GROUNDWATER CONDITIONS AND POTENTIAL IMPACTS OF PUMPING FOR THE ID-4 KERN PARKWAY AND ROSEDALE-RIO BRAVO WSD PROJECTS

prepared for
Improvement District No. 4
Kern County Water Agency
Bakersfield, California

by
Kenneth D. Schmidt & Associates
Groundwater Quality Consultants
Fresno, California

January 2003

KENNETH D. SCHMIDT AND ASSOCIATES
GROUNDWATER QUALITY CONSULTANTS
600 WEST SHAW, SUITE 250
FRESNO, CALIFORNIA 93704
TELEPHONE (559) 224-4412

January 14, 2003

Mr. Martin Varga
District Engineer, ID-4
Kern County Water Agency
P. O. Box 58
Bakersfield, CA 93302-0058

Re: Kern Parkway Hydrogeologic Evaluation

Dear Martin:

Submitted herewith is our report on the Kern Parkway hydrogeologic evaluation. I appreciate the cooperation of KCWA staff and the Central Valley Regional Water Quality Control Board in providing information for this evaluation.

Sincerely yours,

Kenneth D. Schmidt

KDS/cap

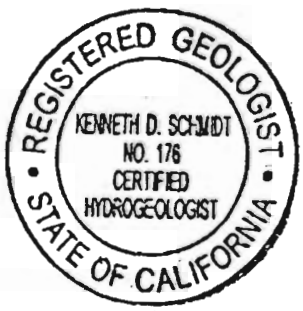


TABLE OF CONTENTS

	Page
LIST OF TABLES	iii
LIST OF ILLUSTRATIONS	iv
INTRODUCTION	1
SUBSURFACE GEOLOGIC CONDITIONS	3
WELL CONSTRUCTION DATA	8
Project Wells	8
Off-site Wells	8
WATER LEVELS	11
Direction of Groundwater Flow	11
Water-Level Hydrographs	16
AQUIFER CHARACTERISTICS	20
GROUNDWATER QUALITY	25
Inorganic Chemical Constituents	25
Radiological Constituents	29
DBCP & EDB	29
Volatile Halocarbons	32
Volatile Aromatics	32
Shell Refinery	32
Former Sunland Refinery	34
MTBE	34
Shell Refinery	34
Former Sunland Refinery	36
PROJECTED DRAWDOWNS	37
Impacts on Water Supply Wells	40
Influence of Recharge	47

Continued:

TABLE OF CONTENTS
(Continued)

	Page
ANTICIPATED CHANGES IN GROUNDWATER QUALITY	48
High Nitrate Area	48
DBCP & EDB	49
Volatile Aromatics	51
MTBE	51
MITIGATING MEASURES	52
REFERENCES	54
APPENDIX A LARGE-SCALE MAPS OF BENZENE AND MTBE PLUMES	

LIST OF TABLES

No.	Title	Page
1	Construction Data for Project Supply Wells	9
2	Construction Data for City of Bakersfield Supply Wells	10
3	Construction Data for Berrenda Mesa Project Wells	12
4	Results of Aquifer Tests on Project Supply Wells	23
5	Projected Drawdown for Starting Water Level at Intermediate Depth	39
6	Projected Drawdown for Starting Water Level at Deep Depth	41
7	Distances of Supply Wells from Pumping Centroids	42
8	Projected Drawdowns at Selected Wells	45

LIST OF ILLUSTRATIONS

No.	Title	Page
1	Location of Selected Wells and Subsurface Geologic Cross Sections	4
2	Subsurface Geologic Cross Section A-A'	5
3	Subsurface Geologic Cross Section B-B'	7
4	Water-Level Elevations and Direction of Groundwater Flow in Spring 1993	13
5	Water-Level Elevations and Direction of Groundwater Flow in Spring 1999	15
6	Water-Level Hydrographs for Well Cluster T29S/R26E-35H	18
7	Water-Level Hydrographs for Well Cluster T30S/R26E-4J	19
8	Concentrations of Selected Inorganic Chemical Constituents and Alpha Activity in Well Water	26
9	Concentrations of Selected Trace Organic Constituents in Well Water	30

GROUNDWATER CONDITIONS AND POTENTIAL IMPACTS OF PUMPING FOR THE ID-4 KERN PARKWAY AND ROSEDALE-RIO BRAVO WSD PROJECTS

INTRODUCTION

In 2001, ID-4 had five new wells constructed and incorporated two existing wells to pump groundwater as part of its Kern River Restoration Program. The location of the well field is generally the area along the north side of the Kern River between Allen Road and Calloway Drive. The wells in this field are currently plumbed into the Cross Valley Canal, where water can be delivered to the Henry C. Garnett Water Purification Plant or used to enhance potential exchanges with other districts and Kern River interests.

In addition to the existing seven wells, ID-4 is currently negotiating a well capacity exchange program with Rosedale-Rio Bravo Water Storage District (RRBWSD), where ID-4 will construct up to seven additional wells. Once ID-4 completes the construction of these wells, the District plans to pump up to seventy cubic feet per second, ten to twelve months out of the year. Under this condition, it is estimated that the wells would be operated once every three years.

In addition to the wells being plumbed into the Cross Valley Canal, there are plans being considered to use the wells for a conjunctive use pipeline. Under this condition, the wells would be

manifolded together and the pipeline would be plumbed into ID-4's Northwest Feeder Pipeline. The wells would operate continuously, delivering 70 cfs to the northwest portion of ID-4's service area. The well field is located adjacent to a reach of the Kern River where ID-4 does a majority of its recharge operations. Past recharge in the area has significantly raised water levels compared to where they would have otherwise been.

Concerns have arisen about drawdown impacts on existing water supply wells in the vicinity, due to pumping of the ID-4 and RRBWSD wells. In addition, a number of groundwater quality problems have been experienced in some parts of the area, including high DBCP, EDB, and nitrate concentrations and high uranium activities in the shallow groundwater. Trace organic contamination of shallow groundwater has also been found near refineries in the Rosedale area. Altered movement of contaminant plumes due to pumping of the wells for the proposed projects is a concern. The focus of this report is to evaluate both the drawdown impacts (including cumulative ones), and potential changes in groundwater quality associated with the proposed projects. In addition, mitigating measures and a proposed groundwater monitoring program are presented.

SUBSURFACE GEOLOGIC CONDITIONS

The project site is on the upper part of the Kern River fan, where coarse-grained deposits are predominant above a depth of about 700 feet. As part of this evaluation, drillers reports and electric logs were obtained for wells and test holes in the vicinity. Two subsurface geologic cross sections were then developed. Figure 1 shows the locations of the River Parkway and proposed RRBWSD wells, the cross sections, and locations of other selected wells referenced in this report. Cross Section A-A' extends generally along the Kern River, from near Heath Road on the southwest, through a number of ID-4 and City of Bakersfield wells, to near the Atchison, Topeka, and Santa Fe Railroad tracks on the northeast. Cross Section B-B' extends from near Palm Avenue north of Brimhall Road on the northwest to the southeast through several KCWA wells, to near Calloway Drive, north of Fraser Road.

Cross Section A-A' (Figure 2) is oriented parallel to the inferred dip of the alluvial deposits. Coarse-grained deposits extend to a depth of at least about 750 feet along much of the section. Stream channel deposits (coarser than sand) are indicated to be present along most of the section. These deposits generally extend to greater depths as one progresses farther southwest. Fine-grained strata that could act as significant confining beds are of limited extent along the section, except below a depth of

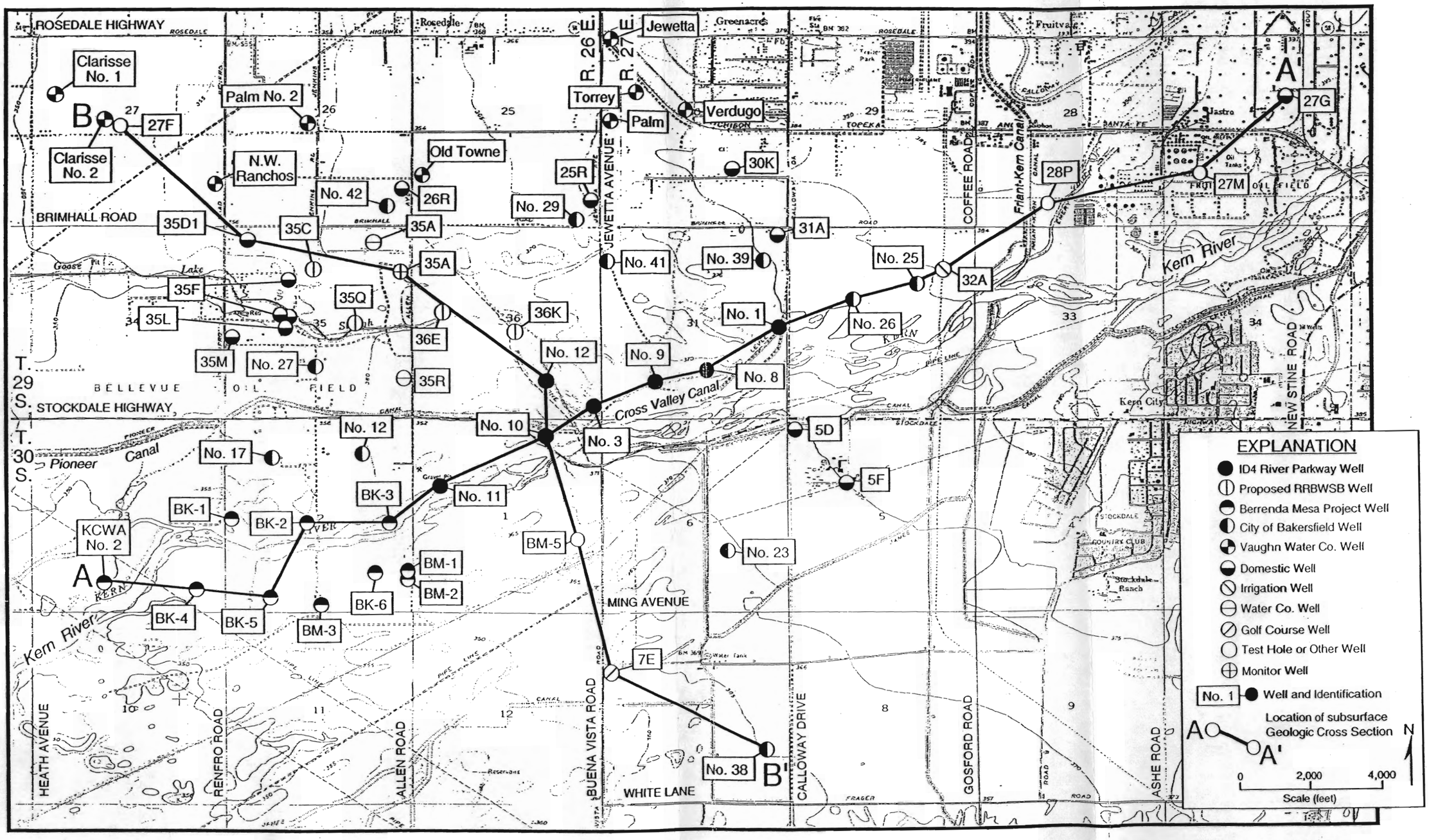


FIGURE 1 - LOCATION OF SELECTED WELLS AND SUBSURFACE GEOLOGIC CROSS SECTIONS

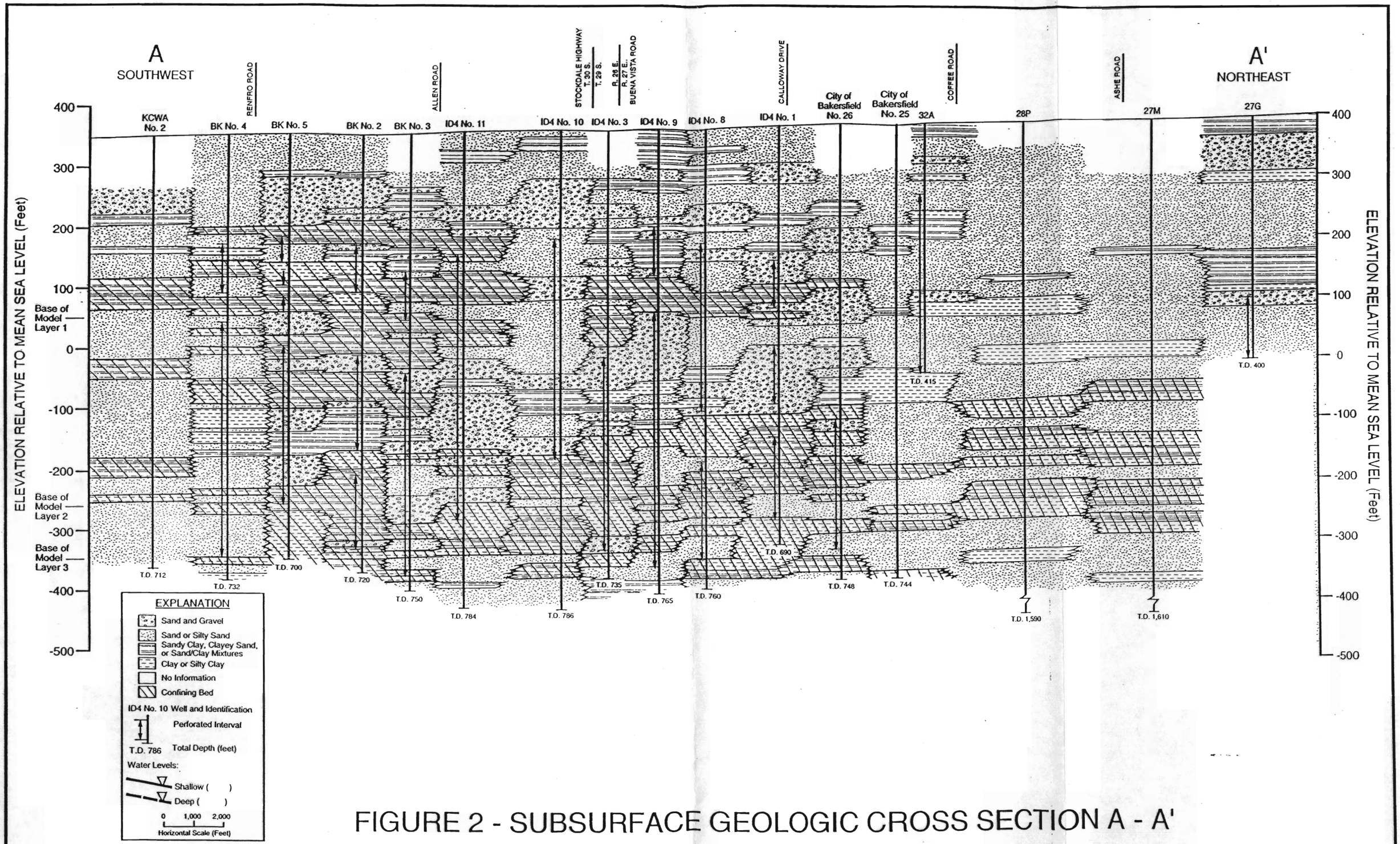


FIGURE 2 - SUBSURFACE GEOLOGIC CROSS SECTION A - A'

about 450 to 500 feet. A fairly continuous confining bed (primarily clay) appears to be present below this depth and above a depth of about 750 feet along most of this section. A localized shallow potential confining bed appears to be present primarily west of Calloway Drive, along this section. The top of this layer is about 150 feet deep. The layer appears to be discontinuous, the deposits are not primarily clay, and the bed is indicated to be much less effective than the deeper more extensive confining bed.

Cross Section B-B' (Figure 3) generally extends perpendicular to the inferred dip of the alluvial deposits. Coarse-grained deposits are also predominant along this section, and are overwhelmingly present in the area north of the Kern River. Stream channel deposits (coarser than sand) are present along this section only in the areas east of Allen Road, and most of these are near or south of the Kern River. A localized, possibly significant shallow confining bed (primarily clay) is present along this section south of the Kern River. The top of this bed is about 150 feet deep. A more extensive deeper confining bed is present below a depth of about 500 feet along the section. This bed is thicker to the southeast, and thinner to the northwest.

Additional subsurface geologic cross sections have been prepared by Environmental Resources Management (2000) for the area east of the Friant-Kern Canal and south of the Calloway Canal.

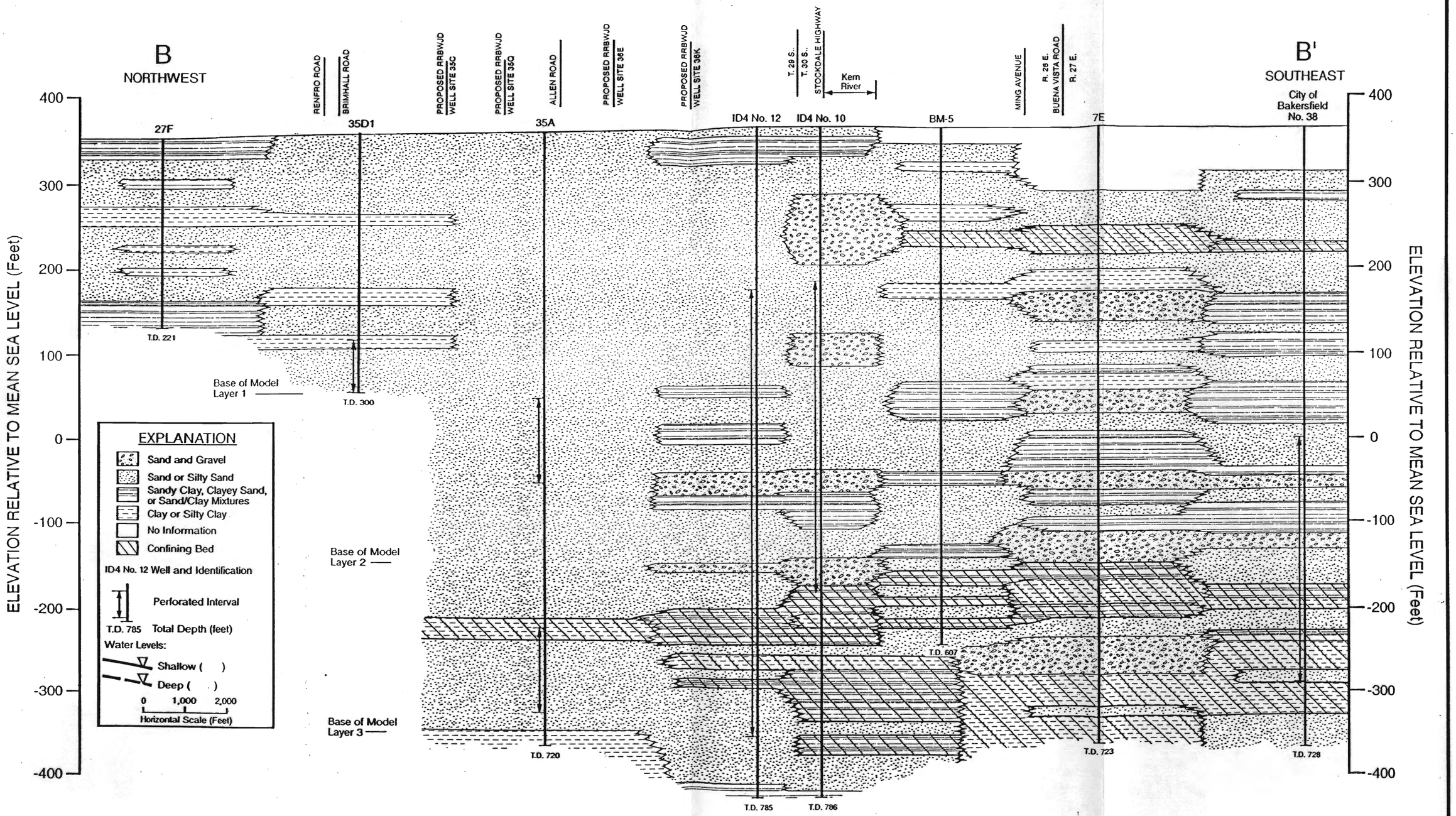


FIGURE 3 - SUBSURFACE GEOLOGIC CROSS SECTION B - B'

These sections extend to a depth of about 250 feet and provide more information in the area of volatile aromatic and MTBE-contaminated groundwater, which is discussed in a subsequent section of this report.

WELL CONSTRUCTION DATA

Project Wells

Table 1 summarizes construction data for ID-4 wells in the area. The first two wells were drilled in early 1991 and the last five in Summer 2001. Depths of these wells range from 560 to 730 feet. The tops of the perforations in most of these wells range from 160 to 220 feet.

Off-Site Wells

Drillers reports are not available for all of the private domestic wells in the vicinity. However, for wells with such reports, depths range from about 200 to 500 feet. Because of the large historical water-level fluctuations in the area, the shallow wells were probably drilled when water levels were shallow (ie. following wet periods and recharge), and the deeper wells when water levels were deeper (ie. such as in the early 1990's). There are nine City of Bakersfield wells in the vicinity. Table 2 summarizes construction data for these wells. Depths of these wells range from about 620 to 750 feet. The tops of the

TABLE 1 - CONSTRUCTION DATA FOR PROJECT SUPPLY WELLS

Well No.	Date Drilled	Depth Drilled (feet)	Casing Diameter (inches)	Depth Cased (feet)	Perforated Interval(ft)	Annular Seal(ft)
1	2/91	690	18	650	220-300 360-460 510-650	0-200 310-340 470-500
3	4/91	735	18	703	193-313 373-693	0-152 324-355
8	5/01	760	20	730	190-470 550-710	0-175
9	6/01	765	20	740	160-240 300-720	0-155
10	5/01	786	20	560	180-540	0-160
11	4/01	784	20	660	200-640	0-155
12	7/01	785	20	730	190-710	0-155

Data from well drillers reports.

TABLE 2 - CONSTRUCTION DATA FOR CITY OF BAKERSFIELD SUPPLY WELLS

Well No.	Date Drilled	Depth Drilled (feet)	Casing Diameter (inches)	Depth Cased (feet)	Perforated Interval (ft)	Annular Seal (ft)
12	11/81	620	16	620	368-620	0-50
17	12/85	680	16	651	352-632	0-300
23	8/92	720	16	720	450-710	0-430
26	6/91	748	16	720	480-700	0-80 417-465
27	6/93	738	16	720	400-700	0-380
29	4/92	738	16	720	430-710	0-400
39	6/98	738	16	730	400-710	0-380
41	12/00	750	16	720	460-720	0-438
42	4/02	730	16	720	600-700	0-580

Data from well drillers reports.

perforations in these wells range from about 350 to 600 feet deep. Except for two of these wells, the top of the perforations are below 400 feet deep. There are eight Berrenda Mesa project wells in the vicinity. Depths of these wells range from about 600 to 730 feet (Table 3). The tops of the perforations in these wells range from 160 to 290 feet below surface. These wells were all drilled in 1991.

There are numerous monitor wells that have been installed at the Shell Refinery (Environmental Resources Management 2000 and GeoSyntec Consultants, Inc. 2002), at the former Sunland Refinery (California Regional WQCB, 2002), and at the PG&E Kern Power Plant (ENV America 2002). The locations and perforated intervals of these are presented in the referenced reports. In addition, there are two Kern Fan cluster monitor wells in the area, and information on the perforated intervals is provided elsewhere in this report.

WATER LEVELS

Direction of Groundwater Flow

Water-level elevation maps are prepared annually for spring measurements as part of the Kern Fan monitoring committee studies associated with water-banking activities. Spring 1993 water-level elevations (Figure 4) are important because these represent a period of low water levels, during and following minimal recharge

TABLE 3 - CONSTRUCTION DATA FOR BERRENDA MESA PROJECT WELLS

Well No.	Date Drilled	Depth Drilled (feet)	Casing Diameter (inches)	Depth Cased (feet)	Perforated Interval (ft)	Annular Seal (ft)
BM-1	7/91	600	16	597	289-597	0-50
BM-2	3/91	720	18	680	180-260 360-520 560-680	0-160 270-348
BM-3	4/91	720	18	700	160-240 355-695	0-140 250-340
BM-5	3/62	706	16	600	210-600	-
BK-1	4/91	720	18	700	160-240 355-695	0-140 250-340
BK-2	3/91	720	18	680	180-260 360-520 560-680	0-160 270-348
BK-3	7/91	750	18	734	224-304 384-724	0-135 310-370
BK-5	4/91	700	18	610	170-210 250-270 350-610	0-150 280-320
BK-6	3/91	760	18	728	189-288 388-728	0-154 298-378

Data from well drillers reports.

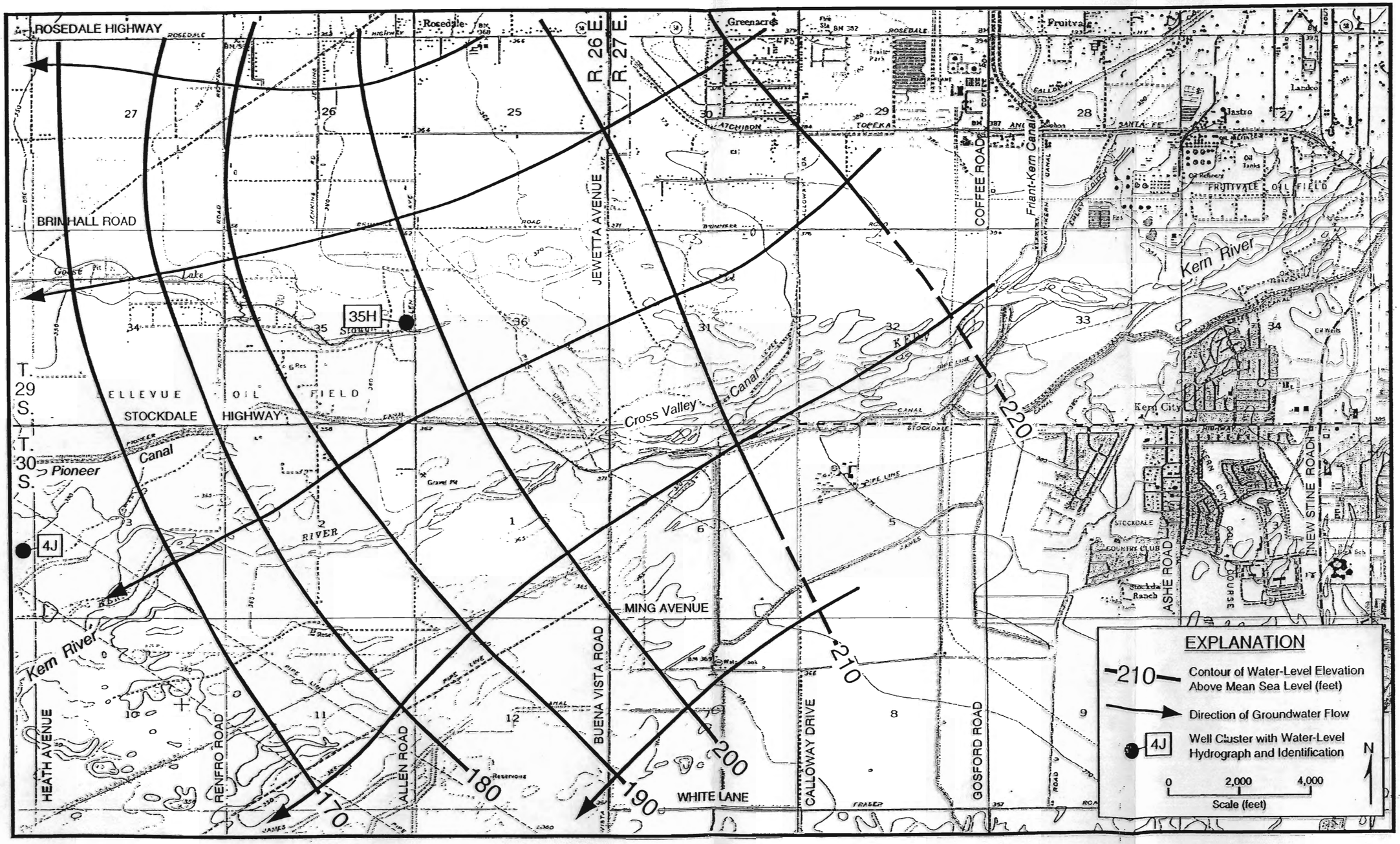


FIGURE 4 - WATER-LEVEL ELEVATIONS AND DIRECTION OF GROUNDWATER FLOW IN SPRING 1993

along and near the Kern River. The water-level contours shown have been smoothed and generalized from the original maps. Figure 4 illustrates a southwest direction of groundwater flow through much of the area. No recharge mound or ridge near the river is indicated in this area at that time. Groundwater was apparently flowing toward large capacity water supply wells located southwest of the project wells.

In contrast, water levels in March 1999 (Figure 5) were near the shallowest in recent decades, following several years of large-scale recharge associated with the Kern Fan water-banking activities. The contours on this map have also been smoothed and generalized from the original map. A significant recharge ridge was present beneath the Kern River in the western part of the study area. Groundwater flowed away from this ridge both to the northwest and southeast. In the eastern part of the area, the highest water-level elevations were north of the river. Groundwater was flowing west near Coffee Road and north of Brimhall Road. The water-level elevations and directions of groundwater flow shown in Figures 4 and 5 are not necessarily for the shallowest groundwater in the area. Rather, these are for the main groundwater producing zone for most large-capacity water supply wells, commonly between about 200 and 700 feet in depth.

Additional information on groundwater flow is available near the Shell and former Sunland Refineries, primarily north of the

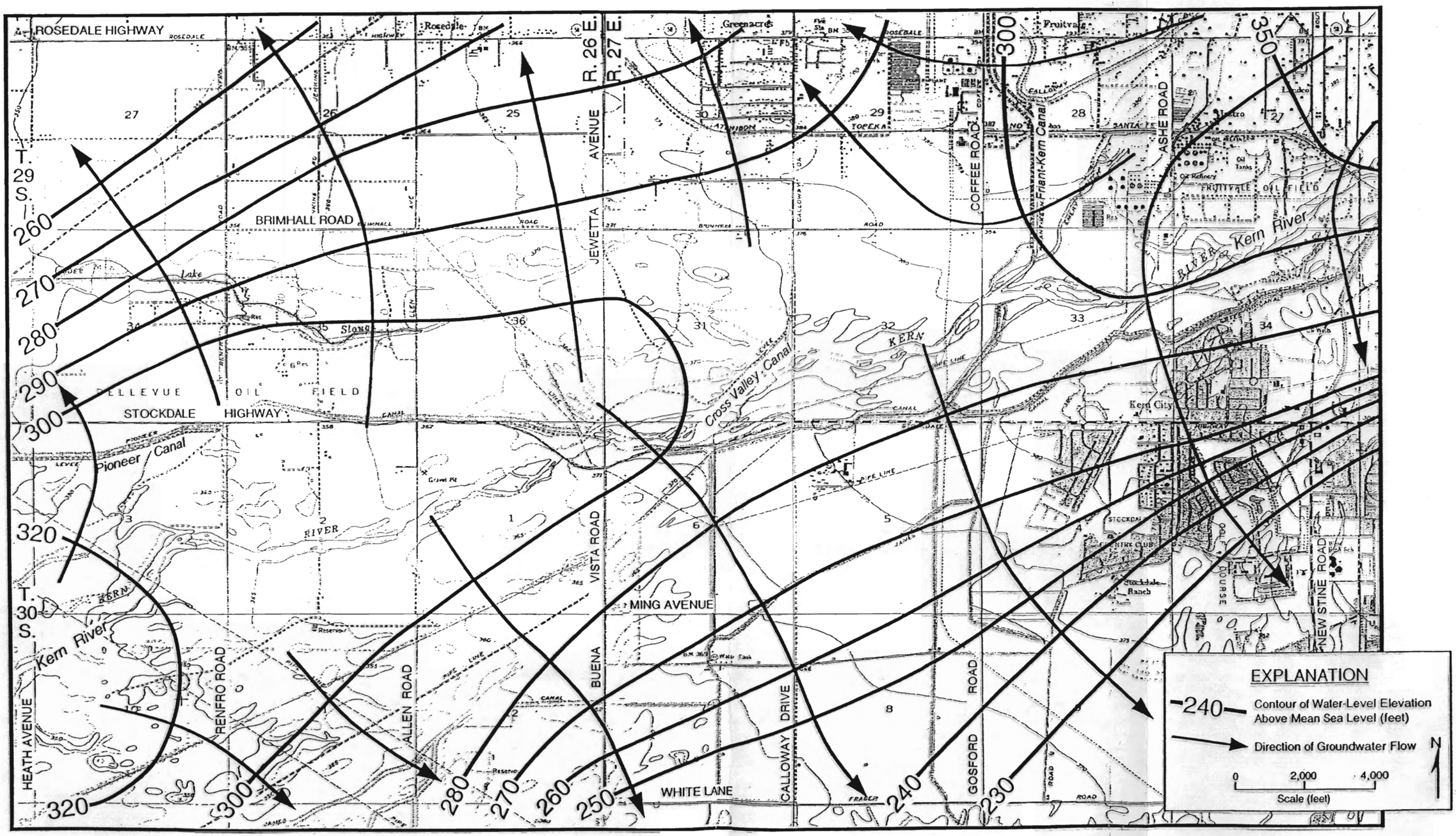


FIGURE 5 - WATER-LEVEL ELEVATIONS AND DIRECTION OF GROUNDWATER FLOW IN SPRING 1999

Kern River, near and south of the Calloway Canal, both east and west of the Friant-Kern Canal. Numerous monitor wells have been installed which tap groundwater above a depth of about 250 feet. The most information is available for above a depth of about 110 feet. Water-level elevation maps are available for several depth intervals in recent years. Also, several plumes of trace organic chemical constituents have been mapped in this area, which also indicate the predominant direction of groundwater flow. These plumes are discussed in more detail in a subsequent part of this report. Two MTBE plumes beneath the Shell Refinery indicate that the predominant direction of shallow groundwater flow during the past decade or so in this area has been to the west or southwest. A plume of volatile aromatics (particularly benzene) that is probably much older than the MTBE plumes, indicates a southwesterly groundwater flow direction. This flow direction was more predominant during the drought period of the late 1980's and early 1990's, when there was substantial pumping of wells in the area southwest of the refineries, and no recharge ridge was present along the Kern River.

Water-Level Hydrographs

Records for two cluster monitor wells in the vicinity are available, as part of the Kern Fan monitoring activities. Well site T29S/R26E-35H comprises three wells. The RRBWSD shop well is

the shallowest well at the site (apparently less than 200 feet deep). The other two wells are cluster monitor wells installed for the KCWA. Well 35H3 is the deepest well, tapping strata from 590 to 680 feet in depth. Well 35H4 is an intermediate depth well, tapping strata from 310 to 410 feet in depth. This cluster monitor well is near the centroid of the proposed RRBWSD well field. Records shown on the hydrographs extend back to early 1996 for the shop well, and back to late 1992 for the other two wells (Figure 6). Depth to water has ranged from about 120 to more than 220 feet at the site since late 1992. Water levels rose about 85 feet at the site between Spring 1993 and Spring 1999. Water levels then fell about 10 feet between Spring 1999 and Spring 2001. Water levels fell more than 20 feet between Spring 2001 and Spring 2002. The water-level declines during 2001 and 2002 were due to greater pumpage in the area during these years.

Figure 7 shows water-level hydrographs for cluster monitor well T30S/R26E-4J, which is located near Heath Road, about half a mile south of Stockdale Highway (in the North Pioneer project well field). Records for this cluster well extend back to mid-1988. Four separate wells are present. The shallowest is perforated from 45 to 65 feet in depth. The others are perforated from 100 to 150 feet, 223 to 375 feet, and 560 to 650 feet. These water level hydrographs show that deeper water levels are present in deep wells, particularly during pumping episodes (such as in the early 1990's and in 2001). Also shown are the shallower water levels in

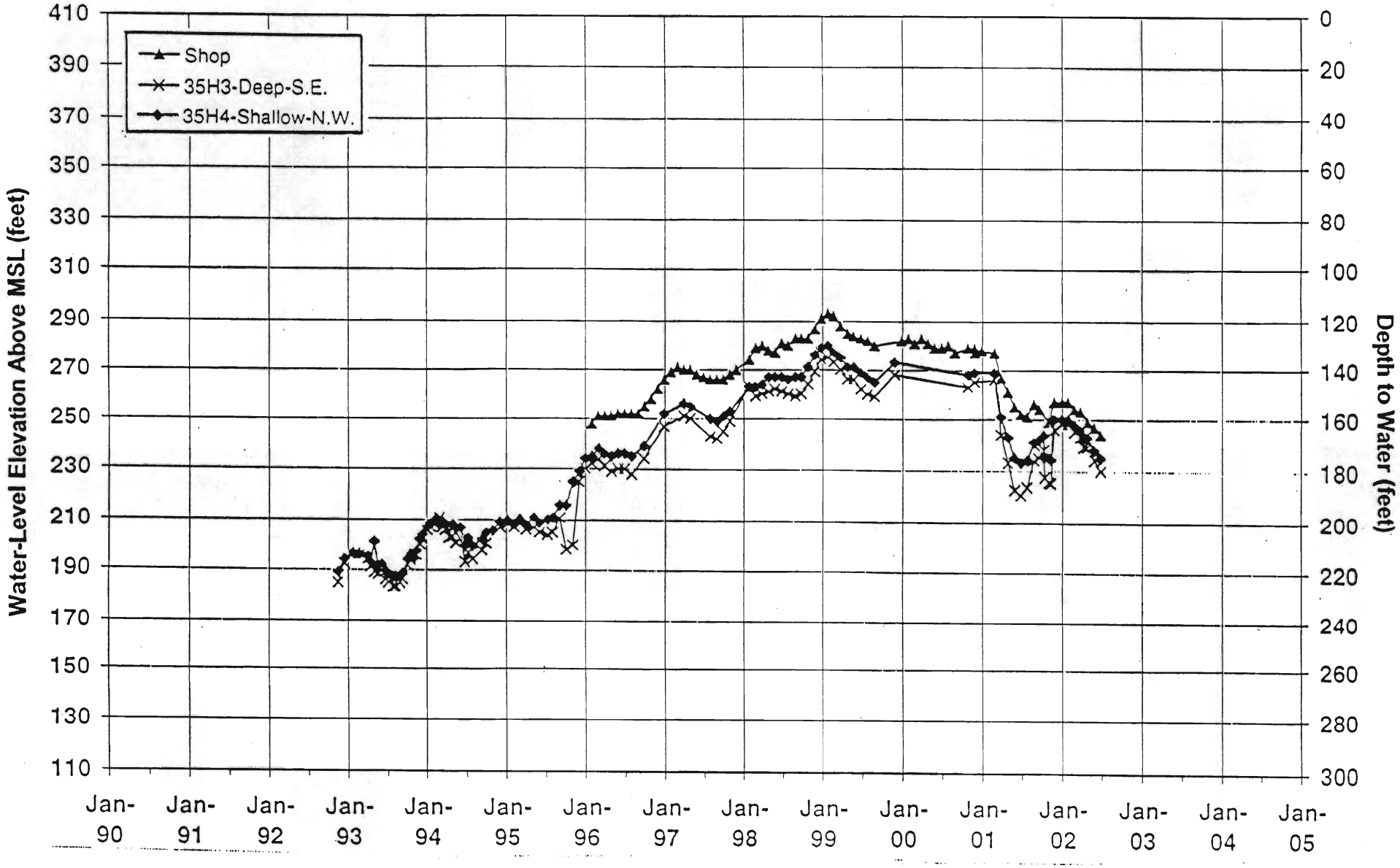


FIGURE 6 - WATER-LEVEL HYDROGRAPHS FOR WELL CLUSTER T29S/R26E-35H

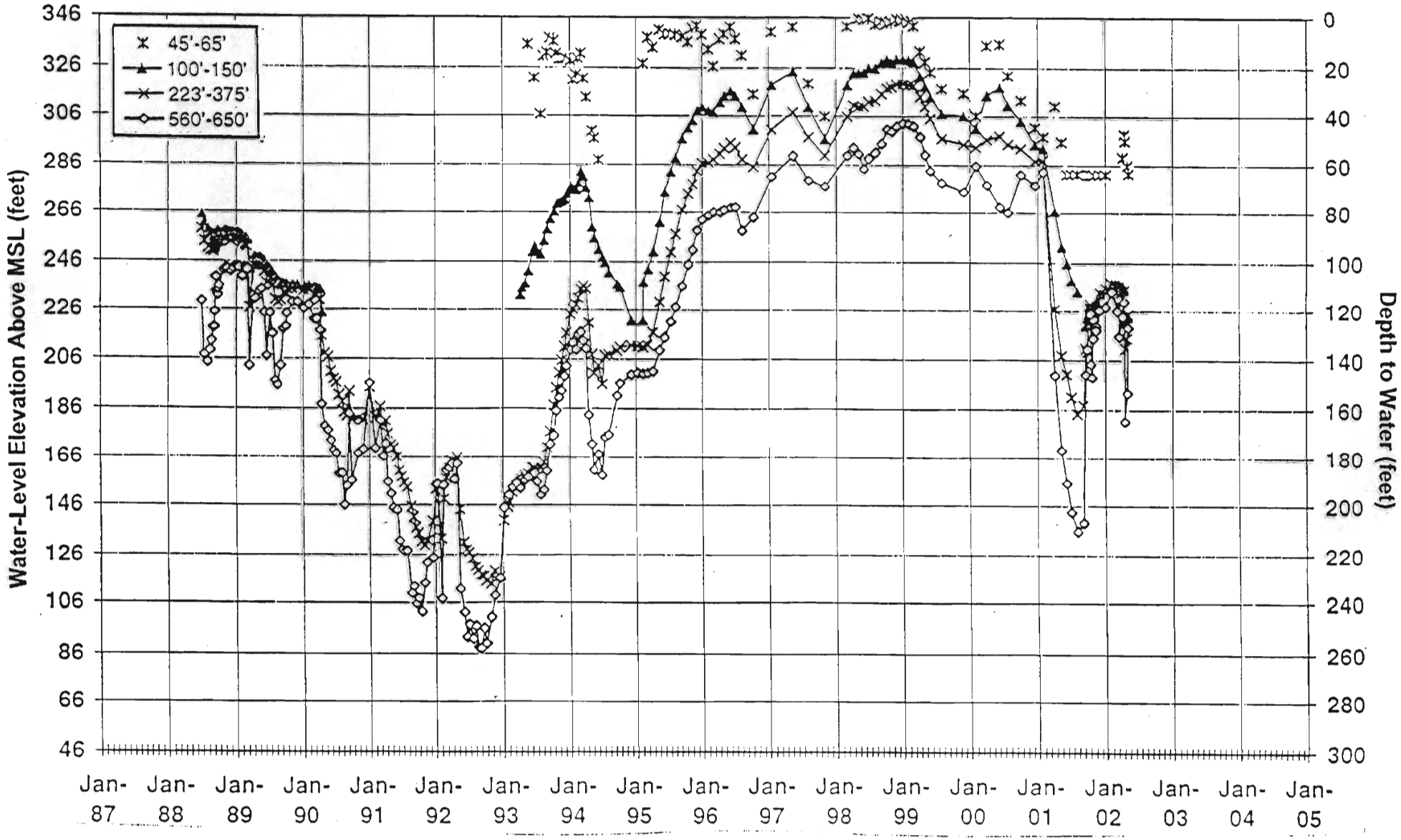


FIGURE 7 - WATER-LEVEL HYDROGRAPHS FOR WELL CLUSTER T30S/R26E-4J

shallower wells, particularly during and following recharge events (such as 1994-2000). Depth to water for the shallowest well has ranged from near the land surface to more than 65 feet. Depth to water for the deepest well has ranged from about 40 feet in Spring 1999 to 260 feet in Summer 1992. Spring water levels fell about 100 feet between 1989 and 1993. Water levels then rose almost 160 feet, between Spring 1993 and Spring 1999, due to large-scale recharge activities. Water levels in the deepest well fell about 20 feet between Spring 1999 and Spring 2001. The water level then fell about 50 feet between Spring 2001 and Spring 2002. Part of the recent water-level declines are due to recession of the recharge ridge, following cessation of large-scale recharge activities in 1998. The remainder is due to pumping of wells in the area, particularly for the North Pioneer wells.

AQUIFER CHARACTERISTICS

Aquifer characteristics have previously been determined from the Pioneer and Berrenda Mesa water-banking projects (Kenneth D. Schmidt and Associates, 1998). These, along with the east part of the City of Bakersfield 2,800-acre area, are the closest previously evaluated water banking project areas to the proposed project wells.

The California Department of Water Resources (DWR) divided the alluvial deposits in the Kern Fan area into three layers for

groundwater modeling. Layer 1 extends from the land surface to a depth of 300 feet, Layer 2 extends from 300 to 500 feet in depth, and Layer 3 extends from 500 to 700 feet in depth. The DWR provided values of transmissivity for the lower two layers and hydraulic conductivity for the upper layer. However, these values weren't based on aquifer tests and evaluations of some recovery well pumping, nor recharge mound evaluations for the local area following large-scale recharge. Substantial aquifer test data are now available for dozens of water bank project recovery wells, including five of the ID-4 wells. In addition, more information on the upper layer aquifer characteristics is available for 1) aquifer tests when the water level was relatively shallow, and 2) evaluations of water-level rises associated with recharge activities for the water-banking projects.

For the Pioneer and Berrenda Mesa projects, values of aquifer characteristics from the DWR Kern Fan Model for areas close to the proposed project were provided by KDSA (1998, Appendix A). Appendix B of that report contained transmissivity values for Layer 1 and the combined values for all three layers when water levels are shallow. Transmissivity values are normally expected to be higher when water levels are shallower and the saturated thickness of the alluvial deposits is greater. DWR model values were modified to incorporate the results of aquifer tests and mounding evaluations. A significantly higher transmissivity (247,000 gpd per foot) was

indicated for the part of the Pioneer area north of the Kern River, compared to the model values. This assumes a starting water level of only 10 feet in depth (the shallow water level condition).

In the Pioneer Project drawdown evaluation, drawdowns were calculated both for a shallow and intermediate starting depth to water. Based on available information, such as specific capacity values for wells covering different time periods, the transmissivity values for the drawdown calculations starting at the intermediate water level (120 feet deep) were reduced only about fifteen percent from those for the shallow water-level conditions (10 feet deep).

Table 4 shows the results of aquifer tests for five ID-4 wells, based on Summer 2001 tests. Pumping rates for these 72-hour constant discharge tests ranged from about 4,500 to 5,055 gpm. Specific capacities ranged from 163 to 232 gpm per foot of drawdown, which are some of the highest observed for such wells in the Kern Fan. The static water levels at the time of these tests averaged about 116 feet deep, or near the "intermediate" level, as previously defined. Transmissivity values for the drawdown measurements were higher than corrected recovery values. Drawdown values for these tests are indicated to be more meaningful, because the duration of measurements was 72 hours, compared to only from

TABLE 4 - RESULTS OF AQUIFER TESTS ON PROJECT SUPPLY WELLS

Well No.	Date	Static Level (ft)	Pumping Rate (gpm)	Pumping Level (ft)	Drawdown (feet)	Specific Capacity (gpm/ft)	Transmissivity (gpd per ft) Drawdown	Transmissivity (gpd per ft) Recovery
8	6/01	116.6	5,055	144.1	27.5	184	381,000	267,000
9	7/01	116.5	4,980	144.6	28.1	177	346,000	-
10	6/01	114.5	5,000	139.1	24.6	203	440,000	377,000
11	5/01	118.1	4,980	148.6	30.5	163	438,000	227,000
12	8/01	116.4	4,500	135.8	19.4	232	440,000	410,000

Drawdown values are for 72 hours of pumping. Recovery values are for only 3 to 6 hours of recovery. The drawdown values are indicated to be more representative.

three to six hours for the recovery measurements. Previous evaluations have indicated that these wells are highly efficient, thus making the use of drawdown measurements more meaningful. Transmissivities ranged from 346,000 to 440,000 gpd per foot, and averaged 409,000 gpd per foot. Although these values are relatively large compared to those elsewhere in the Kern Fan, they are consistent with the high specific capacities for the ID-4 wells. The average transmissivity value for the tested wells was used for drawdown calculations provided later in this report.

The storage coefficient can't be readily determined from the available pump tests, mainly because the tests could not be run for long enough periods in the absence of interference with other wells. Results of short-term tests on wells tapping layered deposits often provide low values for the storage coefficient, which aren't representative of long-term conditions. The average specific yield of Layer 1 is estimated to be about 17 percent, based on the DWR groundwater modeling. Specific yields for Layers 2 and 3 weren't provided in the modeling reports, because it was assumed that groundwater in these layers is confined (ie. specific yields would not be applicable). The measured water-level declines in KCWA recovery wells during the 1991 recovery pumpage provide the best long-term storage coefficients in the area. The best specific yield value that can be used along with the previously developed values for transmissivity to explain the observed water-level declines due to the 1991 recovery pumpage

is 0.10. This is thus considered an appropriate value to use to estimate future water-level declines due to recovery pumpage for the proposed projects.

GROUNDWATER QUALITY

Inorganic Chemical Constituents

Inorganic chemical constituents that are known to be present at problem levels in part of the area are nitrate, arsenic, hydrogen sulfide, and manganese. Figure 8 shows concentrations of selected constituents in water from supply wells. Also, the approximate south boundary of a known area of high nitrate in the shallow groundwater is shown. Nitrate and several trace organic constituents were evaluated as part of the West Bakersfield Toxics Study (California State University Fresno, 1990). Most of the wells sampled for that study were private domestic wells, primarily tapping groundwater above a depth of about 300 feet. High nitrate concentrations (exceeding the MCL of 45 mg/l), were common in shallow groundwater in the area north of the Kern River and west of Highway 99, primarily between Hageman and Seventh Standard Roads (north of the study area). Locally, nitrate concentrations were lower (commonly less than the MCL) in some areas such as near the Calloway Canal, indicating its effectiveness as a recharge source.

Higher concentrations of arsenic have generally been found in water from deep monitor wells (below a depth of about 500 feet) in

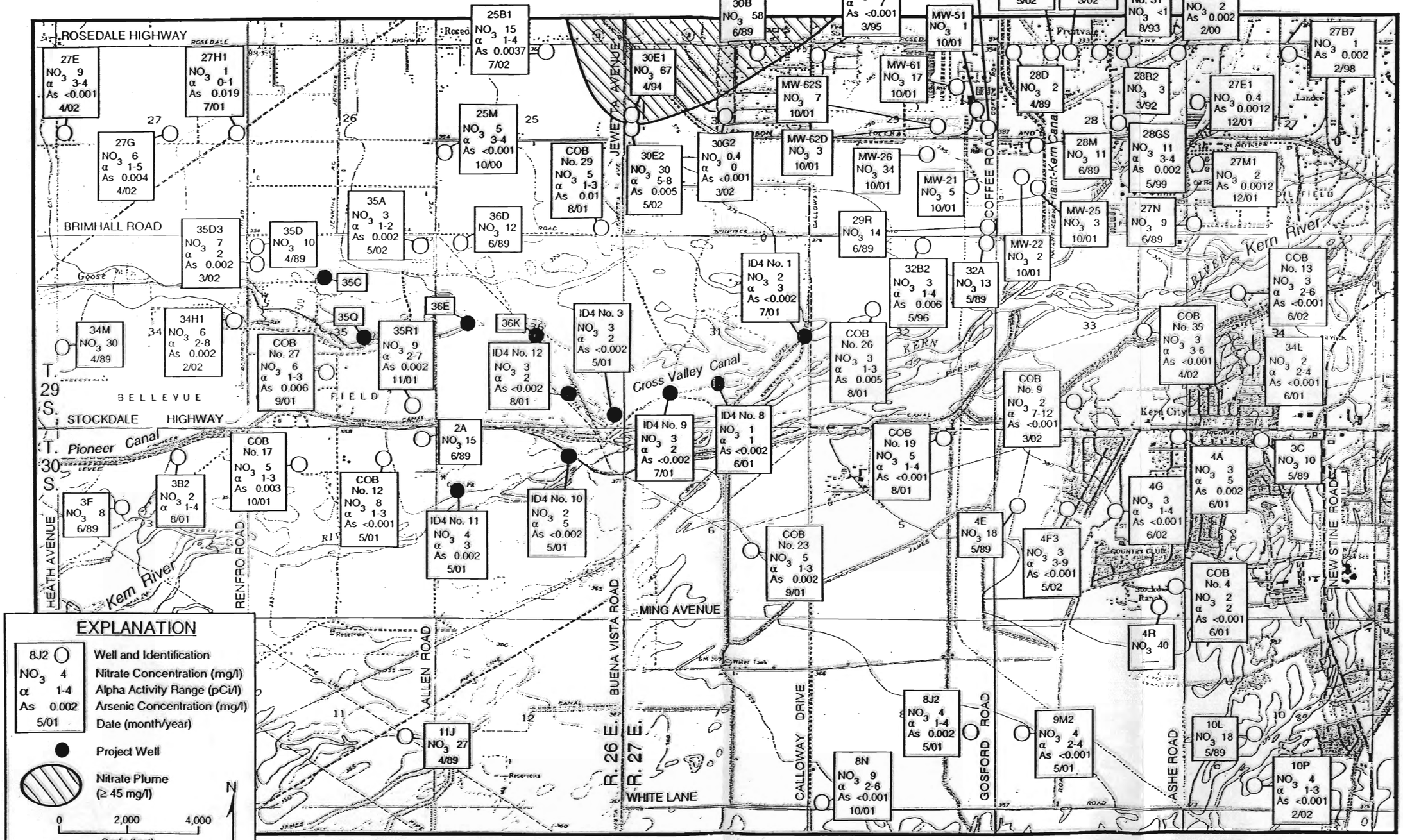


FIGURE 8 - CONCENTRATIONS OF SELECTED INORGANIC CHEMICAL CONSTITUENTS AND ALPHA ACTIVITY IN WELL WATER

the Kern Fan area, particularly in down-fan areas (ie. to the southwest). Arsenic concentrations in well water are indicated to be relatively low in the vicinity of the project wells (less than the new MCL of 0.01 mg/l). High manganese concentrations have also been found in deep reduced groundwater at some locations in and near the area.

Depth sampling programs conducted as part of developing new public supply wells in the Vaughn Water Company service area have provided substantial information on the vertical distribution of nitrate in groundwater in the area northwest of the project wells. Nitrate concentrations in groundwater below the deep extensive confining bed in the area (averaging about 550 feet deep) are normally non-detectable, indicative of reduced conditions in the groundwater. The deposits below this confining bed are primarily blue or green in color, whereas the over-lying deposits are primarily brown in color. The deeper groundwater (particularly below a depth of about 700 feet) in this area commonly has high hydrogen sulfide concentrations. Hydrogen sulfide is common in deeper blue or green colored deposits in the San Joaquin Valley, particularly near oil fields. Several new deep Vaughn Water Company wells have been equipped with treatment facilities to remove hydrogen sulfide from the pumped water. These wells generally tap groundwater in strata between about 650 and 1,100 feet in depth.

The Vaughn Water Company Verdugo Well is located between

Jewetta and Calloway Drives. The reverse rotary method was used to drill an 18-inch diameter pilot hole to a depth of 1,113 feet. Deposits above a depth of 435 feet were primarily brown. A distinctive blue-green clay was present from 500 to 542 feet in depth. Below a depth of 674 feet, all of the deposits were blue-green in color. Water samples were subsequently collected from four depths below 650 feet. Results of analyses indicated increasing hydrogen sulfide concentrations with increasing depth. Concentrations of nitrate, DBCP, and EDB and alpha activities were low in all of the samples. Arsenic concentrations ranged from 4 to 12 ppb between 650 and 775 feet in depth, and were lower in the deeper samples. Arsenic concentrations were less than 2 ppb in two samples below a depth of 960 feet. A new production well was completed and perforated from 750 to 1,100 feet in depth. The well was pump tested at about 2,500 gpm with a specific capacity of 29 gpm per foot.

Although out of the study area, a test well for Vaughn Water Company clearly indicated the vertical distribution of a number of constituents in the high nitrate, DBCP, and EDB area north of Rosedale Highway. Test well T-5419 was drilled east of Jewetta Avenue, one and three quarters mile north of Rosedale Highway. The hole was drilled to a depth of 1,030 feet. Below a depth of 501 feet, the deposits were green in color, whereas, above a depth of 440 feet they were primarily brown. Hydrogen sulfide was primarily

found in groundwater from the green deposits. Water samples were collected from eleven depths above a depth of about 700 feet. A clay layer from 440 to 454 feet in depth effectively separated groundwater of different quality. DBCP, EDB, nitrate concentrations and alpha activity exceeded MCLs in water from some depths in the brown deposits. Except for hydrogen sulfide, groundwater in the green deposits was of excellent chemical quality. Arsenic concentrations were less than 2 ppb in this water.

Radiological Constituents

High uranium and alpha activities have been found in shallow groundwater in some parts of the area north of the river, particularly in the Vaughn Water Company service area. Uranium activities are indicated to be low in the deeper groundwater, below the more generally extensive confining bed. Thus the trend in vertical distribution of uranium is thus similar to that for nitrate. Uranium or alpha activities have generally been low in water from wells in the study area (Figure 8).

DBCP & EDB

Figure 9 shows the most significant known problem areas for trace organic constituents in shallow groundwater. Two formerly used fumigants, dibromodichloropropane (DBCP) and ethylene dibromide (EDB) were found in sampling wells for the previously refer-

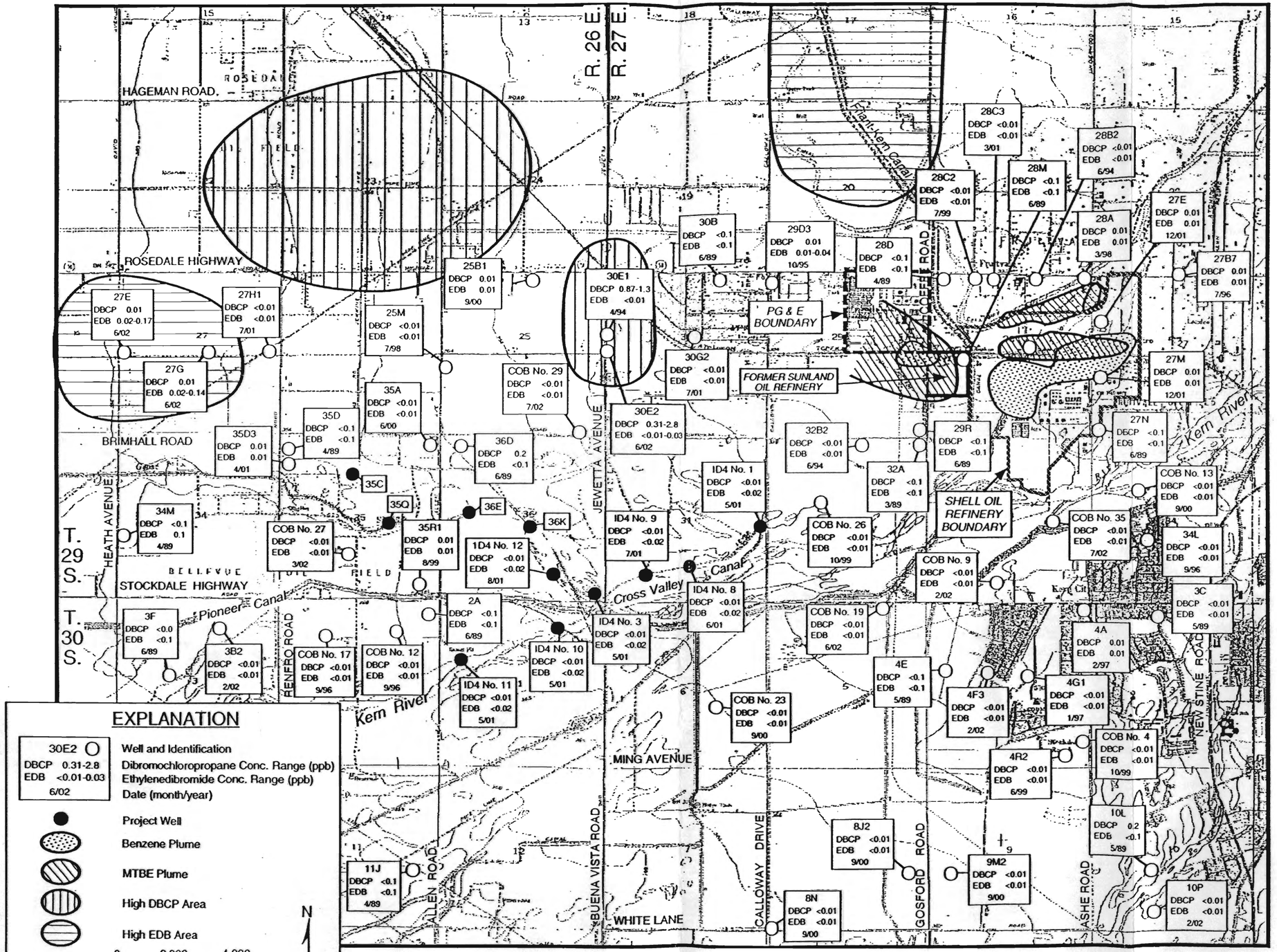


FIGURE 9 - CONCENTRATIONS OF SELECTED TRACE ORGANIC CONSTITUENTS IN WELL WATER

enced West Bakersfield Toxics Study. Use of both these was subsequently banned (DBCP in 1977 and EDB in 1985). An area of high DBCP concentrations (exceeding 1.0 ppb compared to the present MCL of 0.2 ppb) was found from sampling private wells in the area between Hageman Road and Rosedale Highway, and Rudd and Jewett Avenues. More recent sampling has indicated high DBCP concentrations in the area near Jewett Avenue, between Rosedale Highway and Brimhall Road.

High EDB concentrations were found in shallow groundwater in the area primarily between Calloway Drive and Coffee Road, and Snow Road and Rosedale Highway. EDB concentrations as high as 1.3 ppb were found, compared to the present MCL of 0.05 ppb. More recent sampling has indicated high EDB concentrations in the area between Rosedale Highway and Brimhall Road, near and east of Heath Avenue.

The extensive private well sampling program of the West Bakersfield Toxics Study that was conducted in 1989 has not been repeated. Because of the substantial recharge associated with Kern River Water Banking projects after 1992, concentrations of these constituents in groundwater may have significantly changed in some areas. Groundwater levels have risen substantially, and rising groundwater may have interrupted these constituents in percolating water. However, a counter-balancing factor is that recharge of good quality groundwater would act to dilute DBCP and EDB concentrations in the groundwater. Specially conducted depth sampling

deep, 110 to 140 feet deep, and below a depth of 140 feet. The highest benzene concentrations were in the shallowest monitored zone and in the deepest monitored zone. Two distinct benzene plumes were present in the shallow groundwater. Benzene concentrations were highest in the western part of the south plume, which was about 5,000 feet long and from 700 to 1,600 feet wide. This plume extended from the north-northeast to south-southwest, and is primarily located south of the AT&SF railroad tracks. Benzene concentrations ranged from about 860 to 5,800 ppb in the western part of this plume during the second quarter of 2002. Abrupt downgradient decreases in concentrations indicate that this plume is essentially stabilized, as is the normal situation for volatile aromatic plumes. A much smaller benzene plume, only about 600 feet long and 300 hundred feet wide, was present near the terminal. Benzene concentrations ranged from about 220 to 510 ppb in this smaller plume in the shallow groundwater. For the intermediate depth groundwater, benzene concentrations were elevated at only two wells in the south plume area, indicating much more localized contamination. No benzene contamination of intermediate depth groundwater was indicated near the terminal. For deep zone groundwater, no deep monitor wells were present near the terminal. In the south plume area, benzene concentrations ranged from about 100 to 7,600 ppb in the deep zone. Contamination of the deep zone groundwater in the south benzene plume was less extensive than for the shallow groundwater and also appears to be stabilized.

Former Sunland Refinery

The California Regional Water Quality Control Board (2002) provided documents on groundwater conditions at the PG&E Kern Power Plant and the former Sunland Refinery (Figure 9). The power plant is located west of Coffee Road between Rosedale Highway and the AT&SF railroad tracks. The former Sunland Refinery is located west of the Friant-Kern Canal and south of the AT&SF railroad tracks. Benzene concentrations ranging from 130 to 12,000 ppb were indicated in shallow groundwater in an area about 1,200 feet long and from about 200 to 800 feet wide in the second half of 2001. This benzene plume apparently had a west-to-northwest orientation, and was in a fairly localized area near Coffee Road and the AT&SF railroad tracks. Most monitor wells used to define this plume were less than 110 feet deep. Although some deeper composite (perforated over long intervals) monitor wells were present, there appeared to be few monitor wells exclusively tapping the deeper groundwater. Thus the vertical distribution of benzene contamination in this area has not been well defined.

MTBE

Shell Refinery

Two MTBE plumes have also been identified at the Shell Rosedale Highway refinery. Both of these plumes are primarily located

between the Calloway Canal and the AT&SF railroad tracks. For the groundwater above a depth of 110 feet, the northern MTBE plume was at least about 3,500 feet long and from 400 to 800 feet wide as of June 2002. The direction of migration of this plume was to the west-southwest, and recharge from the Calloway Canal appears to have limited migration to the northwest. MTBE concentrations ranging from 41,000 to 86,000 ppb were present in the east part of this plume during the second quarter of 2002. MTBE concentrations in the western part of this plume ranged from about 890 to 4,100 ppb.

Two Interim Remedial Measure (IRM) well fields have been developed for the north MTBE plume at the Shell Refinery. By June 2002, these well fields were used to pump from about 215 to 240 gpm of MTBE-contaminated groundwater from the north plume, primarily from the shallow and intermediate depth zones. Five extraction wells were located in the westerly well field and five in the easterly well field. The extracted water was treated then discharged to the Calloway Canal, under a NPDES permit.

The south MTBE plume in the shallow zone at the Shell Refinery is oriented almost due east-west, and is at least about 3,800 feet long and from 700 to 900 feet wide. MTBE concentrations ranged from about 100 to 800 ppb in this plume. Overall, there is a lack of monitor wells to determine the downgradient extent of both MTBE plumes at the Shell Refinery. No groundwater extraction program has been started for the southern MTBE plume at the Shell Refinery.

For the intermediate depth zone groundwater (110 to 140 feet in depth), much lower MTBE concentrations were present for the north plume. MTBE concentrations ranged from about 40 to 174 ppb. However, there were few intermediate depth monitor wells within the area where the shallow groundwater was contaminated with MTBE. For the south plume, MTBE concentrations ranged from about 50 to 590 ppb, and the contamination appeared to be in a much smaller area than for the shallow groundwater.

For the deep zone groundwater, there was no significant MTBE contamination in the north plume area (for the shallow groundwater). However, for the deep groundwater in the south plume area, MTBE concentrations ranged from 150 to 300 ppb in water from two deep wells. Except for these relatively isolated wells, MTBE concentrations appeared to be relatively low in the deep groundwater.

Former Sunland Refinery

The California Regional Water Quality Control Board (2002) also provided information on MTBE in groundwater in the area west of the Shell Refinery. MTBE concentrations ranging from about 510 to 23,000 ppb have been found in shallow groundwater west of the Friant-Kern Canal and near the AT&SF railroad tracks, at and downgradient of the former Sunland Refinery. This MTBE plume is at least one-half mile long and is about one-half mile wide. A west to northwest historical flow direction is indicated in this area.

The MTBE contamination is more laterally extensive than the benzene contaminated groundwater in this area. Most of the monitor wells used to define the extent of the MTBE contaminated groundwater from the former Sunland Refinery are apparently less than about 110 feet deep. However, one monitor well (GMX-MW-62D), which was perforated from 113 to 141 feet in depth, had a higher MTBE concentration (37 ppb) than for a nearby shallow well. This indicates the need to evaluate MTBE concentrations in the deep groundwater associated with this facility in more detail. Appendix A contains large scale maps of the benzene and MTBE plums discussed in this report.

PROJECTED DRAWDOWNS

Drawdowns were calculated for three operational scenarios, as provided by ID-4. Previous water-level rises associated with water-banking activities must also be considered, in order to determine the net changes in water levels at specific wells due to these projects. The drawdowns projected in this report can be considered a "worst case" situation. Scenario A was to pump the Kern Parkway wells for ten months at average rates of about 2,855 gpm. Such pumping is expected to occur once every three years. Full recovery would thus generally occur between each pumping episode. Scenario B was to pump both the Kern Parkway wells and the new RRBWSD wells for up to ten months, also once every three years. A total of 11 pumped wells were

assumed in this case, each pumping 2,855 gpm. Full recovery was also assumed between pumping episodes for this alternative. Scenario C was to pump both the Kern Parkway wells and the new RRBWSD wells continuously (twelve months a year), as part of the Conjunctive Use Pipeline project. A total of eleven pumped wells were also assumed, each pumping 2,855 gpm. There would be no recovery between pumping episodes in this case, as the wells would be pumped continuously.

A centroid of pumping was determined for the ID-4 Kern Parkway wells and another for the proposed RRBWSD wells. Drawdown calculations were then made for each scenario, using the Theis Non-Equilibria Formula. Calculations were made assuming 1) an intermediate starting water level (120 feet deep), and 2) a deep starting water level (about 200 feet deep). For the intermediate water level starting condition, a transmissivity of 409,000 gpd per foot and storage coefficient of 0.10 were used. For the deep water level starting condition, a transmissivity of 348,000 gpd per foot and a storage coefficient of 0.10 were used. Table 5 shows the projected drawdowns at the two centroids of pumping for each of the well scenarios, assuming a starting water level at a depth of 120 feet. These drawdowns were 25 feet for Scenario A, and from 30 to 35 feet for Scenario B. For Scenario C, drawdowns would range from above 30 to 35 feet after one year of pumping, from about 35 to 40 feet after two years of pumping, and from about 45 to 50 feet after five years

programs primarily in the Vaughn Water Co. service area have indicated that DBCP and EDB aren't present below the extensive deep confining bed (ie. below a depth of about 550 feet). Concentrations of DBCP and EDB are also are expected to decrease with time due to degradation processes, particularly for EDB. These are particularly important in irrigated areas.

Volatile Halocarbons

Only low levels of volatile halocarbons are known to be present in the area based on information in the KCWA groundwater quality data base, and a review of the results of groundwater monitoring at the refineries northeast of the project wells. However, there are extensive areas where no information on volatile halocarbons in shallow groundwater is available, particularly in much of the area west of the Friant-Kern Canal.

Volatile Aromatics

Shell Refinery

GeoSyntec Consultants, Inc. (2002) provided the second quarter 2002 groundwater monitoring report for the Shell Oil Rosedale Highway facility (Figure 9). Dozens of monitor wells have been installed at and downgradient of the facility. As of Summer 2002, there were six deep monitor wells that tapped strata between about 190 and 240 feet in depth. Figures 10, 11, and 12 of that report show benzene contours for three depth intervals: less than 110 feet

TABLE 5 - PROJECTED DRAWDOWN FOR STARTING WATER LEVEL AT INTERMEDIATE DEPTH

Scenario No.	Pumping Duration	ID-4 Wells Centroid	RRB WSD Wells Centroid
A	10 months	25	-
B	1 year	35	29
C	1 year	35	29
	2 years	41	35
	5 years	49	43

These drawdowns are based on a starting water level of 120 feet. A transmissivity of 409,000 gpd per foot and storage coefficient of 0.10 were used.

of pumping. These relatively small drawdowns considering the amount of pumpage are due to the relatively large transmissivities in the area.

Table 6 shows projected drawdowns for a starting water level of 230 feet (the deep condition). Then drawdowns were about 30 feet for Scenario A, and from about 35 to 40 feet for Scenario B. For Scenario C, drawdowns would range from about 35 to 40 feet after one year of pumping, from about 40 to 45 feet after two years of pumping, and from about 50 to 55 feet after five years of pumping.

Impacts on Water Supply Wells

Table 7 lists known water supply wells, including City of Bakersfield and water bank project recovery wells, within about two miles of the project pumping centroids. Drawdown impacts depend highly on where the project wells are perforated. Most of the ID-4 River Parkway wells have the tops of the perforations from about 190 to 220 feet in depth, and the bottoms of the perforations from about 640 to 720 feet deep. Most of the City of Bakersfield wells in the vicinity have the tops of the perforations from about 400 to 480 feet deep and the bottoms of the perforations from about 700 to 710 feet deep. Most Berrenda Mesa project wells have the top of the perforations ranging from about 170 to 225 feet and the bottoms of the perforations from about 600 to 730 feet in depth. Most pri-

TABLE 6 - PROJECTED DRAWDOWN FOR STARTING WATER LEVEL AT DEEP DEPTH

Scenario No.	Pumping Duration	ID-4 Wells Centroid	RRB WSD Wells Centroid
A	10 months	29	-
B	1 year	40	33
C	1 year	40	33
	2 years	46	40
	5 years	56	49

The drawdowns are based on a starting water level of 230 feet. A transmissivity of 348,000 gpd per foot and storage coefficient of 0.10 were used.

TABLE 7 - DISTANCES OF SUPPLY WELLS FROM PUMPING CENTROIDS

Location	Well No.	Perforated Interval (feet)	Distance From Centroid (feet) ID-4	RRBWSD
T29S/R26E-25M	VWC Old Town	-	8,300	4,300
25R1	D	150-200	5,500	6,200
25R2	COB #29	430-710	5,000	5,400
26R	D	-	8,200	3,600
26R	COB #42	600-700	8,200	3,300
35A1	RRBWSD (D)	-	6,800	1,500
35A5	MWC	-	7,800	2,200
35D1	D	-	11,000	4,900
35D2	MWC	-	10,700	4,600
35F1	D	-	9,100	3,100
35F2	D	-	9,400	3,500
35F3	D	-	9,500	3,400
35L2	D	-	9,200	3,300
35M	D	-	10,600	4,800
35P2	COB #27	400-700	8,200	2,800
35R1	MWC	300-600	5,900	1,300
T29S/R27E-30K1	D	150-250	7,300	10,100
31A	COB #37	400-710	5,800	10,100
31A	D	-	6,700	10,800
31D	COB #41	460-720	3,800	5,800
32F	COB #26	480-700	7,500	12,600
T30S/R26E-2B1	COB #12	368-620	6,900	3,700
2L	BK-2	-	8,900	5,900
2C	COB #17	352-632	9,500	5,300
2J	BK-3	224-724	6,900	5,400
2J	BM-1	289-597	7,100	6,600
2R	BK-6	189-728	8,000	6,800
2P	BM-3	160-695	9,900	8,300
2L	BM-2	180-680	8,900	5,900
T30S/R27E-5D	CSUB	-	5,200	11,000
5F	CSUB	289-500	6,900	13,000
6K	COB #23	450-710	4,900	10,600

The perforated intervals refer to the top and bottom of the perforations. A number of wells aren't continuously perforated between the depths shown.

vate domestic wells in the area are indicated to be less than 300 feet deep. In general, the largest drawdowns at any distance due to pumping of project wells would be in other wells tapping the same strata as the project wells. The water-level hydrographs for cluster site T29S/R26E-35, near the RRBWSD well centroid, are particularly useful. These indicate that the water-level decline in the shallow well during the 2001 pumping episode was about 30 feet, compared to an average of about 45 feet in the other two deeper wells. This indicates that drawdowns in shallow private domestic wells would be about two-thirds of those calculated for wells tapping the same strata as the ID-4 wells. As discussed previously, water-level rises due to recharge for water banking projects must also be considered in order to determine the net water-level changes in specific wells. The projected drawdowns in this report thus represent the worst-case situation.

Although the intervals to be perforated for the new RRBWSD wells have not been determined, the use of deeper perforated wells than for the Berrenda Mesa wells and the ID-4 Kern River Parkway wells should be considered. Drilling of deeper recovery wells and sealing off of shallow groundwater would result in:

1. Less drawdowns in shallow wells in the area, particularly private domestic wells.

2. Much less potential to cause changes in migration of contaminated groundwater in the area.

Calculations of drawdowns due to pumping for the proposed projects were also made for different distances from the pumping centroids for the three scenarios. These were done to evaluate drawdowns in COB and Berrenda Mesa project wells in the vicinity.

Table 8 shows the estimated drawdowns due to project well pumping for specific wells. These drawdowns were estimated for starting pumping when water levels are at the intermediate and deep depths. For the intermediate water level starting point for Scenario A, drawdown would range from about 10 to 15 feet in the nearest COB wells, and range from about 5 to 15 feet in the nearest BM wells. For Scenario B, drawdowns would range from about 20 to 25 feet in the nearest COB wells, and from about 15 to 25 feet in the nearest BM wells. For Scenario C, after one year of pumping, drawdowns in the nearest COB wells would range from about 20 to 25 feet, and drawdowns in the nearest BM wells would range from about 15 to 25 feet. After two years of pumping for Scenario C, drawdowns in the nearest COB wells would range from about 25 to 30 feet, and from about 20 to 30 feet in the nearest BM wells. After five years of pumping for Scenario C, drawdowns would range from about 30 to 40 feet in the nearest COB wells, and from about 30 to 35 feet in the nearest BM wells.

TABLE 8 - PROJECTED DRAWDOWNS AT SELECTED WELLS

Drawdown (feet) If Start With Intermediate Depth Water Level

		COB Wells								BM Wells		
Scenario	Time Yrs.	#12	#17	#23	#26	#27	#29	#39	#41	#42	BK-2	BK-3	BK-5
A	0.8	13	8	14	12	10	14	15	16	9	10	13	7
B	1	24	19	20	18	24	25	22	27	23	19	23	15
C	1	24	19	20	18	24	25	22	27	23	19	23	15
	2	30	24	26	23	29	30	27	32	28	25	28	20
	5	37	32	33	31	37	37	34	40	35	32	36	28

Drawdown (feet) If Start With Deep Water Level

		COB Wells								BM Wells		
Scenario	Time Yrs.	#12	#17	#23	#26	#27	#29	#39	#41	#42	BK-2	BK-3	BK-5
A	0.8	14	9	16	14	11	15	16	18	10	10	15	8
B	1	27	21	23	19	27	27	24	30	25	21	26	16
C	1	27	21	23	19	27	27	24	30	25	21	26	16
	2	34	27	29	26	33	34	30	36	31	28	32	22
	5	43	36	38	35	42	43	39	45	40	36	41	32

Intermediate Water-Level Aquifer Characteristics

T = 409,000 gpd per foot
S = 0.10

Deep Water-Level Aquifer Characteristics

T = 348,000 gpd per foot
S = 0.10

For the deep water level starting condition, drawdowns for Scenario A would range from about 10 to 20 feet in the nearest COB wells and from about 10 to 15 feet in the nearest BM wells. For Scenario B, drawdowns would range from about 15 to 30 feet in the nearest COB wells and from about 15 to 25 feet in the nearest BM wells. After one year of pumping for Scenario C, drawdowns would range from about 20 to 30 feet in the nearest COB wells and from about 15 to 25 feet in the nearest BM wells. After two years of pumping for Scenario C, drawdowns would range from about 25 to 35 feet in the nearest COB wells and from about 20 to 30 feet in the nearest BM wells. After five years of pumping for Scenario C, drawdowns would range from about 35 to 45 feet in the nearest COB wells and from about 30 to 40 feet in the nearest BM wells.

Drawdowns were also estimated for the closest two private domestic wells to the Rosedale-Rio Bravo WSD pumping centroid (Wells 35A1 and 35F1, which are located between 1,500 and 3,200 feet from this centroid). For the intermediate water level starting condition, drawdowns for Scenario A would range from about five to ten feet in these wells. For Scenario B, drawdowns would range from about 10 to 20 feet in these wells. After one year of pumping for Scenario C, drawdowns would range from about 10 to 20 feet in these wells. After two years of pumping for Scenario C, drawdowns would range from about 10 to 20 feet in these wells. After five years of pumping for Scenario C, drawdowns would range

from about 15 to 30 feet.

For the deep water level starting condition, drawdowns for Scenario A would range from about five to ten feet in these wells. For Scenario B drawdowns would range from about 10 to 20 feet. After one year of pumping for Scenario C, drawdowns would range from about 10 to 20 feet in these wells. After two years of pumping for Scenario C, drawdowns would range from about 15 to 25 feet in these wells. After five years of pumping for Scenario C, drawdowns would range from about 20 to 30 feet in these wells. The drawdowns in these wells are potentially significant, and careful monitoring of the proposed project is necessary. Provisions should be made to mitigate impacts on these and other private domestic wells to the extent feasible.

Influence of Recharge

Prior to pumping as proposed, intentional recharge would have been practiced for many years. There has been recharge in the Kern River channel, percolation basins operated by the RBBWSD, percolation basins operated as part of the Berrenda Mesa and Pioneer projects, and along the unlined parts of the Cross Valley and Calloway Canals. As part of the River Parkway project, it is anticipated that there normally would be annual recharge in the Kern River wells channel above the Bellevue weir. As much water would be recharged as would be pumped from the River Parkway wells. An estimated 35,000 to 40,000 acre-feet per year would be recharged. This recharge is expected to minimize

the net impacts on water levels in supply wells in the area, and on groundwater quality.

ANTICIPATED CHANGES IN GROUNDWATER QUALITY

Drawdowns due to pumping for the proposed projects were also estimated in the known groundwater quality problem areas. Following is a discussion of the specific problem areas.

High Nitrate Area

Figure 8 indicates that the Rosedale-Rio Bravo WSD well field centroid is about one and a half miles southwest of the high-nitrate area near Jewetta Avenue and the AT&SF railroad tracks. Pumping for the proposed projects in combination with other wells could cause some southerly flow of this high-nitrate groundwater. Considering the perforated intervals of supply wells, this would be of most concern for private domestic wells located north of the project wells and south of the Rosedale Highway. For the inter- mediate water-level condition, drawdown calculations indicate about five feet of drawdown near the south edge of the high nitrate area for Scenario A, and at about ten feet for Scenario B (assuming an intermediate starting water level). For Scenario C, drawdowns would range from about ten feet after one year of pumping to about 20 feet after five years. For the deep water-level condition, estimated drawdowns are about five feet

for Scenario A and fifteen feet for Scenario B. For Scenario C, drawdowns would range from about 15 feet after one year of pumping to about 25 feet after five years. A monitoring program for nitrate in shallow groundwater in this area, between Allen Road and Calloway Drive, could be implemented to help address this concern.

DBCP and EDB

Detailed maps showing the recent distribution of DBCP and EDB in shallow groundwater north of the project wells are not available. However, Figure 9 shows the high DBCP and EDB areas as of 1989, which is the most recent information available. The RRBWSD well centroid would be located about one and a half miles south of the high DBCP shallow groundwater area that is located primarily north of Rosedale Highway, between Heath and Jewetta Avenues. The ID-4 well centroid is about two miles southeast of this high DBCP area. Pumping of project wells and other wells could cause a southerly migration of the high DBCP shallow groundwater. Of most concern would be shallow private domestic wells in the area between Rosedale Highway and Brimhall Road. The projected drawdown at the south edge of this high DBCP area is about five feet for Scenario A and ten feet for Scenario B (starting at the intermediate water level). For Scenario C, the drawdown would be about ten feet after one year and about 20 feet

after five years. For the deep water-level condition, the estimated drawdown would be about five feet for Scenario A and ten feet for Scenario B. For Scenario C, the drawdown would be ten feet after one year and 20 feet after five years. Drawdowns exceeding about fifteen feet are indicated to be potentially significant. A monitoring program for DBCP in shallow groundwater in this area, between Renfro Road and Jewetta Avenue could be implemented to help address this concern.

Figure 9 shows a high EDB area for the shallow groundwater north of the Rosedale Highway, between Calloway Drive and Coffee Road. The RRBWSD well centroid would be located about three miles southwest of this high EDB area. The ID-4 well centroid is located about two and one-half miles south-southwest of this high EDB area. The proposed pumping of project wells would not cause an appreciable change in the EDB contamination, except possibly for Scenario C after five years of pumping. EDB has a relatively short half life, and concentrations have decreased markedly in most shallow groundwater since 1989. EDB concentrations are not expected to be far above the MCL even in the former high EDB shallow groundwater area. A drawdown of 20 feet is projected near the south edge of this plume for Scenario C after five years of pumping starting at the intermediate water level. For the deep water-level condition, the drawdown would be about 25 feet. For the other scenarios evaluated, drawdowns

would be less than 15 feet.

Volatile Aromatics

The benzene plumes shown in Figure 9 are indicated to be relatively stable, based on detailed monitoring data. The RRBWSD well centroid is located about three miles west-southwest of the hot spot in the benzene plume from the former Sunland Refinery, and slightly farther from the northern benzene plume at the Shell Refinery. Because of the large distances and natural attenuation processes for volatile aromatics, pumping of project wells is not projected to significantly affect the benzene plumes at the former Sunland and Shell Refineries.

MTBE

The RRBWSD well centroid would be located about three miles west-southwest of the hot spot for MTBE-contaminated shallow groundwater from the former Sunland Refinery (near Coffee Road and the AT&SF railroad tracks). The ID-4 well centroid is about two and a half miles southwest of this hot spot. The nearest ID-4 well (No. 1) to this MTBE contamination is about one and a half miles to the southwest. Because of the high concentrations of MTBE in this plume, the relative high mobility of MTBE in groundwater, and that no groundwater extraction program is in place for this plume, there could be some altered migration of

the MTBE plume due to project pumping.

The projected drawdowns near the hot spot would be less than five feet for Scenario A and about ten feet for Scenario B (starting at the intermediate water level). For Scenario C, draw- downs would range from about five feet after one year to about 15 feet after five years. For the deep water-level condition, drawdowns would also range from less than five to about five feet for Scenarios A and B, respectively. For Scenario C, drawdowns would range from about five feet after one year of pumping to about fifteen feet after five years. Drawdowns exceeding ten feet are considered potentially significant in this case. Because of these potential drawdowns, a groundwater monitoring program should be undertaken for MTBE in shallow groundwater west of Coffee Road and south of the AT&SF railroad tracks.

MITIGATING MEASURES

An aquifer test was conducted in late 2002 using a number of the ID-4 River Parkway wells to help determine the influence of pumping them on shallow and deep groundwater. This test duration was about three weeks. Observation wells included cluster monitor well T29S/R26E-35H, a number of other water supply wells, and ID-4 Well No. 12. Information from this test is presently being interpreted. The results will provide useful information

on which to determine the perforated intervals for the new RRBWSD wells, and on the proposed operation of the two well fields.

As discussed previously, it may be desirable to perforate the new RRBWSD wells deeper (ie. from about 650 to 1,000 feet in depth) in order to minimize the pumping influence on known contaminant plumes, and also to minimize drawdowns in existing water supply wells. Most City of Bakersfield wells in the area are not perforated above a depth of about 400 feet, and this is advisable for the new RRBWSD wells. For the first RRBWSD well, it is recommended that a test well or pilot hole be used to obtain water samples from selected depths (above a depth of about 1,000 feet). Concentrations of arsenic, manganese, hydrogen sulfide, and other constituents would be carefully evaluated in the deep groundwater. Concentrations of nitrate, alpha activity, DBCP, EDB, MTBE, and volatile halocarbons would be evaluated in the shallow groundwater. This information would be used to determine the approximate perforated intervals for the new wells. A one-week duration pump test should also be done, once all of the RRBWSD wells are completed. This test would focus on drawdowns in wells tapping various depth intervals to the north of this well field.

Recharging more water in and near the Kern River channel between Coffee and Allen Roads to at least counter-balance the pumping for the proposed projects is proposed. For the con-

junctive use pipeline scenario, this would involve recharging an average of about 50,000 acre-feet per year in this area.

It is further recommended that a comprehensive groundwater monitoring program be undertaken for this project, in consultation with the Regional Water Quality Control Board, representatives of the Shell and former Sunland Refineries, the City of Bakersfield, the Berrenda Mesa project, and the Vaughn Water Company.

REFERENCES

California Regional WQCB, 2002, "Groundwater Conditions Document (PG&E Kern Power Plant and Sunland Refinery)".

California State University Fresno, 1990, "West Bakersfield Area Ground Water Quality Management Study", prepared for State Water Resources Control Board.

ENV America, 2002, "Groundwater Monitoring Report", prepared for Pacific Gas and Electric Company, Kern Power Plant, 9 p.

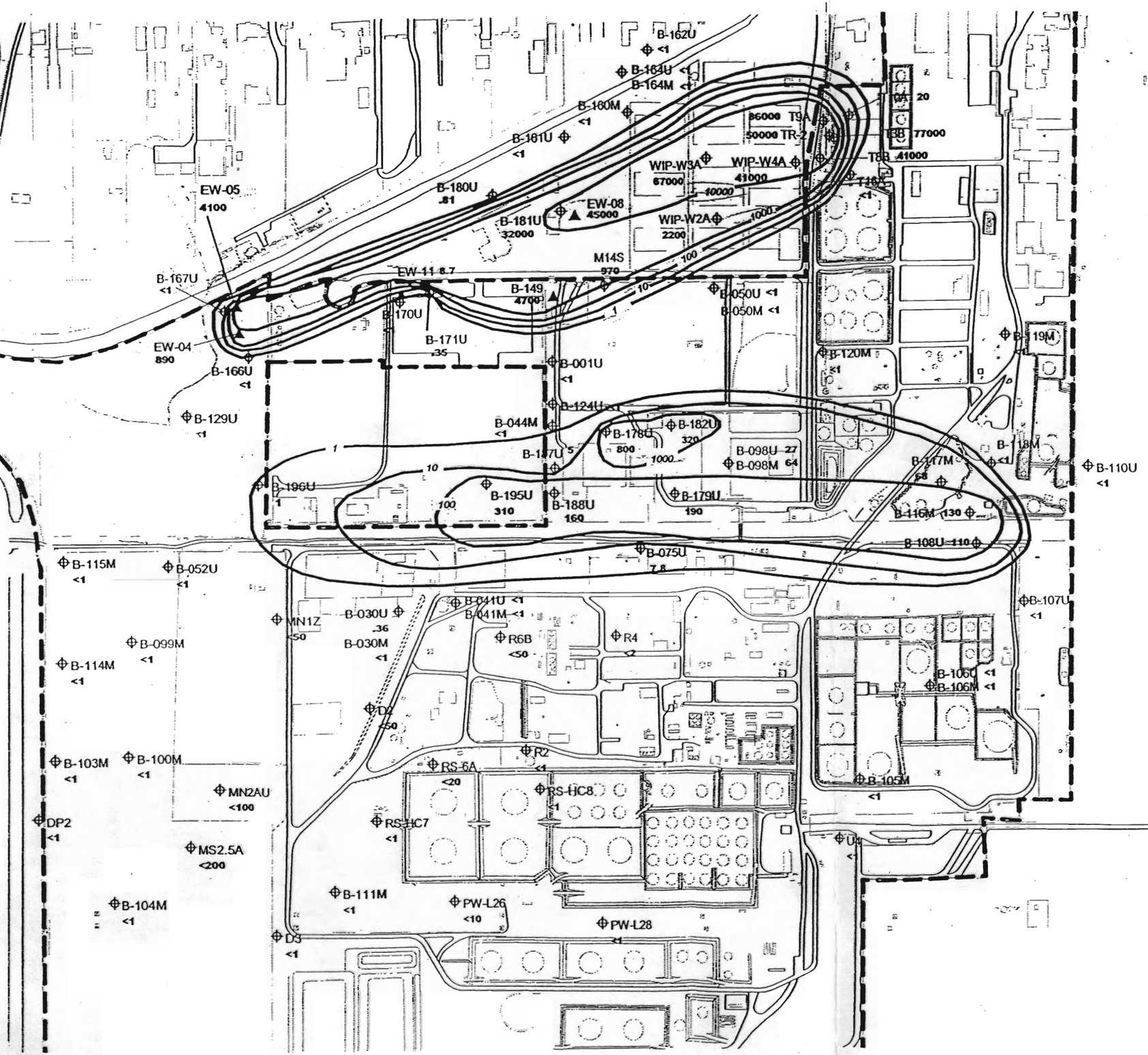
Environmental Resources Management, 2002, "Off-Site Soil and Groundwater Investigation Report", prepared for Bakersfield Refining Company, 20 p.

GeoSyntec Consultants, Inc., 2002, "2nd Quarter 2002 Groundwater Monitoring Report", prepared for Shell Oil Products, U.S., 4 p.

Kenneth D. Schmidt and Associates, 1998, "Maximum Recovery Plan for the Pioneer Kern Fan Project", prepared for Kern County Water Agency, 28 p.

APPENDIX A

LARGE-SCALE MAPS OF BENZENE AND MTBE PLUMES



Source of Information:
GeoSyntec Consultants, Inc., 2002

Legend

B-110U
<1
well name
mtbe concentration (ug/l)
monitoring well location

▲ EW-04 extraction well location

Property Line

Isoconcentration Contours

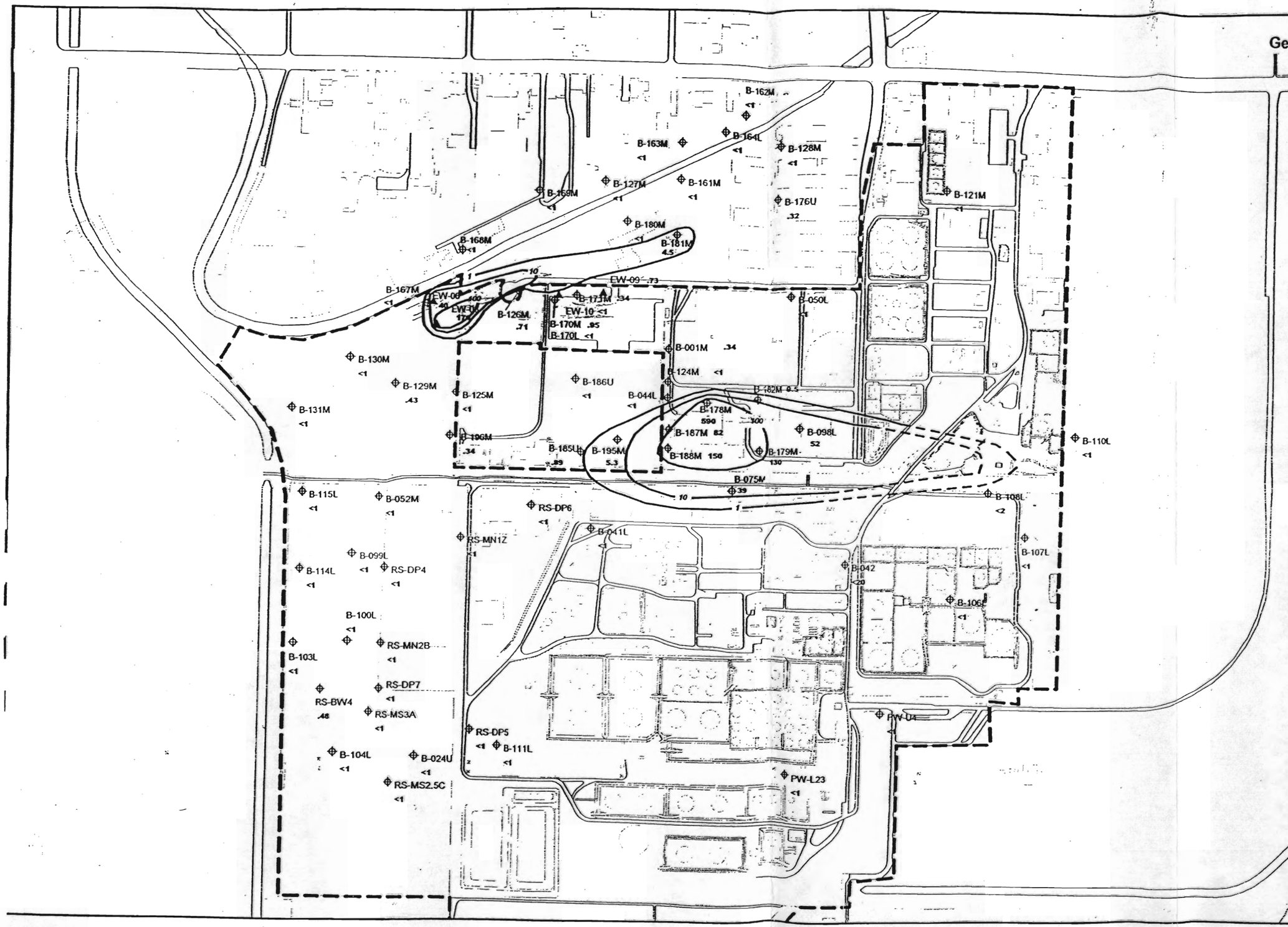
N

0 600 Feet

Shell Bakersfield Refinery
Shell Bakersfield Terminal
Shell Oil Products US

FIGURE 6:
MTBE Plume Contours for Groundwater <110' bgs
April-June, 2002

Source of Information:
GeoSyntec Consultants, Inc., 2002



Legend

B-110L
<1
well name
mtbe concentration (ug/l)
monitoring well location

▲ EW-10 extraction well location

Property Line

Isoconcentration Contours

N

0 600 Feet

Shell Bakersfield Refinery
Shell Bakersfield Terminal
Shell Oil Products US

FIGURE 7:
MTBE Plume Contours for
Groundwater 110'-140' bgs
April - June, 2002

GeoSyntec Consultants

Source of Information:
GeoSyntec Consultants, Inc., 2002

B-128L <1
B-176M .46
B-176L .43
B-127L <1
B-169L <1
B-180L <1
B-181L .47
B-166L <1
B-125L <1
B-171L .51
B-003 <1
EW-07
B-167L <1 .37
B-001L <1
B-119L
B-120L <1
B-130L .44
B-186M .39
B-186L .42
B-183
B-124L .83
B-129L1 <1
B-129L2 .44
B-125L <1
B-173U 3.7
B-173M 2.1
B-173L .49
B-131L2 <1
B-117L <1
B-118L <1
B-187L 1.3
B-196L .3
B-195L 150
B-185M 20
B-185L 1
B-188L 19
B-172U 2.7
B-172M 9.7
B-172L <1
B-177U <20
B-177M <10
B-177L .52
B-116L 300
B-008 <1
B-052L <1
B-175U <50
B-175M <10
B-175L 1
B-030L <1
B-011 1
B-023 <1
B-043 <50
B-014 <1
B-013 5
B-007 <1
B-017 <1
B-024L <1
B-009 <1
B-010 <1

Legend

B-119L
<1
well name
mtbe concentration (ug/l)
monitoring well location

▲ EW-07 extraction well location

Property Line

Isoconcentration Contours

N

0 600 Feet

Shell Bakersfield Refinery
Shell Bakersfield Terminal
Shell Oil Products US

FIGURE 8 :
MTBE Plume Contours for
Groundwater >140' bgs
April - June, 2002

GeoSyntec Consultants

Source of Information:
GeoSyntec Consultants, Inc., 2002

B-162U <0.5
B-164U <0.5
B-164M <0.5
B-160M <0.5
B-161U <0.5
WIP-W3A <250
B-181U <250
B-180U <0.5
EW-08 <130
WIP-W2A <0.5
T9A 510
TR-2 <500
T10A <0.5
18B 220
18B 56
T16A <0.5
WIP-W4A 300
EW-11 <0.5
EW-05 <10
B-167U <0.5
EW-04 <0.5
B-171U
B-170U <0.5
M14S <2.5
B-149 5
B-050U <0.5
B-050M <0.5
B-166U <0.5
B-001U <0.5
B-124U <0.5
B-129U <0.5
B-044M <0.5
B-178U <2.5
B-182U <0.5
B-098U <0.5
B-098M <0.5
B-187U <0.5
B-188U <0.5
B-196U <0.5
B-195U <1
B-179U
B-120M <0.5
B-119M <0.5
B-118M 940
B-110U 7
B-117M 62
1000
B-108U 3000
B-107U <0.5
B-116M 130
B-106M <0.5
B-105M <0.5
U4 <0.5
B-115M <0.5
B-052U <0.5
B-030U <0.5
B-030M 1
B-041U <0.5
B-041M <0.5
B-075U .44
MN1Z 860
B-099M <0.5
B-114M <0.5
R6B 1300
1000
R4 120
D2 5800
B-103M <0.5
B-100M <0.5
RS-6A 1200
R2 <0.5
MN2AU 1600
RS-HC8 <0.5
DP2 <0.5
RS-HC7 <0.5
MS2.5A <100
B-104M <0.5
B-111M 1.8
PW-L26 70
PW-L28 <0.5
D3 <0.5

Legend

B-119M <0.5 — well name; benzene concentration (ug
monitoring well location

▲ EW-05 extraction well location

Property Line

Isoconcentration Contours

N

0 600 Feet

Shell Bakersfield Refinery
Shell Bakersfield Terminal
Shell Oil Products US
FIGURE 10
Benzene Plume Contours for Groundwater <110' bgs
April-June, 2002

Source of Information:
GeoSyntec Consultants, Inc., 2002

B-162M <0.5
B-164L <0.5
B-163M <0.5
B-128M <0.5
B-169M <0.5
B-127M <0.5
B-161M <0.5
B-121M <0.5
B-176U <0.5
B-180M <0.5
B-181M <0.5
B-166M <0.5
B-126M <0.5
EW-10 <0.5
EW-09
EW-06 <0.5
B-167M <0.5
EW-03 <0.5
B-170M <0.5
B-170L <0.5
B-171M <0.5
B-050L <0.5
B-001M <0.5
B-130M <0.5
B-129M .54
B-186U <0.5
B-124M <0.5
B-125M <0.5
B-131M <0.5
B-044L <0.5
B-178M <2.5
B-182M <0.5
B-187M <0.5
B-098L <0.5
B-110L <0.5
B-196M <0.5
B-195M <0.5
B-185U <0.5
B-188M <0.5
B-179M <0.5
B-115L <0.5
B-052M 1.8
RS-DP6 <0.5
B-075M 1.5
B-108L 79
B-141L <0.5
RS-MN1Z .67
B-107L <0.5
B-099L <0.5
B-114L <0.5
RS-DP4 <0.5
B-042 360
B-106U <0.5
B-103L <0.5
B-100L <0.5
RS-MN2B <0.5
RS-BW4 <0.5
RS-DP7 <0.5
RS-MS3A <0.5
PW-04 <0.5
RS-DP5 <0.5
B-111L .45
B-104L <0.5
B-024U <0.5
PW-L23 <0.5
RS-MS2.5C <0.5
100
10
1

Legend

B-110L <0.5 — well name; benzene concentration (ug/l); monitoring well location

▲ EW-03 extraction well location

Property Line

Isoconcentration Contours

N

0 600 Feet

Shell Bakersfield Refinery
Shell Bakersfield Terminal
Shell Oil Products US

FIGURE 11:
Benzene Plume Contours for
Groundwater 110'-140' bgs
April - June, 2002

GeoSyntec Consultants

Source of Information:
GeoSyntec Consultants, Inc., 2002

B-128L <0.5
B-127L <0.5
B-169L <0.5
B-176M <0.5
B-180L <0.5
B-181L <0.5
B-166L <0.5
EW-07
B-167L <0.5
B-126L <0.5
B-171L <0.5
B-003 <0.5
B-119L <0.5
B-120L <0.5
B-001L <0.5
B-130L 1.1
B-186M <0.5
B-186L <0.5
B-124L <0.5
B-129L1 <0.5
B-129L2 <0.5
B-125L <0.5
B-131L1 <0.5
B-131L2 <0.5
B-183 <0.5
B-173U <0.5
B-173M <0.5
B-173L <0.5
B-118L 7600
B-196L <0.5
B-187L <0.5
B-185L <0.5
B-185M <0.5
B-195L <0.5
B-188L <0.5
B-172U <0.5
B-172M <0.5
B-172L <0.5
B-177U 290
B-177M 310
B-177L <0.5
B-117L 480
B-116L 620
B-052L <0.5
B-008 <0.5
B-175U 2100
B-175M 390
B-175L 640
B-030L <0.5
B-023 <0.5
B-011 1.6
B-043 970
B-014 <0.5
B-013 99
B-007 <0.5
B-017 <0.5
B-024L <0.5
B-009 <0.5
B-010 <0.5

1
10
100
1000

Legend

B-119L <0.5 — well name; benzene concentration (ug/l); monitoring well location

B-130L 1.1 — data point not honored in contouring

▲ EW-07 — extraction well location

Property Line

Isoconcentration Contours

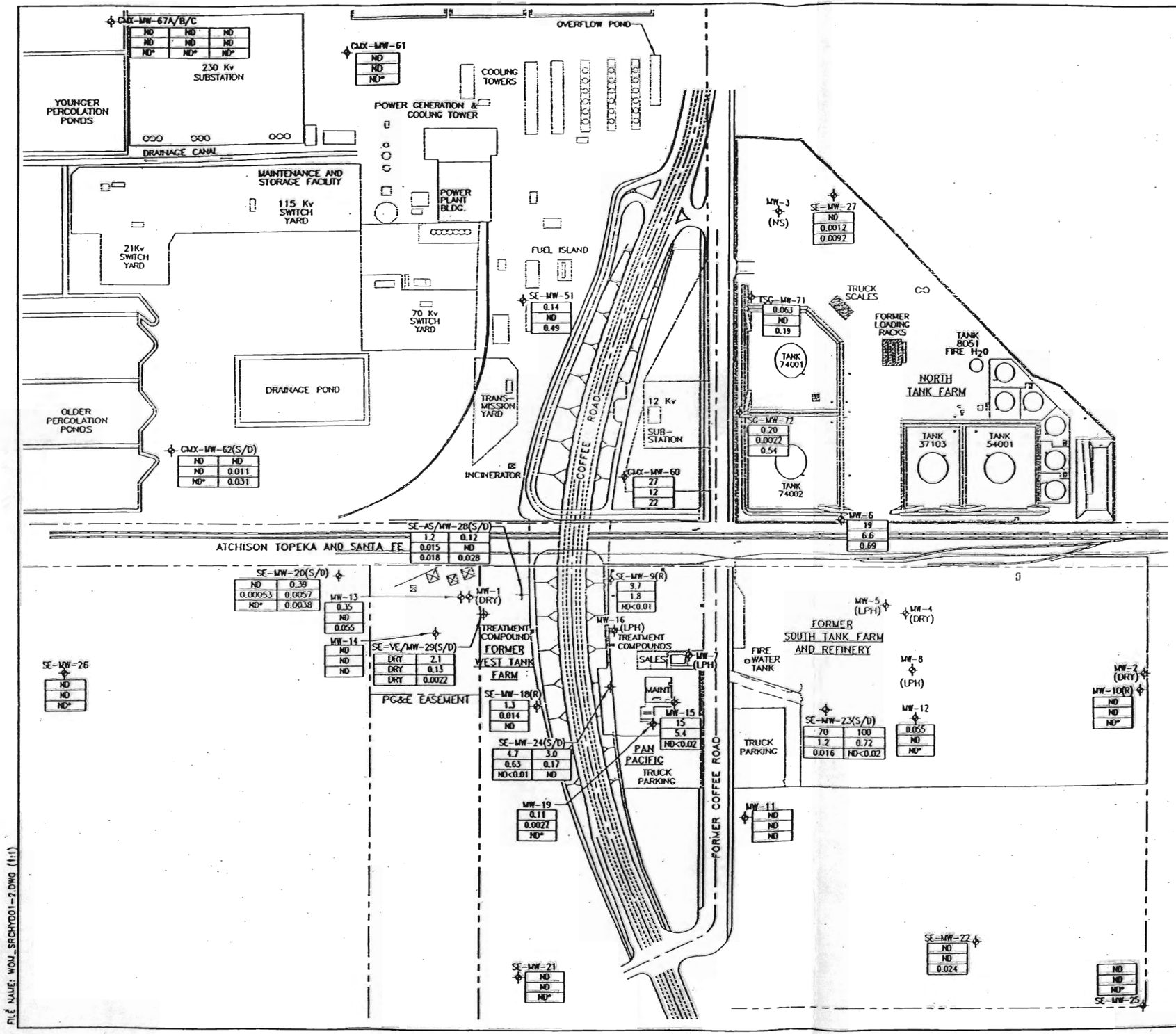
N

0 600 Feet

Shell Bakersfield Refinery
Shell Bakersfield Terminal
Shell Oil Products US

FIGURE 12:
Benzene Plume Contours for Groundwater >140' bgs
April - June, 2002

GeoSyntec Consultants



FILE NAME: WOM_SRCHYD01-2.DWG (1:1)

GENERAL SITE LEGEND

- LEASE LINE, PROPERTY BOUNDARY
- CENTER LINE OF COFFEE ROAD
- 6 FT. CHAIN LINK FENCE LINE
- POWER POLE WIRE LINE
- EARTH CONTAINMENT DIKE
- TSC-MW-72 — GROUNDWATER MONITORING WELL LOCATIONS
- SE-VE/MW-29 — GROUNDWATER MONITORING/SOIL VAPOR EXTRACTION WELL LOCATION
- SE-AS/MW-28 — GROUNDWATER MONITORING/AIR SPARGE POINT WELL LOCATION
- 2'x2' SVE VALVE BOX LOCATIONS

GROUNDWATER MONITORING LEGEND

- TPHG — TOTAL PETROLEUM HYDROCARBONS AS GASOLINE CONCENTRATION (mg/L) (8015M)
- BENZ — BENZENE CONCENTRATION (mg/L) (8260B)
- MTBE — MTBE CONCENTRATION (mg/L) (8260B)
- ND — NOT DETECTED
- * — MTBE CONCENTRATION (mg/L) BY METHOD 8020
- (LPH) — NOT SAMPLED DUE TO THE PRESENCE OF LIQUID-PHASE HYDROCARBONS
- (NS) — NOT SAMPLED, WELL INACCESSIBLE
- DRY — NOT SAMPLED, WELL DRY

Source of Information
California Regional WQCB, 2002

GENERAL SITE NOTES:

1. SOURCE OF MAP: PATRICK AND HENDERSON INC., S.P.C.C. FACILITY PLAN, TANK FARMS AND REFINERY, DATED DECEMBER 13, 1985. NEW COFFEE ROAD ELEVATED BERM, FORMER COFFEE ROAD, AND PG&E SITE INFORMATION FROM CITY OF BAKERSFIELD SEPARATION OF GRADE DISTRICT.
2. MONITORING WELL LOCATIONS AND SITE BOUNDARY LINES WERE SURVEYED BY AZIMUTH BOUNDARY SPECIALISTS ON MARCH 18 AND NOVEMBER 5, 1996. WELLS INSTALLED IN 2001 WERE SURVEYED BY EVANS LAND SURVEYING AND MAPPING ON NOVEMBER 12, 2001.
3. SITE FEATURES AND STRUCTURE LOCATIONS ARE APPROXIMATE.

N

0 300 600
APPROXIMATE SCALE IN FEET

DATE:	FILE NAME:	PROJECT NO.:
11/01	WOM_SRCHYD01-2	02-WOC-034.1

GROUNDWATER HYDROCARBON CONCENTRATION MAP-SECOND HALF, 2001

WORLD OIL CORP
FORMER SUNLAND OIL REFINERY
2152 COFFEE ROAD, BAKERSFIELD, CA

The Source Group, Inc.

FIGURE: 3

SUPPLEMENT TO THE GROUNDWATER CONDITIONS AND POTENTIAL IMPACTS OF PUMPING FOR THE ID-4 KERN PARKWAY AND ROSEDALE-RIO BRAVO WSD PROJECTS

AKA
ALLEN ROAD WELL FIELD
DECEMBER 2002 PUMP TEST

prepared for
Improvement District No. 4
Kern County Water Agency
Bakersfield, California

by
Kenneth D. Schmidt & Associates
Groundwater Quality Consultants
Bakersfield, California

February 28, 2003

KENNETH D. SCHMIDT AND ASSOCIATES
GROUNDWATER QUALITY CONSULTANTS
3701 PEGASUS DRIVE, SUITE 112
BAKERSFIELD, CALIFORNIA 93308
TELEPHONE (661) 392-1630

February 28, 2003

Mr. Martin Varga
District Engineer, ID-4
Kern County Water Agency
P. O. Box 58
Bakersfield, CA 93302-0058

Re: Allen Road Well Field
December 2002 Pump Test

Dear Martin:

Following are the results of my review of the December 2002 pump test on the six ID-4 Wells. Wells No. 1, 3, 8, 9, 10, and 11 were pumped for the test. Pumping of the wells began between 8:23 and 9:29 am on December 10, 2002. Pumping of Well No. 10 stopped at 7:20 pm on December 20, 2002, due to a pump malfunction. Pumping of the remaining wells continued until between 10:35 and 11:35 am on December 30, 2002. Figure 1 shows the locations of these wells and observation wells that were used for the test. A network was developed of both shallow and deep observation wells. There were a total of 13 deep observation wells and three "shallow" observation wells.

Pumpage

Total pumpage and average pumping rates were determined for the first day, next three days, first ten days (through December 20, 2002), and for the entire duration of pumping. Table 1 summarizes pumpage from each of the pumped wells for these periods, based on totalizer readings from the flowmeters on each well. A total of 34,716,000 gallons was pumped during the first day, 101,815,000 gallons during the next three days, 384,900,000 gallons during the first 10 days, and 615,943,000 gallons during the entire 20-day period. The average pumping rates were 24,110 gpm for the first day, 23,570 gpm for the next three days, 23,260 gpm for the first 10 days, and 21,390 gpm for the entire test. Because of the

combined well decreased pumping rate after December 20, drawdowns in the pumped wells and observation wells were primarily examined during the first ten days of the pump test.

Drawdowns

Pumped Wells

Table 2 summarizes drawdowns in the pumped wells that were determined for the test. The centroid of pumping was located about midway between Wells No. 3 and 9. Static water levels in these wells ranged from 127.8 to 131.9 feet, and were deepest to the northeast. Drawdowns in these wells after 10 days of pumping ranged from 31.7 to 55.7 feet. The largest drawdowns were in Wells No. 1 and 3, even though these wells had the lowest pumping rates. Drawdowns after 20 days of pumping ranged for 31.5 to 53.3 feet.

Observation Wells

The primary observation well for the test was ID4 Well No. 12, which is in the vicinity of the pumped wells, and was not pumped during the test. Table 3 shows drawdowns in the deep and shallow observation wells that were measured during the test. The distances of these wells from the centroid of pumping are also shown.

Although three observation wells were initially chacterized as "shallow", only one of these (2-inch galvanized) is believed to tap only the shallowest deposits (Layer 1). The water-level in this well rose during most of the pumping period, and was directly influenced by recharge from streamflow in the Kern River. Well 35A4, located near the RRBWSD office, is perforated from 310 to 410 feet in depth and is actually an intermediate zone (Layer 2) well. The water level in the shallow nearby well (Shop Well) couldn't feasibly be measured during the test. The depth of the Hay Barn Well is not known, but the depth to water in this well is also indicative of an intermediate zone well. Two other shallow monitor wells were planned to be measured during the test, but they were dry. Because of these factors, the pump test did not provide useful information on the influence of pumping the ID4 Allen Road wells on shallow groundwater in the vicinity. However, substantial information was obtained on aquifer characteristics for the composite pumped interval.

Figure 2 is a drawdown plot for Well No. 12. The measurements for the first two days of pumping indicated a transmissivity of 476,000 ppd per foot and storage coefficient of 0.0008. Water-level measurements in this well after six days of pumping the other wells indicated no further drawdown. This was due to recharge from streamflow in the Kern River, which began between December 12 and

16, 2002, and reached the ID4 Well No. 10 vicinity by December 19.

Drawdowns in deep wells (most are actually composite wells) ranged from 1.3 to 26.3 feet after ten days of pumping the ID4 wells. Figure 3 shows drawdowns in these wells after ten days of pumping plotted against the logarithm of distance from the centroid of pumping. The overall trend is excellent, and a transmissivity of 395,000 gpd per foot and storage coefficient of 0.01 were determined. This transmissivity value is in excellent agreement with the average value of 409,000 gpd per foot used in our January 2003 report. The increase in apparent storage coefficient (ten days versus two days) is as expected. Afer several months of pumping the ID4 Allen Road Wells, the storage coefficient is expected to be in the range of 0.05 to 0.10.

Recovery

Recovery measurements indicated almost full recovery within the first day after pumping stopped. Unfortunately, frequent water-level measurements were not made during the first day of recovery. Therefore, values for aquifer characteristics could not be determined from the recovery measurements.

Please call me if you have any questions.

Sincerely Yours,

Kenneth D. Schmidt

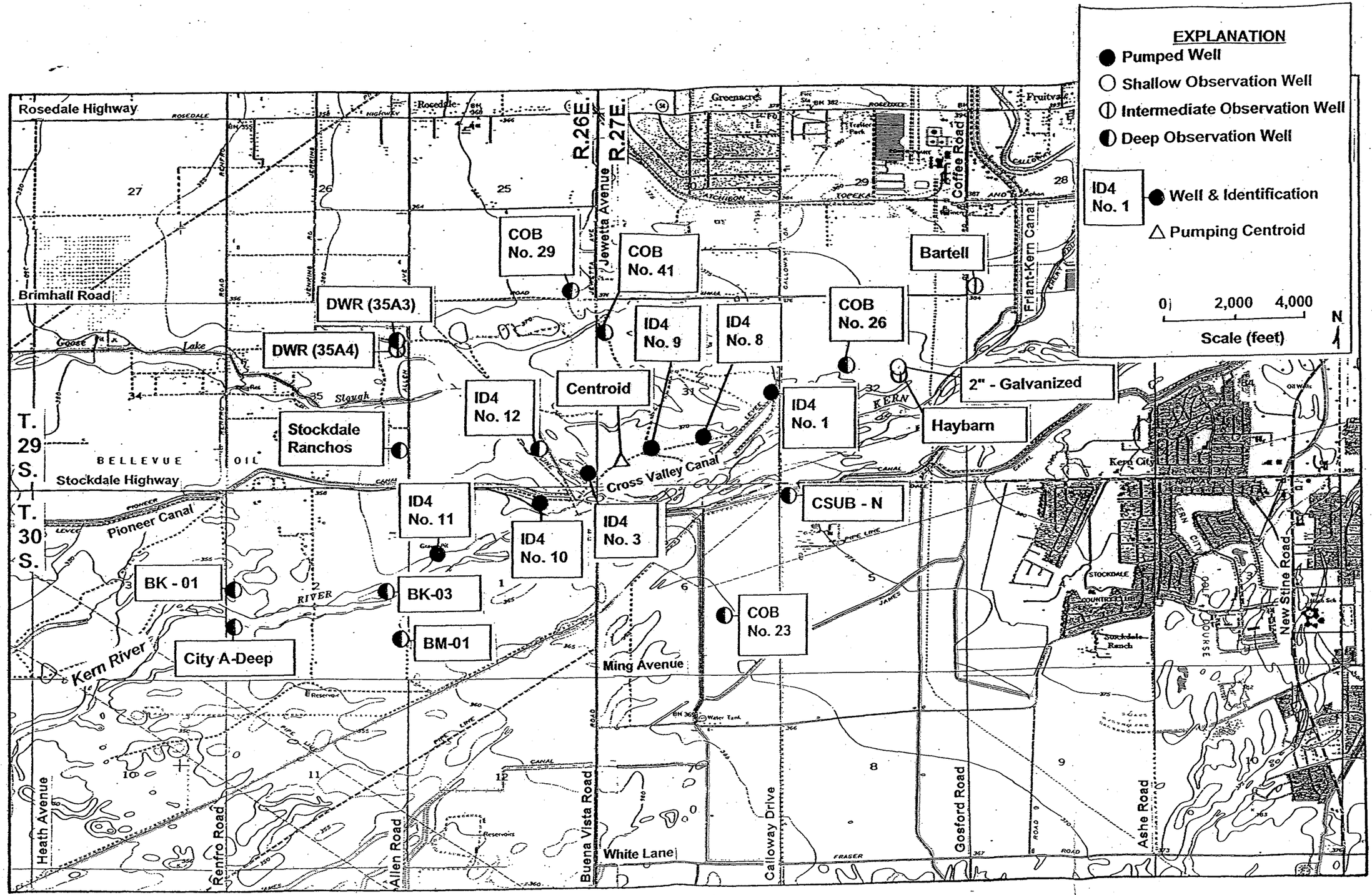


FIGURE 1 - LOCATION OF PUMPED WELLS AND OBSERVATION WELLS

TABLE 1 - PUMPAGE AND PUMPING RATES
FOR THE PUMP TEST

Well	First Day		Next Three Days		First Ten Days		Entire Test	
	1,000g	Ave gpm	1,000g	Ave gpm	1,000g	Ave gpm	1,000g	Ave gpm
1	3,991.7	2,770	11,743.7	2,730	39,209.6	2,730	79,031.9	2,730
3	4,359.9	3,020	12,760.3	2,940	41,969.6	2,920	86,627.5	2,990
8	6,578.9	4,570	19,319.7	4,470	63,407.4	4,410	127,749.9	4,410
9	6,585.5	4,600	19,182.9	4,440	62,863.2	4,370	126,863.6	4,390
10	6,578.9	4,550	19,287.1	4,490	63,446.5	4.410	66,216.2	2,300
11	6,621.3	4,610	19,521.7	4,510	64,003.7	4,450	129,454.1	4,480
Total	34,716.2	-	101,815.4	-	334,900.0	-	615,943.2	-

TABLE 2 - DRAWDOWNS IN PUMPED WELLS

Well No.	Static Level (ft)	December 20, 2002		December 30, 2002	
		Pumping Level (ft)	Drawdown (ft)	Pumping Level (ft)	Drawdown (ft)
01	131.6	187.3	55.7	184.9	53.3
03	125.8	180.8	55.0	176.7	50.9
08	132.1	179.2	47.1	177.7	45.6
09	131.9	163.6	31.7	163.4	31.5
10	129.1	178.0	48.9	Pump Off	-
11	127.8	179.1	51.3	174.2	46.4

TABLE 3 - DRAWDOWNS FOR OBSERVATION WELLS

Zone	Well No.	Distance to Centroid(ft)	Static Level(ft)	December 20, 2002 Depth to Water(ft)	December 20, 2002 Drawdown(ft)	December 30, 2002 Depth to Water(ft)	December 30, 2002 Drawdown(ft)
Shallow	2" Galvanized	8,320	87.6	86.0	-1.6	84.2	-3.4
Intermediate	DWR-35A4	17,150	122.5	131.9	8.5	129.8	7.3
	Bartell	11,250	118.0	132.5	14.5	132.0	14.0
	Hay Barn	8,320	114.3	117.1	2.8	116.5	2.2
Deep	ID4-12	2,240	124.4	150.7	26.3	149.1	24.7*
	COB-23	5,330	145.1	159.2	14.1	156.1	11.0
	COB-26	6,990	134.2	154.1	19.9	153.3	19.1
	COB-29	4,960	139.1	150.0	10.9	148.6	9.5*
	BM-01	7,870	127.4	131.1	3.7	131.3	3.9
	BK-01	11,680	142.1	146.0	3.9	146.7	4.6
	BK-03	7,570	127.8	134.2	6.4	133.1	5.3
	CSUB-N	5,120	133.5	151.8	18.3	150.8	17.3*
	COB 41	3,680	136.7	145.8	9.1	143.1	6.4
	Stockdale Ranchos	6,190	125.0	130.5	5.5	130.0	5.0
	DWR-35A3	7,150	124.5	132.4	7.9	131.3	6.8
	City A-Deep	11,970	124.3	125.6	1.3	126.2	1.9

*Pumping levels and drawdowns were for December 27.

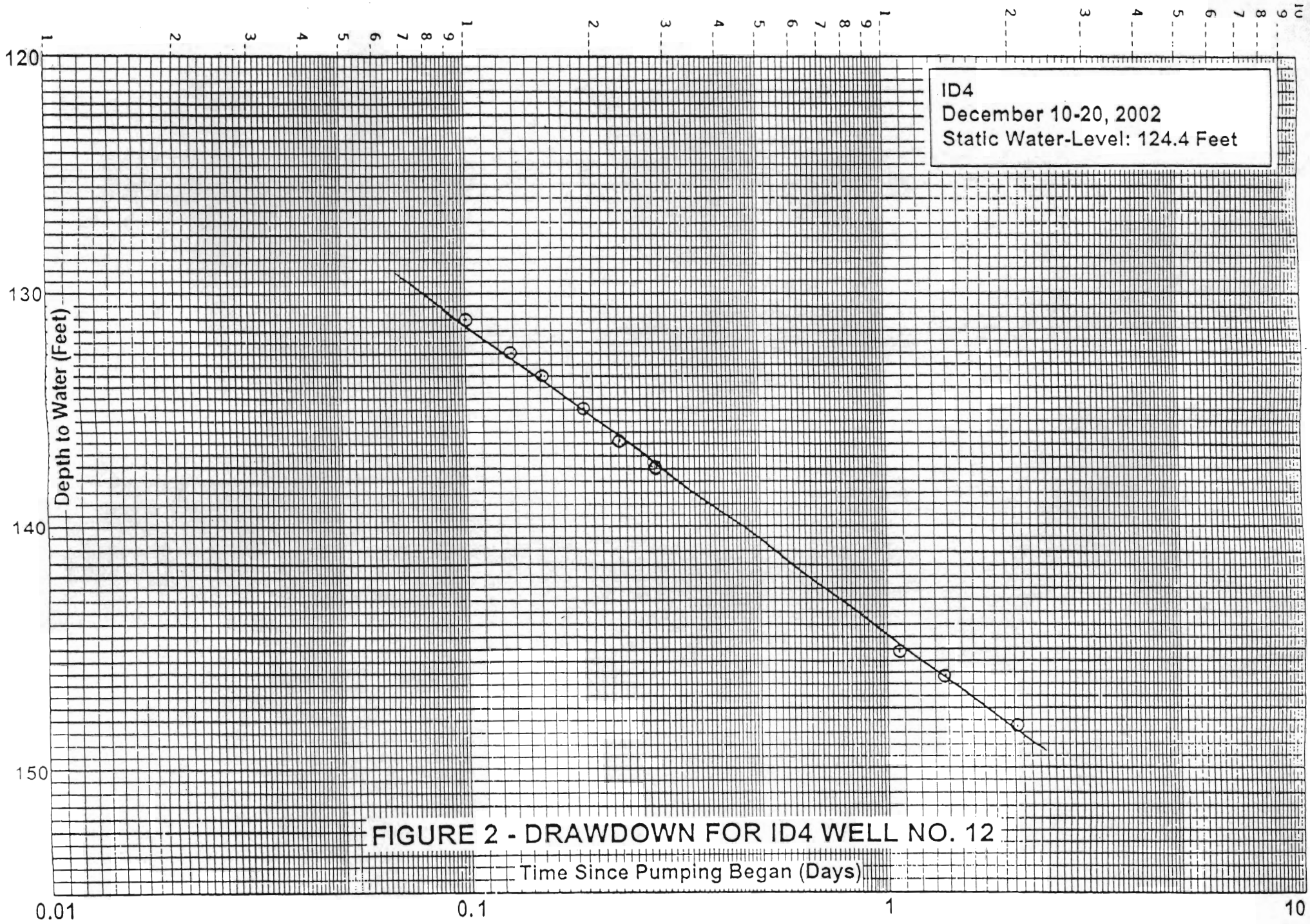


FIGURE 2 - DRAWDOWN FOR ID4 WELL NO. 12

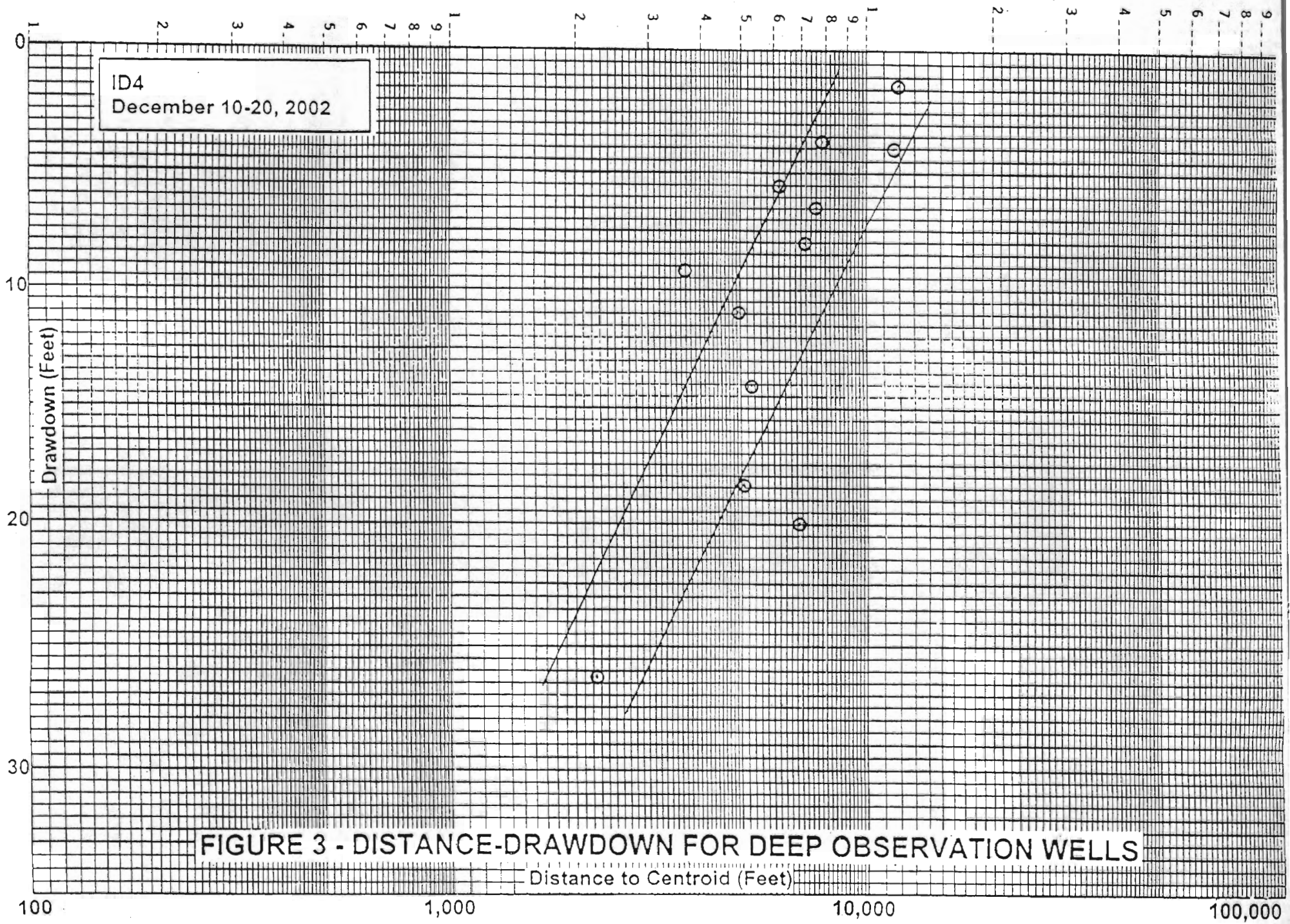


FIGURE 3 - DISTANCE-DRAWDOWN FOR DEEP OBSERVATION WELLS