Appendix 2C – URS 2000 Seismic Report

FINAL REPORT

PROGRAM RESEARCH, ASSESSMENT AND PLAN OF APPROACH SEISMIC ANALYSIS PROGRAM BIG CANYON RESERVOIR NEWPORT BEACH, CALIFORNIA

Prepared for
City of Newport Beach
Public Works Department – Utilities
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1.1 BACKGROUND

Big Canyon Reservoir is a 600 acre-foot potable water storage facility constructed by the City of Newport Beach in 1959. It is located in the San Joaquin Hills, overlooking Newport Bay. The reservoir site plan is presented on Figure 1.

Big Canyon Reservoir is retained on three sides by a homogeneous earthfill embankment dam. The east side and bottom of the reservoir were formed by a slope cut, and the cut material was used to construct the dam. At its maximum section, the dam embankment is 65 feet high. The dam crest elevation is 308 feet (mean sea level datum; MSL), crest length is 3,824 feet, and crest width is 20 feet. The upstream and downstream slopes of the dam are inclined at 3H:1V. The volume of earthfill used to construct the dam is reported to be about 508,000 cu. yd.

The spillway for Big Canyon Reservoir is an ungated concrete-lined overflow structure located in the embankment on the west side of the reservoir. The weir crest elevation is 302.4 feet MSL. At elevation 302.4 feet, the reservoir has a reported surface area of 22 acres, and a capacity of about 600 acre-feet.

As indicated above, Big Canyon Reservoir was formed by cutting the side of a hill slope. It appears that the slope cut exposed bedrock on the bottom of the reservoir and in most of the embankment foundation areas. The bottom of the reservoir and the east cut slope are lined with a minimum 5-foot thick clay blanket, and the entire inside surface of the reservoir, including the embankment and cut slopes, is overlain with a 3-inch thick porous asphalt pavement. Original construction included an underdrain system under the central portion of the west embankment, now referred to as the "west underdrain system."

After the reservoir was constructed, a second underdrain system was installed along the east side of the reservoir (referred to as the "east underdrain system") and the spillway structure has been modified to accommodate a blow-off valve for a water supply line. The City has also completed preliminary design of an HDPE liner and cover for the reservoir.

Historical instrumentation for monitoring the performance of the Big Canyon Reservoir facility has included surface survey markers, piezometers, and underdrain flow meters. However, since about 1996, only nine piezometers have been monitored by the City on a regular basis. In addition, discharges from two local off-site groundwater drains (Bren Tract and Seaview [previously, Broadmoor] drains) had been monitored by the City as part of the Big Canyon Reservoir monitoring program; however, the City discontinued these readings in the mid-1980's.

The Big Canyon Reservoir was permitted by the State Division of Safety of Dams (DSOD) in 1967 to be operated without any restrictions. Since the early 1980's, the DSOD has not noted any condition at the facility that has indicated cause for concern for the integrity and safety of the facility.

1.2 SCOPE OF WORK

In June, 2000, URS Corporations (URS) was retained by the City to conduct an updated seismic analysis of Big Canyon Reservoir. General issues to be addressed by the Seismic Analysis Program (SAP) for the reservoir included:

- General condition of the facility and appurtenances;
- Stability and seismic performance of the dam and reservoir slopes, under both existing and potential future normal and extreme load conditions; and
- Integrity of the overall reservoir system to continue operating in a manner consistent with the City's requirements;

URS's scope of work consisted of a four-stage approach to address these issues, as follows:

- **Stage 1:** **Program Research and Assessment,** consisting of a review of available information on the design, construction, operation and historic and current performance of the reservoir, including as assessment of the current function of the off-site Bren Tract and Seaview groundwater drains.
- **Stage 2:** **Plan of Approach**, in which a plan is developed for obtaining additional data as required to complete a seismic analysis of the Big Canyon Reservoir embankment, and for performing the analysis.
- **Stage 3:** **Development of Seismic Analysis**, including seismic ground motion characterization, modeling of analytical cross-sections, and stability analyses for critical load conditions.
- **Stage 4:** **Report of Findings**, in which the findings from the seismic analysis are presented, and an assessment is made regarding the overall condition of the project, with special emphasis on the asphalt liner and attention to the City's plans for an HDPE reservoir liner and cover. This stage of the work would also include the development of concepts and conceptual-level cost estimates for recommended remediation work if required.

The program research and assessment (Stage 1) and plan of approach (Stage 2) are the subject of this report. Copies of all documents used and/or referenced for the preparation of this report will be provided to the City under separate cover.

2.1 DOCUMENT REVIEW

Existing available information and data on the Big Canyon Reservoir includes the following documents:

- Geologic and geotechnical design reports
- Construction specifications
- As-built project plans
- As-built fill report
- Post-construction groundwater studies reports
- Post-construction seismic hazard report
- Phase I safety report
- Annual inspection notes
- Historic aerial photographs of the project site
- The Seismic Element of the City's General Plan
- Survey, piezometric, and underdrain discharge data

In addition to these documents, we also reviewed internal memoranda of design analyses available in the DSOD files, and various publications and maps relative to the geologic and seismic setting of the project site. A more complete list of the documents reviewed is provided in Section 4, and a summary of the key reports reviewed is provided in Table 1.

In conjunction with our review of available documents, we talked with City personnel familiar with the design, operation and surveillance of the project. We also talked with Mr. Karl Wiebe, retired from James M. Montgomery Consulting Engineers, with respect to the conclusions and recommendations presented in the groundwater studies reports. Mr. Wiebe is a member of the SAP project team that the City has assembled.

2.2 FIELD RECONNAISSANCE

The field reconnaissance was performed the morning of August 11, 2000. At that time, the reservoir surface elevation was about 282 feet MSL, which is 20 feet below spillway crest elevation. The primary objectives of the project reconnaissance were:

- To compare existing visible project features with project descriptions available in the reviewed documents;
- To identify potentially unsafe conditions or evidence of unsatisfactory performance;
- To identify any constraints relative to continued operation of the reservoir;
- To identify conditions that should be taken into account in the project assessment, which may not be readily apparent from the available documents; and
- To understand the City's historic and current reservoir operations.

Personnel participating in the reconnaissance included: Messrs. Karl Wiebe and Steve Bucknam, consultants to the City for the SAP project; Ms. Jean Hill, P.E., Mr. Martin Siem, R.G., and Ms. Caroline Chen of URS; and Messrs. George Murdoch and Pete Antista of the City. The reconnaissance team visited the project site and performed a visual survey of the reservoir, the dam embankment, the spillway, the inlet/outlet system, the on-site underdrain and off-site groundwater drain systems, and other related features and structures. In addition, a visual survey of the surface geology and pertinent geomorphic features relating to the potential proximity of faulting was completed.

2.3 FINDINGS

2.3.1 Project Design and Construction

Big Canyon Reservoir was designed by James M. Montgomery, Inc. (JMM). Geotechnical design recommendations were developed by Converse Foundation Engineers (Converse) in conjunction with Mr. Richard Jahns, an independent geologist. Although Converse developed geotechnical design parameters appropriate for a zoned embankment section, in fact, the embankment has a homogeneous section. Converse recommended a 0.15g pseudo-static force factor for the seismic analysis of the embankment.

The Big Canyon Reservoir project appears to have been constructed essentially as shown on the as-built construction plans. As indicated above, Big Canyon Reservoir was constructed by cut and fill using materials at the site. The site materials consisted of terrace deposits overlying Monterey shale bedrock. The terrace deposits are generally described as dense sand, silty sand, clayey sand and hard clay. The Monterey shale is generally composed of fine- to moderate-grained marine sedimentary rocks of Miocene age, including sandstone, siltstone and claystone. The construction specifications contained provisions for blending the sandier terrace deposits and the Monterey shale materials prior to placing in the dam embankment.

The construction specifications required that the embankment be compacted in layers not exceeding six inches in thickness. The material was to be compacted to at least 90 percent of the maximum laboratory value (compactive effort 33,750 ft-lbs/cf) at a moisture content wet of optimum. Construction testing indicated an average relative compaction of 93 percent based on the 33,750 ft-lbs/cf compactive effort. The DSOD indicated that this would be equivalent to 95 percent of the DWR standard, 20,000 ft-lbs/cf effort.

The foundation material for the embankment consists of either Monterey shale bedrock or terrace deposits overlying the Monterey shale. Foundation conditions were not documented during construction. However, on the basis of pre-construction information on subsurface conditions, the requirements for a minimum of 5 feet of stripping, and previous borings by JMM (1977) and Woodward-Clyde Consultants (WCC; 1979), it is estimated that the terrace deposits are present in the foundation for the southern portion of the west embankment, western portion of the south embankment and the east embankment. On boring logs, the terrace deposits are characterized as being "dense" to "very dense" fine sand and silty sand, and varying in thickness up to about 10 feet.

In the northeast corner of the embankment, a portion of the foundation terrace deposits become saturated when the reservoir is full. However, WCC (1979) determined that the material would not be subject to seismic-induced liquefaction in the event of 0.6g ground surface acceleration.

The Monterey shale is considered to provide relatively impermeable, competent and stable foundation conditions.

2.3.2 Historic Performance and Instrumentation

In the first decade following its construction, Big Canyon Reservoir apparently performed as designed. However, a slough developed on the east side of the reservoir in 1969, after the reservoir had been drained (presumably for routine maintenance and/or inspection). The slough was relatively shallow, with the slip surface approximately coincident with the contact between the clay blanket and the underlying native slope material. It was subsequently concluded that the sloughing occurred as a result of the build-up of pore water pressure behind the liner along the east wall due to leakage through the reservoir lining. The east underdrain system was constructed to mitigate this situation.

Partly in response to the 1969 failure, and partly in response to concerns regarding the rising groundwater table in the vicinity of the reservoir, JMM was retained by the City in the mid-70's and the mid-1980's to conduct hydrogeologic studies of the project. JMM concluded that groundwater in the vicinity of the reservoir occurs primarily as a result of reservoir leakage, with the majority of the leakage occurring through the east reservoir wall, and other leakage occurring at the south reservoir wall. However, JMM also concluded that the east underdrain system was relatively effective in intercepting this leakage and controlling the phreatic surface in the east reservoir slope.

During the field reconnaissance on August 11, 2000, there were no observations of indications of distress of any portion of the visible embankment. The exposed asphalt lining was cracked, but this condition has historically been acknowledged to be surficial in nature and not indicative of a deep-seated stability problem.

Instrumentation for the reservoir consists of open standpipe piezometers installed within the embankment and in the surrounding area as well as flow measurements from the two underdrain systems. A summary of the piezometers that have been installed at the site is provided in Table 2, with an annotation whether they are installed in the embankment or the reservoir area. As summarized in Table 2, of the 23 piezometers installed at the site, nine are currently (September 2000) monitored monthly. Of these nine, one is in the embankment fill, four are in the east reservoir wall, and four are in the reservoir area. The remaining 14 piezometers are considered "out of service" due to either being decommissioned during subsequent development, or being clogged or damaged such that readings are not considered reliable. The locations of all of the piezometers are shown on Figure 1.

The piezometer data indicate that, with the exception of piezometer SL-2, the piezometric elevations generally vary (with some lag time) with the reservoir surface elevation. However, the fluctuation of the reservoir surface is generally on the order of about 30 feet while the water levels in the piezometers generally fluctuate about 5 feet or less. The amount of piezometric fluctuation generally decreases, and the lag time for piezometric response generally increases with distance of the piezometer from the reservoir.

With regard to piezometer SL-2, which is located in the western portion of the embankment, it is noted that the piezometer data indicates very little reaction to changes in reservoir surface elevation. In 1999, the data from SL-2 became erratic, and the piezometer was subsequently abandoned.

The discharge data from the east underdrain system has been relatively stable at about 2 to 5 gpm for the past approximately 20 years. The discharge data from the west underdrain system fluctuates with the reservoir elevation, but is generally on the order of 5 gpm during normal reservoir operations.

2.3.3 Assessment of Off-Site Groundwater Drains

In the late 1960's and early 1970's time frame, a high groundwater table was reported in the residential developments located to the north and west (downstream) of the Big Canyon Reservoir site. In response, the City constructed two off-site groundwater drain systems. The locations of these two drains, known as the Bren Tract and the Seaview (formerly, Broadmoor) drains, are shown on Figure 2. It is our understanding that these drains discharge to the City's storm water system.

As part of the studies in the 1970's, JMM analyzed the levels and quality of groundwater flowing around the reservoir and collecting in the off-site drains. The City continued monitoring the flows in the off-site drains until the mid-1980's, and made a supplemental analyses of the water in the Bren Tract drain in September 2000 as part of this current assessment.

On the basis of JMM's and the City's data, as well as the observed conditions in the residential developments, it is concluded that the relatively high groundwater table downstream from the reservoir is due to both reservoir leakage and percolation of applied water (e.g., irrigation or precipitation). However, measurements of water levels in active piezometer G-26, which is relatively close to a monitoring well for the Seaview drain (see Figure 2), indicates that the groundwater table has remained relatively stable at approximately elevation 270 feet MSL, or 10 feet below ground surface, for the past 10 years. With respect to quality, the water in the Bren Tract drain appears to be improved relative to previous analyses in terms of chloride and nitrate concentrations and specific conductance (as a measure of total dissolved solids).

The absence of recent complaints from homeowners regarding wet conditions in their yards or distressed vegetation due to poor groundwater quality is further substantiation that the off-site groundwater drains are continuing to function for their intended purpose.

2.3.4 Faulting and Seismicity

Active faults, as presently defined by the California Division of Mines and Geology (CDMG), are faults that displace Holocene deposits (last 11,000 years). The faults that have been identified as potential sources of significant ground shaking at the project site (i.e., active, seismogenic faults) include the Newport-Inglewood Fault Zone (NIFZ), the Palos Verdes fault, the Elsinore fault, the San Jacinto fault, and the San Andreas fault. In addition to these surface faults, the recent uplift of the San Joaquin Hills has been interpreted to be the result of slip along the postulated San Joaquin Hills blind thrust fault (Grant, et al., 1999).

No known active faults have been identified as crossing the project site. However, a splay of the Pelican Hill fault has been mapped to the eastern edge of Big Canyon Reservoir (Jahns, 1956; Vedder and others, 1957; Tan and Edgington, 1976; and Morton and Miller, 1981). In addition, as part of this study, a review of aerial photographs from the Fairchild Collection in Whittier California, dating back to 1928, revealed several lineaments crossing the reservoir site and merging with the mapped splay of the Pelican Hill fault trace. This suggests that the mapped splay of the Pelican Hill fault could possibly continue along a northwestern trend across the project site and through the eastern and southern portions of the reservoir embankment, and possibly through the western embankment as well. However, based on offset marine terrace deposits, the Pelican Hill fault is considered a Late Quaternary fault (a fault with displacement within the past 700,000 years) and not active per CDMG criteria.

The Late Quaternary timing of activity on the Pelican Hill fault has been constrained by documenting the age of marine terraces that have either been displaced or have not been displaced by the Pelican Hill fault. Eight marine terraces of Quaternary age have been identified along the coastline of the San Joaquin Hills. These terraces have been referred to as Terraces 1 through 8 (Grant, et al., 1999), with Terrace 1 being the youngest elevated terrace (83,000 to 105,000 years before present) to Terrace 8, the oldest recognized terrace (approximately 1.3 million years before present). Strands of the Pelican Hill fault have been recognized to displace Terrace 7 (900,000 to 1 million years before present) and Terrace 3 (212,000 to 340,000 years before present). However, there has been no recognized displacement of Terrace 2 (122,000 years before present) or younger Holocene deposits associated with the Pelican Hill fault. Based on this data, activity on the Pelican Hill fault is considered to have occurred prior to 122,000 years before present. The Big Canyon Reservoir site is situated on Terrace 4, a 350,000 to 450,000-year-old terrace, with no Holocene deposits remaining on the site that have not been disturbed by grading activities. These relationships are significant because any fault investigation at the site would only reveal information concerning fault location, and would not provide any new data in relation to fault activity.

Although the Pelican Hill fault is not considered active, there is the potential for co-seismic triggered slip to occur along the fault in association with a moderate to large earthquake on the nearby Newport-Inglewood fault zone and/or the San Joaquin Hills blind thrust fault.

2.3.5 Preliminary Simplified Analysis

As an initial evaluation of the stability and seismic performance of the Big Canyon Reservoir embankment, preliminary slope stability analyses and a preliminary simplified two-dimensional seismic deformation analysis were performed for cross section A-A of the embankment located as shown on Figure 1. Cross Section A-A corresponds to the maximum embankment section, and is shown on Figure 3.

The material parameters chosen for the preliminary analyses of Section A-A are the same as used for the design of the embankment, and are presented in Table 3. The phreatic surface used for analysis was based on our review of the limited historic piezometer data and corresponds to the highest levels measured. Seismic parameters were based on URS's 1999 seismic re-evaluation of the nearby San Joaquin Reservoir dam, located approximately 2 km north-east of Big Canyon Reservoir. For the preliminary analysis, a magnitude 6-3/4 (M_w) on the San Joaquin Hills blind thrust producing a peak horizontal ground acceleration of 0.9g was used.

The preliminary slope stability analyses were performed using the computer program UTEXAS-3. The factor of safety (FS) was calculated using Spencer's method. Factors of safety were evaluated for steady-state seepage with full reservoir and during rapid drawdown. Seismically induced deformations were evaluated using the Makdisi-Seed (1978) approach, which yields an estimate of the deformation of the crest of the dam as a result of an MCE event.

The results of the preliminary stability and deformation analyses are provided in Table 4, and the critical surfaces are shown on Figures 4 and 5 for steady-state seepage and rapid drawdown respectively. Table 4 also provides a comparison of results with the results of previous seismic analyses performed by the DSOD in 1980 and Woodward-Clyde in 1979.

The generally accepted criteria for factor of safety and seismic deformations are summarized below

CASE	CRITERIA
Steady-State Seepage	Minimum FS=1.5
Rapid Drawdown	Minimum FS=1.25
Seismic Deformation	Less than 1 percent of the height of embankment and Less than half the available freeboard

Based on the results of the preliminary analyses, presented in Table 4, the minimum acceptable factors of safety are satisfied. However, the results of the preliminary seismic deformation estimate indicate deformations on the order of 1.5 percent of the embankment height. This exceeds the one percent deformation criteria, yet the deformation of less than 12 inches is significantly less than half of the 5.6 feet of available freeboard. It is concluded that the preliminary analyses indicate that the seismic performance of the embankment is adequate for the assumed material and load conditions.

3.1 INTRODUCTION

Stage 2 of URS's authorized scope of services is the development of a plan for obtaining data as required to complete the updated seismic analysis of Big Canyon Reservoir, and performing the analysis. Based on the findings from the Stage 1 work, particularly the preliminary analyses, it appears that the most critical data needs are as follows:

- Site-specific **seismic hazards**, including ground shaking levels and the potential for co-seismic slip on the splay of the Pelican Hill fault that appears to intersect the reservoir and dam embankment
- Verification of the location of the **phreatic surface in the embankment**, which affects the stability of the embankment slopes
- Documentation of the dense consistency of the **terrace deposits** in the portion of the foundation of the south and west sides of the dam embankment, and the potential for liquefaction of those deposits if saturated and subject to seismic shaking

3.2 SEISMIC HAZARDS

As indicated, seismic hazards associated with the Big Canyon Reservoir site include ground shaking (i.e., earthquake-induced ground acceleration) and potential co-seismic slip and ground rupture on the Pelican Hill fault.

The development of the peak horizontal ground acceleration at the project site will be based on the Maximum Credible Earthquake (MCE) events for the previously-identified local and regional seismogenic faults and established ground acceleration relationships. As part of this exercise, we will review with Dr. Lisa Grant the latest geometric model for the San Joaquin Hills blind thrust. Characterization of the other faults of interest will be based on data available from the CDMG and the U.S. Geologic Survey (USGS).

With regard to the potential for ground rupture due to co-seismic slip: We will assume that the splay of the Pelican Hills fault that is directed at the reservoir actually passes through the reservoir and beneath the western portion of the reservoir embankment. We will then evaluate the potential impacts to the reservoir structure and the embankment fill due to co-seismic slip on this fault trace associated with an MCE event on a local or distant source. It is presently the belief that the amount of co-seismic slip will be on the order of tenths of an inch, and thus, have minimal to negligible effect on the integrity of the reservoir and embankment.

We do not anticipate any additional field geotechnical investigations being necessary to characterize the seismogenic faults of concern to the project, nor evaluate the potential for co-seismic slip on a trace of the inactive Pelican Hill fault. However, if the amount of co-seismic slip and associated deformation is considered to be critical to the stability of the embankment and the integrity of the reservoir, then additional investigations may be warranted.

In accordance with our authorized scope of services, our Stage 3 work will also include a probabilistic seismic hazard analysis for the project site.

3.3 SUBSURFACE DOCUMENTATION

We recommend additional field work consisting of borings and installation of piezometers to confirm the previously-reported density of the terrace deposits left in the embankment foundation and to provide a means for monitoring the phreatic surface in the embankment and the foundation terrace deposits. Specifically, we recommend drilling five borings at the locations indicated on Figure 1, and installing piezometers in each boring. Two of the piezometers, namely, those installed in borings UC-1 and UC-4, would function as replacements for piezometers SL-1 and SL-2 previously installed by Converse. Piezometers UC-3 and UC-5 will provide a means for monitoring the phreatic surface in the terrace deposits in the southwest corner of the dam embankment, and piezometer UC-4 will provide data on the phreatic surface in the northern portion of the embankment.

We propose to drill the borings using rotary wash techniques with sampling and standard penetration testing (SPT). SPT blow counts on in situ materials (e.g., the foundation terrace deposits) are considered one of the most appropriate methods for obtaining data relative to the evaluation of liquefaction potential. The SPT has been calibrated with case histories of liquefaction and non-liquefaction during previous earthquakes (commonly referred to as the Seed and Idriss Method). In support of the field work, we recommend laboratory testing consisting of unit weight, water content, gradation and plasticity.

We also recommend that the nine existing active piezometers be cleaned. Cleaning of the piezometer would consist of swabbing and flushing the casing with water, then adding a dilute chlorine solution to the casing and allowing the water level in the piezometer to re-establish equilibrium. Based on a comparison of the piezometer readings before and after the cleaning, a regular schedule of cleaning the piezometers (such as every ten years) may be recommended.

The recommended field and laboratory programs are summarized in Table 5.

3.4 ANALYSIS METHODOLOGY

We will evaluate the liquefaction potential of the in situ terrace deposits using the SPT data and the Seed and Idriss method of evaluating liquefaction potential of sandy deposits. If our evaluation confirms that the terrace deposits left in place are dense, unsaturated, and not subject to liquefaction, then we would finalize the stability analyses we have performed using the updated site-specific seismic parameters. However, if the evaluation indicates that the terrace deposits may undergo significant strength reduction during an earthquake (i.e., liquefaction), then we may recommend performing a more refined numerical analysis of the embankment, such as a finite element analysis using QUAD4 or a finite difference analysis using FLAC.

In any case, our final analyses would also include the cut slope on the east side of the reservoir, as represented by Cross Section B-B located as shown on Figure 1.

3.5 ADDITIONAL RECOMMENDATIONS

In addition to our recommendations regarding replacement piezometers, and on the basis of our review of the available piezometer data, we offer the following suggestions and recommendations relative to the City's monitoring program for Big Canyon Reservoir:

- We suggest that the piezometer monitoring frequency be changed from a monthly schedule to either a three- or six-month schedule, as shown on Table 1. Based on our review, the three-month and six-month schedule is sufficient for monitoring the seasonal fluctuations that have been well documented by the historic monthly readings. For the three-month schedule we recommend monitoring in January, April, July, and October. For the six-month schedule, we recommend monitoring in April and October.
- We recommend that the surface seal on each existing active piezometer be checked by flooding the surface around the collar and observing whether there is infiltration into the piezometer. If it appears that the seals are leaking, and therefore allowing surface water to enter the piezometer casing, then the seals would need to be repaired. The most reliable means of repairing the seals would involve excavating the sealant material to a depth of 5 feet or more, and replacing with new sealant material, such as bentonite or a bentonite-cement grout mix.
- We recommend that the City re-establish as efficient means of monitoring the discharges from the east and west underdrain systems, consistent wit the anticipated flow volumes and reservoir operations.

3.6 ESTIMATED STAGE 3 AND STAGE 4 COSTS

The estimated costs to perform the recommended Stage 3 field and laboratory work, and perform the proposed analyses, amount to $54,730. The breakdown of our estimated costs is provided in

Table 6. As indicated in Table 6, approximately $11,600 would be for subcontract drilling services, $1,400 would be for subcontract piezometer swabbing services and $2,500 would be for the laboratory tests.

Our estimated costs to perform the Stage 4 report work would be as originally proposed, or $21,600.

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TABLES

TABLE 1
BIG CANYON RESERVOIR

SUMMARY REVIEW OF EXISTING DOCUMENTS

Reference	Year	Purpose	Conclusions	Recommendation(s)	Cross Reference
Converse Foundation Engineers, 1966, Soil and Geologic Reports, Big Canyon Reservoir. Reports prepared and compiled for the City of Newport Beach, December.	1966	To obtain information on the foundation soils and embankment materials.	1. The site is suitable for a reservoir. 2. All materials to be excavated are suitable for embankment.	1. Over excavation of at least 3 feet in reservoir area. 2. Soil design properties. 3. The embankment and blanket materials should be compacted to at least 90% of the maximum lab density. 4. A seismic factor of 0.15g be used in the design. 5. Further geological study and additional borings may be required to investigate the landslide above reservoir.	
Converse Foundation Engineers, 1967, Field Density Tests, Controlled Compacted Filled Ground, Big Canyon Reservoir. Report prepared for the City of Newport Beach, February.	1967	To control the compaction of filled ground.	1. With exception of a few documented areas, the controlled fill has been compacted to 90% of the maximum dry density. 2. A relative density of 70% or greater was obtained for cohesionless soils used in the underdrains.	None	
Converse, Davis and Associates, 1969, Reservoir Lining Investigation, Big Canyon Reservoir, Newport Beach, California. Report prepared for the City of Newport Beach, April.	1969	To determine the cause of the slippage in the lower portion of a easterly side section, occurred on February 24, 1969.	1. The clay lining has served its purpose as a relatively impermeable barrier. 2. The triggering of the slippage was the result of coincidental occurrence of reservoir drawdown and heavy rains. The latter one caused the build-up of excess hydrostatic pressure in the sand layer behind the lining. 3. The potential for future excess hydrostatic pressure build-up is presented in the east wall.	1. Restore the damaged clay lining. 2. Provide drainage to the sand layer for the entire length of the east wall. *(Note: Clay lining was repaired, and east wall drain was constructed.)*	

TABLE 1
BIG CANYON RESERVOIR

SUMMARY REVIEW OF EXISTING DOCUMENTS

Reference	Year	Purpose	Conclusions	Recommendation(s)	Cross Reference
James M. Montgomery, 1975, Big Canyon Reservoir Ground Water Study, Progress Report No. 1. Prepared for the City of Newport Beach, January.	1975	To collect sufficient geologic, hydrologic and water quality data to define the quality and direction of ground water flow in the vicinity of Big Canyon Reservoir.	1. Ground water surface is continuous. 2. Overall fluctuations in ground water surface elevation exhibit little relationship to rainfall, or to fluctuations in reservoir water surface elevation. 3. Permeability in the fractured portions of the siltstone bedrock is somewhat higher than that in the terrace sands.	None	
James M. Montgomery, 1975, Big Canyon Reservoir Ground Water Study, Progress Report No. 2. Prepared for the City of Newport Beach, May.	1975	To collect sufficient geologic, hydrologic and water quality data to define the quality and direction of ground water flow in the vicinity of Big Canyon Reservoir.	1. Ground water levels exhibited little direct effect from observed rainfall. 2. Very minor flow change occurred in the main underdrain and the east wall drain with change in reservoir water elevation. 3. The maximum ground water level declines occurred just east of the reservoir. 4. Concentrations of dissolved minerals increased with increasing travel distance.	None	
James M. Montgomery, 1975, Big Canyon Reservoir Ground Water Study, Progress Report No. 3. Prepared for the City of Newport Beach, August.	1975	To collect sufficient geologic, hydrologic and water quality data to define the quality and direction of ground water flow in the vicinity of Big Canyon Reservoir.	1. Ground water levels exhibited little direct effect from observed rainfall. 2. Discharges at the east wall drain increased with the rising reservoir stage. 3. Average main underdrain discharges ranged from 4.95-6.16 GPM. 4. Average Bren drain discharges ranged from 0.83-4.03 GPM. 5. Systematic rises and declines in water levels have been most pronounced in the piezometers nearest the reservoir.	None	

TABLE 1
BIG CANYON RESERVOIR

SUMMARY REVIEW OF EXISTING DOCUMENTS

Reference	Year	Purpose	Conclusions	Recommendation(s)	Cross Reference
James M. Montgomery, 1977, Big Canyon Reservoir Ground Water Study, Phase III Underwater Inspection (B-241). Letter report prepared for the City of Newport Beach, May.	1977	Underwater investigation of lining.	1. Intensive dye checks proved negative. 2. Algae is becoming a problem. 3. Leakage is insignificant. 4. Conclusions drawn in report dated Nov. 9, 1976 remain valid.	1. Undertake algae removal operation. 2. Perform underwater inspection at intervals of about 2-years. 3. Undertake underwater investigation if leakage rate increase. 4. Continue measurements of piezometer levels.	Converse (1976, not avaliable for review)
James M. Montgomery, 1977, Big Canyon Reservoir Ground Water Study, Final Technical Report. Prepared for the City of Newport Beach, July.	1977	To collect sufficient geologic, hydrologic and water quality data to define the quality and direction of ground water flow in the vicinity of Big Canyon Reservoir.	1. Ground water moves around the reservoir locally in both the fractured siltstone bedrock and in the overlying terrace deposits. 2. Saturated terrace deposits could pose a potential hazard of settlement during intense ground motion. 3. Recharge from rainfall was of minor significance to the overall ground water supply. 4. Irrigation did not result in any significant recharge to the ground water. 5. Maximum ground water level fluctuation occurred to east of the reservoir. 6. The major portion of the ground water flowing in the vicinity is supplied by the leakage from the reservoir. 7. The principal leakage is occurring along the east wall. 8. The east wall drain is very effective in removing the leaked water. 9. The repair of cracks in the reservoir liner along the east wall may have reduced the discharge by 30%.	1. Expand monitoring program. 2. Evaluate potential geologic hazards related to the possible settlement of berms above the saturated terrace deposits. 3. Careful monitoring and analysis of east wall drain discharge. 4. A program of inspection and liner reapir should be performed at 2-year intervals. 5. A system of shallow wall drains should be designed and installed if marked increase in reservoir leakage is measured in the east wall drain and subsequent repair efforts fail to stabilize the leakage.	JMM (1975; 3 Progress Reports); WCC (1979)

TABLE 1
BIG CANYON RESERVOIR

SUMMARY REVIEW OF EXISTING DOCUMENTS

Reference	Year	Purpose	Conclusions	Recommendation(s)	Cross Reference
Woodward-Clyde Consultants, 1979, Seismic Stability, Big Canyon Reservoir, Newport Beach, California. Report prepared for the City of Newport Beach, February.	1979	To evaluate the seismic stability of the northeast corner of the reservoir.	1. The sand layer at the site does not appear to be susceptible to liquefaction. 2. A seismic-induced settlement of less than 1 inch was estimated for the sand layer.	None	
State of California, Department of Water Resources, Division of Safety of Dams, 1981, Phase I Inspection Report for Big Canyon Dam. Prepared for the Department of the Army, Corps of Engineers, May.	1981	To identify dams which may pose hazards to human life or property and to recommend additional investigations when required.	1. The foundation is competent if it was prepared adequately according to specifications. 2. The east side slope would not present a safety hazard. 3. The spillway is capable of passing a PMP storm with 2.8 feet of freeboard. 4. Embankment is stable and seepage discharges are within normal limits.	Conduct an investigation of the seismic stability of the embankment. *(Note: WCC's 1979 study was accepted for this investigation. See correspondence, 1961-1990.)*	Converse (1956) Converse (1957) Converse (1969) JMM (1975) WCC (1979)
James M. Montgomery, 1985, Big Canyon Reservoir Ground Water Evaluation. Prepared for the City of Newport Beach, January.	1985	To evaluate ground water behavior in the vicinity of the reservoir.	1. Ground water in the vicinity occurs primarily as a result of reservoir leakage. 2. Ground water recharging from the percolation of rainfall is of minor significance. 3. Ground water level fluctuation generally coincides with the overall reservoir stage fluctuation. 4. Ground water movement is generally toward the northwest. Reservoir leakage continues to cause water to flow around the reservoir. 5. The overall quality of ground water near the reservoir has improved significantly except the east wall.	Either a drainage trench or extraction wells could be constructed should the City elect to approach the problem of ground water behind the east wall.	

TABLE 1
BIG CANYON RESERVOIR

SUMMARY REVIEW OF EXISTING DOCUMENTS

Reference	Year	Purpose	Conclusions	Recommendation(s)	Cross Reference
City of Newport Beach, Big Canyon Dam, miscellaneous correspondence with consultants and State of California Division of Safety of Dams.	1961 to 1990	Respond to DSOD	N/A	N/A	
State of California, Department of Water Resources, Division of Safety of Dams, miscellaneous memoranda and correspondence relative to Big Canyon Dam.	1961 to 1990	Review	1. Big Canyon is made jurisdictional, and permitted to operate without any restrictions. 2. Seismic stability should be evaluated in light of liquefaction potential for terrace deposits left in foundation. 3. Concur with Woodward-Clyde1979 seismic analysis results, and accept this study as the recommended liquefaction/seismic stability evaluation.	N/A	

N/A - Not Applicable

TABLE 2
BIG CANYON RESERVOIR

PIEZOMETER STATUS AND RECOMMENDATIONS
(SEPTEMBER 2000)

Piezometer [1]	Status		Recommendation [3]		
	Monitored [2]	Out of Service	Swab and Flush	Replace	Monitoring Frequency (months)
B-4 (A)		X			
B-7 (A)		X			
B-8 (A)		X			
B-10 (A)		X			
B-23 (A)		X			
G-22 (E)		X			
G-24 (A)		X			
G-25 (A)		X			
G-26 (A)	X		X		6
H-27 (A)		X			3
H-28 (R)		X			3
H-29 (E)		X			3
H-30 (R)	X		X		3
H-32 (R)		X			3
H-35 (R)	X		X		3
H-36 (A)	X		X		6
H-37 (A)	X		X		6
H-38 (E)	X		X		3
H-39 (A)	X		X		3
I-40 (R)	X		X		3
I-41 (R)	X		X		3
SL-1 (R)		X		X	3
SL-2 (E)		X		X	3

(1) See Figure 1 for location of piezometers; (E) = installed in embankment, (R) = east reservoir wall, (A) = installed in reservoir area.
(2) Current monitoring frequency is monthly.
(3) It is also recommended that 3 additional peizometers be added at the locations shown on Figure 1. The additional piezometers would be monitored on a 3 month schedule.

TABLE 3
BIG CANYON RESERVOIR

MATERIAL PROPERTIES USED IN PRELIMINARY SIMPLIFIED ANALYSES

Property	Embankment	Bedrock Foundation
moist unit weight (pcf)	114	117
saturated unit weight (pcf)	116	120
friction angle, ϕ	28°	29°
cohesion, c (ksf)	0.5	2.0

TABLE 4
BIG CANYON RESERVOIR

SUMMARY OF PRELIMINARY SIMPLIFIED ANALYSES

CASE		STATIC FACTOR OF SAFETY (URS)	SEISMIC PERFORMANCE (Estimated Crest Deformation)		
			URS (M_w=6-3/4, a_{max}=0.90g)	**DSOD** (1980 analysis; M_w= 7.5, a_{max}=0.50 g)	**WCC** (1979 analysis; (M_w=7.0, a_{max}=0.60 g)
Downstream steady-state seepage	D/S slope	2.36	<12 in. (<1.5%)	"minor"	<1 in
Stead-State Seepage	U/S slope	4.28	N/D	N/D	N/D
Rapid Drawdown	U/S slope	2.23	N/A	N/A	N/A

N/D = Not Determined
N/A = Not Applicable

TABLE 5
BIG CANYON RESERVOIR

RECOMMENDED BORINGS AND PIEZOMETERS

Piezometer	Anticipated Subsurface Conditions		Proposed Boring Depth (ft)	Piezometer Screen Interval (ft)	Boring Sampling and Lab Testing	Comments
UC-1	0-70'	Embankment Fill	80	20 to 60	• Obtain Modified California samples (2) in embankment • Perform lab testing: Unit weights Water content Sieve analysis Liquid limit Plasticity index	Piezometer will measure phreatic surface in embankment at maximum section. Replaces SL-2.
	>70'	Monterey Shale				
	~47'	Groundwater				
UC-2	0-25'	Embankment Fill	50	20 to 25	• Obtain Modified California samples (1) in embankment • Obtain continuous standard penetration test samples in terrace deposits (~9 samples) • Perform lab testing: Unit weight Water content Sieve analysis Liquid limit Plasticity index	Piezometer will measure phreatic surface in embankment. Boring will evaluate in situ terrace deposits.
	25-33'	Terrace Deposits (Silty Sand, Clay, Clayey Sand)				
	>33'	Monterey Shale				
	~30'	Groundwater				
UC-3	0-14'	Embankment Fill	50	20 to 25	• Obtain continuous standard penetration test sampling in terrace deposits (~10 samples) • Perform lab testing: Sieve analysis Liquid limit Plasticity index	Piezometer will measure phreatic surface in foundation. Boring will evaluate in situ terrace deposits.
	14-25'	Clay and Sand				
	>25'	Monterey Shale				
	~26'	Groundwater				

TABLE 5
BIG CANYON RESERVOIR

RECOMMENDED BORINGS AND PIEZOMETERS

Piezometer	Anticipated Subsurface Conditions		Proposed Boring Depth (ft)	Piezometer Screen Interval (ft)	Boring Sampling and Lab Testing	Comments
UC-4	0-30'	Clay/Silty Sand and Sand (native)	50	20 to 30	None	Piezometer will measure phreatic surface in east reservoir wall. Replaces SL-1.
	>30'	Monterey Shale				
	~10-20'	Groundwater				
UC-5	0-18'	Embankment Fill	55	20 to 25	• Obtain Modified California sample (1) in embankment • Obtain continuous standard penetration test samples in terrace deposits (~10 samples) • Perform lab testing: Unit weights Water content Sieve analysis Liquid limit Plasticity index	Piezometer will measure phreatic surface in foundation. Boring will evaluate in situ terrace deposits.
	18-28'	Terrace Deposits (Sand, Silty Sand)				
	>28'	Monterey Shale				
	~35'	Groundwater				

TABLE 6
BIG CANYON RESERVOIR

BREAKDOWN OF ESTIMATED STAGE 3 COSTS

STAGE 3: DEVELOPMENT OF SEISMIC ANALYSIS

SUMMARY DESCRIPTION:

Element (a) - Fault characterization, including location and geometry of active and potentially active local and regional faults.

Element (b) - Perform 5 rotary wash borings with in situ testing and sampling. Install piezometers in the borings. Swab, bail and redevelop nine existing piezometers. Perform laboratory testing on samples obtained from borings.

Element (c) - Deterministic and probabilistic ground motion characterization.

Element (d) - Static stability and seismic performance analyses of Big Canyon Reservoir embankment slopes and cut slopes under full reservoir, rapid drawdown, and design earthquake load conditions. The seismic analysis would be performed using a Makdisi-Seed methodology. Development of remediation concepts, if required, including design and construction cost estimates. Assessment of overall integrity of the reservoir system.

ASSUMPTIONS / BASIS OF COST ESTIMATE:

Meetings - "Ad hoc" meetings and telephone discussions with City personnel and consultants during course of Stage 3 work; working session during field investigation or analysis elements of work as needed to discuss interim findings; working session during preparation of draft Report of Findings.

Deliverables - None.

COST ESTIMATE:

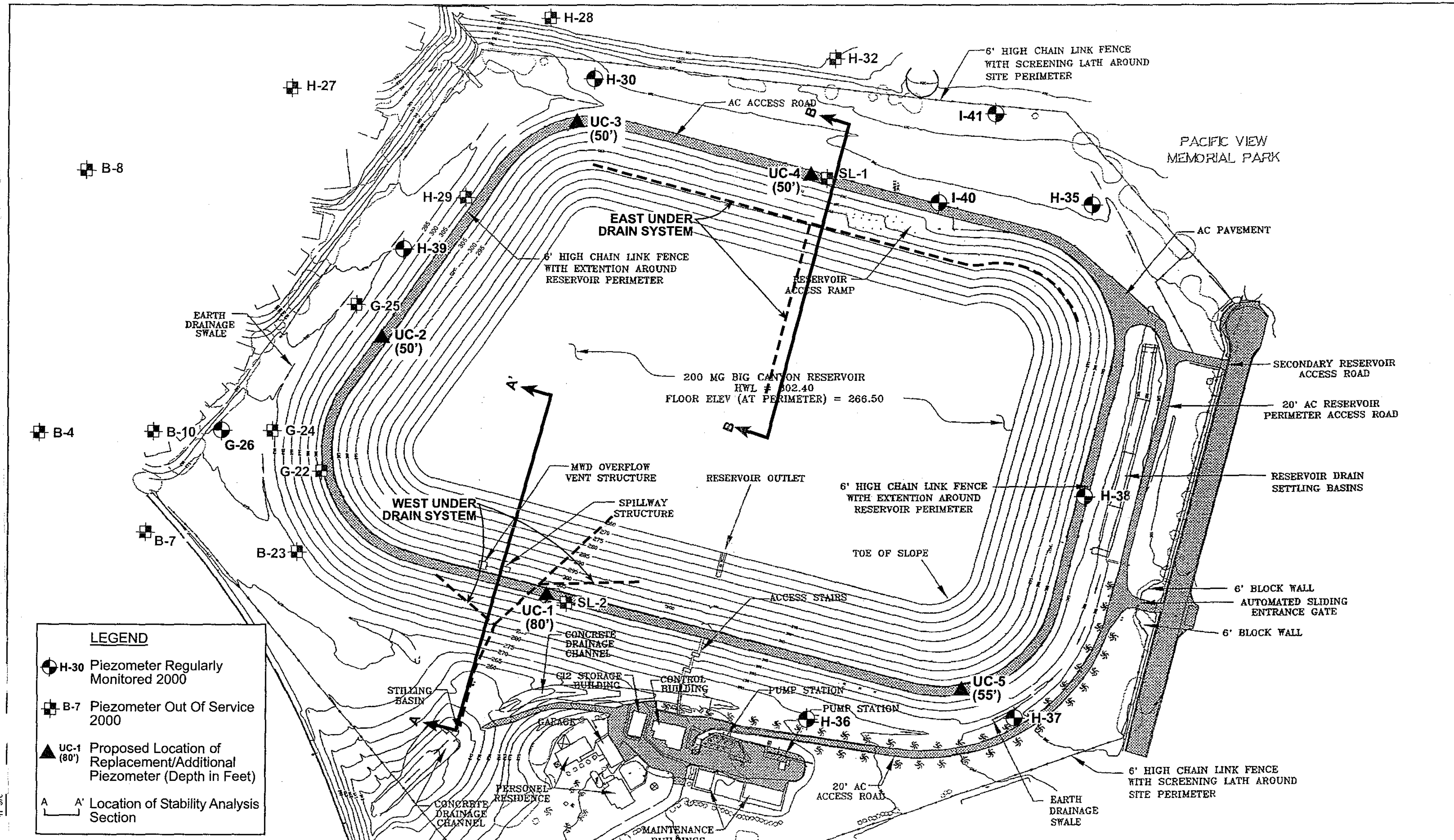
LABOR CLASSIFICATION	AVG. RATE ($/hr)	LABOR HOURS Element (a)	Element (b)	Element (c)	Element (d)	Total	TOTAL ($)
Principal-in-Charge/Peer Review	$ 170.00	2	2	2	4	10	$ 1,700
Project Manager	$ 160.00	4	4	4	8	20	$ 3,200
Consulting/Senior Project Professional	$ 135.00	8	16	32	40	96	$ 12,960
Project Professional	$ 95.00	12	10	8	0	30	$ 2,850
Assistant Project/Senior Staff Prof.	$ 82.50	8	56	24	40	128	$ 10,560
Staff	$ 69.30	0	0	0	0	0	$ -
Drafter/Illustrator	$ 66.00	2	0	0	2	4	$ 264
Technical Assistant/Word Processor	$ 66.00	2	2	0	2	6	$ 396
Clerk	$ 49.50	2	2	0	2	6	$ 297
SUB-TOTAL - Labor		40	92	70	98	300	**$ 32,227**

Other Costs:

DESCRIPTION	RATE	QUANT.	TOTAL
Rotary wash borings with SPTs; water truck support	$ 160 per hour	38	$ 6,080
Piezometer swabbing subcontractor	$ 150 per piez	9	$ 1,350
Truck usage	$ 60 per day	7	$ 420
Drilling supplies and well permits	$ 1,100 per hole	5	$ 5,500
Geotechnical laboratory testing	Estimate	1	$ 2,500
Personal mileage	$0.325 per mile	100	$ 33
Field contingency	15%	$ 12,000	$ 1,800
Reproduction		l.s.	$ 350
Subconsultant services: John Barneich	$ 170 per hour	8	$ 1,360
Mark-up on ODC's	15%	$ 14,290	$ 2,144
Communications (3% on labor)	3%	$ 32,227	$ 967
SUB-TOTAL - Other Costs			**$ 22,503**

TOTAL STAGE 3 COSTS: $54,730

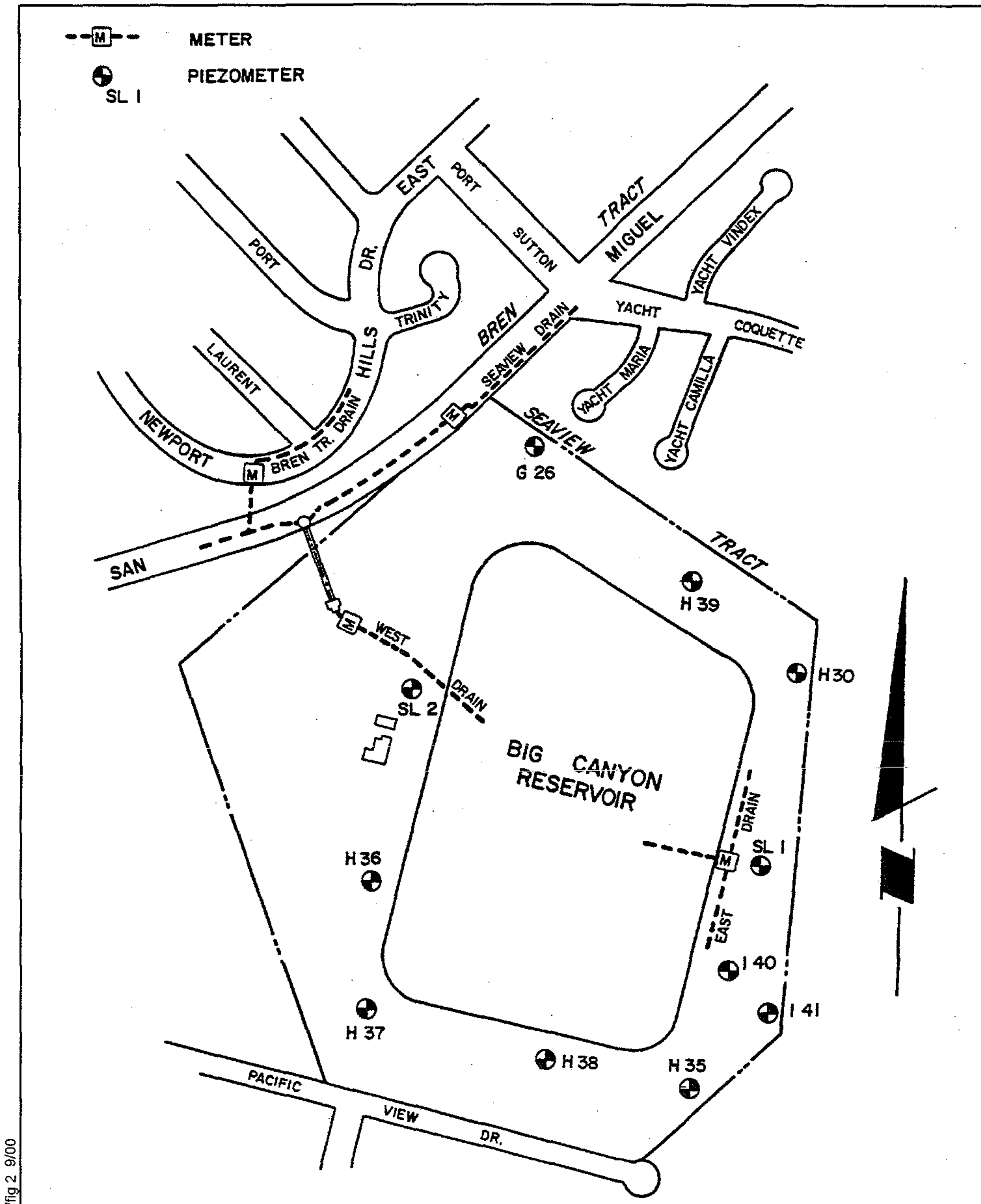
FIGURES



SITE PLAN

Project No.: 5700012020.01	Date: SEPTEMBER 2000	Project: BIG CANYON RESERVOIR	FIGURE 1

URS



OFF-SITE BREN TRACT AND SEAVIEW DRAINS

Project No.: 5700012020.01	Date: SEPTEMBER 2000	Project: BIG CANYON RESERVOIR	Figure 2

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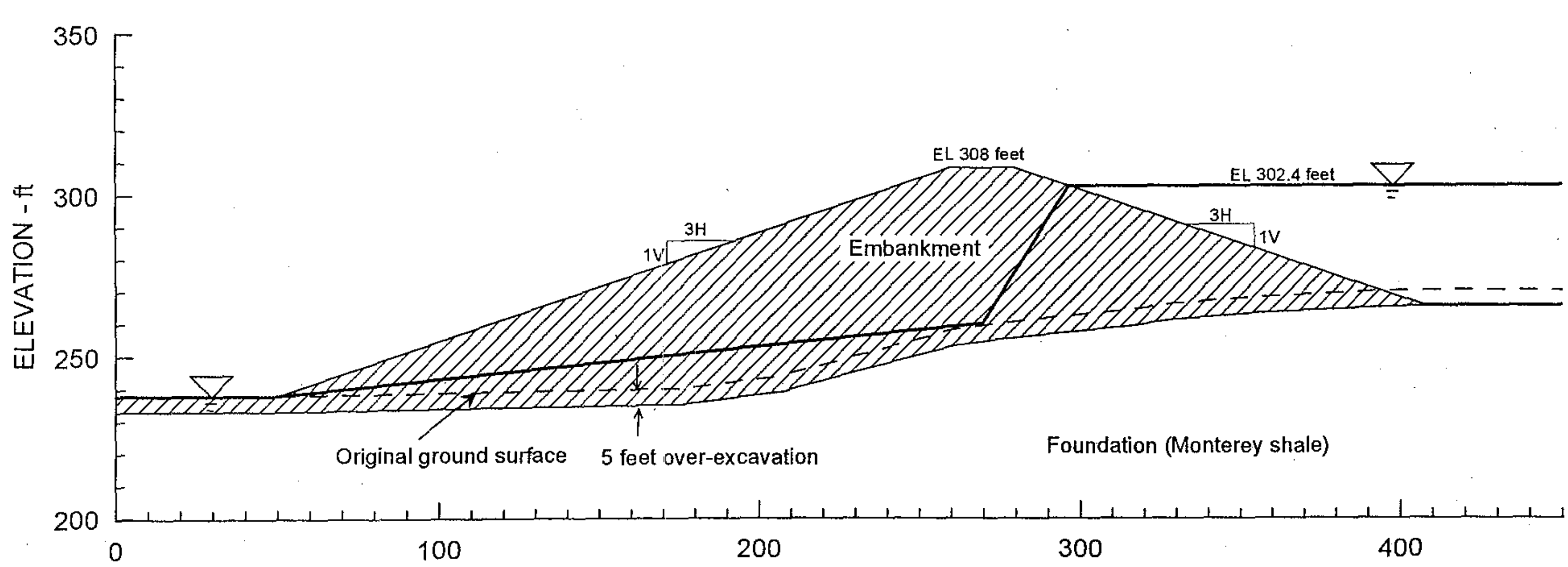

Notes: 1. Material properties are shown in Table 3.
2. See Figure 1 for the location of this cross section.

Project No. 5700012020.01	Date: SEPT 2000	Project: BIG CANYON RESERVOIR	CROSS SECTION A-A EMBANKMENT SECTION USED IN ANALYSES	Fig. 3
URS				

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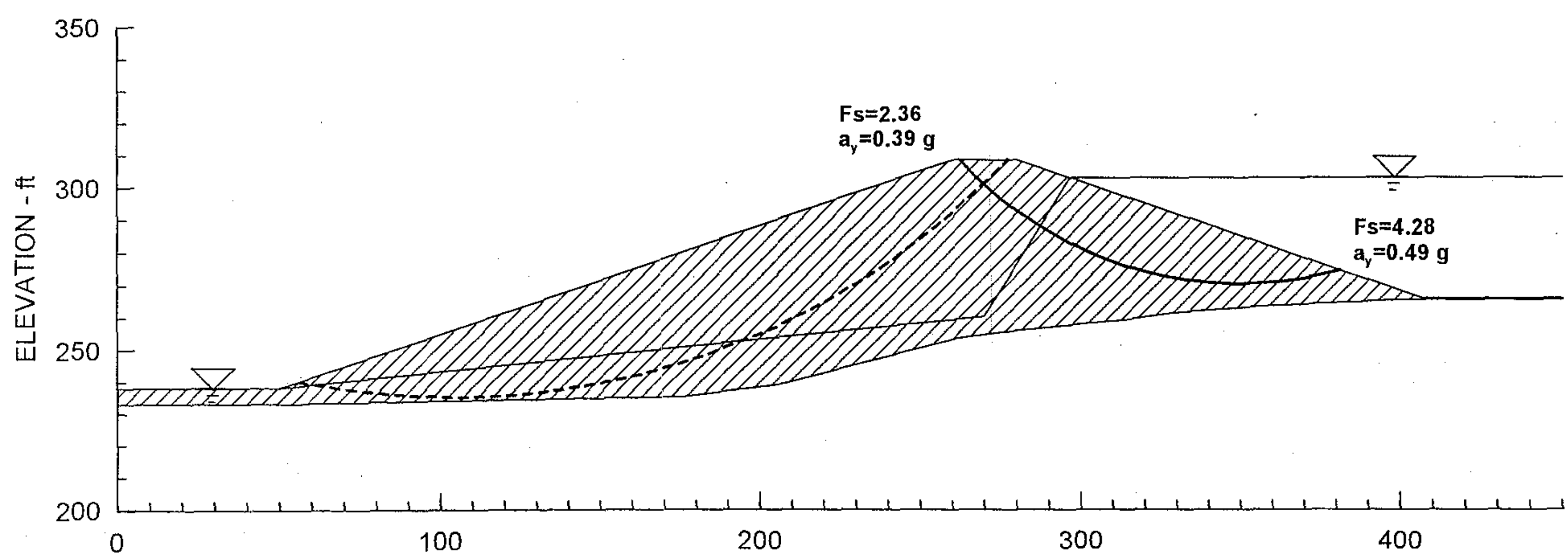

Notes: 1. Material properties are shown in Table 3.
2. See Figure 1 for the location of this cross section.

Project No. 5700012020.01	Date: SEPT 2000	Project: BIG CANYON RESERVOIR	CROSS SECTION A-A CRITICAL SURFACE AND FACTOR OF SAFETY STATIC SLOPE STABILITY ANALYSIS	Fig. 4
		URS		

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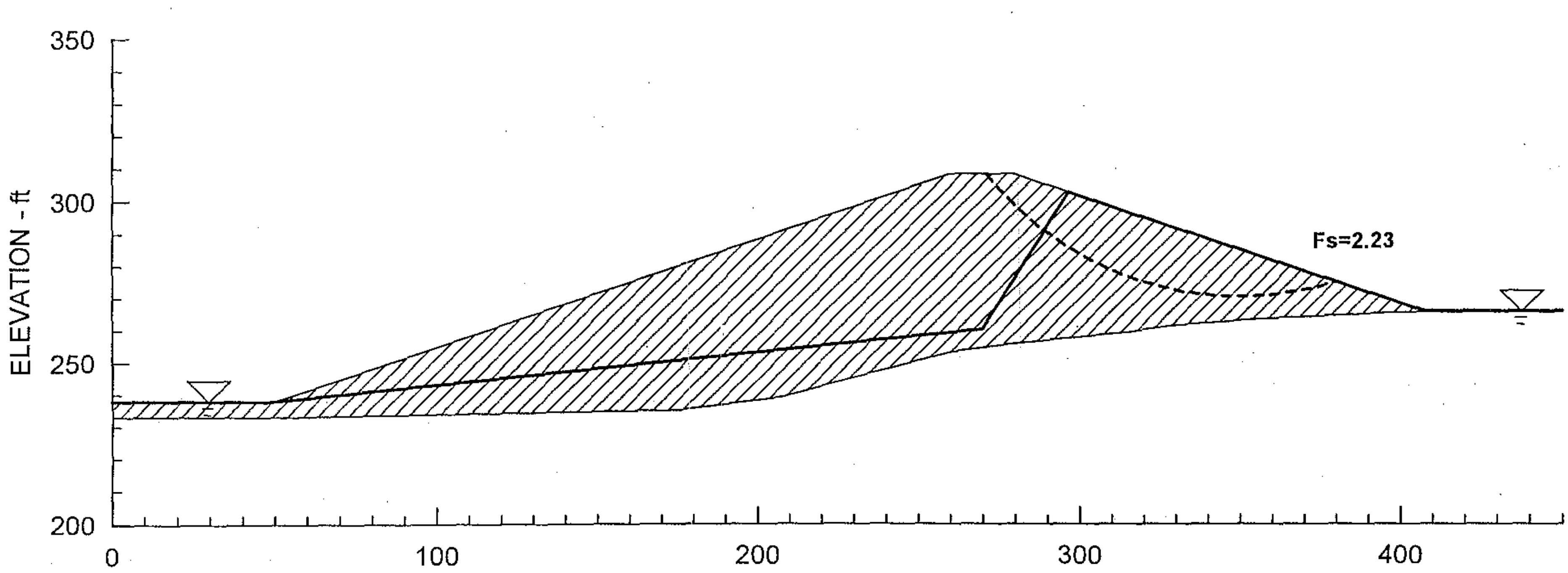

Notes: 1. Material properties are shown in Table 3.
2. See Figure 1 for the location of this cross section.

Project No. 5700012020.01	Date: SEPT 2000	Project: BIG CANYON RESERVOIR	CROSS SECTION A-A CRITICAL SURFACE AND FACTOR OF SAFETY RAPID DRAWDOWN SLOPE STABILITY ANALYSIS	Fig. 5
		URS		

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