CR

1997 SUPPLEMENT TO

MATILIJA DAM

1996 CONCRETE EVALUATION

VENTURA COUNTY PUBLIC WORKS AGENCY
VENTURA COUNTY FLOOD CONTROL DISTRICT
NOVEMBER 1997

BTC LABORATORIES, INC. 2978 SEABORG AVENUE, VENTURA, CALIFORNIA 93003 805-656-6074

BtC Laboratories Incorporated

2978 SEABORG AVENUE, VENTURA, CA 93003 • 805/656-6074

January 26, 1998

JOB NUMBER: 96-8432-VO2
LAB NUMBER: 970191

Mr. Alex Sheydayi, Deputy Director
Ventura County Flood Control District
800 South Victoria Avenue
Ventura, California 93009-1600

ATTENTION: Mr. Charles Burton, P.E., Project Engineer

Gentlemen:

We are pleased to submit herewith the "1997 Supplement to Matilija Dam, 1996 Concrete Evaluation" with final modifications. The report expands on data contained in the 1996 concrete evaluation of Matilija Dam specifically upper dam concrete (elevation 1068).

All concrete segments and pieces will be retained at our laboratory for a minimum of 6 months, except for petrographic specimens which were delivered to Construction Technology Lab.

We appreciate the opportunity to provide this additional information and, if there are any questions, please feel free to call.

Respectfully,

BTC LABORATORIES, INC.

F.L. Franklin, P.E.
Vice President

FLF:hra

LTR

TABLE OF CONTENTS

SUPPLEMENT SUMMARY

This supplement to the 1996 Matilija Dam Concrete Evaluation provides additional and important data for consideration in evaluating the upper dam concrete. With additional strength values from cores taken from the upstream dam face, we can now compare values from the 1975 International Engineering Company's (IECO) investigation with data obtained from cores taken at approximately the same location. This supplemental evaluation deals only with concrete in the upper portion of the dam, specifically at elevation 1068.

With the information obtained from the three additional cores, condition of the concrete can be summarized as follows:

1. Concrete in the areas of cores D-1 and U-1 (core #1) improves in physical strengths values progressively from the downstream dam face to the upstream dam face. Condition of the concrete is further confirmed by the degree and extent of ASR found in the petrographic examination and gel fluorescence tests. It is apparent from the data available, the lower strength concrete in this area of the dam (core D-1 and U-1) can be attributed to Alkali Silica Reactivity.
   Strength values obtained from upstream core tests indicate generally lower values than cores from approximately the same location taken in 1975 as presented in IECO's report, but slightly better values than found in the core taken from the downstream dam face for our 1996 concrete evaluation.

2. Concrete in the area of core #2 (D2 and U2) has been moderately affected by ASR but strength values may not be significantly less than IECO 1975 values. ASR is more prevalent in the concrete toward the downstream face and strength values seem to decrease from upstream to downstream at elevation 1068.

3. Concrete in the area of core #3 (D3 and U3) has strength values comparable to those presented in the IECO 1975 investigation. Petrographic analysis and gel fluorescence results indicate less ASR in this area at this elevation (1068) and less potentially reactive particles than found in concrete represented by cores #1 (D1 and U1) and #2 (D2 and U2).

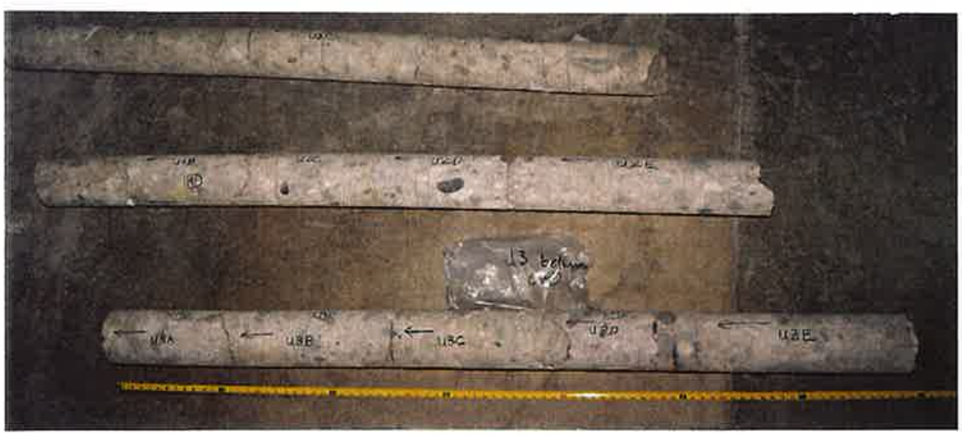
Part 1S PURPOSE AND SCOPE OF THIS SUPPLEMENT

Reference is made to Matilija Dam Concrete Evaluation 1996 by BTC Laboratories, Inc., November 1996, which is the document to which this supplement provides additional information relative to dam concrete.

The above referenced report provided information on current strength properties of dam concrete which were compared with strength values from a 1975 investigation by International Engineering Company, Inc. (IECO). As indicated in the 1996 evaluation, strength properties of cores taken from the downstream face of the dam were compared with cores from the upstream face taken for the IECO investigation. This upstream/downstream comparison showed the greatest variation between the 1996 sampling and the IECO 1975 evaluation.

Subsequent to completing the 1996 evaluation, the Ventura County Flood Control District investigated the possibility of coring the upstream dam face at elevation 1068 in order to obtain specimens more closely related to cores from the 1975 IECO investigation. With cooperation of Casitas Water District, lake water level was lowered allowing access to elevation 1068 on the upstream face and cores were obtained at approximately the locations of IECO's 1975 core numbers 1, 2 and 3. They were also approximately opposite the cores taken from the downstream face for the BTC 1996 evaluation.

Upstream cores were identified and visually evaluated in the laboratory prior to preparing them for tests:



CORE U1

CORE U2

CORE U3

Core U1 Cored from upstream face of the dam at elevation 1068 and approximately station 5+10. The core had considerable cracking, however, segments remained intact except the last segment which separated into several pieces. Total length of core U1 was approximately 7 feet.

Core U2 Cored from upstream face at elevation 1068 and approximately station 3+40. The core was removed in 5 segments, all of which exhibited some cracking but remained intact for testing. Total core length was approximately 7 feet.

Core U3 Cored from upstream face at elevation 1068 and approximately station 1+89. Total core length was also approximately 7 feet and though the core exhibited some random cracking, it was the most sound of the upstream cores.

Part 2S SPECIMENS SELECTED FOR TESTS

From the cores previously described, segments were selected for specific tests with the goal of maximizing the information which could be obtained from this sampling.

Core Segment	Test (s)
U1A, U10, U2A, U2E.2, U3A, U3E	Static Young's Modulus, Poisson's Ratio, Unconfined Compression, Density

Core Segment	Test (s)
U1C, U2D, U3C	Splitting Tensile
U1B.1 & U1C, U2E.1, U3D	Petrographic Analysis by CTL
U1E, U2B, U3B	Gel Fluorescence

Test data on these segments is presented in Table 1S on the following page.

THE FOLLOWING TABLE PRESENTS A COMPARISON OF TEST RESULTS FROM IECO 1975 INVESTIGATION, 1996 EVALUATION AND 1997 SUPPLEMENT

TABLE 1S

COMPARATIVE TEST RESULTS

Sample Identification	Specific Gravity, Bulk	Static Young's Modulus ($x10^6$ psi)	Poisson's Ratio	Compressive Strength, psi	Tensile Strength, psi
		1975 IECO DATA			
1	2.34	4.14	.02	7000	628
2	2.37	2.66	.05	5945	628
3	2.37	3.77	.25	5622	526
4	-	4.20	.04	6637	611
5	2.36	4.06	.07	5593	600
6	-	3.59	.09	5951	574
		1996 EVALUATION DATA			
1 (D1A & 1B)	2.371	(1)	(1)	2690	157
2 (D2D & 2E)	2.389	0.56	.41	2890	226
3 (D3C.2 & 3C.3)	2.397	3.77	.14	5670	563
4 (4A & 4C.2)	2.351	3.95	.20	6610	458
5 (5B.2 & 5C.2)	2.375	2.99	.15	5470	387
6 (6C.2 & 6E.3)	2.380	2.85	.10	5420	519
		1997 SUPPLEMENT			
1 (U1A/U1D, U1C)	2.34/2.36	1.14/1.24	.08/.39	4214/2885	267
2 (U2A/U2E.2, U2D)	2.38/2.38	1.88/1.07	.21/.53	5290/3060	342
3 (U3A/U3E, U3C)	2.40/2.39	3.68/2.74	.13/.22	6130/4590	419

(1) No segment of Core No. 1 was long enough to measure static modulus or poisson's ratio.

D = Downstream cores sampled September 1996
U = Upstream cores sampled May 1997 for this supplement

Part 4S Alkali Silica Reactivity (ASR) Evaluation by Gel Fluorescence

Core Segment U1E:

This core segment represents concrete approximately 6' to 7' in from the upstream dam face which would be considered close to the center of the dam at elevation 1068. The concrete though, micro and macro cracked, is in better condition than the concrete encountered in the downstream core at approximately this location. Both fractured ends of this segment exhibit ASR product as well as numerous particles in various stages of reaction.

Core Segment U2B:

This segment represents concrete approximately 12" to 24" in from the upstream face. The specimen is fractured throughout most of its length and ASR gel was visible in, and coming out of, several cracks. The fractured ends of the segment shows numerous particles reacting but few indications of gel flow.

Core Segment U3B:

This core segment represents concrete from approximately 14" to 32" in from the upstream face. This core segment is fractured but shows less evidence of ASR than did core segments U1E and U2B. This seems to confirm less damage from ASR and better strength values for the concrete represented by core U3.

Petrographic examination of the upstream core segments and gel fluorescence both confirm Alkali Silica Reactivity in the areas sampled and confirm the previous conclusion that the lower strength values in the southern part of the dam at elevation 1068 is due to ASR.

Also, concrete in the area of cores U3 and D3 show considerably less reaction and better strength values than concrete represented by cores U1, U2, D1 and D2.

This is confirmed by CTL's petrographic analysis and gel fluorescence tests.

CE1

Core Segment U1E: This is the end of the segment closest to the dam face. One large rock socket is visible top at center. This area, under UV light, shows residue from gel which flowed around the large rock which originally occupied the socket.

The U1E segment: Under UV light, shows numerous particles of various sizes in various stages of reaction. Gel flows are also visible on right and left side, as well as in the rock socket mentioned above.

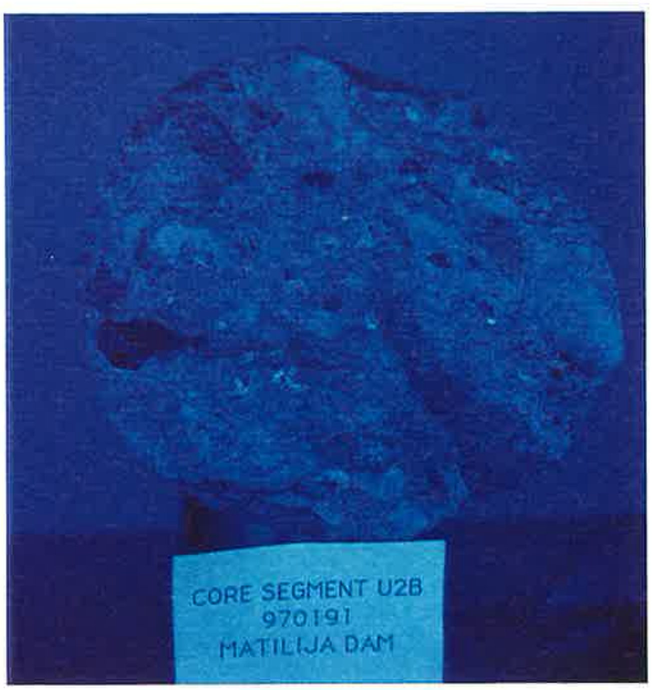
Core segment U1E: This is the fractured end of the segment farthest from the upstream dam face.

The U1E segment fracture, under UV light, showing particles in various stages of reaction and some gel flows. The small bright area, at about three o'clock, is fresh gel which exuded after lime water soak.

Core segment U2B: This end of the segment is about 10" in from the dam's upstream face. This portion of core U2 had several significant fractures, some of which exhibited ASR gel deposits within the cracks.

U2B segment fracture face under UV light. Not as many particles reacting as in segment from core U1. However, a significant number of small aggregate is reacting as well as signs of minor gel flows.

Core segment U2B: This is the opposite end of the segment which would be located approximately 24" in from the dam face.



This end of the core segment under UV light has less particles reacting but some light gel residue is visible at six o'clock and in a rock socket at about nine o'clock.

Core Segment U3B: The upper photos are of the fractured end which is approximately 13" in from the upstream dam face.
Photos below are of the fracture located approximately 31" in from the face. Both fractures under UV light exhibit few reacting particles and no areas of gel flow were observed. Fresh gel is visible in the UV photo below which exuded during lime water soak.

PART 5S

PETROGRAPHIC ANALYSIS BY
CONSTRUCTION TECHNOLOGY LABORATORIES, INC.
SKOKIE, ILLINOIS

CTL Structural/Architectural Engineering, Testing and Materials Technology

5420 Old Orchard Road, Skokie, Illinois 60077-1030
847/ 965-7500 **800/ 522-2CTL** Fax: 847/ 965-6541

PETROGRAPHIC SERVICES REPORT

CTL Project No.: 153437 *Date:* August 14, 1997

Re: Petrographic Examination of Cores Taken from Matilija Dam, Ojai, California

Three concrete cores were received on July 9, 1997 from Mr. Lin Franklin of BTC Laboratories Incorporated, Ventura, California. Reportedly, the cores were taken from the Matilija Dam in Ojai, California. Mr. Franklin stated the structure is a thin-arch concrete dam constructed in 1946 to 1947. The dam has developed a significant cracking problem, initially in the upper portion of the dam. Results of previous investigations by others suggested that expansive alkali-silica reaction (ASR) was a primary cause of cracking in the upper portion of the dam. Due to the problem, the dam was modified by "notching" part of the upper portion of the structure to reduce water retention capacity. Notching was initially done in 1965, then again in 1979. Some advancement of the cracking problem into the middle and lower portions of the dam has been reported since the modifications were made.

In September 1996, cores from the downstream face of the dam were submitted to CTL as part of the ongoing evaluation of the structure. Results of the petrographic examination (CTL Report No. 153406) confirmed the development and effects of ASR in the concrete.

Mr. Franklin stated the three newly submitted samples represent portions of longer cores taken horizontally from the upstream face of the dam, roughly equivalent in location to cores taken in late 1996 (Core Holes 1, 2, and 3). The three cores are identified, as follows:

- Core Segment U1B, with a portion of U1C (Fig. 1)
- Core Segment U2E1 (Fig. 2)
- Core Segment U3D (Fig. 3)

Petrographic examination of the three cores was requested by Mr. Franklin to evaluate the condition of the concrete and the extent of damage due to ASR. Comparison of these findings to those obtained from the 1996 evaluation was also requested.

FINDINGS AND CONCLUSIONS

The following findings and conclusions are based on the results of the petrographic examination, additional details of which are provided in the attached tables.

1. Evidence of alkali-silica reaction (ASR) is observed in each of the three examined concrete segments. Damage attributed to ASR ranges from moderate (Core Segments U1B/U1C and U2E1) to minor (Core Segment U3D). Concrete segments from moderately damaged areas each exhibiting several continuous and discontinuous cracks, hairline cracks, and microcracks (Fig. 4). Concrete from least damaged area (Core U3D) exhibits a few discontinuous hairline cracks and microcracks, but no major cracks or evidence of serious ASR-related distress (Fig. 5).

2. Damage exhibited in Core Segments U1B/U1C and U2E1 consists of a connected network of cracks that appears to originate and radiate from alkali-silica reactive fine aggregates (Fig. 6). Core U1B/U1C was received transversely fractured into two pieces. Otherwise, most of the cracks appear to be oriented roughly perpendicular or diagonal to the dam face and pass mainly around coarse aggregate particles. These crack patterns are fairly characteristic of ASR-related damage in larger concrete structures and likely reflect the degree and direction of internal restraint within the structure.

3. Aggregates affected by ASR appear to include mainly coarse sand particles composed of chert and shale (Fig. 6). These cherts and shales appear to contain some opal (hydrous amorphous silica) as well as microcrystalline quartz (Fig. 7), both of which are considered potentially reactive with alkalies. Most of the reactive aggregates exhibit features typical of ASR, including the presence of ASR gel, alkali reaction rims, and multiple internal cracks, many of which extend into the surrounding cement paste (Fig. 8). The coarse aggregate used in the concrete includes siliceous metamorphic rocks that contain stained quartz, as well as some altered volcanic rocks. These rock types may be susceptible to reaction with alkalies in the cement paste. A few of the metamorphic rocks exhibit apparent alkali-reaction rims and internal cracks consistent with ASR. However, most of the coarse aggregate does not appear to have been significantly affected by ASR.

4. Composition of the concrete appear to be fairly uniform, with slight differences in aggregate gradation and nominal top size (Figs. 4 and 5). Each of the examined concrete samples consists of fairly well-graded, siliceous, natural gravel coarse aggregate (1-1/2 to 3-in. top size) and siliceous sand dispersed in a portland cement paste. No fly ash or other mineral admixtures were observed in the paste. Some differences in sand composition and gradation are apparent between the cores. As a result, some differences exist in the amount of the reactive coarse sand particles. The least damaged core (Segment U2E1) appears to contain significantly fewer reactive sand grains.

5. Variable amounts of other secondary deposits are observed in each core. Ettringite crystals ($3CaO \cdot Al_2O_3 \cdot 3CaSO_4 \cdot 32H_2O$) partially fill or line some voids and portions of some cracks passing through cement paste. A few cracks also contain minor secondary deposits of portlandite (calcium hydroxide) crystals, calcium carbonate, and poorly-crystallized calcium-silicate-hydrate compounds, possibly tobermorite or okenite. The occurrences of these secondary compounds are not suspected to be related to other forms of expansion or damage in the concrete. They are believed to be mainly void or gap-filling in nature and likely precipitated from leachate and pore solutions migrating through the cement paste and cracks in the concrete.

6. Comparison of these petrographic findings to those from the 1996 examination revealed the upstream cores to be of somewhat better condition than the downstream cores taken at roughly equivalent elevation in the dam. This could be related to greater internal restraint of the concrete on the upstream side of the dam. Also, the concrete on the upstream side likely experience less frequent cycles of wetting and drying, which usually exacerbate ASR. The composition of the concretes on both faces of the dam are fairly similar, as would be expected given the similar coring elevations.

DISCUSSION AND RECOMMENDATIONS

The findings of the petrographic examination clearly revealed differences in the development of ASR-related cracks in the concrete. Patterns and severity of cracking in the concrete were likely influenced by structural factors, particularly internal restraint, and differences in the chemical and physical conditions at various locations and depths within the structure. The examination did not clearly determine if the ASR problem will continue in the future, assuming no additional structural modifications are made on the dam. However, sawcut surfaces of some of the concrete wetted with water during sample preparation developed small popouts within a few days, indicating additional expansion of some ASR reactive coarse sand particles. This suggests that alkalies and unreacted silica may still be available. Additional testing of the concrete, including expansion tests on cores taken from the dam, may be needed to determine if such expansion will continue in the structure.

METHODS OF TEST

Petrographic examination of the concrete cores was performed in accordance with ASTM C 856-95, "Standard Practice for Petrographic Examination of Hardened Concrete." Each of the cores was longitudinally saw cut, and one of the resulting surfaces of each was lapped and examined using a stereomicroscope at magnifications up to 45X. Surfaces of freshly broken concrete were also studied with the stereomicroscope. Small rectangular blocks were cut from selected portions of each core, placed on separate glass microscope slides with epoxy, and each reduced to a thickness of approximately 20 micrometers (0.0008 in.). The thin sections were studied using a polarized-light microscope at magnifications up to 400X, to determine aggregate and paste mineralogy and microstructure.

Ronald D. Sturm
Senior Petrographer
Petrographic Services

RDS

153437

Attachments

CTL

1a.

1b.

Fig. 1 Opposing side views of Core Segments U1B and U1C, as received for examination.

2a.

2b.

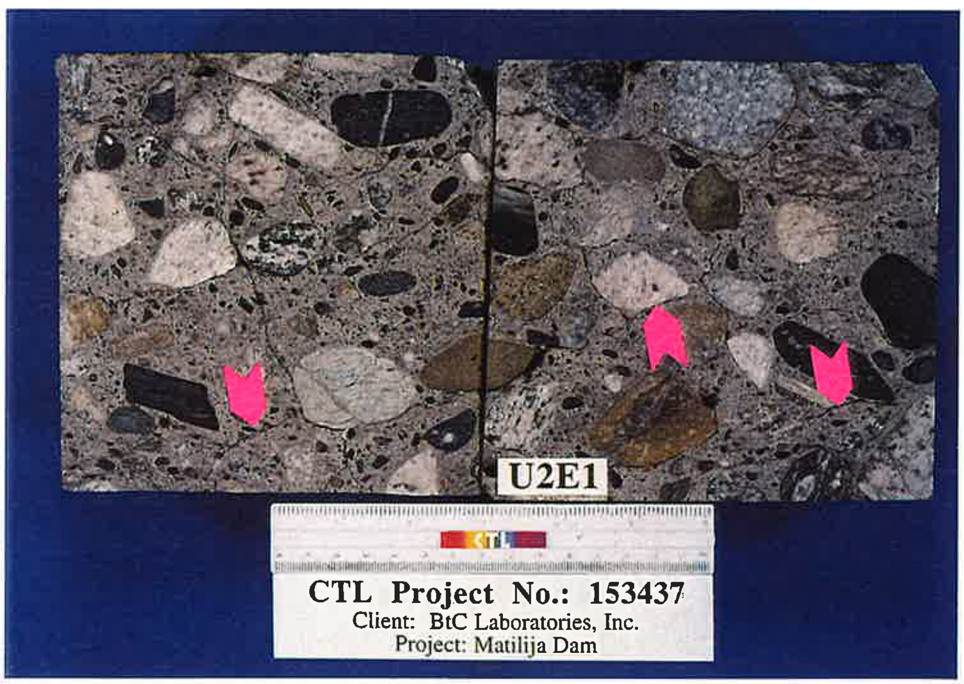
Fig. 2 Opposing side views of Core Segment U2E1, as received for examination.

3a.

3b.

Fig. 3 **Opposing side views of Core Segments U3D, as received for examination.**

4a. U1B/U1C

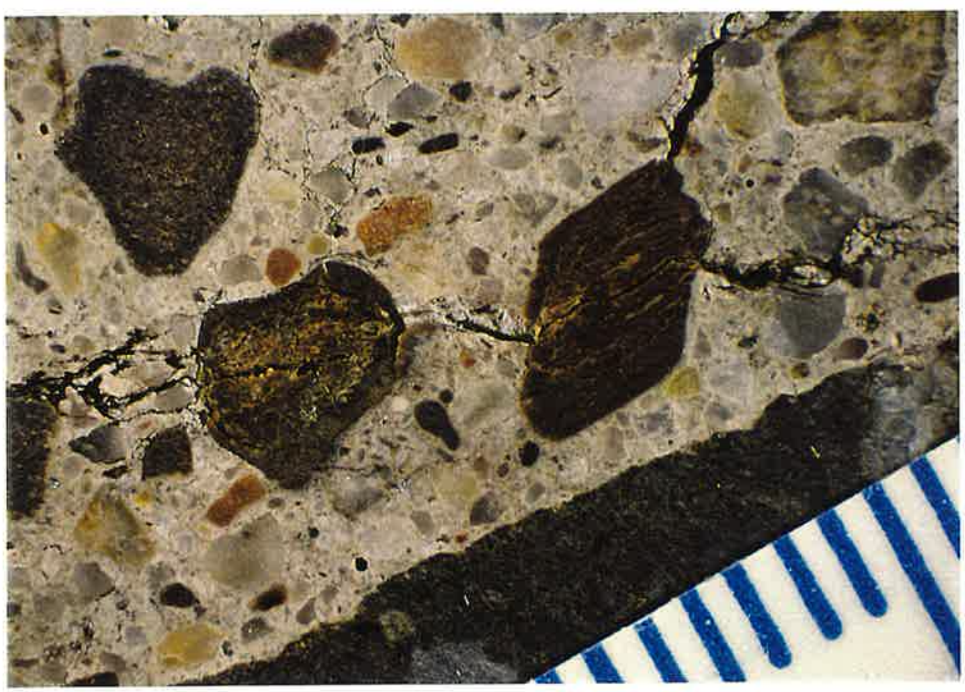


4b. U2E1

Fig. 4 **Lapped longitudinal cross sections of Core Segments U1B/U1C (reassembled) and U2E1, showing ASR-related cracking in each sample. The surfaces were treated with black ink to enhance view of cracks, examples of which are marked with arrows.**

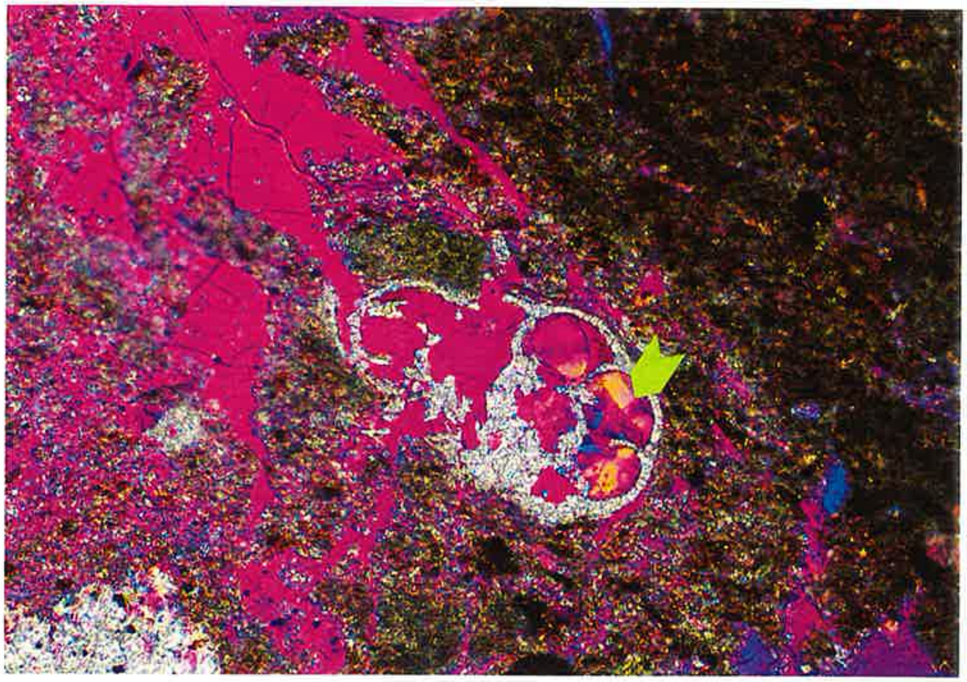
Fig. 5 **Lapped longitudinal cross section of Core Segment U3D showing relatively few hairline cracks and the comparatively good condition of the concrete. The surface was also treated with black ink.**

6a. U1B/U1C

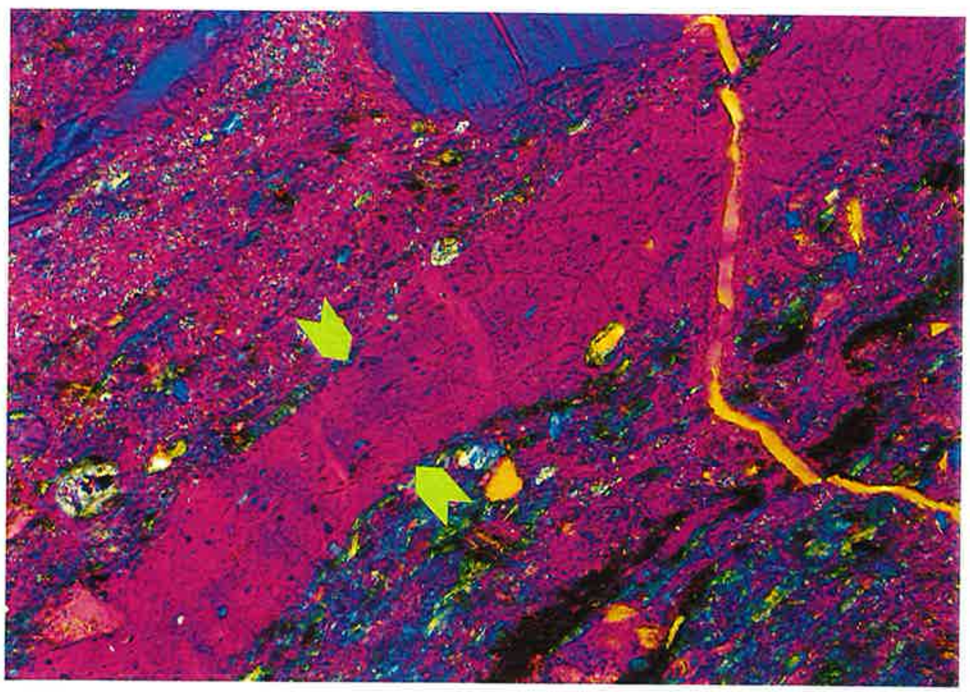


6b. U2E1

Fig. 6 **Selected area of the lapped surfaces of Core Segments U1B/U1C and U2E1 showing hairline cracks radiating from within ASR-expanded coarse sand particles of shale.**

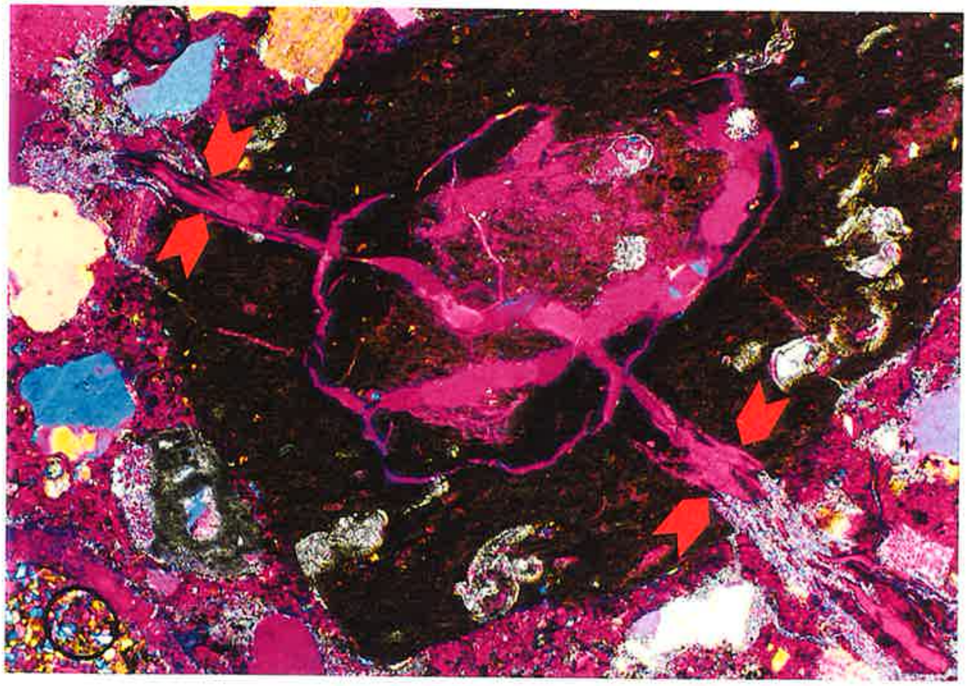


7a. U1B/U1C

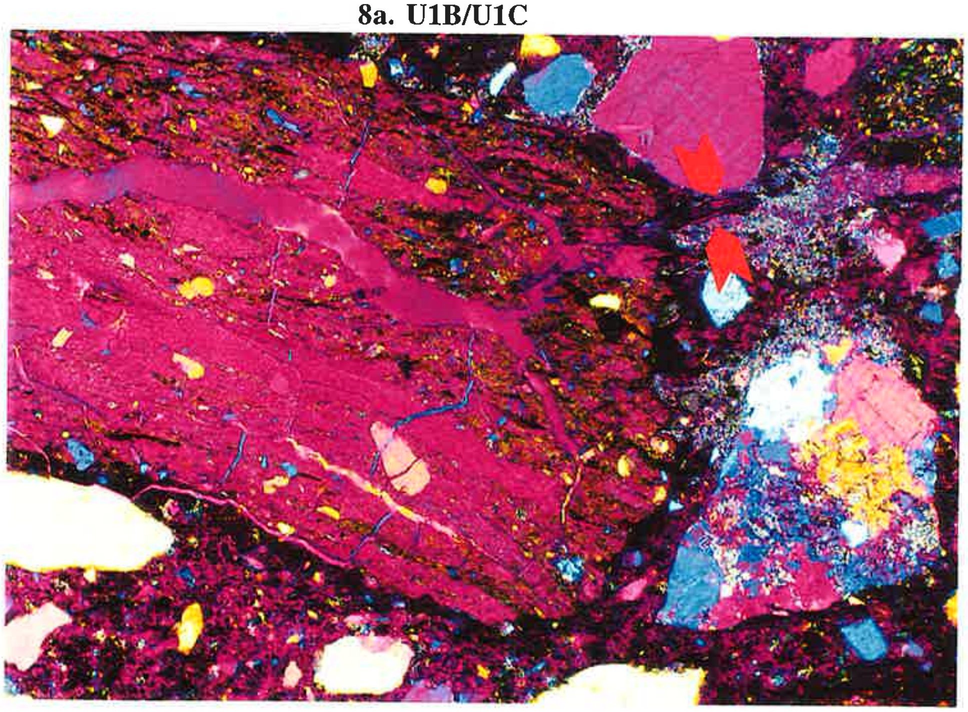


7b. U2E1

Fig. 7 **Thin section photomicrographs showing opaline and microcrystalline material (marked with arrows) within two reactive sand particles in Core Segments U1B/U1C and U2E1. Cross-polarized light with first-order wave plate. The length of each field shown, left to right, is approximately 0.6 mm.**



8a. U1B/U1C



8. U2E1

Fig. 8 Thin section photomicrographs showing ASR gel (marked between arrows) filling cracks radiating from within expanded coarse sand particles of shale in Core Segments U1B/U1C and U2E1. Cross-polarized light with first-order wave plate. The length of each field shown, left to right, is approximately 3 mm.

TABLE 1A: PETROGRAPHIC EXAMINATION OF CONCRETE (ASTM C 856)

CTL

LOCATION: Matilija Dam
Ojai, California

CTL PROJECT NO.: 153437
DATE: August 13, 1997

Sample	Core Dimensions	Aggregate*	Paste Properties	Cracks and Large Voids	Secondary Deposits	Additional Features/Comments	Damage Attributed to ASR**
U1B.1/ U1C	Diameter = 6 in.; Length = 12 in. (reassembled). Both ends are sawcut perpendicular to core length.	CA: Natural gravel composed of a variety of mainly siliceous metamorphic and altered volcanic rocks, including granite gneiss, gneiss, schist, quartzite, amphibolite, granodiorite, dacite porphyry, and other porphyritic and felsitic volcanic rocks; rounded to subangular; fairly well graded to nominal top size of 1.5 in. FA: Natural sand containing grains of quartz, feldspar, shale, chert, and other rocks similar to CA. Coarse sand fractions are rich in sandstone, shale, and chert.	Buff to light gray, moderately hard to hard, and subvitreous. Moderately tight paste-aggregate bond. No mineral admixtures observed. Original water-cement ratio is interpreted as moderately low, based on abundance of in-situ hydrated portland cement clinker particles in the paste.	The core was received in two main pieces. The two large pieces represent two halves of a core segment split by a mid-length transverse crack. Several hairline cracks and a few large cracks extend diagonally and longitudinally through both core segments. Some radiate from reacted sand grains. Most cracks pass mainly around CA but through numerous FA. Numerous small entrapped air voids are observed.	Clear to milky white, amorphous and partially crystallized deposits of alkali-silica reaction (ASR) gel partially soak some paste and line or fill cracks and voids adjacent to numerous alkali-reactive coarse sand particles of chert and shale. Moderate amounts of secondary ettringite crystals (3 $CaO \cdot Al_2O_3 \cdot 3 CaSO_4 \cdot 32 H_2O$), calcium carbonate crystals, and other microcrystalline compounds are also observed in some cracks and voids, mostly away from reactive aggregates.	Reaction rims are observed along the periphery of most reactive chert and shale particles, as well as a few CA. The concrete is not air entrained. Microcracks are abundant; many radiate from reacted sand grains.	Moderate.

* CA - Coarse Aggregate FA - Fine Aggregate
** ASR - Alkali-Silica Reaction

TABLE 1B: PETROGRAPHIC EXAMINATION OF CONCRETE (ASTM C 856)

LOCATION: Matilija Dam
Ojai, California

CTL PROJECT NO.: 153437
DATE: August 13, 1997

Sample	Core Dimensions	Aggregate*	Paste Properties	Cracks and Large Voids	Secondary Deposits	Additional Features/Comments	Damage Attributed to ASR**
U2E1	Diameter = 6 in.; Length = 12 in. Both ends are sawcut perpendicular to core length.	CA: Natural gravel composed of a variety of mainly siliceous metamorphic and altered volcanic rocks, including granite gneiss, gneiss, schist, quartzite, amphibolite, granodiorite, dacite porphyry, and other porphyritic and felsitic volcanic rocks; rounded to subangular; fairly well graded to nominal top size of 1.5 in. FA: Natural sand containing grains of quartz, feldspar, shale, chert, and other rocks similar to CA. Coarse sand fractions are rich in sandstone, shale, and chert.	Buff to light gray, moderately hard to hard, and subvitreous. Moderately tight paste-aggregate bond. No mineral admixtures observed. Original water-cement ratio is interpreted as moderately low, based on abundance of in-situ hydrated portland cement clinker particles in the paste.	The core was received in one piece with several hairline cracks and a few discontinuous larger cracks extending diagonally and longitudinally through the core. Some cracks radiate from reactive sand grains. Cracks pass mainly around CA but through numerous FA. Several small entrapped air voids are observed.	Clear to milky white, amorphous and partially crystallized deposits of alkali-silica reaction (ASR) gel partially soak some paste and line or fill cracks and voids adjacent to numerous alkali-reactive coarse sand particles of chert and shale. Moderate amounts of secondary ettringite crystals (3 CaO• Al_2O_3•3 $CaSO_4$•32 H_2O), calcium carbonate crystals, and other compounds are also observed in some cracks and voids, mostly away from reactive aggregates.	Reaction rims are observed along the periphery of most reactive chert and shale particles, as well as a few CA. The concrete is not air entrained. Microcracks are abundant; many radiate from reacted sand grains.	Moderate.

* CA - Coarse Aggregate FA - Fine Aggregate
** ASR - Alkali-Silica Reaction

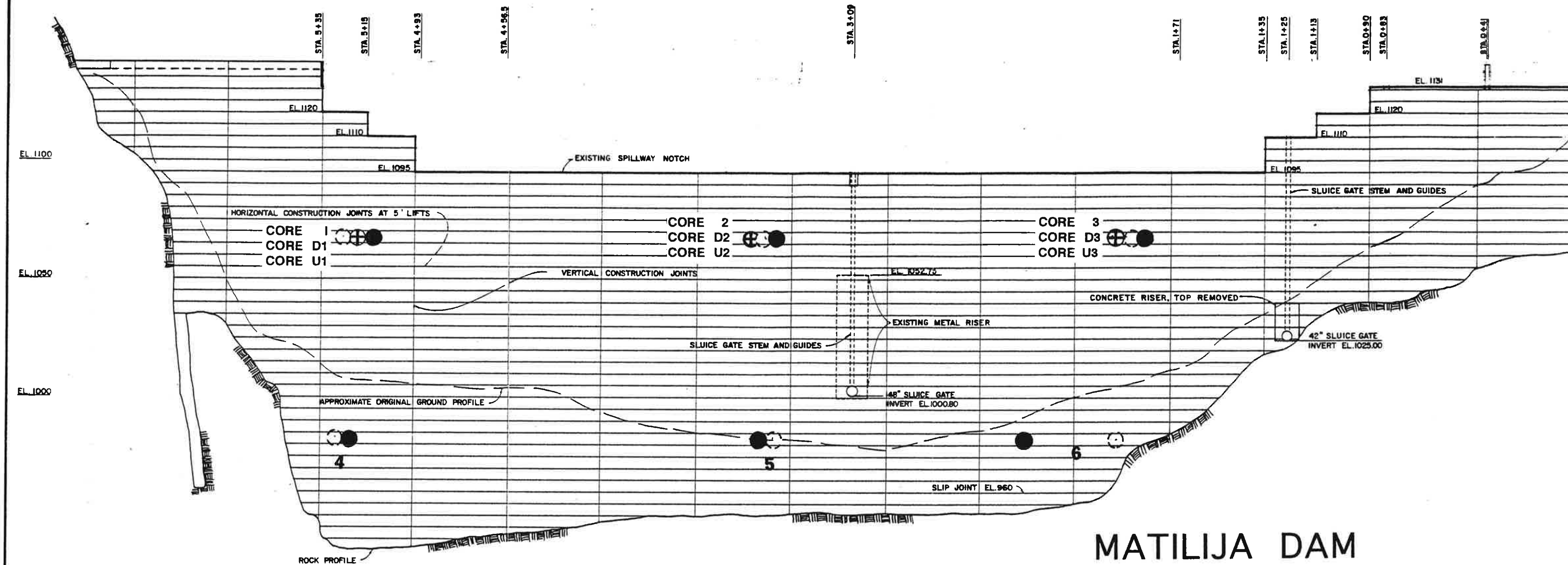
TABLE 1C: PETROGRAPHIC EXAMINATION OF CONCRETE (ASTM C 856)

LOCATION: Matilija Dam
Ojai, California

CTL PROJECT NO.: 153437
DATE: August 13, 1997

Sample	Core Dimensions	Aggregate*	Paste Properties	Cracks and Large Voids	Secondary Deposits	Additional Features/Comments	Damage Attributed to ASR**
U3D	Diameter = 6 in.; Length = 11.5 in.	CA: Natural gravel composed of a variety of mainly siliceous metamorphic and altered volcanic rocks, including granite gneiss, gneiss, schist, quartzite, amphibolite, granodiorite, dacite, and other felsitic and porphyritic volcanic rocks; rounded to subangular; fairly well graded to nominal top size of 2 in. FA: Natural sand containing grains of quartz, feldspar, shale, chert, and other rocks similar to CA. Coarse sand fractions are rich in sandstone, quartzite, gneiss, and lesser amounts of shale, and chert.	Light gray, moderately hard to hard, and subvitreous. Moderately tight paste-aggregate bond. No mineral admixtures observed. Original water-cement ratio is interpreted as moderately low.	The core was received in one piece with a small amount of rubble. Both ends of core are fractured. No major cracks observed. A few hairline cracks and microcracks are observed adjacent to some reacted coarse sand grains of chert and shale and a few internally cracked CA. Several small to large air voids (up to 0.25 in.) are randomly dispersed in the core.	Clear to milky white, amorphous and partially crystallized deposits of alkali-silica reaction (ASR) gel partially soak some paste and line or fill cracks and voids adjacent to a few alkali-reactive coarse sand particles of chert and shale. Small amounts of secondary ettringite crystals ($3\ CaO \cdot Al_2O_3 \cdot 3\ CaSO_4 \cdot 32\ H_2O$) and calcium carbonate crystals are also observed in some cracks and voids, mostly away from reactive aggregates.	Reaction rims are observed along the periphery of most reactive chert and shale particles, as well as a few CA. The concrete is not air entrained. Several microcracks are observed; some radiate from reactive sand grains.	Minor.

* CA - Coarse Aggregate FA - Fine Aggregate
** ASR - Alkali-Silica Reaction



DAM ELEVATION

20 0 20 40
SCALE OF FEET

MATILIJA DAM

CONCRETE EVALUATION 1996

AND 1997 SUPPLEMENT

CORE LOCATIONS

⊕ CORE LOCATION 1997 SUPPLEMENT

● CORE LOCATION 1996 EVALUATION

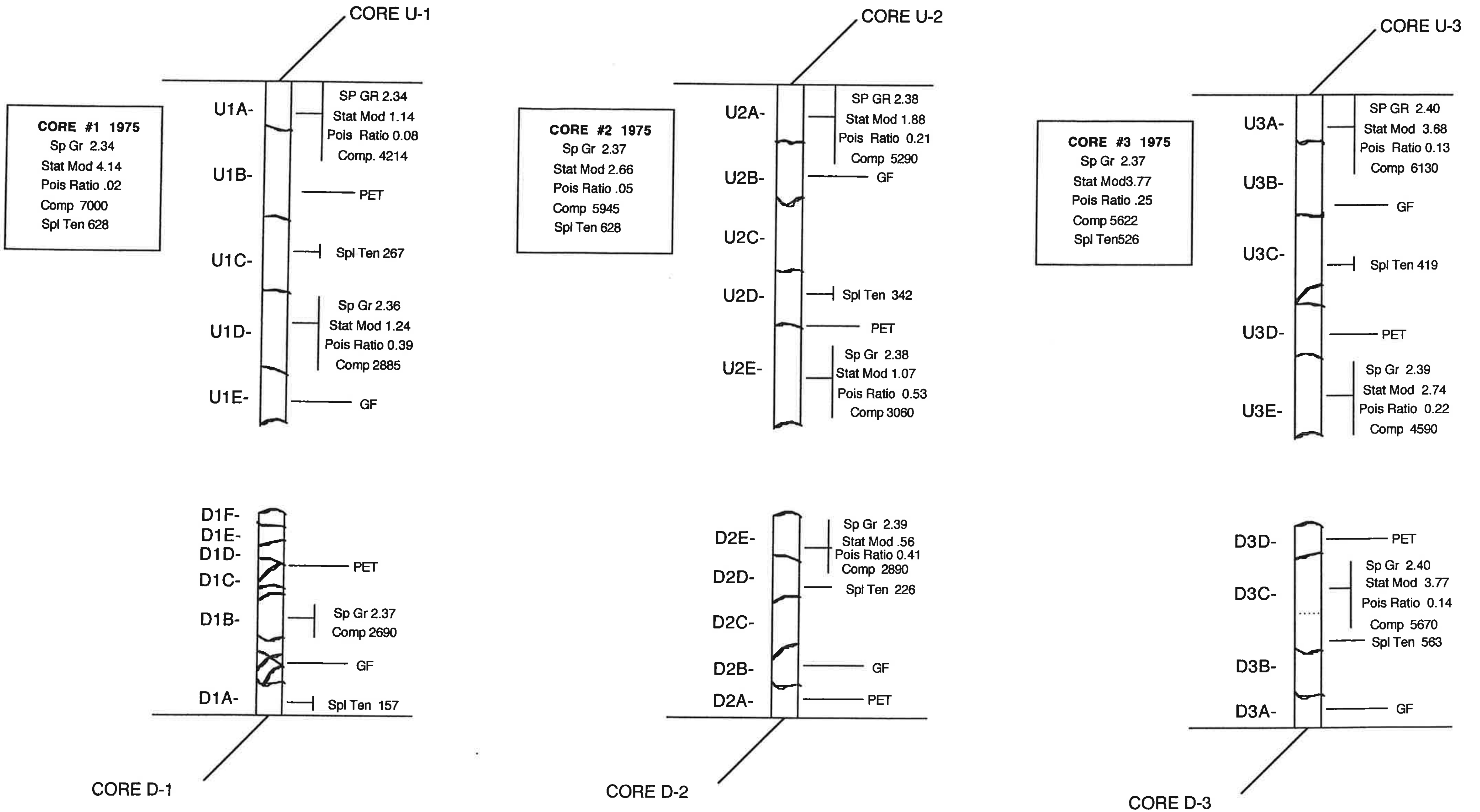
O CORE LOCATION 1976 INVESTIGATION (IECO REPORT)

VENTURA COUNTY FLOOD CONTROL DISTRICT

BTC LABORATORIES, INC. NOVEMBER 1997

96-8432-V02

UP STREAM



DOWN STREAM

KEY TO TEST VALUES

BULK SPECIFIC GRAVITY ASTM C 642: **Sp Gr**
STATIC MODULUS OF ELASTICITY (106) ASTM C 469: **STAT MOD**
POISSON'S RATIO ASTM C 39: **POIS RATIO**
COMPRESSIVE STRENGTH ASTM C 39: **COMP**
SPLITTING TENSILE ASTM C 496 (psi): **SPL TEN**
PETROGRAPHIC EXAMINATION ASTM C 856: **PET**
GEL FLUORESCENCE (SHRP): **GF**

MATILIJA DAM

1996 CONCRETE EVALUATION SUPPLEMENT
RELATIONSHIP OF HORIZONTAL CORE LOCATIONS
AT ELEVATION 1068, WITH COMPARATIVE TEST VALUES
FROM 1975,1996 EVALUATION AND 1997 SUPPLEMENT