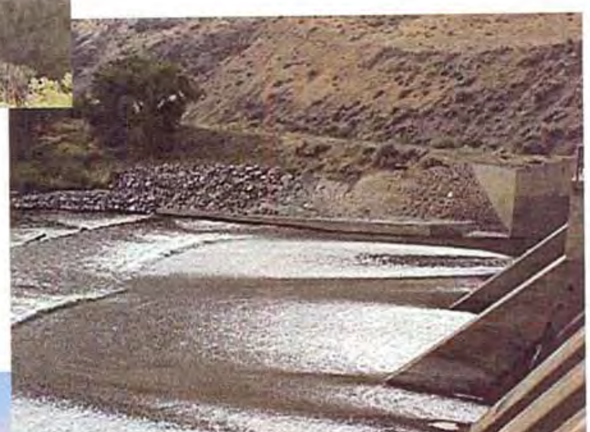
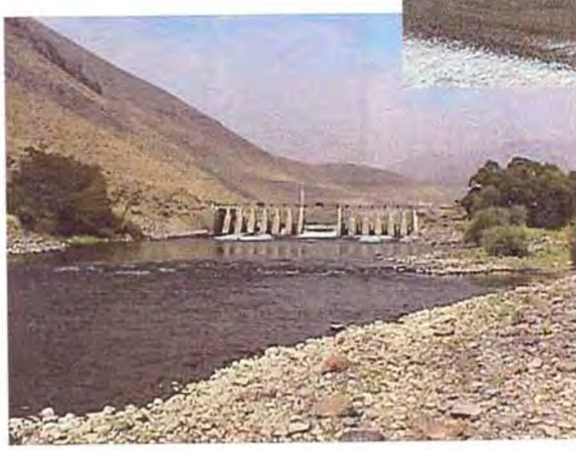
PAP-865

DERBY DAM CONCEPT REPORT

for

TRUCKEE CANAL FISH SCREEN
FISHWAY
AUXILIARY GATED FLOOD CONTROL STRUCTURE





January, 2001

DERBY DAM CONCEPT REPORT

TRUCKEE CANAL FISH SCREEN
FISHWAY
AUXILIARY GATED FLOOD CONTROL STRUCTURE

Prepared
for
U.S. Bureau of Reclamtion
Lahontan Basin Area Office
Carson City, Nv

Prepared by

U.S. Bureau of Reclamation Technical Service Center

Brent Mefford
Arthur Glickman
Jeff Baysinger
Steve Willcut

Table of Contents

Page

Figures

Tables

Appendix A
Itemized Construction Cost Estimates

Appendix B
Conceptual Geologic Design Considerations - Derby Dam Fish Facilities

Derby Dam Fish Protection and Passage

Background and Project Objectives

Derby Diversion Dam, also referred to as the Truckee River Diversion Dam, is located about 20 miles east of Reno, Nevada, figure 1. The dam consists of a concrete buttress style gated spillway structure with a structural height of 31 ft yielding a hydraulic height of 15 ft, canal headworks, and embankment wing, figure 2. The dam is one of Reclamation's first civil structures. The dam and unscreened canal are recognized deterrents to the recovery of native fish populations found in the Truckee River System. The dam is a barrier to upstream fish passage and the unscreened canal provides no means for fish entrained in canal diversion flows to return to the Truckee River. This report provides concept level designs for constructing a fish passage structure on the earthen embankment on the left bank of the river (looking downstream), a fish screen structure downstream of the canal headworks and a gated flood control structure to improve the capability of the facility to pass flood flows and large debris.

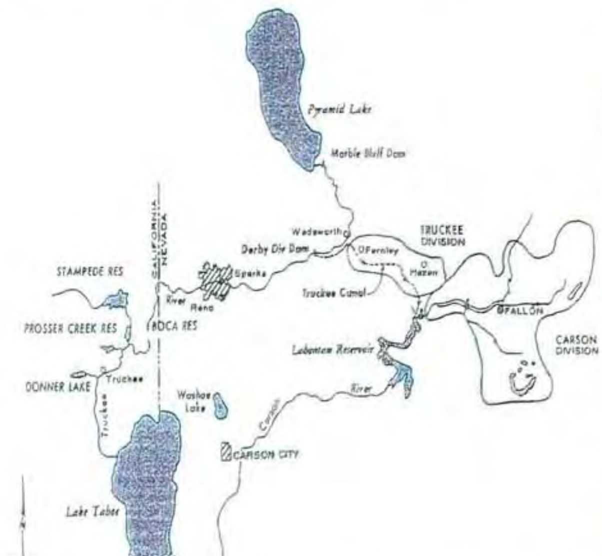


Figure 1 - Location map for Derby Dam and Truckee Canal.

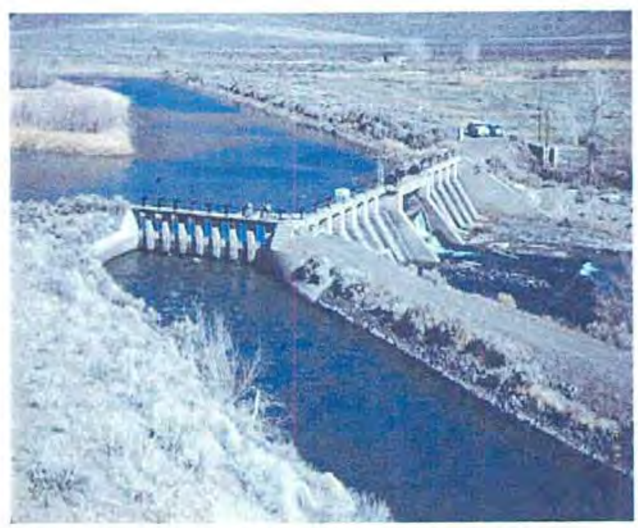


Figure 2 - View of Derby Dam and the Truckee Canal headworks.

Facility Description (Reclamation, 1981)

The dam crest is 1,331 ft long. The spillway is a 155-foot-wide concrete gate structure that spans across the Truckee River channel and originally consisted of 16, 5-foot by 5-foot cast iron slide gates separated by 5 foot-wide-piers, figure 3. To improve debris passage, three gates were removed and replaced by a 25 ft wide overshot gate. The spillway gates are at invert elevation 4196.83. The deck of the bridge is at elevation 4219.16. A sheet pile wall provides the upstream cutoff to the foundation. In 1998, a new concrete spillway apron was constructed downstream of the dam. The apron slopes from elevation 4196.83 to 4191.76 and has a 1 ft high dentated endsill. The embankment wing is located on the left abutment and has a 3:1 upstream slope and 1.5:1 downstream slope. The upstream face is protected by riprap. The crest of the embankment wing varies around elevation 4218.0. The northern end of the embankment wing contains a low section referred to as a "soft plug" with a crest elevation of about 4210.5 that serves as an emergency spillway. The soft-plug is breached during large floods to pass flow and debris around the main dam. Downstream of the low dike section a floodway channel has formed that intersects the main river channel about 650 ft downstream of the dam. During non-flood periods the downstream flood channel forms a shallow backwater slough. The most recent breach occurred in January 1997.

The headworks structure for the Truckee Canal (also called the Main Lower Truckee Canal) is located on the right abutment. The headworks is divided by eight piers supporting a bridge deck and nine 5-foot-wide openings controlled by 5- by 5-foot cast iron slide gates with inverts at elevation 4200.5. The Truckee Canal extends 32 miles from Derby Diversion Dam to Lahonton Reservoir. It has an initial bottom width of 20 feet, side slopes of 1.5:1, a maximum depth of 13 feet and a flow capacity of 1,500 cubic feet per second.

Facility Operation

Flow is diverted through the Truckee Canal headworks year around. The irrigation season typically runs March 15 through November 15. Outside of the irrigation season, the Truckee Canal is used to divert water for storage in Lahonton Reservoir. The maximum normal flow through the canal is less than 1,000 ft^3/s, however the canal is designed to carry a maximum of 1,500 ft^3/s with 2 ft of freeboard. During the irrigation season the spillway gates are normally operated to maintain an upstream pool water surface elevation between 4205 and 4209. Two spillway slide gates are automated and can be remotely operated. The remaining 11 slide gates are hand operated. Figure 4 shows the maximum, minimum and average daily diversion flow that has occurred in each month based on 20 years of record from 1978 to 1998. Peak diversion flow usually occurs during the first six months of the year and then falls during late summer. The diversion pattern follows the typical river flow pattern of the lower Truckee River. Figure 5 shows the 20 year record of canal flow data in percent exceedence. During the period, flow in the canal exceeded 650 ft^3/s about five percent of the time and exceeded 850 ft^3/s about one percent of the time. The maximum canal flow for the period of record was 967 ft^3/s.

During large floods, facility operation and spillway flow capacity is usually affected by washed out trees and logs caught in front of the spillway gates. This material reduces the flood release capacity of the dam by clogging the sluice gates and spillway weir gate. There is no vehicle or equipment access along the top of the spillway and no permanent equipment on the spillway for removing debris. Equipment access is limited to the spillway abutments. When the soft plug is breached all access to the north side of the spillway structure is lost until the breach is repaired. The dike has breached several times during the history of the facility.

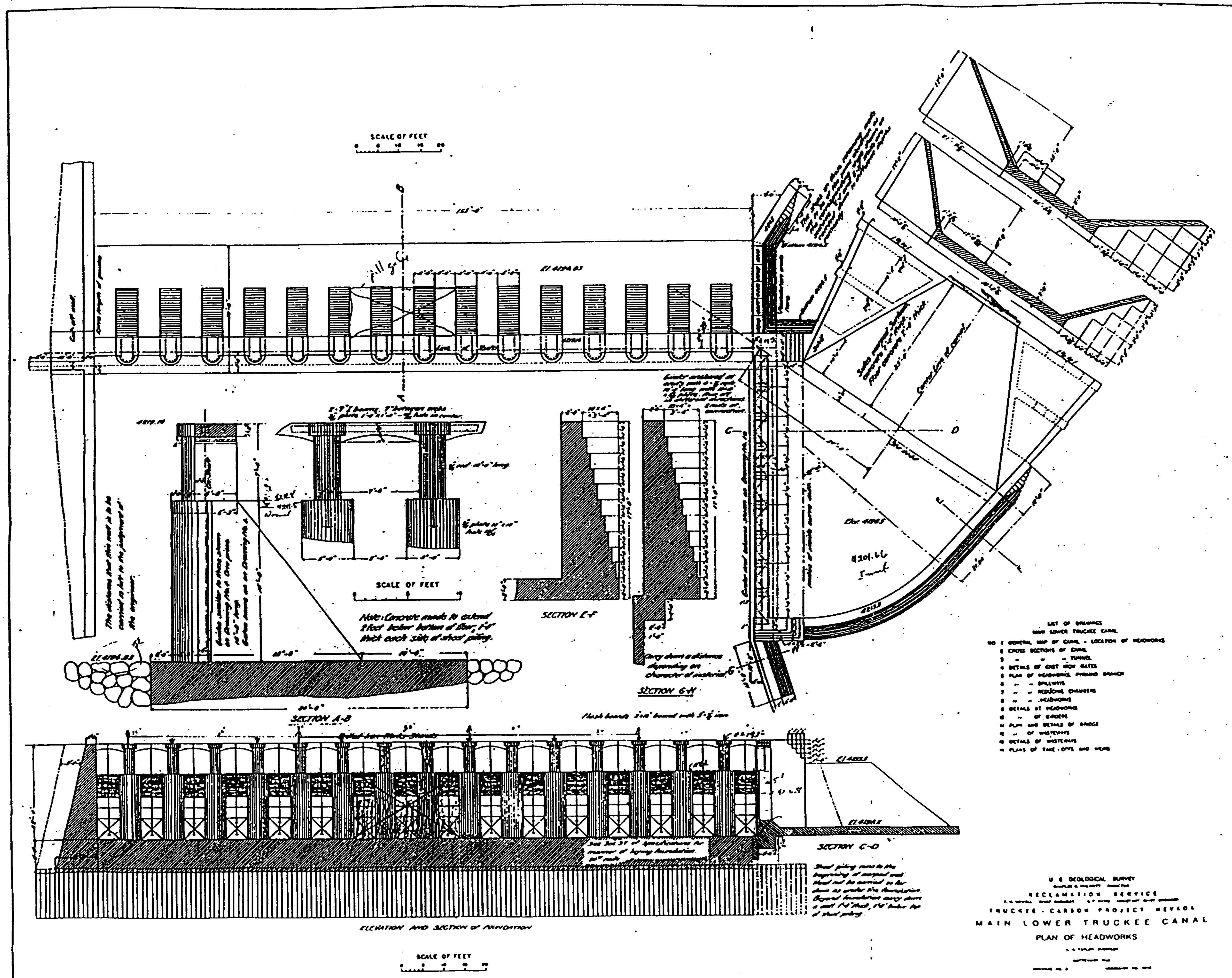


FIGURE 3

1995-15

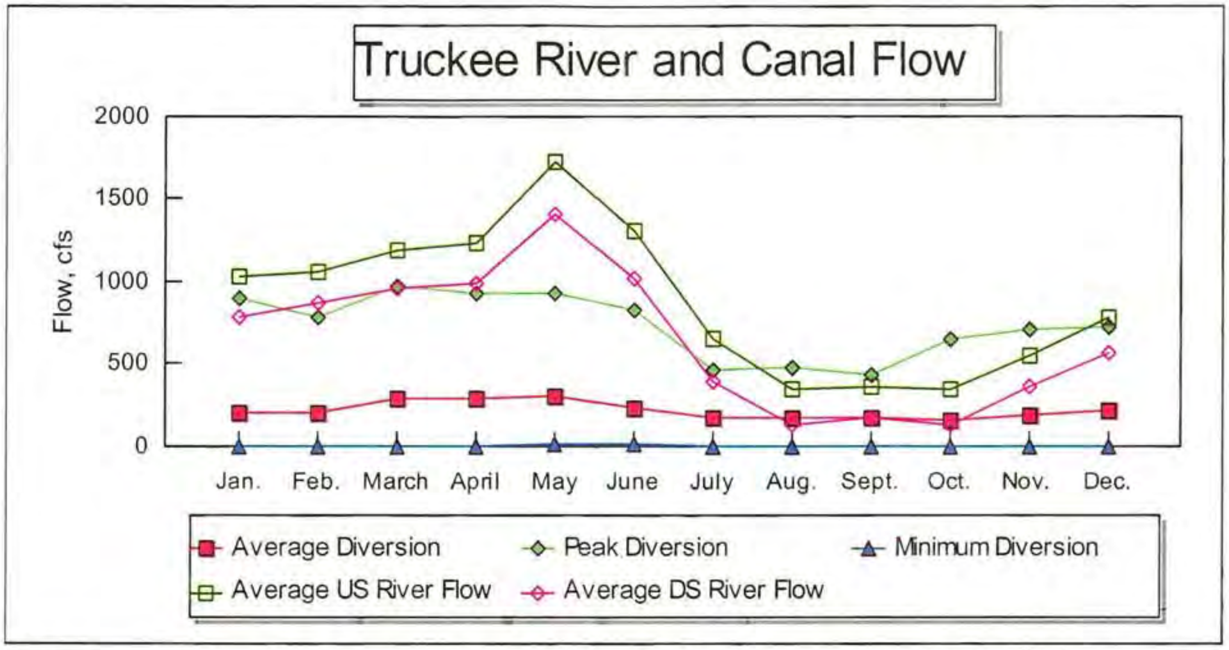


Figure 4 - Graph of Truckee Canal and river flow. River flows are based on USGS river gaging stations 10350400 and 10351600. The stations are located below Tracy, NV. and downstream of Derby Dam, respectively. Canal flow is based on USGS gage 10351300, located in the Truckee Canal at Wadsworth, Nv.

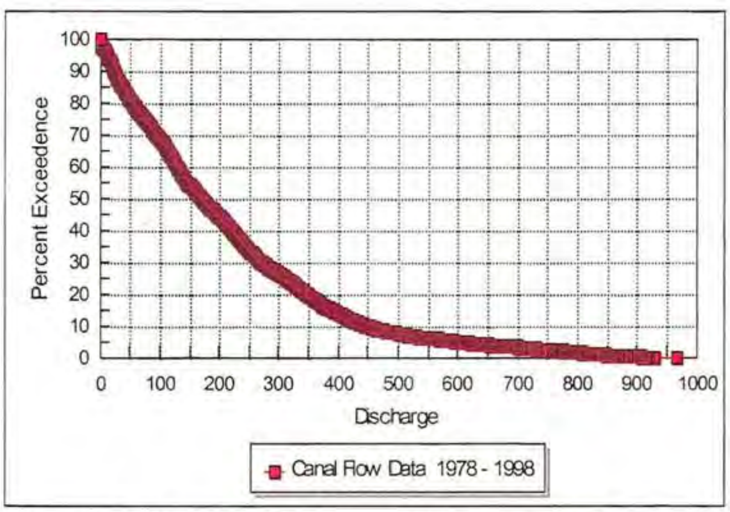


Figure 5 - Percent of time canal flow exceeded. Discharge plotted on the x-axis during the period of 1978 to 1998.

Truckee Canal Fish Exclusion

The Truckee Canal has no fish protection facilities to prevent or discourage entrainment of fish into the canal. Entrainment studies have not be conducted on the canal, however entrainment studies of similar gravity irrigation diversions in the west (Heibert, 2000) show fish entrainment at unscreened gravity diversions can be very high.

Fish Protection

Various methods of reducing fish entrainment are used at water diversions. These methods are generally divided into two categories, positive barriers and behavioral barriers. Positive barrier screens prevent all fish larger than fingerling size and a high percentage of fry from being entrained with diversion flow. Screens allow water to pass through while guiding fish to escape routes commonly called fish bypasses. Behavioral barriers rely on triggering an avoidance response in fish. Most behavioral barriers use artificially imposed stimului to guide fish away from diverted flow. The most common behavioral barriers are louvers, strobe lights, sound generators and electric fields. Behavioral barriers vary widely in effectiveness and application, however no behavioral barriers are considered 100 percent effective. Louvers are a coarse mesh structural barrier designed to generate flow turbulence that fish can detect and avoid. Light, sound and electric fields are non-structural barriers. In most cases, behavioral barriers should only be considered if positive barriers can not be constructed due to site restrictions or cost.

A fish protection facility at Derby Diversion Dam could be placed on-river in front of the diversion headworks structure or off-river in the canal downstream of the headworks. Both locations have advantages and disadvantages. In-river fish barriers are generally preferred where workable because they prevent fish from ever leaving the river and do not require fish to be conveyed back to the river in a bypass pipe or flume. On the down side, in-river means the barrier must be designed to function in front of the existing headworks, contend with large debris, changes in river stage, river bed conditions and relatively poor access to the barrier for maintenance. An off-river location downstream of the canal headworks has the advantage of being removed from extremes of sediment, debris and highly variable flow conditions that exist in front of the headworks. The structure can also be unwatered for inspections and maintenance. The down side, an off-river location adds the potential for fish injury or mortality associated with passing through the headworks gates and increased fish predation due to concentrating of fish in bypass flows. At Derby Dam, the severity of flood flows that carry large debris and lack of access to the river upstream of the canal headworks favor an off-river fish barrier. The potential for injury to fish passing through the canal headworks at Derby is considered small due to the low head differential through the structure.

Positive Barrier Fish Screens

There are two general categories of positive barrier fish screens, fixed and moving screens. Fixed screens designed for open channel diversions are typically designed as a series of flat screen panels positioned nearly vertical. The screens are aligned at an angle to the canal flow to obtain the desired screen area. A strong sweeping flow parallel to the screen face guides fish toward the bypass. A single line of screens (figure 6) or a"V" arrangement (figure 7) can be used. The "V" design allows the structure length to be shortened, but requires the fish bypass be placed mid-channel. The mid-channel bypass is not desirable if large debris is common as it can become wedged in the apex of the "V" and be difficult to remove. A single line screen has a fish bypass positioned at the downstream end of the screen on the channel wall. The screen surface is cleaned by moving a brush or hydraulic spraywash head over the screen. Debris can be either raked vertically up the screen and collected on the screen deck or passed down the length of the screen to the fish bypass to be carried back to the river.

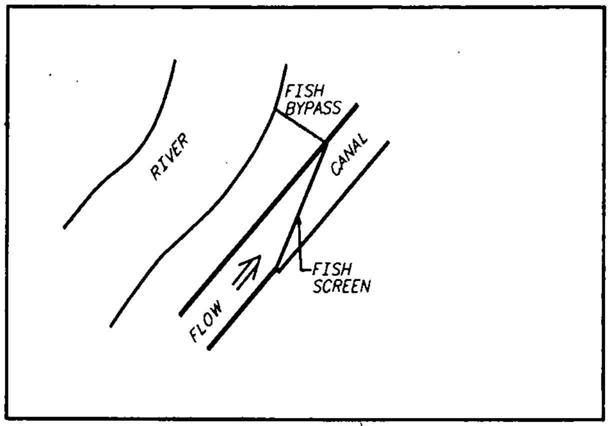


Figure 6 - Typical layout of a linear flat plate fish screen structure.

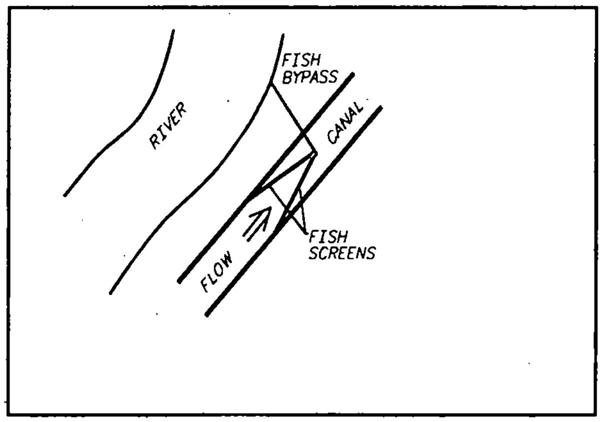


Figure 7 - Typical layout of a "V" shaped fish screen structure.

Moving screens are designed to continuously carry small impinged debris over the screen as they rotate. Drum screens are the most common type of rotating fish screen. For a large diversion, a series of drum screens are set end to end between piers angled to the flow, figure 8. The front face of the piers are shaped to conform to the drums which minimizes blockage of fish guidance along the screen faces. Individual drums consist of rigid cylindrical frames covered by screen material. Rubber seals that seat against the piers are attached to both ends of the drums. A bottom seal is fixed to the structure beneath the drum and seats against the drum surface. The drums rotate about their axis such that the front (upstream) face rises and the back face descends. The upstream water surface is controlled to maintain 70 to 80 percent drum submergence. This submergence is required for proper debris handling. Debris that impinges on the screen is carried over the top by the rotation and washed off the backside by the through flow. This tends to be a very effective cleaning mechanism making drum screens a good self cleaning design. If the submergence drops much below

70 percent, debris tends to not cling to and carry over the drum but instead accumulates along the front face. Larger debris like logs can roll in front of the screen and require manual removal. Drum screens have been constructed ranging from a few feet up to 20 feet in diameter and from the typical 10 to 12 feet length to up 25 to 30 feet in length.

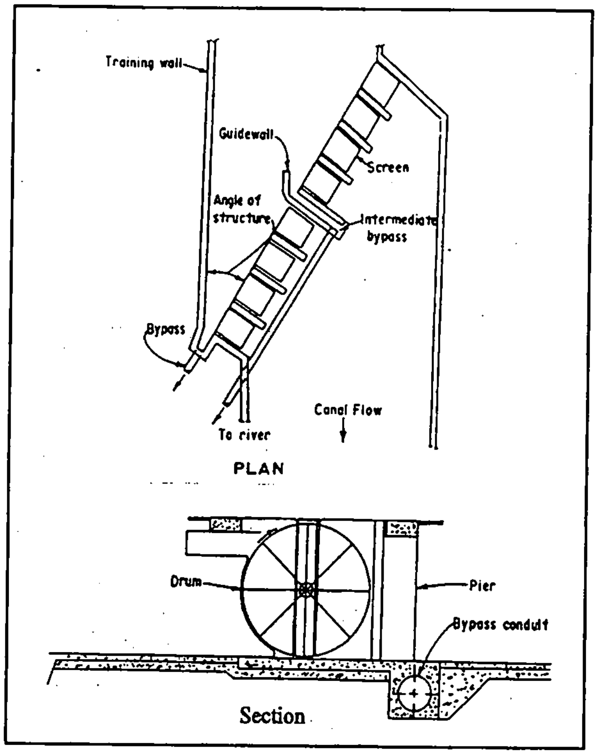


Figure 8 - Layout of a rotating drum fish screen structure. (Liston et al., 1998)

Flow and Screen Criteria for Fish Barriers

Primary objectives and hydraulic criteria of a fish barrier must be established prior to selection of a barrier design. Typical fish protection objectives and hydraulic criteria include: fish species, size and swimming strength; barrier approach velocity (velocity measured perpendicular to the barrier face); barrier sweeping velocity (velocity measured parallel to the barrier face); and barrier design (opening size). Screen opening size and screen velocity criteria for salmon fry and fingerlings have been established by many state and federal agencies, (see table1). Criteria for other species have generally not been established. However, the criteria given in table 1 is generally applicable to most fish species indigenous to a river environment. Consideration should be given to reducing the barrier approach velocity from the values given if very weak swimming fish are to be protected. Barrier approach velocity and barrier size are related. The lower the barrier approach velocity, the larger the structure size.

The Fish and Wildlife Service (FWS) and Nevada State Fish and Wildlife are responsible for establishing and reviewing hydraulic performance criteria for fish screens on the Lower Truckee River. As with many river systems outside of coastal drainages, fish screen performance criteria has not been officially established for the Truckee River. Discussions with FWS on screening the Truckee Canal have resulted in a recommendation to use west coast screen performance criteria for protecting juvenile salmonids as a guide. The decision is based on two primary screening objectives presented by FWS. First, the screen facility should prevent entrainment of adult cui-ui and Lahonton Cutthrout Trout (LCT) and second, the screen should protect juvenile LCT and other resident fish species larger than 25 mm in length. The screen facility is not required to prevent entrainment or screen impingement of larval fish.

Table 1. Agency velocity criteria for screening salmonids. (Sources: EPRI 1986; K. Bates, Washington Department of Fisheries, personal communication.)

Agency	Approach velocity (ft/s)[a]		Sweeping velocity[d]
	Fry[b]	Fingerlings[c]	
National Marine Fisheries Service	≤0.4	≤0.8	Greater than approach velocity
California Department of Fish and Game	≤0.33 for continuously cleaned screens: ≤0.0825 for intermittently cleaned screens	Same as fry	At least twice the approach velocity
Oregon Department of Fish and Wildlife	≤0.5	≤1.0	Approach velocity or greater
Washington Department of Fisheries	≤0.4	≤0.8	Approach velocity or greater
Alaska Department of Fish and Game	≤0.5	Same as fry	No criterion
Idaho Department of Fish and Game	≤0.5	≤0.5	Sufficient to avoid physical injury to fish
Montana Department of Fish Wildlife and Parks	≤0.5	≤1.0	No criterion

[a]Velocity component perpendicular to and approximately 3 inches in front of the screen face.
[b]Fish less than 2.36 inches (60 mm) long.
[c]Fish 2.36 inches (60 mm) or longer.
[d]Theoretical velocity vector along and parallel to the barrier face; often considered equal to the average.

The screen performance criteria selected for Derby Dam are:

1). Design for a one percent flow exceedence based on figure 5. The screen design flow is 850 ft^3/s.

2). Flow velocity component measured normal to the screen face (referred to as screen approach velocity) at a distance of three inches in front of the screen should not exceed 0.4 ft/s for a canal flow of 850 ft^3/s.

3). Flow velocity component measured parallel to the screen face (referred to as screen sweeping velocity) at a distance of three inches in front of the screen should not be less than twice the screen approach velocity.

4). Fish bypasses should be spaced along the screen to limit the maximum flow travel time between bypasses to 120 sec.

5). The screen mesh shall have openings not greater than 0.093 inches (3/32 inch) and shall have a porosity of greater than 27 percent.

6). Entrance velocity to the fish bypass of greater than 2.0 ft/s.

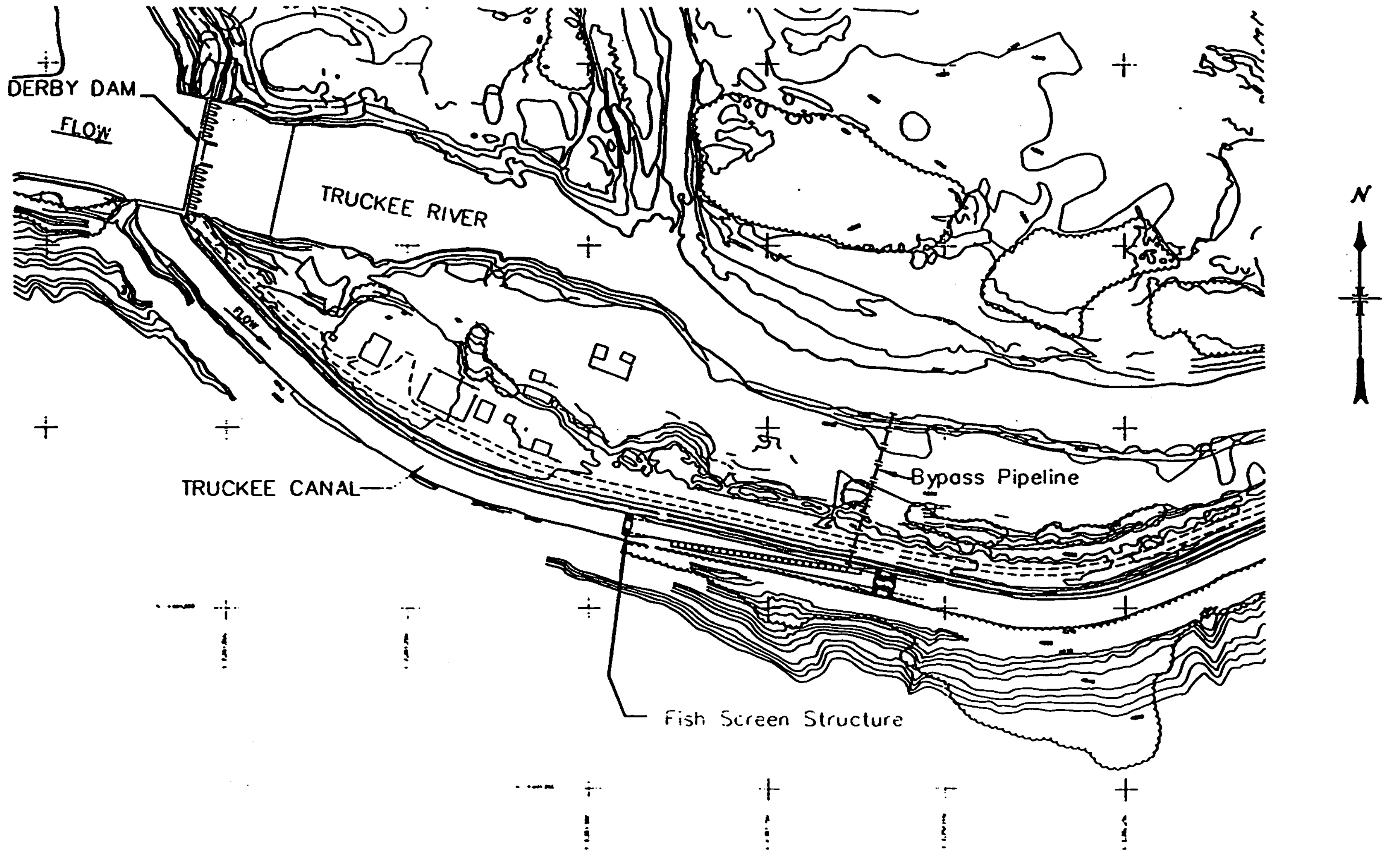
Fish Screen Concept Design

A vertical flat plate fish screen is proposed to be constructed in the canal approximately 850 feet downstream from the headgate structure, figure 9. The fish screen guides fish to the left canal bank and into a fish bypass pipe. The bypass pipe carries fish back to the river downstream of the diversion dam. Figure 10 shows a structural layout of the fish screen. The linear screen crosses the canal at a 4.3 degree angle. The screen structure has 22 screen bays each containing a 10 ft by 10 ft profile wire screen panel with adjustable baffles mounted downstream. Adjustable baffles are used to achieve a uniform approach flow velocity distribution along the screen face. Uniform through-screen flow distribution is important to prevent high velocity hot spots from occurring that can cause fish impingement and debris cleaning difficulties. Baffles are typically 6-inch-wide to 10-inch-wide vertical steel plates with a pin mounted on each end to allow them to be rotated. A typical baffle design used on the Yakima Tieton Canal Fish screen is shown in figure 11. During initial fish screen operation, baffle opening is adjusted to create high resistance to the flow in areas where the canal approach velocity is high and low resistance in areas where velocity is low. Flow between baffles can be restricted by rotating the baffles to decrease the opening between the baffles. The difference in flow resistance along the structure caused by the baffles forces a more uniform flow distribution through the fish screen. The greater the non-uniformity of flow velocity approaching the screen structure the tighter the baffles must be closed to even out the flow and the greater the headloss. A headloss in the range of 0.2 ft to 0.4 ft is expected across the screen and baffle structure proposed for the Truckee Canal.

The fish bypass entrance (gate box) structure is shown in figure 10. The bypass structure is designed to create a gradual acceleration of bypass flow velocity as it enters a 36 inch diameter bypass pipe. Bypass discharge is controlled by a 2 ft by 6 ft slide gate set at a 35 degree angle. The slope mounted gate is designed to provide an unobstructed invert to promote movement of fish and sediment into the bypass. A numerical simulation of flow through the bypass is given in figure 12.

Table 2 gives estimated hydraulic parameters for the Truckee Canal fish screen for a range of diversion flows. The data presented in table 2 is based on flow at normal depth in the canal and an estimated invert elevation of 4,198.3. Operation of check structures and wasteways within the Division 1 canal reach can effect flow depth and through screen flow velocities. Checking up of the canal water surface at downstream control structures can increase flow depth and therefore, reduce approach and sweeping velocities. Operation of downstream wasteways at high diversion flows can result in a draw down of water surface and greater than design flows and approach velocity through the fish screen.

The fish screen will be cleaned by an automated moving brush system shown in figure 10. The brush cleans the fish screen by sweeping debris downstream to the bypass structure. The brush arm retracts out of the flow before moving back to the upstream end of the screen. The frequency of cleaning can be set based on elapsed time or water surface differential measured across the screen. The fish screen structure is estimated to cost $4.3 million. An itemized list of component quantities and costs is included in Appendix A. The cost of providing motor actuators for all canal diversion gates is not included in the itemized list. Additional information on the existing gates is required.

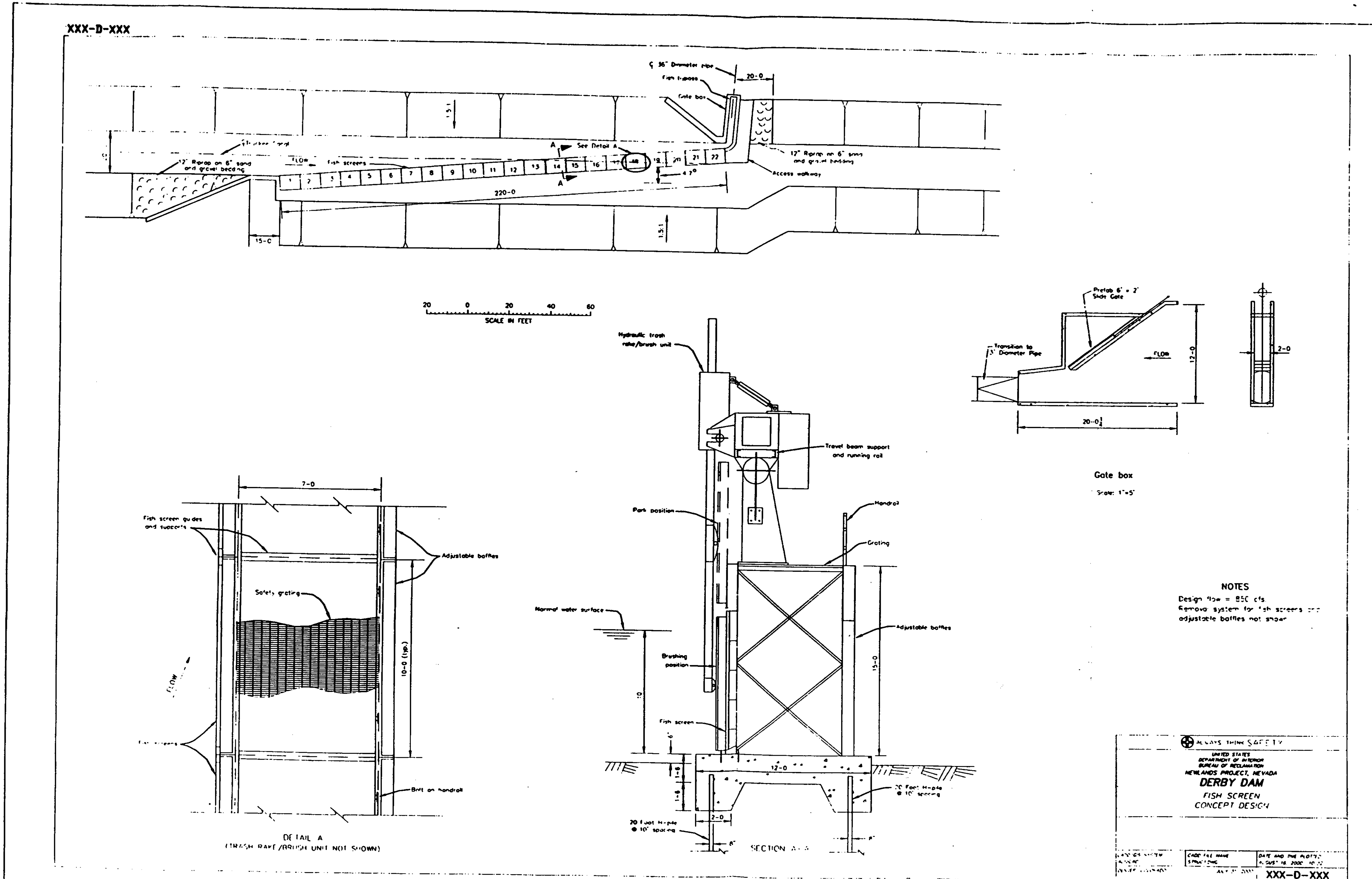


SITE PLAN

NOTES
1. Location of fish screen structure is approximate and may be adjusted.

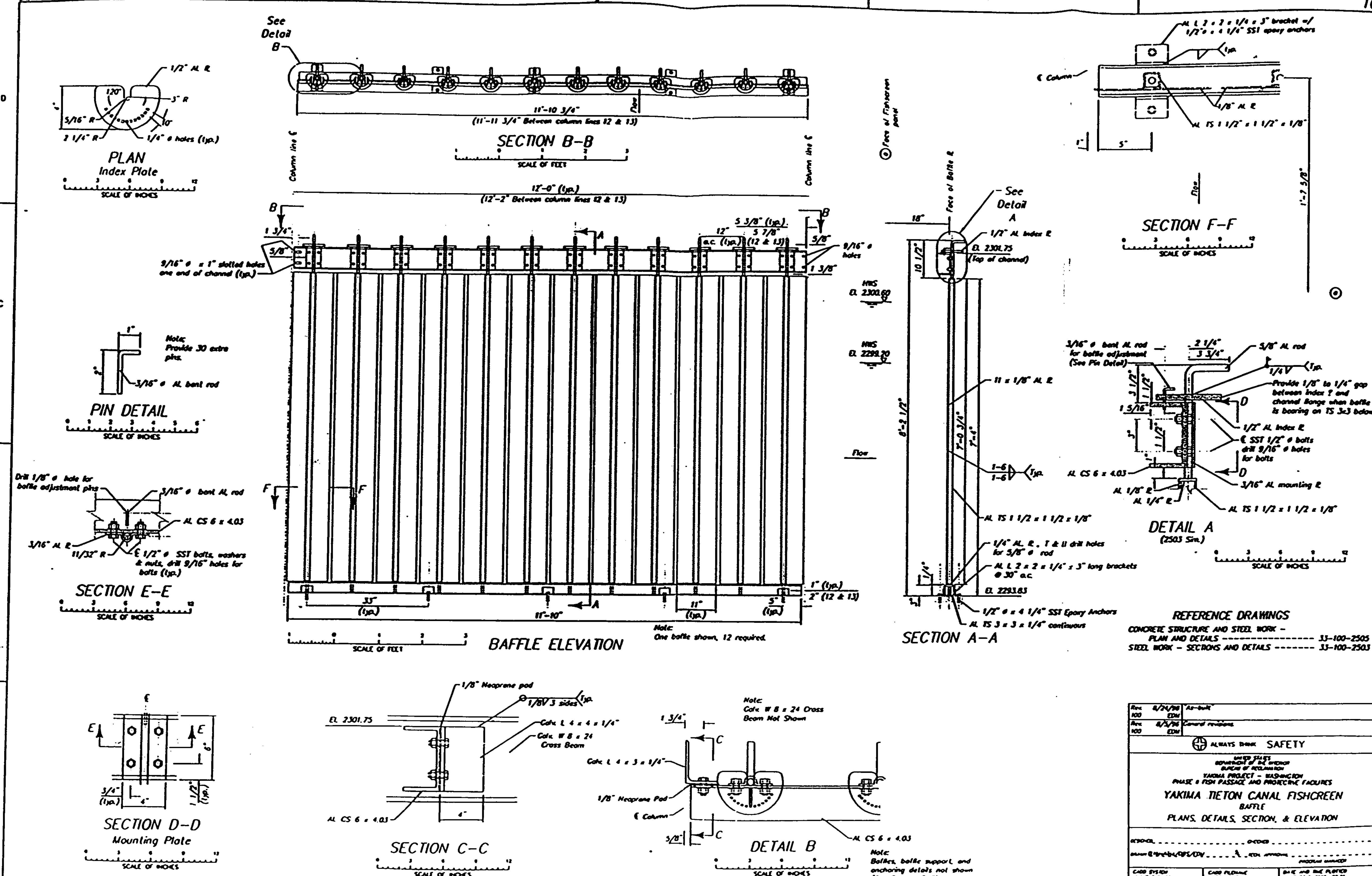
UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION
DERBY DAM FISH SCREEN STRUCTURE CONCEPT DESIGN SITE PLAN
DESIGNED .... CHECKED ....
DRAWN .... TECH APPROVAL ....
APPROVED ....
CADD SYSTEM AutoCAD · CADD FILENAME · DATE AND TIME PLOTTED MARCH 28, 2000 14:30
DENVER, COLORADO · FEBRUARY 28, 2000 · XXX-D-XXX

Figure 9



XXX-D-XXX
36" Diameter pipe
Fish bypass
Gate box
20-0
1.5:1
12" Riprap on 6" sand and gravel bedding
FLOW
Fish screens
See Detail A
Access walkway
220-0
15-0
SCALE IN FEET
Hydraulic trash rake/brush unit
Travel beam support and running rail
Park position
Handrail
Grating
Normal water surface
Adjustable baffles
Brushing position
Fish screen
12-0
15-0
2-0
20 Foot H-pile @ 10' spacing
SECTION A-A
Fish screen guides and supports
Adjustable baffles
Safety grating
10-0 (typ.)
7-0
Bolt on handrail
DETAIL A
(TRASH RAKE/BRUSH UNIT NOT SHOWN)
Prefab 6' x 2' Slide Gate
Transition to 3' Diameter Pipe
12-0
20-0¼
Gate box
NOTES
Design flow = 850 cfs
ALWAYS THINK SAFETY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NEWLANDS PROJECT, NEVADA
DERBY DAM
FISH SCREEN
CONCEPT DESIGN
XXX-D-XXX

Figure 10



REFERENCE DRAWINGS

CONCRETE STRUCTURE AND STEEL WORK - PLAN AND DETAILS ---------- 33-100-2505

STEEL WORK - SECTIONS AND DETAILS ---------- 33-100-2503

ALWAYS THINK SAFETY

UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION

YAKIMA PROJECT - WASHINGTON

PHASE II FISH PASSAGE AND PROTECTIVE FACILITIES

YAKIMA TIETON CANAL FISHSCREEN

BAFFLE

PLANS, DETAILS, SECTION, & ELEVATION

33-100-2504

Figure 11

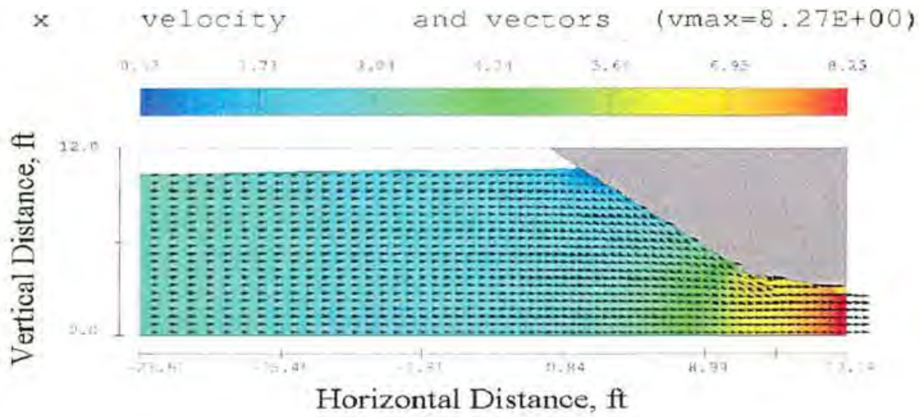


Figure 12 - Numerical simulation of the flow field entering the fish bypass control structure.

Table 2 - Truckee River fish screen hydraulics, 220 ft long screen with 0.5 ft high bottom sill.

Canal Flow ft^3/s	Unchecked Depth, ft	Water Surface Elev., ft	Canal Velocity ft/s	Screen Area ft^2	V_a ft/s	Q_{bypass} ft^3/s	Total Diverted Flow, ft^3/s
100	3.23	4201.6	1.36	578.6	0.17	8.79	108.79
200	4.76	4203.1	1.67	915.2	0.22	15.90	215.90
300	5.94	4204.3	1.88	1174.8	0.26	22.33	322.33
400	6.93	4205.3	2.03	1392.6	0.29	28.14	428.14
500	7.79	4206.2	2.16	1581.8	0.32	33.65	533.65
600	8.56	4207.0	2.27	1751.2	0.34	38.86	638.86
700	9.27	4207.7	2.37	1907.4	0.37	43.94	743.94
800	9.92	4208.3	2.45	2050.4	0.39	48.61	848.61
850	10.22	4208.6	2.49	2138.4	0.40	50.90	900.90
900	10.52	4208.9	2.53	2200.0	0.41	53.23	953.23
1000	11.09	4209.4	2.6	2200.0	0.45	57.67	1057.67

Derby Dam Fish Passage Concepts

Two upstream fishpassage (fishway) concepts were developed for Derby Dam. The basis of the design used for this phase of the project was established during a site visit with FWS. Fish passage at the dam is primarily driven by the need to pass LCT. However, the FWS expressed their desire that a fishway at the dam be designed to pass LCT, cui-ui lake suckers and other native or sport fish species found in the Truckee River. By designing for cui-ui passage, we assume the fishway will be conservative and thus provide passage for the target species and other unidentified native or sport fish. The FWS suspects Derby Dam is located near the upper most extent of cui-ui spawning on the Truckee River. Therefore, large numbers of cui-ui are not expected to be present at the site. Cui-ui and LCT both move up the Truckee River to spawn in the spring from about late March thru early June. During this period, average river flows above the dam range from about 1,000 ft^3/s to 3,000 ft^3/s. By late fall, river flows generally drop to about 350 ft^3/s (see figure 4).

Fishway Design Parameters

Fishway concepts were developed using a 0.5 ft maximum water surface drop criteria across weirs or baffles which corresponds to a maximum passage velocity of about 5.7 ft/s. The water surface drop across Derby Dam varies with river flow and operation of the dam for canal diversion. The percent of river flow diverted to the canal varies widely and may exceed 95 percent, figure 13. Operation of the diversion dam produces a wide range of possible flow scenarios throughout the year. Both upstream and downstream water surface elevations can vary independent of the other. This requires design elevations for upstream and downstream water surfaces be chosen for the fishway.

Fishway designs presented in this report are intended to yield acceptable fishway flow conditions for a range of downstream river flows from about 50 ft^3/s to 3,000 ft^3/s. Designs were developed assuming the dam's spillway gates are regularly adjusted to meet canal diversion targets and optimize fishway flow conditions. The discharge capacity of the sluice gates and spillway is sufficient to control the upstream water surface elevation for river flows up to about 5,000 ft^3/s. Figure 14 gives Truckee River flow below Derby Dam for the major spawning period of March through September in terms of flow exceedence. Flow exceedence provides an estimate of the percentage of the time river flows are likely to be within the selected operating range of the fishway. Based on the last 20 years of record, flow past the dam will exceed 50 ft^3/s about 85 percent of the time between March and September. The corresponding downstream tailwater elevation was estimated based on stage discharge data using USGS river gaging station 10351600 located downstream of the dam and field observations of flow depth at a staff gage mounted downstream of the spillway apron. An estimated tailwater elevation curve is given in figure 15. Tailwater elevation data is not available for downstream river flows less than about 250 ft^3/s. For low river flows, tailwater elevation is likely controlled by a gravel bar located about 150 ft downstream of the spillway apron. For this study a tailwater elevation of 4190 was assumed for a flow of 50 ft^3/s.

A maximum water surface differential across the dam of 17 ft and a minimum fishway design flow of 25 ft^3/s were selected for fishway designs. Fishway design water surfaces and related hydraulic conditions are given in table 3. Passage velocities at the entrance to the fishway will exceed design values if the diversion is operated such that the total water surface drop across the dam is greater than the fishway design of 17 ft. This condition will occur if upstream river flows are less than those show in table 3 for the corresponding canal diversions listed. For example, assume 850 ft^3/s diversion for 900 ft^3/s upstream river flow. For this operation the upstream and downstream water surface elevations would be about 4209.6 and 4190.0, respectively. The difference in water surface elevation would be 19.6 ft. This condition would result in about a 1.5 ft water surface differential across the first weir upstream of the fishway entrance.

Table 3 - Fishway water surface design conditions for a 17 ft maximum water surface differential across the dam.

[1]River flow upstream of Derby Dam, ft^3/s.	Canal diversion, ft^3/s.	River flow downstream of Derby Dam, ft^3/s.	Estimated headloss for diversion and screening, ft.	Upstream pool elevation required for diversion, ft.	Minimum tailwater elevation, ft
550	500	50	0.7	4207	4190
900	650	250	0.8	4208	4191
1400	800	600	0.8	4209	4192
1650	850	800	1.0	4209.6	4192.6

[1]Applies to minimum tailwater condition

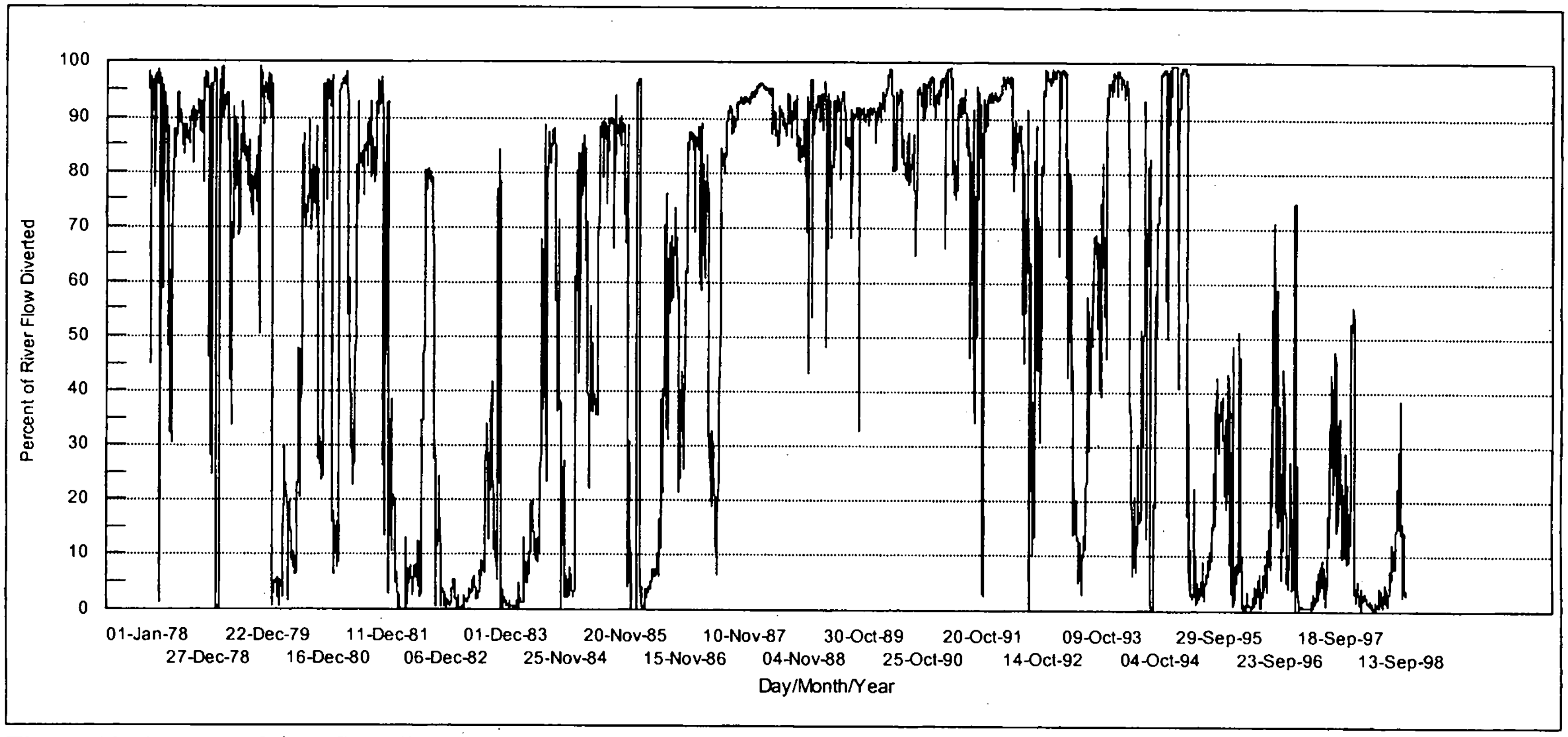


Figure 13 - Percent of river flow diverted at Derby Dam from 1978 to 1998.

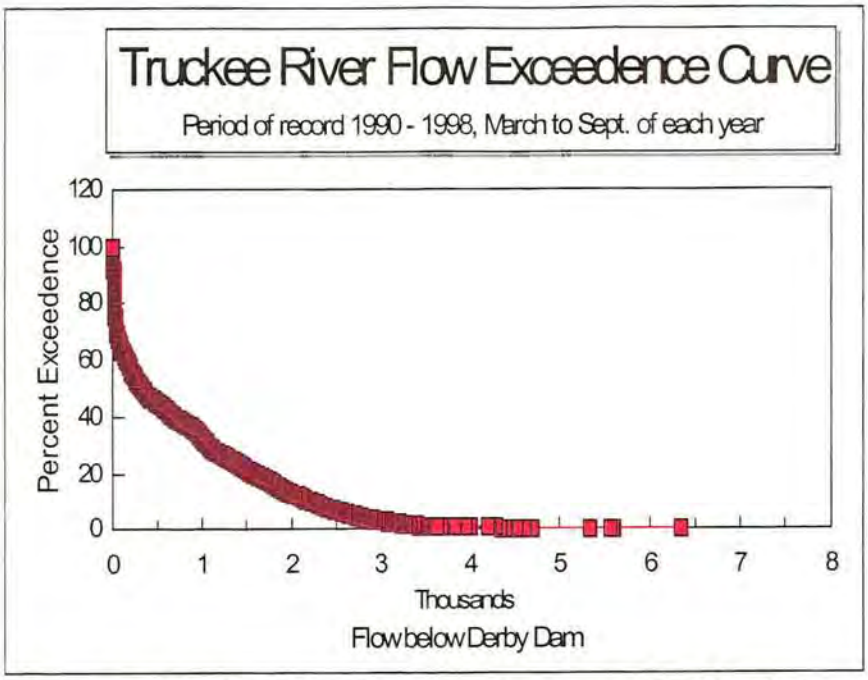


Figure 14 - Truckee River flow exceedence curve for March to September of 1990 to 1998.

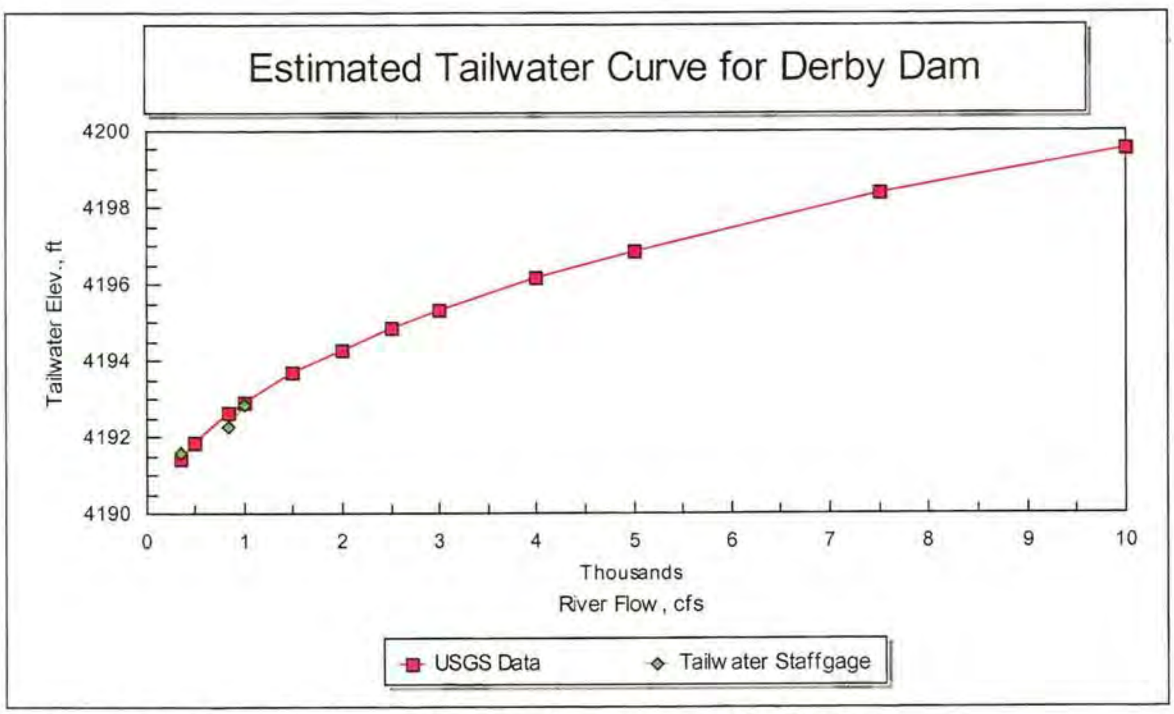


Figure 15 - Estimated tailwater elevation downstream of Derby Dam.

Fishway Concepts

Three fishway concepts were considered for this project. They were: a concrete flume with baffles located on the dam's north abutment, a rock channel with rock drops located along the north dike, and a meander channel lying within the 1997 scoured flood channel. The third alternative was dropped as a viable concept for two reasons. First, the flood channel could not be regraded to the desired slope for a meandering fishway and pass sufficient flood flows. Second, the entrance to the fishway must be located immediately downstream of the dam to provide effective fish attraction. The flood channel rejoins the main river channel about 650 ft downstream of the dam. The first two fishway options are presented herein.

Fishway Option 1 - Rock Channel Fishway with Rock Drops

A rock channel fishway is a steep gradient rock (riprap) lined channel designed specifically for fish passage. Figure 16 shows the proposed layout of a rock channel fishway for Derby Dam. The entrance to the fishway channel is just downstream of the spillway endsill. The channel then slopes at a constant 0.0184 ft/ft for about 920 ft along the toe of the earth embankment. The proposed riprap lined channel has a trapezoid shape with a 4 ft wide bottom and 2:1 side slopes, figure 17. The fishway contains 47 boulder weirs positioned at 20 ft intervals along the fishway. Each weir is formed by placing boulders about 1 ft apart in an upstream pointing chevron pattern. The boulder weirs create a hydraulic control that produces a drop in water surface of about 0.4 ft producing a maximum passage velocity of about 5.0 ft/s. The fishway entrance and exit are set at elevation 4188.0 and 4205.0, respectively. The elevations were selected to maximize the range of operating conditions for which the fishway will operate within desired flow conditions. The elevation of the exit channel is set at elevation 4205 to limit fishway flow and depth to within acceptable levels for a rock lined channel design. Upstream pool elevations for normal operation are intended to be held within the range of 4207 to about 4209. The rock fishway concept is designed to convey about 10 percent of the downstream river flow within the range of 250 ft^3/s to 2,000 ft^3/s. For downstream flows less than about 150 ft^3/s up to 100 percent of the river flow may be passed through the fishway. Table 4 gives the corresponding river flows and fishway hydraulics for the water surface design conditions given in table 3.

Figure 18 shows a comparison of fishway criteria given in table 4 for ten years of dam operation. Operating conditions were within fishway design criteria over 90% of the time when canal diversions were larger than 500 ft^3/s. Figure 18 also shows a large reduction in compliance with fishway criteria occurs for canal diversions less than 500 ft^3/s. This is due to several years during which downstream river flows were often less than 25 ft^3/s.

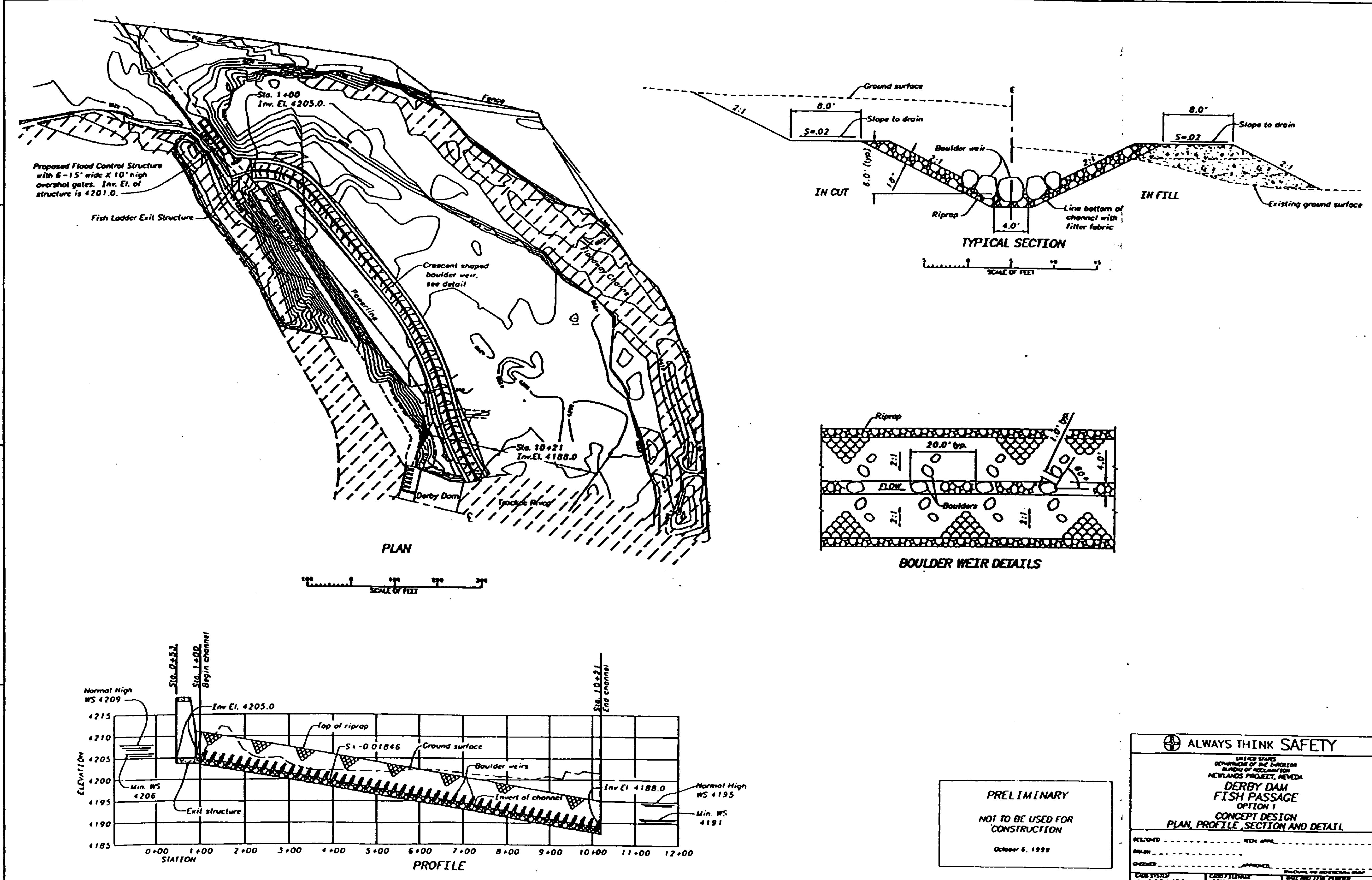
The chevron pattern of the boulder weir directs flow toward the center of each downstream pool thus producing higher velocities in the center of the fishway channel and lower velocities along the edges. Near the fishway exit, the rock channel transitions to a 6 ft wide by 14 ft high concrete culvert set at invert elevation 4204. The culvert will permit vehicle crossing of the fishway exit. The culvert is set horizontal and will be backwatered by the first rock weir located downstream.

Table 4 - Hydraulic design conditions for a rock channel and boulder weir fishway designed for 17 ft of water surface differential, 0.36 ft of drop per boulder weir and 4.7 ft/s maximum passage velocity.

Canal diversion, ft^3/s.	Upstream pool elevation, ft.	Tailwater elevation, ft	River flow upstream of Derby Dam, ft^3/s.	River flow downstream of Derby Dam, ft^3/s.	Fishway flow depth, ft.	Estimated flow area between boulders, ft^2 (assumes spherical shape)	Estimated flow between rock weir boulders, ft^3/s.
500	4207	4190	550	50	2	6.0	28
650	4208	4191	900	250	3	10.5	50
800	4209	4192	1400	600	4	22.0	105
850	4209.6	4192.6	1650	800	4.6	38.0	180

Experience with rock channel fishways is still limited, although quickly growing. Reclamation's non-salmonid fish passage research program has modeled and tested several designs of rock channels. This research has led to four structures being constructed or in the design process. These structures are: a riprap pool and riffle fishway designed to pass razorback suckers constructed on the Colorado River near Grand Junction Colorado in 1997, the Marble Bluff Dam gradient control structure constructed downstream of Marble Bluff Dam in 1998, a rock channel fishway with boulder weirs similar to the proposed design for Derby Dam constructed on the Yellowstone River near Billings Montana, and a roughened fishway without drops on the San Juan River in New Mexico (under construction). All of these rock channel fishways are designed to pass widely diverse fish populations that include many non-salmonid species. Rock fishways that incorporate boulder weirs provide a wide range of flow conditions and often require some adjustment following initial operation. This is due to the random nature of rock shape, size and orientation during placement.

Figure 16 - Approximate location of proposed rock channel fishway.



PRELIMINARY

NOT TO BE USED FOR CONSTRUCTION

October 6, 1999

ALWAYS THINK SAFETY

UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION NEWLANDS PROJECT, NEVADA

DERBY DAM FISH PASSAGE

OPTION 1

CONCEPT DESIGN PLAN, PROFILE, SECTION AND DETAIL

Figure 17

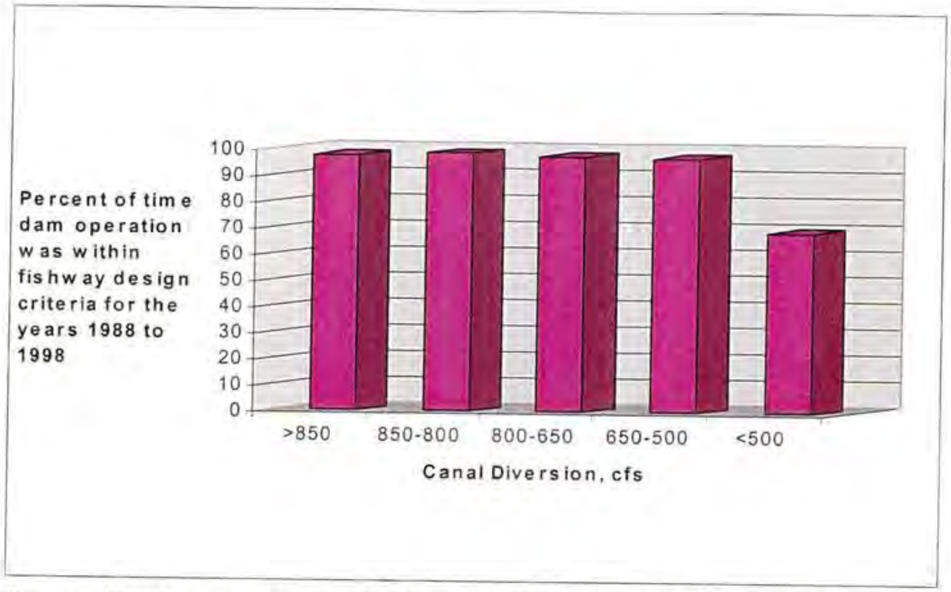


Figure 18 - A comparison of fishway design criteria given in table 3 and historic dam operation from 1988 to 1998 for the rock channel and boulder weir fishway concept.

Fishway construction and maintenance cost estimate - The rock channel and boulder weir fishway is estimated to cost $830,000. An itemized list of component quantities and costs is included in Appendix A. The rock fishway structure will require yearly removal of large debris that may get lodged within the fishway weirs. More frequent cleaning may be required during periods of high river flows if debris loads are heavy. If desired, a course trashrack can be placed across the fishway exit to prevent logs and other large debris from entering the fishway channel. The rock lined channel can be damaged by the unauthorized movement or removal of riprap that lines the channel and forms the boulder weirs. Yearly inspection and repair of displaced riprap should be conducted.

Fishway Option 2- Flume and Baffled Fishway

Fishway Option 2 is an 8-ft-wide by 280-ft-long concrete flume fishway with removable steel baffles. The fishway would be located adjacent to the spillway on the north side of the river as shown in figure 19. A layout of the fishway is shown on figure 20. A fishway slope of 5 percent (0.05 ft/ft) was selected with a maximum water surface drop per baffle of 0.5 ft at the design water surface differential (17 ft). A dual-vertical slot baffle design is proposed (see figure 20 section A-A.). Baffles of this style were designed specifically for cui-ui passage through the new Marble Bluff Dam fishway exit ladder. The ladder design proposed for Derby Dam has 34 baffles spaced about 8 ft apart. The design f low velocity through the vertical slots is 5.7 ft/s. The fishway entrance and exit would be set at elevation 4188 and 4204.0, respectively.

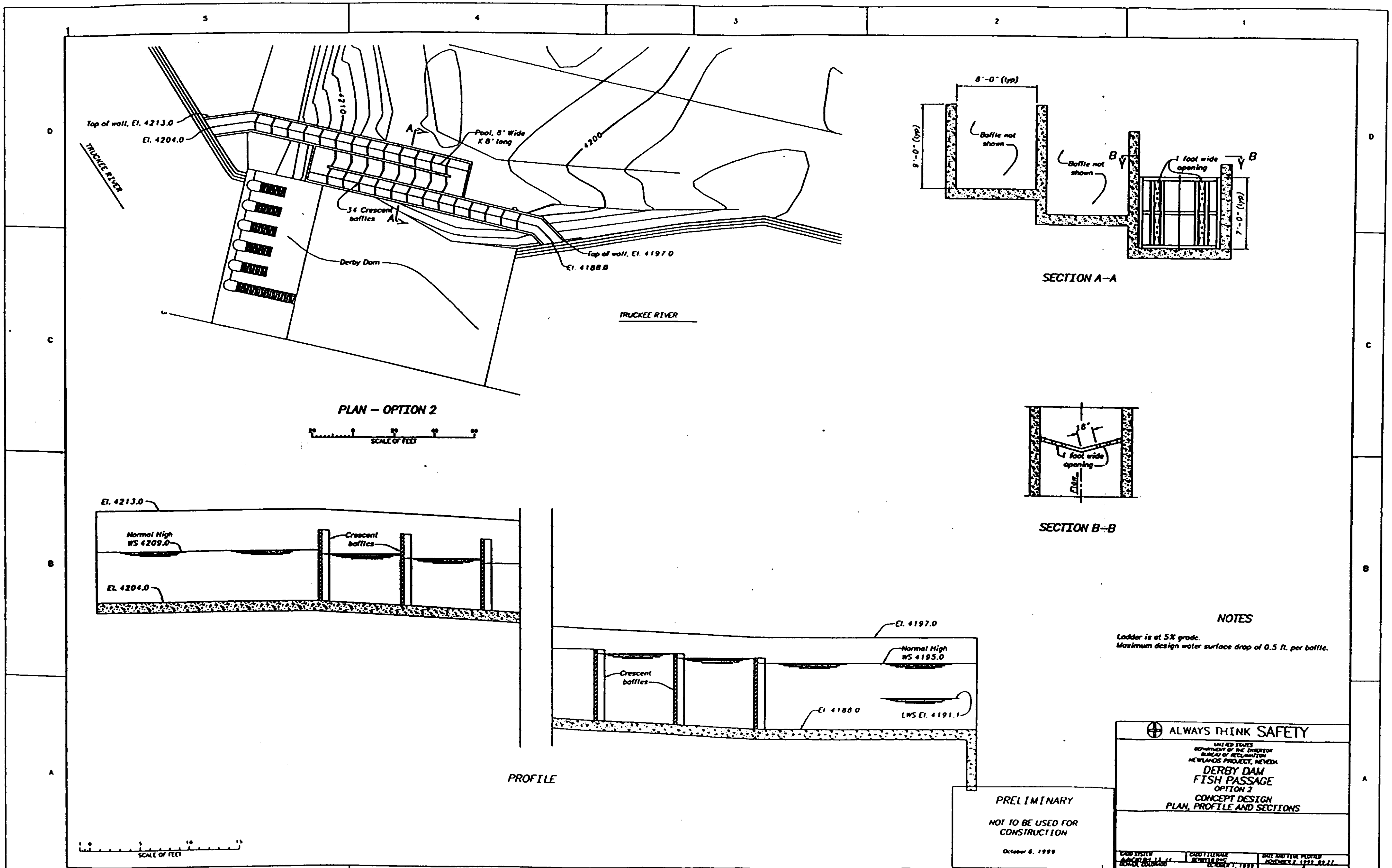
Table 5 gives the corresponding river flows and fishway hydraulics for the water surface design conditions given in table 3. Figure 21 shows a comparison of fishway criteria given in table 5 for ten years of dam operation. Operating conditions were within fishway design criteria over 90% of the time when canal diversions were larger than 500 ft^3/s. Compliance with fishway design criteria falls off to about 75 percent for canal diversions less than 500 ft^3/s. This is due to several years during which downstream river flows were often less than 25 ft^3/s.

The fishway design is based on experience with cui-ui passage at Marble Bluff Dam and Numana Dam on the Truckee River. In 1997, the upper fishway ladder at Marble Bluff Dam was replaced

Figure 19 - Approximate fishway location for the flume and baffle fishway concept.

with a dual-vertical-slot chevron shaped baffled ladder designed at a slope of 3.25 percent. The chevron baffle design was developed using physical model testing, however prototype biological data are not available because the prototype ladder has operated only briefly since construction. The Numana Dam fishway is a standard vertical slot baffle design of similar slope and water surface drop per baffle to the proposed Derby fishway design. The Numana Dam fishway is thought to provide limited passage of cui-ui. In 1998, FWS estimated about 60,000 cui-ui passed through the fishway. However, FWS believes many cui-ui are significantly delayed or prevented from passing the dam each year. Data is not available to link the relatively poor fish passage performance of Numana Fishway to any single aspect of the design.

Fishway construction and maintenance cost estimate - The proposed flume and baffle fishway structure for Derby Dam is estimated to cost $ 840,000. An itemized list of component quantities and costs is included in Appendix A. The flume and baffle structure will require yearly removal of debris that may get trapped within the fishway baffles. Removing debris from the fishway may also be required following each occurrence of high river flows that transport large amounts of debris. A course trashrack can be placed across the fishway exit to prevent logs and other large debris from becoming trapped in the fishway channel.



Top of wall, El. 4213.0
El. 4204.0
TRUCKEE RIVER
Pool, 8' Wide X 8' long
34 Crescent baffles
Derby Dam
Top of wall, El. 4197.0
El. 4188.0
TRUCKEE RIVER
PLAN – OPTION 2
SCALE OF FEET
8'-0" (typ)
9'-0" (typ)
Baffle not shown
1 foot wide opening
7'-0" (typ)
SECTION A–A
18"
1 foot wide opening
Flow
SECTION B–B
El. 4213.0
Normal High WS 4209.0
Crescent baffles
El. 4204.0
El. 4197.0
Normal High WS 4195.0
Crescent baffles
El. 4188.0
LWS El. 4191.1
PROFILE
SCALE OF FEET
NOTES
Ladder is at 5% grade.
Maximum design water surface drop of 0.5 ft. per baffle.
PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION
October 6, 1999
ALWAYS THINK SAFETY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NEWLANDS PROJECT, NEVADA
DERBY DAM
FISH PASSAGE
OPTION 2
CONCEPT DESIGN
PLAN, PROFILE AND SECTIONS

Figure 20

Table 5 - Hydraulic design conditions for a flume and baffle fishway designed for 17 ft of water surface differential, 0.5 ft drop per baffle and 5.7 ft/s maximum passage velocity.

Canal diversion, ft^3/s.	Upstream pool elevation, ft.	Tailwater elevation, ft	River flow upstream of Derby Dam, ft^3/s.	River flow downstream of Derby Dam, ft^3/s.	Fishway flow depth, ft.	Estimated fishway flow, ft^3/s.
400	4206	4190	450	50	2	23
500	4207	4191	750	250	3	34
650	4208	4192	1250	600	4	45
800	4209	4193	1550	800	5	57
850	4209.6	4193.6	2150	1300	5.6	64

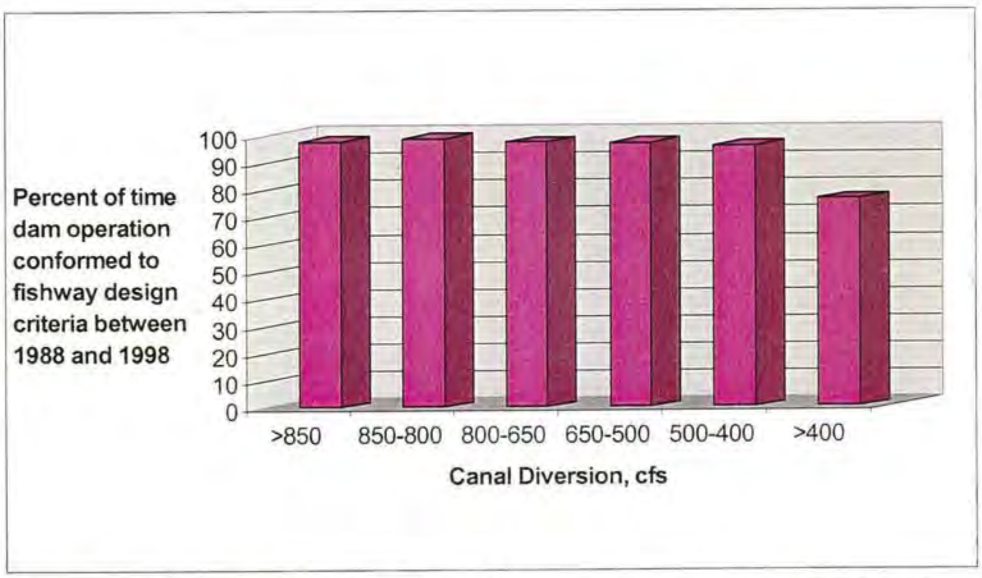


Figure 21 - A comparison of fishway design criteria given in table 3 and historic dam operation from 1988 to 1998 for the flume and baffle fishway concept.

Flood and Debris Control

On at least three occasions river flows have exceeded 15,000 ft^3/s and have required the soft plug in the earthen dike to be breached to protect the structure, figure 22. The flood of record since the dam was constructed occurred in January 1997 when Truckee River flow exceeded a daily average of 15,000 ft^3/s for a two day period with a peak flow estimated at 19,200 ft^3/s. The gated spillway capacity of the dam was not sufficient to handle the magnitude of the flow or the large amount of debris carried by the flood waters. A raft of debris several hundred feet long piled up in front of the dam spillway thus making it impossible to maintain a clear flow path through the spillway gates. To protect the dam, the soft plug was intentionally breached by excavating a trench through the dike. Flow was then allowed to scour the dike material vertically and horizontally. Flow scoured an estimated 80ft long breach to about elevation 4197. The percentage of river flow that passed through the dam spillway gates versus the breach during the 1997 flood is unknown. Past breaching of the soft plug demonstrates that the gated spillway capacity of the dam is insufficient to pass flows and debris during large flood events. The soft plug has successfully protected the dam on several occasions during the life of the dam. Relying on the current soft plug as an emergency spillway is a concern in the design of a fishway that penetrates the earthen dike. The soft plug is not an engineered structure and contains no lateral or vertical breach control. Each time the plug has breached, the breached section has been repaired by dumping large rock and earth into the breach with water flowing through the breach, see figure 23.

To increase controlled flood passage capacity of the dam construction of an auxiliary flood control structure at the location of the soft plug is proposed, (see figure 17). The required flow capacity for the flood control structure presented in this report is preliminary. Flow capacities of the existing structures are not well documented and were estimated for this study. Table 6 gives estimates of the spillway capacity for an upstream pool elevation of 4211 neglecting debris plugging. Pool elevation 4211 was used as it is about one foot higher than the top of the soft plug and approximately the pool elevation for maximum canal diversion. The top elevation of the spillway structure and earthen dike to the south of the soft plug are 4219.16 and 4218, respectfully.

The Lahonton Basin Area Office of Reclamation requested the auxiliary gated flood control structure be sized to pass the 1997 flood of record. They also requested all gates on the dam, canal diversion and auxiliary spillway structures be automated for remote operation. Using the flood of record, the following design criteria was established for the proposed flood control structure: 1). Total gated spillway capacity of 19,200 ft^3/s with five feet of freeboard on the earthen dike. 2). Assume a 20 percent reduction in flow for all spillway gates for debris plugging, and 3). Capability to operate the dam and diversion as originally designed up to pool elevation 4211.

A gated structure is proposed with six-15 ft wide overshot gates with a maximum differential of 10.0 ft (upstream water depth with the gate in the raised position), figure 24. The proposed auxiliary spillway would discharge into the existing floodway channel downstream of the soft plug. The downstream channel will require partial riprapping to stabilize the banks against further erosion during major releases. Figure 25 gives the estimated discharge capacity of the existing spillway, the proposed auxiliary spillway and the total combined capacity. The auxiliary flood gate structure is designed with a 20 ft wide deck capable of supporting gate hoists and vehicle crossing. The estimated construction cost of the proposed auxiliary flood gate structure is $ 1.85 million. An itemized list of component quantities and costs is included in Appendix A. The cost of providing motor actuators for all spillway gates is not included in the itemized list. Additional information on the existing gates is required.

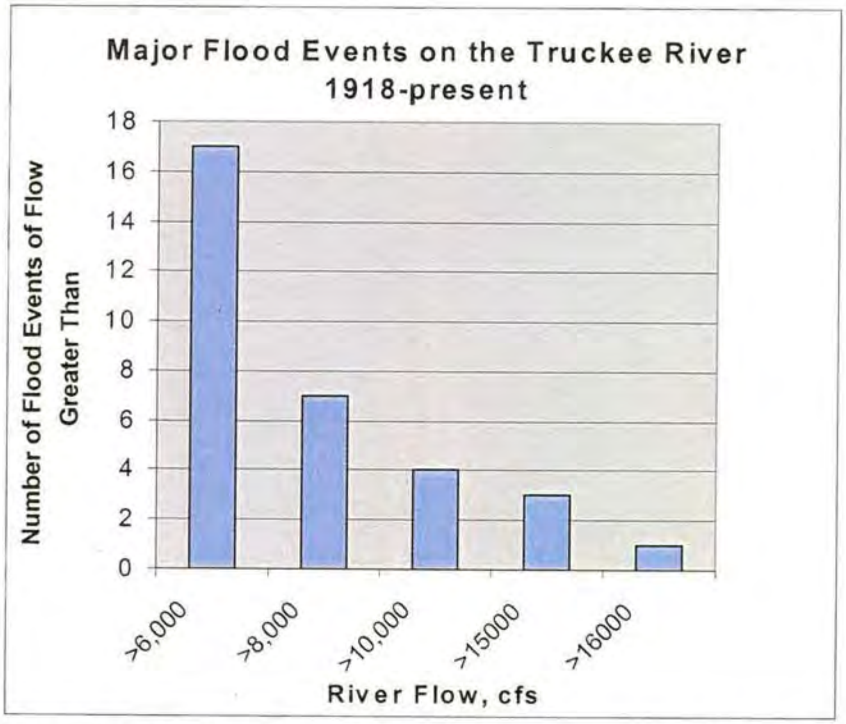


Figure 22 - Number of major flood events occurring at Derby Dam shown as a function of flood magnitude. River flows are based on average daily flows.

Figure 23 - Replacement of the soft plug following 1997 breach.

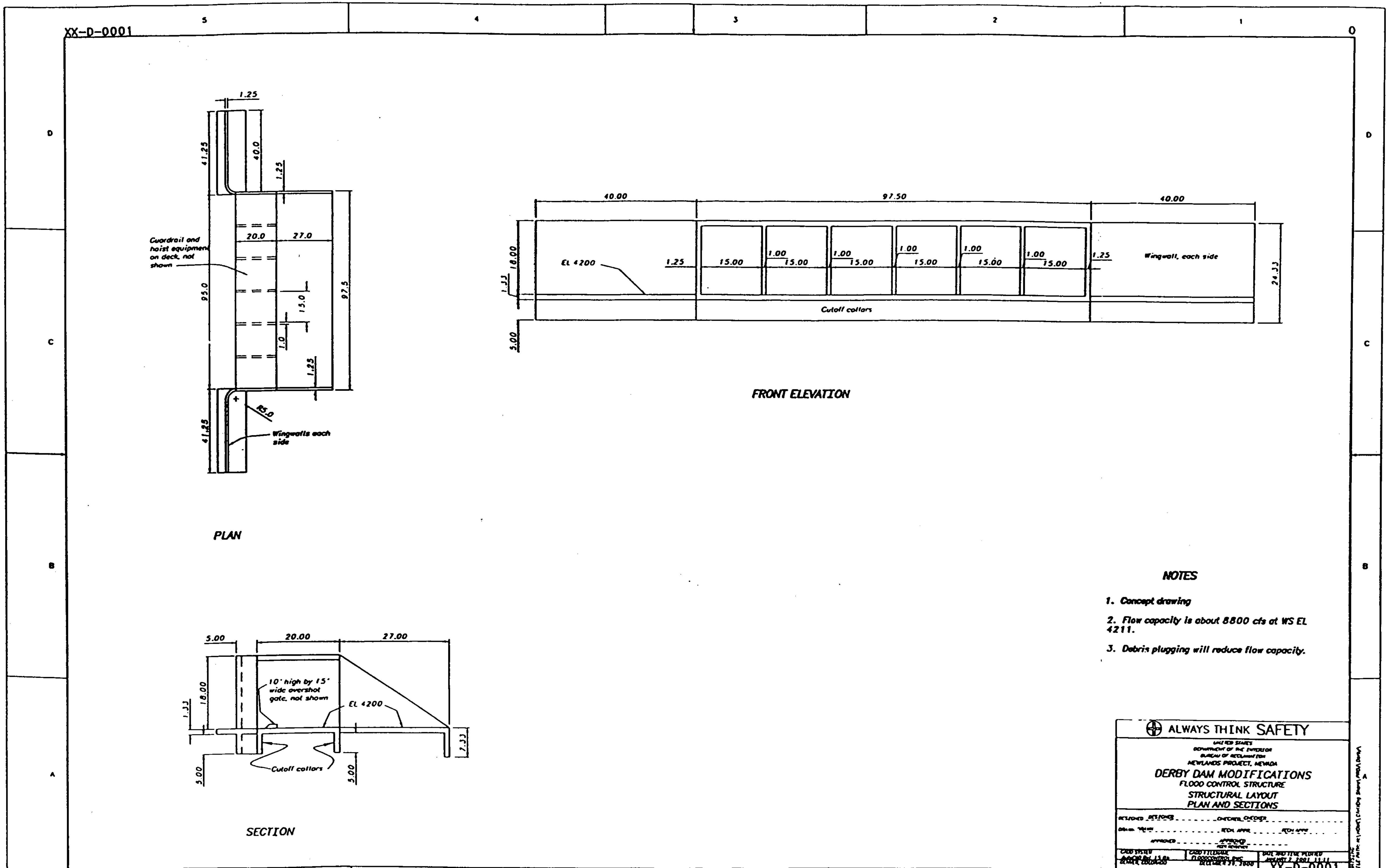

XX-D-0001
1.25
41.25
40.0
1.25
Guardrail and hoist equipment on deck, not shown
20.0
27.0
95.0
97.5
15.0
1.0
1.25
R5.0
41.25
Wingwalls each side
PLAN
40.00
97.50
40.00
18.00
1.33
EL 4200
1.25
15.00
1.00
Wingwall, each side
24.33
Cutoff collars
5.00
FRONT ELEVATION
5.00
20.00
27.00
18.00
1.33
10' high by 15' wide overshot gate, not shown
EL 4200
7.33
Cutoff collars
5.00
SECTION
NOTES
1. Concept drawing
2. Flow capacity is about 8800 cfs at WS EL 4211.
3. Debris plugging will reduce flow capacity.
ALWAYS THINK SAFETY
NEWLANDS PROJECT, NEVADA
DERBY DAM MODIFICATIONS
FLOOD CONTROL STRUCTURE
STRUCTURAL LAYOUT
PLAN AND SECTIONS
XX-D-0001

Figure 24

Table 6 - Estimated discharge capacity of existing control structures at Derby Dam.

Flow Control Feature	Number of Features	Assumed C_d for 100% open	Estimated Discharge at WSE 4211, ft^3/s (Debris loading not considered)
Total Spillway Flow			10,920
Sluice gates, 5 ft x 5 ft, invert elev 4196.8 (tailwater reduces ΔH to 11 ft)	13	0.8	6,920
Weir flow over sluice gates, sill elev 4206.8	13	3.3	1,840
Spillway overshot gate, 25 ft width, sill elev. 4201.8	1	3.1	2,160
Canal Diversion, 5ft x 5ft slide gates, invert elev 4200	9	NA (canal rating used)	1,500

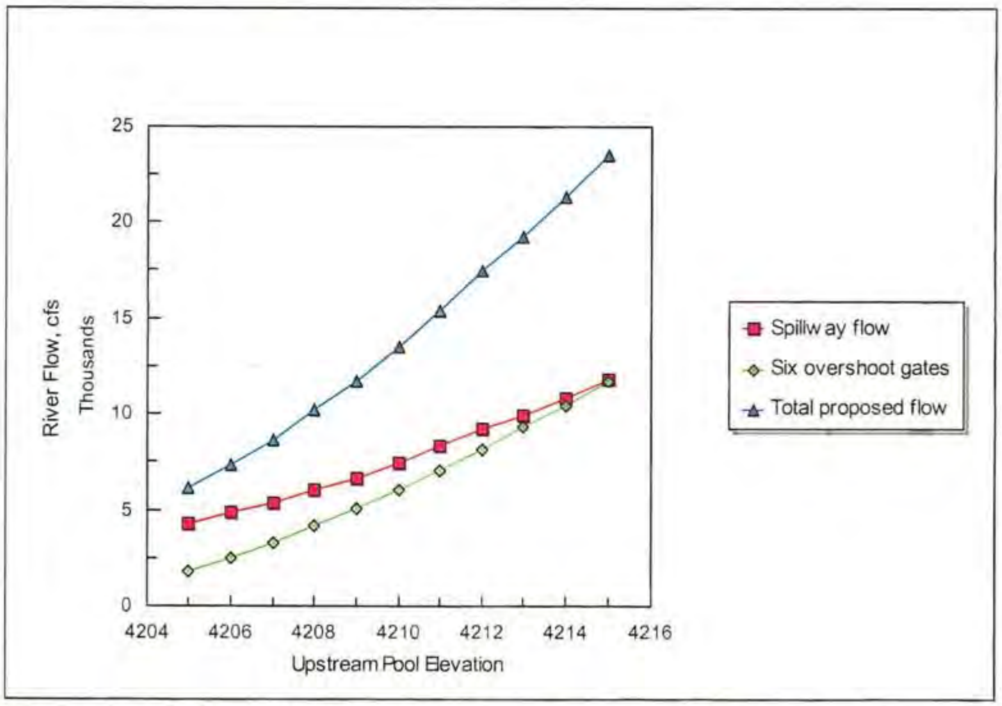


Figure 25 - Estimated spillway flow capacity with a 20 percent reduction in total flow capacity to account for partial blockage of spillway gates and weirs due to debris.

Construction Considerations

Construction Schedule

Due to budget constraints, the construction of the proposed structures will likely be split into two separate construction contracts and constructed sequentially. We recommend in the first contract constructing the fishway and flood control structures. This would allow a common cofferdam and some common dewatering components to be used during construction of both structures. The fish screen structure would be constructed under separate contract following completion of the fishway and flood control structure. Constructing the fish screen second is recommended to take advantage of the increased flood protection of the flood control structure. Constructing the flood control structure prior to the fish screen reduces the risk of needing the canal during fish screen construction to augment spillway capacity in the event of a large flood.

Fish Ladder and Flood Gate Structure. - Construction of these structures will require a cofferdam in the river in front of the fishway entrance, exit and soft plug. A single upstream cofferdam could be used for both structures, however during the period of November through March the soft plug or new auxiliary spillway structure must be operational to protect the dam in the event of a large flood. The cofferdam would likely be constructed following peak spring flows and left in place until November. The proposed construction schedule for the fishway and flood control structure are given in figure 26.

Fish Screen Structure. - Construction of the fish screen structure must not interfere with the operation of the TCID canal except during the allowed time periods. The District will allow a two month period from September 1 to November 1 in which the canal can be unwatered and the fish screen structure constructed. It may not be possible to construct the concrete structure and install the metal frame and fish screens in one season. The proposed schedule calls for completing construction of the fish screen structure in two seasons, figure 27. Most or all of the concrete structure would be constructed in the first season and any remaining concrete structure, steel support frame, fish screens, and sweep would be installed in the second season. The contractor may want to work six ten hour days to complete the work in the allowed time frame.

Consideration was also given to construction of a bypass with sufficient capacity (up to 200 cfs) to allow up to a four month extended construction period. The bypass would be on the north side of the canal. The bypass would probably be a twin 96-inch diameter pipe. The area available for a bypass is not great enough for an open channel. It was also anticipated that by the time the bypass pipeline was installed and a connection made to a headworks gate that there would not be much of a gain in time for the contractor. This option was therefore rejected since it would also be more expensive.

Foundation Support

Fish Screen Structure. - Geologic investigations indicate the top ten feet of material had blow counts as low as 0 to 10 which means the material is extremely weak and not adequate to support even a lightly loaded structure. Considerations were given to either over-excavating and refilling with compacted material or supporting the structure on piles. Over-excavation may not be feasible due to the high ground water and potential for sloughing of the sides. It was therefore decided to support the structure on H-piles. The H-piles will be driven into the gravel and cobble material which is under the ten foot depth of weaker material.

Fish Ladder and Flood Gate Structure. - There are no special requirements for the foundations of these structures. It is anticipated that they will be founded on the excavated surface or compacted backfill.

Siting Fish Screen Structure

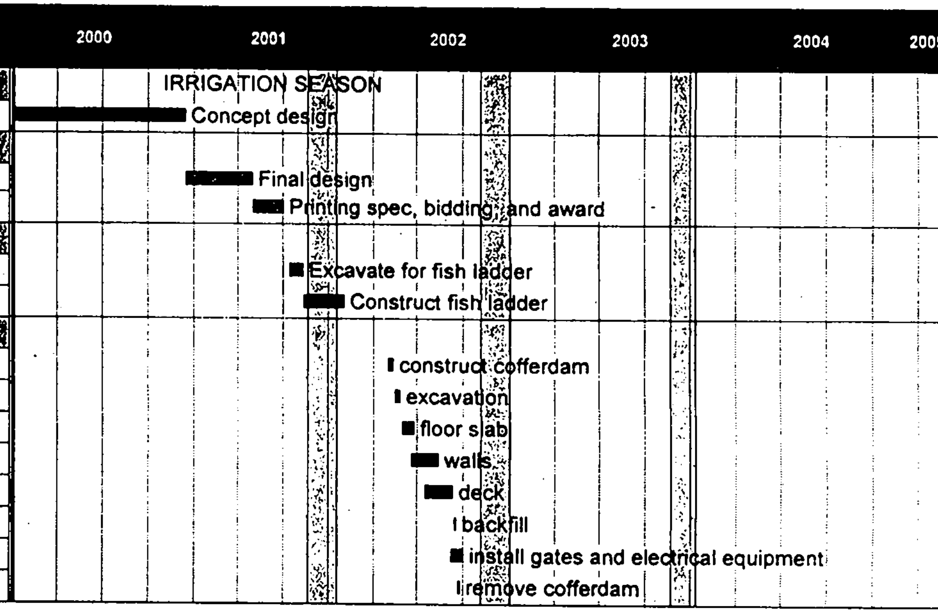
The slope on the right side of the canal, a short distance upstream from the proposed site, shows outcropping of rock. It is anticipated that if rock is encountered during excavation, the rock will not be rippable and would have to be removed by blasting. Therefore the fish screen structure will probably be butted up against the right canal slope and not excavated much into the canal slope. This may mean that the canal would have to be widened to the left side and the O&M road moved accordingly.

Cofferdams and Dewatering

Fish Screen Structure. - The canal headworks will be used to unwater the canal during construction of the fish screen. Sealing of the gates and pumping of leakage flows will likely be required downstream of the canal headgates during construction.. Groundwater dewatering will be done by well points approximately 15 feet deep.

Fish Ladder and Flood Gate Structure. - Cofferdams will be required to construct the flood control structure, the headworks for the fishway, and the outlet for the bypass pipe. It is anticipated that the cofferdams will be constructed using earth embankments or government supplied sheetpile. Groundwater dewatering will be done by sumps approximately 10 feet deep.

Act ID	Description	Orig Dur	Rem Dur	Early Start	Early Finish
Concept Design					
1010	Concept design	247d	247d	01FEB00	15JAN01
Final design					
1020	Final design	98d	98d	16JAN01 *	31MAY01
1030	Printing spec, bidding, and award	44d	44d	01JUN01	02AUG01
Construct fish passage channel					
1210	Excavate for fish ladder	20d	20d	15AUG01 *	11SEP01
1215	Construct fish ladder	60d	60d	12SEP01	04DEC01
Flood gate structure					
1220	construct cofferdam	10d	10d	04MAR02 *	15MAR02
1230	excavation	10d	10d	18MAR02	29MAR02
1240	floor slab	20d	20d	01APR02	26APR02
1250	walls	40d	40d	19APR02	13JUN02
1260	deck	40d	40d	17MAY02	12JUL02
1265	backfill	5d	5d	15JUL02	19JUL02
1270	install gates and electrical equipment	20d	20d	08JUL02	02AUG02
1290	remove cofferdam	5d	5d	22JUL02	26JUL02



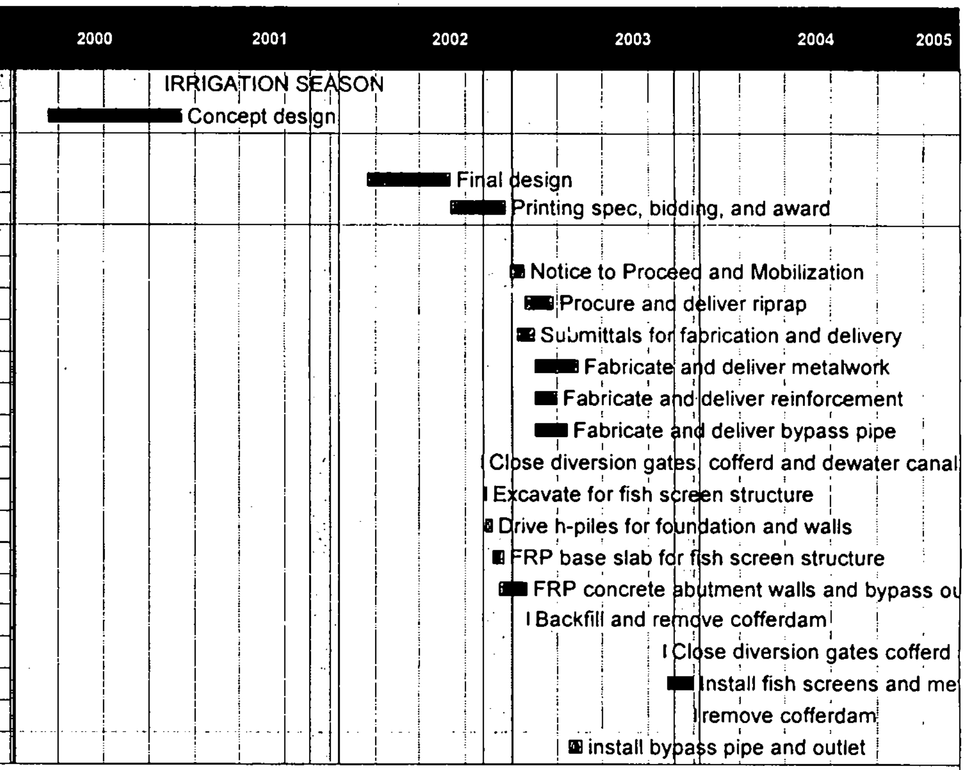
Start date	01FEB00
Finish date	02AUG02
Data date	01FEB00
Run date	05JAN01
Page number	1A

Bureau of Reclamation
FISH PASSAGE AND FLOOD CONTROL STRUCTURE

- Early bar
- Progress bar
- Critical bar
- Summary bar
- Start milestone point
- Finish milestone point

Figure 26

Act ID	Description	Orig Dur	Rem Dur	Early Start	Early Finish
Concept Design					
1010	Concept design	)1d4h	)1d4h	10APR00 *	05JAN01
Final design					
1020	Final design	95d	121d	15JAN02 *	02JUL02
1030	Printing spec, bidding, and award	53d	78d	03JUL02	21OCT02
Construction of fish screen structure					
1040	Notice to Proceed and Mobilization	20d	20d	31OCT02	27NOV02
1050	Procure and deliver riprap	40d	40d	28NOV02	24JAN03
1060	Submittals for fabrication and delivery	25d	25d	14NOV02	18DEC02
1062	Fabricate and deliver metalwork	60d	60d	19DEC02	14MAR03
1063	Fabricate and deliver reinforcement	30d	30d	19DEC02	31JAN03
1064	Fabricate and deliver bypass pipe	45d	45d	19DEC02	21FEB03
1068	Close diversion gates, cofferd and dewater	5d	5d	02SEP02 *	06SEP02
1070	Excavate for fish screen structure	5d	5d	09SEP02	13SEP02
1072	Drive h-piles for foundation and walls	10d	10d	11SEP02	24SEP02
1073	FRP base slab for fish screen structure	17d	17d	25SEP02	17OCT02
1074	FRP concrete abutment walls and bypass	40d	40d	09OCT02	03DEC02
1172	Backfill and remove cofferdam	3d	3d	04DEC02	06DEC02
1176	Close diversion gates cofferd and dewatr	5d	5d	01SEP03 *	05SEP03
1184	Install fish screens and metalwork, etc	40d	40d	08SEP03	31OCT03
1185	remove cofferdam	3d	3d	03NOV03	05NOV03
1190	install bypass pipe and outlet	20d	20d	24FEB03	21MAR03



Start date	01FEB00
Finish date	05NOV03
Data date	01FEB00
Run date	05JAN01
Page number	1A

Bureau of Reclamation
Fish Passage - Screens and Ladder

- Early bar
- Progress bar
- Critical bar
- Summary bar
- Start milestone point
- Finish milestone point

Figure 27

References

Bureau of Reclamation, "Project Data Book," Water and Power Resouces Service, 1981.

Electric Power Research Institute (EPRI), "Assessment of Downstream Migrant Fish Protection Technologies for Hydroelectric Application, ERPI Report AP-4711, Palo Alto, California, 1986.

Heibert S., Wydoski R., and Parks T., "Fish Entrainment at the Lower Yellowstone Diversion Dam, Intake Canal, Montana," U.S. Bureau of Reclamation, Technical Service Center, Applied Fisheries Group, April 2000.

Liston C., Johnson P., Mefford B., and Robinson D., "Fish Passage and Protection Consideration for the Tongue River, Montana, In Association with the Tongue River Dam Rehabilitation Project, U.S. Bureau of Reclamation, Technical Service Center, Applied Fisheries Group, August 1995.

Appendix A

Itemized construction cost estimates

CODE:D-8170

ESTIMATE WORKSHEET

SHEET 1 OF 2

FEATURE: 08-Aug-2000	PROJECT:
Derby Dam - Lahontan Area Reno, Nevada Fish screen in canal Appraisal level	Truckee - Carson Project, Nevada DIVISION: MP - Sacramento, California Office FILE: J:\123R31\DERBYDM.WK4

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Work consists of constructing a fish screen in					
		Truckee Canal prism. Structure contains verrtical					
		screens, concrete structure and mechanical equipment.					
	1	Mobilization, 10%		1	ls		$260,000
	2	F&P Concrete for fish screen structure		400	cy	$550.00	$220,000
		Conc = 4 ksi: 6 sack mix and steel rebar = 125 lb/cy					
		Include F&H cement & rebar in concrete cy price					
	3	Excavation for screen structure, common		1,200	cy	$11.00	$13,200
	4	Backfill for screen structure		900	cy	$9.00	$8,100
	5	Compacted backfill for structure		900	cy	$7.00	$6,300
	6	Furnishing and placing 36" HDPE bypass pipe		210	lf	$135.00	$28,350
	7	Excavation for bypass pipe trench, common		700	cy	$10.00	$7,000
		Based on BuRec earthwork vertical trench					
	8	Backfill in pipe trench		500	cy	$4.50	$2,250
	9	F&P concrete for bypass pipe outlet		20	cy	$600.00	$12,000
	10	Excavation, then backfill earthwork for structure		150		$25.00	$3,750
	11	Riprap		50	cy	$120.00	$6,000
	12	Bedding for riprap		25	cy	$75.00	$1,875
	13	Temporary cofferdam and handling water, outlet		1	ls	$250,000.00	$250,000

QUANTITIES		PRICES	
BY Jeff Baysinger	CHECKED	BY KKC K. Copeland	CHECKED Craig A. [illegible] 8/8/2000
DATE PREPARED 8/7/2000	APPROVED	DATE 08/08/2000	PRICE LEVEL Appraisal

CODE:D-8170

ESTIMATE WORKSHEET

FEATURE: 08-Aug-2000

Derby Dam - Lahontan Area
Reno, Nevada

Fish screen in canal
Appraisal level

PROJECT: Truckee - Carson Project, Nevada

DIVISION: MP - Sacramento, California Office

FILE: J:\123R31\DERBYDM.WK4

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	14	F&I H-piles 20' into foundation		46	ea	$1,000.00	$46,000
	15	Miscellaneous metalwork at screen structure steel handrails		7,000	lbs	$7.30	$51,100
	16	Fish screen, 10'W x 10'H, 22+ 3 spares stainless steel, (approx 2000 lbs/panel		50,000	lbs, SS	$10.00	$500,000
	17	Adjustable baffles, 10'H x 10' W, 22 + 3 spares steel, (approx 3000#/baffle)		75,000	lbs	$7.50	$562,500
	18	Hydraulic trash rake & brushing unit, rail & supports single boom, 220' long (16,000 lbs)		1	ls	$200,000.00	$200,000
	19	Differential water level measuring equipment		1	ls	$15,000.00	$15,000
	20	Screen guides, supports, and grating steel		80,500	lbs	$7.00	$563,500
	21	Steel transition to bypass pipe		12,000	lbs	$6.50	$78,000
	22	Stoplog guides at bypass entrance		550	lbs	$6.50	$3,575
	23	Isolation, 36" dia cast iron slide gate at pipe inlet		3,000	lbs	$6.50	$19,500
	24	Electrical power hookup, 5%		1	ls	$130,000.00	$130,000
		Sub-total					$2,988,000
		Unlisted items, 15%					$412,000
		CONTRACT COST					$3,400,000
		Contingencies, 25%					$900,000
		FIELD COST, TOTAL					$4,300,000

QUANTITIES		PRICES	
BY: Jeff Baysinger	CHECKED:	BY: RKC K. Copeland	CHECKED: Craig A. [signature] 8/8/2000
DATE PREPARED: 8/7/2000	APPROVED:	DATE: 08/08/2000	PRICE LEVEL: Appraisal

CODE:D-8170

ESTIMATE WORKSHEET

SHEET____ OF _____

FEATURE: 08-Aug-2000 Derby Dam - Lahontan Area Reno, Nevada Fish passage - riprap option Appraisal level	**PROJECT:** Truckee - Carson Project, Nevada **DIVISION:** MP - Sacramento, California Office **FILE:** J:\123R31\DERBYDM.WK4

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Work consists of constructing a fish passage structure by Derby Dam. Structure has concrete inlet and outlet transition with chevron riprap channel.					
	1	Mobilization (at 5% of other items)			ls		$27,000
	2	F&P Concrete for fish passage structure		130	cy	$500.00	$65,000
		Conc = 4 ksi: 6 sack mix and steel rebar = 125 lb/cy					-
		Include F&H cement & rebar in concrete cy price					
	3	F&I W-beam guiderail on inlet structure		20	lf	$50.00	$1,000
	4	Excavation		7,500	cy	$12.00	$90,000
	5	Backfill		800	cy	$8.00	$6,400
	6	Compacted backfill for structure		800	cy	$6.50	$5,200
	7	Riprap, d50 about 18 inches		1,900	cy	$120.00	$228,000
	8	F&P boulders in channel, 4 ft diameter (5500 lbs each)		200	ea	$150.00	$30,000
	9	Geotextile fabric, 30-mil non-woven VLDPE		5,000	sy	$4.50	$22,500
	10	Controlling water during construction		1	ls	$100,000.00	$100,000
		Sub-total without mobilization					$548,100
		Sub-total with mobilization					$575,100
		Unlisted items, 15%					$84,900
		CONTRACT COST					$660,000
		Contingencies, 25%					$170,000
		FIELD COST, TOTAL					$830,000

QUANTITIES		PRICES	
BY Jeff Baysinger	CHECKED	BY RKC K. Copeland	CHECKED [signature] 8/8/2000
DATE PREPARED 8/7/2000	APPROVED	DATE 08/08/2000	PRICE LEVEL

CODE:D-8170

ESTIMATE WORKSHEET

SHEET ____ OF ____

FEATURE: 08-Aug-2000

Derby Dam - Lahontan Area
Reno, Nevada

Fish passage - concrete chute w/baffles
Appraisal level

PROJECT: Truckee - Carson Project, Nevada

DIVISION: MP - Sacramento, California Office

FILE: J:\123R31\DERBYDM.WK4

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Work consists of constructing a concrete chute fish passage structure with baffles by Derby Dam.					
	1	Mobilization (at 5% of other items)			ls		$28,000
	2	F&P Concrete for fish passage structure		275	cy	$500.00	$137,500
		Conc = 4 ksi: 6 sack mix and steel rebar = 125 lb/cy					
		Include F&H cement & rebar in concrete cy price					
	3	Excavation for structure, common					
	4	Backfill for structure					
	5	Compacted backfill for structure					
		Earthwork total is 15% of concrete structure cost		1	ls	$20,625.00	$20,625
	6	Baffles, 32 sets (1100#/ baffle, 440#/ guide)		50,000	lbs	$6.00	$300,000
	7	Controlling water during construction		1	ls	$100,000.00	$100,000
		Sub-total of all but mobilization					$558,125
		Sub-total with mobilization					$586,125
		Unlisted items, 15%					$83,875
		CONTRACT COST					$670,000
		Contingencies, 25%					$170,000
		FIELD COST, TOTAL					$840,000

QUANTITIES		PRICES	
BY: Jeff Baysinger	CHECKED:	BY: RKC K. Copeland	CHECKED: [signature] 8/8/2000
DATE PREPARED: 8/7/2000	APPROVED:	DATE: 08/08/2000	PRICE LEVEL:

CODE:D-8170

ESTIMATE WORKSHEET

SHEET ___ OF ___

FEATURE: 08-Aug-2000

Derby Dam - Lahontan Area
Reno, Nevada

Flood Gate Structure
Appraisal level

PROJECT: Truckee - Carson Project, Nevada

DIVISION: MP - Sacramento, California Office

FILE: J:\123R31\DERBYDM.WK4

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Mobilization (at 5% of other items)			ls		$60,000
		Flood Control Structure					
	2	F&P Concrete for flood control structure		750	cy	$500.00	$375,000
		Conc = 4 ksi: 6 sack mix and steel rebar = 125 lb/cy					
		Include F&H cement & rebar in concrete cy price					
	3	W-beam guardrail		250	lf	$40.00	$10,000
	4	Overshot gates (Armtec, 15' W X 9' H)		6	ea	$60,000.00	$360,000
	5	Riprap		600	cy	$120.00	$72,000
	5	Sheetpile cutoff, 30 psf		2,100	sf	$25.00	$52,500
	6	Earthwork (15 % of above)		1	ls	$130,425.00	$130,425
	7	Electrical 5 % of above)		1	ls	$49,996.25	$49,996
		Cofferdams					
	8	Embankment		4,000	cy	$8.00	$32,000
	9	Gravel dam		400	cy	$75.00	$30,000
	10	Controlling water during construction		1	ls	$100,000.00	$100,000
		Sub-total of all but mobilization					$1,211,921
		Sub-total with mobilization					$1,271,921
		Unlisted items, 15%					$178,079
		CONTRACT COST					$1,450,000
		Contingencies, 25%					$400,000
		FIELD COST, TOTAL					$1,850,000

QUANTITIES		PRICES	
BY Jeff Baysinger	CHECKED	BY RKC K. Copeland	CHECKED [signature] 8/8/00
DATE PREPARED 8/7/2000	APPROVED	DATE 08/08/2000	PRICE LEVEL

Appendix B

Conceptual Geologic Design Considerations - Derby Dam Fish Facilities

Location

Derby Dam is approximately 18 miles east of Reno, Nevada on the Truckee River. The Truckee drains the eastern slope of the Sierra Nevada Mountains, flowing between the Pah Rah and Virginia Ranges into Pyramid Lake approximately thirty miles downstream from the dam. Interstate 80 passes along the north side of the valley.

Geologic Setting

Derby Dam is located in west-central Nevada in the Basin and Range physiographic province, an area of geologic complexity. Major events of sedimentation, igneous activity, orogenic deformation and continental rifting has been imprinted on the terrain. The Basin and Range Province is characterized by flat, open depressions with no drainage outlets and forming playa lakes. These basins are bounded by fault-block mountain ranges elongated more than 50 miles north to south and are five to 15 miles wide. Some ranges are either irregular or equi-dimensional in shape. Steep alluvial fans formed from the rocky V-shaped drainages along the mountain fronts. Basin and Range deformation is thought to be related to back-arc spreading associated with subduction of the Pacific Plate which flexed and fractured the western margins of the North American Plate in mid-Tertiary time. Tectonic structure is generally east-west to southeast-northwest. Most faulting is late Pliocene and early Quaternary age. The western edge of the Basin and Range is dominated by two zones of seismic activity: Along the eastern margin of the Sierra Nevada Range a seismic belt extending approximately 50 miles into western Nevada and the Nevada seismic belt which extends from north-central Nevada into California along the 118-degree meridian. Pleistocene lake deposits derived from melting continental glaciers formed Lake Lahontan and fill a large basin south of Derby Dam.

Site Geology

The foundation of Derby Dam is composed of flood plain/alluvial materials. These materials fill the valley from the Truckee Canal on the south side of the valley to I-80 on the north side. The thicknesses of these materials are undetermined at Derby Dam. Tertiary volcanics form the ridges and mountains on both sides of the Truckee River. The physical properties of the volcanic rock range widely and have been mapped but not throughly investigated during recent field exploration at Derby Dam.

Stratigraphy

Quaternary Age - Qal- Alluvium undifferentiated- These materials are undifferentiated between flood plain, alluvium, colluvium, and slopewash deposits. The alluvium and flood plain materials fill the river channels and overbanks along the Truckee River and are the principal units present at Derby Dam. The colluvium and slopewash deposits are derived from sheetwash and gravitational erosion and are found along slopes and hillsides. The alluvium/flood plain materials are composed of discontinuous beds of interbedded gravel and sand lenses with local beach sand deposits. The alluvium generally grades from coarse gravel and cobble-size materials near mountain fronts to finer sand and silt in open valleys and basins.

Tertiary Age - Tvu- Tertiary Volcanics Undifferentiated- The materials are composed of basalt, andesite and dacite flows interbedded with flow breccia and local sedimentary layers. The individual units are undifferentiated in this report because their physical properties are similar. The individual geologic units are:

Tba- Includes Mustang Andesite, Lousetown Formation and unnamed units. Composed of basalt and andesite flows. The flows are widespread and interbedded with local sedimentary layers.

Tk- Kate Peak Formation- Includes dacite flows, flow breccia and lahars. Minor tuffaceous flows are also interlayered within the formation.

Tp - Pyramid Formation- Composed of interlayered andesite, basalt, tuff lava flows, flow breccia and lahars.

Structural Geology

The Truckee River flows through a fault-controlled valley between the Pah Rah and Virginia Ranges, emptying into Pyramid Lake. The structural trend of the faults and fractures are generally northeast along the Truckee River Valley. The age of the tectonic activity is contemporaneous with the volcanic activity in the area.

Investigations

Geologic investigations were conducted in March 2000 for the fish ladder and fish screen structures at Derby Dam. These investigations consisted of seven hollow stem auger holes and seven test pits, figure B1. The drill holes were cored with a hollow stem auger and standard penetration tests (SPT) were conducted to determine the relative strength of the soil materials. The blow counts are shown on the geologic sections in figures B2 and B3. Four auger holes were cored along the dam centerline through the embankment into the alluvial sediments which comprise the foundation of the dam and spillway. Three test pits were excavated in the proposed borrow area in the flood plain deposits downstream of the dam. Two test pits were excavated in a proposed borrow area on BLM land north of I-80.

DH-1-00 was cored downstream of the dam on the left side of the channel near the fish ladder outlets of Fishway Options 1 and 2. DH-2-00 was cored on top of the left embankment of the dam at the inlet of the Fishway Option 2 near the spillway. DH-3-00 was cored along the top of the dam near the proposed inlet for the Option 1 Fishway and on the right side of the "soft plug." DH-4-00 was cored through the dam embankment approximately half way between DH-2-00 and DH-3-00. DH-5-00 was cored through the embankment on the left side of the "soft plug." Drill holes DH-6-00 and DH-7-00 were cored through the canal embankment on the right side of the Truckee Canal to determine subsurface conditions for design of the fish screen.

Fish Ladder Options

Two options are under consideration for construction of the fish ladders. The alignment for Option 1 begins near the right side of the "soft plug" and turns south toward the river along the downstream flood plain. This alignment terminates along the downstream left bank of the river below the spillway. Option 2 begins near the left abutment of the spillway descending to the same location of the termination for Option 1.

Geologic Section A-A' (figure B2) shows the geologic conditions along the alignment of Option 1. The alluvial materials generally consist of a layer of finer grained silt and sand-size materials overlying coarser sand and gravel materials. DH-3-00 was bored in the embankment near the beginning of the alignment and encountered Poorly Graded Sand (SP) and Silty Sand (SM) materials overlying Poorly Graded Gravel with Sand (GP)s. Blow counts ranged from 9 in the Silty Sand (SM) to 29 in the Poorly Graded Sand with Gravel (SP)g. Groundwater was encountered at a depth of 20.0 feet (elevation 4196.7) in DH-3-00. Test pit TP-1 was excavated in the flood plain deposits and encountered Silty Sand (SM) materials overlying Poorly Graded Gravel and Sand (GP)s and Silty Gravel with Sand (GM)s. Ground water was encountered at a depth of 8 feet. DH-1-00 was cored into road fill, flood plain and alluvial deposits along the left bank, downstream of the Derby Dam Spillway. Interbedded materials consisting of Poorly Graded Gravel with Sand (GP)s and Poorly Graded Sand with Gravel (SP)g were encountered. Groundwater was encountered at a depth of 7.5 feet (elevation 4192.1).

Geologic Section B-B'(figure B3) shows the subsurface geology along the alignment of the proposed fish ladder for Option 2. The materials forming the dam embankment consist of finer grained sand and silt. DH-1-00 is portrayed in Section B-B' and was previously described in Section A-A'. DH-2-00 was cored through embankment and alluvial materials on the left spillway abutment along the dam centerline. Blow counts ranged from 4 to 23 in the embankment materials in DH-2-00. TP-4 was excavated through road-fill and alluvial deposits midway between DH-1-00 and DH-2-00.

The high blow counts were due to cobbles and gravel. The low blow counts in the sandy materials indicate draining and shoring will be required to construct the fish ladder. The high water table will create saturated cutslopes. Shoring and stabilization of these materials will be required where these conditions are encountered.

Fish Screen

The alignment for the fish screen lies in the bottom of the Truckee Canal and turns toward the Truckee River where a 36-inch pipe will divert the fish from the canal into the river. The surface geology is composed of floodplain and alluvial materials along the entire length of the alignment. Volcanic rocks composed of basalt and lapilli tuff have been mapped along the right side of the canal. Further investigations have been proposed along the alignment of the fish screen to determine the type of materials present in the bottom of the canal.

Investigations for the Fish Screen consisted of two hollow stem auger holes and a test pit. DH-6-00 and DH-7-00 were bored into the canal embankment and encountered gravelly material overlying Sandy Silt (SM) and Poorly Graded Sand (SP). SPT blow counts ranged from 2 to 61 blows in DH-6-00 and 0 to 59 in DH-7-00. The drill rods fell under their own weight from 17.5 to 18.9 feet. It is likely that saturated soils composed of Silty Sand (SM) were encountered in this interval. Groundwater was encountered at depths of 11.5 and 12.0 feet (approximately elevation 4201.5 feet) in DH-6-00 and -7-00, respectively. The water levels in these holes are directly controlled by the water level in the canal. TP-7 encountered water at a depth of 7 feet near the right bank of the river. The water level in the test pit is directly affected by the water level in the river. The material encountered in TP-7 is composed of alluvial sediments containing sand, gravel, cobbles and boulders.

The alluvial materials will be easy to excavate and will require slope stabilization and water control to maintain safe working conditions during construction of the fish screen. Further geologic investigations are recommended during the Fall of 2000 to better determine the type and thickness of the materials present in the bottom of the Truckee Canal.

Flood Control Structure

The proposed spillway is located near the left abutment of the dam where the original river channel existed. Drill holes DH-3-00 and DH-5-00 were bored into the embankment on both sides of the "soft plug" which now fills the site where the dam failed in 1997. Verbal communication with Mike Larsen of the Carson City Area Office described how flooding along the Truckee River in 1997 created a breach in the dam at this location. In an effort to stem the flow, approximately 20,000 cubic yards of sand, gravel, cobbles and boulders were dumped into the void. The contractor is reported to have placed 3- to 5-foot diameter boulders in the bottom of the breach near the center and the remainder is filled with a mixture of silty sand and gravel.

Borrow Areas

Investigations for borrow materials were conducted in the flood plain downstream of the dam and in an area on the north side of I-80, presently owned by the Bureau of Land Management. Test pits TP-1, -2, and -3 were excavated into the flood plain on 200-foot spacings, approximately 200 to 600 feet downstream from the dam. These test pits encountered alluvial materials ranging from Silty Sand (SM) to Poorly Graded Gravel with Silt (GP-GM). A small percentage of cobble-size materials are also present in the alluvium.

Test pits TP-5 and TP-6 were excavated in slopewash deposits on the BLM land. The materials encountered in test pits TP-5 and -6 are classified as Silt (ML) to Silt with Sand (ML)s.

Engineering Considerations

Excavation Methods.- Based on test pit excavations and drilling performed in the spring of 2000, excavation of the fill, alluvial, and flood plain materials can be performed with common methods. Subsurface investigations at the site have not encountered bedrock. Geologic mapping along the right side of the Truckee Canal indicate that volcanic tuff and basalt are present in this area. These materials dip below a colluvial slope approximately 100 feet upstream from DH-6-00. Based on this evidence, it is expected that the volcanics are buried below the invert of the canal and will not be encountered during construction. Further investigations are planned for the Fish Screen during the Fall of 2000 when water flow through the canal is shutoff or reduced.

Foundation Considerations.- SPT blow counts range widely in the alluvial and embankment materials. The high blow counts (≥9) were generally due to the presence of cobbles and gravel. The low blow counts (≤9) encountered sandy materials which will require draining and shoring before construction can be undertaken. The high water table will create saturated cutslopes. Shoring and stabilization of these materials will be required where these conditions are encountered.

Stability and Deformability of Soils and Bedrock - The unconsolidated alluvial materials are composed of materials ranging in size from silt to boulders. The unconsolidated materials will be susceptible to sloughing and caving when saturated with water. Temporary cutslopes should be sloped to 1 ½: 1 (H:V) to ensure safe working conditions, and 2:1 (H:V) for permanent cutslopes.

Temporary cutslopes in the harder volcanic materials such as basalt and andesite are expected to stand at 1/4:1 (H:V) and permanent cutslopes will stand at 1/2:1 (H:V). The lapilli tuff materials should be sloped to 1 ½: 1 (H:V) in temporary cutslopes and 2:1 (H:V) for permanent cutslopes.

Water Occurrence - Both options for the Fishway and Fish Screen Diversion will be constructed in areas of high water surface elevations. The reservoir behind Derby Dam and Truckee Canal contribute water to the flood plain and alluvial materials with only minor fluctuation from season to season. Groundwater ranges from 6.8 to 17.8 feet below the surface in DH-1-00 and DH-2-00, respectively. The alluvial deposits are highly permeable and water removal will be required during excavation for these structures.

Conclusions and Recommendations - The alluvial materials range from soft to hard with blow counts ranging from 4 to 100. The soils with blow counts ≤9 will require draining and shoring to ensure safe working conditions. Temporary cutslopes should be sloped to 11/2:1 (H:V) to ensure safe working conditions, and 2:1 (H:V) for permanent cutslopes.

Excavation of the volcanic materials will likely be by common methods. Subsurface geologic investigations for the construction of the Fish Screen did not encounter these materials. It is believed that the volcanic rocks adjacent to the canal are highly saturated from the Truckee Canal and will be moderately soft to moderately hard. Temporary cutslopes will stand at 1/4:1 (H:V) and permanent cutslopes will stand at 1/2:1 (H:V).

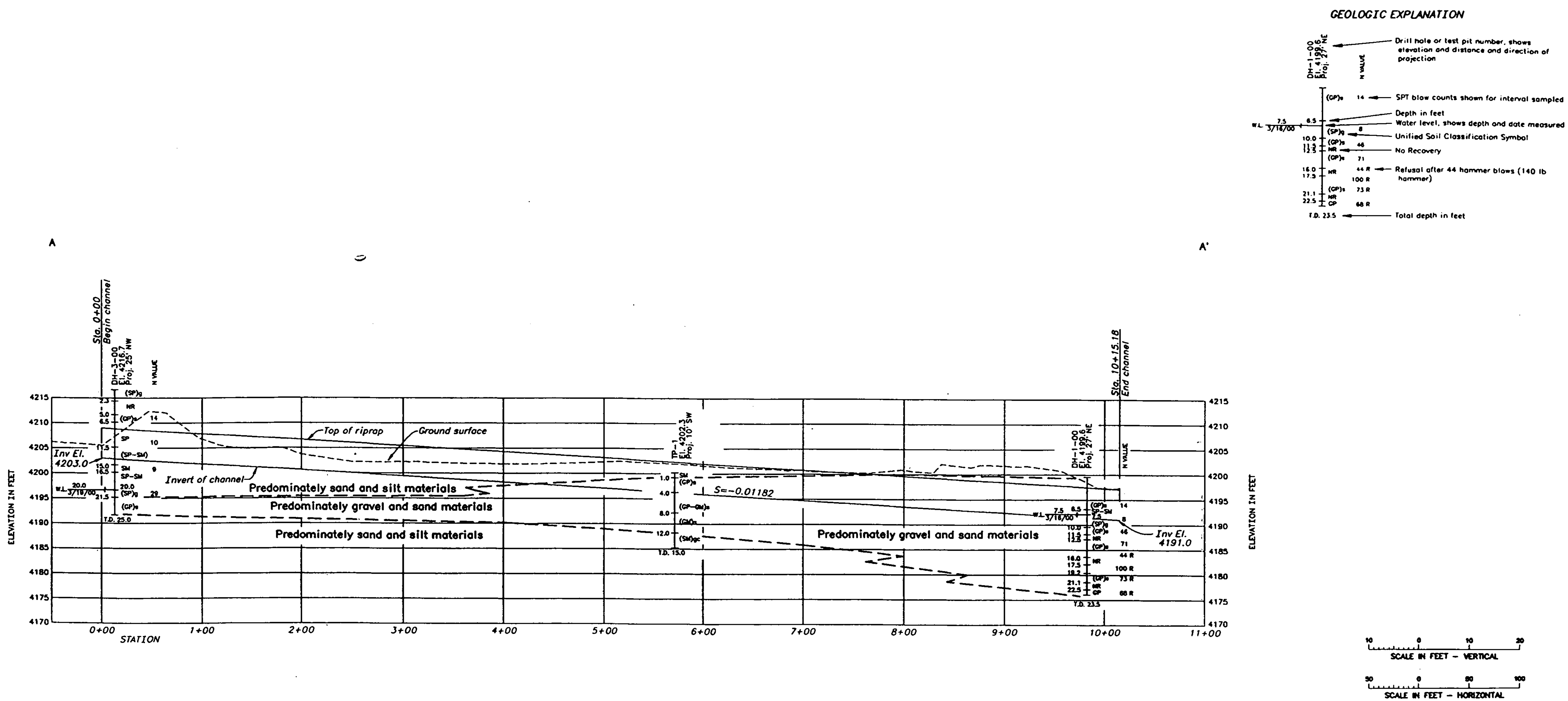
References

Anderson, L.W., La Forge, R., Hawkins, F.A., "Seismotectonic Study for Lahontan Dam and Vicinity, Newlands Project, Nevada," Seismotectonic Report 84-1, U.S. Bureau of Reclamation, September 1984.

Greene, R.C., Stewart, J.H., John, D.A., Hardyman, R.F., Siberling, N.J., Sorensen, M.L., "Geologic Map of the Reno 1° by 2° Quadrangle, Nevada and California," U.S. Geological Survey, 1991.

Holtz, R.D., "Notes for Lecture No. 2, Short Course Lecture Notes, Selected Geotechnical Design Principles for Practicing Engineering Geologists," Association of Engineering Geologists, Chicago, Illinois, October 2, 1979.

Stewart, J.H., "Geology of Nevada," Nevada Bureau of Mines and Geology, Special Publication No. 4, U.S. Geological Survey, 1980.



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

DERBY DAM
FISH LADDER STRUCTURE
CONCEPT DESIGN – OPTION 1
GEOLOGIC SECTION A–A'

GEOLOGY M. MCCULLA CHECKED S. WILLOUT
DRAWN M. MONSON TECH. APPROVAL
APPROVED

CADD SYSTEM AutoCAD | CADD FILENAME | DATE AND TIME PLOTTED JULY 14, 2000
DENVER, COLORADO JUNE 30, 2000 XXX–D–XXX

Figure B1

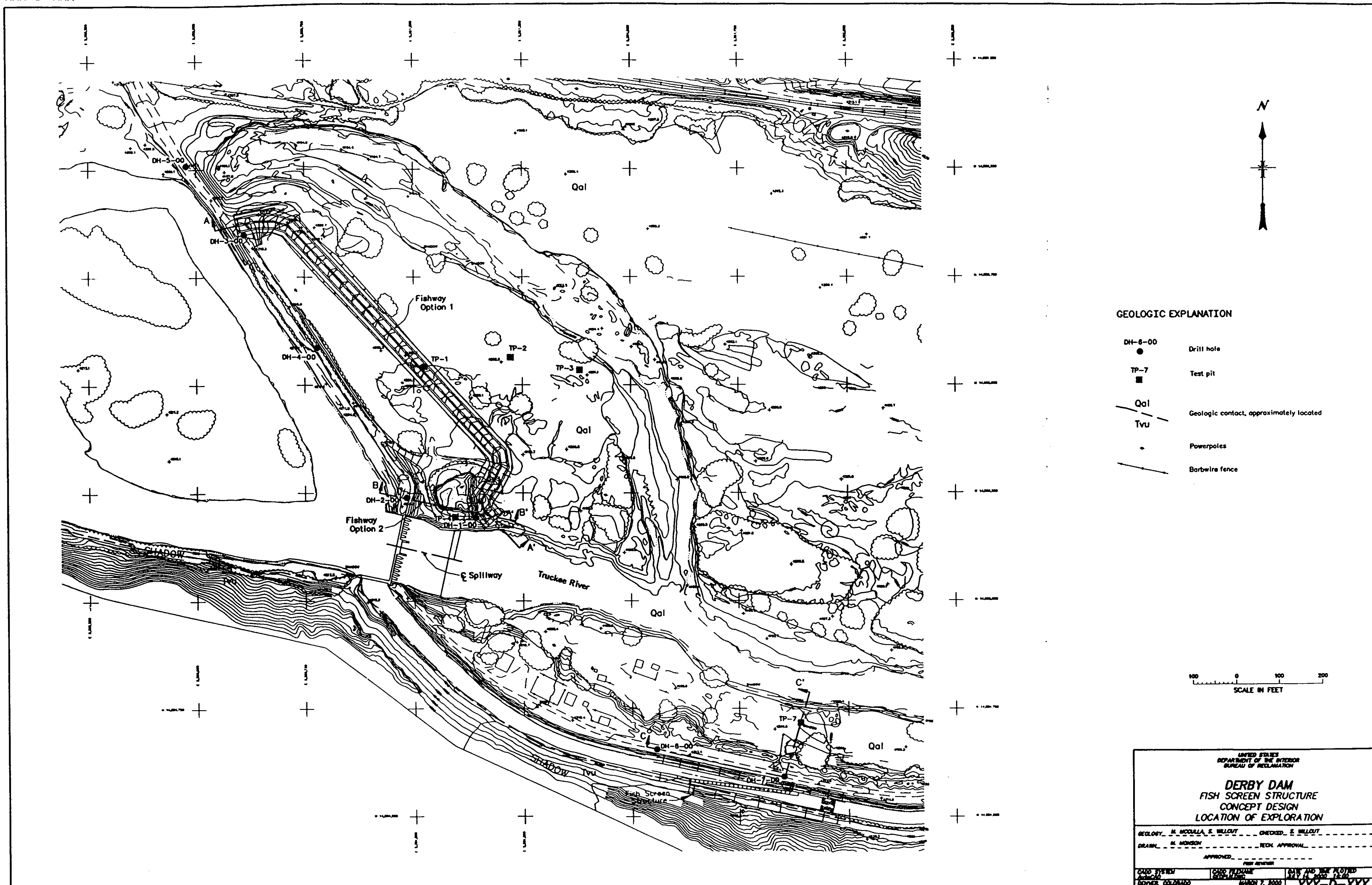
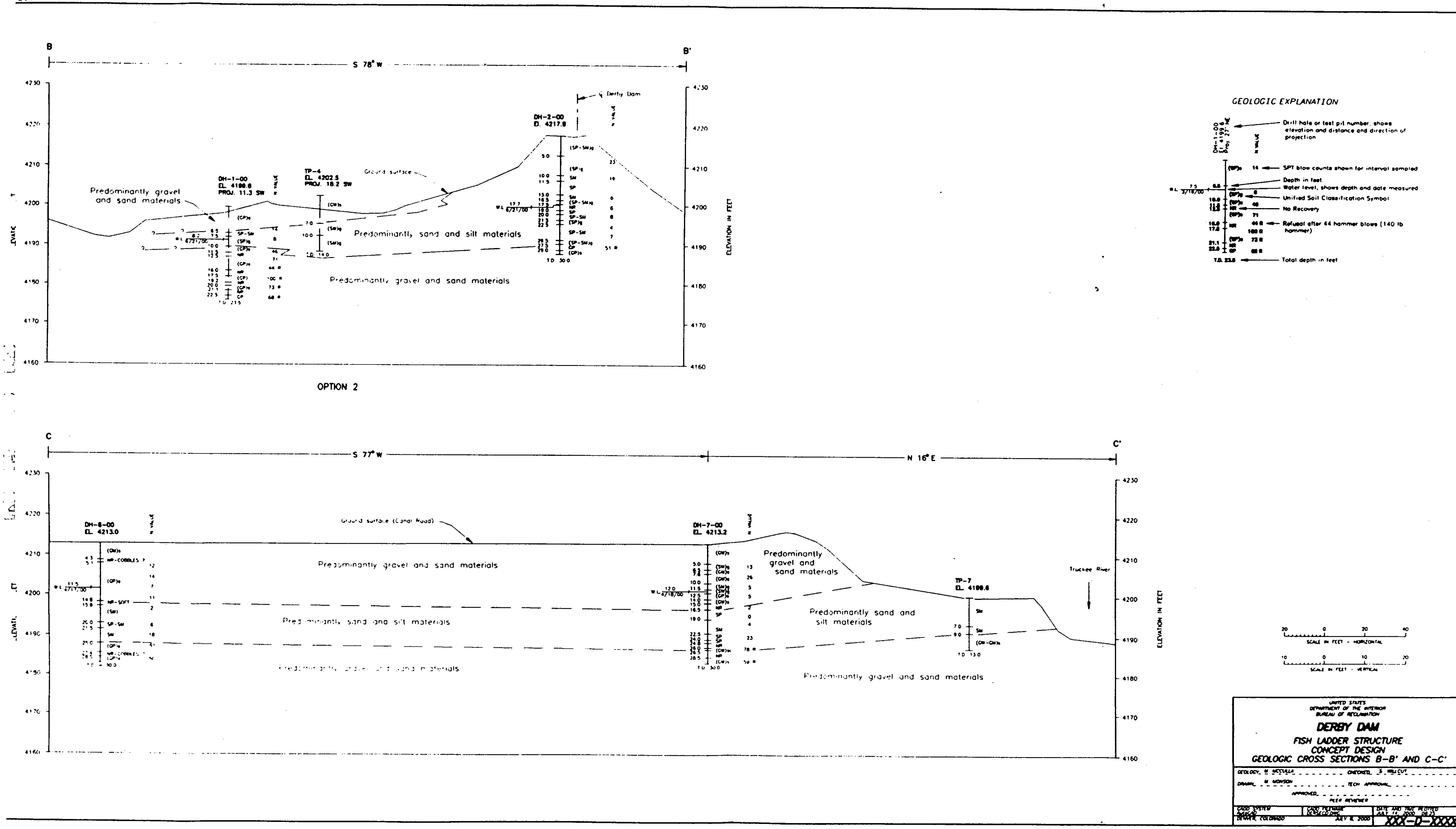

N
GEOLOGIC EXPLANATION
DH-6-00
Drill hole
TP-7
Test pit
Qal
Tvu
Geologic contact, approximately located
Powerpoles
Barbwire fence
100 0 100 200
SCALE IN FEET
Qal
DH-5-00
A
DH-3-00
Fishway Option 1
TP-1
TP-2
TP-3
DH-4-00
B
DH-2-00
B'
Fishway Option 2
TP-4
DH-1-00
A'
SHADOW
Tvu
℄ Spillway
Truckee River
C'
TP-7
C
DH-6-00
DH-7-00
Fish Screen Structure
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
DERBY DAM
FISH SCREEN STRUCTURE
CONCEPT DESIGN
LOCATION OF EXPLORATION
GEOLOGY M. MCCULLA, S. WILLOUT
CHECKED S. WILLOUT
DRAWN M. MONSON
TECH. APPROVAL
APPROVED
DENVER, COLORADO
MARCH 7, 2000
XXX-D-XXX

Figure B2



B
B'
S 78° W
DH-2-00
EL 4217.9
TP-4
EL 4202.5
PROJ. 18.2 SW
DH-1-00
EL 4198.6
PROJ. 11.3 SW
Ground surface
Predominantly gravel and sand materials
Predominantly sand and silt materials
Predominantly gravel and sand materials
ELEVATION IN FEET
OPTION 2
GEOLOGIC EXPLANATION
Drill hole or test pit number, shows elevation and distance and direction of projection
SPT blow counts shown for interval sampled
Depth in feet
Water level, shows depth and date measured
Unified Soil Classification Symbol
No Recovery
Refusal after 44 hammer blows (140 lb hammer)
Total depth in feet
C
C'
S 77° W
N 16° E
DH-6-00
EL 4213.0
Ground surface (Canal Road)
DH-7-00
EL 4213.2
Predominantly gravel and sand materials
Predominantly gravel and sand materials
Predominantly sand and silt materials
Predominantly sand and silt materials
Predominantly gravel and sand materials
Predominantly gravel and sand materials
TP-7
EL 4198.6
Truckee River
SCALE IN FEET - HORIZONTAL
SCALE IN FEET - VERTICAL
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
DERBY DAM
FISH LADDER STRUCTURE
CONCEPT DESIGN
GEOLOGIC CROSS SECTIONS B-B' AND C-C'
DENVER, COLORADO
XXX-D-XXXX

Figure B3