Pyramid Lake Fishway Replacement Feasibility Study

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List of Abbreviations

ft - unit of length in feet
ft/s - flow velocity in feet per second
ft^3/s or cfs - flow discharge in cubic feet per second
WS - water surface
WSE - water surface elevation
El. - elevation
Sta. - station

Pyramid Lake Fishway Feasibility Study

Executive Summary

The objective of this study is to identify the least cost alternative for reconstructing the Pyramid Lake fishway to provide fish passage from Pyramid Lake to above Marble Bluff Dam. Historically, when the Pyramid Lake elevation falls below about 3805, fish passage access up the river is partially or totally blocked by a sediment delta at the river's mouth. During these periods of low lake elevations the fishway serves as the main access for fish moving upriver to spawn. However, the fishway as constructed in 1976 has failed to provide effective fish passage for the endangered and threatened fish species of Pyramid Lake. Without an effective fishway, spawning during years when the lake elevation falls below 3805 is severely restricted.

The existing fishway contains five fish ladders. Starting at the lake, the ladders are referred to as the entrance ladder, intermediate ladders nos. 1, 2, and 3 and the exit ladder. The entrance ladder and much of ladder No. 1 are currently submerged by Pyramid Lake. At the current lake level replacement of the entrance ladder is very costly and not recommended. Replacement of fishway ladders no. 1, no. 2 and no. 3., commonly referred to as the fishway intermediate ladders, is recommended. The entrance elevation of ladder no. 1 is 3805, the lake elevation below which river passage has historically been blocked. Therefore, rehabilitation of the fishway must include a concept that provides for fish passage at lake elevations below 3805. The fishway concept was developed with the approach that the initial construction should provide for fish passage to some elevation below 3805 and the ability for the fishway to be extended to lower lake elevations in the future if needed. In the study, two fishway entrance elevations were carried through all concept designs. The first, referred to as option 1A, lowers the entrance of ladder no.1 five feet to elevation 3800. Option 1B lowers the entrance of ladder no.1 ten feet to elevation of 3795. The fishway exit ladder was replaced with a new design in 1998 as part of the fish lock construction project. The new exit ladder will not require modification for the fishway concepts presented.

The concept study investigated several alternatives for reconstructing the fishway fish ladders and the channel between ladders. Two fish ladder alternatives designed to meet established fish passage criteria for Pyramid Lake species were carried through concept design.

- Replace the existing concrete weir and orifice style fish ladders that are on a 10 percent grade with new concrete ladders on a 3.25 percent grade with vertical slot baffle drops.
- Replace the existing ladders with rock ladders on a 1.2 percent slope with boulder array style drops.

Recommended Fishway Ladder Design - Both fish ladder alternatives developed in the study are expected to provide effective passage for Pyramid Lake fish based on established passage criteria. However, the ladder alternatives differ in construction, flow conditions, expected maintenance and cost. The major differences between the ladder alternatives are summarized in the following table.

Ladder Alternative	Durability	Flexibility	Flow variability	Maintenance	Construction Cost	
					Entrance elev. 3800	Entrance elev. 3795
Concrete flume and baffle ladder	Very good	Limited to removable baffles that can be replaced.	Predictable flow conditions, all baffles provide similar flow conditions	Yearly removal of weeds and debris trapped within the baffles.	$4,718,000	$5,148,000
Rock ladder with boulder weirs	Can be damaged if rock is removed or displaced by people or livestock.	Very flexible, boulder weirs can be adjusted to obtain desired flow conditions.	Flow conditions will vary through each boulder weir drop as rock shape and size will vary. The rock ladder alternative will require some adjustment of the boulder weirs following construction to achieve desire flow conditions.	Yearly removal of weeds and debris trapped within the rock weirs. Repair of any areas where riprap has been visibly disturbed.	$3,238,000	$4,098,000

The rock ladder design is recommended because it offers functionality at the least construction cost. However, the durability of a riprap constructed channel is expected to be less than that of a concrete flume. Yearly inspection and replacement of any riprap that has been visibly disturbed is recommended for the rock ladder alternative. The estimated annual cost of inspecting and replacing riprap is $10,000.

Fishway Channel Recommendations - The fishway channel links together the fish ladders. Since construction in 1976 the channel has changed in shape and no longer contains a viable seepage control lining. The channel is functional, however seepage and channel shape likely reduce the fishway flow to less than the original 50 ft^3/s design flow.

Reconstructing the channel to its original geometry and slope and lining it with a thick, lime treated clay lining is recommended. This type of lining is recommended due to the fluctuating lake elevation and high groundwater table. The lining will support small bobcat style loaders used to remove windblown sand deposits prior to yearly operation. Increasing the channel slope to increase hydraulic flushing of wind blown sediment was investigated. However, hydraulic flushing of wind blown sediment deposits did not prove feasible within the constraints of the fishway design criteria. A summary of the findings for both options are included herein for completeness. The estimated construction cost of reshaping and lining the fishway channel for the concrete flume ladder and rock fish ladder alternatives are $1,816,500 and $1,398,150, respectively. Yearly cleaning of the fishway is estimated to cost $12,000.

Background

The Corps of Engineers (COE) Sacramento District requested the Bureau of Reclamation (Reclamation) Technical Service Center (TSC), Denver, Colorado to conduct a feasibility design study to investigate replacing the Pyramid Lake fishway at Marble Bluff Dam. Marble Bluff Dam is located on the Truckee River approximately 50 miles downstream of Reno, Nevada and approximately 3 miles upstream of Pyramid Lake, Figure 1. The waters of Pyramid Lake are supplied largely by flow from the Truckee River. The lake is a terminal lake with no out flow. The water level in Pyramid Lake has fluctuated widely during its geologic history. Records dating sporadically from about 1844 indicate that the lake elevation remained relatively stable, with cyclical fluctuations of about 20 feet maximum until about 1910, when a general decline began. In the last 100 years, the lake elevation has dropped as much as 80 feet due to upstream diversions coupled with periods of drought, Figure 2. A declining lake elevation resulted in severe degradation of the Lower Truckee River and upstream passage problems for endangered cui-ui lake suckers (Chasmistes cujus) and threatened Lahontan cutthroat trout (Oncorhynchus clarki) (LCT). Both species migrate up the Truckee River to spawn during high spring flows. In 1992 the U.S. Fish and Wildlife Service (FWS) issued a recovery plan for the endangered cui-ui lake sucker [26]. The plan identifies improving passage at Marble Bluff Dam as a key component to the fish's recovery. Excerpts from the Cui-ui Recovery Plan are reprinted herein as background on the fish, its habitat and migration to spawn.

Cui-ui Lake Sucker (FWS) - Lakesuckers (genus Chasmistes) are differentiated from other members of the family Catostomidae by thin lips, the lobes of which are separated and may lack papillae, and by a large terminal, oblique mouth. The four recognized species are residents of three distinct drainage basins: cui-ui (C. cujus) in the Truckee River basin of western Nevada (Pyramid Lake); shortnose sucker (C. brevirostris) in the Klamath River basin of Oregon and California; June sucker (C. liorus) in Utah Lake; and the recently extinct Snake River sucker (C. muriei) of the upper Snake River in Wyoming. Cui-ui is a large, robust sucker with a long, broad, and deep head. The dorsal side of its coarsely-scaled body is blackish-brown with a bluish-gray cast which fades to a creamy-white belly. Female cui-ui have been documented exceeding a length of 27.6 in with males attaining 26.1 in.

At the beginning of the 20th century, cui-ui inhabited Pyramid and Winnemucca Lakes. Obligate stream spawners, cui-ui congregate near the mouth of the Truckee River in spring and are reported to migrate as far as 25 miles upstream (to the vicinity of Wadsworth, Nevada) to spawn. The species was eliminated from Winnemucca Lake when it dried up in the 1930's following unrestricted diversion of water from the Truckee River and a severe drought.

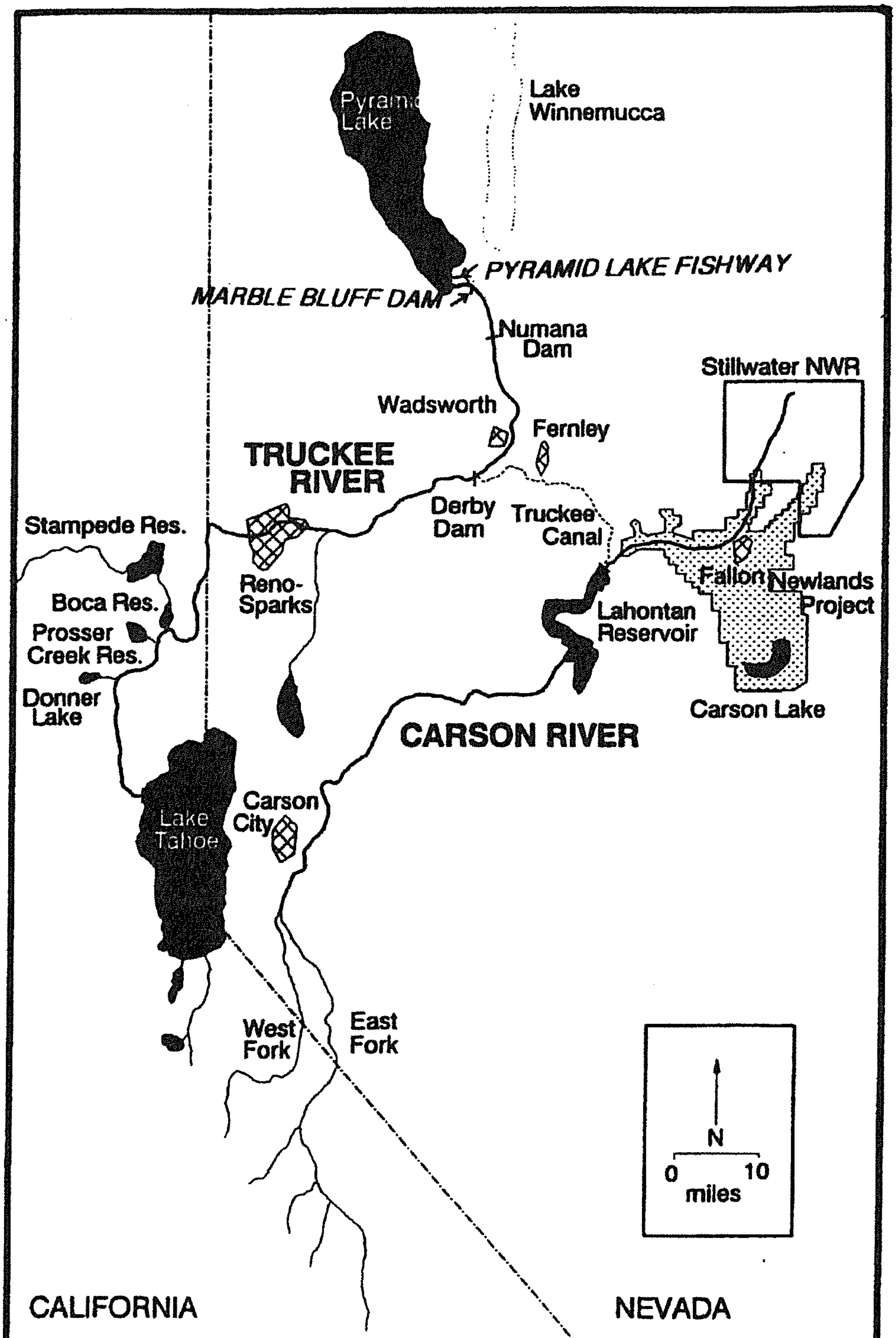


Figure 1 - Area map showing the location of Marble Bluff Dam.

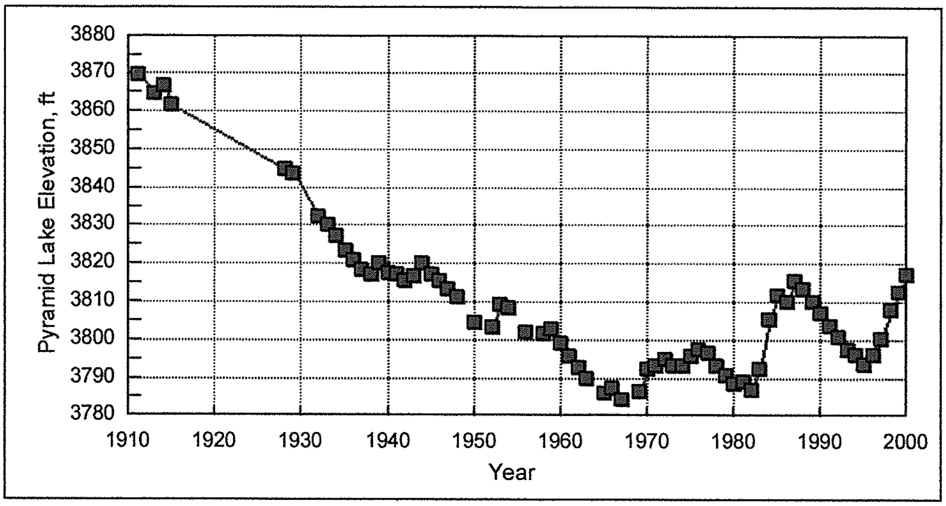


Figure 2 - Pyramid Lake elevation from 1910 to 2000.

Cui-ui are now restricted to Pyramid Lake and the lower Truckee River (downstream from Derby Dam). Pyramid Lake elevation is nearly 80 ft lower than at the turn of the century, and there are now structural impediments (e.g., Marble Bluff and Numana Dams) to fish passage. Adult and juvenile cui-ui inhabit Pyramid Lake year-round. Adults utilize the lower 12 miles of the Truckee River only during the spawning season (ranging from as early as April to as late as June) and only in years in which there are sufficient attraction flow and passage above or around the delta. Most spawners utilize the 10-mile reach between Marble Bluff and Numana Dams; as the fish ladder at Numana Dam is not conducive to passage of cui-ui.

Life History and Habitat (FWS) - Cui-ui is a large, long-lived and omnivorous sucker. Pyramid Lake provides rearing habitat for larvae, juveniles, and adults. The lower Truckee River provides primary spawning habitat. Adults, eggs, and larvae may be present in the river for a maximum of several weeks. Spawning has been observed at freshwater interfaces and springs within Pyramid Lake .

Lake Habitat (FWS) - Pyramid Lake is the terminus of the Truckee River. It is saline (>4.1ppt), alkaline (pH = 9.1-9.3) and categorized as oligotrophic to mesotrophic. From 1981 to 1990 the maximum depth ranged from 365 to 390 ft. Average annual evaporative loss is approximately 440,000 acre-feet, which creates a vertical drop of 4 ft. Pyramid is a monomictic lake and may stratify as early as May; it usually remains stratified until December.

For much of the year adult and juvenile cui-ui inhabit the littoral zone at depths of 60 to 100 ft. Juveniles appear to concentrate at the north and south ends of the lake. They are most active during summer and fall; however, a seasonal migration pattern has not been demonstrated.

River Habitat (FWS) - The lower Truckee River is a low- to moderate-gradient stream descending at a rate of approximately 7.9 ft/mile. The banks are composed of unstable sedimentary material which is vulnerable to severe erosion. The stream channel has changed significantly during this century. Lowering of Pyramid Lake and artificial straightening of the river for flood-control purposes have created a shallow, braided, and unconfined channel network and formed a broad delta at the mouth. Marble Bluff Dam functions as a hydraulic control to reduce upstream erosion, and has also created several miles of habitat suitable for cui-ui spawning immediately upstream.

Discharge in the lower Truckee River is highly variable between seasons and years, depending, in part, on upstream storage and diversions at Derby Dam. Average annual inflow to Pyramid Lake for the period 1918-1970 was approximately 250,000 acre-feet. Runoff, a function of snowmelt, generally peaks in late spring (average of 56,000 acre-feet in May) and is lowest in late summer (average of less than 1,000 acre-feet in August).

Spawning (FWS) - Adult cui-ui congregate in March and April near the mouth of the river prior to migration. Spawning runs begin in April or May, depending upon timing of runoff, river access, and water temperature. There is evidence that a high volume spring runoff attracts more spawners and promotes egg ripening. Most spawners migrate less than 6 miles upstream, but some may travel up to 12 miles. While most spawners spend only a few days in the river, some may remain up to 16 days. Spawning runs may continue for 4 to 8 weeks, but most fish migrate during a 1- to 2-week period.

History of Pyramid Lake Fish Passage

The first major effort to improve fish migration up the lower Truckee River was started by the Bureau of Indian Affairs in 1942 when the lake elevation was 3820. A diversion dam and fishway channel were started near the site of the present facilities. World War II interrupted the construction and the dam washed out during flood flows in 1950. In 1976 Reclamation constructed Marble Bluff Dam and fish passage facilities for the U.S. Fish and Wildlife Service. The facility was designed to aid fish passage and stabilize the rapidly degrading river channel. The dam is a zoned, earth-fill embankment with a 150-ft-long, uncontrolled concrete ogee crest spillway, crest elevation 3854.5, see reference drawing no. 949-D-1230 in appendix A. To the right of the spillway is a 20-ft-wide, gated sluiceway, floor elevation 3847.5. Spillway and sluiceway flows pass down a baffled apron drop to the downstream river channel. The river channel upstream of the dam is silted in to about the elevation of the sluiceway invert. During low flows there is no storage behind the dam. Prior to construction, the river channel bed elevation was about 3842. The down stream end of the baffled apron drop was constructed to elevation 3801.76 to protect the dam against channel degradation, leaving much of the baffled apron buried below the original streambed elevation. Currently the downstream river channel bed elevation is about elevation 3812.

In conjunction with building the dam, two different paths for fish passage from the lake to the river above the dam were constructed. Two paths were needed as river access for fish is often blocked for lake elevations below about 3800 by a large sediment delta at the junction of the river and lake. Historically, when exposed, the delta has caused the river to fan out into a shallow braided channel regime that blocks fish passage up the river. For these conditions the Pyramid Lake fishway was constructed to provide fish passage directly from the lake to upstream of Marble Bluff Dam, Figure 3.

Pyramid Lake fishway is about 3 miles long and contains five fishway ladders. In years when the lake elevation is above 3805, fish move up the river and must be passed over the dam. For this condition, a fish trap and mechanical hoist type fish lift were constructed adjacent to the dam spillway to provide passage for fish reaching the dam, Figure 3. Both of the original fish passage facilities proved

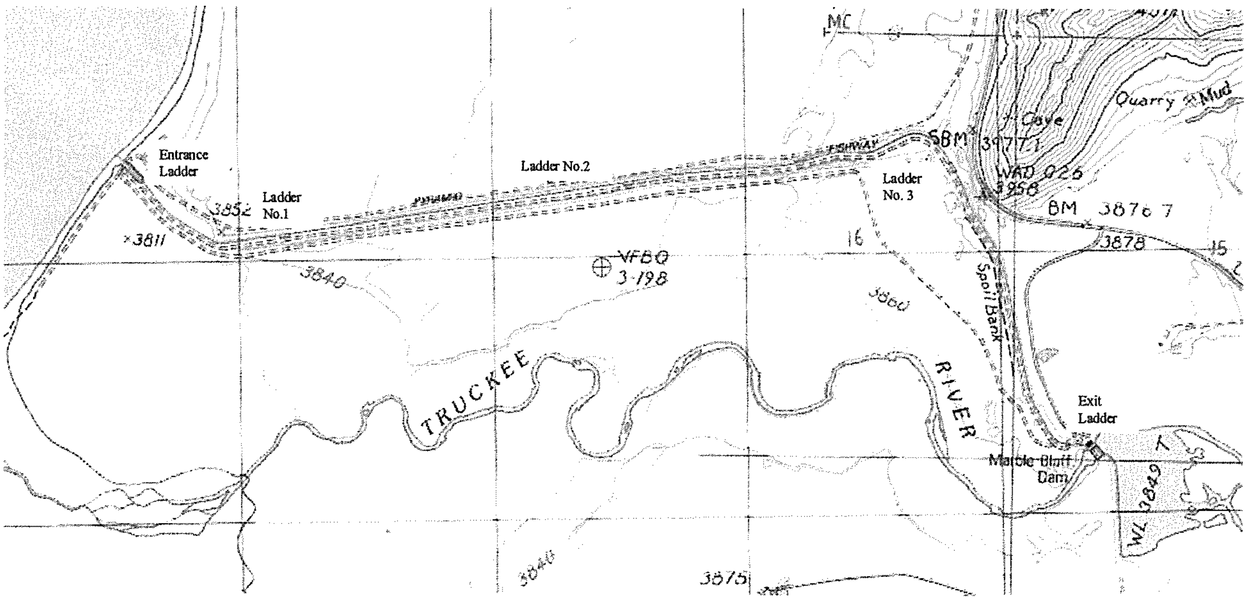


Figure 3 - Location map showing Marble Bluff Dam and Pyramid Lake fishway.

ineffective for passing cui-ui suckers. Cui-ui were incapable of passing the fishway ladders as designed and their crowding behavior often resulted in fish mortality due to overcrowding in the fish trap.

Starting in 1995, [8], Reclamation, FWS and other organizations pursued a project to develop better methods for passing cui-ui suckers and LCT that move up the river to Marble Bluff Dam. The project resulted in three major structures being built. These are; replacement of the fish trap and hoist system with a hydraulic fish lock, construction of a gradient control structure in the river downstream of the dam and replacement of the exit fishway ladder with a new fish ladder designed for cui-ui. The exit fishway ladder was replaced to provided separate exit channels for the fish lock and fishway channel. The fish lock and gradient control structure have functioned well. The fishway channel including the new exit fish ladder is not considered operational as the fish ladders downstream of the exit have not been replaced.

<u>1976 Fish Ladder Design</u> [16] - The fishway was designed to provide fish passage for a maximum elevation gain between the lake and the river upstream of the dam of about 76 ft. The fishway contains five fish ladders linked by an earth lined trapezoidal channel. The fishway ladders are commonly referenced by location in the upstream direction of fish movement. Starting at Pyramid

Lake the ladders are referred to as the fishway entrance ladder (also called terminal ladder), ladder no. 1, ladder no. 2, ladder no. 3 (also referred to as intermediate ladders), and the exit ladder, see Figure 3. The ladders constructed in 1976 slope at a grade of 1 vertical to 10 horizontal (10 percent). Ladders no. 1, no. 2 and no.3 are identical, each providing 13 ft of elevation gain, the entrance ladder provides 31 ft of elevation. The entrance ladder starts at elevation 3774.5 and climbs to elevation 3805.53. Ladder no. 1 climbs from elevation 3805.74 to elevation 3818.74, ladder no. 2 climbs from elevation 3819.17 to elevation 3832.17 and ladder no. 3 climbs from elevation 3832.6 to elevation 3845.6. The exit ladder provides the final elevation gain of about 6.75 ft to the river. The fishway channel linking the ladders slopes 1 ft vertical in 10,000 ft. The channel is designed to convey 50 ft^3/s at a flow depth of 4 ft and a flow velocity of 1 ft/s. Drawings of the original fishway ladder designs are presented in Appendix A, reference drawings 949-D-166 and 949-D-171.

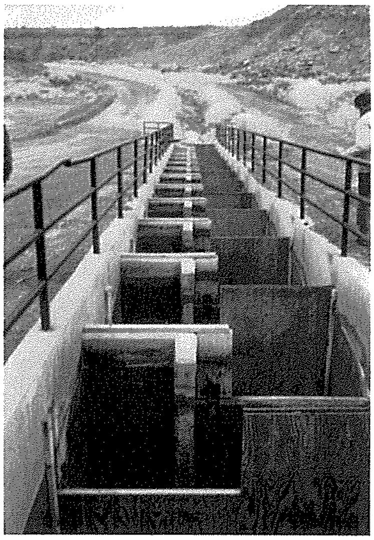


Figure 4 - Pyramid Lake fishway ladder. Shown, with temporary intermediate baffles to reduce the drop in water surface elevation per weir.

Ladder baffles are similar to a style used on Ice Harbor Dam on the Snake River. The baffles are a pool and combination weir and orifice design, Figure 4. Baffles were originally spaced every 10 ft, therefore providing a water surface drop across each baffle of 1 ft and a passage flow velocity of 8 ft/s. The ladder design was based on experience with salmonid passage and available studies of the cui-ui physical and behavioral attributes [4, 5, 6, 10]. During initial operation of the fishway, the ladder baffle design and head drop were found to be a poor match for cui-ui behavior and swimming strength. Cui-ui attempted too move up the ladders crowded near the fishway invert. The 8 ft/s passage velocity was found to be to high for efficient passage, also the bottom oriented behavior of the cui-ui was contrary to passing over a weir that forced them high in the water column. To improve passage, FWS added weirs half way between the original baffles. This reduced the drop over each baffle to 0.5 ft and reduced the pool length between baffles to 5 ft. Velocity over the baffles was reduced to about 5 ft/s. Passage of cui-ui improved, however fish passage efficiency remains low.

1998 Fishway Exit Ladder Replacement - In 1998 Reclamation replaced the Pyramid Lake fishway exit ladder, see reference drawing 949-D-1235 in Appendix A. The ladder was replaced as part of the fish lock construction project. One of the project objectives was to provide separate fishway and fish lock exit channels. This resulted in a new fishway exit ladder being constructed to the north of the fish handling building, Figure 5. The new ladder is 8 ft wide, 6 ft deep, with baffles placed every 8 ft of length. To improve flow conditions, the ladder gradient was reduced to 0.03125-ft-vertical to 1-ft-horizontal (3.125 percent) and new dual-slot-chevron shaped baffles were designed specifically for cui-ui passage.

Fishway flow in the exit ladder varies with river stage at the exit of the fishway. Table 1 gives estimates of ladder hydraulics for a range of river flows. Downstream of the exit ladder a supplemental water supply and a skimming weir are used to regulate fishway channel flow to achieve a steady 50 ft^3/s flow independent of river stage. These structures are located on an extension of the fishway channel that serves the fish handling building, see Figure 5 and reference drawing 949-D-197 in appendix A.

Table 1 - Fishway exit ladder hydraulics

River flow, ft^3/s.	River elevation (upstream of spillway)	Average WS drop per baffle, ft	Estimated flow velocity through baffle slots, ft/s.	Depth of flow in exit ladder, ft	Estimated exit ladder flow, ft^3/s.
1000	3855.9	0.22	3.0	5.1	30.6
2000	3856.75	0.25	3.2	6.0	38.4
3000	3857.5	0.28	3.4	6.75	45.9

Fishway Design Criteria

Fishway ladder and channel options were selected based on achieving flow conditions suitable for efficient cui-ui and LCT passage. Flow criteria used to guide the fishway concept design are listed below.

Fish ladder design objectives:
1). a maximum passage velocity of 4 ft/s (based on average velocity)
2). a minimum flow depth of 4.0 ft
3). a ladder conveyance capacity of 50 ft^3/s
3). maximize downstream flow to enhance fish orientation
4). provide passage at all levels within the water column

Fishway channel design objectives:
1). a flow of 50 ft^3/s (normal maximum)
2). an operating depth of 4 ft (required due to the potential for pelican predation)
3). a maximum flow velocity of 2 ft/s
4). maximize sediment transport

Fishway Ladder Options

Historically, when the Pyramid Lake elevation falls below about 3805, fish passage access up the river is partially or totally blocked by a sediment delta at the river's mouth. Without an effective fishway, cui-ui spawning during years of low lake elevation can be lost. The sediment delta has been a major impediment to cui-ui spawning many times during the last fifty years. As shown in Figure 2, the lake elevation has often been below 3805 since 1950. Currently, the lake elevation is about 3816 and river passage is good. This project proposes to reconstruct the fishway for future use should the lake elevation decline while river access is open and the fishway is not required for fish passage. Under this proposal the fishway would be rebuilt from the lake to the exit fish ladder. Fishway ladders no. 1, no. 2, and no. 3 would be replaced with new ladder designs and the channel linking the ladders would be reconstructed. The exit ladder would not be changed. The channel (elevation 3805) downstream of ladder no. 1 and the top of the entrance ladder are about 10 ft below the current lake elevation. Replacement of the fishway channel downstream of ladder no.1 and the entrance ladder are not part of this project. However, the concepts presented include feasibility level costs for replacement of these structures should it become necessary in the future due to low lake elevations. All fishway concepts considered include the option of extending ladder no.1 lower into the lake to either elevation 3800 or 3795. The objective of lowering the ladder entrance elevation is to increase the range of critical (river passage blocked) lake elevations for which the fishway could operate (with future channel excavation) before the construction of the entrance ladder would have to be pursued.

Two different fish ladder designs were investigated in the feasibility study. The first alternative replaces the old fishway ladders with concrete chute and baffle fish ladders similar in design to the new exit ladder built in 1998. The second alternative replaces the old ladders with rock channel and boulder weir ladders. A rock channel ladder is a low gradient riprapped channel that uses large boulder arrays to create small drops similar in function to a fish ladder baffle. Concept designs are presented for both fishway alternatives. Each alternative is designed to meet the fishway ladder hydraulic design criteria outlined above.

Location of Fishway Ladders

All references to fishway stationing in this report are based on the original 1973 survey data. Fishway stationing increases in the downstream flow direction (opposite the direction used for ladder references). Station 0+00 was located at the upstream end of the trapezoidal fishway channel just west of the fish handling building, see reference drawing 949-D-197 in appendix A. Replacement of the fishway exit ladder in 1997 changed the channel geometry in the area of the original stationing datum and resulted in a separate stationing datum for the exit ladder. During final design data collection for this project a new survey of the fishway should be conducted to tie together the stationing of all the existing fishway structures. Proposed new fish ladders for either the rock and concrete flume concepts are located in approximately the same location as the existing fish ladders.

Two fishway ladder excavation schemes were investigated for each fish ladder alternative (concrete flume or rock). These were, constructing fishway ladders on insitu material by matching the downstream toe stationing of new ladders to that of existing ladders and moving the toe of new ladders downstream and constructing partially on compacted backfill. For ladders no.2 and no.3, moving the toe of each ladder downstream and balancing excavation cut and fill was chosen as the preferred construction method. This construction scheme reduced dewatering requirements and excavation. For ladder no.1, constructing the ladder largely upstream of the existing ladder toe was chosen as the preferred method to minimize construction site unwatering.

Fishway Ladder Alternative 1 - Concrete Flume and Baffle Design

The design of the Pyramid Lake fishway exit ladder constructed in 1998 was developed based on a research study of ladder baffle designs for non-salmonids. The baffle design was developed using both a physical model and a computational fluid dynamics model (CFD). Baffles were designed to enhance cui-ui passage by maximizing the downstream flow field within the pools, providing passage opportunity at all elevations within the water column, maximizing flow within the ladder while meeting passage velocity criteria and avoiding strong vertical turbulence. A chevron shaped baffle was chosen for the center-oriented downstream flow that is created by the convergence of flow from two opposed vertical slots, Figure 6. The vertical slots on the each side of the chevron shape are aligned to join the flow from each slot near the apex of the next downstream baffle. Short wing walls on the upstream inside edge of each slot are used to force the flow to turn toward the center of the downstream pool. The prototype ladder is shown in Figure 7.

For the concrete chute and baffle alternative, we propose replacing the 1976 weir and orifice ladders with a design similar to the exit ladder. New ladders would be constructed on a 0.0325 slope with a water surface drop across each baffle of 0.26 ft, see Figure 8. A slope slightly steeper than used for the exit ladder was selected based on water velocity measurements made in the exit ladder that show maximum passage velocities of less than 4.0 ft/s. The proposed ladder chute is 8 ft wide by 8 ft deep. Similar to the exit ladder, removable baffles are spaced at 8 ft intervals. The ladders are designed to convey 50 ft^3/s at a flow depth of 6.25 ft or about 8 ft^3/s per foot of depth. The channel transitions to the ladder entrance and exits are designed to provide a smooth flow transitions.

Each fishway ladder is designed with a flow bypass system that can convey flow around the fishway ladder. The flow bypass system enables hydraulic conditions through the ladders to be adjusted and provides overflow protection should the fishway baffles become partially plugged with debris. The bypass system includes a combination gated control and overflow weir structure located just upstream of each fishway ladder, an energy dissipation box at the downstream end of each ladder and a 24 inch diameter pipe linking the two structures, see Figure 8. The overflow is designed to pass 35 ft^3/sec flow at top of bank, 1 ft above the weir crest. The gated bypass control is designed to make small ladder flow adjustments if determined necessary by the operators and provide flexibility should the baffles be modified in the future. The gated bypass is designed to pass up to18 ft^3/sec flow at a diffuser approach velocity of 1 ft/s.

Ladder baffles are removable and similar in design to the exit ladder, except slot widths are fixed at 1.0 ft, Figure 9. Downstream of the exit ladder adjustable width baffle slots are not needed as fishway flow can be regulated to 50 ft^3/sec.

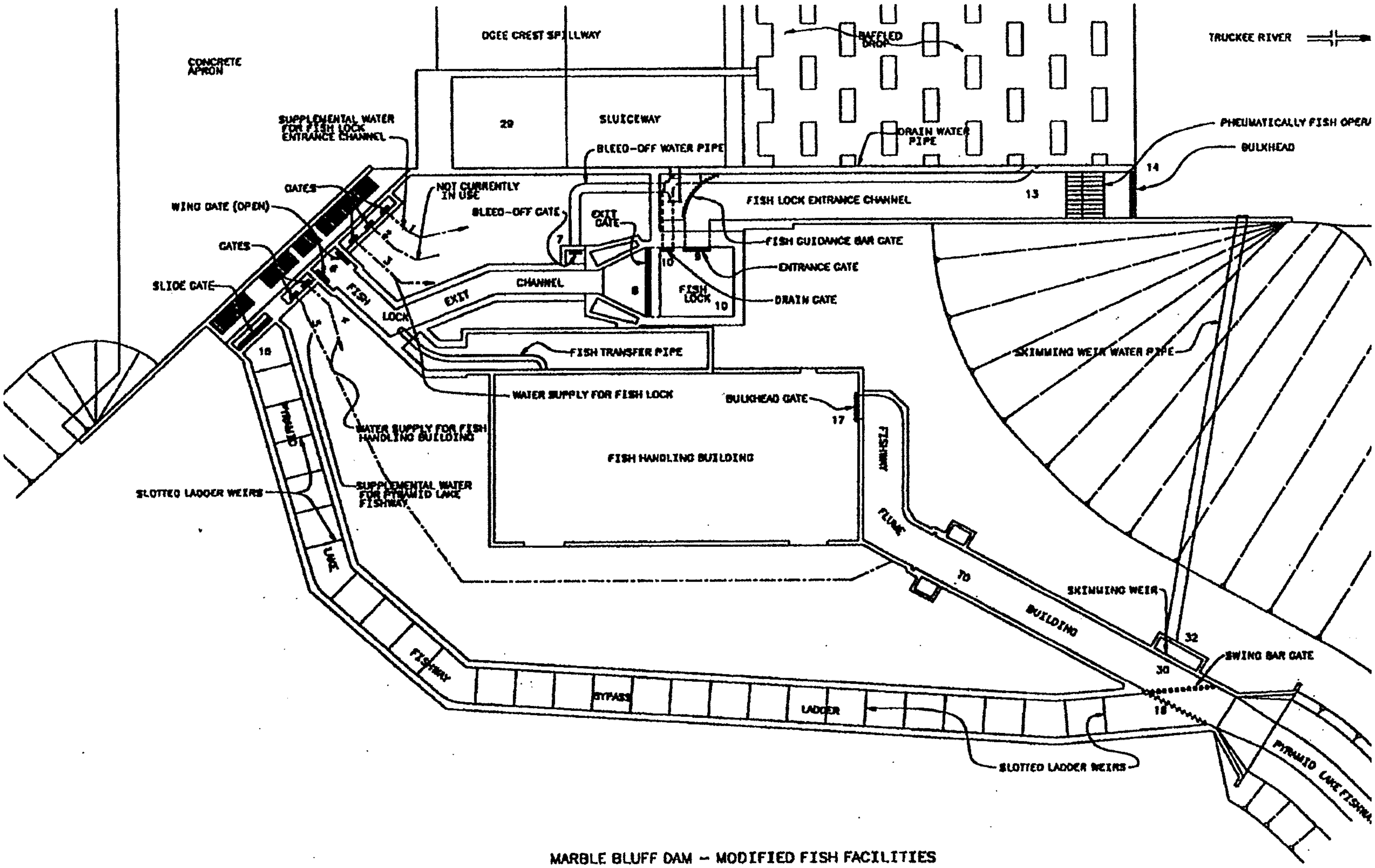


Figure 5 - Marble Bluff Dam fish lock and fishway exit ladder.

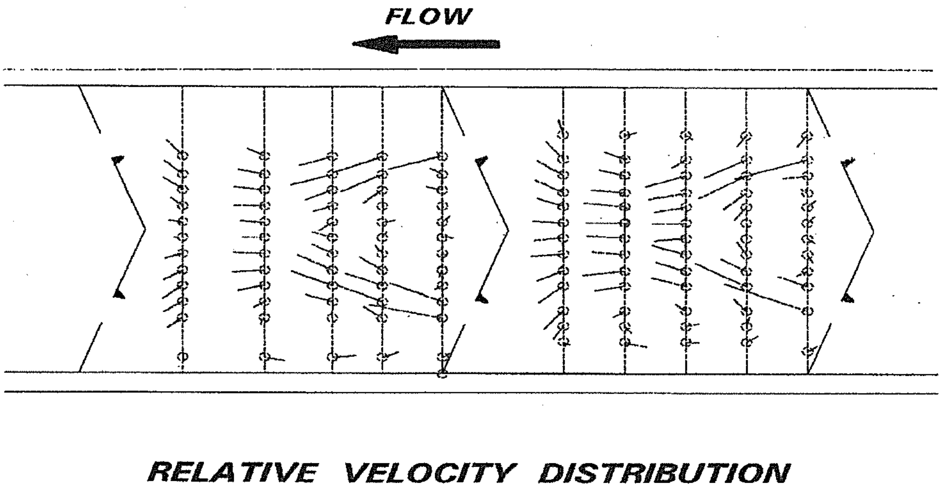
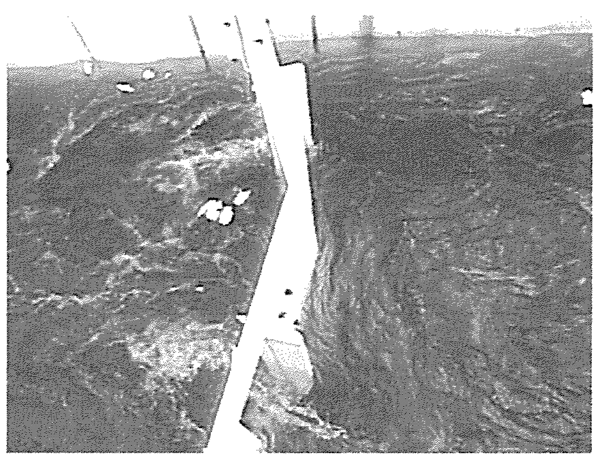


Figure 6 - Velocity vector field measured in a dual vertical slot chevron shaped baffle fishway.

View looking up the fishway exit ladder.



View of the dual vertical slot chevron shaped baffle.

Figure 7 - Marble Bluff Dam Fishway exit Ladder

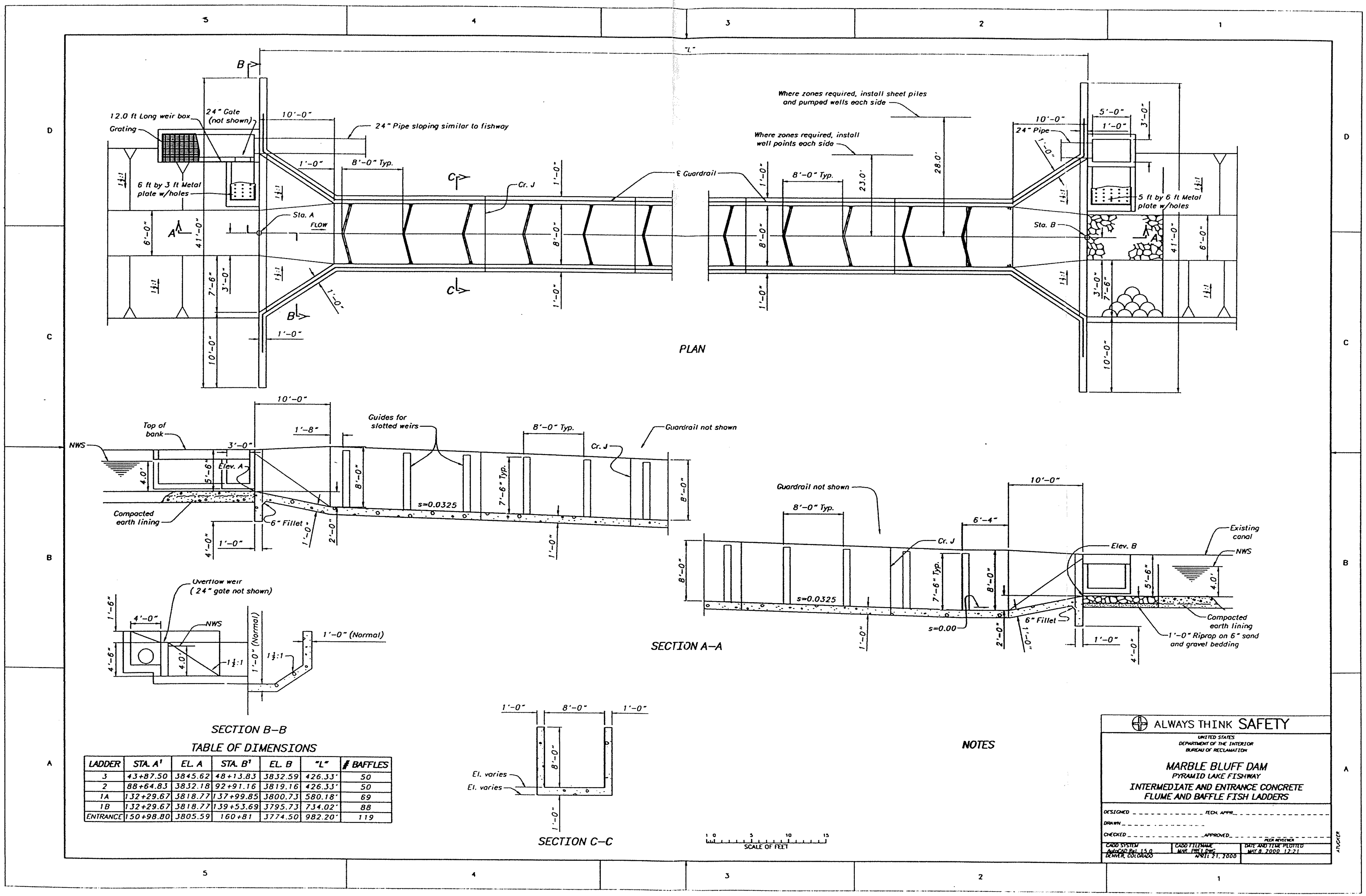
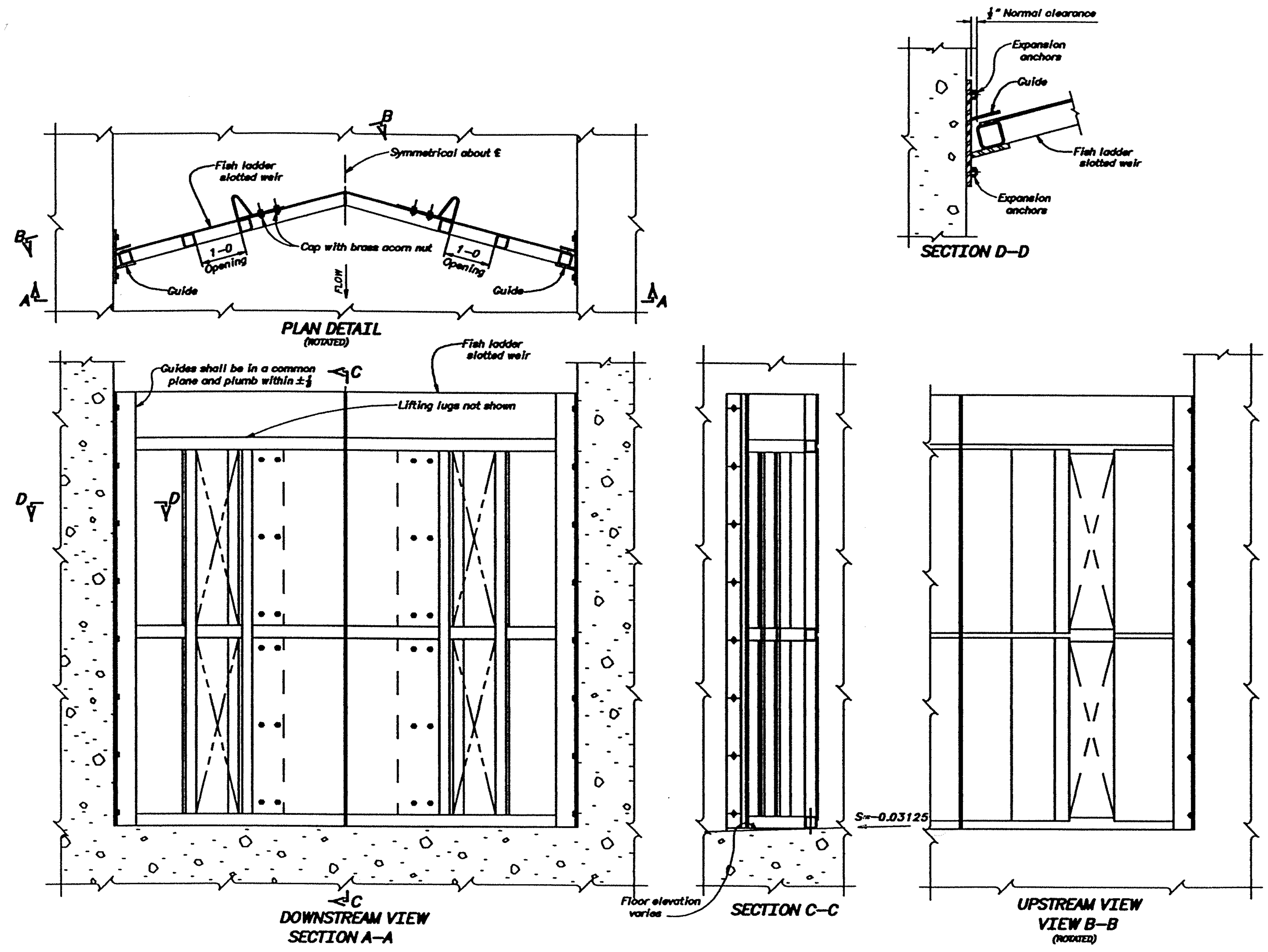


TABLE OF DIMENSIONS

LADDER	STA. A¹	EL. A	STA. B¹	EL. B	"L"	# BAFFLES
3	43+87.50	3845.62	48+13.83	3832.59	426.33'	50
2	88+64.83	3832.18	92+91.16	3819.16	426.33'	50
1A	132+29.67	3818.77	137+99.85	3800.73	580.18'	69
1B	132+29.67	3818.77	139+53.69	3795.73	734.02'	88
ENTRANCE	150+98.80	3805.59	160+81	3774.50	982.20'	119

Figure 8, pg. 14



REFERENCE DRAWINGS

FISH LADDER SLOTTED WEIRS
INSTALLATION 949-D-1267
DETAILS 949-D-1268
FISH PASSAGE FACILITIES MODIFICATIONS
MODIFIED FACILITIES
PLAN 949-D-1232
SECTIONS AND DETAIL 949-D-1235

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
WASHOE PROJECT
STAMPEDE DIVISION – NEVADA – CALIFORNIA
MARBLE BLUFF DAM
PYRAMID LAKE FISHWAY
FISH LADDER SLOTTED WEIRS
INSTALLATION

DESIGNED .... CHECKED ....
DRAWN .... TECHNICAL APPROVAL ....
APPROVED ....

CADD SYSTEM	SLOTTEDF.DWG	APRIL 24, 2000
DENVER, COLORADO ACAD SHEET 1 OF 1	APRIL 24, 2000	

D (22 X 34)

Figure 9, pg. 15

Concrete Chute and Baffle Fish Ladder Layout

(presented in direction of fishway stationing from upstream to downstream)

Ladder No. 3 (existing upstream station = 45+50)

Ladder no. 3 would be removed and replaced by a 426 ft long concrete chute and baffle ladder set at a 3.25 percent slope (0.0325), see Figure 10. The ladder exit would move 162.5 ft upstream and the entrance107.8 ft downstream from current locations. The ladder location selected allows the ladder to be constructed in a straight alignment. The ladder would provide about13 ft of rise, starting at entrance elevation 3832.59 and exiting at elevation 3845.62. Approximately 4,130 ft of fishway channel would connect the exit ladder and ladder no. 3.

Ladder No. 2 (existing upstream station = 90+00)

Ladder no. 2 would be removed and replaced by a 426 ft long concrete chute and baffle ladder set at a 3.25 percent slope (0.0325), see Figure 11. The ladder exit would move 135.2 ft upstream and the entrance135.2 ft downstream from current locations. The ladder would provide about13 ft of rise, starting at entrance elevation 3819.16 and exiting at elevation 3832.18. Approximately 3916 ft of fishway channel would connect ladder no. 3 and ladder no.2.

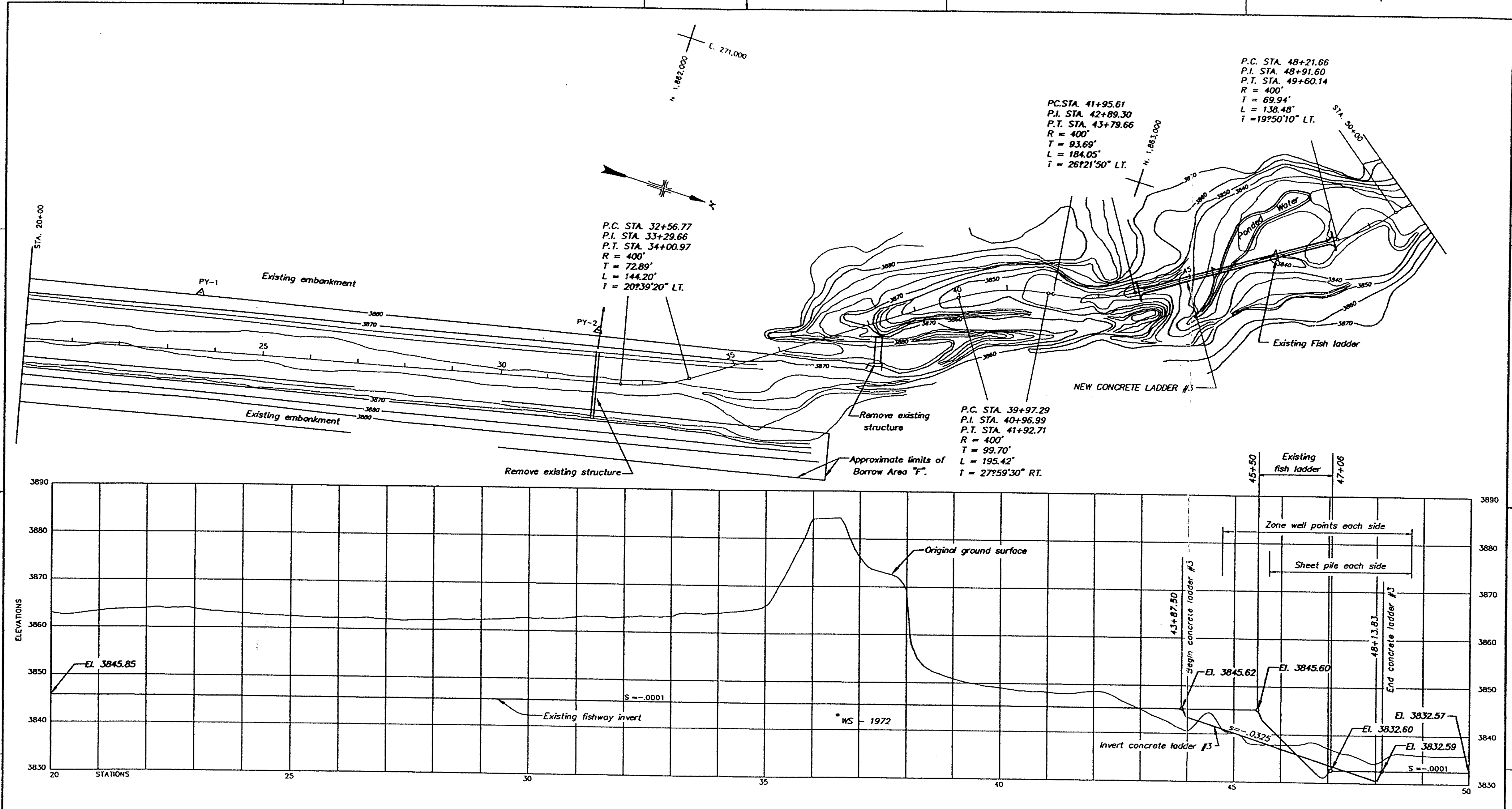
Ladder No. 1 (existing upstream station = 135+00)

Option 1A (entrance elevation 3800.7) - Ladder no. 1 would be removed and replaced by a 570 ft long concrete chute and baffle ladder set at a 3.25 percent slope (0.0325), see Figure 12 (option 1a). The ladder exit would move 270.0 ft upstream and the entrance143.9 ft downstream from current locations. The ladder would initially provide about 13 ft of rise, starting at entrance elevation 3805.7, and future fish passage access to elevation 3800.7. If the lower 5 ft of the fishway height is needed in the future due to declining lake levels, the existing downstream fishway channel would have to be excavated to access the lake. Approximately 1,300 ft of fishway channel would connect ladder no. 2 and ladder no.1.

Option 1B (entrance elevation 3795.7). - Ladder no. 1 would be removed and replaced by a 724 ft long concrete chute and baffle ladder set at a 3.25 percent slope (0.0325), see Figure 12 (option 1b). The ladder exit would move 270.0 ft upstream and the entrance 297.7 ft downstream from current locations. The ladder would initially provide about 13 ft of rise, starting at elevation 3805.7, and future access for passage to elevation 3795.7. If the lower 10 ft of the fishway height is needed in the future due to declining lake levels, the existing downstream fishway channel would have to be excavated to access the lake.

Entrance Ladder (existing upstream station = 157+27)

Options for future construction of the entrance ladder - If the lake level declines below the invert of Ladder no. 1, the entrance ladder would have to be replaced for the fishway to function. The concept presented herein is based on the assumption the entrance ladder would be designed to provide fishway access for lake elevations similar to the existing ladder. The invert of the ladder would be set at elevation 3774.5. The exit elevation would depend on the toe elevation chosen for ladder no. 1. Assuming ladder no. 1- option 1A, the entrance ladder would be 26 ft high and 830.3 ft long. The ladder entrance would be at station 160+81.00 and the exit at station 152+50.70, see Figure 13. Assuming ladder no. 1, option 1B, the entrance ladder would be 21 ft high and 675.2 ft long. The ladder entrance would be at station 160+81.00 and the exit at station 154+05.80. Approximately 1,552 ft of fishway channel would be reconstructed between ladder no.1 and the entrance ladder.



NOTES

Location of ladder #3 is set between the upstream P.T. Sta. and the downstream P.C. Sta. This prevents the ladder from extending into the upstream curve.

ALWAYS THINK SAFETY

UNITED STATES
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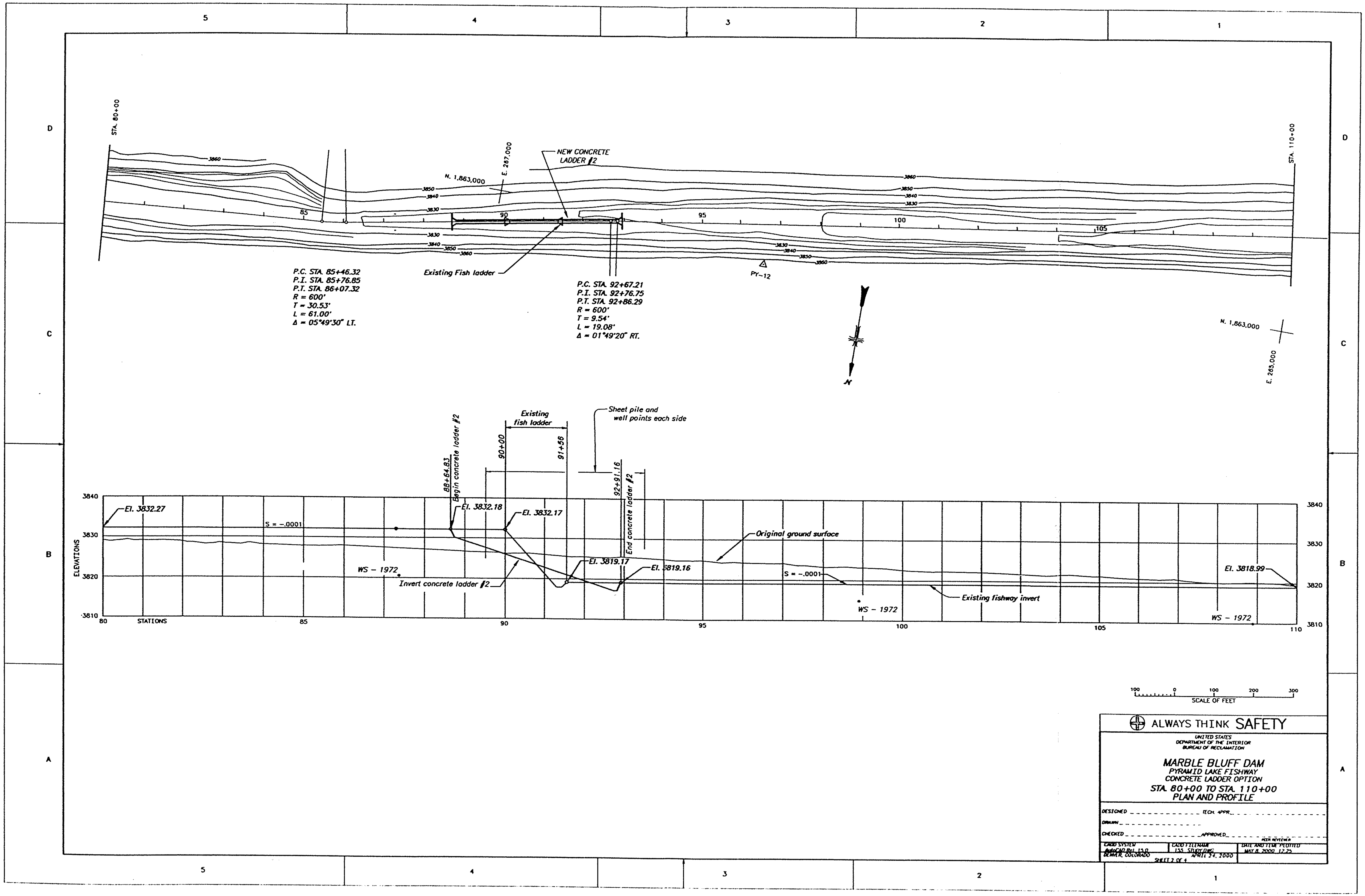
BUREAU OF RECLAMATION

MARBLE BLUFF DAM
PYRAMID LAKE FISHWAY
CONCRETE LADDER OPTION
STA. 20+00 TO STA. 50+00
PLAN AND PROFILE

DESIGNED ______ TECH. APPR. ______
DRAWN ______
CHECKED ______ APPROVED ______

CADD SYSTEM AutoCAD R14. 15.0 | CADD FILENAME 153 STUDY.DWG | DATE AND TIME PLOTTED MAY 5, 2000 12:21
DENVER, COLORADO APRIL 20, 2000
SHEET 1 OF 4

Figure 10, pg. 18



ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

MARBLE BLUFF DAM
PYRAMID LAKE FISHWAY
CONCRETE LADDER OPTION
STA. 80+00 TO STA. 110+00
PLAN AND PROFILE

DESIGNED ______ TECH. APPR. ______
DRAWN ______
CHECKED ______ APPROVED ______

SHEET 2 OF 4

Figure 11, pg. 19

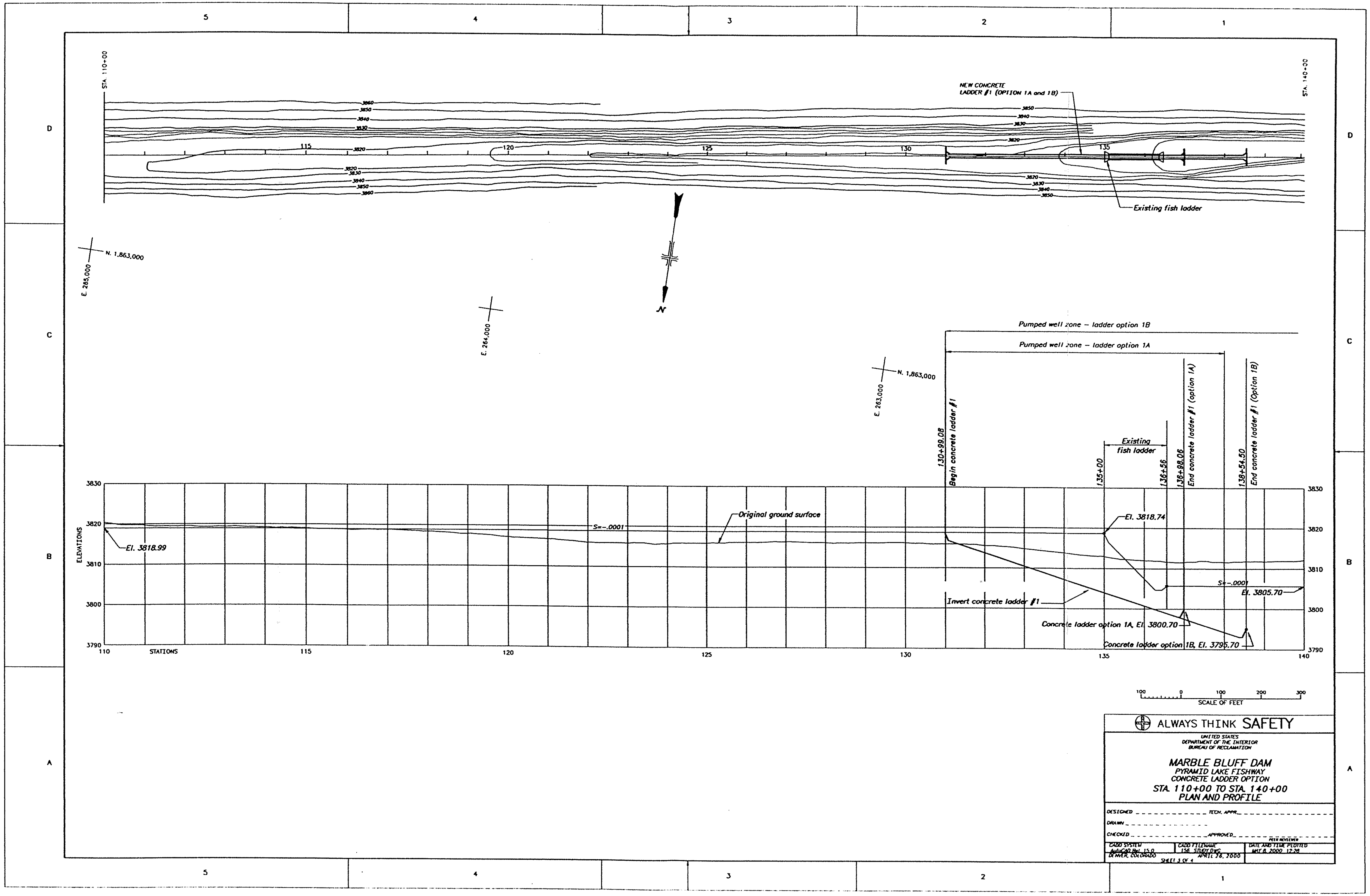


Figure 12, pg. 20

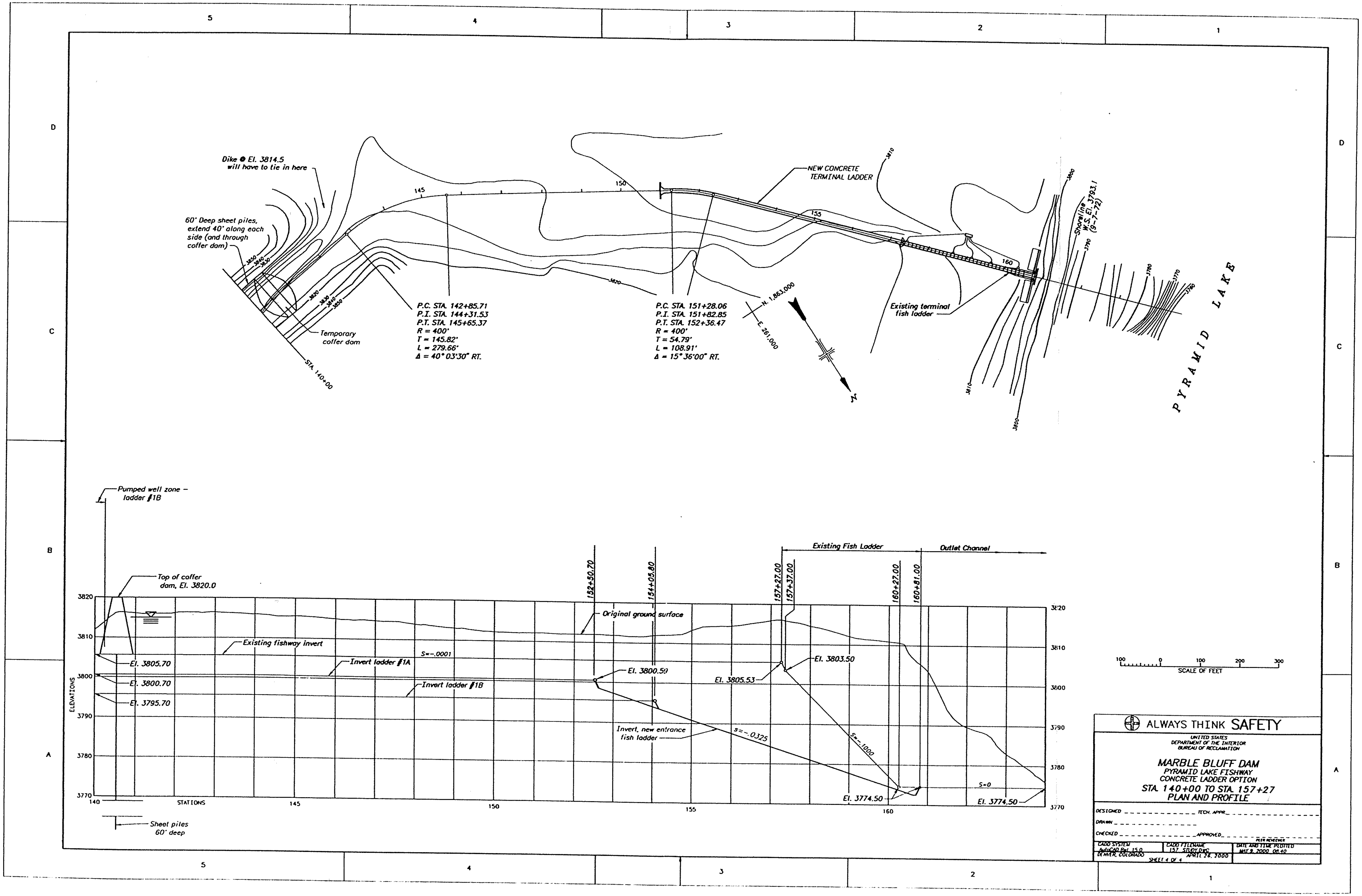


Figure 13, pg. 21

Fishway Ladder Alternative 2 - Rock Channel Fish Ladder Design

Rock fishways are low gradient channels constructed of large rock. A high boundary roughness derived from riprap is combined with features of channel topography and rock weirs or large isolated roughnesses (usually rock boulders)to create flow conditions suitable for fish passage. Rock fishways can be designed as side channels that pass around dams or as an in-stream attribute of a small dam. Rock channel fishways (also called natural bypasses or rock ramps) have been used for many years in Europe and Canada for passing fish at small dams. Recently, Reclamation has constructed several rock channel type fishways for passing non-salmonids. A summary of several designs follows.

<u>Pyramid Lake Fishway, Experimental Bypass Channel</u> - In 1996 FWS and the Nature Conservancy of Northern Nevada constructed a meandering test channel that bypassed the terminal fish ladder, [26]. The meandering channel was constructed to determine if a natural style riffle and pool fishway design could be used to replace the fishway ladders. The test channel was designed to test two different channel slopes. Approximately one-half of the channel length was constructed with an average channel slope of 0.0058 and the other one-half at slope of 0.0096. The channel contained a series of alternating riffle and pool sections. Pools were nearly horizontal and the riffles within the two test sections had slopes of 0.014 and 0.016, respectively. Flow in the pools was 2 to 3 ft deep and about 1 ft deep in the riffle sections. During the testing cui-ui moved steadily up the meandering fishway. Some holding and crowding of fish was observed at the downstream toe of each riffle. The tests proved cui-ui could move through riffles with 4 ft/s mean velocity for distances of at least 30 ft. The tests also demonstrated the importance of flow depth. The relatively shallow flow at the riffle pool interface where fish were holding for short periods subjected the cui-ui to heavy predation by pelicans.

<u>Grand Valley Irrigation Fish Pass</u> - In 1997, Reclamation constructed an in-stream rock channel fishpass on the Grand Valley Irrigation Dam located on the Colorado River near Grand Junction, Colorado, Figure 14. The fishway provides passage over a 5 ft high run-of-river dam for many native and non-native fish found in the Colorado River. The riffle sections are designed for an average velocity of 4 ft/s at a minimum flow and depth of 50 ft^3/s and 1.5 ft, respectively. The design gradients for the fishpass are: riffle slope = 1.3 percent; thalweg slope = 0.7 percent; and channel slope = 0.9 percent. The thalweg slope differs from the channel slope by the sinuosity of the channel. The channel is constructed of riprap laid on a filter fabric. During construction, voids in the riprap were filled with finer material to minimize interstitial flow. The sinuous pattern (meandering channel form) is used to maintain flow depths during low flows. As flow and depth increase the effect of the channel sinuosity on the flow decreases. After three years of operation under a wide range of river flows the riprap fishway channel has remained stable and has blended into the river environment.

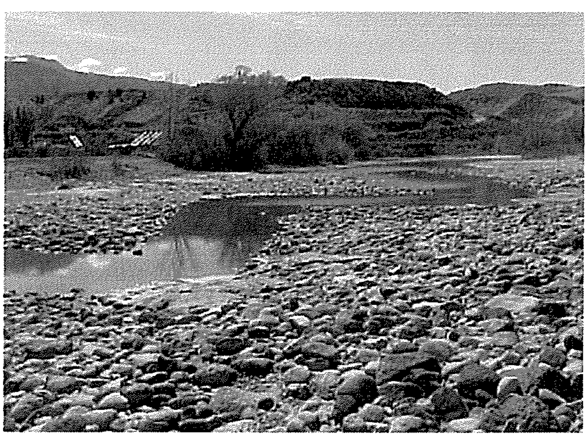


Figure 14 - View of Grand Valley Irrigation Dam rock fishway at low river flow.

Marble Bluff Gradient Restoration Structure - In 1998, the river bed elevation below Marble Bluff Dam was raised about 2 ft and stabilized using a rock ramp design, Figure 15. The structure was designed to prevent further channel degradation downstream of the dam and raise the minimum water surface elevation to provide access for fish to the fish lock entrance channel. The structure was designed based on a 4 ft/s average velocity to ensure fish passage for cui-ui and LCT. Large boulders were added on the north half of the channel to provide additional variability in the flow field. The structure performed well in 1999. An estimated 600,000 cui-ui passed over the structure during the spawning run in 1999 with no apparent delay.

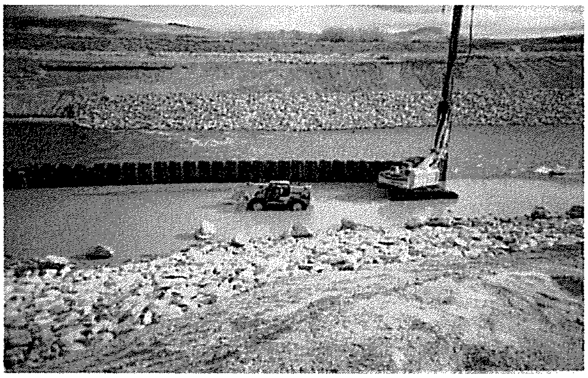


Figure 15 - Construction view of Marble Bluff Dam rock gradient restoration structure and large boulder field.

Huntley Dam Fishway - In 1999, Reclamation assisted in the design of a roughened channel fishway for Huntley Dam located on the Yellowstone River downstream of Billings, Montana. The fishway is designed to pass salmonids and many warm water fish species. The fishway, Figure 16, is a riprapped trapezoidal channel on a 1.8 percent grade with boulder arrays spaced every 20 ft. The fishway was constructed in the fall of 1999 and is undergoing a two year evaluation program.

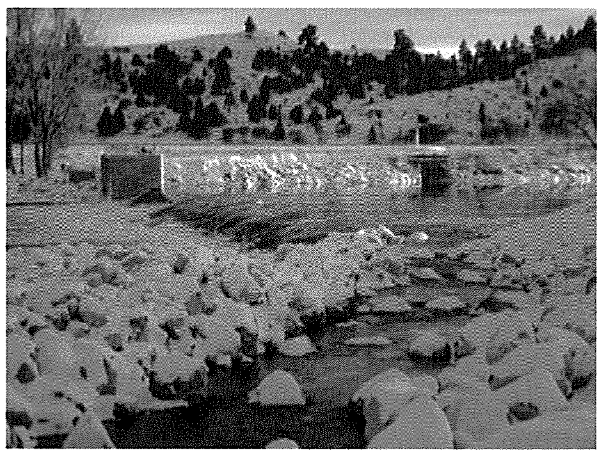


Figure 16 - Huntley Dam rock fishway.

Proposed Rock Fishway Design

A rock channel fishway design similar in concept to the Huntley Dam fishway is proposed. A rock fishway ladder design with a ladder slope of 1.2 percent (0.012) combined with boulder array drop structures spaced every 28 ft was chosen for the fishway, Figure 17. The boulder arrays are designed to pool water to a depth of about 3.5 to 4 ft with an average drop in water surface of about 0.33 ft across each array. The boulder weir drops are designed to produce an average passage velocity of about 4 ft/s. The ladders are designed to convey the full 50 ft^3/s fishway design flow. The rock fishway ladders would be constructed by over excavating the channel 1.5 ft, laying down a geotextile fabric and then riprapping with 1 ft minus material. Voids in the riprap are filled by spreading road base material over the riprap. Three boulders are used for each drop structure. The boulders are shown positioned on a 60 degree angle to the channel centerline with roughly 1 ft of clear space between them. The large center boulders are about 4 ft to 5 ft in diameter and sit on top of the riprap bedding. The boulders to each side of center are about 3.5 ft in diameter. These boulders are set a minimum of 1 ft below grade for stability. As rock boulders are different shapes, flow conditions will vary through each drop structure. Some tuning of the individual boulder arrays after initial operation is expected. The design is based on passing about 20 ft^3/s between the center boulder and each side boulder (total of 40 ft^3/s). The remaining flow will pass to the outside of the side boulders.

Rock Fishway Ladder Layout

(presented in direction of fishway stationing from upstream to downstream)

Ladder No. 3 (existing upstream station = 45+50)

Ladder no. 3 would be removed and replaced by a 1,091 ft long rock fish ladder set at a 1.2 percent slope (0.012), see Figures 18 and 19. The ladder exit would move 467.6 ft upstream and the entrance 467.6 ft downstream from current locations. The ladder location was selected to approximately balance cut and fill quantities. The upper half of the ladder would be constructed on cut excavation and the lower one-half constructed on compacted backfill. The ladder would provide about 13 ft of rise, starting at entrance elevation 3832.55 and exiting at elevation 3845.65. Construction of the ladder would require an estimated 5,195 yds^3 of excavation, 2,070 yds^3 of compacted backfill and 1,985 yds^3 of riprap. About 3,125 yds^3 of waste excavation would be stock piled for cofferdamming. Approximately 3,355 ft of fishway channel would connect the exit ladder and ladder no. 3.

Ladder No. 2 (existing downstream station = 90+00)

Ladder no. 2 would be removed and replaced by a 1,091 ft long rock fish ladder set at a 1.2 percent slope (0.012), see Figure 20. The ladder exit would move 467.6 ft upstream and the entrance 467.6 ft downstream from current locations. The ladder location was selected to approximately balance cut and fill quantities. The upper half of the ladder would be constructed on cut excavation and the lower one-half constructed on compacted backfill. The ladder would provide about 13 ft of rise, starting at entrance elevation 3819.12 and exiting at elevation 3832.22. Construction of the ladder would require an estimated 3,335 yds^3 of excavation, 1,800 yds^3 of compacted backfill and 1,985 yds^3 of riprap. About 1,535 yds^3 of waste excavation would be stock piled for cofferdamming. Approximately 3,359 ft of fishway channel would connect ladder no. 3 and ladder no. 2.

Ladder No. 1 (existing downstream station = 135+00)

Option 1A (entrance elevation 3800) - Ladder no. 1 would be removed and replaced by a 1,573.5 ft long, 18.7 ft high, rock ladder set at a 1.2 percent slope (0.012), see Figure 21 (option 1A). The ladder entrance is shown 5.7 ft below the existing elevation to provide future fish passage access to about lake elevation 3800. To reduce site unwatering requirements during construction the ladder entrance is located at the existing ladder station. As constructed, the ladder would provide fish passage access for lake elevations from 3805.7 to about 3819.9. If the lower 5 ft of the fishway height is needed in the future due to declining lake levels, the existing downstream fishway channel would have to be excavated to access the lake. Therefore, this option would provide passage for lake elevations above about 3800 with future excavation of the downstream fishway channel as needed for lake access. Construction of the ladder would require an estimated 25,595 yds^3 of material be excavated and hauled to a waste site and placement of about 2,775 yds^3 of riprap. Approximately 2,459 ft of fishway channel would connect ladder no. 2 and ladder no. 1.

Option 1B (entrance elevation 3795) - Ladder no. 1 would be removed and replaced by a 1,993.6 ft long, 23.7 ft high, rock ladder set at a 1.2 percent slope (0.012), see Figure 21 (option 1B). The ladder entrance is set 10.7 ft below the existing ladder elevation to provide future fish passage access to about lake elevation 3795. To reduce site unwatering requirements during construction the ladder entrance is located at the existing ladder station. As constructed, the ladder would provide fish passage access for lake elevations from 3805.7 to about 3819.9. If the lower 10 ft of the fishway height is needed in the future due to declining lake levels, the existing downstream fishway channel would have to be excavated to access the lake. Therefore, this option would provides passage for lake elevations above about 3795 with future excavation of the downstream fishway channel as needed for lake access. Construction of the ladder would require an estimated 46,690 yds^3 of material be excavated and hauled to a waste site and placement of about 3,460 yds^3 of riprap. Approximately 2,039 ft of fishway channel would connect ladder no. 2 and ladder no. 1.

Entrance Ladder (existing upstream station = 157+27)

Options for future construction of the entrance ladder - If future lake levels decline below the invert of ladder no.1, the entrance ladder would have to be replaced for the fishway to function. The concept presented herein is based on the assumption the entrance ladder would be designed to provide fishway access for lake elevations similar to the existing ladder. The fish ladder entrance would be set at elevation 3774.5, see Figure 22. The exit elevation would depend on the toe elevation chosen for ladder no. 1. Assuming ladder no. 1- option 1A, the entrance ladder would be about 26 ft high and 2,123 ft long. The ladder entrance would be at station 160+27 and the exit at station 139+04. If ladder no.1- option 1A was constructed upstream, construction of the entrance ladder would require an estimated 64,990 yds^3 of material be excavated and hauled to a waste site and 3,670 yds^3 of riprap placed. Construction of 248 ft of fishway channel between the entrance ladder and ladder no. 1 would be required with an estimated 7,910 yds^3 of material be excavated and hauled to a waste site.

Assuming ladder no. 1, option 1B, the entrance ladder would be about 21 ft high and 1,703 ft long. The ladder entrance would be at station 160+27 and the exit at station 143+24.24. Construction of the ladder would require an estimated 52,125 yds^3 of material be excavated and hauled to a waste site and placement of 2,775 yds^3 of riprap. Construction of 668 ft of channel between the entrance ladder and ladder no. 1 would be required with an estimated 31,160 yds^3 of material be excavated and hauled to a waste site.

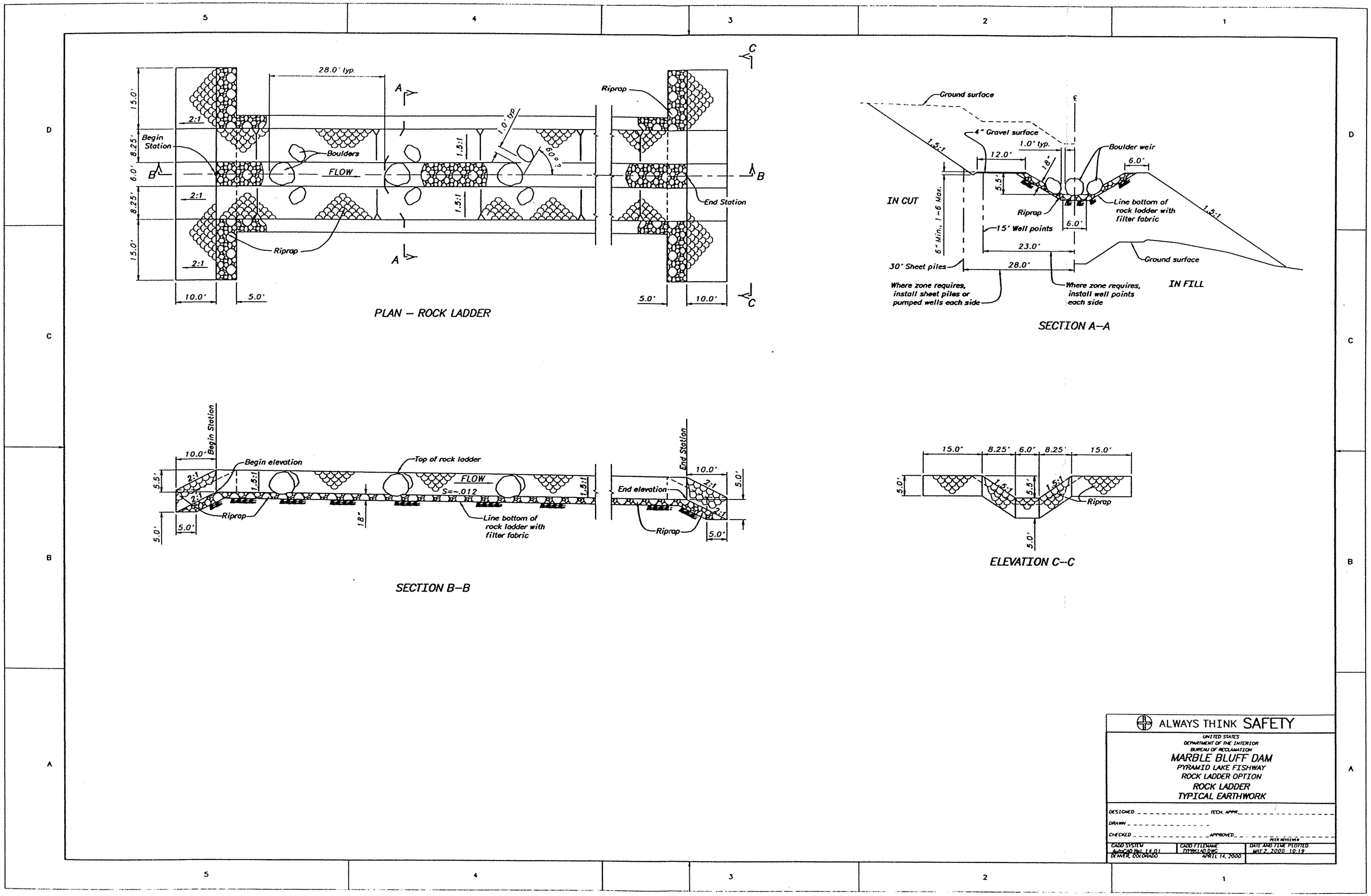


Figure 17, pg. 26

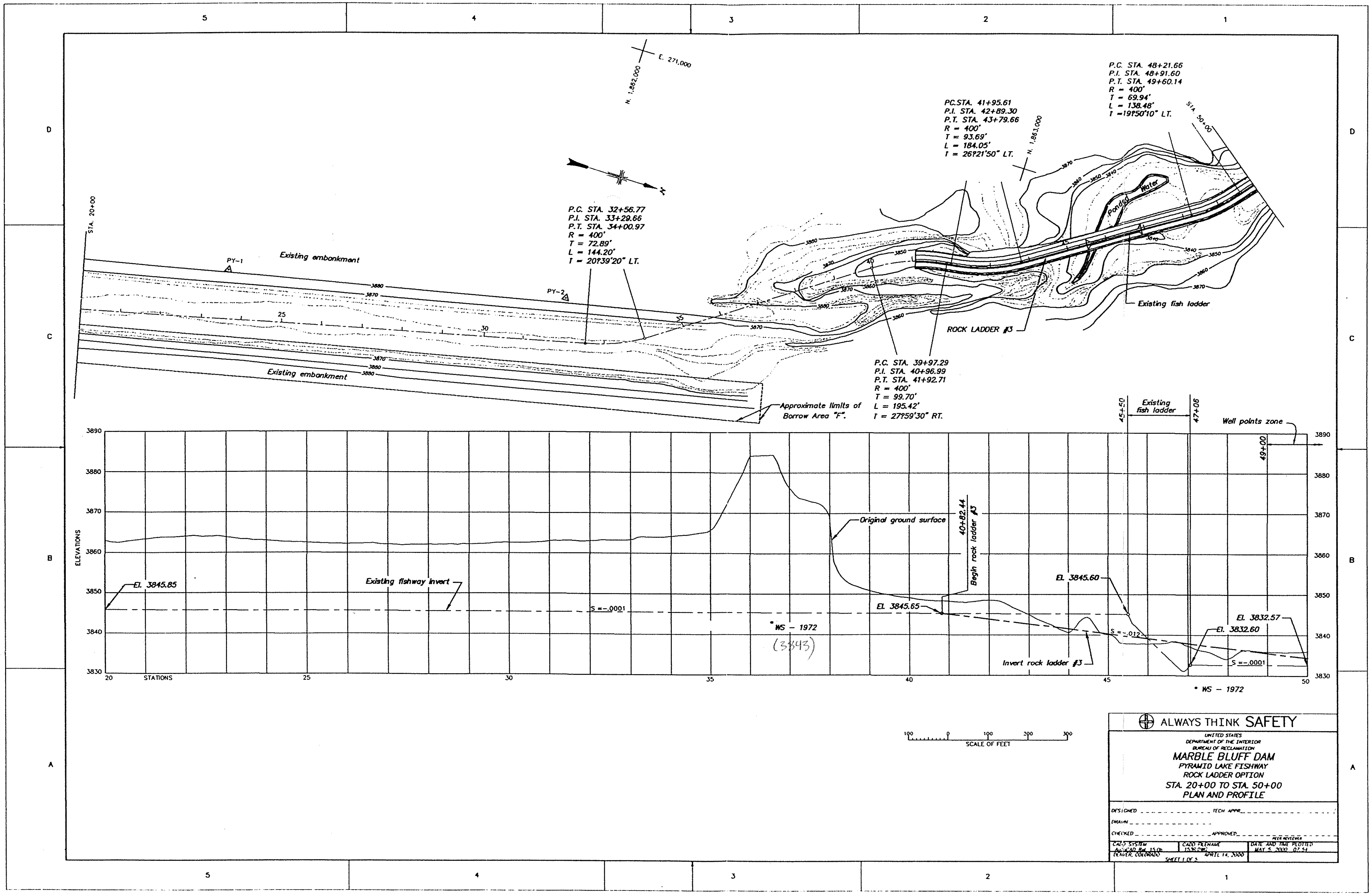


Figure 18, pg. 27

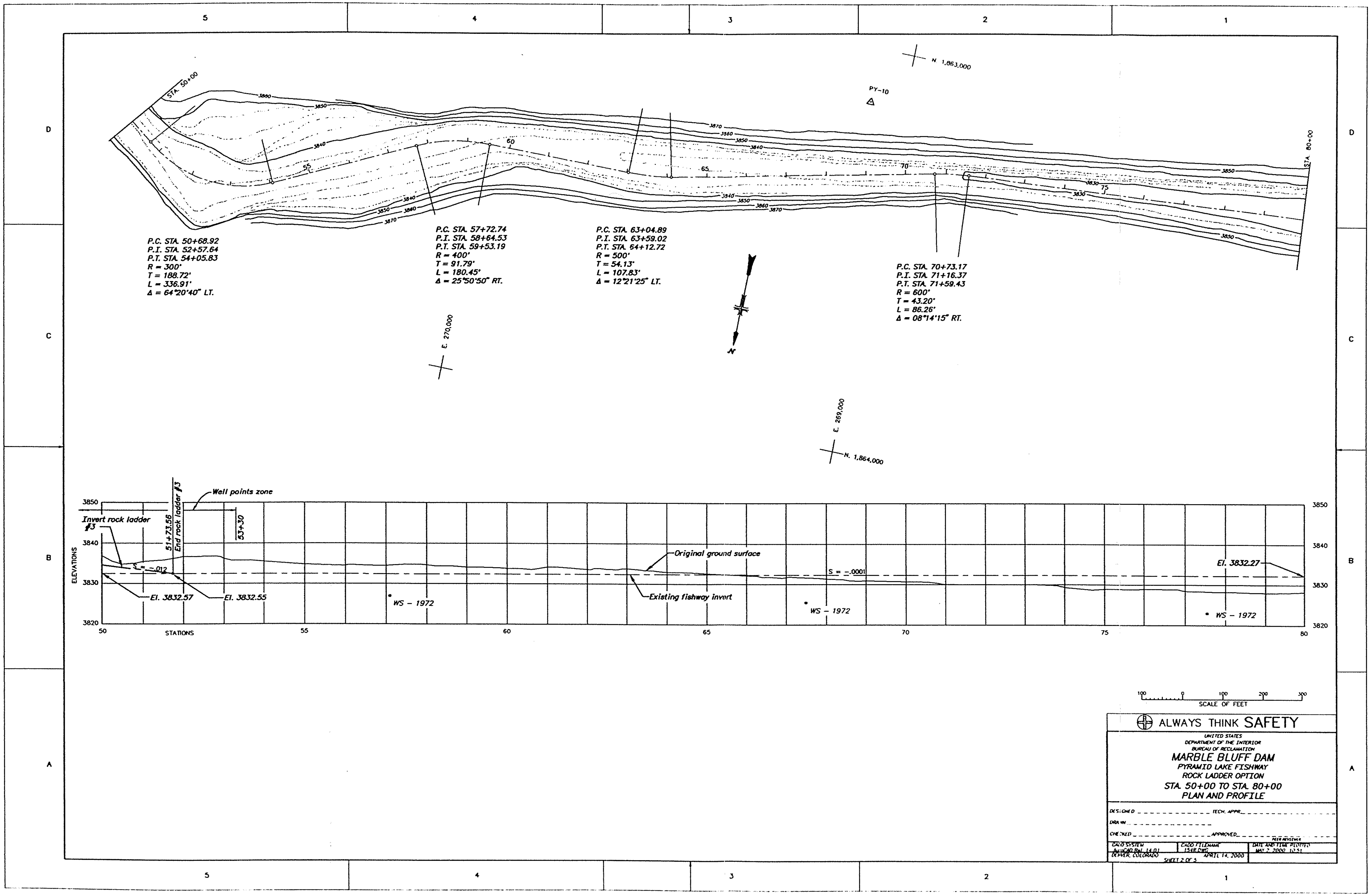


Figure 19, pg. 28

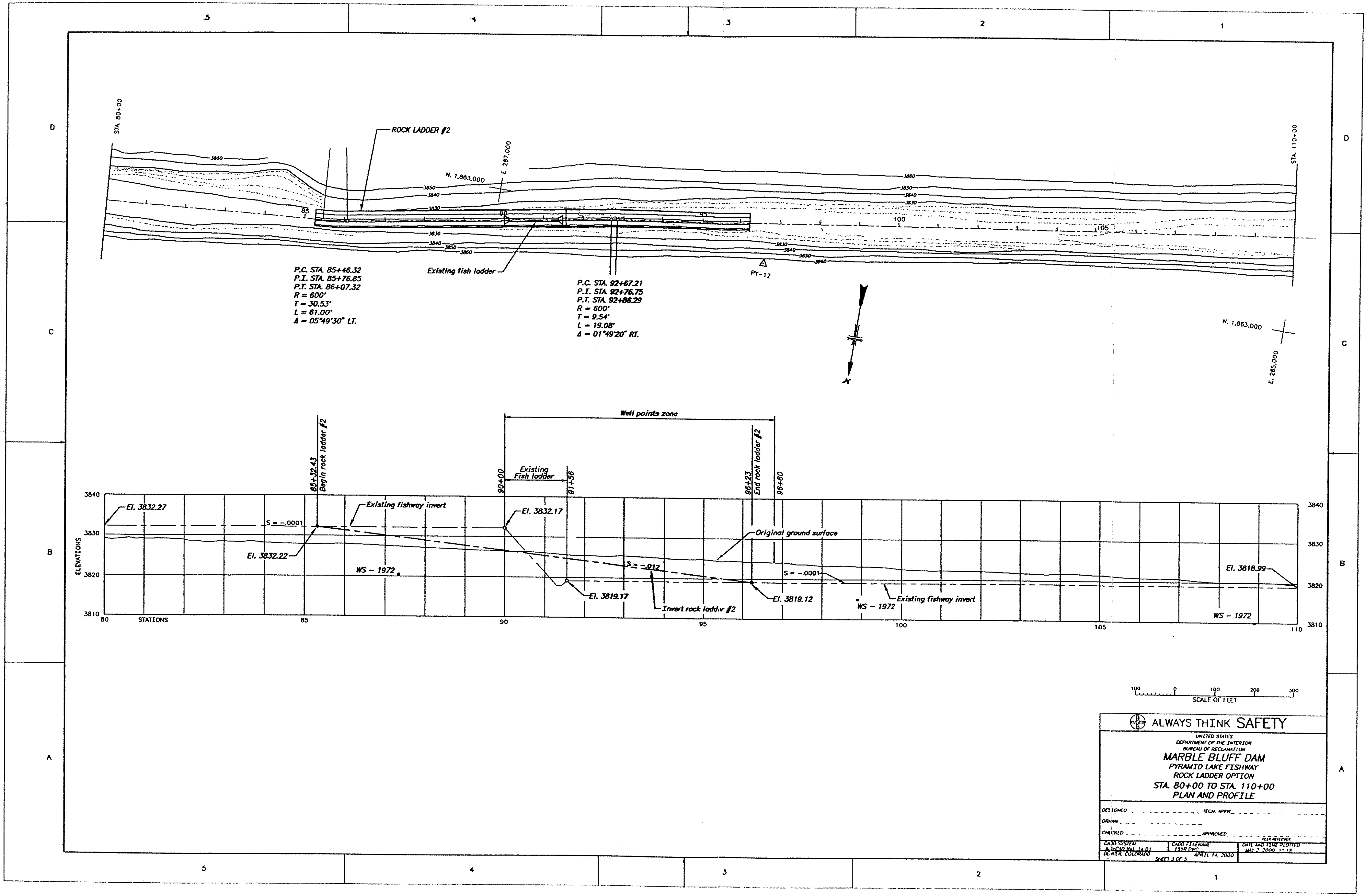


Figure 20, pg. 29

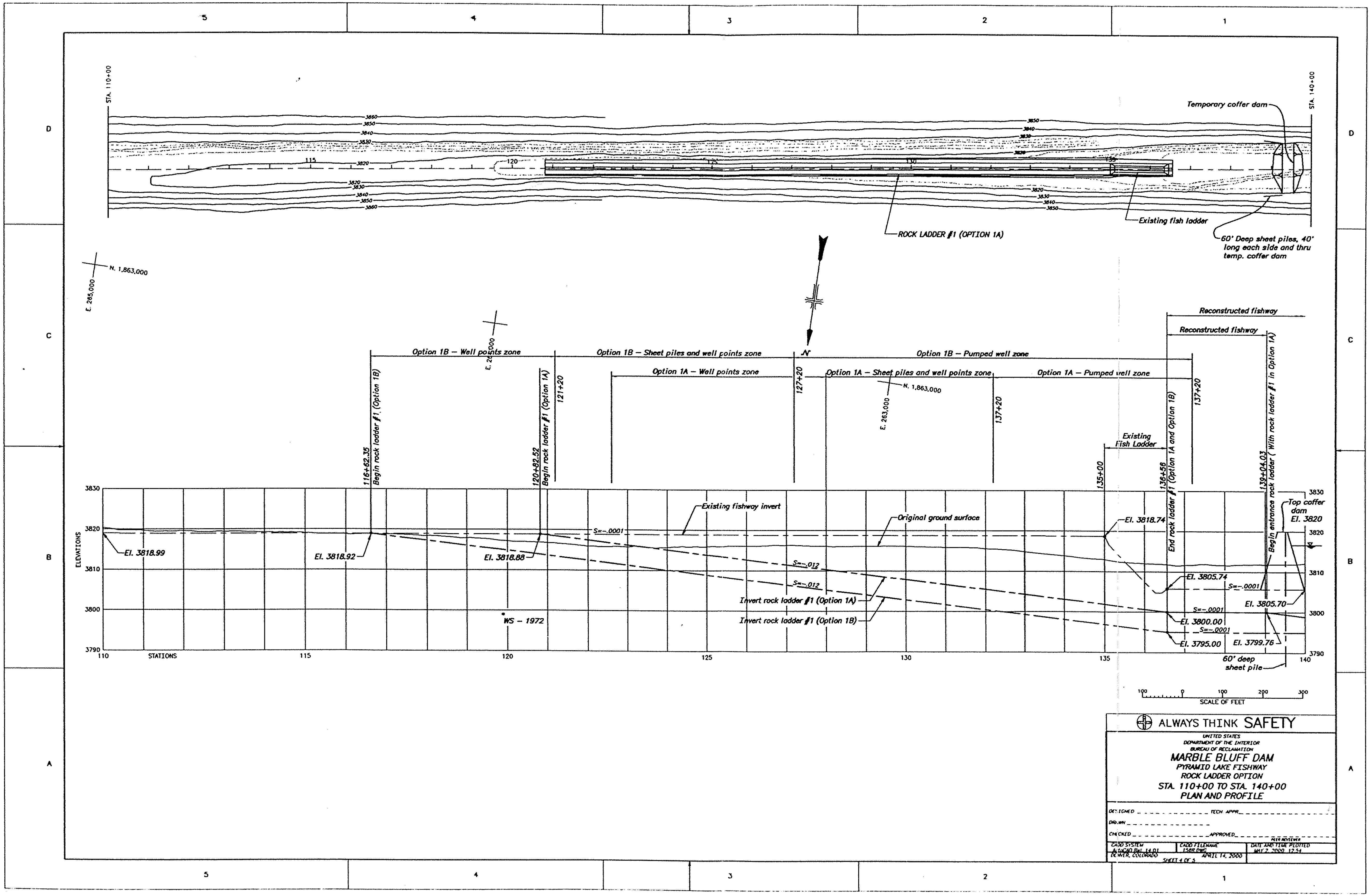


Figure 21, pg. 30

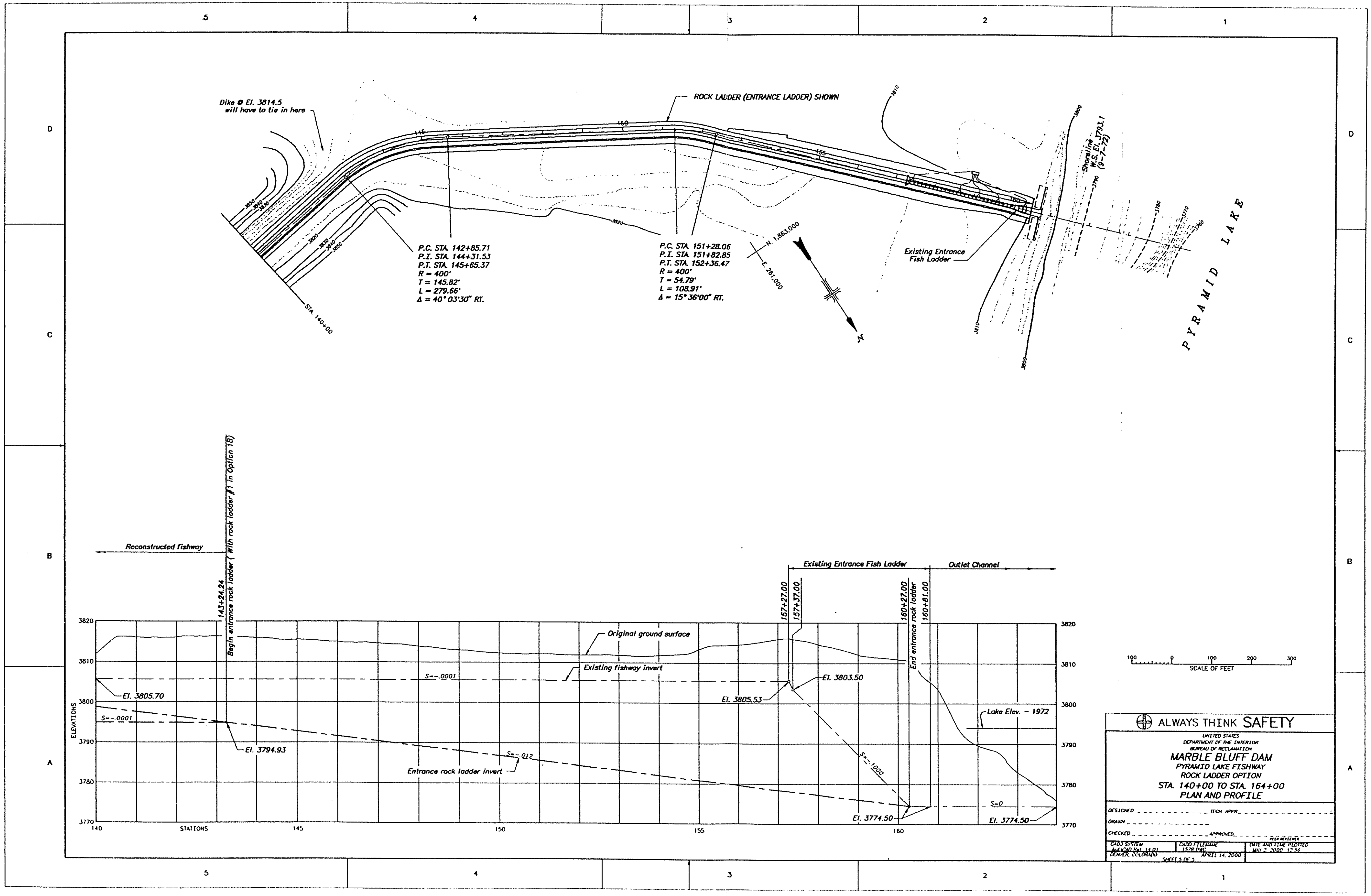


Figure 22, pg. 31

Fishway Channel

The fishway channel is the conveyance channel between fish ladders. The ravine the fishway channel lies within was formed largely by erosion following the construction of a diversion dam and pilot diversion channel in 1941 by the Bureau of Indian Affairs (BIA). The fishway project then included an earth dam and spillway located at the toe of Marble Bluff. A 200-foot-wide by 18-foot-deep channel from the river to Marble Bluff was constructed with compacted earth embankments. Downstream from Marble Bluff a pilot channel was excavated and allowed to widen and deepen by erosion from diversion flows. In 1950, the BIA Diversion Dam failed. By the time the existing fishway was constructed in 1970's, the downstream portion of the diversion channel had eroded to roughly 250 feet wide and up to 40 feet deep with bottom widths ranging from 70 to 150 feet [15].

In 1975 Reclamation constructed a trapezoidal shape fishway channel with a bottom width of 6 ft, 1.5 to 1 side slopes and a bed slope of 0.0001 ft/ft, see reference drawing no. 949-D-161 in Appendix A. The channel was designed to provide a flow velocity of 1 ft/s for a discharge of 50 ft^3/s. Approximately 80 percent of the new fishway was constructed within the diversion channel of the 1941-42 BIA diversion project.

Construction and operation history - Geologic investigations for the Pyramid Lake Fishway channel included 7 bucket auger holes, 13 backhole test pits, and 4 drill holes located along the fishway. Gradation tests were performed on material from test pits TP-1 through TP-13, from Borrow Area, D, and from depths of about 32 to 83 feet in drill hole DH-19, located near the terminal fish ladder, see reference drawing no. 949-D-278 in Appendix A. Generally, most of the materials encountered along the fishway were poorly graded to silty sand with some beds of well graded sand and lesser amounts of silt to sandy silt. The sands and gravels were described as being loose [15]. The erodible nature and high permeability of the natural soil was recognized. One pump out test to determine in-place permeability was performed at the terminal ladder. The permeability was estimated to be 139,000 ft/yr. Therefore, a protective lining for the fishway was designed and constructed consisting of compacted clay having a 1.5-foot thick invert and sides 4-feet-wide horizontally. Based on the construction specifications [16], the compacted impervious earth lining was obtained from Borrow Areas A and F.

During a two-week trial operation of the fishway in October 1975, the lower two reaches eroded with undercutting as much as 8 inches. This was more than normal and after the lining was tested, it was realized that the clay lining was dispersive. Dispersive clays are unusual in that they will erode in slow-moving water. By March 1976, the erosion had increased to 1-1/2 feet laterally. Quarry rock and fines were placed at the waterline by a Reclamation maintenance crew. Rock protection for the remainder of the fishway was placed by November 1976 for slightly over $105,000 (in 1976 dollars) [3].

The channel lining has also been compromised by a periodic cleaning out of fine wind-blown sediments that accumulate in the channel throughout the year. The 1974 geologic report on construction of Pyramid Fishway describes the wind blown sand problem as follows:

The Pyramid Lake area is subject to almost daily blowing from the southwesterly direction and the existing diversion channel contains numerous sand dunes throughout its entire length, particularly along the left side of the channel. These deposits reach a maximum height of about 10 feet between Stations 120 and 135. In some areas, the dunes extend across the entire width of the existing diversion channel.

Since construction several types of excavation equipment, including bobcat type loaders, backhoes and drag lines have been used to clean the channel. These cleaning methods have resulted in the channel being reshaped from the original design. Data defining current channel flow capacity, rate of water percolation or the cross-sectional area is not available downstream of the exit ladder. The present condition of the channel does provide flow conditions suitable for cui-ui passage, however the flow capacity and depth may be less than the original design.

Two channel design options were investigated to address the problems of soil infiltration and removing wind blown sediment deposits. These were: reconstruct the channel to its original geometry by over excavating the channel and installing a 3 ft thick, lime treated clay lining that would support removal of wind blown sediments using small loaders; and, redesigning the channel geometry to create flow conditions that would flush wind blown sediments down the fishway and installing a 1.5 ft thick lime treated clay lining.

Channel Lining

Original fishway channel lining - Material from three borrow areas was tested in Reclamation's Denver laboratory for use as lining for the fishway channel [14]. After the material was compacted at different densities and several chemical sealant treatments applied, the permeability of the samples was tested. Also, gradation, Atterberg limits, and Proctor compaction tests were performed. The samples from Borrow Area A and from the bank of the old existing fishway were considered to be satisfactory lining material based on the permeability tests and were classified respectively as clayey silt (ML-CL) and lean clay (CL). The testing report [14] mentions that soil-cement and concrete were considered as lining materials, but insufficient aggregates were available. Uplift and cracking of thin hard linings is also a concern at the site due to the high groundwater conditions.

Dispersive clays - The Final Construction Report [18] states that during a two-week trial operation of the fishway during October 1975, the lower two reaches eroded with undercutting as much as 8 inches. Because of this unusual erosion, two samples of the clay lining, classified as a lean clay, were tested (chemical analysis, physical erosion, and soil dispersion tests) and found to have a limited degree of dispersiveness [17].

Later, eight samples of material from the fishway lining and Marble Bluff embankment were tested using the Modified Emerson "Crumb" test, Soil Conservation Service Dispersion test, Pin Hole Test, and the Chemical Analysis of Soil Pore Fluid [20]. The embankment clay was found to be dispersive except for one sample. The samples from the lining were given a dispersive rating of "intermediate" and "dispersive."

On May 18, 1977, two engineers from the Denver office inspected the soils in the vicinity of the fishway and the dam and noted that soil along the bluffs by the fishway had the appearance of dispersive clays. They noticed deep, narrow erosion patterns; a continuous channel going from a vertical hole to a horizontal hole; and jug-shaped caverns [19]. Based on this site inspection, it appears likely that dispersive soils are found throughout the area.

Recommended method for lining the fishway channel - Dispersive clay soils will erode in slow-moving or even quiet water as individual colloidal clay particles go into suspension and then are carried away by the flowing water [21]. Dispersive clays can be made nondispersive by adding a small percentage of hydrated lime (about 2 to 4 percent by dry mass of soil) to the clay. The following general procedures have been used by Reclamation for soil-lime construction [21].

a. Handling and Mixing - Soil to be lime treated is pulverized in a high speed rotary mixer or with a disk harrow prior to applying lime, and the moisture content is brought to within 2 percent of optimum. Lime is uniformly spread on the pulverized soil to the specified percent lime by dry mass of soil. Lime is mixed with the soil using a rotary mixer and additional water is added as necessary to again bring the mixture to within 2 percent of optimum. When mixing is completed, the soil-lime moisture is cured for at least 96 hours before placing and compacting. Exposed surfaces of the mixture are either lightly rolled to prevent moisture loss or the mixed material is stockpiled and the surface sealed.

b. Placing - Each section of the foundation is carefully prepared coincident with final mixing and pulverization of the lime-treated material. The soil-lime is mixed until 100 percent passes the 1 inch (25 mm) sieve and 60 percent passes the No. 4 (4.75-mm) sieve. Immediately after final mixing, the lime-treated earthfill is placed and compacted in horizontal lifts of no more than 6 inches after compaction. The material is compacted to no less than 95-percent laboratory maximum dry density, using a tamping roller followed by a pneumatic-tire roller. The top of each compacted lift is scarified or disked before the next lift. The exposed surface of the lime-treated earthfill is compacted with a pneumatic-tire roller to seal the surface, and it is sprinkled with water for 7 days.

It is assumed that nearby borrow areas of clay that could be used for lining the fishway are dispersive. This assumption should be checked by testing potential borrow area material for dispersiveness. Based on available soils data, lime treated clay lining is proposed for the channel. The lining material would be native clays with 5 percent lime added; 4 percent to make the clay nondispersive and an extra 1 percent to account for losses, uneven distribution and incomplete mixing. Construction of a test section during final design is recommended to verify the mix design.

Hydraulic Flushing of Channel Sediments

This analysis was performed to identify the viability of flushing wind blown sediment deposits down the fishway using the 50 ft^3/s design flow. The analysis looked at changes in channel geometry and flow conditions required to move material into suspension and carry it downstream. Channel slope, flow velocity, flow depth and channel width were varied in the study. Flushing wind blown sediments through the channel was investigated using an incipient motion analysis assuming a hardened lime treated clay lining. The analysis methods used provide an estimate of sediment transport rates as a function of material and channel geometry.

Analysis methods are not available that directly assess the time variant nature of the problem of suspension of sediment deposited in the dry. The methods used apply to the problem given the assumption that localized sediment deposits are small compared to the channel cross-sectional area. This assumption is necessary as large sediment deposits may act as sediment dams that divert flow out of the channel prior to establishing flow within the channel.

Approach - A range of velocities and slopes were assumed for different bottom widths up to a maximum velocity of 2 ft/s for a discharge of 50 ft^3/s for a trapezoidal channel with different side slopes. A Manning's n of 0.025 was assumed for the channel based on the original design. Three different discharges were analyzed: 50 ft^3/s, 35 ft^3/s, and 25 ft^3/s. No actual particle size distribution curves were available for the fishway. Therefore, a particle size distribution of very fine to medium sand was assumed for the bed material size of the channel bottom and this gradation was assumed to be the same gradation as the fine, wind-blown sand that was found in the channel. This wind blown sand is similar to the aeolian sands described in the American Society of Civil Engineers Sedimentation Engineering Manual 54, [1] with a particle size D-50 of 0.1 mm.

A channel constructed with a lime treated clay liner was analyzed by looking at particle incipient motion based on the Shields diagram and a modified version of the Shields diagram created by Van Rijn [9]. The treated clay liner prevents erosion of the channel bed. Therefore, the particle transport analysis was conducted with different slope and depth combinations to determine if the particles move into suspension rather than moving as bed load.

Sediment Flushing Study Results

Sediment Transport Concentration - The Corps of Engineers SAM Model for hydraulic design of channels was used to estimate concentration and stable channel dimensions for a sand size material gradation. The range of hydraulic variables used in the analysis are summarized in Table 2. The original design slope of 0.0001 ft/ft and velocity of 1 ft/s were compared with channel slopes of 0.0002, 0.00041 and 0.0005. Four different sediment transport equations were used in the analysis to obtain sediment concentration: Yang, Laursen-Madden, Ackers-White and Engelund and Hansen. Bed sediment size data and estimated sediment transport concentrations for the sand size bed material are summarized in Table 3. The four transport equations produced a wide range of concentrations for the different slopes and flow velocities. Therefore, the concentration values were averaged. The analysis predicts sediment transport concentration would increase by a factor of about 9 by increasing channel slope to 0.0002. Further increasing the channel slope to 0.0005 increases the sediment transport concentration by factor of about 80.

Suspension of Sediment - The shear stress was analyzed for slopes of 0.0001, 0.0002, 0.00041, and 0.0005 for a discharge of 50 ft^3/s and a depth of approximately 4 ft. The shear stress, Boundary Reynolds Number, and dimensionless particle size are summarized in Table 4 for each slope. A comparison of the Boundary Reynolds Number and the dimensionless shear stress for each slope to the Shields diagram (Figure 23) shows all the slopes produce critical shear stress in the range of particle motion. Thus, this analysis method predicts the sand particles are in motion. Particle suspension can be predicted using a similar analysis developed by Van Rijn. Particle suspension is shown as a function of critical shear stress, Θ_{cr}, and a dimensionless particle parameter in Figure 24. This analysis predicts particle suspension for all channel slopes. However, the data presented by Van Rijn shows considerable variance between different investigators. Given the uncertainty of particle size of wind blown sediments near Pyramid Lake and the variability of the predictive model, a minimum Θ_{cr} value of 2.0 was used in the analysis. These results suggest hydraulic flushing of wind blown sediments could be achieved if: 1) the channel had a non-erodible lining, 2) the channel slope was increased to at least 0.00041 and 3) to maintain a flow depth > 3.5 ft, the channel bottom width reduced to about 1 ft, Table 2.

Table 2 - Hydraulic characteristics of the channel for different slopes

Channel characteristics for different channel sizes and slopes							
Discharge (cfs)	Bottom Width (ft)	Side Slope (v:h)	Depth (ft)	Slope (ft/ft)	Velocity (ft/s)	Top Width (ft)	Manning's n
50	6	1.5	4	0.0001	1	18	0.025
35	6	1.5	3.3	0.0001	0.95	15.9	0.025
25	6	1.5	2.8	0.0001	0.83	14.4	0.025
50	2	1.5	4.3	0.0002	1.4	14.9	0.025
35	2	1.5	3.7	0.0002	1.25	13.1	0.025
25	2	1.5	3.2	0.0002	1.15	11.6	0.025
50	2	1	4.1	0.0005	2	10.2	0.025
35	2	1	3.5	0.0005	1.83	9	0.025
25	2	1	3	0.0005	1.68	8	0.025
50	1	1.5	4	0.00041	2	13	0.025
35	1	1.5	3.5	0.00041	1.64	11.5	0.025
25	1	1.5	3	0.00041	1.5	10	0.025

Table 3 – Predicted Sediment Concentration for the sand size bed material gradation

D84(mm) = 0.321 D50(mm) = 0.103 D16(mm) = 0.011 Geom Std Dev – sand material particle size gradation

Sediment concentration (mg/l)

		S=0.0001			S=0.0002			S=0.00041			S =0.0005		
		Discharge (cfs)			Discharge(cfs)			Discharge(cfs)			Discharge(cfs)		
Sediment transport equation		25	35	50	25	35	50	25	35	50	25	35	50
Yang		8	10	12	104	77	83	410	480	600	650	700	850
Laursen-Madden		1	64	85	750	650	900	2670	3000	3640	3700	3900	4500
Ackers-White		4	5	10	300	221	265	965	1370	2083	1800	2400	3500
Engelund-Hansen		30	35	40	200	150	150	550	650	800	1000	800	700
	Sum	43	114	147	1354	1098	1398	4595	5500	7123	7150	781000	9550
	Average	10	23	30	270	220	280	1150	1375	1780	1790	1950	2400

Table 4 – Shields and Van Rijn Incipient Motion Analysis

Slope	Depth (ft)	Tau Shear Stress, (lb/ft^2)	Dimensionless Shear Stress, (Θ_{cr})	Radius, (ft)	Viscosity, nu (ft^2/s)	U* Shear Velocity (ft/s)	Particle diameter (ft)	Boundary Reynolds Number	D*, Particle Parameter
0.0001	4	0.025	0.74	2.61	1.41E-05	0.09	0.00032808	2.13	1.94
0.0002	4.1	0.051	1.51	1.84	1.41E-05	0.11	0.00032808	2.53	1.94
0.0004	4.3	0.110	3.26	1.59	1.41E-05	0.14	0.00032808	3.37	1.94
0.0005	4	0.125	3.69	1.52	1.41E-05	0.16	0.00032808	3.64	1.94

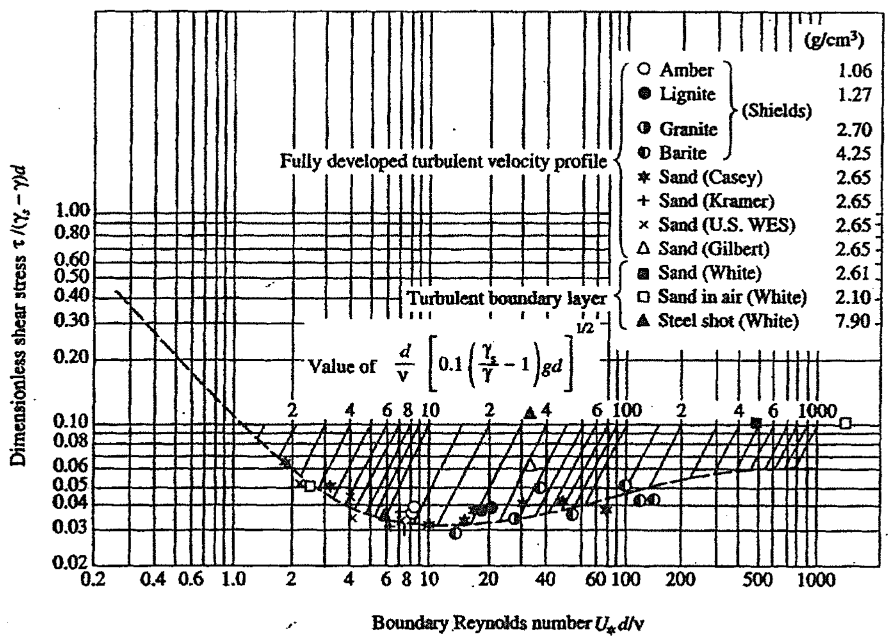


Figure 23 - Shields diagram of particle incipient motion.

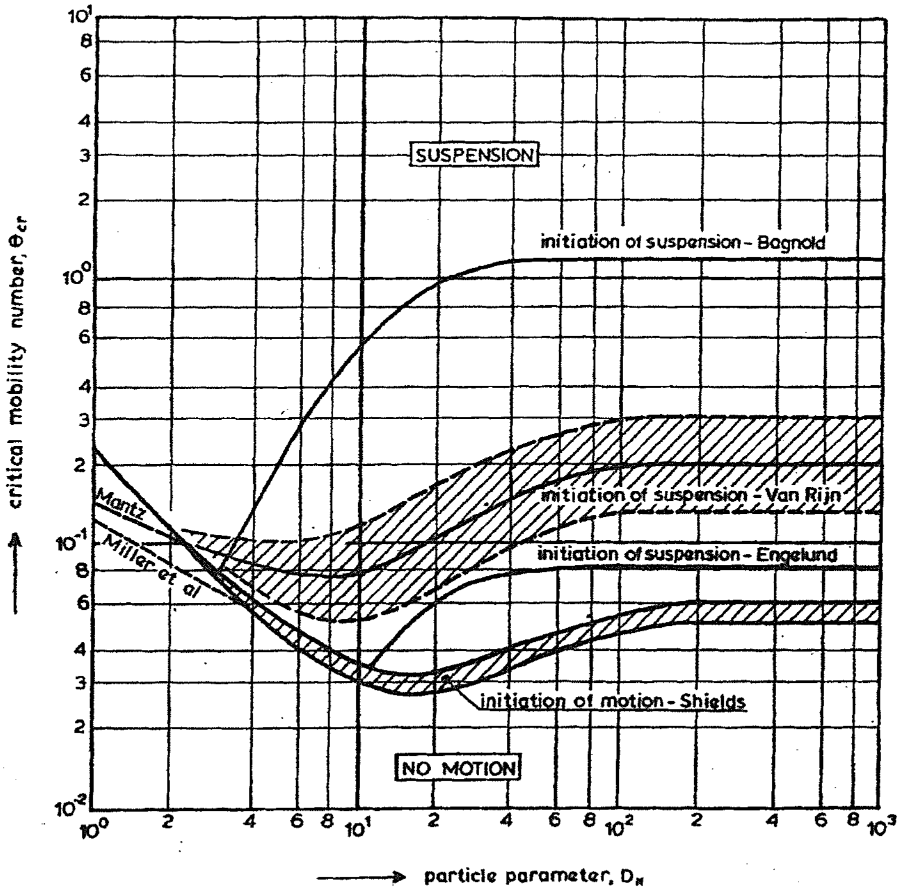


Figure 24 - Van Rijn incipient motion graph.

Channel Design

Improving hydraulic flushing of the channel is only possible if the cross section of the channel prism is significantly reduced. A smaller prism could restrict fish passage or possibly result in reduced dissolved oxygen levels within the fishway when large numbers of fish are present. The channel should be reconstructed to its original dimensions and lined with a lime-treated clay as shown in Figure 25. The thick lining will prevent seepage loss and provide a firm surface on which small bucket type loaders could be used to remove wind blown sands without destroying the lining. Backhoe or dragline removal of material from the fishway would not be acceptable.

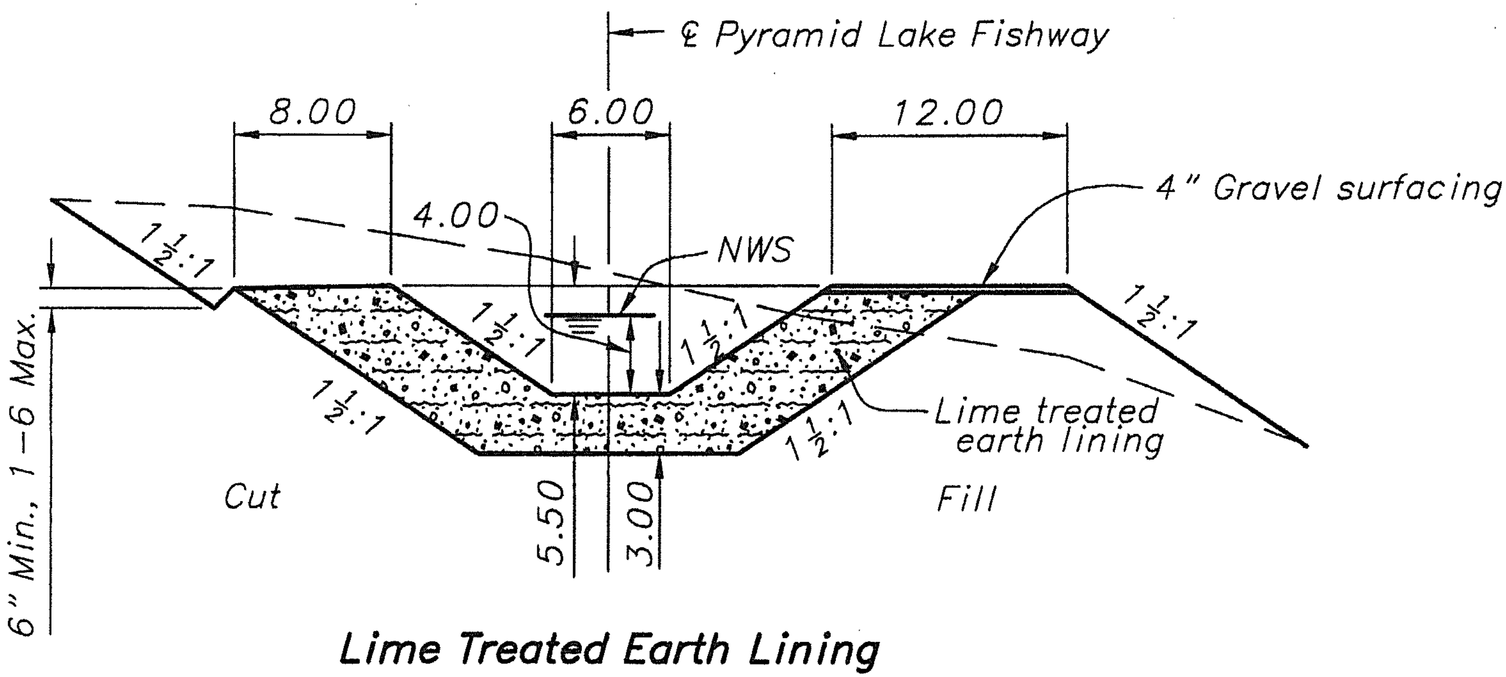


Figure 25 - Typical channel section for Pyramid Lake Fishway.

Geology and Geotechnical Data

Regional Geology [15] - The Marble Bluff site is in a northwesterly trending structural basin formed by faulting within the western portion of the Basin and Range Province as described by [7]. Mountains in the province consist of roughly parallel ranges alternating with basins or troughs. The ranges have been uplifted along faults relative to the adjacent valley areas. Pyramid Lake, in a valley between two of these ranges, is a remnant of old Lake Lahontan which at one time covered all the nearby areas and submerged many of the mountain slopes. Bedrock exposures consisting of limestone and extrusive and intrusive igneous rocks occur primarily in the mountains. There are lake deposits of varying character in the valley areas and on the slopes of mountains. Some alluvial fans, flood-plain and delta deposits occur along the Truckee River.

Pyramid Lake Fishway [13] - The fishway was largely constructed in an existing diversion channel of the earlier Marble Bluff Project which was constructed in 1942 by the Bureau of Indian Affairs. The materials encountered in the investigations along the fishway consist of sand, gravel and silt with minor quantities of clay, cobbles and boulders. Much of the fishway, particularly between Stations 45 and 135, was expected to be excavated in SP-SM, Poorly Graded Sand and Gravelly Sand. When visually classified, these materials appear to contain little or no fines but were found to contain about 10 percent fines when laboratory tested according to Earth Manual Procedure E-5. Microscopic examination and laboratory experiments conducted in the Mid-Pacific Geology Branch laboratory show that the fines occur as durable coatings and as aggregated sand-size masses which break down when vigorously mixed during standard laboratory testing procedures. Increased mixing time (up to 30 min) resulted in greater percentage of fines (up to 25 percent) with marked abrasion of the quartz grains. In the field, these materials have engineering and permeability characteristics of clean (SP) sands containing almost no fines.

Between Stations 45 and 49, the fishway crosses surface deposits of gravelly sand containing cobbles and boulders up to 4 feet in size. The cobbles and boulders are probably riprap, scattered by torrential flows while the former project was in operation. Between Stations 140 and 162, the fishway crosses a delta of unconsolidated sand deposited by diversion channel flows near the terminus of the channel.

Nearly all of the material encountered in the investigations was classed as "loose" or "soft" and will erode easily. The fishway prism should be cut with 1 1/2:1 or flatter slopes and will require a protective lining.

Tufa crops out right of line between stations 42 and 44+50. The southern end of this outcrop has been deposited as a one to two-foot thick rind on gravel but the northern portion may be deposited on marble. This section of the alinement was changed after investigations were completed and consequently it was not explored. While it is anticipated that rock will not be encountered within the fishway prism as it is presently located, this possibility does exist.

A small spring and several water seeps emanating from tufa were noted right of line between Stations 43 and 45. Surface flow from the spring was estimated to be 3 gpm (August 17, 1972); water temperature recorded at the spring was 69^0 F, about 10 degrees warmer than the temperature in test wells at Marble Bluff damsite and the water has a notable H_2S odor. The H_2S content was not measured.

Seismicity - The seismic and geologic factors indicate that the risk of severe, and possibly damaging earthquakes, in the project vicinity is relatively high; but the nature of the project features preclude any catastrophic threat caused by failure of the structure. The design ground acceleration would be 0.25g which has a 90 percent probability of not being exceeded in a 50-year period [USGS].

Frost Heave - Frost heave is a problem in cold climates when ice lenses form and damage overlying structures due to differential movements caused by the growth of the ice lenses. The necessary conditions for frost heave are present at this site: availability of water, frost-susceptible soils and freezing temperatures. The area has an air-freezing design index of about 750 to 1,000 degree Fahrenheit-days and a corresponding depth of frost penetration of 3 to 3.5 feet in silty sand [22].

Frost heave can be controlled or reduced by restricting the amount of water that can move upward from the groundwater table, thereby restricting the growth of ice lenses. Also, frost heave can be controlled by replacing frost-susceptible soil with free-draining material. The effects of frost heave will be more severe for the rigid concrete fish ladders than for the flexible rock fish ladders. Preliminary design measures for frost heave are discussed in the next section.

Fish-Ladder Foundation

The Concrete Fish Ladder - Because the existing soil was classified as "loose" and "soft" in the 1972 exploration logs, the foundation soils may need to be improved where the fish ladder is placed on original ground. It is suggested that the existing structures be inspected for cracking or other forms of distress related to possible differential settlement and frost heave. Further, it is suggested that the foundation of the proposed fish ladder be investigated to determine if it is suitable. This should be accomplished by testing the density of the foundation material. If the foundation needs to be improved, over excavation and replacement with compacted material is usually the cheapest method of improving the soil. The amount of over excavation and compaction would be based on the density test results. For cost estimates, it was assumed that 2 feet of material would be over excavated and recompacted. Of the 2 feet of compacted material, 1-1/2 feet is assumed to be over excavated natural material, such as poorly graded to silty sand and the other ½ foot would be processed, free-draining material, such as clean sand and gravel. The ½ foot of free-draining material would be placed directly beneath the concrete fish ladders. During construction, the foundation material would be uniformly moistened to within 2 percentage points of optimum moisture content and compacted in 6-inch-thick layers to 95 percent laboratory maximum compaction.

The Rock Fish Ladder - The proposed fish ladder is considered to be a flexible structure. Over-excavation and replacement with compacted material and the use of non-frost susceptible soil is not considered necessary. The cost of foundation treatment was not included in the cost estimate.

Recommended Soils Testing [23]

Borrow Area - As mentioned earlier, samples of material for the lining of the fishway from proposed borrow areas should be tested for dispersiveness. Also, index properties tests (gradation and Atterberg limits) and compaction tests should be performed on representative samples.

Reclamation's standard dispersive clay tests are the following:

USBR 5400 (Determining Dispersibility of Clayey Soils by the Crumb Test Method);

USBR 5405 (Determining Dispersibility of Clayey Soils by the Double Hydrometer Method); and
USBR 5410 (Determining Dispersibility of Clayey Soils by the Pinhole Test Method).

Tests on Soil-Lime Mixtures - Laboratory tests should be performed to determine the minimum lime content, USBR 5860 (Performing Compressive Strength Testing of Compacted Soil-Lime Mix) and to determine the optimum moisture content and maximum dry unit weight, USBR 5850 (Performing Laboratory Compaction of Soil-Lime Mixtures).

Construction Control - It will be necessary to control the construction by inspection and testing. Two construction control tests are reccomended: USBR 7240, Performing Rapid Method of Construction Control, and USBR 5865, Performing Construction Control of Compacted Soil-Lime Mixtures.

Cofferdamming and Dewatering of Pyramid Lake Fishway Ladders

Hydro-geologic Setting - Pyramid Lake is located in the Basin and Range Province of western Nevada. Typical of this province are linear block mountain ranges surrounded by valleys. The desert valleys are filled with alluvial materials eroded from the surrounding mountains. Bedrock is near surface at desert edges. In the valley centers, alluvial materials can be hundreds of feet deep.

Pyramid Lake is the terminus for the Truckee River. Present day lake level is around 3816 and could potentially rise higher. The Truckee River has incised a channel through the valley fill alluvial materials. At the upper end of the fishway, Marble Bluff dam checks up the Truckee River to about an average elevation of 3855 feet.

The fishways will be constructed within delta and terrace bank materials deposited in former glacial Lake Lahontan. This lake once extended about 200 feet above the present day level. The interbedded deposits are thought to extend tens of feet below the fishway subgrade. Typical materials range from silty sands to sandy gravels. The amount of fine (passing the #200 sieve) materials overall may be around 10%.

In 1972, water level data was recorded in a number of test pits and drill holes along the fishway alinement. Based on the geologic setting and the water level data, the local groundwater table is unconfined with a gradual slope toward present day Pyramid Lake. Existing layout and water data at time of construction are given in Table 5.

An outcrop of tufa and marble exists around Stations 40 to 45+00, just upstream of the first fish ladder listed above. About three small seeps were recorded about elevation 3840. A measurable flow of 3 gpm was found in one seep. The water table in this location is probably perching above the more impermeable bedrock.

Previous Construction Water Handling Techniques - During the construction of the Pyramid Lake entrance ladder, a semicircular sheet pile cofferdam with pumped wells was used. The dam was 360 feet long, 60 feet deep. Nineteen 12-inch diameter pumped wells, 70 feet deep, were drilled. Reported pump sizes were 450 gpm. Only 6 wells needed pumping to successfully keep the excavation dry. The lake was about 18 ft above the entrance to the ladder during the construction period. For the three intermediate fish ladders, a combination of sumps, buried perforated pipes, and well points were used. The success was described as "tenuous at best" [15].

Dewatering Requirements - Since the Pyramid Lake level is currently about elevation 3816, the terminal ladder is fully submerged, along with the entire channel reach between ladder no.1 and the original terminal ladder. Ladder No.1 is over 3/4 submerged. Table 6 lists fishway stationing and draw down required followed by the total estimated length and average draw down required for each ladder option.

Table 5 - 1972 Ground Water level Data

Ladder Location	Elevation, ft	1972 Ground Water Level Data Sta: EL
Ladder No. 3 Sta. 45+50 to 47+06	3845.6 to 3832.6	36+50: 3842 43+50: 3 gpm seep EL 3840 47+20: 3827
Ladder No. 2 Sta. 90+00 to 91+56	3832.17 to 3819.17	85+25: 3821 98+90: 3816
Ladder No. 1 Sta. 135+00 to 136+56	3818.74 to 3805.74	120+00: 3809.5 140+00: 3799.5
Entrance Ladder Sta. 157+27 to 160+27	3805.53 to 3774.50	140+00: 3799.5 160+00: Pyramid Lake WL 3795.5

Note: Pyramid Lake water level as of spring 2000 was about EL 3816.

During construction the groundwater level needs to be drawn down about 8 feet below the invert of the fish ladders for the concrete option and 6.5 feet below for the rock lined channel options. Estimates of reach lengths needing dewatering and the average amount of water table draw down needed were determined based on 1972 water level data for ladders no. 2 and no. 3. The present lake water level of 3816 was used for ladder no.1. Dewatering requirements were derived by comparing the proposed option invert grades to the former and existing water table levels.

Table 6 - Estimated Groundwater Control Required For Construction.

Ladder No.	Concrete Ladder Alternative Sta: Drawdown, ft	Rock Ladder Alternative Sta: Drawdown, ft
3	48+20: 5 45+20: 0 Length = 300 ft @ 2.5 ft average draw down	51+74: 2 49+50: 0 Length = 224 ft @ 1 ft average draw down
2	91+40: 8 88+40: 0 Length = 300 ft @ 4 ft average draw down	96+23: 4.5 90+50: 0 Length = 573 ft @ 3 ft average draw down
1 Partially submerge	Options 1A and 1B 136+40: 23 (option 1A) or 28 (option 1B) 130+75: 4 (Both options) 129+20:0 (Both options) Option 1A - Length = 565 ft @ 14 ft average draw down Option 1B - Length = 720 ft @ 14 ft average draw down	Options 1A and 1B 136+60: 21.5 (option 1A) or 26.5 (option 1B) 122+50: 0 (option 1A) 116+60: 0 (option 1B) Length = 1410 ft @ 11ft average draw down (option 1A) Length = 2000 ft @ 13ft average draw down (option 1B)

Groundwater Aquifer and Flow - The glacial lake materials are laterally discontinuous and tend to be on the coarser side with a low percentage of fines. An unconfined aquifer is thus assumed. The previous construction reports noted that the materials are loose and some beds have high porosity. Occasional silt and clayey beds are thin and would likely range a few tens to a few hundreds of feet in extent.

The materials are assumed to be homogeneous in the horizontal and vertical directions. The predominant material type is silty sand. Typical hydraulic conductivity values range from about 1 to 100 gallons per day per square foot for a silty sand average [2, 3]. For the concept design a vertical permeability value of about 10 and the horizontal permeability of about 100 was assumed. The concept study dewatering plan is based on an equivalent permeability about 30 gallons per day per square foot.

Water Handling and Analysis Methods - This study is based on water level data and geologic information from the 1972 studies. It is assumed that present ground water levels would be about the same as in 1972, except where the lake has risen. Present ground water levels could be different and should be identified prior to final design.

Dewatering for ladder no.1 will require similar techniques as used in the 1970's for the entrance ladder. The large drawdown depths needed at ladder no.1 will require using pumped wells in combination with sheetpile cutoffs and cofferdaming.

Better groundwater control is proposed for dewatering ladders no. 2 and no. 3 than was used during the prior construction. A combination of well points and sheet pile cutoffs is proposed. Powers [11] found well points work good for surface dewatering of silty sand materials typical of Marble Bluff fishway when minimal draw down is required. Where greater depth of dewatering is needed, well points used in combination with cutoff walls are recommended.

Construction dewatering techniques include placing sheet piles and well points inside the excavation zone. Water will flow horizontally toward the excavation with a vertical component under the sheet pile barrier.

Although well points are suitable for the type of materials at the site, the prior construction of the intermediate ladders had questionable success using only well points and sumps. For this study a combination of well points and cutoff walls are recommended. Excavations for ladders no. 2 and no. 3 will use sheet pile cutoffs and well points for evacuating water. A sheet pile embedment (D) of D = 1.5 to 2.0 H, where H is the excavation change in water surface used in the design. The ladder profiles show the maximum excavation and dewatering level during excavation will be about 10 ft, therefore 30 ft sheet piles were specified for cutoffs.

Well point spacing was determined by estimating the flow under the cutoff wall and the withdrawal rate of the well points for the rock or concrete ladder options at their respective grades. Flow under the sheet pile cutoffs was estimated using a 1-D flow calculation. For the calculations, an excavation depth of 10 feet and a ground water table about 5 feet below original ground surface were assumed. This flow was then compared to the calculated flow into an equivalent circular excavation using a modified (large well) borehole equation. Based on this analysis the following dewatering scheme is recommended.

Dewatering Plan

Ladder No.1 (concrete or rock) - Similar dewatering techniques are proposed for both the concrete and rock ladder options. However, as given in Table 6 and shown on fishway plan and profile drawings, the length and depth of dewatering varies. Construction of ladder no.1 will require a combination of unwatering and dewatering. A maximum draw down of 26 feet was assumed for this study. The data gathered during the prior dewatering of the entrance ladder was used as the basis of design for dewatering areas submerged by the lake. For the proposed construction, a 100' long coffer dam, 20 feet wide, crossing the existing channel would be constructed with dumped materials about the lower ladder site perimeter. Sixty-foot deep sheet piles would be driven through the cofferdam and about 40 ft along each channel side. The Z factor for these piles should be about $S = 14$ in^3. After completing the cutoff work, low head pumps would be used to empty the area of standing water and pumped wells would be drilled. Eight, 8-inch diameter wells fitted with 100 gpm pumps would be needed. At a 50 foot spacing, each well is designed to pump about 60 gallons per minute. During the 1970's entrance ladder dewatering, they found six 12-inch-diameter wells spaced at 60 ft were sufficient.

Ladders No. 2 and No. 3 (concrete or rock) - Similar dewatering techniques are proposed for both the concrete and rock ladder options. The location of proposed sheetpile is shown on the profile view presented for each fish ladder option. Assuming mainly sand and gravel materials are present, the sheet piles need only minimal bending strength. Steel piles with a small Z-factor ($S = 3.4$ in^3) are assumed herein. Fifteen feet long, 1-1/2 in diameter, self jetting well points should be installed. Each well point is estimated to flow at 0.6 gallons per minute. The points should be placed about 5 ft inside and parallel to the walls, spaced 5 feet apart. Well points would be connected to a 3" ID Schedule 80 PVC pipe header pipe connected to a vacuum pump capable of 100 gpm. The vacuum pump would discharge to another pump or a sump. Either a 2-stage pump or a second low head pump would be needed to pump the ground water out of the excavation.

Previous construction reports mention there were some erosion problems when the fishway was operated. Apparently some riprap was placed to control the erosion. The zones of riprap need to be delineated. Use of sheet piles is based on penetrating materials no larger than small gravel.

The actual permeability value will affect how much water is pumped for evacuation. The concept design assumes 100 gpm pumps will be sufficient. For the deep wells, if the soil's permeability value is high, (a horizontal permeability value of closer to 100 instead of the assumed 30), the flow out of the pumped wells will be higher than the specified pump capacity. However, eight-inch diameter wells can fit a pump with a flow rate up to about 300 gpm, so the well size should be adequate if the soil has a higher permeability. The pumps can be easily switched out if determined necessary. Six-inch wells were considered, however they can only fit pumps up to about 120 gpm. This was considered too small as a maximum flow rate.

Where a draw down of 2.5 ft or less is required, the use of well points without a sheet pile cutoff is specified. The well point spacing may be increased in those areas where the needed drawdown approaches zero. Soil stability tests should be conducted prior to final design to determine the drawdown required to support machinery during construction and large riprap.

Earth Waste Areas

Borrow areas excavated during previous construction projects at Marble Bluff Dam could likely be used for earth waste disposal for the fishway project. A number of borrow areas were used during construction of the dam, see reference drawing 949-D-278 in appendix A. Sites on the south side of the river are not considered suitable for waste disposal. These sites are largely in areas that were inundated by water following the dam construction. These areas have typically silted in, now support good vegetation and offer poor access from the fishway channel. Borrow areas identified as areas A and E located on the north side of the river provide good access. The extent to which the areas were excavated during construction and the volume of material that they could receive could not be determined in this study. Borrow area A was used again during the 1998 construction of the fish lock and fishway exit channel. It was established as a small waste/construction use site. A field site survey of area A should be conducted prior to final design to determine the suitability of the site for wasting material excavated from the fishway. Demolition of the existing concrete flumes will require disposal of the broken concrete. The concrete material will be trucked to a managed disposal sight.

Fencing

The Fish and Wildlife Service installed new fence along both sides to the fishway several years ago. The fencing generally runs along the top of the bluffs either side of the fishway channel. Cattle are commonly grazed on the lands on both sides of the fishway and, in the past, have gotten through the fencing and grazed in the fishway channel for extended periods of time. The existing fence is generally in good condition. The fence is constructed of 6 inch square woven wire with barbed wire above. The wire is strung between metal tee posts. Although the fence is generally sufficient to hold out cattle, several wire gates located along the fence are in poor condition and can easily be left open. All existing gates should be replaced with woven wire type stock gates that are spring loaded to close automatically. In the areas where posts and fencing are in poor condition, new fence should be constructed.

Project Construction Costs

Concrete flume and baffle fishway alternative - Project construction cost estimate summarys are given in Tables 7 and 8 for the concrete ladder and baffle fishway options. Table 7 gives the cost of reconstructing the fishway to achieve fish passage to lake elevation 3800 (option1A) and elevation 3795 (option1B). For option1A, the cost of replacing ladders no.1, 2 and 3 with concrete ladders is $4.72 million. Increasing fish passage access to lake elevation 3795, option1B, increases the cost $0.43 million to $5.15 million. Reconstructing and lining the fishway channel from Station 02+50 to Station 138+00 is estimated to cost an additional $1.82 million. The total construction cost for the fishway with ladder no.1 option1A is $6.53 million and ladder no.1 option1B is $6.96 million.

Replacing the entrance ladder in the future will require site unwatering, removal of the existing ladder, excavation of the channel downstream of ladder no. 1 to elevation 3800 or 3795, excavation of the ladder to grade, ladder construction and fishway channel construction. An appraisal level cost estimate for replacing the entrance ladder is presented. The cost estimate is based on site conditions and unwatering requirements being similar to replacement of ladder no.1 with option 1B.

The estimated present cost of constructing a concrete flume style entrance ladder assuming the lake elevation at the time of construction is approximately 3800 is presented in Table 8. Constructing a new concrete flume and baffle entrance fish ladder is estimated to cost $3.10 million

Rock fishway alternative - Project construction cost estimate summaries are given in Tables 10 and 11 for the rock ladder and boulder weir fishway options. Table 10 gives the cost of reconstructing the fishway to achieve fish passage to lake elevation 3800 (option1A) and elevation 3795 (option1B). For option1A, the cost of replacing ladders no.1, 2 and 3 with rock ladders is $3.24 million. Increasing fish passage access to lake elevation 3795, option1B, increases the cost $0.86 million to $4.10 million. Reconstructing and lining the fishway channel from Station 02+50 to Station 138+00 is estimated to cost an additional $1.40 million. The total construction cost for the rock fishway with ladder no.1option1A is $4.63 million and ladder no.1 option1B $5.50 million.

The estimated present cost of constructing a rock style entrance ladder assuming the lake elevation at the time of construction is approximately 3800 is presented in Table 11. Constructing a new rock style entrance fish ladder is estimated to cost $3.35 million.

Itemized construction cost estimates - Itemized cost estimate sheets for the concrete flume and baffle fish ladder alternative, the rock channel and boulder weir fish ladder alternative and lining the fishway are presented in Appendix B.

Operation and Maintenance

The fishway is operated by fully opening the slide gate at the head of the fishway and allowing water to pass down the exit ladder. Auxiliary water can be added downstream of the exit ladder by opening gate 5 of the headworks structure. Flow should be added if the flow depth in the fishway channel is less than 4.0 feet. The swing bar gate at the downstream end of the exit ladder should be positioned to guide fish up the exit ladder.

The existing fishway requires a fish barrier at the entrance of the fishway to prevent overcrowding of fish in the fishway ladders. Overcrowding may or may not occur in the new fishway ladders with the improved passage conditions. However if overcrowding occurs, a fish barrier gate will have to be installed and operated. For the concrete flume ladder alternative a bar rack fish barrier is proposed that can be placed at any baffle location, Figure 26. The bar gate could be moved each year as needed to follow changes in the lake elevation. A control structure was not designed for the rock channel option. Due to the natural irregularity of the rock structure, a bottom weighed net type barrier would likely have to be used to control fish access.

The fishway will require inspection and cleaning each year prior to operation. Cleaning will consist of removing blown in weeds and large sediment deposits. Within the fishway ladders, weeds should be removed to prevent possible debris plugging of the baffles or boulder weirs. The ladders should not require mechanical removal of sediment. If large wind blown sand deposits form within the ladders the fishway should be operated at low flows prior to the fish run to flush material to the toe of each ladder where it can be removed by a small bobcat type loader. In the channel between ladders, blown in weeds should be removed by hand. Large sediment deposits should be removed by a small loader driven along the channel invert. The cleaning crew should be versed in proper cleaning techniques that protect the integrity of the channel lining. Based on FWS experience, cleaning the fishway requires on average two people working five days with equipment. The annual cleaning of the fishway is estimated to cost $12,000[1] for labor and equipment including overhead.

[1]assumes $150/hr for equipment and operator

For the rock ladder option, additional annual maintenance will be required to inspect and repair displaced riprap. The annual estimated maintenance will require two people and equipment for four days at a cost of $10,000.

Table 7 - Fishway construction cost summary for concrete flume and baffle fish ladder design.

Fishway Feature	Demolition	Construction Dewatering	Construction	Total Cost for Feature
Ladder No. 1 (option 1A) or Ladder No. 1 (option 1B)	$ 46,000	$ 810,000 or $ 940,000	$1,000,000 or $1,300,000	$1,856,000 or $2,286,000
Ladder No. 2	$ 46,000	$ 690,000	$ 800,000	$1,536,000
Ladder No. 3	$ 46,000	$ 480,000	$ 800,000	$1,326,000
Fishway ladder subtotal - Fishway ladders with ladder no.1 option1A or - Fishway ladders with ladder no.1 option1B				$4,718,000 or $5,148,000
Fishway channel reconstruction and lining			$1,816,500 (12,110 ft @$150 ft)	$1,816,500
Total Construction Cost - Fishway with ladder no.1 option1A and channel reconstruction and lining or - Fishway with ladder no.1 option1B and channel reconstruction and lining				$6,534,500 or $6,964,500

Table 8 - Cost of replacing the entrance fish ladder with a concrete flume and baffle fish ladder assuming a lake elevation of approximately 3800.

Fishway Feature	Demolition	Construction Dewatering	Construction	Total Cost for Feature
Entrance ladder	$260,000	$940,000	$1,300,000	$2,500,000
Fishway channel excavation, (1460 ft)			$375,000 (15 percent of construction cost)	$375,000
Fishway channel lining, (1460 ft)			$219,000	$219,000
Total Construction Cost				$3,094,000

Table 9 - Fishway construction cost summary for rock channel and boulder weir fish ladder design.

Fishway Feature	Demolition	Construction Dewatering	Construction	Total Cost for Feature
Ladder No. 1 (option 1A) or Ladder No. 1 (option 1B)	$ 46,000	$ 1,350,000 or $ 1,950,000	$ 640,000 or $ 900,000	$ 2,036,000 or $ 2,896,000
Ladder No. 2	$ 46,000	$ 250,000	$ 340,000	$ 636,000
Ladder No. 3	$ 46,000	$ 160,000	$ 360,000	$ 566,000
Fishway ladder subtotal - Fishway ladders with ladder no.1 option1A or - Fishway ladders with ladder no.1 option1B				$ 3,238,000 or $ 4,098,000
Fishway channel reconstruction and lining			$ 1,398,150 (9,320 ft @$150 ft)	$ 1,398,150
Total Construction Cost - Fishway with ladder no.1 option1A and channel reconstruction and lining or - Fishway with ladder no.1 option1B and channel reconstruction and lining				$ 4,636,150 or $ 5,496,150

Table 10 - Cost of replacing the entrance fish ladder with a rock channel and boulder weir fish ladder assuming a lake elevation of approximately 3800.

Fishway Feature	Demolition	Construction Dewatering	Construction	Total Cost for Feature
Entrance ladder	$260,000	$1,950,000	$900,000	$3,110,000
Fishway channel excavation, (150 ft)			$220,000 (7 percent of construction cost)	$220,000
Fishway channel lining (150 ft)			$22,000	$22,000
Total Construction Cost				$3,352,000

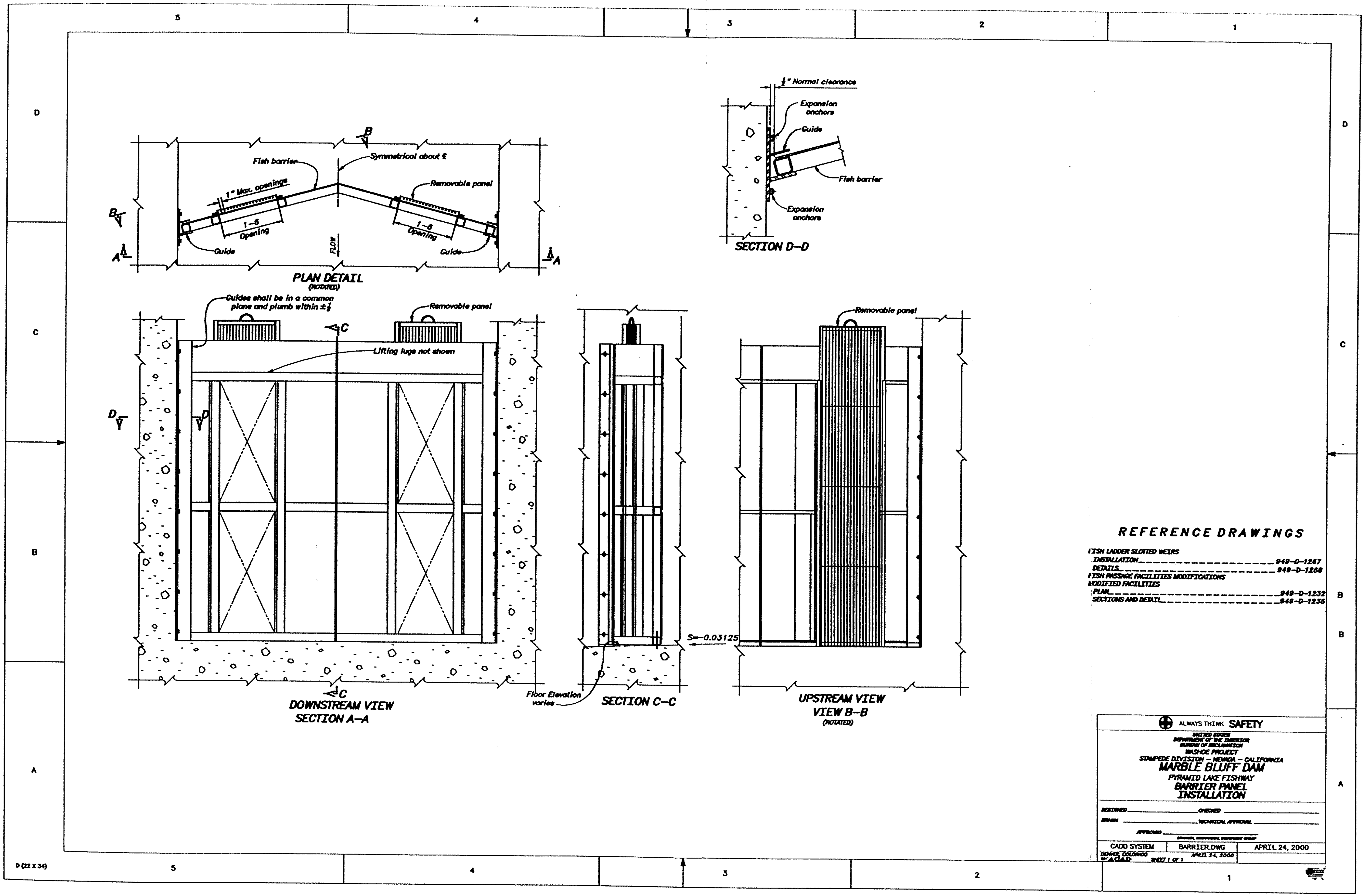


Figure 26, pg. 50

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[4] Koch, D. L., "Life History Information on the Cui-ui Lakesucker (Chasmites cujus Cope 1883) Endemic to Pyramid Lake, Washoe County, Nevada," PhD. Dissertation, University of Nevada, Reno, pp 343, 1972.

[5] Koch, D. L., "Reproductive Characteristics of the Cui-ui Lakesucker (Chasmites cujus Cope) and its Spawning Behavior in Pyramid Lake, Nevada," Trans. Am. Fish. Soc., 102(1):145,149, 1973.

[6] Koch, D. L., "Life History Information on the Cui-ui Lakesucker (Chasmites cujus Cope 1883) in Pyramid Lake, Nevada," Biol. Soc of Nev. Occasional Papers 40:1-12, 1976.

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[11] Sowers, Patrick, J., "Construction Dewatering," Second Edition, Johnson Filtration Systems, St. Paul, MN, 1992.

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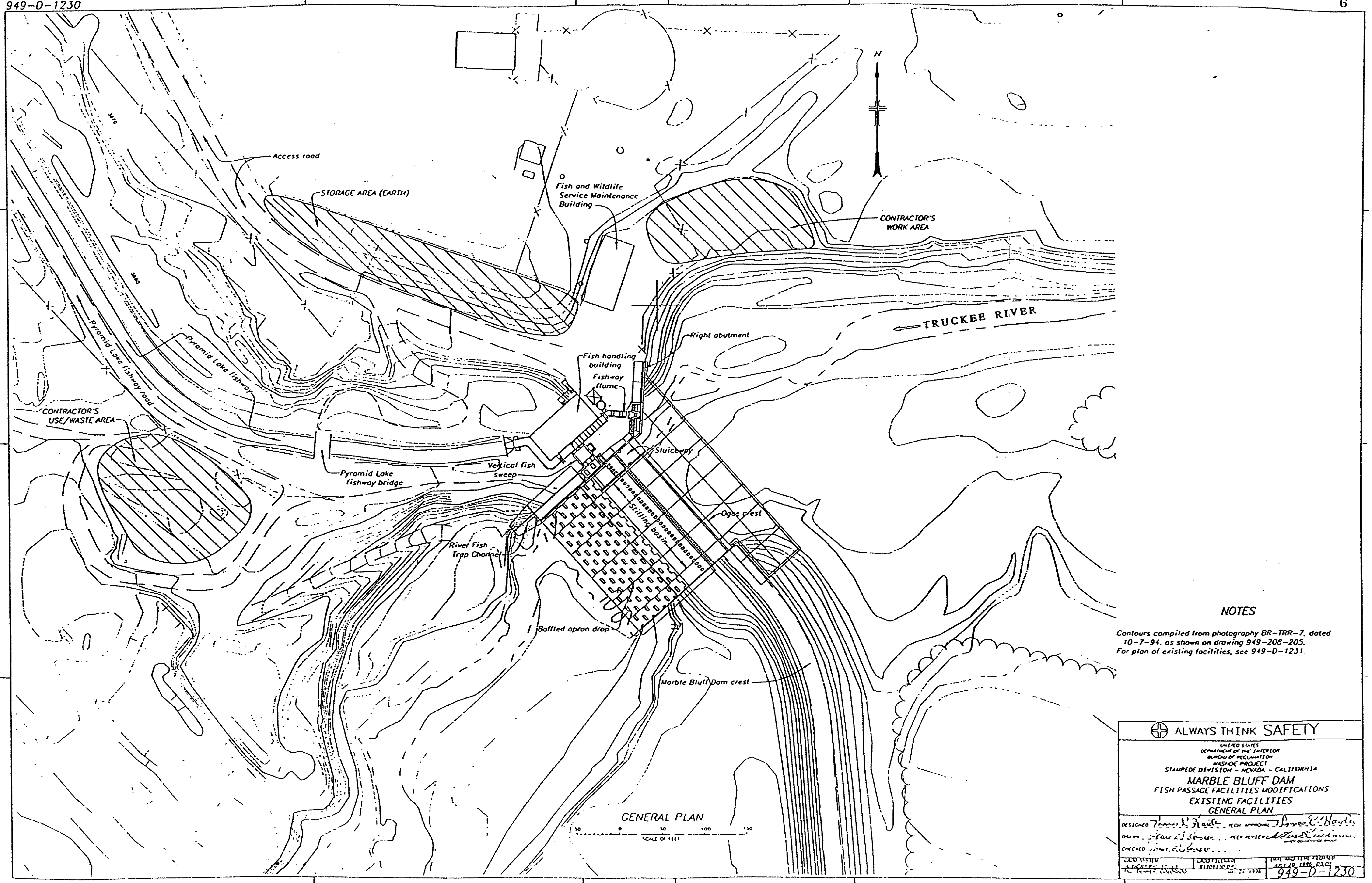
[26] U. S. Fish and Wildlife Service, "Pyramid Lake Fishway Experimental Bypass Channel," The Nature Conservancy, Northern Nevada Office, September, 1995.

Appendix A

Reference Drawing for Marble Bluff Dam and Fishway


Access road
STORAGE AREA (EARTH)
Fish and Wildlife Service Maintenance Building
CONTRACTOR'S WORK AREA
TRUCKEE RIVER
Right abutment
Fish handling building
Fishway flume
Pyramid Lake fishway road
Pyramid Lake fishway
CONTRACTOR'S USE/WASTE AREA
Pyramid Lake fishway bridge
Vertical fish sweep
Sluiceway
Ogee crest
Stilling basin
River Fish Trap Channel
Baffled apron drop
Marble Bluff Dam crest
GENERAL PLAN
SCALE OF FEET
NOTES
Contours compiled from photography BR-TRR-7, dated 10-7-94, as shown on drawing 949-208-205.
For plan of existing facilities, see 949-D-1231
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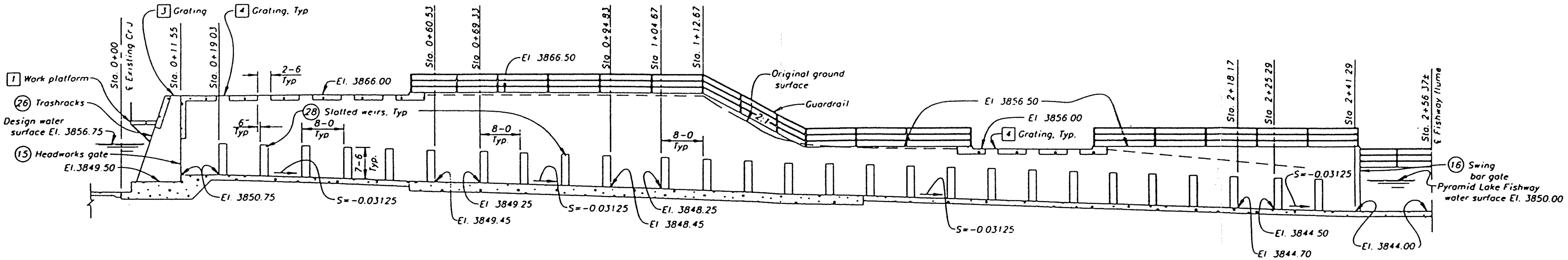
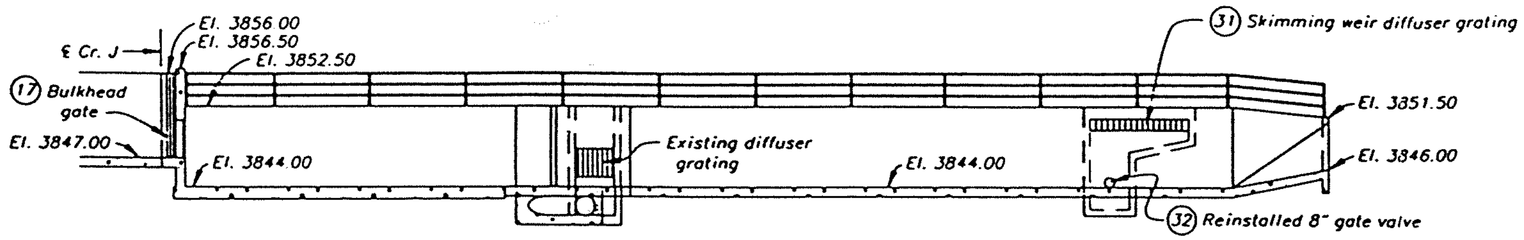
MARBLE BLUFF DAM
FISH PASSAGE FACILITIES MODIFICATIONS
EXISTING FACILITIES
GENERAL PLAN
949-D-1230



SECTION L-L (1232)



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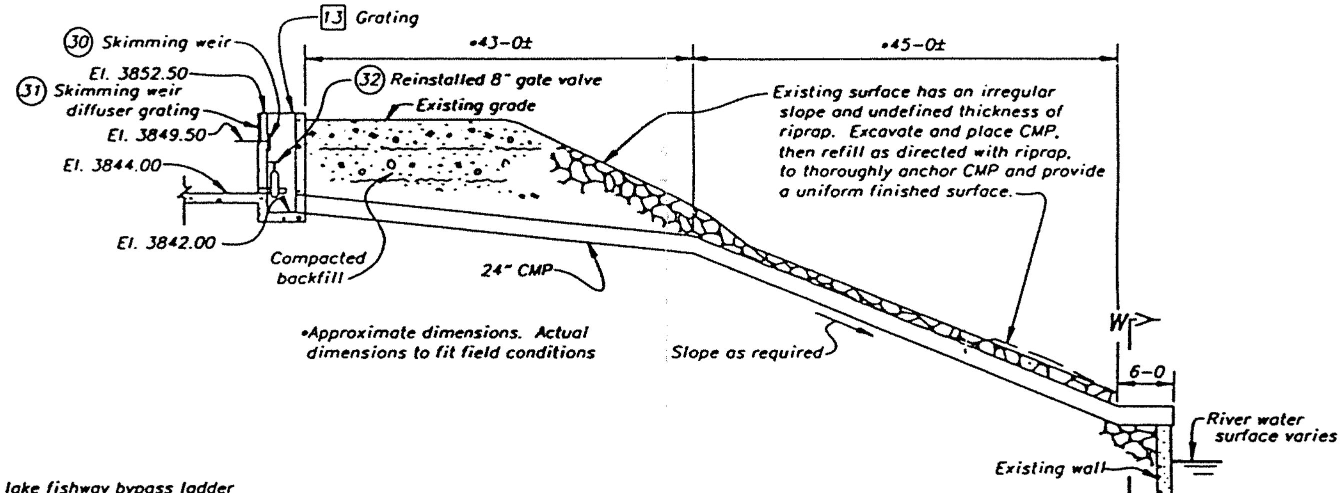

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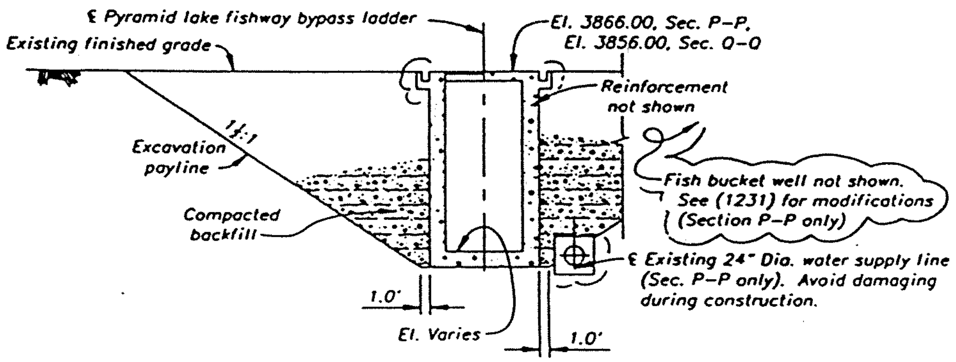

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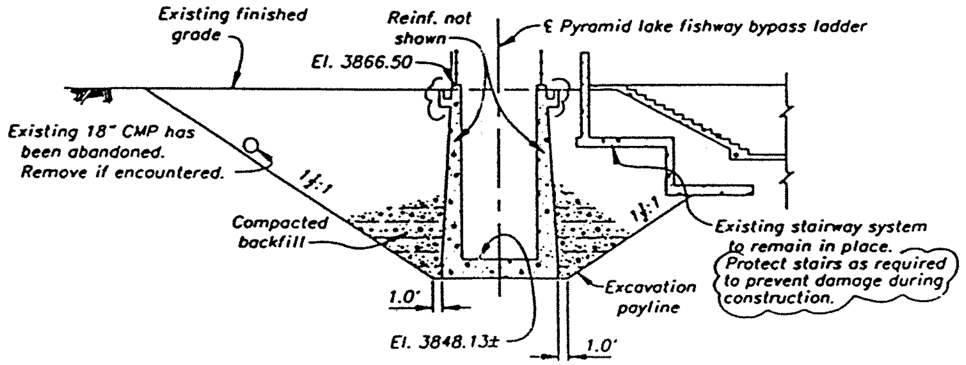
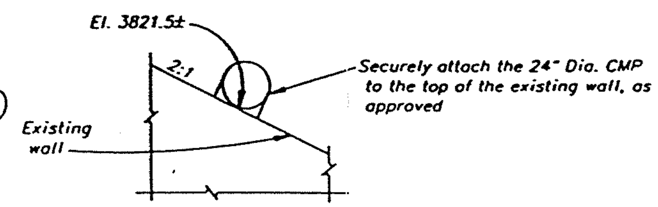
(Section O-O similar)



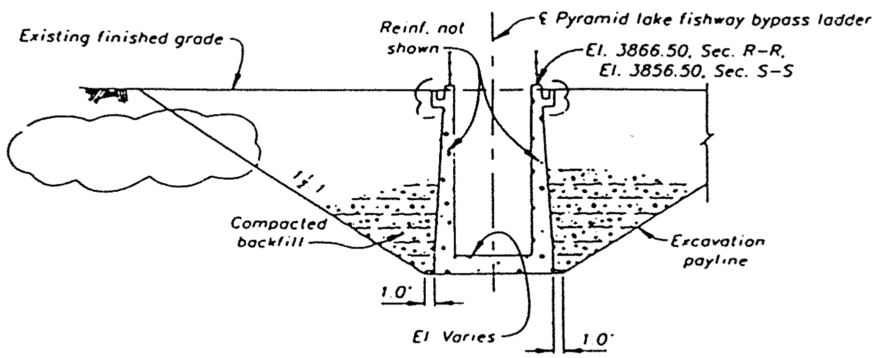
SECTION T-T (1232)



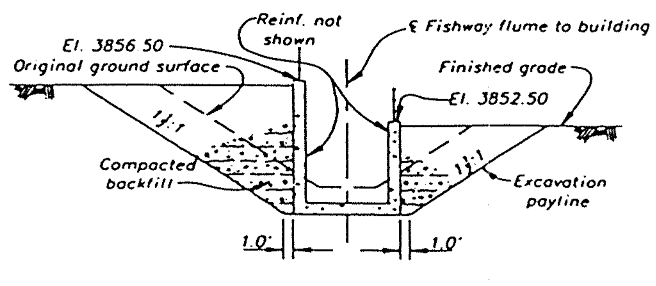
SECTION W-W

NOTE

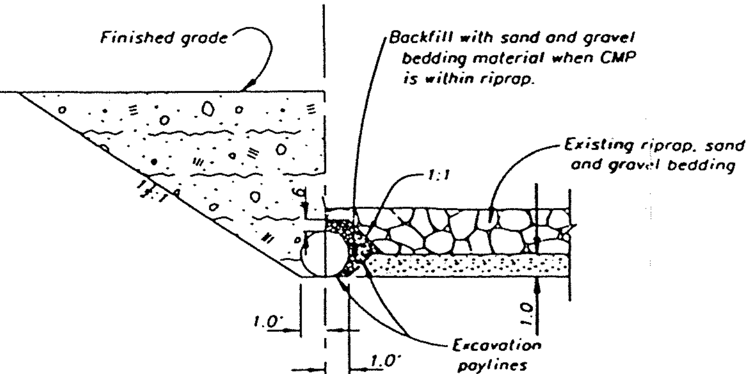
For notes, see 949-D-1233.



SECTION R-R (1232)
(Section S-S similar)



SECTION U-U (1232)



SECTION V-V (1232)

8-15-96	MINOR REVISIONS

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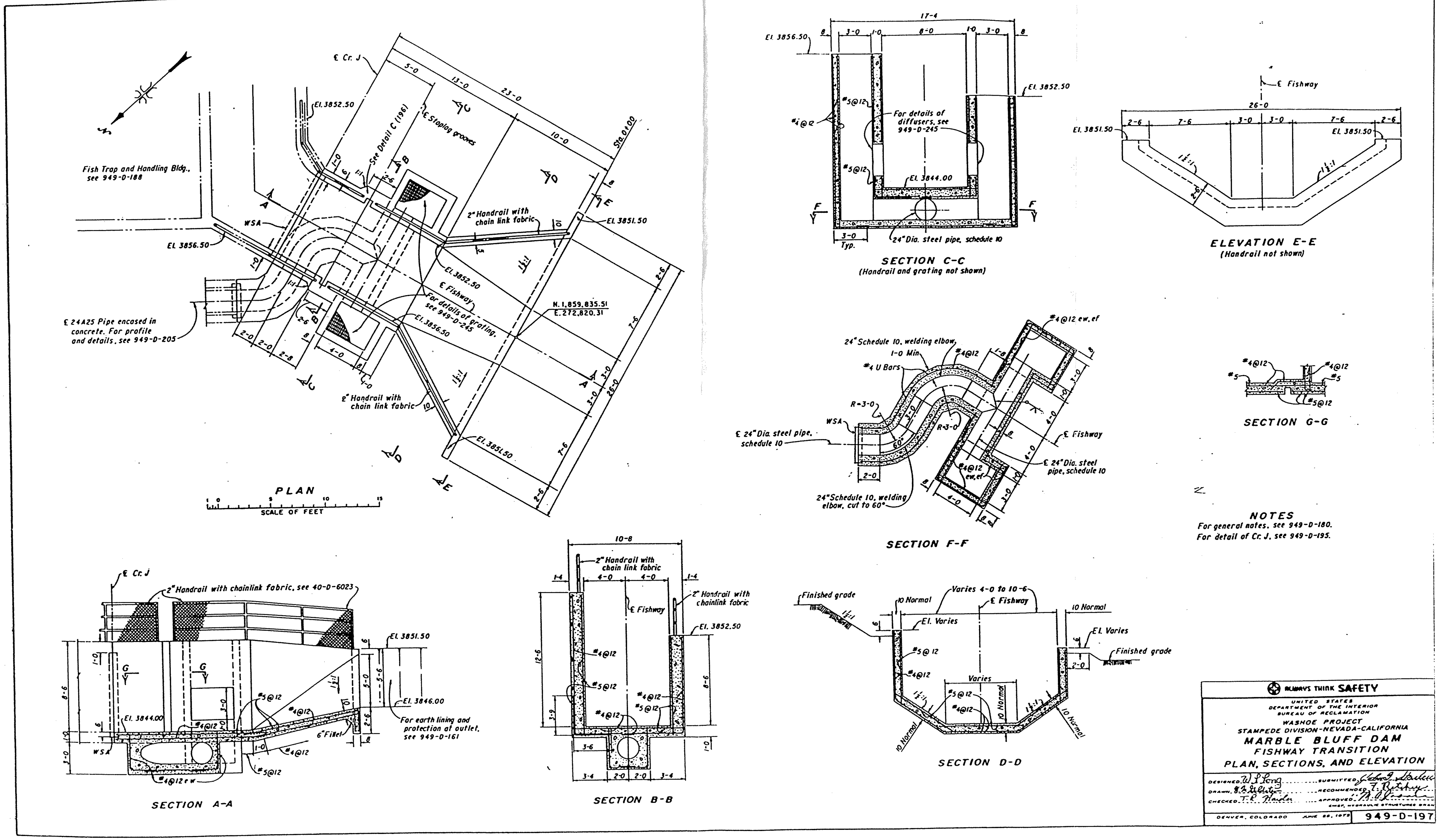
WASHOE PROJECT
STAMPEDE DIVISION – NEVADA – CALIFORNIA

MARBLE BLUFF DAM
FISH PASSAGE FACILITIES MODIFICATIONS
MODIFIED FACILITIES
SECTIONS

DESIGNED THOMAS R. HAIDER — TECH APPROVAL THOMAS R. HAIDER
DRAWN MARY E. BLACK — PEER REVIEW ARTHUR GLICKMAN
CHECKED K. A. SAYER

CADD SYSTEM — CADD FILENAME — DATE AND TIME PLOTTED AUGUST 15, 1996
DENVER, COLORADO — 949-D-1235


PLAN
SCALE OF FEET
Fish Trap and Handling Bldg., see 949-D-188
℄ Cr. J
See Detail C (196)
℄ Stoplog grooves
2" Handrail with chain link fabric
℄ 24A25 Pipe encased in concrete. For profile and details, see 949-D-205
℄ Fishway
For details of grating, see 949-D-245
N. 1,859,835.51
E. 272,820.31
Sta. 0+01.00
El. 3852.50
El. 3856.50
El. 3851.50
WSA
SECTION C-C
(Handrail and grating not shown)
For details of diffusers, see 949-D-245
El. 3844.00
24" Dia. steel pipe, schedule 10
ELEVATION E-E
(Handrail not shown)
SECTION F-F
24" Schedule 10, welding elbow
1-0 Min.
#4 U Bars
24" Schedule 10, welding elbow, cut to 60°
℄ 24" Dia. steel pipe, schedule 10
SECTION G-G
NOTES
For general notes, see 949-D-180.
For detail of Cr. J, see 949-D-195.
SECTION A-A
2" Handrail with chainlink fabric, see 40-D-6023
El. 3846.00
For earth lining and protection at outlet, see 949-D-161
6" Fillet
SECTION B-B
2" Handrail with chainlink fabric
SECTION D-D
Finished grade
Varies 4-0 to 10-6
10 Normal
El. Varies
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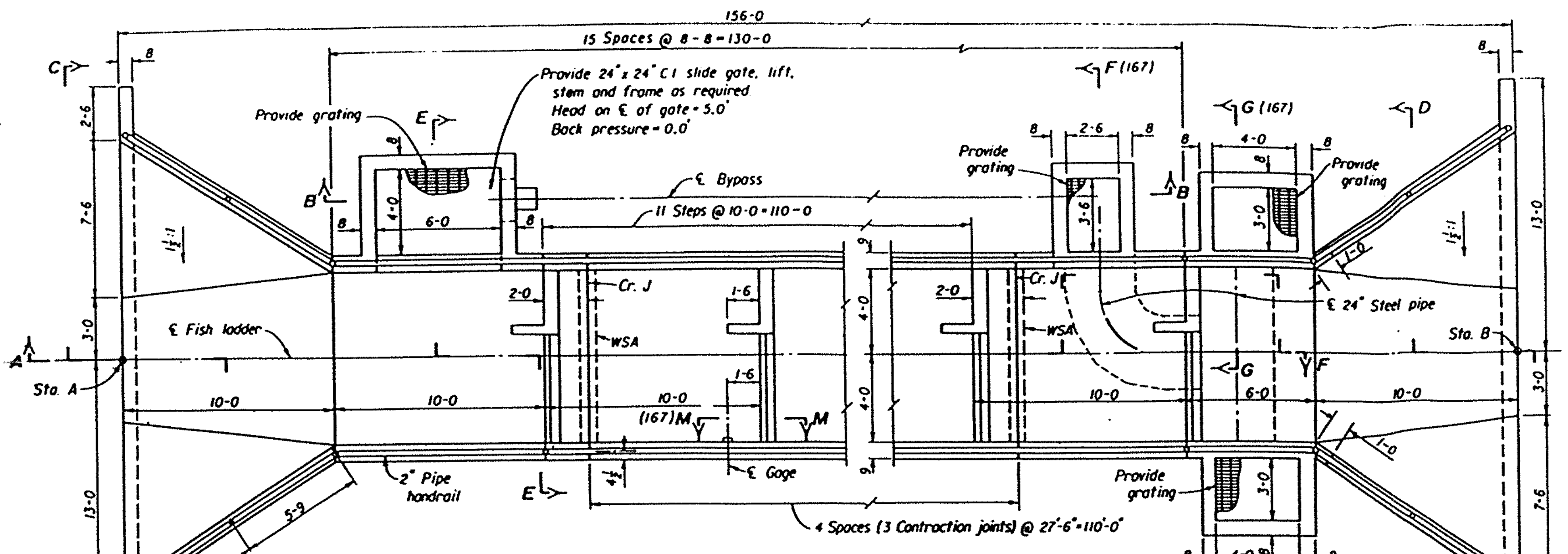
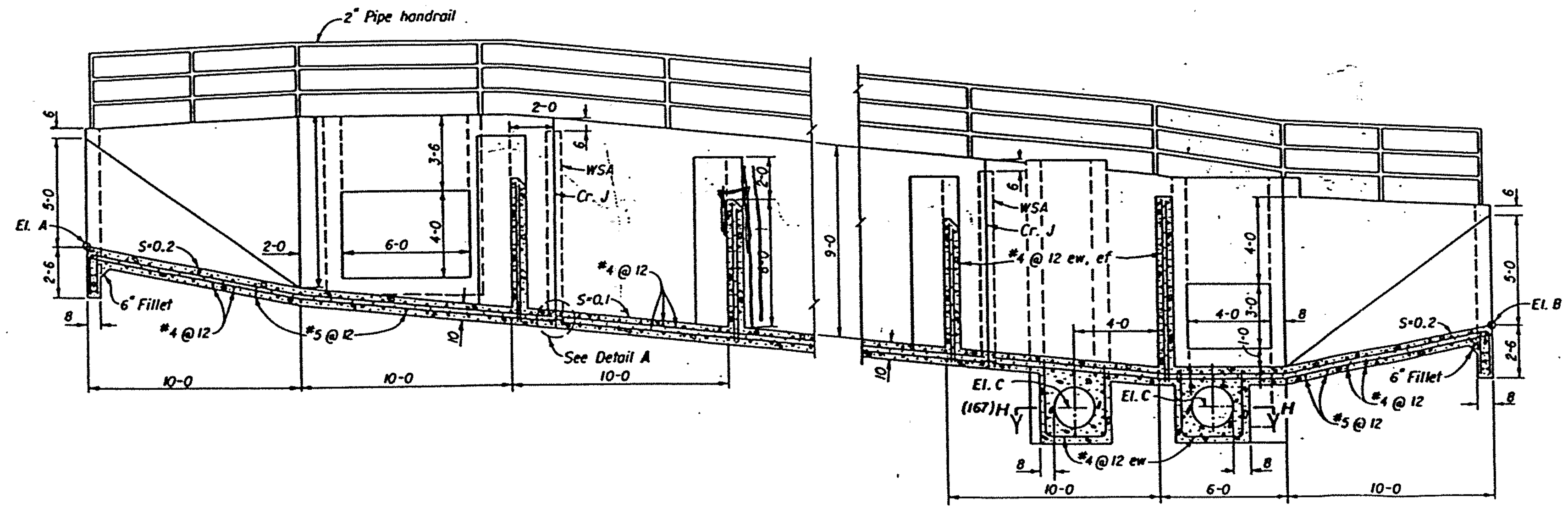
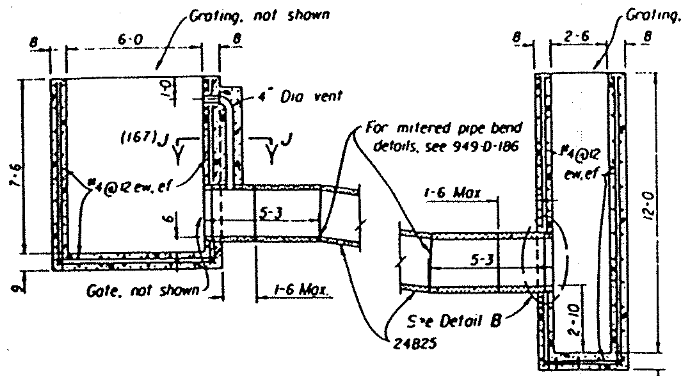
STAMPEDE DIVISION-NEVADA-CALIFORNIA
MARBLE BLUFF DAM
FISHWAY TRANSITION
PLAN, SECTIONS, AND ELEVATION
DENVER, COLORADO
949-D-197



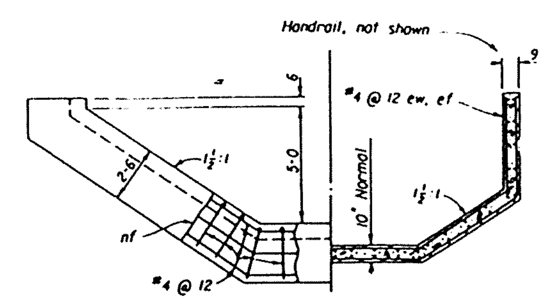
PLAN



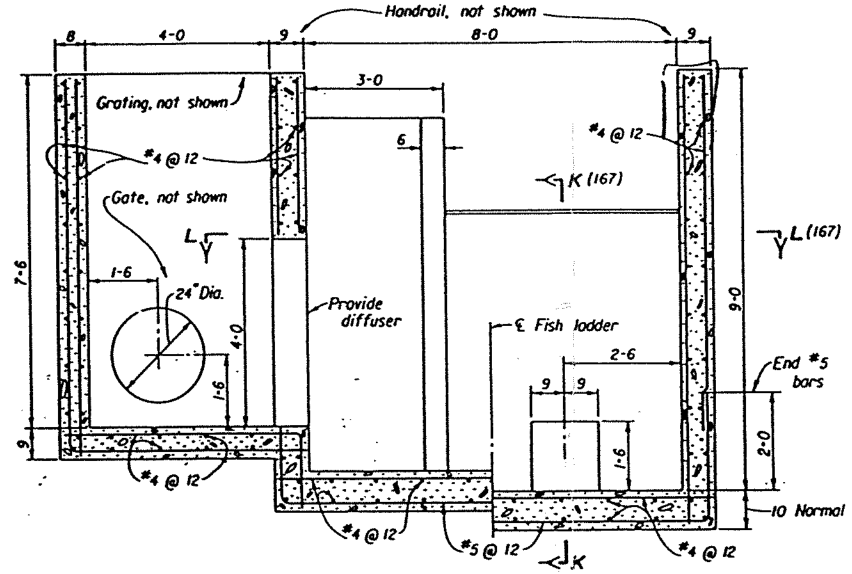
SECTION A-A



SECTION B-B



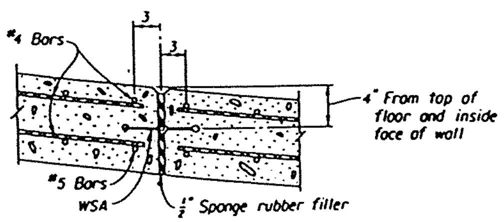
SECTION C-C
(SECTION D-D SIMILAR)



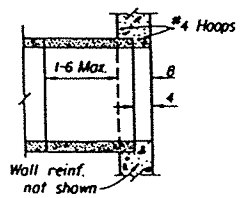
SECTION E-E

NOTES

For general notes, see 949-D-180.
For details of handrail, see 40-D-6023.
For details of grating and diffuser see 949-D-232.



DETAIL A



DETAIL B
(INLET SIMILAR)

STA. A	El. A	STA. B	El. B	El. C
45+50	3845.60	47+06	3832.60	3828.77
90+00	3832.17	91+56	3819.17	3815.34
135+00	3818.73	136+46	3805.73	3801.90

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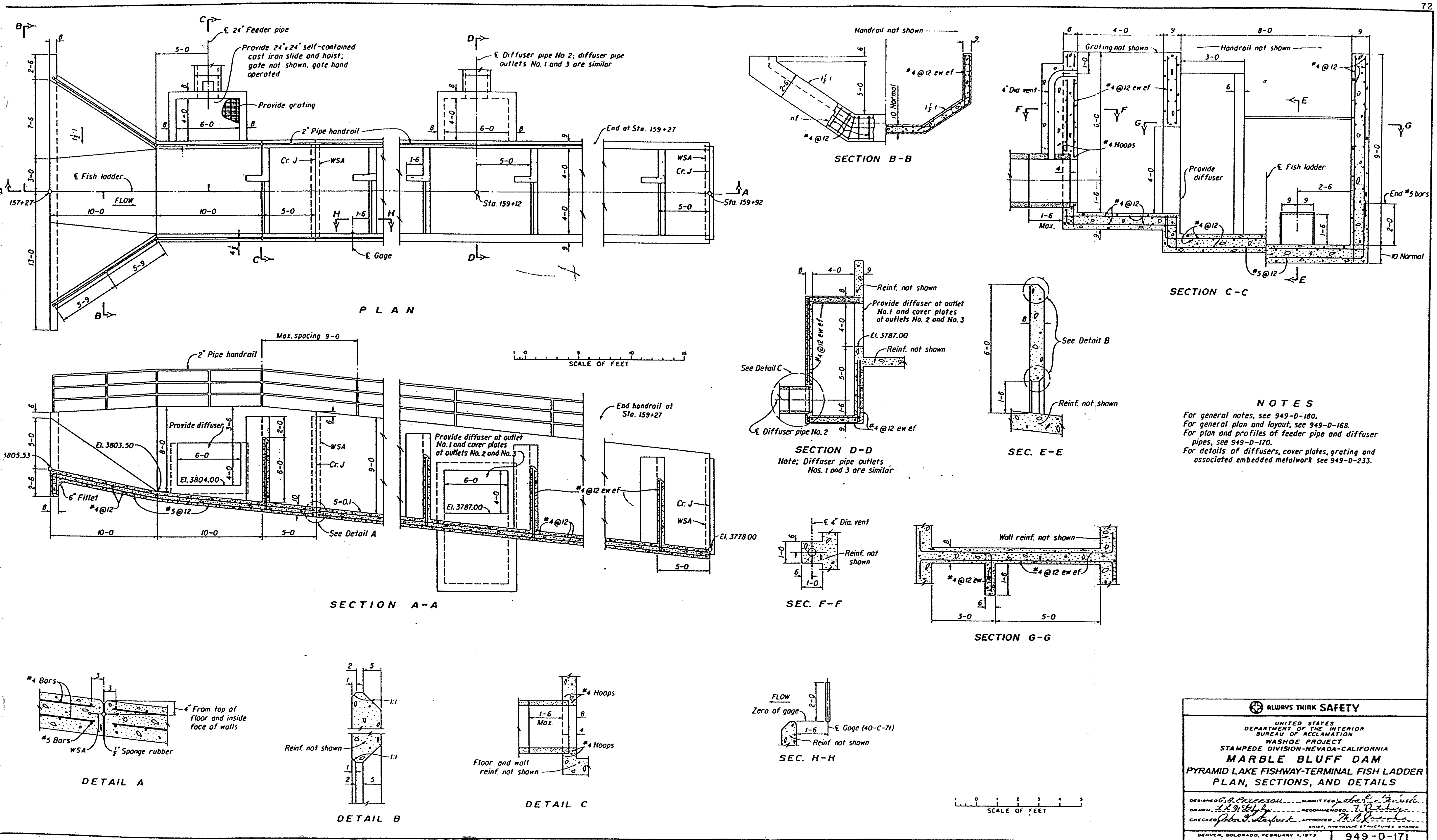
MARBLE BLUFF DAM

PYRAMID LAKE FISHWAY-INTERMEDIATE FISH LADDERS
PLAN, SECTIONS, AND DETAILS

DESIGNED ... SUBMITTED ...
DRAWN ... RECOMMENDED ...
CHECKED ... APPROVED ...

DENVER, COLORADO SHEET 1 OF 2 | JULY 14, 1973 | 949-D-166


PLAN
SECTION A-A
SECTION B-B
SECTION C-C
SECTION D-D
Note; Diffuser pipe outlets Nos. 1 and 3 are similar
SEC. E-E
SEC. F-F
SECTION G-G
SEC. H-H
DETAIL A
DETAIL B
DETAIL C
Provide 24"x24" self-contained cast iron slide and hoist; gate not shown, gate hand operated
℄ 24" Feeder pipe
℄ Diffuser pipe No 2; diffuser pipe outlets No. 1 and 3 are similar
Provide grating
2" Pipe handrail
End at Sta. 159+27
℄ Fish ladder
FLOW
Sta. 159+12
Sta. 159+92
℄ Gage
Max. spacing 9-0
End handrail at Sta. 159+27
Provide diffuser
El. 3803.50
El. 3804.00
El. 3787.00
El. 3778.00
See Detail A
6" Fillet
Provide diffuser at outlet No. 1 and cover plates at outlets No. 2 and No. 3
SCALE OF FEET
Handrail not shown
Grating not shown
4" Dia vent
#4 Hoops
Provide diffuser
End #5 bars
10 Normal
Reinf. not shown
See Detail B
See Detail C
℄ Diffuser pipe No. 2
℄ 4" Dia. vent
Wall reinf. not shown
Zero of gage
℄ Gage (40-C-71)
#4 Bars
#5 Bars
WSA
1/2" Sponge rubber
4" From top of floor and inside face of walls
Floor and wall reinf. not shown
NOTES
For general notes, see 949-D-180.
For general plan and layout, see 949-D-168.
For plan and profiles of feeder pipe and diffuser pipes, see 949-D-170.
For details of diffusers, cover plates, grating and associated embedded metalwork see 949-D-233.
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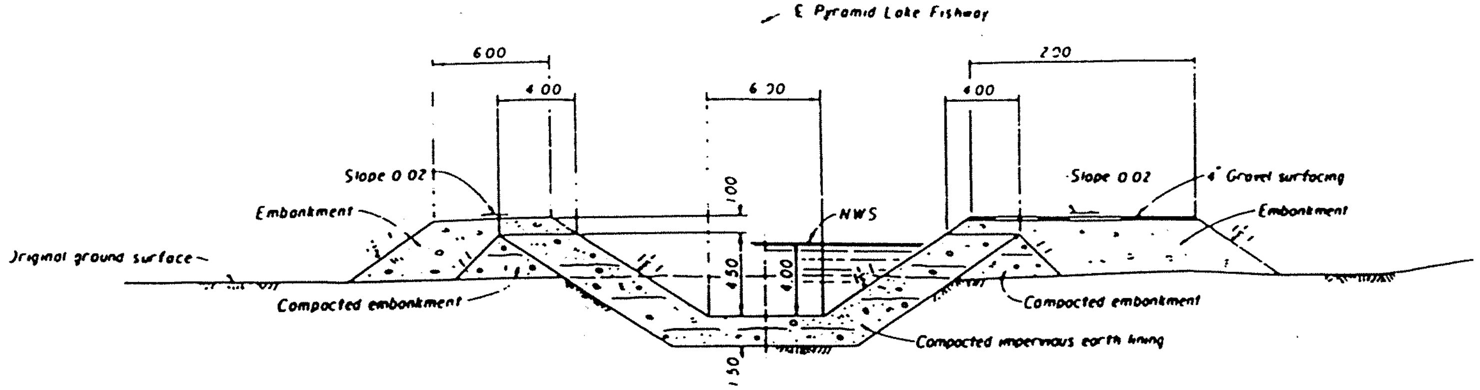
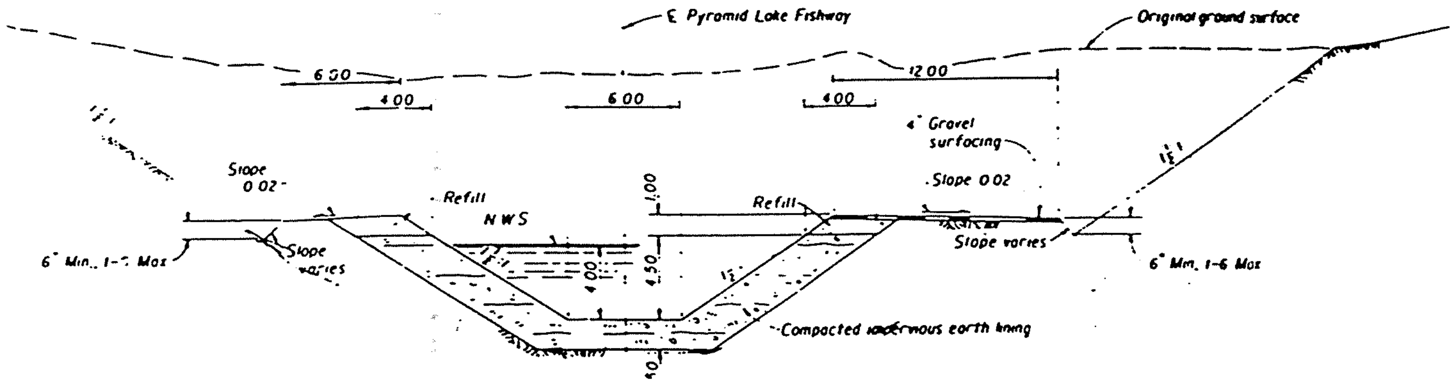
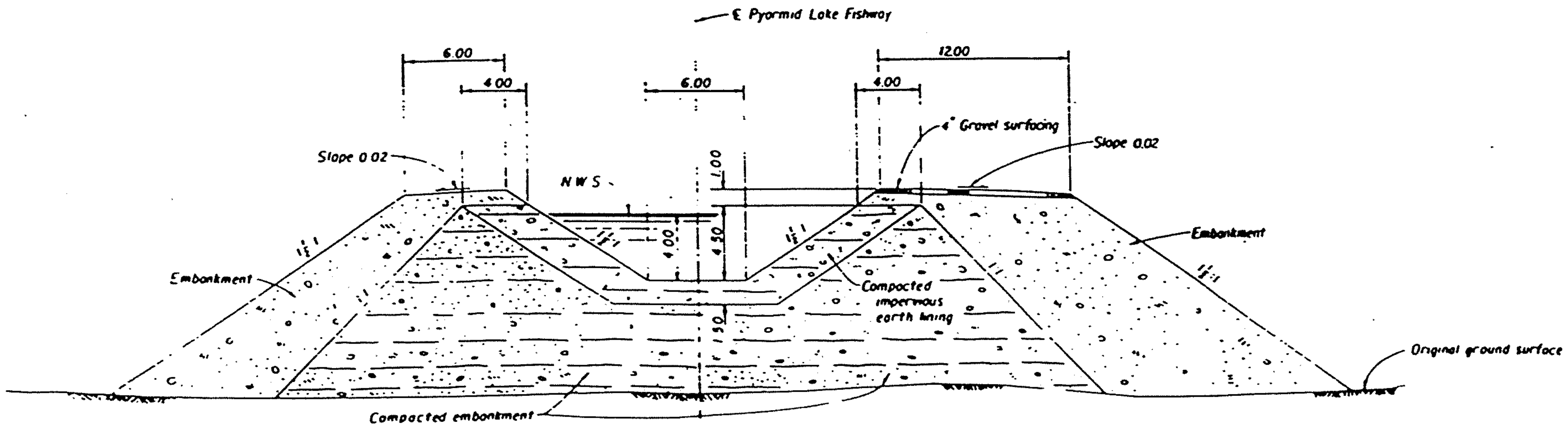
WASHOE PROJECT
STAMPEDE DIVISION-NEVADA-CALIFORNIA
MARBLE BLUFF DAM
PYRAMID LAKE FISHWAY-TERMINAL FISH LADDER
PLAN, SECTIONS, AND DETAILS
DENVER, COLORADO, FEBRUARY 1, 1973
949-D-171



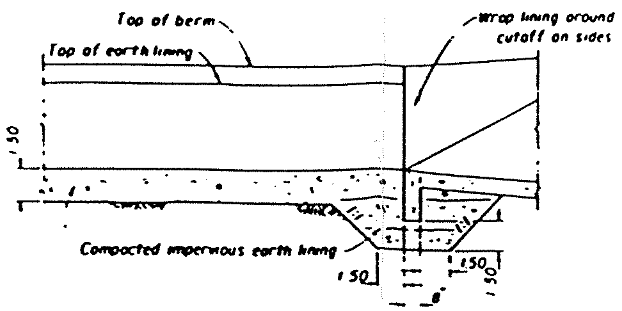
TYPICAL SECTION IN PARTIAL CUT



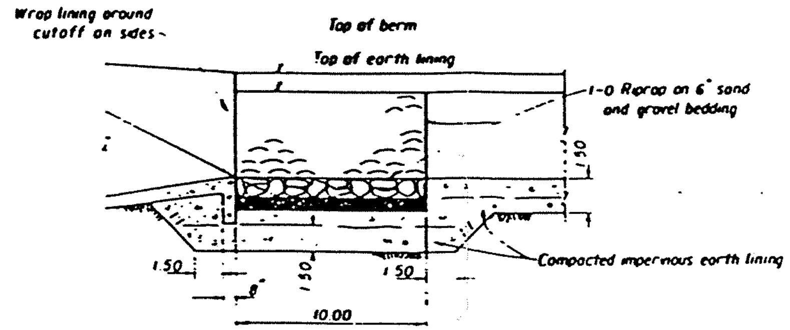
TYPICAL SECTION IN CUT



TYPICAL SECTION ON FILL



EARTH LINING AT STRUCTURE INLETS



EARTH LINING AND PROTECTION AT STRUCTURE OUTLETS

NOTES

For Pyramid Lake Fishway hydraulic properties, see Plan and Profile sheets.

R.O.W. fence to be located 50.0' on each side of Fishway ℄ or as directed by the contracting officer.

For details of R.O.W. Fishway fence, see woven wire type fence on 40-D-6270.

SCALE OF FEET

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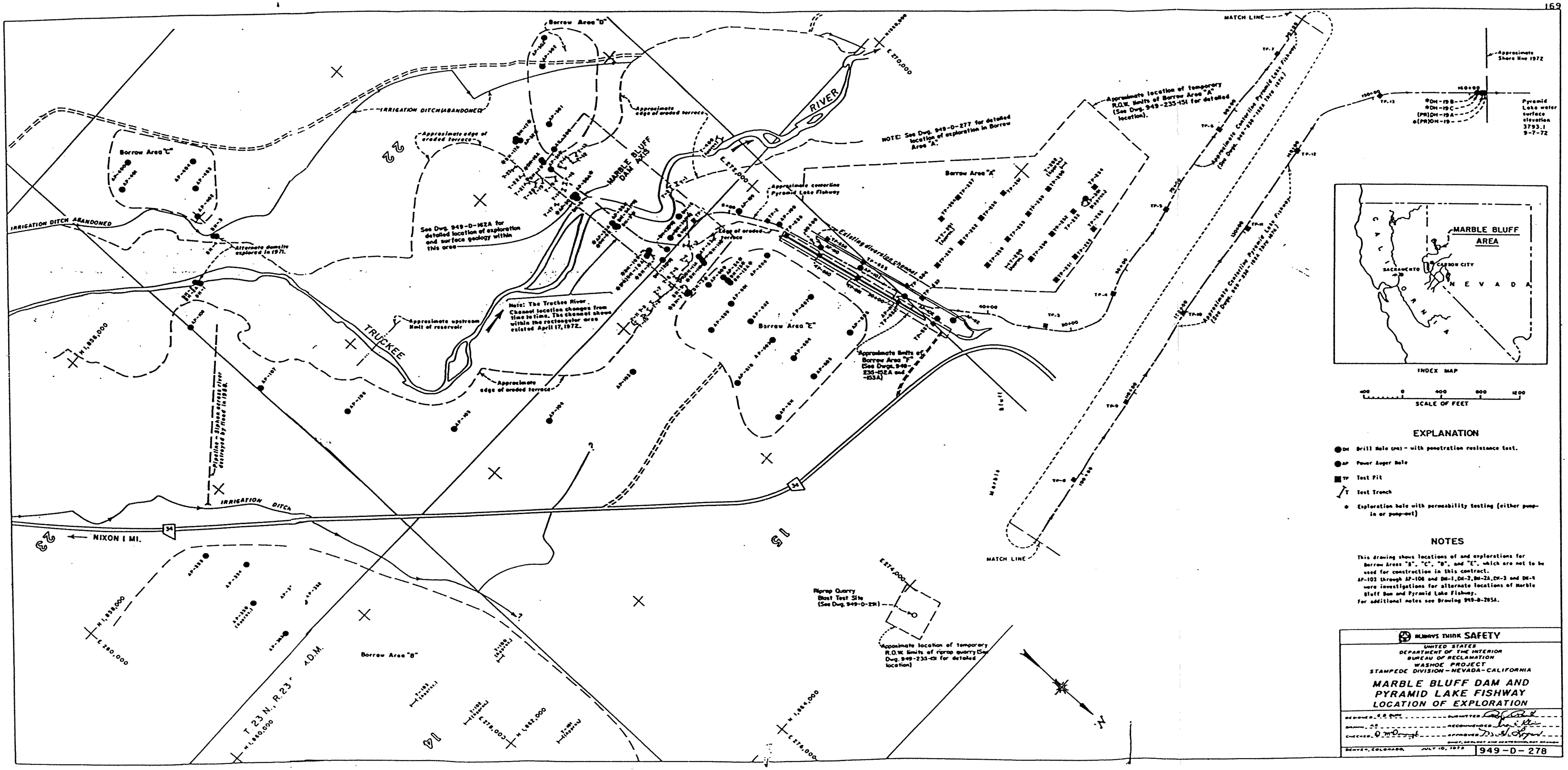
MARBLE BLUFF DAM
PYRAMID LAKE FISHWAY
TYPICAL FISHWAY SECTIONS

G.A. Peterson

949-D-161


Borrow Area "D"
Borrow Area "C"
Borrow Area "A"
Borrow Area "E"
Borrow Area "B"
IRRIGATION DITCH (ABANDONED)
IRRIGATION DITCH ABANDONED
IRRIGATION DITCH
RIVER
TRUCKEE
MARBLE BLUFF DAM AXIS
Approximate edge of eroded terrace
Alternate damsite explored in 1971.
See Dwg. 949-D-162A for detailed location of exploration and surface geology within this area
Note: The Truckee River Channel location changes from time to time. The channel shown within the rectangular area existed April 17, 1972.
Approximate upstream limit of reservoir
NOTE: See Dwg. 949-D-277 for detailed location of exploration in Borrow Area "A".
Approximate centerline Pyramid Lake Fishway
Existing diversion channel
Edge of eroded terrace
Approximate location of temporary R.O.W. limits of Borrow Area "A" (See Dwg. 949-235-151 for detailed location).
Approximate limits of Borrow Area "F" (See Dwgs. 949-235-152A and -153A)
Riprap Quarry Blast Test Site (See Dwg. 949-D-291)
Approximate location of temporary R.O.W. limits of riprap quarry (See Dwg. 949-235-151 for detailed location)
MATCH LINE
Approximate Shore line 1972
Pyramid Lake water surface elevation 3793.1 9-7-72
NIXON 1 MI.
T. 23 N., R. 23 E., M.D.M.
INDEX MAP
MARBLE BLUFF AREA
SACRAMENTO
CARSON CITY
N E V A D A
SCALE OF FEET
EXPLANATION
DH Drill Hole (DH) - with penetration resistance test.
AP Power Auger Hole
TP Test Pit
T Test Trench
Exploration hole with permeability testing (either pump-in or pump-out)
NOTES
This drawing shows locations of and explorations for Borrow Areas "B", "C", "D", and "E", which are not to be used for construction in this contract.
AP-103 through AP-108 and DH-1, DH-2, DH-2A, DH-3 and DH-4 were investigations for alternate locations of Marble Bluff Dam and Pyramid Lake Fishway.
For additional notes see Drawing 949-D-285A.
ALWAYS THINK SAFETY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
WASHOE PROJECT
STAMPEDE DIVISION - NEVADA - CALIFORNIA
MARBLE BLUFF DAM AND
PYRAMID LAKE FISHWAY
LOCATION OF EXPLORATION
DENVER, COLORADO
949-D-278

Appendix B
Construction Cost Estimate Sheets

Cost Estimate Sheets
Demolition of Existing Ladders

CODE:D-8140

ESTIMATE WORKSHEET

FEATURE: 05-May-2000

PYRAMID LAKE FISHWAY
INTERMEDIATE FISH LADDER (ONE)
REMOVAL OF EXISTING LADDER

J:\123R31\MARBLEBL\FEASEST2.WK4

PROJECT: MARBLE BLUFF DAM

DIVISION:

UNIT: MARBLE BLUFF

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		CONCRETE		196	C.Y.	$150.00	$29,400.00
		HANDRAILS		312	L.F.	$5.00	$1,560.00
		24" CONCRETE PIPE		121	L.F.	$10.00	$1,210.00
		SUBTOTAL					$32,170.00
		MOBILIZATION					$1,600.00
		UNLISTED ITEMS (+/-10%)					$3,230.00
		CONTRACT COST					$37,000.00
		CONTINGENCIES (+/-25%)					$9,000.00
		FIELD COST					$46,000.00

QUANTITIES		PRICES	
BY CHOU CHA	CHECKED BY	BY RLC C K. Copeland	CHECKED 5/5/2000
DATE PREPARED 05-May-2000	DATE CHECKED 05-May-2000	DATE 05-May-2000	PRICE LEVEL

CODE:D-8140

ESTIMATE WORKSHEET

FEATURE: 05-May-2000

PYRAMID LAKE FISHWAY
TERMINAL FISH LADDER
REMOVAL OF EXISTING LADDER

J:\123R31\MARBLEBL\FEASEST2.WK4

PROJECT: MARBLE BLUFF DAM

DIVISION:

UNIT: MARBLE BLUFF

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		CONCRETE					
		FISH LADDER		1,089	C.Y.	$150.00	$163,350.00
		DIFFUSER BOX		28	C.Y.	$150.00	$4,200.00
		HANDRAILS		805	L.F.	$5.00	$4,025.00
		24" CONCRETE PIPE		524	L.F.	$10.00	$5,240.00
		SUBTOTAL					$176,815.00
		MOBILIZATION					$8,800.00
		UNLISTED ITEMS (+/-10%)					$14,385.00
		CONTRACT COST					$200,000.00
		CONTINGENCIES (+/-25%)					$60,000.00
		FIELD COST					$260,000.00

QUANTITIES		PRICES	
BY CHOU CHA	CHECKED BY	BY RKC K. Copeland	CHECKED 5/5/2000
DATE PREPARED 05-May-2000	DATE CHECKED 05-May-2000	DATE 05-May-2000	PRICE LEVEL

Cost Estimate Sheets

Construction of Concrete Flume and Baffle Fish Ladder Alternative

CODE:D-8170

ESTIMATE WORKSHEET

SHEET____ OF ____

FEATURE: 05-May-2000 Pyramid Lake Fishway Ladders Construction dewatering per ladder Ladder #3, Concrete option	**PROJECT:** Marble Bluff Dam **DIVISION:** Brent Mefford **FILE:** J:\123R31\MARBLEBL\CONC-3.WK4

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Work consists of installing sheet piles and a vacuum well point system. Zone is about 300' long by 50' wide interior.					
	1	Mobilization			ls		$16,500
	2	F&P Sheet piling, PSA-23, salvage after use		12,000	sf	$12.00	$144,000
		2 sides x 200' x 30' deep (about 25# steel per sq ft)					
	3	F&P well points, self jetting, 1-1/2", 15' deep		160	ea	$400.00	$64,000
		include stop cock valve and pipe and tee to header pipe					
	4	F&P 3" Schedule 80 header pipe		1,000	lf	$8.00	$8,000
	5	Furnish and operate 100 gpm vacuum pump		1	ls	$15,100.00	$15,100
		assume 4 month duration					
	6	Furnish and operate 100 gpm low head pump		1	ls	$2,720.00	$2,720
		assume 4 month duration					
	7	Installing observation wells, 1" dia, 30' deep, push		3	ea	$1,000.00	$3,000
	8	Labor on-site for monitoring		4	month	$24,000.00	$96,000
		Sub-total					$349,320
		Unlisted items, 10%					$30,680
		CONTRACT COST					$380,000
		Contingencies, 25%					$100,000
		FIELD COST, TOTAL					$480,000

QUANTITIES		PRICES	
BY Jeff Baysinger	CHECKED	BY RKC K. Copeland	CHECKED DCD 5-5-2000
DATE PREPARED	APPROVED	DATE 05/05/2000	PRICE LEVEL

CODE:D-8140

ESTIMATE WORKSHEET

SHEET____ OF _____

FEATURE: 05-May-2000

Marble Bluff Dam
Nevada - California

Fish ladder #3 - concrete chute w/baffles - Appraisal level

PROJECT: Washoe Division - Nevada-California

DIVISION: Mid-Pacific Region

FILE: J:\123R31\MARBLEBL\MBTERLAD.WK4

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Work consists of constructing a concrete chute fish passage struc. w/baffles in Pyramid Lake fishway.					
	1	Mobilization (at 5% of other items)			ls		$28,000
	2	F&P Concrete for fish passage structure		438	cy	$500.00	$219,000
		Conc = 4 ksi: 6 sack mix and steel rebar = 125 lb/cy					
		Include F&H cement & rebar in concrete cy price					
	3	Earthwork (15% of item 2)					$32,850
	4	Baffles, 119 sets (1140#/baffle, 400#/guide)		77,000	lbs	$3.00	$231,000
	5	Guardrail		8,200	lbs	$5.00	$41,000
	6	Misc. metalwork		1,800	lbs	$6.00	$10,800
	7	24" pipe		428	ft	$50.00	$21,400
		Sub-total of all but mobilization					$556,050
		Sub-total with mobilization					$584,050
		Unlisted item, 10%					$55,950
		CONTRACT COST					$640,000
		Contingencies, 25%					$160,000
		FIELD COST, TOTAL					$800,000

QUANTITIES		PRICES	
BY Anne M. Tucker	CHECKED	BY RKC K. Copeland	CHECKED Craig A. [signature] 5/5/2000
DATE PREPARED 05/05/2000	APPROVED	DATE 05-May-2000	PRICE LEVEL

CODE:D-8170

ESTIMATE WORKSHEET

SHEET____ OF ____

FEATURE: 05-May-2000

Pyramid Lake
Fishway Ladders

Construction dewatering per ladder
Ladder #2, Concrete option

PROJECT: Marble Bluff Dam

DIVISION: Brent Mefford

FILE: J:\123R31\MARBLEBL\CONC-2.WK4

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Work consists of installing sheet piles and a					
		vacuum well point system. Zone is about 300'					
		long by 50' wide interior.					
	1	Mobilization			ls		$24,000
	2	F&P Sheet piling, PSA-23, salvage after use		24,000	sf	$12.00	$288,000
		2 sides x 400' x 30' deep (about 25# steel per sq ft)					
	3	F&P well points, self jetting, 1-1/2", 15' deep		160	ea	$400.00	$64,000
		include stop cock valve and pipe and tee to header pipe					
	4	F&P 3" Schedule 80 header pipe		1,000	lf	$8.00	$8,000
	5	Furnish and operate 100 gpm vacuum pump		1	ls	$15,100.00	$15,100
		assume 4 month duration					
	6	Furnish and operate 100 gpm low head pump		1	ls	$2,720.00	$2,720
		assume 4 month duration					
	7	Installing observation wells, 1" dia, 30' deep, push		3	ea	$1,000.00	$3,000
	8	Labor on-site for monitoring		4	month	$24,000.00	$96,000
		Sub-total					$500,820
		Unlisted items, 10%					$49,180
		CONTRACT COST					$550,000
		Contingencies, 25%					$140,000
		FIELD COST, TOTAL					$690,000

QUANTITIES		PRICES	
BY Jeff Baysinger	CHECKED	BY KKC K. Copeland	CHECKED DCD 5-5-2000
DATE PREPARED	APPROVED	DATE 05/05/2000	PRICE LEVEL

CODE:D-8140

ESTIMATE WORKSHEET

SHEET____ OF ____

FEATURE: 05-May-2000

Marble Bluff Dam
Nevada - California

Fish ladder #2 - concrete chute w/baffles - Appraisal level

PROJECT: Washoe Division - Nevada-California

DIVISION: Mid-Pacific Region

FILE: J:\123R31\MARBLEBL\MBTERLAD.WK4

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Work consists of constructing a concrete chute fish passage struc. w/baffles in Pyramid Lake fishway.					
	1	Mobilization (at 5% of other items)			ls		$28,000
	2	F&P Concrete for fish passage structure		438	cy	$500.00	$219,000
		Conc = 4 ksi: 6 sack mix and steel rebar = 125 lb/cy					
		Include F&H cement & rebar in concrete cy price					
	3	Earthwork (15% of item 2)					$32,850
	4	Baffles, 119 sets (1140#/baffle, 400#/guide)		77,000	lbs	$3.00	$231,000
	5	Guardrail		8,200	lbs	$5.00	$41,000
	6	Misc. metalwork		1,800	lbs	$6.00	$10,800
	7	24" pipe		428	ft	$50.00	$21,400
		Sub-total of all but mobilization					$556,050
		Sub-total with mobilization					$584,050
		Unlisted item, 10%					$55,950
		CONTRACT COST					$640,000
		Contingencies, 25%					$160,000
		FIELD COST, TOTAL					$800,000

QUANTITIES		PRICES	
BY Anne M. Tucker	CHECKED	BY KKC K. Copeland	CHECKED Craig A. Gush 5/5/2000
DATE PREPARED 05/05/2000	APPROVED	DATE 05-May-2000	PRICE LEVEL

CODE:D-8170

ESTIMATE WORKSHEET

SHEET____ OF _____

FEATURE:	PROJECT:
Pyramid Lake Fishway Ladders Construction dewatering Ladder #1, concrete option -1A 05-May-2000	Marble Bluff Dam
	DIVISION: Brent Mefford
	FILE: J:\123R31\MARBLEBL\CONC-1.WK4

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Work consists of installing sheet piles and a					
		deep well pumping system for a 560' zone, 14' down.					
	1	Mobilization			ls		$28,000
	2	F&P temporary earth coffer dam across channel		3,000	cy	$6.00	$18,000
	3	F&P Sheet piling, PMA-22, salvage after use		10,800	sf	$15.00	$162,000
		Semicircular 180' x 60' deep (about 25# steel per sq ft)					
	4	Furnish and operate 250 gpm for inital site unwatering		1	ls	$500.00	$500
		assume 4 day duration, kept 2 weeks at site					
	5	Drilling 8" diameter, 70 feet deep pump wells		22	ea	$8,000.00	$176,000
		cased with 25 foot well screen					
	6	Furnish and operate 100 gpm pumps in the wells		22	ea	$3,000.00	$66,000
		submersible, assume 4 month duration					
	7	Discharge pipe, 10" Schedule 80 PVC		1,200	lf	$20.00	$24,000
	8	Furnish and operate 500 gpm low head pump		2	ea	$6,000.00	$12,000
		assume 4 month duration					
	9	Installing observation wells, 1" dia, 30' deep, push		4	ea	$1,000.00	$4,000
	10	Labor on-site for monitoring		4	month	$24,000.00	$96,000
		Sub-total					$586,500
		Unlisted items, 10%					$63,500
		CONTRACT COST					$650,000
		Contingencies, 25%					$160,000
		FIELD COST, TOTAL					$810,000

QUANTITIES		PRICES	
BY Jeff Baysinger	CHECKED	BY RKC K. Copeland	CHECKED DCD 5-8-2000
DATE PREPARED	APPROVED	DATE 05/05/2000	PRICE LEVEL

CODE:D-8140

ESTIMATE WORKSHEET

SHEET____ OF ____

FEATURE: 05-May-2000

Marble Bluff Dam
Nevada - California

Fish ladder #1A - concrete chute w/baffles - Appraisal level

PROJECT: Washoe Division - Nevada-California

DIVISION: Mid-Pacific Region

FILE: J:\123R31\MARBLEBL\MBTERLAD.WK4

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Work consists of constructing a concrete chute fish passage struc. w/baffles in Pyramid Lake fishway.					
	1	Mobilization (at 5% of other items)			ls		$35,000
	2	F&P Concrete for fish passage structure		532	cy	$500.00	$266,000
		Conc = 4 ksi: 6 sack mix and steel rebar = 125 lb/cy					
		Include F&H cement & rebar in concrete cy price					
	3	Earthwork (15% of item 2)					$39,900
	4	Baffles, 119 sets (1140#/baffle, 400#/guide)		106,300	lbs	$2.85	$302,955
	5	Guardrail		11,100	lbs	$5.00	$55,500
	6	Misc. metalwork		1,800	lbs	$6.00	$10,800
	7	24" pipe		582	ft	$50.00	$29,100
		Sub-total of all but mobilization					$704,255
		Sub-total with mobilization					$739,255
		Unlisted item, 10%					$70,745
		CONTRACT COST					$810,000
		Contingencies, 25%					$190,000
		FIELD COST, TOTAL					$1,000,000

QUANTITIES		PRICES	
BY Anne M. Tucker	CHECKED	BY RKC K. Copeland	CHECKED Gary A. Gush 5/5/2000
DATE PREPARED 05/05/2000	APPROVED	DATE 05-May-2000	PRICE LEVEL

CODE:D-8170

ESTIMATE WORKSHEET

SHEET____ OF____

FEATURE: 05-May-2000

Pyramid Lake
Fishway Ladders

Construction dewatering
Ladder #1, concrete option - 1B

PROJECT: Marble Bluff Dam

DIVISION: Brent Mefford

FILE: J:\123R31\MARBLEBL\CONC-1B.WK4

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Work consists of installing sheet piles and a deep well pumping system for a 720' zone, 14' down.					
	1	Mobilization			ls		$32,000
	2	F&P temporary earth coffer dam across channel		3,000	cy	$6.00	$18,000
	3	F&P Sheet piling, PMA-22, salvage after use Semicircular 180' x 60' deep (about 25# steel per sq ft)		10,800	sf	$15.00	$162,000
	4	Furnish and operate 250 gpm for inital site unwatering assume 4 day duration, kept 2 weeks at site		1	ls	$500.00	$500
	5	Drilling 8" diameter, 70 feet deep pump wells cased with 25 foot well screen		28	ea	$8,000.00	$224,000
	6	Furnish and operate 100 gpm pumps in the wells submersible, assume 4 month duration		28	ea	$3,000.00	$84,000
	7	Discharge pipe, 12" Schedule 80 PVC		1,600	lf	$25.00	$40,000
	8	Furnish and operate 500 gpm low head pump assume 4 month duration		3	ea	$6,000.00	$18,000
	9	Installing observation wells, 1" dia, 30' deep, push		6	ea	$1,000.00	$6,000
	10	Labor on-site for monitoring		4	month	$24,000.00	$96,000
		Sub-total					$680,500
		Unlisted items, 10%					$69,500
		CONTRACT COST					$750,000
		Contingencies, 25%					$190,000
		FIELD COST, TOTAL					$940,000

QUANTITIES		PRICES	
BY Jeff Baysinger	CHECKED	BY RKC K. Copeland	CHECKED DCD 5-5-2000
DATE PREPARED	APPROVED	DATE 05/05/2000	PRICE LEVEL

CODE:D-8140

ESTIMATE WORKSHEET

SHEET____ OF ____

FEATURE: 05-May-2000

Marble Bluff Dam
Nevada - California

Fish ladder #1B - concrete chute w/baffles - Appraisal level

PROJECT: Washoe Division - Nevada-California

DIVISION: Mid-Pacific Region

FILE: J:\123R31\MARBLEBL\MBTERLAD.WK4

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Work consists of constructing a concrete chute fish passage struc. w/baffles in Pyramid Lake fishway.					
	1	Mobilization (at 5% of other items)			ls		$46,000
	2	F&P Concrete for fish passage structure		731	cy	$500.00	$365,500
		Conc = 4 ksi: 6 sack mix and steel rebar = 125 lb/cy					
		Include F&H cement & rebar in concrete cy price					
	3	Earthwork (15% of item 2)					$54,825
	4	Baffles, 119 sets (1140#/baffle, 400#/guide)		135,500	lbs	$2.75	$372,625
	5	Guardrail		14,000	lbs	$5.00	$70,000
	6	Misc. metalwork		1,800	lbs	$6.00	$10,800
	7	24" pipe		735	ft	$50.00	$36,750
		Sub-total of all but mobilization					$910,500
		Sub-total with mobilization					$956,500
		Unlisted item, 10%					$93,500
		CONTRACT COST					$1,050,000
		Contingencies, 25%					$250,000
		FIELD COST, TOTAL					$1,300,000

QUANTITIES		PRICES	
BY Anne M. Tucker	CHECKED	BY RKC K. Copeland	CHECKED Craig A. [signature] 5/5/2000
DATE PREPARED 05/05/2000	APPROVED	DATE 05-May-2000	PRICE LEVEL

Cost Estimate Sheets

Construction of Rock Channel and Boulder Weir Fish Ladder Alternative

CODE:D-8170

ESTIMATE WORKSHEET

SHEET____ OF ____

FEATURE: 05-May-2000	PROJECT:
Pyramid Lake Fishway Ladders Construction dewatering per ladder Ladder #3, Rock option	Marble Bluff Dam
	DIVISION: Brent Mefford
	FILE: J:\123R31\MARBLEBL\ROCK3-4.WK4

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Work consists of installing sheet piles and a					
		vacuum well point system. Zone is about 220'					
		long by 50' wide interior.		220x2 +60 +100			
	1	Mobilization			ls		$5,600
	2	F&P Sheet piling, PSA-23, salvage after use		none	sf		
		2 sides x 0' x 30' deep (about 25# steel per sq ft)					
	3	F&P well points, self jetting, 1-1/2", 15' deep		128	ea	$350.00	$44,800
		include stop cock valve and pipe and tee to header pipe					
	4	F&P 3" Schedule 80 header pipe		840 (220# 200x2	lf get away from site	$8.00	$6,720
	5	Furnish and operate 100 gpm vacuum pump		1	ls	$7,550.00	$7,550
		assume 2 month duration					
	6	Furnish and operate 100 gpm low head pump		1	ls	$1,360.00	$1,360
		assume 2 month duration					
	7	Installing observation wells, 1" dia, 30' deep, push		3	ea	$1,000.00	$3,000
	8	Labor on-site for monitoring		2	month	$24,000.00	$48,000
		Sub-total					$117,030
		Unlisted items, 10%					$12,970
		CONTRACT COST					$130,000
		Contingencies, 25%					$30,000
		FIELD COST, TOTAL					$160,000

QUANTITIES		PRICES	
BY Jeff Baysinger	CHECKED	BY RKC K. Copeland	CHECKED DCD 5-5-2000
DATE PREPARED	APPROVED	DATE 05/05/2000	PRICE LEVEL

CODE:D-8140

ESTIMATE WORKSHEET

FEATURE: 05-May-2000

LADDER #3

J:\123R31\MARBLEBL\FEASEST1.WK4

PROJECT: MARBLE BLUFF DAM

DIVISION:

UNIT: MARBLE BLUFF ROCK LADDER

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		EXCAVATION		5,195	C.Y.	$12.00	$62,340.00
		BACKFILL WITH COMPACTION		2,070	C.Y.	$9.00	$18,630.00
		RIPRAP		1,985	C.Y.	$75.00	$148,875.00
		GEOTEXTILE		66,580	S.F.	$0.30	$19,974.00
		SUBTOTAL					$249,819.00
		MOBILIZATION					$12,500.00
		UNLISTED ITEMS (+/-10%)					$27,681.00
		CONTRACT COST					$290,000.00
		CONTINGENCIES (+/-25%)					$70,000.00
		FIELD COST					$360,000.00

QUANTITIES		PRICES	
BY BRENT MEFFORD	CHECKED BY	BY RKC K. Copeland	CHECKED BH 5/5/2000
DATE PREPARED 05-May-2000	DATE CHECKED 05-May-2000	DATE 05-May-2000	PRICE LEVEL

CODE:D-8170

ESTIMATE WORKSHEET

SHEET____ OF ____

FEATURE:
Pyramid Lake
Fishway Ladders

Construction dewatering per ladder
Ladder #2, Rock option

08-May-2000

PROJECT:
Marble Bluff Dam

DIVISION:
Brent Mefford

FILE:
J:\123R31\MARBLEBL\ROCK2-4.WK4

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Work consists of installing a					
		vacuum well point system. Zone is about 570'					
		long by 50' wide interior.					
	1	Mobilization			ls		$8,700
	2	F&P Sheet piling, PSA-23, salvage after use		none	sf		
		2 sides x 0' x 30' deep (about 25# steel per sq ft)					
	3	F&P well points, self jetting, 1-1/2", 15' deep		268	ea	$350.00	$93,800
		include stop cock valve and pipe and tee to header pipe					
	4	F&P 4" Schedule 80 header pipe		1,540	lf	$10.00	$15,400
	5	Furnish and operate 150 gpm vacuum pump		1	ls	$9,000.00	$9,000
		assume 2 month duration					
	6	Furnish and operate 150 gpm low head pump		1	ls	$1,800.00	$1,800
		assume 2 month duration					
	7	Installing observation wells, 1" dia, 30' deep, push		6	ea	$1,000.00	$6,000
	8	Labor on-site for monitoring		2	month	$24,000.00	$48,000
		Sub-total					$182,700
		Unlisted items, 10%					$17,300
		CONTRACT COST					$200,000
		Contingencies, 25%					$50,000
		FIELD COST, TOTAL					$250,000

QUANTITIES		PRICES	
BY: Jeff Baysinger	CHECKED	BY: RKC K. Copeland	CHECKED: DCD 5-8-2000
DATE PREPARED	APPROVED	DATE: 05/08/2000	PRICE LEVEL

CODE:D-8140

ESTIMATE WORKSHEET

FEATURE: 05-May-2000

LADDER #2

J:\123R31\MARBLEBL\FEASEST1.WK4

PROJECT: MARBLE BLUFF DAM

DIVISION:

UNIT: MARBLE BLUFF ROCK LADDER

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		EXCAVATION		3,335	C.Y.	$15.00	$50,025.00
		BACKFILL WITH COMPACTION		1,800	C.Y.	$9.00	$16,200.00
		RIPRAP		1,985	C.Y.	$75.00	$148,875.00
		GEOTEXTILE		66,580	S.F.	$0.30	$19,974.00
		SUBTOTAL					$235,074.00
		MOBILIZATION					$11,500.00
		UNLISTED ITEMS (+/-10%)					$23,426.00
		CONTRACT COST					$270,000.00
		CONTINGENCIES (+/-25%)					$70,000.00
		FIELD COST					$340,000.00

QUANTITIES		PRICES	
BY BRENT MEFFORD	CHECKED BY	BY RKC K. Copeland	CHECKED BH 5/5/2000
DATE PREPARED 05-May-2000	DATE CHECKED 05-May-2000	DATE 05-May-2000	PRICE LEVEL

CODE:D-8170

ESTIMATE WORKSHEET

SHEET____ OF ____

FEATURE:	PROJECT:
Pyramid Lake Fishway Ladders Construction dewatering per ladder Ladder #1, Rock option 1A 05-May-2000	Marble Bluff Dam
	DIVISION: Brent Mefford
	FILE: J:\123R31\MARBLEBL\ROCK1-3A.WK4

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Work consists of installing sheet piles, well points,					
		and a deep well pumping system at ladder 1.					
		Zone is 1410' by 11' ave drawdown					
	1	Mobilization			ls		$47,000
	2	F&P temporary earth coffer dam across channel		3,000	cy	$6.00	$18,000
	3	F&P Sheet piling, PMA-22, salvage after use		10,800	sf	$15.00	$162,000
		Semicircular 180' x 60' deep (about 25# steel per sq ft)					
	4	Furnish and operate 250 gpm for inital site unwatering		1	ls	$500.00	$500
		assume 4 day duration, kept 2 weeks at site					
	5	Drilling 10" diameter, 70 feet deep pump wells		20	ea	$9,000.00	$180,000
		cased with 25 foot well screen, 50' well spacings					
	6	Furnish and operate 100 gpm pumps in the wells		20	ea	$1,500.00	$30,000
		submersible, assume 2 month duration					
	7	Discharge pipe, 8" Schedule 80 PVC		1,200	lf	$15.00	$18,000
	8	Furnish and operate 500 gpm low head pump		2	ea	$3,000.00	$6,000
		assume 2 month duration					
		Switch to dewatering system for last 910' where					
		average drawdown is about 6'					
	2	F&P Sheet piling, PSA-23, salvage after use		24,600	sf	$12.00	$295,200
		2 sides x 410' x 30' deep (about 25# steel per sq ft)					
	3	F&P well points, self jetting, 1-1/2", 15' deep		364	ea	$350.00	$127,400
		include stop cock valve and pipe and tee to header pipe					

QUANTITIES		PRICES	
BY Jeff Baysinger	CHECKED	BY RKC K. Copeland	CHECKED [signature] 5-5-2000
DATE PREPARED 05/05/2000	APPROVED	DATE	PRICE LEVEL

CODE:D-8170

ESTIMATE WORKSHEET

SHEET____ OF ____

FEATURE: 05-May-2000	PROJECT:
Pyramid Lake Fishway Ladders Construction dewatering per ladder Ladder #1, Rock option 1A	Marble Bluff Dam
	DIVISION: Brent Mefford
	FILE: J:\123R31\MARBLEBL\ROCK1-3A.WK4

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	4	F&P 4" Schedule 80 header pipe		3,000	lf	$10.00	$30,000
	5	Furnish and operate 250 gpm vacuum pump		1	ea	$12,200.00	$12,200
		assume 2 month duration					
	6	Furnish and operate 250 gpm low head pump		1	ea	$2,640.00	$2,640
		assume 2 month duration					
	9	Installing observation wells, 1" dia, 30' deep, push		14	ea	$1,000.00	$14,000
	10	Labor on-site for monitoring		2	month	$24,000.00	$48,000
		Sub-total					$990,940
		Unlisted items, 10%					$109,060
		CONTRACT COST					$1,100,000
		Contingencies, 25%					$250,000
		FIELD COST, TOTAL					$1,350,000

QUANTITIES		PRICES	
BY Jeff Baysinger	CHECKED	BY RKC K. Copeland	CHECKED ACD 5-5-2000
DATE PREPARED	APPROVED	DATE 05/05/2000	PRICE LEVEL

CODE:D-8140

ESTIMATE WORKSHEET

FEATURE: 05-May-2000

LADDER #1 - OPTION #1A

J:\123R31\MARBLEBL\FEASEST1.WK4

PROJECT: MARBLE BLUFF DAM

DIVISION:

UNIT: MARBLE BLUFF ROCK LADDER

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		EXCAVATION		25,595	C.Y.	$8.00	$204,760.00
		BACKFILL WITH COMPACTION		NONE	C.Y.		
		RIPRAP		2,775	C.Y.	$75.00	$208,125.00
		GEOTEXTILE		95,560	S.F.	$0.30	$28,668.00
		SUBTOTAL					$441,553.00
		MOBILIZATION					$22,000.00
		UNLISTED ITEMS (+/-10%)					$46,447.00
		CONTRACT COST					$510,000.00
		CONTINGENCIES (+/-25%)					$130,000.00
		FIELD COST					$640,000.00

QUANTITIES		PRICES	
BY BRENT MEFFORD	CHECKED BY	BY RKC K. Copeland	CHECKED BH 5/5/2000
DATE PREPARED 05-May-2000	DATE CHECKED 05-May-2000	DATE 05-May-2000	PRICE LEVEL

CODE:D-8170

ESTIMATE WORKSHEET

SHEET____ OF ____

FEATURE: 05-May-2000 Pyramid Lake Fishway Ladders Construction dewatering per ladder Ladder #1, Rock option 1B	PROJECT: Marble Bluff Dam DIVISION: Brent Mefford FILE: J:\123R31\MARBLEBL\ROCK1-3B.WK4

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Work consists of installing sheet piles, well points,					
		and a deep well pumping system at ladder 1.					
		Zone is 2000' by 13' ave drawdown					
	1	Mobilization			ls		$67,000
	2	F&P temporary earth coffer dam across channel		3,000	cy	$6.00	$18,000
	3	F&P Sheet piling, PMA-22, salvage after use		10,800	sf	$15.00	$162,000
		Semicircular 180' x 60' deep (about 25# steel per sq ft)					
	4	Furnish and operate 250 gpm for inital site unwatering		1	ls	$500.00	$500
		assume 4 day duration, kept 2 weeks at site					
	5	Drilling 8" diameter, 70 feet deep pump wells		40	ea	$8,000.00	$320,000
		cased with 25 foot well screen, 50' well spacings					
	6	Furnish and operate 100 gpm pumps in the wells		40	ea	$1,500.00	$60,000
		submersible, assume 2 month duration					
	7	Discharge pipe, 12" Schedule 80 PVC		2,200	lf	$25.00	$55,000
	8	Furnish and operate 500 gpm low head pump		4	ea	$3,000.00	$12,000
		assume 2 month duration					
		Switch to dewatering system for last 1000' where					
		average drawdown is about 6.5'					
	2	F&P Sheet piling, PSA-23, salvage after use		36,000	sf	$12.00	$432,000
		2 sides x 600' x 30' deep (about 25# steel per sq ft)					
	3	F&P well points, self jetting, 1-1/2", 15' deep		400	ea	$350.00	$140,000
		include stop cock valve and pipe and tee to header pipe					

QUANTITIES		PRICES	
BY Jeff Baysinger	CHECKED	BY RFC K. Copeland	CHECKED DED 5-5-2000
DATE PREPARED 05/05/2000	APPROVED	DATE	PRICE LEVEL

CODE:D-8170

ESTIMATE WORKSHEET

SHEET____ OF ____

FEATURE: 05-May-2000

Pyramid Lake
Fishway Ladders

Construction dewatering per ladder
Ladder #1, Rock option 1B

PROJECT: Marble Bluff Dam

DIVISION: Brent Mefford

FILE: J:\123R31\MARBLEBL\ROCK1-3B.WK4

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	4	F&P 4" Schedule 80 header pipe		4,100	lf	$10.00	$41,000
	5	Furnish and operate 250 gpm vacuum pump		2	ea	$12,200.00	$24,400
		assume 2 month duration					
	6	Furnish and operate 250 gpm low head pump		2	ea	$2,640.00	$5,280
		assume 2 month duration					
	9	Installing observation wells, 1" dia, 30' deep, push		20	ea	$1,000.00	$20,000
	10	Labor on-site for monitoring		2	month	$24,000.00	$48,000
		Sub-total					$1,405,180
		Unlisted items, 0%					$144,820
		CONTRACT COST					$1,550,000
		Contingencies, 25%					$400,000
		FIELD COST, TOTAL					$1,950,000

QUANTITIES		PRICES	
BY: Jeff Baysinger	CHECKED	BY: RKC K. Copeland	CHECKED: ACD 5-5-2000
DATE PREPARED	APPROVED	DATE: 05/05/2000	PRICE LEVEL

CODE:D-8140

ESTIMATE WORKSHEET

SHEET 1 OF 1

FEATURE: 05-May-2000

LADDER #1 - OPTION #1B

J:\123R31\MARBLEBL\FEASEST1.WK4

PROJECT: MARBLE BLUFF DAM

DIVISION:

UNIT: MARBLE BLUFF ROCK LADDER

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		EXCAVATION		46,690	C.Y.	$7.00	$326,830.00
		BACKFILL WITH COMPACTION		NONE	C.Y.		
		RIPRAP		3,460	C.Y.	$75.00	$259,500.00
		GEOTEXTILE		120,760	S.F.	$0.30	$36,228.00
		SUBTOTAL					$622,558.00
		MOBILIZATION					$31,000.00
		UNLISTED ITEMS (+/-10%)					$66,442.00
		CONTRACT COST					$720,000.00
		CONTINGENCIES (+/-25%)					$180,000.00
		FIELD COST					$900,000.00

QUANTITIES		PRICES	
BY BRENT MEFFORD	CHECKED BY	BY RKC K. Copeland	CHECKED BH 5/5/2000
DATE PREPARED 05-May-2000	DATE CHECKED 05-May-2000	DATE 05-May-2000	PRICE LEVEL

Cost Estimate Sheets
Construction of Fishway Channel

CODE:D-8140

ESTIMATE WORKSHEET

FEATURE: 05-May-2000

PYRAMID LAKE FISHWAY
CANAL LINING

J:\123R31\MARBLEBL\FEASEST3.WK4

PROJECT: MARBLE BLUFF DAM

DIVISION:

UNIT: MARBLE BLUFF

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		CANAL LINING /100 FT.		520	C.Y.	$15.00	$7,800.00
		(WILL BE LIME TREATED WITH 5%					
		AND THE SPREAD)					
		EXCAVATION /100 FT.		50	C.Y.	$5.00	$250.00
		COMPACTING CANAL LINING /100FT.		520	C.Y.	$3.00	$1,560.00
		O&M ROAD GRAVEL SURFACING/100 FT.		15	C.Y.	$45.00	$675.00
		SUBTOTAL					$10,285.00
		MOBILIZATION					$510.00
		UNLISTED ITEMS (+/-10%)					$1,205.00
		CONTRACT COST					$12,000.00
		CONTINGENCIES (+/-25%)					$3,000.00
		FIELD COST					$15,000.00

QUANTITIES		PRICES	
BY ART GLICKMAN	CHECKED BY	BY RKC K. Copeland	CHECKED
DATE PREPARED 05-May-2000	DATE CHECKED 05-May-2000	DATE 05-May-2000	PRICE LEVEL 5/5/2000