

**APPENDIX O**  
**GROUNDWATER INVESTIGATION**

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## APPENDIX O

### GROUNDWATER INVESTIGATION COLUSA POWER PLANT FOR RELIANT ENERGY

A groundwater investigation program was conducted by URS Corporation (URS) in April 2001 for Reliant Energy in an attempt to identify a potential onsite source of water for the proposed Colusa Power Plant (CPP). The plant is anticipated to require on the order of 300 acre-feet annually; this is approximately 200 gallons per minute (gpm) of continuous pumping.

#### Test Well Drilling

Three test well locations were selected, as illustrated on Figure O-1, based on surface geology and geomorphology. Well #1 was located in the vicinity of an existing windmill about 2,000 feet northwest of the plant site. Well #2 was located near another shallow well at the abandoned ranch house complex about 4,000 feet southeast of the plant site. Well #3 was located adjacent to a drainage swale about 4,000 feet north of the plant site and south of the cross-tie between the Glenn-Colusa and Tehama-Colusa canals. Drilling was performed by Eaton Drilling Co., Inc. of Woodland, California, under the direction of a URS geologist.

Pilot boreholes were advanced using a 6-5/8-inch diameter bit to a typical depth of 300 feet utilizing mud rotary drilling methods. Soil cuttings were logged and collected from the shaker every 20 feet to assess lithology. Logs of the cuttings are presented on Table O-1. If coarse-grained units (sands and gravels) were encountered that appeared to have the potential for a sufficient water source, samples were collected and submitted for grain size analyses. Grain size curves of selected samples are provided on Figures O-2 through O-4. Upon completion of each pilot borehole, an electric log (E-log) was run for spontaneous potential and point resistivity (short and long normal curves) of the formation. E-logs are presented on Figure O-5.

On April 2, 2001, Well #1 was advanced to a depth of 200 feet. A coarse-grained unit was encountered from approximately 135 to 147 feet below ground surface (bgs). On April 3, Well #1 was completed at 300 feet bgs. Coarse-grained units were not encountered from 200 to 300 feet bgs. The single point (short normal curve) resistivity portion of the E-log suggested that the coarse-grained unit (from 135 to 147 feet bgs) might have the potential to produce water. However, the long normal resistivity curve (which describes the resistivity of the formation approximately 6 feet away from the borehole) indicated the presence of a coarse-grained unit, that did not appear to be as productive as the formation immediately adjacent to the borehole.

On April 3, Well #2 was advanced to 140 feet bgs. The well was completed to a depth of 320 feet the following day. The entire borehole consisted of silts and clay with no coarse units. Because this well would not produce sufficient quantities of water it was decided to drill the third pilot borehole.

Well #3 was started on April 4 and completed to a depth of 300 feet on April 5. A coarse-grained unit was present from approximately 210 to 240 feet bgs. Both the short and long normal curve E-logs indicated a potential water source. The unit was sand and gravel with some silty clay.

The results of the three pilot holes indicated that Well #3 had the best potential for producing water for the CPP; however, the static water level was not known due to the type of drilling performed (mud rotary). A 2-inch-diameter PVC pipe was installed at the completion of drilling to provide a basis for evaluating the static water level, and thus the possibility of a water source. The water level was observed

at a depth of 45 feet the next day, indicating a head of approximately 180 feet and potentially favorable conditions.

The Well #3 borehole was reamed with a 12-inch-diameter bit and a 5-inch-diameter schedule 80 PVC temporary well was installed. The well was screened from 215 to 235 feet bgs. The annular space was filled with Monterey sand, which was brought to 27 feet bgs. A 3-foot-thick bentonite seal was placed on top of the Monterey sand. The well was developed by pumping to remove fines.

### **Pumping Test**

On April 16, 2001, a step drawdown pumping test was conducted. The submersible pump was set at 180 feet bgs. The pump test was a four-hour step drawdown with pumping rates of 30, 50, 70 and 110 gpm as well as a measured well recovery period. Static groundwater was 47.34 feet bgs at the beginning of the test.

The results of the step drawdown test are shown in Figure O-6.

The measured specific capacities for each of the three steps were:

Step 1 0.944 gpm/foot

Step 2 0.876 gpm/foot

Step 3 0.607 gpm/foot

The average specific capacity is 0.91 gpm/foot. Variations in the flow rate during step 3 of the test make this value less reliable than steps 1 and 2. The average specific capacity has therefore been calculated for steps 1 and 2 only. The maximum available drawdown in well #3 at the time of the test was 172.2 feet.

The drawdown requirement to achieve a flow rate of 200 gpm is 182 feet. This slightly exceeds the calculated maximum available drawdown in well #3. However, an increase in well efficiency and specific capacity would be achieved with the installation of a properly designed pumping well.

The results of the pumping test suggest that a source of water exists onsite. Additional, longer-term pumping of a properly designed production well would be required to evaluate the long-term viability of this potential source.

### **Water Quality**

A sample of representative groundwater was obtained at the conclusion of the pumping test and submitted for laboratory analysis. The laboratory test results are included as Table O-2.

**Table O-1  
Summary of Logs of Test Well Borings**

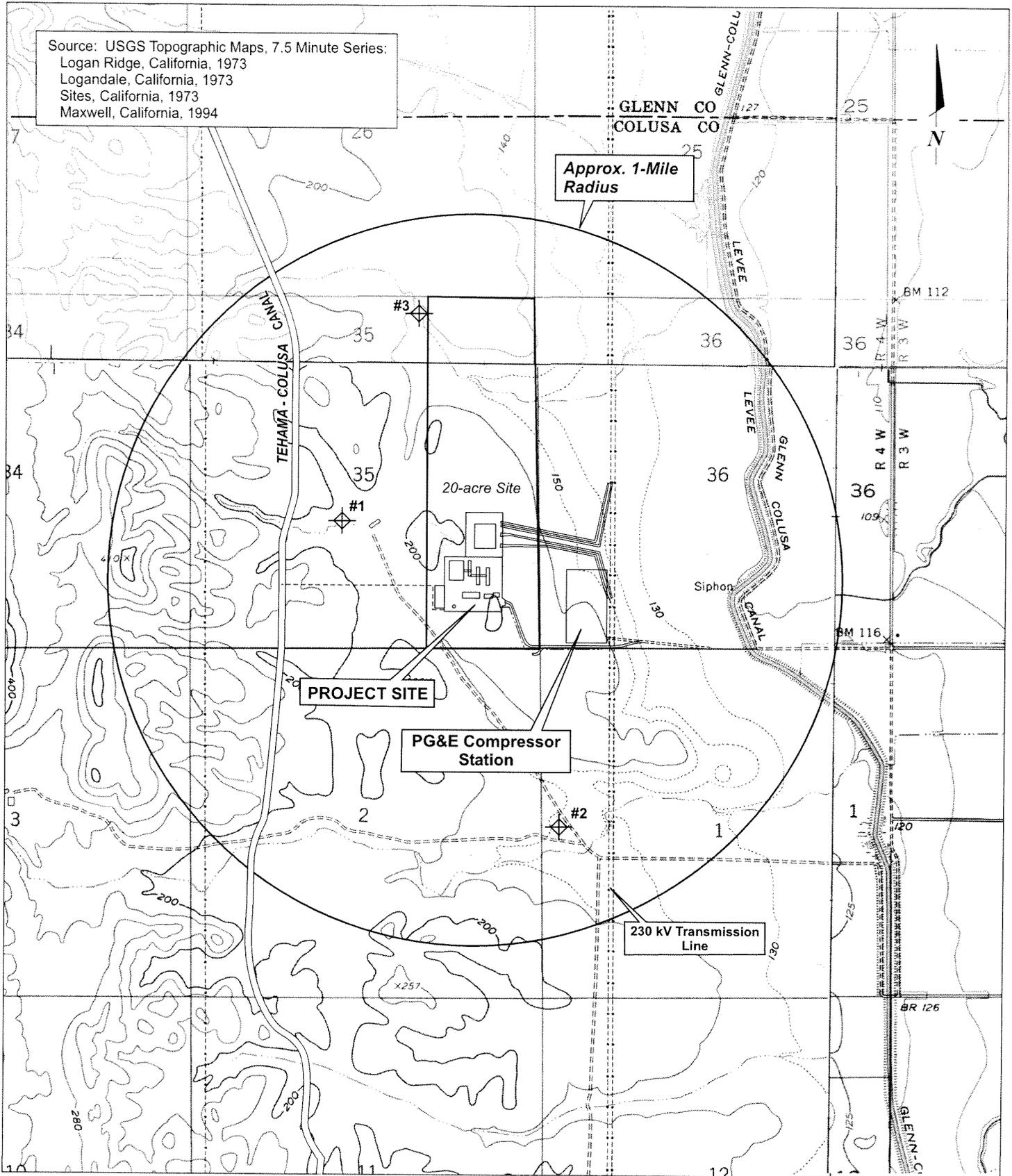
Well #1			Well #2			Well #3		
Depth Interval (feet)	USCS Symbol <sup>1</sup>	Description	Depth Interval (feet)	USCS Symbol <sup>1</sup>	Description	Depth Interval (feet)	USCS Symbol <sup>1</sup>	Description
0-20	CL	Silty clay trace fine sand. Moderately plastic, moist, brown	0-20	CL	Silty clay, trace of fine to coarse sand, low plasticity, light brown	0-20	CL	Silty clay little fine to coarse sand, low plasticity, light brown
20-40	CL	Fine to coarse sandy clay, little silt, moderate plasticity, light brown	20-40	CL	Silty clay trace of fine to coarse sand, fine to medium gravel, low plasticity, light brown	20-40	CL	Silty clay some fine to coarse sand and gravel, low plasticity, light brown
40-60	CL	Fine to coarse sandy clay. Trace silt, some fine-medium gravel, light brown	40-80	CL	Silty clay trace fine to medium sand, mod plasticity, med. grey	40-60	CL	Silty clay trace coarse sand, low plasticity, light brown
60-80	CL	Fine to coarse sandy clay, trace silt, mod. plasticity, medium grey	80-120	CL	Silty clay little fine sand, low plasticity, med. grey, stiffer with depth	60-100	CL	Silty clay trace fine sand low plasticity, light brown
80-100	CL	Silty clay, trace to little fine to coarse sand, mod. plasticity, med. to dark grey, stiff	120-140	SW/GW	Fine to coarse sand and gravel, little silty clay, angular to rounded, dark grey	100-120	CL	Silty clay, trace of fine to medium sand, low plasticity, soft, light brown
100-135	CL	Silty clay trace fine to coarse sand, mod. to highly plastic. Med. to dark grey, less stiff	140-220	CL	Silty clay, mod. to highly plastic, dark grey	120-140	CL	Silty clay trace fine sand, mod plasticity, stiff, dark grey
135-140	SW	Well graded medium to coarse sand and fine to coarse gravel, angular to well rounded, mafic quartz, dark grey and grey	220-240	CL	Silty clay, trace of fine to coarse sand, mod. plasticity, dark grey	140-200	CL	Silty clay, little fine to coarse sand, mod. plasticity, slightly stiff, dark grey
140-160	CL	Silty clay, medium to coarse sand (probably from above), low to mod. plasticity, stiff light brown	240-260	CL	Silty clay, very small trace fine to medium sand, low plasticity, dark grey	200-220	SP/CL	Coarse sand and fine to coarse gravel Angular to rounded, dark grey, quartz, mafic, plagioclase feldspar
160-180	CL	Silty clay, mod. to highly plastic, stiff reddish brown	260-280	CL/SP/GP	Silty clay with poorly graded coarse sand, and fine gravel, low plasticity, dark grey	220-260	CL	Coarse sandy and fine to coarse gravelly clay, low plasticity, dark grey, less coarse-grained material 240-260 feet
180-200	CL	Silty clay, mod. plasticity, stiff, dark brownish grey	280-300	CL	Coarse sand and fine gravel, trace clay, angular to rounded, dark grey	260-295	CL	Silty clay, some coarse sand and fine to medium gravel, low to mod. plasticity, slightly stiff, dark grey
200-220	CL	Silty clay trace fine to medium sand (less sand with depth). Low to mod. plasticity, dark brownish grey	300-320	CL	Silty clay, mod. plasticity, dark grey	295-300	CL	Silty clay, trace coarse sand fine gravel, mod. to high plasticity, light brown
220-240	CL	Silty clay, mod. plasticity, less stiff, dark brownish grey	End of Boring 320 feet			End of Boring 300 feet		
240-260	CL	Silty clay, very small trace medium sand, mod. plasticity, dark brownish grey						
260-280	CL	Silty clay, mod. plasticity, dark brownish grey						
280-300	CL	Silty clay, very small trace medium sand, mod. plasticity, dark brownish grey						
End of Boring 300 feet								

<sup>1</sup> Unified Soil Classification System

<b>Table O-2 Well #3 Water Analyses</b>	
<b>Water Quality Parameter</b>	<b>Concentration</b>
Turbidity	24 NTU
Color	10
pH	7.7
Total Suspended Solids	54 mg/L
Total Dissolved Solids	510 mg/L
Hardness as CaCO <sub>3</sub>	166 mg/L
Calcium	17 mg/L
Magnesium	30 mg/L
Sodium	160 mg/L
Potassium	2.4 mg/L
Barium	0.2 µg/L
Beryllium	–
Total Alkalinity	410 mg/L
Bicarbonate	410 mg/L
Sulfate	13 mg/L
Chloride	77 mg/L
Nitrate	< 1 mg/L
Fluoride	0.3 mg/L
Arsenic	< 0.01 mg/L
Iron (Ferric)	0.2 mg/L
Boron	0.1 mg/L
Silica	24 mg/L
Source: Water Analysis by STL Chroma Lab	
Note: Preliminary data have not yet been validated.	
µg/L	micrograms per liter
mg/L	milligrams per liter
NTU	nephelometric turbidity units

## **FIGURES**

Source: USGS Topographic Maps, 7.5 Minute Series:  
 Logan Ridge, California, 1973  
 Logandale, California, 1973  
 Sites, California, 1973  
 Maxwell, California, 1994



**LEGEND**

#1 Test Well

**TEST WELL LOCATIONS**

Colusa Power Plant  
 Reliant Energy  
 Colusa County, California

43-00066841.00



**FIGURE O-1**

EATON DRILLING CO., INC.  
REVERSE & ROTARY WELL DRILLING

TELEPHONE  
1916) 662-6795

20 W. KENTUCKY AVE.  
WOODLAND, CA 95695

**SAND ANALYSIS**  
(FINE)

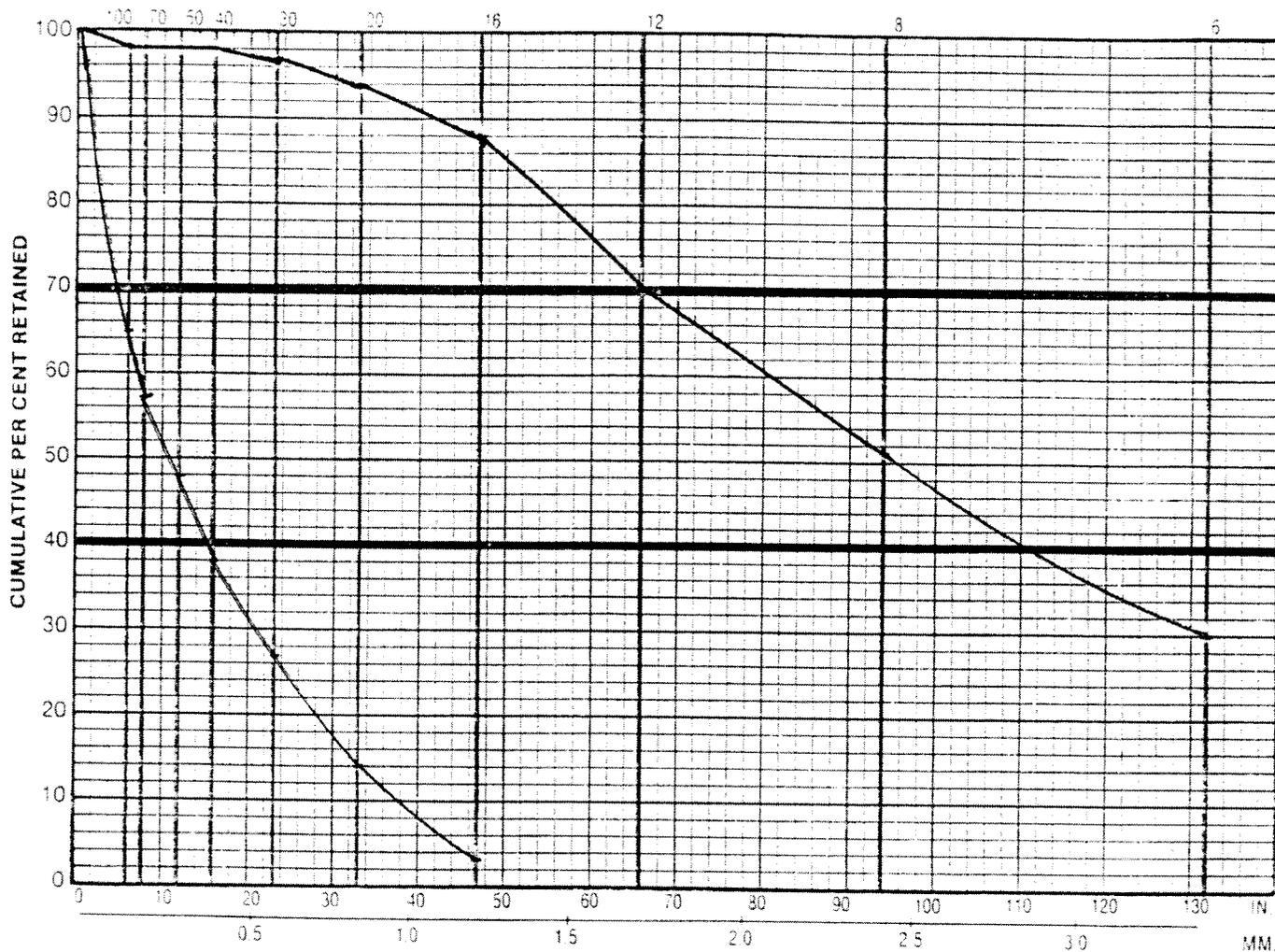
BY *D. J. ...*

Job Name URS (Nolt House Ranch) Job No. 7278-1 Date 4/3/01

City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_

Driller \_\_\_\_\_ Phone \_\_\_\_\_

U.S. STANDARD SIEVE NUMBERS



SLOT OPENING AND GRAIN SIZE IN THOUSANDTHS OF AN INCH AND MM.

U.S. SIEVE NO.	SLOT OPENING		SAMPLE DEPTHS			
	IN	MM	100'	140'	100'	140'
			sand %	course %	sand %	course %
5	.32	3.36	0	0	199	30
8	.294	2.38	0	0	337	51
12	.256	1.68	0	0	469	70
16	.247	1.19	21	3	524	88
20	.233	1.34	84	14	629	94
30	.233	1.60	159	27	646	97
40	.214	1.42	223	38	651	98
50	.212	1.35	284	48	654	98
70	.212	1.21	337	57	655	98
100	.149	1.18	384	65	656	98
Pen			591	100	665	100

Comments *Birdseye fairly well sorted, semi angular & round. some little blue clay.*

**WELL #1**  
**120-140 FOOT DEPTH INTERVAL**  
**GRAIN SIZE DISTRIBUTION**

FIGURE O-2

EATON DRILLING CO., INC.  
REVERSE & ROTARY WELL DRILLING

TELEPHONE  
(916) 662-6795

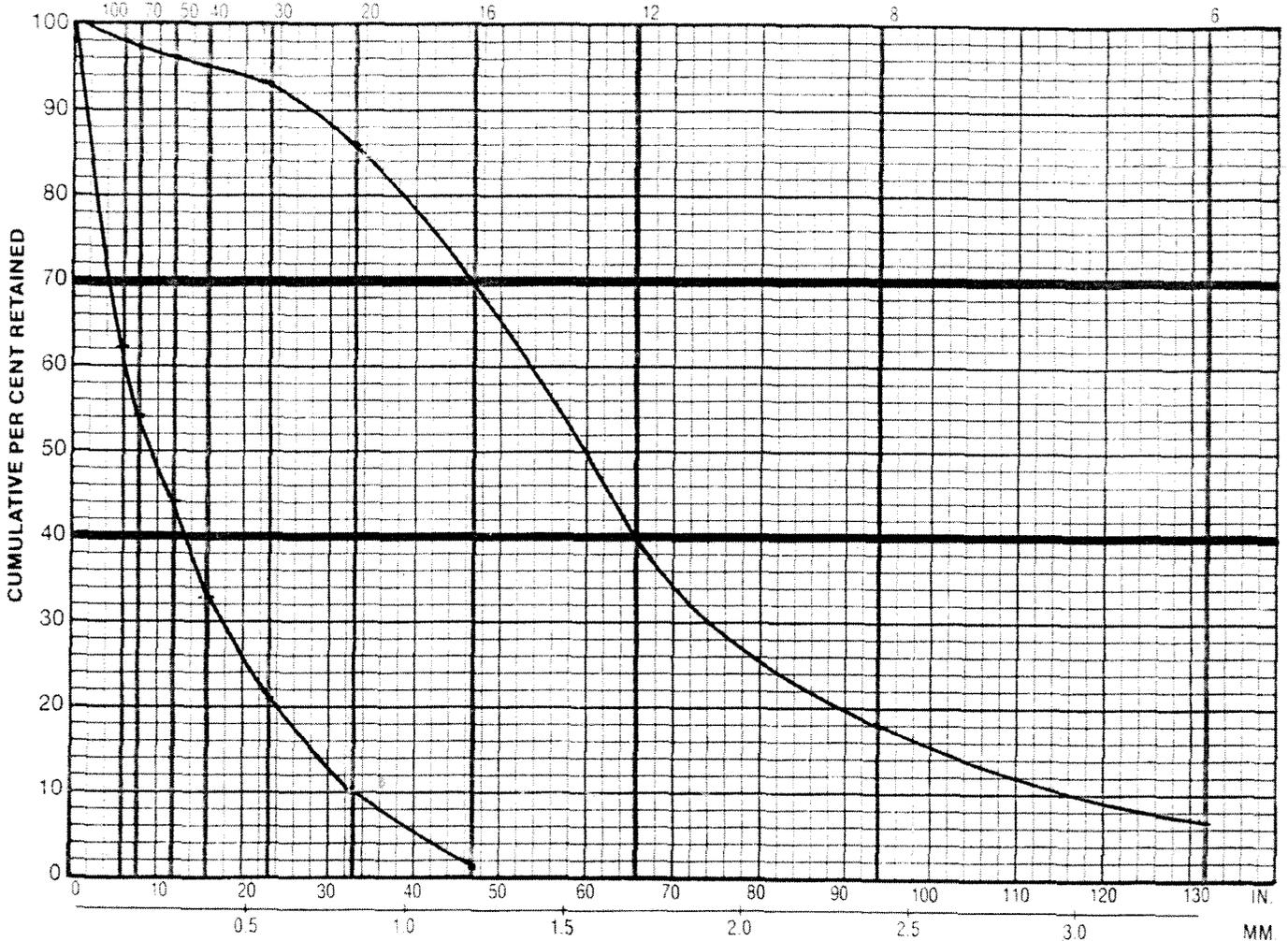
20 W. KENTUCKY AVE  
WOODLAND, CA 95695

**SAND ANALYSIS**  
(FINE)

BY: *[Signature]*

Job Name URS Corp (Holt House Ranch) Job No. 7278-3 Date 4/5/01  
City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_  
Driller \_\_\_\_\_ Phone \_\_\_\_\_

U.S. STANDARD SIEVE NUMBERS



SLOT OPENING AND GRAIN SIZE IN THOUSANDTHS OF AN INCH AND MM.

U.S. SIEVE NO.	SLOT OPENING		200' SAMPLE DEPTHS 220'			
	IN.	MM	Sand %	%	Coarse %	%
6	132	3.36	0	0	36	7
8	094	2.38	0	0	99	18
12	066	1.68	0	0	221	40
16	047	1.19	8	1	382	70
20	033	0.84	50	10	469	86
30	023	0.60	111	21	507	93
40	016	0.42	171	33	518	95
50	012	0.30	231	44	525	96
70	008	0.21	281	54	529	97
100	006	0.15	322	62	532	98
Pen			520	100	545	100

Comments *Birdseye, poorly sorted, semi angular & round. Some little Brown & Blue clay. 10% soft clay.*

**WELL #3**  
**200-220 FOOT DEPTH INTERVAL**  
**GRAIN SIZE DISTRIBUTION**

EATON DRILLING CO., INC.  
REVERSE & ROTARY WELL DRILLING

TELEPHONE 20 W KENTUCKY AVE.  
19161 562-6795 WOODLAND CA 95695

**SAND ANALYSIS**  
(FINE)

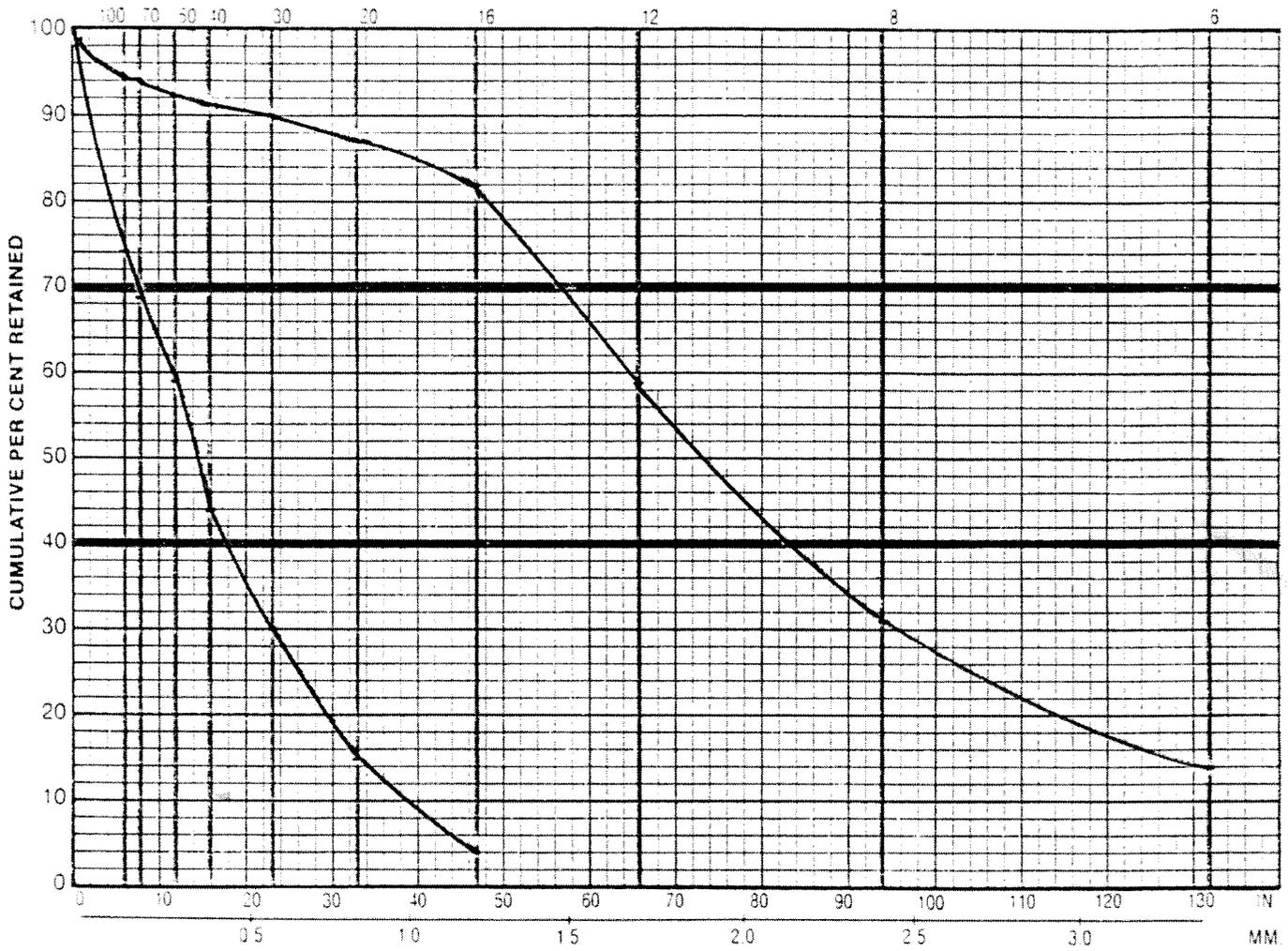
BY: *[Signature]*

Job Name URS (Holt House Ranch) Job No. 7278-3 Date 4/5/01

City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_

Driller \_\_\_\_\_ Phone \_\_\_\_\_

U.S. STANDARD SIEVE NUMBERS



SLOT OPENING AND GRAIN SIZE IN THOUSANDTHS OF AN INCH AND MM.

U.S. SIEVE NO.	SLOT OPENING		SAMPLE DEPTHS			
	IN	MM	220'	%	240'	%
6	.102	2.58	0	0	62	14
8	.094	2.38	0	0	138	31
12	.066	1.68	0	0	260	59
18	.047	1.19	19	4	364	82
20	.030	.76	76	15	387	87
30	.020	.50	154	30	398	90
40	.015	.38	228	44	404	91
50	.012	.30	304	59	409	92
75	.008	.20	354	69	414	94
100	.006	.15	382	74	418	94
<i>Fin</i>			513	100	442	100

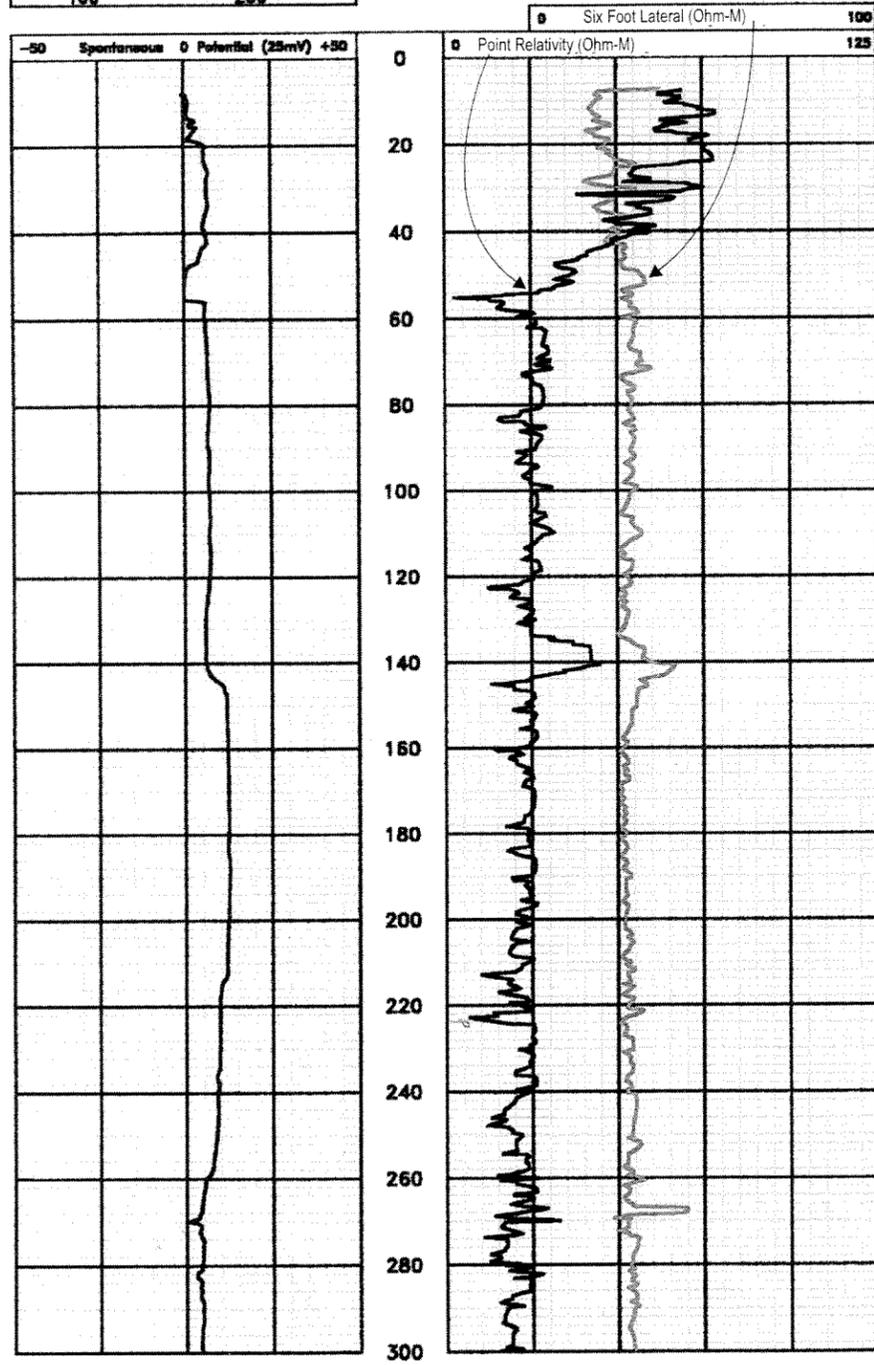
Comments *Bedsign, fairly well sorted, some angular & round. some little Brn. & Blue Clay. 30% soft clay.*

**WELL #3**  
**220-240 FOOT DEPTH INTERVAL**  
**GRAIN SIZE DISTRIBUTION**

**FIGURE O-4**

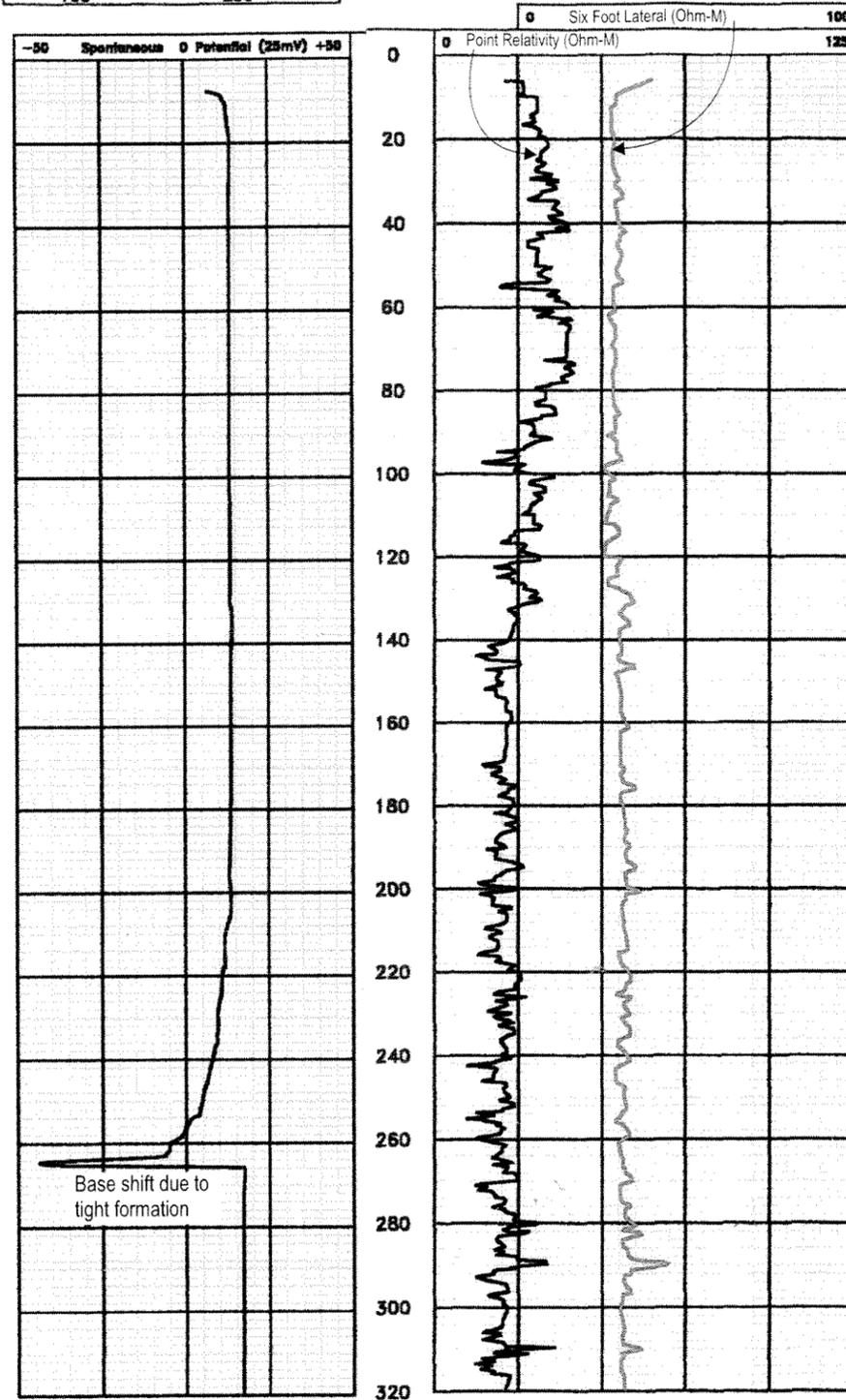
# WELL #1

APN: 011-040-24 County Colusa  
 T.R.S T18N R4W s35 Elev.  
 Water 100 PPM Mud 250 PPM



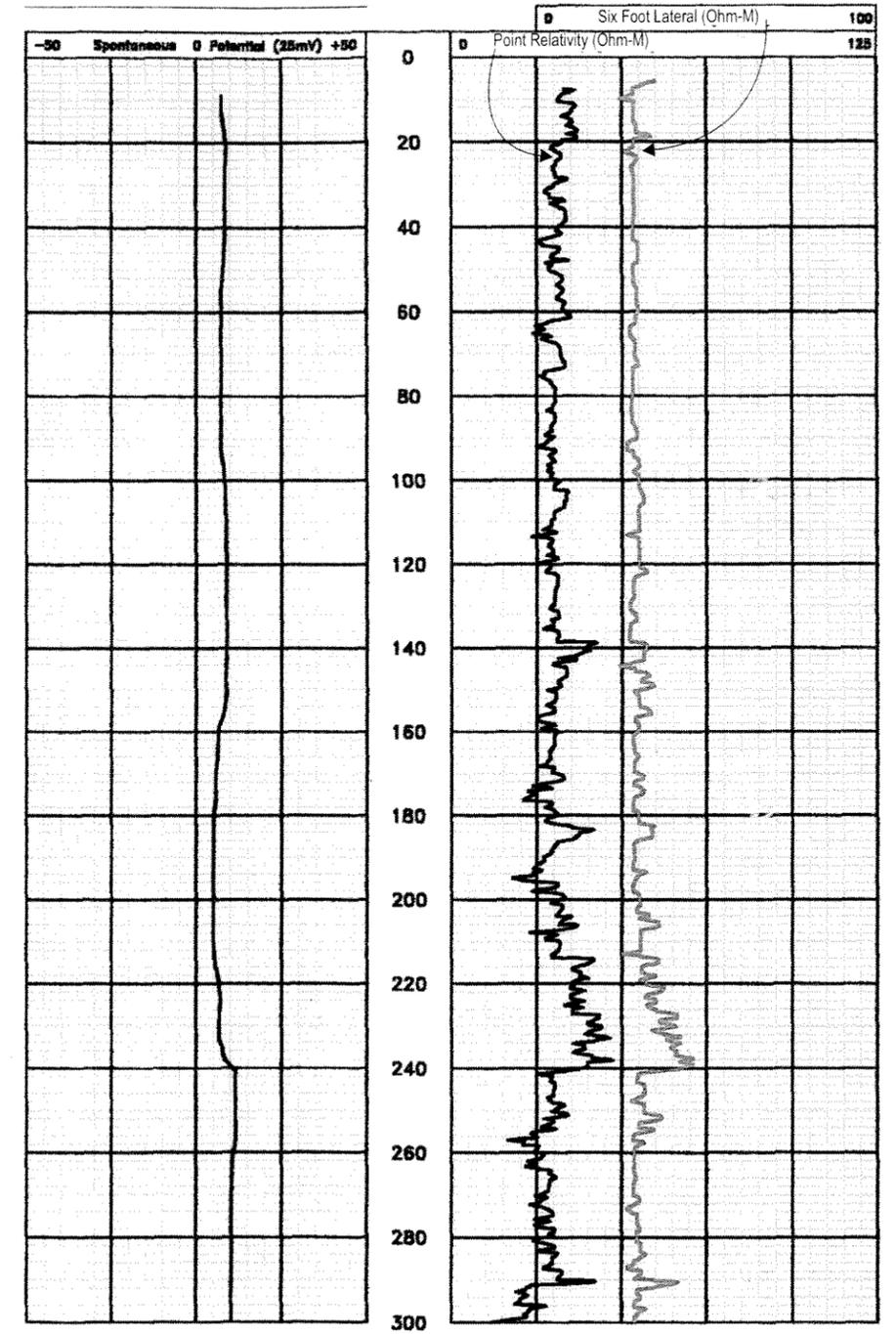
# WELL #2

APN: 011-140-09 County Colusa  
 T.R.S T7N R4W s12 Elev.  
 Water 100 PPM Mud 250 PPM



# WELL #3

APN: 011-140-24 County Colusa  
 T.R.S T18N R4W s35 Elev.  
 Water 300 PPM Mud 325 PPM

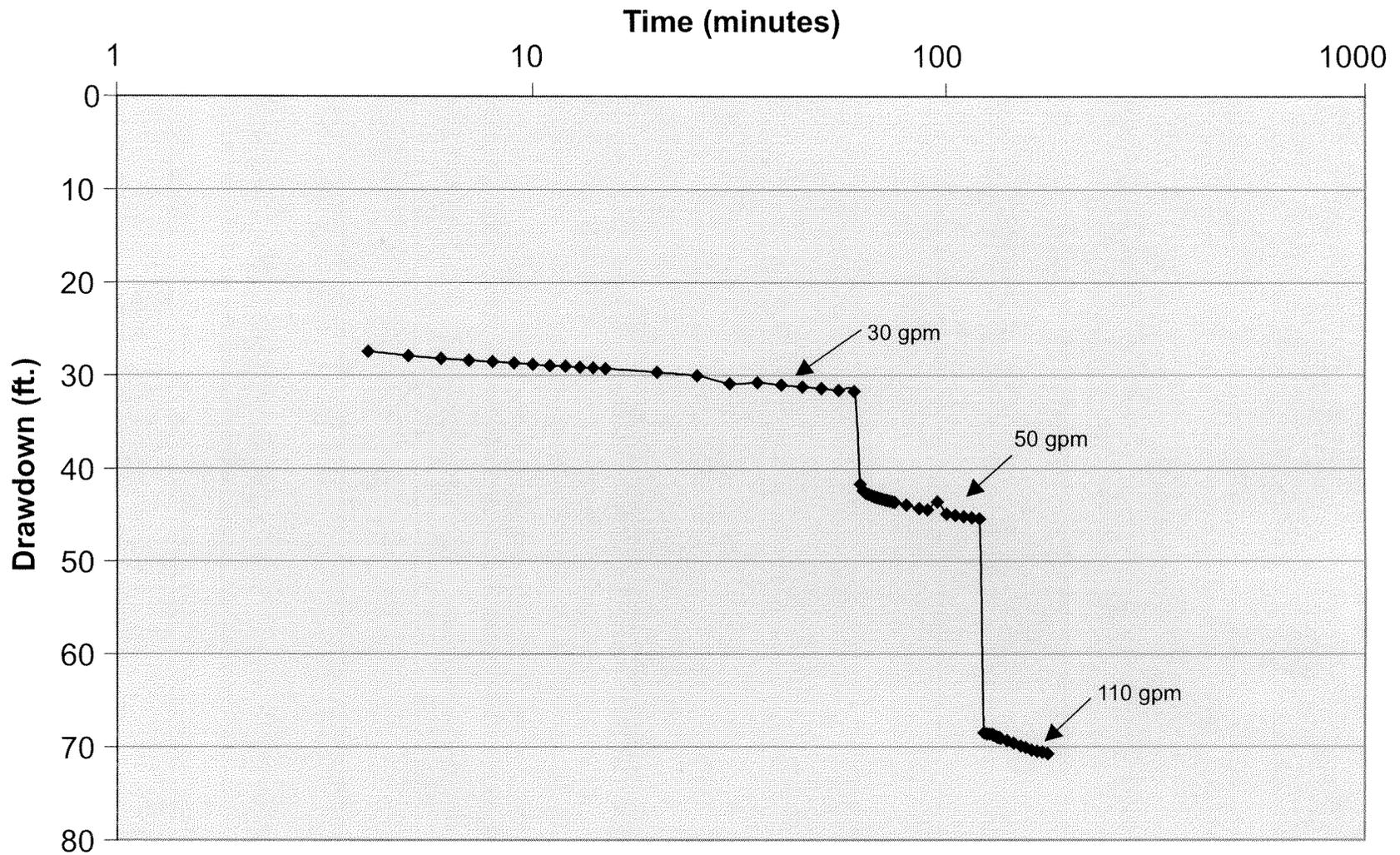


Source:  
 Eaton Drilling Co., Inc.  
 20 West Kentucky Ave.  
 Woodland, CA 95695  
 Tel: (916) 662-6795

Note:  
 Refer to Figure O-1 for location of wells.

TEST WELL E-LOGS

FIGURE O-5



**STEP DRAWDOWN TEST: WELL #3**

Colusa Power Plant  
 Reliant Energy  
 Colusa County, California

43-00066841.00



**FIGURE O-6**