St. Mary Canal

System Improvement Plan

November 23, 2022

Contents

Tables

Figures

Appendices

Executive Summary

The St. Mary Canal (Canal) was constructed in the early 1900s to divert flows from the St. Mary River to the Milk River Basin and supply north-central Montana with water for irrigation of agriculture. The Canal has operated successfully over the past 100 years and has become known as the Lifeline of the Hi-Line, as the water is used for agriculture, domestic water use, recreation, and wildlife. As an agricultural driven economy, much of the Hi-Line community would suffer significant adverse effects if the Canal and its associated facilities failed to function. Water users throughout the Milk River Basin would suffer from a lack of water most years if water was not diverted from the St. Mary basin to the Milk River.

Separate Canal system components include a diversion dam, Canal headgates, three inverted siphons, check and wasteway structures, five hydraulic drop structures, and approximately 29 miles of Canal.

Throughout the course of the Canal's history, the Milk River Joint Board of Control (MRJBOC) and Bureau of Reclamation (Reclamation) have worked together to ensure the Canal is able to deliver water to the Milk River Basin throughout the course of each irrigation season. Efforts to maintain the system have clearly extended the useful life of the Canal and associated control/conveyance structures. Despite these efforts, many of the Canal's features require rehabilitation or replacement simply due to the age of the facilities.

Continued degradation of the diversion and conveyance system has resulted in a diminished capacity. Originally designed to deliver 850 cfs of water during the irrigation season, current capacity is approximately 600 cfs. Deterioration of the facilities and lack of modernization further impacts operating efficiency and diversion opportunity. Annual water shortages in the Milk River Basin have been well documented. Rehabilitation of the St. Mary Canal system back to its original 850 cfs capacity will significantly reduce these shortages and reduce annual operations and maintenance costs.

This purpose of this System Improvement Plan (SIP) is to evaluate the St. Mary Canal system to determine an approach forward for modernizing the Canal system and its appurtenances. To do this, HDR first conducted an evaluation of modernization options to upgrade or replace Canal components. Improvements for the diversion structure were not considered because Reclamation is currently designing a replacement diversion structure and fish ladder that is being evaluated through a separate Environmental Assessment. Options considered for the rehabilitation or replacement of the remaining St. Mary Canal facilities are briefly summarized below.

1. Canal conveyance
    - Canal lining
    - Canal reshaping
    - Piping the Canal
2. Siphon Replacements
    - Full replacement of St. Mary and Halls Coulee Siphons

    - Steel pipe
    - Concrete pipe

3. Wasteways/Turnouts (Drains)
    - Replacement of the existing turnouts
    - Construction of new side channel spillway (overflow spillway) structures
4. Underdrains (Culverts)
    - In-kind replacement
    - 25-year event
5. Slope Stability (Active Slide Area)
    - Removing the load from the top of the slide
    - Adding weight to the base of the slide
    - Increasing the strength of the soil
    - Piped and box culverts
6. Drop Structures
    - In-kind replacement
7. Maintenance Road
    - Improvements to existing maintenance road on north side of Canal
    - Improvements to existing and construction of maintenance road along south side of Canal
8. Animal Intrusion
    - Combination of fencing and turnouts with a small pond or watering tank

Preliminarily Options

MRJBOC, Reclamation, Farmers Conservation Alliance (FCA) and HDR met on August 25, 2022 and August 29, 2022 to discuss the options and reach a consensus on the options that would be considered in more detail as a means of supporting ongoing efforts to obtain funding for rehabilitation / replacement projects. Meeting notes from these meetings are included in Appendix B. During these meetings the following options were identified based on apparent benefits and were selected to be used to develop the estimated costs of addressing issues with the St. Mary Canal facilities:

1. Canal conveyance – A hybrid approach from the options considered including using an improved earthen Canal section and an improved earthen Canal section with a geosynthetic liner.
2. Siphon Replacements – Full replacement of the siphons with a buried installation and include bid alternatives for either steel pipe or concrete cylinder pipe (CCP) to allow a reasonable selection of pipe material given the volatility of the current markets for steel and concrete.

3. Wasteways/Turnouts (Drains) - Replace the existing Kennedy Creek and Halls Coulee Wasteways with new improved structures to include evaluating different gate configurations for the new structures, automation, etc., during design. Improvements also include the replacement of existing turnouts with new side channel spillway structures.
4. Underdrains (Culverts) – Underdrains will be replaced and upgraded to convey the 25-year event.
5. Slope Stability (Active Slide Area) – Slope stability is somewhat dependent on future geotechnical site investigations. The known areas with slope stability concerns along the Canal will be addressed with an earthwork option. For each slide area this includes:
    a. Removing weight off the top of the slides to the extent possible by flattening the exposed slopes.
    b. Relocate excavated material, place and compact on the downhill side of the Canal.
    c. Control of subsurface and surface water will also be addressed in the form of filter drains or surface swales to direct as much water as possible away from the unstable soils.
6. Drop Structures – Drop structures 1, 3, and 4 will be replaced by new structures with a similar design to the recently replaced drop structures 2 and 5.
7. Maintenance Road – The existing access road running along the Canal alignment will be improved. Drainage will be evaluated, and drainage improvements (culverts) may also be included where appropriate.
8. Animal Intrusion – No consensus was reached on a selected option to address potential animal intrusion concerns. It was agreed that HDR will expand on animal intrusion in the SIP and provide costs for fencing both sides of the Canal.

Opinion of Probable Construction Cost

The basis for the opinion of probable construction cost (OPCC) estimate used for this evaluation of modernization options is based on the purpose of the project, general design criteria, significant features and components, and estimated quantities. This estimate is considered a Class 5 estimate by the American Association of Cost Engineers (AACE). The AACE has prepared guidelines for their Cost Estimate Classification System which establishes the accuracy of cost estimating based on the maturity of a project and the detail available for review. A Class 5 estimate is the standard of care for estimating construction costs during the master planning and concept design stage of a project. By AACE definition, a Class 5 opinion of probable construction cost "Accuracy of Estimate" is -35% to +60%. Translated this means that a Class 5 estimate is between 0.65 and 1.6 times the estimate prepared.

Considering that the present analysis is in an initial evaluation phase, the challenging 2022 bidding environment, environmental requirements, remote project location, and market volatility, the +60% Class 5 OPCC is used primarily for the purpose to compare modernization options.

Table ES-1 below is a cost summary of selected improvements for the various St. Mary Canal components with Class 5 estimated costs.

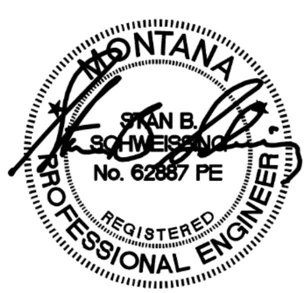
Table ES-1. St. Mary Canal Selected Improvements

Description	Cost
Earthen Canal	$12,000,000
Geosynthetic Lined Canal	$35,000,000
St. Mary Siphon - 102.6" Steel	$55,000,000
Halls Coulee Siphon - 102.6" Steel	$24,000,000
Kennedy Creek Crossing	$3,000,000
Drop 1	$6,000,000
Drop 3	$5,000,000
Drop 4	$7,000,000
Slides - Earthwork	$45,500,000
O&M Road Improvements - One Side	$9,000,000
Replace Kennedy Creek Wasteway	$2,000,000
Replace Halls Coulee Wasteway	$3,000,000
New Side Channel Spillway (9 Total)	$13,500,000
Underdrains	$5,600,000
Fencing	$2,000,000
Subtotal	$224,600,000
Blackfeet Revenue Fee (3%)	$6,700,000
Subtotal	$231,300,000
Escalation to Midpoint of Construction (9%)	$20,817,000
TOTAL	**$255,000,000**

Abbreviations and Acronyms

AACE	American Association of Cost Engineers
AF	Acre-Feet
CCP	Concrete Cylinder Pipe
cfs	Cubic Feet per Second
CY	Cubic Yards
DNRC	Montana Department of Natural Resources
EPA	Environmental Protection Agency
EPANET	Environmental Protection Agency Network
FCA	Farmers Conservation Alliance
fps	Feet per Second
GIS	Geographic Information Systems
HECRAS	Hydrologic Engineering Center River Analysis System
HKM	Now DOWL Engineering
IJC	International Joint Commission
IMP	Irrigation Modernization Program
MISO	Midcontinent Independent Systems Operator
MRJBOC	Milk River Joint Board of Control
MDEQ	Montana Department of Environmental Quality
NAVD	North American Vertical Datum (of 1988)
NRCS	Natural Resources Conservation Service
OPCC	Opinion of Probable Construction Cost
O&M	Operation and Maintenance
RCB	Reinforced Concrete Box Culvert
Reclamation	U. S. Bureau of Reclamation
SIP	System Improvement Plan
TD&H	Thomas, Dean & Hoskins, Inc
TERO	Tribal Employment Rights Office
USACE	United States Army Corps of Engineers
WP-EIS	Watershed Plan - Environmental Impact Statement
WP-EA	Watershed Plan – Environmental Assessment

Certification by a Licensed Professional Engineer



Section 1. Project Overview and Objective

Farmers Conservation Alliance (FCA) contracted with HDR to develop a System Improvement Plan (SIP) for the Milk River Joint Board of Control's (MRJBOC) St. Mary Canal delivery system with support from the National Resource Conservation Service (NRCS). The SIP was authorized through a Consultant Services Agreement between FCA and HDR.

The SIP is a key component of FCA's Irrigation Modernization Program (IMP). FCA designed the IMP to assist irrigators and agricultural water providers in creating modernization strategies for their irrigation water delivery systems that reduce barriers to implementation while increasing opportunities for funding and support. The end goal of the IMP is on-the-ground implementation of projects that provide irrigation communities with a reliable source of irrigation water through the modernization of a community's distribution system.

This document provides an evaluation of the existing St. Mary Canal system, including 29 miles of Canal, three siphons, bridge crossings, turnouts/wasteways, underdrains, surface drainage inlets, and five concrete drop structures. Principle methods for modernization include:

- Siphon replacement - both single pipe and multi pipe options, above ground and buried options, modified inlets, and bridge over the St. Mary River
- Slope stability improvements at locations where the Canal is being adversely affected by landslide activity
- Lining portions of the Canal with geosynthetics
- Reconstruction of all or portions of the Canal using a reduced cross section to reduce seepage and evaporation
- Control structures to improve flow measurement and operational flexibility
- Wasteways to improve emergency response capabilities
- Maintenance road improvements
- Animal intrusion
- Drop structure improvements

HDR developed the SIP to be used as a planning document by the MRJBOC and Reclamation to provide a basis for phased construction of the conveyance system improvements.

Section 2. Existing System

2.1 System Overview

The Milk River is the economic mainstay of North Central Montana from Havre to Glasgow. Most of the Milk River flow utilized by irrigators, municipalities, and for recreational and wildlife benefits is diverted from the St. Mary River basin near Glacier National Park into the North Fork of the Milk River via a 108-year-old, 29-mile-long facility. Components of the Canal system include a diversion dam, Canal headgates, three inverted siphons, check structures, five hydraulic drop structures, and approximately 29 miles of Canal. The diversion facilities are owned and operated by the U.S. Bureau of Reclamation (Reclamation).

Besides being an economic disaster to the irrigators (over 140,000 acres) and the State of Montana, the loss of diverted water to the Milk River Basin would also detrimentally impact the following:

- Municipalities that depend on the Milk River as a source of drinking water,
- Ft. Belknap Indian Nation Reserved Water Rights Compact, which is contingent on diverted water,
- State and Federal wildlife refuges and preserves,
- Recreational and fishing facilities along the Milk River and related storage reservoirs,
- Numerous endangered, threatened, and proposed species, and
- Missouri River flows below the mouth of the Milk River.

Continued degradation of the diversion and conveyance system has resulted in a diminished capacity over the past century. Originally designed to deliver 850 cfs of water during the irrigation season, current capacity is estimated at 600 cfs. Deterioration of the facilities and lack of modernization further impacts operating efficiency and diversion opportunity. Annual water shortages in the Milk River Basin have been well documented. Reclamation and the Montana Department of Natural Resources (DNRC) both agree that rehabilitation of the St. Mary Facilities back to its original capacity would significantly reduce these shortages (Montana Department of Natural Resources and Conservation, and Thomas, Dean & Hoskins, Inc., 2005).

The diversion facilities lie entirely within the boundaries of the Blackfeet Nation, and as such, they are an important stakeholder. For the last 100 plus years, environmental issues and concerns, both Tribal and Federal, have arisen regarding the operation of the facilities. For example, the diversion dam precludes passage of bull trout (a threatened species) during operation, and bull trout as well as other fish species are permanently lost into the conveyance Canal each season (Montana Department of Natural Resources and Conservation, and Thomas, Dean & Hoskins, Inc., 2006).

2.1.1 St Mary River Diversion Structure

The St. Mary Diversion Dam and headgates (Figure 2-1 & Figure 2-2) are located approximately one mile downstream from Lower St. Mary Lake. Both structures were built in 1910 to divert water from the St. Mary River into the St. Mary Canal. The diversion dam is a 6-foot-high concrete weir and sluiceway with length of 198 feet that uses mechanically operated sluice gates installed in 1995.

Figure 2-1. St. Mary Diversion Structure[1]

[1] Unless otherwise noted, all photos by HDR Engineering, Inc.

Figure 2-2. St. Mary Diversion Structure Headgates

Both structures are believed to have a negative impact on tribal fishery resources. The diversion dam acts as a barrier to fish moving upstream and a large number of fish become entrained in the Canal through the headgates during the irrigation season (Montana Department of Natural Resources and Conservation, and Thomas, Dean & Hoskins, Inc., 2006).

Reclamation is currently designing a new diversion structure and fish ladder to address the fishery resources and aging infrastructure separate from this SIP.

2.1.2 St. Mary Canal Conveyance

The St. Mary Canal was constructed between 1907 and 1915 with a design capacity of 850 cfs. The 29-mile Canal portions are earthen, unlined, one-bank, contour design. The current Canal capacity is approximately 600 cfs primarily due to slope instabilities and landslides. Originally, the prism consisted of a 26-foot bottom trapezoidal section with 2:1 (H:V) fill slopes and 1½:1 cut slopes. The invert slope is approximately 0.0001 ft/ft or 0.53 ft per mile.

2.1.3 St. Mary River Siphon

The St. Mary River Siphon consists of two, 90-inch riveted steel barrels that traverse the valley from the inlet, transition down to two, 84-inch steel barrels at the St. Mary River crossing, transition back to two 90-inch steel barrels and traverse up the valley slope to the outlet. The barrels are approximately 3,200 feet in length. The discharge of each barrel is approximately 425 cfs at a velocity of 9.63 feet per second in the two 90-inch section and 11.05 feet per second in the 84-inch section. The maximum head on the Siphons is 165 feet.

The downstream barrel was constructed from 1912-15, and the upstream barrel was constructed in 1925-26. The downstream barrel is buried for approximately half its length at a depth of 3-5 feet, and the right barrel runs entirely above ground. The upstream barrel has undergone a series of extensive repairs due to problems associated with being buried, such as seepage, corrosion, and buckling. A cathodic protection system was installed in the 1950s. Unstable valley sidewalls have resulted in the downslope movement of the steel barrels and concrete supports producing buckling in the siphon barrels, and compression of the expansion/contraction joints.

During the irrigation season, while the Canal system is in operation, there are visible leaks in the steel barrels (Figure 2-3 and Figure 2-4).

Figure 2-3. St. Mary Siphon Leaking Steel Barrels

Figure 2-4. St. Mary Siphon Leaking Steel Barrels

2.1.4 Halls Coulee Siphons

The Halls Coulee Siphon crosses a broad valley about 8 miles downstream of the St. Mary River Siphon. It has two riveted steel barrels, 6.5 feet in diameter and 1,405 feet in length, with concrete saddle supports. The maximum head on the Siphons is 102 feet. The twin barrels have a combined capacity of 850 cfs. Corrosion and weakened concrete saddle supports are visible along the reach of both barrels. Leaking barrels are also evident during the irrigation season (Figure 2-5 and Figure 2-6).

Figure 2-5. Halls Coulee Barrel Leak

Figure 2-6. Halls Coulee Saddle Support

2.1.5 Bridge Crossings

Bridge crossings provide access across the Canal without obstructing flow in the Canal. The St. Mary Canal includes multiple existing private and public bridge crossings along its extent. Existing St. Mary Canal bridge crossings are identified in Table 2-1. Additional details on all bridge crossings, including pictures, are available in the *St. Mary Diversion Facilities Structural Evaluation of Canal Bridge Final Report* (Montana Department of Natural Resources and Conservation, and Thomas, Dean & Hoskins, Inc., 2007).

Table 2-1. Bridge Crossings

Station	Name	Structure Type	Ownership
66+65	Babb County Road (BIA Route 313) Bridge	Cast-in-Place Concrete	Public
260+00	Kennedy Creek (Reid Ranch Access) Bridge	Precast Concrete Beams	Private
395+20	Powell (Memorial) Bridge	Steel Truss w/ Timber Deck	Private
501+00	St. Mary River Siphon Bridge	Steel Truss w/ Timber Deck	Private
670+00	DeWolfe Ranch Access Bridge	Railroad Trailer on Flat Car	Private
990+00	Martin (Whiskey Gap) Country Road Bridge	Precast Concrete Beams	Public
1375+00	Emigrant Gap County Road Bridge	Precast Concrete Beams	Public

2.1.6 Wasteways/Turnouts (Drains)

Canal wasteways serve as protective structures and facilitate the release of excess Canal water from the Canal and/or draining of the Canal. Wasteways can also be designed with spillway crests or other means which may allow for automatically discharging excess Canal water when the Canal water level rises above a certain level.

For typical irrigation canals, turnouts serve to make irrigation water deliveries from the main canal to water users. The St. Mary Canal serves as a conveyance canal, with no water users present along its extent (i.e., no designated irrigation or stock water deliveries are provided along its extent). As such, turnouts located along the St. Mary Canal do not serve for making irrigation water deliveries, but rather are used to provide drainage and release water from the Canal during Canal dewatering and maintenance and are also referred to interchangeably as drains for the purposes of this Report. Grass spillways identified in the *Milk River Project North Central Montana Feasibility Study* (Location Map) (U.S. Department of the Interior Bureau of Reclamation, 1999), are locations where the Canal may overtop at vegetated sections of the Canal. See Appendix D for referenced Reclamation St. Mary Location Map.

The St. Mary Canal originally included two wasteway structures which were designed to release/discharge the Canal design flow. One is located downstream of the Kennedy Creek Siphon and the second is located upstream of the Halls Coulee Siphon. Both were designed for the manual release of water from the Canal via manually operated gates (not designed for automatic spilling) and are not operational. The St. Mary Canal includes four known turnouts identified in the Location Map, however, the *St. Mary Diversion Facilities Feasibility and Preliminary Engineering Report for Facility Rehabilitation*[2] notes eight turnouts along the St. Mary Canal. Existing St. Mary Canal wasteways and turnouts are identified below in Table 2-2 and Figure 2-7. Five grass spillways were identified in the Location Map prepared by Reclamation.

[2] (Montana Department of Natural Resources and Conservation, and Thomas, Dean & Hoskins, Inc., 2006)

Table 2-2. St. Mary Canal Wasteways/Turnouts

Station	Name	Structure Description	Notes
269+91	Grassed Spillway	Natural Grass Overflow Spillway	Unknown Capacity
277+20	Kennedy Creek Wasteway Structure[1]	Cast-in-Place Concrete Structure w/ 2 Radial Gates	Capacity for Canal design flow (Wasteway is not operational)
394+26	Grassed Spillway	Grass Overflow Spillway	Unknown Capacity
438+46	Turnout/Drain	Pipe with slide gate inlet	Unknown Capacity
532+53	Turnout/Drain	Pipe with slide gate inlet	Unknown Capacity
851+22	Turnout/Drain	Pipe with slide gate inlet	Unknown Capacity
884+93	Halls Coulee Wasteway	Cast-in-Place Concrete Structure w/ 3 Slide Gates and Baffled Apron Spillway	Capacity for Canal design flow (Wasteway is not operational)
901+78	Grassed Spillway	Grass Overflow Spillway	Unknown Capacity
1145+71	Grassed Spillway	Grass Overflow Spillway	Unknown Capacity
1205+32	Grassed Spillway	Grass Overflow Spillway	Unknown Capacity
1529+50	Turnout/Drain	Pipe with slide gate inlet	Unknown Capacity

[1]Kennedy Creek Check Structure is located at Station 277+46 and is contiguous to the wasteway structure and operation. The Check Structure is comprised of a cast-in-place concrete structure with three radial gates.

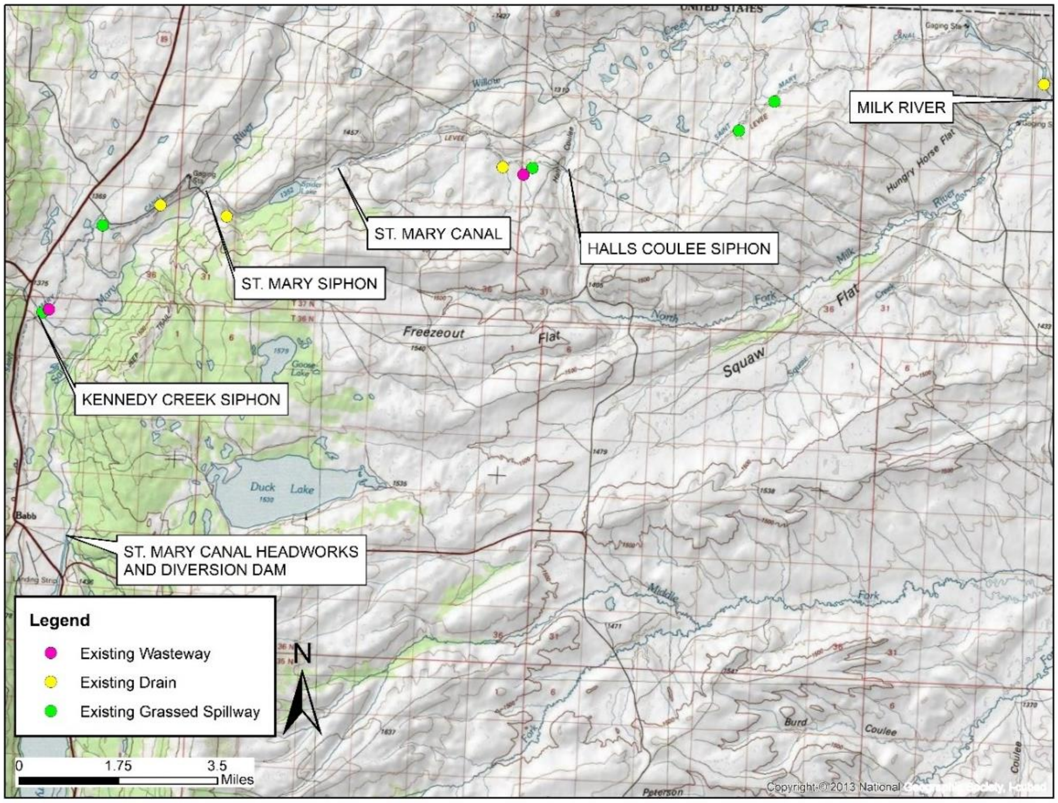


Figure 2-7. St. Mary Canal Wasteways and Turnouts

2.1.7 Underdrains (Culverts)

Canal underdrains (culverts) serve as protective structures to convey offsite surface drainage and runoff under the Canal to prevent additional water from entering the Canal uncontrolled. St. Mary Canal underdrains are located at major natural drainages to convey said surface drainage and runoff under the Canal. The St. Mary Canal includes seven major underdrain structures. Existing St. Mary Canal underdrains are identified in Table 2-3 and Figure 2-8.

In addition to major natural drainages with designated underdrain structures, numerous smaller drainages contribute runoff towards the St. Mary Canal along its extent at locations lacking any structures for the controlled conveyance of drainage and surface runoff either under the Canal (underdrains) or into the Canal (drain inlets). These smaller drainages were not delineated and are generally located between major underdrain structures. At said locations, runoff either collects and ponds upstream of the Canal (i.e., the Canal acts as an earthen dam,) and/or overflows uncontrolled into the Canal.

Table 2-3. St. Mary Canal Underdrains

Station	Name	Existing Structure Description[1]	Existing Structure Length (ft)
330+69	Powell Creek Culvert	2 x 66" RCP	Unknown
794+46	Cow Creek Culvert	54" x 66" RCP	180
979+70	Culvert	30" RCP	143
1052+72	Culvert	30" RCP	140
1096+93	Culvert	30" RCP	168
1134+68	Culvert	30" RCP	143
1194+29	Culvert	30" RCP	157

[1]RCB signifies reinforced concrete box culvert and RCP signifies reinforced concrete pipe.

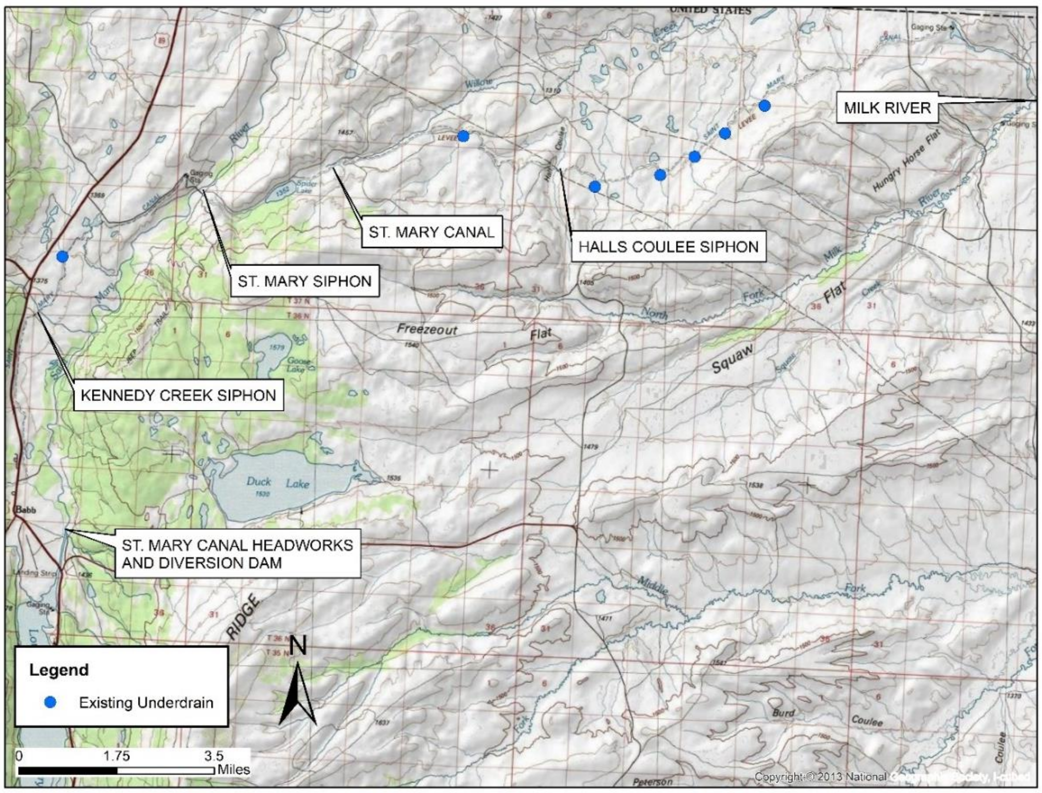


Figure 2-8. St. Mary Canal Underdrains

2.1.8 Drop Structures

Prior to delivering water to the Milk River, the St. Mary Canal achieves energy dissipation through dropping approximately 218 feet from the beginning of Drop 1 to entering the Milk River. 204 feet of this drop in elevation is through a series of five drop structures. These five drop structures are shown in Figure 2-9 below. The length and vertical drop of each structure are detailed in Table 2-4.

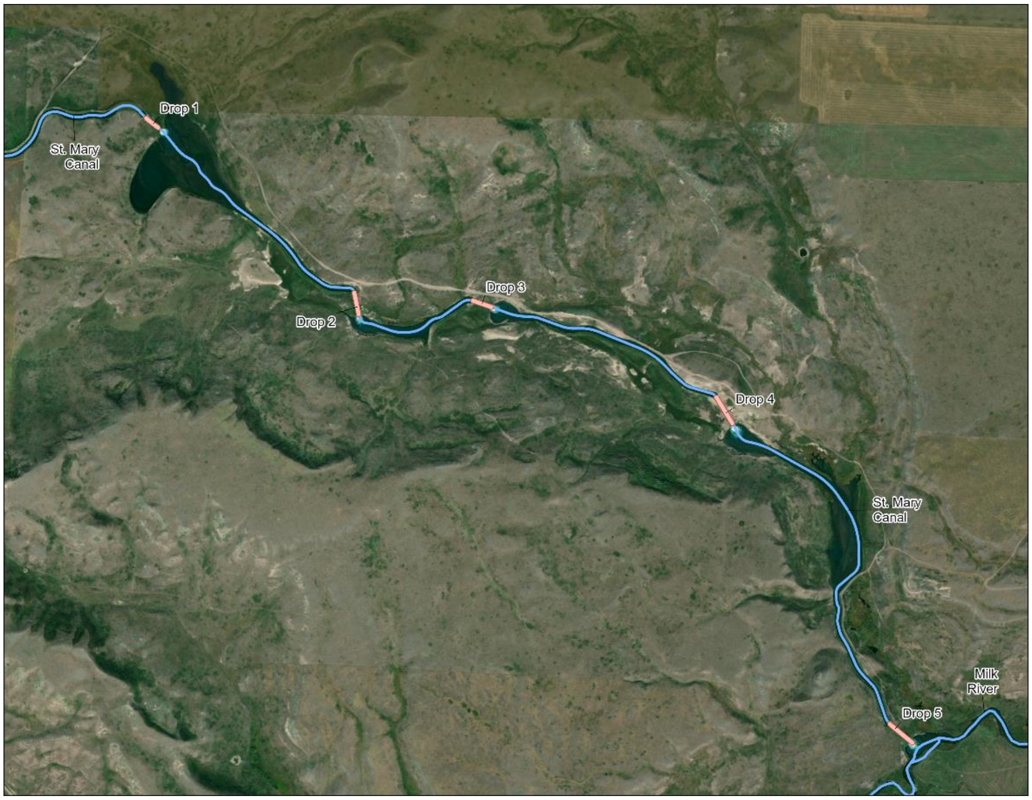


Figure 2-9. St. Mary Canal Drop Structures

Table 2-4. Drop Structure Lengths and Vertical Drops

Drop	Length (ft)	Vertical Drop (ft)
1	215	36.5
2	237	29.5
3	140	27.8
4	340	67
5	347	60.89

All five drop structures are reinforced concrete chutes with plunge pools/stilling basins at the bottom and are designed to convey 850 cfs. The drop structures were constructed between 1912 and 1915. Drops 2 and 5 were replaced in 2020 after the catastrophic failure of Drop 5 on May 17, 2020. See Figure 2-10.

Figure 2-10. Drop 5 Failure on May 17, 2020[3]

According to the Geotechnical Engineering Report (Terracon, 2020), the Drop 5 failure was likely caused by internal erosion of dispersive materials within the structure subgrade. The failure event was observed to have eroded the structure subgrade to maximum depths approximately 25 feet just downslope of the entry weir crest, and to widths as narrow as 10 feet but up to 20 feet in width. Subsequent observations of the structure site also indicate that the subgrade erosion likely precipitated tilting of the floor slabs within the drop structure. Then further erosion and piping ultimately caused the drop structure to become undermined, resulting in the damage to the structure by tilting of the structure slabs and subsequent damage to the drop structure caused by water flow damage.

Over the years, repairs have been made to the drop structures including various concrete repairs ranging from the grouting of cracks to replacing entire sections of a structure due to extensive concrete deterioration and failure. More specifically, repairs include:

- Drop 4 crest and chute replacement (2011)
- Drop 3 chute floor replacement (2004/2005)
- Drop 3 major rebuild of the plunge pool basin and wing walls
- Drop 1 wing walls and stilling basin (2020)

Currently, Drops 1, 3 and 4 show noticeable signs of chute sidewall and slab deterioration, wingwall settlement, exposed rebar throughout, and cracking and spalling

[3] Photo credit, Montana DNRC (Figure 8 - http://dnrc.mt.gov/divisions/water/management/docs/st-mary-rehabilitation-project/drop-structure-pictures.pdf)

concrete evident along the chutes, chute sidewalls, wingwalls, and plunge pool walls of each structure. See Figure 2-11, Figure 2-12, & Figure 2-13 below.

Figure 2-11. Drop 1 Chute Condition

Figure 2-12. Drop 3 Plunge Pool Headwall Condition

Figure 2-13. Drop 4 Chute Condition[4]

In 2014, Reclamation concluded that the Canal drop structures were in poor condition and that they required significant repairs to bring them up to current standards and to improve reliability to acceptable levels (Darlinton, 2014).

In 2018 Reclamation released the report *2018 Associated Facility Review Examination Report St. Mary Diversion Dam and Canal Milk River Project, Montana*[5]. The purpose of the report in part was to perform an inspection of the St. Mary Canal facilities to determine future maintenance needs and to gather design data for the possible replacement of the drop structures. Excerpts from that report are below for Drops 1, 3 and 4.

Drop 1:

The concrete floor of Drop #1's stilling basin is in poor condition, with exposed rebar in various locations and in one location the damage has worn through the first mat of rebar and is beginning to degrade the second mat.

The terminal wall has significant concrete damage, with exposed rebar along the majority of the wall and holes that have extended into and past the second mat of rebar. It doesn't appear that the holes go all the way through to the backfill material, but it could happen in the near future and start to erode backfill material that is not only holding up the wall but also the chute.

There is mention of wingwall deterioration as well, however, the wingwalls were repaired in 2020.

[4] Photo credit: Bureau of Reclamation

[5] (U.S. Department of the Interior Bureau of Reclamation , 2018)

Drop 3

In 2008 the Drop 3 terminal wall and both wingwalls (parallel to flow) were rehabilitated. Poor concrete persists on the far downstream wingwalls that are perpendicular to the flow. The wingwalls are falling into the Canal and are only being held up by the rebar that is tied into the footer and other wingwalls.

Drop 4:

The terminal wall has major cracking and spalling, and due to the nature of the cracking, is broken into separate blocks of concrete rather than one solid wall. The left wingwall has a large bulge and crack in the wall about 1/3 up from the bottom. It is assumed that the pressure being exerted on the wall from the fully saturated soils behind the wall and lack of weep holes in this section is causing the bulge and the wall is largely being held together by the rebar. Some repairs have been made to Drop 4 including stabilization of the right wingwall and the filling in of a large hole downstream of the stilling basin that was approximately 50 deep wide, 70 feet long and 8-10 feet deep.

In Section 4.8.1, Reclamation (2018) concluded the following:

> *"In our opinion, the St. Mary River Siphon and hydraulic drops represent the greatest potential for catastrophic failure due to their present condition and estimated damage resulting from failure. Catastrophic failure of either of these two components would result in severe and irreversible environmental damage to the St. Mary River and the North Fork of the Milk River, respectively. Repairs would most likely take two years for significant failure of one of the two siphon locations and at least one year for a failed drop. This would create an economic disaster for north central Montana directly and indirectly for the remainder of the State."*

Due to the age, existing condition, recent 2020 failure of Drop 5 and available literature reviewed for the drop structures, a replacement in-kind is recommended for Drops 1, 3 and 4 with minor variations in cross section and overall layout to improve capacity, flow characteristics, and structure durability. The 10% design for these in-kind replacements is provided in Appendix C. The replacement drops final design will likely be similar to the Drop 2 and Drop 5 structures constructed in 2020.

The cross section of the replacement chute would be rectangular, instead of trapezoidal to better contain the flow and prevent overtopping of the sides. In addition, the sidewalls at the approach to the chute would be vertical, in place of the current, convoluted transition and warping sidewalls.

Severe deterioration within the existing plunge pools has occurred over time as a result of the impact of falling water, improper ventilation, cavitation and freeze-thaw damage. Protective measures should also be implemented to prolong the life of the concrete, specifically within the plunge pool, including a thicker concrete slab, ventilation, and air-entrained concrete which is more suitable for the harsh freezing conditions realized in this geographic region.

2.2 Water Resources

2.2.1 Watershed Hydrology and Ecology

The St. Mary Canal is approximately 29 miles long and brings water from the St. Mary River to the North Fork of the Milk River. Figure 3-4 shows the extents of the St. Mary Canal system. Water enters the Canal from the St. Mary River at the St. Mary Diversion Dam and then crosses the river 9.5 miles below the diversion through two 90-inch, riveted steel-plate siphons 3,600 feet in length. Eight miles below the river crossing, the second set of riveted steel-plate siphons, 78 inches in diameter and 1,405 feet long, conveys the water across Halls Coulee. A series of five concrete drops at the lower end of the 29-mile Canal provide a total fall of 214 feet to the point where the water discharges into the North Fork of the Milk River. On average, 150,000 acre-feet of water per year are transferred over the Hudson Bay/Gulf of Mexico divide to the North Fork of the Milk River. The water then flows for 216 miles through Alberta, Canada, before returning to Montana where it collects in Fresno Reservoir 14 miles west of Havre, MT. Flows released from Fresno Reservoir provide irrigation and municipal water along the Milk River to its mouth near Nashua, MT, 200 miles east.

The St. Mary River represents a constant and reliable source of water. Its drainage basin covers approximately 277 square miles at the point of the St. Mary Diversion Dam and 462 square miles at the Canadian Border. Flows originate from high mountain streams headwatered on the east slope of the Rocky Mountains in the northeast corner of Glacier National Park. These streams are predominantly derived from melting snow and seasonal rainfall precipitation. After passing the St. Mary Diversion Dam, the St. Mary River runs north into Canada, connecting with the Saskatchewan River system and eventually emptying into the Hudson Bay. Stream flows in the St. Mary River are fairly consistent annually. The USGS has measured daily flows from 1902 to the present at gage station 05020500, located at the U.S.-Canada Boundary. During that period, the maximum flow of the river at the U.S.-Canada Boundary was estimated to be 40,000 cubic feet per second (cfs) on June 5, 1908. The lowest annual seven-day minimum flow was 27.28 cfs ending December 2, 1936. The average annual flow of the river is approximately 712 cfs or 515,465 acre-feet (AF). The mean annual natural flow of the river, including diverted water, is approximately 925 cfs or 670,000 AF.

Conversely, stream flows in the Milk River are more erratic year-to-year compared to flows found in the St. Mary River. The headwaters of the Milk River originate in upland hills and plateaus east of the St. Mary River drainage. Its drainage basin covers approximately 65 square miles at the point of St. Mary Canal. The natural waters of the Milk River are derived from the melting of limited snowpack and seasonal precipitation events. Information on flow near the mouth of the Milk River is available from 1939 to present. During that period, the maximum flow at Nashua, Montana (USGS Station 06174500) near where the river joins the Missouri River was 45,300 cfs, recorded on April 18, 1952. The lowest average seven-day annual flow was 0 cfs, occurring throughout much of July and August in 1984, and again towards the end of May in 2001. The average March - October flow at the Eastern Crossing (USGS Station 06135000) at the U.S.-Canadian border, upstream of Fresno Reservoir, is 500 cfs or 243,000 AF. It is important to note that the flow measurements after 1916 in the St. Mary River downstream of the diversion dam and in the Milk River downstream of Drop No. 5 do not represent natural unencumbered flows but rather the overall effect of the water diversion project.

Reportedly in dry years, 90 to 100 percent of the water in the Milk River Basin is diverted from the St. Mary River. During average years, the diverted St. Mary water represents approximately 70 percent of the Milk River flow from May through September. It is reported that in the late summer, for 4 out of 10 years there is no natural flow in the Milk River (U.S. Department of the Interior Bureau of Reclamation, 2004), and that it would run dry without the diverted St. Mary River water.

Climate change may present difficult and complex challenges for water managers in the area. Warming temperatures, a reduction in summer rainfall, an increase in precipitation intensity, increased rates of evapotranspiration, an overall decrease in soil moisture, less precipitation falling as snow, and earlier snowmelt are examples of such challenges.

For most of its distance, the Milk River runs through short grass prairie: vast, rolling, high plains grasslands, interrupted by island mountain ranges like the Bears Paw and Little Rocky Mountains, and valleys like the Milk River basin and Missouri River basin. Potholes—remnants of glaciers—pock the prairie, providing grassland-wetland habitat. Critical wetland habitat is also provided by the various oxbows and sloughs located throughout the basin. Plants along the waterways are a grass-forb mixture, with occasional concentrations of rose, willow, buffaloberry, and scattered cottonwoods. Upland areas away from the river are largely rangeland and dryland cropland.

Habitats in the region allow for a diverse selection of wildlife and bird species. Big-game species include elk, whitetail and mule deer, and pronghorn antelope. Bison can be found on the Blackfeet and Ft. Belknap Reservations. Many predatory species exist in the region, including grizzly and black bears, mountain lions, lynx, coyotes, red foxes, and badgers. Small mammals, like beavers, muskrat, cottontail and jackrabbits, black-tailed prairie dogs, mink, weasels, raccoons, porcupines, skunk, and several bat species can be found.

The region is a haven for birds: over 150 songbirds; shorebirds (stilt, avocet, willet, and curlew); waterbirds (pelican, loon, goose, and duck); raptors (eagle, falcon, hawk, and owl); and upland game birds (pheasant, partridge, turkey, and grouse) exist in the region.

Many reptile and amphibian species also inhabit the region, including the western painted turtle, soft-shelled turtle, prairie rattlesnake, bull snake, short-horned lizard, and garter snake. Amphibians in the abundant wetlands and riparian areas include the western chorus frog, leopard frog, and Woodhouse’s toad.

There are 10 Montana Wildlife Management Areas in the Milk River basin. Several of them are associated with Milk River Project facilities, including Fresno Reservoir, Dodson Diversion Dam, Dodson South Canal, Nelson Reservoir, and Vandalia Diversion Dam. Bowdoin National Wildlife Refuge is also located in the Milk River Basin near Malta, Montana.

Fish species native to the St. Mary River include bull trout, west slope cutthroat trout, mountain whitefish, lake trout, northern pike, burbot, white sucker, longnose sucker, lake chub, troutperch, longnose dace, pearl dace, mottled sculpin, and spoonhead sculpin. Lakes in the St. Mary drainage also contain native populations of northern pike and sucker species and the only known population of troutperch in Montana. This habitat is shared with non-native populations of Yellowstone cutthroat trout, rainbow trout, brook trout, kokanee, and lake whitefish (U.S. Department of the Interior Bureau of Reclamation, 2004).

A study of the Milk River fishery found approximately 40 species of fish. Flathead chub, river carpsucker, shovelnose sturgeon, and stonecat are most common in spring, with emerald shiner, flathead chub, goldeye, and shorthead redhorse most common in fall (Stash & R.G. White, 2001). Several endangered and threatened species listed under the Endangered Species Act (ESA) may be found in the St. Mary River and Milk River region (Table 2-5) as well as species recognized by the State of Montana to be of special concern (Table 2-6).

Table 2-5. ESA Threatened and Endangered Species[6]

Endangered Species	Threatened Species
Black-footed ferret	Grizzly bear
Whooping crane	Piping Plover
Pallid Sturgeon	Bull trout
Interior least tern	Canada lynx

Table 2-6. Montana Species of Special Concern[7]

Montana Species of Concern		
Arctic grayling	Western glacier stonefly	Townsend's big-eared bat
Western toad	Yellowstone cutthroat trout	Westslope cutthroat trout
Trout-perch	Lake trout	Black-tailed prairie dog
Paddlefish	Greater sage grouse	Western hog-nosed snake
Pearl dace	Sauger	Sicklefin chub
Eastern ringtail	Great plains toad	Chestnut collared longspur
Mountain plover	Blue sucker	Sturgeon chub
Black-footed ferret	Milksnake	Caspian tern
Bull sucker	Shortnose gar	Hoary bat

2.2.2 Diversion Water Quality

Montana classifies its waterbodies according to present and future beneficial uses they are expected to support (Fort Belknap-Montana Compact, 2001). The following details

[6] (U.S. Department of the Interior Bureau of Reclamation, 2004)

[7] (U.S. Department of the Interior Bureau of Reclamation, 2012)

Montana Department of Environmental Quality's (MDEQ) water quality classifications of the St. Mary and Milk Rivers within the Milk River Project Area (U.S. Department of the Interior Bureau of Reclamation Montana Area Office, State of Montana Department of Natural Resources and Conservation, 2012).

- The St. Mary River in Glacier National Park is classified A-1, suitable for all water uses.
- The St. Mary River from Glacier National Park downstream to the Canadian Border is classified as B-1, suitable for drinking and food processing after conventional treatment, as well as all other uses.
- The Milk River from the Eastern Crossing[8] to where the Milk River joins with the Missouri River is classified as B-3, suitable for drinking and food processing after conventional treatment, as well as for all uses except propagation of salmonid fish.

Water quality problems on the Milk River become more pronounced during droughts when dissolved chemical concentrations and water temperatures are highest, although suspended sediments are higher during high-flow events such as spring runoff. Irrigation can contribute to water quality degradation. Problems typically occur when irrigation diversions result in low river flows and when return flows from fields bring higher concentrations of salts, nutrients, suspended solids, and pesticides (U.S. Department of the Interior Bureau of Reclamation, 2012).

2.2.3 Bureau of Reclamation Water Rights

The St. Mary Canal was designed to divert up to 850 cfs. However, the actual conveyance capacity has been reduced as a result of seepage, slides, and Canal bank slumping that have occurred across its range.

International Water Rights

The U.S. and Canada share the waters of the Milk and St. Mary Rivers under the Boundary Waters Treaty of 1909, the International Joint Commission (IJC) 1921 Order, and subsequent Letter of Intent. Canada's share of the St. Mary River at the International Boundary, as stipulated by the IJC 1921 Order, is three-fourths of the natural flow when the Canal's flow is 666 cubic feet per second (cfs) or less during the irrigation season (April 1 to October 31).; and flows above that quantity are divided equally between Canada and the U.S. During the non-irrigation season (November 1 to March 31), the flow is divided equally between the two countries.

The division of the Milk River is similar to the division of waters of the St. Mary River, except the U.S. receives the larger fraction. The U.S.'s share of the Milk River at the Eastern Crossing, as stipulated by the IJC 1921 Order, is three-fourths of the natural flow when the flow is 666 cfs or less during the irrigation season; and flows above that quantity are divided equally between Canada and the U.S. (U.S. Department of the

---

[8] After entering Canada, the Milk River flows through southern Alberta before turning south and re-entering the U.S. at what is referred to as the Eastern Crossing of the International Boundary (Eastern Crossing) just upstream of Fresno Reservoir.

Interior Bureau of Reclamation, 2012). During the non-irrigation season, the flow is divided equally between the two countries.

To comply with the IJC 1921 Order, representatives of both countries make twice-monthly computations of the daily natural flow of each river to determine the flow apportionment during the irrigation season. These 15- or 16-day periods are termed “division periods” and provide an opportunity for each country to respond to varying use and flow conditions. For example, if the U.S. overutilizes its share during a division period, then a surplus of an equivalent volume of water is normally delivered to Canada at the earliest opportunity (Goos & Ethridge, 2008). Current administrations of the Treaty, combined with infrastructure limitations, lead to the U.S. receiving less than its share of St. Mary River flow and Canada receiving less than its share of Milk River flow. The State of Montana and the Province of Alberta met to explore options for both nations to better allocated their shares of the rivers and a study is currently underway by the IJC focusing on two key areas (U.S. Department of the Interior Bureau of Reclamation, 2012):

- The water measurement data and calculations currently used to determine the amount of water that each country receives; and
- Possible options to improve how water is conveyed within the basin. This could include a review of infrastructure such as canals and reservoirs that could improve both countries’ access to waters shared under the Treaty and the 1921 Order.

The IJC has said that recommendations should be out to the governments of Canada and the United States by late 2025 (International St. Mary - Milk Rivers Study Board, 2021).

Fort Belknap Indian Reservation Water Rights

A Water Rights Compact between the State of Montana and the Gros Ventre and Assiniboine Tribes of the Fort Belknap Indian Reservation was ratified by the Montana State Legislature and signed by the Governor in 2001 (Fort Belknap-Montana Compact, 2001). The compact entitles the Tribes to divert up to 645 cfs from the U.S. share of the natural flow of the Milk River. In the historic 1908 Winters vs. United States decision, the U.S. Supreme Court ruled that when Congress reserves land, sufficient water is also reserved to fulfill the purpose of the Fort Belknap Reservation. When the Fort Belknap Reservation was created, 125 cfs were reserved, which established the reserved water rights doctrine.

Blackfeet Tribe Water Rights

The compact negotiated between the Blackfeet Tribe and the State of Montana was approved by the Montana Legislature and recommended for further action by the Blackfeet Tribal Business Council in 2009. The Compact gives the Tribe the right to 50,000 AF per year from the St. Mary drainage, other than Lee Creek and Willow Creek, subject to the Boundary Waters Treaty, and all groundwater in the St. Mary River drainage not subject to the Boundary Waters Treaty. In the Milk River basin, the Tribe has a water right to all natural flows and groundwater available to the U.S. under the Boundary Waters Treaty and all groundwater not subject to the Boundary Waters Treaty in "Basin 40F" (i.e., the Milk River basin) within the Blackfeet Reservation, except for waters subject to the water rights arising under state law on the Blackfeet Reservation. Specific details regarding the Compact are found in Section 85-20-1501 of the Montana Code Annotated (Blackfeet Tribe-Montana-United States Compact, 2017). On April 20, 2017, tribal members of the Blackfeet Nation enacted the Blackfeet Water Compact and Settlement Act. Through this act the Tribe has sole rights to issue permitting for water rights within the Reservation, as well as the exclusive right to develop and market hydropower at Milk River Project facilities on the Reservation.

2.2.4 Milk River Joint Board of Control Water Use

Current Demands

Water demands in the Milk River basin are dominated by agricultural irrigation, while municipal demands are much smaller in comparison. There are non-consumptive water demands for recreation and fish and wildlife purposes associated with the Milk River Project, but these generally are not quantified and historically have been considered by Reclamation as incidental uses of project water.

Agricultural Water Demands

Present irrigation water users generally can be categorized into six groups:

- Water users upstream of the Eastern Crossing
- Water users diverting from tributaries of the Milk River main stem
- Non-project water users diverting from the Milk River main stem
- Tribal water users
- Milk River Project irrigation districts
- Milk River Project contract water users[9]

Water users in the Milk River basin upstream of the Eastern Crossing include U.S. and Canadian irrigators. In the Milk River headwaters on the Blackfeet Reservation in the U.S., irrigation needs vary annually, depending on available water and economic factors. This study assumed that 200 acres from the North Fork of the Milk River, and 2,000 acres in the Milk River watershed upstream of the Western Crossing were irrigated. For the Milk River in Alberta, Canada, between the Western and Eastern Crossings, 8,000 acres were considered irrigated (Montana Department of Natural Resources and Conservation, and Thomas, Dean, & Hoskins, Inc., 2006).

Water users diverting from Milk River tributaries generally have limited irrigation opportunities because of tributary runoff patterns. The tributary streams usually have water available during the snowmelt runoff, which usually is during March and April. Although crop demands are very low during this period, irrigators still apply water to fill the soil profile for later crop use. Tributaries may also flow and have water available from spring and early summer rains in May and June. Approximately 40,000 acres are

[9] Contract water users includes anyone receiving water from the project whether they are represented by an Irrigation District or a Municipality in either Canada or the US.

irrigated from tributary streams in the Milk River basin, although very little of this irrigation approaches full service. There are a few storage reservoirs for irrigation on the tributary streams, the largest being the DNRC's Frenchman Reservoir on Frenchman Creek.

According to the Bureau of Reclamation, a GIS analysis indicated that there are 140,200 acres of land that can be irrigated downstream from the Eastern Crossing on the Milk River's main stem. Presently, the Fort Belknap Indian Irrigation Project area has a total of 10,500 acres, however, only 6,200 of those acres are actively being irrigated from the main stem. There are 110,300 acres currently authorized to receive Milk River Project water. However, GIS analysis has indicated that there may be an additional 12,100 acres being irrigated with this water, giving a total of 122,400 acres being irrigated as part of the Milk River Project. The additional acres appear to be irrigated from project facilities that are not authorized but may have overlapping state-based water rights presently being adjudicated by the Montana Water Court (U.S. Department of the Interior Bureau of Reclamation, 2012).

The remaining 11,600 of the total 140,200 acres are irrigated by private irrigation systems along the Milk River. The water for these systems is usually pumped from the Milk River. Previous studies indicated that there are about 25,000 acres of privately irrigated land in the basin below Fresno Reservoir. If the additional 12,100 unauthorized acres being served by project facilities are included, private irrigation would total approximately 23,700 acres. Milk River irrigated acres below Fresno Reservoir are summarized in Table 2-7.

Table 2-7. Milk River Irrigated Acres Below Fresno Reservoir

Description	Acres
Milk River Project Water	110,300
Unauthorized Usage	12,100
Fort Belknap Indian Reservation	6,200
Private, Non-contract	11,600
Total	140,200

The net irrigation requirement for the crop distribution grown in the Milk River basin downstream from Fresno Reservoir ranges from an average of about 18.3 inches per acre in the Chinook area to an average of about 19.8 inches per acre in the Glasgow area. Thus, the total depletion requirement for the 140,200 acres of land irrigated from the main stem, without water shortages averages about 210,000 AF per irrigation season. When overall basin irrigation efficiencies of about 33 percent are factored in, the total diversion requirement for the 140,200 acres irrigated is about 630,000 AF. The system does not need to provide the entire 630,000 AF to meet diversion requirements because return flows are recycled downstream (U.S. Department of the Interior Bureau of Reclamation, 2012).

Municipal Water Demands

The communities of Havre, Chinook, Harlem, Hill County, and North Havre Water District have water supply contracts with Reclamation for municipal water. The current annual average water use, the maximum annual water-use since 2001, the total water volume of contracts, and the expiration date of the contracts are listed in Table 2-8. The cities deplete part of this water, especially during the summer for lawn and garden use, but much of the diverted flow eventually returns to the Milk River (U.S. Department of the Interior Bureau of Reclamation, 2012).

Table 2-8. Current Contracts for Municipal Water

	Average (AF)	Maximum since 2001 (AF)	Contract Volumes (AF)	Contract Expiration
Havre	1825	2,040	2,800	March 2033
Chinook	360	825	700	September 2016
Harlem	130	140	500	May 2043
Hill County	250	340	500	August 2046
North Havre	35	-	100	August 2046
Total	2,600	-	4,600	-

The communities are presently using an average of about 2,600 AF annually. The combined contracted amount of water is up to 4,600 AF annually, so they are presently using considerably less than the contracted volume. Municipal use represents less than 1 percent of total Milk River diversions.

Fish, Wildlife, and Recreation Demands

The St. Mary River, Milk River, and associated storage reservoirs (Sherburne Lake, Fresno Reservoir, and Nelson Reservoir) provide habitat for many fish and aquatic species. These reservoirs, rivers, and surrounding lands also offer hunting and fishing opportunities; water-borne recreation like boating, water skiing, and swimming; as well as camping, picnicking, and wildlife observation.

The Montana Fish, Wildlife and Parks (FWS) established recommendations in 1998 for reservoir and river operations for fish, wildlife, and recreation. Recommendations for Fresno Reservoir include maintaining a conservation pool above an elevation of 2,560 feet mean sea level (MSL) to provide maximum benefit to the fishery and recreation, and a minimum pool elevation of 2,551 feet MSL. Recommendations for Nelson Reservoir include maintaining a conservation pool above an elevation of 2,215 feet to provide maximum benefit to fishery and recreation, and a minimum pool elevation of 2,210 feet. A gradual drawdown of both reservoirs after mid-May is recommended to allow walleye and perch eggs to hatch.

The Bowdoin National Wildlife Refuge provides food and habitat for migratory birds (including the endangered piping plover and interior least tern), upland birds, and many species of waterfowl. The refuge has water rights on Beaver Creek and a contract with Reclamation for Milk River Project water. Up to 3,500 AF of project water annually is diverted to the refuge from the Dodson South Canal under the contract. The refuge also receives return flow from Malta Irrigation District (U.S. Department of the Interior Bureau of Reclamation, 2012).

Future Demands

The ability of water supplies for the region to meet the demand is expected to change in the future. For the Milk River Project to remain viable, water users will likely have to incorporate new technologies, forge new partnerships, and improve overall water supply management.

Many factors, including unforeseen new uses, increased resource protection, and socioeconomic changes could also affect future water use. Other factors that could increase demands as a result of warmer climate conditions include evaporation, groundwater depletion, and fish, wildlife, and recreation demands.

Agricultural Use

Warmer temperatures and a longer growing season would result in more crop growth and increased evapotranspiration. According to the St. Mary River and Milk River Basins Study Technical Report, 112 different climate change projections were analyzed. (U.S. Department of the Interior Bureau of Reclamation, 2012). These models showed a variety of different scenarios all featuring some aspect of rising temperatures but with varying severity. The model looked at less warming/wetter, more warming/dryer, less warming/dryer, more warming/wetter, and everything in between. (U.S. Department of the Interior Bureau of Reclamation, 2012). All climate change scenarios project a substantial increase in crop irrigation requirements for the irrigated lands.

Even if projected increases in runoff under the wetter future scenarios could be captured and used, by 2050 this would only make up for 33 to 37 percent of the expected increase in irrigation depletions. Because water supplies would not increase enough to meet demands, the river system model results show increased irrigation depletion shortages[10] under all future climate scenarios, with the greatest relative increase during drier years. Irrigation depletion shortages would increase from the current annual average of 71,000 AF to 106,000 AF (U.S. Department of the Interior Bureau of Reclamation, 2012).

Municipal Uses

Future municipal water uses are expected to remain within the current contracted amount.

Fish, Wildlife, and Recreation Demands

According to the St. Mary River and Milk River Basins Study Technical Report, instream flow amounts and temperatures need to be considered for aquatic species. (U.S. Department of the Interior Bureau of Reclamation, 2012). Climate change in northern Montana is generally projected to increase annual mean temperatures, modifying flow volumes both positively and negatively, and shifting the peak of the hydrograph both forward and backward. These effects are localized in different regions of the two basins and can affect ecological resiliency for aquatic species in these basins, primarily the ability of invertebrate and fish species to adapt to changing habitat conditions. With warming temperatures and higher evaporation rates in the future, lower overall water levels at the Bowdoin National Wildlife Refuge could be a concern. Recreational use of

[10] Irrigation depletion shortages means the unmet amount of water a crop needs for optimal growth.

Fresno Reservoir, Nelson Reservoir, and Sherburne Lake, as well as Glacier National Park, is expected to increase, and low water surface elevations might affect public usage (U.S. Department of the Interior Bureau of Reclamation, 2012).

Threatened and Endangered Species

Reclamation has entered into ESA consultation with the U.S. Fish and Wildlife Service (USFWS) for continued O & M of the existing system until 2025. Current water operations to benefit the piping plover are not expected to change in the foreseeable future. Flow requirements for pallid sturgeon might be quantified in the future. Water demands for Species of Special Concern are not anticipated to change.

Future International Uses

Canada does not have storage facilities on the Milk River and is currently unable to capture and use its entire share of the Milk River's natural flow. On average, Canada annually sends about 20,000 AF of its share of Milk River natural flow to the U.S. The Province of Alberta has investigated constructing a reservoir on the Milk River to capture the remaining portion of their share of the Milk River's natural flow. This would increase shortages for U.S. Milk River irrigators (U.S. Department of the Interior Bureau of Reclamation, 2012). As mentioned previously, the IJC is hoping to improve water access for the U.S. and Canada which may change the way water allotments are structured. Their current study is planned to conclude in 2025.

Future Tribal Implementation of Federal Reserved Water Rights

The Tribes of the Blackfeet and Fort Belknap reservations may develop more of their federally reserved water rights for St. Mary River and Milk River flows in the future (the Tribes of the Fort Belknap Reservation only have rights to Milk River flow). The Blackfeet Tribe has recently enacted a congressionally approved compact allowing for greater access and control to waters within the reservation. The Fort Belknap Community has conditionally approved a Water Rights Compact with Montana and has introduced legislation to congress under the Gros Ventre and Assiniboine Tribes of the Fort Belknap Indian Community Water Rights Settlement Act of 2021.

2.2.5 Water Losses

Based on water loss measurements conducted by FCA in the Lower St. Mary Canal (from the St. Mary Siphon to just above Drop 1) from June 26th to June 28, 2021, FCA calculated total near-maximum seepage losses of 39.0 cfs. Per FCA, these Canal losses represent overall system performance during a typical water year delivery. To account for seasonal and year over year variations, FCA performed an analysis of 11 years of flow data from USGS Gage 05018500 indicating that on average, an estimated 11,314 AF is lost in the Lower St. Mary Canal each year (Farmer's Conservation Alliance, 2022). In addition, FCA calculated mean losses of 11,306 AF in the Upper St. Mary Canal (diversion dam to the St. Mary Siphon). Analysis of individual years in the same time period indicated average losses ranging from 3,614 AF to 18,655 AF annually.

Per FCA's analysis, the total estimated annual water loss between the diversion and Drop 1 is 22,620 AF.

Section 3. Modernization Options Evaluation

Options for improvements were considered for the major Canal components. A number of factors contributed to the options that were considered:

- Restoring the Canal system capacity to 850 cfs
- Conservation of water
- Improved operations and maintenance accessibility and efficiency
- Considerations of future operations and maintenance
- Resource protection
- Construction feasibility
- Capital cost

When considering the lining and pressurized piping options, hydraulic modeling was completed to aid in the analysis. Modeling methods and results are described in the following sections.

3.1 Hydraulic Model Methodology

The existing St. Mary irrigation system from immediately downstream of the St. Mary Diversion to the North Fork of the Milk River (approximately 29 miles) was analyzed using the one-dimensional (1D) capabilities of HEC-RAS, Version 6.2. To develop the 1D models, cross sections were placed using the RAS Mapper interface. Cross sections were aligned perpendicular to flow and along assumed equipotential lines. Cross sections are located at key locations along the Canal, including slope breaks, changes in the cross-section shape (ponds and channel changes), and structures within the Canal.

3.1.1 Model Extent

The model extents for analyzing the existing St. Mary irrigation system and the reviewed improvements extended from immediately downstream of the St. Mary Diversion to the North Fork of the Milk River for a total extent of approximately 29 miles. In addition to the Canal extent, the models also represented the major hydraulic structures along the length of the reach. These structures are detailed in Table 3-1.

Table 3-1. Summary of Key Features Along the St. Mary Canal

River Station (ft)	Feature	Description
4	Downstream Study Limit	Furthest downstream extent of the model – Downstream study limit at the confluence with the North Fork of the Milk River
271	Drop 5	Hydraulic control for Drop 5
4544	Drop 4	Hydraulic control for Drop 4
7313	Drop 3	Hydraulic control for Drop 3
8893	Drop 2	Hydraulic control for Drop 2
11734	Drop 1	Hydraulic control for Drop 1
16681	Emigrant Gap Road	80’ single span bridge
54464	Whiskey Gap Road	80’ single span bridge
60589	Halls Coulee Siphon	Double barrel 78” smooth steel siphon culvert
65050	Halls Coulee Wasteway	Inoperable overflow control structure
86038	DeWolfe Ranch Access Bridge	75’ single span bridge
91296	Spider Lake Control Structure	Abandoned control structure, modeled as 27’ single span bridge Spider Lake located upstream.
103514	St. Mary Siphon	Double barrel 90” smooth steel siphon culvert
115445	Powell Bridge / Memorial Bridge	90’ single span bridge
126320	Powell Bridge	Bridge with three 9’x9’ radial gates
127400	Kennedy Creek Crossing	8.5’ x 9.25’ horseshoe (modeled as an 8.5’ x 9.25’ arch)
128007	Reid Ranch Access Bridge	80’ double span bridge with an 8” pier
144894	Boulder Drive / Babb Bridge	60’ three span bridge with 16” piers
152335	Upstream Study Limits	Furthest upstream extent of the model – Upstream study limit immediately downstream of the St. Mary Diversion

3.1.2 Topographic Data

The topographic data used to represent the ground elevation in the model domain was produced using numerous data sources. Most overland areas in the domain are represented using LiDAR coverage produced by QSI Environmental (2021). Bathymetric data and pertinent survey points describing the hydraulic structures and channel thalweg were obtained from the survey performed by HDR (2020) and TD&H (2004). All data sources reference the North American Vertical Datum (NAVD) 88.

3.1.3 Existing Conditions Analysis

The existing conditions of the St. Mary Canal was simulated using the topographic data described in Section 3.1.2 and the structural information described in the as-builts made available by Reclamation. Information describing the bridges and culverts was implemented based on the as-builts. It should be noted that HEC-RAS is incapable of representing the geometry of the siphons and the model can only define linear culverts. Hence, the Manning's values of the siphons were altered to account for the additional headlosses associated with the bends of the siphons.

3.1.4 Boundary Conditions

Model simulations were run using constant discharges of 600 cfs and 850 cfs as these were identified as the current operating discharge and the design discharge. External boundary conditions were applied at the upstream and downstream extent of the model and remained the same between the existing and modernization option conditions runs. A constant flow rate was specified at the upstream external boundary condition, while a normal depth calculation was used for the downstream boundary. A downstream normal depth boundary condition rating curve was developed using the existing terrain, assuming a downstream slope of 0.0001 ft/ft (0.001%), as this approximates the flat slope in grade and energy below Drop 5.

3.1.5 Model Calibration

The FCA collected flow measurements at six locations along the St. Mary Canal between June 26 and June 28, 2021. The flow measurements were collected for the purpose of calculating water losses along the Canal. The flow measurements include the depths of flow as well as the total flow at each observed location. The maximum depth at each section was used in conjunction with the terrain data of the Canal to calculate a water surface elevation at each observed location. An additional flow profile was added to the HEC-RAS model to represent the flow at the time of the flow measurements, which was approximately 595 cfs. This flow profile was used to calibrate the hydraulic model. The known water surface elevations were added to the HEC-RAS model as observed water surface elevations at the cross sections nearest the flow measurement locations. To calibrate the hydraulic model, the Manning's roughness of the Canal was modified so that the water surface elevations represented the measured values within a reasonable tolerance. The Manning's roughness of the Canal was selected to range from 0.023 in the flatter downstream reaches to 0.026 in the upper reaches.

The calculated water surface elevations at each field measurement location as well as the water surface elevation calculated in the HEC-RAS model are shown in Table 3-2 below.

Table 3-2. HEC-RAS results vs. measured water surface elevations

River Station (ft)	Measured WSEL (ft)	HEC-RAS WSEL (ft)	Difference (ft)
12719	4418.96	4418.95	-0.01
12988	4418.96	4419.02	0.06
59187	4423.78	4423.87	0.09
61934	4438.42	4438.30	-0.12
90153	4441.73	4441.75	0.02
96147	4441.67	4442.16	0.49
101640	4442.82	4442.90	0.08

In addition to the measured flow data, there are two USGS gages along the upper reach of the Canal. USGS gage 05018000 is located near the intake of the Canal and gage 05018500 is located at the inlet of the St. Mary Siphon crossing. Upon review of the USGS gage data, it was clear that the datum was not surveyed and was an approximate elevation. The water surface elevations were not aligning with the topographic data of the Canal. Due to this, the datum for each gage was shifted using engineering judgement to arrive at an approximate datum at each gage. The rating curve at each gage was then used to further assess the assigned Manning's roughness at each gage site. Graphs of the shifted rating curves with the model results (Manning's = 0.026) are illustrated in Figure 3-1 and Figure 3-2.

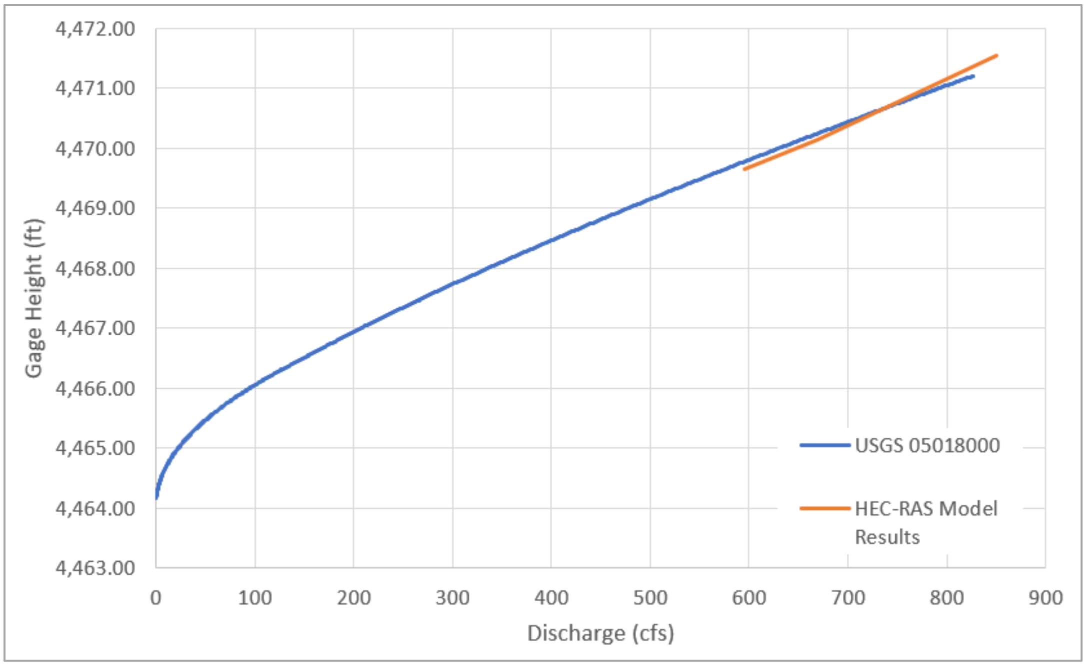


Figure 3-1. USGS Gage 05018000 Adjusted Rating Curve

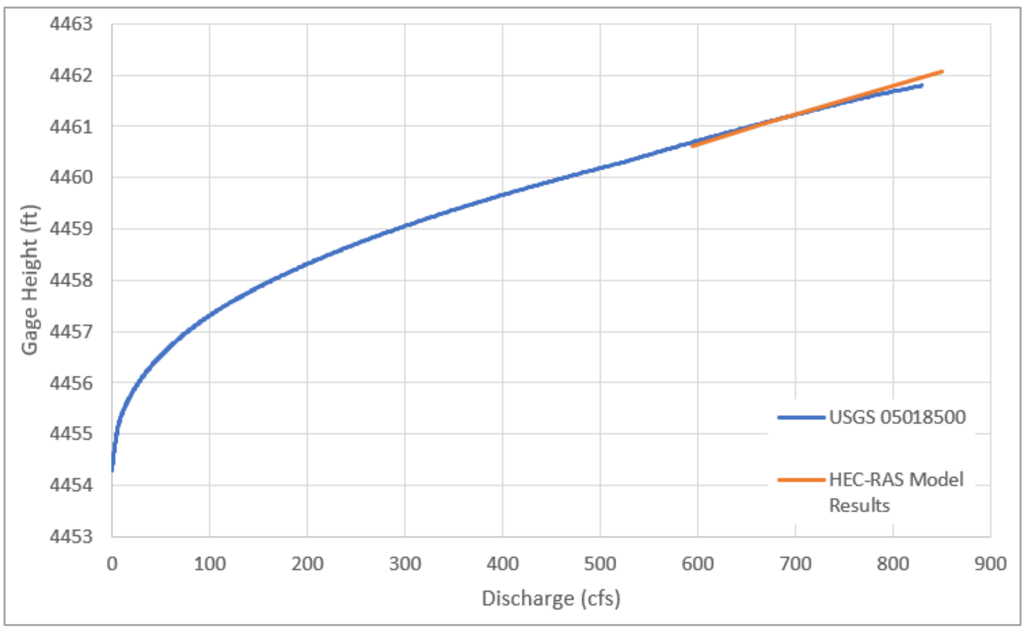


Figure 3-2. USGS Gage 05018500 Adjusted Rating Curve

3.2 Canal Delivery System Modernization Options

3.2.1 Open Channel Options

Multiple open channel options were considered to improve the conveyance of the Canal sections within the St. Mary system: 1) Improved earthen section and 2) Improved section with a geosynthetic liner. For each options, a trapezoidal section with 1.5:1 (H:V) side slopes and 2’ freeboard was considered per correspondence with Reclamation. A typical section of the design Canal is illustrated in Figure 3-3.

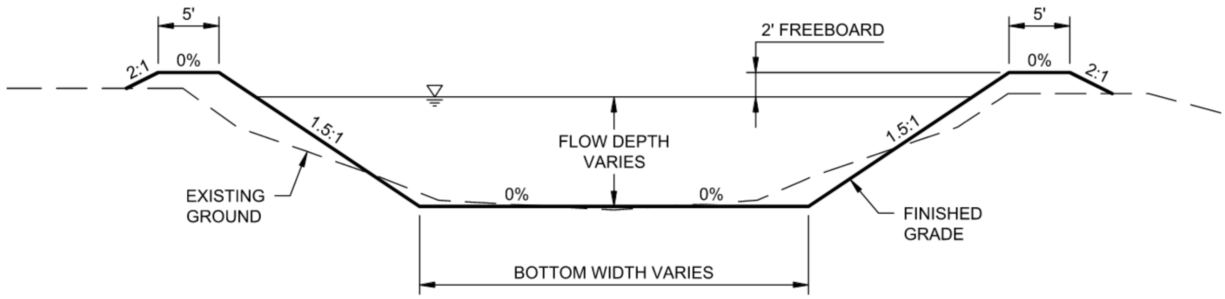


Figure 3-3. Typical Section for the Proposed Canal

Using the existing thalweg profile developed from survey, the focus of the open channel options was set on the four reaches defined in Table 3-3.

Table 3-3. Open channel design reaches along St. Mary Canal

Reach	From	To
1	Diversion	Kennedy Siphon
2	Kennedy Siphon	St. Mary Siphon
3	St. Mary Siphon	Halls Coulee
4	Halls Coulee	Drop 1

The design dimensions of each reach were set to approximate the existing channel widths in order to limit the amount of cut/fill associated with constructions, while also targeting a minimum velocity that would assist in moving the sediment within the system. Due to the minimal slopes of the analyzed reaches, the design velocity was limited to 2.0 feet per second (fps). These velocities will move the suspended load but will be limited when trying to move the larger materials that are imported from neighboring areas of runoff and slides. The resultant design dimensions and velocity for each reach are listed in Table 3-4. Option 1 represents an earthen channel with a Manning's value of 0.025 while Option 2 represents a lined channel with a Manning's value of 0.016.

Table 3-4. Hydraulic design characteristics of the open channel options

Reach	Slope (ft/ft)	Option	Material	Flow Depth (ft)	Bottom Width (ft)	Velocity (fps)	Cut (-) / Fill (+) (CY*)
1	0.000174	1	Earthen	8.5	26.5	2.5	31,716
		2	Liner	6.66	26.5	3.5	-31
2	0.000138	1	Earthen	8.8	28	2.3	143,779
		2	Liner	6.92	28	3.2	106,502
3	0.000105	1	Earthen	9	31.5	2.1	76,269
		2	Liner	7	31.5	2.9	172,163
4	0.000097	1	Earthen	9.17	32	2.0	72,015
		2	Liner	7.16	32	2.8	5,891

* = Cubic Yards

Table 3-5. Summary of the cut/fill totals for the open channel options

Option	Cut (-) / Fill (+) (CY)
1	323,780
2	284,525

While Option 2 requires less earthwork for construction due to the decreased design depth, it assumes an additional geosynthetic liner.

3.2.2 Pressurized Pipe Conveyance

Another option to reduce the hydrologic losses through the St. Mary Canal is a closed pipe conveyance system. This option consists of piping the reaches of the Canal between the existing siphon crossings. A closed pipe system is far less susceptible to the hydrologic losses and earthen instabilities that have been observed along the Canal. For the proposed system to function at full capacity it was determined that a pressurized piping system be assessed. Using a pressurized conveyance system will reduce the likelihood of air entrainment within the pipes, further increasing performance of the system. The Environmental Protection Agency (EPA) computer program EPANET was used to assess the pressurized delivery system for the St. Mary Canal. EPANET simulates the dynamic hydraulic behavior within pressurized-pipe systems. EPANET networks consist of pipe (links), pipe junctions (nodes), pumps, valves, and reservoirs. EPANET tracks the flow of water in each pipe and the resultant pressure at each node. The following assumptions were applied while developing the hydraulic model.

- The model was run at a design operating flow of 850 cfs
- The model was run as a steady state simulation (one time step), the system was not evaluated over an extended period of time
- The Hazen-Williams equation was used to quantify friction head losses

- Minor losses were applied using a generalized loss per mile of reach
- The proposed layout would approximately follow the same alignment as the existing Canal
- Smooth steel pipes were the assumed material, as HDPE in a hydraulically comparable size was found to be significantly more expensive, to procure and transport to the site.
- Pressure flow through the siphons was not evaluated

The hydraulic model for the pressure system consists of four reaches. The first reach begins at the St. Mary Diversion and terminates at the Kennedy Creek siphon inlet. The second reach begins at the Kennedy Creek siphon outlet and terminates at the St. Mary siphon inlet. Reach 3 begins at the St. Mary siphon outlet and terminates at the Halls Coulee siphon inlet. Reach 4 begins at the Halls Coulee siphon outlet and terminates at the Drop 1 intake. Figure 3-4 shows the layout of the EPANET. Table 3-6 shows the physical parameters for each reach. A summary of the results at the pipe junctions is shown in Table 3-7. Based on the results it was determined that three 10-foot barrels will be required to convey the required design flows.

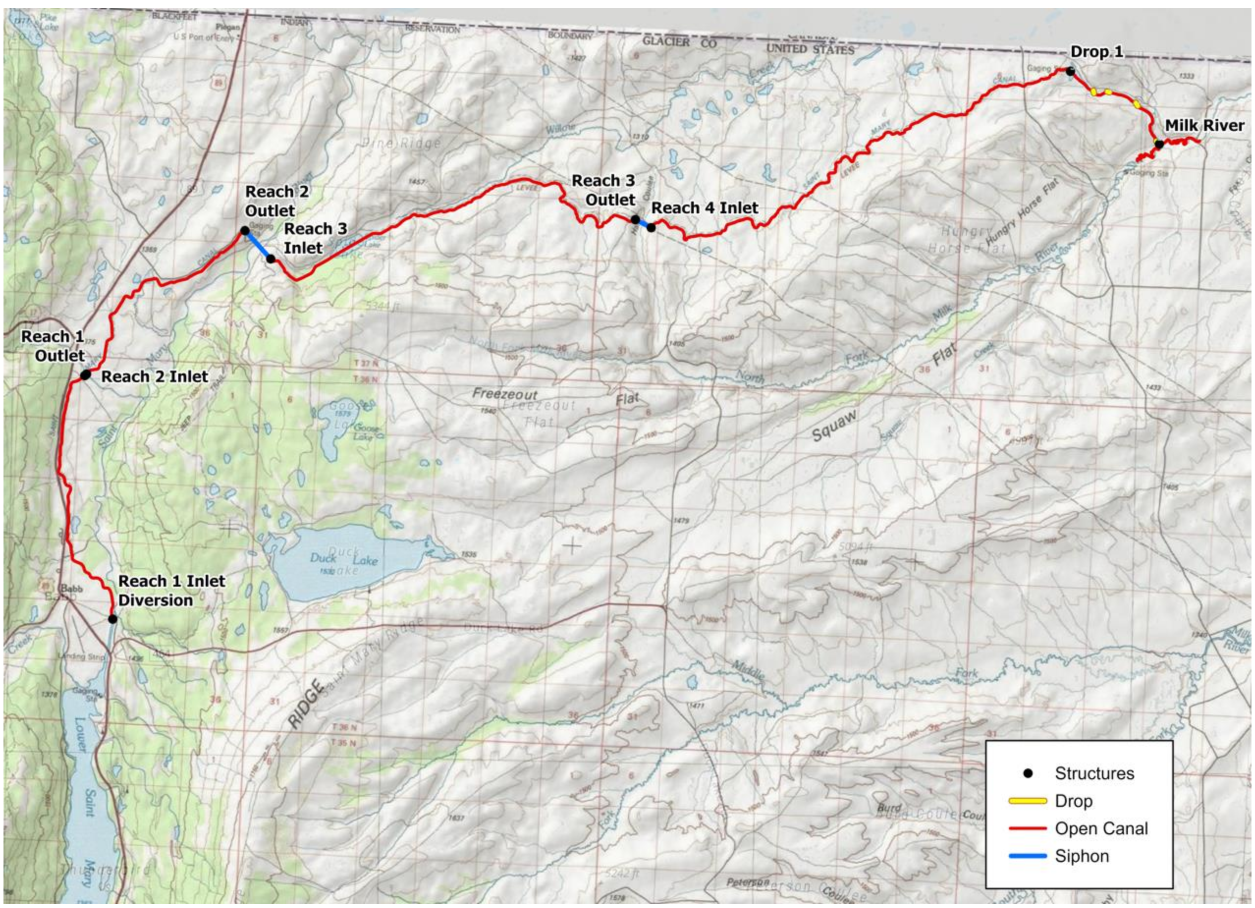


Figure 3-4. EPANET Model Layout

Table 3-6. Reach Modeling Parameters

Reach	Length (ft)	Diameter (ft)	Number of Barrels	Material	Roughness (C Value)	Minor Loss Coefficient
1	24,950	10	3	Smooth Steel	130	38.0
2	22,144	10	3	Smooth Steel	130	33.6
3	40,470	10	3	Smooth Steel	130	61.2
4	48,046	10	3	Smooth Steel	130	72.8

Table 3-7. Node Results

Node	Elevation (ft)	Total Head (ft)	Pressure (psi)
Reach 1 Inlet	4466.07	4482.30	7.03
Reach 1 Outlet	4446.93	4467.90	9.09
Reach 2 Inlet	4447.93	4467.90	8.65
Reach 2 Outlet	4444.93	4455.15	4.43
Reach 3 Inlet	4429.43	4455.15	11.14
Reach 3 Outlet	4423.43	4431.89	3.66
Reach 4 Inlet	4408.93	4431.89	9.95
Reach 4 Outlet	4403.93	4404.24	0.13

3.3 Siphon Modernization Options

3.3.1 St. Mary Siphon Rehabilitation Options

The existing condition of the St. Mary Siphon and bridge over the St. Mary River warrants a full replacement. These facilities are in very poor condition and represent the most susceptible component along the Canal system to failure.

The *Draft Cost and Fatal Flaw Analysis, St. Mary and Hall Coulee Siphons* (HDR Engineering, Inc., 2022), evaluated a number of siphon replacement options including; no-action, replacement in the current footprint, slip-lining, cured-in-place technologies, spray-on technology above ground conveyance, and buried pipe conveyance of the existing siphons. The Cost and Fatal Flaw Analysis recommended burying the siphons and structures outside the footprint of the existing siphon structures to allow for the majority of construction to occur without impacting normal Canal operations during construction. This approach also negates the need for demolition of existing facilities and addresses both the unstable soil conditions and thermal movement. Also, buried pipes pose minimal maintenance requirements during operation, and repairs outside of the season are typically limited to lining repairs.

Based on the St. Mary and Hall Coulee Fatal Flaw Analysis HDR Report, the two most feasible options for the St. Mary Siphon are:

1. Full replacement with buried concrete cylinder pipe (CCP), including the following: a new inlet structure, new outlet structure and replacement of the existing bridge carrying the siphon over the St Mary River.
2. Full replacement with buried steel pipes, including the following: a new inlet structure, new outlet structure and replacement of the existing bridge carrying the siphon over the St. Mary River.

For both options a two-barrel replacement siphon system would likely be relocated downstream of the existing siphon barrels. Both options include buried pipe drains for slope stabilization and stoplog slots to allow for isolation of one conduit for maintenance. Neither option considered burying the siphon under the riverbed due to the associated environmental impacts to the St. Mary River.

3.3.2 Halls Coulee Siphon Rehabilitation Modernization Options

Similar to the St. Mary Siphon, the existing condition of the Halls Coulee Siphon warrants a full replacement. This structure is in very poor condition and represents another susceptible component along the Canal system.

Based on the St. Mary and Hall Coulee Fatal Flaw Analysis HDR Report, the two most feasible options for the St. Mary Siphon are:

1. Full replacement with buried CCP, including a new inlet structure and new outlet structure.
2. Full replacement with buried steel pipes, including a new inlet structure and new outlet structure.

For both options a two-barrel replacement siphon system would likely be relocated east of the existing siphon barrels. Both options include buried pipe drains for slope stabilization and stoplog slots to allow for isolation of one conduit for maintenance.

3.4 Drop Structure Modernization Option

On May 17, 2020, Drop 5 suffered a catastrophic failure (Figure 3-5). As a result of this failure, Drop 5 was replaced in the summer and fall of 2020 along with the Drop 2 structure. Each structure was replaced in kind with a concrete channel and stilling basin to convey flows and dissipate energy.

Prior to the Drop 5 failure, HDR prepared a cost and fatal flaw analysis on Drop 2 (HDR Engineering, Inc., 2020). This analysis considered several alternatives, each considering several variations, for replacement of Drop 2 including:

- Alternative 1: No-Action
- Alternative 2: Reconstruct the Structure in Original Footprint
  - Alternative 2a: Steel Insert
  - Alternative 2b: Concrete Overlay

- Alternative 2c: Headwall and Pipes
- Alternative 2d: Reconstruct in Kind

- Alternative 3: Alternative Replacement Structure
  - Alternative 3a East: Piped Conveyance on East Alignment
  - Alternative 3a West: Piped Conveyance on West Alignment
  - Alternative 3b East: Concrete Conveyance on East Alignment
  - Alternative 3b West: Concrete Conveyance on West Alignment
- Alternative 4: Canal Relocation

Figure 3-5. Drop 5 Failure[11]

Shortly after the Drop 5 failure, the MRJBOC, Reclamation and Montana DNRC conducted an engineering site inspection to assess the damage and determine whether an interim fix was feasible. The team concluded that the complexities and costs associated with an interim solution could not be justified, considering the anticipated

[11] Photo credit, Montana DNRC (Figure 7 - http://dnrc.mt.gov/divisions/water/management/docs/st-mary-rehabilitation-project/drop-structure-pictures.pdf)

costs and the minimal gains in water supply it would allow. Subsequently, the decision was made to immediately replace both Drop 2 and Drop 5.

With the previous Drop 2 fatal flaw analysis, success of the Drop 2 and Drop 5 replacements, and for the purposes of this analysis, the remaining three Drop structures (Drop 1, Drop 3, and Drop 4) will be replaced in kind without consideration of other alternatives.

3.5 Maintenance Road Modernization Options

Existing Canal O&M roads along the St. Mary Canal are generally unmaintained dirt access roads with varying widths, typically 10-12 feet, which run adjacent to the St. Mary Canal. The St. Mary Canal is located in a remote rural area and except for the first reach of the Canal which generally parallels MT Hwy. 89, existing established highways and county roads which cross the St. Mary Canal and allow access are extremely limited. As a result, access for much of the Canal is limited to the existing Canal O&M roads and requires traveling for long distances along said O&M roads.

Due to a lack of gravel surfacing, O&M roads generally do not provide all-weather access, with many sections impassable during adverse weather conditions and when wet. This significantly hinders the ability to perform O&M activities and access irrigation facilities, particularly during and immediately following storm events, which is often the most critical time to access irrigation facilities. This includes access to wasteway and turnout structures which require manual operation to release excess water from the St. Mary Canal. In addition, this poses a significant safety risk during use of the O&M roads, particularly when wet. Several sections also pose safety risks for access during dry conditions due to the narrow width of access roads for some reaches as well as saturation and rutting/settling of the roadway subgrade.

For improved access for O&M along the St. Mary Canal, O&M road improvements are recommended to provide all-weather access for the entire length of the St. Mary Canal. Proposed O&M road improvements would establish a 12-foot-wide all-weather access with 6 inches of compacted gravel surfacing. Subgrade preparation prior to gravel surfacing placement would include grading and compacting to establish a competent subgrade. The roadway subgrade and surface would be graded to provide a consistent cross slope of at least two percent for drainage off the roadway surface to prevent ponding. In addition, for select reaches of the Canal with very poor subgrade conditions, geotextile and/or geogrid placement over the road subgrade and prior to gravel placement may be considered for improved roadway subgrade stability and reduced rutting. O&M road improvements are also recommended to facilitate the proposed rehabilitation of the overall system to better allow for construction access.

A desktop review of existing O&M roads along the St. Mary Canal was completed, which included reviewing areas along the Canal lacking existing O&M road access. The total length of O&M roads along the St. Mary Canal recommended for improvement to provide all-weather access to the entire Canal is 32.7 miles. Figure 3-6 below provides an overview map of the proposed O&M road improvements and Table 3-8 below provides a breakdown of the length of proposed O&M road improvements.

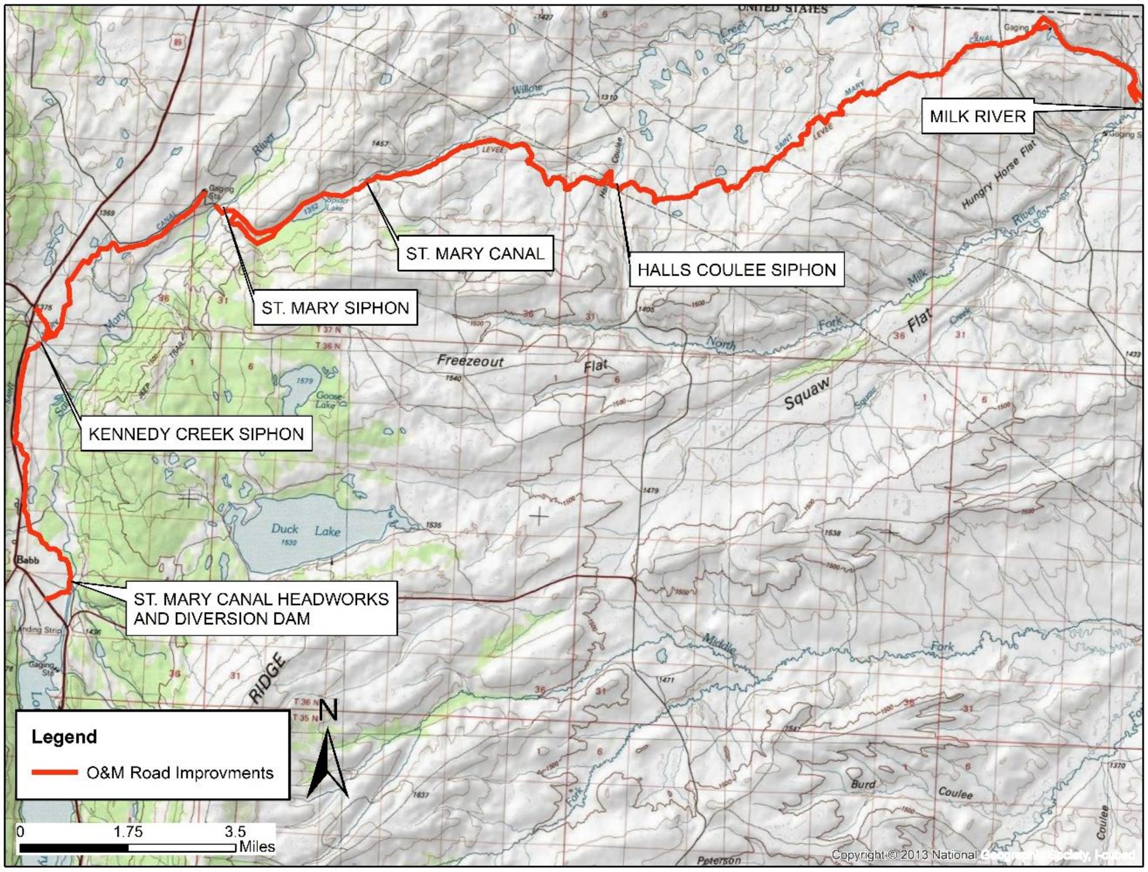


Figure 3-6. **Proposed O&M Road Improvements**

Table 3-8. O&M Road Improvements

Reach Description	Length of O&M Road Improvements (ft)
St. Mary Diversion to Kennedy Siphon	24,846
Kennedy Siphon to St. Mary Siphon	22,279
St. Mary Siphon to Halls Coulee Siphon	41,428
Halls Coulee Siphon to Emigrant Gap Road	46,471
Emigrant Gap Road to Drop 5	17,611
Drop 5 to Fox Ranch Road	4,610
Spider Lake Alternate Route	7,182
Kennedy Wasteway Access	2,984
Kennedy Siphon Access	1,140
St. Mary Diversion Access	2,283
Drop 1 Access	1,191
TOTAL	**172,761**

The two options evaluated for St. Mary Canal O&M road improvements included the following:

1. O&M road improvements to establish an all-weather access road on one side of the St. Mary Canal for its entire length.
2. O&M road improvements to establish an all-weather access road on both sides of the St. Mary Canal for its entire length.

Both options would include the same proposed roadway improvement section. An existing O&M road is present along one side of the St. Mary Canal for much of its length. For Option 2, however, additional subgrade preparation and grading will be required to establish an O&M road on the opposite side of the Canal where one is not currently present. This additional effort is reflected in the cost estimate.

Regarding obtaining road surfacing gravel for O&M road improvements, multiple existing pits are present in proximity to the St. Mary Canal, however, most are located along established highways and county roads. The development of additional gravel sources along the St. Mary Canal should be evaluated to reduce the haul length. This will also facilitate a source for maintenance gravel for future road maintenance and may be needed for construction materials. Developing new gravel sources (mining) will require compliance with all federal, state, local, and tribal requirements.

In addition to initial O&M road improvements, a long-term O&M road maintenance plan is recommended which would include annual maintenance along the Canal in the form of grading and gravel placement. It is proposed that this would include a minimum length of O&M road maintenance each year.

3.6 Monitoring, Instrumentation, and Control Modernization Options

Today the St. Mary Canal and its major structures lack monitoring, instrumentation and control features. The ability to monitor and remotely control or operate certain Canal system components has the ability to improve efficiency, monitoring, and safeguards in the event of emergencies.

Due to the remote location of the St. Mary Canal, there are no United States cell phone carriers operating in the area. Along sections of the Canal there are Canadian cell phone providers with limited cellular access. Due to internal policies, Reclamation cannot use Canadian cellular service providers for monitoring and reporting Canal information. In addition, during the operating season when flows are greater than 500 cfs, Reclamation operations and maintenance crews drive the entire Canal on a daily basis. Radio communication can also be used for monitoring and instrumentation; however, radio repeater towers would likely need to be installed to allow for full coverage of the Canal system. These challenges, combined with the fact that the Canal presently operates without any monitoring and instrumentation and that Reclamation personnel monitor the Canal on a daily basis, make monitoring, instrumentation and control a difficult proposition. Reclamation has also indicated that monitoring, instrumentation and control is not a priority or perceived as an operational benefit to the Canal system at this time (Reference St. Mary Canal System – Modernization Options Analysis meeting notes dated August 25, 2022 in Appendix B).

For the purposes of this analysis, monitoring, instrumentation and control was not analyzed further at this time.

3.7 Wasteway Modernization Options

The St. Mary Canal includes two wasteways, both of which are in poor condition, and eight turnouts/drains with unknown capacities. All structures were designed with manual operation, although many are difficult to operate and/or inoperable. In their current condition, combined with their remote location and difficult access, the existing wasteways and turnouts generally do not serve as effective protective structures. Replacement of the existing structures with new structures designed for automatic spilling of excess discharges from the Canal would provide critical protection of the St. Mary Canal infrastructure, improve system operation and maintenance, and allow for consistent conveyance of the design capacity while still reducing Canal overtopping risk.

Included in the wasteway options are the existing Kennedy Creek Wasteway, Halls Coulee Wasteway, and all existing turnouts/drains identified in Section 2.1.6. This option, however, does not address or include the Kennedy Creek Check Structure, which is contiguous to the Kennedy Creek Wasteway and is also recommended for replacement. The condition of all existing structures warrants replacement. In addition, many of the existing turnouts have slide gates located in the Canal that generally are not accessible or difficult to access and operate when water is flowing in the Canal.

The three options recommended for wasteway options are as follows, with additional details on all options provided below:

1. Full Replacement of Wasteways and Turnouts
    a. Replace the existing Kennedy Creek and Halls Coulee Wasteways in-kind.
    b. Replace existing turnouts with new turnouts. The new turnouts would include concrete inlet structures with slide gates, pipes, and concrete outlet structures designed to function similar to the existing turnouts.
        i. Alternative turnout designs, which could include a vacuum siphon option, a pipe inlet and valve located at the downstream end of the pipe, etc., could be considered.
2. Improved Replacement of Wasteways and Turnouts
    a. Replace the existing Kennedy Creek and Halls Coulee Wasteways with new improved structures. This would include evaluating different gate configurations for the new structures, automation, etc.
    b. Replace existing turnouts with new side channel spillway structures.
3. Improved Replacement of Wasteways and Turnouts and Additional Structures

Option 3 would be the same as Option 2, except that seven additional side channel spillway structures would be added along the St. Mary Canal at the locations identified in Figure 3-9 and Table 3-9. Under Option 3, additional locations would provide additional operational control and protection (i.e., immediately upstream of the Halls Coulee Siphon Inlet where historical overtopping has occurred, upstream of the Kennedy Creek Siphon, existing grassed spillways, etc.) including locations without existing underdrain where surface drainage and runoff can enter uncontrolled into the St. Mary Canal as discussed in Section 2.1.7.

A summary of the three options is presented below in Figure 3-7 through Figure 3-9, Table 3-8, respectively, and they identify the new proposed side channel spillways corresponding with Option 3, as well as the existing wasteways, turnouts (drains), and grassed spillways.

Option 1 includes replacement of the existing turnouts. For this option, although only 4 existing turnouts were identified above in Section 2.1.6 from the Location Map prepared by Reclamation, 8 new turnouts were assumed based on *St. Mary Diversion Facilities Feasibility and Preliminary Engineering Report* (Montana Department of Natural Resources and Conservation, and Thomas, Dean & Hoskins, Inc., 2006) as described above.

Options 2 and 3 include the construction of new side channel spillway (overflow spillway) structures. These structures are proposed for replacement of the existing turnouts (for Option 2) as well as at new locations (for Option 3). A standard design for all side channel spillway structures, modified as needed to match individual site constraints, is proposed. A conceptual side channel spillway structure standard design was developed in accordance with the *Design of Small Canal Structures*, (U.S. Department of the Interior, 1978) and is presented below.

Capacity of the existing turnouts is unknown, and therefore, a reasonable design capacity was established as the basis for the side channel spillway design. Runoff from major drainages along the St. Mary Canal is managed by underdrain culverts (see Section 3.8 below), however, many smaller drainage areas contribute uncontrolled surface drainage and runoff to the St. Mary Canal at locations without underdrain culverts. The intent of the proposed side channel spillways is to provide protection for the St. Mary Canal infrastructure downstream of locations where uncontrolled runoff enters the Canal (automatic spilling of excess discharges), as well as improved operational control. Based on the design discharges developed for underdrain culverts, the following preliminary design criteria was developed for conceptual side channel spillway design:

- Provide 50 cfs of capacity while maintaining 1 foot of freeboard (minor storms)
- Provide 100 cfs of capacity while maintaining 0.5 feet of freeboard (major storms)

The new proposed conceptual side channel spillway structure design would include a cast-in-place concrete structure with a 25-foot-long weir to allow for automatic spilling/overflow from the Canal. The weir crest would be set just above the normal water surface elevation in the Canal. Based on the existing St. Mary Canal typical Canal prism (27-foot bottom, 1.5:1 side slopes, 10-foot Canal depth, and 8-foot normal water depth), and assuming an overflow crest set 0.2 feet above the normal water surface, the proposed side channel spillway design would provide approximately 60 and 125 cfs of capacity, while maintaining Canal freeboard depths of 1.0 and 0.5 feet, respectively (based the Canal design above), and 200 cfs of capacity at Canal overtopping. In addition to the overflow crest, each side channel spillway would be equipped with a 54-inch slide gate to allow for draining of the Canal. The side channel spillway structures would discharge to a 54-inch pipe which would convey flows to a standard Reclamation baffled outlet structure for energy dissipation. The conceptual design presented is one possible design option, and modifications for different design capacities and/or different designs could be considered.

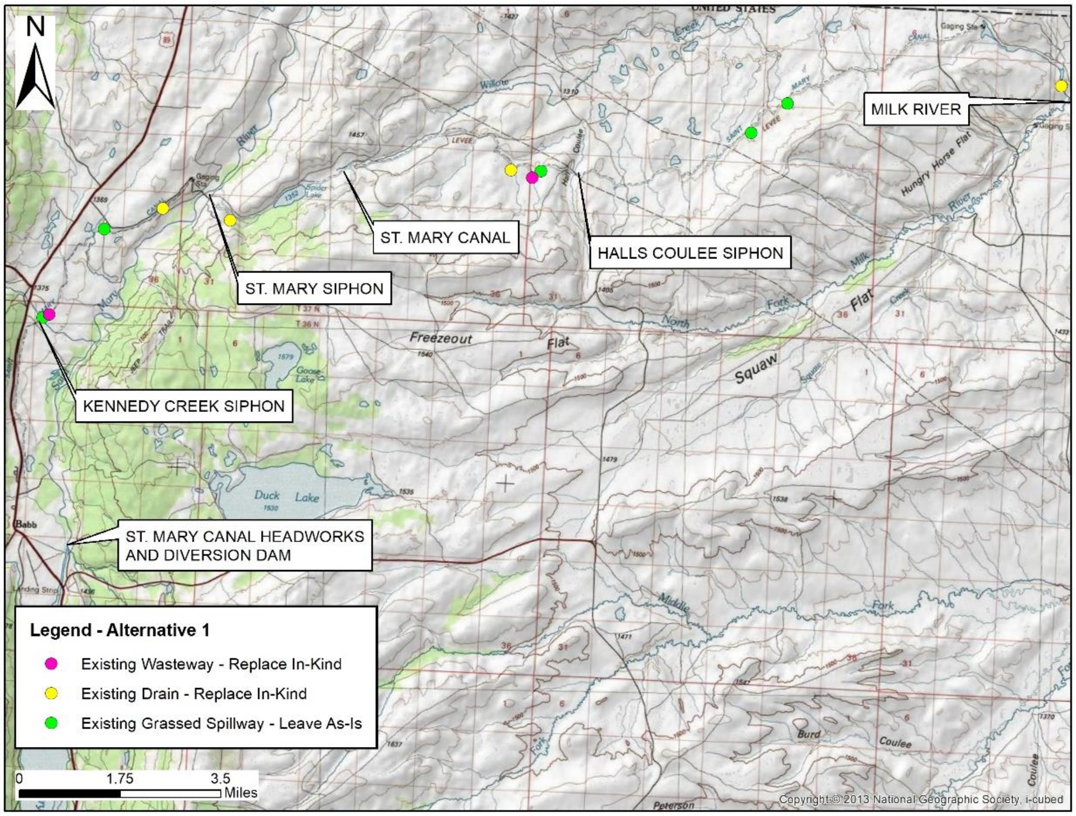


Figure 3-7. Option 1 Overview Map

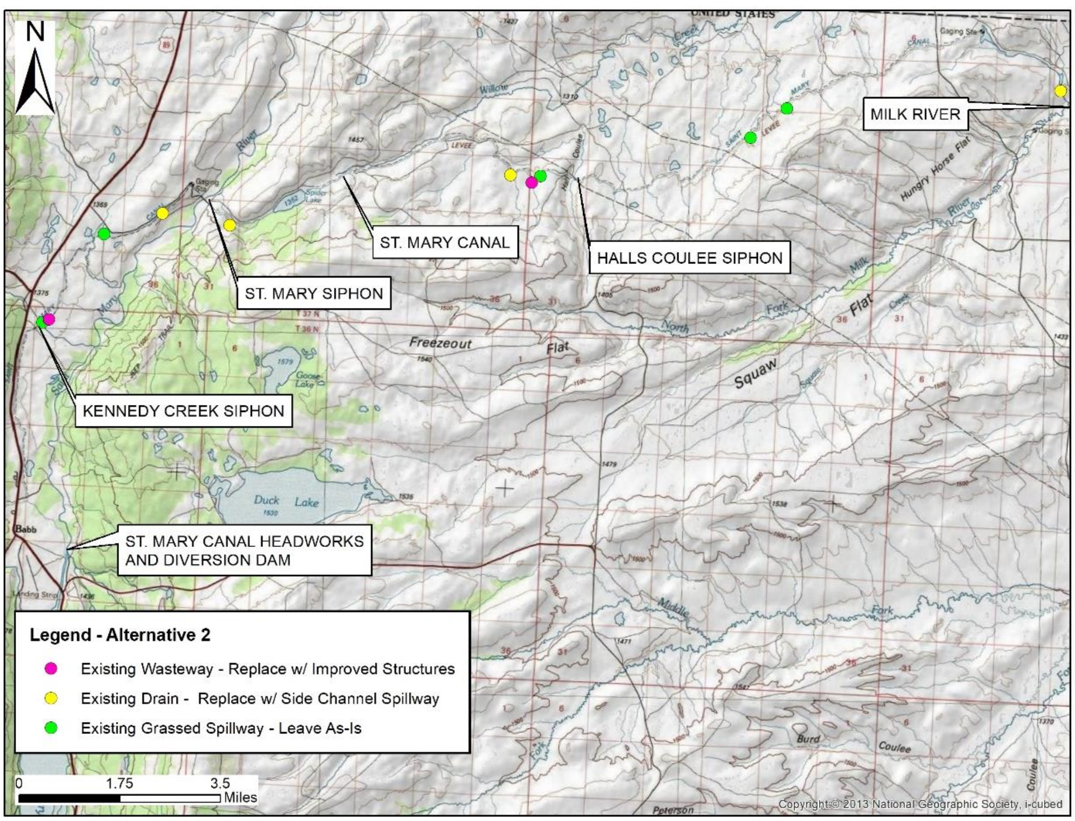


Figure 3-8. Option 2 Overview Map

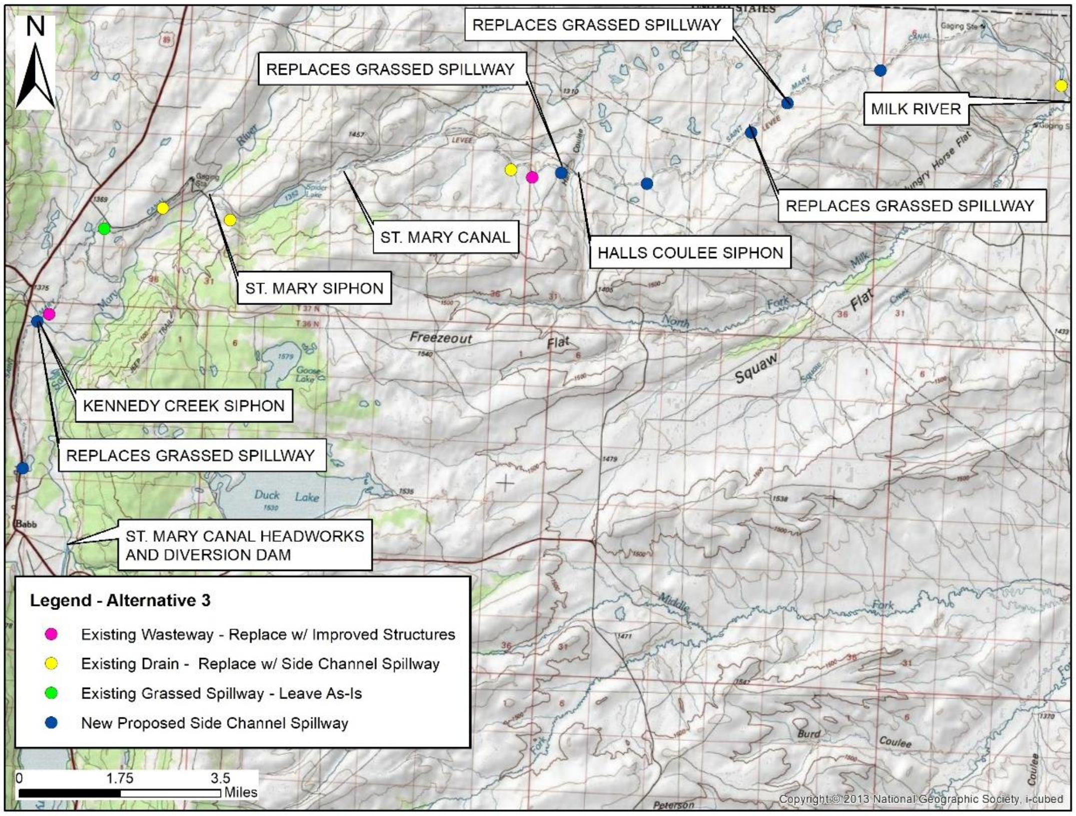


Figure 3-9. **Option 3 Overview Map**

Table 3-9. Wasteways/Turnouts

Station	Existing	Option 1	Option 2	Option 3
130+45	N/A	-	-	New Side Channel Spillway
269+91	Grassed Spillway	Leave as-is	Leave as-is	New Side Channel Spillway U/S of Kennedy Creek Siphon
277+20	Kennedy Creek Wasteway	Replace In-Kind	Replace w/ Improved Structure	Replace w/ Improved Structure
394+26	Grassed Spillway	Leave as-is	Leave as-is	Leave as-is
438+46	Turnout/Drain	Replace	Replace w/ Side Channel Spillway	Replace w/ Side Channel Spillway
532+53	Turnout/Drain	Replace	Replace w/ Side Channel Spillway	Replace w/ Side Channel Spillway
851+22	Turnout/Drain	Replace	Replace w/ Side Channel Spillway	Replace w/ Side Channel Spillway
884+93	Halls Coulee Wasteway	Replace In-Kind	Replace w/ Improved Structure	Replace w/ Improved Structure
901+78	Grassed Spillway	Leave as-is	Leave as-is	New Side Channel Spillway U/S of Halls Coulee Siphon Inlet
1039+45	N/A	-	-	New Side Channel Spillway
1145+71	Grassed Spillway	Leave as-is	Leave as-is	New Side Channel Spillway
1205+32	Grassed Spillway	Leave as-is	Leave as-is	New Side Channel Spillway
1296+10	N/A	-	-	New Side Channel Spillway
1529+50	Turnout/Drain	Replace	Replace w/ Side Channel Spillway	Replace w/ Side Channel Spillway
Unknown[1]	4 Turnouts/Drains	Replace	Replace	Replace

[1]Accounts for 4 additional turnouts/drains as identified in the *St. Mary Diversion Facilities Feasibility and Preliminary Engineering Report*

3.8 Underdrains

Details on the existing underdrain culvert are provided in Section 2.1.7. The condition of existing underdrains is unknown, however, most underdrain culvert crossings have been in place since construction of the original St. Mary Canal. In accordance with *Design of Small Canal Structures* (U.S. Department of the Interior, 1978), the recommended design storm event for underdrain culverts managing offsite surface drainage and runoff for irrigation Canals is the 25-year storm event. Peak discharges contributing to underdrain culvert crossings were estimated using the StreamStats software developed by the U.S. Geological Survey (USGS) for estimating peak-flow frequencies at ungagged sites in Montana. StreamStats was utilized to delineate drainage basins and estimate peak discharges for different design events based on USGS Regression Equations. The St. Mary Canal is located in the Northwest Region, and hence, USGS Regressions Equations for the Northwest Region were utilized within StreamStats to estimate peak discharges. Estimated peak discharges for the 25- and 100-year storm event are presented below in Table 3-11.

For development of the proposed underdrain culvert options, two replacement options were considered. One option assumed replacement of all underdrain culverts in-kind (same size, material, and length as existing). Another option assumed replacement with new underdrain culverts hydraulically designed and sized to manage the 25-year storm event based on the estimated peak discharges presented in Table 3-11.

The software HY-8 developed by the US Department of Transportation Federal Highway Administration was utilized for the conceptual design of underdrain culverts using estimate peak discharges from StreamStats. For designing underdrain culverts, the headwater criteria developed by the Montana Department of Transportation for mainline culvert crossings for the design event was utilized for as the basis for the conceptual hydraulic design. The headwater design criteria utilized is presented below in Table 3-10.

Table 3-10. Maximum Allowable Headwater Depth for the Design Event

Pipe Size	HW @ Design Flow[1]
≤ 42”	< 3.0*D or 3.0*R
48” – 108”	< 1.5*D or 1.5*R
≥ 120”	< D+2.0’ or R+2.0’

[1]D signifies diameter of the pipe, R signifies rise of the pipe.

For developing conceptual proposed underdrain culvert crossing designs, the following assumptions were made:

- Culvert and downstream tailwater channel slopes were estimated as 1%.
- Culverts were sized to meet headwater design criteria presented in Table 3-10 for the 25-year storm.
- Flared and sloped end sections were assumed for reinforced concrete pipe culvert (RCP) and reinforced concrete box culvert (RCB) options, respectively.
- Lengths of all proposed underdrain culverts were assumed to match existing (rounded up to the nearest two feet).
- One proposed option was developed for each existing underdrain location.
- Replacement options assumed the installation of three concrete seepage (percolation) collars along the length of the culverts and outlet riprap aprons.
- Replacement options assumed traditional open cut installation.

The three options recommended for underdrains culverts are as follows, with details on both replacement options presented in Table 3-11.

1. No Action
2. Full Replacement of Underdrains
    a. This option would replace all underdrain in-kind with the same size, material, and length as the existing underdrain culverts.
3. Improved Replacement of Underdrains
    a. The option would replace all underdrains with new underdrain culverts sized to meet the headwater design criteria based on the estimated peak discharges.

Table 3-11. Underdrain Options Summary

Station	Name	25-yr Discharge (cfs)	100-yr Discharge (cfs)	Option 2	Option 3	Length (ft)
330+69	Powell Creek Culvert	681	1,630	2 x 66" RCP	2 x 78" RCB	2 x 150
794+46	Cow Creek Culvert	363	921	54" x 66" RCB	72" x 72" RCB	180
979+70	Culvert	152	421	30" RCP	2 x 36" RCP	2 X 144
1052+72	Culvert	100	290	30" RCP	42" RCP	140
1096+93	Culvert	65	196	30" RCP	36" RCP	168
1134+68	Culvert	65	196	30" RCP	36" RCP	144
1194+29	Culvert	38	121	30" RCP	30" RCP	158

For Option 3, the Powell Creek Culvert may be a good candidate for replacement with an RBC. The proposed option presented in Table 3-11 is comprised of 2 – 78-inch RCPs, however, a 12' x 6' RCB would also meet the design criteria and would have a similar cost to the double barrel RCP option.

All conceptual underdrain culvert designs presented in Option 3 provide larger flow areas/increased capacity versus the existing underdrain culvert crossings except for Station 1194+29. All proposed conceptual underdrain culvert designs presented in Option 3 were also checked for the 100-year storm event. The 100-year storm event exceeds the capacity of all and would result in overtopping into the St. Mary Canal. Providing capacity to manage the 100-year storm event without overtopping into the St. Mary Canal would require considerably larger culverts for most locations. The conceptual designs presented in Option 3 generally provide increased capacity versus the existing culverts. Hence, further increasing the size of culverts was not considered for this Option at this time but could be in the future. Additional coordination with maintenance personnel is recommended to provide additional input into the performance of existing underdrain culverts along the St. Mary Canal.

3.9 Slope Stability Modernization Options

Background

Slope failures are common along the St. Mary Canal and throughout the areas near the Canal due to poorly consolidated glacial sediment, over-steepened slopes and banks, and fluctuations in groundwater conditions due to Canal operations and precipitation. Landslides adversely affect both the reliability (potentially causing overtopping and failure of Canal banks) and the Canal capacity by reducing the cross-sectional area available for Canal flows. Many of the assessments of landslides reference instances or seasons of heavier than usual precipitation and are evidence that consideration of methods of either limiting the amount of water that infiltrates into the soils in a slide area or dewatering the soils in a slide area is important to achieve an effective treatment of the slides.

Reclamation has a long history of addressing areas along the Canal where movement of the soils in the slopes adjacent to the Canal is impacting the Canal to some significant extent. Slope movement adjacent to the Canal has often been addressed by removing the material within the Canal prism at the toe of the slides and reshaping the banks. Excavated material was either hauled off or placed on top of the slide area, depending on available access. More recent slides were repaired by flattening the slopes and rebuilding the banks.

Identified Landslides

The following is a summary of the slides that have impacted the St Mary Canal using excerpts from Reclamation reports. Locations are shown on Figure 3-10. Some have not been active for a number of years and are only being visually monitored. Others remain active and are included in the decisions about where to spend limited funding for maintenance. Regardless of their current status, they have been included here for three reasons: 1) Modernization of the Canal will likely involve excavation/reshaping of the Canal prism in or near these slide areas and could cause the slide to move again unless the instability is addressed, 2) Excavations for modernization of the Canal could cause areas that have been stable to become unstable whether they have been previously identified as a slide area or not, and 3) Specific future high precipitation events could cause new instabilities to appear if the potential is not considered during design phases of the project.

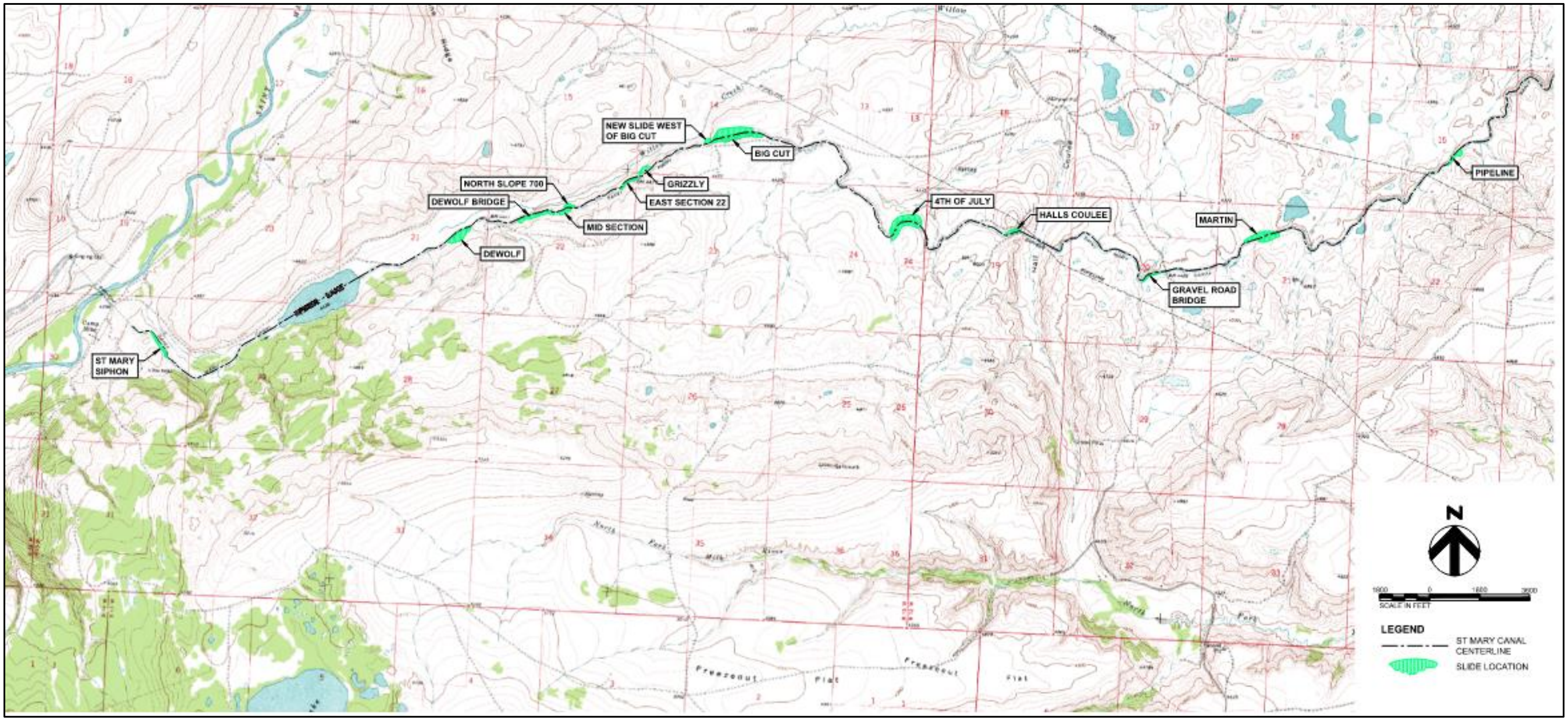


Figure 3-10. Landslide Location Map

St. Mary River Siphon:

The St. Mary River Siphon is located near Camp Nine and transports water across the St. Mary River. Shallow soils in the slopes on both sides of the valley have moved downhill toward the river resulting in damage to the siphon pipes. Remediation work has been done on the siphon pipes. The assessment of this slide in 2020 was that it has been remediated and has been stable for years (Lasater, 2020). The potential for future instability will be addressed as part of the replacement of the existing siphons.

DeWolfe Ranch:

The DeWolfe Ranch slide is located approximately 0.6 mile down Canal from the east end of Spider Lake. This rotational slide is situated in glacial till. The slide is about 1,200 feet long at its base. The slope failed rapidly in 1995, triggered by heavy precipitation. No significant changes were noted during the last inspections.

DeWolfe Bridge:

This slide is located on the south hillside about 1.1 miles down Canal from Spider Lake This rotational slide is situated in glacial till and is approximately 1,000 feet long at its base. Reclamation continues to monitor this slide for movement.

Mid-Section 22:

This slide is located about 1.6 miles down Canal from Spider Lake on a brushy section of the south valley wall in glacial till. The slide is about 500 feet long and first appeared after a period of heavy precipitation triggered movement. Remedial work performed in 2003 included material removal and grading. No change has been observed since remediation. Reclamation considers the slide to be stable.

North Slope 700:

The North Slope 700 slide is located near station 700+00 and occurred on the left side of the Canal access road. This fill slope area was improved by excavation into the right Canal cut-slope – moving the Canal prism to the southeast. This accomplished three primary objectives: a straighter Canal corridor through this section; a wider access road; and an increased seepage pathway through the Canal fill-slope. No significant changes were noted during the last inspections.

East Section 22:

This slide is just east of the Mid-Section 22 slide, approximately 1.7 miles down Canal from Spider Lake and is an old rotational slide in glacial till about 300 feet long. Movement since 1996 has been along the extreme eastern end of the old slide in an area of about 75 feet long by 40 feet high. The slide reactivated in 1998, and then to a minor extent in 2002. Movement is associated with heavy rainfall events. The scarp at this slide is visible, however vegetation is increasing in and around it. No significant changes were noted during the last inspections. Reclamation is continuing to monitor this site.

Grizzly Slide:

This slide was located near station 735+00 on the left side of the Canal. Slope failure occurred along the left Canal bank and into the Canal. The scarp was approximately 1 foot high and encroached about 3 feet into the Canal access roadway. The slide failed after a period of high precipitation and was of small volume (about 75 cubic yards) and estimated at about 15 feet across by 35 feet long. Reclamation considers this slide to be stable.

New Slide West of Big Cut:

Waste material from the remediation of the Big Cut Slide was deposited off of the north bank of the Canal, immediately west of Big Cut. The added weight combined with a seep through the Canal likely contributed to the slide. The head scarp moves toward the Canal every year and is a likely area for a blowout if sliding continues. This slide area will likely need to be reshaped/resloped and seepage through the Canal in these areas should be addressed.

Big Cut:

The Big Cut slide is a series of interconnected rotational slides that persist up to 2,500 feet through a deeply cut section of the Canal. The slide is about 2.8 miles down Canal from Spider Lake. A large excavation program in 1996 removed material from the Canal prism and reshaped the side slopes. Mitigation work was completed between 2011 and 2017 and the slide has remained stable. No changes were noted during the last inspections. Reclamation continues to monitor this area.

4th of July:

This slide is located at approximate station 860+00 on a sharp bend of the Canal in a cut-and-fill section about 4.7 miles down Canal from Spider Lake just upstream from the Halls Coulee wasteway structure. The fill section of the Canal failed in 1995. The Canal alignment was excavated further south into native material which reduced concern of failure. The south bank was rebuilt and remains in good condition. The north slope, downhill of the Canal, was reshaped and drainage was added. No changes were noted during the last inspections. Reclamation considers this slide to be stable.

Halls Coulee:

The Halls Coulee slide complex is located at approximate stations 910+00 and 935+00. Most of the slumping occurred well upstream of the siphon after a period of heavy rainfall. This slide complex is located along the excavated hillside in Quaternary glacial till which mantles the Cretaceous Horsethief Sandstone found at the siphon inlet. The slope has been reshaped and has been stable in the last several inspections.

Gravel Road Bridge:

This slide is located near station 980+00 about 6.2 miles down Canal from Spider Lake on the left side of the Canal and access roadway. The slide occurred into the adjacent ravine. Since mitigation, this slide has not shown any signs of movement, but a seep has been observed near the base of the slope. Reclamation continues to monitor this slide area.

Martin Slide:

The Martin Slide is located near station 1030+00 in a deep cut area of the Canal, approximately 8.1 miles down Canal of Spider Lake. The slide failed several times, most extensively in 2002 after a period of high precipitation. The slope was remediated prior to the 2007 inspection. Since 2007, there has been no change. Reclamation continues to monitor this slide.

Pipeline Slide:

This slide is located near station 1125+00 on the south side of the Canal about 9.9 miles down Canal from Spider Lake. The slide area has been reshaped but exhibits slow creep into the Canal. Reclamation is continuing to monitor this area.

Recommended Actions

Over the years, Reclamation employees have repaired the slide areas numerous times. Slides have generally been repaired by excavating the slide material within the Canal prism and placing it on top of the slide area or disposing of the material up and downstream of the slide. These efforts have had some success.

There are three main elements in repairing landslides: 1) removing the load from the top of the slide, 2) adding weight to the base of the slide, and 3) increasing the strength of the soil. Removal of material located at the top of the slide removes some of the weight that drives the slide. Installing additional material at the base of the slope often required relocating the Canal. Improvement of soil strength is primarily accomplished by reducing the amount of water held in the soils within the slide area – which reduces the weight driving the landslide and pore pressure. Typical landslide repair section views are shown in Figure 3-11. Repair methods for landslides typically use one or more of the three elements. Geologic investigations are critical in determining which method of repair will work best for a particular location.

Long-term solutions for the slide areas should include consideration of the following:

- Geologic investigations need to be conducted prior to finalizing any repair method. Gradations for filter materials need to be based on particle sizes of the native materials.
- Moving the centerline of the Canal away from the slide would allow the installation of additional weight at the toe of the slides (gravel/riprap).
- Removing as much of the weight off the top of the landslides as possible by flattening the exposed slopes. However, only a limited amount of material can be removed due to the topography of the area and the limited amount of easement width.
- Excavated material needs to be removed, placed, and compacted on the downhill side of the Canal.

- Control of subsurface and surface water should be included in the form of filter drains or surface swales to direct as much water as possible away from the unstable soils.
- Placement of gravel/riprap on both banks of the Canal. This will reduce erosion, add weight to the base of the slides, and provide for a filter for seepage entering the Canal.
- All disturbed areas need to be re-seeded to prevent erosion and reduce water absorption into the soils.

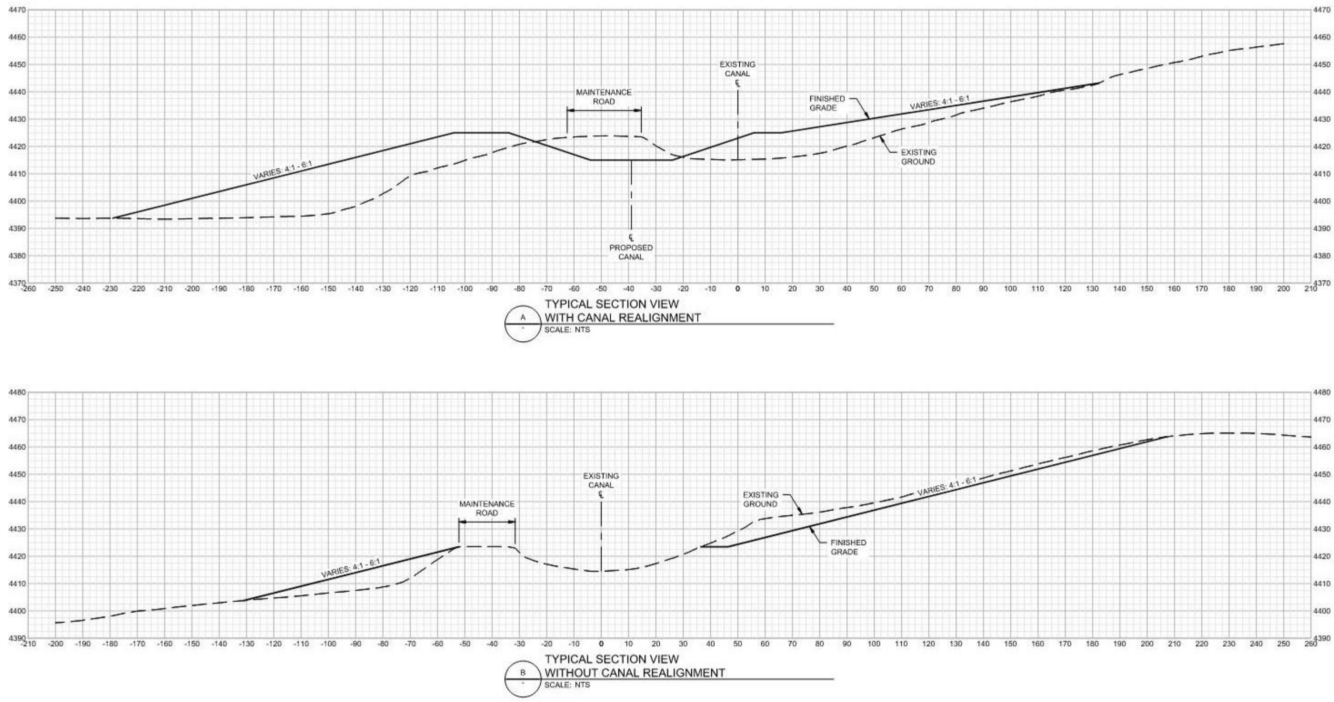
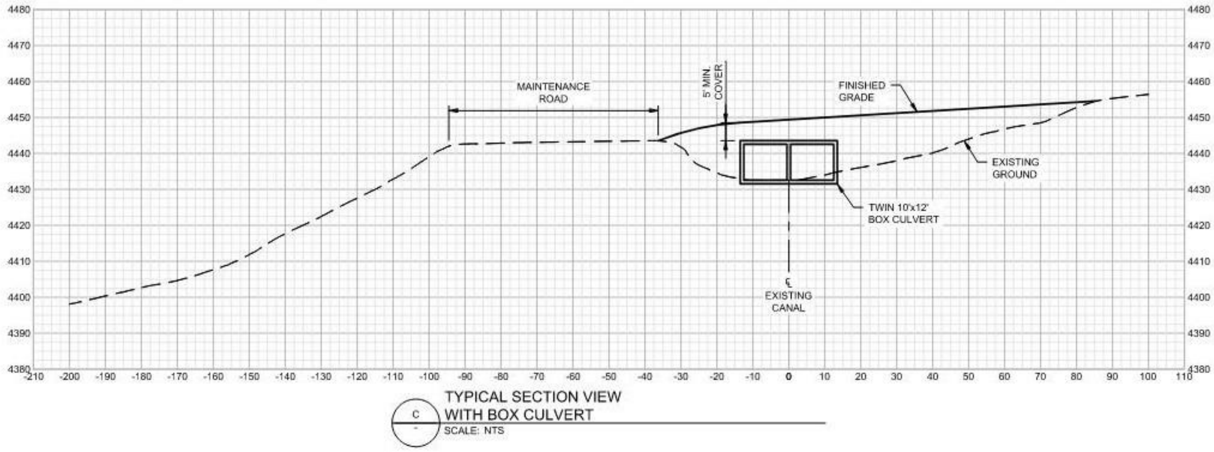


Figure 3-11. Landslide Areas Typical Section Views

Options using box culverts or piping to carry the flow were also considered and are shown in Figure 3-12. HDR evaluated these options using the pressurized piping hydraulic analysis that was completed as described in section 4.3.2. It was assumed that the same size and number of pipes would be adequate for carrying 850 cfs past the slide areas. Therefore, two piping options have been included that use three 10 ft diameter pipes with concrete entrance and exit structures. The pipe would be placed in the existing Canal at the location of the slide and then backfilled to provide approximately 4 to 6 feet of cover. This would place more soil and weight on the toe of the slide as well as reducing at least some of the slope of the slide. To provide a more complete cost analysis, both concrete and steel pipe were considered.

Another option was included that would perform essentially the same as the piping options but would use a twin box culvert. Each of the box culvert openings would be 10' high by 12' wide. Concrete entrance and exit structures would be included and the backfill of the box culvert would be done to provide 4 to 6 feet of cover over the box culvert and provide the same benefits for slope stability that the backfill of the piping would provide.



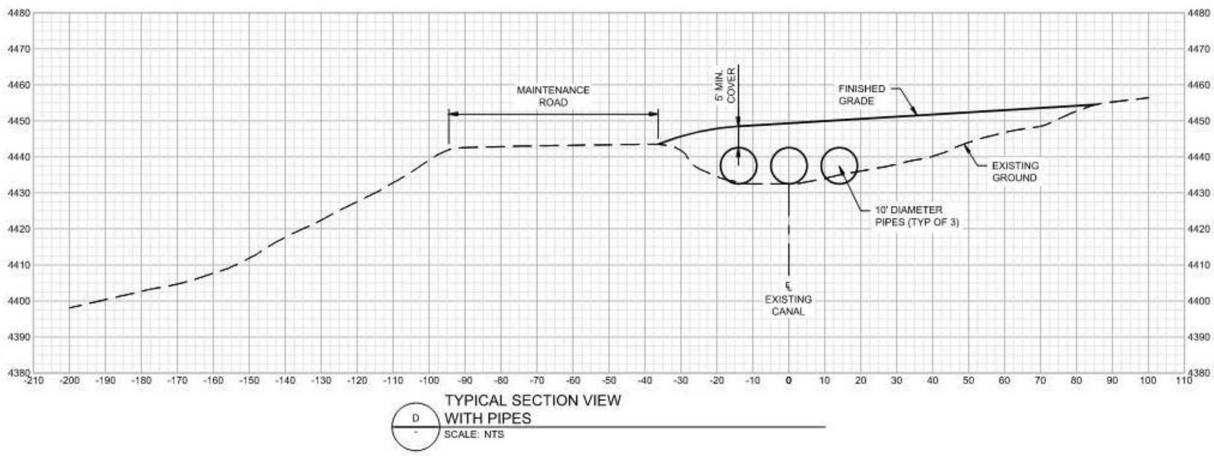


Figure 3-12. Landslide Areas Typical Piping Options

Other areas and locations have been mentioned in the past has having slide activities. Some had no impact on the Canal and were dismissed. Others were minor in nature and were "repaired" with a minimal level of effort. This should not be interpreted to mean that a year of higher precipitation would not result in movement of currently stable slides or the development of slides in areas where none had been previously identified.

The scope of this study is limited to known slides that are or have the potential to impact the Canal. For those slides noted above, the estimated extent of the slide was used in conjunction with available topography to estimate quantities of excavation and length of drainage features. Some geotechnical information has been gathered by Reclamation in the past for some of the slide areas, but these areas have been the subject of past maintenance efforts – making the available information inadequate for conceptual design. At the time design is pursued for remediation of each of these areas, specific geotechnical investigations should be performed and the data pertaining the subsurface materials should be used to guide design decisions and limit the option treatments to just those that would effectively address the known slope instabilities. For the SIP the estimated level of effort was limited to:

- Excavation of materials in the slide to lay back the slopes within the available Canal easement as much as possible;

- Placement and compaction of that material on the downhill side of the Canal;
- Installation of a single swale or drainage trench across the top of the slide area to collect water and redirect that water to a location outside of the swale;
- Placement of riprap across the toe of the laid-back slope; and
- Re-seeding of the disturbed area.

3.10 Animal Intrusion Modernization Options

Livestock and wildlife can damage Canal embankment slopes and/or geosynthetic lining systems by grazing, trampling, and rooting. Livestock also enter the Canal prism to water. Hoofed animals can form depressions that lead to erosion gullies which enlarge over time. Numerous locations along the Canal system indicate bank erosion and impacts to the Canal from livestock and wildlife.

Several options exist to mitigate domestic animal and wildlife intrusion into the Canal prism including fencing and working with wildlife agencies to identify measures to deter wildlife use of the Canal.

One option for mitigating livestock intrusion is to limit and control access to the Canal. Areas where livestock historically access the Canal can be fenced off. Selected access points should have gates and be fenced off to control the area that livestock can access.

A common and often preferred mitigation option is to provide livestock and wildlife water via a turnout with a small pond or watering tank combined with fencing to disincentivize livestock and wildlife access to the Canal. This method is preferred because it will not allow animals direct access to the Canal, preventing embankment damage, erosion and potential water quality issues.

3.11 Hydropower Modernization Options

Hydropower options were assessed through the five drop structures at the end of the St. Mary Canal. The Blackfeet Tribe has first rights to any hydropower generated from the improvements within the St. Mary Canal. Two previous studies were completed on the hydropower feasibility. TD&H prepared a study in 2006 (Montana Department of Natural Resources and Conservation, and Thomas, Dean & Hoskins, Inc., 2006) and HKM Engineering prepared a study in 2007 (HKM Engineering, 2007). The TD&H and HKM studies analyzed historical discharges through the Canal to estimate water supply used for the power generation calculations. It was determined that two flow conditions be used, the operating flow of 700 cfs and the maximum design flow 850 cfs.

These previous estimates of average annual power production may have assumed that the Canal will operate for 12 months per year instead of 6 months (occurring late April through early October). Due to typical winter weather – 6 months are more likely and would reflect a more realistic window Canal operation and corresponding Canal production.

The TD&H study consists of relocating 9,500 feet of the St. Mary Canal and bypassing Drop Structures 1 through 4 and replacing with a single drop structure with three penstocks through the realigned Canal. The TD&H hydropower option with 160 feet of head, and maximum flow ranging from 228.7 cfs to 277.7 cfs, per penstock, would require three Francis or Kaplan turbines (Table 3-12).

Table 3-12: TD&H Hydropower Study Summary

Flow Scenario	Average Monthly Generation (kWh)	Average Annual Generation (MWh)
700 cfs	1,630,869	19,570
850 cfs	1,684,831	20,218

The HKM study analyzed two scenarios that were found to provide greater benefits than the scenarios evaluated in the TD&H study. The first scenario had three separate sections of the drop structures being replaced with penstocks: Drop 1 to Drop 3, Drop 4, and Drop 5. Like the TD&H study, HKM analyzed two flow scenarios through the hydropower options, 700 cfs and 850 cfs (Table 3-13).

Table 3-13: HKM Hydropower Study Summary- Option 1

Flow Scenario	Drop	Head (ft)	Maximum Flow (cfs)	Turbines Needed (Francis or Kaplan)	Average Monthly Generation (kWh)	Average Annual Generation (MWh)	Total Annual Generation (MWh)
700 cfs	1-3	90	228.7	3	917,364	11,008	26,053
	4	66	228.7	3	672,734	8,073	
	5	57	228.7	3	580,997	6,972	
850 cfs	1-3	90	277.7	3	947,717	11,373	26,916
	4	66	277.7	3	694,993	8,340	
	5	57	277.7	3	600,221	7,203	

The HKM study also looked at a second option that constructed a new Canal that bypassed Drops 1 through 4 and then used penstocks to carry the flows to a single power plant near the bottom of Drop 5 (Table 3-14).

Table 3-14: HKM Hydropower Study Summary- Option 2

Flow Scenario	Drop	Average Monthly Generation (kWh)	Total Annual Generation (MWh)
700 cfs	1-5	2,171,095	26,053
850 cfs	1-5	2,242,931	26,916

The HKM report presented Figure 3-13 and Figure 3-14 that represents the two options.

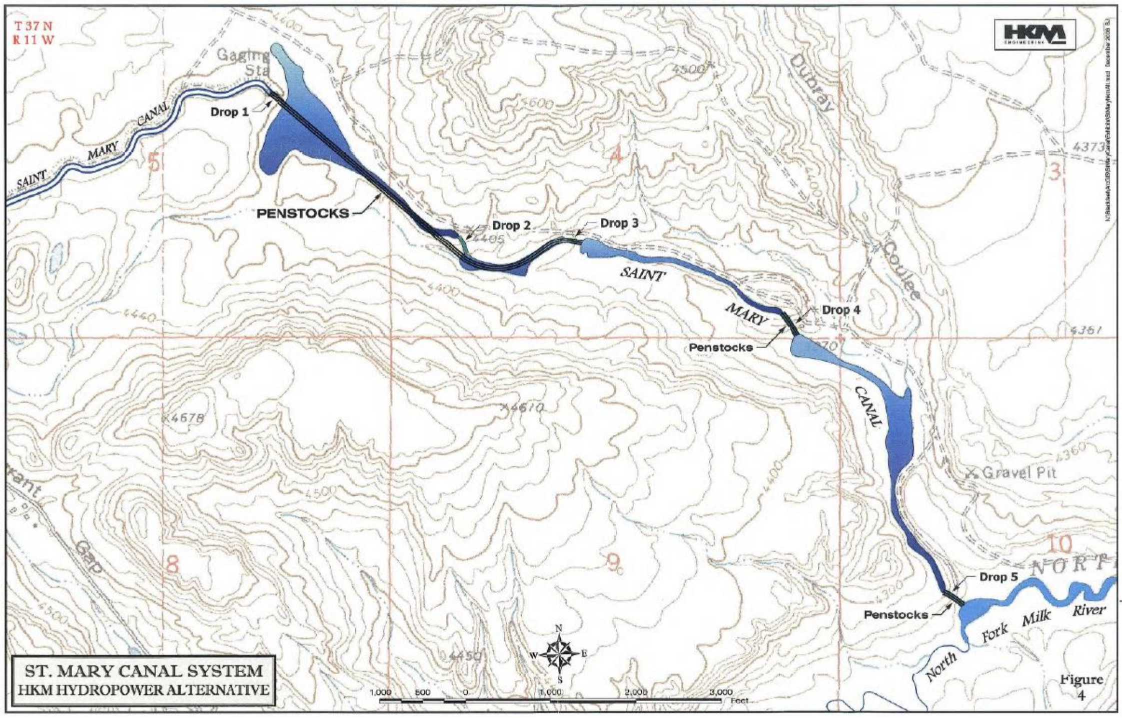


Figure 3-13. HKM Proposed Configuration – Three Penstocks (Drops 1-3, Drop 4, and Drop 5[12]

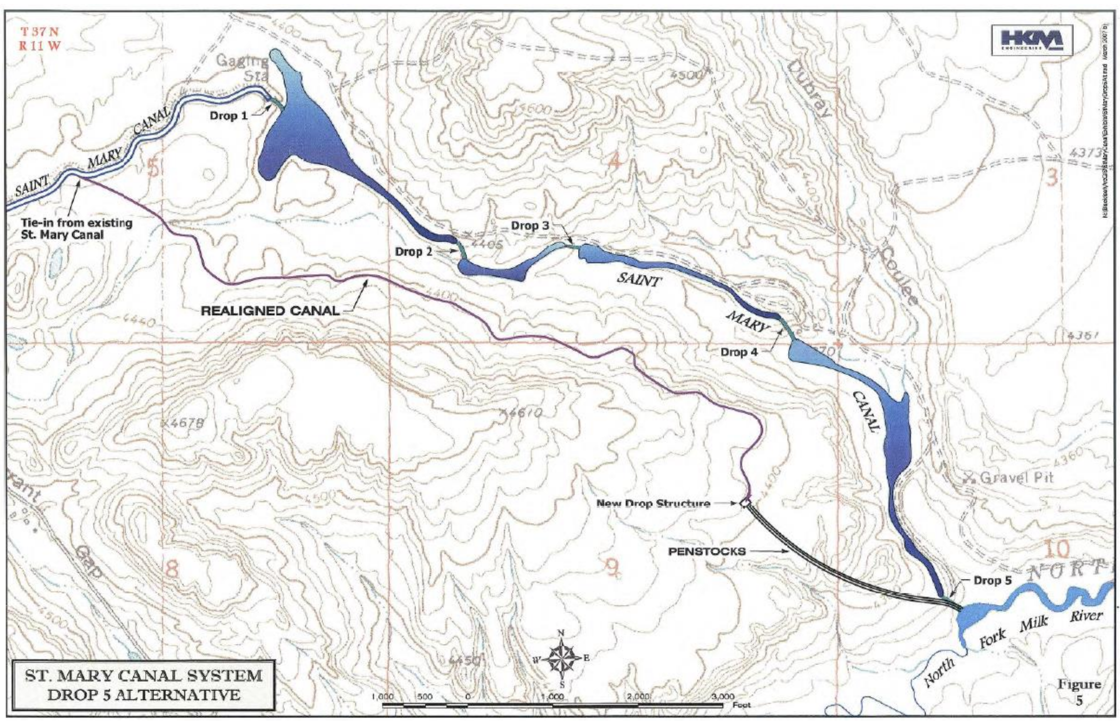


Figure 3-14. HKM Proposed Configuration – Realigned Canal and Drop 5 Penstocks[13]

12 (HKM Engineering, 2007)

13 (HKM Engineering, 2007)

The HKM study assessed the economic feasibility of the options. It was determined that annual net losses occur with every option, as such hydropower from the cost and rate of return basis is not favorable. Table 3-15 shows the original calculations for the two, 850 cfs HKM options as presented in the HKM report.

Table 3-15. Original Hydropower Cost Assessment[14]

	Hydropower Field Costs	Unlisted Items (10%)	Contingency (20%)	Engineering (20%)	Total	Annual O&M Costs
HKM Drops 1-5 at 850 cfs Canal Capacity (Original Calculation)	$22,083,750	$2,208,375	$4,858,425	$5,830,110	$34,980,660	$524,710
HKM Drop 5 at 850 cfs Canal Capacity (Original Calculation)	$25,568,400	$2,556,840	$5,625,048	$6,750,058	$40,500,346	$607,505

The HKM analysis incorporates several assumptions that HDR has addressed in this analysis. First, HKM assumed the Canal would operate year-round as opposed to the 6 months of Canal operation that the Canal is limited to now. Second, HKM did not address the fact that power produced on the Blackfeet Reservation is owned by the Blackfeet Tribe. The HKM study assumed that the power could be carried on transmission lines to a location near the Del Bonita Border Crossing into Canada and then sold into the grid off the reservation. The Blackfeet Tribe has not indicated any preference for what they want to do with the power that could be produced by hydropower development at the St. Mary Canal drop structures. HDR has addressed these issues by:

1. Assuming that power will be carried on transmission lines to Browning for tribal use. In addition, it is known that obtaining right of way for a power line can be extremely complex due to land ownership arrangements on the Reservation. Therefore, the transmission route was altered to follow either the Canal or existing public roadways between the drop structures and Browning. The route begins by following the Canal maintenance road west to Galbreath Road, then south to Duck Lake Road before continuing south to Browning on Duck Lake Road for a total of 38 miles.
2. The analysis of power production will be limited to 6 months in compliance with the existing time frame for Canal operation.

For the purpose of this SIP, HDR reassessed the cost of the hydropower options with updated parameters. The cost calculations (Unlisted Items, Contingency, Engineering) were revised to be a percent of the total field cost and not a continual sum as presented in the HKM study. The 2022 cost assessment adjusted the 2007 figures. The line items adjusted include the penstock cost, Canal conveyance improvements, irrigation re-alignment, and total pipe drop irrigation installed. The Hydropower Unit Capital costs assumed $2,000 per kW for the Drops 1-3, 4, and 5 option and $2,500 per kW for the Drop 5 Single plant option. The capital costs are based on bid prices for similar sized

[14] (HKM Engineering, 2007)

hydropower plants designed by HDR. Updated transmission costs were also included in the revised calculations. Transmission costs were estimated to be $300,000 per mile, based bid prices for multiple transmission projects with similar power capacities in Colorado and the Northwest. The transmission costs were increased for the option constructing smaller power plants at 3 separate locations to account for connecting all three plants to a single transmission line. Engineering and contingency costs were updated to reflect the work required to design the entire hydropower project instead of just design of the hydropower plant. Annual O&M costs were increased to 2.5% in an attempt to adjust for the ongoing changes in labor, fuel, and materials costs. Table 3-16 shows the results of the current cost analysis.

Table 3-16 Revised Hydropower Cost Assessment

	Drops 1-3 (4.5 MW) Drop 4 (3.3 MW) Drop 5 (2.9 MW) Flow: 850 cfs (2022 Pricing)	Drop 1-5 (10.6 MW) Flow: 850 cfs (2022 Pricing)
Hydropower Unit Capital Cost	$21,100,000	$26,375,000
Total Penstock Cost	$9,741,581	$4,453,294
Canal Conveyance Improvements	$5,297,089	$5,297,089
Irrigation Re-alignment	$0	$10,717,258
Total Pipe Drop Installed	$13,453,360	$13,453,360
Transmission Cost	$11,400,000	$12,400,000
Unlisted Items (10%)	$6,099,203	$7,269,600
Contingency (20%)	$13,418,247	$15,993,120
Engineering (20%)	$13,418,247	$15,993,120
Total Cost	$93,927,726	$111,951,842
Total Hydropower Cost	$61,794,144	$63,951,254
Annual O&M Costs	$1,544,854	$1,598,781

Based on the total hydropower cost the financial viability was evaluated for each option. As a simplified financial analysis of the project, the payback period was calculated using a zero-discount rate. The analysis accounted for ongoing O&M costs but did not include adjustments for the changing interest rates over time. The revenue assumed a price of $0.035 per kW based on the rates published by Northwestern Energy for avoided energy and capacity being supplied by the project. The results of the analysis are shown in Table 3-17. The payback periods using revised 2022 figures for the Drops 1-5 option is more than 1,000 years and revenue from the Drop 5 single plant option only covers the estimated O&M annual costs. It is possible that there may be opportunities to mitigate the costs associated with the hydropower development using grants, tax incentives, and other funding sources. These were not included in the analysis because it is unknown how these opportunities may be applied without completing discussions with the Blackfeet Tribe, Reclamation, and the MRJBOC focused on how they might proceed with development of hydropower at this site. In addition, HDR met with Tribal representatives on October 6, 2022 and were informed that the Blackfeet Tribe does not currently see the project as financially viable and is not interested in pursuing the project at this time.

Equipment prices and construction costs are extremely volatile in the current market. Many equipment prices are also being adversely affected by the challenges with shipping – especially from overseas manufacturers. All of these items combine with the potentially lengthy schedule for obtaining the required licenses and permits for a hydropower facility, which contributes to project uncertainty.

Table 3-17. Financial Analysis

	Total Project Costs	Price Per kWh	O & M Costs	Annual Revenue	Annual Profit
Drops 1-3 (4.5 MW) Drop 4 (3.3 MW) Drop 5 (2.9 MW) Flow: 850 cfs (2022 Pricing)	$93,927,726	$1.81	$1,544,854	$1,600,106	$55,252
Drop 1-5 (10.6 MW) Flow: 850 cfs (2022 Pricing)	$111,951,842	$2.53	$1,598,781	$1,600,106	$1,325

3.12 Modernization Option Evaluation Summary

HDR evaluated the options for modernizing the St. Mary Canal using criteria as listed previously in Section 4. Table 3-18 defines each criterion and the corresponding method used to compare each option with that criterion. HDR assigned a scale of 1 to 5 for each option's effectiveness in meeting each criterion, where a scale of 1 translates to an option's limited ability to address a criterion and a scale of 5 translates to a high ability in addressing a criterion.

Table 3-18. Criterion and Option Comparison

Criterion	Definition	Method for Modernization Option Comparison
Restoring Canal Capacity	An option's ability to restore the Canal to its original design capacity of 850 cfs.	The expected Canal capacity of each option is compared; increased Canal capacities are preferred.
Water Conservation	An option's ability to reduce water losses through seepage, evaporation, and/or operational spills.	The expected water losses of each option are compared; reduced losses are preferred.
Operations and Maintenance	An option's ability to reduce the level of labor required and improve the ease to operate and maintain the St. Mary Canal.	Operation and maintenance costs of each option is compared; reduced costs are preferred.
Resource Protection	An option's level of impact to the surrounding wetlands or animal habitat.	The area of wetlands and animal habitat impacted by each option; reduced area of impact is preferred.
Construction Feasibility	An option's level of use in commonly used materials, construction methods, and level of challenges that may result in delays in the construction schedule.	The construction methods, materials, and overall construction challenges of each option is compared; where common construction methods, lower cost materials, and reduced challenges are preferred.

Owner's Preference[15]	An option's ability to meet the owner's goals and expectations with an appropriate level of risk.	How the option meets the owner's goals and expectations is evaluated, where more goals and expectations addressed are preferred.

The scoring methodology for each of the criterion presented in Table 3-25 are described in the tables below.

Table 3-19. Restoring Canal Capacity

Rating	Criteria
5	Provides 850 cfs design capacity
4	Provides 850 cfs design capacity, but requires significant long term maintenance activities to sustain design capacity
3	Initially provides 850 cfs capacity, but does not provide reliable long-term service
2	Initial capacity is 850 cfs, but presents high risk of catastrophic failure
1	Does not provide 850 cfs capacity

Table 3-20. Water Conservation

Rating	Criteria
5	Water delivery (system efficiency) equals at least 95% of diverted water
4	Water delivery will increase by approximately 75% or more of current estimated water losses
3	Water delivery will increase by approximately 25% or more of current estimated water losses
2	Water losses are greater than current deliveries
1	Does not provide water conservation benefits

Table 3-21. Operations and Maintenance

Rating	Criteria
5	O&M limited to daily observation/adjustment, normal lubrication, limited removal of debris/sediment, etc. to achieve/maintain performance goals. Conserves water with automation or normal O&M level of effort.
4	O&M limited to no more than two to three instances per irrigation season of significant repair or actions to maintain and continue expected performance. Water conservation requires additional effort.
3	Normal O&M requires effort to overcome mechanical issues such as bent gate stems, sediment/debris interference, difficult stop log removal/installation. Water conservation requires extended staff hours or reduction of conveyance rates.
2	O&M requires mitigation of safety issues. Normal maintenance requires system shut down. Water conservation is only possible through constant adjustment or cleaning (not addressed by automation).
1	O&M does not meet end user water demands. Maintenance requires equipment or skills not readily available or difficult to procure. Water conservation not achievable or maintainable.

[15] Bureau of Reclamation is Owner

Table 3-22. Resource Protection

Rating	Criteria
5	Creates additional wetlands or habitat
4	Maintains existing wetlands or habitat
3	Reduces or replaces existing wetlands or habitat destroyed or adversely impacted by project
2	Minimal replacement of existing wetlands or habitat destroyed or adversely impacted by project
1	Destroys wetlands or habitat with no mitigation

Table 3-23. Construction Feasibility

Rating	Criteria
5	Can be constructed using commonly or readily available construction equipment, materials, labor, and/or skills. Estimated construction schedule meets or exceeds expectations.
4	Can be constructed using commonly or readily available construction equipment, materials, labor, and/or skills with limited exceptions. Estimated construction schedule meets or exceeds expectations but with significant schedule risks.
3	Requires specialized construction equipment, materials, labor, and/or skills. Estimated construction schedule does not meet expectations.
2	Required construction equipment, material, labor, and/or skills has limited availability – potentially limiting competitive bidding. Schedule does not meet expectations and poses a risk to critical project components such as funding availability and or product quality.
1	Is not constructable and/or schedule may not be achievable.

Table 3-24. Owner[16] Preference

Rating	Criteria
5	Meets or exceeds owner's expectations and/or performance goals with acceptable level of risk
4	Meets or exceeds owner's expectations and/or performance goals with identified risks
3	Meets owner's expectations and/or performance goals with acceptance of known and/or perceived issues
2	Does not meet owner's expectations but has been accepted as best available/affordable solution
1	Fails to meet owner's expectations

[16] Bureau of Reclamation is Owner

Table 3-25. Options Analysis Summary

Options			Factors							
Option No.	Type of Improvement	Option Variation	Restoring Canal Capacity	Water Conservation	Operations and Maintenance	Resource Protection	Construction Feasibility	Owner's Preference	TOTAL	Capital Cost
1	Conveyance	Earthen Canal	3	2	2	4	5	5	21	$18,500,000
2	Conveyance	Geosynthetic - Lined Canal	4	4	3	2	3	5	21	$52,200,000
3	Conveyance	Concrete - Lined Canal	4	3	4	2	2	3	18	$456,000,000
1	Conveyance	Steel Pipe	5	5	5	1	1	1	18	>$1,000,000,000
1	St. Mary Siphon	Steel Pipe	5	5	4	4	3	5	26	$48,300,000
2	St. Mary Siphon	Concrete Pipe	5	5	3	4	2	5	24	$46,600,000
1	Halls Coulee	Steel Pipe	5	5	4	4	3	5	26	$19,300,000
2	Halls Coulee	Concrete Pipe	5	5	3	4	2	5	24	$20,700,000
1	Drop Structure	N/A	5	2	4	1	3	5	20	$13,900,000 (1,3 & 4)
1	Maintenance Road	One Side of Canal	1	1	4	3	4	5	18	$6,300,000
2	Maintenance Road	Two Sides of Canal	1	1	5	3	1	3	14	$16,600,000
1	Wasteways	Full Replacement of Wasteways and Turnouts	3	1	4	2	4	3	17	$5,300,000
2	Wasteways	Improved Replacement of Wasteways and Turnouts	3	2	5	2	3	4	19	$8,400,000
3	Wasteways	Improved Replacement of Wasteways and Turnouts and Additional Structures	4	3	5	2	2	5	21	$14,400,000
1	Underdrains	In-Kind Replacement	3	1	4	2	4	4	18	$3,000,000
2	Underdrains	Improved Replacement	4	1	5	2	3	5	20	$4,000,000
1	Slope Stability	Dual 12' Concrete Box	5	3	4	4	3	3	22	$189,100,000
2	Slope Stability	Triple 120-inch Reinforced Concrete Pipe	5	3	4	4	2	3	21	$199,000,000
3	Slope Stability	Tripe 120" Steel Pipe	5	3	4	4	2	4	22	$239,900,000
4	Slope Stability	Earthwork	5	2	2	1	5	4	19	$29,000,000
1	Animal Intrusion	N/A								

3.13 Modernization Options Further Considered

MRJBOC, Reclamation, Farmers Conservation Alliance (FCA) and HDR met on August 25, 2022 and August 29, 2022 to discuss the options and reach a consensus on the which modernization options should be evaluated further. Meeting notes from these meetings are included in Appendix B. During these meetings the following options were selected:

1. Canal conveyance – A hybrid approach from the options considered including using an improved earthen Canal section and an improved earthen Canal section with a geosynthetic liner.
2. Siphon Replacements – Full replacement of the siphons with a buried installation and bid options for either steel pipe or concrete cylinder pipe (CCP).
3. Wasteways/Turnouts (Drains) - Replace the existing Kennedy Creek and Halls Coulee Wasteways with new improved structures to include evaluating different gate configurations for the new structures, automation, etc. during design. Improvements also include the replacement existing turnouts with new side channel spillway structures.
4. Underdrains (Culverts) – Underdrains will be replaced and upgraded to convey the 25-year event.
5. Slope Stability (Active Slide Area) – Slope stability is somewhat dependent on geotechnical site investigations. The known areas with slope stability concerns along the Canal will be addressed with an earthwork option. For each slide area this includes:
    a. Removing weight off the top of the slides to the extent possible by flattening the exposed slopes.
    b. Relocate excavated material, place and compact on the downhill side of the Canal.
    c. Control of subsurface and surface water will also be addressed in the form of filter drains or surface swales to direct as much water as possible away from the unstable soils.
6. Drop Structures – Drop structures 1, 3, and 4 will be replaced by new structures with a similar design to the recently replaced drop structures 2 and 5.
7. Maintenance Road – The existing access road running along the Canal alignment will be improved. Drainage will be evaluated and drainage improvements (culverts) may also be included where appropriate.
8. Animal Intrusion – No consensus was reached on a selected option to address potential animal intrusion concerns. It was agreed that HDR will expand on animal intrusion in the SIP and provide costs for fencing both sides of the Canal.

Section 4. System Improvement Plan Methodology and 10% Design Considerations

Reclamation's Technical Service Center (TSC) posts its design standards online with the following statement, *"Reclamation Design Standards establish Reclamation technical requirements and processes to enable preparation of designs, documents, and reports necessary to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. Reclamation design activities, whether performed by Reclamation or by a non-Reclamation entity, must be performed in accordance with Reclamation design criteria and standards. Deviations from Reclamation criteria and standards shall be submitted in accordance with Reclamation Manual Directive and Standard, "Design Activities," FAC 03-03. The use of Reclamation design criteria and standards outside of Reclamation is entirely voluntary."*

As part of this SIP, the 10% design drawings were created with the intent of following Reclamation design standards and not to consider design criteria and standards outside of Reclamation's standards. Below are Reclamation design standards that will likely apply to this project. Reclamation lists them under two categories; "Final Reclamation Design Standards" and "In Progress and Not in Progress Reclamation Design Standards." Both categories of standards below are anticipated to be used for the design of this project. As design progresses, additional design standards may apply and should be used accordingly, unless a deviation is proposed.

Final Reclamation Design Standards

Design Standards No. 1: General Design Standards (September 2009; updated May 2012)

- Chapter 1: Preparing and Using Design Standards
- Chapter 2: Design Standards Index

Design Standards No. 6: Hydraulic and Mechanical Equipment

- Chapter 6: Bulkhead Gates and Stoplogs (January 2018)

Design Standards No. 13: Embankment Dams

- Chapter 1: General Design Standards (October 2011)
- Chapter 2: Embankment Design (December 2012)
- Chapter 3: Foundation Surface Treatment (July 2012)
- Chapter 7: Riprap Slope Protection (May 2014)
- Chapter 8: Seepage (January 2014)
- Chapter 9: Static Deformation Analysis (November 2011)
- Chapter 10: Embankment Construction (May 2012)

- Chapter 12: Foundation and Earth Materials Investigation (July 2012)
- Chapter 13: Seismic Analysis and Design (May 2015)
- Chapter 15: Foundation Grouting (September 2014)
- Chapter 16: Cutoff Walls (July 2014)
- Chapter 17: Soil-Cement Slope Protection (August 2013)
- Chapter 20: Geomembranes (September 2018)

In Progress and Not in Progress Reclamation Design Standards

Design Standards No. 3: Water Conveyance Facilities, Fish Facilities, and Roads and Bridges

- Chapter 1: Open Channels
- Chapter 2: Canal Structures and Canal Automation
- Chapter 3: Diversion Dams and Headworks
- Chapter 6: Water Measurement
- Chapter 7: Cross Drainage for Canals
- Chapter 8: Pipelines and Pipe Distribution Systems
- Chapter 9: Bridges and Roads
- Chapter 12: General Structural Considerations

Design Standards No. 10: Transmission Structures

- Chapter 1: Steel Design and Details
- Chapter 2: Concrete Footing Design

4.2 Additional Design Considerations

As design of the St. Mary Canal improvements proceed, there are many unknown conditions and design considerations to address. Geotechnical investigations must be completed to provide an understanding of subsurface conditions, groundwater, soil characteristics and provide for a basis of design.

Land ownership on the Blackfeet Indian Reservation can be challenging due to the complexities of granting access to Trust lands on the reservation. Along the Canal where improvements are proposed, obtaining a clear understanding of land ownership and/or footprint required for improvements is necessary.

Additional construction challenges to be considered during design include timing and construction sequencing due to the short construction season, adverse weather conditions, and the remote location and housing of contractor personnel during construction.

The below sections include design considerations made for the various components of the Canal system included in this evaluation.

4.3 Canal Improvements

Open channel options considered for improvements to the Canal include an improved earthen Canal section and an improved earthen Canal section with a geosynthetic liner.

The design considerations utilized consists of:

- An operational discharge of 850 cfs,
- Approximating the existing channel widths in order to limit the amount of cut/fill associated with construction,
- Maximizing the velocity of the normal operational discharge to improve sediment transport within the Canal,
- Including 2’ of freeboard to provide a factor of safety within the Canal and mitigate risk associated with a potential surcharge or occurrence creating an unaccounted inefficiency within the conveyance system,
- Use a side slope of 1.5:1 to maximize the cross-sectional efficiency of the section.
- In correspondence with MRJBOC and Reclamation, it was decided to review the applicability of lining the Canal from the diversion to the Big Cut area (minus Spider Lake) and providing an earthen Canal from Big Cut to Drop 1.

4.4 Siphon Replacements

Demolition of the existing siphon structures would not be required if the new siphons are constructed outside the existing siphons footprint (see Figures 4-1 and 4-2). Once the new siphons are constructed and placed into service the existing structures will require decommissioning to address public safety. At the siphon inlets the Canal will need to extend to tie into the new siphon inlet structures. At the siphon outlets the Canal will also be extended from the new siphon outlet structures and blended in with the existing Canal.

The proposed inlet structures will be new cast-in-place concrete structures with stop-log bays so that each pipe can be isolated. Cutoff walls will be constructed in each of the structures and the Canal will be lined for 100 to 150 feet to discourage seepage around the structure that could lead to pipe and slope instabilities.

Siphon pipes will be installed adjacent to the existing siphon structures at a sufficient depth to be below existing unstable soil materials or maintain a minimum cover, whichever is deeper. The pipes will be installed with access manholes and drain piping to pump water out of the pipe for inspection. Corrosion protection should be considered with test stations at intervals along the length of the pipe. For the portion of the St. Mary siphons crossing the St. Mary River, the pipe will be installed on top of a new bridge spanning the St. Mary River.

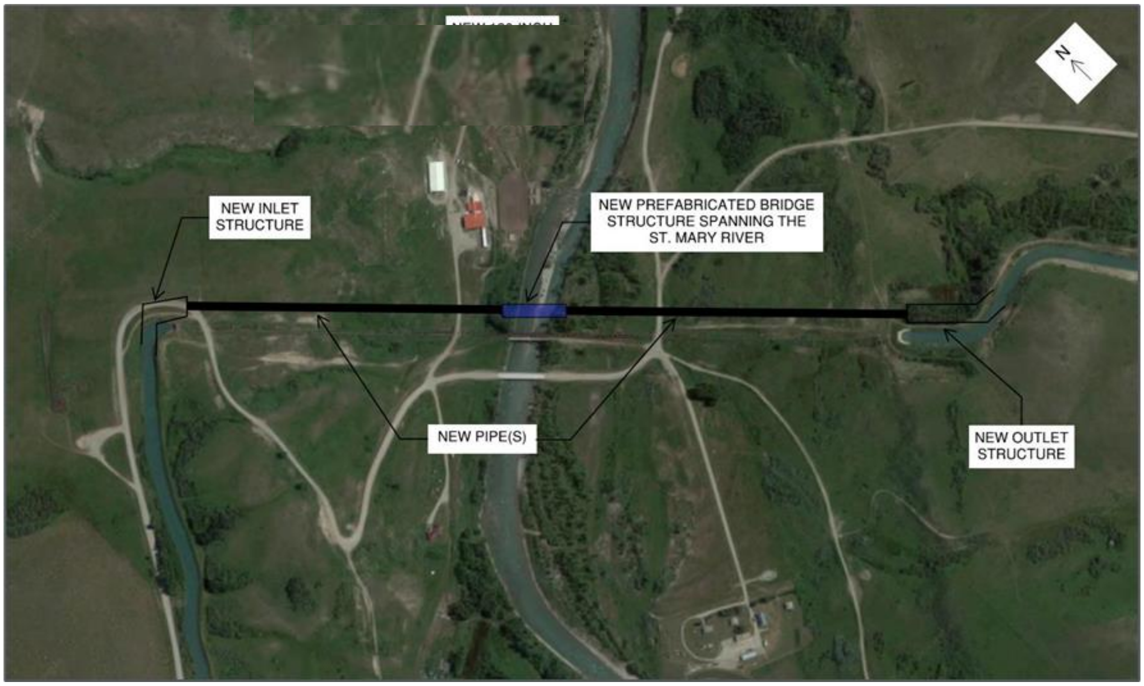


Figure 4-1. St. Mary Canal Siphon

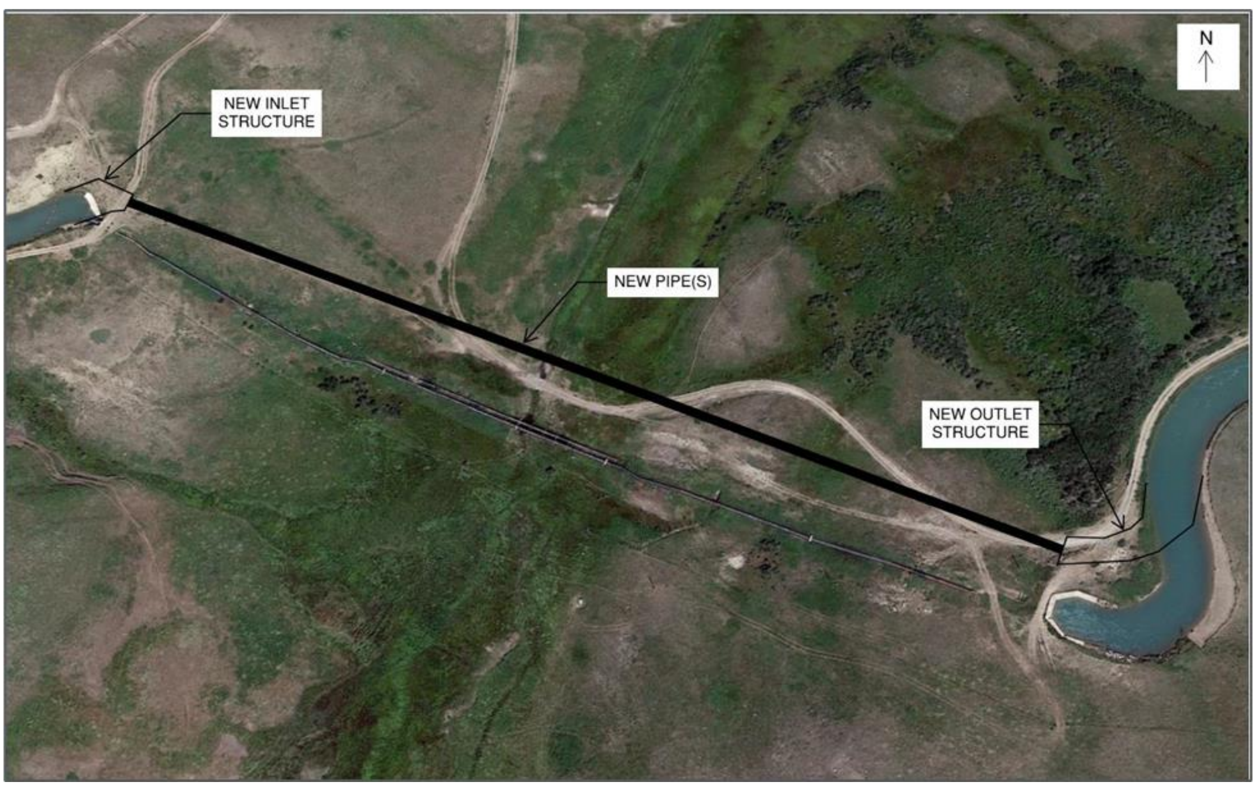


Figure 4-2. Halls Coulee Siphon

4.5 Kennedy Creek Crossing

Based on the preliminary hydraulic analysis described in Section 3, the existing Kennedy Creek crossing was noted as resulting in excess backwater, ponding the design discharge in the Canal. This results in a decrease in conveyance and velocity within the Canal witnessed from the Kennedy Creek crossing to almost the diversion. Due to this decreased velocity, the Canal is incapable of mobilizing the fine sediment recruited within the Canal, further exacerbating the lack of conveyance. In order to increase the conveyance within the upper reach of the Canal, HDR proposes to add a 10' x 10' reinforced concrete box (RCB). The proposed box can sit within the existing footprint of the Canal crossing, running parallel to the existing culvert. HDR assumes that the existing headwall can be cut and sectionally demolished to allow for the RCB to be placed. In order to construct the box length, Kennedy Creek will need to be temporarily diverted to one side of the crossing while half of the box is placed. Then the creek will need to be diverted over the newly constructed section while the remaining box length is placed. Hence, Kennedy Creek will need to be reconstructed to its existing location and dimensions once the crossing is constructed.

4.6 Drop Structure Replacements

Design of the three drop structures will require detailed hydraulic modeling to address components of the structures, including analysis of the intake structures with ogee crest weirs, chute spillways, and stilling basins. The hydraulics analysis for the design of the intake structure, chute spillway, and stilling basin will be conducted using guidance provided by the Reclamation's Hydraulic Design of Stilling Basins and Energy Dissipators and Design of Small Dams.

A steady flow one-dimensional (1D) mixed flow regime HEC-RAS model will be used to assess the hydraulics in the upstream Canal, intake structure, and chute spillway. Stilling basin hydraulics will also need to be evaluated.

In addition to the above drop structure design considerations, additional design considerations will include seismic design criteria, downstream pools and channels, structural design, groundwater remediation, construction staging and sequencing, and site remediation after construction.

4.7 Slides

There are three main elements in repairing landslides: 1) removing the load from the top of the slide, 2) adding weight to the base of the slide, and 3) increasing the strength of the soil within the area of the slide and particularly at the subsurface boundary where the material is moving. Removal of material located at the top of the slide removes some of the weight that drives the slide. Installing additional material at the base of the slope may require relocation of the Canal to provide sufficient room for the placement of additional material. Improvement of soil strength is often accomplished by reducing the amount of water held in the soils within the slide area – which reduces the weight driving the landslide and pore pressure within the slide area. Repair methods for landslides typically use one or more of the three elements. Evaluation of techniques that are typically more expensive and difficult than mass excavation or mass fill - such as chemical grouting, soil nails, soil mixing, micro piles, and jet grouting - were not included in the scope of this evaluation.

Geotechnical investigations have not been carried out for each of the slide areas and therefore the methodology for design of mitigation / stabilization of the slide areas has been based on commonly employed techniques throughout the industry and historical efforts that have resulted in some protection of the Canal. Geotechnical investigations are critical in determining the design approach that will work best for a particular location.

Work to stabilize the slide areas and/or mitigate their impact on the Canal has been on-going for many years. Slides have generally been addressed by excavating the slide material within the Canal prism and placing it on top of the slide area or disposing of the material up and downstream of the slide. In some cases, equipment was used to reduce the slope of the slide by moving material from the face of the slide down through the Canal section and then placing the material on the downhill slope of the Canal embankment. Reclamation has worked on the slides numerous times and have had some success at a reasonable cost, but these efforts have not resulted in complete stabilization of the slide areas. Therefore, this study has taken a more comprehensive approach using mass excavation and mass fill approaches over a larger area to better and more completely address the entire extent of the slide and achieve a greater potential for long term stability.

Methodology for long-term solutions for the slide areas should include the following:

- Geologic investigations and lab analysis (not included in this study).
- Place additional weight on the toe of the slides (gravel, riprap, or other free draining fill).
- Removing as much of the weight off the top of the landslides as possible.
- Material removed or placed must be properly compacted to provide long term stability.
- Control of subsurface and surface water should be included in the form of filter drains or surface swales to direct as much water as possible away from the unstable area (dependent on availability of geotechnical information).
- If necessary, control erosion at the toe of the slope using gravel/riprap.
- Re-seed disturbed areas to prevent erosion and reduce water absorption into the soils.

4.8 O&M Road Improvements

O&M road improvements will consist of improvements to existing O&M roads. O&M road improvements will be implemented to establish an all-weather access road on one side of the St. Mary Canal for its entire length. This will generally be the downstream side of the Canal to facilitate O&M of irrigation facilities. The O&M road surface section will be 12 feet wide and sloped at 2% cross slopes away from the Canal with 6 inches of compacted gravel comprising the driving surface. A 1-foot tall (minimum) windrow will be constructed adjacent to the Canal, and where the O&M road is adjacent to a cut slope, a

1-foot deep (minimum) ditch will be constructed parallel to the O&M road to provide surface drainage.

Prior to gravel placement, grading and compaction of the top 12 inches of the subgrade to a minimum of 85% relative compaction will be completed to establish a competent subgrade. In areas with poor subgrades (e.g., exhibiting signs of rutting), over-excavation and the importing of subbase material, and potentially geotextile and/or geogrid placement, is proposed for subgrade stabilization. O&M road improvement will be constructed for a total of approximately 32.7 miles along the length of the St. Mary Canal.

4.9 Wasteway/Turnout Replacements

All existing wasteways and turnouts/drains along the St. Mary Canal are proposed to be replaced. The existing Kennedy Creek and Halls Coulee Wasteways are the only two major wasteways along the St. Mary Canal designed to handle the entire Canal capacity of 850 cfs. These structures will be replaced with new improved structures, similar in design to the existing structures, including the baffled apron spillway for the Halls Coulee Wasteway. Improvements which will be considered include improved safety features, different gate types and configurations for improved O&M, automation, etc. The new structures will warrant hydraulic and structural analysis and design. Of note, the Kennedy Creek Wasteway is integral to the Kennedy Creek Check Structure, and replacement of the Check Structure with a new improved structure is also proposed.

The existing wasteways and turnouts are proposed to be replaced with new side channel spillway structures designed to serve as both protective structures while also allowing for discretionary water deliveries/removal from the Canal. In addition to the eight existing turnouts/drains that will be replaced with side channel spillways, a new side channel spillway is also proposed to be added upstream of the Kennedy Creek Siphon. Side channel spillways will be designed in accordance with the *Design of Small Canal Structures* (U.S. Department of the Interior, 1978) and the following design criteria:

- The overflow weir crest will be set 0.2 feet above the normal water surface elevation to provide automatic spilling of excess flows in the Canal and will be designed to provide the following capacities:
  - 50 cfs of capacity while maintaining 1 foot of freeboard (minor storms)
  - 100 cfs of capacity while maintaining 0.5 feet of freeboard (major storms)
- A slide gate will be provided at the structure/Canal invert to allow for discretionary deliveries and/or draining of the Canal.
- The outlet pipe will include soil-cement bedding where it passes under the Canal.
- For outlet pipes with high outlet velocities (>10 feet/second), a standard Reclamation baffled outlet structures will be provided for energy dissipation at the outfall. For outlet pipes with low outlet velocities, a standard reinforced concrete flared end section and culvert outlet riprap protection aprons is proposed.

A single preliminary conservative standard side channel spillway design was developed which includes a 25-foot long weir crest and 54-inch slide gate and outlet pipe designed to provide required capacity. The preliminary design provides 60 and 125 cfs of capacity, exceeding Reclamation's minimum design capacities of 50 and 100 cfs, while maintaining Canal freeboard depths of 1.0 and 0.5 feet. The design could also be modified to provide smaller structures with decreased capacity and small outlet pipes and slide gates. Further hydraulic and structural analysis and design will occur as the design progresses.

4.10 Underdrain Replacements

All existing underdrains along the St. Mary Canal are proposed to be replaced. In accordance with *Design of Small Canal Structures* (U.S. Department of the Interior, 1978), the recommended design storm event for underdrain culverts managing offsite surface drainage and runoff for irrigation Canals is the 25-year storm event. Peak discharges contributing to underdrain culvert crossings were estimated using the StreamStats software developed by the U.S. Geological Survey (USGS). StreamStats was utilized to delineate drainage basins and estimate peak discharges based on USGS Regression Equations, with estimated peak discharges for the 25- and 100-year storm events presented below in Table 5-2.

Proposed design criteria for underdrain culverts are presented below:

- The software HY-8 developed by the US Department of Transportation Federal Highway Administration will be used for underdrain culvert hydraulic analysis.
- Culverts will be designed to meet the headwater criteria developed by the Montana Department of Transportation and presented below in Table 4-1 for the 25-year design event.

Table 4-1. Maximum Allowable Headwater Depth for the Design Event

Pipe Size	HW @ Design Flow[1]
≤ 42”	< 3.0*D or 3.0*R
48” – 108”	< 1.5*D or 1.5*R
≥ 120”	< D+2.0’ or R+2.0’
[1]D signifies diameter of the pipe, R signifies rise of the pipe.	

- Flared and sloped end sections will be used for reinforced concrete pipe culvert (RCP) and reinforced concrete box culvert (RCB) options, respectively, and all underdrain culverts will include culvert outlet riprap protection aprons.
- Underdrain culverts will include three concrete seepage (percolation) collars and soil-cement (controlled low strength material) bedding underneath the Canal.
- Underdrain culvert profiles will match the existing stream channel/thalweg and provide a minimum of 2-feet of cover (measured from the Canal invert).
- Aquatic organism passage will not be considered for underdrain culverts.

HY-8 was used for a preliminary analysis of existing underdrain culverts and preliminary sizing of proposed underdrain culverts, with the result presented in Table 5-2. Preliminary lengths provided in Table 5-2 were estimated based on the existing underdrain culvert lengths. For most underdrain culverts, upsizing of the culvert is recommended. The Powell Creek Culvert may be a good candidate for replacement with an RBC. The proposed option presented below is comprised of 2 – 78-inch RCPs, however, a 12’ x 6’ RCB would also meet the design criteria and be similar in cost to the double barrel RCP option. Final design will include finalizing underdrain culvert sizing and establishing final alignments and profiles.

Table 4-2. Underdrain Options Summary

Station	Name	25-yr Discharge (cfs)	100-yr Discharge (cfs)	Existing	Proposed	Length (ft)
330+69	Powell Creek Culvert	681	1,630	2 x 66” RCP	2 x 78” RCB	2 x 150
794+46	Cow Creek Culvert	363	921	54” x 66” RCB	72” x 72” RCB	180
979+70	Culvert	152	421	30” RCP	2 x 36” RCP	2 X 144
1052+72	Culvert	100	290	30” RCP	42” RCP	140
1096+93	Culvert	65	196	30” RCP	36” RCP	168
1134+68	Culvert	65	196	30” RCP	36” RCP	144
1194+29	Culvert	38	121	30” RCP	30” RCP	158

4.11 Animal Intrusion

The objective of fencing both sides of the Canal is to limit and control access to the Canal by wildlife and livestock animals. For the System Improvement Plan, fencing was considered for both sides of the Canal from the St. Mary River diversion structure to the Drop 1 intake area. This length is approximately 26 miles long equating to approximately 52 miles of fencing. Design considerations for fencing options need to consider: posts and post spacing, gate frames, braces, rails, wire and fittings. Additionally, land ownership needs to be verified along the fenced routes and accommodations made for crossings. Access points should have gates and be fenced off to control the area that livestock can access.

Section 5. Proposed System Improvements

5.1 Water Conservation and Improved Water Reliability

FCA conducted a water loss assessment on the St. Mary Canal. (Farmers Conservation Alliance, St. Mary Canal, Water Loss Assessment, February 2022). That assessment divided the canal into a series of reaches as depicted in Figure 4-3 borrowed from that report.

Figure 1-1. Seepage Sub-Reach Locations on St. Mary Canal, June 26-28, 2021.

Figure 5-1. FCA Water Loss Assessment Seepage Sub-Reach Locations

The field work directly measured flows in the Canal to define the amount of water loss being experienced by each of the identified reaches. In addition, the work was calibrated using USGS gage data from 2006 through 2016. The identified water losses presented in **Error! Reference source not found.** are also from the FCA study.

Canal Name	Sub-Reach	Median Flow Loss (cfs)	Seasonal Median Loss (af/season)	Median Percent Loss
Upper St. Mary Canal	St. Mary_0	20.0	10,193	8.19%
Lower St. Mary Canal	St. Mary_1	14.9	4,619	2.64%
Lower St. Mary Canal	St. Mary_2	14.1	4,359	2.49%
Lower St. Mary Canal	St. Mary_3	7.55	2,336	1.34%
	Total:	**56.6**	**21,507**	

Notes: af/day: acre-feet per day; cfs: cubic feet per second

Figure 5-2. FCA Water Loss Assessment Identified Losses

These results represent the total loss of water measured at the time of the field work. There is no separation of evaporation, vegetation uptake, leakage from headgates, and stock watering. The measurements were made when temperatures were relatively high. Lower temperatures in the spring and fall could reduce the impacts of evaporation. Providing separation of these factors would require additional work over a number of years to collect enough data to quantify the water loss that is attributable to factors other than seepage. Based on HDR's over 40 years of experience with irrigation projects across the western half of the United States and the fact that there are few (if any) large trees growing within the Canal prism - it is believed that seepage represents the majority of the measured losses.

Of the projects identified by the MRJBOC and Reclamation, the Canal lining and Canal reshaping projects present the largest potential for water conservation. Estimating the anticipated water savings and improved water reliability for each of the preferred actions presents the following challenges and explanations:

5.1.1 Canal Improvements

The existing Canal would be re-shaped and an uphill embankment would be constructed. This would eliminate the many locations where the water in the Canal widens into a "backwater" area that increases both seepage and evaporation losses. It would also result in a more efficient conveyance of the water; however, the earthen section would still be subject to some seepage losses. Estimating the reduction in water loss is difficult due to the uncertainty of the amount of losses that can be attributed to wider areas of the Canal now. The proposed re-shaped earthen Canal sections are downstream from the St. Mary River Siphons (identified in the FCA Water Loss study as reaches 1 through 3). Without additional data, a savings of 50% of the existing water losses in this reach of the Canal was assumed or approximately 5,700 AF per irrigation season. These annual water savings assume an irrigation season for the St. Mary Canal, although weather dependent, is generally from April 15 through October 15 each year.

The existing Canal between the St. Mary River diversion and the St. Mary River Siphon would be re-shaped and an uphill embankment would be constructed. Once the Canal has been reshaped, a geosynthetic liner would be placed within the newly constructed Canal prism. This would eliminate the many locations where the water in the Canal widens into a "backwater" area that increases both seepage and evaporation losses. It would also result in a more efficient conveyance of the water as well as eliminating a majority of the water losses in this section of the Canal (identified in the FCA Water Loss study as reach 0). Without additional data, a savings of 90% of the existing water losses in this reach of the Canal was assumed or approximated at 9,200 AF per irrigation season. To estimate these annual water savings, HDR assumed the same irrigation season duration as mentioned for the earth Canal section.

5.1.2 Kennedy Creek Crossing, St Mary, and Halls Coulee Siphons

Replacement of the siphons primarily represents an improvement in system reliability and reduction of the risk of a service loss during the irrigation season. A failure of one of the siphons would result in the inability to convey water to irrigators, negating any benefits of other system improvements. The actual water loss via leaks in the siphons is generally less than 5 cfs due to ongoing maintenance efforts but it changes from year to year as new failures in the pipe wall occur and then are repaired. A savings of 2.5 cfs was assumed for replacement / improvement of the siphons or approximately 900 AF per irrigation season.

5.1.3 Drop Structures 1, 3, and 4

Replacement of the drop structures primarily represents an improvement in system reliability and reduction of the risk of a service loss during the irrigation season. A failure of one of the drop structures would result in the inability to convey water to irrigators, negating any benefits of other system improvements. A failure event was experienced in 2020 with Drop 5, and the expedited repairs were able to return the system to service for two to three weeks at the end of the season. To affect the repairs, water had to be removed from the system and wasted into drainage areas along the Canal. The inability to use the Canal resulted in critical impacts to agriculture and municipal water users. There is leakage occurring through the structures that have yet to be replaced but there is no feasible way to measure the amount of leakage. In addition, it is not possible to anticipate the timing of the next failure.

5.1.4 Slides

A number of unstable slopes exist along the length of the Canal, primarily downstream from the St. Mary River Siphons. The slopes have the potential to move and either fill the Canal with soil or destroy a section of the Canal by moving it down slope. More commonly, the movement of soil into the Canal simply restricts flow down the Canal and reduces the ability of the Canal to deliver water. In the more extreme case, the failure causes impacts similar to the loss of a drop structure, requiring expedited repairs. However, the loss of service for an extended period of time and the loss of water in the Canal when that water must be wasted to empty the Canal is a loss of water. When these unstable slopes move material into the Canal – reducing the capacity of the Canal – the impacts are similar to seepage losses by effectively reducing the amount of water that can be delivered to the North Fork of the Milk River. The amount of water loss is difficult to quantify, and the frequency of these events cannot be reliably predicted, but it is reasonable to assume that the loss of water during a given season could be as much as 1% to 2% of the flow in the Canal or approximately 9 cfs. If this is not corrected for the duration of an irrigation season the water loss would equate to approximately 11,000 AF per irrigation season.

5.1.5 O&M Road Improvements

Both daily operation of the Canal and emergency response to failures require access to the Canal regardless of weather conditions. Currently precipitation events can make the maintenance road impassible. The inability to access the Canal reduces the efficiency of water deliveries by preventing normal maintenance activities including removal of obstructions from the Canal or drop structures that could result in an overtopping event that would breach the Canal. Construction of an all-weather surface on the Canal maintenance road primarily represents an improvement in system reliability and reduction of the risk of a service loss during the irrigation season. It also improves the ability to conduct normal maintenance activities outside of the irrigation season.

5.1.6 Kennedy Creek and Halls Coulee Wasteways

In the unfortunate event of a failure along the Canal, it is critical to be able to remove the water from the Canal in an expedited fashion so as to effect repairs as soon as possible. In addition, wasteways can be used to remove excess water from the Canal in the event of a storm event that discharges water into the Canal. These two existing wasteway structures either do not operate well or do not operate at all due to the condition of the structures. Construction of new wasteway structures surface on the Canal maintenance road primarily represents an improvement in system reliability and reduction of the risk of a service loss during the irrigation season. It also improves the ability to conduct emergency maintenance activities during the irrigation season.

5.1.7 New Side Channel Spillway

There is no current protection of the Canal from a rise in water surface within the Canal resulting from either storm events or a blockage in the Canal. Either of these events could result in overtopping the Canal bank and a breach failure of the Canal embankment. Again, these improvements primarily represent an improvement in system reliability and reduction of the risk of a service loss during the irrigation season.

5.1.8 Underdrains

Underdrains were constructed as a part of the original Canal construction but have become partially blocked and do not afford the protection of the Canal that was originally desired. Reconstruction of these underdrains primarily represents an improvement in system reliability and reduction of the risk of a service loss during the irrigation season.

5.1.9 Fencing

Animal intrusion into the Canal erodes the Canal bank and increases the probability of a Canal embankment breach. In addition, stock water is not part of the authorized functions of the St. Mary Canal. Information from the Pennsylvania State Extension service indicates that a single cow can drink as much as 50 gallons per day. This translates into approximately 3 AF annually per 100 head of cattle. Based on observations along the Canal, we estimate approximately 500 head of cattle or more graze the land adjacent to the Canal and could represent as much as 15 AF annually in water savings that could be realized through the placement of fences along the length of the Canal.

Based on the above explanation the highest probability of water conservation results from reconstructing and lining the Canal from the St. Mary River Diversion to the St. Mary River Siphons and the reconstruction of the Canal from the St. Mary River Siphons to the top of Drop 1. The remainder of the proposed improvements are primarily focused on improving the reliability of water delivery. Some of the proposed improvements also result in some minor water conservation in addition to the reliability improvement. The estimated water savings for the proposed improvements is approximately 15,000 AF annually that can be assumed to be a reliable amount of conservation if all of the proposed improvements are made. This amount does not include the estimated 11,000 AF per irrigation season to account for slides due to the unpredictable frequency of these events.

5.2 Delivery System Improvements

5.2.1 Costing Methodology

The opinions of cost provided in this report do not constitute a detailed evaluation or prediction of actual construction costs.

The basis for this opinion of probable construction cost estimate is based on the purpose of the project, general design criteria, significant features and components, and estimated quantities. This estimate is considered a Class 5 estimate by the American Association of Cost Engineers (AACE). The AACE has prepared guidelines for their Cost Estimate Classification System which establishes the accuracy of cost estimating based on the maturity of a project and the detail available for review. A Class 5 estimate is the standard of care for estimating construction costs during the master planning and concept design stage of a project. By AACE definition, a Class 5 opinion of probable construction cost "Accuracy of Estimate" is -35% to +60%. Translated this means that a Class 5 estimate is between 0.65 and 1.6 times the estimate prepared.

Considering that the present analysis is the initial options evaluation phase, the challenging 2022 bidding environment, environmental requirements, remote location and market volatility, the +60% Class 5 OPCC is used primarily for option analysis.

The costs include the following items as a percentage of the estimated construction cost:

- Engineering – 10%
- Tribal Employment Rights Office (TERO) – 4%
- Environmental Compliance – 5%
- Construction Administration – 10%
- Program Management – 4%
- Blackfeet Revenue Fee – 3%

Where appropriate, unit costs were obtained from past cost experience in Montana with similar type facilities, consultation with contractors, and, in the absence of previous similar Montana estimates for similar work, unit costs were based on similar projects in the country.

5.2.2 Conveyance (Open Channel)

Costs for conveyance improvements to the Canal are identified below. Additional details on the cost estimates can be found in Appendix A.

Table 5-1. Earthen Canal Cost Estimates

Name	($)
Earthen Canal	$12,000,000
Geosynthetic Lined Canal	$35,000,000

5.2.3 Siphons

The St. Mary River Siphons, Halls Coulee Siphons and Kennedy Creek Crossing will be fully replaced with bid options for concrete cylinder pipe and steel pipe replacement for the St. Mary River Siphons and Halls Coulee Siphons. Due to unstable soils, only full pipe bury was considered. Costs for the steel pipe options are identified below. Additional details on the cost estimates can be found in Appendix A.

Table 5-2. Siphon Replacement Cost Estimates

Name	Steel ($)
St. Mary River Siphon	$55,000,000
Halls Coulee Siphon	$24,000,000
Kennedy Creek Crossing	$3,000,000

5.2.4 Drop Structures

Due to the age, existing condition, recent 2020 failure of Drop 5, and available literature reviewed for the drop structures, a replacement in-kind was selected for Drops 1, 3 and 4 with minor variations in cross section and overall layout to improve capacity, flow characteristics, and structure durability. No other drop structure replacement options were considered. Costs for the options are identified below. Additional details on the cost estimates can be found in Appendix A.

Table 5-3. Drop Structures Replacement Cost Estimates

Name	Full Replacement ($)
Drop 1	$6,000,000
Drop 3	$5,000,000
Drop 4	$7,000,000

5.2.5 Maintenance Road

Proposed O&M road improvements will establish a 12-foot-wide all-weather access with 6 inches of compacted gravel surfacing. Additional details on the cost estimates can be found in Appendix A.

Table 5-4. Maintenance Road Cost Estimate

Name	One Side ($)
Maintenance Road	$9,000,000

5.2.6 Wasteway/Turnouts

Both existing wasteways (Kennedy Creek and Halls Coulee) will be replaced in kind and the existing turnout and drain structures will be replaced with new side channel spillways. Additional details on the cost estimates can be found in Appendix A.

Table 5-5. Wasteway Replacement Cost Estimates

Description	Option 1
Replace Kennedy Creek WW	$2,000,000
Replace Halls Coulee WW	$3,000,000
New Side Channel Spillways	$13,500,000

5.2.7 Underdrains

Existing underdrains (seven piped and one box culvert) will be replaced along the Canal alignment designed to convey a 25-year event. Additional details on the cost estimates, a breakdown of the cost for different sizes of pipe, concrete seepage collars, riprap, etc., can be found in Appendix A.

Table 5-6. Underdrain Replacement Cost Estimate

Name	25-Year Event ($)
Underdrains	$5,600,000

5.2.8 Slope Stability

Relocation of the Canal to move it away from the unstable slope was not included, but the estimated quantities and costs were treated conservatively to attempt to identify an appropriate budget for the work. Cost estimates were developed for earthwork to reduce the slope of the slide area, unweight the crest of the slide, and weight the toe of the slide.

Table 5-7. Slope Stability Cost Estimates

Slide Name	Earthwork
DeWolfe Slide	$2,000,000
DeWolfe Bridge Slide	$22,000,000
Mid Section 22 Slide - North 700 Slide	$1,000,000
East Section 22 Slide	$9,000,000
Grizzly Slides	$900,000
New Slide West of Big Cut	$700,000
Big Cut Slide	$2,000,000
4th of July Slide	$2,000,000
Halls Coulee Slide Complex	$1,000,000
Gravel Road Bridge Slide	$600,000
Martin Slide	$600,000
Pipeline Slide	$3,000,000
New Slide	$700,000
Total All Slides	**$45,500,000**

5.2.9 Animal Intrusion

To address animal intrusion, costs were developed to fence along both sides of the Canal from the St. Mary River diversion to the intake of Drop 1. Additional details on the cost estimates can be found in Appendix A.

Table 5-8. Animal Intrusion Fencing Cost Estimate

Description	Cost ($)
Fencing both sides	$2,000,000

5.2.10 Total Estimated Construction Cost

Total estimated construction cost to construct the features outlined in this System Improvement Plan is identified in Table 5-9. Note that recommendations from geotechnical field investigations, land ownership, and findings from the Watershed Plan – Environmental Impact Statement (WP-EIS)may impact design considerations and subsequent cost implications.

Table 5-9. System Improvement Plan Cost Estimate

Description	Cost
Earthen Canal	$12,000,000
Geosynthetic Lined Canal	$35,000,000
St Mary Siphon - 102.6" Steel	$55,000,000
Halls Coulee Siphon - 102.6" Steel	$24,000,000
Kennedy Creek Crossing	$3,000,000
Drop 1	$6,000,000
Drop 3	$5,000,000
Drop 4	$7,000,000
Slides - Earthwork	$45,500,000
O&M Road Improvements - One Side	$9,000,000
Replace Kennedy Creek Wasteway	$2,000,000
Replace Halls Coulee Wasteway	$3,000,000
New Side Channel Spillway (9 Total)	$13,500,000
Underdrains	$5,600,000
Fencing	$2,000,000
Subtotal	$224,600,000
Blackfeet Revenue Fee (3%)	$6,700,000
Subtotal	$231,300,000
Escalation to Midpoint of Construction (9%)	$20,817,000
TOTAL	**$255,000,000**

Section 6. Summary

Based on the analysis completed for this St. Mary Canal System Improvement Plan, the Milk River Joint Board of Control and its water users would benefit from modernization through canal reshaping and lining, replacement of aging drop, siphon, wasteway and underdrain structures, maintenance road improvements, and addressing areas of slope instability along the canal. These improvements will provide increased reliability of the canal system from just below the St. Mary River diversion structure to the discharge into the Milk River nearly 29 miles downstream and conserve water loss due to seepage, slides, and aging infrastructure.

In addition to the improvements discussed in this System Improvement Plan, there may be additional opportunities to evaluate other operational features that could contribute to improved efficiencies that may come up during detailed design such as a minimal pool raise at Spider Lake or passive aquifer storage opportunities in the Milk River Drainage.

Section 7. References

Blackfeet Tribe-Montana-United States Compact. (2017). *Montana Code Annotated 2021 §85-20-15*. Retrieved from https://leg.mt.gov/bills/mca/title_0850/chapter_0200/part_0150/sections_index.html

Darlinton, S. (2014). *Travel Report: Spring Inspection of Lake Sheburne Dam and St. Mary Canal and Drop 2 Repair.* U.S. Department of the Interior Bureau of Reclamation, Montana Area Office, Billings, MT.

Farmer's Conservation Alliance. (2022). *St. Mary Canal, Water Loss Assessment.*

Federal Highway Administration and Aquaveo LLC. (2021). *HY-8 v7.70.10.*

Fort Belknap-Montana Compact. (2001). *Montana Code Annotated 2021 §85-20-10*. Retrieved from https://leg.mt.gov/bills/mca/title_0850/chapter_0200/part_0100/sections_index.html

Goos & Ethridge. (2008). *Report to the International Joint Commission on the Division of the Waters of the St. Mary and Milk Rivers.*

HDR Engineering, Inc. (2020). *Draft Cost and Fatal Flaw Analysis, Drop 2 Alternatives Analysis and 30% Design.*

HDR Engineering, Inc. (2022). *Draft Cost and Fatal Flaw Analysis, St. Mary and Hall Coulee Siphons.*

HKM Engineering. (2007). *Final Report- Saint Mary Canal System Hydropower Feasibility Study.*

International Joint Commission. (2021). Directive to the Internation St. Mary - Milk Rivers Study Board.

International St. Mary - Milk Rivers Study Board. (2021). *The St. Mary and Milk Rivers Study 2021-2025: Overview.* Retrieved from https://www.ijc.org/en/smmr/directive

Irrigation Leader. (2020, July/August). Catastrophic Failure on the Milk River Project. *Irrigation Leader, 11*(7).

Lasater, J. (2020). *Inspection of Motana Landslides in 2018, 2019, and 2020.* U.S. Department of the Interior Bureau of Reclamation, Missouri Basin Region, Geology and Exploration Services Group.

Montana Department of Natural Resources and Conservation, and Thomas, Dean & Hoskins, Inc. (2005). *St. Mary Diversion Facilities Data Review, Preliminary Cost Estimate and Proposed Rehabilitation Plan.* Conservation and Resource Development Division.

Montana Department of Natural Resources and Conservation, and Thomas, Dean & Hoskins, Inc. (2006). *St. Mary Diversion Facilities Feasibility and Preliminary Engineering Report for Facility Rehabilitation.* Conservation and Resource Development Division.

Montana Department of Natural Resources and Conservation, and Thomas, Dean & Hoskins, Inc. (2007). *St. Mary Diversion Facilities Structural Evaluation of Canal Bridge Final Report.* Conservation and Resource Development Division.

Montana Department of Natural Resources and Conservation, and Thomas, Dean & Hoskins, Inc. (2009). *St. Mary Diversion and Conveyance Facilities Failure and O&M Reference Guide.* Water Resouces Division.

Montana Department of Natural Resources and Conservation, and Thomas, Dean, & Hoskins, Inc. (2006). *ST. MARY DIVERSION FACILITIES HYDROLOGIC AND HYDRAULIC DESIGN*

CONSIDERATIONS FOR OVERALL CANAL REHABILITATION. Conservation and Resource Development Division.

Montana Department of Transportation. (2022). Hydraulics Manual: Chapter 11 - Culverts.

Stash, S., & R.G. White, D. F. (2001). *Distribuition, Relative Abundance, and Habitat Associations of Millk River Fishes Related to Irrigation Diversion Dams.* Bozeman, Montana: USGS Cooperative Fishery Research Unit, Montana State University.

Terracon. (2020). *Geotechnical Engineering Report, St. Mary Canal Drop Structure #5 Replacement, Glacier County, Montana.*

U.S. Department of the Interior. (1978). *Design of Small Canal Structures.*

U.S. Department of the Interior Bureau of Reclamation . (2018). *2018 Associated Facility Review Examination Report St. Mary Diversion Dam and Canal Milk River Project, Montana.* Great Plains Region.

U.S. Department of the Interior Bureau of Reclamation. (1999). *Milk River Project North Central Montana Feasibility Study Mary Canal Location Map, 15-600-593.*

U.S. Department of the Interior Bureau of Reclamation. (2004). *Regional Feasibility Report North Central Montana.* Montana Area Office.

U.S. Department of the Interior Bureau of Reclamation. (2012). *St. Mary River and Milk River Basins Study Technical Report.* Montana Area Office.

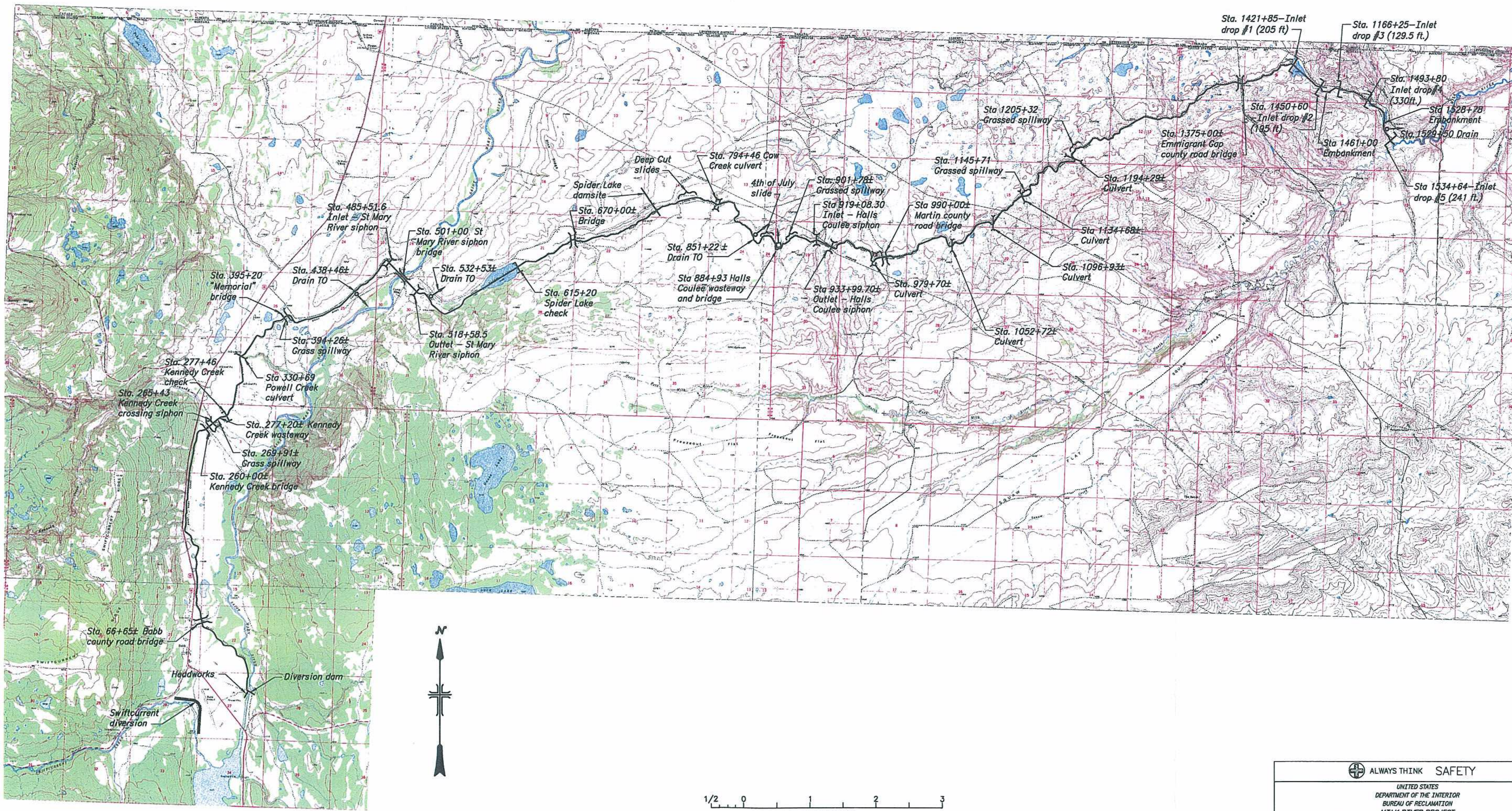
U.S. Department of the Interior Bureau of Reclamation Montana Area Office, State of Montana Department of Natural Resources and Conservation. (2012). *St. Mary River and Milk River Basins Study Summary Report.*

U.S. Geological Survey. (2016). *Methods for Estimating Peak-Flow Frequencies at Ungauged Sites in Montana Based on Data through Water Year 2011.*

U.S. Geological Survey. (2022). *StreamStats Version v4. 10.0:Montana*. Retrieved from https://streamstatsags.cr.usgs.gov/streamstats/

Appendix A. OPCC SUPPORTING INFO

15-600-593



ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MILK RIVER PROJECT
NORTH CENTRAL MONTANA FEASIBILITY STUDY

ST. MARY CANAL

LOCATION MAP

LOCATION MAP

DESIGNED G. GLIKO CHECKED
DRAWN ENGINEERING SUPPORT TECH. APPR. GEORGE A. GLIKO, P.E.
APPROVED LD ARMER, P.E.

CADD SYSTEM AutoCAD Rel. 17.0s (LMS Tech)	CADD FILENAME X078C
BILLINGS, MONTANA 11/3/1999 SHEET 1 OF 1	15-600-593

DATE AND TIME PLOTTED DECEMBER 12, 2006 09:25

St. Mary Canal System Improvement Plan 10% Opinion of Probable Construction Costs		
Description	**Cost**	
Earthen Canal Alternative	$	12,000,000
Geosynthetic Lined Canal Alternative	$	35,000,000
St Mary River Siphon Cost Estimate	$	55,000,000
Halls Coulee Siphon Cost Estimate	$	24,000,000
Kennedy Creek Crossing Cost Estimate	$	3,000,000
Drop 1 Replacement Cost Estimate	$	6,000,000
Drop 3 Replacement Cost Estimate	$	5,000,000
Drop 4 Replacement Cost Estimate	$	7,000,000
Slides - Earthwork	$	45,500,000
Maintenance Road Cost Estimate	$	9,000,000
Replace Kennedy Creek Wasteway Cost Estir	$	2,000,000
Replace Halls Coulee Wasteway Cost Estimat	$	3,000,000
New Side Channel Spillways Cost Estimate	$	13,500,000
Underdrains Replacement Cost Estimate	$	5,600,000
Animal Intrusion Fencing Cost Estimate	$	2,000,000
Subtotal	$	227,600,000
Blackfeet Revenue Fee (3%)	$	6,800,000
Subtotal	$	234,400,000
Escalation to Midpoint of Construction (9%)	$	21,096,000
TOTAL	**$**	**255,000,000**

Earthen Canal Cost Estimate				
Description	**Quantity**	**Units**	**Unit Cost**	**Subtotal**
Earthwork	171,603	CY	$ 30	$ 5,148,102
			Subtotal	**$ 5,148,102**
	Engineering		10%	$ 514,810
	Mobilization		10%	$ 514,810
	TERO		4%	$ 205,924
	Environmental Compliance		5%	$ 257,405
	Construction Management		10%	$ 514,810
	Program Management		4%	$ 205,924
			Subtotal	**$ 7,361,786**
	Class 5 Contingency		**-35%**	**$ 5,000,000**
	Class 5 Contingency		**60%**	**$ 12,000,000**

Geosynthetic Lined Canal Cost Estimate				
Description	**Quantity**	**Units**	**Unit Cost**	**Subtotal**
Earthwork	197,177	CY	$ 30	$ 5,915,298
Canal Liner	3,690,901	SF	$ 2.50	$ 9,227,253
			Subtotal	**$ 15,142,551**
	Engineering		10%	$ 1,514,255
	Mobilization		10%	$ 1,514,255
	TERO		4%	$ 605,702
	Environmental Compliance		5%	$ 757,128
	Construction Management		10%	$ 1,514,255
	Program Management		4%	$ 605,702
			Subtotal	**$ 21,653,847**
	Class 5 Contingency		**-35%**	**$ 14,000,000**
	Class 5 Contingency		**60%**	**$ 35,000,000**

St Mary River Siphon Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Demolition	1	EA	$1,500,000	$ 1,500,000
Structural Excavation	100,750	CY	$ 30	$ 3,022,500
Structural Fill	18,700	CY	$ 25	$ 467,500
Concrete (Cast-in-place)	360	CY	$ 2,000	$ 720,000
Rip Rap	70	CY	$ 150	$ 10,500
102.6" Steel Barrel	6,512	LF	$ 1,650	$ 10,744,800
Pipe Fittings	11	EA	$ 75,000	$ 825,000
Pipe Expansion Joints	4	EA	$ 125,000	$ 500,000
Bridge	1	EA	$5,500,000	$ 5,500,000
Seeding/Grading/Site Rehab	1	LS	$ 75,000	$ 75,000
			Subtotal	**$ 23,365,300**
		Mobilization	10%	$ 2,336,530
			Subtotal	**$ 25,701,830**
		Engineering	10%	$ 2,570,183
		TERO	4%	$ 1,028,073
		Environmental Compliance	5%	$ 1,285,092
		Construction Management	10%	$ 2,570,183
		Program Management	4%	$ 1,028,073
			Subtotal	**$ 34,183,434**
		Class 5 Contingency	**-35%**	**$ 22,000,000**
		Class 5 Contingency	**60%**	**$ 55,000,000**

Halls Coulee Siphon Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Demolition	1	EA	$1,500,000	$ 1,500,000
Structural Excavation	55,600	CY	$ 30	$ 1,668,000
Structural Fill	19,500	CY	$ 25	$ 487,500
Concrete (Cast-in-place)	330	CY	$ 2,000	$ 660,000
Rip Rap	70	CY	$ 150	$ 10,500
102.6" Steel Barrel	2,940	LF	$ 1,650	$ 4,851,000
Pipe Fittings	10	EA	$ 75,000	$ 750,000
Pipe Expansion Joints	4	EA	$ 125,000	$ 500,000
Seeding/Grading/Site Rehab	1	LS	$ 50,000	$ 50,000
			Subtotal	**$ 10,477,000**
		Mobilization	10%	$ 1,047,700
			Subtotal	**$ 11,524,700**
		Engineering	10%	$ 1,152,470
		TERO	4%	$ 460,988
		Environmental Compliance	5%	$ 576,235
		Construction Management	10%	$ 1,047,700
		Program Management	4%	$ 460,988
			Subtotal	**$ 15,223,081**
		Class 5 Contingency	**-35%**	**$ 10,000,000**
		Class 5 Contingency	**60%**	**$ 24,000,000**

Kennedy Creek Crossing Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Demolition	1	EA	$ 50,000	$ 50,000
Structural Excavation	2,437	CY	$ 30	$ 73,111
Structural Fill	1,496	CY	$ 25	$ 37,407
Granular Bedding Material	119	CY	$ 50	$ 5,926
Foundation Material	119	CY	$ 50	$ 5,926
10 ' x 10' Reinforced Concrete Box	200	LF	$ 4,000	$ 800,000
Headwall	10	CY	$ 2,500	$ 25,000
Grading/Site Rehab	1	LS	$ 100,000	$ 100,000
			Subtotal	**$ 1,097,370**
		Mobilization	10%	$ 109,737
			Subtotal	**$ 1,207,107**
		Engineering	10%	$ 120,711
		TERO	4%	$ 48,284
		Environmental Compliance	5%	$ 60,355
		Construction Management	10%	$ 120,711
		Program Management	4%	$ 48,284
			Subtotal	**$ 1,605,453**
		Class 5 Contingency	**-35%**	**$ 1,000,000**
		Class 5 Contingency	**60%**	**$ 3,000,000**

Drop 1 Replacement Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Demolition/Site preparation	1	EA	$1,000,000	$ 1,000,000
Structural Excavation	5,375	CY	$ 30	$ 161,250
Structural Fill	220	CY	$ 25	$ 5,500
Concrete (Cast-in-place)	520	CY	$ 2,000	$ 1,040,000
Rip Rap	1,750	CY	$ 150	$ 262,500
Seeding/Grading/Site Rehab	1	LS	$ 50,000	$ 50,000
			Subtotal	**$ 2,519,250**
		Mobilization	**10%**	**$ 251,925**
			Subtotal	**$ 2,771,175**
		Engineering	10%	$ 277,118
		TERO	4%	$ 110,847
		Environmental Compliance	5%	$ 138,559
		Construction Management	10%	$ 277,118
		Program Management	4%	$ 110,847
			Subtotal	**$ 3,685,663**
		Class 5 Contingency	**-35%**	**$ 2,000,000**
		Class 5 Contingency	**60%**	**$ 6,000,000**

Drop 3 Replacement Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Demolition/Site preparation	1	EA	$1,000,000	$ 1,000,000
Structural Excavation	3,500	CY	$ 30	$ 105,000
Structural Fill	145	CY	$ 25	$ 3,625
Concrete (Cast-in-place)	430	CY	$ 2,000	$ 860,000
Rip Rap	1,750	CY	$ 150	$ 262,500
Seeding/Grading/Site Rehab	1	LS	$ 50,000	$ 50,000
			Subtotal	**$ 2,281,125**
		Mobilization	10%	$ 228,113
			Subtotal	**$ 2,509,238**
		Engineering	10%	$ 250,924
		TERO	4%	$ 100,370
		Environmental Compliance	5%	$ 125,462
		Construction Management	10%	$ 250,924
		Program Management	4%	$ 100,370
			Subtotal	**$ 3,337,286**
		Class 5 Contingency	**-35%**	**$ 2,000,000**
		Class 5 Contingency	**60%**	**$ 5,000,000**

Drop 4 Replacement Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Demolition/Site preparation	1	EA	$1,000,000	$ 1,000,000
Structural Excavation	11,330	CY	$ 30	$ 339,900
Structural Fill	300	CY	$ 25	$ 7,500
Concrete (Cast-in-place)	660	CY	$ 2,000	$ 1,320,000
Rip Rap	1,750	CY	$ 150	$ 262,500
Seeding/Grading/Site Rehab	1	LS	$ 50,000	$ 50,000
			Subtotal	**$ 2,979,900**
		Mobilization	10%	$ 297,990
			Subtotal	**$ 3,277,890**
		Engineering	10%	$ 327,789
		TERO	4%	$ 131,116
		Environmental Compliance	5%	$ 163,895
		Construction Management	10%	$ 327,789
		Program Management	4%	$ 131,116
			Subtotal	**$ 4,359,594**
		Class 5 Contingency	**-35%**	**$ 3,000,000**
		Class 5 Contingency	**60%**	**$ 7,000,000**

Maintenance Road Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Mobilization	1	LS	$ 393,542	$ 393,542
Gravel Surfacing	38400	CY	$ 35	$ 1,344,000
O&M Road Subgrade Preparation	172761	LF	$ 15	$ 2,591,415
			Subtotal	**$ 4,328,957**
		Engineering	10%	$ 432,896
		TERO	4%	$ 173,158
		Environmental Compliance	5%	$ 216,448
		Construction Management	10%	$ 432,896
		Program Management	4%	$ 173,158
			Subtotal	**$ 5,757,512**
		Class 5 Contingency	**-35%**	**$ 4,000,000**
		Class 5 Contingency	**60%**	**$ 9,000,000**

Replace Kennedy Creek Wasteway Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Mobilization	1	LS	$ 61,625	$ 61,625
Demolition	1	LS	$ 50,000	$ 50,000
Structural Excavation	300	CY	$ 30	$ 9,000
Structural Fill	300	CY	$ 25	$ 7,500
Concrete (Cast-in-place)	150	CY	$ 2,000	$ 300,000
Rigid Foam Insulation	2000	SF	$ 5	$ 10,000
Dewatering	1	LS	$ 100,000	$ 100,000
Riprap	120	CY	$ 150	$ 18,000
Sand and Gravel Bedding	40	CY	$ 50	$ 2,000
36" Walkway with Handrails	60	LF	$ 200	$ 12,000
Slide Gate	6	EA	$ 25,000	$ 150,000
Miscellaneous Metal	1000	LBS	$ 10	$ 10,000
Gravel Surfacing	50	CY	$ 25	$ 1,250
O&M Road Subgrade Preparation	250	LF	$ 10	$ 2,500
Grading	1	AC	$ 1,500	$ 1,500
Seeding	1	AC	$ 1,500	$ 1,500
			Subtotal	**$ 736,875**
		Engineering	10%	$ 73,688
		TERO	4%	$ 29,475
		Environmental Compliance	5%	$ 36,844
		Construction Management	10%	$ 73,688
		Program Management	4%	$ 29,475
			Subtotal	**$ 980,044**
		Class 5 Contingency	**-35%**	**$ 600,000**
		Class 5 Contingency	**60%**	**$ 2,000,000**

Replace Halls Coulee Wasteway Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Mobilization	1	LS	$ 99,038	$ 99,038
Demolition	1	LS	$ 75,000	$ 75,000
Structural Excavation	1500	CY	$ 30	$ 45,000
Structural Fill	1500	CY	$ 25	$ 37,500
Concrete (Cast-in-place)	325	CY	$ 2,000	$ 650,000
Rigid Foam Insulation	1500	SF	$ 5	$ 7,500
Dewatering	1	LS	$ 100,000	$ 100,000
Riprap	150	CY	$ 150	$ 22,500
Sand and Gravel Bedding	50	CY	$ 50	$ 2,500
Crushed Rock	15	CY	$ 75	$ 1,125
20' x 7' RCB	30	LF	$ 2,500	$ 75,000
Slide Gate	4	EA	$ 20,000	$ 80,000
Miscellaneous Metal	750	LBS	$ 10	$ 7,500
Gravel Surfacing	50	CY	$ 25	$ 1,250
O&M Road Subgrade Preparation	250	LF	$ 10	$ 2,500
Grading	1	AC	$ 1,500	$ 1,500
Seeding	1	AC	$ 1,500	$ 1,500
			Subtotal	**$ 1,209,413**
	Engineering		10%	$ 120,941
	TERO		4%	$ 48,377
	Environmental Compliance		5%	$ 60,471
	Construction Management		10%	$ 120,941
	Program Management		4%	$ 48,377
			Subtotal	**$ 1,608,519**
	Class 5 Contingency		**-35%**	**$ 1,000,000**
	Class 5 Contingency		**60%**	**$ 3,000,000**

New Side Channel Spillways Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Mobilization	1	LS	$ 51,438	$ 51,438
Demolition	1	LS	$ 100,000	$ 100,000
Structural Excavation	800	CY	$ 30	$ 24,000
Structural Fill	800	CY	$ 25	$ 20,000
Concrete (Cast-in-place)	80	CY	$ 2,000	$ 160,000
Rigid Foam Insulation	450	SF	$ 5	$ 2,250
Dewatering	1	LS	$ 180,000	$ 180,000
Riprap	65	CY	$ 150	$ 9,750
Sand and Gravel Bedding	15	CY	$ 50	$ 750
Crushed Rock	5	CY	$ 75	$ 375
54" RCP with Soil Cement Bedding	250	LF	$ 425	$ 106,250
Slide Gate	1	EA	$ 17,500	$ 17,500
Miscellaneous Metal	500	LBS	$ 20	$ 10,000
Grading	1	AC	$ 5,000	$ 5,000
Seeding	1	AC	$ 2,500	$ 2,500
			Subtotal	**$ 689,813**
	Engineering		10%	$ 68,981
	TERO		4%	$ 27,593
	Environmental Compliance		5%	$ 34,491
	Construction Management		10%	$ 68,981
	Program Management		4%	$ 27,593
			Subtotal	**$ 917,451**
	Class 5 Contingency		**-35%**	**$ 600,000**
	Class 5 Contingency		**60%**	**$ 1,500,000**
	9 Side Channel Spillways		-	**$ 13,500,000**

Underdrains Replacement Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Mobilization	1	LS	$ 229,929	$ 229,929
Demolition	1	LS	$ 100,000	$ 100,000
Concrete (Cast-in-place)	123	CY	$ 2,000	$ 246,000
Earthwork	10700	CY	$ 30	$ 321,000
Dewatering	1	LS	$ 500,000	$ 500,000
Riprap	402	CY	$ 150	$ 60,300
Sand and Gravel Bedding	101	CY	$ 50	$ 5,050
Crushed Rock	76	CY	$ 75	$ 5,700
Pipe Bedding	416	CY	$ 40	$ 16,640
30" RCP	158	LF	$ 200	$ 31,600
36" RCP	600	LF	$ 250	$ 150,000
42" RCP	140	LF	$ 300	$ 42,000
78" RCP	300	LF	$ 1,500	$ 450,000
6' x 6' RCB	180	LF	$ 2,500	$ 450,000
Grading	7	AC	$ 1,500	$ 10,500
Seeding	7	AC	$ 1,500	$ 10,500
			Subtotal	**$ 2,629,219**
		Engineering	10%	$ 262,922
		TERO	4%	$ 105,169
		Environmental Compliance	5%	$ 131,461
		Construction Management	10%	$ 262,922
		Program Management	4%	$ 105,169
			Subtotal	**$ 3,496,861**
		Class 5 Contingency	**-35%**	**$ 2,300,000**
		Class 5 Contingency	**60%**	**$ 5,600,000**

Dewolfe Slide Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Mobilization	1	LS	$ 75,755	$ 75,755
Dewatering	1	LS	$ 200,000	$ 200,000
Riprap	70	CY	$ 150	$ 10,500
Fill	21882	CY	$ 25	$ 547,050
			Subtotal	**$ 833,305**
			Total Estimated Cost Including Engineering & Admin	**$ 1,108,296**
		Class 5 Contingency	**-35%**	**$ 700,000**
		Class 5 Contingency	**60%**	**$ 2,000,000**

Dewolfe Bridge Slide Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Mobilization	1	LS	$ 928,673	$ 928,673
Dewatering	1	LS	$ 200,000	$ 200,000
Riprap	70	CY	$ 150	$ 10,500
Fill	363049	CY	$ 25	$ 9,076,225
			Subtotal	**$ 10,215,398**
			Total Estimated Cost Including Engineering & Admin	**$ 13,586,479**
		Class 5 Contingency	**-35%**	**$ 9,000,000**
		Class 5 Contingency	**60%**	**$ 22,000,000**

Mid Section 22 - North 700 Slide Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Mobilization	1	LS	$ 48,422	$ 48,422
Dewatering	1	LS	$ 200,000	$ 200,000
Riprap	70	CY	$ 150	$ 10,500
Cut	18248	CY	$ 15	$ 273,720
			Subtotal	**$ 532,642**
			Total Estimated Cost Including Engineering & Admin	**$ 708,414**
		Class 5 Contingency	**-35%**	**$ 500,000**
		Class 5 Contingency	**60%**	**$ 1,000,000**

East Section 22 Slide Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Mobilization	1	LS	$ 404,063	$ 404,063
Dewatering	1	LS	$ 200,000	$ 200,000
Riprap	70	CY	$ 150	$ 10,500
Fill	153205	CY	$ 25	$ 3,830,125
			Subtotal	**$ 4,444,688**
Total Estimated Cost Including Engineering & Admin				**$ 5,911,434**
Class 5 Contingency			**-35%**	**$ 4,000,000**
Class 5 Contingency			**60%**	**$ 9,000,000**

Grizzly Slides Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Mobilization	1	LS	$ 36,607	$ 36,607
Dewatering	1	LS	$ 200,000	$ 200,000
Riprap	70	CY	$ 150	$ 10,500
Cut	10371	CY	$ 15	$ 155,565
			Subtotal	**$ 402,672**
Total Estimated Cost Including Engineering & Admin				**$ 535,553**
Class 5 Contingency			**-35%**	**$ 300,000**
Class 5 Contingency			**60%**	**$ 900,000**

New Slide West of Big Cut Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Mobilization	1	LS	$ 28,441	$ 28,441
Dewatering	1	LS	$ 200,000	$ 200,000
Riprap	70	CY	$ 150	$ 10,500
Cut	4927	CY	$ 15	$ 73,905
			Subtotal	**$ 312,846**
Total Estimated Cost Including Engineering & Admin				**$ 416,085**
Class 5 Contingency			**-35%**	**$ 300,000**
Class 5 Contingency			**60%**	**$ 700,000**

Big Cut Slide Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Mobilization	1	LS	$ 101,414	$ 101,414
Dewatering	1	LS	$ 200,000	$ 200,000
Riprap	70	CY	$ 150	$ 10,500
Cut	53576	CY	$ 15	$ 803,640
			Subtotal	**$ 1,115,554**
		Total Estimated Cost Including Engineering & Admin		**$ 1,483,687**
		Class 5 Contingency	**-35%**	**$ 1,000,000**
		Class 5 Contingency	**60%**	**$ 2,000,000**

4th of July Slide Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Mobilization	1	LS	$ 81,218	$ 81,218
Dewatering	1	LS	$ 200,000	$ 200,000
Riprap	70	CY	$ 150	$ 10,500
Cut	40112	CY	$ 15	$ 601,680
			Subtotal	**$ 893,398**
		Total Estimated Cost Including Engineering & Admin		**$ 1,188,219**
		Class 5 Contingency	**-35%**	**$ 800,000**
		Class 5 Contingency	**60%**	**$ 2,000,000**

Halls Coulee Slide Complex Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Mobilization	1	LS	$ 37,409	$ 37,409
Dewatering	1	LS	$ 200,000	$ 200,000
Riprap	70	CY	$ 150	$ 10,500
Rock Fill	2595	CY	$ 50	$ 129,750
Cut	2256	CY	$ 15	$ 33,840
			Subtotal	**$ 411,499**
		Total Estimated Cost Including Engineering & Admin		**$ 547,294**
		Class 5 Contingency	**-35%**	**$ 400,000**
		Class 5 Contingency	**60%**	**$ 1,000,000**

Gravel Road Bridge Slide Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Mobilization	1	LS	$ 27,660	$ 27,660
Dewatering	1	LS	$ 200,000	$ 200,000
Riprap	70	CY	$ 150	$ 10,500
Cut	4406.6	CY	$ 15	$ 66,099
			Subtotal	**$ 304,259**
			Total Estimated Cost Including Engineering & Admin	**$ 404,664**
	Class 5 Contingency		**-35%**	**$ 300,000**
	Class 5 Contingency		**60%**	**$ 600,000**

Martin Slide Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Mobilization	1	LS	$ 26,497	$ 26,497
Dewatering	1	LS	$ 200,000	$ 200,000
Riprap	70	CY	$ 150	$ 10,500
Cut	3631	CY	$ 15	$ 54,465
			Subtotal	**$ 291,462**
			Total Estimated Cost Including Engineering & Admin	**$ 387,644**
	Class 5 Contingency		**-35%**	**$ 300,000**
	Class 5 Contingency		**60%**	**$ 600,000**

Pipeline Slide Cost Estimate

Description	Quantity	Units	Unit Cost	Subtotal
Mobilization	1	LS	$ 139,498	$ 139,498
Dewatering	1	LS	$ 200,000	$ 200,000
Riprap	70	CY	$ 150	$ 10,500
Fill	47379	CY	$ 25	$ 1,184,475
			Subtotal	**$ 1,534,473**
			Total Estimated Cost Including Engineering & Admin	**$ 2,040,848**
	Class 5 Contingency		**-35%**	**$ 1,300,000**
	Class 5 Contingency		**60%**	**$ 3,000,000**

Appendix B. MODERNIZATION OPTION EVALUATION MEETING NOTES

MEETING NOTES

St. Mary Canal System – Evaluation of Modernization Options

DATE, August 25, 2022 (9:00-11:00 MDT/8:00-10:00 PDT)
Webex
https://meethdr.webex.com/meethdr/j.php?MTID=m54ef838a4c7f782501b998a05375065f

INVITEES

FCA
☒ Mattie Bossler
☒ Amanda Schroeder
☒ Andrea Silverman

HDR
☒ Stan Schweissing
☒ Ben Fennelly
☒ Ken Demmons
☐ Leif Sande

NRCS
☐ Robert Molaceck
☐ Corey Wolfe

BOR
☒ Steve Darlington
☐ Chris Gomer

MRJBOC
☒ Jennifer Patrick

AGENDA:

I. Introductions

II. Project and Meeting Objectives

a. Review the alternatives considered to modernize the St. Mary Canal

b. Evaluation of costs and benefits of alternatives for the canal system

c. Obtain consensus of selected alternatives for the canal system

III. Diversion Structure

a. Not evaluated in this evaluation of modernization options

i. 60% design completed by Reclamation.

ii. Permitting is a challenge

iii. Schedule remains to begin construction in Spring 2024

IV. Model Results

a. HEC-RAS

i. HDR modeled from a simplified approach the entire system, from the upstream end of the diversion through the North Fork of the Milk River.

ii. HDR use a 1-D model and considered multiple discharges: the full design capacity of 850 cfs and 650 and 670 cfs. It was a constant flow rate. The model was backed up by the survey and lidar data. Structural information taken from as-builts provided by USBR.

iii. For open channel, they looked at improved earthen canal, improved earthen with geosynthetic (HDPE), and concrete. They broke the canal up into four different sections.

iv. The "Improved Earthened" modernization option sought to limit cut/fill and keep velocities over 2 fps for sediment transport

v. BOR noted that 670 cfs is diverted but at the gage near the St. Mary Siphon measured flows are 590 cfs – 610 cfs due to the seepage and other losses occurring upstream of the St. Mary Siphon. The SIP should be updated to describe this.

vi. The existing canal has little to no remaining freeboard in some sections even at these lower than 670 cfs flows

vii. The Kennedy Siphon appears to result in backwatering and most of the canal experiences backwater conditions. Due to the backwater conditions, the different liner options don't really translate to different hydraulic conditions

b. EPANET

i. The canal slope is flat which is challenging when looking at gravity piping options

ii. Three 10-foot steel barrels are needed to convey 850 cfs

iii. Piping will need to be buried 5' – 6' to convey flows

iv. Order of magnitude – Approximately 300 10-foot fittings (e.g., bends) would be needed to remain within the 150' from centerline canal property and at $50k to $75k per fitting this would substantially increase costs, translating to over $1B in capital costs. Land ownership, particularly Tribal Trust land is complex.

v. Steel was chosen over profile wall HDPE due to confidence of placement and handling of steel pipe vs. profile wall HDPE, as well as previous issues with profile wall HDPE joints performing under pressure.

V. Modernization Options Considered

a. Canal Improvements

i. Earthen versus Lining (Concrete, Geosynthetics or combination)

1. General agreement that concrete lining would be ideal, however, costs, freeze/thaw environment and higher O&M costs for maintenance of a concrete lined channel make this a difficult modernization option to proceed with.

    a. Jennifer noted in particular that irrigator assessments cover 74% of the annual O&M budget and the $100k+ repairs that would be needed every 5 to 10 years would be untenable to them.

2. If the canal is lined, accommodations need to be accounted for both environmental (e.g., wetland) and cultural resources (e.g., sweat lodges) on Tribal land

    a. These issues will be discussed with the Blackfeet during the EIS process

3. Some geosynthetic liners withstand animal traffic better than others. Animal intrusion should be handled with any option considered. Likely with fencing or even stockwater ponds at strategic locations along the canal length.

4. Another option is to place a geosynthetic liner and pour 4-inches of concrete over it. This is a concern for MRJBC and irrigators cost share because it is difficult to budget for the larger repair/cost expenditures when the concrete fails and repairs to the lining system are necessary.

5. The concrete lining option cost outweighs the benefit. Unlikely to get $456M for concrete lining.

6. Reclamation looked at lining the canal with geosynthetic from the St Mary River diversion to St. Mary Siphon - $30M estimated cost, which approximates the reported cost in the evaluation of modernization options. This is the area of highest leakage from the canal. Further downstream soils are more clay with less leakage.

7. Could consider phasing:

    a. Phase I – Line from diversion to St. Mary Siphon.

        i. Lining the canal would allow for a reduced canal size given the improved hydraulics associated with the smooth surface and helps reduce the footprint of the canal.

    b. Phase II – Earthened repairs and additional liner from outlet of Spider Lake to Big Cut Slide area. Will also need some improvements to the Spider Lake outlet structure.

8. Consensus - Reclamation and MRJBC agreed to HDR evaluating a hybrid, phased approach using an improved earthened section and lining and report back to the group for discussion and consensus to the canal lining approach going forward.

b. Canal Piping

i. Precast box culverts, steel, concrete, FRP & HDPE were considered

ii. Configuration – entire canal, high seepage areas, area with adjacent slope stability issues

iii. Reviewed the EPANET model approach. The piping option will require three 10-barrels.

    1. In previous discussions with BOR, it was noted that acquiring neighboring land or easements to “straight line” the pipe would be extremely difficult. Hence, it was assumed that the piping would be along the canal centerline.

iv. Estimated construction costs are over $1B making this option financially unrealistic.

c. Siphons

i. St Mary River Siphons

    1. Existing conditions

    2. Modernization Options and recommended improvements

        a. The bury option addresses thermal expansion and soil stability issues. Buried pipe also removes it from potential interference with flow in the St Mary River floodplain.

b. A new bridge to carry the siphon barrels over the St. Mary River will be required. Likely a prefabricated, single-span bridge with abutments outside the river.

c. HDPE pipe (solid wall 10' diameter) was considered, but it is only made on the east coast of the United States and shipping will cost $25,000 per 40' stick of pipe to get it to the project site – making it cost prohibitive.

d. Some discussion about material type – CCP or steel. Costs are similar. Steel will likely be shipped from the west Coast – California or Oregon. Concrete will likely be shipped from Texas. Will likely bid both.

e. Consensus - HDR recommended to proceed with buried design and include bid alternatives for both CCP and steel pipe and Reclamation and MRJBC agreed

ii. Hall Coulee Siphons

1. Existing conditions

2. Modernization Options and recommended improvements

a. Consensus - Similar to the St. Mary Siphons – HDR recommended to proceed with buried design and include bid alternatives for both CCP and steel pipe and Reclamation and MRJBC agreed

d. Slope Stability

i. Areas of known issues

ii. Improvement alternatives and recommended improvements

1. Geotechnical data is lacking. Once available, it will likely impact some decisions.

a. Estimated geotechnical effort for the slide areas is $200,000- $300,000.

2. Two primary options: 1) weight the toe of the slide and unweight the crest to help reduce slide potential or 2) convey flows through slide areas with piping or a box culvert.

3. Dewatering the slide area is also another common approach to unstable slide areas, but without geotechnical data and given our experience in the area with ground water flows – it is extremely

difficult to believe that we can reasonably predict what this would take or even if it would be effective.

4. Another concern is land ownership and land required to make improvements may infringe on private property. May need to have discussions with landowners and get temporary easements to address slide issues.

5. Consensus – Reclamation and MRJBC agreed that HDR will proceed with earthwork option to address existing slides. Should geotechnical investigations yield different results then adjust once that data is available.

    a. HDR will also elaborate on the geotechnical investigations needed in the SIP.

e. Wasteways/Turnouts

i. Full replacement

ii. Improved replacement

iii. Improved replacement plus additional structures

iv. Discussed the three options. Option 2 stood out due to no loss of canal embankment, a passive O&M requirement and no need for gate adjustments during a rain event.

v. Consensus – Reclamation and MRJBC agreed that HDR will proceed with Option 2 recommendations.

f. Underdrains/Culverts

i. HDR considered two options for improvements: 1) replace similar to the existing structure or 2) upgrade so the underdrains can convey the 25-year event.

ii. Consensus – Reclamation and MRJBC agreed that HDR will proceed with Option 2 recommendations.

iii. Stan wanted to confirm a 25-year flood event would be adequate for sizing the underdrain. Steve was comfortable with the 25-year event.

The below items were discussed on August 29, 2022 (12:00 MDT/11:00 PDT) via a virtual meeting.

g. Bridge Crossings

i. Summary of findings and related recommendations

1. Bridges were evaluated to look at hydraulic capacity (i.e., not restricting flow). Also, no scouring is evident. Bridge condition assessments were not part of the analysis.

2. Reclamation affirmed that no bridges are known to restrict canal flows.

3. There are currently three public bridges and four private bridges over the canal.

4. Consensus - Reclamation and MRJBC agreed with replacing Kennedy Creek bridge and Reclamation agreed although was surprised that it impeded the flow.

5. Some discussion followed regarding how to line the canal under/near the bridges. This is something that will be addressed in detail during design. May use batton strips to secure the liner to the abutments.

h. Maintenance Road

i. Existing condition

1. The existing road is unimproved and sometimes becomes impassable during rain & snow events.

ii. Need for improvements

iii. Recommended improvements

1. All weather access road recommended. May need some measures in places to stabilize the subgrade.

2. Some discussion with Reclamation to consider access along both sides of the canal. Reclamation said this is not necessary. Access on the other side of the drop structures would be nice. After discussion considering cost, ownership and relatively infrequent need to access the other side of the drop structures, it was decided that improvements to the existing access road are sufficient.

3. Consensus - Reclamation agreed and MRJBC agreed with HDR proceeding with the option to improve the existing access road and do nothing on the non-access road side of the canal.

fca HDR

i. Hydropower

i. Summary of findings, hydropower potential and transmission

1. HDR reviewed the hydropower assessments completed by HKM and TDH and does not see a viable pathway for these projects based on the limited revenue compared to the high transmission costs and facility costs that contribute to the overall capital costs.

2. FCA provided comments on the hydropower assessment in the Modernization Option Evaluation. HDR needs to address the comments in response to FCA comments.

3. Ken will check with Lyle to gage Tribal interest in hydropower.

4. Steve mentioned that in 2018 a hydropower value planning study was conducted by Reclamation and had similar conclusions to HKM and TDH . He will try to find this document and share with the group. Since the Blackfeet were involved with this study and came to similar conclusions, its likely they would agree with HDR.

5. HDR will address FCA comments, review the hydropower value planning study and update the modernization options analysis with this information.

ii. Recommendations

1. Pending the outcome of Ken checking with Lyle, hydropower will not be investigated any further.

j. Animal Intrusion

i. Modernization Options and recommendations

1. Animal intrusion is an issue now with sections of the canal bank that have been damaged primarily by livestock.

2. Presently there are no known stock ponds along the canal.

3. There are potential water rights implications if stock ponds are installed.

4. Also, if stock ponds is further considered then ponds may need to be installed for all adjacent landowners. An all or nothing solution.

5. Stan discussed using angular rock as a barrier along the canal banks. Costs for this potential option are unknown at this time. This would inhibit cows but not elk.

6. Lief proposed installing access points for the cows. Steve said he's seen that with other Reclamation projects to help wildlife get out of concrete lined canals.

7. Fencing is also an option. Costs and long-term O&M of the fence are unknown.

8. Consensus - Animal intrusion will be expanded on in the SIP to include costs for the options listed above but no option would be selected at this time.

k. **Drop Structures**

i. Existing conditions, options and recommendations (Drops 1, 3 and 4)

1. Drops 1, 3 & 4 will be replaced in a similar fashion to Drops 2 & 5.

2. Consensus – Reclamation agreed with replacing Drops 1, 3 and 4 in-kind.

l. **Monitoring, Instrumentation and Control Options**

i. Need

1. Not really a need from Reclamation's perspective for remote monitoring and control of canal systems.

2. Reclamation would prefer passive wasteways to SCADA.

3. Currently if there are canal issues requiring wasting water, Reclamation uses the Kennedy Creek wasteway and this is not an issue.

ii. Integration into Reclamation system

VI. Additional Factors/Considerations

a. Tribal

b. Land/ownership

c. Environmental

d. Remote location

e. Construction season

VII. Next Steps

a. Begin work on System Improvement Plan

b. 10% design

   i. For now, HDR will prepare 11” x 17” plan sheets to be included in an appendix and prepare figures for the body of the SIP.

c. Cost estimating

VIII. Schedule

a. Review remaining schedule

Action Items:

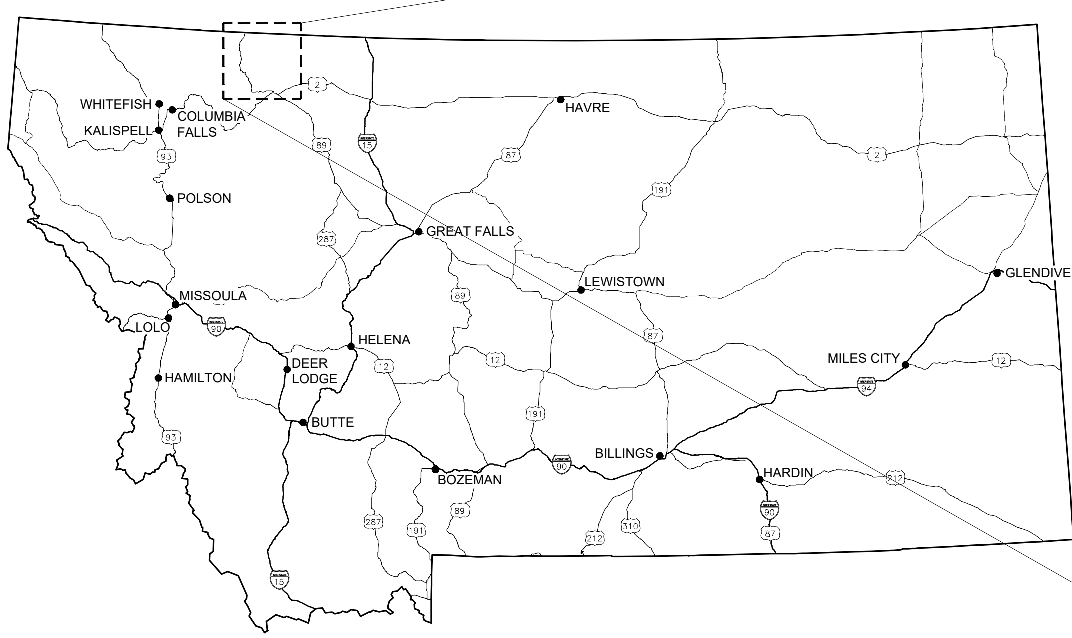
Item	Description	Responsible
1	HDR will evaluate a hybrid, phased approach using an improved earthened section and lining and report back to the group for discussion and consensus to the canal lining approach going forward.	**HDR**
2	Tribal interest in hydropower	**HDR/Ken**
3	Hydropower value planning study	**Steve D**
4		
5		
6		
7		
8		
9		
10		

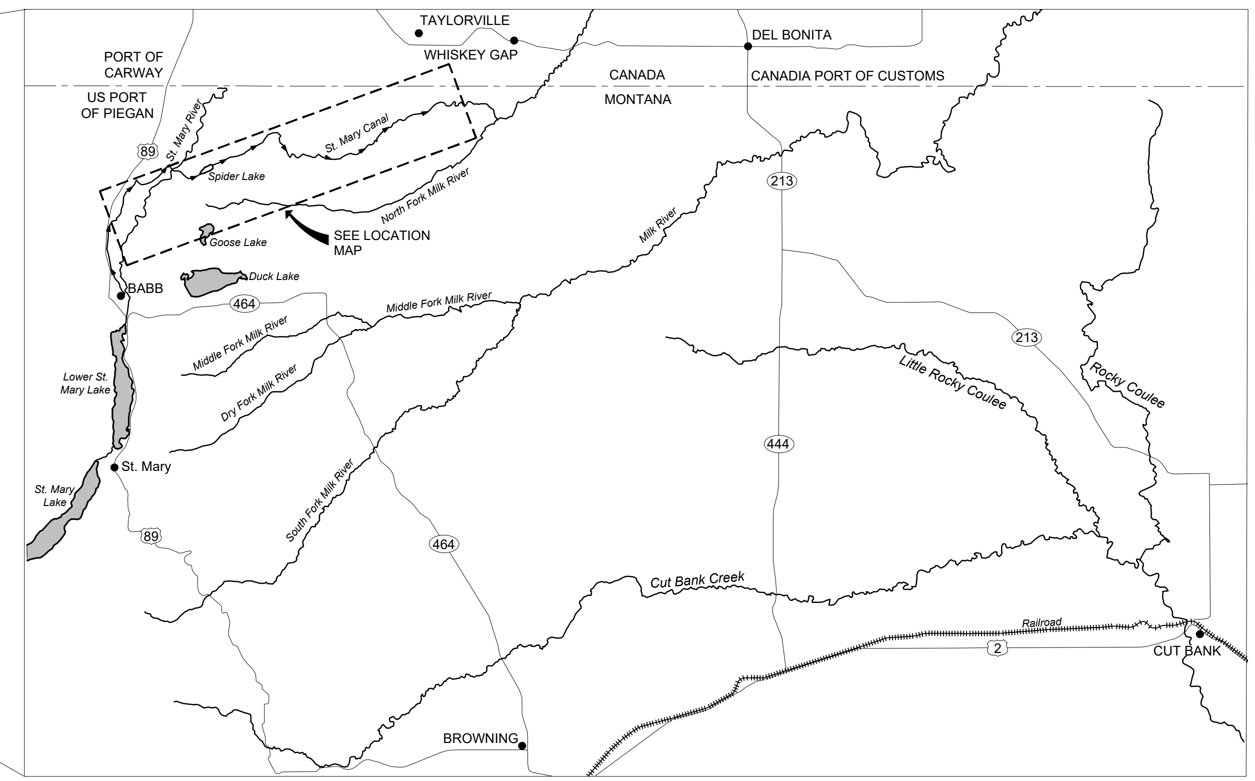
Appendix C. 10% PLAN SHEETS

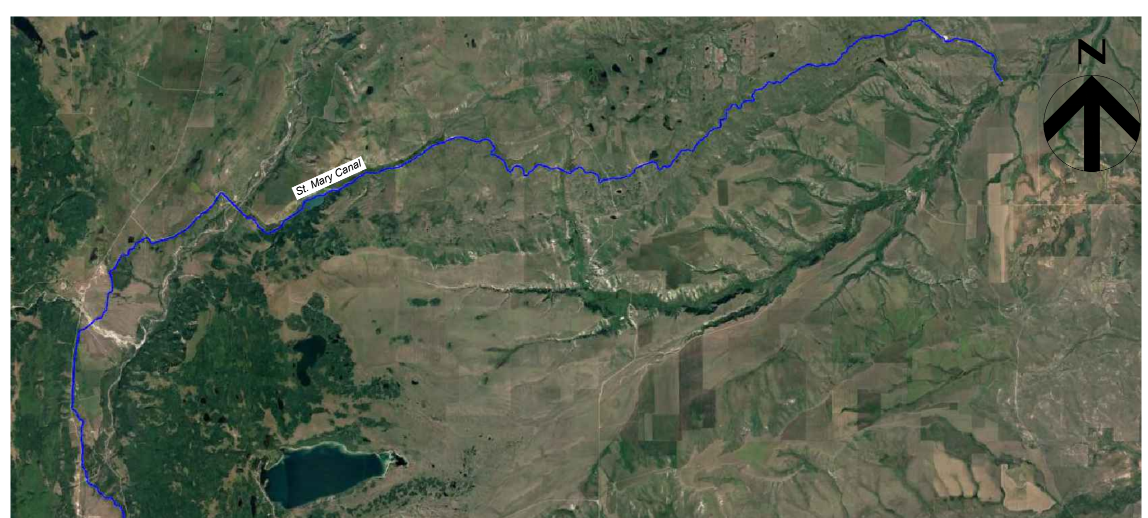
FARMERS CONSERVATION ALLIANCE

Contract Drawings For

ST MARY CANAL SIP
10% DESIGN







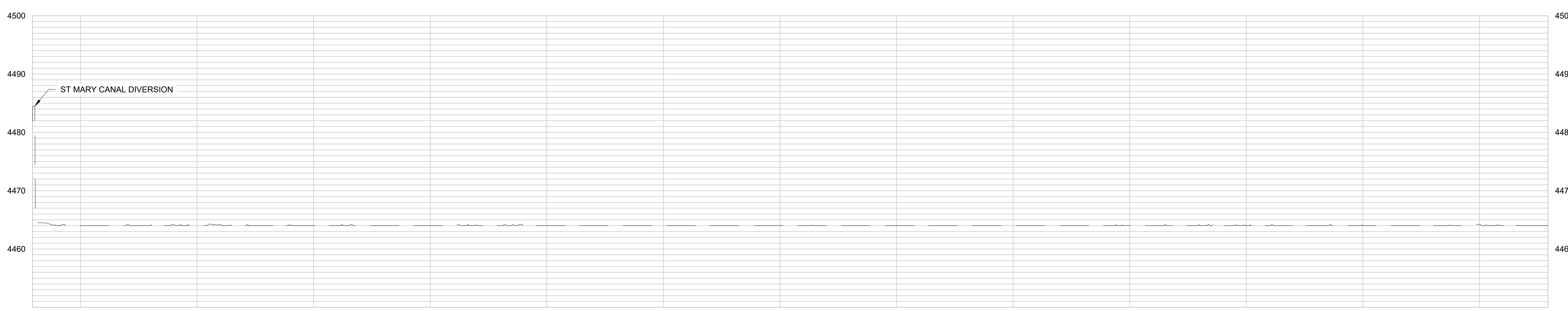
LOCATION MAP

GLACIER COUNTY, MONTANA
NOVEMBER 2022

INDEX OF DRAWINGS

PLAN VIEW

SCALE: 1" = 250'
CONTOUR INTERVAL = 0.5 FT



PROFILE VIEW

HORIZ SCALE: 1" = 250'
VERT SCALE: 1" = 20'

ISSUE	DATE	DESCRIPTION
1	OCT 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

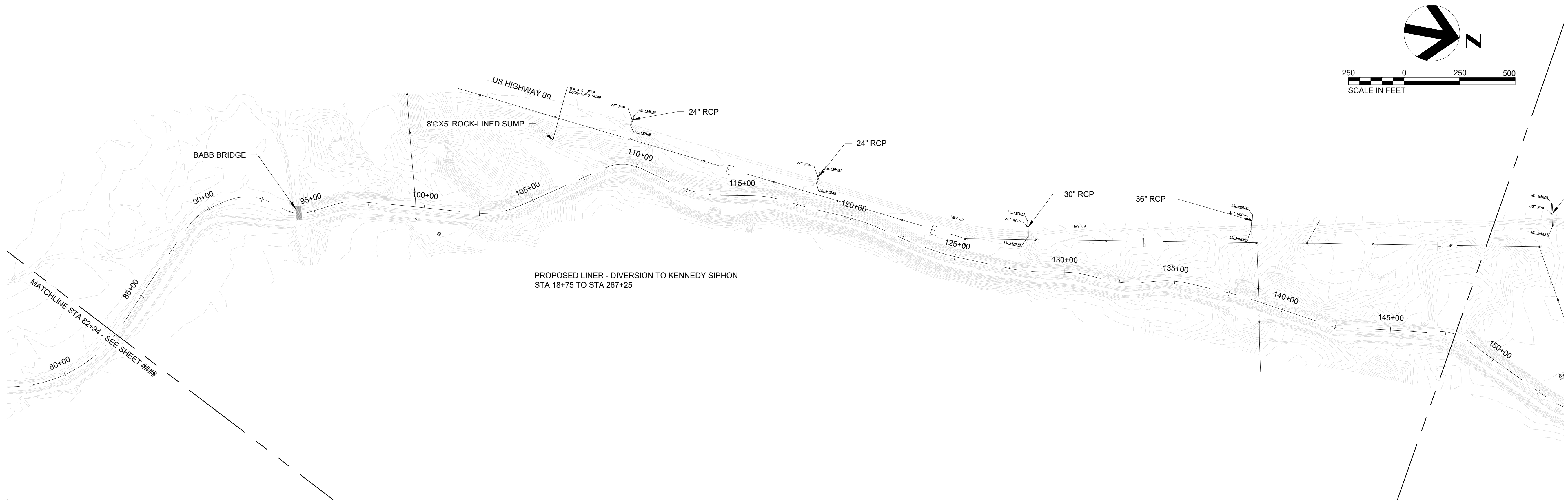
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
PLAN AND PROFILE
STA 17+94 TO STA 82+94

0 1" 2"

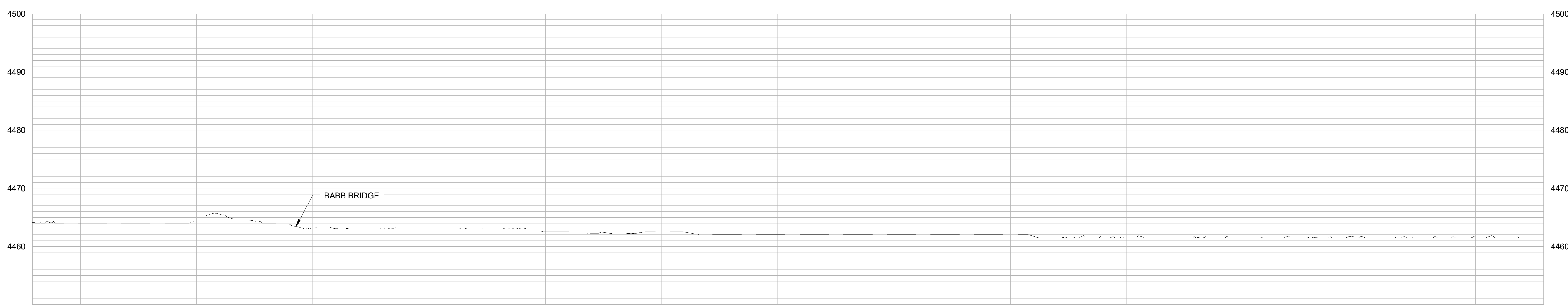
FILENAME 03C-003.DWG
SCALE AS NOTED

SHEET **03C-003**



PLAN VIEW

SCALE: 1" = 250'
CONTOUR INTERVAL = 0.5 FT



PROFILE VIEW

HORIZ SCALE: 1" = 250'
VERT SCALE: 1" = 20'

ISSUE	DATE	DESCRIPTION
1	OCT 2022	10% DESIGN

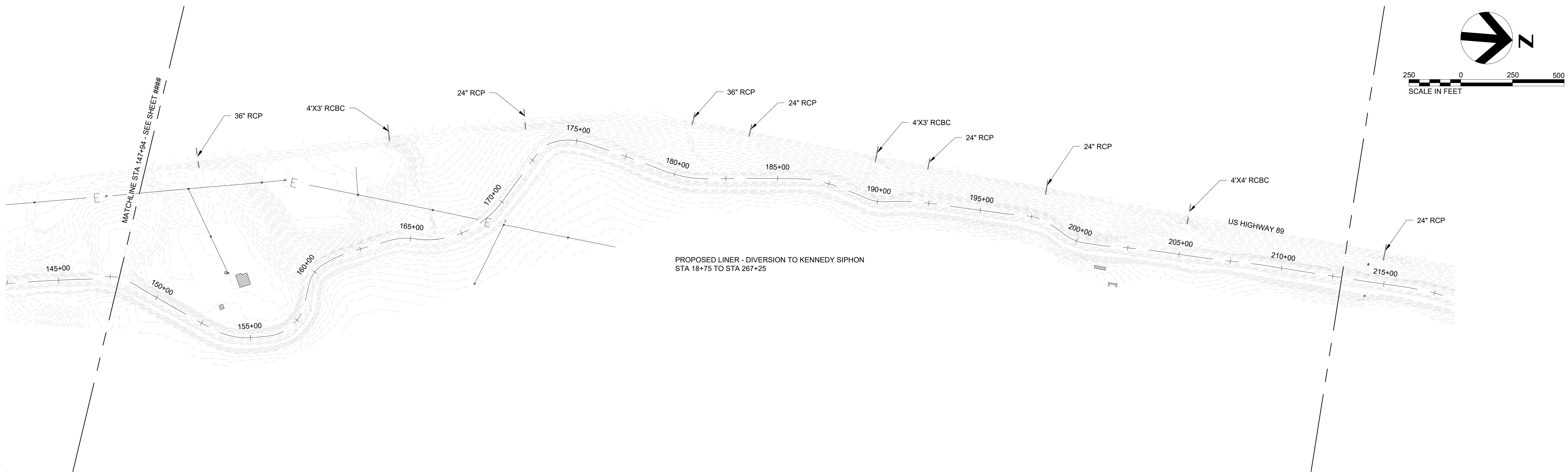
PROJECT MANAGER S. SCHWEISSING
DESIGNER 1
DRAWN BY
CHECKED BY
PROJECT NUMBER 10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
PLAN AND PROFILE
STA 82+84 TO 147+94

FILENAME 03C-004.DWG
SCALE AS NOTED
SHEET 03C-004



PLAN VIEW

SCALE: 1" = 250'
CONTOUR INTERVAL = 0.5 FT

PROFILE VIEW

HORIZ SCALE: 1" = 250'
VERT SCALE: 1" = 20'

ISSUE	DATE	DESCRIPTION
1	OCT 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

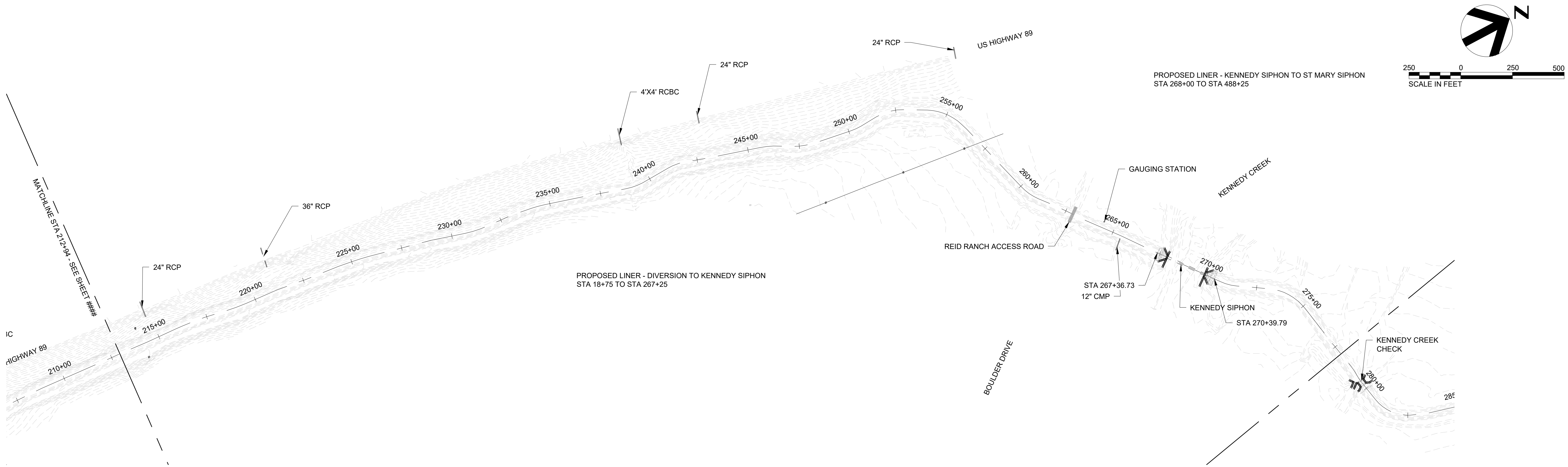
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
PLAN AND PROFILE
STA 147+94 TO 212+94

0 1" 2"

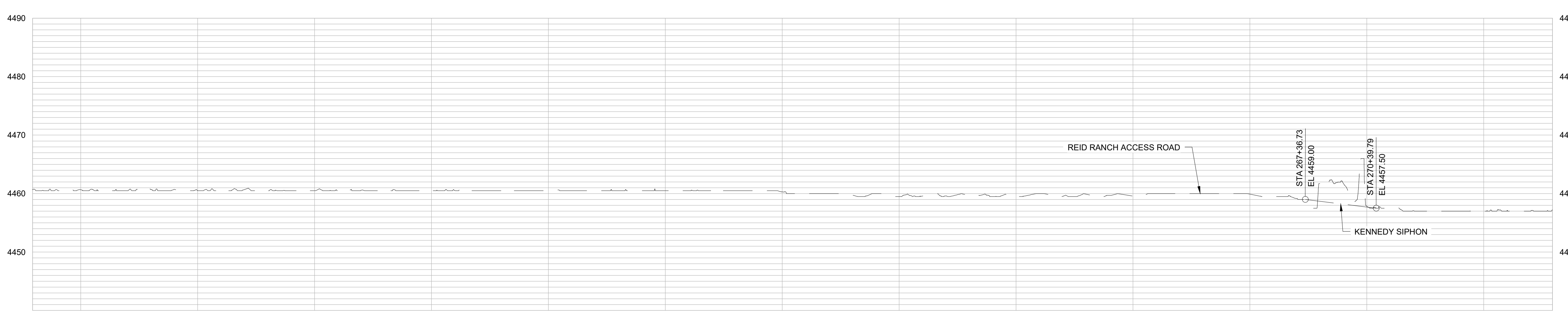
FILENAME 03C-005.DWG
SCALE AS NOTED

SHEET
03C-005



PLAN VIEW

SCALE: 1" = 250'
CONTOUR INTERVAL = 0.5 FT



PROFILE VIEW

HORIZ SCALE: 1" = 250'
VERT SCALE: 1" = 20'

HDR

ISSUE	DATE	DESCRIPTION
1	OCT 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

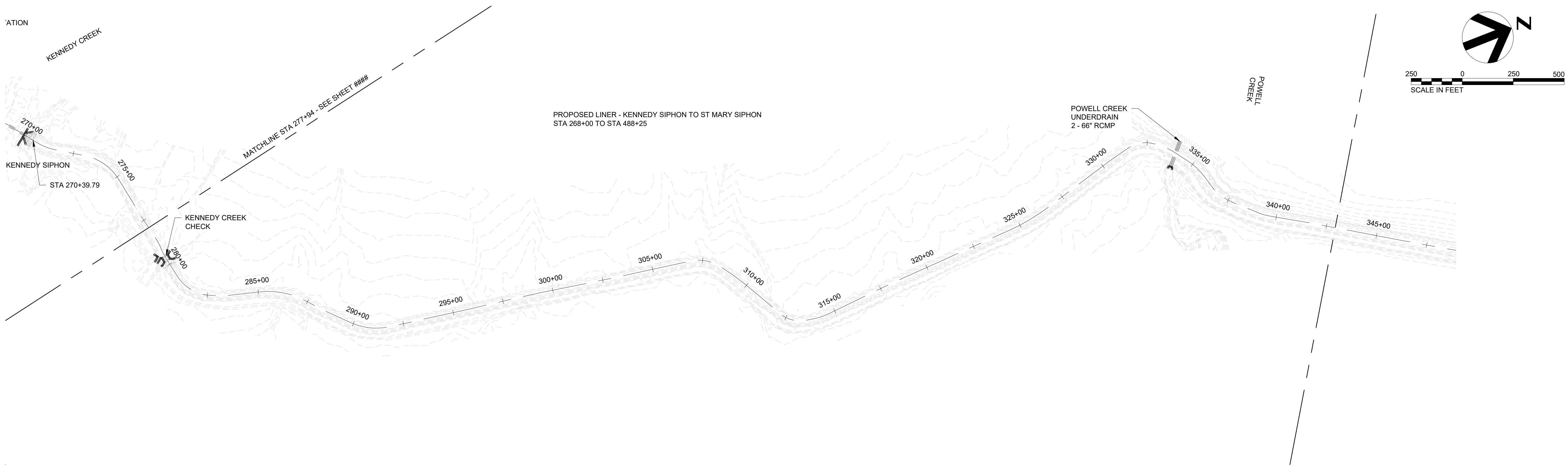
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
PLAN AND PROFILE
STA 212+94 TO 277+94

0 1" 2"

FILENAME 03C-006.DWG
SCALE AS NOTED

SHEET **03C-006**



PLAN VIEW

SCALE: 1" = 250'
CONTOUR INTERVAL = 0.5 FT

PROFILE VIEW

HORIZ SCALE: 1" = 250'
VERT SCALE: 1" = 20'

HDR

ISSUE	DATE	DESCRIPTION
1	OCT 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

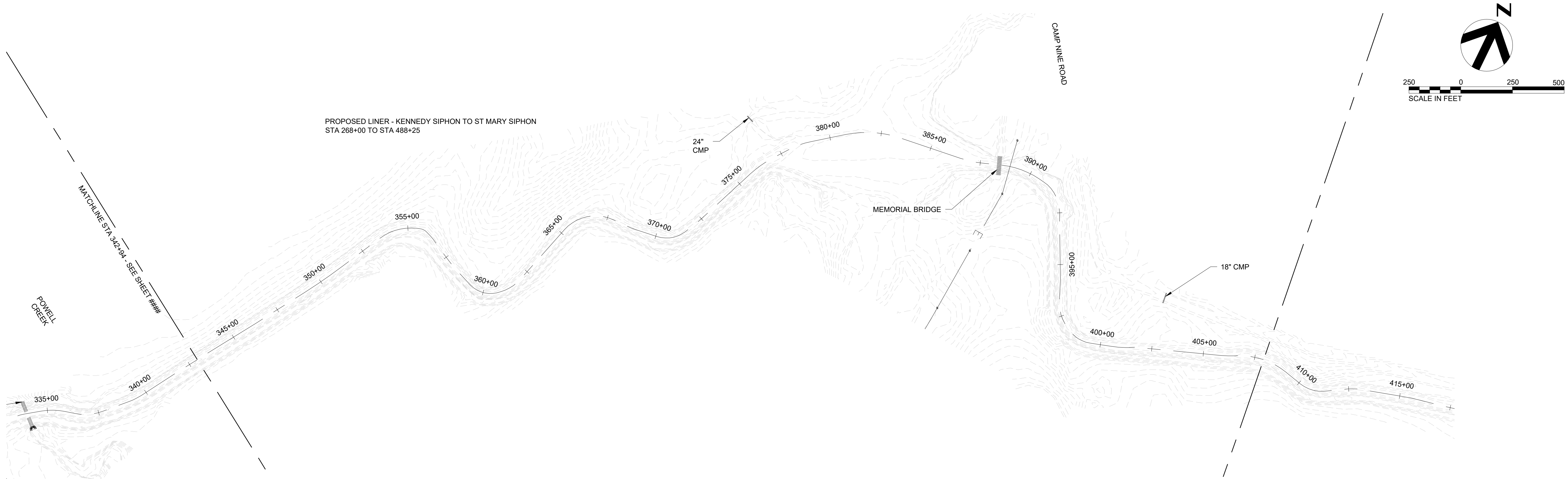
PRELIMINARY
NOT FOR
CONSTRUCTION
OR
RECORDING

FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
PLAN AND PROFILE
STA 277-94 TO STA 342+94

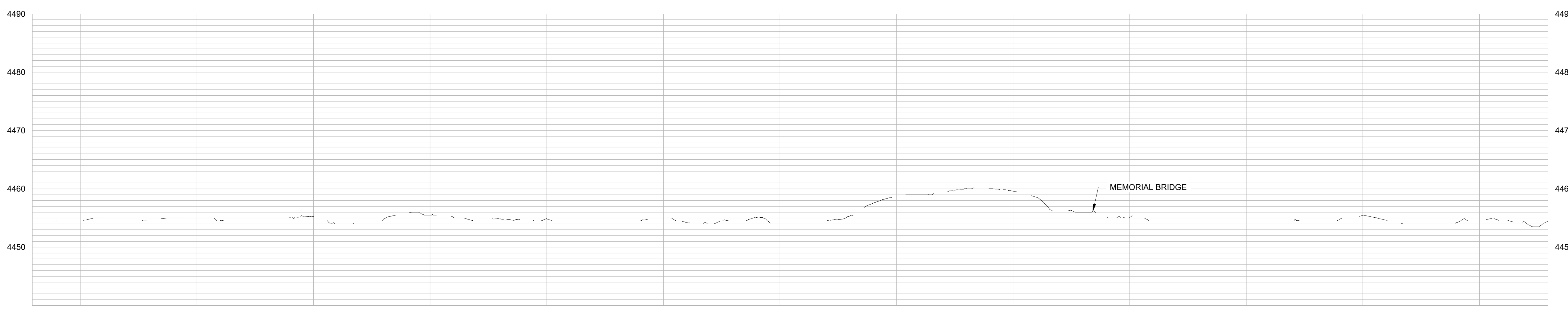
0 1" 2"

FILENAME 03C-007.DWG
SCALE AS NOTED
SHEET 03C-007



PLAN VIEW

SCALE: 1" = 250'
CONTOUR INTERVAL = 0.5 FT



PROFILE VIEW

HORIZ SCALE: 1" = 250'
VERT SCALE: 1" = 20'

HDR

ISSUE	DATE	DESCRIPTION
1	OCT 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

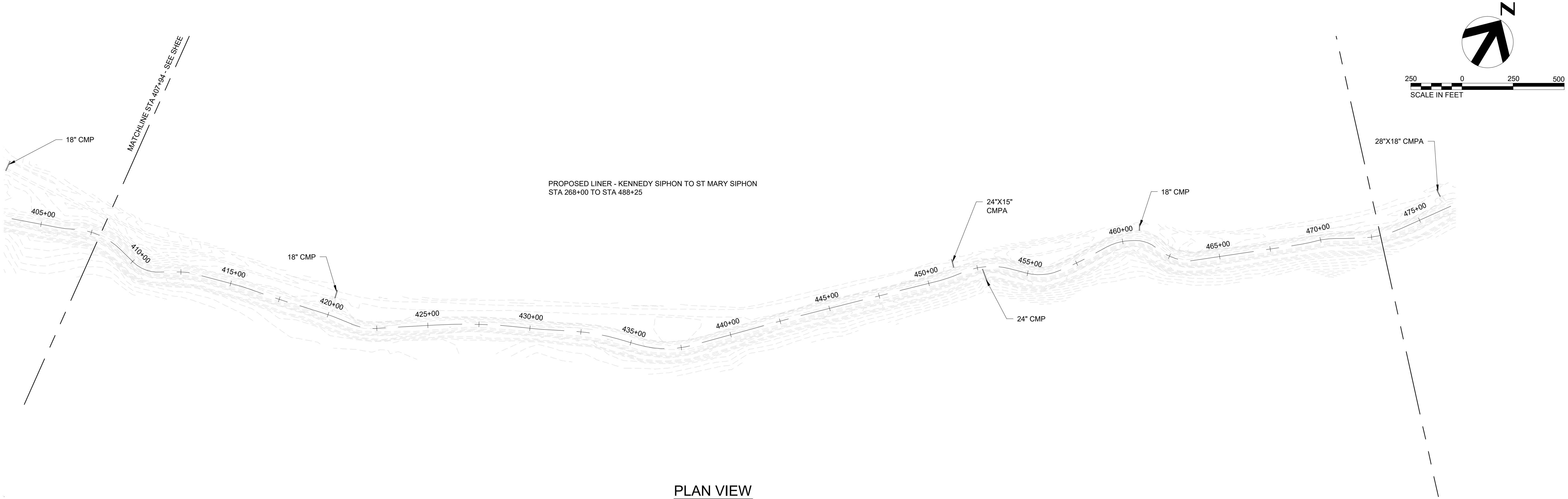
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
PLAN AND PROFILE
STA 342+94 TO STA 407+94

0 1" 2"

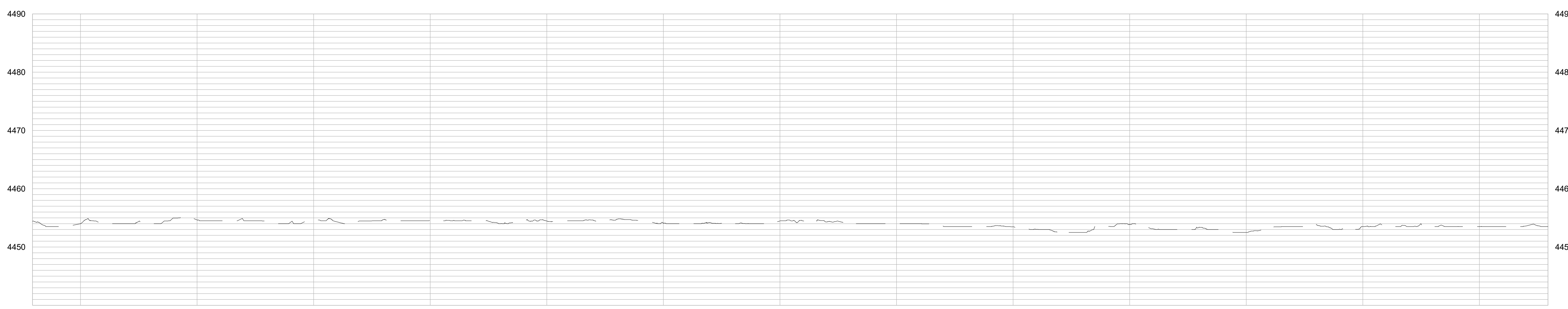
FILENAME 03C-008.DWG
SCALE AS NOTED

SHEET
03C-008



PLAN VIEW

SCALE: 1" = 250'
CONTOUR INTERVAL = 0.5 FT



PROFILE VIEW

HORIZ SCALE: 1" = 250'
VERT SCALE: 1" = 20'

HDR

ISSUE	DATE	DESCRIPTION
1	OCT 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

FARMERS CONSERVATION ALLIANCE ST MARY CANAL SIP

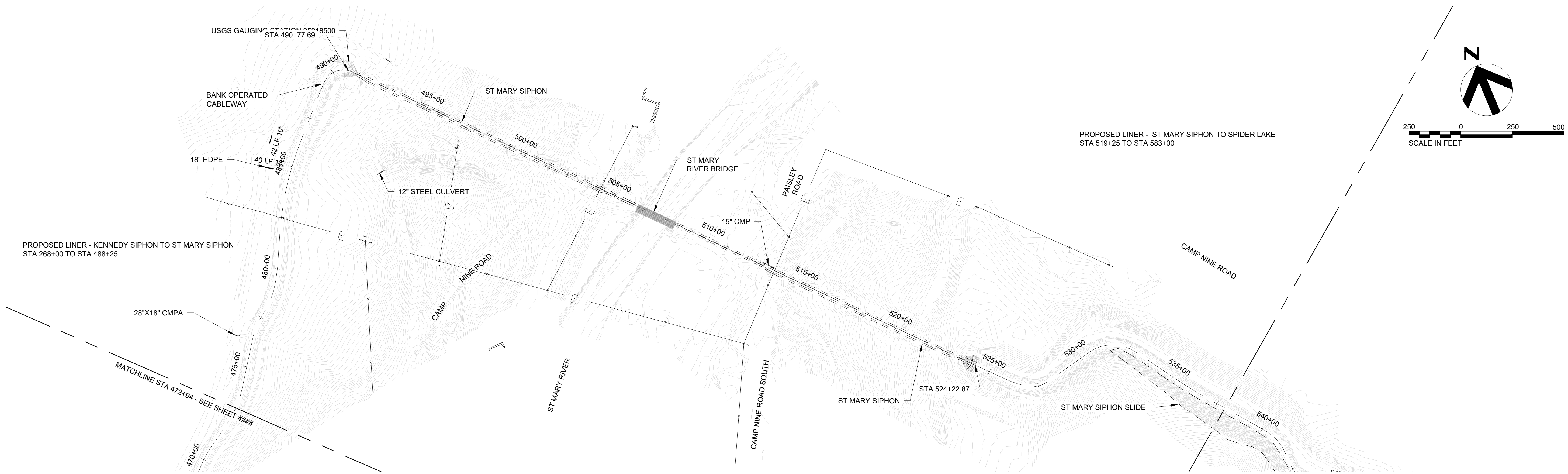
CIVIL PLAN AND PROFILE STA 407+94 TO STA 472+94

0 1" 2"

FILENAME 03C-009.DWG

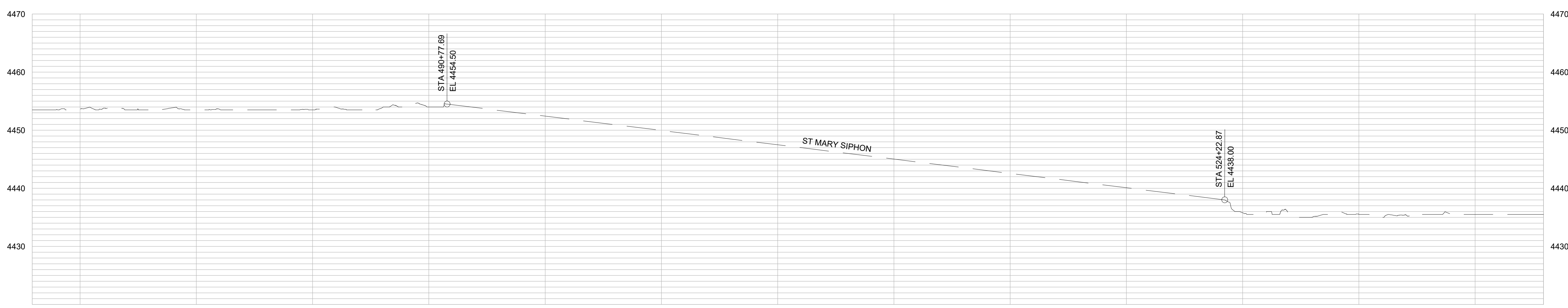
SCALE AS NOTED

SHEET **03C-009**



PLAN VIEW

SCALE: 1" = 250'
CONTOUR INTERVAL = 0.5 FT



PROFILE VIEW

HORIZ SCALE: 1" = 250'
VERT SCALE: 1" = 20'

HDR

ISSUE	DATE	DESCRIPTION
1	OCT 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

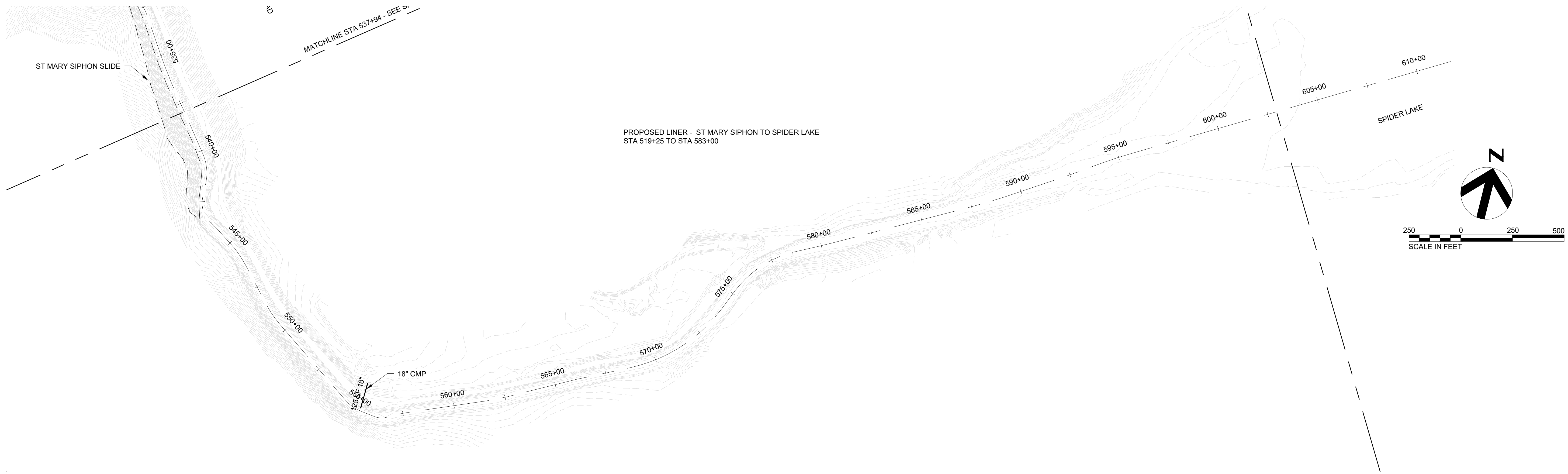
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
PLAN AND PROFILE
STA 472+94 TO 537+94

0 1" 2"

FILENAME 03C-010.DWG
SCALE AS NOTED

SHEET **03C-010**



PLAN VIEW

SCALE: 1" = 250'
CONTOUR INTERVAL = 0.5 FT

PROFILE VIEW

HORIZ SCALE: 1" = 250'
VERT SCALE: 1" = 20'

ISSUE	DATE	DESCRIPTION
1	OCT 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

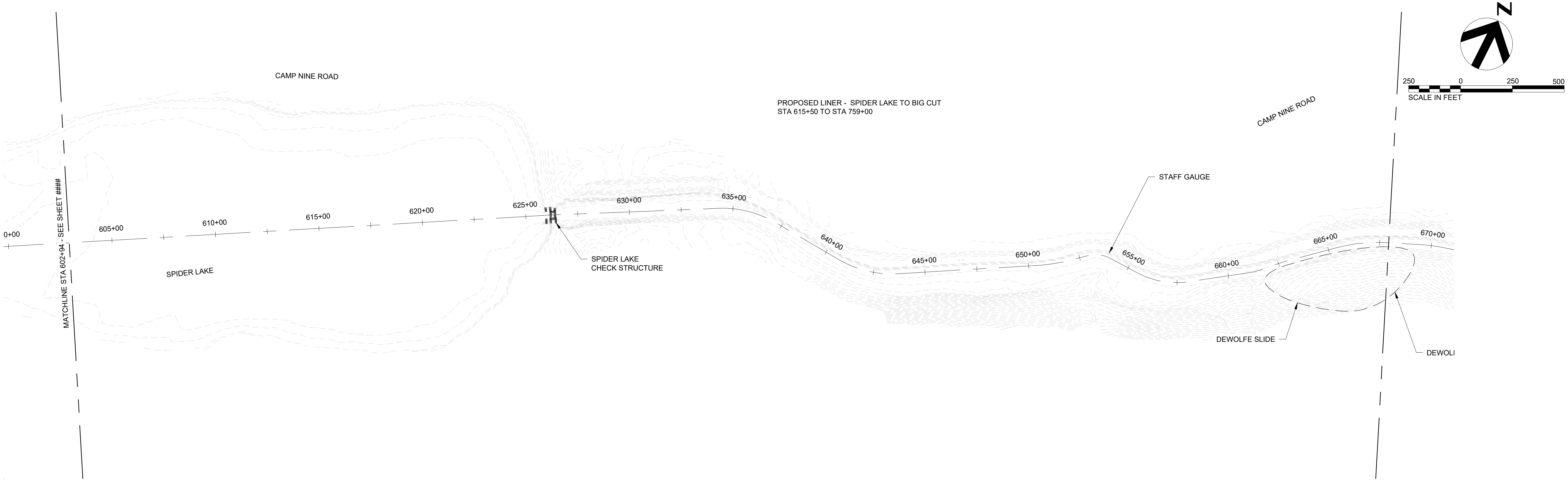
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
PLAN AND PROFILE
STA 537+94 TO 602+94

0 1" 2"

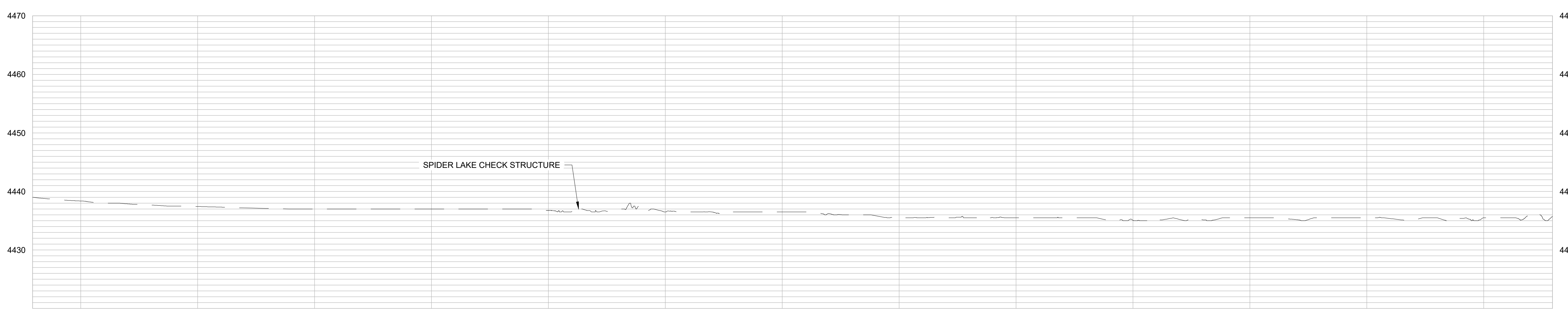
FILENAME 03C-011.DWG
SCALE AS NOTED

SHEET **03C-011**



PLAN VIEW

SCALE: 1" = 250'
CONTOUR INTERVAL = 0.5 FT



PROFILE VIEW

HORIZ SCALE: 1" = 250'
VERT SCALE: 1" = 20'

ISSUE	DATE	DESCRIPTION
1	OCT 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

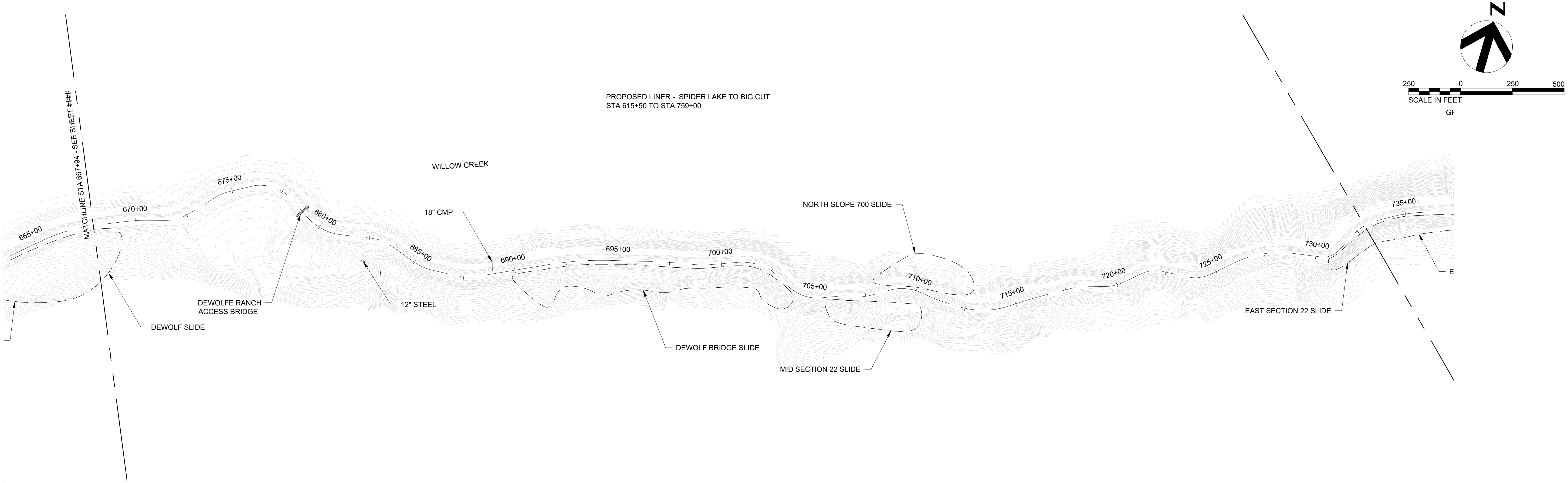
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
PLAN AND PROFILE
STA 602+94 TO 667+94

0 1" 2"

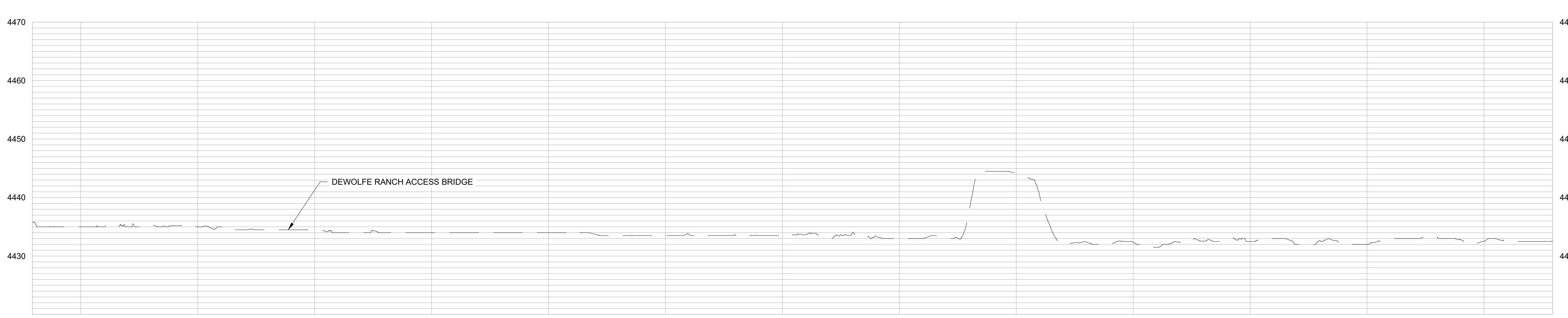
FILENAME 03C-012.DWG
SCALE AS NOTED

SHEET **03C-012**



PLAN VIEW

SCALE: 1" = 250'
CONTOUR INTERVAL = 0.5 FT



PROFILE VIEW

HORIZ SCALE: 1" = 250'
VERT SCALE: 1" = 20'

ISSUE	DATE	DESCRIPTION
1	OCT 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY
NOT FOR
CONSTRUCTION
OR
RECORDING

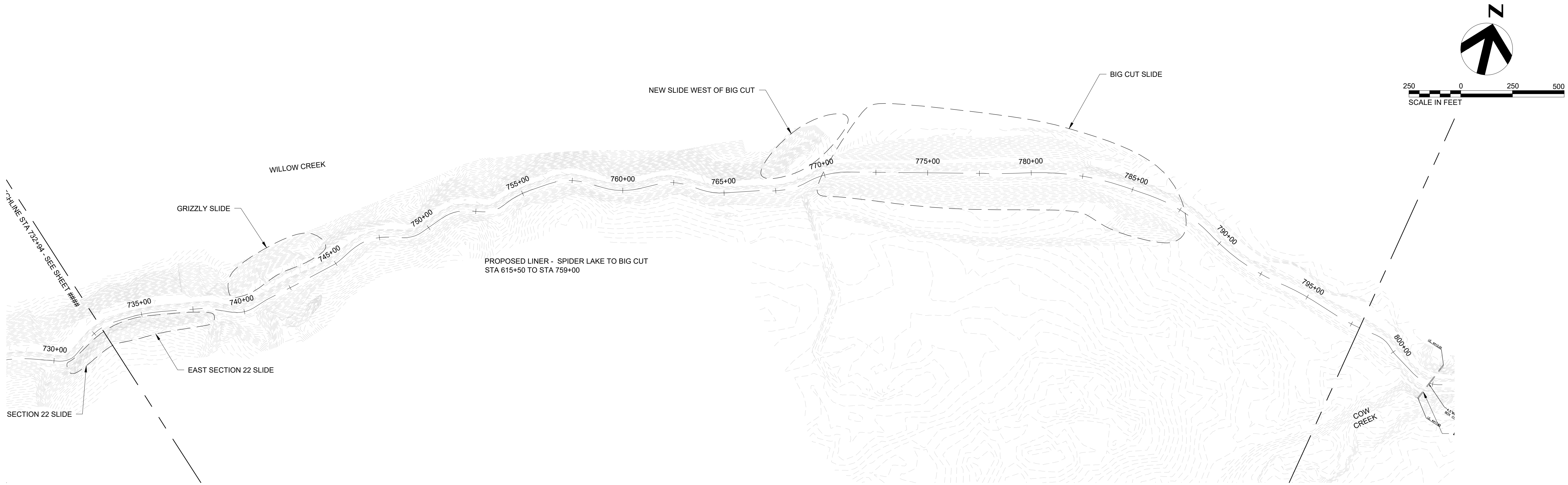
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
PLAN AND PROFILE
STA 667+94 TO STA 732+94

FILENAME 03C-013.DWG

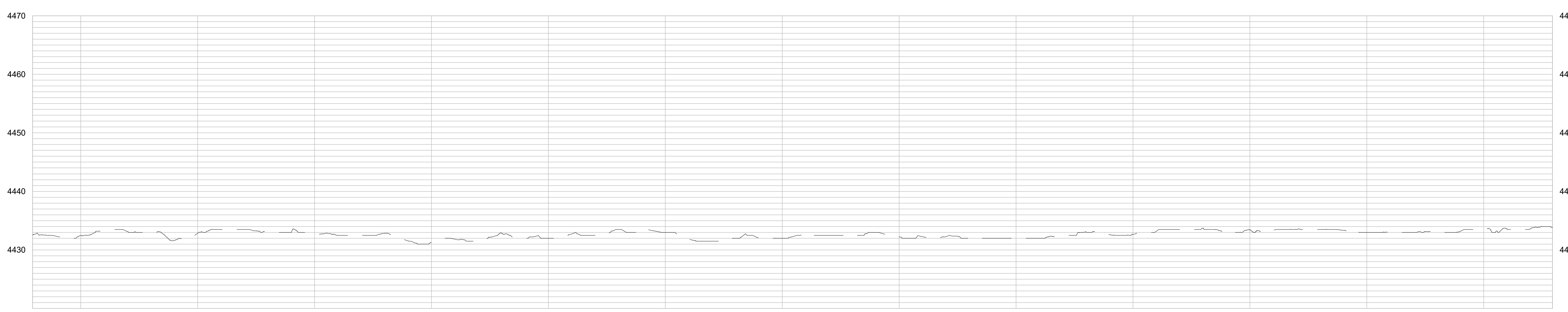
SCALE AS NOTED

SHEET 03C-013



PLAN VIEW

SCALE: 1" = 250'
CONTOUR INTERVAL = 0.5 FT



PROFILE VIEW

HORIZ SCALE: 1" = 250'
VERT SCALE: 1" = 20'

ISSUE	DATE	DESCRIPTION
1	OCT 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

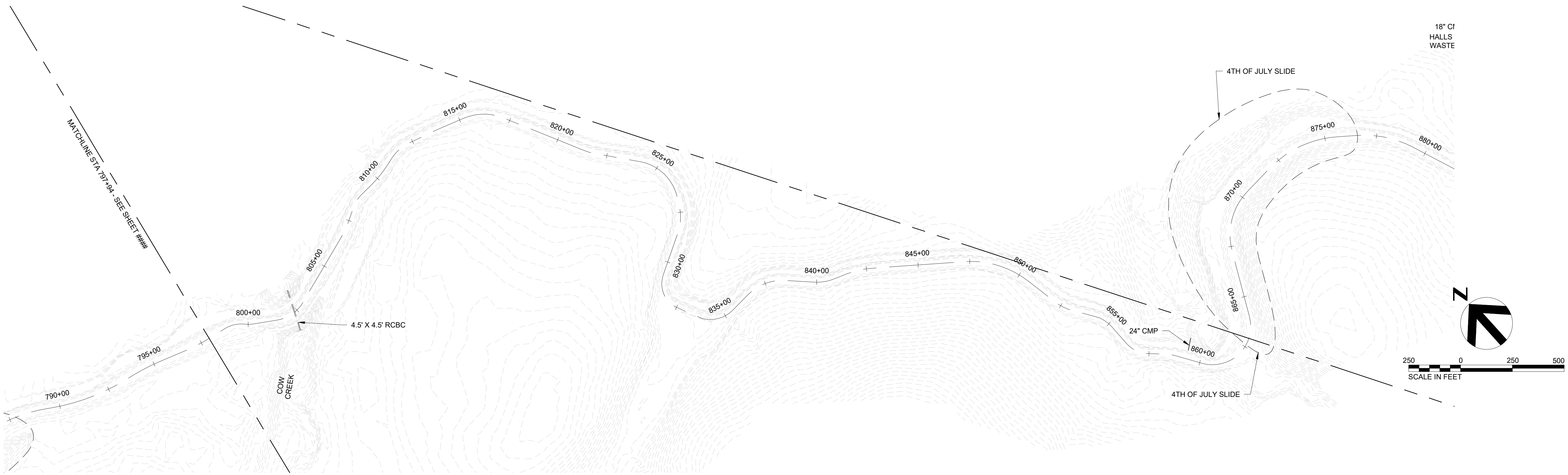
PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
PLAN AND PROFILE
STA 732+94 TO STA 797+94

0 1" 2"

FILENAME: 03C-014.DWG
SCALE: AS NOTED
SHEET: 03C-014



PLAN VIEW

SCALE: 1" = 250'
CONTOUR INTERVAL = 0.5 FT

PROFILE VIEW

HORIZ SCALE: 1" = 250'
VERT SCALE: 1" = 20'

HDR

ISSUE	DATE	DESCRIPTION
1	OCT 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

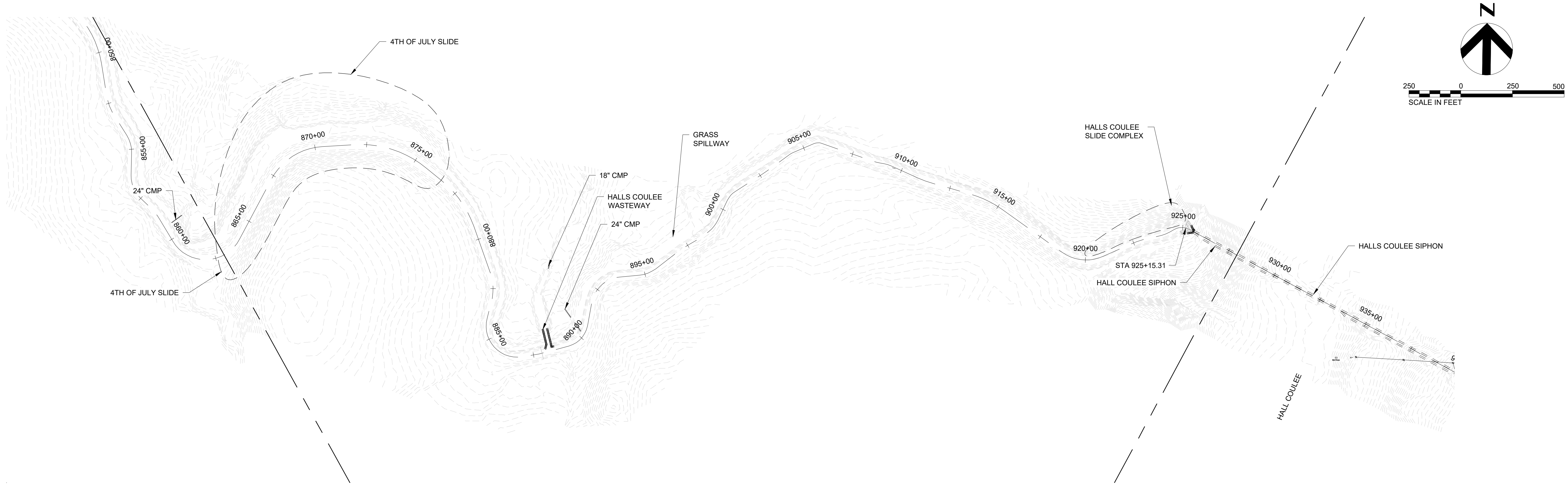
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
PLAN AND PROFILE
STA 797+94 TO STA 862+94

0 1" 2"

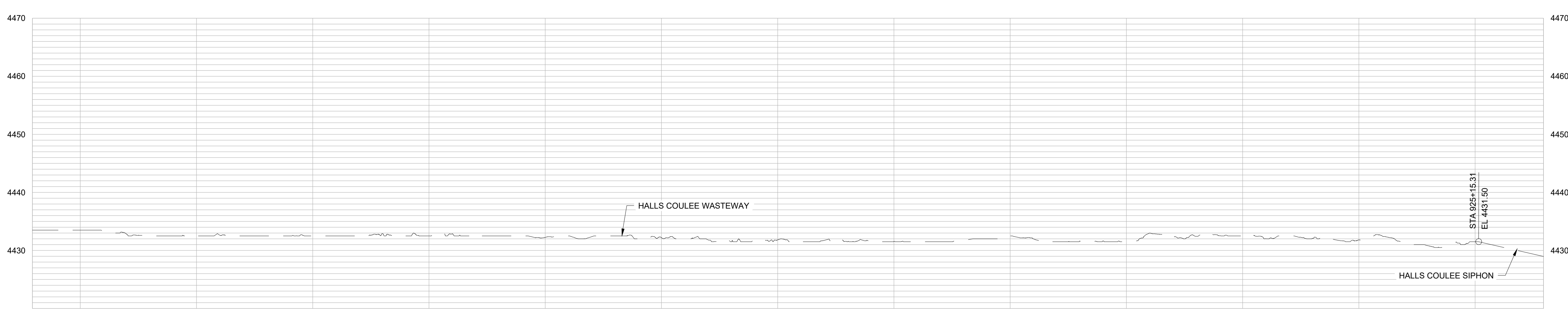
FILENAME 03C-015.DWG
SCALE AS NOTED

SHEET 03C-015



PLAN VIEW

SCALE: 1" = 250'
CONTOUR INTERVAL = 0.5 FT



PROFILE VIEW

HORIZ SCALE: 1" = 250'
VERT SCALE: 1" = 20'

ISSUE	DATE	DESCRIPTION
1	OCT 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

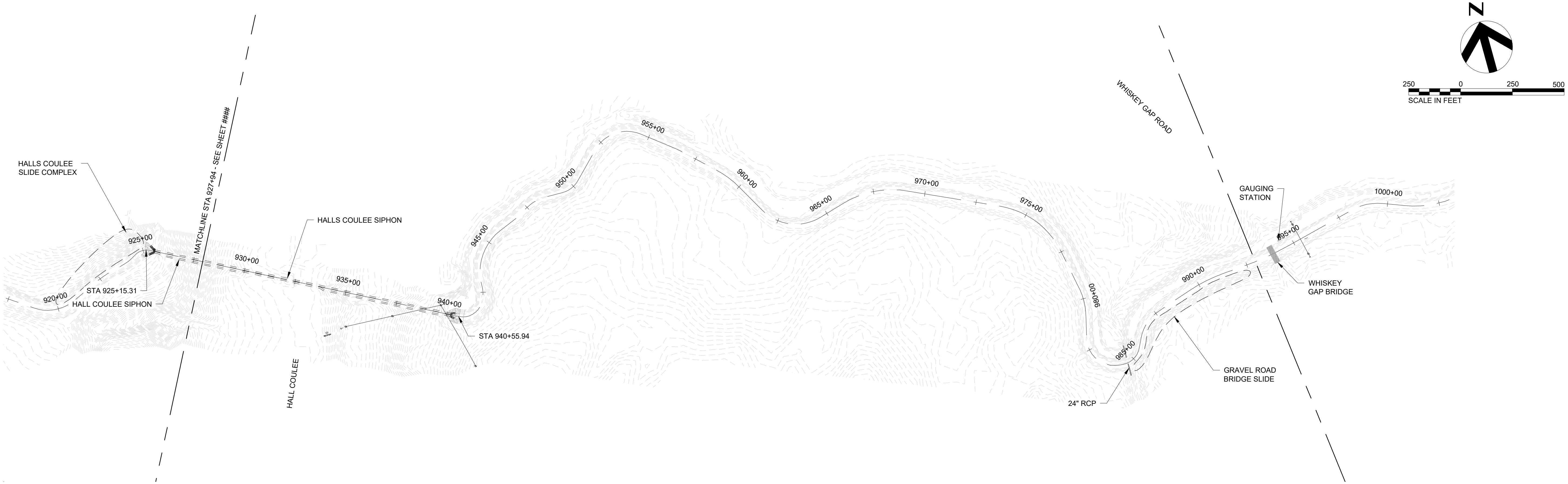
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
PLAN AND PROFILE
STA 862+94 TO STA 927+94

0 1" 2"

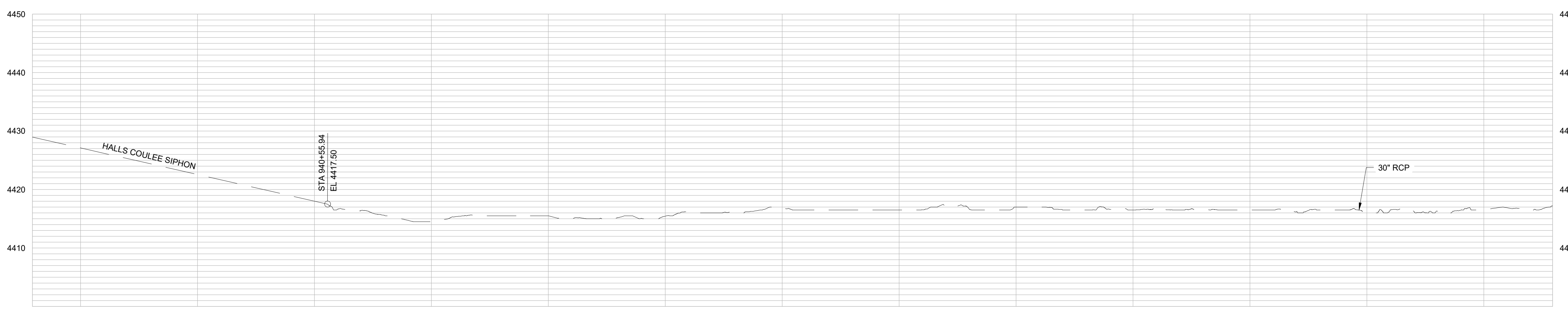
FILENAME 03C-016.DWG
SCALE AS NOTED

SHEET **03C-016**



PLAN VIEW

SCALE: 1" = 250'
CONTOUR INTERVAL = 0.5 FT



PROFILE VIEW

HORIZ SCALE: 1" = 250'
VERT SCALE: 1" = 20'

HDR

ISSUE	DATE	DESCRIPTION
1	OCT 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

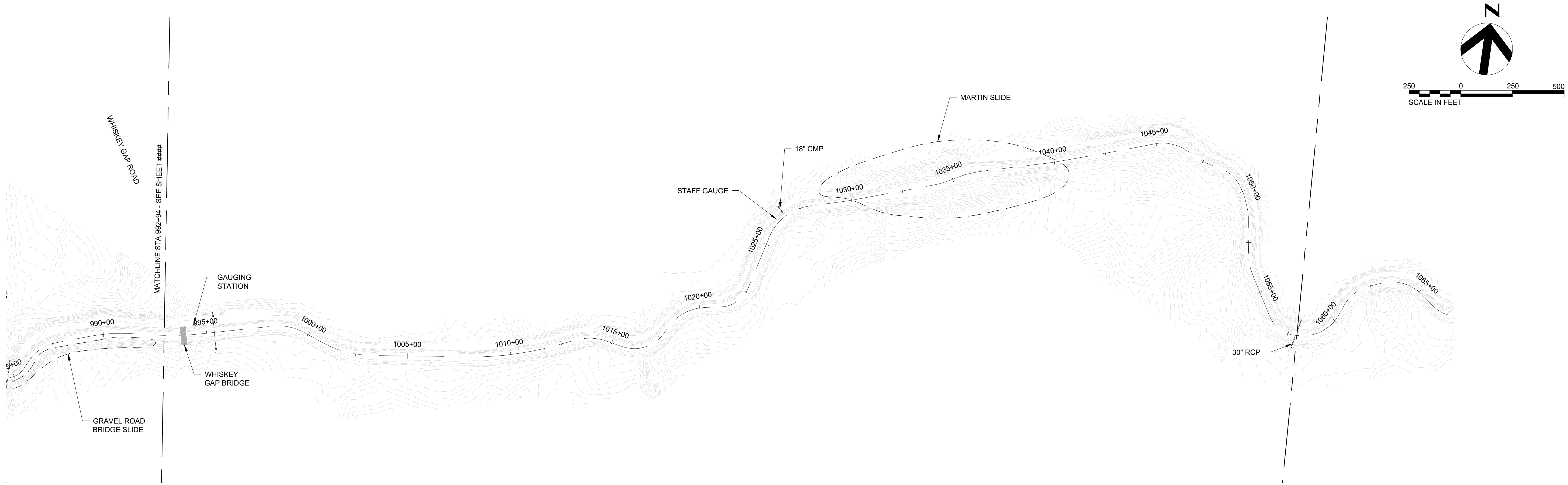
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
PLAN AND PROFILE
STA 927+94 TO STA 992+94

0 1" 2"

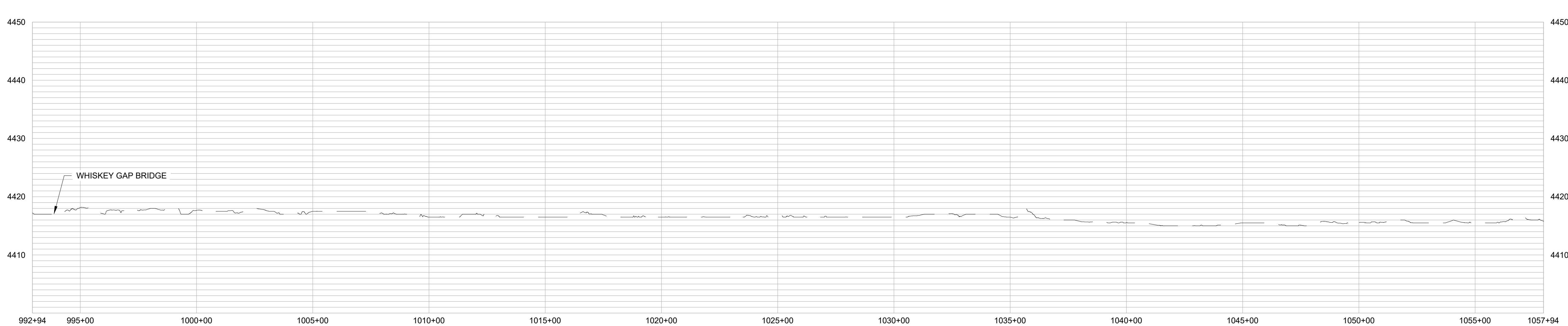
FILENAME 03C-017.DWG
SCALE AS NOTED

SHEET
03C-017



PLAN VIEW

SCALE: 1" = 250'
CONTOUR INTERVAL = 0.5 FT



PROFILE VIEW

HORIZ SCALE: 1" = 250'
VERT SCALE: 1" = 20'

ISSUE	DATE	DESCRIPTION
1	OCT 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

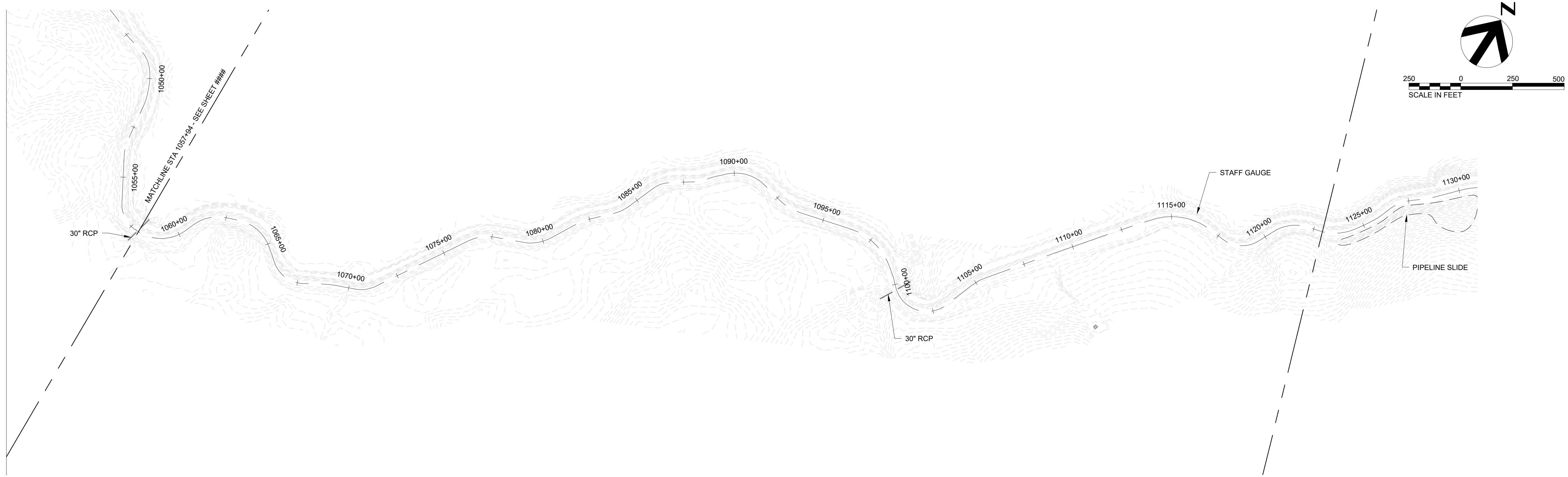
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
PLAN AND PROFILE
STA 992+94 TO STA 1057+94

0 1" 2"

FILENAME 03C-018.DWG
SCALE AS NOTED

SHEET **03C-018**



PLAN VIEW

SCALE: 1" = 250'
CONTOUR INTERVAL = 0.5 FT

PROFILE VIEW

HORIZ SCALE: 1" = 250'
VERT SCALE: 1" = 20'

ISSUE	DATE	DESCRIPTION
1	OCT 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

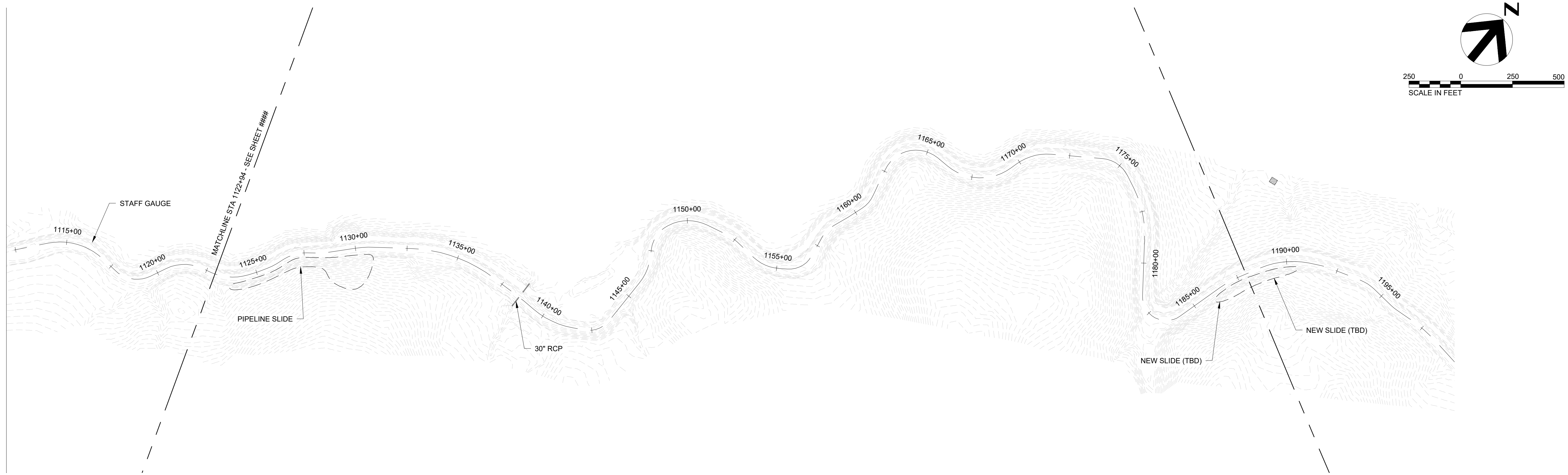
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
PLAN AND PROFILE
STA 1057+94 TO STA 1122+94

0 1" 2"

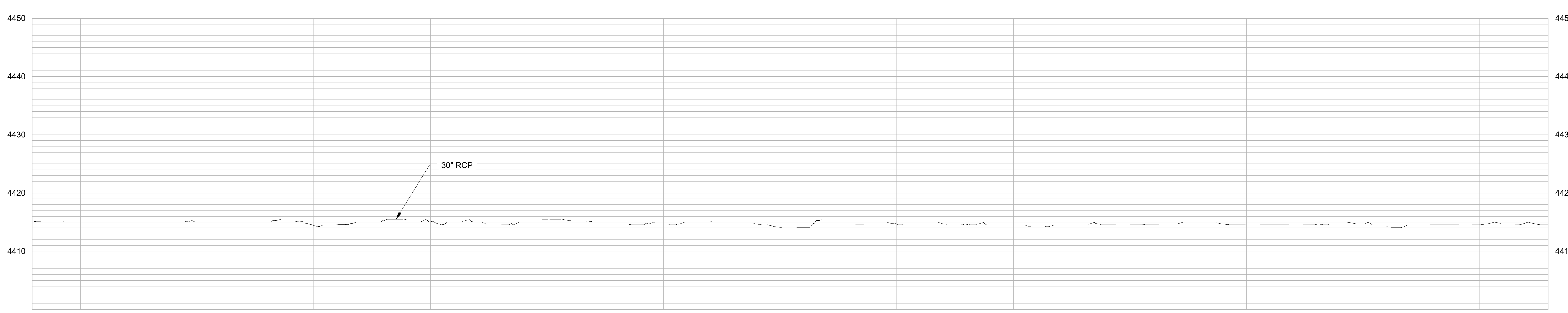
FILENAME: 03C-019.DWG
SCALE: AS NOTED

SHEET: 03C-019



PLAN VIEW

SCALE: 1" = 250'
CONTOUR INTERVAL = 0.5 FT



PROFILE VIEW

HORIZ SCALE: 1" = 250'
VERT SCALE: 1" = 20'

HDR

ISSUE	DATE	DESCRIPTION
1	OCT 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

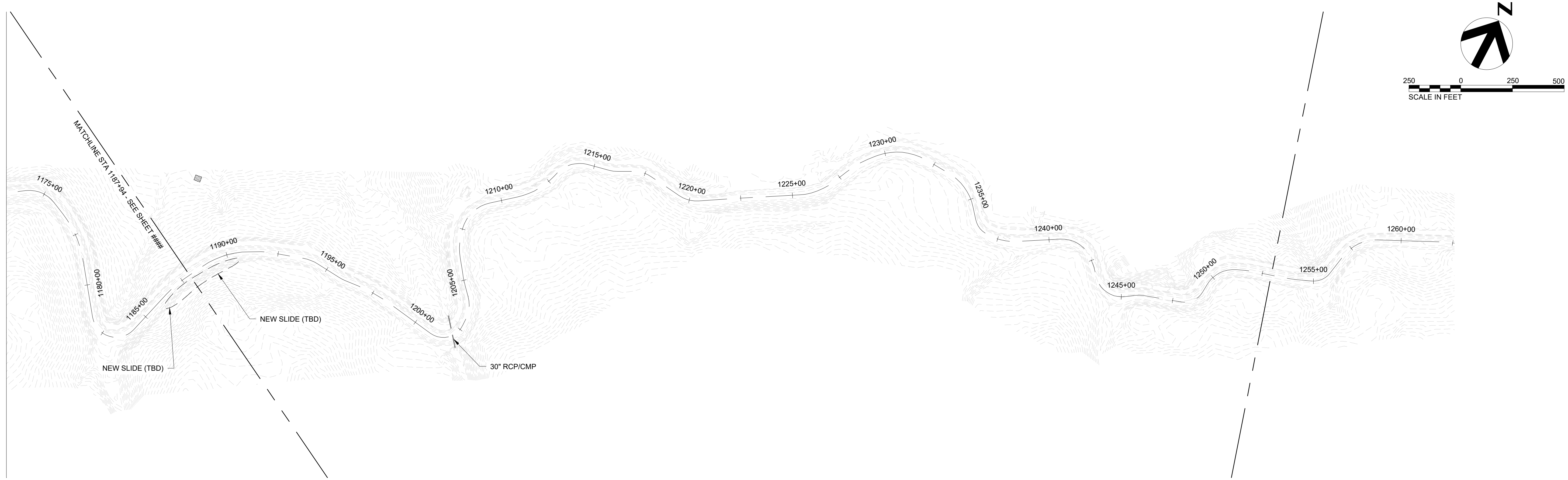
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
PLAN AND PROFILE
STA 1122+94 TO STA 1187+94

0 1" 2"

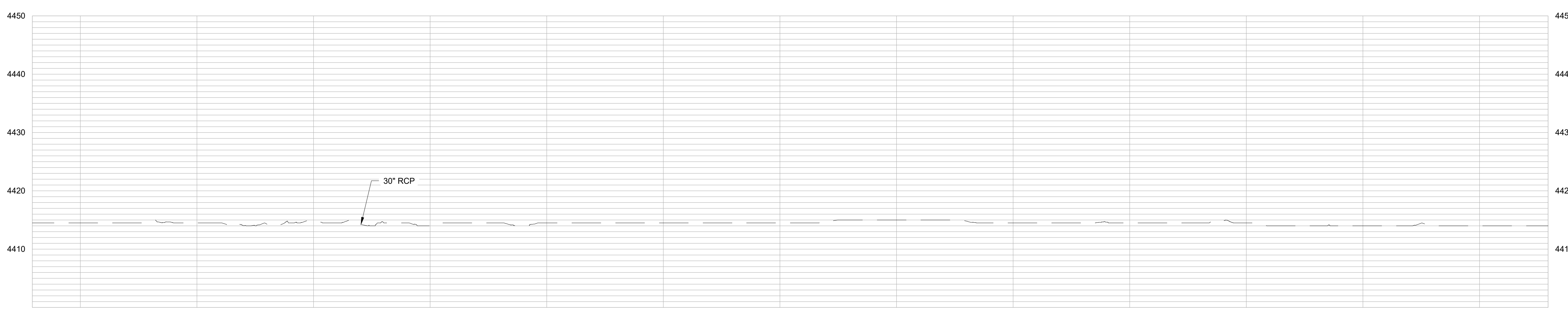
FILENAME 03C-020.DWG
SCALE AS NOTED

SHEET **03C-020**



PLAN VIEW

SCALE: 1" = 250'
CONTOUR INTERVAL = 0.5 FT



PROFILE VIEW

HORIZ SCALE: 1" = 250'
VERT SCALE: 1" = 20'

HDR

ISSUE	DATE	DESCRIPTION
1	OCT 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

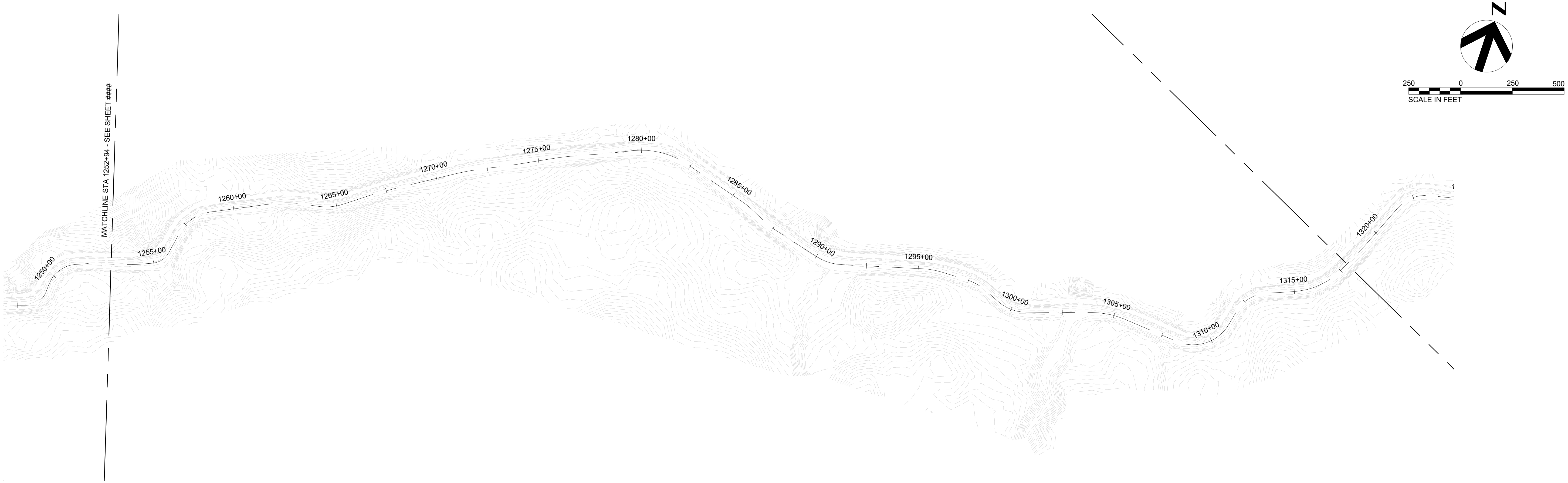
PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
PLAN AND PROFILE
STA 1187+94 TO STA 1252+94

0 1" 2"

FILENAME	03C-021.DWG
SCALE	AS NOTED
SHEET	03C-021



PLAN VIEW

SCALE: 1" = 250'
CONTOUR INTERVAL = 0.5 FT

PROFILE VIEW

HORIZ SCALE: 1" = 250'
VERT SCALE: 1" = 20'

ISSUE	DATE	DESCRIPTION
1	OCT 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

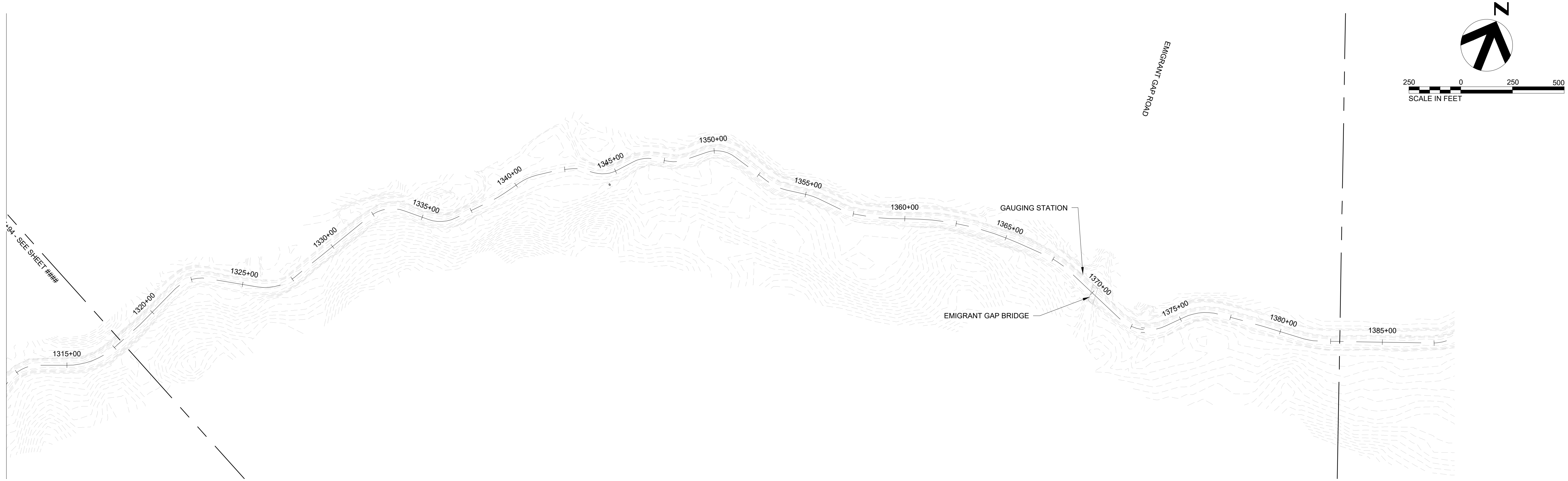
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
PLAN AND PROFILE
STA 1252+94 TO STA 1317+94

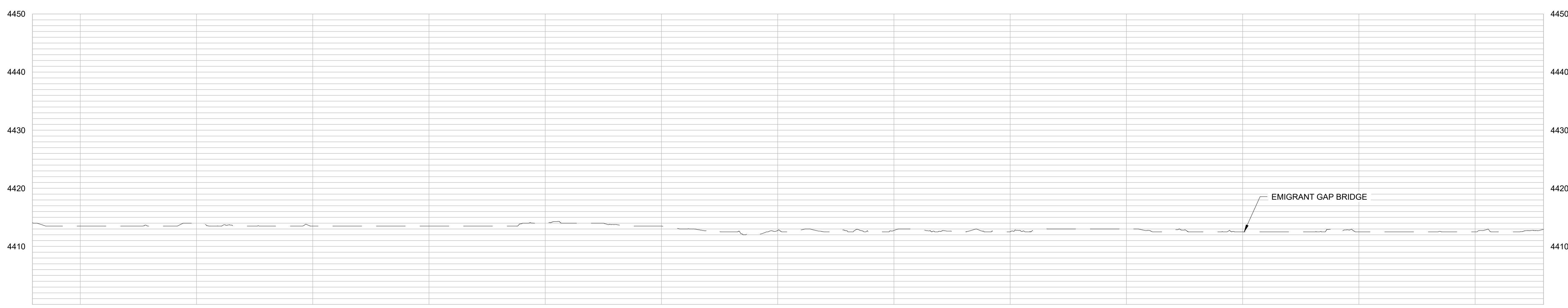
0 1" 2"

FILENAME 03C-022.DWG
SCALE AS NOTED

SHEET
03C-022



PLAN VIEW
SCALE: 1" = 250'
CONTOUR INTERVAL = 0.5 FT



PROFILE VIEW
HORIZ SCALE: 1" = 250'
VERT SCALE: 1" = 20'

ISSUE	DATE	DESCRIPTION
1	OCT 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

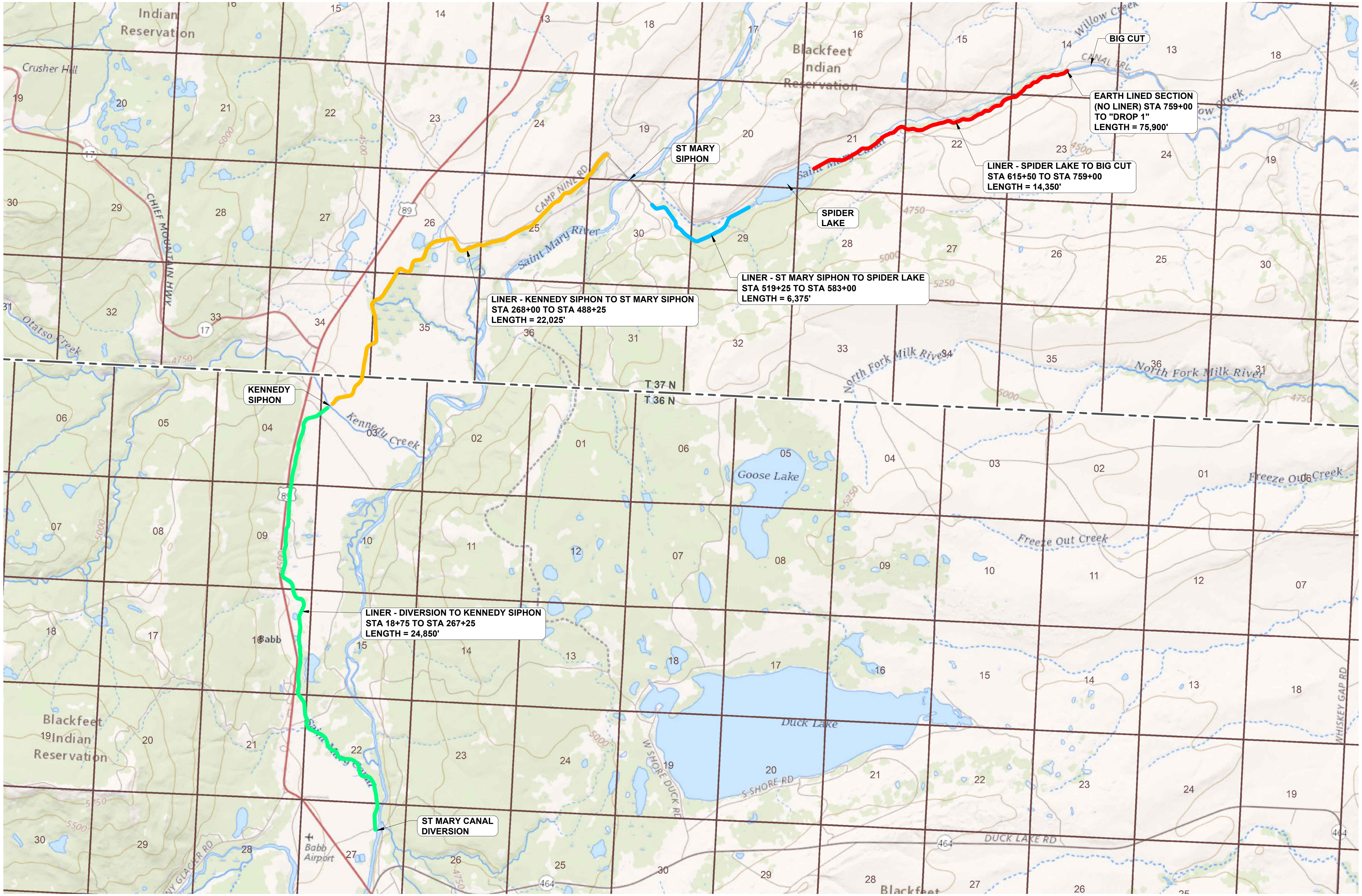
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
PLAN AND PROFILE
STA 1317+94 TO 1382+94

0 1" 2"

FILENAME 03C-023.DWG
SCALE AS NOTED

SHEET
03C-023



N

2500 0 2500 5000
SCALE IN FEET

LEGEND

- PROPOSED LINER DIVERSION TO KENNEDY SIPHON
- PROPOSED LINER KENNEDY SIPHON TO ST MARY SIPHON
- PROPOSED LINER ST MARY SIPHON TO SPIDER LAKE
- PROPOSED LINER SPIDER LAKE TO BIG CUT

NOTE:
LIMITS OF CONSTRUCTION ARE CONSIDERED TO BE THE FULL LENGTH OF THE CANAL, MINUS SPIDER LAKE, AND ENCOMPASS 75' EACH SIDE OF THE CENTERLINE.

HDR

ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

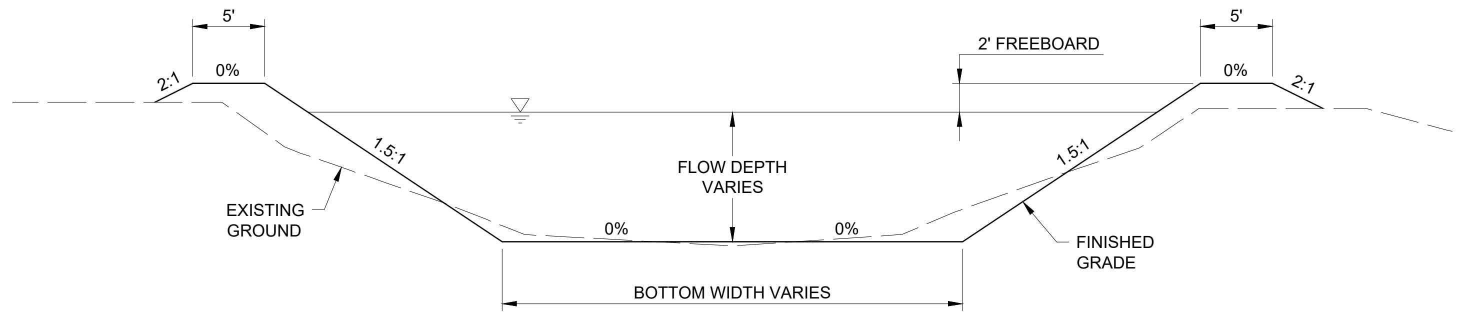
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
CANAL LINER AREAS
PLAN VIEW

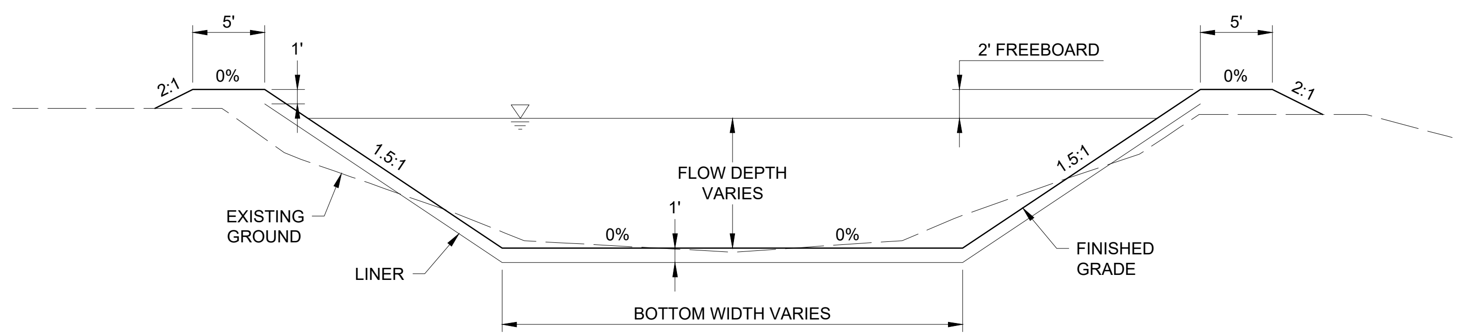
0 1" 2"

FILENAME 03C-024.DWG
SCALE AS SHOWN

SHEET
03C-024



A
-
ST. MARY CANAL - TYPICAL UNLINED SECTION
SCALE: NTS



B
-
ST. MARY CANAL - TYPICAL LINED SECTION
SCALE: NTS

ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

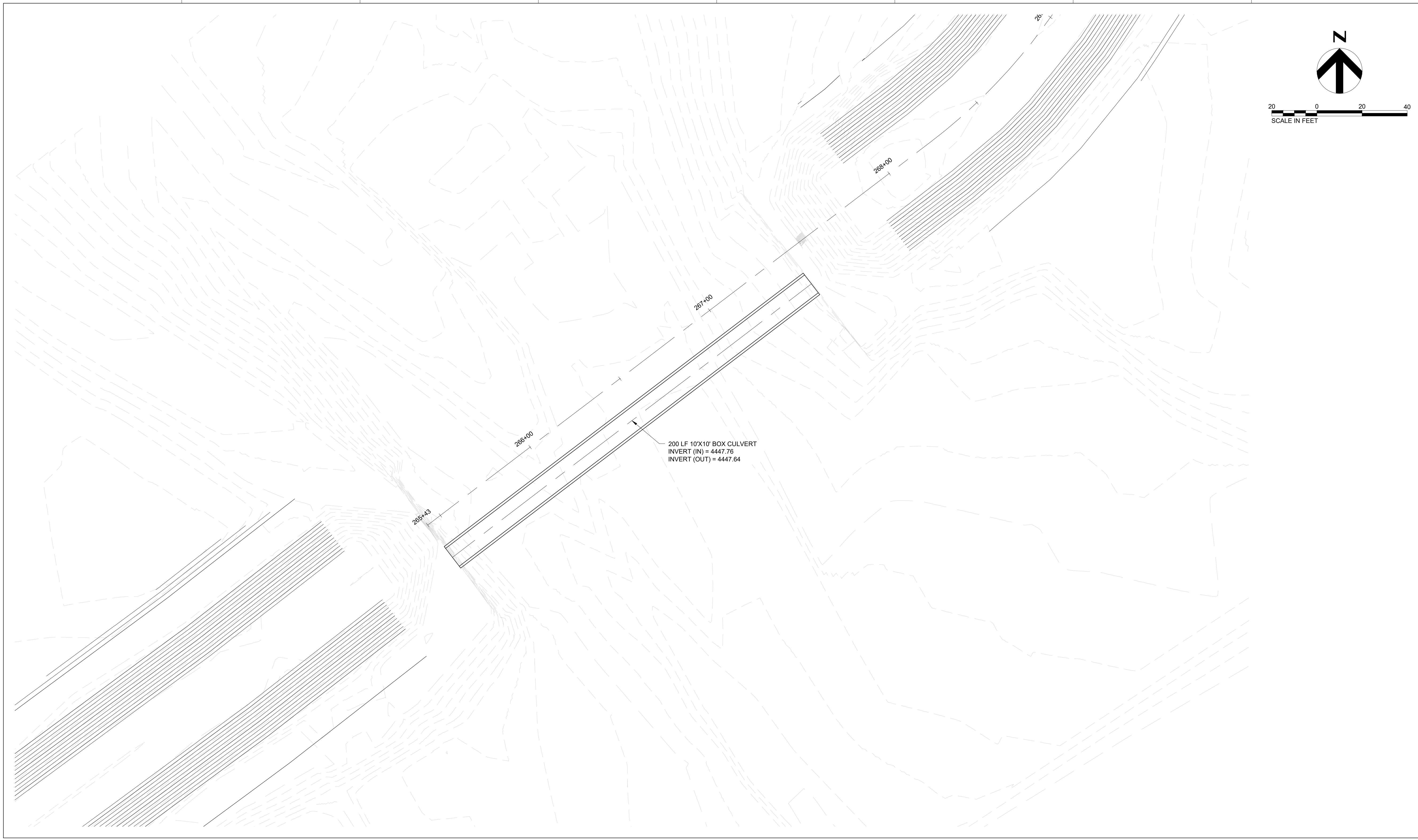
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
CANAL LINER AREAS
TYPICAL SECTION VIEWS

0 1" 2"

FILENAME 03C-024.DWG
SCALE AS SHOWN

SHEET
0C3-025



ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

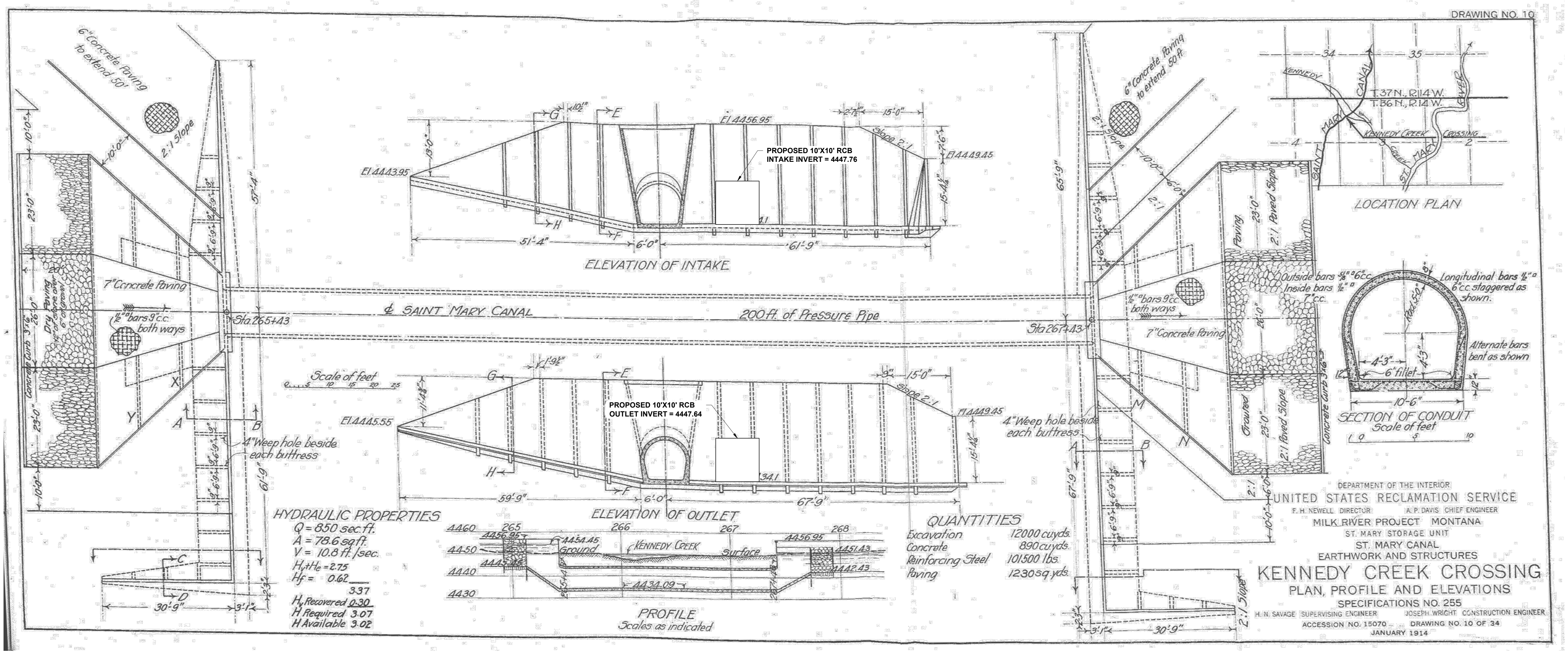
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

KENNEDY CREEK CROSSING
PROPOSED BOX CULVERT
PLAN VIEW

0 1" 2"

FILENAME 03C-026.DWG
SCALE AS SHOWN

SHEET
03C-026



PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

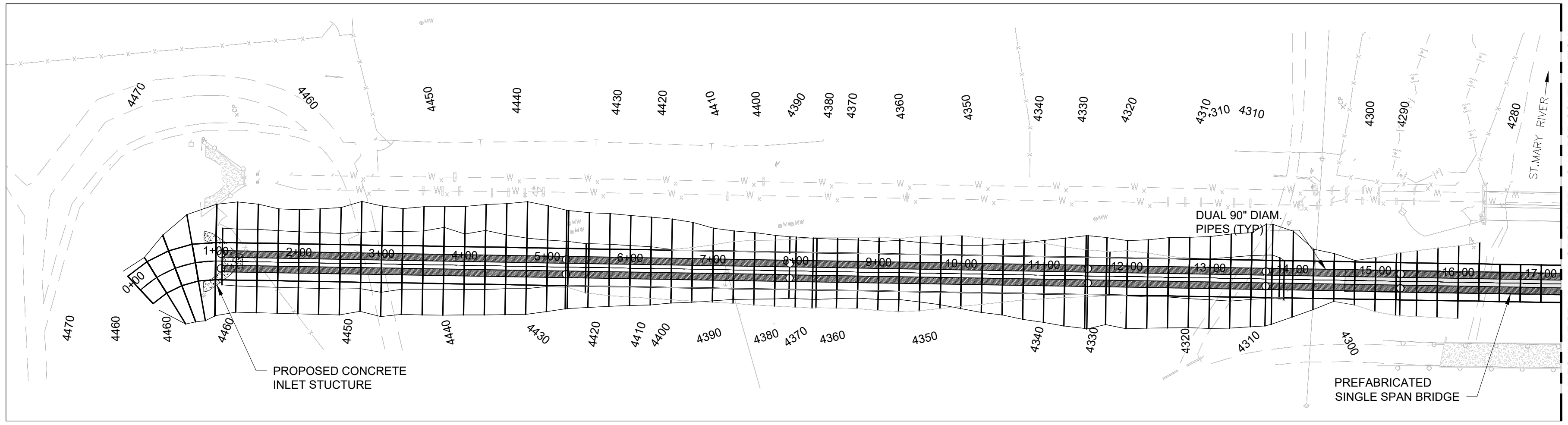
ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

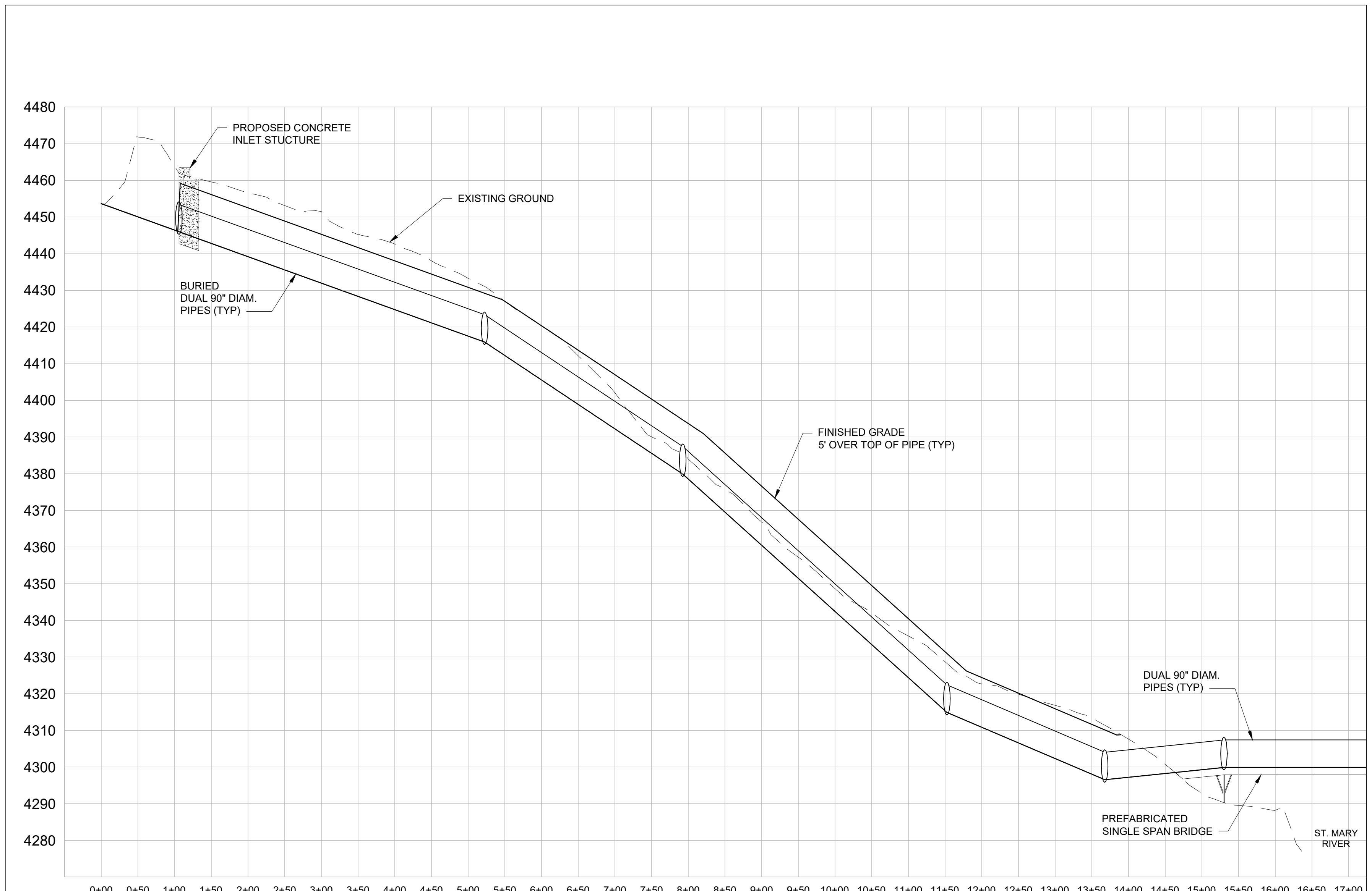
PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

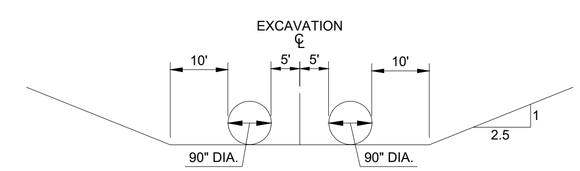
KENNEDY CREEK CROSSING
PROPOSED BOX CULVERT
ELEVATION VIEW

FILENAME 03C-026.DWG
SCALE NONE
SHEET **03C-027**





NOTE:
TOTAL ESTIMATED CUT/FILL VOLUMES FOR PROJECT:
CUT: 100,677 C.Y.
FILL: 18,377 C.Y.
NET CUT: 82,300 C.Y.



TYP. CROSS-SECTION:
DOUBLE PIPE

SCALE IN FEET
HORIZONTAL SCALE:

SCALE IN FEET
VERTICAL SCALE:

ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

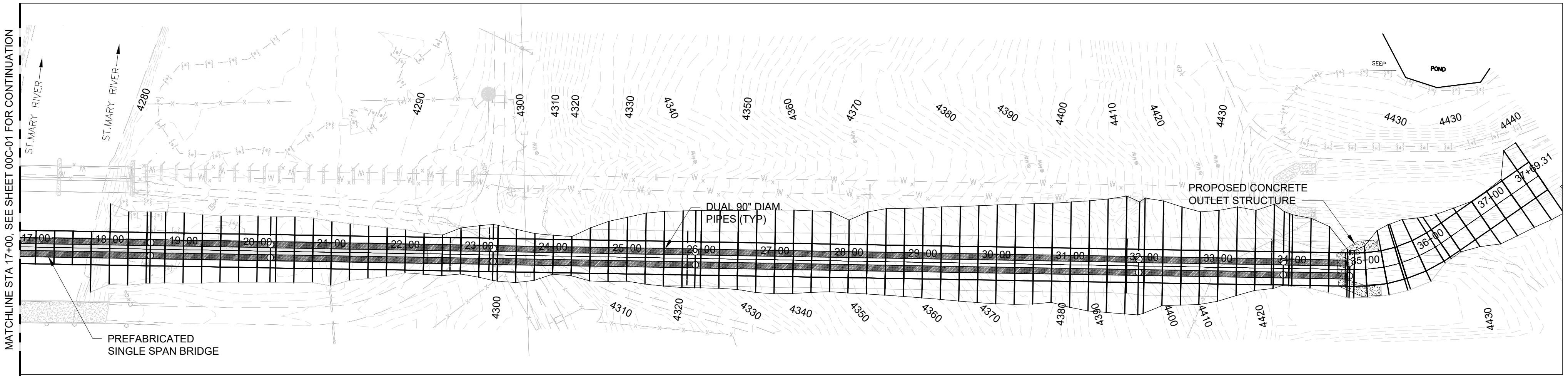
PROJECT MANAGER S. SCHWEISSING
DESIGNER 1
DRAWN BY
CHECKED BY
PROJECT NUMBER 10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

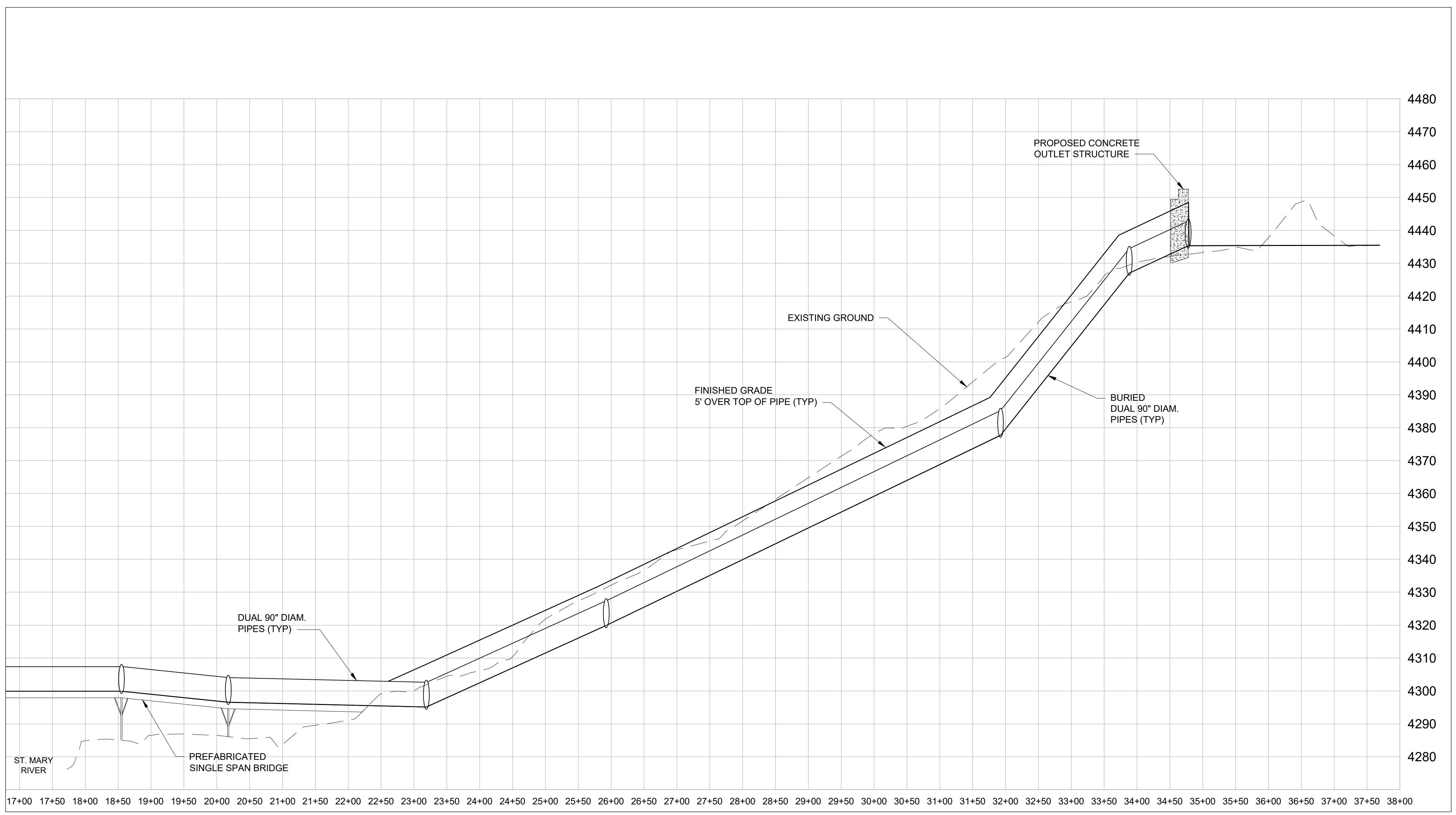
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
ST MARY SIPHON
DOUBLE PIPE OPTION
PLAN AND PROFILE STA 0+00 - STA 17+00

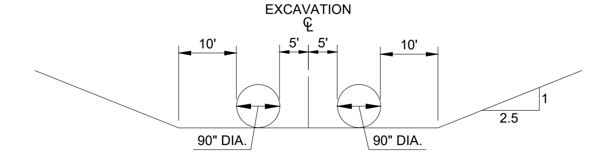
FILENAME 03C-028.dwg
SCALE NONE
SHEET 03C-028



SCALE IN FEET



NOTE:
TOTAL ESTIMATED CUT/FILL VOLUMES FOR PROJECT:
CUT: 100,677 C.Y.
FILL: 18,377 C.Y.
NET CUT: 82,300 C.Y.



TYP. CROSS-SECTION:
DOUBLE PIPE

SCALE IN FEET
HORIZONTAL SCALE:

SCALE IN FEET
VERTICAL SCALE:

ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

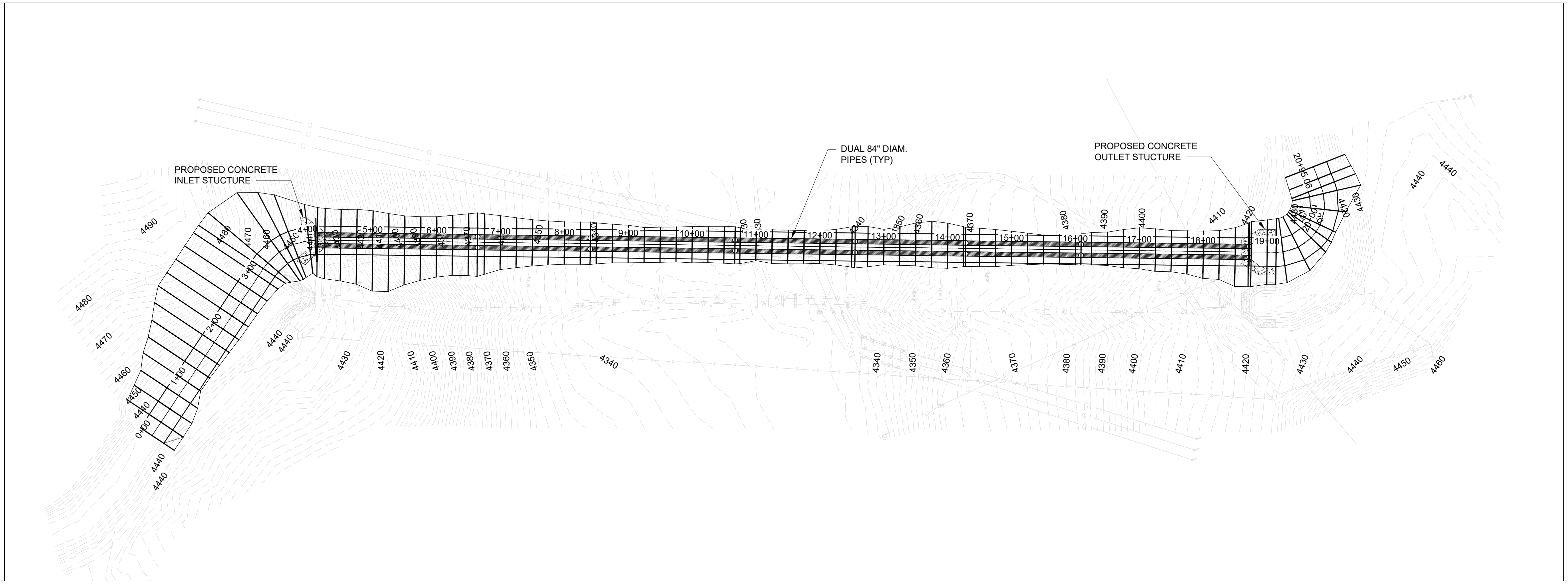
PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY
NOT FOR
CONSTRUCTION
OR
RECORDING

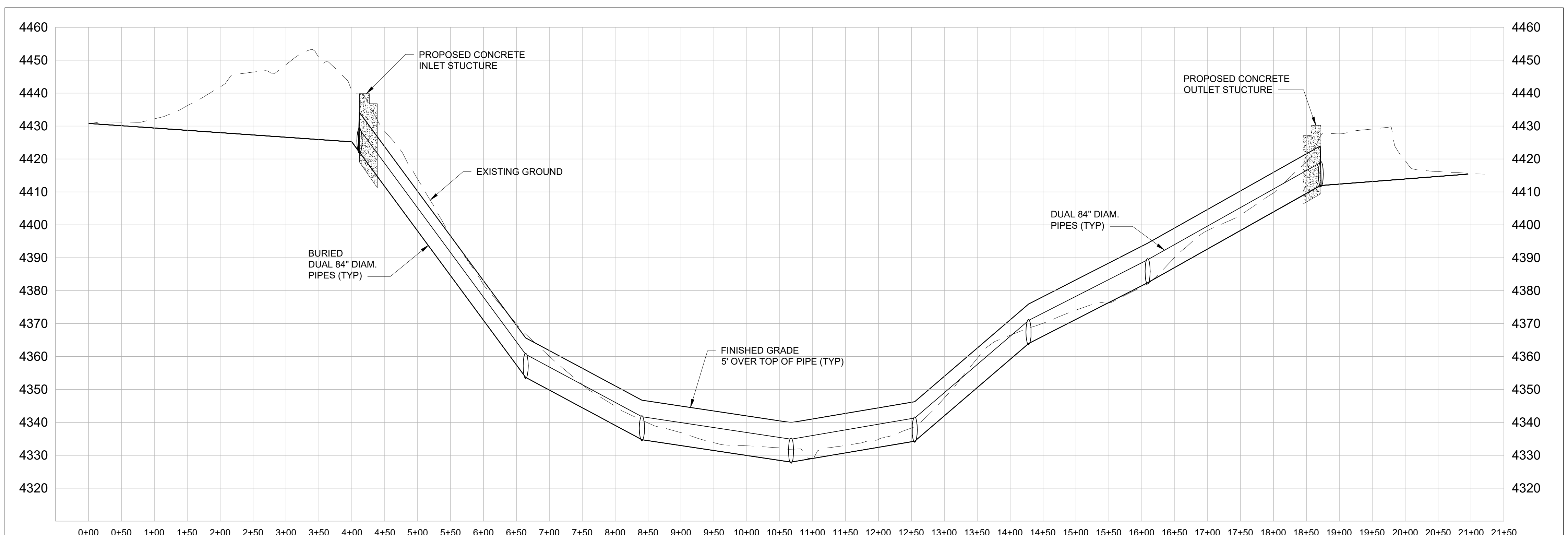
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
ST MARY SIPHON
DOUBLE PIPE OPTION
PLAN AND PROFILE STA 17+00 - STA 37+50

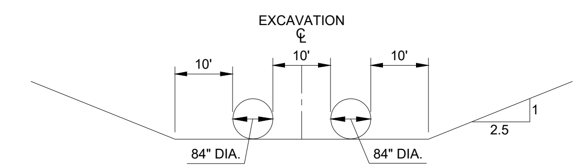
FILENAME 03C-029.dwg
SCALE NONE
SHEET 03C-029



100 0 100 200
SCALE IN FEET



NOTE:
TOTAL ESTIMATED CUT/FILL VOLUMES FOR PROJECT:
CUT: 31,524 C.Y.
FILL: 2,386 C.Y.
NET CUT: 29,138 C.Y.



TYP. CROSS-SECTION:
DOUBLE PIPE

100 0 100 200
SCALE IN FEET
HORIZONTAL SCALE:

20 0 20 40
SCALE IN FEET
VERTICAL SCALE:

HDR

ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY
NOT FOR
CONSTRUCTION
OR
RECORDING

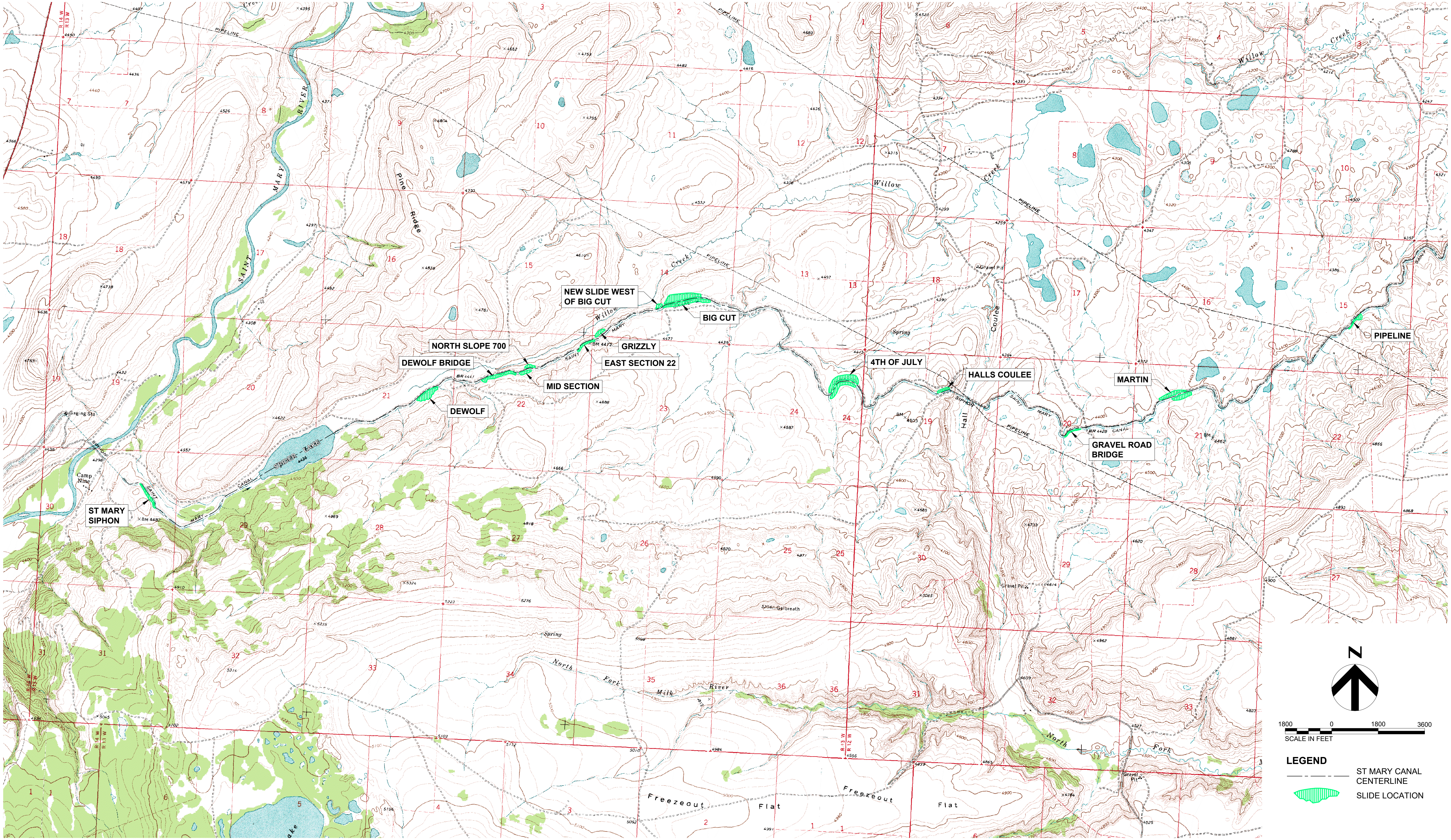
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
HALLS COULEE SIPHON
DOUBLE PIPE OPTION
PLAN AND PROFILE STA 0+00 - STA 21+00

0 1" 2"

FILENAME 03C-030.dwg
SCALE AS SHOWN

SHEET
03C-030



ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

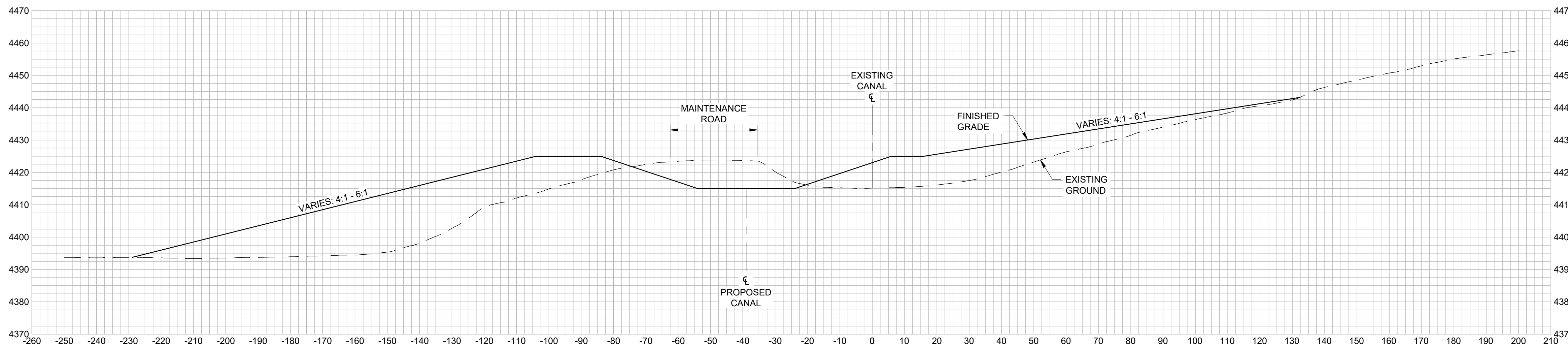
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
LANDSLIDE AREAS
PLAN VIEW

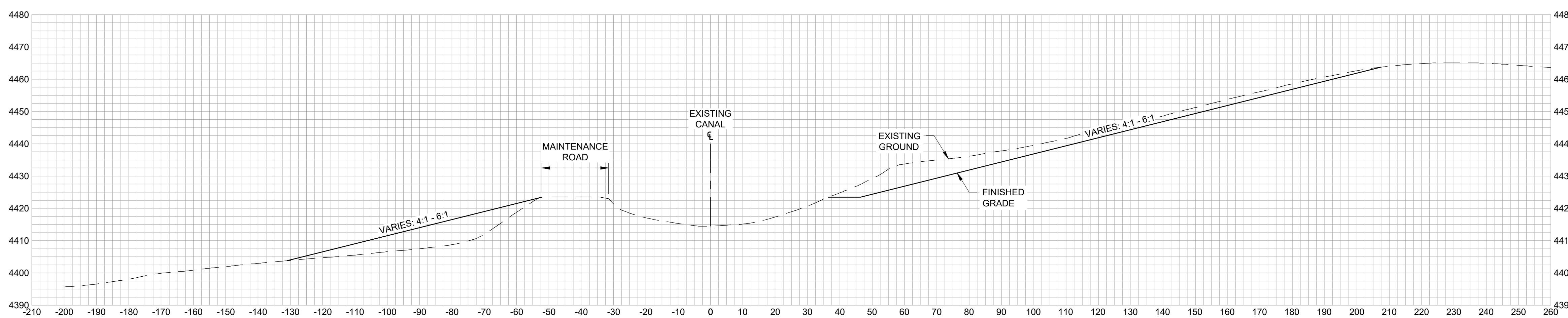
0 1" 2"

FILENAME 03C-031.DWG
SCALE AS SHOWN

SHEET **03C-031**



A
TYPICAL SECTION VIEW
WITH CANAL REALIGNMENT
SCALE: NTS



B
TYPICAL SECTION VIEW
WITHOUT CANAL REALIGNMENT
SCALE: NTS

ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

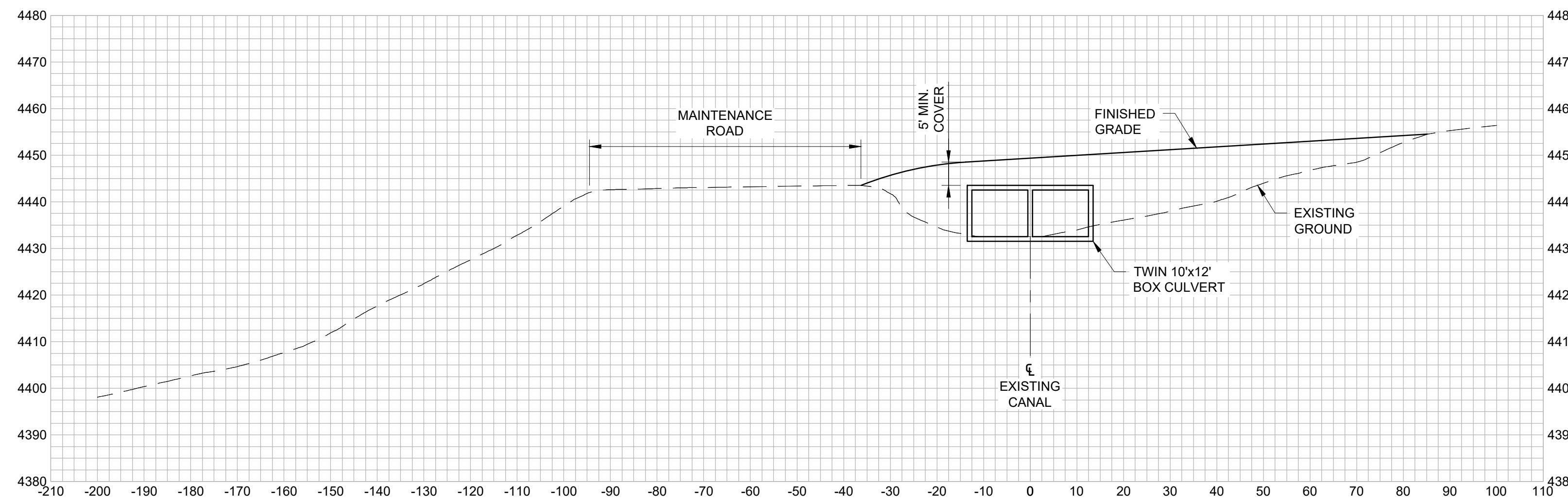
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
LANDSLIDE AREAS
TYPICAL SECTION VIEWS

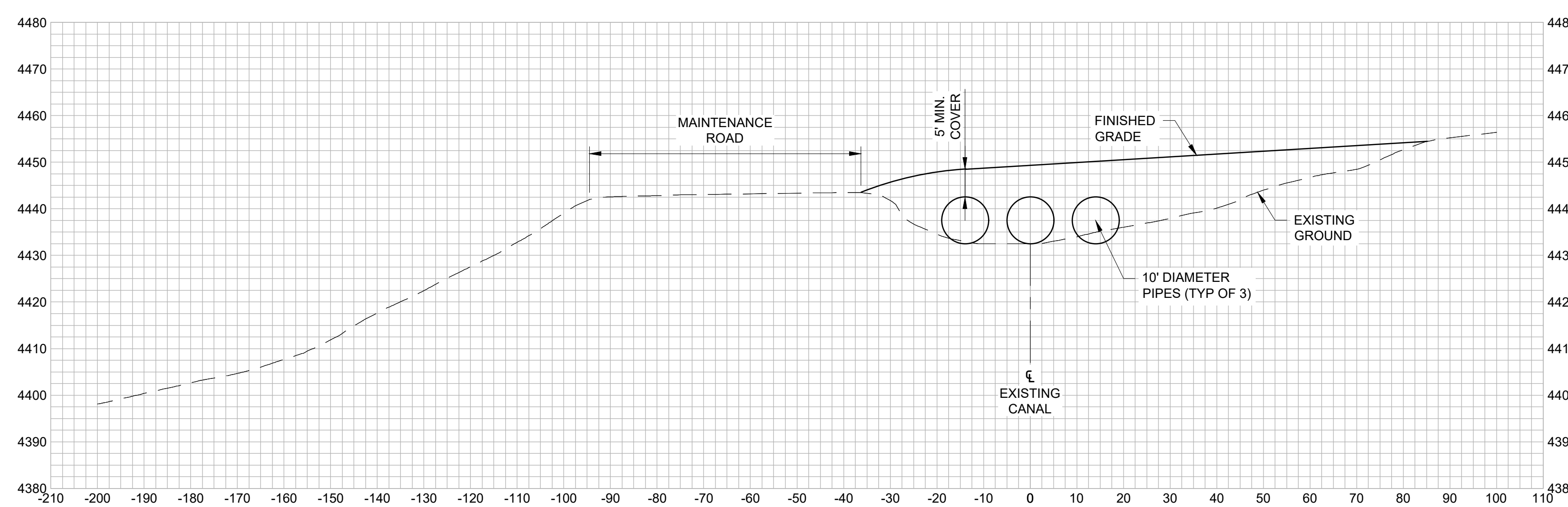
0 1" 2"

FILENAME 03C-032.DWG
SCALE AS SHOWN

SHEET **03C-032**



C
TYPICAL SECTION VIEW
WITH BOX CULVERT
SCALE: NTS



D
TYPICAL SECTION VIEW
WITH PIPES
SCALE: NTS

ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

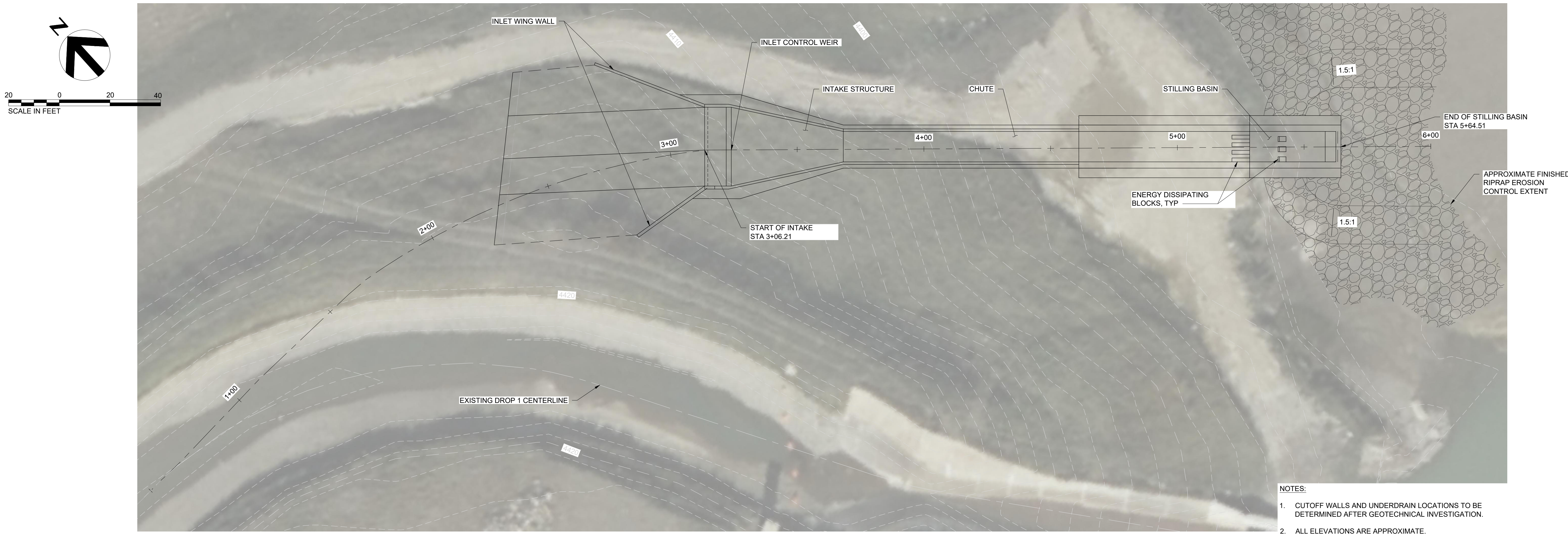
PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
LANDSLIDE AREAS
TYPICAL PIPING SECTION VIEWS

0 1" 2"

FILENAME 03C-033.DWG
SCALE AS SHOWN
SHEET **03C-033**

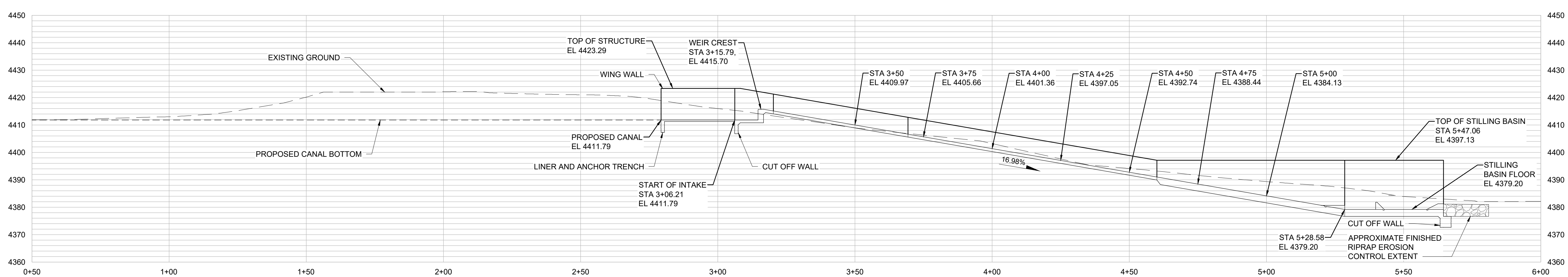


PLAN VIEW

SCALE: 1" = 20'-0"

NOTES:

1. CUTOFF WALLS AND UNDERDRAIN LOCATIONS TO BE DETERMINED AFTER GEOTECHNICAL INVESTIGATION.
2. ALL ELEVATIONS ARE APPROXIMATE.
3. CANAL TO BE RESHAPED TO ENTER INTAKE OF NEW DROP STRUCTURE.
4. EXISTING DROP 1 STRUCTURE TO BE BACKFILLED, COMPACTED, AND SEEDED WITH NATIVE SEED MIX.



PROFILE VIEW

SCALE: HORIZ & VERT 1" = 20'-0"

HDR

ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY
NOT FOR
CONSTRUCTION
OR
RECORDING

FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
DROP 1
SITE PLAN AND PROFILE

0 1" 2"

FILENAME 03C-034.DWG

SCALE AS SHOWN

SHEET 03C-034

N

30 0 30 60

SCALE IN FEET

ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

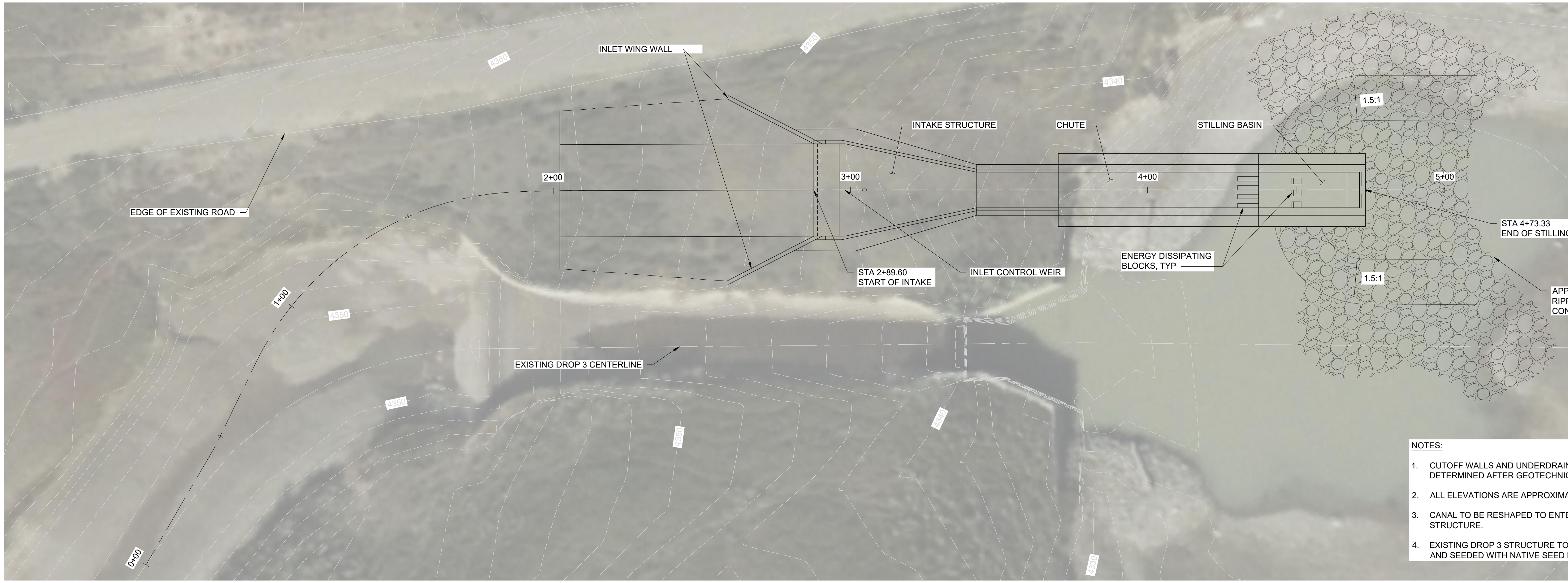
CIVIL
DROP 1
CONSTRUCTION EXTENTS

0 1" 2"

FILENAME	03C-035.DWG
SCALE	AS SHOWN

SHEET
03C-035

1	2	3	4	5	6	7	8

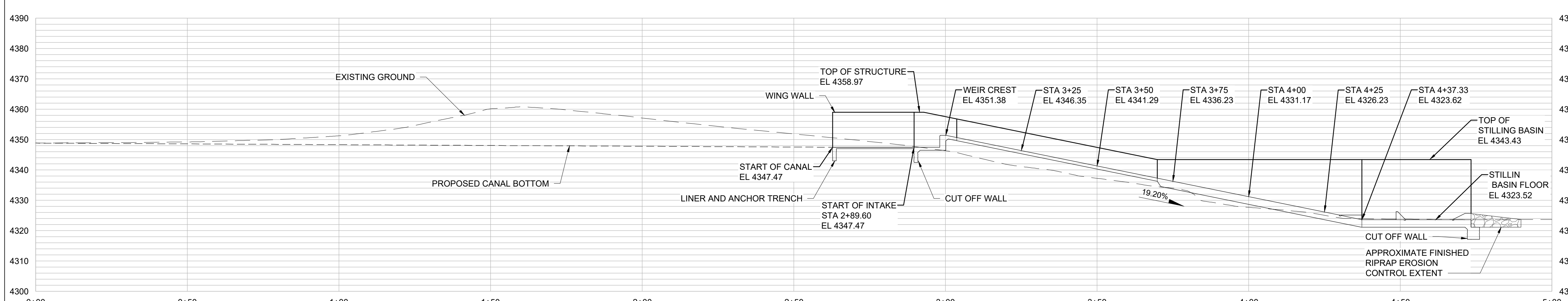


NOTES:

1. CUTOFF WALLS AND UNDERDRAIN LOCATIONS TO BE DETERMINED AFTER GEOTECHNICAL INVESTIGATION.
2. ALL ELEVATIONS ARE APPROXIMATE.
3. CANAL TO BE RESHAPED TO ENTER INTAKE OF NEW DROP STRUCTURE.
4. EXISTING DROP 3 STRUCTURE TO BE BACKFILLED, COMPACTED, AND SEEDED WITH NATIVE SEED MIX.

PLAN VIEW

SCALE: 1" = 20'-0"



PROFILE VIEW

SCALE: HORIZ & VERT 1" = 20'-0"

D
C
B
A

HDR

ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
DROP 3
SITE PLAN AND PROFILE

0 1" 2"

FILENAME 03C-036.DWG

SCALE AS SHOWN

SHEET **03C-036**

PROJECT MANAGER S. SCHWEISSING
DESIGNER 1
DRAWN BY
CHECKED BY
PROJECT NUMBER 10337597

ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
DROP 3
CONSTRUCTION EXTENTS

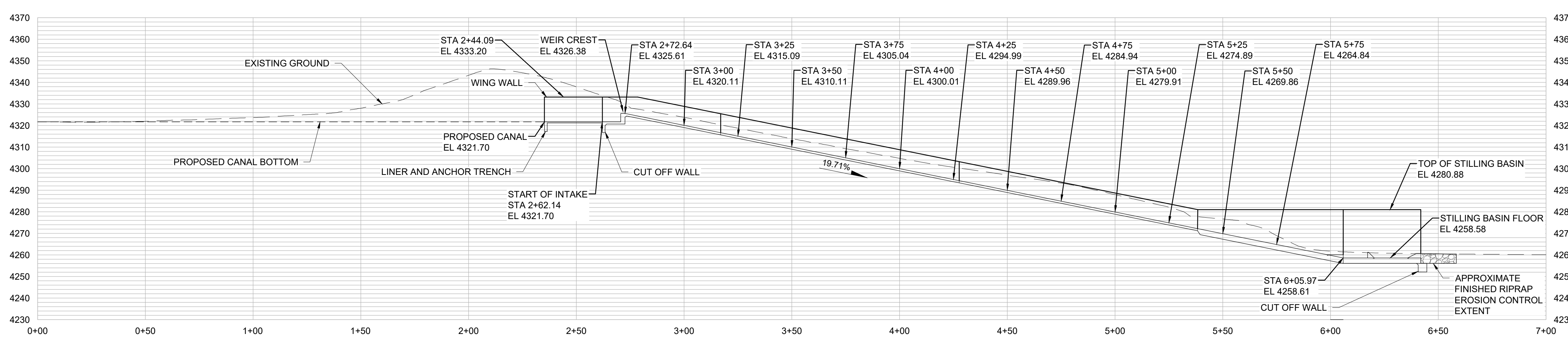
FILENAME 03C-037.DWG
SCALE AS SHOWN
SHEET 03C-037

NOTES:

1. CUTOFF WALLS AND UNDERDRAIN LOCATIONS TO BE DETERMINED AFTER GEOTECHNICAL INVESTIGATION.
2. ALL ELEVATIONS ARE APPROXIMATE.
3. CANAL TO BE RESHAPED TO ENTER INTAKE OF NEW DROP STRUCTURE.
4. EXISTING DROP 4 STRUCTURE TO BE BACKFILLED, COMPACTED, AND SEEDED WITH NATIVE SEED MIX.

PLAN VIEW

SCALE: 1" = 30'-0"



PROFILE VIEW

SCALE: HORIZ & VERT 1" = 30'-0"

HDR

ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
DROP 4
SITE PLAN AND PROFILE

0 1" 2"

FILENAME 03C-038.DWG

SCALE AS SHOWN

SHEET 03C-038

N

40 0 40 80
SCALE IN FEET

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

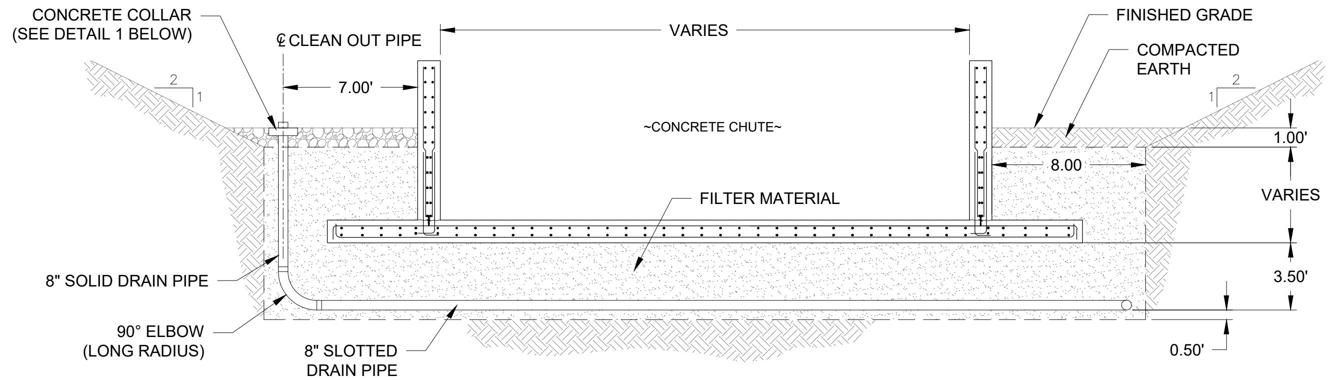
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
DROP 4
CONSTRUCTION EXTENTS

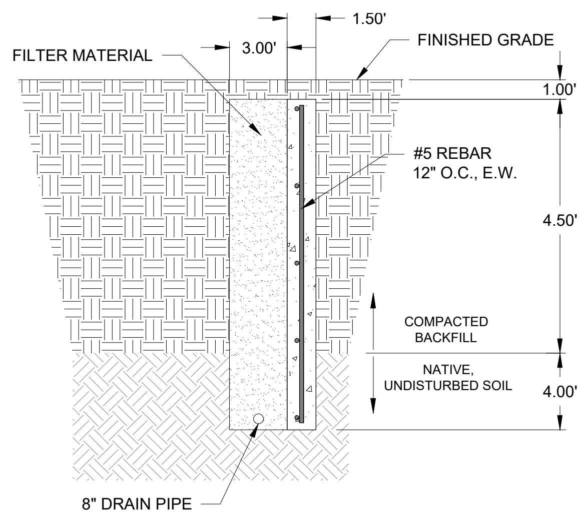
0 1" 2"

FILENAME 03C-039.DWG
SCALE AS SHOWN

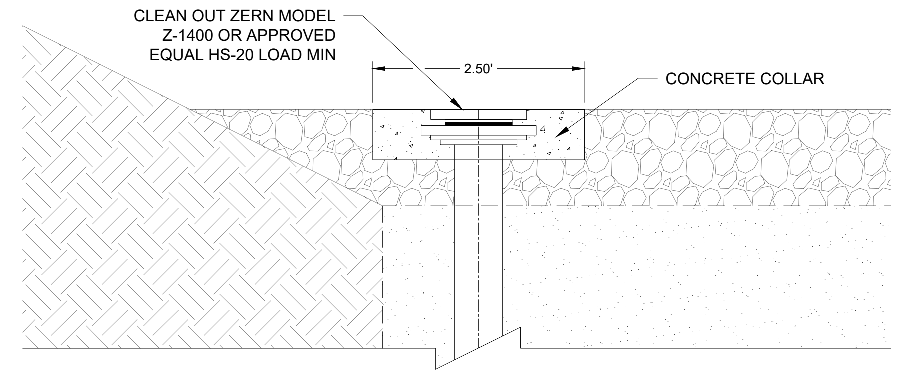
SHEET
03C-039



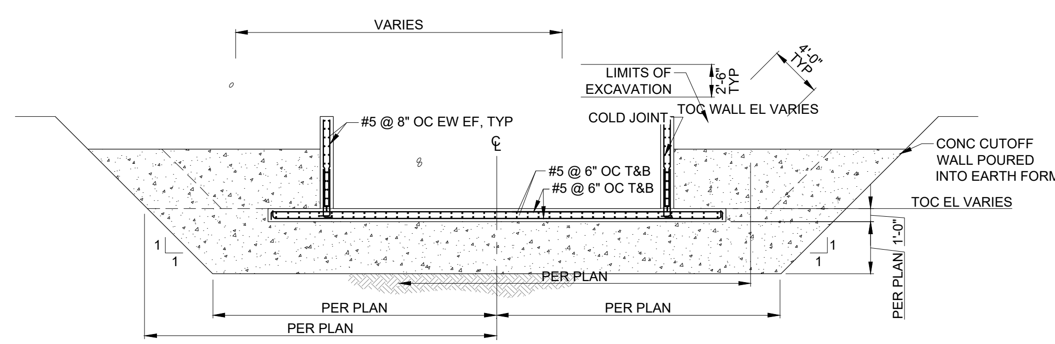
FILTER DIAPHRAGM SECTION 1 (X / XXX)
SCALE: 1" = 5'-0"



FILTER DIAPHRAGM SECTION 2 (X / XXX)
NOT TO SCALE



FILTER DIAPHRAGM CLEAN OUT DETAIL (X / XXX)
NOT TO SCALE



CUTOFF WALL SECTION (X / XXX)
NOT TO SCALE

ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

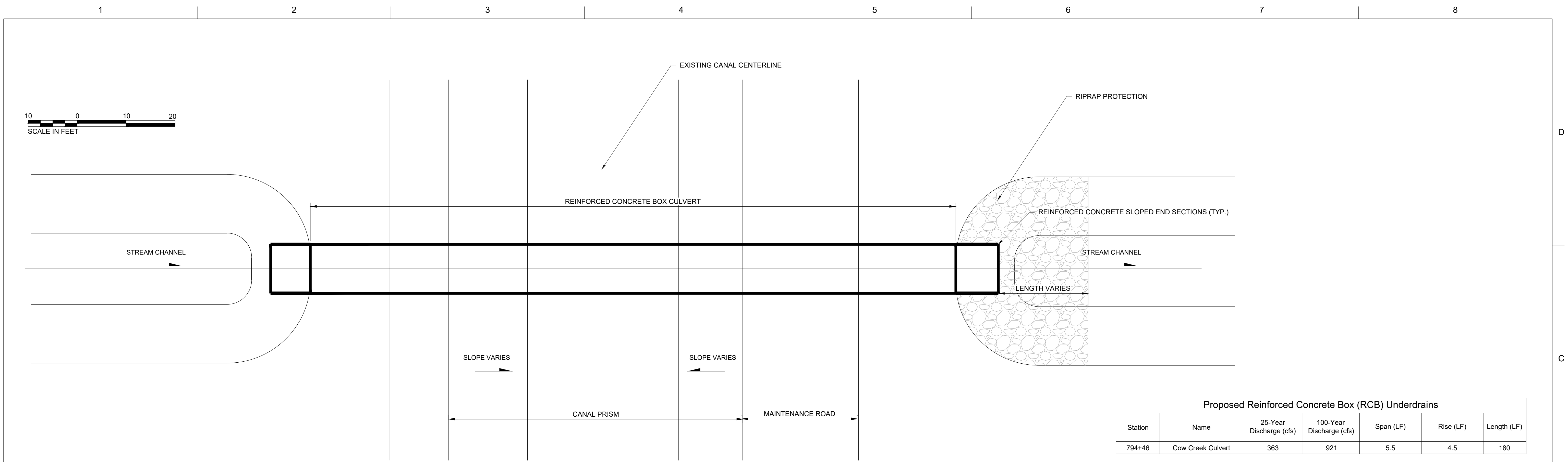
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
SECTIONS AND DETAILS 1

0 1" 2"

FILENAME 03C-040.DWG
SCALE AS SHOWN

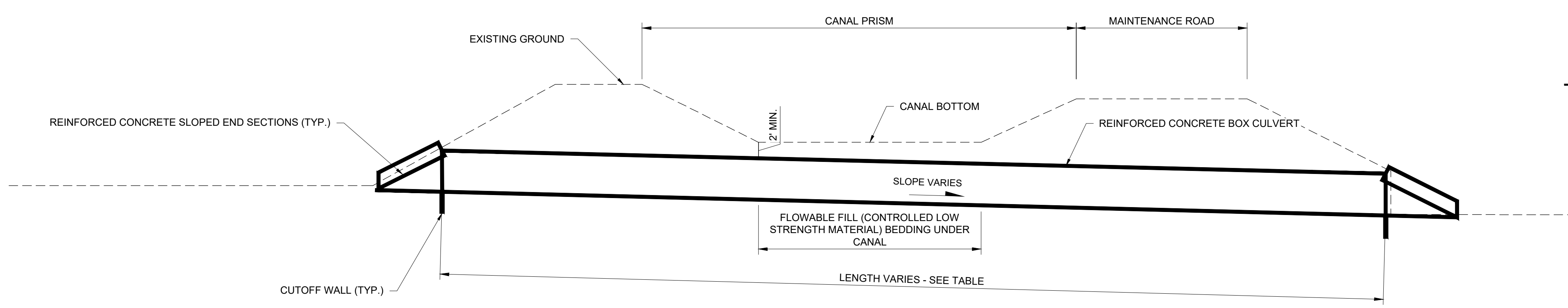
SHEET **03C-040**



Proposed Reinforced Concrete Box (RCB) Underdrains						
Station	Name	25-Year Discharge (cfs)	100-Year Discharge (cfs)	Span (LF)	Rise (LF)	Length (LF)
794+46	Cow Creek Culvert	363	921	5.5	4.5	180

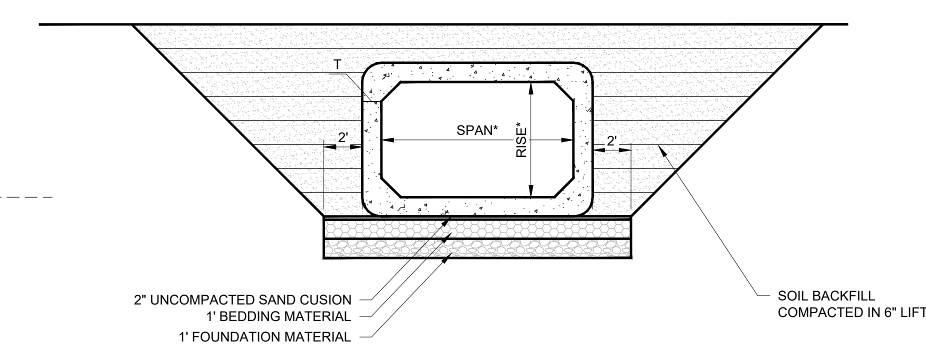
PLAN VIEW
SCALE: 1" = 10'-0"

SECTION B-B



PROFILE VIEW
SCALE: HORIZ & VERT 1" = 10'-0"

SECTION A-A



*SPAN AND RISE VARY - REFER TO TABLE

SECTION VIEW
SCALE: HORIZ & VERT 1" = 5'-0"

ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

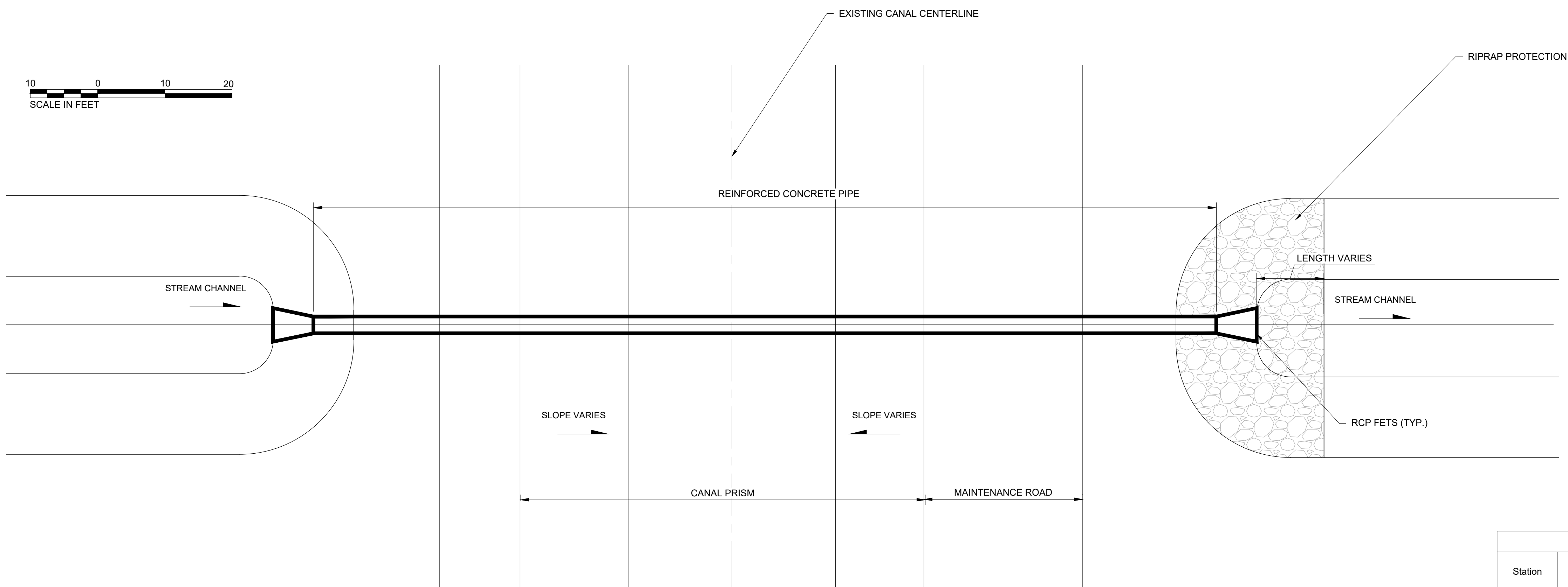
CIVIL
BOX CULVERT DETAIL

0 1" 2"

FILENAME 03C-041.DWG
SCALE AS SHOWN

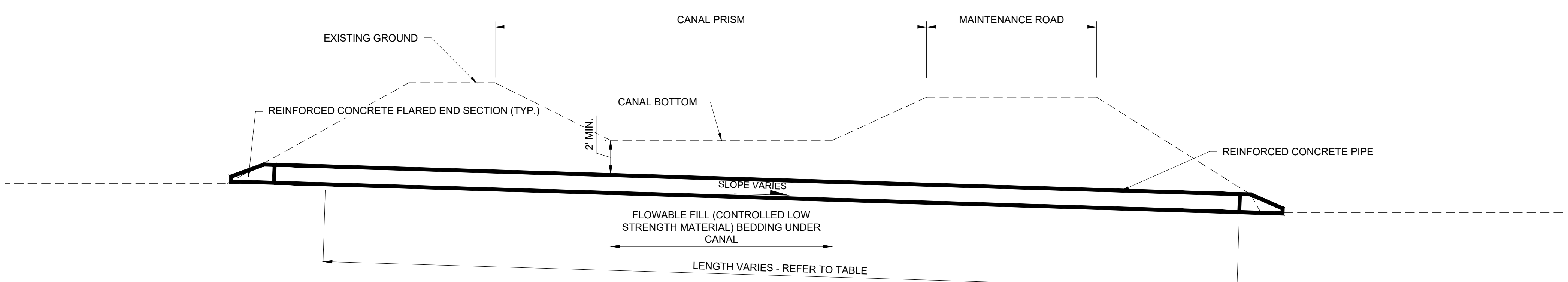
SHEET **03C-041**

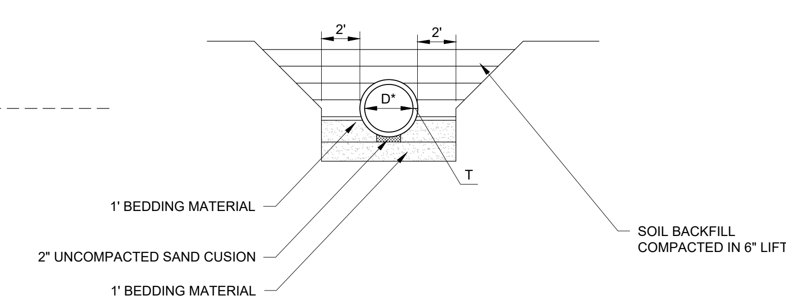
10 0 10 20
SCALE IN FEET



Proposed Reinforced Concrete Pipe (RCP) Underdrains					
Station	Name	25-Year Discharge (cfs)	100-Year Discharge (cfs)	Diameter (D) (in)	Length (LF)
330+69	Powell Creek Culvert	681	1630	2 x 66" RCP	2 x 150
979+70	Culvert	152	421	30" RCP	144
1052+72	Culvert	100	290	30" RCP	140
1096+93	Culvert	65	196	30" RCP	168
1134+68	Culvert	65	196	30" RCP	144
1194+29	Culvert	38	121	30" RCP	158

PLAN VIEW
SCALE: 1" = 10'-0"





*D VARIES - REFER TO TABLE

PROFILE VIEW
SCALE: HORIZ & VERT 1" = 10'-0"

SECTION VIEW
SCALE: HORIZ & VERT 1" = 5'-0"

HDR

ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

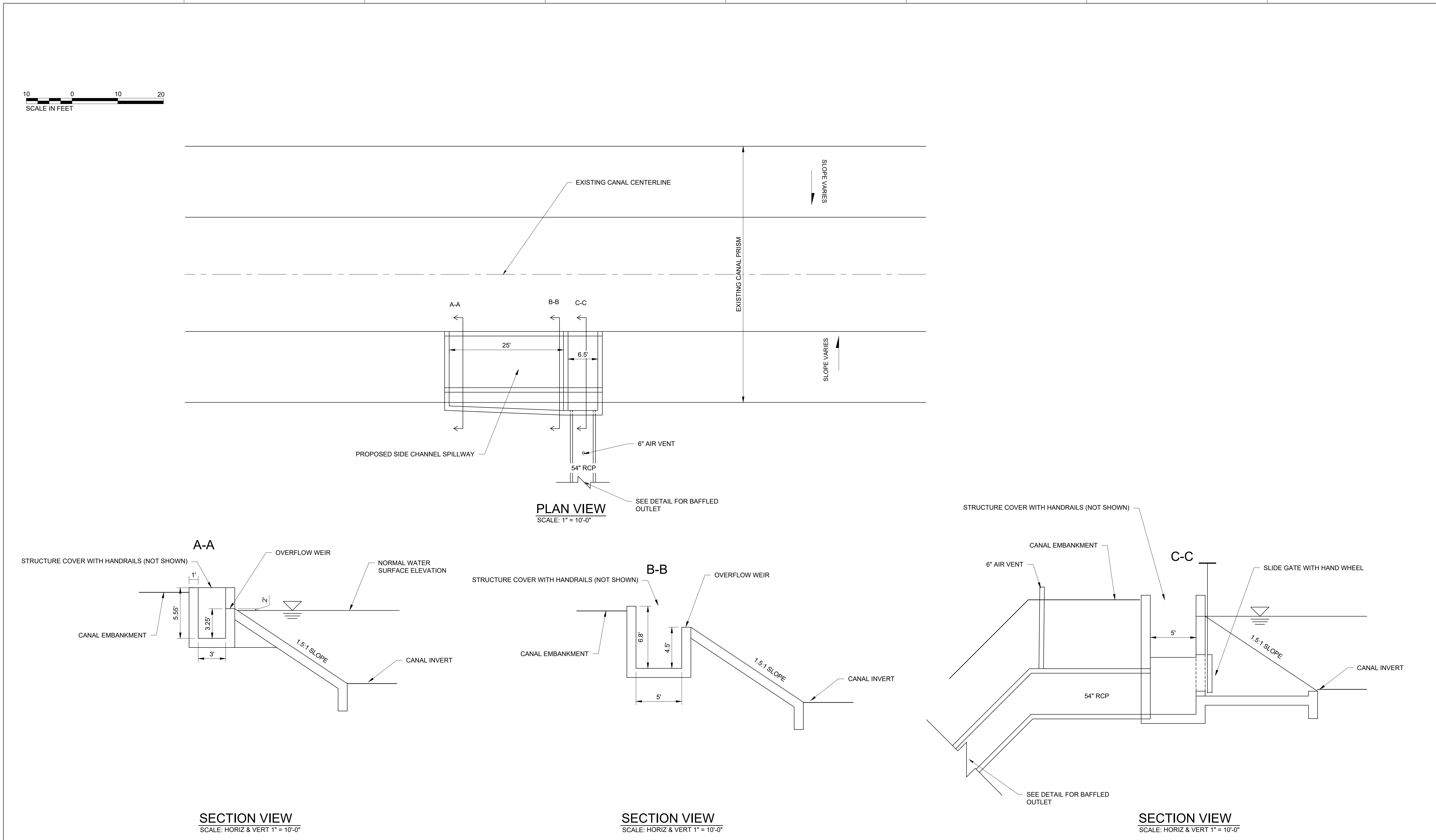
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
CIRCULAR CULVERT DETAIL

0 1" 2"

FILENAME 03C-042.DWG
SCALE AS SHOWN

SHEET
03C-042



HDR

ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

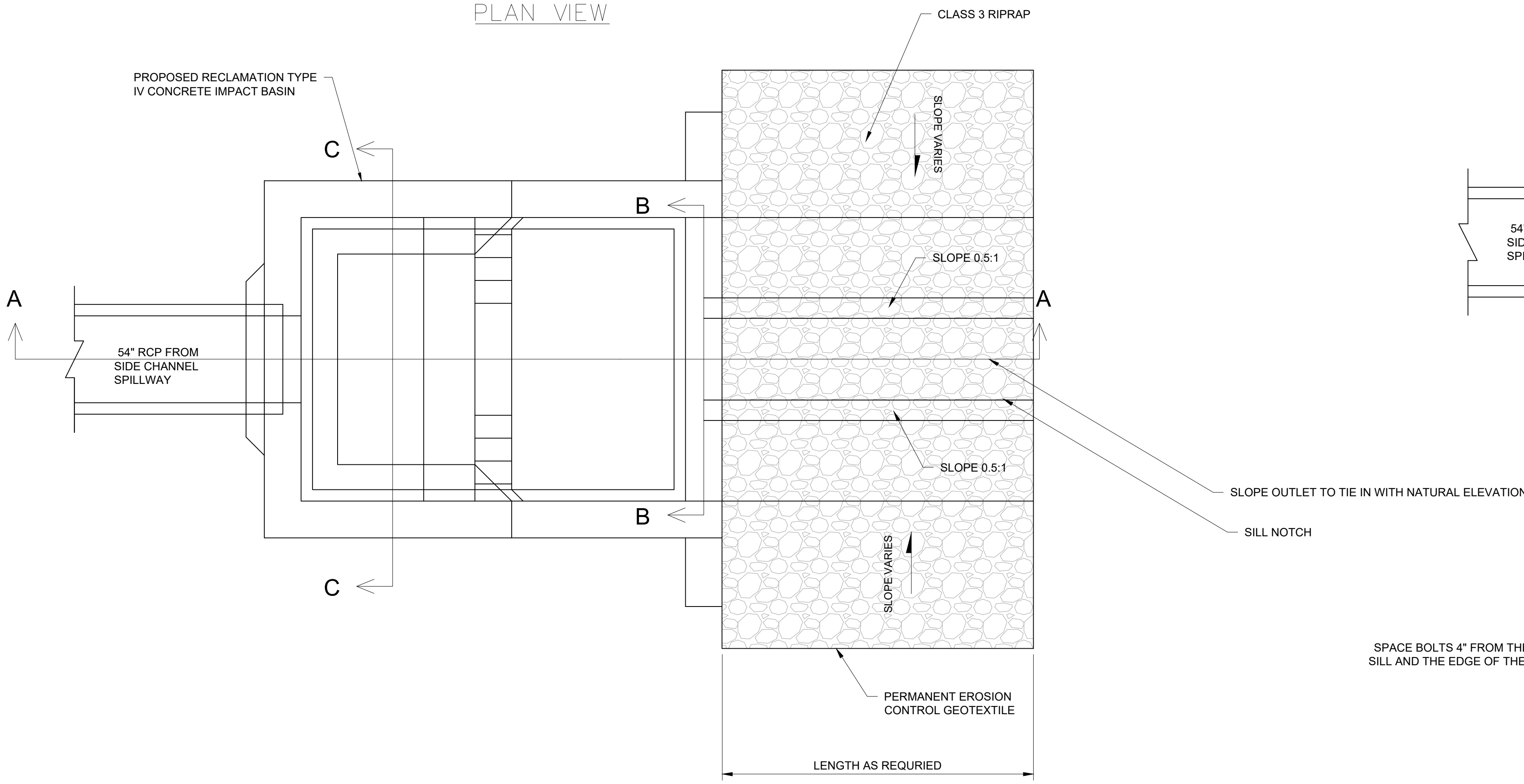
CIVIL
SIDE CHANNEL SPILLWAY DETAIL

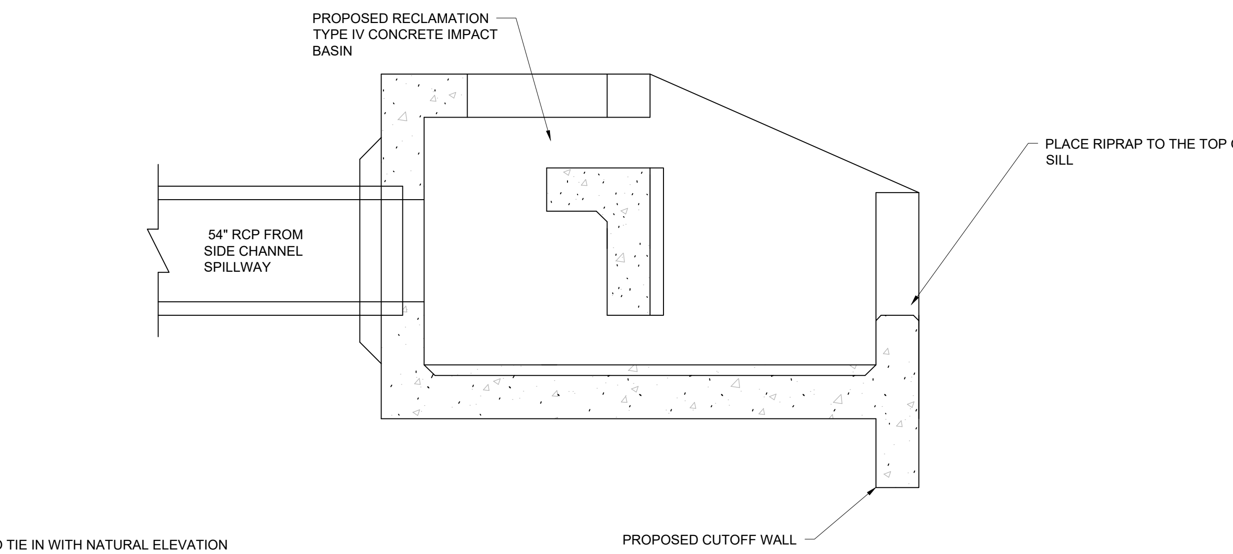
0 1" 2"

FILENAME 03C-043.DWG
SCALE AS SHOWN

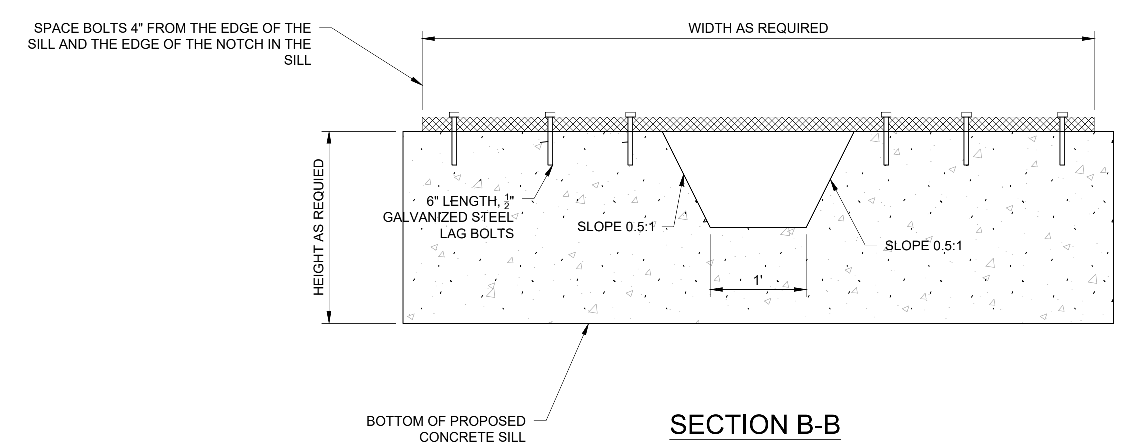
SHEET **03C-043**

PLAN VIEW

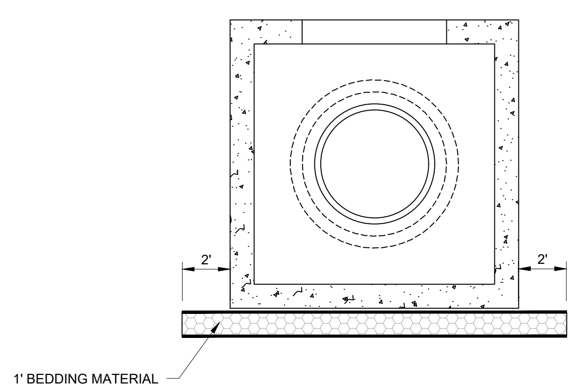




SECTION A-A



SECTION B-B



SECTION C-C

HDR

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

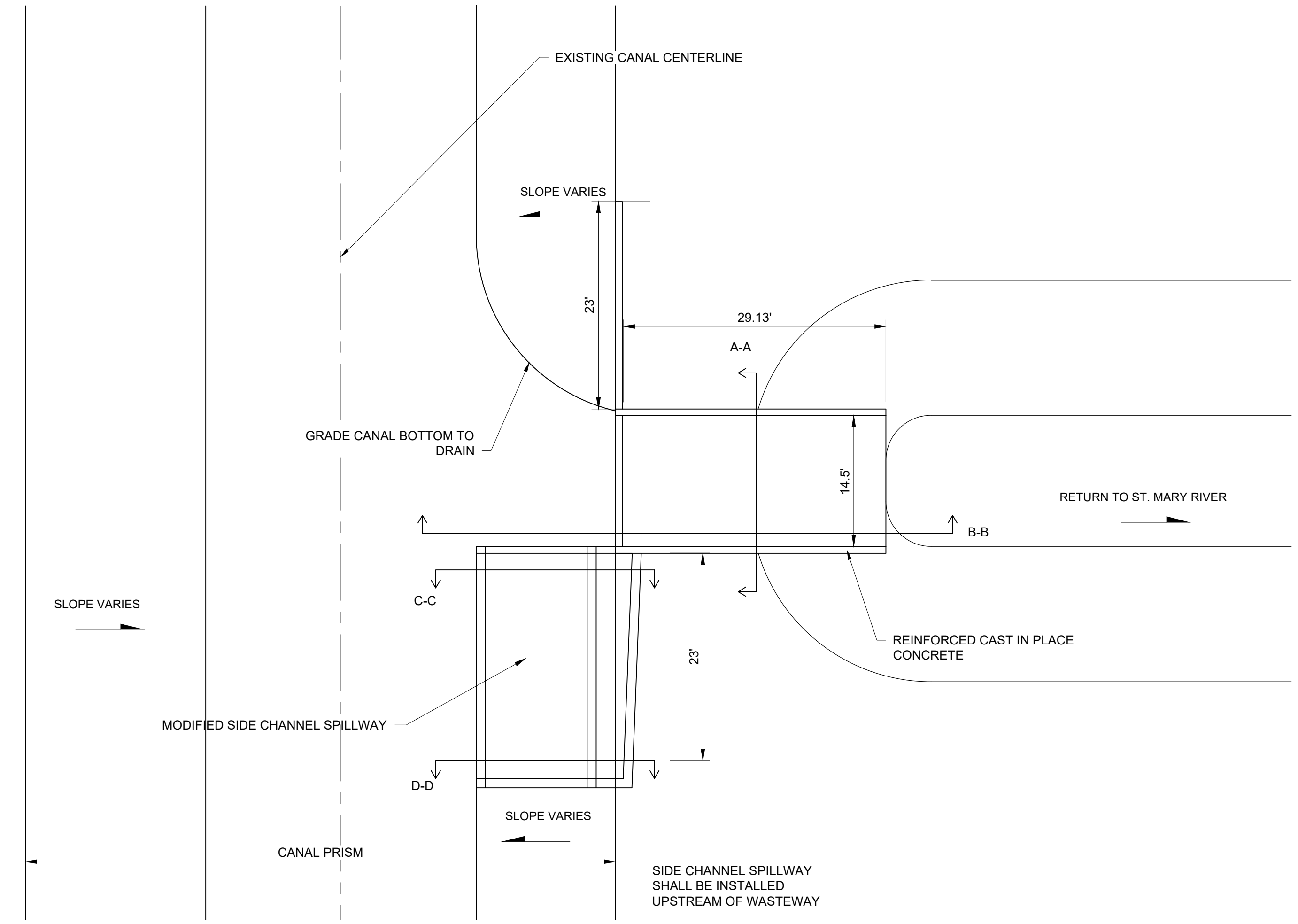
CIVIL
SPILLWAY OUTLET DETAIL

0 1" 2"

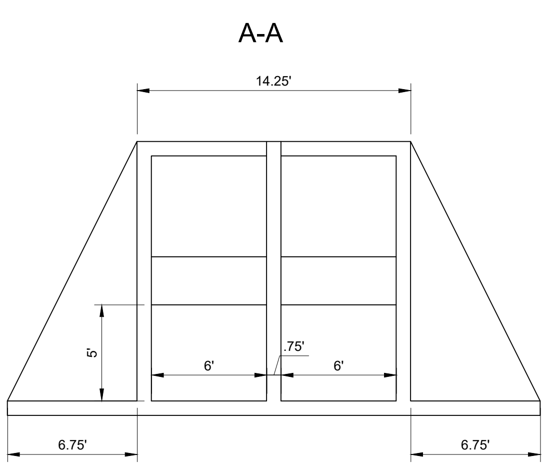
FILENAME 03C-044.DWG
SCALE AS SHOWN

SHEET
03C-044

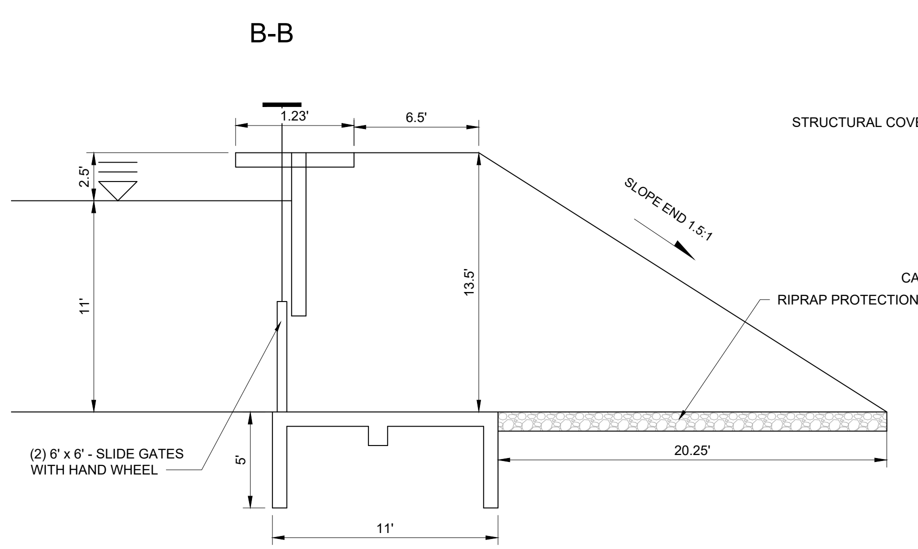
10 0 10 20
SCALE IN FEET



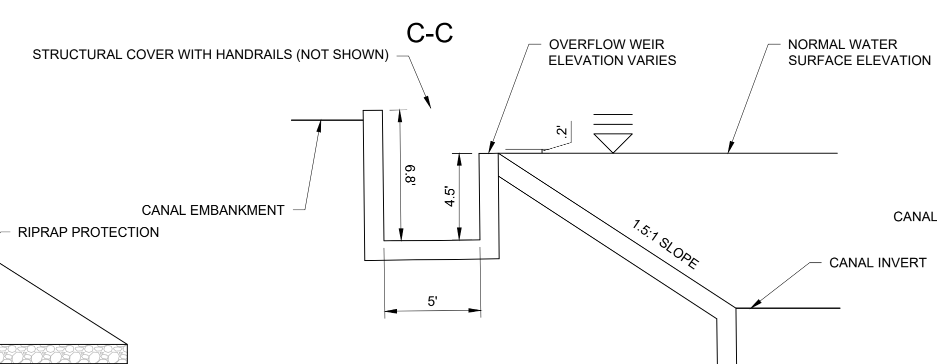
PLAN VIEW
SCALE: 1" = 10'-0"



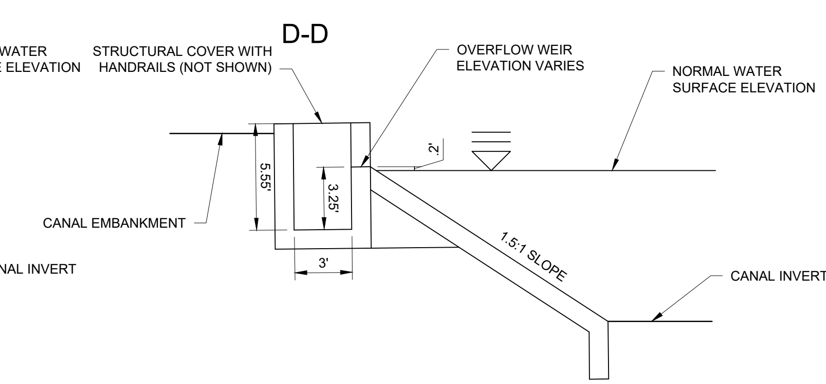
SECTION VIEW
SCALE: HORIZ & VERT 1" = 5'-0"



SECTION VIEW
SCALE: HORIZ & VERT 1" = 10'-0"



SECTION VIEW
SCALE: HORIZ & VERT 1" = 5'-0"



SECTION VIEW
SCALE: HORIZ & VERT 1" = 5'-0"

HDR

ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

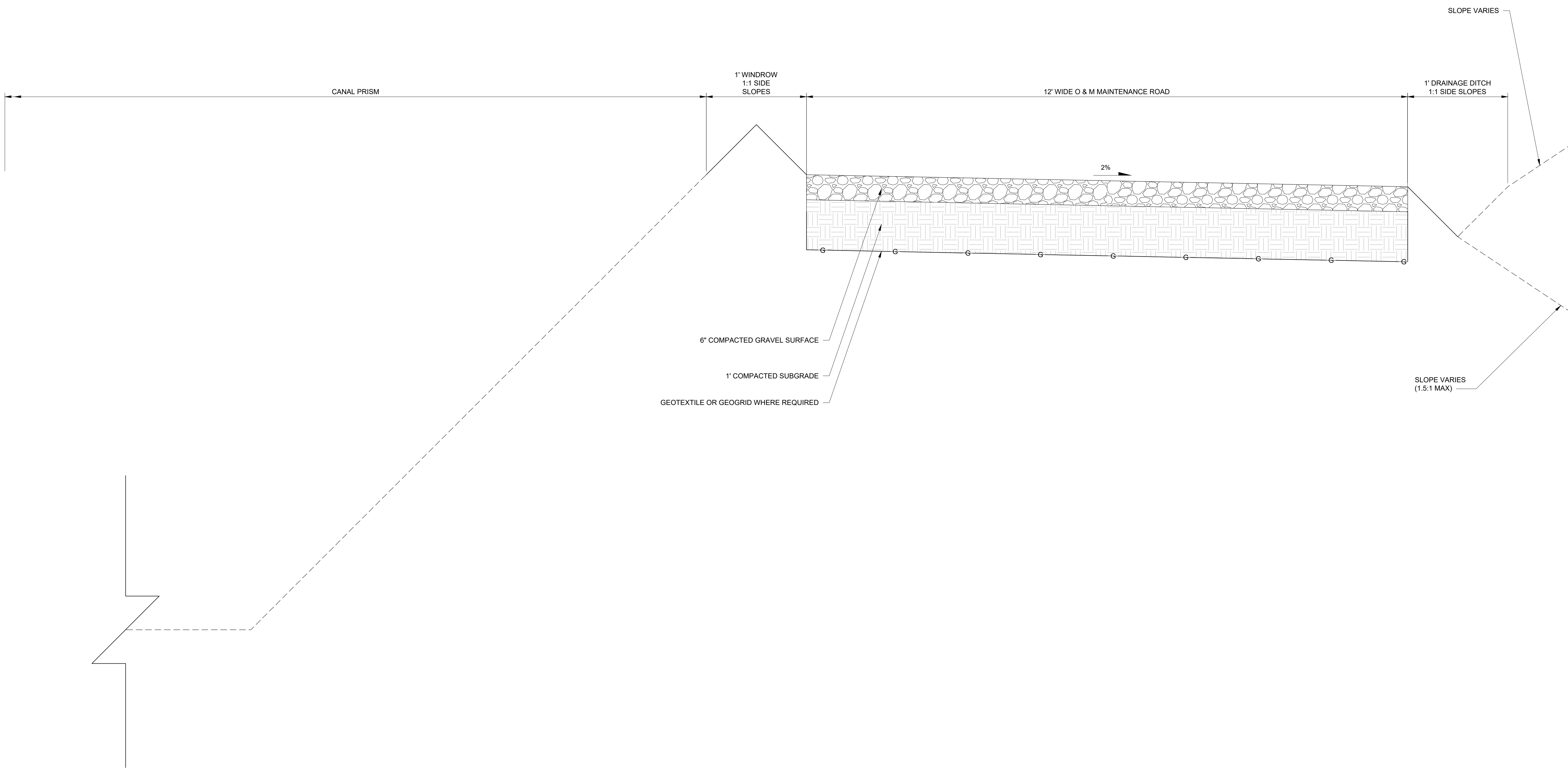
FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

CIVIL
KENNEDY CREEK AND HALLS COULEE WASTEWAY DETAIL

0 1" 2"

FILENAME 03C-045.DWG
SCALE AS SHOWN

SHEET **03C-045**



PROJECT MANAGER	S. SCHWEISSING
DESIGNER 1	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	10337597

ISSUE	DATE	DESCRIPTION
1	NOV 2022	10% DESIGN

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

FARMERS CONSERVATION ALLIANCE
ST MARY CANAL SIP

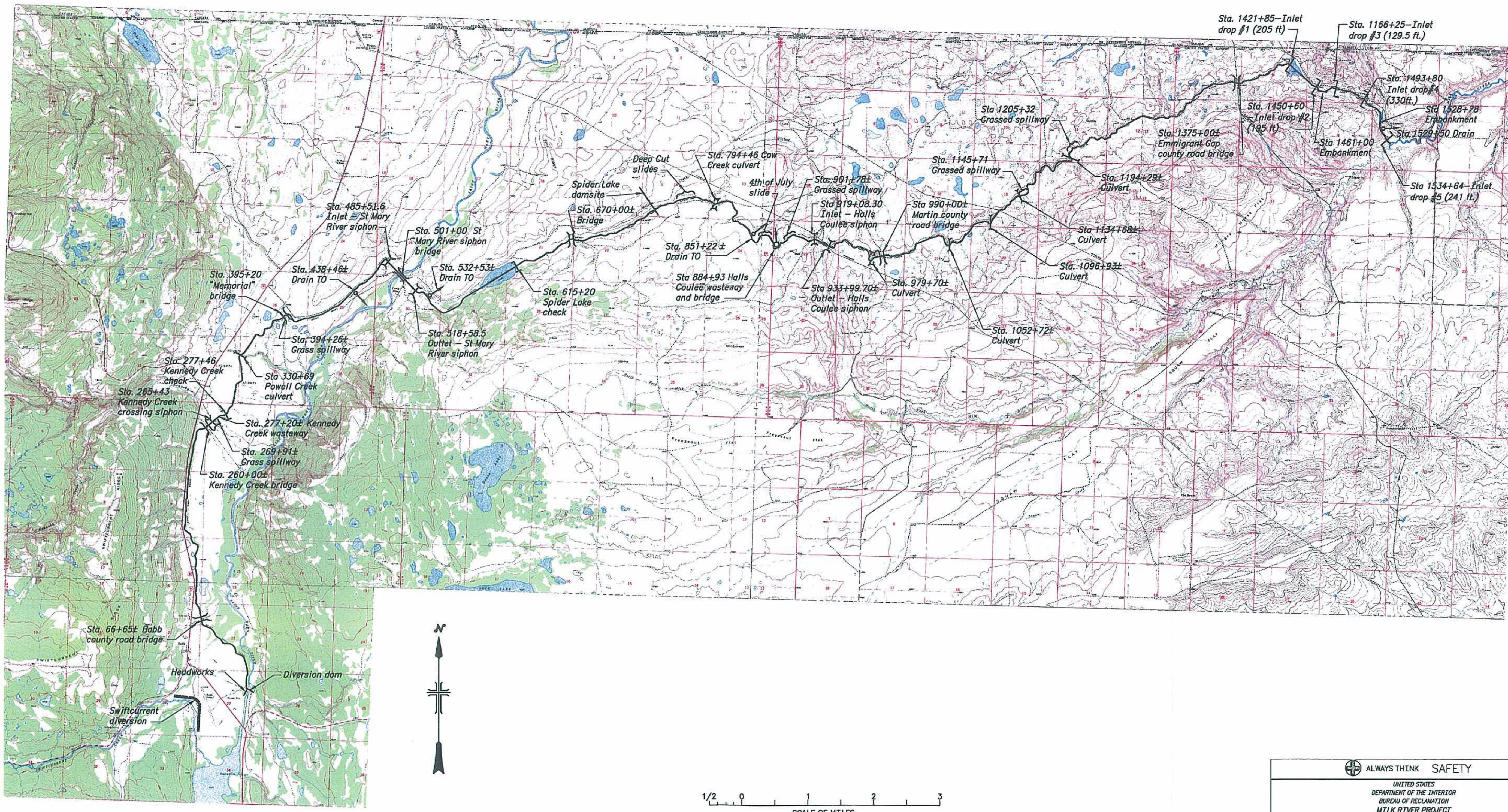
CIVIL
MAINTENANCE ROAD DETAIL

0 1" 2"

FILENAME 03C-046.DWG
SCALE AS SHOWN

SHEET **03C-046**

Appendix D. RECLAMATION ST. MARY LOCATION MAP



ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MILK RIVER PROJECT
NORTH CENTRAL MONTANA FEASIBILITY STUDY

ST. MARY CANAL

LOCATION MAP

LOCATION MAP

DESIGNED G. GLIKO CHECKED
DRAWN ENGINEERING SUPPORT TECH. APPR. GEORGE A. GLIKO, P.E.
APPROVED LD ARMER, P.E.

CADD SYSTEM AutoCAD Rel. 17.0s (LMS Tech)	CADD FILENAME X078C
BILLINGS, MONTANA 11/3/1999 SHEET 1 OF 1	15-600-593

DATE AND TIME PLOTTED
DECEMBER 12, 2006 09:25

FOR OFFICIAL USE ONLY