STRAIN GAGE PROGRAM - MATILIJA DAM 1965 - 1975

Strain gages to monitor the movements of Matilija Dam were first installed in the right and left abutments during the latter part of February 1965 by Carlson Instruments of Campbell, California. Four strain gages were installed in the left abutment (1L, 2L, 2aL and 3L) and four in the right abutment (1R, 2R, 2aR and 3R).

Strain gage meter calibrations and lead resistances were computed by Carlson Instruments and the necessary data needed to monitor the dam movements were listed on eight abutment yield measurement data sheets and presented to the Ventura County Flood Control District.

On March 8, 1965, instructions for operation of the instruments and computation of the data were given to Flood Control personnel and the first readings were made. The initial abutment yield measurement data sheets and data of the first readings are shown in Exhibit A (8 sheets).

On April 10, 1967, Carlson Instruments visited Mailija Dam and made a check of lead resistances of the eight strain gages. The readings are tabulated in Exhibit B.

STRAIN GAGE CLEANING AND REPLACEMENT September 28, 1972

On July 6, 1972, the technician in charge of reading the strain gages discovered an open circuit to Strain Gage 1L. A decision was made to have Carlson Instruments visit the dam and advise the Flood Control District as to the condition of the meters and leads to all strain gages.

Dr. Carlson advised us to remove and visually inspect all strain gage meters for broken seals, bellows damage, etc.

On August 2, 1972, after reading the meters, all were removed and inspected. Five were found to be defective. They were 1L, 2aL, 3L 2aR and 3R. The meters were sent to Carlson Instruments where they were reconditioned and returned to the Flood Control District along with new calibration data (Exhibit C).

On September 28, 1972, the installation of the five new meters and the cleaning of the remaining three was completed and the lead resistances were checked (Exhibit D).

The calibration values for the 'abutment yield data'' sheets of the five reconditioned meters had to be changed at this time. Data for the changes were supplied by Carlson Instruments (Exhibit C) and computations made by the Flood Control Field Hydrology staff. (See "Report -Removal and Replacement of Meters", dated September 1972.)

The only calibration necessary on the three meters that were cleaned was the "resistance ratio at initial reading", which was disturbed due to removal from its mounting. This calibration was performed by merely adjusting the meter in its mounting until the "resistance ratio in percent" was somewhere close to its reading prior to the cleaning operation.

Because of the length of time between the removal and installation of the meters, it became apparent that continued movement of the dam during the interval, plus new positioning of the meters on their mounting frames would necessitate an adjustment of the "resistance ratio at initial reading" in order that abutment yield measurements made after September 28 would correlate with past readings when they were plotted. (See memorandum dated 3/30/73 from S. G. Marsh to J. B. Quinn.)

After the "adjusted resistance ratio" was computed, new "abutment yield measurement data"sheets were typed and put into use (Exhibit E).

STRAIN GAGE LEAD MODIFICATION AND CALIBRATION March 6, 1975

On December 10, 1973, because of continued deterioration of the concrete of the upper portion of Matilija Dam, it became necessary to discontinue monitoring the right abutment strain gages due to unsafe access conditions.

In February 1975, a contract was awarded to J. D. Hadley, Inc., a general engineering contractor with Zeger's Electric Company as subcontractor to install new leads to the right abutment strain gages and

- 2 -

extend them across the canyon to the valve house on the left abutment. On February 21, 1975, the original leads to the right abutment strain gages were severed according to plan. The new, extended leads were installed by the subcontractor and on February 26, 1975, the connections of these leads to the meters and their testing for resistance was completed by the Flood Control Hydrology staff (Exhibit F).

Due to the increased resistance caused by extending the leads, it became necessary to change the values of three of the calibrations on abutment yield data sheets 1R, 2R, 2aR and 3R. To compute these values, it was necessary to have certain data relating to the characteristics of the strain gages. As two of the strain gages on the right abutment (1R and 2R) are the original gages installed by Carlson Instruments of Campbell, California, the necessary data was not available in our files. Telephone calls to Carlson Instruments and Dr. Roy Carlson, personally, revealed that this necessary information was no longer in their files.

Carlson Instruments suggested that we remove the two strain gages 1R and 2R and send them to their laboratory for recalibration and examination. However, by use of an equation sent to us some years ago by Carlson Instruments, the Hydrology staff, using certain data taken from early abutment yield data sheets, was able to derive the missing data. The equation is as follows, as originally furnished by Carlson Instruments to derive the necessary calibrations to compute the movements of the dam.

$$C' = C + \frac{.89 \text{ yC}}{R}$$

where

C' = Calibration constant, corrected for leads.

C = Calibration constant of the meter.

y = Resistance of a pair of leads.

R = Meter resistance at 0° F.

The missing data from the original meters 1R and 2R is as follows:

C = Calibration constant of the meter.

 $R = Meter resistance at 0^{\circ} F.$

Data researched by the Hydrology staff from early abutment yield data sheets and a copy of the original resistance of a pair of leads, which were in our files, is as follows:

C' = Calibration constant corrected for leads.

y = Resistance of a pair of leads.

To obtain the missing R of the equation, the original resistance of a pair of leads was subtracted from the meter resistance at 0° F corrected for leads, which is given in the early abutment yield data sheets from our files. This left only one unknown in the equation which was C. To solve for C, the equation was stated as follows:

$$RC' = RC + .89 yC$$

 $RC' = C(R + .89 y)$
 $C = RC'$
 $R + .89 y$

With all the missing elements of the equation for Meters 1R and 2R now at our disposal, the staff proceeded to obtain the necessary calibrations for the extended leads as shown in Table 1, Exhibit G.

Using the meter calibration data for strain gages 2aR and 3R (Exhibit E), the derived meter calibration data for strain gages 1R and 2R (Exhibit G) plus the adopted values of the lead resistances (Exhibit F) in the original Carlson Instruments' equation, the new calibrations for the right abutment strain gages were computed.

As only five days had elapsed between the severing of the right abutment strain gages leads and the completion of installation of the lengthened leads, it was decided to adjust the new resistance ratio at initial reading in order that the abutment yield measurements made on February 21 at 8 A.M. would correlate exactly with measurements made on February 26 at 8 A.M. (See "Equation - Computation of Adjusted Resistance Ratio", dated March 6, 1975.)

New abutment yield measurement data sheets were typed for meters 1R, 2R, 2aR and 3R. It was not necessary to type new abutment yield measurement data sheets for the left abutment strain gages, as no changes were made there (Exhibit H).

The indicated movement from initial position in inches <u>prior</u> to severing the original leads and <u>after</u> lengthening the leads is tabulated in Exhibit H for clarification purposes only.

- 4 -

STRAIN GAGE DH-1L REPLACEMENT

AUGUST 4, 1976

In July, 1976, Meter J-12 located in Drill Hole 1L was recognized as being inoperative. From observations made during the past year, it became obvious that approximately from January 5, 1976, through July 12, 1976, readings made at DH-1L were in error.

On July 23, 1976, Meter J-12 was removed from its foundation at DH-1L and found damaged. Upon examination of data concerning the range limits of this meter, it was found that about the first part of January, 1976, the closed limit had been reached. It is assumed that from January, 1976 through July 23 the compression at this location continued and eventually damaged the meter.

A new meter was installed on July 26, 1976, and its Initial Resistance Ratio set to read 102.60 percent on the Carlson Test Set. A resistance check was made on the leads from the monitoring station to the new meter and found to be in good condition (Exhibit J). A new "Abutment Yield Data Sheet" was initiated and the Initial Resistance Ratio recorded (Exhibit K). The "Calibration Constant Corrected for Leads" was computed by use of an equation shown in Exhibit L. Other data on the Data Sheet was supplied with the new meter received from Carlson Instruments. (Exhibit M).

In order to provide some estimate of the movement between the Left Abutment and the Dam during the inoperative period, a graph was drawn on rectangular coordinate graph paper through two plotted points representing the readings of the deformation in inches for August 1, 1974, and August 1, 1975. A straight line was extended on the graph to August 1, 1976 and the deformation in inches read off. (Exhibit N).

In order to correlate plots of previous deformation readings and plots of future readings, an adjustment of the "Initial Resistance Ratio" was calculated (Exhibit P) and entered on the new Abutment Yield Data Sheet. An asterisk precedes this entry.

Mr. Gordon L. Dukleth, Division Engineer, for the California Division of Safety of Dams was informed by letter dated August 6, 1976, of the foregoing proceedings(Exhibit Q).

George A. Consman George A. Gonsman Supervisor, Field Hydrology

Project: MATILIJA DAM

Drill-h	ole	No.	DH-1L	
Meter	No.		M-8	
Sheet	No.			

Calibrations:

Calibration constant, corrected for leads $\underline{1001194}$ inches per 0.01% ratio change Resistance ratio at initial reading $\underline{99.96}$ per cent Resistance ratio, meter closed: $\underline{97.3}$ per cent Resistance ratio, meter open: $\underline{102.2}$ per cent Meter resistance at 0°F, corrected for leads $\underline{51.18}$ ohms Change in temperature per ohm change in resistance $\underline{10.84}$ °F

		Ten	perati	ire	Total	Increase		Pesistance	Change	Indicated	
Date	Pac Std Time	Min.	Max.	At time of Obs.	resistance from 0 F ohms (S ₂)	in resistance from 0 F ohms	Tomp F	ratio per cent (S ₁)	ratio from initial reading per cent	movement from initial position inches	Lake elev.
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Project: MATILIJA DAM

Drill-hole	No. DH-2L
Meter No.	M-3
Sheet No.	

Calibrations:

Calibration constant, corrected for leads <u>...001073</u> inches per 0.01 % ratio change Resistance ratio at initial reading <u>101.16</u> per cent Resistance ratio, meter closed: <u>98.6</u> per cent Resistance ratio, meter open: <u>104.2</u> per cent Meter resistance at 0°F, corrected for leads <u>49.67</u> ohms Change in temperature per ohm change in resistance <u>10.95</u> °F

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Dute	Pac Std Dime	- Min.	Sax.	At time of Obs.	resistance from 0°F ohms (S ₂)	in resistance from O F ohms	Tomp F	ratio per cent (S_)	in ratio from initial reading per cent	from initial position inches	Lake clev.
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Project: MATILIJA DAM

Drill-H	ole	No.	DH-2aL
Meter	No.		M-7
Sheet	No.		

Calibrations:

Calibration constant, corrected for leads $\frac{.001032}{.04}$ inches per 0.01% ratio change Resistance ratio at initial reading $\frac{.101.04}{.04}$ per cent Resistance ratio, meter closed: $\frac{.98.4}{.98.4}$ per cent Resistance ratio, meter open: $\frac{.104.2}{.04.2}$ per cent Meter resistance at 0°F, corrected for leads $\frac{.49.84}{.04}$ ohms Change in temperature per ohm change in resistance $\frac{.10.91}{.04.2}$ °F

1		Tea	perata	re	Total	Increase	1	Resistance	Change	Indicatud	
Date	Pac Std Time	Min.	Max.	At time of Qbs:	resistance from 0 F ohms (S ₂)	in resistance from O F ohms	Tcmp OF	ratio per cent (S_) 1	in ratio from initial reading per cent	movement from initial position inches	Lake elev.
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MEASUREMENT DATA

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Project: MATILIJA DAM

Drill-1	ole	No. DH-1R
Meter	No.	M-6
Sheet	No.	

Calibrations:

Calibration constant, corrected for leads <u>.001159</u> inches per 0.01% ratio change Resistance ratio at initial reading <u>100.76</u> per cent Resistance ratio, meter closed: <u>98.0</u> per cent Resistance ratio, meter open: <u>103.6</u> per cent Meter resistance at 0°F, corrected for leads <u>49.76</u> ohms Change in temperature per ohm change in resistance <u>10.88</u> °F

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Date	Pac Std Cime	Min.	Max.	At time of Obs.	resistance from 0 F ohms (S ₂)	in resistance from 0 F ohms	Temp	ratio per cent (S_)	in ratio from initial reading per cent	initial position inches	Lake elev.
			F	RST	READ	ING MA	RC H	8 19	65		· · · · · · · · · · · · · · · · · · ·
3-8-65	3:05 PM			62°				100.77	+0.01	70.0012	
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Project: MATILIJA DAM

Drill-1	ole	No. DH-2R
Meter	No.	M-1
Sheet	No.	

Calibrations:

Calibration constant, corrected for leads <u>.001147</u> inches per 0.01 % ratio change Resistance ratio at initial reading <u>100.82</u> per cent Resistance ratio, meter closed: <u>97.9</u> per cent Resistance ratio, meter open: <u>103.0</u> per cent Meter resistance at 0°F, corrected for leads <u>50.07</u> ohms Change in temperature per ohm change in resistance <u>10.95</u> °F

	1	Tem	perati	are	Total	Increase]	Resistance	Change	Indicated	
Date	Pac Std Dime	Min.	Max.	At time of Obs.	resistance from 0°F ohms (S ₂)	in resistance from 0°F ohms	Tomp F	ratio per cent (S_) 1	in ratio from initial reading per cent	movement from initial position inches	Lake clev.
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Project: MATILIJA DAM

Drill-hole	No. DH-2aR
Meter No.	M-5
Sheet No.	

Calibrations:

Calibration constant, corrected for leads .001194 inches per 0.01% ratio change Resistance ratio at initial reading ______ 100.84 per cent Resistance ratio,meter closed: ______98.4 per cent Resistance ratio,meter open: ______103.8 per cent Meter resistance at 0°F, corrected for leads ______999 ohms Change in temperature per ohm change in resistance ______0.93 °F

	1	Temperature		Total Increase			Resistance	Ci.ango	Indicated	DUR, WINDLIDADAR	
Date	Pac Std Time	Min.	Max.	At time of Obs.	resistance from 0 F ohms (S ₂)	in resistance from 0 F ohms	Tomp F	ratio per cent (S ₁)	ratio from initial reading per cent	movement - from initial position inches	Lake elev.
			FIR	ST	READI	NG MA	PC.H	0 104	5		
3-8-65	3:05 PM			620				100.86	+0.02	+0.0024	
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Project: MATILIJA DAM

Drill-H	ole	No.	DH-3R
Meter	Nov		M-4
Sheet	No.		

Calibrations:

and the second second	T	Temperature			Total Increase			Resistance	Change Indicated			
Date	Pac Std Cime	Min.	Max.	At time of Obs.	resistance from 0°F ohms (S ₂)	in resistance from 0°F ohms	Tomp F	ratio per cent (S_)	ratio from initial reading per cent	movement from initial position inches	Lake elev	
			FI	RST	READI	NG MAR	CH	8 1965				
3-8-65	3:05 PM			62°				101.80	+0.01	+0,0011		

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TABLE OF READINGS

TAKEN ON APRIL 10, 1967

		All Rea	adings in c	ohms.	1. 1
Meter No.	Black & White	White & Green	Black & Green	Lead Resistance	Adopted Value
1Ĺ	56.30	28.745	28.745	1.19	1.17
	56.39	28.77	28.77	1.15	ан а ² х
2L	55.96	28.52	28.14	0.70	0.70
	55.97	28.52	28.15	0.70	5) 10
2aL	55.71	28.33	28.04	0.66	0.67
	55.72	28.35	28.05	0.68	с и с
3L	56.82	29.99	29.52	2.69	2.70
2	56. 85	30.01	29.55	2.71	
1R	54.63	27.62	27.43	0.42	0.42
	54.67	27.62	27.47	0.42	
2 R	54.69	28.04	27.74	1.09	1.08
2	54.68	27.95	27.79	1.06	- 1
a 2aR	55.20	28.18	27.92	0.90	0.89
	55.19	28.16	27.90	0.87	0 11 -042 11
3R	55.42	28.67	28.21	1.46	1.46
- 8 (4)	55.44	28.69	28.21	1.46	

MODEL NO. JO .5

DATE 8-28-72

CUSTOMER Ventura County Public Works Dept.

SALES ORDER NO. 0062

METER CALIBRATION DATA

Meter	Meter	Resistance	Degrees	Calibration	Resistance Ratios				
Location	No.	at 0° F.	per Ohm	Constant	Open	Closed	As Shipped		
1L	J-12	53.85	9.61	.00063	103.7	95.8	97.3		
2aL	J-13	54•17	9.56	.00062	104.0	96.0	97.2		
3L	J-14	53.89	9.61	.00065	102.9	95.2	96.6		
2aR	J-15	53.73	9.65	.00063	104.0	96.1	97.6		
3R	J-16	53.66	9.66	.00063	104.6	96.7	98.2		

EXHIBIT "C"

TABLE OF READINGS

TAKEN ON SEPT. 28, 1972

TIME: Left abut. 1200 PST. Right abut. 1300 PST. AIR TEMPERATURE: Left abut. 78° F. Right abut. 73° F. RESERVOIR ELEV.: 1046.59 ft.

ELEV. OF SILT, UPSTREAM FACE OF DAM (AV): 1036 ft.

All readings in ohms.

F

METER NO.	BLACK & WHITE	WHITE & GREEN	BLACK & GREEN	LEAD RES ISTANCE	ADOPTED VALUE
1L C	63.81 63.85	32.51 32.53	32•51 32•52	1.21 1.20	1.20
2L	56.86 56.87	28.80 28.81	28.76 28.76	•70 •70	•70
2aL	63.01 63.02	31.84 31.84	31.84 31.84	.67 .66	.67
3L	63.95 63.96	33.42 33.42	33 . 39 33 . 39	2.86 2.85	2.86
1R	56.04 56.04	28.23 28.23	28.19 28.19	•38 •38	.38
2R	56.18 56.18	28.62 28.61	28.55 28.55	•99 •98	•98
2aR	61.50 61.50	31.27 31.28	31.13 31.13	• 90 • 91	• 90
3R	62.29	31.92	31.89	1.52	1.52

EXHIBIT "D"

REPORT

REMOVAL AND REPLACEMENT OF METERS

September 1972

In September 1972, Strain Gage Meters 1L, 2aL, 3L, 2aR and 3R were removed and replaced with new meters. The calibration constants on the Abutment Yield Data sheets for these meters were changed at this time from data supplied by Carlson Instruments, Campbell, California (EXHIBIT "C") and computations and tests made by the Ventura County Flood Control Field Hydrology staff.

The calibrations computed by the Hydrology staff are as follows:

Calibration constant, corrected for leads Meter resistance at 0° F, corrected for leads

The equation used in these computations is as follows:

where

C: = New calibration constant, corrected for leads
C = Calibration of meter
y = Resistance of a pair of leads
R = Meter resistance at 0° F

Example of Meter 1L $1.20 \times .00063 \times .89$ C' = _________ = .00001249 + .00063 = .00064249 53.85

C = .000642 (See EXHIBIT E)

To obtain the <u>Meter resistance at 0° F corrected for leads</u>, the Resistance at 0° F for the meters (EXHIBIT C) was added to the Adopted value of the lead resistance to each meter. (EXHIBIT D)

The only calibration necessary on the three meters that were <u>cleaned</u> only was the <u>Resistance ratio at initial reading</u> which was disturbed due to removal from it's mounting. This calibration was performed by merely adjusting the meter in it's mounting until the resistance ratio was someplace close to it's reading prior to the cleaning operation.

The <u>Adjusted resistance ratio after 9-28-72</u> which is preceeded by an asterisk, was determined by Mr. Gordon Marsh of the Ventura County Public Works Roads Section, in order to make the new Abutment Yield measurements correlate with past readings when they are plotted. (See memorandum dated March 30, 1973 from S. G. Marsh to J. B. Quinn)

Project.	MATILIJA
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New meter installed 9-28-72.

DAM

Drill-	-h ole	No	DH-1	L
Meter	No.		J-12	
Sheet	No.			

Calibrations:

Calibration constant, corrected for leads.000642 inches per 0.01% ratio change Resistance ratio at initial reading 100.06 per cent ***** Resistance ratio, meter closed: 95.8 per cent Resistance ratio, meter open:<u>103.7</u>per cent Meter resistance at 0°F, corrected for leads 55.05 ohms Change in temperature per ohm change in resistance 9.61 ^{o}F *Adjusted resistance ratio after 9-28-72 (103 LO9)

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Date	Pac Std Time	 Min.	peratu Max.	At time of Obs.	Total resistance from 0 ^o F ohms (S ₂)	Increase in resistance from () ⁰ F ohms	Temp ^O F	Resistance ratio per cent (S ₁)	in ratio from initial reading per cent	movement from initial position inches].ake elev.
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	Resi	stance	e rati	o. me	ter closed:	98.6 per c	ent	cont		•	
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	Mete	r res	istand	ce at (0° F. correc	ted for lead	ls4	9.670hms			
	Chan	ge in	tempe	atur	e per ohm cl	hange in res	istan	ce_10.95	° _F		
	*Ad	juste	d res	sista	nce ratio	after 9-	28-7	2 (100.0	6).		~
	[Tem	perat	ure	Total	Increase	r	Poststance	Change	Indicated	
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	Dag			At	from O ^O F	resistance		per cent	from	from	
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Date	Time	Min.	Max.	Obs.	(S ₂)	ohms	0 F	(s ₁)	per cent	inches	elev.
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New meter installed 9-28-72.

Drill-	hole	No	DH-2aL
Meter	No.	-	J-13
Sheet	No.		,

Calibrations:

Calibration constant, corrected for leads.000627 inches per 0.01% ratio change Resistance ratio at initial reading 100.04 per cent * Resistance ratio, meter closed: 96.0 per cent Resistance ratio, meter open: 104.0 per cent Meter resistance at 0°F, corrected for leads 54.84 ohms Change in temperature per ohm change in resistance 9.56 °F

*Adjusted resistance ratio after 9-28-72 (99.88). Temperature Change Indicated Total Increase Resistance in movement resistance in ratio ratio At from from 0°F resistance per cent from Pac time initial from O^OF ohms Temp initial Lake Std position of reading per cent o_F (S₂) ohms (S1) elev. inches Time Min. Max. Date Obs. EXHIBIT "E

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MATILIJA DAM

New meter installed 9-28-72.

Drill-	-h ole	No	DH-3L
Meter	No.		J-14
Sheet	No.		

Calibrations:

Calibration constant, corrected for leads <u>.000681</u> inches per 0.01% ratio change Resistance ratio at initial reading <u>100.14</u> per cent * Resistance ratio, meter closed: <u>95.2</u> per cent Resistance ratio, meter open: <u>102.9</u> per cent Meter resistance at 0°F, corrected for leads <u>.56.75</u> ohms Change in temperature per ohm change in resistance <u>9.61</u> °F

*Adjusted resistance ratio after 9-28-72 (98.231). Change Temperature Indicated Tota1 Increase Resistance in movement resistance in ratio ratio At from O^OF from resistance per cent from Pac time initial from 0°F ohms initial Temp Lake Std position of reading per cent °F. (S₂) ohns (S₁) elev. inches Time Min. Max. Obs. Date EXHIBIT "E'

Pro je	ct	MATJ	[LIJA	DAM			11	Dr	ill-hole 1	No DH-1R	<u> </u>
)		Orte	-1-01	Toto	loopod	c		Me	ter No.	M-6	
		rei	insta	11ed	9-28-72.	. ἀ		Sh	eet No.		
Calib	ration	s:									
	Cali	bratic	on con	istant,	, corrected	for leads	0115	8 inches pe	er 0.01% r	atio chang	e
	Resi	stance	e rati	o at i	initial read	ing 100.1	<u>p</u> er	cent *			
	Resi	stance	e rati	.o, met	ter closed:_	<u>98.0</u> per c	ent			E	
	Resi	stance	e rati	.o, met	ter open: $\underline{10}$	3.0 per cer	it -	76 ,			
	Mete	r res:	istanc	e at u) ⁻ F, correct	ted for lead	s t eran	10_{\circ} onms $10_{\circ}88$	0 _ច		
	*Ad	iuste	ed re	sista	nce ratio	after 9-2	28-72	(100.8	- <u>-</u> (61).		
			norati		Totol	Γ	1		Change	Indicated	
		1.51	lorati		resistance	in		Resistance ratio	in	movement	
	Pac			At	from O ^O F	resistance		per cent	ratio from	from	
-	Std			of	ohms	from OF	Temp		initial reading	position	Lake
Date	Time	Min.	Max.	Obs.	(32)	Опль	r	(51)	per cent	inches	elev.
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			TT T T A					Dre	ll-hole N	DH-2R	
Projec	et	MAT	TTTT	A DAM	a a second a			Mei	ter No	M-1	
)		Ori rei	ginal nstal	l meto	er-cleane 9-28-72.	4 &	2	She	et No.		
Calib	ration	s;			6	1.8			1.1		<i>9</i> 2
191	Cali	bratic	on con	stant,	corrected	for leads 0	0114	5 inches pe	r 0.01% r	atio change	9
	Posi	stance	s rati	o met	an alocad	97.9 per c	ent	Cent	10		
	Resi	stance	- rati	o met	$er open \cdot 10$	3.0 per cen	t	5			
	Mete	r rest	lstanc	e at C	^o F, correct	ed for lead	<u>50.</u>	<u>07</u> ohms			
	Chan	ge in	tempe	rature	per ohm ch	nange in res	istan	ce_10.95	- °F		
	*Ad	juste	d rea	sista	nce ratio	after 9-2	8-72	(_).		
	9.1	Tem	perati	ure	Total	Increase		Resistance	Change	Indicated	
и -	Doo			At	resistance from 0 ⁰ F	in resistance	2	ratio per cent	in ratio from	movement from	
×	Std	- N		time	ohms	from O ^O F	Temp		initial reading	position	Lake
Date	Time	Min.	Max.	Qbs.	(S ₂)	ohms	F	(S ₁)	per cent	inches	elev.
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Projec	:t	MATI	LIJA	DAM	<u> </u>			Dr	ill-hole N	loDH-2a	<u>R</u>
)	×	Nou	moto	w inc	talled 0	 00 70		Met	ter No.	J-15	
		New	meter	c ins	Larred 9-	20-72.		She	et No.		
Calibr	ation	в:							131.	× .	2
	Calil	oratic	on con	stant,	corrected	for leads	0063	9 inches pe	r 0.01% r	atio change	ə
. <u>1</u> . r	Resi	stance	rati	o at i	nitial read	$\lim_{m \to \infty} \frac{100.52}{100}$	per	cent *			× .
	Resi	stance) rati	o, met	er closed:	<u>90.1</u> per c	ent				
8	Resi	stance) rati	o, met	er open: <u>10</u>	4.U per cen	t 254.	63 ohma		· * 4	
	Mete: Chan	r resi	tempe	e at u	per ohm ch	ed for lead	istan	<u>9.65</u>	0 _F		
	*Ad	juste	d rea	sista	nce ratio	after 9-2	8-72	(100.0	82).		
T		Tem	nerati	ure	Total	Ingroups		Registeres	Change	Indicated	
		101			resistance	in		ratio	in	movement	
	Pac			At	from O ^O F	resistance		per cent	from	initial	
	Std			of	ohms (Sa)	from OF	Temp or	(5-)	reading	position	Lake
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Proje	et	MATII	IJA	DAM				Dr	ill-hole ;	$\frac{DH-3K}{T-14}$	
2	*	New n	neter	inst	alled 9 - 2	8-72.		Me Sh	eet No.	<u>J-10</u>)
Calib	ration	s:									
	Cali Resi Resi Resi	bratic stance stance stance	on con e rati e rati e rati	astant, .o at i .o, met .o. met	corrected initial reac ter closed:_ ter open:10	for leads: hing 100.1 96.7 per c 4.6 per cer	00064 3 per cent	<u>∔6</u> inches pe cent *	er 0.01% r	atio chang	e
	Mete Chan *Ad	r resi ge in juste	istanc tempe ed re	ce at (erature sista	D ^o F, correct e per ohm ch nce ratio	ted for lead nange in res after 9-2	is <u>55.</u> Sistan 28-72	$\frac{18}{9.66}$ (100.13	_ ° _F		
	Pac Std	Tem	perati	At time of	Total resistance from O ^O F ohms	Increase in resistance from 0°F	Temp	Resistance ratio per cent	Change in ratio from initial reading	Indicated movement from initial position	Lake
Date	Time	Min.	Max.	Obs.	(52)	Onns	r	(\$1)	per cent	inches	erev
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TABLE OF READINGS

DATE OF READINGS: Feb. 25, 1975

TIME OF READINGS: Right Abutment 1100 PST

All readings in ohms

METER READING	BLACK & WHITE	WHITE & GREEN	BLACK & GREEN	LEAD RESISTANCE	ADOPTED VALUE
1R	57.76 57.77	30.56 30.56	30.40 30.41	3.20 3.20	3.20
2R	57•97 57•98	30.87 30.87	30.88 30.88	3.78 3.77	3.77
2aR	63.30 63.32	33•57 33•57	33•46 33•47	3.73 3.72	3.73
3R	64.16 64.16	34•45 34•45	34•34 34•34	4.63 4.63	4.63

EXHIBIT "F"

TABLE 1

DERIVED CALIBRATION CONSTANTS FOR STRAIN GAGES 1R AND 2R

MARCH 5, 1975

Meter Meter Location Number	Meter	Resistance	Degrees	Calibration	Resistance Ratios		
	90° F.	Per Unin	Constant	Open	Closed		
1 R	M-6	49.34	10.88	.001150	103.6	98.0	
2 R	M-1	48.99	10.95	.0011/25	103.0	97.9	

Equation:

$$C = \frac{RC!}{R+.89 y}$$

where

C = Calibration constant of the meter.

R = Meter resistance at 0° F.

C'= Calibration constant, corrected for leads.

y = Resistance of a pair of leads.

Computed by William C. Minger

Checked by George A. Gonsman

EXHIBIT "G"

Pro ject	MATILIJA	DAM
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New Meter installed 9-28-72

Drill-ho	le No	DH - 1L	
Meter No	•	J - 12	
Sheet No	·	1	

Calibrations:

Calibration constant, corrected for leads <u>•000642</u> inches per 0.01% ratio change Resistance ratio at initial reading <u>100.06</u> per cent * Resistance ratio, meter closed: <u>95.8</u> per cent Resistance ratio, meter open: <u>103.7</u> per cent Meter resistance at 0°F, corrected for leads <u>55.05</u> ohms Change in temperature per ohm change in resistance <u>9.61</u> °F * Adjusted resistance ratio after 9-28-72 (103.409)

Change Indicated Temperature Total Increase Resistance in movement resistance in ratio ratio from At from 0°F resistance per cent from Pac initial time from 0°F initial ohms Temp Lake position Std of reading o_F (S₂) ohms elev. (s₁) inches Time Min. Max. per cent Obs. Date . EXHIBIT H

Proje	e t 🤄	MAT	ILIJA	DAM				Dr	ill-hole l	to <u>DH-2L</u>	
)		Ori rei	gina] nsta]	l meț lled	er-cleaned 9-28-72.	d €x		Me	ter No. eet No.	M-3	
Calib:	ration Cali Resi	s: bratic stance	on con è rati	stant, o at i	corrected initial read	for leads_	0010 per	73inches pe cent *	or 0.01% r	atio chang	e
	Resi Resi Mete	stance stance r resi	e rati e rati istanc	o, met o, met e at (cer closed: cer open: <u>1(</u>) ⁰ F', correct	<u>98.6</u> per c 04.2per cen ted for lead	ent it ls <u>4</u>	9.670hms		, í	
	Chan *Adj	ge in uste	tempe d res	rature	e per ohm ch nce ratio	after 9-	istan 28-7	2 (10.95)	_ ⁰ F 6)	ž	
		Tem	peratu	ire	Tota1	Increase		Resistance	Change	Indicated	
Date	Pac Std Time	Min.	Max.	At time of Obs.	resistance from 0 ⁰ F ohms (S ₂)	in resistance from () ⁰ F ohms	Temp ^O F	ratio per cent (S ₁)	ratio from initial reading per cent	from initial position inches	Lake elev.
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MATILIJA DAM

New meter installed 9-28-72.

Drill-	-h ol e	No	DH-2aL
Meter	No.		J-13
Sheet	No.	<u> </u>	

Calibrations:

Calibration constant, corrected for leads 000627 inches per 0.01% ratio change Resistance ratio at initial reading 100.04 per cent * Resistance ratio, meter closed: <u>96.0</u> per cent Resistance ratio, meter open: <u>104.0</u> per cent Meter resistance at 0°F, corrected for leads <u>54.84</u> ohms Change in temperature per ohm change in resistance <u>9.56</u> °F *Adjusted resistance ratio after 9-28-72 (99.88).

		Temperature			Total	Increase	1	Resistance	Change	Indicated	31
Date	Pac Std Time	Min,	Max.	At time of Obs.	resistance from 0 ⁰ F ohms (S ₂)	in resistance from 0 ⁰ F ohms	Temp oF	ratio per cent (S ₁)	in ratio from initial reading per cent	movement from initial position inches	Lake elev.
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iect	MATTLTTA	DAM
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New meter installed 9-28-72.

D rill -h	ole No	DH-3L
Meter N	io	J-14
Sheet N	ło	2

Calibrations:

Calibration constant, corrected for leads.000681 inches per 0.01% ratio change Resistance ratio at initial reading 100.14 per cent * Resistance ratio, meter closed: 95.2 per cent Resistance ratio, meter open: 102.9 per cent Meter resistance at 0°F, corrected for leads 56.75 ohms Change in temperature per ohm change in resistance 9.61 °F *Adjusted resistance ratio after 9-28-72 (98.231).

		Tem	'emperature		Total	Increase		Resistance	Change in	Indicated movement	•
Date	Pac Std Time	Min.	Max.	At time of Obs.	from 0°F ohms (S ₂)	in resistance from 0°F ohms	Temp ^O F	ratio per cent (S ₁)	ratio from initial reading per cent	from initial position inches	Lake elev.
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EQUATION COMPUTATION OF ADJUSTED RESISTANCE RATIO March 6, 1975

The following equation was used to adjust the <u>Resistance ratio at initial</u> reading after the leads were lengthened so that the plots on the Right Abutment graphs would be consistent with plots made before leads were lengthened.

Equation used when "M" or movement prior to lengthening leads was positive.

$$Ra = \frac{C'R + M}{C'}$$

Equation used when "M" or movement prior to lengthening leads was negative.

$$Ra = \frac{C'R - M}{C'}$$

where

Ra = Adjusted resistance ratio.

- C' = Calibration constant corrected for leads in inches per 1 % ratio change.
- R = Resistance ratio at initial reading in per cent.
- M = Indicated movement from initial position in inches prior to lengthening leads.

Project	MATILIJA DAM		Drill-hole No DH - 1R				
)			Meter No.	<u>M - 6</u>			
	Leads extended 2-26-75		Sheet No.	.			
Calibrati	lons:	×.					

Calibration constant, corrected for leads <u>001216</u> inches per 0.01% ratio change Resistance ratio at initial reading <u>100.57</u> per cent * Resistance ratio, meter closed: <u>98.0</u> per cent Resistance ratio, meter open: <u>103.6</u> per cent Meter resistance at 0°F, corrected for leads <u>52.19</u> ohms Change in temperature per ohm change in resistance <u>10.88</u> °F

* Adjusted resistance ratio after 2-26-75 (100.723)

		Tem	perati	ure I	Total resistance	Increase		Resistance	Change in	Indicated movement	
Date	Pac Std Time	Min.	Max.	At time of Obs.	from 0°F ohms (S ₂)	resistance from 0°F ohms	Temp ^O F	per cent (S ₁)	ratio from initial reading per cent	from initial position inches	Lake elev.
2-21-75	0800				Prior to le	ngthening	leads			-0.0186	
					After leng	thening lea	ds				
2-26-75	0800			49.	56.83	4.64	50.	100.57	-0.153	-0.0186	1074.25
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Project ____MATILIJA DAM

Leads extended 2-26-75

Drill-	-h ol e	No <u>DH - 2R</u>
Meter	No.	<u>M - 1</u>
Sheet	No.	

Calibrations:

Calibration constant, corrected for leads <u>•001202</u> inches per 0.01% ratio change Resistance ratio at initial reading <u>100.00</u> per cent * Resistance ratio, meter closed: <u>97.9</u> per cent Resistance ratio, meter open: <u>103.0</u> per cent Meter resistance at 0°F, corrected for leads <u>52.73</u> ohms Change in temperature per ohm change in resistance <u>10.95</u> °F * Adjusted resistance ratio after 2-26-75 (99.828)

Change Indicated Temperature Total Increase Resistance in movement resistance in ratio ratio At from from 0°F resistance per cent from Pac initial time from 0°F ohms initial Temp Lake position Std of °F reading per cent (S_2) ohns (S₁) elev. inches Time Min. Obs. Date Max 2-21-75 0800 Prior to lengthening leads +0.0207 After lengthening 57.18 4.45 eads 490 490 +0.172 2-26-75 0800 57.18 100.00 +0.0207 1047.25 EXHIBIT H

Project	MATILIJA DAM	*	1.1	Drill-hole	No DH - 2aR
	· · · · · · · · · · · · · · · · · · ·			Meter No.	J-15
· · · ·	Leads extended 2-26-75			Sheet No.	
Calibrati	ons:		15		

Calibration constant, corrected for leads <u>.000669</u> inches per 0.01% ratio change Resistance ratio at initial reading <u>100.37</u> per cent* Resistance ratio, meter closed: <u>96.1</u> per cent Resistance ratio, meter open: <u>104.0</u> per cent Meter resistance at 0°F, corrected for leads <u>57.46</u> ohms Change in temperature per ohm change in resistance <u>9.65</u> °F

* Adjusted resistance ratio after 2-26-75 (99.827)

		Temperature			Total	T	Destatures	Change	Indicated	ı T	
Date	Pac Std Time	Min.	Max.	At time of Obs.	resistance from O ^O F ohms (S ₂)	in resistance from 0 ⁰ F ohms	Temp ^O F	ratio per cent (S ₁)	in ratio from initial reading per cent	movement from initial position inches	l.ake elev.
2-21-75	0800				Prior to lei	gthen ing	leads			+0.0363	
					After les	athening 1	eads				
2-26-75	0800	-		49°	63.16	5.70	55°	100.37	+0.543	+0.0363	1047.25
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Project ____MATILIJA DAM

Leads extended 2-26-75

Drill-	hole	No	DH	– 3R	
Meter	No.	2000	J -	16	
Sheet	No.				

Calibrations:

Calibration constant, corrected for leads <u>.000678</u> inches per 0.01% ratio change Resistance ratio at initial reading <u>100.38</u> per cent * Resistance ratio, meter closed: <u>96.7</u> per cent Resistance ratio, meter open: <u>104.6</u> per cent Meter resistance at 0°F, corrected for leads <u>58.29</u> ohms Change in temperature per ohm change in resistance <u>9.66</u> °F

* Adjusted resistance ratio after 2-26-75 (100.16)

Date 2-21-75	Pac Std Time	<u>Tem</u>	peratu Max.	At time of Obs.	Total resistance from 0°F ohms (S ₂)	Increase in resistance from 0°F ohms	Temp ^O F	Resistance ratio per cent (S ₁)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
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					After le	nathening	leads				
2-26-75	0800			4.90	63.37	5.08	49.	100.38	+0.22	+0.0149	1074.25
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MEMORANDUM

MATILIJA DAM

STRAIN GAGE PROGRAM

JULY 23, 1976

LEAD RESISTANCE CHECK PRIOR TO NEW STRAIN GAGE METER INSTALLATION. DH-1L

METER J-17

Following instructions supplied by Carlson Instruments, Campbell, California, the following equation was used for measuring the resistance of a pair of leads during the installation of the new strain meter J-17 in Drill Hole 1L.

EQUATION

B + C - A = resistance of a pair of leads.

Check No. 1.

Reading A = 63.30) Reading B = 32.67) Resistance = 1.22 ohms. Reading C = 31.85)

Check No. 2

Reading A = 63.40) Reading B = 32.71) Resistance = 1.19 ohms. Reading C = 31.88)

2.41 ohms.

$$2.41 - 2 = 1.20$$
 ohms.

Resistance of a pair of leads = 1.20 ohms.

EXHIBIT J

Project MATILIA DAM

Drill-hole	No <u>DH-17.</u>
Meter No.	J-17
Sheet No.	

New meter installed 7/23/76

Calibrations:

Calibration constant, corrected for leads <u>000653</u> inches per 0.01% ratio change Resistance ratio at initial reading <u>102.60</u> per cent^{*} Resistance ratio, meter closed: <u>96.3</u> per cent

Resistance ratio, meter open: <u>104</u> oper cent Meter resistance at 0°F, corrected for leads <u>55.70</u> ohms Change in temperature per ohm change in resistance <u>9.51</u> °F

* Adjusted resistance ratio at initial reading after 7/21/76 (111.559)

		Temperature		Total	Increase		Registance	Change	Indicated		
Date	Pac Std Time	Min.	Max.	At time of Obs.	resistance from 0°F ohms (S ₂)	in resistance from O ^O F ohms	Temp o _F	ratio per cent (S1)	in ratio from initial reading per cent	movement from initial position inches	Lake elev.
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MEMORANDUM

MATILIJA DAM

STRAIN GAGE PROGRAM

JULY 26, 1976

OBTAINING "CALIBRATION CONSTANT CORRECTED FOR LEADS DH-1L METER J-17

EQUATION

$$C' = C + \frac{yC (0.89)}{R}$$

where

C' is the new calibration constant. C is the original calibration constant. y is the resistance of a pair of leads. R is the meter resistance at 0° F

$$C^{1} = C + \frac{1.20 \times .00064 \times 0.89}{54.50}$$

 $C^{1} = .00064 + .00001254$

 $C^{1} = .000653$

MODEL NO	J0.5			DATE 9-12-73					
CUSTOMER	Ventura	County		SALES ORDER	NO. 02	62			
METER	RESISTANCE AT 0 DEG.F	DEGREES PER OHM	CALIERATION CONSTANT	OPEN	ISTANCE RATI	IOS AS SHIPPED			
J17	54.50	9.51	.00064	1.042	.963	.981			

Exhibit M

R.

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MEMORANDUM

MATILIJA DAM

STRAIN GAGE PROGRAM

JULY 29, 1976

EXTRAPOLATION OF STRAIN GAGE READINGS JANUARY 5 TO AUGUST 1, 1976 DH-1L METER J-12

In July, 1976, meter J-12 located in Drill Hole 1-L was recognized as being inoperative. From observations made during the past year, it became obvious that approximately from January 5, 1976 thru July 12, 1976, readings made at DH-1L were in error. In order to provide some estimate of the movement between the Left Abutment and the Dam at DH-1L, the following method was used and results plotted on the Deformation vs. Time graph:

From the current graph Deformation vs. Time, the deformation in inches for August 1, 1974 and August 1, 1975 was plotted on rectangular coordinate graph paper and was extended by a straight line to August 1, 1976. A reading of -.5850 was picked from the extended graph line and plotted on the DH-1L Deformation vs. Time graph for August 1, 1976. A dashed line was drawn from January $\frac{1}{2}$, 1976 to August 1, 1976 to represent the approximate deformation at DH-1L during the period of erroneous record.

0140 a.C

George A. Gonsman Supervisor, Field Hydrology

EXHIBIT N

MEMORANDUM

MATILIJA DAM

STRAIN GAGE PROGRAM

AUGUST 2, 1976

ADJUSTMENT OF INITIAL RESISTANCE RATIO READINGS AT DH-1L Reference: Memorandum from S. G. Marsh to J. B. Quinn dated March 30, 1973

At the time of installation of Strain Meter J-17 in Drill Hole 1-L, the "Resistance ratio at initial reading" was set to read 102.60 percent with a balanced circuit on the Carlson Test Set. In order to make subsequent readings correspond to previous readings on the DH-1L Deformation vs. Time graph, the following calculations were made:

The previously plotted deformation of -.5850 for August 1, 1976 (see memo dated July 29, 1976) was devided by the Calibration Constant Corrected for Leads per 1% ratio change of .0653 (see memo dated July 26, 1976). The resulting adjustment of -.8959 was added to the initial reading of 102.60 percent for an <u>adjusted resistance ratio</u> at initial reading of 111.559 percent.

The first reading made on July 26, 1976 after installation of the new meter will now correspond to previous readings and the estimated projected reading plotted for August 1, 1976.

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George A. Gonsman Supervisor, Field Hydrology

EXHIBIT P

Drill-hole No. DH 1-L

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Adjustment of initial resistance ratio readings to provide completed indicated movements from the new meter readings that will plot in the same range as those from the old meter readings.

<u>-,5850</u> Adjustment of the indicated movement from initial position in inches.

Calibration constant, corrected for leads .000653 inches per 0.01% ratio change or .0653 inches per 1% ratio change.

-.5850 \div .0653 = -8.959 Adjustment to resistance ratio at initial reading.

<u>/02.600</u> Resistance ratio at initial reading in percent per <u>7-26-76</u> <u>**8**.959</u> Adjustment to resistance ratio at initial reading (Note*) <u>///.559</u> Adjusted resistance ratio at initial reading in percent.

*NOTE: If adjusted resistance ratio at initial reading is negative add; if positive subtract.

EXHIBIT P

PUBLIC WORKS AGENCY

county of ventura

Director

A. P. Stokes

Deputy Directors

D. A. Betlach

- Roads & Surveyor
 D, Shinavar
- Field Operations G. J. Nowak
- Flood Control & Drainage H. P. Nilmeier
- Water & Sanitation
- T. M. Morgan Special Projects

©. B. Perry Management Services

Mr. Gordon L. Dukleth, Division Engineer Division of Safety of Dams State Department of Water Resources P. O. Box 388 Sacramento, California 95802

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

Dear Mr. Dukleth:

August 6, 1976

Our letter to you dated July 9, 1976, transmitted updated copies of deflections for the twelve face targets on Matilija Dam, and plots of deformation versus time for the eight straingages. Recent deflections shown for the meter in Drill Hole 1L indicate an uncharacteristic flattening of the data points which has been recently reviewed by our staff. Our review indicates the current graph for DH-1L for most of 1976 is erroneous and we have enclosed a revised copy.

Meter J-12 was installed in Drill Hole 1L in September 1972. Information from the factory indicated that the resistance ratio for that meter at the closed position was 95.8 percent. Earlier this year an apparent deviation in the data points from the historic trend was noted; however, the resistance ratio at that time was well above 96 percent and it was assumed the indicated readings were authentic. Following a continuation of that trend into July of this year Meter J-12 was examined and found to be operating in

EXHIBIT Q

Gordon L. Dukleth, Division Engineer Division of Safety of Dams State Department of Water Resources August 6, 1976 Page Two

MATILIJA DAM - REVISED REPORT OF INSTRUMENT READINGS, FLOOD ZONE I

a closed position. Further analysis indicated that the resistance ratio at the closed position did not consider resistance in the lead wires. After measuring resistances of the leads, we estimate the meter has been closed since mid-January of this year.

On July 23 the meter was replaced and on July 26 the replacement was reset to an initial reading of -0.585. The initial reading for the replacement meter was approximated by extending deformation measured during late July and early August from recent years to the present time. This technique assumes that deformation during this period varied linearly with time and it represents an approximation. However, we believe this alternative more appropriate than continuing the plots from an initial reading of zero.

We have adjusted the new meter to allow a greater compressive deformation; and, with the resistance of the leads now determined, we hope to monitor more closely the deformation of this meter with respect to its closed position. If you have any questions regarding this problem or our procedures used in determining the initial reading, please do not hesitate to contact us.

Very truly yours,

Gerald J. Nowak, Deputy Director Flood Control and Drainage Department

By <u>Slever D. Rilled</u> Gerald D. Bickel

Gerald D. Bickel Supervising Hydrologist

Enclosure

GDB:ggh



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