National Dam Inspection Program

Phase I

Inspection Report for June 1979 MATILIJA DAM

Prepared for Department of the Army
The Corps of Engineers
Sacramento District

By State of California
The Resources Agency
Department of
Water Resources
Division of Safety
of Dams

Incl 1

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
650 CAPITOL MALL
SACRAMENTO, CALIFORNIA 95814

REPLY TO
ATTENTION OF

SPKED-D

17 August 1979

Mr. A. P. Stokes
Director of Public Works
and Engineering Manager
Ventura County Flood Control District
800 South Victoria Avenue
Ventura, CA 93309

Dear Mr. Stokes:

Inclosed is one copy of Phase I Investigation Report for Matilija Dam prepared for the Sacramento District, U. S. Army Corps of Engineers, by the State of California, Department of Water Resources, in accordance with the National Dam Inspection Act.

One copy of this report has also been sent to Governor Brown.

Under provisions of the Freedom of Information Act, these reports will be subject to release upon request after receipt by you or your representatives.

Under the National Dam Inspection Program the State is required to keep me informed of what actions are taken pursuant to the recommendations of this report. Your cooperation with the State will be greatly appreciated.

Sincerely,

PAUL F. KAVANAUGH
Colonel, CE
District Engineer

1 Incl
As stated

CF: w/o Incl
Mr. James J. Doody
Chief, Division of Safety of Dams
Dept of Water Resources, P.O. Box 388
Sacramento, CA 95802

National Dam
Inspection Program

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Report for

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NATIONAL PROGRAM FOR INSPECTION OF DAMS
PHASE I INSPECTION REPORT
FOR
MATILIJA DAM
VENTURA COUNTY, CALIFORNIA

AUTHORIZATION: The preparation of this report was authorized by the National Dam Inspection Act, Public Law 92-367.

BRIEF ASSESSMENT: This report has been reviewed by this office and I concur with your assessment that Matilija Dam appears to be safe. I also agree with recommendations for monitoring behavior of the dam.

This conclusion is based on information presented in the report which includes past investigations initiated by the owner as well as the investigations done for this report, and the maintenance done by the owner as a result of those investigations.

In light of the detailed stability and hydrologic studies performed, further in-depth studies and a Phase II-type report are not required.

APPROVAL: This report creates no liability on the United States, its officers or employees. The owner and operator continue to be solely responsible for all legal duties, obligations, or liabilities associated with the ownership or operation of the dam.

DATE: 30 July 79

PAUL F. KAVANAUGH
Colonel, CE
District Engineer

NATIONAL DAM INSPECTION PROGRAM
PHASE I REPORT
MATILIJA DAM

BRIEF ASSESSMENT

The Phase I investigation of Matilija Dam has been completed. The two primary conclusions of the investigation are that alkali-aggregate reaction is gradually destroying the dam and that the reservoir is gradually filling with erosional depositions from the drainage area.

The owner is aware of, and has evaluated and taken action as a result of these problems. The owner has employed the Bechtel Corporation and the International Engineering Company to evaluate the safety of the dam. In 1965 a 280-foot long by 30-foot deep section of the dam was removed as a result of concrete deterioration caused by reactive aggregate. Additional concrete also was removed in 1977-78 at the ends of the notch cut in 1965. As modified, the dam is safe for the near term future.

The principal recommendations of the report are that:

- the dam should continue to be kept under close observation to detect changes beyond the bounds of those anticipated when making the foregoing studies, and

- periodic testing of the concrete should be continued, including strength, petrographic and soniscopic tests at intervals of 5 years or less as recommended in the August 1967 Bechtel Corporation Report "Review of Matilija Dam."

Those recommendations have been provided to the owner. The owner also has been requested to repair the intake riser of the dam. The owner has filed and received approval from the California Division of Safety of Dams for replacement of the intake riser; construction is scheduled for the fall of 1979.

We do not recommend further investigation of the dam at this time.

ENGINEERING CERTIFICATION

This report has been prepared under my direction as the professional engineer in direct responsible charge of the work, in accordance with the provisions of the Professional Engineers' Act of the State of California.

JJ Doody

James J. Doody, Chief
Division of Safety of Dams
Registered C. E. No. 6500
Date: JUL 20 1979

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
Division of Safety of Dams

NATIONAL DAM INSPECTION PROGRAM

PHASE I REPORT

Dam	Matilija
State	California
County	Ventura
Stream	Matilija Creek
Tributary to	Ventura River
Owner	Ventura County Flood Control District

Report prepared under the direction of

James J. Doody
Division Chief
RCE 6500

Under the supervision of

R. E. Stephenson
Supervising Engineer
RCE 11334

by

J. Fred Chaimson
Senior Engineer
RCE 12393

TABLE OF CONTENTS

National Dam Inspection Program
Phase I Report

MATILIJA DAM

1. INTRODUCTION

1.1 Authority

This evaluation is made under the authority of the National Dam Inspection Act, Public Law 92-367, August 8, 1972 and the contract executed between the United States of America (represented by the Sacramento District, United States Army Corps of Engineers) and the State of California (represented by the Department of Water Resources).

1.2 Purpose

The purpose of a Phase I investigation is to identify dams which may pose hazards to human life and property and to recommend additional investigation when required.

1.3 Scope

The Phase I investigation is primarily a review of records and a systematic visual inspection. Records considered include, where available, the plans and specifications under which the dam was built, exploration, testing and design reports leading to that design, evaluations, and the studies and reports made by and in the files of the State of California, Department of Water Resources, Division of Safety of Dams.

2. DESCRIPTION OF PROJECT

2.1 Data Summary

a. General Data

Owner	Ventura County Flood Control District
Stream	Matilija Creek
Location	5 miles northwest of Ojai
Purpose	Water Conservation (See Section 2.2 i.)
Drainage Area	55 square-miles
Year Completed	1949

b. Reservoir Data

Normal Pool Elevation	1,095
Normal Storage	1,800 acre-feet (see Section 5.3h)

c. Main Dam

Type	Concrete Arch
Dam Crest Elevation	1,138 feet
Freeboard	27 feet[1]
Height	163 feet
Length of Crest	620 feet
Thickness at Crest	8.0 feet
Volume	47,825 cubic yards

d. Auxiliary Dams

None

[1]Distance from maximum design flood water surface to top of dam with spillway as notched in 1978.

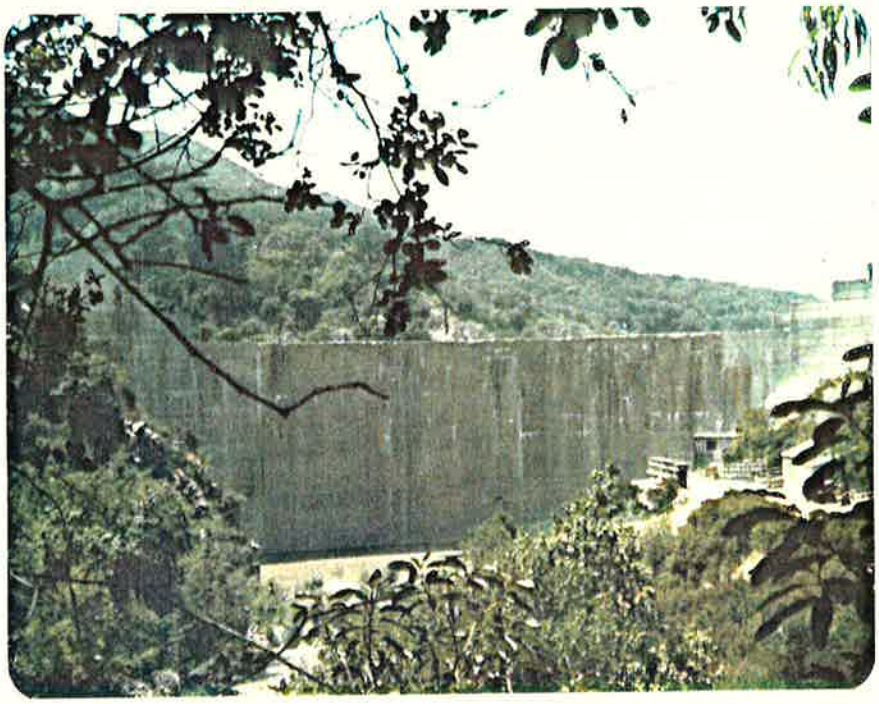
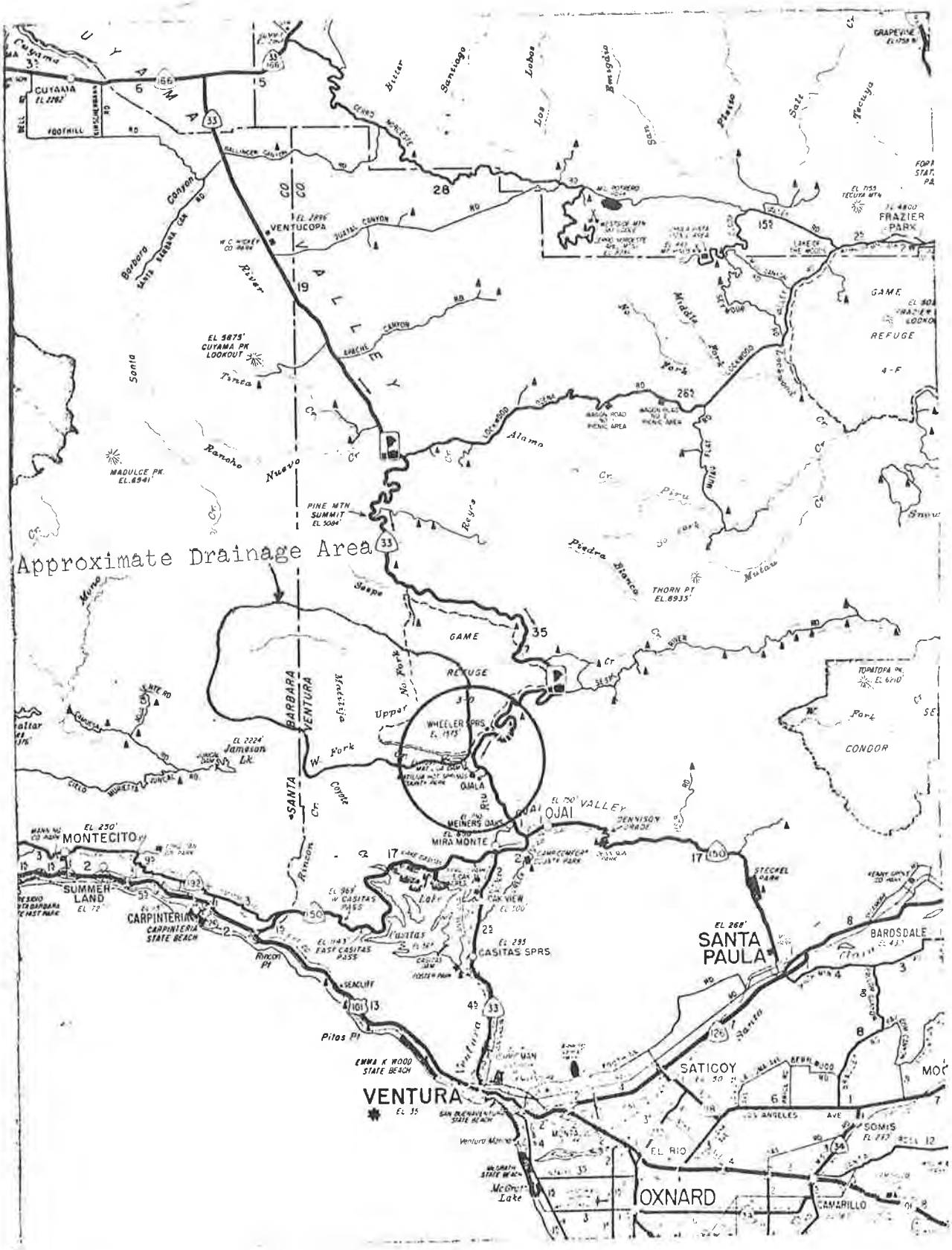


Photo No. 2.1
View from operator's house.

Photo No. 2.2
View from left abutment.

Location Map



VICINITY MAP
Basic Map Reproduced by Permission of California
State Automobile Association, Copywrite Owner

SCALE

d. Outlet Works

There is a 48-inch sluice at the crown of the arch at Elevation 1,000.8 which is presently planned to be abandoned. A 36-inch outlet pipe near the left abutment at Elevation 1,025 discharges directly into the main of the Casitas Municipal Water District. A 36-inch butterfly valve on this line provides blowoff directly to the stream. Under construction (in July 1978) is another outlet (42 inches) just above the 36-inch outlet at Elevation 1042.5. This is expected to provide about 630 cfs capacity when construction is complete, including a new outlet riser.

e. Spillway

The spillway is a 360 foot-wide notch cut in the dam at Elevation 1,095. It is estimated to discharge the Probable Maximum Flood peak of 76,108 cfs with 16.0 feet of head.

f. Size Classification

The dam, with a maximum height of 120 feet and storage capacity of 1,800 feet, is classified by size as large in accordance with Table 1, Attachment A, of the contract (Section I-1) Recommended Guidelines for Safety Inspection of Dams (Reference 1).

g. Hazard Classification

The hazard classification is rated as "high" based on the indicated inundation of numerous houses and several county road bridges in the vicinity of Meiners Oaks and Live Oak Acres.

h. Ownership

The dam is owned by the Ventura County Flood Control District, 597 East Main Street, Ventura, California. The dam is operated under contract for the benefit of the Casitas Municipal Water District.

i. Purpose

The purpose for constructing the dam was water conservation and flood control. Because of the small size of the reservoir it has negligible effect on large floods.

j. Operation Procedures

The following information is extracted from the Report "Matilija Dam, Reservoir Operation and Modification Cost Study April 1975" by the Ventura County Public Works Agency, Flood Control District, and Casitas Municipal Water District(CMWD) (see Reference 2).

"The operation criteria for Matilija Reservoir used in this study was developed by the CMWD and became effective on December 14, 1970. The reservoir is operated as follows:

1. On November 1 of each year, reduce reservoir level to the minimum pool of 533 acre-feet.

2. Store excess flows in Matilija only when discharge at diversion canal exceeds 520 cfs.

3. Release from Matilija such that flow in diversion canal is at least 50 cfs.

4. Draw reservoir to minimum pool of 533 acre-feet as soon as possible after storm.

5. On April 1 of each year, allow reservoir level to increase to around 1,000 acre-feet for emergency summertime storage."

k. Watershed

The drainage area is about 55-square-miles of steep, sparsely covered land comprising all of the drainage of Matilija Creek from about 0.4 mile above its confluence with the North Fork of Matilija Creek. The drainage rises from 1,095 foot elevation at the site to 6,003 feet at Monte Arido. The drainage is very fan-shaped, dividing into two major tributaries and numerous sub-tributaries.

l. Instrumentation and Monitoring

Installed instrumentation includes survey plates on the surface of the dam, six deformation meters in the abutments (Carlson meters attached to anchored pipes) and three measuring plates at the slip plane. The schedule of reading and submittal to the Division of Safety of Dams is shown on the following page:

Instrument	Reading	Submittal
Surface plates	Quarterly/ Semi-Annually	Quaterly/ Semi-Annually
Deformation meters	Weekly	Quaterly
Slip Plane plates	*	*

*The plates at the slip plane are submerged by the stilling basin pool. They are read occasionally to confirm or deny questionable readings of other instruments or other unusual circumstances.

The dam is attended daily as the operator lives on site. During high storage periods the outlet is frequently attended. The Division of Safety of Dams inspects the dam twice a year.

Drawings showing typical installed instrumentation are shown in Appendix 2. Some of these surface monuments have been removed or replaced since these drawings were made. The results of readings over the years are discussed in Section 3 General History.

3. GENERAL HISTORY

Matilija Dam was designed by the Donald R. Warren Company of Los Angeles in 1946. The design method was stated to be by use of "Fowler's Curves" (Fowler, E. H. "A Graphical Method for Determining the Stresses in Circular Arches by the Cain Formulas" Trans. ASCE Volume 92, 1928, p. 1512). Arch action alone is considered in this analysis, an adequate method for a thin arch dam of moderate height. Waterload and temperature drop were considered. A summary of the computations is included as Appendix 4. As computed, compressive stresses ranged as high as 1,043 psi; no tensile stresses were reported.

Independent analyses by the California Division of Water Resources was by Perkins' Method (Subsequently published as ASCE Paper No. 2559, Transactions, Vol. 118, 1953, p. 725). This method also only considers horizontal arch action and does include temperature drop. Approval of the State of California for this construction was conditioned upon two requirements:

1. After excavation the arches would be redesigned to a maximum stress of 800 psi, and

2. Shear stresses at the base would be minimized.

This second requirement virtually directed the use of the sliding joint in the base.

Difficulties were experienced during construction when unsound rock was discovered high on the left abutment. Construction was shut down by State order on April 23, 1947, while several eminent consultants studied the problem. Construction remained shut down until May 24, when further excavation was reviewed. Consultants for the State were Fred C. Herrmann, Engineer of San Francisco; Walter Huber, Engineer of San Francisco; and Chester Marliave, Geologist.

Dr. John Buwalda, Geologist, and William P. Creager, Engineer, consulted for the Warren Company. Charles P. Berkey, Geologist of Columbia University, and Thomas L. Bailey, Geologist, of Ventura, consulted for Ventura County. The dam was completed uneventfully.

By 1960 progressive upstream movement of monuments and cracking of the concrete was suggesting to observers that alkali-aggregate reaction was taking place. In 1964 the Supervisor, Safety of Dams, of the State of California, requested the owner to investigate the condition of the dam. The owner engaged the Bechtel Corporation for this investigation which resulted in the report "Review of Matilija Dam, February 1965" (Reference 2) which recommended the spillway be lowered and a program of inspection and monitoring be commenced.

8. Thermometers should be embedded in core holes.

9. Sonic testing of concrete should be done if core drilling indicated poor quality concrete.

The recommended concrete coring and testing was carried out and reported in "Matilija Dam Phase II Investigations", International Engineering Company, December 1975. Table 1 of this study "Laboratory Test Results" is reproduced in Appendix 6.

At the time of this writing (1978) there is a project in progress to remove the spillway bridge, to remove deteriorated concrete adjacent to the spillway notch cut in 1965 (above Elevation 1,095) and to put an additional outlet through the dam near the left abutment replacing the inoperable sluiceway. The removal of the deteriorated concrete further increases the spillway capacity of the dam.

4. ENGINEERING DATA

4.1 Geologic Conditions

a. Areal Geology

The dam is on the coastal flank of the Santa Ynez Mountains of the Transverse Range. The geologic structure is dominated by the overturned Matilija anticline, and bedding generally dips steeply to the northwest. Complex local folding and faulting is common in the area.

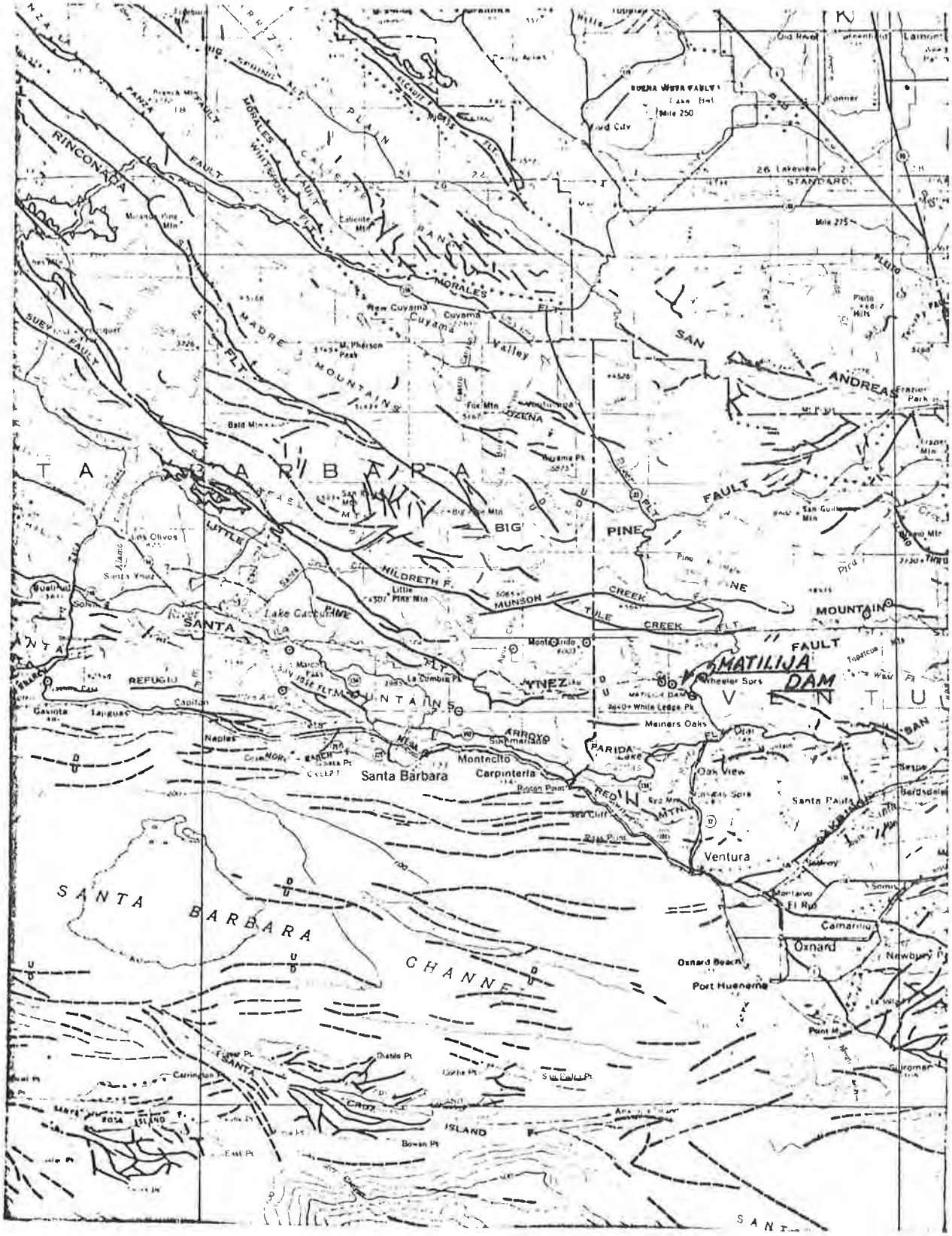
The Eocene Matilija formation underlies the dam. It is composed of comparatively massive sandstones interbedded with thin, closely fractured sandstone beds and weak shale beds. The shales are soft, closely fractured and subject to air slaking.

There are several major faults trending parallel or sub-parallel to the mountain range. The Santa Ynez fault, two miles north of the dam, is the closest. The San Andreas fault is about 25 miles to the north.

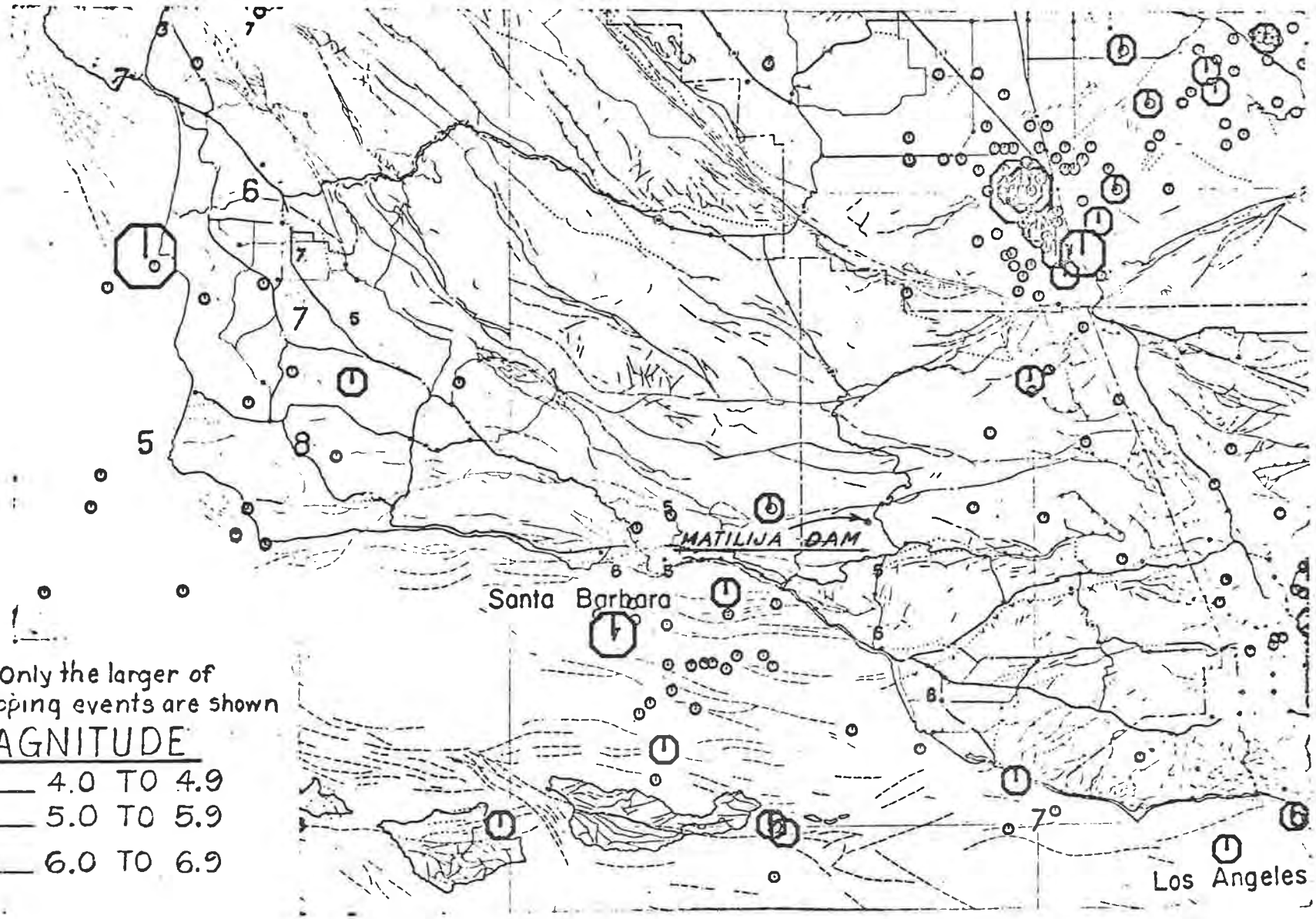
Maps showing faults and earthquake epicenters in the vicinity of the dam are shown on the following pages.

b. Regional Seismicity and Faulting

Fault	Santa Ynez	San Cayetano	Big Pine
Maximum Credible Richter Magnitude (M)	7.5	6.75	7.5
Distance from Dam (mi/km)	1½/2	5/8	13/21
Peak Bedrock Acceleration (g)	0.7	0.5	0.35
Duration Bracketed Strong Motion, ±0.05g (sec)	32	23	28
Predominant Period (sec)	0.37	0.27	0.37
Probable Sense of Motion	dip slip, reversed	dip slip, thrust	left lateral



MAP OF FAULTS IN THE VICINITY OF PROJECT
Scale 1:750,000
Reproduced from CDMG Fault Map of California 1975



NOTE: Only the larger of overlapping events are shown

MAGNITUDE

- 4.0 TO 4.9
- 5.0 TO 5.9
- 6.0 TO 6.9
- 7.0 TO 7.9
- 8.0 OR GREATER

INTEGER—MAX. REPORTED INTENSITY

MILES

30 20 10 0

EXCERPT OF 1900 TO 1974
EARTHQUAKE EPICENTER MAP OF CALIFORNIA
CDMG – OPEN FILE REPORT 76-4 SAC

The San Cayetano fault is considered to be a part of the Arroyo Parida-More Ranch line of faulting. (Fault Map of California, Jennings, 1975)

Tectonic deformation is possible, but the potential is low.

c. Foundation

Dam - The dam foundation consists of sandstone and shale interbedded. The upper right abutment is moderately fractured sandstone and contains a weak shale seam. The remainder of the sandstone foundation is crushed to very badly fractured, the shales are sheared. A fault zone of gouge and crushed sandstone up to 150 feet thick underlies the right channel area. The foundation rock is generally weak.

The foundation was grouted to consolidate the bedrock and reduce leakage.

Sulphur springs were observed in the dam foundation.

d. Spillway

The overpour, center of dam, and stilling basin foundation are protected by a concrete apron.

e. Data

Geologic logs, sections and plan by Thomas L. Bailey, are in Appendix 3.

4.2 Design

a. Structural

As discussed in Section 3.1 the dam was originally designed and checked by suitable methods which are satisfactory, if conservative, to this day. That is, the simplified assumptions generally neglect strengths which the dam possesses such as the cantilever action, effects of gravity, and the shorter inclined arches which actually act to resist loads.

b. Hydrology and Hydraulics

The Bechtel Report of 1965 found the then existing spillway to be inadequate to pass a Probable Maximum Flood (PMF). Based on some broad judgments (Reference 2, pg. 4-5) Bechtel estimated the peak of the PMF to be between 70,000 and 80,000 cfs. This flow is discharged with 18.7 feet of head on the spillway notch installed in 1966 (Reference 2, pg. 2-1).

Because of the broad judgments involved it was decided for the Phase I report to recompute a PMF based on HMR No. 36 (see Appendix 1). The Probable Maximum Flood was computed from the Probable Maximum Precipitation using basin characteristics derived from "Generalized Standard Project Rain Flood Criteria for Southern California Coastal Streams" publication of the Hydrologic Engineering Center, March 1967. The hydrograph was computed using USCE program L228 as modified for use on the Department of Water Resources' computer.

This flood is passed without routing through the spillway notch under construction in 1978 with a reservoir surface elevation of 1,111.0. The flood peak is 76,108 cfs, approximately as estimated by the Bechtel Company. Spillway capacity is computed by weir formula $Q = CLH\ 3/2$. "C" is assumed as 3.2 from Table 5-3 "Handbook of Hydraulics", King and Brater, Fifth Edition. This computation is contained in Appendix 1.

4.3 Construction

The construction history is available in detail in the records of the Division of Safety of Dams and is summarized in Section 3. Reference 2, page V-4 refers to 28-day cylinder breaks averaging in the range of 4,500 to 5,000 psi. Several examples of concrete cylinder break reports of concrete placed in August of 1947 are included in the files of the Division of Safety of Dams. These 6 tests, covering 2 days' placement, average 4,532 psi.

4.4 Operation

Readings of dam movement as indicated by surface monuments and deformation meters are received and evaluated quaterly in the Division of Safety of Dams. An example of a reading transmittal and evaluation are shown in Appendix 2. At the present time several meters are out of service. The readings are plotted as "Deformation Vs Time" with "Reservoir Level Vs Time" available for comparison.

The submitted plots are not suitable for reproduction but are available in the files of the Division of Safety of Dams for inspection. The dam continues to deflect upstream presumably related to the alkali aggregate reaction.

5. VISUAL INSPECTION

5.1 General

A field inspection of the dam, appurtenant structures, reservoir area, and downstream channel in the vicinity of the dam was conducted on July 6, 1978. Photographs were taken.

5.2 Participants

Mr. Alex Sheydayi, Engineer, Ventura County Flood Control District

Mr. Roger Stephenson, Supervising Engineer, Regional Field Engineer, Division of Safety of Dams

Mr. J. F. Chaimson, Senior Engineer, preparer, Phase I Report, Division of Safety of Dams

5.3 Conditions Noted

a. Dam

The dam continues to crack both along lift lines and subparallel to the boundaries of the spillway notch which was cut in 1965 and enlarged in 1978.

b. Reservoir Level

Water was in storage approximately 42 feet below the spillway crest.

c. Leakage

No leakage was visible above the stilling basin.

d. Stilling Basin

With the discharges to the stream of turbid water little of the stilling basin could be seen. However, a rib of natural rock could be seen across the streambed a short distance below the stilling basin, thereby assuring that the stilling basin has not been undermined.

e. Outlets

Leakage from the riser structure was being passed through the 36-inch valve and bypassed to the stream. The new 42-inch outlet was under construction at the time of the inspection. A subcontractor for this blasting was at work, setting off two small trimming blasts during the inspection. The hole for the outlet was open through to the riser from the downstream face but not trimmed out to full diameter.

In event of a power outage, the outlets can be operated either with emergency power or manually.

f. Outlet Riser

The temporary meter riser installed in 1970 was found to be damaged, apparently buckled inward during releases this past winter. Mr. Stephenson informed Mr. Sheydayi that the riser should be replaced this year. (Subsequently confirmed by letter July 12, 1978.)

g. Releases

A small release of the natural inflow (estimated 5 cfs) was being made to the stream at the center sluiceway. This was for the purpose of lowering the reservoir for work in progress at the outlet and stream release.

h. Reservoir Condition

At the reported storage level, it could be seen that the reservoir level was shallow up to a point approximately 50 feet from the dam. Mr. Sheydayi reported that about 900 acre-feet of sand and gravel was deposited in the reservoir during the winter of 1977-1978, leaving only about 1,800 acre-feet of storage. There are no slide areas which threaten displacement of significant amounts of the reservoir. There are numerous slide areas in the drainage which threaten continued deposition of erosional material.

i. Attendance

The operator's house located on the road about 1,000 feet downstream of the dam is occupied although he is not in full-time attendance at the dam.

j. Hazard Classification

Matilija Hot Springs County Park is located just downstream of the dam. State Highway 33 would obviously be obliterated at the junction to the North Fork by failure of the dam.

k. Warning System

Mr. Sheydayi explained that no special or automatic downstream warning systems are in service because outlet releases are small in comparison to stream capacity and spillway flows are only a small part of the total flow in the Ventura River because of the contributions of other tributaries.

5.4 Conclusions of Visual Inspection

a. The dam continues to deteriorate due to alkali-aggregate reaction within the concrete. The deterioration has not progressed to the point of invalidating the IECO studies.

b. The reservoir continues to be filled in by erosional deposits and may have a very limited useful life.

Photo No. 5.1
Dam and reservoir depositions.

Photo No. 5.2
Drainage area showing steepness and erosional areas.

Photo No. 5.3
Left side of arch. Note cracking at lift lines.

Photo No. 5.4
Center arch. Note crack pattern on lifts and between lifts.

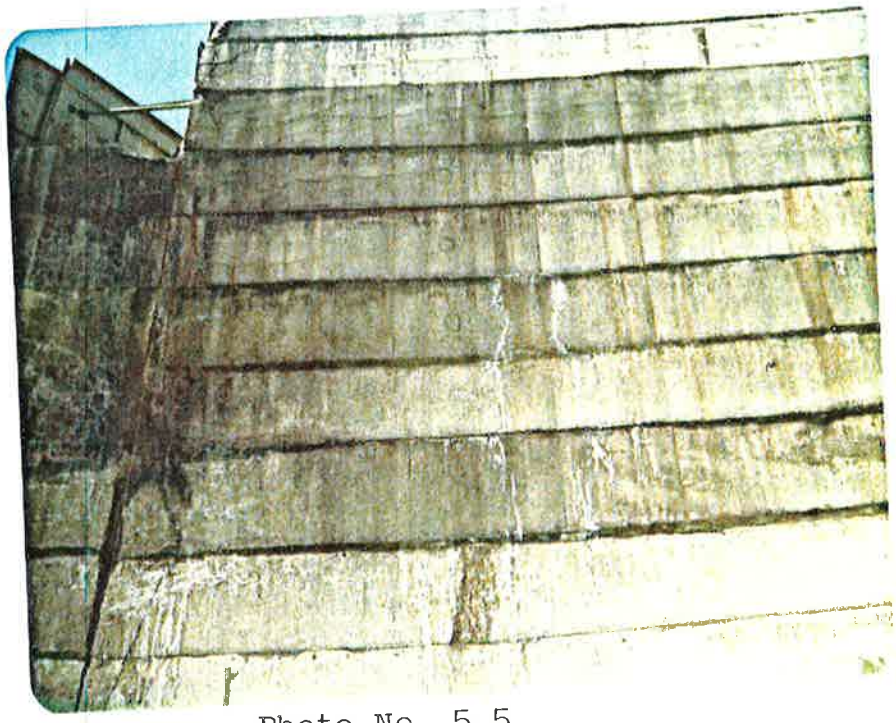


Photo No. 5.5
Downstream face above outlet. Note cracking adjacent to notch and large crack openings on lift joints.

Photo No. 5.6
Downstream face above and left of outlet. Note cracking.

Photo No. 5.7
New 42-inch outlet under construction.

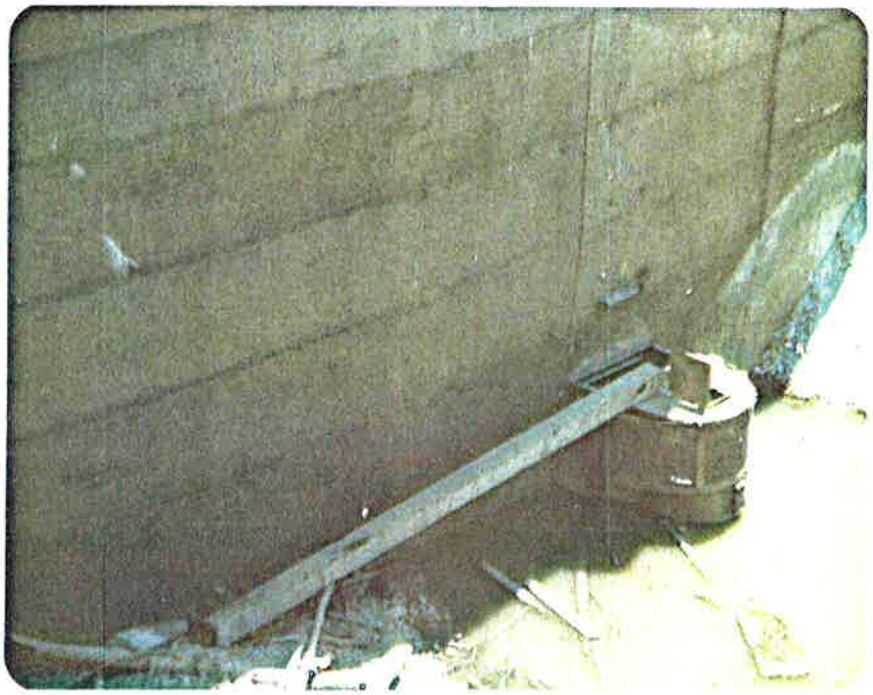


Photo No. 5.8
Outlet intake riser. Note damaged area.

6. CONCLUSIONS

The Flood Estimate and Spillway Analysis presented in Appendix I, shows that irrespective of the method of reservoir operation, the dam will safely pass the PMF with a freeboard of 27 feet.

Alkali-aggregate reaction is gradually destroying this dam. In the course of 30 years concrete strengths have been reduced from around 4,500 psi (Reference 2) to 3,445 psi in the upper 40 feet (Reference 5). The potential for continuing alkali-aggregate reaction in the entire dam has been shown to exist (Reference 5). Visual observations indicate continued cracking and expansion of cracked areas where confining pressures are relieved by remedial measures.

The deterioration of the dam is recognized by the owners and they retained IECO to evaluate the stress conditions of the dam using the latest analysis techniques (References 4 and 5). The conclusions of these analyses are that the dam is presently and for the near future, safe for use.

The reservoir is gradually filling with erosional depositions from the drainage area.

The owners also are cognizant of the siltation problem and have given it serious study. Prior to cutting the notch in the central portion of the dam in 1965, various alternatives were investigated including complete removal of the dam to Elevation 980.

In March 1974, the Ventura County Board of Supervisors authorized a study which considered both possible dam modifications and siltation. Six alternatives were investigated including destruction of the dam to Elevation 1040, four alternative operation schemes with various structural modifications, and complete clean-out of the reservoir debris deposited since 1948. A computer program was developed and used to predict storage lost to silt. The program predicted that the reservoir would not completely silt in until after the year 2000. The study concluded that a more economical alternative source of water is not available, and unless Matilija Dam is found to be unsafe, hazardous, or otherwise unfit for operation or storage of waters, its continued operation as a water conservation reservoir is in the best interests of the public (Reference 6).

7. RECOMMENDATIONS

1. The owners should continue the present program of close observation, both visually and instrumentally, to detect changes beyond the bounds of those used in the studies prepared by the International Engineering Company in August 1972 and December 1975, and the "Matilija Dam, Reservoir Operation Cost Study" of April 1975. (See References 4, 5, and 6).

2. Periodic testing of the concrete should be continued, including strength, petrographic and soniscopic tests at intervals of 5 years or less as recommended in the August 1967 Bechtel Corporation Report "Review of Matilija Dam." (See Reference 3).

3. To maintain outlet capacity the intake riser should be repaired. This has been requested of the owner. The owner has filed and received approval from the California Division of Safety of Dams for replacement of the intake riser; construction is scheduled for the fall of 1979.

4. No further investigation is recommended at this time.

8. REFERENCES

(1) "Recommended Guidelines for the Safety Inspection of Dams", Department of the Army, Office of the Chief of Engineers.

(2) "Review of Matilija Dam", Bechtel Corporation, February 1965.

(3) "Review of Matilija Dam", Bechtel Corporation, August 1967.

(4) "Matilija Dam, Stress Investigations", International Engineering Company (IECO), Autust 1972.

(5) "Matilija Dam, Phase II Investigation", IECO, December 1975.

(6) "Matilija Dam, Reservoir Operation and Modification Cost Study", Ventura County Flood Control District, Casitas Municipal Water District, April 1975.

9. APPENDIXES

(1) Flood Estimate and Spillway Analysis for Matilija Dam, J. F. Chaimson, June 1978.

(2) Movement Records and Instrumentation Installation.

(3) Geology Logs.

(4) Design Summary by Donald R. Warren Company.

(5) Drawings.

(6) Concrete Test Reports.

APPENDIX 1

Flood Estimate and Spillway Analysis for Matilija Dam, J. F. Chaimson, June 1978

1. Dave Wong
2. File

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
Division of Safety of Dams

FLOOD ESTIMATE AND SPILLWAY ANALYSIS

Name of Dam MATILIJA Type of Dam CONCRETE ARCH Dam No. 86

County VENTURA Hazard Class IV Total Class Wt. 32

Located on MATILIJA CK Tributary to VENTURA RIVER

I. DRAINAGE BASIN

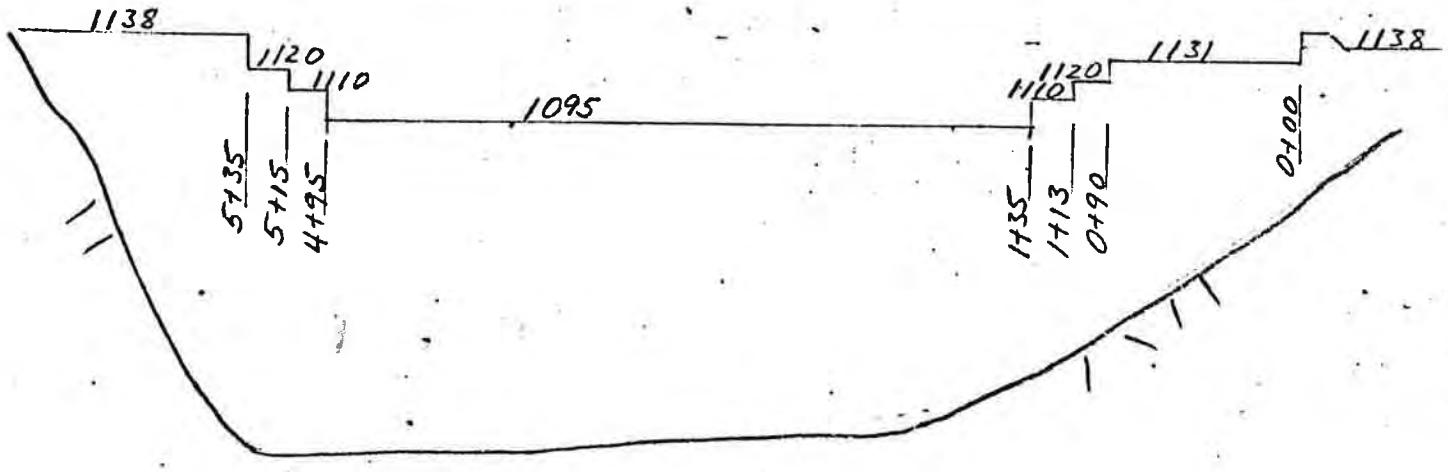
1.	Drainage Area - Sq. Mi.	55
2.	Impaired?	NO
3.	Mean Elevation	3500'
4.	Mean Latitude	34°32.5'
5.	Mean Longitude	119° 24'
6.	Annual Precip. - In.	31
7.	Elevation Index	N/A *
8.	Cover Factor, C	N/A *

II. DAM AND RESERVOIR

1.	Reservoir Area @ S/W-Ac	86 ①
2.	Res. Capac. to S/W-AF	1800 ②
3.	Surcharge Storage - AF	NOT DETERMINED ③
4.	Spillway Crest Elev.	1095'
5.	Dam Crest Elevation	1138'
6.	Total Freeboard	43'
7.	Max. Storage Level	1095'
8.	Gated?	NO
9.	Spillway Rating Q =	$C L H^{3/2}$

① PER 1948 TOPO ② PER 1978 ESTIMATE ③ UPPER PARTS WILL NOT SUPPORT FULL WATER LOAD

Sketch of Spillway, as per V.Co.F.C.D. Sh 2/13 Proj 4651 Date 8-2-77



Calculated by J.F. Chaimsm Date Oct '78 / Nov Approved by _____ Date _____
Project Engineer

DWR 852 (Rev. 3/77)

III. FLOOD HYDROLOGY

1.	Flood Type	HMR36-PMP				
2.	Storm Precip.-In.	62.22				
3a.	Precip. Dur.-Hr.	72				
b.	K(J) Std. Dev.	—				
c.	Risk Level					
4.	Peak Inflow-cfs	76,108				
5.	Peak Inflow-csm	1384				
6.	Runoff - AF	138,219				
7.	Runoff - In.	47.12				
8.	Runoff Coeff.	76%				
9.	Div. Inflow-cfs	No				
10.	Routed?	No				
11.	Peak Outflow-cfs	—				
12.	Peak Outflow-csm	—				
13.	Resid. Freeboard	27.0'				
14.	Max. Res. Stage	1111.0'				
15.	Max.Spill.Cap.-cfs	Not Comp. see note (3)				
16.	Max.Spill.Cap.-csm	—				
17.	TC - Hr.	1.87 *				
18.	R/TC	0.8 *				
19a.	BASEL	0.80 *				
b.	Loss Rate					
20.	Check Adopted Flood					

REMARKS: * Basin characteristics from "Generalized S.P. Rainflood Criteria, So Cal Coastal Streams" HEC. March 1967

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
Division of Safety of Dams

HAZARD CLASSIFICATION FOR FLOOD ESTIMATE AND SPILLWAY ANALYSIS

Name of Dam MATILIJA Type of Dam CONC ARCH Dam No. 86

County VENTURA Located on MATILIJA CK

Hazard Class

		Extreme	High	Moderate	Low
Capacity 1800 A.F. (circle weight)		100,000 & Over 6	1,000-99,999 (4)	100-999 2	15-99 0
Height 133 Ft. (circle weight)		150 & Over 6	100-149 (4)	50-99 2	6-49 0
Estimated Evacuation ____ (circle weight)		1,000 & Over (12)	100-999 8	1-99 4	None 0
Potential D/S Damage (circle weight)		High (12)	Moderate 8	Low 4	None 0
Weight-Range	0-6 7-18 19-30 31-36		Total Class Weight		32
Class	I II III IV		Class		IV

DWR 3365 (Rev. 3/77)

Project MATILIJA DAM NO 86 Sheet

Feature HYDROLOGY Designed JFC Date 5-30-78

Item BASIN CHARACTERISTICS Checked Date

FROM "GENERALIZED S.P.R.F. CRITERIA FOR SO. CAL. COASTAL STREAMS"

H.E.C. MARCH 1967

$T.C. = a(D.A. \times L.C.)^{.25}$

$= 0.4(55.0 \times 8.7)^{.25}$ $a = 0.4$ from Ch 6

$= 1.87$ hrs

$R/TC = .8$ (generalized in study)

$R = 1.50$

Project Matilija Dam No 86 Sheet

Feature Hydrology Designed JFC Date 5-30-78

Item HMR 36 - PMP Checked Date REVISED NOV 1978

Longitude 119° 24'

Latitude 34° 32.5'

1. Orographic PMP Index 6hr-Jan -10"
2. Basin width 10.6 mi
3. Adjustment factor -100%.
4. 6Hr increments orographic PMP x%
   table 5-5 p85 Coast Range

6Hr	1	2	3	4	5	6	7	8	9	10	11	12
%	100	78	63	52	44	37	31	26	22	18	14	11
in	10.00	7.80	6.30	5.20	4.40	3.70	3.10	2.60	2.20	1.80	1.40	1.10

From fig 4-12 6 hr convergence PMP = 3.0"
From fig 4-13b

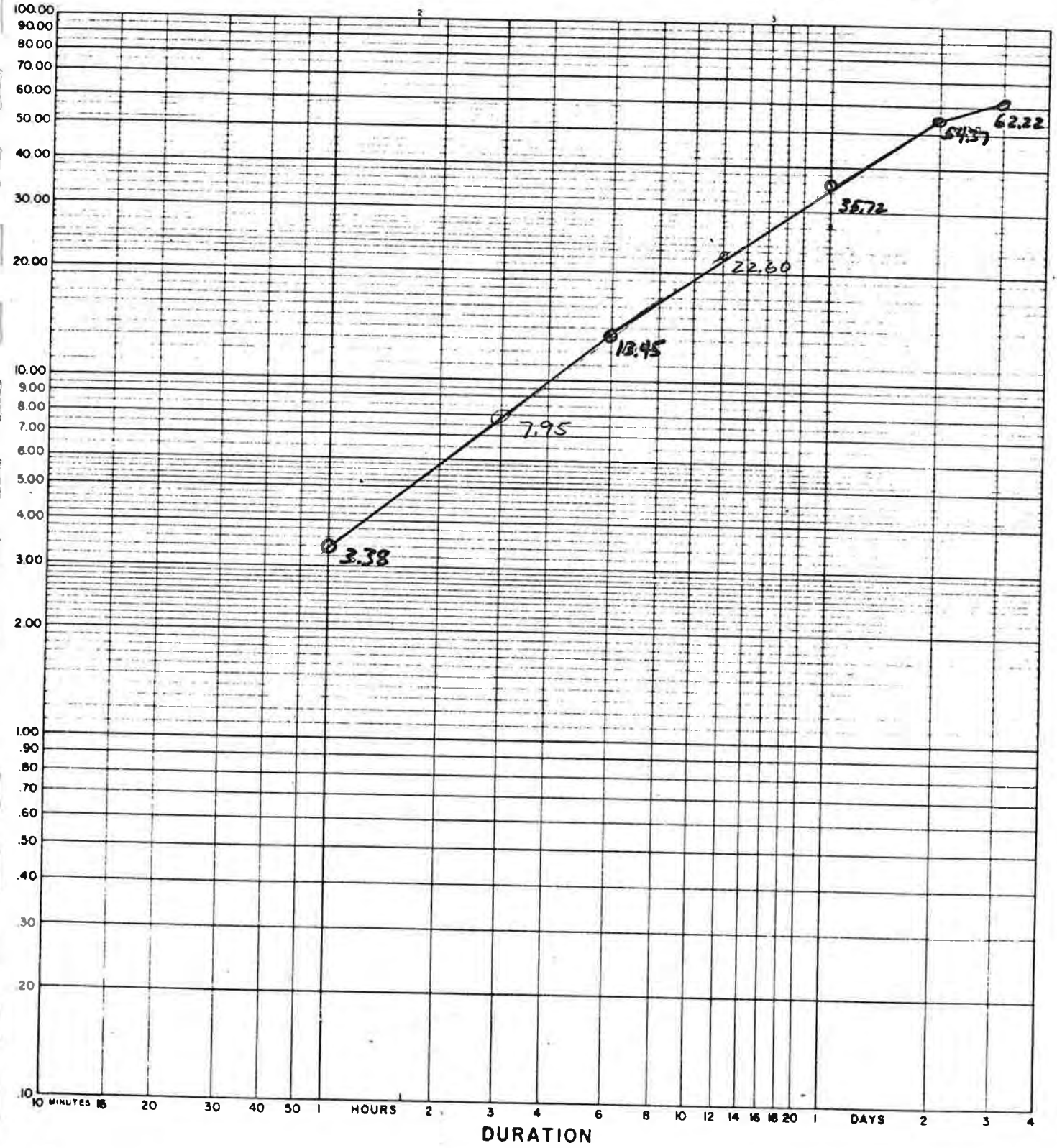
%	115	45	31	23	19	16	14	13	12	11	11	11
in	3.45	1.35	.93	.69	.57	.48	.42	.39	.36	.33	.33	.33
Comb.	13.45	9.15	7.23	5.89	4.97	4.18	3.52	2.99	2.56	2.13	1.73	1.43
Accm.	13.45	22.60	29.83	35.72	40.69	44.87	48.39	51.37	53.93	59.06	60.79	62.22

	Orographic	Convergence	Total
1hr P =	.20 x 10.00 = 2.00"	.46 x 3.0 = 1.38	3.38"
3hr P =	.54 x 10.00 = 5.40"	.85 x 3.0 = 2.55	7.95"

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

PRECIPITATION DEPTH - DURATION - FREQUENCY CURVE

NAME OF DAM MATILIJA No 86 CALCULATED BY JFC DATE 11-7-78



DWR 3414

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Project MATILIJA Sheet

Feature HYDRO106.5 Designed JFC Date 11-8-78

Item RAIN INCREMENTS Checked Date

TIME	PRECIP	INCR	TIME	PRECIP	INCR	TIME	PRECIP	INCR
1	3.38	3.38	25		.95	49	54.74	.37
2	5.76	2.38	26		.94	50		.37
3	7.88	2.16	27		.92	51		.36
4	9.84	1.95	28		.91	52		.36
5	11.69	1.84	29		.90	53		.35
6	13.45	1.76	30		.89	54		.35
7	14.92	1.47	31		.88	55		.35
8	16.32	1.40	32		.87	56		.34
9	17.66	1.34	33		.86	57		.34
10	18.96	1.30	34		.86	58		.33
11	20.21	1.25	35		.85	59		.33
12	21.43	1.18	36		.84	60		.33
13	22.61	1.16	37		.83	61		.32
14	23.76	1.15	38		.83	62		.32
15	24.89	1.13	39		.82	63		.32
16	25.99	1.10	40		.81	64		.31
17	27.07	1.08	41		.80	65		.31
18	28.13	1.06	42		.80	66		.31
19		1.04	43		.79	67		.30
20		1.02	44		.79	68		.30
21		1.01	45		.78	69		.30
22		.99	46		.77	70		.29
23		.98	47		.77	71		.29
24	34.13	.96	48	54.37	.76	72		.29

1 hr Intercept

$$Slope_{1-6} = \frac{\log 13.45 - \log 3.38}{\log 6 - \log 1} = .770808$$

$line_{1-6}$ $P_1 = 3.38$

$$Slope_{6-48} = \frac{\log 54.37 - \log 13.45}{\log 48 - \log 6} = .671735$$

$\log P_1 = \log P_{48} - .671(\log 48)$

$line_{6-48}$ $P_1 = 4.038554$

$$Slope_{48-72} = \frac{\log 62.22 - \log 54.37}{\log 72 - \log 48} = .332615$$

$\log P_1 = \log P_{72} - .332(\log 72)$

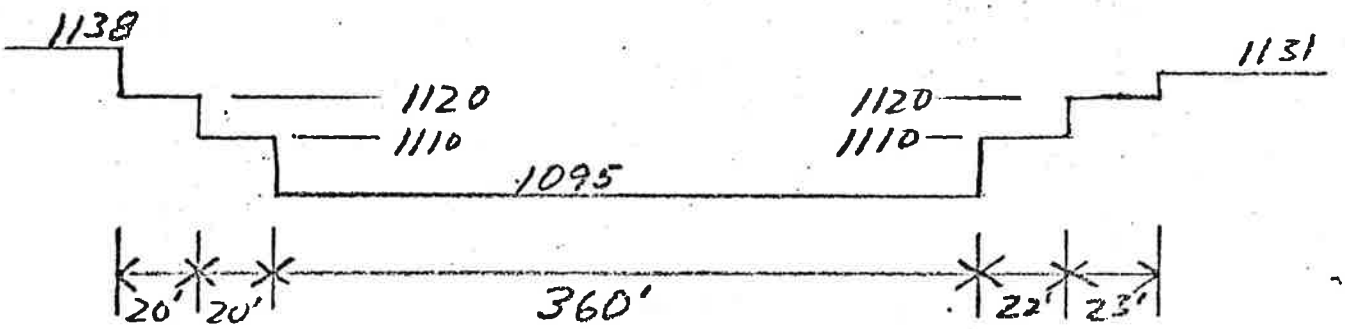
$line_{48-72}$ $P_1 = 15.002145$

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Project MATILIJA DAM NO 86 Sheet

Feature SPILLWAY CAPACITY Designed JFC Date 5-30-78

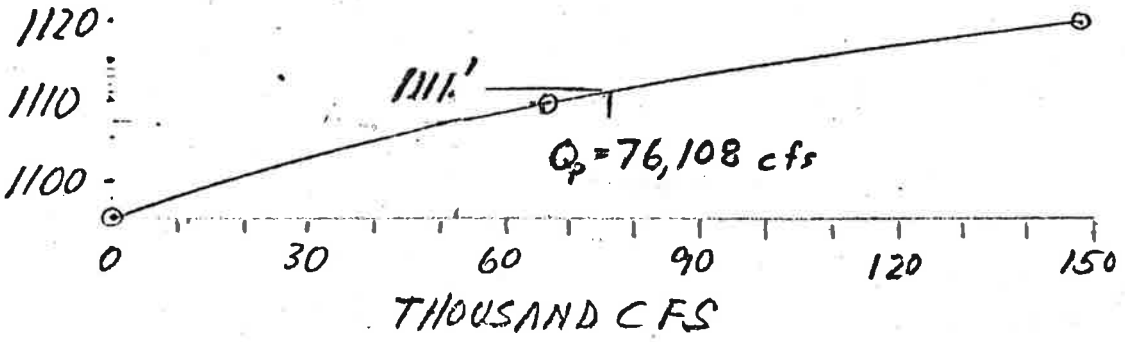
Item Checked Date Rev Nov 78



$$Q = C L H^{3/2}$$

$C = 3.2$ Ref Table 5-3 Kings 5th Ed

W.S.el.	Q_{360}	Q_{42}	Q_{43}	Q_{TOTAL}
1110	66925	—	—	66,925
1120	144,000	4,250		148,250



MATILIJA DAM NO 86
HYDROGRAPH COMPUTATION PROGRAM L228
CHAIMSON REVISED OCT 1978

ISTA	NHT	NUHGQ	NCLRK	IPNCH	QRCSN	EXTA	RTIMP
0	1	0	0	1	0	1.50	0

DA	TR	TP	CP	TC	RTIOR	RTIOL	RCVRY	E	RCLRK
55.00	60.00	0	0	1.87	1.00	4.00	0	.70	1.50
		1.70	.541	1.87					1.50

UNGR NQ= 10 TR= 60.00 MINS SUMQU= 35400 VOL= 35475

PMP FLOOD

NP	BASEL	DELTAL	STARTQ	STORM	SPFE	PMS	TRSPC	TRSDA
72	.80	0	0	0	0	0	0	0

HR	MIN	RAIN	LOSS	EXCESS	UNIT HG	RECSN	FLOW	
1	0	.2900	.2900	-0.0000	4889	0	-0	
2	0	.2900	.2900	-0.0000	11313	0	-0	
3	0	.3000	.3000	-0.0000	9637	0	-0	
4	0	.3100	.3100	0	4818	0	-0	
5	0	.3100	.2988	.0112	2409	0	55	
6	0	.3200	.2931	.0269	1205	0	258	
7	0	.3300	.2876	.0424	602	0	619	
8	0	.3300	.2763	.0537	301	0	1055	
9	0	.3400	.2716	.0684	151	0	1507	
10	0	.3500	.2669	.0831	75	0	1980	
11	0	.3600	.2623	.0977		0	2477	
12	0	.3700	.2579	.1121		0	2984	
13	0	.7600	.4118	.3482		0	4577	
14	0	.7700	.3925	.3775		0	7668	
15	0	.7900	.3785	.4115		0	10579	
16	0	.8000	.3623	.4377		0	12581	
17	0	.8100	.3476	.4624		0	14069	
18	0	.8300	.3369	.4931		0	15286	
19	0	.8400	.3242	.5158		0	16376	
20	0	.8600	.3151	.5449		0	17385	
21	0	.8700	.3041	.5659		0	18340	
22	0	.8900	.2962	.5938		0	19256	
23	0	.9100	.2888	.6212		0	20170	
24	0	.9400	.2838	.6562		0	21151	
25	0	.9600	.2769	.6831		0	22191	
26	0	.9900	.2723	.7177		0	23258	
27	0	1.0200	.2677	.7523		0	24373	
28	0	1.0600	.2650	.7950		0	25582	
29	0	1.1000	.2622	.8378		0	26912	
30	0	1.1500	.2608	.8892		0	28377	
31	0	1.1800	.2561	.9239		0	29904	
32	0	1.3000	.2645	1.0355		0	31724	
33	0	1.4000	.2686	1.1314		0	34230	
34	0	1.7600	.3037	1.4563		0	38365	
35	0	1.9500	.3129	1.6371		0	44579	
36	0	2.3800	.3444	2.0356		0	52529	
37	0	3.3800	.4198	2.9602		0	65277	
38	0	2.1600	.2895	1.8705		0	76108	← Q_p
39	0	1.8400	.2486	1.5914		0	74174	
40	0	1.4700	.2052	1.2648		0	64795	
41	0	1.3400	.1869	1.1531		0	55551	
42	0	1.2500	.1735	1.0765		0	48259	
43	0	1.1600	.1608	.9992		0	43108	
44	0	1.1300	.1544	.9756		0	39415	
45	0	1.0800	.1464	.9336		0	36840	
46	0	1.0400	.1397	.9003		0	34908	
47	0	1.0100	.1342	.8758		0	33324	
48	0	.9800	.1290	.8510		0	32102	
49	0	.9500	.1240	.8260		0	31062	
50	0	.9200	.1192	.8008		0	30111	
51	0	.9000	.1154	.7846		0	29237	
52	0	.8800	.1118	.7682		0	28479	
53	0	.8600	.1083	.7517		0	27812	
54	0	.8500	.1059	.7441		0	27231	
55	0	.8300	.1026	.7274		0	26727	
56	0	.8200	.1003	.7197		0	26261	

57	0	.3000	.0972	.7028		0	25811
58	0	.7900	.0951	.6949		0	25368
59	0	.7800	.0930	.6870		0	24972
60	0	.7700	.0910	.6790		0	24634
61	0	.3700	.0538	.3162		0	22590
62	0	.3600	.0524	.3076		0	18277
63	0	.3500	.0510	.2990		0	14559
64	0	.3500	.0506	.2994		0	12591
65	0	.3400	.0493	.2907		0	11535
66	0	.3300	.0479	.2821		0	10889
67	0	.3200	.0466	.2734		0	10414
68	0	.3200	.0463	.2737		0	10067
69	0	.3100	.0450	.2650		0	9819
70	0	.3000	.0437	.2563		0	9577
71	0	.3000	.0434	.2566		0	9359
72	0	.2900	.0421	.2479		0	9175
73	0					0	7796
74	0					0	4873
75	0					0	2426
76	0					0	1202
77	0					0	591
78	0					0	285
79	0					0	133
80	0					0	57
81	0					0	19
TOTAL		62.1500	15.0253	47.1247	35400	0	1668196

$\frac{47.12}{62.15} = 76\%$ runoff

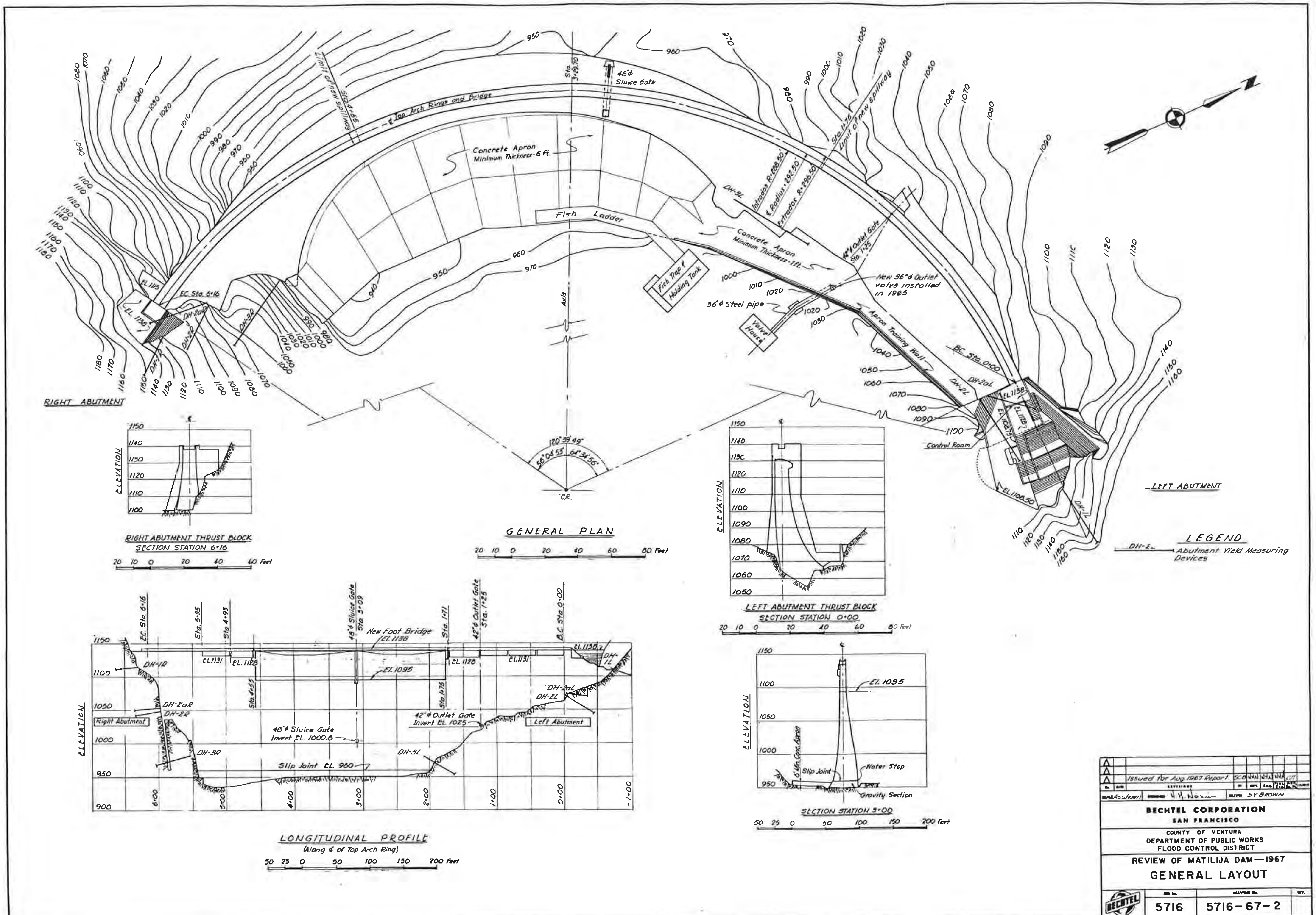
$\frac{47.12}{12} \times 55 \times 640 = 138,219$ Acre feet runoff

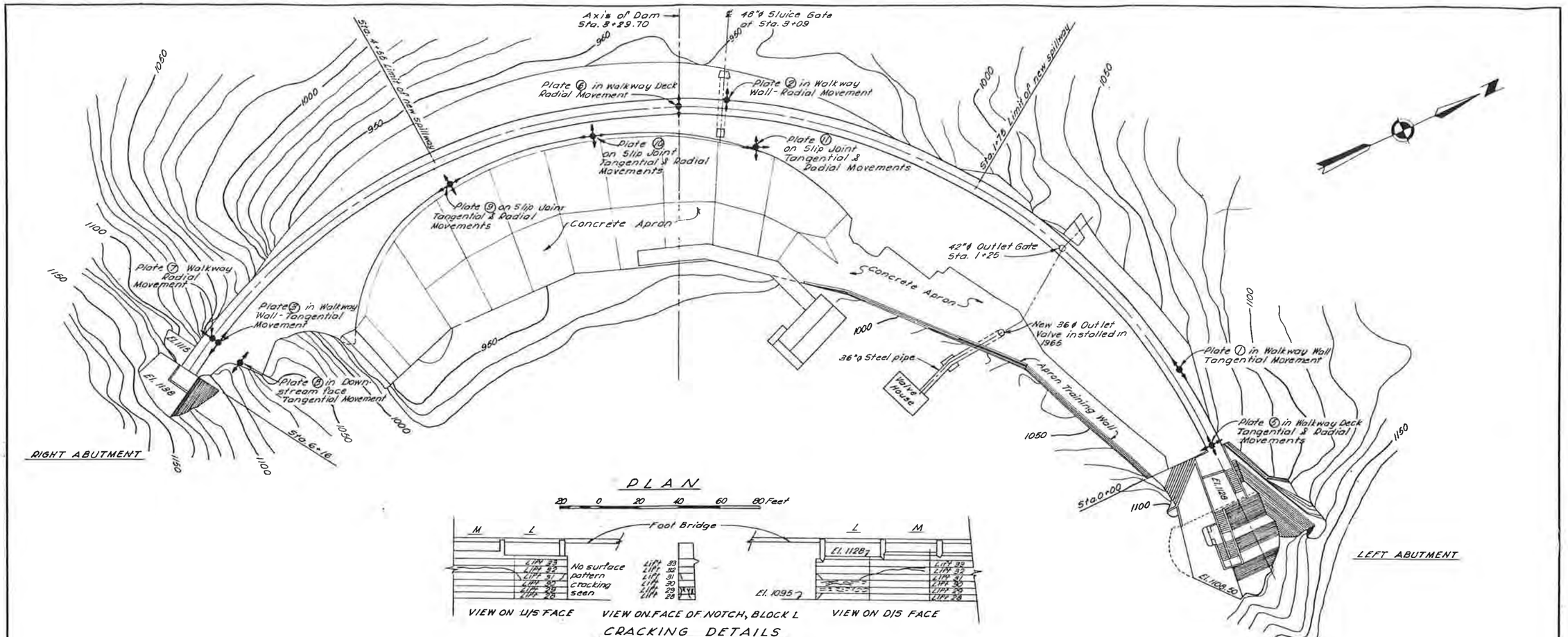
∴ routing is consequential

$\frac{Q_p}{D.A} = \frac{76,108}{55} = 1384$ csm

APPENDIX 2

Instrumentation Installation 1965
Data Transmittal 1978
Data Review 1978


GENERAL PLAN
20 10 0 20 40 60 80 Feet
RIGHT ABUTMENT
LEFT ABUTMENT
Limit of new spillway
Sta. 4+56
Top Arch Rings and Bridge
Sta. 3+29.70
48"φ Sluice Gate
Concrete Apron
Minimum Thickness-6 ft.
Fish Ladder
Fish Trap & Holding Tank
Concrete Apron
Minimum Thickness-1 ft.
Sta. 1+76
Limit of new spillway
Intrados R=288.50'
℄ Radius=292.50'
Extrados R=296.50'
42"φ Outlet Gate
Sta. 1+25
New 96"φ Outlet valve installed in 1965
36"φ Steel pipe
Valve House
Apron Training Wall
B.C. Sta. 0+00
DH-2aL
DH-2L
DH-3L
EL. 1138
EL. 1128
EL. 1108.50
DH-1L
Control Room
EL. 1135
EL. 1138
E.C. Sta. 6+16
DH-2aR
DH-2R
DH-1R
DH-3R
Axis
120°39'49"
56°04'53"
64°34'56"
C.R.
RIGHT ABUTMENT THRUST BLOCK
SECTION STATION 6+16
20 10 0 20 40 60 Feet
ELEVATION
LEFT ABUTMENT THRUST BLOCK
SECTION STATION 0+00
20 10 0 20 40 60 80 Feet
LEGEND
DH-L Abutment Yield Measuring Devices
LONGITUDINAL PROFILE
(Along ℄ of Top Arch Ring)
50 25 0 50 100 150 200 Feet
New Foot Bridge
EL. 1138
EL. 1131
EL. 1128
EL. 1095
48"φ Sluice Gate
Invert EL. 1000.8
Slip Joint EL. 960
42"φ Outlet Gate
Invert EL. 1025
Right Abutment
Left Abutment
Sta. 5+35
Sta. 4+95
Sta. 4+55
Sta. 3+09
Sta. 1+71
Sta. 1+78
Sta. 1+25
B.C. Sta. 0+00
SECTION STATION 3+00
EL. 1095
Water Stop
Slip Joint
Gravity Section
6" Min. Conc. Apron
50 25 0 50 100 150 200 Feet
Issued for Aug. 1967 Report
SCALE As shown
DRAWN SY BROWN
BECHTEL CORPORATION
SAN FRANCISCO
COUNTY OF VENTURA
DEPARTMENT OF PUBLIC WORKS
FLOOD CONTROL DISTRICT
REVIEW OF MATILIJA DAM—1967
GENERAL LAYOUT
5716
5716-67-2



NOTES

1. The only plates shown on this drawing are those which have been surveyed long enough and frequently enough to yield meaningful data on the behavior of the dam.

LEGEND

- ○ Soniscope Testing performed by Bechtel.
- □ Soniscope Testing performed by PCA.

No.	Date	Revisions	By	Chkd
1	9/67	Issued for Aug 1967 Report		

Scale As shown — Designed M. Morris — Drawn S.Y. Brown

BECHTEL CORPORATION
SAN FRANCISCO

COUNTY OF VENTURA
DEPARTMENT OF PUBLIC WORKS
FLOOD CONTROL DISTRICT

REVIEW OF MATILIJA DAM — 1967

DAM MOVEMENT
PLATE LOCATIONS AND ELEVATIONS

BECHTEL — Job No. 5716 — Drawing No. 5716-67-3 — Rev.

PUBLIC WORKS AGENCY
county of ventura

Director
Arthur E. Goulet

Deputy Directors
Donald A. Betlach
Road Department
T. M. Morgan
Engineering Services
G. J. Nowak
Flood Control/Water Resources
Donald B. Perry
Management Services
E. D. Shinavar
Construction Services

July 19, 1978

Mr. James J. Doody, Chief
Division of Safety of Dams
State Department of Water Resources
P.O. Box 388
Sacramento, California 95802

Subject: MATILIJA DAM-REPORT OF INSTRUMENT READINGS, FLOOD ZONE I

Dear Mr. Doody:

Enclosed for your information are updated copies of Abutment Yield Measurement Data at subject location for the period April 5, 1978 through July 3, 1978, and graphs of reservoir elevation versus time, deformation versus time, and survey data showing deflection of the face targets.

You will note that the modification work on the dam has removed two face targets and the survey will now include a total of ten targets. In our last report, we indicated that four strain gages were not operating. One instrument has now been repaired and the remaining three will be examined when the modification and cleanup work is completed.

Very truly yours,

Gerald J. Nowak, Deputy Director
Flood Control and Water Resources Department

by Gerald D. Bickel
Gerald D. Bickel
Supervising Hydrologist

Enclosures

GDB:ggh

800 South Victoria Avenue, Ventura, CA 93009

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

INSTRUMENTATION DATA REVIEW

Name of Dam Matilija Dam No. 86

Data Period Second quarter of 1978

Significant Observations and Remarks:

Stage

The water level in the reservoir fluctuated between three and 11 feet below the certified spillway elevation of 1095 feet until late June on June 20, the owner emptied the reservoir.

Abutment Yield Deformations

The deformations confirmed the continuation of past trends in the right abutment instruments.

With the completion of the modification and clean up work, repair of the inoperable strain gages should shed light upon the compression of 0.128-inch in the last year at DH-IL and the unusual compression double the past trends at DH-2L.

Face Targets

Except for the contradiction movement at targets 5 and 6, the upper targets, including 1, 10, 11, and 12 moved upstream and toward the left abutment at an increasing annual rate. The maximum 25mm. upstream and 10mm. left deflection occurred at target 10 in the left corner of the spillway.

General Conditions Indicated by the Data:

The target data indicated an increase in the left and upstream movement of the upper face of the dam.

APPENDIX 3

Geology Logs, Section and Plan
by Thomas L. Bailey

APPENDIX 4

Design Summary
Donald R. Warren Company

APPENDIX 5

Selected Drawings, Matilija Dam

LEFT ABUTMENT - NORTHEAST

B

INCLINATION 50° N.N.W.

NO BOND
9½'
FEW ANGULAR TO DRILL ROUNDED FRAGMENTS OF HARD SANDSTONE
CUTTINGS OF SOFT WHITE CRUSHED SANDSTONE.
LOOSE FRAGMENTS OF SHATTERED SANDSTONE.
SOFT CRUSHED SANDSTONE (ACCORDING TO DRILLER)
15'
SHATTERED (LOOSE FRAGMENTS)
18½'
SOFT CRUSHED SANDSTONE (DRILLER)
CHIPS & SLIVERS OF SANDSTONE
25'
SHATTERED SANDSTONE & SOME SHALE FRAGMENTS.
30' BADLY FRACTURED TO ½" SHATTERED.
33½'
G FAULT
FAULT GOUGE CORED
BADLY FRACTURED TO 38½' PARTLY CRUSHED.
52'
MODERATELY FRACTURED TO SHATTERED & PARTLY CRUSHED, CALCITE VEINLETS.
62' DARK GRAY SILTY SANDSTONE. 63' BLACK FAULT GOUGE.
69' VERTICAL DIP
73' CRUSHED TO SEMI-CRUSHED SHEARED SHALE STREAKS
77'
82' SHATTERED SANDY SHALE
85'
87'
BLACK SANDY SHALE (SHEARED)
94'
CRUSHED FRIABLE SANDSTONE WITH HARDER SLIVERS.
TOTAL DEPTH 100'

3-H INCLINATION 40° NW

NO BOND
14'
FEW FRAGMENTS OF SANDSTONE. BLACK SHALE FRAGMENTS.
18' ORIGINAL DEPTH
SHATTERED TO SEMI-SHATTERED SANDSTONE
23'
28'
SHATTERED TO CRUSHED SANDSTONE, HARD FRAGMENTS.
31'
33'
38½'
1" SHEARED SHALE
SMALL FAULT
43½' SHALE LAMELLAE
48'
53'
57' LAM SHALE
SLICKEN. SANDSTONE FRAG. 6" LONG AND THIN SHEARED SHALE.
61'
TOTAL DEPTH 62½' (REDRILLED)

13-H INCLINATION 45° NW

TOP OF GROUT IN REDRILLED HOLE
NO BOND
11'
17'
1" WIDE CHANNELS THROUGH GROUT CORE IN REDRILLED HOLE.
FEW FRAGMENTS OF GROUT CORES RECOVERED IN THIS INTERVAL IN REDRILLED HOLE.
LITTLE GROUT CORE RECOVERY.
40'
30% OF GROUT CORE NOT RECOVERED IN REDRILLED HOLE.
SHALE
ORIGINAL TOTAL DEPTH BEFORE GROUTING.
63'
65' LOOSE FRAGMENTS
67'
70'
½" GROUT SEAM
77'
82' BADLY SHATTERED TO CRUSHED
90'
TOTAL DEPTH 100' (REDRILLED)

5-1 INCLINATION 40° NW

NO BOND
2'
FEW FRAGMENTS OF SHALE. SHALE. 15'
11½' SHALE
18½'
20'
26'
30'
33'
38'
TOTAL DEPTH 40'

10-1 INCLINATION 45° NW

BONDED WITH SANDSTONE
10½'
12'
LAMINATED SHALE (BADLY FRACTURED)
DIP 90°
17' LAMINATED BLACK SHALE
GROUT CORES CHANNELED IN REDRILLED HOLE 13' TO 24'
27'
PARTLY CRUSHED SANDSTONE
30'
SHEARED SHALE PARTING
40'
49½'
SLICKENSIDED SHALE FRAGMENTS
51'
52½'
SILTY SANDSTONE & SHALE
SHALE CUTTINGS
59½'
62½' 3½" CRUSHED BLACK SHALE IN REDRILLED HOLE GROUT CORES BADLY CHANNELED & FRAGMENTARY.
67' ORIGINAL TOTAL DEPTH 67'.
68' GROUT CEMENTED BRECCIA SHOWS CAVING CONDITIONS
71'
75'
77'
2" BLACK GOUGE
79' SHALY SANDSTONE WITH SHALE BLEBS.
84'
86'
94'
98'
TOTAL DEPTH 100' (REDRILLED)

4-J INCLINATION 40° NW

GOOD BOND
3'
DIP 85° SHALY SANDSTONE AND SHALE
11½'
11½' 2 CHIPS
13½'
TOTAL DEPTH 14½'

11-J INCLINATION 45° NW

GOOD BOND WITH SANDSTONE.
6'
9'
LAMINATED BLACK HARD SHATTERED SILICEOUS SHALE WITH HARD SANDSTONE LAMELLAE.
14'
18' SHATTERED SHALE. ORIGINAL TOTAL DEPTH 20'.
27'
32'
35'
40'
46' GROUT SEAM 1½" THICK.
49' HARD BLACK FRACTURED SHALE.
50'
SMALL FAULT AT 54'
57' DRILLER REPORTS 2' OF SHALE.
59' 1½" FRAGMENT OF SHALE
67'
75'
78' 2" SHALE
81'
84'
85'
87'
91'
SHATTERED SANDSTONE IN LOOSE FRAGMENTS
96'
TOTAL DEPTH 100' (REDRILLED)

15-K INCLINATION 35° N

NOT BONDED
CONCRETE OF DAM
NC
WELL BONDED
31½'
39½'
LOCALLY CRUSHED
45'
LOCALLY CRUSHED ALONG FRACTURES
55'
60'
64½'
SEMI-CRUSHED
TOTAL DEPTH 69'

16-K INCLINATION 35° N

NOT BONDED
12' LOOSE FRAGMENTS OF HARD OXIDIZED SANDSTONE.
20½' DARK GRAY SHALY SANDSTONE.
27'
32' OXIDIZED IN PART
RUSTY SHALE (REPORTED BY DRILLER)
34½'
SMALL FRAGMENTS OF SHALY SANDSTONE
DARK BROWN, PARTLY CRUSHED SANDY SHALE CUTTINGS.
ORIGINAL DEPTH 38½'
1' RECOVERED OF COMPLETELY CRUSHED SOFT LIGHT GRAY MUCKY SANDSTONE.
SHATTERED SANDSTONE FRAGMENTS
48'
TOTAL DEPTH 66' (REDRILLED)

17-L INCLINATION 35° N

OPEN SPACES IN CONCRETE OF DAM (UP TO 1½")
NO BOND
SHATTERED GRAY TO RUSTY SANDSTONE.
24' RUSTY STREAKS
TOTAL DEPTH 32'
NO FURTHER PROGRESS POSSIBLE DUE TO BAD CAVING CONDITIONS EVEN THOUGH GROUTED TWICE AND REDRILLED IN SAME HOLE.

19-L INCLINATION 60° NW

BONDED
20½'
25½'
DARK GRAY SHALY SANDSTONE & THIN SHALE LAMINAE.
THIN CRUSHED SHALE
46'
54'
CORES NOT STUDIED BELOW 54'; REPORTED GOOD ROCK MOSTLY.
TOTAL DEPTH 70'

18-M INCLINATION 10° N

BONDED TO SANDSTONE
15½'
HARD BUFF SANDSTONE WITH THIN RUSTY CLAY LAMINAE ALONG CRACKS.
20' RUSTY SANDSTONE FRAGMENTS.
21'
RUSTY SHATTERED SANDSTONE.
24'
OXIDIZED ALONG CRACKS.
27'
LOOSE SAND & CLAY CUTTINGS.
31' BUFF SANDSTONE (FAIRLY HARD)
32'
FRAGMENT OF BLACK SANDY SHALE, 2"
BLUE TO WHITISH
37'
40½' FAIRLY HARD BLACK SHALE.
42' SHATTERED SHALE
43½' WITH HARD SANDSTONE STREAKS.
SHATTERED TO MODERATELY FRACTURED BLACK SHALE & HARD SANDSTONE.
47'
TOTAL DEPTH 49'

LEGEND

- SOLID SANDSTONE
- SLIGHTLY FRACTURED SANDSTONE
- MODERATELY FRACTURED SANDSTONE
- BADLY FRACTURED SANDSTONE
- SHATTERED SANDSTONE
- CRUSHED SANDSTONE
- SOLID SHALE
- FRACTURED SHALE
- CRUSHED SHALE
- SHALY FAULT GOUGE
- SHALY SANDSTONE (SOLID)
- CONCRETE OF DAM OR APRON
- GROUT FILLED CRACK
- NC NO CORE RECOVERED

NOTE: PERCENTAGE OF SPACE (BETWEEN NUMBERED DEPTHS ON RIGHT SIDE OF CORE) LEFT BLANK (NC) SHOWS PERCENTAGE OF CORE NOT RECOVERED.

CORE OF ANGULAR ROCK FRAGMENTS (CAVINGS) CEMENTED BY GROUT (ONLY IN HOLES REDRILLED AFTER GROUTING.

M. D. 2157 11103

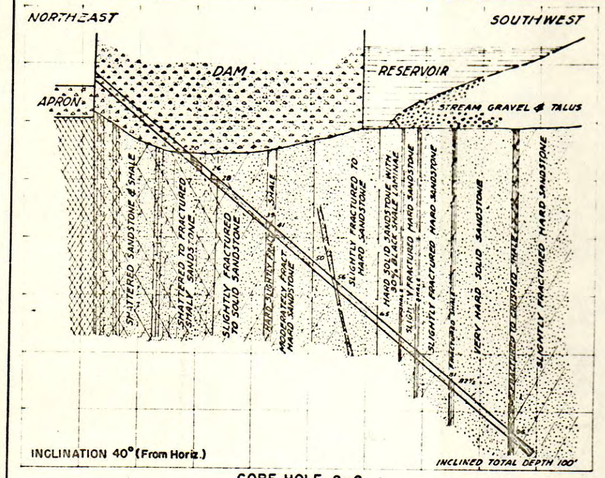
VENTURA COUNTY FLOOD CONTROL DISTRICT
ZONE ONE

DETAIL LOGS OF CORE HOLES

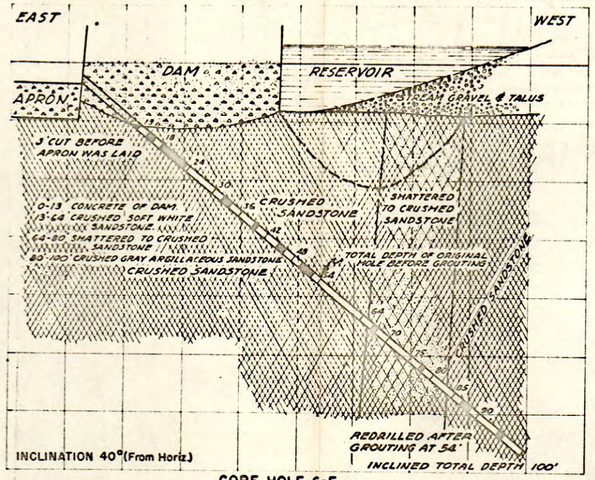
MATILIJA DAM

PREPARED BY THOMAS L. BAILEY, CONSULTING GEOLOGIST
DECEMBER 1948
VERTICAL SCALE 1" = 5'
(NO HORIZ. SCALE)

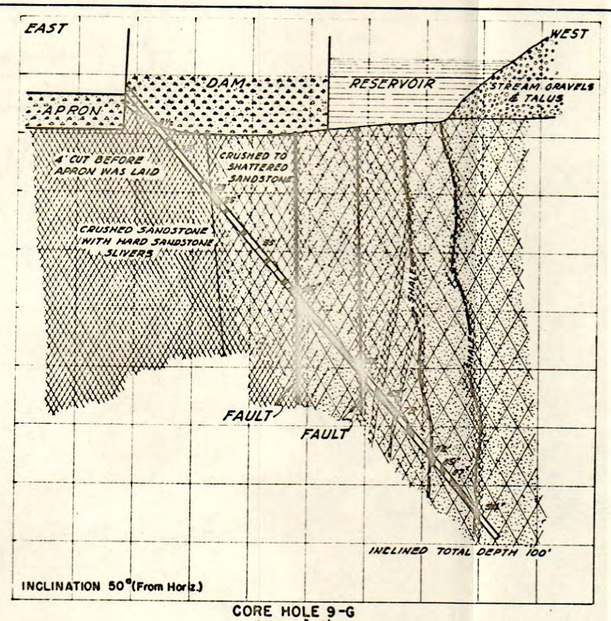
H-3-1 86



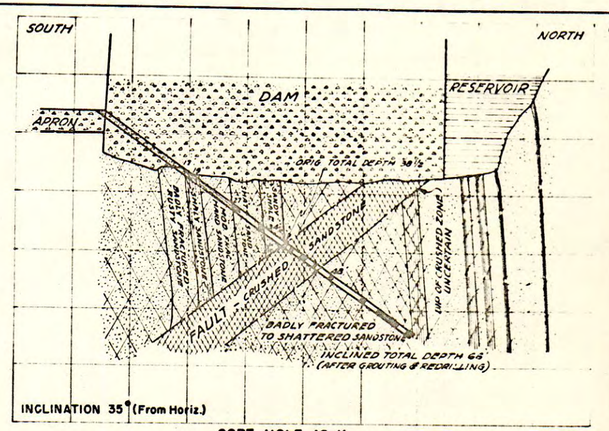
CORE HOLE 8-C
SCALE 1"=10'



CORE HOLE 6-E
SCALE 1"=10'



CORE HOLE 9-G
SCALE 1"=10'



CORE HOLE 16-K
SCALE 1"=10'

M. D.	
2157	11163

VENTURA COUNTY FLOOD CONTROL DISTRICT
ZONE ONE

MATILIJA DAM

TYPICAL CROSS SECTIONS SHOWING STRUCTURAL INTERPRETATION FROM CORE HOLE AND SURFACE DATA

BY THOMAS L. BAILEY
Drawn February 7, 1949

86

H-3-1

2315

UTHWEST – RIGHT ABUTMENT

RA3 INCLINATION 15° S

- DOUBTFUL BOND
- OXIDIZED SEAMS 20'-20½'
- SOFTER RUSTY STREAKS
- 2 HARD BLACK ½" SHALE LAMELLAE GRAY TO RUSTY
- FEW THIN YELLOW CLAY SEAMS
- 71' NOT RECOVERED
- 57' REPORTED AS SHALE
- SLIGHTLY OXIDIZED
- 71'
- PARTLY OXIDIZED BUT HARD

TOTAL DEPTH 75'

RA2 INCLINATION 15° S

- NOT BONDED. PROBABLY 6" RUSTY SHALE NOT RECOVERED.
- BADLY FRACTURED (60% RECOVERED).
- 1" CRUSHED SANDSTONE.
- 8½" 1" FRACTURED SHALE.
- RUSTY
- PROBABLY CRUSHED
- 63' SHALE LOST.
- THIN SHATTERED ZONE.

TOTAL DEPTH 75'

RA1 INCLINATION 15° S

- CORES KNOCKED BY ROCK AND SCATTERED; SAND STONE PARTLY OXIDIZIED BUT HARD. NO SHALE NOTED
- CONCRETE REPLACING MINED OUT SHALE ZONE
- PARTLY OXIDIZED SHATTERED STREAK
- CONTAINS ⅛" SEAMS OF YELLOW CLAY

TOTAL DEPTH 93'

8-C INCLINATION 40° N

- NOT BONDED TO BED ROCK.
- SHALY PARTINGS AND BLEBS.
- SHALE LAMINAE
- BLACK SHALE
- HARD SHALY SS WITH 20% BLACK SHALE; HARD AND STRONG
- BADLY FRACTURED SANDY SHALE AND SHALY SS.
- CRUSHED SHALE

TOTAL DEPTH 100'

12-D INCLINATION 40° W

- NO BOND
- SOFT AND MUCKY
- COMPLETELY CRUSHED MUCKY

TOTAL DEPTH 50'

14-D INCLINATION 45° N

- NO BOND
- VERY SOFT AND BREAKS DOWN INTO MUD WHEN SOAKED.
- SHALY FAULT GOUGE
- MUDDY
- SHALY STREAKS
- CRUSHED TO SHATTERED
- SOME SHATTERED SHALY SANDSTONE CRUSHED STREAKS

TOTAL DEPTH 100'

7-D INCLINATION 45° W

- NO BOND
- VERY SOFT AND FRIABLE
- SHALE LAMINATED SANDSTONE
- CRUSHED TO SHATTERED

TOTAL DEPTH 56'

6-E INCLINATION 40° W

- BONDED TO UPPER 2' OF SAND STONE
- VERY FRIABLE
- MUCKY
- RECOVERED GROUT IN REDRILLED HOLE.
- VERTICAL SHEAR PLANE
- MUCKY FEW SMALL HARD FRAGMENTS OF SAND STONE.
- 1½" GOUGE
- 1" GOUGE; VERT. DIP
- BOTTOM OF ORIG HOLE
- LOOSE SAND CUTTINGS VERY SOFT DRILLING
- ANGULAR FRAGMENTS PARTLY CRUSHED SANDSTONE
- SOFT AND MUCKY
- 3" ANGULAR FRAGMENTS OF HARD SANDSTONE

TOTAL DEPTH 100' (REDRILLED)

1-F INCLINATION 40° W

- TOP OF GROUT IN REDRILLED HOLE
- NO BOND
- 60° DIP
- CRUSHED SHALE & GOUGE
- SHATTERED HARD SANDSTONE
- 65° DIP ON LAMIM. S S.
- LAMINATED SANDSTONE
- (MANY SHALE & SANDSTONE CAVINGS INCLUDED IN GROUT CORES FROM REDRILLED HOLE BELOW 29')
- SHATTERED SHALY SANDSTONE
- DIP 90°
- BOTTOM OF ORIGINAL HOLE
- CAVINGS CEMENTED WITH GROUT
- SMALL FRAGMENTS OF HARD SHATTERED SANDSTONE
- SHATTERED WHITE SANDSTONE FRAGMENTS
- CRUSHED ALONG FRACTURE
- CRUSHED SANDSTONE 73½' TO 74'
- FEW SMALL FRAGMENTS OF SHATTERED SANDSTONE
- SHATTERED TO CRUSHED SANDSTONE
- ⅛" BLACK FAULT GOUGE
- SHATTERED TO CRUSHED SANDSTONE
- CRUSHED SANDSTONE WITH CALCITE VEINLETS
- SMALL FRAGMENTS, PARTLY CRUSHED TO CRUSHED SANDSTONE.
- SHATTERED DARK GRAY SILTY SANDSTONE
- SHEARED SHALE PARTINGS
- MODERATELY FRACTURED TO SHATTERED

TOTAL DEPTH 100' (REDRILLED)

2-G INCLINATION 40° WNW

- NO BOND
- CUTTINGS OF BLACK SHALY FAULT GOUGE AND LOOSE WHITE SAND GOUGE PLUGGED BIT

TOTAL DEPTH 24'

9-G INCLINATION 50° NNW

- NO BOND
- FEW ANGULAR TO DRILL ROUNDED FRAGMENTS OF HARD SANDSTONE
- CUTTINGS OF SOFT WHITE CRUSHED SANDSTONE.
- LOOSE FRAGMENTS OF SHATTERED SANDSTONE.
- SOFT CRUSHED SANDSTONE (ACCORDING TO DRILLER)
- SHATTERED (LOOSE FRAGMENTS)
- SOFT CRUSHED SANDSTONE (DRILLER)
- CHIPS & SLIVERS OF SANDSTONE
- SHATTERED SANDSTONE & SOME SHALE FRAGMENTS.
- BADLY FRACTURED TO SHATTERED.
- G FAULT
- FAULT GOUGE CORED BADLY FRACTURED TO PARTLY CRUSHED.
- MODERATELY FRACTURED TO SHATTERED & PARTLY CRUSHED; CALCITE VEINLETS.
- DARK GRAY SILTY SANDSTONE.
- BLACK FAULT GOUGE.
- VERTICAL DIP
- CRUSHED TO SEMI-CRUSHED
- SHEARED SHALE STREAKS
- SHATTERED SANDY SHALE
- BLACK SANDY SHALE (SHEARED)
- CRUSHED FRIABLE SANDSTONE WITH HARDER SLIVERS.

TOTAL DEPTH 100'

3-H INCLINATION 40° NW

- NO BOND
- FEW FRAGMENTS OF SANDSTONE. BLACK SHALE FRAGMENTS.
- ORIGINAL DEPTH
- SHATTERED TO SEMI-SHATTERED SANDSTONE
- SHATTERED TO CRUSHED SANDSTONE, HARD FRAGMENTS.
- 1" SHEARED SHALE
- SMALL FAULT
- 25% SHALE LAMELLAE
- LAM SHALE
- SLICKEN. SANDSTONE FRAG. 6" LONG AND THIN SHEARED SHALE.

TOTAL DEPTH 62½' (REDRILLED)

13-

VENTURA COUNTY FLOOD CONTROL DISTRICT

ZONE 1

MATILIJA DAM

GEOLOGY OF FOUNDATION ROCK

BY

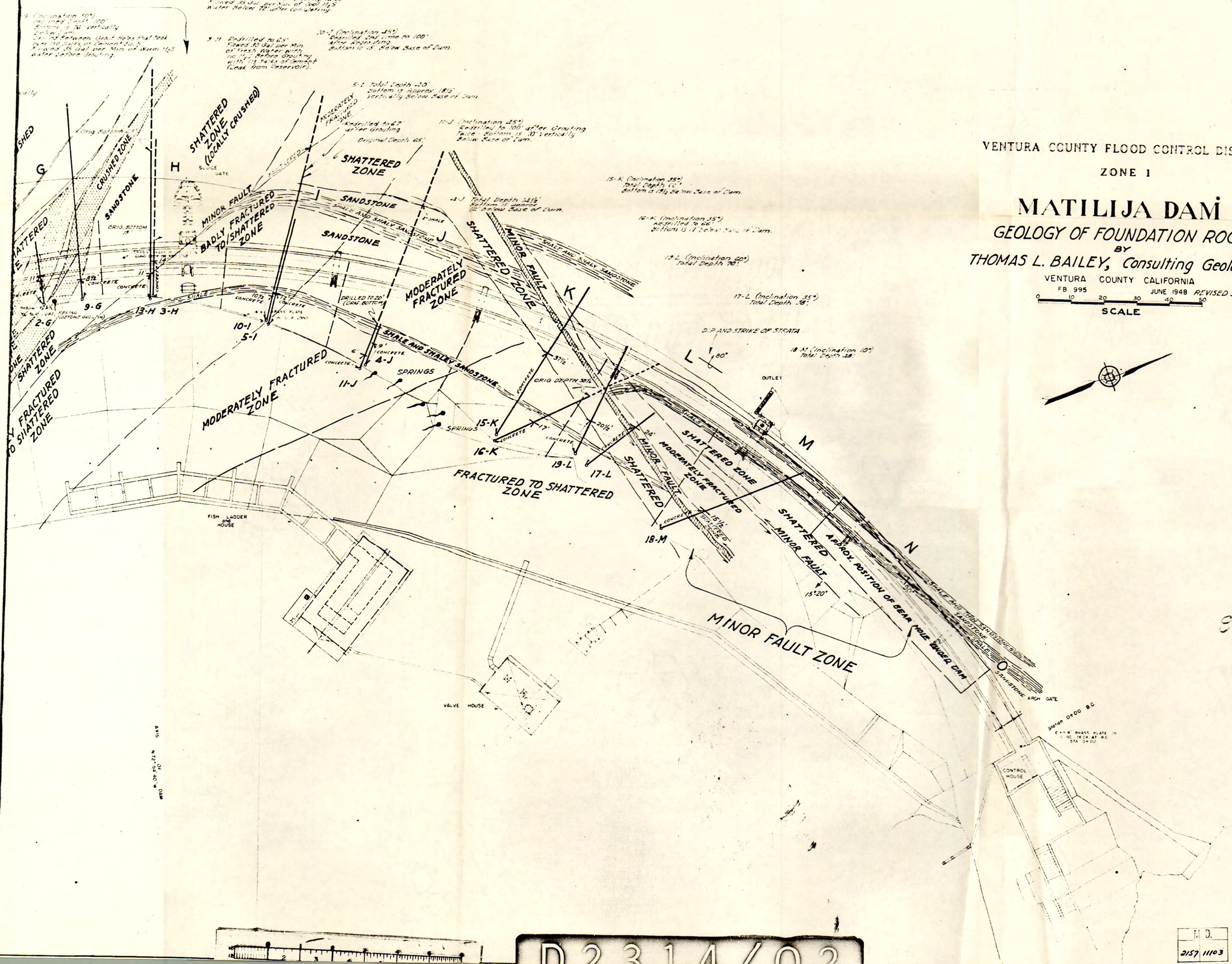
THOMAS L. BAILEY, Consulting Geologist

VENTURA COUNTY CALIFORNIA

FB 995 JUNE 1948 REVISED JAN. 1949 SHM

0 10 20 30 40 50

SCALE



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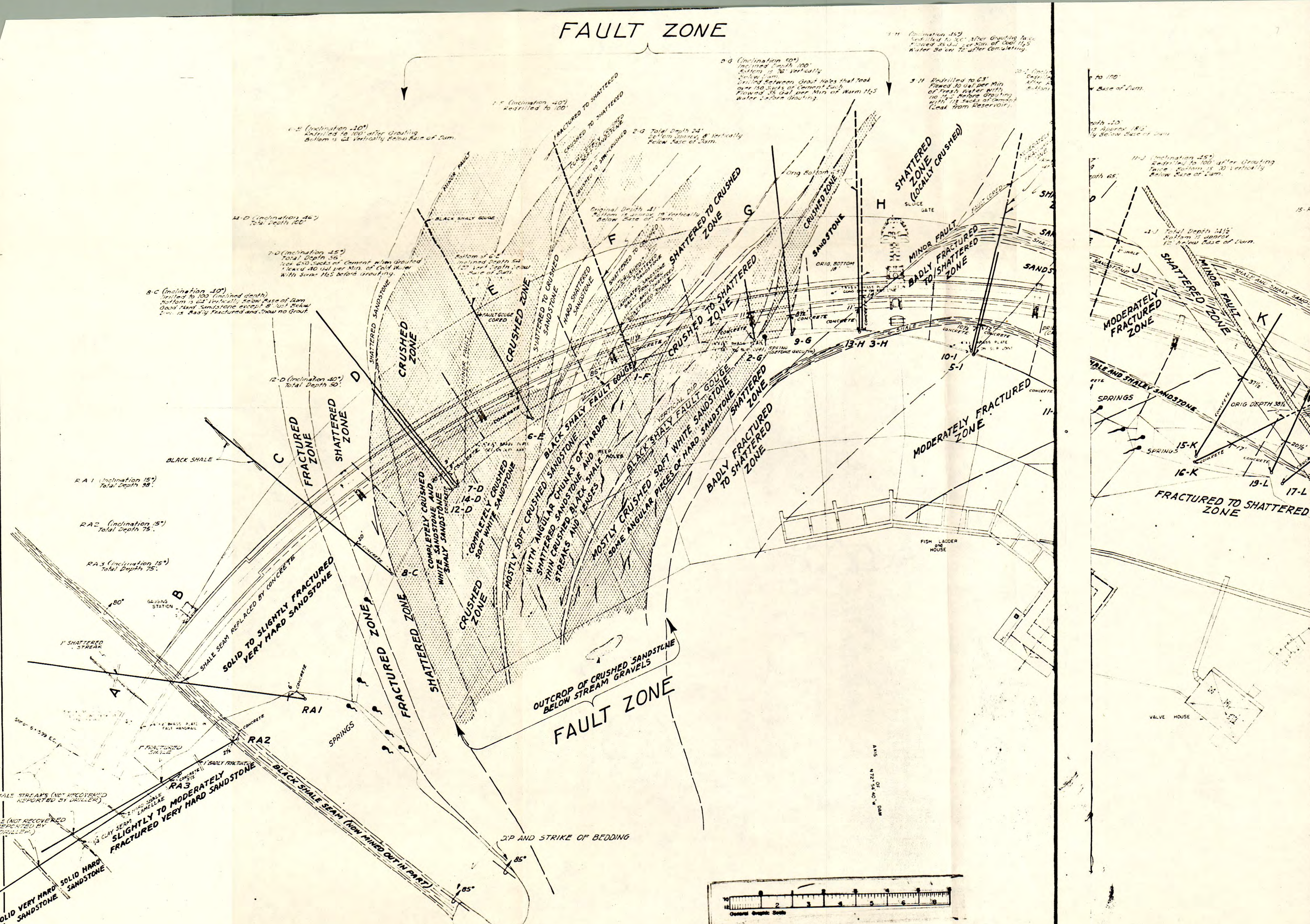

FAULT ZONE
SHATTERED ZONE (LOCALLY CRUSHED)
CRUSHED ZONE
SHATTERED ZONE
FRACTURED ZONE
SHATTERED SANDSTONE
SHATTERED TO CRUSHED SANDSTONE
HARD SHATTERED SANDSTONE
SHATTERED TO CRUSHED ZONE
CRUSHED TO SHATTERED ZONE
BLACK SHALY FAULT GOUGE
BLACK SHALY GOUGE
MINOR FAULT
BADLY FRACTURED TO SHATTERED ZONE
MODERATELY FRACTURED ZONE
MODERATELY FRACTURED ZONE
SHATTERED ZONE
FRACTURED TO SHATTERED ZONE
SHALE AND SHALEY SANDSTONE
COMPLETELY CRUSHED WHITE SANDSTONE AND SHALY SANDSTONE
COMPLETELY CRUSHED SOFT WHITE SANDSTONE
MOSTLY SOFT CRUSHED SANDSTONE WITH ANGULAR CHUNKS OF HARDER SHATTERED SANDSTONE AND THIN CRUSHED BLACK SHALE STREAKS AND LENSES
MOSTLY CRUSHED SOFT WHITE SANDSTONE SOME ANGULAR PIECES OF HARD SANDSTONE
OUTCROP OF CRUSHED SANDSTONE BELOW STREAM GRAVELS
SOLID TO SLIGHTLY FRACTURED VERY HARD SANDSTONE
SLIGHTLY TO MODERATELY FRACTURED VERY HARD SANDSTONE
SOLID VERY HARD SANDSTONE
SOLID HARD SANDSTONE
BLACK SHALE SEAM (NOW MINED OUT IN PART)
SHALE SEAM REPLACED BY CONCRETE
BLACK SHALE
SPRINGS
DIP AND STRIKE OF BEDDING
FISH LADDER AND HOUSE
VALVE HOUSE
GAGING STATION
SLUICE GATE
A
B
C
D
E
F
G
H
J
K
RA1
RA2
RA3
8-C
7-D
14-D
12-D
6-E
1-F
2-G
9-G
13-H
3-H
10-I
5-I
15-K
16-K
19-L
17-L
RA 1 (Inclination 15°) Total Depth 98'.
RA2 (Inclination 15°) Total Depth 75'.
RA3 (Inclination 15°) Total Depth 75'.
12-D (Inclination 40°) Total Depth 50'.
14-D (Inclination 46°) Total Depth 100'
7-D (Inclination 45°) Total Depth 56
ORIG DEPTH 38½
General Graphic Scale

ASSUMPTIONS FOR CALCULATIONS

B. [illegible] water load and temperature stresses
Concrete: Compression [illegible] #/Sq.In.
Tension [illegible] #/Sq.In.
Shear 300 #/Sq.In.
When earthquake and other forces are included, allow 33% more

C. TOTAL HEAD OF WATER is figured up to El. 1137

D. SPILLWAY CAPACITY: 60000 Cu.Ft./Sec. Net crest length of Intrados = 585'

Maximum Head at	El. 1137'
Average Crest Line at	El. 1126'
Total Head above Crest	11'
Deduct Velocity Head $(\frac{60000}{[illegible]})^2 \div 2 \times 32.2$ =	2'
Height of water above Crest	9'

Check on Spillway Capacity $3.8 \times 585 \times 9^{3/2} = 60000$ Cu.Ft./Sec.

E. TEMPERATURE VARIATION
F = [illegible] in degrees Farenheit above and below closing temperature which is assumed to be the mean annual.
Elastic Modulus = 1500000 #/Sq.In. has been assumed, taking Temperature Expansion Coefficient for Concrete $C_T = 0.0000055$

F. EARTHQUAKE FORCES: 10% of Gravity
Increase in Water Pressure = 10%
Arches are figured for Earthquake Forces acting parallel to Canyon.
For Earthquake Forces acting crosswise to Canyon, the Dam is assumed to act mainly as a Shear Wall, with Arch Action of minor importance.

G. METHODS OF CALCULATION.
1. ARCHES AT EL. 1061 AND ABOVE are constant thickness, circular arches and have been figured according to Fowler's Curves.
2. ARCHES AT EL. 1041, 1011 and 981 are analyzed on Calculation Sheets C-2, C-3 and C-4 respectively according to the Theory of Elasticity, using the following Formulas, based on locating Origin at the Elastic Center:

Location of Elastic Center: $y_0 = \frac{\Sigma y_c \frac{\Delta s}{I}}{\Sigma \frac{\Delta s}{I}}$

Lateral Thrust at Elastic Center: $H_0 = -\frac{D_x}{A_x}$

Moment at Elastic Center: $M_0 = -\frac{D_\alpha}{C_\alpha}$

where: $A_x = \Sigma y^2 \frac{\Delta s}{I} + \Sigma \frac{\Delta s}{t} \cos^2\alpha + n\Sigma \frac{\Delta s}{t} \sin^2\alpha$

$C_\alpha = \Sigma \frac{\Delta s}{I}$

$D_\alpha = \Sigma \frac{\Delta s}{I} M_E$

$D_x = \Sigma \frac{\Delta s}{I} y M_E - (n-1)\Sigma(\frac{\Delta s}{t} \sin\alpha \cos\alpha \Sigma P_y) + \Sigma(\frac{\Delta s}{t} \cos^2\alpha \Sigma P_x) + n\Sigma(\frac{\Delta s}{t} \sin^2\alpha \Sigma P_x) + C_T F E_c X_a$

n = 2.4 to agree with Fowler Curves
$M_E = 0.5 H_i \Delta t$ where $H_i = .0625 R_e h$ (See Creager, Justin & Hinds p.48[illegible])

Extreme Fiber Stress = $p(\frac{H}{t} \pm \frac{M}{[illegible]})$
where: $p = \frac{R_e}{R_e + 0.5t}$ for extrados; $p = \frac{R_e}{R_e - 0.5t}$ for intrados (on fillet portion use [illegible])

3. ARCHES AT EL. 1051, 1031, 1021, 1001, 991 & 971 are analyzed by determining the statically indeterminate quantities from the following formulas:

$y_0 = C_y \times y_a$

$M_0 = C_M \times H_i \Delta t_a$

$H_0 = C_H \times \frac{H_i t_c t_a}{y_a^2}$

The coefficients C_y, C_M and C_H are interpolated between the known values for arches at El. 1061, 1041, 1011 and 981. As will be seen from the graph below, the geometrical determinants 2ϕ, R_e, t_c and t_a for the arches in question vary so regularly that such interpolation is allowable with negligible error. Note: Length of fillet in all cases is ¼ of the total length of arch.

4. BELOW EL. 971 no arch action can be expected, because of restraint in nearby rock. Stability of this portion has been investigated as a cantilever, using the thickest section at Sta. 9+35

H. SIGN CONVENTION
Ordinates and Angles — Deformations — Moments and Thrusts

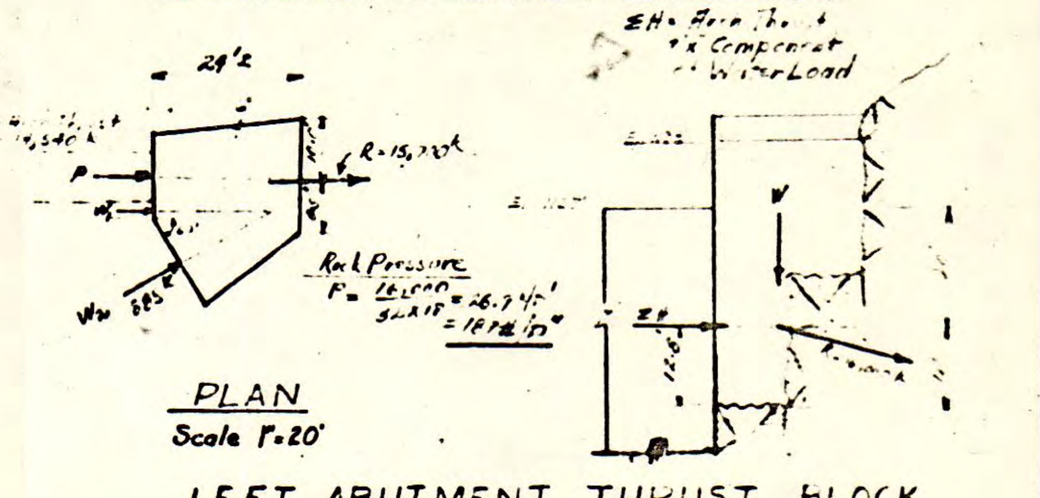
J. NOMENCLATURE (see also Arch sketches on Calculation Sheets C-2, C-3 and C-4)
α refers to angles on ℄ of Arch; β refers to angles on extended ℄ of constant thickness Arch (See Creager, Justin & Hinds, p.482)
$H_i = 0.0625 \times R_e \times h$ (in kips)
h = head below El. 1137 in feet
$I = \frac{t^3}{12}$ = Moment of Inertia of Arch Section in Ft.⁴
R_e = Radius for Extrados in feet
R_i = Radius for Intrados in feet
R_c = Radius for ℄ of Constant Thickness portion of Arch in feet
R_{fc} = Radius for ℄ of Fillet portion of Arch (average radius) in feet
R_{fi} = Radius for Intrados of Fillet in feet
Δs = Length of Arch Element
t = Thickness of Arch at any point
t_c = Thickness of Arch at Crown
t_a = Thickness of Arch at Abutment
$\Delta t_a = t_a - t_c$; $\Delta t = t - t_c$
x = Abscissa with origin at Elastic Center
y = Ordinate with origin at Elastic Center
y_c = Ordinate with origin at Crown
2φ = Total Included Angle on Intrados

SUMMARY OF ARCH ANALYSES

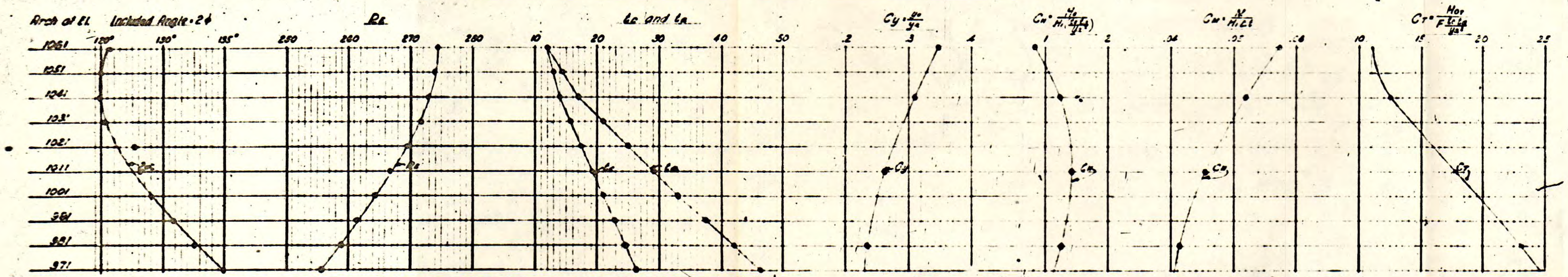
1 Arch Ring at El	2 Head below El 1137 h	3 Radius Extrados R_e	4 Radius of ℄ R_c	5 Thickness of Arch Crown t_c	6 Thickness of Arch Abut t_a	7 Total Arch L on Intrados 2φ	8 Cos α at Abut.	9 t_c/R_c	10 Arch Rise y_a	11 Elastic Cen. Dist fm Crown y_0	12 For Water Load H_i Kips	13 H_0 Kips	14 M_0 ft-kips	15 M_c ft-kips	16 M_a ft-kips
1101	36	280	276	8	8	128°43'		.0290							
1091	46	278	273.5	9	9	130°15'		.0328							
1081	56	276.5	271.5	10	10	129°10'		.0367							
1071	66	275.5	270	11	11	125°45'		.0405							
1061	76	274.5	268.5	12	12	121°30'	0.4986	.0444	137.3	47.2	1330	8.1	0	370	710
1051	86	274	267.5	13	14.5	119°55'	0.5118		128.5	42.5	1472	18.2	[illegible]	655	587
1041	96	273	266.0	14	17	119°52'	0.5295		121.1	37.6	1638	33.1	255	988	562
1031	106	271.75	263.88	15.75	21	120°30'	0.5310		119.0	34.6	1800	58.3	413	1547	563
1021	116	269.50	261.75	17.5	25	125°30'	0.5090		115.5	32.1	1955	91.4	755	2230	980
1011	126	266.75	257.12	19.25	29	126°15'	0.5210		109.66	28.73	2110	137.5	950	3025	1975
1001	136	264.50	254.00	21	33	128°10'	0.5265		103.5	25.9	2240	202	1130	4040	3515
991	146	261.55	250.17	22.75	37.5	131°50'	0.5237		97.2	23.4	2385	288	1510	5210	5160
981	156	259	246.75	24.5	42	135°00'	0.5270		90.7	21.4	2525	332	1825	6575	6875
971	166	254.75	241.62	26.25	46.5	140°00'	0.5225		83.5	19.0	2640	531	2150	8050	10300

1 Arch Ring at El	17 Water Load Crown f_e #/□"	18 Crown f_i #/□"	19 Abutment f_e #/□"	20 Abutment f_i #/□"	21 F	22 H_0	23 Temp. Drop M_c	24 M_a	25 Crown f_e #/□"	26 Crown f_i #/□"	27 Abutment f_e #/□"	28 Abutment f_i #/□"	29 Water Load & Temp. Drop Crown f_e #/□"	30 Crown f_i #/□"	31 Abutment f_e #/□"	32 Abutment f_i #/□"
1101	+590	+500	+452	+658	21°	0.3°	15.7	-31.4	+10	-11	-20	+20	+600	+489	+432	+658
1091	+652	+58[illegible]	+515	+746	20°	0.4°	21.2	-42.4	+11	-12	-22	+24	+693	+579	+493	+770
1081	+748	+62[illegible]	+555	+825	19°	0.6°	31.0	-62.0	+12	-13	-24	+26	+760	+609	+531	+849
1071	+785	[illegible]	+541	+891	18°	0.8°	39.2	-78.4	+13	-14	-26	+28	+798	+633	+515	+919
1061	+844	+664	+555	+973	17°	1.2°	54.9	-109.8	+14	-15	-28	+28	+858	+669	+527	+1001
1051	+915	+632	+569	+841	16°	2.10°	[illegible]	-151.0	[illegible]	-24	-35	+35	+985	+608	+534	+876
1041	+977	+539	+560	+767	15°	3.05°	115.0	[illegible]	+22	[illegible]	-36	+36	+993	+571	+524	+803
1031	+934	+526	+510	+670	14°	4.4°	[illegible]	[illegible]	+24	+30	-36	+38	+1018	+436	+464	+708
1021	+1006	+454	+441	+630	13°	[illegible]	213.0	-567.0	[illegible]	-34	-37	+39	+1032	+420	+404	+669
1011	+1010	+331	+352	+616	12°	[illegible]	[illegible]	-817.0	+27	[illegible]	-40	+41	+1037	+343	+312	+657
1001	+1012	+305	+286	+630	12°	[illegible]	[illegible]	[illegible]	+31	-44	-43	+46	+1043	+261	+243	+676
991	+1006	+235	+235	+626	11°	[illegible]	[illegible]	-1575.0	+32	-49	-45	+50	+1038	+186	+190	+676
981	+1001	+155	+192	+616	10°	29°	[illegible]	[illegible]	+33	-54	-45	+51	+1034	+101	+147	+667
971	+985	+77	+34	+640	10°	[illegible]	[illegible]	[illegible]	+36	-66	-53	+60	+1021	+11	+81	+700

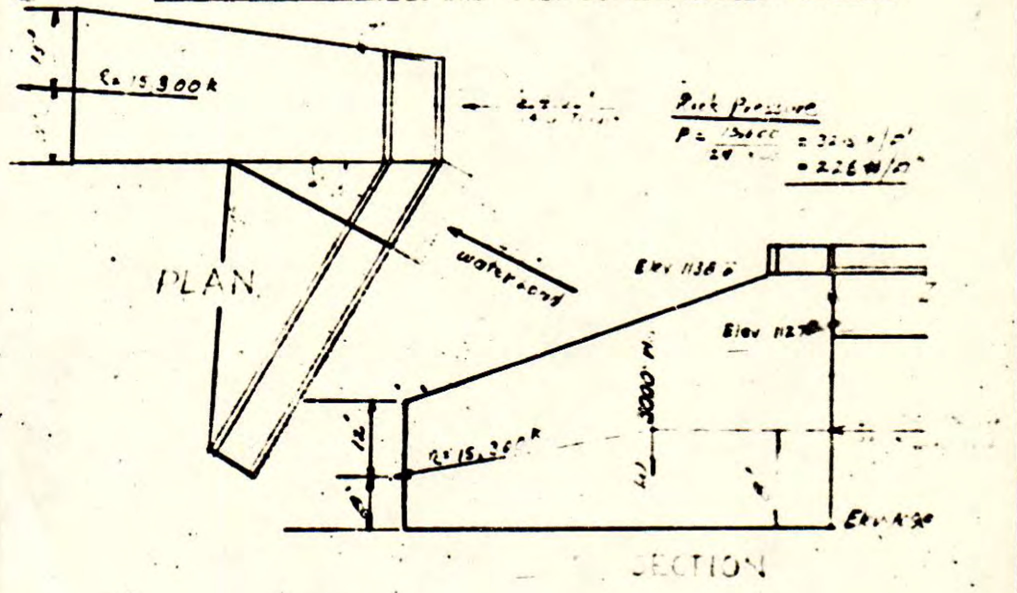
RIGHT ABUTMENT THRUST BLOCK



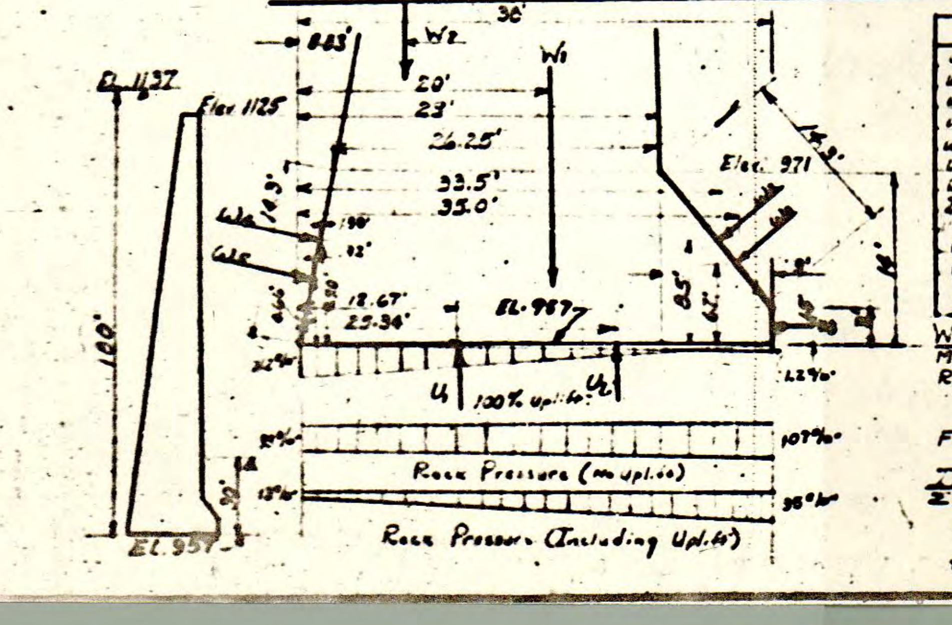
GRAPH FOR INTERPOLATION OF ARCH COEFFICIENTS



LEFT ABUTMENT THRUST BLOCK



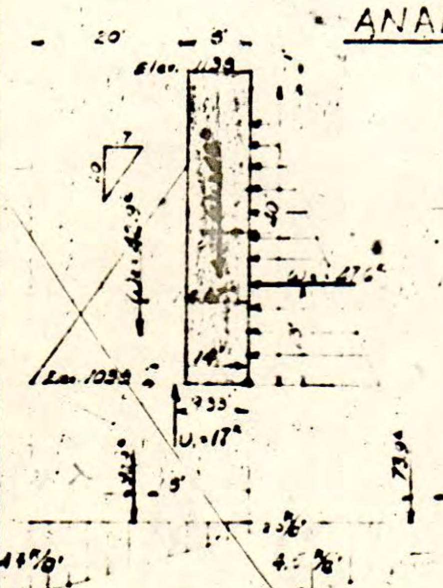
CANTILEVER ANALYSIS FOR SECTIONS BELOW ELEVATION 971



	P_y	P_x	x	y	$P_y x$	$P_x y$	M
W1	+410		+20.0		+8200		
W2	+9.0	-11.1	+33.5	8.5	+332	-94	
W3	+3.1	-3.8	+35.0	6.7	+105	-25	
W4	+28.4	+146.5	+1.38	7.0	+39	+1018	
W5	+1.1	+5.8	+.92	4.67	+1.0	+27	
W6		-5.6		1.5		-8	
W7	+94.5		8.83		835		
Σ	+546.1	+130.8			9512	+1118	+10632
U1	-213.6		12.67		-2700		
U2	-35.6		25.33		-900		
Σ	+296.9	+130.8			+5912	+1118	+7030

WITHOUT UPLIFT
Mom @ ℄ Base ΣM = 10630 − 546.1 × 9 = 5430 k
Rock Pressure $P = \frac{\Sigma P_y}{L} \pm \frac{\Sigma M}{\frac{1}{6}L^2}$ = [illegible]
= 14.4 ± 1.0 = 15.4 [illegible] = 107 [illegible]; 13.4 [illegible] = 93 [illegible]
FRICTION $f = \frac{\Sigma P_x}{\Sigma P_y} = \frac{130.8}{296} = .44$
INCLUDING UPLIFT
ΣM = 7030 − 296 × 19 = 1410 ᵏ
$P = \frac{296}{38} \pm \frac{1410}{\frac{1}{6} \times 38^2}$ = 7.8 ± 5.9 = 13.7 k/□' = 95 #/□"; 1.9 k/□' = 13 #/□"
$f = \frac{\Sigma P_x}{\Sigma P_y} = \frac{130.8}{296} = .44$

ANALYSIS OF GRAVITY ABUTMENTS



	P_y	P_x	ARM	M	
W1	48.0		0	430	Conc. Wt.
W2	42.3		+3.67	+79	
W3		47.6	+3	[illegible]	Water Load
Σ	90.3	47.6		[illegible]	
U1	-17.0		-4.67	+79	Uplift
Σ	73.9	47.6		+247	

Rock Pressure
$p = \frac{90.3}{25} \pm \frac{168}{\frac{1}{6} \times 25^2} = 3.2 \pm 1.2$ = 4.4 #/□"; 2.0 #/□"
Friction Coef. $f = \frac{47.6}{90.3} = 0.53$
Rock Pressure
$p = \frac{73.9}{28} \pm \frac{247}{\frac{1}{6} \times 28^2} = 2.6 \pm 1.9$ = +4.5 #/□"; +0.7 #/□"
Friction Coef. $f = \frac{47.6}{73.9} = 0.65$

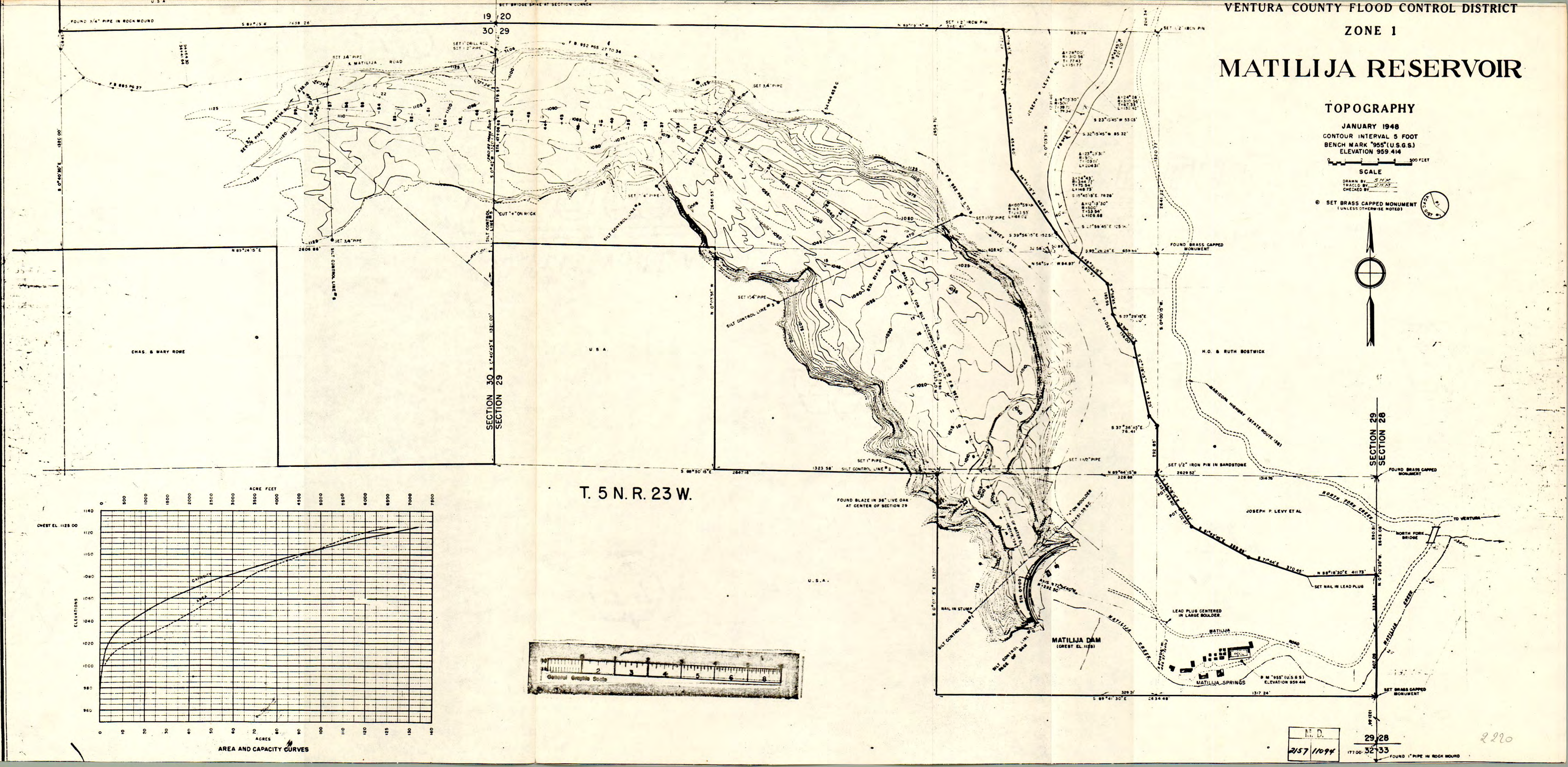
BUCKLING OF ARCHES

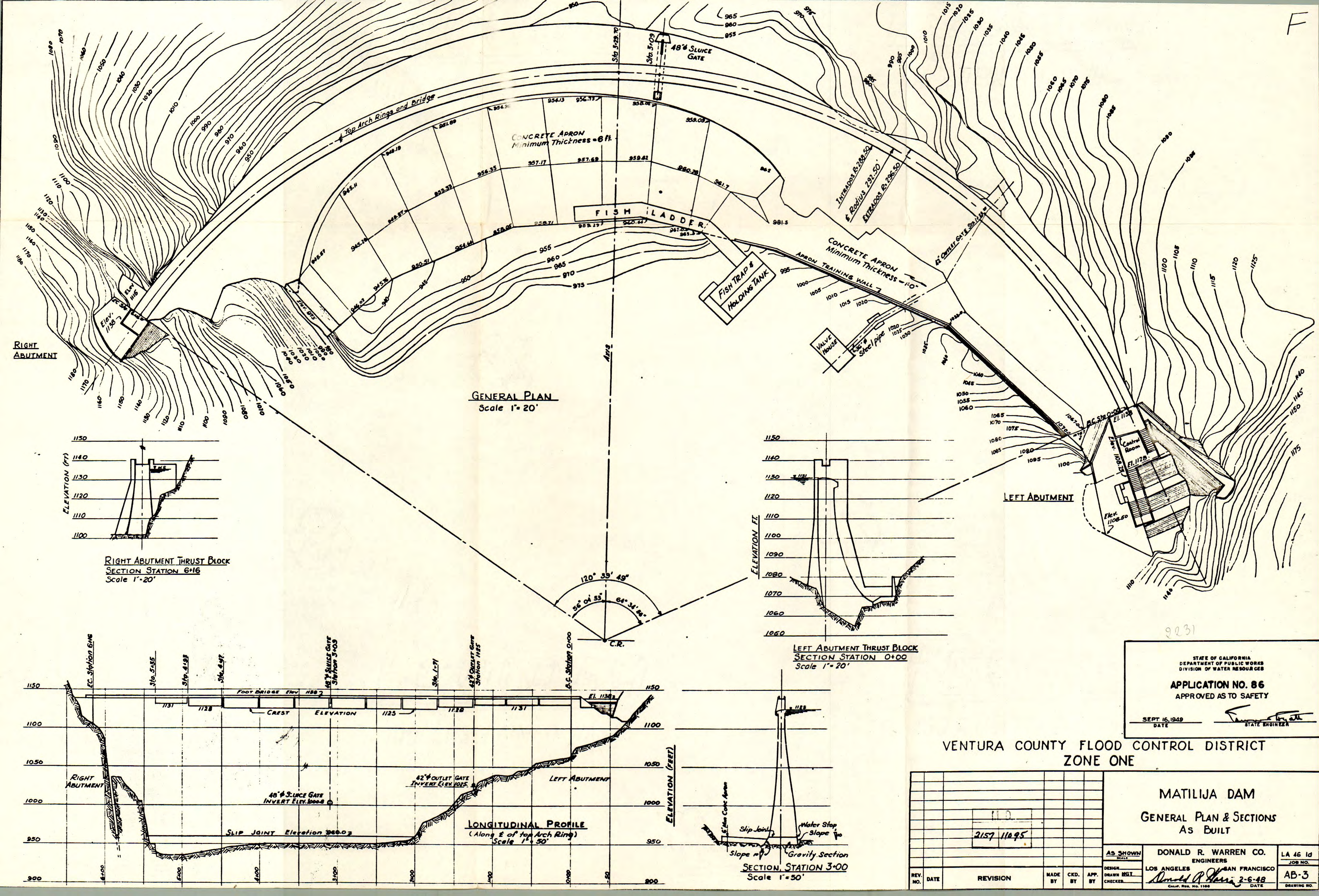
Critical Water Pressure for Arch at Elev. 1101 $P_{cr} = \frac{EI}{R_c^3}[(\frac{360}{2\alpha})^2 - 1]$
Using Elast. Modulus E = 3000 #/□" = 432 000 #/□' t = 8' R_c = 276' 2α = 128.7°
$P_{cr} = \frac{432000}{276^3} \times \frac{8^3}{12}[\frac{360^2}{128.7^2} - 1] = 6.8$ #/□'. Max. Available Water Pressure P = .0625 × 36 = 2.25 #
Safety Factor against Buckling $\frac{P_{cr}}{P} = \frac{6.8}{2.25} = 3.02$ Slenderness Ratio: $\frac{L}{t} = \frac{620}{8} = 77.5$ Recommended Min. = 30

REV. NO.	DATE	REVISION	MADE BY	CKD. BY	APP. BY
		2157 1109			

VENTURA COUNTY
FLOOD CONTROL DISTRICT ZONE I
MATILIJA DAM
SUMMARY OF COMPUTATIONS

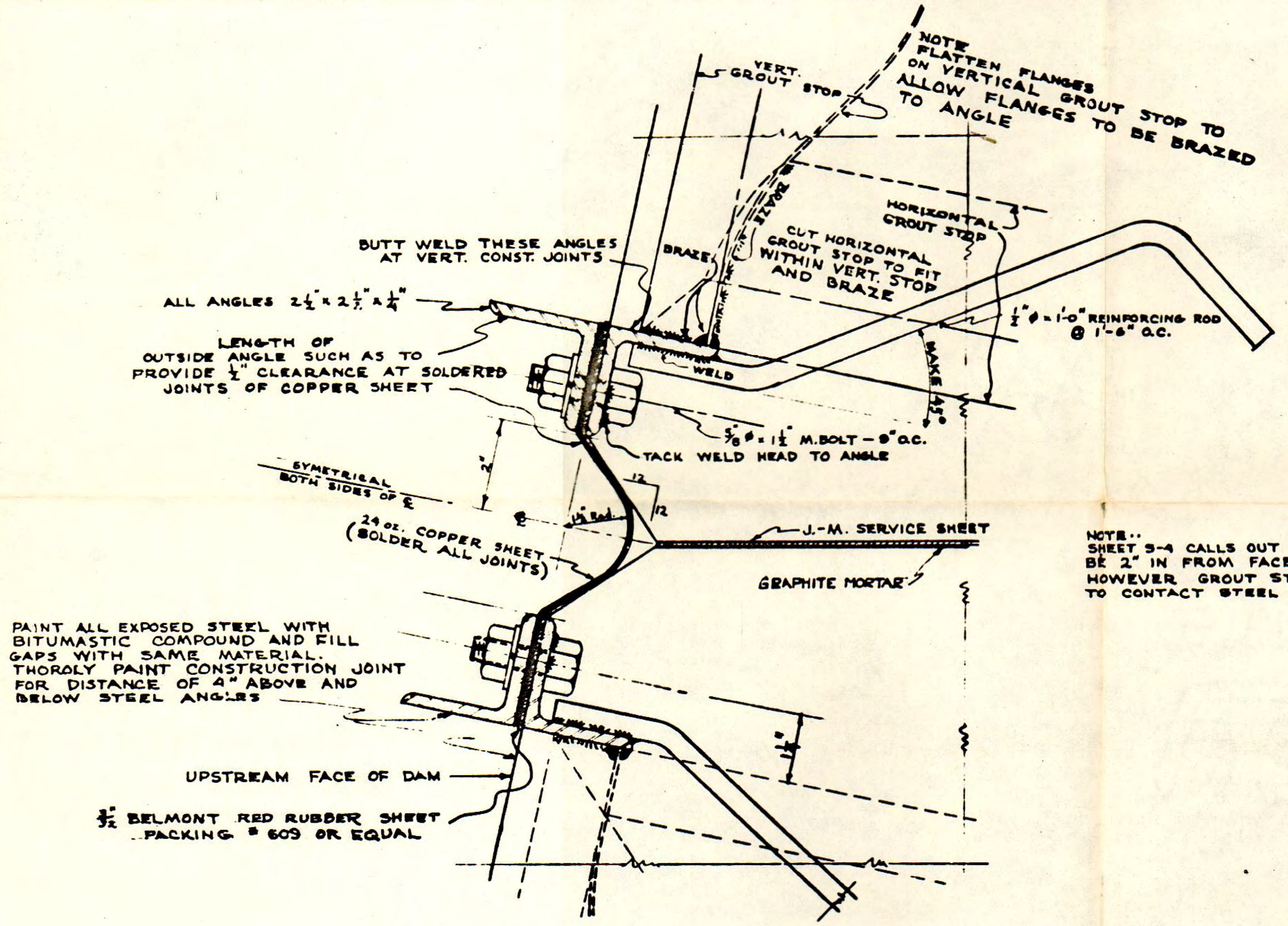
DESIGN [illegible] DRAWN F.S.F. CHECKED [illegible]
DONALD R. WARREN CO. ENGINEERS
LOS ANGELES SAN FRANCISCO
DATE 4-2[illegible]
LA48-16
C-1


VENTURA COUNTY FLOOD CONTROL DISTRICT
ZONE 1
MATILIJA RESERVOIR
TOPOGRAPHY
JANUARY 1948
CONTOUR INTERVAL 5 FOOT
BENCH MARK "955" (U.S.G.S.)
ELEVATION 959.414
SCALE
SET BRASS CAPPED MONUMENT (UNLESS OTHERWISE NOTED)
T. 5 N. R. 23 W.
SECTION 30
SECTION 29
SECTION 29
SECTION 28
CHAS. & MARY ROWE
U.S.A.
H.O. & RUTH BOSTWICK
JOSEPH P. LEVY ET AL
MARICOPA HIGHWAY (STATE ROUTE 150)
NORTH FORK CREEK
NORTH FORK BRIDGE
TO VENTURA
MATILIJA CREEK
MATILIJA DAM
(CREST EL. 1125)
MATILIJA SPRINGS
LEAD PLUG CENTERED IN LARGE BOULDER
FOUND BLAZE IN 36" LIVE OAK AT CENTER OF SECTION 29
FOUND BRASS CAPPED MONUMENT
SET 1/2" IRON PIN IN SANDSTONE
SET NAIL IN LEAD PLUG
SET BRASS CAPPED MONUMENT
FOUND 1" PIPE IN ROCK MOUND
FOUND 3/4" PIPE IN ROCK MOUND
SILT CONTROL LINE
CREST EL. 1125.00
ACRE FEET
ELEVATIONS
ACRES
CAPACITY
AREA
AREA AND CAPACITY CURVES
General Graphic Scale
M.D.
2157 11094
2220



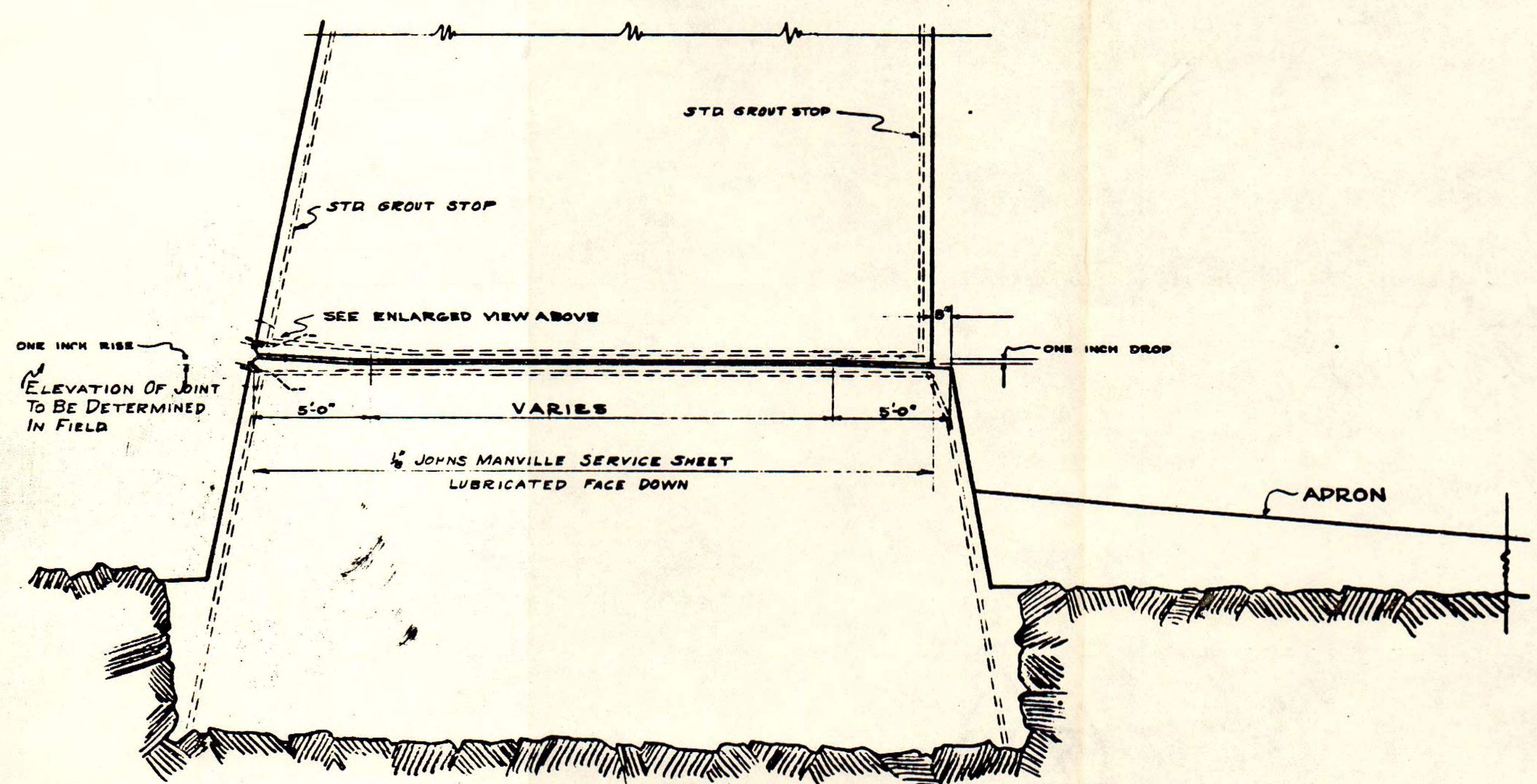
F
Top Arch Rings and Bridge
48" ⌀ Sluice Gate
Concrete Apron
Minimum Thickness = 6 ft.
Fish Ladder
Fish Trap & Holding Tank
Intrados R. 289.50
℄ Radius 292.50
Extrados R. 296.50
Concrete Apron
Minimum Thickness = 1.0'
Apron Training Wall
Valve House
Steel pipe
Right Abutment
Left Abutment
Control Room
General Plan
Scale 1" = 20'
120° 33' 49"
56° 01' 53"
64° 31' 56"
C.R.
Axis
Right Abutment Thrust Block
Section Station 6+16
Scale 1" = 20'
Elevation (ft)
Left Abutment Thrust Block
Section Station 0+00
Scale 1" = 20'
Elevation Ft.
Foot Bridge Elev. 1138
Crest Elevation
Slip Joint Elevation 960.07
Right Abutment
Left Abutment
48" ⌀ Sluice Gate Invert Elev. 1000.8
42" ⌀ Outlet Gate Invert Elev. 1025
Longitudinal Profile
(Along ℄ of top Arch Ring)
Scale 1" = 50'
Elevation (feet)
Slip Joint
Water Stop
Gravity Section
Section, Station 3+00
Scale 1" = 50'
9231
State of California
Department of Public Works
Division of Water Resources
Application No. 86
Approved as to safety
Sept 16, 1949
Date
State Engineer
Ventura County Flood Control District
Zone One
Matilija Dam
General Plan & Sections
As Built
As Shown
Donald R. Warren Co.
Engineers
Los Angeles San Francisco
2-6-48
LA 46 Id
Job No.
AB-3
Drawing No.
Rev. No. Date Revision Made by Ckd. by App. by
2157 11095

F

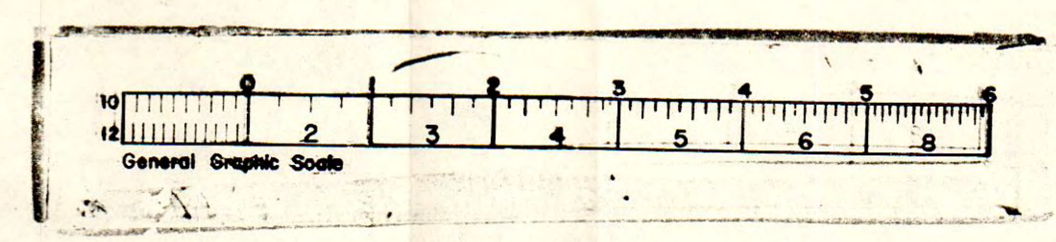


ENLARGED VIEW OF COPPER WATER STOP
SCALE ½" = 1"

NOTE:
SHEET S-4 CALLS OUT FOR GROUT STOP TO BE 2" IN FROM FACE OF CONCRETE. HOWEVER GROUT STOP MAY BE WARPED TO CONTACT STEEL ANGLES AS SHOWN



TYPICAL CROSS SECTION
SCALE ¼" = 1'-0"



M.D.
2157 11096

VENTURA COUNTY FLOOD CONTROL DISTRICT
ZONE I

2240

MATILIJA DAM

86

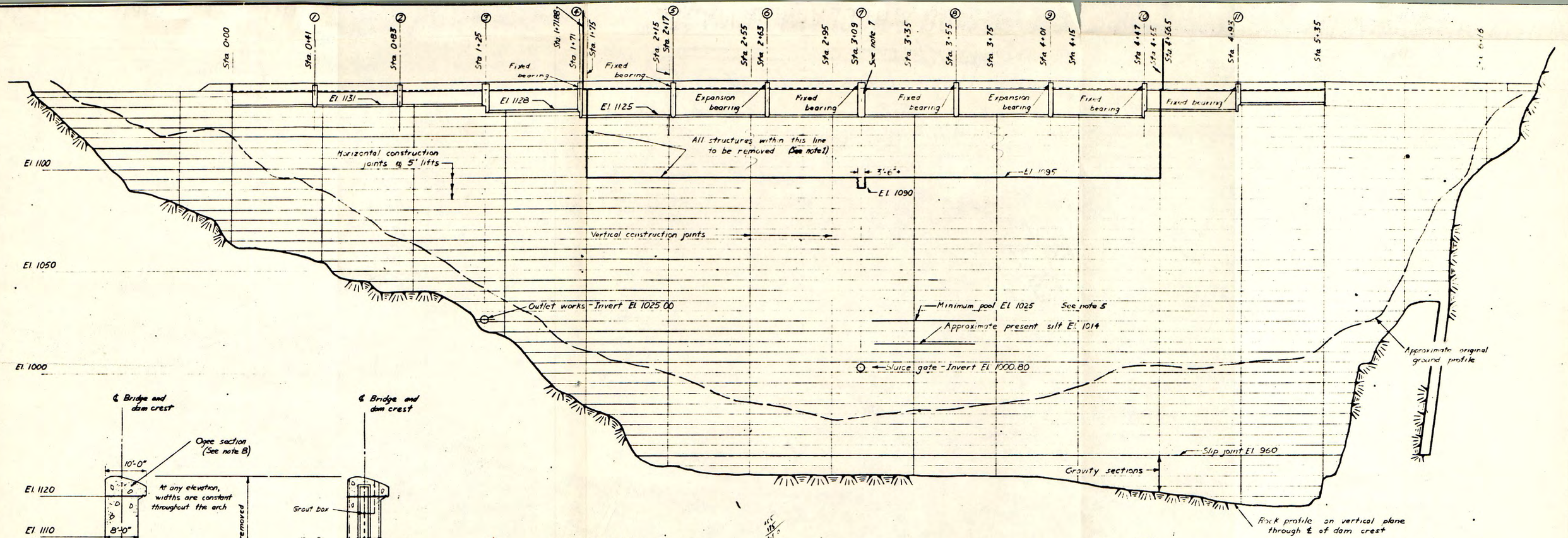
SLIP JOINT DETAILS

REV. NO.	DATE	REVISION	MADE BY	CKD. BY	APP. BY
		As Built			
1	3/29/46	GRAPHITE MORTAR ADDED.	A.H.		

As Shown (SCALE)
DESIGN
DRAWN C.J.A.
CHECKED

DONALD R. WARREN CO.
ENGINEERS
LOS ANGELES SAN FRANCISCO
Donald R. Warren
CALIF. REG. No. 1166
8-23-46 DATE

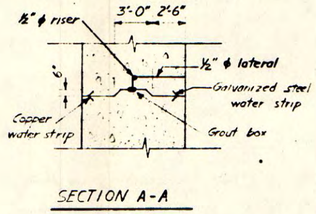
LA-46-IC JOB NO.
S-10 DRAWING NO.



SECTION AT STA. 2+00

SECTION AT TYPICAL CONSTRUCTION JOINT

Showing grouting system as installed (See note 2)



SECTION A-A

DEVELOPED ELEVATION ON UPSTREAM FACE

20 0 20 40 60 80 FT.
1 in. = 20 ft.

10 0 10 20 30 40 FT.
1 in. = 10 ft.

5 0 5 10 FT.
1 in. = 5 ft.

REFERENCE DRAWINGS

5214-R-2	General Layout
5214-R-4	Reinforcement Steel for Concrete to be Removed
5214-R-5	Metalwork to be Removed from Pier No. 7.
5214-R-8	Electrical Work

NOTES

1. See specifications for requirements concerning removal of concrete by blasting.
2. All embedded metalwork or reinforcement steel, whether shown or not, will be considered as part of the concrete to be removed.
3. See specifications for disposal area.
4. All structures and equipment shall be protected from damage at all times.
5. The District will maintain a pool of minimum elevation 1025. See specifications for more details.
6. For details of reinforcement in piers and bridge - See drawing 5214-R-4.
7. For details of metalwork to be removed from pier no. ⑦ - See drawing 5214-R-5.
8. Concrete to be removed above El. 1120 other than piers and bridge is designated "Ogee Section."

Approved		By	Chief Engineer
Approved 9-4-63		By J. L. Wiles	Chief FC Engr.
Approved			Dir. of Pub. Wks.

No.	DATE	REVISIONS	BY	CHK'D	ENG'R	FC ENG'R	CNTY SURV	CLIENT
1	9/4/63	Issued for Construction	GWS	MM	NHN	EJT	JGT	

SCALE | DESIGNED MM / NHN | DRAWN Bauman

BECHTEL CORPORATION
SAN FRANCISCO

COUNTY OF VENTURA
DEPARTMENT OF PUBLIC WORKS
FLOOD CONTROL DISTRICT
MATILIJA DAM - REMEDIAL WORKS

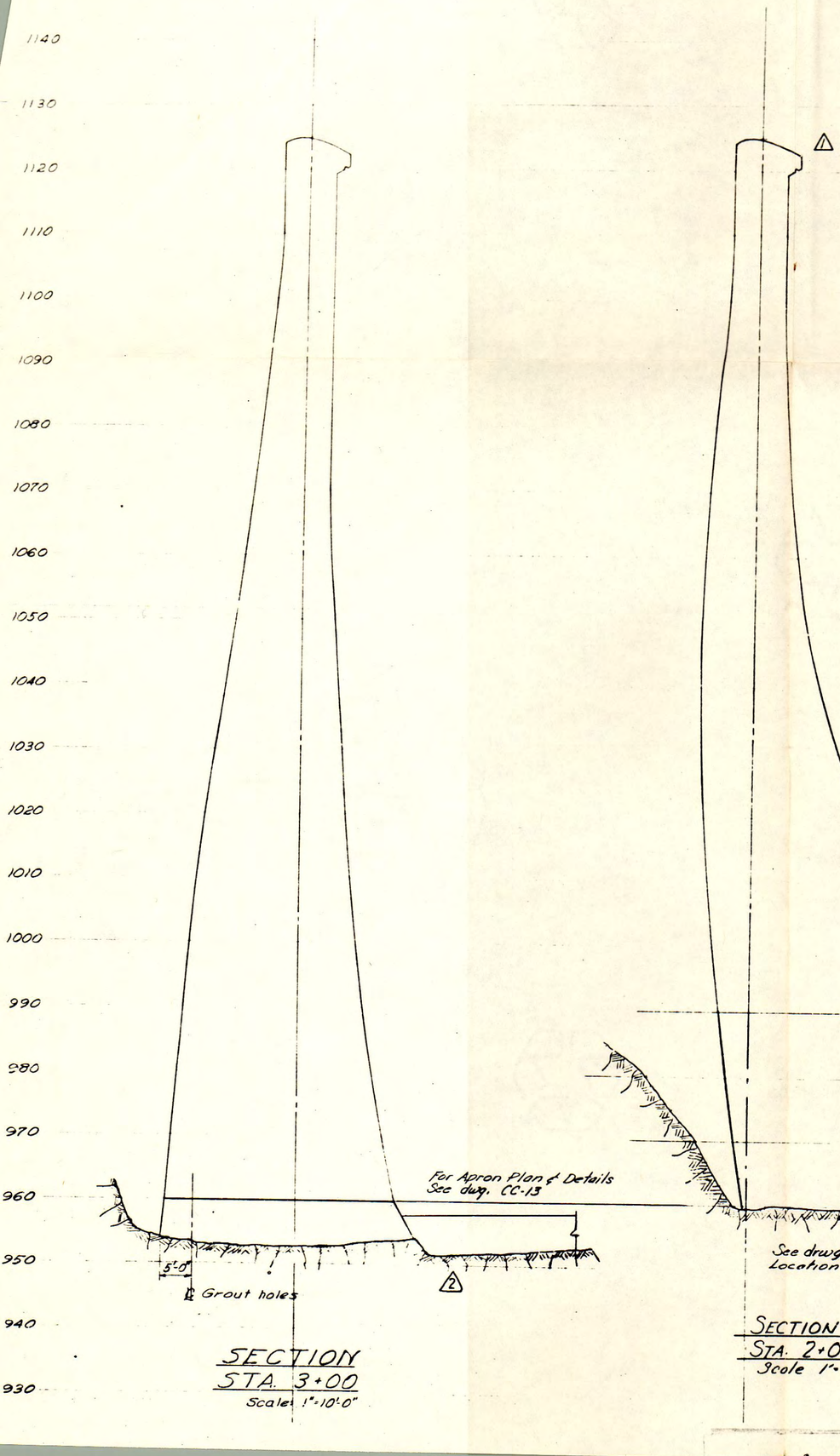
DAM CONCRETE TO BE REMOVED

REGISTERED CIVIL ENGINEER — J. GEORGE THOM — NO. 8397 — STATE OF CALIFORNIA

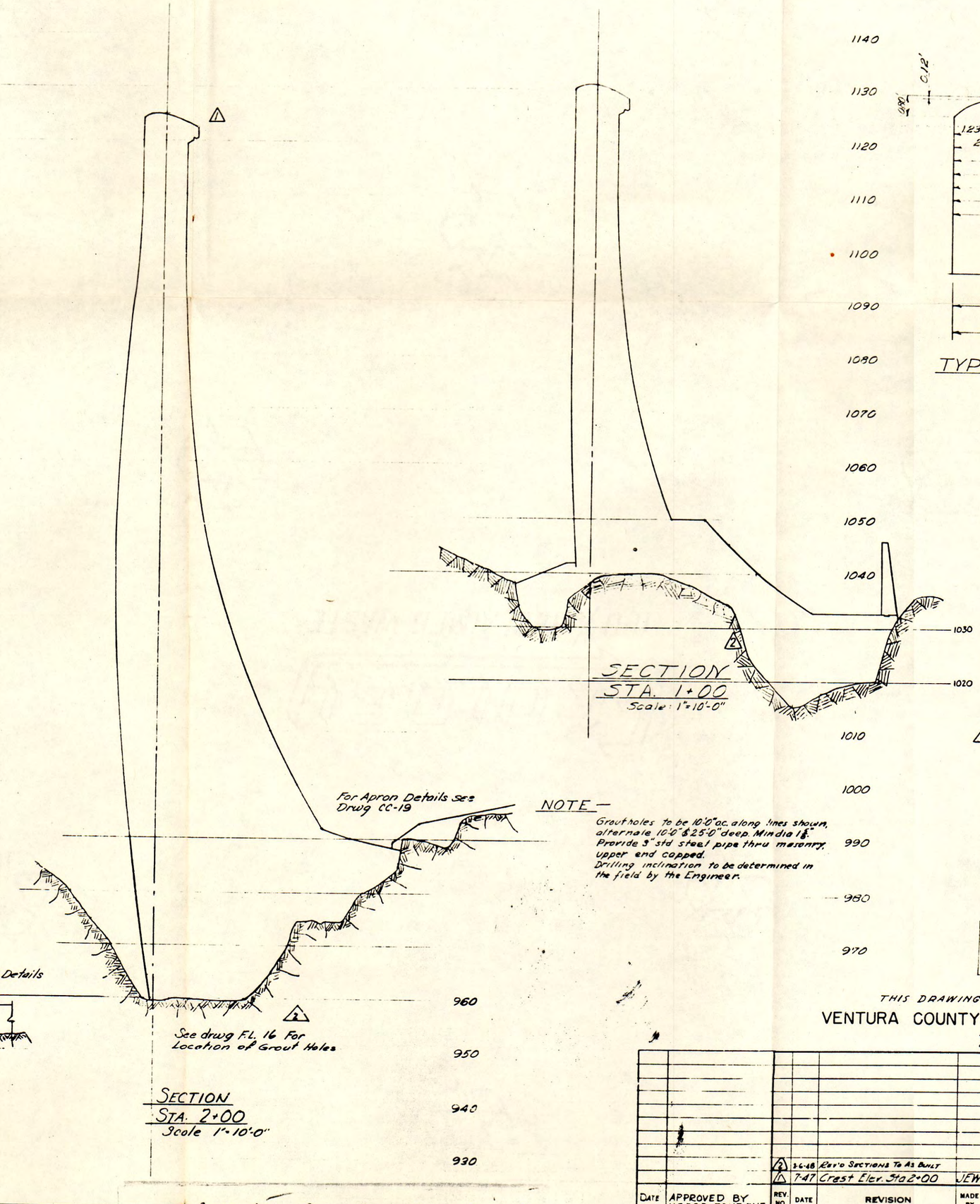
BECHTEL

JOB No.	DRAWING No.	REV.
5214	5214-R-3	0

F

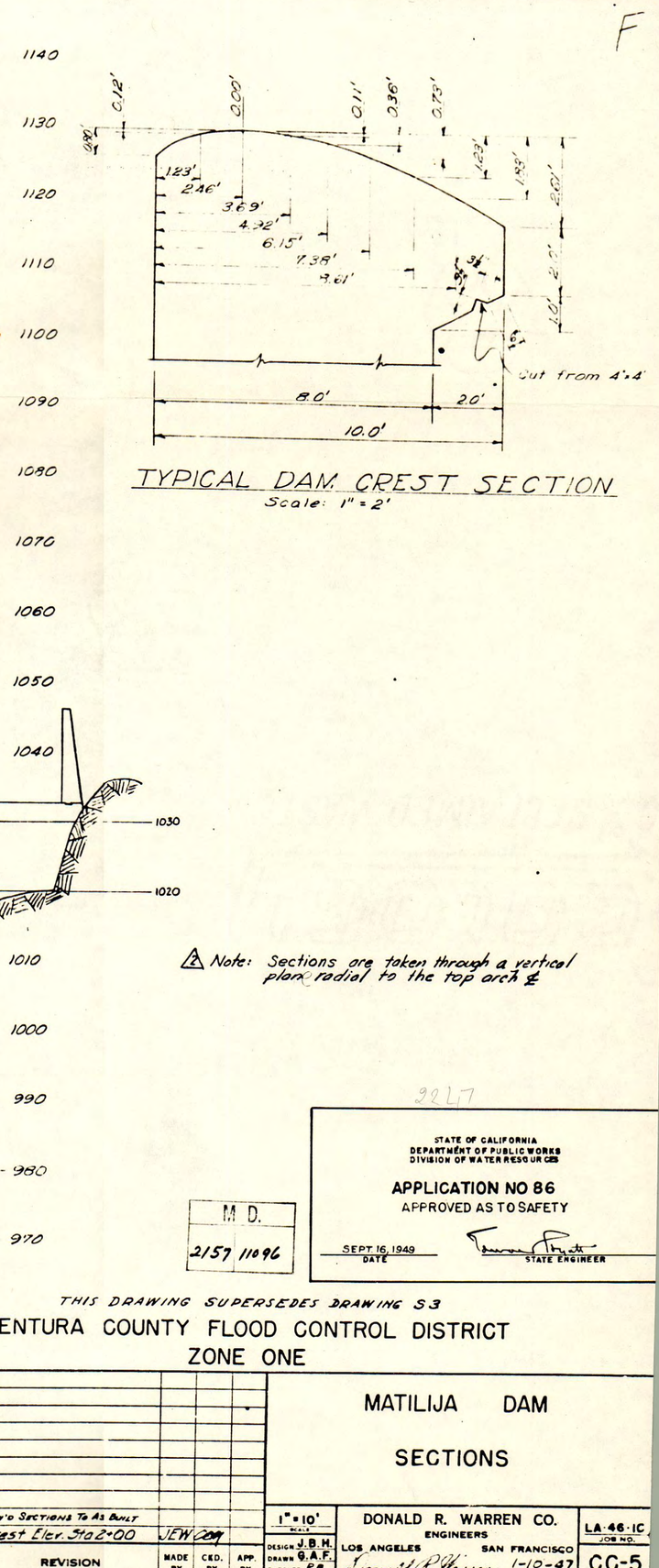


SECTION
STA. 3+00
Scale: 1"=10'-0"



SECTION
STA. 2+00
Scale 1"=10'-0"

SECTION
STA. 1+00
Scale: 1"=10'-0"



TYPICAL DAM CREST SECTION
Scale: 1" = 2'

2 Note: Sections are taken through a vertical plane radial to the top arch ℄

NOTE —
Grout holes to be 10'0" oc. along lines shown, alternate 10'0" & 25'0" deep. Mindia 1½". Provide 3" std steel pipe thru masonry, upper end capped. Drilling inclination to be determined in the field by the Engineer.

M. D.
2157 | 11096

9247

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
APPLICATION NO 86
APPROVED AS TO SAFETY
SEPT 16, 1949 DATE
STATE ENGINEER

THIS DRAWING SUPERSEDES DRAWING S 3

VENTURA COUNTY FLOOD CONTROL DISTRICT
ZONE ONE

MATILIJA DAM

SECTIONS

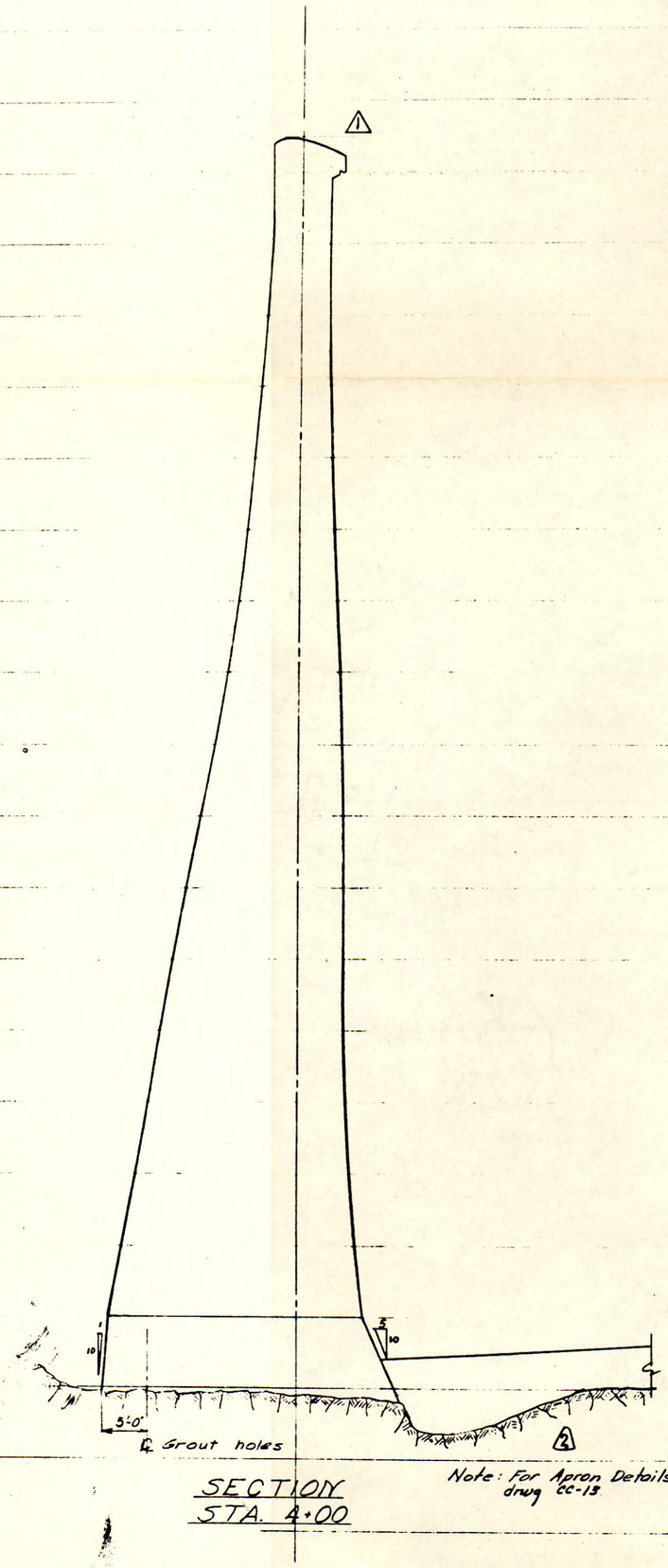
DATE	APPROVED BY V.C.F.C.D. ZONE ONE

REV. NO.	DATE	REVISION	MADE BY	CKD. BY	APP. BY
2	3-6-48	Rev'd Sections To As Built			
△	7-47	Crest Elev. 3+02+00	JEW		

1" = 10' SCALE
DESIGN J.B.H.
DRAWN G.A.F.
CHECKED R.S.

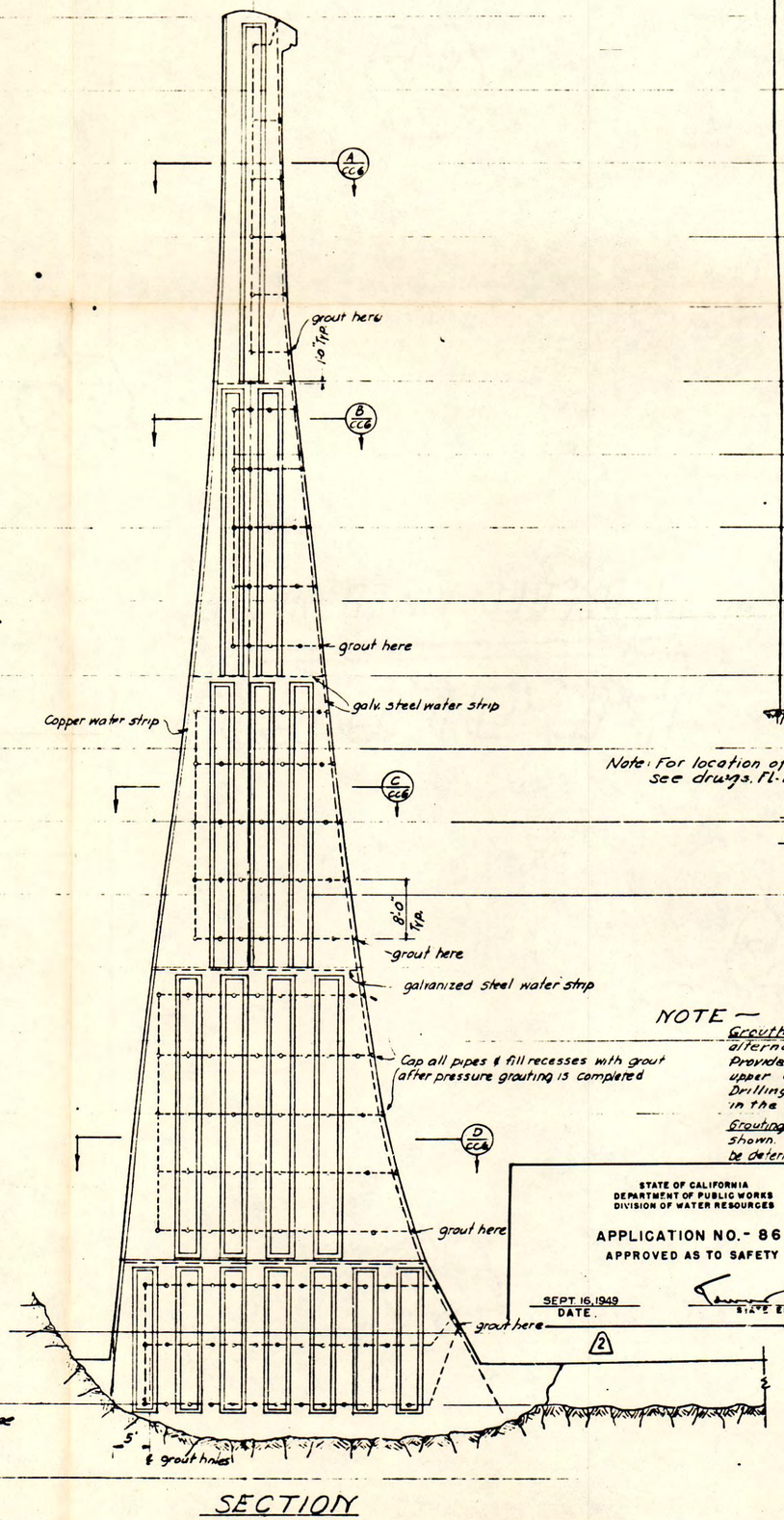
DONALD R. WARREN CO.
ENGINEERS
LOS ANGELES SAN FRANCISCO
Donald R. Warren
Calif. Reg. No. 1158
1-10-47 DATE

LA-46-IC JOB NO.
CC-5 DRAWING NO.

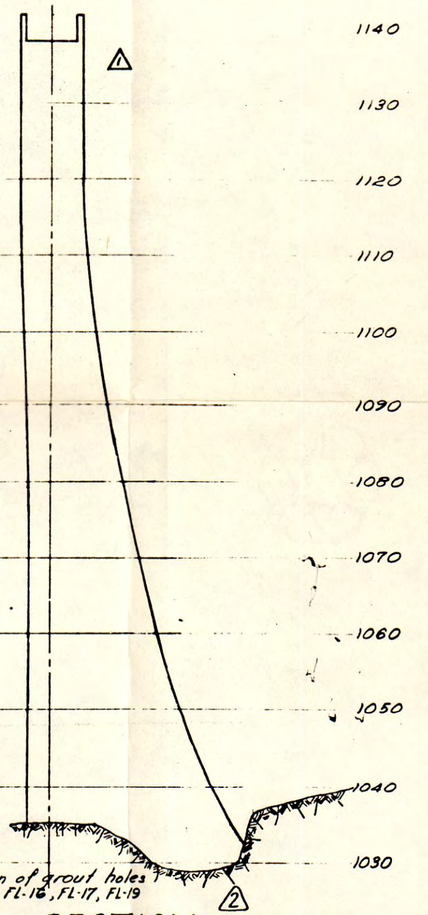


SECTION
STA. 4+00

Note: For Apron Details See drwg CC-13



SECTION
STA 5+00



Note: For location of grout holes see drwgs. FL-16, FL-17, FL-19

SECTION
STA. 5+75

NOTE —

Groutholes to be 10'-0" oc. along lines shown, alternate 10'-0" & 25'-0" deep. Min. dia. 1½". Provide 3" std. steel pipe thru masonry, upper end capped. Drilling Inclination to be determined in the field by the Engineer.

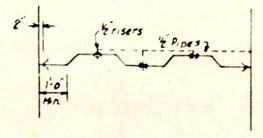
Grouting System for typical contraction joint shown. Location of risers & grout boxes to be determined in the field by the Engineer.

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

APPLICATION NO. - 86
APPROVED AS TO SAFETY

SEPT 16, 1949
DATE

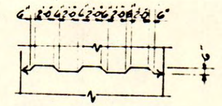
STATE ENGINEER



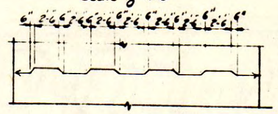
TYPICAL GROUT DETAIL
No Scale

SECTION (A/CC6)
Scale ⅛" = 1'-0"

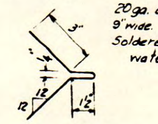
SECTION (B/CC6)
Scale ⅛" = 1'-0"



SECTION (C/CC6)
Scale ⅛" = 1'-0"

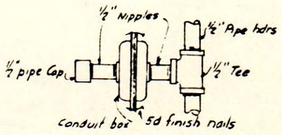


SECTION (D/CC6)
Scale ⅛" = 1'-0"



20 ga. annealed copper strip 9" wide. Ends copper riveted & Soldered to make a continuous water tight strip

COPPER WATER STRIP
GALV. STEEL WATER STRIP SIMILAR
No Scale



TYPICAL GROUT CONDUIT BOX
No Scale

960 THIS DRAWING SUPERSEDES DRAWING S4

VENTURA COUNTY FLOOD CONTROL DISTRICT
ZONE ONE

9248

M. D.
2157/1096

REV. NO.	DATE	REVISION	MADE BY	CKD. BY	APP. BY
2	2-6-48	Revd Sections To As Built	H.G.T.		
1	7/47	Spillway Steps & Bridge	JEW		

MATILIJA DAM

SECTIONS

1" = 10' SCALE

DESIGN J.D.H.
DRAWN G.A.F.
CHECKED

DONALD R. WARREN CO.
ENGINEERS
LOS ANGELES SAN FRANCISCO
Calif. Reg. No. 1186
1-10-47 DATE

LA-46-IC JOB NO.

CC-6 DRAWING NO.

APPENDIX 6

Concrete Test Reports

a. 1 cylinder break from construction February 1947
b. Table 1 from Reference 5

COPY

SMITH-EMERY COMPANY
620 SANTEE STREET
LOS ANGELES, CALIFORNIA

MATILIJA DAM

29

COPY

Lab. No. P120564 CONCRETE MIXTURE DESIGN REPORT

Matilija Dam DATE February 13, 1947

RESS Atkinson, Kier, Bressi, & Berenda Constr. Co.

RESS CONCRETE MIXTURE DESIGN NUMBER 47-41

MBER OF SACKS OF CEMENT PER CUBIC YARD OF CONCRETE 5.00

LLONS OF WATER PER SACK OF CEMENT - - - ALLOWABLE 5.9 DESIGNED 5.9 W/C .787

PORTIONS W.C. Sand- Saticoy Rock Co. Saticoy, California

RCE OF MATERIAL Gravel Cons. Rock Prodc. Co. PLANT Irwindale, California

NED CONCRETE SAND - - - - - - - CLAY AND LOAM 1.6 % ORGANIC MATTER OK

VE ANALYSIS

FINE AGGREGATES — PER CENT PASSING TYLER STANDARD SIEVE

MATERIAL	3"	1-1/2"	1"	1/2"	NO. 4	NO. 8	NO. 14	NO. 28	NO. 48	NO. 100	F. M.
% W. C. SAND	100.0	100.0	100.0	100.0	97.4	84.0	65.3	42.0	15.5	4.5	2.913
% FINE											
D BLEND											

COARSE AGGREGATES — PER CENT PASSING TYLER STANDARD SIEVE

RAVEL	100.0	100.0	77.4	17.7	1.4						7.035
E GRAVEL	100.0	100.0	4.0								7.960
E MIX	100.0	20.4									8.796
	100.0	76.9	42.6	32.7	29.4	25.2	19.6	12.6	4.7	1.4	6.549

SPECIFIC GRAVITY (SATURATED AND SURFACE DRY)

AGGREGATE 1 2.593 2 2.692 3 2.720

E AGGREGATE 1 2.667

DESIGN FOR ONE CUBIC YARD OF CONCRETE (SATURATED AND SURFACE DRY PROPORTIONS)

K = ABSOLUTE VOLUME OF AGGREGATES IN ONE CUBIC YARD OF CONCRETE.

Cf = CEMENT FACTOR IN SACKS OF CEMENT IN ONE CUBIC YARD OF CONCRETE.

W/C = WATER CEMENT RATIO.

0.48 = ABSOLUTE VOLUME OF ONE SACK OF CEMENT.

GM = SPECIFIC GRAVITY OF AGGREGATES IN ONE CUBIC YARD BATCH.

B = WEIGHT OF AGGREGATES IN ONE CUBIC YARD BATCH OF CONCRETE.

NOTE: This mix to be used ONLY with 0.3# type 1 pozzolith admixture per sack of cement. 2"to3" slump 3000 P.S.I. at 28 days with type 2 cement.

27 − Cf (W/C + 0.48) = 20.665 CUBIC FEET = 2.6657

$$+\frac{.30}{2.593} + \frac{.15}{2.667} + \frac{.26}{2.692} + \frac{.29}{2.720}$$

K X GM X 62.5 = 3442.92 POUNDS

	% B	BATCH	SP. GR.	ABSOLUTE VOLUMES	
SAND	30.0	1032.88	2.593	6.373	CUBIC FEET
AVEL 1"	15.0	516.43	2.667	3.098	CUBIC FEET
EL 1-1/2"	26.0	895.16	2.692	5.320	CUBIC FEET
RAVEL 3"	29.0	998.45	2.720	5.873	CUBIC FEET
		245.74		3.935	CUBIC FEET
		470.00		2.400	CUBIC FEET
			TOTAL	26.999	CUBIC FEET

SATURATED AND SURFACE DRY PROPORTIONS FOR

CK BATCH SACK BATCH

ND 206.58 POUNDS POUNDS

E 1" 103.29 POUNDS POUNDS

EL 1-1/2" 179.03 POUNDS POUNDS

VEL 3" 199.69 POUNDS POUNDS

RESPECTFULLY SUBMITTED:

Smith-Emery Co

INSPECTING AND TESTING ENGINEERS

Rec 2-25-47

Table 1

LABORATORY TEST RESULTS

Boring/ Specimen Number*	Depth** (feet)	Bulk Specific Gravity	Static Young's Modulus ($\times 10^6$ psi)	Poisson's Ratio	Compressive Strength (psi)	Tensile Strength (psi)
1	61	2.34	4.14	.02	7,000	628
2	61	2.37	2.66	.05	5,945	628
3	61	2.37	3.77	.25	5.622	526
4	151		4.20	.04	6,637	611
5	151	2.36	4.06	.07	5,593	600
6	151		3.59	.09	5,951	574
B1	5	2.35	2.78	.06	4,384	1,271
B3	54		4.13			95
B4	66	2.31	2.72	.09	7,158	1,326
B5	79	2.35	3.62	.34	6,530	1,299
B5	91		3.87	.05	7,850	1.066
C3	42	2.35	1.13	.05	4,842	1,081
C4	56	2.36	2.55	.29	5,115	1,277
C7	112 (Rock)		2.24	.08	19,206	2,150
C8	141 (Rock)				19,957	
C9	167 (Rock)	2.61	2.19	.27	3,663	70
A2	38.5				2,505	760
A3	50	2.28	3.74	.03	5,726	1,104
A4	70	2.31	2.05	.10	4,928	1,318
A5	80	2.38	3.24	.06	6,138	1,007
A6	90	2.34	2.94	.30	7,098	1,544
A7	110		3.82	.14	7,537	978
A8	132	2.34	5.62	.21	7,728	1,339
A9	150	2.30	2.13	.07	6,388	1,406
A10	170	2.25	2.29	.10	5,732	1.069
A12	202 (Rock)		3.36	.19	5.221	

* Boring numbers 1 through 6 are horizontal and were drilled from the face of the dam. Borings A, B and C are vertical holes drilled from the crest of the dam (see Drawing HR-11-038).

** Depth is measured from El. 1128, crest of dam.