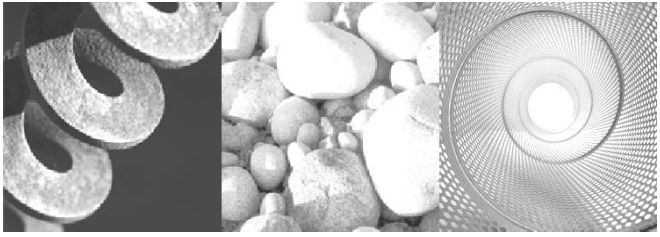

GEI Consultants

Consulting Engineers and Scientists

Lopez Dam Inundation Technical Study

State Dam No. 1055.000
National Dam No. CA00887

Prepared for:
San Luis Obispo County Flood Control and Water Conservation District
County Government Center, Room 206
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December 2017
Project No. 1704408
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Engineer's Certifications

I, Mark Fortner, herby certify on December 27, 2017, that I supervised the preparation of this study, *Lopez Dam Inundation Technical Study*, as a professional engineer licensed in the State of California.

I, Chong Vang, hereby certify on December 27, 2017, that I performed the dam failure and inundation analysis of this study, *Lopez Dam Inundation Technical Study*, as a professional engineer licensed in the State of California.

Executive Summary

San Luis Obispo County Flood Control and Water Conservation District (District) retained GEI Consultants, Inc. (GEI) to perform an analysis to estimate the downstream flooding due to a hypothetical failure of Lopez Dam for a fair weather (sunny day) event and a hypothetical failure of the uncontrolled Lopez Dam spillway. The District is required to submit inundation maps to the California Department of Water Resources (DWR) Division of Safety of Dams (DSOD) for Lopez Dam by January 1, 2018, per recently adopted "Emergency Regulations for Inundation Maps." The analysis was performed to assess the potential adverse incremental consequences, including loss of life and significant property damage. The dam is currently classified as an "extremely high" hazard dam by California Department of Water Resources (DWR) Division of Safety of Dams (DSOD). This analysis does not refer to the structural integrity of the dam itself, but rather the potential impacts if a dam failure or spillway failure should occur.

Lopez Dam is owned and operated by the District since its construction in 1969 as part of the Lopez Water Supply Project. Lopez Dam and Lake is a head water to the Arroyo Grande Creek in San Luis Obispo County, California, approximately 7.6 miles northeast of the center of the town of Arroyo Grande, California. Lopez Lake provides recreational, storage, domestic, and agricultural water uses for the local downstream communities. The lake has an area of 950 acres and a storage capacity of 49,388 acre-feet (2002 Bathymetric Survey) at the spillway crest elevation of 522.6 ft. The maximum reservoir level is at El. 533.9 ft (NAVD 88).

GEI simulated a hypothetical piping failure of the Lopez Dam starting at the full reservoir pool to the upstream toe at El. 392.6 ft with an average breach width of 573.1 ft, and a time to failure of 1 hour. The hypothetical failure of the spillway was at full reservoir pool elevation with a failure depth to the spillway apron, design head of 7 ft and estimated length of 237 ft.

The hypothetical failure of Lopez Dam for the sunny day mode would create a flood wave that could reach 66 ft-high downstream of the dam in the Arroyo Grande Creek and 30 ft-high depths in the overbanks with a peak breach flow of 833,330 cubic feet per second (cfs). The flood wave would travel 12.6 miles downstream, inundating approximately 5,584 acres of floodplain downstream of the dam through the City of Arroyo Grande, City of Grover Beach, City of Pismo Beach, and the town of Oceano before discharging into the Pacific Ocean. Approximately 1,003 acres of Arroyo Grande, 186 acres of Grover Beach, and 220 acres of Pismo Beach would be inundated by the dam failure. The peak flood wave for the sunny day failure would take 1 hours and 39 minutes to reach the ocean.

The spillway failure for the sunny day model would create a peak discharge of 10,524 cfs and take the peak flow to travel for 9 hours and 40 minutes before terminating into the ocean.

The flood inundation maps for the sunny day, full reservoir storage dam failure analyses are provided in **Appendix C**. The spillway failure flood inundation maps are provided in **Appendix D**.

1. Introduction

1.1 Purpose

Under a newly enacted state law, effective July 1, 2017, all dam owners are required to prepare an Emergency Action Plan (EAP) for their dams and critical appurtenant structures under certain conditions and specific time limits (California Water Code Sections 6160 – 6162). Lopez Dam, classified as an "extremely high" hazard dam by the California Department of Water Resources (DWR) Division of Safety of Dams, an EAP is to be submitted to DSOD and California Governor's Office of Emergency Services (CalOES) by the end of January 1, 2018. As owner of Lopez Dam, San Luis Obispo County Flood Control and Water Conservation District (District) retained GEI Consultants, Inc. (GEI) to develop inundation maps for a Lopez Dam failure mode analysis and the spillway concrete failure mode analysis to be submitted to DSOD per recent adopted "Emergency Regulations for Inundation Maps." The EAP for dams are a guidance document identifying the potential emergency conditions at the dam and specific actions to be followed to minimize loss of life and property damage. The level of detail to be included in the EAP consists of dam break inundation maps identifying the extents of the breach flood wave attenuation downstream of Lopez Dam.

The dam break analyses and inundation mapping are to be consistent with California Code of Regulations, Title 23. Waters, Division 2. Department of Water Resources, Chapter 1. Dams and Reservoirs, Article 6. Inundation Maps. GEI performed dam and spillway breach analyses by modeling a fair weather (sunny day) breach in accordance with Federal Emergency Management Agency (FEMA) guidelines and routed the breach hydrograph downstream with the latest hydraulic numerical model program from the US Army Corps of Engineers (USACE) called Hydrologic Engineering Center's River Analysis System (HEC-RAS).

A summary of the scope of work performed by GEI for this study is presented below:

Data Collection

1. Research and collect information of the dam at DSOD record library and identify potential downstream flood wave extents. Coordinate with the District to obtain data of obstruction structures that may impact the flood wave downstream.

Dam Inundation Technical Study

1. Develop floodplain terrain based on light detection and ranging (LiDAR) collected from Pacific Gas and Electric Company (PG&E), California Coastal Conservancy Coastal LiDAR Project, and US Geological Survey (USGS) National Elevation Dataset (NED). Assigned roughness values for the channels and overland flow areas are based on National Land Cover Database (NLCD) 2011 Land Cover by USGS.

2. Develop breach parameters for the hypothetical dam failure and develop dam breach outflow hydrographs. Develop spillway failure outflow hydrograph.

3. Perform dam breach parameter sensitivity analyses.

4. Route the base case scenario dam breach hydrograph and spillway failure hydrograph through the downstream area to create inundated floodplains using HEC-RAS software for unsteady flow conditions.

5. Perform sensitivity analyses to test influence of key assumptions on the flow modeling results.

6. Develop downstream inundation maps with the use of Geographic Information System (GIS) software, ArcMap.

7. Prepare report to summarize the dam and spillway breach analyses, present key assumptions of the unsteady flow model input and output results.

1.2 Horizontal and Vertical Datum

The projection used in preparation of this report is in California State Plane Coordinate System Zone 5. The horizontal datum is in the North American Datum of 1983 (NAD83), GRS80 spheroid. Elevations in this report are in feet and referenced with respect to the North American Vertical Datum of 1988 (NAVD88) unless noted on the description. The vertical datum conversation from National Geodetic Vertical Datum 1929 (NGVD29) to NAVD88 is +2.868 feet based on VERTCON conversion at Lopez Dam. The abbreviation “El” represents elevation.

2. Project Description

2.1 Dam and Reservoir

Lopez Dam and Lake are in San Luis Obispo County, California, approximately 7.6 miles northeast of the City of Arroyo Grande. The dam is owned and operated by the District. A site location map is shown on **Figure 1**. Lopez Dam is an earth fill dam that was completed in 1969 as part of the Lopez Water Supply Project to provide storage, municipal, and domestic water uses for downstream communities. The center core of the dam is composed of materials identified as Impervious Core. See As-Builts drawings in **Appendix A**. The 166 ft high dam impounds a volume of 49,388 ac-ft of water with a crest length of 1,120 ft. A summary of the dam and lake data for Lopez Dam is presented in **Table 1**. See **Figure 2** for dam aerial view. See **Figure 3** for storage-elevation capacity curve of Lopez Dam. The analysis is based on the original capacity curve (**Figure 3**) of the reservoir and best available data collected during this study.

A reinforced concrete spillway is located on the right abutment of the dam. The side-channel inlet structure consists of an approach apron, an ungated L-shaped crest formed by an ogee section, and a trapezoidal trough section with base width of 40 ft expanding to a width of 120 ft along the 173 ft length. The ogee crest is at elevation 522.6 ft. The ogee crest has a design head of 7 ft. The invert slope of the spillway trapezoidal side-channel is at 0.0745 ft/ft until reaching the spillway transition zone to a rectangular chute with a slope of 0.01 ft/ft. The structure is joined at its downstream end by the vertical-walled spillway chute, which discharges into the Arroyo Grande Creek channel below the dam. The upper end of the spillway chute is tranversed by a reinforced concrete bridge deck supported by the counterforted sidewalls of the chute. The spillway plan, profile, and sections are shown in **Appendix A**.

Lopez Dam has an upstream control outlet structure comprising of seven 20-inch butterfly valves and a 36-inch butterfly valve installed in a sloping intake structure. The 36-inch butterfly valve is located at the bottom of the structure and isolates the sloping structure to the entrance of the outlet pipe. Reportedly, the 36-inch valve is never operated. Of the seven butterfly valves, six upper upstream butterfly valves are fully cycled, and the valve located at the lowest elevation is not cycled due to sediment concerns. Downstream control for the low-level outlet consists of a 42-inch knife gate blow-off valve, and the blow-off valve is fully cycled.

2.2 Watershed and Hydrology

Lopez Dam and Lake lay in the mouth between the Lopez Canyon sub-basin watershed and the Upper Arroyo Grande Creek sub-basin watershed (USGS Watershed Boundary Dataset [WBD], Hydrologic Unit 10) of the Arroyo Grande Creek watershed (WDB Unit 12) (shown on **Figure 4**). The Lopez Canyon sub-basin has a drainage area of 32 square miles and the

Upper Arroyo Grande Creek has a drainage are of 35.7 square miles. Both upper sub-basins drain into the Lower Arroyo Grande Creek sub-basin watershed where the lake resides.

The climate in the County of San Luis Obispo is mild with precipitation ranges from less than 10 inches per year in the eastern portion to more than 40 inches per year at higher elevations in the Santa Lucia Mountain range. In Arroyo Grande, CA the beginning of a water year can reach mean precipitation of 1.7 inches in November to 3.87 inches in February to March (Hydrology Report 2005). Record low temperatures can reach 23 degrees Fahrenheit in the winter season to record highs of 108 degrees Fahrenheit in summer months.

2.3 Downstream Impact Areas

Downstream of Lopez Dam are the cities of Arroyo Grande, Grover Breach, Pismo Beach, and unincorporated community of Oceano. Arroyo Grande has an estimated population of 18,097 (US Census, 2016) and a total area of 5.83 square miles, Grover Beach has an estimated population of 13,641 (US Census, 2016), Pismo Beach has an estimated population of 8,198 (US Census, 2016) with a total area of 13.48 square miles, and Oceano with a population of 7,286 (US Census, 2010) and total area of 1.55 square miles. The cities are in the coastal plains between the Pacific Ocean and the coastal mountain and valleys with majority of the cities in the low lying flat area with average elevations of El. 130 ft in the northeast city limits of Arroyo Grande close to the mountain terrains to southwest area with average elevations of 50 feet towards Grover Beach and Oceano. The flow path downstream of the dam will flow into Arroyo Grande Creek traveling southwest. Dense residential neighborhoods, commercial and industrial developments, recreational facilities, public facilities, and schools are concentrated in the southern portions of the cities of Arroyo Grande and Grover Beach and northern portion of Oceano.

Twelve in-line bridge/structures are identified as impact structures due to a hypothetical dam and spillway failure from Lopez Dam to the termination point into the ocean. These structures are considered significant in that they can impact and impede the flood wave of the dam breach and are incorporated in the hydraulic model development. **Table 2** includes the list of structures that are included in the hydraulic model evaluation.

2.4 Topographic Data and Field Survey

The best available topographic data was obtained through National Oceanic and Atmospheric Administration (NOAA) Office for Coastal Management, Digital Coast. The Digital Coast houses data sets which ranges from economic data to satellite imagery. A data request for the San Luis Obispo County area through the Digital Coast retrieved LiDAR data by PG&E (2011 and 2013 dataset) and the California Coastal Conservancy Coastal LiDAR Project (2010). Additional terrain data from the National Elevation Dataset (NED) raster product produced and distributed by the USGS were collected. The NED is derived from diverse source data and processed to a common coordinate system and unit of vertical measure. The NED was available at a resolution at 1/3-arc-second (approximately 10 meters) for San Luis Obispo County. The NED raster was used as a supplemental dataset for data gaps within the PG&E and Coastal LiDAR Project.

The LiDAR was mosaic with the Geographic Information Systems (GIS) software ArcMap with the PG&E data set as the priority set, Coastal data set as secondary, and the USGS NED set as last priority. The gridded raster resolution was set as the finest grid from the data sets which was the PG&E data at 1 foot grid. The three data were projected to the same projection, California State Plane Coordinate System Zone 5, in units of feet.

GEI staff coordinated with the District staff to obtain data of bridge structures along Arroyo Grande Creek. A developed hydraulic model, HEC-RAS, was provided to GEI showing the bridge crossings from Highway 101 downstream to the railroad crossing. Field survey and measurement of the structures performed by the District is listed on **Table 3**.

3. Previous Studies and Records

3.1 DSOD Record Documents

Recorded documents of Lopez Dam were retrieved from DSOD. The documents listed below are documents considered relevant to this study and does not include all documents at DSOD. The documents included:

1. DSOD Records of Inspection of Dam and Reservoir in Certified Status.

2. Preliminary Design Memorandum, Lopez Dam, Arroyo Grande, California, Lopez Water Supply Project, San Luis Obispo County Water Agency. DSOD File 1055, Item # 3.

3. Koebig and Koebig, Spillway Design Calculations. DSOD File 1055, Item # 15.

4. Lopez Project, Hydrology Review. DSOD File 1055, Item # 17.

5. Hydrologic Balance of Arroyo Grande Ground Water Basin. DSOD File 1055, Item # 18.

6. DSOD, National Dam Inspection Program, Phase 1 Inspection Report for Lopez Dam. DSOD File 1055, Item # 22.

7. Spillway Evaluation. DSOD File 1055, Item # 24.

8. Spillway Repair Interim Report. DSOD File 1055, Item # 30.

9. Rating Table for Lopez Reservoir Spillway. DSOD File 1055, Item # 40.

3.2 District Record Documents

Previous flood inundation studies of Lopez Dam have been analyzed for the District. In the *Downstream Flooding Due to the Hypothetical Failure of Lopez Dam* report of February 1999, Lopez Dam was evaluated for a hypothetical sunny day failure due to a design Maximum Credible Earthquake (MCE) and route the dam breach flood wave down Arroyo Grande Creek to the Pacific Ocean. The analysis determined that a dam failure (Scenario 1) would result in a dam breach peak discharge of 738,000 cfs and peak in 1.05 hours. The flood wave would travel downstream along the Arroyo Grande Creek and at the termination point of the ocean have a peak discharge of 29,700 cfs in approximately 2.71 hours after initial breach, have an initial flood time of 2.18 hours, create a maximum inundation depth of 15.7 ft, and deflood time of 7.6 hours. The maximum depth would be at Mason Street, approximately 7.3 miles downstream of the dam with a depth of 60.1 ft and peak discharge of 577,000 cfs.

4. Dam Breach Inundation Analysis

4.1 Hydraulic Model

A hydraulic model was developed to evaluate the hypothetical dam and spillway failure analysis of Lopez Dam using HEC-RAS, version 5.0.3. This version of HEC-RAS can perform one-dimensional (1D), two-dimensional (2D), as well as combined 1D and 2D unsteady-flow modeling (Saint Venant equations or Diffusive Wave equations). The hypothetical dam and spillway failure produced outflow hydrographs that was routed downstream into the floodplain. The advantages of using 2D modeling for the hypothetical dam failure are:

- Detailed dam and spillway breach analyzes.
- Detailed 2D channel and floodplain modeling.
- Direct connection of Lopez Lake storage area into the 2D floodplain areas with a hydraulic structure connection (Lopez Dam), and/or the ease of transfer of the dam break hydrograph as an indirect inflow hydrograph boundary condition to the 2D floodplain downstream of the dam.
- One floodplain area modeled from the reservoir to the termination point.
- Mixed flow regime is applied for this application. The 2D capability can handle supercritical and subcritical flow, flow transition from subcritical to super critical, and super critical to subcritical (hydraulic jumps).

2D modeling of the lake and floodplain are accomplished by using HEC-RAS geometric feature of adding or drawing *Storage Area* and *2D Flow Area* elements/polygons into the model, developing the 2D computational mesh (structured and unstructured), then linking the 2D flow areas to 1D elements such as hydraulic structures and/or directly connecting boundary conditions to the 2D areas. Associating the terrain to the 2D flow area, HEC-RAS will run a 2D geometric pre-processor for each mesh to establish a list of hydraulic properties table. Additional explanation and detailed procedure are included in the HEC-RAS 2D Modeling User's Manual.

4.2 HEC-RAS Model Development

The developed hydraulic 2D model encompasses the downstream floodplain simulated as an open area under unsteady state flow condition. **Figure 5** shows the topographic terrain extents and the hydraulic model geometric features detailed in HEC-RAS.

4.2.1 2D Flow Area

A HEC-RAS geometry *2D Flow Area* was developed downstream of Lopez Dam to the Pacific Ocean to evaluate the floodplain. To determine the appropriate grid selection for the *2D Flow Area*, a model with 2D mesh cell spacing of 50 ft x 50 ft, a model of 100 ft x 100 ft, and a model of 200 ft x 200 ft was analyzed for comparison. The three models were evaluated for floodplain inundation extents downstream of the dam using the same inflow hydrograph with a peak discharge of 25,391 cfs and a volume of 840 ac-ft. Comparing the three gridded models, the 50 ft gridded model inundated a total area of 3,439 acres, the 100 ft gridded model inundated a total area of 3,537 acres, and the 200 ft gridded model inundated a total area of 3,492 acres. The comparison of the additional results are provided in **Table 4**. From the comparison, the grid spacing of 100 ft x 100 ft was selected as the optimal grid size to perform detailed floodplain modeling. Although the time to finish the simulation was not as short as the 200 ft gridded model, the 100 ft gridded model inundation results are within a tolerable range with the 50 ft gridded model, which can capture reasonable results for urban area flood mapping.

HEC-RAS geometric *2D Area Breaklines* was added to capture the alignment of ridges, berms, and high grounds. The *2D Area Breaklines* forced the generated mesh to align its cell faces along the line. This feature will provide additional details to the floodplain area to direct flood wave to the appropriate flow path.

4.2.2 SA/2D Area Connections

HEC-RAS hydraulic connection features called *SA/2D Area Connections* was included in the 2D flow area to represent in-line structures (such as bridges) listed on **Table 3**. *SA/2D Area Connections* is a feature to input data for bridges into the model, such as elevation of top deck, bridge dimensions, culverts, piers, bridge coefficients, etc. The dimensions were referenced from the field survey collected by the District and a previous hydraulic model (HEC-RAS) developed by the District.

4.2.3 Land Cover

Land cover was based on USGS National Land Cover Database (NLCD) of 2011. Calibration efforts was not performed due to unavailable data, therefore, roughness (Manning's N-Value) values were assigned based on values reported for natural stream channels (Chow 1959) and based on best engineering judgement. **Table 5** includes the list of land cover type and the assigned roughness in the hydraulic model.

Additional sensitivity testing was performed for the land cover by increasing and decreasing the base n-values by 10 percent. The land cover sensitivity test was performed to test the n-value sensitivity associated with the floodplain. The analyses would determine if the selected base n-values should be changed based on the percentage of depth difference at specific locations downstream of the dam. The 100 ft x 100 ft gridded *2D Flow Area* described in Section 4.2.1 was used with the n-values from **Table 5** as the base land cover model. Comparing the base land cover model to the 10 percent increase of n-value and 10 percent

decrease of n-value models, the base land cover model inundated a total area of 3,537 acres, 3,551 acres for the +10 percent case, and 3,492 acres for the -10 percent case. **Table 6** summaries the comparison of depth results at specific locations within the floodplain.

By increasing the base n-values, the +10 percent model results generally decreased the inundation depths. By decreasing the n-values, the inundation depths increased. As the inundation depths increase in the floodplain, the comparative depth percent differences decreased, meaning the inundation depths were marginally the same as the inundation depth increased. Example, on **Table 6** the Huasna Road Bride percent differences were -0.7 percent for 10 percent increase of n-value, and 0.7 percent for 10 percent decrease when comparing to the base n-value. From the n-value comparative results, the base n-values were used for the Lopez Dam and spillway failure inundation analysis.

4.2.4 Boundary Conditions

In accordance to the FEMA guidelines for a sunny day dam failure, the reservoir was modeled at normal storage capacity with the starting water surface elevation set at the spillway elevation of 522.6 feet. A constant inflow of 10 cfs into the reservoir was applied to account for upstream inflow.

The downstream boundary condition at the model termination point, Pacific Ocean, was assigned a normal depth, friction slope of 0.001. The termination point was extended downstream to a point such that the hydraulic calculated energy slope would not impact the results upstream.

4.2.5 Computational Settings

The dam and spillway break model evaluation utilized a 1-second computation time step. This provided a balance between the level of accuracy desired and numerical tolerance stability for expected high velocities, exceeding 20 feet per second (fps). The dam and spillway break analysis used a mixed-flow regime along with the Diffusive Wave equation. These options can be used for rapidly varied flows such as flow transitions from subcritical to supercritical flow and hydraulic jumps.

4.3 HEC-RAS 2D Modeling Limitations

HEC-RAS can perform 2D modeling with known limitations. The following is a list of items HEC is working on to improve the software, and will be available in future versions:

1. More flexibility for adding internal hydraulic structures inside of a 2D flow area.
2. Cannot perform sediment transport erosion/deposition in the 2D flow areas.
3. Cannot perform water quality modeling in 2D flow areas.
4. Cannot connect pump stations to 2D flow area cells

5. Cannot use the HEC-RAS bridge modeling capabilities inside of a 2D flow area, but can be added as culverts, weir, and breaching by using the *SA/2D Area Conn* tool.

5. Breach Failure Analysis

5.1 Dam Breach Parameters

Breach parameters for Lopez Dam were developed based on published guidance documents, the foundation profile, and dam composition. Breach parameters were not selected to achieve a predetermined breach hydrograph but to provide a basis of potential breach hydrographs due to different conditions that could cause a dam failure. A fair weather (sunny day) non-hydrologic dam breach sensitivity analysis was performed for the earthen fill dam. The sunny day failure mode was selected to evaluate the dam breach and are based on the FEMA P-946 guidelines. The selection of parameters of the dam failure were based on best available data collected during this study and may not reflect real time conditions (e.g., weather conditions, vegetation and land cover, location of potential dam failure, reservoir conditions, etc.). For this case study, the parameters are kept consistent to test the dam breach peak, the release of volume, and attenuation. The sunny day dam failure is analyzed by establishing an initial reservoir water level and commencing a breach analysis with minimal inflow into the reservoir.

The Federal Energy Regulatory Commission (FERC) engineering guidelines recommends an average breach width of 1 to 5 times the height of the dam for earthen fill embankments. FERC guidelines for side slopes for engineered earthen structure is 0H: 1V to 1H: 1V and the time to failure is equal to 0.1 to 1 hour. **Table 7** is a summary of the possible estimates for breach characteristics for the various types of dam composition.

The dam breach was not evaluated with the National Weather Service BREACH Model due to lack of information to perform a breach analysis. The NWS BREACH model is a mathematical model used to simulate piping and/or over topping failure of earthen dams, either man-made or naturally formed by a landslide. To perform the dam breach analysis required the soil composites, and the geometric and material properties of the dam which are not currently available.

Referencing the dam breach characteristics set by FERC, the base case scenario for Lopez Dam breach was modeled as a sunny day, full reservoir, linear piping failure initiating at El. 500 ft, with a final bottom breach width of 500 ft, a side slopes of 0.5H: 1V, and a breach formation time of 1 hour. The breach geometry resulted in an average breach width of 575 ft. The bottom elevation of the breach was set at El. 372.9 ft. The failure was initiated with the lake pool at El. 522.6 ft. The breach parameters used for the modeling efforts are summarized in **Table 8**.

5.2 Dam Breach Sensitivity Analysis

In addition to the selection of the dam breach parameters for the base case, three sensitivity scenarios of parameter changes were analyzed by increasing and decreasing the breach width, time to failure, and side slope of the failure of the dam (Case 1, 2, and 3). The

sensitivity analysis was performed to test the sensitivity of the sunny day base case modeling scenarios with different dam breach parameters.

The minimum and maximum breach parameters were selected based on guidance from the estimates of dam breach parameters of FERC. The minimum and maximum times to fail for the earthen fill dam breach varied from 0.5 to 1.3 hour. The side slopes were varied from 0.2H: 1V to 1H: 1V and the minimum and maximum bottom breach widths were selected as 200 ft and 750 ft. This resulted in average breach widths varying from a minimum of 230 ft to a maximum of 900 ft.

The three failure cases are summarized below:

- Case 1 (maximum breach width, short time to failure, and maximum side slopes): Lopez Dam average breach width of 900 ft, 0.5 hour to time to failure, and side slopes of 1H: 1V.

- Case 2 (minimum breach width, medium time to failure, and minimum side slopes): Lopez Dam average breach width of 203 ft, 0.75 hour to time to failure, and side slopes of 0.2H: 1V.

- Case 3 (medium breach width, long time to failure, and medium side slopes): Lopez Dam average breach width of 440 ft, 1.3 hour to time to failure, and side slopes of 0.6H: 1V.

In addition to the sensitivity analyses recommended in the FERC Engineering Guidelines, published dam breach parameter estimation methods (parametric regression equations) were analyzed to evaluate the dam breach results. The breach parameters developed from Froehlich (2008), Von Thun & Gillette (1990), and Xu & Zhang (2009) methods were performed. The regression equations developed by Froehlich, Von Thun & Gillette, and Xu & Zhang have been used for several dam safety studies found in literature and are presented in greater detail in the *HEC-RAS for Dam Break Study, August 2014*.

Following the recommendations from the dam break study, the three additional failure cases are summarized below:

- Case 4 (Froehlich method, 2008): Lopez Dam average breach width of 314 ft, 0.88 hour to time to failure, and side slopes of 0.7H: 1V.

- Case 5 (Von Thun & Gillette method, 1990): Lopez Dam average breach width of 553 feet, 1.18 hour to time to failure, and side slopes of 0.5H: 1V.

- Case 6 (Xu & Zhang, 2009): Lopez Dam average breach width of 291.5 feet, 2.62 hour to time to failure, and side slopes of 0.47H: 1V.

The breach parameters used for each sensitivity analysis are shown on **Table 9**. The sensitivity analysis results for Lopez Dam and selected locations downstream are discussed in the Results Section.

5.3 Spillway Failure Analysis

Defined in the California Water Code, "critical appurtenant structure refers to a man-made barrier or hydraulic control structure that impounds the same reservoir as the dam and is 25 feet or more in height; impounds a minimum of 5,000 acre-feet of water at full reservoir conditions; or has the potential to inundate downstream life or property, including but not limited to emergency spillways, gated spillways, and saddle dams." Per the requirements of the California Water Code, the Lopez Dam spillway was evaluated for a failure mode because the spillway 1) impounds a minimum of 8,000 acre-feet of water with its design head of 7 ft ogee crest, and 2) has the potential to inundate downstream life or property.

Lopez Dam spillway was not evaluated for all possible case scenarios but was evaluated under a worse case condition involving complete failure of the spillway. The failure mode included the volume of storage behind the spillway ogee crest and total length of the spillway. The failure parameters were not selected to achieve a predetermined breach hydrograph but to provide the circumstance for a potential breach that could cause the spillway to fail. A sunny day dam spillway failure mode analysis was performed. The spillway failure analysis was based on best available data collected during this study and may not reflect real time conditions (e.g., weather conditions, location and extents of potential spillway failure, reservoir conditions, etc.). The sunny day dam failure is analyzed by establishing an initial reservoir water level and commencing a breach analysis with minimal inflow into the reservoir.

The case scenario for Lopez Dam spillway breach was modeled as a sunny day, full reservoir, linear piping failure initiating at El. 515.9 ft, with a final bottom breach width equal to the length of the spillway of 237 ft, vertical side slopes of 0H: 1V, and a breach formation time of 0.1 hour. The bottom elevation of the breach was set at El. 515.9 ft. The failure was initiated with the lake pool at the spillway crest, El. 522.6 ft.

6. Results

The results indicate that a hypothetical failure of the Lopez Dam and failure of the spillway for the sunny day conditions would potentially cause adverse consequences such as loss of life, property damage, and economic, social, and environmental impacts. There may also be potential impacts upstream of the dam due to backwater flooding or landslides around the lake.

Sections 6.1 and 6.2 summarizes the results of the hypothetical dam sunny day failure and the floodplain inundation. **Table 11** provides a summary of the model results at selected cross sections for the dam failure. Sections 6.3 and 6.4 summarizes the results of the hypothetical dam spillway failure and floodplain inundation. **Table 13** provides a summary of the model results at selected cross sections for the spillway failure. The tabulated results include the initial flood wave arrival time, time to peak, time to deflood, peak water surface elevation (WSEL), peak flow, peak velocity, and maximum inundation depth.

The "initial wave arrival time" is the elapsed time from breach initiation to a 1 ft increase in WSEL at a cross section. The "time to peak" is the elapsed time from breach initiation to peak WSEL at a cross section. The "deflood time" is the time elapsed from the flood wave arrival time until water recedes to within 1 ft of its preflood water elevation at a cross section. The "peak inundation depth" is the maximum water depth at a station within the cross section. The "peak velocity" is the maximum velocity at a station resulted across the cross section. The "peak discharge" is an estimate of the maximum flow rate integrated over the entire cross section. The "peak water elevation" is the maximum water surface elevation reached at a station resulted across the cross section.

The inundation maps for the hypothetical sunny day failure of the dam under base case and failure of the spillway are provided in **Appendix C**. The HEC-RAS electronic files are provided in **Appendix D**. The electronic data files associated with the inundation maps (including shapefiles, raster and PDF images of the maps, and metadata text files) are provided in **Appendix D**.

6.1 Dam Sunny Day Failure Results

The hypothetical dam failure resulted in hydrographs that was used for the hydraulic inundation model analysis. The analysis for the dam breach, base case scenario indicates that a sunny day hypothetical failure of Lopez Dam would produce a peak discharge of 833,330 cfs at the dam approximately 54 minutes after the breach initiates. The breach would drain the reservoir in approximately 4 hours and 36 minutes. The dam breach hydrograph is shown on **Figure 6**. Comparing the base case scenario to the sensitivity analysis of Case 1 to Case 6 (as shown on **Table 10**), the base case scenario was within the high ranges of maximum flows from all seven scenarios. The maximum peak flow occurred on Case 1 with a discharge of 1,545,667 cfs. This maximum flow can be attributed to a fast time to failure of 0.5 hour and the widest breach opening that resulted with a fast and intense release of water from the

dam breach. The lowest peak flow occurred on Case 6 with a breach discharge of 323,755 cfs which can be attributed to the small breach width opening compared to the seven cases and the longest time to failure.

6.2 Dam Failure Flood Inundation Results

The base case of the hypothetical Lopez Dam sunny day failure results at specific locations are presented in **Table 11**. The tabular table includes the time to peak, maximum water surface elevation, maximum flow, and deflood time. The flood inundation extents and details are provided in **Appendix C**. The results for the sunny day failure assume the flood wave is not diverted into the local stormwater drainage system, no loss of water due to soil infiltration, no pumps are active, and no buildings in place to obstruct, divert, or store the flood wave.

The model results of the sunny day hypothetical failure of Lopez Dam produced a peak discharge of 833,330 cfs at the dam approximately 54 minutes after the breach initiates. The breach would drain the reservoir in approximately 276 minutes (4 hours and 36 minutes). As the peak flood wave is routed downstream of the dam, the flood wave is dispersed and attenuated through the meandering Arroyo Grande Creek and water flowing out of the channel into the overbanks. The flood wave would travel 12.6 miles downstream reaching the Pacific Ocean at approximately 1 hour and 39 minutes. **Figure 7** shows the flood wave attenuation at specific cross sections detailed below (**Appendix C** shows the cross sections location). The maximum depth of the flood wave would reach 66 ft in the Arroyo Grande Creek and inundate the overbanks with depths up to 30 ft. Approximately 1,003 acres of the City of Arroyo Grande is inundated within the areas along the Arroyo Grande Creek. Southern communities of Oceano would be inundated at the south bend of Arroyo Grande Creek downstream of Cabrillo Highway. As the immense flood wave travels through the City of Arroyo Grande, it will travel to the neighboring cities of Grover Beach and Pismo Beach and inundate approximately 187 acres of Grover Beach and 220 acres of Pismo Beach. Downstream of Lopez Dam, 11 critical facilities such as healthcare facilities, schools/day cares, and law enforcement facilities are impacted by the flood wave. **Table 12** shows the depth of the impacted facilities.

Cross Section #1, located about 1.6 miles downstream of the lake, the flood wave would arrive about 15 minutes after the breach initiates. About 58 minutes after the breach, the peak water surface elevation would be at El. 380 ft resulting in an incremental maximum rise of 39.7 ft. The flow would be approximately 825,491 cfs with velocities at 37.6 fps.

Cross Section #2, the flood wave would arrive at Camino Las Ventanas located 2.5 miles downstream of Lopez Dam at approximately 21 minutes after the breach initiates. The peak water surface elevation would overtop the bridge deck at flows of 822,973 cfs with a maximum depth of 43.5 ft in Arroyo Grande Creek.

Cross Section #3, 2.9 miles downstream at Talley Farms Road crossing over Arroyo Grande Creek reaches flows of 820,185 cfs. The flood wave would arrive about 24 minutes after the

breach and result in a maximum inundation depth of 35.7 ft in Arroyo Grande Creek in 1 hour and 1 minutes.

Cross Section #4, located about 3.4 miles downstream and southeast of Terminal Dam and Reservoir, the flood wave would arrive about 27 minutes after the breach initiates. About 1 hour and 2 minutes after the breach, the peak inundation depths would reach 28.5 ft. The flood wave would reach peak flows of 819,320 cfs and peak velocities of 25.7 fps. It would take 5 hours and 37 minutes for the water to recede below 1 ft.

Cross Section #5, the flood wave would reach 4.8 miles downstream of the dam at approximately 35 minutes after the breach initiates. The peak water surface elevation would reach El. 251 ft at flows of 815,789 cfs with a maximum depth of 37.3 ft in Arroyo Grande Creek. The flood wave would peak at 1 hour and 5 minutes.

Cross Section #6, 6.1 miles downstream at Huasna Road crossing over Arroyo Grande Creek reaches flows of 810,902 cfs and velocities of 21 fps. The flood wave would arrive at 41 minutes after the breach and results in an incremental rise of 51.3 ft in 1 hour and 8 minutes in Arroyo Grande Creek. The maximum depth would overflow the channel and inundate the overbanks with depths up to 20 ft.

Cross Section #7, located approximately 6.8 miles downstream of the dam to the Tar Spring Creek, the flood wave would arrive at 46 minutes after the breach initiates. About 1 hour and 11 minutes after the breach, the peak water surface elevation would reach El. 193 ft resulting in an incremental rise of 55.9 ft in the channel. The peak flow would be at 800,646 cfs. Within the cross-sectional extents, the flood wave would recede below 1 ft after 8 hours and 18 minutes.

Cross Section #8, 7.7 miles downstream of Arroyo Grande Creek the flood wave reaches flows of 778,847 cfs. The flood wave would arrive about 51 minutes after the breach and result in a maximum inundation depth of 55.9 ft in Arroyo Grande Creek in 1 hour and 15 minutes. Overbanks depths would reach 30 ft-high with velocities of 23.2 fps.

Cross Section #9, 8.7 miles downstream of the dam at Traffic Way crossing over Arroyo Grande Creek, the maximum flows would be at 747,274 cfs with velocities of 15.4 fps. The channel depths would reach 54.2 ft overtopping the crossing and inundate the overbanks with heights of 27 ft. The initial flood wave would arrive at 1 hour and peak at 1 hour and 20 minutes. It would take 13 hours and 28 minutes for the flood wave to recede to 1 ft and below.

Cross Section #10, located approximately 8.8 miles downstream of the dam at US Highway 101, the flood wave would arrive at 1 hour and 1 minute after the breach initiates. About 1 hour and 21 minutes after the breach, the peak water surface elevation would reach El. 137 ft resulting in an incremental rise of 47.2 ft in the channel. The peak flow would be at 745,518 cfs with velocities of 13.6 fps. Within the cross-sectional extents, the flood wave would recede below 1 ft after 13 hours and 42 minutes.

Cross Section #11, the flood wave would arrive at Fair Oaks Avenue located 9.5 miles downstream of the dam at approximately 1 hour and 7 minutes after the breach initiates. The peak flows would reach 738,637 cfs with a maximum depth of 42.9 ft in the channel. Peak velocities would reach 23.5 fps.

Cross Section #12, 10.6 miles downstream of the dam at Cabrillo Highway (Highway 1) the flood wave would reach flows of 712,253 cfs. The arrival time to 1 ft would be at 1 hour and 17 minutes after the breach initiates and result in an incremental rise to 23 ft at 1 hour and 30 minutes in the channel and average depths of 15 ft in the overbanks.

Cross Section #13, located approximately 11.5 miles downstream of the dam at the railroad crossing Arroyo Grande Creek, the flood wave would arrive at 1 hours and 23 minutes after the breach initiates. About 1 hour and 35 minutes the flood wave would reach the peak water surface elevation of 42 ft, resulting in a maximum inundation depth of 18.2 ft in the channel and average depths of 13 ft in the overbanks. The peak flow would be at 687,619 cfs with velocities of 18.2 fps. Within the cross-sectional extents, the flood wave would recede below 1 ft after 18 hours and 50 minutes.

Cross Section #14, the extents of the flood wave would reach the outlet of Arroyo Grande Creek into the coastal shores, at approximately 1 hour and 39 minutes. At 12.6 miles downstream, the peak flood wave would take 2 hours and 18 minutes to reach peak flows after flooding and attenuating through the channel and overbank areas. Peak flows would reach 243,239 cfs. The incremental rise would reach a maximum depth of 22.7 ft in the channel and maximum velocities of 13.6 fps.

6.3 Spillway Failure Results

The hypothetical Lopez Dam spillway failure resulted in hydrographs that were used for the hydraulic inundation model analysis. The analysis for the spillway failure indicates that a sunny day hypothetical failure would produce a peak discharge of 10,524 cfs at the dam approximately 8 minutes after the breach initiates. The dam breach hydrograph is shown on **Figure 8**. The 7 ft-high flood waves would create a volume of 4,811 ac-ft discharging into the spillway and into the Arroyo Grande Creek.

6.4 Spillway Failure Flood Inundation Results

Downstream of Lopez Dam, two critical facilities such as healthcare facility and school/day care are impacted by the flood wave. **Table 13** shows the depth of the impacted facilities. The hypothetical Lopez Dam spillway failure results at specific locations are presented in **Table 14**. The tabular table includes the time to peak, maximum water surface elevation, maximum flow, and deflood time. The flood inundation extents and details are provided in **Appendix C**. The results for the spillway failure assumes the flood wave is not diverted into the local stormwater drainage system, no loss of water due to soil infiltration, no pumps are active, and no buildings in place to obstruct, divert, or store the flood wave.

The model results of the hypothetical spillway failure of Lopez Dam produced a peak discharge of 10,524 cfs at the dam approximately 8 minutes after the breach initiates. As the peak flood wave is routed into the spillway and downstream of the dam, the flood wave is dispersed and attenuated through the meandering Arroyo Grande Creek and water flowing out of the channel into the overbanks. The flood wave would travel 12.6 miles downstream reaching the Pacific Ocean at approximately 3 hours and 54 minutes. **Figure 8** shows the flood wave attenuation at specific cross sections detailed below (**Appendix C** shows the cross sections location). The maximum depth of the flood wave would reach 31 ft in Arroyo Grande Creek and inundate over the banks with depths up to 5 ft. Approximately 101 acres of the City of Arroyo Grande is inundated within the areas along the Arroyo Grande Creek. Southern communities of Oceano would be inundated at the south bend of Arroyo Grande Creek downstream of Cabrillo Highway.

Cross Section #1, located about 1.6 miles downstream of the lake, the flood wave would arrive about 20 minutes after the breach initiates. About 38 minutes after the breach, the peak water surface elevation would be at El. 346 ft resulting in an incremental maximum rise of 5.5 ft. The flow would be at approximately 9,803 cfs with velocities at 7.5 fps.

Cross Section #2, the flood wave would arrive at Camino Las Ventanas located 2.5 miles downstream of Lopez Dam at approximately 32 minutes after the breach initiates. The peak flows would be at 9,655 cfs with a maximum depth of 11.6 ft in Arroyo Grande Creek.

Cross Section #3, 2.9 miles downstream at Talley Farms Road crossing over Arroyo Grande Creek reaches flows of 9,227 cfs. The flood wave would arrive about 38 minutes after the breach and result in a maximum inundation depth of 21.2 ft in Arroyo Grande Creek in 1 hour and 10 minutes.

Cross Section #4, located about 3.4 miles downstream and southeast of Terminal Dam and Reservoir, the flood wave would arrive about 46 minutes after the breach initiates. About 1 hour and 16 minutes after the breach, the peak inundation depths would reach 10.2 ft. The flood wave would reach peak flows of 9,180 cfs and peak velocities of 10.2 fps. It would take 55 hours and 12 minutes for the water to recede below 1 ft.

Cross Section #5, the flood wave would reach 4.8 miles downstream of the dam at approximately 1 hour and 2 minutes after the breach initiates. The peak water surface elevation would reach El. 224 ft at flows of 9,009 cfs with a maximum depth of 12.1 ft in Arroyo Grande Creek. The flood wave would peak at 1 hour and 30 minutes.

Cross Section #6, 6.1 miles downstream at Huasna Road crossing over Arroyo Grande Creek reaches flows of 8,529 cfs and velocities of 9.5 fps. The flood wave would arrive at 1 hour and 18 minutes after the breach and result in an incremental rise of 26.7 ft in 2 hours and 4 minutes in Arroyo Grande Creek.

Cross Section #7, located approximately 6.8 miles downstream of the dam to the Tar Spring Creek, the flood wave would arrive at 1 hour and 30 minutes after the breach initiates. About 2 hours and 16 minutes after the breach, the peak water surface elevation would reach El. 152 ft resulting in an incremental rise of 16.0 ft in the channel. The peak flow would be at 8,421

cfs. Within the cross-sectional extents, the flood wave would recede below 1 ft after 57 hours and 6 minutes.

Cross Section #8, 7.7 miles downstream of Arroyo Grande Creek the flood wave reaches flows of 8,249 cfs. The flood wave would arrive about 1 hour and 50 minutes after the breach and result in a maximum inundation depth of 22.8 ft in Arroyo Grande Creek in 2 hour and 40 minutes.

Cross Section #9, 8.7 miles downstream of the dam at Traffic Way crossing over Arroyo Grande Creek, the maximum flows would be at 8,151 cfs with velocities of 5.5 fps. The channel depths would reach 22.4 ft. The initial flood wave would arrive at 2 hour and 14 minutes and peak at 3 hours and 2 minutes. It would take 60 hours and 32 minutes for the flood wave to recede to one foot and below.

Cross Section #10, located approximately 8.8 miles downstream of the dam at US Highway 101, the flood wave would arrive at 2 hours and 16 minutes after the breach initiates. About 3 hours and 2 minutes after the breach, the peak water surface elevation would reach El. 96 ft resulting in an incremental rise of 19.2 ft in the channel. The peak flow would be at 8,128 cfs with velocities of 4.1 fps. Within the cross-sectional extents, the flood wave would recede below 1 ft after 60 hours and 40 minutes.

Cross Section #11, the flood wave would arrive at Fair Oaks Avenue located 9.5 miles downstream of the dam at approximately 2 hour and 30 minutes after the breach initiates. The peak flows would reach 8,052 cfs with a maximum depth of 20.5 ft in the channel. Peak velocities would reach 6.1 fps.

Cross Section #12, 10.6 miles downstream of the dam at Cabrillo Highway (Highway 1) the flood wave would reach flows of 7,966 cfs. The arrival time to 1 ft would be at 2 hours and 56 minutes after the breach initiates and result in an incremental rise to 11.1 ft at 3 hours and 42 minutes in the channel.

Cross Section #13, located approximately 11.5 miles downstream of the dam at the railway crossing Arroyo Grande Creek, the flood wave would arrive at 3 hours and 20 minutes after the breach initiates. About 4 hours and 54 minutes the flood wave would reach the peak water surface elevation of 32 ft, resulting in a maximum inundation depth of 9.1 ft in the channel. The peak flow would be at 6,597 cfs with velocities of 4.7 fps. Within the cross-sectional extents, the flood wave would recede below 1 ft after 63 hours and 42 minutes.

Cross Section #14, the extents of the flood wave would reach the outlet of Arroyo Grande Creek into the coastal shores, at approximately 3 hours and 54 minutes. At 12.6 miles downstream, the peak flood wave would take 9 hours and 40 minutes to reach peak flows after flooding and attenuating through the channel and overbank areas. Peak flows would reach 2,716 cfs. The incremental rise would reach a maximum depth of 7.7 ft in the channel and maximum velocities of 2.2 fps.

7. Limitation of Liability

Our professional services for preparing the Lopez Dam and Spillway Inundation Technical Study were performed in accordance with generally accepted engineering practices; no other warranty, expressed or implied, is made. This report presents the results of a hypothetical failure of Lopez Dam and its critical appurtenant structures subsequent downstream flooding. The hypothetical failure of the Lopez Dam and the subsequent flood wave routing results are based on our best judgment and the suggested breach parameters and hydraulic modeling techniques as recommended in the Federal Emergency Management Agency (FEMA) Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures, First Edition, July 2013 (FEMA P-946). The results of this analysis should only be used to estimate potential downstream impacts based on the assumed failure conditions. If any portion of the Lopez Dam were to fail, actual breach conditions, peak flows, and peak water surface elevation may vary from those presented in this report.

The hypothetical failure of the dam and spillway, and assumed breach conditions, do not indicate or represent the actual integrity, condition, or safety of Lopez Dam. Reuse of this report for any other purposes, in part or in whole, is at the sole risk of the user.

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Table 1. Lopez Dam Statistics Summary (Source: DSOD)

Description	Value
Elevation of dam crest (feet)	538.9
Elevation of spillway crest (feet)[1]	522.6
Upstream slope	3H: 1V
Downstream slope	3H: 1V
Elevation of upstream toe (estimated, feet)[1]	392.6
Elevation of streambed, downstream toe (estimated, feet)	372.9
Storage capacity at max. pool elevation (estimated, acre-feet)	70,000
Storage capacity at spillway elevation (estimated, acre-feet)[1]	49,388
Dam height (feet)	166
Dam crest length (feet)	1,120
Dam crest width (feet)	40
Total Freeboard (top of crest to spillway, feet)	16.3

1. Data obtained from the District, in references to the Lopez Lake Reservoir Survey performed on March 2002.
2. Elevation datum NAVD 88.

Table 2. Hydraulic Structures Downstream of Lopez Dam

Structures	Distance Downstream of Dam
Camino Las Ventanas crossing over Arroyo Grande Creek	2.5 miles
Talley Farms Road	2.9 miles
Cecchetti Road crossing over Arroyo Grande Creek	4.8 miles
Huasna Road crossing over Arroyo Grande Creek	6.1 miles
Mason Street crossing over Arroyo Grande Creek	8.4 miles
Bridge Street crossing over Arroyo Grande Creek	8.6 miles
Traffic Way crossing over Arroyo Grande Creek	8.7 miles
US Highway 101 crossing over Arroyo Grande Creek	8.8 miles
Fair Oaks Avenue crossing over Arroyo Grande Creek	9.5 miles
Cabrillo Highway (Hwy 1) crossing over Arroyo Grande Creek	10.6 miles
2nd Street crossing over Arroyo Grande Creek	11.4 miles
Railroad bridge crossing over Arroyo Grande Creek	11.5 miles

Table 3. Field Measurement of Bridges (December 2017)

Structures	Deck Width (ft)	Deck Length (ft)	Abutment Length (ft)	# Piers
Grieb Ranch Way	24	130		24
Talley Farms Road	24	94		
Huasna Road	22	87	43	
Mason Street	28	169	22	
Bridge Street	36	141		
Traffic Way	45	225		
Fair Oaks Avenue	76	130		5 groups

Table 4. 2D Flow Area Gridded Model Sensitivity Comparison

Results	50 ft Grids	100 ft Grids	200 ft Grids
Area of Inundation Extents (acre)	3,439	3,537	2,394
Model Simulation Time (hh:mm:ss)	1:28:28	0:42:37	0:06:36
Maximum Depth (feet)	58.1	51.1	38.2
Model Grid Cells (No.)	269,980	67,360	16,791

Table 5. NLCD Land Cover and Assigned Manning's N-Value

USGS ID	Description	Manning's N-Value
11	Open Water	0.03
12	Perennial Ice/Snow	0.03
21	Developed, Open Space	0.08
22	Developed, Low Intensity	0.1
23	Developed, Medium Intensity	0.15
24	Developed, High Intensity	0.2
31	Barren Land (Rock/Sand/Clay)	0.04
41	Deciduous Forest	0.1
42	Evergreen Forest	0.1
43	Mixed Forest	0.1
52	Shrub/Scrub	0.07
71	Grassland/Herbaceous	0.035
81	Pasture/Hay	0.04
82	Cultivated Crops	0.035
90	Woody Wetlands	0.05
95	Emergent Herbaceous Wetlands	0.08

Table 6. Assigned Manning's N-Value Model Sensitivity Results Comparison

Location #	Location / Description	D/S of Dam (mi)	Base Case Depth (ft)	+10% Case Depth (ft)	-10% Case Depth (ft)
1	Huasna Road Bridge	6.1	42.72	42.43	43.02
2	Intersection Allen St & Garden St	8.1	6.68	5.9	7.43
3	Intersection Leanna Dr. & Pearl Dr.	10.1	5.16	4.52	5.73
4	Cabrillo Hwy Bridge	10.6	0.89	0.9	1.08
5	South of Oceano County Airport	12.6	1.74	1.77	1.71
6	Intersection 22nd St & Produce Pl	11.4	0.37	0.24	0.54

Table 7. Ranges of Possible Values for Breach Characteristics (Source: *HEC-RAS Dam Break Study, August 2014*)

Dam Type	Average Breach Width (B_{ave})	Horizontal Component of Breach Side Slope (H) (H:V)	Failure Time, t_f (hours)	Agency
Earthen/Rockfill	(0.5 to 3.0) x HD	0 to 1.0	0.5 to 4.0	USACE 1980
	(1.0 to 5.0) x HD	0 to 1.0	0.1 to 1.0	FERC
	(2.0 to 5.0) x HD	0 to 1.0 (slightly larger)	0.1 to 1.0	NWS
	(0.5 to 5.0) x HD*	0 to 1.0	0.1 to 4.0*	USACE 2007
Concrete Gravity	Multiple Monoliths	Vertical	0.1 to 0.5	USACE 1980
	Usually ≤ 0.5 L	Vertical	0.1 to 0.3	FERC
	Usually ≤ 0.5 L	Vertical	0.1 to 0.2	NWS
	Multiple Monoliths	Vertical	0.1 to 0.5	USACE 2007
Concrete Arch	Entire Dam	Valley wall slope	≤ 0.1	USACE 1980
	Entire Dam	0 to valley walls	≤ 0.1	FERC
	(0.8 x L) to L	0 to valley walls	≤ 0.1	NWS
	(0.8 x L) to L	0 to valley walls	≤ 0.1	USACE 2007
Slag/Refuse	(0.8 x L) to L	1.0 to 2.0	0.1 to 0.3	FERC
	(0.8 x L) to L		≤ 0.1	NWS

*Note: Dams that have very large volumes of water, and have long dam crest lengths, will continue to erode for long durations (i.e., as long as a significant amount of water is flowing through the breach), and may therefore have longer breach widths and times than what is shown in Table 3. HD = height of the dam; L = length of the dam crest; FERC - Federal Energy Regulatory Commission; NWS - National Weather Service

Table 8. Sunny-Day Breach Parameters (Base Case)

Parameter	Value
Failure Scenario	Sunny Day
Failure Mode	Piping
Failure Progression	Linear
Initial Water Surface Elevation (feet)	522.6
Initial Storage (acre-feet)	49,388
Bottom Breach Elevation (feet)	392.6
Breach Height (feet)	146.3
Bottom Breach Width (feet)	500
Side Slopes (_H:1V)	0.5
Average Breach Width (feet)	573.1
Time to Full Formation (hours)	1

Table 9. Lopez Dam Breach Sensitivity Analysis Parameters

Parameters	Base Case	Case 1	Case 2	Case 3	Case 4 Froehlich (2008)	Case 5 Von Thun & Gillete	Case 6 Xu & Zhang
Dam Crest Length, feet	1120	1120	1120	1120	1120	1120	1120
Dam Crest Elevation, feet	538.9	538.9	538.9	538.9	538.9	538.9	538.9
Min Foundation Elevation, feet	372.9	372.9	372.9	372.9	372.9	372.9	372.9
Max Height of Dam, feet	166	166	166	166	166	166	166
Dam Breach Height, feet	146.3	146.3	146.3	146.3	146.3	146.3	146.3
Side Slopes, _H:1V	0.5	1	0.2	0.6	0.7	0.5	0.52
Top Breach Width, feet	646.3	1042.5	258.5	525.5	421.8	578.3	356.1
Average Breach Width, feet	573.1	896.3	229.3	437.8	319.4	505.1	280.1
Bottom Breach Width, feet	500	750	200	350	217	432	204
Bottom Breach Elevation, feet	392.6	392.6	392.6	392.6	392.6	392.6	392.6
Maximum Reservoir Elevation, feet	533.9	533.9	533.9	533.9	533.9	533.9	533.9
Reservoir Elevation at Breach Initiation, feet	522.6	522.6	522.6	522.6	522.6	522.6	522.6
Time of Failure, hours	1	0.5	0.75	1.3	0.98	1.04	2.81

Table 10. Lopez Dam Breach Sensitivity Hydrograph Comparison

Scenario #	Peak Discharge (cfs)	Time to Peak from Initial Breach (hh:mm)	Time for Reservoir to Drain (hh:mm)
Base Case	833,330	0:54	4:36
Case 1	1,545,667	0:30	3:12
Case 2	665,408	0:46	8:12
Case 3	648,866	1:12	5:58
Case 4	708,575	1:00	7:52
Case 5	793,942	0:58	5:04
Case 6	323,755	2:30	9:30

Table 11. Lopez Dam Inundation Cross Sectional Results

Cross Section	Distance from Dam (mi)	Station	Initial Wave Arrival Time, 1 Foot (hh:mm)	Time to Peak (hh:mm)	Deflood Time, 1 Foot (hh:mm)	Peak Inundation Depth[1] (ft)	Peak Velocity (fps)	Peak Discharge (cfs)	Peak Water Surface Elevation (ft)	Location Description
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	805,882	N/A	At Lopez Dam
1	1.6	83+22	0:14	1:00	4:41	33.1	37.2	797,987	379	Downstream of Lopez Lake
2	2.5	131+49	0:20	1:02	5:41	42.3	37.4	794,928	343	Camino Las Ventanas
3	2.9	153+20	0:23	1:03	6:13	45.1	36.6	791,872	328	Talley Farms Road
4	3.4	179+80	0:26	1:04	6:35	31.0	25.4	790,853	301	Downstream of Terminal Reservoir
5	4.8	255+54	0:33	1:07	7:14	36.9	31.7	786,875	251	Cecchett Road
6	6.1	320+24	0:40	1:10	7:58	50.5	20.8	781,609	217	Upstream of Huasna Road
7	6.8	359+57	0:45	1:12	8:35	55.4	20.5	771,138	195	Downstream of Tar Spring Creek
8	7.7	406+81	0:51	1:16	10:40	55.3	22.5	750,551	172	
9	8.7	460+77	1:00	1:22	12:03	53.4	15.1	722,966	142	Traffic Way
10	8.9	467+83	1:01	1:23	12:16	46.9	13.4	721,210	136	US 101 Highway
11	9.5	503+18	1:07	1:26	13:14	42.3	23.2	715,282	103	Fair Oaks Avenue
12	10.6	560+97	1:16	1:32	14:32	22.5	19.0	692,569	69	Cabrillo Highway (Hwy 1)
13	11.6	610+70	1:24	1:36	15:58	19.3	16.9	670,080	42	Railroad Bridge downstream of 22nd Street
14	12.6	667+86	1:40	2:22	>24:00	22.9	13.8	251,224	31	Outlet of Arroyo Grande Creek into Ocean

1. Peak Inundation Depth is not representative of the flooding depth along the entire cross section but the water surface elevation to the lowest ground of the cross section.

Table 12. Lopez Dam Sunny Day Failure Impacted Facilities

Facility #	Facility	Name	Max. Inundation Depth (ft)
1	Healthcare	Community Health Centers Arroyo Grande H.S.	11.5
2	Healthcare	Community Health Centers, Arroyo Grande	20.4
3	Healthcare	Community Health Centers, Oceano	16.2
4	School/Day Care	Village Preschool	26.2
5	School/Day Care	Arroyo Grande High School	20.3
6	School/Day Care	Lighthouse Christian School	21.6
7	School/Day Care	Pacific Coast Christian School	15.8
8	Law Enforcement	Parks & Rec. – Pismo Beach/Ocean Campground	4.5
9	Law Enforcement	SLO County Sheriff – South Patrol	0.4
10	Law Enforcement	P&R – PD State Vehicle Recreation Area	5.9
11	Law Enforcement	P&R – Pismo Beach/North Beach Campground	7.1

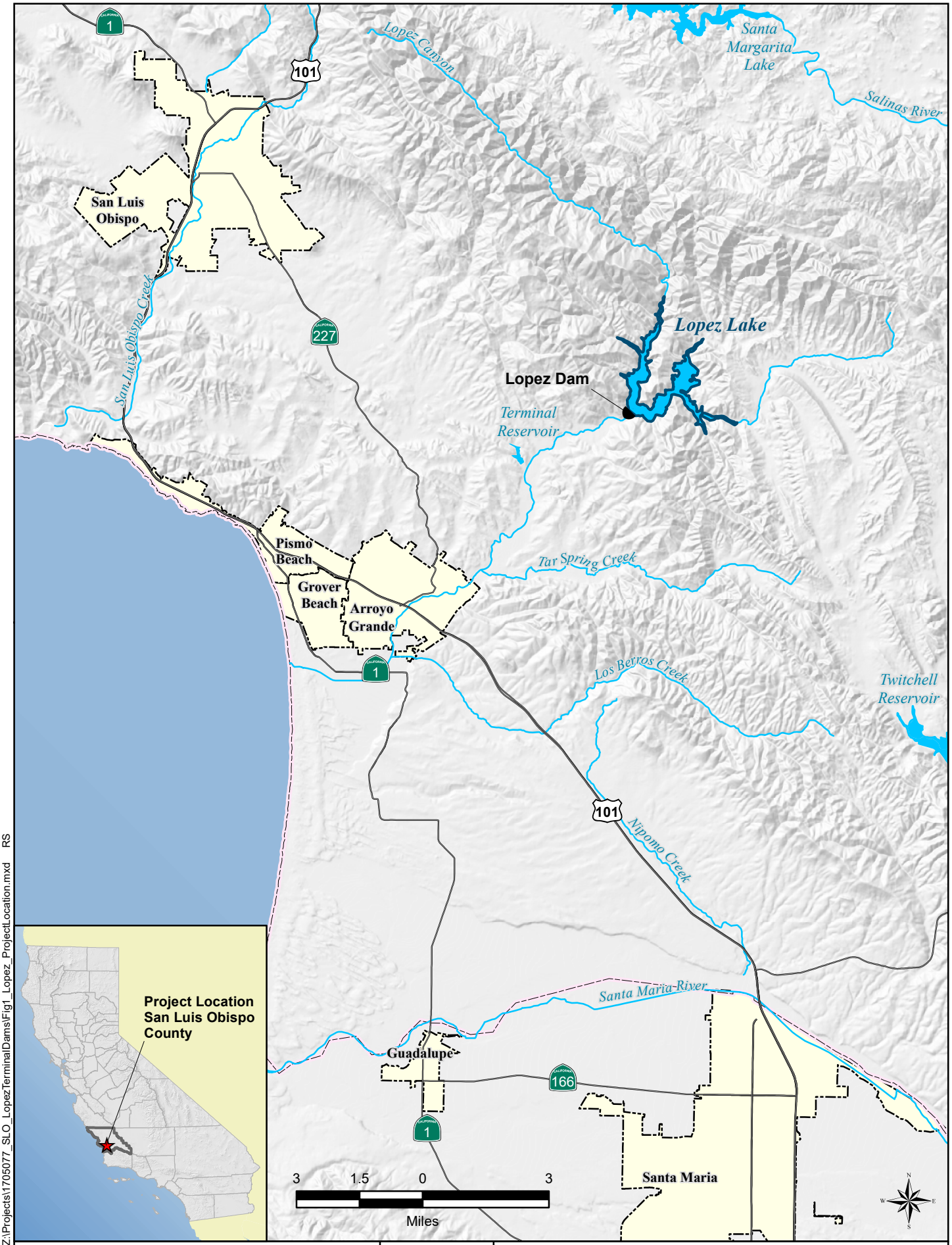
Table 13. Lopez Dam Spillway Failure Impacted Facilities

Facility #	Facility	Name	Max. Inundation Depth (ft)
1	Healthcare	Community Health Centers, Oceano	3.3
2	School/Day Care	Lighthouse Christian School	21.6

Table 14. Lopez Dam Spillway Inundation Cross Sectional Results

Cross Section	Distance from Dam (mi)	Station	Initial Wave Arrival Time, 1 Foot (hh:mm)	Time to Peak (hh:mm)	Deflood Time, 1 Foot (hh:mm)	Peak Inundation Depth[1] (ft)	Peak Velocity (fps)	Peak Discharge (cfs)	Peak Water Surface Elevation (ft)	Location Description
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	10,524	N/A	At Lopez Dam Spillway
1	1.6	83+22	0:20	0:38	54:00	5.5	7.5	9,803	346	Downstream of Lopez Lake
2	2.5	131+49	0:32	0:50	54:26	11.6	6.2	9,655	311	Camino Las Ventanas
3	2.9	153+20	0:38	1:10	54:58	21.2	9.2	9,227	306	Talley Farms Road
4	3.4	179+80	0:46	1:16	55:12	10.2	10.1	9,180	279	Downstream of Terminal Reservoir
5	4.8	255+54	1:02	1:30	55:50	12.1	6.7	9,009	224	Cecchett Road
6	6.1	320+24	1:18	2:04	56:30	26.7	9.5	8,529	193	Upstream of Huasna Road
7	6.8	359+57	1:30	2:16	57:06	16.0	4.2	8,421	152	Downstream of Tar Spring Creek
8	7.7	406+81	1:50	2:40	59:06	22.8	8.9	8,249	138	
9	8.7	460+77	2:14	3:02	60:32	22.4	5.5	8,151	100	Traffic Way
10	8.9	467+83	2:16	3:04	60:40	19.2	4.1	8,128	96	US 101 Highway
11	9.5	503+18	2:30	3:18	61:30	20.5	6.1	8,052	79	Fair Oaks Avenue
12	10.6	560+97	2:56	3:42	62:46	11.1	4.4	7,966	53	Cabrillo Highway (Hwy 1)
13	11.6	610+70	3:20	4:54	63:42	9.1	4.7	6,597	32	Railroad Bridge downstream of 22nd Street
14	12.6	667+86	3:54	9:40	67:12	7.7	2.2	2,716	16	Outlet of Arroyo Grande Creek into Ocean

1. Peak Inundation Depth is not representative of the flooding depth along the entire cross section but the water surface elevation to the lowest ground of the cross section.



Lopez Dam Inundation Technical Study
San Luis Obsipo County, California

San Luis Obispo County Flood Control and Water Conservation District

GEI Consultants

Project Location

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FIGURE 1

26Dec2017 Z:\Projects\1705077_SLO_LopezTerminalDams\Fig1_Lopez_ProjectLocation.mxd RS

Lopez Dam Inundation Technical Study
San Luis Obsipo County, California

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Lopez Dam and Spillway

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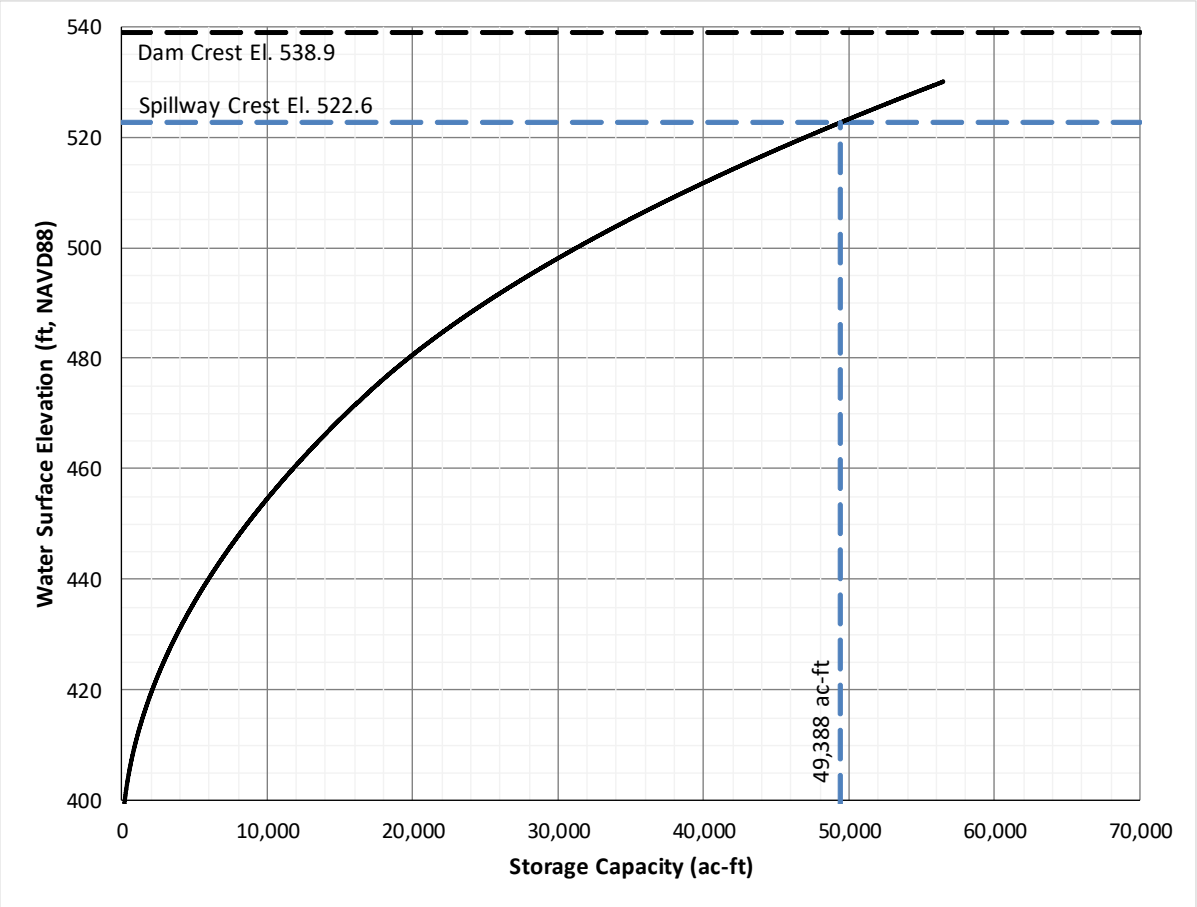
FIGURE 2

26Dec2017 Z:\Projects\1705077_SLO_LopezTerminalDams\Fig2_Lopez_DamSpillway.mxd RS



Notes:

1. Elevation-storage capacity curve based on March 2002 survey obtained from the District.

Elevation (ft)	Storage (ac-ft)	Elevation (ft)	Storage (ac-ft)	Elevation (ft)	Storage (ac-ft)
392.6	0.0	442	6427.0	492	26143.6
394	16.7	444	6940.2	494	27364.7
396	57.4	446	7473.0	496	28627.5
398	117.8	448	8025.6	498	29932.0
400	197.9	450	8597.8	500	31278.2
402	297.7	452	9189.7	502	32666.1
404	417.1	454	9801.3	504	34095.7
406	556.3	456	10432.6	506	35567.0
408	715.1	458	11083.6	508	37080.0
410	893.6	460	11754.2	510	38634.7
412	1091.8	462	12444.6	512	40231.2
414	1309.7	464	13154.6	514	41869.3
416	1547.2	466	13884.3	516	43549.1
418	1804.5	468	14633.7	518	45270.6
420	2081.4	470	15402.8	520	47033.8
422	2378.1	472	16226.2	522	48838.7
424	2694.4	474	17030.2	524	50685.3
426	3030.4	476	17876.0	526	52573.6
428	3386.0	478	18763.5	528	54503.6
430	3761.4	480	19692.7	530	56465.4
432	4156.5	482	20663.6		
434	4571.2	484	21676.2		
436	5005.6	486	22730.5		
438	5459.7	488	23826.5		
440	5933.5	490	24964.2		

Lopez Dam Inundation Technical Study
San Luis Obsipo County, California

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Elevation - Storage Capacity Curve

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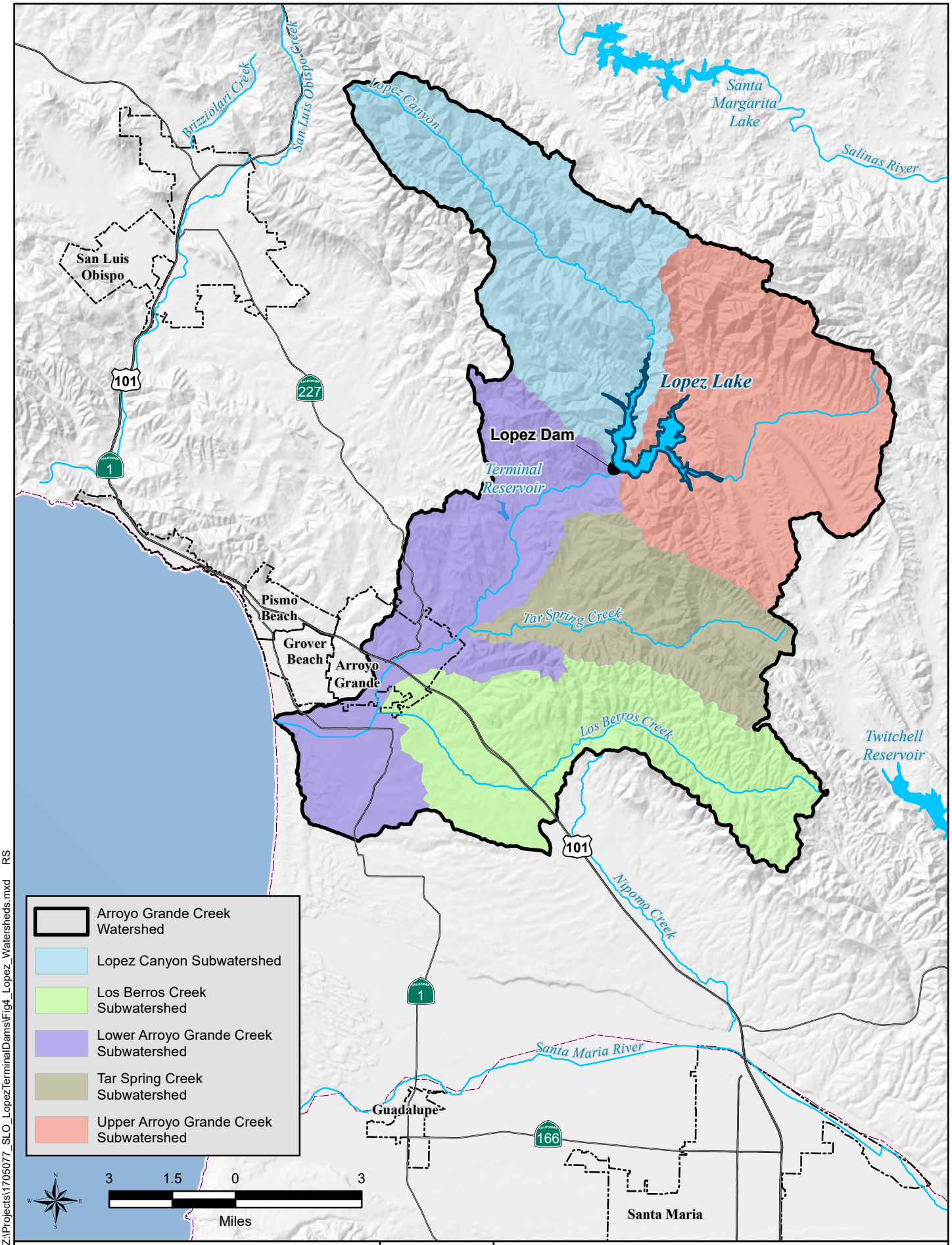
FIGURE 3



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26Dec2017

Lopez Dam Inundation Technical Study
San Luis Obsipo County, California

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Drainage Watersheds

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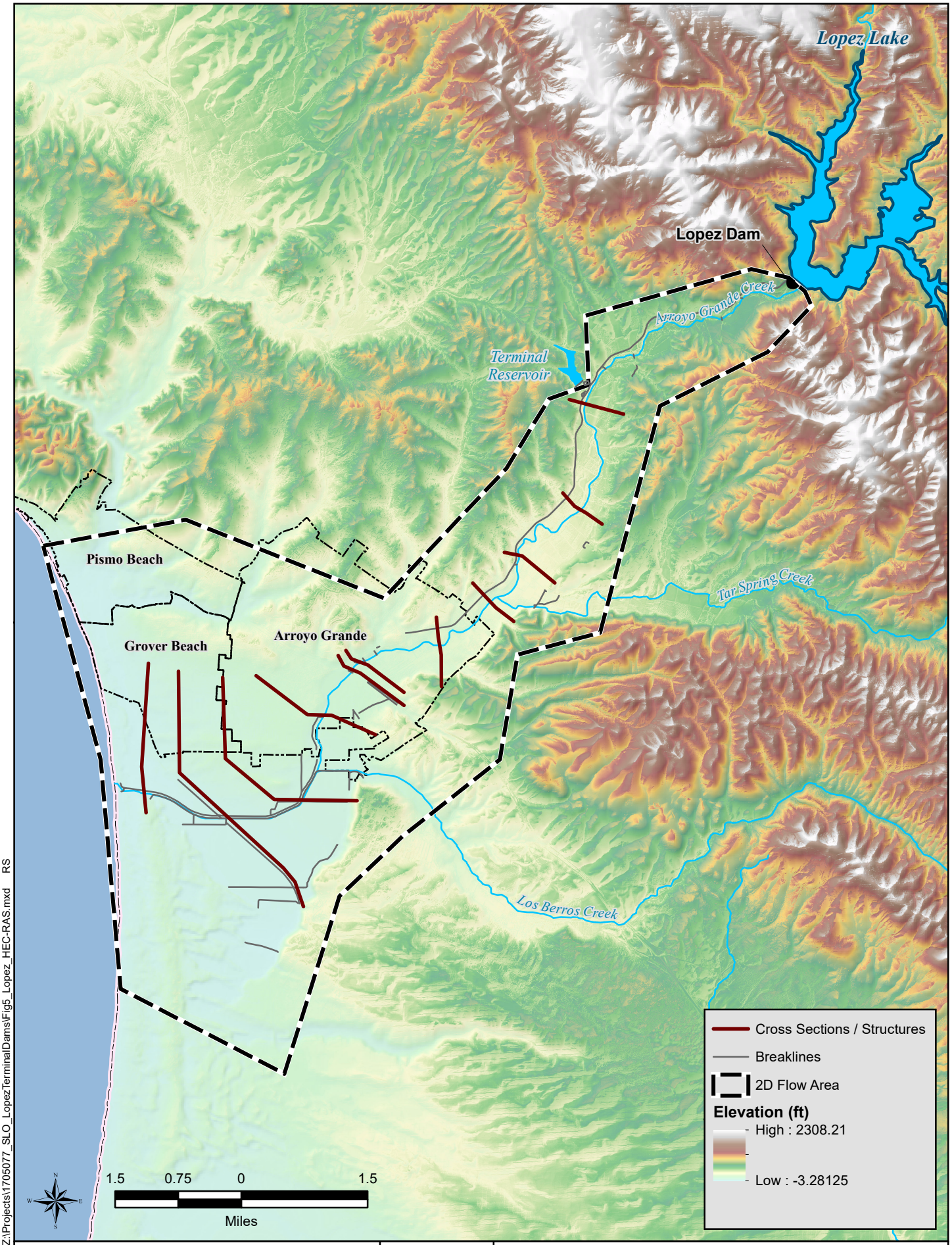
FIGURE 4



Lopez Dam Inundation Technical Study
San Luis Obsipo County, California

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HEC-RAS Model Extents and Geometry Features

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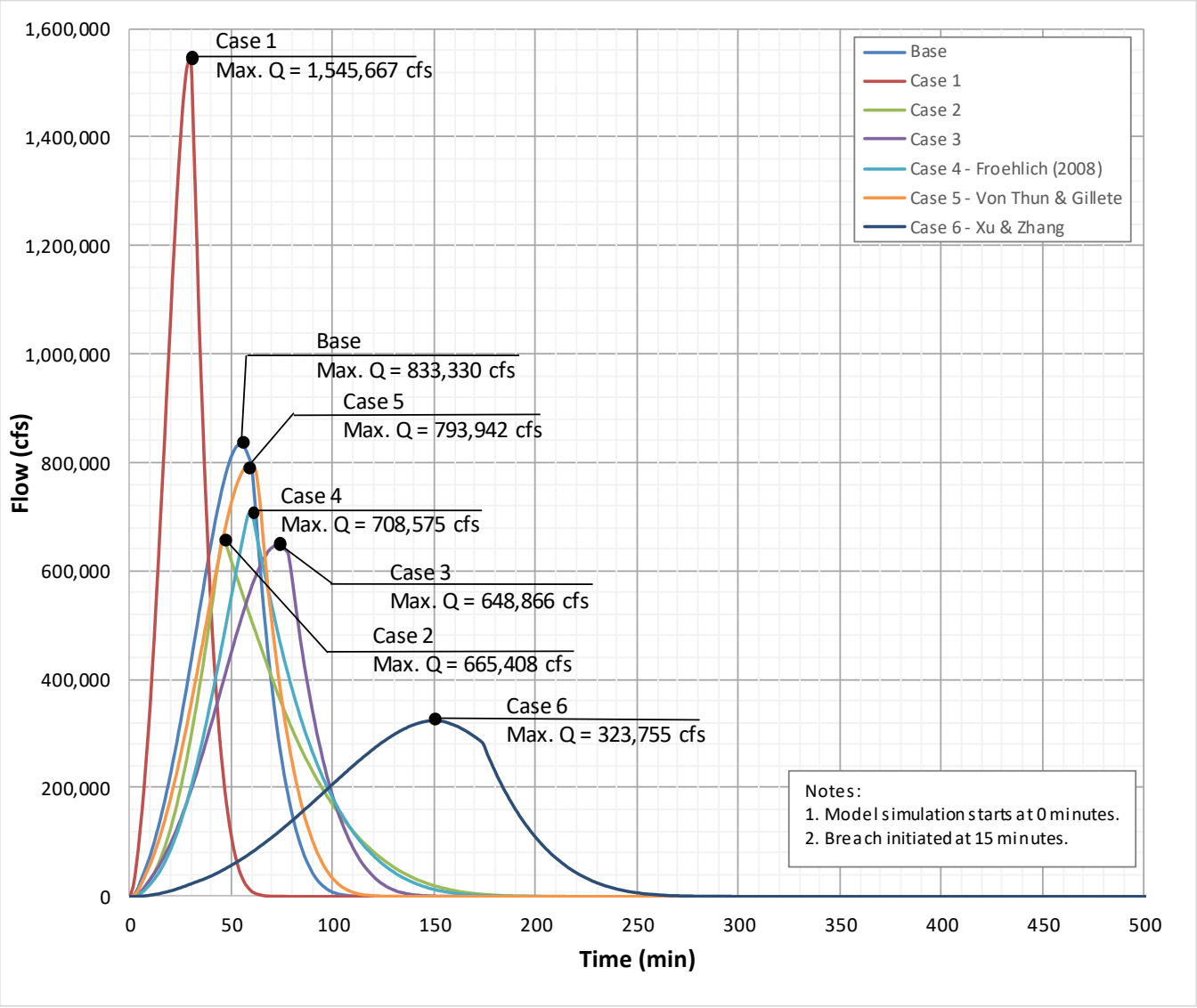
FIGURE 5

26Dec2017 Z:\Projects\1705077_SLO_LopezTerminalDams\Fig5_Lopez_HEC-RAS.mxd RS



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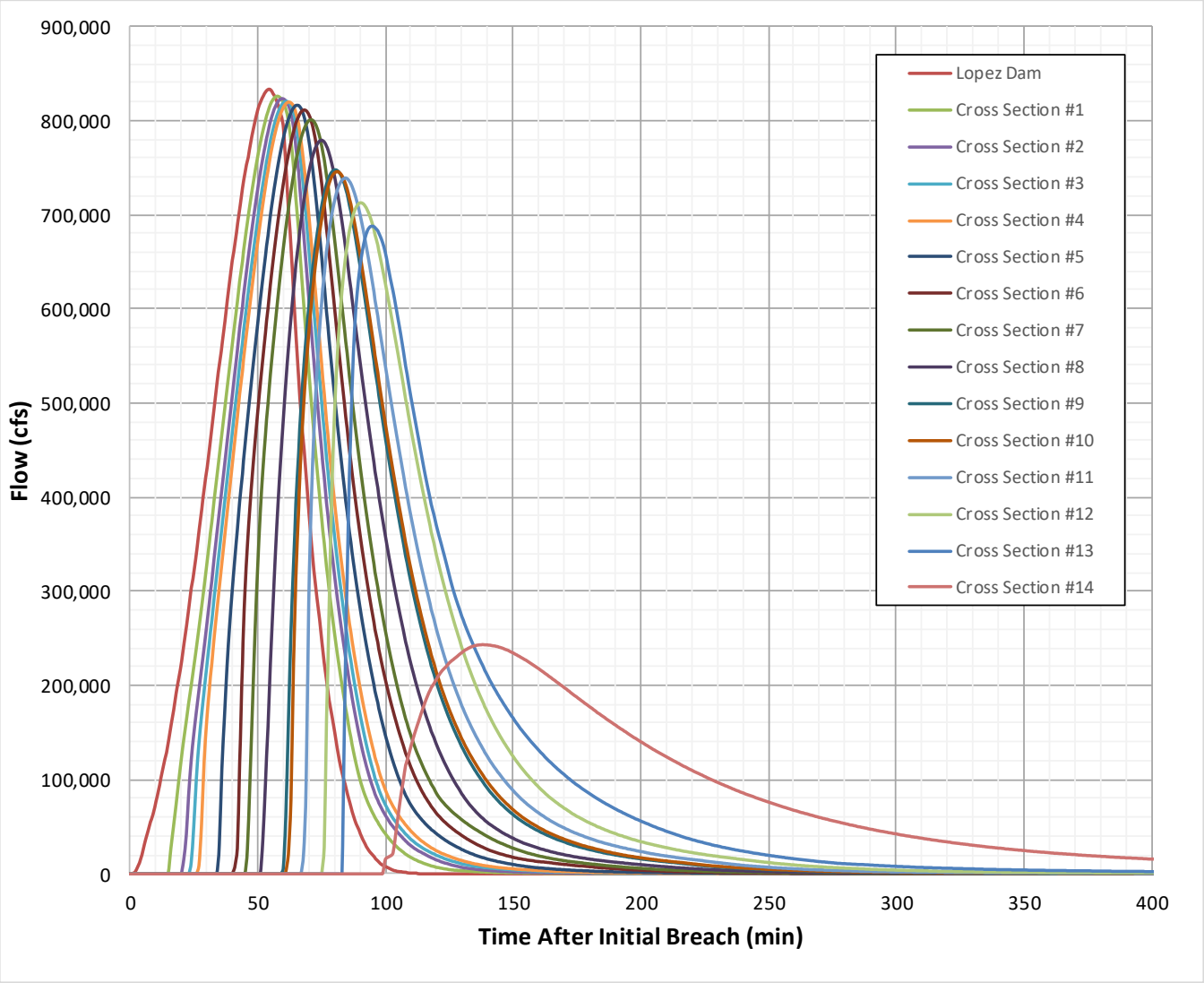
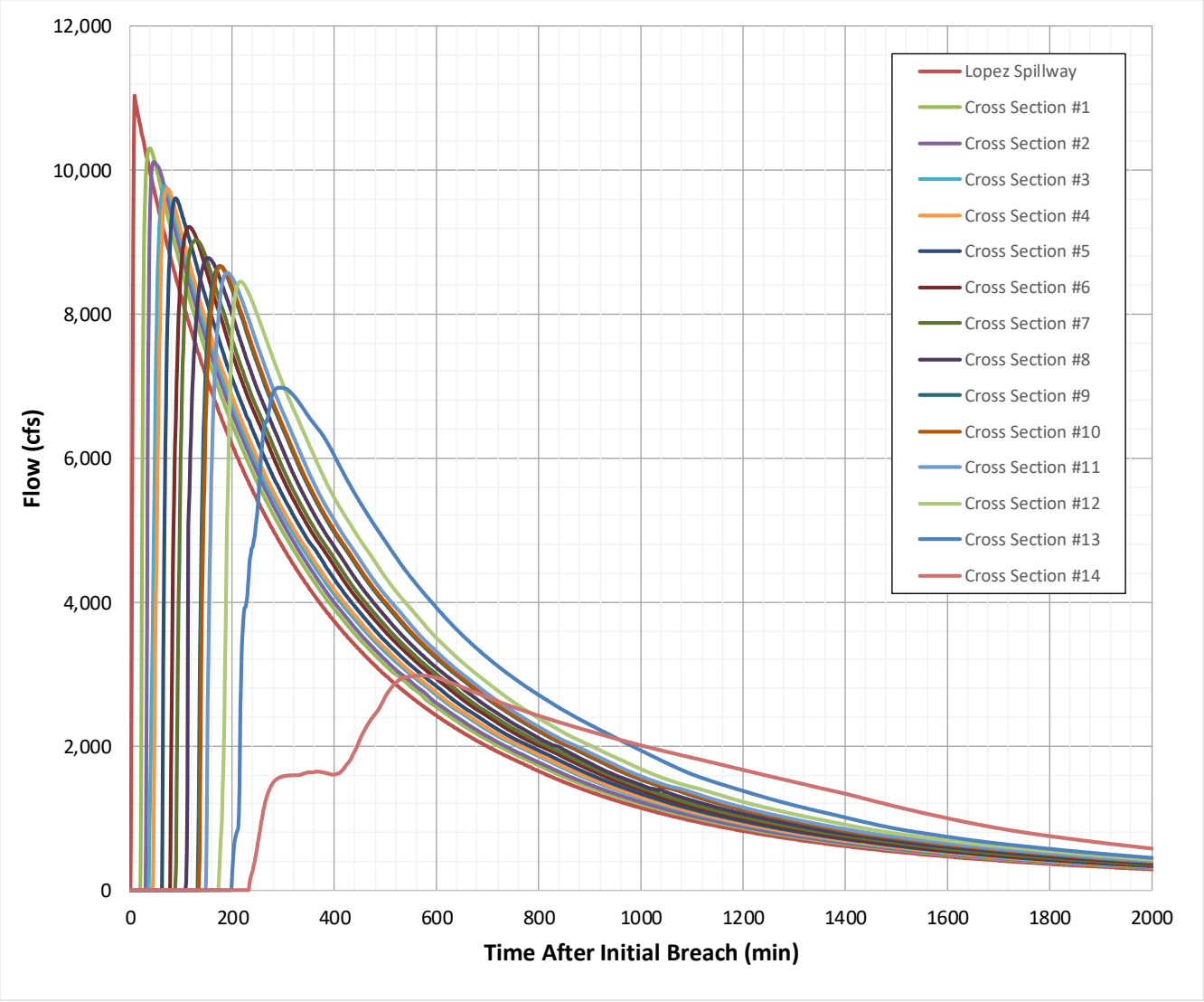
Lopez Dam Inundation Technical Study San Luis Obsipo County, California	GEI Consultants	Lopez Dam Breach Hydrograph Comparisons	
San Luis Obispo County Flood Control and Water Conservation District		DECEMBER 2017	FIGURE 6



Lopez Dam Inundation Technical Study San Luis Obsipo County, California	GEI Consultants	Downstream Dam Flood Wave Attenuation	
San Luis Obispo County Flood Control and Water Conservation District		DECEMBER 2017	FIGURE 7

27-Dec-2017 Z:\Projects\1705077_SLO_LopezTerminalDams\LopezReport_Figure7.mxd CV



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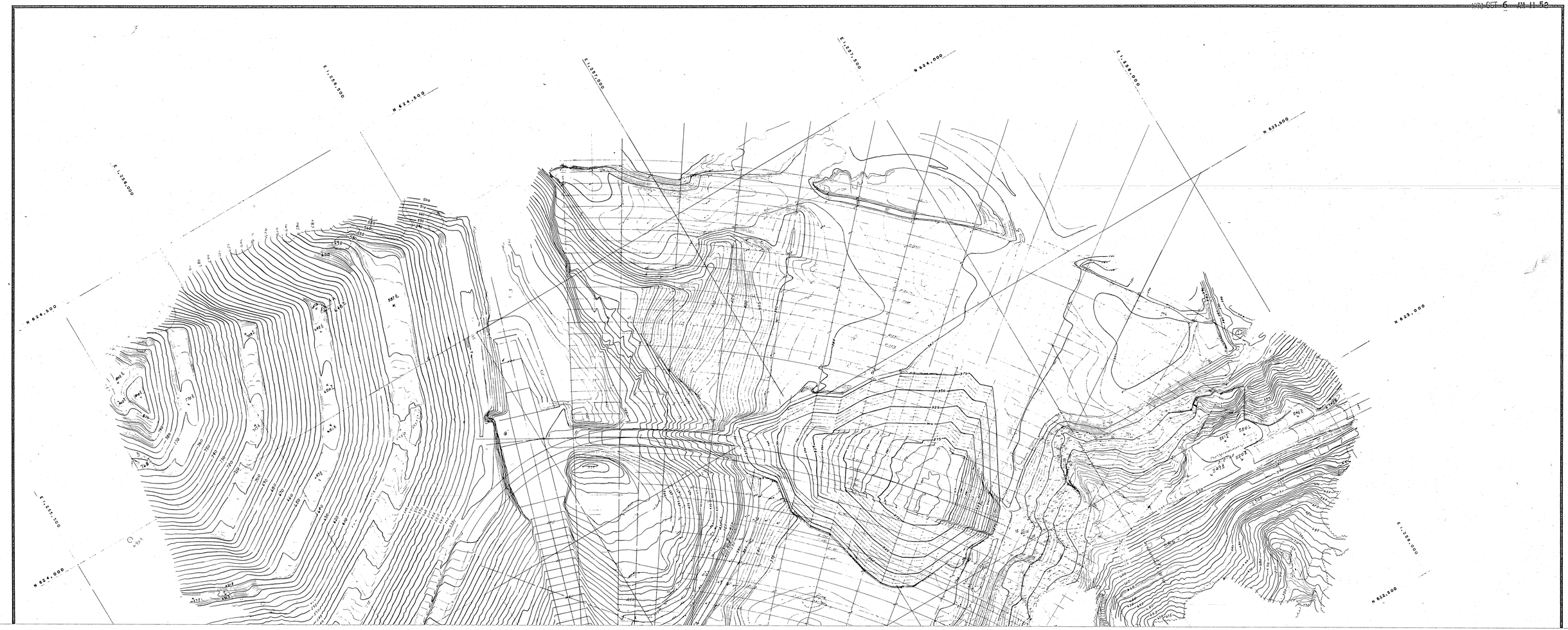
Lopez Dam Inundation Technical Study San Luis Obsipo County, California	GEI Consultants	Downstream Spillway Flood Wave Attenuation
San Luis Obispo County Flood Control and Water Conservation District	DECEMBER 2017	FIGURE 8

Appendix A

Lopez Dam Design/As-Built Drawings



DIVISION OF SAFETY OF DAMS
DEPARTMENT OF WATER RESOURCES
OCT 6 1970

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

APPLICATION NO.
APPROVED AS TO SAFETY

NOV 12 1970

DIVISION ENGINEER. REG. C.E. No. 7113

PLANS PREPARED BY
KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING

DATE Oct. 1968
BY

SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

LOPEZ WATER SUPPLY PROJECT

DAM AND APPURTENANT FACILITIES

FOUNDATION EXCAVATION
AS CONSTRUCTED

RECOMMENDED — DATE
APPROVED — COUNTY HYDRAULIC ENGINEER R.C.E. NO. 9614
DRAWN RWS | TRACED RWS | CHKD | SUPPLEMENTARY SHEET 57C OF

MAP "F"

PROFILE
HORIZ. SCALE: 1"= 20'
VERT. SCALE: 1"= 20'

400
350
300
250
200

9+00 8+00 7+00 6+00 5+00 4+00

LEGEND
DEPTH OF WELL
DIAMETER OF WELL
IDENTIFICATION NUMBER

N 623,418.25
E 1,257,009.89

N 51°29'38" W

N 35°45'33" W

AXIS OF DAM RADIUS 2000'

9+50 8+50 7+50 6+50 5+50 4+50 3+50

N 623,106.67
E 1,257,234.27

PLAN - SEEPAGE RELIEF WELLS
SCALE 1"=20'

⊗ = SURVEYED LOCATION
○ = APPROXIMATE LOCATION

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DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

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C J Gottright
DIVISION ENGINEER. REG. C.E. No. 7113

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KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING

DATE
BY

REV. NO	DATE	REVISIONS	REV	CKD	APP.
		AS CONSTRUCTED	RWS		DMO

SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

LOPEZ WATER SUPPLY PROJECT

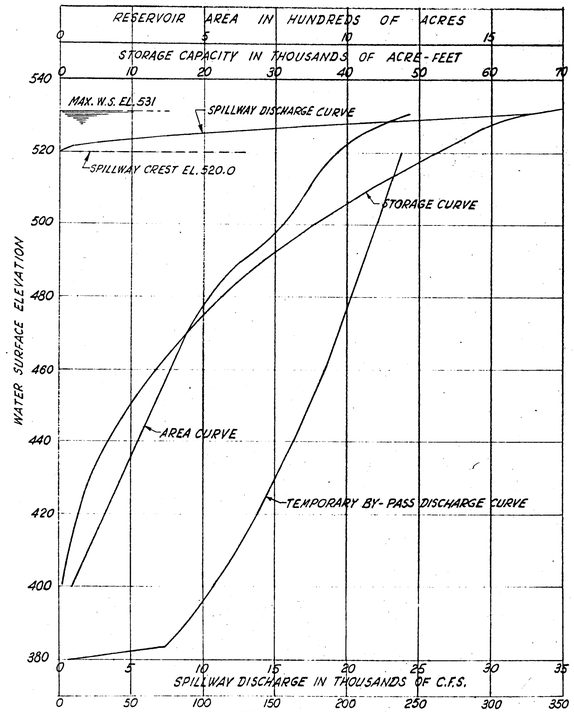
DAM AND APPURTENANT FACILITIES

PLAN & PROFILE - SEEPAGE RELIEF WELLS AS CONSTRUCTED

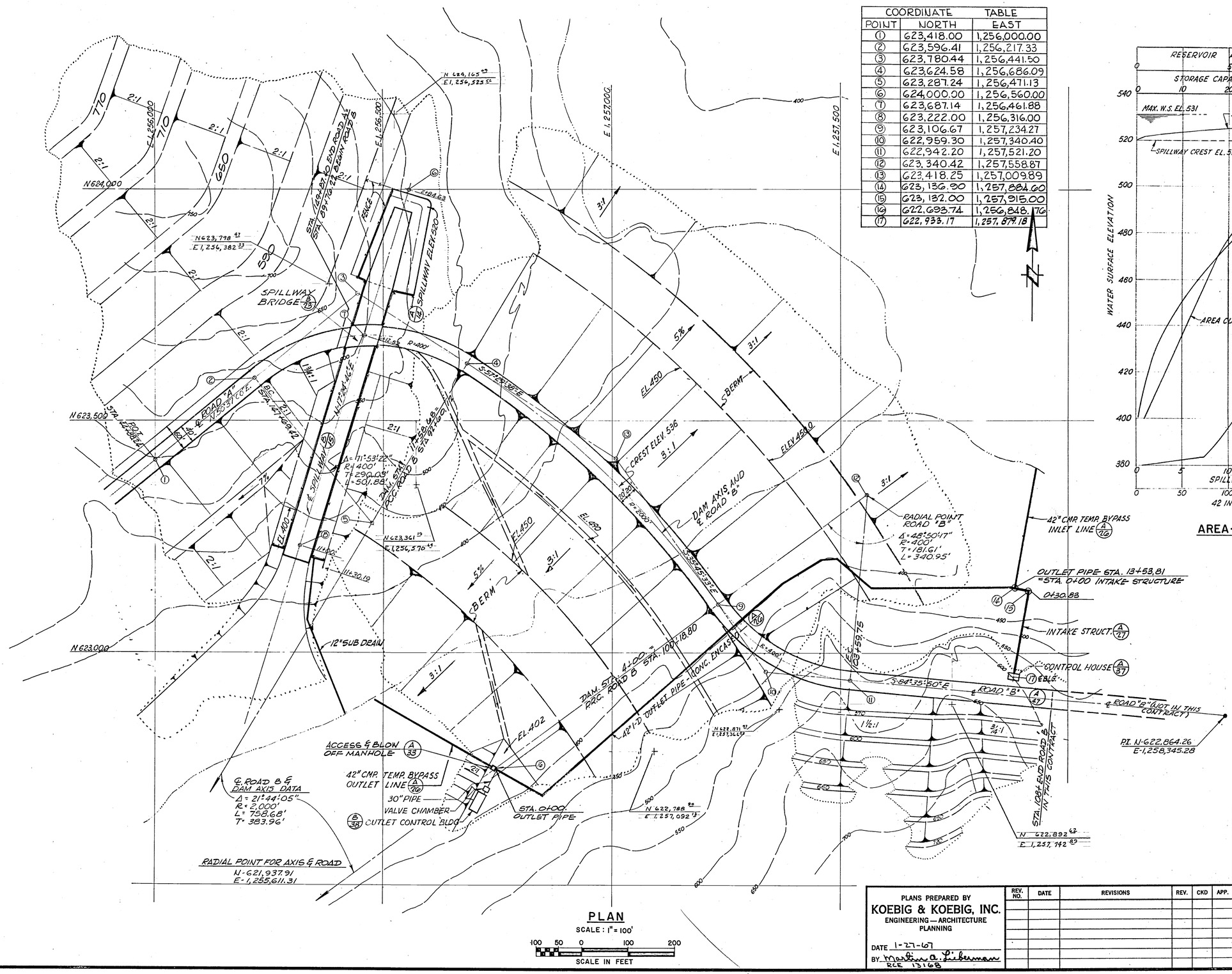
RECOMMENDED _____ DATE _____
COUNTY HYDRAULIC ENGINEER R.C.E. NO. 9464
APPROVED _____

DRAWN RWS | TRACED RWS | CHKD | SUPPLEMENTAL SHEET 578 OF

COORDINATE TABLE		
POINT	NORTH	EAST
①	623,418.00	1,256,000.00
②	623,596.41	1,256,217.33
③	623,780.44	1,256,441.50
④	623,624.58	1,256,686.09
⑤	623,287.24	1,256,471.13
⑥	624,000.00	1,256,560.00
⑦	623,687.14	1,256,461.88
⑧	623,222.00	1,256,316.00
⑨	623,106.67	1,257,234.27
⑩	622,959.30	1,257,340.40
⑪	622,942.20	1,257,521.20
⑫	623,340.42	1,257,558.87
⑬	623,418.25	1,257,009.89
⑭	623,136.90	1,257,884.60
⑮	623,132.00	1,257,915.00
⑯	622,693.74	1,256,848.76
⑰	622,933.17	1,257,874.18



AREA - STORAGE - DISCHARGE CURVES



PLAN

SCALE : 1" = 100'

100 50 0 100 200

SCALE IN FEET

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

APPLICATION NO. 1055
APPROVED AS TO SAFETY

FOR THE CHIEF ENGINEER

FEB 3 1967

ACTING DIVISION ENGINEER, REG. C.E. No. 71-3

PLANS PREPARED BY
KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING

DATE 1-27-67

BY Martin A. Liberman
RCE 13168

REV. NO.	DATE	REVISIONS	REV.	CKD	APP.

SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

LOPEZ WATER SUPPLY PROJECT

DAM AND APPURTENANT FACILITIES

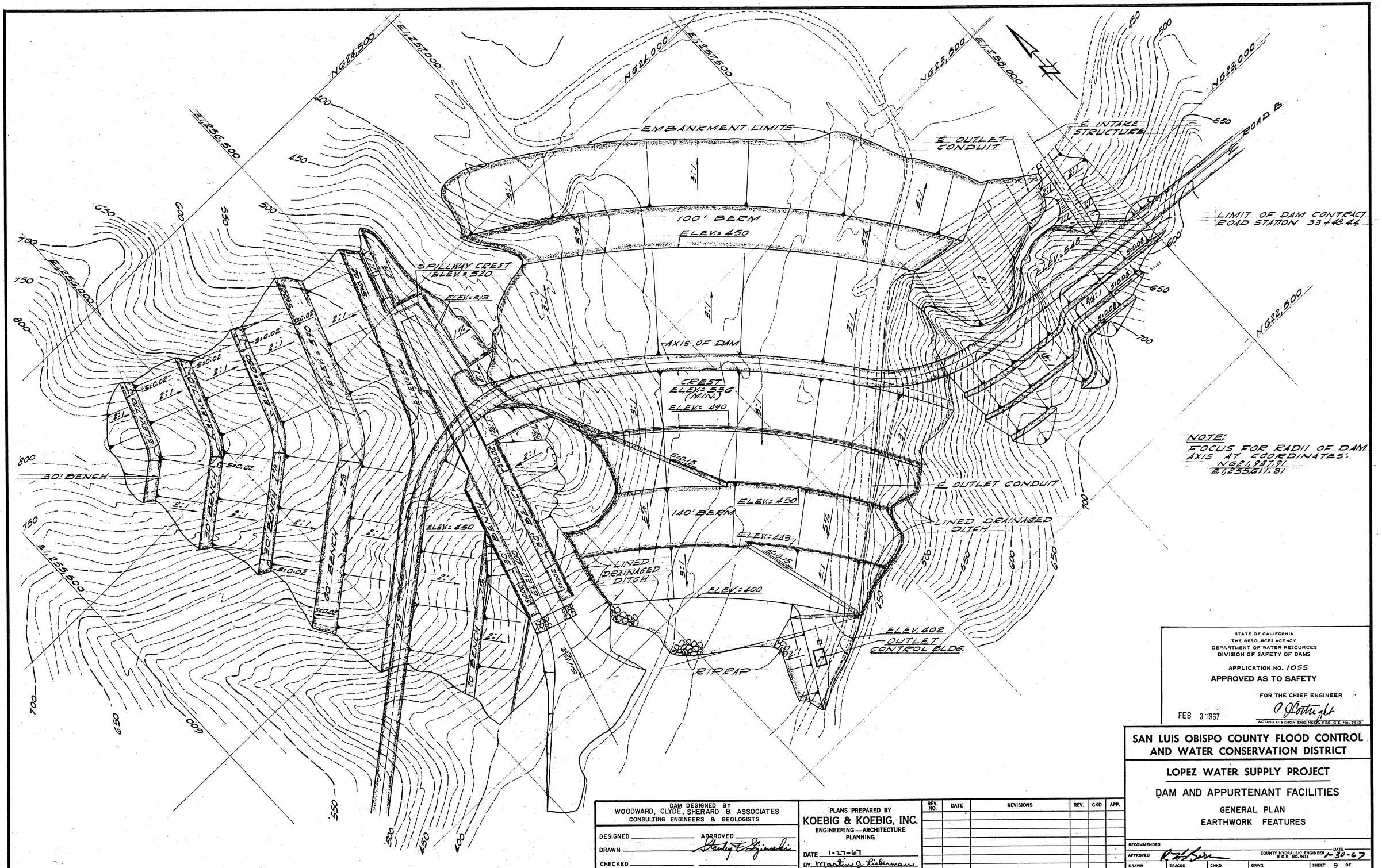
LOCATION MAP

RECOMMENDED

APPROVED

COUNTY HYDRAULIC ENGINEER R.C.E. NO. 9614 DATE 1-30-67

DRAWN | TRACED | CHKD | DRWG | SHEET 3 OF



STATE OF CALIFORNIA
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DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

APPLICATION NO. 1055
APPROVED AS TO SAFETY

FOR THE CHIEF ENGINEER
FEB 3 1967
C. J. Gotteright
ACTING DIVISION ENGINEER, REG. C.E. No. 7113

DAM DESIGNED BY
WOODWARD, CLYDE, SHERARD & ASSOCIATES
CONSULTING ENGINEERS & GEOLOGISTS

DESIGNED _____ APPROVED Stanley T. Ejiri
DRAWN _____
CHECKED _____

PLANS PREPARED BY
KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING

DATE 1-27-67
BY Martin A. Liebermann
RCE 13168

REV. NO.	DATE	REVISIONS	REV.	CKD	APP.

SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

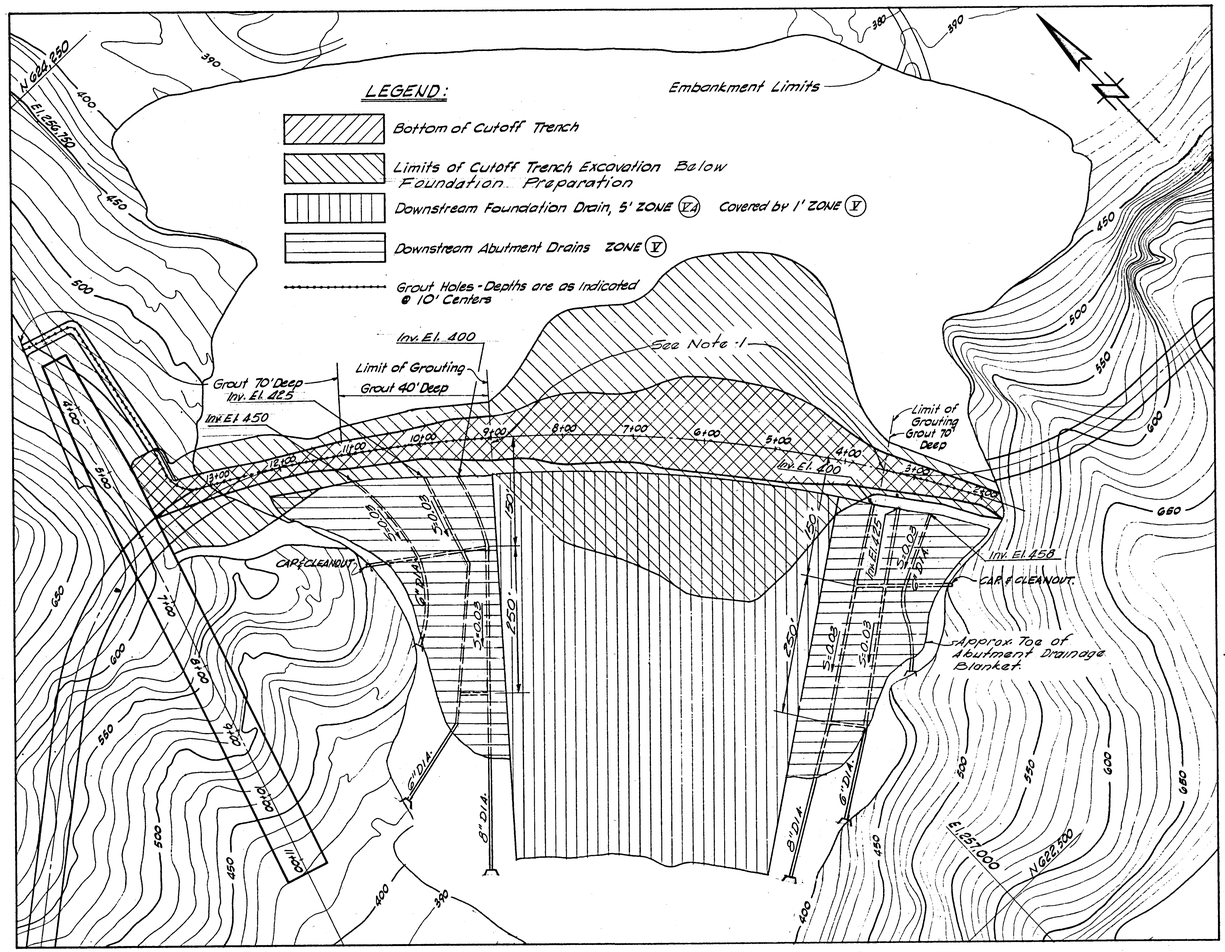
LOPEZ WATER SUPPLY PROJECT

DAM AND APPURTENANT FACILITIES

GENERAL PLAN
EARTHWORK FEATURES

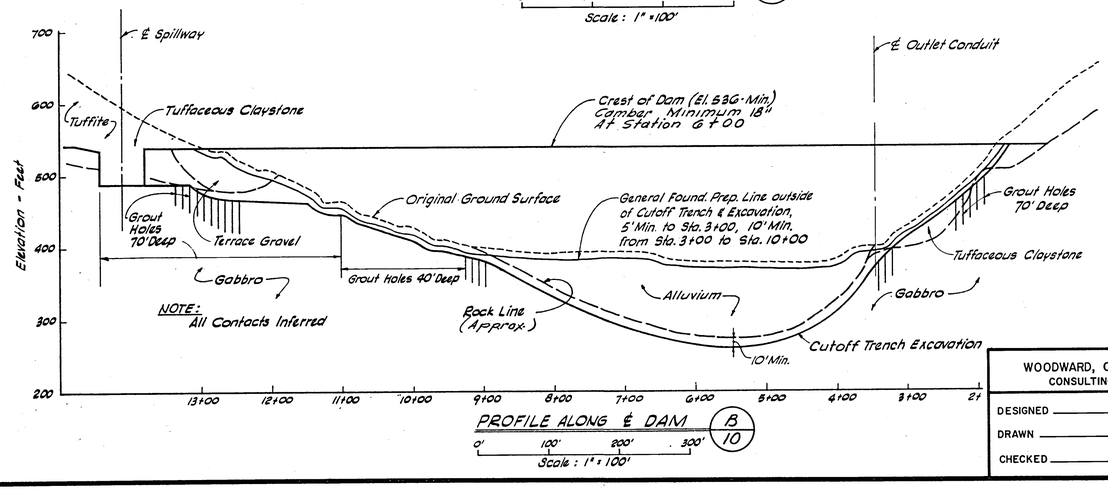
RECOMMENDED
APPROVED R. Z. Gibson COUNTY HYDRAULIC ENGINEER R.C.E. NO. 9614 DATE 1-30-67

DRAWN	TRACED	CHKD	DRWG	SHEET 9 OF



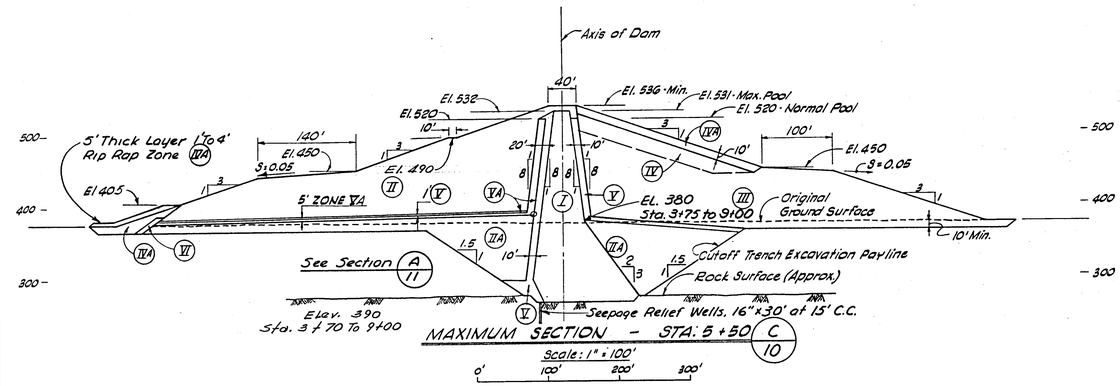
PLAN (A/10)

Scale: 1" = 100'



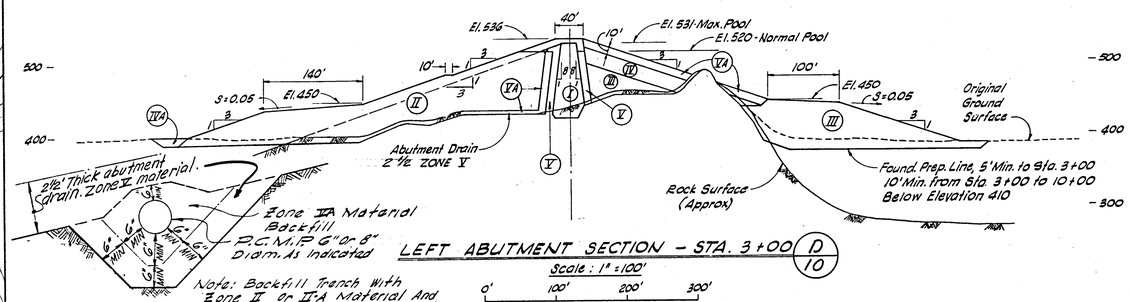
PROFILE ALONG ℄ DAM (B/10)

Scale: 1" = 100'



MAXIMUM SECTION - STA. 5+50 (C/10)

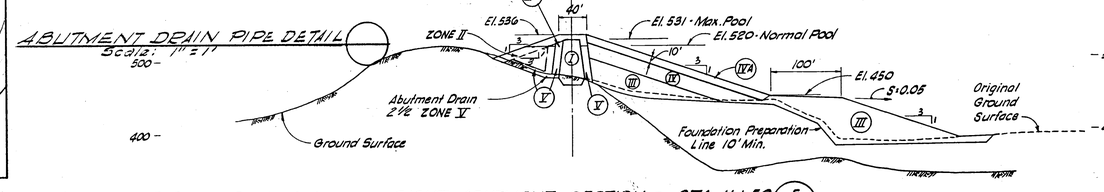
Scale: 1" = 100'



LEFT ABUTMENT SECTION - STA. 3+00 (D/10)

Scale: 1" = 100'

Note: Backfill Trench With Zone II or IIA Material And Use Sealed Corrugated Metal Pipe Outside Limits of Abutment Drain.



ABUTMENT DRAIN PIPE DETAIL

Scale: 1" = 1'

RIGHT ABUTMENT SECTION - STA. 11+50 (E/10)

Scale: 1" = 100'

EMBANKMENT ZONING LEGEND

- (I) Impervious Core
- (II) Downstream Random
- (IIA) Semi-Pervious Random
- (III) Upstream Random
- (IV) Tuffite
- (IVA) Graded Tuffite
- (V) Filter Drains
- (VA) Gravel Drains
- (VI) Well Graded Gravel ½" To 6"

NOTES:

1. Engineer to Determine in field Whether grout holes required Between Sta. 3+75 And 9+00.
2. Relief Wells Shall Be Installed Between Sta. 3+75 And 9+00 In Accordance With Details on Sheet 11.
3. 6-Inch Sub-Surface drain Pipe shall daylight into Grouted Ditches. Concrete Headwalls Shall Be Provided For 8-Inch Subsurface Drain Pipe Which Daylight In RipRap. See Detail on Sheet

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

APPLICATION NO. 1055

APPROVED AS TO SAFETY

FOR THE CHIEF ENGINEER

FEB 3 1967

ACTING DIVISION ENGINEER, REG/C.E. No. 7113

DAM DESIGNED BY
WOODWARD, CLYDE, SHERARD & ASSOCIATES
CONSULTING ENGINEERS & GEOLOGISTS

DESIGNED — APPROVED

DRAWN

CHECKED

PLANS PREPARED BY
KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING

DATE 1-27-67

BY Martin A. Liebermann RCE 13168

REV. NO.	DATE	REVISIONS	REV.	CKD	APP.

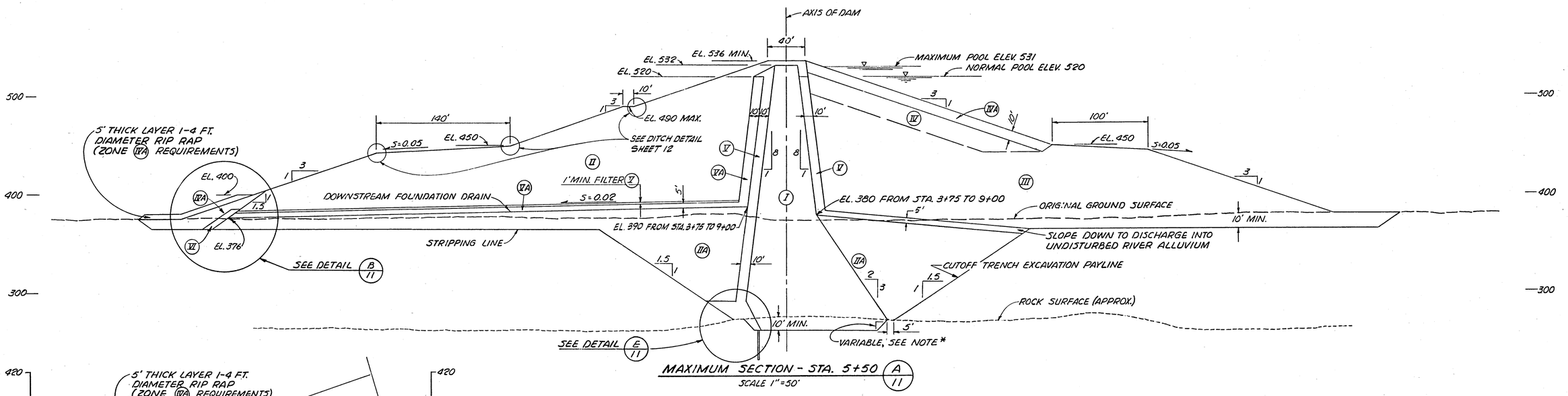
SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

LOPEZ WATER SUPPLY PROJECT

DAM AND APPURTENANT FACILITIES

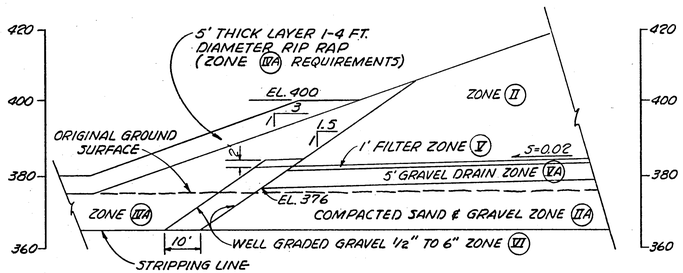
FOUNDATION PLAN AND PROFILE, TYPICAL EMBANKMENT SECTIONS

RECOMMENDED					
APPROVED			COUNTY HYDRAULIC ENGINEER R.C.E. NO. 9614	DATE	1-30-67
DRAWN	TRACED	CHKD	DRWG	SHEET	10 OF



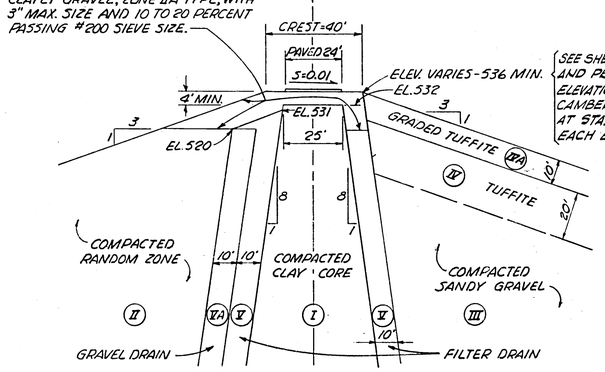
MAXIMUM SECTION - STA. 5+50 (A/11)

SCALE 1"=50'



DOWNSTREAM TOE DETAIL (B/11)

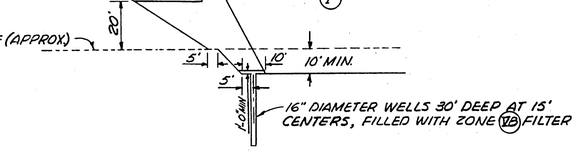
SCALE 1"=20'



CREST DETAIL (D/11)

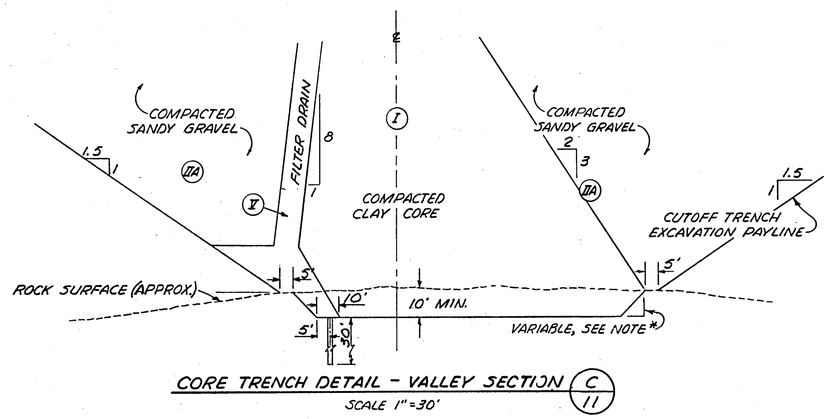
SCALE 1"=30'

SEE SHEET 52, ROAD "B" PLAN AND PROFILE FOR FINISH GRADE ELEVATIONS DAM CREST. CAMBEE 18" ABOVE ELEVATION AT STA. 6+00 AND TAPER TO EACH END OF DAM.



SEEPAGE CONTROL WELLS AND DETAILS (E/11)

SCALE 1"=30'



CORE TRENCH DETAIL - VALLEY SECTION (C/11)

SCALE 1"=30'

NOTE:
CORE TRENCH SIDE SLOPES IN ROCK SHALL NOT BE STEEPER THAN 1/2:1 (HORIZONTAL TO VERTICAL) NOR FLATTER THAN 1:1.

NOTES:

1. ALL DIMENSIONS OF FILTER AND DRAIN ZONES ARE NORMAL TO TOP FACE OF ZONE.
2. MINIMUM OF 4 FT. OF IMPERVIOUS COVER SHALL BE PLACED OVER FILTER ZONES AT ABUTMENTS.

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS
APPLICATION NO. 1055
APPROVED AS TO SAFETY
FOR THE CHIEF ENGINEER
FEB 3 1967
ACTING DIVISION ENGINEER, REG. C.E. No. 7113

DAM DESIGNED BY
WOODWARD, CLYDE, SHERARD & ASSOCIATES
CONSULTING ENGINEERS & GEOLOGISTS

DESIGNED _____ APPROVED _____
DRAWN _____ Stanley T. Zyzinski
CHECKED _____ _____

PLANS PREPARED BY
KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING
DATE 1-27-67
BY Martin A. Liberman RCE 13168

REV. NO.	DATE	REVISIONS	REV.	CKD	APP.

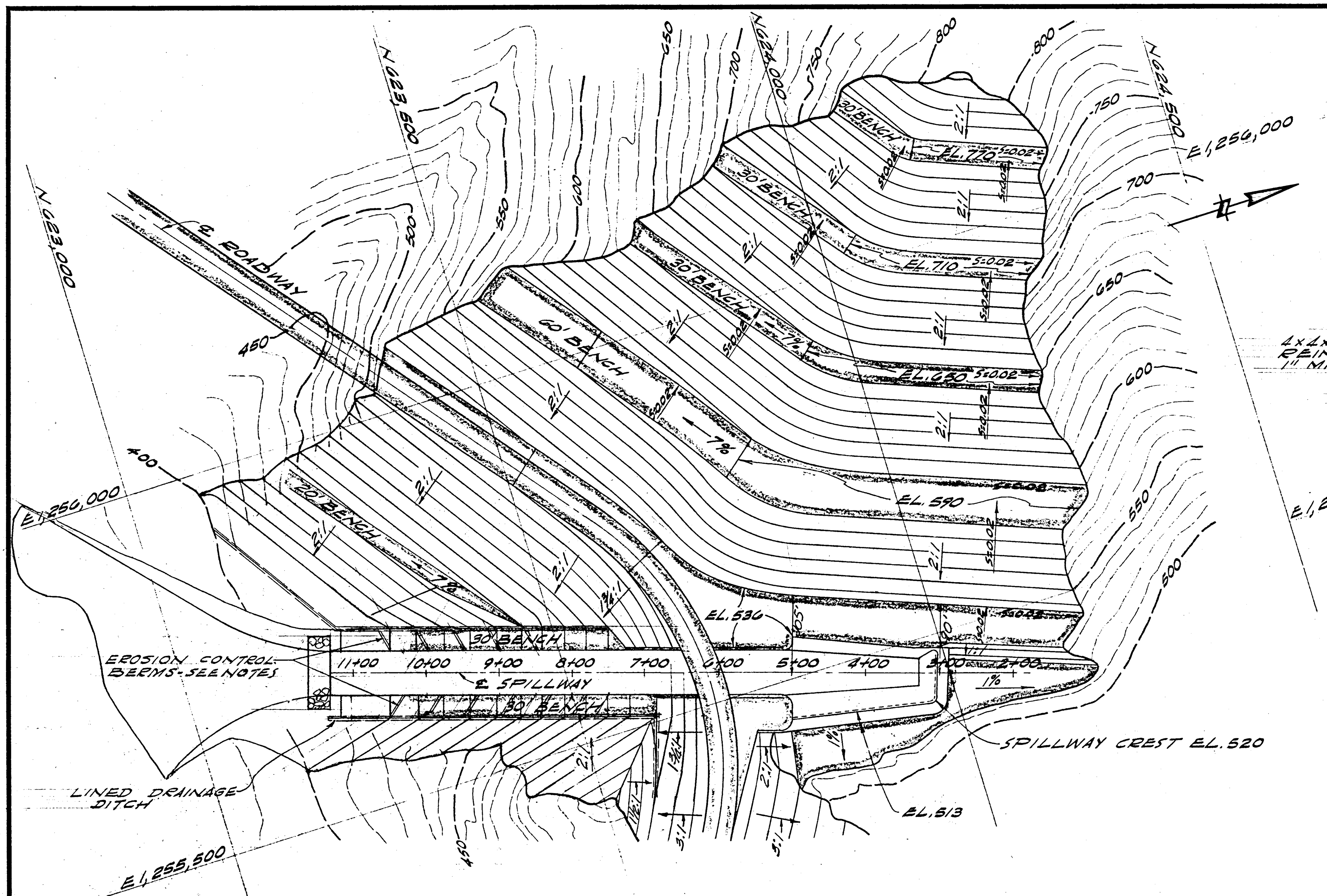
SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

LOPEZ WATER SUPPLY PROJECT

DAM AND APPURTENANT FACILITIES

EMBANKMENT SECTIONS AND DETAILS

RECOMMENDED _____
APPROVED R. L. Lyon COUNTY HYDRAULIC ENGINEER R.C.E. NO. 9614 DATE 1-30-67
DRAWN | TRACED | CHKD | DRWG | SHEET 11 OF

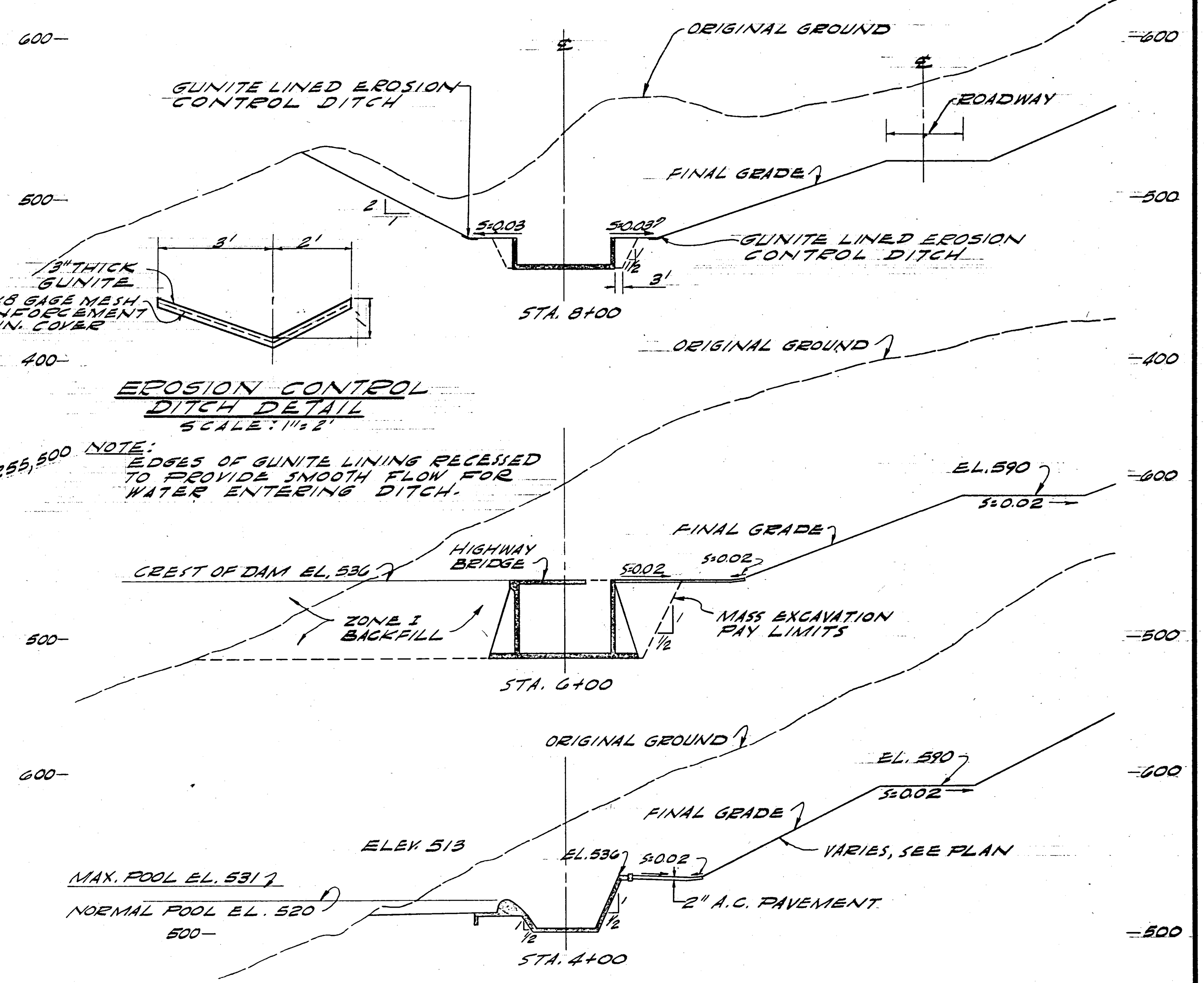


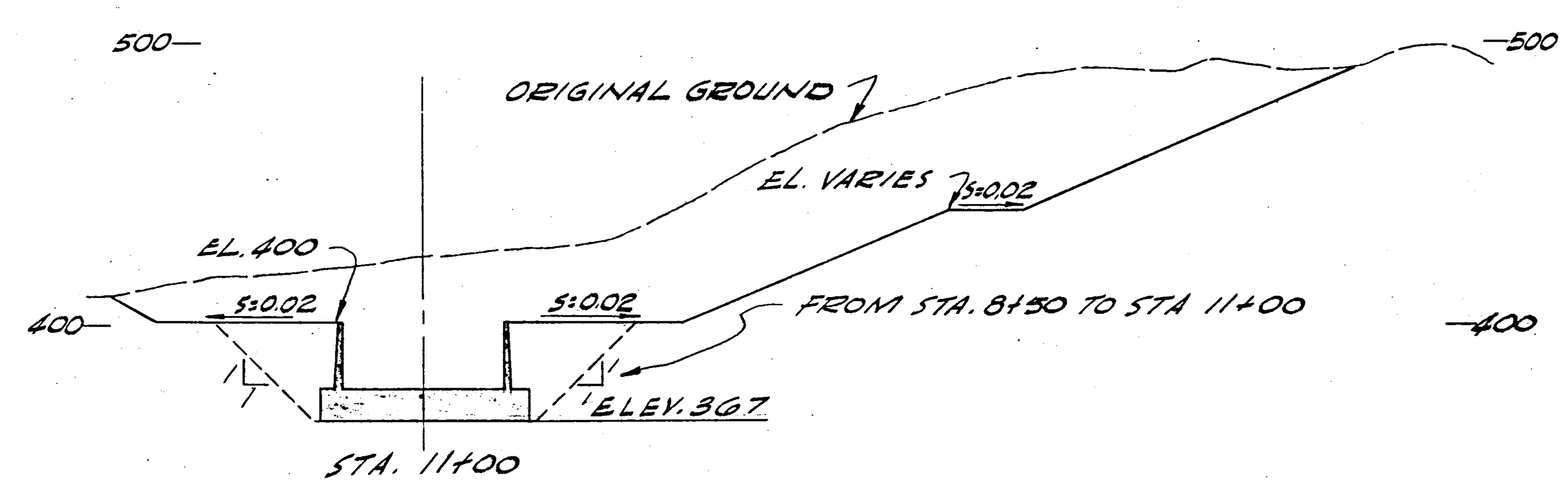
SPILLWAY PLAN
SCALE: 1"=100'

NOTE:
1. THE INFERRED CONTACTS BETWEEN GEOLOGICAL FORMATIONS AND MATERIALS ARE BASED ON EXPOSURES IN TEST PITS AND BORINGS AND SHOULD BE CONSIDERED AS APPROXIMATE ONLY.
2. EROSION CONTROL BERMS, 6 INCHES HIGH, INCLINED AT 30° TO SPILLWAY AXIS, AT 50' INTERVALS TO BE CONSTRUCTED OF GUNITE.

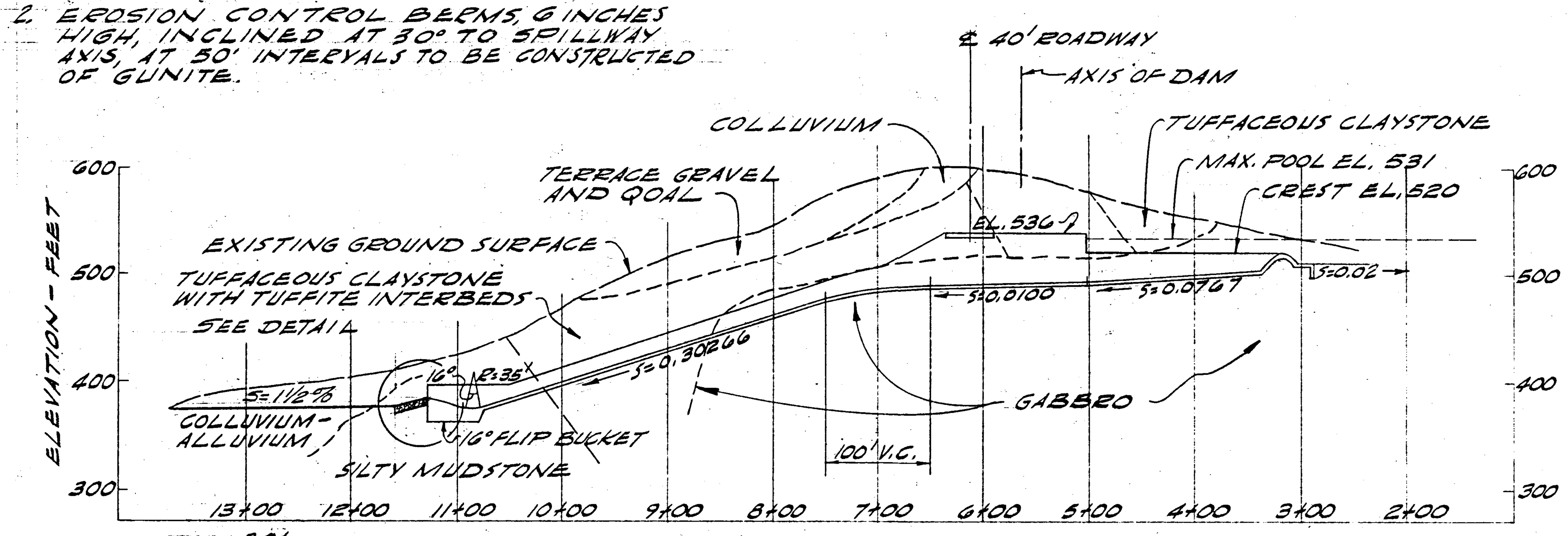
EROSION CONTROL DITCH DETAIL
SCALE: 1"=2'

NOTE: EDGES OF GUNITE LINING RECESSED TO PROVIDE SMOOTH FLOW FOR WATER ENTERING DITCH.

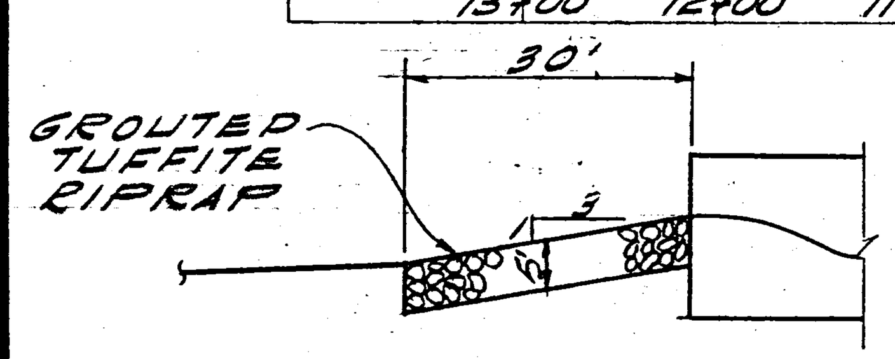




TYPICAL CROSS SECTIONS
SCALE: 1"=50'



SPILLWAY PROFILE
SCALE: 1"=100'



RIPRAP DETAIL
NO SCALE

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS
APPLICATION NO. 1055
APPROVED AS TO SAFETY
FOR THE CHIEF ENGINEER
FEB 3 1967
ACTING DIVISION ENGINEER, REG. C.E. No. 7113

DAM DESIGNED BY
WOODWARD, CLYDE, SHERARD & ASSOCIATES
CONSULTING ENGINEERS & GEOLOGISTS

DESIGNED	APPROVED
DRAWN	
CHECKED	

PLANS PREPARED BY
KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING
DATE 1-27-67
BY Martin A. Lieberman
RCE 13168

REV. NO.	DATE	REVISIONS	REV.	CKD	APP.

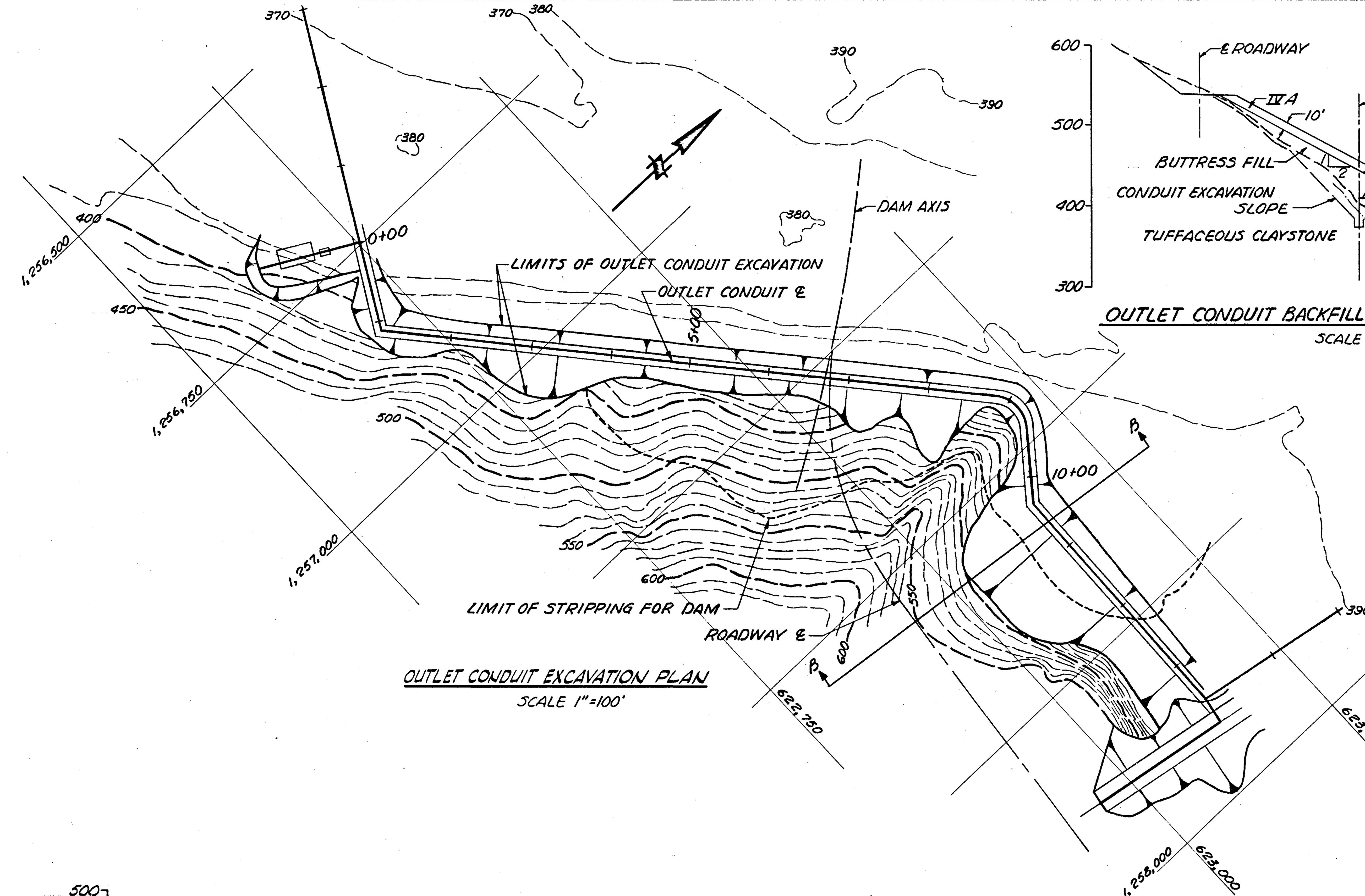
SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

LOPEZ WATER SUPPLY PROJECT

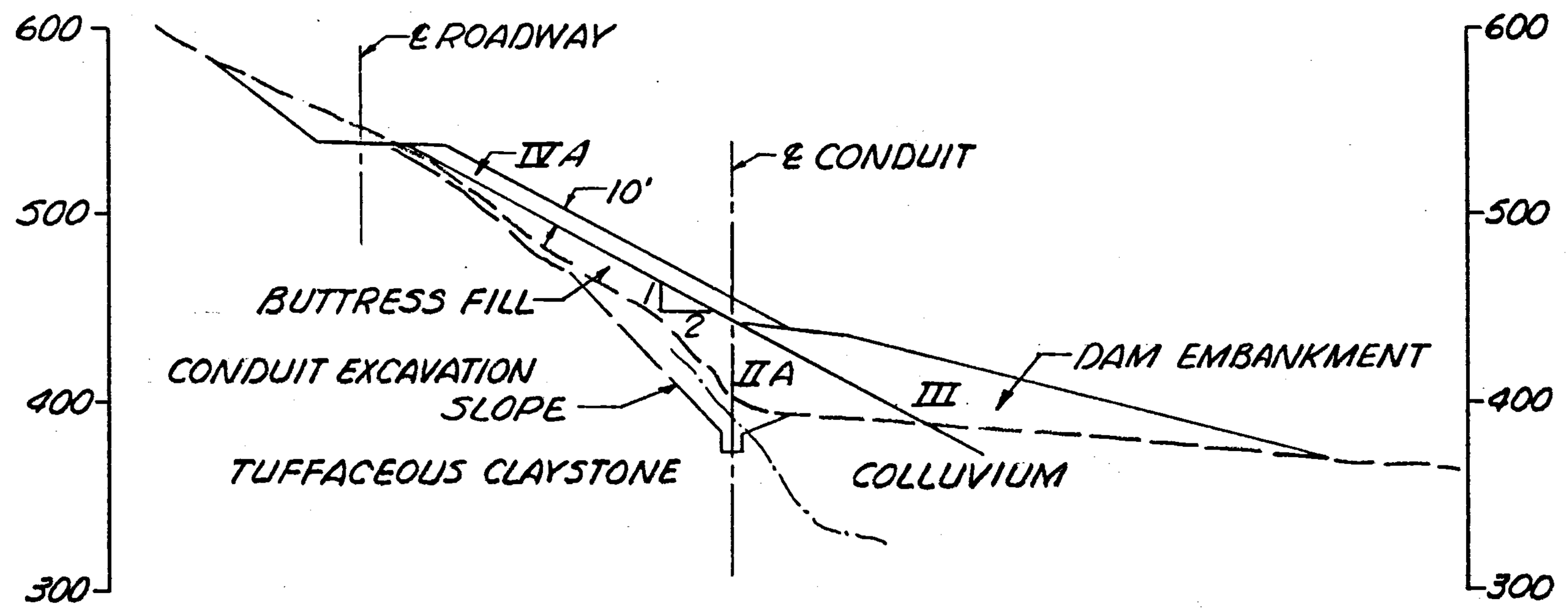
DAM AND APPURTENANT FACILITIES

SPILLWAY EXCAVATION PLAN, PROFILE AND TYPICAL CROSS-SECTIONS.

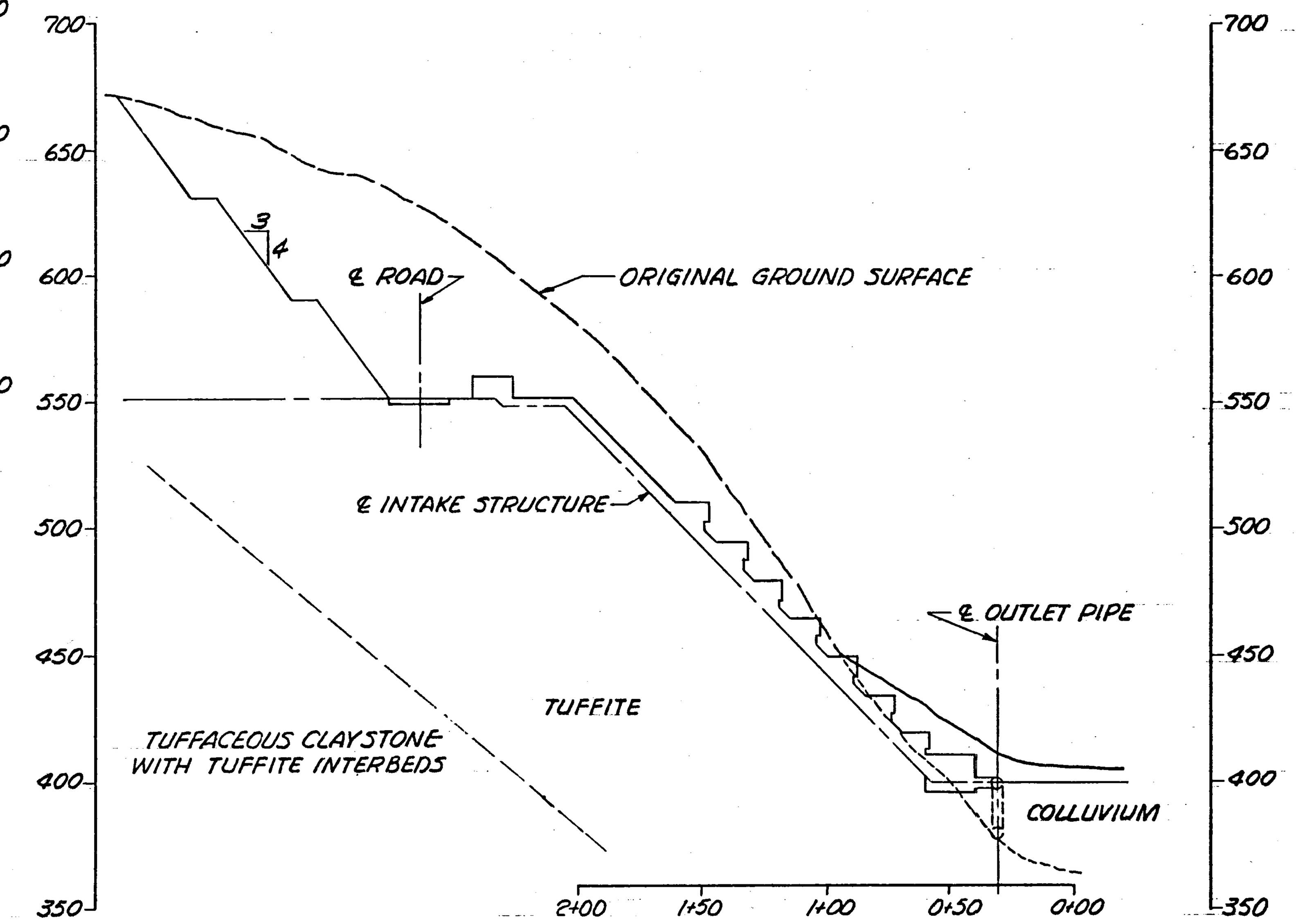
RECOMMENDED
APPROVED — COUNTY HYDRAULIC ENGINEER R.C.E. NO. 9614 — DATE 1-30-67
DRAWN | TRACED | CHKD | DRWG | SHEET 12 OF



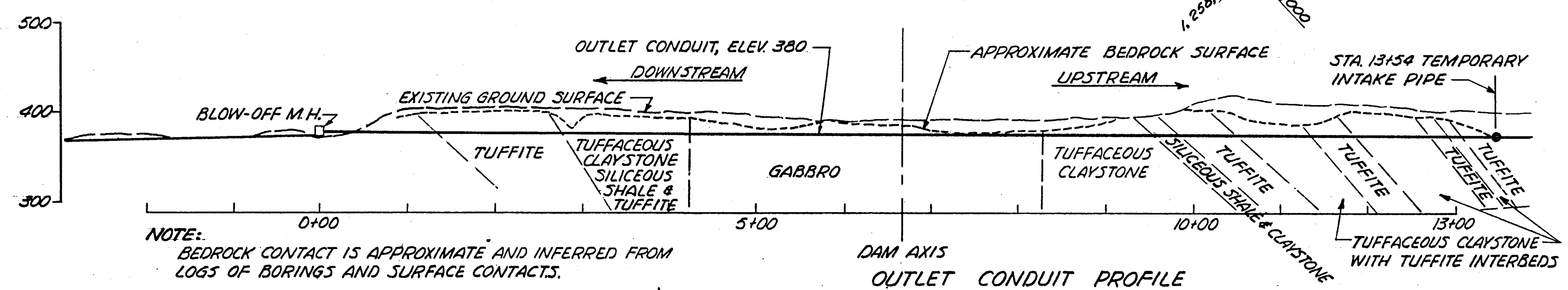
OUTLET CONDUIT EXCAVATION PLAN
SCALE 1"=100'



OUTLET CONDUIT BACKFILL & BUTTRESS FILL-SECTION B-B
SCALE 1"-100'

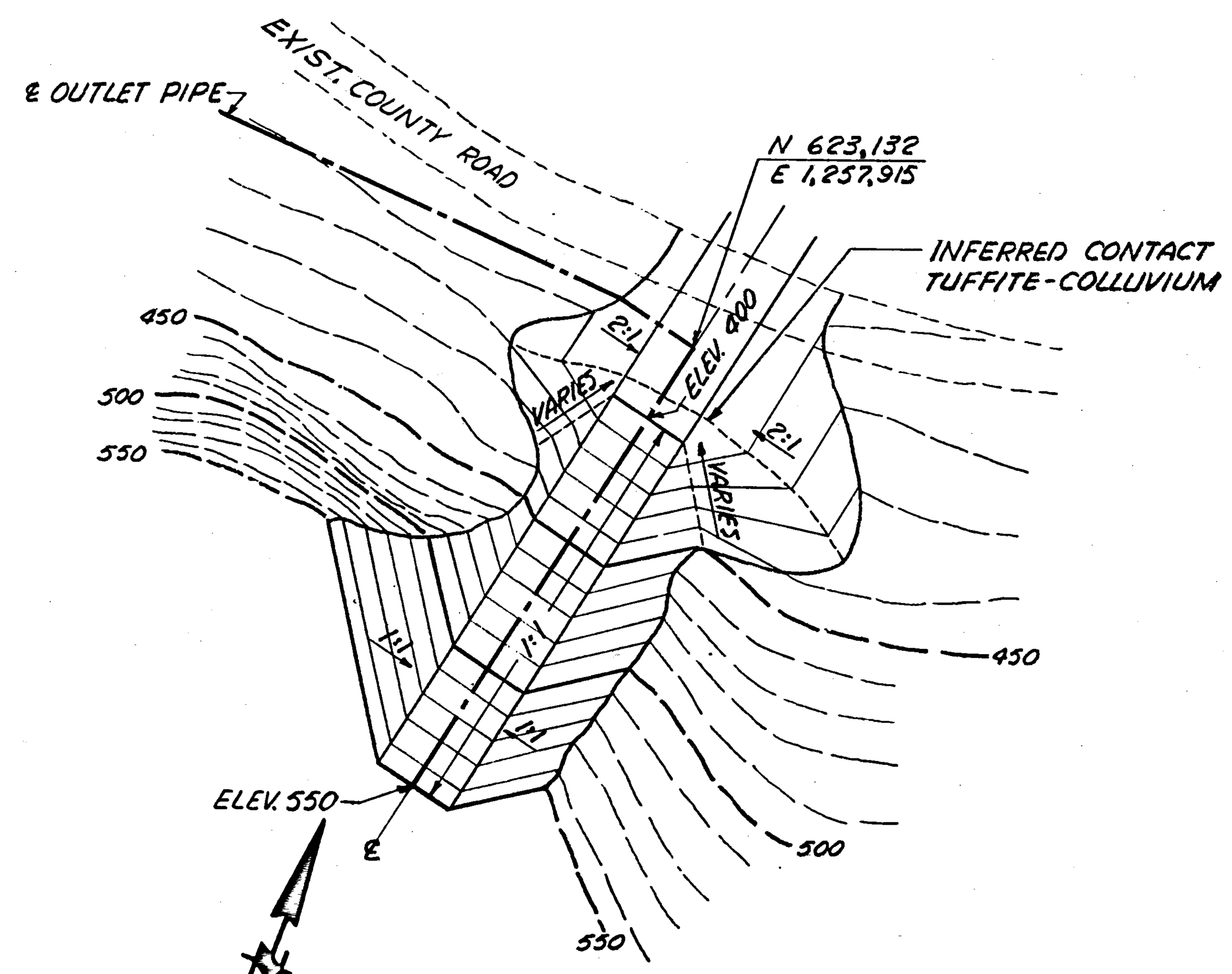


INTAKE STRUCTURE PROFILE
SCALE 1"=50'

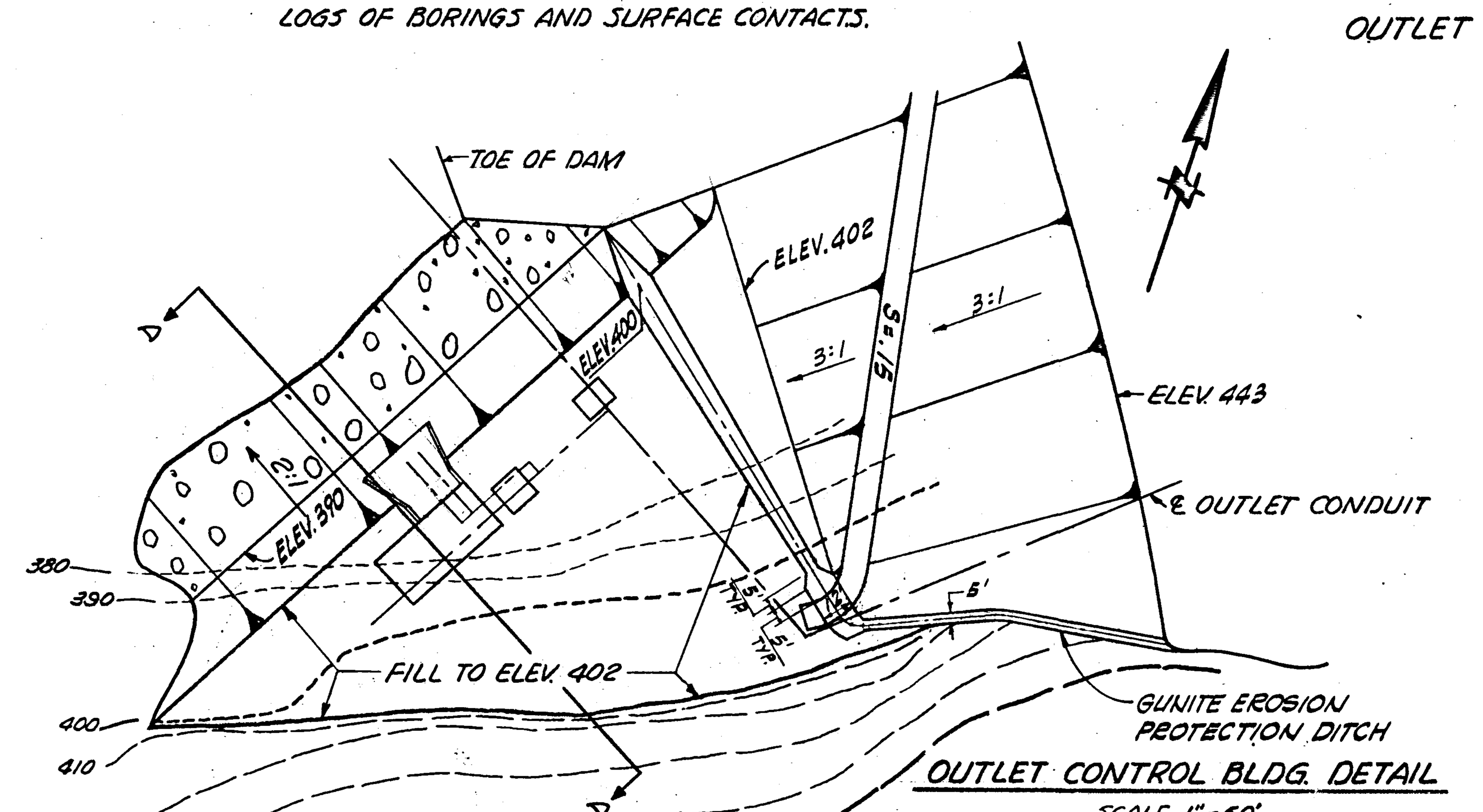


NOTE:
BEDROCK CONTACT IS APPROXIMATE AND INFERRED FROM LOGS OF BORINGS AND SURFACE CONTACTS.

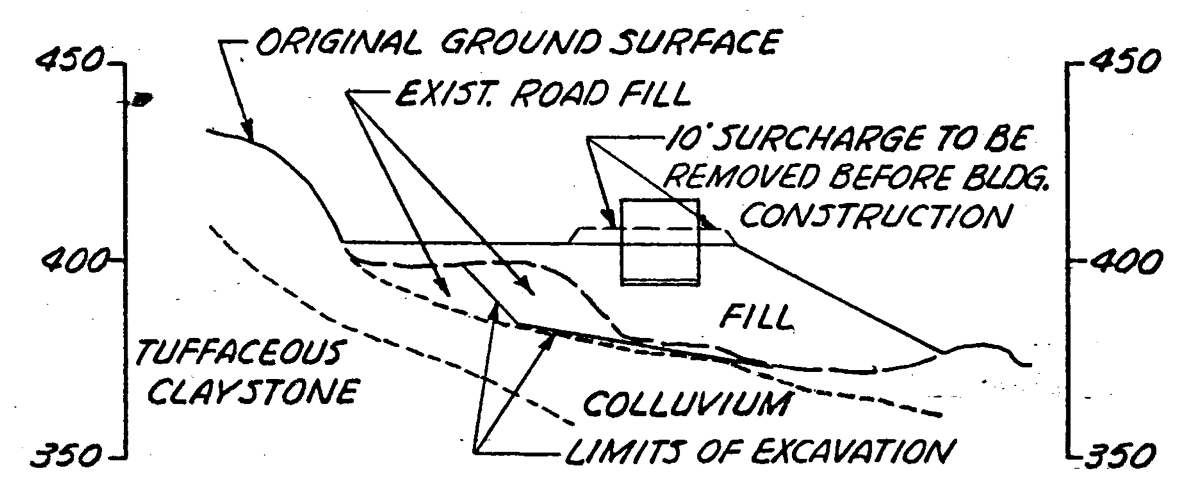
OUTLET CONDUIT PROFILE
SCALE 1"=100'



EXCAVATION PLAN INTAKE STRUCTURE
SCALE 1"=50'



OUTLET CONTROL BLDG. DETAIL
SCALE 1"=50'



OUTLET CONTROL BLDG.-SECTION A-A
SCALE 1"=50'

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS
APPLICATION NO. 1055
APPROVED AS TO SAFETY
FOR THE CHIEF ENGINEER
FEB 3 1967
ACTING DIVISION ENGINEER, REG. C.E. No. 7113

DIVISION OF SAFETY OF DAMS
JAN 30 1967

DAM DESIGNED BY
WOODWARD, CLYDE, SHERARD & ASSOCIATES
CONSULTING ENGINEERS & GEOLOGISTS

DESIGNED ____ APPROVED Stanley E. [signature]
DRAWN ____
CHECKED ____

PLANS PREPARED BY
KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING
DATE 1-27-67
BY Martin A. Lieberman
RCE 13168

REV. NO.	DATE	REVISIONS	REV.	CKD	APP.

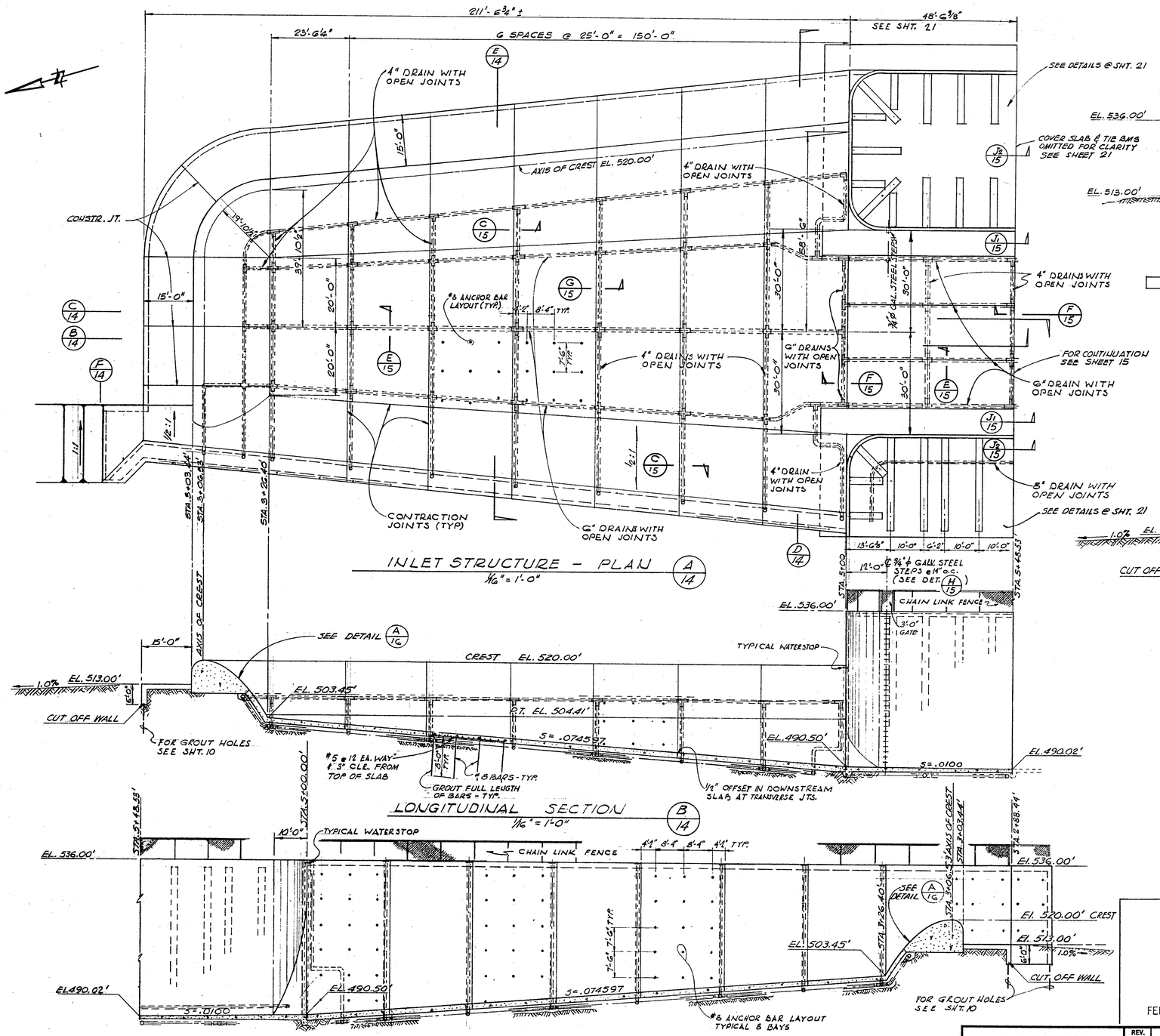
SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

LOPEZ WATER SUPPLY PROJECT

DAM AND APPURTENANT FACILITIES

INTAKE STRUCTURE AND OUTLET PIPE EXCAVATION PLAN AND PROFILE

RECOMMENDED
APPROVED [signature] COUNTY HYDRAULIC ENGINEER R.C.E. NO. 9614 DATE 1-30-67
DRAWN TRACED CHKD DRWG SHEET 13 OF



NOTE: FOR GENERAL NOTES SEE SHT. 16

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

APPLICATION NO. 1055

APPROVED AS TO SAFETY

FOR THE CHIEF ENGINEER

FEB 3 1967

ACTING DIVISION ENGINEER, REG. C.E. No. 7119

PLANS PREPARED BY
KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING

DATE Jan. 27 1967

BY SE 928

REV. NO.	DATE	REVISIONS	REV.	CKD	APP.

SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

LOPEZ WATER SUPPLY PROJECT

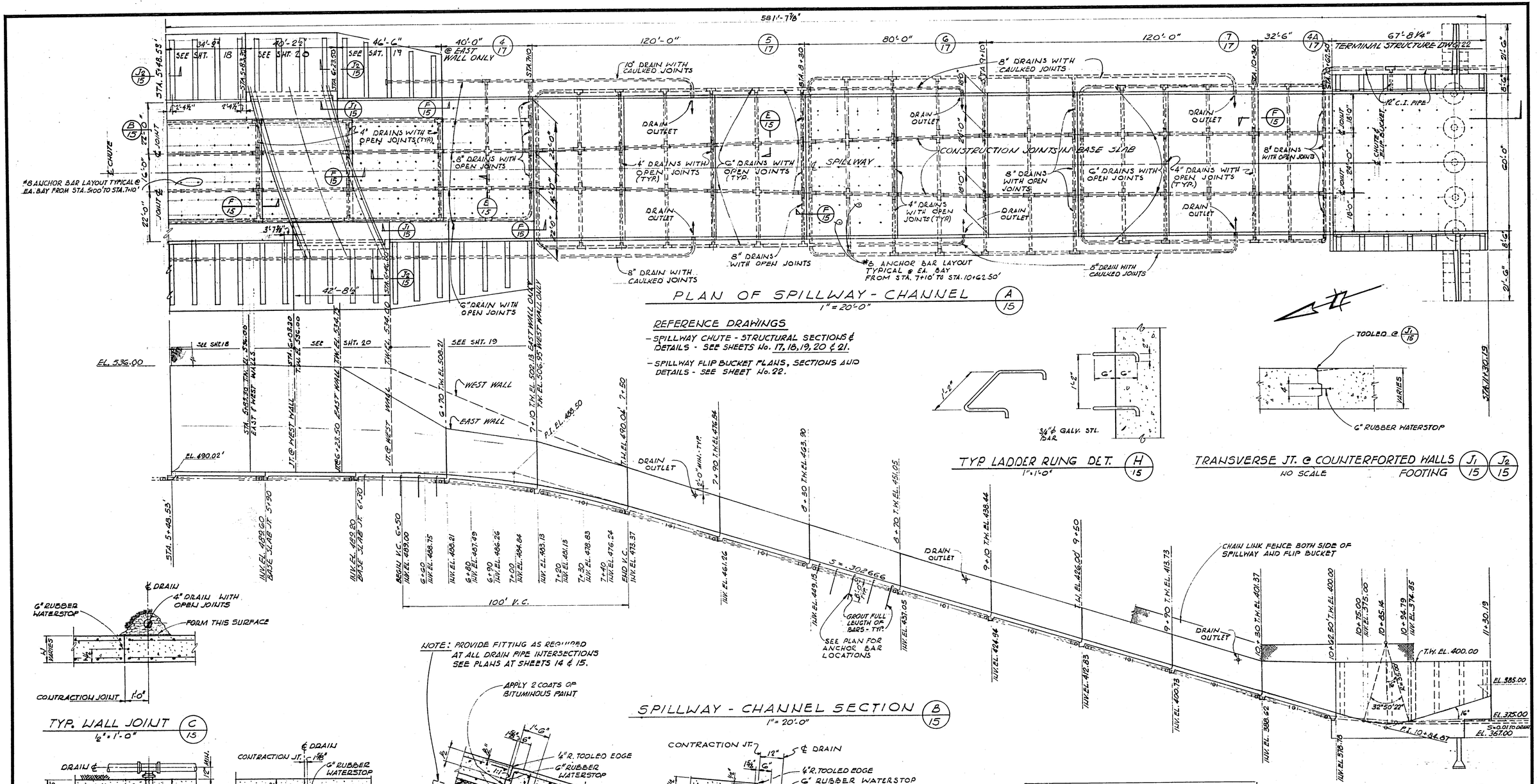
DAM AND APPURTENANT FACILITIES

SPILLWAY, INLET STRUCTURE PLAN AND SECTIONS

RECOMMENDED

APPROVED R. Hilborn COUNTY HYDRAULIC ENGINEER R.C.E. NO. 9614 DATE 1-30-67

DRAWN H.G./S.K. | TRACED | CHKD | DRWG | SHEET 14 OF



PLAN OF SPILLWAY - CHANNEL (A/15)

1" = 20'-0"

REFERENCE DRAWINGS

- SPILLWAY CHUTE - STRUCTURAL SECTIONS & DETAILS - SEE SHEETS No. 17, 18, 19, 20 & 21.
- SPILLWAY FLIP BUCKET PLANS, SECTIONS AND DETAILS - SEE SHEET No. 22.

TYP. LADDER RUNG DET. (H/15)

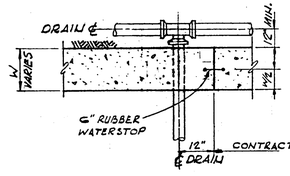
1" = 1'-0"

TRANSVERSE JT. @ COUNTERFORTED WALLS (J1/15) (J2/15) FOOTING

NO SCALE

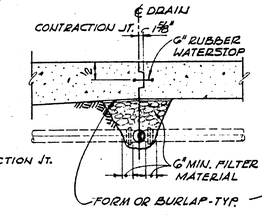
TYP. WALL JOINT (C/15)

½" = 1'-0"



TYP. WALL JOINT (D/15)

½" = 1'-0"



TYP. LONGITUDINAL JT. (E/15)

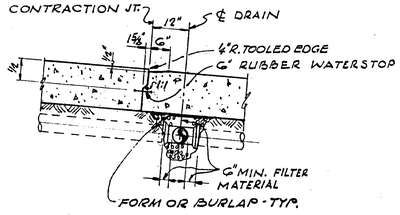
½" = 1'-0"

NOTE: PROVIDE FITTING AS REQUIRED AT ALL DRAIN PIPE INTERSECTIONS SEE PLANS AT SHEETS 14 & 15.

TYP. TRANSVERSE JT. (F/15)

FROM STA. 5+00 TO STA. 10+62.50

½" = 1'-0"



TYP. TRANSVERSE JT. (G/15)

FROM STA. 3+26.40 TO STA. 4+75.00

½" = 1'-0"

SPILLWAY - CHANNEL SECTION (B/15)

1" = 20'-0"

NOTE: FOR GENERAL NOTES SEE SHT 16.

STATE OF CALIFORNIA
THE RESOURCES AGENCY
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DIVISION OF SAFETY OF DAMS

APPLICATION NO. 1055

APPROVED AS TO SAFETY

FOR THE CHIEF ENGINEER

FEB 3 1967

ACTING DIVISION ENGINEER, REG. C.E. No. 7119

PLANS PREPARED BY
KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING

DATE Jan 27, 1967

BY SE 928

REV. NO.	DATE	REVISIONS	REV.	CKD	APP.

SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

LOPEZ WATER SUPPLY PROJECT

DAM AND APPURTENANT FACILITIES

SPILLWAY CHUTE,
PLAN, PROFILE AND DETAILS

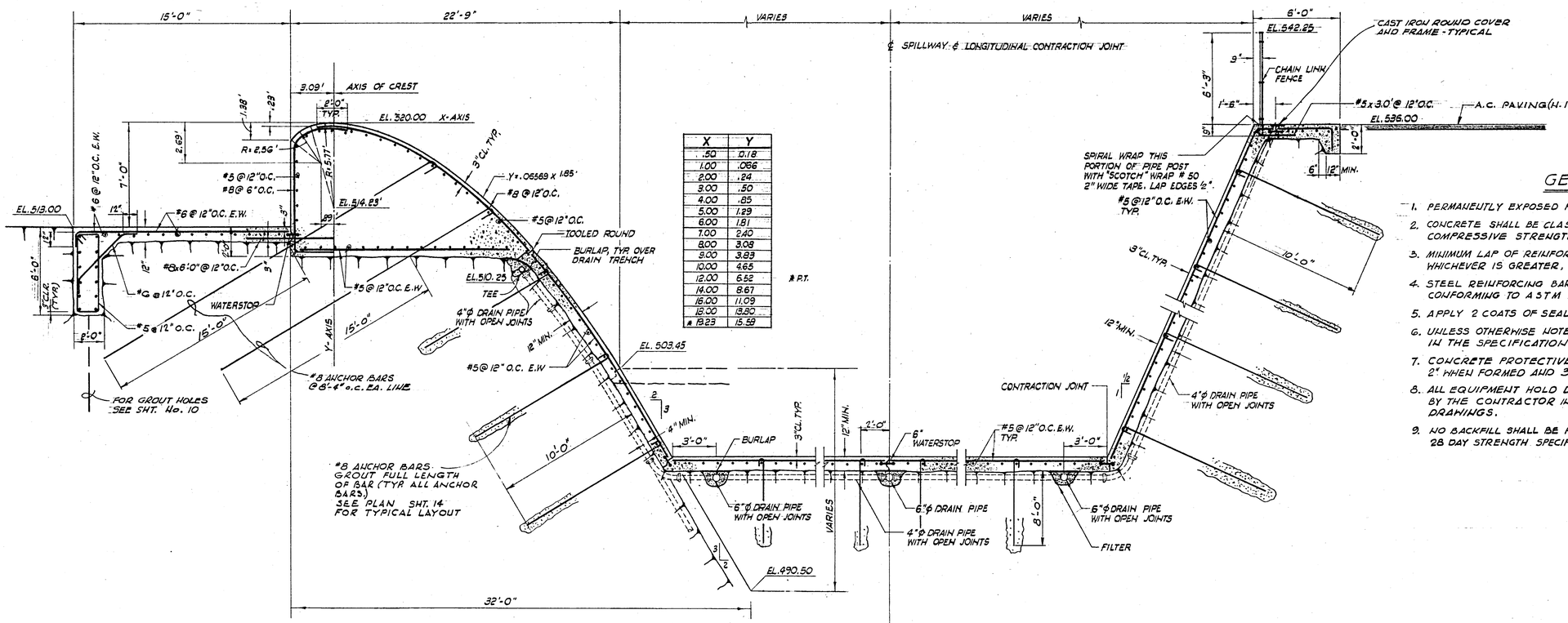
RECOMMENDED

APPROVED

COUNTY HYDRAULIC ENGINEER R.C.E. No. 9614 DATE 1-30-67

DRAWN H.G. & S.K. | TRACED | CHKD | DRWG | SHEET 15 OF

JAN 30 1967



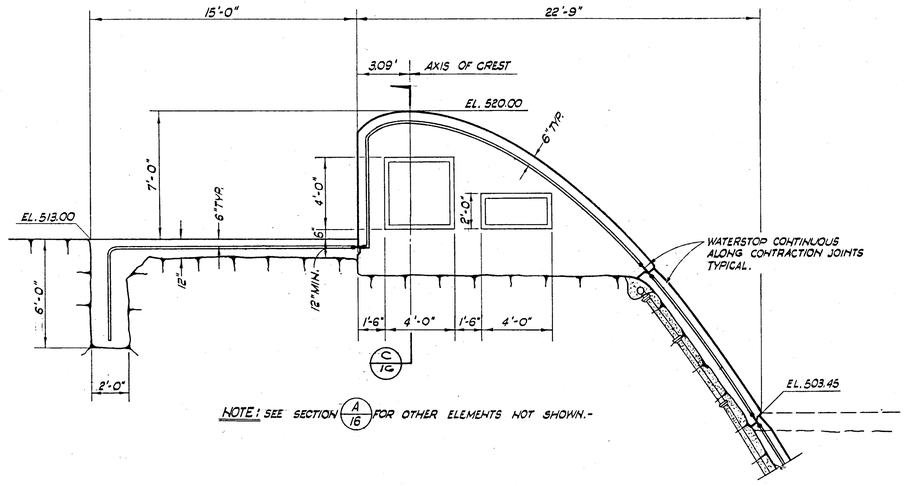
X	Y
.50	.018
1.00	.066
2.00	.24
3.00	.50
4.00	.85
5.00	1.29
6.00	1.81
7.00	2.40
8.00	3.08
9.00	3.83
10.00	4.65
12.00	6.52
14.00	8.67
16.00	11.09
18.00	13.80
* 19.23	15.59

* P.T.

SECTION THRU SPILLWAY INLET STRUCTURE (A/16)
1/4" = 1'-0"

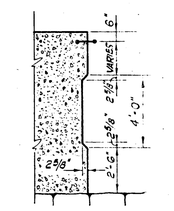
GENERAL NOTES :

1. PERMANENTLY EXPOSED FORMED EDGES SHALL BE CHAMFERED ¾" x ¾"
2. CONCRETE SHALL BE CLASS A-1½" AND SHALL ATTAIN A MINIMUM ULTIMATE COMPRESSIVE STRENGTH OF 3000 PSI AT 28 DAYS.
3. MINIMUM LAP OF REINFORCEMENT BARS SHALL BE 30 DIAMETERS OR 12" WHICHEVER IS GREATER, UNLESS OTHERWISE SHOWN.
4. STEEL REINFORCING BARS SHALL BE INTERMEDIATE GRADE, DEFORMED, CONFORMING TO A.S.T.M. A 305
5. APPLY 2 COATS OF SEALING COMPOUND TO ONE SIDE OF CONTRACTION JOINTS.
6. UNLESS OTHERWISE NOTED, CONCRETE FINISHES SHALL BE AS DESCRIBED IN THE SPECIFICATIONS.
7. CONCRETE PROTECTIVE COVERING FOR REINFORCEMENT STEEL SHALL BE 2" WHEN FORMED AND 3" WHEN PLACED AGAINST GROUND, UNLESS OTHERWISE SHOWN.
8. ALL EQUIPMENT HOLD DOWN BOLTS SHALL BE FURNISHED AND INSTALLED BY THE CONTRACTOR IN ACCORDANCE WITH APPROVED MANUFACTURERS DRAWINGS.
9. NO BACKFILL SHALL BE PLACED UNTIL THE CONCRETE HAS ATTAINED THE 28 DAY STRENGTH SPECIFIED.

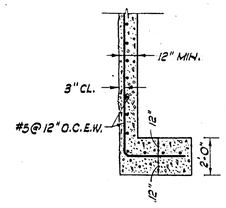


NOTE: SEE SECTION (A/16) FOR OTHER ELEMENTS NOT SHOWN.-

TYPICAL WIER AND SLAB CONTRACTION JOINT (B/16)
1/4" = 1'-0"



SECTION (C/16)
1/4" = 1'-0"



SECTION (D/16)
1/4" = 1'-0"

STATE OF CALIFORNIA
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DIVISION OF SAFETY OF DAMS

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FOR THE CHIEF ENGINEER

FEB 3 1967

ACTING DIVISION ENGINEER, REG. C.E. No. 7113

SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

LOPEZ WATER SUPPLY PROJECT

DAM AND APPURTENANT FACILITIES

SPILLWAY INLET, SECTIONS AND DETAILS

PLANS PREPARED BY
KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING
DATE Jan. 27, 1967
BY S.E. 928

REV. NO.	DATE	REVISIONS	REV.	CKD	APP.

RECOMMENDED
APPROVED — COUNTY HYDRAULIC ENGINEER R.C.E. No. 9614 — DATE 1-30-67
DRAWN E.M. & S.K. | TRACED | CHKD | DRWG | SHEET 16 OF

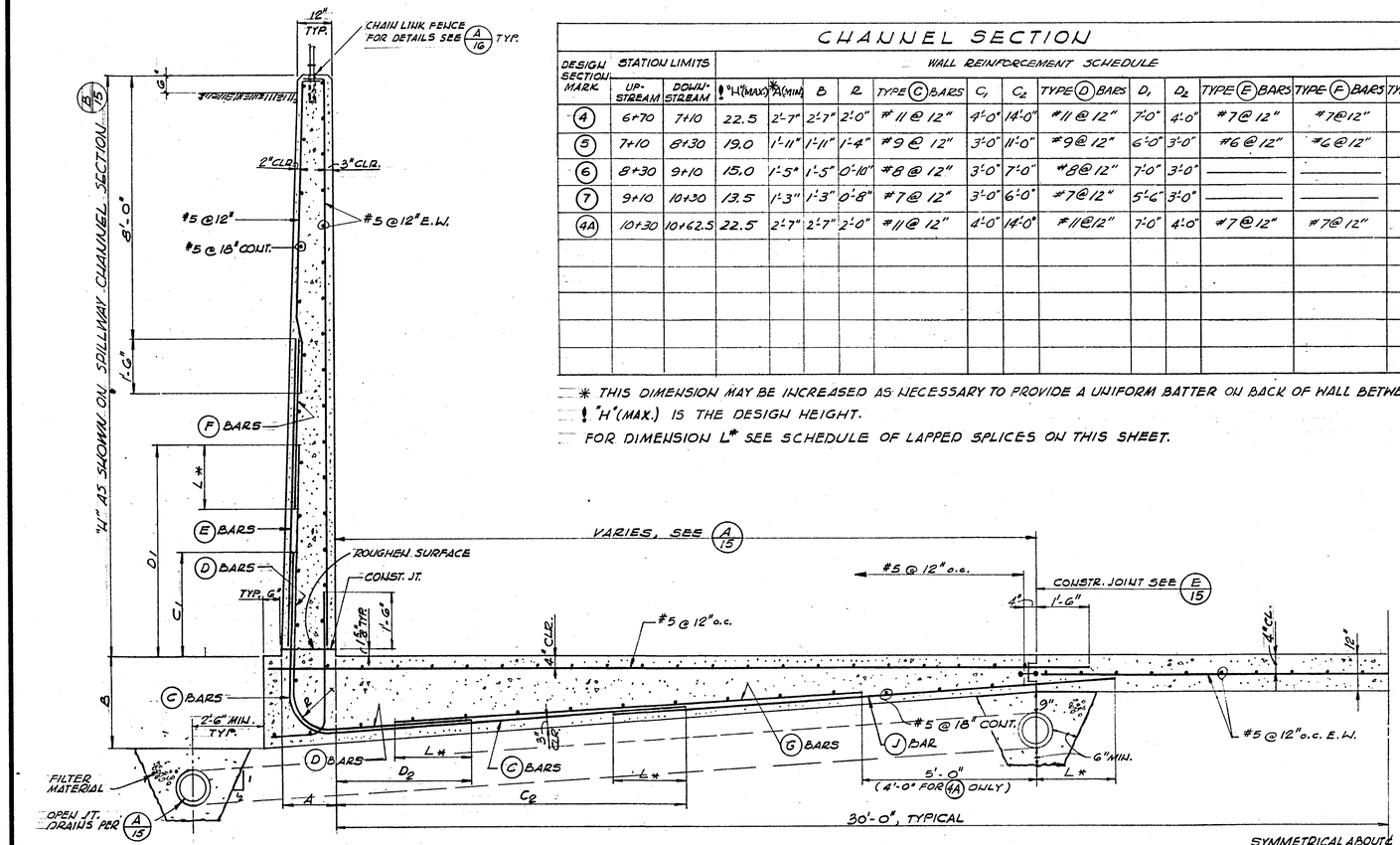
CHANNEL SECTION

DESIGN SECTION MARK	STATION LIMITS UP-STREAM	STATION LIMITS DOWN-STREAM	WALL REINFORCEMENT SCHEDULE ! "H" (MAX.)	*A (MIN.)	B	L	TYPE (C) BARS	C_1	C_2	TYPE (D) BARS	D_1	D_2	TYPE (E) BARS	TYPE (F) BARS	TYPE (G) BARS	TYPE (J) BARS	ELEV. Z Z See det. B/17
(4)	6+70	7+10	22.5	2'-7"	2'-7"	2'-0"	#11 @ 12"	4'-0"	14'-0"	#11 @ 12"	7'-0"	4'-0"	#7 @ 12"	#7@12"	#7@12"	#7@12"	TYPE A
(5)	7+10	8+30	19.0	1'-11"	1'-11"	1'-4"	#9 @ 12"	3'-0"	11'-0"	#9@12"	6'-0"	3'-0"	#6 @ 12"	#6@12"	#7@12"	#6@12"	TYPE A
(6)	8+30	9+10	15.0	1'-5"	1'-5"	0'-10"	#8 @ 12"	3'-0"	7'-0"	#8@12"	7'-0"	3'-0"	——	——	#6@12"	#5@12"	TYPE B
(7)	9+10	10+30	13.5	1'-3"	1'-3"	0'-8"	#7 @ 12"	3'-0"	6'-0"	#7@12"	5'-6"	3'-0"	——	——	#5@12"	#5@12"	TYPE B
(4A)	10+30	10+62.5	22.5	2'-7"	2'-7"	2'-0"	#11@ 12"	4'-0"	14'-0"	#11@12"	7'-0"	4'-0"	#7@12"	#7@12"	#7@12"	#7@12"	TYPE A

* THIS DIMENSION MAY BE INCREASED AS NECESSARY TO PROVIDE A UNIFORM BATTER ON BACK OF WALL BETWEEN VERTICAL CONSTR. JOINTS.

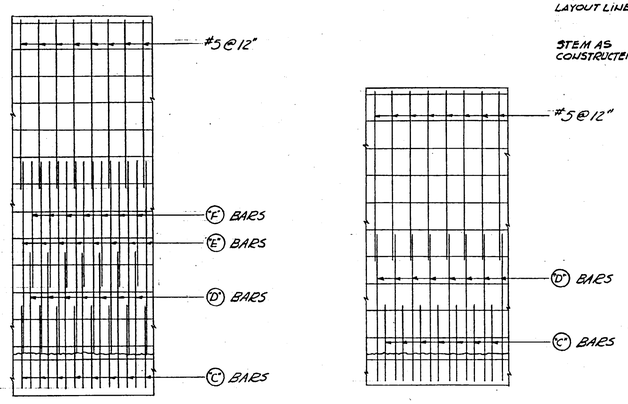
! "H" (MAX.) IS THE DESIGN HEIGHT.

FOR DIMENSION L* SEE SCHEDULE OF LAPPED SPLICES ON THIS SHEET.

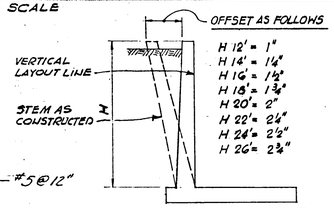


TYPICAL CHANNEL SECTION REINFORCING-LAYOUT (A/17)

NO SCALE



ELEVATION SHOWING EARTH FACE REINFORCEMENT (B/17)



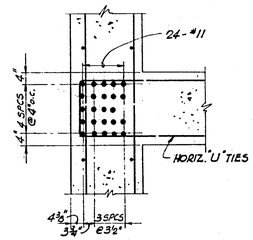
WALL OFFSET (C/17)

SCHEDULE OF LAPPED SPLICES	
BAR SIZE	MIN. LAP DIMENSION.
#4	14"
#5	18"
#6	22"
#7	25"
#8	30"
#9	39"
#10	49"
#11	61"

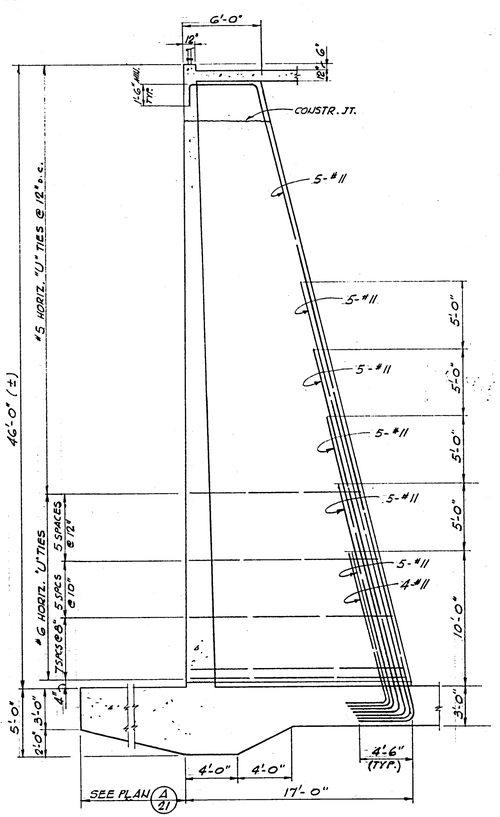
NOTE: LAP DIMENSION IS FOR THE SMALLER BAR SIZE OF TWO BARS BEING LAPPED.

NOTES:

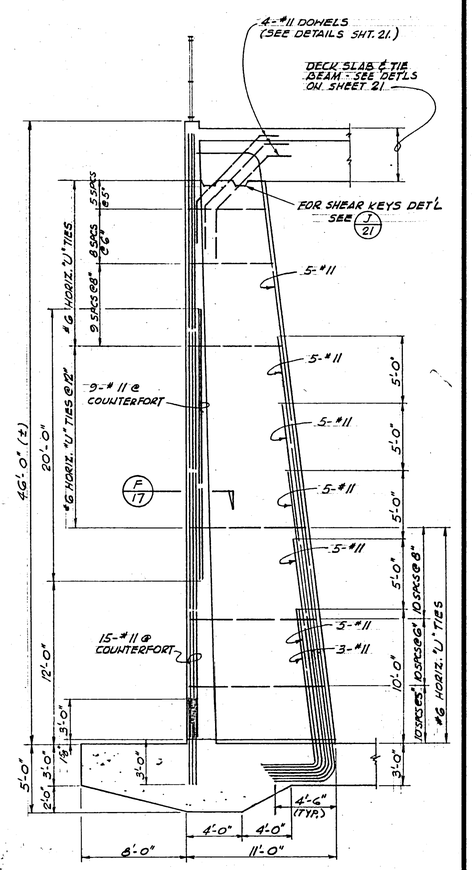
1. ALL EXPOSED EDGES OF CONCRETE SHALL BE CHAMFERED ¾" UNLESS OTHERWISE NOTED.
2. SPLICES IN LONGITUDINAL REINFORCEMENT SHALL BE STAGGERED 4'-0"
3. ALL BENDS IN REINFORCEMENT SHALL BE MADE AROUND A PIN HAVING A MINIMUM DIAMETER AS FOLLOWS: 5 BAR DIAMETER FOR #3, #4 OR #5; 6 BAR DIAMETER FOR #6, #7 OR #8; AND 8 BAR DIAMETER FOR #9, #10 OR #11. FOR SIZES #6 TO #11 INCLUSIVE, IN INTERMEDIATE GRADE OF BARS ONLY, THE MINIMUM PIN DIAMETER MAY BE 5 BAR DIAMETERS.
4. TRANSVERS CONSTRUCTION JOINTS IN INVERT SLAB WILL BE REQUIRED AT THE END OF EACH CONTINUOUS POURING OPERATION, AS PROVIDED BY THE ENGINEER AND SHALL BE FORMED JOINT AS PER DETAIL (F/15) OR (G/15)
5. VERTICAL CONSTRUCTION JOINTS IN CHANNEL WALLS SHALL BE AS PER DETAIL D/15 UNLESS OTHERWISE INDICATED AND TYPICALLY SHALL BE LOCATED AT 40 FOOT INTERVALS AS INDICATED.
6. PROVIDE THE OFFSET AS SHOWN AT DETAIL (C/17).
7. FOR GENERAL NOTES SEE SHEET 16.



SECTION (F/17)
½"=1'-0"



CORNER DIAGONAL COUNTERFORT (D/17)
3/16"=1'-0"



CORNER COUNTERFORT (E/17)
3/16"=1'-0"

NOTE: EXCEPT AS MODIFIED BY DETAILS (D/17) AND (E/17), CONSTRUCT AND REINFORCE FACE SLABS (WALLS). COUNTERFORTS, FOOTING PAD, DECK SLAB AND TIE BEAMS PER DETAILS ON SHEET 21.

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

APPLICATION NO. 1055

APPROVED AS TO SAFETY

FOR THE CHIEF ENGINEER

FEB 3 1967

ACTING DIVISION ENGINEER, REG. C.E. NO. 7113

JAN 0 1967
DIVISION OF SAFETY OF DAMS
DEPARTMENT OF WATER RESOURCES

PLANS PREPARED BY
KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING
DATE Jan. 27, 1967
BY SE 928

REV. NO.	DATE	REVISIONS	REV.	CKD	APP.

SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

LOPEZ WATER SUPPLY PROJECT

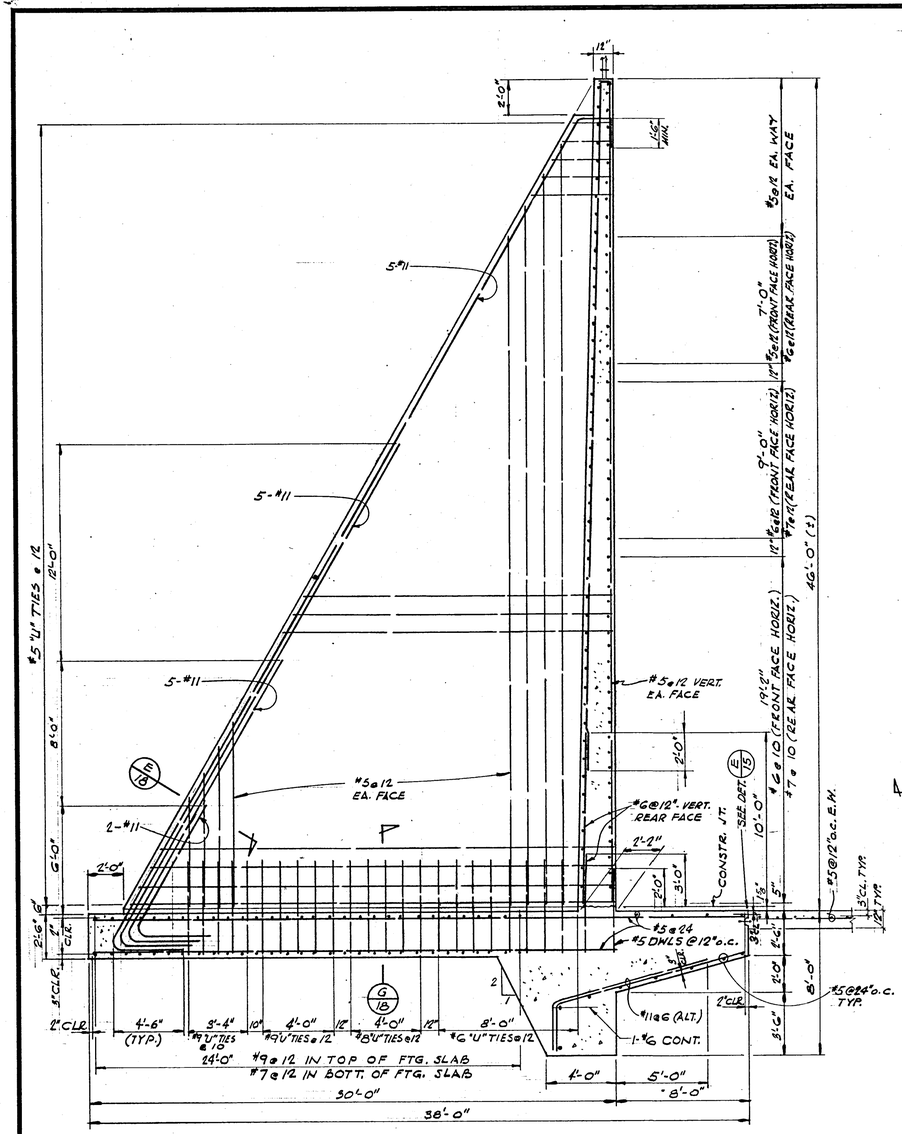
DAM AND APPURTENANT FACILITIES

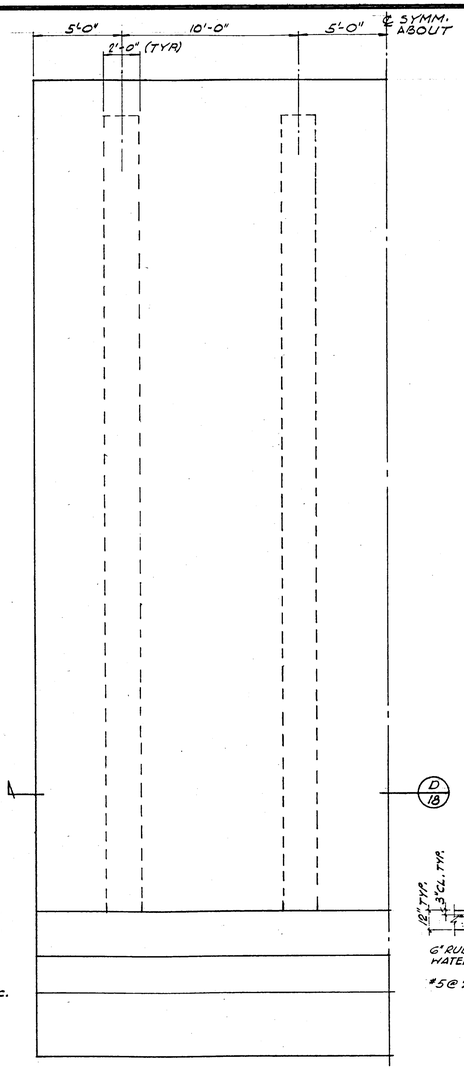
SPILLWAY CHUTE,
L-SHAPED WALLS, SECTIONS AND DETAILS

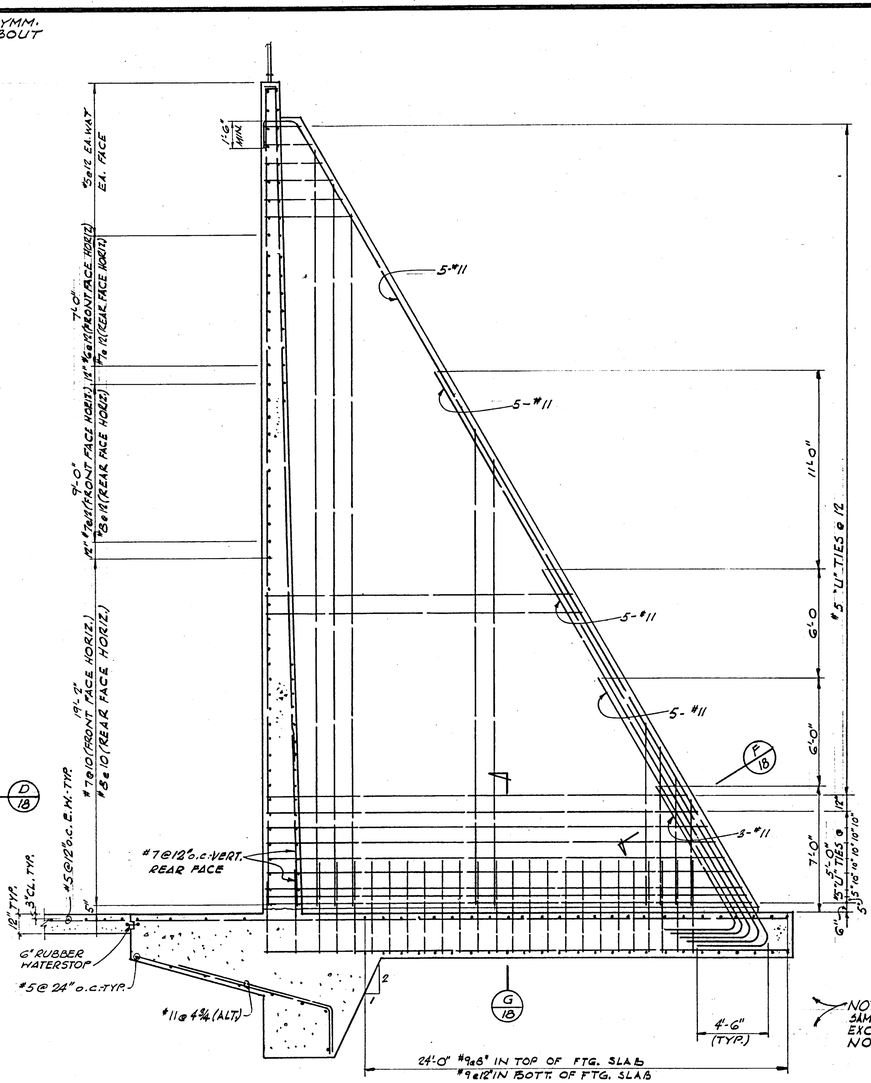
RECOMMENDED

APPROVED — COUNTY HYDRAULIC ENGINEER R.C.E. NO. 9614 — DATE 1-30-67

DRAWN H.G.&E.K. | TRACED | CHKD | DRWG | SHEET 17 OF



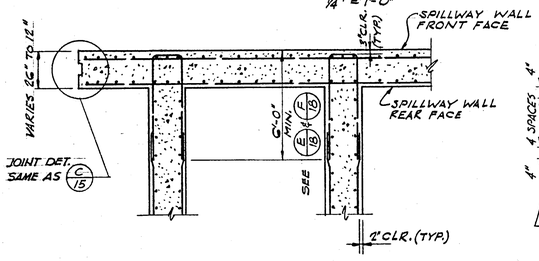




NOTE: REINFOREMENT & DIMELSIONS SAME AS SECTION A/18 EXCEPT AS NOTED.

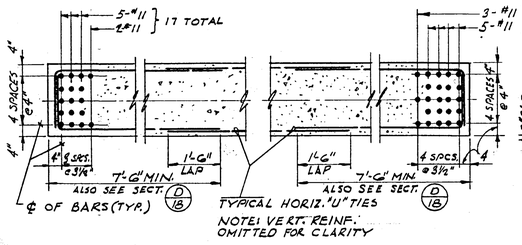
WEST SPILLWAY RETAINING WALL & COUNTERFORT (A/18)

1/4" = 1'-0"



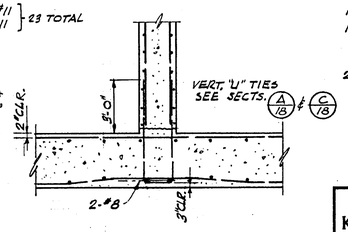
TYPICAL FRONT ELEVATION (B/18)

1/4" = 1'-0"



(C/18) EAST SPILLWAY RETAINING WALL & COUNTERFORT

1/4" = 1'-0"



NOTES;

1. PROVIDE HOLES IN COUNTERFORTS FOR DRAIN LINES INDICATED ON SPILLWAY INLET STRUCTURE PLAN AND SPILLWAY CHUTE PLAN, SHTS. 14 & 15.
2. FOR GENERAL NOTES SEE SHT. 16.

SECTION (D/18)

4" = 1'-0"

SECTION (E/18)

1/2" = 1'-0"

SECTION (F/18)

1/2" = 1'-0".

SECTION (G/18)

1/4" = 1'-0"

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

APPLICATION NO. 1055
APPROVED AS TO SAFETY

FOR THE CHIEF ENGINEER
FEB 3 1967
C. J. Costigan
ACTING DIVISION ENGINEER, REG. C.E. NO. 7113

DIVISION OF SAFETY OF DAMS
DEPARTMENT OF WATER RESOURCES
JAN 30 1967

SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

LOPEZ WATER SUPPLY PROJECT

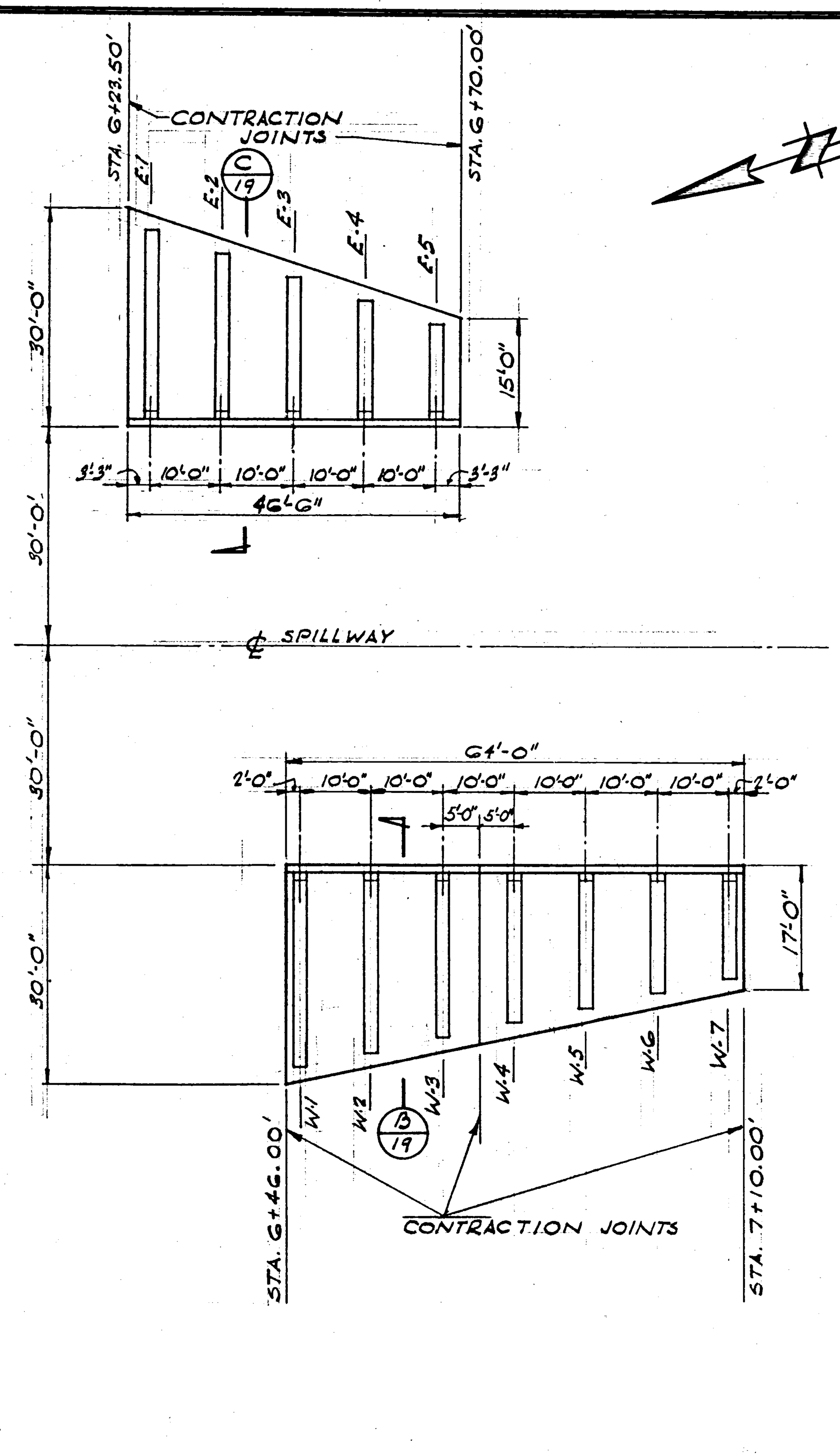
DAM AND APPURTENANT FACILITIES

TYPICAL EAST & WEST SIDES COUNTERFORTED WALLS

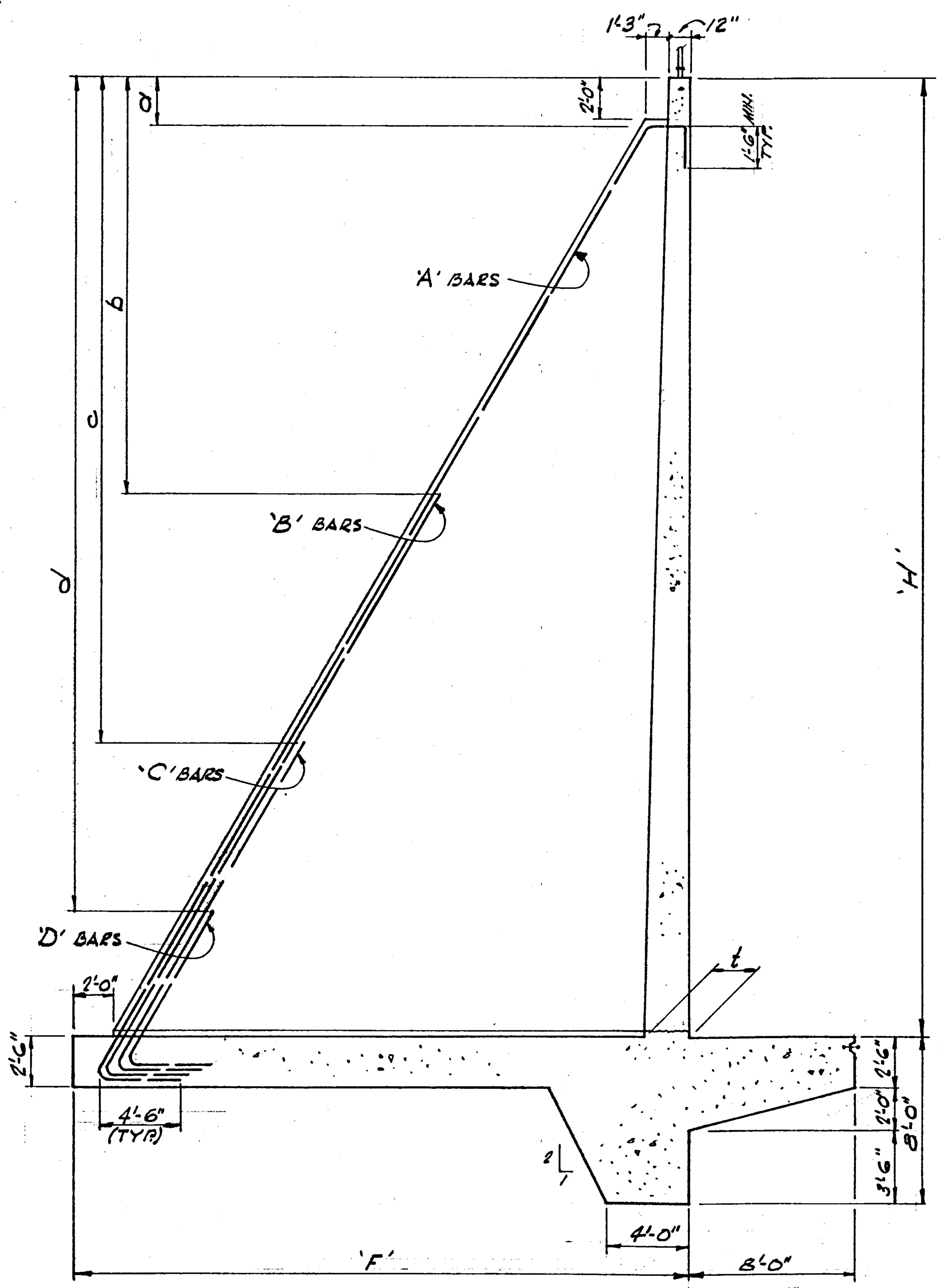
PLANS PREPARED BY
KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING
DATE Jan 27, 1967
BY SE 928

REV. NO.	DATE	REVISIONS	REV.	CKD	APP.

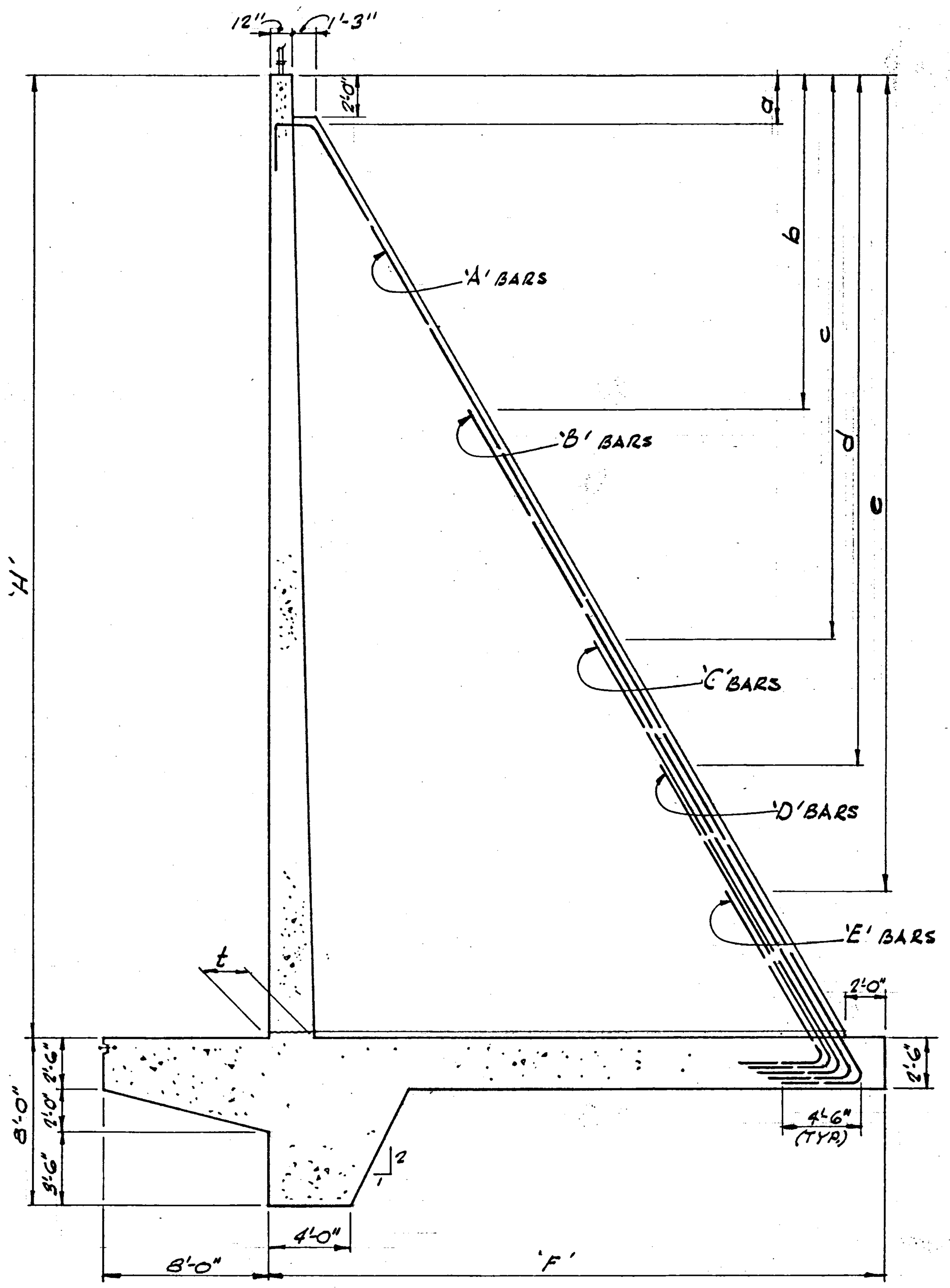
RECOMMENDED
APPROVED — COUNTY HYDRAULIC ENGINEER R.C.E. NO. 9614 — DATE 1-30-67
DRAWN R.A.W. | TRACED | CHKD | DRWG | SHEET 18 OF



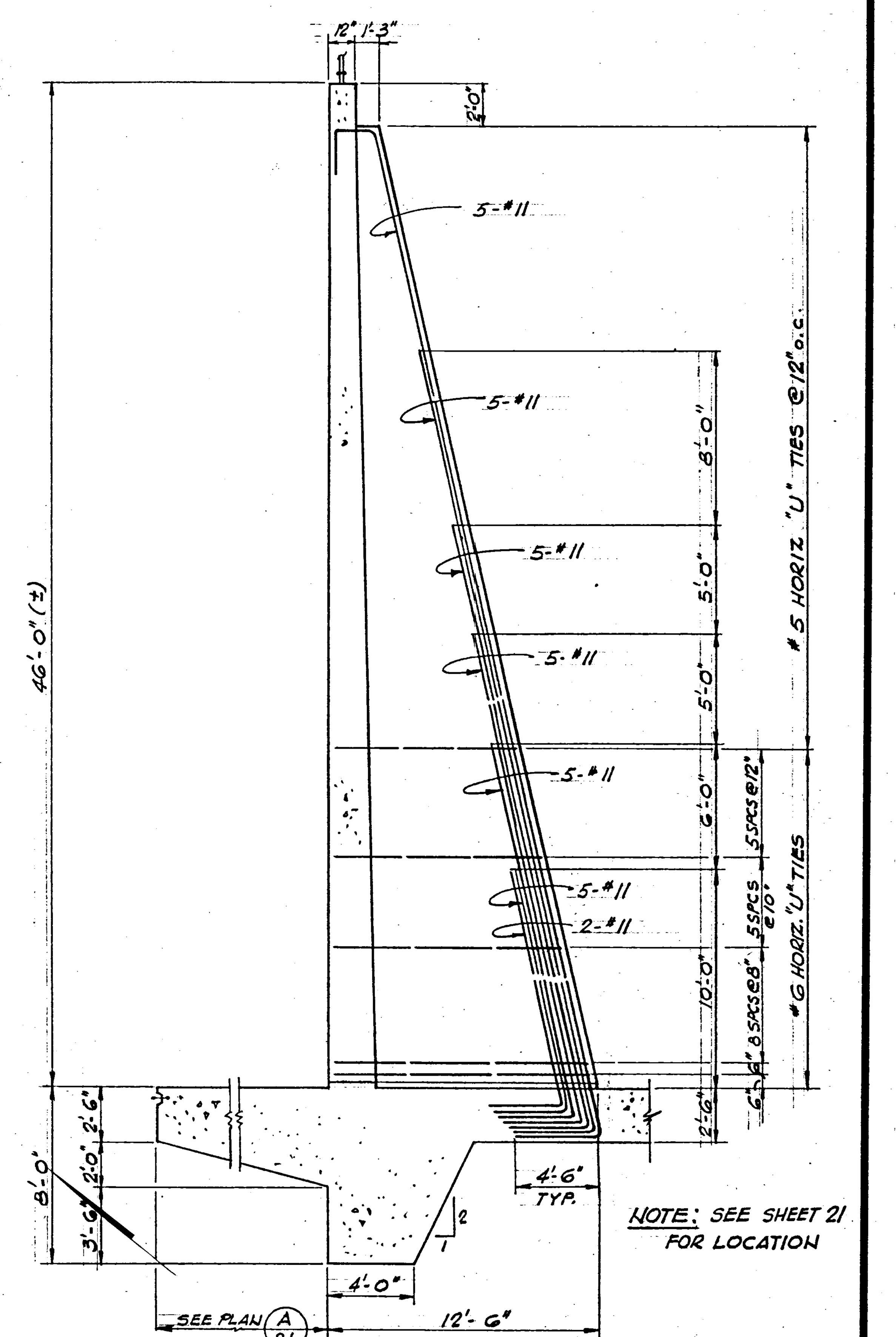
SPECIAL EAST & WEST WALL PLAN (A/19)
1/16" = 1'-0"



WEST WALL SECTION (B/19)
NO SCALE



EAST WALL SECTION (C/19)
NO SCALE



COUNTERFORT SECTION (D/19)
3/16" = 1'-0"

SPECIAL COUNTERFORTED WALL SCHEDULE

COUNTERFORT No.	STATION	'H'	'F'	t	a 'A' BARS	b 'B' BARS	c 'C' BARS	d 'D' BARS	e 'E' BARS	REMARKS
E-1	6+26.75	44'-2"	29'-2"	2'-2"	2'-4" 5-#11	16'-0" 5-#11	27'-0" 5-#11	33'-0" 5-#11	39'-0" 3-#11	SAME AS SECT. (C/18)
E-2	6+36.75	38'-7½"	25'-10"	2'-0½"	2'-4" 5-#11	16'-0" 5-#11	27'-0" 5-#11	33'-0" 5-#11	—	
E-3	6+46.75	33'-0½"	22'-6"	1'-10"	2'-4" 5-#11	16'-0" 5-#11	27'-0" 5-#11	—	—	
E-4	6+56.75	27'-5"	19'-2"	1'-8½"	2'-4" 5-#11	16'-0" 5-#11	—	—	—	
E-5	6+66.75	21'-10"	15'-10"	1'-7"	2'-4" 5-#11	16'-0" 5-#11	—	—	—	
W-1	6+48.00	45'-2¾"	29'-6"	2'-2"	2'-4" 5-#11	20'-0" 3-#11	32'-0" 5-#11	40'-0" 2-#11	—	SAME AS SECT. (A/18)
W-2	6+58.00	41'-5½"	27'-6"	2'-1"	2'-4" 5-#11	20'-0" 5-#11	32'-0" 5-#11	—	—	
W-3	6+68.00	38'-5"	25'-6"	2'-0"	2'-4" 5-#11	20'-0" 5-#11	32'-0" 5-#11	—	—	
W-4	6+78.00	35'-0"	23'-6"	1'-11"	2'-4" 5-#11	20'-0" 5-#11	30'-0" 5-#11	—	—	
W-5	6+88.00	31'-6¾"	21'-6"	1'-10"	2'-4" 5-#11	20'-0" 5-#11	—	—	—	
W-6	6+98.00	28'-1½"	19'-6"	1'-9"	2'-4" 5-#11	20'-0" 5-#11	—	—	—	
W-7	7+08.00	24'-8½"	17'-6"	1'-8"	2'-4" 5-#11	18'-0" 5-#11	—	—	—	

NOTES FOR SPECIAL EAST & WEST SPILLWAY CHUTE WALLS

1. CONSTRUCT FACE SLABS (WALLS) SIMILAR TO THE RESPECTIVE EAST AND WEST TYPICAL COUNTERFORTED WALLS PER DETAILS ON SHEET 18. WALL THICKNESS AND REINFORCEMENT ARE THE SAME AT THE CORRESPONDING DISTANCES DOWN FROM THE TOP OF THE WALLS.
2. EXCEPT AS INDICATED ON THIS SHEET, CONSTRUCT THE RESPECTIVE EAST AND WEST COUNTERFORTS THE SAME AS THE TYPICAL EAST AND WEST COUNTERFORTS PER DETAILS ON SHEET 18. DIMENSIONS AND REINFORCEMENT ARE THE SAME AT THE CORRESPONDING DISTANCES DOWN FROM THE TOP OF THE WALLS.
3. EXCEPT AS INDICATED ON THIS SHEET, CONSTRUCT THE RESPECTIVE EAST AND WEST FOOTING PADS THE SAME AS THE TYPICAL EAST AND WEST FOOTING PADS PER DETAILS ON SHEET 18. MAKE REINFORCEMENT AND PLACING PATTERNS THE SAME AT THE CORRESPONDING DISTANCES FROM THE FRONT FACE OF THE WALLS.
4. PROVIDE HOLES IN COUNTERFORTS FOR DRAIN LINES INDICATED ON SPILLWAY INLET STRUCTURE PLAN AND SPILLWAY CHUTE PLAN.
5. FOR GENERAL NOTES SEE SHEET 16.

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS
APPLICATION NO. 1055
APPROVED AS TO SAFETY
FOR THE CHIEF ENGINEER
FEB 3 1967 C. J. Cortright
ACTING DIVISION ENGINEER, REG. C.E. No. 7113

PLANS PREPARED BY
KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING
DATE Jan. 27, 1967
BY [signature] SE 928

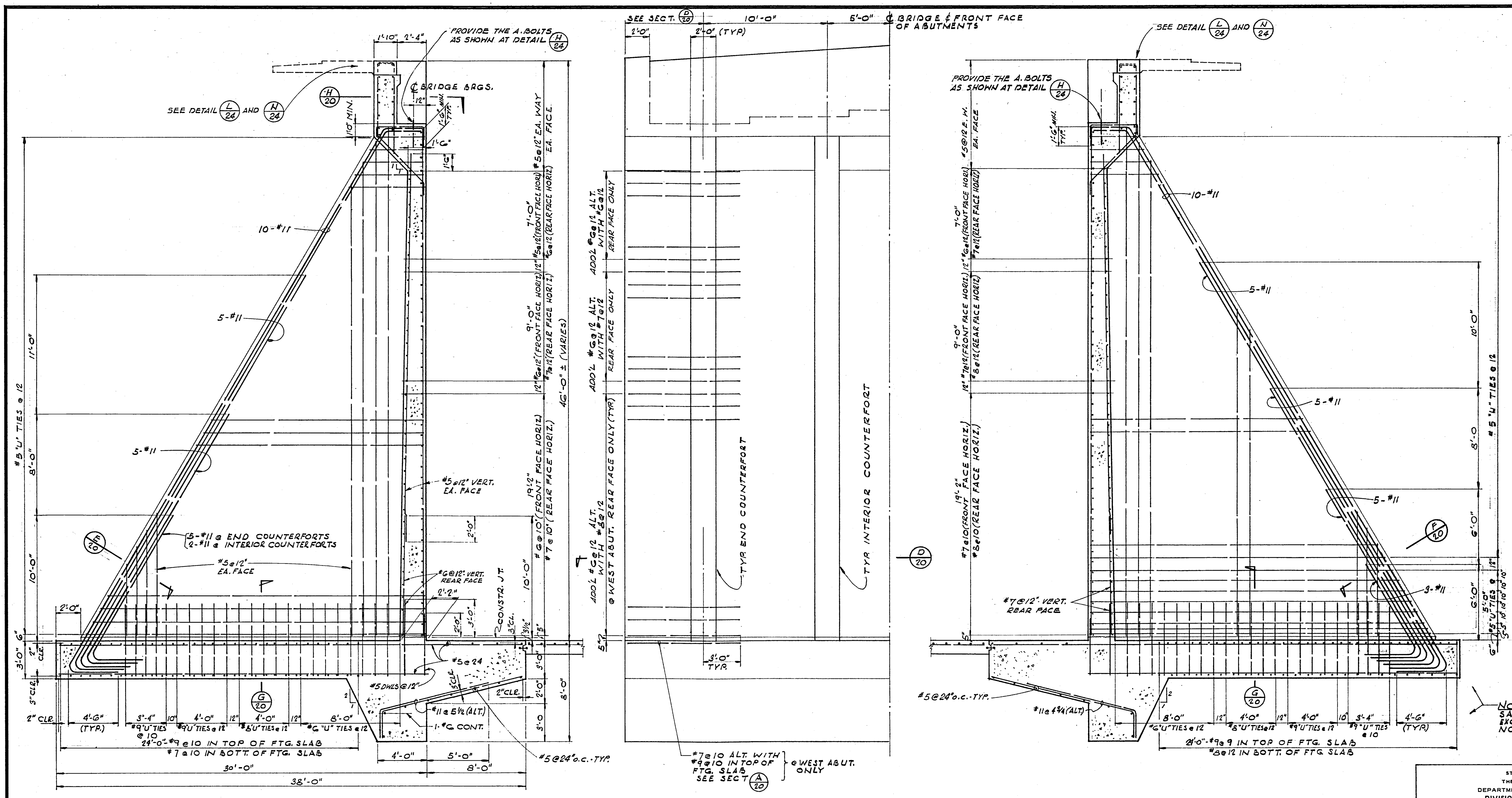
REV. NO.	DATE	REVISIONS	REV.	CKD	APP.

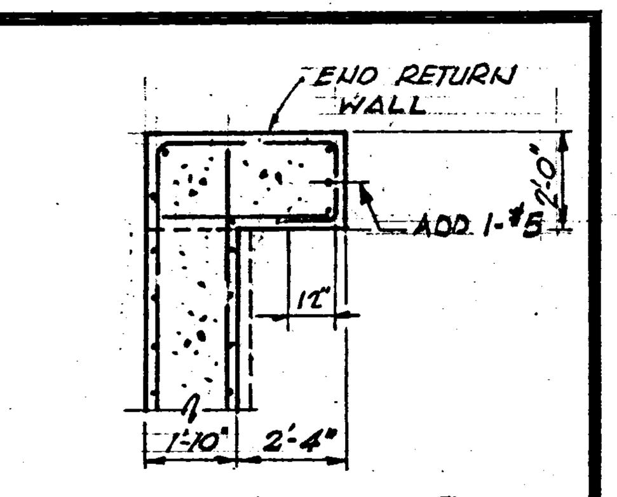
SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

LOPEZ WATER SUPPLY PROJECT

DAM AND APPURTENANT FACILITIES
SPILLWAY CHUTE,
SPECIAL EAST & WEST SIDES COUNTERFORTED WALLS

RECOMMENDED
APPROVED [signature] COUNTY HYDRAULIC ENGINEER R.C.E. NO. 9614 DATE 1-30-67
DRAWN R.A.S. TRACED CHKD DRWG SHEET 19 OF



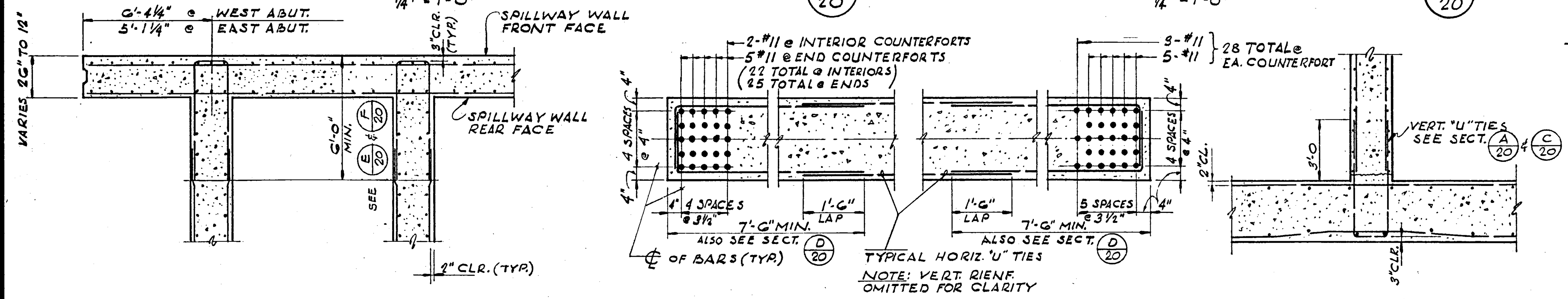


SECTION (H/20)
1/4" = 1'-0"

WEST SPILLWAY BRIDGE ABUTMENT SECTION (A/20)
1/4" = 1'-0"

TYPICAL REAR ELEVATION (B/20)
1/4" = 1'-0"

(C/20) EAST SPILLWAY BRIDGE ABUTMENT SECTION
1/4" = 1'-0"



SECTION (D/20)
1/4" = 1'-0"

SECTION (E/20)
1/2" = 1'-0"

SECTION (F/20)
1/2" = 1'-0"

SECTION (G/20)
1/4" = 1'-0"

NOTES:

1. PROVIDE HOLES IN COUNTERFORTS FOR DRAIN LINES INDICATED ON SPILLWAY INLET STRUCTURE PLAN AND SPILLWAY CHUTE PLAN.
2. FOR GENERAL NOTES SEE SHEET 16.
3. FOR WEST AND EAST FINAL ABUTMENT ELEVATIONS SEE DETAILS (J/24) & (K/24)

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

APPLICATION NO. 1055
APPROVED AS TO SAFETY

FOR THE CHIEF ENGINEER

FEB 3 1967

ACTING DIVISION ENGINEER, REG. C.E. No. 7113

PLANS PREPARED BY
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ENGINEERING — ARCHITECTURE
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DATE Jan. 27, 1967
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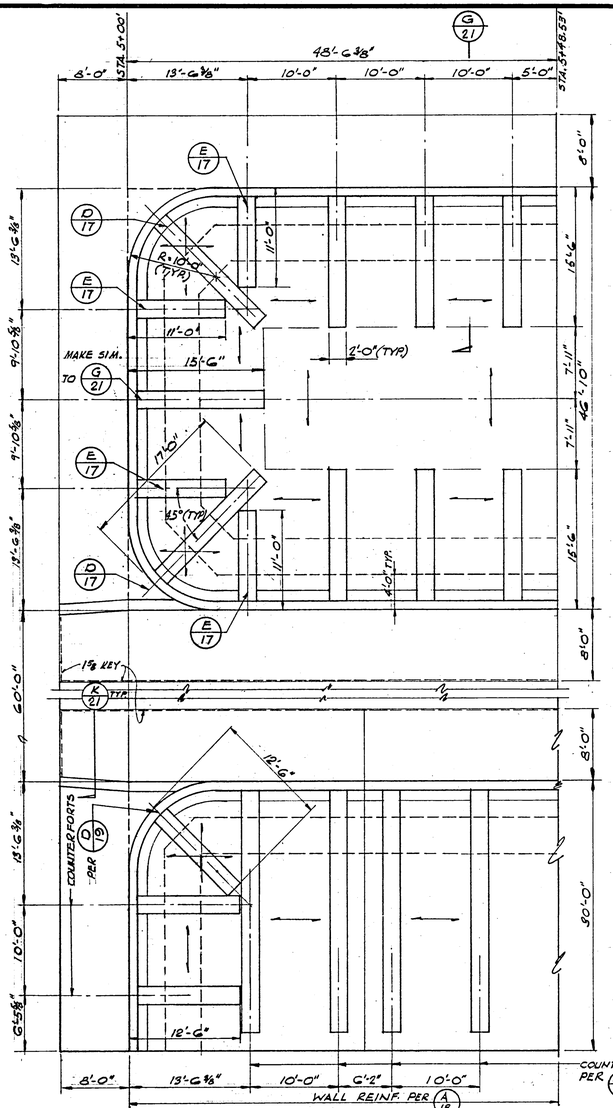
SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

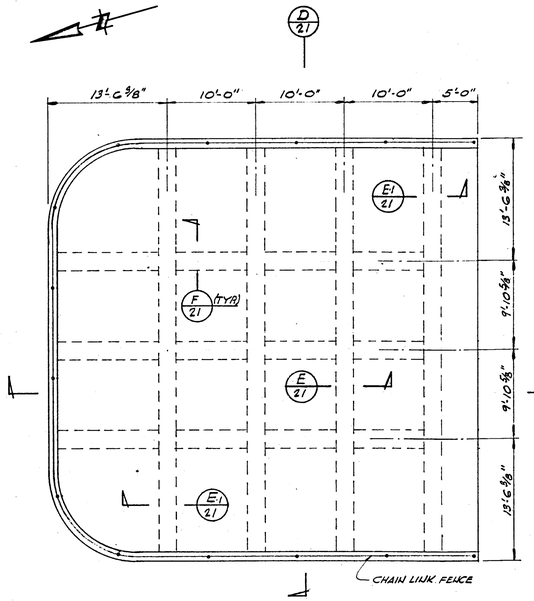
LOPEZ WATER SUPPLY PROJECT

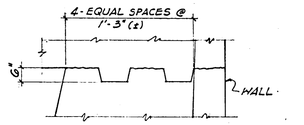
DAM AND APPURTENANT FACILITIES
SPILLWAY CHUTE,
EAST AND WEST COUNTERFORTED BRIDGE ABUTMENTS

RECOMMENDED
APPROVED [signature] COUNTY HYDRAULIC ENGINEER R C E NO. 9614 DATE 1-30-67
DRAWN R.A.W. TRACED CHKD DRWG SHEET 20 OF

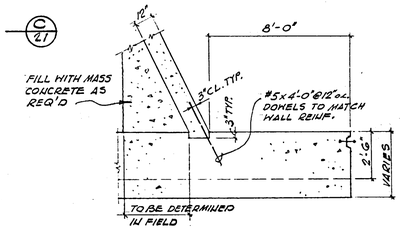


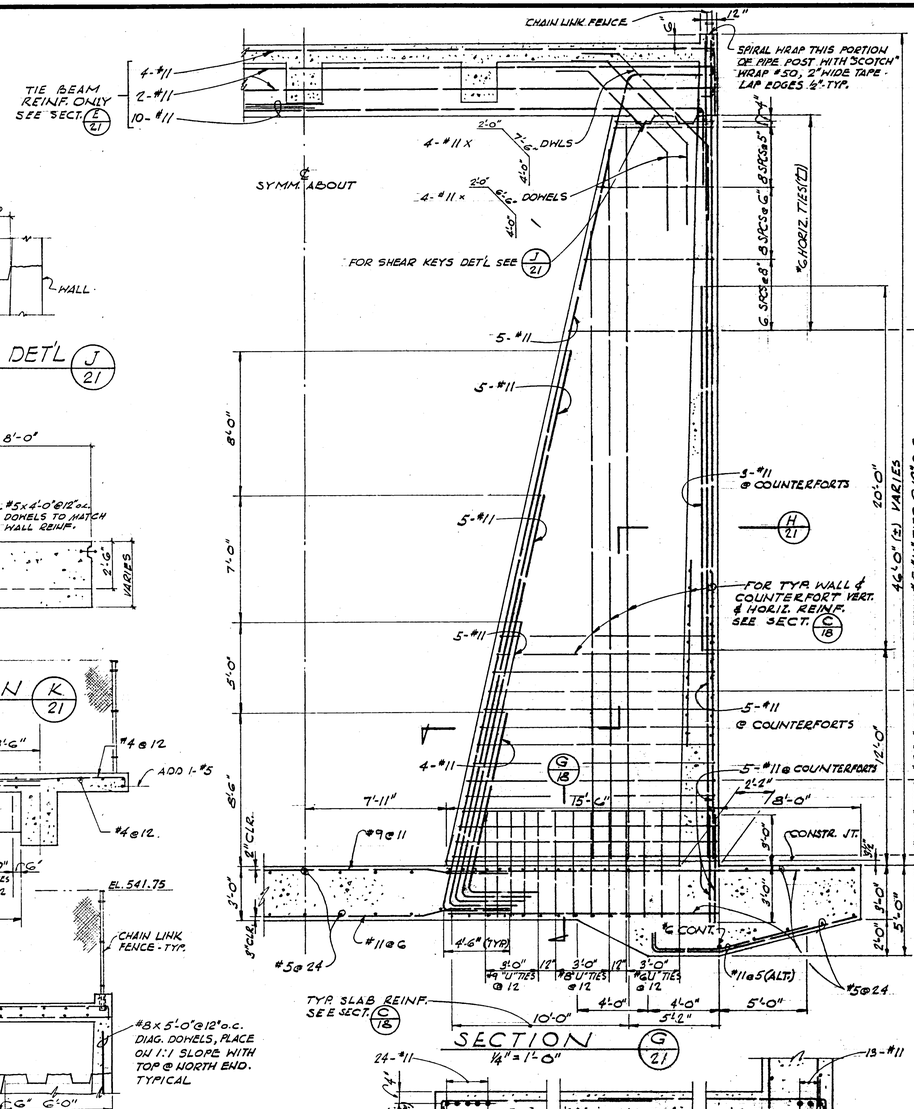
FOOTING & COUNTERFORT PLAN (A/21)
1/8" = 1'-0"



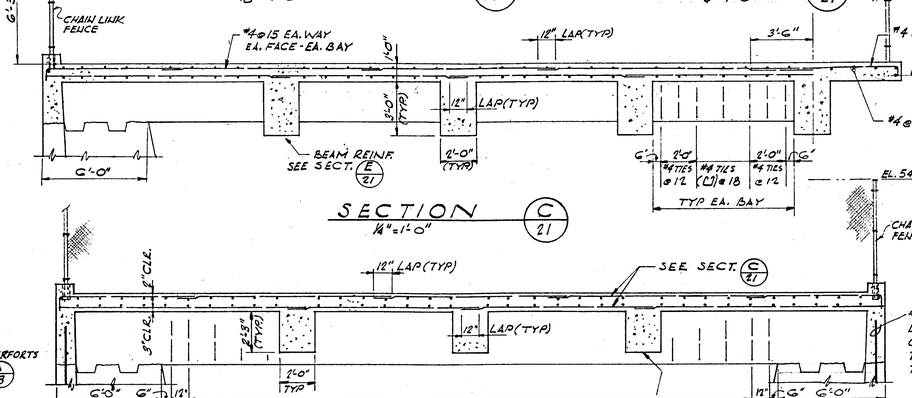


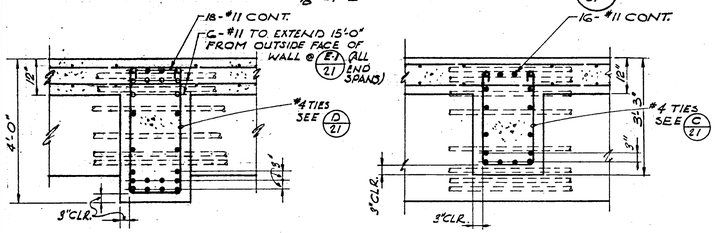
SHEAR KEYS DET'L (J/21)
3/8" = 1'-0"





SECTION (G/21)
1/4" = 1'-0"

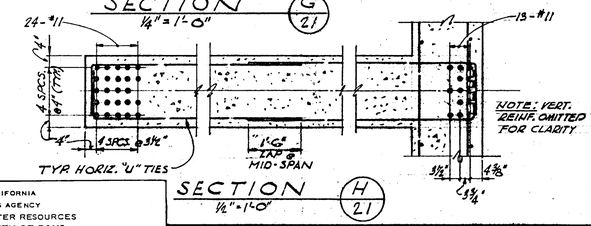




NOTE: CROSSING BARS SHOWN FOR CLARITY OF PLACEMENT

SECTION (E/21) (E-1/21)
1/2" = 1'-0"

SECTION (F/21)
1/2" = 1'-0"



SECTION (H/21)
1/2" = 1'-0"

NOTES:

1. FOR GENERAL NOTES SEE SHEET 16.
2. IN PLAN (A/21) THE SYMBOL ——— DENOTES DIRECTION OF THE MAIN TOP AND BOTTOM FOOTING PAD REINFORCEMENT. SEE THE APPROPRIATE COUNTERFORT SECTIONS FOR BAR SIZES AND SPACING.

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS
APPLICATION NO. 1055
APPROVED AS TO SAFETY
FOR THE CHIEF ENGINEER
FEB 3 1967
ACTING DIVISION ENGINEER, REG. C.E. NO. 7113

PLANS PREPARED BY
KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING
DATE Jan 27, 1967
BY RCE 928

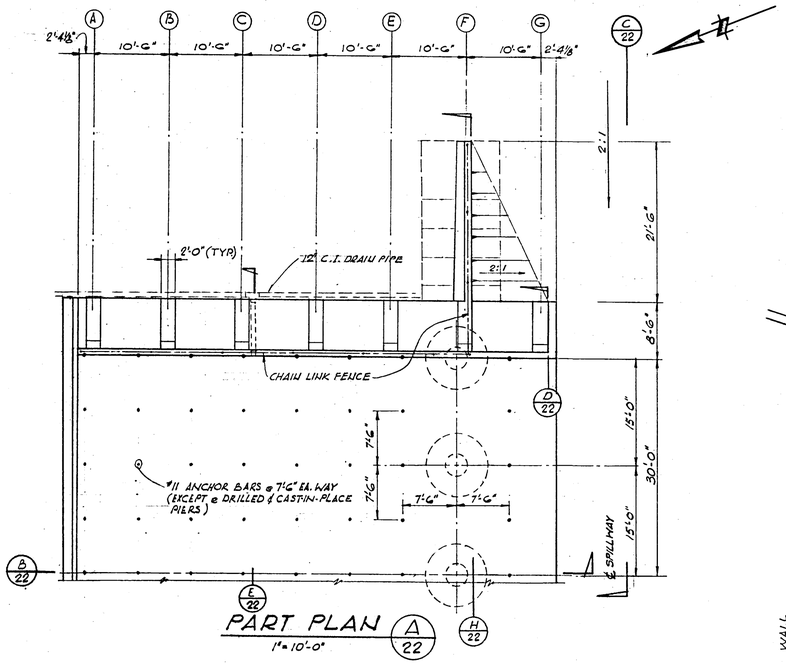
REV. NO.	DATE	REVISIONS	REV.	CKD	APP.

SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

LOPEZ WATER SUPPLY PROJECT

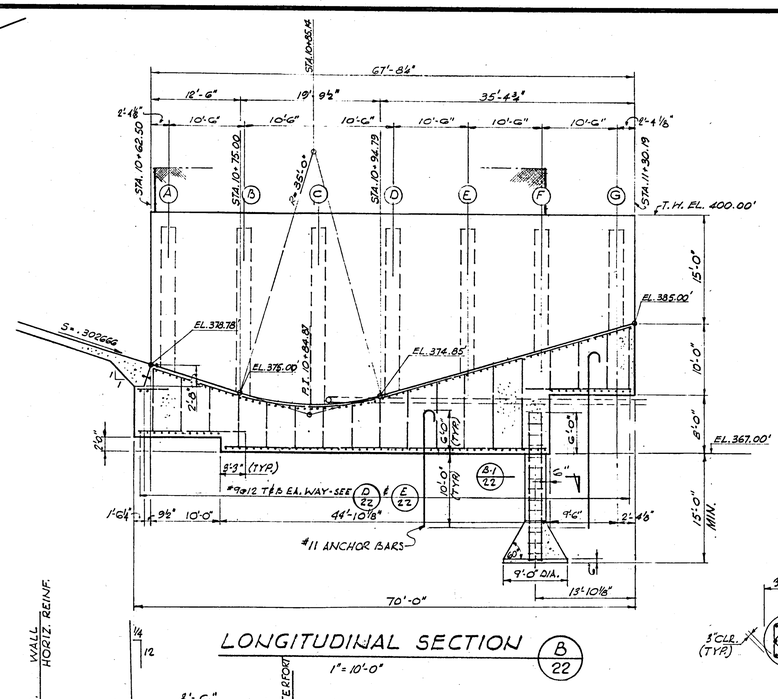
DAM AND APPURTENANT FACILITIES
SPILLWAY CHUTE,
EAST SIDE COUNTERFORTED WALLS,
STA. 5+00 TO STA. 5+50

RECOMMENDED
APPROVED
COUNTY HYDRAULIC ENGINEER, RCE NO. 9614
DATE 1-30-67
DRAWN R.A.W. | TRACED | CHKD | DRWG | SHEET 21 OF



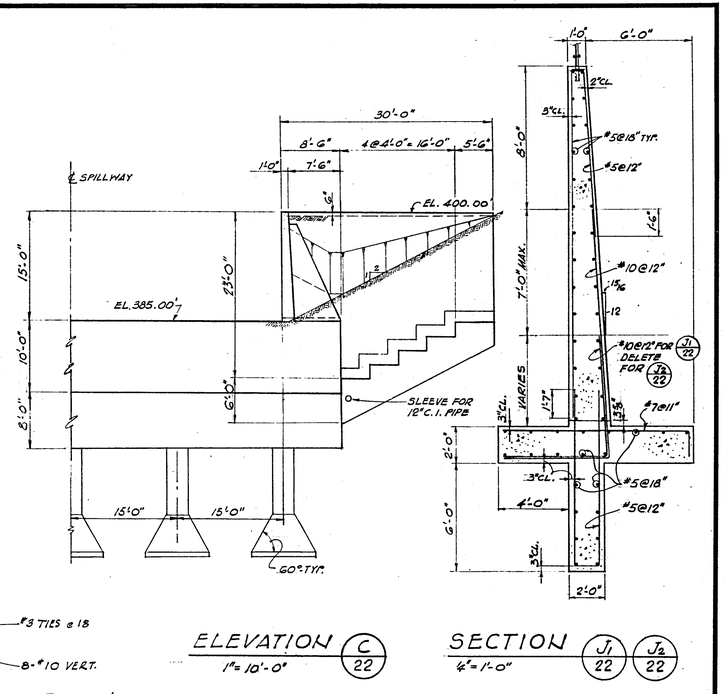
PART PLAN (A 22)

1" = 10'-0"



LONGITUDINAL SECTION (B 22)

1" = 10'-0"

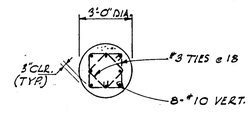


ELEVATION (C 22)

1" = 10'-0"

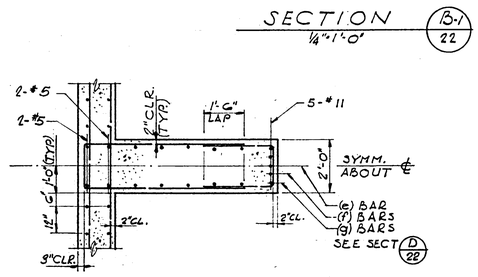
SECTION (J1 22) (J2 22)

4" = 1'-0"



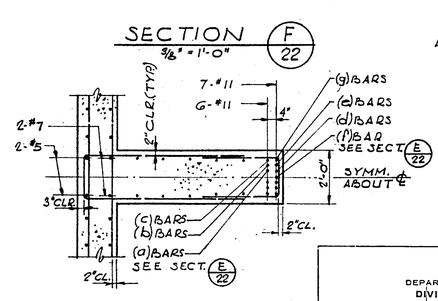
SECTION (B-1 22)

1¼" = 1'-0"



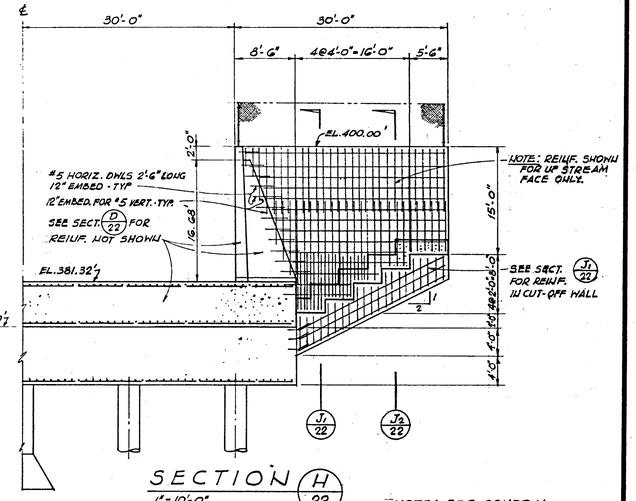
SECTION (F 22)

3/8" = 1'-0"



SECTION (G 22)

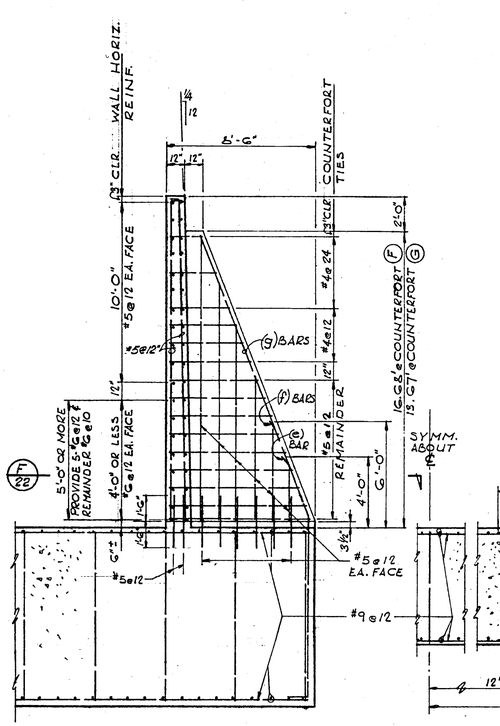
3/8" = 1'-0"



SECTION (H 22)

1" = 10'-0"

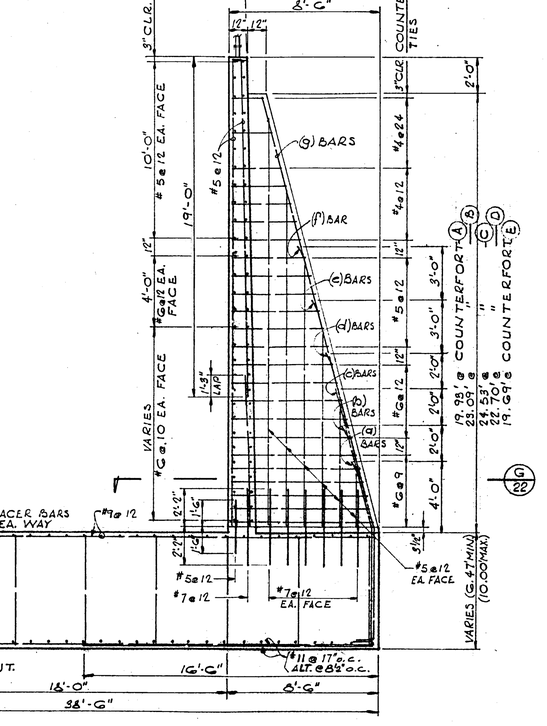
NOTE: FOR GENERAL NOTES SEE SHT. 16



SECTION (D 22)

4" = 1'-0"

STA. 11+12.09 TO STA. 11+30.19



SECTION (E 22)

1/4" = 1'-0"

STA. 10+62.50 TO STA. 11+12.09

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

APPLICATION NO. 1055

APPROVED AS TO SAFETY

FOR THE CHIEF ENGINEER

FEB 3 1967

ACTING DIVISION ENGINEER, REG. C.E. No. 7113

DIVISION OF SAFETY OF DAMS DEPARTMENT OF WATER RESOURCES JAN 30 1967

PLANS PREPARED BY
KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING
DATE Jan 27, 1967
BY SE 928

REV. NO.	DATE	REVISIONS	REV.	CKD	APP.

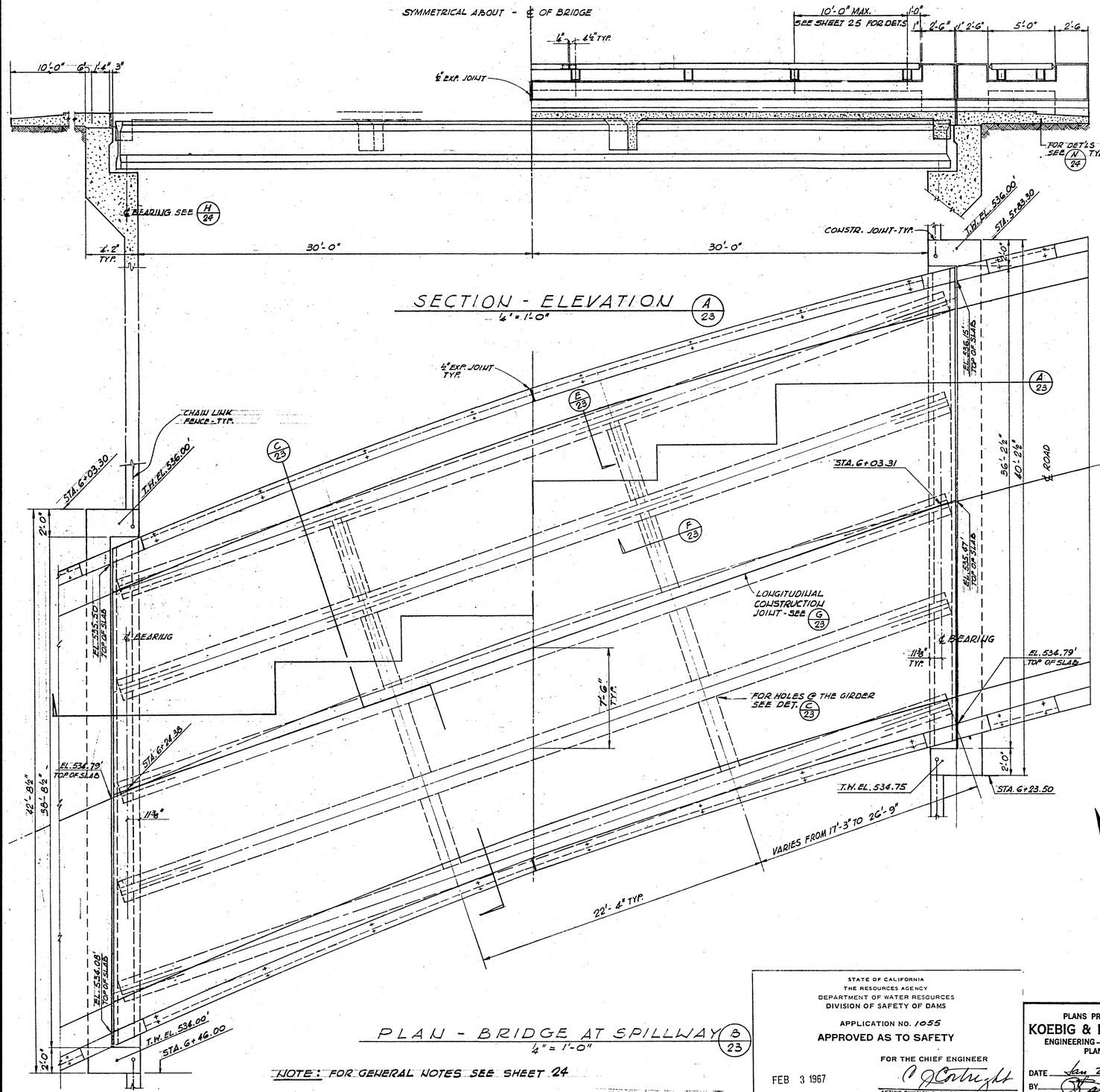
SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

LOPEZ WATER SUPPLY PROJECT

DAM AND APPURTENANT FACILITIES

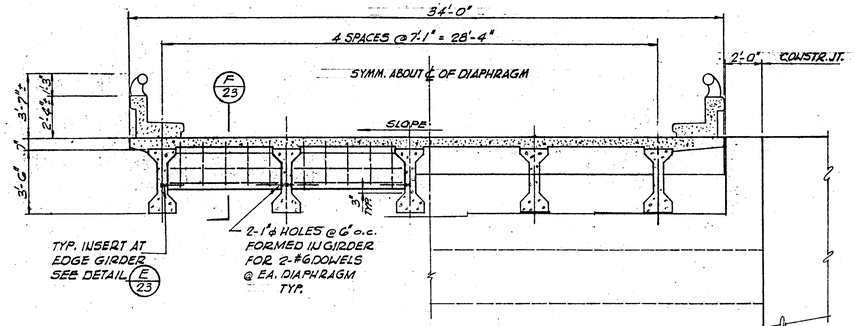
SPILLWAY FLIP BUCKET
PLANS, SECTIONS AND DETAILS

RECOMMENDED
APPROVED — COUNTY HYDRAULIC ENGINEER R.C.E. NO. 9614 — DATE 1-30-67
DRAWN S.K. | TRACED | CHKD | DRWG | SHEET 22 OF

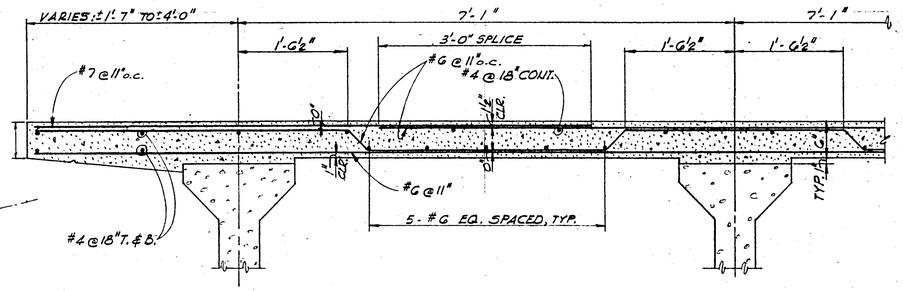


PLAN - BRIDGE AT SPILLWAY (B/23)
4" = 1'-0"

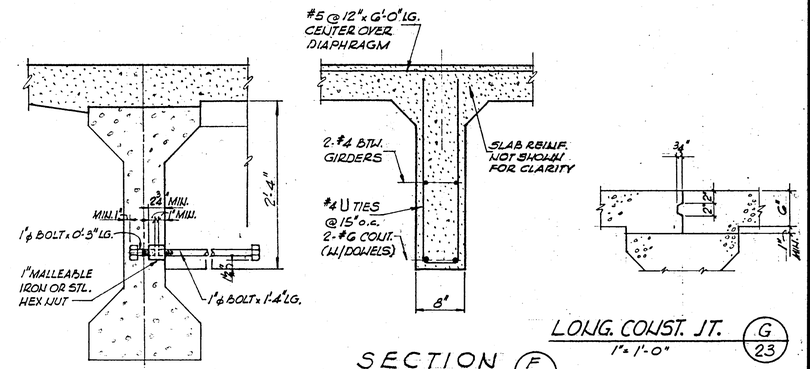
NOTE: FOR GENERAL NOTES SEE SHEET 24



ELEVATION, DIAPHRAGM & SUPPORT (C/23)
4" = 1'-0"



TYP. SLAB REINFORCING - SECTION (D/23)
1" = 1'-0"



SECTION (F/23)
1" = 1'-0"

LONG. CONST. JT. (G/23)
1" = 1'-0"

SECT. - ELEV. (E/23)
1" = 1'-0"

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

APPLICATION NO. 1055

APPROVED AS TO SAFETY

FOR THE CHIEF ENGINEER

FEB 3 1967

ACTING DIVISION ENGINEER, REG. C.E. No. 7113

DIVISION OF SAFETY OF DAMS
DEPARTMENT OF WATER RESOURCES
JAN 30 1967

PLANS PREPARED BY
KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING
DATE Jan 27, 1967
BY SE 928

REV. NO.	DATE	REVISIONS	REV.	CKD	APP.

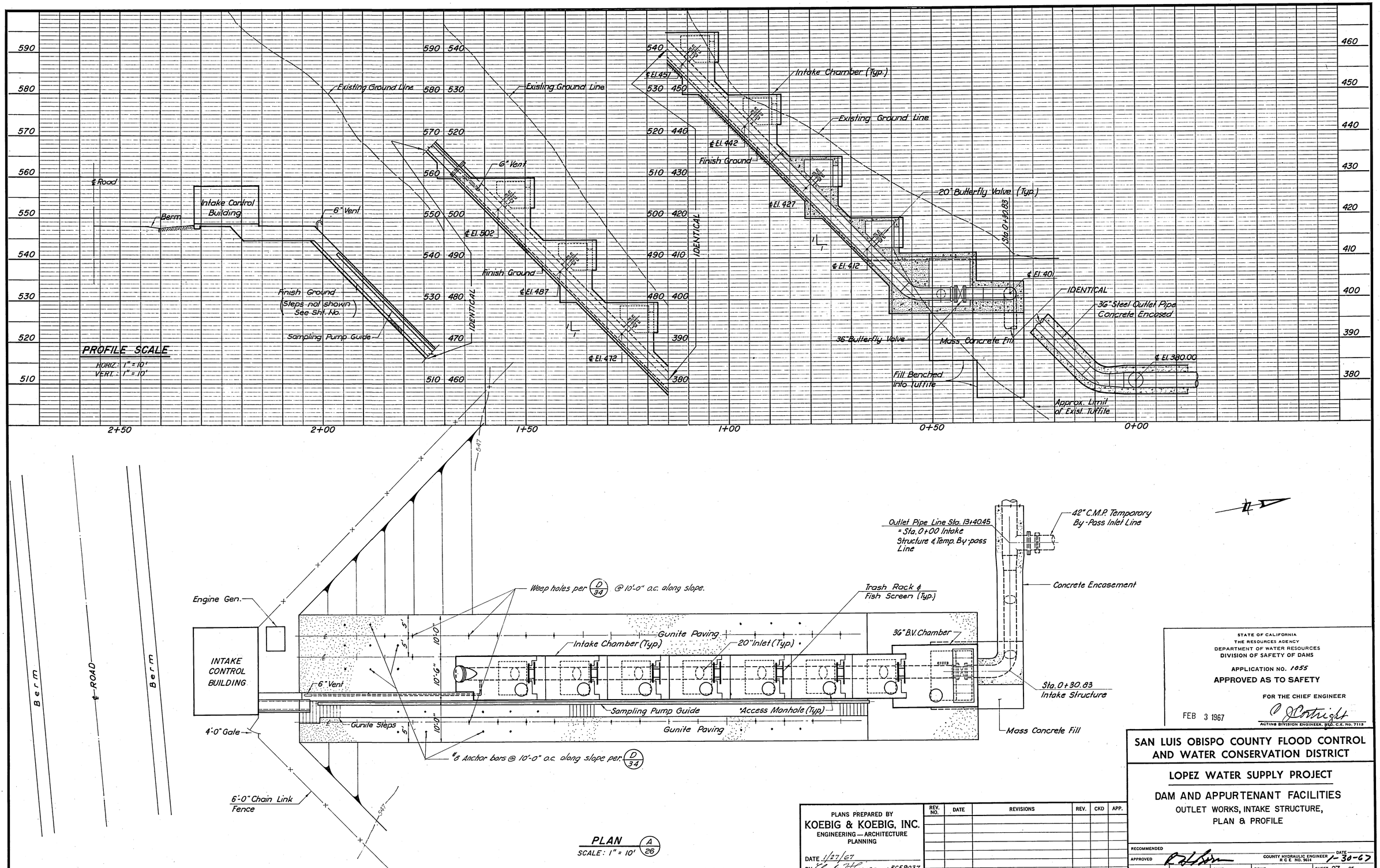
SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

LOPEZ WATER SUPPLY PROJECT

DAM AND APPURTENANT FACILITIES

BRIDGE AT SPILLWAY, PLAN AND SECTIONS

RECOMMENDED
APPROVED — COUNTY HYDRAULIC ENGINEER R.C.E. NO. 9614 — DATE 1-30-67
DRAWN S.K. | TRACED | CHKD | DRWG | SHEET 23 OF



PLAN (A/26)
SCALE: 1" = 10'

PLANS PREPARED BY
KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING
DATE 1/27/67
BY Charles Thompson RCE 9037

REV. NO.	DATE	REVISIONS	REV.	CKD	APP.

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS
APPLICATION NO. 1055
APPROVED AS TO SAFETY
FOR THE CHIEF ENGINEER
FEB 3 1967
ACTING DIVISION ENGINEER, REG. C.E. No. 7113

SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

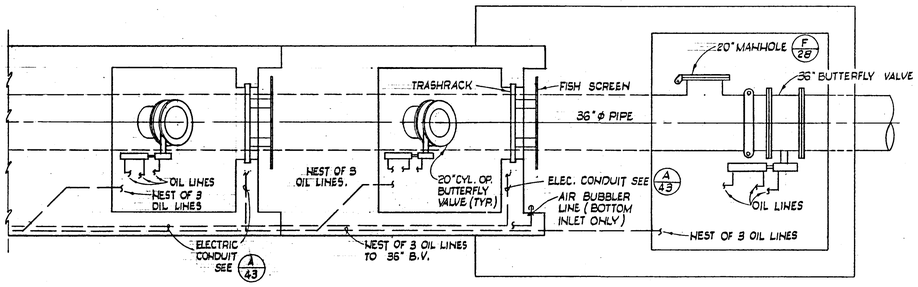
LOPEZ WATER SUPPLY PROJECT

DAM AND APPURTENANT FACILITIES

OUTLET WORKS, INTAKE STRUCTURE, PLAN & PROFILE

RECOMMENDED
APPROVED
COUNTY HYDRAULIC ENGINEER R.C.E. NO. 9614
DATE 1-30-67
DRAWN | TRACED | CHKD | DRWG | SHEET 27 OF

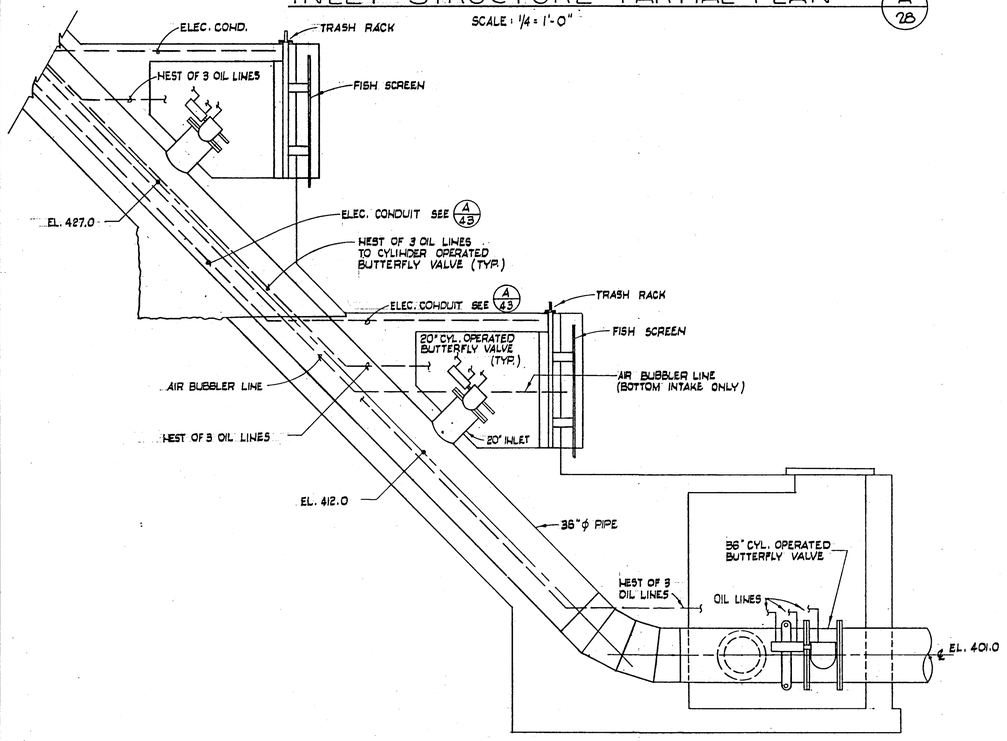
DIVISION OF SAFETY OF DAMS
STATE WATER RESOURCES BOARD
JAN 30 1967



NOTE: TOP SLAB SHOWN REMOVED.

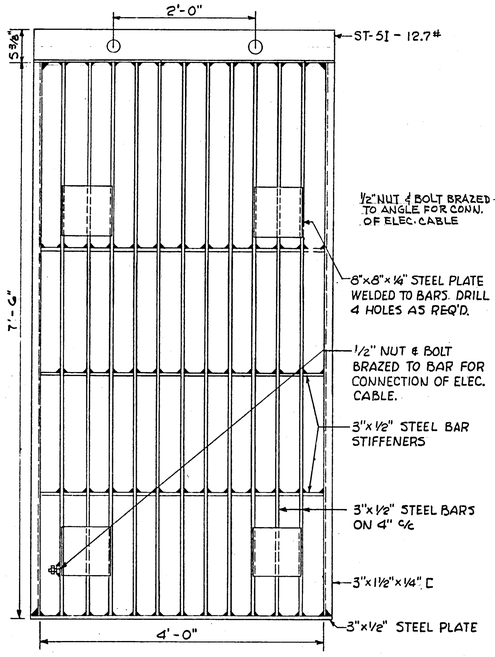
INLET STRUCTURE PARTIAL PLAN (A/28)

SCALE : 1/4 = 1'-0"



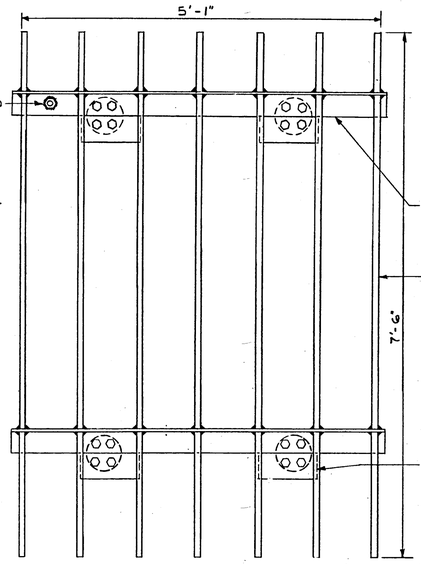
INLET STRUCTURE SECTION (B/28)

SCALE : 1/4" = 1'-0"



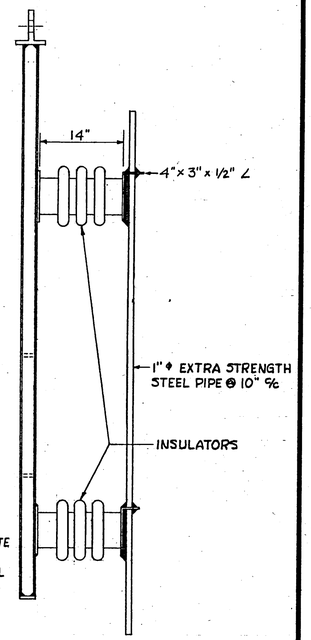
TRASH RACK (C/28)

SCALE 1" = 1'-0"



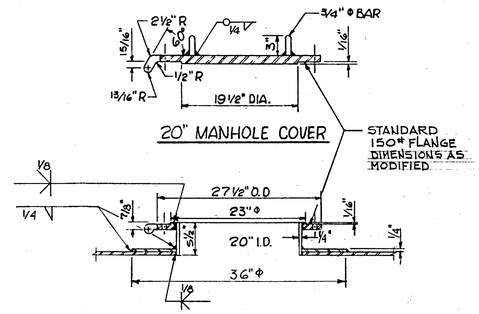
FISH SCREEN (D/28)

SCALE 1" = 1'-0"



FISH SCREEN AND TRASH RACK (E/28)

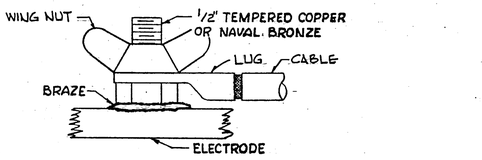
SCALE 1" = 1'-0"



20" MANHOLE NOZZLE

20" MANHOLE ASSEMBLY (F/28)

SCALE 1" = 1'-0"



FISH SCREEN ELECTRICAL CONNECTION (G/28)

NO SCALE

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

APPLICATION NO. 1055

APPROVED AS TO SAFETY

FOR THE CHIEF ENGINEER

FEB 3 1967

ACTING DIVISION ENGINEER, REG. C.E. No. 7113

PLANS PREPARED BY
KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING

DATE 1/27/67
BY Charles A. Laurence RCE 9037

REV. NO.	DATE	REVISIONS	REV.	CKD	APP.

SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

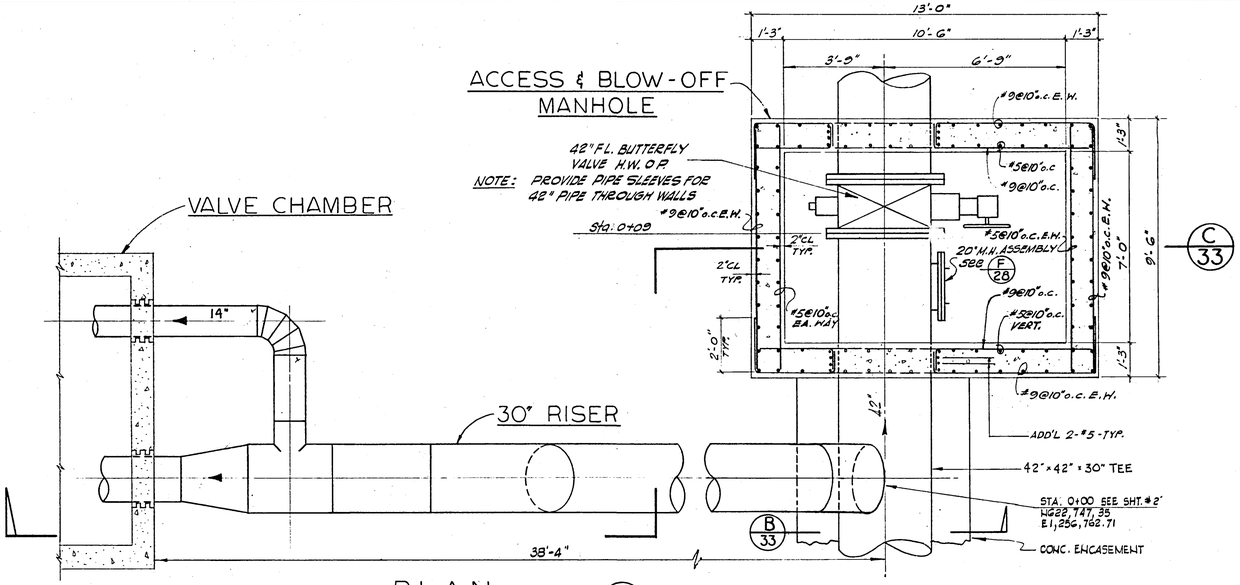
LOPEZ WATER SUPPLY PROJECT

DAM AND APPURTENANT FACILITIES

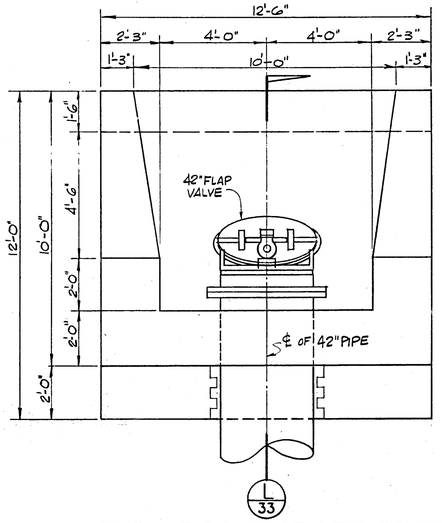
OUTLET WORKS, INTAKE STRUCTURE, MECHANICAL DETAILS

RECOMMENDED				
APPROVED	COUNTY HYDRAULIC ENGINEER R C E NO. 9614		DATE 1-30-67	
DRAWN	TRACED	CHKD	DRWG	SHEET 28 OF

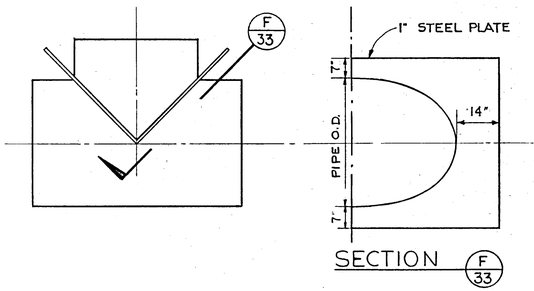
JAN 30 1967
DIVISION OF SAFETY OF DAMS
DEPARTMENT OF WATER RESOURCES



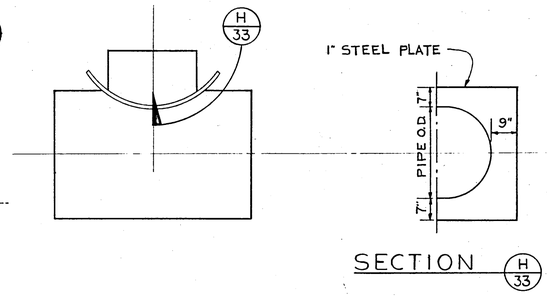
PLAN
SCALE 3/8" = 1'-0" (A/33)



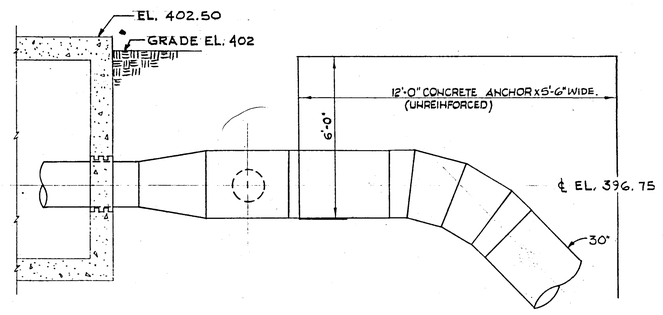
PLAN DISCHARGE STRUCTURE (K/33)
SCALE: 3/8"-1'-0"

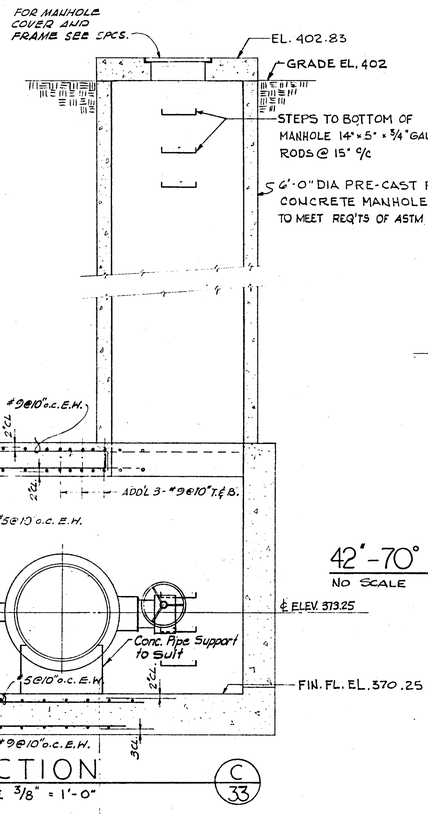


42" TEE (E/33)
NO SCALE

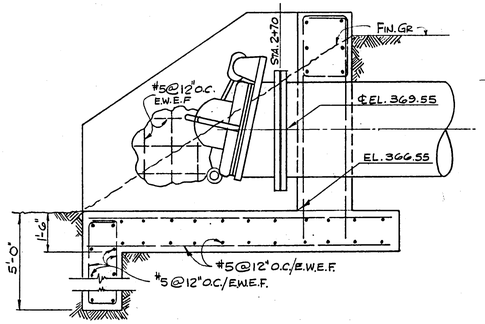


42"x 42"x 30" TEE (G/33)
NO SCALE

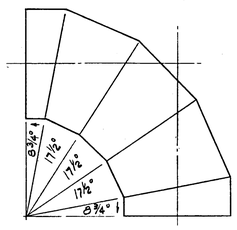




SECTION (C/33)
SCALE 3/8" = 1'-0"



SECTION (L/33)

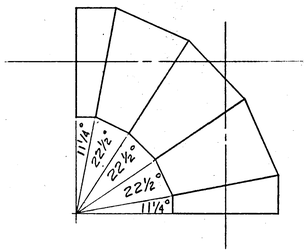


42"-70° BEND 5 PIECE (D/33)
NO SCALE

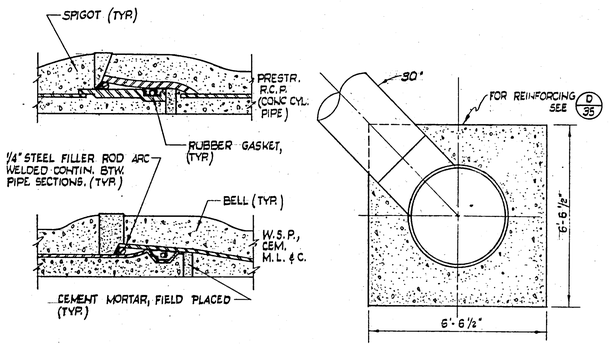
NOTES:

BENDS	70°	AND	90°	TO	BE	5	PIECE AS SHOWN
"	45°	"	49°	"	"	4	"
"	24°	"	41°	"	"	3	"
"	9°	"	10°	"	"	2	"

BEVELED PIPE MAY BE USED IN LIEU OF 2 PIECE BENDS.



36" 90° BEND 5 PIECE (J/33)
NO SCALE



WELDING OF RUBBER GASKETED JOINT DETAIL
NO SCALE

SECTION (B/33)
SCALE 3/8" = 1'-0"

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

APPLICATION NO. 1055

APPROVED AS TO SAFETY

FOR THE CHIEF ENGINEER

FEB 3 1967

ACTING DIVISION ENGINEER, REG. C.E. NO. 7110

PLANS PREPARED BY
KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING
DATE 1/27/67
BY Charles H. Lawrence RCE 9037

REV. NO.	DATE	REVISIONS	REV.	CKD	APP.

SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

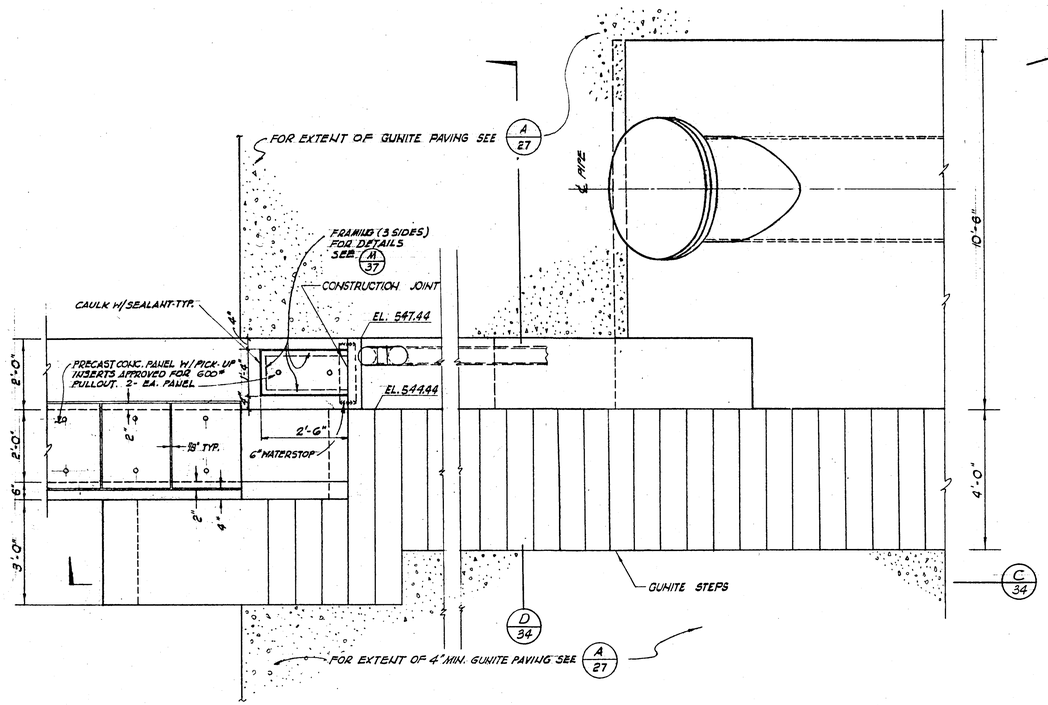
LOPEZ WATER SUPPLY PROJECT

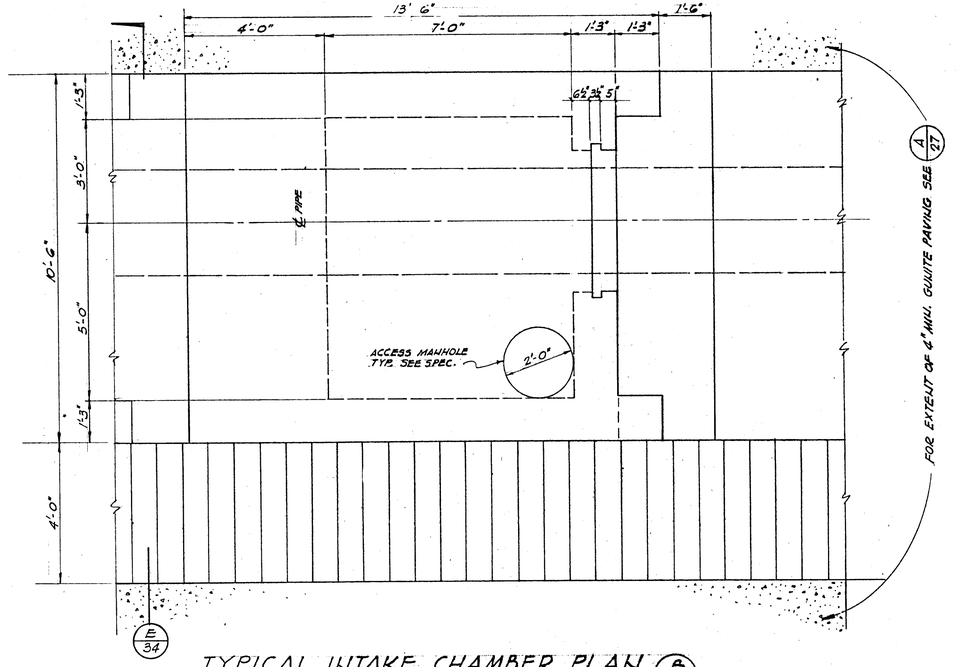
DAM AND APPURTENANT FACILITIES

OUTLET WORKS,
MISC. PIPING DETAILS

RECOMMENDED
APPROVED
COUNTY HYDRAULIC ENGINEER R.C.E. NO. 9614 DATE 1-30-67
DRAWN | TRACED | CHKD | DRWG | SHEET 33 OF

RECEIVED
JAN 30 1967
DIVISION OF SAFETY OF DAMS
DEPARTMENT OF WATER RESOURCES



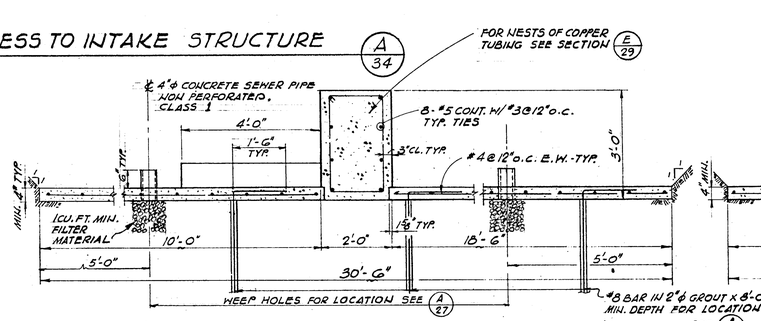


TYPICAL INTAKE CHAMBER PLAN B/34

½"=1'-0"

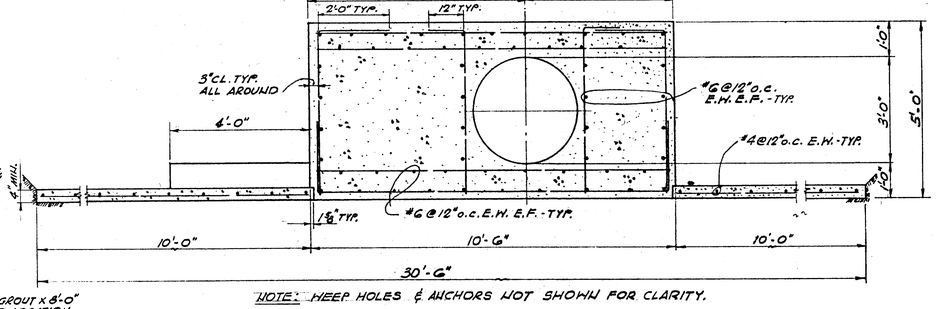
TYP. CONTROL SYSTEM ENCASEMENT & ACCESS TO INTAKE STRUCTURE A/34

½"=1'-0"



SECTION THRU CONTROL SYSTEM ENCASEMENT D/34

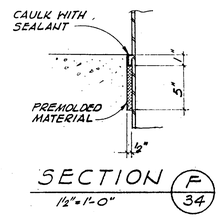
½"=1'-0"



NOTE: WEEP HOLES & ANCHORS NOT SHOWN FOR CLARITY.

SECTION THRU INTAKE SYSTEM ENCASEMENT E/34

½"=1'-0"



SECTION F/34

1½"=1'-0"

NOTES: 1. FOR SIZE OF ANCHOR BOLTS FOR SAMPLING PUMP DISCHARGE SEE SHEET No. 29. PLACING SHALL BE DONE FROM APPROVED SHOP DWGS.
2. FOR GENERAL NOTES SEE SHT 16.

SECTION THRU ACCESS TO INTAKE STRUCTURE C/34

½"=1'-0"

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

APPLICATION NO. 1055

APPROVED AS TO SAFETY

FOR THE CHIEF ENGINEER

FEB 3 1967

ACTING DIVISION ENGINEER, REG. C.E. No. 7113

PLANS PREPARED BY
KOEBIG & KOEBIG, INC
ENGINEERING — ARCHITECTURE
PLANNING
DATE Jan. 27, 1967
BY
52928

REV. NO.	DATE	REVISIONS	REV.	CKD	APP.

SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

LOPEZ WATER SUPPLY PROJECT

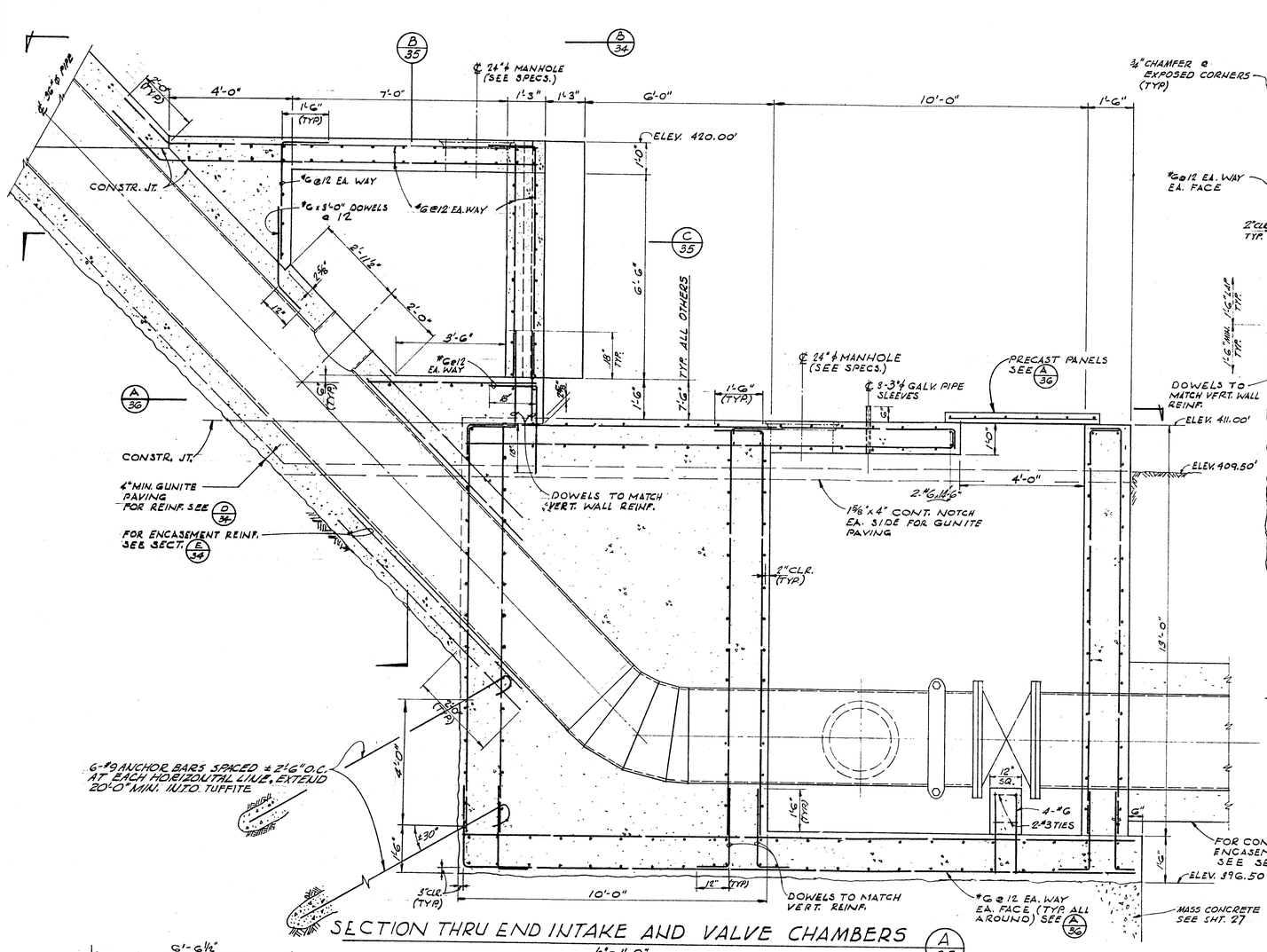
DAM AND APPURTENANT FACILITIES

OUTLET WORKS,
INTAKE STRUCTURE, PLAN, SECTIONS AND DETAILS

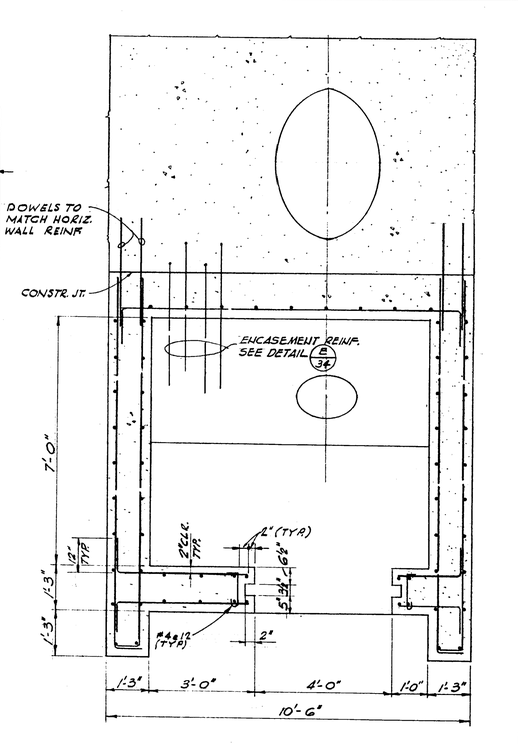
RECOMMENDED
APPROVED
COUNTY HYDRAULIC ENGINEER R.C.E. NO. 9614
DATE 1-30-67

DRAWN S.K.	TRACED	CHKD	DRWG	SHEET 34 OF

JAN 0 1967
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS



SECTION THRU END INTAKE AND VALVE CHAMBERS A 35
½"=1'-0"

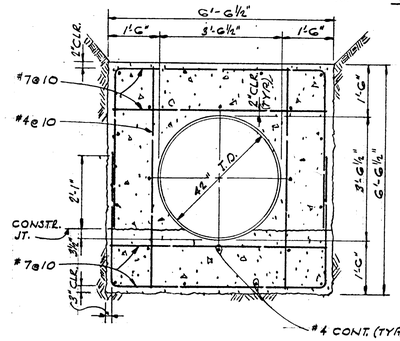


VERT. SECT. THRU INTAKE CHAMBER B 35
½"=1'-0"

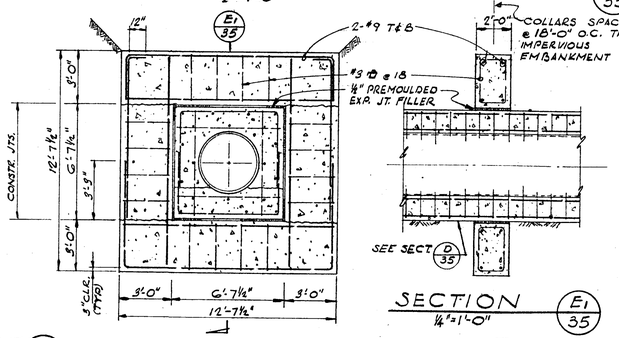
HORIZ. SECT. THRU INTAKE CHAMBER C 35
½"=1'-0"

NOTES:

1. FOR GENERAL NOTES SEE SHEET 16.
2. AT VALVE CHAMBER REMOVE ALL MATERIAL THAT IS NOT TUFFITE AND FILL WITH LEAN CONCRETE TO THE ELEVATION SHOWN.
3. FOR EXTENT OF GUNITE PAVING AROUND INTAKE STRUCTURE AND VALVE CHAMBER SEE SHEET No. 27.
4. VALVE CHAMBER - LONGITUDINAL REINFORCEMENT AT TRANSVERSE CONSTRUCTION JOINTS SHALL HAVE A MINIMUM OF 32 BAR DIAMETERS.
5. AT ENCASEMENTS:
   a. TRANSVERSE CONSTRUCTION JOINTS SHALL BE AT 30' MAX. OR AS SHOWN AT THE INLET STRUCTURE.
   b. TRANSVERSE CONSTRUCTION JOINTS IN WALLS AND SLABS SHALL BE IN THE SAME PLANE. NO STAGGERING OF JOINTS WILL BE PERMITTED. JOINTS SHALL BE NORMAL OR RADIAL TO THE CENTERLINE OF CONSTRUCTION.
   c. LONGITUDINAL STEEL SHALL BE CONTINUOUS AND EXTEND THROUGH ALL CONSTRUCTION JOINTS.
   d. AT LOCATIONS OF ANGLES IN THE PIPE LINE, UNLESS OTHERWISE SHOWN IN THE DETAILS, MINIMUM CONCRETE DIMENSIONS SHALL BE MEASURED HORIZONTALLY OR VERTICALLY ON THE PROFILE, AND PARALLEL TO OR AT RIGHT ANGLES TO THE ℄ OF FABRICATED PIPE BENDS. THICKNESS OF CONCRETE ENCASEMENT MAY BE INCREASED TO SIMPLIFY TRENCH EXCAVATION OR CONCRETE FORMWORK.

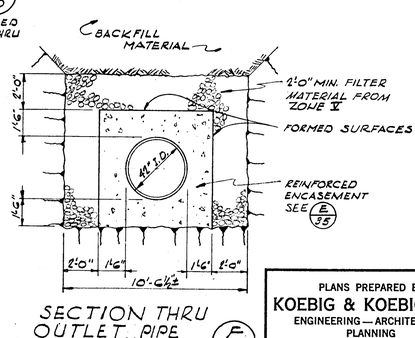


SECTION THRU OUTLET PIPE ENCASEMENT D 35
½"=1'-0"



SECTION E1 35
1¼"=1'-0"

SECTION @ CUT-OFF COLLARS E 35
¼"=1'-0"



SECTION THRU OUTLET PIPE F 35
1¼"=1'-0"
(FROM DOWNSTREAM BOUNDARY OF CLAY CORE TO STA. 0+00)

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

APPLICATION NO. 1055
APPROVED AS TO SAFETY

FOR THE CHIEF ENGINEER
FEB 3 1967
ACTING EXECUTIVE ENGINEER, REG. C.E. No. 7113

PLANS PREPARED BY
KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING
DATE Jan. 27, 1967
BY SE 028

REV. NO.	DATE	REVISIONS	REV.	CKD	APP.

DIVISION OF SAFETY OF DAMS
DEPARTMENT OF WATER RESOURCES
JAN 30 1967

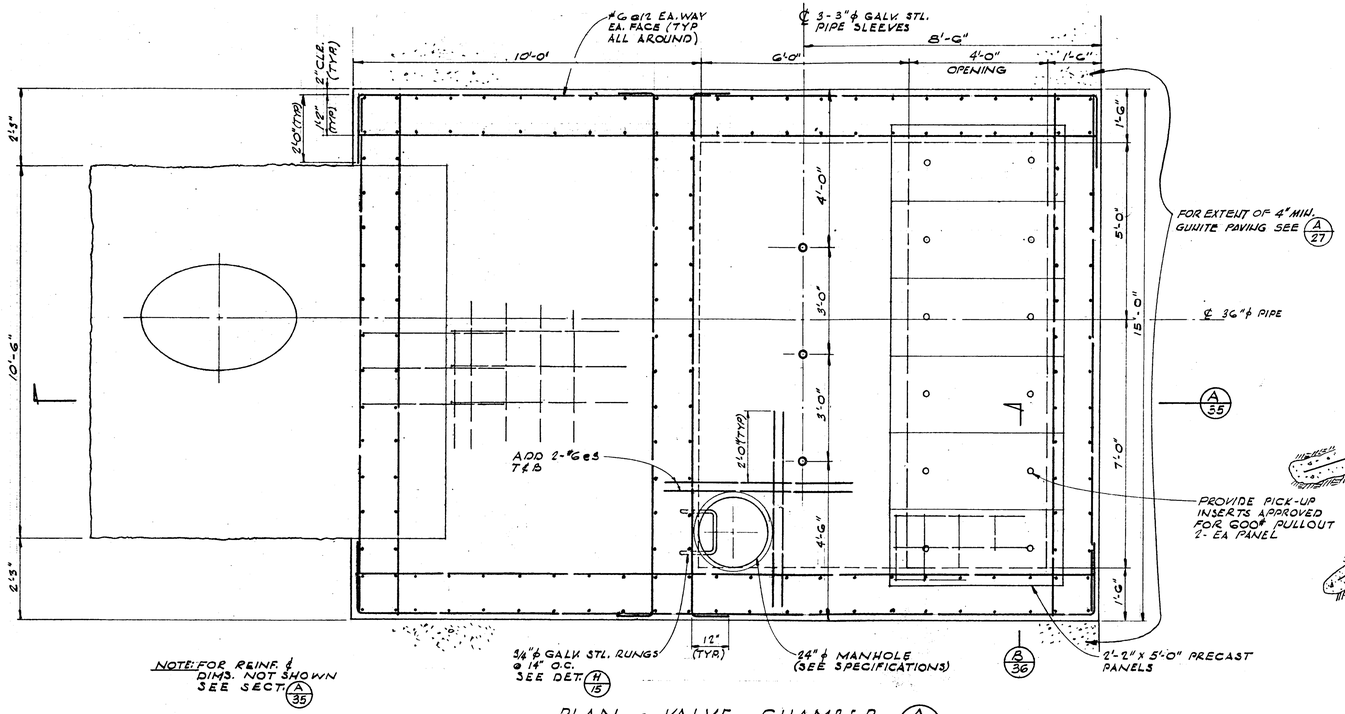
SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

LOPEZ WATER SUPPLY PROJECT

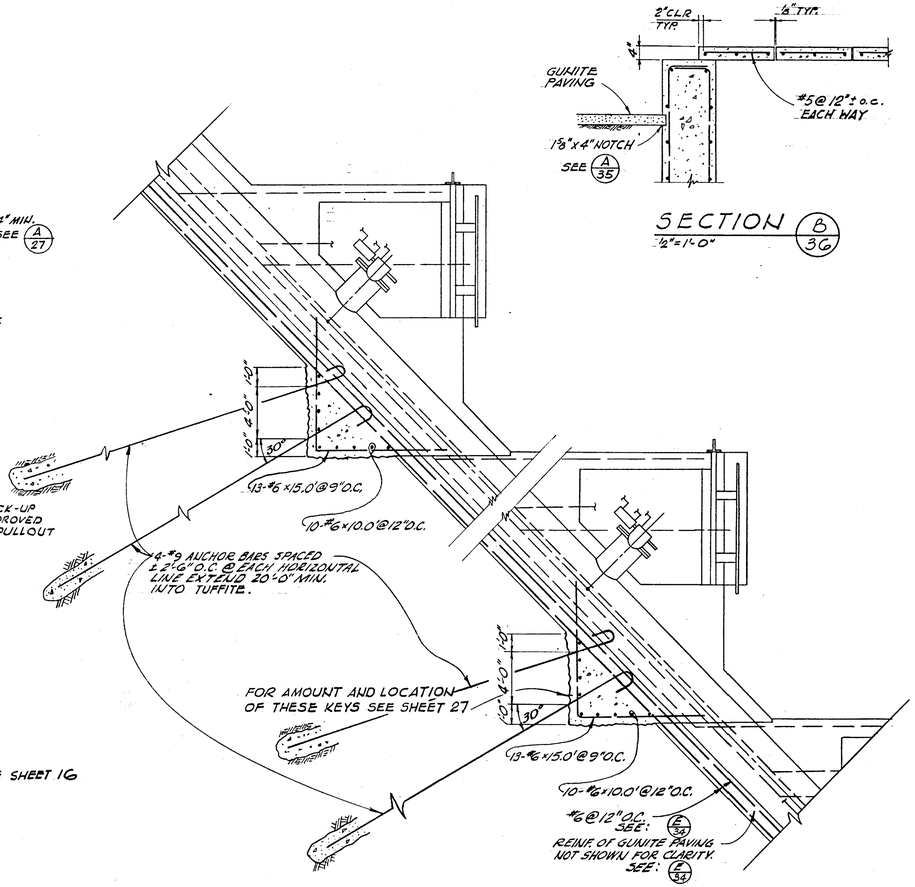
DAM AND APPURTENANT FACILITIES

OUTLET WORKS,
INTAKE STRUCTURE, SECTIONS AND DETAILS - 1

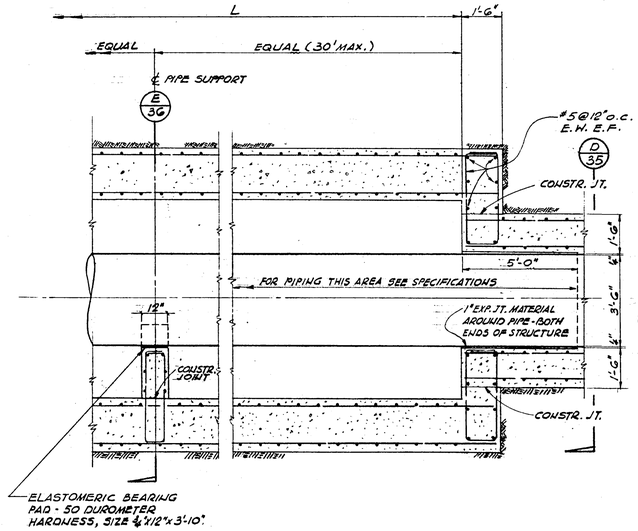
RECOMMENDED
APPROVED — COUNTY HYDRAULIC ENGINEER R.C.E. NO. 9614 — DATE 1-30-67
DRAWN S.K. | TRACED | CHKD | DRWG | SHEET 35 OF



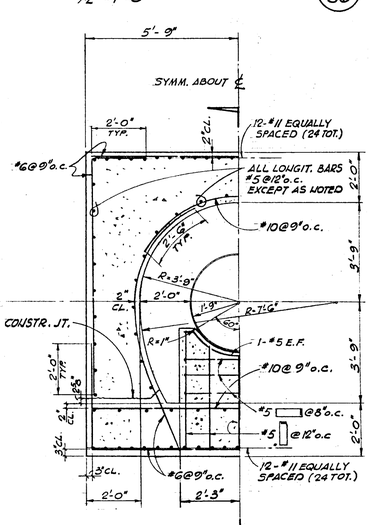
PLAN @ VALVE CHAMBER (A/36)
1/2" = 1'-0"



NOTE: FOR GENERAL NOTES SEE SHEET 16



SECTION THRU ANNULAR CONC. PROTECTION (D/36)
3/8" = 1'-0"



SECTION (E/36)
3/8" = 1'-0"

INLET STRUCTURE SECTION (C/36)
SCALE: 1/4" = 1'-0"

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

APPLICATION NO. 1055

APPROVED AS TO SAFETY

FOR THE CHIEF ENGINEER

FEB 3 1967

ACTING DIVISION ENGINEER, REG. C.E. No. 7113

DIVISION OF SAFETY OF DAMS
DEPARTMENT OF WATER RESOURCES
JAN 30 1967

PLANS PREPARED BY
KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING
DATE Jan 27, 1967
BY [signature] RCE 928

REV. NO.	DATE	REVISIONS	REV.	CKD	APP.

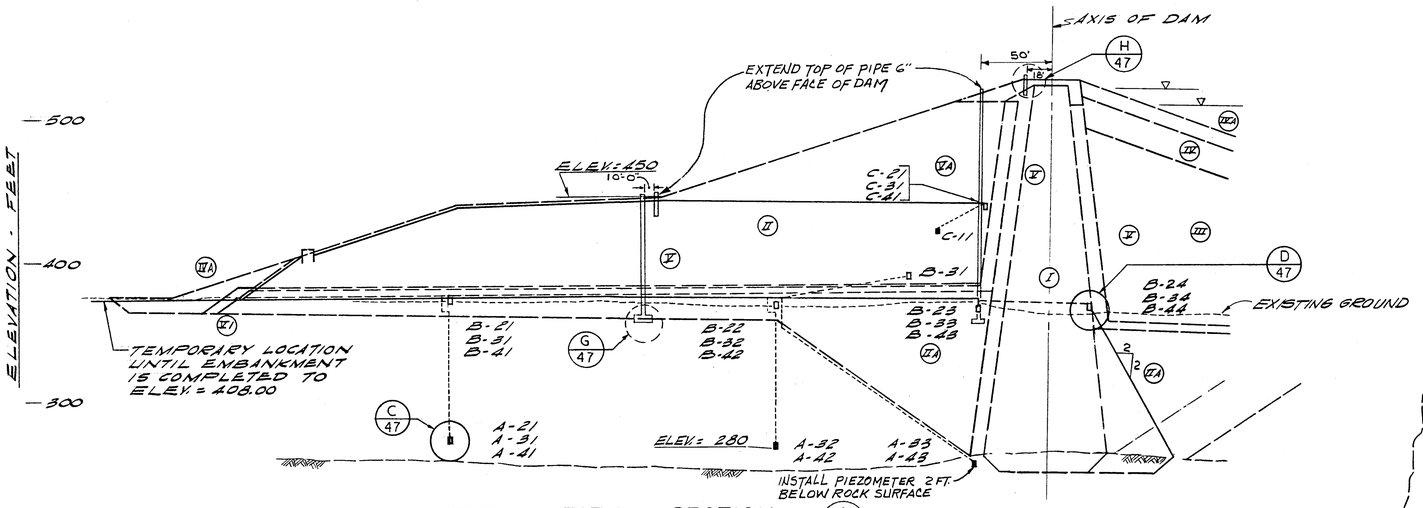
SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

LOPEZ WATER SUPPLY PROJECT

DAM AND APPURTENANT FACILITIES
OUTLET WORKS,
INTAKE STRUCTURE, SECTIONS AND DETAILS-2

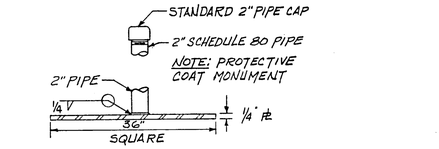
RECOMMENDED
APPROVED [signature] COUNTY HYDRAULIC ENGINEER R.C.E. NO. 9614 DATE 1-30-67

DRAWN S.K. | TRACED | CHKD | DRWG | SHEET 36 OF



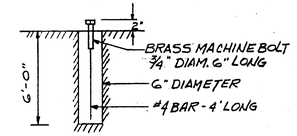
INSTRUMENTATION SECTION (A/47)

SCALE 1" = 50'-0"



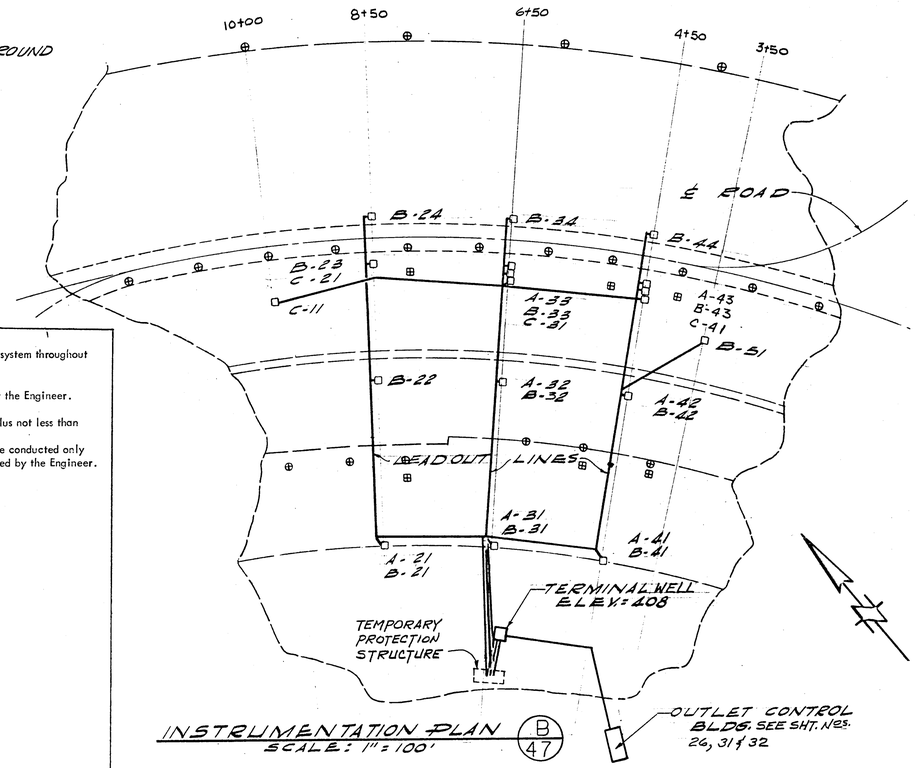
FOUNDATION SETTLEMENT MONUMENT DETAIL (G/47)

NO SCALE



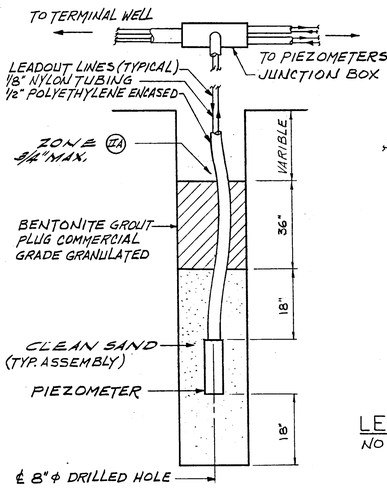
CONCRETE SURFACE MOVEMENT MONUMENT DETAIL (H/47)

NO SCALE



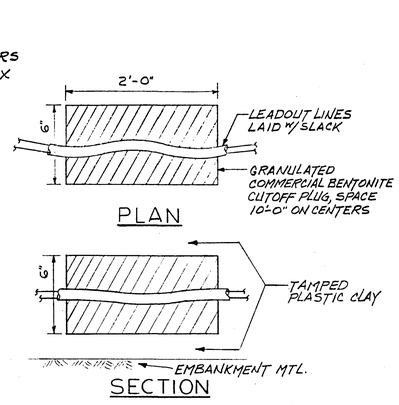
INSTRUMENTATION PLAN (B/47)

SCALE: 1" = 100'



DETAIL (C/47)

NO SCALE



LEADOUT LINE TRENCH DETAIL (E/47)

NO SCALE

NOTES

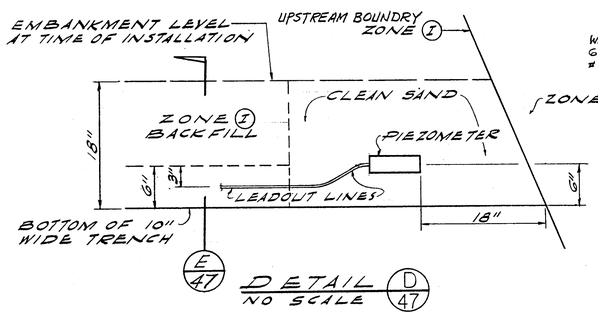
1. Provide continuous protection, location and identification of entire instrumentation system throughout construction.
2. Piping and protective coating shall be as specified.
3. Local soil materials may be used for construction purposes subject to the approval by the Engineer.
4. Construction scheduling shall be subject to approval by the Engineer.
5. Provide adequate number of junction boxes to accommodate all piezometers shown plus not less than 50% additional leadout lines for future spares.
6. Contractor's operations involving installation of embankment instrumentation shall be conducted only during the presence of the manufacturer's representative unless otherwise authorized by the Engineer.

LEGEND

- ⊕ SURFACE MOVEMENT MONUMENTS
- ⊞ FOUNDATION SETTLEMENT MONUMENTS
- ▮ PIEZOMETER INSTALLED IN DRILLED HOLES
- ▯ PIEZOMETER INSTALLED IN SAND POCKETS
- ------ SINGLE UNIT LINE
- —— MULTIPLE UNIT LINE

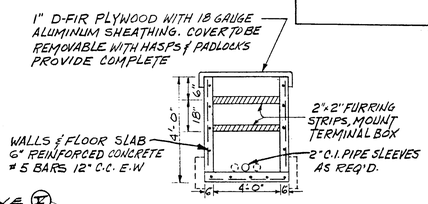
LEVEL	APPROXIMATE ELEVATION
A	270, 280
B	380
C	450

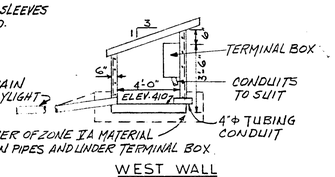
ROW	STATION
10	10 + 00
20	8 + 50
30	6 + 50
40	4 + 50
50	3 + 50



DETAIL (D/47)

NO SCALE





TERMINAL WELL DETAIL (F/47)

NO SCALE

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

APPLICATION NO. 1655

APPROVED AS TO SAFETY

FOR THE CHIEF ENGINEER

FEB 3 1967

ACTING DIVISION ENGINEER, R.C.E. No. 7113

DAM DESIGNED BY
WOODWARD, CLYDE, SHERARD & ASSOCIATES
CONSULTING ENGINEERS & GEOLOGISTS

DESIGNED — APPROVED

DRAWN — Stanley T. Shinoda

CHECKED —

PLANS PREPARED BY
KOEBIG & KOEBIG, INC.
ENGINEERING — ARCHITECTURE
PLANNING

DATE 1/27/67

BY Charles H. Lawrence RCE 9037

REV. NO.	DATE	REVISIONS	REV.	CKD	APP.

SAN LUIS OBISPO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

LOPEZ WATER SUPPLY PROJECT

DAM AND APPURTENANT FACILITIES

EMBANKMENT INSTRUMENTATION PLAN AND DETAILS

RECOMMENDED

APPROVED R. N. Born — COUNTY HYDRAULIC ENGINEER R.C.E. NO. 9614 — DATE 1-30-67

DRAWN | TRACED | CHKD | DRWG | SHEET 47 OF

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS
FILED
JUN 20 1967

Appendix B

Survey Field Notes Performed by the District

Bridge Data, from US to DS

Grieb Ranch Way

Bridge Length = 130’; Bridge width = 24’

24 pilings each 12-14” with 3”x8” cross brace

Talley Farms Road

Bridge Length = 94’; Bridge width = 24’; Single span

Huasna Road

Bridge Length = 87’; Bridge width = 22’

Center span/opening = 43’

Abutment each side, Length = 20’, Height = 35-40’ (approximate)

Mason Street

Bridge Length = 169’; Bridge width = 28’

Abutment, with concrete arch support under deck

Abutment length = 22’

Bridge Street

Bridge length = 141’; Bridge width = 36’

Traffic Way

Bridge length = 225’; Bridge width = 45’

5 groups/sets of piers

US 101 – Bridge 49-175

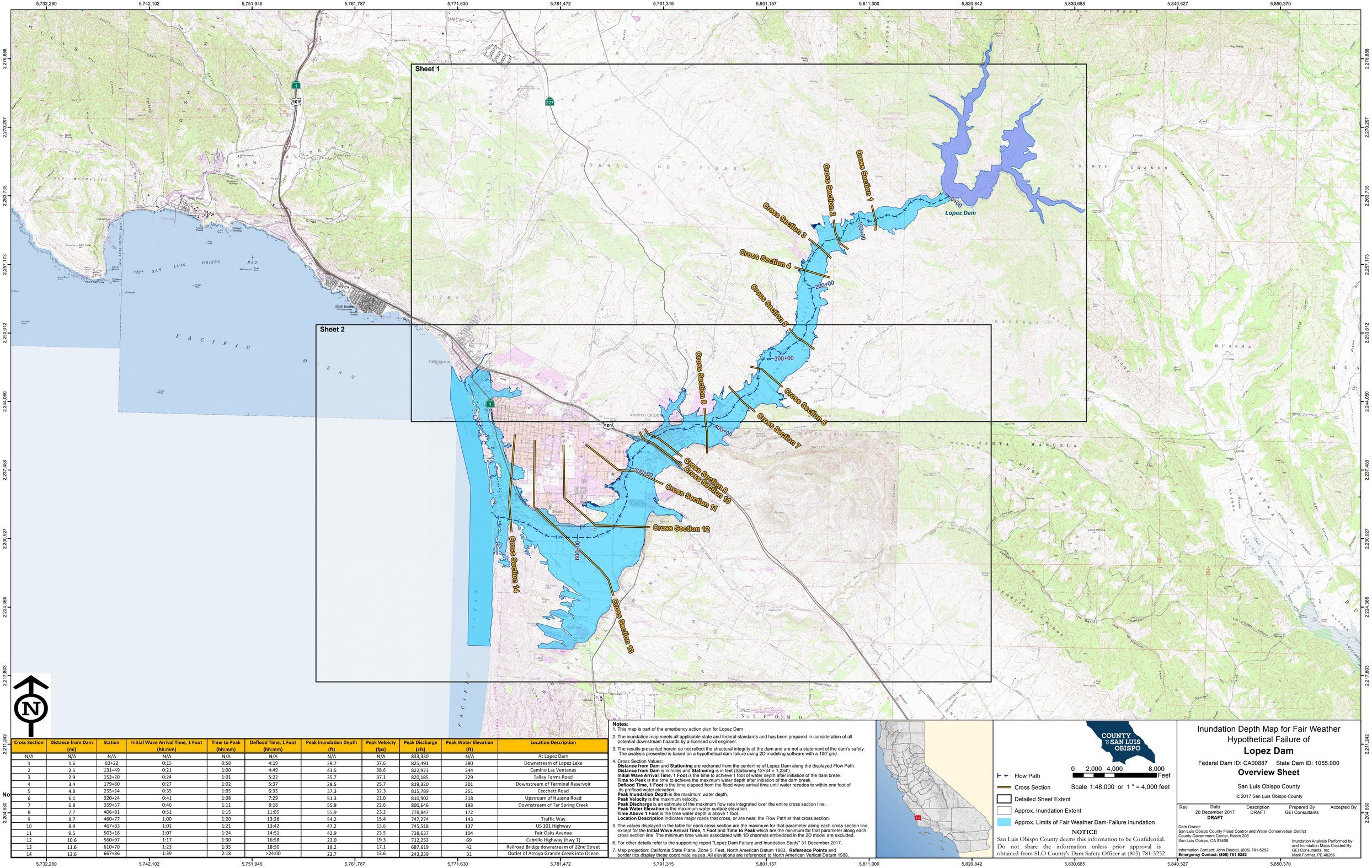
Unable to photograph

Fair Oaks

Bridge Length = 130’; Bridge width = 76’

Appendix C

Lopez Dam Failure Flood Inundation Maps



Cross Section	Distance from Dam (mi)	Station	Initial Wave Arrival Time, 1 Foot (hh:mm)	Time to Peak (hh:mm)	Deflood Time, 1 Foot (hh:mm)	Peak Inundation Depth (ft)	Peak Velocity (fps)	Peak Discharge (cfs)	Peak Water Elevation (ft)	Location Description
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	833,330	N/A	At Lopez Dam
1	1.6	83+22	0:15	0:58	4:19	39.7	37.6	825,491	380	Downstream of Lopez Lake
2	2.5	131+49	0:21	1:00	4:49	43.5	38.6	822,973	344	Camino Las Ventanas
3	2.9	153+20	0:24	1:01	5:22	35.7	37.1	820,185	329	Talley Farms Road
4	3.4	179+80	0:27	1:02	5:37	28.5	25.7	819,320	301	Downstream of Terminal Reservoir
5	4.8	255+54	0:35	1:05	6:35	37.3	32.3	815,789	251	Cecchetti Road
6	6.1	320+24	0:41	1:08	7:29	51.3	21.0	810,902	218	Upstream of Huasna Road
7	6.8	359+57	0:46	1:11	8:18	55.9	22.6	800,646	193	Downstream of Tar Spring Creek
8	7.7	406+81	0:51	1:15	11:05	55.9	23.2	778,847	172	
9	8.7	460+77	1:00	1:20	13:28	54.2	15.4	747,274	143	Traffic Way
10	8.9	467+83	1:01	1:21	13:42	47.2	13.6	745,518	137	US 101 Highway
11	9.5	503+18	1:07	1:24	14:51	42.9	23.5	738,637	104	Fair Oaks Avenue
12	10.6	560+97	1:17	1:30	16:58	23.0	19.3	712,253	69	Cabrillo Highway (Hwy 1)
13	11.6	610+70	1:23	1:35	18:50	18.2	17.1	687,619	42	Railroad Bridge downstream of 22nd Street
14	12.6	667+86	1:39	2:18	>24:00	22.7	13.6	243,239	31	Outlet of Arroyo Grande Creek into Ocean

Notes:

1. This map is part of the emerbency action plan for Lopez Dam
2. The inundation map meets all applicable state and federal standards and has been prepared in consideration of all potential downstream hazards by a licensed civil engineer.
3. The results presented herein do not reflect the structural integrity of the dam and are not a statement of the dam's safety. The analysis presented is based on a hypothetical dam failure using 2D modeling software with a 100' grid.
4. Cross Section Values:
   Distance from Dam and **Stationing** are reckoned from the centerline of Lopez Dam along the displayed Flow Path.
   Distance from Dam is in miles and **Stationing** is in feet (Stationing 12+34 = 1,234').
   Initial Wave Arrival Time, 1 Foot is the time to achieve 1 foot of water depth after initiation of the dam break.
   Time to Peak is the time to achieve the maximum water depth after initiation of the dam break.
   Deflood Time, 1 Foot is the time elapsed from the flood wave arrival time until water recedes to within one foot of its prefood water elevation.
   Peak Inundation Depth is the maximum water depth.
   Peak Velocity is the maximum velocity.
   Peak Discharge is an estimate of the maximum flow rate integrated over the entire cross section line.
   Peak Water Elevation is the maximum water surface elevation.
   Time Above 1 Foot is the time water depth is above 1 foot.
   Location Description indicates major roads that cross, or are near, the Flow Path at that cross section.
5. The values displayed in the table for each cross section are the maximum for that parameter along each cross section line, except for the **Initial Wave Arrival Time, 1 Foot** and **Time to Peak** which are the minimum for that parameter along each cross section line. The minimum time values associated with 1D channels embedded in the 2D model are excluded.
6. For other details refer to the supporting report "Lopez Dam Failure and Inundation Study" 31 December 2017.
7. Map projection: California State Plane, Zone 5, Feet, North American Datum 1983. **Reference Points** and border tics display these coordinate values. All elevations are referenced to North American Vertical Datum 1988.

Flow Path
Cross Section
Detailed Sheet Extent
Approx. Inundation Extent
Approx. Limits of Fair Weather Dam-Failure Inundation

0 2,000 4,000 8,000 Feet

Scale 1:48,000 or 1 " = 4,000 feet

NOTICE

San Luis Obispo County deems this information to be Confidential. Do not share the information unless prior approval is obtained from SLO County's Dam Safety Officer at (805) 781-5252.

Inundation Depth Map for Fair Weather Hypothetical Failure of **Lopez Dam**

Federal Dam ID: CA00887 State Dam ID: 1055.000

Overview Sheet

San Luis Obispo County

Rev	Date	Description	Prepared By	Accepted By
	28 December 2017	DRAFT	GEI Consultants	

DRAFT

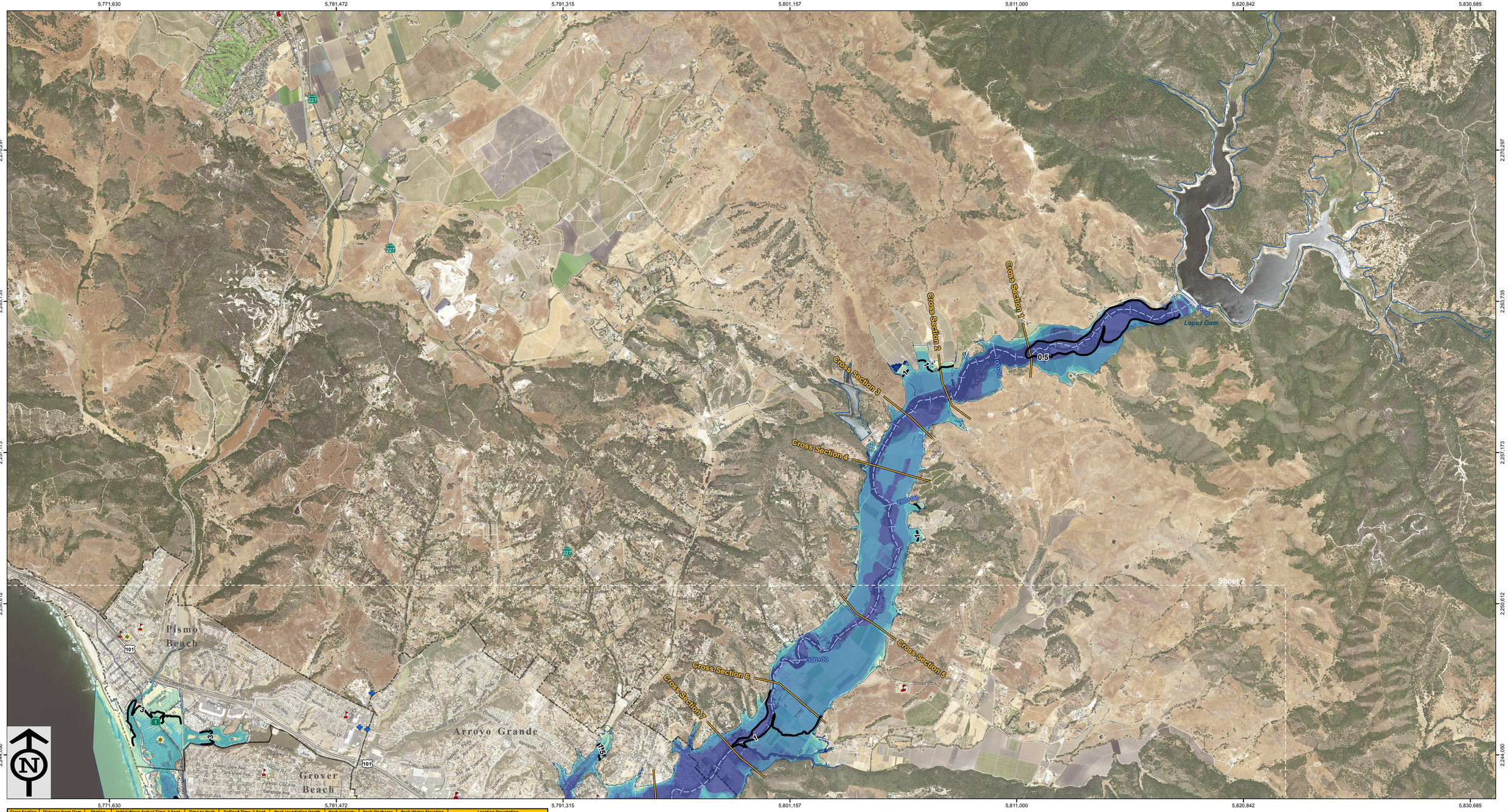
Dam Owner:
San Luis Obispo County Flood Control and Water Conservation District
County Government Center, Room 206
San Luis Obispo, CA 93408

Information Contact: John Diodati, (805) 781-5252
Emergency Contact: (805) 781-5252

Inundation Analysis Performed by and Inundation Maps Created By:
GEI Consultants, Inc.
Mark Fortner, PE 48266

Topographic Reference, USGS 7.5' 1:24,000 scale quadrangles: Port San Luis (1994), Pismo Beach (1994), Arroyo Grande (1993), Tar Spring Ridge (1967), Caldwell Mesa (1967), Oceano (1994), Nipomo (1965), and Huasna Peak (1974).

Z:\Projects\1705077_SLO_LopezTerminalDams\LopezDam_InundationOverview.mxd



Cross Section	Distance from Dam (mi)	Station	Initial Wave Arrival Time, 1 Foot (hh:mm)	Time to Peak (hh:mm)	Deflood Time, 1 Foot (hh:mm)	Peak Inundation Depth (ft)	Peak Velocity (fps)	Peak Discharge (cfs)	Peak Water Elevation (ft)	Location Description
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	833,330	N/A	At Lopez Dam
1	1.6	83+22	0:15	0:58	4:19	39.7	37.6	825,491	380	Downstream of Lopez Lake
2	2.5	131+49	0:21	1:00	4:49	43.5	38.6	822,973	344	Camino Las Ventanas
3	2.9	153+20	0:24	1:01	5:22	35.7	37.1	820,185	329	Talley Farms Road
4	3.4	179+80	0:27	1:02	5:37	28.5	25.7	819,320	301	Downstream of Terminal Reservoir
5	4.8	255+54	0:35	1:05	6:35	37.3	32.3	815,789	251	Cecchett Road
6	6.1	320+24	0:41	1:08	7:29	51.3	21.0	810,902	218	Upstream of Huasna Road
7	6.8	359+57	0:46	1:11	8:18	55.9	22.6	800,646	193	Downstream of Tar Spring Creek

Notes:

1. This map was developed for the benefit of local emergency managers and the California Emergency Management Agency. The infomation shown is approximate and should be used as a guide for emergency response and preparation purposes.

2. The inundation map meets all applicable state and federal standards and has been prepared in consideration of all potential downstream hazards by a licensed civil engineer.

3. The results presented herein do not reflect the structural integrity of the dam and are not a statement of the dam's safety. The analysis presented is based on a hypothetical dam failure using 2D modeling software with a 100' grid.

4. Cross Section Values:
Distance from Dam and **Stationing** are reckoned from the centerline of Lopez Dam along the displayed Flow Path.
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Initial Wave Arrival Time, 1 Foot is the time to achieve 1 foot of water depth after initiation of the dam break.
Time to Peak is the time to achieve the maximum water depth after initiation of the dam break.
Deflood Time, 1 Foot is the time elapsed from the flood wave arrival time until water recedes to within one foot of its preflood water elevation.

4. Cross Section Values continued:
Peak Inundation Depth is the maximum water depth.
Peak Velocity is the maximum velocity.
Peak Discharge is an estimate of the maximum flow rate integrated over the entire cross section line.
Peak Water Elevation is the maximum water surface elevation.
Time Above 1 Foot is the time water depth is above 1 foot.
Location Description indicates major roads that cross, or are near, the Flow Path at that cross section.

5. The values displayed in the table for each cross section are the maximum for that parameter along each cross section line, except for the **Initial Wave Arrival Time, 1 Foot** and **Time to Peak** which are the minimum for that parameter along each cross section line. The minimum time values associated with 1D channels embedded in the 2D model are excluded.

6. For other details refer to the supporting report "Lopez Dam Inundation Technical Study" 31 December 2017.

7. Structures are shown in the aerial photo on the maps but may not clearly display all possible structures potentially within the inundation limits.

8. Map projection: California State Plane, Zone 5, Feet, North American Datum 1983. **Reference Points** and border tics display these coordinate values. All elevations are referenced to North American Vertical Datum 1988.

0 0.25 0.5 1 Miles

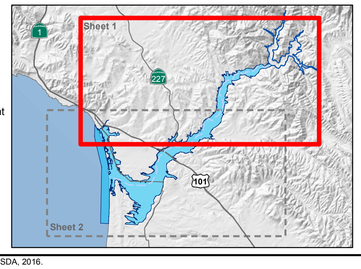
0 1,000 2,000 4,000 Feet

Scale 1:24,000 or 1 " = 2,000 '

- School/Day Care
- Law Enforcement Facility
- CalFire Facility
- Licensed Healthcare Facility
- Flow Path
- Cross Section
- Approx. Time to 1 Foot Depth (hrs)
- Approx. Maximum Flooding Extent

Maximum Inundation Depth (feet)

- ≤ 2
- >2 to 5
- >5 to 10
- >10 to 20
- >20



COUNTY OF SAN LUIS OBISPO

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Inundation Depth Map for Fair Weather
Hypothetical Failure of

Lopez Dam

Flood Depth and Arrival Time

Federal Dam ID: CA00887 State Dam ID: 1055.000

Detail Sheet 1 of 2

San Luis Obispo County

Rev	Date	Description	Prepared By	Accepted By
	31 December 2017	DRAFT	GEI Consultants	
	DRAFT			

Dam Owner:
San Luis Obispo County Flood Control and Water Conservation District
County Government Center, Room 206
San Luis Obispo, CA 93408

Information Contact: John Diodati, (805) 781-5252
Emergency Contact: (805) 781-5252

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Mark Fortner, PE 48266

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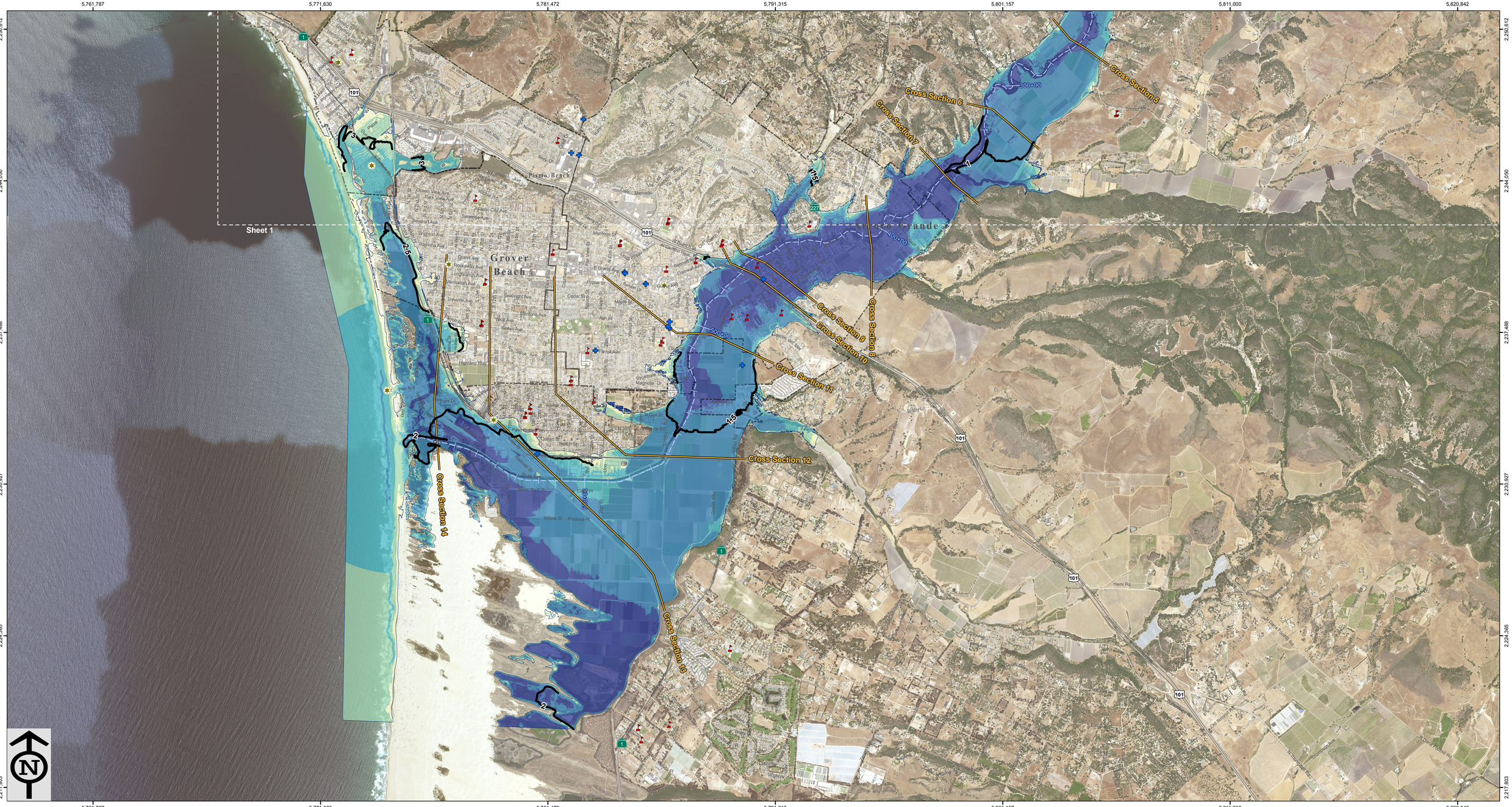

Cross Section	Distance from Dam (mi)	Station	Initial Wave Arrival Time, 1 Foot (hh:mm)	Time to Peak (hh:mm)	Deflood Time, 1 Foot (hh:mm)	Peak Inundation Depth (ft)	Peak Velocity (fps)	Peak Discharge (cfs)	Peak Water Elevation (ft)	Location Description
5	4.8	255+54	0:35	1:05	6:35	37.3	32.3	815,789	251	Cecchetti Road
6	6.1	320+24	0:41	1:08	7:29	51.3	21.0	810,902	238	Upstream of Huasna Road
7	6.8	359+57	0:46	1:11	8:18	55.9	22.6	800,646	193	Downstream of Tar Spring Creek
8	7.7	406+83	0:51	1:15	13:05	55.9	23.2	778,847	172	
9	8.7	460+77	1:00	1:20	13:28	54.2	15.4	747,274	143	Traffic Way
10	8.9	467+83	1:01	1:21	13:42	47.2	13.6	745,518	137	US 101 Highway
11	9.5	503+18	1:07	1:24	14:53	42.9	23.5	738,637	104	Fair Oaks Avenue
12	10.6	560+97	1:17	1:30	16:58	23.0	19.3	712,253	69	Cabrillo Highway (Hwy 1)
13	13.6	610+70	1:23	1:35	18:50	18.2	17.1	687,619	42	Railroad Bridge downstream of 22nd Street
14	12.6	667+86	1:39	2:18	>24:00	22.7	18.6	243,239	11	Outlet of Arroyo Grande Creek into Ocean

Notes:

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4. Cross Section Values continued:
   Peak Inundation Depth is the maximum water depth.
   Peak Velocity is the maximum velocity.
   Peak Discharge is an estimate of the maximum flow rate integrated over the entire cross section line.
   Peak Water Elevation is the maximum water surface elevation.
   Time Above 1 Foot is the time water depth is above 1 foot.
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6. For other details refer to the supporting report "Lopez Dam Inundation Technical Study" 31 December 2017.

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8. Map projection: California State Plane, Zone 5, Feet, North American Datum 1983. **Reference Points** and border tics display these coordinate values. All elevations are referenced to North American Vertical Datum 1988.

0 0.25 0.5 1 Miles

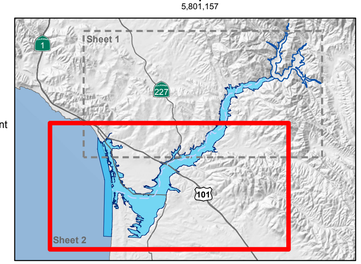
0 1,000 2,000 4,000 Feet

Scale 1:24,000 or 1 " = 2,000 '

- School/Day Care
- Law Enforcement Facility
- CalFire Facility
- Licensed Healthcare Facility
- Flow Path
- Cross Section
- Approx. Time to 1 Foot Depth (hrs)
- Approx. Maximum Flooding Extent

Maximum Inundation Depth (feet)

- ≤ 2
- >2 to 5
- >5 to 10
- >10 to 20
- >20



COUNTY OF SAN LUIS OBISPO

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Inundation Depth Map for Fair Weather
Hypothetical Failure of

Lopez Dam

Flood Depth and Arrival Time

Federal Dam ID: CA00887 State Dam ID: 1055.000

Detail Sheet 2 of 2

San Luis Obispo County

Rev	Date	Description	Prepared By	Accepted By
	31 December 2017	DRAFT	GEI Consultants	

DRAFT

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5,771,630 5,781,472 5,791,315 5,801,157 5,811,000 5,820,842 5,830,685

2,270,297 2,263,735 2,257,173 2,250,612 2,244,050

Lopez Dam

Cross Section 1
Cross Section 2
Cross Section 3
Cross Section 4
Cross Section 5
Cross Section 6
Cross Section 7

200+00
300+00

Sheet 2

Pismo Beach
Arroyo Grande
Grover Beach

227
101
1

Cross Section	Distance from Dam (mi)	Station	Initial Wave Arrival Time, 1 Foot (hh:mm)	Time to Peak (hh:mm)	Deflood Time, 1 Foot (hh:mm)	Peak Inundation Depth (ft)	Peak Velocity (fps)	Peak Discharge (cfs)	Peak Water Elevation (ft)	Location Description
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	833,330	N/A	At Lopez Dam
1	1.6	83+22	0:15	0:58	4:19	39.7	37.6	825,491	380	Downstream of Lopez Lake
2	2.5	131+49	0:21	1:00	4:49	43.5	38.6	822,973	344	Camino Las Ventanas
3	2.9	153+20	0:24	1:01	5:22	35.7	37.1	820,185	329	Talley Farms Road
4	3.4	179+80	0:27	1:02	5:37	28.5	25.7	819,320	301	Downstream of Terminal Reservoir
5	4.8	255+54	0:35	1:05	6:35	37.3	32.3	815,789	251	Cecchett Road
6	6.1	320+24	0:41	1:08	7:29	51.3	21.0	810,902	218	Upstream of Huasna Road
7	6.8	359+57	0:46	1:11	8:18	55.9	22.6	800,646	193	Downstream of Tar Spring Creek

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0 0.25 0.5 1 Miles

0 1,000 2,000 4,000 Feet

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- School/Day Care
- Law Enforcement Facility
- CalFire Facility
- Licensed Healthcare Facility
- Flow Path
- Cross Section
- 6 Approx. Deflood Time (hrs)
- Approx. Maximum Flooding Extent

Maximum Inundation Depth (feet)

- ≤ 2
- >2 to 5
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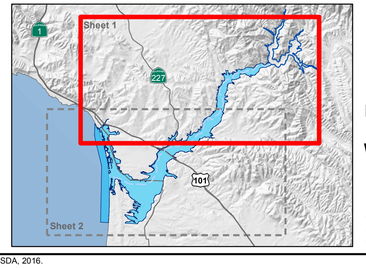

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COUNTY OF SAN LUIS OBISPO

Inundation Depth Map for Fair Weather Hypothetical Failure of

Lopez Dam

Flood Depth and Time to Deflood

Federal Dam ID: CA00887 State Dam ID: 1055.000

Detail Sheet 1 of 2

San Luis Obispo County

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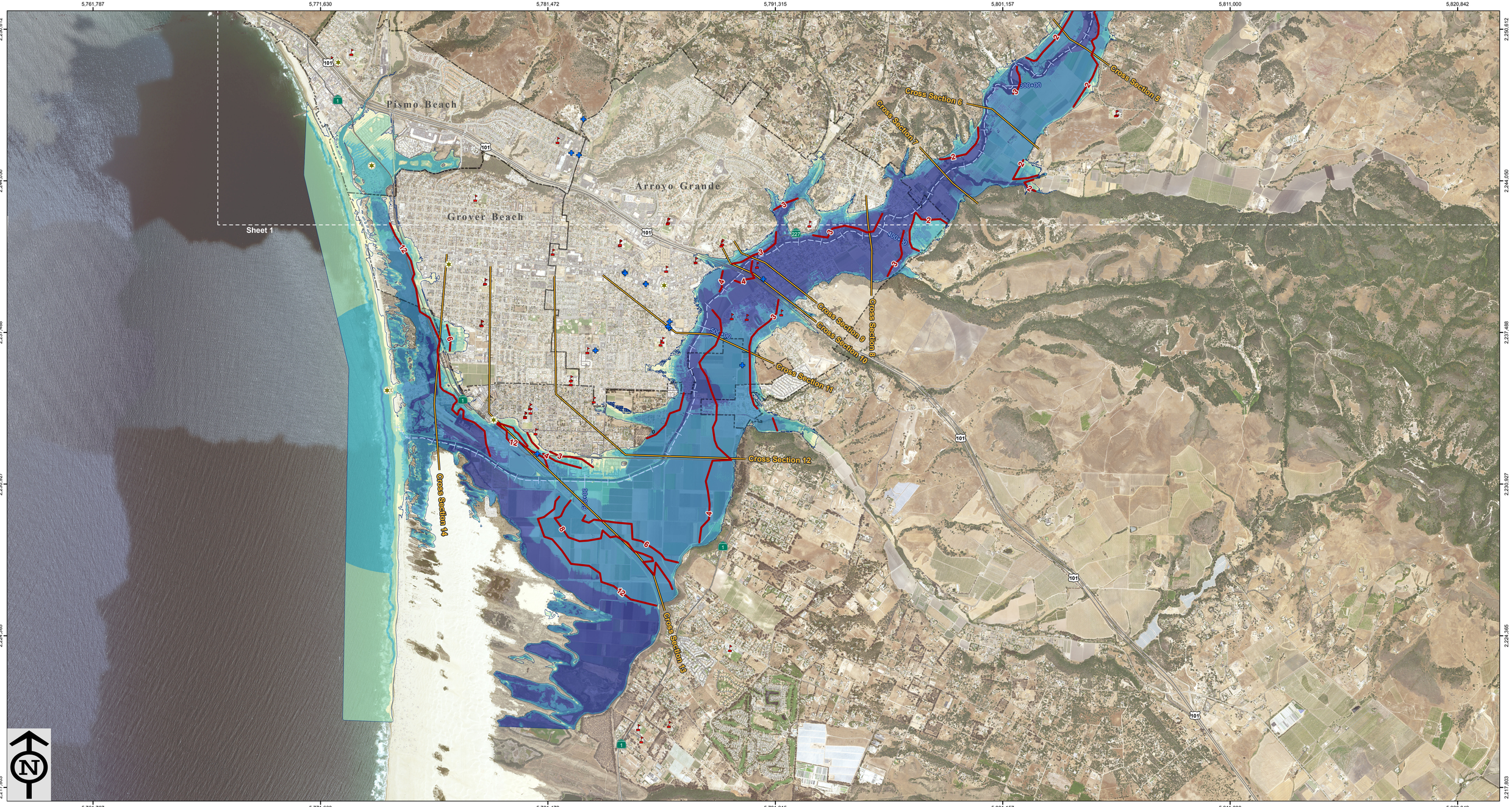

Cross Section	Distance from Dam (mi)	Station	Initial Wave Arrival Time, 1 Foot (hh:mm)	Time to Peak (hh:mm)	Defload Time, 1 Foot (hh:mm)	Peak Inundation Depth (ft)	Peak Velocity (fps)	Peak Discharge (cfs)	Peak Water Elevation (ft)	Location Description
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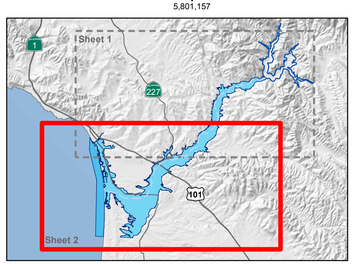

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Inundation Depth Map for Fair Weather
Hypothetical Failure of

Lopez Dam

Flood Depth and Time to Defload

Federal Dam ID: CA00887 State Dam ID: 1055.000

Detail Sheet 2 of 2

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Appendix D

Lopez Dam Spillway Failure Flood Inundation Maps