DRAFT Reconnaissance Level Investigation of Sediment Augmentation Alternatives to Reduce Sediment Deficits in the J2 Return Channel Downstream of Lexington, NE

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Executive Summary

The Platte River Recovery Implementation Program (Program or PRRIP) is responsible for implementing certain aspects of the recovery plans for three threatened and endangered species including the highly endangered whooping crane (Grus americana). More specifically, the Program has a management objective to improve survival of whooping cranes during migration through increased use of the Associated Habitat Reach (AHR) of the Platte River in central Nebraska (PRRIP 2006a). This ninety-mile reach extends from Lexington, NE downstream to Chapman, NE and includes the Platte River channel and off-channel habitats within three and a half miles of the river.

An important factor in maintaining whooping crane habitat is maintaining wide shallow sand bars within the Platte River in the vicinity of the project area. The project area evaluated in this study is shown in Figure E.1. The J2 Return is a clear water release into a southern portion of the Platte River floodplain, referred to as the J2 Return Channel and J2 Return Channel in this report, from hydropower facilities operated by Central Nebraska Public Power and Irrigation District (CNPPID). This clear water release has resulted in significant erosion of the J2 Return Channel that can reduce availability of the wide, shallow sand bars. This erosion is progressing downstream (PRRIP, 2024).

During the First Increment of the Program, Adaptive Management Plan (AMP; PRRIP 2007) activities included additional monitoring, modeling, and evaluation of the feasibility and performance of various strategies to augment sediment. By 2016, Program decision makers advised by the Independent Science Advisory Committee (ISAC) concluded the best way to evaluate the performance of sediment augmentation was to initiate a full-scale sediment augmentation management experiment designed to offset the total sediment deficit downstream of the J2 Return. Implementation began in 2017, and annual augmentation continued through 2022. The augmentation has been performed primarily through mechanical means using heavy machinery. The PRRIP is considering alternatives to mechanical augmentation, and one such alternative is hydraulic augmentation, which entails using flow to recruit sediment into the J2 Return Channel. The Governance Committee (GC) retained Stantec Consulting Services, Inc. (Stantec) in cooperation with GEI Consultants, Inc. (GEI) (Consultant Team) to develop and evaluate alternatives to mechanical augmentation of sediment. The goal of this study is to evaluate alternatives for sediment augmentation at the Reconnaissance Level. The study assumes that additional analysis, design and permitting will be required to further understand the feasibility of the selected alternatives.

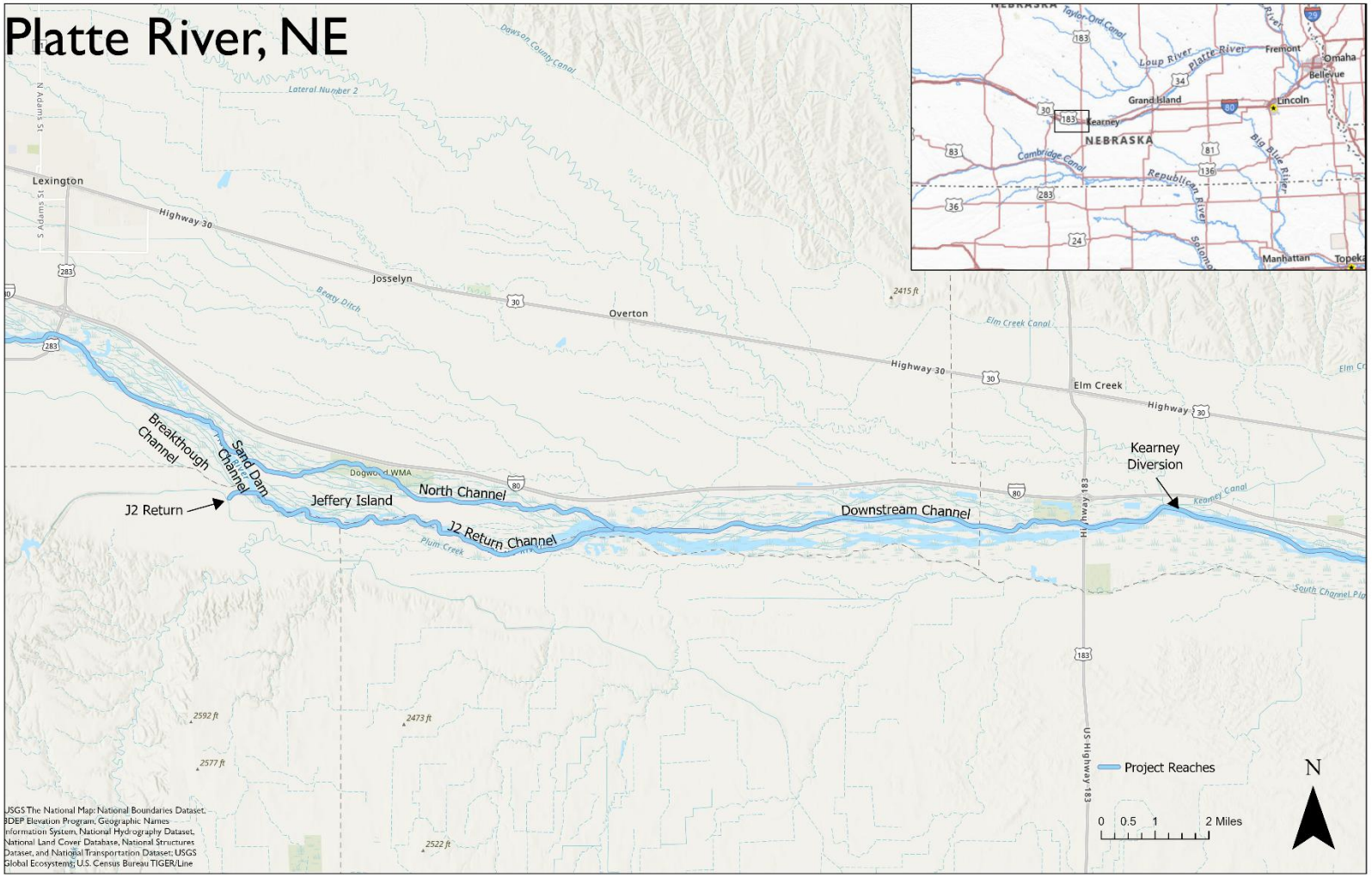

Figure E.1. Definition of Project Reaches

Alternatives were developed in cooperation with PRRIP and are summarized in Table E.1.

Table E.1. Description of Alternatives Analyzed

Alternative Category	Label	Alternative Description
No Action	N1	Continued current operations. No Sediment Augmentation, and continued maintenance of Sand Dam and Breakthrough Channel Control Structure.
J2 Return Modification	R1	Re-regulate the J2 flows to prevent hydropeaking, creating more steady release of flow
	R2	Use J2 Return water to erode material from Platte River floodplain. The J2 return water would be re-routed to the floodplain and/or Sand Dam Channel. Potential new outlet and channels are necessary.
Sand Dam	S1	Remove Sand Dam
	S2	Construct overflow weir at Sand Dam Location to allow flood flows to enter Sand Dam Channel and erode material
	S3	Construct bottom opening gate structure at Sand Dam Location to allow flood flows to enter Sand Dam Channel and erode material
Jeffrey Island	I1	Diversion of flow from North Channel to Jeffrey Island
	I2	Use J2 Return water to erode material from Jeffrey Island

HEC-RAS one-dimensional (1D) and two-dimensional (2D) numerical models were used to simulate the alternatives to estimate the response in the project area. The models used flow and sediment data collected by prior studies in the Platte River including observed hourly flow data, bed material gradations, bed load, and suspended load.

A 1D HEC-RAS sediment transport model was developed and calibrated to model the sediment transport in the Platte River for the project area. The area includes the North Channel (from approximately Darr, NE to the confluence with the J2 Return Channel), the J2 Return Channel (from the J2 Return confluence with to the J2 Return Channel to the confluence with the North Channel), and from the confluence of the North and J2 Return Channels to the Kearney Canal Diversion Structure. The model calibration period began on October 1, 2016 and was run for seven continuous years until September 30, 2023. This calibration period includes six years of sediment augmentation within the J2 Return Channel and one year of post-augmentation, Water Year (WY) 2023. The sediment transport formula that was most accurate in simulating all three reaches (North, J2, and Downstream Channels) was selected first, then the roughness parameter was adjusted so that the model reasonably simulated the observed channel erosion in the North, J2, and Downstream channels during the calibration period. The 1D HEC-RAS model was able to simulate the total observed erosion to within 4 %.

A 2D HEC-RAS sediment transport model was developed including the North Channel between the US HWY 283 and 444th Road (Overton) bridges, the Breakthrough Channel, the Sand Dam Channel, Jeffreys Island, and the J2 Return Channel. The 2D model was calibrated using observed erosion in the Breakthrough Channel from 2016 to 2017. The 2016-2017 event was selected as it matched the shorter

term (single year), rapid incisional processes that the 2D model was intended to replicate. The sediment transport formula and active layer thickness were adjusted to reasonably simulate the observed erosion volume in the Breakthrough Channel. The calibrated 2D model simulated the observed quantity of erosion volume to within 23 percent. The 2D model does not have the ability to explicitly simulate the bank erosion that will occur as vertical incision progresses. Therefore, the total volume of erosion and the channel widening that occurred was slightly underestimated.

After calibration, the 1D model was used to simulate the response in the North Channel and J2 Return Channel, and the reach downstream of the junction of the J2 and North Channels. A 14-yr period was simulated for each alternative and the erosion and deposition within each reach was estimated. The 2D model was used to simulate the more complex, short-term responses in newly-formed channels and terraces where flow would be introduced to source erodible materials to the J2 Return Channel.

For the alternatives using flow to erode the Sand Dam Channel, both 1D and 2D models were used to estimate the erosion that would occur in the Sand Dam Channel. The predicted erosion from the Sand Dam Channel in the 1D model was significantly larger than predicted in the 2D model. The primary reason for the difference in model results is that the 1D model erodes the wetted portions of the cross section uniformly, while the 2D model will erode the high velocity areas much quicker than the low velocity areas. The 2D model also does not have the ability to explicitly simulate the bank erosion that will occur as vertical incision progresses. For the purposes of alternative assessment, the larger of the erosion estimates is used to evaluate the alternatives. If the alternative is not considered to perform well with the larger estimate of channel erosion, then it would be considered to only perform worse with the smaller estimate.

Both 1D and 2D models have uncertainties associated with them and therefore the models are primarily used in comparison to the No Action Alternative. The erosion and deposition from each alternative are compared against that predicted under No Action.

Conceptual designs and Opinions of Probable Construction Cost (OPCC) were developed for each alternative, except for the alternative requiring re-regulation of the J2 Return (R1). The simulated results and costs for each alternative are summarized in this report. The most effective alternative at reducing erosion in the J2 Return Channel and in promoting stability or deposition in the Downstream Channel is Alternative I2. The alternative is estimated to cost approximately $29 million and could produce up to 2.4 million tons of sediment from Jeffery's Island over the 14-year simulation period.

It would be possible to combine alternatives. For example, R1 (Re-regulation of J2 Return Flows) could be combined with any of the other alternatives to further reduce the erosion of the J2 Return Channel. R2 (Route J2 Return flows to Sand Dam Channel) and I1 (Route J2 flows to Jeffery Island) could also be combined such that the channel is first constructed to the Sand Dam Channel and then extended to Jeffery Island.

Acronyms / Abbreviations

Acronym / Abbreviation	Full Name
AHR	Associated Habitat Reach
cfs	cubic feet per second
CU YD	cubic yards
ft	feet
GC	Governance Committee
GEI	GEI Consultants, Inc
HR	hour
mm	millimeters
PRRIP	Platte River Recovery Implementation Program
SQ FT	square foot
Stantec	Stantec Consulting Services Inc.
USGS	United States Geological Survey
WSE	Water Surface Elevation
WY	Water Year
yd^3	cubic yards

1 Introduction

The Platte River Recovery Implementation Program (Program or PRRIP) is responsible for implementing certain aspects of the recovery plans for three threatened and endangered species including the endangered whooping crane (Grus americana). More specifically, the Program has a management objective to improve survival of whooping cranes during migration through increased use of the Associated Habitat Reach (AHR) of the Platte River in central Nebraska (PRRIP 2006a). This ninety-mile reach extends from Lexington, NE downstream to Chapman, NE and includes the Platte River channel and off-channel habitats within three and a half miles of the river.

The Program has implemented an adaptive management program to test strategies for increasing suitability of whooping crane habitat in the AHR. One area of focus has been the impact of a sediment deficit at the upstream end of the AHR on channel morphology. More specifically, channel incision and narrowing has occurred downstream of a clearwater hydropower return and Program stakeholders are concerned those impacts could progress downstream through time, impeding the ability to maintain the wide, unvegetated, braided river morphology that is suitable for whooping crane roosting. The Johnson No. 2 Hydropower Return (J2 Return) began operations and concerns about incision emerged in the 1980s. Several investigations were conducted in the late 1990s and early 2000s to evaluate the magnitude of the deficit and develop the concept of sediment augmentation into a management action to be implemented during the First Increment of the Program (2007-2019).

During the First Increment of the Program, Adaptive Management Plan (AMP; PRRIP 2007) activities included additional monitoring, modeling, and evaluation of the feasibility and performance of various strategies to augment sediment. By 2016, Program decision makers advised by the Independent Science Advisory Committee (ISAC) concluded the best way to evaluate the performance of sediment augmentation was to initiate a full-scale sediment augmentation management experiment designed to offset the total sediment deficit downstream of the J2 Return. Implementation began in 2017, and annual augmentation continued through 2022. The augmentation has been performed primarily through mechanical means using heavy machinery.

The Program is considering alternatives to mechanical augmentation to recruit sediment into the J2 Return Channel. The Governance Committee (GC) has retained Stantec Consulting Services, Inc. (Stantec) in cooperation with GEI Consultants, Inc. (GEI) (Consultant Team) to develop and evaluate alternatives to mechanical augmentation of sediment. This report summarizes the findings of this alternative evaluation.

This goal of this study is to evaluate alternatives for hydraulic sediment augmentation at the Reconnaissance Level. The study assumes that additional analysis, design and permitting will be required to further understand the feasibility of the selected alternatives.

2 Approach Overview

The reaches being considered in this report are shown in Figure 2-1. For the purposes of this document, the reaches are defined as the North Channel, the J2 Return Channel, and the Downstream Channel (also known as Cottonwood Ranch reach). Some of the previous studies on the aggradation and degradation are summarized below.

The North Channel for this study extends from Lexington Bridge to the junction with the J2 Return Channel. PRRIP (2015) analyzed cross section data collected from 2010 to 2014 and found that there was an average of 170,000 tons/year of aggradation in this reach. However, in some years the reach experienced degradation and the long-term trend was not clear.

The primary source of flow in the J2 Return Channel is the clear water supply from the J2 Return. PRRIP (2024) concluded that a wave of vertical incision propagated down through the study area after J2 Return began operations. In the early 2000s, the primary mechanism of channel degradation shifted from incision to lateral migration, with the highest intensity of migration occurring in the upper half of the J2 Return Channel. PRRIP (2024) estimated annual cubic yards of erosion from the Augmentation boundary (approximately downstream of the return) of 122,700 to 105,000 yd^3/yr pre-augmentation (2009 – 2016) and 88,800 yd^3/yr post-augmentation (2016 – 2021). Assuming a dry bulk density of 97 lb/ft^3, the estimated erosion from the J2 Return Channel is 161,000 tons/yr to 138,000 tons/yr pre-augmentation and 116,000 tons/yr post-augmentation.

The Downstream Channel extends from the confluence of the J2 Return channel and the North channel to the Kearney Canal Diversion. The PRRIP estimated while the degradation rates from Overton Bridge to the Kearney Diversion of 200,400 to 130,700 yd^3/yr pre-augmentation and 51,000 yd^3/yr post-augmentation. Assuming a dry bulk density of 97 lb/ft^3, the estimated erosion is 263,000 tons/yr to 171,000 tons/yr pre-augmentation and 67,000 tons/yr post-augmentation.

The Breakthrough Channel connects the North Channel to the upstream end of the J2 Return Channel. It becomes active when high flows exceed the capacity of the North Channel. Between 2009 and 2019 there were several occasions when high flows from the North Channel entered the Breakthrough Channel and caused extensive erosion of the channel (PRRIP, 2024). The Breakthrough Channel was bermed in 2019 to prevent flow from entering and endangering a gas pipeline.

The Sand Dam Channel is a remnant of a historical south channel of the Platte River that was cutoff by the Sand Dam structure. The channel receives continual water from seepage from the North Channel beneath the Sand Dam but does not appear to receive any surface water from the North Channel.

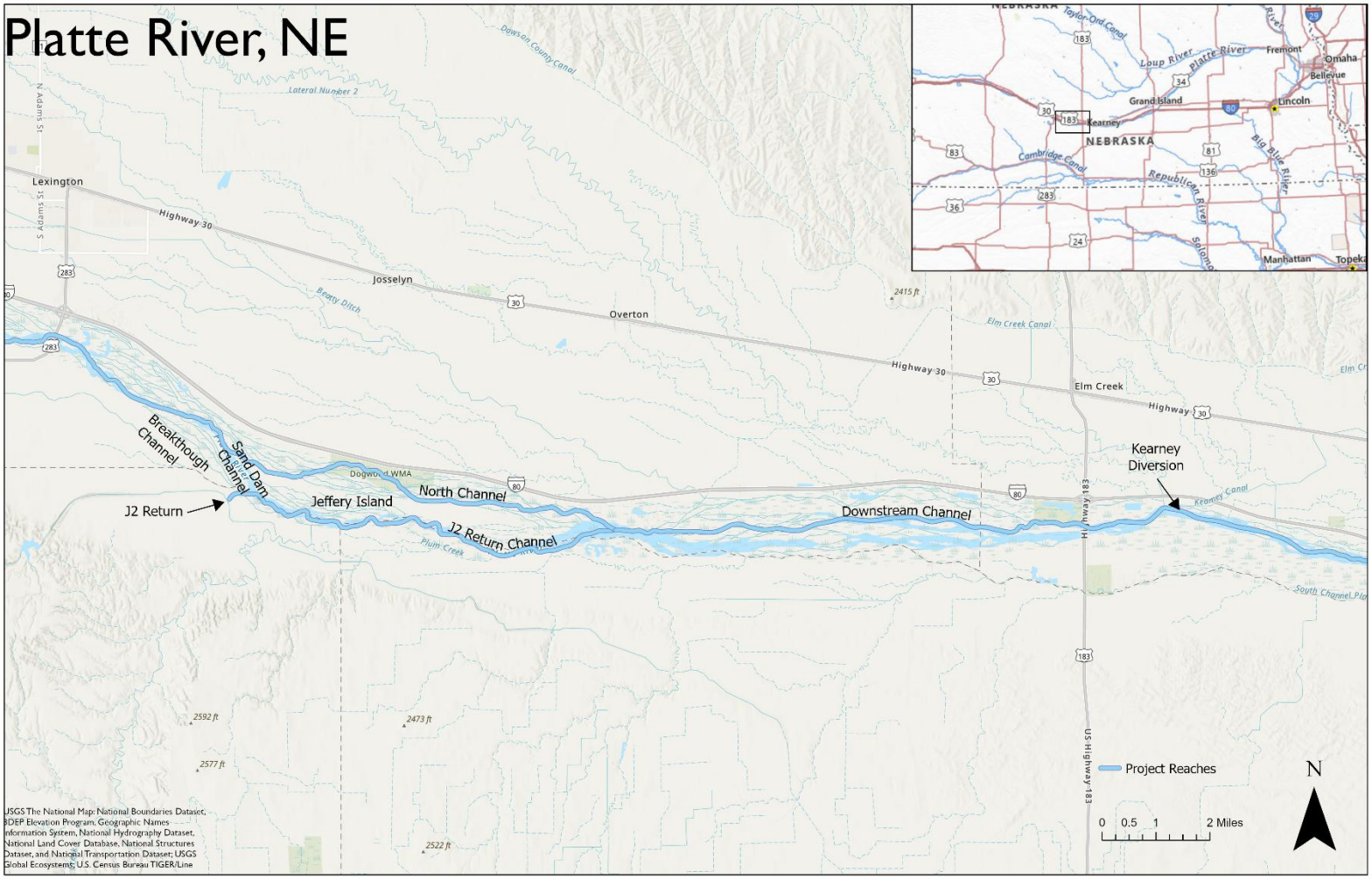

Figure 2-1. Reach Definition

The goal of the sediment augmentation is to decrease the degradation of habitat within the project reaches. Of particular interest is maintaining Whooping Crane habitat suitability in the Downstream Reach (PRRIP, 2024). The analysis approach is centered around assessing the potential degradation of habitat by quantifying the sediment balances in the project reaches. Sediment erosion will tend to decrease habitat suitability whereas stability or deposition would maintain habitat suitability. The analysis approach will quantify the erosion and deposition within the project reaches as the metric by which to evaluate alternatives.

The analysis approach uses mobile bed sediment transport models. These models simulate hydraulic conditions, then use those hydraulic conditions to predict the sediment transport capacity of the river based upon bed material. If the transport capacity is greater than the sediment supply, then erosion occurs. If the transport capacity is lower than the sediment supply, then deposition occurs. The bed geometry is then updated based upon the computed erosion or deposition. Hydraulics, sediment transport, and bed geometry are calculated at incremental time steps over a total simulation duration which allows for progression of morphological trends and system responses.

The total length of the project reach was almost 30 miles and the analysis period was over 10 years. To facilitate multiple modeling objectives, a combined one-dimensional (1D) and two-dimensional (2D) modelling approach was used. 1D modeling represents the river as a series of cross sections. It computes the cross sectionally averaged hydraulic properties then computes average erosion and deposition at the cross section. The advantage of 1D modeling is that it can simulate large spatial and temporal scales and the computation of total erosion and deposition is straightforward. One limitation of 1D models is that they cannot simulate the spatial patterns of erosion and deposition within complex geometries.

2D models represent the river as user-defined grid cells. The model computes the depth and depth averaged velocity at each cell, then computes the erosion and deposition at each 2D cell. The advantage of 2D models is that they compute spatially variable deposition and erosion within the model domain and may better resolve single rapid morphological events. The disadvantage of 2D models is that they are computationally much more expensive and even with modern computational facilities, it is not practical to simulate large spatial and temporal scales.

The general strategy was to use the 1D model to simulate the entire project domain over a simulation period of at least 10 years. The 2D model was used to supplement the 1D results to describe the complex response in areas where the erosion could be in multiple channels and where flow is introduced into locations not currently being exposed to riverine flows. In cases where the models overlap, the more optimistic result is used. The reason for analyzing the alternatives in this way is that this is a Reconnaissance study where the goal is to identify alternatives that could potentially meet PRRIP objectives. If an alternative is found to meet these objectives, then additional analysis of the alternative could be performed to refine it.

For example, the Sand Dam alternatives, both 1D and 2D models were used to estimate the erosion that would occur in the Sand Dam Channel. The predicted erosion from the Sand Dam Channel in the 1D model was significantly larger than predicted in the 2D model. The primary reason for the difference in model results is that the 1D model erodes the wetted portions of the cross section uniformly, while the 2D model

will erode the high velocity areas much quicker than the low velocity areas. The 2D model also does not have the ability to explicitly simulate the bank erosion that will occur as vertical incision progresses. For the purposes of alternative assessment, the larger of the erosion estimates is used to evaluate the alternatives. If the alternative is not considered to perform well with the larger estimate of channel erosion, then it would be considered to only perform worse with the smaller estimate.

3 Alternative Development

Reconnaissance level alternatives were developed in conjunction with PRRIP and presented to the Technical Advisory on February 5, 2025. The carried forward into the alternative analysis are given in Table 3-1. Before describing the selected alternatives, a list of alternatives not selected for analysis are given below.

Alternatives considered but not carried forward into the analysis were:

1. Removal of the J2 Return. Under this alternative, the release of flow from the J2 hydropower plant into the J2 Return Channel would be eliminated. This alternative was not considered because PRRIP there is no reservoir or location into which the where the flow could be released. Furthermore, no releasing the water into the J2 Return Channel would violate current water agreements downstream.

2. Mechanical Augmentation. This alternative would entail future mechanical augmentation into the J2 Channel. Continued mechanical augmentation is not evaluated as it was considered outside the scope of this project. PRRIP is planning to evaluate mechanical augmentation in another project.

3. Allow Additional Flow into the Breakthrough Channel. This alternative would modify the grade control at the upstream end of the breakthrough channel to allow additional flow into the Breakthrough Channel. This alternative was not considered because it would potentially endanger the pipeline crossing the breakthrough channel.

The Alternatives carried forward are described in more detail below and plan view drawings of the alternatives are given in Appendix A. More detailed drawings are given for some of the alternatives requiring structural modifications in Appendix B.

No Action (N1)

Under No Action, it is assumed that no intentional sediment augmentation is performed. No mechanical augmentation measures are performed, and no other flow management measures are performed to introduce sediment into the system. In addition, no significant activation of the Breakthrough Channel is assumed.

Re-regulate J2 Flows (R1)

The hydropeaking of flow from the J2 Return channel is eliminated in this alternative. Currently, the flow released into the J2 Return Channel can vary between near 0 to over 2000 cfs within a given day. Under this alternative the flows leaving the J2 Return Channel will be re-regulated so that the flow is steady over each day and equal to the average daily flow of the hydropeaking flows under the No Action Alternative. The mechanism to re-regulate the flows is not determined as part of this project but would likely require additional reservoirs or a change to the hydropower operations. An example of the flows under Alternative R1 as compared to No Action is given in Figure 3-1.

Instead of the measured hourly J2 flows, the daily average flows are used as input into the model. The intention of this alternative is to reduce the erosive power of the higher flows of the J2 Return to reduce the erosion rate in the J2 Return Channel. The daily flow volumes of the J2 Return are the same between No Action and this alternative. There is no intentional sediment augmentation performed as part of this alternative.

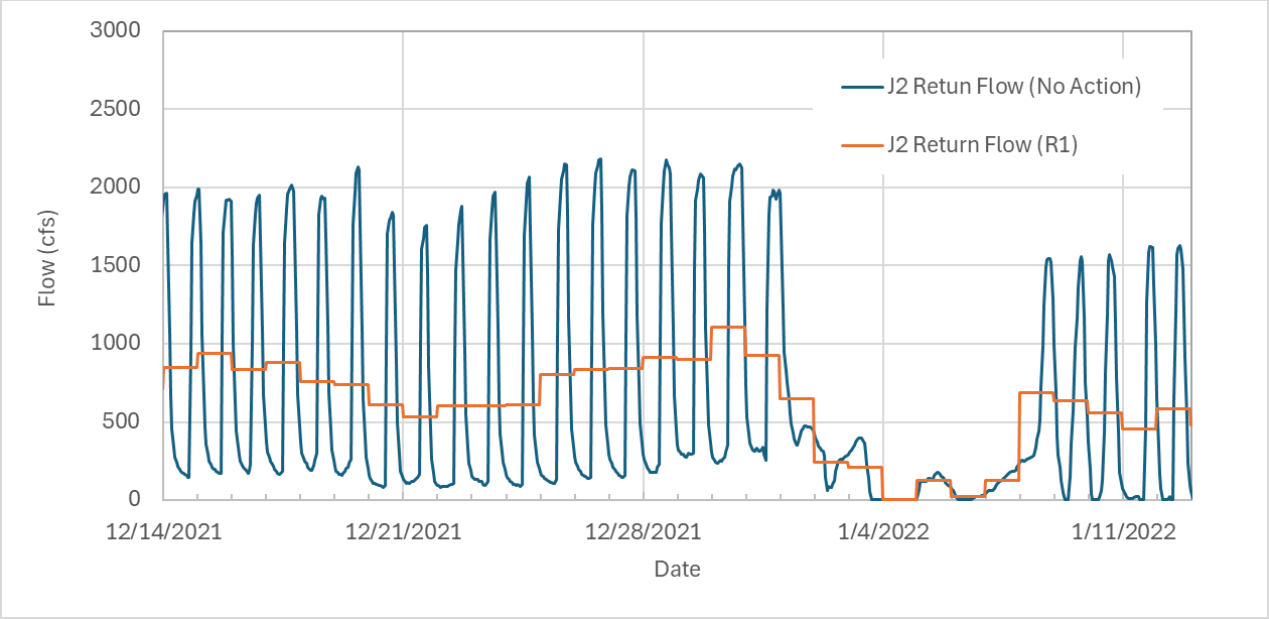

Figure 3-1. Example of flow re-regulation for the R1 Alternative.

Divert J2 Flows into Sand Dam Channel (R2)

The flow from the J2 Return is diverted into a new channel and released into the Sand Dam Channel downstream of the Sand Dam. The intention of this alternative is to use the clear water from the J2 Return to erode sediment from the Sand Dam Channel that will then flow into the J2 Return Channel. There is no mechanical sediment augmentation performed as part of this alternative.

This alternative requires the construction of a new gated structure in the J2 canal and a new open channel. The channel will need to pass over a small tributary and the Breakthrough Channel. New culverts would be constructed to allow flow from the small tributary and Breakthrough Channel to pass underneath the new open channel.

A plan and profile of the new open channel and control structures is given in Appendix B.

Remove Sand Dam (S1)

This alternative removes the Sand Dam identified in Figure 2-1 and uncontrolled flow is allowed into the Sand Dam Channel. It is realized that this could result in the eventual capture of most of the North Channel

flow into the J2 Return Channel. The intention of this alternative is primarily to determine the results of the capture of North Channel flow into the J2 Return Channel.

Overflow Weir at Sand Dam (S2)

An overflow weir is installed in the Sand Dam location. The intention of this alternative is to divert a portion of the high flow in the North Channel into the Sand Dam Channel to erode sediment from that channel and pass it into the J2 Return Channel. The weir is intended to control how much flow enters the Sand Dam Channel and prevent a total capture of North Channel flow into the J2 Return Channel.

The weir is assumed to be at an elevation of 2355.7 ft, which is approximately 1 foot higher than the low flow channel bank elevation at this location. The weir is 150 ft wide and activates at 1,000 cfs. Based upon the seven-year stream gage which is used in this analysis (Water Year 2016 to 2023), 1000 cfs is exceeded approximately 5% of the time in the North Channel. It is recognized that design of this alternative would require an evaluation of multiple elevations to determine the optimal design, however, the current assumption allows for an evaluation of an alternative that seeks to keep the majority of flow and sediment in the North Channel, while still using peak flows to erode sediment from the Sand Dam Channel and pass it into the J2 Return Channel.

A plan and profile of the weir for Alternative S2 is given in Appendix B.

Bottom Opening Gate at Sand Dam (S3)

A weir with a bottom opening gate (such as a sluice or radial gate) is installed in the Sand Dam location. The intention of this alternative is to divert a portion of the high flow in the North Channel into the Sand Dam to erode sediment from that channel and pass it into the J2 Return Channel. The weir and gate is intended to control how much flow enters the Sand Dam Channel and prevent a total capture of flow into the J2 Return Channel. The potential advantage of this alternative is that it diverts flow from a lower elevation in the water column than the Overflow Weir Alternative (S2) where sediment concentrations are higher, increasing the sediment delivery into the J2 Return Channel.

The weir is assumed to be at an elevation of 2354.7 ft, which is near the bank elevation at this location. The weir is 150 ft wide and activates at 400 cfs. For the purposes of this alternative, the gates are assumed to only be open above flows of 500 cfs. Based upon the stream gage record, 500 cfs is exceeded approximately 15% of the time in the North Channel. The weir was designed so that approximately one-third of the North Channel flow is diverted into the Sand Dam Channel at a flow of 1,000 cfs. It is recognized that multiple iterations would be required to optimize this alternative, but the intention is to evaluate the condition where the Sand Dam Channel is active a relatively large percentage of the time and would transmit a large percentage of the flow and sediment into the Sand Dam Channel.

One key assumption on the S2 and S3 alternatives is that there is no structure across the North Channel. A control structure on the North Channel would likely have to be similar in scale to the structure at Kearney Canal Diversion and this is not considered a feasible alternative in this study.

Diversion of North Channel water into Jeffrey Island (I1)

An overflow weir is installed near the upstream end of Jeffery Island. The intention of this alternative is to divert a portion of the high flow in the North Channel into a constructed pilot channel to erode sediment from the island and pass it into the J2 Return Channel. The weir is intended to control how much flow enters the pilot channel in Jeffery Island and prevent a total capture of North Channel flow into the J2 Return Channel. The weir would be designed to be of similar size and activate similar to the overflow weir of the Sand Dam Alternative S2.

Diversion of J2 water into Jeffrey Island (I2)

This alterative is designed similarly to Alternative R2, but instead of releasing water into the Sand Dam Channel the alternative releases water into Jeffery Island. The intention of this alternative is to use the clear water from the J2 Return to erode sediment from Jeffery Island that will then flow into the J2 Return Channel. There is no mechanical sediment augmentation performed as part of this alternative.

The alternative requires construction of similar features as the R2 alternative. However, in addition the constructed open channel needs to be extended to pass over the Sand Dam Channel, then a pilot channel will need to be constructed into Jeffery Island to direct flow into the areas intended for erosion.

A plan and profile of the new channel for Alternative I2 is given in Appendix B.

Table 3-1. Summary of Alternatives Analyzed

Alternative Category	**Label**	**Alternative Description**
No Action	N1	Continued current operations. No Sediment Augmentation, and continued maintenance of Sand Dam and Breakthrough Channel Control Structure.
J2 Return Modification	R1	Re-regulate the J2 flows to prevent hydropeaking, creating more steady release of flow
	R2	Use J2 Return water to erode material from Platte River floodplain. The J2 return water would be re-routed to the floodplain and/or Sand Dam Channel. Potential new outlet and channels are necessary.
Sand Dam	S1	Remove Sand Dam
	S2	Construct overflow weir at Sand Dam Location to allow flood flows to enter Sand Dam Channel and erode material
	S3	Construct bottom opening gate structure at Sand Dam Location to allow flood flows to enter Sand Dam Channel and erode material
Jeffrey Island	I1	Diversion of flow from North Channel to Jeffrey Island
	I2	Use J2 Return water to erode material from Jeffrey Island

4 Data

This section describes the data used in the study to support the modeling analyses.

4.1 Hydrology

4.1.1 Available Data

Stream gage discharge data available from both the Nebraska Department of Water, Energy, and Environment (DWEE) and the United Stated Geological Survey (USGS) for the Platte River within the project reach were reviewed and assessed for applicability in the sediment transport analyses. Two inflow time series were necessary for the model development, one for the Platte River (North Channel) upstream of the Lexington bridge and one for the J-2 Return Channel. The streamgage data used in in this investigation are presented in the following table (Table 4-1) and the locations of the streamgages are show in Figure 4-1.

Table 4-1. Available streamgage data.

Location	**Data Source**	**Description**
Cozad, NE	DWEE	• Platte River (Combined) near Cozad - 15-min interval from 2005 to 2016, 15-min interval from 2016 - current
Darr, NE	DWEE	Platte River near Darr - 15-min data from 2016 to present
J2 Return	USGS	J2 Outflow (discharge) to South Channel Platte River - 15-min data from Aug 2024 to present
Overton, NE	USGS	• Platte River near Overton - 15-min data from 1998 to current • Daily mean discharge from 1930 to current

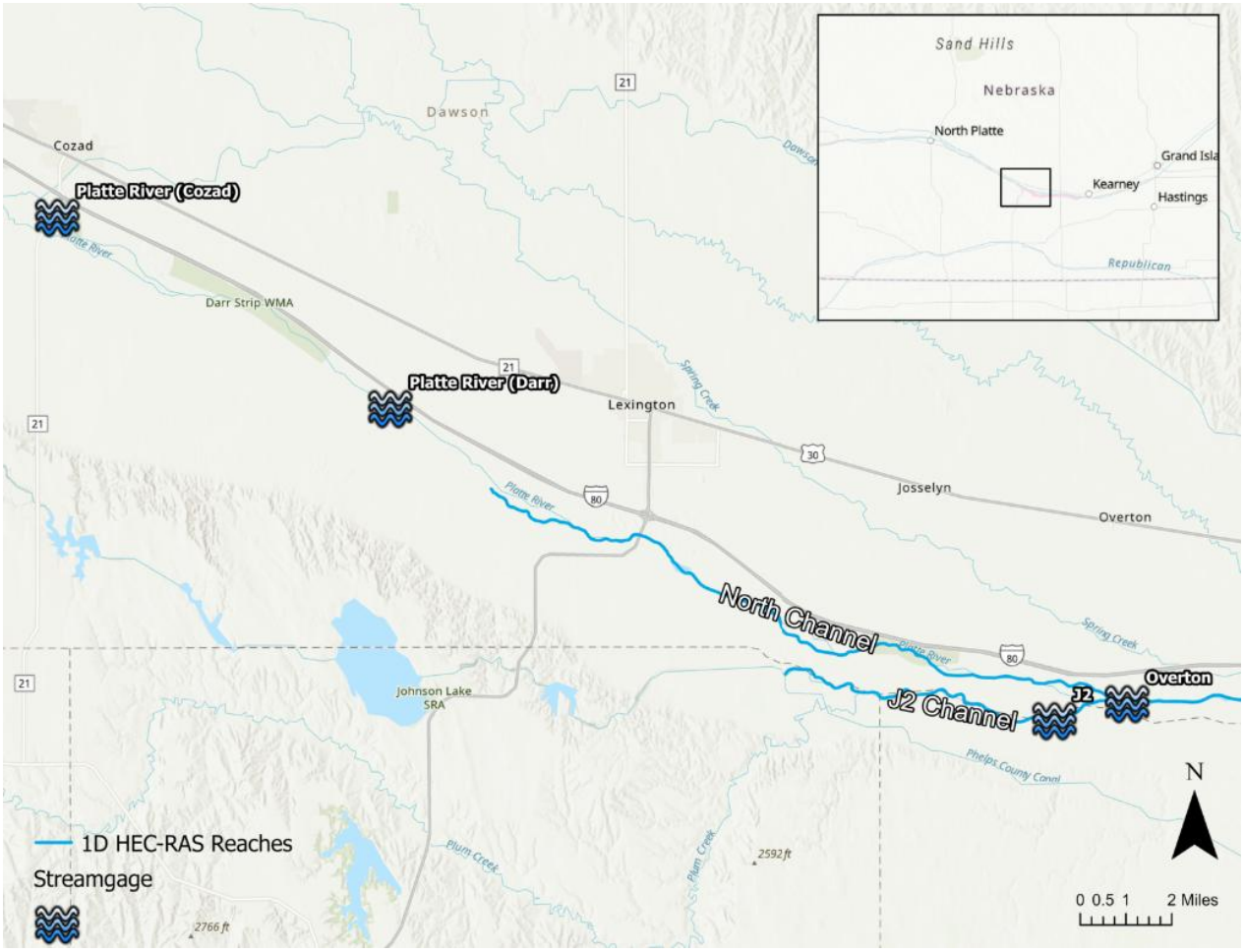

Figure 4-1. Streamgages used in investigation.

4.1.2 HEC-RAS Model Calibration Discharge Data Development

The HEC-RAS 1D sediment transport model was developed to assess the effects of the range of alternatives and was calibrated for the period of record beginning with the first year of augmentation (2017) and extended after the last year of augmentation (2022). The period of record chosen for this analysis was 01 October, 2016 through 30 September, 2023 for a total of seven years.

For the North Channel, the Platte River near Darr streamgage was chosen to provide the necessary flow series due to both proximity and period of applicable record. To simplify data analysis, a 1-HR average flow series was obtained from the DWEE instantaneous data. The DWEE Darr instantaneous values (15-minute interval) indicated that the potential for ice affected discharge values are possible. To minimize the possibility of ice affected discharge values the Darr 1-HR data was compared to a 1-HR flow series obtained from the upstream Cozad Combined streamgage. Visual inspection identified periods of record where the Darr record exceeded the Cozad record. These periods were assumed to represent ice affected

discharge records at Darr and the corresponding Cozad (Combined) record was used in place of the Darr record. Six such periods of record were identified, totaling 477 days, and the first period (5 December, 2016 through 15 May, 2017) is shown below in Figure 4-2.

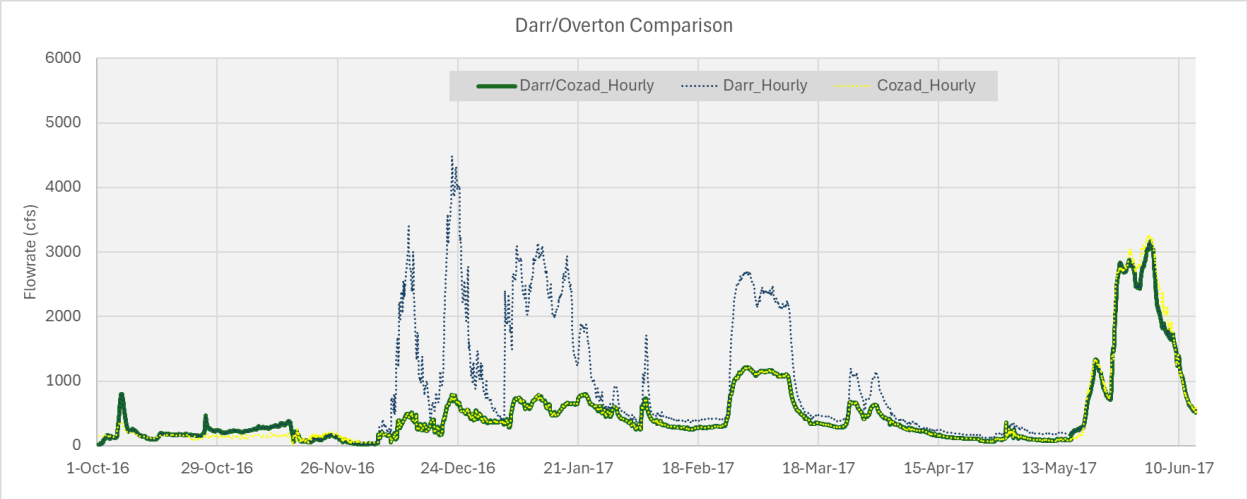

Figure 4-2. Platte River at Darr and Cozad (Combined) hourly discharge records compared and showing the resulting Darr/Cozad record used for the North Channel.

For the J2 Return Channel, a suitable flow series wasn't available for the modeling periods. The J2 Return Channel 1-HR duration flow series was therefore derived from differencing between the Darr streamgage data and the Overton (USGS) streamgage data using the following process.

First, 1-HR average discharge data was compiled for the Darr (see above) and Overton (USGS) streamgages as well as the J2 Return Channel (USGS) for the record from 13 June, 2024 to 18 December, 2024. Then, a simple differencing model was used to calculate the J2 Return Channel discharge by subtracting Darr discharge from Overton discharge, this assumes both no attenuation in flows or other gains/losses between the two streamgages. The calculated J2 Return Channel discharge was then compared to the USGS 1-HR average values and the residual (error) of the estimated value was calculated as well as the error sum of squares for all observed/estimated pairs. To account for the travel time between a flow measured at Darr to the same flow measured at Overton, a range of time offsets were applied to the differencing model such that Darr discharge values (at an offset time) were subtracted from the Overton discharge at a given time. The minimization of the resulting error sum of squares was used to determine which offset best predicted the measured discharge at the J2 Return Channel USGS streamgage. The final offset from this analysis was found to be -6 hours.

Second, to relate the derived J2 Return Channel discharge time to the J2 inlet location (the outlet gate at the canal), a simple time correction was used to visually line up the ascending hydrograph limbs of the derived J2 flow series with the observed values from the USGS J2 Return streamgage during a period of minimal change in the Darr discharge (mid-November). This simple analysis indicated an approximate offset of -45 minutes best corrected the derived J2 Return Channel discharge to match the USGS

streamgage record. This offset (-45 minutes/8,900 ft of channel length between the J2 and Overton gages), was then applied to the approximate channel length between the Overton gage and the J2 inlet (45,100 ft), resulting in an approximate offset of -3.8 hours between the Overton gage and the J2 inlet, which was rounded up to -4 hours to best match the required flow duration of the flow series.

Third, the Overton - North Channel (Darr/Cozad) differencing model (with the -6 hour offset) was used to derive the expected J2 Return Channel discharge for the calibration period (2016 – 2023). The derived J2 Return Channel discharge values were then offset in time by -4 hours to generate the necessary flow series at the upstream end of the J2 Return Channel. The resultant 1-HR discharge time series at the upstream ends of the Platte River (North Channel) and J2 Return Channels were then converted to 2-HR discharge time series using a simple moving average to conform with the HECRAS 1D hydrograph input constraints for a long time-period.

4.1.3 HEC-RAS Model Alternative Analysis Discharge Data Development

The calibrated HEC-RAS 1D sediment transport model was used to analyze the long term effects of the alternatives presented above (Section 3). The seven year calibration flow series for the Platte River (North Channel) and the J2 Return Channel was duplicated, recurring on Oct. 2023 and Oct. 2030 for a total duration of fourteen years. This fourteen year hydrologic series is used to simulate each alternative. The range in alternatives necessitated variations in the respective flow series and will be discussed further in their respective Sections.

A minimum of a 10-yr simulation was desired by PRRIP to evaluate the alternatives. The simulation was extended to fourteen years because shortening it to 10 years would have oversampled one of the seven years that has daily flow data available for the upstream stream gage in the North Channel. Oversampling one of seven years would bias the average results.

4.2 Terrain and Bathymetry

Starting in 2016, topo-bathymetric LiDAR was deployed which allowed for the collection of both topographic and bathymetric data. These acquisitions used near-infrared-wavelength lasers to collect topographic data in non-water areas and used water-penetrating green-wavelength lasers to collect bathymetry. Between 2016 and 2023 LiDAR elevation data were collected by Quantum Spatial Inc. (QSI) in either October or November (QSI, 2016- 2023). Annual survey and ground control points were used to calibrate new LiDAR surfaces and ensure consistency with past years. Bathymetric accuracy of the calibrated LiDAR surface was evaluated with check points captured in submerged areas of the channel at the time of LiDAR flights. Data is processed by QSI and delivered as 3-foot resolution elevation rasters. Tested accuracies for those rasters are shown in Table 4-2 . The accuracy values in Table 4-2 represent the 95% confidence interval, as derived from the population of differences between field-measured and DEM values. Accuracy assessments are designed to meet the guidelines of the Federal Geographic Data Committee National

Standard for Spatial Data Accuracy (FGDC, 1998). From 2016 to 2021 the accuracy assessment data indicate elevation values in wet areas had consistently higher uncertainty than dry areas across all years due to inherent differences in bathymetric and topographic LiDAR data acquisition and processing (Szafarczyk and Toś, 2023). As a result of deeper and more turbid water during the period of data collection, wet areas in 2019 had a higher vertical uncertainty value at 9 inches.

To determine the volume of erosion or deposition within the reaches, we simply differenced the two LiDAR data sets clipped to the erodible areas. This is the process recommended by PRRIP (2024) which assumes LiDAR errors are normally distributed positive and negative errors are assumed to cancel one another out, removing the need for thresholding. The results are given in Table 4-3. To convert the volume of erosion and deposition to weight in tons, a conversion of 1.31 tons/yd^3 is used (97 lb/ft^3). The areas of mechanical sediment augmentation were excluded from the analysis.

Table 4-2. Vertical accuracy estimates for the LiDAR DEM surfaces from each year for wet and dry areas. Accuracy values represent 95% confidence in the estimate

Year	Dry Unvegetated Accuracy (in)	Wet Accuracy (in)
2016	1.7	3.1
2017	2.2	4.6
2018	1.2	4.2
2019	1.2	9.0
2020	2.2	3.1
2021	1.7	2.1

Table 4-3. Computed erosion and deposition by reach.

	Erosion (-) / Deposition (+), tons		
Year	**North Channel**	**J2 Return Channel**	**Downstream Channel**
2016-2017	118,770	-79,663	34,826
2017-2018	-267,549	-358,793	-433,518
2018-2019	238,963	-214,515	166,656
2019-2020	-211,652	-198,466	-349,584
2020-2021	254,255	-94,289	236,244
2021-2022	-117,354	-137,163	-147,732
2022-2023	-299,138	-130,173	-261,168
Total (2016 - 2023)	-283,683	-1,213,062	-754,236

4.3 Bed material

PRRIP provided bed material data collected from each reach in the Project area. The sample locations are given in Figure 4-3. A systematic sample of locations along the river have served as "anchors" for data collection. These locations, referred to as anchor points (APs), are spaced at approximately 4,000-meter (2.5-mile) intervals along the centerline of the river, and each point has been labeled with a U.S. Army Corps of Engineers (USACE) River Mile (RM). The APs used in our analysis are: AP-38, AP-37A, AP-36A, AP-35B, and AP-34.

The sampling protocol was described in PRRIP (2015). In collecting the samples, the sampler was pushed 4 to 6 inches deep at an angle into the bed of the channel at the sampling location. The sampler is shown in Figure 4-4. Typically, each transect was subdivided into three segments, and a representative bed-material sample was collected from each segment, ensuring that one sample was taken from near the thalweg and the other two taken from the lowest elevation surface in other two segments. The sample data collected by PRRIP from Aug 2023 were used in simulations. At each location, the samples were averaged to develop an average gradation, given in Figure 4-7. The bed material in the Platte River generally is dominated by coarse sand (0.5 to 2 mm) and fine gravel (2 mm to 8 mm).

No bed material sample data were available for the Upper J2 Return Channel, where the bed material is significantly coarser than the other reaches. A photograph of the bar immediately downstream of the confluence with the Breakthrough Channel (Figure 4-5). A picture of the bed material in the Upper J2 Return Channel were taken on a field trip in November 2024 and the Federal Highways Hydraulic Toolbox Version 5.4.0 was used to develop a gradation of the surface material in the upper J2 Return Channel. Representing the armoring of the Upper J2 Return Channel is important to representing the erosion of this channel.

The final gradations used in the analysis are given in Figure 4-7 for each sample location.

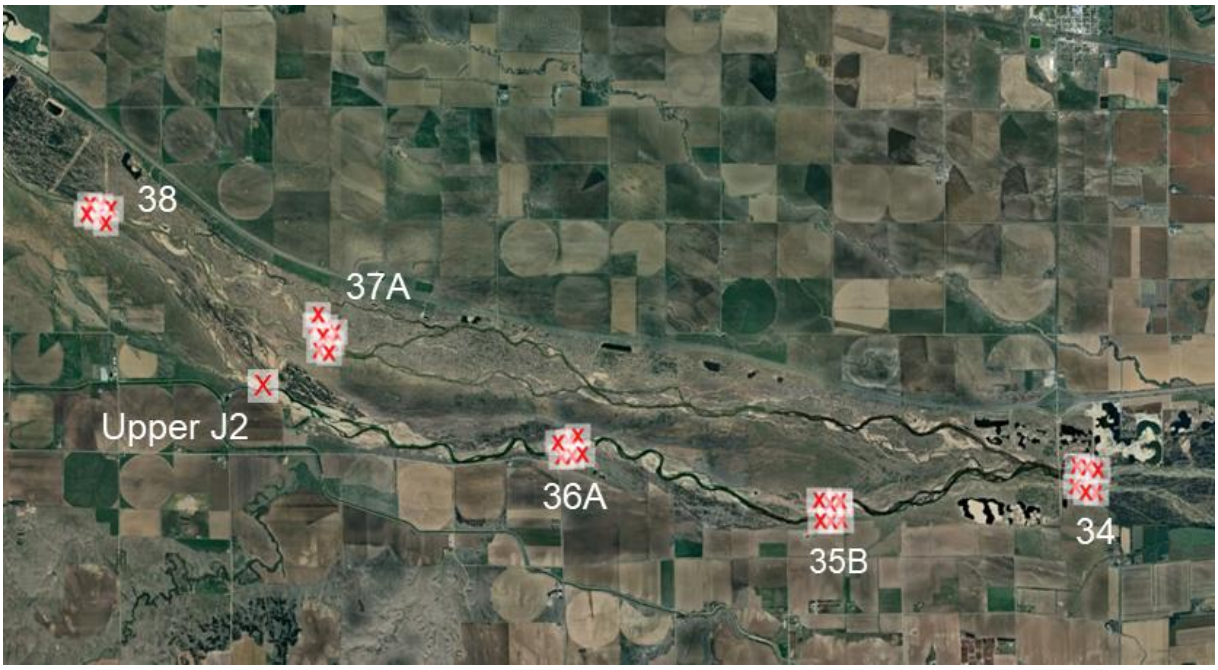

Figure 4-3. Location of Bed Material samples.

Figure 4-4. Pipe dredge used to collect bed-material samples (photograph from PRRIP, 2015).

Figure 4-5. Picture of bar downstream of J2 return.

Figure 4-6. Photograph of upper J2 Return Channel bed material (40.69308 N, 99.67805 W)

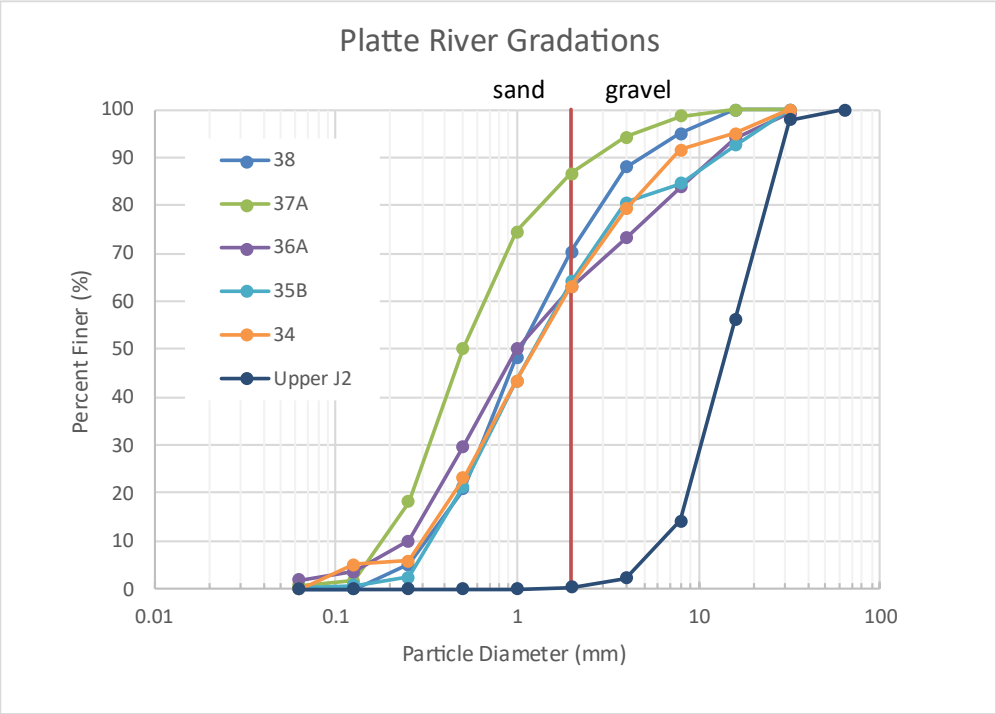

Figure 4-7. Gradation of Bed Material in Project Reach from samples collected in 2023 - 2024.

4.4 Sediment Augmentation

The full-scale augmentation experiment was initiated in 2017 with augmentation occurring annually from 2017 through 2021. The sediment augmentation sites are located in the J2 Return Channel, beginning approximately 3 0.75 miles downstream of the J2 Return and extending one mile east. Sediment augmentation is implemented in the late summer/early fall each year to coincide with relative low flows out of the J2 Return. Summer low flows allow sediment to be staged, whereas long, high flow releases beginning in mid-September transport material away from the site. The volume of augmentation is given in Table 4-4

There was also significant sediment supplied to the J2 Return Channel by the Breakthrough Channel in 2016 through 2018. The Breakthrough Channel was bermed in 2019 to prevent flow from entering and endangering a gas pipeline (PRRIP, 2024).

Table 4-4. Sediment supply to J2 Return Channel from 2016 through 2023.

Year	Breakthrough Channel Volume (yd^3)	Augmented Volume (yd^3)
2016	71.600	0
2017	61,100	23,000
2018	19,900	42,900
2019	0	42,300

2020	0	57,700
2021	0	51,300
2022	0	43,900
2023	0	0

4.5 Sediment Load and Budget

Suspended load sediment transport rates (Q_{ss}) and bed load sediment transport rates (Q_{sb}) have been measured at the Darr (State Hwy L-24A) and Overton (State Hwy 24B) stream gage locations (PRRIP, 2015). Bias corrected rating curves relating the measured load to measured flow rates have also been developed by PRRIP (2015). The total sediment load (Q_s) can be estimated by combining these curves to determine the total transport rates at these locations (see Table 4-6, and Figure 4-8). Only the sand and gravel load are analyzed, and the wash load (silt/clay) is ignored.

These sediment rating curves were combined with the hourly stream record to estimate the annual sediment loading for WY 2017 through 2023. The estimated transport rates at the Darr and Overton stream gage locations by WY and the average over this period are given in Table 4-5. The average annual sand and gravel transport rate at Darr stream gage was 225,000 tons, while at Overton, the transport rate was 522,000 tons.

The sediment loads, combined with the LiDAR differencing, and sediment augmentation volumes, can be used to develop a sediment budget of the project reach over the period Oct 2016 to Oct 2023, or WY 2017 through 2023. To convert the volume of erosion and deposition to weight in tons, a conversion of 1.31 tons/yd^3 is used (97 lb/ft^3).

The annual average transport rates, sediment augmentation weights, and erosion weights are given in schematic form in Figure 4-9. As a check on the sediment budget, a comparison of the computed average annual supply of the North Channel and the J2 Return Channel are compared against the computed annual average transport rates at Overton. The estimated supply to the Downstream Channel and the computed loads at Overton correspond to within 4%, which gives confidence in the measurement techniques and methods used to develop the sediment budget. Year to year comparisons are much more uncertain because of the relative errors in the load and LiDAR differencing. The error in an individual year varied between an overestimate of sediment supply at Overton of 100% (WY 2023) to an underestimate of 90% (WY 2021).

However, over the 7-year period, the agreement is considered excellent.

Table 4-5. Estimated sediment transport annual loads at the Darr and Overton Stream gages.

Water Year	Estimated Sand and Gravel Transport (tons)	
	Darr Gage	Overton Gage
2017	267,000	670,000
2018	164,000	431,000

2019	298,000	773,000
2020	309,000	852,000
2021	126,000	323,000
2022	90,000	233,000
2023	317,000	372,000
Average (2017 - 2023)	225,000	522,000
Total (2017 - 2023)	1,572,000	3,653,000

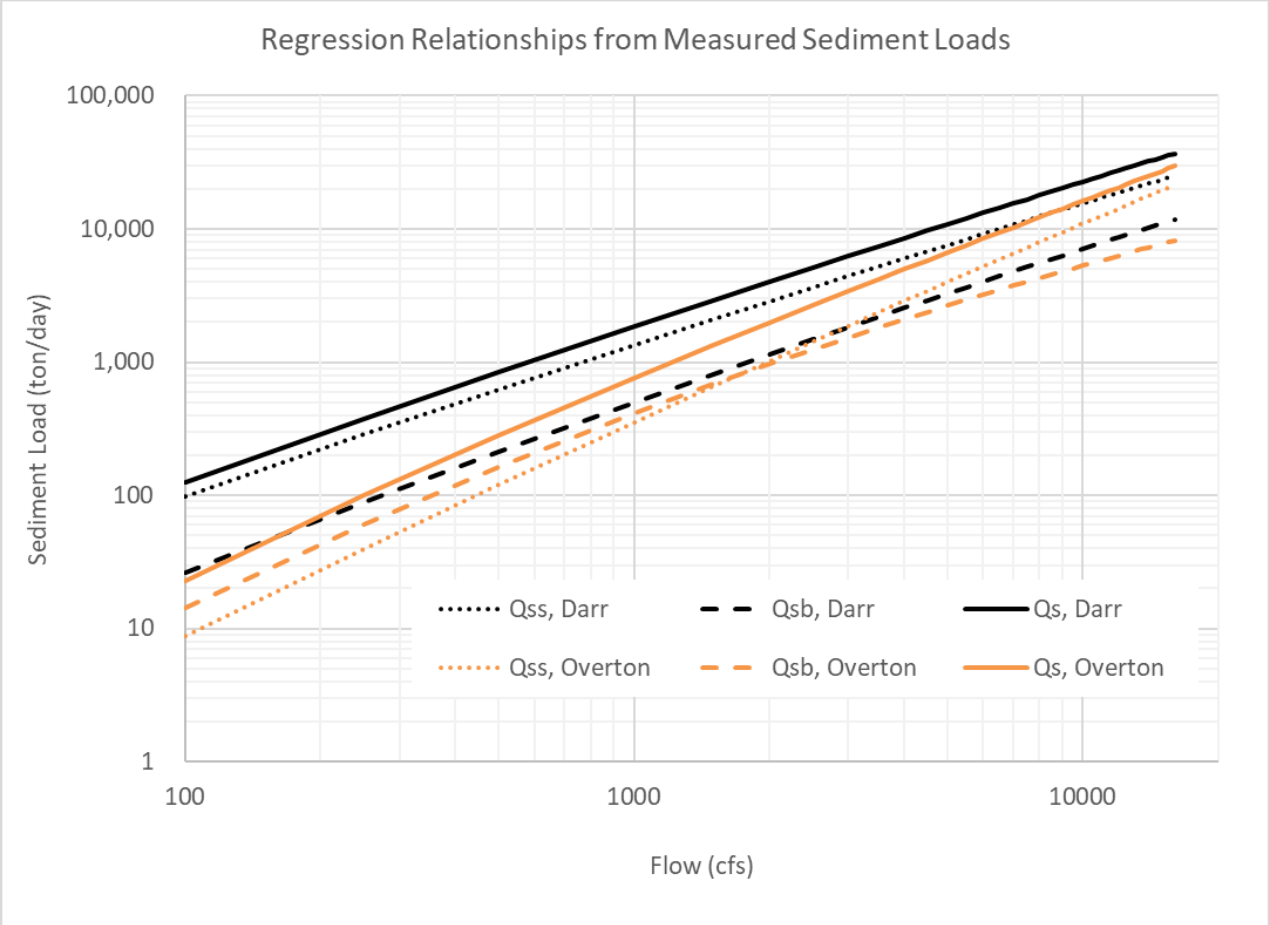

Figure 4-8. Sediment Rating Curves developed by PRRIP (2015).

Table 4-6. Sediment Rating Curves developed by PRRIP (2015).

Daily mean Q (cfs)	Darr			Overton		
	Suspended Sand Sediment, tons/day	Bedload Sediment, tons/day	Total Load, Sand and Gravel, tons/day	Suspended Sand Sediment, tons/day	Bedload Sediment, tons/day	Total Load, Sand and Gravel, tons/day
Q	Q_{ss}	Q_{sb}	Q_s	Q_{ss}	Q_{sb}	Q_s
100	99	26	126	9	14	23
250	286	88	374	39	60	100
500	627	212	840	119	163	282
1000	1,353	499	1,852	353	410	763
1500	2,106	813	2,919	658	681	1,339
2000	2,874	1,144	4,017	1,020	962	1,981
2500	3,650	1,485	5,135	1,428	1,246	2,674
3000	4,433	1,835	6,268	1,877	1,532	3,409
3500	5,220	2,192	7,412	2,362	1,818	4,180
4000	6,010	2,554	8,564	2,880	2,102	4,982
4500	6,803	2,920	9,723	3,427	2,384	5,812
5000	7,597	3,289	10,887	4,003	2,664	6,667
6000	9,189	4,038	13,227	5,229	3,217	8,446
7000	10,784	4,795	15,579	6,547	3,758	10,306
8000	12,380	5,559	17,939	7,947	4,288	12,236
9000	13,976	6,329	20,305	9,422	4,807	14,229
10000	15,571	7,103	22,674	10,966	5,316	16,281
11000	17,166	7,880	25,045	12,573	5,813	18,386
12000	18,758	8,660	27,418	14,239	6,301	20,540
13000	20,349	9,442	29,791	15,961	6,779	22,740
14000	21,938	10,225	32,163	17,736	7,248	24,984
15000	23,525	11,010	34,535	19,561	7,707	27,268
16000	25,110	11,796	36,906	21,433	8,159	29,591

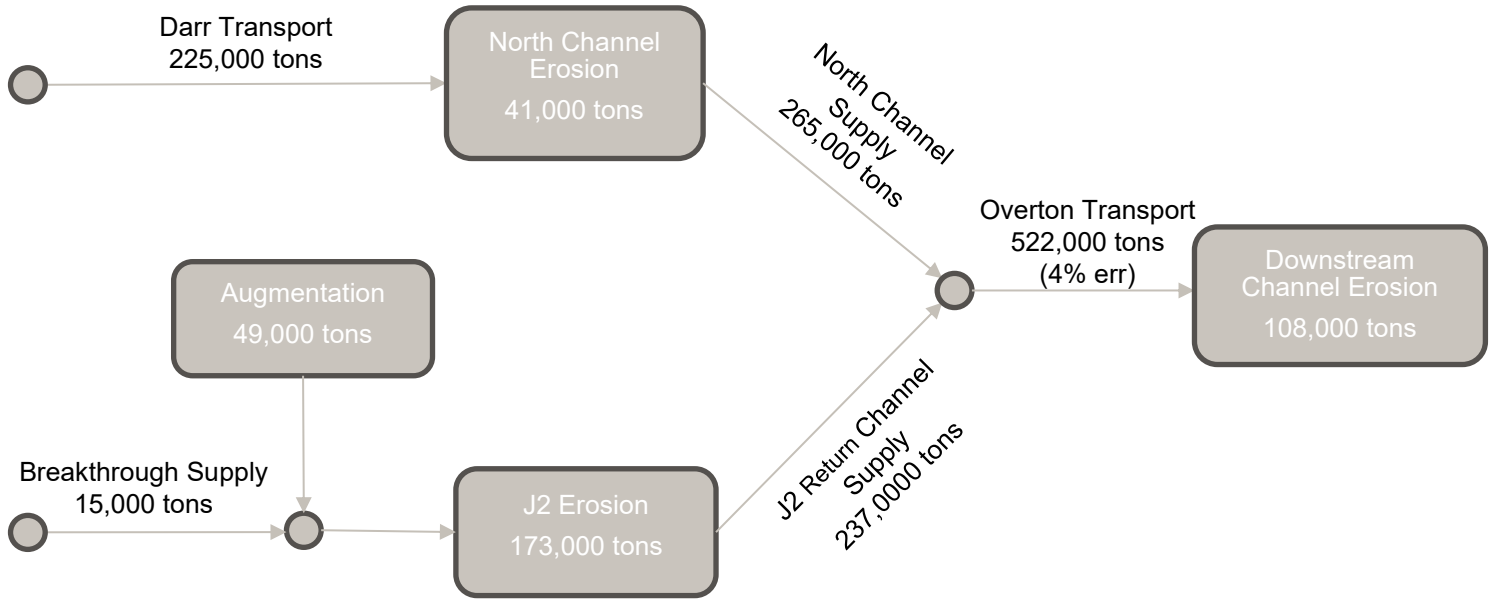

Figure 4-9. Summary of annual average of sediment transport and erosion from WY 2017 through WY 2023.

5 One-Dimensional Model Development

The reconnaissance-level 1D HEC-RAS sediment transport model was developed to model the sediment transport in the Platte River for the North Channel (from approximately Darr, NE to the confluence with the J2 Return Channel), the J2 Return Channel (from the Johnson Power Return to the South Channel of the Platte River to the confluence with the North Channel), and from the confluence of the North and South (J2 Return) Channels to the Kearney Diversion Structure. The model calibration period began on Oct 01, 2016 and run for seven continuous years until Sep 30, 2023. This calibration period includes six years of sediment augmentation within the J2 Return Channel and one year of no augmentation, Water Year (WY) 2023.

The HEC-RAS 1D model was developed to use quasi-unsteady flow series to reflect the hydrologic variability within the calibration period of seven years. The quasi-unsteady model greatly improves model run-time and stability compared to an unsteady model, allowing for a longer analysis period and larger geographical extent. The quasi-unsteady flow model simplifies hydrodynamics, representing a continuous hydrograph as a series of discrete steady flow profiles. HEC-RAS keeps flow constant for each flow record, computing transport throughout the model domain (all reaches) for each flow record duration. The flow record duration is the time over which a discrete steady flow value (in cfs) is held constant. The model calculates discrete transport of sediment at each cross section, including modification of the cross section coordinates to show erosion or deposition. For each flow record duration, the results are extended across the respective reaches to account for reach-wide discrete and cumulative sediment transport.

An example of a quasi-unsteady flow series is given in Figure 5-1. The measured hourly data and quasi-unsteady flow series used in the 1D model for June 22, 2024 to June 24, 2024 is shown in the figure. The 1D model assumes the flow is steady during each 2-hr period, with the flow being calculated based upon the average measured flow during this period. The model represents the changing flow conditions and effects of hydro-peaking on the sediment transport in the J2 Return Channel and Platte River. There is a slight loss of time resolution using the quasi-unsteady approach, but this is considered not significant as the 1D model is primarily being used to generate long term estimates of sediment transport.

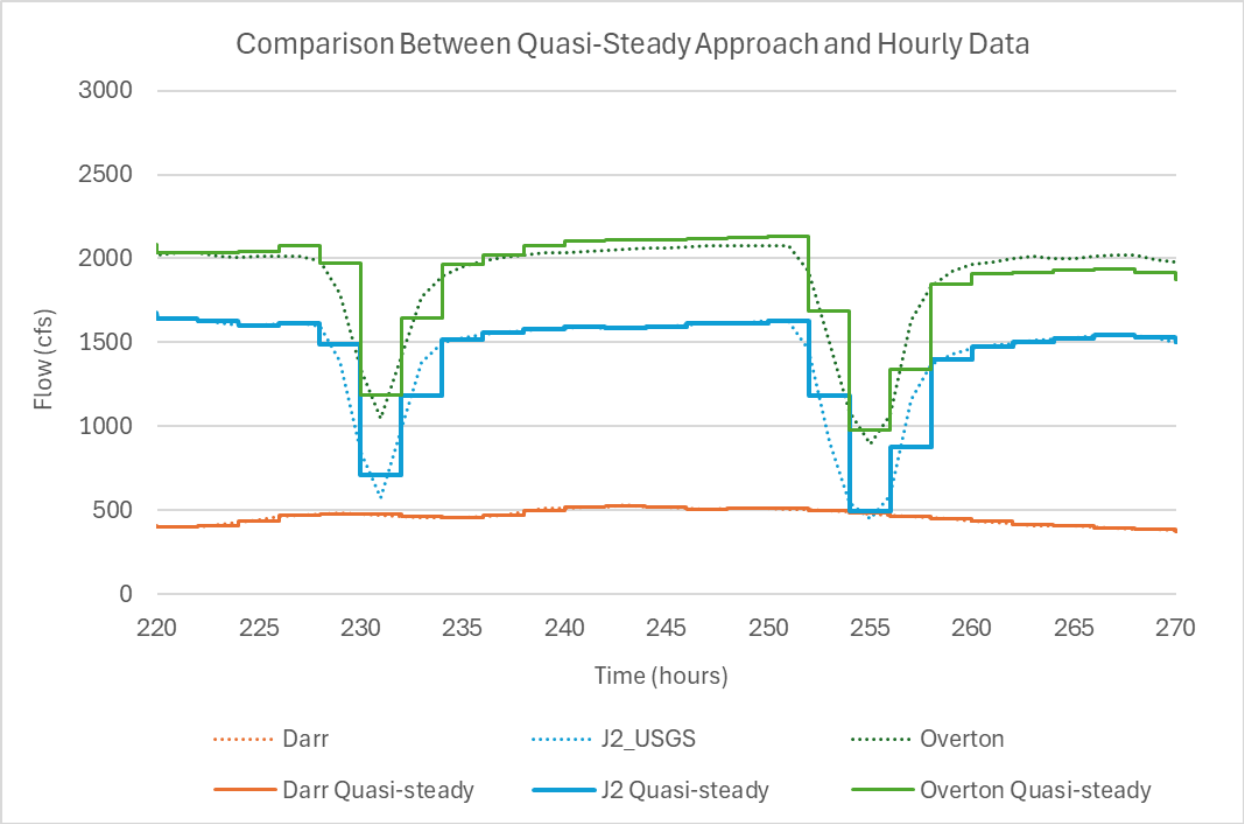

Figure 5-1. Comparison between hourly flow data and quasi-steady flow assumption. June 22, 2024 to June 24, 2024.

5.1 Model Input Data

5.1.1 Hydrology

For the 1D calibration model, the period of analysis (seven years) and the HEC-RAS limitation of number of ordinates (or number of discrete steady flow profiles) of no more than 40,000, required a 2-HR flow duration flow series. Thus, the 1-HR flow records for both the Platte River (North Channel) and J2 Return Channel were used to develop a simple moving average 2-HR flow series for each. The North Channel and J2 Return Channel confluence was modeled as a junction of the two upstream channels, simply adding the two flows for the flowrate applied throughout the Downstream Channel.

5.1.2 River Geometry

The PRRIP provided HEC-RAS model files from a 1D Hydraulic and Sediment Transport Model (HDR, 2011) which contained a steady state model with a developed geometry from Lexington to Chapman. From this geometry, the 1D model domain was developed by first truncating the model cross sections to retain only those above the Kearney Diversion structure at river station 391309. Numerous flow splits were

removed to simplify the 1D sediment transport analysis and increase model stability. This prompted the need to combine contiguous cross section alignments into floodplain spanning, continuous alignments. All cross sections were then updated to the 2016 LiDAR surface and all bank stations and flow obstruction (levee, obstructions, and ineffective flow area) stations were updated. The resulting model geometry was simplified into three reaches: the North Channel extending from the original upstream extent near Lexington down to the junction with J2 Return Channel (river stations 530513.3 to 450433), the J2 Return Channel from the J2 Canal outlet to the junction with the North Channel (river stations 41371.71 to 3655.815), and the Downstream Channel from the J2/North Channel junction to the Kearney diversion structure (river stations 446850 to 391309) Figure 5-2.

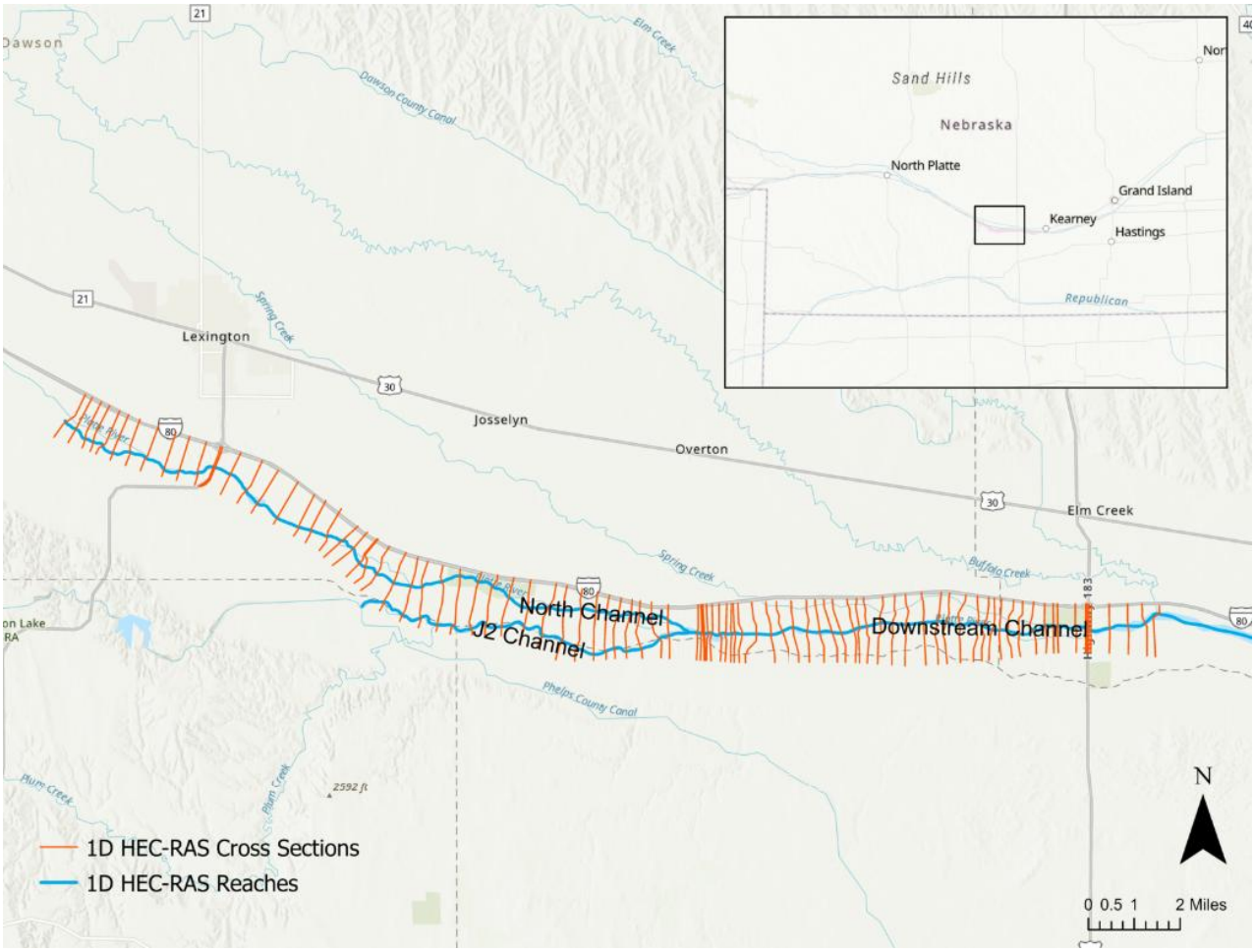

Figure 5-2. HEC-RAS 1D model domain

5.1.3 Riverbed Sediment

The bed sampling data and locations discussed in Section 4.3 were used to define the bed gradation at their respective locations. Between the sampling locations, the 1D model was set up to interpolate the

gradations at each cross section. Additional inputs of the sediment augmentation for years 2017-2022 and the Breakthrough Channel for years 2017-2019 were additionally applied to the J2 Return Channel at river stations 35647.45 and 41371.71, respectively. The augmentation load series and Breakthrough Channel sediment load series were developed by applying the total annual mass (in tons) over an assumed 90-day period beginning 01 Oct. of each year that either augmentation or breakthrough occurred.

5.1.4 Boundary Conditions

Boundary conditions within the 1D model require upstream flow and sediment discharge to be defined, while the downstream boundary condition requires only flow conditions. For the North Channel, the flow condition of Platte River Combined (from the Darr and Cozad stream gages, as described in Section 0) was input as the 2-HR average flow series. The North Channel upstream sediment discharge condition was chosen as equilibrium load, as opposed to a sediment rating curve, as the upstream model extent was sufficiently distant from the area assessed by both the calibration and alternative analyses.

The J2 Return Channel upstream flow boundary condition was the derived J2 flow series discussed in Section 0. The J2 Return Channel upstream sediment discharge boundary condition was set to clear water to reflect the assumed lack of sediment in the J2 return flows which are reflective of the reservoir outflow and stable canal bed (concrete).

The Downstream Channel downstream flow condition used a rating curve that was developed from the expected range of flows using the steady state model provided by PRRIP (HDR, 2011). The upstream flow and sediment discharge conditions of the Downstream Channel are determined by the 1D quasi-unsteady model.

5.1.5 Hydraulic and Sediment Modeling Parameters

Several model parameters are necessary to specify values for the simulations. First, the Transport Parameters in the HEC-RAS Sediment Data need to be specified. A number of transport functions were assessed during calibration, including Engelund-Hansen, Yang, Wilcock-Crowe, and Laursen-Copeland. Engelund-Hansen, Yang, and Laursen-Copeland are all total load transport equations, meaning the transport formula is intended to represent both the suspended and bed load portions of the load, whereas Wilcock-Crowe is a bedload transport equation that computes only the bed load.

Other than the above transport functions, further sediment model parameters were held constant between the different model runs. The active layer approach was used to model bed mixing and the active layer thickness was set to 1 x d90 or a minimum of 0.25 ft. No hiding and exposure functions were used in the sediment transport formulas. The Veneer bed change option was used for the main channel and overbanks. The erosion width (or movable bed limit) was specified at the left and right bank station throughout the model reaches.

The model flow duration was set to 2-HR (see Section 4.1.3) and the computation increment was set to 1-HR. The local energy slope method was used and ten bed exchange iterations per time step was used. The sediment computation multiplier was set to 1.

5.2 Model Calibration

The 1D HEC-RAS model was calibrated to the total computed erosion/deposition presented in Table 4-3 by calculating the difference between sediment entering the reach and sediment leaving the reach, this includes any augmentation or Breakthrough Channel sediment transport. Model calibration included sensitivity analysis to transport functions, the armoring of the upper J2 Return Channel, and variation in channel roughness.

First, the total cumulative sediment erosion/deposition for all reaches (North, J2, and Downstream Channels) were compared to the LiDAR surface differencing between the four different transport functions. Table 5-1 below indicates that Engelund-Hansen (Engelund and Hansen, 1967) most accurately predicts the total cumulative sediment erosion/deposition for all reaches, with large overpredictions from Wilcock-Crowe (Wilcock and Crowe, 2003) and Laursen-Copeland (Copeland and Thomas, 1989), and large underprediction from Yang (Yang, 1979).

Table 5-1. Cumulative Total Reach Sediment Erosion/Deposition results.

Method	Cumulative Total Reach Sediment Erosion/Deposition (tons)	Percent Difference (from LiDAR)
LiDAR	-2,250,980	-
Engelund-Hansen	-2,583,853	15%
Yang	-1,164,824	-48%
Wilcock-Crowe	-4,104,885	82%
Laursen-Copeland	-3,472,890	54%

Next, the role of armoring within the upper J2 Return Channel was assessed for all transport functions. This was done by replacing the sampled gradation at the head of the J2 Return Channel with that discussed in Section 4.1.3. The results are presented below in Table 5-2. This resulted in increased accuracy for all transport functions other than Yang, which further underpredicted total cumulative sediment erosion/deposition. This result identified the Engelund-Hansen transport function as the most representative among those assessed for total cumulative sediment erosion/deposition.

Table 5-2. Cumulative Total Reach Sediment Erosion/Deposition (with armored upper J2 Return Channel) results.

Method	Cumulative Total Reach Sediment Erosion/Deposition with Armored J2 (tons)	Percent Difference (from LiDAR)
LiDAR	-2,250,980	-
Engelund-Hansen	-2,375,258	6%
Yang	-1,073,678	-52%
Wilcock-Crowe	-3,894,245	73%
Laursen-Copeland	-3,319,555	47%

Next, the role of channel roughness (Manning's *n*) was assessed using only the Engelund-Hansen transport function by varying channel roughness of all reaches by +/- 0.07 (from the original value of 0.028). The results are provided below in Table 5-3. The results indicate that a higher channel roughness of 0.035 most accurately represents the total cumulative sediment transport using the Engelund-Hansen formula.

Table 5-3. Cumulative Total Reach Sediment Erosion/Deposition (with armored upper J2 Return Channel) for Engelund-Hansen formula using varying Manning's n values.

Method	Cumulative Total Reach Sediment Erosion/Deposition with Armored J2 (tons)	Percent Difference (from LiDAR)
LiDAR	-2,250,980	-
Engelund-Hansen (*n*=0.021)	-2,664,976	18%
Engelund-Hansen (*n*=0.028)	-2,375,258	6%
Engelund-Hansen (*n*=0.035)	-2,159,952	-4%

The cumulative total reach sediment erosion/deposition results depicted above are only part of the story, and do not illustrate either the spatial (between reaches) or temporal (annual) variation during the calibration process. The following discussion presents the calibration results for the annual cumulative sediment erosion/deposition for the North Channel, J2 Return Channel, and Downstream Channels. For simplicity, the results are limited to the condition of the armored upper J2 Return Channel based on the findings presented in Table 5-2.

The North Channel cumulative annual sediment erosion/deposition is presented with the annual and cumulative LiDAR surface difference (expressed in tons of erosion/deposition sediment) are shown below in Table 5-4 and Figure 5-3 (Wilcock-Crowe was omitted for clarity). The annual LiDAR sediment erosion/deposition is presented as the change from the following year, while all other values are cumulative compared to 2016. After seven years of discharge, the Engelund-Hansen model with n=0.035 shows the closest estimate of the actual cumulative LiDAR sediment erosion/deposition measured and is within 1% (bold values in Table 5-4). Figure 5-3 illustrates the annual variability with no clear trend, and that the North Channel experienced years of both erosion (2017-2018) and deposition (2016-2017). Except for the Yang results for 2022-2023, every method presented estimates annual erosion within the North Channel as evidenced by the sequential increasing negative values in Table 5-4.

Table 5-4. Cumulative Annual North Channel Sediment Erosion/Deposition (with armored upper J2 Return Channel).

North Channel Sediment Transport (tons)								
			Cumulative HEC-RAS 1D Model Transport Function					
Year	Annual LiDAR	Cumulative LiDAR	Engelund-Hansen (n=0.021)	Engelund-Hansen (n=0.028)	Engelund-Hansen (n=0.035)	Yang	Wilcock-Crowe	Laursen-Copeland
2016-2017	118,770	118,770	-92,787	-158,513	-84,014	-14,473	-937,965	-76,427
2017-2018	-267,549	-148,778	-120,159	-179,246	-111,159	-24,962	-1,124,109	-107,214
2018-2019	238,963	90,185	-205,524	-241,683	-156,832	-31,081	-1,426,268	-247,070
2019-2020	-211,652	-121,467	-272,974	-303,593	-205,491	-35,360	-1,683,470	-348,029
2020-2021	254,255	132,787	-295,230	-325,768	-224,475	-45,380	-1,722,051	-413,521
2021-2022	-117,354	15,433	-304,961	-334,439	-232,100	-55,373	-1,761,154	-455,040
2022-2023	-299,138	**-283,704**	-393,166	-399,843	**-285,224**	-41,506	-2,013,585	-626,206

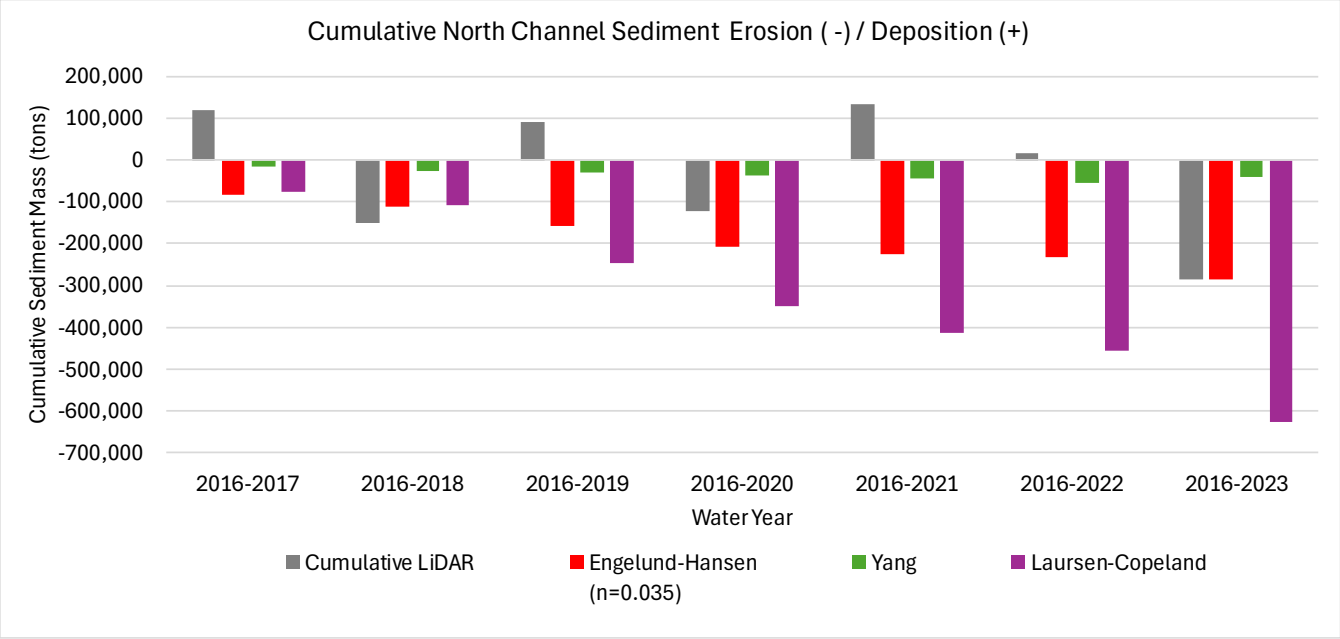

Figure 5-3. Cumulative Annual North Channel Sediment Erosion/Deposition (with armored upper J2 Return Channel).

The J2 Return Channel cumulative annual sediment erosion/deposition is presented similarly below in Table 5-5 and Figure 5-4. After seven years of discharge, the Yang model shows the closest estimate of the actual cumulative LiDAR sediment erosion/deposition measured, underpredicting by 16% (bold values in Table 5-5), while the Engelund-Hansen (n=0.035) overpredicts by 28%. Figure 5-4 shows increasing erosion in both LiDAR and model estimates for all years.

Table 5-5. Cumulative Annual J2 Return Channel Sediment Erosion/Deposition (with armored upper J2 Return Channel).

J2 Sediment Transport (tons)								
			Cumulative HEC-RAS 1D Model Transport Function					
Flow Season	Annual LiDAR	Cumulative LiDAR	Engelund-Hansen (n=0.021)	Engelund-Hansen (n=0.028)	Engelund-Hansen (n=0.035)	Yang	Wilcock-Crowe	Laursen-Copeland
2016-2017	-79,663	-79,663	-428,963	-347,384	-347,382	-258,763	-366,843	-516,145
2016-2018	-358,793	-438,455	-602,542	-488,159	-474,621	-340,240	-549,022	-774,924
2016-2019	-214,515	-652,970	-917,130	-777,092	-747,920	-480,722	-858,377	-1,148,399
2016-2020	-198,466	-851,435	-1,263,270	-1,092,812	-1,064,632	-631,847	-1,320,880	-1,526,678
2016-2021	-94,289	-945,725	-1,474,897	-1,280,720	-1,248,819	-768,912	-1,738,048	-1,778,198
2016-2022	-137,163	-1,082,888	-1,672,805	-1,465,531	-1,429,926	-909,437	-1,988,751	-1,999,446
2016-2023	-130,173	**-1,213,061**	-1,801,713	-1,591,004	-1,555,294	**-1,017,485**	-2,129,994	-2,118,452

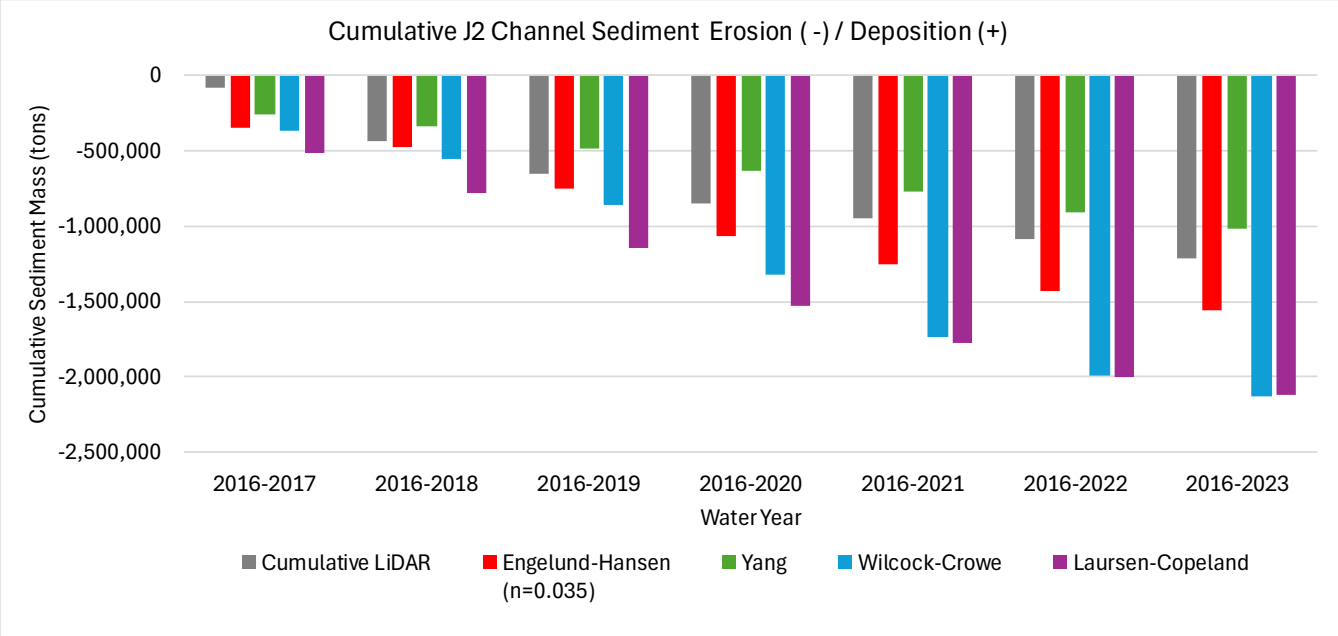

Figure 5-4. Cumulative Annual J2 Return Channel Sediment Erosion/Deposition (with armored upper J2 Return Channel).

The Downstream Channel cumulative annual sediment erosion/deposition is presented below in Table 5-6 and Figure 5-5. Both show a channel that experiences annual erosion and deposition, with an overall trend of erosion (compared to 2016). This is in part mirrored by the Engelund-Hansen, Yang, and Laursen-Copeland functions all showing cumulative erosion in 2023, all underpredicting measured erosion/deposition, with accuracies of 58%, 98%, and 24%, respectively. The Wilcock-Crow function initially indicated deposition with subsequent years showing both erosion and deposition.

Table 5-6. Cumulative Annual Downstream Channel Sediment Transport (with armored upper J2 Return Channel).

Downstream Channel Sediment Transport (tons)								
			Cumulative HEC-RAS 1D Model Transport Function					
Flow Season	**Annual LiDAR**	**Cumulative LiDAR**	**Engelund-Hansen (n=0.021)**	**Engelund-Hansen (n=0.028)**	**Engelund-Hansen (n=0.035)**	**Yang**	**Wilcock-Crowe**	**Laursen-Copeland**
2016-2017	34,826	34,826	-164,822	-132,062	-159,553	-118,489	315,169	-273,744
2016-2018	-433,518	-398,692	-230,810	-190,805	-194,412	-75,306	222,497	-352,358
2016-2019	166,656	-232,036	-388,489	-319,862	-301,796	-109,600	67,511	-508,880
2016-2020	-349,584	-581,620	-572,783	-490,113	-447,888	-173,822	-11,796	-727,174
2016-2021	236,244	-345,376	-578,168	-484,609	-427,892	-117,521	74,685	-707,015
2016-2022	-147,732	-493,109	-589,726	-484,041	-415,289	-81,503	49,159	-699,419
2016-2023	-261,168	**-754,276**	-470,098	-384,411	-319,434	-14,687	249,335	**-574,897**

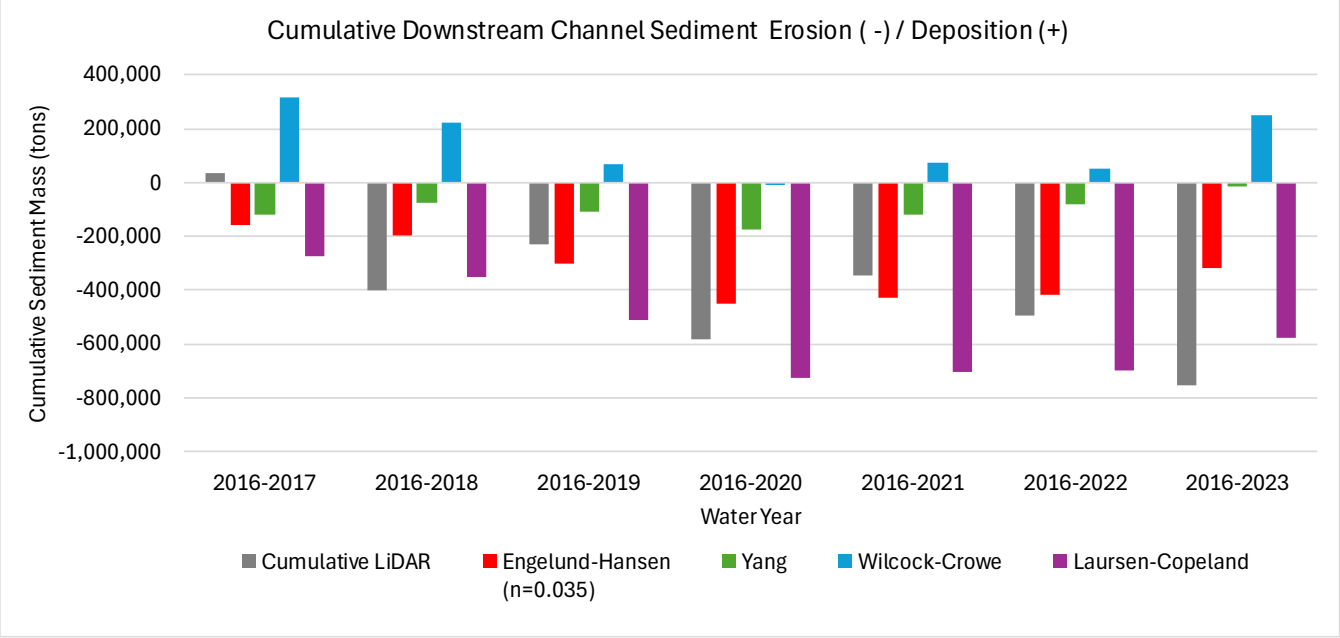

Figure 5-5. Cumulative Annual Downstream Channel Sediment Erosion/Deposition (with armored upper J2 Return Channel).

Overall, the 1D HEC-RAS model calibration showed that interannual variability (when a switch between erosion or deposition) in the measured surface is poorly predicted by all model functions, but the overall trend of erosion in each reach is predicted. Wilcock-Crowe showed poor total reach accuracy, greatly over-estimating erosion in the North and J2 Return Channels, and under-estimating erosion in the Downstream Channel to the point of predicting deposition. Laursen-Copeland similarly over-estimated erosion in the North and J2 Return Channels, while most accurately estimating the Downstream erosion. Yang consistently under-estimated erosion in the North and Downstream Channels, while best estimating erosion in the J2 Return Channel. Engelund-Hansen, with a channel roughness value of 0.035 was the best overall estimator for the total reach sediment erosion/deposition (see Table 5-1 through Table 5-3), was the best estimate of erosion in the North Channel, second best estimate of erosion in the J2 Return Channel, and was at least consistent in estimating overall erosion in the Downstream Channel. From the above, the Engelund-Hansen transport function, with a channel roughness of 0.035, was chosen as the model function to best predict the possible response during the 1D HEC-RAS Alternative Analysis.

The predicted bed change elevation at the end of the calibration period for the Engelund-Hansen function is presented in Figure 5-6. This figure shows the chosen model function generally over-estimated channel bed elevation for all but the lower downstream channel, illustrating the role of calibrating the model parameters to the mass balance derived from the annual LiDAR differencing, not the resultant channel elevation. This is further illustrated in a cross section within the J2 Return Channel (Figure 5-7). The HEC-RAS 1D model limits erosion to points within the Moveable Bed Limits which does not allow for the bank migration shown in the 2023 LiDAR. A cross section from a more stable reach of the Platte River below the Overton Bridge (Figure 5-8) similarly shows erosion in the main channel (between the movable bed limits) where no notable bank migration occurred between 2016 and 2023.

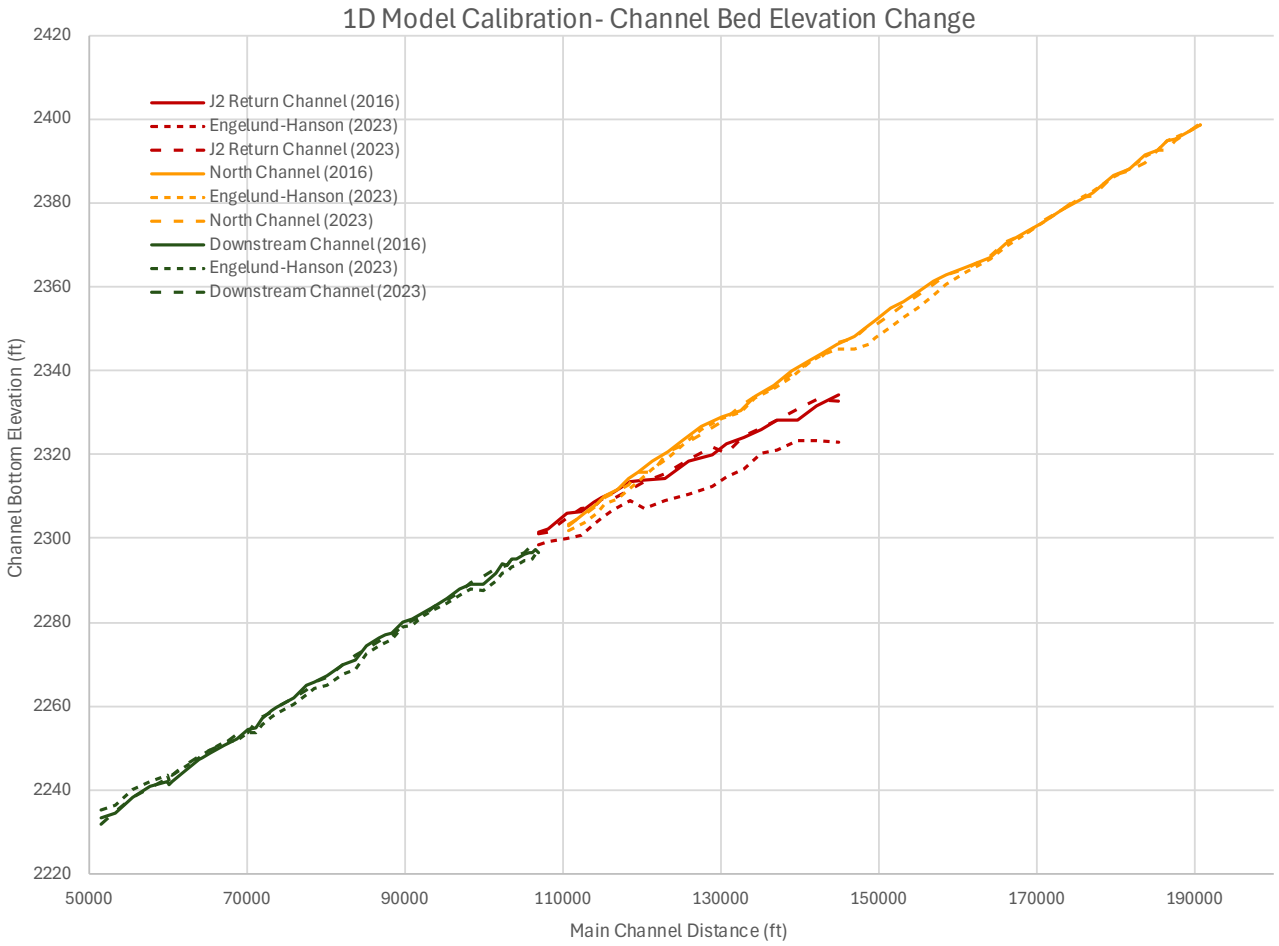

Figure 5-6. Predicted bed elevation change at the end of the calibration period for the Engelund-Hansen function with a bed roughness of 0.035 for each reach in comparison to measured channel bed elevations from LiDAR values at the start (2016) and end (2023) of the calibration period.

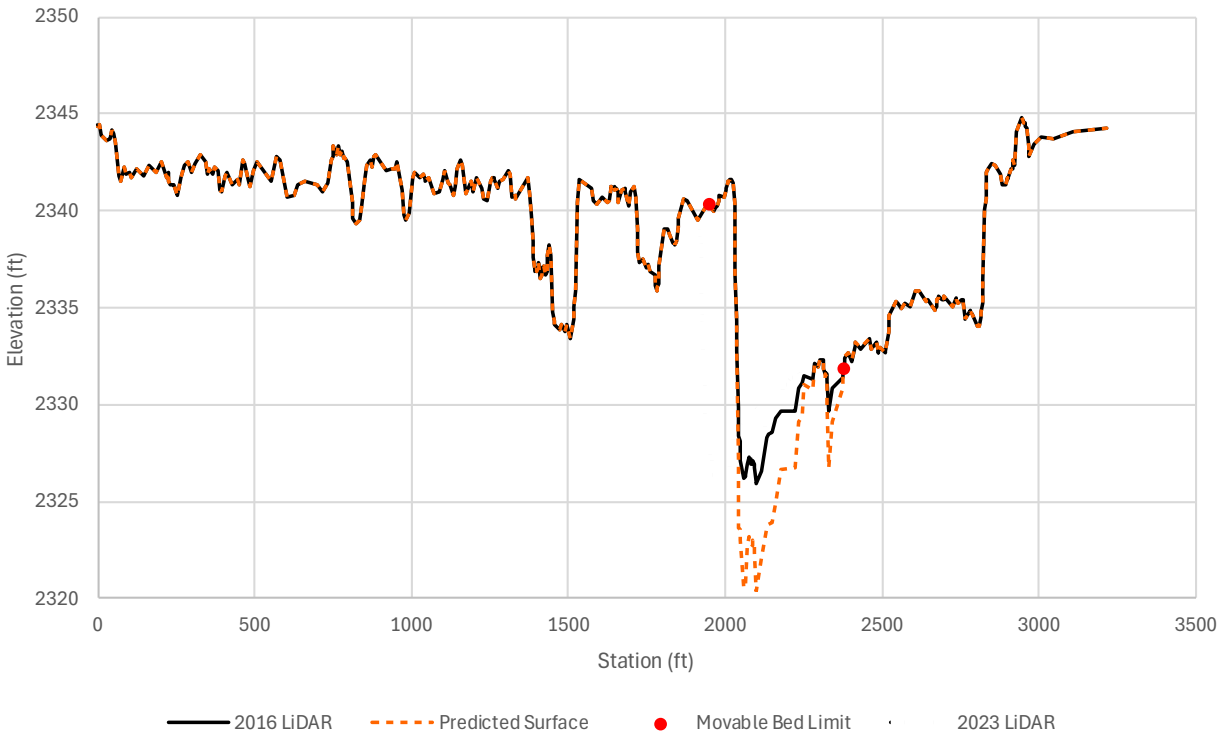

Figure 5-7. Predicted bed elevation change at the end of the calibration period for the Engelund-Hanson function with a bed roughness of 0.035 for a cross section within the J2 Return Channel in comparison to measured channel bed elevations from LiDAR values at the start (2016) and end (2023) of the calibration period.

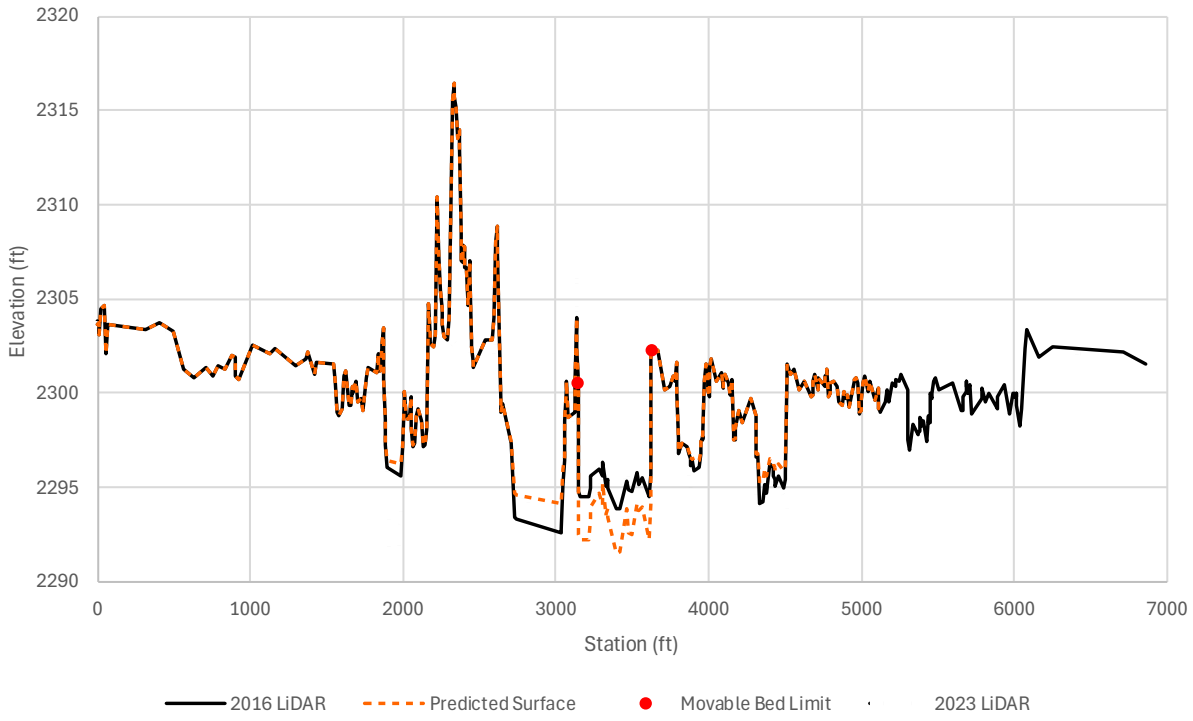

Figure 5-8. Predicted bed elevation change at the end of the calibration period for the Engelund-Hanson function with a bed roughness of 0.035 for a cross section below the Overton Bridge in comparison to measured channel bed elevations from LiDAR values at the start (2016) and end (2023) of the calibration period.

Based upon the calibration, the 1D model overestimates erosion in the J2 Return Channel by approximately 28% and underestimates erosion in the Downstream Channel by approximately 50%. The error in the downstream reach is partially due to the overestimation of erosion in the J2 Return Channel because more sediment is simulated to be introduced into the downstream reach than what occurred. The error in the model will be partially mitigated by comparing all alternatives to the No Action alternative. Therefore, the more important values will be the results in comparison to the No Action rather than the absolute value of the results.

The 1D was successful at replicating the erosion and depositional volumes in the river but is limited in predicting the bank erosion and increasing in river meandering in the J2 Return Channel that is occurring (PRRIP, 2024). Based upon the analysis of PRRIP (2024) the majority of the erosion occurring in the J2 Return Channel is occurring through lateral erosion processes. The 1D and 2D models are not currently configured to simulate this lateral process directly, but the models are able to simulate the volume of erosion and deposition. Therefore, the primary metrics of alternative assessment will be erosion and deposition amounts rather than the channel elevations or lateral bank changes.

6 Two-Dimensional Model Development

Two-dimensional (2D) modeling evaluations were performed in HEC-RAS v 6.6 for a variety of existing and alternative configurations. Descriptions of the model development, extents, boundary conditions, numerical parameters and assumptions, and calibrations are provided below.

6.1 Model terrain

Goals of the 2D modeling included calibration to a known bed-change event and the simulation of proposed alternative actions. For the calibration scenario, the 2017 water year (October 1, 2016 – September 30, 2017) was identified with a focus on the Breakthrough Channel. The hydrology data from that period is provided in Section 5.1.1. Spring 2017 flows resulted in a notable erosion signal in the Breakthrough Channel as evidenced in the comparison between the 2016 and 2017 LiDAR data (Figure 6-1). Following these events, a weir was constructed across the Breakthrough Channel entrance which limited flow capture, which is present in the 2018 LiDAR data. Alternatives evaluated with the 2D modeling promote a response similar to the changes in the Breakthrough Channel where sourcing of floodplain sediment materials through erosional and incision processes are desired. Therefore, the 2016 and 2017 LiDAR data served as the basis for the calibration runs. Model calibrations are described in sections below.

Additional goals of the 2D model included evaluation of alternatives with the most current LiDAR data. At the time of this analysis, the 2023 LiDAR data was the most current representation of the terrain and bathymetry available and was used for alternatives analysis.

6.2 Fixed-bed Simulations

Sediment simulations can require intensive time and computational resources for large simulation domains and long-term durations. To reduce computational time, 2D models were developed with a hybrid approach using larger model domains simulated under fixed-bed conditions to ascertain flow distributions and boundary conditions which were then transferred to reduced-scale mobile-bed simulation domains for calibration and alternative evaluations. Simulations were performed on the 2016 and 2023 LiDAR dataset. Flow within the fixed-bed models was increased in a continuous eight-day simulation from base flow up to the 500-year flood discharge. Flood values used herein are reported in the Flood Insurance Study (FIS) for the area (FIS 31047CV000A) (FEMA, 2011), see Table 6-1. Flows were introduced at an upstream boundary at US-283. Downstream boundary conditions were established from a rating curve developed from the Overton (USGS) streamgage applied at Overton Bridge. Fixed-bed simulations were performed with equivalent applicable numerical parameters and grid sizing as calibration runs described in sections below. Representative flow conditions at approximately the 50-year return flood are provided with boundary condition locations in Figure 6-2. Data extracted at the illustrated outflow boundaries was incorporated into mobile-bed simulations as rating curves. Inflow boundaries were input as flow hydrographs following split distributions observed at various flow rates in the North Channel and Breakthrough Channel, where necessary. J2 Return flows were directly simulated.

Table 6-1. Flood Frequency of the Platte River at Lexington, NE from FEMA (2011).

Return Period (yr)	Flow at Lexington on Platte River (cfs)
10	11,000
50	25,000
100	34,000
500	53,000

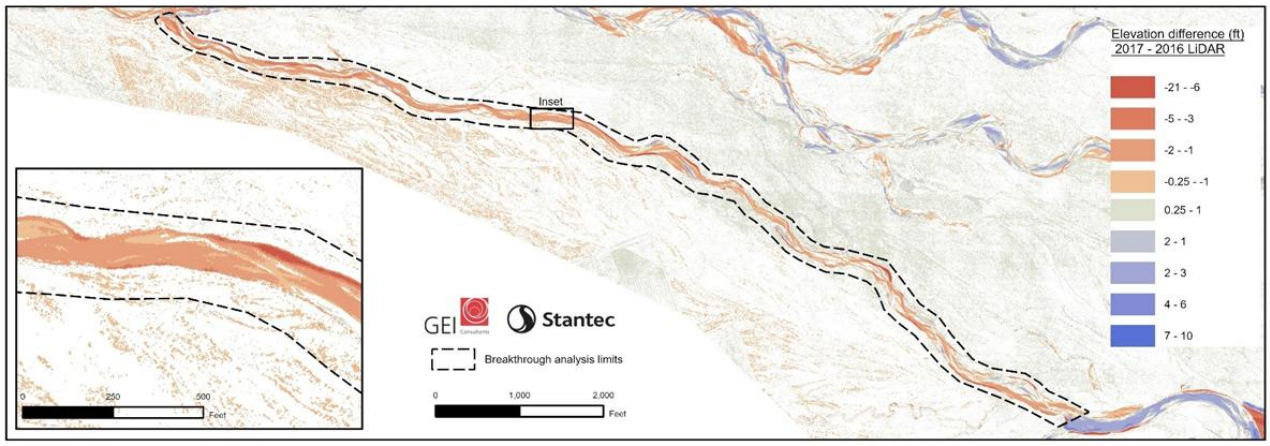

Figure 6-1. 2017 to 2016 LiDAR difference with Breakthrough Channel analysis limits

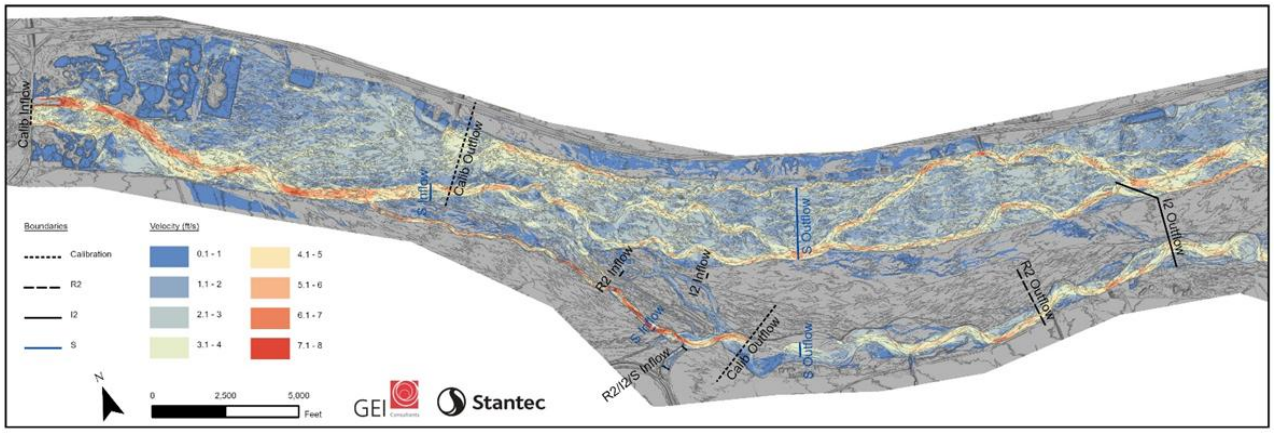

Figure 6-2. Fixed-bed simulation representative results with proposed alternative boundary conditions: 2023 LiDAR at approximately 50-year flood (25,000 cfs)

6.3 Hydrology

Mobile-bed 2D simulations focused on the 2017 water year hydrograph at an hourly time step as described in above sections with some modifications. Hourly flows below 100 cfs entering the North Channel were extracted from the flow hydrograph to condense the simulation duration to the most active sediment transport. The timing of the J2 Return flows were modified to accommodate the removed North Channel Flows. Figure 6-3 provides the 2017 flow hydrograph for the various alternatives evaluated with Breakthrough Channel splits determined from the 2023 terrain analysis.

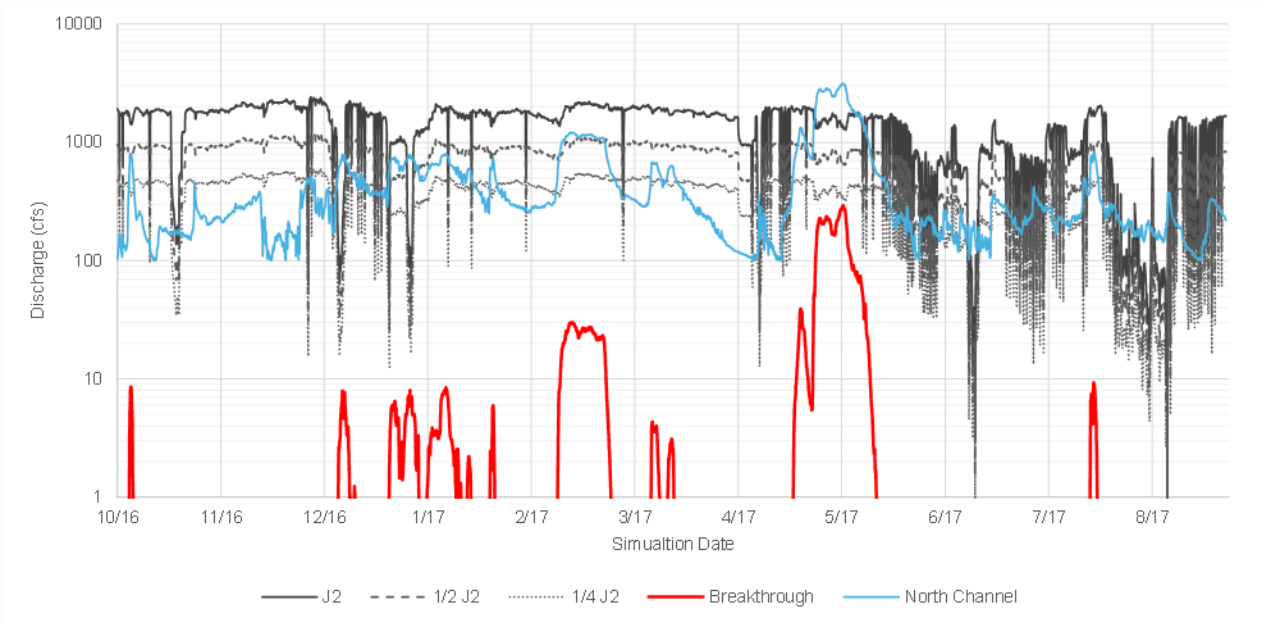

Figure 6-3. Flow hydrographs for 2D model alternatives

6.4 Modeling Settings

HEC-RAS has a multitude of flow- and sediment-specific parameters which can be adjusted by the user and which change simulation run times, numerical stability, and model results. Of these parameters, some were applicable to all 2D project modeling efforts regardless of calibration. Described below are modeling parameters and routines for the Platte River application. Where not specified, HEC-RAS defaults were used.

6.4.1 Flow and Simulation Domain

Models were simulated using an explicit SWM-ELM advection scheme and a FGMRES-SOR pressure scheme. Manning's *n* roughness was set at 0.03 uniformly across the simulation domain. Grid sizing was established with cells within focal areas on the order of 15-ft (approximately 10 cells per top width of Breakthrough Channel and Sand Dam Channel) expanding to 30-ft in areas of reduced interest based on simulation goals. Sediment models targeted total cells below 75,000 for computational efficiencies. Time

steps were established to find tractable run times without introducing modeling instabilities. Minimum time steps ranged from 3.75 seconds to 7.5 seconds. Overall simulation times for mobile-bed models generally ranged from 10 – 25 days depending on time step and model size evaluated on a dedicated 16-core modeling computer.

6.4.2 Sediment

Sediment modeling parameters included a FGMRES-SOR matrix solver, computational layer maximum thickness of 6 ft, sediment computational multiplier of two-times the hydraulic time step, total load correction with Van Rijn-Wu bed-load factor and exponential concentration suspended-load correction, and a weighted total load adaptation coefficient with a constant 30-ft bed-load length and Zhou and Lin suspended coefficient. Active-layer sorting methods were used with a Soulsby fall velocity method. Sediment grain-size distributions followed the values of sample location 38 (Figure 4-2) limited to coarse sand fractions and above to improve model stability.

The upstream sediment load boundary condition was assigned as an equilibrium sediment loading. This allows the 2D model to predict the incoming bed-material sediment load based upon the computed hydraulics at the upstream location and the measured bed material. Another option would be to use the estimated sediment load rating curves presented in Section 4.5. The sediment load rating curves were not used in the simulation because the suspended load did not have the gradation of the sand size material. In addition, based upon the previous LiDAR assessment, there is no long-term erosion or deposition occurring in the North Channel appears to be in a sediment balance.

6.5 Calibration

The calibration dataset used for the 2D model included the 2017 water year hydrograph introduced to the simulation domain to approximate observed channel incision and erosion. Figure 6-1 illustrates LiDAR differencing of the Breakthrough Channel. Total volume calculated within the limits of analysis was 75,693 cubic yards (CY) which translates to 99,200 tons at a 1.31 ton/CY conversion. The dates of LiDAR data collection roughly corresponded to the 2017 water year. Model parameters were investigated for calibration which primarily included the sediment transport method and active layer thickness. Multiple shakedown runs and calibration iterations were performed using hydrology selections from the complete 2017 hydrograph including a 500 cfs threshold spring 2017 subset, an ice-affected flow series, and the 100 cfs threshold series described above. Table 6-2 provides descriptions and results for select calibration examinations. Erosional volumes were calculated by raster differencing initial and final conditions at a 3-ft grid size. Results indicated that both Engelund-Hansen and Yang transport methods under predicted observed sediment production. Wilcock-Crowe produced the greatest sediment generation of the methods examined and most closely matched the calibration condition; however, only represented 54% of the total volume mobilized from the LiDAR differencing when evaluated over the 2017 water year. Flux comparisons (e.g., sediment produced as tracked through reference monitors) indicated a mobilized volume of 83,700 tons, which represented 84% of the 2017 LiDAR differenced mass. From these results, it was determined that Wilcock-Crowe with an active layer thickness of 0.5 ft was the best calibration combination of model parameters examined and was selected to simulate comparative alternatives.

Table 6-2. Calibration runs and volume differences

Trial	Method	Active Layer Thickness (ft)	Hydrology	Volume Difference (CY)
1	Engelund-Hansen	0.2	> 500 cfs, spring	31,275
2	Wilcock Crowe	1	> 500 cfs, spring	59,439
3	Engelund-Hansen	1	> 500 cfs, spring	46,412
4	Wilcock-Crowe	0.5	> 100 cfs, ice affected	58,957
5	Yang	0.5	> 100 cfs, ice affected	30,806
6	Yang	1	> 100 cfs, ice affected	38,470
7	Wilcock-Crowe	0.5	> 100 cfs	60,779
Baseline	LiDAR Differencing	-	-	75,693

Figure 6-4 illustrates the planform bed change from the sediment transport model calibration and Figure 6-5 provides a profile of the 2016 and 2017 LiDAR and final model conditions. Figure 6-6 and Figure 6-7 provide sectional results from Section A (STA 7300) and Section B (STA 10000), respectively. In general, the 2D simulation captured incision trends observed in the Breakthrough Channel. The model trends towards vertical incision rather than lateral expansion, resulting in a deeper and narrower channel in the simulation results than compared to that observed in the LiDAR data. Avalanching parameter adjustments in HEC-RAS did not significantly affect these outcomes. Increased sediment through bank erosion and widening is a physically observed process within the project area not accounted for in the 2D model.

The transport formula that resulted in the best calibration is different between the 2D and 1D models. The primary reason that the calibration resulted in different formulas is that the 2D model results in channel narrowing and does not simulate bank erosion. The 1D model also cannot simulate bank erosion, but the model does not result in channel narrowing because the model erodes the entire wetting portion of the channel uniformly.

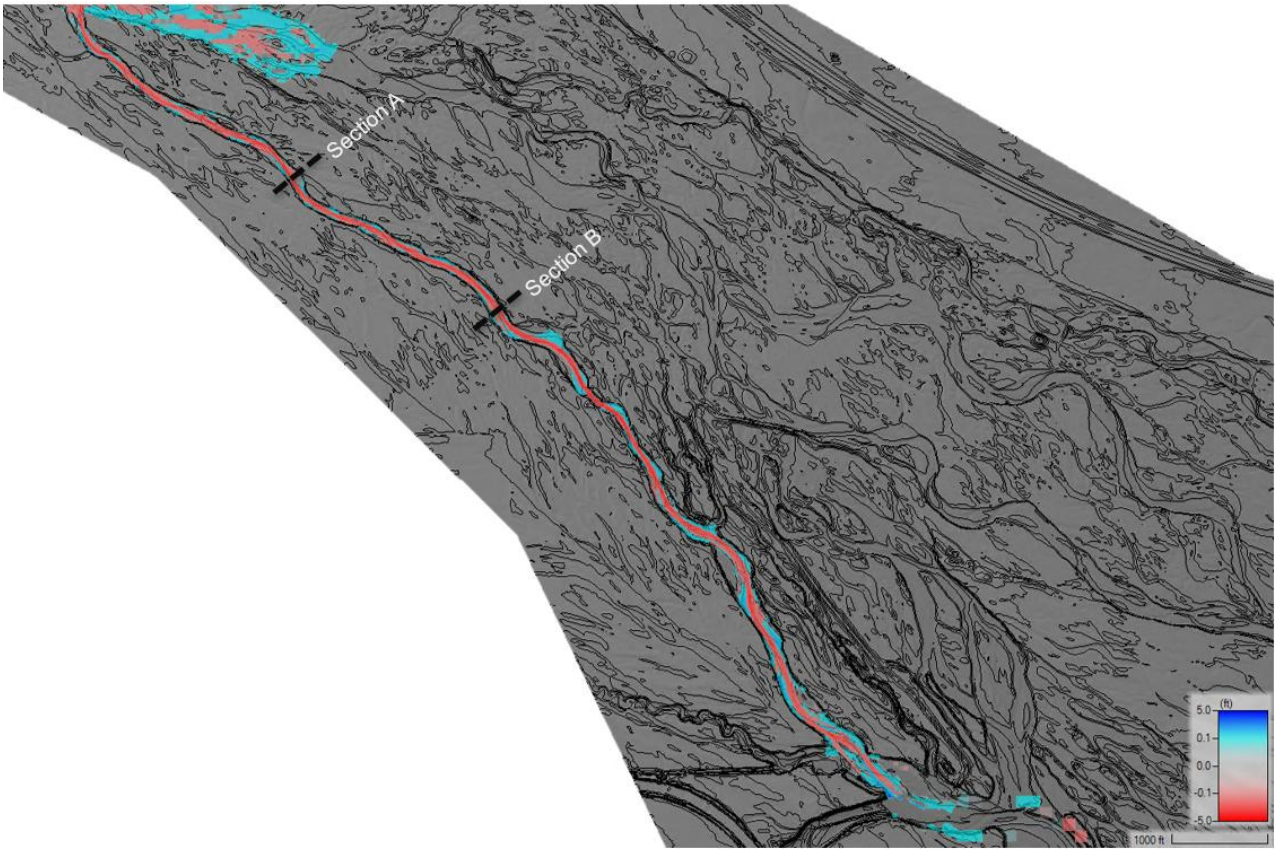

Figure 6-4. Bed change distribution for 2017 calibration

Figure 6-5. 2016 and 2017 LiDAR surface and 2017 calibration - Breakthrough Channel profile

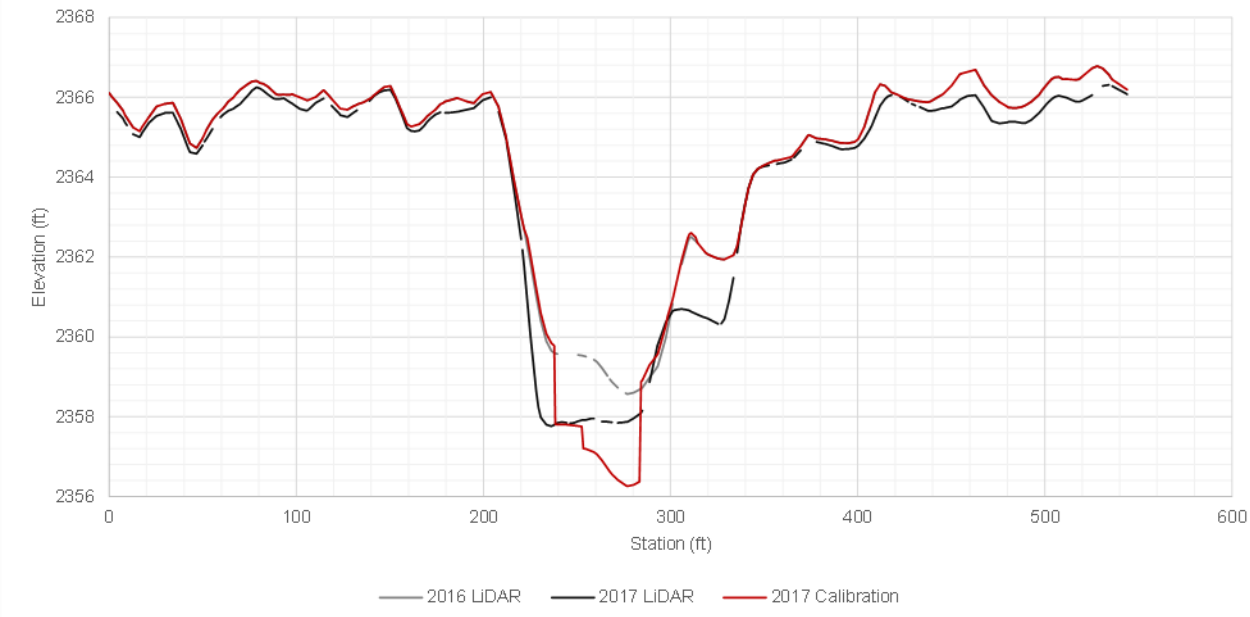

Figure 6-6. Section A LiDAR difference and calibration results

Figure 6-7. Section B LiDAR difference and calibration results

7 Simulation of Alternatives

As discussed in the approach overview, the general strategy was to use the 1D model to simulate the entire project domain over a simulation period of at least 10 years. The 2D model was used to supplement the 1D results to describe the complex response in areas where the erosion could be in multiple channels and where flow is introduced into locations not currently being exposed to riverine flows. The simulation period of the 2D models was typically 1 year. In cases where the models overlap, the more optimistic result is used. The reason for analyzing the alternatives in this way is that this is a Reconnaissance study where the goal is to identify alternatives that could potentially meet PRRIP objectives. If an alternative is found to meet these objectives, then additional analysis of the alternative could be conducted to refine it.

These models are appropriate tools for this type of analysis but are simplifications of complex physical processes. For example, both models are limited in their ability to simulate bank erosion and river meandering that begins after the river incises. This means that the models may overestimate the amount of vertical erosion and underestimate the amount of horizontal erosion (i.e. bank erosion). The current 1D and 2D models do not have the capability to simulate the river meandering process and the bank erosion that will occur. This model limitation is the main reason why the calibration and predictions were focused primarily on simulating total volumes of sediment and not the specific source of that sediment. The models are considered sufficiently accurate in their prediction of total sediment transport rates and sediment volumes. They are less reliable in predicting bed elevations and bank erosion. However, the conclusions in this report do not explicitly rely upon the prediction of bed elevation or bank erosions and therefore, this limitation is important to note but does not invalidate the conclusions in this report.

Because some of the 2D simulation results are used in the 1D analysis, the 2D results will be discussed first.

7.1 2D Simulations

Alternatives simulated in the 2D model were similar to that of the calibration condition of the Breakthrough Channel. Flow entering the Sand Dam Channel (S and R alternatives) and Jeffrey's Island (I alternatives) was assumed to first channelize and then incise as erosion of the in-situ substrates occurred. Models were conducted using the 2017 water year hydrograph, model settings, and calibration parameters described above. As with the calibration exercise, the results of the simulated alternatives overestimate incision and underestimate lateral erosion and widening.

7.1.1 Description of Scenarios Analyzed

The 2D model was used to simulate alternatives S1, S2, R2, and I2. Multiple configurations of each alternative were evaluated in some cases. Table 7-1 details the overall 2D test matrix with simulation descriptions.

Table 7-1. 2D simulation matrix

Alternative	Alternative Description	Simulation	Description
R2	Sand Dam Channel activation from J2 conveyance channel	R2A	1/2 J2 Flow at Location A
		R2B	1/2 J2 Flow at Location B
		R2B2	Added obstruction for forced avulsion
		R2B3	Added obstruction for forced avulsion
S	Sand Dam Channel activation from North Channel	S1	Removed Sand Dam
		S2	Modified Fixed Weir
I2	Jeffrey's Island activation from J2 conveyance channel	I2	1/4 J2 Flow
		I2B	1/2 J2 Flow

7.1.2 2D Results

Results from the 2D models are summarized by the planform bed change, profiles and differences, and total load transport rate as produced by each evaluated alternative over the period of simulation. Transport rates were either determined directly from reference lines established within the simulation, or through numerical integration of total load over the active channel width. The integration approach was necessary when certain simulations were terminated prior to completion or HEC-RAS encountered data write errors. The methods produce equivalent results; however, where integration was necessary, model data writes were at a one-day time step instead of hourly.

7.1.2.1 R2A

This simulation analyzes Alternative R2 (diversion of J2 Flow into the Sand Dam Channel, see Section 3). It was assumed that only ½ of the J2 flow is diverted into the Sand Dam Channel. This assumption was made as a first estimate of balancing the costs of construction with erosion effectiveness.

R2A delivered ½ of the J2 clear water flow to a preexisting channel location on the right side of the Sand Dam Channel downstream of the existing Sand Dam. Full J2 flow diverted to R2A resulted in model instabilities and uncontrollable erosion and depositional patterns. Figure 7-1 illustrates bed change through the Sand Dam Channel at the end of the simulation. Channel erosion occurred within three branches of the Sand Dam Channel before rejoining at a singular outlet to the J2 Return Channel. Figure 7-2 provides a profile of one eroded channel for the alternative, where deposition is noted in the downstream extents. Figure 7-3 details the total load production with a decrease noted over time. Approximately 90% of the sediment delivered occurred by four months into the year-long simulation. A total of 80,300 tons were calculated to be produced from erosion during the R2A simulation.

The erosion in the Sand Dam Channel is predicted to occur relatively quickly as the flow erodes into the channel vertically. The model does not erode laterally and therefore likely underestimates the erosion over the long term. The vertical erosion in the Sand Dam Channel is limited to approximately 10 ft because that is the head differential between the upstream elevation in the Sand Dam Channel and the elevations in the J2 Return Channel. The elevations in the J2 Return Channel also increase during the simulation due to the deposition in the J2 Return Channel.

As will be shown in the next section, the 1D model predicted significantly more erosion in the Sand Dam channel than the 2D model for both the R2 and S2 Alternatives. As this is a Reconnaissance study, the

larger prediction of erosion is used to assess the R2 Alternative. If the alternative does not perform well given the larger prediction of erosion, it will only perform worse with the lower estimate. If this alternative performs sufficiently well given the high estimate of erosion, then additional simulations could be performed in future studies to refine the estimate.

Despite the fact the 2D simulation of R2 was not directly used in the quantitative analysis, the simulation was useful to understand the potential erosion and deposition patterns that could form. In particular, it is useful to understand the potential channel grading activities required to redirect flow and erode the Sand Dam Channel.

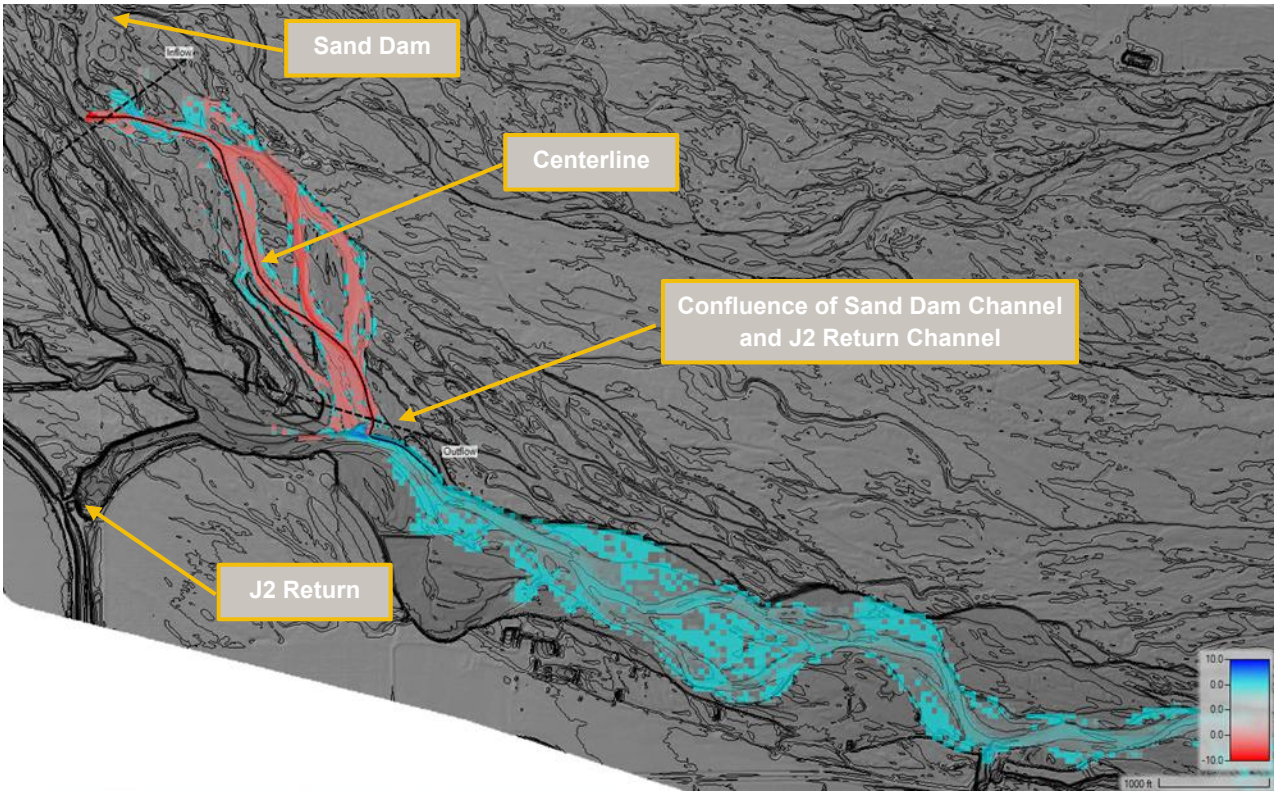

Figure 7-1. R2A bed change distribution

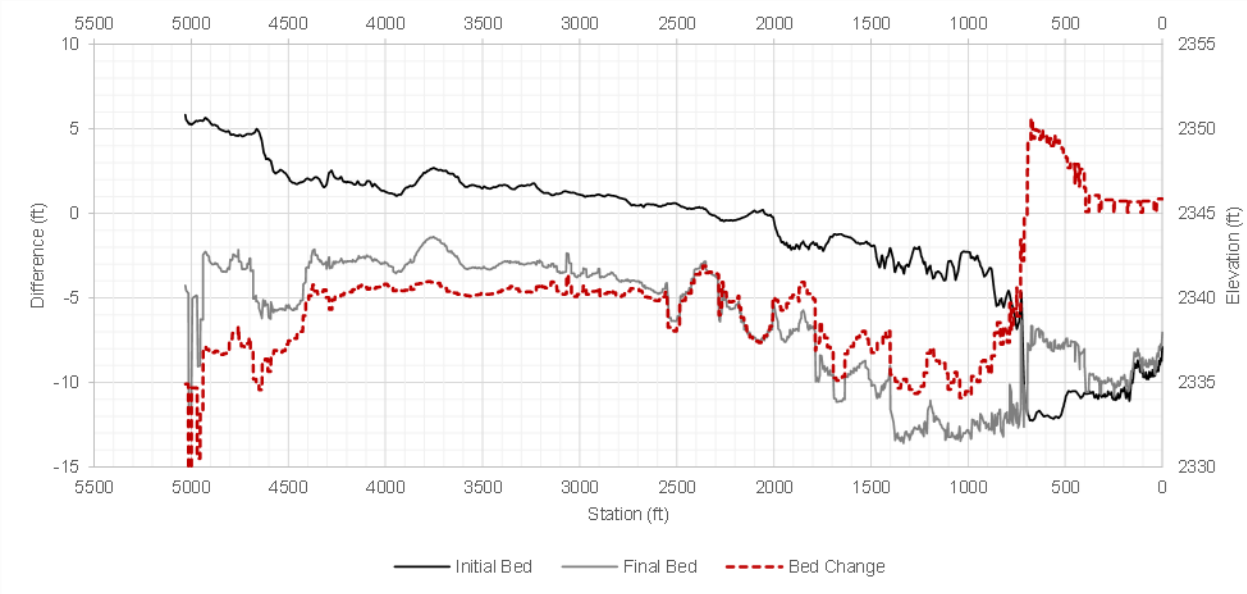

Figure 7-2. R2A bed change profile along defined centerline. Stationing downstream (STA 0+00) to upstream

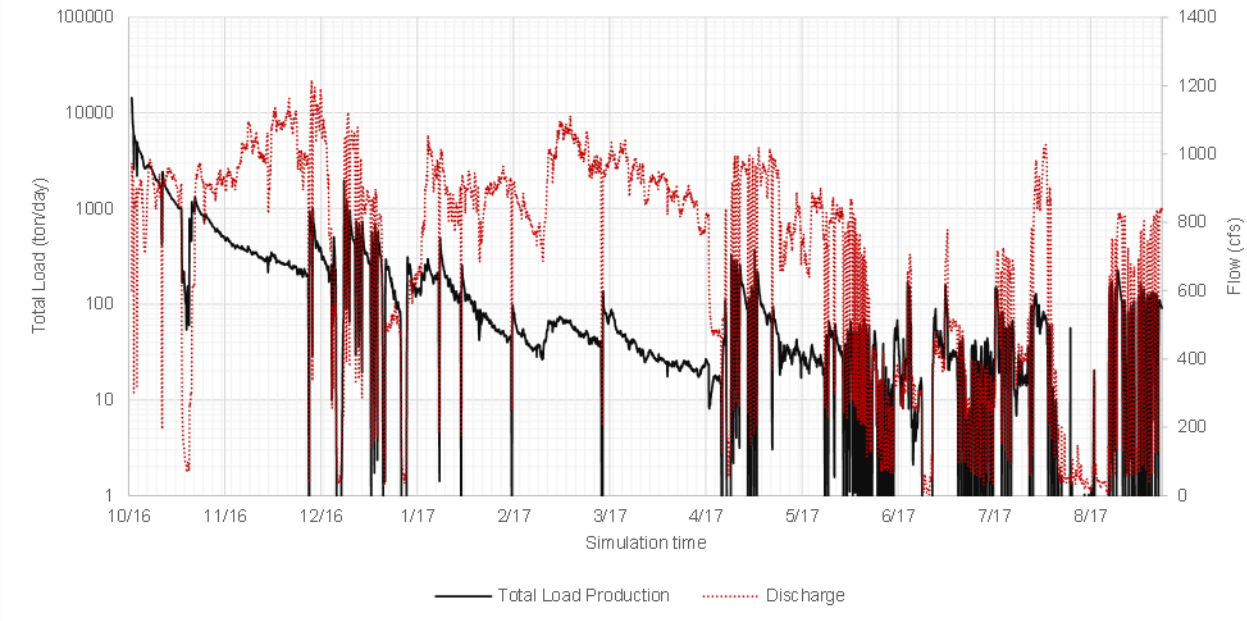

Figure 7-3. R2A total load production.

7.1.2.2 R2B

R2B delivered ½ of the J2 clear water flow to a preexisting channel location on the left side of the Sand Dam Channel downstream of the existing Sand Dam. Full J2 flow diverted to R2B resulted in model instabilities and uncontrollable erosion and depositional patterns. Figure 7-4 illustrates bed change through the Sand Dam Channel at the end of the simulation. Channel erosion occurred within three branches of the Sand Dam Channel before rejoining at a singular outlet to the J2 Return Channel. Figure 7-5 provides a profile of one eroded channel for the alternative, where deposition is noted in the downstream extents. Figure 7-6 details the total load production with a decrease noted over time. Approximately 80% of the sediment delivered to the J2 Return Channel occurred by four months into the year-long simulation. A total of 41,200 tons were calculated to be produced from erosion during the R2B simulation.

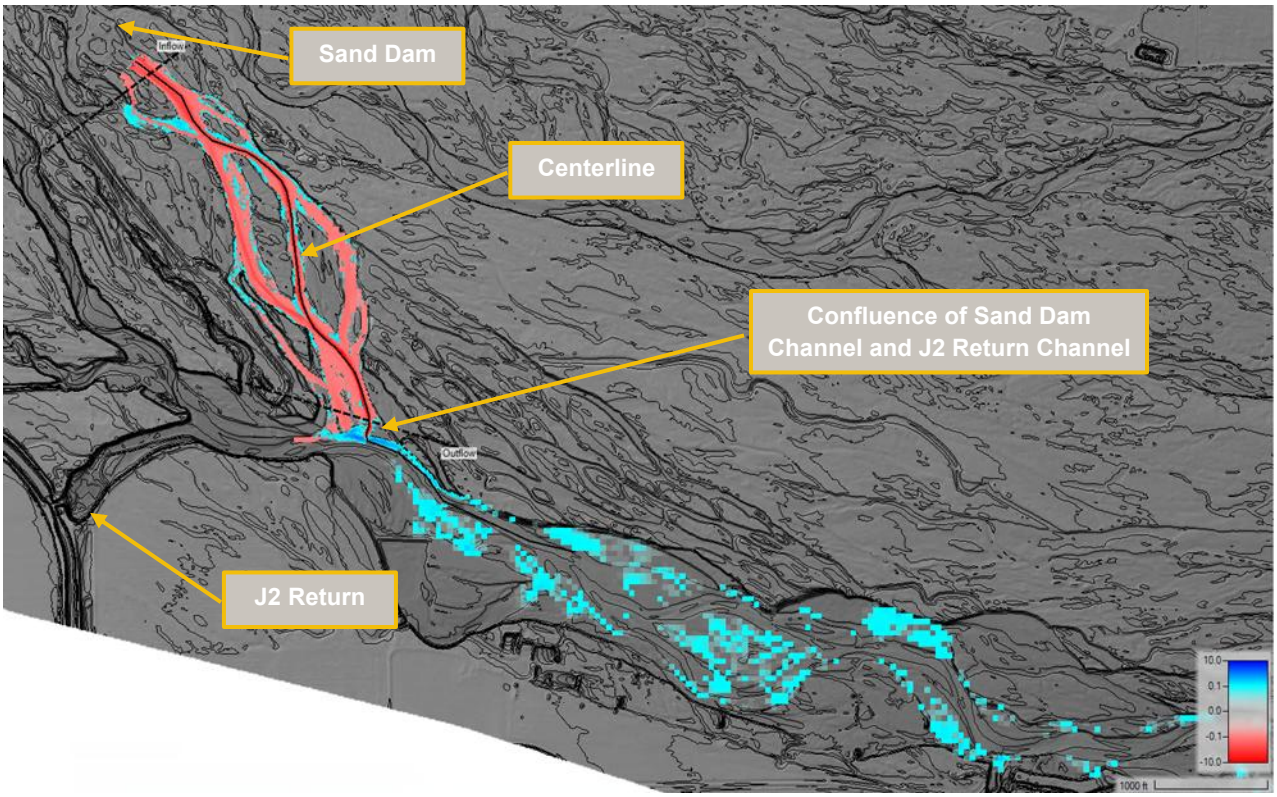

Figure 7-4. R2B bed change distribution

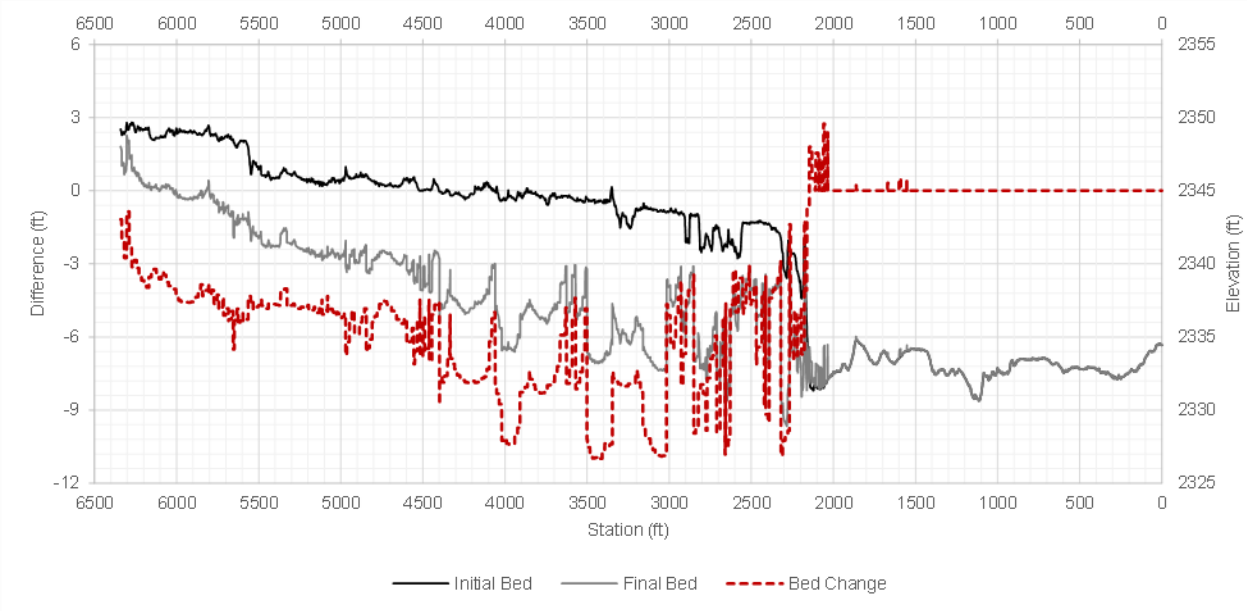

Figure 7-5. R2B bed change profile. Stationing downstream (STA 0+00) to upstream

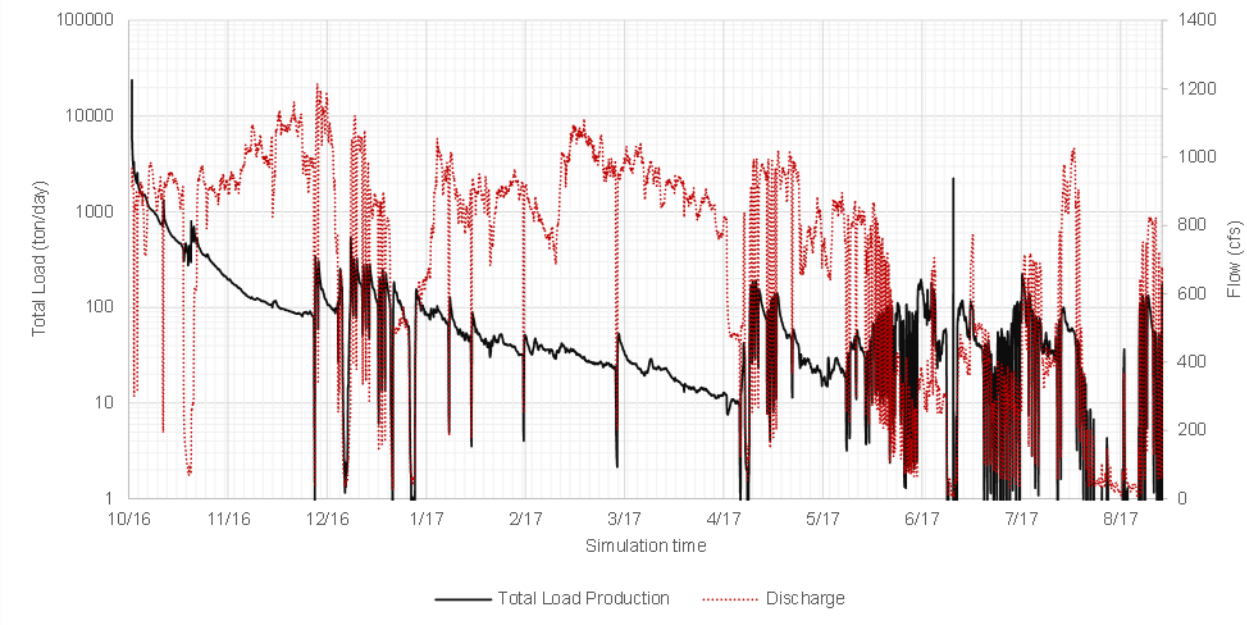

Figure 7-6. R2B total load production

7.1.2.3 R2B-2

R2B-2 examined the inclusion of two channel-spanning obstructions to force an avulsion to the left portions of the Sand Dam Channel. The obstructions were added following the erosion which occurred during R2B. Figure 7-7 illustrates bed change through the Sand Dam Channel at the end of the simulation. Channel erosion occurred within the activated left branch of the Sand Dam Channel before rejoining the outlet to the J2 Return Channel. Figure 7-8 provides a profile of one eroded channel for the alternative, where deposition is noted in the downstream extents. Figure 7-9 details the total load production with a decrease noted over time. R2B-2 did not complete a full simulation run before termination. Approximately 90% of the sediment delivered occurred by four months into the year-long simulation as extrapolated by trends observed with other R2 alternatives. A total of 50,200 tons were calculated to be produced from erosion during the R2B-2 simulation.

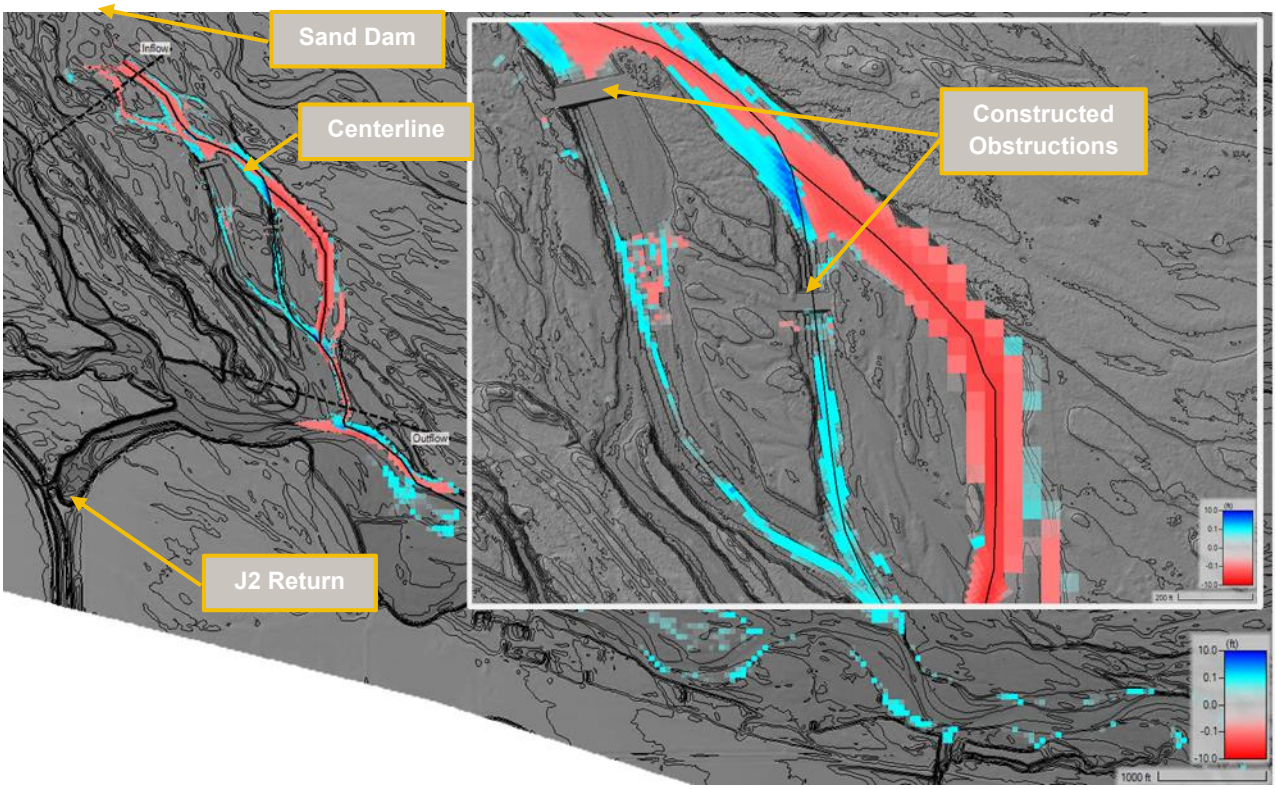

Figure 7-7. R2B-2 bed change distribution

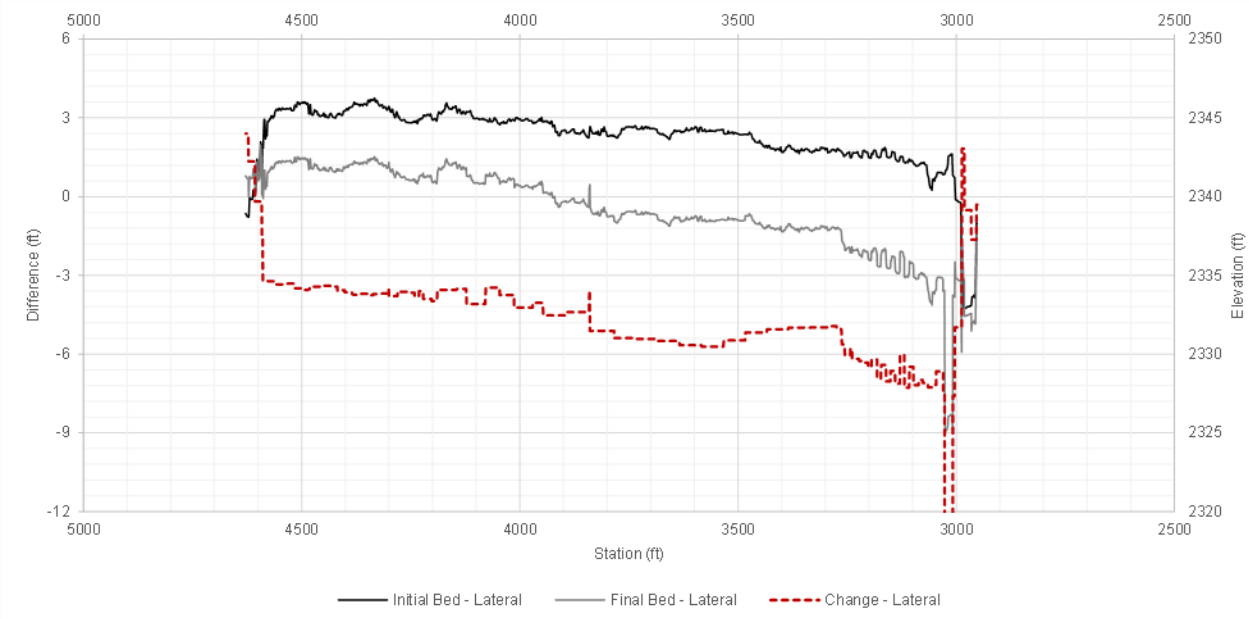

Figure 7-8. R2B-2 bed change profile. Stationing downstream (STA 25+00) to upstream

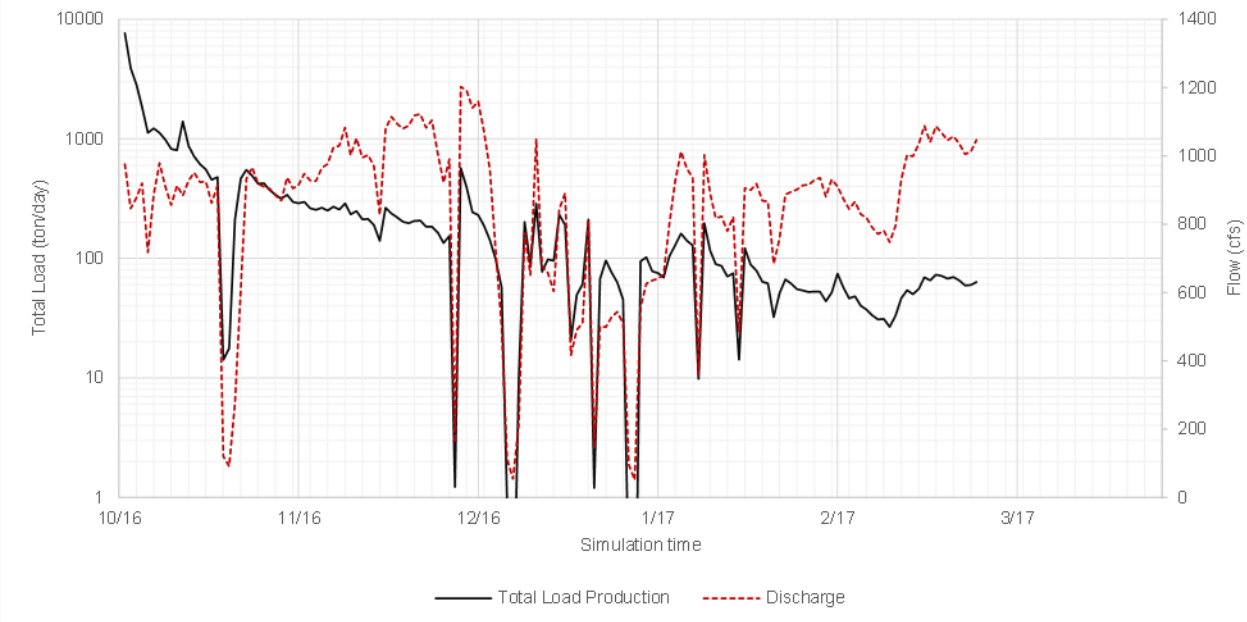

Figure 7-9. R2B-2 total load production.

7.1.2.4 R2B-3

R2B-3 examined the inclusion of two channel-spanning obstructions to force an avulsion to the left portions of the Sand Dam Channel. The obstructions were added following the erosion which occurred during R2B and R2B-2. Figure 7-10 illustrates bed change through the Sand Dam Channel at the end of the simulation. Channel erosion occurred around the obstruction which then avulsed back to the pre-eroded channel from R2B without gaining additional overbank channelization. Figure 7-11 provides a profile of one eroded channel for the alternative, where deposition is noted in the downstream extents. Figure 7-12 details the total load production with a decrease noted over time. R2B-3 did not complete a full simulation run before termination. Approximately 90% of the sediment delivered occurred by four months into the year-long simulation as extrapolated by trends observed with other R2 alternatives. A total of 12,700 tons were calculated to be produced from erosion during the R2B-3 simulation.

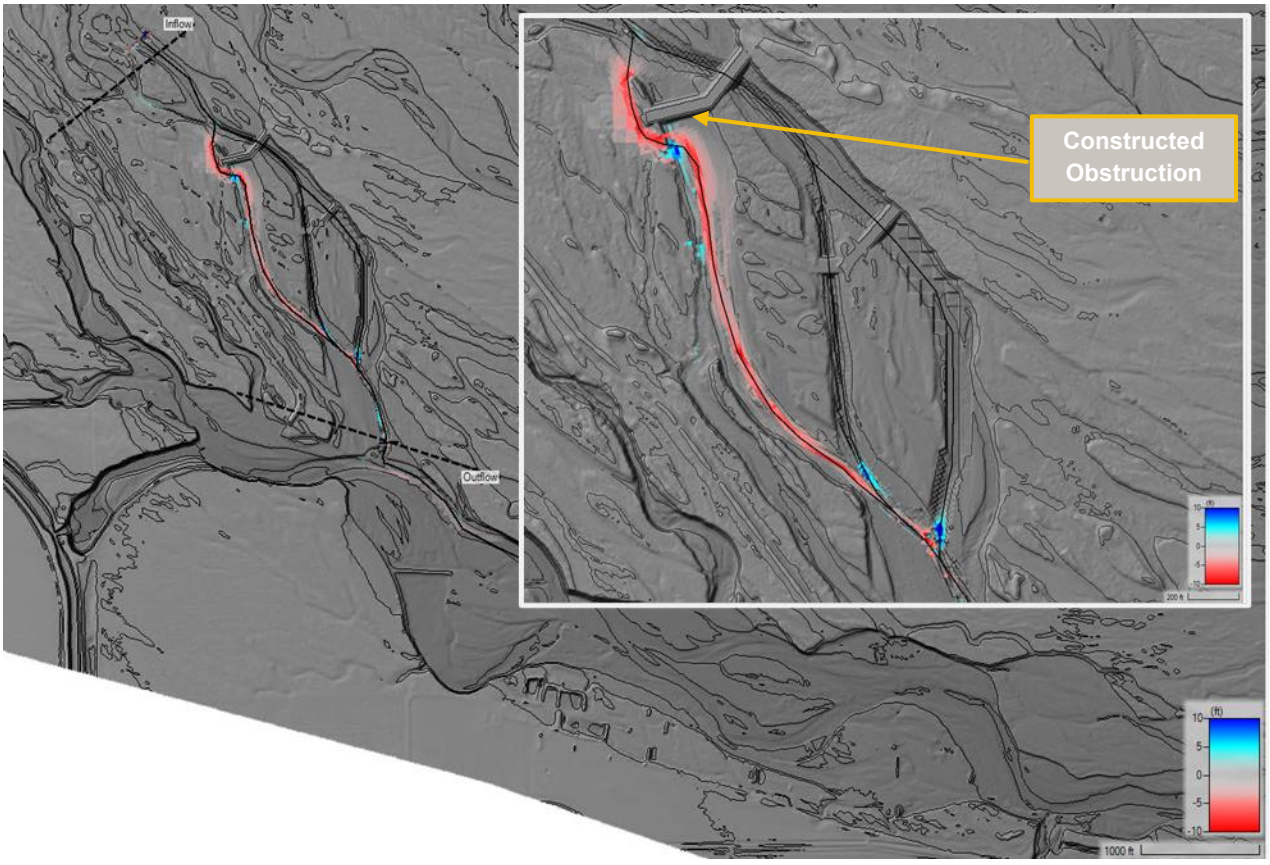

Figure 7-10. R2B-3 bed change distribution

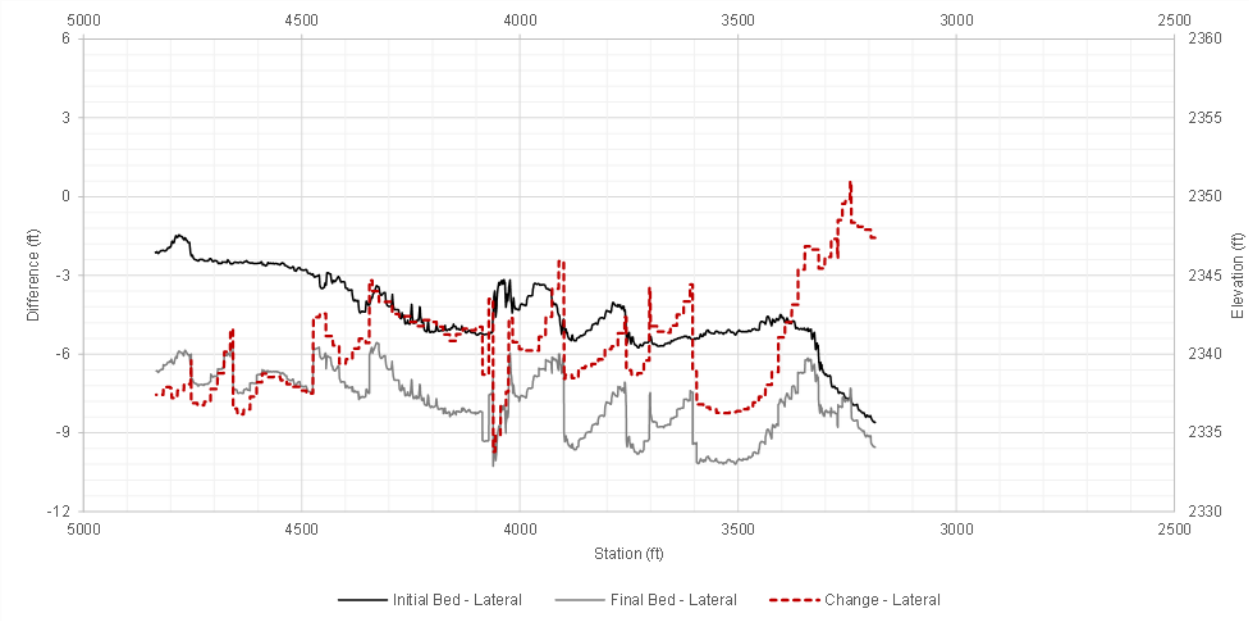

Figure 7-11. R2B-3 bed change profile. Stationing downstream (STA 25+00) to upstream

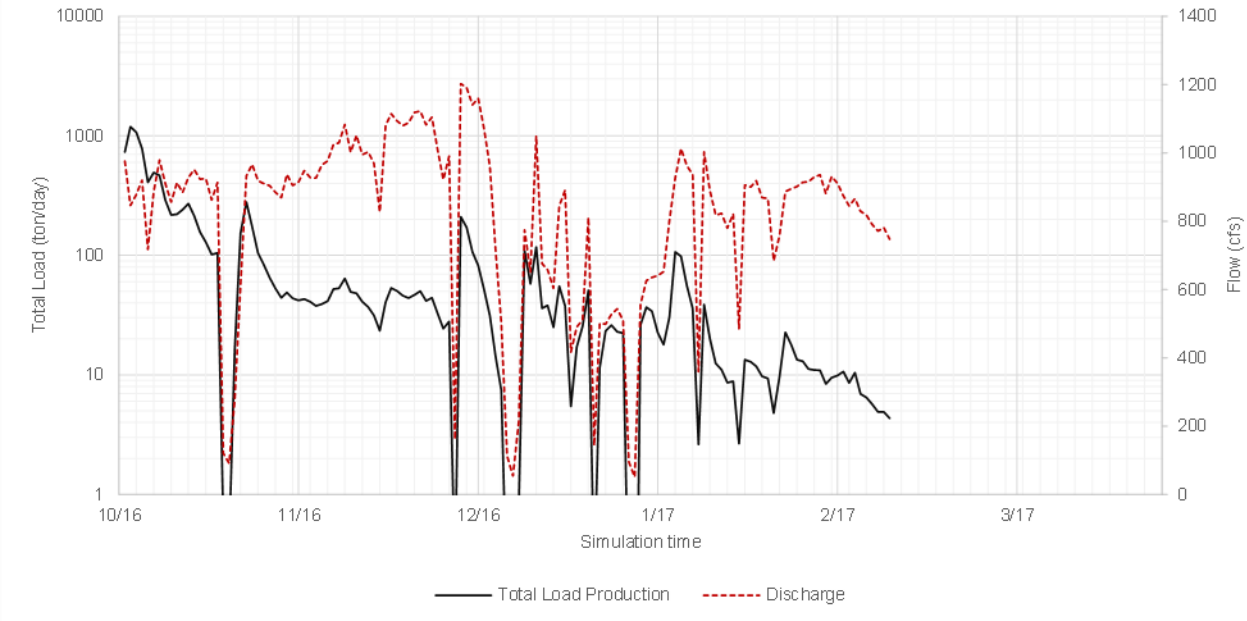

Figure 7-12. R2B-3 total load production

7.1.2.5 S1

This simulation analyzes Alternative S1 (the removal of Sand Dam, see Section 3). The removal of the existing Sand Dam was performed by incorporating a 400 ft wide opening in the Sand Dam with an invert elevation of 2352.7 ft. A 44 ft wide pilot channel set at an elevation of 2352.6 was included to help direct flow from the North Channel through the opening. Figure 7-13 illustrates bed change through the model limits on the North Channel and J2 Return Channel, while Figure 7-14 provides a closer view of the Sand Dam Channel bed change. Channel erosion also occurred within three branches of the Sand Dam Channel before rejoining at a singular outlet to the J2 Return Channel. Figure 7-15 provides a profile of one eroded channel for the alternative, where deposition is noted in the downstream extents.

Figure 7-16 provides a profile of the North Channel, including the final bed elevations for S1. Up to 4 ft of erosion occurred in the North Channel upstream of the Sand Dam, and then deposition immediately downstream. Figure 7-17 shows that the majority of flow in the North Channel is diverted through the Sand Dam Channel within the first month of the simulation, with over 79% of the North Channel flow being diverted through the Sand Dam Channel throughout the remainder of the simulation. At times, over half the flow remaining in the North Channel is conveyed through secondary channels that split from the main channel upstream of the removed Sand Dam section. Figure 7-18 details the total load production with a decrease noted over time. Approximately 50% of the sediment delivered occurred by four months into the year-long simulation and nearly 90% by seven months into the simulation. A total of 26,600 tons were calculated to be produced from erosion within the Sand Dam Channel in the one-year simulation.

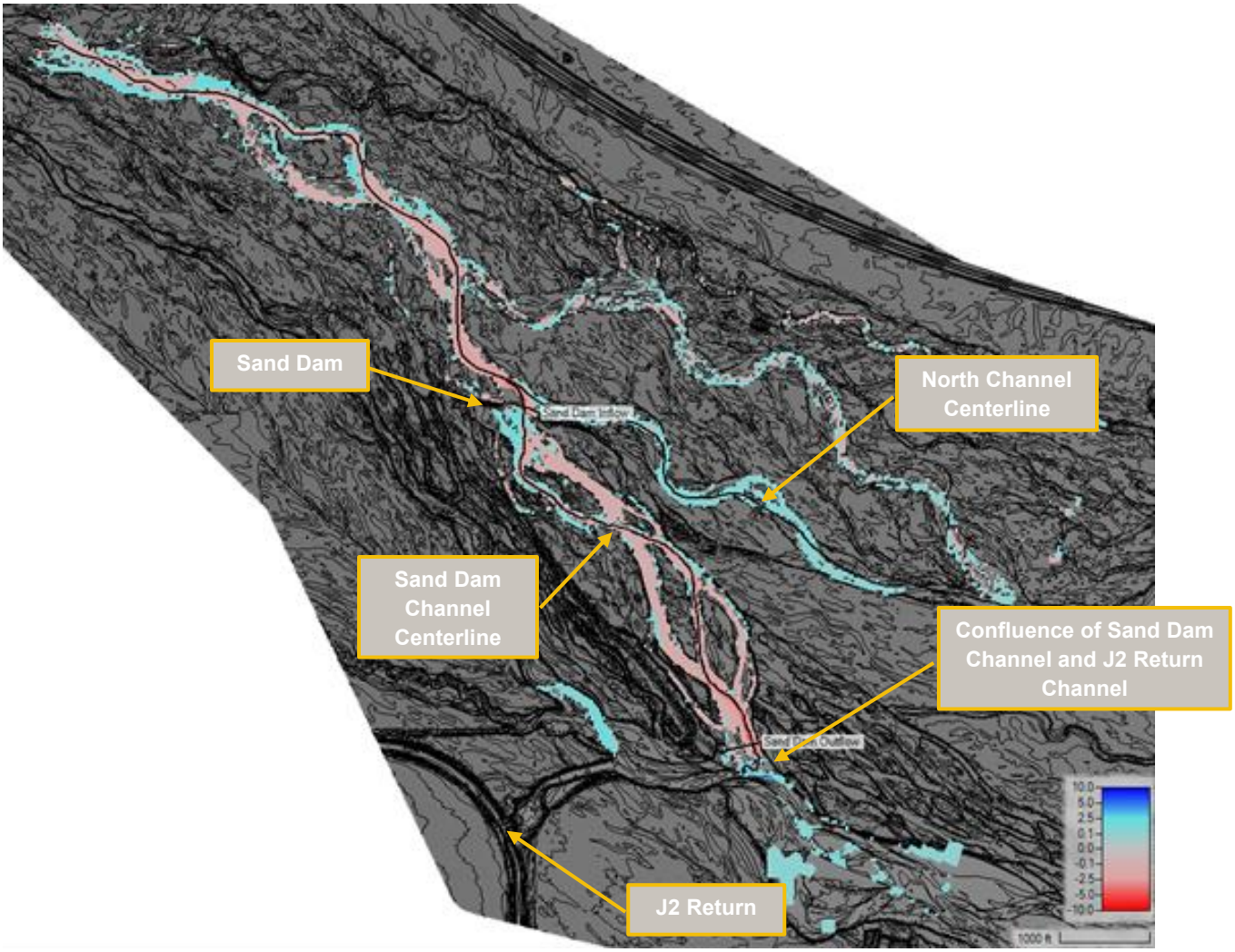

Figure 7-13. S1 bed change distribution

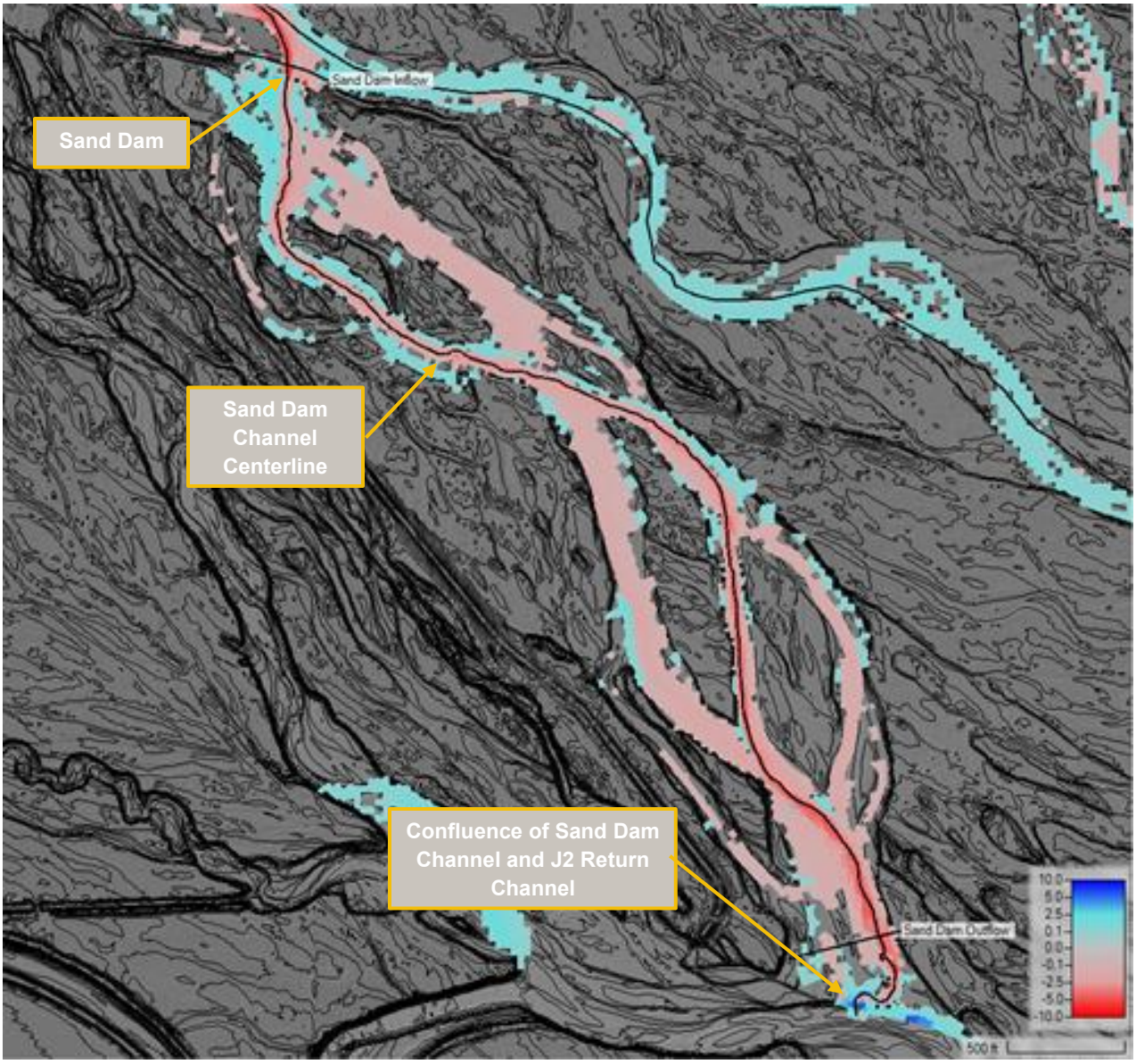

Figure 7-14. S1 Sand Dam Channel bed change distribution

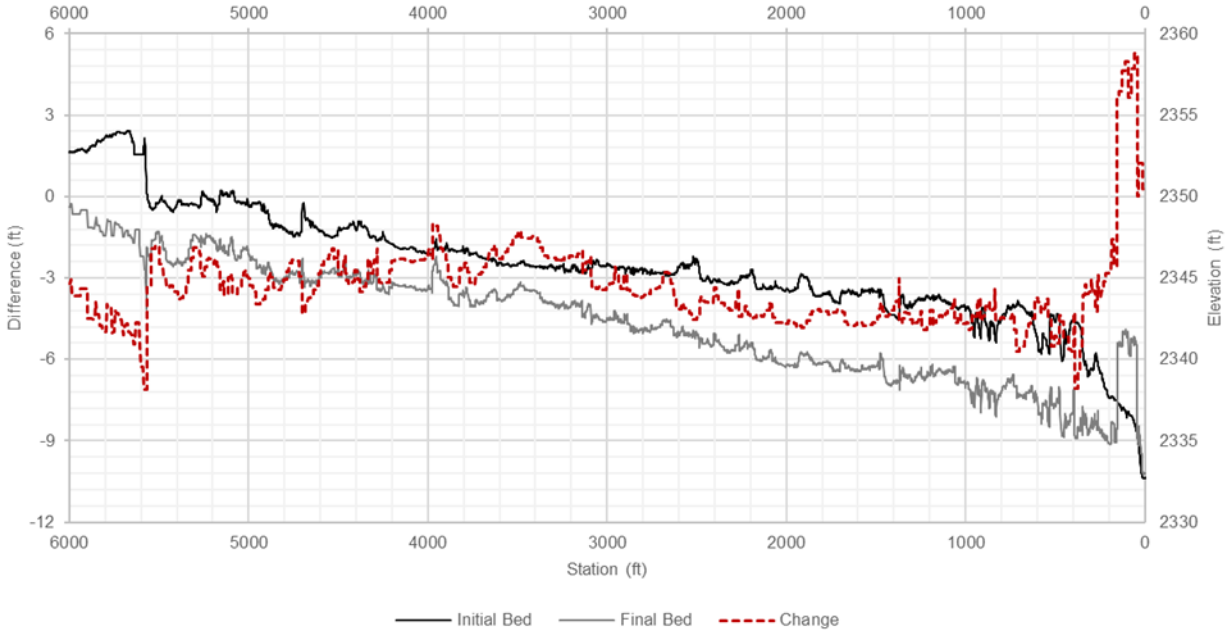

Figure 7-15. S1 Sand Dam Channel bed change profile. Stationing downstream (STA 0+00) to upstream

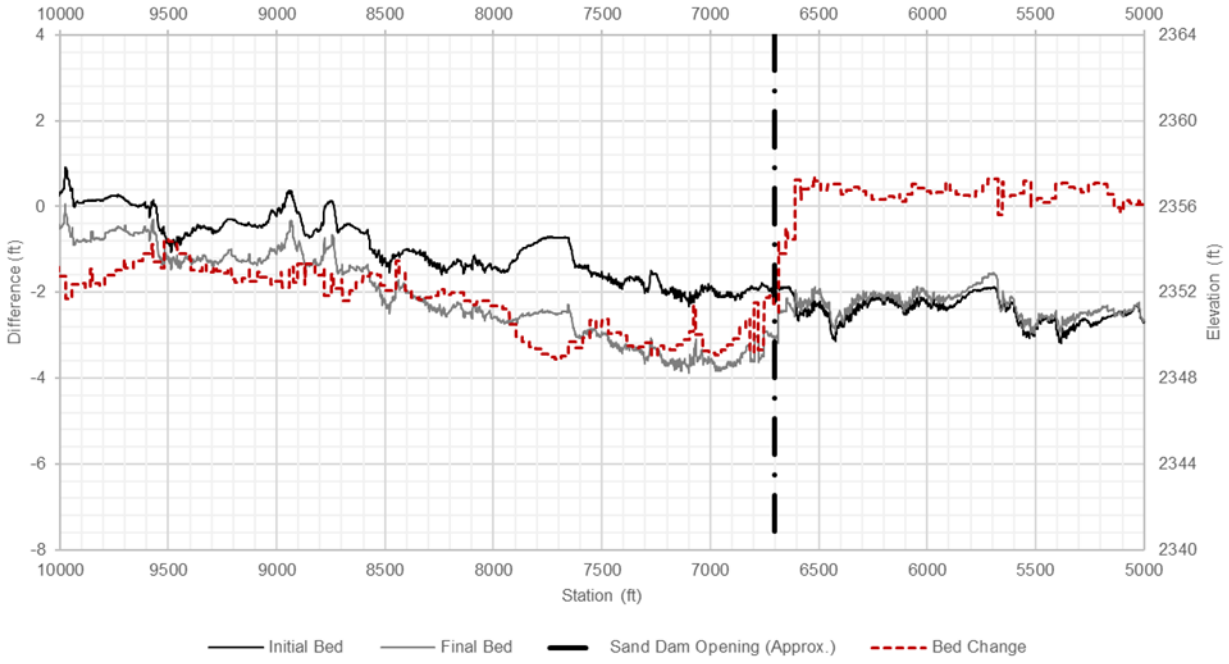

Figure 7-16. S1 North Channel bed change profile. Stationing downstream (STA 0+00) to upstream

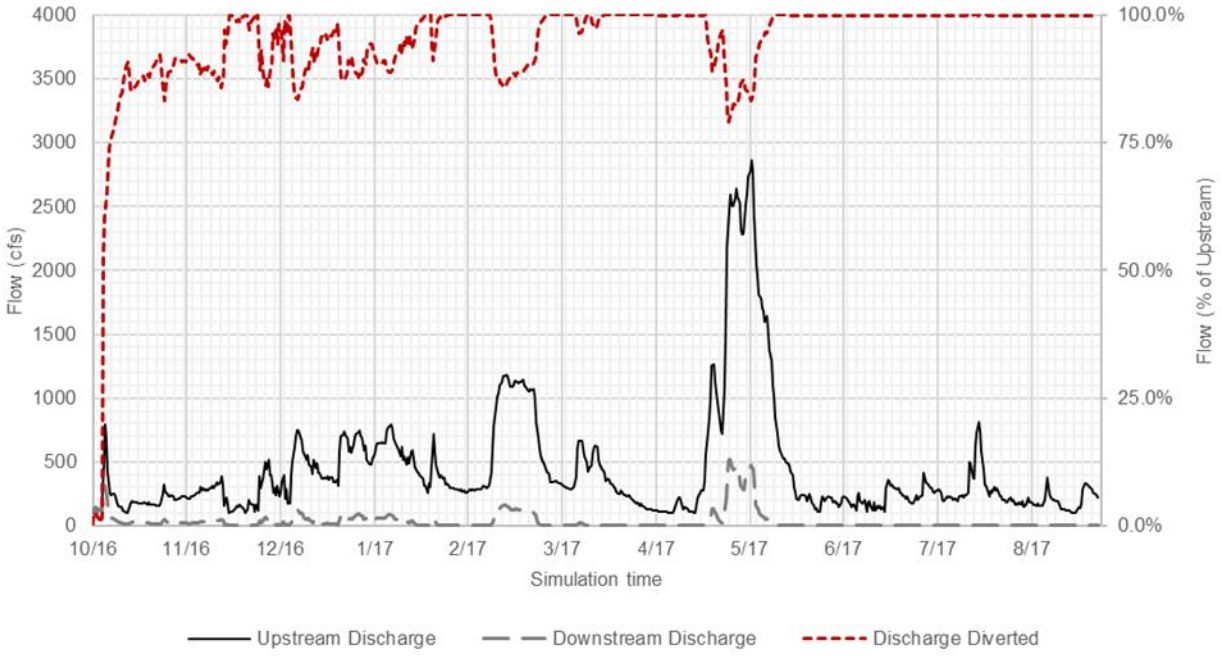

Figure 7-17. S1 North Channel flows upstream and downstream of Sand Dam removed section

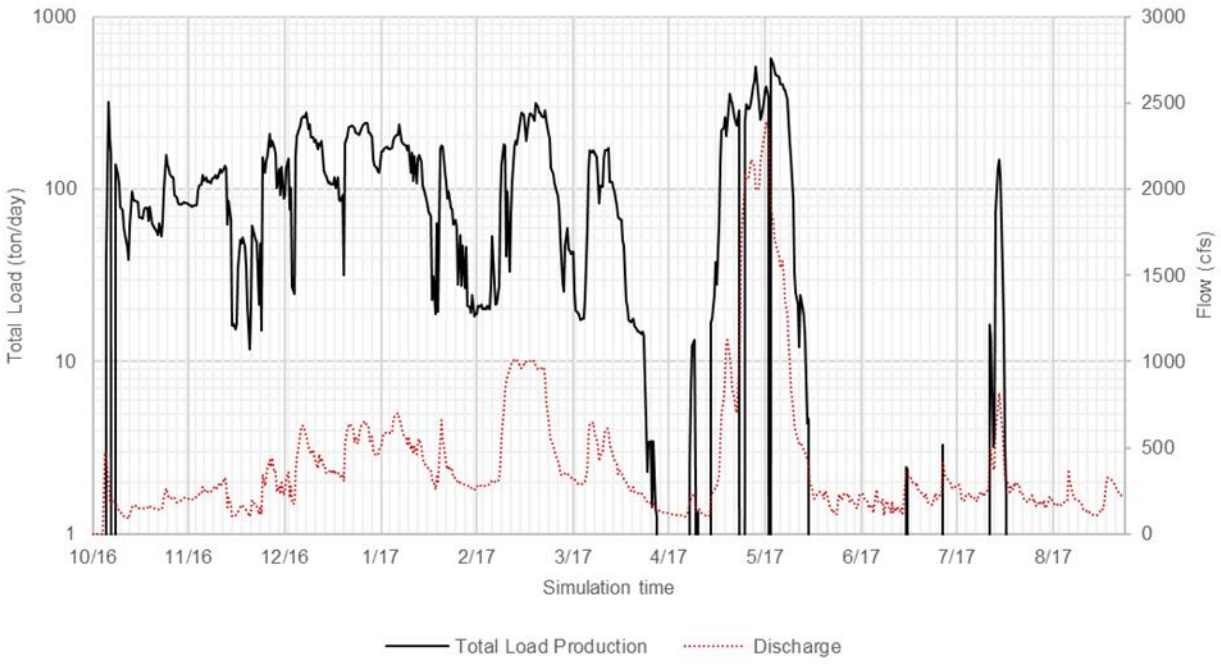

Figure 7-18. S1 total load production

7.1.2.6 S2

This simulation analyzes Alternative S2 (the installation of an overflow weir at the Sand Dam, see Section 3 for a description). S2 modeled a 150 ft wide fixed crest weir set in the Sand Dam. The weir crest was set at 2353.9, intended to activate at a flow of approximately 500 cfs. Figure 7-19 illustrates bed change through the model limits on the North Channel and J2 Return channel, while Figure 7-20 provides a closer view of the Sand Dam Channel bed change. Channel erosion occurred primarily within one branch of the Sand Dam Channel. Figure 7-21 provides a profile of the Sand Dam Channel for the alternative, where erosion is noted on the slope downstream of the weir crest and in the downstream extents. Figure 7-22 shows flow in the North Channel and Sand Dam Channel. A total of 20,100 tons were produced from erosion within the Sand Dam Channel in the one-year simulation. The erosion in the Sand Dam Channel is significantly less under S2 than R2. The main reasons for this are that there is less flow entering the Sand Dam Channel under S2 than R2, and that S2 brings in sediment from the North Channel.

The S2 alternative was also simulated with the 1D model. As will be shown in later sections, the 1D model predicted significantly more erosion of the Sand Dam channel than the 2D model. As this is a Reconnaissance study, the higher prediction of erosion is used to assess the S2 Alternative. If the alternative does not perform well given the higher prediction of erosion, it will only perform worse with the lower estimate. Even though the 2D simulation of S2 was not directly used in the quantitative analysis, the simulation was useful to understand the potential erosion and deposition patterns that could form. In particular, the erosional channel developed similarly to the erosional channels of R2. Significant flow redirection and channel grading would likely be required to accomplish erosion within the Sand Dam Channel after a dominant flow path is developed, similar to Alternative R2.

The S2 alternative simulation predicted erosion in the North Channel, however, there is uncertainty regarding the North Channel response under S2. Because of the relatively short reach simulated in the 2D model, the results in the North Channel are sensitive to the upstream boundary condition. The intention of the equilibrium boundary is that the North Channel would be stable, but the model predicted erosion. Additional testing of different boundary conditions would be necessary to resolve the North Channel response. If this alternative is pursued further, additional 2D model simulations are recommended to resolve the response of the North Channel near the weir. The response of the North Channel is also discussed in the 1D simulation section.

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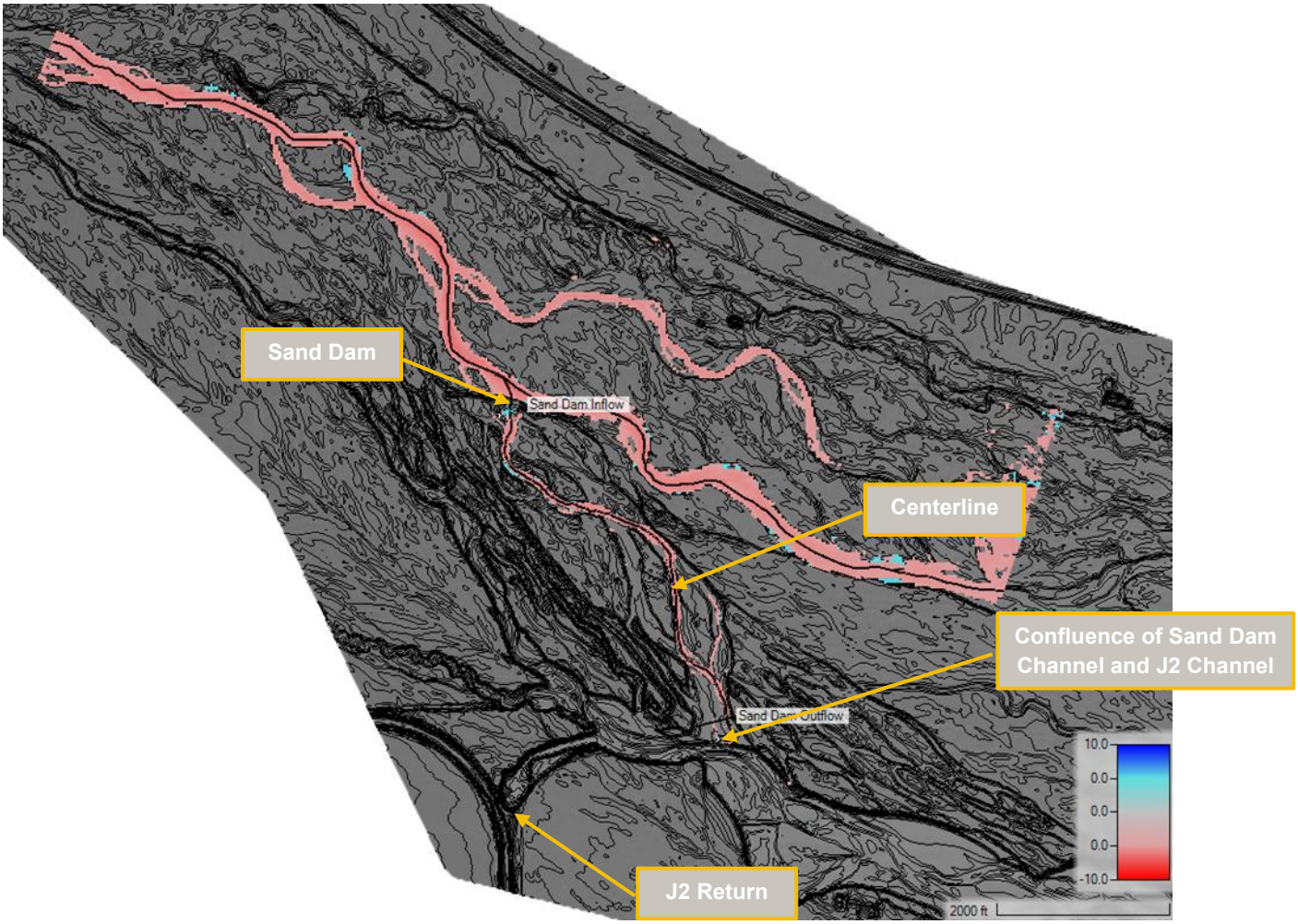

Figure 7-19. S2 bed change distribution

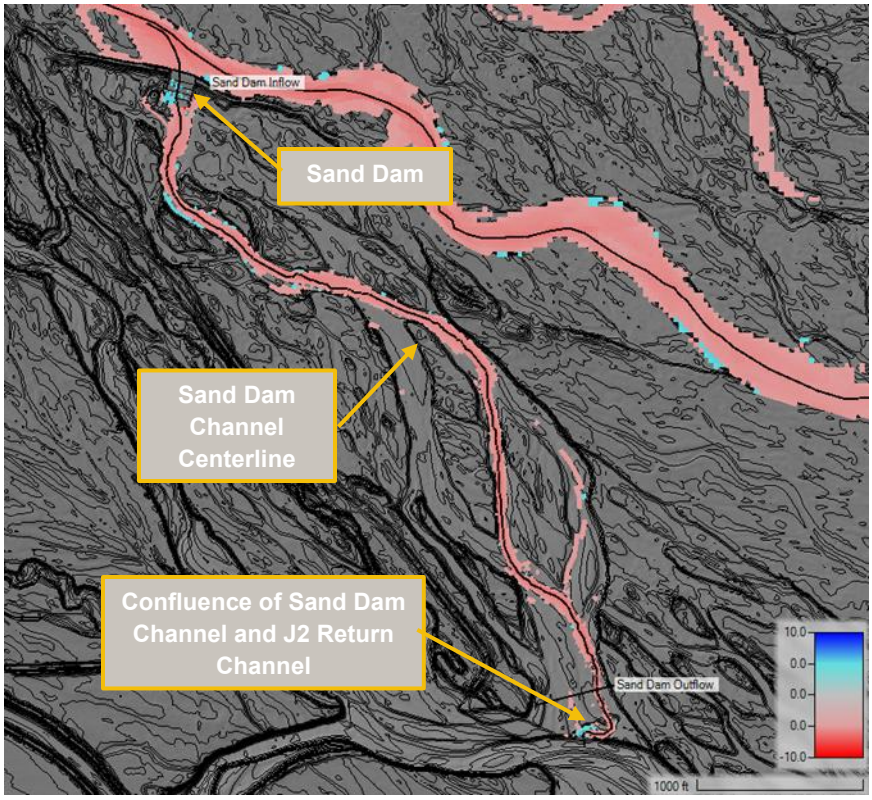

Figure 7-20. S2 Sand Dam Channel bed change distribution

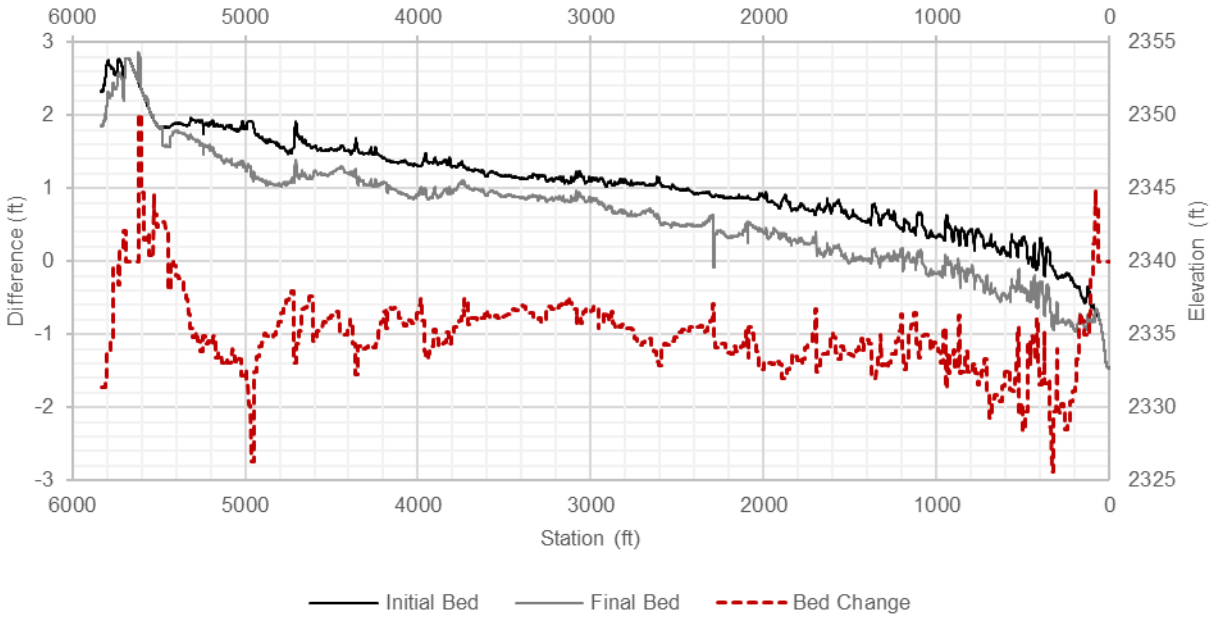

Figure 7-21. S2 Sand Dam Channel bed change profile. Stationing downstream (STA 0+00) to upstream

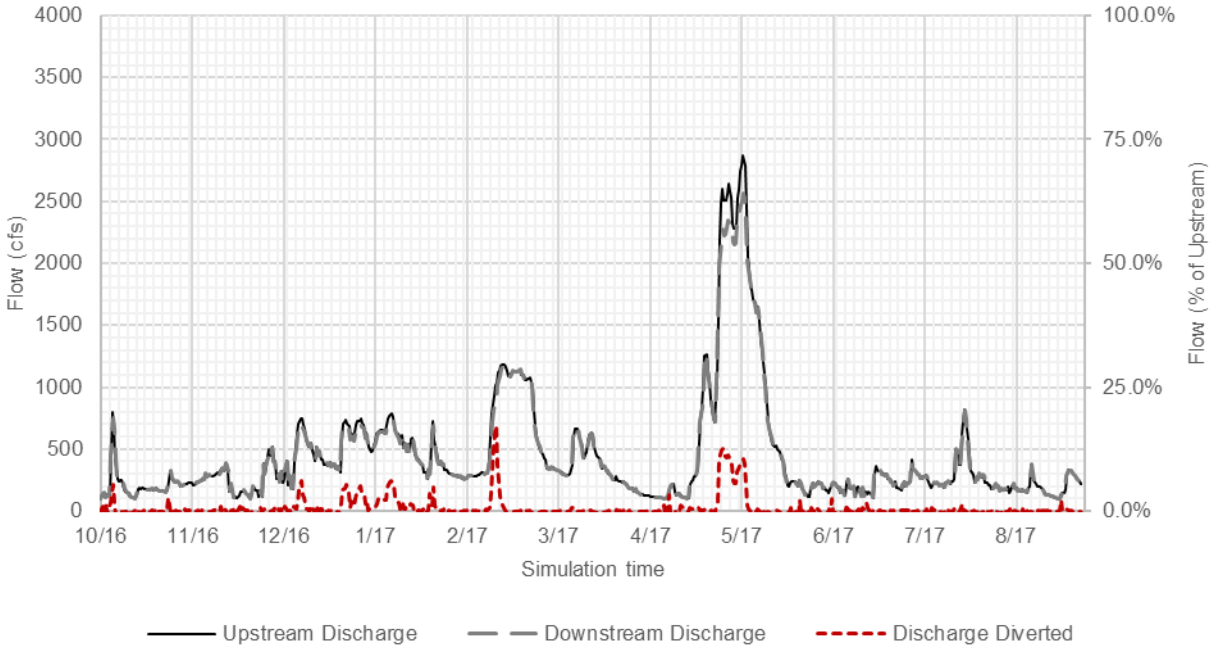

Figure 7-22. North Channel flows upstream and downstream of Sand Dam weir

7.1.2.7 S3

The alternative S3 (Bottom Opening Gate at Sand Dam) was not simulated in the 2D model because gate operations could not be directly simulated in the 2D model. In addition, the 2D model is depth averaged and the sediment routing of the model does not distinguish between flow passing over a weir or passing under a gate. The alternative is also simulated with the 1D model and is discussed in that section.

7.1.2.8 I2

This simulation analyzes Alternative I2 (the diversion of J2 Return flow into Jeffery Island, see Section 3). The first simulation of I2, assumed a delivery of ¼ of the J2 clear water flow to a trapezoidal dredged channel connecting to relict channels at Jeffrey's Island. The pilot channel was conceptualized with a 50-ft bottom width and 2:1 H:V side slopes. Two outlets into the overbank areas were considered, one near the upstream entrance and one further downstream. Trial simulations of J2 flows greater than ¼ resulted in uncontrollable erosion and depositional patterns with unexpected avulsions to the North Channel. I2 alternatives, if pursued, should incrementally ramp discharges to form stabilized pilot channels prior to larger flow releases. It is noted that model results from I2 are functionally equivalent to those achieved under I3 as they pertain to sediment entrainment through Jeffrey's Island. Figure 7-23 illustrates bed change through Jeffrey's Island at the end of the I2 simulation. Channel erosion occurred through the pilot channel and deposited sediment within dredged portions of the relict channel before activating a braided

overbank network and joining downstream with the J2 Return Channel. Profiles of I2 are not provided due to the complex nature of the observed flow distributions. Figure 7-24 details the total load production with a decrease noted over time. Approximately 90% of the sediment delivered occurred by seven months into the year-long simulation. A total of 108,700 tons were calculated to be produced from erosion during the I2 simulation.

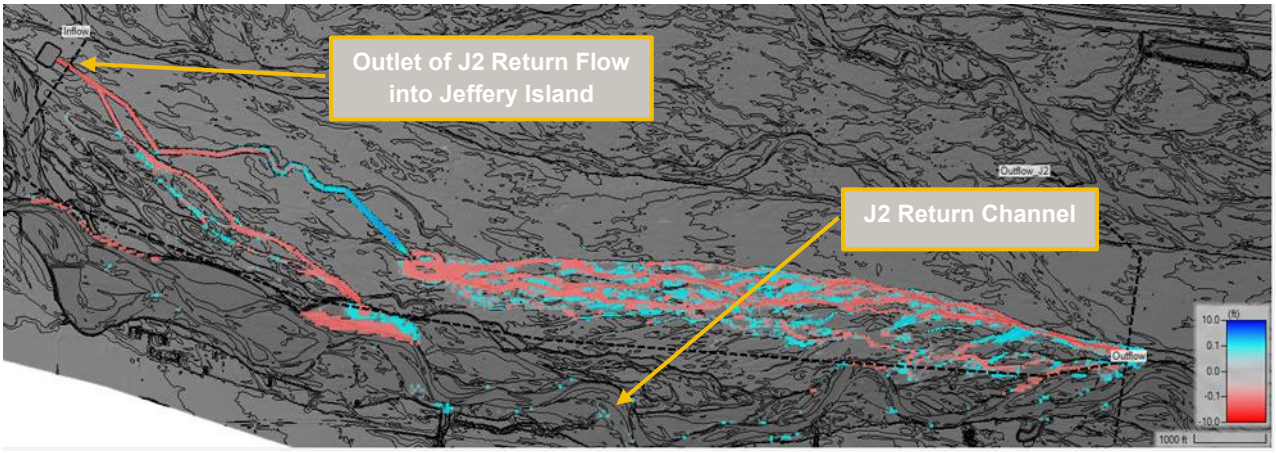

Figure 7-23. I2 bed change distribution

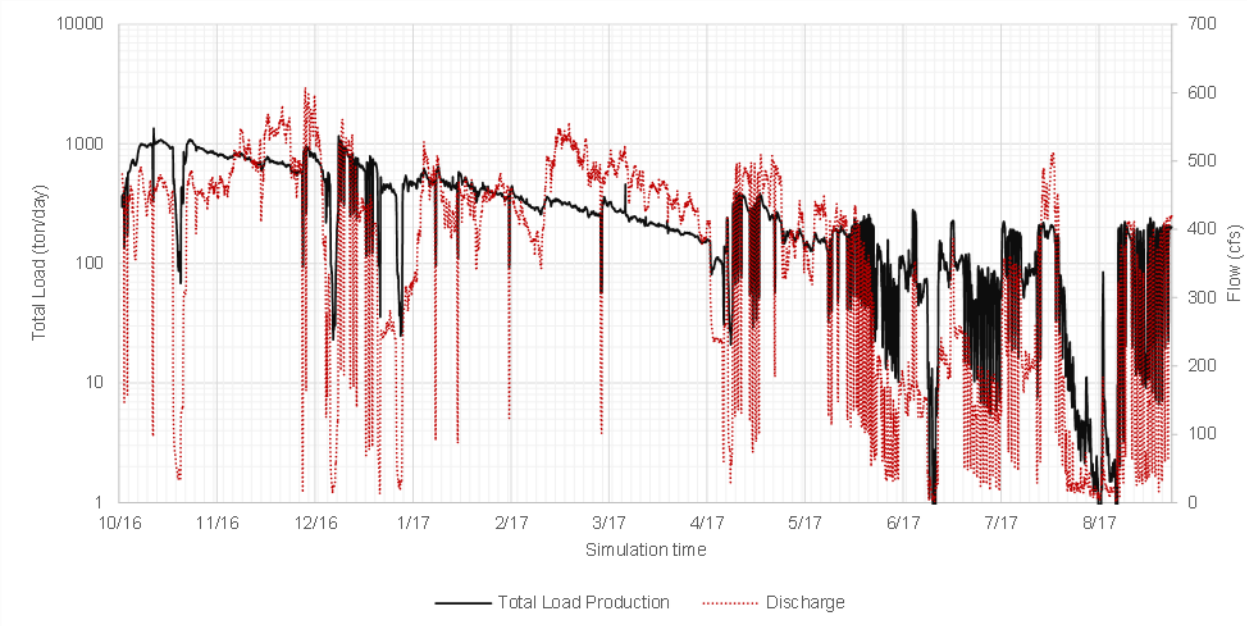

Figure 7-24. I2 total load production

7.1.2.9 I2-2

I2-2 delivered ½ of the J2 clear water flow to the I2 configuration after one year of simulated erosion at the ¼ flow distribution under I2. Figure 7-25 illustrates bed change through Jeffrey's Island at the end of the simulation. Channel erosion largely reinforced the pathways that were developed during the I2 simulation without activating new overbank channels. Profiles of I2-2 are not provided due to the complex nature of the flow distributions. Figure 7-26 details the total load production with a decrease noted over time. Approximately 90% of the sediment delivered occurred by seven months into the year-long simulation. A total of 181,100 tons were calculated to be produced from erosion during the I2-2 simulation.

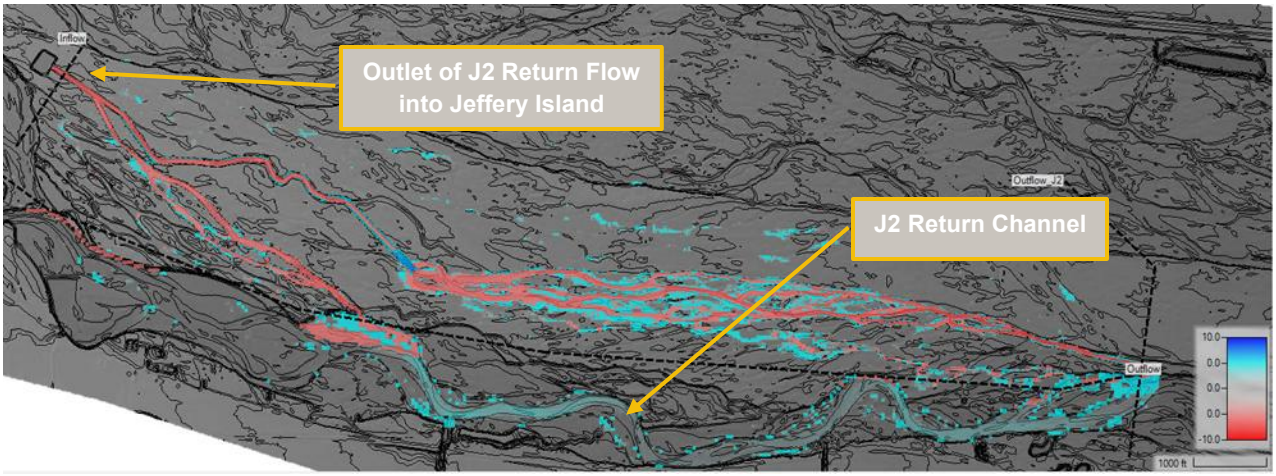

Figure 7-25. I2-2 bed change distribution.

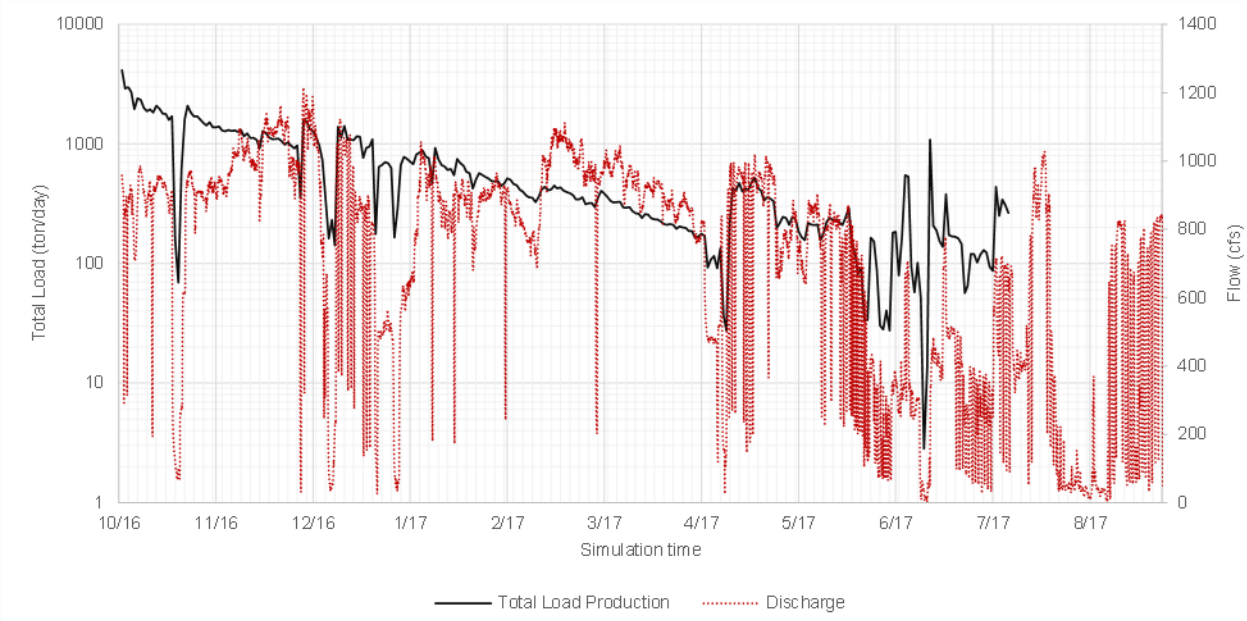

Figure 7-26. I2-2 total load production

7.1.2.10 2D Simulation Summary

The 2D model was used to simulate response in channels that currently do not experience flow, which include the Sand Dam Channel and Jeffery Island. Single year simulations were performed using the 2D model for these alternatives. Sediment simulations with the 2D model indicated similar trends across the simulated alternatives, where introduced flows incited erosion and channelization of relict or existing thalwegs which then successively eroded and incised within that planform.

For Alternative S1, the 2D model predicted up to 4 ft of erosion in the North Channel upstream of the Sand Dam. This erosion would be expected to continue until the entire Platte River avulses into the Sand Dam Channel and all the flow from the North Channel enters the Sand Dam Channel and passes into the J2 Return Channel.

For Alternative S2, the 2D model predicted relatively modest amounts of erosion (20,100 tons) within the Sand Dam Channel because of two primary reasons. One reason is that the Sand Dam Channel was only active when the North Channel exceeded 500 cfs, and another reason is that sediment is introduced from the North Channel into the Sand Dam Channel which limits the erosive power of the flow. This alternative is also simulated with the 1D model and additional discussion on the channel response is included in that section.

For alternatives R2 and I2, reach-averaged equilibrium erosion was typically on the order of five feet below the initial bed configuration. Results indicated that increasing the rates of flow to the R2 or I2 alternatives may provide additional sediment production and that ramping flows is a possible management strategy for hydraulic sediment augmentation. Flows above ½ of the J2 Canal flow were not examined. Additional years of sediment production within the Sand Dam Channel under the R2 alternatives is possible with the inclusion of obstructions. Model results indicated that approximately 3 – 4 iterations of forced channel avulsion may be possible before diminishing returns in the Sand Dam Channel. Obstructions were not examined in Jeffrey's Island; however, it is expected additional erosion production is possible through this area through reconfiguration of upstream pilot channels and flow delivery to new areas. Examination of I2 alternatives emphasized that uncontrolled erosion, deposition, and avulsion patterns are possible. Additional modeling, planning, and engineering is recommended prior to flow deployment if I2, or R2, are pursued along with systematic monitoring and adaptive management.

As demonstrated in the calibration of the 2D model, the simulated erosion primarily occurred through vertical incision and bank erosion is not directly simulated in the 2D model. It is likely that the 2D model may underestimate the erosion of channels in the alternatives. Thus, the 1D model was also used to predict erosion for Sand Dam Alternatives S2 and S3. The 1D model predicted significantly more erosion in the Sand Dam channel than the 2D model. The larger prediction of erosion is used to assess the S2, S3, and R2 Alternatives. If an alternative does not perform well given the larger prediction of erosion, it will only perform worse with the lower estimate.

Table 7-2. 2D simulation summary

Alternative	Alternative Description	Simulation	Sediment Produced (tons)
S	Sand Dam Channel activation from North Channel	S1	26,600
		S2	20,100
R2	Sand Dam Channel activation from J2 conveyance channel	R2A	80,300
		R2B	41,200
		R2B2	50,200
		R2B3	12,700
I2	Jeffrey's Island activation from J2 conveyance channel	I2	108,700
		I2-2	181,100

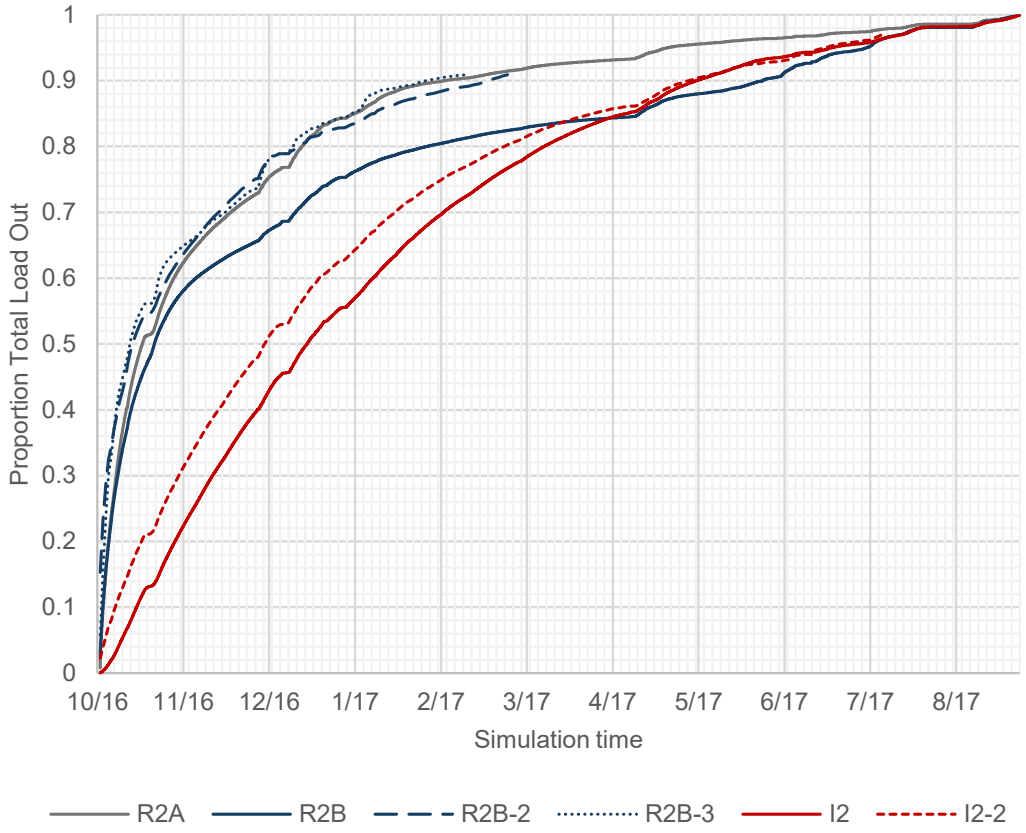

Figure 7-27. 2D model total load delivered as function of 2017 water year simulation time.

7.2 1D Simulations

Following the identification of the model parameters that best estimate sediment transport in the North, J2, and Downstream Channels during the calibration of the 1D HEC-RAS model, alternative models were developed to assess the future performance of a range of sediment management scenarios. The 1D calibration model was based on the observed changes through 2023 as compared to the 2016 LiDAR surface. For the alternatives analysis, a new starting point was used for channel geometry. The 1D model was updated to 2023 LiDAR through the model reach and each cross section was updated for elevation and bank station location. No notable revision to obstructed or ineffective flow areas was noted and were not changed.

The 1D HEC-RAS quasi-unsteady model offered the most efficient option to assess near-future estimates of sediment transport under the range of alternatives. As such, the seven-year hydrologic period used by the calibration model was doubled to fourteen years, from 2023 through 2037. No hydrologic forecasting was performed for this analysis, but the 2016-2023 hydrology developed for the calibration model was duplicated, sequentially, to generate a hydrologic regime that encompassed the range of flows experienced during the calibration modelling. Limitations in the HEC-RAS quasi-unsteady flow data required a time-step revision from the original 2-HR flow data to a 4-HR dataset. The moving average technique used on the 1-HR to develop the 2-HR flow data was repeated to generate a 4-HR dataset for both the Platte River (North Channel) and J2 Return Channels. Additional revisions to hydrologic input were required for specific alternatives and will be discussed in the following section.

7.2.1 Description of Scenarios Analyzed

7.2.1.1 N1 – No Action

The North, J2, and Downstream Channels were assessed across the 14-year analysis period. No sediment augmentation or contribution from the Breakthrough Channel was assumed for this run.

7.2.1.2 R1 – Regulation of J2 Canal Inflows to the J2 Return Channel

This model differs from the N1 model by replacing the variable, 4-HR J2 inflow hydrograph with a 4-HR hydrograph of daily average flows calculated from the original 1-HR J2 inflow data. This means the flow volumes are the same in a given day, but constant for that day.

7.2.1.3 R2 – J2 Inflow Re-Distribution

This model differs from the N1 model by applying half of the 4-HR J2 inflow hydrograph to the J2 Return Channel, and the other half to the Sand Dam Channel just downstream of the Sand Dam. This required the addition of the Sand Dam Channel reach to the model using the 2023 LiDAR as the base geometry. This reach was joined with the J2 Return Channel at the current location of the exiting Sand Dam Channel. No additional sediment was added to the model, other than that generated by the addition of “clear water” to the head of the Sand Dam Channel.

7.2.1.4 S1 – Remove Sand Dam

The Sand Dam Channel geometry developed for the R2 model was extended to a junction with the North Channel. A cross section was placed across the Sand Dam alignment, and the topography was replaced with a trapezoidal channel with a bottom elevation set to that of the adjacent North Channel (2351 ft), three hundred feet wide at the base, with side slopes of 2:1.

A distributary junction was created to allow flow to enter the Sand Dam channel from the North channel. Adding the junction split the North Channel into two new reaches, Upper and Lower North Channel. There are two options to simulate junction flow. One option forces the flow to be equally split between the two distributary channels and the other allows the program to compute the flow split based upon a water energy balance at the junction. For S1, when the option allowing the program to compute the energy balance at the junction was used, the program failed to simulate even the first year. This is because the model predicted extensive erosion in the Sand Dam channel and deposition in the North Channel, resulting in a stream avulsion of the North Channel into the J2 Return Channel. HEC-RAS cannot simulate zero flow within a reach and therefore no 14-yr model results are produced for this alternative. It would be possible to simulate this alternative by simply starting with the North Channel avulsed into the J2 Return Channel, but this was not considered a feasible alternative in this study because it would result in an abandonment of the lower North Channel.

7.2.1.5 S2 – Overflow Weir at Sand Dam

The S2 model added an overflow weir to the S1 model at the location of the Sand Dam in the Sand Dam Channel. The weir was set to an invert elevation of 2355.7 ft and was 150 ft wide.

As with S1, two options for modeling the distributary junction at the Sand Dam were possible. The first option simply splits the flow 50/50 between the North Channel and Sand Dam Channel equally. The second computes the flow split based upon the energy balance at the junction. As with S1, HEC-RAS could not simulate the 14-yr record of the S2 alternative using the energy balance method. Even through there is a weir located in the Sand Dam channel, the deposition in the North Channel eventually could cause an avulsion into the Sand Dam channel. In this alternative, however, there is a control structure at the Sand Dam that could be used to prevent the avulsion. To replicate this possibility, it is assumed that the weir and gates are operated to prevent the avulsion and therefore option 1 is used where the flow is equally split between the Sand Dam and the North Channel.

The split flow also caused an instability/error in the HEC-RAS model that resulted in the upstream boundary condition of equilibrium loading (sediment leaving the cross section from erosion is replaced with a like amount of incoming sediment from upstream) to return a zero value of sediment entering the reach. This was addressed by replacing the North Channel boundary condition with a sediment load time series generated from the calibration run. This generated approximately an equivalent amount of sediment entering the North Channel.

The S2 geometry also caused instability in the downstream junction with the J2 Return Channel, where the cross section upstream of the junction eroded down to the maximum allowed (20 ft) within the first year of

the analysis. This resulted in an over-eroded North Channel downstream of the Sand Dam Channel split. This was addressed by fixing the maximum allowable erosion at this cross section to 0.

7.2.1.6 S3 – Bottom Opening Gate at Sand Dam

The S3 model added gate operation to the S2 model and lowered the weir elevation to 2354.7 ft. A gate opening time series was added to the model to open the gates fully when flow in the North Channel exceeds 500 cfs. At flows above 500 cfs it is assumed that the flow is equally split between the Sand Dam Channel and the North Channel. The flow split assumption is similar to the assumption with S2 but this alternative does not divert flow into the Sand Dam Channel when the flow in the North Channel is less than 500 cfs. Both the flow split and weir elevation can determine how much sediment enters the Sand Dam channel, but the flow split is the dominant factor over the long term. If the weir elevation is high, then it will cause sediment to deposit in front of it, but if the flow continues to go over the weir, then the sediment eventually deposits up to the sill of the weir and then is transported over the weir.

The intention of this alternative is to have a lower-level weir that would preferentially divert sediment into the Sand Dam Channel. The current simulation assumes that the sediment and flow are split equally at flows above 500 cfs. If this alternative is pursued further, different assumptions in this sediment split could be performed. However, as will be shown in the results, there are some inherent sediment issues with the S alternatives that suggested that further analysis was not warranted. This topic is revisited in the Alternative evaluation section.

7.2.1.7 I2 – J2 Inflow Re-Distribution Across Jeffrey Island

The I2 model, based on the N1 model geometry, added a sediment time series to the J2 Reach at a single location approximately 2.8 miles downstream of the J2 inlet (as based on the results in the above 2D results). The 1-D model treated the total sediment generated by the 2D model I2-2 as point source addition using a sediment time series. The sediment time series was created by developing a rating curve based on cumulative sediment load (in tons) to cumulative inflow. The cumulative ½ J2 flow 4-HR time series was then used to look up the cumulative sediment load from the rating table, and the 4-HR incremental sediment load was calculated by differencing from the previous time step. This method assumes an inexhaustible sediment supply that lasts the duration of the analysis period. The sediment load series was accompanied by a lateral inflow time series in the quasi-unsteady flow data equal to ½ the J2 inflow and the J2 inflow was similarly halved.

The sediment loading was derived from the 2D model. Two 2D simulations were performed to understand sediment transport under this alternative. The first 2D simulation diverted one-fourth of the J2 Return flow to Jeffery Island and that flow was predicted to eroded 108,700 tons of sediment. The second simulation diverted one-half of the J2 Return flow to Jeffery Island and resulted in 181,100 tons of erosion of sediment. This rate of sediment eroded from Jeffery Island was apportioned based upon the volume of water delivered to the J2 Return Channel. The erosion from Jeffery Island occurring within a year varied between 130,000 tons to 221,000 tons depending upon the volume of J2 Return flow delivered to Jeffery Island. The total erosion of Jeffery Island over the 14-year period was estimated to be 2.4 million tons of erosion. As a check to estimate if this amount of sediment is available in the Jeffry Island area, a volume analysis was

performed for the Sand Dam Channel and Jeffery Island. The erodible area was estimated based upon the extent of the 2D erosion limits and is shown in Figure 7-28. The erodible depth was also based upon the maximum erosion depth from the 2D model.

Based upon the 2D results, it is likely that significant channel grading and manipulation would be required to encourage bank erosion and access sediment within this area. The total fraction of sediment that could ultimately be accessed withing the Sand Dam Channel and within the Jeffery Island is uncertain. As an initial estimate the 1D analysis (given below in Section 7.2.2.2) was used to estimate the fraction within this area would ultimately be eroded. Based upon the 1D analysis, approximately 1/3 of the available sediment could be eroded from the Sand Dam Channel. Applying this percentage to the Sand Dam Channel and the Jeffery Island gives an estimate of 0.8 million tons that could ultimately be eroded in Sand Dam and 2.8 million tons eroded from Jeffery Island (Table 7-3).

Table 7-3. Estimated Erodible Weight in Sand Dam Channel and Jeffery Island.

	Sand Dam Channel	Jeffery Island
Potential Erodible Area (acres)	108	395
Average Erodible Depth (ft)	10.5	10
Total Weight within Erodible Area (Million tons)	2.4	8.3
Assume Erosion Efficiency (%)	33	33
Total Estimated Erodible Weight (Million tons)	0.8	2.8

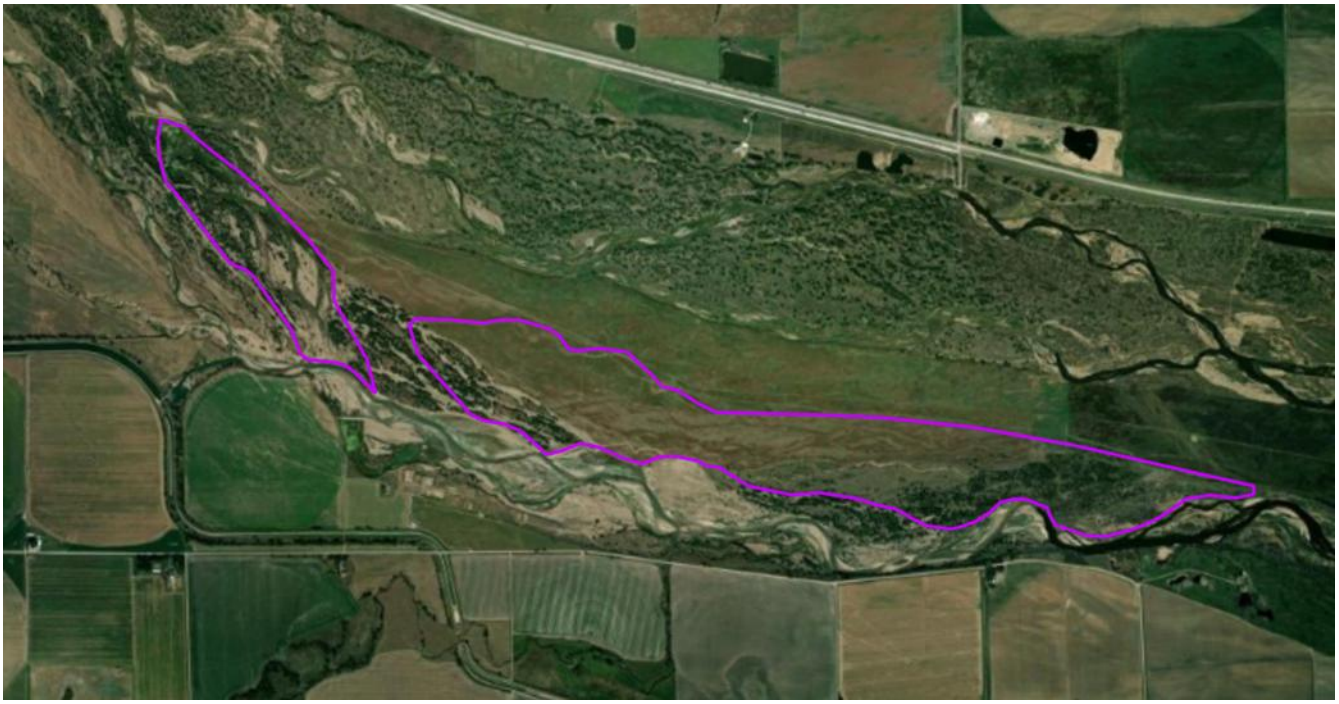

Figure 7-28 Assumed erodible area of Sand Dam Channel and Jeffery Island.

7.2.2 1D Results

Results from the above alternative models were run for the 14-year analysis period and cumulative sediment erosion/deposition in tons are compared below by reach.

7.2.2.1 North Channel

Cumulative North Channel sediment erosion/deposition is presented below in Figure 7-29. The N1, R1, R2, and I2 models all show a gradual eroding North Channel response. By the end of the 14-year period, the

least erosion in I2 and the most erosion in R2 bracket the N1 and R1 results. The S2 and S3 models predict gradual deposition in the North Channel.

The alternative S1 is not shown because the S1 alternative results in an avulsion of the North Channel into the J2 Return Channel. The model cannot simulate zero flow in a reach and therefore the model simulation terminated within the first year of simulation.

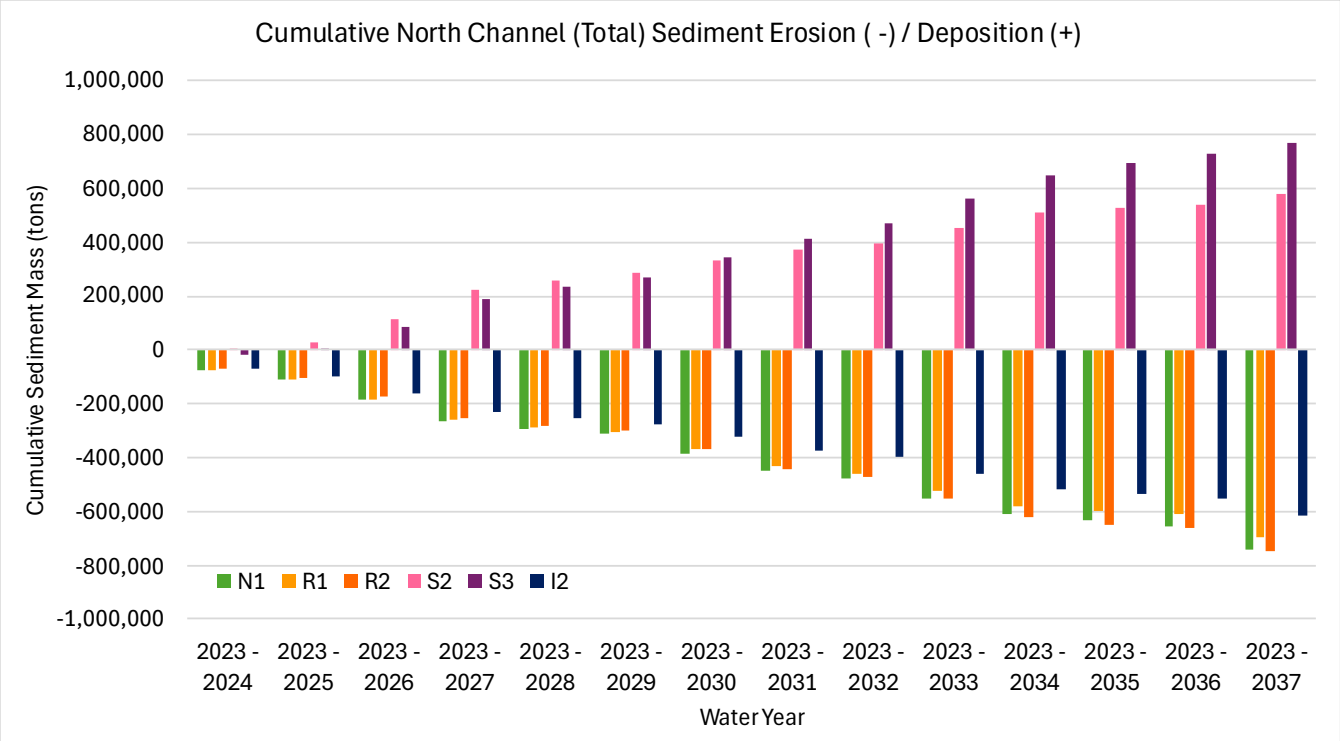

Figure 7-29. Cumulative Annual North Channel Sediment Erosion/Deposition Results from the 1D HEC-RAS models.

As the different alternatives treat the flow split between the Sand Dam Channel and the North Channel differently, results for the North Channel upstream (Figure 7-30) and downstream (Figure 7-31) are presented below. Similar amounts of erosion are shown in the Upstream North Channel for N1, R1, R2, and I2 alternatives while S2 and S3 estimate deposition upstream of the Sand Dam Channel. Downstream of the Sand Dam Channel, the North Channel shows a similar trend to the reach total, indicating the conditions below the Sand Dam Channel dictate the overall sediment erosion/deposition in the North Channel.

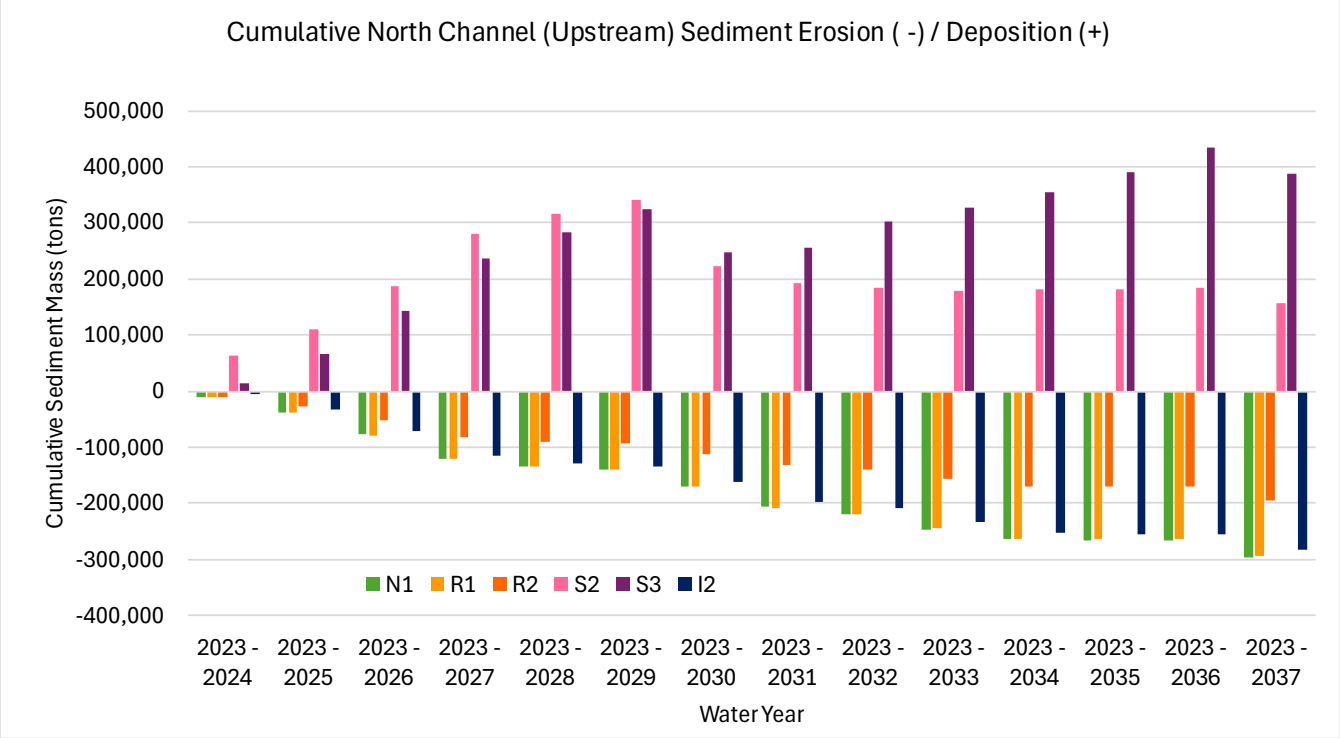

Figure 7-30. Cumulative Annual North Channel (Upstream of the Sand Dam Channel) Sediment Erosion/Deposition Results from the 1D HEC-RAS models.

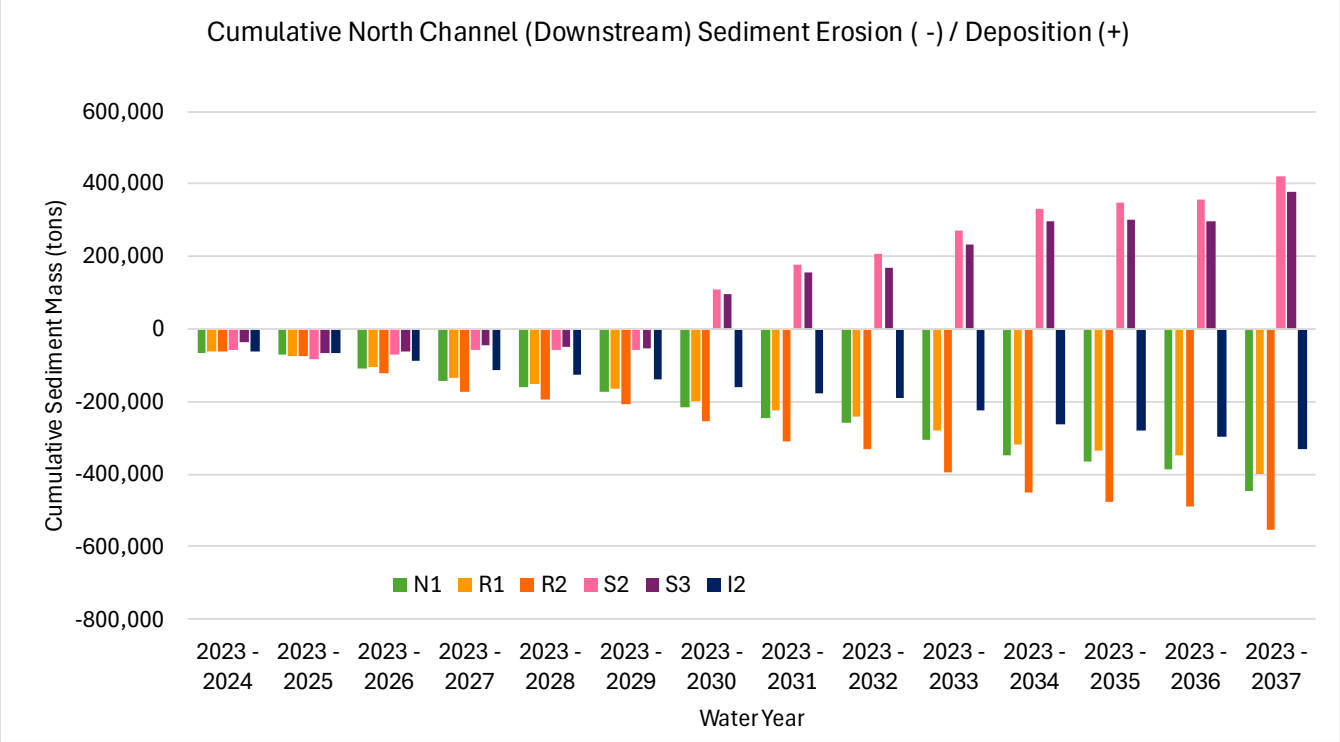

Figure 7-31. Cumulative Annual North Channel (Downstream of the Sand Dam Channel) Sediment Erosion/Deposition Results from the 1D HEC-RAS models.

7.2.2.2 Sand Dam Channel

Cumulative Sand Dam Channel sediment erosion/deposition is presented below in Figure 7-32. The clear water inflow of the R2 alternative (1/2 the J2 inflow) shows the erosive capacity of the Sand Dam Channel, while the sediment-laden inflows from the S alternatives indicate a more stable Sand Dam Channel is possible. All results show a marked erosion within the first year, then a period of increased erosion followed by a more stagnant response in the latter years. Within 5 years, the R2 alternative has scoured all available sediment within the Sand Dam Channel to that extent allowed by the model setup of 20 ft maximum scour depth.

The predicted erosion from the Sand Dam Channel in the 1D model was significantly larger than predicted in the 2D model. The primary reason for this is that the 1D model erodes the wetted portions of the cross section uniformly, while the 2D model will erode the high velocity areas much quicker than the low velocity areas. The 2D model also does not have the ability to explicitly simulate the bank erosion that will occur as vertical incision progresses. The net result is that the 2D model eroded a much smaller area than the 1D model. As mentioned previously, the alternatives analysis assumes that the larger estimate of the 1D and 2D model is used. If the alternative does not perform well with the larger estimate of erosion, it will only perform worse with the smaller estimate.

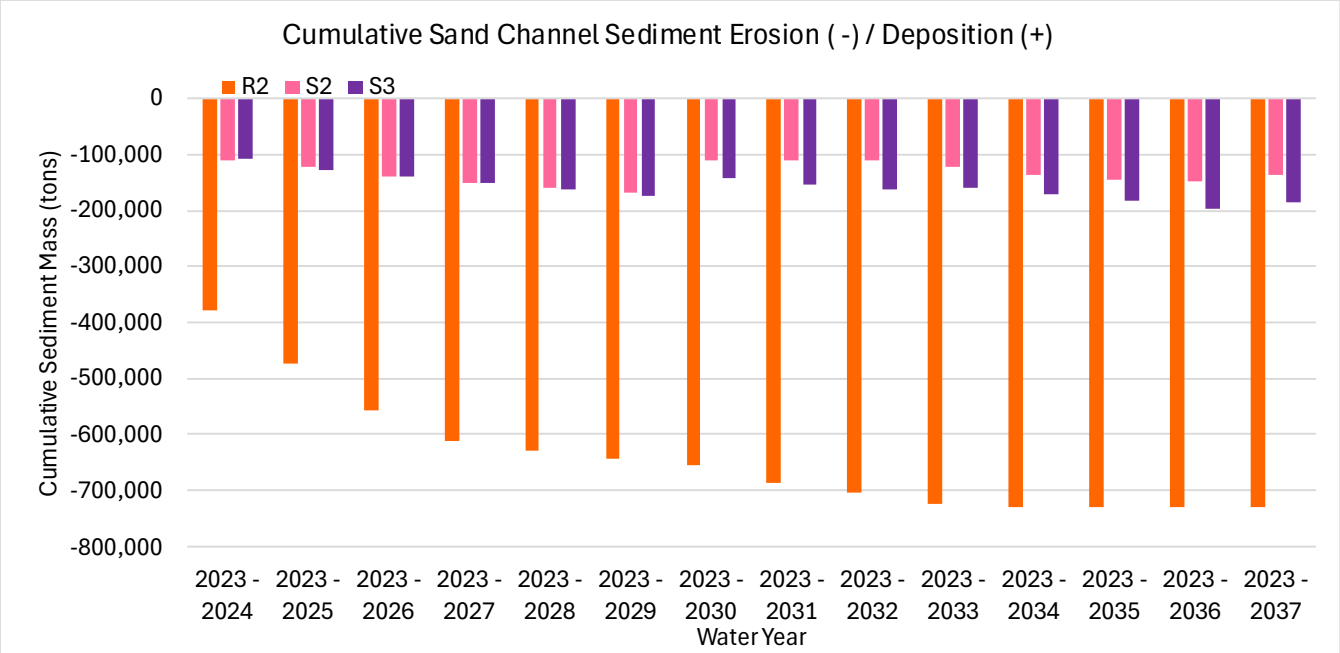

Figure 7-32. Cumulative Annual Sand Dam Channel Sediment Erosion/Deposition Results from the 1D HEC-RAS models.

7.2.2.3 J2 Return Channel

Cumulative Sand Dam Channel sediment erosion/deposition is presented below in Figure 7-33. All alternatives estimate continued erosion of the J2 Return Channel. The No Action alternative (N1) and Sand Dam structure (S2 and S3) clearly predict the most erosion in the J2 Return Channel, followed by the flow regulation alternatives (R1 and R2) with the Jeffrey Island alternative (I2) showing the least erosion within the J2 Return Channel.

The slightly counter intuitive result of alternatives S2 and S3 predicting as much or more erosion of the J2 Return Channel can be explained by a couple of mechanisms. One is that the transport capacity is non-linearly related to the flow rate. The computed average transport capacity for bed material in the North Channel and J2 Return Channels are shown in Figure 7-34. The sediment transport is approximately proportional to the flow rate raised to the 1.5 power. Therefore, this means that all other things being equal, increasing the flow rate by a factor of 2 increases the sediment transport rate by a factor of 2.8. For example, if the J2 Return Channel is running at 1500 cfs and 1000 cfs is transported to the J2 Return Channel from the North Channel, the transport capacity in the J2 Return Channel increases by approximately 9000 tons/day. The transport capacity of the North Channel at flow of 1000 cfs is only 6000 tons/day, so even though the North Channel is diverting sediment to the J2 Return Channel, the erosion of the J2 Return Channel could be increased because of the non-linear response of the J2 Return Channel. Of

course, initially the Sand Dam Channel supplies additional sediment, but this is exhausted after 5 years and long-term only sediment from the North Channel is supplied to the J2 Return Channel.

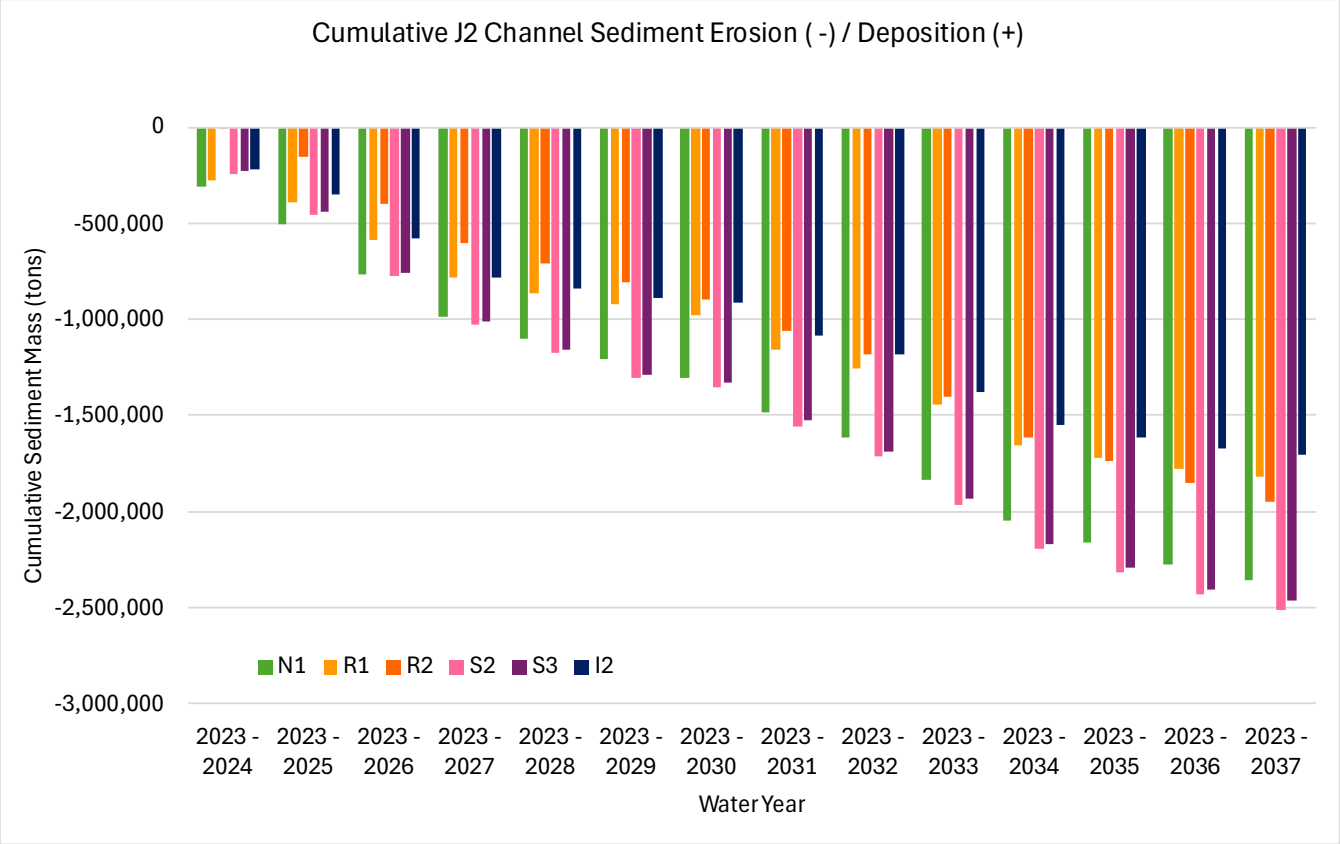

Figure 7-33. Cumulative Annual J2 Return Channel Sediment Erosion/Deposition Results from the 1D HEC-RAS models.

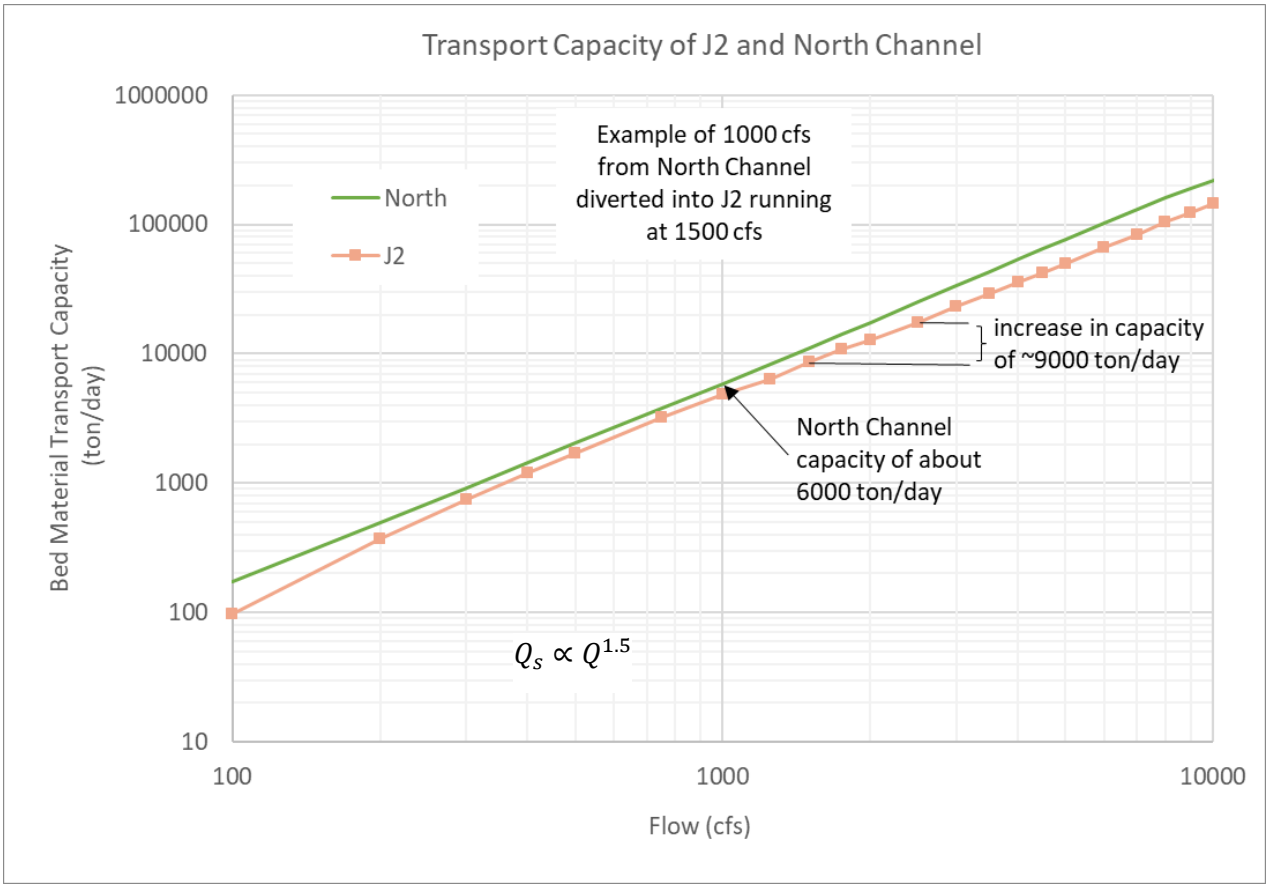

Figure 7-34. Transport Capacity Analysis of North and J2 Return Channels.

7.2.2.4 Downstream Channel

Cumulative Downstream Channel sediment erosion/deposition is presented below in Figure 7-33. The Downstream Channel estimated sediment erosion/deposition offers the most varied response as compared to the other reaches. The S2 and S3 alternative shows consistent, increasing deposition in the Downstream Channel with theN1, R1, and R2 alternatives predicting erosion that varies across the 14-year prediction time. The I2 alternative initially erodes sediment in the Downstream Channel but switches to deposition in the latter half of the analysis period. Of note is the relatively low amount of erosion/deposition as compared to the incoming sediment transport shown below in Figure 7-36. The delivery of sediment to the Downstream Channel appears relatively similar among the alternatives over the duration of the assessment period.

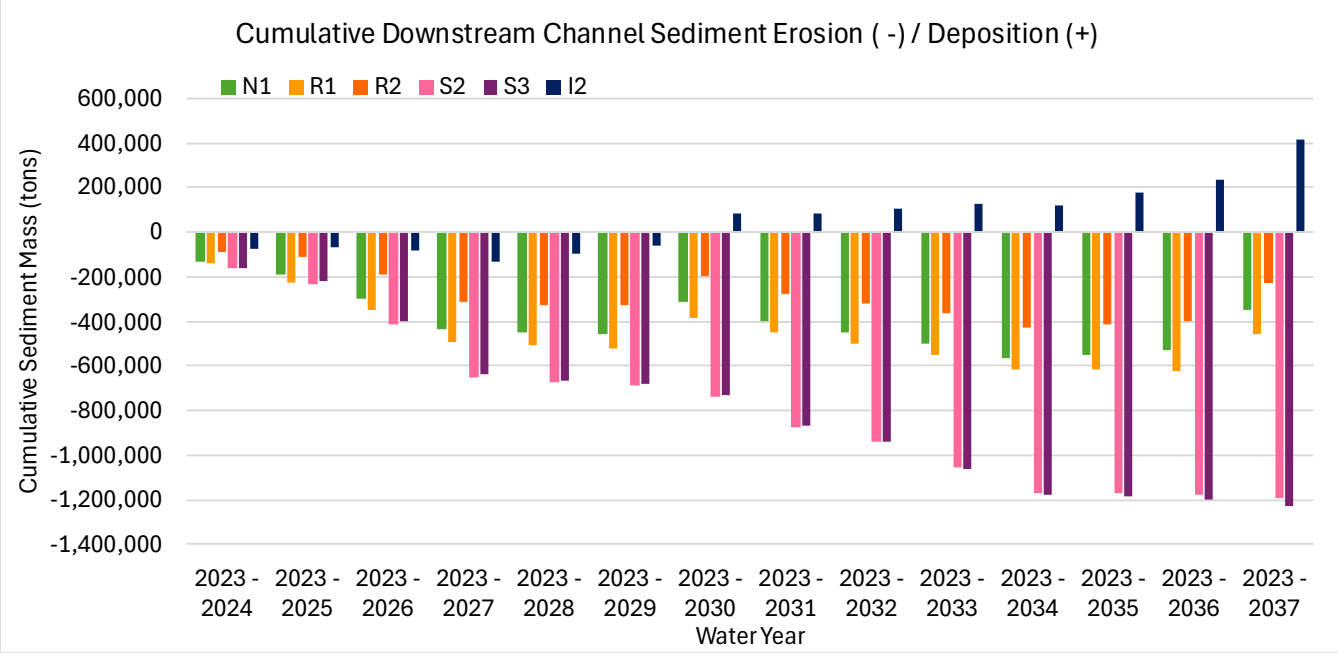

Figure 7-35. Cumulative Annual Downstream Channel Sediment Erosion/Deposition Results from the 1D HEC-RAS models.

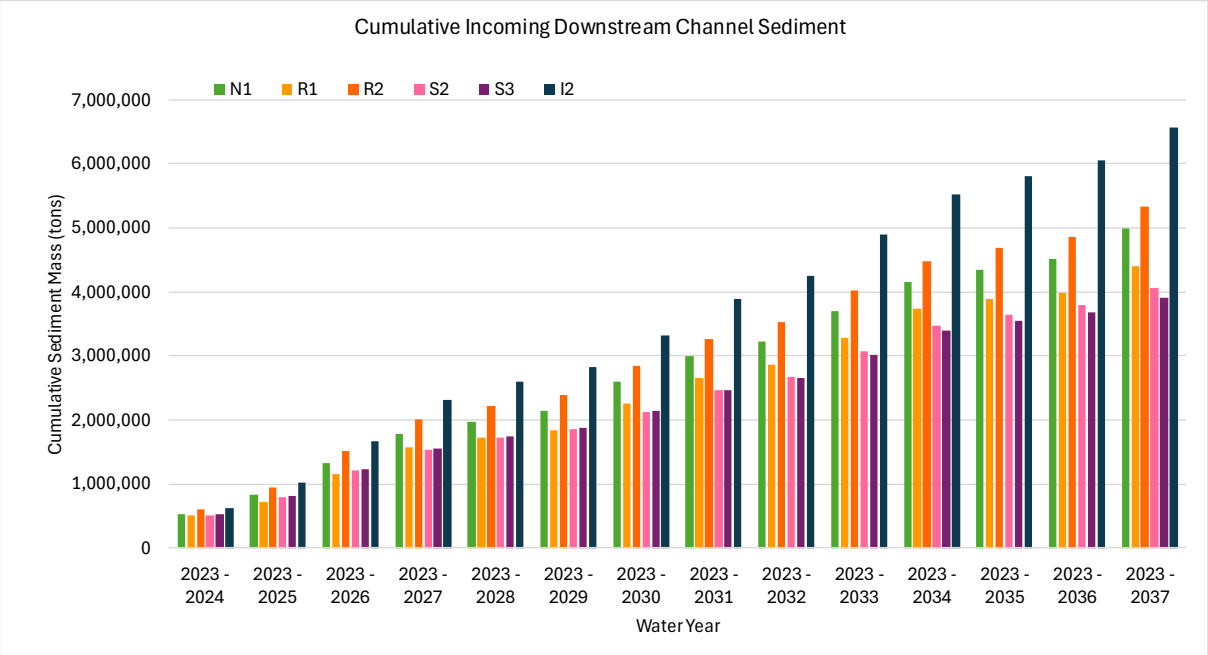

Figure 7-36. Cumulative Annual Incoming Sediment at upstream end of Downstream Channel from the 1D HEC-RAS models.

8 Conceptual Design and OPCC

Simulations S2, R2, and I2 were selected for conceptual design and for development of Opinion of Probable Construction Costs (OPCC) as representative options for each alternative as part of the Reconnaissance level analysis. Conceptual design plans are included in Appendix B. For each alternative cost analysis, initial conditions were included. The costs include construction and design, but do not include other non-contract costs such as contract management and it does not include maintenance costs.

Alternative S2 includes the fixed weir along with a Type II stilling basin to provide energy dissipation (see Appendix B for conceptual design). The wall heights and stilling basin length were designed to accommodate a 100-year event. With future design efforts, consideration should be given to more detailed analysis of the crest length and tailwater depth. Weir gates were included to provide the opportunity to cut off flow to the Sand Dam Channel if necessary. Modifications to the existing Sand Dam were not included in the design or cost analysis and should be considered with future design efforts. Costs for S2 are included in Table 8-1.

Table 8-1. S2 OPCC estimate

PAY ITEM DESCRIPTION	ITEM NO. FOR PRICING*	UNIT	QUANTITY	UNIT PRICE	TOTAL COST	ITEM NOTES
ENGINEERING DESIGN SERVICES		LUMP SUM	1	$ 870,000	$ 870,000	
CONSTRUCTION						
Mobilization		LUMP SUM	1	$ 870,000	$ 870,000	
General Clearing and Grubbing		LUMP SUM	1	$ 85,000	$ 85,000	
Traffic Control		LUMP SUM	1	$ 130,000	$ 130,000	
Construction Staking and Surveying		LUMP SUM	1	$ 170,000	$ 170,000	
Water Control/Dewatering		LUMP SUM	1	$ 260,000	$ 260,000	
Erosion Control		LUMP SUM	1	$ 220,000	$ 220,000	
Earthwork	1010.27	CU YD	2,400	$ 34	$ 81,600	Net earthwork cut
Granular Backfill	8091	CU YD	2,350	$ 44	$ 103,400	
Class 47B-4000 Concrete	4115.28	CU YD	780	$ 1,032	$ 804,960	
Epoxy Coated Reinforcing Steel	4159.55	POUND	134,220	$ 5.10	$ 684,522	
Steel Sheet Piling	6310.00	SQ FT	5,660	$ 31	$ 175,460	
Weir Gates		LUMP SUM	1	$ 2,000,000	$ 2,000,000	
Construction Incidentals		LUMP SUM	1	$ 1,080,000	$ 1,080,000	
				CONSTRUCTION SUBTOTAL (nearest $1000)	$ 6,665,000	
				CONSTRUCTION CONTINGENCY (nearest $1000)	$ 1,999,000	Assumes 30%
				CONSTRUCTION TOTAL (nearest $1000)	$ 8,664,000	
CONSTRUCTION ENGINEERING SERVICES		LUMP SUM	1	$ 870,000	$ 870,000	
				TOTAL (nearest $1000)	**$ 10,404,000**	

* Item numbers and pricing based on Nebraska DOT standard items and 2024 cost data where included unless otherwise noted. Items without numbers based on percentage of total construction cost unless otherwise noted.

R2 requires an inlet on the J2 Canal 150 ft wide set at an invert elevation of 2357 ft (see Appendix B for conceptual design). It was assumed that the existing J2 Canal check gates at the J2 Return Channel outlet would be modified to provide the necessary head to convey flow for R2. Future design efforts should include consideration of impacts of backing up additional water in the J2 Canal and any modifications necessary to the J2 Canal resulting from the impacts. Flow transitions from the inlet to a 50 ft wide trapezoidal conveyance channel. Reinforced concrete box culverts were included beneath the concrete channel to convey Breakthrough Channel flow corresponding with a 50-year event on the North Channel. A reinforced concrete box culvert was also included beneath the concrete channel to convey flow for the channel immediately to west of the Breakthrough Channel and designed based on an assumed flow of 200 cfs. Future design efforts should include analysis of the hydrology for the channel to determine a more accurate design flow. To minimize seepage from the conveyance channel over the box culverts, concrete cloth lining was included. For the existing channel east of the Breakthrough Channel and the three main Sand Dam Channel branches, it was assumed that flow would be blocked off at the existing channel locations due to minimal clearance between the existing channel inverts and the conveyance channel inverts at the corresponding locations. At these locations, cohesive cores were included in the upstream embankment along the conveyance channel and riprap protective cover on the downstream embankment slopes at these locations. Concrete cloth lining was included in the conveyance channel as well. Riprap protection was included at the outlet of the concrete channel. Further design consideration should be given to the necessity for protection at events other than the North Channel 50-year event. Consideration should also be given to syphoning flow beneath the conveyance channel for existing channels proposed to be blocked off or to re-routing those existing channels to alternative locations. OPCC for R2 are included in Table 8-2.

Table 8-2. R2 OPCC estimate

PAY ITEM DESCRIPTION	ITEM NO. FOR PRICING*	UNIT	QUANTITY	UNIT PRICE	TOTAL COST	ITEM NOTES
ENGINEERING DESIGN SERVICES		LUMP SUM	1	$ 1,110,000	$ 1,110,000	
CONSTRUCTION						
Mobilization		LUMP SUM	1	$ 1,780,000	$ 1,780,000	
General Clearing and Grubbing		LUMP SUM	1	$ 230,000	$ 230,000	
Traffic Control		LUMP SUM	1	$ 340,000	$ 340,000	
Construction Staking/Surveying		LUMP SUM	1	$ 450,000	$ 450,000	
Water Control/Dewatering		LUMP SUM	1	$ 670,000	$ 670,000	
Erosion Control		LUMP SUM	1	$ 550,000	$ 550,000	
Earthwork	1010.27	CU YD	49,500	$ 34	$ 1,683,000	Net earthwork fill
Rock Riprap	1031	TON	5,330	$ 97	$ 517,010	
Granular Backfill	8091	CU YD	5,400	$ 73	$ 394,200	Inlet structure, cast-in-place concrete box culvert, wingwalls for box culverts
Slurry Cut-Off Wall	521-00000 [1]	SQ FT	12,430	$ 40	$ 497,200	
Class 47B-3000 Concrete for Box Culvert	4101.06	CU YD	1,270	$ 841	$ 1,068,070	Cast-in-place triple 20' x 10'
Class 47B-3000 Concrete	4100.06	CU YD	900	$ 1,237	$ 1,113,300	Inlet structure, wingwalls for box culverts
Epoxy Coated Reinforcing Steel	4159.55	POUND	421,750	$ 5.10	$ 2,150,925	Inlet structure, cast-in-place concrete box culvert, wingwalls for box culverts
Precast Reinforced Concrete Box Culvert	603-70804 [1]	LIN FT	165	$ 2,160	$ 356,400	8' x 4'
Modify Existing Check Gates	—— [2]	EACH	1	$ 1,000,000	$ 1,000,000	
Concrete Cloth Liner	—— [2]	SQ YD	14,320	$ 130	$ 1,861,600	
Flowable Fill Concrete	3089.8	CU YD	720	$ 410	$ 295,200	Concrete cloth trench backfill
Construction Incidentals		LUMP SUM	1	$ 2,225,000	$ 2,225,000	
				CONSTRUCTION SUBTOTAL (nearest $1000)	$ 17,182,000	
				CONSTRUCTION CONTINGENCY (nearest $1000)	$ 5,155,000	Assumes 30%
				CONSTRUCTION TOTAL (nearest $1000)	$ 22,336,000	
CONSTRUCTION ENGINEERING SERVICES		LUMP SUM	1	$ 2,240,000	$ 2,240,000	
				TOTAL (nearest $1000)	**$ 25,686,000**	

* Item numbers and pricing based on Nebraska DOT standard items and 2024 cost data where included unless otherwise noted. Items without numbers based on percentage of total construction cost unless otherwise noted.
[1] Item numbers and pricing based on Colorado DOT standard items and 2024 cost data or cost data projected to 2024 values
[2] Pricing estimated based on bid results from 2024

I2 requires the same inlet at the J2 Canal, modifications to the existing J2 Canal check gates, and conveyance channel dimensions as R2B (see Appendix B for conceptual design). Similarly, future design efforts should consider any impacts to the J2 Canal and modifications required by them. Reinforced concrete box culverts were included beneath the conveyance channel to pass flows corresponding with a North Channel 50-year event for the Breakthrough Channel, the channel immediately east of the Breakthrough Channel, and for the three main branches of the Sand Dam Channel. A reinforced concrete box culvert was also assumed for the channel immediately west of the Breakthrough Channel, with sizing based on the assumed flow of 200 cfs. As previously stated, future design efforts should include analysis of the hydrology of the channel to determine a more accurate design flow. Concrete cloth lining was included in the conveyance channel where it crosses the box culverts to minimize seepage from the conveyance channel. At the outlet of the conveyance channel, flow enters a riprap lined basin to dissipate energy prior to entering the Jeffery Island pilot channel. Further design consideration should be given to the necessity for protection in the event that the conveyance channel embankments are overtopped. OPCC for I2 are included in Table 8-3.

Table 8-3. I2 OPCC estimate

PAY ITEM DESCRIPTION	ITEM NO. FOR PRICING*	UNIT	QUANTITY	UNIT PRICE	TOTAL COST	ITEM NOTES
ENGINEERING DESIGN SERVICES		LUMP SUM	1	$ 1,000,000	$ 1,000,000	
CONSTRUCTION						
Mobilization		LUMP SUM	1	$ 1,610,000	$ 1,610,000	
General Clearing and Grubbing		LUMP SUM	1	$ 200,000	$ 200,000	
Traffic Control		LUMP SUM	1	$ 295,000	$ 295,000	
Construction Staking and Surveying		LUMP SUM	1	$ 395,000	$ 395,000	
Water Control/Dewatering		LUMP SUM	1	$ 595,000	$ 595,000	
Erosion Control		LUMP SUM	1	$ 500,000	$ 500,000	
Earthwork	1010.27	CU YD	118,100	$ 34	$ 4,015,400	Net earthwork cut
Rock Riprap	1031.00	TON	1,100	$ 97	$ 106,700	
Granular Backfill	8091.00	CU YD	8,230	$ 73	$ 600,790	Inlet structure, cast-in-place concrete box culvert, wingwalls for box culverts
Class 47B-3000 Concrete for Box Culvert	4101.06	CY	1,230	$ 841	$ 1,034,430	Cast-in-place triple 20' x 10'
Class 47B-3000 Concrete	4100.06	CY	1,150	$ 1,237	$ 1,422,550	Inlet structure, wingwalls for box culverts
Epoxy Coated Reinforcing Steel	4159.55	POUND	442,300	$ 5.10	$ 2,255,730	Concrete channel, cast-in-place concrete box culvert, wingwalls for box culverts
Precast Reinforced Concrete Box Culvert	603-70603 [1]	LIN FT	162	$ 1,957	$ 317,034	6' x 3'
Precast Reinforced Concrete Box Culvert	SS-01-001 [3]	LIN FT	178	$ 1,071	$ 190,638	10' x 3'
Precast Reinforced Concrete Box Culvert	SS-01-003 [3]	LIN FT	166	$ 1,428	$ 237,048	16' x 3'
Precast Reinforced Concrete Box Culvert	603-70804 [1]	LIN FT	179	$ 2,158	$ 386,282	8' x 4'
Precast Reinforced Concrete Box Culvert	603-70503 [1]	LIN FT	165	$ 2,338	$ 385,770	8' x 6'
Modify Existing Check Gates	—— [2]	EACH	1	$ 1,000,000	$ 1,000,000	
Concrete Cloth Liner	—— [2]	SQ YD	17,900	$ 130	$ 2,327,000	
Flowable Fill Concrete	3089.80	CU YD	900	$ 410	$ 369,000	Concrete cloth trench backfill
Construction Incidentals		LUMP SUM	1	$ 2,025,000	$ 2,025,000	
				CONSTRUCTION SUBTOTAL (nearest $1000)	$ 20,162,000	
				CONSTRUCTION CONTINGENCY (nearest $1000)	$ 6,049,000	Assumes 30%
				CONSTRUCTION TOTAL (nearest $1000)	$ 26,211,000	
CONSTRUCTION ENGINEERING SERVICES		LUMP SUM	1	$ 2,020,000	$ 2,020,000	
				TOTAL (nearest $1000)	**$ 29,230,000**	

* Item numbers and pricing based on Nebraska DOT standard items and 2024 cost data where included unless otherwise noted. Items without numbers based on percentage of total construction cost unless otherwise noted.
[1] Item numbers and pricing based on Colorado DOT standard items and 2024 cost data or cost data projected to 2024 values
[2] Pricing estimated based on bid results from 2024
[3] Item numbers and pricing based on Mile High Flood District standard items and cost data projected to 2024 values

The OPCC for each alternative are summarized for comparison in Table 8-4.

Table 8-4. OPCC comparison

DESCRIPTION	S2 TOTAL COST	R2 TOTAL COST	I2 TOTAL COST
ENGINEERING DESIGN SERVICES	$ 415,000	$ 1,110,000	$ 1,000,000
CONSTRUCTION TOTAL	$ 4,159,000	$ 22,336,000	$ 26,210,000
CONSTRUCTION ENGINEERING SERVICES	$ 415,000	$ 2,240,000	$ 2,020,000
TOTAL	**$ 10,404,000**	**$ 25,686,000**	**$ 29,230,000**

9 Alternative Evaluation

The results from the 1D and 2D HEC-RAS simulations are combined to develop recommendations for each alternative. As described previously, the 1D model was used to simulate the total erosion and deposition in each reach over the 14-yr period of simulation. It provides a consistent framework from which to compare results among all alternatives. The 2D model was used to represent shorter-duration, complex erosion response in the Sand Dam Channel and in Jeffery Island for the alternatives where flow is used to erode sediment at those locations. Because 2D numerical simulation times were long, the model was limited to simulating a single year; however, sediment production was noted to approach an equilibrium condition for all evaluations at the conclusion of the year simulation.

In some cases, the 1D and 2D model simulations produced different results. These discrepancies are described in the section below and the range of possibility is considered in the alternative evaluation. In cases where there are different estimates, the higher estimate of erosion (sediment production) is used to evaluate the alternative. If the alternative does not perform well under the optimistic assumption, it can be assumed to perform worse if a lower sediment production is assumed. The uncertainties associated with the model are also mitigated by comparing the erosion and deposition predicted against the No Action Alternative. Therefore, the more important result is the relative change from the No Action and not the absolute result.

9.1 No Action (N1)

Under No Action, there is no active sediment augmentation and the J2 return flows are similar to the existing condition. The erosion trends under No Action are similar to those observed in the recent past.

The North Channel is estimated to experience erosion of approximately 53,000 tons/yr, and this erosion rate is considered to be relatively small as it would be spread out over the 11-mile-long reach. The erosion rate per mile is 4,800 tons/mi/yr. Based upon the previous historical analysis from 2016 – 2023, there are years that experienced deposition and years that experienced erosion, and it is likely that periods of erosion and deposition will continue into the future in the North Channel.

The J2 Return Channel is predicted to erode at a rate of 169,000 tons/yr. The rate of erosion of J2 Return channel is approximately the same as the rates over the last 7 years (173,000 tons/yr). The pattern of increased meandering is expected to continue, though the relative balance of vertical bed degradation versus bank erosion is not a direct output of the HEC-RAS model and difficult to predict.

The Downstream Channel is estimated to be relatively stable over the 14-yr simulation period with only 25,000 tons/yr of erosion predicted, with periods of erosion and deposition estimated to occur during the simulation. The erosion in the Downstream Channel is similar to the calibration period. Eventually, the erosional trend observed in the J2 Return Channel is predicted to propagate into the Downstream Channel, but the simulations were not long enough to determine when this would occur. One complication in extrapolating the mobile bed sediment simulations to multiple decadal simulations is that the 1D or 2D

model cannot represent the increase in river sinuosity and therefore bank erosion that is occurring within the J2 Return Channel. However, because we calibrated the models to the observation over the previous 7 years, the extrapolation to the next 14-year period is considered reasonable.

A schematic showing annual average transport rates and erosion/deposition rates is given in Figure 9-1.

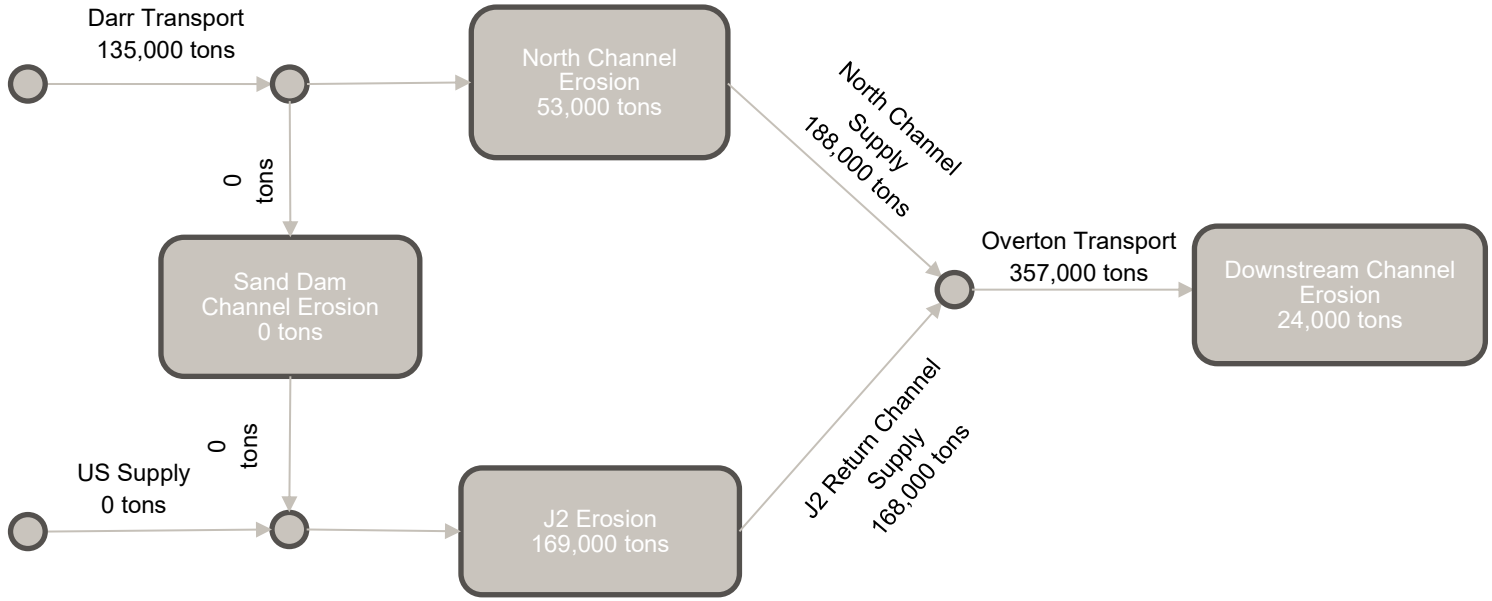

Figure 9-1. Predicted annual average sediment budget for N1 Alternative during 14-yr simulation period.

9.2 Re-Regulation of J2 Return Flows (R1)

This alternative alters the timing of the flow being discharged into the J2 Return Channel. Instead of the hourly fluctuations in flow resulting from hydropower operations, the flow rate over each month is assumed constant. On a monthly basis this alternative has the same volume of flow as the No Action alternative. Because this alternative does not materially affect the flow or sediment regime in the North Channel, there is no significant change in the North Channel for this alternative relative to No Action.

The reduction of peak flows from the J2 return is estimated to reduce the erosion in the J2 Return Channel by approximately 23% from 169,000 tons/yr to 130,000 tons/yr. The Downstream Channel is still relatively stable, with only 33,000 tons/yr of erosion. There is not a clear trend of erosion or deposition in the Downstream Channel and there are years of deposition and years of erosion in the Downstream Channel.

The alternative would require significant changes to the hydropower operations or the construction of a re-regulation facility downstream of the hydropower facility. The cost of implementing R1 is unknown as designing the operations and/or facilities necessary to accomplish this alternative were outside the scope of this study.

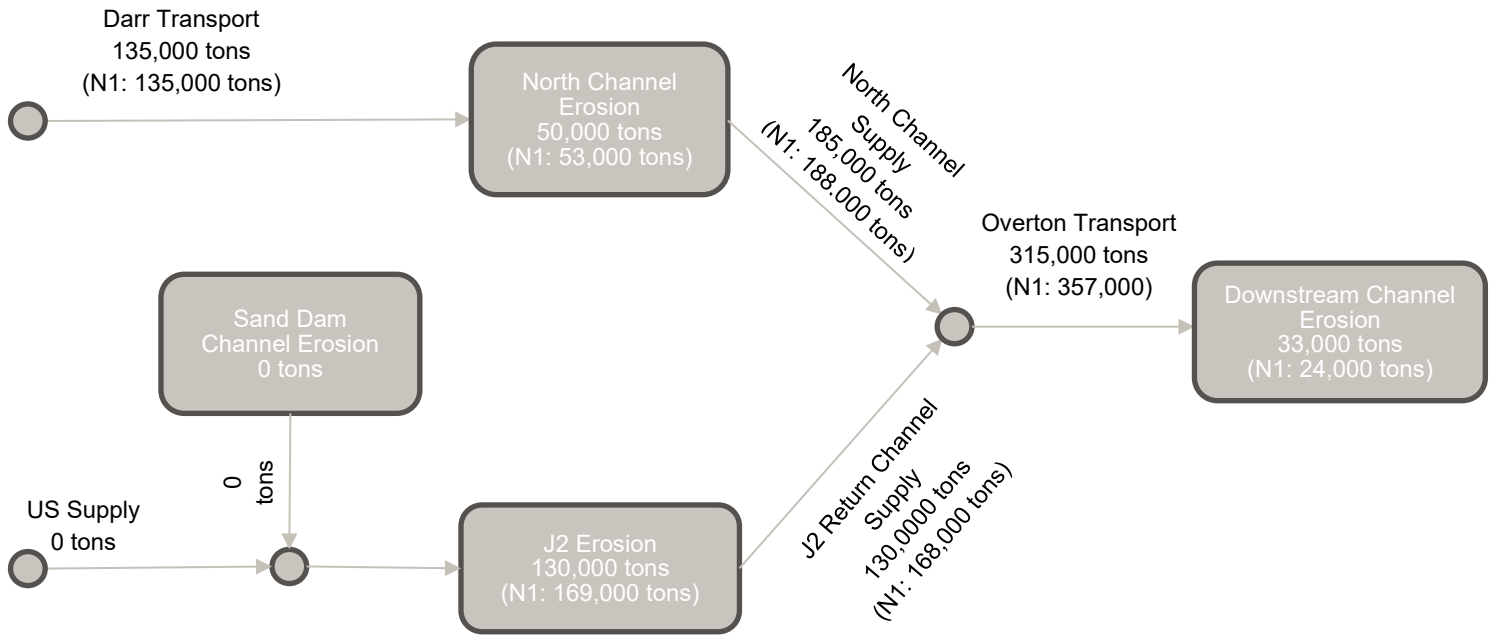

Figure 9-2. Predicted annual average sediment budget for R1 Alternative during 14-yr simulation period. Values for the No Action Alternative (N1) are given in parenthesis for comparison.

9.3 Route J2 Return Flows to Sand Dam (R2)

The R2 alternative routes one-half of the flow from the J2 Return to the Sand Dam Channel. It is possible to design this alternative to divert more or less flow than one-half of the J2 return, but as an initial estimate of balancing cost of construction versus effectiveness, we simply assumed that half of the J2 return would be diverted, which equates to a maximum flow of approximately 1000 cfs routed in the Sand Dam channel.

Several 1D and 2D simulations were performed to understand sediment transport under this alternative. The 2D simulations predicted 40,000 to 80,000 tons of erosion of sediment in the first year, depending upon the location where the flow is released. In subsequent years, it was necessary to assume that significant channel grading or flow diversion structures would be required to erode significant additional sediment out of the Sand Dam Channel. After 3 years, the 2D model results suggested that the sediment may be effectively exhausted from the Sand Dam Channel. However, as stated previously, the 2D model is expected to underestimate that lateral erosion processes would occur and the 3-year duration of erosion may be conservatively low.

The 1D model was also used to simulate the R2 alternative. The 1D model assumes that the areas of the cross section that are inundated at a given time step all erode the same depth. While the lateral erosion processes are not directly incorporated into the 1D model, the erosion width in the 1D model is significantly greater than the 2D model. The result is that the 1D model estimates significantly more erosion of sediment than the 2D model. The 1D model predicts that over 350,000 tons of sediment is eroded the first year, then by year 5, the erosion in the Sand Dam Channel is essentially complete with slightly over 700,000 tons of erosion predicted in the Sand Dam Channel. It is likely that the 1D and 2D results represent the range of uncertainty associated with this alternative. If the amount of erosion that occurs is closer to the 2D result, additional mechanical manipulation would be required to access the 700,000 tons of sediment in the Sand Dam that the 1D model predicted.

Based upon the 1D model, the Alternative R2 is predicted to essentially arrest erosion of the J2 Return Channel for 2 years. Over the 14-yr simulation period, however, there is still predicted to be almost 2,000,000 tons of erosion of the J2 Return Channel, but this is approximately 380,000 tons less erosion than estimated under No Action. The alternative also results in slightly less erosion (19,000 tons/yr) of sediment in the Downstream Channel over the simulation period.

The OPCC of implementing R2 was estimated to be $25,686,000.

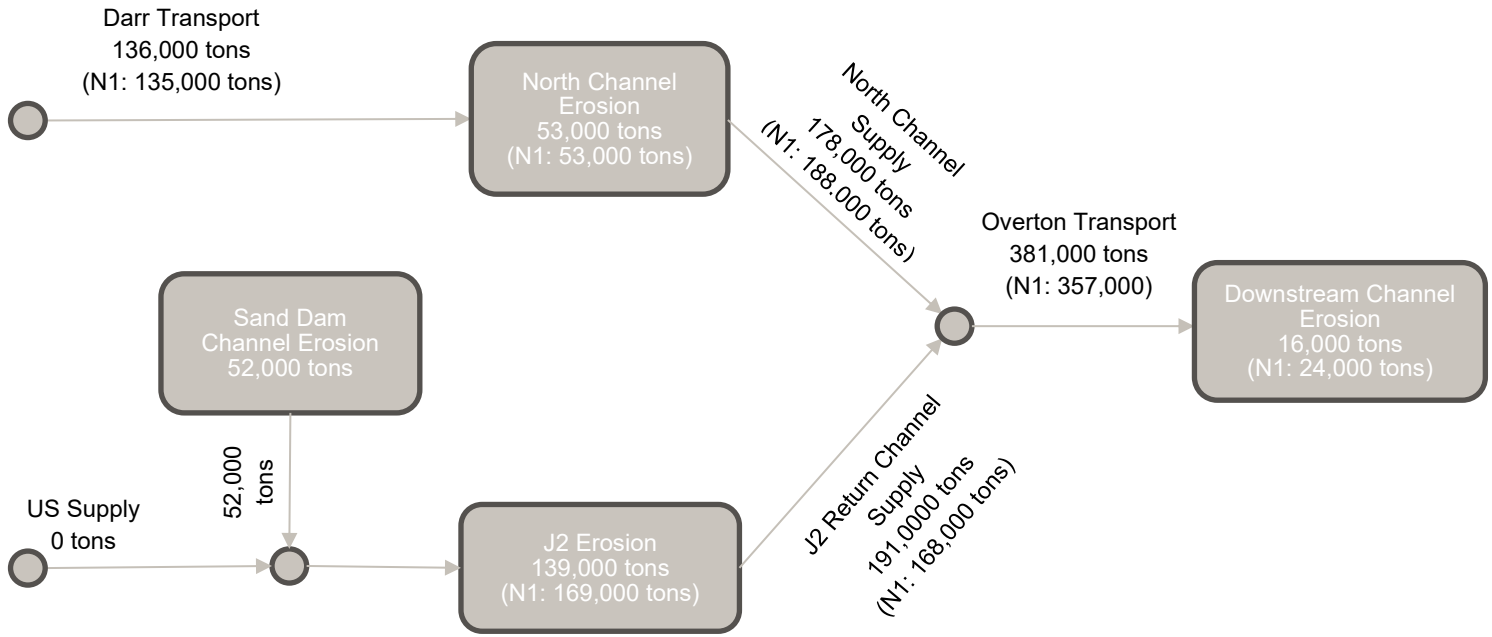

Figure 9-3. Predicted annual average sediment budget for R2 Alternative during 14-yr simulation period. Values for the No Action Alternative (N1) are given in parenthesis for comparison.

9.4 Remove Sand Dam (S1)

The 2D and 1D models were used to evaluate the removal of the Sand Dam. Both models predicted that an avulsion of the North Channel into the J2 Return Channel would begin to form within the first year of simulation. This would mean that the North Channel downstream of the Sand Dam would be dry until the confluence of the J2 Return Channel and the Downstream Channel. It would be possible to simulate this alternative, but the avulsion of the North Channel into the J2 Return Channel was not considered a viable alternative to pursue in this study.

9.5 Construct Overflow Weir at Sand Dam (S2)

The Sand Dam Alternative, S2, constructs an overflow weir that routes flow and sediment into the Sand Dam Channel. In this reconnaissance assessment, it is assumed that the flow in the North Channel is split equally between the Sand Dam Channel and the Downstream North Channel in the 1D model.

The response of the Platte River system to this alternative is complex because of the re-routing of flow and sediment into the Sand Dam Channel. The average transport and erosion rates over the 14-yr simulation is shown in Figure 9-4. This alternative erodes material from the Sand Dam Channel, but the amounts are smaller than those predicted under the R2 alternative, because while the R2 alternative diverts clear water in the Sand Dam Channel, the S2 alternative diverts both flow and sediment to the Sand Dam Channel. There are also significantly larger flow volumes entering the Sand Dam Channel under R2 than S2.

In the first 5 years, the 1D model predicted approximately 160,000 tons of erosion within the Sand Dam Channel. After the first 5 years, no appreciable erosion occurs within the Sand Dam Channel.

The S2 alternative is predicted to decrease erosion of the J2 Return Channel the first two years, but long term the effect is not significant. In the first two years, the erosion in J2 is reduced by 9%, but over the 14-yr period, the model predicts a slight increase in erosion. The erosion of the Sand Dam Channel essentially stops after 5 years, and while the weir diverts sediment into the J2 Return Channel, the alternative is also diverting additional flow which increases the sediment demand in the J2 Return Channel. The 2D model predicted significantly less erosion of the Sand Dam channel than the 1D model, and the sediment budget presented below is using the 1D results. If the 2D estimate for were used for erosion of the Sand Dam Channel, the erosion of the J2 Return Channel would be expected to increase and there could also be a modest increase in the Downstream Channel Erosion.

This alternative reduces the high flows in the North Channel, and the reduction in flow in the North Channel results in deposition and significantly less sediment is delivered to the downstream channel. This results in significant increase in erosion of the Downstream Channel, increasing the average annual erosion from 24,000 under N1 to 84,000 tons under S2.

The OPCC of implementing S2 was estimated to be $10,404,000.

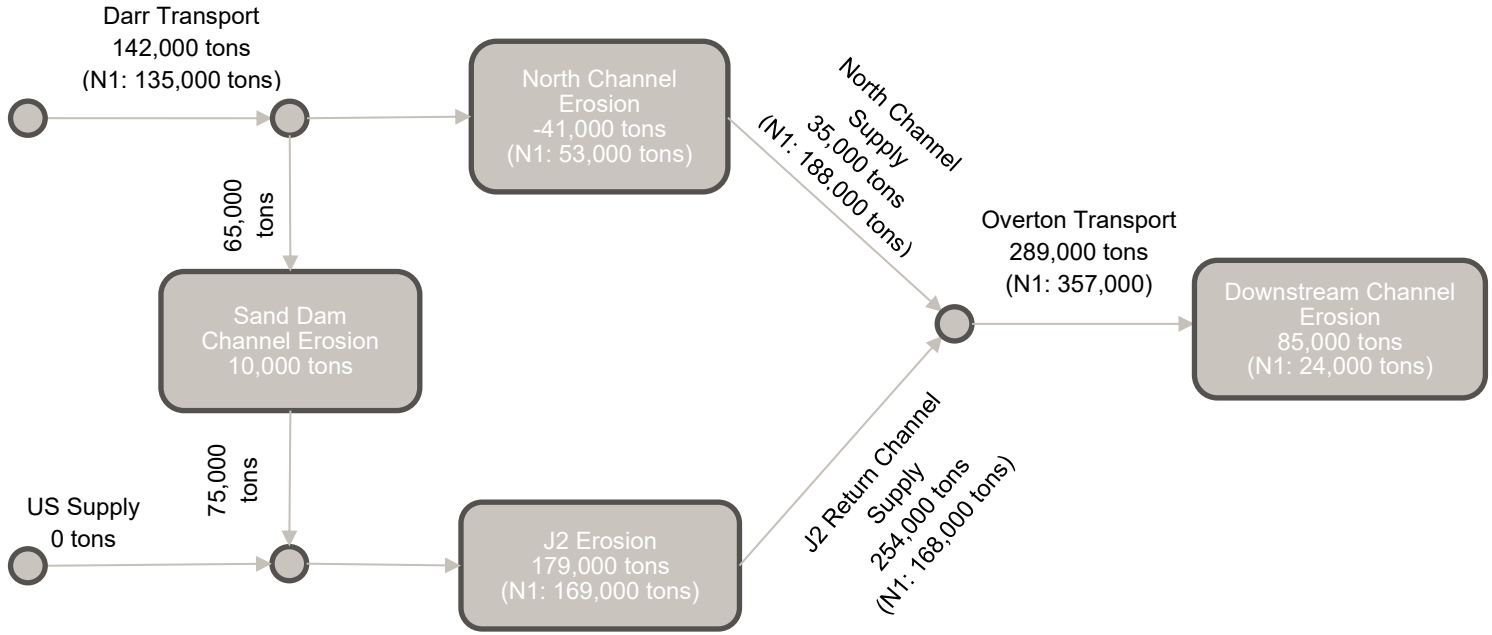

Figure 9-4. Predicted annual average sediment budget for S2 Alternative during 14-yr simulation period. Values for the No Action Alternative (N1) are given in parenthesis for comparison.

9.6 Construct Bottom Opening Date at Sand Dam (S3)

The Sand Dam Alternative, S3, constructs a bottom opening gate that will open at high flow to route flow and sediment into the Sand Dam Channel. This alternative starts to activate the Sand Dam Channel at flows above 500 cfs in the North Channel, which would occur approximately 15 % of the time.

The response of the Platte River system to this alternative is complex because of the re-routing of flow and sediment. The average transport and erosion rates over the 14-yr simulation is shown in Figure 9-5. This alternative eroded material from the Sand Dam Channel, but the amounts are smaller than those predicted under the R2 alternative, because while the R2 alternative diverts clear water in the Sand Dam Channel, the S2 alternative diverts both flow and sediment to the Sand Dam Channel. There is also significantly less flow entering the Sand Dam Channel under S3 than R2, with approximately three times the flow entering the Sand Dam channel under Alternative R2 as compared to S3 alternative.

In the first 5 years, the model predicted approximately 140,000 tons of erosion within the Sand Dam Channel. After the first 5 years, no appreciable erosion occurs within the channel. This alternative diverts significantly both flow and sediment from the North Channel into the Sand Dam Channel and the predicted annual average transport into the Sand Dam Channel is 58,000 tons/yr.

The erosion of the J2 Return Channel is estimated to reduce the first few years of the S3 alternative, but long term the effect is not significant. In the first two years, the erosion in J2 Return Channel is reduced by 13%, but over the 14-yr period, the reduction is not significant. This is because the erosion of the Sand Dam Channel essentially stops after 5 years, and while the weir diverts sediment into the J2 Return Channel, the alternative diverts additional flow which increases the sediment demand in the J2 Return Channel.

The 2D model predicted significantly less erosion of the Sand Dam channel than the 1D model, and the sediment budget presented below is using the 1D results. If the 2D estimate for were used, the erosion of the J2 Return Channel would be expected to increase and there could also be a modest increase in the Downstream Channel Erosion.

Similar to the S2 alternative, the alternative results in a significant increase in erosion of the Downstream Channel, increasing the average annual erosion from 24,000 under N1 to 88,000 tons/yr under S2.

The OPCC of S3 was estimated to be similar to S2 for the purposes of the Reconnaissance level analysis, or $10,404,000.

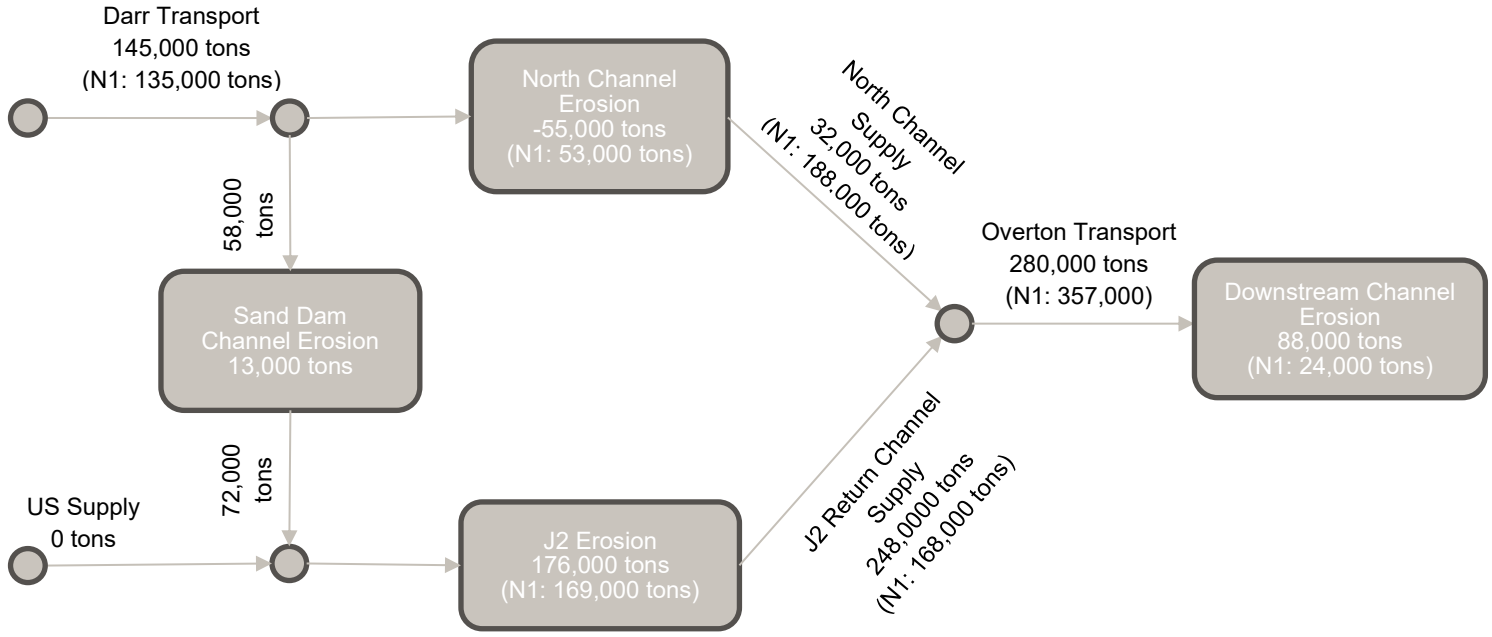

Figure 9-5. Predicted annual average sediment budget for S3 Alternative during 14-yr simulation period. Values for the No Action Alternative (N1) are given in parenthesis for comparison.

9.7 Diversion of North Channel water into Jeffrey Island (I1)

This alternative was not explicitly simulated after reviewing the analyses of the S2 and S3 alternatives. The Alternative does not appear to offer significant benefits over the S2 and S3 alternatives and costs would be similar because the dimension of the weir would be similar to the S2 and S3 alternatives.

Because S2 and S3 did not demonstrate significant benefits to the J2 Return Channel or Downstream Channel, this alternative was not pursued.

9.8 Route J2 Return Flows to Jeffery Island (I2)

The I2 alternative routes one-half of the flow from the J2 Return to the Jeffery Island area. It is similar in principle to the R2 alternative that routes J2 Return water to the Sand Dam Channel.

Two 2D simulations were performed to understand sediment transport under this alternative. The first 2D simulation diverted one-fourth of the J2 Return flow to Jeffery Island and that flow was predicted to eroded 108,700 tons of sediment over a one-year period. The second simulation diverted one-half of the J2 Return flow to Jeffery Island and resulted in 181,100 tons of erosion of sediment over one year. We assumed that this rate of sediment delivery from Jeffery Island to the J2 Return Channel would continue for the 14-year simulation. The amount of sediment delivered to the J2 Return Channel was estimated to be 2.4 million tons during this period. Based upon the modeling the first two years could produce large amount of sediment, but similar to the S2 and S2 alternative, it would be necessary to perform significant channel grading or flow diversion structures to erode significant additional sediment from Jeffery Island.

The 1D model was also used to simulate the I2 alternative. Over the 14-yr simulation period, there is still predicted to be almost 1.7 million tons of erosion of the J2 Return Channel, but this is approximately 650,000 tons less erosion than estimated under No Action (reduction of 28%). The alternative also results in deposition of 30,000 tons/yr in the Downstream Channel over the simulation period. The alternative does not eliminate erosion in the J2 Return Channel despite the large volume of sediment delivered to the J2 Return Channel. The reasons for this are:

1. Only one-half of the flow is diverted to Jeffery Island and the remaining is still clear water release.
2. Adding sand and fine gravel to the J2 Return Channel will tend to decrease the bed material size of the J2 Return Channel which increases the transport rate.
3. The upper section of J2 Return Channel continues to be sediment starved because the sediment eroded from Jeffery Island enters the J2 Return Channel part way down the reach.

The OPCC of implementing I2 was estimated to be $29,230,000.

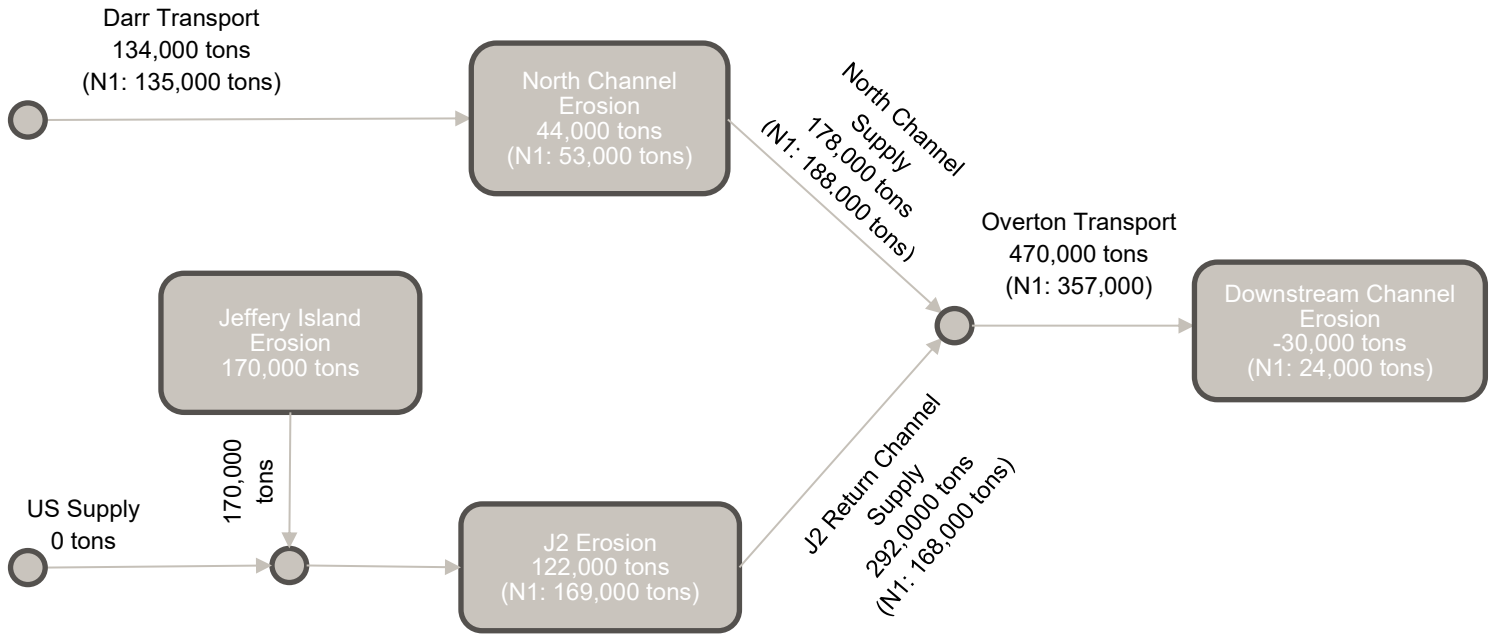

Figure 9-6. Predicted annual average sediment budget for I2 Alternative during 14-yr simulation period. Values for the No Action Alternative (N1) are given in parenthesis for comparison.

9.9 Comparison Summary

A summary of each channel's response and OPCC for each alternative is given in Table 9-1 and Figure 9-7. A brief summary of the study conclusions are:

- The No Action alternative is predicted to result in continued erosion of the J2 Return Channel. The Downstream Reach is also projected to continue to erode but at relatively smaller rates over the next 14 years. The rate of erosion of the Downstream Channel is likely to increase in time, but the process is relatively slow because J2 Return Channel still has large volume of sediment to erode and the North Channel supplies sediment.

- Re-regulation of the J2 Return (Alternative R1) is estimated to reduce the sediment transport demand in the J2 Return Channel by 23% relative to No Action. The re-regulation may not have immediate benefits to the downstream channel, but R1 will reduce required sediment augmentation volumes and will delay the potential negative impacts to the Downstream Reach.

- Using clear water to erode the Sand Dam Channel (Alternative R2) is predicted to have significant benefits to the J2 Return Channel, but because of the limited volumes of sediment present in the Sand Dam Channel, the reduction in erosion of the J2 Return Channel is limited to only 17% over the 14 years and may require additional local mechanical regrading and augmentation to the Sand Dam Channel which is not included in the OPCC.

- Removing Sand Dam (Alternative S1) would likely result in avulsion of the North Channel into the J2 Return Channel. This would cause the North Channel to have essentially no flow between the Sand Dam location and the junction with the J2 Return Channel.

- Using a weir and/or gate to divert flow into the Sand Dam Channel (S2 and S3 Alternatives) is predicted to result in significant deposition in the North Channel and is not expected to decrease the erosion of the J2 Return Channel. These alternatives are also estimated to result in the largest erosion of the Downstream Channel. These alternatives do not appear to accomplish PRRIP goals. Similarly, using a weir to divert flow into Jeffery Island (Alternative I1) would have similar limitations as S2 and S3 alternatives.

- Using J2 Return water to erode material from Jeffery Island (Alternative I2) is considered the most effective alternative at reducing erosion in the J2 Return Channel and in stopping or reversing erosion in the Downstream Channel. Jeffrey Island was estimated to supply up to 2.8 million tons of sediment, which could be used to supply sediment at a rate of over 180,000 tons per year for over 15 years with anticipated significant local mechanical grading and augmentation that is not included in the OPCC. Even with these relatively large augmentation rates, the J2 Return Channel is predicted to be erosional, but the augmentation is successful at eliminating erosion of the Downstream Channel in the model.

- Simulations indicate that up to 170,0000 tons/yr of sediment augmentation are necessary to cease erosion and cause deposition in the Downstream Channel.

- It is recommended that alternatives are combined to increase benefits. For example, R1 (Re-regulation of J2 Return Flows) could be combined with any of the other alternatives to further reduce the erosion of the J2 Return Channel. Alternatives R2 and I2 could also be combined such that the conveyance channel is first constructed to the Sand Dam Channel and then extended to Jeffery Island, and both the Sand Dam Channel and Jeffery Island are used to erode sediment.
- There would be monitoring and additional channel grading necessary to access sediment within the Sand Dam Channel and Jeffery Island. There was not an estimate of the cost of these activities.

Table 9-1. Alternative comparison matrix for alternatives.

	Average Annual Deposition (+) or Erosion (-)				
Alternat-ive	**North Channel (tons/yr)**	**J2 Return Channel (tons/yr)**	**Downstream Channel (tons/yr)**	**Total (tons/yr)**	**OPCC Relative to N1 ($)**
N1	-53,000	-169,000	-24,000	-246,000	0
R1	-50,000	-130,000	-33,000	-213,000	Unknown
R2	-53,000	-139,000	-16,000	-208,000	25,700,000
S2	41,000	-179,000	-85,000	-223,000	10,400,000
S3	55,000	-176,000	-88,000	-209,000	10,400,000
I2	-44,000	-122,000	30,000	-136,000	29,200,000

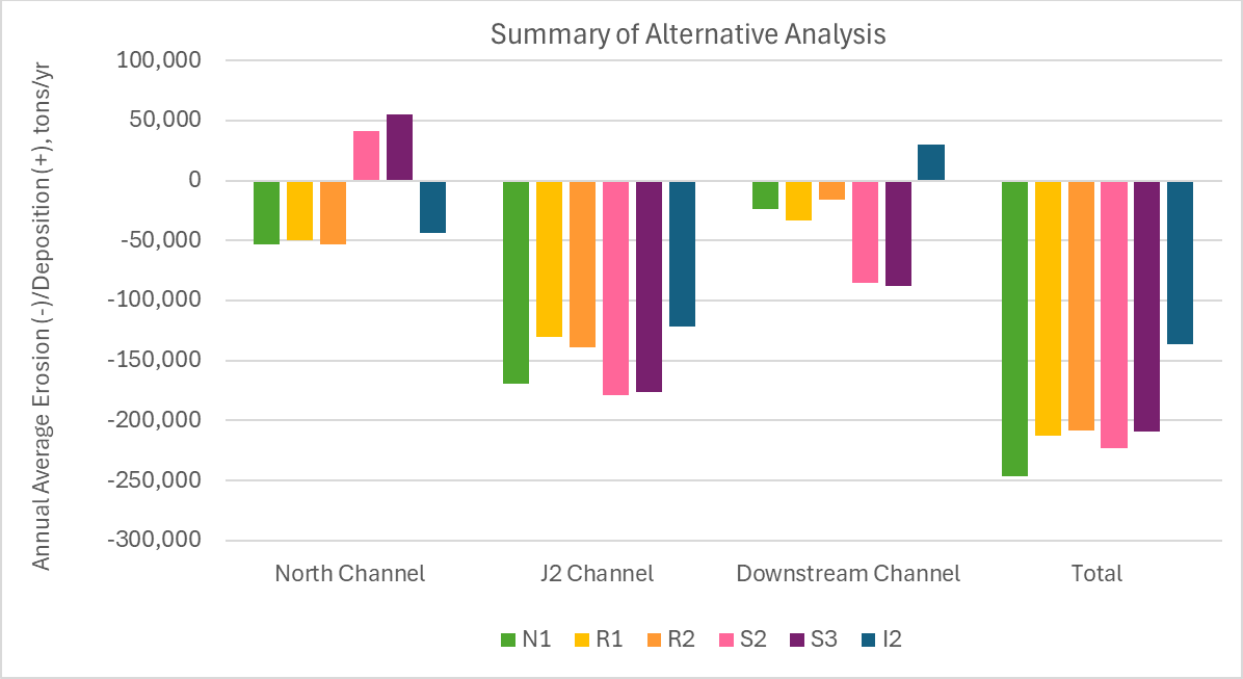

Figure 9-7. Summary Erosion and Deposition response of alternatives.

9.10 Limitations and Recommended Future Studies

This report is a summary of a reconnaissance level analysis and design. It was based upon available data and the analysis relies upon HEC-RAS 1D and 2D mobile bed analysis. These models are appropriate tools for this type of analysis but are simplifications of complex physical processes. For example, both models are limited in their ability to simulate bank erosion and river meandering. This means that they may overestimate the amount of vertical erosion and underestimate the amount of horizontal erosion (i.e. bank erosion). This model limitation is the main reason why the calibration and predictions were focused primarily on simulating total volumes of sediment and not the specific source of that sediment. The models are considered sufficiently accurate in their prediction of total sediment transport rates and sediment volumes. They are less reliable in predicting bed elevations and bank erosion. However, the conclusions in this report do not explicitly rely upon the prediction of bed elevation or bank erosions and therefore, this limitation is important to note but does not invalidate the conclusions in this report.

If any of the alternatives are pursued, additional data collection, analysis and design will be required to develop more reliable descriptions of the project performance, design, and costs. A partial list of these additional items are:

- Collection of gradation data of the channel and terraces used for augmentation (e.g. Sand Dam Channel or Jeffery Island). For the purposes of this study, sediment gradation of these terraces were assumed to be similar to the gradation of the North Channel. Sediment cores approximately 5 to 10 feet deep should be collected to determine the gradation of material throughout the erodible depth of these features.
- Identification of additional activities and maintenance that were not estimated as part of this study.
- Alternatives which erode the Sand Dam Channel (R2, S2, S3) and Jeffrey's Island (I2) would require significant channel grading, flow diversion modifications, local augmentation, and planning efforts erode the amount of sediment assumed in the alternative. Diverting flow into the Sand Dam Channel and Jeffery Island is effective at eroding sediment, but once a dominant channel is formed within the features, the amount of erosion could decrease significantly. It would be necessary to block or regrade the dominant channel to force flow into another area that could be eroded. Unregulated and unplanned releases within the features was noted to have the risk of rapid erosional and depositional trends resulting in potentially adverse avulsions.
- Development of detailed design and cost estimates. The current designs and cost estimates are conceptual or pre-appraisal level.

10 References

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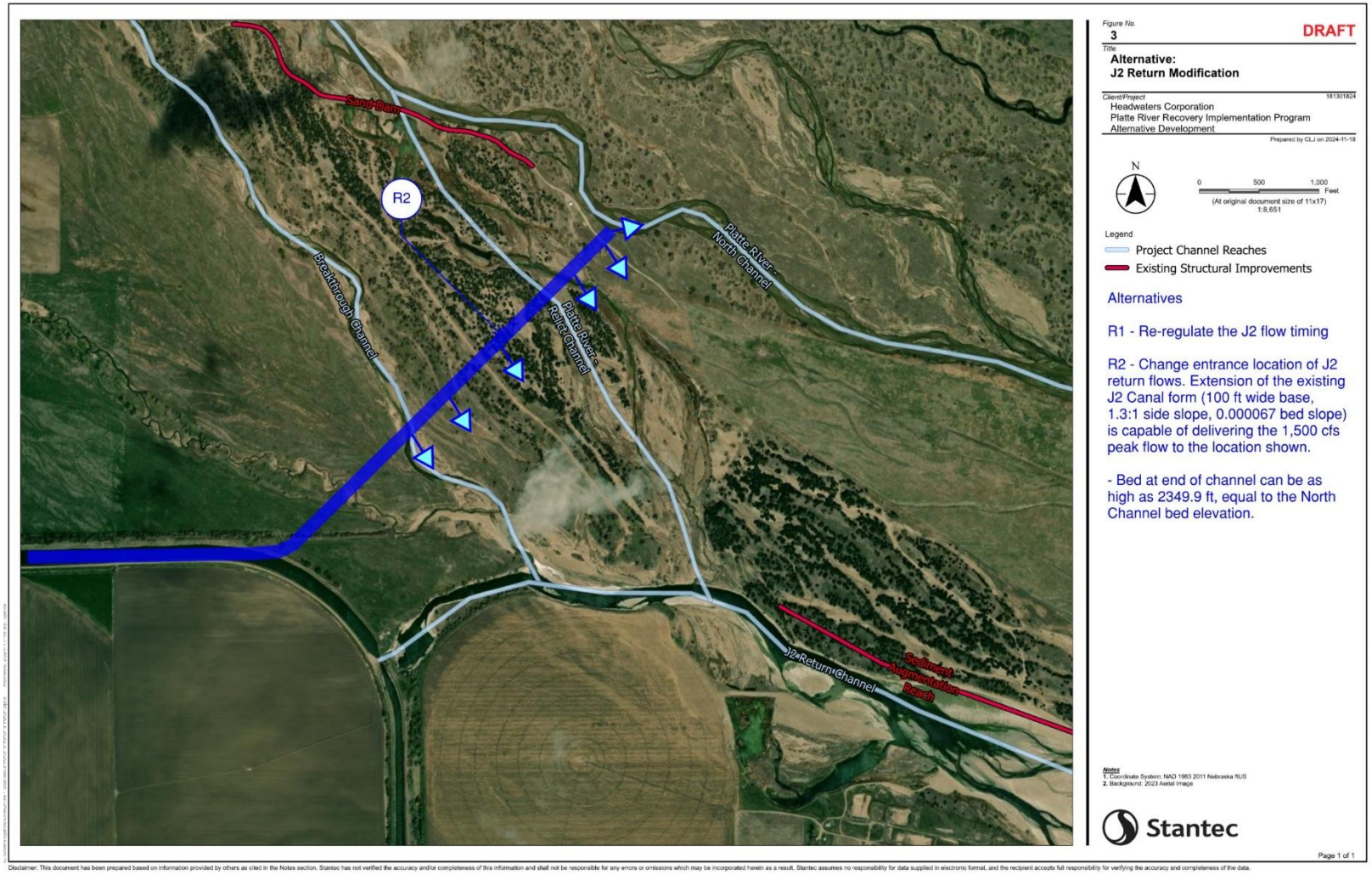
Appendices

Appendix A Reconnaissance Level Alternatives



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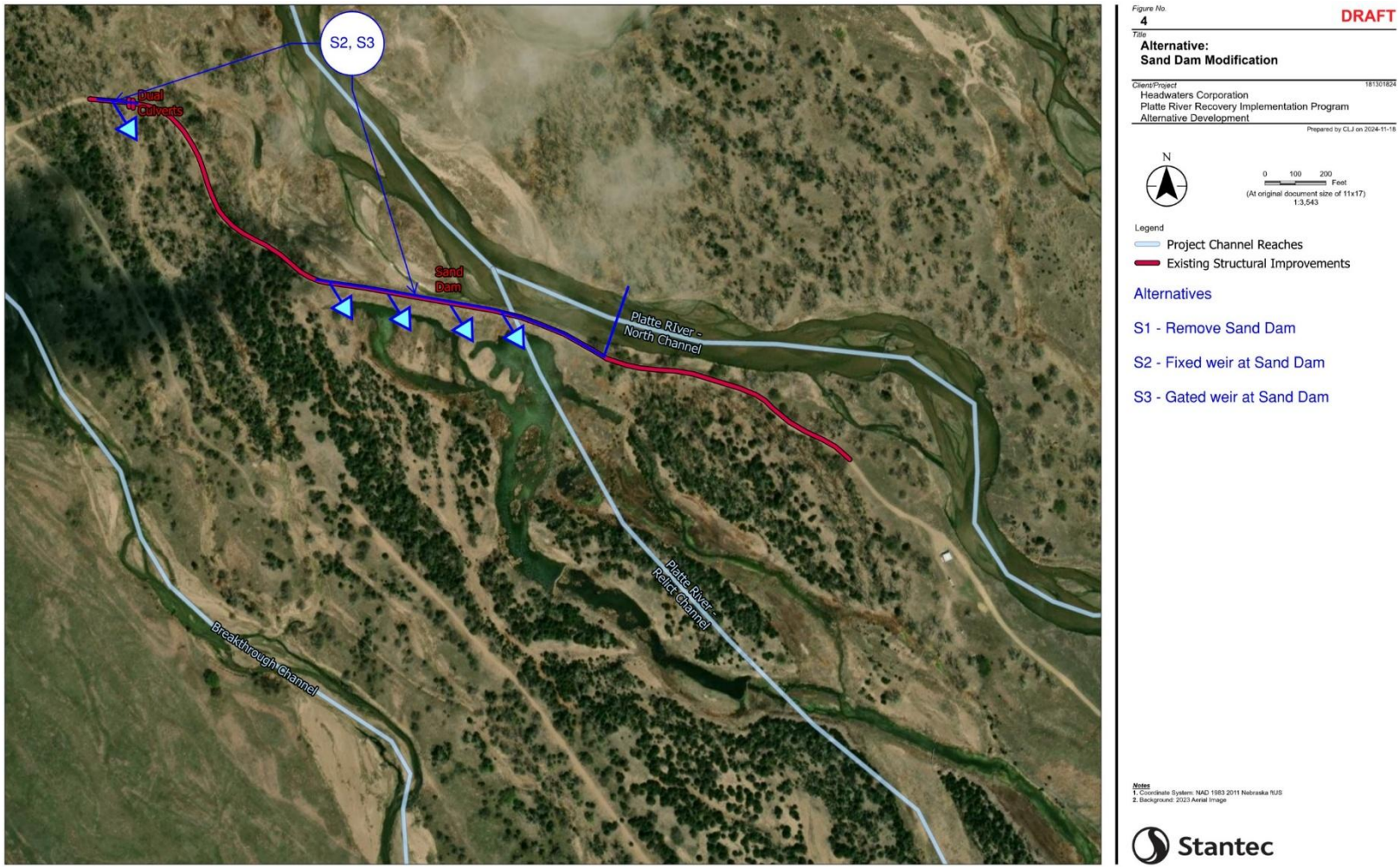
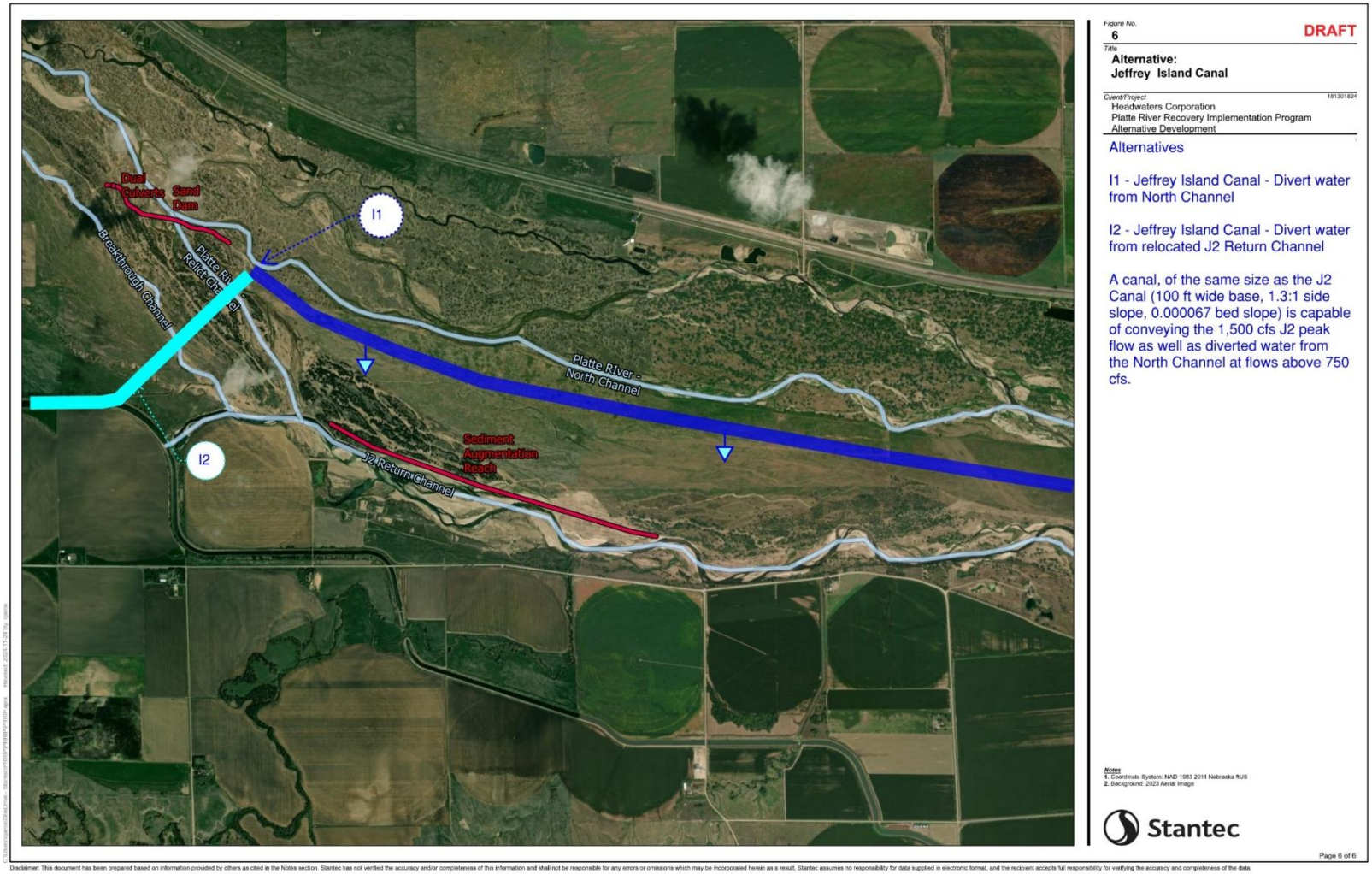

S2, S3
Dual Culverts
Sand Dam
Platte River - North Channel
Platte River - Relict Channel
Breakthrough Channel
Figure No.
4
DRAFT
Title
Alternative:
Sand Dam Modification
Client/Project
181301824
Headwaters Corporation
Platte River Recovery Implementation Program
Alternative Development
Prepared by CLJ on 2024-11-18
N
0 100 200
Feet
(At original document size of 11x17)
1:3,543
Legend
Project Channel Reaches
Existing Structural Improvements
Alternatives
S1 - Remove Sand Dam
S2 - Fixed weir at Sand Dam
S3 - Gated weir at Sand Dam
Notes
1. Coordinate System: NAD 1983 2011 Nebraska ftUS
2. Background: 2023 Aerial Image
Stantec


Dual Culverts
Sand Dam
I1
Breakthrough Channel
Platte River Relief Channel
Platte River - North Channel
Sediment Augmentation Reach
I2
J2 Return Channel
Figure No.
6
DRAFT
Title
Alternative:
Jeffrey Island Canal
Client/Project
181301824
Headwaters Corporation
Platte River Recovery Implementation Program
Alternative Development
Alternatives
I1 - Jeffrey Island Canal - Divert water from North Channel
I2 - Jeffrey Island Canal - Divert water from relocated J2 Return Channel
A canal, of the same size as the J2 Canal (100 ft wide base, 1.3:1 side slope, 0.000067 bed slope) is capable of conveying the 1,500 cfs J2 peak flow as well as diverted water from the North Channel at flows above 750 cfs.
Notes
1. Coordinate System: NAD 1983 2011 Nebraska ftUS
2. Background: 2023 Aerial Image
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Page 6 of 6
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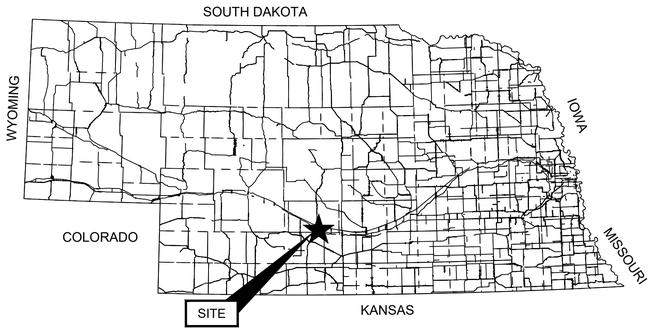
Appendix B Conceptual Designs

PLATTE RIVER SEDIMENT ALTERNATIVES MODELING

CONCEPTUAL DESIGN PLANS



STATE MAP
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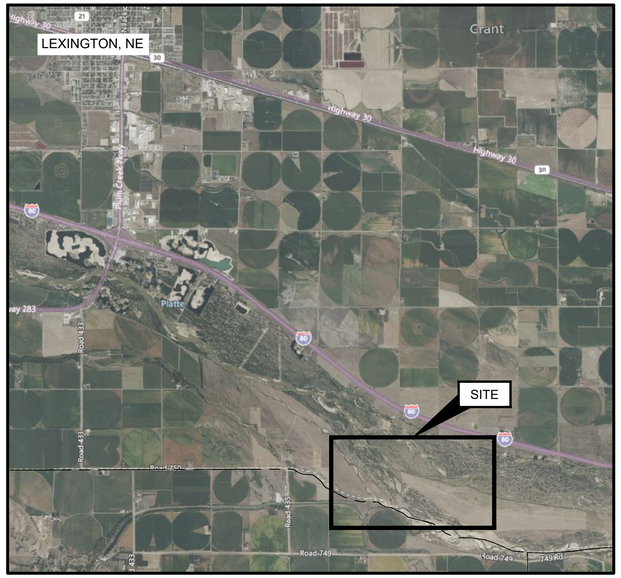

SOURCE:
MICROSOFT; BING MAPS

SITE LOCATION MAP
(NOT TO SCALE)

SHEET INDEX

SHEET NO.	DRAWING NO.	TITLE
1	G-1	COVER SHEET
2	G-2	SITE MAP
3	C-1	ALTERNATIVE S2
4	C-2	ALTERNATIVE R2 (SHEET 1 OF 2)
5	C-3	ALTERNATIVE R2 (SHEET 2 OF 2)
6	C-4	ALTERNATIVE I2 (SHEET 1 OF 4)
7	C-5	ALTERNATIVE I2 (SHEET 2 OF 4)
8	C-6	ALTERNATIVE I2 (SHEET 3 OF 4)
9	C-7	ALTERNATIVE I2 (SHEET 4 OF 4)

PREPARED FOR:

PLATTE RIVER RECOVERY
IMPLEMENTATION PROGRAM
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308.237.5728

PREPARED BY:

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	1 OF 9

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SITE MAP

DWG. NO. G-2

SHEET NO. 2 OF 9

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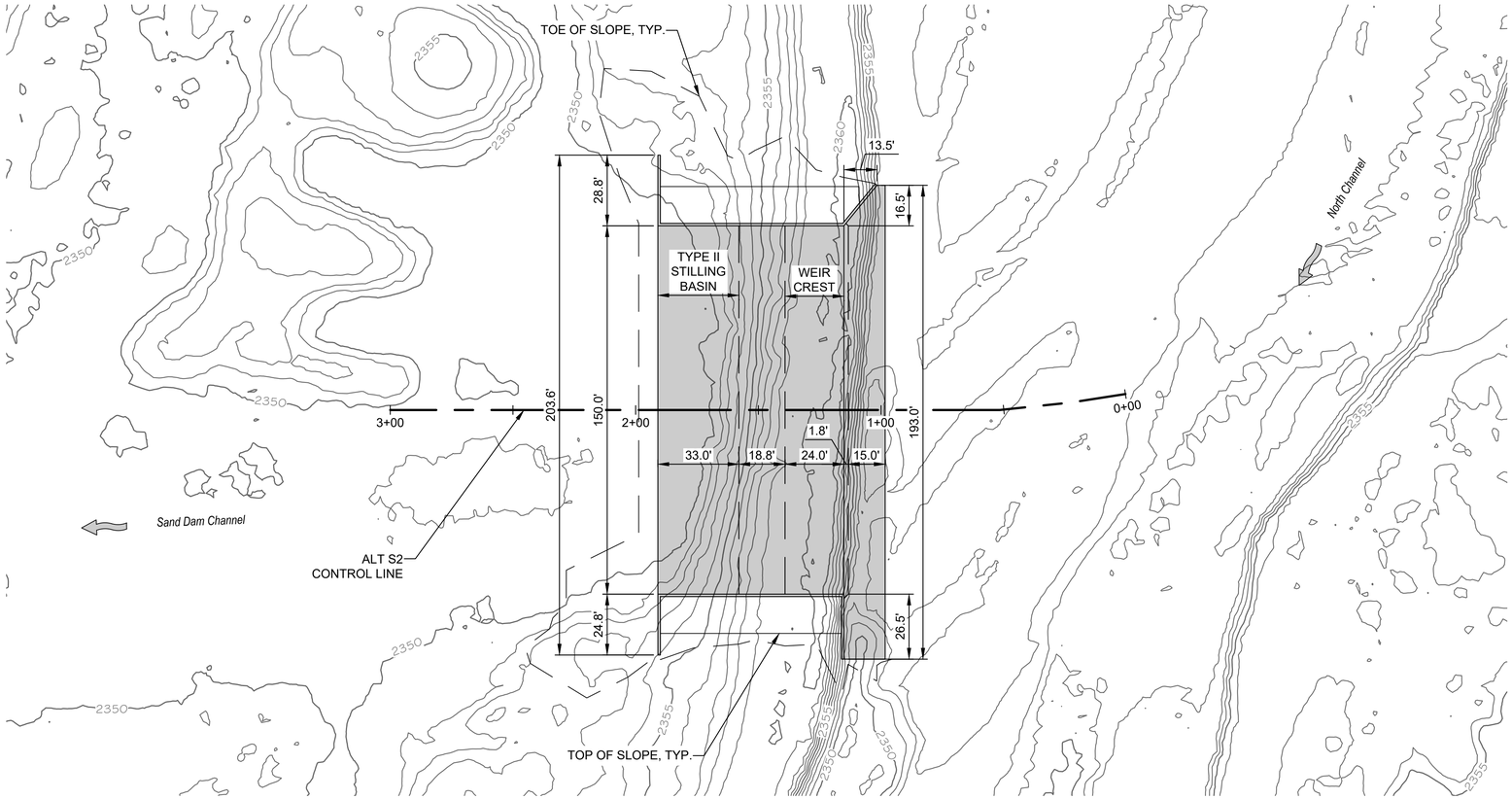

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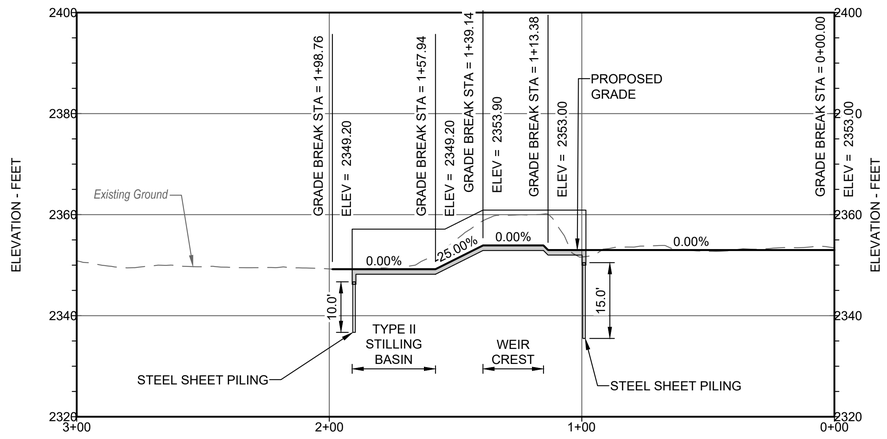

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ALTERNATIVE S2

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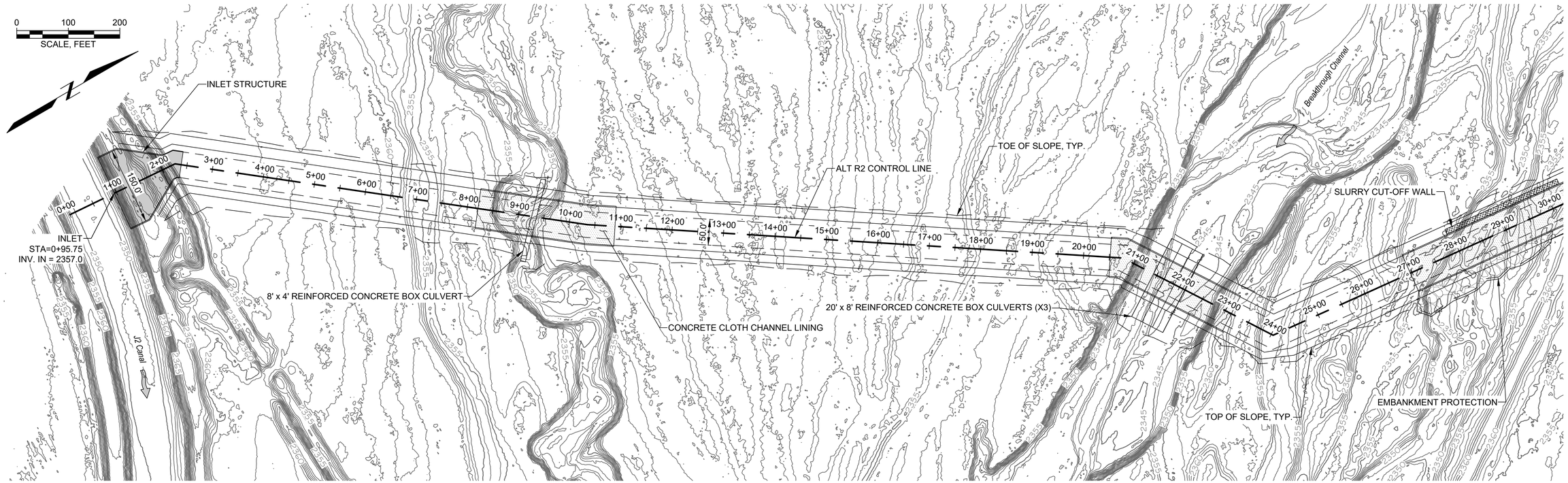
SHEET NO. 3 OF 9



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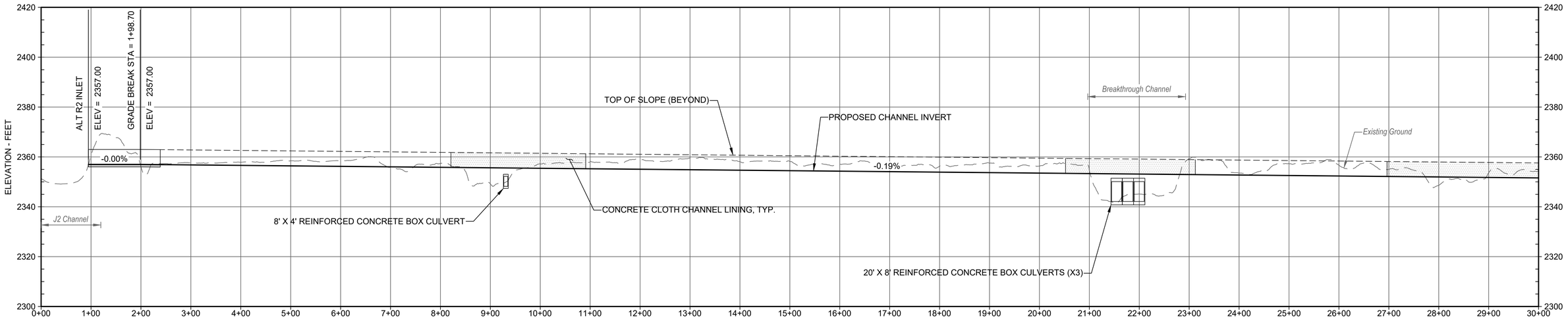

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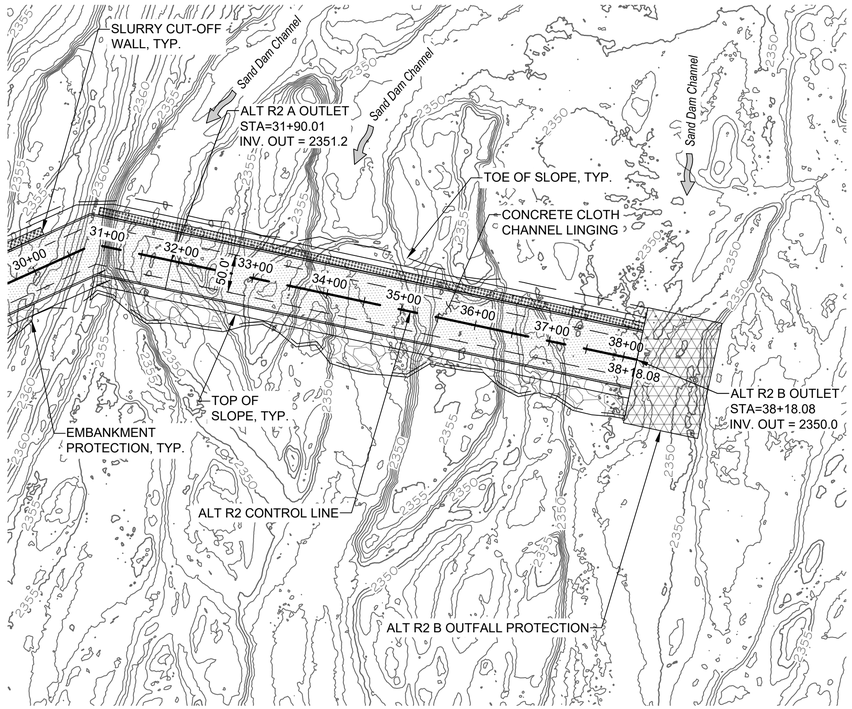
DWG. NO. C-2

SHEET NO. 4 OF 9



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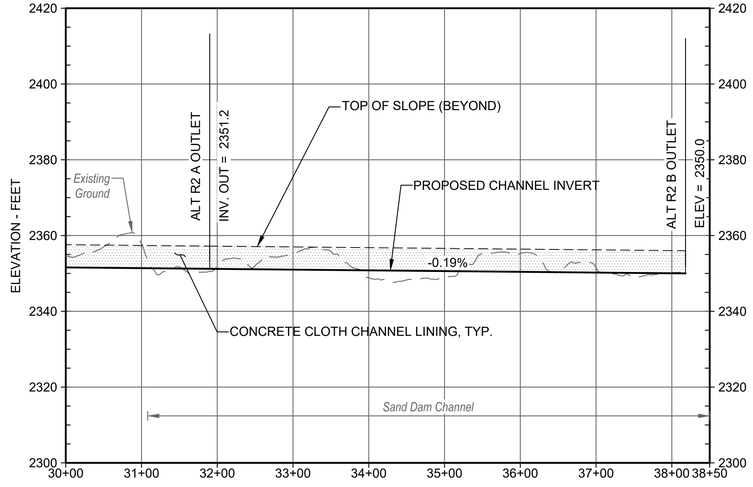

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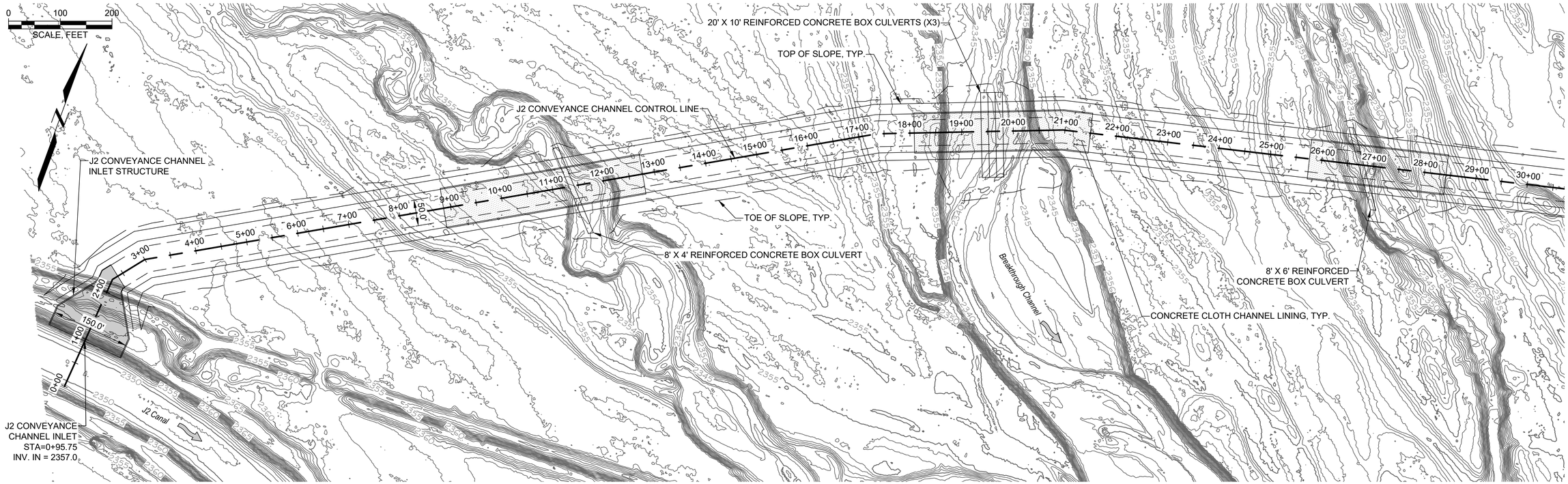

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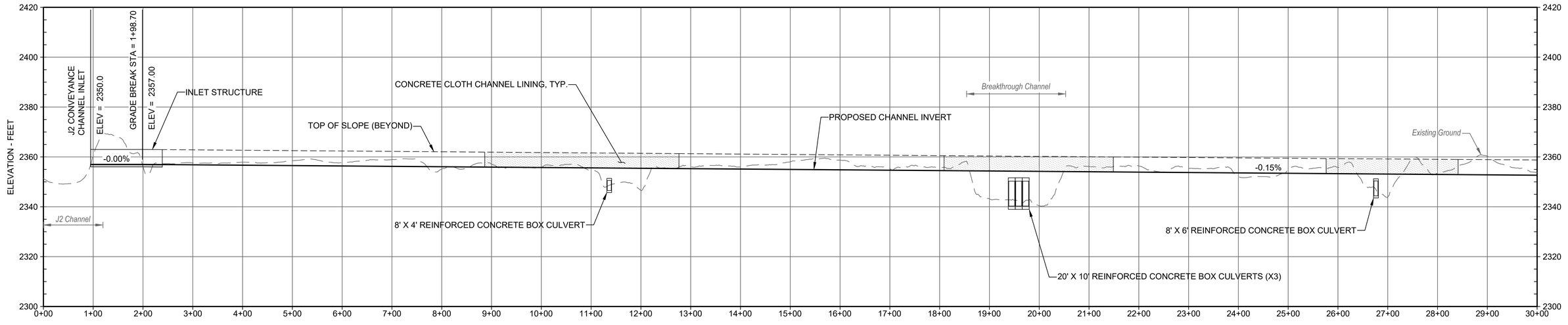

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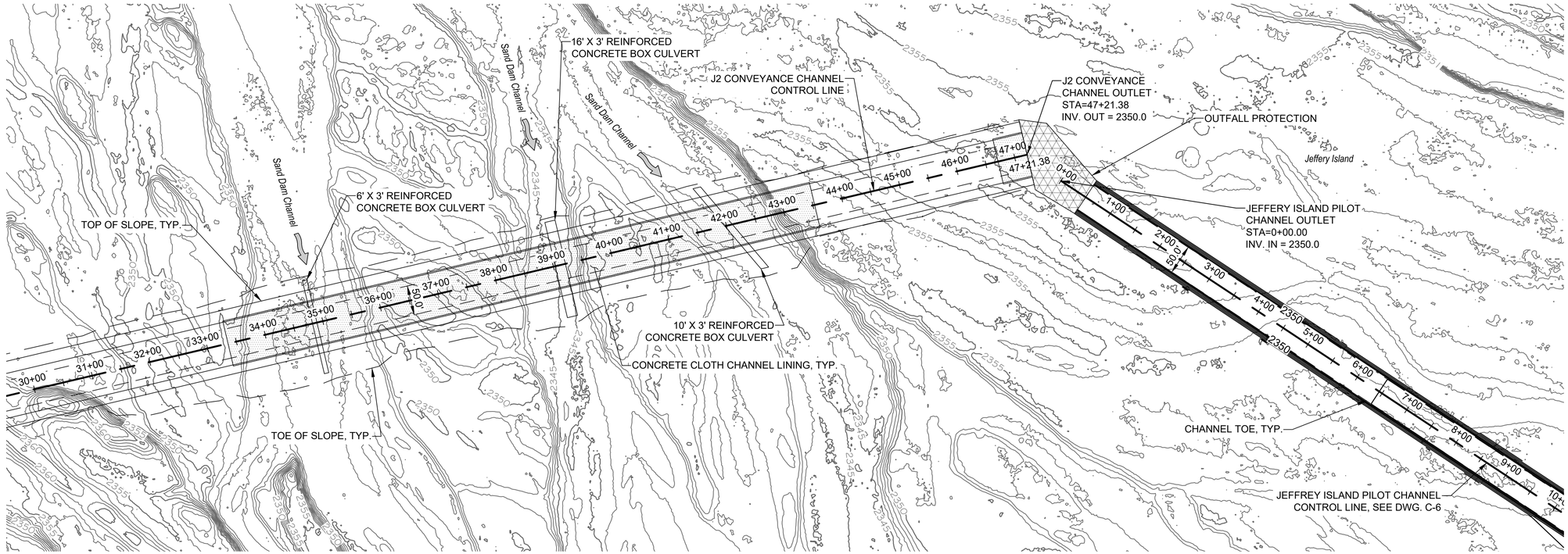

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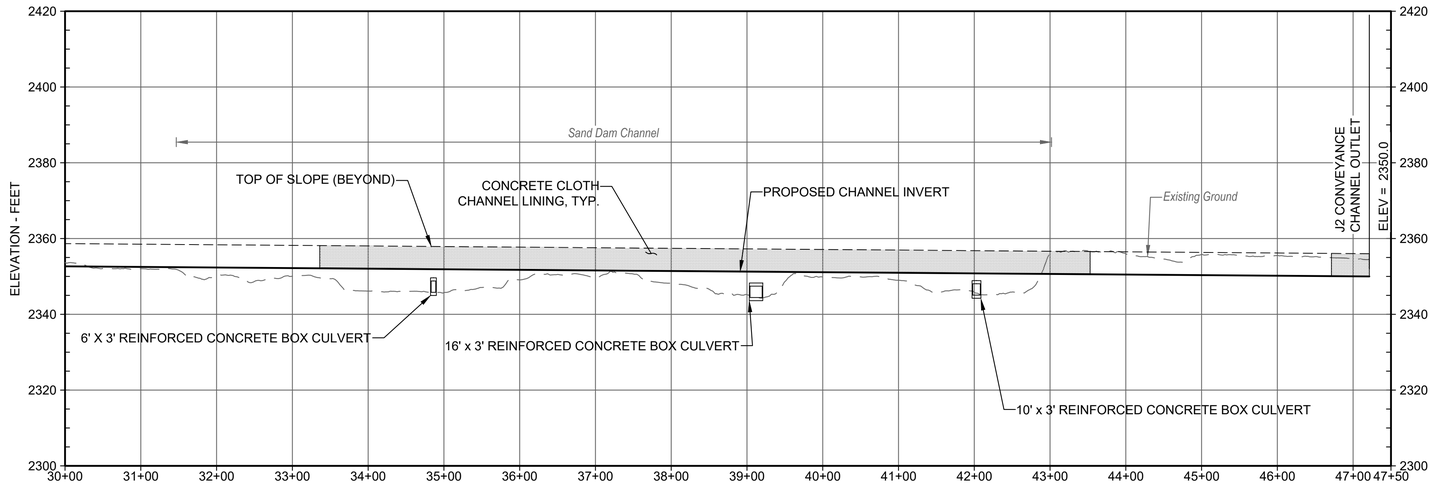

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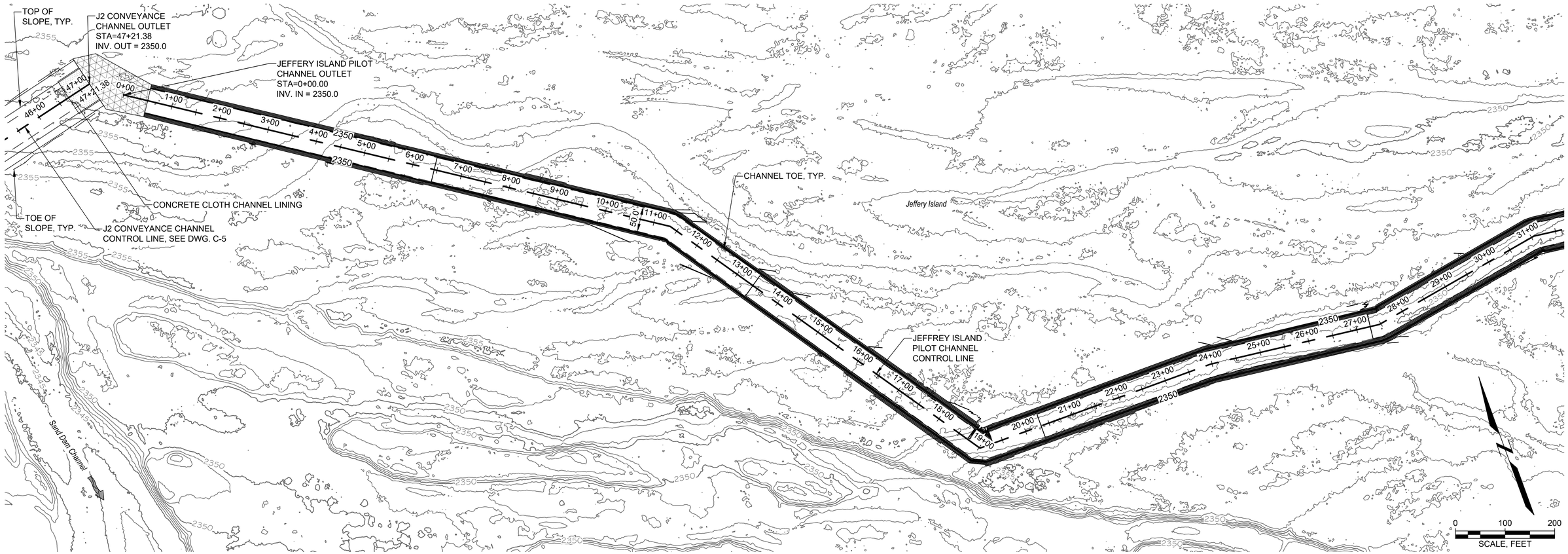
ALTERNATIVE I2
(SHEET 2 OF 4)

DWG. NO. C-5

SHEET NO. 7 OF 9



ALTERNATIVE I2 - JEFFERY ISLAND PILOT CHANNEL

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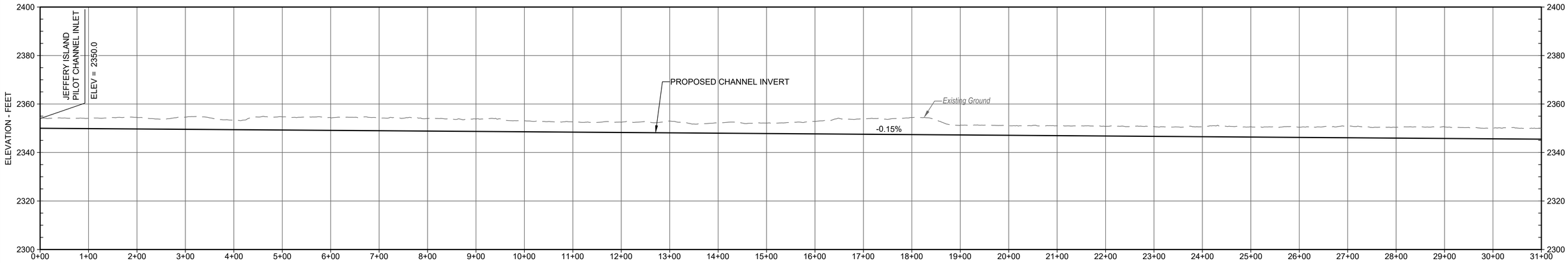

ALTERNATIVE I2 - JEFFERY ISLAND PILOT CHANNEL

PROFILE SCALE: 1" = 100' (HORIZ.)
1" = 20' (VERT.)

NO.	DATE	ISSUE/REVISION	APP
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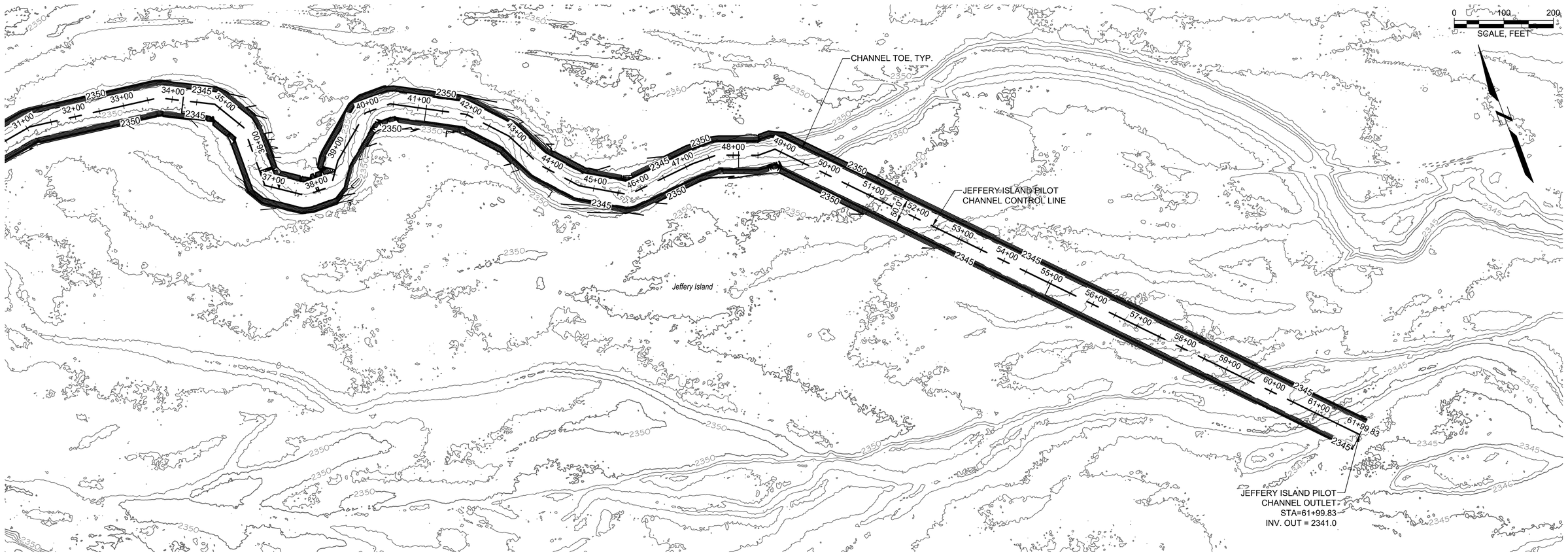
PLATTE RIVER SEDIMENT ALTERNATIVES MODELING
PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM
KEARNEY, NEBRASKA

ALTERNATIVE I2
(SHEET 3 OF 4)

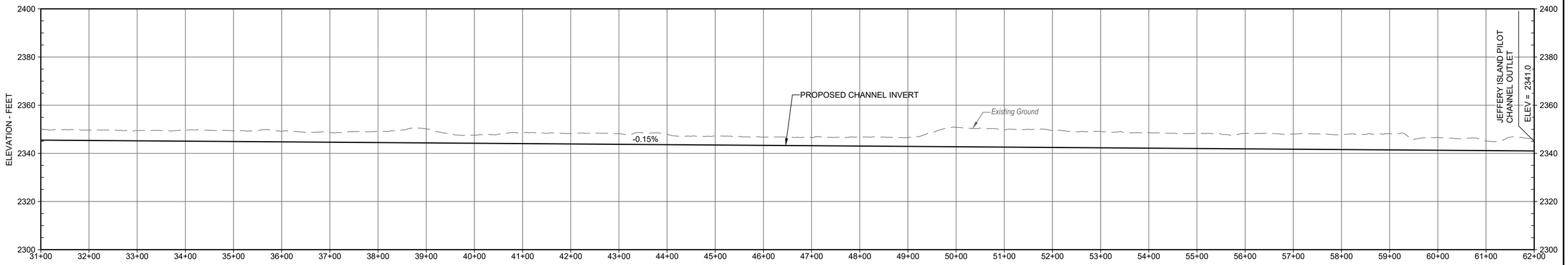
DWG. NO. C-6

SHEET NO. 8 OF 9



ALTERNATIVE I2 - JEFFERY ISLAND PILOT CHANNEL

PLAN SCALE: 1" = 100'



ALTERNATIVE I2 - JEFFERY ISLAND PILOT CHANNEL

PROFILE SCALE: 1" = 100' (HORIZ.)
1" = 20' (VERT.)

Attention:

0 1"

If this scale bar does not measure 1" then drawing is not original scale.

NO.	DATE	ISSUE/REVISION	APP
0			

CONCEPTUAL DESIGN PLANS

Designed:	NY
Checked:	MS
Drawn:	NY
Submitted By:	-
P.E. Number:	-

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PLATTE RIVER SEDIMENT ALTERNATIVES MODELING
PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM
KEARNEY, NEBRASKA

ALTERNATIVE I2
(SHEET 4 OF 4)

DWG. NO. C-7

SHEET NO. 9 OF 9

Stantec

Stantec is a global leader in sustainable engineering, architecture, and environmental consulting. The diverse perspectives of our partners and interested parties drive us to think beyond what's previously been done on critical issues like climate change, digital transformation, and future-proofing our cities and infrastructure. We innovate at the intersection of community, creativity, and client relationships to advance communities everywhere, so that together we can redefine what's possible.

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