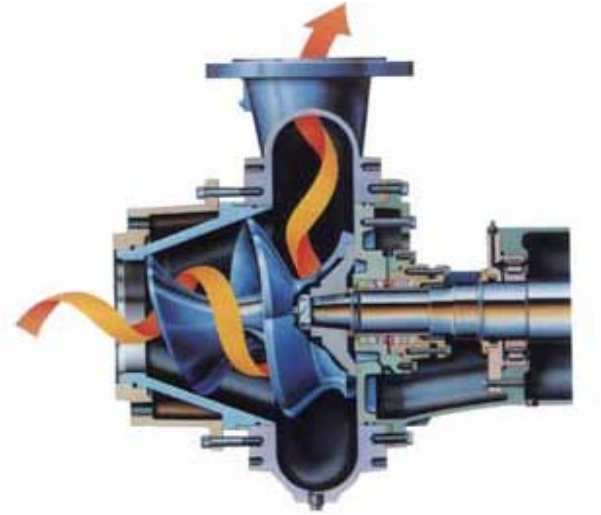
RECLAMATION

Managing Water in the West

Hydraulic Laboratory Technical Memorandum PAP-1035

Concept Level Design of a Fish-Friendly Pump System

Tracy Fish Collection Facility



U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Hydraulic Investigations and Laboratory Services Group
Denver, Colorado

May 2011

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Concept Level Design of a Fish-Friendly Pump System

Tracy Fish Collection Facility

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5-20-2011
Date

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Hydraulic Investigations and Laboratory Services Group
Denver, Colorado

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Abstract

Newer methods of operation are needed at the Tracy Fish Collection Facility to meet fish salvage criteria. The existing facility is no longer capable of meeting hydraulic design criteria due to adverse flow conditions and water levels in the primary channel (primary). The secondary channel (secondary) depends on energy head (difference in water surface elevations) from the primary channel to drive the bypass flows necessary for optimum fish salvage. Current performance of the secondary suffers due to frequent periods of low water levels in the primary channel. WEMCO-Hidrostal fish-friendly pumps were investigated as a method to produce additional head needed during periods of low water levels to allow the secondary to meet performance standards. Various fish pump system designs were considered, focusing on hydraulic criteria and space limitations at the facility. One concept level design was determined to be feasible and is recommended for further investigation and design.

Introduction

The Tracy Fish Collection Facility (TFCF) is a fish salvage facility located at the head of the Delta-Mendota Canal in the San-Joaquin Delta, California. It was built in the 1950's with the purpose of preventing fish from entering the Delta-Mendota Canal which leads to the Tracy (C.W. Bill Jones) pumping plant. Fish drawn towards the pumping plant are collected at the TFCF, loaded into large haul trucks and transported to the Sacramento River. The fish are guided from the primary channel into underground bypass pipes that lead to a secondary channel and then to large circular holding tanks (Figure 1). The existing facility was designed to use gravity to provide the necessary flow from the primary channel to the secondary channel for effective fish collection.

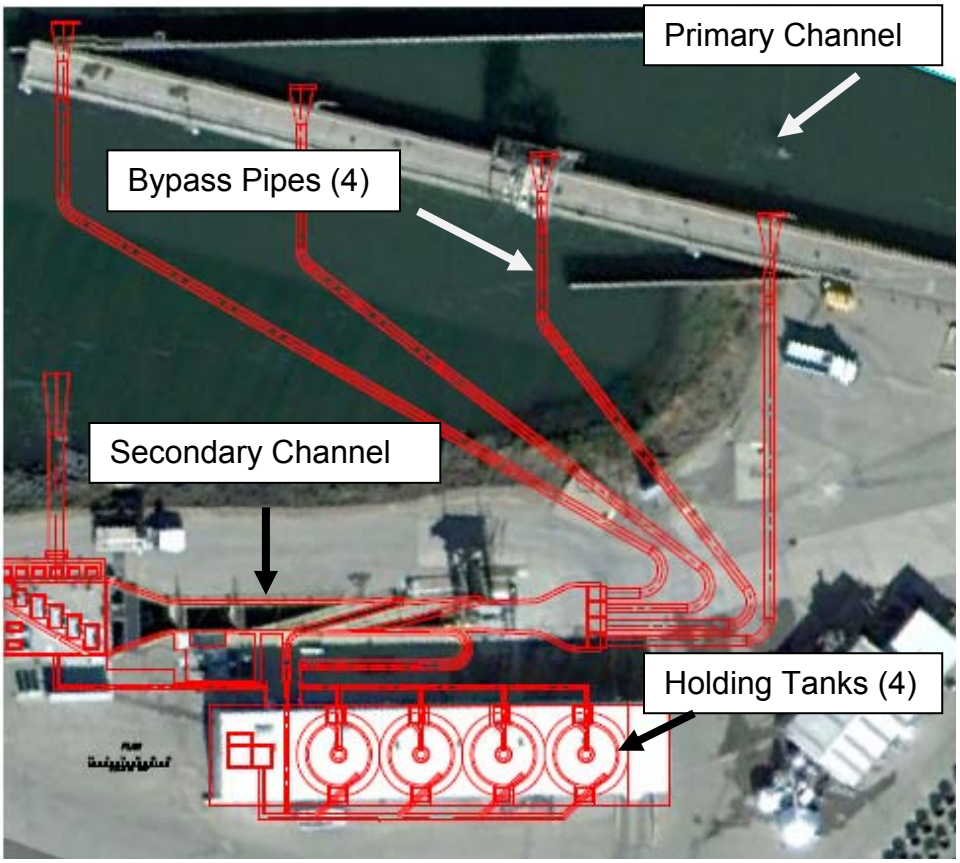

Figure 1 – Existing Tracy Fish Collection Facility site

Over the last few decades, additional facilities have been added to the San-Joaquin Delta. In addition to these facilities, operational changes at the Tracy pumping plant and tidal fluctuations cause water levels to vary in the primary channel. Frequent periods of extremely low water levels in the primary channel make current facility operation difficult. Often fish salvage criteria (flow depth, velocity, and bypass ratio standards) are impossible to achieve in the secondary channel. To consistently meet these hydraulic criteria, additional energy head is required to provide adequate flow to the secondary channel.

In April of 2010 TFCF personnel asked the Technical Service Center (TSC) to investigate the feasibility of using Wemco-Hidrostal pumps as a retrofit to transport fish to the secondary. These "fish-friendly" pumps are an attractive option for the TFCF because they are capable of providing consistent flow during periods of low water levels and enhancing fish salvage without modifying or replacing a major portion of the existing facility infrastructure and operation.

The primary objective of this study was to determine the feasibility of using fish-friendly pumps to "*enhance the efficiency of screening, fish survival, and reduction of predation within the secondary channel structure*" (NMFS, 2009). Hydraulic conditions and space limitations were the main focus in developing the design alternatives. Existing hydraulic conditions in the secondary channel were first determined for comparison to the projected conditions for each design

concept. Appraisal level cost estimates for each alternative were also determined. Although various preliminary fish pump system concepts were developed as part of this study (Appendix C), only two alternatives are presented in this report.

Existing Conditions

Existing hydraulic conditions were analyzed to assess the need to modify operation of the secondary channel. Depth and velocity data that were collected at the TFCF from February 2006 to April 2010 were analyzed. Velocities and bypass ratios (ratio of bypass velocity to channel velocity) were measured by TFCF personnel using ultrasonic pipe flow meters and other instrumentation. Table 1 summarizes the existing conditions in comparison to operational standards that have been established for seasonal time periods at this facility (NMFS, 2009 and CSWRCB, 1978).

The data show large variance for the secondary channel, which also affects depths in the holding tanks. The average values shown may be deceiving from an operational standpoint because each parameter is constantly changing. While some of the variance may have been intentionally controlled (predator removal, research, etc.) the majority was caused by fluctuating water levels in the primary channel.

Table 1 – Current hydraulic operating conditions of secondary channel

Existing Hydraulic Conditions - Secondary Channel					
Parameter	**Period**	**Standard**	**Results**		
-	-	-	*Max*	*Min*	*Avg.*
Velocity (*fps*)	Nov - May	3.0	6.76	0.25	2.85
	Feb - May	3.0 - 3.5	6.76	0.25	2.85
	May - June	1.0	4.77	0.51	2.28
	June - August	≤ 2.5, 1.5 preferred	6.51	0.25	1.89
	Sept. - Oct.	1.0	5.73	0.26	2.17
Bypass Ratio (BR)	Nov - May	> 1.0	4.96	0.11	1.33
	May - June	> 1.0	4.30	0.70	1.58
	June - August	> 1.0	4.97	0.53	1.87
	Sept. - Oct.	> 1.0	4.66	0.54	1.60
Flow Depth (*ft*)	Nov - May	-	10.80	1.20	5.78
	May - June	-	10.30	4.00	6.77
	June - August	-	10.41	2.20	6.31
	Sept. - Oct.	-	8.90	3.00	5.87
NFMS 2009 B.O.					
Decision 1485					

Hydraulic conditions in the secondary are directly influenced by water levels in the primary channel as shown in Figure 2. As water levels in the primary fluctuate so does the energy head that drives flow through the secondary louvers and bypass inlets. These fluctuations are caused by the Tracy Pumping Plant downstream as well as the tide. Frequent changes in tide can cause primary water levels to fluctuate up to four feet within a twenty-four hour period, making consistent operation of the secondary difficult to achieve. Consistent and controlled operation of the secondary and bypass system will be possible only if flow conditions in the secondary can be controlled independently.

Due to the strong correlation of primary flow conditions to system operation, modification of the fish collection system is needed. Historic operational data from the TFCF suggest that hydraulic separation of the primary and secondary channels would allow consistent facility operation resulting in increased fish salvage efficiencies.

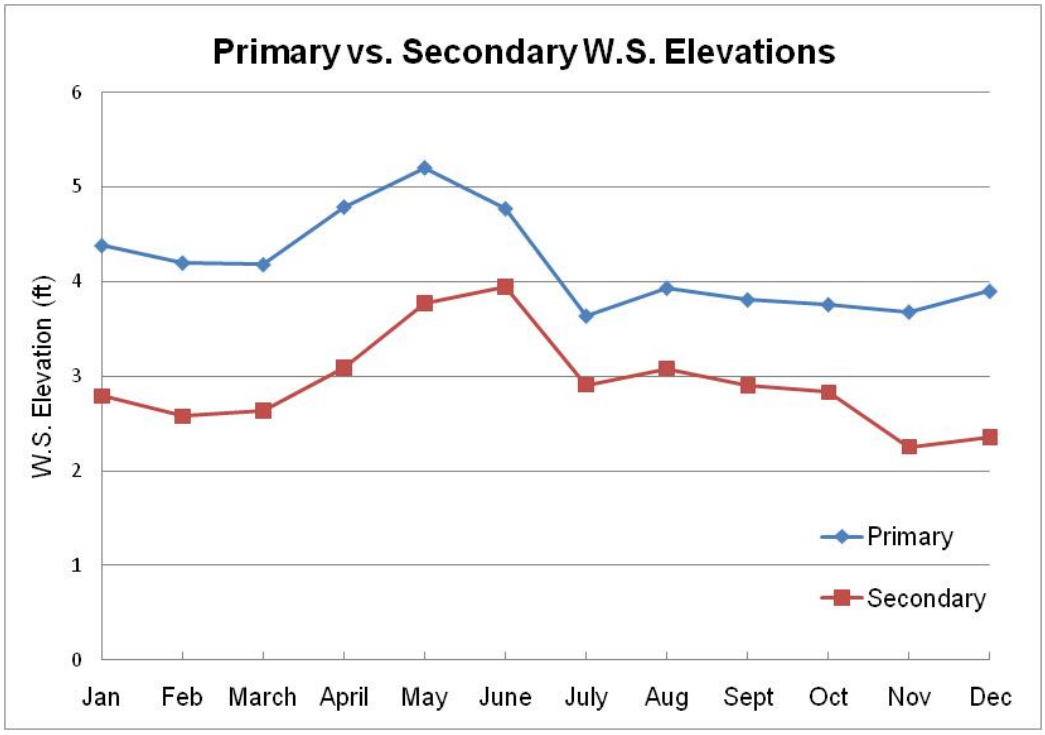

Figure 2 – Average monthly water surface elevations in primary and secondary channels (2/2006 to 4/2010)

Concept Alternatives

To help improve overall fish salvage efficiencies at the TFCF the use of Wemco-Hidrostal pumps to consistently meet facility operational criteria was investigated. Wemco-Hidrostal pumps have a unique design that allows them to safely transport fish. They are also known as "screw pumps" because of the single enclosed impeller that effectively moves flow from the pump inlet to the outlet (Figure 3). This single enclosed design reduces the probability of a fish being struck by the impeller. Also, pressure differential, turbulence, and shear are reduced which provides a smoother transition from the suction to the discharge end of the pump. These characteristics allow Wemco-Hidrostal pumps to be used as an effective and safe means of transporting fish.

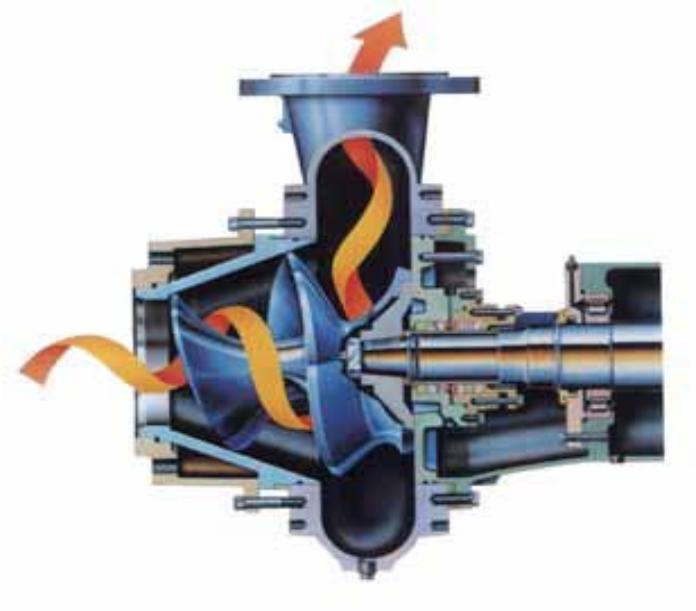

Figure 3 – Cross section of a Wemco-Hidrostal pump

Specifically, this pump design has been tested at Reclamation's Red Bluff and Tracy facilities to determine their effect on mortality of various fish species. Results represent fish that were inserted upstream of the pump, passed through the pump, and then discharged from a vertical drop into a pool where they were under observation for up to 96 hours. Specific test procedures, results and conclusions can be found in the Volume Series Reports referenced in Table 2. Summarized results shown in Table 2 indicate that these pumps are safe for most fish species and may be used to transport fish. Concept design alternatives presented in this study attempt to incorporate Wemco-Hidrostal pumps into the existing TFCF infrastructure to optimize hydraulic operation and fish salvage.

Table 2 – Summary of test results of fish that were passed through a Wemco-Hidrostal pump at TFCF and Red Bluff

Tracy - 16 inch diameter pump

Series Report	Species Tested	Fish Survival	Dates
Tracy, Vol. 16	Sacramento splittail	93%	Dec. 98 - July 99
	Chinook Salmon	96%	
Tracy, Vol. 24	Striped Bass	95%	Dec. 99 - Feb. 02
	Steelhead	99%	
	Delta Smelt	87%	

Red Bluff - 36 inch diameter pump

Series Report	Species Tested	Fish Survival	Dates
Red Bluff, Vo. 7	Chinook Salmon	94%	Feb. 97 - June 98
Red Bluff, Vo. 11	Juvenile Chinook Salmon	96%	April - July 99
Tracy, Vol. 25	Rainbow Trout	91%	April - June 02

Alternative 1

Alternative 1 is comprised of four 28 inch diameter Wemco-Hidrostal fish pumps enclosed in a single vault that discharge directly into the existing secondary channel. Figure 4 shows how the proposed vault, pumps and overhead piping tie into the existing facility. A tee is inserted into each existing bypass pipe with two 36 inch knife gate valves to direct flow either straight to the secondary (gravity flow) or through the pump. For pump operation, the flow is lifted to ground level and then piped over to the mouth of the secondary where it is openly discharged into the channel (existing concrete cap would be removed). The fixed discharge elevation allows the pumps to operate within an acceptable efficiency range. More detailed drawings of Alternative 1 can be found in Appendix A.

Once discharged into the secondary, hydraulic conditions are controlled to optimize fish passage to the holding tanks. The combination of controlled inflow and flow depth result in acceptable channel velocities and bypass ratios. The inflow is controlled by the fish pumps and the depth is controlled by an adjustable overshot gate inserted in the secondary channel downstream of the existing louvers. Automation of the overshot gate and the variable frequency drives (VFD) on the fish pumps provide for consistent operation of the secondary as water levels fluctuate in the primary channel.

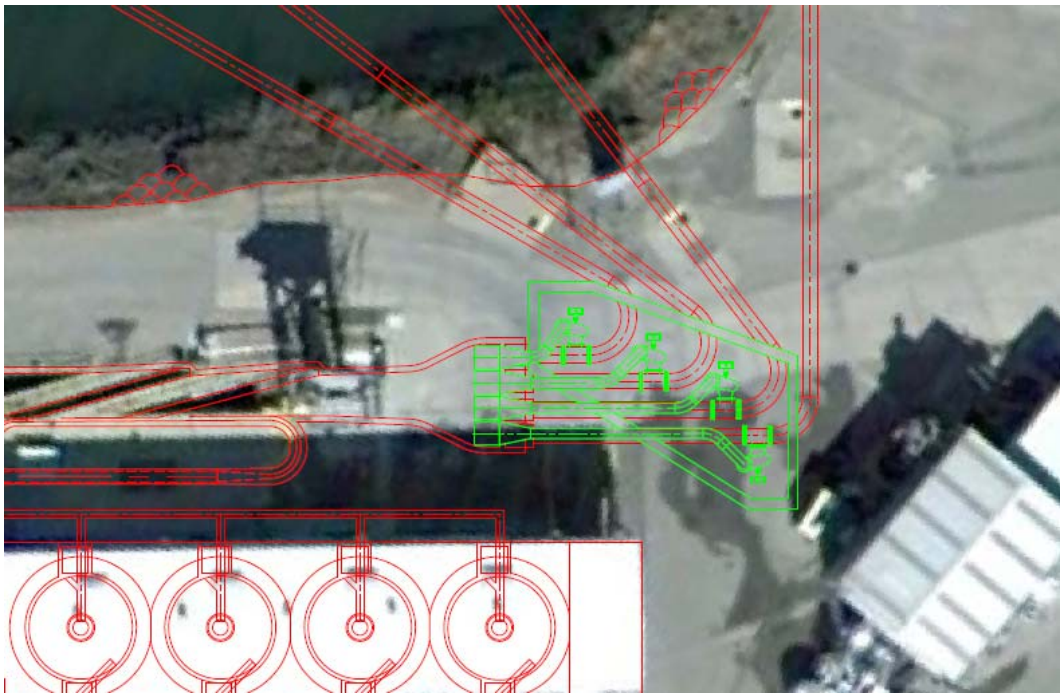

Figure 4 – Layout of Alternative 1 at existing TFCF site. Proposed infrastructure is shown in green; existing shown in red

Advantages vs. Disadvantages

Advantages:

- Consistently meet hydraulic criteria in secondary (independent of primary)
- Operational Flexibility
  - existing gravity operation
  - pumped operation

Disadvantages:

- Reduced space
  - above ground pipes and pump motors prevent haul trucks from pulling into holding tank building and eliminate critical driveways
  - Non-uniform flow into pumps due to sharp turn at tee which will likely reduce pump efficiency and be harmful to fish
- Significant modification to existing facility
  - remove existing concrete cap and control panels located at upstream end of secondary
  - re-route or modify existing utilities and equipment located in area of proposed pump vault

Although this design is hydraulically feasible, the above space limitations would cause significant modifications to the existing infrastructure as well as impede day to day operations. Due to the significance of these disadvantages, Alternative 1 was considered to be non-feasible.

Costs

- Total Construction Costs ≈ $9.5 million
  - Hidrostal Pumps $5,000,000
  - Piping, valves, electrical $710,000
  - Pump Vault $600,000

- Moblization 5%
- Design Contingencies 15%
- Construction Contingencies 25%

Alternative 2

Alternative 2 includes four 28 inch diameter Wemco-Hidrostal fish pumps tied into the existing bypass pipes. Pump flow discharges into a new secondary channel which then transports the fish into the existing holding tanks. The layout in Figure 5 shows the proposed pumps, vaults, piping, and new secondary next to the paved road in what is currently part of the canal downstream of the primary louvers. This area will become usable by constructing a permanent cofferdam with back fill that is compacted to the same elevation as the road. Constructing the proposed system in this location will help prevent major modifications to existing utilities, equipment, and traffic.

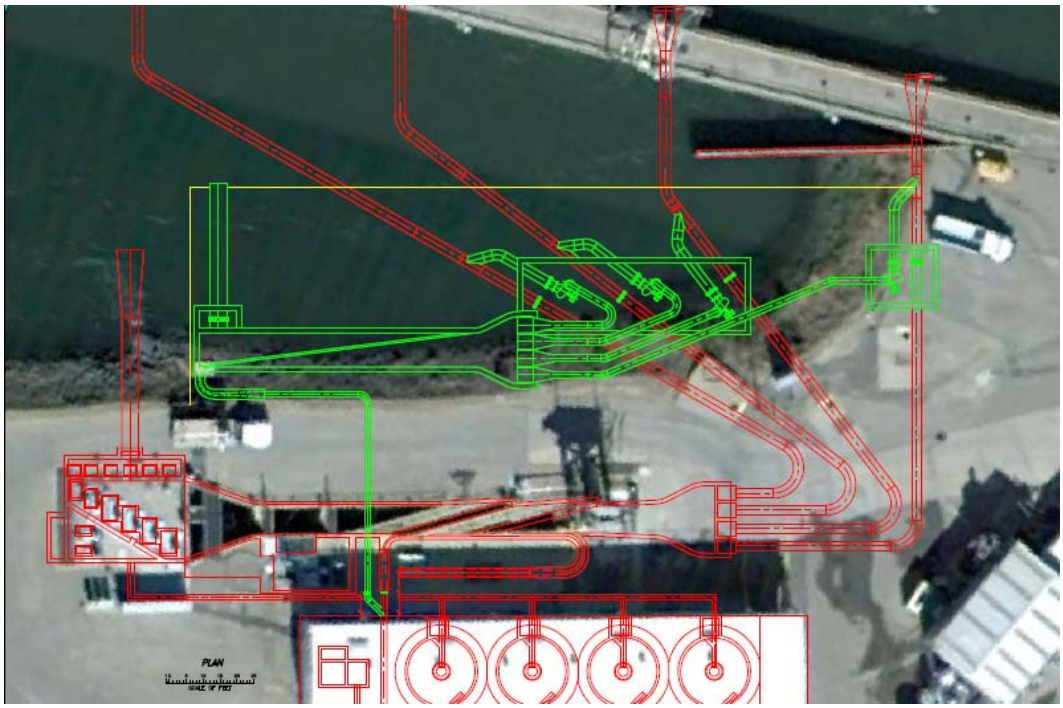

Figure 5 - Layout of Alternative 2 at existing TFCF site. Proposed pumps, vaults, and new secondary are shown in green; proposed cofferdam shown in yellow; and existing infrastructure shown in red

This design alternative also includes both gravity and pump options. Knife gate valves direct flow either straight ahead to the existing secondary (gravity flow) or through the pumps. For pump operation, flow is diverted from the existing bypass pipes through a 45° wye and then a straight section of pipe leading into the pump. The flow is then lifted to an elevation of 14 feet and piped to the new secondary where it is openly discharged into the channel (Figure 6).

The 36 inch diameter inlet piping is reduced to 28 inch diameter to match the pump inlet. Discharge piping is further reduced to 24 inch diameter to create additional head loss which is necessary for the pump to consistently operate within 5% of peak efficiency for all conditions. Each pump includes an automated VFD to hold a constant flow rate as water levels in the primary fluctuate. At the discharge, the pipes transition from circular to a 36 inch x 54 inch rectangular flare which reduces flow velocities as the fish drop into the channel. The maximum velocity a fish would experience at the flare discharge would only be about 3 feet per second (Appendix B).

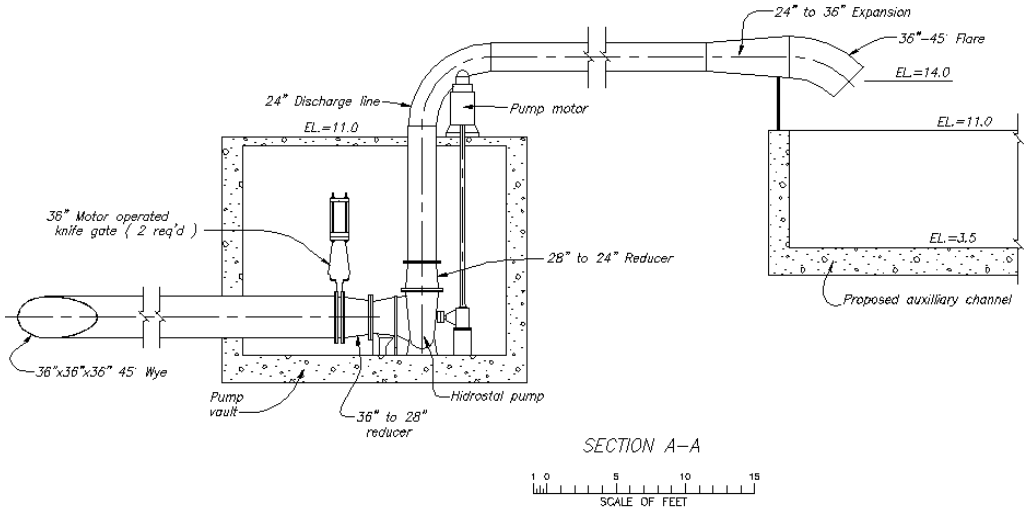

Figure 6 – Section view of pump vaults and discharge piping into new secondary

Once discharged into the new secondary channel the fish are guided into a bypass channel by a traveling fish screen (Figure 7). Water that flows through the traveling screens is discharged through a 60 inch circular conduit back to the Delta Mendota Canal. An automated knife gate is installed on the conduit to control depth in the new secondary. The fish bypass transitions from a rectangular channel to a 20 inch pipe that is buried under the road and ties into the existing bypass pipe that leads to the holding tanks (Appendix B).

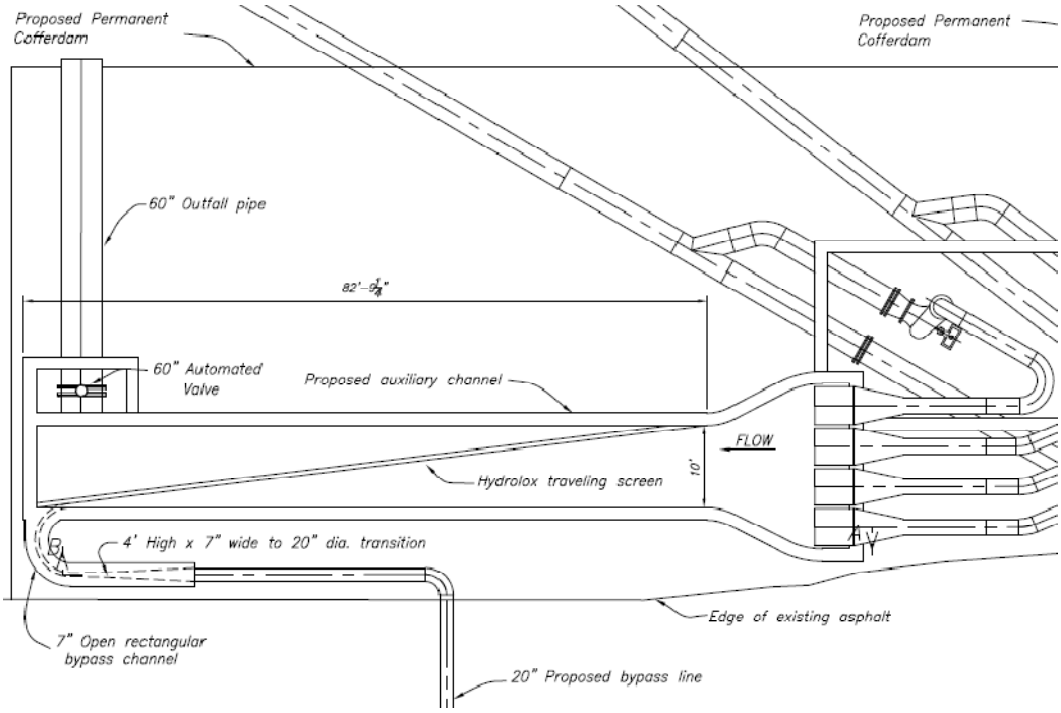

Figure 7 – Plan view of new secondary and inlet to fish bypass

Hydraulic conditions in the new secondary are controlled in accordance with specified criteria for fish passage. According to these criteria, channel velocities range from 1 to 3.5 feet per second depending on the time of year and fish species present at the facility. They also state that the bypass ratio must always be equal to or greater than 1.0. By controlling channel depth with the knife gate in the downstream conduit and the inflow with the fish pumps, criteria are consistently met. Table 3 shows the projected hydraulic results in the new secondary channel.

Separate hydraulic pump calculations suggest that a 28 inch diameter Wemco-Hidrostal pump is suitable for this system. Investigation of the other system components also shows that this design is a feasible alternative. These components include the plunge pool at the head of the new secondary, traveling fish screens, and bypass to the holding tanks which were designed according to Reclamation guidelines (BOR, 2006). Additional calculations for this design can be found in Appendix B.

Table 3 – Projected hydraulic conditions in new secondary

Standard	Controlled Parameters		Results	
Channel Velocity	Inflow	Depth	Bypass Flow (HT)	Bypass Ratio
ft/s	*cfs*	*ft*	*cfs*	-
1.00	60	6.00	11.4	3.3
1.50	90	6.00	11.4	2.2
2.00	100	5.00	10.4	1.8
2.50	120	4.80	9.9	1.4
3.00	140	4.67	9.6	1.2
3.50	160	4.57	9.4	1.0

Advantages vs. Disadvantages

Advantages:

- Consistently meet hydraulic criteria in secondary (independent of primary)
- Operational Flexibility
  - existing gravity operation
  - pumped operation
  - additional secondary channel (possible simultaneous operation of gravity and pump systems)
- Predation reduction
  - predator isolation at open discharge to new secondary using active separators or other methods at the discretion of TFCF operators
  - greater influence on predators in bypass pipes (create higher bypass velocities with pumps to move predators into new secondary)
- Additional space
  - 13,000 sq-ft total
  - 5,600 sq-ft usable (not including space occupied by new channel and pump vaults)
- Minimal modification to existing infrastructure

Disadvantages:

- Difficult cofferdam construction
  - maneuvering around existing bypass pipes
  - far reach for equipment from road
- Additional trash handling from traveling water screens
- Increased operation and maintenance of pumps, new channel and traveling screens

The significant advantages of this design in conjunction with the hydraulic calculations summarized in Table 3 indicate that Alternative 2 is a feasible concept level design. The disadvantages that exist can be addressed by specialized construction techniques and additional planning and are not likely to become significant impediments to this design.

Costs

- Total Construction Costs ≈ $15 million
  - Hidrostal Pumps $5,000,000
  - New Secondary $1,700,000
  - Cofferdam and fill $1,600,000
  - Piping, valves, electrical $930,000
  - Pump vaults $550,000

- Moblization 5%
- Design Contingencies 15%
- Construction Contingencies 25%

Conclusions and Recommendations

Two concept level design alternatives of a fish pump system were presented as a retrofit to improve hydraulic operation of the TFCF. Alternative 1 was determined to be non-feasible primarily due to space limitations at the facility. Although hydraulics in the secondary would be greatly improved, haul truck traffic would be permanently interrupted, utilities would be relocated, and a significant portion of the facility would be modified.

Alternative 2 was determined to be feasible and is recommended for further investigation and design. This design features four 28 inch diameter Wemco-Hidrostal pumps, one on each existing bypass pipe that diverts the flow to a new secondary channel. In the newly proposed secondary channel the fish are screened into a single bypass pipe that transports them to the existing holding tanks. This pump system will allow the facility to consistently meet hydraulic criteria independent of fluctuating water levels in the primary channel.

Alternative 2 is capable of enhancing overall TFCF performance by offering more options and operational flexibility. This pump system will be a retrofit to the existing facility without disrupting operation of the existing gravity system. With both pump and gravity options available, facility operation can be optimized and hydraulic criteria can be met consistently. Flow rates, velocities, and depths can be adjusted for target fish species or other events at the discretion of TFCF operators. Predation can be addressed by increasing bypass pipe velocities with the pumps and using the open discharge to separate large predators from other fish species using active separators or other methods. Also, having both gravity and pump options will allow the facility to continually operate during maintenance and/or repair to any part of the system.

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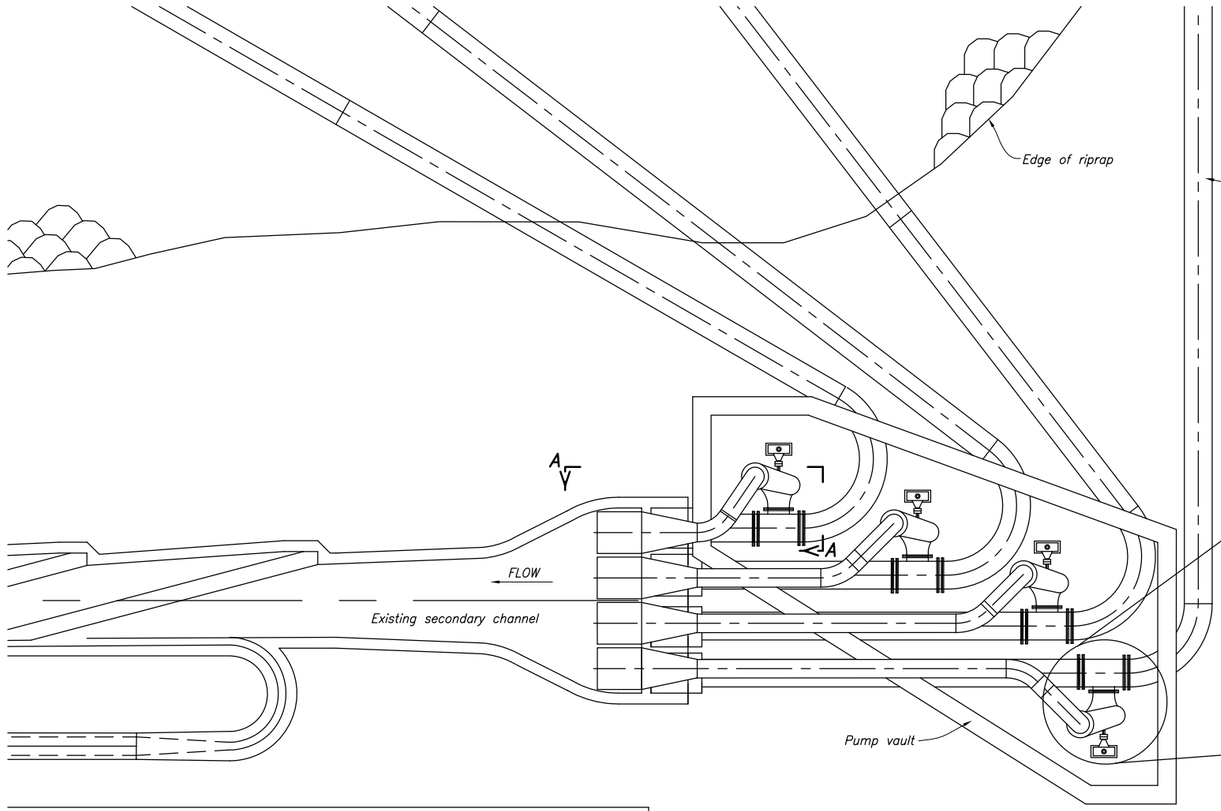
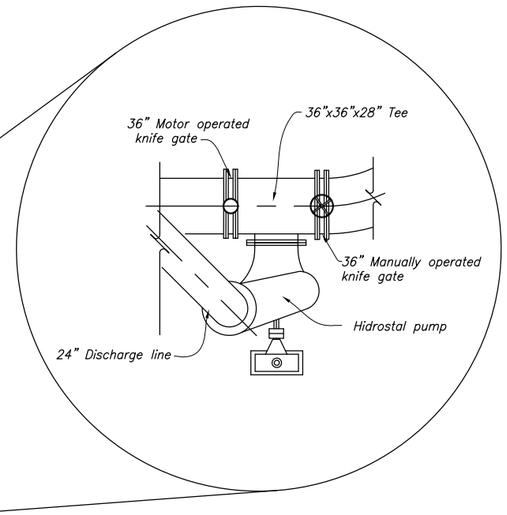
APPENDIX A

ALTERNATIVE 1





PLAN

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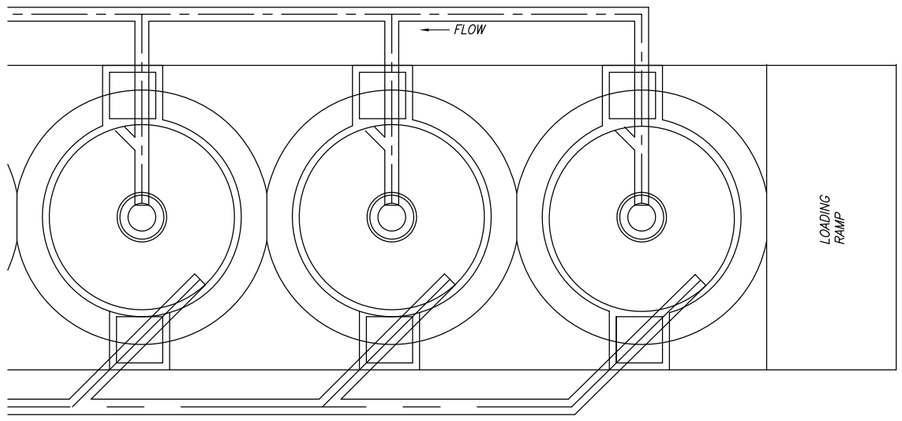

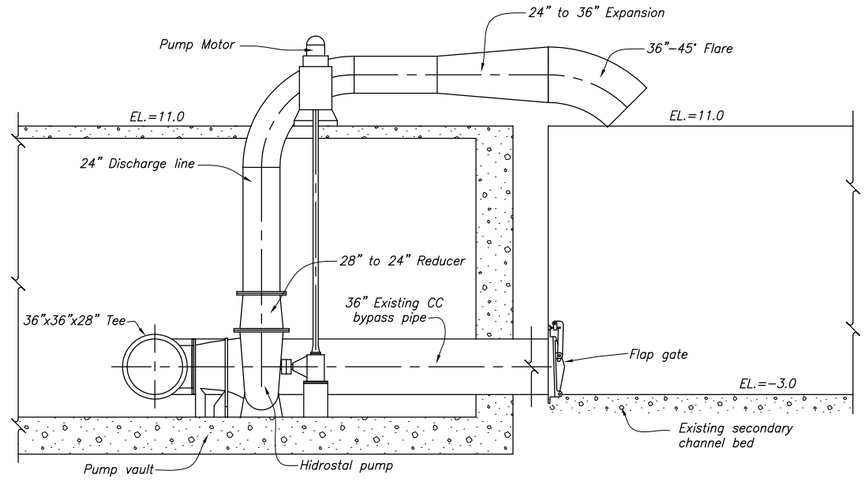

SECTION A–A

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SCALE OF FEET

RECLAMATION
Managing Water in the West

FOR ALWAYS THINK SAFETY
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

TRACY PUMPING PLANT

HIDROSTAL PUMP LAYOUTS
OPTION 2

Draft
Not For Distribution
Use Only

DESIGNED
DRAWN
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TECH. APPR. – NAME – TITLE
APPROVED – PEER REVIEWER – NAME – TITLE

DENVER, COLORADO

SHEET 1 OF 1

DATE AND TIME PLOTTED
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CAD SYSTEM
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BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
TRACY FISH FACILITY - DESIGN ACCT NO. 4
86-68460, Hydraulic Investigations and
Laboratory Services Group
Tracy Fish Collection Facility
Fish Pump System - Alternative 1

PROJECT:
Central Valley Project - California

WOID:	TRRN4	ESTIMATE LEVEL:	Appraisal
REGION:	MP	UNIT PRICE LEVEL:	Jul - 10
FILE:	U:\0001 ESTIMATES\Tracy Fish Fac - Fish Pump System\Estimate\[Tracy FF_Fish Pump System_Opt 2_Appraisal_Aug 2010.xls]Opt 2 Sht 2 of 4		

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Furnish and instal steel manifold					
		Steel piping					
	1a	28" Sch. 5 Wt. = 74.2 b/ft	86-68460	100	lin ft.	$250.00	$25,000.00
	2	Furnish and instal steel pipe fittings					
		45° Welded Elbow					
	2a	28" Diameter: Wt. per elbow = 209 lb	86-68460	4	elbow	$1,000.00	$4,000.00
		90° Welded Elbow					
	2b	28" Diameter: Wt. per elbow = 420 lb	86-68460	4	elbow	$2,000.00	$8,000.00
		Welded Tee					
	2c	36" x 28" Reducing: Wt. per tee = 787 b	86-68460	4	tee	$4,800.00	$19,200.00
		Welded 45° bend flares					
	2d	28" Diameter to 36" x 54" rectangular flare	86-68460	4	flare	$9,000.00	$36,000.00
	3	Furnish and install valves					
	3a	36" Diameter Motorized Knife Gate Valve	86-68460	4	valve	$50,000.00	$200,000.00
	3b	36" Diameter Manual Knife Gate Valve	86-68460	4	valve	$30,000.00	$120,000.00
	3c	36" Diameter Flap Gate. Wt per gate = 7440 l	86-68460	4	gate	$8,000.00	$32,000.00
	4	Furnish and install automated Rubicon Overshot Gate					
		Rubicon Overshot Gate	86-68460	1	gate	$80,000.00	$80,000.00
		SUBTOTAL THIS SHEET	1				$524,200.00

QUANTITIES		PRICES	
BY	CHECKED	BY	CHECKED
Josh Mortensen	Bryan Heiner	T. Hanke	9/16/10
DATE PREPARED	PEER REVIEW / DATE	DATE PREPARED	PEER REVIEW / DATE
08/24/10	Bryan Heiner / 08/24/10	09/15/10	DCB 9/15/10

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE: TRACY FISH FACILITY - DESIGN ACCT NO. 4
86-68460, Hydraulic Investigations and
Laboratory Services Group
Tracy Fish Collection Facility
Fish Pump System - Alternative 1

PROJECT: Central Valley Project - California

WOID:	TRRN4	ESTIMATE LEVEL:	Appraisal
REGION:	MP	UNIT PRICE LEVEL:	Jul - 10

FILE: U:\0001 ESTIMATES\Tracy Fish Fac - Fish Pump System\Estimate\[Tracy FF_Fish Pump System_Opt 2_Appraisal_Aug 2010.xls]Opt 2 Sht 2 of 4

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	5	Electrical Work					
		Assume necessary electric access already on site					
		Allocation for electrical work	86-68460	1	LS	$185,000.00	$185,000.00
	6	Pump Vault Excavation					
		Assume common material stockpiled for reuse and backfill					
		Assume material stockpiled for reuse and backfill					
		Stockpiles will be located within 1/2 mile of site					
		Vault Excavation	86-68460	1,000	yd3	$30.00	$30,000.00
		Note: Item Unit Price includes placing and compacting backfill for structures (approximately 33% of excavated quantity assumed)					
	7	Furnish, form and place reinforced concrete					
		Vault Concrete	86-68460	325	yd3	$1,250.00	$406,250.00
	8	Furnish and install sump pump for vault					
		Allocation for sump pump	86-68460	1	LS	$4,000.00	$4,000.00
	9	Furnish and install grating					
		48" x 48" grating around piping protruding through concrete vault ceiling	86-68460	4	grate	$1,200.00	$4,800.00
	10	Dewatering					
		Allocation for dewatering	86-68460	1	LS	$150,000.00	$150,000.00
		SUBTOTAL THIS SHEET	2				$780,050.00

QUANTITIES		PRICES	
BY	CHECKED	BY	CHECKED
Josh Mortensen	Bryan Heiner	T. Hanke	9/16/10
DATE PREPARED	PEER REVIEW / DATE	DATE PREPARED	PEER REVIEW / DATE
08/24/10	Bryan Heiner / 08/24/10	09/15/10	9/15/10

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:
TRACY FISH FACILITY - DESIGN ACCT NO. 4 86-68460, Hydraulic Investigations and Laboratory Services Group Tracy Fish Collection Facility Fish Pump System - Alternative 1 Hydraulic Equip. Group (86-68420)	Central Valley Project - California WOID: TRRN4 ESTIMATE LEVEL: Appraisal REGION: MP UNIT PRICE LEVEL: Jul - 10 FILE: U:\0001 ESTIMATES\Tracy Fish Fac - Fish Pump System\Estimate\[Tracy FF_Fish Pump System_Opt 2_Appraisal_Aug 2010.xls]Opt 2 Sht 2 of 4

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		FURNISH AND INSTALL THE FOLLOWING:					
		Pump Items 11 thru' 15 - Complete		**4**	**Ea**	**$1,250,000.00**	**$5,000,000.00**
		PUMP w/ Falk Spacer Coupling to Gear Reducer					
	11	4 - Wemco Hdrostal Screw Centrifugal Fish Pump, Model M28DA/M700, single stage, 555 rpm, Rated 18,000 gpm (40 cfs) pump @ ~3' TDH, 28" diam. suction/discharge, water lube packing (11,000 lbs each) - stainless steel casing w/ stainless steel impeller - stainless steel pump shaft - pump vibration limits at Hydraulic Institute Stds - Gov't-witnessed pump shop test - pump shop testing with job motor & gear drive	86-68420	44,000	lbs		
		RIGHT-ANGLE GEAR DRIVE SPEED REDUCER					
	12	4 - LFW right-angle gear reducer, 3.20:1 gear ratio, 125 hp @ 1775 rpm, (1,000 lbs each)	86-68420	4,000	lbs		
		VERTICAL SHAFTING (motor to gear drive)					
	13	4 - Johnson Power vertical shafting, 14 feet total length (2 - 7' sections w/ end couplings & 1 steady bearing between sections) (300 lbs each)	86-68420	1,200	lbs		
		MOTOR					
	14	4 - Vertical, 50-degree C, inverter-rated motor, WPI encl, 125 hp, 1800 rpm, solid shaft, Premium Efficiency, 460V/3Ph/60Hz (2,500 lbs each)	86-68420	10,000	lbs		
		VARIABLE-FREQUENCY DRIVE (VFD) & Enclosure					
	15	4 - Adjustable-speed drive unit for the pump motor, capable of operating down to 55% of full speed, 125 hp, NEMA 4 walk-in encl w/ air conditioner, 460V/3Ph/60Hz	86-68420	4	Each		
		SUBTOTAL THIS SHEET 3					$5,000,000.00

QUANTITIES		PRICES	
BY R. Zelenka	CHECKED --	BY T. Hanke	CHECKED 9/16/10
DATE PREPARED 08/31/10	PEER REVIEW / DATE --	DATE PREPARED 09/15/10	PEER REVIEW / DATE DCD 9/15/10

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
TRACY FISH FACILITY - DESIGN ACCT NO. 4
86-68460, Hydraulic Investigations and
Laboratory Services Group
Tracy Fish Collection Facility
Fish Pump System - Alternative 1

PROJECT:
Central Valley Project - California

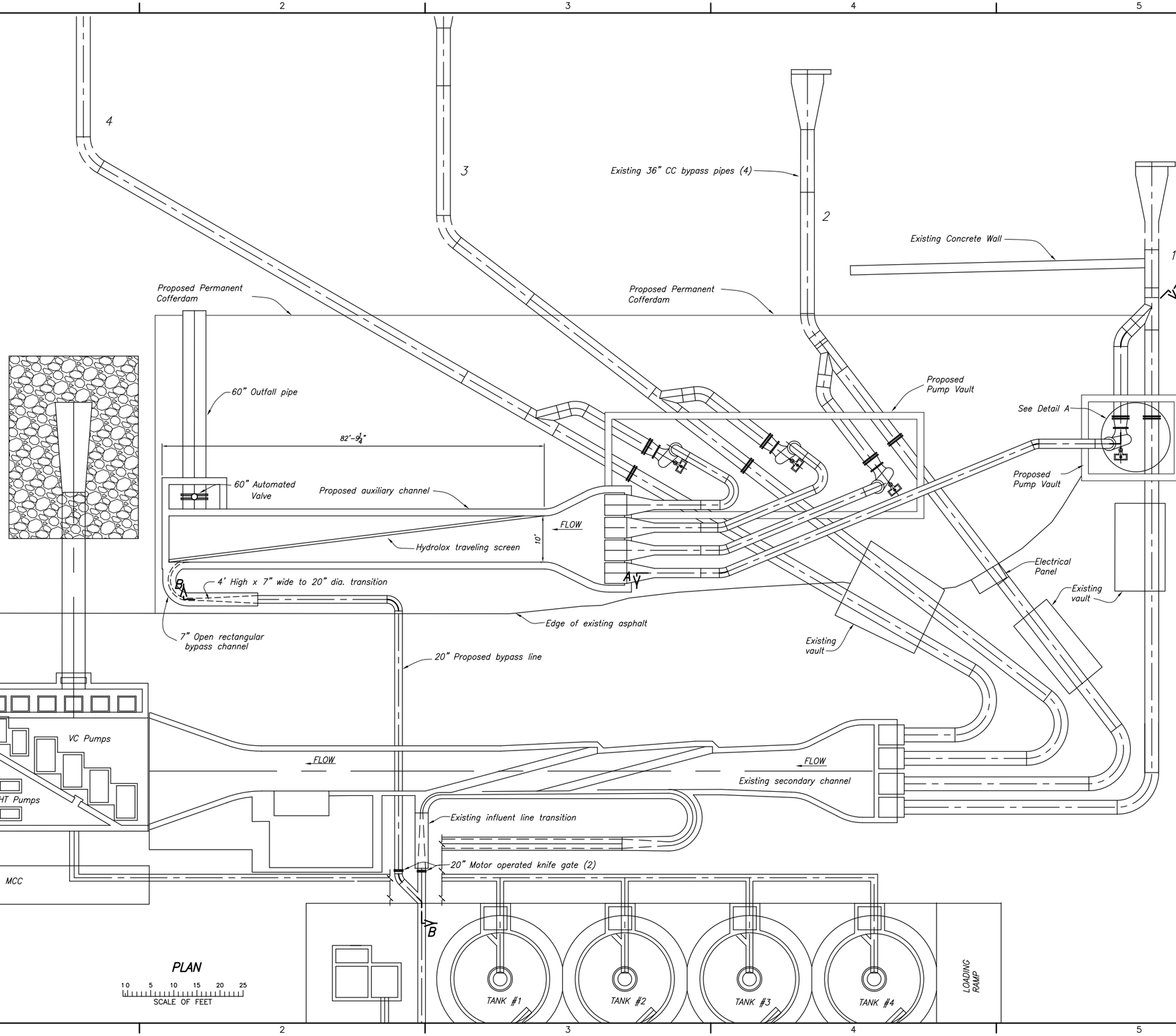
WOID:	TRRN4	ESTIMATE LEVEL:	Appraisal
REGION:	MP	UNIT PRICE LEVEL:	Jul - 10
FILE:	U:\0001 ESTIMATES\Tracy Fish Fac - Fish Pump System\Estimate\[Tracy FF_Fish Pump System_Opt 2_Appraisal_Aug 2010.xls]Opt 2 Sht 2 of 4		

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	Summary -						
		Subtotal Sheet 1					$524,200.00
		Subtotal Sheet 2					$780,050.00
		Subtotal Sheet 3					$5,000,000.00
		Subtotal 1					**$6,304,250.00**
		Mobilization	5%	+/-			$320,000.00
		Subtotal 2 = Subtotal 1 + Mobilization					**$6,624,250.00**
		Design Contingencies	15%	+/-			$975,750.00
		Subtotal 3 = Subtotal 2 + Design Contingencies					**$7,600,000.00**
		Allowance for Procurement Strategies (APS)	0.0%	+/-			$0.00
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 4 = Subtotal 3 + APS					**$7,600,000.00**
		CONTRACT COST					**$7,600,000.00**
		Construction Contingencies	25%	+/-			$1,900,000.00
		FIELD COST					**$9,500,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY Josh Mortensen	CHECKED Bryan Heiner	BY T. Hanke	CHECKED 9/16/10
DATE PREPARED 08/24/10	PEER REVIEW / DATE Bryan Heiner / 08/24/10	DATE PREPARED 09/15/10	PEER REVIEW / DATE 9/15/10

APPENDIX B

ALTERNATIVE 2



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SCALE OF FEET

DATE AND TIME PLOTTED
MARCH 23, 2011 13:27
PLOTTED BY
JMORTENSEN

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AutoCAD Rel. 18.0s
CAD FILENAME
OPTION 4_RUDY.DWG

RECLAMATION
Managing Water in the West

IF ALWAYS THINK SAFETY

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

TRACY PUMPING PLANT

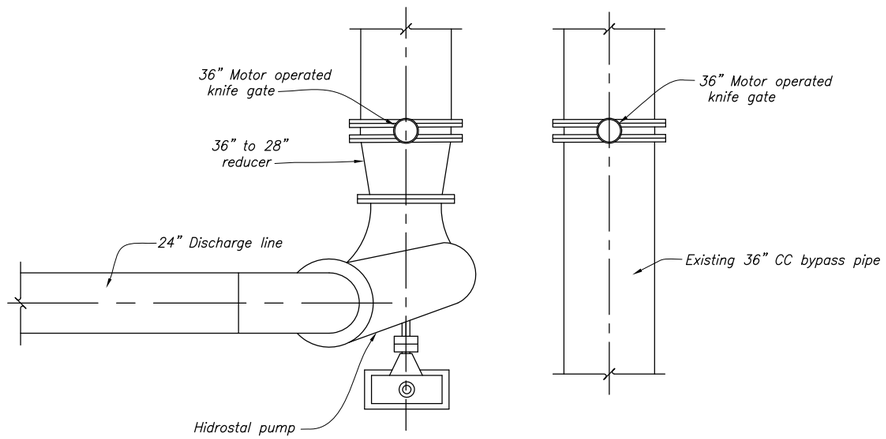
HIDROSTAL PUMP LAYOUTS
OPTION 4

Project Use Only
Not For Distribution

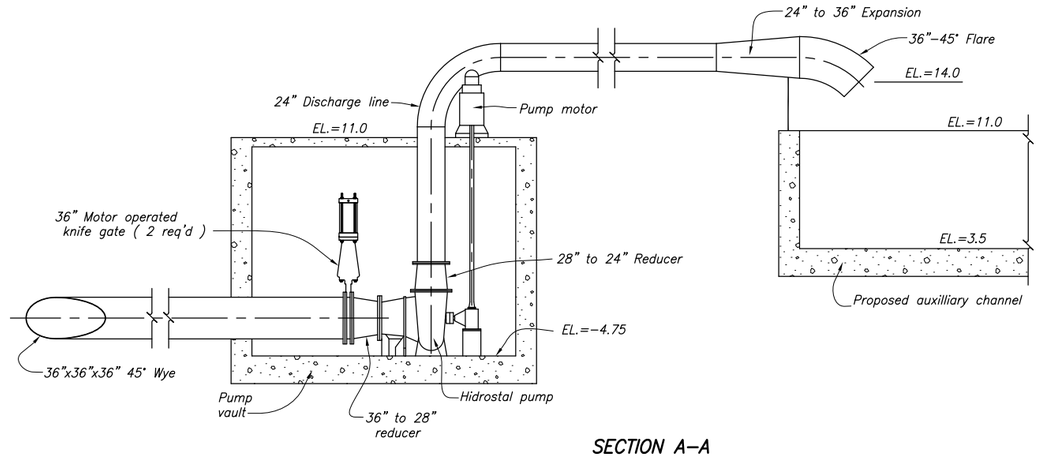
DESIGNED
DRAWN
CHECKED
TECH. APPR. NAME - TITLE
APPROVED PEER REVIEWER - NAME - TITLE

DENVER, COLORADO

SHEET 1 OF 2



DETAIL A
Not to scale



SECTION A–A

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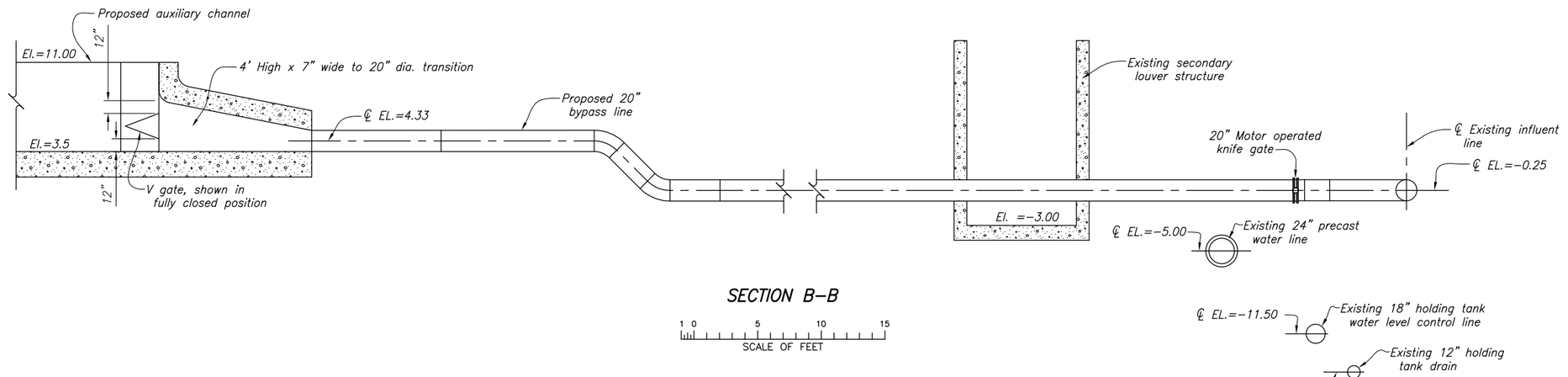
SCALE OF FEET



SECTION B–B

1 0 5 10 15
SCALE OF FEET

RECLAMATION
Managing Water in the West

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U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Use Only
Draft
Not For Distribution

TRACY PUMPING PLANT

HIDROSTAL PUMP LAYOUTS
FOR OPTION 4

DESIGNED
DRAWN
CHECKED
TECH. APPR. – NAME – TITLE
APPROVED – PEER REVIEWER – NAME – TITLE
DENVER, COLORADO

SHEET 2 OF 2

DATE AND TIME PLOTTED
Not Plotted
PLOTTED BY
Not Plotted

CAD SYSTEM
AUTOCAD
CAD FILENAME
UNKNOWN

FEATURE:
TRACY FISH FACILITY
86-68460, Hydraulic Investigations and Laboratory Services Group
Tracy Fish Collection Facility
Fish Pump System - Alternative 2

PROJECT:
Central Valley Project - California

WOID: AF555 **ESTIMATE LEVEL:** Appraisal
REGION: MP **UNIT PRICE LEVEL:** Mar-11
FILE: D:\Tracy\Fish-Friendly Pumps\OPTIONS\OPTION 4 - Auxiliary Channel\[Option4$Estimate_jm.xls]Sheet 4

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Furnish and install steel manifold	86-68460				
		Steel piping					
	1a	20" Sch. 10 Wt. = 53 lb/ft		100	lin ft.	$180.00	$18,000.00
	1b	24" Sch. 10 Wt. = 63.5 lb/ft		210	lin ft.	$215.00	$45,150.00
	1c	36" Sch. 5 Wt. = 95.5 lb/ft		60	lin ft.	$300.00	$18,000.00
	1d	60" PCCP		45	lin ft.	$465.00	$20,925.00
	2	Furnish and install steel pipe fittings	86-68460				
		Welded Lateral (Y)					
	2a	36" Diameter: Wt per lateral = 1000 lb		4	lateral	$6,000.00	$24,000.00
		22.5º Welded Elbow					
	2b	24" Diameter: Wt per elbow = 78 lb		4	elbow	$375.00	$1,500.00
		30º Welded Elbow					
	2c	24" Diameter: Wt per elbow = 105 lb		9	elbow	$500.00	$4,500.00
		45º Welded Elbow					
	2d	20" Diameter: Wt per elbow = 85 lb		3	elbow	$405.00	$1,215.00
	2e	36" Diameter: Wt per elbow = 345 lb		4	elbow	$1,500.00	$6,000.00
		90º Welded Elbow					
	2f	20" Diameter: Wt per elbow = 170 lb		1	elbow	$810.00	$810.00
	2g	24" Diameter: Wt per elbow = 310 lb		4	elbow	$1,500.00	$6,000.00
		Welded 45º bend flares					
	2h	24" Diameter to 36"x54" rectangular flare		4	flare	$9,000.00	$36,000.00
		Welded Reducer	86-68460				
	2i	36" x 28" Wt. per reducer = 340 lb		4	reducer	$2,500.00	$10,000.00
	2j	28" x 24" Wt. per reducer = 265 lb		4	reducer	$1,950.00	$7,800.00
	3	Furnish and Install Valves	86-68460				
	3	20" Diameter Motorized Knife Gate Valve		2	valve	$10,000.00	$20,000.00
	3b	36" Diameter Motorized Knife Gate Valve		8	valve	$50,000.00	$400,000.00
	3c	60" Diameter Motorized Butterfly Valve		1	valve	$50,000.00	$50,000.00
		SUBTOTAL THIS SHEET					**$669,900.00**

QUANTITIES		**PRICES**	
BY	**CHECKED**	**BY**	**CHECKED**
J. Mortensen	-	-	-
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
03/22/11	-	-	-

FEATURE:
TRACY FISH FACILITY
86-68460, Hydraulic Investigations and Laboratory Services Group
Tracy Fish Collection Facility
Fish Pump System - Alternative 2

PROJECT:
Central Valley Project - California

WOID: AF555 **ESTIMATE LEVEL:** Appraisal
REGION: MP **UNIT PRICE LEVEL:** Mar-11
FILE: D:\Tracy\Fish-Friendly Pumps\OPTIONS\OPTION 4 - Auxiliary Channel\[Option4$Estimate_jm.xls]Sheet 4

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		FURNISH AND INSTALL THE FOLLOWING:					
		Pump Items 5 Thru 9 - Complete		4	Ea	$1,250,000.00	$5,000,000.00
		PUMP w/ Falk Spacer Coupling to Gear Reducer					
	4	4 - Wemco Hidrostal Screw Centrifugal Fish Pump,	86-68420	44,000	lbs		
		Model M28DA/M700, single stage, 555 rpm,					
		Rated 18,000 gpm (40 cfs) pump @ 13' TDH,					
		28" diam. suction/discharge, water lube packing					
		(11,000 lbs each)					
		- stainless steel casing w/ stainless steel impeller					
		- stainless steel pump shaft					
		- pump vibration limits at Hydraulic Institute Stds					
		- Gov't-witnessed pump shop test					
		- pump shop testing with job motor & gear drive					
		RIGHT-ANGLE GEAR DRIVE SPEED REDUCER					
	5	4 - LFW right-angle gear reducer, 3.20:1 gear ratio,	86-68420	4,000	lbs		
		125 hp @ 1775 rpm,					
		(1,000 lbs each)					
		VERTICAL SHAFTING (motor to gear drive)					
	6	4 - Johnson Power vertical shafting, 14 feet total	86-68420	1,200	lbs		
		length (2 - 7' sections w/ end couplings &					
		1 steady bearing between sections)					
		(300 lbs each)					
		MOTOR					
	7	4 - Vertical, 50-degree C, inverter-rated motor,					
		WPI encl, 125 hp, 1800 rpm, solid shaft, Premium	86-68420	10,000	lbs		
		Efficiency, 460V/3Ph/60Hz					
		(2,500 lbs each)					
		VARIABLE-FREQUENCY DRIVE (VFD) & Enclosure					
	8	4 - Adjustable-speed drive unit for the pump motor,	86-68420	4	Ea		
		capable of operating down to 55% of full speed,					
		125 hp, NEMA 4 walk-in encl w/ air conditioner,					
		460V/3Ph/60Hz					
		SUBTOTAL THIS SHEET					**$5,000,000.00**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
R. Zelenka	--	T. Hanke	
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
08/31/10	--	09/15/10	

FEATURE:
TRACY FISH FACILITY
86-68460, Hydraulic Investigations and Laboratory Services Group
Tracy Fish Collection Facility
Fish Pump System - Alternative 2

PROJECT:
TRACY FF DESIGN ACCT NO. 4
86-68460

WOID: TRRN4 **ESTIMATE LEVEL:** Appraisal
REGION: MP **UNIT PRICE LEVEL:**
FILE: D:\Tracy\Fish-Friendly Pumps\OPTIONS\OPTION 4 - Auxiliary Channel\[Option4$Estimate_jm.xls]Sheet 4

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	9	Electrical Work	86-68460				
		Assume necessary electric access already on site					
		Allocation for electrical work		1	LS	$335,000.00	$335,000.00
	10	Furnish and Install Traveling Fish Screen					
		Assume motors, sprayers, and conveyors included					
	10a	Hydrolox traveling fish screen	86-68460	820	SF	$1,320.00	$1,082,400.00
	11	Excavation	86-68460				
		Assume common material stockpiled for reuse and backfill					
		Assume material stockpiled for reuse and backfill					
		Stockpiles will be located within 1/2 mile of site					
	11a	Pump Vault Excavation		1,300	yd3	$30.00	$39,000.00
	11b	Channel Excavation		535	yd3	$30.00	$16,050.00
	11c	Bypass Pipe Excavation		120	yd3	$30.00	$3,600.00
		Note: Item Unit Price includes placing and compacting backfill for structures					
		(approximately 33% of excavated quantity assumed)					
	12	Furnish, form and place reinforced conrete	86-68460				
	12a	Vault Concrete		400	yd3	$1,250.00	$500,000.00
	12b	Channel Concrete		240	yd3	$1,250.00	$300,000.00
	12c	Bypass Concrete		165	yd3	$1,250.00	$206,250.00
	13	Furnish and install sump pump for vault	86-68460				
		Allocation for sump pumps		1	LS	$8,000.00	$8,000.00
	14	Furnish and install grating	86-68460				
		48" x 48" grating around piping protruding		4	grate	$1,200.00	$4,800.00
		SUBTOTAL THIS SHEET					**$2,495,100.00**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
J. Mortensen	-	-	-
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
03/23/11	-	-	-

FEATURE:
TRACY FISH FACILITY
86-68460, Hydraulic Investigations and Laboratory Services Group
Tracy Fish Collection Facility
Fish Pump System - Alternative 2

PROJECT:
TRACY FF DESIGN ACCT NO. 4
86-68460

WOID: TRRN4 **ESTIMATE LEVEL:** Appraisal
REGION: MP **UNIT PRICE LEVEL:**
FILE: D:\Tracy\Fish-Friendly Pumps\OPTIONS\OPTION 4 - Auxiliary Channel\[Option4$Estimate_jm.xls]Sheet 4

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	16	Furnish and place back fill material	86-68460				
		Assume compaction and hauling included					
		Assume fill is available within 25 miles from site					
		Backfill Material		3,200	yd3	$30.25	$96,800.00
	17	Furnish and install sheet pile cofferdam	86-68460				
		Assume sheet piles will remain permanent					
	17a	Steel sheet pile cofferdam		130	Ton	$4,600.00	$598,000.00
	17b	Steel for permanent walers, bracing, etc.		6	Ton	$1,400.00	$8,400.00
	17c	Specialized equipment, procedures, grouting, etc. for		3	Ea	$200,000.00	$600,000.00
		sheet piling around existing bypass pipes					
	18	Dewatering	86-68460				
	18a	Allocation for dewatering		1	LS	$300,000.00	$300,000.00
		SUBTOTAL THIS SHEET					**$1,603,200.00**

QUANTITIES		**PRICES**	
BY	**CHECKED**	**BY**	**CHECKED**
J. Mortensen	-	-	-
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
03/23/11	-	-	-

FEATURE:
TRACY FISH FACILITY
86-68460, Hydraulic Investigations and Laboratory Services Group
Tracy Fish Collection Facility
Fish Pump System - Alternative 2

PROJECT:
TRACY FF DESIGN ACCT NO. 4
86-68460

WOID: TRRN4 **ESTIMATE LEVEL:** Appraisal
REGION: MP **UNIT PRICE LEVEL:**
FILE: D:\Tracy\Fish-Friendly Pumps\OPTIONS\OPTION 4 - Auxiliary Channel\[Option4$Estimate_jm.xls]Sheet 4

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	Summary -						
		Subtotal Sheet 1					$669,900.00
		Subtotal Sheet 2					$5,000,000.00
		Subtotal Sheet 3					$2,495,100.00
		Subtotal Sheet 4					$1,603,200.00
		Subtotal 1					$9,768,200.00
		Mobilization	5%	+ / -			$488,410.00
		Subtotal 2 = Subtotal 1 + Mobilization					$10,256,610.00
		Design Contingencies	15%	+ / -			$1,538,491.50
		Subtotal 3 = Subtotal 2 + Design Contingencies					$11,795,101.50
		Allowance for Procurement Strategies (APS)	0.0%	+ / -			$0
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 4 = Subtotal 3 + APS					$12,000,000.00
		CONTRACT COST					$12,000,000.00
		Construction Contingencies	25%	+ / -			$3,000,000.00
		FIELD COST					$15,000,000.00

QUANTITIES		**PRICES**	
BY	**CHECKED**	**BY**	**CHECKED**
J. Mortensen	-	-	-
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
03/23/11	-	-	-

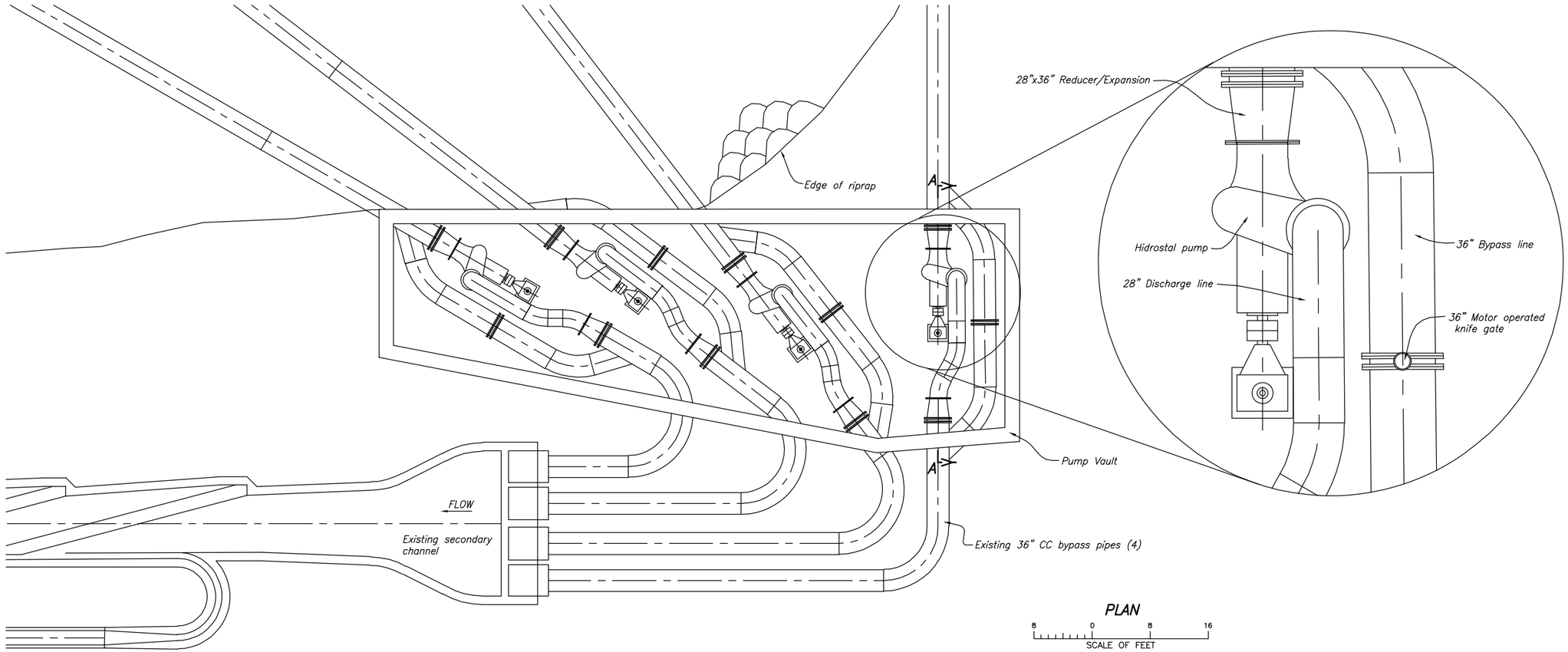
ALTERNATIVE 2 - PROJECTED HYDRAULIC CONDITIONS

Standard	Fish Pumps					New Secondary Channel					
Channel Velocity	***Single Pump Flow***	***Inflow***	***36" Suction Pipe Velocity***	***24" Discharge Pipe Velocity***	***Flare Discharge Velocity***	***Depth***	***Vertical Fish Drop***	***Fish Impact Velocity***	***Energy Dissipation Factor***	***Screen Approach Velocity***	***Bypass Ratio***
ft/s	*cfs*	*cfs*	*ft/s*	*ft/s*	*ft/s*	*ft*	*ft*	*ft/s*	*ft lb/s/ft^3*	*ft/s*	-
1.00	30.00	60	4.24	9.55	1.11	6.00	4.50	17.06	10.14	0.10	3.3
1.50	22.50	90	3.18	7.16	1.67	6.00	4.50	17.10	15.30	0.16	2.2
2.00	25.00	100	3.54	7.96	1.85	5.00	5.50	18.91	24.93	0.22	1.8
2.50	30.00	120	4.24	9.55	2.22	4.80	5.70	19.29	32.42	0.28	1.4
3.00	35.00	140	4.95	11.14	2.59	4.67	5.83	19.55	39.98	0.34	1.2
3.50	40.00	160	5.66	12.73	2.96	4.57	5.93	19.76	47.65	0.40	1.0

APPENDIX C

DRAWINGS OF OTHER CONCEPT DESIGNS CONSIDERED

Both concepts shown in Appendix C were not considered feasible because the system did not match the required pump curve of the pump size required to meet secondary flow requirements. They also presented issues for space limitations.



PLAN

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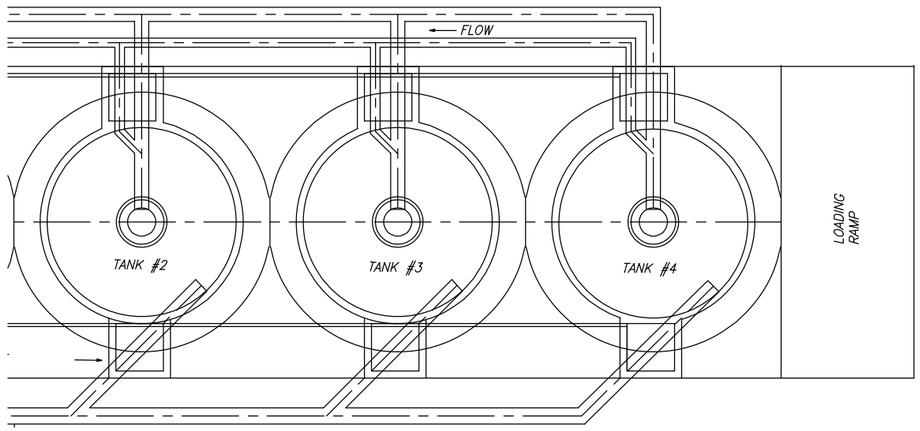
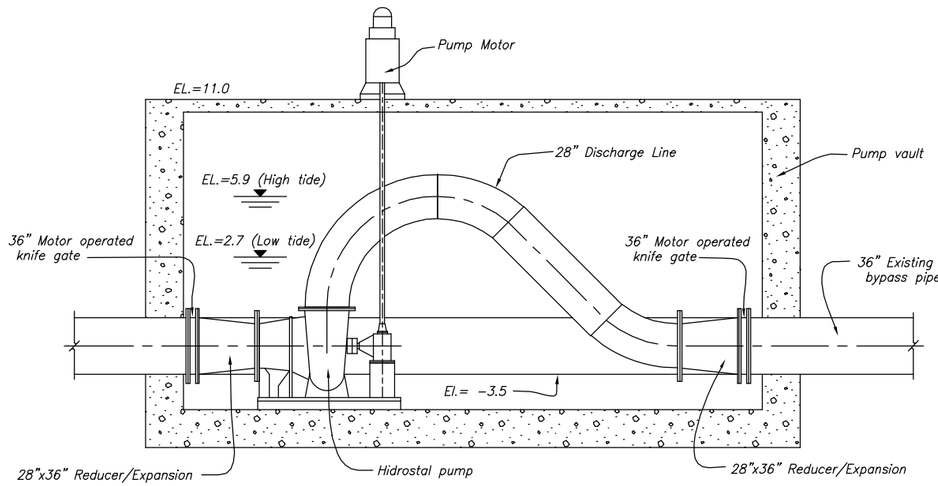




SECTION A–A

1 0 5 10 15
SCALE OF FEET

RECLAMATION
Managing Water in the West

ALWAYS THINK SAFETY

U.S. Department of the Interior
Bureau of Reclamation

TRACY PUMPING PLANT

HIDROSTAL PUMP LAYOUTS
OPTION 1

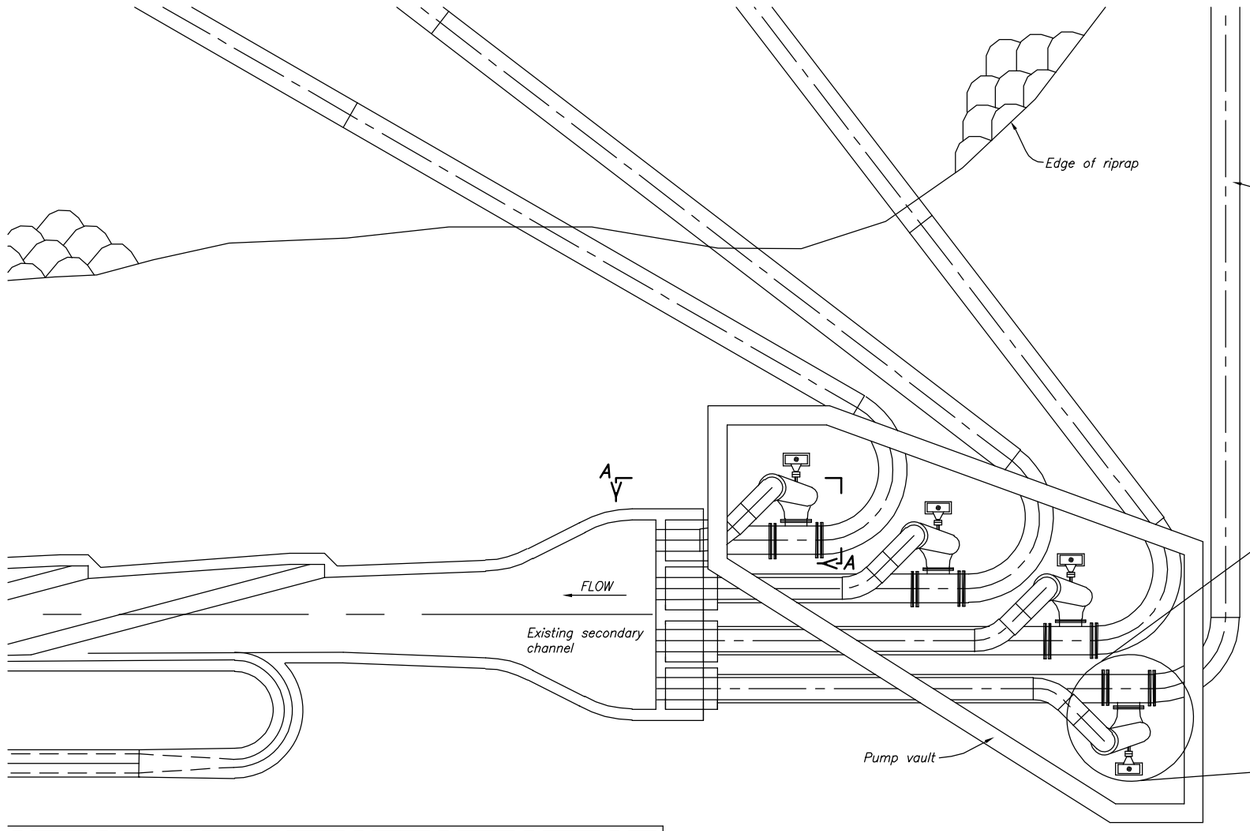
Use Only
Not For Distribution

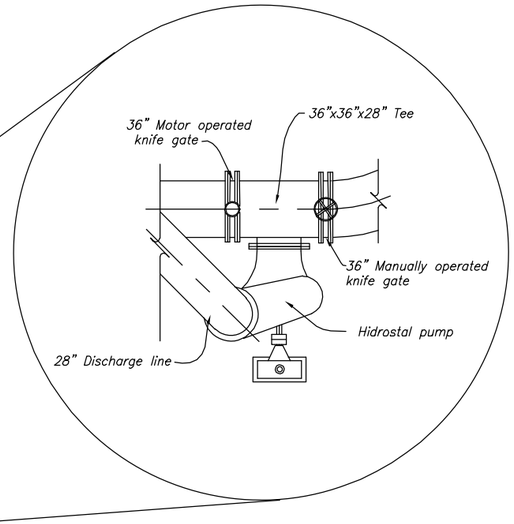
DESIGNED
DRAWN
CHECKED
TECH. APPR. – NAME – TITLE
APPROVED – PEER REVIEWER – NAME – TITLE
DENVER, COLORADO

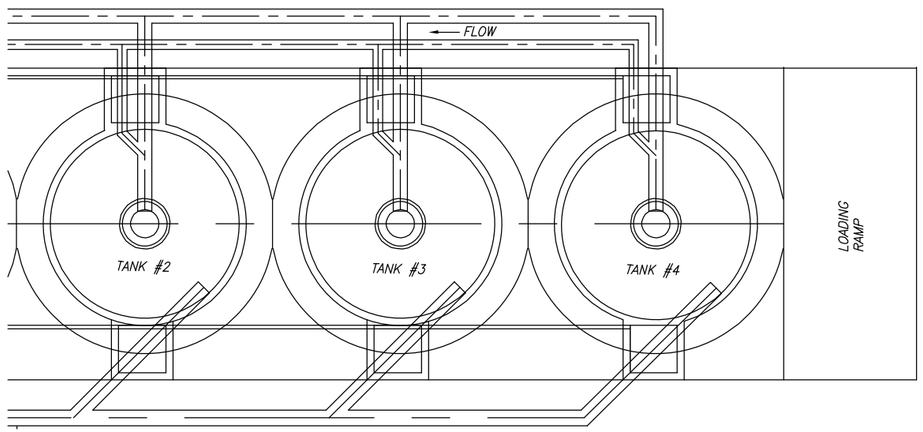
SHEET 1 OF 1

DATE AND TIME PLOTTED
Not Plotted
PLOTTED BY
Not Plotted

CAD SYSTEM
AUTOCAD
CAD FILENAME
UNKNOWN

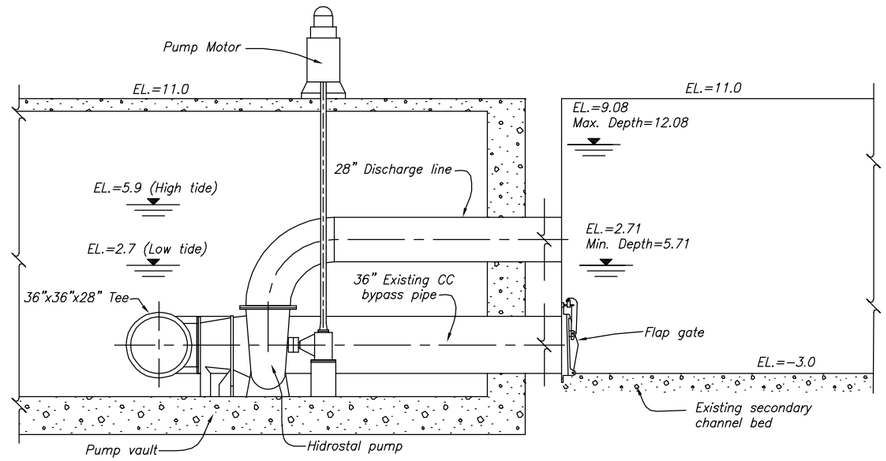






PLAN

8 0 8 16
SCALE OF FEET



SECTION A–A

1 0 5 10 15
SCALE OF FEET

RECLAMATION
Managing Water in the West

ALWAYS THINK SAFETY
U.S. Department of the Interior
Bureau of Reclamation

TRACY PUMPING PLANT
HIDROSTAL PUMP LAKOUTS
OPTION 3

FOR Use Only
Not For Distribution

DESIGNED
DRAWN
CHECKED
TECH. APPR. NAME – TITLE
APPROVED PEER REVIEWER – NAME – TITLE
DENVER, COLORADO

SHEET 1 OF 1

DATE AND TIME PLOTTED
Not Plotted
PLOTTED BY
Not Plotted

CAD SYSTEM
AUTOCAD
CAD FILENAME
UNKNOWN