New Mexico Bureau of Mines and Mineral Resources

Open-File Report 338

RECHARGE AT THE VEGUITA LANDFILL SITE, SOCORRO COUNTY, NEW MEXICO

by

William J. Stone
Senior Hydrogeologist

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SEE ADDENDUM

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INTRODUCTION

When the northern Socorro County landfill opposite the Veguita Store neared capacity in 1985, Socorro and Valencia Counties acquired approximately 75 acres of land south of Veguita to serve as a new facility for the adjacent portions of the two counties. The site lies in the Casa Colorada Grant. If the land grid is projected into the site, it occupies the northern parts of Sections 16 and 17, Township 3 North, Range 2 East (Figure 1).

In response to a suit brought against the counties by some of the adjacent land owners, a site characterization study was called for by Socorro County. The work was performed under contract by John W. Shomaker, Inc. of Albuquerque. As a supplement to that evaluation, pre-development ground-water recharge was evaluated by the New Mexico Bureau of Mines and Mineral Resources. The purpose of the recharge study was to determine the average long-term rate at which water has moved downward at the site, under the influence of precipitation alone. This report gives the results of the Bureau's recharge investigation.

REGIONAL SETTING

The Veguita site is situated in the Albuquerque-Belen structural Basin within the Mexican Highlands Section of the Basin and Range physiographic province. More specifically, it lies at the western edge of the Llano de Manzano, the broad upland surface extending from the Manzano Uplift westward to the Rio Grande Valley (Machette, 1978). The site overlooks the valley from a position averaging approximately 140 ft above the river.

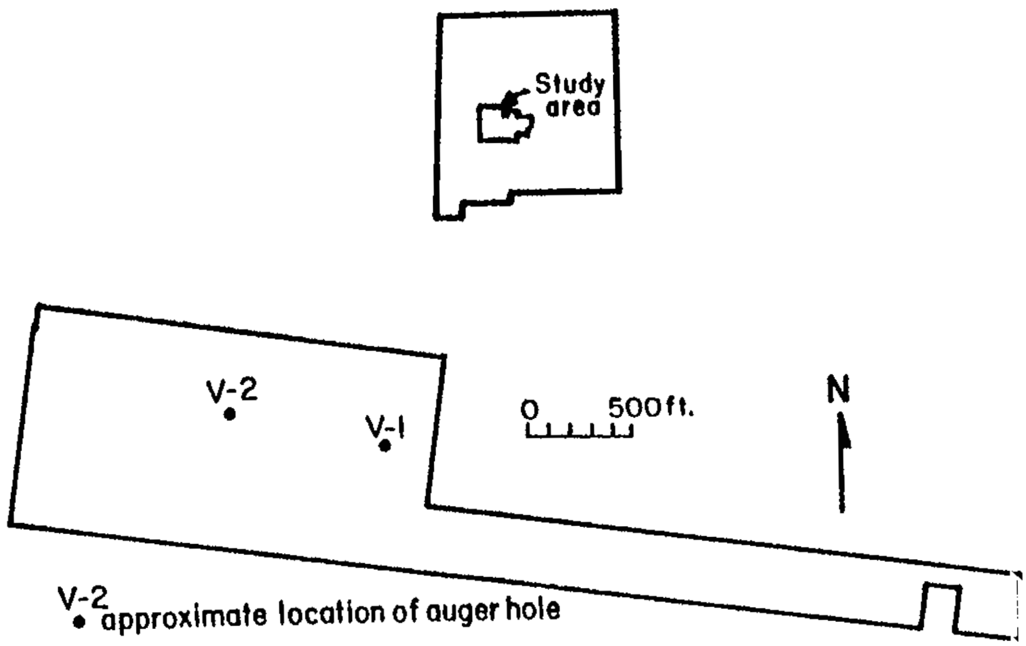


Figure 1. Location of Veguita study area and auger holes.

A veneer (lag) of coarse gravel lies at the surface on the higher divide areas of the property. Beneath this are unconsolidated sediments of the Santa Fe Formation (Tertiary). Figure 2 and the Appendix show that the upper 99 ft of this unit consists of clay, silty clay, silty sand, sand, and gravelly sand. These materials represent deposition in stream channels, floodplains, temporary lakes, as well as dune fields. Thickness of the Santa Fe in this vicinity is approximately 2,000 ft, based on an oil well north of the site (Kelley, 1977, Figure 20, cross-section D-D').

Data presented by Spiegel (1955) suggest the water table lies at depths of 70-125 ft below the property and that ground-water flow is southwesterly toward the river. A hydraulic gradient of 5-15 ft/mi is indicated. Although Spiegel (1955) gave no chemical analyses for water in this township, he reported that water from two wells had a sulfate taste.

METHODS

Recharge was determined by the chloride mass-balance method. In this relatively simple and inexpensive procedure, it is assumed that

$$P \cdot Clp = R \cdot Clsw$$

where,

P = average annual precipitation (in/yr), Clp = annual chloride input via precipitation (mg/L), R = recharge rate (in/yr), Clsw = average soil-water chloride content below the root zone (mg/L). Rewritten for recharge this becomes

$$R = (P \cdot Clp)/Clsw.$$

P and Clp are either obtained from the literature or by

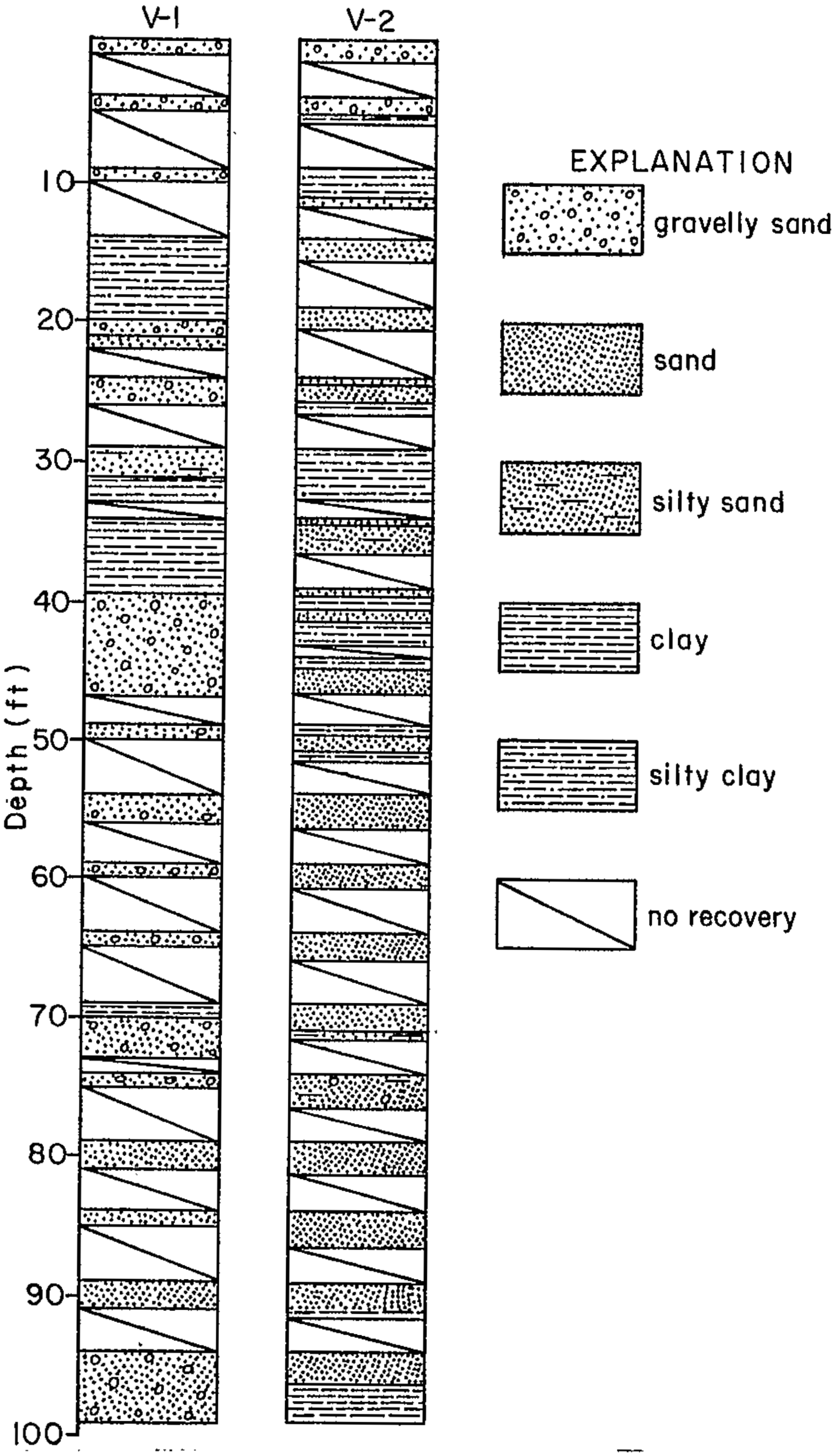


Figure 2. Lithologic logs for Veguita auger holes.

measurements made on site. Clsw is determined from samples of the unsaturated zone (above the water table).

Preliminary tests suggest the general lab procedures used are valid (McGurk and Stone, 1985). The method has been widely used in arid settings (Allison and Hughes, 1978; Allison and others, 1985; Stone, 1986).

SAMPLING

Samples of the unsaturated zone were taken at two sites by means of coring with a hollow-stem auger rig. More specifically, a CME-55 continuous sampling system with a 5-ft split barrel was hired for the work. Each 5-ft core at Hole V-1 was subsampled at 1-ft intervals for the recharge study. Samples were taken in 1-oz screw-top, plastic jars. To prevent moisture loss, these were also sealed with plastic electrical tape, placed in zip-top plastic bags, and stored out of the sun. Cores at Hole V-2 were taken in acrylic liners for permeability tests (see Shomaker's report).

In the case of incomplete recovery, it was assumed for consistency that the partial core was obtained, then the barrel became plugged. Thus, the core obtained was routinely assigned to the upper part of the interval drilled. For example, if only 3 ft were recovered in the interval 10-15 ft, the core was assigned to a depth of 10-13 ft.

ANALYSIS

Various steps are necessary in order to determine Clsw. First, moisture content of each sample is determined gravimetrically. In other words, each sample is weighed as it comes from the field, oven dried to remove moisture, then weighed again. The weight loss is attributed to moisture content. Next, samples are shaken gently with a known volume of deionized water to remobilize the salt (chloride). The resulting solution is decanted off and its chloride content measured with a pH meter and chloride electrode. The chloride content of the original soil water (Cl) in each sample is calculated using

$$Cl = (Cle \cdot W/Sd)/(Sw-Sd/Sd-J) \cdot Db$$

where, Cle = chloride content of the extract (mg/L), W = weight of water added in extraction (g), Sd = dry weight of the sample (g), Sw = wet weight of the sample (g), J = weight of the jar (g) and Db is the bulk density of the sample (approximately 1.5).

Once Cl values are calculated for each sample, they are plotted versus depth. A typical plot is characterized by a chloride peak near the surface corresponding to the root zone. Plants take up water but leave salts behind. This accumulates over time to produce the chloride peak. For every volume of water that comes in, through precipitation/infiltration, an equivalent volume of water moves downward by piston flow. In most storms there is rarely enough precipitation to displace any water out of the root zone. However, intense storms do result in deep percolation/displacement. This shows up as lower chloride values below the peak. Only these are used to determine Clsw.

RESULTS

In spite of partial recovery due to plugging of the core barrel, enough samples were obtained. Chloride content of the soil water varies from less than 1 to just over 115 mg/L (Table 1).

Table 1. Results of chloride analyses, Veguita Hole V-1.

Sample No.	Sample Depth (ft)	Moist. Content (cu.m/cu.m)	Dry Wt. Soil (gm)	Wt. Wtr. Added (gm)	Cl in Extract (ppm)	Cl in Soil Wtr. (mg/l)
1	1.00	1.52	54.69	81.03	3.90	3.80
2	5.00	0.61	59.48	75.25	5.20	10.78
3	10.00	4.24	36.82	81.79	220.00	115.26
4	15.00	3.76	32.67	80.57	140.00	91.83
5	16.00	4.22	40.18	80.58	190.00	90.29
6	17.00	3.68	42.90	81.21	180.00	92.59
7	18.00	5.10	44.19	80.28	240.00	85.49
8	19.00	2.52	44.09	80.89	90.00	65.52
9	20.00	1.64	49.73	80.69	28.00	27.70
10	21.00	0.43	54.05	81.65	10.10	35.48
11	22.00	2.09	48.04	80.86	60.00	48.32
12	25.00	0.59	47.66	80.72	4.00	11.48
13	26.00	2.80	39.88	80.81	6.80	4.92
14	30.00	1.33	48.70	80.38	3.40	4.22
15	31.00	2.94	43.82	81.62	10.00	6.34
16	32.00	6.29	36.31	81.13	7.00	2.49
17	33.00	5.46	34.69	80.29	7.20	3.05
18	35.00	6.62	35.62	81.48	8.00	2.76
19	36.00	6.00	33.42	81.71	7.60	3.10
20	37.00	6.52	34.50	82.26	9.00	3.29
21	38.00	7.50	32.23	80.73	10.10	3.37
22	39.00	6.73	33.94	80.81	8.20	2.90
23	40.00	1.68	45.48	81.63	4.40	4.70
24	41.00	2.30	40.13	80.07	4.10	3.56
25	42.00	2.35	48.37	79.75	5.20	3.65
26	43.00	3.09	45.12	81.02	5.20	3.02
27	44.00	3.62	42.93	79.80	4.40	2.26
28	45.00	1.82	53.46	80.32	3.50	2.89
29	46.00	0.64	48.35	81.41	3.30	8.68
30	47.00	3.72	44.40	81.31	3.80	1.87
32	55.00	0.65	53.61	79.49	4.00	9.12
33	56.00	0.36	49.69	80.48	6.80	30.59
34	60.00	0.90	57.53	80.62	4.40	6.85
35	65.00	0.87	50.62	80.42	3.50	6.39
36	70.00	3.55	37.51	80.42	4.80	2.90
37	71.00	7.70	28.88	81.76	4.60	1.69
38	72.00	3.57	46.02	79.74	4.40	2.14
39	73.00	1.54	51.49	81.48	6.40	6.58
40	75.00	1.97	50.10	79.49	6.40	5.15
41	80.00	2.23	41.81	79.71	3.70	3.16
42	81.00	2.04	44.93	79.81	6.40	5.57
43	85.00	1.73	52.36	81.09	5.60	5.01
44	90.00	1.48	49.90	80.18	4.40	4.78
45	91.00	1.59	45.59	80.45	3.80	4.22
46	95.00	10.69	32.49	79.80	4.50	1.03
47	96.00	10.92	28.74	81.00	4.00	1.03
48	97.00	10.90	25.89	81.04	4.20	1.21
49	98.00	11.92	28.85	80.52	4.60	1.08
50	99.00	9.42	40.18	80.95	3.30	0.71

Moisture content is generally less than 5 cu. m/cu. m, except between 30 and 40 ft and below 95 ft.

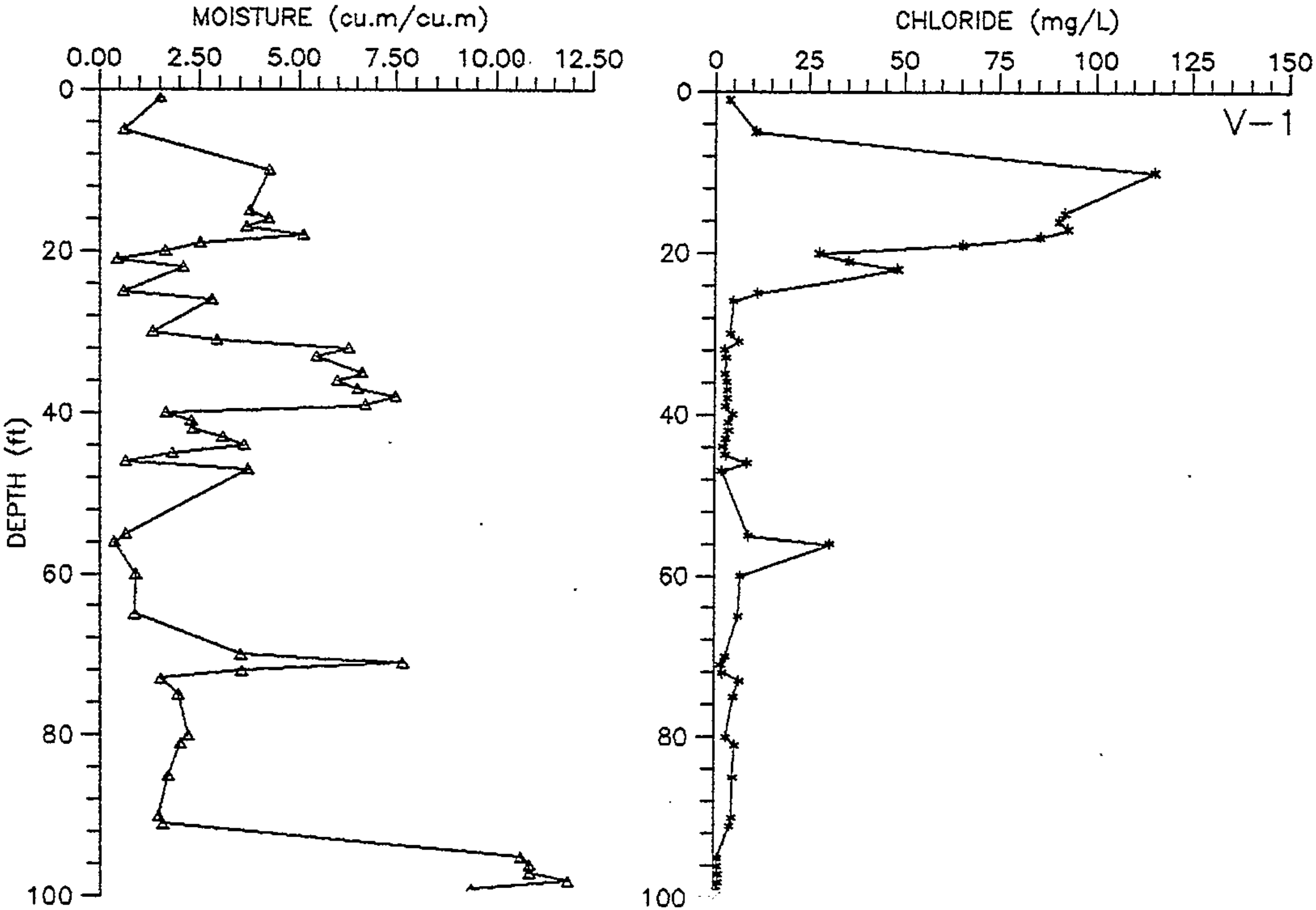
The chloride profile obtained is typical, with a shallow bulge representing the root zone and lower values below that (Figure 3). A secondary peak of 30 mg/L occurs at a depth of 56 ft. A Clsw of nearly 5 mg/L is obtained.

Published values for P and Clp were used in the recharge calculation. The value of 8.18 in/yr used for P comes from Sabinal, approximately 3 mi west of the site (Gabin and Lesperance, 1977). The value of 0.37 mg/L used for Clp comes from Socorro, approximately 30 mi to the south (Phillips and others, 1984).

The mass-balance equation gives a recharge rate of approximately 0.7 in/yr. This is slightly higher than values reported previously for New Mexico (Stone, 1986). This is to be expected in view of the sandy texture of most of the material at this site (Santa Fe Formation). It is a reasonable baseline value for deep percolation driven by precipitation alone. It should be noted that the recharge rate given above is a long-term average. It may include input from wetter conditions in the geologic past.

CONCLUSIONS

Deep percolation rate after the landfill is in operation should not be appreciably higher. The aridity and presumed lack of liquid waste should essentially preclude the development of a leachate at the Veguita site. As an additional precaution, trenches should be covered with relatively impermeable material



P = 8.18 (in/yr)
Clp = 0.37 (mg/L)

CLSW = 4.68 (mg/L)
R = 0.66 (in/yr)

Figure 3. Chloride and moisture vs depth profiles, Veguita Hole V-1.

when filled to hinder infiltration/leachate formation. Additionally runoff (including arroyo flow) should be diverted from reaching the fill and trenches.

If a leachate should somehow develop, its migration would be controlled by the texture of the materials below the trench. Unsaturated flow behaves just the opposite of saturated flow (Winograd, 1974). Under saturated conditions, coarse intervals (sand and gravel) are high-flow pathways. By contrast, such materials are barriers to unsaturated flow. Under unsaturated conditions flow is greatest through fine intervals (clay and silt).

Conceptually, a leachate would thus move downward until it encountered either a sufficiently coarse horizon, where it would stop, or a sufficiently fine horizon, along which it would migrate laterally until it ran out of fluid or the horizon ended/changed. The interbeds of silty sand, silty clay, and clay beneath the site (Figure 2, Table 3, and Appendix) should cause any leachate that might develop to move more laterally than vertically. The thickness of the silty clay at the bottom of Hole V-2 (Table 3) is not known as drilling stopped within it, but other beds on the order of 6-7 ft were penetrated. Such material would slow the downward progress of any leachate plume that might develop.

In view of the results of this study and the present landfill regulations, the Veguita site is deemed suitable for solid waste disposal. With proper management it should provide no threat to local ground-water quality.

Table 3. Analysis of basal clay, Hole V-2. Under mineralogy S = smectite, I = illite, K = kaolinite, I/S = mixed layer illite/smectite.

Texture (%)*			Mineralogy (parts in 10)			
Sand	Silt	Clay	S	I	K	I/S
2	42	56	2	2	3	3

*sand = greater than 0.062 mm
silt = 0.016-0.062 mm
clay = less than 0.016 mm

ACKNOWLEDGMENTS

This work was done without charge as a public service to Socorro County. Lab and computer work was performed by Lori Leser (undergraduate student, New Mexico Tech). Clay analysis was done under the supervision of George Austin (New Mexico Bureau of Mines and Mineral Resources). Drilling costs were born by Socorro County.

ADDENDUM TO OPEN-FILE REPORT 338

Due to an error in calculating soil-moisture content, the soil-water chloride values and thus recharge rate originally reported for the Veguita landfill site are incorrect. However, the original report is retained in the files as it contains other useful information and is of historical interest in terms of the court case. The error arose when the lab assistant mistakenly calculated moisture as simply the wet wt minus the dry wt; it should have been calculated using wet wt minus dry wt, divided by dry wt minus average jar wt. To make matters worse, raw data were never entered in the lab book and could not be located, so recalculation was impossible.

Fortunately, however, samples from another hole at the site (BH-1), cored in April 1990 by Cathy Aimone-Martin (New Mexico Tech Department of Mining, Environmental and Geological Engineering), provided an opportunity to re-evaluate recharge at the site. In addition to samples, she provided moisture content (as % by weight), sample depths and a lithologic log for the hole. The moisture values were converted to grams of moisture per gram of soil:

$$\text{moisture wt} = \frac{\% \times \text{dry wt}}{100} .$$

Chloride content was analyzed as described in the original report.

Correct moisture and chloride contents for this hole are given in Table A-1. Moisture and chloride profiles, as well as a lithologic log, are presented in Figure A-1. The chloride profile shows that the hole got below the root zone (main chloride bulge) but the chloride content had not leveled off yet. Using the lowest chloride value occurring below the bulge (120.82 mg/L at 60 ft) and the same values for P (8.18 in/yr) and Clp (0.37 mg/L) as in the original report, a minimum recharge rate of 0.025 in/yr is obtained. This value is more in line with values from similar settings elsewhere in the state (Stone, 1986).

The recalculation shows that recharge is even slower than originally reported. Thus, the original conclusion that deep percolation should not be appreciable at the site is even more appropriate.

Table A-1. Results of chloride analysis, Veguita Hole BH-1.

Sample	Sample Depth (ft)	Wet Wt (g)	Dry Wt (g)	Moist Content (g/g)	Spl Wt (g)	Wt Wtr Added (g)	Cl in extract (ppm)	Cl in soil water (mg/L)
1	3	54.26	53.01	0.03	53.01	116.08	2.8	306.57
2	5	60.30	59.31	0.02	59.31	98.67	6.8	848.44
3	7	60.60	59.51	0.02	59.51	100.02	10.0	1,260.54
4	9	59.99	58.49	0.03	58.49	97.95	15.3	1,281.10
5	17	60.98	59.71	0.02	59.71	97.01	11.2	1,364.73
6	20	59.86	58.68	0.02	58.68	101.65	10.3	1,338.18
7	26	58.13	57.14	0.02	57.14	98.39	7.5	968.58
8	32	63.77	62.80	0.02	62.80	103.04	5.6	689.11
9	36	59.04	58.13	0.02	58.13	99.18	4.5	575.83
10	42	63.54	62.63	0.02	62.63	103.55	4.3	533.20
11	47	59.94	59.18	0.01	59.18	108.17	4.9	1,343.27
12	52	39.37	38.85	0.02	38.85	118.55	2.4	549.27
13	57	57.35	55.97	0.03	55.97	118.07	1.9	200.40
14	62	54.88	53.67	0.03	53.67	99.77	1.3	120.82

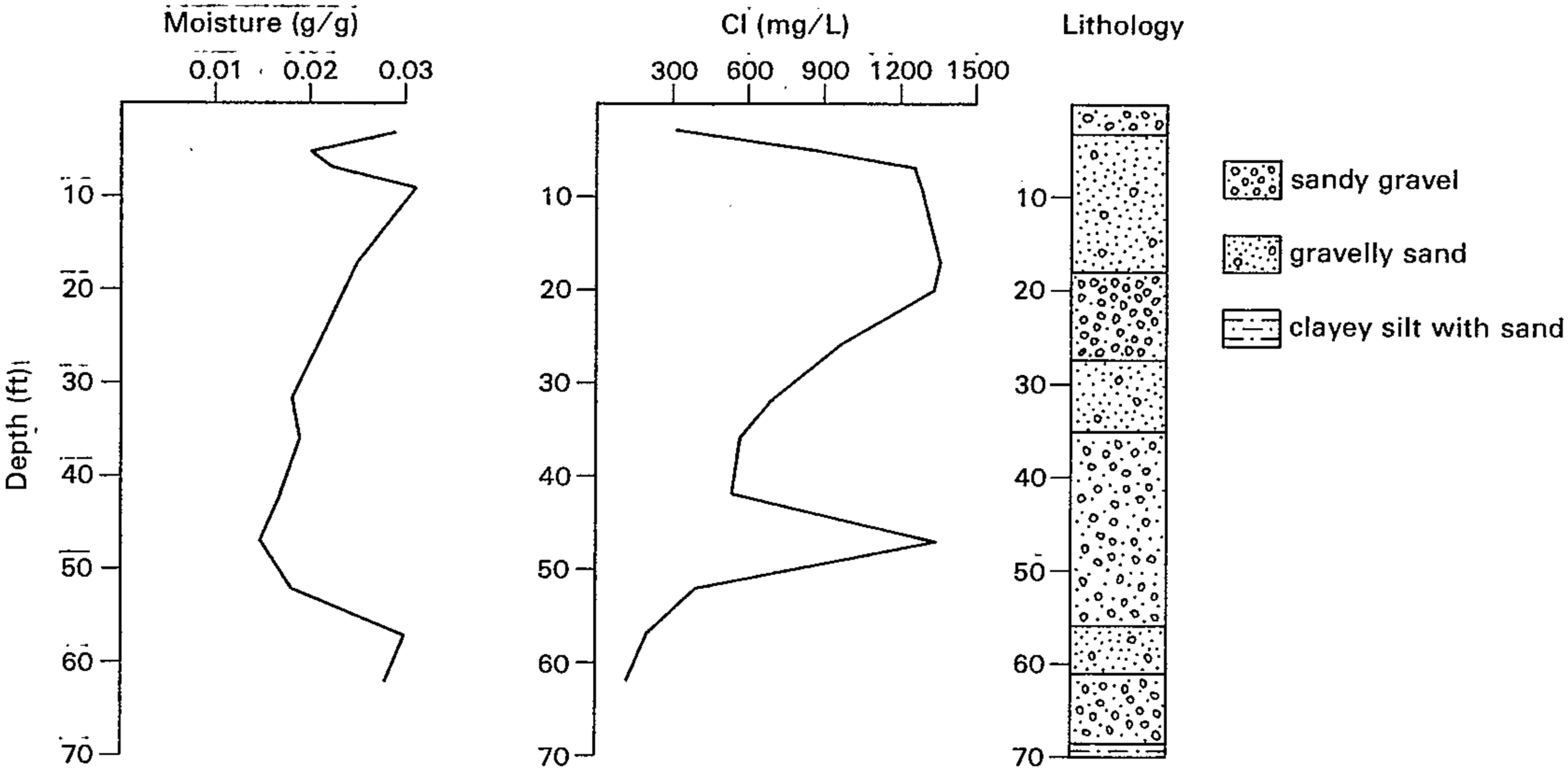


Figure A-1. Moisture and chloride vs depth profiles and geology, Veguita Hole BH-1.

REFERENCES

Allison, G. B., and Hughes, M. W., 1978, The use of environmental chloride and tritium to estimate total recharge to an unconfined aquifer: Australian Journal of Soil Research, v. 16, p. 181-195.

Allison, G. B., Stone, W. J., and Hughes, M. W., 1985, Recharge through karst and dune elements of a semiarid landscape as indicated by natural isotopes and chloride: Journal of Hydrology, v. 76, p. 1-25.

Fleischhauer, H. L., Jr., and Stone, W. J., 1982, Quaternary geology of Lake Animas, Hidalgo County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circular 174, 25 p.

Gabin, V. L., and Lesperance, L. E., 1977, New Mexico climatological data, precipitation, temperature, evaporation, and wind--monthly and annual means: W. K. Summers and Associates, Socorro, New Mexico, 436 p.

Kelley, V. C., 1977, Geology of the Albuquerque Basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Memoir 33, 60 p.

Machette, M. N., 1978, Dating Quaternary faults in the southwestern United States by using buried calcic paleosols: U.S. Geological Survey, Journal of Research, v. 6, no. 3, p. 369-381.

McGurk, B. E., and Stone, W. J., 1985, Evaluation of laboratory procedures for determining soil-water chloride: New Mexico Bureau of Mines and Mineral Resources, Open-file Report 215, 34 p.

Phillips, F. M., Trotman, K. N., Bentley, H. W., and Davis, S. N., 1984, The bomb-36 Cl pulse as a tracer for soil-water movement near Socorro, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Hydrologic Report 7, p. 271-280.

Spiegel, Zane, 1955, Geology and ground-water resources of northeastern Socorro County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Ground-Water Report 7, 99 p.

Stone, W. J., 1986, Natural recharge in Southwestern landscaping --examples from New Mexico: Proceedings, National Water Well Association Focus Conference on Southwestern Ground-Water Issues, p. 595-602.

Stone, W. J., 1987, Paleorecharge, climatohydrologic variability, and water-resource management: Proceedings, IAHS Symposium on Influence of Climate Change and Climatic Variability on the Hydrologic Regime and Water Resources, Vancouver, IAHS Publication no. 168, p. 143-152.

Van Devender, T. R., and Spaulding, W. G., 1979, Development of vegetation and climate in the southwestern United States: Science, v. 204, p. 701-710.

Winograd, I. J., 1974, Radioactive waste storage in the arid zone: EOS, Transactions of the American Geophysical Union, v. 55, no. 10, p. 884-894.

APPENDIX

Brief Field Description of Cores

Hole V-1 (chloride samples)--Just north of existing trenches in middle of property near boundary.

Sample No.	Depth (ft)	General Lithology
1	0-1	Sandy gravel, light gray
	1-4	No recovery
2	4-5	Sandy gravel as above
	5-9	No recovery
3	9-10	Gravelly sand and clay
	10-14	No recovery
4-9	14-20	Silty clay, red
10	20-21	Gravelly sand, loose
11	21-22	Clayey sand, reddish tan
	22-24	No recovery
12,13	24-26	Gravelly sand, pink
	26-29	No recovery
14,15	29-31	Silty sand, pink/red
16,17	31-33	Clay and silty clay, reddish brown
	33-34	No recovery
18-22	34-39.5	Clay as above with rusty mottles
23-30	39.5-47	Sand, very fine to fine, and gravel in places, reddish brown
	47-49	No recovery
31	49-50	Sand as above but less gravel
	50-54	No recovery
32,33	54-56	Sand as above but coarser, gravelly at base
	56-59	No recovery
34	59-60	Sand and gravel, pinkish gray
	60-64	No recovery

Sample No.	Depth (ft)	General Lithology
35	64-65	Sand and gravel as above
	65-69	No recovery
36	69-70	Clay, rusty green
37-39	70-73	Gravelly sand, yellowish gray
	73-74	No recovery
40	74-75	Gravelly sand as above
	75-79	No recovery
41,42	79-81	Sand, very fine to medium, gray
	81-84	No recovery
43	84-85	Sand as above with some granules
	85-89	No recovery
	89-91	Sand as above
	91-94	No recovery
46-50	94-99	Sand and gravel as above
	TOTAL DEPTH = 99 ft	

Hole V-2 (permeameter samples)--Due west of Hole V-1 at middle (in E-W sense) of narrow divide which is last sizeable finger of high ground on west end of property.

Sleeve No.	Depth (ft)	General Lithology
1	0-1.5	Gravelly sand
	1.5-4	No recovery
2	4-5.25	Gravelly sand as above but finer
	5.25-5.75	Clayey silt
	5.75-9	No recovery
3	9-11	Clayey silt as above
	11-11.5	Sand, very fine-fine
	11.5-14	No recovery
4	14-15.5	Sand as above, but up to medium
	15.5-19	No recovery
5	19-20.75	Sand as above, finer in bottom half
	20.75-24	No recovery
6	24-24.5	Pebbly, clayey sand
	24.5-25.75	Sand as above but no pebbles
	25.75-26.50	Alternating sand and silty clay
	26.50-29	No recovery
7	29-32.75	Interbedded silty clay, clay and silt; clay chocolate colored, waxy
	32.75-34	No recovery
8	34-35.75	Pebbly, silty sand
	35.75-37.75	Silt and sand, powdery white material at surface
	37.75-39	No recovery
9	39-39.5	Sand as above
	39.5-40.25	Clay, silty(?)

Sleeve No.	Depth (ft)	General Lithology
	40.25-41.25	Sand as above
	41.25-43.25	Silty clay and clay
	43.25-44	Sand, very fine to fine
10	44-44.75	Silty clay
	44.75-46.5	Sand, very fine to fine
	46.5-49	No recovery
11	49-49.5	Silty clay
	49.5-51	Sand, very fine to fine
	51-51.5	Silty clay as above
	51.5-54	No recovery
12	54-55.5	Sand, very fine at base, fine to medium at top
	55.5-56.25	Alternating silty clay, silt, and very fine sand
	56.25-59	No recovery
13	59-60.5	Sand, very fine to medium
	60.5-64	No recovery
14	64-66	Sand as above
	66-69	No recovery
15	69-70.5	Sand as above
	70.5-71.5	Clay and clayey sand
	71.5-74	No recovery
16	74-77	Clayey sand, some pebbles
	77-79	No recovery
17	79-81.25	Sand, fine to medium, some granules
	81.25-84	No recovery

Sleeve No.	Depth (ft)	General Lithology
18	84-86.5	Sand as above
	86.5-89	No recovery
19	89-91.5	Sand as above, but clayey in lower half
	91.5-94	No recovery
20	94-96.25	Sand as above
	96.25-99	Clay, chocolate texture, light brown
	TOTAL DEPTH = 99 ft	