

**TECHNICAL STUDY OF PROPOSED
OLCESE SUB-BASIN**

**Prepared for
Olcese Water District
Bakersfield, California**

**By
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March 31, 2016

Mr. Jim Nickel
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P. O. Box 60679
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Re: Olcese Water District Sub-basin
Technical Study Report

Dear Jim:

Submitted herewith is our report on the Olcese Water District Sub-basin. I appreciate the cooperation of the Nickel Family, LLC in providing information for this study.

Sincerely Yours,



Kenneth D. Schmidt
Geologist No. 1578
Certified Hydrogeologist
No. 176

KDS/td

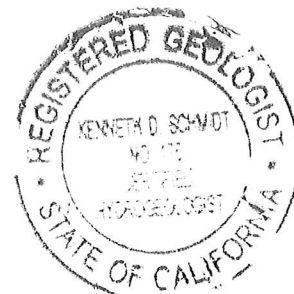


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TECHNICAL STUDY OF PROPOSED OLCESE SUB-BASIN

INTRODUCTION

The Olcese Water District (OWD) is located between the mouth of the Kern River Canyon and Lake Ming, along Highway 178 east of Bakersfield. Most of the District is in Sections 1-3, and 10-12 of T29S/R29E and in Section 6 of T29S/R30E (Figure 1). The Kern River and several tributaries, including Cottonwood Creek, pass through the District. Shallow deposits below the uppermost 100 feet or so are fine-grained and of low water production capacity. However, below depths ranging from about 300 feet to the east and greater than 900 feet to the west, highly productive deposits of the Olcese sand are present. The first known water well (Canyon View Ranch) tapping this sand in this area was completed in Fall 1963. Two additional larger capacity irrigation wells No. 1 and 2 were subsequently installed at the Rio Bravo Ranch about half to two thirds of a mile southwest of the Canyon View Ranch Well, and the first was subsequently replaced by Well No. 3. A fourth irrigation well (No. 4) was completed in February-March 2016. These are the only known water supply wells tapping the Olcese sand in this area.

The purpose of this report is to provide technical information on hydrogeologic conditions beneath the OWD and nearby

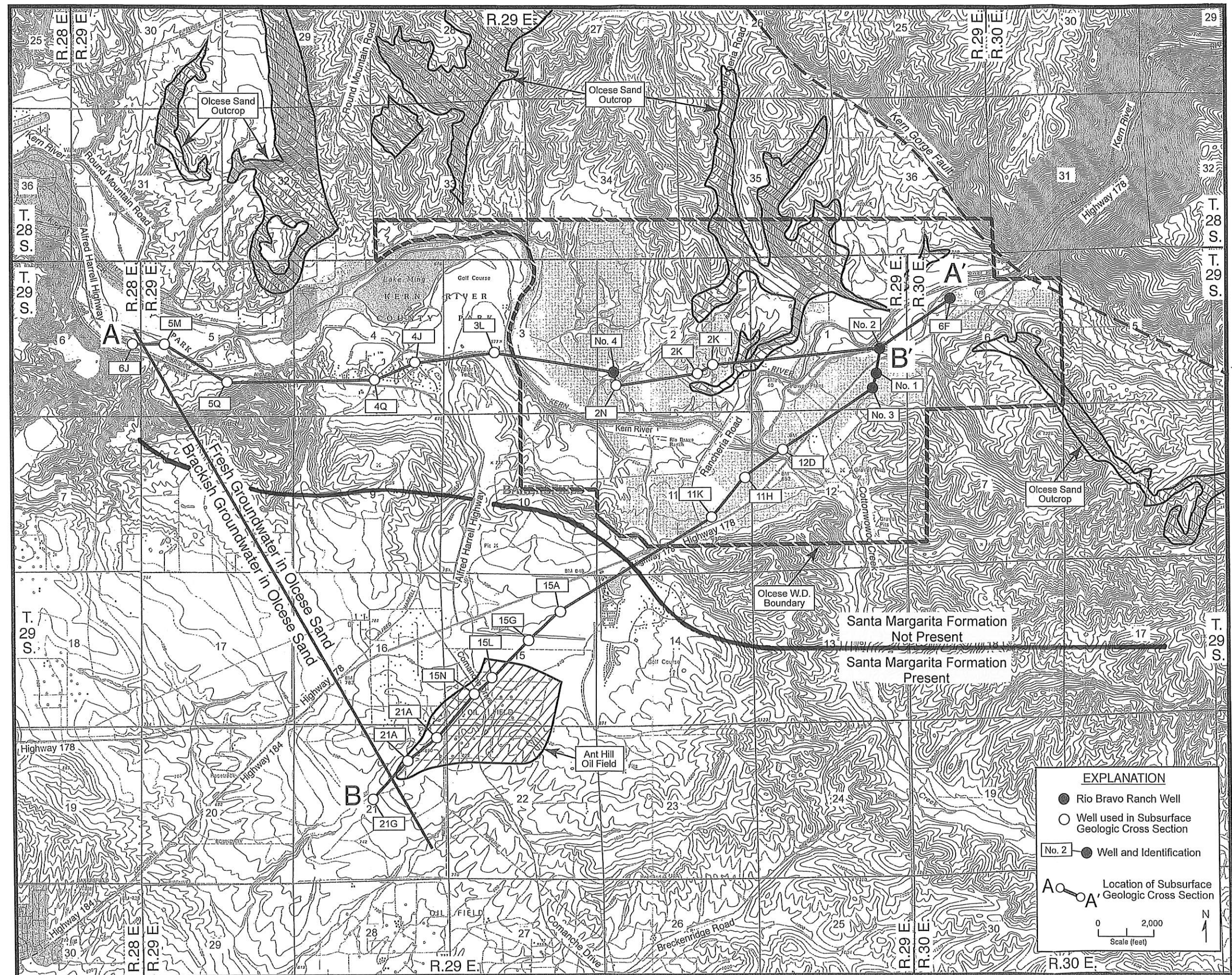


FIGURE 1 - LOCATION OF WELLS AND SUBSURFACE GEOLOGIC CROSS SECTIONS

lands. A sub-basin is delineated, in which good quality groundwater is present in the Olcese sand, and it is overlain by an effective confining bed (the Round Mountain Formation).

SUBSURFACE GEOLOGIC CONDITIONS

There are two marine units along the southeast part of the San Joaquin Valley that are tapped by deep water supply wells: The Santa Margarita Formation and Olcese sand. These dip to the southwest in the Rio Bravo Ranch area. Fresh (low salinity groundwater) is now present to the east and near the outcrops of these units. Farther to the west and down dip, salty groundwater is present. Beneath most of the OWD, the Santa Margarita Formation is indicated to not be present. Selected electric logs are provided in Appendix A. Fine-grained deposits of the Round Mountain Formation (locally termed the Edison Shale) are locally present either near the ground surface or at shallow depth. These deposits form an effective confining bed for groundwater in the Olcese sand. Groundwater in the Olcese sand is under pressure and is underlying confined. Information from oil and gas test holes indicates that the Santa Margarita Formation is present south of the south boundary of the OWD. Some of the deeper wells in the Arvin-Edison Water Storage District to the south tap groundwater in this formation.

Bartow (1984) mapped the location of outcrops of the Olcese sand along the southeastern margin of the San Joaquin Valley, including near the Kern River. These outcrops are shown in Figure 1. The Kern Gorge Fault, a predominant feature in the area, is also shown. Essentially, non-water bearing granitic rocks are present northeast of the fault, whereas sedimentary rocks are present to the southwest. Olcese sand outcrops are present south of the Kern River along a northwesterly trending band more than a mile east of Cottonwood Creek and are widespread on the north side of the Kern River floodplain, both east and west of Rancheria Road. Additional outcrops of the Olcese sand are present north of the Kern River near Lake Ming and Hart Park.

The Round Mountain silt (locally known also as the Edison Shale) is a very low permeability bed that ranges from about 300 feet to more than 1,300 feet thick in the vicinity of the OWD. Textural classifications, resistivities shown on electric logs, and other evidence indicates that the Round Mountain silt is an effective confining bed, separating groundwater in the Olcese sand from that in the overlying materials.

There have been several historical evaluations of potential groundwater production from the Olcese sand in the vicinity of the Rio Bravo Ranch. Anderson (1958) conducted an evaluation

for the Bakersfield Municipal Water District. He noted that this sand cropped out in the foothills near the Kern River. His subsurface evaluation was based primarily on logs for oil and gas test holes. He indicated that the Olcese sand ranged from about 300 feet to 1,100 feet in thickness, and was comprised of coarse sand, gravel, and conglomerate beds. Anderson indicated that recharge from surface water drainages, including the Kern River, were sources of recharge to the groundwater in the Olcese sand. He recommended that a test well be done near where Rio Bravo Ranch Well No. 2 was subsequently constructed (Figure 1).

Clare and O'Neill (1965) reported on the Canyon View Ranch water well that was drilled in Fall 1965. This well tapped about 36 feet of Olcese sand between 294 and 347 feet in depth. They noted that another source of recharge to groundwater in the sand was downward movement of Kern River water through the Kern Gorge Fault zone (Figure 1).

Stetson Engineers (1979) reported on potential sources of water for the Rio Bravo annexation in to the City of Bakersfield. By this time, Rio Bravo Ranch Wells Nos. 1 and 2 had been completed, and both essentially tapped the full thickness of the Olcese sand (from about 1,000 to 1,200 feet thick) at those locations. Stetson Engineers (1979, Plate 2) delineated approxi-

mately where fresh groundwater was present in the Olcese sand beneath the area. They estimated that there could be about 200,000 acre-feet of groundwater in the sand in this area.

As part of this evaluation, two subsurface geologic cross sections were developed, based primarily on electric logs. Subsurface geologic cross section A-A' (Figure 2) extends from the west near Hart Park to the east, through the OWD and Rio Bravo Ranch Wells No. 2 and 4, to the Canyon View Ranch Well (5B). Subsurface Cross Section B-B' extends from southwest of the Ant Hill Oil Field near the center of the Section 21, T29S/R29E to the northeast, through the Rio Bravo Golf Course and Rio Bravo Ranch Wells No. 1, 2, and 3 (Figure 3).

A characteristic of both the Santa Margarita Formation and the Olcese sand is that as one moves down dip (to the southwest), the groundwater eventually becomes brackish. That is, the salty water originally in the formation has not been replaced or diluted with fresh groundwater. Interpretation of the electric logs indicates that brackish groundwater is present at Well T29S/R29E-6J and Well T29S/R29E-21G. This is consistent with the observation that brackish groundwater is present beneath much of the Edison oilfield to the south of Well 21G.

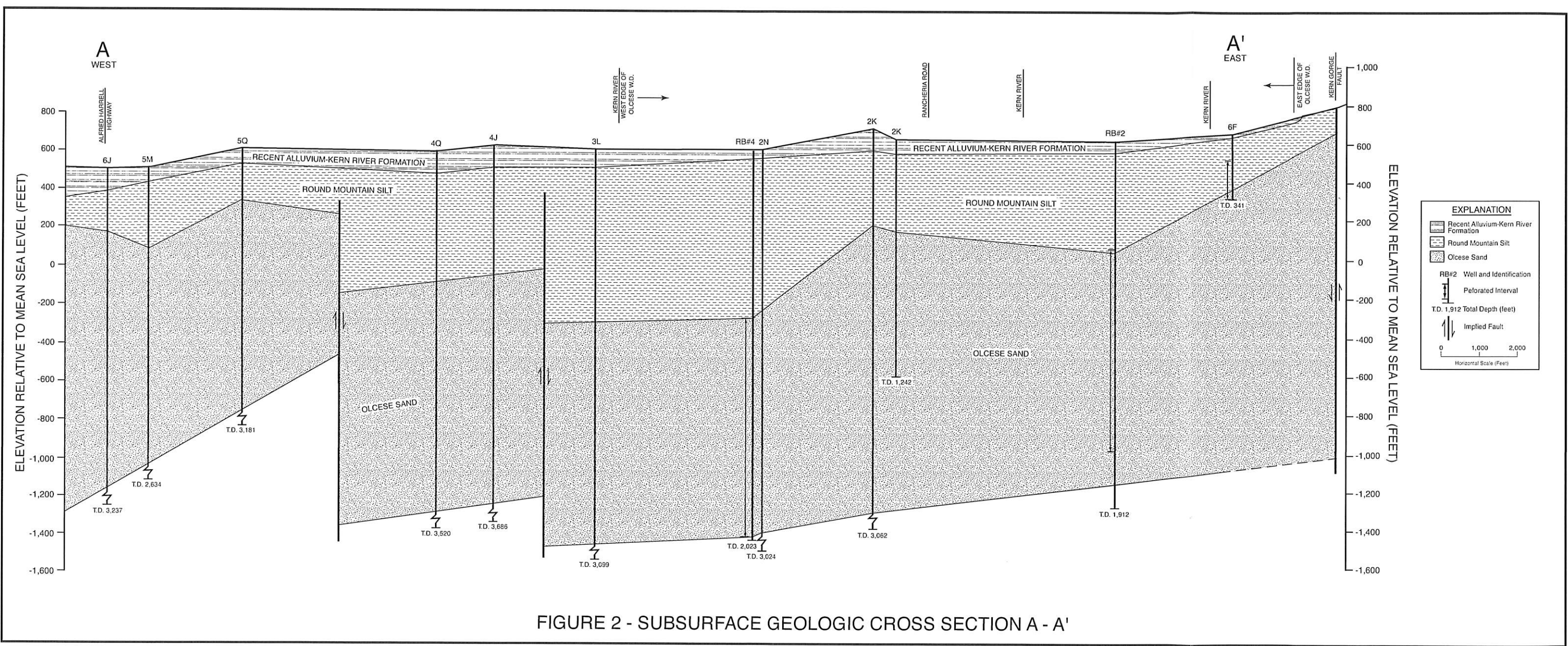


FIGURE 2 - SUBSURFACE GEOLOGIC CROSS SECTION A - A'

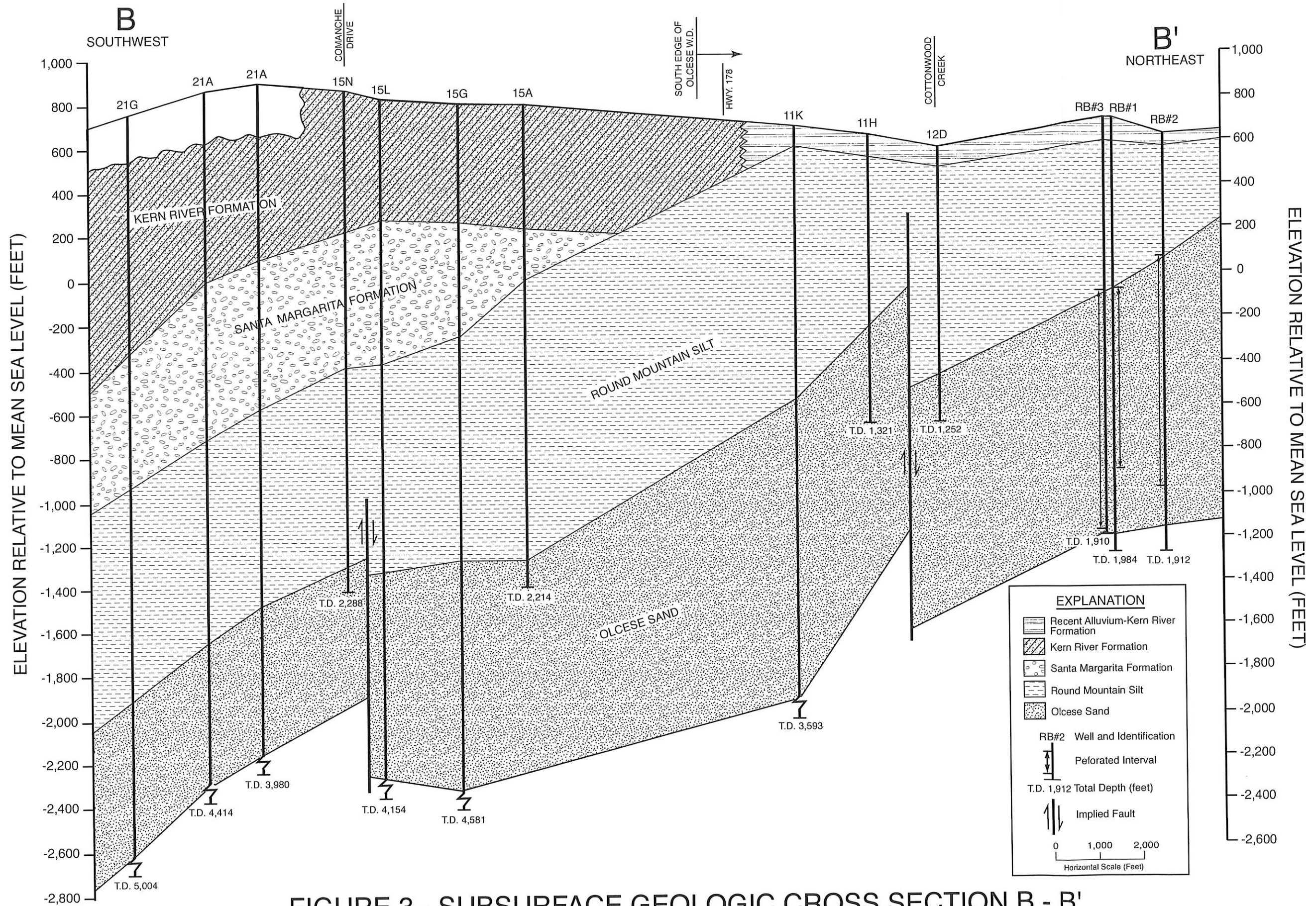


FIGURE 3 - SUBSURFACE GEOLOGIC CROSS SECTION B - B'

Subsurface Geologic Cross Section A-A'

Deposits of the Kern River Formation and Recent alluvium overlie the Round Mountain Formation and range from about 20 to 120 feet thick along the section. The top of the Round Mountain silt ranges from about 50 to 100 feet deep along most of the section. Along Cross Section A-A', the top of the Olcese sand is deepest (about 930 feet deep) near Well 3L, and is the shallowest (less than 300 feet deep) at Wells 5Q and 6F. In general, the shallower depths are close to outcrops of the Olcese sand. The base of the Olcese sand ranges from about 1,300 feet deep at well 5Q to more than 2,000 feet at Well No. 3L. Based on interpretation of electrical resistivities, fresh groundwater is indicated to be present in the Olcese sand along this section except at the westernmost Well 6J. Two faults appear to have offset the top of the Olcese sand along the section, with the upthrown sides to the west.

Subsurface Geologic Cross Section B-B'

Deposits of the Recent alluvium and Kern River Formation thicken to the southwest along this section. The thickness of these deposits west of Well 9K ranges from about 600 to about 1,100 feet. Along Cross Section B-B' the top of the Olcese sand

deepens from almost about 600 feet deep at Rio Bravo Ranch Well No. 2 to about 1,900 feet from at Well 21G. Brackish groundwater was found in the Olcese sand at Well 21G. At the Ant Hill oil field, oil is present in the uppermost 50 to 150 feet of the Olcese sand. The Santa Margarita Formation is present only southwest of Well 11K along this section, where it ranges from about 200 to 650 feet thick. The Round Mountain Formation is thickest (about 1,300 feet) at Well 15A and thinnest at Rio Bravo Ranch Well No. 2 (about 530 feet). A fault is apparently present between Wells 11H and 12D and the top of the Olcese has apparently been displaced about 350 feet, with the downthrown side on the northeast.

RANCH WELLS

Table 1 provides data on the four ranch wells and the Canyon View Ranch Well. Well No. 1 was completed in February 1966, as part of the site selection process for the new Cal State University, Bakersfield campus. Well No. 1 tapped the full thickness of the Olcese sand. Well No. 2 was constructed in February 1977 at a location 1,322 feet north of Well No. 1. This well tapped about 1,040 feet of the Olcese sand, compared to 1,220 feet at Well No. 1. Well No. 3 was constructed in October 2008 to replace Ranch Well No. 1, which had filled in substantially due to

TABLE 1-CONSTRUCTION DATA FOR RIO BRAVO RANCH WELLS

Well No.	Date Drilled	Cased Depth (feet)	Casing Diameter (inches)	Perforated Interval (feet)	Annular Seal (feet)
Canyon View Ranch	10/65	340	10	146-340	0-50
1	02/66	1,130	14	785-1,130	N.A.
		773	10	1,130-1,890	
2	06/77	712	16	560-711	0-80
		1,612	12	711-1,612	
3	10/08	900	16	800-900	0-500
		1,900	12	905-1,890	
4	03/16	2,000	18	860-2,000	0-800

Well No. 1 is unused and has been destroyed

excessive sand production. Well No. 3 essentially taps all of the Olcese sand at that location. Well No. 4 was being constructed during March 2016. This well taps Olcese sand below a depth of 870 feet and above a depth of 2,000 feet.

Significant pumping from Wells No. 1 and 2 began in 1987. Annual pumpage records from ranch wells are provided in Appendix B. The highest annual pumpage prior to 2014 was in 1990 and 1991 (1,715 acre-feet and 2,173 acre-feet). The pumpage from Wells No. 2 and 3 during 2014 and 2015 was 2,307 acre-feet and 1,501 acre-feet, respectively. Pumpage was generally low in 1993-95, 1998, and from 2000 to 2006.

WATER LEVELS

Static water levels have been periodically measured in Wells No. 1, 2, and 3. The shallowest water level in Well No. 1 was 147 feet deep in November 1965, and the deepest water level was about 330 feet deep in Summer 2015. The shallowest water level in Well No. 2 was 187 feet deep in February and the deepest was 287 feet deep in August 1991. Figure 4 shows water-level hydrographs for the Rio Bravo Ranch wells.

Static water levels in Well No. 1 usually ranged from about 310 to 370 feet deep during 1990-94. Static water levels in



FIGURE 4-WATER-LEVEL HYDROGRAPHS FOR RIO BRAVO RANCH WELLS NO. 2 AND NO. 3

Well No. 2 ranged from about 255 to 290 feet during 1991-92. Static water levels in Well No. 2 usually ranged from about 250 to 300 feet during 2014-15. Static water levels in Well No. 3 ranged from about 330 to 390 feet during 2014-15. Following heavy pumping of Wells No. 1 and 2 in 1990-91, pressure levels rose to near the levels before pumping began.

There is no sign of overdraft indicated by these pressure levels, as the Olcese sand was indicated to remain full of groundwater at all times. Thus there was no significant change in storage in the Olcese sand.

Water-Level Elevations

Water-level measurements on February 9, 2000 indicated a water-level elevation of about 612 feet above mean sea level at the Canyon View Ranch well and 540 feet at Ranch Well No. 1. The difference in elevation indicated a water-level slope of about 140 feet per mile to the southwest.

SOURCES OF RECHARGE AND DISCHARGE

Previous investigations (Anderson, 1958 and Stetson Engineers, 1979) have indicated that the groundwater in the Olcese sand is recharged primarily by 1) rainfall and runoff over where the

Olcese sand crops out or is covered by a thin veneer of overlying materials, and 2) downward movement of Kern River water along the Kern Gorge Fault zone, which crosses the river near the northeast corner of Section 6, T29S/R30E.

Because groundwater flows down-dip (to the southwest) in the Olcese sand, the good quality groundwater eventually flows into blackish groundwater, primarily in the area southwest of a line connecting Wells T29S/R29E-6J and 21G. The groundwater in the Olcese sand in the area southwest of this line is brackish or salty. Because of this factor and the effective confining nature of the Round Mountain Formation, pumping of groundwater from the Olcese sand acts to develop a source of groundwater that is not connected and will not affect other usable groundwater in the Kern basin.

AQUIFER CHARACTERISTICS

Table 2 provides pump test results for the ranch wells. All of these wells tap the Olcese sand, however the Canyon View Ranch well only taps the upper part. Pumping rates for the ranch irrigation wells ranged from 1,400 to 3,000 gpm, and specific capacities ranged from 45 to 97 gpm per foot. In June-

TABLE 2-PUMP TEST RESULTS FOR RIO BRAVO RANCH WELLS

<u>Well No.</u>	<u>Date</u>	<u>Pumping Rate (gpm)</u>	<u>Static Level (feet)</u>	<u>Pumping Level (feet)</u>	<u>Drawdown (feet)</u>	<u>Specific Capacity (gpm/ft)</u>
Canyon View Ranch	11/10/15	250	147	170	23	11
1	7/90	1,400			28	49
2	4/89	2,867			64	45
	6/19/02	1,864	157	243	86	22
3	10/1/08	3,000	307	338	31	92

Two tests are shown for Well No. 2. The first test is considered more representative, as the lower specific capacity for the second test was probably affected by partial plugging of the Well.

July, 2002, a 21-day aquifer test was conducted. Well No. 2 was pumped alone for the first 12 days at an average rate of 1,864 gpm. The static level in Well No. 2 prior to pumping was 157 feet deep and the pumping level after almost 12 days of pumping was 243 feet. The drawdown was 86 feet and the specific capacity was 22 gpm per foot. Drawdown measurements in this well (Figure 6) indicated a transmissivity of 47,000 gpd per foot, in good agreement with the specific capacity. Drawdown measurements in Well No. 2 indicated a transmissivity of 35,000 gpd per foot. Well No. 1 was indicated to be filled into a depth of 1,037 feet at the time of the test, and was thus a partially penetrating well. The value of 47,000 gpd per foot is thus considered the best transmissivity value for the 12-day test.

GROUNDWATER QUALITY

Table 3 shows the results of chemical analyses of water from three Rio Bravo Ranch wells. Total dissolved solids (TDS) concentrations ranged from 980 to 1,100 mg/l. The water was of the sodium sulfate type. Sodium concentrations ranged from 200 to 260 mg/l and sulfate concentrations from 490 to 542 mg/l. Sulfate concentrations were near or slightly exceeded the recommended maximum contaminant level (MCL) of 500 mg/l for public water supplies. Nitrate, arsenic, and chromium concentrations

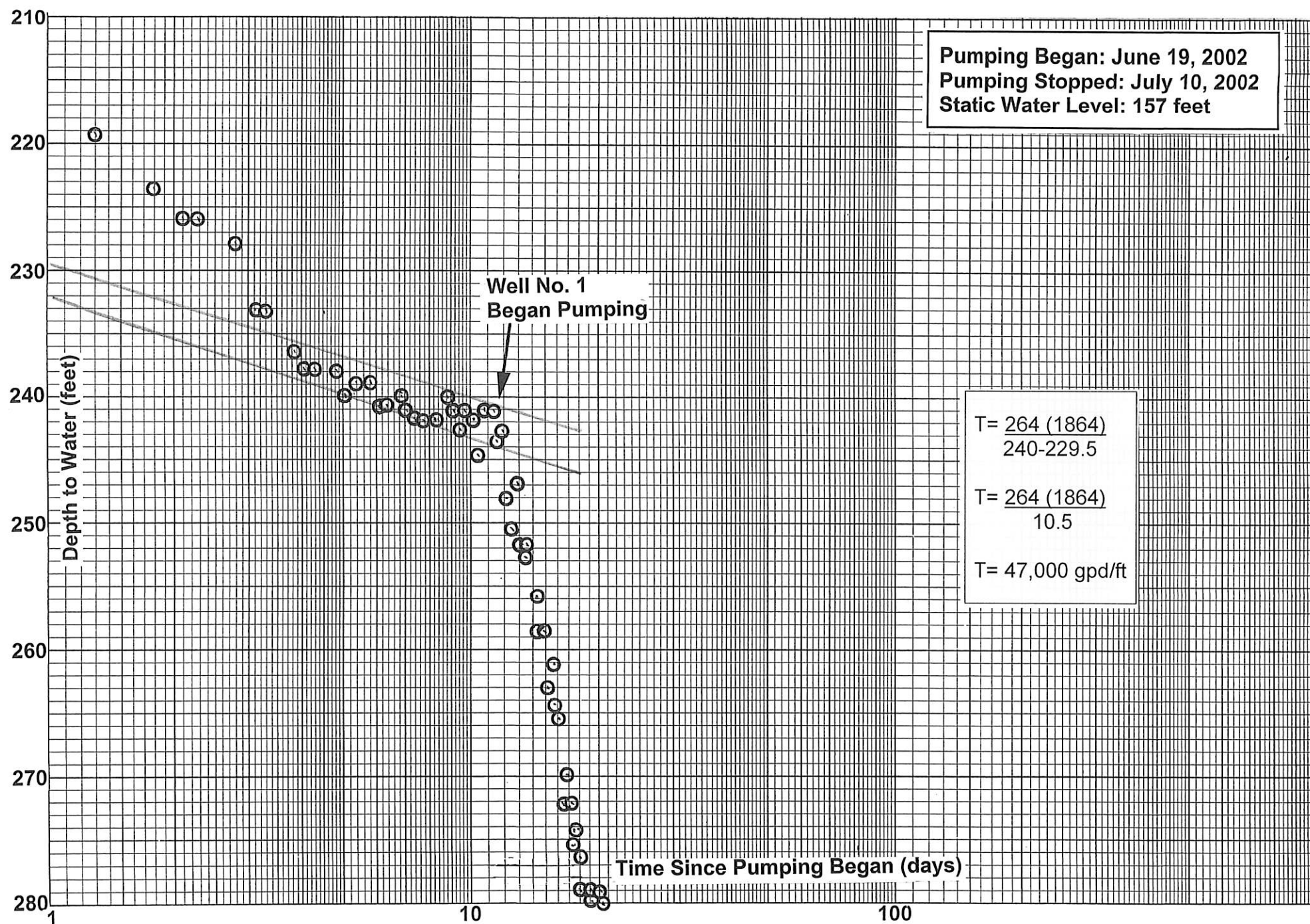


FIGURE 5-DRAWDOWN FOR RIO BRAVO RANCH WELL NO. 2

TABLE 3-CHEMICAL QUALITY OF WATER FROM RIO BRAVO RANCH WELLS

<u>Constituent (mg/l)</u>	<u>Well No. 1</u>	<u>Well No. 2</u>	<u>Well No. 3</u>	<u>MCL</u>
Calcium	69	87	79	
Magnesium	10	14	13	
Sodium	245	200	260	
Potassium	19	12	15	
Carbonate	<10	<2	<2	
Bicarbonate	220	210	220	
Sulfate	542	490	510	500
Chloride	61	33	44	500
Nitrate	<0.4	<1	<1	45
pH	7.7	8.0	8.1	
Electrical Conductivity (micromhos/cm @ 25°C)	1,640	1,360	1,500	
Total Dissolved Solids	1,150	980	1,100	
Boron	0.6	-	0.6	
Iron	<0.05	1.2	0.5	0.3
Manganese	0.06	0.04	0.035	0.05
Arsenic (ppb)	<2	<2	<2	10
Chromium (ppb)	<1	<10	<10	10
Alpha Activity (picocuries/l)	0.0	- 0.0		
Date	7/10/02	2/19/14	2/9/14	
Laboratory	FGL Env.	BC Labs	BC Labs	

were below the respective MCLs. Iron concentrations in water from Wells No. 2 and 3 ranged from 0.5 to 1.2 mg/l, exceeding the recommended MCL of 0.3 mg/l for public water supplies. The manganese concentration in water from Well No. 1 was 0.06 mg/l, exceeding the recommended MCL of 0.05 mg/l for public water supplies. Manganese concentrations in water from Well No. 2 and 3 ranged from 0.035 to 0.04 mg/l, less than the recommended MCL. Alpha activities were well below the MCL of 15 picocuries per liter for public water supplies. Determination of a number of trace organic chemical constituents indicated no detectable levels. Copies of the laboratory reports are provided in Appendix C.

In February 2015 water samples were collected from Wells No. 2 and 3 and the Kern River for determination of the stable isotopes of water. Oxygen-18 concentrations ranged from -8.9 to -9.0 o/oo, and the deuterium concentration was -70 o/oo. For comparison, Kern River water had an oxygen-18 concentration of -11.9 o/oo and a deuterium concentration of -92 o/oo. All of the analyses of water from the ranch wells indicated no evidence of Kern River water in the pumped water.

DELINEATION OF PROPOSED OLCESE SUB-BASIN

Figure 6 shows the proposed Olcese Sub-basin boundary. The northeast boundary near the Kern River is the Kern Gorge Fault. The Olcese Formation is not present northeast of this fault. The southwest boundary is the southwesternmost extent of fresh groundwater in the Olcese Formation. The south boundary is the north boundary of where the Santa Margarita Formation is present in the subsurface. South of this boundary, groundwater in the Olcese Formation is not used for water supply, as groundwater in shallower overlying deposits is tapped. The north and east boundaries are essentially the DWR exterior boundary of the Kern Basin, which is defined primarily by topographic conditions.

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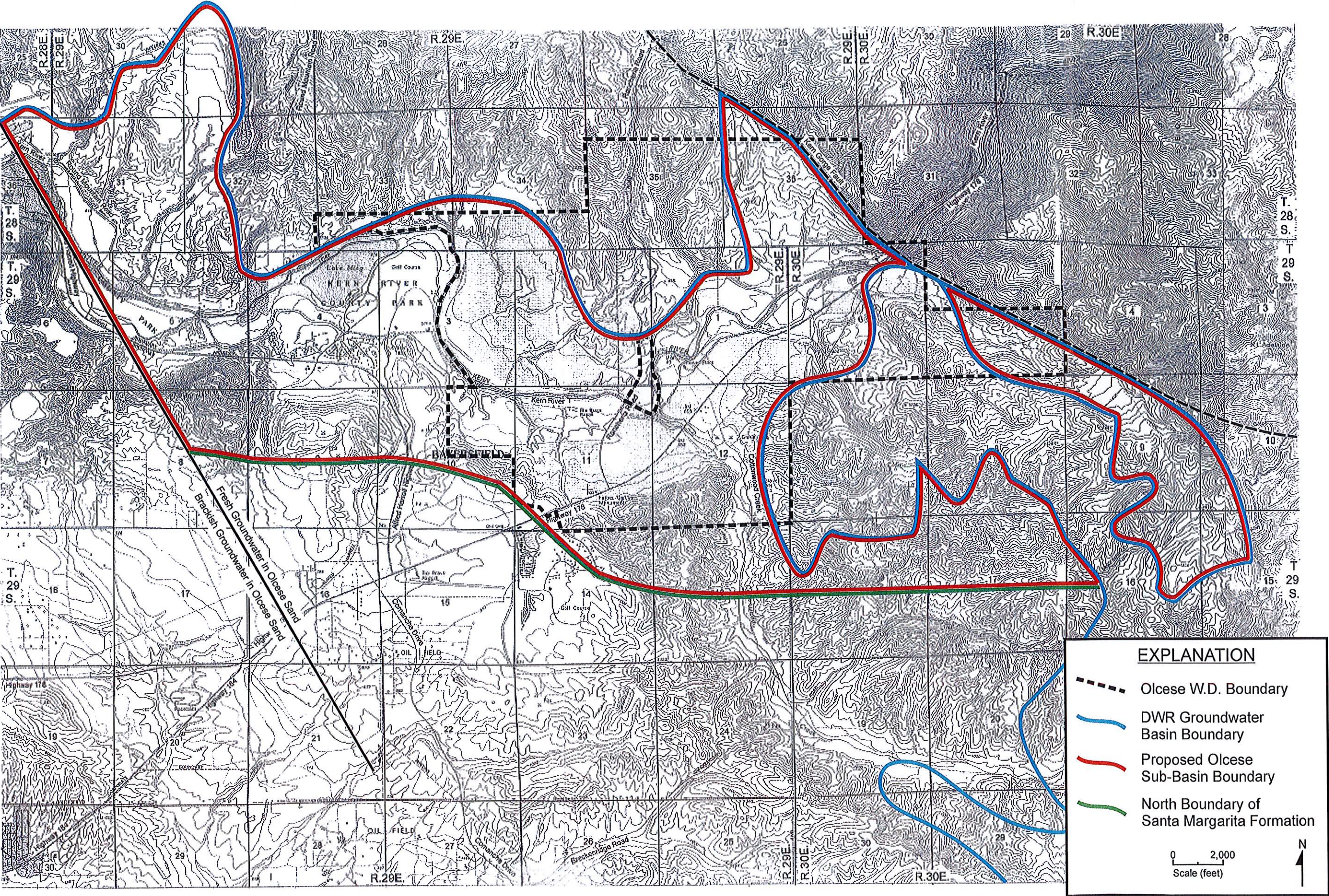


FIGURE 6 - PROPOSED BOUNDARIES OF OLCESE SUB-BASIN