# APPENDIX A, Design

## Additional Water Storage Project, Draft Feasibility Report & EIS

**Howard Hanson Dam,**
**Green River, Washington**
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prepared by
**Seattle District**
**US Army Corps of Engineers**

Tacoma Public Utilities

US Army Corps of Engineers®

# APPENDIX A
# DESIGN

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**DRAWINGS**

**Sheets 29 through 35 – Fish Collection Facility, Alternative 9A8, Recommended Plan**

**(A complete set of drawings is included in Appendix H)**

# SECTION 1 GENERAL DESCRIPTION

## 1.1 PROPOSED FISH COLLECTION FACILITY

The proposed fish collection facility is a new structure that is intended to pass migrating juvenile fish downstream through the Howard A. Hanson dam. It is not intended to pass migrating adult fish upstream through the dam. The main features of the fish collection facility are:

- A wet-well,
- a floating fish collector,
- a fish lock,
- a discharge conduit
- a fish transport pipeline.

Currently, the entire Green River flow must pass through the existing outlet works intake structure. Upon completion of the new facility, which will be located adjacent to the existing outlet works, flows will pass through either the existing intake structure or the new fish collection facility.

Essentially, this facility will operate as a lock. The fish are collected into the fish lock by a floating fish collector located in the wet-well, just upstream of the fish lock. Under ideal conditions, all of the reservoir's flow will pass through the fish collector. The fish collector houses a modular-inclined screen that allows 95 percent of the flow to pass through it, while preventing the fish from passing through it. The remaining five percent of the flow "washes" the fish across the modular-inclined screen into a flume that deposits the fish into the fish lock. When a sufficient number of fish are collected, the water level in the fish lock is lowered to a predetermined elevation, and the remaining quantity of water and fish are then discharged as a unit through the fish transport pipeline to the Green River just below the existing stilling basin.

Under operating conditions, there will be a small difference between the upstream reservoir water elevation and the wet-well water elevation, and a 2-foot difference between the wet-well water elevation and the fish lock water elevation. This difference in water elevations, or head, provides the (hydraulic) energy necessary to make the fish collector function.

## 1.2 EXISTING FACILITY

The existing outlet works facility is comprised of:

- an intake tower;
- a 19-foot-wide horseshoe tunnel that is fully lined with reinforced concrete;
- a concrete-encased 48-inch-diameter steel bypass pipeline;
- a reinforced concrete stilling basin at the outlet of the tunnel and bypass pipeline;
- a dam crest spillway with two radial, or tainter, gates; and
- a reinforced concrete flume just downstream of the spillway gates.

The intake tower houses two vented conduits, each with a hydraulically actuated radial gate, that act as the primary discharge control mechanism, and, a single, mechanically hoisted emergency gate that may be positioned to close either conduit.

Under the current operating rules, this facility maintains a reservoir upstream of the dam with a minimum elevation of 1069 feet and a maximum elevation of 1141 feet. Flood protection is provided by allowing a pool of up to 1221 feet in elevation. If the outlet works discharge capacity is insufficient to maintain a flood pool elevation below 1221 feet, then the spillway crest gates are used to augment the outlet works discharge.

## 1.3 SITE GEOLOGY

The dam is located in a narrow rock canyon known as Eagle Gorge. The bedrock at this site is composed of andesitic and basaltic flows, tuffs, and breccias. There are five rock types within the immediate vicinity of the proposed fish collection facility: A hard, dense, black basalt; a moderately hard, dense, green andesite; a hard, dense, light gray feldsite; basalt pyroclastics that vary in hardness from soft to hard; and soft, light gray andesite pyroclastics.

Based upon a very limited exploration conducted during 1995 and 1996, and an examination of the construction documents compiled during the construction of the dam, it is estimated that the top of rock surface in the vicinity of the proposed site for the fish collection facility is located between elevation 1140 feet and 1160 feet.

The maximum credible earthquake (MCE) is a crustal earthquake of magnitude 6.5 to 6.7 occurring on a fault located within 30 miles of the dam. There are four potential faults that could generate an MCE.

## 1.4 DESIGN CRITERIA

### 1.4.1 Guide Documents (Codes)

In lieu of more specific criteria, the following codes will be used in the development of the fish collection facility:

| | |
|---|---|
| General Design: | Minimum Design Loads For Buildings and Other Structures; ANSI/ASCE 7-95; American Society of Civil Engineers (ASCE) |
| Bridges: | Standard Specifications for Highway Bridges, 15th Edition with Interim Publications, 1995; American Society of State Highway and Transportation Officials (AASHTO). |
| Buildings: | 1997 Uniform Building Code, Volume 2, Structural Engineering Design Provisions; International Conference of Building Officials (ICBO). |
| Concrete: | Building Code Requirements for Structural Concrete, ACI 318-95; American Concrete Institute (ACI). |
| Reinforcing Steel: | Specification A615, latest revision; American Society for Testing and Materials(ASTM). |
| Structural Steel: | Steel Construction Manual, Allowable Stress Design, 9th Edition, 1989; American Institute of Steel Construction (AISC). |
| Other metals: | Various specifications, latest revision; American Society for Testing and Materials. |
| Welding: | Structural Welding Code-Steel, D1.1; American Welding Society (AWS). |

### 1.4.2 Corps of Engineers Documents

The following documents will be used in the development of the fish collection facility:

CENPS-EN-GT; *Design Memorandum Supplement No. 26; Earthquake Analysis of Howard A. Hanson Dam*; September, 1983.

CENPS-EN; *Howard A. Hanson Dam Additional Water Storage Project Feasibility Report; Appendix E: Fish Passage Facility and Reservoir Slope Stability Geotechnical Report*; 02 August 1996, by R. E Eckerlin.

CECW-ED; *Seismic Design and Evaluation of Intake Towers*, ETL 1110-2-339; 31 March 1993.

Howard Hanson Dam Fish Passage Technical Committee; *Howard A. Hanson Dam Fish Passage Alternatives for Proposed New Operating Rule Curve*; November, 1990.

HQUSACE; *Engineering Instructions, Load Assumptions for Buildings,* EI 01S010; 01 August 1996.

CECW-P; *Ecosystem Restoration in Civil Works Programs (Draft),* EC 1165-2-201; 1 June, 1995.

### 1.4.3 Loads

The following loads were considered in the development of a design for the feasibility report.

**a. Seismic**

The seismic load due to the maximum credible earthquake was determined to be a normalized Seed's response spectrum for rock scaled to a peak ground acceleration of 0.35g at 5 percent damping and a duration above 0.05g of ten seconds. This seismic load will be used for the development of the design for the Feature Design Memorandum.

**b. Wind**

The wind load was based upon a basic wind speed of 90 miles per hour (mph).

**c. Snow**

The ground snow load was assumed to be 50 pounds per square foot (psf).

### 1.4.4 Geotechnical

For preliminary excavation planning, the rock was assumed to have a unit weight of 165 pounds per cubic foot (pcf). A bond stress of 200 pounds per square inch (psi) was assumed for all rock anchors and tendons. (See also Appendix E, Geotechnical Considerations.)

### 1.4.5 Hydraulic

The proposed fish collection facility structures, as shown in the drawings, were designed to accommodate the relevant fish and hydraulic criteria. These criteria were developed by federal and state fisheries resource agencies and nationally recognized experts in the field of fish passage as developed through research and operating experience at numerous adult and juvenile passage facilities.

# SECTION 2 CIVIL DESIGN

## 2.1 FISH COLLECTOR BYPASS ROAD

The existing spillway access road which passes in front of the project spillway in the area southwest of the dam crosses the location of the proposed fish bypass structure. This road will be relocated about 75 feet into the left abutment from the proposed fish collection facility structure. The road will be 16 feet wide, generally in a cut with 1 vertical to 1.5 horizontal side slopes. Small ditches 1 foot deep on each side of the road were used in the road design template. The new road will diverge from the existing spillway access road alignment at a point under the tower access bridge in front of the spillway.

The road will intersect the southwest corner of the maintenance platform (elevation 1185 feet) adjacent to the fish collection facility structure, and will provide access to the completed facility from the spillway area. The upper portion of this road will be located about 30 feet from the southwest corner of the fish collection facility structure. The bottom of the excavation for the fish bypass structure is at an elevation of 1030 feet, and the road is at 1185 feet. The rock at this location is very sound and should provide a steep-sided excavation for the fish bypass structure which will not run out to the location of the access road. A cut slope of 80 degrees will intersect existing grade a few feet from the edge of the fish collector bypass road. A temporary guard rail will be installed during construction where the road skirts the excavation.

This road will be designed to accommodate most types of trucks currently in use in this general area. The road contains a fairly sharp turn in front of the spillway. This is a 50-foot-radius circular curve which is comparable to the turn in the existing road. The intersection with the access road for the 1140 deck at the existing intake works provides a widened road section here which will allow vehicles with large turning radii or vehicles with trailers to negotiate this corner. The subsequent turns have 200-foot, 300-foot, and 100-foot radii and have rather minor deflections. The maximum grade on this road is 11.5 percent for a distance of about 85 feet. This exceeds the maximum grade recommended in EM 385-1-1 of 10 percent, however, the present grade of the existing road is 14.5 percent for a distance of about 400 feet where it descends the upstream face of the dam.

## 2.2 FOREBAY ACCESS ROAD

The fish collection facility structure and the forebay will require approximately 50,000 cubic yards of hard rock excavation and tunneling. The proposed method to accomplish the excavation work is through conventional excavation methods. Primarily, the rock will either be machine-ripped or blasted, and then removed with excavators and hauling (dump) trucks.

An access road is required in order to remove the in-situ material to the bottom elevation of the structure (approximately 1030 feet). The road will begin at a point located approximately 700 feet from the existing intake tower along an azimuth of North 71 degrees. At this point, the ground elevation is approximately 1205 feet. The road will then proceed for 240 feet along a heading of North 8 degrees 30 minutes East, to an elevation of 1175 feet. This segment of the road will have a grade of 12.5 percent. The road will then proceed for 330 feet along a heading of S 19 degrees 30 minutes W, to an elevation of 1122 feet. This segment of the road will have a grade of 16 percent. The road will then proceed for 570 feet along a heading of N 66 degrees 30 minutes W, to an elevation of 1035 feet. This segment of the road will have a grade of 16 percent. The end of the road will be located approximately at the mouth of the wet-well intake horn of proposed fish collection facility.

Preliminary geotechnical investigation has indicated a high rock quality in the vicinity of the access road below an elevation of 1120 feet, and poor rock quality above an elevation of 1120 feet. Accordingly, the proposed access road excavation will have a 6 vertical to 1 horizontal slope below an elevation of 1120 feet and a 2 vertical to 1 horizontal slope above an elevation of 1120 feet. It is anticipated that some additional geotechnical and structural work may be required in areas that are primarily overburden.

## 2.3 RESERVED

## 2.4 WIND GENERATED WAVES

The effect of wind generated waves on the project features and the shoreline of the raised pool was considered during design and was not deemed to be a significant design consideration. The raised pool will not appreciably increase fetch lengths and is not expected to change reflection and refraction patterns of the pool appreciably.

The structural features of the project near the existing outlet works are at the head of a narrow arm of the reservoir at a location with a very short fetch length of 2,400 feet toward the northeast. Waves may diffract around the point of land to the east of the fish collector site. The greatest fetch length at this point of land is 2,500 feet to the southeast. Waves arriving at this point from the southeast diffract roughly 45 degrees to arrive at the fish collector site.

Wave heights calculated based on ½-mile fetch length are shown in the following table.

| Wind Speed (mph) | $U_A$ | Wave Height (ft) | Period (sec) |
|---|---|---|---|
| 20 | 23.4 | 0.6 | 1.3 |
| 40 | 55.0 | 1.25 | 1.8 |
| 60 | 90.6 | 2.2 | 2.1 |
| 80 | 129.1 | ~3 | ~2.5 |

Wave heights under 3 feet will have no significant effect on the temporary cofferdam or on construction activities. Spray coming over the cofferdam adjacent to the existing intake structure is only a minor nuisance associated with the worst-case wind waves.

The shoreline erosion report prepared by the Corps' geotechnical branch intrinsically includes consideration of wave exposure and the susceptibility of segments of the pool shoreline to wave induced erosion.

The structural design of the floating apparatus in the fish collector and the mechanism which holds this unit in place should be designed to be able to withstand 3-foot waves with 2.5-second periods. It may be necessary to design the fish collector such that the operation of the facility may occasionally be interrupted during high wind wave events.

# SECTION 3 CONSTRUCTION METHODOLOGY

## 3.1 GENERAL

At this level of investigation, it is assumed that most of the features of the fish collection facility can be constructed using normal construction techniques and practices familiar to contractors doing business in the Pacific Northwest region.

## 3.2 ROCK EXCAVATION

All rock excavation, including the tunnel for the new conduit, will most likely be accomplished by either controlled blasting or mechanical ripping. (Additional details on rock and geology in the project site can be found in Appendix E, Geotechnical Considerations). The spoil, or blasted rock, would then be removed using conventional excavation methods. Preliminary investigation has revealed that the rock in the vicinity of the proposed location for the fish collection facility will safely remain in place, or free-standing, when cut at an angle up to 80 degrees above horizontal. Excavation designs should include several 5-foot-wide benches, or "set-backs," on free-standing rock faces.

## 3.3 FOREBAY

The existing forebay will be widened to accommodate the new fish collection facility intake horn. Approximately 50,000 cubic yards of rock will be removed. At this level of investigation, it is anticipated that conventional excavation methods will be used to remove this material. Most likely, this portion of the work will not commence until after completion of most of the wet-well portion of the fish collection facility structure, as this rock material comprises an ersatz cofferdam, and is adjacent to the structural cofferdam feature.

As it is very desirable to avoid underwater excavation work, it is envisioned that the excavation of the forebay material will be a "top-down" process that follows a declining reservoir elevation. However, as the bottom elevation of the new forebay will be at the same elevation as the existing forebay, it is anticipated that a portion of this work will have to be accomplished underwater.

Alternatively, should a "run-of -the-river" operating condition be achievable for a period of time long enough to allow for completion of the proposed excavation work, other methods of removing the lowermost portions of rock from the proposed forebay area will be investigated. This may include placement of temporary rock levees in the existing forebay in order to divert the river away from the excavation work and into the existing intake tower so that conventional excavation methods can be used to complete the construction of this feature.

## 3.4 COFFERDAM

A temporary cofferdam is required in order to construct the fish collection facility at the location shown on the drawings. This feature is described in Paragraph 4.18 of this appendix.

The proposed construction methodology is to construct the underwater portions of the abutments using concrete modified with an anti-washout admixture and a prefabricated steel, or "tremie," form. Conventional concrete formwork would be utilized for portions of the abutments above water. A conventional construction crane would be utilized to support the tremie form and the preassembled reinforcing steel and tendon duct assembly during placement of the concrete.

As indicated in Paragraph 4.18 of this appendix, the proposed cofferdam abutments are to be monolithic piers constructed of concrete, in-situ rock, reinforcing steel, prestressing tendons, and rock anchors. The proposed methodology to construct the abutments is as follows:

- Lower the reservoir elevation as much as possible. A "run of the river" operating condition is the most desirable condition.
- Remove weathered rock from the face.
- Install the high-strength shear anchors. This work will entail hard rock drilling and grouting of Dywidag-style threaded rock anchor bars. Most likely this work will be accomplished from a suspended platform or a barge. Depending on the reservoir elevation at the time of construction (presently anticipated to be between 1040 feet and 1070 feet), some of these anchors may need to be installed underwater.
- Prefabricate an assembly of regular reinforcing steel and prestressing tendon ducts.
- Install a prefabricated, removable steel tremie form.
- Install the prefabricated reinforcing steel and tendon duct assembly into the tremie form.
- Place the concrete in the form. For concrete placed underwater, it is anticipated that anti-washout admixtures will be required.

- Once the concrete mixture has obtained sufficient strength (probably within one to three days of placement), remove the tremie form and modify the form for the next lift.

- Upon completion of the abutments, the preformed ducts will be used as a drilling guide for the installation of the longitudinal (vertical) prestressing tendons. These tendons will be installed to a depth of about 35 feet below the base of the abutment (approximately elevation 1000 feet). Upon completion of drilling, install, stress, and grout the prestress tendon.

Upon completion of the two abutments, the fabricated steel bulkhead units will then be installed using a conventional construction crane.

# SECTION 4 STRUCTURAL DESIGN

## 4.1 WET-WELL STRUCTURE

The wet-well structure is a 105-foot-long by 30-foot-wide by 150-foot-deep open-end box structure. Approximately 105 to 115 feet of the structure will be embedded in rock. The structure has a top elevation of 1185 feet and a floor elevation of 1035 feet. It is located at a 60-degree skew to the axis of the existing intake tower and conduits. The upstream end, or intake horn, of the wet-well structure is flared to a width of about 45 feet, and the right edge abuts the left side of the existing intake tower trashrack structure. The floating trashrack, described in Paragraph 4.5 of this appendix, is attached at the flared end of the wet-well structure.

The existing intake tower forebay will be widened to accommodate the mouth of the wet-well. A removable steel framework and grating will be installed on top of the structure to provide a work deck for safety, operation, maintenance, and debris handling functions. This framework will also prevent the fish collector from floating out of the wet-well structure while reservoir elevations exceed 1185 feet.

The structure will be constructed of normal weight reinforced concrete, with an average wall thickness of 24 inches to 72 inches. For the portion of the structure embedded in rock, anchoring the structure with rock anchors may provide a more economical design than for a free-standing, or unanchored, design. Prestressing the concrete may provide a more economical design as well. Both rock anchors and prestressed concrete should be considered in the development of design for the Feature Design Memorandum.

## 4.2 FISH COLLECTOR ASSEMBLY

The fish collector assembly is, essentially, a floating container for a modular inclined screen. The modular-inclined screen (MIS) will be mounted in the center of the collector housing, and will have hinges along its center of rotation that attach it to the housing framework. The MIS is held in position by low-pressure hydraulically powered mechanical actuators, and may be rotated to allow accumulated debris to be washed off of the screen. Various instrument sensors will be installed to monitor water flow and debris accumulation.

As mentioned in Paragraph 1.1, the MIS allows 95 percent of the flow to pass through it, while preventing the fish from passing through the screen. The remaining five percent of the flow "washes" the fish across the modular-inclined screen into a flume that deposits the fish into the fish lock.

The housing will be designed to provide optimal hydraulic flow conditions, in order to attract the maximum number of fish. Specifically, the upstream portion, or inlet horn, will have elliptical-shaped surfaces (walls, roof, and floor) so as to minimize changes in water velocity as the flow passes through the collector. Minimizing the changes in water velocity is believed to help reduce schooling of the fish just upstream of the collector. In other words, rapid fluctuations in localized water velocities is believed to discourage migrant fish movement.

Attached to the lower lip of the intake horn will be a skirt. This skirt will have neoprene bulb seals attached to its edges, and will press against the back side of the stoplogs.

Located at the downstream end of the fish collector will be a flume that will discharge the fish over the stoplog set that separates the wet-well from the fish lock. There will be a skirt, similar to the one attached to the fish collector intake horn, attached to the discharge flume. This skirt will have neoprene bulb seals that will bear against the upstream face of the stoplog set that separates the wet-well from the fish lock. If the fish collector house is to have a variable depth below the water surface, as discussed below, then this flume must be designed to adjust for the location of the collector house, in order to maintain the 2-foot head between the fish lock and the wet-well.

The fish collector assembly will be suspended from a pontoon. The pontoon provides the buoyancy necessary to maintain the fish collector at a predetermined height below the wet-well water surface. This height may be varied by changing the length of the locating struts that attach the collector to the pontoon. A steel framework attached to the walls of the wet-well will provide support for bearings attached to the pontoon and collector assembly. The bearings will be designed to allow for vertical movement of the assembly while maintaining the location of the collector assembly within the wet-well.

The surface skin of the collector housing, along with the MIS framework, will most likely be constructed of stainless steel. Supporting structural members and components will most likely be made of hot-dipped galvanized steel.

## 4.3 STOPLOGS

The stoplogs are an integral part of this facility. There are three sets of stoplogs. There is one set of large stoplogs at the upstream end of the wet-well structure, separating the fish collector assembly from the reservoir. There are two sets of smaller stoplogs: one set between the wet-well and the fish lock, and, one set between the fish lock and the fish lock regulation well. The large stoplogs will have a span of about 25 feet, and both sets of the smaller stoplogs will have a span of about 5 feet.

Each stoplog set will be comprised of 15 identical stoplogs, each 10 feet in height, that will be stacked for a total height of 150 feet. There may be a slight cost savings associated with designing each individual stoplog for a specific location within the stack; however, doing this may create more complicated storage and handling problems. From an emergency operations perspective, it may be desirable to be able to use any individual stoplog at any location within the stack.

As noted above, each stoplog will be approximately 10 feet in height. This is to allow the fish collector to move 10 feet without removing a stoplog. At this time, it is not anticipated that the reservoir elevation will fluctuate more than 10 feet during a 16-hour period. The mating surfaces of each stoplog will most likely incorporate a neoprene seal. For the large stoplogs that separate the reservoir from the wet-well, a seal between each stoplog is required in order to meet the fish criteria. These criteria state that, under operating conditions, it is undesirable to have any flow from the reservoir to the wet-well at any point other than at the intake horn of the fish collector.

Each stoplog set, or stack, will be designed to withstand a water level difference of a 150 feet, in order to allow for dewatering of the respective areas behind the stoplogs. However, they will not be designed to be placed under flowing conditions. Accordingly, a bearing system should not be required. Most likely the stoplogs will be constructed of hot-dipped galvanized structural steel members.

When not installed in an appropriate guide slot, the stoplogs will most likely be stored in storage racks attached to the right wall of the wet-well structure. The outer face of the right wall will be exposed above the 1140 foot elevation. A steel framework, or rack, installed along this wall could be constructed so as to store up to five stoplogs per rack. As indicated above, the stoplog system is an integral part of the operation of this facility. As the reservoir elevation changes, the fish collector floats along with it. A skirt attached to the lower lip of the fish collector intake horn provides for a watertight seal between the fish collector and the uppermost stoplog of the upstream stoplog stack. As noted in Paragraph 4.2 of this appendix, a similar skirt is attached to the discharge flume (at the downstream end of the fish collector). This skirt will bear against the upstream face of the stoplog set that separates the wet-well from the fish lock If the reservoir elevation moves more than 10 feet, then a stoplog must be added to, or removed from, the stack. Handling of the stoplogs will be accomplished with the service crane.

## 4.4 SERVICE CRANE

As mentioned in Paragraph 4.3 of this appendix, a service crane will be used in the regular operation of the fish collection facility. Its primary function is to handle the stoplogs. This crane will also be used to remove and install the floating trashrack, and will be used for debris removal and clearing tasks. It is also intended to be the primary lifting equipment for maintenance of the structure, including removing and installing the fish collector assembly. A variety of hook attachments are envisioned, including stoplog lifting beams, clamshell buckets, grapples, and personnel baskets.

The crane will most likely be permanent, or fixed base, pedestal machine, with a 360-degree rotating carbody and a luffing lattice boom. It will most likely have electrically powered, mechanically driven swing, hook, and boom hoists. It should be equipped with at least two independently operated hooks: a main hook, with a capacity of 70 tons at 80 feet, and a sister hook, with a capacity of 15 tons at 120 feet. Both hooks should be equipped for "power-down" operation, and the sister hook should allow for "free-fall" operation as well.

This unit will most likely be located adjacent to the flared, or intake horn, portion of the wet-well structure. Both sides of the wet-well should be considered before selecting a final position. The foundation for the pedestal will be a reinforced concrete structure that is integral with the wet-well structure up to the 1185 foot level. The pedestal, above the 1185 foot level, will be a round, steel structure that will be attached to the concrete foundation with anchor bolts. This steel "pipe" structure, with an approximate diameter of 10 feet, should be watertight and provide suitable space for power supply lines, control lines, and personnel access for maintenance and inspection. The base of the carbody should be located no lower than an elevation of 1250 feet, in order to clear the top of the adjacent existing intake tower. Normal personnel access will most likely be a pedestrian bridge, or "catwalk," between the existing intake tower access bridge and the crane.

Because of the location and height of the crane, it is desirable to eliminate as much routine and occasional maintenance as possible. It is especially desirable to eliminate the transfer and storage of motor fuel from the carbody. Accordingly, at this level of investigation, it is envisioned that this unit will be electrically powered, rather than engine driven. Since the existing power supply system is inadequate to meet the power requirements for such a crane, and, since the existing facility power supply system most likely will not require a substantial increase in capacity otherwise, the crane will most likely be powered by a remote-mounted engine-generator set. This generator system should be sized to provide both the peak operating power requirements and the starting loads. It is apparent that this generator, even if sized solely for the crane's power requirements on an intermittent use basis, would be more than sufficient to provide for all of the emergency power requirements for the entire project. The existing emergency power generator would be eliminated under this scenario.

## 4.5 TRASHRACK

The trashrack provides primary protection for the fish collector assembly from floating debris. It is to be a steel grillage comprised mostly of welded structural tube shapes. It is arched in plan view, with an arc of about 120 degrees, and has bearings at each end of the primary arch ribs. These bearing assemblies will ride in guide slots built into the intake horn portion of the wet-well structure. The assembly is to be about 40 feet tall and will operate over the full 150-foot height of the wet-well structure. At the top of the grillage, an integral steel pontoon is envisioned. This pontoon will provide the buoyancy necessary to allow the structure to float. By allowing the trashrack to float, it is believed that sufficient debris protection may be achieved without the need to construct a more costly full-height trashrack. At this level of investigation, the fish criteria are somewhat ambivalent about the use of a trashrack and indicate that, during periods of low debris influx, it is desirable to operate the fish collection facility without a trashrack. Accordingly, the trashrack structure is envisioned to be a single unit that can be lifted with the service crane. It will be stored on the maintenance platform during periods of non-use.

## 4.6 FISH LOCK

The fish lock structure is a 35-foot-long by 30-foot-wide by 135-foot-deep closed-end box structure. Approximately 90 to 100 feet of the structure will be embedded in rock. The structure has a top elevation of 1185 feet and a floor elevation of 1049 feet. It is located at a 60-degree skew to the axis of the existing intake tower and conduits and is to be constructed monolithically with the wet-well structure. The common wall that separates the fish lock from the wet-well will contain the guide slot for the stoplog set that serves the same purpose. Integral with the right-hand wall will be the guide slot for the fish lock regulating well stoplog set and floating weir. This vertical slot will have a full height screen, made of the same wedge-wire fabric as the MIS, to prevent fish from entering the regulation well. At the bottom of the fish lock is a full-coverage fish screen, made of the same wedge-wire fabric as the MIS. This screen will be sloped to funnel fish into the fish transport pipe inlet at the base of the right-hand wall. A removable steel framework and grating will be installed on top of the fish lock structure to provide a work deck for safety, operation, and maintenance functions.

As with the wet-well, the fish lock structure will be constructed of normal weight reinforced concrete with an average wall thickness of 24 inches to 72 inches. For the portion of the structure embedded in rock, anchoring the structure with rock anchors may provide a more economical design than for a free-standing, or unanchored, design. Prestressing the concrete may provide a more economical design as well. Both rock anchors and prestressed concrete should be considered in the development of the design for the Feature Design Memorandum.

## 4.7 FISH LOCK REGULATING WELL

The fish lock regulating well structure is a 12-foot-long by 15-foot-wide by 135-foot-deep closed-end box structure. Approximately 90 to 100 feet of the structure will be embedded in rock. The structure has a top elevation of 1185 feet and a floor elevation of 1050 feet. It is located at a 60-degree skew to the axis of the existing intake tower and conduits and is to be constructed monolithically with the wet-well and fish lock structures. Integral with the right-hand wall of the fish lock structure is the guide slot for the fish lock regulating well stoplog set and floating weir. This vertical slot will have a full height screen, made of the same wedge-wire fabric as the MIS, on the fish lock face of the wall to prevent fish from entering the regulation well. The regulating well stoplogs will be designed to accommodate a floating weir assembly, to be located on the fish lock side of the stoplogs. The floating weir assembly will be ballasted so as to locate the weir notch just above the top of the stoplog set. This should provide a constant flow discharge into the regulating well, thus keeping the fish lock elevation at a constant level with respect to the wet-well water elevation. The bottom of the fish lock regulating well will drain into the fish transport pipeline.

As with the wet-well and fish lock, the fish lock regulating well structure will be constructed of normal weight reinforced concrete with an average wall thickness of 12 inches to 72 inches. For the portion of the structure embedded in rock, anchoring the structure with rock anchors may provide a more economical design than for a free-standing, or unanchored. design. Prestressing the concrete may provide a more economical design as well. Both rock anchors and prestressed concrete should be considered in the development of the design for the Feature Design Memorandum.

## 4.8 FISH TRANSPORT PIPELINE

The fish transport pipeline is a 36-inch-diameter steel pipe that will run continuously from the fish lock to the Green River just downstream of the existing stilling basin. This pipeline will be suspended along the roof of the new discharge conduit (described in Paragraph 4.9) and along the crown of the existing outlet works tunnel. The pipeline will be attached to the tunnel crown with a suitable anchor bolt and saddle assembly. At the present time, it is envisioned that the fish transport pipeline will be supported along the right-hand side of the stilling basin, in the vicinity of the existing 48-inch bypass line.

### 4.8.1 Fish Transport Pipeline Inspection Station

An inspection station will be constructed at the exit point of the fish transport pipeline, in order to allow for the monitoring of the fish as they are discharged into the river. A small outbuilding may be required in order to house monitoring equipment and to provide a workspace for monitoring personnel.

## 4.9 DISCHARGE CONDUIT

The discharge conduit is a new tunnel that connects the new wet-well structure to the existing outlet works tunnel. The new conduit is to be designed to pass flows ranging from 500 to 1700 cubic feet per second (cfs). These flows will be regulated by a radial gate (described in Paragraph 4.11). Upstream of the gate, the flow regime is pressurized, and downstream of the gate the flow will be open-channel.

The new conduit will enter the existing tunnel just downstream of the location of the existing splitter wall. It will enter the existing tunnel with a floor elevation of about 1034 feet (the existing tunnel's floor elevation is about 1023 feet at this point). The new conduit begins at the downstream end of the wet-well structure, with a base elevation that matches the wet-well base elevation of 1035 feet, and has an alignment that is parallel with the new wet-well centerline. Its alignment then turns 90 degrees toward the existing facility and continues unchanged to its access portal in the wall of the existing tunnel.

The discharge tunnel will be horseshoe-shaped in cross-section, with a width of 7 feet, a central height of 6½ feet, a height of 10 feet, and a crown radius of 3½ feet. The conduit's floor and sides will most likely be lined with steel plate.

## 4.10 BYPASS CONDUIT

The bypass conduit is a new 48-inch-diameter pipeline that will connect the new wet-well structure with the existing 48-inch bypass line in the existing tunnel. The bypass conduit will be designed to pass flows up to 500 cubic feet per second (cfs). These flows will be regulated by the existing 48-inch bypass line valve system.

The new bypass conduit will be installed along the centerline of the new discharge conduit. A 10-foot-wide by 10-foot-high inlet horn will be installed in the right-hand wall of the new wet-well structure, with a base elevation of about 1058 feet. Use of this base elevation will allow operation with a reservoir elevation of at least 1070 feet, while still providing sufficient height above the wet-well floor to minimize the likelihood of silt intrusion into the bypass system. This inlet will have a hydraulically actuated closure gate and trashrack.

This conduit will be a welded steel pipeline that is encased in concrete. It will be installed with a centerline elevation that is approximately 4 feet below the floor elevation of the discharge conduit.

## 4.11 REGULATING GATE

As noted in Paragraph 4.9, the discharge conduit will most likely be regulated by a radial gate. The gate design will comply with the latest revision of the Corps of Engineers Engineering Manual for Tainter Gates (EM 1110-2-2702).

This gate will be mechanically actuated with a single, low pressure hydraulic cylinder. The gate will have a radius of approximately 20 feet and have two main radial frames, each supported by a trunnion bearing and anchor system.

The gate edges will have air-inflated bulb seals, similar in design to the seals used on the existing radial gates.

## 4.12 EMERGENCY GATE

The discharge conduit will have an emergency control gate located just upstream of the radial gate. This tractor gate will most likely be mechanically actuated with a single, low pressure hydraulic cylinder. The actuating cylinder will be located above the 1185 foot level, in order to facilitate routine maintenance. If located as such, it will most likely be connected to the gate structure itself by a long strut fabricated from structural steel. If a sliding tractor gate is used, it will have an endless-chain type of roller bearings in order to allow the gate to close under high flow conditions.

## 4.13 VALVE EQUIPMENT ROOM

The valve equipment room is a 25-foot-wide by 20-foot-long room, with a floor-to-ceiling height of about 20 feet. It will have a floor elevation of about 1045 feet. This room is located between the fish lock structure and the gate chamber portion of the new intake tower. The purpose of this room is to house the valves, operating equipment, lines, and related appurtenances that will be used to control the operation of the various compartments of the fish collection facility.

This structure will be constructed of normal weight reinforced concrete with an average wall thickness of 18 inches to 72 inches. It will be constructed monolithically with the fish lock structure and the gate chamber portion of the new intake tower. Thinner wall sections may be possible by anchoring the walls to the surrounding rock.

## 4.14 TOWER

The new intake tower will house the gate chamber, vent shaft, and access shaft. The gate chamber is about 30 feet by 20 feet in plan, has a base elevation of 1035 feet, and an upper elevation of about 1085 feet. It will house a single radial gate and operating hydraulic actuator. A guide slot for the emergency tractor gate will be located just upstream of the radial gate.

The gate chamber and tower will be monolithically constructed of normal weight reinforced concrete structure.

### 4.14.1 Access Shaft

Between the 1085 foot level and the 1226 foot level, the tower has a 20-foot by 20-foot plan with a single chamber that houses a staircase and a dropshaft. The staircase will most likely be a prefabricated, hot-dipped galvanized steel structure with an open grillage tread and a round tubular handrail.

### 4.14.2 Vent Shaft

The vent shaft is a 7-foot by 5-foot rectangular opening that rises alongside the access shaft structure, from the top of the gate chamber to the 1226 foot level. This shaft should be designed to provide the air necessary due to the draft created by the discharge conduit.

### 4.14.3 Access Room

The access room is located on top of the access shaft and below the control room. It has a 20-foot by 20-foot plan, a floor elevation of 1226 feet, and a ceiling elevation of 1240 feet. This room will be the primary access point for personnel. It will probably have a 16-foot-wide by 12-foot-high roll-up door facing the access bridge. This door will include a personnel "pass-through" door. Approximately one half of the floor area is open, to allow for the hoisting of equipment to and from the valve equipment room. Most likely, a 5-ton electric hoist and supporting monorail will be installed to provide for the hoisting of tools, supplies, and equipment. The remaining floor area will be comprised of staircase landings. There are two staircase landings: a landing for the staircase to the valve equipment room, and a landing for the staircase to the control room.

### 4.14.4 Control Room

The control room is located on top of the access room. It has a 20-foot by 20-foot plan, a floor elevation of 1241 feet, and a roof elevation of about 1254 feet. This room will be used to house the control systems that will be used for operating the fish collection facility. It is envisioned that this room is the primary control point for this project, and will house both manual and automated control systems. Remote control systems, envisioned to be in the project administration building and in the Seattle District Office of the Corps of Engineers, will connect to the system at this point.

## 4.15 ACCESS BRIDGE

The access bridge will provide vehicle, utility and personnel access to the new facility. It will have a deck width of about 20 feet and will connect to the exiting intake tower access bridge with an expansion joint. As this bridge will approach the existing bridge at an unusual angle, it is anticipated that the new bridge will be a free-standing structure and will not be supported by the existing bridge.

At this time, the bridge is envisioned to be a concrete structure. Most likely, the superstructure will be either precast prestressed concrete girders supporting a conventionally reinforced concrete deck or a cast-in-place post-tensioned double cell concrete box girder. The substructure will most likely be monolithic reinforced concrete piers, each with a spread footing founded directly on rock.

## 4.16 MAINTENANCE PLATFORM

The maintenance platform is an area adjacent to the wet-well and fish lock structure. It will have a surface elevation of 1185 feet and will be constructed of reinforced concrete pavement over compacted backfill. This platform will provide a work area for the maintenance and repair of the stoplogs, the fish collector assembly, and the floating trashrack. It is envisioned that these large structures will be disassembled into smaller components while on the platform, and the components will be refurbished in the maintenance building (described in Paragraph 4.17.2).

## 4.17 BUILDINGS

Three new buildings are proposed as part of the fish collection facility. As described below, these are: an administration building, a maintenance building, and a generator building. The proposed maintenance and administration buildings were identified after consultation with Project Operations staff. If a new administration building is included, then the existing administration and maintenance building should be demolished.

### 4.17.1 Administration

The present administration building does not appear to contain sufficient useable space for the required personnel and equipment. The fish collection facility includes remote and semi-automated control and monitoring systems, some of which are anticipated to be installed in the administration building. Preliminary evaluation indicates that renovation and expansion of the existing structure will most likely to be more expensive than constructing a new, purpose-built, single structure. This new building will be designed to house both the new functions associated with the fish collection facility and the existing project operations functions.

At this level of investigation, it is envisioned that the new building would most likely be located on the site of the present administration and maintenance building.

Most likely, this structure will be a single story conventional building with masonry walls, a joist-supported standing seam metal roof, a monolithic floor slab, and conventional strip footings set below the frost depth.

### 4.17.2 Maintenance

Presently, there is no structure available at this site to provide a properly ventilated and heated shelter for the routine and periodic maintenance and repair work that is anticipated as part of the operation of the fish collection facility. Accordingly, a new building is required to provide a ventilated, heated and secure workspace for routine maintenance and repair work. This building would also provide space for the storage of tools, spare parts, and maintenance supplies. Ideally, it should be large enough to allow the repair of sizable structural components such stoplogs (described above), and log booms. If the present administration building is replaced, as described above, then the maintenance and light repair functions for watercraft, motor vehicles, and heavy equipment should be transferred to this building, as well.

A pre-engineered metal building, approximately 40 feet by 60 feet in plan, with a 20-foot eave height should meet the above-noted criteria. Most likely, this building will be located near the present storage building on the left bank of the reservoir.

### 4.17.3 Generator

A small building will be required to house the engine-generator set (described in Paragraph 4.4 of this appendix) and its appurtenances. Because of the high noise level produced by the generator, ideally this building should be a separate structure and not part of another building. Adjacent to this structure will be an above-ground fuel storage tank and spill containment structure.

Most likely, this structure will be a single story conventional building with masonry walls, a joist-supported standing seam metal roof, a monolithic floor slab, and conventional strip footings set below the frost depth. A roll-up door at one end of the building will be sized so that the generator may be readily removed and reinstalled without modifying or disassembling a portion of the building structure.

## 4.18 COFFERDAM

A temporary cofferdam is required in order to construct the fish collection facility at the location shown on the drawings.

The purpose of the cofferdam is to allow reservoir elevations of up to 1145 feet during the construction period. The proposed facility will require open-cut excavation to an elevation of about 1030 feet and tunneling to an elevation of about 1029 feet. The excavation cuts will be made adjacent to the existing intake tower facility. Current authorization and operational agreements preclude lowering the reservoir to a "run-of-the-river" condition for all but very short periods of time during a typical flood season. This restriction prevents dewatering the forebay in order to construct the lowermost components of the proposed facility. Accordingly, a cofferdam is required to withstand the reservoir adjacent to areas that will be excavated.

Preliminary analysis indicates that the left abutment (looking downstream) rock that forms the left wall of the existing intake tower forebay can withstand a head of about 120 feet as a gravity monolith, if it has a base width of at least 80 feet. That is, all excavation to elevation 1030 must be located at least 80 feet behind the face of the existing rock wall and intake tower structure. As the proposed fish collection facility is located within 25 feet of the existing intake tower, utilization of the in-situ rock as an ersatz cofferdam is unlikely to prove successful without substantial geotechnical and structural reinforcement.

The proposed cofferdam consists of a fabricated steel bulkhead, or "stoplog," and two structural abutments. This cofferdam will extend immediately upstream of the existing intake tower for about 40 feet, sheltering the area immediately adjacent to the left side of the existing intake tower. The cofferdam bulkhead will be aligned perpendicular to the existing tower's trashrack, with an abutment at each end. The downstream abutment will be located in line with the trashrack, and the upstream abutment will be aligned parallel to it, about 40 feet upstream of the trashrack.

The bulkhead units will be fabricated from welded plate steel and structural steel members. Most likely, each bulkhead unit will have a height of about eight to ten feet. The bulkheads will be designed for their respective vertical location within the bulkhead column. It is anticipated that neoprene seals will be installed between each bulkhead unit.

The bulkhead abutments will be designed to completely support the bulkhead stack. Preliminary design and analysis indicated that a prestressed concrete free-standing, fixed base, cantilevered pier will require a cross-section dimension of about 10 feet in width and 25 feet in length. As the rock face in the location of the proposed abutments has a 4-on-1 slope, about one-half of each abutment pier will be comprised of in-situ rock, and the remaining portion comprised of normal weight concrete. High strength reinforcing steel bars will be grouted into the rock portion of the abutment piers, such that they extend over the full depth of the abutment (25 feet). These high strength reinforcing bars will provide the required shear strength necessary for these two materials to act compositely as structural abutment. Additionally, longitudinal prestress will be applied with approximately 700 one-half inch diameter, seven-wire, high strength, low relaxation prestressing strands. These strands will be installed in groups, or bundles, of about 50 strands each into 6-inch-diameter ducts, and bonded with high-strength grout. The ducts will be installed and grouted into the in-situ rock below the base of the abutment for a depth of about 35 feet and will extend to the top of the abutment pier.

The proposed construction methodology for this feature is discussed in Paragraph 3.4 of this appendix.

# SECTION 5 MECHANICAL DESIGN

**5.1** The primary mechanical features of the project include hydraulic fluid power systems and crane hoists.

**5.2** Hydraulic systems will be used for all water flow control devices. The majority of flow through the structure will be through a radial gate with a tractor style gate located immediately upstream. Hydraulic cylinders will be used to modulate the radial gate and provide two position control for the emergency gate.

**5.3** Flow through the fish flume will be maintained at a steady rate, regardless of the flow through the main radial gate, by maintaining a fixed differential between the reservoir and the fish lock. The flow out of the lock will be controlled by weirs and/or valves.

**5.4** All hydraulic components will be sized to operate at 1500 psi to be consistent with the operating pressures utilized at the existing facility. This will allow a single hydraulic power unit to serve both the existing and the new facility thereby requiring less maintenance without affecting reliability.

**5.5** Both the existing and the new system will be capable of being automatically controlled. In addition, each system would be capable of being isolated such that any given system or sub-system could be provided with routine or emergency maintenance activities without affecting the entire system. The hydraulic power unit would consist of a single reservoir with duplex hydraulic pumps. This would allow repair or replacement of a pump without affecting the operation of the remaining equipment.

**5.6** The hydraulic power unit will replace the existing unit located in the existing intake tower. Every effort will be made to preclude the placement of line voltage equipment at or below any expected waterline. All valves needing to be automatically operated will be equipped with hydraulic motors.

**5.7** Hoisting equipment will be required for operation of the fish passage facility. Items of equipment which will be regularly moved include the stop logs both upstream and downstream of the fish screen.

**5.8** The upstream stop logs may weigh as much as 25 tons if they are designed to be used for dewatering the structure. The maximum lift would be from the 1035 to the 1185 foot elevation (150 feet) plus any necessary clearance. This hoist may require up to a 15-horsepower motor.

**5.9** Debris removal, although infrequent, may represent the greatest hoisting load requirements due to the desired cycle time. With a 15-ton load and a 5-minute lift for 175 feet, a hoist with an overall efficiency of 65 percent would require a 50-horsepower motor. It may be possible to reduce this motor size by refining the load conditions. For instance, while the breakaway load for debris removal may be 15 tons, the dead weight of the debris to be removed will likely be substantially less. For illustrative purposes, 10 tons of wood debris at a specific gravity of 1 could be a 100-foot-long, 2-foot-diameter log.

**5.10** While the hoist loads and hook speeds may not require much power, the location of the crane/hoist may have the most significant impact upon cost. For instance, one proposed location gives a maximum lift radius of 80 feet to handle upstream and downstream stop logs and debris removal. This same location requires a 115-foot radius in order to be able to pick the operating gate cylinders. However, as regular maintenance would not require these cylinders to be picked, consideration will be given to alternate methods of lifting, e.g., mobile equipment brought in as required.

**5.11** Other mechanical features to be provided include compressed air, drainage, and ventilation systems. The drainage system will be designed to preclude undesirable pressurization of any parts of the structure which must be accessed by personnel. This may be accomplished by float activated drains, and or powered ventilation to negate these effects.

**5.12** To the greatest extent practicable, the design will be based upon minimizing the type and quantity of equipment which is readily subject to deterioration from the environment expected.

# SECTION 6 ELECTRICAL DESIGN

## 6.1 ELECTRICAL DISTRIBUTION

Electrical power to Howard Hanson Dam is provided by Puget Sound Energy, the local utility company, over a government owned overhead power line. The line extends from the meter at the City of Tacoma's Diversion Dam Project Office to Howard Hanson Dam, approximately 4 miles. The new fish collection facility introduces an additional load to the electrical system at the site. Although the ampacity rating of the existing #6 copper conductors is sufficient to handle the increased load, the conductors and wood poles are in very poor condition. Over the years there have been numerous repairs to these conductors. The poles have deteriorated beyond their useful life. To insure reliable service to the new fish collection facility, the poles and conductors will be replaced in kind.

The new fish collection facility requires a separate tower with its own equipment. To handle this additional load, the site's electrical distribution system will be upgraded. The facility will contain equipment similar to that in the existing tower, except the fish facility also has monitoring and control loads. It is assumed that the new load will be somewhat larger than the existing tower's load. To upgrade the distribution system, the existing 3-25kVA transformers, located next to the existing Administration Building, will be replaced with a 3-phase, pad mounted transformer rated 150kVA, 12470-120/208v. This transformer will supply the existing tower and all other existing exterior loads as well as the new tower and any new support buildings that are required.

Conductors to the existing tower and spillway are routed underground in a ductbank. This existing ductbank system will be expanded to route power and communications to the new fish collection facility. Two 4-inch conduits for power and two 4-inch conduits for communications (telephone and control) will be added to the ductbank.

## 6.2 SUPPORT FACILITIES

There will be no changes to the electrical system or equipment in the existing tower.

The existing Administration Building is not adequate for the current operational needs of project personnel. The building is more than 20 years old and inappropriately configured so it would be difficult to remodel to support the fish collection operations. The same is true for the Maintenance Building. Several maintenance functions are being done in the

Administration Building. Therefore, these buildings will be replaced with new ones. The buildings will be provided with power, lighting, ventilation, communications and fire protection systems that are appropriate for the building's type of construction and usage.

The secondary conductors from the existing transformers are routed underground into the Administration Building. From the Main Distribution Panel in the building, power is routed underground throughout the site. This equipment has exceeded its useful life and cannot be easily upgraded to supply the new loads. In the new Administration Building, a 600A, 120/208v, 3-phase switchboard will be installed as the main service point for the site. Conductors from the new switchboard will be routed out of the building in a new concrete encased PVC ductbank to the first manhole to intercept the existing conductors for the remainder of the site. The existing service will be retained until the new Administration Building is completed. At that time, the existing service and building will be demolished.

Fish monitoring equipment will be located on the outlet side of the fish passage tunnel. A small building with power and telephone will be provided.

### 6.3 FISH COLLECTION FACILITY

The Control Room for the fish collection facility is located at the top of the tower. A panelboard in the Control Room will provide the circuits for the new fish passage equipment. These circuits will be low voltage control as required by the hydraulic system, lighting in the new fish passage tower stairway and access chambers, sensors and monitoring devices required for data collection and reporting, and any ventilation equipment. Due to the height of the tower, the conductor lengths will exceed 100 feet, therefore the minimum size for all of the interior conductors will be #10 AWG in ½-inch conduit.

For normal operation as well as maintenance of the facility, a crane is required. The size of the crane at this point in the design has been set at 300 horsepower. Puget Sound Energy's system cannot support a load of this size. Therefore a new diesel generator will be provided to supply power for the crane. The generator will also provide emergency power for the site when utility power fails. The generator will be housed in a new generator building located near the tower.

# DRAWINGS

## Sheets 29 through 35 -- Fish Collection Facility, Alternative 9A8, Recommended Plan

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**SITE PLAN**

SCALE: 1" = 40'

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**CORPS OF ENGINEERS**
SEATTLE, WASHINGTON

HOWARD HANSON DAM
ADDITIONAL WATER STORAGE PROJECT

**FISH COLLECTION FACILITY**
**ALTERNATIVE 9A8**
**SITE PLAN-1**
**RECOMMENDED PLAN**

GREEN RIVER — WASHINGTON

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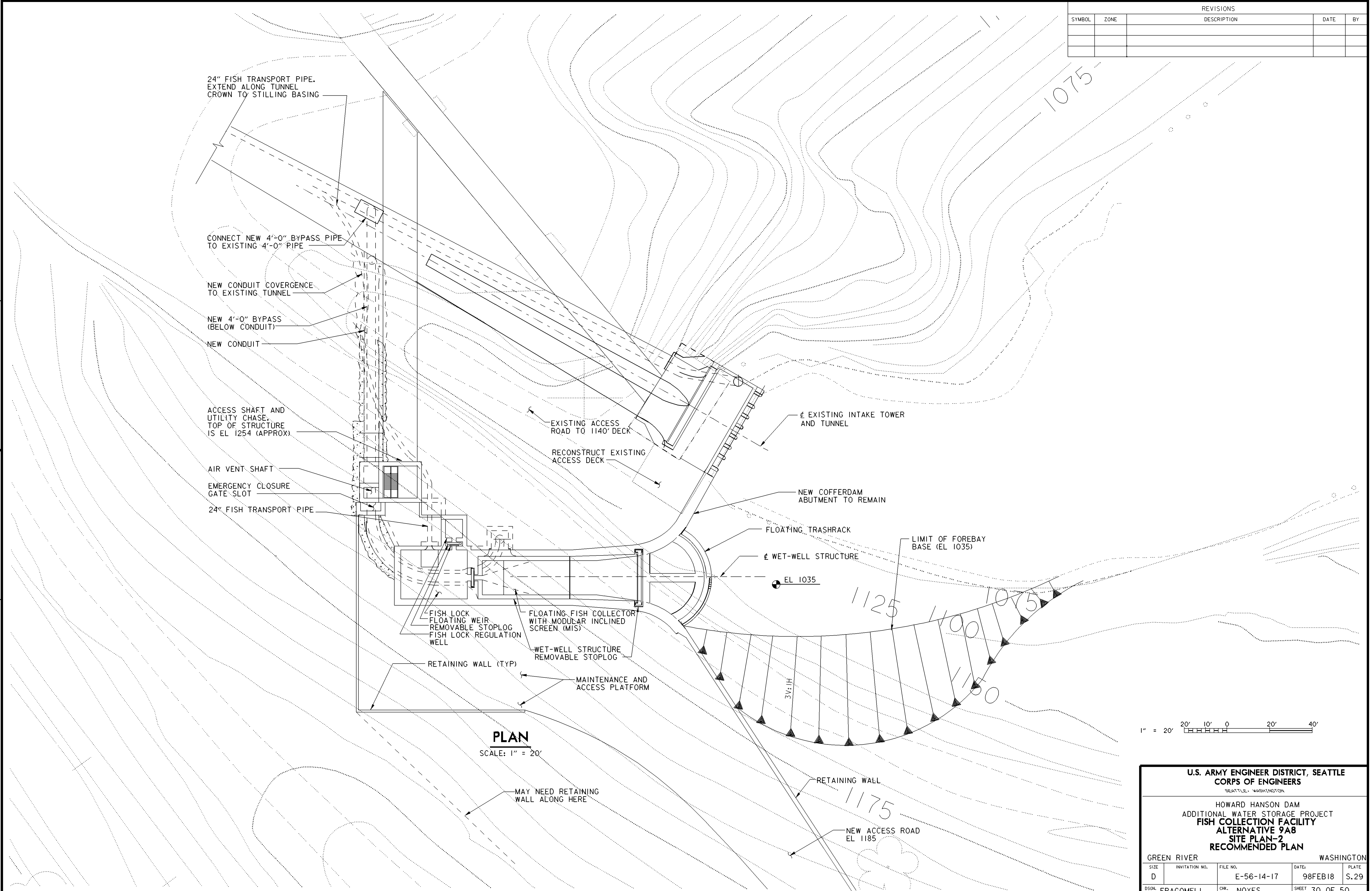


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HOWARD HANSON DAM
ADDITIONAL WATER STORAGE PROJECT
**FISH COLLECTION FACILITY**
**ALTERNATIVE 9A8**
**SITE PLAN-2**
**RECOMMENDED PLAN**

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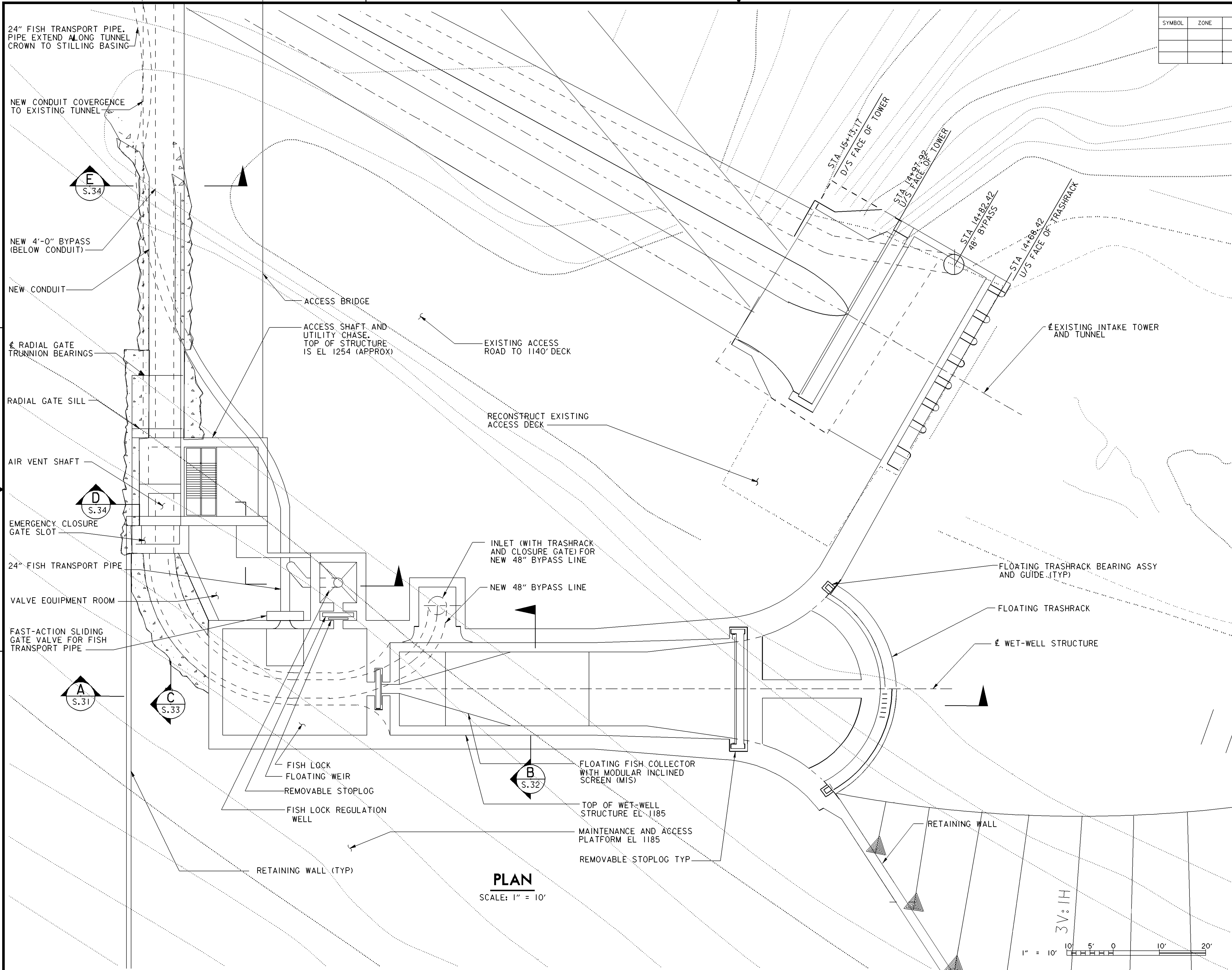


**PLAN**
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HOWARD HANSON DAM
ADDITIONAL WATER STORAGE PROJECT
**FISH COLLECTION FACILITY**
**ALTERNATIVE 9A8**
**STRUCTURAL PLAN**
**RECOMMENDED PLAN**

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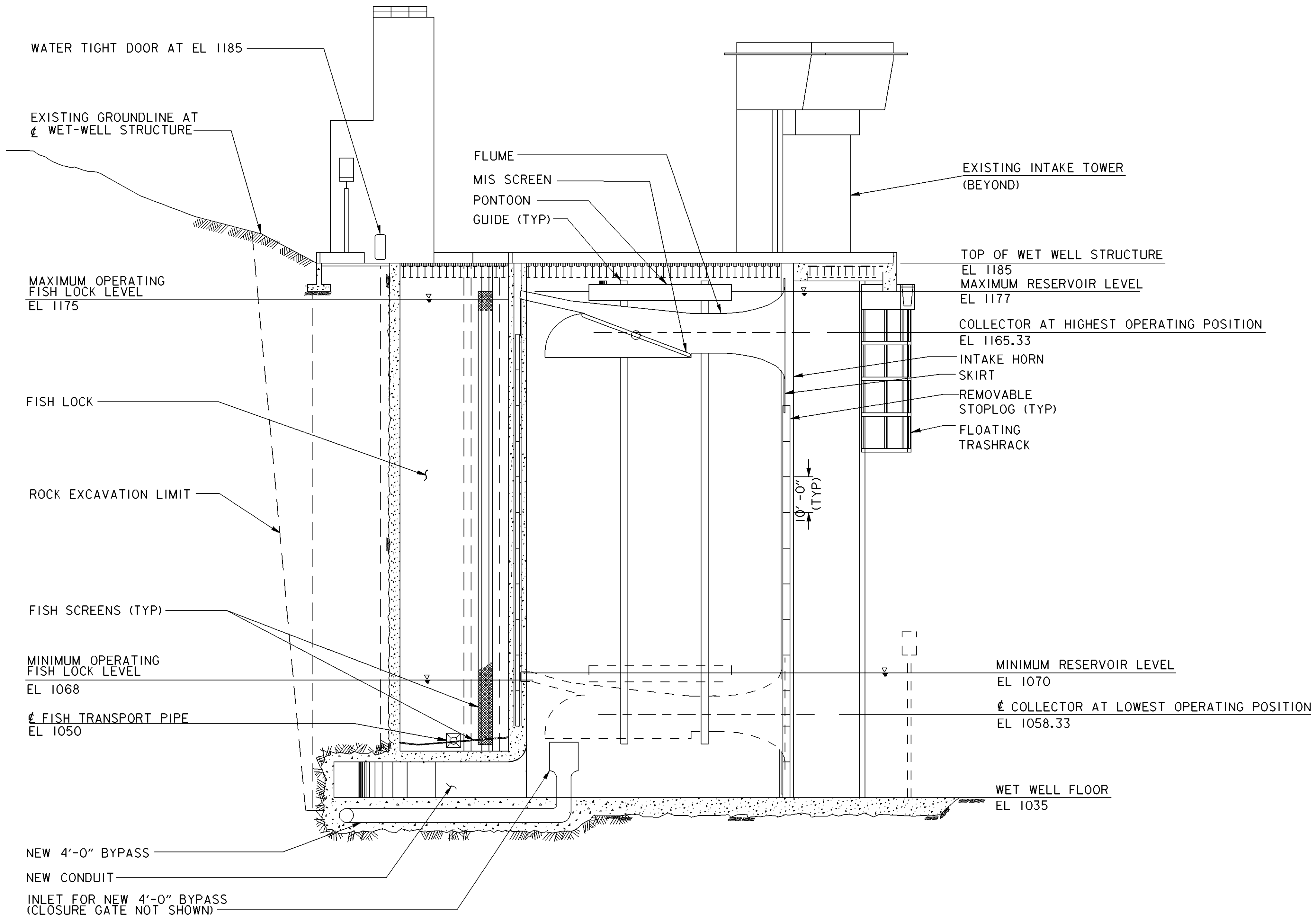


**SECTION** (A / S.30)

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HOWARD HANSON DAM
ADDITIONAL WATER STORAGE PROJECT
**FISH COLLECTION FACILITY**
**ALTERNATIVE 9A8**
**WET-WELL STRUCTURE**
**SECTION ALONG CENTERLINE**

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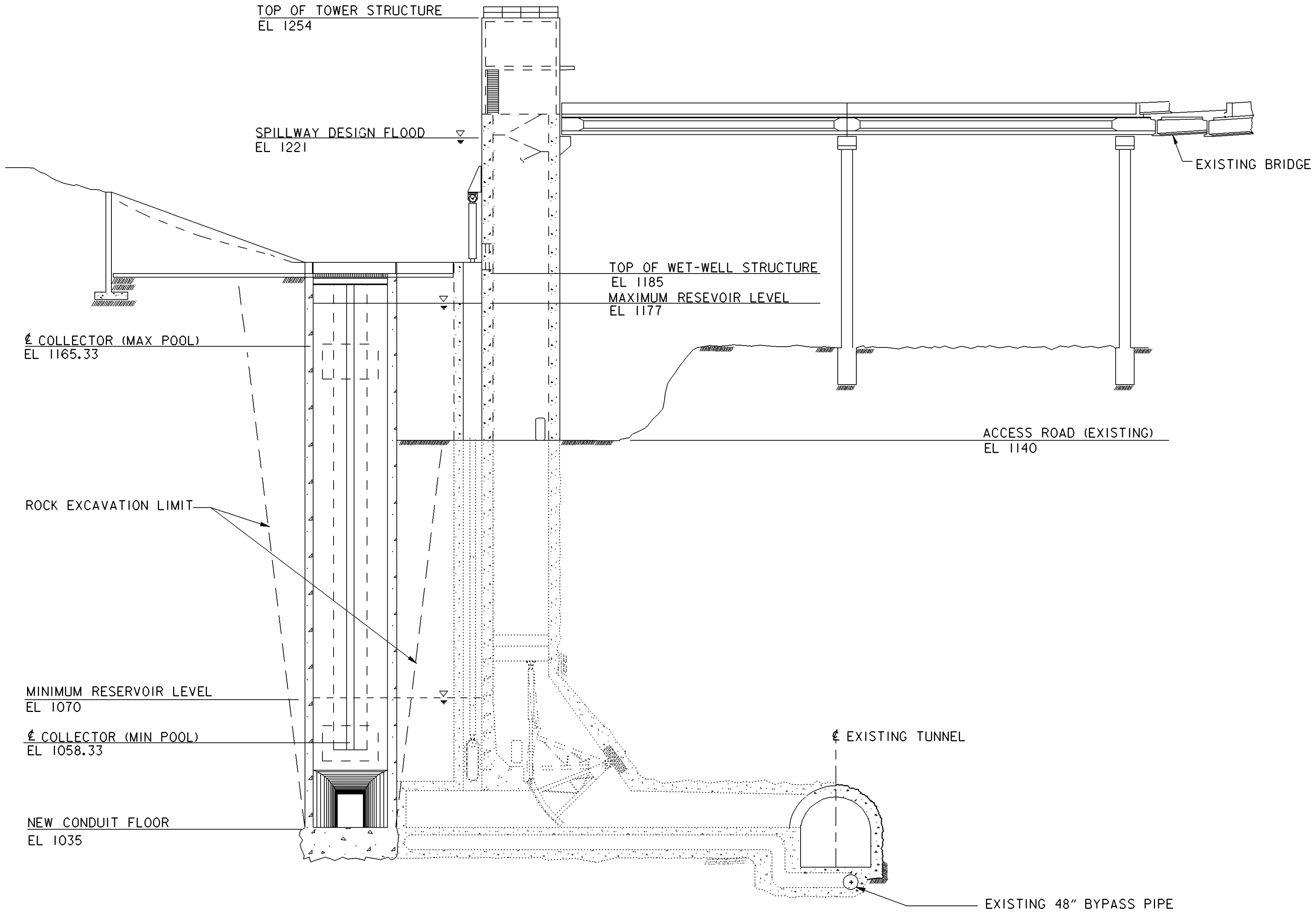


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HOWARD HANSON DAM
ADDITIONAL WATER STORAGE PROJECT

**FISH COLLECTION FACILITY**
**ALTERNATIVE 9A8**
**WET-WELL STRUCTURE**
**CROSS-SECTION**

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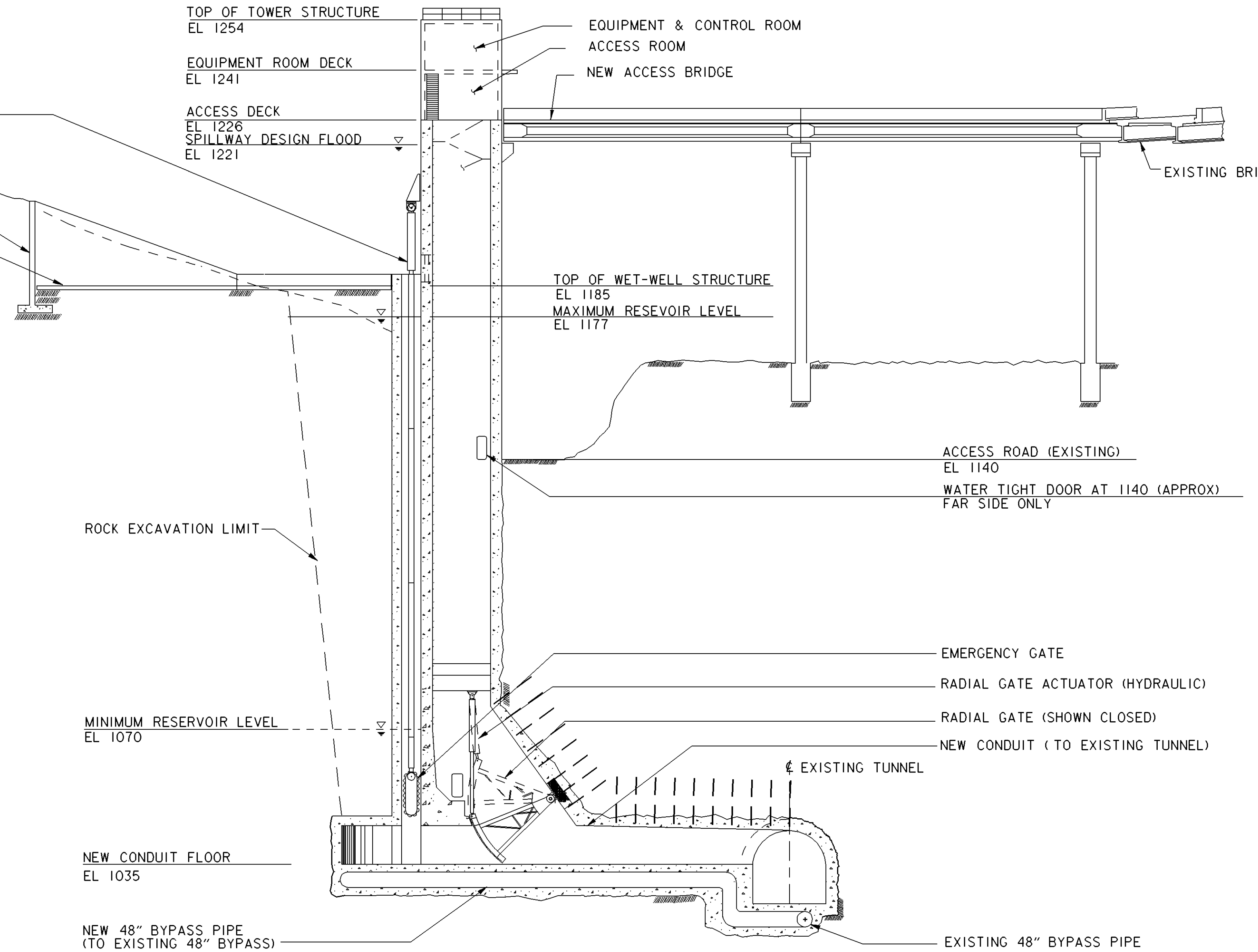


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HOWARD HANSON DAM
ADDITIONAL WATER STORAGE PROJECT
**FISH COLLECTION FACILITY**
**ALTERNATIVE9A8**
**DISCHARGE CONDUIT AND INTAKE TOWER**
**SECTION ALONG CENTER LINE**

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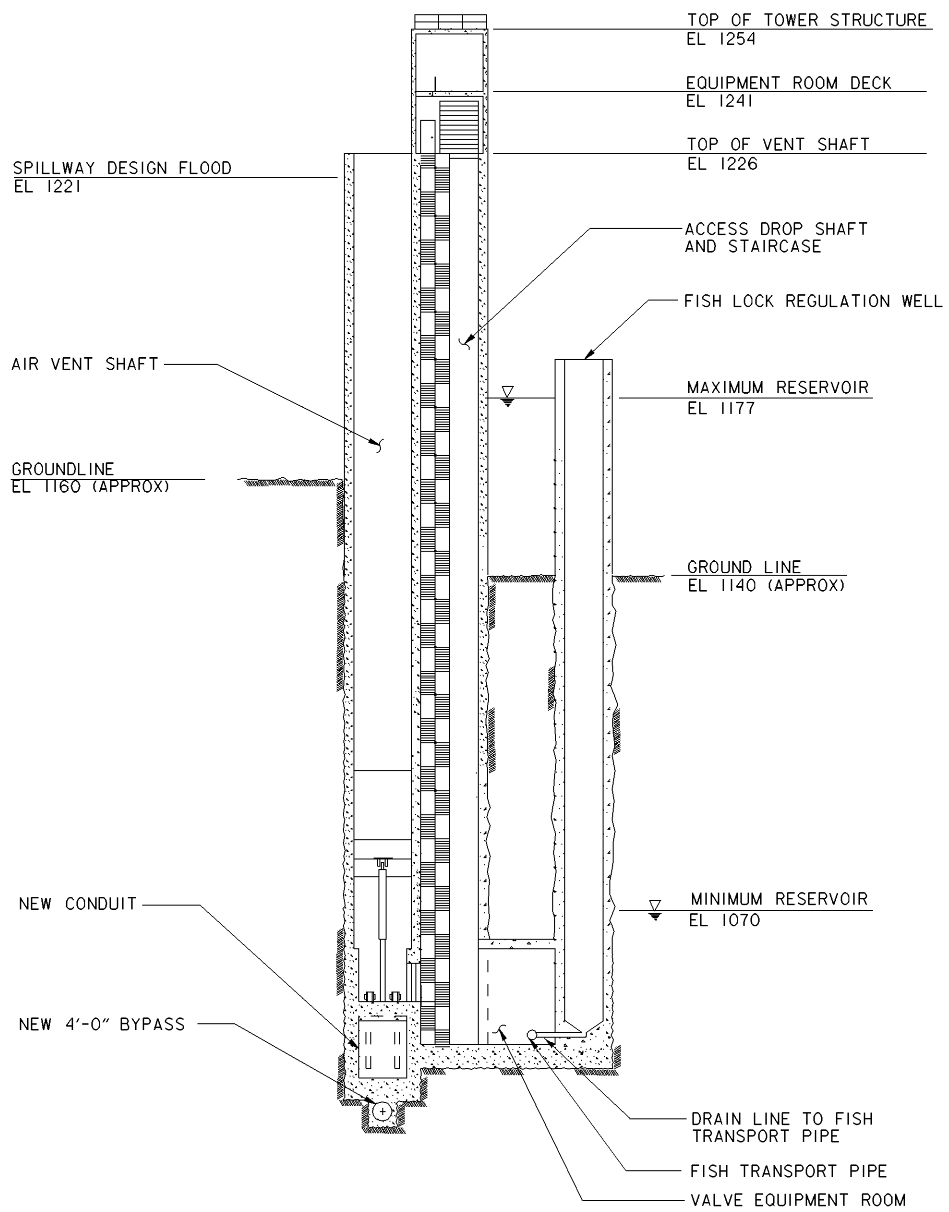


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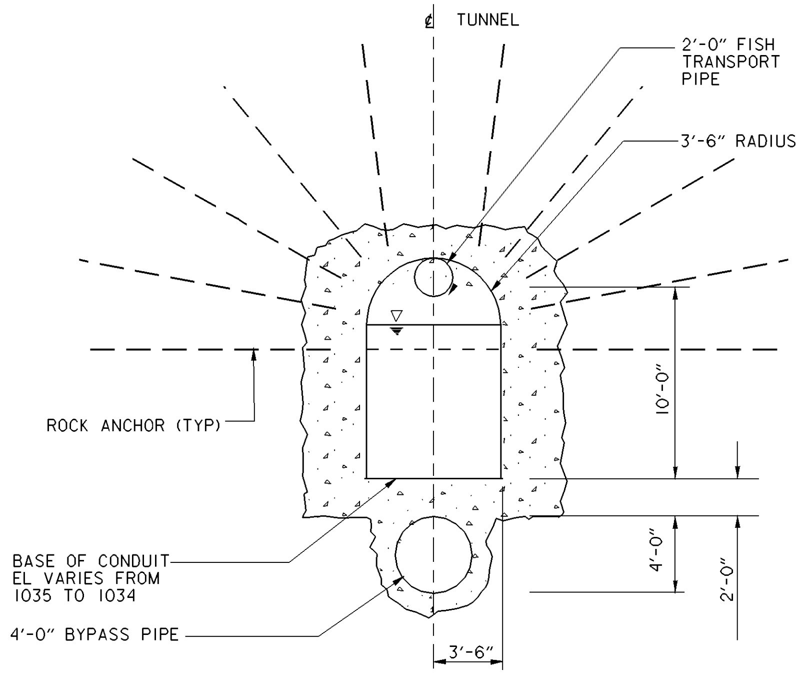


NEW DISCHARGE CONDUIT
CROSS-SECTION

**SECTION** E S.30

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HOWARD HANSON DAM
ADDITIONAL WATER STORAGE PROJECT
**FISH COLLECTION FACILITY**
**ALTERNATIVE 9A8**
**DISCHARGE CONDUIT AND INTAKE**
**TOWER CROSS SECTIONS**

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| DSGN. FRAGOMELI | | CHK. NOYES | SHEET 35 OF 50 | |

DESIGN FILE: I:ødesignsøhhawøfeasibilityøstrøCopy of hhawse01.dgn
DATE AND TIME PLOTTED: 27-OCT-2008 15:41

DATE AND TIME PLOTTED: 27-OCT-2008 15:48 DESIGN FILE: I:ødesignsøhhawøfeasibilityøstrøCopy of hhawse0d.dgn

| REVISIONS | | | | |
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| SYMBOL | ZONE | DESCRIPTION | DATE | BY |
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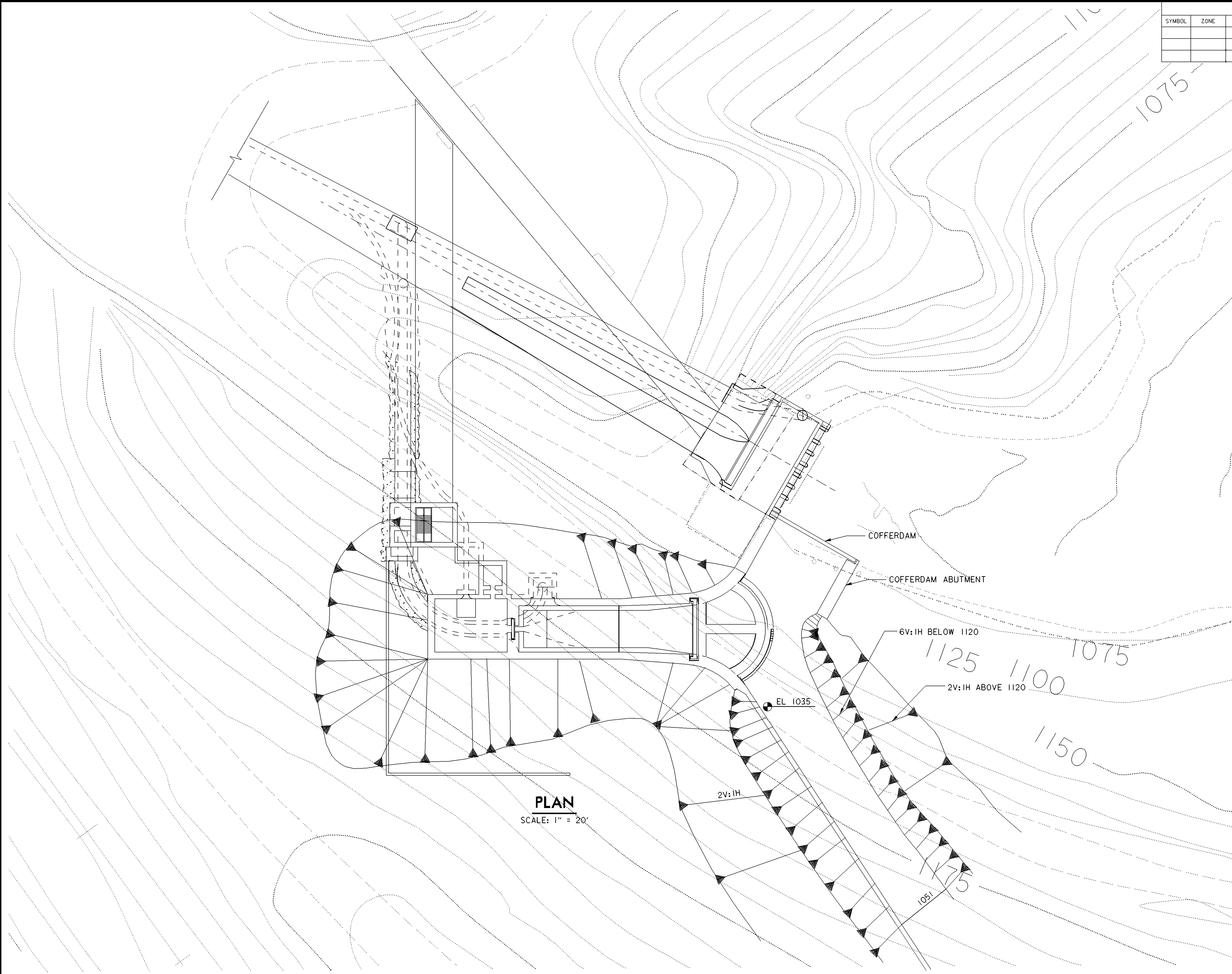



**PLAN**
SCALE: 1" = 20'

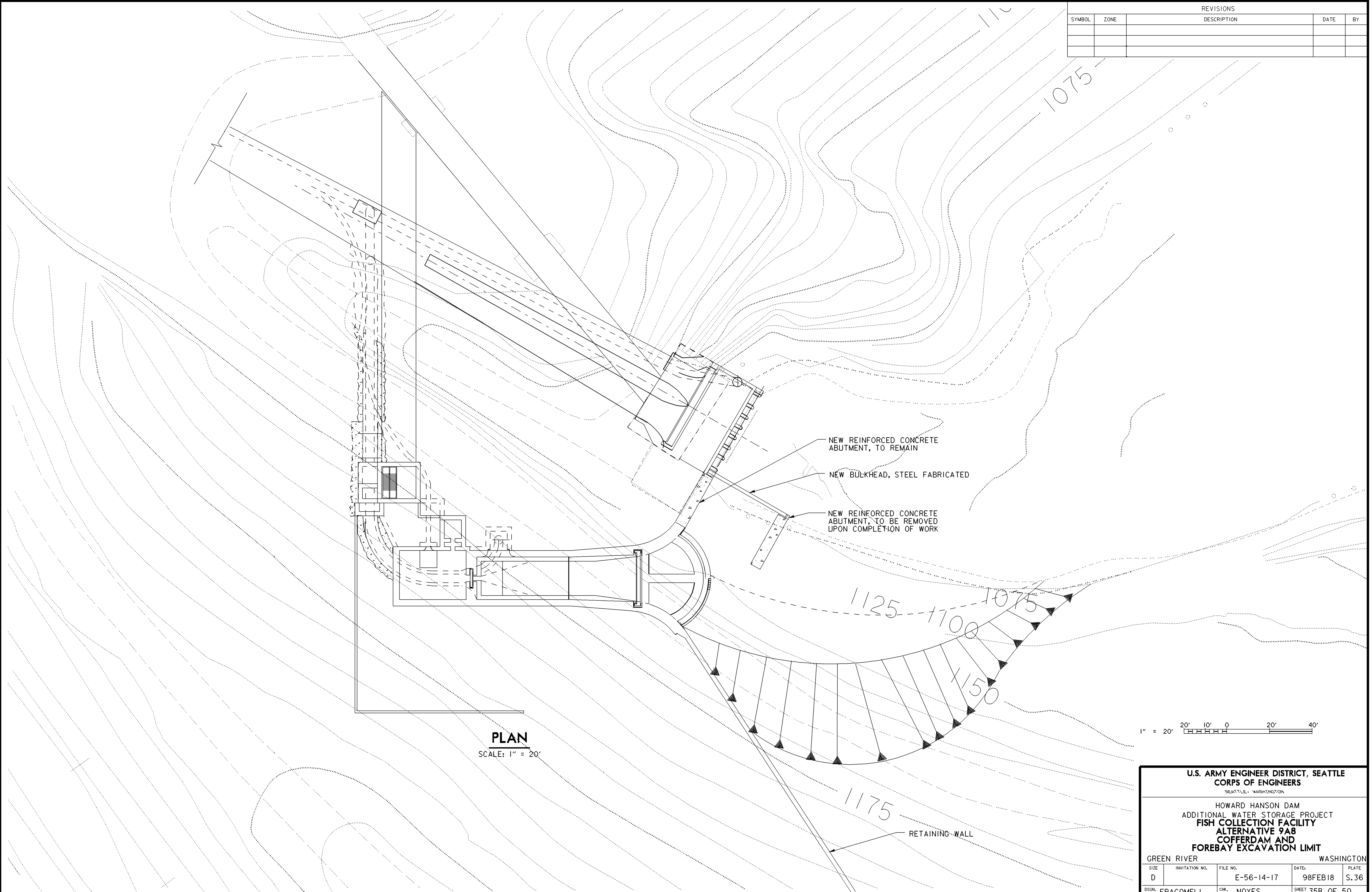
1" = 20' 20' 10' 0 20' 40'

**U.S. ARMY ENGINEER DISTRICT, SEATTLE**
**CORPS OF ENGINEERS**
SEATTLE, WASHINGTON

HOWARD HANSON DAM
ADDITIONAL WATER STORAGE PROJECT
**FISH COLLECTION FACILITY**
**ALTERNATIVE 9A8**
**COFFERDAM AND**
**ACCESS EXCAVATION LIMITS**

GREEN RIVER WASHINGTON

| SIZE | INVITATION NO. | FILE NO. | DATE: | PLATE |
| --- | --- | --- | --- | --- |
| D | | E-56-14-17 | 98FEB18 | S.35 |
| DSGN. FRAGOMELI | | CHK. NOYES | SHEET 35A OF 50 | |




| REVISIONS | | | | |
|---|---|---|---|---|
| SYMBOL | ZONE | DESCRIPTION | DATE | BY |

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

HOWARD HANSON DAM
ADDITIONAL WATER STORAGE PROJECT
**FISH COLLECTION FACILITY**
**ALTERNATIVE 9A8**
**COFFERDAM AND**
**FOREBAY EXCAVATION LIMIT**

GREEN RIVER WASHINGTON

| SIZE | INVITATION NO. | FILE NO. | DATE: | PLATE |
|---|---|---|---|---|
| D | | E-56-14-17 | 98FEB18 | S.36 |
| DSGN. FRAGOMELI | | CHK. NOYES | SHEET 35B OF 50 | |

DATE AND TIME PLOTTED: 27-OCT-2008 16:08 DESIGN FILE: I:\designs\hhaw\feasibility\str\Copy of hhawse0e.dgn