Oakdale Irrigation District Memorandum

To: Tim O'Laughlin

From: General Manager, Steve Knell, P.E. (License No. 50256)

Date: April 6, 2015

Re: New Melones/Old Melones Analysis

Background:
A question has been raised about the extent of the sediment upstream of Old Melones Dam. The question is, "Has the sediment built-up behind Old Melones such that it would block the flow of water through the Old Melones outlet?"

Physical Layout:
In developing that answer, a review and understanding of the physical layout of Old Melones Dam is needed. Attached as Exhibit 1 is the Melones Dam General Plan of Works (Final Version).

It is important to note the key features in this Exhibit. One is the elevation of the dam crest at elevation 723. At an elevation lower than 723, the water upstream of Old Melones is separated from the pool of water that would lie between both New and Old Melones Dams. At that point, the only connection between the two pools is water flowing into and through the Tunnel identified in Exhibit 1 in both the Plan and Profile views.

The Tunnel (or Penstock) curves around Old Melones on the south side of the structure and heads downstream to what was the Old Melones Powerhouse, approximately 4,956 feet downstream (ref. Exhibit 2). The Tunnel dimensions indicated on Exhibit 2 show an equivalent area of the Tunnel to equate to a 15 foot diameter pipe.

In about 405 feet along the Tunnel pathway exists 4-60 inch diameter outlet pipes designated on Exhibit 1 as "Irrigation Outlets." These outlets discharge into the pool that would exist between Old Melones and New Melones Dams when the water level drops below elevation 723.

Current Soundings at Old Melones:
Late last week and this morning Tri Dam Project personnel used sounding and video equipment to investigate the current status of Old Melones Dam. Tri Dam Project personnel located and sounded the top of the Old Melones Dam and took a sounding in front of the dam to gather information on the depth of sedimentation in front of the dam. From the sounding taken at the top of the dam to a flat elevation in front of the dam, the elevation difference was 100 feet.

Those reference numbers would place the sediment in front of Melones at elevation 623. For note, the sediment likely to be found is more like a "muck," a mixture of both fine sediment and dead decaying algae that has fallen to the bottom of lakes. It is generally unconsolidated material and easily re-suspended in the water column when disturbed.

With the bottom invert of the 15 foot Tunnel at elevation 610, that would make the top of tunnel elevation 625. That 2 foot gap would mean the Tunnel is open and viable for moving water from upstream of Old Melones to the pool downstream of the dam when the water level drops below elevation 723.

When Water Begins to Move:
As the water surface in the pool of water between Old Melones and New Melones drops and begins to separate itself from the water surface upstream of Old Melones, a head differential will begin to establish itself between the two pools of water. This head differential will create a hydraulic gradient that will begin forcing water through the 2 foot gap. As water moves into and through the gap the velocity of that movement will begin picking up sediment. Usually at 1.5 to 2.5 feet per second (fps) fine sediment particles, as likely to be found in front of the tunnel will be picked up and transported away.

As the head differential between the two pools increases, the water velocity also increases flowing through the gap, picking up more and more sediment and enlarging itself as it cleans out the tunnel entrance. This process will continue until an energy balance is reached. At that point the head differential between the two pools creates a flow volume equal to the volume of water being released downstream from New Melones Dam.

Sediment will stop being picked up when the area created in the sediment by the water velocity has enlarged to the point that the transport velocity of the flow drops below the 1.5-2.5 fps threshold.

1992 Release Accounts:
The situation we are facing today occurred in 1992. Anecdotal accounts from Tri Dam personnel indicate that the pool level downstream of Old Melones Dam continued to drop after the crest elevation of 723 on the dam was reached. The pool downstream of Old Melones continued to drop as water was released from New Melones until a 6 to 8 foot differential was reached between the two pools. At this point the hydraulic pressure/gradient had moved the material out of the tunnel inlet.

2013 Release Accounts:
New Melones' low level outlet was exercised in the fall of 2013 for a period of 10 days, with a maximum outlet flow of 1,300 cfs and a longer, steadier outlet flow of 360 cfs. No sediment or turbidity issues were seen in Tulloch Lake.

Turbidity Analysis:
From the physical layout of Melones Dam; the sounding data supplied by Tri Dam Project personnel; and the history of past occurrences; it is my professional opinion that the Tunnel from Old Melones Dam will reopen itself as it did in 1992.

Firsthand visual accounts in 1992 recall an ever so slight differential in water color between the two dams when the 6-8 foot differential was reached, indicating some turbidity was present. There are no accounts of discernable turbidity issues being reported at Tulloch Lake in 1992.

Displaced Sediment Analysis

Assume an outflow volume from New Melones of 600 cfs to meet an October pulse flow. That flow demand would generate an inlet velocity of 3.3 fps (V = Q/A) at the inlet to the Melones Tunnel. To get the velocity down to the minimum 2 fps "outside" the Tunnel would require a flow area of 300 sq. ft.

Assume that the required 300 square feet flow area was laid our horizontally at the Tunnel inlet, it would represent a circle with a diameter of 20 feet. Assume the 20 foot circle represents the sediment cone at the mouth of the Tunnel that would need to be opened up to accommodate the 600 cfs at a non-erosive velocity. Further assume (conservatively) that all the sediment 20 feet upstream of the tunnel was removed, as well as the 13 foot of sediment depth at the mouth of the Tunnel, and assume (conservatively) 20 foot inside the Tunnel was also full of sediment; from those dimensions, the entire volume of muck would total less than 300 yards of material ((40 X 15 X 13)/27). Not a substantial amount of material by engineering standards.

This amount of sediment and organic material that would be dispersed will likely fallout within the existing pool between New Melones and Old Melones or be retained in Lake Tulloch. Based on eyewitness accounts from 1992 there was no sediment discharge into Lake Tulloch from New Melones.

Summary:

- The upstream pool of water in Melones Dam is available and accessible.
- The volume of sediment that potentially could be dispersed by using the Old Melones Dam Tunnel would be minimal and will likely be dispersed and settled out in the pool between the two dams.

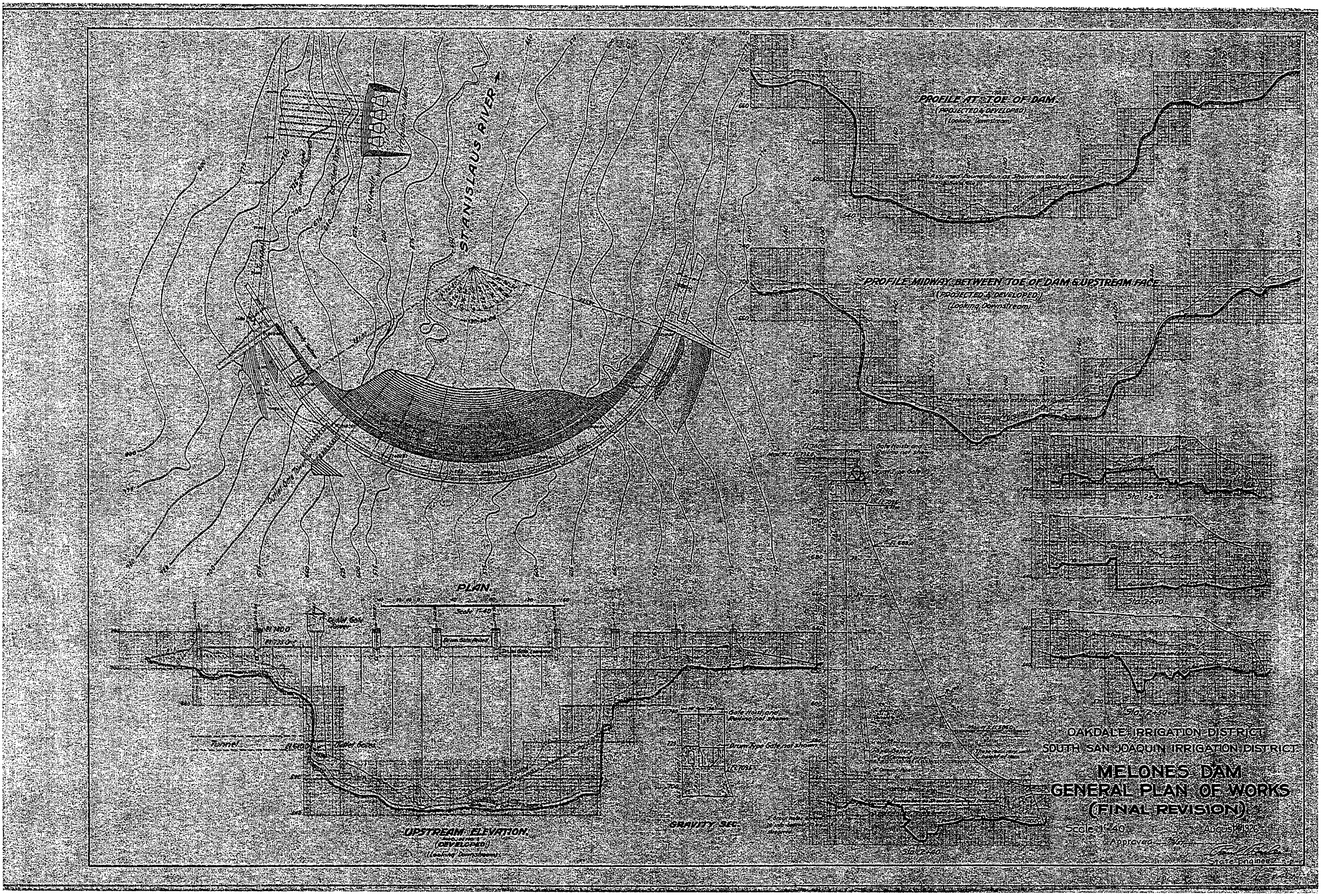

STANISLAUS RIVER
PROFILE AT TOE OF DAM.
(PROJECTED & DEVELOPED)
(Looking Downstream)
PROFILE MIDWAY BETWEEN TOE OF DAM & UPSTREAM FACE
(PROJECTED & DEVELOPED)
(Looking Downstream)
PLAN.
UPSTREAM ELEVATION.
(DEVELOPED)
(Looking Downstream)
GRAVITY SEC.
Tunnel
OAKDALE IRRIGATION DISTRICT
SOUTH SAN JOAQUIN IRRIGATION DISTRICT
MELONES DAM
GENERAL PLAN OF WORKS
(FINAL REVISION)
Scale 1"=40'
Approved
State Engineer

EXHIBIT 1

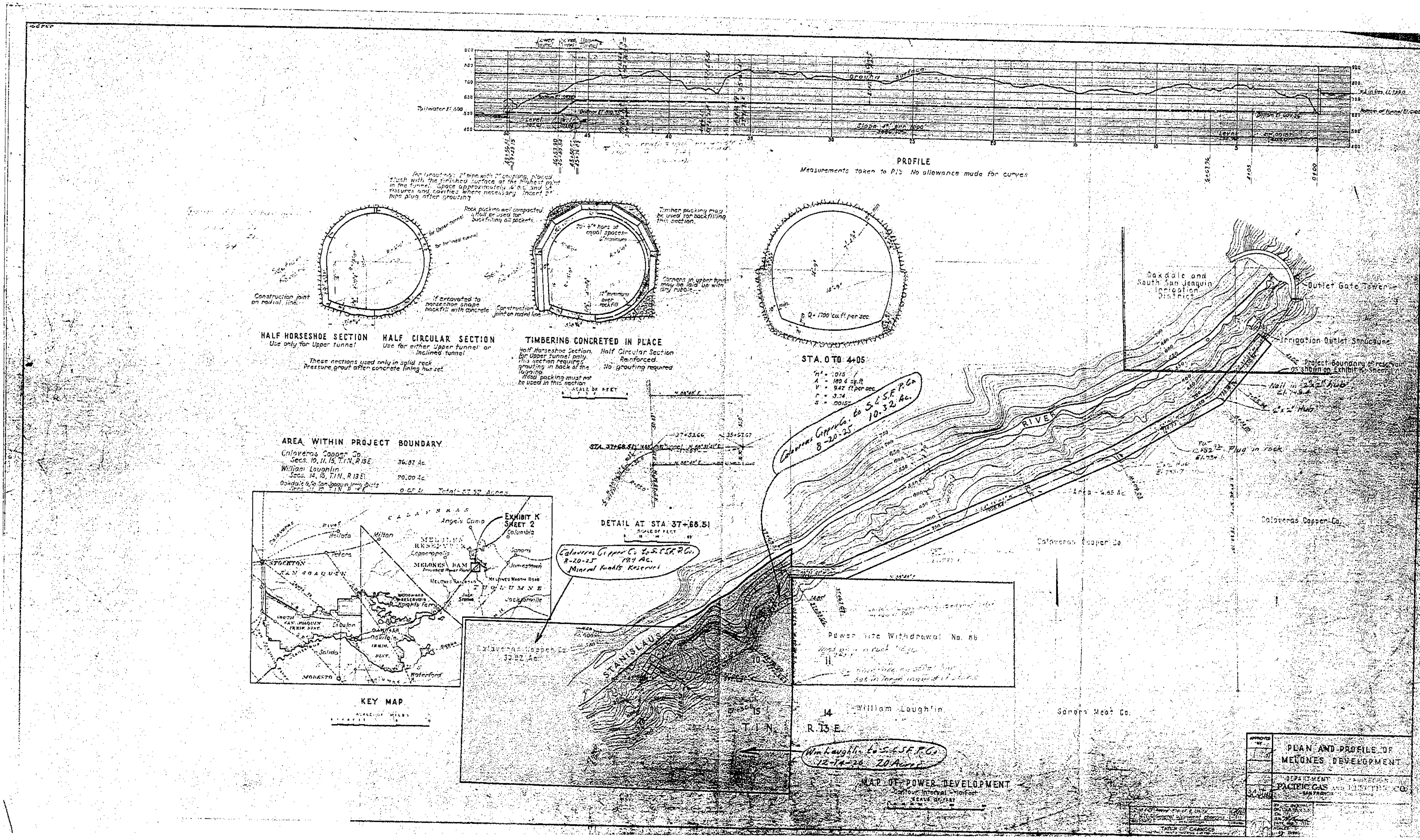
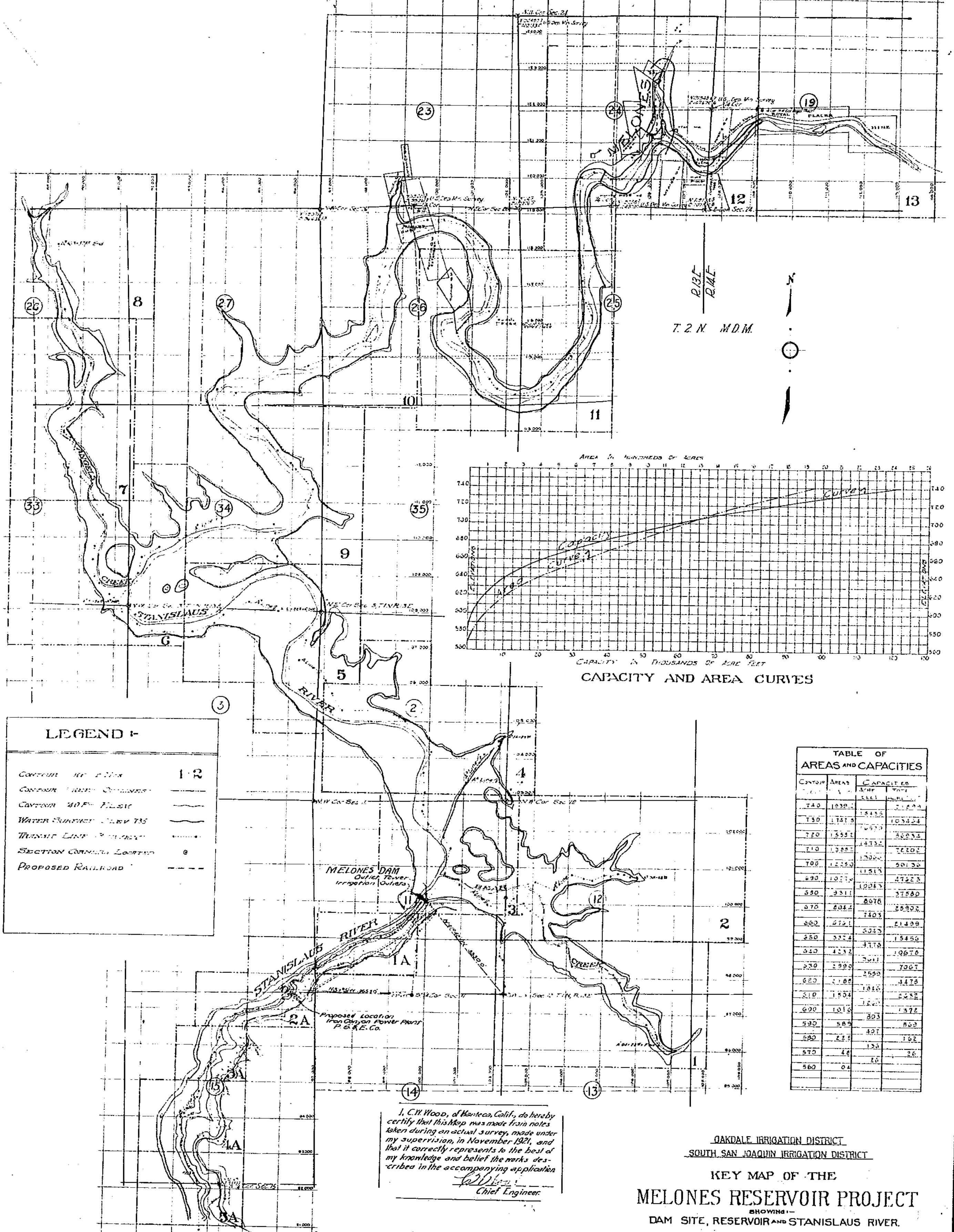

PROFILE
Measurements taken to P.I.'s. No allowance made for curves
Tailwater El. 500
Ground Surface
HALF HORSESHOE SECTION
Use only for Upper tunnel
HALF CIRCULAR SECTION
Use for either Upper tunnel or Inclined tunnel
These sections used only in solid rock
Pressure grout after concrete lining has set.
Construction joint on radial line
TIMBERING CONCRETED IN PLACE
Half Horseshoe Section. For Upper tunnel only. This section requires grouting in back of the lagging. Wood packing must not be used in this section
Half Circular Section Reinforced. No grouting required
Timber packing may be used for backfilling this section.
STA. 0 TO 4+05
Q = 1700 cu.ft per sec.
Oakdale and South San Joaquin Irrigation Districts
Outlet Gate Tower
Irrigation Outlet Structure
Project Boundary of reservoir as shown on Exhibit K Sheet
Calaveras Copper Co. to S.C.S.F.P.Co. 8-20-25 10.32 Ac.
AREA WITHIN PROJECT BOUNDARY
Calaveras Copper Co.
Secs. 10, 11, 15, T.1 N., R.13 E.
William Laughlin
Secs. 14, 15, T.1 N., R.13 E.
Oakdale & So San Joaquin Irrig. Dists
DETAIL AT STA. 37+68.51
Calaveras Copper Co. to S.C.S.F.P.Co. 8-20-25 Mineral Rights Reserved
KEY MAP
EXHIBIT K SHEET 2
Angels Camp
Columbia
Milton
MELONES RESERVOIR
Copperopolis
MELONES DAM
Sonora
Jamestown
STOCKTON
SAN JOAQUIN
Jacksonville
Escalon
Oakdale
Salida
Modesto
Waterford
RIVER
STANISLAUS
Calaveras Copper Co.
Power Site Withdrawal No. 86
William Laughlin
Sonora Meat Co.
T.1 N.
R.13 E.
Wm Laughlin to S.C.S.F.P.Co. 12-14-26 20 Acres
MAP OF POWER DEVELOPMENT
PLAN AND PROFILE OF MELONES DEVELOPMENT
PACIFIC GAS AND ELECTRIC CO.

EXHIBIT Z



Contour	Areas	Capacities: Acre Feet	Total Acre Feet
740	19392		[illegible]
		15435	
730	17475		103454
		[illegible]	
720	15551		88934
		14732	
710	13882		74202
		[illegible]	
700	12250		[illegible]
		11513	
690	[illegible]		47223
		10043	
680	9311		37580
		8676	
670	8044		28902
		7403	
660	6761		21499
		6043	
650	5374		15456
		4778	
640	4232		10676
		[illegible]	
630	2990		7067
		2589	
620	2188		4478
		1816	
610	1504		2652
		[illegible]	
600	1016		1372
		803	
590	589		569
		407	
580	225		162
		136	
570	46		26
		26	
560	04		

I, C. W. Wood, of Manteca, Calif., do hereby certify that this Map was made from notes taken during an actual survey, made under my supervision, in November 1921, and that it correctly represents to the best of my knowledge and belief the works described in the accompanying application

C. W. Wood
Chief Engineer.

OAKDALE IRRIGATION DISTRICT

SOUTH SAN JOAQUIN IRRIGATION DISTRICT

KEY MAP OF THE

MELONES RESERVOIR PROJECT

SHOWING:—

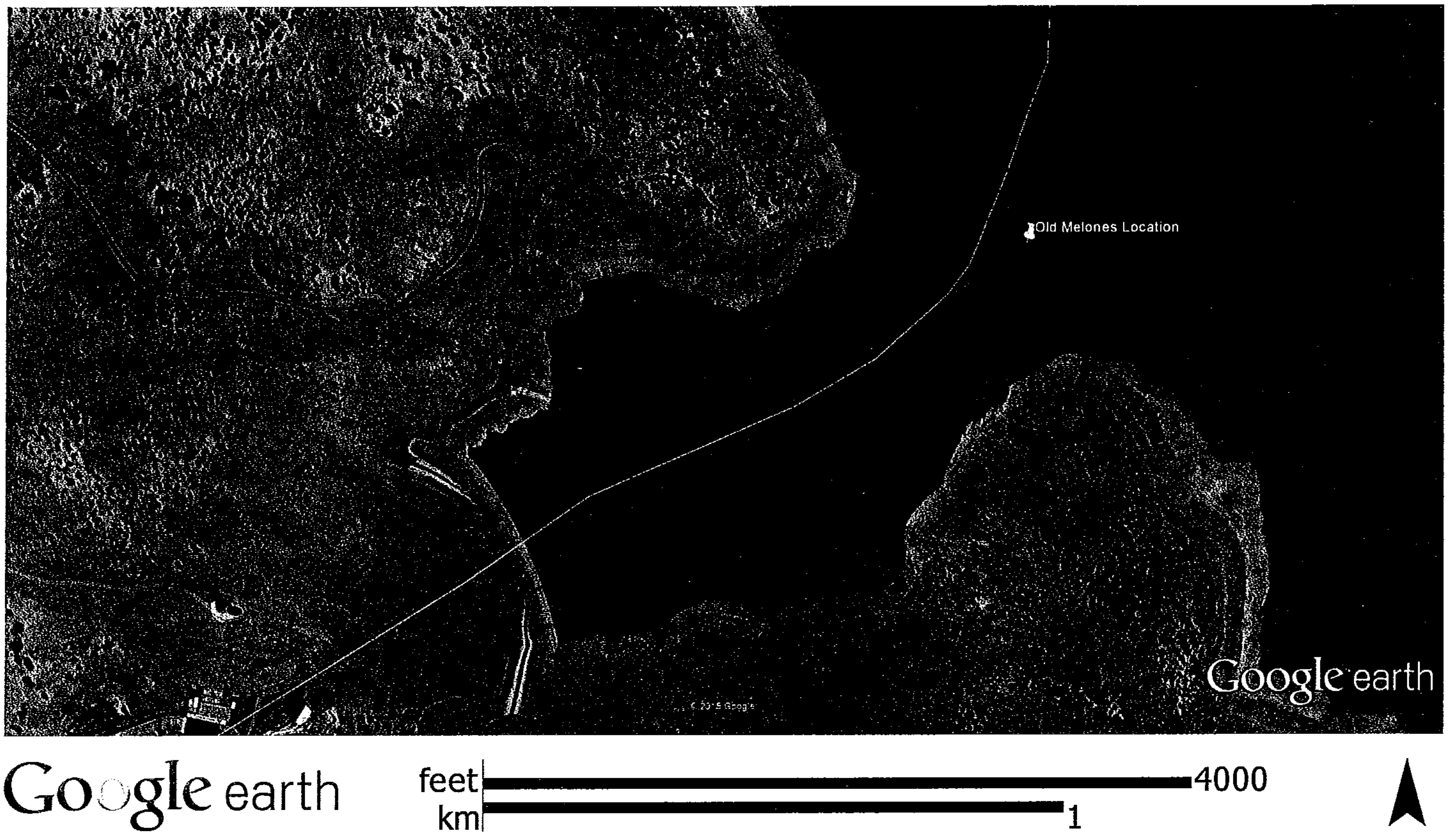
DAM SITE, RESERVOIR AND STANISLAUS RIVER.

MANTECA, CAL. MAR. 1922. SCALE: 1" = 1000'

DRAWN BY: [illegible] CHECKED BY: R.E.H.

APPROVED: C. W. Wood, CHIEF ENGINEER Sheet No. 1 A. J. Wiley, CONSULTING ENGINEER

A-3-2


Old Melones Location
Google earth
Google earth
feet
4000
km
1

Old Melones Outlet Flow

Written By: E. Sheldon
Date: 4/6/15

Steel Pipe Irrigation Outlet diameter (ft)	Orifice area (ft^2)	U/S Water Level elev. (ft)	D/S Water Level elev. (ft)	Δh (ft)	Q (cfs)	Total Q (cfs)- 4 irrigation outlets	Velocity per steel pipe irrigation outlet (ft/s)	Outlet Tunnel Area (ft^2)- 14' 9" Tunnel Diameter	Outlet Tunnel Flow (cfs)	Outlet Tunnel Velocity (ft/s)
5	19.63	723	722	1.0	97.6	390.6	4.98	170.79	849.7	4.98
5	19.63	723	721	2.0	138.1	552.4	7.04	170.79	1201.7	7.04
5	19.63	723	720	3.0	169.1	676.5	8.62	170.79	1471.8	8.62
5	19.63	723	719	4.0	195.3	781.1	9.95	170.79	1699.5	9.95
5	19.63	723	718	5.0	218.3	873.4	11.13	170.79	1900.1	11.13
5	19.63	723	717	6.0	239.2	956.7	12.19	170.79	2081.4	12.19
5	19.63	723	716	7.0	258.3	1033.4	13.16	170.79	2248.2	13.16

Notes:
1) Per final Melones Dam drawings, HWL is 735' w/ drum gates raised, and 723' w/o drum gates raised; assumption is that the drum gates have been removed.
2) Per final Melones Dam drawings, the four (4) irrigation outlets are 60" diameter steel pipe; assumption is that the needle valves are removed

Using equation:
$$Q = C_d A \sqrt{2g\Delta h}$$
Where:
C_d= coefficient of discharge (0.62)
g= acceleration due to gravity (32.2 ft/s^2)
Δh= head differential (u/s-d/s water elev.)