Subject:	**Dewatering Estimates for Intake Facilities and Southern Forebay Emergency Spillway (Final Draft)**
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Prepared by:	Delta Conveyance Design and Construction Authority (DCA)
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1. Introduction

The construction and operation of some Delta Conveyance Project (project) facilities would require dewatering. Dewatering is primarily anticipated at the intakes and the Southern Forebay, with more localized dewatering required at planned bridge replacements and during miscellaneous site improvements, such as installation of utilities. This technical memorandum (TM) provides groundwater modeling-based estimates of dewatering rates and durations for dewatering at the intake facilities near Hood, California, and at the Emergency Spillway of the Southern Forebay (referred to herein as the sites). These two locations were selected, as they likely represent typical dewatering scenarios for other elements of the project. For the intake facilities, modeling included the construction and maintenance scenarios for the sedimentation basins, as well as the construction case for the box conduits that connect the intakes to the sedimentation basins. For the Emergency Spillway, modeling only included the construction dewatering scenario.

The results presented in this TM should only be considered preliminary and suitable for the assessment of viability at a conceptual engineering stage. The results rely on historical boring logs and aquifer test results, and in some cases, data gaps exist.

1.1 Organization

This TM is organized into the following sections:

- Introduction
- Hydrogeology
- Model Construction
- Model Application – Intake Facilities
- Model Application – Southern Forebay Emergency Spillway
- Summary and Conclusions
- Recommendations
- References
- Document History and Quality Assurance
- Tables
- Figures
- Attachment 1, Subsurface Cross-Sections at Intake Facilities and Southern Forebay Spillway
- Attachment 2, Relevant Boring Logs

1.2 Modeling Objectives

The modeling objectives include estimating the base extraction rate (that is, the steady extraction rate required to maintain groundwater levels at the target dewatering levels), the time to achieve target dewatering levels, and the associated pumping rates. Because of the general uncertainty in hydrogeological properties at both sites, sensitivity evaluations were conducted to provide insight into the uncertainty of the estimates.

The general approach was to use site-specific, numerical groundwater flow models to evaluate the pumping rates and durations needed for dewatering.

1.3 Site Details

This section describes the facilities and scenarios the dewatering estimates were provided for.

1.3.1 Intake Facilities

The project's Notice of Preparation identified up to three potential intake locations along the Sacramento River (Figure 1). The evaluation described herein focuses on the conditions around Intake 5, south of Hood (Figure 2). Each intake would contain the features shown on Figure 3. A groundwater cutoff wall surrounding the sedimentation basin would be installed to elevation (El.) -85 feet (all elevations are in reference to North American Vertical Datum of 1988 [NAVD88]). Each box conduit connecting the intakes to the sedimentation basins would have a shoring system and cutoff wall around the perimeter to El. -55 feet. The shoring system would be anticipated to consist of deep, mechanically mixed cutoff walls, planned as a grid of ground improvement at the site and reinforced locally, to serve as excavation support for the conduit construction.

Even with the cutoff walls, there would be a need for dewatering at the sedimentation basin and the shored box conduits (connecting structures between the intake structure and sedimentation basin) during construction due to the site's proximity to the Sacramento River. During operations, there could be an infrequent need to empty the sedimentation basin for maintenance, which also could require dewatering for a short period.

The dewatering needs would be as follows:

- Dewater the footprint of the sedimentation basin to 5 feet below its base during construction and future maintenance (El. -20 feet).
- Dewater the footprint of the shored box conduit excavations during construction (El. -20 feet).

1.3.2 Southern Forebay Emergency Spillway

Figure 4 shows the Southern Forebay Emergency Spillway location; it is near the Italian Slough and across the slough from the Clifton Court Forebay (CCF). The footprint of the area to be dewatered during construction is 300 feet by 300 feet, and would be dewatered to 20 feet below the current land surface. There is no cutoff wall associated with this construction, and there would be an upward-sloping grade extending horizontally 75 feet in each direction from the base of the excavation.

2. Hydrogeology

2.1 Intake Facilities

The intake facilities would be situated adjacent to the Sacramento River. The river at the Intake 5 location is about 600 feet wide and 30 feet deep (DWR, 2020a). The riverbed is at about El. -20 feet, and the tops of the levees are higher than El. 20 feet. The surrounding land use is agricultural, with the land surface near El. 0 feet. River levels are above the ground surface at the lands to the east of the river levees and berms.

Project and historical boring logs between Hood and Intake 5 were compiled into conceptual cross sections (Attachment 1). The stratigraphy generally consists of interlayered alluvial deposits ranging from coarse sand to clay. Both sites have organic-rich, fine-grained deposits within the upper 20 feet.

Immediately south of Hood, the fine-grained deposits are underlain by abundant sands with some interbedded silts and clays to about El. -80 feet, followed by a thick sequence of silts and clays between about El. -80 and El. -120 feet.

At Intake 5, the upper organic-rich zone is underlain by about 30 feet of sands, with about 30 feet of silts and clays separating this from more sands in the El. -80 to -120 feet range. At both locations, the boring logs indicate fine and coarse intervals are not homogeneous; rather, they have discrete interbeds.

An aquifer test was performed between Hood and Intake 5 in 1982 (DWR, 1982) (Figure 2). The pumping and observation wells were screened within the upper 40 feet and encountered a sandy deposit from about 15 to 30 feet below ground surface (bgs). The pumping well produced 245 gallons per minute (gpm) for 24 hours. The resulting hydraulic conductivity (K) value of the upper sand unit was about 250 feet per day (fpd) (8.82×10^{-2} centimeters per second [cm/s]). Storativity ranged from 0.0005 to 0.023.

The Sacramento River is generally considered to be in continuity with the groundwater under lands along the river in Sacramento County, including the area of the intakes (SCGA, 2019).

2.2 Southern Forebay Emergency Spillway

The spillway would be located on low-relief farmland with a ground surface between El. 0 and -10 feet. Several historical borings have been drilled near the proposed Southern Forebay, and those nearest to the spillway foundation are provided in Attachment 2. The borings generally extend 30 to 50 feet bgs. These logs indicate extensive organic-rich clay deposits in the upper 15 to 25 feet, with apparently continuous silty or clayey sands from about 25 to 40 feet bgs. The thickness of the sandy zone ranges from about 7 to 15 feet. Groundwater was generally encountered within the upper 10 feet of the subsurface, or around El. -10 to -14 feet.

Groundwater elevation data from nearby monitoring wells were accessed through the Sustainable Groundwater Management Act (SGMA) Data Viewer (Figure 4). The logs were reviewed, and information is summarized here. Along the Italian Slough, north of the site, groundwater elevations ranged from about El. -5 to El. -15 feet over the period 2000 to 2015. While most of the wells along the slough are shallow wells with a depth of 20 feet, wells BD-2 and BD-3 are screened from 90 to 100 feet depth and had groundwater elevations very similar to nearby shallow wells. At Discovery Bay, well 6MW-250 is screened from 200 to 210 feet depth and had groundwater elevations in the range of about El. -10 to El. -30 feet over the same time period, fluctuating seasonally (DWR, 2020c).

Water surface elevations (WSEs) of the Italian Slough Headwaters (Station ISH), located near the southern end of the Southern Forebay, ranged from about El. 1.5 to El. 7 feet during 2019; WSE stages at the West Canal (Station WCI) on the western side of the CCF ranged from about El. 1.75 to about El. 7.25 feet (CDEC, 2020) (Figure 4 shows the location). WSEs in the Southern Forebay area generally range from about El. 1.5 feet to about El. -3 feet (MacWilliams and Gross, 2013).

3. Model Construction

The numerical groundwater flow models described herein use the MODFLOW 2005 code with the NWT configuration (MODFLOW-NWT) (Niswonger et al., 2011). This code was selected for the following reasons:

- MODFLOW-NWT is built on the U.S. Geological Survey (USGS) MODFLOW model (Harbaugh et al., 2000), which is in wide use and is well-documented. MODFLOW-NWT has been benchmarked and verified, meaning the numerical solutions generated by the code have been compared with one or more analytical solutions, subjected to scientific review, and used on previous modeling projects. The verification of the code confirms MODFLOW 2005-NWT can accurately solve the governing equations that constitute the mathematical model (Niswonger et al., 2011).
- MODFLOW-NWT is an improvement on earlier versions of the MODFLOW code, related to drying and rewetting of model cells.

3.1 Intake Facilities

A single groundwater flow model was constructed to represent conditions in the Intake 5 area, based on available data. The model was initially designed to simulate sedimentation basin dewatering, and was then modified slightly for the box conduit dewatering modeling.

3.1.1 Sedimentation Basin

Figure 5 shows the model location, grid, and boundary conditions for Intake 5. Cell sizes range from 20 feet by 20 feet, to 80 feet by 80 feet, with 13 layers; for a total of 331,240 active cells. The model grid was rotated 50 degrees counter-clockwise from north-south to place the grid orientation parallel with the Sacramento River.

Figure 6 shows a cross section through the Sacramento River and the sedimentation basin. Land surface topography and the bathymetry of the Sacramento River (DWR, 2020a) are the bases for the top of Model Layer 1. The model layer thickness was variable for Model Layer 1, and below the Model Layer 1 and Model Layer 2 interface, the layers are horizontal planar.

3.1.1.1 Hydraulic Properties

The hydraulic property distribution shown on Figure 6 represents one configuration, and was varied extensively during the modeling evaluation. The K value of the fine-grained units was set to 10 fpd horizontal (Kh) (3.5×10^{-3} cm/s) and 0.1 fpd vertical (Kv) (3.5×10^{-5} cm/s), for a Kh to Kv ratio of 100:1. These Kh and Kv values are greater than typical values for silt or clay deposits, and represent a conservative approximation, intending to account for discontinuities or interlayering. The Kh and Kv of the coarse or sandy deposits were generally held to 250 fpd (8.8×10^{-2} cm/s) and 2.5 fpd (8.8×10^{-4} cm/s), respectively, apart from evaluations where the Kh and Kv values were increased to 1,000 fpd (3.5×10^{-1} cm/s) and 10 fpd (3.5×10^{-3} cm/s), respectively.

3.1.1.2 Boundary Conditions

Model boundary conditions include a general head boundary (GHB) along the western and eastern model edges, a river boundary for the Sacramento River, and no-flow along the northern and southern model edges (Figures 5 and 6). The eastern GHB was set up with a head specified at 0 foot and a distance component of the conductance term set to 2,000 feet. The western GHB was set up with a head specified at El. -3.8 feet and a distance component of the conductance term also set to 2,000 feet. This configuration imposes a 0.0005 foot per foot (ft/ft) hydraulic gradient, approximately the value observed near the Sacramento River about 5 miles north of Hood, in fall 2016 (DWR, 2020b). Because the imposed hydraulic gradients are very flat, the exact direction of ambient groundwater flow should not influence the dewatering calculations. The K component of the GHBs was set to 250 fpd (8.8×10^{-2} cm/s).

The cutoff wall, which is assumed to be a soil-cement-bentonite wall constructed using deep mechanical mixing, was simulated with the Horizontal Flow Barrier (HFB) package, with an assigned width of 4 feet and a K of 0.00028 fpd (1.0×10^{-7} cm/s).

3.1.2 Box Conduit

The model was modified slightly to simulate the dewatering of a single shored excavation for intake box conduit construction (Figure 7). Adjustments included removing the river boundary from the footprint of the cofferdam (because the cofferdam would be constructed and empty at this time), refining the grid cells to 10 feet by 10 feet in the box conduit shored excavation area, and splitting Model Layers 2 and 3 to provide greater resolution in the upper portion of the model.

Each box conduit would have a cutoff wall installed around the perimeter to El. -55 feet. The cutoff wall is simulated with the HFB package, as discussed.

3.2 Southern Forebay Emergency Spillway

Figure 8 shows the Emergency Spillway model grid. The model has cell sizes ranging from 10 feet by 10 feet to 100 feet by 100 feet, with 6 model layers for 163,344 active cells. Land surface topography (DWR, 2020a) is the basis for the top of Model Layer 1.

Figure 9 shows the model in a west to east cross section through the area to be dewatered. Model Layer 1 has uniform thickness of 5 feet, Model Layer 2 has variable thickness, and Model Layers 3 through 6 are horizontal planar with a thickness of 15 feet.

3.2.1 Hydraulic Properties

The initial K distribution illustrated on Figure 9 is continuous throughout the model. The K of the silty sands was varied from 1 to 20 fpd (3.5×10^{-4} to 7.10×10^{-3} cm/s) because dewatering rates were most sensitive to this parameter. The K values in Model Layers 1 and 2 were varied until reasonable matches to boring log groundwater heads were achieved (the properties of the silty-sand had much less effect on head levels in the adjacent wells than the properties of the upper clays).

3.2.2 Boundary Conditions

Model boundary conditions include river recharge boundaries for the Italian Slough and the CCF, a GHB along the northern border, and no-flow for the remaining perimeter (Figures 8 and 9). The head in the Italian Slough and the CCF was specified at 8 feet, representing high-water conditions.

The GHB boundary was assigned a head of approximately El. -20 feet with a distance component of the conductance term of 8,000 feet. The El. -20-foot head is based on data from well 06MW-250 (DWR, 2020c) (Figure 4).

4. Model Application – Intake Facilities

An extensive series of steady-state models was developed to evaluate the sensitivity of the base extraction rates related to key hydrogeological properties. This was followed by transient modeling with a more limited set of variables.

4.1 Sedimentation Basin

The sedimentation basin simulations include scenarios for both construction and maintenance dewatering. For construction dewatering, initial conditions are preconstruction conditions, with water levels slightly bgs. For maintenance cases, initial conditions are conditions with water levels in the sedimentation basin lowered to El. -10 feet by the draining of the basin through the outlet gates, or other means (for example, sump pumps).

4.1.1 Steady-state Case

The objective of the steady-state modeling was to determine reasonable ranges of groundwater flow into the sedimentation basin, with the installed cutoff wall to El. -85 feet, under a range of plausible K distributions. During the modeling, the water budget of the model was tracked, with particular attention to the drain rates. These models represent stabilized steady-state dewatering conditions.

4.1.1.1 Construction Dewatering

For the steady-state modeling, the drain package was implemented over the footprint of the sedimentation basin in Model Layer 3. The drain head was set to El. -20 feet, with a very high-K component of the conductance term (K = 1,000 fpd [3.5×10^{-1} cm/s]; drain thickness = 5 feet) to avoid adding additional resistance beyond that of the surrounding aquifer.

Table 1 summarizes the variables adjusted and the resultant model flow rates for the steady-state sensitivity evaluations (all tables are located at the end of the TM). The results are discussed here.

Base Case Cutoff

Models D0_10 and D0_20 modeled the river stage at El. 10 feet and El. 20 feet, respectively, with no drain implemented (no active dewatering). These represent approximate existing mid- and high-water conditions, with the cutoff wall installed, and represent the initial conditions for later transient modeling. When river stage is increased from El. 10 to El. 20 feet, river leakage rates increase by a factor of nearly 2, GHB inflows decrease by nearly 30 percent, and GHB outflows increase by nearly 25 percent (Table 1). The high-stage condition (El. 20 feet) was used for most of the remaining steady-state model runs.

Variability of Low-K Soils within Cutoff Wall

Models D1 through D5 sequentially decrease the thickness of the low-K zone within the cutoff wall footprint, from 40 to 5 foot thick. The drain rate (the rate needed to maintain a target groundwater elevation of El. -20 feet) increases from 358 to 1,529 gpm as the clay thickness decreases. Most of the additional water is delivered via the GHB boundaries, with river leakage increasing by 42 gpm overall. Flow through the cutoff wall is very low for these simulations (around 2 gpm) (Table 1).

Models D6 through D10 repeat the sequential thinning of the low-K layer, but with the Kh and Kv of this layer reduced one order of magnitude from 10 to 1 fpd (3.5×10^{-3} to 3.5×10^{-4} cm/s) and 1 to 0.1 fpd (3.5×10^{-4} to 3.5×10^{-5} cm/s), respectively. Flow rates of the drain are reduced nearly an order of magnitude (range 41 to 287 gpm), with about a 0.5 gpm increase in flow through the wall (Table 1).

Breaches in the Low-K Soil Layer within the Cutoff Wall

Models D11 through D16 simulate vertical breaches that are 20, 40, and 80 feet wide in the clay layer, with two variations on the clay K (Table 1). The simulated breaches run continuously along the river-side edge of the sedimentation basin (Figure 6) and represent scenarios where the lower-K materials are not laterally continuous within the cutoff wall. For these simulations, the thickness of the clay was set at 30 feet, such that the effect of the breaching compares with previous models using 30-foot-thick lower-K zone D2 (higher-K clay) and D7 (lower-K clay). These simulations illustrate that even small breaches in the clay can dramatically increase groundwater flow into the dewatered area. With a 20-foot-wide breach, the drain rate increases from 459 to 611 gpm, with the higher-K clay (compare D2 with D11) and increases from 54 to 238 gpm with the lower-K clay (compare D7 with D12). With the 80-foot-wide breach, the flow rate increases to 934 gpm with the higher-K clay (D15) and 628 gpm with the lower-K clay (D16).

Variability of Cutoff Wall Properties

Model D17 simulates an order-of-magnitude decrease of the wall K from 0.028 fpd (1.0×10^{-5} cm/s) to 0.0028 fpd (1.0×10^{-6} cm/s) and a reduction of the wall thickness from 4 to 2 feet (with a high-K, 30-foot-thick clay layer). The effect is an increase of wall leakage from 2 to 38 gpm (comparing D2 with D17) (Table 1).

Variability of Soil Strata

Models D18 and D19 evaluate the condition where the clay layer is deeper, no longer confined within the cutoff wall, now beginning at the base of the cutoff wall and continuing below. Two cases were simulated, with 10-foot and 30-foot thicknesses. With a 10-foot-thick layer, the drain flows are very similar to flows with the clay at higher elevations (1,092 gpm [D19] versus 1,041 gpm [D4]). But with a 30-foot-thick layer, drain flows are much higher in the deeper case (686 gpm under D18 conditions versus 459 gpm under D2 conditions). The reason for this is likely that the clays are not continuous in the model past the boundary of the cutoff wall, only extending about 100 feet beyond the edge of the wall. This would allow groundwater to flow sideways through the clay and up into the sedimentation basin.

Variability in Hydraulic Conductivity

Model D20 tests the K of the coarse-grained sediments (high-K zone) by increasing K from 250 fpd (8.8×10^{-2} cm/s) to 1,000 fpd (3.5×10^{-1} cm/s) (with a 30-foot-thick clay layer). A comparison with Model D2 shows the drain rate increases by about 10 percent, from 459 to 498 gpm. The overall flow rate through the GHBs increases by about 50 percent, from 607 to 931 gpm.

The effect of increasing the K of the river bed was evaluated in Models D26 and D27, where the K was increased by one and two orders of magnitude, respectively. Compared with Model D2, the effect on the drain is relatively minor (increased drain rate from 459 gpm to 479 and 483 gpm), but the effect on overall river leakage is major (from 832 gpm to 1,661 and 1,846 gpm). This suggests errors in estimating river leakage rates have little bearing on the drain flux rates, at least with the current model configuration. Table 1 shows four cases where the drain rate increased substantially, and the additional water came from the boundary of the model on the eastern and western sides (GHBs); whereas, river leakage did not increase appreciably.

The steady-state modeling provides a range of about 200 to 1,000 gpm required to maintain target groundwater elevations (not to reach the target), under a reasonable range of conditions. The steady-state flow predictions are most sensitive to the Kv of the sediments within the cutoff wall and the presence and nature of vertical discontinuities within any clay strata. Variations in the riverbed Kv and bulk aquifer K appear to have little effect on estimated groundwater flow rates into the sedimentation basin.

4.1.1.2 Maintenance Dewatering

Both the construction and maintenance dewatering cases have the objective of dewatering to El. -20 feet; as such, the steady-state modeling described in Section 4.1.1.1 also applies to maintenance dewatering. The primary difference in the scenarios is the starting point for transient simulations.

Models D21 through D25 represent the maintenance-case initial conditions for transient modeling with different K assumptions. For these simulations, the drain head is specified at El. -10 feet, to represent the conditions at the end of sedimentation basin emptying for maintenance. The drain rates for these simulations represent the amount of water that would be flowing into the sedimentation basin upon drainage through the gates and into tunnels (Figure 3).

4.1.2 Transient Case

The transient sedimentation basin dewatering simulations include scenarios for construction dewatering and for maintenance dewatering. As discussed, initial conditions for construction dewatering are contemporary conditions, with water levels slightly below land surface. For maintenance cases, initial conditions are the point at which water levels in the sedimentation basin are assumed to be drawn down to the approximate sill elevation of the radial gates (El. -10 feet) by the draining of the reservoir through the outlet gates, or other means (for example, sump pumps).

Transient modeling requires estimates of aquifer storativity. Although the 1982 aquifer test (DWR, 1982) provided estimates of storativity (combined specific storage and specific yield) ranging from 4.0×10^{-5} to 2.3×10^{-2}, the values derived from the test were shown to be increasing throughout the test. As the dewatering program is scheduled to last much longer than the 1982 aquifer tests, these values were not used.

For the dewatering transient modeling, two values were used for specific yield (0.1 and 0.2), and a value of 1e-4 was used for specific storage. The specific yield is the more important parameter for dewatering efforts, and can have a major effect on the rate of drawdown during pumping.

Two distributions of K were evaluated under transient conditions:

1) 10-foot-thick clay layer within the cutoff wall, with Kh = 10 fpd (3.5×10^{-3} cm/s) and Kv = 0.1 fpd (3.5×10^{-5} cm/s)
2) 30-foot-thick clay layer within the cutoff wall, with Kh = 10 fpd (3.5×10^{-3} cm/s) and Kv = 0.1 fpd (3.5×10^{-5} cm/s)

The drain flux rates at steady-state for these configurations were 1,041 gpm (Model D4) and 459 gpm (Model D2), respectively (Table 1).

For transient modeling, an array of seven pumping wells (MODFLOW MNW package [Niswonger et al., 2011]) was placed between the cutoff wall and the base of the area to be dewatered (Figure 10). The wells were screened in Model Layers 2 through 5. Two total pumping rates were evaluated (that is, 1,000 gpm and 2,000 gpm) with the flow rate divided evenly among the 7 pumping wells (143 and 286 gpm per well, respectively).

Varying the thickness of the clay layer, the specific yield, and pumping rates resulted in eight scenarios each for construction and maintenance dewatering (Table 2). A virtual observation well was placed in the center of the modeled sedimentation basin to evaluate transient water levels during dewatering (Figure 10).

4.1.2.1 Construction Dewatering

Figure 11 shows the results of construction dewatering simulations by displaying the observation well heads from Model Layers 2 and 3. Note, groundwater levels in Model Layer 3 reach the El. -20-foot target more quickly than in Model Layer 2. Model Layer 2 represents low-permeability sediments that are slower to drain than the higher-K sandy deposits. Target drawdown is reached more quickly, at about 16 days with a higher pumping rate, thicker low-K zone, and lower specific yield (refer to the DT5 results on Figure 11). The models fail to reach target levels within 60 days in the two scenarios where the clay layer is thin and the pumping rate is 1,000 gpm (refer to DT2 and DT4 on Figure 11).

Figure 12 shows the timing of drawdown from Model Layer 2 only, for the 30-foot-thick clay layer scenarios (DT1, DT3, DT5, and DT7) and for the 10-foot-thick clay layer scenarios. Figure 12 presents the differences in timing for the higher and lower rates and different values of specific yield. These results suggest that 1,000 gpm of dewatering might not be adequate unless there is an abundance of finer-grained material within the perimeter of the cutoff wall. Conversely, 2,000 gpm (if dewatering wells can achieve this rate) might be needed to achieve target drawdowns within 2 to 6 weeks.

Although the sedimentation basin model runs were not explicitly designed to determine the necessary number and location of pumping wells, observations from the model budgets are insightful. The minimum pumping level in the extraction wells was set deep, at El. -100 feet, to minimize reductions to pumping rates due to limitations in transmissivity at the pumping well. And for most scenarios, pumping rates were not reduced. However, for scenarios with higher thicknesses of lower-K deposits within the cutoff wall, extraction rates were slightly reduced by the end of the simulations (DT1 11 percent, DT3 1 percent, and DT5 5 percent). This suggests that for less productive geological settings, additional wells could be needed to sustain target pumping rates; or conversely, in some cases, lower rates could meet drawdown requirements.

4.1.2.2 Maintenance Dewatering

Maintenance dewatering was conducted separately from construction dewatering, despite them having the same overall objective (dewater to El. -20 feet) because of differences in initial conditions and river stage. The initial conditions for the maintenance scenario start with groundwater rates into the sedimentation basin of 217 gpm for the 30-foot-thick clay layer and 1,000 (D21 in Table 1) or 495 gpm for the 10-foot-thick clay layer (D23 in Table 1).

Figure 13 shows the results for the 30-foot-thick clay layer at 1,000 gpm and 2,000 gpm pumping, with the variations in specific yield. Each scenario results in target dewatering by about 9 to 34 days after the initiation of pumping, with quicker durations at the higher pumping rate. Figure 13 also shows the results for the 10-foot-thick clay layer, with target drawdown not achieved at 1,000 gpm, and target drawdown achieved in about 13 to 24 days for 2,000 gpm.

4.2 Box Conduit

Box conduit simulations were completed to evaluate dewatering rates during construction. For construction dewatering, initial conditions are preconstruction conditions, with water levels slightly below land surface. The model grid was modified to represent altered site conditions before box conduit construction (Figure 7).

The river stage was set at 10 feet for all simulations, representing approximate average conditions (instead of the potentially high-water conditions that could occur during sedimentation basin construction dewatering).

4.2.1 Steady-state Case

Drains were established within the box conduit footprint, with head specified at El. -20 feet. Three steady-state scenarios were simulated for the box conduit. In the first, there was no low-K sediment layer within the cutoff wall, and the groundwater inflow into the box conduit was 43 gpm. The second scenario added a 5-foot-thick layer of lower-K material with a Kh of 10 fpd (3.5×10^{-3} cm/s) and a Kv of 1 fpd (3.5×10^{-4} cm/s) within the cutoff wall, and the groundwater flow is reduced to 11 gpm. In the third scenario, the low-K layer is 10 feet thick, and the groundwater flow is reduced to 6 gpm. In all cases, the groundwater flow through the wall was about 0.1 gpm.

These scenarios provide a range of 6 to 43 gpm needed to sustain groundwater levels at or below the target of El. -20 feet. Transient modeling was conducted to determine the range of rates needed to reach El. -20 feet.

4.2.2 Transient Case

The same K variations in the steady-state modeling were repeated for the transient evaluation, with the specific yield varying between 0.1 and 0.2. For simplicity, drains were used instead of wells to remove water in the box conduit transient model, where a single cell in the center of the box conduit was assigned as the drain. Drawdown was monitored in the edge of the box conduit in Model Layers 2, 3, and 4.

Table 3 summarizes the transient model simulations, and Figure 14 shows the changes in head and extraction rate over time. With no lower-K layer (BC1 and BC4), the extraction rates start off greater than 70 gpm, and the drawdown target is achieved in about 3 to 4 weeks. With a 5-foot-thick lower-K layer (BC2 and BC5), extraction rates taper from about 40 to 50 gpm to a little over 10 gpm by 30 days. Target dewatering levels are achieved in about 2 to 4 weeks. With a 10-foot-thick lower-K layer (BC3 and BC6), extraction rates also start around 40 to 50 gpm and decrease to less than 10 gpm, with target dewatering levels achieved in about 2 to 3 weeks.

Table 3 provides the time-weighted average rates for the transient box conduit simulations. For the scenarios simulated, the time-weighted average extraction rate for the first 10 days of dewatering ranged from about 15 to 65 gpm. The rates taper off less for higher-K conditions; and with some lower-K materials present, they taper off to less than 10 gpm (approaching the steady-state rate).

4.3 Intake Dewatering Summary

Because of uncertainty in the lithological configuration between the proposed cutoff walls and within box conduits, several model configurations were used to simulate dewatering at these locations.

For the sedimentation basin, most modeling scenarios resulted in dewatering rates of between 200 and 1,000 gpm, with higher rates required (such as 2,000 gpm) to more quickly achieve target dewatering levels (2 to 6 weeks for initial dewatering, and 1 to 3 weeks for maintenance dewatering). The results appear to be most sensitive to the Kv of the materials within the perimeter of the cutoff wall, and relatively insensitive to the K of the Sacramento River sediments.

For the box conduits, the most conservative case evaluated suggested that extraction rates of up to 60 gpm might be needed to achieve target dewatering levels within 2 to 4 weeks. Scenarios with lower-K materials required lower long-term dewatering rates (10 to 15 gpm).

5. Model Application – Southern Forebay Emergency Spillway

A series of steady-state models was developed to evaluate the sensitivity of the base extraction rates related to important variables, followed by transient modeling with a more limited set of variables.

5.1 Steady-state Case

Three baseline model configurations were chosen for evaluation, with the requirement that the resultant water levels generally honor the approximate elevation of the water table as observed in the well logs (there are no other calibration targets). The K of the silty sand in Model Layer 3 is the variable adjusted for the three configuration, between 1 fpd (3.5×10^{-4} cm/s) (FBa), 10 fpd (3.5×10^{-3} cm/s) (FBb), and 20 fpd (7.1×10^{-3} cm/s) (FBc) (each with Kh:Kv = 10:1). By varying these values, the steady-state (no-extraction) models resulted in heads at the dewatering site of approximately El. -11.5 feet, El. -11.9 feet, and El. -14 feet. These are within the ranges observed in logs of historical borings in the vicinity (Attachment 2). Figure 15 shows the simulated groundwater levels near the spillway with the FBa configuration, with groundwater flow directions leading from the surface water bodies to the northwest.

Dewatering simulations used eight drain cells placed at the edge of the area to be graded (two on each side of the site) as a potential configuration for extraction wells. A virtual observation well was placed in the center of the modeled site to evaluate drawdown. A series of model simulations was conducted for each K configuration, with the stage of the drain sequentially lowered.

Figure 16 shows the results for each scenario, with the observation head plotted against the overall drain rate for each simulation. For FBa and FBb, the drain stage was set at El. -35 feet, El. -37 feet, El. - 40 feet, and El. -43 feet. For FBa, this resulted in extraction rates between about 6 and 7 gpm, with the target of El. -33 feet reached for the two higher rates. For FBb, the extraction rates were more variable, ranging from about 24 to 32 gpm, with only the 32-gpm scenario (drain set to El. -43 feet) resulting in sufficient dewatering. For the FBc scenario, the drain was set at three levels: El. -43 feet, El. -46 feet, and El. -49 feet, resulting in extraction rates of about 42, 46, and 49 gpm, respectively. The 46- and 49-gpm steady-state rates achieved successful dewatering.

5.2 Transient Case

Transient simulations used multinode wells in place of drains for only the FBb configuration. Three scenarios were simulated:

1) Eight wells pumping 5 gpm each, for 40 gpm total
2) Eight wells pumping 20 gpm each, for 160 gpm total
3) Sixteen wells pumping 10 gpm each, for 160 gpm total

These rates are greater than the 32-gpm rate required to maintain dewatering in the steady-state FBb scenario (Figure 16). The modeled specific yield value is 0.05, which is considered reasonable for clays. Virtual observation wells were placed in Model Layer 2 (clays) and Model Layer 3 (silty sands). The pumping wells were assigned a minimum pumping level of El. -45 feet (the bottom of Layer 3), so the extraction rate would be reduced if aquifer transmissivity decreased at the well.

Figure 17 shows the drawdown curves in Model Layers 2 and 3 at 40-gpm total pumping (rates were not reduced over time). The target dewatering level is not reached after 90 days, and very little drawdown has occurred by that time in Model Layer 2 (clays). By the end of 90 days, a total of about 9 million gallons (MG) have been withdrawn.

Figure 18 shows the drawdown and extraction rate curves for the simulations with the wells initially pumping 160 gpm, total. With 8 wells pumping, the pumping rate drops very rapidly (within 100 minutes) to less than below 100 gpm, and somewhat stabilizes at just under 40 gpm by the end of the simulation (the rate is dropping about 0.02 gpm per day by day 90). Drawdown in Layer 3 does not reach the target elevation within 90 days. With 16 wells pumping, higher overall extraction rates persist for longer, resulting in more rapid drawdown, and the target elevation is reached in the silty-sand aquifer (Layer 3) after about 31 days. For both scenarios, very little drawdown occurs in Layer 2, the overlaying clays.

These results suggest that the upper clays could be difficult to drain, and rates several times larger than the steady-state pumping rate would be needed to achieve timely target dewatering levels within the silty-sand aquifer.

5.3 Southern Forebay Emergency Spillway Summary

For the Southern Forebay Emergency Spillway simulations, the predictions were most sensitive to the K of a widespread silty-sand layer simulated in Layer 3. For steady-state modeling, K values varied between 1 to 20 fpd (3.5×10^{-4} to 7.1×10^{-3} cm/s). The results suggest that extraction rates required to maintain target groundwater elevations could vary between less than 10 gpm to nearly 50 gpm.

The transient model was performed to evaluate the rates and time frames needed to reach required groundwater elevations. The transient model used a K of 10 fpd (3.5×10^{-3} cm/s) for Layer 3, with a specific yield of 0.05. Transient conditions were simulated with extraction rates of 40 and 160 gpm. The 160-gpm scenarios showed that the number of pumping wells could be of importance. At 160 gpm with 8 wells, the head in the silty-sand aquifer did not reach target elevation after 90 days. With 16 wells, the target was reached after about 31 days. Both 160-gpm simulations did not dewater the upper clays (Layer 2) within 90 days. However, dewatering of the clay could not be required if excavation slopes are planned accordingly.

6. Summary and Conclusions

Dewatering evaluations were performed for two sites associated with the proposed Delta Conveyance Project: the intake structures near Hood, California, and the proposed Southern Forebay Emergency Spillway, near the CCF. Because site-specific aquifer performance data are limited or nonexistent, the modeling approach focused on providing results for reasonable ranges of aquifer properties. Extraction rates were provided for steady-state conditions (after the target water level had been reached), as well as for initial dewatering efforts (the process of reducing water levels to the target).

6.1 Intake Facilities

The intake facilities included the sedimentation basin and a typical shored excavation for a box conduit. The sedimentation basin includes a perimeter cutoff wall to El. -85 feet, and the box conduits include cutoff walls to El. -55 feet. Target dewatering depth is El. -20 feet for both areas. Lithology is variable between (Figure 2), with pervious sands (K = approximately 250 fpd [8.8×10^{-2} cm/s]) and clay deposits of unknown continuity existing at different elevations between Hood and Randall Island.

6.1.1 Sedimentation Basin

Sedimentation basin modeling included initial dewatering during construction and dewatering for basin maintenance. The modeling results are based on simplistic depictions of site lithology. In all cases, the K value of the low-K deposits was set at a Kh of 10 fpd (3.5×10^{-3} cm/s) and a Kv of 1 fpd (3.5×10^{-4} cm/s). These K values are higher than a typical pure clay or silt, and are more representative of silty or clayey sands. These values were used to incorporate some conservatism in the dewatering rates.

Most of the simulated variations in the K distribution resulted in groundwater flow into the basin of about 200 to 1,000 gpm. This applies to both construction and maintenance phases. The predictions are most sensitive to the Kv of materials within the perimeter of the cutoff wall. Lateral discontinuities in thick layers of fine-grained deposits can also substantially increase needed extraction rates. Variations in riverbed K and bulk aquifer properties had little effect on results.

Transient modeling suggests that well extraction rates of 1,000 gpm would not achieve target dewatering levels, except in cases with robust and continuous lower-K zones within the cutoff wall. An overall extraction rate of 2,000 gpm achieved target dewatering levels in 2 to 6 weeks for the scenarios evaluated. For conceptual-level planning, a rate of 1,500 gpm can be assumed if dewatering is started sufficiently in advance of planned excavation. This 1,500-gpm flow rate would taper into the 200- to 1,000-gpm continuous rate after 2 to 6 weeks and would remain relatively constant through completion of basin first filling, with slight variations due to changes in river level.

Much like the construction phase dewatering, evaluations of maintenance dewatering suggest that 1,000 gpm is only a sufficient rate with continuous and thick low-K deposits; 2,000 gpm was predicted to dewater the basin within 1 to 4 weeks. For conceptual-level planning, a rate of 1,500 gpm can be assumed if dewatering is started sufficiently in advance of planned maintenance. This 1,500-gpm flow rate would taper into the 200- to 1,000-gpm continuous rate after 1 to 3 weeks and would remain relatively constant through completion of basin refilling, with slight variations due to changes in river level.

6.1.2 Box Conduit

Transient simulations suggest that up to 60 gpm would be required to dewater within 2 to 4 weeks in a more conservative case, where no fine-grained deposits exist within the cutoff wall. Lower-flow rates, in the range of 10 to 15 gpm, could result in achieved dewatering targets in the presence of continuous fine-grained deposits within the box conduit cutoff wall. Once target groundwater elevations are reached, the modeling suggests that groundwater flows into the box conduit could vary from 6 to 43 gpm, depending on the assumed thickness of low-K deposits (from 0 to 10 feet thick in the model). These flows would continue throughout the excavation, conduit construction, and backfill for each individual conduit section.

6.2 Southern Forebay Emergency Spillway

For the Southern Forebay Emergency Spillway construction dewatering, the modeling results are based on highly generalized site lithology. Steady-state modeling suggested that the results are most sensitive to the K of Model Layer 3, the widespread silty-sand layer. The results of transient modeling indicated that 160 gpm with 16 wells met the drawdown target after about 30 days; at which time, steady-state flows would be achieved and could vary between less than 10 gpm to nearly 50 gpm. These flows would be required until the completion of the Southern Forebay Emergency Spillway foundations and their backfilling.

7. Recommendations

At all of the locations evaluated, site-specific lithologic data are limited, especially with respect to aquifer performance data, and even general groundwater condition. The modeling results presented herein are based on simplistic depictions of site lithology, and although attempts were made to provide boundaries for potential extraction rates and times-to-dewater, considerable uncertainty remains.

Site-specific aquifer testing is recommended at any location needing dewatering. Such testing should focus on the hydraulic aquifer properties of areas within any proposed cutoff wall, with particular attention to the Kv, and connectivity of both fine- and coarse-grained units.

8. References

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9. Document History and Quality Assurance

Reviewers listed have completed an internal quality review check and approval process for deliverable documents that is consistent with procedures and directives identified by the Engineering Design Manager (EDM) and the DCA.

Approval Names and Roles			
Prepared by	**Internal Quality Control review by**	**Consistency review by**	**Approved for submission by**
Brian Boer / Geologist	Andrew Finney / EDM Geotechnical Lead	Gwen Buchholz / DCA Environmental Consultant	Terry Krause / EDM Project Manager

This interim document is considered preliminary and was prepared under the responsible charge of Andrew Finney, California Professional Engineering License GE2759.

Note to Reader

This is an early foundational technical document. Contents therefore reflect the timeframe associated with submission of the initial and final drafts. Only minor editorial and document date revisions have been made to the current Conformed Final Draft for Administrative Draft Engineering Project Report version.

Tables

Table 1
Summary of Results from Sensitivity Analysis

Model ID	High K Zone	Low K Zone	Thickness Low K Zone	Riverbed Kv	Note	River Stage	Wall Thickness	Wall K	Drain	Through Slurry Wall	Up from Bottom	GHB In	GHB Out	River Leakage
	(Kh/Kv ft/d)	(Kh/Kv ft/d)	(ft)	(ft/d)		(ft)	(ft)	(ft/d)	(gpm)	(gpm)	(gpm)	(gpm)	(gpm)	(gpm)
D0_10	250/2.5	10/0.1	30	0.016	No Drain or Wall	10	N/A	N/A	N/A	N/A	N/A	521	961	440
D0_20	250/2.5	10/0.1	30	0.016	No Drain or Wall	20	N/A	N/A	N/A	N/A	N/A	373	1189	816
D1	250/2.5	10/0.1	40	0.016		20	4	0.00028	358	1.8	356	555	1024	828
D2	250/2.5	10/0.1	30	0.016		20	4	0.00028	459	2.0	457	607	980	832
D3	250/2.5	10/0.1	20	0.016		20	4	0.00028	637	2.1	635	699	900	838
D4	250/2.5	10/0.1	10	0.016		20	4	0.00028	1041	2.1	1039	907	718	852
D5	250/2.5	10/0.1	5	0.016		20	4	0.00028	1529	1.9	1527	1158	499	870
D6	250/2.5	1/0.01	40	0.016	Lower K fine grained	20	4	0.00028	41	1.9	41	393	1168	816
D7	250/2.5	1/0.01	30	0.016	Lower K fine grained	20	4	0.00028	54	2.1	52	400	1163	817
D8	250/2.5	1/0.01	20	0.016	Lower K fine grained	20	4	0.00028	79	2.3	77	414	1153	818
D9	250/2.5	1/0.01	10	0.016	Lower K fine grained	20	4	0.00028	152	2.5	150	452	1121	821
D10	250/2.5	1/0.01	5	0.016	Lower K fine grained	20	4	0.00028	287	2.5	285	522	1060	826
D11	250/2.5	10/0.1	30	0.016	20 ft wide zone with no low K layer	20	4	0.00028	611	1.9	610	668	896	840
D12	250/2.5	1/0.01	30	0.016	20 ft wide zone with no low K layer	20	4	0.00028	238	2.0	236	476	1064	826
D13	250/2.5	10/0.1	30	0.016	40 ft wide zone with no low K layer	20	4	0.00028	734	1.9	732	720	830	845
D14	250/2.5	1/0.01	30	0.016	40 ft wide zone with no low K layer	20	4	0.00028	387	2.0	385	539	985	833
D15	250/2.5	10/0.1	30	0.016	80 ft wide zone with no low K layer	20	4	0.00028	934	1.8	932	805	725	854
D16	250/2.5	1/0.01	30	0.016	80 ft wide zone with no low K layer	20	4	0.00028	628	1.9	626	643	858	843
D17	250/2.5	10/0.1	30	0.016	More permeable wall	20	2	0.0028	489	38	451	622	967	833
D18	250/2.5	10/0.1	30	0.016	Low K layer below base of wall	20	4	0.00028	686	2.4	684	720	874	841
D19	250/2.5	10/0.1	10	0.016	Low K layer below base of wall	20	4	0.00028	1092	2.2	1089	932	694	854
D20	1000/10	10/0.1	30	0.016	High K	20	4	0.00028	498	2.0	496	931	1275	843
D21	250/2.5	10/0.1	30	0.016	Drain -10 ft	10	4	0.00028	218	1.0	217	483	1089	823
D22	250/2.5	10/0.1	20	0.016	Drain -10 ft	10	4	0.00028	303	1.0	302	528	1051	826
D23	250/2.5	10/0.1	10	0.016	Drain -10 ft	10	4	0.00028	496	1.0	495	627	965	833
D24	250/2.5	10/0.1	30	0.16	High Riverbed K Drain -10 ft	20	4	0.00028	238	1.1	237	186	1593	1644
D25	250/2.5	10/0.1	30	1.6	High Riverbed K Drain -10 ft	20	4	0.00028	242	1.1	241	120	1705	1827
D26	250/2.5	10/0.1	30	0.16	High Riverbed K	20	4	0.00028	479	2.1	477	306	1488	1661
D27	250/2.5	10/0.1	30	1.6	High Riverbed K	20	4	0.00028	483	2.1	481	239	1601	1846

Notes
K = Hydraulic Conductivity
Kv = Vertical Hydraulic Conductivity
GHB = General Head Boundary
gpm = gallons per minute
N/A = Not Applicable

Table 1
Transient Model Summary

ID	Description	Low K Thickness (ft)	Specific Yield	River Stage (ft)	Extraction Rate per Well (gpm)	Total Extraction Rate (gpm)
DT1	Construction	30	0.1	20	142.9	1000
DT2	Construction	10	0.1	20	142.9	1000
DT3	Construction	30	0.2	20	142.9	1000
DT4	Construction	10	0.2	20	142.9	1000
DT5	Construction	30	0.1	20	285.7	2000
DT6	Construction	10	0.1	20	285.7	2000
DT7	Construction	30	0.2	20	285.7	2000
DT8	Construction	10	0.2	20	285.7	2000
DTop1	Maintenance	30	0.1	10	142.9	1000
DTop2	Maintenance	10	0.1	10	142.9	1000
DTop3	Maintenance	30	0.2	10	142.9	1000
DTop4	Maintenance	10	0.2	10	142.9	1000
DTop5	Maintenance	30	0.1	10	285.7	2000
DTop6	Maintenance	10	0.1	10	285.7	2000
DTop7	Maintenance	30	0.2	10	285.7	2000
DTop8	Maintenance	10	0.2	10	285.7	2000

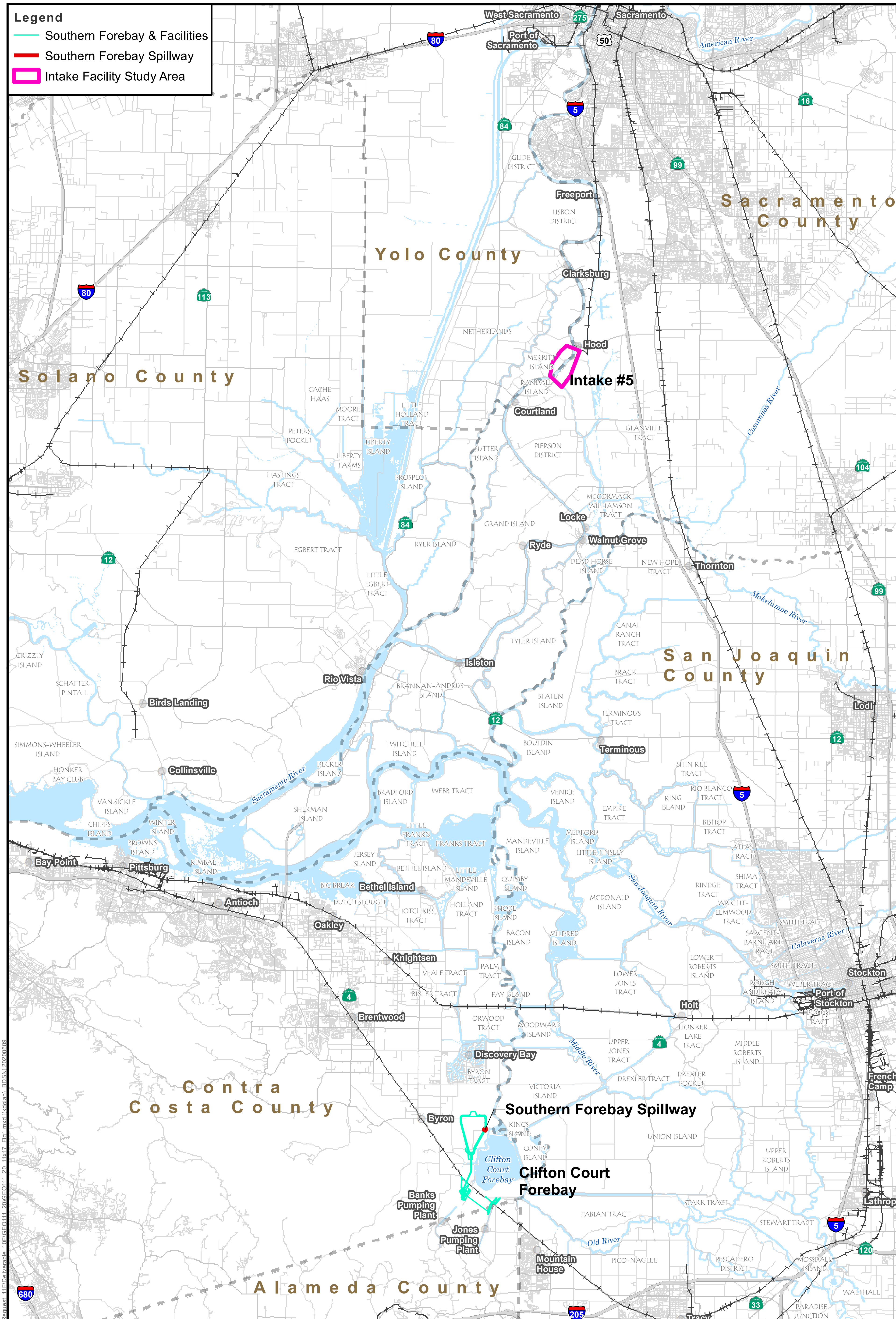
Notes
K = Hydraulic Conductivity
gpm = gallons per minute
Number of pumping wells = 7

Table 3
Box Conduit Transient Model Summary

ID	Low K Thickness (ft)	Specific Yield	Time-Weighted Extraction Rate, Days 1-10 (gpm)	Time-Weighted Extraction Rate, Days 11-30 (gpm)	Days to Target Elevation
BC1	0	0.1	62	57	18
BC2	5	0.1	18	11	14
BC3	10	0.1	14	6.8	13
BC4	0	0.2	64	59	27
BC5	5	0.2	21	13	26
BC6	10	0.2	18	8.6	23

Notes
K = Hydraulic Conductivity
gpm = gallons per minute

Figures



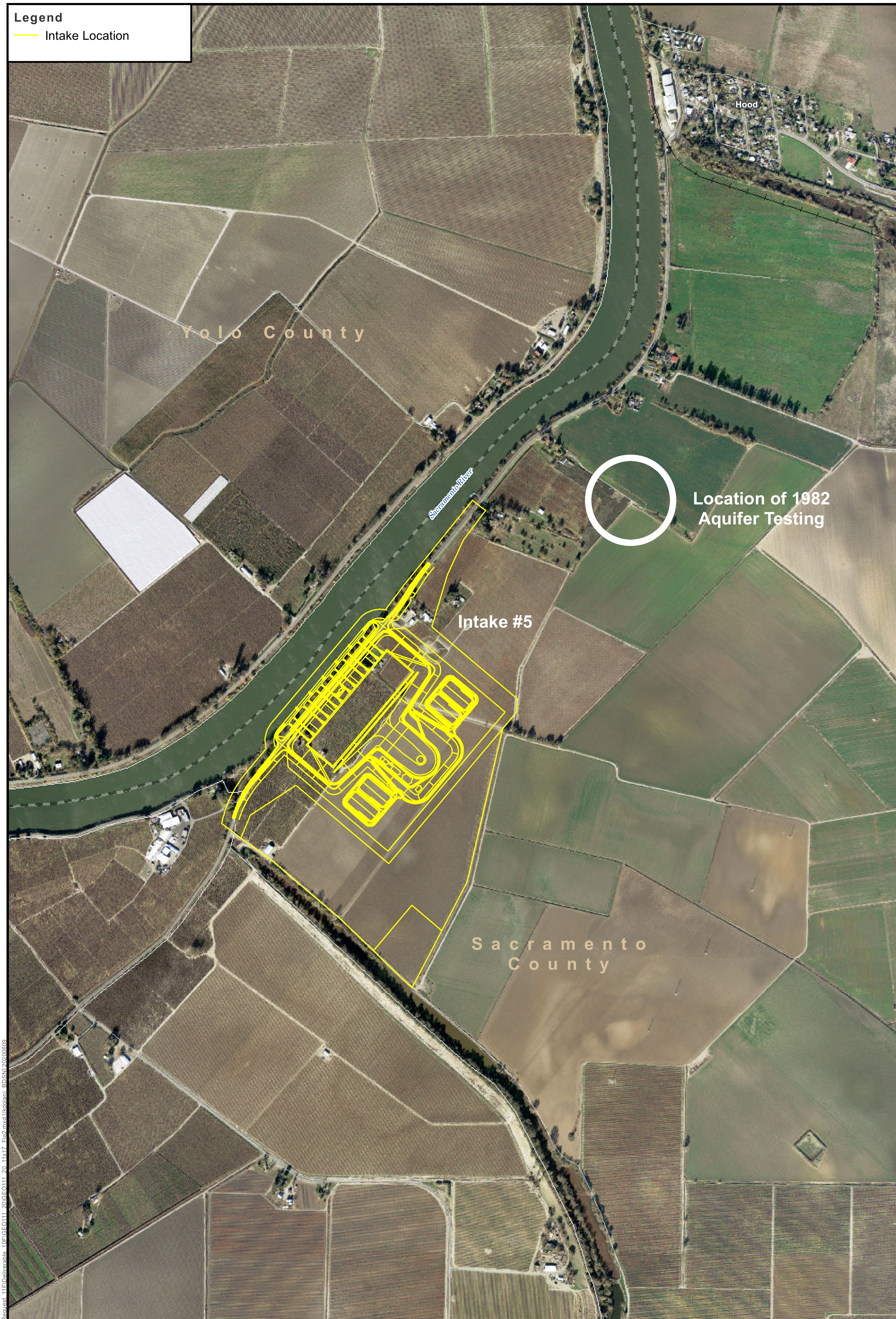
N

0 2 4 Miles

For Illustration Purposes Only

Figure 1
Site Location

Data Source: DCA, DWR



DCA DELTA CONVEYANCE DESIGN & CONSTRUCTION AUTHORITY

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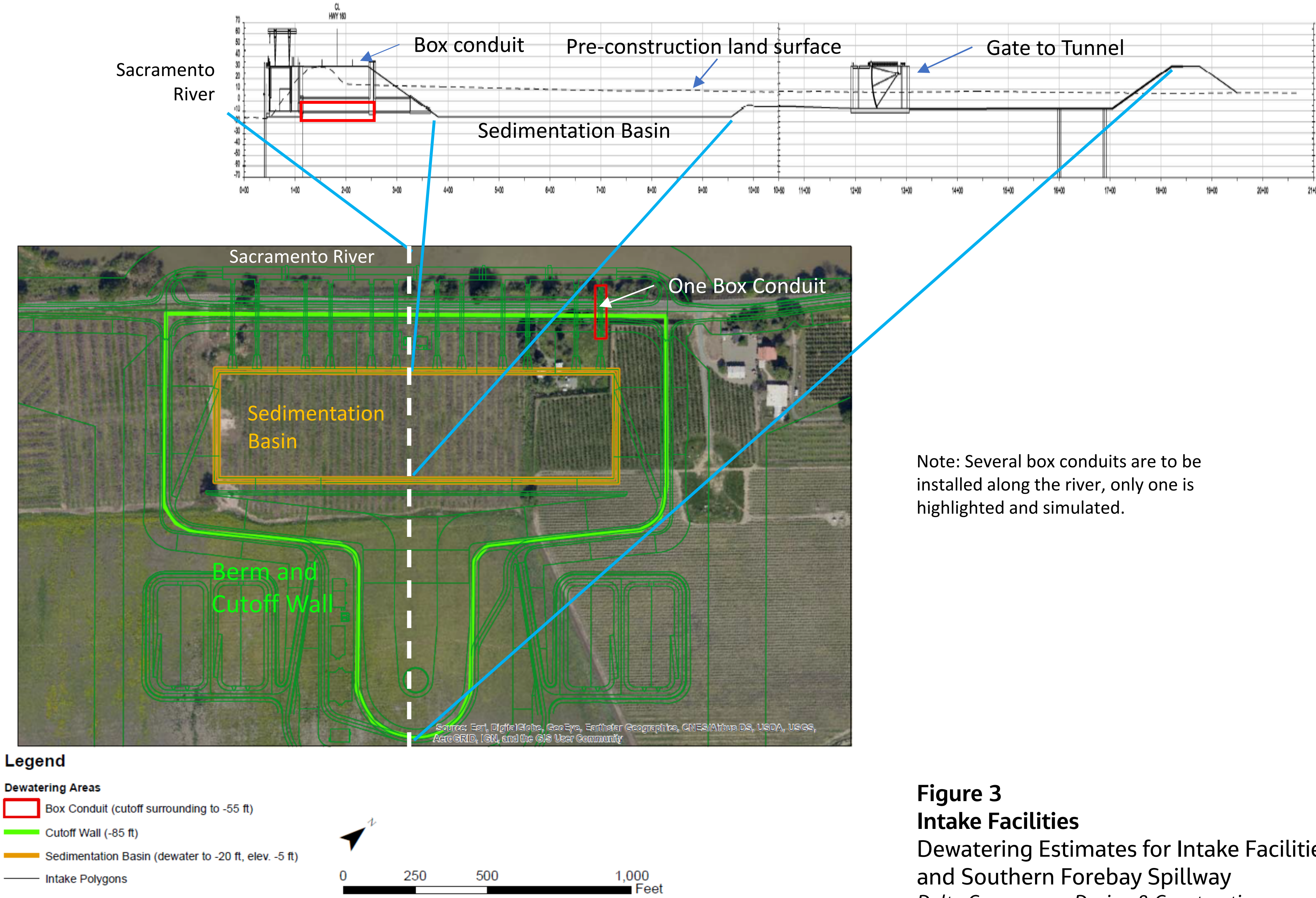
N

0 500 1,000 Feet

Figure 2
Intake Facility Study Area

Data Source: DCA, DWR



Note: Several box conduits are to be installed along the river, only one is highlighted and simulated.

Figure 3
Intake Facilities
Dewatering Estimates for Intake Facilities and Southern Forebay Spillway
Delta Conveyance Design & Construction Authority

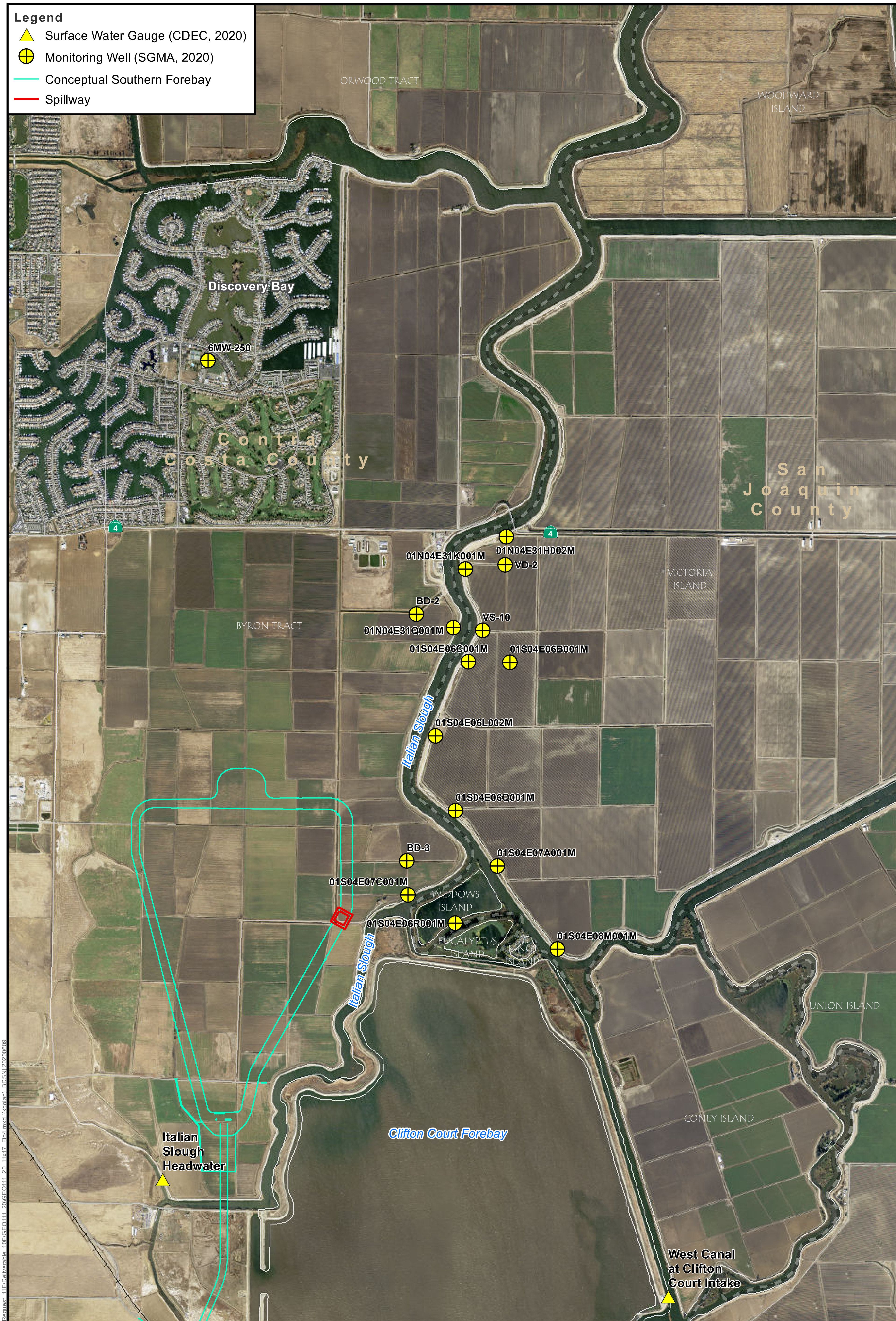


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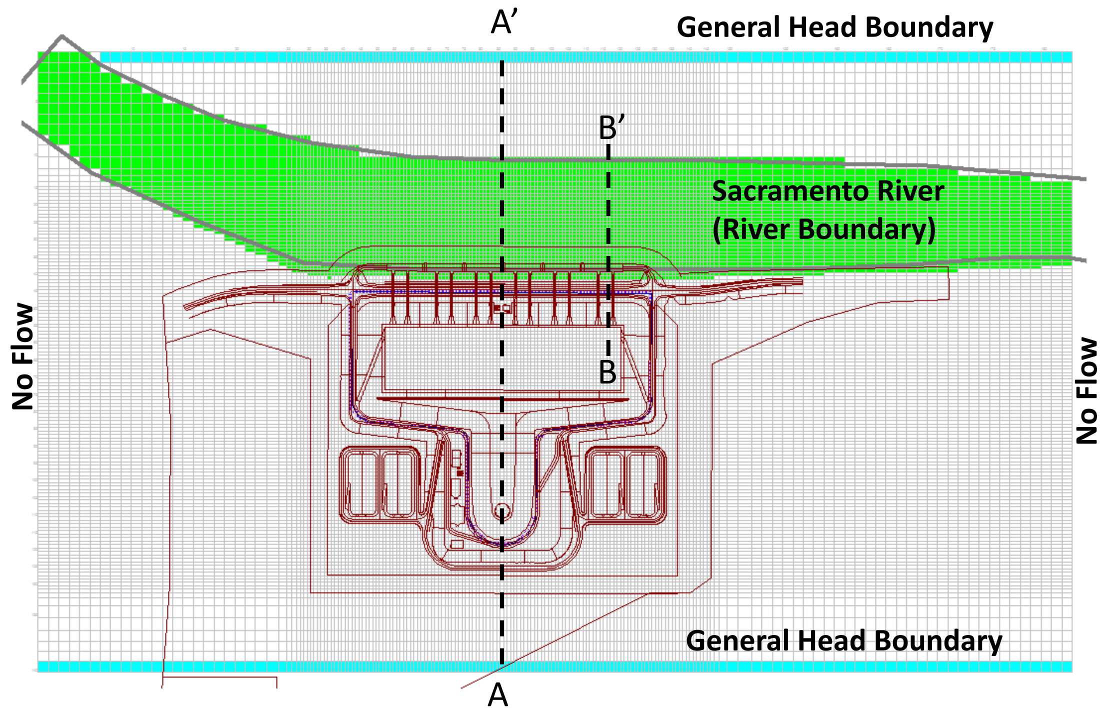
Figure 4
Southern Forebay Spillway Location

Data Source: DCA, DWR, California Data Exchange Center (CDEC), 2020. Historical Data Selector. http://cdec.water.ca.gov/selectQuery.html Accessed 5/9/2020, Sustainable Groundwater Management Act (SGMA) Data Viewer. https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#gwlevels. Accessed 5/10/2020. Factsheet provides additional detail on data sources.



Notes:

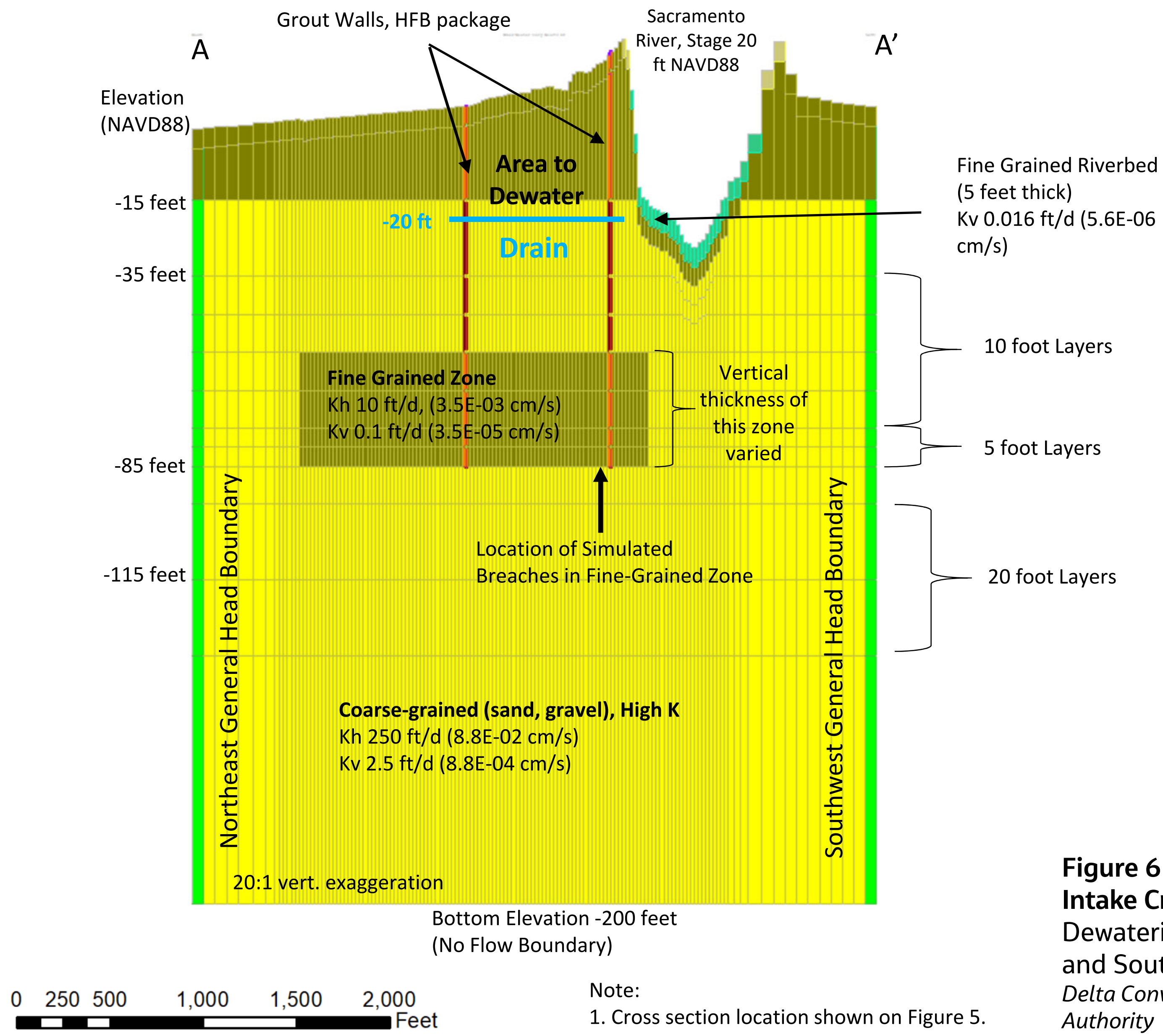
1. Location is Intake #5
2. 20 x 20 feet minimum cell size
3. 50 degree grid rotation
4. A-A’ cross section shown on Figure 6.
5. B-B’ cross section shown on Figure 7.

Figure 5

Model Grid, Intake Facilities

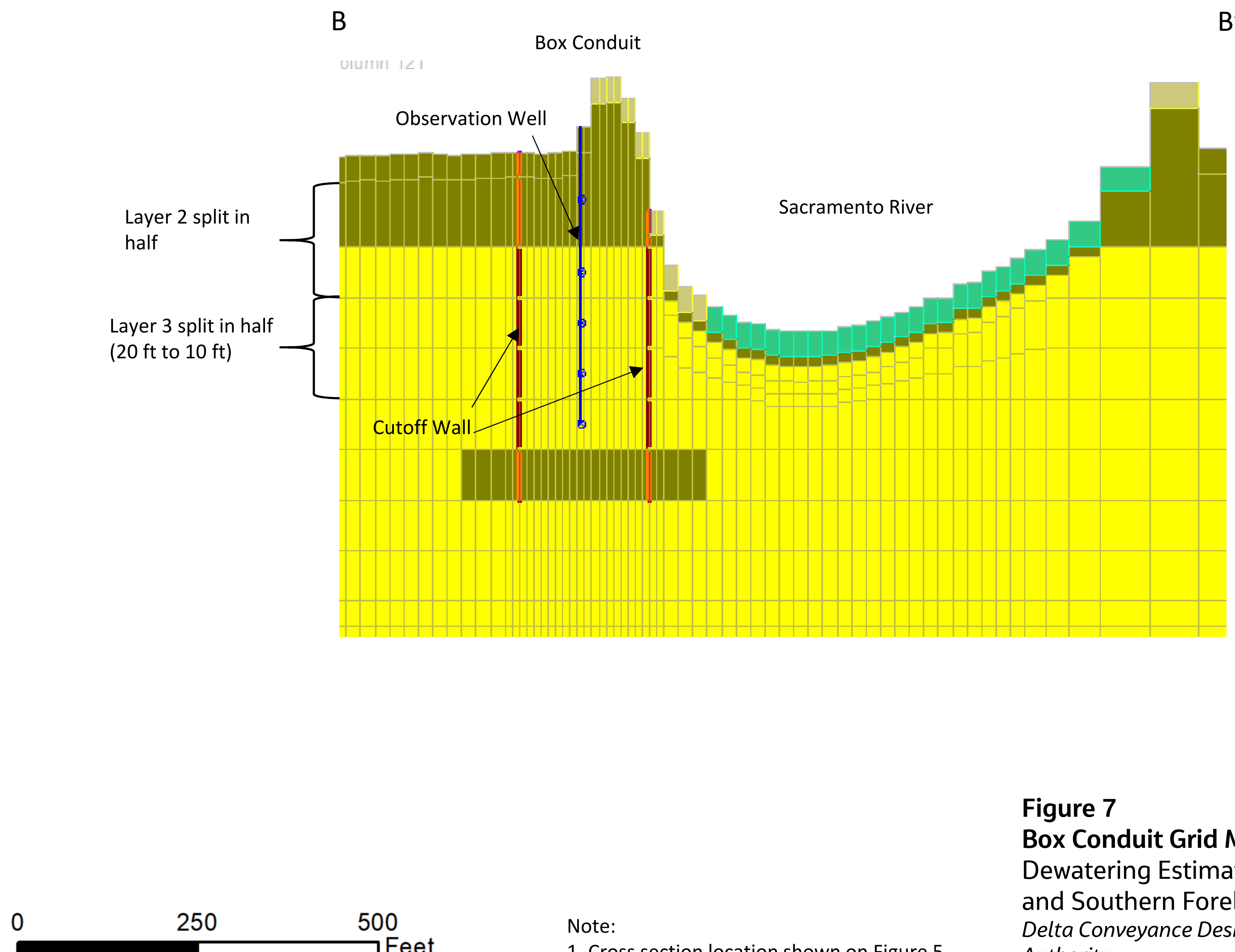
Dewatering Estimates for Intake Facilities and Southern Forebay Spillway

Delta Conveyance Design & Construction Authority



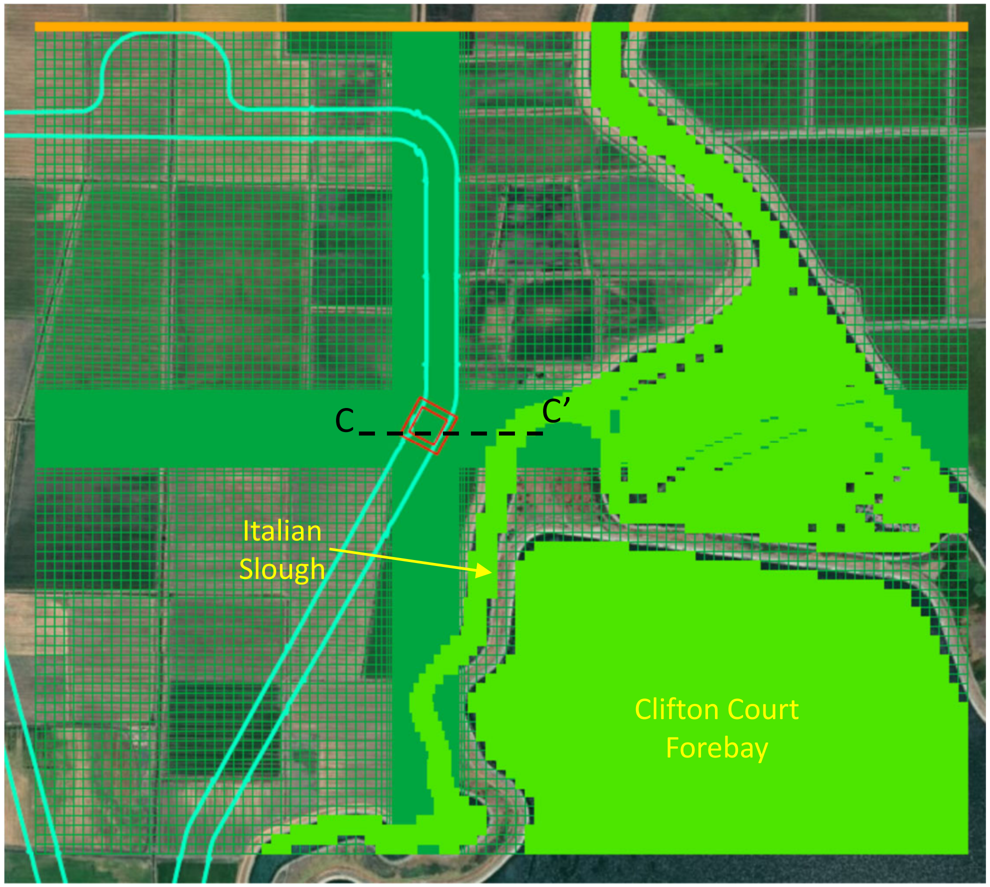
Note:
1. Cross section location shown on Figure 5.

Figure 6
Intake Cross Section
Dewatering Estimates for Intake Facilities and Southern Forebay Spillway
Delta Conveyance Design & Construction Authority



Note:
1. Cross section location shown on Figure 5.

Figure 7
Box Conduit Grid Modifications
Dewatering Estimates for Intake Facilities and Southern Forebay Spillway
Delta Conveyance Design & Construction Authority

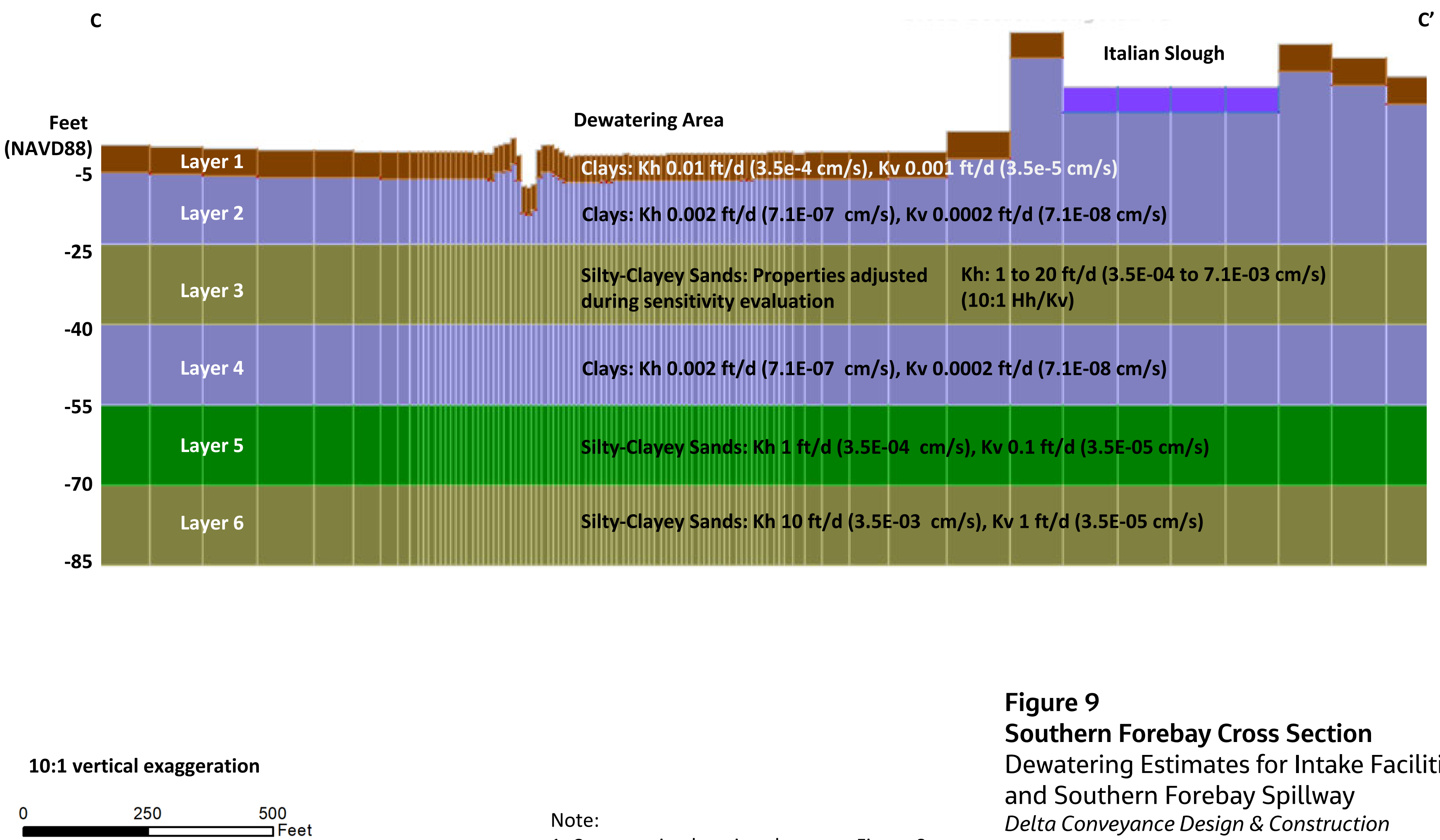


Legend

- Conceptual Southern Forebay
- Spillway Foundation
- Model Grid
- River Boundary
- General Head Boundary

Note.
1. C-C'' cross section shown on Figure 9.

Figure 8
Southern Forebay Model Grid
Dewatering Estimates for Intake Facilities and Southern Forebay Spillway
Delta Conveyance Design & Construction Authority



Note:
1. Cross section location shown on Figure 8.

Figure 9
Southern Forebay Cross Section
Dewatering Estimates for Intake Facilities and Southern Forebay Spillway
Delta Conveyance Design & Construction Authority

Well Locations

- Observation wells at center of basin to evaluate results, Layers 2-5
- 7 Pumping wells, screened in Layers 2-5

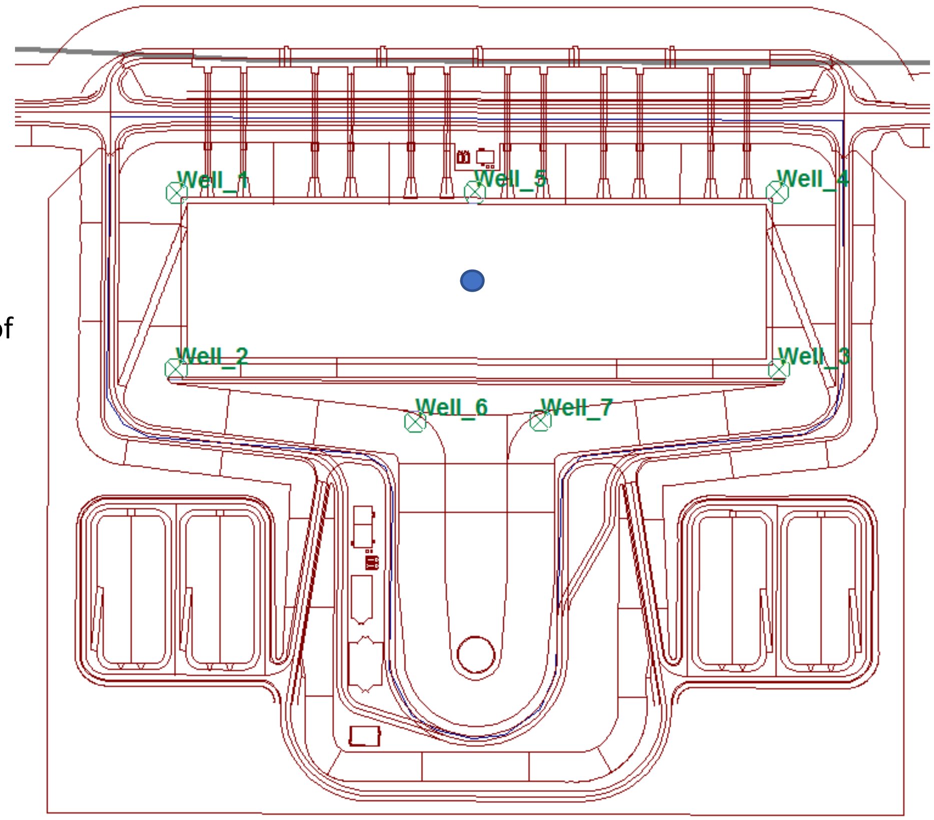
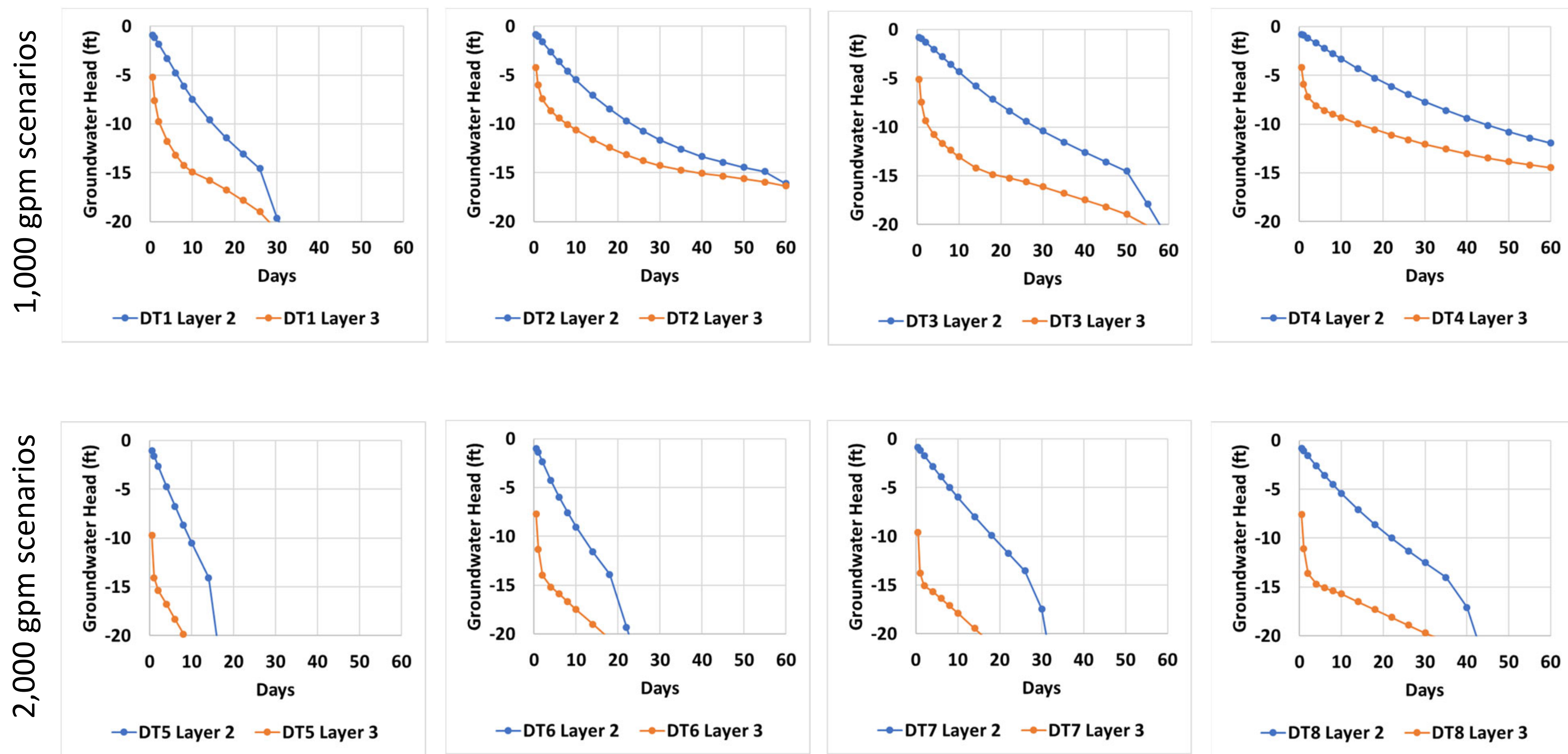


Figure 10
Intake Modeling Well Locations
Dewatering Estimates for Intake Facilities and Southern Forebay Spillway
Delta Conveyance Design & Construction Authority

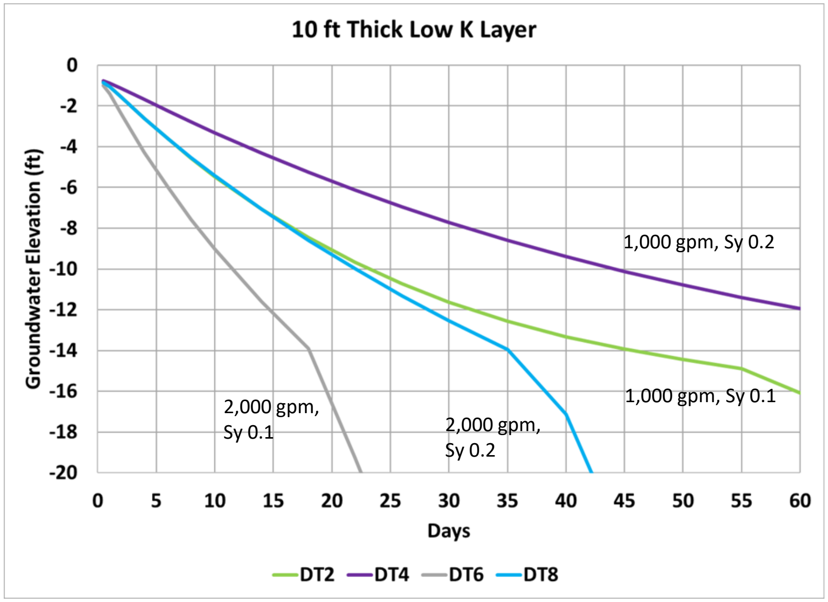


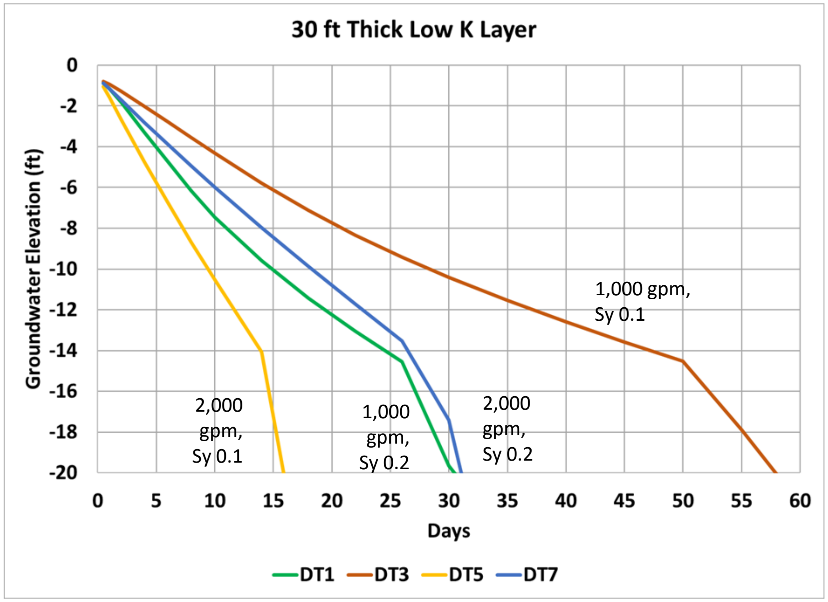
Model Key

ID	Low K Thickness (ft)	Sy	Total Rate (gpm)
DT1	30	0.1	1000
DT2	10	0.1	1000
DT3	30	0.2	1000
DT4	10	0.2	1000
DT5	30	0.1	2000
DT6	10	0.1	2000
DT7	30	0.2	2000
DT8	10	0.2	2000

Note: These results illustrate potential nuances during dewatering, as the upper fine-grained layer is slower to dewater.

Figure 11
Construction Phase Transient Results, Layer Comparison
Dewatering Estimates for Intake Facilities and Southern Forebay Spillway
Delta Conveyance Design & Construction Authority

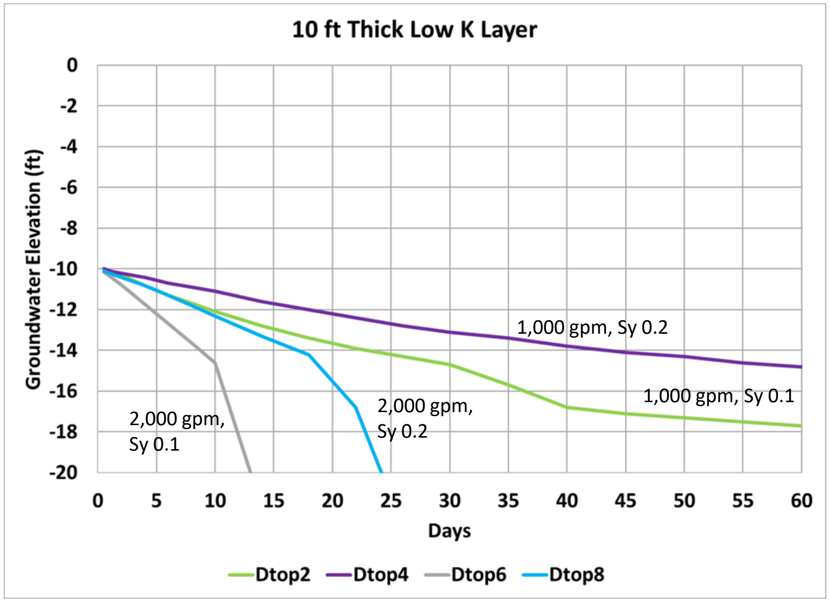


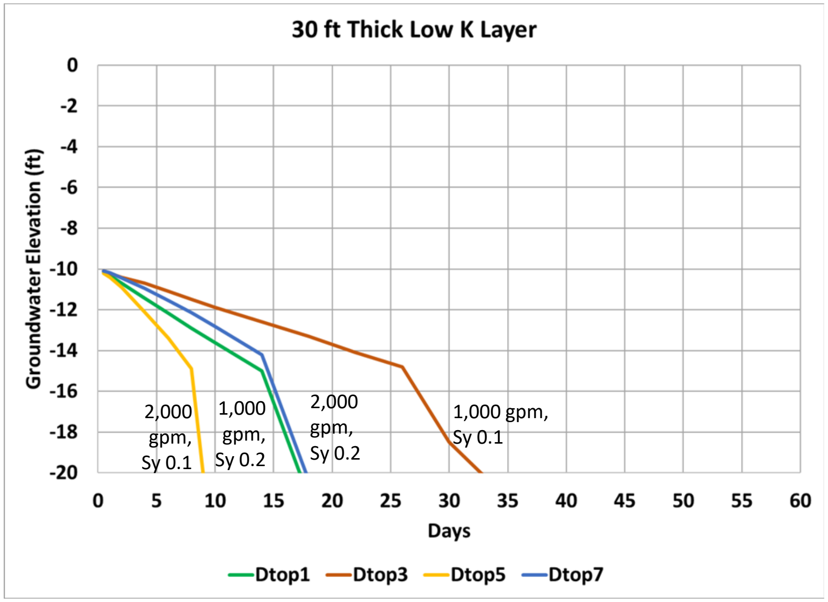


Model Key

ID	Low K Thickness (ft)	Sy	Total Rate (gpm)
DT1	30	0.1	1000
DT2	10	0.1	1000
DT3	30	0.2	1000
DT4	10	0.2	1000
DT5	30	0.1	2000
DT6	10	0.1	2000
DT7	30	0.2	2000
DT8	10	0.2	2000

Figure 12
Transient Results, Construction Phase, Model Layer 2
Dewatering Estimates for Intake Facilities and Southern Forebay Spillway
Delta Conveyance Design & Construction Authority

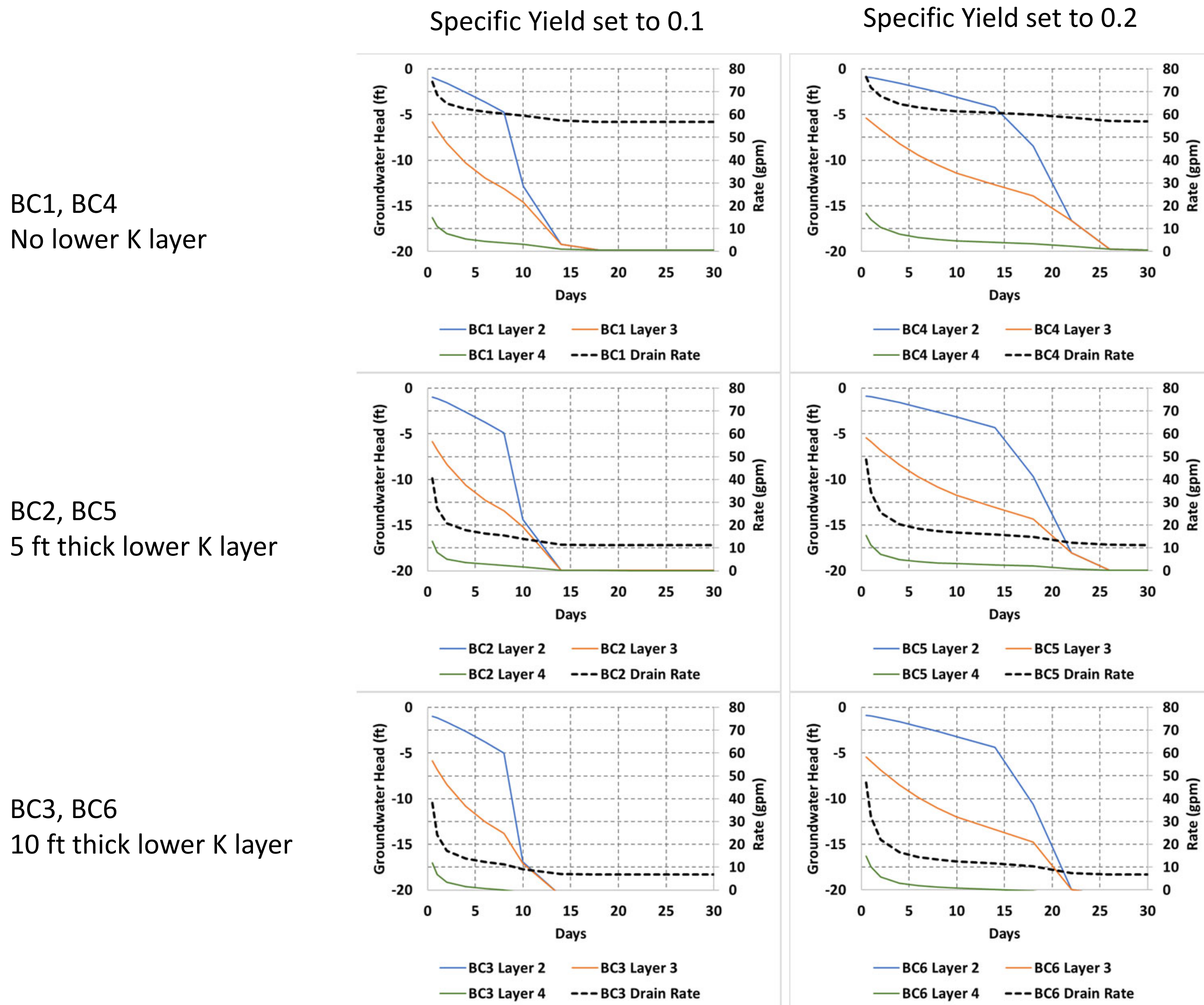




Model Key

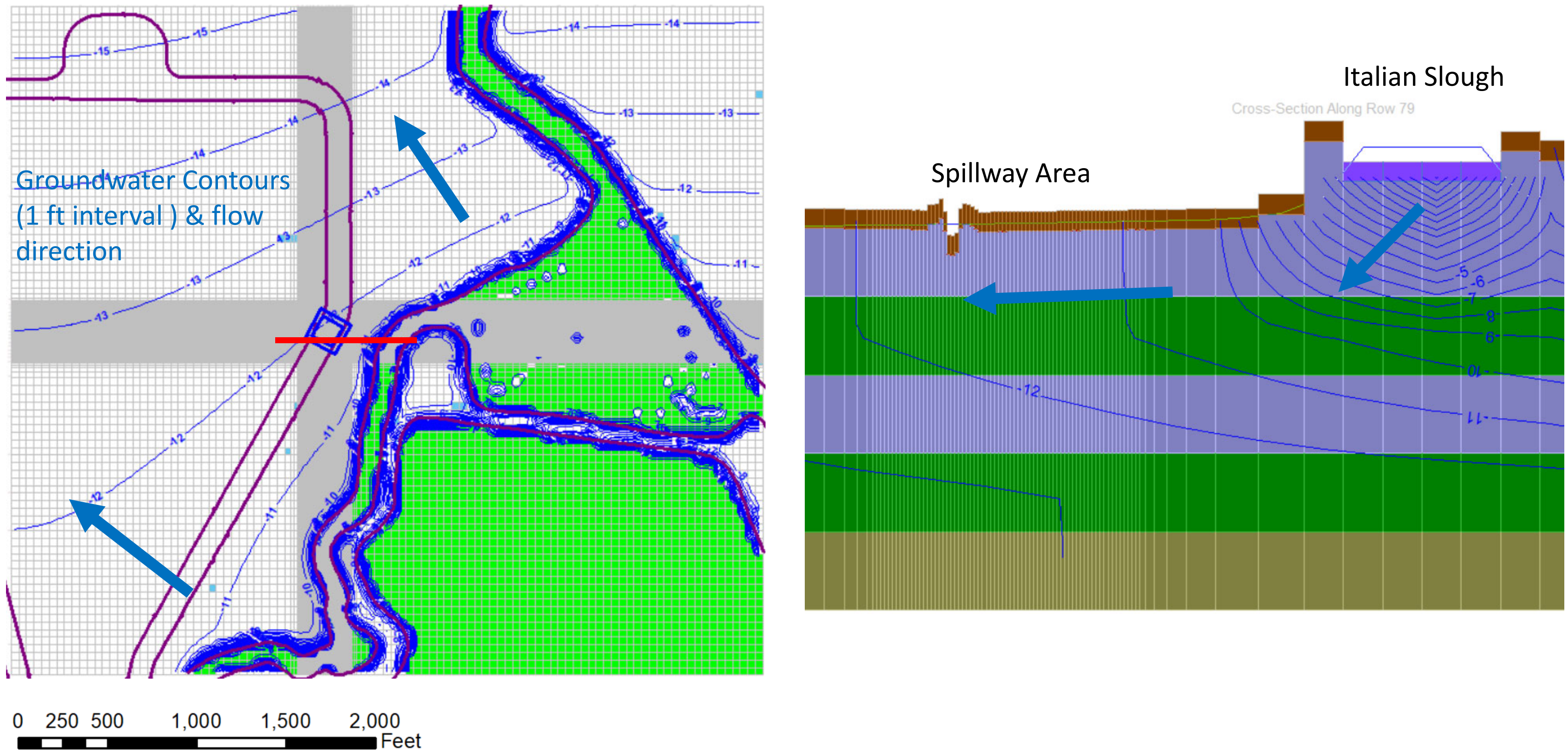
ID	Low K Thickness (ft)	Sy	Total Rate (gpm)
DTop1	30	0.1	1000
DTop2	10	0.1	1000
DTop3	30	0.2	1000
DTop4	10	0.2	1000
DTop5	30	0.1	2000
DTop6	10	0.1	2000
DTop7	30	0.2	2000
DTop8	10	0.2	2000

Figure 13
Transient Results, Maintenance Phase, Model Layer 2
Dewatering Estimates for Intake Facilities and Southern Forebay Spillway
Delta Conveyance Design & Construction Authority



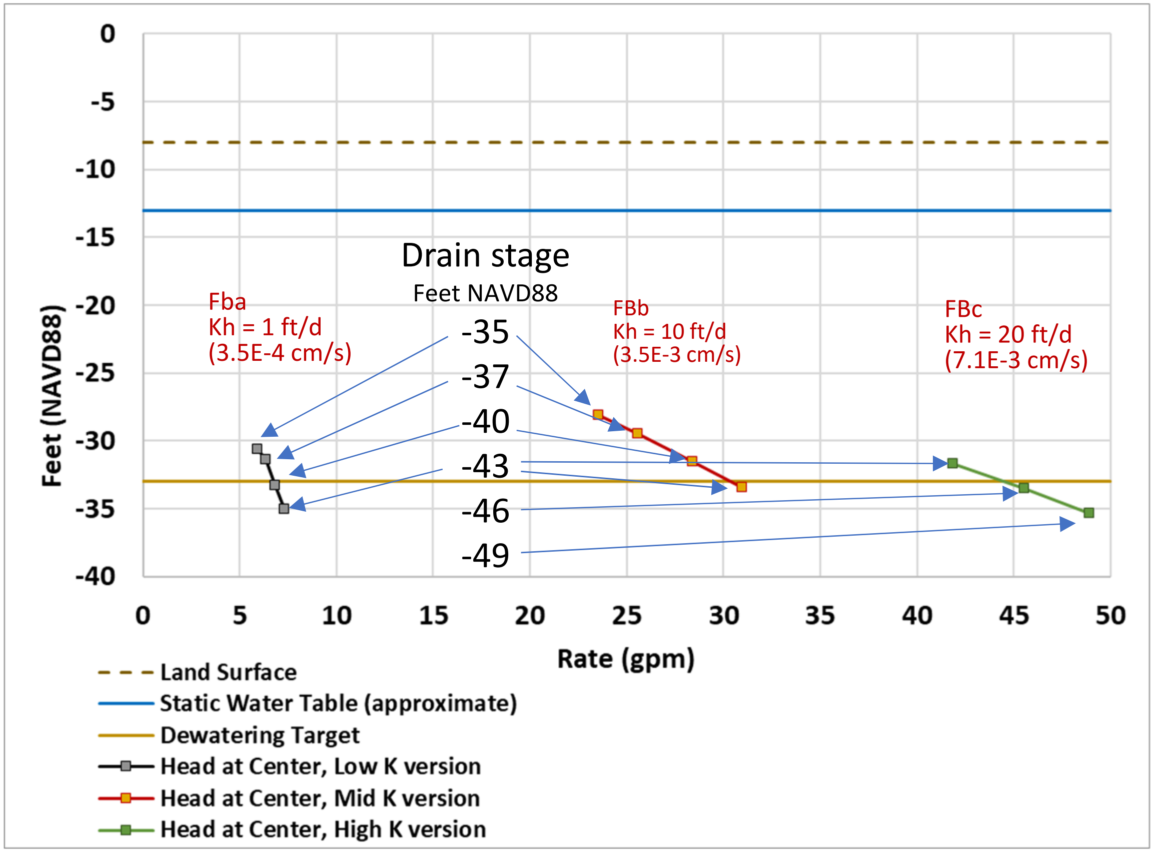
Note:
Results are shown for 3 different hydraulic conductivity distributions, with two variations of specific yield for each.

Figure 14
Box Conduit Modeling Results
Dewatering Estimates for Intake Facilities and Southern Forebay Spillway
Delta Conveyance Design & Construction Authority



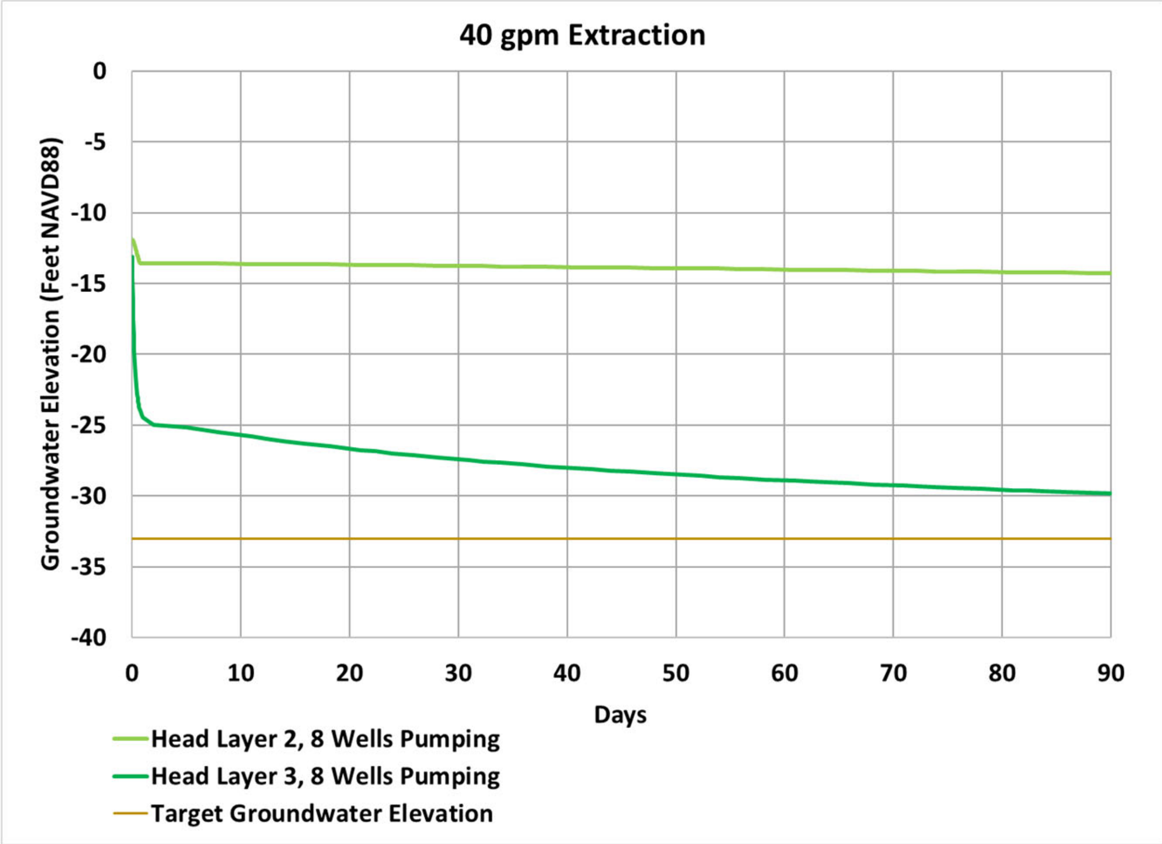
Notes:
Red line shows location of cross section.

Figure 15
Southern Forebay Simulated Groundwater Elevations, Steady State
Dewatering Estimates for Intake Facilities and Southern Forebay Spillway
Delta Conveyance Design & Construction Authority



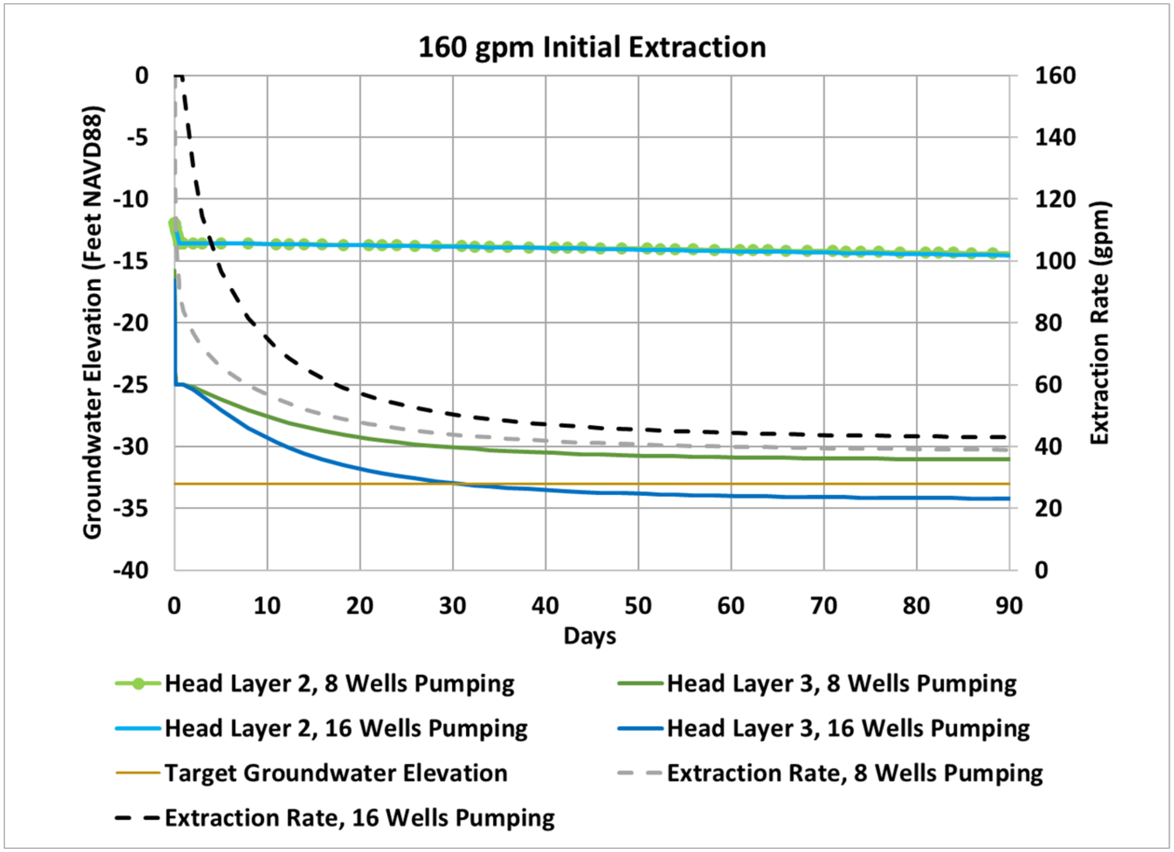
Notes:
1. The drain stage is specified for each model scenario, and the resulting drain discharge and steady state head is computed by the model.
2. Kh = Horizontal Hydraulic Conductivity

Figure 16
Southern Forebay Steady State Results
Dewatering Estimates for Intake Facilities and Southern Forebay Spillway
Delta Conveyance Design & Construction Authority



Note:
The pumping rate for the 40 gpm extraction scenario did not vary.

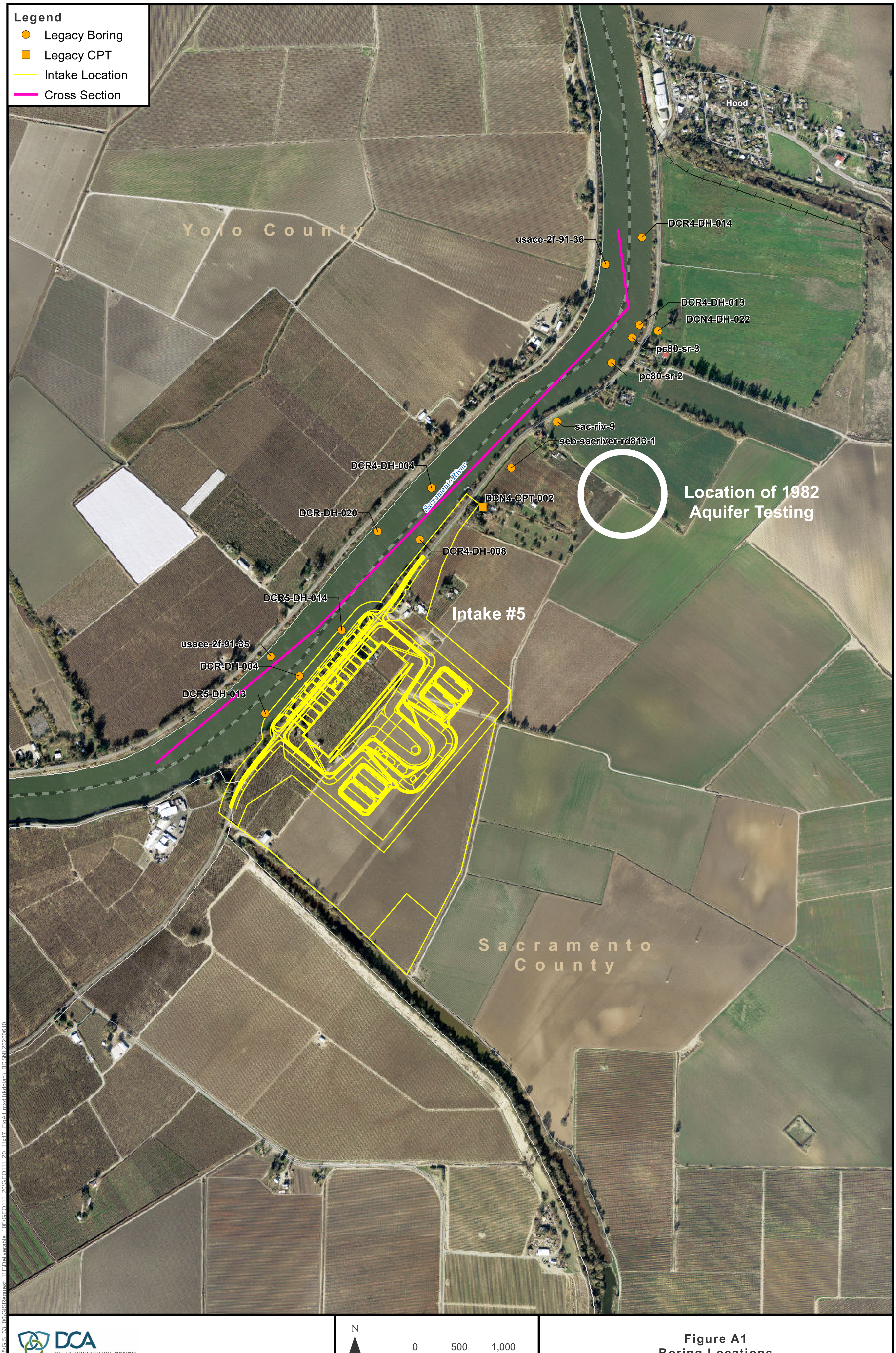
Figure 17
Southern Forebay Transient Results
Dewatering Estimates for Intake Facilities and Southern Forebay Spillway
Delta Conveyance Design & Construction Authority



Note:
The pumping rate decreases over time due to increasingly limited transmissivity at the wells.

Figure 18
Southern Forebay Transient Results
Dewatering Estimates for Intake Facilities and Southern Forebay Spillway
Delta Conveyance Design & Construction Authority

Attachment 1
Subsurface Cross Sections at Intake Facilities and Southern Forebay Spillway



T:\WGI-38\GIS_33_00\GISRequest_11F\Deliverable_10F\GEO111_20\GEO111_20_11x17_FigA1.mxd [(kdolan) BDSN] 20200610

DCA DELTA CONVEYANCE DESIGN & CONSTRUCTION AUTHORITY

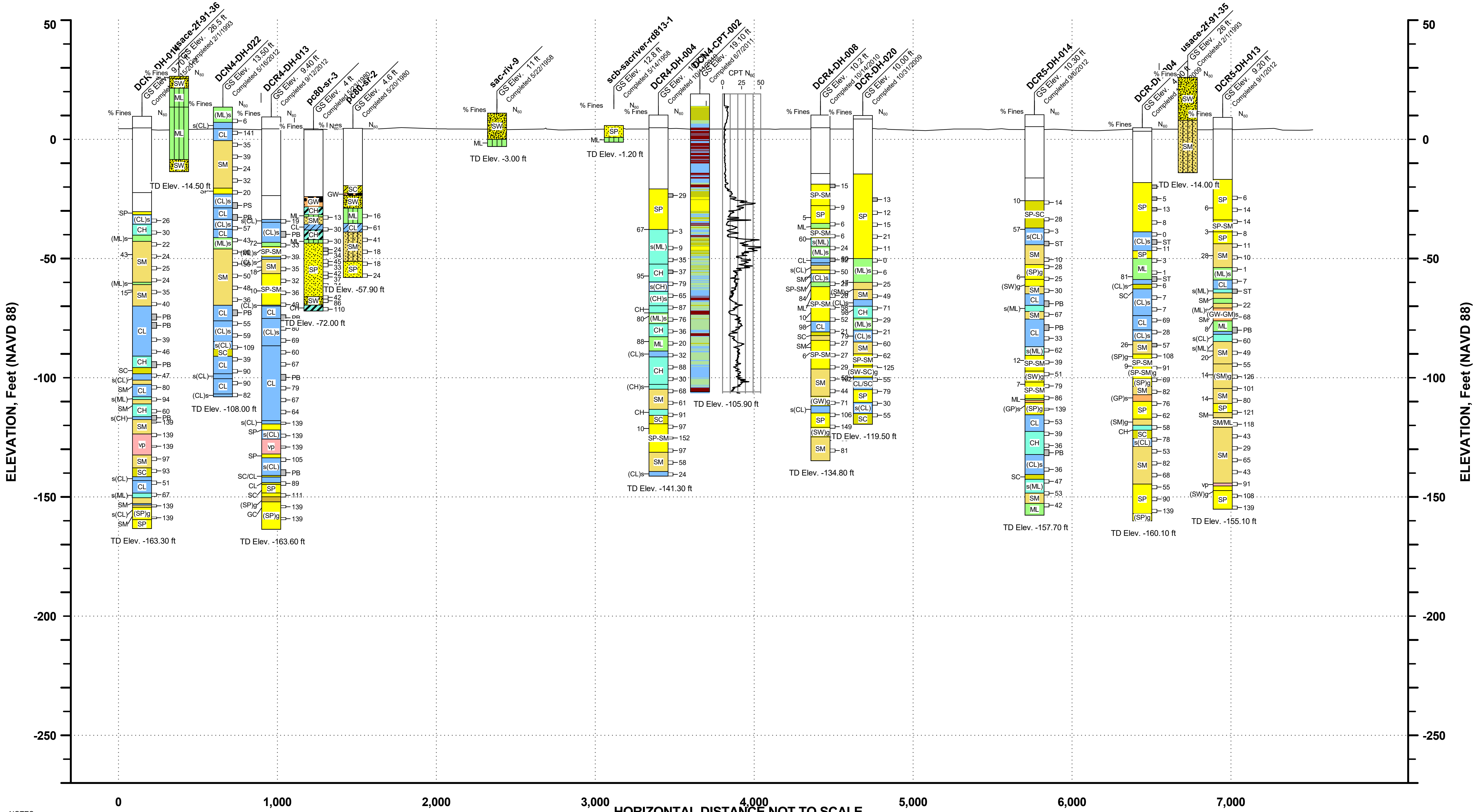
For Illustration Purposes Only

N

0 500 1,000 Feet

Figure A1
Boring Locations

Data Source: DCA, DWR



NOTES:

1. CORRELATION OF LITHOLOGIES BETWEEN WIDELY SPACED BORINGS IS NOT RECOMMENDED
2. GS Elev FOR OVERWATER BORINGS IS THE ELEVATION OF THE DRILL DECK

DCDCA-Geotechnical
DWR-Internal Only
WORKING DRAFT - Subject to Change

0 20 40 60 80 100 Vertical Scale 40.00 ft/in.

Delta Conveyance Design & Construction Authority
California Department of Water Resources

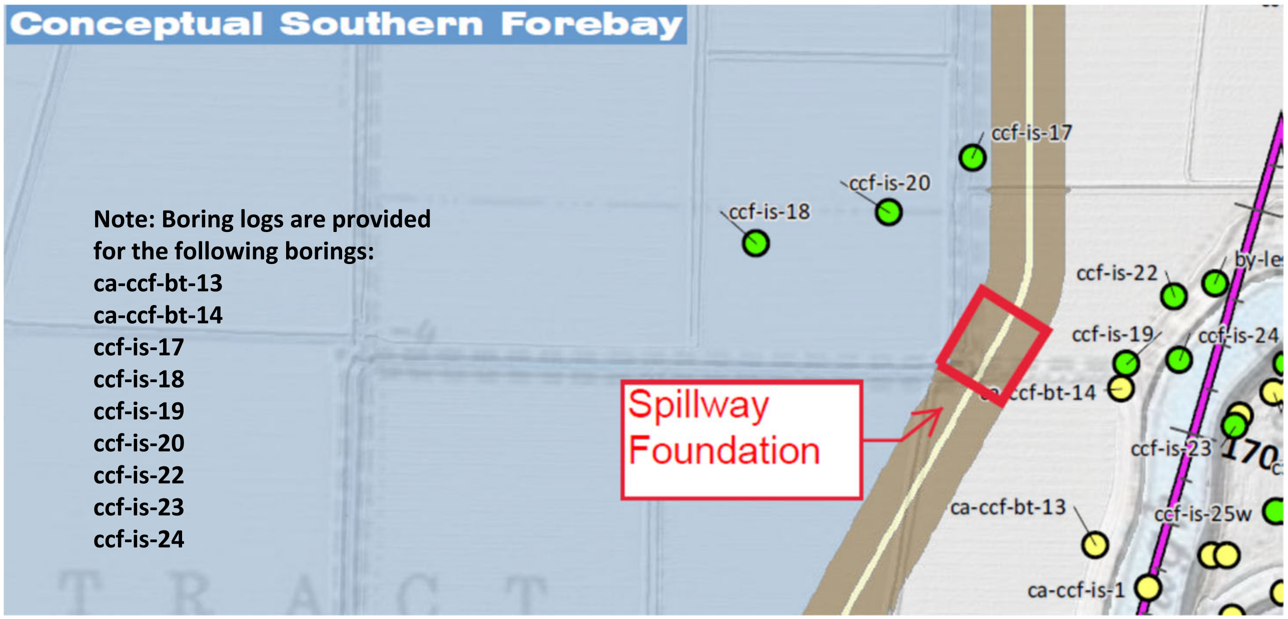
THINK SAFETY - ACT SAFELY

WORKING PROFILE

GRAPHIC BORING AND CPT LOGS

Figure A2

Attachment 2
Relevant Boring Logs



N

0 500 1,000 2,000
Feet

Projection: CA State Plane III NAD83 (ft)
Background: USGS 7.5' Topo/DWR CVFED LiDAR 2006

Figure B1
Boring Locations, Southern Forebay
Dewatering Estimates for Intake Facilities and Southern Forebay Spillway
Delta Conveyance Design & Construction Authority

DCA

STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF DESIGN AND CONSTRUCTION
PROJECT GEOLOGY BRANCH

DRILLING AND SAMPLING LOG

CALIFORNIA AQUEDUCT
NORTH SAN JOAQUIN DIVISION

HOLE NO. BT-13

ELEV. -8.1

FEATURE Clifton Court Forebay | DEPTH 41.0'

LOCATION California Coordinates, Zone V N. 496,247 E. 1,687,233 | COUNTY Contra Costa

LOGGED BY Mack Oropeza | DATE DRILLED 10/27-28/1966 | WATER LEVEL 10-27-66 5.5'

DRILLING CO. C. Corder | DRILLER John Ives | DRILL RIG Failing 1500

Hole #1 - Pushed 3" I.D. Shelby tube to 8.5'; remainder with Pitcher core barrel.
Hole #2 - Pushed or drove DWR 2-1/2" I.D. sampler
Drilled with 4-5/8" drag bit.
1/ - Sample number and field density (PCF)

ELEV. (DEPTH)	CLASS.	DESCRIPTION Field Identification	SAMPLE 1/ NUMBER	MODE #2	MODE #1	REMARKS
-8.1 (0.0)	OH	0.0-2.2 ORGANIC CLAY: Very slow to no dilatancy; low to medium plasticity; slight to medium toughness; dusky yellowish-brown.		RD		Hole #1 Augered 0.0-1.0' Hole #2
		1.6-2.0' Layer of clay-silt.			P	Pushed 2.5-3.5' Maximum pressure 140#
	CL-ML					
	OH	2.2-4.3 PEAT: Moist; finely shredded organic material with inclusion of larger pieces of plant remains; olive-black to dark reddish-brown.			2.0 / 2.5	Could not measure depth of hole after push due to cave in.
	PT		L-1 188.2#	P		Pushed 5.0-7.0' Maximum pressure 180#
-12.1 (4.0)	CL	4.3-5.0 CLAY: Moist; very slow dilatancy; medium plasticity; medium gray.		RD	P	
	ML	5.0-7.1 SANDY SILT: Moist to wet; quick dilatancy; no plasticity; slightly loose; medium dark gray; fine-grained sand varies from 20-35%.			2.3 / 2.5	
			L-2B 112.0#			
			L-2C 113.7#	P		Pushed 7.0-9.0' Maximum pressure 200#
			L-2D 118.1#		P	
		7.1-9.4 SILT: Moist; moderately quick to slow dilatancy; slight plasticity; moderately soft; medium dark gray.			2.1 / 2.5	
			L-3B 110.4#			
-16.1 (8.0)	ML	Some plastic fines present from 8.5'.	L-3C 112.1#	P		
			L-3D 116.9#			
	CL	9.4-19.0 SANDY CLAY: Moist; no dilatancy; medium plasticity; stiff; dark greenish-gray; fine-grained sand occurs in amount of 15-25%.		RD	RD 2.1 / 2.5	
		Amount of fine-grained sand increases to about 35-40% from 11.0'.				
-20.1 (12.0)					RD 2.1 / 2.5	

SHEET 1 OF 3

DRILLING AND SAMPLING LOG

FEATURE Clifton Court Forebay HOLE NO. BT-13

ELEV. (DEPTH)	CLASS.	DESCRIPTION Field Identification	SAMPLE NUMBER	MODE #2	MODE #1	REMARKS
-38.1 (30.0)	ML	29.8-35.3 SANDY SILT: Contd.	L-7B 127.6# L-7C 127.2# L-7D 126.5#	P RD	RD RD 1.8/2.5	Pushed 30.0-32.0' Maximum pressure 360#
-42.1 (34.0)					RD 2.3/2.5	
	SM	35.3-40.6 SILTY SAND: Wet to saturated; poorly graded; fine- to medium-grained sand; subangular; loose to slightly compact; moderate yellowish-brown; plastic fines vary from 15-35%.	L-8B 123.1# L-8C 123.1# L-8D 121.9#	RD P	RD 2.0/2.5	Pushed 37.0-39.0' Maximum pressure 400#
-46.1 (38.0)					RD 2.2/2.5	
-49.1 (41.0)	CL	40.6-41.0 SANDY CLAY:				Bottomed Hole #1 at 41.0' Bottomed Hole #2 at 39.0' Backfilled both holes and marked site by lath.

DWR 885 (2)

STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF DESIGN AND CONSTRUCTION
PROJECT GEOLOGY BRANCH

DRILLING AND SAMPLING LOG

CALIFORNIA AQUEDUCT

NORTH SAN JOAQUIN DIVISION

HOLE NO. BT-14

ELEV. -7.2

FEATURE Clifton Court Forebay

DEPTH 41.0'

LOCATION California Coordinates, Zone V N. 496,915 E. 1,687,342

COUNTY Contra Costa

LOGGED BY Mack Oropeza

DATE DRILLED 10-31-66

WATER LEVEL 3.0' (10-31-66)

DRILLING CO. C. Corder

DRILLER John Ives

DRILL RIG Failing 1500

Hole #1 - Pushed 3" I.D. Shelby tube to 8.5'; cored remainder with Pitcher core barrel.
Hole #2 - Pushed or drove 2-1/2" DWR I.D. sampler
Drilled with 4-5/8" drag bit

1/ - Sample number and field density (PCF)

ELEV. (DEPTH)	CLASS.	DESCRIPTION Field Identification	SAMPLE 1/ NUMBER	MODE #2	MODE #1	REMARKS
-7.2 (0.0)	OH	0.0-3.0 ORGANIC CLAY: Moist; very slow to no dilatancy; low to medium plasticity; dusky yellowish-brown.		RD		Pushed 1.0-3.0' Maximum pressure 180#
		Amount of organic material increases at 2.0'.	L-1C 84.6#	P	P .6/2.5	
	---?---?---	3.0-6.0 PEAT: Moist; stiff; some plastic fines present; brownish-black.	L-1D 85.6#			
-11.2 (4.0)	PT			RD	P 1.8/2.5	Pushed 5.0-7.0' Maximum pressure 160#
		6.0-6.8' ORGANIC CLAY	L-2B 78.4#	P		
	OH		L-2C 80.6#			
		6.8-9.4 LEAN CLAY: Moist; very slow dilatancy; medium plasticity; soft; dark greenish-gray; high amount of minute mica flakes present.	L-2D 82.9#		P 2.0/2.5	Pushed 7.0-9.0' Maximum pressure 160#
			L-3B 110.6#			
-15.2 (8.0)	CL		L-3C 112.1#	P		
			L-3D 109.1#			
		9.2-9.4' Clayey sand				
	SC	9.4-11.0 LEAN TO FAT CLAY: Moist; no dilatancy; medium to high plasticity; moderately stiff; dark greenish-gray; some fine-grained sand present.			RD 2.2/2.5	
	CL-CH			RD		
		11.0-21.0 SANDY CLAY: Moist; no dilatancy; medium plasticity; stiff; dark greenish-gray; fine-grained sand varies from 15-25%.			RD 1.4/2.5	
-19.2 (12.0)	CL					

SHEET 1 OF 3

DRILLING AND SAMPLING LOG

FEATURE Clifton Court Forebay HOLE NO. BT-14

ELEV. (DEPTH)	CLASS.	DESCRIPTION Field Identification	SAMPLE NUMBER	MODE #2	MODE #1	REMARKS
-19.2 (12.0)	CL	11.0-21.0 SANDY CLAY: Contd.	L-4B 126.9# L-4C 126.1# L-4D 125.9#	P	RD	Pushed 12.0-14.0' Maximum pressure 260#
		Color of sandy clay becomes moderate yellowish-brown at 14.6'.		RD	RD 2.0/2.5	
-23.2 (16.0)		Increase in the amount of fine-grained sand occurs at 16.0' to 35-40%.			RD 1.4/2.5	
	SM	19.2-19.7' Silty sand; moist; poorly graded fine-grained sand; moderate brown.	L-5B 123.2#	P	RD 1.7/2.5	Pushed 19.0-21.0' Maximum pressure 200#
-27.2 (20.0)	CL		L-5C 121.7# L-5D 124.0#			
	CL-CH	21.0-24.5 LEAN TO FAT CLAY: Moist; no dilatancy; medium to high plasticity; moderately stiff; moderate yellowish-brown.		RD	RD	
			L-6C 127.2# L-6D 124.2#	P	1.6/2.5	Pushed 22.0-24.0' Maximum pressure 260#
-31.2 (24.0)	ML	24.1-24.5' Silt.				
	CL-CH	24.5-28.8' SANDY CLAY: Moist; very slow dilatancy; low to medium plasticity; moderately stiff; moderate yellowish-brown.		RD	RD 1.5/2.5	
	CL	26.0-26.4' Lean clay.				Pushed 26.0-28.0' Maximum pressure 240#
	ML	26.4-26.9' Silt.				
	CL	27.9-28.2' Fat clay.	L-7C 130.4# L-7D 127.7#	P	RD 2.2/2.5	
-35.2 (28.0)	CH					
	CL					
	ML	28.8-33.6 CLAYEY SILT: Moist; slow to very slow dilatancy; slight to low plasticity; moderately stiff; moderate yellowish-brown.		RD	RD 2.1/2.5	

DRILLING AND SAMPLING LOG

FEATURE Clifton Court Forebay HOLE NO. BT-14

ELEV. (DEPTH)	CLASS.	DESCRIPTION	SAMPLE NUMBER	MODE #2	MODE #1	REMARKS
-32.2 (30.0)	ML	28.8-33.6' CLAYEY SILT: Contd.	L-8B 124.4#	P	HD	Pushed 30.0-32.0' Maximum pressure 240#
		21.0-31.8' Lean to fat clay.	L-8C 118.7#			
	CL-CH		L-8D 126.6#			
	ML				RD	
		33.4-33.6' Silty sand.			2.0/2.5	
	SM	33.6-36.8' SANDY CLAY: Moist; very slow dilatancy; low to medium plasticity; moderately soft; light olive-gray.				
-41.2 (34.0)	CL			RD	RD	
					2.0/2.5	
		36.5-36.8' Clayey sand.				
	SC	36.8-39.3 CLAYEY SILT: Slow to very slow dilatancy; slight plasticity; stiff; moderate yellowish-brown.			HD	Pushed 37.0-39.0' Maximum pressure 440#
			L-9B 129.7#		1.5/2.5	
-45.2 (38.0)	ML		L-9C 131.9#	P		
			L-9D 134.4#			Pushed 39.0-41.0' Maximum pressure 440#
		39.3-40.0 SANDY CLAY: Moist; light olive-gray.			RD	
	CL	40.0-41.0 LEAN TO FAT CLAY: Moist; light olive-gray, some fine-grained sand present.	L-10C 132.0#	P	2.5/2.5	
	CL-CH		L-10D 132.0#			
-48.2 (41.0)						Bottomed Hole #1 at 41.0' Bottomed Hole #2 at 41.0' Backfilled both holes

DWR 885 (2)

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 1 of 2
HOLE NO. IS-17
ELEV. -8.20 (Survey) FEET
DEPTH 32.5 FEET

PROJECT North San Joaquin Division
DATE DRILLED 10/19/01
FEATURE Clifton Court Forebay, Italian Slough (Intake Structure)
ATTITUDE Vertical
LOCATION N. 2,138,309 E. 6,248,069
LOGGED BY J. Van Gilder
CONTR. Layne Christensen DRILL RIG CME 850
DEPTH TO WATER 5.0'

DR - 18" Standard Penetration Test
P - Push
B - Bag Sample
NS - No Sample
S - Shelby Tube Sample
RD - Rotary Drilling
PP - Pocket Penetrometer
SV - Shear Vain

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0.0 (-8.2)	ML/CL	QUATERNARY ALLUVIUM 0.0 to 32.5'		AD	Began drilling with a 4 -1/2" drag bit from 0.0 to 5.0'.
2.0		0.0 to 3.0' Silt to Lean Clay, (ML/CL): About 90% nonplastic to very low plasticity fines; about 10% very fine sand; very loose; dry; grayish brown; no reaction to HCl.	NS		No sample from 0.0 to 5.0'.
4.0	Pto	3.0 to 5.5' Peaty Organic Soil, (Pto): About 60% dark brown to black organics; about 40% low to high plasticity fines; dry to moist; no reaction to HCl.			Return dark brown with organics from 3.0 to 5.5'. Water at 5.0'.
6.0	ML/CL	5.5 to 7.0' Silt to Lean Clay, (ML/CL): About 90% nonplastic to low plasticity fines; about 10% very fine sand; soft; medium brown; moist to wet; no reaction to HCl.	Box 1	P 2.5/2.5	250 psi PP - 1.4 tsf SV - 0.34 tsf
8.0	CL/CH	7.0 to 17.0' Lean to Fat Clay, (CL/CH): About 90% low to high plasticity fines (mostly low to medium), medium dry strength; firm; about 10% very fine sand; wet; bluish-gray with brown mottling; no reaction to HCl.	B-1	DR 1.0/1.5	PP - 0.8 tsf 2/2/3 N= 5
			NS	RD	
10.0 (-18.2)			S-1	P	250 psi
12.0			B-2	DR 1.1/1.5	4/4/4 N= 8
14.0			NS	RD	
16.0		15.2 Color changes to medium brown.	Box 1	P	

DWR 885 (1) (Rev. 9-84)

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
DRILL HOLE LOG

SHEET 2 OF 2

HOLE NO. IS-17

PROJECT & FEATURE North San Joaquin Division - Clifton Court Forebay, Italian Slough (Intake Structure)

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
16.0	CL/CH	QUATERNARY ALLUVIUM 0.0 to 32.5'	Box 1	P 2.2 2.5	PP - 0.60 tsf SV - 0.20 tsf
	SM/SC	7.0 to 17.0 ' Lean to Fat Clay (CL/CH): (cont.)			
18.0		17.0 to 22.0' Silty Sand to Clayey Sand; (SM/SC): About 60% very fine to fine sand; about 40% nonplastic to low plasticity fines; loose; wet; medium brown; no reaction to HCl.	B-3	DR 0.8 1.5	2/3/3 N= 6
			NS	RD	
20.0 (-28.7)			S-2	P 2.0 2.5	250 psi
22.0	CL/CH	22.0 to 25.5' Lean to Fat Clay with Sand, (CL/CH)s: About 85% low to medium plasticity fines; about 15% very fine to fine sand; loose; wet; medium brown; no reaction to HCl.	B-4	DR 1.0 1.5	3/4/5 N= 9
24.0			NS	RD	Return muddy brown.
			Box 1	P 2.0 2.5	550 psi PP - 1.5 tsf SV - 0.09 tsf
26.0	SM/SC	25.5 to 32.5' Silty Sand to Clayey Sand, (SM/SC): About 80% very fine to fine sand; about 20% nonplastic to low plasticity fines; medium dense; wet; medium brown; no reaction to HCl.			
28.0			B-5	DR 1.4 1.5	4/6/8 N= 14
			NS	RD	
30.0 (-38.7)			S-3	P 2.2 2.5	550 psi
32.0					
		Total Depth: 32.5'			IS-17 backfilled with 5% cement/bentonite grout on 10/19/01.

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 1 of 4
HOLE NO. IS-18
ELEV. -7.10 (Survey) FEET
DEPTH 32.5 FEET
DATE DRILLED 10/25/01 to 10/26/01
ATTITUDE Vertical
LOGGED BY J. Van Gilder
DEPTH TO WATER 6.0'

PROJECT North San Joaquin Division
FEATURE Clifton Court Forebay, Italian Slough (Intake Structure)
LOCATION N. 2,137,947 E. 6,247,136
CONTR. Layne Christensen DRILL RIG CME 850

DR - 18" Standard Penetration Test
P - Push
B - Bag Sample
NS - No Sample
S - Shelby Tube Sample
RD - Rotary Drilling
PP - Pocket Penetrometer
SV - Shear Vain

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0.0 (-7.1)	ML/CL	QUATERNARY ALLUVIUM 0.0 to 62.5'		AD	Began drilling with a 4 -1/2" drag bit from 0.0 to 5.0'.
2.0		0.0 to 3.0' Silt to Lean Clay, (ML/CL): About 90% nonplastic to very low plasticity fines; about 10% very fine sand; very loose; dry to moist; grayish brown; no reaction to HCl.	NS		No sample from 0.0 to 5.0'.
4.0	Pto	3.0 to 7.0' Peaty Organic Soil, (Pto): About 70% organic material; about 30% low to high plasticity fines; moist to wet; dark brown to black; no reaction to HCl.			Return dark brown with organics from 3.0 to 5.5'.
6.0			Box 1	P 1.8/2.5	Lost circulation in the peat. Placed 10.0' of casing. Water at 6.0'.
8.0	SM	7.0' to 8.0' Silt Sand, (SM): About 85% very fine to fine sand; about 15% nonplastic fines; loose; wet; light brown to grayish blue; no reaction to HCl.	B-1	DR 1.2/1.5	3/3/4 N= 7
	CH	8.0 to 10.0' Fat Clay, (CH): About 95% high plasticity fines; high dry strength; no dilatancy; about 5% very strength; firm; wet; grayish blue; no reaction to HCl.	NS	RD	
10.0 (-17.1)	ML/CL	10.0 to 12.0' Color changes from grayish blue to medium brown.	S-1	P 2.2/2.5	300 psi
12.0		10.0 to 14.5' Silt to Lean Clay, (ML/CL): About 90% nonplastic to low plasticity fines (mostly low plasticity), low dry strength; slow dilatancy; about 10% very fine sand; soft; wet; medium brown; no reaction to HCl.	B-2	DR	PP - 1.0 tsf 2/2/3 N= 5
14.0			NS	RD	
16.0	CH	14.5 to 21.0' Fat Clay, (CH): About 95% medium to high plasticity fines, medium dry strength; about 5% very fine sand; firm; wet; medium brown; no	Box 1	P	400 psi

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 2 OF 4

HOLE NO. IS-18

PROJECT & FEATURE North San Joaquin Division - Clifton Court Forebay, Italian Slough (Intake Structure)

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
16.0	CH	QUATERNARY ALLUVIUM 0.0 to 62.5' 14.5 to 21.0' Fat Clay, (CH): (cont.)	Box 1	P 2.0/2.5	PP - 2.0 tsf SV - 0.36 tsf
18.0			B-3	DR 1.3/1.5	2/3/4 N= 7
			NS	RD	
20.0 (-27.1)			S-2	P	300 psi
	ML/CL	21.0 to 25.0' Silt to Lean Clay, (ML/CL): About 95% nonplastic to low plasticity fines; low dry strength; about 5% very fine sand; firm; wet; medium brown; no reaction to HCl. 22.8 to 23.2' Fat Clay.		2.5/2.5	
22.0			B-4	DR 1.2/1.5	PP - 0.9 to 1.4 tsf 5/6/6 N= 6
24.0			NS	RD	Return muddy brown.
	CH	25.0 to 28.5' Fat Clay, (CH): About 100% high plasticity fines; high dry strength; high toughness; no dilatancy; trace very fine sand; stiff to very stiff; wet; medium brown; no reaction to HCl.	Box 1	P 2.0/2.5	400 psi PP - 2.1 tsf SV - 0.34 tsf
26.0					
28.0			B-5	DR 1.2/1.5	6/12/12 N= 24
	SM	28.5 to 35.0' Silty Sand, (SM): About 80% very fine to fine sand; about 20% nonplastic to very low plasticity fines; loose; wet; medium brown; no reaction to HCl.	NS	RD	
30.0 (-37.1)			S-3	P 2.4/2.5	500 psi
32.0			B-6	DR 1.5/1.5	PP - 1.2 tsf 3/3/3 N= 6
34.0			NS	RD	
36.0	ML/CL	35.0 to 37.0' Silt to Lean Clay, (ML/CL): About 90% nonplastic to low plasticity fines; about 10% very fine sand; wet; medium brown; no reaction to HCl.	Box 1	P	500 psi

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DRILL HOLE LOG

HOLE NO. IS-18

PROJECT & FEATURE North San Joaquin Division - Clifton Court Forebay, Italian Slough (Intake Structure)

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
36.0	ML/CL	QUATERNARY ALLUVIUM 0.0 to 62.5' 35.0 to 37.0' Silt to Lean, (ML/CL): (cont.)	Box 1	P 2.3/2.5	PP - 2.0 tsf SV - 0.0.8 tsf
	(CL/CH)s	37.0 to 40.0' Lean to Fat Clay with Sand, (CL/CH)s: About 85% low to high plasticity fines; about 15% very fine sand; stiff; wet; medium brown; no reaction to HCl	B-7	DR 1.4/1.5	5/5/8 N= 13
38.0			NS	RD	
40.0 (-47.1)	SM	40.0 to 45.0' Silty Sand, (SM): About 80% very fine to fine sand; about 20% nonplastic to very low plasticity fines; medium dense; wet; medium brown; no reaction to HCl.	S-4	P 2.3/2.5	500 psi
42.0			B-8	DR 1.1/1.5	7/8/9 N= 17
44.0			NS	RD	
	CH	45.0 to 55.0' Fat Clay, (CH): About 95% medium to high plasticity; high dry strength; about 5% very fine sand; stiff to very stiff; wet; medium brown; no reaction to HCl.	Box 1	P	
46.0			Box 2	2.3/2.5	PP - 1.9 tsf SV - 0.42 tsf
48.0			B-9	DR 1.3/1.5	5/7/9 N= 16
			NS	RD	
50.0 (-57.1)			S-5	P	
52.0		53.2 to 53.6' About 20% fine sand.	B-10	DR	PP - 1.8 tsf 7/9/9 N= 18
54.0			NS	RD	
	SM	55.0 to 57.0' Silty Sand, (SM): About 80% fine sand; about 20% nonplastic fines; wet; medium brown; no reaction to HCl.	Box 2	P	
56.0					

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DRILL HOLE LOG

HOLE NO. IS-18

PROJECT & FEATURE North San Joaquin Division - Clifton Court Forebay, Italian Slough (Intake Structure)

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
56.0	SM	QUATERNARY ALLUVIUM 0.0 to 62.5'	Box 2	P 2.4/2.5	
	CH	55.0 to 57.0' Silty Sand, (SM): (cont.)			
58.0			B-11	DR 1.3/1.5	PP - 0.7 tsf 6/7/7 N= 14
		59.0 to 62.5' Fat Clay, (CH): About 95% medium to high plasticity fines; high dry strength; about 5% very fine sand; stiff to very stiff; wet; medium brown; no reaction to HCl.	NS	RD	
60.0 (-67.1)			S-6	P 2.3/2.5	500 psi
62.0					
		Total Depth: 62.5'			IS-18 backfilled with 5% cement/bentonite grout on 10/26/01

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DRILL HOLE LOG

SHEET 1 of 4
HOLE NO. IS-19
ELEV. -1.3 (Survey) FEET
DEPTH 62.5 FEET

PROJECT North San Joaquin Division
DATE DRILLED 11/5/01 to 11/6/01
FEATURE Clifton Court Forebay, Italian Slough (Intake Structure)
ATTITUDE Vertical
LOCATION N. 2,137,430 E. 6,248,730
LOGGED BY J. Van Gilder
CONTR. Layne Christensen DRILL RIG CME 850
DEPTH TO WATER 7.0'

DR - 18" Standard Penetration Test
P - Push
B - Bag Sample
NS - No Sample
S - Shelby Tube Sample
RD - Rotary Drilling
PP - Pocket Penetrometer
SV - Shear Vain

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0.0 (-1.3)	ML/CL	QUATERNARY ALLUVIUM 0.0 to 62.5' 0.0 to 5.6' Silt to Lean Clay, (ML/CL): About 85% nonplastic to low plasticity fines; about 10% very fine sand; about 5% organics; dry; dark brown; no reaction to HCl.	Box 1	P 2.0/2.5	Began with "Push" samples from 0.0 to 7.5'.
2.0			Box 1	P 1.1/2.5	100 psi
4.0					
	Pto	5.2 to 12.5' Peaty Organic Soil, (Pto): About 60% medium to high plasticity fines; about 40% organics; very soft; moist to wet; dark brownish black; no reaction to HCl.	Box 1	P	100 psi Water at 7.0'.
6.0					
8.0			NS	DR 0.0/1.5	Samples not recovered from 7.5 to 12.5'. 0/1/1 N= 2
			NS	RD	Return dark muddy brown with organics.
10.0 (-11.3)			NS	P 0.0/2.5	7.5 to 12.5' logged at Pto.
12.0	CL/CH	12.5 to 14.0' Lean to Fat Clay, (CL/CH): About 90% low to medium plasticity fines; medium dry strength; about 10% very fine sand, very loose; wet; dark brown; no reaction to HCl.	B-1	DR 0.8/1.5	0/0/0
14.0	CH	14.0 to 25.5' Fat Clay, (CH): About 95% medium to high plasticity fines; about 5% very fine sand; very soft to firm; wet; bluish gray; no reaction to HCl.	NS	RD	
16.0			Box 1	P	250 psi

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DRILL HOLE LOG

HOLE NO. IS-19

PROJECT & FEATURE North San Joaquin Division - Clifton Court Forebay, Italian Slough (Intake Structure)

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
16.0	CH	QUATERNARY ALLUVIUM 0.0 to 62.5' 14.0 to 25.5' Fat Clay, (CH): (cont.)	Box 1	P 2.0/2.5	PP - 1.1 to 1.5 tsf SV - 0.36 to 0.51 tsf
18.0			B-2	DR 0.9/1.5	4/4/4 N= 8
			NS	RD	
20.0 (-21.3)			S-1	P 2.3/2.5	300 psi
22.0		23.0' Color changes to medium brown.	B-3	DR 1.1/1.5	3/4/4 N= 8
24.0			NS	RD	
26.0	SM	25.5 to 42.0' Silty Sand, (SM): About 70% very fine to fine sand; about 30% nonplastic fines; loose; wet; medium brown; no reaction to HCl.	Box 1	P	300 psi PP - 1.3 tsf SV - 0.10 tsf
28.0			B-4	DR 1.1/1.5	3/3/6 N= 9
			NS	RD	Return muddy brown.
30.0 (-31.3)			S-2	P 2.3/2.5	300 psi
32.0			B-5	DR 0.7/1.5	5/5/7 N= 12
34.0	SC	33.6 to 39.2' Clayey Sand, (SC): About 60% very fine sand; about 40% nonplastic to plasticity fines; wet; medium brown; no reaction to HCl.	NS	RD	
36.0	SM		Box 2	P	300 psi

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DRILL HOLE LOG

HOLE NO. IS-19

PROJECT & FEATURE North San Joaquin Division - Clifton Court Forebay, Italian Slough (Intake Structure)

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
36.0	SM	QUATERNARY ALLUVIUM 0.0 to 62.5' 25.5 to 42.0' Silty Sand, (SM): (cont.)	Box 2	P 2.0/2.5	PP - 1.2 tsf SV - 0.29 tsf
38.0		36.4 to 36.6' Fat Clay. 37.0 to 37.4' Fat Clay	B-6	DR 1.2/1.5	3/4/5 N= 9
			NS	RD	
40.0 (-41.3)			S-3	P 2.2/2.5	400 psi
42.0	(CH)s	42.0 to 47.0' Fat Clay with Sand, (CH)s: About 85% medium to high plasticity fines; medium dry strength; medium toughness; about 15% very fine sand; firm; wet; medium brown; no reaction to HCl.	B-7	DR 1.2/1.5	6/6/6 N= 12
44.0			NS	RD	
46.0		46.0 to 46.6' Sandy Clay.	Box 2	P 2.0/2.5	400 psi PP - 2.4 tsf SV - 0.40 tsf
48.0	CH	47.0 to 62.5' Fat Clay, (CH): About 95% medium to high plasticity fines; medium dry strength; no dilatancy; about 5% very fine sand; firm to stiff; wet; medium brown; no reaction to HCl.	B-8	DR 1.1/1.5	5/6/6 N= 12
			NS	RD	
50.0 (-51.3)			S-4	P 2.3/2.5	500 psi
52.0			B-9	DR 1.2/1.5	6/7/8 N= 15
54.0			NS	RD	
56.0			Box 2	P	500 psi

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DRILL HOLE LOG

SHEET 4 OF 4
HOLE NO. IS-19

PROJECT & FEATURE North San Joaquin Division - Clifton Court Forebay, Italian Slough (Intake Structure)

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
56.0	(CH)	QUATERNARY ALLUVIUM 0.0 to 62.5' 47.0 to 62.5' Fat Clay, (CH): (cont.)	Box 2	P 2.0 2.5	PP - 1.9 tsf SV - 0.42 tsf
58.0			B-10	DR 1.3 1.5	3/4/5 N= 9
			NS	RD	
60.0 (-61.3)			S-5	P 2.1 2.5	400 psi
62.0					
		Total Depth: 62.5'			IS-19 backfilled with 5% cement/bentonite grout on 11/06/01

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DRILL HOLE LOG

SHEET 1 of 4
HOLE NO. IS-20
ELEV. -6.9 (Survey) FEET
DEPTH 62.5 FEET

PROJECT	North San Joaquin Division
FEATURE	Clifton Court Forebay, Italian Slough (Intake Structure)
LOCATION	N. 2,138,078 E. 6,247,709
CONTR.	Layne Christensen
DRILL RIG	CME 850
DATE DRILLED	10/26/01 to 10/29/01
ATTITUDE	Vertical
LOGGED BY	J. Van Gilder
DEPTH TO WATER	Not Determined

DR - 18" Standard Penetration Test
P - Push
B - Bag Sample
NS - No Sample
S - Shelby Tube Sample
RD - Rotary Drilling
PP - Pocket Penetrometer
SV - Shear Vain

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0.0 (-6.9)	ML/CL	QUATERNARY ALLUVIUM 0.0 to 62.5'		RD	Began drilling with a 4 -1/2" drag bit from 0.0 to 5.0'.
2.0, 4.0		0.0 to 5.0' Silt to Lean Clay, (ML/CL): About 90% nonplastic to very low plasticity fines; about 10% very fine sand; very loose; dry to moist; grayish brown; no reaction to HCl.	NS		No sample from 0.0 to 5.0'. Logged by cuttings. 0.0 to 5.0' Return muddy brown .
6.0	Pto	5.0 to 7.0' Peaty Organic Sand, (Pto): About 60% organic material; about 40% low to high plasticity fines; moist to wet; dark brown to black; no reaction to HCl.	Box 1	P 2.5/2.5	250 psi
8.0	SM	7.0 to 8.8' Silty Sand, (SM): About 80% very fine to fine sand; about 20% nonplastic fines; very loose; wet; bluish gray; no reaction to HCl.	B-1	DR 1.3/1.5	1/1/2 N= 3
	CH	8.8 to 15.0' Fat Clay, (CH): About 95% medium to high plasticity fines; about 5% very fine sand; wet; medium brown; no reaction to HCl.	NS	RD	
10.0 (-16.9), 12.0			S-1	P 2.4/2.5	250 psi
14.0			B-2	DR 1.2/1.5	3/4/5/ N= 9
			NS	RD	
16.0	ML/CL	15.0 to 32.0' Silt to Lean Clay, (ML/CL): About 90% nonplastic to low plasticity fines; about 10% very fine sand; soft to firm; wet; medium brown; no reaction to HCl.	Box 1	P	300 psi

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DRILL HOLE LOG

HOLE NO. IS-20

PROJECT & FEATURE North San Joaquin Division - Clifton Court Forebay, Italian Slough (Intake Structure)

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
16.0	ML/CL	<u>QUATERNARY ALLUVIUM</u> 0.0 to 62.5' 15.0 to 32.0' <u>Silt to Lean clay, (ML/CL):</u> (cont.)	Box 1	P 2.0/2.5	PP - 2.1 tsf SV - 0.24 tsf
18.0		17.2 to 18.0' Fat Clay.	B-3	DR 1.1/1.5	4/4/5 N= 9
			NS	RD	
20.0 (-26.9)			S-2	P 2.3/2.5	400 psi
22.0	ML/CL	22.0 to 24.0' About 30% very fine sand.			
			B-4	DR 1.3/1.5	4/4/5 N= 9
24.0	CH	24.0 to 26.0' <u>Fat Clay, (CH)</u>: About 95% high plasticity fines; high dry strength; no dilatancy; firm to stiff; wet; medium brown; no reaction to HCl.	NS	RD	Return muddy brown.
			Box 1	P 2.1/2.5	450 psi PP - 2.0 tsf SV - 0.40 tsf
26.0	ML/CL				
28.0			B-5	DR 1.3/1.5	5/7/8 N= 15
			NS	RD	
30.0 (-36.9)			S-3	P 2.2/2.5	450 psi
32.0	s(ML/CL)	32.0 to 35.0' <u>Sandy Silt to Lean Clay, s(ML/CL)</u>: About 70% nonplastic to low plasticity fines; about 30% very fine sand.	B-6	DR 1.1/1.5	6/7/7 N= 14
34.0			NS	RD	
36.0	CH	35.0 to 58.4' <u>Fat Clay, (CH):</u> About 95% medium to high plasticity fines; about 5% very fine sand; firm to very stiff; wet; medium brown; no reaction to HCl.	Box 1	P	450 psi

DRILL HOLE LOG

SHEET 3 OF 4
HOLE NO. IS-20

PROJECT & FEATURE North San Joaquin Division - Clifton Court Forebay, Italian Slough (Intake Structure)

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
36.0	CH	QUATERNARY ALLUVIUM 0.0 to 62.5' 35.0 to 58.4' Fat Clay, (CH): (conrt.).	Box 1	P 2.3/2.5	PP - 1.8 tsf SV - 0.24 tsf
38.0		36.6 to 37.8' Silt to Lean Clay.	B-7	DR 1.2/1.5	5/5/7 N= 12
			NS	RD	
40.0 (-46.9)			S-4	P	500 psi
42.0		42.0 to 43.6' Sand Silt to Lean Clay.		2.3/2.5	
			B-8	DR 1.2/1.5	5/5/7 N= 12
44.0	CH		NS	RD	
			Box 1	P	500 psi
46.0				2.0/2.5	PP - 2.2 tsf SV - 0.36 tsf
48.0			B-9	DR 1.1/1.5	PP - 2.1 tsf 6/8/9 N= 17
			NS	RD	
50.0 (-56.9)			S-5	P	500 psi
52.0				2.3/2.5	
			B-10	DR 0.7/1.5	5/8/10 N= 18
54.0			NS	RD	
	CH			P	500 psi
56.0					

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DRILL HOLE LOG

HOLE NO. IS-20

PROJECT & FEATURE North San Joaquin Division - Clifton Court Forebay, Italian Slough (Intake Structure)

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
56.0	CH	QUATERNARY ALLUVIUM 0.0 to 62.5' 35.0 to 58.4' Fat Clay, (CH) (cont.)	NS	P 0.0 2.5	Sample not recovered due to bent tube.
58.0		56.0 to 57.0' Silt to Lean Clay.	B-11	DR 1.4 1.5	6/8/10 N= 18
	ML/SM	58.4 to 62.5' Sandy Silt to Silty Sand, (ML/SM): About 50% nonplastic fines; about 50% very fine s and; medium dense; wet; medium brown no reaction to HCl.	NS	RD	
60.0 (-66.9)			S-6	P 2.3 2.5	500 psi
62.0					
		Total Depth: 62.5'			IS-20 backfilled with 5% cement/bentonite grout on 10/30/01.

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DRILL HOLE LOG

SHEET 1 of 4
HOLE NO. IS-22
ELEV. -7.8 (Survey) FEET
DEPTH 62.5 FEET
DATE DRILLED 10/23/01 to 10/24/01
ATTITUDE Vertical
LOGGED BY J. Van Gilder
DEPTH TO WATER 6.0

PROJECT North San Joaquin Division
FEATURE Clifton Court Forebay, Italian Slough (Intake Structure)
LOCATION N. 2,137,714 E. 6,248,940
CONTR. Layne Christensen DRILL RIG CME 850

DR - 18" Standard Penetration Test
P - Push
B - Bag Sample
NS - No Sample
S - Shelby Tube Sample
RD - Rotary Drilling
PP - Pocket Penetrometer
SV - Shear Vain

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0.0 (-7.8)	ML/CL	QUATERNARY ALLUVIUM 0.0 to 62.5' 0.0 to 3.0' Silt to Lean Clay, (ML/CL): About 90% nonplastic to very low plasticity fines; about 10% very fine sand; very loose; dry to moist; grayish brown; no reaction to HCl.	NS	RD	Began drilling with a 4 1/2" drag bit from 0.0 to 5.0'. No samples taken from 0.0 to 5.0'. Return dark brown water organics from 3.0 to 5.0'.
2.0					
4.0	Pto	3.0 to 12.5' Peaty Organic Soil, (Pto): About 80% organic material; about 20% low to high plasticity fines; moist to wet; dark brown to black; no reaction to HCl.			
6.0		7.0 Grades into 60% organics and 40% fines.	Box 1	P 2.0/2.5	Water at 6.0'. 100 psi.
8.0			B-1	DR 0.8/1.5	SPT sample dropped 2.0' under sampler weight. 0/0/0
			NS	RD	Lost circulation through the peat.
10.0 (-17.8)			S-1	P 2.3/2.5	100 psi
12.0	SM	12.5 to 13.5' Silty Sand, (SM): About 80% very fine to fine sand; about 20% nonplastic fines; very loose; wet; bluish gray; micaceous; no reaction to HCl.	B-2	DR 0.9/2.5	2/0/0 N= 0
14.0	S(CL/CH	13.5 to 18.0' Sandy Lean to Fat Clay, s(CL/CH): About 70% very low to high plasticity fines; about 30% very fine sand; very soft; wet; bluish gray to brown at 16.5'; micaceous; no reaction to HCl.	NS	RD	
16.0			Box 1	P	

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DRILL HOLE LOG

SHEET 2 OF 4

HOLE NO. IS-22

PROJECT & FEATURE North San Joaquin Division - Clifton Court Forebay, Italian Slough (Intake Structure)

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
16.0	S(CL/CH)	QUATERNARY ALLUVIUM 0.0 to 62.5' 13.5 to 18.0' Sandy Lean to Fat Clay, s(CL/CH): (cont.)	Box 1	P	PP - 1.4 tsf SV - 0.38 tsf
18.0	CH	18.0 to 22.0' Fat clay, (CH): About 95% high plasticity fines, high dry strength, high toughness; no dilatancy; about 5% very fine sand; stiff; wet; medium brown; no reaction to HCl.	B-3	DR 1.3/1.5	3/3/3 N= 6
			NS	RD	
20.0 (-27.8)			S-2	P 2.2/2.5	250 psi
22.0	ML	22.0 to 23.6' Sandy Silt, (ML): About 80% nonplastic fines; about 20% very fine sand; loose; wet; medium brown; no reaction to HCl.	B-4	DR	3/4/4 N= 8
24.0	SM	23.6 to 27.8' Silty Sand, (SM): About 70% very fine sand; about 30% nonplastic fines; loose; wet; medium brown; no reaction to HCl.	NS	RD	
26.0			Box 1	P	Placed 20' of casing to stop water take. PP - 1.0 tsf SV - 0.17 tsf
28.0			B-5	DR 1.3/1.5	3/4/5 N= 9
	(CL)s	27.8 to 33.6' Lean Clay with Sand, (CL)s: About 80% low to high plasticity fines; medium dry strength; low to medium toughness; about 20% very fine sand; stiff; wet; medium brown; no reaction to HCl.	NS	RD	
30.0 (-37.8)			S-3	P 2.3/2.5	350 psi
32.0			B-6	DR 1.3/1.5	4/4/6 N= 10
34.0	CH	33.6 to 42.0' Fat Clay, (CH): About 95% high plasticity fines; high dry strength; high toughness; no dilatancy; about 5% very fine sand; stiff; wet; medium brown; no reaction to HCl.	NS	RD	
36.0			Box 1	P	400 psi

PROJECT & FEATURE North San Joaquin Division - Clifton Court Forebay, Italian Slough (Intake Structure)

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
36.0	CH	QUATERNARY ALLUVIUM 0.0 to 62.5' 33.6 to 42.0' Fat Clay, (CH): (cont.)	Box 1	P 1.8/2.5	PP - 0.6 tsf SV - 0.50 tsf
38.0			B-7	DR 1.3/1.5	PP - 0.7 tsf 5/5/6
			NS	RD	
40.0 (-47.8)			S-4	P 2.4/2.5	450 psi
42.0	CL/CH	42.0 to 62.5' Lean to Fat Clay, (CL/CH): About 90% low to high plasticity fines; about 10% very fine sand; stiff; wet; medium brown; no reaction to HCl.			
			B-8	DR 1.4/1.5	5/7/7 N= 14
44.0			NS	RD	
			Box 1	P	500 psi PP - 2.4 tsf
46.0			Box 2	2.2/2.5	SV - 0.38 tsf
48.0		48.0 to 48.4' About 15% very fine sand.	B-9	DR 1.4/1.5	6/7/8 N= 15
			NS	RD	
50.0 (-57.8)			S-5	P	PP - 1.6 tsf SV - 0.38 tsf
52.0 (xxx)			B-10	DR 1.5/1.5	5/5/6 N= 11
54.0			NS	RD	
56.0				P	400 psi

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DRILL HOLE LOG

SHEET 4 OF 4

HOLE NO. IS-22

PROJECT & FEATURE North San Joaquin Division - Clifton Court Forebay, Italian Slough (Intake Structure)

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
56.0	CL/CH	QUATERNARY ALLUVIUM 0.0 to 62.5' 42.0 to 62.5' Lean to Fat Clay, (CL/CH): (cont.)	Box 2	P 2.4/2.5	PP - 1.6 tsf SV - 0.38 tsf
58.0		58.6 to 59.2' Fat Clay.	B-11	DR 1.5/1.5	PP - 1.4 tsf 6/7/8 N= 15
			NS	RD	
60.0 (-67.8) 62.0			S-6	P 2.4/2.5	400 psi
		Total Depth: 62.5'			IS-22 backfilled with 5% cement/bentonite grout on 10/24/01.

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DRILL HOLE LOG

HOLE NO. IS-23
ELEV. -2.3 (Survey) FEET
DEPTH 62.5 FEET

PROJECT North San Joaquin Division
DATE DRILLED 11/01/01 to 11/02/01
FEATURE Clifton Court Forebay, Italian Slough (New Intake Structure)
ATTITUDE Vertical
LOCATION N. 2,137,159 E. 6,249,201
LOGGED BY J. Van Gilder
CONTR. Layne Christensen DRILL RIG CME 850
DEPTH TO WATER 8.0'

DR - 18" Standard Penetration Test
P - Push
B - Bag Sample
NS - No Sample
S - Shelby Tube Sample
RD - Rotary Drilling
PP - Pocket Penetrometer
SV - Shear Vain

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0.0	ML/CL	QUATERNARY ALLUVIUM 0.0 to 62.5' 0.0 to 3.0' Silt to Lean Clay, (ML/CL): About 85% nonplastic to low plasticity fines; about 5% very fine sand; dry, medium brown; about 10% roots and organics 0.0 to 3.5'; no reaction to HCl.	NS	P	Began with "Push" samples from 0.0 to 7.5'.. No samples taken from 0.0 to 5.0'.
2.0					
			NS	P	
4.0					
			Box 1	P 1.2 2.5	400 psi. PP - 1.5 tsf SV - 0.33 tsf
6.0					
		7.0 to 12.0' Micaceous.			
8.0			B-1	DR 0.8 1.5	Water at 8.0'. 1/1/1 N= 2
	SM	8.4 to 12.0' Silty Sand, (SM): About 60% very fine sand; about 40% nonplastic fines; very loose; moist to wet; dark gray; micaceous; no reaction to HCl.	NS	RD	Return dark muddy brown.
10.0 (-12.3)			S-1	P 2.2 2.5	200 psi
12.0	CH	12.0 to 18.8' Fat Clay, (CH): About 95% medium to high plasticity fines; high dry strength; no dilatancy; about 5% very fine sand; wet; dark grayish blue; no reaction to HCl.	B-2	DR 1.5 2.5	2/3/4 N= 7
	ML/CL	13.0 to 13.8' Silt to Lean Clay.			
14.0	CH		NS	RD	
			Box 1	P	
16.0					

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DRILL HOLE LOG

HOLE NO. IS-23

PROJECT & FEATURE North San Joaquin Division - Clifton Court Forebay, Italian Slough (Intake Structure)

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
16.0	CH	QUATERNARY ALLUVIUM 0.0 to 62.5' 12.0 to 18.8' Fat Clay, (CH): (cont.)	Box 1	P 2.0/2.5	PP - 1.6 tsf SV - 0.36 tsf
18.0		18.0' Color changes to medium brown.	B-3	DR 1.2/1.5	4/4/6 N= 10
	SM	18.8 to 21.4' Silty Sand, (SM): About 60% very fine sand; about 40% nonplastic fines; loose; wet; medium brown; no reaction to HCl.	NS	RD	
20.0 (-22.3)			S-2	P 2.3/2.5	500 psi
22.0	ML/CL	21.4 to 22.8' Silt to Lean Clay, (ML/CH): About 95% nonplastic to low plasticity fines; about 5% very fine sand; wet; medium brown; no reaction to HCl.			
24.0	CH	22.8 to 25.4' Fat Clay, (CH): About 95% medium to high plasticity fines; high dry strength; high toughness; about 5% very fine sand; stiff; wet; medium brown; no reaction to HCl.	B-4	DR 0.9/1.5	5/5/5 N= 10
			NS	RD	
26.0	SM	25.4 to 27.2' Silty Sand, (SM): About 60% very fine sand; about 40% nonplastic fines; loose; wet; medium brown; no reaction to HCl.	Box 1	P 2.0/2.5	500 psi PP - 1.5 tsf SV - 0.29 tsf
28.0	(CL/CH)s	27.6 to to 33.0' Lean To Fat Clay with Sand, (CL/CH)s: About 85% low to high plasticity fines; about 15% very fine sand; soft; wet; medium brown; no reaction to HCl.	B-5	DR 1.2/1.5	2/2/2 N= 4
			NS	RD	
30.0 (-32.3)			S-3	P 2.3/2.5	500 psi
32.0			B-6	DR 1.5/1.5	4/5/9 N= 14
34.0	CH	33.0 to 62.5' Fat Clay, (CH): About 95% medium to high plasticity fines; high dry strength; about 5% very fine sand; stiff; wet; medium brown; no reaction to HCl.	NS	RD	
36.0			Box 1	P	500 psi

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DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
36.0	CH	QUATERNARY ALLUVIUM 0.0 to 62.5' 33.0 to 62.5' Fat Clay, (CH): (cont.).	Box 1	P 2.0/2.5	PP - 3.8 tsf SV - 0.190 tsf
38.0		36.4 to 36.8' Silt.	B-7	DR 1.5/1.5	4/6/14 N= 20
			NS	RD	
40.0 (-42.3)			S-4	P 2.3/2.5	500 psi
42.0	SM	42.0 to 43.6' Silty Sand, (SM): About 60% very fine sand; about 40% nonplastic fines; medium dense; wet; medium brown; no reaction to HCl.	B-8	DR 1.3/1.5	5/5/6 N= 11
44.0	CH		NS	RD	
46.0	SM	45.4 to 48.0' Silty Sand, (SM): About 60% very fine sand; about 40% nonplastic fines; medium dense; wet; medium brown; no reaction to HCl.	Box 1	P 2.0/2.5	500 psi PP - 2.4 tsf SV - 0.34 tsf
48.0	CH		B-9	DR 1.3/1.5	4/5/6 N= 11
			NS	RD	
50.0 (-52.3)			S-5	P	500 psi
52.0			B-10	DR	6/6/7 N= 13
54.0			NS	RD	
56.0			Box 2	P	500 psi

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DRILL HOLE LOG

SHEET 4 OF 4
HOLE NO. IS-23

PROJECT & FEATURE North San Joaquin Division - Clifton Court Forebay, Italian Slough (Intake Structure)

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
56.0	CH	QUATERNARY ALLUVIUM 0.0 to 62.5' 33.0 to 62.5' Fat Clay, (CH): (cont.)	Box 2	P 2.3/2.5	PP - 1.6 tsf SV - 0.32 tsf
58.0			B-11	DR 1.2/1.5	5/6/8 N= 14
			NS	RD	
60.0 (-62.3)			S-6	P 2.3/2.5	500 psi
62.0					
		Total Depth - 62.5'			IS-23 backfilled with 5% cement/bentonite grout on 11/2/01.

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DRILL HOLE LOG

HOLE NO. IS-24
ELEV. -7.4 (Survey) FEET
DEPTH 62.5 FEET

PROJECT North San Joaquin Division
DATE DRILLED 10/22/01 to 10/23/01
FEATURE Clifton Court Forebay, Italian Slough (New Intake Structure)
ATTITUDE Vertical
LOCATION N. 2,137,445 E. 6,248,690
LOGGED BY J. Van Gilder
CONTR. Layne Christensen DRILL RIG CME 850
DEPTH TO WATER 6.0'

DR - 18" Standard Penetration Test
P - Push
B - Bag Sample
NS - No Sample
S - Shelby Tube Sample
RD - Rotary Drilling
PP - Pocket Penetrometer
SV - Shear Vain

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0.0	ML/CL	QUATERNARY ALLUVIUM 0.0 to 62.5' 0.0 to 3.0' Silt to Lean Clay, (ML/CL): About 90% nonplastic to very low plasticity fines; about 10% very fine sand; very loose, dry to moist; grayish brown; no reaction to HCl.	NS	P	Began drilling with a 4 1/2" drag bit from 0.0 to 5.0'. No samples from 0.0 to 5.0'.
2.0					
	Pto	3.0 to 4.0' Peaty Organic Soil, (Pto): About 60% dark brown to black organics; about 40% low to high plasticity fines; moist, no reaction to HCl.			Return dark brown with organics from 3.0 to 4.0'.
4.0	ML/CL	4.0 to 7.0' Silt to Fat Clay, (ML/CH): About 50% nonplastic fines; about 50% low to high plasticity fines; trace very fine sand; very soft; moist to wet; bluish gray; no reaction to HCl.			Water at 6.0'.
6.0			Box 1	P 2.0 2.5	250 psi PP - 0.2 to 1.1 tsf SV - 0.02 tsf
	CH	7.0 to 12.0' Fat Clay, (CH): About 95% medium to high plasticity fines; about 5% very fine sand; very soft; wet; bluish gray to brown; grades into a clayey sand; no reaction to HCl.			
8.0			B-1	DR 1.2 1.5	PP - 1.5 tsf 2/2/3 N= 5
			NS	RD	Return brownish gray.
10.0 (-17.4)			S-1	P 2.4 2.5	400 psi
12.0	SC	12.0 to 15.0' Clayey Sand, (SC): About 60% very to fine sand; about 40% low to high plasticity fines; loose; wet; brown; no reaction to HCl.	B-2	DR	2/3/3 N= 6
14.0			NS	RD	
	CL/CH	15.0 to 28.0' Lean to Fat Clay, (CL/CH): About 90% low high plasticity fines; about 10% very fine sand; firm to stiff; wet; medium brown; no reaction to HCl.	Box 1	P	500 psi
16.0					

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HOLE NO. IS-24

PROJECT & FEATURE North San Joaquin Division, Clifton Court Forebay, Italian Slough (Intake Structure)

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
16.0	CL/CH	QUATERNARY ALLUVIUM 0.0 to 62.5' 1.0 15.0 to 28.0' Lean to Fat Clay,(CL/CH): (cont.)	Box 1	P 2.0/2.5	PP - 1.8 tsf SV - 0.38 tsf
18.0		16.8 to 17.2' Fat Clay.	B-3	DR 1.5/1.5	4/4/5 N= 9
			NS	RD	
20.0 (-27.4)			S-2	P 2.3/2.5	500 psi
22.0		22.4 to 22.8' Silty Sand.			
			B-4	DR 1.4/1.5	PP - 2.6 tsf 4/6/7 N= 13
24.0			NS	RD	
			Box 1	P 1.1/2.5	400 psi
26.0	CL/CH	26.8 to 27.2' Sandy Silt.			
28.0	SM	28.0 to 32.0' Silty Sand, (SM): About 70% very fine to fine sand; about 30% nonplastic to very low plasticity fines; medium dense; wet; medium brown; no reaction to HCl.	B-5	DR 1.5/1.5	5/7/9 N= 16
			NS	RD	
30.0 (-37.4)			S-3	P 2.2/2.5	400 psi
32.0	S(ML/CL)	32.0 to 36.5' Sandy Silt to Sandy Lean Clay, s(ML/CL): About 60% nonplastic to low plasticity fines; about 40% fine sand; medium dense; wet; medium brown; no reaction to HCl.	B-6	DR 1.3/1.5	7/7/7 N= 14
34.0			NS	RD	
36.0			Box 1	P	450 psi PP - 1.4 tsf (IN SM) SV - 0.02 tsf (IN SM)

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DRILL HOLE LOG

HOLE NO. IS-24

PROJECT & FEATURE North San Joaquin Division, Clifton Court Forebay, Italian Slough (Intake Structure)

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
36.0 (xxx)	S(ML/CL)	QUATERNARY ALLUVIUM 0.0 to 62.5' 32.0 to 36.5' Sandy silt to Sandy Lean Clay, s(ML/CL): (cont.)	Box 1	P	P P = 0.5 tsf S V = 0.58 tsf
38.0		36.5 to 52.8' Fat Clay, (CH): About 90% high plasticity fines; high dry strength; medium toughness; no dilatancy; about 10% very fine sand; stiff; wet; medium brown; no reaction to HCl.	B-7	DR 1.5/1.5	5/7/8 N= 15
			NS	RD	
40.0			S-4	P 2.2/2.5	400 psi
42.0			B-8	DR	5/5/6 N= 11
44.0 (xxx)			NS	RD	Return muddy brown.
46.0	SM	45.0 to 46.8' Silty Sand, (SM): About 60% very fine sand; about 40% nonplastic to very low plasticity fines; wet; medium brown; no reaction to HCl.	Box 1	P	500 psi
	(CH)s	46.8 to 47.6' Lean Clay with Sand, (CL)s: About 85% very low to low plasticity fines; about 15% very fine sand; wet; medium brown; no reaction to HCl.		2.2/2.3	P P = 0.7 to 1.7 tsf S V = 0.021 tsf
48.0	CH		B-9	DR 1.5/1.5	P P = 0.7 tsf 5/6/7 N= 13
			NS	RD	
50.0			S-5	P 2.3/2.5	500 psi
52.0 (xxx)	ML/CL	52.8 to Silt to Lean Clay, (ML/CL): About 90% nonplastic to low plasticity fines; about 10% very fine sand; stiff to medium dense; wet; medium brown; no reaction to HCl.	B-10	DR 1.3/1.5	6/7/7 N= 14
54.0			NS	RD	
56.0			Box 2	P	

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HOLE NO. IS-24

PROJECT & FEATURE North San Joaquin Division - Clifton Court Forebay, Italian Slough (Intake Structure)

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
56.0	ML/CL	QUATERNARY ALLUVIUM 0.0 to 62.5' 52.8 to Silt to Lean Clay, (ML/CL): (cont.) 56.8 to 57.2' Silty Sand.	Box 2	P 2.2/2.5	PP - 1.7 to 2.0 tsf SV - 0.34 tsf
58.0			B-11	DR 1.5/1.5	8/9/9 N= 18
			NS	RD	
60.0 (-67.4)			S-6	P 1.2/2.5	500 psi
62.0					
		Total Depth: 62.5"			IS-24 backfilled with 5% cement/bentonite grout on 10/23/01.