Red Fox/Darlene Rd – No Action and Alt B H2

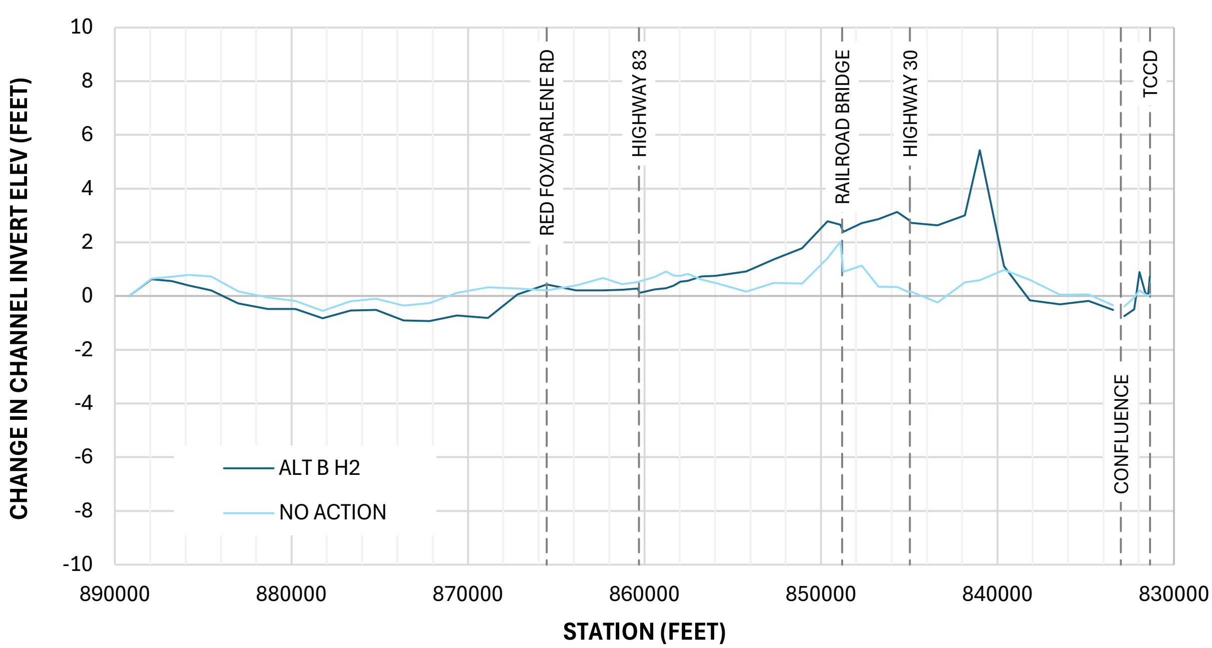

Figure C-6 Change in Channel Invert Elevation – No Action and Alt B H2

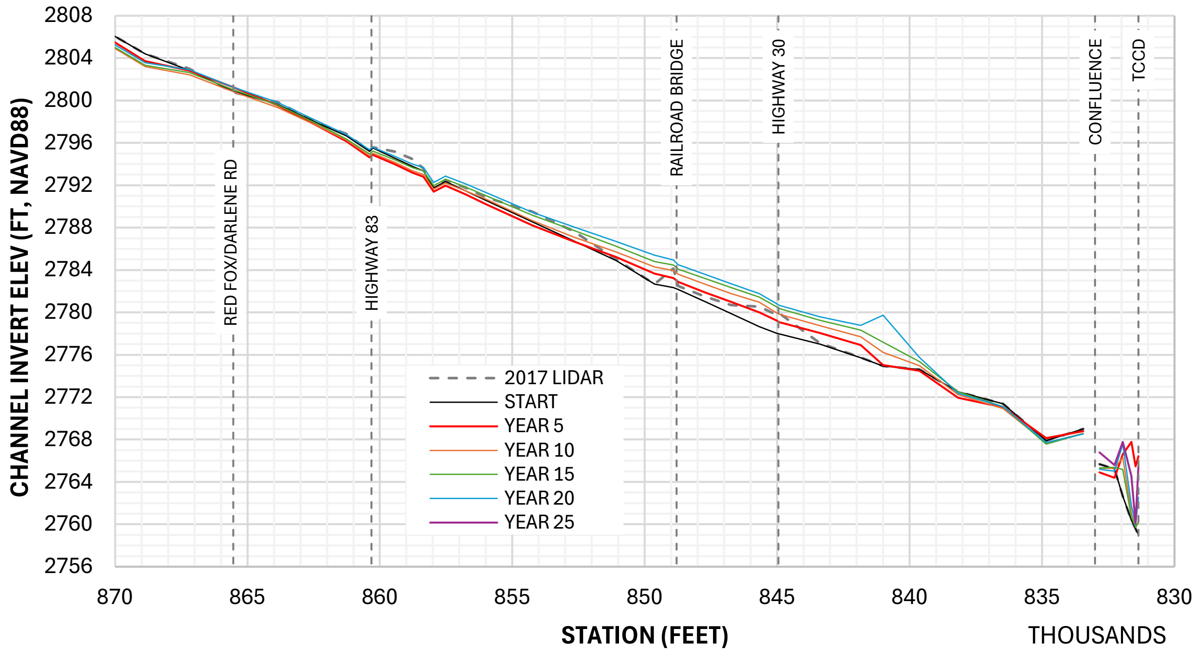

Figure C-7 Channel Profile through Time – Alt B H2

Table C-1 Ave Annual Dredging Volume – No Action and Alt B H2

Alternative	Average Annual Dredging at TCCD
Sediment Removal Alt A	153,958 cyds/yr
No Action	193,629 cyds/yr

Attachment D. Sediment Removal Alternative C

Sediment Removal Alternative C (Alt C) includes an even more limited extent of excavation, with the downstream boundary located upstream of the railroad, see Figure D-1. This alternative requires excavation of roughly 233,000 CY of sediment along 3.3 miles of the river. Alt C channel slope is 0.115% and is shown in profile in Figure D-2. As noted with Alt B, achieving a reasonable slope along the length of the excavated channel and meeting the target hydraulic capacity requires a flatter slope at the downstream tie-in to the existing channel, which is problematic.

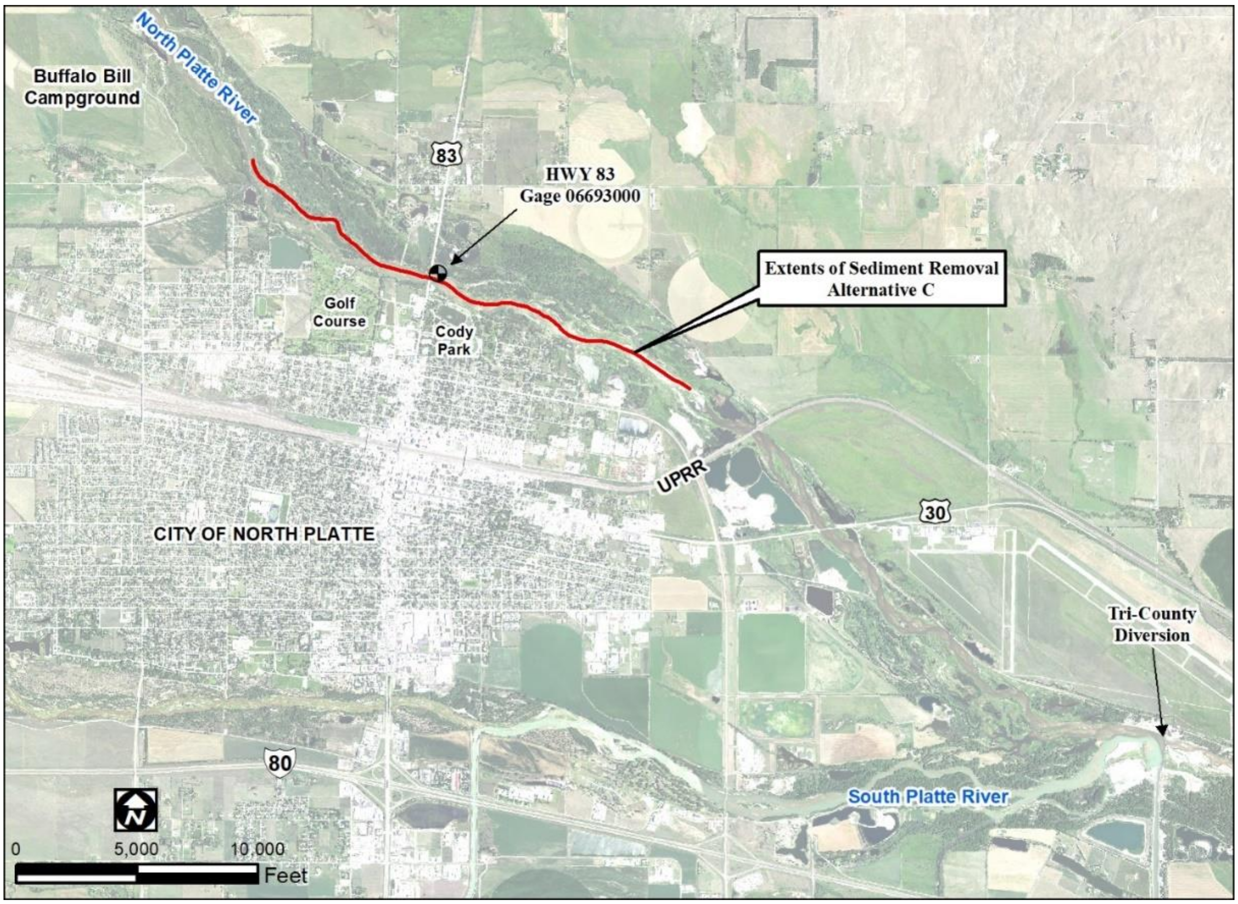

Figure D-1 Extents of Sediment Removal Alternative C

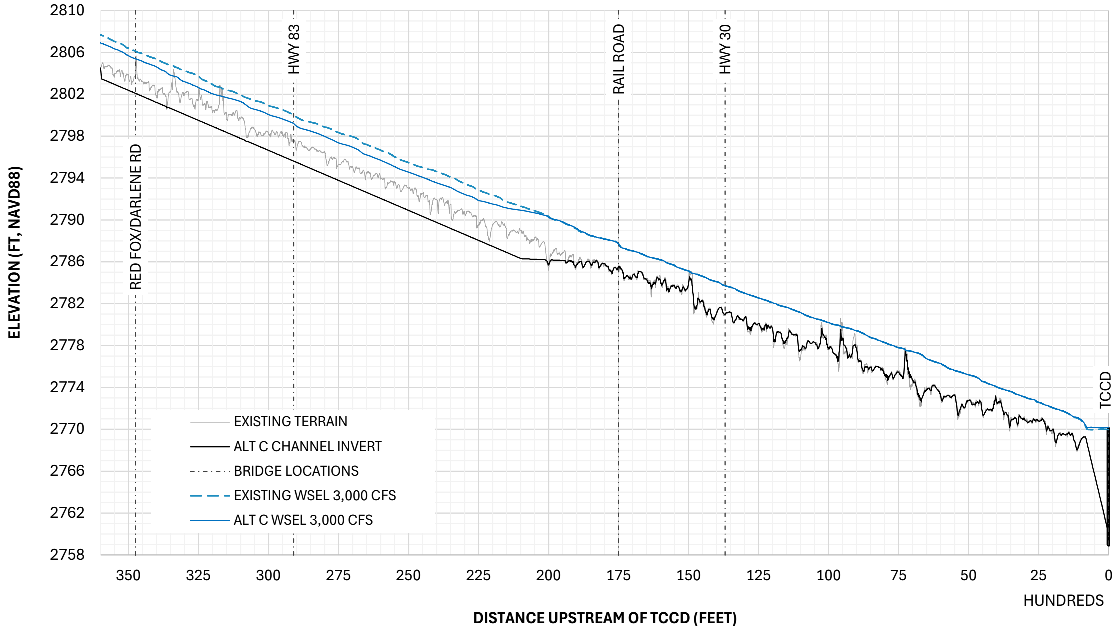

Figure D-2 3,000 cfs Water Surface Profile - Existing Condition and Alt C

D.1 Alternative C – H2 Hydrograph

Results for Sediment Removal Alternative C 25-year forecast modeling using the H2 hydrograph is provided in Figure D-3 through Figure D-7Figure B-12.

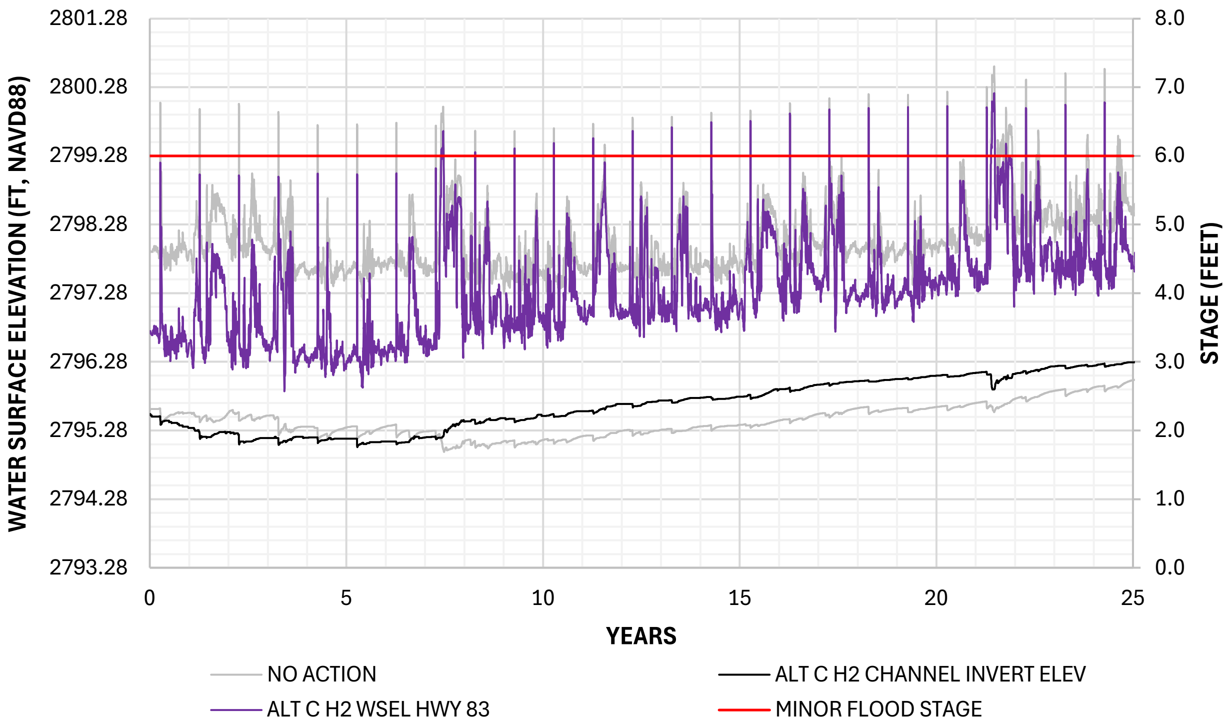

Figure D-3 Water Surface and Channel Elevation at HWY 83 – No Action and Alt C H2

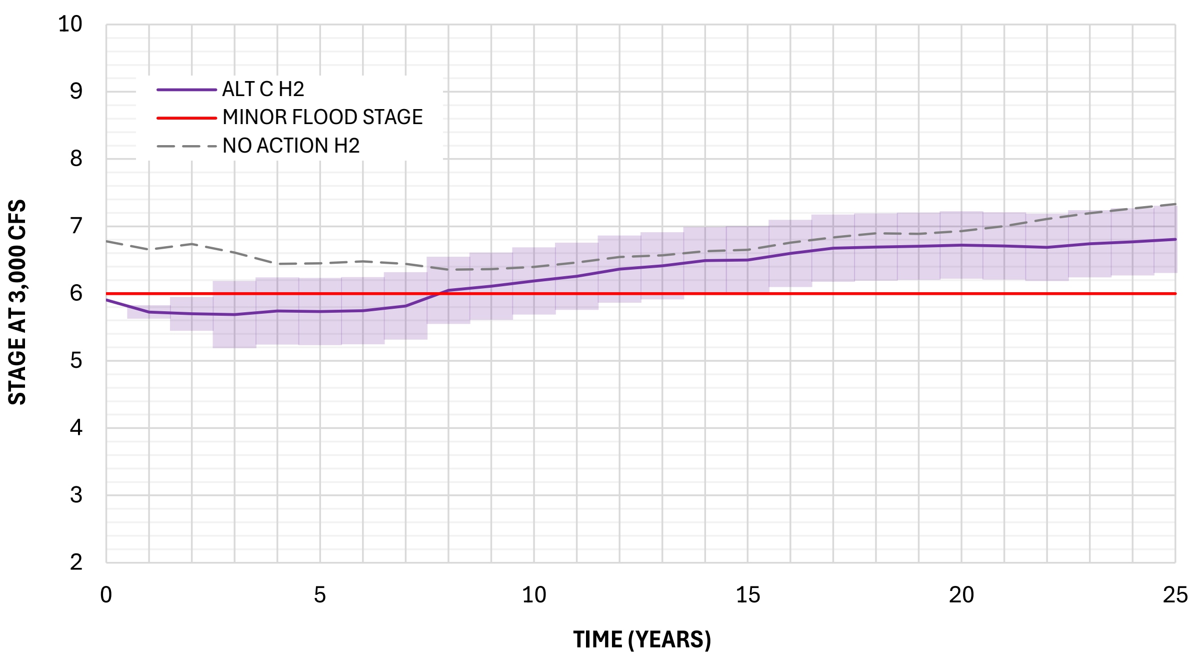

Figure D-4 Stage at HWY83 at 3,000 cfs through Time – No Action and Alt C H2

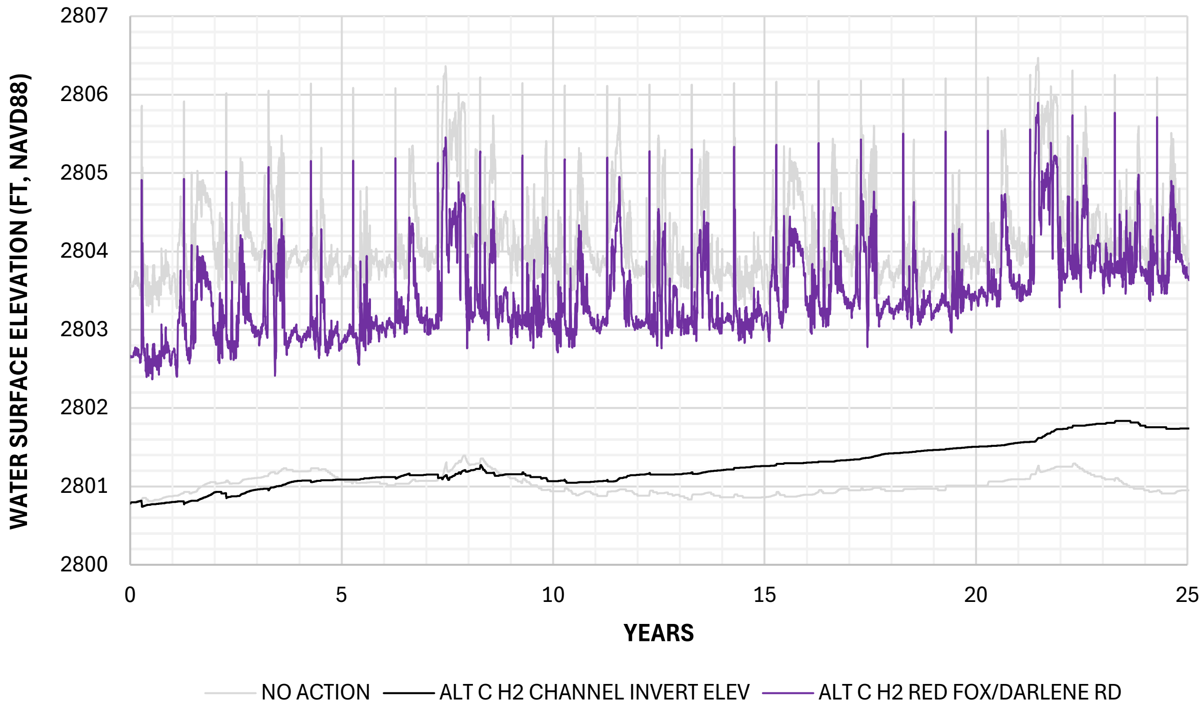

Figure D-5 Water Surface and Channel Elevation at Red Fox/Darlene Rd – No Action and Alt C H2

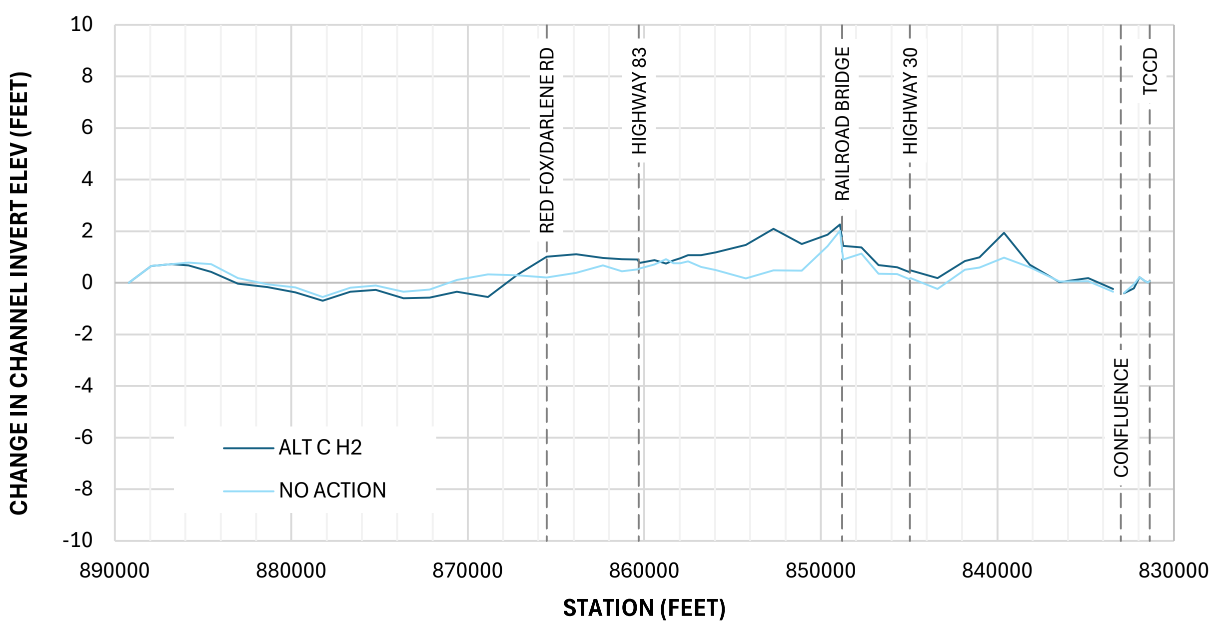

Figure D-6 Change in Channel Invert Elevation – No Action and Alt C H2

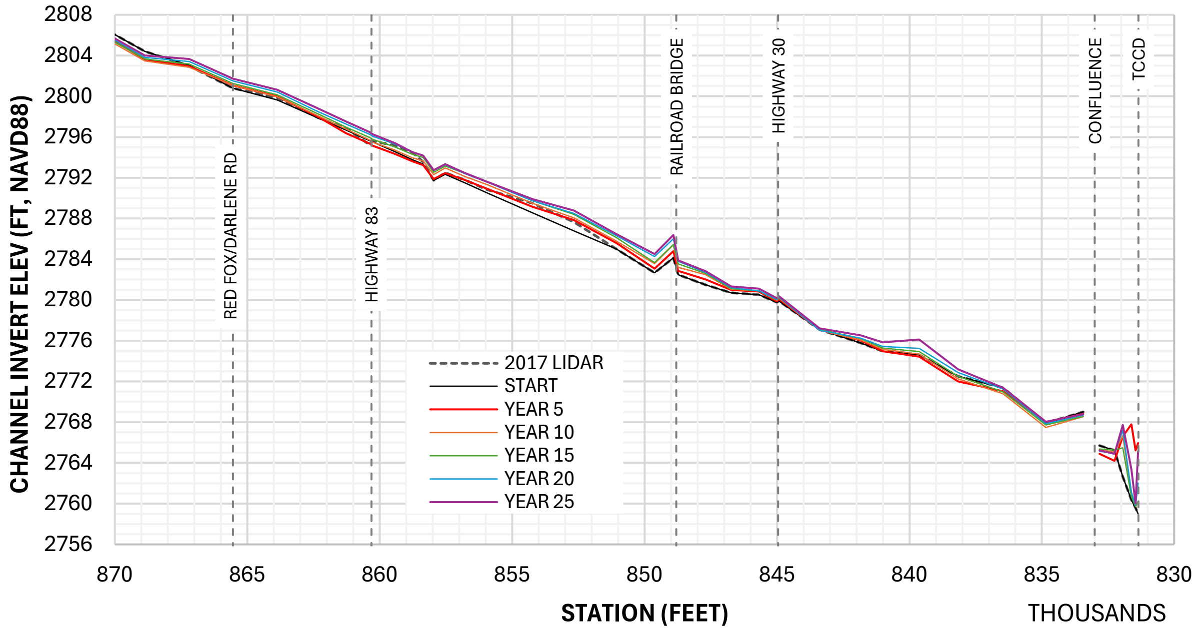

Figure D-7 Channel Profile through Time – Alt C H2

Table D-1 Ave Annual Dredging Volume – No Action and Alt C H2

Alternative	Average Annual Dredging at TCCD
Sediment Removal Alt A	195,229 cyds/yr
No Action	193,629 cyds/yr

Attachment F. ACE 2016 Channel Modification Alternative

The ACE 2016 channel modification/sediment removal alternative identified in Phase II was slightly modified and modeled. This alternative was originally developed in 2016 with the goal of achieving more consistent sediment transport capacity through the Chokepoint upstream of the railroad. A modified version (Mod ACE 2016 Alt) of the concept was developed and includes widening of the channel upstream of HWY 83 to 300 feet in combination with the same channel excavation as Alt C downstream of HWY 83. The upstream and downstream extents are the same as Alt C. A total of 203,000 CY of sediment removal would be required for the Mod ACE 2016 Alt. This concept is intended to promote sediment continuity and reduce deposition near HWY 83.

F.1 ACE2016 Channel Modification Alternative – H2 Hydrograph

Results for ACE 2016 Channel Modification Alternative 25-year forecast modeling using the H2 hydrograph is provided in Figure F-1Figure D-3 through Figure F-5Figure B-12.

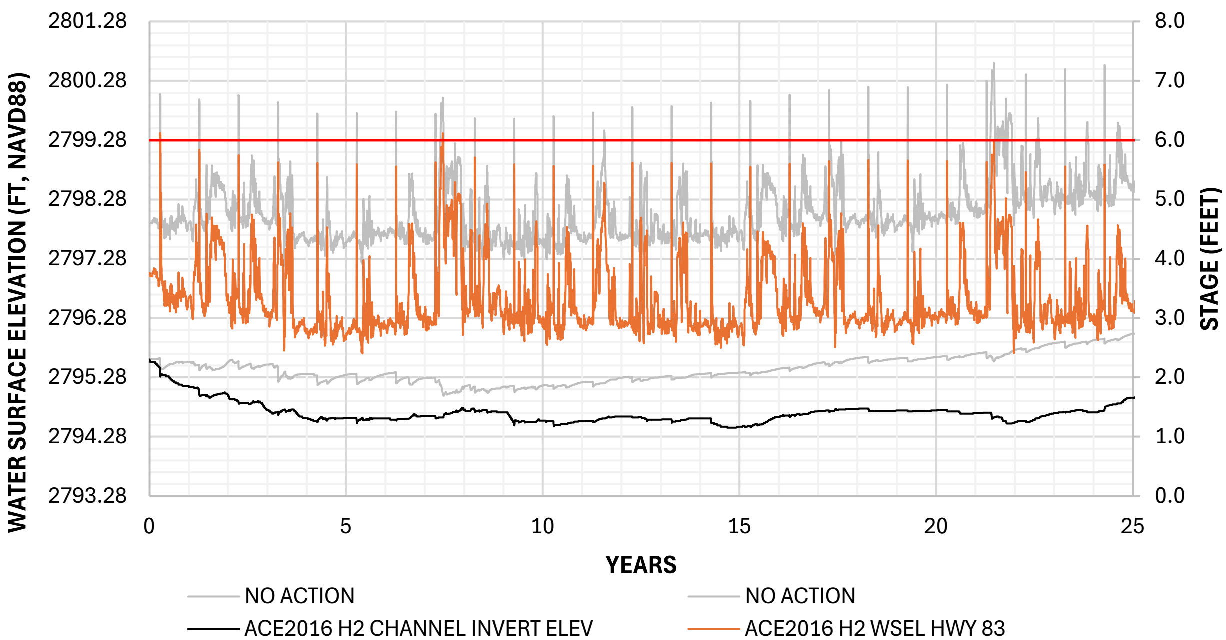

Figure F-1 Water Surface and Channel Elevation at HWY 83 – No Action and ACE2016 Alt H2

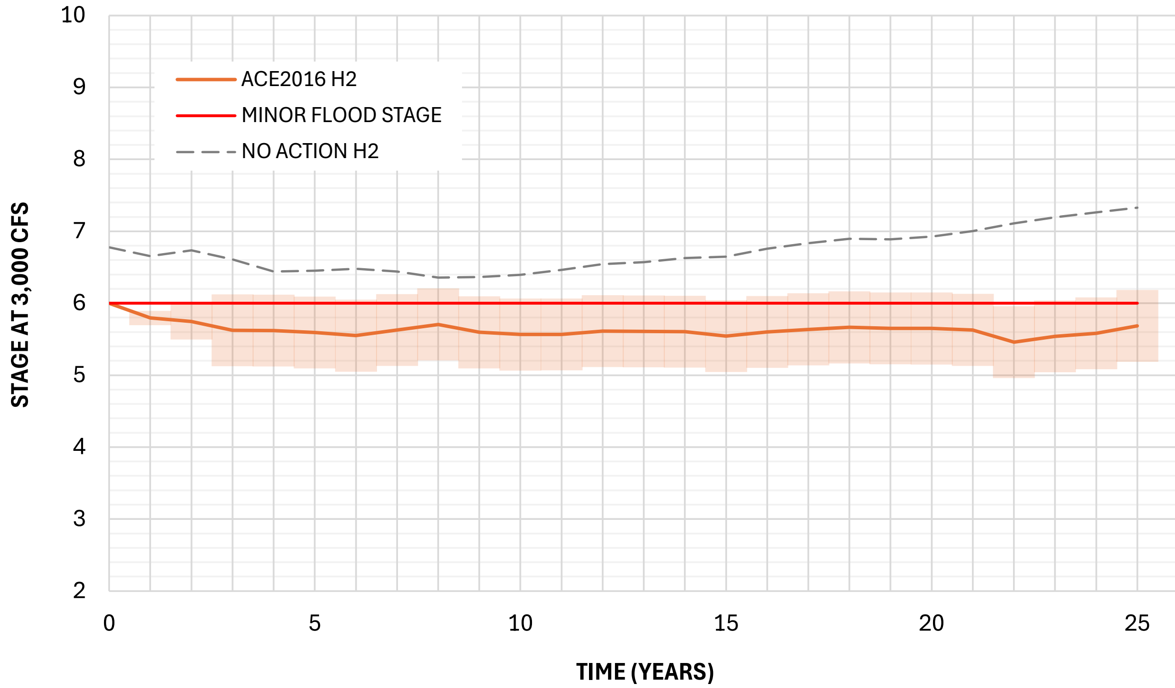

Figure F-2 Stage at HWY83 at 3,000 cfs through Time – No Action and ACE2016 Alt H2

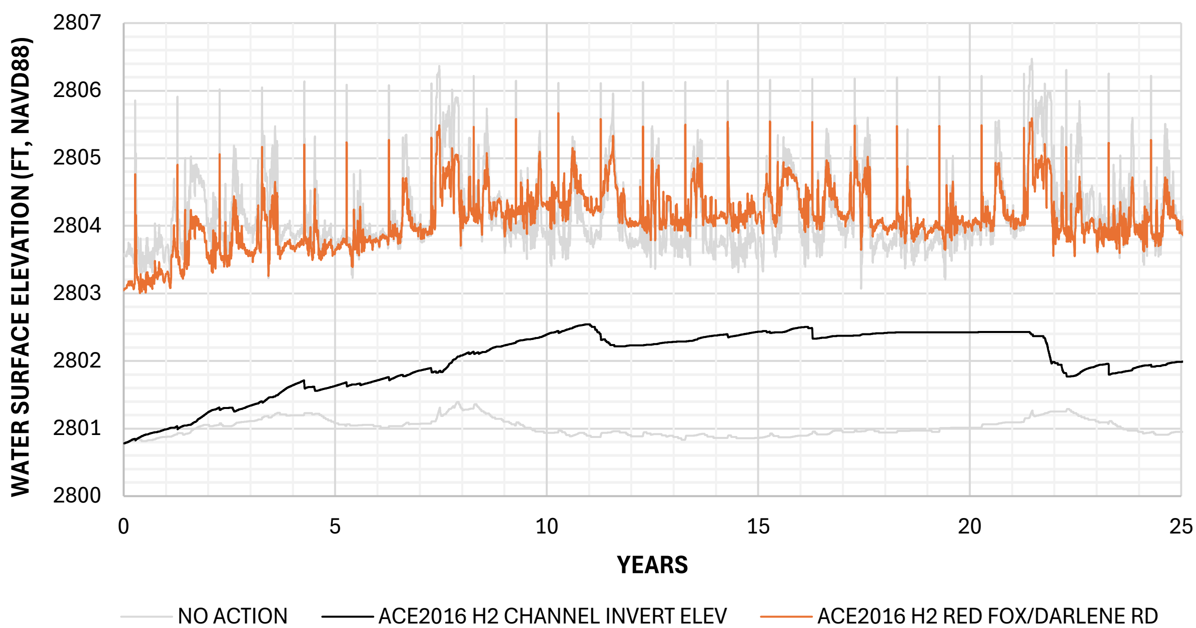

Figure F-3 Water Surface and Channel Elevation at Red Fox/Darlene Rd – No Action and ACE2016 Alt H2

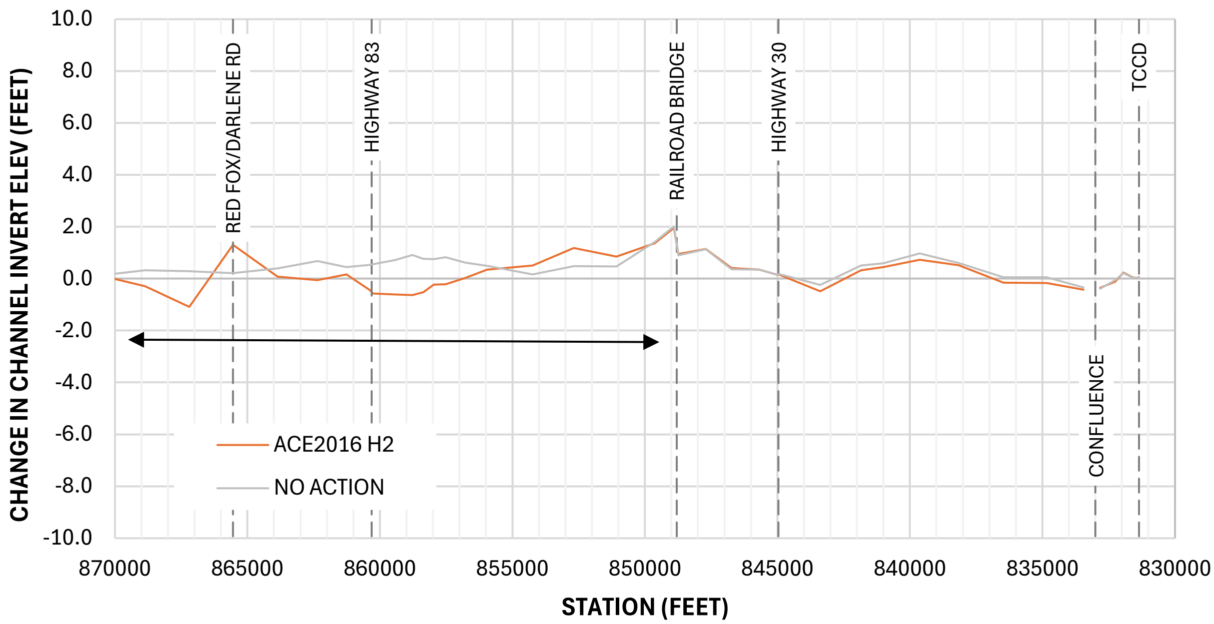

Figure F-4 Change in Channel Invert Elevation – No Action and ACE2016 Alt H2

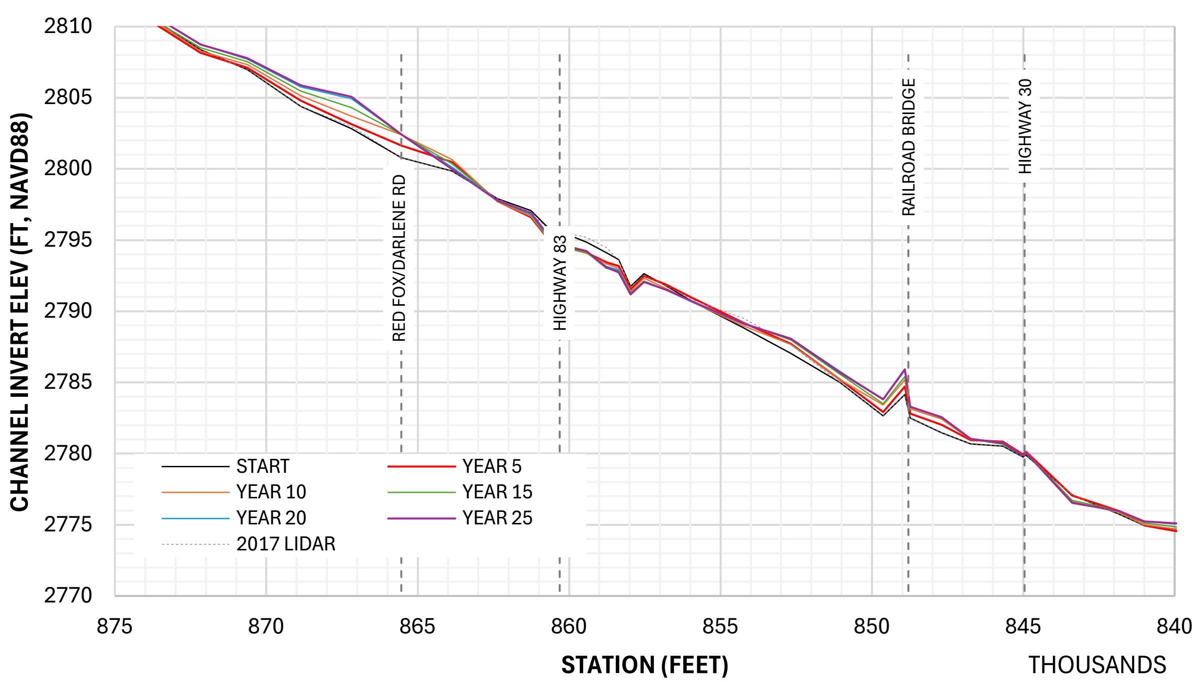

Figure F-5 Channel Profile through Time – ACE2016 Alt H2

Table F-1 Ave Annual Dredging Volume – No Action and ACE2016 Alt H2

Alternative	Average Annual Dredging at TCCD
Sediment Removal Alt A	192,722 cyds/yr
No Action	193,629 cyds/yr