Pardee Reservoir

Pardee Outlet Tower Condition Assessment

April 2013

EAST BAY MUNICIPAL UTILITY DISTRICT

Prepared by:

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1 Introduction

Jacobs Associates was retained by East Bay Municipal Utility District (EBMUD) to provide a conditional assessment of the Pardee Reservoir's outlet tower. This report presents the findings of the visual inspection performed on November 28, 2012.

Prior to the inspection, Jacobs Associates and Mead & Hunt (team) reviewed available historical documentation, including the original as-built drawings, construction photographs, and the preliminary seismic analysis and structural design reports prepared in 1987 and 1998 (Dames & Moore, 1987; HDR, 1998).

A remotely operated vehicle (ROV) was utilized to inspect the interior and exterior of the outlet tower, and the submerged approach channel while the outlet tower remained in service. Because of concerns regarding potential contamination of the Pardee Reservoir with the zebra mussel, EBMUD supplied the ROV for Underwater Resources to pilot.

The team inspected the interior and exterior surfaces of the concrete tower structure, the interior of the screening chamber, and the 450 feet elevation inlet channel entrance, which is roughly 120 feet away from the outlet tower. In addition, all inlet slide gates, stems, stem guides, screens, and their respective connections were assessed. The operation of each gate operator unit and slide gate was also observed during the raising and lowering of each inlet slide gate.

2 Project Background

The Pardee Dam and Reservoir are located on the Mokelumne River in the foothills of the Sierra Nevada Mountains, near the town of Valley Springs in Calaveras County, California. Water is diverted from the Pardee Reservoir through the Pardee outlet tower and tunnel. The Pardee outlet tower and tunnel are located about 0.75-mile southeast of Pardee Dam. The dam was completed in 1929, and the tunnel and outlet tower were constructed during the same time period. The relationship of the dam, the reservoir, and the outlet tower is shown in Figure 1.

The outlet tower is located along the reservoir's western shore, approximately 840 feet from the tunnel's eastern portal. The outlet tower is 226 feet tall from its foundation at approximately El. 380 to the top of the gate house at El. 606. The tower is a partially submerged reinforced concrete structure which is accessed from the shoreline by a footbridge.

The 317-foot-long footbridge connects the tower's operating floor, the gate lift house floor at El. 585, with the shoreline. The bridge consists of four spans, approximately 5 feet wide, supported by intermediate piers. The span closest to the shore consists of a reinforced concrete deck about 46 feet long. The three other spans are steel trusses, each about 90 feet long. The pier closest to the shore is reinforced concrete, while the two other piers are of steel construction.

The outlet tower shaft extends from approximately El. 380 feet to El. 583 feet, and supports the gate lift house. Of the overall height, the tower shaft is surrounded by rock below El. 479 feet and is free-standing from El. 479 to El. 583 feet.

The tower includes 12 externally and 3 internally mounted slide gates. The operators and control panels for all slide gates are housed in the outlet tower's gate lift house. The exterior gate system includes four elevations of slide gates, with three gates per level. The gate guide stems and screens are mounted on the external walls of the tower. The interior gate system includes 3 bonneted slide gates located at the base of the outlet tower which control water flow from the East Tunnel Portal into the shaft. The interior gates are not routinely operated.

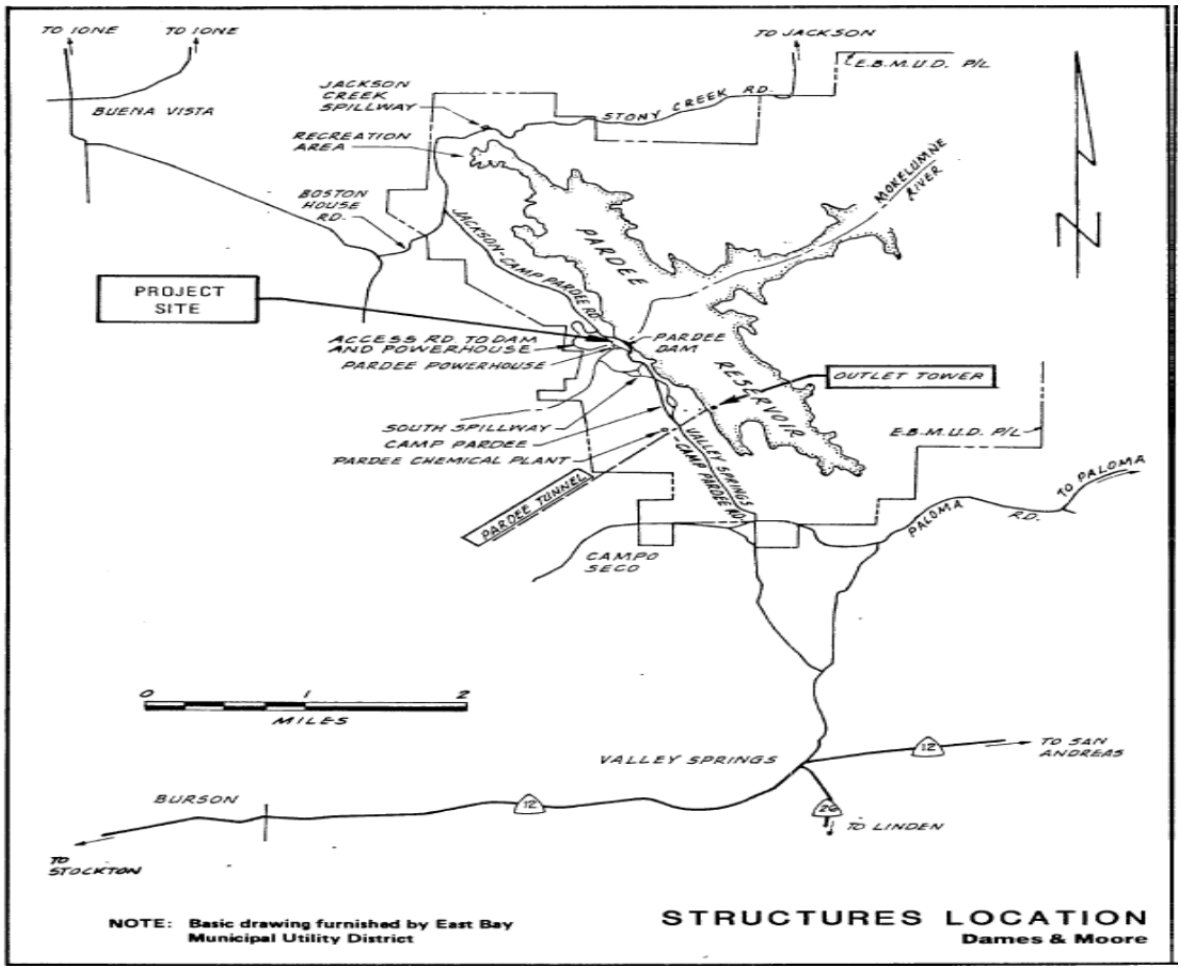

Figure 1. Location of Pardee Dam

Figure 2. Outlet Structure During a Drought

Figure 3. Outlet Structure in Operation

3 Inspection Methodology

The inspection team consisted of a lead inspector/civil engineer and a civil engineer from Jacobs Associates accompanied by a mechanical engineer from Mead & Hunt. Prior to the inspection, the team reviewed the available existing information and data provided by EBMUD, including as-built records and previous assessments and recommendations. Table 1 is a list of most relevant documents reviewed.

Table 1. EBMUD As-Built Drawings

Project Record No.	Name of Drawing	Year
DH-1350-6	General Arrangement	1928
DH-1245-2	Location of Inlet Channel General Arrangement	1928
DH-1358-6	30 x 36 inch Slide Gates	1928
DH-1359-6	30 x 36 inch Slide Gates Frames	1928
DH-1363-6	Screening Chamber	1928
DH-1403-6	Screens	1928

3.1 Inspection Plan

Based upon the available as-built records, Jacobs Associates developed a plan to visually inspect the interior and exterior surfaces of the outlet tower, screening chamber, inlet channel entrance, and all visible concrete connections via a remotely operated vehicle (ROV). In addition, the inspection plan's aim was to assess the condition of the mechanical equipment—gate operators, inlet slide gates, stems, stem guides, and screens. The detailed inspection plan and schedule are attached as Appendix B.

3.1.1 Structural Inspection Plan

The following inspection plan outline was used throughout the inspection:

1. Outlet Tower Interior:
    a. Examine the concrete structure (cracks, exposed rebar, anchor bolt corrosion, spalling).
    b. Examine ladders, stairs, handrails, and all mechanical component attachments to the concrete tower.
2. Outlet Tower Exterior:
    a. Examine the concrete structure (cracks, exposed rebar, anchor bolt corrosion, spalling).
    b. Examine all mechanical attachments (stem guides and trash rack) to the concrete tower.
3. Inlet Channel Entrance (El. 450 feet):
    a. Search and locate entrance.
    b. Examine condition (cracks, exposed rebar, anchor bolt corrosion, spalling).
4. Eastern Tunnel Portal Entrance (El. 392 feet):
    a. Search and locate entrance.
    b. Examine condition (cracks, exposed rebar, anchor bolt corrosion, spalling).

3.1.2 Mechanical Inspection Plan

The mechanical inspection plan was developed following a review of the tower general arrangement and the development of the structural inspection plan. The following inspection plan outline was used throughout the inspection:

1. Outlet Tower Interior:
    a. Examine all gate operators.
    b. Examine inlet slide gates, sills and sleeves for three gates at four vertical locations at El. 550 feet, El. 520 feet, El. 490 feet and El. 460 feet.
    c. Examine three low-level bonneted slide gates, stems, stem guides, and sleeves.
2. Outlet Tower Exterior:
    a. Examine multiple level inlet slide gate stem guides and sleeves.
    b. Examine basket screens and their support chains and connections at each elevation: El. 550 feet, El. 520 feet, El. 490 feet, and El. 460 feet.

3.1.3 Operational Assessment

1. Gate Operators:
    a. Observe operation of each gate operator.
2. Slide Gates:
    a. Observe operation of each inlet slide gate and bonneted slide gate.

4 Inspection

On November 28, 2012, the Team gathered at Pardee Reservoir to perform the inspection. The entire Team, including EBMUD, met to review the inspection objectives, job safety, and sequencing. EBMUD was concerned about potentially contaminating Pardee Reservoir with the invasive zebra mussel and required Underwater Resources to utilize EBMUD's ROV during the outlet tower inspection. During setup and testing, Underwater Resources determined that the ROV's depth gauge and compass were providing inaccurate readings. After several unsuccessful attempts to reset the ROV's navigational equipment, the Team decided to use the ROV's tether cable as a depth gauge by marking it in 5-foot increments, ignoring the instrumentation. Following the set up and testing of the ROV equipment, the condition assessment of the outlet tower began.

The inlet slide gates and their operators are distinguished by their elevation and are lettered sequentially in groups (A–C), from left to right when entering the outlet tower's gate lift house as shown in Figure 4. The observations of the outlet tower exterior, screening chamber and screens were referenced to the same letter groups, with the exception of the inlet channel entrance. The observations of the interior structure were referenced by depth.

The following structural and mechanical features were not inspected:

- The tower's roof
- The access truss

The Pardee Reservoir water surface elevation during the inspection was at El. 561. The inspection was completed during Day One (see schedule in Appendix B). Field notes are included in Appendices C and D and the DVD record of the inspection is indexed in Appendix E. A summary table of recommendations is included in Section 5.

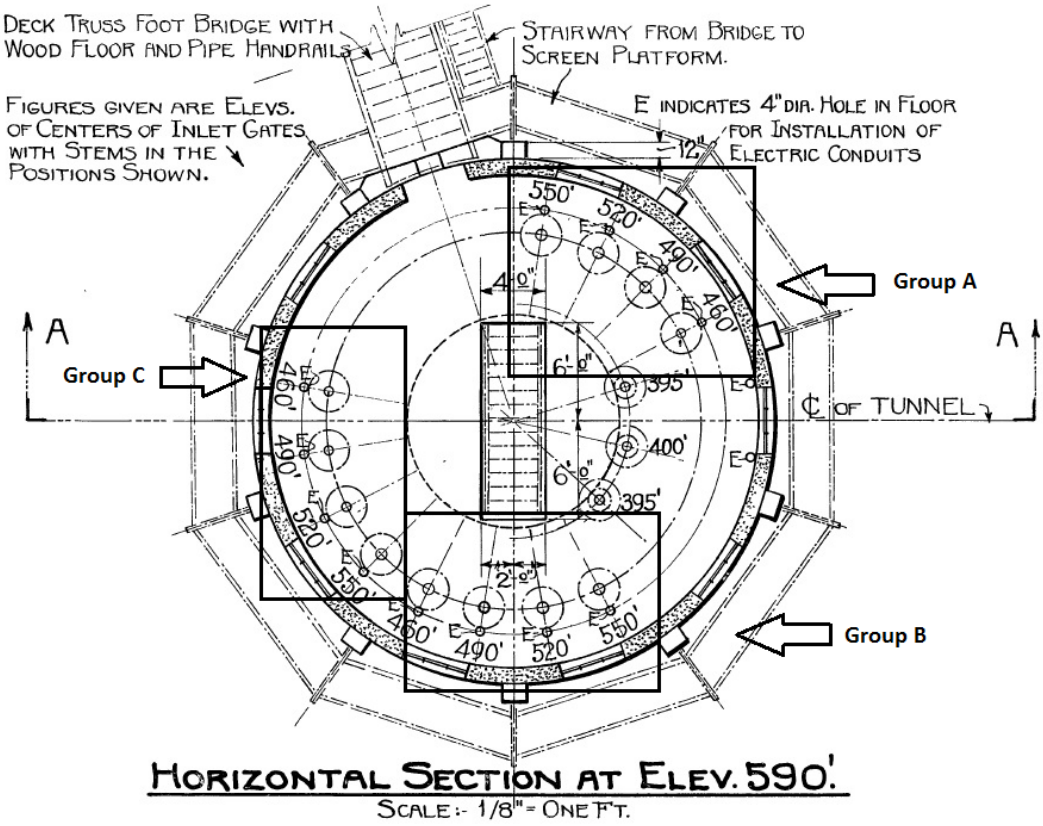

Figure 4. Labeling of Gate Groups

4.1 Outlet Tower Structural Assessment

The outlet tower gate house is 30 feet in diameter and consists of a 12-inch-thick cast-in-place concrete operating floor with 12-inch-thick walls. The inside diameter of the outlet tower shaft is 19 feet from top to its base. The outlet tower shaft outside diameter tapers from 28 feet at the tower's base to 23 feet immediately below the gate house. The concrete shaft wall varies in thickness from 54 inches at its base to 48 inches at El. 421, then to 18 inches at the gate house floor at El. 585. The slide gates located at El. 460 are located within a screening chamber embedded approximately 30 feet into the rock (see Figures A1 and A2 in Appendix A).

4.1.1 Interior and Exterior Surface

The interior and exterior surfaces of the outlet tower were visually inspected during the site visit. A walk-around was performed to assess the condition of the tower gate house and the interior and exterior walls above the water line. The assessment of the outlet tower and screening chamber below the water line was conducted using the ROV.

Both the outlet tower and the screening chamber appear to be in excellent condition. The visual inspection did not identify any visible indicators of concrete deterioration, efflorescence, or reinforcement corrosion. There were no signs of structural distress or cracking on the observed surfaces of concrete. Hairline cracks were observed at construction joints between concrete pours. All mechanical and structural anchorages to the concrete walls were intact and showed no signs of wear or corrosion.

On the exterior of the tower adjacent to Gate 550B, a honeycombed pocket was identified as shown in Figure 5. This defect appears to have originated with the original construction, and there are no indications of an active deterioration process.

Figure 5. Gate 550B Honeycombed Pocket

4.2 Elevation 450 Inlet Channel Entrance Assessment

A 120-foot long, 6-foot by 6-foot concrete culvert connects the reservoir and screening chamber to slide gates 460A, B and C. A steel trashrack, located at the entrance to the culvert, prevents debris from entering the screening chamber. The invert of the inlet channel and culvert is at El. 450 feet (see Figure A3 in Appendix A).

The ROV visual inspection of the inlet channel shows the culvert entrance to be in good working condition. The steel trashrack at the culvert entrance is not obstructed and has minimal organic deposit growth. There is no sediment buildup in the channel at the culvert entrance, and a current into and through the trashrack was visible when the upper slide gates were closed.

4.3 Elevation 392 East Tunnel Portal Entrance Assessment

The eastern tunnel portal entrance is located approximately 840 feet away from the outlet tower in a north easterly direction at El. 392 feet. EBMUD could not locate the eastern portal to place a buoy using surveying methods prior to the inspection. To locate and inspect this portal, the team and members of Underwater Resources were planning to use a boat to set up and launch the ROV.
After discussions with EBMUD, the search for the eastern tunnel portal entrance was abandoned. Because EBMUD is not currently using, or planning to use, this inlet to transfer water from the reservoir into the outlet tunnel, spending another day searching for it and inspecting it did not appear to be cost effective.

4.4 Outlet Tower Mechanical Assessment

The outlet tower has four levels of 30 x 36-inch inlet slide gates, located at El. 550, 520, 490, and 460 feet, respectively. Each level has three slide gates distributed around the shaft perimeter, each controlled by a dedicated electric gate operator located on the gate lift house operating floor at El. 585. Gate stems connect the operators and slide gates, and are supported by brackets attached to the exterior of the tower. The gates allow water to be drawn from different elevations of the reservoir into the outlet tower and discharged through three 4-foot diameter outlet pipe at El. 395 into the outlet tunnel at El. 392. Each gate is protected with a screen on its exterior side to prevent large-sized debris from entering the outlet tower and the tunnel.

Additional information and figures on these gates are found in Appendix C, Mead and Hunt's Evaluation of Mechanical Components Report.

At the base of the tower at El. 395 feet and immediately upstream of the shaft, three bonneted valves control the flow from the East Tunnel Portal into the outlet tunnel. These bonneted slide gates are in the closed position and appear to have not been operated in approximately 25 years.

4.4.1 Interior

The interior mechanical inspection assessed the condition and operation of the submerged inlet slide gates, gate frames, and bonneted slide gates. The condition and operation of the gate operators for the inlet slide gates were observed via the ROV's cameras and video monitor. The bonneted slide gates at El. 395 were identified by the ROV at the base of the tower and only their condition was observed because they could not be operated.

All of the slide gates were examined by maneuvering the ROV into each gate portal and assessing its condition and operation through the ROV camera. Each inlet slide gate was raised and lowered using the respective gate operator to detect leakage and assess the condition of the entire inlet gate and gate frame. There is no significant visible leakage, deterioration, corrosion or wear to any of the gate frames or inlet slide gates. All of the gate operators, limit switches, and associated controls are in good working condition.

After each of the 12 exterior slide gates were inspected, the ROV went to the base of the outlet tower and inspected the condition of the bonneted slide gates. The bonneted slide gates could not be opened because their submerged gate stems were unable to rotate. It could not be determined during the inspection whether the stem support bearing or the valves were preventing the stems from rotating. The butterfly valves of two of the three bonneted gates are visible as seen in Figure 6. The third butterfly valve is covered by a blank flange with a steel pipe protruding.

Debris comprising varying sized steel pipes was observed in the vicinity of the bonneted slide gates and the outlet pipes at El. 395 ft, but because of the flow disturbance it was not possible to gauge the extent of other debris in the bottom of the tower. The flow into the outlet pipes was observed via the ROV's camera and appeared to be unaffected by the debris.

Figure 6. Closed Bonneted Slide Gate

4.4.2 Exterior

After finishing the interior inspection, the ROV was placed in the reservoir to examine the outlet tower's exterior. The submerged gate stems, stem couplings, stem guides, screen guide tracks, and screens were assessed using the ROV's camera. Each of the gate stems were followed from the surface to inspect the stem guide supports and locate and assess the screens and gates placed around the perimeter of the outlet tower.

There was no evidence of any loose or failing hardware attached to the outlet tower. All gate stems, stem couplings, stem guides, screens, and screen guide tracks appeared in acceptable condition. However, considerable amounts of debris and deposits were found on the surface of the screens and mechanical components at El. 520 and 550 feet as shown in Figure 7 for the screen at 550B. A failure was noted of the coupling hardware connecting the lifting chain to the screens at gates 490A, 520A, 520B, and 520C as shown in Figure 8 for example.

Figure 7. Gate 550B Screen Clogged with Deposits

Figure 8. Gate 520A Broken Coupling of Hardware Connecting Lifting Chain to Screen

5 Conclusions and Recommendations

5.1 Conclusions

Overall, the Pardee Reservoir Outlet Tower is in good condition. The visual inspection of the outlet tower and inlet channel on November 28, 2012 did not identify any major structural or mechanical deficiencies affecting the outlet's continued reliability. Jacobs Associates and EBMUD recognize that ROV inspection includes inherent observational and tactile limitations which affect the effectiveness of the inspection.

The Team identified the following items for EBMUD's consideration.

- A broken shackle connecting the lifting chain to the screen was observed at inlet slide gates 490A, 520A, 520B, and 520C. The hardware failure does not affect the structural integrity of the outlet tower, but needs to be repaired to facilitate cleaning of the screens.
- The screens found at El. 520 and 550 feet are obstructed with considerable amounts of debris and growth.
- The bonneted slide gates located at the bottom of the outlet tunnel could not be opened because of their submerged gate stems being unable to rotate, and further evaluation is needed if these gates are to be used in the future.

5.2 Recommendations

Based upon the field observations on November 28, 2012, recommendations to maintain the outlet tower's reliability are presented in three categories: High Priority, Moderate Priority, and Low Priority. Specific recommendations are included in Table 2.

- **High Priority.** These items reflect deficiencies that immediately affect the outlet tower's operational reliability and structural integrity, and jeopardize personnel safety. It is recommended that such items be completed within the next 6 months.
- **Moderate Priority.** These items reflect maintenance items which could affect the outlet tower's operational reliability in the future. It is recommended that such items be completed within three years.
- **Low Priority.** These items reflect maintenance items which could have a long term effect on the outlet tower's operational reliability. It is recommended that such items be completed at the convenience of the owner and within the next five years.
- **Observation/Monitoring.** These items reflect issues that should be monitored and observed on a regular basis to ensure that they do not become maintenance items.

Table 2. Recommendations

Priority	Location	Recommended Action
High	Slide Gates 490A, 520A, 520B, 520C - Coupling Hardware	Replace broken coupling hardware.
Moderate	Slide Gate Screens at El. 520 and 550 feet	Remove debris and deposits from the surface of screens and mechanical components.
Low	Bonneted Slide Gates at El. 395	Determine why bonneted slide gates will not open.
Low	All Inlet Slide Gates	Automate the operation of the gates.
No Action	Gate 550B concrete construction defect below screen	Do nothing.

6 References

Dames & Moore. 1987. *Final Report Preliminary Seismic Evaluation Pardee Outlet Tower and Tunnel.* San Francisco, CA.

HDR. 1998. *Pardee Reservoir Raised Intake Tower Preliminary Seismic Analysis & Structural Design.* Vol.14. Oakland, CA.

7 Revision Log

Revision No.	Date	Revision Description
0	February 18, 2013	Draft Issued for Review and Comment
1	April 22, 2013	Final Report Issued

Appendix A: Reference Drawings

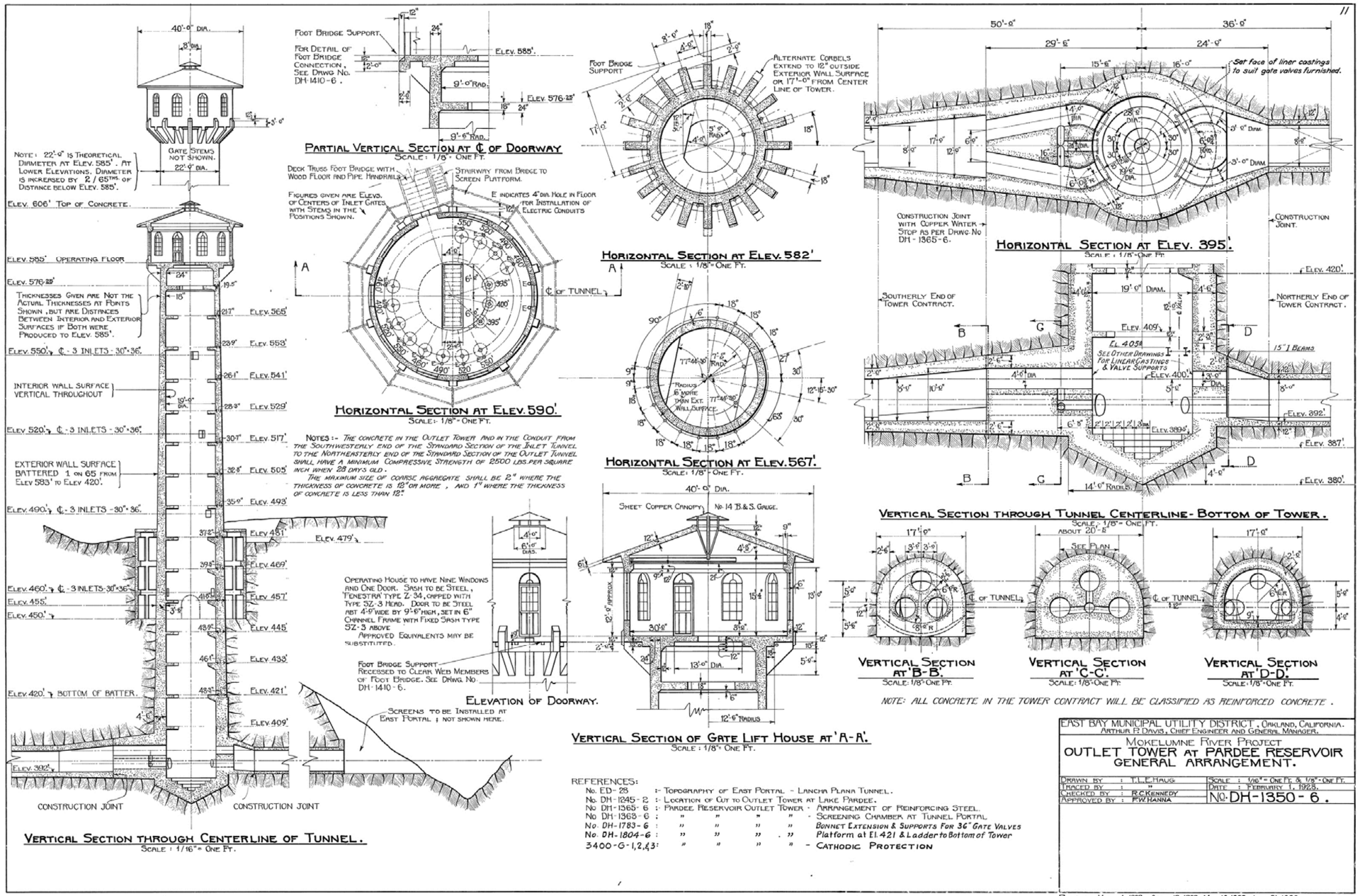

Figure A1. General Arrangement: Outlet Tower at Pardee Reservoir

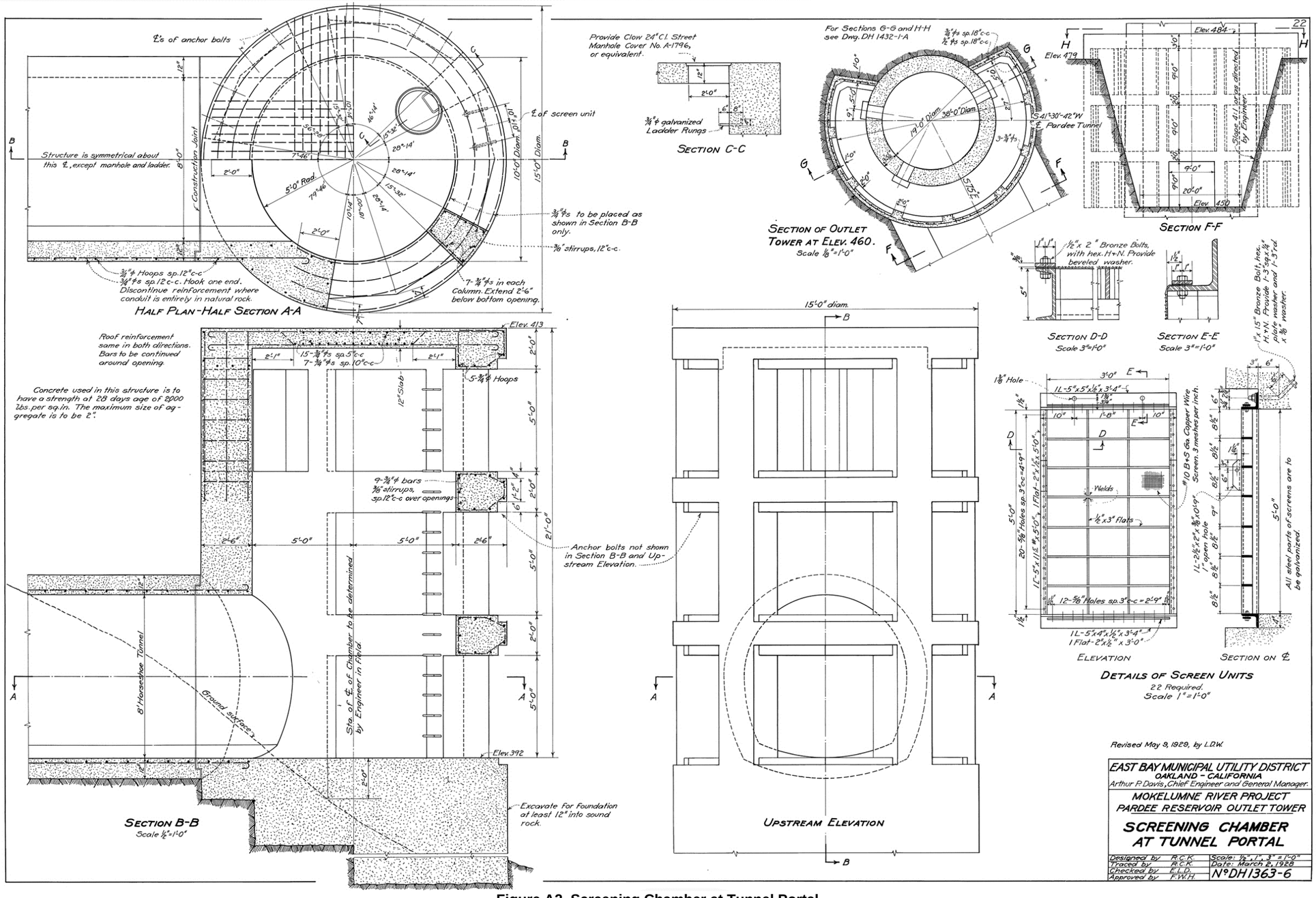

Figure A2. Screening Chamber at Tunnel Portal

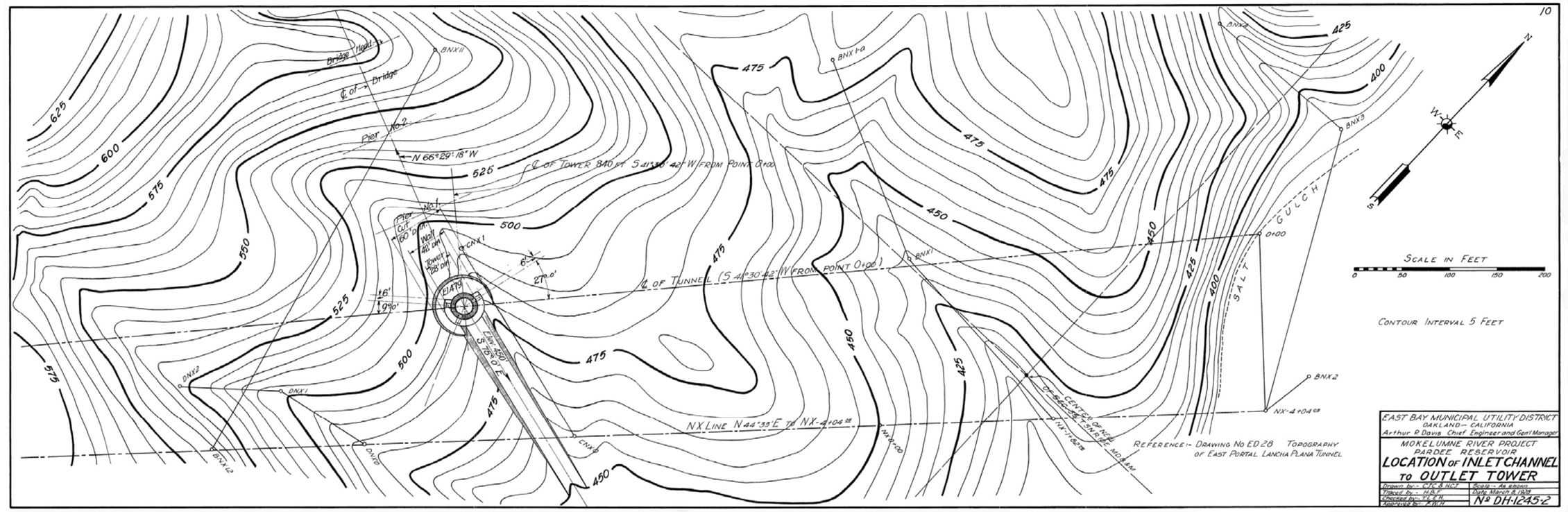

Figure A3. Location of Inlet Channel to Outlet Tower

Appendix B: Inspection Plan and Schedule

JACOBS ASSOCIATES
Engineers/Consultants

EBMUD Pardee Reservoir Outlet Tower

ROV Inspection Plan

1. Location of Pardee Reservoir and Tower

   The Pardee Dam and Reservoir are located on the Mokelumne River in the foothills of the Sierra Nevada Mountains, near the town of Valley Springs, Calaveras County, California. The attached locality map also shows the location of the Tower.

2. Scope of Services

   Under controlled flow conditions, conduct an underwater inspection of the outlet tower and its inlet gates with a remotely operated vehicle (ROV) to assess the tower's current condition. The inspection shall include a detailed visual inspection of the interior and exterior surfaces of the tower structure. In addition, the exterior mounted inlet gates, guides, and couplings will be inspected using the ROV. The ROV will also be used to record the gate operation throughout a full gate travel test for each gate. The general arrangement of the outlet tower is shown on the attached Drawing DH-1350-6. District staff will be on hand to operate the gates at the various levels to allow an assessment of their condition and functioning. The deliverables of the inspection shall consist of:

   a. A high resolution color video of the inspection in digital form.

   b. Jacobs Associates will prepare drawings documenting inspection observations as required.

3. Tower inspection schedule

   a. Inspection is planned for a three day period within the week of 26 to 30 November, 2012. Final dates to be agreed with the ROV contractor and the District.

   b. The proposed inspection schedule is:

      Day 1: Mobilize, set up and test equipment. Perform External inspection and gate operation.

      Day 2: Perform internal inspection and gate operation.

      Day 3: Float in case of problems and demobilization.

      See additional comments in 6a and 6b below and the detail Inspection Schedule attached.

4. Elements of tower inspection to be included, as conditions permit:

   a. The tower interior wet assessment would include the following:

      i. Three low level (El 395) sluice gate gates, stems, stem guides and sleeves, including attachment to the concrete tower. Includes three 48-inch diameter downstream and three 36-inch diameter upstream ports.

      ii. Sluice gate gates, sills and sleeves for three gates at four vertical locations at El 550, El 520, El 490, & El 460.

iii. Ladders, stairs, and handrails including attachment to the concrete tower, quantity unknown.

iv. Examination of the concrete structure (cracks, exposed rebar, anchor bolt corrosion, spalls).

b. The tower exterior wet assessment would include the following:

i. Multiple level sluice gate stems, twelve total.

ii. Multiple level sluice gates stem guides and sleeves, including attachment to concrete tower, three gates at each of four vertical locations at El 550, El 520, El 490, & El 460.

iii. Three basket screens at each elevation: El 550, El 520, El 490, & El 460, twelve locations, including stainless steel support chains, shackle between basket and chain. One location has the original rectangular style basket screen and the rails need to be checked for obstructions/deformations (to explain why the new basket won't fit).

iv. The annular concrete inlet chamber below El 482 for obstructions and sediment load.

v. The approach channel and trash screens at El 395, at the tunnel portal about 840 feet away from the Tower.

vi. The connections of the cathodic protection system to each basket screen.

c. The following pieces of equipment or systems would NOT be included in the assessment:

i. Sluice gate mechanical/electrical operators.

ii. Electric wire rope hoists for basket screens, three total.

iii. Station power (electrical) including shoreline service, conduits from shore to the tower, tower main panel, house wiring, lighting, and motor control center.

5. Availability of services

a. The tower area is within a secure enclosure.

b. A securable shed is available for storage of equipment.

c. Power is available in the tower: 480/220/110V, 3-phase.

d. The 2.5 ton hoist in the tower is available for hoisting the ROV.

e. Accommodation is available at the lodge on site or camping can be arranged.

6. General outlet tower operational information

a. External inspection (day 1) – assume Mokelumne Aqueduct Flow is unrestricted (Normal 150 MGD to 220 MGD)

- All gates will be open and the flow in the vicinity of the individual gate being inspected will be less than 1 FPS.

b. Internal Inspection (day 2) – assume Mokelumne Aqueduct Flow is restricted to 80 MGD

c. The normal water surface elevation is El 567.67 and the low water level is generally about El 557 (10 feet below normal).

d. The lowest inlets are at El 395 are closed and were last operated in the 1970's. There is no plan to operate these gates during the test inspection.

e. The normal daily flow range is 180 to 230 MGD (278 cfs to 356 cfs) and the normal minimum winter daily flow is 135 MGD (209 cfs).

f. During normal conditions a limited number of gates at a single elevation are open and there can be considerable turbulence in the water in the tower which may make ROV operation difficult. During this test condition the gates at all elevations (except 395 ft) will be open reducing flows at each gate. During the internal inspection reduced total flow of 80 MGD proposed above should limit the amount of turbulence.

g. Except for the El 395 gates noted above, there are no problems with operation of the other gates.

h. Only the upper levels of access ladders are visible. It appears that the lower levels of ladders are vertical, but cannot be visually confirmed. According to earlier inspection reports the lower levels of ladders are in very poor condition.

i. There may be pumps, piping and other equipment that have been dropped over the years, at the bottom of the tower.

j. The cathodic protection system was replaced/upgraded in April 2012.

k. The bypass piping around the Pardee Aqueduct valves can be used to throttle the flow providing enough water velocity to clear any silt stirred up by the ROV.

Pardee Tower ROV Inspection Schedule

SCHEDULE:

Week of November 19th, 2012

- Pardee Outlet Tower Water Quality Sampling for filterability results
- Results to Service Area WTP's

Week of November 26th to 30th, 2012

- External & internal inspection of Pardee Outlet Tower
- See detailed schedule and dates below

PRE PLANNING:

- External inspection – assume Mokelumne Aqueduct Flow is unrestricted (Normal 150 MGD to 220 MGD)

- Internal Inspection – assume Mokelumne Aqueduct Flow is restricted to 80 MGD
  - Lowest flow for Mokelumne Aqueducts is based on last year's maximum demand at the service area water treatment plants:
    - WC WTP = 45 MGD Maximum (Normal 30 MGD) (Laf Aq#2)
    - Laf WTP = 15 MGD (Normal 8 MGD) (Laf #1)
    - Orinda WTP = 60 MGD Mokelumne + Drafting Briones 70 MGD (Normal 105 MGD) (Laf #1)
  - Controls for Mokelumne Aqueducts will be set at:
    - Mokelumne #1 = 10 MGD (Bypass)
    - Mokelumne #2 = 10 MGD (Bypass)
    - Mokelumne #3 = 60 MGD (Throttle Valve)

INSPECTION SCHEDULE:

Date/Time	Action	By
Day Zero Tues, Nov. 27	**Travel to site and mobilize Equipment**	
	▪ Contractor arrive on site ▪ Unpack, Setup and Test ROV equipment	EBMUD/ JA/UR
Day One Wed, Nov 28	**External Inspection – Normal Aqueduct Flows**	
8:00 – 10:00	▪ Launch boat and place buoy ▪ Inspect trash rack and entrance to 395' tunnel	EBMUD/ JA/UR
9:00 – 10:00	Pardee Test Staff open Tower Gates ▪ Open all gates at each elevation (12) (approximately 1 FPS in the vicinity at each gate) ▪ Minimizes flow at the individual gates during inspection	EBMUD
10:00 -16:00	Aqueduct Flow unrestricted (150 to 220 MGD) ▪ Contractor perform EXTERNAL ROV inspection of Tower ▪ Pardee Test Staff - coordinate individual gate inspections with contractor ▪ Cycle (closed then open) each Tower Gate (one at a time) as ROV	EBMUD JA/UR EBMUD

	inspects the gate(s). ▪ Inspection of 390 approach channel	EBMUD JA/UR
16:00	▪ Clean up for Day ▪ ROV Equipment stored in "Old Carpenter Shop"	JA/UR JA/UR
Day Two **Thurs, Nov. 29**	**Internal Inspection – Reduced Aqueduct Flows**	
7:00 - 8:00	Contractor Setup and Test ROV for internal inspection	JA/UR
8:00 – 11:00	Pardee Test Staff – coordinate individual gate inspections with contractor ▪ Close upper three levels of Tower Gates (550, 520, 490) if need by contractor (Turbulence in tower may effect ROV) ▪ Contractor inspect interior of Tower at Elevations above 470 ft. ▪ Hold above 470 level CAUTION: While inspecting below 410 Ft elevation the ROV must stay on the gate (East) side of the tower to avoid the higher flows (> 3FPS) on the tunnel side. The 395 Ft elevation gates will remain closed.	EBMUD JA/UR
11:00 to 13:00	Pardee ACC (with support from Treatment and Aqueduct Sections) reduce total Aqueduct flow to minimum flow in all three Mokelumne Aqueducts ▪ #1 – 10 MGD (Bypass) ▪ #2 – 10 MGD (Bypass) ▪ #3 – 60 MGD (Throttle valve) ROV Contractor on hold	EBMUD JA/UR
13:00 to 14:00	▪ Pardee Test Staff open All Tower Gates ▪ Contractor inspect lower tower (level 470 down to 390)	EBMUD JA/UR
14:00 to 16:00	▪ Contractor clear ROV from tower ▪ Pardee ACC (with support from Treatment and Aqueduct Section) Return all three Mok Aqueducts to normal flows on main throttling valves (Bypass closed)	JA/UR EBMUD
16:00	▪ Clean up for Day ▪ If additional time is needed for inspections communicate with Treatment & Distribution for Day 3 inspection ▪ If testing complete adjust tower gates per Treatment direction	JA/UR EBMUD EBMUD
Day Three **Fri, Nov. 30**	**If Needed**	
	Additional time as needed for inspections ▪ Establish desired flows – communicate with Treatment & Distribution ▪ Inside tower down to 470 level ▪ Outside tower all levels ▪ 390 approach channel ▪ Close tower gates as directed based on water quality	JA/UR EBMUD

Appendix C: Mead and Hunt Report

Evaluation of Mechanical Components

Pardee Reservoir Outlet Tower

Prepared for

East Bay Municipal Utility District

Report prepared by

Mead & Hunt

www.meadhunt.com

February 2013

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Appendices

NAME OF PROJECT: Pardee Outlet tower mechanical component condition evaluation

DATE OF OBSERVATION: November 26 & 27, 2012

ASSESSMENT BY: G. Frank Ransley, PE

EAST BAY MUNICIPAL UTILITY DISTRICT REPRESENTATIVES: M. Bilgin Atalay & Bruce Stewart

JACOBS ASSOCIATES REPRESENTATIVES: Andrew Wozencroft & Jan Van Greunen

1. SUMMARY

On November 26 and 27, 2012 the onsite evaluation was performed to determine the condition of the mechanical components on the Pardee Reservoir outlet tower. The condition of the gate operators was observed from the operating floor of the tower. The underwater components including the gates, stems, and trashracks and trashrack tracks were observed utilizing a remotely operated vehicle (ROV) provided by Underwater Resources of San Francisco, CA. The gates were observed utilizing the ROV on the interior of the tower, and the stems, trashracks, and trashrack tracks were observed utilizing the ROV from the exterior of the tower. Drawings of the tower, the gates, and gate frames were available for use during the evaluation. Drawings of the gate stems and stem guides, and the trashracks and trashrack tracks were provided following the onsite evaluation and were utilized in this report. No detailed drawings or prints of the gate operators have been located at this time.

The gate operators were all found to be in good working condition. The operation was observed for each unit in fully closed to fully open operating range. There was no visible wear on the ACME screw threads of the rising stems. Limit switches and associated controls were operational for all units. The gate slides (leaves) were all found to be in acceptable condition. The gate frames appear to be securely fastened to the tower structure and no significant corrosion, wear or deterioration of the gate slides and frames was visible. The operation was observed for each gate from the fully open to fully closed position. The gate stems, stem guides, trashracks, and trashrack tracks were found to be in acceptable condition. All exterior components appear to be securely fastened to the tower structure. No exterior mechanical items were found indicating excessive wear or deterioration due to corrosion. The gates, operators, and trashracks appear to be capable of operation as-is for an extended period of time. Photos of the tower, gate operators, gates and other associated mechanical components are included in the inspection form in the third section of this document.

Should the district desire to automate the operation of the gates, the mechanical and electrical components of the gate operators are relatively accessible for retro-fitting of position sensors and electrical controls for remote operation.

2. COMMENTS AND OBSERVATIONS

The Pardee tower is outfitted with (4) sets of (3) slide gates, with the sets located at elevations 550, 520, 490, and 460 feet. The sets at each elevation are labeled A, B, and C. The gates and gate frames are located on the exterior surface of the tower, and each gate is located in front of a portal or passage through the tower wall leading to the center hollow portion of the tower. The center of the tower serves as

a vertical conduit for water to flow from the gates downward to the outlet passage at the bottom of the tower at elevation 390.
The gates are designed for a hydrostatic head of 116 feet. However, EBMUD personnel indicated that the water level between the exterior and interior of the tower never exceeds six feet. Consequently the gates are operated at only a fraction of their rated service, which results in minimal loading of the gate slides and gate operators.

The gate operators were manufactured by the Joshua Hendy Iron Works of San Francisco, CA, which became part of Westinghouse post World War II, and eventually was sold to Northrop Grumman in 1996. The operators consist of an electric motor and gear train mounted integrally on a cast iron pedestal. The gear train rotates an ACME nut and lifts the gate stem that is threaded on the upper portion. The stem is outfitted with collars which actuate limit switches for shut down of the motors when the gates reach full open or full closed position. The operators are equipped with manual crank handles which may be engaged with their respective gear trains so that the gates may be operated in the event of a motor failure or electrical power outage. The construction of the operators appears to be very robust, typical of that era of manufacturing. No detailed drawings or prints of the operators have been located at this time. The Iron Man Museum located in Sunnyvale, California, which manages the archived drawings from Joshua Hendy Iron Works does not have any drawings of these gate operators on file.

The interior tower inspection was performed by examining the (3) gates at a given elevation with the ROV in sequence before moving to a different elevation. All (12) gates were set in the 'open' position to reduce the overall average velocity of flow and the ROV was maneuvered into the portal behind each gate, and landed on the bottom of the gate portal. The camera of the ROV was maneuvered to record the condition of the entire perimeter of each gate frame and surrounding structural material. The gate operator was then energized and the operation of the gate slide (leaf) was observed from the fully open to the fully closed position. The ROV camera was then maneuvered to examine the entire perimeter of the gate and identify leakage points along the gate slide and frame which were noted by transport of particulates illuminated by the ROV light. The gate slide was then opened with the ROV camera recording the entire operation from fully closed to fully open. During this operation it was possible to observe the lip of the gate slide which rides in the groove on the sides of the gate frame. There was no significant visible deterioration or wear on any of the gate frames or gate slides noted during these observations. Some leakage was observed at gates 550B, 550C, 520C, and 490B.

The bottom of the tower is also outfitted with (3) bonneted slide gates set at elevation 395, which are connected to the water conduit from the East portal. The bonneted slide gates are provided with non-rising stem actuators. These gates have not operated for approximately 25 years, and from the ROV video, appear to be in the closed position. The gate operators appeared to be functional but the gate stems were jammed below water level and would not rotate. It was not possible to determine whether the stem support bearings or the valves were preventing rotation of the stems.

The sequence of operations for observation of the exterior of the mechanical components on the tower consisted of grouping the observations starting with 550C and moving downward to examine the 'C' gates at elevations 520, 490, and 460, before moving counterclockwise around the tower to the 'B' gates and finally the 'A' gates. This was mainly for benefit of the personnel operating and tending the ROV since it was relatively easy to find the adjacent gate stem and follow it up or down as required.

The original plans show the gate and stem hardware anchored securely in the tower structure. There was no evidence of any loose or failing hardware or anchors. The gate stems, stem couplings, stem guides, trashrack guide tracks, and trashracks all appeared to be in acceptable condition. The only failures noted were coupling hardware on the lift chains of the trashracks on gates 490A, 520A, 520B, and 520C. There was considerably more debris on the trashracks at the higher elevations as well as more growth and deposits on the components at higher elevations.

During the evaluation of the mechanical components of the tower, items were noted that should be included in the seismic analysis of the tower. These included the gate stems and the trashrack tracks which consist of relatively long and thin members, periodically attached to the tower structure with brackets and guides. For purposes of incorporation into the seismic analysis, the first mode resonant frequency for these members was calculated utilizing VisualAnalysis 10.0, and a hand calculation was performed to verify results. The first mode resonant frequency of the gate stems was calculated to be approximately 32 Hertz (Hz). The first mode resonant frequency of the trashrack track channels was calculated to be 21.7 Hz about the Y-Y axis of the channel, and 71 Hz about the X-X axis of the channel. The gate operators which are cantilevered off of the tower operating floor were also noted as items that could possibly be affected during a seismic event. As noted previously, drawings of the operators were not available, and as a consequence it was not possible to calculate a resonant frequency. However, due to the robust construction of the operators, and the relatively low height to width ratio, it is unlikely these units present a problem.

INSPECTOR'S SIGNATURE: _____

3. Inspection Form and Reference Photos

Phase 1 – Pardee Reservoir Outlet Tower

Date Inspected: _____

Inspected By: _____

RATED ITEM	A	M	U	N/A	EVALUATION	LOCATION/ REMARKS/ RECOMMENDATIONS
1. Outlet Tower Operating Log (A or U only)					**A** Operation and maintenance log is present at the pump station and is being used and updated, and personnel have been trained in pump station operations. Names and last training date shown in the log book.	N/A
					U No operating log present, or refresher training for personnel has not been conducted.	
2. Outlet Tower Operations and Maintenance Manual (A or U only)					**A** Operation and Maintenance Manual and/or posted operating instructions are present and adequately cover all pertinent pump station features.	N/A
					U Operation and Maintenance Manual missing or sponsor is unsure of location.	
3. Outlet Tower	X				**A** The building is in good structural condition, with no major cracks in concrete or brick. There are no exposed electrical components, and the working environment is safe.	Reference Photos 1, 2, 3, and 4.
					M There is significant cracking in the building structure, or the building is damaged in other ways such that it needs repair but does not threaten gate operations.	
					U The structural integrity or stability of the building is threatened, or there is other damage to the building such that gate operations cannot be performed as intended.	
4. Safety (A or U only)					**A** Fire safety hardware (hand rails, grates for wetwells, etc) is installed. Safety guarding and fencing in place.	N/A
					U Safety issues exist that could cause injury or loss of life.	
5. Cranes RODI	X				**A** Crane operational, and have been inspected and load tested in accordance with OSHA requirements.	Reference Photo 5.
					M Crane has not been inspected or operationally tested with the past year, or there are visible signs of corrosion, oil leakage, etc, requiring maintenance.	
					U Crane not operational, or tagged out of service.	
					N/A There are no cranes.	
6. Power Source (A or U only)	X				**A** The power source is adequate, safe, and reliable. Backup generators are on hand or there is a reliable backup power plan in place. Backup units are properly sized, operational, periodically exercised, and properly maintained.	Note gate operators have back-up manual operation handles (Reference Photo 6).
					M Normal power source and backup units, if applicable, are operational with minor discrepancies or maintenance, inspection and exercising record is present but not up to date. Preventative maintenance or repairs are required.	
					U Power source or generators are not operational and must be repaired; or generator, if required, is not on site.	

Date Inspected: _____

Inspected By: _____

7. Electrical Systems	X				**A** Operational and maintained free of damage, corrosion, and debris. Preventative maintenance and system testing is being performed periodically.	Electrical feeder panel and gate control panel in good condition. Minor corrosion on the back of the gate control panel (Reference Photos 7 and 8).
					M Operational with minor discrepancies. Preventative maintenance or repairs are required, but the components are expected to function adequately during the next flood event.	
					U Components of the electrical system will not function adequately during the next flood event and must be replaced.	
8. Gate Hoist Control Systems	X				**A** Operational and maintained free of damage, corrosion, or other debris.	Gate control panel in good condition. Minor corrosion on the back of the gate control panel (Reference Photo 9).
					M Operational with minor discrepancies. Will function adequately during next operation.	
					U Pump controls not operational. May not function adequately during the next flood event.	
9. Trash Racks (non-mechanical)	X				**A** Trash racks are fastened in place and properly maintained.	Noted partially plugged trash racks in review of ROV video for gates 550A, 550B, 550C, 490A, 490B, 490C, and 460A (Reference Photo 10). Operators have not indicated any problems with obtaining flow due to plugged racks. The trash racks appear to be in generally good condition (Reference Photo 11). The trash racks are provided with tracks and a lift chain to allow raising to the surface (Reference Photo 12 and 13). The track support brackets appear to be securely fastened to the wall of the tower.
					M Trash racks are in place but are unfastened or have bent bars that allow debris to enter into the pipe or pump station. Repair or replacement is required.	
					U Trash rack is missing or damaged to the extent that it is no longer functional and must be replaced.	
					N/A There are no non-mechanical trash rakes.	
10. Sluice / Slide Gates	X				**A** Gates open and close freely with minor leakage. Sill is free of sediment and other obstructions. Gates and lifters have been maintained.	All gates at elevations 550, 520 490 and 460 opened and closed smoothly. These are rising stem gates (Reference Photo 15). There was no obvious or visible deterioration of the gates and gate frames (Reference Photo 16). Maximum differential between the outside and inside of the outlet tower across the gates is approximately 6 feet. Gates are rated for a differential head of 116 feet per photo of print DH 1358-6 (Reference Photo 14). Minor leakage was witnessed on 550B, and 520C. More significant leakage was witnessed on the right side of 490B. The presence of leakage was determined by particle transport which was
					M Gates have been damaged or have deteriorated, and open and close with resistance or binding. Leakage quantity is controllable and is not a threat to project performance. Maintenance is required.	
					U Gates do not open or close. Gate, stem, lifter and/or guides may be damaged or corroded.	
					N/A There are no sluice/slide gates.	

Date Inspected: _____

Inspected By: _____

						visible in the ROV camera light. The bonneted slide gates on the inlet conduits at elevation 390 are jammed and have not operated for at least 25 years. These are non-rising stem gates (Reference Photos 17, 18, and 19). The gate operators appeared to be functional but the gate stems were jammed below water level and would not rotate. It was not possible to determine whether the stem support bearings or the valves were preventing rotation of the stems.
11. Electric Gate Operators for Sluice / Slide Gates (Intake/ Discharge)	X				**A** All electric gate operators are in good working condition and are adequately powered, and are capable of opening and closing the gate properly. Preventative maintenance is being performed and the system is tested periodically.	All operators exhibited smooth operation with the stems rising and falling at a steady velocity. Some rattling was noticeable, likely from the clutching and locking mechanism. There were no sounds associated with gear wear or immanent failure. The stem threads were in excellent condition. The threads are labeled as 'square thread' on the gate drawing DH 1358-6 as shown in Reference Photo 14, however the actual installed threads appear to be ACME type with a tapered profile (Reference Photo 20). The 'full open' and 'full closed' positions of the gate are sensed by limit switches that are actuated by the gate stem (Reference Photo 21 and 15).
					M All electric gate operators are operational with minor deficiencies, but should perform through the next period of usage.	
					U The electric gate operators are not operational, or the power source is not considered reliable to sustain operations during flood conditions.	
					N/A There are no electric gate operators	
12. Manual Operators (Backups) for Sluice / Slide Gates	X				**A** All manual gate operators are in good working condition and are capable of opening and closing the gate properly. Preventative maintenance is being performed and the system is tested periodically.	A manual crank handle is provided on each electric gate operator. The handle is disengaged for electric operation (Reference Photo 22).
					M Manual gate operators are operational with minor deficiencies, but should perform through the next period of usage.	
					U Manual gate operators are not operational.	
					N/A If there are sluice or slide gates, there needs to be means of operating them manually. If there are no sluice/slide gates, this item is N/A.	
13. Other Metallic Items (Equipment, Ladders, Platform Anchors, etc)	X				**A** All metal parts are protected from corrosion damage, and show no rust, damage, or deterioration that would cause a safety concern.	Gate stem guides all appeared to be in good condition (Reference Photo 23). The outlet tower is provided with an active cathodic protection system which appears to be effective

Date Inspected: _____

Inspected By: _____

						in preventing corrosion (Reference Photos 24, 25, 26, and 27).
					M Corrosion seen on metallic parts appear to be maintainable.	
					U Metallic parts are severely corroded and require replacement to prevent failure, equipment damage, or safety issues.	
					N/A There are no other significant metallic items associated with the pump stations.	

Key: **A** = Acceptable. **M** = Minimally Acceptable; Maintenance is required. **U** = Unacceptable. **N/A** = Not Applicable. **RODI** = Requires Operation During Inspection

Phase 1 – Pardee Reservoir Outlet Tower

Date Inspected: _____

Inspected By: _____

	
Reference Photo 1	**Reference Photo 2**

Date Inspected: _____

Inspected By: _____

	
Reference Photo 3	**Reference Photo 4**

Date Inspected: _____

Inspected By: _____

	
Reference Photo 5	**Reference Photo 6**
	Note gate operators have back-up manual operation handles.

Date Inspected: _____

Inspected By: _____

	
Reference Photo 7	**Reference Photo 8**
Electrical feeder panel and gate control panel in good condition. Minor corrosion on the back of the gate control panel.	

Date Inspected: _____

Inspected By: _____

	
Reference Photo 9	**Reference Photo 10**
Gate control panel in good condition. Minor corrosion on the back of the gate control panel.	Noted partially plugged trash racks in review of ROV video for gates 550A, 550B, 550C, 490A, 490B, 490C, and 460A.

Date Inspected: _____

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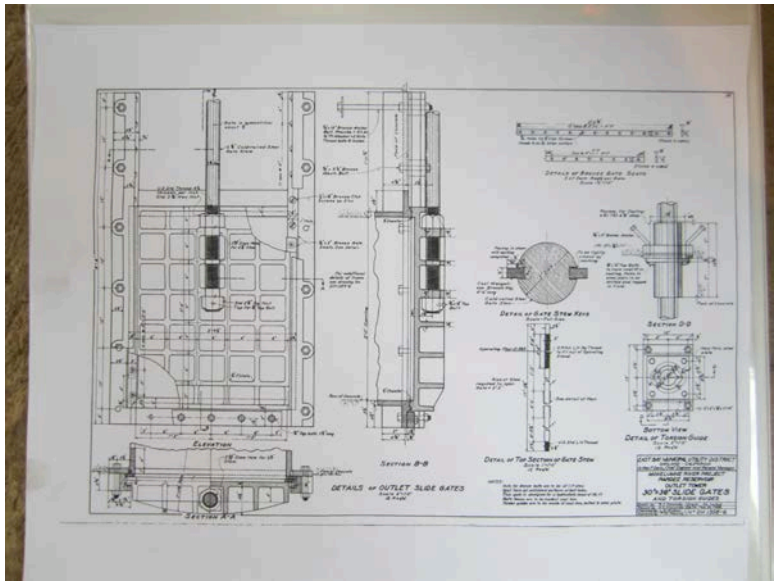
Reference Photo 11	**Reference Photo 12**
Operators have not indicated any problems with obtaining flow due to plugged racks. The trash racks appear to be in generally good condition.	The trash racks are provided with tracks and a lift chain to allow raising the rack to the surface.

Date Inspected: _____

Inspected By: _____

	
Reference Photo 13	**Reference Photo 14**
The trash racks are provided with tracks and a lift chain to allow raising to the surface.	Gates are rated for a differential head of 116 feet per photo of print DH 1358-6

Date Inspected: _____

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Reference Photo 15	**Reference Photo 16**
These are rising stem gates.	There was no obvious or visible deterioration of the gates and gate frames.

Date Inspected: _____

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Reference Photo 17	**Reference Photo 18**
The bonneted slide gates on the inlet conduits at elevation 390 are jammed and have not operated for at least 25 years. These are non-rising stem gates.	

Date Inspected: _____

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Reference Photo 19	**Reference Photo 20**
Gate operators for the bonneted slide gates on the inlet conduits at elevation 390. These are non-rising stem gates. The gate stems appeared to be jammed below water level and would not rotate.	The threads are labeled as ‘square thread’ on the gate drawing DH 1358-6 as shown in Reference Photo 14, however the actual installed threads appear to be ACME type with a tapered profile.

Date Inspected: _____

Inspected By: _____

	
Reference Photo 21	**Reference Photo 22**
The ‘full open’ and ‘full closed’ positions of the gate are sensed by limit switches that are actuated by the gate stem.	A manual crank handle is provided on each electric gate operator. The handle is disengaged for electric operation.

Date Inspected: _____

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Reference Photo 23	**Reference Photo 24**
Gate stem guides all appeared to be in good condition.	The outlet tower is provided with an active cathodic protection system which appears to be effective in preventing corrosion.

Date Inspected: _____

Inspected By: _____

	
Reference Photo 25	**Reference Photo 26**
The outlet tower is provided with an active cathodic protection system which appears to be effective in preventing corrosion.	

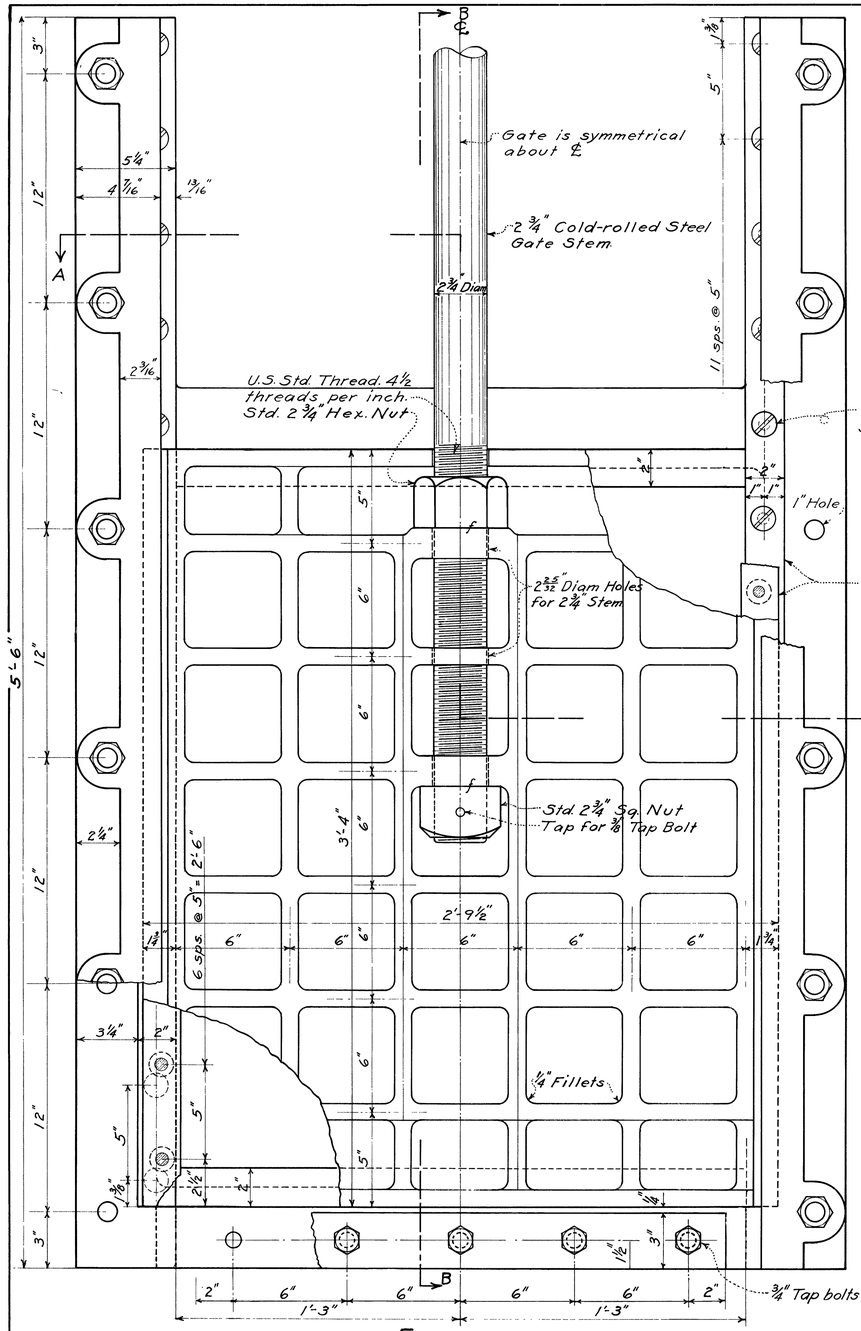
Date Inspected: _____

Inspected By: _____

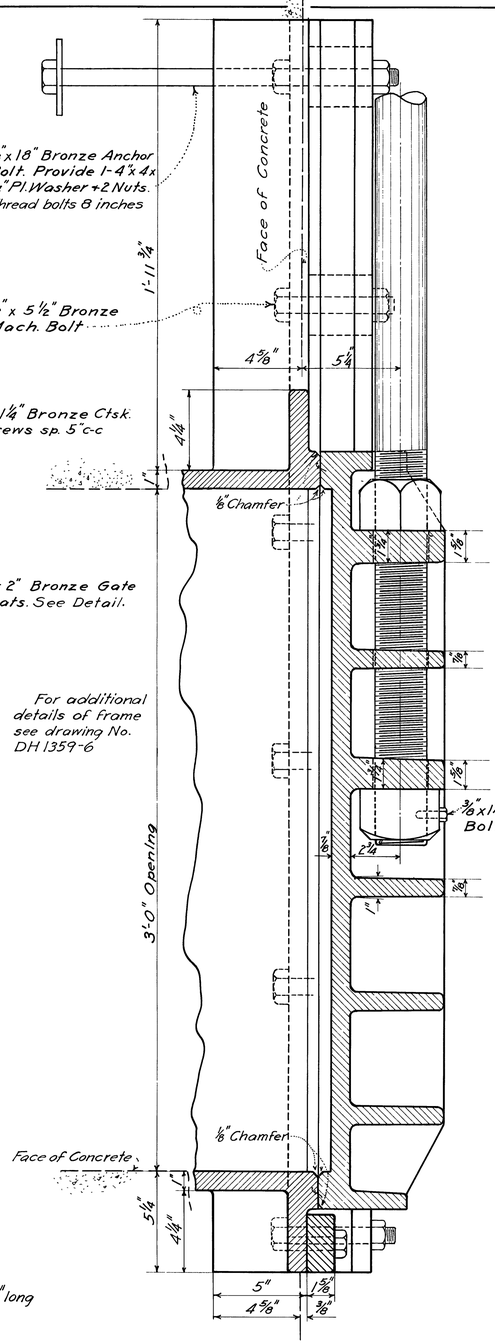
Reference Photo 27

The outlet tower is provided with an active cathodic protection system which appears to be effective in preventing corrosion.

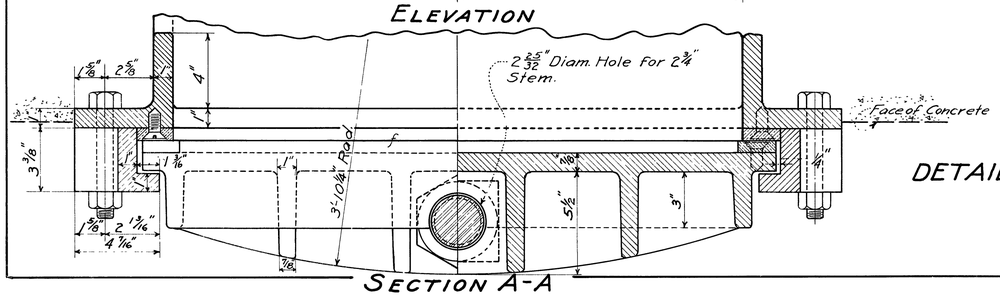
Appendix A. Drawings



ELEVATION

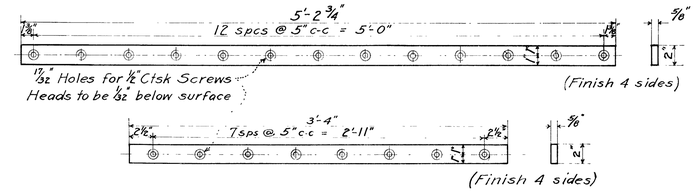


SECTION B-B

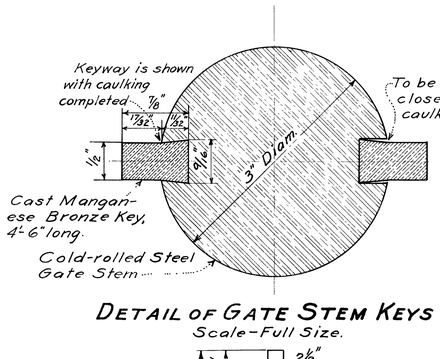


SECTION A-A

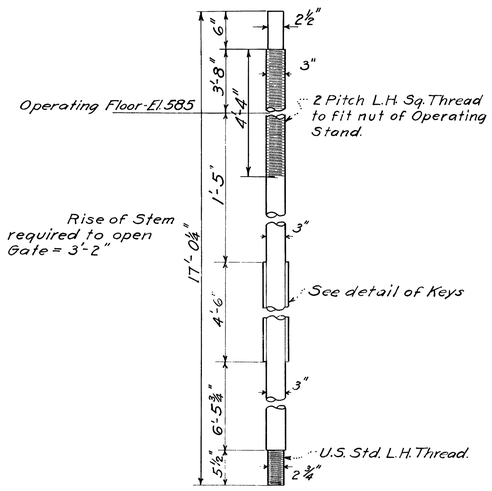
DETAILS OF OUTLET SLIDE GATES
Scale 3"=1'-0"
12 Req'd.



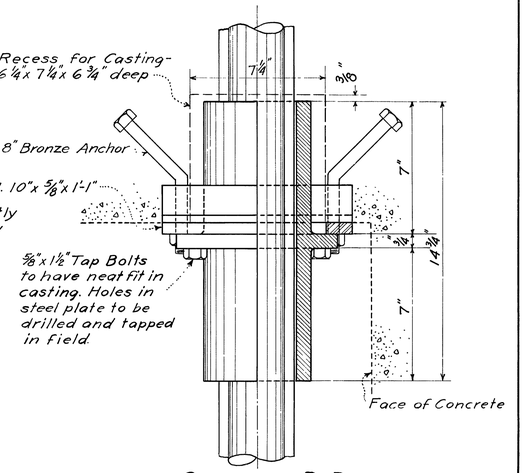
DETAILS OF BRONZE GATE SEATS
2 of Each Req'd per Gate.
Scale 1½"=1'-0"



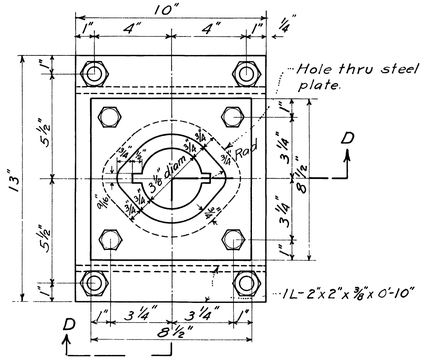
DETAIL OF GATE STEM KEYS
Scale-Full Size.



DETAIL OF TOP SECTION OF GATE STEM
Scale 1"=1'-0"
12 Req'd.



SECTION D-D



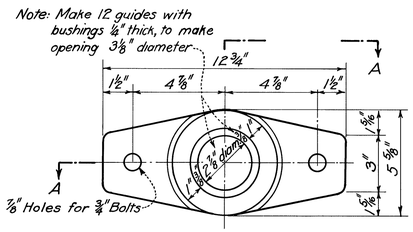
BOTTOM VIEW
DETAIL OF TORSION GUIDE
Scale 3"=1'-0"
12 Req'd.

NOTES:
Nuts for bronze bolts are to be of C.P. steel.
Spot face all unfinished surfaces at bolt holes.
This gate is designed for a hydrostatic head of 116 Ft.
Gate leaves are to be made of cast iron.
Torsion guides are to be made of cast iron, bolted to steel plate.

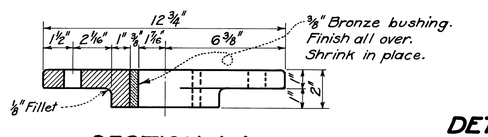
EAST BAY MUNICIPAL UTILITY DISTRICT
OAKLAND - CALIFORNIA
Arthur P. Davis, Chief Engineer and General Manager.

MOKELUMNE RIVER PROJECT
PARDEE RESERVOIR
OUTLET TOWER
30"x36" SLIDE GATES
AND TORSION GUIDES

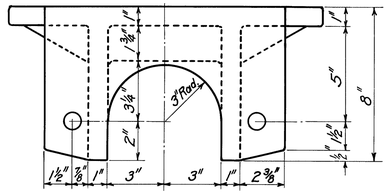
Drawn by R.C. Kennedy	Scale: As noted
Traced by R.C. Kennedy	Date: Feb. 14, 1928.
Checked by L.D. Wilbur	
Approved by F.W. Hanna	No DH 1358-6



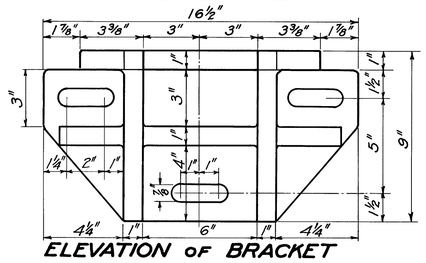
BOTTOM VIEW OF GUIDE



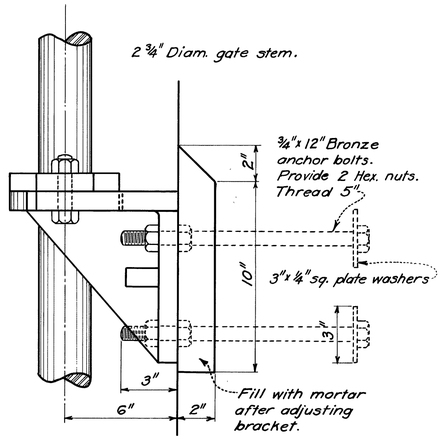
SECTION A-A



PLAN OF BRACKET



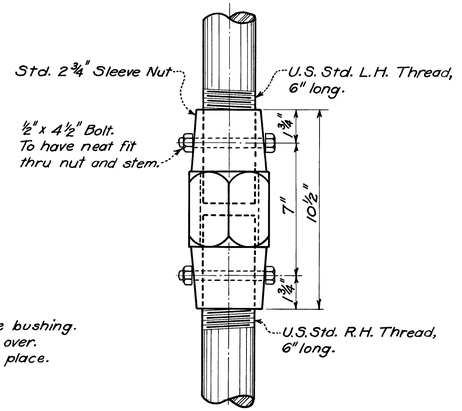
ELEVATION OF BRACKET



ASSEMBLY

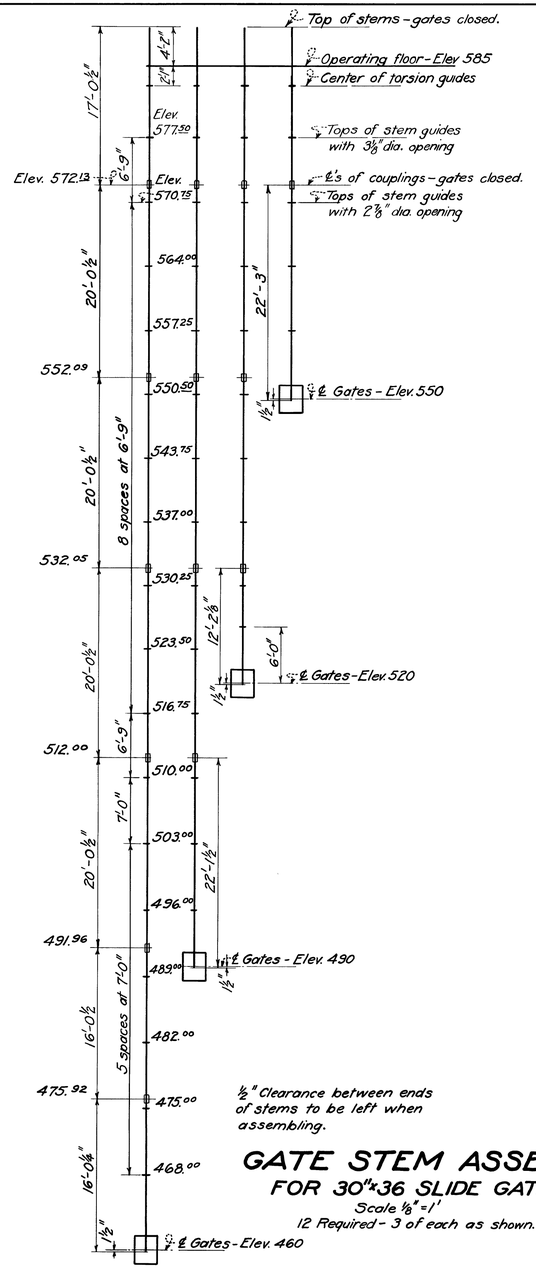
DETAIL OF GUIDES FOR 2¾" STEM

Scale 3"=1'-0"
129 Required
CAST IRON



DETAIL OF 2¾" STEM COUPLING

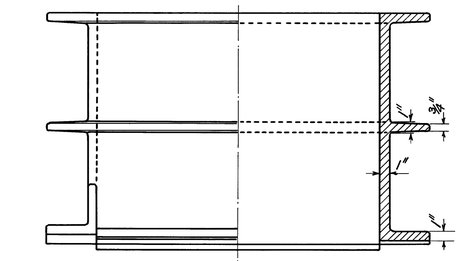
Scale 3"=1'-0"
42 Required



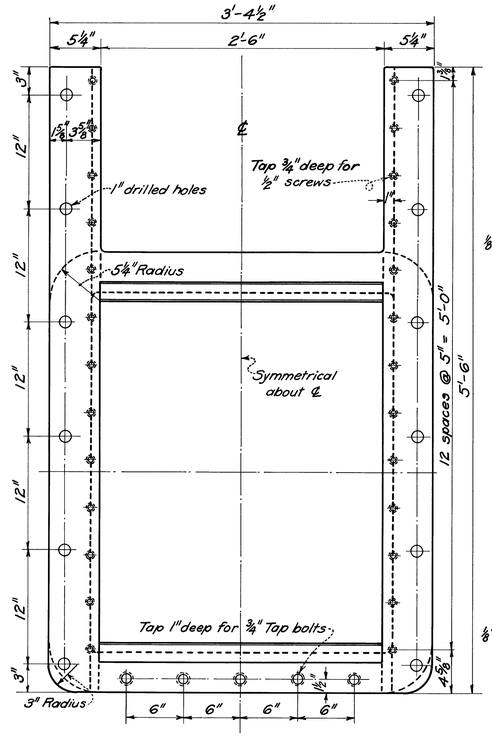
½" clearance between ends of stems to be left when assembling.

GATE STEM ASSEMBLY FOR 30"x36" SLIDE GATES

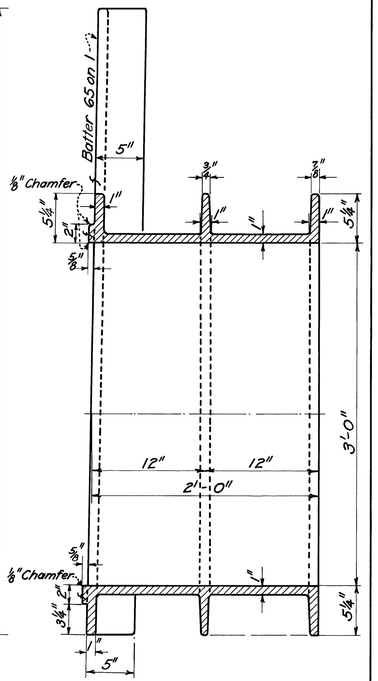
Scale ⅛"=1'
12 Required - 3 of each as shown.



HALF PLAN | HALF SECTION on ℄



FRONT ELEVATION



VERTICAL SECTION on ℄

DETAIL OF FRAMES FOR 30"x36" SLIDE GATES

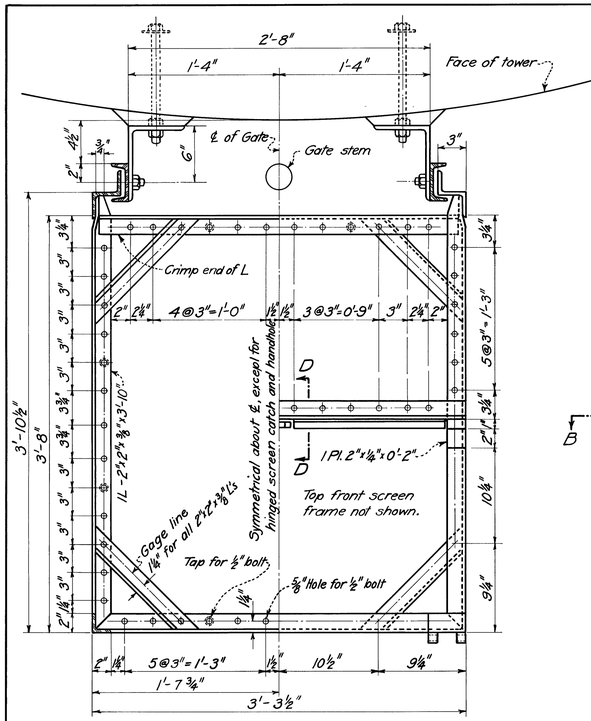
Scale 1½"=1'
12 Required
CAST STEEL

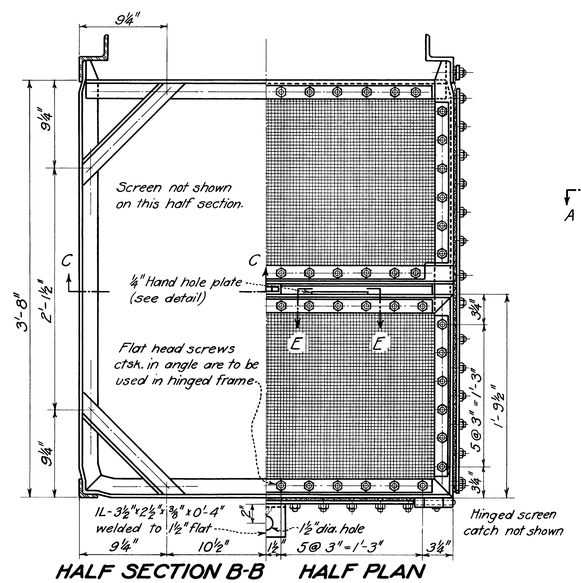
EAST BAY MUNICIPAL UTILITY DISTRICT
OAKLAND - CALIFORNIA
Arthur P. Davis, Chief Engineer and General Manager.

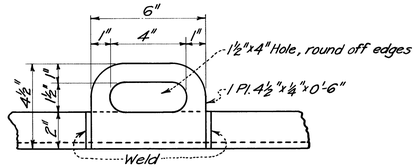
MOKELUMNE RIVER PROJECT
PARDEE RESERVOIR
OUTLET TOWER

30"x36" SLIDE GATE FRAMES, GATE STEMS AND APPURTENANCES

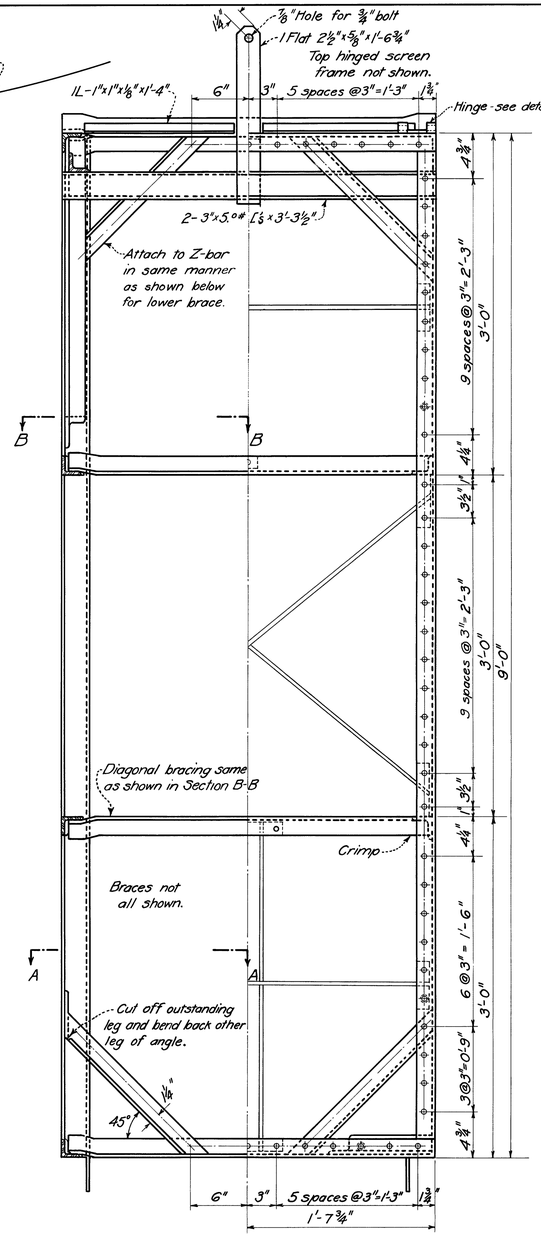
Drawn by L.D.Wilbur	Scale: ⅛", 1½" & 3"=1'
Traced by L.D.Wilbur	Date: February 29, 1928.
Checked by E.L.Driggs	No. DH1359-6
Approved by F.W.Hanna	

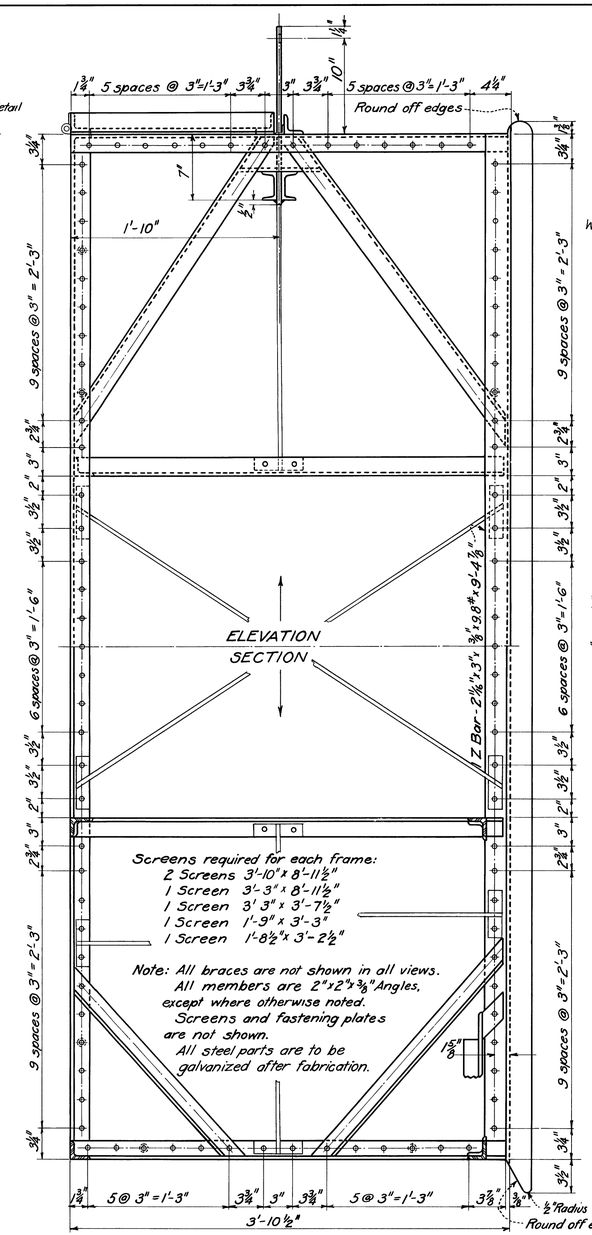


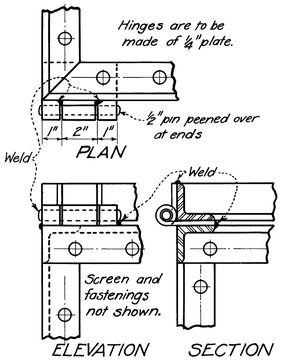




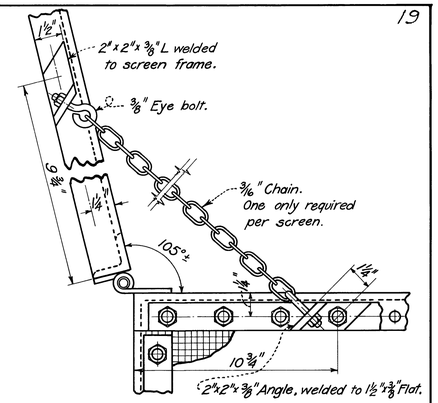
SECTION E-E
SHOWING DETAIL OF HAND HOLE
Scale 3"=1'



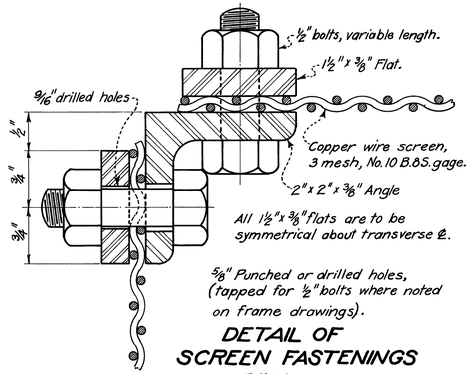




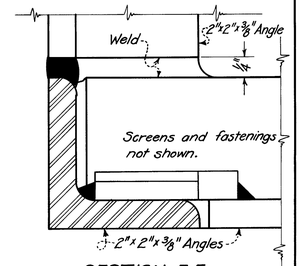
DETAIL OF HINGE
Scale 3"=1'



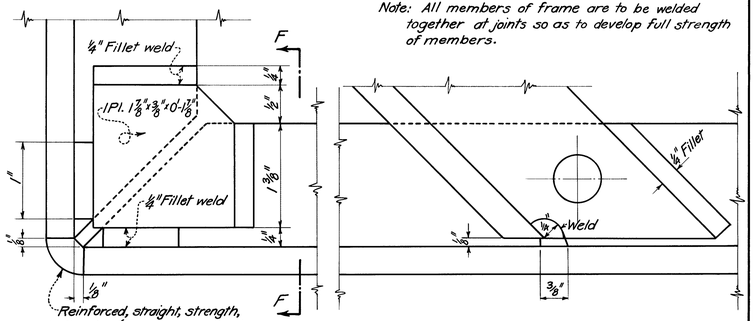
DETAIL OF HINGED SCREEN CATCH
Scale 3"=1'



DETAIL OF SCREEN FASTENINGS
Full Size

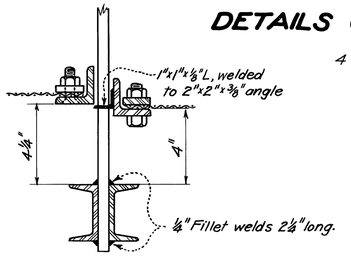


SECTION F-F



CORNER WELD DETAILS
DIAGONAL BRACE

TYPICAL WELD DETAILS
Scale: Full Size



SECTION D-D
Scale 3"=1'-0"

DETAILS OF SCREEN FRAMES

Scale 1½"=1'
4 Screens Required

See Drawing No. DH 1875-3 for Screen Supports.
Revised Aug. 27, 1929.

EAST BAY MUNICIPAL UTILITY DISTRICT
OAKLAND - CALIFORNIA
Arthur P. Davis, Chief Engineer and General Manager.

MOKELUMNE RIVER PROJECT
PARDEE RESERVOIR
OUTLET TOWER
SCREENS
FOR 30"x 36" SLIDE GATES

Drawn by L.D.Wilbur	Scale: As shown
Traced by L.D.Wilbur	Date: April 5, 1928.
Checked by E.L. Driggs	
Approved by F.W. Hanna	No DH 1403-6

Appendix B. Calculations

Project: Pardee Dam Gate/Operator Inspection

Andy Knauf, Mead & Hunt, Inc. January 18, 2013
R2775900-120683.01
X:\2775900\120683.01\TECH\Struct\2.75 round.vap

Pardee Dam Gate/Operator Inspection

X:\2775900\120683.01\TECH\Struct\2.75 round.vap

Company: Mead & Hunt, Inc. Engineer: Andy Knauf Billing: R2775900-120683.01
VisualAnalysis a.00 Report

Nodes

Node	X	Y	Z	Fix DX	Fix DY	Fix DZ	Fix RX	Fix RY	Fix RZ	Scissor?
	in	in	in							
N001	0.000	0.000	0.000	Yes	Yes	Yes	Yes	No	No	No
N002	81.000	0.000	0.000	Yes	Yes	Yes	No	No	No	No

Member Elements

Member	Section	Material	(1)Node	(2)Node	Length	Rz1	Rz2	One Way	Framing
					in				
BmX002	Round 2.75	ASTM A992 Grade 50	N001	N002	81.000	Rigid	Rigid	Normal (2-way)	Beam

Section Properties

Section	Beta	Theta	Ax	J	Iy	Iz	Sz(+y)	Sz(-y)	Sy(+z)	Sy(-z)
	deg	deg	in^2	in^4	in^4	in^4	in^3	in^3	in^3	in^3
Round 2.5	0.000	0.000	4.909	3.835	1.917	1.917	1.534	1.534	1.534	1.534
Round 2.75	0.000	0.000	5.940	5.615	2.807	2.807	2.042	2.042	2.042	2.042
Square 8	0.000	0.000	64.000	546.133	341.333	341.333	85.333	85.333	85.333	85.333

Mode Shape Results

Result Case Name	f(Hz)	T(sec)	X Part	Y Part	Z Part	X Mass	Y Mass	Z Mass	Total Mass
						K	K	K	K
Mode # 1 (32.7 Hz)	32.695	0.031	0.000	0.677	0.132	0.000	0.092	0.018	0.137

Project: Pardee Dam Gate/Operator Inspection

Andy Knauf, Mead & Hunt, Inc. January 18, 2013
R2775900-120683.01
X:\2775900\120683.01\TECH\Struct\C4x7.2.vap

Pardee Dam Gate/Operator Inspection

X:\2775900\120683.01\TECH\Struct\C4x7.2.vap

Company: Mead & Hunt, Inc. Engineer: Andy Knauf Billing: R2775900-120683.01
VisualAnalysis a.00 Report

Member Elements

Member	Section	Material	(1)Node	(2)Node	Length	Rz1	Rz2	One Way	Framing
					in				
BmX002	C4x7.2	ASTM A36	N001	N002	81.000	Rigid	Rigid	Normal (2-way)	Beam

Section Properties

Section	Beta	Theta	Ax	J	Iy	Iz	Sz(+y)	Sz(-y)	Sy(+z)	Sy(-z)
	deg	deg	in^2	in^4	in^4	in^4	in^3	in^3	in^3	in^3
C4x7.2	0.000	0.000	2.130	0.082	0.425	4.580	2.290	2.290	0.926	0.337

Mode Shape Results

Result Case Name	f(Hz)	T(sec)	X Part	Y Part	Z Part	X Mass	Y Mass	Z Mass	Total Mass
						K	K	K	K
Mode # 1 (21.2 Hz)	21.243	0.047	0.000	0.000	0.809	0.000	0.000	0.040	0.049
Mode # 2 (69.7 Hz)	69.735	0.014	0.000	0.809	0.000	0.000	0.040	0.000	0.049

Mead & Hunt, Inc.

Job No. 2775900 Sheet 1 of 2
Job Name Jacobs/Pardee
Task
Calculated by GFR Date 12-26-2012
Checked by DVL Date 1-18-2013

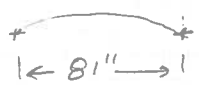
Calculate Resonant Frequencies for Gate Stem and Trash rack channels

gate stem 2-3/4" dia

Generalized Methods of Vibration Analysis – Harker Wiley & Sons 1983

single span $k = \frac{EI}{\ell^3} = \frac{(30\times10^6 \text{ lb/in}^2)\left(\pi\frac{(2.75)^4}{64}\text{ in}^4\right)}{(81)^3 \text{ in}^3} = 158 \text{ lb/in}$

$m = \rho A \ell = \left(.28516 \frac{\text{lb}}{\text{in}^3}\right)\left(\pi(1.375)^2\right)(81) = 137 \text{ lbm}$



$\omega_1 = \sqrt{\frac{k}{m}} = \sqrt{\frac{158 \text{ lbf/in} \times 386 \text{ lbm-in/sec}^2\text{-lbf}}{137 \text{ lbm}}} = 21 \frac{\text{rad}}{\text{sec}} = 3.3 \text{ Hz}$

1st mode $\omega_{ni} = (g_{ni})(\omega_1)$ for single span $g_{ni} = \pi^2$

$\omega_{ni} = (\pi^2)(3.3) = 32.5 \text{ Hz}$

Check calc in metric units

steel = .008 kg/cm³

$E = 20 \times 10^6 \text{ N/cm}^2$

dia = 6.985 cm

A = 38.3 cm²

$I = \frac{\pi(6.985)^4}{64} = 117 \text{ cm}^4$

m = 63 kg

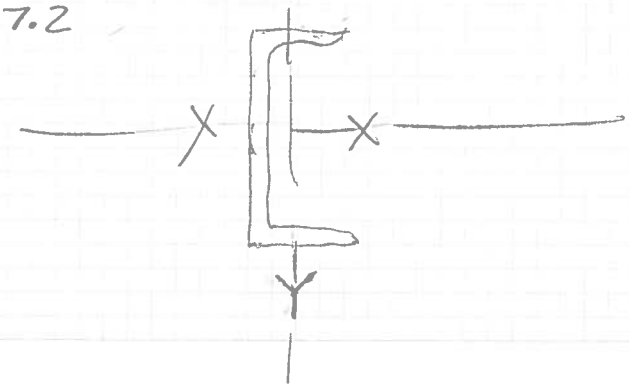
$k = \frac{(20\times10^6 \text{ N/cm}^2)(117 \text{ cm}^4)}{(205.74 \text{ cm})^3} = 269 \frac{\text{N}}{\text{cm}} = 26900 \text{ N/m}$

$m = \rho A \ell = 63 \text{ kg}$

$\omega_1 = \sqrt{\frac{269}{63}} = 2.066 \frac{\text{rad}}{\text{sec}}$ OK

Trash rack channel

C4 x 7.2



Steel Construction Manual

$I_{XX} = 4.58 \text{ in}^4$

$I_{YY} = .425 \text{ in}^4$

Mead & Hunt, Inc.

Job No. 2775900 Sheet 2 of 2
Job Name Jacobs/Pardee
Task
Calculated by GFR Date 1-14-2013
Checked by DVL Date 1-18-2013

trash rack channel - supports at 81" intervals, same as gate stem

$k = \frac{EI}{\ell^3}$ $K_{xx} = \frac{(30\times10^6)(4.58)}{(81)^3} = 259 \text{ lbf/in}$

$K_{YY} = \frac{(30\times10^6)(.425)}{(81)^3} = 24 \text{ lbf/in}$

$m = (w/\ell) = \left(\frac{7.2 \text{ lb}}{\text{ft}}\right)\left(\frac{81 \text{ in}}{12 \text{ in/ft}}\right) = 48.6 \text{ lbm}$

$\omega_{1xx} = \sqrt{\frac{k}{m}} = \sqrt{\frac{259 \text{ lbf/in} * 386 \text{ lbm-in}}{48.6 \text{ lbm} \quad \text{sec}^2 \text{ lbf}}} = 45.4 \text{ rad/sec} = 7.2 \text{ Hz}$

$\omega_{1YY} = \sqrt{\frac{24 \text{ lbf/in} * 386 \text{ lbm-in}}{48.6 \text{ lbm} \quad \text{sec}^2 \text{ lbf}}} = 13.8 \text{ rad/sec} = 2.2 \text{ Hz}$

1st mode $\omega_{ni} = (g_{ni})(\omega_1)$ for single span $g_{ni} = \pi^2$

$\omega_{nixx} = (\pi^2)(7.2) = 71 \text{ Hz}$

$\omega_{niyy} = (\pi^2)(2.2) = 21.7 \text{ Hz}$

Appendix D: Jacobs Associates Inspection Notes

Pardee Reservoir

Water Elevation – 561 ft

Gate Depths	*Difference Per Water Elevation*
El. 550 ft	11 ft
El. 520 ft	41 ft
El. 490 ft	71 ft
El. 460 ft	101 ft

Note:* See Appendix E for index to the DVD recording of the inspection. *Times recorded in the videos do not match times in the notes below because of malfunctions with the ROV equipment during the inspection.

Inside Tower

Notes (Following Timing Sequence of Video)

Due to turbulence, all gates at Elevation 550 ft level were closed.

Gate A (El. 550 ft)

- Viewed at 09:30 on video clock, correlates to 8:40 am (PST)
- Gate was closed
  - Bubbles seen around perimeter of gate providing evidence of leakage
  - Leakage has caused scouring of algae on edges of gate

Gate B (El. 550 ft)

- Viewed at 09:36 on video clock, correlates to 8:46 am (PST)
- Gate was closed
  - Bubbles seen around perimeter of gate providing evidence of leakage
  - Leakage has caused excessive scouring of algae on edges of gate

At 8: 50 am (PST) video clock resets due to ROV issues. ROV looses depth gauge so technicians perform maintenance. The ROV cable is labeled in 5ft intervals to provide depth readings.

Gate A (El. 520 ft)

- Viewed at 10:30 on video clock Closing
- Viewed at 10:33 on video clock Opening
  - Less noticeable leakage since edges of gate have less scouring of algae
  - About 2” of overlap of bottom edge of gate when closed

Gate B (El. 520 ft)

- Viewed at 10:36 on video clock Closing
- Viewed at 10:39 on video clock Opening
  - Less noticeable leakage since edges of gate have less scouring of algae
  - About 2” of overlap of bottom edge of gate when closed

At 10:40 am (PST) video clock resets due to ROV issues

Gate C (El. 520 ft)

- Viewed at 04:00 on video clock Closing, correlates to 10:46 am (PST)
- Viewed at 08:30 on video clock Opening, correlates to 10:50 am (PST)
  - Less noticeable leakage since edges of gate have less scouring of algae
  - About 2" of overlap of bottom edge of gate when closed

At 10:53 am (PST) video clock resets and does not appear on video anymore

Gate C (El. 550 ft)

- Viewed at 10:56 am (PST) Opening
  - Underside of gate has built up algae
  - Outside screen has a lot of debris and needs cleaning

Gate B (El. 550 ft)

- Viewed at 11:00 am (PST) Opening
  - Leakage has caused excessive scouring of algae on edges of gate

Gate A (El. 550 ft)

- Viewed at 11:05 am (PST) Opening
  - About 1" of overlap on sides gate

Gate A (El. 490 ft)

- Viewed at 11:18 am (PST) Closing
- Viewed at 11:22 am (PST) Opening
  - Cleaner than El 520 ft and 550 ft gates. May be due to depth receiving less light and not allowing the algae to grow

ROV went to the bottom of the tower on video after El. 490 ft Gate A recording. Video shows the three main pipes at the bottom of the tower.

Gate C (El. 490 ft)

- Viewed at 11:42 am (PST) Closing
- Viewed at 11:45 am (PST) Opening
  - Less noticeable leakage since edges of gate have less scouring of algae

Gate B (El. 490 ft)

- Viewed at 11:50 am (PST) Closing
- Viewed at 11:55 am (PST) Opening
  - Bottom right corner of gate shows leakage

- Gate remains about 1 to 2” open when closing

Gate B (El. 460 ft)

- Viewed at 12:00 (PST) Closing
- Viewed at 12:02 pm (PST) Opening
  - A lot of built up algae with little scouring
  - No sign of leakage
  - Gate is not opened much

Gate A (El. 460 ft)

- Viewed at 12:08 pm (PST) Closing
- Viewed at 12:10 pm (PST) Opening
  - A lot of built up algae with little scouring
  - No sign of leakage
  - Gate is not opened much

Gate C (El. 460 ft)

- Viewed at 12:16 pm (PST) Closing
- Viewed at 12:20 pm (PST) Opening
  - A lot of built up algae with little scouring
  - No sign of leakage
  - Gate is not opened much
  - Gate remains about 2 to 3” open when closing

ROV goes to the bottom of the tower again on video after El. 460 ft Gate C recording. Video shows the three main pipes at the bottom of the tower.

Outside Tower

Water Elevation – 561 ft

Gate Depths	*Difference Per Water Elevation*
El. 550 ft	11 ft
El. 520 ft	41 ft
El. 490 ft	71 ft
El. 460 ft	101 ft

Notes (Following Timing Sequence of Video)

Gates C:

- **El. 460 ft**
  - Viewed at 13:33 pm (PST) going Down
    - Cathodic protection is working well
    - Bolts and guides look good
    - Slack in chain above trash rack
    - Trash rack in good condition

- **El. 490 ft**
  - Viewed at 13:50 pm (PST) going Up
    - Cathodic protection is working well
    - Bolts and guides look good
    - Trash rack needs cleaning

- **El. 520 ft**
  - Viewed at 14:05pm (PST) going Down
    - Cathodic protection is working well
    - Bolts and guides look good
    - Trash rack chain is broken above trash rack, cathodic protection may not be working on chain
    - Trash rack needs cleaning

- **El. 550 ft**
  - Viewed at 14:15pm (PST) going Up
    - Bolts and guides look good
    - Trash rack chain is pitted, cathodic protection may not be working on chain
    - Trash rack needs cleaning

Gates B:

- **El. 460 ft**
  - Viewed at 14:26 pm (PST) going Down
    - Cathodic protection is working well
    - Bolts and guides look good
    - Trash rack in good condition
    - Pieces of old cathodic protection laying against trash rack

- **El. 520 ft**
  - Viewed at 14:55pm (PST) going Down
    - Cathodic protection is working well
    - Bolts and guides look good
    - Trash rack chain is broken above trash rack, cathodic protection may not be working on chain
    - Trash rack looks clean

- **El. 490 ft**
  - Viewed at 15:05 pm (PST) going Down
    - Cathodic protection is working well
    - Bolts and guides look good
    - Trash rack needs cleaning recording

- **El. 550 ft**
  - Viewed at 15:43pm (PST) going Up
    - Bolts and guides look good
    - Trash rack chain is corroded, cathodic protection may not be working on chain
    - Trash rack stop block shows signs of honeycombing of concrete (6 min into recording)

Gates A:

- **El. 460 ft**
  - Viewed at 15:53 pm (PST) going Down
    - Cathodic protection is working well
    - Bolts and guides look good
    - Horizontal bar is seen attaching guide rails
    - Instead of chain, two stainless cables are used to hold trash rack

- Trash rack needs cleaning
- Trash rack is not resting completely on stop block

- **El. 490 ft**
  - Viewed at 16:13 pm (PST) going Down
    - Cathodic protection is working well
    - Bolts and guides look good
    - Trash rack chain is broken above trash rack, cathodic protection may not be working on chain
    - Trash rack is not resting completely on stop block

- **El. 520 ft**
  - Viewed at 16:35 pm (PST) going Down
    - Cathodic protection is working well
    - Bolts and guides look good
    - Trash rack chain is broken above trash rack, cathodic protection may not be working on chain
    - Trash rack has average algae growth

- **El. 550 ft**
  - Viewed at 16:41 pm (PST) going Up
    - Cathodic protection is working well
    - Bolts and guides look good
    - Trash rack is not resting completely on stop block
    - Trash rack needs cleaning

<u>ROV search's for El. 450 ft inlet channel entrance out in reservoir after El. 550 ft gate A recording</u>

The ROV was launched in the general direction of the entrance on the water surface, but wind and wave action made it very difficult to maintain course.
After adding weights to the ROV, it was launched again underwater and made good progress. The culvert entrance and trashrack were located and inspected.

Appendix E: DVD of ROV Inspection

Pardee ROV Inspection

***Note:* Times recorded in videos do not match times noted in the JA Inspection Notes (Appendix D) because of malfunctions with the ROV equipment during the inspection.**

Tape 1: 9:04am - 11:26am

- **Start of internal inspection**
- Inspection of EL. 550 ft Gates A, B & C
- Marking of ROV cable for measuring depth
- Inspection of EL. 520 ft Gate A

Tape 2: 11:27am - 12:30pm

- Inspection of EL. 520 ft: Gates A, B & C
- Inspection of EL. 550 ft: Gates C, B & A
- Inspection of EL. 490 ft: Gate A
- Inspection of EL. 395 ft: Bonneted Valves and Outlet Pipes

Tape 2.1: 12:30pm - 12:37pm

- Inspection of EL. 490 ft: Gate C

Tape 2.2: 12:37pm - 12:53pm

- Inspection of EL. 490 ft: Gates C & B

Tape 2.3: 12:53pm - 12:56pm

- Inspection of EL. 460 ft: Gate B

Tape 3: 12:58pm - 2:45pm

- Inspection of EL. 460 ft: Gates A & C
- Inspection of EL. 395 ft: Bonneted Valves and Outlet Pipes

- **Start of external inspection**
- Inspection of EL. 460 ft: Gate C and Screening Chamber

Tape 3.1: 2:45pm – 3:37pm

- Inspection of EL. 490 ft, 520 ft and 550 ft: Gates C
- Inspection of EL. 460 ft: Gate B and Screening Chamber

Tape 3.2: 3:37pm – 4:19pm

- Inspection of EL. 520 ft, 490 ft: Gates B and Screening Chamber

Tape 3.3: 4:19pm – 4:35pm

- Inspection of EL. 490 ft: Gate B Screening Chamber

Tape 4: 4:35pm – 5:41pm

- Inspection of EL. 550 ft: Gate B

- Inspection of EL. 460 ft, 490 ft, 520 ft, 550 ft: Gates A

Tape 5: 5:43pm – 6:46pm

- Searching for El. 450 ft Inlet Channel Entrance

Tape 6: 6:46pm – 7:35pm

- Inspection of El. 450 ft Inlet Channel Entrance