2002-18

Value Planning

Final Report

St. Mary Diversion Dam and Headworks Replacement

(A10-0015-4999-000-00-0-0 and 6A124)

March 28, 2002

Conducted in Cooperation with the Blackfeet Indian Nation, Alfalfa Irrigation District, Milk River Joint Board of Control, U.S. Fish and Wildlife Service, and Bureau of Reclamation - Montana Area Office and Great Plains Region

Bureau of Reclamation, Technical Service Center, Denver, Colorado

Table of Contents

Executive Summary

The Value Study Team met on March 11, 2002, for a 5-day study of the proposed St. Mary Diversion Dam and Headworks Replacement Project. The estimated preliminary construction cost of the baseline concept is $ 10,000,000. The Team developed nine proposals which are summarized below. If all the avoidance proposals are accepted, their maximum avoidance potential is $6,615,000 (from Proposal Nos. 4 and 5). Note that in calculating the maximum potential avoidances, the cost of the study ($30,000) was deducted only once.

The following proposals are generally independent of each other and can be combined for increased benefits. However, Proposal Nos.1 and 8 are mutually exclusive, as are Proposal Nos. 5, 6, and 7.

Proposal No. 1. Use Gates to Raise the Diversion Crest and Retain Storage. The estimated added costs of this proposal are $234,000 before adding study and/or implementation costs. This proposal retains about 7,000 acre-feet of water annually. At $50 per acre-foot, the proposal would retain $350,000 worth of water annually.

Proposal No. 2. Install a Temporary Downstream Fish Passage in the Existing Sluiceway. The added costs of this proposal were not formally estimated. However the study team feels the costs would be around $10,000 before deducting study and/or implementation costs. This proposal provides reduced canal entrainment until permanent fish screens are installed.

Proposal No. 3. Replace the Proposed Fish Flume Ladder with a Rock Ramp. The estimated added costs of this proposal are $655,000 before adding study and/or implementation costs. This proposal would provide greatly improved upstream fish passage efficiency for a broader range of species.

Proposal No. 4. Use the Existing Dam and Build New Headworks, Fish Screens, and Fish Passage. The estimated avoidances of this proposal are $1,650,000 before deducting study and/or implementation costs.

Proposal No. 5. Replace Drum Screens with an Electric Barrier System. The estimated avoidances of this proposal are $4,995,000 before deducting study and/or implementation costs. This proposal includes new (unproven) technology which after use, may be determined to provide insufficient protection for listed species. If this occurs, the Electric Barrier System may require replacement by or augmentation with another remedy.

Proposal No. 6. Replace the Drum Screen with an Infiltration Gallery. The estimated added costs of this proposal are $4,385,000 before adding study and/or implementation costs. The study team was asked to present this proposal to document that is was pursued, even though it appears to provide less value than the baseline.

Proposal No. 7. Replace the Drum screens with Vertical Screens. The estimated avoidances of this proposal are $815,000 before deducting study and/or implementation costs. The study team did not have time to prepare life cycle comparisons, but feels the vertical screens will also have lower operation and maintenance costs than drum screens.

Proposal No. 8. Move the proposed headworks to St. Mary Lake. The estimated added costs of this proposal are $216,000, before adding study and/or implementation costs. If the 4,100-foot dike to prevent future migration of Swiftcurrent Creek is omitted (or greatly shortened and relocated to protect only the headworks area), the proposal would provide an avoidance of $462,000 to $362,000.

Proposal No. 9. Locate a temporary Rock Fish Pass Channel on the East Side of the Diversion. The estimated added costs of this proposal are $37,000 before adding study and/or implementation costs.

Other Ideas: The Team identified 27 additional ideas for further consideration and development that are listed in the "Disposition of Ideas" table near the end of this report.

Value Study Team Members

Name/Title/Discipline	Address/Phone Number
Norm Hyndman Value Study Team Leader General Engineer	Bureau of Reclamation, Technical Service Center PO Box 25007 (D-8170), Denver CO 80225-0007 Phone: 303-445-3251 FAX: 303-445-6475 E-mail: nhyndman@do.usbr.gov
Patrick Erger Part time Value Study Assistant Team Leader Hydraulic Engineer	Bureau of Reclamation, Montana Area Office PO Box 30137 (MT-745), Billings MT 59101 Phone: 406-247-7313 FAX: 406-247-7338 E-mail: perger@gp.usbr.gov
Jim Mogen Fisheries Biologist	U.S. Fish and Wildlife Service, Bozeman Office 4052 Bridger Canyon Road, Bozeman MT59715 Phone: 406-582-0717 FAX: 406-586-6798 E-mail: jim_mogen@fws.gov
Orrin Ferris Civil Engineer	Blackfeet Tribe (HKM Engineering) PO Box 31318, Billings MT 59107 Phone: 406-656-6399 FAX: 406-656-6398 E-mail: oferris@hkminc.com
Sue Camp Fisheries Biologist	Bureau of Reclamation, Montana Area Office PO Box 30137 (MT-225), Billings MT 59101 Phone: 406-247-7668 FAX: 406-247-7338 E-mail: scamp@gp.usbr.gov
Jack Gist Irrigation District Member	Alfalfa Irrigation District, Milk River Joint Board of Control Rural Route 1, Box 7, Chinook MT 59523 Phone: 406-357-4183 FAX: None E-mail: gistfarm@ttc-cmc.net
Kay Blatter Irrigation District Member	Fort Belknap Irrigation District, Milk River Joint Board of Control, Route Route1, Box 105, Chinook MT 59523 Phone: 406-357-2931 FAX: 406-357-3177 E-mail: none
Jerry Moore Civil Engineer	Bureau of Reclamation, Montana Area Office PO Box 30137 (MT-430), Billings MT 59101 Phone: 406-247-7308 FAX: 406-247-7338 E-mail: jmoore@gp.usbr.gov
Brent Mefford Civil Engineer	Bureau of Reclamation, Technical Service Center PO Box 25007 (D-8560), Denver CO 80225-0007 Phone: 303-445-2149 FAX: 303-445-6324 E-mail: bmefford@do.usbr.gov

Value Study Team Members

George Gliko Civil Engineer	Bureau of Reclamation, Great Plains Region Office PO Box 36900 (GP-2200), Billings MT 59107-6900 Phone: 406-247-7651 FAX: 406-247-7793 E-mail: ggliko@gp.usbr.gov
Allan Steiner Facilities Manager	Bureau of Reclamation, Tiber Dam/Milk River Field Office Tiber Dam (MT-460), Chester MT 59522 Phone: 406-456-3226 FAX: 406-456-3238 E-mail: asteiner@gp.usbr.gov
Richard Long Civil Engineer, Supervisor Part time team member	Bureau of Reclamation, Montana Area Office PO Box 30137 (MT-400), Billings MT 59101 Phone: 406-247-7307 FAX: 406-247-7338 E-mail: rlong@gp.usbr.gov

Acknowledgment of Design Team and Consultant Assistance

The Value Study Team wishes to express their thanks and appreciation to the Design Team Leader, Mr. George Gliko, and the members of the design team, who fully and cordially provided all requested information and consultation on the conceptual design. The team would not have been as successful without the design team's cooperation and assistance.

The Value Study Team wishes also to express thanks and appreciation to those listed on the Consultation Record of this report. Their cooperation and help contributed significantly to the technical foundation and scope of the team's investigation and final proposals.

The goal of the value method is to achieve the most appropriate and highest value solution for the project. It is only through the efforts of a diverse, high performing team, including all those involved, that this goal can be achieved. This study is the product of such an effort.

Value Method Process

The Value Method is a decision making process, originally developed in 1943 by Larry Miles, to creatively develop alternatives that satisfy essential functions at the highest value. It has many applications but is most often used as a management or problem-solving tool.

The study process follows a Job Plan that provides a reliable, structured approach to the conclusion. Initially, the team examined the component features of the program, project or activity to define the critical functions (performed or desired), governing criteria, and associated costs. Using creativity (brainstorming) techniques, the team suggested alternative ideas and solutions to perform those functions, consistent with the identified criteria, at a lower cost or with an increase in long term value. The ideas were evaluated, analyzed and prioritized, and the best ideas were developed to a level suitable for comparison, decision making and adoption.

This report is the result of a "formal" Value Study, by a team comprised of people with the diversity, expertise, and independence needed to creatively attack the issues. The team members bring a depth of experience and understanding of the discipline they represent, and an open and independent enquiry of the issues under study, to creatively solve the problems at hand. Ideally, the team members have not been notably involved in the issues prior to the study. The team applied the Value Method to the issues and supporting information, and took a "fresh look" at the problems to create alternatives that fulfill the client's needs at the greatest value.

Current Description

The St. Mary Diversion Dam and Headworks is located about 10 miles south of the Montana - Canada Border and about 5 miles east of Glacier National Park. It is on the St. Mary River about 1 mile north and downstream of the Lower St. Mary Lake outlet. It was constructed between 1913 and 1915 and is part of the Milk River Project in north central Montana. See Figure No. 1.

During the 1880's, settlers in the Milk River Valley first built individual irrigation systems (Chinook Irrigation Districts). In the 1890's a lack of water in the Milk River Basin prompted investigations to find supplemental water. The selected plan involved trans-basin diversion of water by a 29-mile canal from the St. Mary River Basin near Babb, Montana, to the headwaters of the north fork of the Milk River. This system was built in the early 1910's and 1920's.

The diversion dam and headworks diverts water at rates of up to 850 cubic feet per second (CFS) from upstream reservoirs and snowmelt runoff into the St. Mary Canal. The water then flows down by way of the 29-mile St. Mary Canal discharging into the North Fork of the Milk River. The water then flows through Canada for 216 miles before returning to the United States where it is stored in Fresno Reservoir, located west of Havre, Montana. From Fresno Reservoir the water is released to irrigate about 120,600 acres of land.

The diversion dam has a crest elevation of 4472.3 (1988 vertical datum, including a 1-foot batter board), a crest length of about 250 feet, including a 57-foot-wide sluiceway section at the west end made up of six sluice gates. Only two sluice gates are currently operated. The headworks consists of eight slide gates, each 5 feet by 5 feet 6 inches. Gates 1 and 4 are currently inoperable. See Figure No. 2.

Typically the canal is watered up in early March. From early March through late September water is released from the upstream reservoirs, as needed, 1) to maximize the amount of snowmelt runoff and stored water available to the canal, 2) to provide the flows in the St. Mary River below the dam required to meet the 1909 Boundary Waters Treaty Act, and 3) to prevent flooding. During most of time the canal is in use the sluicegates are closed. Most of the time diversions vary from as much as 3/4 of the river flows (typically in June and July) to as little as 1/4 of the river flows (in March and September). From late September until early March the canal is typically empty and the sluice gates are open.

After almost ninety years of operation, the diversion dam and headworks may be near or at the end of its service life. Thirty six concrete cores were drilled to better estimate the structural integrity of the dam and headgates. Only a few cores were intact enough to perform load testing. From test results, concrete strength from intact cores appears to range from about 2300 to 3600 pounds per square inch (psi). Normal concrete strengths are above 4000 psi.

At the time of this study, Reclamation is preparing a North Central Montana Regional Feasibility Study, as part of a larger effort to explore water supply problems and opportunities in the Milk River and Marias River basins.

Current Description

In 1999, the U. S. Fish and Wildlife Service listed the St. Mary Bull Trout as a threatened species under the Federal Endangered Species Act. Reclamation, in cooperation with the Milk River Irrigation Districts Joint Board of Control, is currently in informal consultation with the U.S. Fish and Wildlife Service to prepare the Biological Assessment addressing proposed actions to protect the species.

When the canal is carrying water (typically from early March to late September), the diversion dam is a barrier to upstream fish migration and some fish are entrained in the canal. Bull Trout and other fish species have become isolated and perished in the canal. When the canal is not carrying water (typically late September to early March, when the headworks gates are closed and the sluice gates are open) the dam is not a significant barrier to migration.

To address both fish migration needs and long term diversion and headworks needs, the design team is developing a concept to replace the diversion and headworks with a new dam and headworks slightly downstream of the existing structure that includes a fish screen in the canal (with a fish bypass to the river) and a fish ladder with the dam. The new structure would differ from the existing structure principally in having radial gates in the sluiceway and headworks, instead of stoplog panels and slide gates, respectively. See Figure No. 3.

The preliminary cost estimate for the replacement structure is $10,000,000. This amount includes $5,115,000 for a 240-foot-long drum screen, cleaning system, and fish bypass; $2,480,000 for the headworks; $2,360,000 for the diversion dam and fish ladder section; and $45,000 to relocate the existing in-canal gaging station. These figures include allowances for mobilization (10-15 percent), contingency (20-30 percent), and cold weather construction (10-15 percent).

Project funding is not expected for 5 or 10 years, in part because authorizations may be delayed until issues raised in the North Central Montana Feasibility Study are better known and negotiations over unallocated water rights of the Blackfeet Nation have begun. This study looked at both long term and short term alternatives.

Figure 1. Location Map.

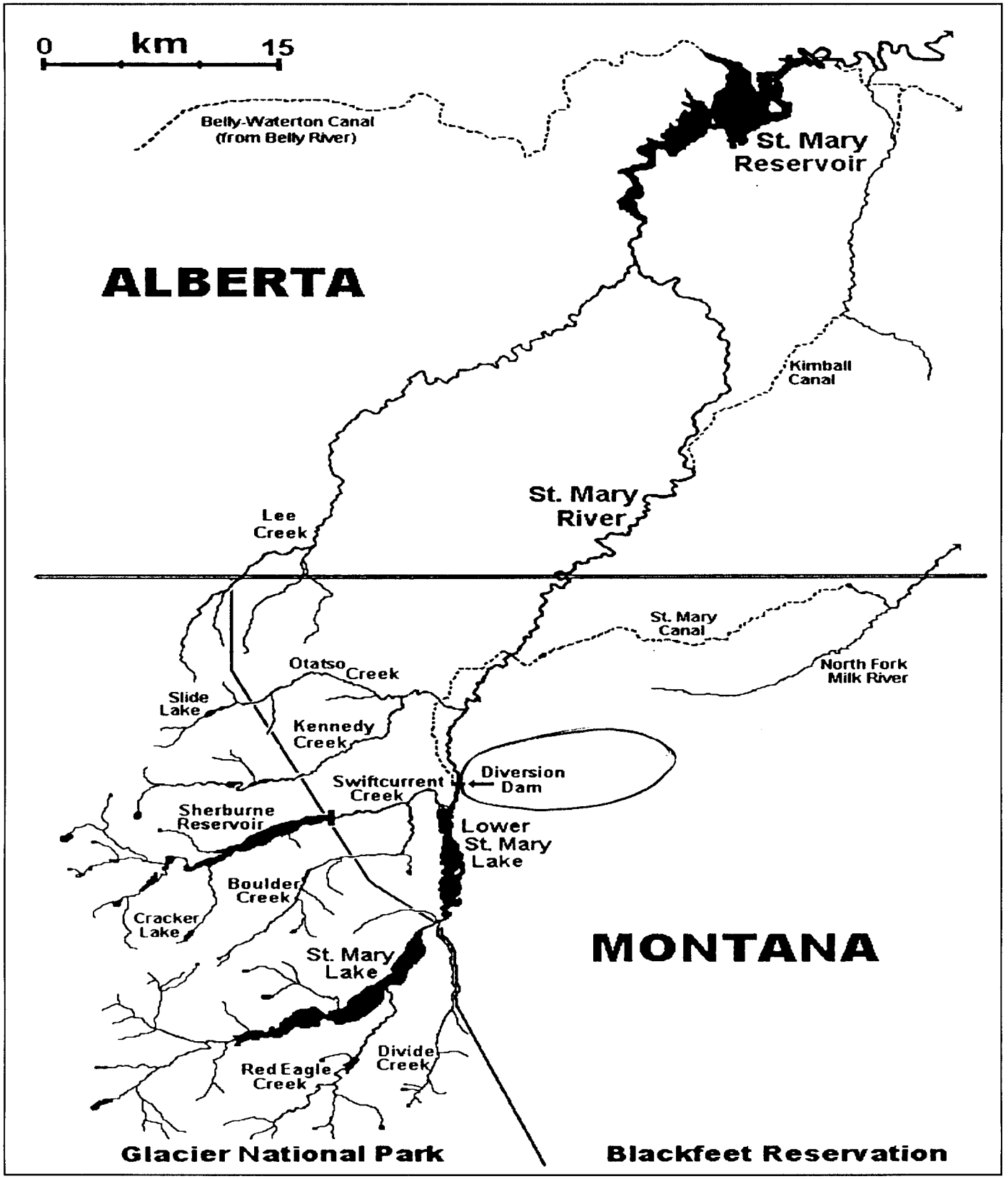


Figure 2. Site Map.

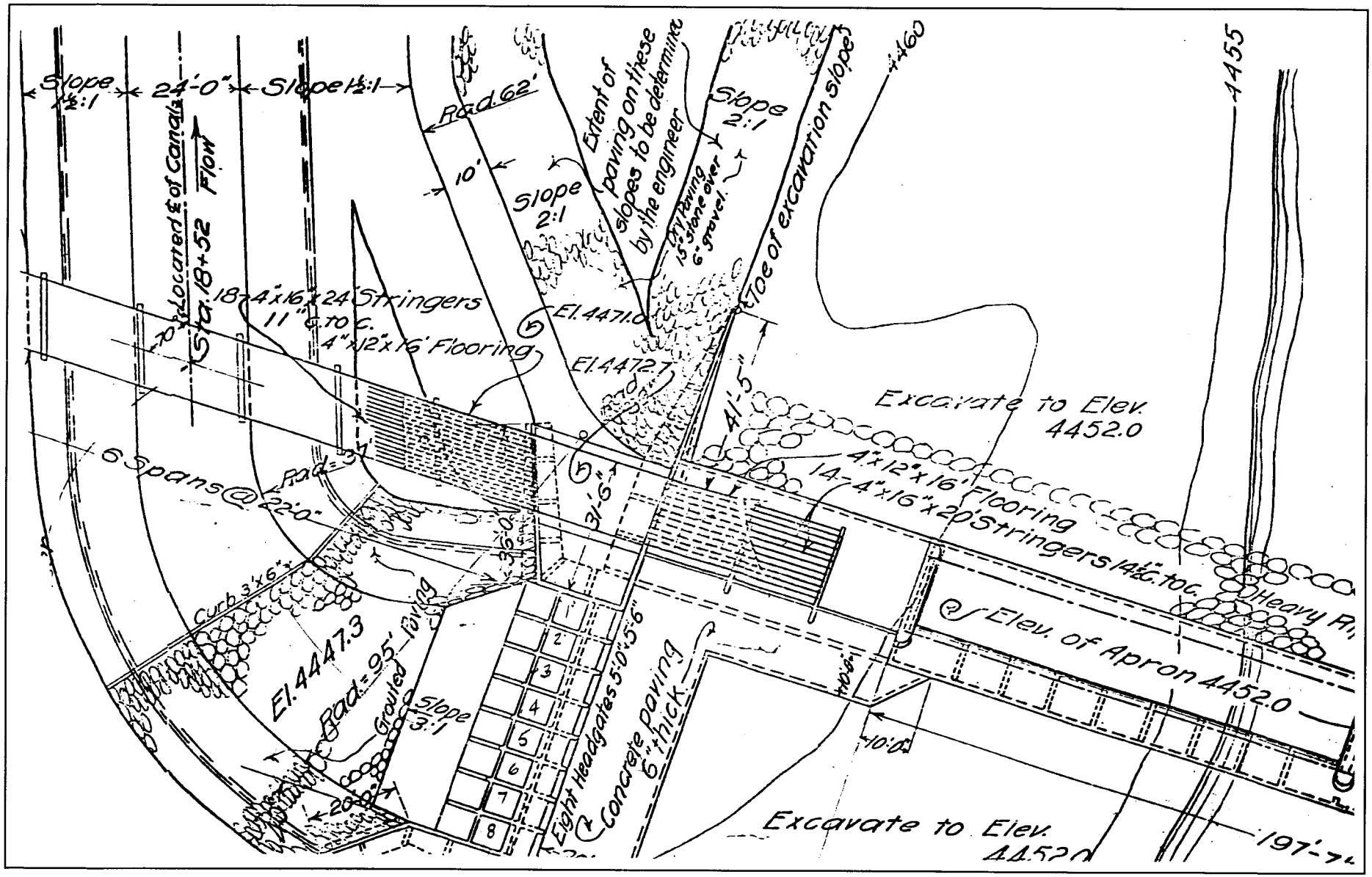
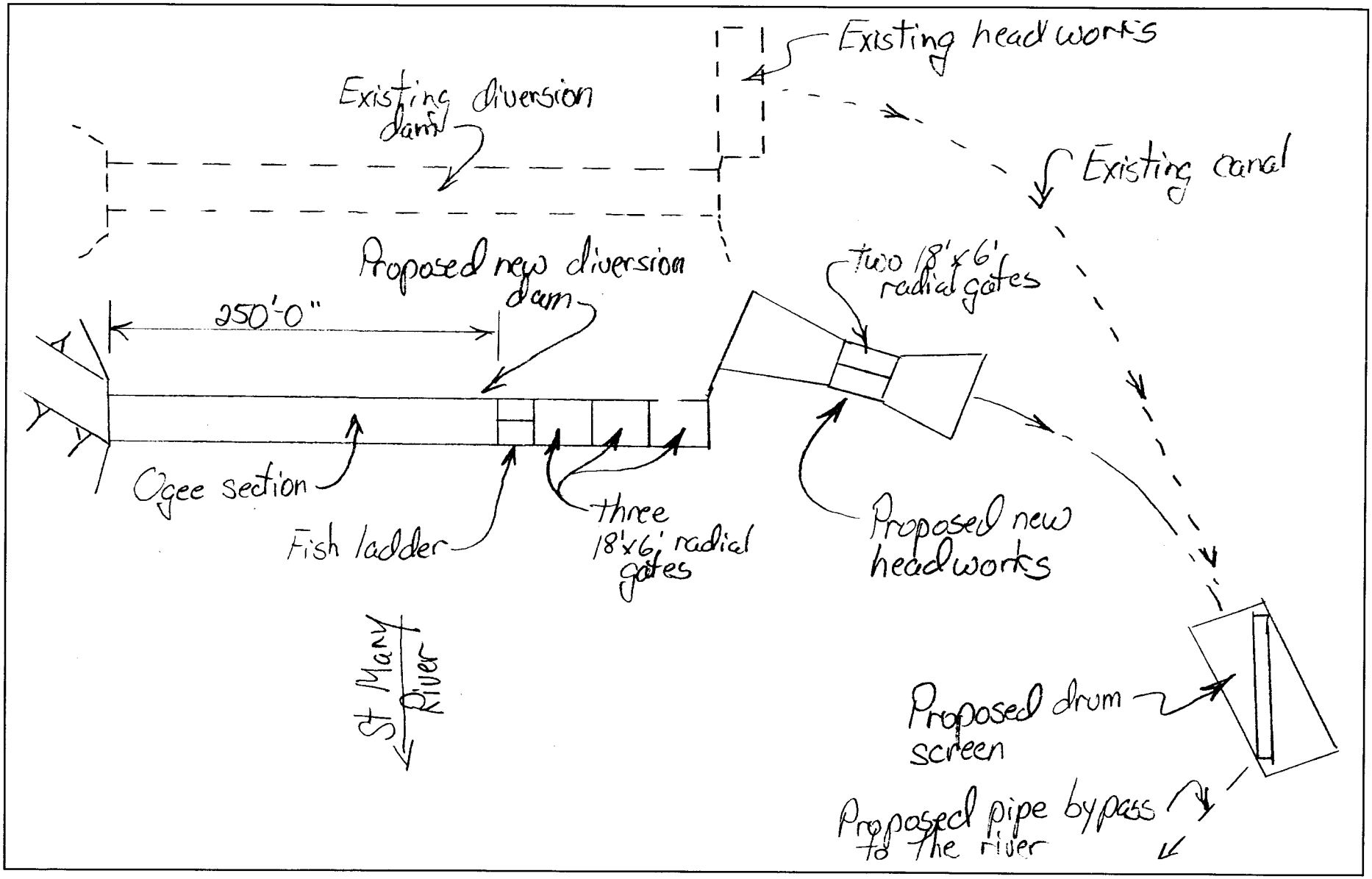


Figure 3. Baseline Schematic.



Owner, Users, and Stakeholders List
Identification and Issues Determination

Owner (Identification of the owner or owners)	Owner Issues (Identification of issues important to every owner)	Desire/ Criteria?
U. S Bureau of Reclamation	Compliance with Contract; Operation and Maintenance Compliance with all laws and regulations	Criteria Desire Criteria
User (Identification of the user or users)	User Issues (Identification of issues important to every user)	Desire/ Criteria?
Milk River Water Users	Reliability of Water Supply Cost of Water	Criteria Criteria
Blackfeet Tribe	In streamflow and aesthetics	Criteria
Stakeholder (Identify of the stakeholder or stakeholders)	Stakeholder Issues (Identification of issues important to every stakeholder)	Desire/ Criteria?
U.S. Fish and Wildlife Services	Migration barriers to threatened species	Criteria
Canada	St. Mary - Milk River allocations by international treaty	Criteria

Function Analysis

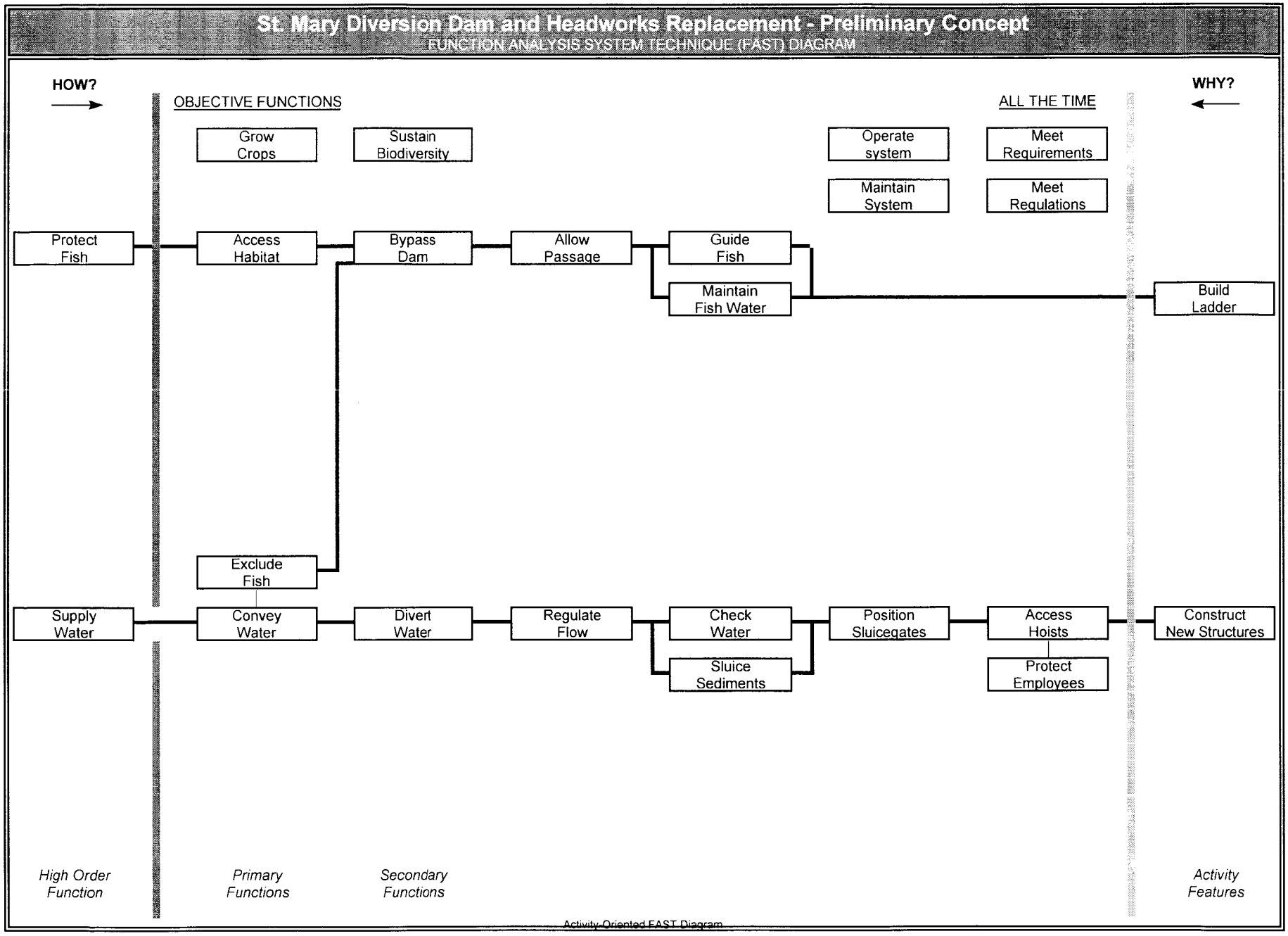
Component	Active Verb	Measurable Noun
Diversion Dam	Check Block Accumulate Degrade Pass	Water Fish Sediment Habitat Debris
Canal	Convey Leak Entrain Create Pass Generate	Water Water Fish Habitat Weeds Power
Headworks	Divert Catch Regulate Regulate Stop Entrain Supply Generate	Water Trash Water Diversion Fish Fish Water Power
Retaining Wall	Confine	Sediment
Sluice Gates	Pass Check Sluice Regulate	Water Water Sediment Water
Catwalk	Access Protect	Hoists Employees
Hoists	Position	Gates
Pulsators	Exclude Protect Exclude	Fish Fish Movement
Fish Screen	Exclude Protect	Fish Fish
Fish Ladder	Allow Elevate Bypass Bypass Access	Passage Fish Barrier Dam Habitat

Function Analysis

Water	Irrigate Grow Support Satisfy Transport Transport Drill	Land Crops Life Irrigators Weeds Exotics Wells
Debris	Block Block Create Damage Snag Trip	Gates Water Habitat Structure Lure Biologist
Fish	Sustain Satisfy Feed Feed	Biodiversity Laws Predators Fishermen

Function Analysis System Technique (FAST)

The Value Study Team used the function-analysis process to generate a Function Analysis System Technique (FAST) diagram, designed to describe the present solution from a functional point of view. The FAST diagram helped the Team identify those design features that support critical functions and those that satisfy noncritical objectives. The FAST diagram also helped the Team focus on potential value mismatches, and generate a common understanding of how project objectives are met by the present solution.


St. Mary Diversion Dam and Headworks Replacement - Preliminary Concept
FUNCTION ANALYSIS SYSTEM TECHNIQUE (FAST) DIAGRAM
HOW?
WHY?
OBJECTIVE FUNCTIONS
ALL THE TIME
Grow Crops
Sustain Biodiversity
Operate system
Meet Requirements
Maintain System
Meet Regulations
Protect Fish
Access Habitat
Bypass Dam
Allow Passage
Guide Fish
Maintain Fish Water
Build Ladder
Exclude Fish
Supply Water
Convey Water
Divert Water
Regulate Flow
Check Water
Position Sluicegates
Access Hoists
Construct New Structures
Sluice Sediments
Protect Employees
High Order Function
Primary Functions
Secondary Functions
Activity Features
Activity-Oriented FAST Diagram

St. Mary Diversion Dam and Headworks Replacement

VALUE STUDY

COST MODEL

COMPONENT/PERCENT PROJECT COST		PROJECT COST PROPORTION
Fish Screen and Bypass	(51.1%)	
Headworks	(24.8%)	
Diversion Dam and Ladder	(23.6%)	
Relocate Gaging Station	(0.4%)	

COST MODEL AND ESTIMATE INFORMATION

The Value Study Team cost model is based on the preliminary concept estimates provided by the design team for the preferred project design. The cost model was developed by the Value Study Team and was used to focus on features with the greatest potential for avoidances. In several cases unit prices were reviewed by the Cost Estimator and Value Study Team members, to ensure reliability and applicability.

Cost avoidances/savings and the original design concept estimates are of the same general level of development, although these costs may vary as final designs are pursued.

Proposal No. 1

Description

Proposal No. 1. Use Gates to Raise the Diversion Crest and Retain Storage.

- Proposal Description: This proposal would add gates along the full width of the new diversion dam. The gates would raise the crest elevation from the current elevation of the top of batter board at 4472.32 (1988 vertical datum) to a new crest height of elevation 4475.32. Crest gates would be lowered to pass flood flows. A west dike could be constructed, if needed to protect adjacent property. The raised crest backs about 3 feet of water into Lower St Mary Lake to retain about 7,000 acre-feet currently lost to winter releases and eliminates or greatly reduces the current practice of charging Lower St. Mary Lake to initiate spring flows into the canal. All elevations are on the 1988 vertical datum. See Figure Nos. 4 and 5.

- Critical Items to Consider: Protection of West Bank Landowners and, to some extent, the landowners along Lower St. Mary Lake.

- Ways to Implement: A separate gated 3-foot-tall structure (with a separate fish passage could be built at the Lower St. Mary Lake Outlet to retain storage. The whole diversion structure could be built at the Lake Outlet (See Proposal No. 8). Although an inflatable bladder and weir are shown, several gate types could be used or combined.

- Changes from the Baseline Concept: Add gates along the full width of the crest to raise the diversion dam crest about 3 feet. Extend the fish ladder to operate at the higher crest elevation.

Advantages	Disadvantages
• Conserve about 7,000 acre feet per year. • Reduces/eliminates charging Lower St Mary Lake. • Improves Lake aesthetics during the Spring season.	• None noted.

Potential Risks

Upstream passage for Burbot may be less efficient.

Proposal No. 1

Cost Items	Nonrecurring Costs
Original Baseline Concept	$ 0
Value Concept*	$ 234,000
Avoidances	$ (234,000)
Value Study Costs	$ 30,000
Implementation Costs	$ 0
Net Avoidances	**$ (264,000)**

* If the value of the retained water is $50/acre-foot, a conservative estimate, this idea would retain $350,000 worth of water every year, recovering the initial cost in less than one year, and providing additional benefits in all following years. The Value Concept cost was developed by the Study Team.

Figure 4. Plan of Diversion Weir Gates.

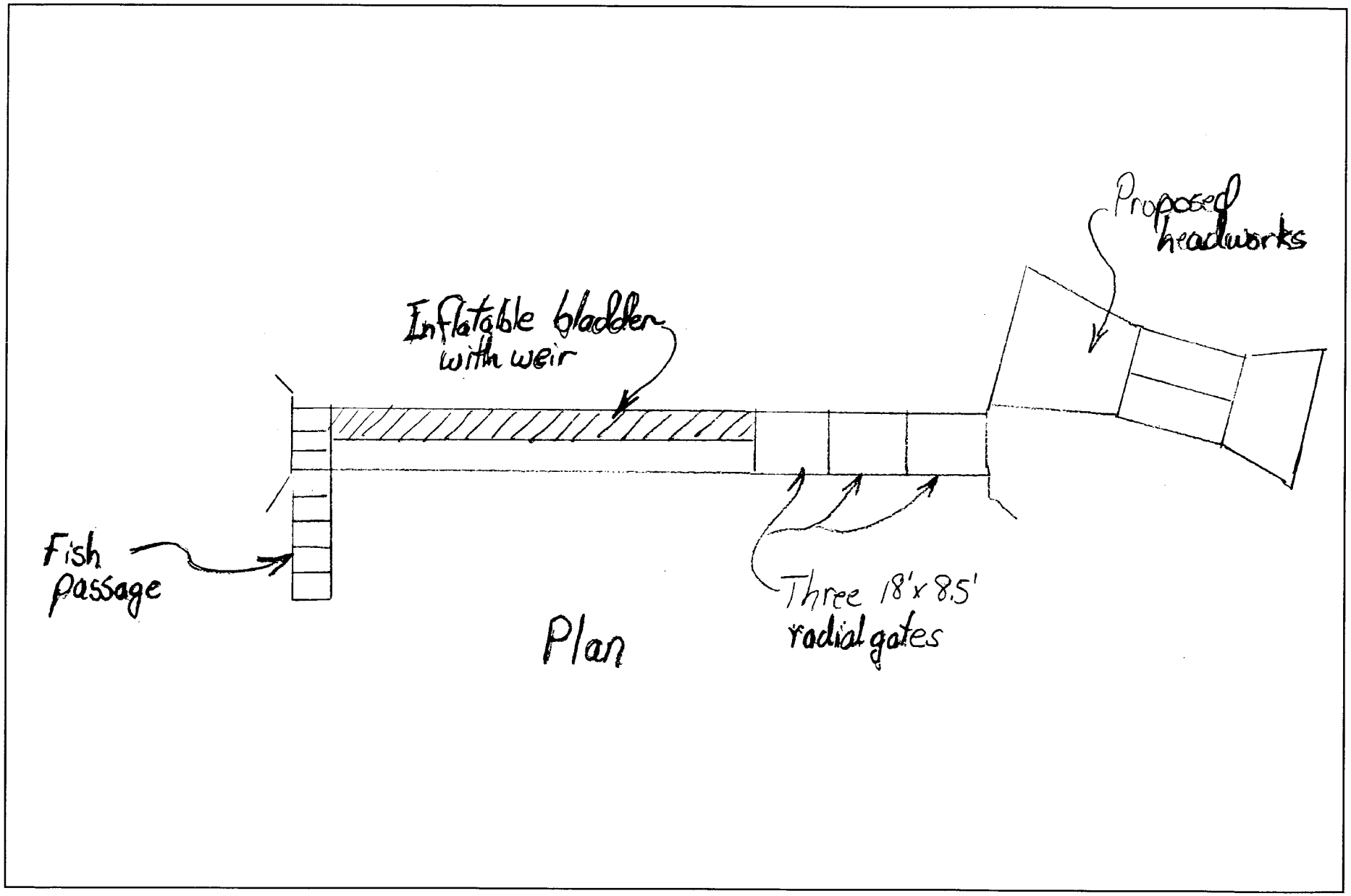
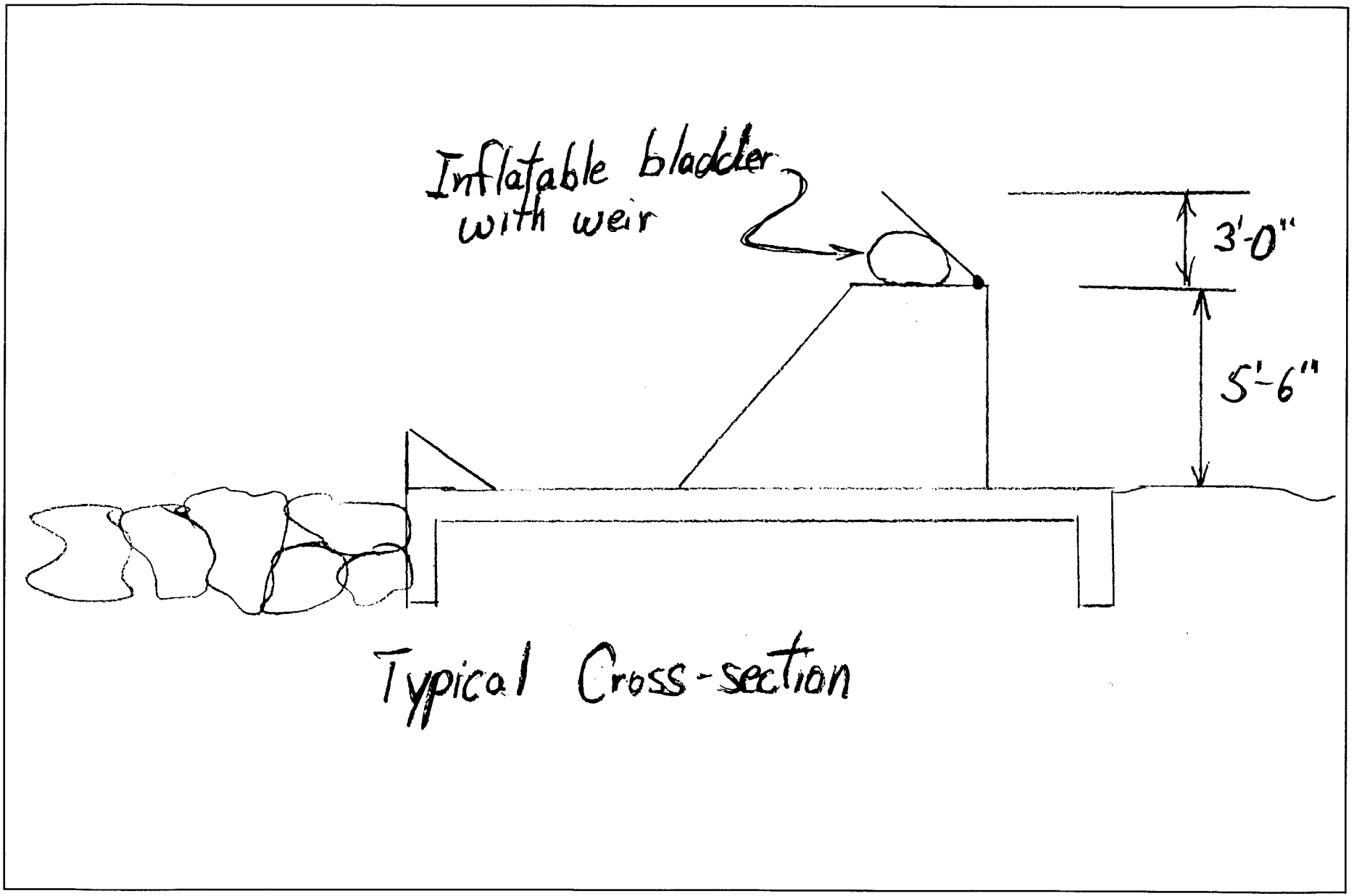


Figure 5. Section of Weir Gates.



Proposal No. 2

Description

Proposal No 2. Install a Temporary Downstream Fish Passage in the Existing Sluiceway.

- Proposal Description: For near-term fish protection, install a continuous sluice (a downstream fish bypass) in the easternmost existing sluiceway. This sluice would be used in conjunction with the Electric Fish Barrier to improve fish movement downstream. The entrance would be constructed of an angled steel plate to attract fish into the one-foot-wide discharge. The one foot opening would be fitted with a waterman slide gate for water control. The idea is to move fish away from the headgates and allow downstream passage. See Figure No. 6.

- Critical Items to Consider: The continuous sluice needs to be sized for the normal operation flow range and to not waste water. The sluice needs to be designed to maintain head for diversion.

- Ways to Implement: Install a "funnel" in the 3rd sluice bay. Provide access to operate the "funnel" in the 3rd bay. Remove existing stoplogs and silt from the 3rd bay. The "funnel" would be essentially the same as a typical inlet to a fish bypass. Use bypass flows to carry sediment out of the 3rd bay. A coarse trashrack could be installed in the existing stoplog slots if debris is a problem.

- Changes from the Baseline Concept: This proposal does not change the baseline. It provides improved downstream fish passage and indirectly improves performance of the electric fish barrier, prior to construction of the baseline.

Advantages	Disadvantages
• Reduces fish loss into the canal until the baseline is constructed. • Demonstrates progress towards Endangered Species Act compliance, facilitating Section 7 consultation. • May provide additional fish behavior information for design of the baseline.	• None noted.

Potential Risks

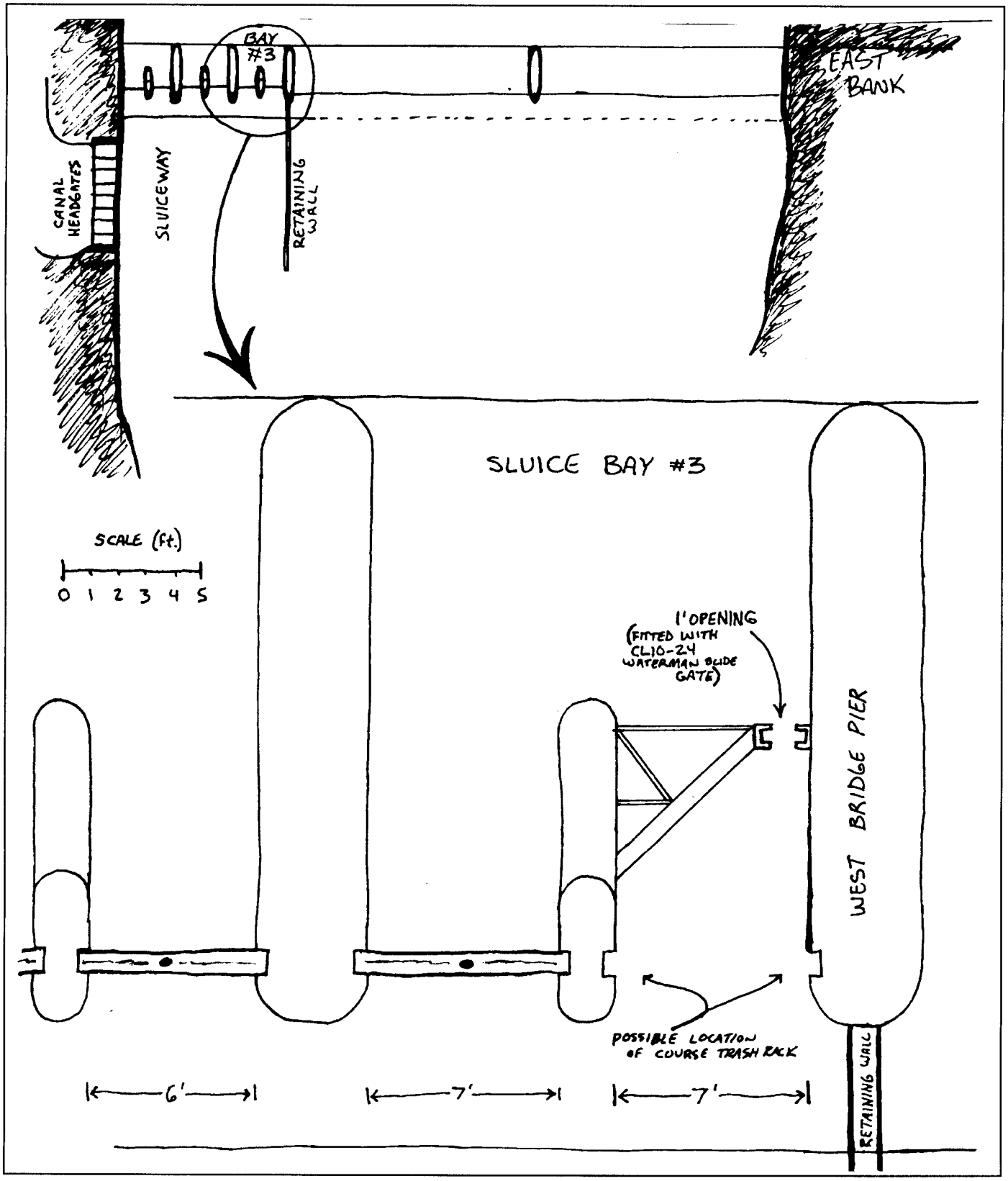
None noted.

Proposal No. 2

Cost Items	Nonrecurring Costs
Original Base line concept	$ 0
Value Concept *	$ 10,000
Avoidances	$ (10,000)
Value Study Costs	$ 30,000
Implementation Costs	$ 0
Net Avoidances	**$ (40,000)**

*The Value Concept cost was developed by the study team. A detailed cost estimate was not prepared for this proposal during the study.

Figure 6. Temporary Downstream Fish Pass.



Proposal No. 3

Description

Proposal No. 3. Replace the Proposed Fish Ladder with a Rock Ramp Fishway.

- Proposal Description: At the proposed new diversion dam, replace the fish ladder with a rock ramp at a 3-percent slope. The "rock ramp" fish pass would be as wide as the weir (about 200 feet wide) and about 200 feet long. A section of the rock ramp would be designed to simulate a thalweg of the river at low flow. It would also be designed to dissipate hydraulic energy during high flows. See Figure Nos. 7 and 8.
- Critical Items to Consider: Redirecting fish that may migrate upstream into the pool below the sluicegates.
- Ways to Implement: The slope could be increased to 5 percent.
- Changes from the Baseline Concept: Replaces a typical fish flume ladder with a rock ramp structure.

Advantages	Disadvantages
• Debris is less likely to obstruct fish migration. • Wider ramp increases ability of fish to find entrance and use passage. • More aesthetically pleasing.	• None noted.

Potential Risks

Local climate may result in freeze/thaw damage to grouted riprap structure.

Cost Items	Nonrecurring Costs
Original Baseline Concept	$ 25,000
Value Concept	$ 680,000
Avoidances	$ (655,000)
Value Study Costs	$ 30,000
Implementation Costs	$ 0
Net Avoidances	**$ (685,000)**

The cost estimate for this proposal was prepared by GP Region.

Figure 7. Notch in Thalweg.

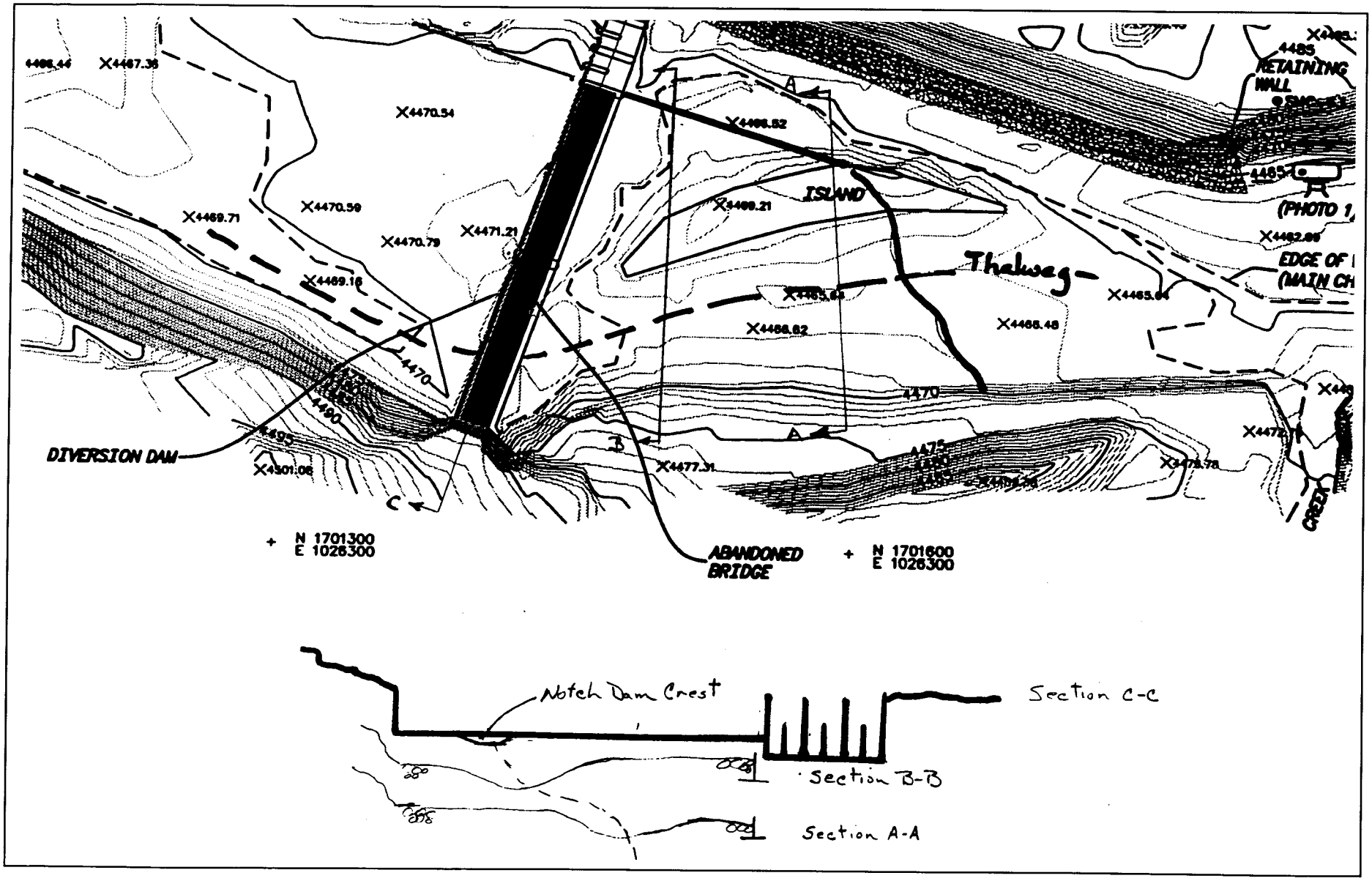
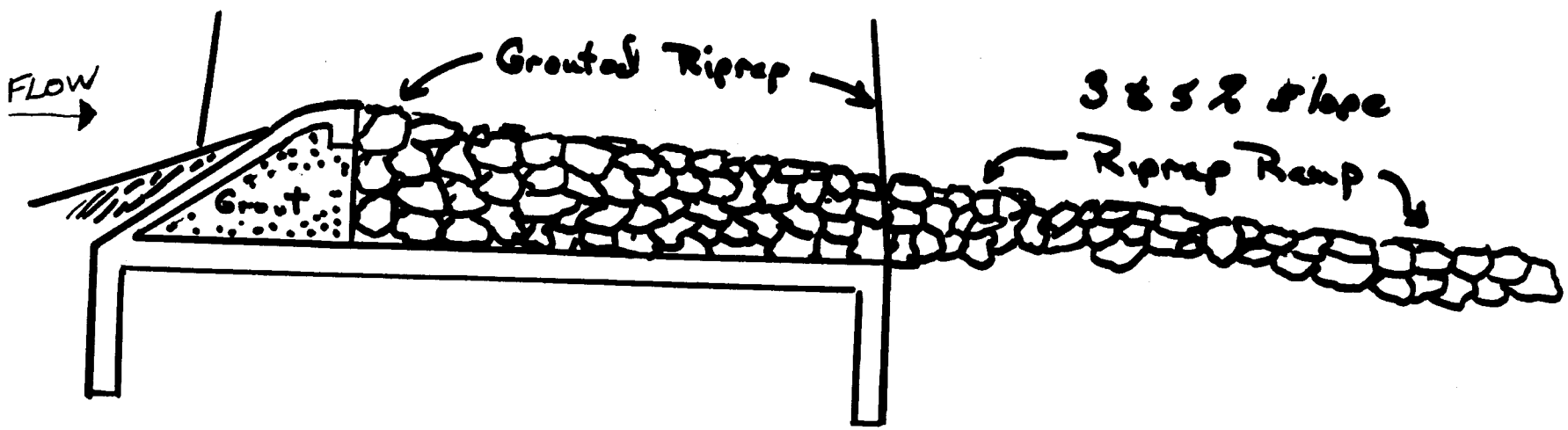


Figure 8. Rock Ramp Section.



Proposal No. 4

Description

Proposal No. 4. Use Existing Dam and Build New Head-Works, Fish-Screens and Fish-Passage.

- Proposal Description: Rehabilitate the existing dam, construct new head works, fish screen and passage while maintaining water supply in the canal. The existing dam would be fortified by filling the buttress cavities with lean grout or grouted riprap. New headworks would be constructed immediately down canal from the existing headworks, using a bypass channel to maintain water supply. Similarly the fish screen would be constructed using the bypass channel. A concrete wall could be constructed from the west end of the existing weir downstream to a new sluiceway that would be installed there. See Figure No. 9.
- Critical Items to Consider: None noted.
- Ways to Implement: The design could include a widened canal inlet. This proposal could be used with Proposal No. 3.
- Changes from the Baseline Concept: Rehabilitates existing diversion dam.

Advantages	Disadvantages
• Fewer permits are needed. • Avoids real estate acquisition.	• None noted.

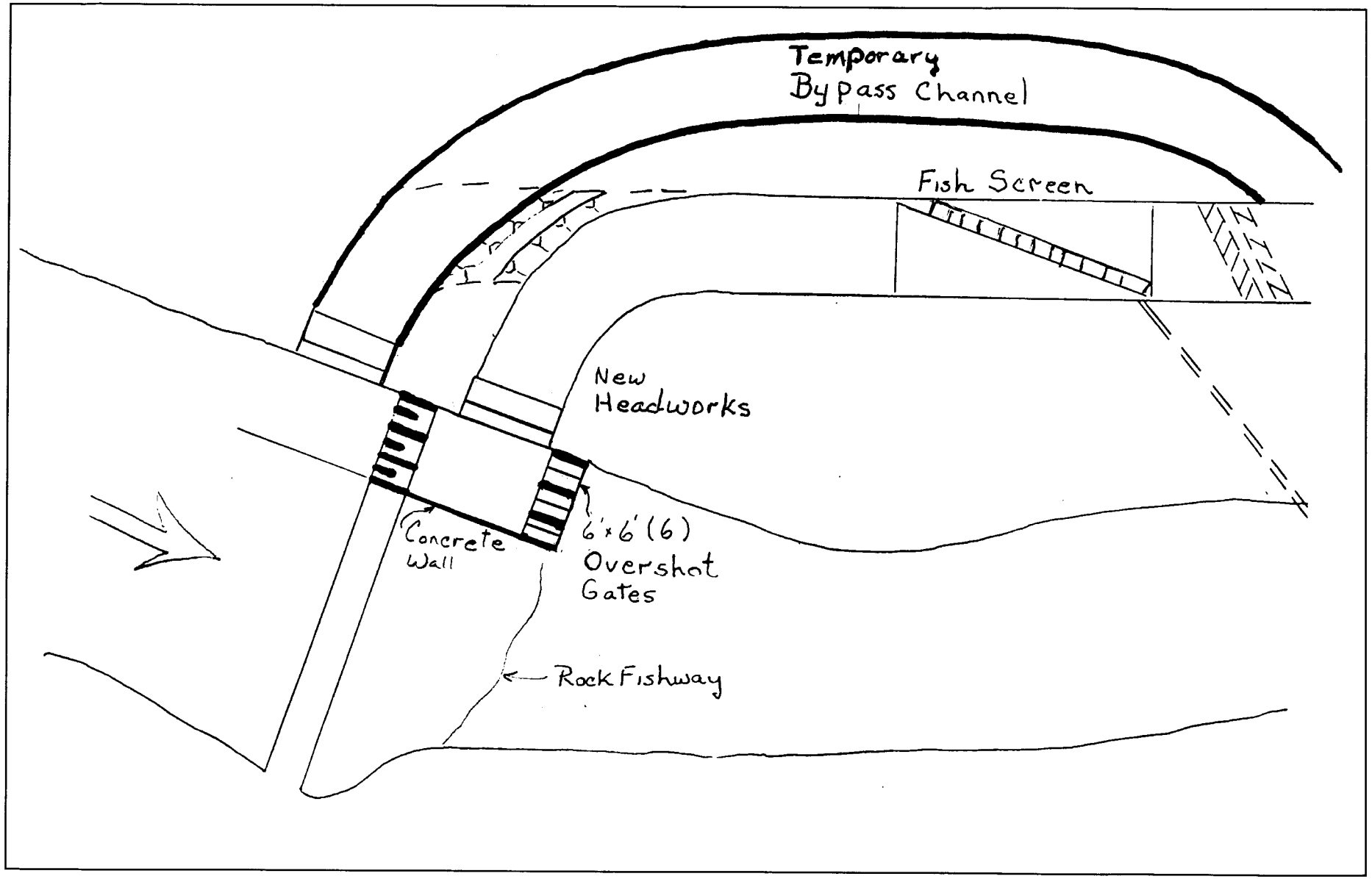
Potential Risks

None noted.

Cost Items	Nonrecurring Costs
Original Baseline Concept	$ 2,360,000
Value Concept	$ 710,000
Avoidances	$ 1,650,000
Value Study Costs	$ 30,000
Implementation Costs	$ 0
Net Avoidances	**$ 1,620,000**

The cost estimate for this proposal was prepared by GP Region staff.

Figure 9. Dam Rehabilitation Schematic.



Proposal No. 5

Description

Proposal No. 5. Replace Screen With Electric Barrier.

- Proposal Description: Install an electric barrier and direct fish away from the headworks. An electric barrier will soon be evaluated for effective fish entrainment prevention at the existing headworks. Providing the evaluation is favorable, an electric barrier would be installed permanently at the new diversion dam and headworks. The electric barrier arrays would be placed in front of the proposed headwork radial gates. See Figure No. 10. Additional information on electric fish barriers is available at www.smith-root.com.
- Critical Items to Consider: Initial approval by regulatory agencies. Future approval by regulatory agencies for future listings.
- Ways to Implement: Additional arrays could be used to improve barrier performance. Additional research may identify the potential for installation in the canal at the proposed screen location to direct fish to the proposed in-canal bypass. A wider canal section or louvers may be used to reduce canal velocities for increased electric barrier performance.
- Changes from the Baseline Concept: Replaces a drum screen system with an electric barrier array.

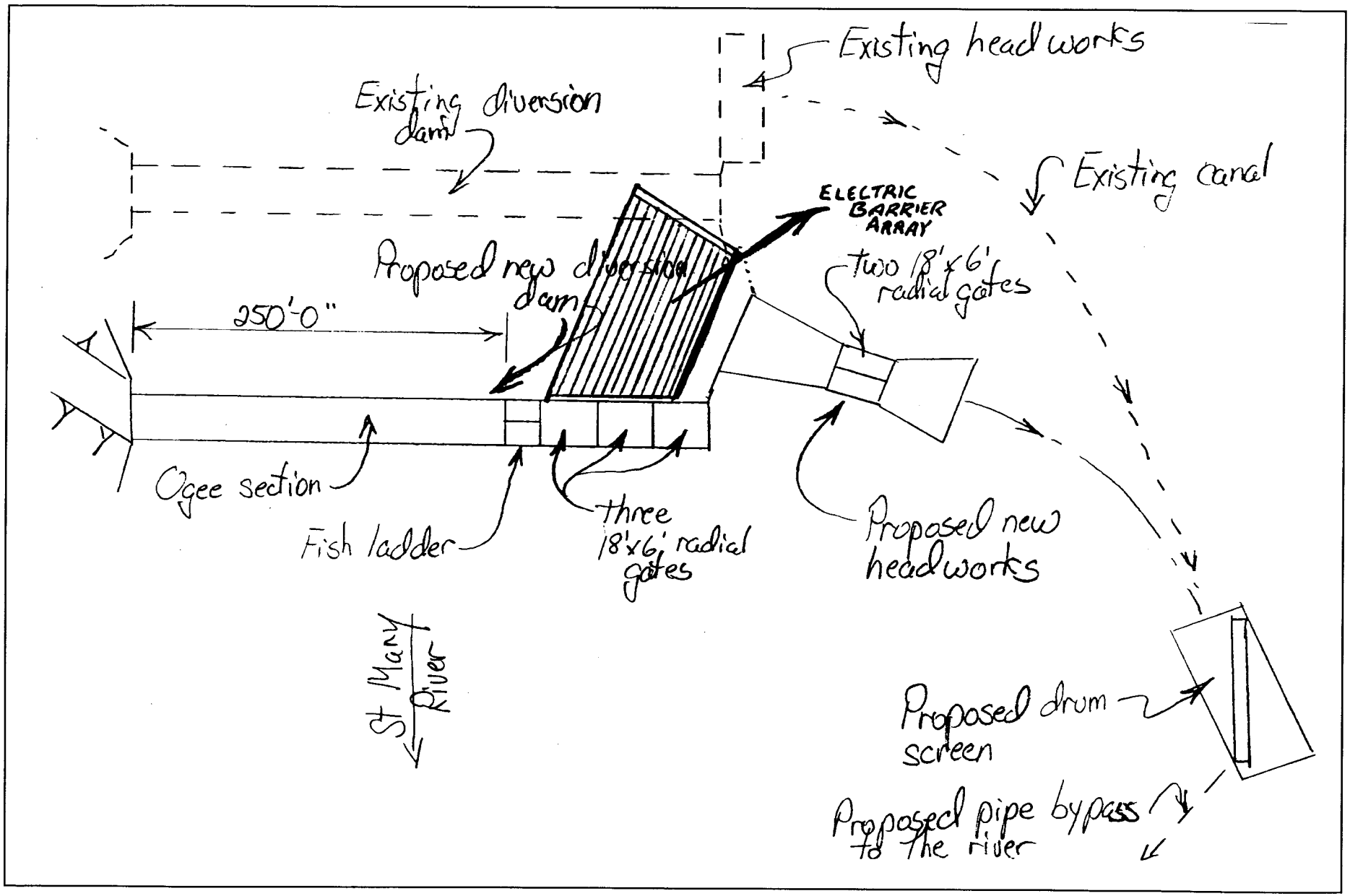
Advantages	Disadvantages
• Passes debris.	• Not 100-percent efficient

Potential Risks

The electric barrier may not redirect all species of fish as effectively as the drum screen. This technology may not receive regulatory approval for future listings.

Cost Items	Nonrecurring Costs
Original Baseline Concept	$ 5,115,000
Value Concept	$ 120,000
Avoidances	$ 4,995,000
Value Study Costs	$ 30,000
Implementation Costs	$ 0
Net Avoidances	**$ 4,965,000**

Figure 10. Electric Barrier Layout.



Proposal No. 6

Description

Proposal No. 6. Replace Fish Screen with an Infiltration Gallery.

- Proposal Description: Extend the canal 3000 feet upstream and construct infiltration galleries to replace the proposed fish screen. Control flow into the canal with gates The infiltration gallery would be composed of 40 collectors. Each collector would be 250 feet long. Each collector would have 40 Poly Vinyl Chloride (PVC) well-screen laterals under the river bed, below the scour line. Gates at the existing canal would control intake. See Figure Nos. 11 and 12.
- Critical Items to Consider: The suitability of the geology and infiltration characteristics of the source area need to be estimated or measured. Field or bench tests may be needed to estimate the plugging potential of the filter materials. Installing the laterals under the river bed would require major excavation in the river channel. Need to obtain Right-Of-Ways.
- Ways to Implement: Use pipe, open channel, pit sections. Gates could be at each lateral.
- Changes from the Baseline Concept: Do not build new head works and fish screen. (Still need to build diversion dam and fish passage).

Advantages	Disadvantages
• Does not entrain fish. • No need for a fish screen. • Aesthetically pleasing. • Allows free passage of ice and debris.	• Needs large area. • A lot of spoil to be disposed of with open channel option. • Access to home owners limited with channel option. • Flooding or overflow of the sewage lagoon may increase sewage taken into the canal.

Potential Risks

In the spring, frozen ground and gallery pipes may prevent use when needed. May have to pump to meet water requirements.

Proposal No. 6

Cost Items	Nonrecurring Costs
Original Baseline Concept	$ 5,115,000
Value Concept	$ 9,500,000
Avoidances	$ (4,385,000)
Value Study Costs	$ 30,000
Implementation Costs	$ 0
Net Avoidances	**$ (4,415,000)**

This estimate was prepared by GP Region staff.

Figure 11. Infiltration Gallery Plan.

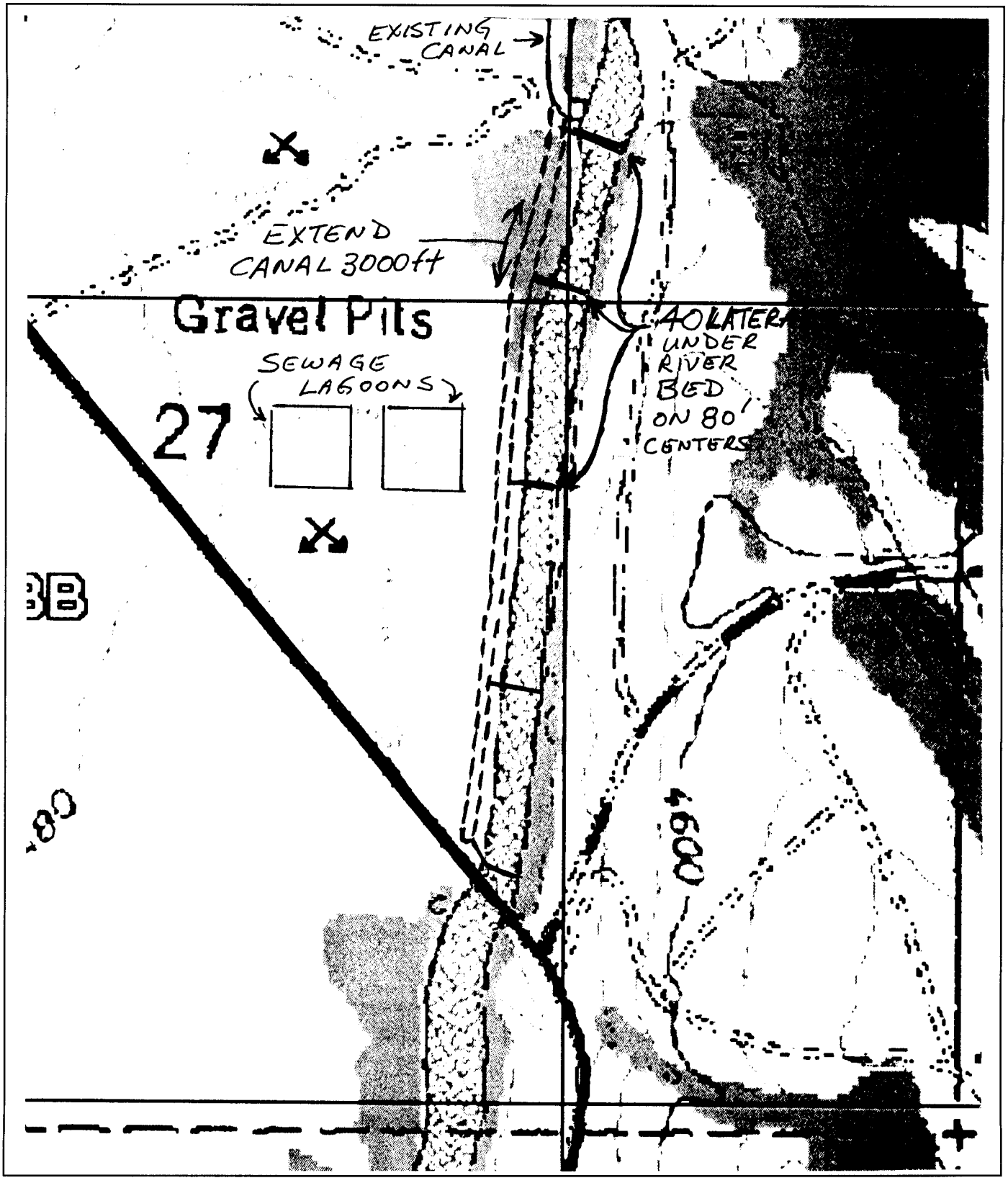
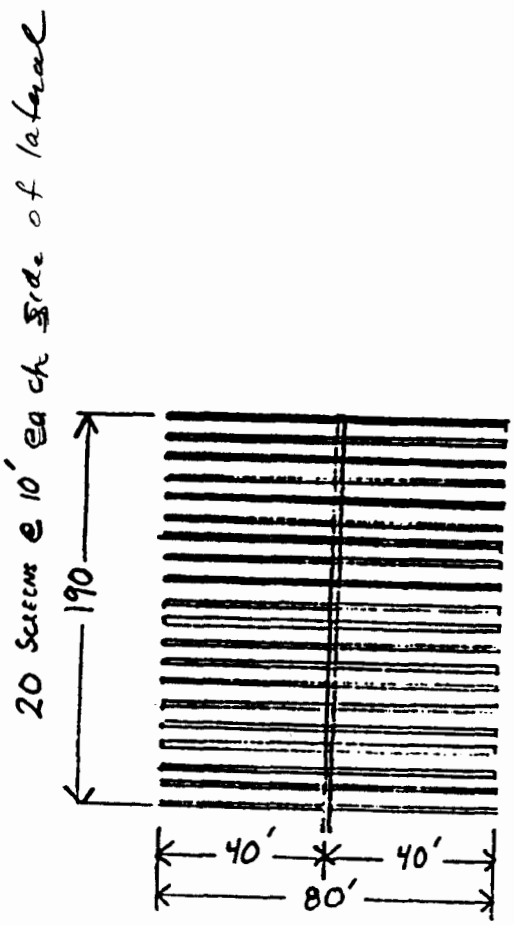
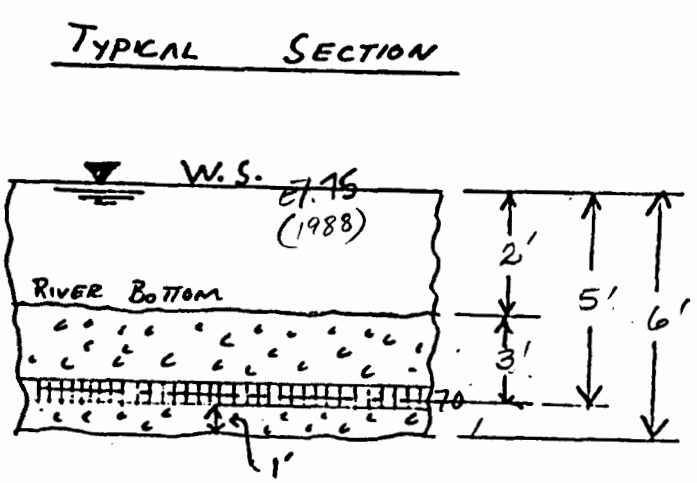


Figure 12. Infiltration Gallery Details.



Typical Lateral Layout (40 Required)



Proposal No. 7

Description

Proposal No. 7. Replace Drum Screens With Vertical Screens.

- Proposal Description: Install a vertical fish screen with self-cleaning brush mechanism at the same location as proposed for the drum screen structure. The proposed fish bypass remains the same as in the baseline concept. See Figure Nos. 13, 14, and 15.
- Critical Items to Consider: None noted.
- Ways to Implement: Designers could use high-velocity fish screens, traveling screens, or invert screens, instead of vertical screens.
- Changes from the Baseline Concept: Uses flat, vertical screens instead of drum screens.

Advantages	Disadvantages
• Less icing problems in cold climate. • Fewer moving parts. • Lower power requirement. • Fewer seals to maintain. • Handles large trash easier.	• None noted.

Potential Risks

None noted.

Cost Items	Nonrecurring Costs
Original Baseline Concept	$ 5,115,000
Value Concept	$ 4,300,000
Avoidances	$ 815,000
Value Study Costs	$ 30,000
Implementation Costs	$ 0
Net Avoidances	**$ 785,000**

Figure 13. Vertical Screen Plan.

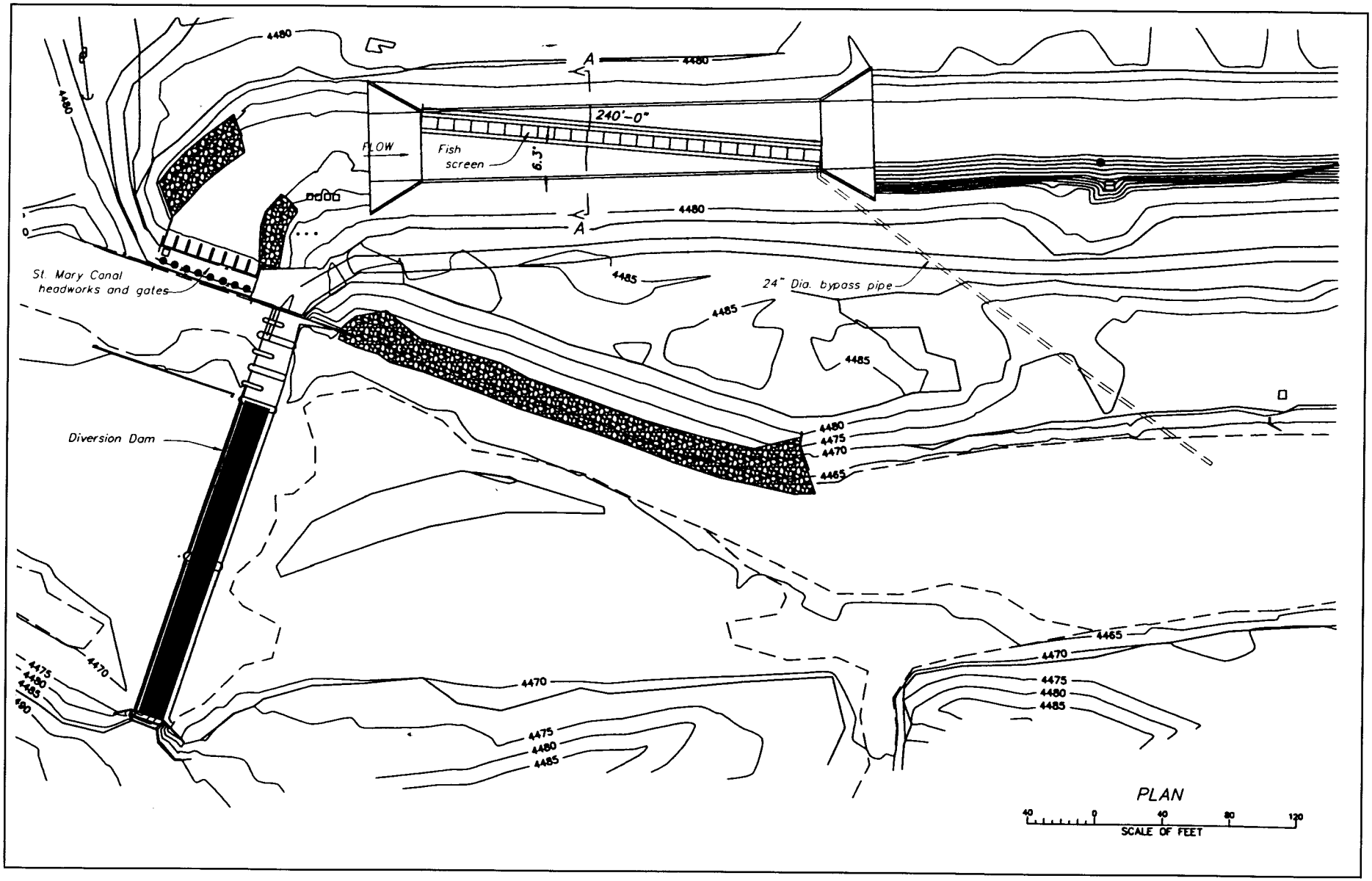


Figure 14. Vertical Screen Sections.

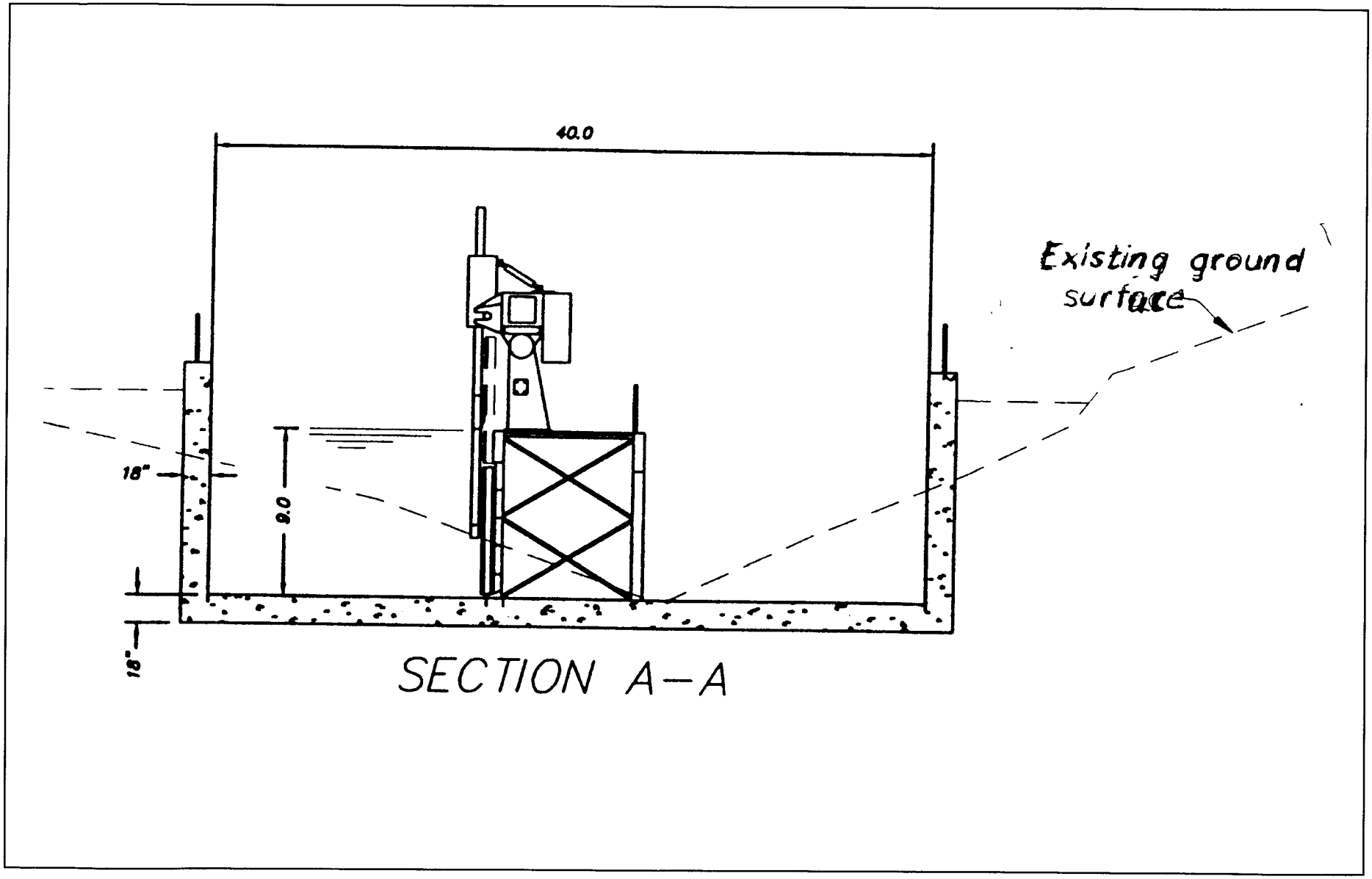
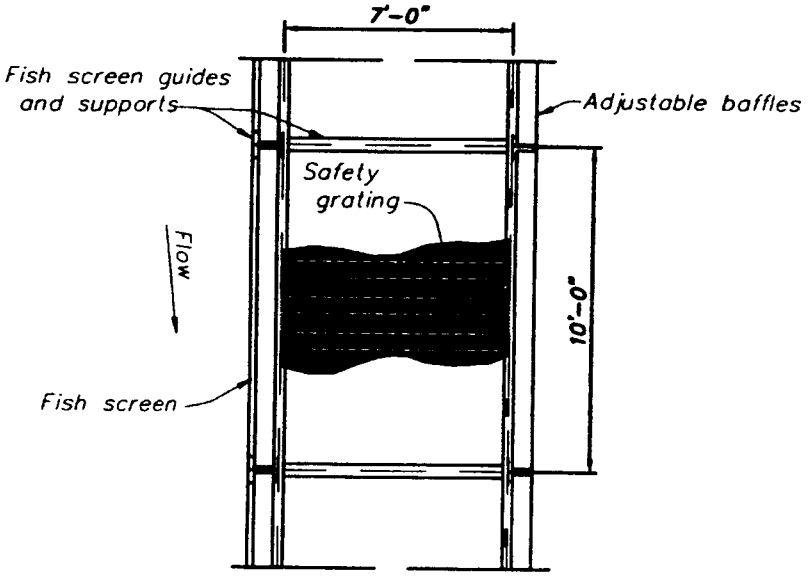
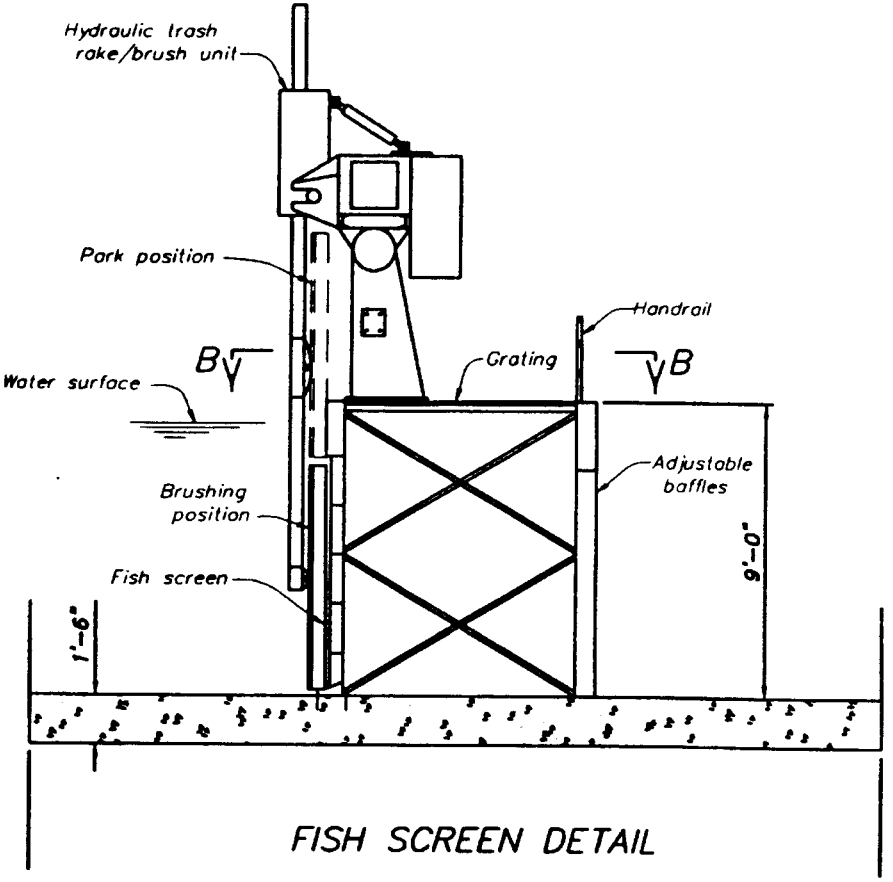


Figure 15. Vertical Screen Section B-B and Detail.



SECTION B–B



FISH SCREEN DETAIL

Proposal No. 8

Description

Proposal No. 8. Move the Proposed Headworks to St Mary Lake.

- Proposal Description: This proposal would relocate the diversion dam, headworks, and fish passage and screen to St Mary Lake outlet area. Water releases from St Mary Lake would be controlled to store winter releases from Lake Sherburne. A 3-foot inflatable weir would be placed at the riffle at the lake outlet about 500 feet south of the highway bridge. A headwork structure would be constructed about 800 feet south of the weir. The canal would be extended about 5,000 feet to the new headworks and would be routed west of the sewage lagoons and under the highway. A 4,100-foot dike would be constructed adjacent to the current channel of Swiftcurrent Creek to prevent future migration to the headworks and canal. The proposed fish screen and bypass could be located near the existing headworks where the canal runs closest to the river, or could be located with the new headworks. See Figure Nos. 16, 17, and 18.

- Critical Items to Consider: Obtaining Rights-Of-Way and permitting for construction and regulation of St Mary Lake. Geologic information may need to be collected for design.

- Ways to Implement: Could install pipeline in place of some or all of the canal extension. Use canal excavation material to construct Swiftcurrent Dike.

- Changes from the Baseline Concept: Location of all facilities differs from baseline. Uses inflatable weir in place of reinforced concrete diversion dam. Provides for control of water surface in St Mary Lake. Adds 5,000 feet of canal.

Advantages	Disadvantages
• Smaller diversion structure. • Easier to provide fish passage. • Places headworks in lake setting. • Easier to prevent fish entrainment.	• Fish bypass is 5,000 feet below the headworks, subjecting entrained fish to canal conditions for this length.

Potential Risks

None noted.

Proposal No. 8

Cost Items	Nonrecurring Costs
Original Baseline Concept	$ 10,000,000
Value Concept	$ 10,216,000
Avoidances	$ (216,000)
Value Study Costs	$ 30,000
Implementation Costs	$ 0
Net Avoidances	**$ (246,000)**

This cost estimate was prepared by GP Region staff.

Figure 16. Lakeside Headworks Plan.

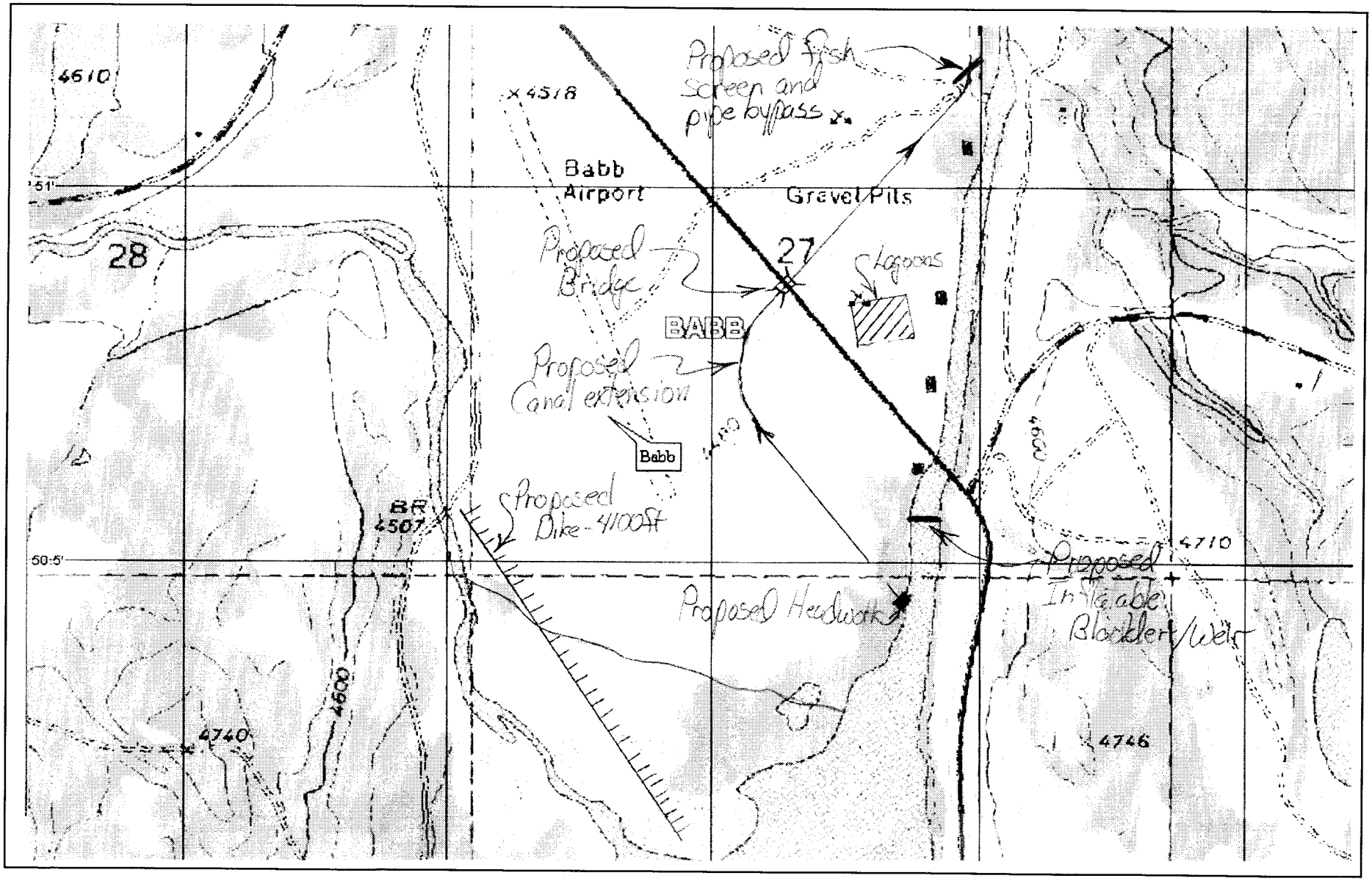


Figure 17. Lakeside Headworks Sections.

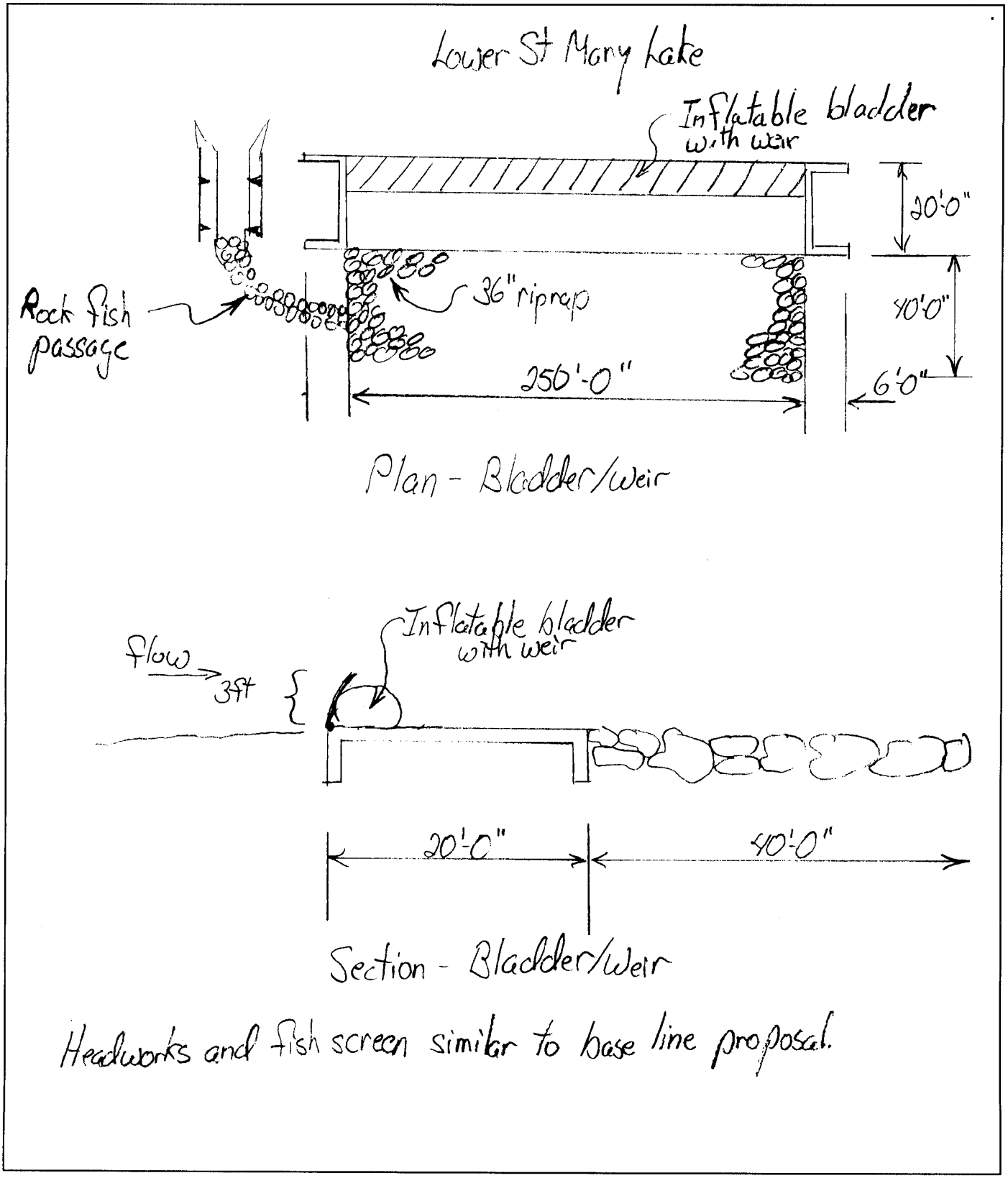
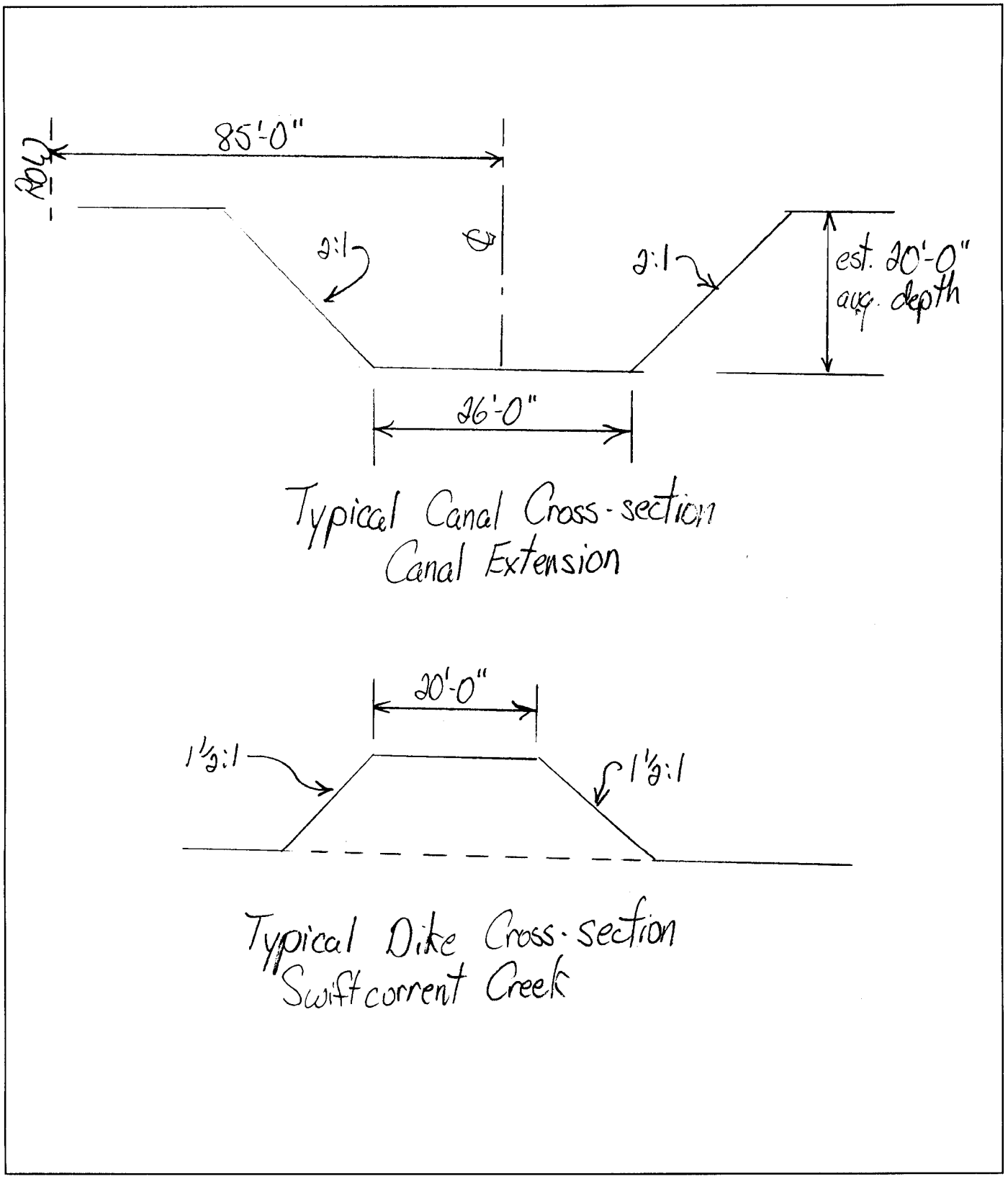


Figure 18. Lakeside Canal Sections.



Proposal No. 9

Description

Proposal No. 9. Locate a Temporary Rock Channel Fishway on East Side of Diversion.

- Proposal Description: Construct a grouted riprap rock channel fishway on the east side of the existing diversion dam, below the weir. See Figure Nos. 19 and 20. Channel low flows to the upstream end of the rock channel fishway. The fishway would provide improved upstream migration until a new replacement diversion, headworks and new fish screen and fish passage are funded and built.
- Critical Items to Consider: None noted.
- Ways to Implement: Normal construction techniques.
- Changes from the Baseline Concept: Adds a temporary upstream fishway to the existing diversion dam.

Advantages	Disadvantages
• Provides improved upstream fish migration during consultation and design.	• None noted.

Potential Risks

None noted.

Cost Items	Nonrecurring Costs
Original Baseline Concept	$ 0
Value Concept	$ 37,000
Avoidance	$ (37,000)
Value Study Costs	$ 30,000
Implementation Costs	$ 0
Net Avoidances	**$ (67,000)**

Figure 19. Temporary Rock Ramp Plan and Sections.

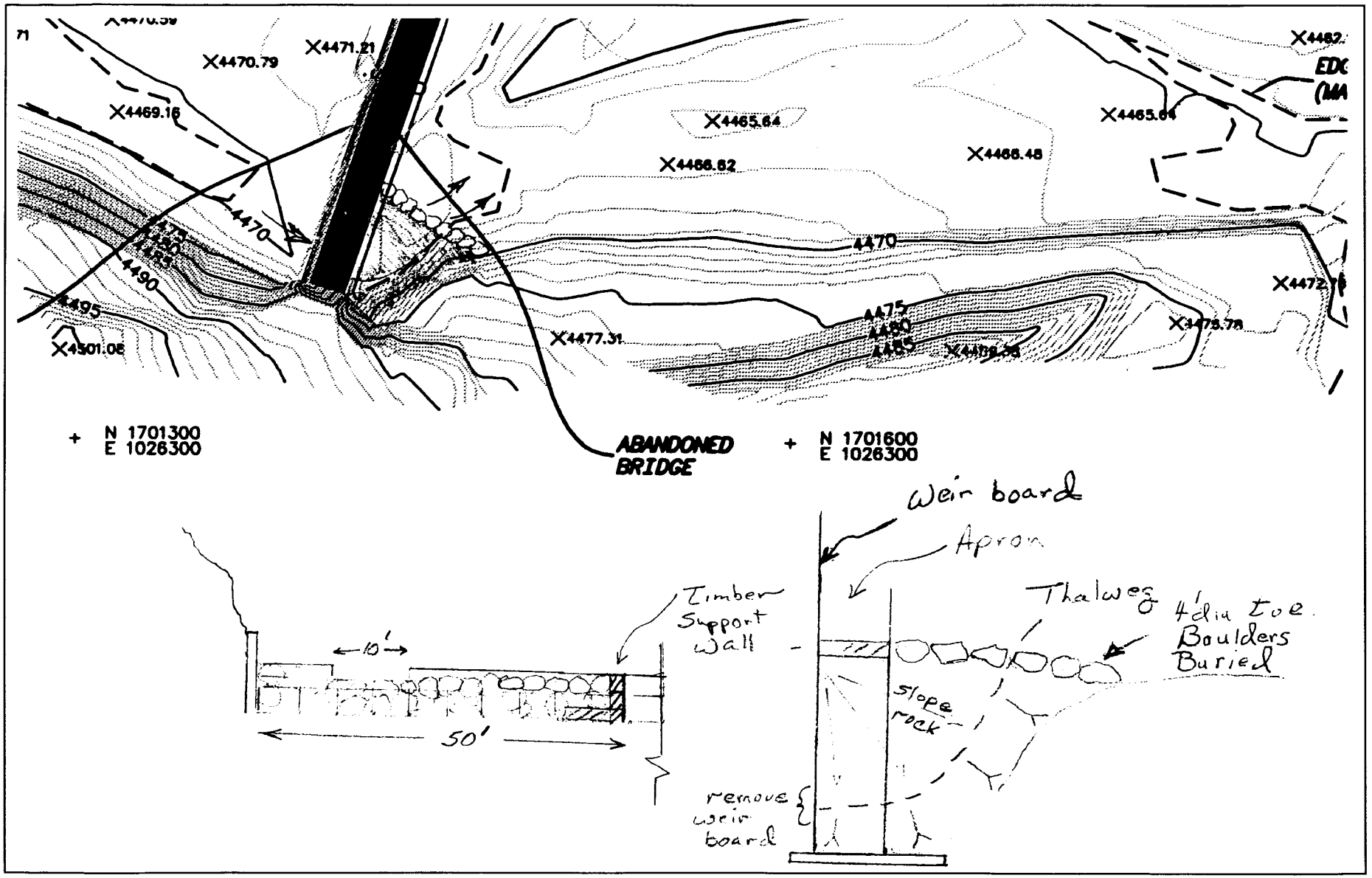


Figure 20. Temporary Rock Channel Fishway.

Disposition of Ideas

Value Study Elements Considered as Potential Proposals and Their Disposition	
Idea	**Disposition**
Screen in front of the headworks.	The study team felt this idea had little potential.
Use a two array electric barrier system.	Refer to design team for consideration.
Extend splitter wall upstream and exclude fish at that point.	The study team felt this idea has little potential.
Exclude fish in a "lake" setting.	Developed as part of Proposal No. 8.
Incorporate the electric fish barrier with the trash racks.	Refer to design team for consideration.
Use fish elevator in lieu of ladder.	Refer to design team for consideration.
Abandon system and use Tiber water.	The study team thought this idea is outside the scope of the study.
Pump from Lower St. Mary Lake through 10-mile tunnel and outlet to North Fork of the Milk River	The study team felt this idea has little potential economically.
Build new headworks ½ above the existing headworks.	Refer to design team for consideration.
Build the All-American Canal along the Border.	The study team felt this idea is outside the scope of the study.
Move the border 50 miles north, in exchange for North Dakota.	The study team felt this idea has little potential
Use flood lamps or strobe lights with the electric barrier.	Refer to design team for consideration.
Collect water in an infiltration gallery on the left bank or the bottom of the river.	Developed as Proposal No. 6.
Excavate a channel through the east sediment bank down to the diversion.	Refer to design team for consideration.
Use the existing foundation with a fish ladder on east side.	Developed as part of Proposal No. 4.
Use the existing foundation with inflatable weirs.	Developed as part of Proposal No. 1.
Rehab the existing structure.	Developed as part of Proposal No. 4.

Disposition of Ideas

Put fish screen and bypass at the Kennedy or St. Mary siphons.	Not developed in favor of other screening sites.
Put a pumping plant at the Lower St. Mary Lake.	The study team felt this idea has little potential.
Move the diversion to the Lower St. Mary Lake outlet.	Developed as Proposal No. 8.
Connect Swiftcurrent Creek directly to the canal.	The study team felt this idea has little potential.
Pipe water from Sherburne Lake to the canal.	The study team felt this idea has little potential.
Install a pumping plant at Camp Nine and pump to the existing canal.	The study team thought this idea has little potential economically.
Construct a dam at Spider Lake.	The study team thought this idea is outside the scope of this study; refer to design team for consideration.
Install power plants at canal drops to generate revenue.	Outside the scope of this study; refer to design team for consideration.
Line the canal from the diversion to the St. Mary siphon, include turnouts for wetlands if needed.	The study team thought this idea is outside the scope of this study; refer to design team for consideration.
Scare fish with holographic eagles.	The study team felt this idea has little potential.
Use tribal labor to operate entrainment nets.	The study team felt this idea has little potential.
Put a cement plant at Camp Nine to facilitate work.	Refer to design team for consideration.
Build new headworks behind existing headworks (can widen canal too).	Developed as Proposal No. 4.
Build a dam on Boulder Creek.	The study team felt this idea has little potential.
Use high velocity fish screens.	Refer to design team for consideration.
Use traveling fish screens.	Refer to design team for consideration.
Use invert fish screens.	Refer to design team for consideration.
Modify or eliminate the retaining wall to avoid fish attraction.	Refer to design team for consideration.
Put a pipe in the sluiceway to bypass fish and sediment.	Developed as Proposal No. 2.

Disposition of Ideas

Heat screens to minimize ice blockage.	Refer to design team for consideration.
Enclose screens and heat the enclosure.	The study team felt this idea has little potential.
Build wind farms near Babb Flats.	The study team felt this idea has little potential.
Use a bubbler system to prevent icing.	The study team felt this idea has little potential.
Use solar panels to power the electric fish barrier and/or deicing.	Refer to design team for consideration.
Install a conduit for fish and sediment to flow under the stoplogs.	Duplicates another idea developed as Proposal No. 2.
Build deflectors or wing walls to push current (fish) away from the headworks.	Refer to design team for consideration.
Build a rock ramp below the dam, on the side opposite the headworks.	Developed as part of Proposal No. 3.
Fortify the existing diversion with rock or concrete, sloped to allow fish passage	Developed as part of Proposal Nos. 3 and 4.
Build attractive habitat for fish on the east side of channel.	Refer to design team for consideration.
Widen channel to allow fish to move away from gated headworks and not downstream into canal.	Refer to design team for consideration.
Modify electric fish barrier to include a fish passage, avoid having fish in the box.	Duplicates another idea developed as Proposal No. 2.
Bypass canal flows for 1-year and reconstruct existing diversion dam.	Developed as part of Proposal No. 4.
Buyout canal users for one year.	The study team felt this idea has little potential.
Buy and use 80 Chrisafoli pumps.	The study team felt this idea has little potential.
Build terraced baffled fish passage structure in 3rd stoplog bay.	The study team felt this idea has little potential.
Siphon water over canal into North Fork Milk River.	The study team felt this idea has little potential.
Use vertical column similar to Soap Creek installation for fish bypass.	Refer to design team for consideration.
Make diversion from radial gates, overshot gates.	Refer to design team for consideration.

Disposition of Ideas

Use Ted Turner fish collars.	The study team felt this idea has little potential.
Fish food activated gate.	The study team felt this idea has little potential.
Build switchback water slide fishway.	Refer to design team for consideration.
Use old Swiftcurrent channel to tie into canal.	The study team felt this idea has little potential.
Replace drum screens with vertical screens.	Developed as Proposal No. 7.
Raise weir except east end of structure where rock ramp fish bypass would be constructed.	Refer to design team for consideration.
Identify criteria for fish passage and screen.	Refer to design team for consideration.
Construct Butler Building over fish screens and heat during icing conditions.	The study team felt this idea has little potential.
Pull screens for the 2 to 4 week period in early spring or late fall to avoid ice plugging.	Refer to management for consideration.
Within the canal - widen an area to slow velocities and install electric fish barrier here with a bypass structure to the river.	Developed as part of Proposal No. 5.
Raise diversion dam to store winter releases from Sherburne Reservoir.	Developed as Proposal No. 1.
Raise outlet from St. Mary Lake.	Refer to the design team to consider.
Obtain water for Milk River irrigation from St. Mary Lake (in Canada) and Tiber Reservoir.	The study team felt this idea is outside the scope of this study; refer to design team for consideration.
Bring some water for lower Milk River Project from Ft. Peck Reservoir.	The study team felt this idea is outside the scope of this study; refer to design team for consideration.
Pulsing fish bypass flows.	The study team felt this idea has little potential.
Put electric barrier as blanket.	Developed as part of Proposal No. 5.
Place an international boundary dam on the border between Canada and United States.	The study team felt this idea is outside the scope of this study; refer to design team for consideration.
Add a sluice gate in east 1/3 of the diversion dam.	The study team felt this idea has little potential.
Build an Obermeyer Dam at the highway St. Mary Lake outlet.	Developed as part of Proposal No. 8.

Design Team Presentation Attendance List
March 11, 2002 - 8:00 a. m.

Name/Title/Discipline	Address/Phone Number
Norm Hyndman Value Study Team Leader General Engineer	Bureau of Reclamation, Technical Service Center PO Box 25007 (D-8170), Denver CO 80225-0007 Phone: 303-445-3251 FAX: 303-445-6475 E-mail: nhyndman@do.usbr.gov
Patrick Erger Value Study Assistance Team Leader Hydraulic Engineer	Bureau of Reclamation, Montana Area Office PO Box 30137 (MT-745), Billings MT 59101 Phone: 406-247-7313 FAX: 406-247-7338 E-mail: perger@gp.usbr.gov
Jim Mogen Fisheries Biologist	U.S. Fish and Wildlife Service, Bozeman Office 4052 Bridger Canyon Road, Bozeman MT59715 Phone: 406-582-0717 FAX: 406-586-6798 E-mail: jim_mogen@fws.gov
Orrin Ferris Civil Engineer	Blackfeet Tribe (HKM Engineering) PO Box 31318, Billings MT 59107 Phone: 406-656-6399 FAX: 406-656-6398 E-mail: joferris@hkminc.com
Sue Camp Fisheries Biologist	Bureau of Reclamation, Montana Area Office PO Box 30137 (MT-225), Billings MT 59101 Phone: 406-247-7668 FAX: 406-247-7338 E-mail: scamp@gp.usbr.gov
Jack Gist Irrigation District Member	Alfalfa Irrigation District, Milk River Joint Board of Control Rural Route 1 Box 7, Chinook MT 59523 Phone: 406-357-4183 FAX: None E-mail: gistfarm@ttc-cmc.net
Kay Blatter Irrigation District Member	Ft. Belknap Irrigation District, Milk River Joint Board of Control Route Route1 Box 105, Chinook MT 59523 Phone: 406-357-2931 FAX: 406-357-3177 E-mail: None
Jerry Moore Civil Engineer	Bureau of Reclamation, Montana Area Office PO Box 30137 (MT-430), Billings MT 59101 Phone: 406-247-7308 FAX: 406-247-7338 E-mail: jmoore@gp.usbr.gov

Design Team Presentation Attendance List
March 11, 2002 - 8:00 a. m.

Brent Mefford Civil Engineer	Bureau of Reclamation, Technical Service Center PO Box 25007 (D-8560), Denver CO 80225-0007 Phone: 303-445-2149 FAX: 303-445-6324 E-mail: bmefford@do.usbr.gov
George Gliko Civil Engineer	Bureau of Reclamation, Great Plains Region Office PO Box 36900 (GP-2200), Billings MT 59107-6900 Phone: 406-247-7651 FAX: 406-247-7793 E-mail: ggliko@gp.usbr.gov
Allan Steiner Facilities Manager	Bureau of Reclamation, Tiber Dam/Milk River Field Office Tiber Dam (MT-460), Chester MT 59522 Phone: 406-456-3226 FAX: 406-456-3238 E-mail: asteiner@gp.usbr.gov
Richard Long Civil Engineer, Supervisor	Bureau of Reclamation, Montana Area Office PO Box 30137 (MT-400), Billings MT 59101 Phone: 406-247-7307 FAX: 406-247-7338 E-mail: rlong@gp.usbr.gov
Scott Guenthner Hydraulic Engineer	Bureau of Reclamation, Montana Area Office PO Box 30137 (MT-432), Billings MT 59101 Phone: 406-247-7312 FAX: 406-247-7338 E-mail: sguenthner@gp.usbr.gov
Lenny Duberstein Civil Engineer, Supervisor	Bureau of Reclamation, Montana Area Office PO Box 30137 (MT-400), Billings MT 59101 Phone: 406-247-7331 FAX: 406-247-7338 E-mail: lduberstein@gp.usbr.gov
Lloyd Crutchfield Geologist	Bureau of Reclamation, Great Plains Region Office PO Box 36900 (GP-2300), Billings MT 59107-6900 Phone: 406-247-7816 FAX: 406-247-7793 E-mail: lcrutchfield@gp.usbr.gov

Value Study Team Presentation Attendance List
March 15, 2002 - 1 p. m.

Name/Title/Discipline	Address/Phone Number
Norm Hyndman Value Study Team Leader General Engineer	Bureau of Reclamation, Technical Service Center PO Box 25007 (D-8170), Denver CO 80225-0007 Phone: 303-445-3251 FAX: 303-445-6475 E-mail: nhyndman@do.usbr.gov
Jim Mogen Fisheries Biologist	U.S. Fish and Wildlife Service, Bozeman Office 4052 Bridger Canyon Road, Bozeman MT 59715 Phone: 406-582-0717 FAX: 406-586-6798 E-mail: jim_mogen@fws.gov
Orrin Ferris Civil Engineer	Blackfeet Tribe (HKM Engineering) PO Box 31318, Billings MT 59107 Phone: 406-656-6399 FAX: 406-656-6398 E-mail: joferris@hkminc.com
Sue Camp Fisheries Biologist	Bureau of Reclamation, Montana Area Office PO Box 30137 (MT-225), Billings MT 59101 Phone: 406-247-7668 FAX: 406-247-7338 E-mail: scamp@gp.usbr.gov
Jack Gist Irrigation District Member	Alfalfa Irrigation District, Milk River Joint Board of Control Rural Route 1 Box 7, Chinook MT 59523 Phone: 406-357-4183 FAX: none E-mail: gistfarm@ttc-cmc.net
Kay Blatter Irrigation District Member	Ft. Belknap Irrigation District, Milk River Joint Board of Control Route Route1 Box 105, Chinook MT 59523 Phone: 406-357-2931 FAX: 406-357-3177 E-mail: None
Jerry Moore Civil Engineer	Bureau of Reclamation, Montana Area Office PO Box 30137 (MT-430), Billings MT 59101 Phone: 406-247-7308 FAX: 406-247-7338 E-mail: jmoore@gp.usbr.gov
Brent Mefford Civil Engineer	Bureau of Reclamation, Technical Service Center PO Box 25007 (D-8560), Denver CO 80225-0007 Phone: 303-445-2149 FAX: 303-445-6324 E-mail: bmefford@do.usbr.gov

Value Study Team Presentation Attendance List
March 15, 2002 - 1 p. m.

George Gliko Civil Engineer	Bureau of Reclamation, Great Plains Region Office PO Box 36900 (GP-2200), Billings MT 59107-6900 Phone: 406-247-7651 FAX: 406-247-7793 E-mail: ggliko@gp.usbr.gov
Allan Steiner Facilities Manager	Bureau of Reclamation, Tiber Dam/Milk River Field Office Tiber Dam (MT-460), Chester MT 59522 Phone: 406-456-3226 FAX: 406-456-3238 E-mail: asteiner@gp.usbr.gov
Richard Long Civil Engineer, Supervisor	Bureau of Reclamation, Montana Area Office PO Box 30137 (MT-400), Billings MT 59101 Phone: 406-247-7307 FAX: 406-247-7338 E-mail: rlong@gp.usbr.gov
Scott Guenthner Hydraulic Engineer	Bureau of Reclamation, Montana Area Office PO Box 30137 (MT-432), Billings MT 59101 Phone: 406-247-7312 FAX: 406-247-7338 E-mail: sguenthner@gp.usbr.gov
Lenny Duberstein Civil Engineer, Supervisor	Bureau of Reclamation, Montana Area Office PO Box 30137 (MT-400), Billings MT 59101 Phone: 406-247-7331 FAX: 406-247-7338 E-mail: lduberstein@gp.usbr.gov
Susan Kelly Area Office Manager	Bureau of Reclamation, Montana Area Office PO Box 30137 (MT-100), Billings MT 59101 Phone: 406-247-7298 FAX: 406-247-7338 E-mail: skelly@gp.usbr.gov
Tom Sawatzke Resources Management Division Manager	Bureau of Reclamation, Montana Area Office PO Box 30137 (MT-200), Billings MT 59101 Phone: 406-247-7314 FAX: 406-247-7338 E-mail: tsawatzke@gp.usbr.gov
Larry Armer Technical Services Manager	Bureau of Reclamation, Great Plains Region Office PO Box 36900 (GP-2200), Billings MT 59107-6900 Phone: 406-247-7653 FAX: 406-247-7793 E-mail: larmer@gp.usbr.gov
Dan Jewell Assistant Area Office Manager	Bureau of Reclamation, Montana Area Office PO Box 30137 (MT-100A), Billings MT 59101 Phone: 406-247-7667 FAX: 406-247-7338 E-mail: djewell@gp.usbr.gov

Value Study Team Presentation Attendance List
March 15, 2002 - 1 p. m.

Rick Blaskovich	Bureau of Reclamation, Montana Area Office PO Box 30137 (MT-220), Billings MT 59101 Phone: 406-247-7311 FAX: 406-247-7338 E-mail: rblaskovich@gp.usber.gov
Bill Vincent	Bureau of Reclamation, Montana Area Office PO Box 30137 (MT-227), Billings MT 59101 Phone: 406-247-7315 FAX: 406-247-7338 E-mail: wvincent@gp.usbr.gov
Tim Felchle	Bureau of Reclamation, Montana Area Office PO Box 30137 (MT-450), Billings MT 59101 Phone: 406-247-7318 FAX: 406-247-7338 E-mail: tfelchle@gp.usbr.gov