State of California
The Resources Agency

Department of Water Resources
Northern District

DRAFT

RECONNAISSANCE LEVEL ENGINEERING INVESTIGATION

FOR FISH PASSAGE FACILITIES ON BATTLE CREEK

MEMORANDUM REPORT

September 1998

State of California

The Resources Agency

Memorandum

Date: September 16, 1997

To: Naser Bateni, Chief
Northern District

Brian Stewart

From: Department of Water Resources

Subject: Reconnaissance Level Engineering Investigation for Fish Passage Facilities on Battle Creek. This investigation was conducted under the direction of CalFED

The Engineering Studies Section of the California Department of Water Resource, Northern District, under the direction of Bill Mendenhall, Section Chief, has completed a reconnaissance level engineering investigation for improving fish passage at five diversion sites on Battle Creek. The five sites are Coleman Diversion, lnskip Diversion, South Diversion, Wildcat Diversion, and North Battle Creek Feeder Diversion. This report is the results of the investigation. Information dealing with fish passage improvements at Eagle Canyon Diversion have also been included, which was published by DWR December of 1997.

The information provided will establish a baseline from which planning can be conducted to formulate an inclusive restoration plan. Once a restoration plan has been established, DWR will provide additional engineering and consultation regarding fish passage facilities at these five sites in much greater detail. This is consistent with the current cost sharing contracts with Metropolitan Water District of Southern California and United States Bureau of Reclamation. DWR is continuing to gather essential data and information which will be needed to further the design alternatives.

The following people assisted in the preparation and field activities for this report: Curtis Anderson, Associate Engineer; Kevin Dossey, Associate Engineer; Jim West, Assistant Land Surveyor; Jason Jurrens, Student Assistant E&A; Felica Gibbons, Student Assistant E&A; Scott Kennedy, Student Assistant E&A; Jared Meredith, Student Assistant E&A.

Enclosure

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Summary

Information provided in this report is at the reconnaissance level and can be used to aid stakeholders in development of an inclusive restoration plan. Once a plan is developed, it is DWR's goal to provide preliminary designs for fish passage on at least three of the five sites discussed in this report. DWR is continuing to gather engineering and biological data which will be used to develop more detailed and site specific solutions with input from stakeholders, landowners, and agency experts.

For ease of use, Table 1 is provided. Table 1 is a summary of the report showing the site, the proposed components to improve fish passage, and the estimated component costs. A detailed written description and discussion of each site is included in the report, along with appendices which provide photographs and drawings.

Table 1. Summary of Fish Passage Components on Battle Creek

Site Name	Component	Approximate Component Cost($)
Coleman Diversion	Tailrace Connector *	~~$2,125,000~~ 2,600,000
	340 cfs Fish Screen	$2,080,000
	60 cfs Fish Screen	$685,000
	Fish Ladder	$857,000
Inskip Diversion	220 cfs Fish Screen	$1,500,000
	Fish Ladder	$1,050,000
	Tunnel-Tailrace Connection	$5,000,000
	In Stream Channel Realignment	$125,000 Initial Year ($40,000/Year)
South Diversion	90 cfs Fish Screen	$1,090,000
	Retrofit Existing Fish Ladder	$100,000
	New Fish Ladder	$770,000
Wildcat Diversion	20 cfs Fish Screen	$425,000
	Fish Ladder	$620,000
North Battle Creek Feeder	55 cfs Fish Screen	$585,000
	Fish Ladder	$630,000
Eagle Canyon'	70 cfs Fish Screen	$1,098,000
	Fish Ladder	$1,028,000

1 information from DWR, North Fork Battle Creek Eagle Canyon Diversion Preliminary Engineering Fish Passage Project.

Introduction

Battle Creek is a tributary of the upper Sacramento River. It is approximately 40 miles long and encompasses a watershed of 337 square miles. The creek is largely fed by rainfall and snowmelt on the western slopes of the Cascade Range within Lassen National Forest. The overall gradient of Battle Creek is high; falling over 5,000 feet in less than 50 miles. Two main forks make up Battle Creek: North Fork Battle Creek and South Fork Battle Creek, each containing approximately 50 percent of the total creek flow (based on watershed area ratio). The split of the two forks occurs about 12 miles up from the confluence with the Sacramento River. North Fork Battle Creek has run off flows supplemented by large amounts of spring water which emerge along its banks. Both forks are made up of steady flowing cold water, which flow through deep gorges, and have relatively high flows even during dry seasons.

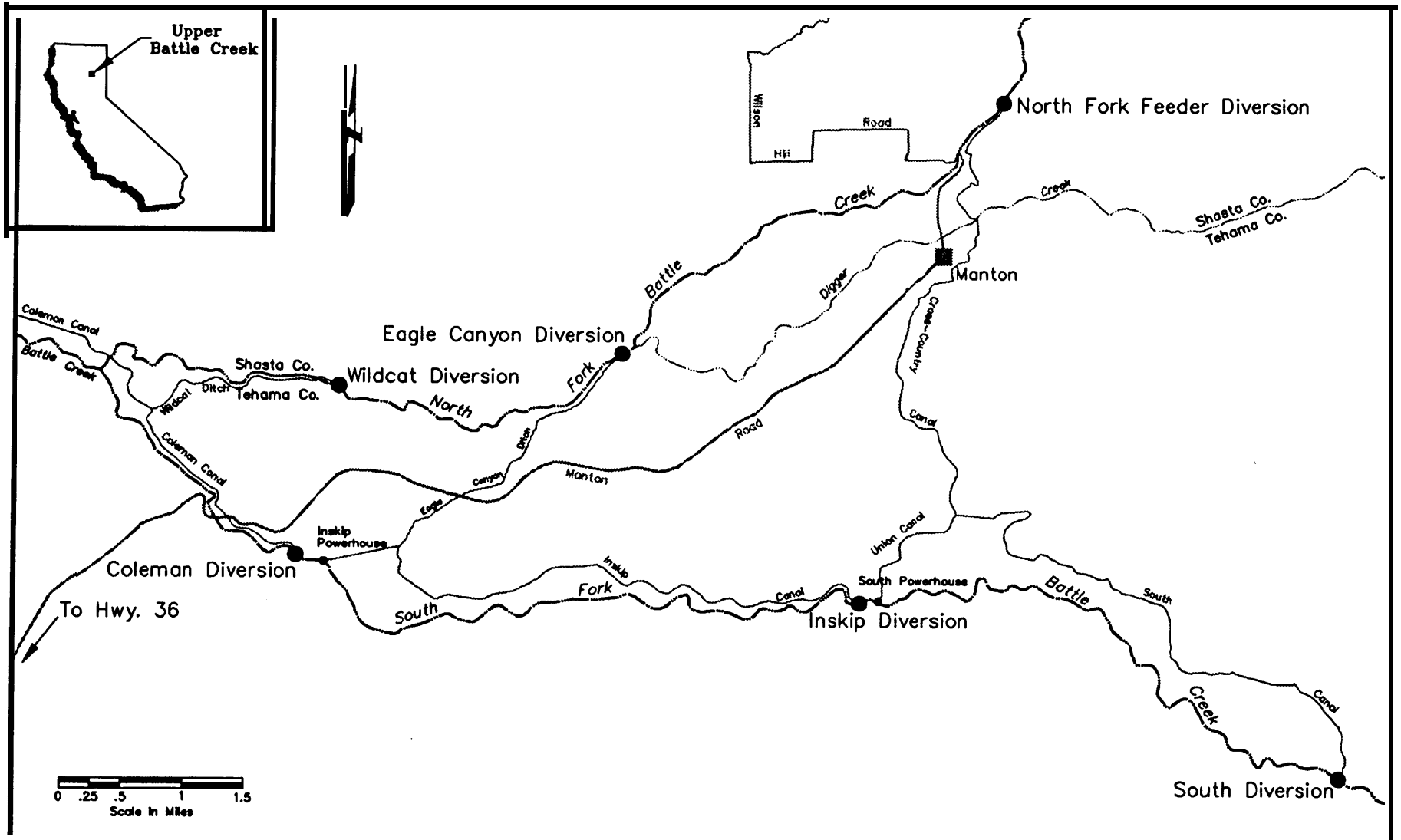
The late nineteenth and early twentieth centuries brought great changes to Northern California. One of the largest changes was the need for electricity, and hydroelectric power generation was a potential local resource. Over a short time Battle Creek was developed into a highly efficient hydroelectric system, with several small diversions, many miles of canal, and some low-volume/high-head power generators. Today the Battle Creek Project (FERC Number 1121) is owned and operated by Pacific Gas and Electric Company. The project consists of five powerhouses, two storage reservoirs, six diversions, a number of small tributary diversions, and a complex network of canals, pipelines, flumes, and tunnels.

Battle Creek has long been recognized as one of the most important Sacramento River tributaries in which spring-run chinook salmon, winter-run chinook salmon, and steelhead trout continue to exist. Past hydroelectric power development and hatchery operations have seriously reduced annual runs of naturally reproducing anadromous fish in Battle Creek. Efforts to develop restoration activities have been ongoing, but none so much as the current actions. Correcting fishery problems at the diversions on Battle Creek due to ineffective fish ladders and unscreened diversions would provide enormous potential for restoring salmonid populations.

Project Location

Five diversions on Battle Creek have been investigated for fish passage in this report. The sixth diversion, Eagle Canyon, was evaluated in a Preliminary Engineering Report completed by California Department of Water Resources, Northern District, Engineering Studies Section late 1997. The five diversions of concern are Coleman, Inskip, and South on the South Fork Battle Creek and Wildcat and North Battle Creek Feeder on the North Fork (Figure 1).

The Shingletown, United States Geological Survey, quad map shows three of the diversions (Wildcat, Coleman, and Inskip). Wildcat diversion is located on the North Fork Battle Creek, which serves as the county line between Shasta and Tehama Counties, and is approximate two miles upstream of the confluence of the forks.



Location Map for UPPER BATTLE CREEK SYSTEM near Manton, California

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Northern District

Figure 1

2

Coleman diversion is the first on the South Fork Battle Creek, upstream two miles from the confluence of the two forks. The next diversion, Inskip, is located on the South Fork Battle Creek about 5.5 miles upstream of Coleman diversion. South diversion is located on South Fork Battle Creek and can be found on USGS quad map Finley Butte. South diversion is the most remote of all the sites. The last site of interest would be North Battle Creek Feeder diversion which is located on North Fork Battle Creek upstream of the Volta Powerhouses. This diversion supplements the flow in the Cross-Country Canal.

Project Description

The current proposed target is to improve fish passage in Battle Creek. This goal would be achieved first by investigating fish passage problems at PG&E diversions and suggesting solutions that are feasible and conform to regulations set forth by fishery agencies. Since February 1997 the Battle Creek Working Group has been working on providing a plan to restore anadromous fish to the Battle Creek system. A number of alternatives for improving fish passage at each diversion has been discussed over the past few months with staff from California Department of Fish and Game, PG&E, DWR, United States Fish and Wildlife Service, National Marine Fisheries Service, MWD, and USBR participating. Each alternative needs to be evaluated from biological, engineering, operational, and economic perspective. Within the constraints of a reconnaissance level study, this report will identify the engineering, operational, and economic issues associated with the fish passage alternatives at each of the five diversion sites discussed previously. This report will coincide with a similar report completed by USBR for the purpose of objectively exploring diversion decommissioning alternatives and associated costs.

It is the intent of this reconnaissance study to provide objective information allowing members of the Battle Creek Working Group to evaluate feasibility and maximize the potential for identifying and moving forward with practical alternatives. Detailed analysis, field exploration, and material investigation are not in the scope of this report. Therefore, it is not a final feasibility report. If detailed survey, geological, and historic data is available or obtained for a given site then this data is used for this report. Otherwise, considerable analysis and exploration work must be performed before feasibility or preliminary engineering investigation can be completed.

A detailed project description is outlined for each diversion site. The description includes a brief discussion of current conditions, planned alternatives, and a summary of planned features. The features were sized with simple hydraulic calculations and engineering judgment, taking into account criteria that has been set forth by DFG and NMFS. Simple, standard drawings are provided to clarify plans and features. If applicable, supporting data and information is provided for each site in the appendices. Photographs of each site can also be found in the appendices.

Project Sites/Alternatives

Coleman Diversion

The diversion at Coleman consists of a rock-filled masonry dam. The dam is 127 feet long and 15 feet high and diverts water from the South Fork of Battle Creek to the Coleman Canal. The creek and canal are separated by a tall, two foot wide rock filled masonry wall. Control of the canal flow is carried out by a number of gates and gages at various locations at the diversion site. The canal is designed to carry 340 cfs at the upper end. There are approximately 9.7 miles of conveyance systems associated with Coleman Diversion, including sections of concrete bench, concrete lined canal, unlined canal, tunnel, and steel pipe.

Coleman Diversion Site is readily accessible to all vehicular traffic. PG&E maintains access to the site from Manton Road by means of a paved road. PG&E also owns the land on which the dam and powerhouse sit. lnskip Powerhouse is located about 1000 feet upstream of Coleman Dam. There is a large flat work area between the powerhouse and the dam which served as a housing area for project operators and maintenance personnel until 1979. This flat area sits well above the stream, preventing flood flows from destroying any buildings or structures.

During high flows, access to the south side of the dam is impossible. There currently is a small fish ladder on the south side of the dam that has been blocked and abandoned. An Alaska Steeppass fish ladder had been placed at the north end of the dam, near a radial gate structure. This ladder is designed to carry a maximum of 7 cfs and has been deemed insufficient and undersized. DFG has requested that the fish ladder be closed to prevent fish from passing upstream of Coleman Dam. There is no fish screen in place at Coleman Diversion.

There are a number of alternatives which could be implemented at Coleman Diversion to improve fish passage. This report addresses the capital improvement options which would require engineering and construction of new fish friendly facilities. Four new components, or combinations of components, are addressed including; a tailrace connector between lnskip Powerhouse and Coleman Canal, a 340 cfs fish screen, a 60 cfs fish screen, and a new fish ladder.

Tailrace Connector

A tailrace connector between lnskip Powerhouse and Coleman Canal is a proposed alternative. This connector would allow water, that is currently being discharged from the powerhouse into South Fork Battle Creek, to be conveyed directly to Coleman Canal. Current conditions are such that the water discharged from the powerhouse enters the stream channel and is diverted again at Coleman Dam. Maximum turbine capacity at lnskip Powerhouse is 300 cfs. The turbine operates under 382 feet of head and typical back-pressure created by the normal water depth of 12 feet. The velocity of the water exiting the powerhouse can be extremely high and

turbulent if water is being bypassed around the turbine. Normally there is 3.5 feet of head loss between the normal water surface elevation at the powerhouse tailrace and the Coleman Dam crest. The water entering the connector from the tailrace would be previously screened water and would not require an on-site fish screen. Creating a deeper back-water would reduce the efficiency of the turbine and is an undesirable condition. Therefore, a large forebay must be designed and constructed, leading to a large diameter conduit approximately 6 feet in diameter, that would have a full flow capacity of 300 cfs. The invert of the conduit must be set at an elevation which is consistent with that of the existing draft tube of the powerhouse. Construction would be large scale and will require 30 foot deep cuts through a complex, hard geologic Tuscan formation of volcanic rock. Detailed planning, design, and engineering are needed to make an efficient, but cost effective system. Schematic drawings of the forebay and afterbay can be found in Appendix 1.

340 CFS Fish Screen

A 340 cfs fish screen would be needed at Coleman Diversion Site if diversion operations continue at present. The fish screen would be placed on Coleman Canal just downstream of the diversion dam. This would be a very large fish screen. Thus, maintenance and operation costs would be relatively high. Due to the large size of the fish screen a great deal of planning, design, and construction would be needed to produce an effective screen system. Reconnaissance level designs currently show a vertical fixed plate type in a linear configuration. It will require an intermediate bypass, therefore demand a large amount of bypass flow. Coleman Diversion Site provides plenty of room to design and construct a fish screen in this area which is protected from high flows, sedimentation, and debris. A schematic of the reconnaissance design can be found in Appendix 1.

60 CFS Fish Screen

A 60 cfs fish screen may be required at Coleman Diversion Site if Coleman Dam remains in place and a tailrace connection is constructed. The screen would probably be located in the canal upstream of the tailrace connector tie in point to Coleman Canal. Reconnaissance level design currently show a vertical fixed plate type screen in a linear configuration. A schematic of the reconnaissance design can be found in Appendix 1.

Fish Ladder

Coleman Dam will require a large fish ladder. It is desired to have a fish ladder that will have a range of flows from 35 to 80 cfs. The ladder would be designed to climb 15 feet, which is the height of the dam. The current reconnaissance design calls for a step pool type fish ladder which will have 12 foot wide by I0 foot long pools and an one foot drop between each pool. The ladder would be constructed of concrete and would be constructed on site.

Table 2 is a summary of the cost associated with each component discussed previously. Each component is shown independently and this is reflected in the cost estimates.

Table 2. Summary of Cost to Improve Fish Passage at Coleman Diversion Site

Component	Estimated Capital Cost
Tailrace Connector	~~$2,125,000~~ 2.6
340 cfs Fish Screen	$2,080,000
60 cfs Fish Screen	$685,000
Fish Ladder	**$857,000**

Inskip Diversion

Inskip Diversion possesses the tallest dam on Battle Creek. The dam crest sits 25 feet above the stream below. The dam is about 100 feet long and is rock-filled masonry type. The dam provides water to Inskip Canal, which consists of tunnel sections, concrete lined canal sections, unlined canal sections, and steel flume. South Powerhouse is about 1500 feet upstream of the dam. The dam and associated downstream facilities are located on private property, whereas the powerhouse property is owned by PG&E. Access to Inskip Diversion Dam is limited by very steep terrain, but access to South Powerhouse is adequate. The dam resides at the base of a very steep slope. This prevents vehicle access from the north side. Personnel must park vehicles near the powerhouse and walk 1800 feet downstream along a narrow, rocky pathway. When South Fork Battle Creek is at low flow, access to the dam is obtained by fording the creek near South Powerhouse. During high flows, maintenance and operation of the dam is difficult because of the access problems. Currently, there is a concrete fish ladder near the center of the dam, which has been modified by inserting an Alaska Steep pass type fish ladder. The Alaska Steep pass fish ladder only carries about 7 cfs maximum flow and the last run section is long and steep.

Upstream and downstream fish passage needs to be improved at this site. The corrections would include a new higher capacity fish ladder for upstream migration and a fish screen for downstream juvenile outflow. Another issue of concern at Inskip Diversion Site is the tailrace discharge from South Powerhouse to South Fork Battle Creek. The discharge is made up of a mixture of South Fork Battle Creek water and North Fork Battle Creek water. It is desired to limit mixing of the effluent of the powerhouse and South Fork Battle Creek. A short description of the components proposed at Inskip Diversion Site follows. Table 3 is a summary of the estimated cost for each proposed component. Photographs and drawings can be found in Appendix 2.

220 CFS Fish Screen

The fish screen must be sized for 220 cfs of diverted water. The fish screen must be located in the canal, near the head, downstream of a short tunnel section. The current proposed site is located on private property, therefore negotiations with owners would be necessary. Access to Inskip Diversion must be improved to insure proper operation and maintenance of a new fish screening facility during all seasons. This would be a large fish screen and current designs suggest a vertical fixed plate type in a chevron configuration. Appendix 2 contains some of the preliminary drawings of the fish screening system.

Fish Ladder

Designing and constructing a fish ladder at this site would be very expensive, because of the 25 foot high of the dam and the complex assortment of rock which must be excavated to provide a foundation. A fish ladder placed on the south side of the dam would have better access for construction, operation, and maintenance. Access and construction for this fish ladder will require landowner negotiations. The fish ladder would be constructed on-site mostly of concrete. The most likely configuration would be a step pool type fish ladder. It would have a capacity of 40 to 80 cfs.

Limit Mixing of South Powerhouse Discharge and South Fork Battle Creek

Two designs can be considered to minimize mixing of the waters. The first alternative would be to eliminate mixing altogether by providing a tunnel works that would take the 222 cfs discharge flow from the powerhouse directly to Inskip Canal. This would be a large scale project and would be very expensive. The second alternative would be to provide a barrier in stream which would limit the mixing of waters during low/medium flow periods. This project could be incorporated into a gravel recruitment project. The conceptual designs call for a channel realignment of both the tailrace and the stream. Gravels would be collected each year and would be stockpiled and dispersed downstream of the dam. The project requires the cooperation of land owners in the area. The goal would be to limit mixing of the water to provide **50** to 70 percent efficiency. Adaptive management could be used to insure that a chemical trace of water taken above the powerhouse matches that of one taken in stream below the dam. In addition, this alternative would have an ongoing operation cost every year for the life of the project.

Table 3. Summary of Cost to Improve Fish Passage at Inskip Diversion Site

Component	Estimated Capital Cost
220 cfs Fish Screen	$1,500,000
Fish Ladder	$1,050,000
Tunnel-Tailrace Connection	$5,000,000
In-stream Channel Realignment	$125,000 Initial Year ($40,000/Year)

South Diversion

South Diversion is the only dam on Battle Creek that has been totally retrofitted. It once was a timber crib structure, but now it is a steel crib dam which diverts 90 cfs of water from South Fork Battle Creek through a short tunnel and into South Canal. Currently, there is a denil type fish ladder located at the dam. This fish ladder capacity is estimated to be between 25-35 cfs. At this time there is no fish screen on site. Property around South Diversion is owned by PG&E. The dam is about 12 feet high. Access to South Diversion site is difficult. Driving time from Manton to the site is over 45 minutes and requires the use of four-wheel drive vehicles.

Both upstream and downstream fish passage must be addressed at this site. Downstream fish passage would be corrected by constructing a fish screen on site. Upstream fish passage could be improved by either retrofitting the existing fish ladder for easier passage or constructing a new higher capacity fish ladder. A short description of the three systems at South Diversion follow, and the cost associated with these are shown in Table 4. Photographs and drawings can be found in Appendix 3.

90 CFS Fish Screen

An off-stream in-canal fish screen is proposed for the South Diversion site. This fish screen would be designed for a maximum diversion of 90 cfs. There would be a juvenile bypass flow between 10-20 cfs. Based on initial calculations the screen would be about 55 feet long and would be in a linear vertical fixed plate configuration. Access to the fish screening location must be improved to insure proper operation and maintenance of the fish screen.

Fish Ladder Retrofit

The configuration of the current fish ladder at South Diversion is fair. Initial calculations reveal that maximum fish ladder capacity is between 25-35 cfs. This fish ladder is a denil type and has a minimum flow of 7 cfs. However, it can be improved so that upstream migrating fish can find the entrance to the ladder during higher flow events. This task could be accomplished by controlling spill over the dam or providing an auxiliary water system to increase flow at the entrance of the fish ladder.

New Fish Ladder

A new fish ladder constructed at South Diversion would be a full denil or pool type. It must be constructed to overcome about a 14 foot elevation change and have a capacity range of 35-80 cfs. The fish ladder would need to be located near the current fish ladder location to provide access for maintenance and operations. There is an extremely high debris load at this location and therefore the fish ladder design must account for this.

Table 4. Summary of Cost to Improve Fish Passage at South Diversion Site

Component	Estimated Capital Cost
90 cfs Fish Screen	**$1,090,000**
Retrofit Existing Fish Ladder	$100,000
New Fish Ladder	$770,000

Wildcat Diversion

Wildcat Diversion consists of a small dam standing only 8 feet tall. The dam is made of rock filled masonry and is approximately 55 feet long. The dam provides water to a 30 inch diameter canal pipe which carries a flow of about 20 cfs. Wildcat Canal system is approximately 1.9 miles long and is made up of pipe, concrete lined sections, and unlined sections. Access to the Wildcat Dam Site is difficult. The dam sits in a steep canyon which is about 100 feet deep. PG&E currently accesses the site from the north rim of Battle Creek. Vehicles must park on the north rim and crews must walk down a steep narrow foot path which leads down to the dam site. Regular maintenance work is currently being conducted from a series of narrow platforms and walkways that are set above the stream. During high flows there is no access to the south side of the dam. There is a small existing fish ladder on the south end of the dam. The fish ladder has been determined to be inefficient and undersized. Damage to existing structures has occurred in the past due to rock falling from the canyon walls. The pipeline leaving Wildcat Diversion was recently damaged by a rock slide which occurred while the system was out of operation per the terms of an interim flow agreement with USBR.

To provide reliable fish passage at Wildcat Diversion, a fish ladder and fish screen should be designed and constructed. The fish screen needs to be designed for a 20 cfs diversion and the fish ladder should operate between 30 to 80 cfs. The fish screening system can be fabricated off-site and placed at the diversion by means of helicopter. A full streamflow fish ladder could be designed and constructed at Wildcat Diversion which would allow fish to pass upstream without delay. The construction of such a fish ladder would be complicated due to the access limitations. There would be high maintenance and operation costs associated with any fish protection devices at this site. Table 5 shows the capital cost of the fish screen and fish ladder components at Wildcat Diversion. Photographs and drawings can be found in Appendix 4.

Table 5: Summary of Cost to Improve Fish Passage at Wildcat Diversion Site

Component	Estimated Capital Cost
20 cfs Fish Screen	$425,000
Fish Ladder	$620,000

North Battle Creek Feeder Diversion

North Battle Creek Feeder Diversion has a relatively small dam. The dam is less than 8 feet tall and around 50 feet long. It is made of rock-filled masonry dam that diverts water from North Fork Battle Creek directly into a metal flume which eventually flows into the Cross-Country Canal. There is currently a fish ladder at the center of the dam, but the diversion does not have a fish screen. Maintenance of the fish ladder during higher flow events is impossible. Access to North Battle Creek Feeder Diversion is difficult. Currently, access to the dam is by foot only. Vehicles must park near Volta II Powerhouse and walk upstream along 700 feet of flume.

Fish passage improvements at North Battle Creek Feeder Diversion will address both upstream and downstream migration. A 55 cfs fish screen needs to be designed and constructed for downstream passage and a 35 to 80 cfs fish ladder needs to be designed and constructed for upstream migration. More data is needed to perform a full design of the structures. Table 6 shows the capital cost for improving the fish passage at North Battle Creek Feeder Diversion.

Table 6. Summary of Cost to Improve Fish Passage at North Battle Creek Feeder Diversion Site

Component	Estimated Capital Cost
55 cfs Fish Screen	$585,000
Fish Ladder	$630,000

Eagle Canyon Diversion

A preliminary engineering fish passage report has been completed for the Eagle Canyon Diversion Site. This report was completed by DWR Northern District, under the direction of Bill Mendenhall, Section Chief. The final report contains preliminary designs for fish ladders and fish screens at the diversion site. The report also provides preliminary cost estimates for the preferred fish passage alternatives. The final alternatives included one fish screen design and two fish ladder designs. The fish screen design was a vertical fixed plate screen in a chevron configuration able to screen 70 cfs of water. The two fish ladders designs were a Denil type II fish ladder and a step pool with orifices. Fish ladder are sized to carry a flow of 10 to 50 cfs. Table 7 shows the project costs for the preferred alternatives.

Table 7. Summary of Cost to Improve Fish Passage at Eagle Canyon Diversion Site

Component	Estimated Capital Cost
70 cfs Fish Screen	$1,098,000
Fish Ladder	$1,028,000

References

Department of Water Resources. 1997. *North Fork Battle Creek Eagle Canyon Diversion Preliminary Engineering Fish Passage Project.* Echols, Glyn and Stewart, Brian.

Historic American Engineering Record. 1980. *The Battle Creek Hydroelectric System: An Historical Study.* Reynold, Terry S. and Scott, Charles.

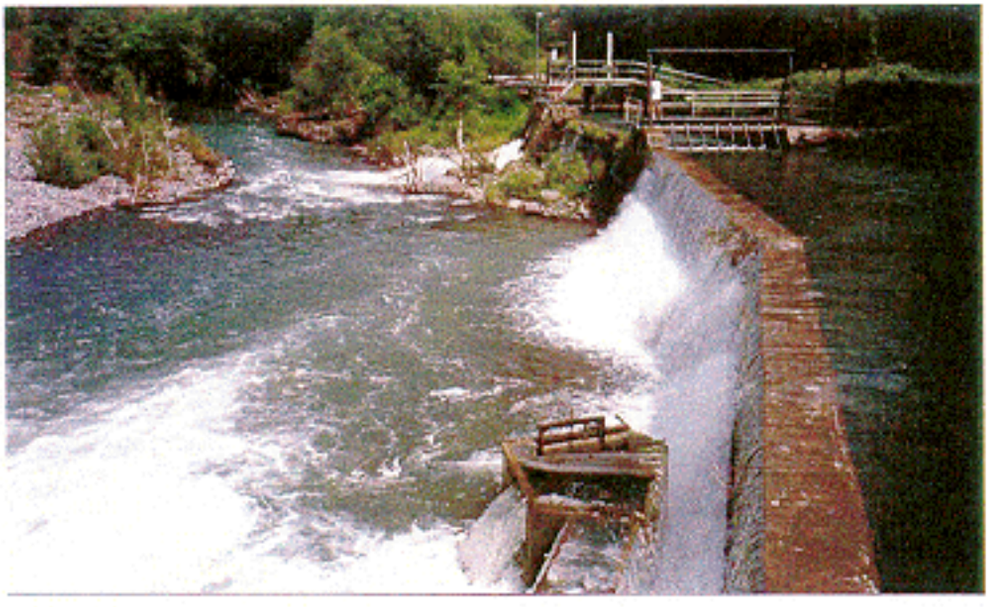
Pacific Gas and Electric Company. 1969. *Battle Creek System Project 1121.* Federal Power Commission.

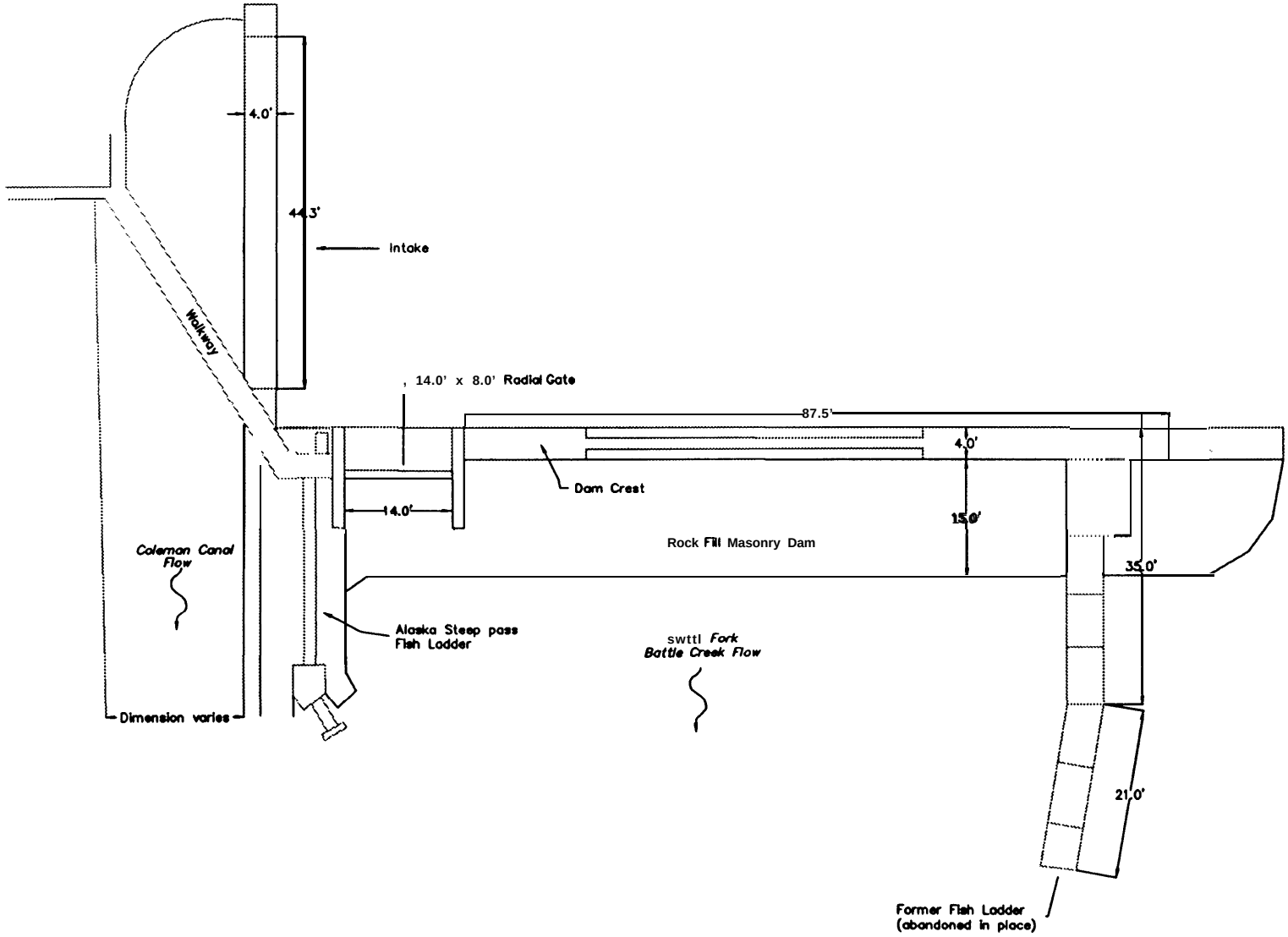
SB1086 Advisory Council. 1989. *Upper Sacramento River Fisheries and Riparian Habitat Management Plan.* pp. 135-l 39.

APPENDIX 1
Coleman Diversion

Photograph 1:
Aerial view of Coleman Diversion located on Battle Creek. This view is looking northeast with Inskip powerhouse located upstream in the upper right portion of the photograph. (credit CDFG)

Photograph 2:
View of Battle Creek looking downstream from the dam. Note the high flow causing water to spill over the diversion canal wall. (credit DWR-ND)



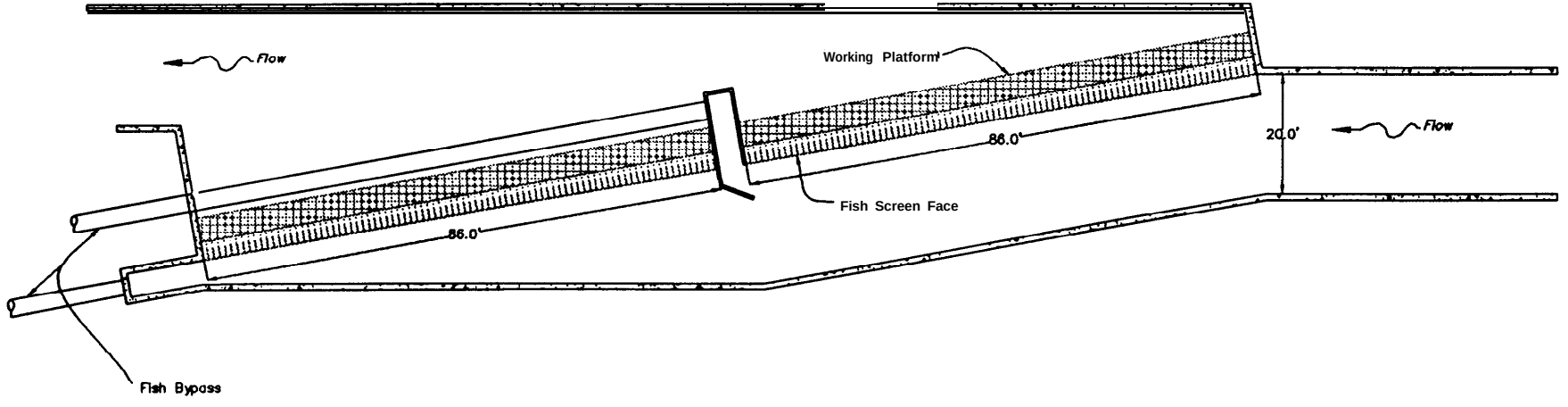


Not to Scale

Reconnaissance Fish Passage Improvements Battle Creek	**Existing Coleman Diversion Dam**		DRAWING : Colemandam.dwg
		Revision Date 9/14/98	

This screen design includes:

1) Coleman Dam remains in place
2) A flaw of 340 cfs may be diverted
3) No tailrace connection
4) Steelhead criteria is used
5) Canal upstream of fish screen designed for 360 cfs
6) Bypass flow to be 10 cfs per bypass entrance
7) Angie between screen face and canal flow set at 6 degrees
8) Wetted depth 6 feet

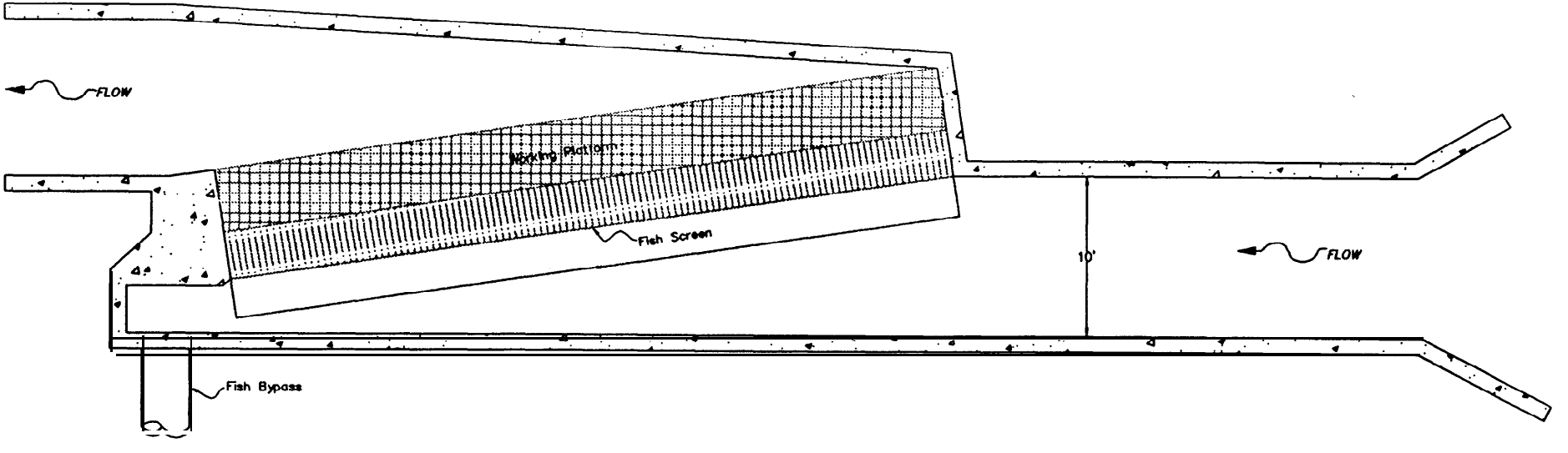


Not to Scale

Reconnaissance Fish Passage Improvements Battle Creek	Fish Screen Design for Coleman Diversion	[illegible] DEPARTMENT OF WATER RESOURCES	DRAWING : fisheorcen300.dwg
		Revision Date: 9 14 98	

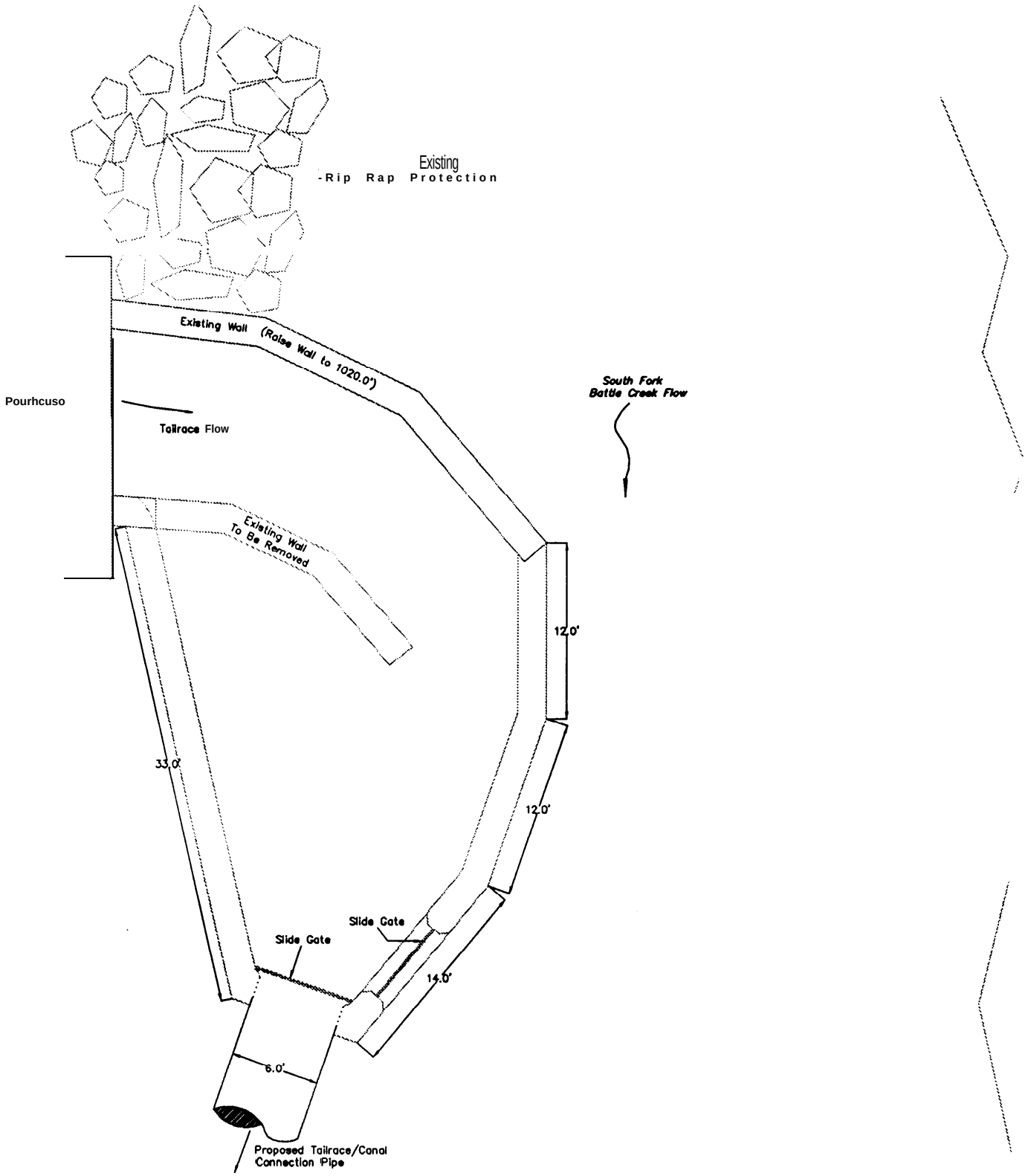
This screen design includes:

1) Coleman Dam remains in place
2) A flow of 60 cfs may be diverted
3) Tailrace connection tie-in is downstream of this screen
4) Steelhead screen criteria is used
5) Canal upstream of fish screen designed for 80 cfs
6) Bypass flow to be 20 cfs
7) Angle between screen face and canal flow set at 8.5 degrees
8) Wetted depth 4 feet



No **Scale**

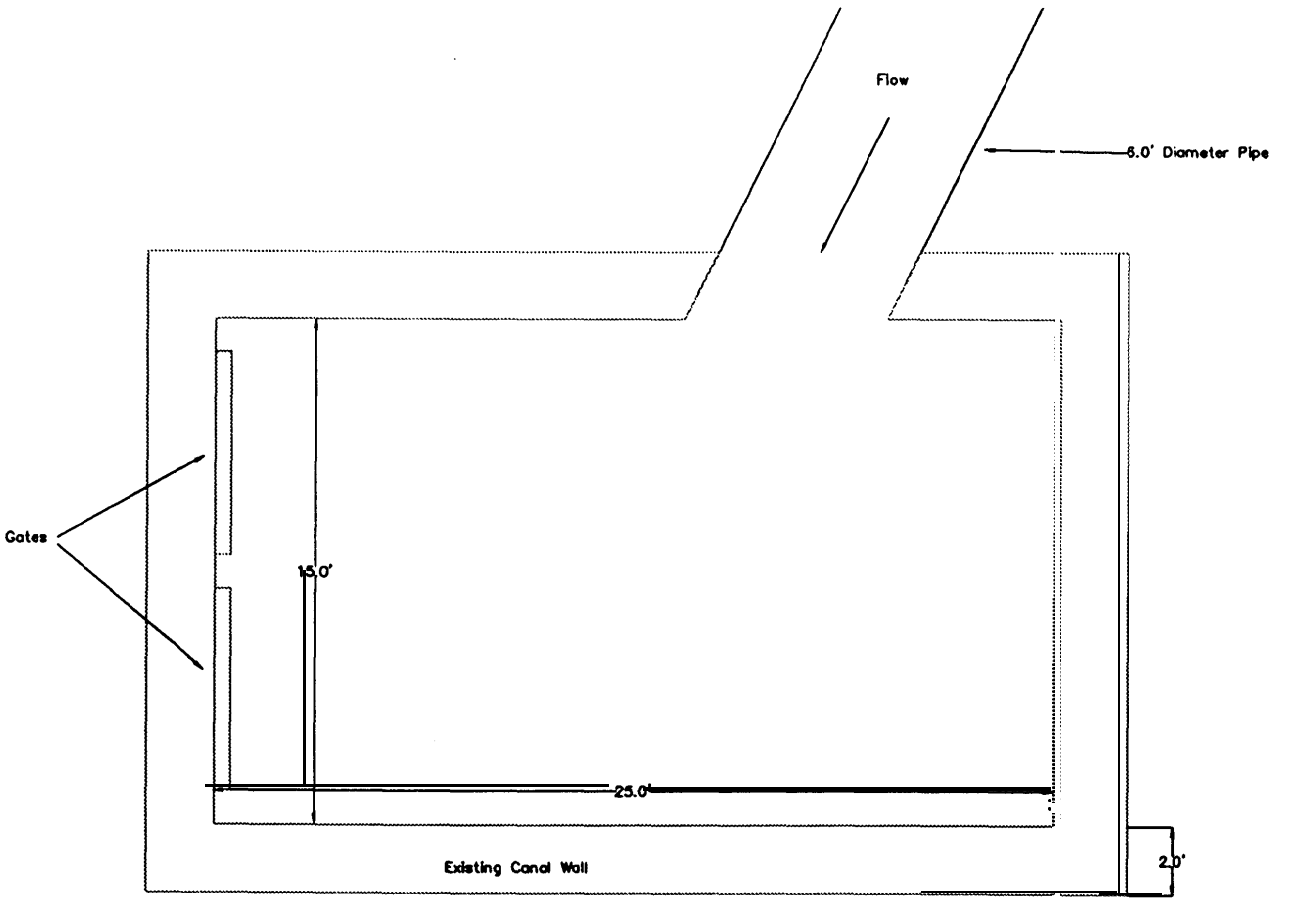
Reconnaissance Fish Passage Improvements Battle Creek	**Fish Screen Design For Coleman Diversion**	Revision Date: 9/14/98	DRAWING : fishscreen60.dwg



NOTES:
2.0' Walls (TYP)
Top of Wall Elevation @ 1020.0' (TYP)
Top of Concrete Floor Elevation at 995.5'
Pipe Invert @ 998.0'

Not to Scale

Reconnaissance Fish Passage Improvements Battle Creek	Coleman Diversion Forebay		DRAWING :
		Revision Date 9/14/98	



2.0' Walls TYP – 1.0' Thick Floor
Invert of Pipe 992.5'
Top of Conc Floor @ 992.0'
Top of All Walls @ 1003.5'
(Match existing wall and canal)

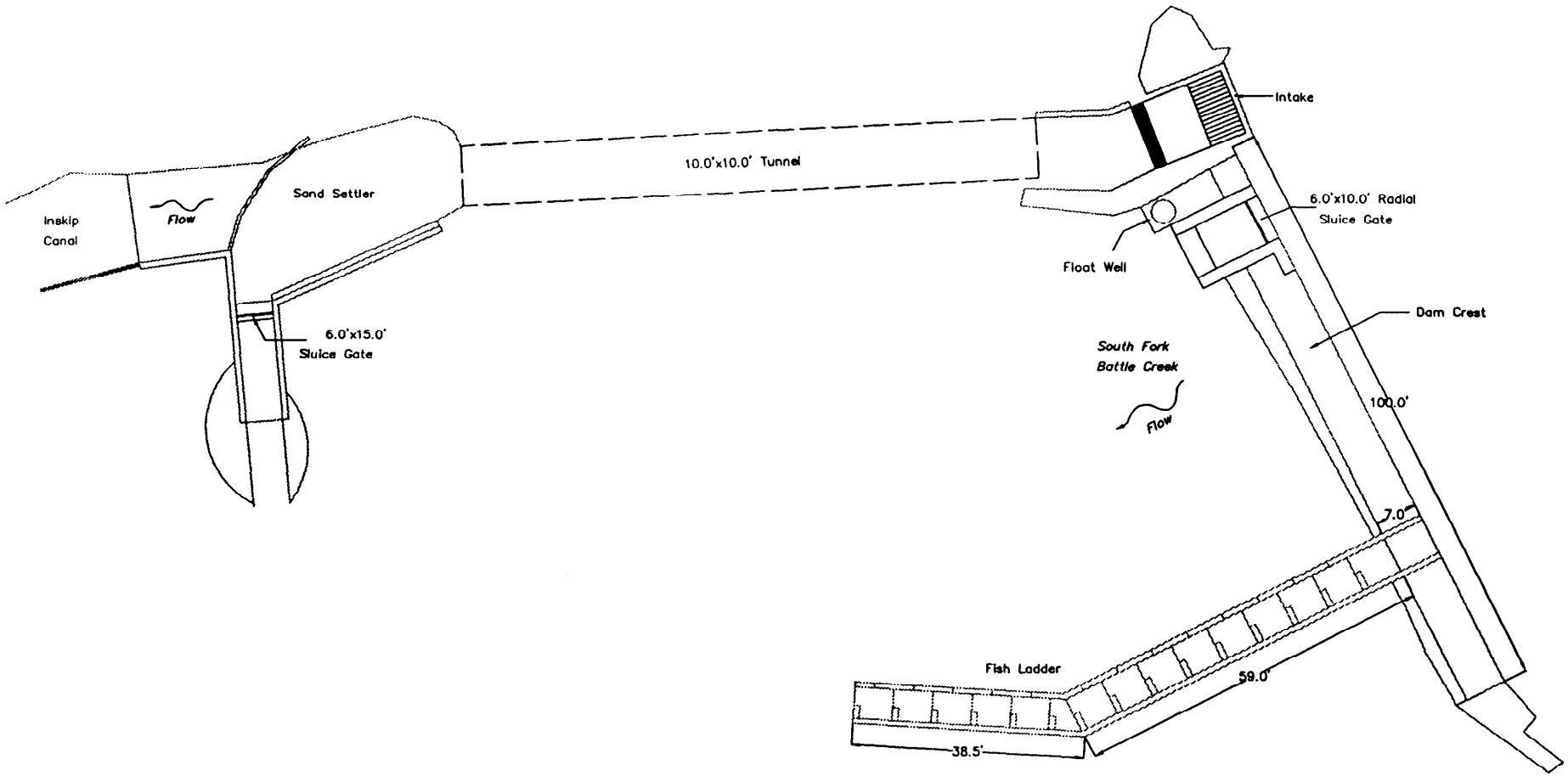
Not to Scale

Reconnaissance Fish Passage Improvements Battle Creek	Coleman Diversion Afterbay		DRAWING : afterbay.dwg
		Revision Date: 9/14/98	

APPENDIX 2
Inskip Diversion

Photograph 3:
Aerial view looking east at Inskip Diversion Dam on Battle Creek. South Powerhouse is located upstream, and the Oasis Springs Resort is located southeast of the diversion dam. (credit CDFG)

Photograph 4:
Aerial view looking at downstream face of Inskip Diversion Dam. Note the large rocks that are present below the dam. (credit CDFG)

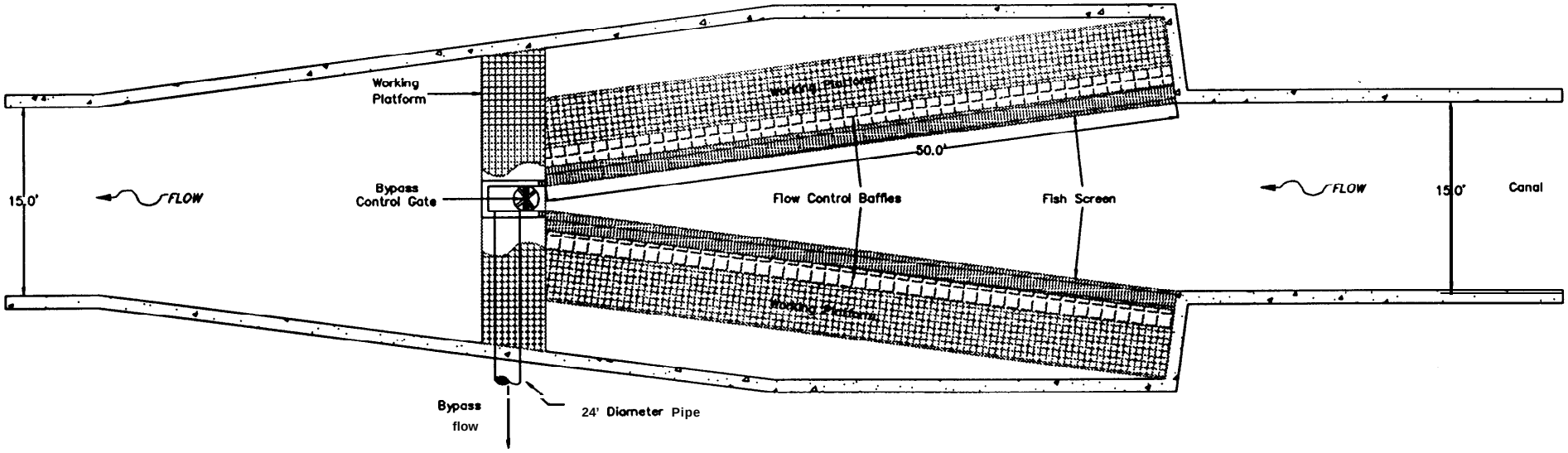


Not to Scale

Reconnaissance Fish Passage Improvements Battle Creek	Existing Inskip Canal Diversion	DEPARTMENT OF WATER RESOURCES Revision Date: 9/14/98	DRAWING : inskipdiversion.dwg

This screen design includes:

1) A flow of 220 cfs may be diverted
2) Stedhead screen criteria is used
3) Canal upstream of fish screen designed for 240 cfs
4) Bypass flow to be 20 cfs
5) Angle between screen face and canal flow set at 7.5 degrees
6) Wetted depth 6.7 feet



Not to **Scale**

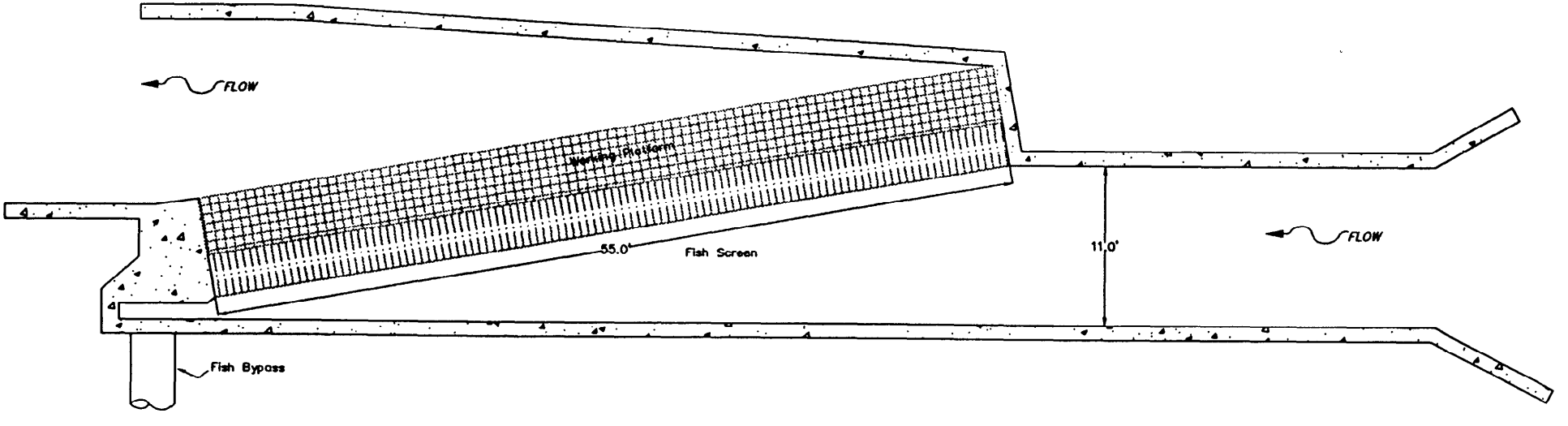
Reconnaissance Fish Passage Improvements Battle Creek	Fish Screen Design for Inskip Diversion	[illegible]	DRAWING : Inskipscreen.dwg
		Date 9/14/98	

APPENDIX 3
South Diversion

Photograph 5:
Aerial view of South Diversion area. (credit CDFG)

Photograph 6:
View of downstream face of South Diversion Dam. (credit CDFG)

This Screen Design Includes:
1) A flow of 90 cfs may be diverted
2) Steelhead screen criteria is used
3) Canal upstream of fish screen designed for 110 cfs
4) Bypass flow to be 20 cfs
5) Angle between screen face and canal flow set at 10 degrees
6) Wetted depth 5 feet



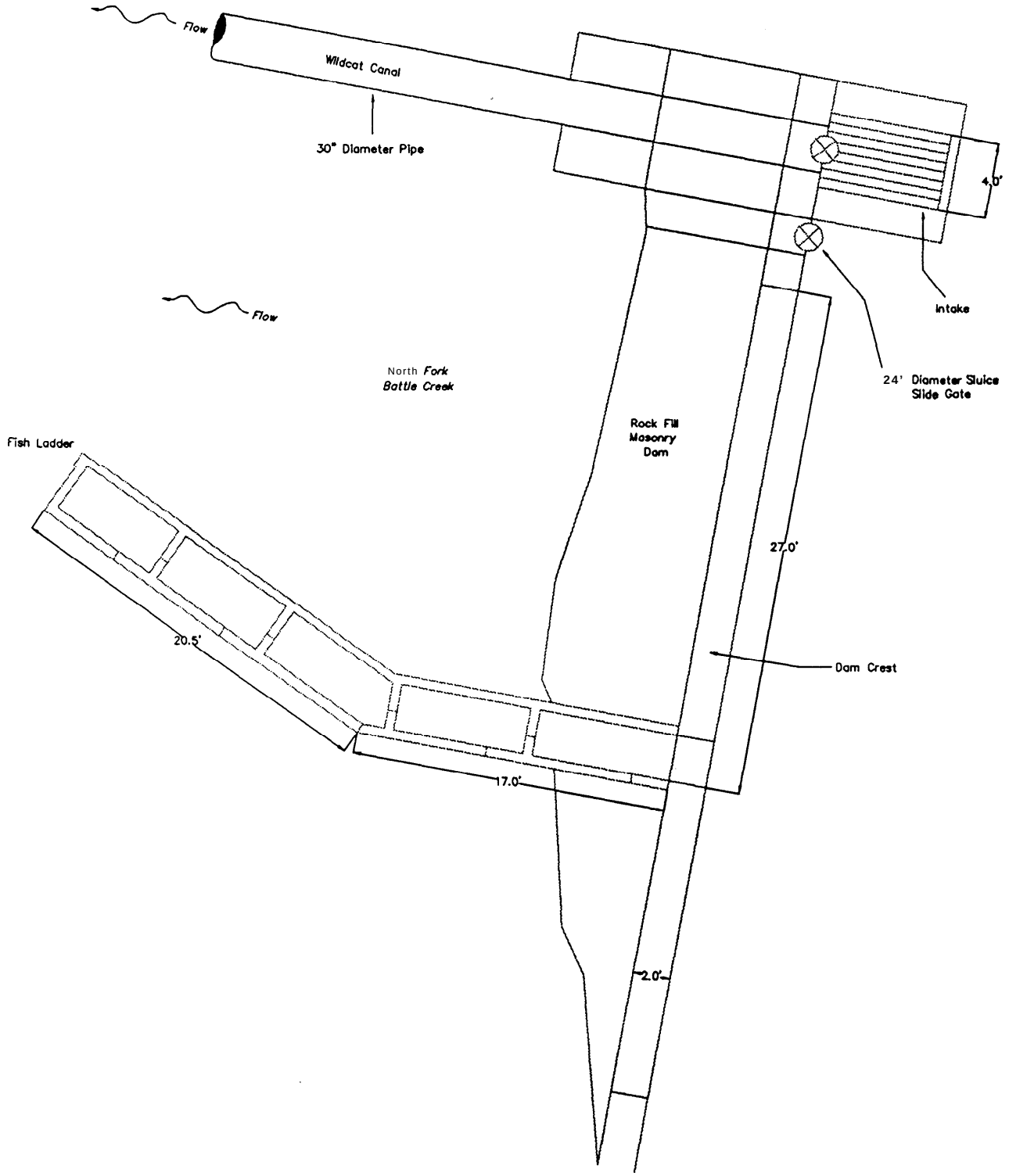
Not to **Scale**

Reconnaissance Fish Passage Improvements Battle Creek	Fish Screen Design for South Diversion	DEPARTMENT OF WATER RESOURCES	DRAWING : southscreen.dwg
		Revision Date: 9/14/98	

APPENDIX 4
Wildcat Diversion

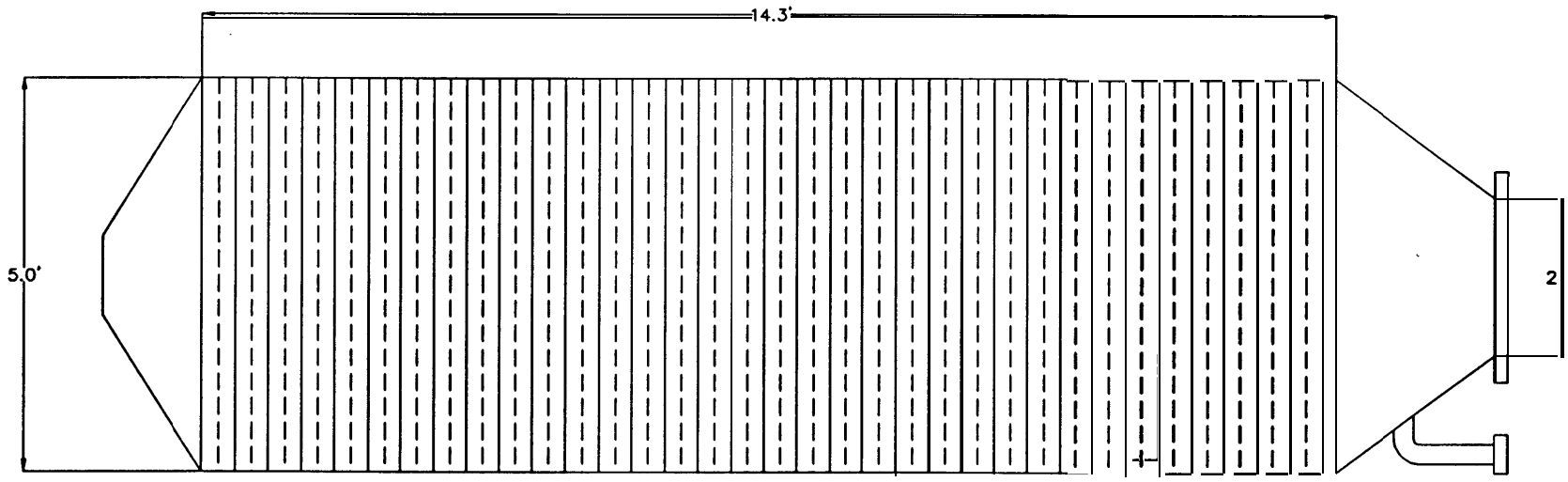
Photograph 7:
Wildcat Diversion during a medium flow event. Note 24-inch pipe downstream of dam and steep canyon walls (credit CDFG)

Photograph 8.
View of downstream face of Wildcat Diversion. Note fish ladder on left bank. (credit DWR-ND)



Not to Scale

Reconnaissance Fish Passage Improvements Battle Creek	Existing Wildcat Canal Diversion	DRAWING 1 9/14/98



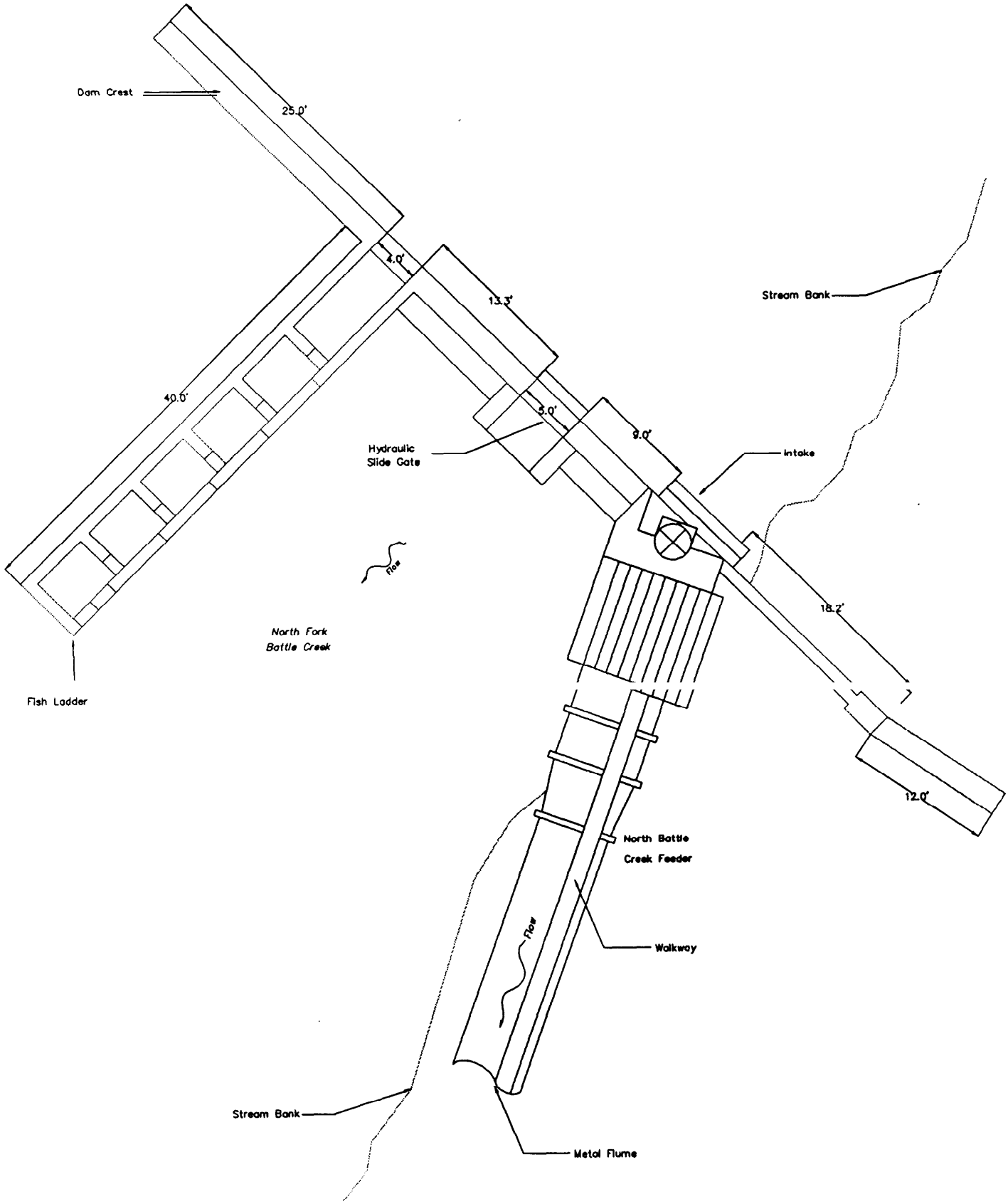
Not to Scale

Reconnaissance Fish Passage Improvements Battle Creek	Wildcat Fish Screen	DRAWING : Colemandam.dwg
		Revision Date 9/4/98

APPENDIX 5
North Battle Creek Feeder Diversion

Photograph 9:
Aerial view of North Battle Creek Feeder Diversion. (credit CDFG)

Photograph 10:
Flume section of North Battle Creek Feeder, just downstream of Diversion. (credit DWR-ND)



No **Scale**

Reconnaissance Fish Passage Improvements Battle Creek	**Existing North Bottle Creek Diversion Dam**	[illegible] Revision Date 9/4 98	DRAWING : [illegible]