

Figure B.3-45. Sacramento River Pumping/Generating Plant Transverse Section



## Appendix B.3 Design Considerations

Table B.3-13 shows the amount of power required and the power generated by the SRPGP.

Table B.3-13. Sacramento River Pumping/Generating Plant

	<b>Q = 2,000 cfs (Pumping)</b>
Number of Installed Pumping Units	4 + 1 spare
Unit Pump Capacity (cfs)	600
Number of Installed Generating Units	2
Unit Generating Capacity (cfs)	750
Dynamic Head (feet)	256
Static Head (feet)	150
Unit Pump Power (hp) <sup>a</sup>	22,000
Unit Turbine Power Produced (MW) <sup>a</sup>	9.8

Key:

cfs = cubic feet per second

hp = horsepower

MW = megawatt(s)

### Afterbay

An afterbay (approximately 100,000 square feet) with bottom elevation of 35.0 feet would also be constructed. The fish screen facilities would be along the river at the entrance to the forebay/afterbay. A maintenance and access road is proposed around the afterbay at elevation 72.0 feet. The maximum and minimum water elevations in the afterbay are 70.0 feet and 51.0 feet, respectively. Water also would flow back through turbines at the plant, generating electricity and reducing the discharge head, then discharge into the afterbay back through the fish screen structure and into the river.

A sediment spoil area, for the afterbay sediment removal, is provided on the northeastern end of the afterbay. To remove sediment, a long-reach excavator is required in combination with a suction dredge or a clamshell. The suction dredge or clamshell would be used to remove the additional sediment in the area where the excavator cannot reach. The sediment ultimately would be hauled off site.

### Air Chamber

An air chamber (Figure B.3-47) would be required on each discharge line to control the surge pressures in the pipeline during normal start-up and shutdown, and during unusual events such as a loss of power. The air chamber is sized so that the upsurge pressure is limited to 125 percent of the rated pumping head (256 feet).

### Access Road

To have easy and safe access to the plant, a new access road connection to Highway 45 would be constructed. The width of the access road would be approximately 40 feet. The road would lead to both the plant building and the fish screen facility.

### Mechanical Features

Mechanical features of the SRPGP would include:

- Pumping and Generating Units

- 84-inch online spherical valve on each discharge line
- Air chambers ( 4 total) and butterfly valves with hydraulic power units
- Compressors
- Generators
- Gantry crane – 100 tons
- Service air and water systems
- Acoustical flowmeters

### **Electrical Features**

Electrical features of the SRPGP would include:

- Switchyard
- Governors
- Transformers
- Control system
- Switchgears
- Grounding grids
- Control cabinets

### **Facility Location Selection**

#### ***Site Geomorphology***

This section summarizes the June 2008 Sacramento River Fish Screen Facility Feasibility Study findings.

The proposed fish screen facility location, on the west bank of the Sacramento River at RM 158.5, was chosen on the basis of favorable hydraulic conditions (reduced bedload movement and aligned flow lines), geologic stability of the bank, and minimization of riparian disruption (Figure B.3-48).

The following historical river meander information is taken from the DWR’s 2007 pre-design report for this site:

“The proposed Sacramento River Pumping/Generating Facility location is in a section of river that is generally considered active. Within this section of river the main river channel has meandered significantly throughout the monitored history of the river (1896 to present).”

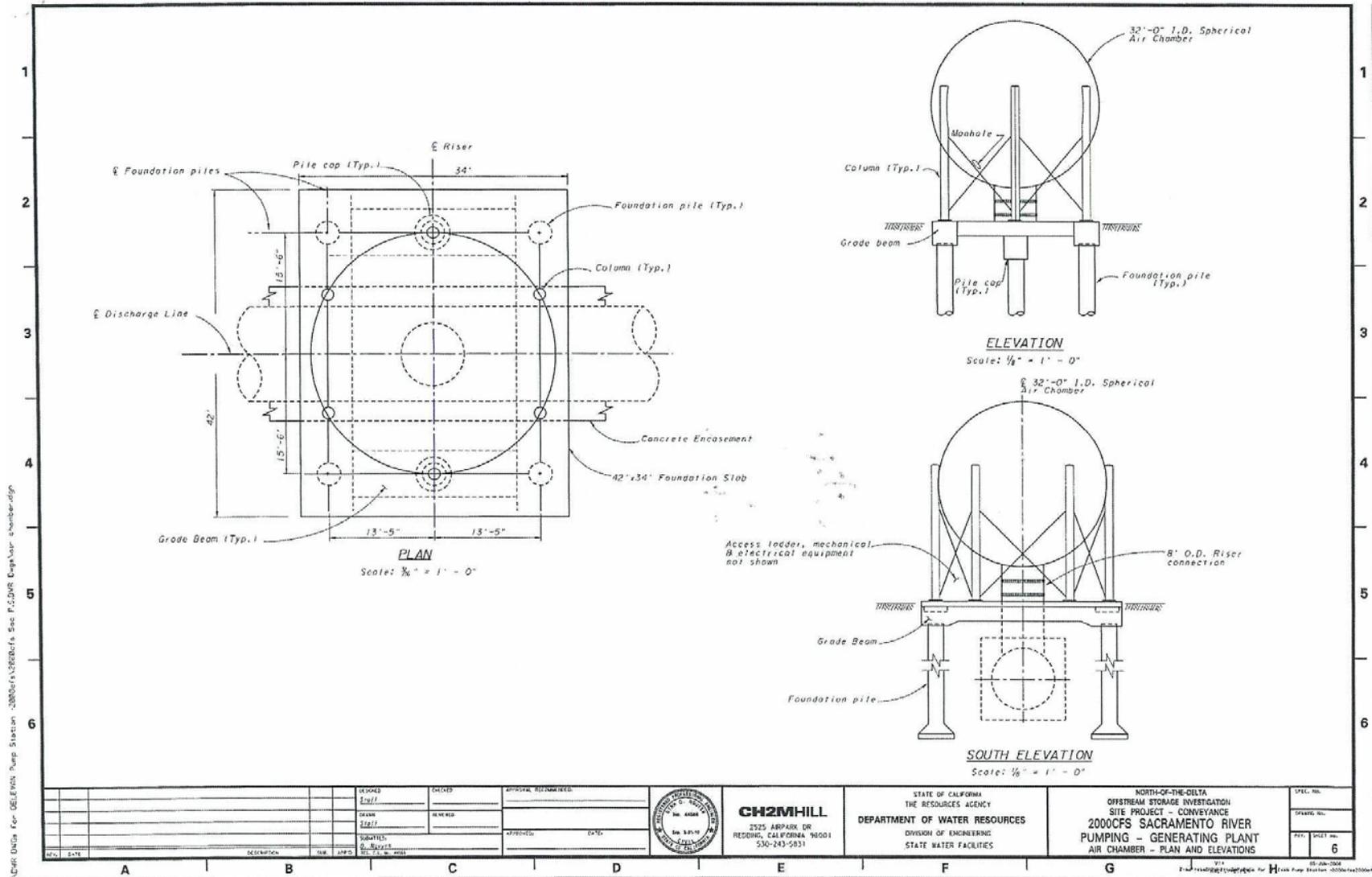


Figure B.3-47. Sacramento River Pumping/Generating Plant Air Chamber Plan and Elevations



Figure B.3-48. Proposed Site of Sacramento River Pumping/Generating Plant

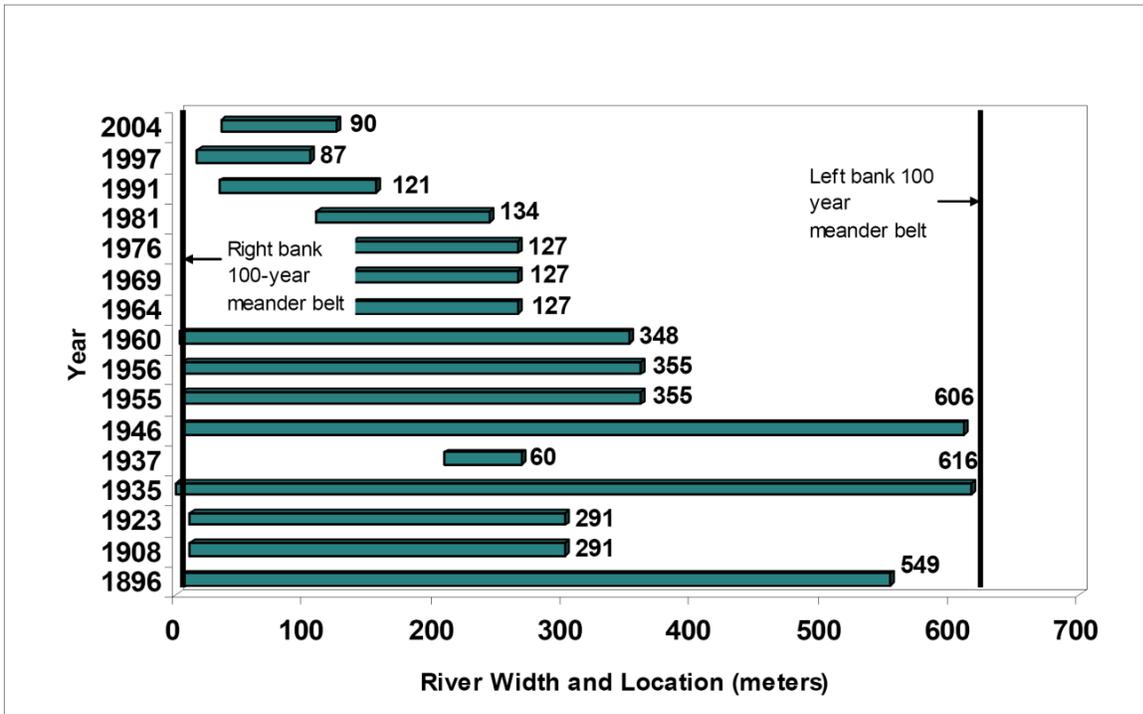


Figure B.3-49. Width and Location of Sacramento River at Moulton Weir (1896 to 2004)

Observation of the over 100 years of river meander data at Moulton Weir shows that the western bank of the river was stable until 1960, when it moved 138 meters east. Maxwell Irrigation District, which has a screened intake immediately upstream of the proposed pumping/generating facility location, has had to move its facility, because the river has meandered to the east. Since that time, the river has slowly moved westerly (Figure B.3-49). The existing data indicate that the current location (2004) is less than 40 meters east of the most westerly extent of the 100-year meander belt.

Figure B.3-49 also shows that the current configuration of the river channel is quite narrow by comparison with historical conditions. A wider river channel could appreciably change the sweeping flow velocities and sediment transport characteristics in the area, and change the operational capacity of fish screens. The 2004 configuration shows an approximate river channel width of 90 meters at the proposed pumping/generating facility location. The 100-year average channel width at this location has been approximately 268 meters, and has exceeded 600 meters in width, at times. Since the completion of Shasta Dam in 1946, the river has averaged 225 meters in width. River meander data over the last several decades suggest that the point bar to the north of the proposed pumping/generating facility location has been quite active, moving generally south (Figure B.3-49). If this trend continues, the point bar could eventually envelop the pumping/generating facility location, cutting it off from the river channel.

Subsequent study by DWR indicates that as of 2012, the point bar is approximately 430 meters north of the proposed intake facility location. A second point bar in the vicinity of the proposed intake facility is directly across the river on the eastern bank.

The upstream point bar moved downstream approximately 120 meters between 1958 and 1976, or the equivalent of 7 meters per year. In 1981, the USACE installed bank protection along the bank across from the point bar, and then extended the bank protection both upstream and downstream in 1987. Between 1976 and 1990, the point bar moved an additional 45 meters, but has not moved in the last 22 years since then. This is a typical point bar reaction to the placement of bank protection, and it is expected that the point bar would not move in the future if the bank protection continues to function.

The downstream point bar, across from the diversion point on the eastern bank, also moved downstream for a distance of approximately 300 meters between 1958 and 1990, or the equivalent of 10 meters per year. During this time, the river was meandering westward at the same rate as the point bar. Around 1990, the river encountered geologic control (older, more erosion-resistant geologic deposits) along the western bank, essentially stopping the migration. Since then, the point bar has not moved.

The river meander and point bar analyses conducted for the NODOS/Sites Reservoir Project indicate the following:

- The upstream point bar would not continue to move downstream as long as the bank protection installed in 1981 and 1987 remains intact.
- The downstream point bar across from the diversion point has not moved since about 1990. It may migrate downstream, although unlikely, but this movement would not affect the Delevan Pipeline Intake Facilities fish screen.

It is possible, however, that the intake facilities may become a locus of deposition. A possibility exists that the point bar across from the intake facilities may develop a cutoff channel along the eastern boundary, essentially turning the existing point bar into an island. This is not an uncommon occurrence on the Sacramento River once a bend has bank protection installed, or encounters geologic control (geologic control and the fish screens would have the same effect as bank protection). Normally, this type of cutoff forms during large flood events.

There is evidence of an incipient high-flow channel, and periodic maintenance dredging occurs at this site to facilitate flow into Moulton Weir during floods. If a cutoff should occur along the high-flow channel alignment, and this channel becomes the main channel, then the Delevan diversion point would be in a backwater area. Deposition may then occur along the length of the fish screens, and sweeping flow velocities along the screens may not be sufficient to meet established criteria (this is similar to the conditions at the GCID diversion near Hamilton City, where the diversion channel requires periodic dredging to maintain proper function). The probability is low that a cutoff would occur. Should a cutoff occur in the future, periodic dredging could be required to maintain connectivity with the river and to provide sweeping velocities for proper screen function.

### **River Hydraulics**

The Sacramento River is a regulated river that is largely controlled by Shasta Dam. Several unregulated side streams between Redding and the NODOS/Sites Reservoir Project site can contribute notable runoff in the winter. The river has several overflow weirs, but they are

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downstream of the project site. The flood flows in this reach of the Sacramento River can exceed 150,000 cfs with some regularity.

### Velocity Profiles

Previous work by DWR in 2007, and related DWR experience along the Sacramento River both upstream and downstream of this site, indicate that sweeping velocities would not be problematic for the NODOS/Sites Reservoir Project. The location of this site on a stable, outside river bend is favorable for sweeping velocities, fish passage, and prevention of sediment deposition in front of the fish screen structure. The following passage is taken from DWR's previous pre-design report for this site.

Using bathymetric data at 2-foot contour intervals, cross sections were drawn at 25 foot intervals along the horizontal center line of the river channel. Three cross sections (shown on Figure B.3-50) were selected and analyzed to determine the stage-velocity-flow relationship. The locations were chosen to develop the proposed Sacramento River Pump Station intake location. Using the cross sections, the area and wetted parameter of the channel were calculated for various stage heights. Manning's Equation was then used to calculate the theoretical average velocity of the river at these locations for the various stage heights.

The analysis shows that even at very low stages with theoretical flows of 500 to 2,000 cfs, the river velocity stays above 2 feet per second. CALSIM II operations runs for NODOS project Alternative WS1B indicate that diversions from the proposed SRPGP would take place at minimum river flows greater than 4000 cfs. Measured velocity profiles of the area would be required for final design of the fish screen facility; however, these data indicate that sweeping velocity should not be a limiting factor in the design and operation of the facility. An assumption of sweeping velocity greater than 0.66 feet per second is reasonable for planning level design.”

### Development of the Rating Curve and Monthly Flow Duration

A rating curve (Figure B.3-51) for the fish screen facility was created using a mathematical method and four measured points. Flow-duration information was developed on a monthly scale to look at seasonal influences and flows in the river.

Flow-duration curves were developed from a single gauging station. Using the daily flow data at each station—and flow data at the Butte City gauge, considered to be more applicable to the fish screen facility—flow-duration curves were developed from the flow-duration table with daily flow data compiled from 1970 to 1995.

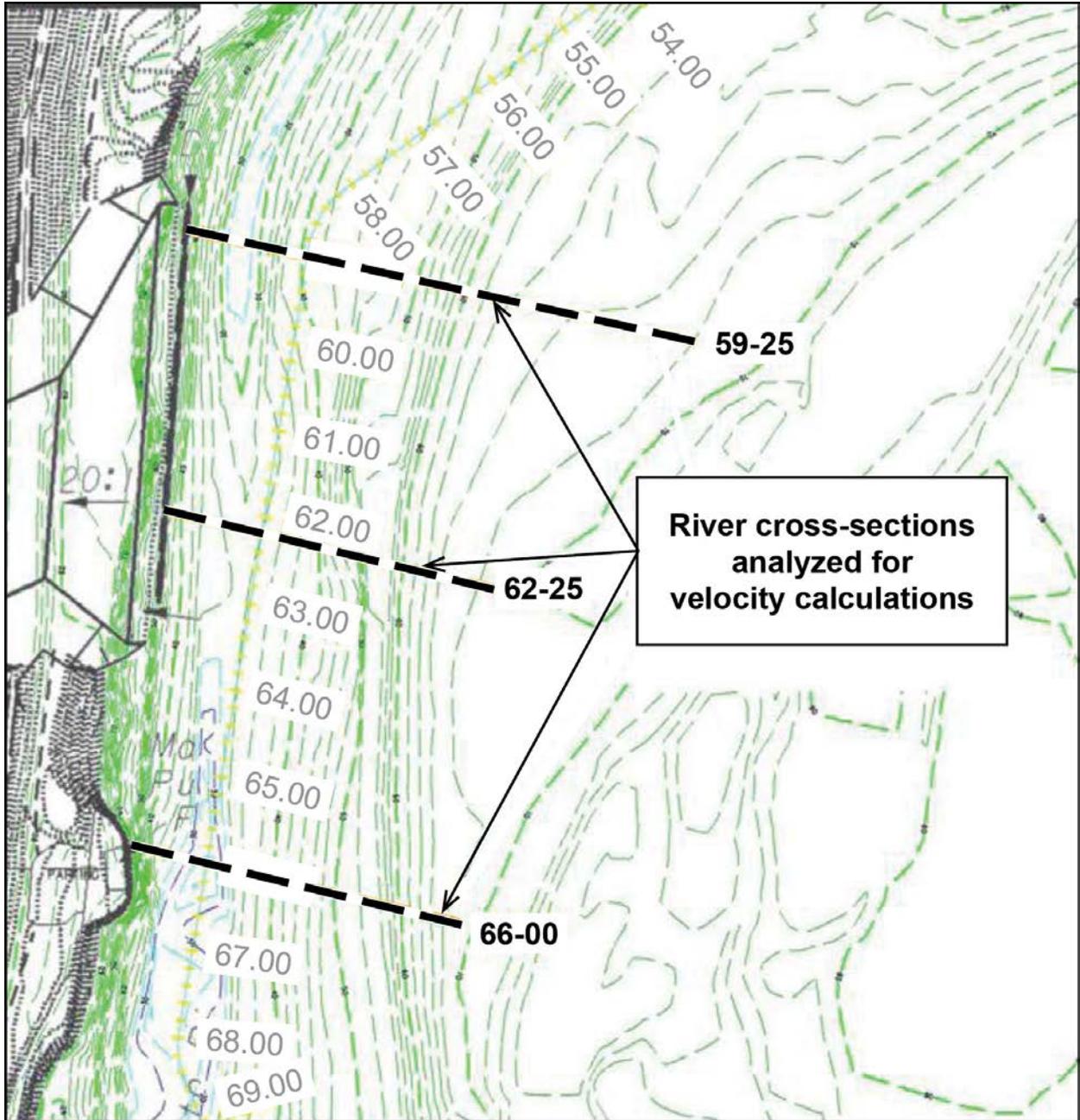


Figure B.3-50. Plan View of NODOS/Sites Reservoir Project Location with Cross Sections

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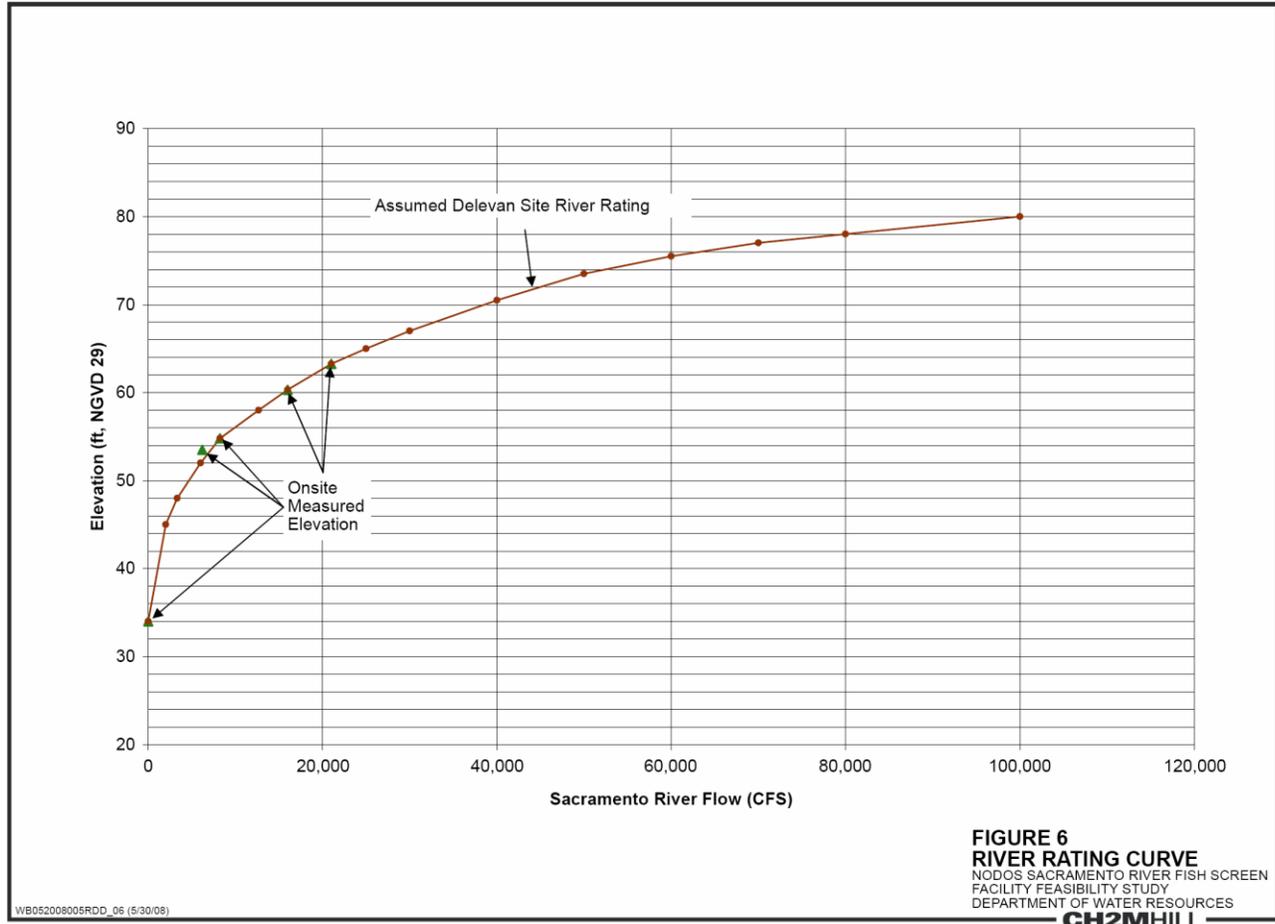


Figure B.3-51. River Rating Curve

Assuming normal-depth flow, rating curves at Butte City and Colusa, and using the following measured and assumed points shown in Table B.3-14, a rating curve (Figure B.3-51) was developed for the fish screen facility.

Table B.3-14. On-Site Measured Points, North-of-the-Delta Offstream Storage, Sacramento River Fish Screen Facility Feasibility Study

Date of Point Taken	Maxwell Irrigation District Deck Elevation (feet, NGVD)	Depth to Water Surface (feet)	Calculated Sacramento Water Surface Elevation (feet)	Flow Rate (cfs)
2/5/2008	71	10.67	60.33	16,000
2/27/2008	71	7.75	63.25	21,000
3/10/2008	71	16.20	54.80	8,230
4/4/2008	71	17.50	53.50	6,212

Key:  
 cfs = cubic feet per second  
 NGVD = National Geodetic Vertical Datum

## Sacramento River Intake Fish Screens

Two intake alternatives that were considered are described as follows:

- Alternative 1 – Flat-Plate Fish Screen – This alternative consists of one large structure with minimal moving parts drawing water through 13-foot by 15-foot flat-plate screens of stainless-steel wedge wire. Multiple fish screen bays would convey water through the structure, and blow-out bays would allow for equalization of WSE in an emergency situation. No separate discharge facilities would be required with this alternative. Water would be discharged back to the river through the screening facility.
- Alternative 2 – T-screens – This alternative consists of one large structure with a number of moving parts drawing water through 14 units, with a total of 28 fish screen barrels. A separate discharge facility would be required for this alternative.

Alternative 1 was selected as the preferred alternative for the intake fish screens. Alternative 1 was deemed the best alternative for addressing predation issues, providing operational flexibility, handling large debris, handling sediment, minimizing the number of moving parts, reducing operating costs, and avoiding additional discharge facilities. There is also more available performance data for the flat-plate fish screen; this reduces the risk and uncertainty (CH2M Hill 2008). Aspects of this alternative are described below.

### Design Criteria and Assumptions

The development of the conceptual fish screening and discharge alternatives considered as part of the NODOS/Sites Reservoir Project is based on certain design criteria and assumptions, as follows:

- Regulatory criteria, as presented and discussed with the Anadromous Fish Screen Program Technical Team that is composed of representatives from the following Federal and State resources agencies: the United States Fish and Wildlife Service, Reclamation, the National Marine Fisheries Service, DWR, and the California Department of Fish and Wildlife (CDFW).
- Mechanical and structural criteria, based on engineering principles, and design and construction experience of similar structures along the Sacramento River and in the Pacific Northwest.
- Operational and maintenance criteria, based on discussions with DWR and experience with diversions along the Sacramento River.
- River hydraulics.

### Regulatory Criteria

The following regulatory criteria were considered for fish screen intakes:

- Average approach velocity (water velocity perpendicular to the screen, 3 inches from the face of the screen), less than or equal to 0.33 fps
- Minimum sweeping velocity (water velocity parallel to the screen, 3 inches from the face of the screen) of two times the approach velocity

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- Uniform distribution of the approach velocity across individual fish screen panels
- In-river construction window of April 1 to November 1 – a waiver is required
- Screen slot opening size of 1.75 millimeters

### ***Mechanical and Structural Criteria***

The following mechanical and structural criteria were considered:

- The structure would be constructed in the dry using a cofferdam.
- The structure would need to divert water at high river levels and high river flows.
- The structure would need to divert water in a varying degree of river elevations.
- The invert elevation of the structure would be set at 38 feet.
- Facilities would be sited and designed so that electrical equipment would be sealed or placed at an elevation above the 100-year flood stage plus 2 feet of freeboard (elevation 84 feet).
- A log boom would keep large, floating debris from hitting and potentially damaging the screen.
- Panels would be 13 feet tall by 15 feet wide, with an effective screen area of 95 percent.
- Panels would be made of stainless-steel vertical-wedge wire.
- Panels would be positioned with minimum protrusion into the river channel parallel to river flow.
- The fish screen structure would contain the following:
  - Two blow-out panels, in the event that water levels need to be rapidly equalized to maintain the integrity of the structure (i.e., prevent a serious overturning moment).
  - A louver system to manipulate the inflow uniformity across the screens.
  - A continuous catwalk below the fish screen structure deck with an access hatch to provide adequate access for screen and louver maintenance.
  - A sediment removal system that keeps river sediment from accumulating in the fish screen structure (sedimentation affects the uniformity of the fish screen approach velocity).
  - A screen-cleaning system that keeps small debris from plugging the screen, within the parameters set by the resource agencies.
- Pier walls separating each bay would be 1.5 feet wide.
- Screen panels would be submerged to the degree necessary to allow diversions without violating fish protection criteria.

**Operational and Maintenance Criteria**

The following operational and maintenance criteria (discussed in greater detail in following sections) were considered:

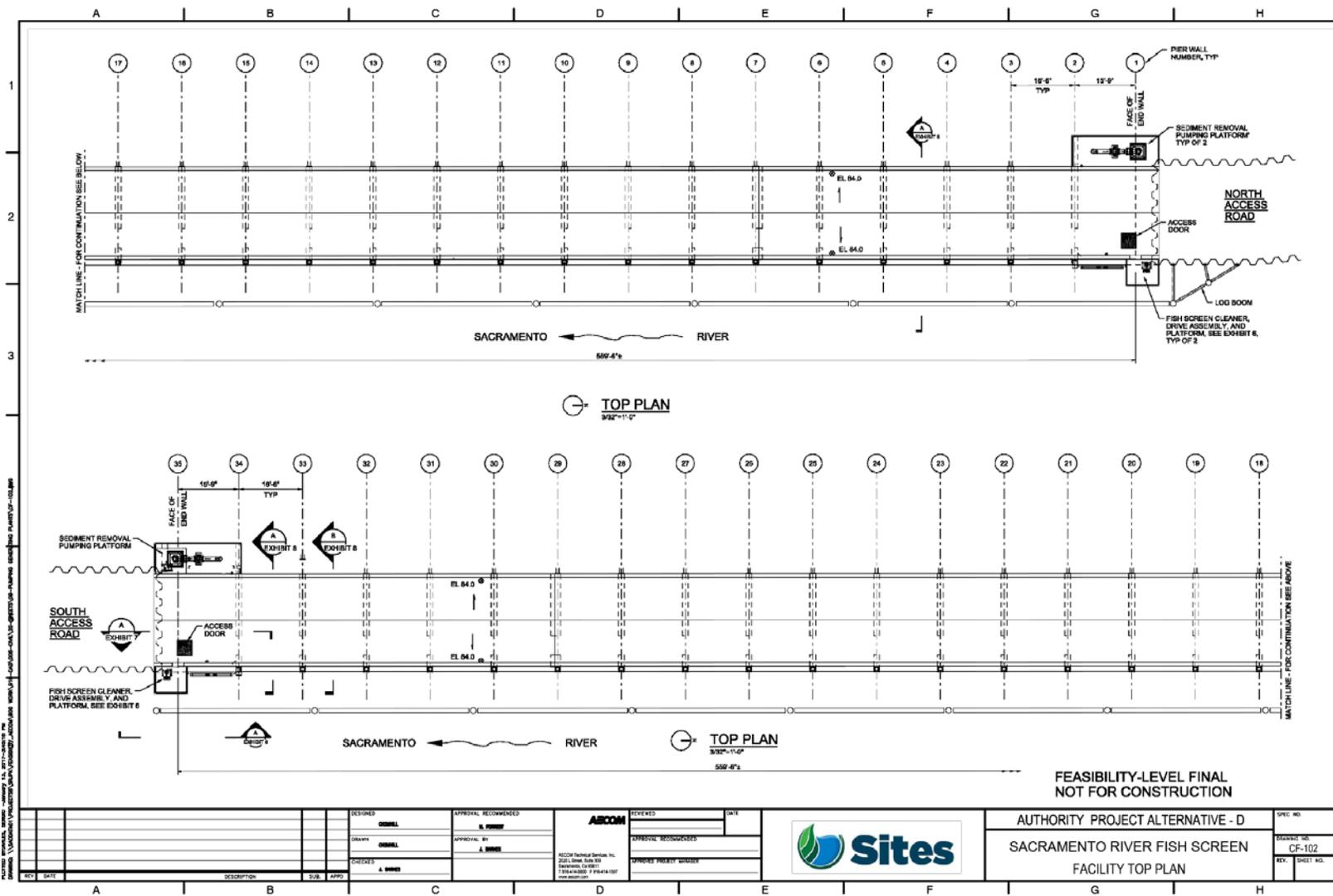
- Diversion operations would be such that a minimum of 4,000 cfs would remain in the river channel immediately downstream of the diversion point.
- Water would be diverted within a minimum of 5,000 to 6,000 cfs in the river channel immediately upstream of the diversion point. The assumed associated minimum WSE at this design condition is 51 feet.
- A sediment removal system would be installed in the fish screen bays, moving sediment back into the river channel or into the forebay. Sediment that has settled out into the forebay would be removed mechanically to maintain optimal operational hydraulics. This effort likely would be an annual operation.

**Fish Screen Structure Details**

The fish screen structure, as shown on Figure B.3-52 through Figure B.3-55 for a 2,000 cfs diversion, consists of thirty-two 13-foot by 15-foot flat-plate screens, two blow-out bays, two fish screen cleaners, a sediment removal system, and tuning baffles. Each item is necessary for the proper function of the proposed fish screen.

The flat-plate screens provide the screening mechanism to prevent fish from entering the pumps. The blow-out bays prevent damage to the fish screen structure by providing a mechanical safeguard to prevent differential levels in WSE between the forebay and the Sacramento River from exceeding 4 feet. The fish screen cleaner is a mechanism that moves along the river side of the screen, and removes debris buildup by means of a large brush. The sediment removal system is a system that pumps water into the sediment removal piping and forces the water out at high pressure through nozzles in each bay. This jetting action suspends and moves the sediment out of the fish screen structure. The tuning baffles behind the screen panels provide a means to distribute the velocities of water across the fish screen to reduce uneven distribution of flow across the structure.

The fish screen's size, as shown on Figure B.3-53, allows a maximum pumped flow of 2,000 cfs through the structure, while not exceeding an intake velocity of 0.33 fps across the screens. Using the river's flow/stage durations and a design river flow of 6,000 cfs, the minimum river stage at which the facility would operate is 51 feet. The invert of the screen structure is set at 38 feet, 4 feet above the invert of the river; this position would reduce sediment deposition in front of the screen panels. The river's stage and the screen's invert at the designed flow results in a screen height of 13 feet. For this design, the screens are 15 feet wide, and an estimated 32 screen bays are required to match the desired 0.33-fps velocities across the screen. The structure would be 559.5 feet long, the distance created by 32 screen bays, the additional two blow-out bays, and room for screen-cleaning equipment.



FEASIBILITY-LEVEL FINAL  
NOT FOR CONSTRUCTION

DESIGNED OMMEL		APPROVAL RECOMMENDED G. PERRY			REVIEWED	DATE	AUTHORITY PROJECT ALTERNATIVE - D SACRAMENTO RIVER FISH SCREEN FACILITY TOP PLAN	SPEC. NO.
DRAWN OMMEL		APPROVAL BY J. BERRY			APPROVAL RECOMMENDED			ISSUED TO CF-102
CHECKED A. BERRY					APPROVED PROJECT MANAGER			REV. SHEET NO.
NO.	DATE	DESCRIPTION		DATE				

Figure B.3-52. Sacramento River Fish Screen Levee Piping Plan

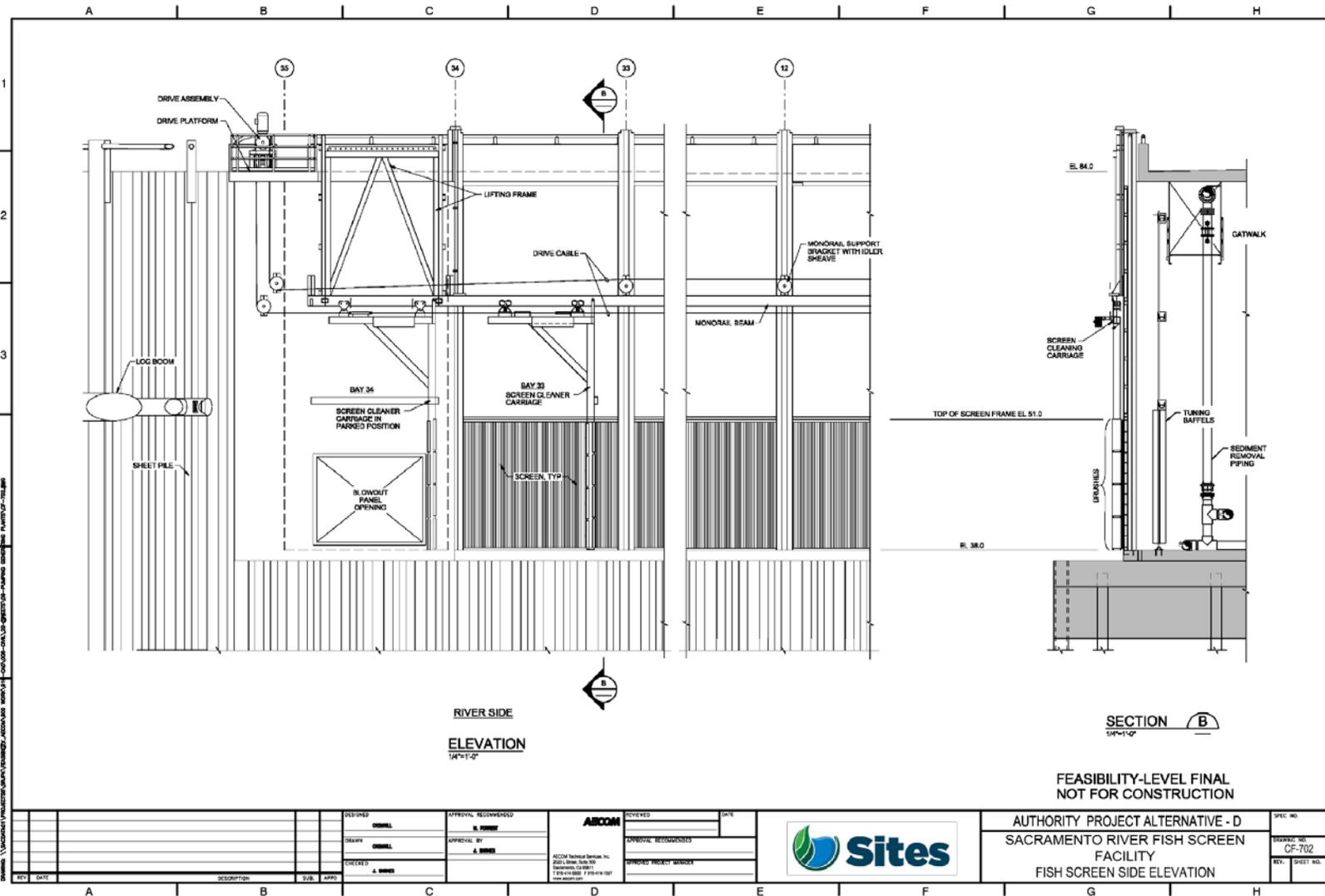


Figure B.3-53. Sacramento River Fish Screen Levee Piping Plan

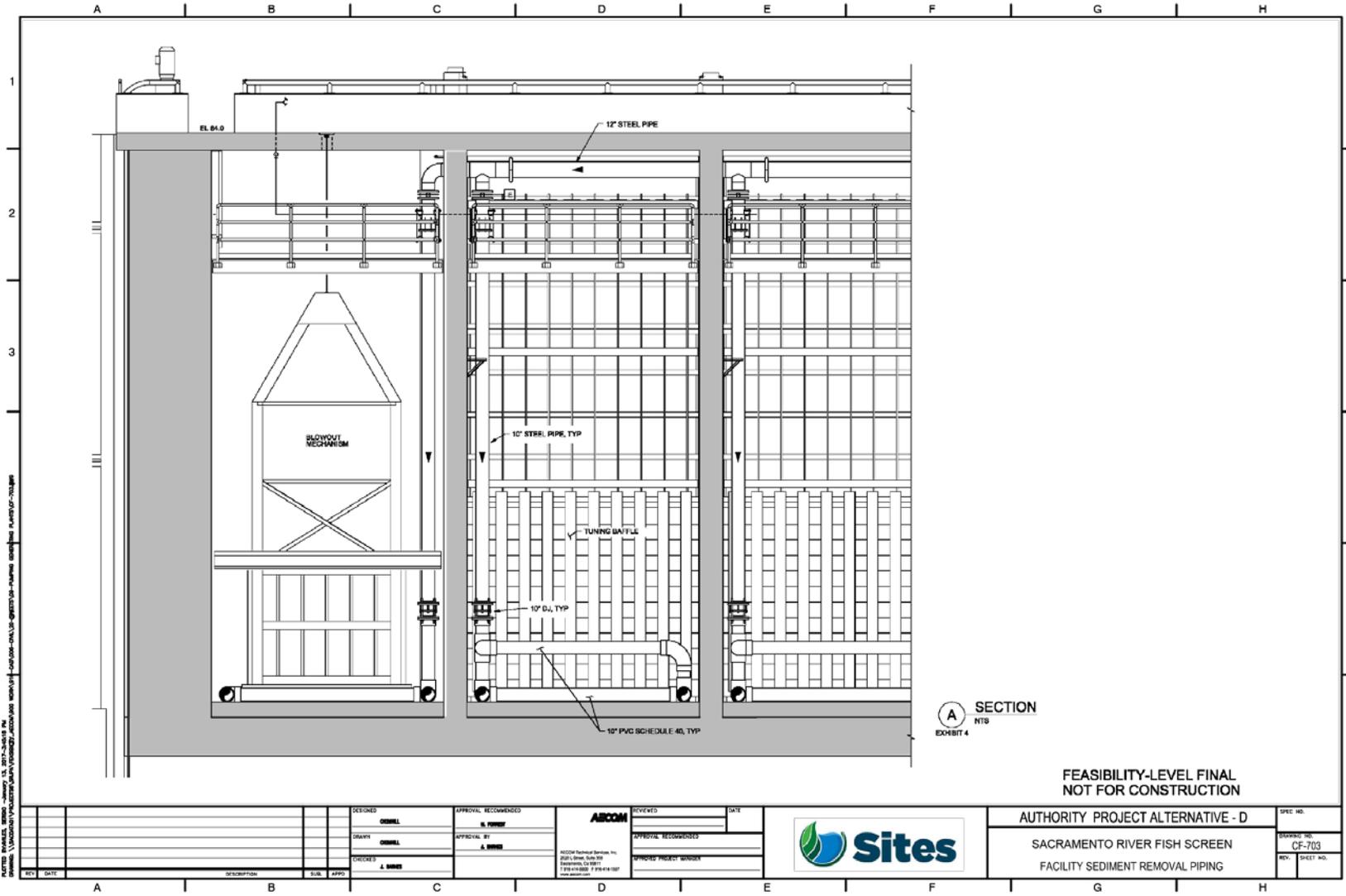


Figure B.3-54. Sacramento River Fish Screen Levee Piping Plan

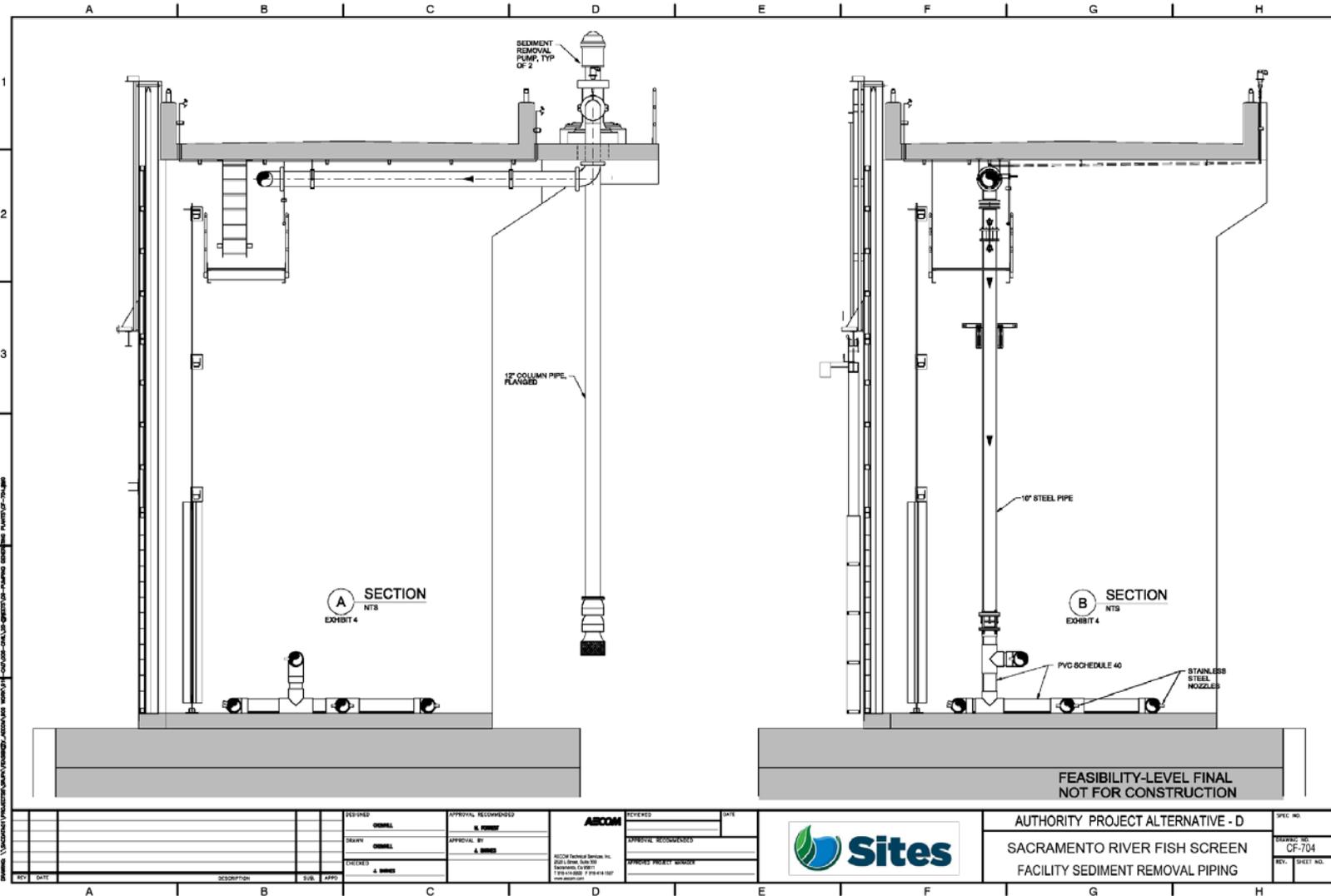


Figure B.3-55. Sacramento River Fish Screen Levee Piping Plan