New Mexico Bureau of Mines & Mineral Resources

Open-File Report 86

HYDROGEOLOGIC STUDIES OF THE SOCORRO LANDFILL SITE BY NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES

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Contents

INTRODUCTION

Operations at the Socorro sanitary landfill began in October, 1977. The landfill site is in a tributarv of Nogal Arroyo located northwest of the City of Socorro Bldg. at Escondida. Most of the operation is located in the southeast quarter of Sec. 26, T.2 S., R.1 W. Citizens from the community of Escondida voiced concern over the location of the landfill from the standpoint of litter and potential contamination of the local water supply. In response to this concern additional investigations have been conducted by the Environmental Improvement Agency and the New Mexico Bureau of Mines and Mineral Resources. This report is a summary of the studies done by members of the staff of the Bureau. Included are analyses of two auger holes drilled for the City of Socorro by Albuquerque Testing Labs under the supervision of Dennis Engineering Co. and baseline water data from wells in the vicinity of the landfill operation. Detailed information on textural analyses and water chemistry are on file at the Bureau. Additional data on trace elements and clay analyses will be forwarded as soon as available.

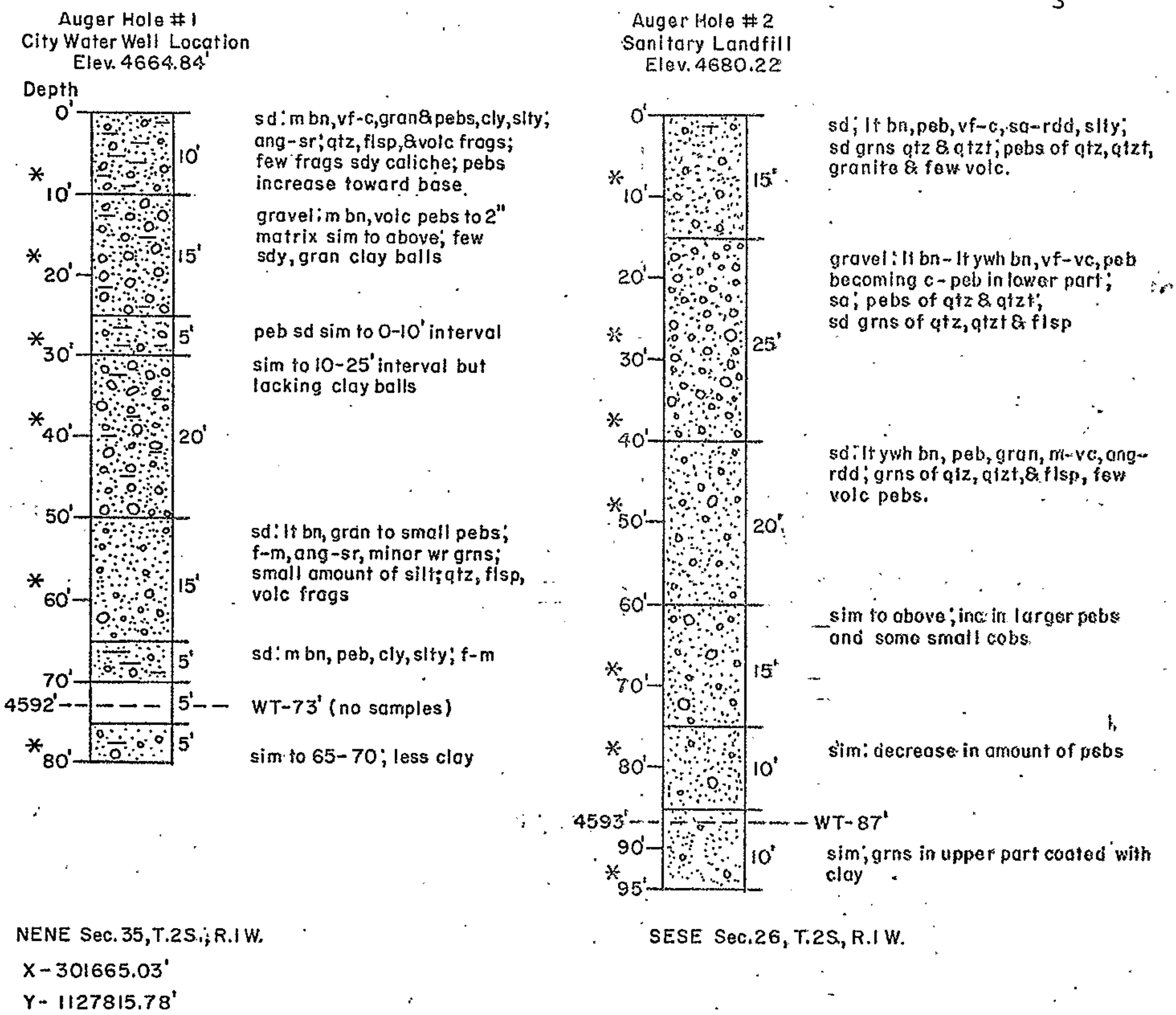
RESULTS OF AUGER HOLE INVESTIGATIONS

On November 17 and 18, 1977 two auger holes were drilled to determine the depth to ground water and the nature of the sediments underlying the area of the Socorro sanitary landfill. During drilling operations samples were collected at 5-foot intervals by personnel of Dennis Engineering Co. and the New Mexico Bureau of Mines. The first test (Auger Hole 1) was drilled near the northeast corner of Sec. 35, T.2 S., R.1 W. to a depth of 80 feet. This test is at the site of the planned water well for the City of Socorro and reached the water table at a depth of 73 feet. Auger Hole 2 was located in the landfill about 1200 feet north of Hole 1 in the southeast quarter of Sec. 26, T.2 S., R.1 W. This test was drilled to a depth of 95 feet and encountered the water table at 87 feet. Elevations measured by Dennis Engineering show that Hole 2 is slightly over 15 feet higher than Hole 1; the water table is therefore nearly at the same elevation in the two wells. During drilling it was noted by those present that samples were moist from the surface to the water table. Further, the water content appeared to be greater in Hole 2 at the landfill.

The general nature of the sands and gravels penetrated in the two auger holes are shown in Figure 1. The interpretation is based on microscopic examination of the cuttings and the general distribution of grain sizes is estimated.

Sediments penetrated in Hole 1 consist of light to medium brown clayey sands and gravels. In Hole 2 sediments consist of light brown to light yellowish brown sands and gravels with a smaller percentage of clay and silt. In Hole 1 the larger clasts consist mostly of volcanic material; in Hole 2 these are minor volcanic clasts with most of the material consisting of fragments of quartz, quartzite, feldspar and granite.

Sediments underlying the higher surface north of Nogal Arroyo in the vicinity of Hole 2 were deposited by the Rio Grande. The source for these sediments is to the north and, based on the type of clasts present, was derived from a Precambrian terrane such as in the Ladron or Manzano Mountains. The material underlying the lower



* textural analysis

cly	clayey	ang	angular
slty	silty	sa	subangular
sd	sand	sr	subrounded
sdy	sandy	rdd	rounded
vf	very fine	qtz	quartz
f	fine	qtzt	quartzite
m	medium	flsp	feldspar
c	coarse	volc	volcanic
vc	very coarse	bn	brown
grans	granules	ywh	yellowish
pebs	pebbles	lt	light
cobs	cobbles	frags	fragments
		sim	similar
		grns	grains
		inc	increase
		WT	water table

Holes drilled by Albuquerque Testing Lab.

Figure 1. Logs of Auger Holes 1 and 2

area near the site of Hole 1 is younger and was deposited by the drainage system of Nogal Arroyo following dissection of the higher surface to the north. The primary source for the material would be from a volcanic terrane such as exposed to the west in the Socorro and Lemitar Mountains.

Textural analyses were made of 13 samples, six from Hole 1, and seven from Hole 2. The location of these samples is indicated by an asterisk on Figure 1 and the results are summarized in Table 1. Only one of the textural parameters determined, size range, is presented in the table. From these data it can be seen that the sediments in Auger Hole 2 at the landfill are in general coarser than in Auger Hole 1. In addition the average amount of clay and silt is only 3.37 percent in Hole 2. The presence of clay minerals is highly important in a sanitary landfill in that certain clay minerals can attenuate lateral or vertical movement of toxic substances and thus potential contamination of ground-water supplies. It is doubtful from the small amount of fine-grained material encountered at the landfill that there is sufficient clay to form an effective natural barrier to migration of possibly hazardous substances.

The clay mineralogy was determined by George Austin of the Bureau staff. Samples were divided into plus and minus two micron fractions and the finer material sedimented on glass slides. Samples were analyzed by x-ray diffraction of the original material, following saturation with ethylene gylcol and finally after being heated to 375°C for one hour.

All of the eleven samples contained illite, kaolinite and random mixed-layer illite-smectite. One sample (G 780001) from Auger Hole 1 contained a small amount of smectite. Non-clay minerals in the minus 2 micron fraction included quartz, feldspar and calcite. The depth interval studies for each of the auger holes and relative proportion of clay minerals (in parts of 10) are given in table 2.

TABLE 1: TEXTURAL ANALYSES AUGER HOLES 1 AND 2*

(Values given in weight percent)

Interval (depth in feet)	Gravel		Sand					Silt and Clay
	Pebble >4mm	Granules 2-4mm	Very Coarse 1-2mm	Coarse 0.5-1mm	Medium 0.25-0.5mm	Fine 0.125-0.25mm	Very Fine 0.062-0.125mm	< 0.062mm
Auger Hole 1								
5-10	3.75	5.33	7.43	11.23	13.74	18.90	16.91	22.72
15-20	14.45	8.70	11.58	12.55	13.54	14.02	10.86	14.31
25-30	6.53	5.78	10.06	14.54	16.81	17.69	11.63	16.95
35-40	38.37	13.10	8.38	9.48	9.62	8.32	5.42	7.32
55-60	5.47	4.27	4.44	7.00	15.21	31.87	23.27	8.46
75-80	28.64	4.18	6.23	12.59	15.98	15.78	9.10	7.50
Averages	16.20	6.89	8.02	11.23	14.15	17.76	12.87	12.88
Auger Hole 2								
5-10	18.84	4.81	3.87	5.43	17.42	24.49	11.70	13.45
20-25	29.53	10.36	11.97	20.06	15.41	7.94	2.25	2.50
30-35	54.62	4.86	6.16	13.82	14.09	4.88	1.0	0.56
45-50	19.24	6.56	10.05	24.63	27.85	8.78	1.91	0.98
65-70	46.79	5.05	6.58	14.46	18.16	6.86	1.48	0.63
75-80	10.82	9.55	15.55	25.39	28.09	8.07	1.66	0.86
90-95	6.21	8.51	9.91	22.58	29.35	13.78	5.02	4.64
Averages	26.58	7.10	9.16	18.05	21.48	10.69	3.57	3.37

*Complete results given in Appendix A

Table 2: CLAY MINERALOGY

Sample #	Well	Depth	Ill	Kao	Smec	Mx Layer	Remarks
			CLAY MINERALOGY				
G 780001	1	10'	2	3	1	4	w/quartz, feldspar, calcite
G 780002	1	25-30'	3	3	0	4	w/quartz, feldspar
G 780003	1	35-40'	5	3	0	2	w/quartz, feldspar
G 780004	1	55-60'	4	4	0	2	w/quartz, feldspar, calcite
G 780005	1	57-80'	3	5	0	2	w/quartz, feldspar, calcite
G 780006	2	5-10'	5	5	0	0	w/quartz, feldspar, calcite
G 780007	2	20-25'	3	3	0	4	w/quartz, feldspar, calcite
G 780008	2	30-35'	0	5	0	5	very little clay - size material
G 780009	2	65-70'	3	3	0	4	w/quartz, feldspar
G 780010	2	75-80'	3	4	0	3	w/quartz, feldspar
G 780011	2	90-95'	3	4	0	3	w/quartz, feldspar

WATER-WELL STUDY

General Statement

In order to determine the present water-table position and baseline ground-water chemistry in the vicinity of the new Socorro landfill, a study of water wells in the Escondida-Florida area (Sec. 25, 26, 35, and 36, T. 2 S., R. 1 W.) was carried out during early October, 1977. This study focused on 25 wells; five wells (1, 3, 4, 20, and 23) lie outside the area cited above but add useful information (fig. 3). Results of the well inventory are given in Table 3. Water samples were obtained from 23 of the 25 wells inventoried. Results of analyses for common dissolved constituents are given in Table 4. Analyses for trace elements have not yet been completed; results will be furnished as Table 5 when available. A trilinear plot of dissolved solids appears in Appendix B.

Results of Chemical Analyses

Calcium and sodium are the major anions present in the samples (Table 4). Calcium may be readily derived from various sedimentary rocks (limestone, dolostone, gypsum, gypsiferous shales) whereas sodium is available mainly from clay and feldspar minerals and salt beds. Sewage and industrial waste may also be sources for both constituents. The concentration of sodium approaches the recommended limit for domestic use in only 2 of the samples (wells 1 and 11, Table 4). There is no recommended limit for calcium.

Bicarbonate is the principle cation detected in the samples; sulfate, or in some case chloride, is the next most abundant cation. Bicarbonate and sulfate may be derived from the same sedimentary rocks as listed above for calcium and sodium whereas chloride is

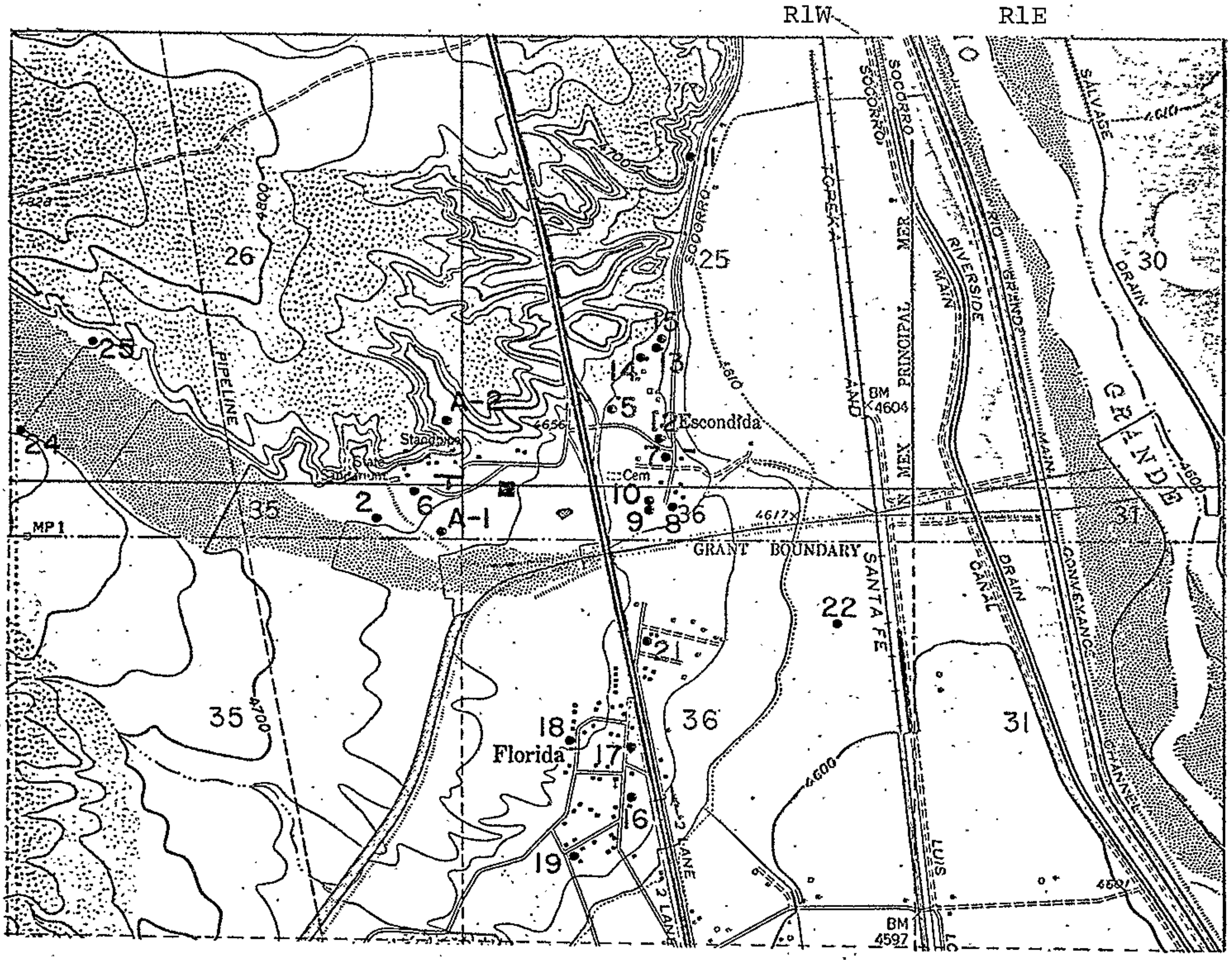


Figure 3. Portion of Socorro 7.5' topographic quadrangle showing location of study area and major wells inventoried (see Table 3 for additional information).

Table 3. Records of Wells Included in Socorro Landfill Study

Well Name	Field[1] No. ABS-	Location No.[2]	Approx. Elev.	Well Depth (ft)[3]	Depth[3] to Water (ft)	Water-Table Elev. (ft)	Type	Use[4]	Sampled[5]	Remarks
Nogal No. 1	1	2.1.29.423	4900	34	16	4884	Drilled	S	X	
Sanitarium	2	2.1.35.221	4682	NA	NA	NA	Drilled	D	X	
Olguin	3	2.1.31.222a	4600	35 R	18 R	4582	Driven	D	X	WL = 9', 1960(R)
Olguin	4	2.1.31.222b	4600	25 R	14 R	4586	Driven	S	X	
Shaw	5	2.1.25.341	4640	110 R	42 R	4598	NA	D	X	
City No. 2	6	2.1.35.221	4685	NA	NA	NA	NA	P	X	
Crespin	7	2.1.25.344	4625	NA	NA	NA	NA	D	X	
J. Smith	8	2.1.36.122a	4625	52.5 R	35.5 R	4590	Drilled	D	X	
S. Smith	9	2.1.36.122b	4630	NA	NA	NA	Drilled	D	X	
Howes	10	2.1.36.122c	4630	NA	NA	NA	Drilled	D	X	
Gibbins	11	2.1.25.231	4625	NA	NA	NA	Drilled	D	X	
Green	12	2.1.25.344	4620	NA	NA	NA	Drilled	D	X	
Dorr	13	2.1.25.342a	4620	NA	±15 R	4605	Drilled	D	X	
Sickle	14	2.1.25.342b	4620	NA	NA	NA	Drilled	S	X	
Cole	15	2.1.25.342c	4620	NA	NA	NA	Drilled	S	X	
Torres	16	2.1.36.323	4628	120 R	35 R	4593	Drilled	IR	X	pumped at 600 gpm
Mossberg	17	2.1.36.321	4630	60 R	NA	NA	Drilled	D	X	
Nuanz	18	2.1.36.312	4640	130 R	90-100 R	4545(?)	Drilled	D	X	levels uncertain
Herron	19	2.1.36.314	4630	NA	NA	NA	NA	D	X	sample from tap
Grice	20	3.1.2.244	4610	89	20	4590	Drilled	IR	X	sample from tap
Kennedy	21	2.1.36.143	4630	80 R	NA	NA	Drilled	D	X	
Daniel	22	2.1.36.241	4605	94 R	35 R	4570	Drilled	D	X	
Kelly house	23	2.1.22.133	4835	NA	NA	NA	Drilled	D	X	
Kelly ranch	24	2.1.26.333	4755	259	140.5	4615	NA	S	PNW	
Nogal No. 2	25	2.1.26.313	4760	>500	>500	<4260	NA	S	PNW	

[1]See fig. 2 for locations; all wells produce from young or old valley fill.

[2]State Engineer system (see fig. 2).

[3]Depths measured unless accompanied by "R" (reported value); NA = not available.

[4]Use: S = stock, D = domestic, P = public, IR = irrigation.

[5]"X" indicates sample analyzed (see Table 4); PNW = pump not working.

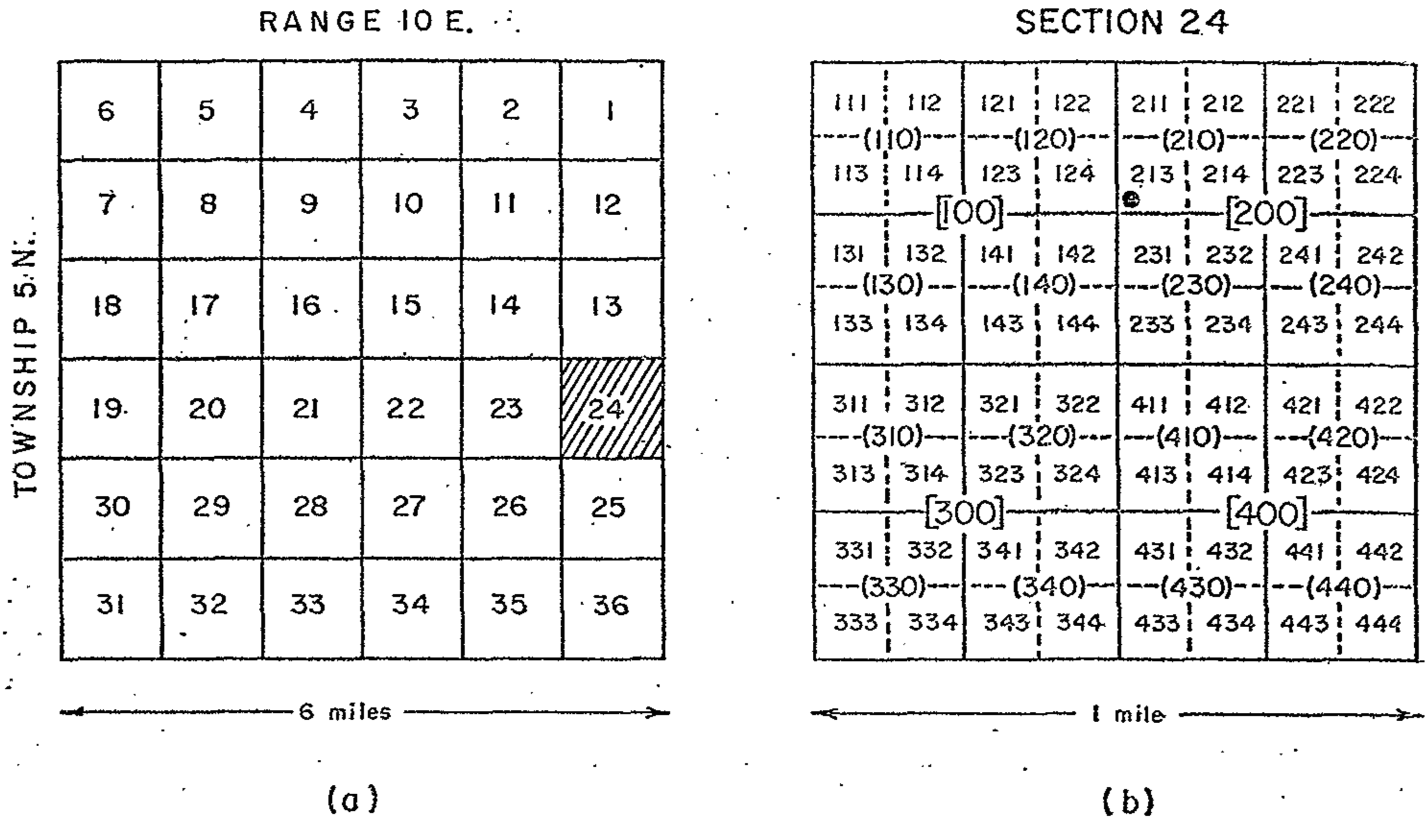


FIGURE 2--Method of numbering wells and springs: a) subdivision of a township into sections, b) subdivision of a section into quarter-quarter-quarter section blocks (dot indicates location of a well numbered 5.10.24.213).

Table 4. Dissolved Solids in Ground Water, Escondida-Florida Area [1]

Well No. ABS-	Anions (ppm)				Cations (ppm)					Calculated
	Ca	Mg	Na	K	HCO_3	SO_4	Cl	CO_3	NO_3	TDS (ppm)
1	59.4	9.8	108.0	2.6	227.0	179.0	21.0	12.0	0.0	496.3
2	31.0	5.6	26.3	1.2	120.0	4.3	13.4	4.0	.5	182.0
3	124.0	34.0	94.0	3.6	270.0	175.0	94.0	0.0	.9	660.0
4	95.0	28.0	69.0	4.6	195.0	238.0	65.0	10.0	1.0	600.0
5	37.0	7.5	24.0	3.4	112.0	53.0	17.0	6.0	1.3	201.0
6	40.0	6.9	27.0	1.4	112.0	59.0	15.0	6.0	.04	207.0
7	25.0	7.2	28.0	2.9	100.0	29.0	19.0	8.5	.7	164.0
8										
9	46.0	10.0	48.0	3.3	224.0	23.0	29.0	11.0	2.0	276.0
10	86.0	22.5	76.0	4.3	212.0	193.0	57.0	11.0	7.9	555.0
11	99.0	19.0	112.0	13.0	261.0	228.0	80.0	11.0	0.0	684.0
12	46.0	21.0	79.0	3.4	114.0	216.0	25.0	11.0	0.9	516.0
13	57.0	15.0	38.0	3.2	134.0	104.0	45.0	0.0	1.5	330.0
14	49.0	15.0	30.0	3.2	134.0	97.0	33.0	0.0	0.6	294.8
15	66.0	19.0	36.0	3.7	151.0	124.0	42.0	0.0	0.4	367.0
16	35.0	12.0	30.0	3.0	146.0	56.0	19.0	0.0	7.0	235.0
17	36.0	8.5	30.0	2.5	144.0	42.0	19.0	0.0	0.8	211.0
18	36.0	8.3	27.0	2.8	151.0	39.0	13.0	0.0	0.6	202.0
19	63.0	16.0	38.0	3.2	171.0	128.0	29.0	0.0	1.5	450.0
20	26.0	5.0	50.0	1.5	146.0	46.0	17.0	0.0	0.8	219.0
21	56.0	14.2	40.0	3.4	188.0	89.0	31.0	0.0	3.3	331.0
22	100.0	17.0	41.0	4.3	220.0	138.0	52.0	0.0	1.2	464.0
Recommended Limits (ppm) [2]	None	125.0	115.0	None	None	250.0	250.0	None	44.0	500.0 [3]

[1] See Appendix B for trilinear plot of dissolved solids.

[2] For domestic use (California State Water Pollution Control Board)

[3] 1000.0 ppm is acceptable but 500 is recommended by U.S. Public Health Service

Table 5. Trace Elements in Ground Water (ppm), Escondida - Florida Area

Well No.	PO_4	F	Fe	Mn	Cd	Cu	Zn	Cr
1	0.16	0.66	38.0	0.19	0.0008	.005	.51	<.01
2	0.39	0.62	0.69	0.68	<0.0005	.008	.06	<.01
3	0.22	0.52	1.3	0.48	0.0013	.003	.39	<.01
4	0.31	0.41	1.1	0.33	0.0009	.008	<.05	<.01
5	0.25	0.47	1.0	0.15	<0.0005	.01	<.05	<.01
6	<0.1	0.52	2.7	<0.05	0.0026	.01	<.05	<.01
7	0.28	0.52	0.26	0.35	< .001	0.012	<.05	<.01
8	0.7	0.43	2.0	0.21	< .001	0.0026	.50	<.01
9	0.25	0.42	1.05	0.07	< .001	0.034	.37	<.01
10	0.19	0.47	1.05	0.04	< .001	0.01	.06	<.01
11	0.13	0.42	0.51	0.66	< .001	0.004	.05	<.01
12	0.26	0.43	0.45	0.41	< .001	0.024	<.05	<.01
13	0.18	0.46	0.35	0.06	.003	0.007	.30	<.01
14	0.23	0.49	0.14	0.05	.005	0.018	<.05	<.01
15	0.22	0.40	0.20	0.09	.002	0.024	<.05	<.01
16	0.38	0.56	0.45	0.09	< .001	0.009	<.05	<.01
17	<0.1	0.57	0.16	0.07	< .001	0.006	<.05	<.01
18	0.25	0.56	2.1	0.06	< .001	0.005	.44	<.01
19	<0.1	0.52	0.11	0.05	< .001	0.02	.07	<.01
20	0.33	0.51	0.76	0.04	< .001	0.007	.15	<.01
21	<0.1	0.51	0.19	0.02	< .001	0.150	.18	<.01
22	<0.1	0.38	3.6	0.06	< .001	0.022	<.05	<.01
24	0.22	0.45	0.23	<0.01	< .001	0.068	.16	<.01
Recommended limits[1] for Health/Domestic Use (ppm)	None	1.5	1.0	0.2	0.01	1.0	10.0	0.05

[1]U.S. Environmental Protection Agency

available from most rocks and soils, sewage, and industrial effluents. Only three wells approach the recommended limit for sulfate (well numbers 4, 11, and 12, Table 4). None of the samples analyzed contains excessive chloride. There is no recommended limit for bicarbonate.

The presence of nitrate in most of the samples is of special interest. This cation may be derived from decayed organic matter, nitrate fertlizers, animal excrement, and sewage. Although nitrate does not exceed the recommended limit in any of the samples, its presence may be an indication that domestic sewage is locally coming in contact with the ground-water supply and septic tanks should be examined.

Total dissolved solids (TDS) contents of the waters are excellent, falling generally well below the recommended 500 ppm (parts per million) standard for drinking water; several do not even approach half of this value (Table 4 and fig. 4). Only 5 samples exceeded this standard (wells 3, 4, 10, 11, and 12); one of these (number 4) is not used for domestic purposes. There is no need for concern over the remaining 4 wells as water is considered potable and fresh if TDS content does not exceed 1000 ppm; lacking better quality supplies, many communities have reportedly used even more saline waters without harmful effects.

Ground-Water Table and Movement

Local water levels were difficult to measure at all but 4 of the wells owing mainly to methods of well completion (no access for water-level-indicator cable). Reported values were obtained, however,

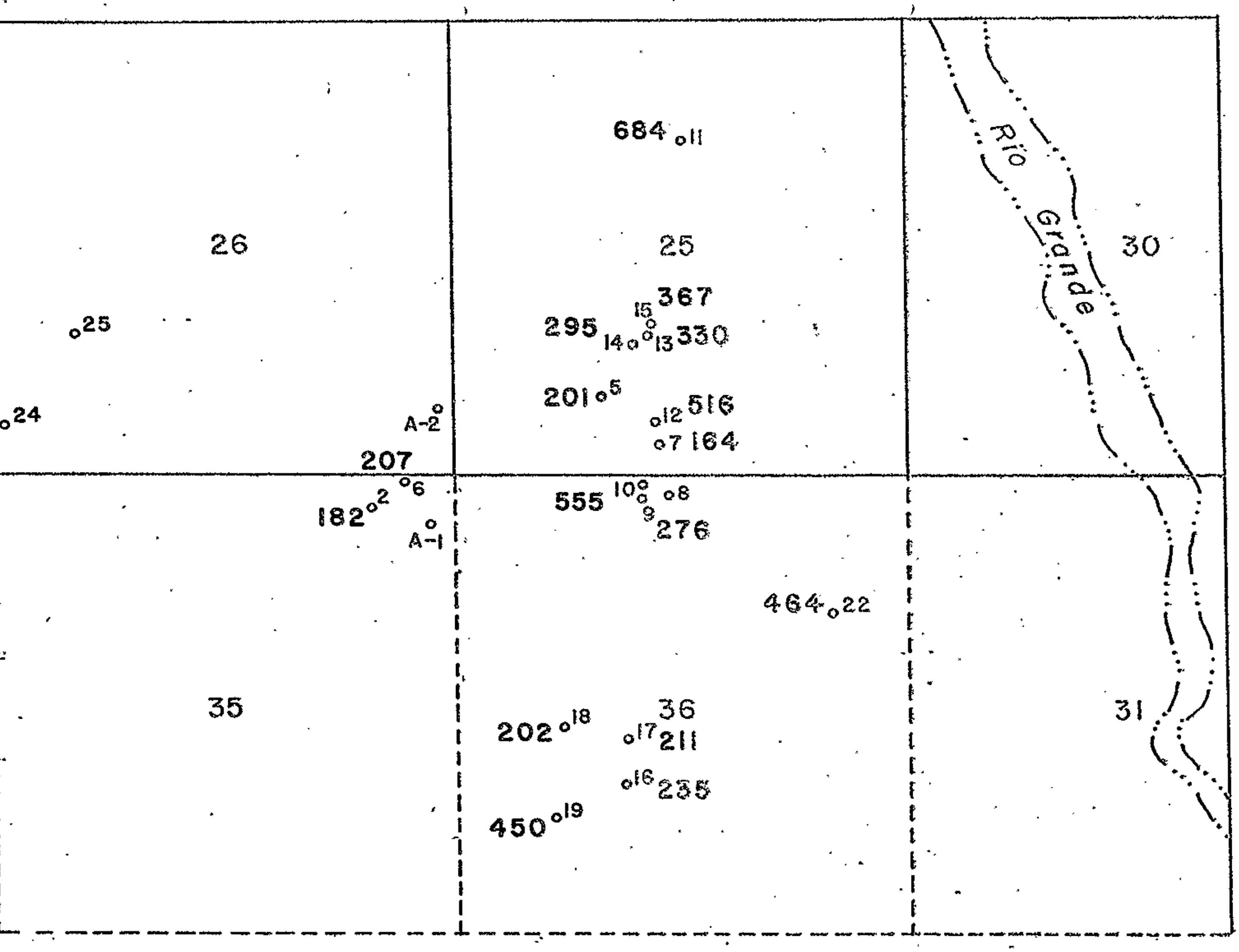


Figure 4. Map showing total dissolved solids (ppm) in ground waters in study area (complete results of chemical analyses given in Table 4). Well numbers same as in Table 3; A-1 and A-2 are auger holes shown in fig. 1.

for 10 other wells (Table 3). It should be noted that these reported values are for different times in the past and thus are not necessarily compatible or representative of the present situation. Based on levels measured in the present study, the water table near the landfill appears to slope toward the Rio Grande (fig. 5). It occurs at an elevation of about 4964 ft. at well number 1 (3 miles west of the landfill), at about 4620 ft. in well number 24 (1 mile west of the landfill) at 4592 ft. and 4593 ft. in Auger Holes 1 and 2 at the landfill and at about 4590 ft. at well number 8 (.2 mile east of Interstate 25).

An anomalous water-level measurement was obtained at well number 25. At this well, located just short of a mile west of the landfill, the entire length of a 500-ft. water-level-indicator cable was lowered without reaching water or the bottom of the well. If this well is open to the water table, this means that the water table there lies at an elevation less than 4250 ft. At well number 24, located directlv across Nogal Arroyo to the west (fig. 3), water was encountered at a depth of 140.5 ft. (elevation 4590 ft.) or at least 340 ft. above that at well 25.

One explanation of this discrepancy is that the 2 wells are separated by a fault or fracture along which there has been vertical movement displacing the water-bearing strata upward on the west and downward on the east. Although wells 24 and 25 did not yet exist, Waldron (1956) postulated the presence of a fault in the same area on the basis of a refractive seismic profile which showed an

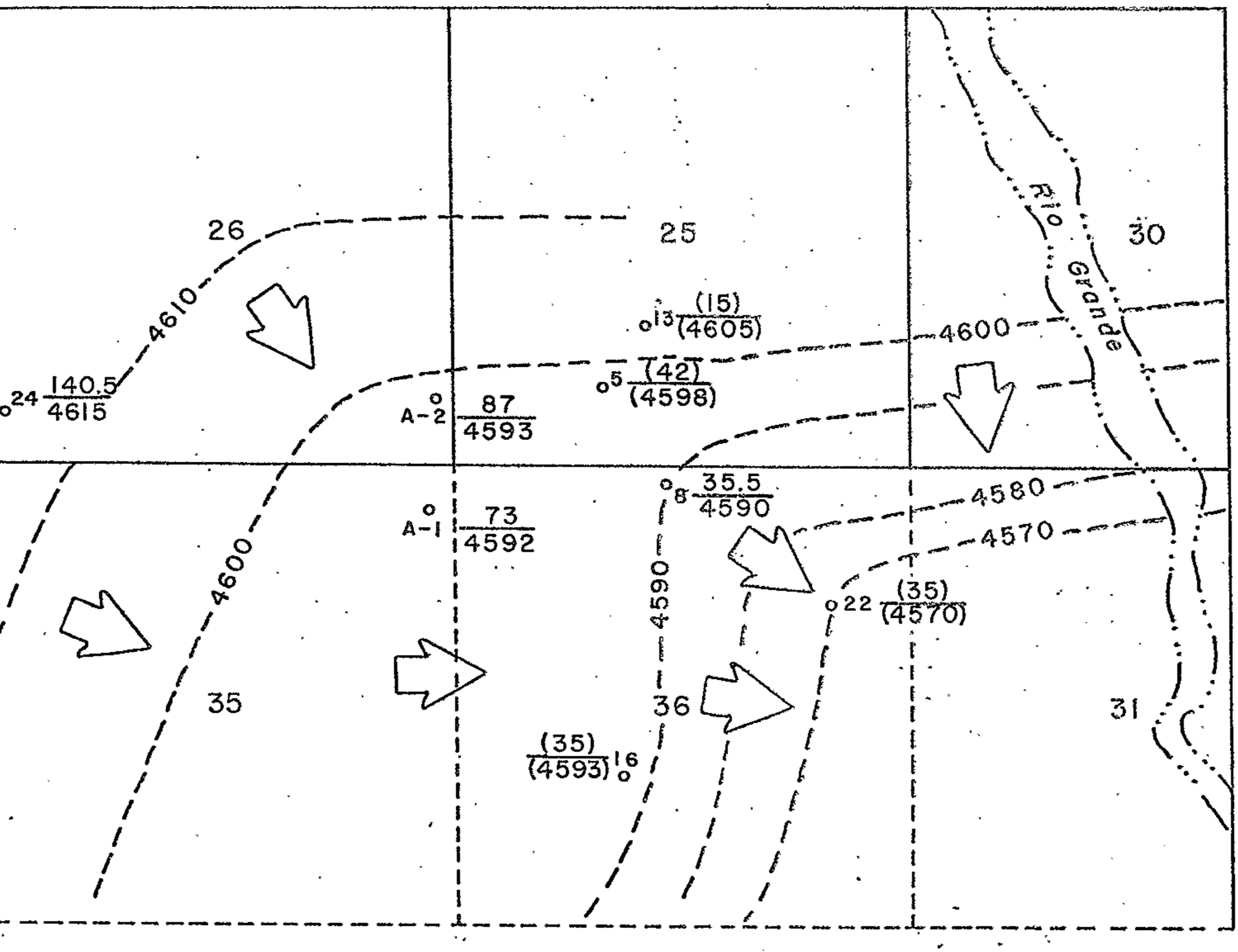


Figure 5. Map showing generalized ground-water table and movement in study area. Upper values are depths to water; lower values are elevations of water table (reported values are in parentheses). See Table 3 for other well data; A-1 and A-2 are auger holes shown in fig. 1.

abrupt 35-ft. offset in what was interpreted to be the water table. Further study would be necessary to confirm the presence of a fault and to determine why seismic data show a 35-ft irregularity in water table whereas well 25 suggests more than 300 ft. of offset. The question may be merely academic as regards ground water at the landfill because water levels near there and in adjacent Escondida and Florida seem to be compatible (all available water levels, with the exception of the anomalous value for well 25 and an uncertain reported value for well 18, are plotted on fig. 5).

Because local data are sparse, regional compilations of water level were consulted to confirm the determined water-table configuration. Regional water-level maps were plotted by Waldron (1956) and Bushman (1963). In conjunction with a reconnaissance study for the New Mexico Bureau of Mines and Mineral Resources of the hydrogeologic aspects of the Socorro Peak geothermal area, Stone (1977) prepared maps from ground-water data available in various Bureau Circulars. The Bureau of Mines maps cover the area from Magdalena to just across the Rio Grande east of Socorro and from a few miles north of Polvadera to a few miles south of Socorro.

Based on these various regional maps the following may be concluded:

1. Two flow systems operate on the west side of the Rio Grande Valley: one next to the mountain front in which flow is easterly and one in the lower flood plain areas in which flow is southerly. The resultant flow direction in the zone where the 2 systems merge is southeasterly

(fig. 5; flow is perpendicular to water-level contours) The southeasterly trend of the lower part of Nogal Arroyo may be a reflection of this resultant flow direction.

2. The water-chemistry of the 2 flow systems differs; ground waters next to the mountain front are fresh (TDS much less than 1000 ppm) whereas ground waters on the lower flood plain are slightly saline (TDS in excess of 1000 ppm).
3. Locally, opposite favorable places on the mountain front, ground waters in the lower flood plain are anomalously fresh owing to dilution by fresh waters from the mountain flow system (fig. 4).
4. The waters of the mountain flow system are fresh because they originate only a short distance to the west in the Magdalenas and travel rapidly (waters discharging at Socorro Spring have been determined to move through the ground at a rate of about 35 ft/day or 7 times normal; Holmes, 1963) across the Snake Ranch Flats, through fractures in the mountains, and down the drainage of Nogal Arroyo.
5. The salinity of waters of the flood plain flow system may be explained in several ways. First of all, this water is closely related to river water. Saline irrigation return flow is one source of elevated total dissolved solids in both the river and associated flood plain ground waters. Also, there are natural sources for the dissolved constituents as mentioned above: limestones, dolostones, and gypsum (occurring as layers in both the ancient bedrock and valley fill and as veins or fracture-filling material in mudstones of the ancient bedrock and valley fill).

With this regional picture in mind, the local ground-water situation at the landfill can be more readily summarized. The landfill lies in an area in which ground water is dominated by the mountain flow system. In this area, a tongue of fresh ground water flows easterly from the mountain front, along Nogal Arroyo, toward the Rio Grande. This tongue of ground water interrupts the flood plain flow system in the vicinity of Escondida and Florida. This condition is suggested by both available water-table data and results of chemical analyses of local ground waters (figs. 3, 4, and 5). Although it was not the purpose of the water-well study to determine whether or not the landfill will result in ground-water contamination, it is within the scope of this report to point out the significance of the ground-water setting determined for the area. The significance of such a setting is that should any contamination occur at the landfill, it can be expected to migrate easterly toward various residences in Escondida or southeasterly toward those in Florida.

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Appendix A

Results of Textural Analyses

EXPLANATION

The texture of the 13 samples studied was determined by sieving with a whole phi* sieve set (difference between adjacent sieves in the stack was 1 phi unit). The pages which follow are Xerox reductions of computer-printout sheets designed to present the various results of sieve analyses. For each sample there are 3 sheets. The first gives raw weights, calculated percentages (by weight), and cumulative percentages (by weight) for each size class based on the sieving (see Table 1 for names corresponding to numerical size classes). The second sheet shows the grain-size distribution for the sample by means of a bar graph or histogram and a cumulative curve. Textures of samples may be compared both visually and statistically through the use of these graphs. The third sheet presents the statistical characteristics of the grain-size distribution. The statistical parameters given are defined below following Folk (1974):

Mean (measure of average grain size)

<u>arithmetic mean</u> = $\frac{\Sigma DW}{\Sigma W}$ where Σ means the sum, D is the phi size of the class midpoint, and W is the class weight.

<u>graphic mean</u> = $\frac{(\phi 16 + \phi 50 + \phi 84}{3}$; average of grain sizes (in phi units) corresponding to the 16th, 50th, and 84th percentiles on cumulative curve.

---

* The phi unit (ϕ) is a logarithmic transformation of the Wentworth (1922) millimeter grain-size scale employed for ease in computations.

Median = grain size corresponding to the 50th percentile.

Mode = most frequently occurring grain size; not given on computer-printout sheets but apparent in Table 1.

Standard deviation (measure of central tendency or, in the case of sediments, sorting)

<u>quartile deviation</u> = $\frac{(\phi 75 - \phi 25)}{2}$; focuses on central half of the distribution.

<u>graphic standard deviation</u> = $\frac{(\phi 84 - \phi 16)}{2}$; covers broader portion of the distribution.

<u>inclusive graphic deviation</u> = $\frac{(\phi 84 - \phi 16)}{4} + \frac{(\phi 95 - \phi 5)}{6.6}$; covers extremes of the distribution; best measure of sorting:

Inclusive Graphic Deviation	Sorting
0.350	= very well sorted
0.35-0.500	= well sorted
0.50-0.710	= moderately well sorted
0.71-1.000	= moderately sorted
1.00-2.000	= poorly sorted
2.00-4.000	= very poorly sorted
4.000	= extremely poorly sorted

Skewness (measure of symmetry of grain-size distribution or presence of excess fine or coarse material)

<u>graphic skewness</u> = $\frac{\phi 16 + \phi 84 - 2\phi 50}{(\phi 84 - \phi 16)}$

<u>inclusive graphic skewness</u> = $\frac{\phi 16 + \phi 84 - 2\phi 50}{2(\phi 84 - \phi 16)} + \frac{\phi 5 + \phi 95 - 2\phi 50}{2(\phi 95 - \phi 5)}$;

best measure of symmetry (excess fines or coarse materials):

+1.0 to + 0.3 = strongly fine skewed

+0.3 to + 0.1 = fine skewed (excess fines)

+0.1 to - 0.1 = nearly symmetrical

-0.1 to - 0.3 - coarse skewed (excess coarse)

-0.3 to - 1.0 = strongly coarse skewed

Kurtosis (measure of peakedness of grain-size distribution).

$$\text{graphic kurtosis} = \frac{\phi 95 - \phi 5}{2.44\ (\phi 75 - \phi 25)}$$

LANDFILL 1/10

PHI	DIAMETER (MM)	WEIGHT (GRMS)	WEIGHT PERC	CUM PERC
-3.000000	8.000000	1.690	1.05054	1.0505
-2.000000	4.000000	4.340	2.69783	3.7484
-1.000000	2.000000	8.570	5.32728	9.0756
0.0	1.000000	11.950	7.42836	16.5040
1.000000	0.500000	18.070	11.23268	27.7367
2.000000	0.250000	22.100	13.73780	41.4745
3.000000	0.125000	30.400	18.89723	60.3717
4.000000	0.062500	27.200	16.90805	77.2797
5.000000	0.031000	36.550	22.72020	99.9999

```
LANDFILL 1/10
                                   WEIGHT(PERCENT)
                    0         10        20        30        40        50        60        70        80        90        100
                    I.........I.........I.........I.........I.........I.........I.........I.........I.........I.........I

-3.00000            .O

-2.00000            .***O

-1.00000            .*****   O

 0.0                .*******         O

 1.00000            .***********                O

 2.00000            .**************                          O

 3.00000            .*******************                                        O

 4.00000            .*****************                                                           O

 5.00000            .***********************                                                                            O
```

LANDFILL 1/10

STATISTICS

CUMULATIVE PERCENT	PHI VALUE
5.	-2.000
16.	-1.000
25.	0.0
50.	2.000
75.	3.000
84.	4.000
95.	4.000

ARITHMETIC MEAN DIAMETER = 0.6307805

MEDIAN = 2.00000

GRAPHIC MEAN = 1.66667

QUARTILE DEVIATION = 1.50000

GRAPHIC STANDARD DEVIATION = 2.50000

INCLUSIVE STANDARD DEVIATION = 2.15909

GTAPHIC SKEWNESS = -0.20000

INCLUSIVE GRAPHIC SKEWNESS = -0.266667

GRAPHIC KURTOSIS = 0.819672

LANDFILL 1/15-20

PHI	DIAMETER (MM)	WEIGHT (GRMS)	WEIGHT PERC	CUM PERC
-3.000000	8.000000	3.930	3.75969	3.7597
-2.000000	4.000000	11.170	10.68593	14.4456
-1.000000	2.000000	9.090	8.69607	23.1417
0.0	1.000000	12.100	11.57563	34.7173
1.000000	0.500000	13.120	12.55142	47.2687
2.000000	0.250000	14.150	13.53679	60.8055
3.000000	0.125000	14.660	14.02469	74.8302
4.000000	0.062500	11.350	10.85813	85.6883
5.000000	0.031000	14.960	14.31169	100.0000

LANDFILL 1/15-20

```
                                              WEIGHT(PERCENT)
              0         10        20        30        40        50        60        70        80        90        100
              I.........I.........I.........I.........I.........I.........I.........I.........I.........I.........I

 -3.00000     .***0

 -2.00000     .**********   0

 -1.00000     .*********          0

  0.0         .************                 0

  1.00000     .*************                          0

  2.00000     .**************                                     0

  3.00000     .**************                                                0

  4.00000     .***********                                                             0

  5.00000     .**************                                                                     0
```

LANDFILL 1/15-20

STATISTICS

CUMULATIVE PERCENT	PHI VALUE
5.	-3.000
16.	-2.000
25.	-1.000
50.	1.000
75.	3.000
84.	3.000
95.	4.000

ARITHMETIC MEAN DIAMETER = 1.2637367

MEDIAN = 1.00000

GRAPHIC MEAN = 0.66667

QUARTILE DEVIATION = 2.00000

GRAPHIC STANDARD DEVIATION = 2.50000

INCLUSIVE STANDARD DEVIATION = 2.31061

GTAPHIC SKEWNESS = -0.20000

INCLUSIVE GRAPHIC SKEWNESS = -0.171429

GRAPHIC KURTOSIS = 0.717213

LANDFILL 1/25-30

PHI	DIAMETER (MM)	WEIGHT (GRMS)	WEIGHT PERC	CUM PERC
-3.000000	8.000000	5.620	3.88443	3.8844
-2.000000	4.000000	3.840	2.65413	6.5386
-1.000000	2.000000	8.360	5.77827	12.3168
0.0	1.000000	14.560	10.06359	22.3804
1.000000	0.500000	21.030	14.53552	36.9159
2.000000	0.250000	24.320	16.80951	53.7254
3.000000	0.125000	25.600	17.69421	71.4197
4.000000	0.062500	16.820	11.62566	83.0453
5.000000	0.031000	24.530	16.95465	100.0000

```
LANDFILL 1/25-30
                              WEIGHT(PERCENT)
                    0         10        20        30        40        50        60        70        80        90        100
                    I.........I.........I.........I.........I.........I.........I.........I.........I.........I.........I

  -3.00000          .***0

  -2.00000          .***   0

  -1.00000          .******     0

   0.0              .**********          0

   1.00000          .***************                   0

   2.00000          .*****************                                  0

   3.00000          .*****************                                                  0

   4.00000          .************                                                                  0

   5.00000          .*****************                                                                               0
```

LANDFILL 1/25-30

STATISTICS

CUMULATIVE PERCENT	PHI VALUE
5.	-3.000
16.	-1.000
25.	0.0
50.	1.000
75.	3.000
84.	4.000
95.	4.000

ARITHMETIC MEAN DIAMETER = 0.7076033

MEDIAN = 1.00000

GRAPHIC MEAN = 1.33333

QUARTILE DEVIATION = 1.50000

GRAPHIC STANDARD DEVIATION = 2.50000

INCLUSIVE STANDARD DEVIATION = 2.31061

GRAPHIC SKEWNESS = 0.20000

INCLUSIVE GRAPHIC SKEWNESS = 0.028571

GRAPHIC KURTOSIS = 0.956284

LANDFILL 1/35-40

PHI	DIAMETER (MM)	WEIGHT (GRMS)	WEIGHT PERC	CUM PERC
-3.000000	8.000000	65.510	25.68816	25.6882
-2.000000	4.000000	32.340	12.68136	38.3695
-1.000000	2.000000	33.400	13.09701	51.4665
0.0	1.000000	21.360	8.37581	59.8423
1.000000	0.500000	24.180	9.48161	69.3239
2.000000	0.250000	24.530	9.61885	78.9428
3.000000	0.125000	21.230	8.32484	87.2676
4.000000	0.062500	13.810	5.41526	92.6828
5.000000	0.031000	18.660	7.31707	99.9999

LANDFILL 1/35-40

```
                                  WEIGHT(PERCENT)
             0         10        20        30        40        50        60        70        80        90        100
             I.........I.........I.........I.........I.........I.........I.........I.........I.........I.........I

-3.00000     .*************************O

-2.00000     .*************                       O

-1.00000     .*************                                    O

 0.0         .********                                                  O

 1.00000     .*********                                                          O

 2.00000     .**********                                                                   O

 3.00000     .********                                                                             O

 4.00000     .*****                                                                                      O

 5.00000     .*******                                                                                          O
```

LANDFILL 1/35-40

STATISTICS

CUMULATIVE PERCENT	PHI VALUE
5.	-3.000
16.	-3.000
25.	-3.000
50.	-2.000
75.	1.000
84.	2.000
95.	4.000

ARITHMETIC MEAN DIAMETER = 1.4107170

MEDIAN = -2.00000

GRAPHIC MEAN = -1.00000

QUARTILE DEVIATION = 2.00000

GRAPHIC STANDARD DEVIATION = 2.50000

INCLUSIVE STANDARD DEVIATION = 2.31061

GRAPHIC SKEWNESS = 0.60000

INCLUSIVE GRAPHIC SKEWNESS = 0.657143

GRAPHIC KURTOSIS = 0.717213

LANDFILL 1/55-60

PHI	DIAMETER (MM)	WEIGHT (GRMS)	WEIGHT PERC	CUM PERC
-3.000000	8.000000	3.870	2.34588	2.3459
-2.000000	4.000000	5.150	3.12178	5.4677
-1.000000	2.000000	7.050	4.27350	9.7412
0.0	1.000000	7.320	4.43717	14.1783
1.000000	0.500000	11.550	7.00127	21.1796
2.000000	0.250000	25.100	15.21489	36.3945
3.000000	0.125000	52.580	31.87247	68.2670
4.000000	0.062500	38.390	23.27089	91.5378
5.000000	0.031000	13.960	8.46215	100.0000

```
LANDFILL 1/55-60
                                   WEIGHT(PERCENT)
                    0         10        20        30        40        50        60        70        80        90        100
                    I.........I.........I.........I.........I.........I.........I.........I.........I.........I.........I

     -3.00000       .*0

     -2.00000       .*** 0

     -1.00000       .****     0

      0.0           .****         0

      1.00000       .*******             0

      2.00000       .***************                    0

      3.00000       .********************************                                   0

      4.00000       .***********************                                                                    0

      5.00000       .********                                                                                           0
```

LANDFILL 1/55-60

STATISTICS

CUMULATIVE PERCENT	PHI VALUE
5.	-3.000
16.	0.0
25.	1.000
50.	2.000
75.	3.000
84.	3.000
95.	4.000

ARITHMETIC MEAN DIAMETER = 0.5771676

MEDIAN = 2.00000

GRAPHIC MEAN = 1.66667

QUARTILE DEVIATION = 1.00000

GRAPHIC STANDARD DEVIATION = 1.50000

INCLUSIVE STANDARD DEVIATION = 1.81061

GTAPHIC SKEWNESS = -0.33333

INCLUSIVE GRAPHIC SKEWNESS = -0.380952

GRAPHIC KURTOSIS = 1.434426

LANDFILL 1/75-80

PHI	DIAMETER (MM)	WEIGHT (GRMS)	WEIGHT PERC	CUM PERC
-3.000000	8.000000	23.800	21.65802	21.6580
-2.000000	4.000000	7.670	6.97971	28.6377
-1.000000	2.000000	4.590	4.17690	32.8146
0.0	1.000000	6.850	6.23351	39.0481
1.000000	0.500000	13.840	12.59442	51.6425
2.000000	0.250000	17.560	15.97962	67.6221
3.000000	0.125000	17.340	15.77942	83.4016
4.000000	0.062500	10.000	9.10001	92.5016
5.000000	0.031000	8.240	7.49841	100.0000

LANDFILL 1/75-80

```
                                  WEIGHT(PERCENT)
                0         10        20        30        40        50        60        70        80        90        100
                I.........I.........I.........I.........I.........I.........I.........I.........I.........I.........I

-3.00000        .*********************O

-2.00000        .*******                     O

-1.00000        .****                            O

0.0             .******                                O

1.00000         .*************                                      O

2.00000         .****************                                                   O

3.00000         .****************                                                                  O

4.00000         .*********                                                                                   O

5.00000         .*******                                                                                            O
```

LANDFILL 1/75-80

STATISTICS

CUMULATIVE PERCENT	PHI VALUE
5.	-3.000
16.	-3.000
25.	-3.000
50.	0.0
75.	2.000
84.	3.000
95.	4.000

ARITHMETIC MEAN DIAMETER = 0.8335965

MEDIAN = 0.0

GRAPHIC MEAN = 0.0

QUARTILE DEVIATION = 2.50000

GRAPHIC STANDARD DEVIATION = 3.00000

INCLUSIVE STANDARD DEVIATION = 2.56061

GTAPHIC SKEWNESS = -0.0

INCLUSIVE GRAPHIC SKEWNESS = 0.071429

GRAPHIC KURTOSIS = 0.573771

LANDFILL 2/5-10

PHI	DIAMETER (MM)	WEIGHT (GRMS)	WEIGHT PERC	CUM PERC
-3.000000	8.000000	21.720	11.91508	11.9151
-2.000000	4.000000	12.620	6.92303	18.8331
-1.000000	2.000000	8.760	4.80553	23.6436
0.0	1.000000	7.060	3.87295	27.5166
1.000000	0.500000	9.900	5.43091	32.9475
2.000000	0.250000	31.760	17.42278	50.3702
3.000000	0.125000	44.640	24.48843	74.3587
4.000000	0.062500	21.320	11.69565	86.5543
5.000000	0.031000	24.510	13.44561	99.9999

LANDFILL 2/5-10

```
                                       WEIGHT(PERCENT)
                0         10        20        30        40        50        60        70        80        90        100
                I.........I.........I.........I.........I.........I.........I.........I.........I.........I.........I

 -3.00000       .***********0

 -2.00000       .*******            0

 -1.00000       .*****                   0

  0.0           .****                        0

  1.00000       .*****                             0

  2.00000       .*****************                                 0

  3.00000       .**************************                                                 0

  4.00000       .*************                                                                           0

  5.00000       .**************                                                                                       0
```

LANDFILL 2/5-10

STATISTICS

CUMULATIVE PERCENT	PHI VALUE
5.	-3.000
16.	-3.000
25.	-1.000
50.	1.000
75.	3.000
84.	3.000
95.	4.000

ARITHMETIC MEAN DIAMETER = 0.7868749

MEDIAN = 1.00000

GRAPHIC MEAN = 0.33333

QUARTILE DEVIATION = 2.00000

GRAPHIC STANDARD DEVIATION = 3.00000

INCLUSIVE STANDARD DEVIATION = 2.56061

GRAPHIC SKEWNESS = -0.33333

INCLUSIVE GRAPHIC SKEWNESS = -0.238095

GRAPHIC KURTOSIS = 0.717213

LANDFILL 2/20-25

PHI	DIAMETER (MM)	WEIGHT (GRMS)	WEIGHT PERC	CUM PERC
-3.000000	8.000000	28.500	15.99596	15.9960
-2.000000	4.000000	24.100	13.52641	29.5224
-1.000000	2.000000	18.450	10.35528	39.8776
0.0	1.000000	21.330	11.97171	51.8493
1.000000	0.500000	35.740	20.05949	71.9088
2.000000	0.250000	27.460	15.41225	87.3211
3.000000	0.125000	14.150	7.94185	95.2629
4.000000	0.062500	4.000	2.24505	97.5080
5.000000	0.031000	4.440	2.49200	100.0000

LANDFILL 2/20-25

```
                                              WEIGHT(PERCENT)
             0         10        20        30        40        50        60        70        80        90        100
             I.........I.........I.........I.........I.........I.........I.........I.........I.........I.........I

 -3.00000    .***************0

 -2.00000    .**************               O

 -1.00000    .**********                             O

  0.0        .************                                       O

  1.00000    .********************                                                   O

  2.00000    .***************                                                                       O

  3.00000    .********                                                                                     O

  4.00000    .**                                                                                              O

  5.00000    .**                                                                                                O
```

LANDFILL 2/20-25

STATISTICS

CUMULATIVE PERCENT	PHI VALUE
5.	-3.000
16.	-3.000
25.	-3.000
50.	-1.000
75.	1.000
84.	1.000
95.	2.000

ARITHMETIC MEAN DIAMETER = 1.5282202
MEDIAN = -1.00000
GRAPHIC MEAN = -1.00000
QUARTILE DEVIATION = 2.00000
GRAPHIC STANDARD DEVIATION = 2.00000
INCLUSIVE STANDARD DEVIATION = 1.75758
GTAPHIC SKEWNESS = -0.0
INCLUSIVE GRAPHIC SKEWNESS = 0.100000
GRAPHIC KURTOSIS = 0.512295

LANDFILL 2/30-35

PHI	DIAMETER (MM)	WEIGHT (GRMS)	WEIGHT PERC	CUM PERC
-3.000000	8.000000	76.370	47.98917	47.9892
-2.000000	4.000000	10.550	6.62938	54.6185
-1.000000	2.000000	7.740	4.86364	59.4822
0.0	1.000000	9.810	6.16438	65.6456
1.000000	0.500000	22.000	13.82431	79.4709
2.000000	0.250000	22.430	14.09451	93.5654
3.000000	0.125000	7.760	4.87621	98.4416
4.000000	0.062500	1.590	0.99912	99.4407
5.000000	0.031000	0.890	0.55926	99.9999

LANDFILL 2/30-35

```
                                          WEIGHT(PERCENT)
                      0         10        20        30        40        50        60        70        80        90        100
                      I.........I.........I.........I.........I.........I.........I.........I.........I.........I.........I

   -3.00000           .***********************************************O

   -2.00000           .*******                                               O

   -1.00000           .*****                                                     O

    0.0               .******                                                           O

    1.00000           .**************                                                                O

    2.00000           .**************                                                                               O

    3.00000           .*****                                                                                           O

    4.00000           .*                                                                                                O

    5.00000           .*                                                                                                 O
```

LANDFILL 2/30-35

STATISTICS

CUMULATIVE PERCENT	PHI VALUE
5.	-3.000
16.	-3.000
25.	-3.000
50.	-3.000
75.	0.0
84.	1.000
95.	2.000

ARITHMET IC MEAN DIAMETER = 0.8030149

MEDIAN = -3.00000

GRAPHIC MEAN = -1.66667

QUARTILE DEVIATION = 1.50000

GRAPHIC STANDARD DEVIATION = 2.00000

INCLUSIVE STANDARD DEVIATION = 1.75758

GTAPHIC SKEWNESS = 1.00000

INCLJSIVE GRAPHIC SKEWNESS = 1.000000

GRAPHIC KURTOSIS = 0.683060

LANDFILL 2/45-50

PHI	DIAMETER (MM)	WEIGHT (GRMS)	WEIGHT PERC	CUM PERC
-3.000000	8.000000	19.560	13.86841	13.8684
-2.000000	4.000000	7.570	5.36727	19.2357
-1.000000	2.000000	9.250	6.55842	25.7941
0.0	1.000000	14.180	10.05389	35.8480
1.000000	0.500000	34.740	24.63132	60.4793
2.000000	0.250000	39.280	27.85025	88.3295
3.000000	0.125000	12.380	8.77765	97.1072
4.000000	0.062500	2.700	1.91435	99.0215
5.000000	0.031000	1.380	0.97845	100.0000

LANDFILL 2/45-50

```
                                   WEIGHT(PERCENT)
                0        10        20        30        40        50        60        70        80        90        100
                I.........I.........I.........I.........I.........I.........I.........I.........I.........I.........I

 -3.00000       .************O

 -2.00000       .*****            O

 -1.00000       .*******                 O

  0.0           .**********                        O

  1.00000       .************************                                O

  2.00000       .***************************                                                 O

  3.00000       .*********                                                                            O

  4.00000       .**                                                                                    O

  5.00000       .*                                                                                      O
```

LANDFILL 2/45-50

STATISTICS

CUMULATIVE PERCENT	PHI VALUE
5.	-3.000
16.	-3.000
25.	-2.000
50.	0.0
75.	1.000
84.	1.000
95.	2.000

ARITHMETIC MEAN DIAMETER = 0.9774800

MEDIAN = 0.0

GRAPHIC MEAN = -0.66667

QUARTILE DEVIATION = 1.50000

GRAPHIC STANDARD DEVIATION = 2.00000

INCLUSIVE STANDARD DEVIATION = 1.75758

GTAPHIC SKEWNESS = -0.50000

INCLUSIVE GRAPHIC SKEWNESS = -0.350000

GRAPHIC KURTOSIS = 0.683060

LANDFILL 2/65-70

PHI	DIAMETER (MM)	WEIGHT (GRMS)	WEIGHT PERC	CUM PERC
-3.000000	8.000000	100.710	42.30801	42.3080
-2.000000	4.000000	10.660	4.47824	46.7862
-1.000000	2.000000	12.030	5.05377	51.8400
0.0	1.000000	15.660	6.57873	58.4187
1.000000	0.500000	34.410	14.45556	72.8743
2.000000	0.250000	43.230	18.16080	91.0351
3.000000	0.125000	16.330	6.86019	97.8953
4.000000	0.062500	3.520	1.47874	99.3740
5.000000	0.031000	1.490	0.62595	99.9999

LANDFILL 2/65-70

```
                             WEIGHT(PERCENT)
              0        10        20        30        40        50        60        70        80        90       100
              I.........I.........I.........I.........I.........I.........I.........I.........I.........I.........I

  -3.00000    .*****************************************O

  -2.00000    .****                                          O

  -1.00000    .*****                                              O

   0.0        .*******                                                  O

   1.00000    .**************                                                          O

   2.00000    .******************                                                                        O

   3.00000    .*******                                                                                          O

   4.00000    .*                                                                                                 O

   5.00000    .*                                                                                                  O
```

LANDFILL 2/65-70

STATISTICS

CUMULATIVE PERCENT	PHI VALUE
5.	-3.000
16.	-3.000
25.	-3.000
50.	-2.000
75.	1.000
84.	1.000
95.	2.000

ARITHMETIC MEAN DIAMETER = 0.7100493

MEDIAN = -2.00000

GRAPHIC MEAN = -1.33333

QUARTILF DEVIATION = 2.00000

GRAPHIC STANDARD DEVIATION = 2.00000

INCLUSIVE STANDARD DEVIATION = 1.75758

GTAPHIC SKEWNESS = 0.50000

INCLUSIVE GRAPHIC SKEWNESS = 0.550000

GRAPHIC KURTOSIS = 0.512295

LANDFILL 2/75-80

PHI	DIAMETER (MM)	WEIGHT (GRMS)	WEIGHT PERC	CUM PERC
-3.000000	8.000000	6.900	4.05310	4.0531
-2.000000	4.000000	11.530	6.77279	10.8259
-1.000000	2.000000	16.260	9.55122	20.3771
0.0	1.000000	26.480	15.55451	35.9316
1.000000	0.500000	43.230	25.39354	61.3251
2.000000	0.250000	47.820	28.08975	89.4149
3.000000	0.125000	13.730	8.06508	97.4800
4.000000	0.062500	2.830	1.66236	99.1423
5.000000	0.031000	1.460	0.85761	99.9999

LANDFILL 2/75-80

```
                                          WEIGHT(PERCENT)
               0         10        20        30        40        50        60        70        80        90        100
               I.........I.........I.........I.........I.........I.........I.........I.........I.........I.........I

-3.00000       .***O

-2.00000       .*******   O

-1.00000       .**********         O

 0.0           .****************                   O

 1.00000       .*************************                                   O

 2.00000       .****************************                                                            O

 3.00000       .********                                                                                        O

 4.00000       .**                                                                                                O

 5.00000       .*                                                                                                  O
```

LANDFILL 2/75-80 STATISTICS

CUMULATIVE PERCENT	PHI VALUE
5.	-3.000
16.	-2.000
25.	-1.000
50.	0.0
75.	1.000
84.	1.000
95.	2.000

ARITHMETIC MEAN DIAMETER = 1.2390900

MEDIAN = 0.0

GRAPHIC MEAN = -0.33333

QUARTILE DEVIATION = 1.00000

GRAPHIC STANDARD DEVIATION = 1.50000

INCLUSIVE STANDARD DEVIATION = 1.50758

GTAPHIC SKEWNESS = -0.33333

INCLUSIVE GRAPHIC SKEWNESS = -0.266667

GRAPHIC KURTOSIS = 1.024590

LANDFILL 2/90-95

PHI	DIAMETER (MM)	WEIGHT (GRMS)	WEIGHT PERC	CUM PERC
-3.000000	8.000000	1.850	1.38432	1.3843
-2.000000	4.000000	6.450	4.82640	6.2107
-1.000000	2.000000	11.370	8.50793	14.7186
0.0	1.000000	13.240	9.90721	24.6259
1.000000	0.500000	30.180	22.58305	47.2089
2.000000	0.250000	39.230	29.35498	76.5639
3.000000	0.125000	18.410	13.77582	90.3397
4.000000	0.062500	6.710	5.02095	95.3607
5.000000	0.031000	6.200	4.63933	100.0000

```
LANDFILL  2/90-95
                                WEIGHT(PERCENT)
            0         10        20        30        40        50        60        70        80        90        100
            I.........I.........I.........I.........I.........I.........I.........I.........I.........I.........I

-3.00000    .0

-2.00000    .*****0

-1.00000    .*********      0

 0.0        .**********               0

 1.00000    .***********************                        0

 2.00000    .******************************                                               0

 3.00000    .**************                                                                            0

 4.00000    .*****                                                                                          0

 5.00000    .*****                                                                                              0
```

LANDFILL 2/90-95

STATISTICS

CUMULATIVE PERCENT	PHI VALUE
5.	-3.000
16.	-1.000
25.	0.0
50.	1.000
75.	1.000
84.	2.000
95.	3.000

ARITHMETIC MEAN DIAMETER = 1.0055885

MEDIAN = 1.00000

GRAPHIC MEAN = 0.66667

QUARTILE DEVIATION = 0.50000

GRAPHIC STANDARD DEVIATION = 1.50000

INCLUSIVE STANDARD DEVIATION = 1.65909

GTAPHIC SKEWNESS = -0.33333

INCLUSIVE GRAPHIC SKEWNESS = -0.333333

GRAPHIC KURTOSIS = 2.459017

STOP 0

/8

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Appendix B

Trilinear Plot of Dissolved Solids

EXPLANATION

The total dissolved solids contents of the water samples were plotted on a trilinear diagram to permit their comparison and classification. Trilinear diagrams consist of 3 parts: 2 triangular fields and a diamond-shaped field. The triangular fields depict the distribution of cations and anions separately, whereas, the diamond-shaped field shows the combined chemistry of the water. Each sample is thus represented by 3 points on the trilinear diagram, 1 in each of the 3 parts. Points in the cation and anion fields are located on the basis of percentage of specific ions. Points on the diamond field are located at the intersection of lines projected, parallel to percentage boundaries, from the cation and anion triangles (see points plotted for "P" in accompanying diagram).

In making trilinear plots, the concentrations of dissolved solids are converted from parts per million values (as used in Table 4) to a value which better reflects the true chemical character of the water, equivalents per million (epm). The epm value is obtained as follows:

$$\text{epm} = \frac{\text{ppm of ion}}{\text{equivalent weight of ion}} \quad \text{and}$$

$$\text{equivalent wt.} = \frac{\text{atomic weight of ion}}{\text{chemical valence of ion}}$$

The conversion of ppm to epm in this study was done by computer. The accompanying table is a Xerox reduction of the printout sheet giving epm values and computed percentages for each ion. The trilinear diagram given here was prepared from these data.

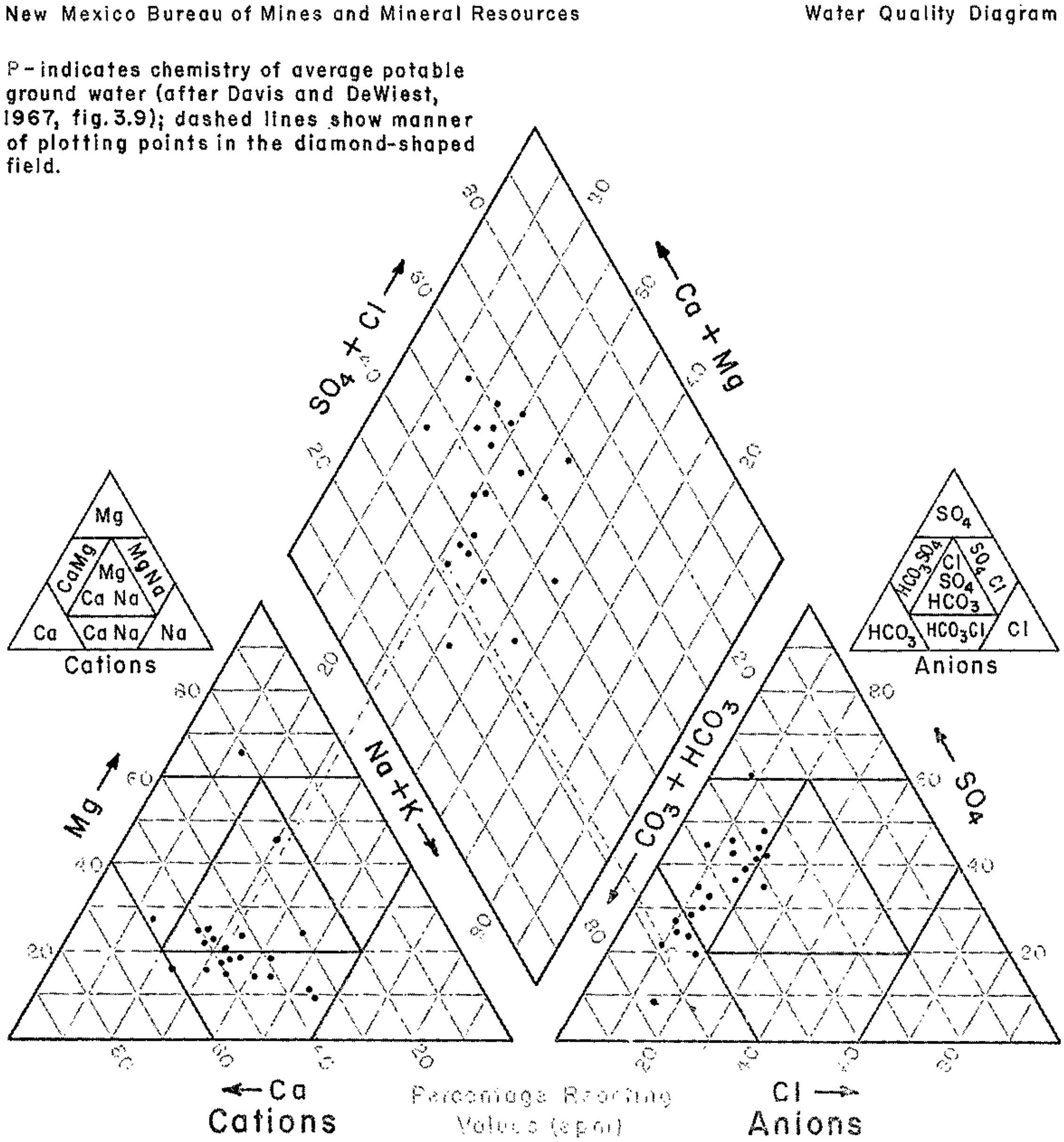
Waters from different aquifers may plot in distinctly different portions of the trilinear diagram. The waters involved in this study, however, all come from essentially the same (single) aquifer and thus plot in about the same region on each part of the diagram.

Ground waters may be classified on the basis of dissolved constituents. To facilitate this, the cation and anion triangles in the trilinear diagram are subdivided into smaller fields, corresponding to dominant ions in the water. These subdivisions are used in classifying the water (see small triangles at sides of the diagram); a water is assigned a name from first the cation triangle and then another from the anion triangle. The waters in the vicinity of the Socorro land fill would be classified as calcium-sodium-magnesium-sulfate-bicarbonate waters.

DATA REDUCTION FOR PIPER DIAGRAM

WELL	CATION FIELD RAW DATA (EPM) CA	MG	NA + K	TOTAL-C	PERCENTAGES CA	MG	NA+K	ANION FIELD RAW DATA (EPM) CO3+HCO3	SO4	CL	TOTAL-A	PERCENTAGES CO3+HCO3	SO4	CL
1	2.960	0.806	4.767	8.533	34.689	9.446	55.865	4.120	3.720	0.592	8.432	48.861	44.118	7.021
2	1.550	0.494	1.172	3.216	48.197	15.361	36.443	2.103	0.895	0.378	3.376	62.293	26.511	11.197
3	6.190	2.800	1.613	10.603	58.380	26.408	15.213	4.430	3.640	2.650	10.720	41.325	33.955	24.720
4	4.740	2.300	3.117	10.157	46.667	22.644	30.688	3.503	4.960	1.830	10.293	34.033	48.188	17.779
5	1.850	6.180	1.136	9.166	20.183	67.423	12.394	2.040	1.100	0.479	3.619	56.369	30.395	13.236
6	2.000	0.567	1.205	3.772	53.022	15.032	31.946	2.040	1.230	0.423	3.693	55.240	33.306	11.454
7	1.250	0.592	1.294	3.136	39.860	18.878	41.263	1.920	0.604	0.536	3.060	62.745	19.739	17.516
9	2.300	0.822	2.175	5.297	43.421	15.518	41.061	4.040	0.479	0.818	5.337	75.698	8.975	15.327
10	4.290	1.850	3.421	9.561	44.870	19.349	35.781	3.840	4.020	1.161	9.021	42.567	44.563	12.870
11	4.940	1.550	5.203	11.693	42.247	13.256	44.497	4.650	4.750	2.260	11.660	39.880	40.738	19.383
12	2.300	1.730	3.523	7.553	30.451	22.905	46.644	2.240	4.500	0.705	7.445	30.087	60.443	9.469
13	2.941	1.230	1.732	5.903	48.957	21.196	29.847	2.200	2.170	1.270	5.640	39.007	38.475	22.518
14	2.450	1.230	1.392	5.072	48.304	24.251	27.445	2.200	2.020	0.931	5.151	42.710	39.216	18.074
15	3.290	1.560	1.665	6.515	50.499	23.945	25.556	2.470	2.580	1.180	6.230	39.647	41.413	18.941
16	1.750	0.987	1.387	4.124	42.435	23.933	33.632	2.390	1.170	0.536	4.096	58.350	28.564	13.086
17	1.800	0.699	1.374	3.873	46.476	18.048	35.476	2.360	0.874	0.536	3.770	62.599	23.183	14.218
18	1.800	0.683	1.242	3.725	48.322	18.336	33.342	2.470	0.812	0.367	3.649	67.690	22.253	10.058
19	3.140	1.320	1.732	6.192	50.711	21.318	27.972	2.800	2.660	0.818	6.278	44.600	42.370	13.030
20	1.300	0.411	2.718	3.929	33.087	10.461	56.452	2.390	0.958	0.479	3.827	62.451	25.033	12.516
21	2.790	1.170	1.827	5.787	48.212	20.218	31.571	3.080	1.850	0.874	5.804	53.067	31.875	15.059
22	4.990	1.400	1.890	8.280	60.266	16.908	22.826	3.610	2.870	1.470	7.950	45.409	36.101	18.491

65



Trilinear plot of dissolved solids encountered in ground waters of Socorro landfill study area