From: "Stillwell, Daniel" <dwstillwell@STPEGS.COM>
To: "Mark Tonacci" <MET@nrc.gov>
Date: 11/15/2007 3:54:28 PM
Subject: Additional Information on Main Cooling Reservoir Breach
cc: "David Dujka" <dldujka@STPEGS.COM>,"Gregory T Gibson" <gtgibson@STPEGS.COM>,"John T Conly" <jtconly@STPEGS.COM>,"Steven Thomas" <sethomas@STPEGS.COM>,"William Mookhoek" <wemookhoek@STPEGS.COM>

Mark,

The attached files contain additional information on the main cooling reservoir breach from the licensing of Units 1 and 2. Sediment deposit following a nonmechanistic breach of the main cooling reservoir was not considered during the licensing of Units 1 and 2, however, scour and erosion were the subject of several NRC meetings and much correspondence starting in 1983 when HL&P notified the NRC of a potentially reportable condition concerning erosion and scour associated with failure of the MCR embankment that had the potential to affect the structural backfill supporting the foundations of Seismic Category I structures (ST-AE-HL-1011, 9-28-83). This issue was the result of a revision to RG 1.59 to Rev. 2 that required consideration of erosion and scour for Design Basis Flood events. After discussion, the NRC indicated that scour and erosion did not need to be considered if it can be demonstrated that 1) significant overtopping of the MCR embankment would not occur during any probable maximum flood event; 2) the MCR embankment facing the STP Category I structures is not susceptible to internal embankment failure; and 3) the MCR embankment facing the STP Category I structures would not fail in a Safe Shutdown Earthquake in combination with a 25 year recurrent MCR water level. Letter ST-HL-AE-002572 (3-15-88) documents the completion of the remedial work. Letters ST-AE-HL-093934 (9-19-94) and ST-HL-AE-004817 (9-20-94) contain information that closed the last of the MCR monitoring issues.

After consideration of the additional analysis and the remedial work, the South Texas Project SER Appendix J, Reevaluation of the Completed Main Cooling Reservoir on page 6 summarized the NRCs position on considering scour and erosion from a nonmechanistic breach of the north face of the main cooling reservoir as follows, "The postulation of an instantaneous breach of 2000 feet if the section embankment immediately adjacent to the South Texas units is not considered necessary. Measures to protect the plant from scour and erosion from such a nonmechanistic breach are also unnecessary."

The instantaneous 2000 foot breach considered for Units 1 and 2 was to determine a maximum water level for safety related building design, the extension of the analysis to an instantaneous 4700+ feet breach for units 3 and 4 was also to determine a maximum water level for safety related building design.

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Hearing Identifier: SouthTexas34Public
Email Number: 10

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TWGWPO02.HQGWDO01	nrc.gov

Files	Size	Date & Time
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TEXT.htm	5546	12/6/2007 11:14:27 AM
STEX_ST-HL-AE-004817.pdf	77483	12/6/2007 11:14:27 AM
STEX_SER_APPJ.pdf	1355040	12/6/2007 11:14:27 AM
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Mime.822	2368270	12/6/2007 11:14:27 AM

Options
Priority: Standard
Reply Requested: No
Return Notification: None
None

Concealed Subject: No
Security: Standard

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06/20/94 ST-HL-AE-4817 MAIN COOLING RESERVOIR

June 20, 1994
ST-HL-AE-4817
File No.: G09.18, C13.05
10CFR50

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

South Texas Project
Units 1 and 2
Docket Nos. STN 50-498, STN 50-499
Main Cooling Reservoir

Reference: Correspondence from S. L. Rosen (HL&P) to NRC Document Control Desk, dated February 22, 1993 (ST-HL-AE-4317)

Houston Lighting & Power Company (HL&P) submitted the referenced letter to describe the performance of the South Texas Project Main Cooling Reservoir and Essential Cooling Pond during and after filling. In a conference call between HL&P (W. Harrison/K. Cope/D. Bize) and NRC (L. Kokajako/R. Pichumani) on June 13, 1994, HL&P determined that corrections/clarifications to page 12 of the referenced letter were necessary. A new page 12 is attached with the changed portions marked by a vertical line in the margin.

In addition, the minimum factor of safety for piping around the Main Cooling Reservoir was discussed during the conference call. ASCE Standard N-725, "Guideline for Design and Analysis of Nuclear Safety Related Earth Structures", in Section 4.4.6, recommends a minimum factor of safety of 1.2 for dynamic loading (e.g., piping) for ultimate heat sink earth structures. Although the Main Cooling Reservoir is not an ultimate heat sink, a preliminary calculation of piping factors of safety at worst case locations yielded a minimum factor of safety of 10.0.

If there are any questions, please contact either Mr. A. W. Harrison at (512) 972-7298 or me at (512) 972-8787.

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Attachment: Corrected page 12 from ST-HL-AE-4317

The spillway stilling basin is designed to dissipate the kinetic energy of water flowing down the spillway chute. The stilling basin is lined with a graded granular filter and rip-rap to protect the filter material from erosion. Since the water in the stilling basin was 14 feet deep, the effectiveness of the liner material could not be verified by inspection. Filling the stilling basin with sand increases the flow path from the reservoir to the exit point and allows access to the area by the reservoir inspector. Seepage of 75 gpm was recorded before filling the stilling basin with sand. Seepage of only a few gpm continues on both sides of the stilling basin.

The stilling basin still functions as an energy dissipator. During operation of the emergency spillway the sand filling the basin will be eroded down to the original rip-rap basin lining. Use of the spillway is not anticipated under the present reservoir operating plan.

Seepage Gradient: The seepage gradient was measured at 34 locations around the reservoir where there are three to four piezometers in a line normal to the embankment axis. The seepage gradient around the reservoir is generally between 1% to 2.5%. **There are three locations with elevated seepage gradients of 4%, 5% and 8%.** Sand and clay borrow pits within the confines of the embankment were not permitted within 800 feet of the embankment centerline. This restriction was to preserve the natural surface clay lining to the extent that lateral head loss from an exposed sand layer in the barrow area would equal the vertical head loss through the surface clay at the inside embankment toe. A permeable layer is probably exposed near the embankment at the three locations with high seepage gradients. The seepage exits at all three areas are monitored closely.

Uplift Pressures: Factors of safety against uplift pressures **remain at or above 1.5 at a reservoir pool elevation of +45 feet** MSL. In addition to the safety factor, the ditches where the safety factors are the lowest are provided with filters and sand drains.

Circulating Water Intake Structure: Settlement measurements on the intake structure began in 1977. To date, the structure has settled about 0.4 feet on the north side closest to the embankment and about 0.3 feet on the south side.

5.2 Essential Cooling Pond

Embankment and Training Dike: ECP settlement data was first collected in 1979. The survey monuments are located on the inside berm. Measurements to-date indicate a range from

APPENDIX J

REEVALUATION OF THE COMPLETED MAIN COOLING RESERVOIR

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REEVALUATION OF THE COMPLETED MAIN COOLING RESERVOIR

To satisfy the provisions of Regulatory Guide (RG) 1.59, "Design Basis Floods for Nuclear Power Plants," Revision 0, in effect at the time the South Texas construction permit was docketed, an instantaneous nonmechanistic breach of the embankment was postulated to determine flood levels resulting from a breach of the main cooling reservoir (MCR). This postulated breach, discussed in Section 2.4 of the Final Safety Analysis Report (FSAR), consisted of the instantaneous removal, or breach, of a 2000-foot-long section of the embankment. Flood protection designs of the south, west, and east sides of safety-related structures and components, including the essential cooling pond (ECP), were based on the most critical effects of this breach. Issuance of Revision 2 of RG 1.59 changed Appendix A of the guide to American National Standards Institute (ANSI) Standard N170 for guidelines on postulation of events producing the design-basis flood. ANSI N170 suggested evaluation of the effects of scour and erosion caused by a postulated breach. The applicant chose to make an evaluation of the integrity of the segment of the MCR embankment facing the safety-related plant structures rather than an assessment of scour effects on the plant.

After Bechtel assumed architect/engineer responsibilities for South Texas, the following items were studied in a review of the condition of the completed MCR:

(1) stability of the as-built embankment under design loading conditions

(2) dispersive potential of embankment clays and the effect of the sand core and drainage blanket on embankment stability

(3) pipe and structural penetrations through the embankment

(4) underseepage monitoring and control measures

(5) potential for embankment overtopping during the probable maximum flood (PMF) and erosion potential during a flood external to the MCR

(6) construction quality of the as-built embankment

To assist in the reevaluation of the completed MCR embankment and resolution of several of these items, Bechtel retained a Consulting Review Board (CRB). Emphasis was placed on the embankment section between stations 640+00 to 655+00 and 0+00 to 40+00 (see Figure 1) because of its proximity to the South Texas safety-related structures. During a meeting in Bethesda, Maryland, on April 2, 1985, between NRC staff and consultant and HL&P personnel, consultants, and architects/engineers, the applicant indicated that an embankment breach outside this section would not affect the safety-related structures. Each of the abovementioned review items is discussed in the following paragraphs.

Stability of A[illegible] Embankment

Stability analyses were performed based on strength parameters established for the initial design. Additional field investigations (see Figure 2) and soil testing were performed to verify the original design parameters. A total of 48 borings were drilled to obtain undisturbed samples and to perform standard penetration tests. Laboratory testing included consolidation tests and triaxial and direct shear-strength tests. These tests confirmed that strength parameters used in the stability analyses are conservative. Results of the field and laboratory programs are presented by Harza Engineering Company (Vols. 2 and 3, 1984). The stability of the embankment was studied for steady-state seepage, rapid drawdown, and seismic conditions. These analyses are presented in detail by Harza Engineering Company (Vol. 1, 1984) and summarized in Table 1. A typical embankment cross-section with selected material strengths is shown on Figure 3.

Analyses were also performed at stations 105+00, 250+00, and 365+00. These analyses indicated adequate safety factors.

Because the project is located in a very low seismicity zone with the clay embankment founded on clays and medium dense to dense sands, a Newmark-type displacement analysis was performed. Also, a liquefaction potential analysis was performed for the embankment between stations 42+50 and 72+50 where low-blow-count sandy material was encountered. Results of the displacement analyses are presented on Figure 4 and show that permanent deformations will not occur because the yield accelerations are much greater than the safe shutdown earthquake (SSE)-induced accelerations. Also, clay embankments on clay or dense sand have successfully withstood earthquake accelerations much higher than the SSE for the South Texas plant with no significant effects (Seed, Makdisi, and DeAlba, 1978). Results of the liquefaction potential analysis are shown on Figure 5 with the cyclic strength determined for average corrected standard penetration values and the cyclic stress determined from a response spectrum analysis corrected for confinement pressures (depth) estimated for nonlevel ground near the embankment.

In early 1985, a surface or "skin" slide occurred on the downstream face of the embankment. The approximate location and configuration of the slide are shown on Figure 6. The embankment soils are highly plastic; such soils tend to shrink and swell with alternating drying and wetting cycles. Surface slides are to be expected in these type materials; however, they do not affect the overall stability of the embankment. The staff concurs with this assessment of the effect of surface slides.

Dispersive Potential of Embankment Clays

Laboratory tests were conducted to further evaluate the dispersive potential of the embankment clays into the sand core. The tests, described by Olson and Schieve (1985) and Olson (1985), lasted about 5 months and involved hydraulic gradients in the range of 150 to 200--values more than two orders of magnitude above any anticipated in the field. There was no tendency for the hydraulic conductivity to increase with time and no cloudy effluent. When the test equipment was dismantled, there was no sign of intrusion of clay into the sand. The test confirmed earlier judgments that erosion of the clay embankment into the central sand core should not occur.

Pipe and Structural Penetrations Through Embankment

There are a number of pipe and structural penetrations through the existing embankment as shown on Figure 7. Only the circulating water intake and discharge pipes are located in the section of the embankment opposite the power block. These pipes, shown on Figure 8, consist of eight 96-inch-diameter pipes for the intake that tap into four 138-inch-diameter pipes near the toe berm, and four 138-inch-diameter pipes of the same type for the discharge. The pipes that penetrate the embankment have bell and spigot joints with rubber gaskets and are embedded in sand and surrounded by embankment material. Some joints were welded at bends to provide thrust restraint, and some were harnessed to permit joint rotation. Major concerns related to these pipes included a lack of inspectability and lack of watertightness of joints that could open, causing leakage and subsequent embankment failure. Remedial measures to alleviate these concerns are currently in progress (see Figure 9). Measures consist of removing the existing pipes, installing new concrete pipes at the crest and slopes in concrete chutes to provide erosion protection and inspectability of joints, and installing additional piezometers along the existing pipes at the berm to detect any leakage that might develop.

In addition to the above modifications, individual joint liners for makeup and blowdown pipes and chemical grout barriers for the makeup structure and spillway are being implemented to improve the reliability of the reservoir embankment.

During excavation of the intake and discharge pipes, a testing program was initiated to investigate existing embankment materials in the excavation. Testing consisted of in-place densities, soil classification, Atterburg limits, gradation, moisture content and standard Proctor compaction. Results, shown in letters from the architect/engineer (Bechtel) to the applicant numbered ST-YB-HL-11635 dated March 19, 1985, and ST-YB-HL-11714 dated April 12, 1985, indicated that the material was high plasticity clay (CH) compacted to at least 95% of standard Proctor maximum density. During a site visit on March 19, 1985, by David E. Wright of the U.S. Army Corps of Engineers, there was no visual evidence of heave in the bottom of the excavation after removal of the discharge pipes. Field observations (Engen, April 17, 1985) during removal of the 138-inch discharge pipes revealed that some joints had been tack welded. The applicant has implemented an inspection program to ensure that other joints in the embankment toe berm are welded. Corrective actions, if required, will be determined on the basis of the investigation.

Underseepage Control Measures

Underseepage control is provided by over 650 relief wells extending into sand layer 2 near the toe of the downstream berm. The applicant retained McClelland Engineers, Inc. (MEI) to address underseepage control. MEI cleaned and refurbished the wells not affected by power block dewatering and developed recommendations for further renovation of that portion of the relief well system. Proper functioning of the underseepage control measures will be checked by periodic monitoring of piezometers. Figure 10 shows the plans for these instruments. The embankment will be closely monitored during filling, and the data will be used to evaluate uplift pressures in the foundation. Additional relief wells, if required, will be installed to ensure satisfactory embankment performance. The monitoring program during reservoir filling will provide the basis for long-term monitoring during normal plant operation. See Table 2 for present monitoring plans.

Embankment Overtopping

The as-built embankment crest, corrected for settlement, ranges from elevation 65 feet to over elevation 66 feet. The normal maximum operating water level is elevation 49.0 feet. The estimated total rise in water level from a PMF event in combination with a wind setup and wave runup on the north section of the embankment is approximately 13 feet, or 3 feet below the top of the embankment. The wind setup and wave runup associated with a probable maximum hurricane was approximately 1.4 feet below the top of the dam.

External Erosion Potential

Possible erosion of the exterior slope of the embankment near the power block was considered for calculated velocities past the embankment and for sustained wave action. Water levels above plant grade only occur for a PMF or failure of upstream dams in the Colorado River basin. Although the discharge at the site is large for either event, the area of the flooded section is sufficiently large to prevent flow velocities required for erosion of compacted soils. Considering the limited duration of these events, the well-compacted clay, and the protective grass cover, wave erosion potential is negligible.

Construction Quality of As-Built Embankment

In addition to the design aspects, the applicant also addressed construction quality. Reviews by Harza and Bechtel (letter ST-HL-AE-1240 dated May 6, 1985, from M. R. Wisenburg, HL&P, to G. W. Knighton, NRC) of construction records for the embankment section opposite the power block revealed that 33 standard Proctor compaction tests were conducted. In-place density tests (average one per 1000 yd^3 of fill) averaged 98% maximum compaction. Of the construction reports, 5% were sampled to determine disposition and action taken if a field test did not meet specifications. On the basis of this sampling, 7.5% of the field tests failed to meet specification requirements; however, in all cases reviewed, the fill was reworked and retested until acceptable results were achieved.

The reviewer who prepared this safety evaluation on behalf of the NRC staff conducted a sampling review of construction quality by reviewing construction records during a site visit on March 19, 1985. He concluded that the applicant's specifications for the main cooling reservoir earthwork ("Specification, Cooling Reservoir Earthwork," 7Y510HS001D, revised February 1976) included adequate provisions for the following items:

(1) dewatering
(2) clearing and grubbing of foundation areas
(3) embankment material classifications
(4) foundation preparation
(5) fill placement
(6) compaction (moisture-density) requirements

The basic project organization is shown on Figure 11, which indicates that the resident engineer developed and technically administered the quality control program for reservoir construction. The quality control program, in turn, was subject to inspection and audit by Brown and Root quality assurance personnel and by HL&P personnel. Figure 12 shows the reservoir inspection and testing organization. Typical examples of reports prepared included a report by the earthworks placement inspector (Figure 13), field test results (Figure 14), and reports by the senior inspector (Figure 15), Brown & Root, Inc., Quality Assurance Department (Figure 16), and HL&P surveillance personnel (Figure 17). In all the cases checked during the site visit, it appeared that proper materials, equipment, and procedures were used, adequate inspection was performed, and corrective measures were taken, when required.

Throughout construction of the embankment, personnel of the Texas Department of Water Resources (TDWR) also performed periodic inspections to ensure compliance with approved plans and specifications (personal communication from E. J. Biskup, TDWR, to D. Wright, U.S. Army Corps of Engineers, July 25, 1985). These inspections were generally performed on a monthly basis. Construction records or documentation were provided to TDWR periodically. At the completion of construction, a completion certificate was furnished to TDWR by the applicant which certified that the dam "was constructed in accordance with and includes all items in plans and specifications filed with and approved by the Texas Water Commission."

Instrumentation Monitoring and Inspection

Instruments have been installed to monitor the performance of the main cooling reservoir during initial filling and the operational stage. The types, number, and monitoring frequency of the instruments are presented in Table 2.

Instrument locations and specific instructions pertaining to maintenance, monitoring procedures, standards, reports, etc. are presented in the applicant's "Specification for Geotechnical Instrumentation Monitoring and Inspection of Main Cooling Reservoir," revised December 8, 1983.

In addition to the monitoring of instruments, the applicant has implemented an inspection program. The objective of this program is to evaluate the performance of the reservoir, embankment, and appurtenant structures to identify existing or potential conditions that could affect their functions or cause a safety hazard. Two types of inspections will be conducted--a general or periodic inspection conducted at a prescribed frequency and special inspections to address specific conditions or features. A detailed discussion of these planned inspections is presented in the applicant's "Specification for Geotechnical Instrumentation Monitoring and Inspection of Main Cooling Reservior," revised December 8, 1983.

Conclusions

Considering the applicant's original and postconstruction studies, an adequate number and type of field investigations and laboratory tests were performed to define the engineering properties of the foundation and embankment materials for the various conditions that are expected to exist in the MCR. Selected geotechnical design parameters are considered reasonable. Detailed studies were performed to evaluate all reasonable modes of failure or potential problems that could lead to failure of the MCR. These studies included analyses of settlement, slope stability (static and dynamic), liquefaction potential, through and underseepage, dispersion, overtopping, and erosion from an external flood. In all cases, adequate safety factors were obtained or measures were incorporated into the design and construction to control potential problem areas. The staff considers that the investigations and design of the MCR embankment, dikes, and appurtenant structures are reasonable and acceptable from a geotechnical standpoint.

Specifications for the construction of the embankment and dikes were in accordance with commonly accepted practices for earthfill embankments. Records indicate that adequate equipment (number and type) and construction procedures were used, the work was sufficiently inspected and tested, and corrective work was accomplished, when required, to conform with the approved plans and specifications. Construction procedures used for the MCR embankment and dikes, certified to have been completed on February 18, 1981, are considered reasonable and acceptable.

Deliberate impoundment of the MCR began on January 23, 1980. As of the summer of 1985, the maximum sustained impoundment level has been approximately elevation 25 feet msl. The project has been monitored since construction began, and no unexpected conditions have been encountered. The reservoir will be filled in stages and closely monitored, which is considered good practice. The applicant has implemented a detailed inspection and monitoring program for the operational life of the project. This program is considered to be in agreement with State and Federal recommendations for periodic inspections and monitoring of dams. With the intended inspection and monitoring program and with the performance of remedial measures or maintenance, as required, the MCR embankment, dikes, and appurtenant works should perform satisfactorily for the design life of the project. Design, construction, and operational procedures and plans are considered reasonable and acceptable. The staff, therefore, has concluded that there is reasonable assurance that the MCR dike in the vicinity of plant structures is capable of containing the reservoir under all anticipated operational conditions. The postulation of an instantaneous breach of 2000 feet of the section embankment immediately adjacent to the South Texas units is not considered necessary. Measures to protect the plant from scour and erosion from such a nonmechanistic breach are also unnecessary.

Because initial filling of the reservoir to elevation 49 feet msl and the period immediately following filling are most critical to the stability and safety of the MCR dike, the staff's final judgment of the MCR must await the results of the applicant's future work. The staff will report the results of its evaluation in a supplement to this SER. This is a confirmatory item that was addressed in Section 2.5 of this SER.

References

Bechtel, letter ST-YB-HL-11635 (with enclosure) to HL&P, "South Texas Project, Bechtel Job No. 14926-001, Main Cooling Reservoir, File No.: C13.5.1," March 19, 1985.

---, letter ST-YB-HL-11714 (with enclosure) to HL&P, "South Texas Project, Bechtel Job No. 14926-001, Main Cooling Reservoir Embankment, C. W. Pipe Excavation - Soil Testing," April 12, 1985.

Engen, R., HL&P, memorandum to D. Wright, U.S. Army Corps of Engineers, "Circulating Water Discharge Pipe Joints," Identification Number W6B/E720/JJ, April 17, 1985.

Harza Engineering Company, Evaluation of Strength Parameters and Stability, Main Cooling Reservoir Embankment, Vol. 1, "Report"; Vol. 2, "Field Exploration and Laboratory Testing"; Vol. 3, "Additional Laboratory Testing," September 1984.

Olson, R. E., "Erodibility Test Results, Main Cooling Reservoir, South Texas Project," University of Texas, Austin, March 25, 1985.

---, and E. W. Schieve, "Report on Erodibility Test, South Texas Project," University of Texas, Austin, March 10, 1985.

Seed, H. B., F. I. Makdisi, and P. DeAlba, "Performance of Earth Dams During Earthquakes," in Journal of the Geotechnical Engineering Division, American Society of Civil Engineers, Vol 104, No. GT7, July 1978, pp. 967-994.

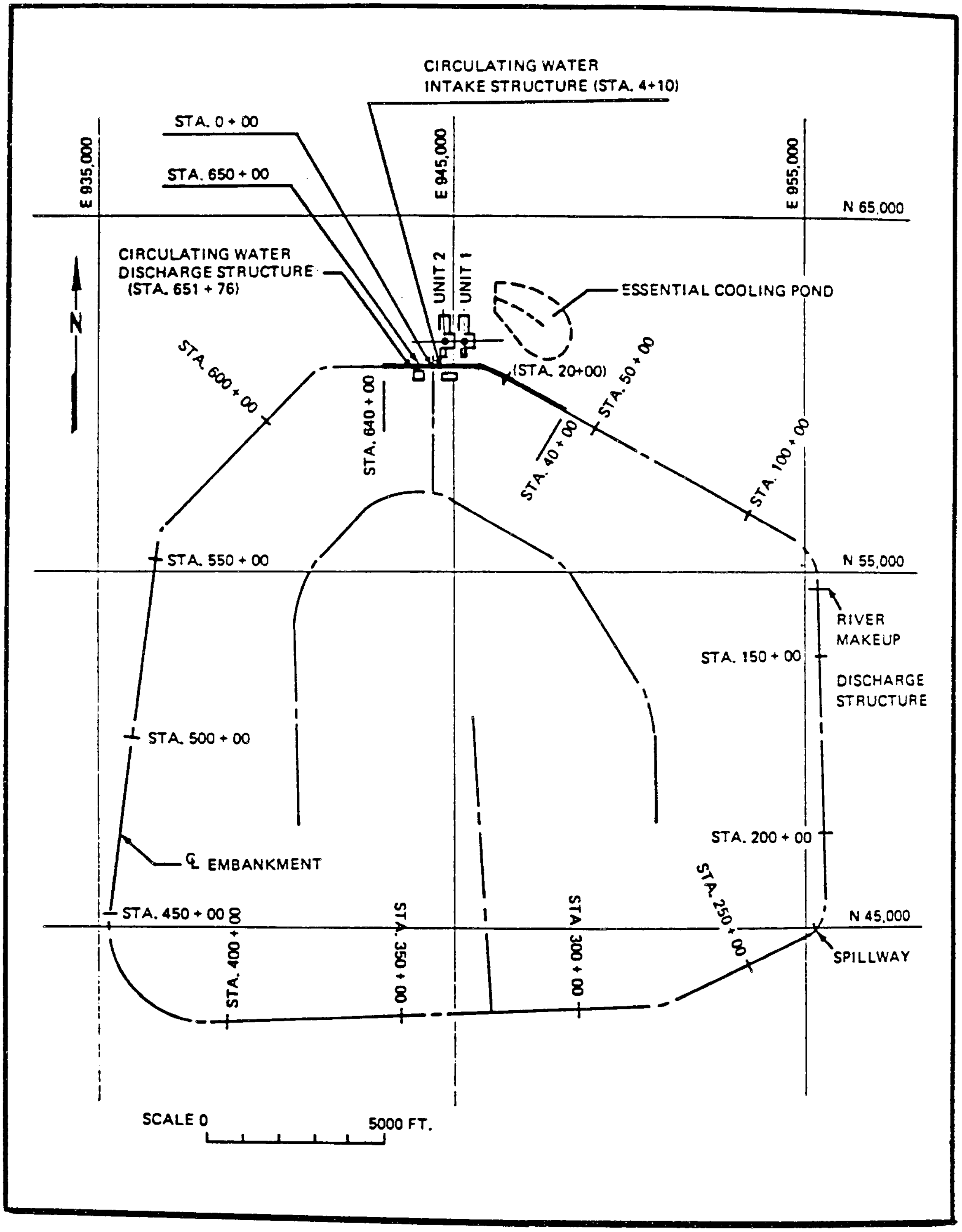
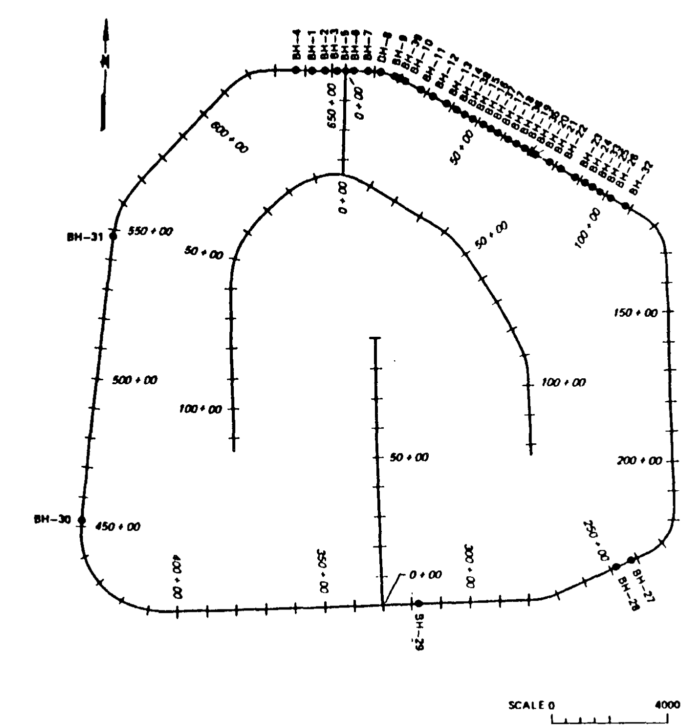


Figure 1 Main cooling reservoir--key plan
Source: Provided at meeting between NRC and applicant, Bethesda, Maryland, April 2, 1985



BOREHOLE No.	STATION	LOCATION
BH 1	642 + 60	D/S
BH-2	647 + 50	CREST
BH-3	652 + 50	U/S
BH-4	637 + 50	D/S
BH-5	0 + 00	D/S
BH-6	2 + 60	U/S
BH-7	7 + 50	CREST
BH-8	12 + 50	D/S
BH-9	17 + 60	U/S
BH-10	22 + 60	D/S
BH-11	27 + 60	CREST
BH-12	32 + 50	U/S
BH-13	37 + 50	D/S
BH-14	42 + 60	U/S
BH-15	47 + 60	D/S
BH-16	52 + 50	U/S
BH-17	57 + 50	D/S
BH-18	62 + 50	U/S
BH-19	67 + 50	D/S
BH-20	72 + 50	U/S
BH-21	77 + 50	D/S
BH-22	82 + 60	U/S
BH-23	87 + 60	D/S
BH-24	92 + 60	U/S
BH-25	97 + 50	D/S
BH-26	102 + 50	U/S
BH-27	242 + 60	CREST
BH-28	247 + 60	D/S
BH-29	317 + 60	D/S
BH-30	452 + 50	D/S
BH-31	547 + 60	CREST
BH-32	107 + 50	U/S
BH-33	96 + 25	D/S
BH-35	71 + 25	U/S
BH-36	66 + 25	D/S
BH-37	56 + 25	U/S
BH-38	46 + 75	D/S
BH-39	20 + 00	CREST

Figure 2 Confirmatory program--borehole location plan
Source: Provided at meeting between NRC and applicant, Bethesda, Maryland, April 2, 1985.

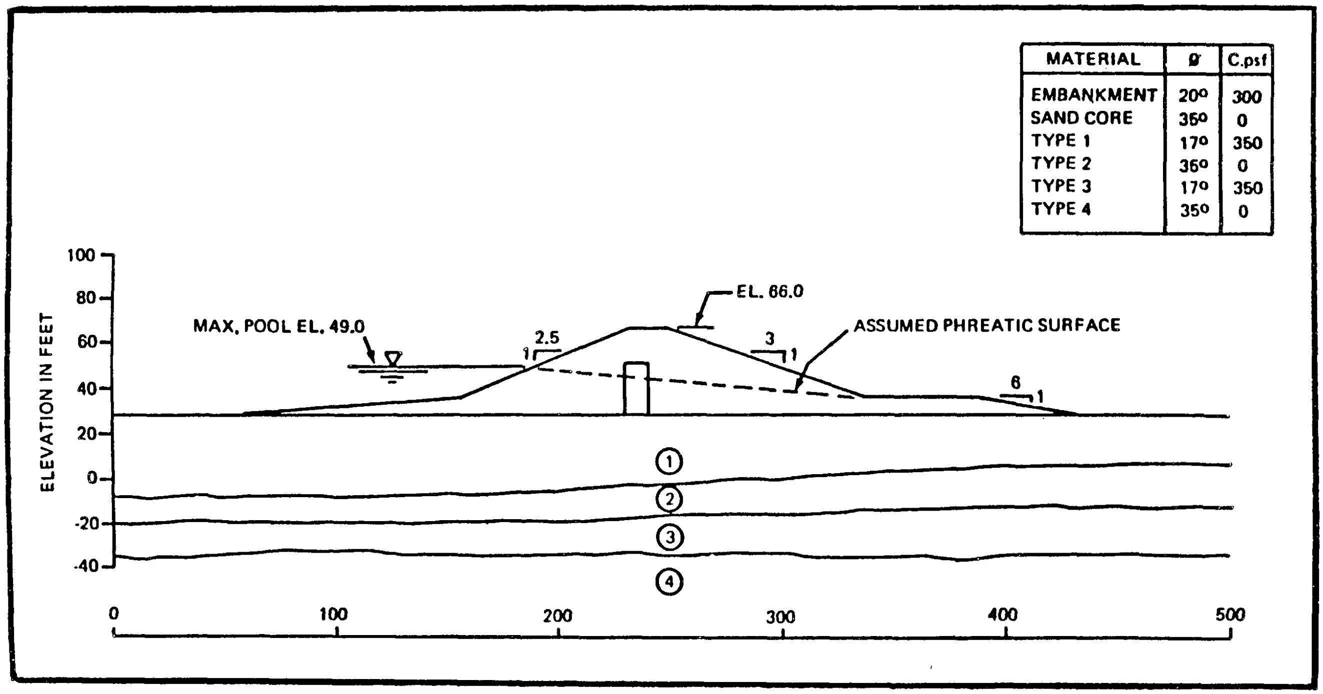


Figure 3 Typical cross-section for analysis
Source: Provided at meeting between NRC and applicant, Bethesda, Maryland, April 2, 1985

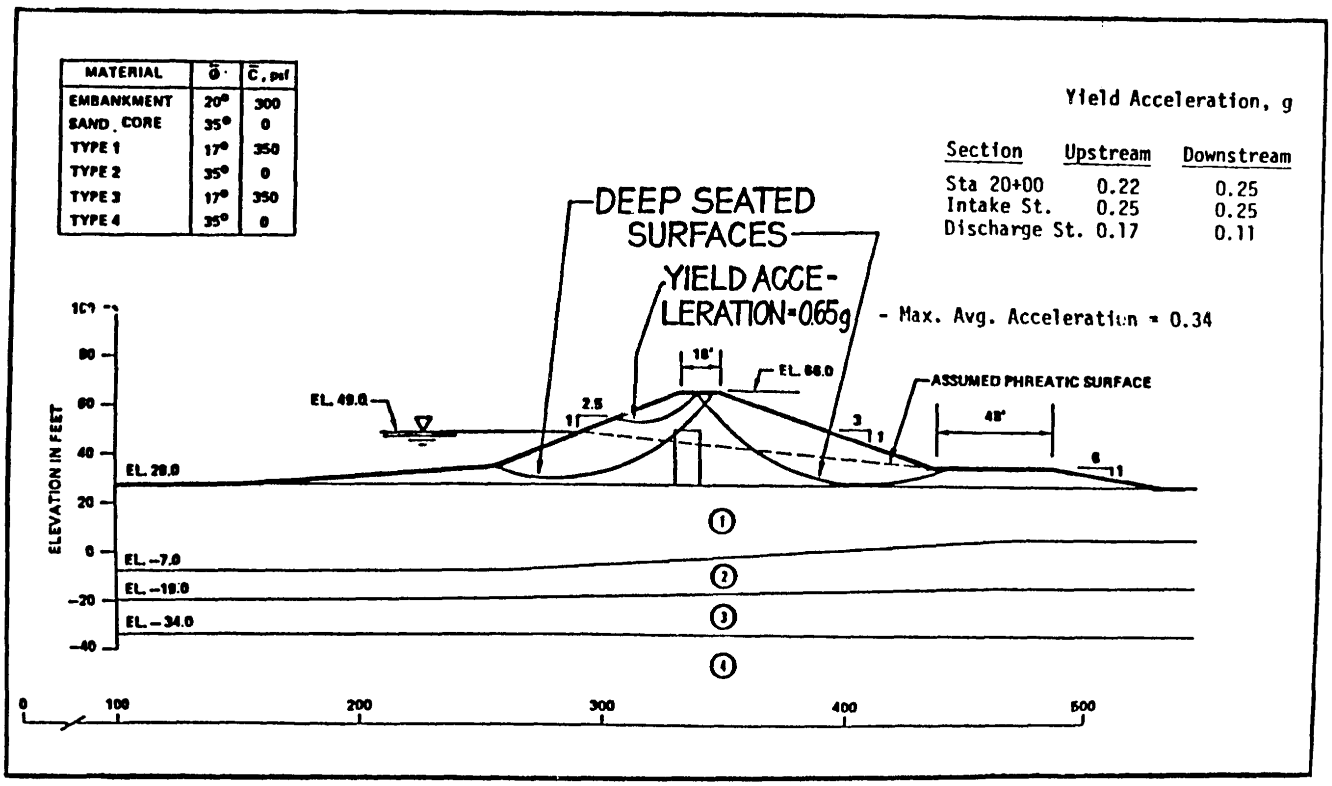


Figure 4 Seismic stability evaluation
Source: Provided at meeting between NRC and applicant, Bethesda, Maryland, April 2, 1985

Station	Elevation	$F.S. = \frac{\text{Cyclic Strength}}{\text{Cyclic Stress}}$		
		Crest	D/S Berm	Free Field
		Fines 15% - 35%	Fines 15% - 35%	Fines 15% - 35%
637± to 10±	-13 to -3	3.0 - 3.6	1.8 - 2.1	1.8 - 2.1
637± to 10±	+ 5 to +10	2.9 - 3.4	1.4 - 1.7	1.5 - 1.8
16± to 40±	+ 2 to +10	3.7 - 4.6	1.9 - 2.3	2.0 - 2.5
30± to 45±	+13 to +16	2.6 - 3.1	1.2 - 1.5	1.4 - 1.7

Figure 5 Results of liquefaction potential analysis
Source: Provided at meeting between NRC and applicant, Bethesda, Maryland, April 2, 1985

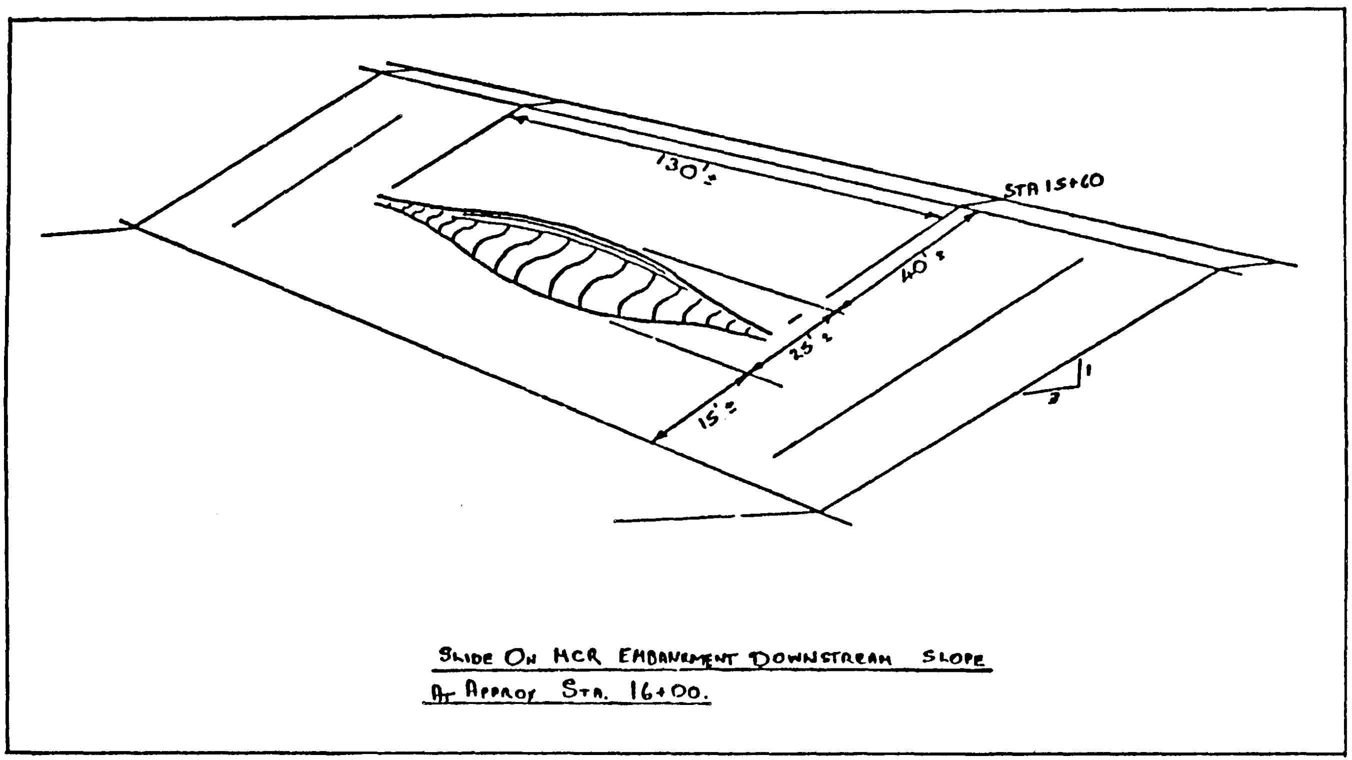


Figure 6 Surface slide
Source: HL&P

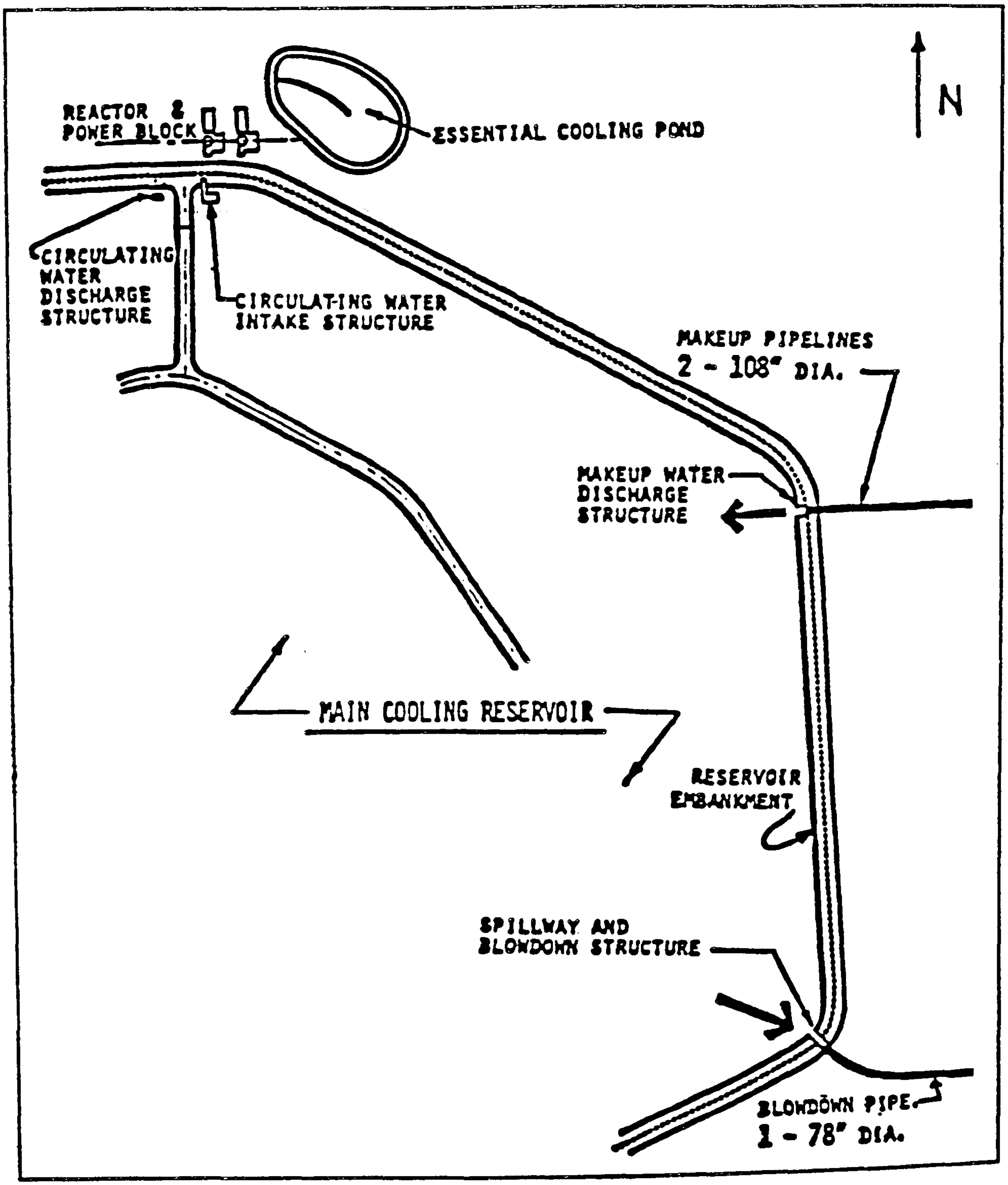


Figure 7 Penetration through the embankment
Source: Provided at meeting between NRC and applicant, Bethesda, Maryland, April 2, 1985

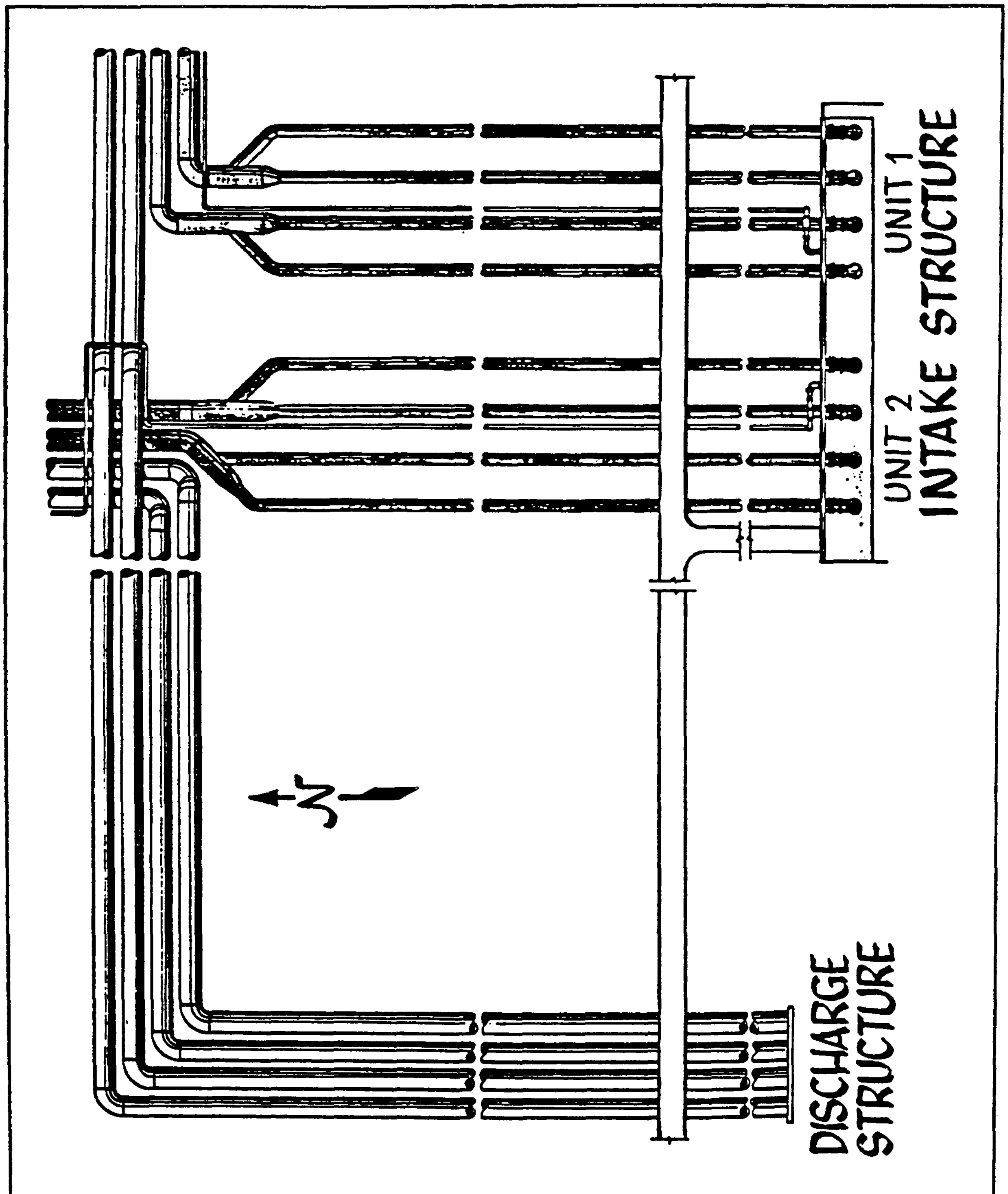


Figure 8 Circulating water intake and discharge structures
Source: Provided at meeting between NRC and applicant, Bethesda, Maryland, April 2, 1985

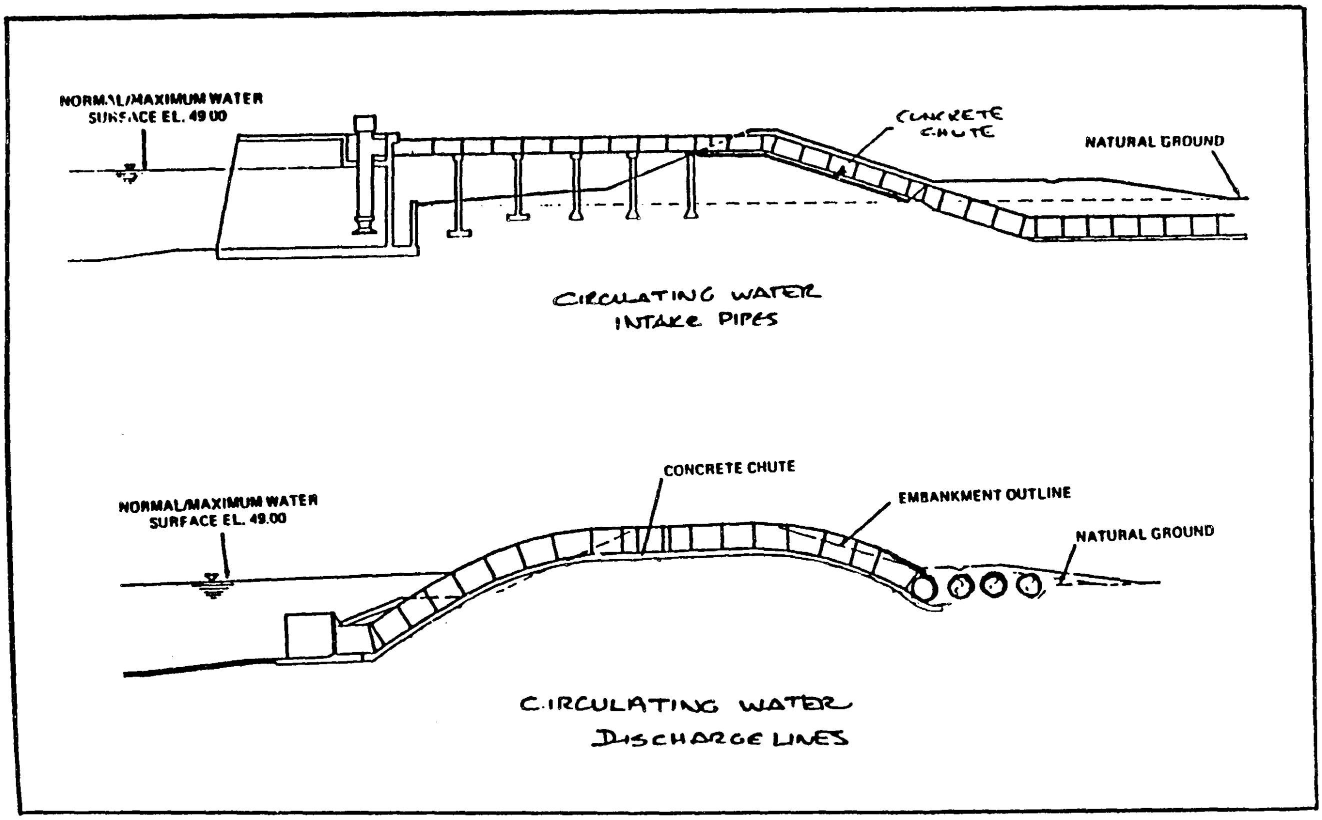


Figure 9 Circulating water intake and discharge pipes before modifications
Source: Provided at meeting between NRC and applicant, Bethesda, Maryland, April 2, 1985

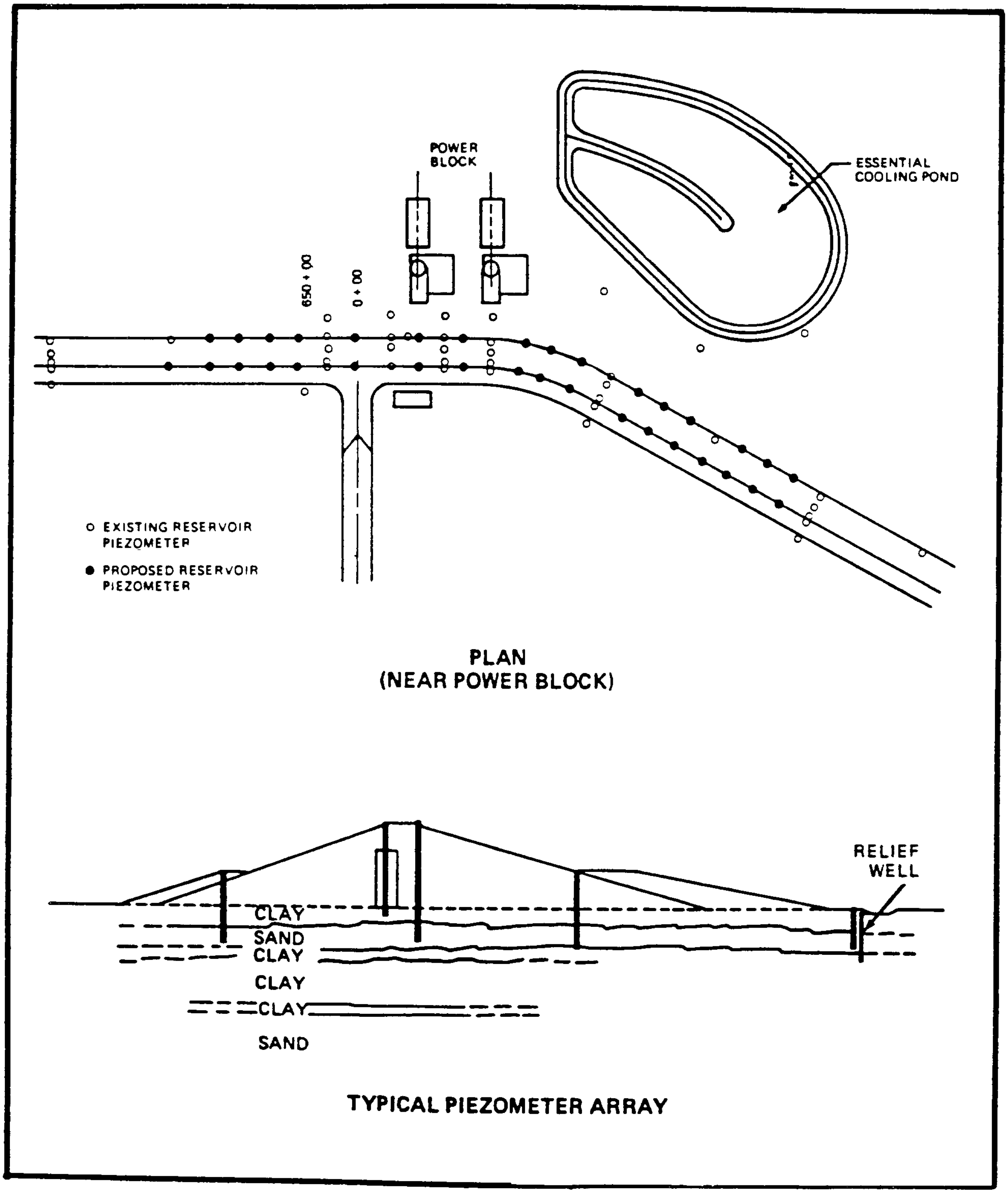


Figure 10 Instrument locations
Source: Provided at meeting between NRC and applicant, Bethesda, Maryland, April 2, 1985

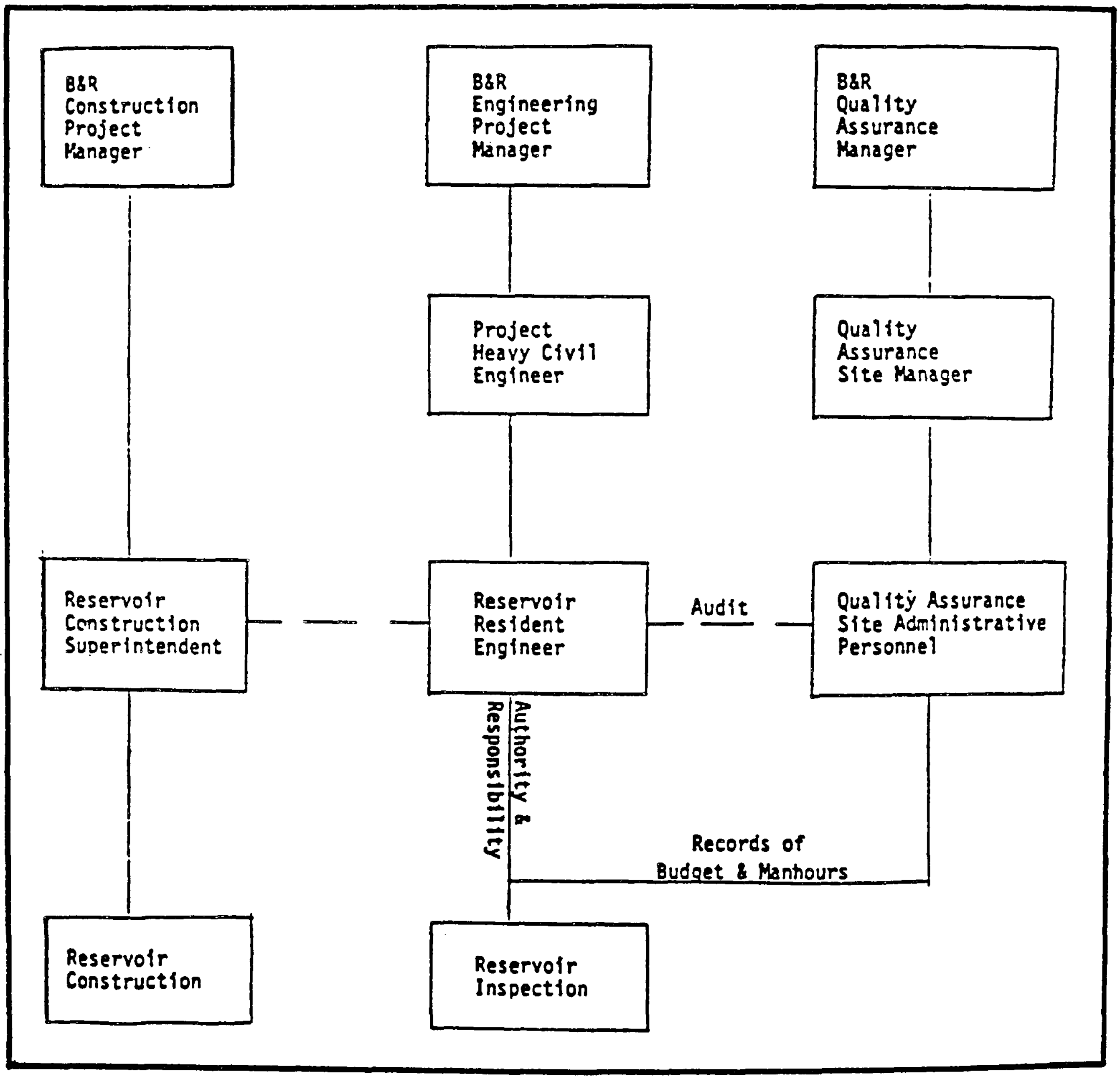


Figure 11 Basic project organization
Source: Provided during site visit on March 19, 1985

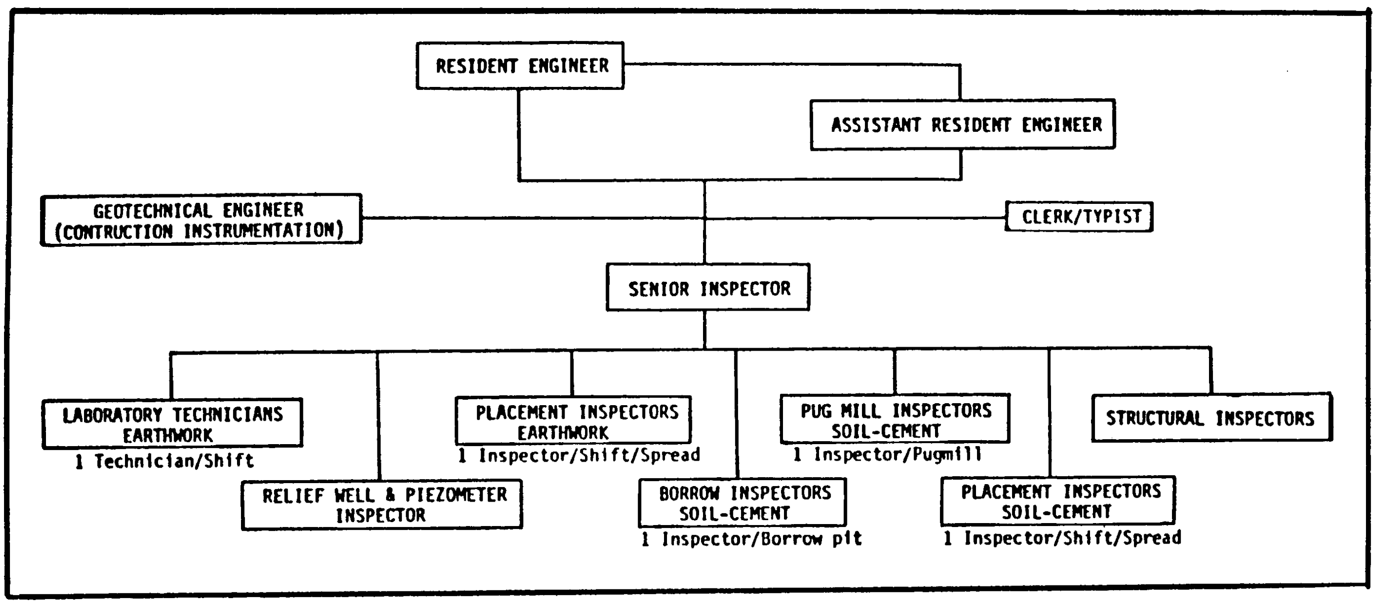


Figure 12 Reservoir inspection and testing organization
Source: Provided during site visit on March 19, 1985

SOUTH TEXAS PROJECT
COOLING RESERVOIR INSPECTION & TESTING

COPY NO.: [illegible]

0 2 1 0 7 1 7 1 4 9 0

FORM NO.: 15TR

EARTHWORK PLACEMENT INSPECTOR'S DAILY REPORT

NAME: Goza HOURS WORKED: 5:30-4:30 DATE: 8/24/76

CONSTRUCTION EQUIPMENT:

6 scrapers
8 D-8 dozers
4 sheepsfoot rollers
2 Hysters
3 cat rollers
3 disk plows
2 water trucks
7 light plants
4 maintainers

CONSTRUCTION ACTIVITIES:

Processed area 238 - 285 L ℄ and area 262 - 285

Placed fill area 244 - 250+50

TESTING EQUIPMENT: rings
torvane

TESTING & INSPECTION ACTIVITIES:

Tested areas 250 - 262 R ℄ and 238 - 250 L ℄

Inspected various Processing and Fill placing activities.

COMMENTS: Was informed by Don Deacon that fill placement was to be stoped untill area L ℄ at same stations was processed. Processing equiptment was brought in and processing done.

Attach all test results and all forms completed during day

Figure 13 Earthwork placement inspector's daily report
Source: Provided during site visit on March 19, 1985

FORM NO.: 15TR

SOUTH TEXAS PROJECT
COOLING RESERVOIR TESTING & INSPECTION
SUMMARY OF EARTHWORK COMPACTION TESTS

REPORT NO.: GN/31
PAGE 1 OF 1
DATE: 9-26-76

TEST NO.	LOCATION					MATERIAL DESCRIPTION	LL	PI	PROCTOR		FIELD TEST		% OF ASTM D-698	SHEAR STRENGTH (psf)	PASS/ FAIL
	ITEM	ZONE	STA.	OFFSET	ELEV.				MC	UDW	MC	UDW			
GN 0097	Embankment	B	34+00	20' Lt	27.0	Foundation	60	42	20.4	103.0	22.3	104.3	101.3	5000	PASS
GN 0098	Embankment	D	18+50	170 Lt	26.0	R & LCl, s/s	64	46	19.9	105.1	22.2	97.5	92.8	1650	FAIL
GN 0099	Embankment	D	24+75	175 Lt	25.5	Foundation	60	42	20.4	103.0	23.0	103.3	100.3	3000	PASS
GN 0098A	Embankment	D	18+00	170 Lt	26.0	R & LCl, s/s	64	46	19.9	105.1	24.4	102.7	97.7	4000	PASS

REMARKS: Test GN 0098 Failed due to low compaction. Retested GN 0098A after more compaction. This Test passed.

INSPECTOR: [signature]

ENGINEER: A R Stub[signature]

Figure 14 Field test results
Source: Provided during site visit on March 19, 1985

SOUTH TEXAS PROJECT
COOLING RESERVOIR INSPECTION & TESTING **COPY**
0 2 1 0 7 1 6 1 0 8 3

ABB

SENIOR INSPECTOR'S DAILY REPORT

NAME: [illegible] **HOURS WORKED:** 1700 – 0330 **DATE:** 5-23-24-78

NO. & TYPE OF INSPECTION PERSONNEL		CHANGES IN TESTING EQUIPMENT
Lab Technicians (Erthwk)	—	NONE
Placement Inspectors (Erthwk)	3	
Borrow Inspectors (S-C)	1	
Pug Mill Inspectors (S-C)	2	
Placement Inspectors (S-C)	2	
Structural Inspectors	—	
Relief Well & Piez. Inspector	—	

CONSTRUCTION ACTIVITIES:

PLACING & COMPACTING SOIL-CEMENT ON THE WEST EMB & THE E. DIKE.
PROCESSING, PLACING & COMPACTING FILL @ VARIOUS EMB. LOCATIONS BETWEEN 638± & 650± AND 35± 100±.
EXCAVATING SAND SOURCE 'A' & C.W. INTAKE CHANNEL.
STOCKPILING SAND CHIMNEY SAND @ EMB. STOCKPILE STA 630±.

TOTAL FILL PLACED (15000 cuyds) TOTAL S-C PLACED: 4900 cuyds)

COMMENTS:

AREA BETWEEN STA 35± & 55±, AFTER BEING PROCESSED WAS CHECKED FOR DRY MATERIAL THROUGHOUT THE LIFT. SUGGESTED TO CONSTRUCTOR HE TRY PRESOAKING THE NEXT AREA ON DAY SHIFT TO ELIMINATE THE EXTRA THICK DRY CRUST & PLACE A THINNER LIFT TO ENABLE FULL PENETRATION BY THE PROCESSING EQUIPMENT.

Attach all Inspector's and Technician's daily reports complete with all test reports

Figure 15 Senior inspector's daily report
Source: Provided during site visit on March 19, 1985

Brown & Root, Inc.
QUALITY ASSURANCE DEPARTMENT
SYSTEM INSPECTION REPORT

PROJECT: South Texas   JOB NO. 35-1197   UNIT: 1 & 2   PAGE 1 OF 1

SYSTEM:	DRAWING NO(s):	PLAN NO.	REV.	REPORT NO.
M.E.I. Surveillance	PO #35-1197-0113	YS1-1	1	8

LOCATION:	ITEM(s):	ITEM NO(s):
Cooling Reservoir	Subcontract Surveillance	300 Series

Date(s) of Inspection: 3/9/77

Type of Inspection: ☐ INITIAL ☐ IN PROCESS ☒ WITNESS TEST ☐ FINAL ☐ ______

No.	Inspection Characteristic	Sat.	Unsat.	N/A	Inspection Results
300	Performance				
	Test Methods and Procedures	X			
314					
		x			Observed field density driving test performed by M.E.I. technician R. Morley at approximately STA 244 on the reservoir embankment.

Supplemental Details

I was accompanied by R.A. Day on field trip to observe McClelland Engineers testing procedures of field density tests. Able only to observe one technician performing tests.

Personnel Contacted:	Next Inspection Due:	Inspected by:	DATE:
R.A. Day		[signature]	3/9/77
DISTRIBUTION		REVIEWED BY:	DATE: / /

1077100085

Figure 16 Brown & Root, Inc., Quality Assurance Department Report
Source: Provided during site visit on March 19, 1985

Organization B&R	Checklist No. C6.5- 001	Date(s) 10-15-79	Activity COOLING RESERVOIR CONSTRUCTION
Unit No. I & II	By [signature]	Code Explanation S=Satisfactory	N=Not Audited U=Unsatisfactory NA=Not Applicable

No.	Item Characteristic & Description	Code	Remarks
	INSPECTOR'S REPORTS		
1	The Senior Inspector's daily report is in order. (Y510HM034, Sec. 4.1.3)	S	
2	The Senior Inspector is keeping a diary of all construction, testing, inspection activities and pertinent QC discussions with the Constructor. (Y510HM034, Sec. 4.1.3)	S	
3	Tests by the Earthwork Placement Inspector reports in-place density, in-place moisture and in-place shear strength on Form 15TR. (Y510HM034, Sec. 4.1.5)	S	
4	The Relief Well and Piezometer Inspector submits a daily report on Form 08DR to the Senior Inspector at the end of each day. (Y510HM034, Sec. 4.1.10)	S	
	FILL MATERIAL		
5	The initial frequency of moisture content and field density testing is once every 2000 cubic yards but may be reduced to once every 5000 cubic yards as a sufficient level of confidence is established. (Y510HM034, Sec. 5.1.4)	S	
	GRAVEL ROADS		
6	The gradation of the base material and aggregate is tested as required by the Resident Engineer to ensure that it complies with specifications. (Y510HM034, Sec. 5.1.8.2)	S	
7	A one point Proctor is performed on the base material as required by the Resident Engineer and is recorded on Form 05TR. (Y510HM034, Sec. 5.1.8.2)	~~NA~~ S	RJS 10-15-79
8	The in-place density, moisture content and thickness of the compacted layer of base will be tested as required by the Resident Engineer and is recorded on Form 15TR. (Y510HM034, Sec. 5.1.8.2)	S	
	Obtained during site visit 3-19-85 Figure 2.5.6.21		

20 Approval Signature [signature] Rev. No. 0 Approval Date 9-26-79

Figure 17 HL&P surveillance personnel report
Source: Provided during site visit on March 19, 1985

Table 1 Stability analyses results--station 20+00

Case	Computed factor of safety
Steady seepage	
Upstream	1.82
Downstream	1.72
Rapid drawdown (elevation 49 to 39 feet)	1.50
Pseudostatic (seismic)	1.30

Table 2 Main cooling reservoir instrumentation--type, number, and frequency of monitoring

		Frequency of monitoring			
			After filling		
Type	Number	During filling	0-1 year	1-15 years	After 5 years
Benchmarks and settlement plates	75	Monthly	Bimonthly	Quarterly	Semiannually
Piezometers	230	Biweekly	Monthly	Bimonthly	Quarterly
Relief wells	669	Biweekly	Monthly	Bimonthly	Quarterly
Inclinometers	12	Biweekly	Monthly	Bimonthly	Quarterly

NRC FORM 335 (6-83)

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

1. REPORT NUMBER (Assigned by TIDC, add Vol. No., if any)
NUREG-0781

2. Leave blank

TITLE AND SUBTITLE
Safety Evaluation Report Related to Operation of the South Texas Project

4. RECIPIENT'S ACCESSION NUMBER

5. DATE REPORT COMPLETED
MONTH: APRIL YEAR: 1986

6. AUTHOR(S)

7. DATE REPORT ISSUED
MONTH: APRIL YEAR: 1986

8. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)
PWR Licensing-A
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

9. PROJECT/TASK/WORK UNIT NUMBER

10. FIN NUMBER

11. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)
Same as 8. above

12a. TYPE OF REPORT
Safety Evaluation Report

12b. PERIOD COVERED (Inclusive dates)
July 1978 - April 1986

13. SUPPLEMENTARY NOTES
Docket Nos. 50-498 and 50-499

14. ABSTRACT (200 words or less)

This report provides the results of the NRC staff review of Houston Lighting and Power Company's application for licenses to operate the South Texas Project. The facility consists of two pressurized water nuclear reactors located in Matagorda County, Texas. Subject to favorable resolution of the items discussed in the Safety Evaluation Report, the staff concludes that the facility can be operated by the applicant without endangering the health and safety of the public.

15a. KEY WORDS AND DOCUMENT ANALYSIS

15b. DESCRIPTORS

16. AVAILABILITY STATEMENT
UNLIMITED

17. SECURITY CLASSIFICATION (This report)
UNCLASSIFIED

18. NUMBER OF PAGES

19. SECURITY CLASSIFICATION (This page)
UNCLASSIFIED

20. PRICE
$

09/19/94 ST-AE-HL-93934 SOUTH TEXAS PROJECT, UNITS 1 AND 2 - SAFETY EVALUATION ON THE MAIN COOLING RESERVOIR AND ESSENTIAL COOLING POND PERFORMANCE DURING AND AFTER FILLING (TAC NOS. M86279 AND M86280)

September 19, 1994

Mr. William T. Cottle
Group Vice-President, Nuclear
Houston Lighting & Power Company
South Texas Project Electric
Generating Station
Post Office Box 289
Wadsworth, Texas 77483

Dear Mr. Cottle:

SUBJECT: SOUTH TEXAS PROJECT, UNITS 1 AND 2 - SAFETY EVALUATION ON THE MAIN COOLING RESERVOIR AND ESSENTIAL COOLING POND PERFORMANCE DURING AND AFTER FILLING (TAC NOS. M86279 AND M86280)

The NRC staff has completed its review of Houston Lighting & Power Company's (HL&P) submittals of February 22, 1993, October 1, 1993, March 28, 1994, and June 20, 1994, on the performance of the main cooling reservoir (MCR) and the essential cooling pond (ECP) at South Texas Project (STP). The submittals are in response to NRC's Safety Evaluation Report related to operation of STP, Supplement 2, Section 2.5.7, "Reevaluation of Completed Main Cooling Reservoir," and the NRC's requests for additional information.

Based on our review of the submittals, the staff concludes that the performance of the MCR and the ECP during and after the filling of the MCR to EL +45 ft mean sea level is generally satisfactory and that the MCR should provide a safe source of cooling water over the life of the plant if the current monitoring and inspection of the MCR are continued.

However, the seepage gradient values (3.8 percent, 4 percent, and 5 percent) at three locations of the MCR embankment are very close to HL&P's criterion value of 4 percent. HL&P is closely monitoring the seepage exits at the three areas. It is the judgment of the staff that there is no immediate safety concern at these locations. The staff agrees that HL&P should continue the close monitoring of seepage exists since one of the principle causes of catastrophic failures of embankments and dams is know to be 'piping' (the progressive erosion of the embankment material due to leaks developing under or through the dam) due to excessive seepage.

The staff requests that HL&P make the results of such monitoring available to the NRC staff for review at the site. The results should include quantity and quality (such as coloration, clear or muddy) of seepage water. The staff intends to inspect the MCR embankment and review the stability and seepage calculations pertaining to the MCR on a mutually convenient date. Our related safety evaluation is enclosed. this closes TAC Nos. M86279 and M86280.

Sincerely,

Thomas W. Alexion, Project Manager
Project Directorate IV-1
Division of Reactor Projects III/IV
Office of Nuclear Reactor Regulation

Docket Nos. 50-498
and 50-499

Enclosure: Safety Evaluation

cc w/enclosure: See next page

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATING TO PERFORMANCE OF MAIN COOLING RESERVOIR

AND ESSENTIAL COOLING POND

HOUSTON LIGHTING & POWER COMPANY

CITY PUBLIC SERVICE BOARD OF SAN ANTONIO

CENTRAL POWER AND LIGHT COMPANY

CITY OF AUSTIN, TEXAS

SOUTH TEXAS PROJECT UNITS 1 & 2

DOCKET NOS. 50-498 AND 50-499

1.0 BACKGROUND

On February 22, 1993, Houston Lighting & Power Company (HL&P) submitted a report on the performance of the main cooling reservoir (MCR) and the essential cooling pond (ECP) to meet the requirements of the STP Safety Evaluation Report (SER) Supplement 2, Section 2.5.7, dated January 1987, and the Updated Final Safety Analysis Report (UFSAR) Section 2.5.6.10 for the South Texas Project, Units 1 and 2 (STP). The ECP is used as a source of cooling water for safe shutdown of the plant and as the normal heat sink for plant auxiliaries. The ECP is normally supplied with water from MCR, but it also has an emergency backup from wells.

The operational level of the MCR was fixed at elevation (E1) +49 feet (ft) mean sea level (msl). Since the initial filling of the reservoir to the operational level, and the period immediately following the filling, are most critical to the stability and integrity of the MCR embankment, HL&P adopted a program of controlled reservoir filling. This program consisted of filling the reservoir in stages to final pool elevation, and monitoring the embankment instrumentation and visually observing the embankment performance during each incremental filling before proceeding to the next level. In September 1986, HL&P submitted a report prepared by its consultant, Harza Engineering Company, which evaluated the performance of the embankment underseepage control system during the filling of the reservoir to E1 +35 ft, and identified certain remedial work to be done to improve the safety of the MCR embankment at the operating pool level.

After reviewing HL&P's September 1986 report, the staff stated (SER Supplement 2) that the favorable evaluation of the MCR embankment was conditional on the completion of the remedial work and on the continued instrument monitoring before exceeding the pool elevation of 35 ft msl. On March 15, 1988, HL&P reported completion of the remedial work which consisted, among other things, of providing filters at critical locations of the embankment, and adding relief

wells in order to lower uplift pressures in certain reaches around the MCR where factors of safety against uplift were expected to drop below 1.5 at a pool elevation of +49 ft msl. Further, HL&P committed to provide to the NRC the results of the performance of MCR underseepage control system at El 49 ft. However, based on a study conducted in 1992 to optimize reservoir conditions with respect to safety, operability, etc., HL&P changed the testing requirements, by letter dated February 22, 1993, to evaluate the MCR performance at the current operating level of El 45 ft. msl. Since the maximum water storage capacity is not needed for current operations, HL&P currently has no plans to raise the operating level above El. 45 ft. HL&P further stated that it will reevaluate the MCR underseepage control system at a higher pool elevation if and when additional storage capacity is needed at a later date, or if the pool level is raised significantly by natural means.

The objective of this safety evaluation is to briefly describe the general features of the MCR and the ECP, and evaluate the performance of the MCR embankment during and after its filling to the current operating level of El 45 ft. msl, as reported in HL&P's February 22, 1993, submittal. Although the MCR is not a Category I structure, its north-side embankment is designed to withstand the effects of the safe shutdown earthquake (SSE), since the failure of this embankment would cause the design basis flood for all safety related structures. The staff's evaluation and acceptance of the integrity of the north-side MCR embankment to withstand the SSE loading conditions is documented in the original STP SER (NUREG-0781).

Therefore, the scope of this safety evaluation is limited to an examination of the MCR embankment performance during the normal filling of the reservoir to El 45 ft. msl.

2.0 EVALUATION

Main Cooling Reservoir

a. Description

The MCR is an above-ground reservoir covering about 7000 acres; its embankment is 65507 ft long with a crest elevation of about +66 ft msl which is about 40 to 50 ft above the ground surface elevation. The embankment consists of an interior slope of 2.5:1 and an exterior slop of 3:1, and is built of compacted clay, with a 10-ft wide sand core. The sand core extends the full length of the embankment centerline from ground surface to El +50 ft msl. As described in the STP UFSAR Section 2.5.6.4, the sand core will provide a granular interruption for any potential pinhole seepage paths in the upstream portion of the embankment which might develop due to the dispersive characteristics of the clay, thus sealing any potential 'pipes' or cavities as they are formed. The sand core has no drainage except at three isolated locations where horizontal sand drainage blankets intercepting the sand core were installed.

These horizontal drainage blankets intercept seepage resulting from high uplift pressures under the embankment. there is a berm at the exterior base of the embankment with a crest elevation of about +35 ft msl and a width of 33 ft to 48 ft. The berm provides additional slope stability and effectively increases the seepage path in the foundation soils.

As described in STP UFSAR Section 2.5.6.2.1, the foundation soils below the embankment consist predominantly of stiff to hard clays and medium-dense to dense sands. The soils up to a depth of 80 ft below the embankment can be divided into five generalized strata based on their properties, the top two strata and the fourth stratum consist of clayey soils, while the third and the last strata consist of pervious sandy soils. The third (pervious sand) stratum generally occurs between the depths of 8 and 42 ft below the embankment, while the last sand stratum occurs below 60 ft.

b. MCR Performance During Its First Filling

Following the previously described plan of incremental filling, HL&P raised the MCR level first to El +28 ft in November 1984, and then to El +35 ft in November 1985. At the latter pool elevation, sand boils were observed in the various drainage ditches around the MCR embankment, and in the Spillway Drainage channel. Sand boils were eliminated by placing suitable filter materials in the inverts of the ditches and the spillway channel. Additional details of the remedial work performed after filling to El +35 ft to control the hydrostatic uplift pressures are described by letter dated February 22, 1993. The MCR pool elevation was raised to El +40 ft msl between March and April 1988, and to El +45 ft between January 1989 and June 1990. On both occasions, additional sand boils were observed at the edge of several relief well pads. The affected splash pads were removed and filter material placed to eliminate the sand boils. After completing the filling of the MCR to El +45 ft msl, HL&P undertook an evaluation of the reservoir conditions at various operating levels, and decided to operate the reservoir at a pool elevation of 45 ft.

c. Settlement and Deformations

Regarding the general performance of the MCR, HL&P has reported satisfactory conditions related to the embankment settlement and deformations. The embankment construction was completed in 1979. The MCR is being inspected daily. No signs of unexpected total or differential settlement have been observed based on current surveys and observations. A survey that was started in 1989 indicated a settlement of only 1 inch to 2 inches through 1992.

Inclinometers were installed at four locations along the south side of the embankment (which is the highest section of the embankment). At each location, three inclinometers were installed to monitor

lateral movements of the inner slope, the outer slope and the crest of the embankment at those locations. The inside slope experienced less movement (about 1 inch) than the outside slop (about 2.5 inches), even though the former is steeper. This may be due to the fact that the soil-cement covering on the inside slope prevents significant changes of soil moisture. Three shallow slides on the outer slope were observed and these were promptly repaired. Except for these, inclinometer measurements and observations over the entire length of the embankment reveal no significant deformations. Erosion protection for the embankment is effectively provided by soil-cement on the inside slope and grass on the outside slope. HL&P has observed minor spalling and frequent lateral cracking of the soil-cement; however, it has observed no defects that would affect the function of the soil-cement.

d. Underseepage Control

During the MCR design phase, underseepage control was recognized as a major element. Two options were considered to control underseepage through the pervious soil strata (1) constructing a slurry trench to encircle the reservoir and effectively block the shallow aquifers under the embankment, and (2) installing relief wells to intercept seepage flow. HL&P chose the latter option as the most cost effective solution.

Piezometers

Underseepage at the MCR is being monitored by piezometers which are provided at critical locations (i.e., embankment crest, top of the outside berm, and the toe of the embankment, etc.) to measure the efficiency of the relief wells in controlling the uplift pressures. The piezometer data are given in Figures 1 through 69 in the February 22, 1993 letter. Figures 1 through 34 are traverses of 3 to 4 piezometers located at right angles to the embankment axis and at varying distances from the reservoir. Each of the 34 traverses includes a piezometer in the embankment sand core which is drained only in 3 locations. Where the sand core is drained, the piezometric levels in the sand core are relatively low, whereas at other locations the piezometric levels were recorded as being higher than the reservoir pool elevations during the MCR filling. HL&P could not identify the cause of the high water table in the sand core; however, it has reported that the water level in the sand core is stable and is not affected by changes in the reservoir pool elevation. Based on this fact, HL&P concludes that the existence of high water table in the sand core demonstrates the water retention capabilities of the upstream and downstream sides of the embankment. Furthermore, HL&P has reported in response to a staff question that the original stability analysis assumed a phreatic surface extending from the maximum design reservoir elevation of 49 ft to the top of the downstream berm which is at elevation 35 ft. Such stability analyses indicated acceptable

factors of safety against slope failure under such high phreatic levels (March 28, 1994, submittal). This response satisfies the staff's concern on this matter.

Relief Wells

Relief wells have been provided in the MCR embankment reaches where subsurface borings taken along the embankment centerline during the original design indicated the presence of sand layers at shallow depths below the embankment. The relief wells discharge into the Plant Area Drainage Ditch (PADD) along the north-east side of the reservoir, Relocated Little Robins Slough (RLRS) along the west side of the reservoir and into concrete-lined collector ditches along the east, south and north-west sides of the reservoir. Relief wells provide pressure relief as well as an engineered seepage exit, but intercept only a fraction of the seepage. A significant amount of seepage flows directly into the relief well drainage ditches. The critical locations for design of seepage and uplift control are the ditch inverts. The relief well flow rates are monitored to evaluate changes in flow that may indicate clogging of the well screen or changes in flow patterns.

Sand Drains and Seepage Filters

In addition to the relief wells, sand drains are installed in the bottom of the plant area drainage ditch (into which the relief wells discharge), and in the concrete-lined ditches on the east and south sides of the MCR. These drains are designed to lower the uplift pressures where the confining clay layer is relatively thin (5 ft or less). In order to prevent the formation of sand boils in addition to those noticed during filling, seepage filters consisting of either graded granular material or filter fabric have been installed in all ditches except in two short sections of the drainage ditch system. In these two sections no apparent seepage occurred due perhaps to thick surface clay layers.

Seepage Gradient

HL&P has computed hydraulic gradients under the MCR embankment from piezometer readings taken at 34 locations around the reservoir, and found them to vary generally between 1 percent and 2.5 percent. These seepage gradient values are lower than the licensee's criterion value of 4 percent set in 1986 by its consultant, Harza Engineering Company, based on its review of failures at other projects. However, HL&P first reported in its February 22, 1993 submittal that seepage gradients were as high as 8 percent at three locations. In response to a staff question on this matter, HL&P provided the following updated information: the seepage gradient calculated at one location between piezometer P38 which is closer to the embankment centerline and piezometer P40 beyond the toe of the berm is about 8 percent; however, the seepage gradient between

piezometer P39 which is located further downstream of the embankment (near the beginning of the berm) and piezometer P40 is only 3.8 percent. HL&P stated during a teleconference on June 13, 1994, that, at the other two locations where gradient values as high as 8 percent were originally reported, the actual gradients are only 4 percent and 5 percent (June 20, 1994, submittal). HL&P further stated that the higher gradient values previously reported at these two locations were typographical errors.

Thus, the seepage gradient values (3.8 percent, 4 percent, and 5 percent) at three locations of the MCR embankment are very close to, or slightly above, the licensee's criterion value of 4 percent. HL&P has stated that it is closely monitoring the seepage exits at these locations. it is the judgment of the staff that there is no immediate safety concern at these locations. The staff, however, recommends that HL&P maintain, and make available to the staff, for review at the site, the results of such monitoring, since one of the principal causes of catastrophic failures of embankments and dams is known to be 'piping' (the progressive erosion of the embankment material due to leaks developing under or through the dam) (see "Earth and Earth-Rock Dams-Engineering Problems of Design and Construction," J. L. Sherard, et al., 1963). The results should include the quantity and quality (such as the coloration, clear or muddy) of seepage water.

Uplift

Factors of safety (FS) against uplift across the top stratum in the drainage ditch inverts are reported to remain at 1.5 or above for the reservoir elevation of 45 ft msl. The value of 1.5 was established by HL&P's consultants in 1986 as an appropriate minimum FS for the MCR.

Essential Cooling Pond

a. Description

The ECP is an excavated pond covering about 46.5 acres at the normal operating pool elevation of +25.5 ft msl to +26.0 ft msl. the natural grade in the ECP area is at an approximate elevation of 26 ft msl. Water make-up is either from the MCR or from well water. MCR water was used for the initial filling of the ECP. The ECP embankment is designed to protect the pond from potential flooding caused by either the failure of the MCR embankment or that of dams on the Colorado river. The ECP embankment, with its crest elevation at +34 ft msl, is built with rolled clay with reinforced concrete erosion protection over the Category 1 portion of the ECP and soil-cement erosion protection over the remaining portion of the embankment. The embankment is separated from the pond by a 30-ft wide berm at El +26 ft msl. Within the ECP there is a centralized ("training") dike around which water circulates.

The crest elevation of this dike is +38 ft msl.

b. Seepage

Water required for the safe shutdown of the plant is maintained by keeping the water level in the ECP between 25.5 and 26.0 ft msl. Seepage from the ECP is minimal due to the low permeability of the natural soils and compacted clay backfill. A seepage rate of no more than 1.2 cubic feet per second (cfs) is specified in the ECP design criteria; actual ECP seepage losses are required to be measured once every five years to verify compliance with the design criteria. The measured seepage was 0.3 cfs in 1986 when the ECP seepage evaluation began. In 1990, a seepage evaluation, made by HL&P using a simplified water balance study, revealed a total water loss rate of 0.975 cfs. Since this total water loss rate was less than design seepage rate of 1.2 cfs, HL&P did not make separate estimates of the seepage and evaporation rates.

c. Settlement and Deformations

The ECP is inspected in accordance with Regulatory Guide (RG) 1.127, "Inspection of Water-Control Structures Associated with Nuclear Power Plants." The ECP embankment and training dikes are in good condition, except for minor (inconsequential) cracking in the soil-cement and reinforced concrete used for erosion protection. No significant settlement or deformations of either the embankment or training dikes is reported. Sediment accumulation in the ECP is measured annually to ensure that the required volume of water is available for safe shutdown of the plant. HL&P has reported that there has been no measurable accumulation of sediment in the ECP so far.

General

The response of the MCR during and after its filling to El +35 ft was studied in great detail by HL&P's architect & engineering firm, Bechtel Corporation, assisted by two geotechnical consultants who prepared detailed engineering evaluations of the MCR response in 1986 and proposed remedial measures that were implemented by HL&P. However, the MCR filling completion report submitted in February 1993 after filling the MCR to El +45 ft was not as extensive as the 1986 report. Also some of the submitted data has not been signed by HL&P's staff. However, HL&P assured the NRC staff that the data submitted to the NRC was reviewed by HL&P and approved by appropriate personnel. In this connection, the staff notes with satisfaction that a geotechnical engineer supervises the program of monitoring and inspection of both the reservoirs, and that the geotechnical engineer is supported by a reservoir inspector and a two-man survey crew to assist in monitoring reservoir instrumentation.

CONCLUSION

On the basis of a review of the licensee's February 22, 1993 submittal and the additional information provided with its submittals of October 1, 1993, March 28, 1994, and June 20, 1994, the staff concludes that the performance of the main cooling reservoir and the emergency cooling pond during and after the filling of the MCR to El +45 ft msl is generally satisfactory. The staff further concludes that the MCR should provide a safe source of cooling water over the life of the plant if the current monitoring and inspection of the MCR and the ECP are continued. HL&P has reported that the MCR is inspected daily and the ECP is inspected in accordance with Regulatory Guide 1.127.

Since the seepage gradient values (3.8 percent, 4 percent, and 5 percent) at three locations of the MCR embankment are very close to the licensee's criterion value of 4 percent, HL&P has stated that it is closely monitoring the seepage exits at these locations. It is the judgment of the staff that there is no immediate safety concern at these locations. The staff, however, recommends that HL&P continue the close monitoring of the seepage exits, and make available to the NRC staff for review at the site the results of such monitoring, since one of the principal causes of catastrophic failures of embankments and dams is known to be 'piping' (the progressive erosion of the embankment material due to leaks developing under or through the dam). Such reports should include the quantity and quality (such as the coloration, clear or muddy) of seepage water. The staff intends to inspect the MCR embankment and review the stability and seepage calculations pertaining to the MCR on a mutually convenient date.

Principal Contributor: R. Pichumani, ECGB

Date: September 19, 1994

03/15/88 ST-HL-AE-2572 MAIN COOLING RESERVOIR; COMPLETION OF REMEDIAL WORK

March 15, 1988
ST-HL-AE-2572
File No.: G9.18
G13.05

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

South Texas Project Electric Generating Station
Units 1 and 2
Docket Nos. STN 50-498, STN 50-499
Main Cooling Reservoir; Completion of Remedial Work

The Main Cooling Reservoir (MCR) remedial work referenced in the South Texas Project Safety Evaluation Report (SER), Supplements 2 and 4 was completed in February, 1988. The objective of the remedial work was to: 1) provide filters at seepage exits located in the Plant Area Drainage Ditch (PADD), Relocated Little Robins Slough (RLRS) and Spillway Discharge Channel (SDC); 2) add new relief wells in order to lower uplift pressures in reaches around the MCR where factors of safety were expected to drop below 1.5 at a pool elevation of +49 ft.; 3) raise the invert of the PADD and RLRS to design elevations and protect the ditch inverts from further erosion and 4) improve inspectability of all MCR collector ditches.

Based on our observations of the MCR and pertinent instrumentation data, it is our conclusion that the above stated objectives have been accomplished. Observations of the MCR and analysis of instrumentation will be intensified during the filling stages above a pool elevation of +35 ft. Any detected deviations in MCR response during filling will be analyzed and if required, filling suspended while required modifications are made.

The first increment of MCR filling started in March, 1988. The MCR will be filled to a pool elevation of +40 ft. and held at this elevation for an observation period of three months. Filling will again be interrupted at a pool elevation of +45 ft. for a second observational period prior to the final filling to +49 ft.

HL&P believes that the above information fulfills the requirements of the SER as it pertains to this item (SER Section 2.5.7). As requested by the NRC in SER Supplement 2, HL&P will provide the results of the performance of the MCR embankment underseepage control system at +49 ft.

If you should have any questions on this matter, please contact Mr. J. S. Phelps at (512) 972-7071.

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JSP/KRC/hg

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Revised 02/23/88

L4/NRC/ao

02/22/93 ST-HL-AE-4317 PERFORMANCE OF MAIN COOLING RESERVOIR AND ESSENTIAL COOLING POND DURING AND AFTER FILLING

February 22, 1993
ST-HL-AE-4317
File No.: G09.18
C13.05
10CFR50

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

South Texas Project Units 1 and 2
Docket Nos. STN 50-498, STN 50-499
Performance of Main Cooling Reservoir and Essential Cooling Pond During and After Filling

Reference: Correspondence from M. A. McBurnett (HL&P) to NRC Document Control Desk, dated March 15, 1988 (ST-HL-AE-2572)

Houston Lighting & Power Company (HL&P) submits the attached report describing the performance of the South Texas Project (STP) Main Cooling Reservoir (MCR) and Essential Cooling Pond (ECP) during and after filling. The report fulfills the requirements in the STP Safety Evaluation Report, Supplement 2, Section 2.5.7, and in the above reference for reporting the results of remedial work performed on the MCR, and the performance of the MCR embankment underseepage control system with the reservoir at elevation 49 feet mean sea level (MSL). The report also meets a commitment in UFSAR Section 2.5.6.10 that embankment performance history be available when the MCR and the ECP are filled.

The original plan was to test the MCR at the maximum design pool elevation at +49 feet MSL. Since the maximum water storage capacity is not needed for current operations, the testing requirements were changed to evaluate MCR performance at the current MCR operating level of +45 feet MSL. The MCR underseepage control system will be reevaluated at a higher pool elevation only if additional reservoir storage capacity is later determined to be required, or the pool level is raised significantly by natural means.

The MCR underseepage control system provides the design control of hydrostatic uplift pressures and provides engineered exits for seepage from the reservoir. The current inspection and monitoring program is designed to provide a periodic evaluation of this system for the life of the reservoir.

The MCR and ECP embankments are in good condition. Except for final repairs to two surficial slides on the MCR embankment, there are no outstanding modifications or service requests to improve or restore the embankments or training dikes.

If there are any questions, please contact either Mr. P. L. Walker at (512) 972-8392 or me at (512) 972-7138.

S. L. Rosen
Vice President,
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PLW/ag

Attachment: Main Cooling Reservoir and Essential Cooling Pond Performance During and After Filling

MISC\93-018.001

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Revised 02/03/92

MAIN COOLING RESERVOIR and ESSENTIAL COOLING POND PERFORMANCE DURING AND AFTER FILLING

HOUSTON LIGHTING & POWER COMPANY
DECEMBER 1992

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Tables and Figures

1.0 PURPOSE OF REPORT

The purpose of this report is to document the performance of the Main Cooling Reservoir (MCR) and the Essential Cooling Pond (ECP) after the initial filling of both reservoirs to their normal operating levels. This report contains a description of the reservoir monitoring organization, a description of the reservoirs, a summary of the filling operations, an evaluation of observations both during filling and after operating pool elevations were reached, and concluding remarks on the general condition of both reservoirs.

This report is intended to meet the requirements of the South Texas Project SER supplement 2 section 2.5.7, UFSAR section 2.5.6.10 and letter ST-HL-AE-2572, dated March 15, 1988. Although the referenced commitments describe the maximum pool level of +49 feet MSL as the completion criteria for the MCR, plans to test the reservoir at this level have been changed. There are currently no plans to raise the pool elevation above the +45 foot MSL operating level as discussed in section 4.1 of this report.

2.0 SITE ORGANIZATION FOR RESERVOIR MONITORING AND INSPECTION

In accordance with South Texas Project SER Supplement 4 Section 2.5.7 a geotechnical engineer supervises monitoring and inspection of both reservoirs. The geotechnical engineer is supported by a reservoir inspector and a two-man survey crew to assist in monitoring reservoir instrumentation.

The MCR is inspected daily. The ECP is inspected in accordance with Regulatory Guide (RG) 1.127. In addition, embankment and pertinent structure elevations, piezometer levels and relief well flows are measured and recorded as per SER Appendix J Table 1. Monitoring information is stored on a computer database. Reservoir monitoring data is periodically plotted and reviewed.

3.0 RESERVOIR DESCRIPTION

3.1 Main Cooling Reservoir

Site Geology: The near-surface soils at the South Texas Project site belong to the Beaumont formation which is the youngest Pleistocene deposit of the Quaternary coastal plain. The formation in the area of the MCR generally consist of discontinuous interfingering beds that grade laterally in short distances from clays to sands.

Reservoir Description: The MCR is an above-ground reservoir covering about 7000 acres. At the normal operating pool elevation of +45 feet MSL, the reservoir contains about 175,000 acre-feet of water.

Embankment and Training Dikes: The embankment forming the reservoir is 65,507 feet in length with a crest elevation of about +66 MSL feet which is 40 to 50 feet above the ground surface elevation. The interior embankment slope is 2.5:1 and the exterior slope is 3.0:1. The embankment is made of compacted clay with a sand core.

The 10-ft. wide sand core extends from the ground surface to elevation +50 feet MSL. The purpose of the sand core is to prevent piping through the embankment itself. The sand core will act as a filter for any material washed from the upstream half of the embankment. The sand core has no drainage except at isolated locations where a drained horizontal sand blanket intercepts the core. Horizontal sand drainage blankets were installed at three locations where the shallow aquifer does not extend to the relief well line. The sand drainage blankets are to intercept seepage resulting from high uplift pressures under the embankment.

There is a berm at the exterior base of the embankment with a crest elevation of about +35 feet MSL and a width of 33 ft. to 48 ft. The berm provides additional slope stability and effectively increases the seepage path in the foundation soils. An interior berm is present over most of the length of the embankment. The interior berm is 20 ft. wide and provides additional stability.

Erosion protection of the interior slope is a 2.5-ft. thick layer of soil-cement. Grass is used for erosion protection on the exterior embankment slope and berm.

Water circulation within the reservoir is controlled by a series of training dikes. The dikes have a crest elevation of +52 feet MSL with side slopes of 2.5:1 and 2.5 ft. thick layer of soil-cement for erosion protection.

Spillway: The MCR spillway is located in the south-east corner of the reservoir. Since the only uncontrolled filling of the reservoir is through precipitation, the spillway is relatively small. The spillway is a reinforced concrete structure consisting of an approach channel, four 9.5-ft. tall by 6-ft. wide sliding gates, a spillway chute with a top elevation of +40-foot MSL, a stilling basin, and a discharge channel leading to the Colorado River. Except for an accidental opening of one spillway gate, the spillway has not been used. The stilling basin and the spillway discharge channel have been modified as discussed below. Their basic functions remain unchanged.

Reservoir Blow-down: The blow-down entrance is built into the south wall of the spillway approach channel. The system consists of a gate with a +29-foot MSL base elevation and a 78-in. diameter pipe leading to seven 3-ft. diameter exit ports located south of the spillway discharge channel on the west bank of the Colorado River. The blow-down system allows circulation of reservoir water to prevent an excessive accumulation of a salt in a closed basin. The concentration of salts in the reservoir increased dramatically during the filling from +28 feet MSL to +35 feet MSL. At that time there were no restrictions on make-up water quality. Since then, strict water chemistry requirements have been imposed and the reservoir water quality has steadily improved. The blow-down system has not been used to-date. With a steady reservoir pool elevation, use of the blow-down system will be used to maintain water chemistry standards probably beginning in 1994.

Reservoir Make-up and Discharge Structure: The Reservoir Make-up Pumping Facility (RMPF) is located on the west bank of the Colorado River about one mile upstream from the spillway discharge channel exit. The pumping facility consists of a rotating filter screen structure, forebay and eight pump bays. The RMPF has four 240 cfs pumps and four 60 cfs pumps for a total capacity of 1200 cfs. Water is pumped to the reservoir through two 108-in. diameter pipes exiting at the reservoir discharge structure located at the north-east corner of the reservoir.

The reservoir make-up discharge structure is a reinforced concrete chute with energy dissipators and a submerged rip-rap lined channel.

Circulating Water Intake: The circulating water intake structure is built inside the reservoir embankment opposite the power block on the east side of the north-central training dike. The structure includes a rotating screen filter system and eight (four for each unit) 226,850 gpm pumps. Each pump is connected to a 96-in. diameter pipe. The pipes are supported on columns between the intake structure and the embankment. The 96-in diameter pipes converge into four 108-in. diameter pipes at the outside base of the embankment.

Circulating Water Discharge: The circulating water discharge structure is located just south-west of the power block and west of the north-central training dike. The system consists of four 108-in. diameter pipes leading to a siphon/energy dissipation structure and a rip-rap lined discharge channel.

Seepage Control: Seepage and excess hydrostatic pressure in near surface sand layers are partially controlled by relief wells surrounding the reservoir. The relief wells discharge into the Plant Area Drainage Ditch (PADD) along the north-east side of the reservoir, Relocated Little Robins Slough (RLRS) along the west side of the reservoir and into concrete-lined collector ditches along the east, south and north-west sides of the reservoir. Relief wells intercept only a fraction of the seepage. A significant amount of seepage flows directly into relief well drainage ditches that surround the reservoir. For this reason, most ditches have some type of filter lining to prevent sand boils from developing.

The effect of the reservoir on hydrostatic pressure in the near surface aquifers and the efficiency of the relief wells in controlling uplift pressures are measured with piezometers at locations around the reservoir. Piezometers are located at the embankment crest, at the top of the outside berm, along the toe of the embankment and along the crest of the relief well drainage ditches.

3.2 Essential Cooling Pond

<u>ECP Description:</u> The ECP is an excavated pond covering about 46.5 acres at the normal operating pool elevation of +25.5 feet MSL to +26.0 feet MSL. Natural grade in the area is about +25 feet. MSL. The pond is 8.5 to 9 feet deep depending on the pool elevation. When full, the ECP contains about 388 acre-feet of water. Water make-up is either from the MCR or well water. MCR water was used for the first filling. Replacement water is primarily well water to improve water quality. Excess water is pumped from the ECP into the MCR. There is no spillway.

<u>Embankment and Training Dikes:</u> Unlike the MCR, the ECP is an excavated reservoir. The perimeter embankment is designed to protect the bond from potential flooding caused by the failure of the MCR embankment or flooding due to the failure of dams on the Colorado River. The surrounding embankment is rolled clay with reinforced concrete erosion protection over the category 1 area of the ECP (south half) and a 1.25-ft. thick layer of soil-cement erosion protection over the remaining portion of the embankment. The embankment has a crest elevation of +34 feet MSL and interior and exterior side slopes of 3:1. The excavated portion of the pond has side slopes of 5:1 and soil-cement erosion protection. The embankment is separated from the pond by a 30-ft wide berm at elevation +26 feet MSL.

Water in the ECP circulates around a centralized training dike. The training dike has a crest elevation of +38 feet MSL. Erosion protection is reinforced concrete. The dike is separated from the pond by a 30-ft. wide berm at elevation +26 feet MSL. The dike side slopes are 3:1. The side slope of the excavated portion of the dike is 5:1. Soil-cement provides erosion protection on the dike berm and the excavated portion of the dike.

<u>Circulating Water Intake and Discharge Structure:</u> The circulating water intake structure includes a rotating screen filter system and six (three for each unit) pump bays. Water is pumped from the pond through 30-in. diameter pipes to the units. The discharge structure is simply a reinforced concrete funnel. Water is discharged above the pond level through six 30-in diameter pipelines.

<u>Seepage Control:</u> Seepage from the ECP is minimal due to the low permeability of the natural soils and compacted clay backfill. Any silty or sandy material encountered during construction was excavated to a depth of 2 feet below design grade and backfilled with compacted clay. Sandy soil was encountered over the east half of the bottom of the ECP excavation. The bottom was over-excavated 2 feet and filled to design grade with compacted clay.

<u>Design Assumptions:</u> A seepage rate of no more than 1.2 cfs is part of the design criteria for the ECP. Seepage in excess of this value along with anticipated evaporative losses

would deplete the water in the pond before cool-down of the units is complete under emergency conditions and assuming no makeup to the pond. Actual ECP seepage losses are measured once every five years to verify compliance with this design criteria.

In addition to the seepage criteria described above, the initial volume of water stored in the ECP is critical to the safe shutdown of the plant. The minimum ECP storage capacity is 95% of the design capacity. The required volume of water is maintained by keeping the water level between +25.5 and +26 feet MSL.

Sediment accumulating in the pond will also affect the water storage capacity. The ECP bottom elevation is measured annually to quantify sediment accumulation

4.0 FIRST TIME FILLING

4.1 Main Cooling Reservoir

Incremental Filling: The soil that supports the reservoir embankment has not been completely characterized. This is due to the extreme length of the embankment, the inability of soil borings to detect every detail of the stratigraphy, and the complex nature of the local geology. Since the foundation configuration is a critical part of the design of a water retaining structure, the incremental fill and observe approach was adopted for the first reservoir filling. Prior to filling the reservoir, the underseepage control system was constructed to handle all anticipated flow conditions under the embankment. Unexpected conditions observed during reservoir filling were corrected prior to initiating the next increment of filling.

+28 Foot Pool Elevation: Filling began in July, 1983 and stopped November, 1984 at a reservoir pool elevation of +28 feet MSL. The most significant modification at this pool elevation was the change in the circulating pipe penetrations through the embankment. The original design and construction was to bury the pipes in the embankment. However, leaks in the circulating pipes could have degraded the stability of the embankment through underground erosion and by locally elevating the water table. Therefore, instead of penetrating the embankment, the circulating water pipes are now exposed and run over the embankment in concrete saddles. Other work included relief well repairs and replacement.

+35 Foot Pool Elevation: Between August and November, 1985, the reservoir pool elevation was raised from +28 feet MSL to +35 feet MSL.

At this pool elevation, sand boils were noticed in the PADD, RLRS, the east side concrete drainage ditch, and the Spillway Discharge Channel. Sand boils were eliminated at the above locations by placing various types of filter materials in the ditch and spillway channel inverts. The filters consist of filter fabric in areas where little seepage is anticipated to graded granular filters where significant seepage is expected. Rock was placed over the filter materials to prevent erosion.

Chronic seepage into some areas of the embankment toe ditches was also observed. The toe ditches lie between the embankment and the relief well drainage ditches. To eliminate this surface seepage, the toe ditches on the north side east of the units, at the north east corner, and along the west side have been partially filled with sand. Some of the filled ditches have a perforated pipe drain located at the original bottom of the ditch. These ditches were intended to channel rainwater to lateral ditches leading to the PADD, RLRS or lead directly to the concrete collector ditch along the east side of the reservoir. At reaches where drainage is not required, the ditches were completely filled. In areas where drainage is required, enough of the ditch was left to accomplish the design function.

Where the natural clay layer in the relief well drainage ditch invert was thin (five feet or less), sand drains were installed to intercept seepage. These are 6-in. diameter holes drilled on 5-ft. centers through the clay and backfilled with poorly graded fine to coarse sand. Flow measurements taken in the PADD and the east and south concrete lined drainage ditches indicated a significant increase in seepage flow after installation of the sand drains.

Additional piezometers and relief wells were added as required to measure and control hydrostatic uplift pressures. To improve relief well performance, some of the new wells along RLRS were placed at the outside toe of the embankment and connected to a header pipe that drains into RLRS.

The elevations of the outfalls of all the relief wells surrounding the spillway stilling basin were originally constructed too high. Although these wells were designed to intercept seepage into the stilling basin, they never operated in their original configuration. The well connections to the outfall pipes were lowered to a level just above the level of the stilling basin pond and connected to a header pipe emptying into the stilling basin. These wells are now operating.

Hydrostatic pressures increased significantly between the reservoir and Kelly Lake with a corresponding increase in relief well flows in this area. The original relief wells were drilled next to the drainage ditch between the reservoir and Kelly Lake some 60 ft. away from the embankment toe. New relief wells were installed at the embankment toe. These wells intercept seepage closer to the source and more effectively reduce the uplift pressure.

<u>+40 Foot Pool Elevation:</u> Between March and April 1988, the reservoir pond level was raised to elevation +40 feet MSL. Additional sand boils were observed at the edge of some concrete relief well splash pads in RLRS and the PADD. The affected splash pads were removed and the filter application in the ditch was extended to cover the area.

<u>+45 Foot Pool Elevation:</u> From January 1989 through June 1990, the reservoir level was raised to +45 feet MSL. Additional sand boils were noted at the edge of several relief well pads in RLRS. As before, the pads were removed and filter material placed to eliminate the sand boils.

In 1991, the stilling basin was filled with sand to improve inspectability in this area.

Reservoir Operating Level: In order to optimize reservoir conditions with respect to safety, operability, and water chemistry, a study undertaken to evaluate reservoir conditions at various operating levels. Completed in 1992, the conclusion was to operate the reservoir at a pool elevation of +45 feet MSL. This will provide sufficient storage capacity to support operations through conditions of the drought of record, will not adversely impact water chemistry, and will provide and extra margin of safety by operating at a level below the maximum operating level of +49 feet MSL. There are currently no plans to raise the reservoir pool level +45 feet MSL.

4.2 Essential Cooling Pond

Construction on the ECP was formally completed in March, 1980 when the reservoir was inspected and cleared for filling. Prior to filling the pond, a second inspection of Civil/Structural features was completed in April, 1982. Since the reservoir was not filled to the operating level until August, 1985, a supplementary prefilling inspection was conducted in July, 1985. The first annual inspection after filling was conducted in July, 1986. Since the initial filling, the ECP has been inspected annually in accordance with RG 1.127.

5.0 RESERVOIR PERFORMANCE DURING AND AFTER FILLING

5.1 Main Cooling Reservoir

Embankment: A complete history of embankment settlement and consolidation of embankment materials has not been calculated. Although embankment elevations have been monitored since the beginning of construction, several different control points were used. Since there are no signs of unexpected total or differential settlement based on current surveys and observations, embankment elevation measurements have not been converted to a common datum. Currently, the survey control for the embankment level loop is the same control point used for monitoring other plant facilities. Use of this control points started in 1989. Embankment construction was completed in 1979. Measurements since 1989 indicate a slight settlement of 1 in. to 2 in. through 1992.

Embankment Deformation Measurements: Inclinometers were installed in the embankment at four locations along the south side of the reservoir. The south side of the reservoir was selected because it is the highest section of the embankment. There are three inclinometers at each location to evaluate lateral movements of the inner slope, the outer slope, and the crest of the embankment (figures 71 through 82). Inclinometer readings began in 1983. There is no record of embankment deformations between the end of construction in 1979 and the first inclinometer readings.

All of the inside slope inclinometers recorded surface movements of less than an inch in a northerly direction, toward the reservoir. The crest and outside slope inclinometers recorded surface movements up to 2.5 inches toward the south, away from the reservoir. The depth of significant disturbance, greater than half an inch, is confined to the upper 10 feet in all cases. Reversals in movement trends over the three years shown on the figures may be due to instrument damage by mowing equipment.

The greater movement on the outside slope is most likely due to seasonal moisture changes and corresponding changes in soil volume. The crest inclinometers are also affected by soil volume changes and, as expected, moved toward the slope with the greatest deformation. Although the inside slope is steeper than the outside slope, the inside slope experienced less movement probably because the soil-cement covering prevents significant changes in the soil moisture content. The soil-cement may also provide some structural support for the inside slope.

Embankment Slope Failures: Except for three incidents of shallow slides on the outer slope (embankment stations 16, 20, and 435), inclinometer measurements and observation over the entire embankment reveal no significant deformations. All three slides were repaired soon after they appeared. The slides are most likely a result of weakened surface soils caused by cyclic changes in moisture content and associated soil volume changes. As the soil dries, cracks are formed that inevitably fill to some extent with loose material. When the soil is rehydrated it expands and the cracks close. If the cracks are partially filled, the expanding soil block will move laterally creating a weakened zone at the base of the block.

Erosion Protection: The embankment is protected from erosion by soil-cement on the inside slope and grass on the outside slope. The training dikes are covered with soil-cement. The embankment and dike surfaces are inspected at least annually for signs of erosion.

The soil-cement has minor spalling and frequent lateral cracking. There have been no observed defects that affect the function of the soil-cement. There is currently no noticeable damage to the soil-cement as a result of wave action. Based on these observations, the soil-cement should provide erosion protection for the life of the plant without major repairs.

The grass on the embankment outer slope effectively protects the soil from erosion. The grass is mowed regularly to maintain inspectability, prevent large plants with deep root systems from becoming established and to eliminate shade that inhibits grass growth. The only problems encountered with grass are isolated incidents of wild pigs rooting on the embankment slope. These areas have been regraded and replanted. There is an ongoing trapping program to control the site pig population.

Underseepage Control: There are currently 428 reservoir piezometers used to evaluate the effect of the reservoir on adjacent near-surface permeable zones. The ground water level just outside the reservoir embankment is a function of the ground surface elevation, recent precipitation, proximity to the effective reservoir seepage entrance, and the reservoir pool elevation. Piezometer readings were used during the first reservoir filling to evaluate the effectiveness of the relief well system. At several locations, additional relief wells were installed to reduce hydrostatic pressures. Piezometers continue to be monitored to evaluate the performance of the relief wells and as an early indication of potential changes in seepage patterns.

Piezometer Levels: Piezometer data are displayed on figures 1 through 69. In addition to the piezometric levels, the reservoir pool elevation is plotted to show the changes in the water table compared with changes in the reservoir pool elevation. Figures 1 through 34 are traverses of three to four piezometers aligned at right angles to the embankment axis and at varying distances from the reservoir. As shown on the plots, the piezometric level fluctuates with the reservoir pool elevation to varying degrees depending on the distance from the piezometer to the reservoir.

In addition to piezometers in the shallow aquifer, each of the 34 traverses includes a piezometer in the embankment sand core. The sand core is only drained in three locations or only at about 10% of the length of the embankment. At the drained locations, the piezometric level in the sand core is relatively low. Where the sand core is undrained, piezometric levels above the reservoir pool elevation were recorded during reservoir filling. As shown on the plots, the water level in the sand core is stable and not affected by changes in the reservoir pool elevation.

Although the origin of the high water table in the sand core is not understood, its existence demonstrates the water retention capabilities of both the upstream and downstream sides of the embankment.

Figures 35 through 69 are plots of the piezometers at the crest of the relief well drainage ditches surrounding the reservoir. The water table near the drainage ditches is of particular interest because the ditches are often the closest seepage exits.

Relief Wells: There are 774 relief wells around the reservoir. Recent measured relief well flows are recorded on tables 1 through 34. The purpose of the relief wells is to lower uplift pressures and intercept seepage. The relief well flow rates vary from 0 gpm to 25 gpm depending on the local hydraulic gradient and the permeability of the aquifer. The flow rates are measured to evaluate changes in flow that indicate clogging of the well screen or changes in flow patterns.

Relief well flow rates have generally increased as the reservoir pool elevation increased. The relief wells adjacent to the plant are not flowing because the water table is just below the elevation of the well outflow pipe.

Sand Drains: In addition to the relief wells, sand drains have been installed in the ditch bottoms of the PADD, and the concrete-lined ditches on the east and south sides of the reservoir. The drains were installed where the clay layer was five feet thick or less. The drains are designed to lower uplift pressures where the confining clay layer was relatively thin and to intercept seepage. Measurements of ditch flow and relief well flow before and after installation of the sand drains indicate an increase in ditch flow and a decrease in relief well flow. Piezometric levels adjacent to the ditches also decreased.

Seepage Filters: Except for two short sections of the drainage ditch system at the northeast and northwest corners of the MCR, all ditches incorporate some form of filter blanket. The two sections of ditch that do not have any drainage protection are in areas with thick surface clay layers and no apparent seepage. The filters are either graded granular material or filter fabric. The filter application was necessary to prevent the formation of sand boils. Some sand boils still occur in high seepage flow areas either through filter defects or through gaps between the filter material and relief well splash pads. Sand boils in these areas have been eliminated with remedial measures such as increasing the thickness of filter materials or removal of the concrete splash pads.

Spillway and Stilling Basin: The spillway structure is in good condition. Recent modifications to the spillway system include filling the stilling basin with sand and adding a filter and erosion protection to a portion of the spillway discharge channel. The spillway discharge channel was an area of active sand boils. To eliminate this problem, the bottom and sides of the first 750 feet of the channel were over excavated, backfilled with sand, filter material, and a final layer of rip-rap. This modification eliminated the sand boils and provides erosion protection.

The spillway stilling basin is designed to dissipate the kinetic energy of water flowing down the spillway chute. The stilling basin is lined with a graded granular filter and rip-rap to protect the filter material from erosion. Since the water in the stilling basin was 14 feet deep, the effectiveness of the liner material could not be verified by inspection. Filling the stilling basin with sand increases the flow path from the reservoir to the exit point and allows access to the area by the reservoir inspector. Seepage of 75 gpm was recorded before filling the stilling basin with sand. Seepage of only a few gpm continues on both sides of the stilling basin.

The stilling basin still functions as an energy dissipator. During operation of the emergency spillway the sand filling the basin will be eroded down to the original rip-rap basin lining. Use of the spillway is not anticipated under the present reservoir operating plan.

Seepage Gradient: The seepage gradient was measured at 34 locations around the reservoir where there are three to four piezometers in a line normal to the embankment axis. The seepage gradient around the reservoir is generally between 1% to 2.5%. There are, however, three locations with seepage gradients as high as 8%. Sand and clay borrow pits within the confines of the embankment were not permitted within 800 feet of the embankment centerline. This restriction was to preserve the natural surface clay lining to the extent that lateral head loss from an exposed sand layer in the barrow area would equal the vertical head loss through the surface clay at the inside embankment toe. A permeable layer is probably exposed near the embankment at the three locations with high seepage gradients. The seepage exits at all three areas are monitored closely.

Uplift Pressures: Factors of safety against uplift pressures remain at or below 1.5 at a reservoir pool elevation of +45 feet MSL. In addition to the safety factor, the ditches where the safety factors are the lowest are provided with filters and sand drains.

Circulating Water Intake Structure: Settlement measurements on the intake structure began in 1977. To date, the structure has settled about 0.4 feet on the north side closest to the embankment and about 0.3 feet on the south side.

5.2 Essential Cooling Pond

Embankment and Training Dike: ECP settlement data was first collected in 1979. The survey monuments are located on the inside berm. Measurements to-date indicate a range from almost no movement to about 0.1 ft. of heave. The heave is probably a combination of expansion of the soil due to increased moisture content as a result of a localized high water table and stress relief due to the excavation of the ECP pond.

ECP Piezometers: The water table elevation around the ECP ranges from about +18 feet MSL to +24 feet MSL. The lower piezometric level closer to the plant is due to the relatively low water table in the category 1 backfill. The piezometer level history is shown on figure 70. Also plotted is the MCR pool elevation. There is a slight correlation with the fluctuation of the MCR reservoir level and ECP piezometer readings

Erosion Protection: The annual ECP inspections have revealed nothing that would affect or limit the performance of the ECP. Although, cracks in the soil-cement are common, none of the cracks impact the erosion protection function of the soil-cement. The reinforced concrete panels, especially the lower panels, have longitudinal cracks. These cracks are not open and do not affect the erosion protection provided by the reinforced concrete slab.

Seepage Evaluation: ECP seepage evaluation began in 1986. The first seepage measurement was a water balance study. Precipitation, evaporation, make-up, and blow-down quantities were measured. The remaining unaccountable change in volume was attributed to seepage. Measured seepage was 0.3 cubic feet/second (cfs). The design maximum seepage loss is 1.2 cfs.

Seepage measurements remain a continuing commitment. Every five years, a simplified water balance study is conducted. The simplified water balance includes measurements of precipitation and decline in reservoir pool elevation. Make-up and blow-down not permitted during the evaluation. Evaporative losses are conservatively attributed to seepage loss. The 1990 simplified seepage evaluation revealed a measured water loss rate of 0.975 cfs. Since the total water loss rate was less than design seepage rate, there is no need to separate seepage and evaporation rates.

Sediment Accumulation: The bottom elevation of the pond is measured annually along five traverses. The measurements are compared with the design elevations to determine the amount of sediment accumulation or scour. To date, there is no significant sedimentation or scour. The capacity of the ECP is essentially at the design value.

Circulating Water Intake and Discharge Structures: ECP intake structure movements through the first quarter of 1992 range from just over 0.3 inches on the north and west sides to a slight heave of about 0.1 inches on the south and east sides. This produces a tilt of about 0.4 of an inch. The allowable tilt is 0.75 inches.

The discharge structure has settled as much as 0.26 inches on the north and west sides and as little as 0.04 inches on the south side. The maximum tilt across the structure is 0.22 inches. The allowable tilt is again, 0.75 inches.

6.0 CONCLUSION

6.1 Main Cooling Reservoir:

Underseepage Control: During the MCR design phase, underseepage control was recognized as a major element. Two options were considered for controlling seepage and uplift forces. the first option was to construct a positive cutoff wall in the form of a slurry trench that would encircle the reservoir and effectively block the shallow aquifers under the embankment. The second option was to control underseepage by intercepting seepage flow with relief wells. Relief wells were selected as the most cost effective solution. The wells provide pressure relief as well as an engineered seepage exit. Inherent with the relief well approach in a complex geological setting is the need for inspections and modifications during first time filling and over the life of the reservoir.

Although at the end of the reservoir construction phase the relief well system was in place to handle expected seepage conditions at the maximum design reservoir pool level of +49 feet. MSL, significant modifications were required during filling to control unexpected sand boils and uplift pressures. The current good condition of the reservoir and underseepage system demonstrates the effectiveness of the inspection and modification program. The MCR should provide a safe reliable source of cooling water over the life of the plant with the continued use of the inspection program.

Embankment Adjacent to the Plant: Except for shallow embankment slides at stations 16 and 18, there have been no problems with the embankment or underseepage control system adjacent to the plant. This is most likely due to the concentrated attention to this reach of the embankment during the design phase, closely spaced relief wells, and the site grade generally slopes to the south making the reservoir about 8 feet deeper on the south side.

Appurtenant MCR Structures: The circulating water intake and discharge structures, the make-up water discharge structure and the spillway are all in good condition. The concrete structures exhibit some cracking, however, these cracks were noted in the preimpoundment report. There is no observable degradation of these facilities.

Reservoir Maintenance: Maintenance on the outside embankment, drainage ditches and the spillway discharge channel is consistent with operating and inspection requirements. The grass from the embankment crest to just past the outside edge of the reservoir drainage ditches is well maintained. All of the drainage ditches and the spillway discharge channel are routinely cleared of weeds to allow flow and inspection of the ditch bottoms.

Reservoir Operating Level: The plan to operate the reservoir at a pool elevation of +45 feet MSL is designed to provide optimum operational flexibility and safety. There are currently no plans to artificially raise the reservoir pool level above +45 feet MSL.

6.2 Essential Cooling Pond:

Embankment and Training Dikes: The embankment and training dikes are in good condition. Minor cracking in the soil-cement and reinforced concrete do not affect erosion protection. There is no significant settlement or deformations of either the embankment or training dikes.

Seepage Measurements: ECP seepage rates are measured every five years to verify design limits on the rate of water loss. The first seepage measurement separated seepage losses and evaporative losses. The results of that measurement was a seepage rate of 0.30 CFS. Subsequent simplified water balance studies attribute all water loss to seepage. The first simplified study was conducted in 1990. The measured water loss was 0.975 cfs. The simplified water balance method will be used to evaluate seepage losses as long as the total water loss is less than the design maximum seepage loss rate. If future measurements reveal a water loss greater than the maximum allowable seepage rate of 1.2 cfs, evaporative losses will be considered.

ECP Volume Change: Sediment accumulation is measured in the ECP annually. To date, there has been no measurable accumulation of sediment in the ECP. The current pond volume is essentially the original design volume.

Circulating Water Structures: The concrete on both the intake and discharge structures are in good condition. Measured settlement and heave of the structures are within allowable differential movements.

09/28/83 ST-HL-AE-1011 FIRST INTERIM REPORT CONCERNING THE DESIGN BASIS FLOOD FOR THE SOUTH TEXAS PROJECT

September 28, 1983
ST-HL-AE-1011
File Number: G12.162

Mr. John T. Collins
Regional Administrator, Region IV
Nuclear Regulatory Commission
611 Ryan Plaza Dr., Suite 1000
Arlington, Texas 76012

Dear Mr. Collins:

South Texas Project
Units 1 & 2
Docket Nos. STN 50-498, STN 50-499
First Interim Report Concerning the Design Basis Flood for the South Texas Project

On August 30, 1983, pursuant to 10CFR50.55(e), Houston Lighting & Power Company (HL&P) notified your office of an item concerning the Design Basis Flood (DBF) for the South Texas Project (STP). Attached is the first interim report concerning this item. The next report will be submitted to your office by January 20, 1984.

If you should have any questions concerning this item, please contact Mr. Michael E. Powell at (713) 877-3281.

Very truly yours,

G. W. Oprea, Jr.
Executive Vice President

MEP/mg
Attachment

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Revision Date 07-05-83

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<u>Interim Report Concerning The Design Basis Flood for the South Texas Project</u>

I. <u>Summary</u>

The DBF evaluation for STP, as documented in the FSAR, was open in accordance with Regulatory Guide 1.59, Rev. 0. This Regulatory Guide does not require consideration of the effects of erosion and scour resulting from the DBF event. Subsequently Regulatory Guide 1.59, Rev. 2 was issued which includes an endorsement of ANSI N170-1976 which requires consideration of the effects of erosion and scour.

The DBF event of concern is the non-mechanistic failure of the Main Cooling Reservoir (MCR) embankment and associated flooding of the STP Category I structures. Based on a preliminary report from BEC which indicated that the erosion and scour associated with this non-mechanistic embankment failure has the potential to affect the structural backfill supporting the foundations of STP Category I structures, HL&P notified USNRC Region IV that this item was "potentially" reportable pursuant to 10 CFR 50.55(e) on August 30,

1983. HL&P further informed Region IV that this item would be discussed with the NRR staff in Bethesda in order to clarify the NRC staff licensing position for STP.

II. Description of the Deficiency

On August 30, 1983, pursuant to 10CFR50.55(e), Houston Lighting & Power Company (HL&P) notified the NRC Region IV of an item concerning the DBF for the STP. Prior to the project transition phase, the previous Architect Engineer, Brown & Root Inc. (B&R), initiated Engineering Design Deficiency (EDD) Report No. 81-0698 identifying a concern relative to the potential of erosion of Category I structural backfill due to a postulated non-mechanistic breach of the MCR embankment. B&R made a preliminary judgement that structures would not be significantly affected. However, the evaluation was not completed prior to the termination of B&R activities on STP.

Evaluation of potential erosion effects of a postulated embankment breach was neither a licensing requirements nor the subject of NRC review at the Construction Permit (C.P.) stage. As a result, this consideration was not included in the design criteria for the STP. As required by R.G. 1.59 (Rev. 0), the FSAR addresses only the hydrostatic and hydrodynamic effects due to an assumed non-mechanistic embankment breach. Subsequently ANSI-N170 was issued (and referenced in Revision 2 of R.G. 1.59 dated August 1977) requiring the evaluation of scour and erosion effects associated with DBF events.

Bechtel has performed a preliminary evaluation of the postulated non-mechanistic embankment breach and the potential scour and erosion effects on safety-related structures and systems as part of the disposition of the B&R EDD. The evaluation did not assess the potential for an embankment failure to occur. Rather, it assumed the occurrence of an embankment breach of size and location that would cause case scour and erosion in the STP power block area.

The results of the preliminary evaluation indicated that it could not be conclusively demonstrated that certain safety-related structures (i.e. those on the near side of the power block to the MCR) would be unaffected by the scour and erosion effects of the postulated breach.

III. Corrective Action

In order to fully clarify the NRC licensing position for STP, HL&P has been in contact with the NRC Hydrology and Geotechnical Branch of NRR. Included in these informal discussions was the question of the appropriate design basis for flooding effects to be used by NRR in their continuing review of STP. As a result of these preliminary discussions, NRR has indicated that no detailed analysis of the degree of erosion and scour associated with the postulated non-mechanistic MCR embankment failure would be required if it could be demonstrated that the MCR embankment will not fail from any credible event. During these discussions it was assumed that the only credible failure modes would be overtopping due to a flood event, internal soil failure, or a seismic event.

The NRC indicated that an acceptably low risk of catastrophic failure of the MCR embankment can be shown if it can be demonstrated that 1) significant overtopping of the MCR embankment would not occur during any probable maximum flood event; 2) the MCR embankment facing the STP Category I structures is not susceptible to internal embankment failure; and 3) the MCR embankment facing the STP Category I structures would not fail in a Safe Shutdown Earthquake in combination with a 25 year recurrent MCR water level.

Based upon these early discussions, HL&P is preparing a plan of action to resolve these issues and is proposing to meet formally with the NRC-NRR in the near future to discuss our resolution.