APPENDICES TO

GEOLOGY AND HYDROLOGY OF A SITE PROPOSED FOR BURIAL OF LOW-LEVEL SOLID RADIOACTIVE WASTE

WESTERN COLFAX COUNTY, NEW MEXICO

APPENDIX I FIELD INVESTIGATIONS

PREPARED FOR

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Appendix I-O.--Test Hole and Piezometer Coordinates

Appendix I-0.--Test-hole and piezometer coordinates.

WELL	GRID LOCATION	
CNA-1	N2,025,416	E380,037
CNA-2	N2,025,372	E380,070
CNA-3	N2,025,376	E380,014
CNC-1	N2,028,330	E378,700
CNC-2	N2,027,630	E378,770
CNC-3	N2,030,060	E379,990
CNC-4	N2,028,270	E380,020
CNC-5	N2,026,780	E380,070
CNC-6	N2,025,390	E380,040
CNC-7	N2,024,040	E380,030
CNC-8	N2,026,360	E381,790
CNG-1	N2,025,530	E378,780
CNG-2	N2,030,030	E380,930
CNG-3	N2,029,770	E380,850
CNG-4	N2,029,490	E380,740
CNP-1	N2,032,760	E383,720
CNP-2	N2,030,330	E383,180
CNP-3, 3A&3B	N2,028,490	E383,100
CNP-4, 4A&4B	N2,025,950	E383,080
CNP-5	N2,024,430	E383,070
CNP-6	N2,021,350	E382,000
CNP-6A	N2,021,350	E382,020
CNP-6B	N2,021,650	E382,100
CNP-7 &7A	N2,024,800	E386,750
CNP-8 &8A	N2,023,700	E390,650
CNP-9	N2,022,410	E394,560
CNS-1	N2,031,920	E382,850
CNS-2	N2,030,410	E381,060
CNS-3	N2,029,460	E379,600
CNS-4	N2,028,720	E381,330
CNS-5	N2,027,030	E381,040
CNS-6	N2,027,500	E381,260
CNS-7	N2,027,140	E377,460
CNS-8	N2,026,800	E379,140
CNS-9	N2,025,300	E380,730

Appendix I-0.--Test-hole and piezometer coordinates (cont).

CNS-10	N2,025,160	E379,300
CNS-11	N2,024,500	E376,890
CNS-12	N2,025,700	E377,110
CNS-13	N2,025,880	E378,820
CNS-14	N2,025,840	E380,800
CNS-15	N2,025,750	E381,960
CNS-16	N2,027,540	E379,400
CNS-17	N2,027,820	E380,430
CNS-18	N2,027,840	E381,250
CNS-19	N2,029,110	E380,610
CNS-20	N2,028,830	E379,760
CNS-21	N2,026,530	E377,250
CNS-22	N2,027,110	E382,870
CNS-23	N2,031,330	E382,880
CNS-24	N2,029,700	E382,440
CNS-25	N2,030,330	E382,590
CNS-26	N2,029,090	E382,440
CNS-27	N2,030,370	E381,840
CNS-28	N2,024,740	E380,040
CNS-29	N2,024,020	E378,060
CNS-30	N2,024,040	E379,040
CNS-31	N2,024,030	E381,060
CNS-32	N2,024,000	E382,020
CNS-33	N2,024,830	E382,030
CNS-34	N2,024,940	E278,090
CNW-1	N2,024,100	E380,000
CNW-2	N2,024,040	E380,000
CNW-3	N2,021,500	E381,710
CNW-4	N2,021,400	E379,620

List as of January 6, 1977

Appendix I-00.--Test Hole Altitude and Piezometer Construction Data

Appendix I-00.--Test-hole altitude and piezometer construction data.

Hole number	Date completed	Hole diameter (ft)	Land surface altitude (ft)	Measuring point altitude (ft)[1]	Drive point altitude (ft)[2]	Screen length (ft)[3]	Date piezometer installed	Height of gravel above drive point altitude (ft)	Date cemented	Cement amount (gal)	Lithology at screen
CNC-1[5]	11-4	0.47	6371.5	6373.1							
CNC-2[4]	10-7	0.46	6338.5								
CNC-3	11-11	0.56	6265.9	6270.8	6220.9	2.5	12-8	3.0	12-9	115	shale
CNC-4	11-29	0.46	6291.4	6297.6	6238.1	2.5	12-8	3.6	12-23	80	shale
CNC-5	11-30	0.46	6265.5								
CNC-6	12-7	0.46	6225.5	6230.0	6129.2	2.5	12-22	3.0	12-23	60	shale
CNC-7	11-15	0.56	6209.9	6213.2	6157.7	2.5	11-15	4.5	12-8	85	gravel
CNC-8	12-1	0.46	6245.5	6250.8	6189.8	2.5	12-22	3.0	12-23	80	shale
CNG-1[4, 6]	11-23	0.46	6257.0								
CNG-2	11-23	0.46	6242.7	6246.2	6179.9	2.5	12-8	3.0	12-9	120	shale
CNG-3[7]	11-5	0.56	6246.5								
CNG-4[4]	11-5	0.56	6251.5								
CNP-1[7]	11-22	0.56	6176.7	6180.9	6125.5	2.5	11-22	3.0	12-9	120	shale
CNP-2	10-4	0.56	6209.8								
CNP-3	9-28	0.56	6218.0	6224.1	6124.0	2.5	10-18	3.0	10-21	260	shale
CNP-3A	10-14	0.56	6218.0	6221.2	6190.0	2.5	10-14	5.0	10-22	120	gravel
CNP-3B	11-22	0.56	6218.0	6222.0	6151.5	3.0	11-29	4.2	12-1	100	shale
CNP-4	9-28	0.56	6235.0	6239.8	6129.0	2.5	10-19	3.0	10-20	210	shale
CNP-4A	10-14	0.56	6235.0	6239.5	6202.0	2.5	10-18	3.0	10-20	90	gravel
CNP-4B	11-22	0.56	6235.0	6239.7	6166.0	3.0	11-29	4.2	12-1	105	shale
CNP-5	11-8	0.56	6218.0	6220.2	6143.0	3.0	11-24	4.2	12-3	140	shale
CNP-6	11-18	0.56	6141.3	6146.1	6093.3	2.5	11-18	3.0	11-18	50	shale

Appendix I-00.--Test-hole altitude and piezometer construction data (cont).

Hole number	Date completed	Hole diameter (ft)	Land surface altitude (ft)	Measuring point altitude (ft)[1]	Drive point altitude (ft)[2]	Screen length (ft)[3]	Date piezometer installed	Height of gravel above drive point altitude (ft)	Date cemented	Cement amount (gal)	Lithology at screen
CNP-6A	11-18	0.56	6141.1	6145.1	6124.6	2.5	11-18	3.0	11-18	20	gravel
CNP-6B	11-18	0.56	6160.9	6165.2	6123.9	2.5	11-18	3.0	11-19	65	gravel
CNP-7	11-19	0.56	6225.0	6229.6	6140.0	2.5	11-22	3.0	11-23	140	shale
CNP-7A	11-19	0.56	6225.2	6227.8	6214.2	2.5	11-19	8.5	11-23	35	gravel
CNP-8	11-19	0.56	6121.9	6124.1	6067.9	2.5	11-19	3.0	11-22	95	shale
CNP-8A	11-19	0.56	6122.1	6126.6	6102.6	2.5	11-19	4.5	11-22	45	gravel
CNP-9	11-19	0.56	6065.2	6070.6	6036.2	2.5	11-19	4.0	11-19	85	gravel
CNS-1[d]	11-5	0.56	6185.6	6191.5	6135.6	2.5	11-5	3.0	12-3	95	shale
CNS-2	11-4	0.56	6236.6	6238.3	6161.6	3.0	11-23	4.2	12-1	115	shale
CNS-3	10-5	0.56	6282.5	6288.7	6242.5	2.5	10-22	3.0	10-27	75	shale
CNS-4	10-5	0.56	6242-0	6243.6	6192.0	2.5	10-20	3.0	10-21	70	shale
CNS-5	10-5	0.56	6255.3	6257.3	6205.3	2.5	10-20	3.0	10-26	95	shale
CNS-6[4]	10-5	0.56	6338.5								
CNS-7	10-5	0.56	6278.5	6382.8	6238.5	2.5	10-22	3.0	10-26	90	shale
CNS-8[4]	10-5	0.56	6268.0								
CNS-9[4]	11-8	0.56	6219.5								
CNS-10	10-8	0.56	6227.0	6231.0	6192.0	2.5	10-25	3.0	10-27	60	weathered shale and shale
CNS-11	10-8	0.56	6239.6	6245.3	6193.1	2.5	10-8	6.0	10-11	95	weathered shale
CNS-12	10-11	0.56	6253.5	6259.5	6193.5	2.5	10-11	9.0	10-12	120	gravel
CNS-13	10-12	0.56	6238.8	6243.1	6203.8	2.5	11-2	7.8	12-6	60	shale
CNS-14[4]	11-5	0.56	6245.5								
CNS-15[4]	10-13	0.56	6235.5								

Appendix I-00.--Test-hole altitude and piezometer construction data (cont).

Hole number	Date completed	Hole diameter (ft)	Land surface altitude (ft)	Measuring point altitude (ft)[1]	Drive point altitude (ft)[2]	Screen length (ft)[3]	Date piezometer installed	Height of gravel above drive point altitude (ft)	Date cemented	Cement amount (gal)	Lithology at screen
CNS-16[4]	10-13	0.56	6312.0								
CNS-17[4]	10-13	0.56	6269.5								
CNS-18	10-13	0.56	6245.5	6246.8	6195.5	2.5	10-20	3.0	10-22	65	shale
CNS-19	10-13	0.56	6257.5	6260.3	6207.5	2.5	10-22	3.0	10-25	90	weathered shale
CNS-20[4]	10-13	0.56	6285.5								
CNS-21	10-13	0.56	6259.0	6262.0	6195.5	2.5	10-13	7.2	10-25	100	shale
CNS-22	10-6	0.56	6218.8	6223.4	6171.3	2.5	10-18	3.0	10-20	105	shale
CNS-23	11-5	0.56	6197.6	6201.0	6122.6	3.0	11-29	4.2	12-1	135	shale
CNS-24[4]	11-8	0.56	6226.5								
CNS-25	11-11	0.56	6211.9	6218.1	6151.9	3.0	11-24	4.2	12-2	125	shale
CNS-26	11-11	0.56	6222.8	6228.6	6162.8	3.0	11-24	4.2	12-2	130	shale
CNS-27[7]	11-11	0.56	6226.5								
CNS-28[4]	11-17	0.56	6216.0								
CNS-29	11-16	0.56	6234.8	6236.1	6191.8	2.5	11-16	3.6	12-8	100	gravel
CNS-30	11-16	0.56	6222.6	6223.9	6148.6	2.5	12-6	3.6	12-8	95	shale
CNS-31	11-17	0.56	6199.6	6202.2	6160.1	2.5	11-17	4.2	12-7	125	sand
CNS-32	11-18	0.56	6199.1	6201.9	6129.1	3.0	11-24	4.2	12-3	75	shale
CNS-33[4]	11-17	0.56	6212.0								
CNS-34	11-16	0.56	6239.3	6242.8	6183.4	2.5	11-17	3.6	12-8	115	shale
CNA-1[9]	12-10	0.47	6225.5								
CNA-2	12-17	0.47	6225.5								
CNA-3	12-22	0.47	6225.5								

Appendix I-00.--Test-hole altitude and piezometer construction data (cont).

Hole number	Date completed	Hole diameter (ft)	Land surface altitude (ft)	Measuring point altitude (ft)	Drive point altitude (ft)	Screen length (ft)	Date piezometer installed	Height of gravel above drive point altitude (ft)	Date cemented	Cement amount (gal)	Lithology at screen
CNW-2[10]	12-23	0.66	6210.0	6211.5	6161[11]	5.0	12-38	40			gravel
CNW-4	12-31	0.66	6170	6171.3	6137[11]	5.0	1-4	20			gravel
CNW-3[4]											

[1] top of casing.
[2] bottom of drive point at bottom of screen.
[3] bottom of screen 0.5 ft above bottom of hole.
[4] plugged and abandoned.
[5] CNC -- corehole.
[6] CNG -- hole for geophysical information.
[7] CNP -- piezometer hole.
[8] CNS -- hole to determine top of shale.
[9] CNA -- angle hole.
[10] CNW -- hole for water well.
[11] bottom of screen.

Appendix I-1.--Test Hole Lithology

Appendix I-1. -- Lithology at CNC-1.

	Depth (ft)	Altitude (ft)
Land surface	0	6371.5
Weathered Pierre shale	21.0	6350.5
Unweathered Pierre shale	50.0	6321.5
Total depth	400.0	5971.5

Depth (ft) From	To	Description
0	8.0	sand, gravel and clay; surface material as large as 2.0' diameter, but averages about 0.3'
8.0	12.0	sand - brown, fine-medium grain
12.0	17.0	sand and gravel
17.0	21.0	sandy clay - brown
21.0	50.0	weathered Pierre shale - gray - brown
50.0	400.0	unweathered Pierre shale - black
		51.0'-128.5' solid core
		128.5'-138.5' somewhat broken up core
		132.0'-133.5', 134.5'-134.8' 45° fractures
		138.5'-180.0' solid core
		138.5'-139.0', 142.3'-142.8' sandy zones
		151.3'-151.5' altered zone
		176.0'-177.0' sandy zone
		180.0'-197.0' somewhat broken up core
		180.0'-185.0', 190.5'-197.0' vertical fractures
		186.0'-187.0' sandy lenses
		197.0'-204.4' solid core
		204.4'-210.0' broken core
		210.0'-232.6' solid core
		227.0'-232.6' altered zone
		232.6'-260.0' somewhat broken up core
		232.6'-233.0', 233.3'-234.0', 240.8'-240.9' altered zones
		260.0'-292.9' solid core
		275.2'-275.6' altered zone
		280.0'-282.0' sandy lenses

Appendix I-1. -- Lithology at CNC-2.

	Depth (ft)	Altitude (ft)
Land surface	0	6338.5
Weathered Pierre shale	3.5	6335.0
Unweathered Pierre shale	33.5	6305.0
Total depth	36.4	6302.1

Depth (ft) From	To	Description
0	3.5	gravel, sand and clay; surface material as large as 3.0' in diameter but averages about 0.3'
3.5	33.5	weathered Pierre shale - gray - brown; 18.7'-28.7' core somewhat broken up
33.5	36.4	unweathered Pierre shale - black; 28.7'-38.7' solid core

Appendix I-1. -- Lithology at CNC-3(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6265.9
Weathered Pierre shale	not present	
Unweathered Pierre shale	40.5	6225.4
Total depth	45.0	6220.9

Depth (ft)		
From	To	Description
0	2.0	sandy clay - dark brown
2.0	7.0	clayey sand - light brown
7.0	21.0	sandy clay - brown; caliche zone at about 8.5'-9.5'
21.0	25.0	clayey sand with little gravel
25.0	35.5	sandy clay - brown, quite damp
35.5	40.5	gravel and sand, quite damp
40.5	45.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNC-4(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6291.4
Weathered Pierre shale	13.0	6278.4
Unweathered Pierre shale	33.0	6258.4
Total depth	53.3	6238.1

Depth (ft) From	To	Description
0	9.5	clayey sand - light to dark brown; caliche zone at about 6.5'-7.5'
9.5	11.5	sandy clay - brown
11.5	12.0	sand, gravel and clay
12.0	13.0	sandy clay - brown
13.0	33.0	weathered Pierre shale - gray - brown; core fairly badly broken 16.7'-33.0'
33.0	53.3	unweathered Pierre shale - black 42.2'-42.3' altered zone (crumbly) 33.0'-53.3' solid core

Appendix I-1. -- Lithology at CNC-5.

	Depth (ft)	Altitude (ft)
Land surface	0	6265.5
Weathered Pierre shale	5.0	6260.5
Unweathered Pierre shale	29.0	6236.5
Total depth	46.6	6218.9

Depth (ft)		
From	To	Description
0	2.5	clayey sand - brown
2.5	5.0	sandy clay - dark brown
5.0	29.0	weathered Pierre shale - gray - brown; core broken up and somewhat damp
29.0	46.6	unweathered Pierre shale - black 45.9'-46.0' altered zone (crumbly) 29.5'-49.9' solid core

Appendix I-1. -- Lithology at CNC-6(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6225.5
Weathered Pierre shale	3.5	6222.0
Unweathered Pierre shale	30.0	6195.5
Total depth	96.3	6129.2

Depth (ft)		
From	To	Description
0	2.0	sandy clay - brown
2.0	3.5	clay - yellow
3.5	30.0	weathered Pierre shale - gray - brown; core fairly well broken up; few solid sections
30.0	96.3	unweathered Pierre shale - black 30.0'-37.0' solid core 37.0'-40.5' somewhat broken core 40.5'-92.0' solid core 51.'-53.', 62.'-63.' sandy lenses 92.0'-92.4' broken up core 92.4'-96.3' solid core

Appendix I-1. -- Lithology at CNC-7(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6209.9
Weathered Pierre shale	not present	
Unweathered Pierre shale	52.0	6157.9
Total depth	54.0	6155.9

Depth (ft) From	Depth (ft) To	Description
0	3.0	sandy clay - dark brown
3.0	4.5	sand - yellow, fine grain
4.5	9.0	sandy clay - brown; 6.0'-6.5' caliche zone
9.0	9.5	sand - yellow, fine-medium grain
9.5	10.5	sandy clay - brown
10.5	16.0	sand - yellow, fine-medium grain
16.0	27.5	sand with small amount of gravel
27.5	30.0	sand and gravel, damp
30.0	45.0	sand - yellow, fine-medium grain, wet
45.0	52.0	sand and gravel, wet
52.0	54.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNC-8(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6245.5
Weathered Pierre shale	9.0	6236.5
Unweathered Pierre shale	39.0	6206.5
Total depth	55.7	6189.8

Depth (ft)		
From	To	Description
0	1.0	sandy clay - dark brown
1.0	7.5	sand - light brown, fine-medium grain
7.5	9.0	sandy clay - brown; caliche zone at about 8.5'-9.0'
9.0	39.0	weathered Pierre shale - gray - brown;
		19.0'-36.3' core badly broken up
		22.0'-35.0' core damp
		32.5'-37.0' vertical fracture
39.0	55.7	unweathered Pierre shale - black; solid core

Appendix I-1. -- Lithology at CNG-1.

	Depth (ft)	Altitude (ft)
Land surface	0	6257.0
Weathered Pierre shale	13.0	6244.0
Unweathered Pierre shale	27.0	6230.0
Total depth	39.0	6218.0

Depth (ft) From	Depth (ft) To	Description
0	4.0	clayey sand - light brown, medium grain
4.0	6.5	sandy clay - brown
6.5	8.0	clayey sand - light brown; caliche zone at about 7.5'-8.0'
8.0	8.5	sand and gravel
8.5	13.0	sandy clay - brown
13.0	27.0	weathered Pierre shale - gray - brown
27.0	39.0	unweathered Pierre shale - black
		28.0' possible damp zone
		30.3'-32.3' slightly soft zone
		few limey lenses; oysters common
		29.5'-39.0' solid core

Appendix I-1. -- Lithology at CNG-2(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6242.7
Weathered Pierre shale	42.0	6200.7
Unweathered Pierre shale	51.0	6191.7
Total depth	62.8	6179.9

Depth (ft) From	Depth (ft) To	Description
0	9.5	clayey sand - light brown, medium grain
9.5	18.5	sandy clay - brown; caliche zone at about 11.0'-12.5'
18.5	41.0	sand and gravel with some clay
41.0	42.0	sandy clay - brown
42.0	46.0	weathered Pierre shale - gray - brown
46.0	51.0	slightly weathered Pierre shale - tan
51.0	62.8	unweathered Pierre shale - black
		52.8'-62.8' very good core; contains distorted calcite bands and oysters
		56.0'-58.0' possible vertical fracture

Appendix I-1. -- Lithology at CNG-3.

	Depth (ft)	Altitude (ft)
Land surface	0	6246.5
Weathered Pierre shale	31.0	6215.5
Unweathered Pierre shale	38.0	6208.5
Total depth	54.5	6192.0

Depth (ft) From	Depth (ft) To	Description
0	3.0	clayey sand - light brown, fine-medium grain
3.0	4.5	sandy clay - brown
4.5	5.5	sand and gravel
5.5	8.0	sandy clay - brown; 6.5'-7.5' caliche zone
8.0	9.0	clayey sand - light brown, medium grain
9.0	10.5	sand and gravel
10.5	13.0	sandy clay - brown; caliche zone from about 10.5'-11.0'
13.0	13.5	sand and gravel
13.5	22.5	sandy clay - brown
22.5	28.0	gravel and sand
28.0	31.0	sandy clay - reddish brown
31.0	38.0	weathered Pierre shale - gray - brown
38.0	54.5	unweathered Pierre shale - black

	Size Analysis Grain size (mm)	Weight percent
25.0'-28.0'	>2.0	55.7
	0.15-2.0	34.5
	0.075-0.15	1.7
	<.075	8.1

Appendix I-1. -- Lithology at CNG-4.

	Depth (ft)	Altitude (ft)
Land surface	0	6251.5
Weathered Pierre shale	36.0	6215.5
Unweathered Pierre shale	41.0	6210.5
Total depth	54.5	6197.0

Depth (ft) From	To	Description
0	4.0	clayey sand with small amount of gravel
4.0	7.5	sandy clay - brown
7.5	11.0	sand and gravel
11.0	12.0	sandy clay - brown; 11.0'-11.5' caliche zone
12.0	14.0	sand and gravel
14.0	30.5	sandy clay - brown, fairly damp
30.5	32.0	gravel and sand, wet
32.0	36.0	sandy clay - reddish brown
36.0	41.0	weathered Pierre shale - gray - brown
41.0	54.5	unweathered Pierre shale - black

	Size Analysis: Grain size (mm)	Weight percent
29.0'-30.0'	>2.0	4.2
	0.15-2.0	9.0
	0.075-0.15	9.5
	<.075	77.3

Appendix I-1. -- Lithology at CNP-1.

	Depth (ft)	Altitude (ft)
Land surface	0	6176.7
Weathered Pierre shale	8.0	6168.7
Unweathered Pierre shale	17.0	6159.7
Total depth	52.0	6124.7

Depth (ft)		
From	To	Description
0	8.0	sand and gravel; 1.5'-2.0' caliche zone
8.0	17.0	weathered Pierre shale - gray - brown
17.0	52.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNP-2.

	Depth (ft)	Altitude (ft)
Land surface	0	6209.8
Weathered Pierre shale	23.0	6186.8
Unweathered Pierre shale	26.0	6183.8
Total depth	400.0	5809.8

Depth (ft)		
From	To	Description
0	14.0	gravel and sand with some clay
14.0	18.0	sand - yellow, medium grain
18.0	23.0	gravel and sand
23.0	26.0	weathered Pierre shale - gray - brown
26.0	400.0	unweathered Pierre shale - black
		116', 132', 182', 363' limey spots

Appendix I-1. -- Lithology at CNP-3.
(includes CNP-3A and CNP-3B)

	Depth (ft)	Altitude (ft)
Land surface	0	6218.0
Weathered Pierre shale	27.5	6190.5
Unweathered Pierre shale	38.0	6180.0
Total depth	94.0	6124.0

Depth (ft) From	Depth (ft) To	Description
0	1.0	sandy clay - dark brown
1.0	7.0	clayey sand - brown to white; caliche zone at about 5.5'-7.0'
7.0	9.0	sandy clay - brown
9.0	10.5	clayey sand - light brown
10.5	27.5	gravel and sand
27.5	38.0	weathered Pierre shale - gray - brown
38.0	94.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNP-4.
(includes CNP-4A and CNP-4B)

	Depth (ft)	Altitude (ft)
Land surface	0	6235.0
Weathered Pierre shale	47.5	6187.5
Unweathered Pierre shale	56.5	6178.5
Total depth	106.0	6129.0

Depth (ft)		
From	To	Description
0	2.5	clayey sand - brown, medium grain
2.5	4.5	sandy clay - brown
4.5	8.0	clayey sand - light brown, fine grain
8.0	10.5	sand - light brown, fine-medium grain
10.5	12.5	sand and gravel
12.5	17.5	clayey sand - brown
17.5	28.5	sand - light brown, medium grain
28.5	32.0	sand and gravel
32.0	47.5	sandy clay - brown
47.5	56.5	weathered Pierre shale - gray - brown
56.5	106.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNP-5.

	Depth (ft)	Altitude (ft)
Land surface	0	6218.0
Weathered Pierre shale	27.0	6191.0
Unweathered Pierre shale	43.0	6175.0
Total depth	75.0	6143.0

Depth (ft) From	To	Description
0	9.5	sandy clay - brown
9.5	16.0	silty clay - light tan; 9.5'-9.8' caliche zone
16.0	19.5	sand and gravel
19.5	22.0	clayey sand - light brown
22.0	24.0	sand and gravel
24.0	27.0	sand - brown, fine-medium grain
27.0	43.0	weathered Pierre shale - gray - brown
43.0	75.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNP-6.
(includes CNP-6A)

	Depth (ft)	Altitude (ft)
Land surface	0	6141.3
Weathered Pierre shale	20.5	6120.8
Unweathered Pierre shale	22.5	6118.8
Total depth	48.0	6093.3

Depth (ft)		
From	To	Description
0	0.8	gravel and sand
0.8	1.6	sand with small amount of gravel
1.6	3.0	gravel and sand
3.0	4.0	sand - yellow, medium grain
4.0	6.0	sand and fine gravel
6.0	7.5	sand and gravel
7.5	10.0	sand and fine gravel
10.0	14.0	sandy clay - brown; making water
14.0	20.5	sand and gravel; much water
20.5	22.5	weathered Pierre shale - gray - brown
22.5	48.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNP-6B.

	Depth (ft)	Altitude (ft)
Land surface	0	6160.9
Total depth	37.0	6123.9

Depth (ft) From	To	Description
0	4.0	clayey sand - brown, fine grain
4.0	7.5	sandy clay - dark brown
7.5	9.0	clayey sand - brown, fine-medium grain
9.0	20.5	sandy clay - brown
20.5	34.0	clayey sand - brown, fine-medium grain
34.0	37.0	sand and gravel

Appendix I-1. -- Lithology at CNP-7. (includes CNP-7A)

	Depth (ft)	Altitude (ft)
Land surface	0	6225.0
Weathered Pierre shale	12.5	6212.5
Unweathered Pierre shale	32.0	6193.0
Total depth	85.0	6140.0

Depth (ft) From	Depth (ft) To	Description
0	2.5	clayey sand with small amount of gravel; caliche zone from about 2.0'-2.5'
2.5	11.0	gravel and sand
11.0	12.5	sandy clay - brown
12.5	32.0	weathered Pierre shale - gray - brown
32.0	85.0	unweathered Pierre shale - black 66.0'-66.5', 69.5'-70.5' limey zones

Appendix I-1. -- Lithology at CNP-8.
(includes CNP-8A)

	Depth (ft)	Altitude (ft)
Land surface	0	6122.0
Weathered Pierre shale	19.5	6102.5
Unweathered Pierre shale	33.0	6089.0
Total depth	54.0	6068.0

Depth (ft) From	Depth (ft) To	Description
0	2.5	clayey sand - brown, fine grain
2.5	6.5	sandy clay - dark brown
6.5	9.5	clayey sand - brown, fine-medium grain
9.5	15.0	sandy clay - brown; 9.5'-10.0', 13.0'-14.0' caliche zones
15.0	19.5	gravel and sand
19.5	33.0	weathered Pierre shale - gray - brown
33.0	54.0	unweathered Pierre shale - black; limey zone about 1.0' thick at top; water at about 51.5', blowing about 1 gpm

Appendix I-1. -- Lithology at CNP-9.

	Depth (ft)	Altitude (ft)
Land surface	0	6065.2
Weathered Pierre shale	not present	
Unweathered Pierre shale	28.0	6037.2
Total depth	29.0	6036.2

Depth (ft)		
From	To	Description
0	4.5	clayey sand - tan, fine-medium grain
4.5	7.0	sandy clay - brown
7.0	8.0	clayey sand - brown, fine grain
8.0	11.5	sandy clay - brown
11.5	22.5	clayey sand - brown, fine-medium grain
22.5	28.0	sand and gravel
28.0	29.0	unweathered Pierre shale - black; thin limey zone at top

Appendix I-1. -- Lithology at CNS-1(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6185.6
Weathered Pierre shale	24.0	6161.6
Unweathered Pierre shale	26.0	6159.6
Total depth	50.0	6135.6

Depth (ft)		
From	To	Description
0	14.0	sandy clay - brown
14.0	18.0	gravel and sand
18.0	22.0	sand - light brown, medium grain
22.0	24.0	gravel and sand
24.0	26.0	weathered Pierre shale - gray - brown
26.0	50.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-2(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6236.6
Weathered Pierre shale	19.0	6217.6
Unweathered Pierre shale	35.0	6201.6
Total depth	75.0	6161.6

Depth (ft) From	Depth (ft) To	Description
0	15.0	sandy clay - reddish brown; 8.0'-8.5' caliche zone
15.0	19.0	gravel and sand
19.0	35.0	weathered Pierre shale - gray - brown
35.0	75.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-3(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6282.5
Weathered Pierre shale	8.0	6275.5
Unweathered Pierre shale	34.5	6248.0
Total depth	40.0	6242.5

Depth (ft) From	Depth (ft) To	Description
0	8.0	sandy clay - brown; 7.0'-8.0' caliche zone
8.0	34.5	weathered Pierre shale - gray - brown
34.5	40.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-4(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6242.0
Weathered Pierre shale	40.0	6202.0
Unweathered Pierre shale	47.0	6195.0
Total depth	50.0	6192.0

Depth (ft) From	Depth (ft) To	Description
0	7.0	sandy clay - brown
7.0	8.5	sand and gravel
8.5	32.0	slightly sandy clay - brown; 27.0' thin sand lens
32.0	40.0	sand and gravel
40.0	47.0	weathered Pierre shale - gray - brown
47.0	50.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-5(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6255.3
Weathered Pierre shale	13.5	6241.8
Unweathered Pierre shale	44.0	6211.3
Total depth	50.0	6205.3

Depth (ft) From	Depth (ft) To	Description
0	6.0	sandy clay - brown
6.0	8.0	clayey sand - light brown, fine grain
8.0	12.5	sandy clay - brown
12.5	13.5	sand - tan, fine-medium grain
13.5	44.0	weathered Pierre shale - gray - brown
44.0	50.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-6.

	Depth (ft)	Altitude (ft)
Land surface	0	6338.5
Weathered Pierre shale	3.5	6335.0
Unweathered Pierre shale	33.5	6305.0
Total depth	40.0	6298.5

Depth (ft)		
From	To	Description
0	3.5	gravel, sand and clay
3.5	33.5	weathered Pierre shale - gray - brown
33.5	40.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-7(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6278.5
Weathered Pierre shale	27.0	6251.5
Unweathered Pierre shale	35.5	6243.0
Total depth	40.0	6238.5

Depth (ft)		
From	To	Description
0	2.0	clayey sand - light brown, fine grain
2.0	17.0	slightly sandy clay - brown
17.0	27.0	clayey sand - light brown, fine grain
27.0	35.5	weathered Pierre shale - gray - brown
35.5	40.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-8.

	Depth (ft)	Altitude (ft)
Land surface	0	6268.0
Weathered Pierre shale	13.0	6255.0
Unweathered Pierre shale	34.0	6234.0
Total depth	35.0	6233.0

Depth (ft)		
From	To	Description
0	13.0	clayey sand - light brown, fine grain
13.0	34.0	weathered Pierre shale - gray - brown
34.0	35.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-9.

	Depth (ft)	Altitude (ft)
Land surface	0	6219.5
Weathered Pierre shale	12.0	6207.5
Unweathered Pierre shale	40.0	6179.5
Total depth	75.0	6144.5

Depth (ft)		
From	To	Description
0	4.0	sandy clay - brown
4.0	8.5	sand - light brown, fine grain
8.5	12.0	clayey sand - brown, fine grain
12.0	40.0	weathered Pierre shale - gray - brown
40.0	75.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-10(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6227.0
Weathered Pierre shale	22.0	6205.0
Unweathered Pierre shale	33.0	6194.0
Total depth	35.0	6192.0

Depth (ft)		
From	To	Description
0	5.0	sandy clay - brown
5.0	7.0	clayey sand - light brown, fine grain
7.0	12.0	slightly sandy clay - tan
12.0	22.0	sandy clay - brown
22.0	33.0	weathered Pierre shale - gray - brown
33.0	35.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-11(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6239.6
Weathered Pierre shale	47.0	6192.6
Unweathered Pierre shale	54.0	6185.6
Total depth	55.0	6184.6

Depth (ft) From	Depth (ft) To	Description
0	3.0	sandy clay - brown
3.0	7.0	clayey sand - light brown, fine grain
7.0	9.5	sandy clay - dark brown
9.5	12.5	clay - brown; 9.5'-10.0' caliche zone
12.5	21.0	clayey sand - tan, fine-medium grain
21.0	25.0	sand and gravel
25.0	29.0	slightly clayey sand - tan, medium grain, fairly hard
29.0	36.0	sand and gravel
36.0	37.5	sand - yellow, fine-medium grain
37.5	47.0	sand and gravel, wet
47.0	54.0	weathered Pierre shale - gray - brown
54.0	55.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-12(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6253.5
Weathered Pierre shale	66.0	6187.5
Unweathered Pierre shale	68.0	6185.5
Total depth	70.0	6183.5

Depth (ft)		
From	To	Description
0	6.5	sandy clay - brown
6.5	8.5	clayey sand - light brown, fine grain
8.5	11.0	clay - brown; caliche zone from about 8.5'-8.7'
11.0	22.0	sandy clay - brown, quite damp
22.0	32.0	clay - brown, slightly damp
32.0	34.0	clayey sand - brown, medium grain, damp
34.0	37.0	sand - light brown, medium grain, damp
37.0	53.0	sand and gravel, very damp
53.0	66.0	sand, clay and gravel, wet
66.0	68.0	weathered Pierre shale - gray - brown
68.0	70.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-13(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6238.8
Weathered Pierre shale	14.0	6224.8
Unweathered Pierre shale	31.0	6207.8
Total depth	35.0	6203.8

Depth (ft) From	Depth (ft) To	Description
0	4.5	sandy clay - brown
4.5	5.5	clayey sand - light brown, fine-medium grain
5.5	14.0	slightly sandy clay - brown; 8.0'-8.5' caliche zone
14.0	31.0	weathered Pierre shale - gray - brown; 18.0' reddish streaks
31.0	35.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-14.

	Depth (ft)	Altitude (ft)
Land surface	0	6245.5
Weathered Pierre shale	15.5	6230.0
Unweathered Pierre shale	36.5	6209.0
Total depth	75.0	6170.5

Depth (ft)		
From	To	Description
0	3.0	sandy clay - brown
3.0	4.5	sand - light brown, fine grain
4.5	11.5	sandy clay - brown
11.5	13.5	clayey sand - brown, fine-medium grain
13.5	15.0	sandy clay - brown
15.0	15.5	sand, gravel and clay
15.5	36.5	weathered Pierre shale - gray - brown
36.5	75.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-15.

	Depth (ft)	Altitude (ft)
Land surface	0	6235.5
Weathered Pierre shale	25.0	6210.5
Unweathered Pierre shale	37.5	6198.0
Total depth	40.0	6195.5

Depth (ft) From	Depth (ft) To	Description
0	8.5	sandy clay - brown
8.5	25.0	slightly sandy clay - light brown; 8.5'-9.0' caliche zone
25.0	37.5	weathered Pierre shale - gray - brown
37.5	40.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-16.

	Depth (ft)	Altitude (ft)
Land surface	0	6312.0
Weathered Pierre shale	17.0	6295.0
Unweathered Pierre shale	34.0	6278.0
Total depth	40.0	6272.0

Depth (ft) From	Depth (ft) To	Description
0	1.5	sandy clay - brown
1.5	6.0	clayey sand - light brown, fine grain
6.0	9.0	sandy clay - brown
9.0	12.5	clayey sand - brown, fine-medium grain
12.5	16.5	sand with some gravel; 12.5'-13.0' caliche zone
16.5	17.0	sandy clay - brown
17.0	34.0	weathered Pierre shale - gray - brown
34.0	40.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-17.

	Depth (ft)	Altitude (ft)
Land surface	0	6269.5
Weathered Pierre shale	12.0	6257.5
Unweathered Pierre shale	27.0	6242.5
Total depth	30.0	6239.5

Depth (ft) From	Depth (ft) To	Description
0	3.0	sandy clay - brown
3.0	6.5	clay - brown
6.5	8.0	sand, clay and gravel
8.0	12.0	clay - brown
12.0	27.0	weathered Pierre shale - gray - brown
17.0	30.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-18(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6245.5
Weathered Pierre shale	22.0	6223.5
Unweathered Pierre shale	46.5	6199.0
Total depth	50.0	6195.5

Depth (ft)		
From	To	Description
0	6.0	sandy clay - brown
6.0	12.0	clay - brown; 8.5'-9.5' caliche zone
12.0	19.0	clay - tan; 12.0'-12.5' caliche zone
19.0	22.0	clay - brown
22.0	46.5	weathered Pierre shale - gray - brown
46.5	50.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-20.

	Depth (ft)	Altitude (ft)
Land surface	0	6285.5
Weathered Pierre shale	18.0	6267.5
Unweathered Pierre shale	31.0	6254.5
Total depth	33.5	6252.0

Depth (ft) From	Depth (ft) To	Description
0	4.0	sandy clay - brown
4.0	12.0	clayey sand - light brown, fine grain
12.0	18.0	slightly sandy clay - brown; 18.0'-18.5' caliche zone
18.0	31.0	weathered Pierre shale - gray - brown
31.0	33.5	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-19(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6257.5
Weathered Pierre shale	32.0	6225.5
Unweathered Pierre shale	45.0	6212.5
Total depth	50.0	6207.5

Depth (ft) From	To	Description
0	7.0	sandy clay - brown
7.0	12.0	clayey sand - light brown, fine grain; 7.0'-7.5' caliche zone
12.0	14.0	sandy clay - brown
14.0	18.0	clay - tan
18.0	32.0	sandy clay - brown
32.0	45.0	weathered Pierre shale - gray - brown
45.0	50.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-21(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6259.0
Weathered Pierre shale	33.0	6226.0
Unweathered Pierre shale	43.0	6216.0
Total depth	64.5	6194.5

Depth (ft) From	Depth (ft) To	Description
0	2.0	sandy clay - brown
2.0	4.5	clayey sand - light brown, fine grain
4.5	9.0	sandy clay - light brown
9.0	18.0	clay - brown, slightly damp
18.0	21.5	sandy clay - brown
21.5	28.0	clayey sand - tan, fine-medium grain, damp
28.0	31.5	sand and gravel, damp
31.5	33.0	sandy clay - brown
33.0	43.0	weathered Pierre shale - gray - brown
43.0	64.5	unweathered Pierre shale - black; shale making about ½ gpm water at 62.0'

Appendix I-1. -- Lithology at CNS-23(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6197.6
Weathered Pierre shale	30.0	6167.6
Unweathered Pierre shale	37.0	6160.6
Total depth	75.0	6122.6

Depth (ft)		
From	To	Description
0	3.5	sand and gravel
3.5	8.5	sandy clay - brown
8.5	9.5	sand, clay and gravel
9.5	11.5	sandy clay - brown
11.5	14.0	sand, gravel and clay
14.0	23.0	sandy clay - brown
23.0	30.0	sand, gravel and clay
30.0	37.0	weathered Pierre shale - gray - brown
37.0	75.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-24.

	Depth (ft)	Altitude (ft)
Land surface	0	6226.5
Weathered Pierre shale	22.0	6204.5
Unweathered Pierre shale	33.5	6193.0
Total depth	90.0	6136.5

Depth (ft) From	Depth (ft) To	Description
0	4.5	clayey sand - brown, fine-medium grain
4.5	9.0	sandy clay - brown
9.0	11.0	clayey sand - brown, medium grain
11.0	15.0	gravel, sand and clay
15.0	22.0	sandy clay - light brown
22.0	33.5	weathered Pierre shale - gray - brown
33.5	90.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-25(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6211.9
Weathered Pierre shale	23.0	6188.9
Unweathered Pierre shale	30.5	6181.4
Total depth	60.0	6151.9

Depth (ft) From	Depth (ft) To	Description
0	13.0	sandy clay - brown; 11.0'-12.0' caliche zone
13.0	15.0	gravel and sand
15.0	19.0	clayey sand - light brown, medium grain
19.0	21.5	sand, clay and gravel
21.5	23.0	slightly sandy clay - brown
23.0	30.5	weathered Pierre shale - gray - brown
30.5	60.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-26(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6222.8
Weathered Pierre shale	23.0	6199.8
Unweathered Pierre shale	35.0	6187.8
Total depth	60.0	6162.8

Depth (ft) From	Depth (ft) To	Description
0	3.0	sandy clay - brown
3.0	6.0	clayey sand - brown, fine grain; caliche zone from about 4.5'-5.0'
6.0	6.5	sandy clay - brown
6.5	10.5	sand, clay and gravel
10.5	11.0	sand - tan, fine-medium grain
11.0	13.0	sand, clay and gravel
13.0	21.5	gravel and sand
21.5	23.0	sandy clay - brown
23.0	35.0	weathered Pierre shale - gray - brown
35.0	60.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-27.

	Depth (ft)	Altitude (ft)
Land surface	0	6226.5
Weathered Pierre shale	10.5	6216.0
Unweathered Pierre shale	29.0	6197.0
Total depth	31.0	6195.5

Depth (ft) From	Depth (ft) To	Description
0	2.0	clayey sand - light brown, fine grain
2.0	7.0	sandy clay - brown; caliche zone from about 5.0'-6.0'
7.0	9.5	gravel, sand and clay
9.5	10.5	sandy clay - brown
10.5	29.0	weathered Pierre shale - gray - brown; concentration of salts at about 25.'
29.0	31.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-28.

	Depth (ft)	Altitude (ft)
Land surface	0	6216.0
Weathered Pierre shale	14.0	6202.0
Unweathered Pierre shale	31.0	6185.0
Total depth	31.2	6184.8

Depth (ft)		
From	To	Description
0	4.5	clayey sand - light brown, fine grain
4.5	8.0	sandy clay - brown
8.0	9.5	clayey sand - brown, fine-medium grain; 8.5'-9.5' caliche zone
9.5	11.0	sand, gravel and clay
11.0	13.0	gravel and sand
13.0	14.0	sandy clay - brown
14.0	31.0	weathered Pierre shale - gray - brown, damp
31.0	31.2	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-29(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6234.8
Total depth	43.0	6191.8

Depth (ft) From	To	Description
0	2.0	clayey sand - light brown, fine-medium grain
2.0	8.0	sand with little gravel
8.0	14.0	sandy clay - brown; 12.5'-14.0' caliche zone
14.0	16.0	clayey sand - brown, fine grain
16.0	23.5	sandy clay - tan
23.5	24.5	clayey sand - brown, fine grain
24.5	26.0	sandy clay - reddish brown
26.0	32.0	clayey sand - brown, medium grain, damp
32.0	34.0	sand and gravel, damp
34.0	35.5	sand - tan, medium grain, damp
35.5	43.0	sand and gravel, wet; making about 3/4 gpm water at about 42.'

Appendix I-1. -- Lithology at CNS-30(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6222.6
Weathered Pierre shale	38.0	6184.6
Unweathered Pierre shale	47.0	6175.6
Total depth	74.5	6148.1

Depth (ft) From	Depth (ft) To	Description
0	2.5	sandy clay - brown
2.5	4.0	clayey sand - brown, fine grain
4.0	14.5	sandy clay - brown; 4.0'-5.0' caliche zone
14.5	16.0	clayey sand - light brown, fine grain
16.0	21.0	sandy clay - brown, damp
21.0	25.5	clay - brown, damp
25.5	26.0	sandy clay - brown, very damp
26.0	26.5	clayey sand - brown, fine grain, very damp
26.5	28.0	sandy clay - brown, very damp
28.0	34.0	sand with some gravel, wet
34.0	38.0	sandy clay - brown, wet
38.0	47.0	weathered Pierre shale - gray - brown, damp
47.0	74.5	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-31(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6199.6
Weathered Pierre shale	45.5	6154.1
Unweathered Pierre shale	47.0	6151.6
Total depth	47.2	6151.4

Depth (ft) From	To	Description
0	3.0	clayey sand - light brown, fine grain
3.0	8.5	sandy clay - brown; 4.5'-5.0', 7.0'-8.0' caliche zones
8.5	10.5	clayey sand - tan, medium grain
10.5	12.5	sand and gravel
12.5	14.0	clayey sand - tan, medium grain
14.0	16.0	sandy clay - brown, damp
16.0	16.5	sand - brown, fine-medium grain
16.5	19.0	sandy clay - brown
19.0	20.0	clayey sand - light brown, medium grain
20.0	38.0	gravel and sand; making about ½ gpm water at about 34.'
38.0	45.5	sand - yellow, medium-coarse grain
45.5	47.0	weathered Pierre shale - gray - brown
47.0	47.2	unweathered Pierre shale - black

Size Analysis

	Grain size (mm)	Weight percent
20.0'-38.0'	>2.0	75.8
	0.15-2.0	20.2
	0.075-0.15	1.1
	<.075	2.9

Appendix I-1. -- Lithology at CNS-32(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6199.1
Weathered Pierre shale	19.5	6179.6
Unweathered Pierre shale	29.0	6170.1
Total depth	70.0	6129.1

Depth (ft) From	To	Description
0	5.5	sandy clay - brown
5.5	8.0	clayey sand - light brown, fine grain; 7.5'-8.0' caliche zone
8.0	16.5	sandy clay - reddish brown
16.5	19.5	sand, gravel and clay
19.5	29.0	weathered Pierre shale - gray - brown
29.0	70.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-33.

	Depth (ft)	Altitude (ft)
Land surface	0	6212.0
Weathered Pierre shale	19.5	6192.5
Unweathered Pierre shale	40.5	6171.5
Total depth	75.0	6137.0

Depth (ft) From	Depth (ft) To	Description
0	3.5	sandy clay - brown
3.5	7.5	clayey sand - brown, fine-medium grain
7.5	9.0	sand, gravel and clay
9.0	10.5	sandy clay - reddish brown
10.5	11.0	clayey sand - light brown, fine grain
11.0	15.5	sandy clay - brown; 12.0'-13.0' caliche zone
15.5	19.5	sand, gravel and clay
19.5	40.5	weathered Pierre shale - gray - brown
40.5	75.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNS-34(P).

	Depth (ft)	Altitude (ft)
Land surface	0	6239.3
Weathered Pierre shale	50.5	6188.8
Unweathered Pierre shale	51.5	6187.8
Total depth	52.2	6187.1

Depth (ft) From	To	Description
0	4.0	sandy clay - brown
4.0	7.0	clayey sand - light brown, fine grain
7.0	13.0	sandy clay - brown; 7.5'-8.0' caliche zone
13.0	18.0	clayey sand - brown, fine grain
18.0	21.5	sandy clay - brown, little damp
21.5	30.0	clayey sand - tan, fine-medium grain, damp
30.0	43.5	sand and gravel, wet; making near ½ gpm water at about 42.'
43.5	50.5	sand - tan, medium-coarse grain, wet
50.5	51.5	weathered Pierre shale - gray - brown
51.5	52.2	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNW-1.

	Depth (ft)	Altitude (ft)
Land surface	0	6205.0
Weathered Pierre shale	41.0	6164.0
Unweathered Pierre shale	47.0	6158.0
Total depth	53.0	6152.0

Depth (ft) From	Depth (ft) To	Description
0	6.5	clayey sand - light brown, fine grain; 4.0'-5.0' caliche zone .
6.5	7.0	sandy clay - brown
7.0	13.0	clayey sand - brown, fine-medium grain
13.0	24.0	sand - tan, fine-coarse grain, wet
24.0	31.0	gravel and sand, wet
31.0	41.0	sand - tan, medium-coarse grain, wet
41.0	47.0	weathered Pierre shale - gray - brown
47.0	53.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNW-2.

	Depth (ft)	Altitude (ft)
Land surface	0	6210.0
Weathered Pierre shale	not present	
Unweathered Pierre shale	51.0	6159.0
Total depth	52.0	6158.0

Depth (ft) From	Depth (ft) To	Description
0	3.0	sandy clay - dark brown
3.0	4.5	sand - yellow, fine grain
4.5	9.0	sandy clay - brown; 6.0'-6.5' caliche zone
9.0	9.5	sand - yellow, fine-medium grain
9.5	10.5	sandy clay - brown
10.5	16.0	sand - yellow, fine-medium grain
16.0	27.5	sand with small amount of gravel
27.5	30.0	sand and gravel, damp
30.0	45.0	sand - yellow, fine-medium grain, wet
45.0	51.0	sand and gravel, wet
51.0	52.0	unweathered Pierre shale - black

Appendix I-1. -- Lithology at CNW-3.

	Depth (ft)	Altitude (ft)
Land surface	0	6161.0
Weathered Pierre shale	40.0	6121.0
Total depth	42.0	6119.0

Depth (ft) From	To	Description
0	5.0	sandy clay - brown
5.0	8.0	clayey sand - light brown, fine grain
8.0	18.0	sandy clay - brown
18.0	21.0	clayey sand - tan, fine-coarse grain
21.0	40.0	sand and gravel, wet
40.0	42.0	weathered Pierre shale - gray - brown

Appendix I-1. -- Lithology at CNW-4.

	Depth (ft)	Altitude (ft)
Land surface	0	6170.0
Weathered Pierre shale	34.0	6136.0
Unweathered Pierre shale	35.0	6135.0
Total depth	36.0	6134.0

Depth (ft) From	To	Description
0	3.0	sandy clay - brown
3.0	4.0	clayey sand - brown, fine grain
4.0	5.5	sandy clay - brown
5.5	6.5	clayey sand - tan, fine grain
6.5	8.0	sandy clay - brown
8.0	10.5	clayey sand - light brown, fine-medium grain
10.5	11.5	sandy clay - reddish brown
11.5	13.0	clayey sand - tan, fine-coarse grain
13.0	16.0	sand with some gravel
16.0	17.0	sandy clay - reddish brown
17.0	27.0	clayey sand - yellow, medium-coarse grain, wet
27.0	34.0	sand and gravel, wet
34.0	35.0	weathered Pierre shale - gray - brown
35.0	36.0	unweathered Pierre shale - black

Appendix I-2.--Depth-to-water measurements and water-level altitudes

Appendix I-2. -- Depth-to-water measurements and water-level altitude in CNC-1

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
11- 9-76				hole filled with water for bore-hole geophysical studies
11-11-76		24.25	6348.80	
11-13-76		32.55	6340.50	
11-18-76		53.19	6319.91	
12- 3-76		112.73	6260.37	
12- 4-76		113.00	6260.10	water-table altitude 6275 ft
12- 5-76		113.27	6259.83	
12- 6-76		112.97	6260.13	
12- 7-76		113.51	6259.60	
12- 8-76		114.00	6259.10	
12- 9-76		114.35	6258.75	
12-10-76		115.43	6257.67	
12-11-76		116.50	6256.60	
12-12-76		117.40	6255.70	
12-13-76		118.35	6254.75	
12-14-76		119.02	6254.08	
12-15-76		119.74	6253.36	
12-16-76		122.29	6250.81	
12-17-76		124.85	6248.25	
12-18-76		127.40	6245.70	
12-19-76		133.67	6239.43	
12-20-76		129.96	6243.14	
12-21-76		134.36	6238.74	
12-22-76		134.20	6238.90	
12-23-76		135.33	6237.77	
12-27-76		142.70	6230.40	
12-28-76		143.61	6229.49	
12-29-76	0915	144.22	6228.88	
12-30-76	0934	143.50	6229.60	
12-31-76	1034	144.50	6228.60	
1- 1-77	1215	145.56	6227.54	
1- 2-77	1000	146.40	6226.70	
1- 4-77	0900	148.00	6225.10	
1- 5-77	0430	148.86	6224.24	
1-14-77	1100	153.73	6218.47	

MP* = measuring point top of casing, 0.96' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNC-3(P)

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
12- 7-76		50.40	6220.40	
12- 8-76		50.35	6220.45	
12- 9-76		49.93	6220.87	cemented
12-10-76		49.90	6220.90	
12-11-76		49.90	6220.90	
12-12-76		49.88	6220.92	
12-13-76		49.89	6220.91	
12-14-76		49.84	6220.96	
12-15-76		49.80	6221.00	
12-16-76		49.79	6221.01	
12-17-76		49.75	6221.05	
12-18-76		49.43	6221.37	slug test
12-19-76		48.33	6222.47	
12-20-76		48.11	6222.69	
12-21-76		48.40	6222.40	
12-22-76		48.31	6222.49	
12-23-76		47.87	6222.93	
12-27-76		47.81	6222.99	
12-28-76		47.79	6223.01	
12-29-76	1507	47.69	6223.11	
12-30-76	1335	47.84	6222.96	
12-31-76	1328	47.39	6223.41	
1- 1-77	1414	47.41	6223.39	
1- 2-77	1201	47.50	6223.30	
1- 4-77	1049	47.89	6222.91	

MP* = measuring point 5.10' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNC-4(P)

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
12- 8-76		59.60	6211.20	installed & cemented
12- 9-76		59.50	6211.30	
12-10-76		56.40	6214.40	
12-11-76		55.61	6215.19	
12-12-76		54.80	6216.00	
12-13-76		54.02	6216.22	
12-14-76		56.75	6214.05	
12-15-76		56.70	6214.10	
12-16-76		55.94	6214.86	
12-17-76		55.63	6215.17	
12-18-76		55.54	6215.26	
12-19-76		55.68	6215.12	
12-20-76		50.93	6219.87	
12-21-76		55.56	6215.24	
12-22-76		54.46	6216.34	
12-23-76		56.79	6214.01	
12-27-76		56.80	6213.00	
12-28-76		56.82	6213.98	
12-29-76	1515	56.73	6214.07	
12-30-76	1336	56.82	6213.98	
12-31-76	1333	56.73	6214.07	
1- 1-77	1419	56.74	6214.06	
1- 2-77	1209	56.77	6214.03	
1- 4-77	1105	55.90	6214.90	

MP* = measuring point 6.20' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNC-6(P)

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
12-22-76				installed
12-23-76				cemented
12-29-76	0948	39.97	6190.03	
12-30-76	1010	39.88	6190.12	
12-31-76	1050	39.88	6190.12	
1- 1-77	1250	39.88	6190.12	
1- 2-77	1030	39.88	6190.12	
1- 4-77	0927	39.89	6190.11	
1- 5-77	0518	40.07	6189.93	
1- 14-77	1140	40.17	6189.93	

MP* = measuring point

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNC-7(P)

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
11-15-76				installed
12- 4-76		34.27	6178.93	
12- 5-76		34.28	6178.92	
12- 6-76		34.27	6178.93	
12- 7-76		34.32	6178.88	
12- 8-76		34.31	6178.89	cemented
12- 9-76		34.24	6178.96	slug test
12-10-76		34.37	6178.83	
12-11-76		34.32	6178.88	
12-12-76		34.43	6178.77	
12-13-76		34.47	6178.73	
12-14-76		34.43	6178.77	
12-15-76		34.34	6178.86	
12-16-76		34.93	6178.27	
12-16-76		31.83	6181.37	
12-17-76		34.20	6179.00	
12-18-76		34.29	6178.91	
12-19-76		34.36	6178.84	
12-20-76		34.27	6178.93	
12-21-76		34.24	6178.96	
12-22-76		34.28	6178.92	
12-23-76		34.26	6178.94	
12-27-76		34.80	6178.40	
12-28-76	1130	34.88	6178.32	
12-28-76	1205	38.01	6175.19	
12-29-76	1026	37.49	6175.71	
12-29-76	1330	38.59	6174.61	
12-29-76	1622	41.89	6171.31	
12-30-76	1016	36.51	6176.69	
12-30-76	1348	38.97	6174.23	
12-31-76	1057	35.22	6177.98	
12-31-76	1345	35.07	6178.13	
1- 1-77	1200	34.63	6178.57	
1- 1-77	1421	34.58	6178.62	
1- 1-77	1716	34.54	6178.66	
1- 2-77	1047	34.49	6178.71	
1- 2-77	1221	34.49	6178.71	
1- 2-77	1456	34.49	6178.71	
1- 4-77	0845	34.54	6178.66	
1- 4-77	0936	34.49	6178.71	
1-14-77	1150	34.55	6178.52	

MP* = measuring point 3.50' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNC-8(P)

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
12-22-76				installed
12-23-76				cemented
1- 4-77	1119	41.73	6209.07	

MP* = measuring point 5.30' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNG-2(P)

Date: Day	Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
12- 8-76		43.35	6202.85	installed
12- 9-76		42.60	6203.60	cemented
12-10-76		45.69	6200.51	
12-11-76		47.15	6199.05	
12-12-76		48.57	6197.63	
12-13-76		50.02	6196.18	
12-14-76		50.52	6195.68	
12-15-76		50.70	6195.50	
12-16-76		50.07	6196.13	
12-17-76		49.98	6196.22	
12-18-76		50.01	6196.19	
12-19-76		49.34	6196.86	
12-20-76		49.75	6196.45	
12-21-76		49.99	6196.21	
12-22-76		50.02	6196.14	
12-23-76		50.06	6196.14	
12-27-76		50.27	6195.93	
12-28-76		50.29	6195.91	
12-29-76	1502	50.56	6195.64	
12-30-76	1330	49.28	6195.48	
12-31-76	1320	49.24	6196.96	
1- 1-77	1404	48.97	6197.23	
1- 2-77	1153	48.01	6198.19	
1- 4-77	1046	47.38	6198.82	

MP* = measuring point 4.10' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNG-4

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
12-12-76		54.55	6196.95	Open hole - no casing

MP*= land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitude in CNP-1

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
11-22-76				installed
12- 3-76		dry		
12- 4-76		dry		damp sand on end of tape
12- 5-76		dry		damp sand on end of tape
12- 6-76		-		damp sand on end of tape
12- 7-76		-		damp sand
12- 8-76		dry		
12- 9-76		dry		cemented
12-10-76		dry		
12-11-76		dry		
12-12-76		dry		
12-13-76		-		damp clay and sand on end
12-14-76		-		damp clay and sand on end
12-15-76		-		damp clay and sand on end
12-16-76		dry		
12-17-76		dry		
12-18-76		dry		
12-19-76		dry		
12-20-76		dry		
12-21-76		dry		
12-22-76		dry		
12-23-76		dry		

MP* = measuring point 4.60' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitude in CNP-2

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
11- 9-76				hole filled with water for Schlumberger
11-10-76		17.80	6192.20	
11-11-76		18.17	6191.83	
11-12-76		19.29	6190.71	
11-13-76		20.41	6189.59	
11-14-76		20.64	6189.36	
11-17-76		21.15	6188.85	
11-18-76		21.42	6188.58	
11-20-76		22.03	6187.97	
11-23-76		18.46	6191.54	
12- 3-76		23.78	6186.22	
12- 4-76		23.75	6186.25	
12- 5-76		23.72	6186.28	
12- 6-76		23.70	6186.30	
12- 7-76		23.68	6186.32	
12- 8-76		23.65	6186.35	
12- 9-76		23.63	6186.37	
12-10-76		23.68	6186.32	
12-11-76		23.73	6186.27	
12-12-76		23.76	6186.24	
12-13-76		23.84	6186.16	
12-14-76		23.90	6186.10	
12-15-76		23.97	6186.03	
12-16-76		24.00	6186.00	
12-17-76		24.04	6185.96	
12-18-76		24.02	6185.98	
12-19-76		23.99	6186.01	
12-20-76		23.94	6186.06	
12-21-76		24.79	6185.21	
12-22-76		24.06	6185.94	
12-23-76		23.95	6186.05	
12-27-76		23.97	6186.03	
12-28-76		24.06	6185.94	
12-29-76	1430	24.12	6185.88	
12-30-76	1310	24.16	6185.84	
12-31-76	1145	24.18	6185.82	
1- 1-77	1333	24.20	6185.80	
1- 2-77	1125	24.76	6185.24	
1- 4-77	1012	24.36	6185.64	
1-14-77	1246	24.61	6185.39	

MP* = measuring point, top of 6 inch casing 0.2' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNP-3

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
10-18-76				installed
10-21-76				cemented
10-22-76		95.29	6128.81	
10-23-76		95.14	6128.96	
10-24-76		95.03	6219.07	
10-25-76		94.98	6129.12	
10-26-76		94.87	6129.23	
10-27-76		95.01	6129.09	
10-28-76		94.93	6129.17	
10-29-76		94.88	6129.22	
10-30-76		94.84	6129.26	
10-31-76		94.64	6129.46	
11- 1-76		94.24	6129.86	
11- 2-76		94.28	6129.83	
11- 3-76		94.02	6130.08	
11- 4-76	1025	93.27	6130.83	before chemical analysis sample
11- 4-76		94.24	6139.86	after chemical analysis sample
11- 4-76		94.21	6129.89	
11- 5-76		93.97	6130.13	
11- 6-76		93.87	6130.23	
11- 7-76		93.81	6130.29	
11- 8-76		93.45	6130.65	
11- 9-76		93.27	6130.83	
11-10-76		93.11	6130.99	
11-11-76		92.98	6131.12	
11-12-76		92.85	6131.25	
11-13-76		92.73	6131.37	
11-14-76		92.35	6131.75	
11-15-76		92.09	6132.01	
11-16-76		91.88	6132.22	
11-17-76		93.51	6130.59	
11-18-76		91.96	6132.14	
11-19-76		90.22	6133.88	
11-20-76		88.70	6135.40	slug test
11-21-76		89.47	6134.63	
11-22-76		91.55	6132.55	
11-23-76		88.34	6135.76	
12- 2-76		86.34	6137.76	
12- 3-76		87.24	6136.86	
12- 4-76		87.27	6136.83	
12- 5-76		87.30	6136.80	

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNP-3 (cont)

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
12- 6-76		87.25	6136.85	
12- 7-76		86.88	6137.22	
12- 8-76		87.20	6136.90	
12- 9-76		87.04	6137.06	
12-10-76		87.10	6137.00	
12-11-76		87.07	6137.03	
12-12-76		87.11	6136.99	
12-13-76		87.05	6137.05	
12-14-76		86.86	6137.24	
12-15-76		86.87	6137.23	
12-16-76		86.86	6137.24	
12-17-76		86.71	6137.39	
12-18-76		86.69	6137.41	
12-19-76		86.60	6137.50	
12-20-76		86.68	6137.42	
12-21-76		86.79	6137.31	
12-22-76		86.49	6137.61	
12-23-76		86.49	6137.61	
12-27-76		86.24	6137.86	
12-28-76		86.06	6138.04	
12-29-76	1421	85.94	6138.16	
12-30-76	1305	85.90	6138.20	
12-31-76	1118	85.90	6138.20	
1- 1-77	1325	85.87	6138.23	
1- 2-77	1118	85.88	6138.22	
1- 4-77	1002	85.50	6138.60	
1-14-77	1240	85.17	6138.93	

MP* = measuring point 6.10' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNP-3(A)

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
10-14-76				installed
10-22-76		dry		cemented
10-23-76		dry		
10-24-76		dry		
10-25-76		dry		
10-26-76		dry		
10-27-76		dry		
10-28-76		dry		
10-29-76		dry		
10-30-76		dry		
10-31-76		dry		
11- 1-76		dry		
11- 2-76		dry		
11- 3-76		dry		
11- 4-76		dry		
11- 5-76		dry		
11- 6-76		dry		
11- 7-76		dry		
11- 8-76		dry		
11- 9-76		dry		
11-10-76		dry		
11-11-76		dry		
11-12-76		dry		
11-13-76		dry		
11-14-76		dry		
11-15-76		dry		
11-16-76		dry		
11-17-76		dry		
11-18-76		dry		
11-19-76		dry		
11-20-76		dry		
11-21-76		dry		
11-22-76		dry		
11-23-76		dry		
12- 3-76		dry		
12- 4-76		dry		
12- 5-76		dry		
12- 6-76		dry		
12- 7-76		dry		
12- 8-76		dry		
12- 9-76		dry		
12-10-76		dry		
12-11-76		dry		

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNP-3(A) (cont)

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
12-12-76		dry		
12-13-76		dry		
12-14-76		dry		
12-15-76		dry		
12-16-76		dry		
12-17-76		dry		
12-18-76		dry		
12-19-76		dry		
12-20-76		dry		
12-21-76		dry		
12-22-76		dry		
12-23-76		dry		
12-27-76		dry		
12-28-76		dry		
12-29-76	1420	dry		
12-30-76	1306	dry		
12-31-76	1128	dry		
1- 1-77	1327	dry		
1- 2-77	1120	dry		
1- 4-77	1006	dry		
1-14-77	1241	dry		

MP* = measuring point 3.20' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNP-3(B)

Date: Day	Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
11-29-76				installed
12- 1-76				cemented
12- 3-76		38.56	6183.44	
12- 4-76		38.37	6183.63	
12- 5-76		38.11	6183.89	
12- 6-76		37.95	6184.05	
12- 7-76		37.94	6184.06	
12- 8-76		36.64	6185.36	
12- 9-76		37.45	6184.55	
12-10-76		37.40	6184.60	
12-11-76		37.44	6184.56	
12-12-76		37.45	6184.55	
12-13-76		37.43	6184.57	
12-14-76		37.39	6184.61	
12-15-76		37.40	6184.60	slug test
12-16-76		36.66	6185.34	
12-17-76		37.10	6184.90	
11-18-76		37.37	6184.63	
12-19-76		37.11	6184.89	
12-20-76		37.31	6184.69	
12-21-76		37.24	6184.76	
12-22-76		37.16	6184.84	
12-23-76		37.32	6184.68	
12-27-76		37.20	6184.80	
11-18-75		37.05	6184.95	
12-29-76	1426	37.06	6184.94	
12-30-76	1308	36.94	6185.06	
12-31-76	1129	36.98	6185.02	
1- 4-77	1329	37.00	6185.00	
1- 2-77	1121	37.06	6184.94	
1- 4-77	1008	37.05	6184.95	
1-14-77	1252	37.28	6184.58	

MP* = measuring point 4.03' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in GNP-4

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
10-19-76				installed
10-20-76				cemented
10-22-76	1550	84.24	6155.56	
10-23-76		82.79	6157.01	
10-24-76		81.53	6158.27	
10-25-76		80.10	6159.70	
10-26-76		78.14	6161.66	
10-27-76		76.91	6162.89	
10-28-76	1210	76.66	6163.14	
10-29-76		74.90	6164.90	
10-30-76		73.30	6166.30	
10-31-76		72.41	6167.39	
11- 1-76		72.41	6167.39	
11- 2-76		72.48	6167.32	
11- 3-76		70.22	6169.58	
11- 4-76		70.37	6169.43	
11- 5-76		69.87	6169.93	
11- 6-76		69.35	6170.45	
11- 7-76		69.03	6170.77	
11- 8-76		68.60	6171.20	
11- 9-76	0410	68.60	6171.20	before water sample
11- 9-76		74.32	6165.48	after water sample
11- 9-76		73.10	6166.70	
11-10-76		72.36	6167.44	
11-11-76		71.58	6168.22	
11-12-76		70.78	6169.02	
11-13-76		70.00	6169.80	
11-14-76		69.52	6170.28	
11-15-76		68.93	6170.87	
11-16-76		68.51	6171.29	
11-17-76		65.00	6174.80	
11-18-76		64.91	6174.89	
11-19-76		64.81	6174.99	
11-20-76		64.83	6174.97	
11-21-76		64.87	6174.93	
11-22-76		64.91	6174.89	
11-23-76		64.97	6174.83	
12- 2-76		64.80	6175.00	
12- 3-76		64.77	6175.03	
12- 4-76		64.75	6175.05	
12- 5-76		64.73	6175.07	
12- 6-76		64.74	6175.06	
12- 7-76		64.69	6175.11	

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNP-4 (cont)

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
12- 8-76		64.66	6175.14	
12- 9-76		64.64	6175.16	
12-10-76		64.88	6174.92	
12-11-76		64.90	6174.90	
12-12-76		64.92	6174.88	
12-13-76		64.98	6174.82	
12-14-76		64.74	6175.06	
12-15-76		64.83	6174.97	
12-16-76		64.94	6174.86	
12-17-76		64.82	6174.98	
12-18-76		64.87	6174.93	
12-19-76		64.70	6175.10	
12-20-76		64.94	6174.86	
12-21-76		64.78	6175.02	
12-22-76		64.73	6175.07	
12-23-76		64.79	6175.01	
12-27-76		64.74	6175.06	
12-28-76		64.69	6175.11	
12-29-76	1407	64.53	6175.27	
12-30-76	1135	64.48	6175.32	
12-31-76	1110	64.41	6175.39	
1- 1-77	1315	64.44	6175.36	
1- 2-77	1105	64.57	6175.23	
1- 4-77	1050	64.18	6175.62	
1-14-77	1220	64.66	6175.14	

MP* = measuring point 4.80' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitude in CNP-4A

Date Day	Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
10-18-76				installed
10-20-76				cemented
10-22-76		dry		
10-23-76		dry		
10-24-76		dry		
10-25-76		dry		
10-26-76		dry		
10-27-76		dry		
10-28-76		dry		
10-29-76		dry		
10-30-76		dry		
10-31-76		dry		
11- 1-76		dry		
11- 2-76		dry		
11- 3-76		dry		
11- 4-76		dry		
11- 5-76		dry		
11- 6-76		dry		
11- 7-76		dry		
11- 8-76		dry		
11- 9-76		dry		
11-10-76		dry		
11-11-76		dry		
11-12-76		dry		
11-13-76		dry		
11-14-76		dry		
11-15-76		dry		
11-16-76		dry		
11-17-76		dry		
11-18-76		dry		
11-19-76		dry		
11-20-76		dry		
11-21-76		dry		
11-22-76		dry		
11-23-76		dry		
12- 1-76		dry		
12- 2-76		dry		
12- 3-76		dry		
12- 4-76		dry		
12- 5-76		dry		
12- 6-76		dry		
12- 7-76		dry		
12- 8-76		dry		
12- 9-76		dry		
12-10-76		dry		

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNP-4A (cont)

Date Day	Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
12-11-76		dry		
12-12-76		dry		
12-13-76		dry		
12-14-76		dry		
12-15-76		dry		
12-16-76		dry		
12-17-76		dry		
12-18-76		dry		
12-19-76		dry		
12-20-76		dry		
12-21-76		dry		
12-22-76		dry		moist sand on bottom of tape
12-23-76		dry		moist sand on bottom of tape
12-27-76		dry		
12-28-76		dry		
12-29-76	1408	dry		
12-30-76	1150	dry		
12-31-76	1111	dry		
1- 1-77	1316	dry		
1- 2-77	1106	dry		
1- 4-77	1051	dry		
1-14-77	1221	dry		

MP* - measuring point 4.53' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNP-4B

Date Day	Date Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
11-29-76				installed
12- 1-76				cemented
12- 3-76		58.80	6180.90	
12- 4-76		58.69	6181.01	
12- 4-76		58.55	6181.15	
12- 6-76		58.43	6181.27	
12- 7-76		58.66	6181.04	
12- 8-76		58.72	6180.98	
12- 9-76		58.22	6181.48	
12-10-76		58.70	6181.00	
12-11-76		58.71	6180.99	
12-12-76		58.76	6180.94	
12-13-76		58.79	6180.91	
12-14-76		58.82	6180.88	
12-15-76		58.80	6180.90	slug test
12-16-76		52.88	6186.82	
12-17-76		52.92	6186.78	
12-18-76		52.95	6186.75	
12-19-76		52.95	6186.75	
12-20-76		52.43	6187.27	
12-21-76		52.94	6186.76	
12-23-76		53.00	6186.70	
12-27-76		53.00	6186.10	
12-28-76		53.01	6168.69	
12-29-76	1411	53.01	6186.69	
12-30-76	1150	53.01	6186.69	
12-31-76	1113	53.02	6186.68	
1- 1-77	1318	53.02	6186.68	
1- 2-77	1107	53.02	6186.68	
1- 4-77	1057	53.04	6186.66	
1-14-77	1224	52.09	6187.64	

MP* = measuring point 4.66' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNP-5

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
11-24-76				installed
12- 3-76				cemented
12- 4-76		51.20	6169.00	slug test
12- 5-76		51.00	6169.20	
12- 6-76		50.83	6169.37	
12- 7-76		50.85	6169.35	
12- 8-76		50.87	6169.33	
12- 9-76		50.73	6169.47	
12-10-76		50.80	6169.40	
12-11-76		50.85	6169.35	
12-12-76		50.91	6169.29	
12-13-76		50.99	6169.21	
12-14-76		50.86	6169.34	
12-15-76		50.88	6169.32	
12-16-76		50.92	6169.28	
12-17-76		50.89	6169.31	
12-18-76		50.86	6169.34	
12-19-76		50.70	6169.50	
12-20-76		50.96	6169.24	
12-21-76		50.84	6169.36	
12-22-76		50.74	6169.46	
12-23-76		50.79	6169.41	
12-27-76		50.74	6169.46	
12-28-76		50.72	6169.48	
12-29-76	1400	28.59	6191.61	
12-30-76	1120	50.45	6169.75	
12-31-76	1107	50.50	6169.70	
1- 1-77	1311	50.49	6169.71	
1- 2-77	1100	50.49	6169.71	
1- 4-77	0946	50.36	6169.84	
1- 5-77	0606	50.40	6169.80	
1-14-77	1203	50.55	6169.65	

MP* = measuring point 2.20' above land surface

Appendix I-2. -- Depht-to-water measurements and water-level altitudes in CNP-6

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
11-18-76				installed & cemented
11-23-76		16.20	6129.90	
12- 2-76		15.24	6130.86	
12- 3-76		15.32	6130.78	
12- 4-76		15.30	6130.80	
12- 5-76		15.27	6130.83	
12- 6-76		15.23	6130.87	
12- 7-76		15.21	6130.89	
12- 8-76		15.19	6130.91	
12- 9-76		15.07	6130.03	
12-10-76		15.33	6130.77	
12-11-76		15.25	6130.85	
12-12-76		15.26	6130.84	
12-13-76		15.21	6130.89	
12-14-76		15.16	6130.94	
12-15-76		15.20	6130.90	
12-16-76		15.21	6130.89	
12-17-76		15.06	6130.04	
12-18-76		15.04	6131.06	
12-19-76		15.18	6130.92	
12-20-76		15.12	6130.98	
12-21-76		14.98	6131.12	
12-22-76		15.04	6131.06	
12-23-76		14.98	6131.12	
12-27-76		14.96	6131.14	
12-28-76		14.98	6131.12	
12-29-76	1547	14.96	6131.14	
12-30-76	1417	14.80	6131.30	
12-31-76	1355	14.96	6131.14	
1- 1-77	1447	14.92	6131.18	
1- 2-77	1238	14.88	6131.22	
1- 4-77	1132	14.78	6131.32	

MP* = measuring point 4.70' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNP-6A

Date: Day	Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
11-18-76				installed & cemented
11-23-76		11.07	6134.03	
12- 2-76		10.91	6134.19	
12- 3-76		10.98	6134.12	
12- 4-76		11.01	6134.09	
12- 5-76		11.00	6134.10	
12- 6-76		11.02	6134.08	
12- 7-76		11.03	6134.07	
12- 8-76		11.07	6134.03	
12- 9-76		11.08	6134.02	
12-10-76		11.09	6134.01	
12-12-76		11.09	6134.01	
12-13-76		11.10	6134.00	
12-14-76		11.10	6134.00	
12-15-76		11.11	6133.99	
12-16-76		11.12	6133.98	
12-17-76		11.07	6134.03	
12-18-76		11.08	6134.02	
12-19-76		11.10	6134.00	
12-20-76		11.12	6133.98	
12-21-76		11.09	6134.01	
12-22-76		10.99	6134.11	
12-23-76		11.10	6134.00	
12-27-76		11.09	6134.01	
12-28-76		11.08	6134.02	
12-29-76	1545	11.07	6134.03	
12-30-76	1415	11.06	6134.04	
12-31-76	1355	11.05	6134.05	
1- 1-77	1443	11.06	6134.04	
1- 2-77	1235	11.10	6134.00	
1- 4-77	1129	11.15	6133.95	

MP* = measuring point 3.94' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNP-6B

Date: Day	Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
11-18-76				installed
11-19-76				cemented
11-23-76		29.02	6136.18	
12- 2-76		28.76	6136.44	
12- 3-76		28.83	6136.37	
12- 4-76		28.95	6136.25	
12- 5-76		29.04	6136.16	
12- 6-76		29.10	6136.10	
12- 7-76		29.12	6136.08	
12- 8-76		29.15	6136.05	
12- 9-76		29.15	6136.05	
12-10-76		29.17	6136.03	
12-11-76		29.16	6136.04	
12-12-76		29.18	6136.02	
12-13-76		29.19	6136.01	
12-14-76		29.19	6136.01	
12-15-76		29.19	6136.01	
12-16-76		29.18	6136.02	
12-17-76		29.19	6136.01	
12-18-76		29.20	6136.00	
12-19-76		29.16	6136.04	
12-19-76		29.18	6136.02	
12-20-76		29.18	6136.02	
12-21-76		29.18	6136.02	
12-22-76		29.17	6136.03	
12-23-76		29.18	6136.02	
12-27-76		29.18	6136.02	
12-28-76		29.17	6136.03	
12-29-76	1540	29.16	6136.04	
12-30-76	1410	29.13	6136.07	
12-31-76	1352	29.14	6136.06	
1- 1-77	1440	29.14	6136.06	
1- 2-77	1230	29.14	6136.06	
1- 4-77	1126	29.14	6136.06	

MP* = measuring point 4.29' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNP-7

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
11-22-76				installed
11-23-76		83.64	6145.96	cemented
12- 2-76		83.45	6146.15	
12- 3-76		84.17	6145.43	
12- 4-76		84.22	6145.38	
12- 5-76		84.31	6145.29	
12- 6-76		84.38	6145.22	
12- 7-76		84.62	6144.98	slug test
12- 8-76		81.22	6148.38	
12- 9-76		81.27	6148.33	
12-10-76		81.30	6148.30	
12-11-76		81.34	6148.26	
12-12-76		81.41	6148.19	
12-13-76		81.48	6148.12	
12-14-76		81.56	6148.04	
12-15-76		81.60	6148.00	
12-16-76		81.64	6147.96	
12-17-76		81.60	6148.00	
12-18-76		81.61	6147.99	
12-19-76		81.64	6147.96	
12-20-76		81.62	6147.98	
12-21-76		81.73	6147.87	
12-22-76		81.70	6147.90	
12-23-76		81.64	6147.96	
12-27-76		81.63	6147.97	
12-28-76		81.63	6147.97	
12-29-76	1555	81.63	6147.97	
12-30-76	1610	81.63	6147.97	
12-31-76	1535	81.64	6147.96	
1- 1-77	1628	81.63	6147.97	
1- 2-77	1438	81.65	6147.95	
1- 4-77	1222	81.20	6148.20	

MP* = measuring point 4.88' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNP-7A

Date Day	Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
11-19-76				installed
11-23-76				cemented
12- 2-76		dry		
12- 3-76		dry		
12- 4-76		dry		
12- 5-76		dry		
12- 6-76		dry		
12- 7-76		dry		damp on tip
12- 8-76		13.67	6214.13	
12- 9-76		13.60	6214.20	
12-10-76		13.40	6214.40	
12-11-76		13.53	6214.27	
12-12-76		13.62	6214.18	
12-13-76		13.71	6214.10	
12-14-76		dry		damp on tip
12-15-76		dry		
12-16-76		dry		
12-17-76		dry		
12-18-76		dry		
12-19-76		dry		
12-20-76		dry		
12-21-76		dry		
12-22-76		dry		
12-23-76		dry		
12-27-76		dry		
12-28-76		dry		
12-29-76		dry		
12-30-76		dry		
12-31-76		dry		
1- 1-77		dry		
1- 2-77		dry		

MP* = measuring point 2.70' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitude in CNP-8

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
11-19-76				installed
11-22-76				cemented
12- 3-76		28.11	6095.99	
12- 4-76		28.07	6096.03	
12- 5-76		28.01	6096.09	
12- 6-76		27.98	6096.12	
12- 7-76		28.30	6095.80	
12- 8-76		26.10	6098.00	pressure injected
12- 9-76		28.02	6096.08	
12-10-76		28.07	6096.03	
12-11-76		28.09	6096.01	
12-12-76		28.12	6095.98	
12-13-76		28.15	6095.95	
12-14-76		28.19	6095.91	
12-15-76		28.19	6095.91	
12-16-76		28.20	6095.90	
12-17-76		28.15	6095.95	
12-18-76		28.17	6095.93	
12-19-76		28.16	6095.94	
12-20-76		28.17	6095.93	
12-21-76		28.07	6096.03	
12-22-76		28.10	6096.00	
12-23-76		28.07	6096.03	
12-27-76		28.08	6096.02	
12-28-76		28.13	6095.97	
12-29-76	1500	28.10	6096.00	
12-30-76	1513	28.05	6096.05	
12-31-76	1520	28.07	6096.03	
1- 1-77	1610	28.04	6096.06	
1- 2-77	1420	28.05	6096.05	
1- 4-77	1148	29.05	6095.05	

MP* = measuring point 2.80' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNP-8A

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
11-19-76				installed
11-22-76				cemented
12- 2-76		dry		8 has moisture
12- 3-76				Bentonite plug at 27.58'
12- 4-76				Bentonite plug at 27.58'
12- 5-76				Bentonite plug at 27.58'
12- 6-76				Bentonite plug at 27.58'
12- 7-76				Bentonite plug at 27.58'
12- 8-76		hit bottom		pressure injection test
12- 9-76		hit bottom		
12-10-76		hit bottom		
12-11-76		hit bottom		
12-12-76		hit hottom		
12-13-76		hit bottom		
12-14-76		hit bottom		
12-15-76		hit bottom		
12-16-76		hit bottom		
12-17-76		hit bottom		
12-18-76		hit bottom		
12-19-76		hit bottom		
12-20-76		hit bottom		
12-21-76		hit bottom		
12-22-76		dry		
12-23-76		dry		
12-27-76		dry		
12-28-76		dry		
12-29-76		dry		
12-30-76		dry		
12-31-76		dry		
1- 1-77		dry		
1- 2-77		dry		
1- 4-77		dry		

MP* = measuring point 2.18' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNP-9

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
11-19-76				installed & cemented
11-23-76		28.28	6042.32	
12- 2-76		28.57	6042.03	
12- 3-76		28.75	6041.85	
12- 6-76		28.67	6041.93	slug test
12- 7-76		28.61	6041.99	
12- 8-76		28.61	6041.99	
12- 9-76		28.60	6042.00	
12-10-76		28.60	6042.00	
12-11-76		28.60	6042.00	
12-12-76		28.60	6042.00	
12-13-76		28.60	6042.00	
12-14-76		28.53	6042.07	
12-15-76		28.56	6042.04	
12-16-76		28.58	6042.02	
12-17-76		28.54	6042.06	
12-18-76		28.56	6042.04	
12-19-76		28.54	6042.06	
12-20-76		28.56	6042.04	
12-21-76		28.49	6042.11	
12-22-76		28.47	6042.13	
12-23-76		28.48	6042.12	
12-27-76		28.47	6042.13	
12-28-76		28.45	6042.15	
12-29-76	1510	28.46	6042.14	
12-30-76	1525	28.46	6042.14	
12-31-76	1525	28.46	6042.14	
1- 1-77	1618	28.46	6042.14	
1- 2-77	1428	28.45	6042.15	
1- 4-77	1159	28.50	6042.10	

MP* = measuring point 5.42' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-1 (P)

Date: Day	Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
11- 4-76		dry		open hole - no piezometer installed
11- 5-76		dry		
11- 6-76		dry		
11- 7-76		dry		
11- 8-76		dry		
11- 9-76		dry		
11-10-76		dry		
11-11-76		dry		
11-12-76		dry		
11-13-76		dry		
11-14-76		dry		
11-15-76		dry		
11-16-76		dry		
11-17-76		dry		
11-18-76		dry		
11-19-76		dry		
11-20-76		dry		
11-21-76		dry		
11-22-76		dry		
11-23-76		dry		
12- 2-76		dry		
12- 3-76		dry		cemented
12- 4-76		dry		
12- 5-76		dry		
12- 6-76		dry		
12- 7-76		dry		
12- 8-76		dry		
12- 9-76		dry		
12-10-76		dry		
12-11-76		dry		
12-12-76		dry		
12-13-76		dry		
12-14-76		dry		
12-15-76		dry		
12-27-76		dry		
12-28-76		dry		
12-29-76		dry		
12-30-76		dry		
12-31-76		dry		
1- 1-77		dry		
1- 4-77	1015	dry		
1-14-77	1251	dry		

MP* = measuring point 6.31' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-2(P)

Date: Day	Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
11-23-76				installed
12- 1-76				cemented
12- 4-76		47.03	6191.27	
12- 5-76		48.79	6189.51	
12- 6-76		48.97	6189.33	
12- 7-76		49.56	6188.74	
12- 8-76		50.64	6187.66	
12- 9-76		50.29	6188.01	
12-10-76		51.40	6186.90	
12-11-76		51.54	6186.76	
12-12-76		51.22	6187.08	
12-13-76		51.04	6187.26	
12-14-76		51.14	6187.16	
12-15-76		51.19	6187.11	
12-16-76		51.20	6187.10	
12-17-76		51.30	6187.00	slug test
12-18-76		51.25	6187.05	
12-19-76		47.40	6190.90	
12-20-76		47.82	6190.48	
12-21-76		47.99	6190.02	
12-22-76		48.28	6190.02	
12-23-76		48.46	6189.84	
12-27-76		48.75	6189.55	
12-28-76		49.09	6189.21	
12-29-76	1505	49.35	6188.95	
12-30-76	1333	49.46	6188.84	
12-31-76	1324	49.38	6188.92	
1- 1-77	1409	49.62	6188.68	
1- 2-77	1156	49.74	6188.56	
1- 4-77	1050	49.40	6188.90	

MP* = measuring point 1.80' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-3(P)

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
10-22-76	1517	29.17	6241.63	installed
10-23-76		28.71	6241.83	
10-24-76		28.91	6241.89	
10-25-76		27.53	6243.27	
10-26-76		27.16	6243.64	
10-27-76		26.30	6244.50	cemented
10-28-76		26.89	6244.11	
10-29-76		26.74	6244.06	
10-30-76		26.52	6244.28	
10-31-76		26.56	6244.24	
11- 1-76		26.54	6244.26	
11- 2-76		26.55	6244.25	
11- 3-76		26.58	6244.22	
11- 4-76	0915	26.40	6244.40	before chemical analysis sample
11- 4-76		27.17	6243.63	after chemical analysis sample
11- 4-76		27.16	6243.64	
11- 5-76		26.80	6244.00	
11- 6-76		26.58	6244.22	
11- 7-76		26.59	6244.21	
11- 8-76		26.48	6244.32	
11- 9-76	0925	27.35	6243.45	before water sample
11- 9-76		31.97	6238.83	after water sample
11- 9-76		30.89	6239.91	
11-10-76		29.65	6241.15	
11-11-76		28.58	6242.22	
11-12-76		27.54	6243.26	
11-13-76		26.66	6244.14	
11-14-76		26.88	6243.92	
11-15-76		26.56	6244.24	
11-16-76		26.51	6244.28	
11-17-76		26.50	6244.30	
11-18-76		26.39	6244.41	
11-19-76		26.32	6244.48	
11-20-76		26.27	6244.53	
11-21-76		26.36	6244.44	slug test
11-22-76		25.93	6244.87	
11-23-76		25.99	6244.81	
12- 2-76		26.29	6244.51	
12- 3-76		25.92	6244.88	
12- 4-76		25,90	6244.90	
12- 5-76		25.87	6244.93	
12- 6-76		25.78	6245.02	

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-3(P) (cont)

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
12- 7-76		25.82	6244.98	
12- 8-76		25.83	6244.97	
12- 9-76		25.76	6245.04	
12-10-76		25.76	6245.04	
12-11-76		25.85	6244.95	
12-12-76		25.83	6244.97	
12-13-76		25.89	6244.91	
12-14-76		25.57	6245.23	
12-15-76		25.74	6245.06	
12-16-76		25.69	6245.11	
12-17-76		25.62	6245.18	
12-18-76		25.57	6245.23	
12-19-76		25.68	6245.12	
12-20-76		25.82	6244.98	
10-21-76		25.72	6245.08	
12-22-76		25.61	6245.19	
12-23-76		25.68	6245.12	
12-27-76		25.65	6245.15	
12-28-76		25.61	6245.19	
12-29-76	1510	25.68	6245.12	
12-30-76	1333	25.48	6245.32	
12-31-76	1330	25.53	6245.27	
1- 1-77	1415	25.54	6245.26	
1- 2-77	1205	25.55	6245.25	
1- 4-77	1100	25.52	6245.28	

MP* = measuring point 5.35' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-4(P)

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
10-20-76				installed
10-21-76				cemented
10-22-76	1523	42.42	6201.18	
10-23-76		42.48	6201.12	
12-24-76		42.41	6201.19	
10-25-76		42.40	6201.20	
10-26-76		42.39	6201.21	
10-27-76		42.62	6200.98	
10-28-76		42.33	6201.27	
10-29-76		42.24	6201.36	
10-30-76		42.15	6201.45	
10-31-76		42.26	6201.34	
11- 1-76		42.17	6201.43	
11- 2-76		42.25	6200.85	
11- 3-76		42.31	6201.29	
11- 4-76	0950	42.19	6201.41	before chemical analysis sample
11- 4-76		42.97	6200.63	after chemical analysis sample
11- 4-76		43.00	6200.60	
11- 5-76		42.24	6201.36	
11- 6-76		42.06	6201.54	
11- 7-76		42.21	6201.39	
11- 8-76		43.07	6200.53	
11- 9-76	0900	41.94	6201.96	before water sample
11- 9-76		47.12	6196.04	after water sample
11- 9-76		44.83	6198.77	
11-10-76		43.26	6200.34	
11-11-76		42.57	6201.03	
11-12-76		42.25	6201.35	
11-13-76		42.05	6201.55	
11-14-76		41.80	6201.80	
11-15-76		41.78	6201.82	
11-16-76		41.75	6201.85	
11-17-76		41.97	6201.63	
11-18-76		41.79	6201.81	
11-19-76		41.80	6201.80	slug test
11-20-76		41.21	6202.39	
11-21-76		41.31	6202.29	
11-22-76		41.36	6202.24	
11-23-76		41.79	6201.81	
12- 2-76		41.64	6201.96	
12- 3-76		41.82	6201.78	

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-4(P) (cont)

Date Day	Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
12- 4-76		41.79	6201.81	
12- 5-76		41.76	6201.84	
12- 6-76		41.73	6201.87	
12- 7-76		41.72	6201.88	
12- 8-76		41.60	6202.00	
12- 9-76		41.60	6202.00	
12-10-76		41.78	6201.82	
12-11-76		41.82	6101.78	
12-12-76		41.89	6201.71	
12-13-76		41.95	6201.65	
12-14-76		41.78	6201.82	injection test
12-15-76		41.28	6202.32	
12-16-76		41.56	6202.94	
12-17-76		41.83	6201.77	
12-18-76		41.90	6201.70	
12-19-76		41.63	6201.97	
12-20-76		41.83	6201.77	
12-21-76		41.62	6201.98	
12-22-76		41.69	6201.91	
12-23-76		41.68	6201.92	
12-27-76		41.66	6201.94	
12-28-76		41.64	6201.96	
12-29-76		41.45	6202.15	
12-30-76		41.44	6202.16	
12-31-76		41.40	6202.20	
1- 1-77		41.39	6202.21	
1- 2-77		41.50	6202.10	
1- 4-77		41.44	6202.16	
1-14-77		41.57	6202.03	

MP* = measuring point 1.65' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-5(P)

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
10-20-76				installed
10-22-76	1557	32.87	6224.43	
10-23-76		33.04	6224.26	
10-24-76	1623	33.19	6224.11	
10-25-76		33.34	6223.96	
10-26-76		33.48	6223.82	cemented
10-27-76		33.60	6223.70	
10-28-76		33.78	6223.52	
10-29-76		33.91	6223.39	
10-30-76		34.00	6223.30	
10-31-76		34.09	6223.21	
11- 1-76		34.20	6223.10	
11- 2-76		34.21	6223.09	
11- 3-76		34.18	6223.12	
11 -4-76	1100	34.45	6222.85	before chemical analysis sample
11- 4-76		33.87	6223.43	after chemical analysis sample
11- 4-76		34.34	6223.96	
11- 5-76		34.22	6223.08	
11- 6-76		34.30	6223.00	
11- 7-76		34.35	6223.95	
11- 8-76		34.40	6223.90	
11- 9-76	0820	34.33	6222.97	before water sample
11- 9-76		39.83	6217.47	after water sample
11- 9-76		33.37	6224.93	
11-10-76		34.48	6223.82	
11-11-76		34.33	6223.97	

MP* = measuring point 2.00' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-5(P)

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
11-12-76		34.27	6223.03	
11-13-76		34.25	6223.05	
11-14-76		34.21	6223.09	
11-15-76		34.24	6223.06	
11-16-76		34.26	6223.04	
11-17-76		34.28	6223.02	
11-18-76		34.33	6222.97	
11-19-76		32.42	6224.88	slug test
11-20-76		33.72	6223.58	
11-21-76		33.79	6223.51	
11-22-76		33.83	6223.47	
11-23-76		33.95	6223.35	
12- 3-76		33.93	6223.37	
12- 4-76		33.90	6223.40	
12- 5-76		33.87	6223.43	
12- 6-76		33.83	6223.47	
12- 7-76		33.70	6223.60	
12- 8-76		33.82	6223.48	
12- 9-76		33.79	6223.51	
12-10-76		33.78	6223.52	
12-11-76		33.83	6223.47	
12-12-76		33.92	6223.38	
12-13-76		33.99	6223.31	
12-14-76		33.93	6223.37	
12-15-76		33.92	6223.38	
12-16-76		33.92	6223.38	
12-17-76		33.91	6223.39	
12-18-76		33.91	6223.39	
12-19-76		33.87	6223.43	
12-20-76		33.52	6223.78	slug test
12-21-76		33.60	6223.70	
12-22-76		33.71	6223.59	
12-22-76		33.70	6223.60	
12-23-76		33.64	6223.66	
12-27-76		33.70	6223.70	
12-28-76		33.76	6223.54	
12-29-76	1522	33.74	6223.56	
12-30-76	1350	33.70	6223.60	
12-31-76	1340	33.68	6223.62	
1- 1-77	1428	33.68	6223.62	
1- 2-77	1219	33.67	6223.63	
1- 4-77	1114	33.63	6223.67	

MP* = measuring point 2.00' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-7(P)

Date Day	Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
10-22-76	1608	41.31	6341.49	installed
10-23-76		41.15	6341.65	
10-24-76	1611	41.00	6341.80	
10-25-76		40.72	6342.08	
10-26-76		40.43	6342.37	cemented
10-27-76		40.42	6342.38	
10-28-76		40.20	6342.60	
10-29-76		39.98	6342.82	
10-30-76		39.81	6342.99	
10-31-76		39.66	6343.14	
11- 1-76		39.20	6343.60	
11- 2-76		39.47	6342.33	
11- 3-76		38.86	6343.94	
11- 4-76	1125	38.64	6344.16	before chemical analysis sample
11- 4-76		40.38	6342.42	after chemical analysis sample
11- 4-76		38.94	6343.86	
11- 5-76		38.80	6344.00	
11- 6-76		38.94	6343.86	
11- 7-76		38.54	6344.26	
11- 8-76		39.04	6343.76	
11- 9-76		38.97	6343.83	
11-10-76		38.34	6344.46	
11-11-76		38.30	6344.50	
11-12-76		38.78	6344.02	
11-13-76		38.65	6344.15	
11-14-76		38.14	6344.66	
11-15-76		38.05	6344.75	
11-16-76		37.66	6345.14	
11-17-76		37.88	6344.92	slug test
11-18-76		36.34	6346.46	
11-19-76		36.65	6346.15	
11-20-76		36.86	6345.94	
11-21-76		36.94	6345.86	
11-22-76		37.01	6345.79	
11-23-76		37.01	6345.79	
12- 2-76		37.07	6345.73	
12- 3-76		37.08	6345.72	
12- 4-76		37.08	6345.72	
12- 5-76		37.21	6345.59	
12- 6-76		37.36	6345.44	

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-7(P) (cont)

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
12- 7-76		36.90	6345.90	
12- 8-76		36.94	6345.86	
12- 9-76		36.90	6345.90	
12-10-76		37.39	6345.41	
12-11-76		37.33	6345.47	
12-12-76		37.21	6345.59	
12-13-76		37.19	6345.61	
12-14-76		37.01	6345.79	
12-15-76		37.00	6345.80	
12-16-76		37.02	6345.78	
12-17-76		37.06	6345.74	
12-18-76		37.04	6345.76	
12-19-76		36.84	6345.96	
12-20-76		37.04	6345.76	
12-21-76		36.98	6345.82	
12-22-76		36.87	6345.93	
12-22-76		36.86	6345.94	
12-27-76		36.80	6346.00	
12-28-76		36.76	6346.04	
12-29-76	0920	36.79	6346.01	
12-30-76	0947	36.57	6346.23	
12-31-76	1036	36.65	6346.15	
1- 1-77	1220	36.68	6346.12	
1- 2-77	1007	36.70	6346.10	
1- 4-77		36.48	6346.32	
1- 5-77	0435	36.76	6346.04	
1-14-77	1107	36.76	6346.04	

MP* = measuring point 5.10' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-10(P)

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
10-25-76				installed
10-27-76		28.75	6202.25	cemented
10-28-76		29.63	6201.37	
10-29-76		29.87	6201.13	
10-30-76		29.95	6201.05	
10-31-76		30.07	6200.93	
11- 1-76		30.15	6200.85	
11- 2-76		30.27	6200.73	
11- 3-76		30.31	6200.69	
11- 4-76		30.25	6200.75	
11- 5-76		30.23	6200.77	
11- 6-76		30.23	6200.77	
11- 7-76		30.32	6200.68	
11- 8-76		30.20	6200.80	
11- 9-76		30.15	6200.85	
11-10-76		30.07	6200.93	
11-11-76		30.15	6200.85	
11-12-76		30.20	6200.80	
11-13-76		30.18	6200.82	
11-14-76		30.07	6200.93	
11-15-76		30.11	6200.89	
11-16-76		30.20	6200.80	
11-17-76		30.26	6200.74	
11-18-76		30.06	6200.94	
11-19-76		30.09	6200.91	
11-20-76		30.11	6200.89	
11-21-76		30.15	6200.85	
11-22-76		30.21	6200.79	slug test
11-23-76		29.88	6201.12	
12- 2-76		31.21	6199.79	
12- 3-76		29.18	6201.82	
12- 4-76		29.31	6201.69	
12- 5-76		29.82	6201.18	
12- 6-76		29.97	6201.03	
12- 7-76		29.97	6201.03	
12- 8-76		29.75	6201.25	
12- 9-76		29.98	6201.02	
12-10-76		30.16	6200.84	
12-11-76		30.18	6200.82	
12-12-76		30.15	6200.85	
12-13-76		30.12	6200.88	
12-14-76		29.91	6201.09	
12-15-76		30.10	6200.90	
12-16-76		30.11	6200.89	
12-17-76		30.02	6200.98	

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-10(P) (cont)

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
12-18-76		30.05	6200.95	
12-19-76		29.96	6201.04	
12-20-76		30.14	6200.86	
12-21-76		30.04	6200.96	
12-22-76		29.98	6201.02	
12-23-76		30.11	6200.89	
12-27-76		30.01	6200.99	
12-28-76		29.98	6201.02	
12-29-76	0952	29.94	6201.06	
12-30-76	1007	29.81	6201.19	
12-31-76	1048	29.93	6201.07	
1- 1-77	1247	29.95	6201.05	
1- 2-77	1035	29.96	6201.04	
1- 4-77	0925	29.36	6201.64	
1-14-77	1135	29.99	6200.80	

MP* = measuring point 4.02' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-11(P)

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
10- 8-76				installed
10-11-76				cemented
10-15-76		44.90	6200.40	
10-16-76		45.17	6200.13	
10-17-76		45.15	6200.15	
10-18-76		45.12	6200.18	
10-19-76		45.11	6200.19	
10-21-76	1817	45.10	6200.20	
10-11-76	1620	45.11	6200.19	
10-23-76		45.16	6200.14	
10-24-76	1545	45.19	6200.11	
10-25-76		45.17	6200.13	
10-26-76		45.13	6200.17	
10-27-76		45.12	6200.18	
10-28-76		45.10	6200.20	
10-29-76		45.28	6200.02	
10-30-76		45.39	6199.91	
10-31-76		45.42	6199.88	
11- 1-76		45.43	6199.87	
11- 2-76		45.21	6200.09	
11- 3-76		44.85	6200.45	
11- 4-76		44.85	6200.45	before chemical analysis sample
11- 4-76		45.83	6199.87	after chemical ananlysis sample
11- 4-76		45.41	6199.89	
11- 5-76		45.38	6199.92	
11- 6-76		45.14	6200.16	
11- 7-76		45.16	6200.14	
11- 8-76		45.15	6200.15	
11- 9-76		45.16	6200.14	before water sample
11- 9-76		45.50	6199.80	after water sample
11- 9-76		45.16	6200.14	
11-10-76		45.18	6200.12	
11-11-76		45.10	6200.20	
11-12-76		45.42	6199.88	
11-13-76		45.31	6199.99	
11-14-76		45.37	6199.93	
11-15-76		45.41	6199.89	
11-16-76		45.11	6200.19	slug test

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-11(P) (cont)

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
11-17-76		45.04	6200.26	
11-18-76		45.14	6200.16	
11-19-76		45.17	6200.13	
11-20-76		45.20	6200.10	
11-21-76		45.37	6199.93	
11-22-76		45.52	6199.78	
11-23-76		45.16	6200.14	
12- 2-76		44.52	6200.78	
12- 3-76		44.47	6200.83	
12- 4-76		44.77	6200.53	
12- 5-76		45.21	6200.09	
12- 6-76		45.39	6199.91	
12- 7-76		45.10	6200.20	
12- 8-76		45.40	6199.90	
12- 9-76		45.41	6199.89	
12-10-76		45.39	6199.91	
12-11-76		45.37	6199.93	
12-12-76		45.38	6199.92	
12-13-76		45.09	6200.21	
12-14-76		45.41	6199.89	
12-15-76		45.07	6200.23	
12-16-76		45.01	6200.29	
12-17-76		45.22	6200.08	
12-18-76		45.15	6200.15	
12-19-76		45.50	6199.80	
12-20-76		45.51	6199.79	slug test
12-21-76		45.48	6199.82	
12-22-76		48.02	6197.28	
12-23-76		45.09	6200.21	
12-27-76		45.05	6200.25	
12-28-76		45.03	6200.27	
12-29-76	0935	45.07	6200.23	
12-30-76	0956	45.10	6200.20	
12-31-76	1048	45.06	6200.24	
1- 1-76	1234	45.05	6200.25	
1- 2-76	1018	45.05	6200.25	
1- 4-76	0913	45.06	6200.24	
1- 5-76	0445	45.12	6200.18	
1-14-76	1122	45.07	6200.20	

MP* = measuring point 5.66' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-12(P)

Date: Day	Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
10-11-76				installed
10-12-76				cemented
10-15-76		48.07	6211.43	
10-16-76	1005	47.91	6211.59	
10-17-76		47.98	6211.52	
10-18-76		48.02	6211.48	
10-19-76	1731	48.06	6211.44	
10-21-76	1813	48.35	6211.15	
10-22-76	1615	48.23	6211.27	
10-23-76		48.17	6211.33	
10-24-76	1550	48.09	6211.41	
10-25-76		48.05	6211.45	
10-26-76		48.00	6211.50	
10-27-76		47.94	6211.56	
10-28-76		48.00	6211.50	
10-29-76		47.98	6211.52	
10-30-76		47.96	6211.54	
10-31-76		47.91	6211.59	
11- 1-76		47.92	6211.58	
11- 2-76		47.98	6211.52	
11- 3-76		47.64	6211.86	
11- 4-76		48.05	6211.45	
11- 5-76		48.05	6211.45	
11- 6-76		48.08	6211.42	
11- 7-76		48.02	6211.48	
11- 8-76		48.01	6211.49	
11- 9-76		48.01	6211.49	
11-10-76		48.01	6211.49	
11-11-76		48.05	6211.45	
11-12-76		47.98	6211.52	
11-13-76		48.00	6211.50	
11-14-76		48.18	6211.32	
11-15-76		48.17	6211.33	
11-16-76		48.15	6211.35	
11-17-76		48.16	6211.34	slug test
11-18-76		48.19	6211.31	
11-19-76		48.21	6211.29	
11-20-76		48.24	6211.26	
11-21-76		48.22	6211.28	
11-22-76		48.23	6211.27	
11-23-76		48.17	6211.33	
12- 2-76		48.02	6211.48	
12- 3-76		47.98	6211.52	
12- 4-76		48.00	6211.50	
12- 5-76		47.99	6211.51	
12- 6-76		48.01	6211.49	

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-12(P) (cont)

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
12- 7-76		48.06	6211.44	
12- 8-76		48.06	6211.44	
12- 9-76		48.09	6211.41	
12-10-76		48.14	6211.36	
12-11-76		48.11	6211.39	
12-12-76		48.09	6211.41	
12-13-76		48.11	6211.39	
12-14-76		48.10	6211.40	
12-15-76		48.10	6211.40	
12-16-76		48.07	6211.43	
12-17-76		48.09	6211.41	
12-18-76		48.05	6211.45	
12-19-76		48.20	6211.30	
12-20-76		48.03	6211.47	
12-21-76		48.05	6211.45	
12-22-76		48.06	6211.44	
12-23-76		48.04	6211.46	
12-27-76		48.06	6211.44	
12-28-76		48.59	6210.91	
12-29-76	0925	47.82	6211.68	
12-30-76	0952	47.84	6211.66	
12-31-76	1040	47.82	6211.68	
1- 1-77	1230	47.85	6211.65	
1- 2-77	1015	47.89	6211.61	
1- 4-77	0911	47.74	6211.76	
1- 5-77	0442	47.91	6211.59	
1-14-77	1120	47.89	6210.67	

MP* = measuring point 5.95' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-13(P)

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
11- 2-76				installed
11- 3-76		36.90	6206.20	
11- 4-76		36.94	6206.16	
11- 5-76		36.88	6206.22	
11- 6-76		36.77	6206.33	
11- 7-76		36.70	6206.40	
11- 8-76		36.38	6206.72	
11- 9-76		36.03	6207.07	
11-10-76		35.66	6207.44	
11-11-76		36.40	6206.70	
11-12-76		36.29	6206.81	
11-13-76		36.21	6206.89	
11-14-76		36.11	6206.99	
11-15-76		36.00	6207.10	
11-16-76		36.14	6206.96	
11-17-76		36.15	6206.95	
11-18-76		35.96	6207.14	
11-19-76		35.80	6207.30	
11-20-76		35.69	6207.41	
11-21-76		35.83	6207.27	
11-22-76		35.85	6207.25	
11-23-76		35.53	6207.57	
12- 2-76		35.11	6207.99	
12- 3-76		35.03	6208.07	
12- 4-76		34.98	6208.12	
12- 5-76		34.86	6208.24	
12- 6-76		34.70	6208.40	
12- 7-76		34.70	6208.40	
12- 8-76		34.70	6208.40	cemented
12- 9-76		34.78	6208.32	
12-10-76		34.73	6208.37	
12-11-76		34.71	6208.39	
12-12-76		34.66	6208.44	
12-13-76		34.68	6208.42	
12-14-76		34.63	6208.47	slug test
12-15-76		33.78	6209.32	
12-16-76		33.98	6209.12	
12-17-76		34.02	6209.08	
12-18-76		34.09	6209.01	
12-19-76		34.14	6208.96	
12-20-76		34.22	6208.88	
12-21-76		34.28	6208.82	
12-22-76		34.64	6208.46	
12-23-76		34.64	6208.46	
12-27-76		34.31	6208.79	
12-28-76		34.27	6208.83	

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-13(P) (cont)

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
12-29-76	0944	34.29	6208.81	
12-30-76	1003	34.26	6208.84	
12-31-76	1045	34.28	6208.82	
1- 1-77	1243	34.26	6208.84	
1- 2-77	1024	34.26	6208.84	
1- 4-77	0921	34.25	6208.85	
1- 5-77	0453	34.31	6208.79	
1-14-77	1133	34.27	6208.84	

MP* = measuring point 4.70' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitude in CNS-18(P)

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
10-20-76				installed
10-22-76	1601	34.11	6212.69	cemented
10-23-76		34.07	6212.73	
10-24-76	1628	33.98	6212.82	
10-25-76		33.78	6213.02	
10-26-76		33.62	6213.18	
10-27-76		33.15	6213.65	
10-28-76		33.75	6213.05	
10-29-76		33.78	6213.02	
10-30-76		33.79	6213.01	
10-31-76		33.61	6213.19	
11- 1-76		33.69	6213.11	
11- 2-76		33.80	6212.00	
11- 3-76		33.82	6212.92	
11- 4-76		33.51	6213.29	
11- 5-76		33.55	6213.25	
11- 6-76		33.68	6213.12	
11- 7-76		33.89	6212.91	
11- 8-76		33.63	6213.17	
11- 9-76		33.59	6213.21	
11-10-76		33.52	6213.28	
11-11-76		33.58	6213.22	
11-12-76		33.61	6213.19	
11-13-76		33.60	6213.20	
11-14-76		33.32	6213.48	
11-15-76		33.41	6213.29	
11-16-76		33.38	6213.42	
11-17-76		33.70	6213.10	
11-18-76		33.46	6213.34	
11-19-76		33.42	6213.38	
11-20-76		33.45	6213.35	
11-21-76		33.65	6213.15	slug test
11-22-76		33.24	6213.56	
11-23-76		33.46	6213.34	
12- 3-76		33.50	6213.30	
12- 4-76		33.45	6213.35	
12- 5-76		33.36	6213.44	
12- 6-76		33.41	6213.39	
12- 7-76		33.46	6213.34	
12- 8-76		33.45	6213.35	
12- 9-76		33.31	6213.49	
12-10-76		33.62	6213.18	
12-11-76		33.62	6213.18	
12-12-76		33.61	6213.19	
12-13-76		33.60	6213.20	
12-14-76		33.47	6213.33	

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-18(P) (cont)

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
12-15-76		33.58	6213.22	
12-16-76		33.58	6213.22	
12-17-76		33.44	6213.36	
12-18-76		33.47	6213.33	
12-19-76		33.43	6213.37	
12-20-76		33.46	6213.34	
12-21-76		33.42	6213.38	
12-22-76		33.48	6213.32	
12-23-76		33.44	6213.36	
12-27-76		33.42	6213.38	
12-28-76		33.41	6213.39	
12-29-76	1520	33.01	6213.79	
12-30-76	1345	33.22	6213.58	
12-31-76	1335	33.17	6213.63	
1- 1-77	1423	33.20	6213.60	
1- 2-77	1214	33.25	6213.55	
1- 4-77	1111	33.22	6213.58	

MP* = measuring point 1.30' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-19(P)

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
10-22-76	1511	41.98	6218.32	installed
10-23-76		41.67	6218.63	
10-24-76		41.48	6218.82	
10-25-76		41.39	6218.91	cemented
10-26-76		41.24	6219.06	
10-27-76		42.04	6218.26	
10-28-76		42.03	6218.27	
10-29-76		41.97	6218.33	
10-30-76		41.84	6218.46	
10-31-76		42.00	6218.30	
11- 1-76		41.94	6218.36	
11- 2-76		42.01	6218.29	
11- 3-76		41.96	6218.34	
11- 4-76	1005	41.88	6218.42	before chemical analysis sample
11- 4-76		42.48	6217.82	after chemical analysis sample
11- 4-76		42.05	6218.25	
11- 5-76		41.89	6218.41	
11- 6-76		42.27	6218.03	
11- 7-76		42.62	6217.68	
11- 8-76		41.99	6218.31	
11- 9-76		42.14	6218.16	
11-10-76		41.77	6218.53	
11-11-76		41.83	6218.47	
11-12-76		42.23	6218.07	
11-13-76		41.97	6218.33	
11-14-76		41.98	6218.32	
11-15-76		41.65	6218.65	
11-16-76		41.67	6218.63	
11-17-76		41.90	6218.40	
11-18-76		41.70	6218.60	
11-19-76		41.65	6218.65	
11-20-76		41.63	6218.67	
11-21-76		40.93	6219.37	slug test
11-22-76		41.54	6218.76	
11-23-76		41.99	6218.31	
12- 2-76		41.44	6218.86	
12- 3-76		41.97	6219.33	
12- 4-76		41.78	6219.22	
12- 5-76		41.57	6219.43	
12- 6-76		41.40	6219.60	

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-19(P) (cont)

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
12- 7-76		41.43	6219.57	
12- 8-76		41.47	6219.53	
12- 9-76		41.31	6219.69	
12-10-76		41.50	6219.50	
12-11-76		41.61	6219.39	
12-12-76		41.60	6219.40	
12-13-76		41.59	6219.41	
12-14-76		41.48	6219.52	
12-15-76		41.48	6219.52	
12-16-76		41.59	6219.41	
12-17-76		41.44	6219.56	
12-18-76		41.49	6219.51	
12-19-76		41.40	6219.60	
12-20-76		41.55	6219.45	
12-21-76		41.38	6219.62	
12-22-76		41.69	6219.31	
12-23-76		41.41	6219.59	
12-27-76		41.37	6219.63	
12-28-76		41.32	6219.68	
12-29-76	1458	41.16	6219.84	
12-30-76	1327	41.14	6219.86	
12-31-76	1318	41.11	6219.89	
1- 1-77	1400	41.18	6219.82	
1- 2-77	1150	41.17	6219.83	
1- 4-77	1041	41.04	6219.96	
1-14-77	1369	41.02	6219.10	

MP* = measuring point 2.80' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-20

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
12-13-76		36.63	6248.87	Open hole - no casing

MP* = land surface

Appendix I-2 . -- Depth-to-water measurements and water-level altitude in CNS-21(P).

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
10-13-76				installed
10-15-76		45.10	6216.90	
10-16-76	0957	44.98	6217.10	
10-17-76		44.87	6217.10	
10-18-76		44.90	6217.10	
10-19-76	1725	44.84	6217.16	
10-21-76	1805	44.81	6217.19	
10-22-76	1600	44.77	6217.23	
10-23-76		44.74	6217.26	
10-24-76	1555	44.67	6217.33	
10-25-76		44.73	6217.27	cemented
10-26-76		44.77	6217.23	
10-27-76		44.80	6217.20	
10-28-76		44.96	6217.04	
10-29-76		44.88	6217.12	
10-30-76		44.79	6217.21	
10-31-76		44.82	6217.18	
11- 1-76		44.69	6217.31	
11- 2-76		44.83	6217.17	
11- 3-76		44.85	6217.15	
11- 4-76		44.73	6217.27	
11- 5-76		44.57	6217.43	
11- 6-76		44.75	6217.25	
11- 7-76		44.90	6217.10	
11- 8-76		44.65	6217.35	
11- 9-76		44.65	6217.35	
11-10-76		44.64	6217.36	
11-11-76		44.68	6217.32	slug test
11-12-76	1415	44.77	6217.23	
11-13-76		44.70	6217.30	
11-14-76		44.67	6217.33	
11-15-76		44.79	6217.21	
11-16-76		44.82	6217.18	
11-17-76		44.90	6217.10	using 300' tape
11-18-76		44.80	6217.20	
11-19-76		44.82	6217.18	
11-20-76		44.80	6217.20	
11-21-76		44.85	6217.15	
11-22-76		44.91	6217.09	slug test
11-23-76		44.84	6217.16	
12- 2-76		44.74	6217.26	
12- 3-76		44.68	6217.32	
12- 4-76		44.62	6217.38	
12- 5-76		44.60	6217.40	
12- 6-76		44.51	6217.49	

Appendix I-2. -- Depth-to-water measurements and water-level altitude in CNS-21(P) (cont).

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
12- 7-76		44.55	6217.45	
12- 8-76		44.65	6217.35	
12- 9-76		44.60	6217.40	
12-10-76		44.68	6217.32	
12-11-76		44.64	6217.36	
12-12-76		44.71	6217.29	
12-13-76		44.79	6217.21	
12-14-76		44.69	6217.31	
12-15-76		44.70	6217.30	
12-16-76		44.73	6217.27	
12-17-76		44.68	6217.32	
12-18-76		44.70	6217.30	
12-19-76		44.67	6217.33	
12-20-76		44.76	6217.24	
12-21-76		48.43	6213.57	
12-22-76		47.53	6214.47	
12-23-76		44.72	6217.28	
12-27-76		44.66	6217.34	
12-28-76		44.65	6217.35	
12-29-76	0923	44.62	6217.38	
12-30-76	0940	44.51	6217.49	
12-31-76	1038	44.55	6217.45	
1- 1-77	1228	44.55	6217.45	
1- 2-77	1012	44.57	6217.43	
1- 4-77	0910	44.48	6217.52	
1- 5-77	0439	44.57	6217.43	
1-14-77	1112	44.62	6217.38	

MP* = measuring point 3.0' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-22(P)

Date: Day	Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
10-18-76				installed
10-20-76				cemented
10-22-76		44.37	6179.03	
10-23-76		44.69	6178.71	
10-24-76		44.91	6178.49	
10-25-76		45.07	6178.33	
10-26-76		45.12	6178.28	
10-27-76		45.27	6178.13	
10-28-76		45.22	6178.18	
10-29-76		45.17	6178.23	
10-30-76		45.10	6178.30	
10-31-76		45.24	6178.16	
11- 1-76		45.00	6178.40	
11- 2-76		45.18	6178.22	
11- 3-76		45.12	6178.28	
11- 4-76		45.07	6178.33	
11- 5-76		45.04	6178.36	
11- 6-76		45.17	6178.23	
11- 7-76		45.11	6178.29	
11- 8-76		45.29	6178.11	
11- 9-76		45.07	6178.33	
11-10-76		44.90	6178.50	
11-11-76		44.95	6178.45	
11-12-76		44.88	6178.52	
11-13-76		44.92	6178.48	
11-14-76		45.08	6178.32	
11-15-76		44.85	6178.55	
11-16-76		44.95	6178.45	
11-17-76		40.92	6182.48	
11-18-76		40.68	6182.52	slug test
11-19-76		41.84	6181.56	
11-20-76		41.97	6181.43	
11-21-76		42.02	6181.38	
11-22-76		42.06	6181.34	
11-23-76		42.32	6181.08	
12- 3-76		42.39	6181.01	
12- 4-76		42.27	6181.13	
12- 5-76		42.11	6181.29	
12- 6-76		41.90	6181.50	
12- 7-76		41.79	6181.61	
12- 8-76		41.97	6181.43	
12- 9-76		41.95	6181.45	
12-10-76		42.05	6181.35	
12-11-76		42.07	6181.33	
12-12-76		42.10	6181.30	
12-13-76		42.11	6181.29	

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-22(P) (cont)

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
12-14-76		42.01	6181.39	
12-15-76		42.04	6181.36	
12-16-76		42.17	6181.23	
12-17-76		41.89	6181.51	
12-18-76		41.97	6181.43	
12-19-76		41.98	6181.42	
12-20-76		42.07	6181.33	
12-21-76		41.96	6181.44	
12-22-76		41.97	6181.43	
12-23-76		42.00	6181.40	
12-27-76		41.98	6181.42	
12-28-76		41.97	6181.43	
12-29-76	1416	41.83	6181.57	
12-30-76	1240	41.83	6181.57	
12-31-76	1115	41.83	6181.57	
1- 1-77	1322	41.83	6181.57	
1- 2-77	1114	41.83	6181.57	
1- 4-77	1059	40.85	6182.55	
1-14-77	1232	41.87	6181.57	

MP* = measuring point 4.60' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-23(P)

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
11-29-76				installed
12- 1-76				cemented
12- 3-76		68.44	6201.00	
12- 4-76		68.42	6200.98	
12- 5-76		68.57	6132.43	
12- 6-76		68.64	6132.36	
12- 7-76		69.42	6131.58	
12- 8-76		69.67	6131.33	
12- 9-76		69.74	6131.26	
12-10-76		69.75	6131.25	
12-11-76		69.76	6131.24	
12-12-76		69.78	6131.22	
12-13-76		69.77	6131.23	
12-14-76		69.77	6131.23	
12-15-76		70.11	6130.89	
12-16-76		70.10	6130.90	slug test
12-17-76		66.25	6134.75	
12-18-76		66.30	6134.70	
12-19-76		67.44	6133.56	
12-20-76		67.98	6133.02	
12-21-76		68.09	6132.91	
12-22-76		67.66	6133.34	
12-23-76		67.60	6133.40	
12-27-76		68.01	6132.99	
12-28-76		68.07	6132.93	
12-29-76	1436	68.24	6132.76	
12-30-76	1313	68.26	6132.74	
12-31-76	1222	68.34	6132.66	
1- 1-77	1345	68.40	6132.60	
1- 2-77	1133	68.45	6132.55	
1- 4-77	1024	68.64	6132.36	
1-14-77	1254	69.65	6131.39	

MP* = measuring point 3.50' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitude in CNS-25(P).

Date: Day	Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
11-24-76				installed
12- 3-76		59.77	6158.33	
12- 4-76		60.08	6158.02	
12- 5-76		60.09	6158.01	
12- 6-76		60.11	6157.99	
12- 7-76		60.70	6157.40	
12- 8-76		61.23	6156.87	
12- 9-76		61.50	6156.60	
12-10-76		60.98	6157.12	
12-11-76		60.83	6157.27	
12-12-76		60.70	6157.40	
12-13-76		60.58	6157.52	
12-14-76		60.05	6158.05	
12-15-76		58.98	6159.12	
12-16-76		59.80	6158.30	slug test
12-17-76		53.36	6164.74	
12-18-76		53.62	6164.48	
12-19-76		53.33	6164.77	
12-20-76		54.30	6163.80	
12-21-76		53.13	6164.97	
12-22-76		53.00	6165.10	
12-23-76		52.91	6165.19	
12-27-76		53.00	6165.10	
12-28-76		52.97	6165.13	
12-29-76	1445	52.81	6165.29	
12-30-76	1316	52.81	6165.29	
12-31-76	1231	52.81	6165.29	
1- 1-77	1349	52.80	6165.30	
1- 2-77	1138	52.75	6165.35	
1- 4-77	1029	52.74	6165.36	
1-14-77	1300	52.33	6165.8	

MP* = measuring point 6.35' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitude in CNS-26(P)

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
11-24-76				installed
12- 2-76				cemented
12- 3-76		59.59	6169.01	
12- 4-76		59.07	6169.53	
12- 5-76		58.50	6170.10	
12- 6-76		58.17	6170.43	
12- 7-76		57.98	6170.62	
12- 8-76		57.09	6171.51	
12- 9-76		55.85	6172.75	
12-10-76		54.70	6173.90	
12-11-76		53.95	6174.65	
12-12-76		53.37	6175.23	
12-13-76		52.82	6175.78	
12-14-76		52.56	6176.04	
12-15-76		52.25	6176.35	slug test
12-16-76		47.44	6181.16	
12-17-76		47.88	6180.72	
12-18-76		48.11	6180.49	
12-19-76		48.26	6180.34	
12-20-76		48.52	6180.08	
12-21-76		48.63	6179.97	
12-22-76		48.81	6179.79	
12-23-76		48.89	6179.71	
12-27-76		48.96	6179.64	
12-28-76		49.12	6179.48	
12-29-76	1448	49.24	6179.36	
12-30-76	1320	49.26	6179.34	
12-31-76	1245	49.26	6179.34	
1- 1-77	1353	49.32	6179.28	
1- 2-77	1142	49.38	6179.22	
1- 4-77	1034	49.47	6179.13	
1-14-77	1303	49.74	6178.89	

MP* = measuring point 5.97' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-29(P)

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
11-16-76				installed
12- 6-76		39.43	6196.67	
12- 7-76		39.46	6196.64	
12- 8-76		39.46	6196.64	cemented
12- 9-76		39.39	6196.71	
12-10-76		38.77	6197.33	
12-11-76		39.31	6196.79	
12-12-76		39.42	6196.68	
12-13-76		39.48	6196.62	
12-14-76		39.48	6196.62	
12-15-76		39.49	6196.61	
12-16-76		39.47	6196.63	
12-17-76		39.45	6196.65	
12-18-76		39.43	6196.67	
12-19-76		37.86	6198.24	
12-20-76		39.40	6196.70	
12-21-76		39.47	6196.63	
12-22-76		37.58	6198.52	
12-23-76		39.49	6196.61	
12-27-76		39.49	6196.61	
12-28-76		39.47	6196.63	
12-29-76	1348	39.48	6196.62	
12-30-76	1025	39.49	6196.61	
12-31-76	1053	39.50	6196.60	
1- 1-77	1253	39.49	6196.61	
1- 2-77	1040	39.48	6196.62	
1- 4-77	0931	39.50	6196.60	
1- 5-77	0526	39.49	6196.61	
1-14-77	1144	39.50	6196.65	

MP* = measuring point 1.80' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitude in CNS-30(P)

Date: Day	Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
12- 6-76				installed
12- 7-76		44.21	6179.69	
12- 8-76		43.80	6180.10	cemented
12- 9-76		43.49	6180.41	slug test
12-10-76		37.51	6186.39	
12-11-76		37.50	6186.40	
12-12-76		37.47	6186.43	
12-13-76		37.46	6186.44	
12-14-76		32.43	6186.47	injection test
12-15-76		34.99	6188.91	
12-16-76		35.37	6188.53	
12-17-76		35.54	6188.36	
12-18-76		35.51	6188.39	
12-19-76		35.77	6188.13	
12-20-76		35.70	6188.20	
12-21-76		35.70	6188.20	
12-22-76		35.73	6188.17	
12-23-76		35.76	6188.14	
12-27-76		35.78	6188.12	
12-28-76		35.77	6188.13	
12-29-76	1350	35.78	6188.12	
12-30-76	1028	35.80	6188.10	
12-31-76	1055	35.80	6188.10	
1- 1-77	1258	35.80	6188.10	
1- 2-77	1043	35.79	6188.11	
1- 4-77	0933	35.78	6188.12	
1- 5-77	0537	35.81	6188.09	
1-14-77	1147	45.82	6178.09	

MP* = measuring point 2.95' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-31(P)

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
11-17-76				installed
12- 3-76				partially cemented
12- 4-76		28.08	6174.12	
12- 5-76		28.22	6173.98	
12- 6-76		28.34	6173.86	
12- 7-76		28.34	6173.86	cemented
12- 8-76		28.38	6173.82	slug test
12- 9-76		28.37	6173.83	
12-10-76		28.39	6173.81	
12-11-76		28.37	6173.83	
12-12-76		28.38	6173.82	
12-13-76		28.35	6173.85	
12-14-76		28.38	6173.82	
12-15-76		28.36	6173.84	
12-16-76		26.97	6175.23	
12-17-76		28.36	6173.84	
12-18-76		28.35	6173.85	
12-19-76		28.36	6173.84	
12-20-76		28.39	6173.81	
12-21-76		28.39	6173.81	
12-22-76		28.39	6173.81	
12-23-76		28.37	6173.83	
12-27-76		28.36	6173.84	
12-28-76		28.36	6173.84	
12-29-76	1145	28.36	6173.84	
12-29-76	1219	28.36	6173.84	slug test
12-30-76	1052	28.36	6173.84	
12-31-76	1103	28.36	6173.84	
1- 1-77	1305	28.36	6173.84	
1- 2-77	1054	28.36	6173.84	
1- 4-77	0939	28.35	6173.85	
1- 5-77	0537	28.46	6173.74	
1-14-77	1155	28.40	6173.79	

MP* = measuring point 2.83' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-32(P)

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
11-24-76				installed
12- 3-76		31.45	6170.45	cemented
12- 4-76		31.70	6170.20	
12- 5-76		31.69	6170.21	
12- 6-76		31.65	6170.25	
12- 7-76		31.79	6170.11	
12- 8-76		31.83	6170.07	slug test
12- 9-76		31.66	6170.24	
12-10-76		31.85	6170.05	
12-11-76		31.93	6169.97	
12-12-76		31.98	6169.92	
12-13-76		32.03	6169.87	
12-14-76		31.77	6170.13	
12-15-76		31.78	6170.12	
12-16-76		31.84	6170.06	
12-17-76		31.78	6170.12	
12-18-76		31.77	6170.13	
12-19-76		31.66	6170.24	
12-20-76		31.80	6170.10	
12-21-76		31.77	6170.13	
12-22-76		31.65	6170.25	
12-23-76		31.72	6170.18	
12-27-76		31.70	6170.20	
12-28-76		31.57	6170.33	
12-29-76		31.65	6170.25	
12-30-76		31.50	6170.40	
12-31-76		31.40	6170.50	
1- 1-77		31.46	6170.44	
1- 2-77		31.45	6170.45	
1- 4-77		31.36	6170.54	
1- 5-77		31.34	6170.56	
1-14-77		30.53	6171.40	

MP* = measuring point 2.95' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitudes in CNS-34(P)

Date		Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
Day	Hour (MST)			
11-17-76				installed
12- 3-76		41.60	6201.20	
12- 4-76		41.88	6200.92	
12- 5-76		41.89	6200.91	
12- 6-76		41.91	6200.89	
12- 7-76		41.92	6200.88	slug test
12- 8-76		42.15	6200.65	cemented
12- 9-76		42.08	6200.72	
12-10-76		42.11	6200.69	
12-11-76		42.04	6200.76	
12-12-76		42.01	6200.79	
12-13-76		41.90	6200.90	
12-14-76		41.91	6200.89	slug test
12-15-76		42.12	6200.68	
12-16-76		42.29	6200.51	
12-17-76		42.11	6200.69	
12-18-76		42.15	6200.65	
12-19-76		42.38	6200.42	
12-20-76		42.40	6200.40	
12-21-76		42.38	6200.42	
12-22-76		42.39	6200.41	
12-23-76		42.15	6200.65	
12-27-76		42.10	6200.70	
12-28-76		42.07	6200.73	
12-29-76	0932	42.13	6200.67	
12-30-76	0959	42.01	6200.79	
12-31-76	1044	42.11	6200.69	
1- 1-77	1239	42.12	6200.68	
1- 2-77	1021	42.13	6200.67	
1- 4-77	0916	42.14	6200.66	
1- 5-77	0449	42.13	6200.67	
1-14-77	1130	42.50	6200.30	

MP* = measuring point 3.70' above land surface

Appendix I-2. -- Depth-to-water measurements and water-level altitude in CNW-2(P)

Date: Day	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)	Comments
12-30-76	1402	42.46	6169.04	installed
12-31-76	1100	33.41	6178.09	
12-31-76	1345	33.30	6178.20	
1- 1-77	1203	33.08	6178.42	
1- 1-77	1421	33.02	6178.48	
1- 1-77	1718	32.38	6179.12	
1- 2-77	1050	32.78	6178.72	
1- 2-77	1455	32.71	6178.79	
1- 4-77	0847	32.75	6178.75	
1- 4-77	0937	32.72	6178.78	
1- 5-77	0828	32.78	6178.72	
1-14-77	1152	32.78	6178.72	

MP* = measuring point

Appendix I-2 supplement.--Depth-to-water measurements and water-level altitudes.

Hole	Date: February 1977	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)
CNC-1	7	1519	158.20	6214.00
	8	1425	158.34	6213.86
CNC-3	7	1430	46.00	6224.80
	8	1354	45.99	6224.81
CNC-4	7	1512	56.60	6241.00
	8	1420	56.58	6241.02
CNC-5	7	1508	dry	
	8	1417	dry	
CNC-6	7	1034	40.45	6189.55
	8	1026	40.38	6189.62
CNC-7	7	1053	34.48	6178.72
	8	1040	34.45	6178.75
CNC-8	7	1325	40.57	6210.23
	8	1254	40.55	6210.25
CNG-2	7	1421	47.08	6199.12
	8	1350	47.04	6199.16
CNP-1	7	1410	dry	
	8	1355	dry	
CNP-2	7	1350	25.20	6184.60
	8	1320	25.20	6184.60
CNP-3	7	1332	83.97	6140.13
	8	1302	83.92	6140.18
CNP-3A	7	1335	dry	
	8	1304	dry	
CNP-3B	7	1337	37.29	6184.71
	8	1306	37.30	6184.70
CNP-4	7	1315	64.87	6174.93
	8	1245	64.79	6175.01
CNP-4A	7		dry	
	8	1247	dry	
CNP-4B	7	1320	53.05	6186.65
	8	1249	53.07	6186.63
CNP-5	7	1130	50.74	6169.46
	8	1117	50.67	6169.53
CNP-6	7	1107	14.98	6131.12
	8	1055	14.91	6131.19
CNP-6A	7	1110	10.98	6134.12
	8	1058	10.95	6134.15
CNP-6B	7	1113	29.05	6136.15
	8	1102	29.05	6136.15
CNP-7	7	1140	80.97	6148.63
	8	1127	80.89	6148.71
CNP-7A	7		dry	
	8	1129	dry	

Appendix I-2 supplement.--Depth-to-water measurements and water-level altitudes. (cont)

Hole	Date February 1977	Date Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)
CNP-8	7	1153	28.16	6095.94
	8	1140	28.10	6096.00
CNP-8A	7	1155	dry	
	8	1142	dry	
CNP-9	7	1213	28.34	6042.26
	8	1150	28.30	6042.30
CNS-1	7	1406	dry	
	8	1329	dry	
CNS-2	7	1416	51.15	6187.15
	8	1346	51.18	6187.12
CNS-3	7	1434	25.60	6263.10
	8	1357	25.60	6263.10
CNS-4	7	1444	41.76	6201.84
	8	1401	36.90	6206.70
CNS-5	7	1505	33.88	6223.42
	8	1413	33.89	6223.41
CNS-7	7	950	36.93	6245.87
	8	958	36.90	6245.90
CNS-10	7	1040	30.12	6200.88
	8	1030	30.07	6200.93
CNS-11	7	1013	45.00	6200.30
	8	1010	44.97	6200.33
CNS-12	7	1008	47.90	6211.60
	8	1006	47.87	6211.63
CNS-13	7	1027	34.28	6208.82
	8	1022	34.22	6208.88
CNS-18	7	1450	33.54	6213.26
	8	1408	33.47	6213.33
CNS-19	7	1438	41.23	6219.07
	8	1401	41.18	6219.12
CNS-21	7	1008	47.90	6214.10
	8	1002	44.64	6217.36
CNS-22	7	1328	41.90	6181.50
	8	1258	41.89	6181.51
CNS-23	7	1358	69.40	6131.60
	8	1324	69.44	6131.56
CNS-25	7	1347	51.91	6166.19
	8	1314	51.93	6166.17
CNS-26	7	1342	50.20	6178.40
	8	1310	50.21	6178.39
CNS-29	7	1017	39.47	6196.63
	8	1014	39.46	6196.64
CNS-30	7	1045	36.12	6187.78
	8	1033	36.15	6187.75

Appendix I-2 supplement.--Depth-to-water measurements and water-level altitudes. (cont)

Hole	Date: February 1977	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)
CNS-31	7	1121	28.38	6173.82
	8	1109	28.36	6173.84
CNS-32	7	1125	31.52	6170.38
	8	1113	31.51	6170.39
CNS-34	7	1020	42.04	6200.76
	8	1017	42.00	6200.80
CNW-2	7	1050	32.74	6178.76
	8	1037	32.71	6178.79
CNW-4	7	1058	26.31	6144.99
	8	1045	26.31	6144.99

*see Appendix I-2

Appendix I-2 supplement.--Depth-to-water measurements and water-level altitudes.

Hole	Date: Day 1977	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)
CNC-1	2-28	1730	158.63	6213.57
	3- 1	1237	158.60	6213.60
CNC-3	2-28	1700	45.52	6225.28
	3- 1	1202	46.10	6224.70
CNC-4	2-28	1725	56.71	6240.89
	3- 1	1230	56.66	6240.94
CNC-5	2-28	1722	dry	
	3- 1	1220	dry	
CNC-6	2-28	1434	40.31	6189.69
	3- 1	0935	40.17	6189.83
CNC-7	2-28	1449	34.42	6178.78
	3- 1	0946	34.43	6178.77
CNC-8	2-28	1618	40.31	6210.49
	3- 1	1117	40.38	6210.42
CNG-2	2-28	1656	45.65	6200.55
	3- 1	1158	45.64	6200.56
CNP-1	2-28	1648	dry	
	3- 1	1149	dry	
CNP-2	2-28	1639	25.36	6184.44
	3- 1	1138	25.40	6184.40
CNP-3	2-28	1625	82.87	6141.23
	3- 1	1127	82.81	6141.29
CNP-3A	2-28	1628	dry	
	3- 1	1122	dry	
CNP-3B	2-28	1629	37.11	6184.89
	3- 1	1129	37.25	6184.75
CNP-4	2-28	1610	64.73	6175.07
	3- 1	1110	64.61	6175.19
CNP-4A	2-28	1612	dry	
	3- 1	1111	dry	
CNP-4B	2-28	1613	53.04	6186.66
	3- 1	1113	53.15	6186.55
CNP-5	2-28	1519	50.57	6169.63
	3- 1	1010	50.41	6169.79
CNP-6	2-28	1458	14.73	6131.37
	3- 1	0955	14.62	6131.48
CNP-6A	2-28	1500	10.92	6134.18
	3- 1	0957	10.96	6134.14
CNP-6B	2-28	1505	28.98	6136.22
	3- 1	0959	29.05	6136.15

Appendix I-2 supplement.-- Dpeth-to-water measurements and water-level altitudes (cont).

Hole	Date: Day 1977	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)
CNP-7	2-28	1527	80.66	6148.94
	3- 1	1018	80.62	6148.98
CNP-7A	2-28	1530	dry	
	3- 1	1016	dry	
CNP-8	2-28	1538	28.01	6096.09
	3- 1	1030	28.00	6096.10
CNP-8A	2-28	1541	dry	
	3- 1	1029	dry	
CNP-9	2-28	1548	28.29	6042.31
	3- 1	1037	28.27	6042.33
CNS-1	2-28	1645	dry	
	3- 1	1145	dry	
CNS-2	2-28	1654	51.65	6186.65
	3- 1	1156	51.75	6186.55
CNS-3	2-28	1704	25.64	6263.06
	3- 1	1205	25.64	6263.06
CNS-4	2-28	1711	41.59	6202.01
	3- 1	1212	41.43	6202.17
CNS-5	2-28	1718	33.71	6223.59
	3- 1	1217	33.69	6223.61
CNS-7	2-28	1355	36.84	6245.96
	3- 1	0910	36.75	6246.05
CNS-10	2-28	1438	30.10	6200.90
	3- 1	0938	30.05	6200.95
CNS-11	2-28	1416	44.98	6200.32
	3- 1	0920	45.07	6200.23
CNS-12	2-28	1412	47.89	6211.61
	3- 1	0916	48.01	6211.49
CNS-13	2-28	1430	34.23	6208.87
	3- 1	0930	34.25	6208.85
CNS-18	2-28	1715	33.35	6213.45
	3- 1	1214	33.22	6213.58
CNS-19	2-28	1708	41.02	6219.28
	3- 1	1208	40.95	6219.35
CNS-21	2-28	1400	44.59	6217.41
	3- 1	0913	44.52	6217.48
CNS-22	2-28	1621	41.79	6181.61
	3- 1	1120	41.77	6181.63
CNS-23	2-28	1642	69.23	6131.77
	3- 1	1142	69.30	6131.70

Appendix I-2 supplement.--Depth-to-water measurements and water-level altitudes (cont).

Hole	Date: Day 1977	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level (ft)
CNS-25	2-28	1635	51.64	6166.46
	3- 1	1135	51.71	6166.39
CNS-26	2-28	1632	50.47	6178.13
	3- 1	1132	50.56	6178.04
CNS-29	2-28	1421	39.52	6196.58
	3- 1	0924	39.48	6196.62
CNS-30	2-28	1442	36.22	6187.68
	3- 1	0941	36.27	6173.63
CNS-31	2-28	1511	28.34	6173.86
	3- 1	1003	28.33	6173.87
CNS-32	2-28	1515	31.23	6170.67
	3- 1	1005	31.29	6170.61
CNS-34	2-28	1425	41.98	6200.82
	3- 1	0927	42.02	6200.78
CNW-2	2-28	1446	32.68	6178.82
	3- 1	0944	32.69	6178.81
CNW-4	2-28	1453	25.75	6145.55
	3- 1	0950	25.73	6145.57

* see Appendix I-2

Appendix I-2 Supplement.--Depth-to-water measurements and water-level altitudes.

Hole	Date March 1977	Hour (MST)	Depth to water from MP* (ft)	Altitude of water level(ft)
CNC-3	23	1400	45.49	6225.31
	24	1132	45.49	6225.31
CNC-4	23	1430	54.70	6242.90
	24	1201	54.69	6242.91
CNC-6	23	1118	40.47	6189.53
	24	0912	40.26	6189.74
CNC-7	23	1126	34.56	6178.64
	24	0918	34.51	6178.69
CNC-8	23	1304	40.32	6210.48
	24	1044	40.30	6210.50
CNG-2	23	1355	44.70	6201.50
	24	1129	44.95	6201.25
CNP-1	23	1338	dry	dry
	24	1117	dry	dry
CNP-2	23	1332	25.88	6183.92
	24	1110	25.89	6183.91
CNP-3	23	1313	81.60	6142.50
	24	1050	81.52	6142.58
CNP-3A	23	1317	dry	dry
	24	1057	dry	dry
CNP-3B	23	1320	37.12	6184.88
	24	1100	37.27	6184.73
CNP-4	23	1257	64.79	6175.01
	24	1035	64.63	6175.17
CNP-4A	23	1255	dry	dry
	24	1037	dry	dry
CNP-4B	23	1300	53.32	6186.38
	24	1040	53.32	6186.38
CNP-5	23	1200	50.61	6169.59
	24	0947	50.46	6169.74
CNP-6	23	1139	15.77	6130.33
	24	0930	14.60	6131.50
CNP-6A	23	1144	11.08	6134.02
	24	0932	11.06	6134.04
CNP-6B	23	1147	29.11	6136.09
	24	0935	29.13	6136.07
CNP-7	23	1210	80.51	6149.09
	24	0955	dry	dry
CNP-7A	23	1213	dry	dry

Appendix I-2 Supplement.--Depth-to-water measurements and water-level altitudes. (cont)

Hole	Date: March 1977	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level(ft)
CNP-8	23	1238	28.18	6095.92
	24	1007	28.32	6095.78
CNP-8A	23	1241	dry	dry
	24	1010	dry	dry
CNP-9	23	1226	28.37	6042.23
	24	1015	28.39	6042.21
CNS-1	23	1345	dry	dry
	24	1122	dry	dry
CNS-2	23	1359	52.10	6186.20
	24	1127	52.09	6186.21
CNS-3	23	1407	25.78	6262.92
	24	1135	25.68	6263.02
CNS-4	23	1413	41.59	6202.01
	24	1150	41.48	6202.12
CNS-5	23	1421	33.78	6223.52
	24	1158	33.66	6223.64
CNS-7	23	1042	36.78	6246.02
	24	0845	37.83	6244.97
CNS-10	23	1115	30.20	6200.80
	24	0910	30.09	6200.91
CNS-11	23	1058	45.18	6200.12
	24	0855	45.14	6200.16
CNS-12	23	1050	48.19	6211.31
	24	0850	48.24	6211.26
CNS-13	23	1111	34.87	6208.23
	24	0907	34.30	6208.80
CNS-18	23	1418	33.34	6213.46
	24	1154	33.22	6213.58
CNS-19	23	1410	41.00	6219.30
	24	1139	40.90	6219.40
CNS-21	23	1045	44.70	6217.30
	24	0847	44.58	6217.42
CNS-22	23	1308	41.83	6181.57
	24	1046	41.74	6181.66
CNS-23	23	1335	69.79	6131.21
	24	1113	68.98	6132.02
CNS-25	23	1329	51.65	6166.45
	24	1105	51.62	6166.48
CNS-26	23	1325	50.79	6177.81
	24	1102	50.78	6177.82

Appendix I-2 Supplement.--Depth-to-water measurements and water-level altitudes. (cont)

Hole	Date: March 1977	Date: Hour (MST)	Depth to water from MP* (ft)	Altitude of water level(ft)
CNS-29	23	1106	39.58	6196.52
	24	0902	39.53	6196.57
CNS-30	23	1122	36.58	6187.32
	24	0916	36.55	6187.35
CNS-31	23	1155	28.40	6173.80
	24	0942	28.40	6173.80
CNS-32	23	1152	31.33	6170.57
	24	0939	31.30	6170.60
CNS-34	23	1100	42.09	6200.71
	24	0858	42.11	6200.69
CNW-2	23	1130	32.79	6178.71
	24	0921	33.75	6177.75
CNW-4	23	1134	25.69	6145.61
	24	0925	25.68	6145.62

* see Appendix I-2

Appendix I-3.--Water-level data

Appendix I-3--CNA-3 - Water-level data.

Date Mo	Day	Hour (MST)	Elapsed time (min)	Airline pressure (psi)	Depth to water (ft)	s(ft)
1	18	0350	0	28.2	69.06	
		0355	5	26.0	74.14	5.08
		0400	10	24.0	78.76	9.70
		0405	15	22.5	82.22	13.16
		0410	20	21.5	84.53	15.47
		0415	25	20.0	88.00	18.94
		0420	30	18.6	91.23	22.17
		0425	35	16.5	96.08	27.02
		0430	40	14.4	100.94	31.88
		0435	45	12.0	106.48	37.42
		0440	50	10.2	110.64	41.58
		0445	55	7.9	115.95	46.89
		0450	60	5.5	121.49	52.43
		0455	65	3.5	126.11	57.05
		0500	70	2.0	129.58	60.52*
		0505	75	3.2	126.81	57.75
		0510	80	3.2	126.81	57.75
		0515	85	3.2	126.81	57.75
		0520	90	3.3	126.81	57.75
		0525	95	3.2	126.81	57.75
		0530	100	3.2	126.81	57.75

* shut off

Appendix I-3. -- CNA-3 - Pump test - discharge data.

Date: January 1977	Date: Hour (MST)	Elapsed time (min) t	Meter	Total discharge (gal)	Running average (gpm)	Incremental: ΔQ (gal)	Incremental: Δt (min)	Incremental: ΔQ/Δt (gpm)	Comments
18	0350	0	1966.1						
						7.40	2.00	3.70	
	0352	2	1973.5	7.40	3.70				
						1.50	2.00	.75	
	0354	4	1975.0	8.90	2.23				
						1.60	1.00	1.60	
	0355	5	1976.6	10.50	2.10				
						2.00	2.00	1.00	
	0357	7	1978.6	12.50	1.79				
						2.70	2.00	1.35	
	0359	9	1981.3	15.20	1.69				
						1.30	1.00	1.30	
	0400	10	1982.6	16.50	1.65				
						4.30	2.00	2.15	
	0402	12	1986.9	20.80	1.73				
						5.80	3.00	1.93	
	0405	15	1992.7	26.60	1.77				
						1.60	2.00	.80	
	0407	17	1994.3	28.20	1.66				
						3.30	3.00	1.10	
	0410	20	1997.6	31.50	1.58				
						5.50	5.00	1.10	
	0415	25	2003.1	37.00	1.48				
						6.40	5.00	1.28	
	0420	30	2009.5	43.40	1.45				average Q 1st step = 1.45 gpm
						9.80	5.00	1.96	
	0425	35	2019.3	53.20	1.52				
						8.60	5.00	1.72	
	0430	40	2027.9	61.80	1.55				

Appendix I-3. -- CNA-3 -- Pump test - discharge data. (cont)

Date: January 1977	Date: Hour (MST)	Elapsed time (min) t	Meter	Total discharge (gal)	Running average (gpm)	Incremental: ΔQ (gal)	Incremental: Δt (min)	Incremental: ΔQ/Δt (gpm)	Comments
18						8.40	5.00	1.68	
	0435	45	2036.3	70.20	1.56				
						8.60	5.00	1.72	
	0440	50	2044.9	78.80	1.58				
						10.60	5.00	2.12	
	0445	55	2055.5	89.40	1.63				
						10.00	5.00	2.00	
	0450	60	2065.5	99.40	1.66				
						9.10	5.00	1.82	
	0455	65	2074.6	108.50	1.67				
						7.40	5.00	1.48	
	0500	70	2082.0	115.90	1.66				average Q 2nd step = 1.79 gpm

Appendix I-3. -- CNW-2 - water-level data--pumping well.

Date: January 1977	Date: Hour (MST)	Elapsed time (min) t	Depth to water (ft): steel	Depth to water (ft): electric	Comments
5	0828	0	32.78		
	0855	27			connected electric tape to steel tape
	0856	28			trouble with tape
	0912	44		31.42	
	0917	49		31.32	
	0923	55		31.33	
	0928	60		31.34	
	0946	78		31.36	
	1004	96	30.53	31.40	
	1010	102		31.38	
	1023	115		31.44	
	1044	136		31.40	
	1049	141		31.39	
	1140	192		31.41	
					changed electric tape
	1159	211		32.64	
	1207	219		35.33	turned pump on 1200
	1209.75	221.75		34.41	
	1210.15	222.15		34.21	
	1210.5	222.5		34.	
	1210			34.02	
	1210.75	222.75		33.91	
	1211.25	223.25		33.83	
	1211.58	223.58		33.72	
	1211			33.55	
	1212.23	224.23		33.57	
	1212.55	224.55		33.50	
	1213	225		33.43	
	1213			33.39	
	1213.5	225.5		33.35	

Appendix I-3. -- CNW-2 - water-level data--pumping well. (cont)

Date: January 1977	Hour (MST)	Elapsed time (min): t	t_1	s (ft)	Depth to water (ft): steel	electric	Comments
5	1213.75	225.75				33.32	
	1214.15	226.15				33.29	turned pump off
	1214.5	226.5				33.28	
	1214.75	226.75				33.25	
	1215	227				33.18	
	1215.25	227.25				33.14	
	1215.58	227.58				33.11	
	1215.98	227.98				33.09	
	1216.5	228.5				33.08	
	1217.08	229.08				33.05	
	1223.15	235.15				32.93	
	1228.5	240.5				32.92	
	1240	252				32.85	
	1245.75	257.75				32.33	
	2335	907			31.80		
	2345	917			31.78		
6	0130	1022			31.68		
	0133	1025			31.54		
	0320	1132			31.31		
	0322	1134			31.28		
	1145	1637			32.76		
	1215	1667				32.71	
	1252	1704				32.70	
	1303	1715				32.70	
	1310	1722				32.70	
	1315	1727	0	2.19		33.59	pump on
	1316.15	1728.15	1.15	2.48		33.88	
	1316.83	1728.83	1.83	2.98		34.38	
	1317	1729	2	3.03		34.43	
	1317.25	1729.25	2.25	3.12		34.52	
	1317.5	1729.5	2.5	3.21		34.61	

Appendix I-3. -- CNW-2 - water-level data--pumping well. (cont)

Date January 1977	Hour (MST)	Elapsed time (min) t	Elapsed time (min) t_1	s (ft)	Depth to water (ft) electric	Comments
6	1317.75	1729.75	2.75	3.37	34.77	
	1318.5	1730.5	3.5	3.47	34.87	
	1318.75	1730.75	3.75	3.55	34.95	
	1319	1731	4	3.66	35.06	
	1320	1732	5	3.78	35.18	
	1320.33	1732.33	5.33	3.87	35.27	
	1320.75	1732.75	5.75	4.13	35.53	
	1321.25	1733.25	6.25	4.01	35.41	
	1321.5	1733.5	6.5	4.09	35.49	
	1322	1734	7	4.12	35.52	
	1322.75	1734.75	7.75	4.22	35.62	
	1323	1735	8	4.27	35.67	
	1323.25	1735.25	8.25	4.31	35.71	
	1323.5	1735.5	8.5	4.34	35.74	
	1323.75	1735.75	8.75	4.37	35.77	
	1324	1736	9	4.40	35.80	
	1324.25	1736.25	9.25	4.43	35.83	
	1324.5	1736.5	9.5	4.46	35.86	
	1324.75	1736.75	9.75	4.51	35.91	
	1325	1737	10	4.52	35.92	
	1325.25	1737.25	10.25	4.55	35.95	
	1325.5	1737.5	10.5	4.58	35.98	
	1326	1738	11	4.65	36.05	
	1326.25	1738.25	11.25	4.66	36.06	
	1326.5	1738.5	11.5	4.68	36.08	
	1326.75	1738.75	11.75	4.70	36.10	
	1327	1739	12	4.73	36.13	
	1327.25	1739.25	12.25	4.76	36.16	
	1327.5	1739.5	12.5	4.78	36.18	
	1327.75	1739.75	12.75	4.80	36.20	
	1328	1740	13	4.82	36.22	

Appendix I-3. -- CNW-2 - water-level data--pumping well. (cont)

Date: January 1977	Date: Hour (MST)	Elapsed time (min): t	Elapsed time (min): t_1	s (ft)	Depth to water (ft) electric	Comments
6	1328.25	1740.25	13.25	4.84	36.24	
	1328.5	1740.5	13.5	4.86	36.26	
	1329	1741	14	4.91	36.31	
	1329.25	1741.25	14.25	4.93	36.33	
	1329.5	1741.5	14.5	4.94	36.34	
	1329.75	1741.75	14.75	4.96	36.36	
	1330	1742	15	4.98	36.38	
	1330.25	1742.25	15.25	5.00	36.40	
	1330.5	1742.5	15.5	5.02	36.42	
	1331	1743	16	5.06	36.46	
	1331.5	1743.5	16.5	5.08	36.48	
	1331.75	1743.75	16.75	5.10	36.50	
	1332	1744	17	5.13	36.53	
	1332.25	1744.25	17.25	5.14	36.54	
	1332.5	1744.5	17.5	5.15	36.55	
	1333	1745	18	5.18	36.58	
	1333.5	1745.5	18.5	5.21	36.61	
	1334	1746	19	5.25	36.65	
	1334.25	1746.25	19.25	5.26	36.66	
	1334.5	1746.5	19.5	5.28	36.68	
	1334.75	1746.75	19.75	5.30	36.70	
	1335	1747	20	5.31	36.71	
	1337	1749	22	5.42	36.82	
	1339	1751	24	5.54	36.94	
	1341	1753	26	5.69	37.09	
	1343	1755	28	5.79	37.19	
	1345	1757	30	5.89	37.29	
	1347	1759	32	5.98	37.38	
	1349	1761	34	6.08	37.48	
	1351	1763	36	6.18	37.58	
	1354	1766	39	6.30	37.70	

Appendix I-3. -- CNW-2 - water-level data--pumping well. (cont)

Date January 1977	Hour (MST)	Elapsed time (min) t	t_1	s (ft)	Depth to water (ft) electric	Comments
6	1355	1767	40	6.35	37.75	
	1357	1769	42	6.42	37.82	
	1359	1771	44	6.50	37.90	
	1400	1772	45	6.58	37.98	
	1403	1775	48	6.65	38.05	
	1405	1777	50	6.72	38.12	
	1408	1780	53	6.82	38.22	
	1409	1781	54	6.87	38.27	
	1411	1783	56	6.94	38.34	
	1413	1785	58	7.02	38.42	
	1415	1787	60	7.11	38.51	
	1420	1792	65	7.31	38.71	
	1425	1797	70	7.49	38.89	
	1430	1802	75	7.58	38.98	
	1435	1807	80	7.69	39.09	
	1440	1812	85	7.78	39.18	
	1447	1819	92	7.92	39.32	
	1451	1823	96	8.04	39.44	
	1456	1828	101	8.16	39.56	
	1500	1832	105	8.28	39.68	
	1510	1842	115	8.54	39.94	
	1530	1862	135	8.96	40.36	
	1535	1867	140	9.03	40.43	
	1545	1877	150	9.23	40.63	
	1555	1887	160	9.57	40.97	
	1605	1897	170	9.77	41.17	
	1615	1907	180	10.05	41.45	
	1625	1917	190	10.17	41.57	
	1700	1952	225	10.83	42.23	
	1730	1982	255	11.37	42.77	
	1815	2027	300	12.12	43.52	

Appendix I-3. -- CNW-2 - water-level data--pumping well. (cont)

Date January 1977	Hour (MST)	Elapsed time (min) t	t_1	s (ft)	Depth to water (ft) electric	Comments
6	1830	2042	315	12.42	43.82	
	1900	2072	345	12.90	44.30	
	1929	2101	374	13.40	44.80	
	2000	2132	405	13.79	45.19	
	2030	2162	435	14.04	45.44	
	2104	2196	469	14.27	45.67	
	2130	2222	495	14.56	45.96	
	2200	2252	525	13.75	45.15	
	2230	2282	555	14.35	45.75	
	2300	2312	585	14.40	45.80	
	2330	2342	615	14.58	45.98	
7	0000	2372	645	14.58	45.98	
	0032	2404	677	14.59	45.99	
	0100	2432	705	14.58	45.98	
	0130	2462	735	14.59	45.99	
	0200	2492	765	14.98	46.38	
	0230	2522	795	15.09	46.49	
	0300	2552	825	15.20	46.60	
	0330	2582	855	15.37	46.77	
	0400	2612	885	15.49	46.89	
	0430	2642	915	15.55	46.95	
	0500	2672	945	15.51	46.91	
	0538	2710	983	15.67	47.07	
	0600	2732	1005	12.74	44.14	
	0630	2762	1035	15.78	47.18	
	0700	2792	1065	15.91	47.31	
	0730	2822	1095	15.98	47.38	
	0800	2852	1125	16.12	47.52	
	0831	2883	1156	16.11	47.51	
	0900	2912	1185	16.22	47.62	

Appendix I-3. -- CNW-2 - water-level data--pumping well. (cont)

Date January 1977	Date (MST)	Elapsed time (min) t	t_1	t_1'	t_1/t_1'	s (ft)	Depth to water (ft) electric	Comments
7	0930	2942	1215			16.31	47.71	
	1000	2972	1245			16.35	47.75	
	1025	2997	1270			16.03	47.43	
	1027	2999	1272			15.90	47.30	
	1028	3000	1273			15.84	47.24	
	1030	3002	1275	0				pump off
	1030.42	3002.42	1275.42	.42	3036.71	15.25	46.65	
	1030.75	3002.75	1275.75	.75	1701.00	15.08	46.48	
	1031	3003	1276	1	1276.00	14.88	46.28	
	1031.25	3003.25	1276.25	1.25	1021.00	14.72	46.12	
	1031.5	3003.5	1276.5	1.5	851.00	14.59	45.99	
	1031.83	3003.83	1276.83	1.83	697.72	14.48	45.88	
	1032.13	3004.13	1277.13	2.13	599.59	14.36	45.76	
	1032.42	3004.42	1277.42	2.42	527.86	14.27	45.67	
	1032.58	3004.58	1277.58	2.58	495.19	14.16	45.56	
	1033	3005	1278	3	426.00	14.08	45.48	
	1033.17	3005.17	1278.17	3.17	403.21	14.02	45.42	
	1033.38	3005.38	1278.38	3.38	378.22	13.94	45.34	
	1033.67	3005.67	1278.67	3.67	348.41	13.86	45.26	
	1033.92	3005.92	1278.92	3.92	326.26	13.81	45.21	
	1034.17	3006.17	1279.17	4.17	306.76	13.74	45.14	
	1034.33	3006.33	1279.33	4.33	295.46	13.68	45.08	
	1034.67	3006.67	1279.67	4.67	274.02	13.63	45.03	
	1034.83	3006.83	1279.83	4.83	264.98	13.59	44.99	
	1035.17	3007.17	1280.17	5.17	247.62	13.52	44.92	
	1035.42	3007.42	1280.42	5.42	236.24	13.47	44.87	
	1035.67	3007.67	1280.67	5.67	225.87	13.43	44.83	
	1035.92	3007.92	1280.92	5.92	216.37	13.38	44.78	
	1036.17	3008.17	1281.17	6.17	207.65	13.34	44.74	
	1036.5	3008.5	1281.5	6.5	197.15	13.28	44.68	

Appendix I-3. -- CNW-2 - water-level data--pumping well. (cont).

Date		Elapsed time (min)					Depth to water (ft)	
January 1977	Hour (MST)	t	t_1	t_1'	t_1/t_1'	s (ft)	electric	Comments
7	1036.83	3008.83	1281.83	6.83	187.68	13.23	44.63	
	1037.17	3009.17	1282.17	7.17	178.82	13.19	44.59	
	1037.5	3009.5	1282.5	7.5	171.00	13.15	44.55	
	1037.75	3009.75	1282.75	7.75	165.52	13.11	44.51	
	1038	3010	1283	8	160.38	13.07	44.47	
	1038.17	3010.17	1283.17	8.17	157.06	13.06	44.46	
	1038.42	3010.42	1283.42	8.42	152.43	13.02	44.42	
	1038.67	3010.67	1283.67	8.67	148.06	13.00	44.40	
	1038.92	3010.92	1283.92	8.92	143.94	12.97	44.37	
	1039.17	3011.17	1284.17	9.17	140.04	12.94	44.34	
	1039.42	3011.42	1284.42	9.42	136.35	12.93	44.31	
	1039.58	3011.58	1284.58	9.58	134.09	12.90	44.30	
	1039.83	3011.83	1284.83	9.83	130.70	12.88	44.28	
	1040	3012	1285	10	128.50	12.86	44.26	
	1040.17	3012.17	1285.17	10.17	126.37	12.85	44.25	
	1040.42	3012.42	1285.42	10.42	123.36	12.82	44.22	
	1040.58	3012.58	1285.58	10.58	121.51	12.80	44.20	
	1041	3013	1286	11	116.91	12.78	44.18	
	1041.17	3013.17	1286.17	11.17	115.15	12.77	44.17	
	1041.42	3013.42	1286.42	11.42	112.65	12.74	44.14	
	1041.58	3013.58	1286.58	11.58	111.10	12.73	44.13	
	1041.83	3013.83	1286.83	11.83	108.78	12.71	44.11	
	1042	3014	1287	12	107.25	12.70	44.10	
	1042.25	3014.25	1287.25	12.25	105.08	12.68	44.08	
	1042.58	3014.58	1287.58	12.58	102.35	12.66	44.06	
	1042.75	3014.75	1287.75	12.75	101.00	12.64	44.04	
	1042.92	3014.92	1287.92	12.92	99.68	12.63	44.03	
	1043.08	3015.08	1288.08	13.08	98.48	12.63	44.03	
	1043.33	3015.33	1288.33	13.33	96.65	12.61	44.01	
	1043.5	3015.5	1288.5	13.5	95.44	12.60	44.00	
	1043.75	3015.75	1288.75	13.75	93.73	12.58	43.98	

Appendix I-3. -- CNW-2 - water-level data--pumping well. (cont)

Date January 1977	Hour (MST)	Elapsed time (min) t	t_1	t_1'	t_1/t_1'	s (ft)	Depth to water (ft) electric	Comments
7	1044	3016	1289	14	92.07	12.56	43.96	
	1044.25	3016.25	1289.25	14.25	90.47	12.56	43.96	
	1044.42	3016.42	1289.42	14.42	89.42	12.55	43.95	
	1044.67	3016.67	1289.67	14.67	87.91	12.53	43.93	
	1044.92	3016.92	1289.92	14.92	86.46	12.52	43.92	
	1045	3017	1290	15	86.00	12.52	43.92	
	1045.25	3017.25	1290.25	15.25	84.61	12.50	43.90	
	1045.42	3017.42	1290.42	15.42	83.68	12.49	43.89	
	1045.75	3017.75	1290.75	15.75	81.95	12.47	43.87	
	1046	3018	1291	16	80.69	12.45	43.85	
	1046.42	3018.42	1291.42	16.42	78.65	12.45	43.85	
	1046.75	3018.75	1291.75	16.75	77.12	12.43	43.83	
	1047	3019	1292	17	76.00	12.42	43.82	
	1047.17	3019.17	1292.17	17.17	75.26	12.41	43.81	
	1047.33	3019.33	1292.33	17.33	74.57	12.40	43.80	
	1047.58	3019.58	1292.58	17.58	73.53	12.39	43.79	
	1047.92	3019.92	1292.92	17.92	72.15	12.38	43.78	
	1048.17	3020.17	1293.17	18.17	71.17	12.38	43.78	
	1048.33	3020.33	1293.33	18.33	70.56	12.36	43.76	
	1048.67	3020.67	1293.67	18.67	69.29	12.35	43.75	
	1048.83	3020.83	1293.83	18.83	68.71	12.35	43.75	
	1049.08	3021.08	1294.08	19.08	67.82	12.33	43.73	
	1049.25	3021.25	1294.25	19.25	67.23	12.32	43.72	
	1049.42	3021.42	1294.42	19.42	66.65	12.32	43.72	
	1049.82	3021.82	1294.82	19.82	65.33	12.31	43.71	
	1050	3022	1295	20	64.75	12.28	43.68	
	1052	3024	1297	22	58.95	12.23	43.63	
	1054	3026	1299	24	54.13	12.15	43.55	
	1056	3028	1301	26	54.04	12.09	43.49	
	1058	3030	1303	28	46.54	12.03	43.43	

Appendix I-3. -- CNW-2 - water-level data--pumping well. (cont)

Date January 1977	Hour (MST)	Elapsed time (min) t	t_1	t_1'	t_1/t_1'	s (ft)	Depth to water (ft) electric	Comments
7	1100	3032	1305	30	43.50	11.98	43.38	
	1102	3034	1307	32	40.84	11.67	43.07	
	1104	3036	1309	34	38.50	11.16	42.56	
	1106	3038	1311	36	36.42	10.96	42.36	
	1108	3040	1313	38	34.55	10.90	42.30	
	1110	3042	1315	40	32.88	11.67	43.07	
	1114	3046	1319	44	29.98	11.63	43.03	
	1116	3048	1321	46	28.72	11.59	42.99	
	1120	3052	1325	50	26.50	11.52	42.92	
	1122	3054	1327	52	25.52	11.45	42.85	
	1124	3056	1329	54	24.61	11.40	42.80	
	1126	3058	1331	56	23.77	11.38	42.78	
	1128	3060	1333	58	22.98	11.32	42.72	
	1130	3062	1335	60	22.25	11.29	42.69	
	1135	3067	1340	65	20.62	11.20	42.60	
	1140	3072	1345	70	19.21	11.10	42.50	
	1145	3077	1350	75	18.00	11.01	42.41	
	1150	3082	1355	80	16.94	10.92	42.32	
	1155	3087	1360	85	16.00	10.82	42.22	
	1200	3092	1365	90	15.17	10.74	42.14	
	1205	3097	1370	95	14.42	10.67	42.07	
	1210	3102	1375	100	13.75	10.58	41.98	
	1219	3111	1384	109	12.70	9.92	41.32	
	1237	3129	1402	127	11.04	10.32	41.72	
	1240	3132	1405	130	10.81	10.29	41.69	
	1242	3134	1407	132	10.66	9.91	41.31	
	1300	3152	1425	150	9.50	9.85	41.25	
	1310	3162	1435	160	8.97	9.73	41.13	
	1323	3175	1448	173	8.37	9.55	40.95	
	1330	3182	1455	180	8.08	9.48	40.88	

Appendix I-3. -- CNW-2 - water-level data--pumping well. (cont)

Date January 1977	Hour (MST)	Elapsed time (min) t	t_1	t_1'	t_1/t_1'	s (ft)	Depth to water (ft) electric	Comments
7	1340	3192	1465	190	7.71	9.35	40.75	
	1400	3212	1485	210	7.07	9.13	40.53	
	1431	3243	1516	241	6.29	8.81	40.21	
	1502	3274	1547	272	5.69	8.51	39.91	
	1532	3304	1577	302	5.22	8.24	39.64	
	1602	3334	1607	332	4.84	7.99	39.39	
	1635	3367	1640	365	4.49	7.71	39.11	
	1707	3399	1672	397	4.21	7.47	38.87	
	1731	3423	1696	421	4.03	7.28	38.68	
	1801	3453	1726	451	3.83	7.06	38.46	
	1830	3482	1755	480	3.66	6.84	38.24	
	1902	3514	1787	512	3.49	1.64	33.04?	
	1930	3542	1815	540	3.36	6.49	37.89	
	2004	3576	1849	574	3.22	6.28	37.68	
	2028	3600	1873	598	3.13	5.63	37.03	
	2100	3632	1905	630	3.02	5.91	37.31	
	2201	3693	1966	691	2.85	5.62	37.02	
	2231	3723	1996	721	2.77	5.49	36.89	
	2300	3752	2025	750	2.70	5.29	36.69	
	2330	3782	2055	780	2.63	5.15	36.55	
8	0000	3812	2085	810	2.57	5.02	36.42	
	0100	3872	2145	870	2.47	4.90	36.30	
	0130	3902	2175	900	2.42	4.77	36.17	
	0200	3932	2205	930	2.37	4.65	36.05	
	0231	3963	2236	961	2.33	4.52	35.92	
	0330	4022	2295	1020	2.25	4.32	35.72	
	0402	4054	2327	1052	2.21	4.20	35.60	
	0430	4082	2355	1080	2.18			trouble with electric tape on well
	0650	4222	2495	1220	2.05	2.74	34.14	

Appendix I-3. -- CNW-2 - water-level data--pumping well. (cont)

Date January 1977	Hour (MST)	Elapsed time (min) t	t_1	t_1'	t_1/t_1'	s (ft)	Depth to water (ft) steel	electric	Comments
8	0701	4233	2506	1231	2.04	3.70		35.10	
	0732	4264	2537	1262	2.01	3.64		35.04	
	0800	4292	2565	1290	1.99	3.57		34.97	
	0831	4323	2596	1321	1.97	3.50		34.90	
	0932	4384	2657	1382	1.92	3.35		34.75	
	1002	4414	2687	1412	1.90	3.29		34.69	
	1115	4487	2760	1485	1.86	3.11		34.51	
	1145	4517	2790	1515	1.84	3.06		34.46	
	1215	4547	2820	1545	1.83	2.97		34.37	
	1245	4577	2850	1575	1.81	2.92		34.32	
	1315	4607	2880	1605	1.79	2.87		34.27	
	1345	4637	2910	1635	1.78	2.82		34.22	
	1415	4667	2940	1665	1.77	2.79		34.19	
	1628	4800	3073	1798	1.71	2.62	34.02		
	1700	4832	3105	1830	1.70	2.61	34.01		
	1731	4863	3136	1861	1.69	4.36	35.76		
	1958	5010	3283	2008	1.63	1.86	33.26		
	2320	5212	3485	2210	1.58	2.19	33.59		
9	0402	5494	3767	2492	1.51	2.87	34.27		
	0603	5615	3888	2613	1.49	1.98	33.38		
	1015	5867	4140	2865	1.45	1.74	33.14		
	1612	6224	4497	3222	1.40	1.77	33.17		
10	0812	7184	5457	4182	1.30	1.54	32.94		

Appendix I-3. -- CNW-2 - Pump test - discharge data.

Date: Jan 1977	Date: Hour (MST)	Elapsed time (min) t_2	Meter	Total discharge (gal)	Running average (gpm)	Incremental: ΔQ (gal)	Incremental: Δt (min)	Incremental: ΔQ/Δt (gpm)
6	1315	0	11714.85					
						5.15	2.50	2.06
	1317.5	2.5	11720.00	5.15	2.06			
						3.45	2.50	1.38
	1320	5.0	11723.45	8.60	1.72			
						11.50	5.75	2.00
	1325.75	10.75	11734.95	20.10	1.87			
						5.85	3.00	1.95
	1328.75	13.75	11740.80	25.95	1.89			
						3.85	2.25	1.71
	1331	16.0	11744.65	29.80	1.86			
						5.85	2.75	2.13
	1333.75	18.75	11750.50	35.65	1.90			
						4.30	2.25	1.91
	1336	21.0	11754.80	39.95	1.90			
						30.20	15.50	1.95
	1351.5	36.5	11785.00	70.15	1.92			
						9.75	4.50	2.17
	1356	41.0	11794.75	79.90	1.95			
						18.15	10.00	1.82
	1406	51.0	11812.90	98.05	1.92			
						11.45	6.00	1.91
	1412	57.0	11824.35	109.50	1.92			
						27.10	14.00	1.94
	1426	71.0	11851.45	136.60	1.92			
						10.45	5.00	2.09
	1431	76.0	11861.90	147.05	1.93			
						27.35	10.00	2.74
	1441	86.0	11889.25	174.40	2.03			
						44.60	30.00	1.49
	1511	116.0	11933.85	219.00	1.89			
						45.15	25.00	1.81
	1536	141.0	11979.00	264.15	1.87			
						16.00	9.00	1.78
	1545	150.0	11995.00	280.15	1.87			
						17.30	10.00	1.73
	1555	160.0	12012.30	297.45	1.86			
						21.05	11.00	1.91
	1606	171.0	12033.35	318.50	1.86			
						19.95	10.00	2.00
	1616	181.0	12053.30	338.45	1.87			
						16.35	10.00	1.64

Appendix I-3. -- CNW-2 - Pump test - discharge data. (cont)

Date		Elapsed		Total	Running	Incremental		
Jan 1977	Hour (MST)	time (min) t_2	Meter	discharge (gal)	average (gpm)	ΔQ (gal)	Δt (min)	ΔQ/Δt (gpm)
6	1626	191.0	12069.65	354.80	1.86			
						59.45	33.00	1.80
	1659	224.0	12129.10	414.25	1.85			
						1520.65	996.00	1.53
7	0935	1220.0	13649.75	1934.90	1.59			
						32.15	30.00	1.07
	1005	1250.0	13681.90	1967.05	1.57			
						1.40	1.00	1.40
	1006	1251.0	13683.30	1968.45	1.57			
						31.25	24.00	1.30
	1030	1275.0	13714.55	1999.70	1.57			

Appendix I-3. -- CNW-2 - Water-level data for observation well CNC-7(P).

Date		Elapsed time (min)	Depth to water (ft)		Comments
January 1977	Hour (MST)	t	steel	electric	
5	0942	74		34.42	
	0954	86		34.44	
	0955	87	34.46	34.49	
	1007	99		34.42	
	1021	113		34.41	
	1036	128		34.39	
	1100	152		34.37	
	1139	191		34.38	
	1202	214		34.41	
	1206.25	218.25		34.42	
	1206.42	218.42		34.44	
	1206.83	218.83		34.44	
	1207.75	219.75		34.45	
	1208.83	220.83		34.45	
	1209.17	221.17		34.46	
	1209.83	221.83		34.48	
	1210.25	222.25		34.46	
	1210.67	222.67		34.48	
	1211.17	223.17		34.48	
	1212.25	224.25		34.56	
	1212.5	224.5		34.58	
	1213	225		34.60	
	1213.25	225.25		34.60	
	1213.67	225.67		34.60	
	1214.17	226.17		34.61	
	1214.58	226.58		34.62	
	1214.83	226.83		34.62	
	1215.67	227.67		34.64	
	1216.27	228.27		34.63	
	1216.58	228.58		34.63	
	1217	229		34.63	

Appendix I-3. -- CNW-2 - Water-level data for observation well CNC-7(P). (cont)

Date January 1977	Hour (MST)	Elapsed time (min) t	t_1	Depth to water (ft) steel	electric	s (ft)	Comments
5	1217.33	229.33			34.63		
	1217.75	229.75			34.64		
	1218.17	230.17			34.63		
	1218.58	230.58			34.63		
	1223.58	235.58			34.63		
	1228	240.58			34.63		
	1233	245			34.63		
	1238	250			34.63		
	1242	254			34.61		
	1248	260			34.61		
	2330	902		34.08			
	2340	912		34.35			
6	0131	1023		34.54			
	0135	1027		34.52			
	0328	1140		34.16			
	0330	1142		34.10			
	1151	1643		34.37			
	1212	1664			35.00		
	1214	1666			34.49		
	1219	1671			34.38		
	1227	1679			34.44		
	1232	1684			34.44		
	1254	1706			34.46		
	1305	1717			34.46		
	1310	1722			34.46		
	1315	1727	0		34.46	.06	
	1316	1728	1		34.46	.06	
	1316.17	1728.17	1.17		34.49	.09	
	1316.42	1728.42	1.42		34.49	.09	
	1316.92	1728.92	1.92		34.51	.11	

Appendix I-3. -- CNW-2 - Water-level data for observation well CNC-7(P). (cont)

Date January 1977	Hour (MST)	Elapsed time (min) t	t_1	Depth to water (ft) electric	s (ft)	Comments
6	1317.25	1729.25	2.25	34.51	.11	
	1317.75	1729.75	2.75	34.51	.11	
	1317.92	1729.92	2.92	34.54	.14	
	1318.17	1730.17	3.17	34.54	.14	
	1318.42	1730.42	3.42	34.56	.16	
	1318.67	1730.67	3.67	34.54	.14	
	1319.08	1731.08	4.08	34.56	.16	
	1319.42	1731.42	4.42	34.56	.16	
	1319.67	1731.67	4.67	34.56	.16	
	1319.92	1731.92	4.92	34.56	.16	
	1320.17	1732.17	5.17	34.59	.19	
	1320.5	1732.5	5.5	34.60	.20	
	1320.75	1732.75	5.75	34.60	.20	
	1321	1733	6	34.61	.21	
	1321.25	1733.25	6.25	34.61	.21	
	1321.5	1733.5	6.5	34.63	.23	
	1321.75	1733.75	6.75	34.64	.24	
	1322	1734	7	34.64	.24	
	1322.25	1734.25	7.25	34.66	.26	
	1322.75	1734.75	7.75	34.68	.28	
	1323	1735	8	34.69	.29	
	1323.25	1735.25	8.25	34.69	.29	
	1323.5	1735.5	8.5	34.70	.30	
	1323.83	1735.83	8.83	34.71	.31	
	1324.25	1736.25	9.25	34.73	.33	
	1324.5	1736.5	9.5	34.73	.33	
	1324.75	1736.75	9.75	34.75	.35	
	1325	1737	10	34.75	.35	
	1325.5	1737.5	10.5	34.78	.38	
	1325.75	1737.75	10.75	34.80	.40	

Appendix I-3. -- CNW-2 - Water-level data for observation well CNC-7(P). (cont)

Date January 1977	Hour (MST)	Elapsed time (min) t	t_1	Depth to water (ft) electric	s (ft)	Comments
6	1326	1738	11	34.80	.40	
	1326.25	1738.25	11.25	34.81	.41	
	1326.5	1738.5	11.5	34.84	.44	
	1326.75	1738.75	11.75	34.84	.44	
	1327	1739	12	34.85	.45	
	1327.25	1739.25	12.25	34.86	.46	
	1327.5	1739.5	12.5	34.86	.46	
	1327.75	1739.75	12.75	34.87	.47	
	1328	1740	13	34.88	.48	
	1328.5	1740.5	13.5	34.90	.50	
	1328.75	1740.75	13.75	34.93	.53	
	1329	1741	14	34.95	.55	
	1329.25	1741.25	14.25	34.98	.58	
	1329.58	1741.58	14.58	34.98	.58	
	1329.83	1741.83	14.83	34.98	.58	
	1330	1742	15	34.98	.58	
	1330.25	1742.25	15.25	34.98	.58	
	1330.5	1742.5	15.5	34.99	.59	
	1330.67	1742.67	15.67	34.99	.59	
	1330.83	1742.83	15.83	35.00	.60	
	1331.17	1743.17	16.17	35.02	.62	
	1331.5	1743.5	16.5	35.05	.65	
	1331.75	1743.75	16.75	35.08	.68	
	1332	1744	17	35.08	.68	
	1332.08	1744.08	17.08	35.08	.68	
	1332.25	1744.25	17.25	35.09	.69	
	1332.5	1744.5	17.5	35.10	.70	
	1332.67	1744.67	17.67	35.11	.71	
	1332.75	1744.75	17.75	35.11	.71	
	1333	1745	18	35.12	.72	

Appendix I-3. -- CNW-2 - Water-level data for observation well CNC-7(P). (cont)

Date January 1977	Hour (MST)	Elapsed time (min) t	t_1	Depth to water (ft) electric	s (ft)	Comments
6	1333.5	1745.5	18.5	35.13	.73	
	1333.75	1745.75	18.75	35.15	.75	
	1334	1746	19	35.16	.76	
	1334.25	1746.25	19.25	35.17	.77	
	1334.5	1746.5	19.5	35.17	.77	
	1334.75	1746.75	19.75	35.18	.78	
	1335	1747	20	35.20	.80	
	1335.25	1747.25	20.25	35.21	.81	
	1335.5	1747.5	20.5	35.21	.81	
	1337.5	1749.5	22.5	35.31	.91	
	1339.5	1751.5	24.5	35.38	.98	
	1341.5	1753.5	26.5	35.48	1.08	
	1343.5	1755.5	28.5	35.56	1.16	
	1345.5	1747.5	30.5	35.65	1.25	
	1347.5	1759.5	32.5	35.73	1.33	
	1349.5	1761.5	34.5	35.79	1.39	
	1351.5	1763.5	36.5	35.90	1.50	
	1353.5	1765.5	38.5	35.98	1.58	
	1355.5	1767.5	40.5	36.03	1.63	
	1357.5	1769.6	42.5	36.12	1.72	
	1359.5	1771.5	44.5	36.17	1.77	
	1401.5	1773.5	46.5	36.25	1.85	
	1403.5	1775.5	48.5	36.31	1.91	
	1405.5	1777.5	50.5	36.39	1.99	
	1407.5	1779.5	52.5	36.43	2.03	
	1409.5	1781.5	54.5	36.50	2.10	
	1411.5	1783.5	56.5	36.57	2.17	
	1413.5	1785.5	58.5	36.64	2.24	
	1415.5	1787.5	60.5	36.68	2.28	
	1420.5	1792.5	65.5	36.85	2.45	

Appendix I-3. -- CNW-2 - Water-level data for observation well CNC-7(P). (cont)

Date: January 1977	Hour (MST)	Elapsed time (min): t	t_1	Depth to water (ft): electric	s (ft)	Comments
6	1425.5	1797.5	70.5	37.00	2.60	
	1430.5	1802.5	75.5	37.15	2.75	
	1435.5	1807.5	80.5	37.30	2.90	
	1440.5	1812.5	85.5	37.41	3.01	
	1445.5	1817.5	90.5	37.58	3.18	
	1450.5	1822.5	95.5	37.67	3.27	
	1455.5	1827.5	100.5	37.82	3.42	
	1505.5	1837.5	110.5	37.97	3.57	
	1515	1847	120	38.24	3.84	
	1525	1857	130	38.38	3.98	
	1535	1867	140	38.46	4.06	
	1545	1877	150	38.84	4.44	
	1555	1887	160	39.03	4.63	
	1606	1898	171	39.21	4.81	
	1616	1908	181	39.41	5.01	
	1625	1917	190	39.58	5.18	
	1700	1952	225	40.16	5.76	
	1730	1982	255	40.59	6.19	
	1805	2017	290	41.11	6.71	
	1835	2047	320	43.50	9.10	
	1903	2075	348	41.89	7.49	
	1931	2103	376	44.21	9.81	
	2003	2135	408	42.50	8.10	
	2032	2164	437	42.84	8.44	
	2100	2192	465	43.10	8.70	
	2132	2224	497	43.37	8.97	
	2200	2252	525	43.61	9.21	
	2229	2281	554	43.89	9.49	
	2300	2312	585	43.91	9.51	
	2328	2340	613	43.98	9.58	

Appendix I-3. -- CNW-2 - Water-level data for observation well CNC-7(P). (cont)

Date January 1977	Hour (MST)	Elapsed time (min) t	t_1	t_1'	t_1/t_1'	Depth to water (ft) electric	s (ft)	Comments
6	2357	2369	642			44.05	9.65	
7	0000	2372	645			45.45	11.05	
	0028	2400	673			44.18	9.78	
	0030	2402	675			44.18	9.78	
	0100	2432	705			44.23	9.83	
	0200	2492	765			44.41	10.01	
	0231	2523	796			44.53	10.13	
	0300	2552	825			44.61	10.21	
	0333	2585	858			44.69	10.29	
	0400	2612	885			44.77	10.37	
	0432	2644	917			44.85	10.45	
	0500	2672	945			44.92	10.52	
	0535	2707	980			45.00	10.60	
	0600	2732	1005			45.50	11.10	
	0630	2762	1035			45.11	10.71	
	0702	2794	1067			45.21	10.81	
	0730	2822	1095			45.23	10.83	
	0801	2853	1126			45.35	10.95	
	0830	2882	1155			45.37	10.97	
	0900	2912	1185			45.43	11.03	
	0929	2941	1214			45.47	11.07	
	1000	2972	1245			45.55	11.15	
	1025	2997	1270			45.61	11.21	
	1030	3002	1275	0		45.61	11.21	pump shut down
	1030.75	3002.75	1275.75	.75	1701	45.61	11.21	
	1031	3003	1276	1	1276	45.61	11.21	
	1031.25	3003.25	1276.25	1.25	1021	45.61	11.21	
	1031.5	3003.5	1276.5	1.5	851	45.59	11.19	
	1031.75	3003.75	1276.75	1.75	729.571	45.59	11.19	
	1032	3004	1277	2	638.5	45.59	11.19	

Appendix I-3. -- CNW-2 - Water-level data for observation well CNC-7(P). (cont)

Date January 1977	Hour (MST)	Elapsed time (min) t	t_1	t_1'	t_1/t_1'	Depth to water (ft) electric	s (ft)	Comments
7	1032.25	3004.25	1277.25	2.25	567.667	45.59	11.19	
	1032.5	3004.5	1277.5	2.5	511	45.59	11.19	
	1032.75	3004.75	1227.75	2.75	464.636	45.59	11.19	
	1033	3005	1278	3	426	45.59	11.19	
	1033.25	3005.25	1278.25	3.25	393.308	45.59	11.19	
	1033.5	3005.5	1278.5	3.5	365.286	45.59	11.19	
	1033.75	3005.75	1278.75	3.75	341	45.59	11.19	
	1034	3006	1279	4	319.75	45.59	11.19	
	1034.25	3006.25	1279.25	4.25	301	45.59	11.19	
	1034.5	3006.5	1279.5	4.5	284.333	45.59	11.19	
	1034.75	3006.75	1279.75	4.75	269.421	45.59	11.19	
	1035	3007	1280	5	256	45.59	11.19	
	1035.25	3007.25	1280.25	5.25	243.857	45.59	11.19	
	1035.5	3007.5	1280.5	5.5	232.818	45.59	11.19	
	1035.75	3007.75	1280.75	5.75	222.739	45.58	11.18	
	1036	3008	1281	6	213.5	45.57	11.17	
	1036.25	3008.25	1281.25	6.25	205	45.57	11.17	
	1036.5	3008.5	1281.5	6.5	197.154	45.57	11.17	
	1036.75	3008.75	1281.75	6.75	189.889	45.57	11.17	
	1037	3009	1282	7	183.143	45.57	11.17	
	1037.25	3009.25	1282.25	7.25	176.862	45.57	11.17	
	1037.5	3009.5	1282.5	7.5	171	45.57	11.17	
	1037.75	3009.75	1282.75	7.75	165.516	45.57	11.17	
	1038	3010	1283	8	160.375	45.57	11.17	
	1038.25	3010.25	1283.25	8.25	155.545	45.57	11.17	
	1038.5	3010.5	1283.5	8.5	151	45.57	11.17	
	1038.75	3010.75	1283.75	8.75	146.714	45.57	11.17	
	1039	3011	1284	9	142.667	45.54	11.14	
	1039.25	3011.25	1284.25	9.25	138.838	45.54	11.14	
	1039.5	3011.5	1284.5	9.5	135.211	45.53	11.13	

Appendix I-3. -- CNW-2 - Water-level data for observation well CNC-7(P). (cont)

Date January 1977	Hour (MST)	Elapsed time (min) t	t_1	t_1'	t_1/t_1'	Depth to water (ft) electric	s (ft)	Comments
7	1039.75	3011.75	1284.75	9.75	131.769	45.53	11.13	
	1040	3012	1285	10	128.5	45.53	11.13	
	1040.25	3012.25	1285.25	10.25	125.390	45.53	11.13	
	1041	3013	1286	11	116.909	45.53	11.13	
	1041.25	3013.25	1285.25	11.25	114.333	45.53	11.13	
	1041.5	3013.5	1286.5	11.5	111.870	45.53	11.13	
	1041.75	3013.75	1286.75	11.75	109.511	45.53	11.13	
	1042	3014	1287	12	107.25	45.50	11.10	
	1042.5	3014.5	1287.5	12.5	103	45.49	11.09	
	1042.75	3014.75	1287.75	12.75	101	45.48	11.08	
	1043	3015	1288	13	99.077	45.48	11.08	
	1043.25	3015.25	1288.25	13.25	97.226	45.48	11.08	
	1043.5	3015.5	1288.5	13.5	95.444	45.48	11.08	
	1043.75	3015.75	1288.75	13.75	93.727	45.48	11.08	
	1044	3016	1289	14	92.071	45.48	11.08	
	1044.25	3016.25	1289.25	14.25	90.474	45.48	11.08	
	1044.5	3016.5	1289.5	14.5	88.93	45.48	11.08	
	1044.75	3016.75	1289.75	14.75	87.441	45.47	11.07	
	1045	3017	1290	15	86	45.46	11.06	
	1045.25	3017.25	1290.25	15.25	84.607	45.46	11.06	
	1045.5	3017.5	1290.5	15.5	83.258	45.44	11.04	
	1045.75	3017.75	1290.75	15.75	81.952	45.44	11.04	
	1046	3018	1291	16	80.688	45.43	11.03	
	1046.25	3018.25	1291.25	16.25	79.462	45.42	11.02	
	1046.5	3018.5	1291.5	16.5	78.273	45.42	11.02	
	1046.75	3018.75	1291.75	16.75	77.119	45.41	11.01	
	1047	3019	1292	17	76	45.40	11.00	
	1047.25	3019.25	1292.25	17.25	74.913	45.40	11.00	
	1047.5	3019.5	1292.5	17.5	73.857	45.39	10.99	
	1047.75	3019.75	1292.75	17.75	72.831	45.38	10.98	

Appendix I-3. -- CNW-2 - Water-level data for observation well CNC-7(P). (cont)

Date January 1977	Hour (MST)	Elapsed time (min) t	t_1	t_1'	t_1/t_1'	Depth to water (ft) electric	s (ft)	Comments
7	1048	3020	1293	18	71.833	45.37	10.97	
	1048.25	3020.25	1293.25	18.25	70.863	45.37	10.97	
	1048.5	3020.5	1293.5	18.5	69.919	45.37	10.97	
	1048.75	3020.75	1293.75	18.75	69	45.37	10.97	
	1049	3021	1294	19	68.105	45.36	10.96	
	1049.25	3021.25	1294.25	19.25	67.234	45.36	10.96	
	1049.5	3021.5	1294.5	19.5	66.385	45.36	10.96	
	1049.75	3021.75	1294.75	19.75	65.557	45.35	10.95	
	1050	3022	1295	20	64.75	45.34	10.94	
	1052	3024	1297	22	58.955	45.28	10.88	
	1054	3026	1299	24	54.125	45.22	10.82	
	1056	3028	1301	26	50.038	45.18	10.78	
	1058	3030	1303	28	46.536	45.16	10.76	
	1100	3032	1305	30	43.5	45.11	10.71	
	1102	3034	1307	32	40.844	45.07	10.67	
	1104	3036	1309	34	38.5	45.00	10.60	
	1106	3038	1311	36	36.417	44.98	10.58	
	1108	3040	1313	38	34.553	44.92	10.52	
	1110	3042	1315	40	32.875	44.90	10.50	
	1112	3044	1317	42	31.357	44.88	10.48	
	1114	3046	1319	44	29.977	44.86	10.46	
	1116	3048	1321	46	28.717	44.80	10.40	
	1118	3050	1323	48	27.563	44.76	10.36	
	1120	3052	1325	50	26.5	44.72	10.32	
	1122	3054	1327	52	25.519	44.65	10.25	
	1124	3056	1329	54	24.611	44.60	10.20	
	1126	3058	1331	56	23.768	44.58	10.18	
	1128	3060	1333	58	22.983	44.52	10.12	
	1130	3062	1335	60	22.25	44.50	10.10	
	1135	3067	1340	65	20.615	44.47	10.07	

Appendix I-3. -- CNW-2 - Water-level data for observation well CNC-7(P). (cont)

Date January 1977	Hour (MST)	Elapsed time (min) t	t_1	t_1'	t_1/t_1'	Depth to water (ft) electric	s (ft)	Comments
7	1140	3072	1345	70	19.214	44.35	9.95	
	1145	3077	1350	75	18	44.28	9.88	
	1150	3082	1355	80	16.938	44.17	9.77	
	1155	3087	1360	85	16	44.06	9.66	
	1200	3092	1365	90	15.167	43.99	9.59	
	1205	3097	1370	95	14.421	43.91	9.51	
	1210	3102	1375	100	13.75	43.83	9.43	
	1220	3112	1385	110	12.591	43.73	9.33	
	1230	3122	1395	120	11.625	43.55	9.15	
	1241	3133	1406	131	10.733	43.39	8.99	
	1250	3142	1415	140	10.107	43.21	8.81	
	1300	3152	1425	150	9.5	43.15	8.75	
	1310	3162	1435	160	8.969	43.07	8.67	
	1323	3175	1448	173	8.370	42.90	8.50	
	1330	3182	1455	180	8.083	42.80	8.40	
	1341	3193	1466	191	7.675	42.71	8.31	
	1400	3212	1485	210	7.071	42.53	8.13	
	1430	3242	1515	240	6.313	42.40	8.00	
	1500	3272	1545	270	5.722	41.85	7.45	
	1530	3302	1575	300	5.25	41.56	7.16	
	1600	3332	1605	330	4.864	41.29	6.89	
	1634	3366	1639	364	4.503	41.04	6.64	
	1705	3397	1670	395	4.228	40.77	6.37	
	1730	3422	1695	420	4.036	40.68	6.28	
	1800	3452	1725	450	3.833	40.37	5.97	
	1829	3481	1754	479	3.662	40.15	5.75	
	1900	3512	1785	510	3.5	39.96	5.56	
	1930	3542	1815	540	3.361	39.78	5.38	
	2001	3573	1846	571	3.233	39.53	5.13	
	2027	3599	1872	597	3.136	39.40	5.00	

Appendix I-3. -- CNW-2 - Water-level data for observation well CNC-7(P). (cont)

Date		Elapsed time (min)				Depth to water (ft)			
January 1977	Hour (MST)	t_1	t_1	t_1'	t_1/t_1'	steel	electric	s (ft)	Comments
7	2100	3632	1905	630	3.024		39.21	4.81	
	2200	3692	1965	690	2.848		38.87	4.47	
	2230	3722	1995	720	2.771		38.73	4.33	
	2301	3753	2026	751	2.698		38.58	4.18	
	2331	3783	2056	781	2.633		38.44	4.04	
8	0001	3813	2086	811	2.572		38.29	3.89	
	0031	3843	2116	841	2.516		38.16	3.76	
	0131	3903	2176	901	2.415		38.03	3.63	
	0201	3933	2206	931	2.369		37.90	3.50	
	0230	3962	2235	960	2.328		37.80	3.40	
	0330	4022	2295	1020	2.25		37.60	3.20	
	0400	4052	2325	1050	2.214		37.48	3.08	
	0428	4080	2353	1078	2.183		37.35	2.95	
	0500	4112	2385	1110	2.149		37.29	2.89	
	0530	4142	2415	1140	2.118		37.28	2.88	
	0634	4206	2479	1204	2.059		36.99	2.59	
	0700	4232	2505	1230	2.037	37.04		2.64	
	0730	4262	2535	1260	2.012	36.96		2.56	
	0802	4294	2567	1292	1.987	36.87		2.47	
	0830	4322	2595	1320	1.966	36.81		2.41	
	0930	4382	2655	1380	1.924	36.58		2.18	
	1000	4412	2685	1410	1.904	36.64		2.24	
	1115	4487	2760	1485	1.859	36.40		2.00	
	1145	4517	2790	1515	1.842	36.37		1.97	
	1215	4547	2820	1545	1.825	36.29		1.89	
	1245	4577	2850	1575	1.810		36.12	1.72	
	1315	4607	2880	1605	1.794		36.05	1.65	
	1345	4637	2910	1635	1.780		36.01	1.61	
	1415	4667	2940	1665	1.766		35.94	1.54	
	1623	4795	3068	1793	1.711	35.82		1.42	
	1700	4832	3105	1830	1.697	34.62		.22	

Appendix I-3. -- CNW-2 - Water-level data for observation well CNC-7(P). (cont)

Date January 1977	Hour (MST)	Elapsed time (min) t	t_1	t_1'	t_1/t_1'	Depth to water (ft) steel	s (ft)	Comments
7	1735	4867	3140	1865	1.684	34.76	.36	
	1957	5009	3282	2007	1.635	35.55?	1.15?	
	2322	5214	3487	2212	1.576	35.38	1.48	
9	0400	5492	3765	2490	1.512	35.74	1.34	
	0618	5630	3903	2628	1.485	34.14	-.26	
	1010	5862	4135	2860	1.446	35.08	.68	
	1619	6231	4504	3229	1.395	35.00	.60	
10	0814	7186	5459	4184	1.305	34.76	.36	

Appendix I-3. -- CNW-4 - Water-level data.

Date January 1977	Hour (MST)	Elapsed time (min) t	Elapsed time (min) t_1	s (ft)	Depth to water (ft) steel	Depth to water (ft) electric	Comments
8	1100	0			26.50		
	1200	60			26.33		
	1231	91			27.55		
	1416	196			26.27		
	1418	198				26.29	
	1419	199					
	1500	240				26.30	
	1600	300				26.27	
	1715	375				26.27	
	1732	392				26.30	
	1805	425				26.30	
	1905	485				26.30	
	1612?					26.30	
9	2154	2094				26.30	
	2158	2098				26.30	
	2200.5	2100.5				26.32	attempted start
	2205.25	2105.25				26.32	
10	0819	2719				26.33	
	0850	2750				26.34	
	0900.5	2760.5				26.30	
	0901	2761				26.30	attempted start; pipes frozen
	0920	2780				26.30	
	1257	2997			26.37	26.32	
	1300	3000				26.32	
	1323	3023				26.32	
	1330	3030	0	.02		26.32	pump on
	1330.25	3030.25	.25	.11		26.41	
	1330.5	3030.5	.5	.16		26.46	
	1330.75	3030.75	.75	.37		26.67	
	1331.5	3031.5	1.5	.10		26.40	

Appendix I-3. -- CNW-4 - Water-level data. (cont)

Date: January 1977	Date: Hour (MST)	Elapsed time (min): t	Elapsed time (min): t_1	s (ft)	Depth to water (ft) electric	Comments
10	1331.75	3031.75	1.75	.10	26.40	
	1332	3032	2	.09	26.39	
	1332.25	3032.25	2.25	.10	26.40	
	1332.5	3032.5	2.5	.11	26.41	
	1334	3034	4	-.42	25.88	
	1334.25	3034.25	4.25	-.43	25.87	
	1334.5	3034.5	4.5	-.43	25.87	
	1334.75	3034.75	4.75	-.46	25.84	
	1335	3035	5	-.40	25.90	
	1335.25	3035.25	5.25	-.41	25.89	
	1335.5	3035.5	5.5	-.40	25.90	
	1336	3036	6	-.45	25.85	
	1336.25	3036.25	6.25	-.42	25.88	
	1336.5	3036.5	6.5	-.60	25.70	
	1336.75	3036.75	6.75	-.71	25.59	
	1337	3037	7	-.66	25.64	
	1337.75	3037.75	7.75	.11	26.41	
	1338	3038	8	.10	26.40	
	1338.25	3038.25	8.25	.10	26.40	
	1338.75	3038.75	8.75			
	1339.25	3039.25	9.25	.10	26.40	
	1339.5	3039.5	9.5	.11	26.41	
	1339.75	3039.75	9.75	.11	26.41	
	1340	3040	10	.11	26.41	
	1340.5	3040.5	10.5	.11	26.41	
	1340.75	3040.75	10.75	-.91	25.39	generator died
	1341	3041	11	-.90	25.40	
	1341.25	3041.25	11.25	-.87	25.43	
	1341.5	3041.5	11.5	-.87	25.43	
	1341.75	3041.75	11.75	-.87	25.43	

Appendix I-3. -- CNW-4 - Water-level data. (cont)

Date		Elapsed time (min)			Depth to water (ft)	
January 1977	Hour (MST)	t	t_1	s (ft)	electric	Comments
10	1342.5	3042.5	12.5	.11	26.41	
	1342.75	3042.75	12.75	.11	26.41	
	1343	3043	13	.11	26.41	
	1343.25	3043.25	13.25	.11	26.41	
	1343.5	3043.5	13.5	.11	26.41	
	1343.75	3043.75	13.75	.11	26.41	
	1344	3044	14	.11	26.41	
	1344.25	3044.25	14.25	.11	26.41	
	1344.5	3044.5	14.5	.11	26.41	
	1344.75	3044.75	14.75	.11	26.41	
	1345	3045	15	.12	26.42	
	1345.25	3045.25	15.25	.12	26.42	
	1345.5	3045.5	15.5	.11	26.41	
	1346.25	3046.25	16.25	.12	26.42	
	1346.5	3046.5	16.5	.12	26.42	
	1346.75	3046.75	16.75	.11	26.41	
	1347.5	3047.5	17.5	.12	26.42	
	1347.75	3047.75	17.75	.12	26.42	
	1348	3048	18	.12	26.42	
	1348.25	3048.25	18.25	.11	26.41	
	1348.5	3048.5	18.5	.12	26.42	
	1348.75	3048.75	18.75	.12	26.42	
	1349.25	3049.25	19.25	.12	26.42	
	1349.5	3049.5	19.5	.12	26.42	
	1349.75	3049.75	19.75	.12	26.42	
	1350	3050	20	.12	26.42	
	1350.25	3050.25	20.25	.12	26.42	
	1350.5	3050.5	20.5	.12	26.42	
	1350.75	3050.75	20.75	.12	26.42	

Appendix I-3. -- CNW-4 - Water-level data. (cont)

Date: January 1977	Date: Hour (MST)	Elapsed time (min): t	Elapsed time (min): t_1	s (ft)	Depth to water (ft): steel	Depth to water (ft): electric	Comments
10	1351	3051	21	.12		26.42	
	1353	3053	23	.13		26.43	
	1355	3055	25	.12		26.42	
	1357	3057	27	.11		26.41	
	1359	3059	29	.11		26.41	
	1401	3061	31	.11		26.41	
	1403	3063	33	.11		26.41	
	1405	3065	35	.11		26.41	
	1410	3070	40	.11		26.41	
	1413	3073	43	.12		26.42	
	1415	3075	45	.12		26.42	
	1417	3077	47	.12		26.42	
	1419	3079	49	.12		26.42	
	1420	3080	50	.12		26.42	
	1425	3085	55	.12		26.42	
	1431	3091	61	.18		26.48	
	1431.5	3091.5	61.5	.19		26.49	
	1431.75	3091.75	61.75	.19		26.49	
	1432	3092	62	.19		26.49	
	1432.25	3092.25	62.25	.19		26.49	
	1432.5	3092.5	62.5	.19		26.49	
	1432.58	3092.58	62.58	.18		26.48	
	1432.75	3092.75	62.75	.18		26.48	
	1433	3093	63	.18		26.48	
	1433.25	3093.25	63.25	.18		26.48	
	1433.5	3093.5	63.5	.18		26.48	
	1433.75	3093.75	63.75	.18		26.48	
	1434.5	3094.5	64.5	.18	26.48		
	1435	3095	65	.18		26.48	
	1435.25	3095.25	65.25	.18		26.48	

Appendix I-3. -- CNW-4 - Water-level data. (cont)

Date: January 1977	Date: Hour (MST)	Elapsed time (min): t	Elapsed time (min): t_1	s (ft)	Depth to water (ft): electric	Comments
10	1436.25	3096.25	66.25	.19	26.49	
	1436.5	3096.5	66.5	.19	26.49	
	1436.75	3096.75	66.75	.18	26.48	
	1437	3097	67	.18	26.48	
	1437.25	3097.25	67.25	.19	26.49	
	1437.5	3097.5	67.5	.19	26.49	
	1437.75	3097.75	67.75	.19	26.49	
	1438	3098	68	.18	26.48	
	1439	3099	69	.18	26.48	
	1439.75	3099.75	69.75	.17	26.47	
	1440	3100	70	.17	26.47	
	1442	3102	72	.17	26.47	
	1444	3104	74	.18	26.48	
	1446	3106	76	.18	26.48	
	1448	3108	78	.18	26.48	
	1450	3110	80	.18	26.48	
	1452.5	3112.5	82.5	.18	26.48	
	1454	3114	84	.18	26.48	
	1455	3115	85	.18	26.48	
	1500	3120	90	.18	26.48	
	1505	3125	95	.18	26.48	
	1510	3130	100	.18	26.48	
	1515	3135	105	.18	26.48	
	1520	3140	110	.18	26.48	
	1525	3145	115	.17	26.47	
	1530	3150	120	.35	26.65	
	1530.5	3150.5	120.5	.34	26.64	
	1530.75	3150.75	120.75	.35	26.65	
	1531.25	3151.25	121.25	.35	26.65	
	1531.5	3151.5	121.5	.35	26.65	

Appendix I-3. -- CNW-4 - Water-level data. (cont)

Date: January 1977	Date: Hour (MST)	Elapsed time (min): t	Elapsed time (min): t_1	s (ft)	Depth to water (ft) electric	Comments
10	1531.75	3151.75	121.75	.35	26.65	
	1532	3152	122	.36	26.66	
	1532.25	3152.25	122.25	.36	26.66	
	1532.5	3152.5	122.5	.36	26.66	
	1532.75	3152.75	122.75	.36	26.66	
	1533	3153	123	.36	26.66	
	1533.25	3153.25	123.25	.36	26.66	
	1533.5	3153.5	123.5	.37	26.67	
	1533.75	3153.75	123.75	.37	26.67	
	1534	3154	124	.36	26.66	
	1534.25	3154.25	124.25	.37	26.67	
	1534.5	3154.5	124.5	.37	26.67	
	1534.75	3154.75	124.75	.37	26.67	
	1535.25	3155.25	125.25	.37	26.67	
	1535.5	3155.5	125.5	.37	26.67	
	1535.75	3155.75	125.75	.37	26.67	
	1536	3156	126	.37	26.67	
	1538	3158	128	.40	26.70	
	1540	3160	130	.40	26.70	
	1542	3162	132	.40	26.70	
	1544	3164	134	.43	26.73	
	1546	3166	136	.43	26.73	
	1548	3168	138	.42	26.72	
	1550	3170	140	.42	26.72	
	1552	3172	142	.42	26.72	
	1554	3174	144	.42	26.72	
	1556	3176	146	.42	26.72	
	1601	3181	151	.42	26.72	
	1606	3186	156	.42	26.72	
	1611	3191	161	.42	26.72	

Appendix I-3. -- CNW-4 - Water-level data. (cont)

Date		Elapsed time (min)			Depth to water (ft)	
January 1977	Hour (MST)	t	t_1	s (ft)	electric	Comments
10	1616	3196	166	.42	26.72	
	1621	3201	171	.43	26.73	
	1626	3206	176	.43	26.73	
	1630	3210	180	.21	26.51	
	1630.25	3210.25	180.25	.21	26.51	
	1630.5	3210.5	180.5	.19	26.49	
	1631.25	3211.25	181.25	.18	26.48	
	1631.5	3211.5	181.5	.16	26.46	
	1631.75	3211.75	181.75	.15	26.45	
	1632	3212	182	.15	26.45	
	1632.25	3212.25	182.25	.15	26.45	
	1632.5	3212.5	182.5	.15	26.45	
	1632.75	3212.75	182.75	.15	26.45	
	1633.75	3213.75	183.75	.15	26.45	
	1634	3214	184	.14	26.44	
	1634.25	3214.25	184.25	.14	26.44	
	1634.5	3214.5	184.5	.13	26.43	
	1634.75	3214.75	184.75	.13	26.43	
	1635	3215	185	.44	26.74	
	1635.75	3215.75	185.75	.45	26.75	
	1635.5?			.45	26.75	
	1635.75?			.51	26.81	
	1636	3216	186	.50	26.80	
	1636.25	3216.25	186.25	.49	26.79	
	1636.5	3216.5	186.5	.49	26.79	
	1636.75	3216.75	186.75	.50	26.80	
	1638	3218	188	.50	26.80	
	1638.25	3218.25	188.25	.50	26.80	
	1638.5	3218.5	188.5	.50	26.80	
	1638.75	3218.75	188.75	.51	26.81	

Appendix I-3. -- CNW-4 -- Water-level data. (cont)

Date January 1977	Hour (MST)	Elapsed time (min) t	t_1	s (ft)	Depth to water (ft) electric	Comments
10	1639	3219	189	.50	26.80	
	1639.25	3219.25	189.25	.51	26.81	
	1639.5	3219.5	189.5	.51	26.81	
	1639.75	3219.75	189.75	.51	26.81	
	1640	3220	190	.51	26.81	
	1640.25	3220.25	190.25	.52	26.82	
	1640.5	3220.5	190.5	.52	26.82	
	1640.75	3220.75	190.75	.52	26.82	
	1641.75	3221.75	191.75	.52	26.82	
	1642	3222	192	.52	26.82	
	1642.25	3222.25	192.25	.52	26.82	
	1642.5	3222.5	192.5	.52	26.82	
	1642.75	3222.75	192.75	.52	26.82	
	1643	3223	193	.52	26.82	
	1643.25	3223.25	193.25	.52	26.82	
	1643.5	3223.5	193.5	.52	26.82	
	1643.75	3223.75	193.75	.52	26.82	
	1644	3224	194	.52	26.82	
	1644.75	3224.75	194.75	.53	26.83	
	1645	3225	195	.52	26.82	
	1647	3227	197	.54	26.84	
	1649	3229	199	.56	26.86	
	1651	3231	201	.62	26.92	
	1653	3233	203	.62	26.92	
	1655	3235	205	.62	26.92	
	1657	3237	207	.62	26.92	
	1659	3239	209	.58	26.88	
	1701	3241	211	.60	26.90	
	1703	3243	213	.60	26.90	
	1708	3248	218	.60	26.90	

Appendix I-3. -- CNW-4 - Water-level data. (cont)

Date: January 1977	Date: Hour (MST)	Elapsed time (min): t	Elapsed time (min): t_1	Elapsed time (min): t_1'	s (ft)	Argument of Harrill's Equation	Depth to water (ft) electric	Comments
10	1713	3253	223		.60		26.90	
	1718	3258	228		.57		26.87	
	1723	3263	233		.57		26.87	
	1728	3268	238		.60		26.90	
	1730	3270	240	0				shut down pump
	1732	3272	242	2	.25	66.603	26.55	
	1733	3273	243	3	.40	44.773	26.70	
	1734	3274	244	4	.44	33.858	26.44	
	1734.75	3274.75	244.75	4.75	.42	28.687	26.42	
	1735	3275	245	5	.10	27.308	26.40	
	1736	3276	246	6	.10	22.942	26.40	
	1736.25	3276.25	246.25	6.25	.08	22.068	26.38	
	1736.5	3276.5	246.5	6.5	.08	21.262	26.38	
	1736.75	3276.75	246.75	6.75	.08	20.516	26.38	
	1737	3277	247	7	.08	19.822	26.38	
	1737.25	3277.25	247.25	7.25	.10	19.177	26.40	
	1737.75	3277.75	247.75	7.75	.13	18.011	26.43	
	1738	3278	248	8	.15	17.483	26.45	
	1738.17	3278.17	248.17	8.17	.15	17.142	26.45	
	1738.25	3278.25	248.25	8.25	.15	16.986	26.45	
	1738.5	3278.5	248.5	8.5	.15	16.519	26.45	
	1738.75	3278.75	248.75	8.75	.15	16.079	26.45	
	1739	3279	249	9	.15	15.663	26.45	
	1739.25	3279.25	249.25	9.25	.15	15.269	26.45	
	1739.5	3279.5	249.5	9.5	.15	14.896	26.45	
	1739.75	3279.75	249.75	9.75	.15	14.542	26.45	
	1740	3280	250	10	.16	14.206	26.46	
	1740.25	3280.25	250.25	10.25	.15	13.887	26.45	
	1740.5	3280.5	250.5	10.5	.15	13.582	26.45	
	1740.75	3280.75	250.75	10.75	.15	13.292	26.45	

Appendix I-3. -- CNW-4 - Water-level data. (cont)

Date		Elapsed time (min)				Argument	Depth to	
January 1977	Hour (MST)	t	t_1	t_1'	s (ft)	of Harrill's Equation	water (ft) electric	Comments
10	1741	3281	251	11	.14	13.015	26.44	
	1741.25	3281.25	251.25	11.25	.14	12.750	26.44	
	1741.5	3281.5	251.5	11.5	.14	12.497	26.44	
	1741.75	3281.75	251.75	11.75	.14	12.254	26.44	
	1742	3282	252	12	.14	12.022	26.44	
	1744	3284	254	14	.13	10.461	26.43	
	1746	3286	256	16	.13	9.290	26.43	
	1748	3288	258	18	.11	8.379	26.41	
	1750	3290	260	20	.11	7.650	26.41	
	1755	3295	265	25	.11	6.336	26.41	
	1800	3300	270	30	.10	5.460	26.40	
	1805	3305	275	35	.10	4.833	26.40	
	1810	3310	280	40	.10	4.362	26.40	
	1815	3315	285	45	.10	3.996	26.40	
	1820	3320	290	50	.09	3.702	26.39	
	1825	3325	295	55	.09	3.462	26.39	
	1830	3330	300	60	.08	3.261	26.38	
	1835	3335	305	65	.08	3.092	26.38	
	1840	3340	310	70	.08	2.946	26.38	
	1850	3350	320	80	.08	2.708	26.38	
	1900	3360	330	90	.07	2.523	26.37	
	1930	3390	360	120	.06	2.152	26.36	
	2000	3420	390	150	.06	1.927	26.36	
	2030	3450	420	180	.04	1.777	26.34	
	2100	3480	450	210	.08	1.669	26.38	
	2130	3510	480	240	.03	1.588	26.33	
	2200	3540	510	270	.07	1.525	26.37	
	2234	3574	544	304	.04	1.468	26.34	
	2300	3600	570	330	.05	1.433	26.35	

Appendix I-3. -- CNW-4 - Water-level data. (cont)

Date		Elapsed time (min)						
January 1977	Hour (MST)	t	t_1	t_1'	s (ft)	Argument of Harrill's Equation	Depth to water (ft) electric	Comments
10	2330	3630	600	360	.04	1.398	26.34	
11	0000	3660	630	390	.03	1.368	26.33	
	0030	3690	660	420	.03	1.343	26.33	
	0100	3720	690	450	.07	1.321	26.37	
	0130	3750	720	480	.04	1.302	26.34	

Appendix I-3. -- CNW-4 - Pump test - discharge data. (cont)

Date: January 1977	Date: Hour (MST)	Elapsed time (min) t	Meter (gal)	Total discharge (gal)	Running average (gpm)	Incremental: ΔQ (gal)	Incremental: Δt (min)	Incremental: ΔQ/Δt (gpm)	Comments
10	1531	0	713.90						
						38.45	4.00	9.61	
	1535	4	752.35	38.45	9.61				
						107.70	10.00	10.77	
	1545	14	860.05	146.15	10.44				
						262.95	29.00	9.07	
	1614	43	1123.00	409.10	9.51				
						136.00	13.00	10.46	
	1627	56	1259.00	545.10	9.73				average Q 3rd step = 9.73 gpm
	1639	0	1347.00						
						18.10	2.50	7.24	
	1641.5	2.5	1365.10	18.10	7.24				
						37.65	3.00	12.55	
	1644.5	5.5	1402.75	55.75	10.14				
						150.45	11.50	13.08	
	1656	17	1553.20	206.20	12.13				
						211.20	19.00	11.12	
	1715	36	1764.40	417.40	11.59				
						116.25	9.00	12.92	
	1724	45	1880.65	533.65	11.86				average Q 4th step = 11.86 gpm

Appendix I-3. -- CNW-4 - Pump test - discharge data.

Date		Elapsed		Total	Running	Incremental			
January 1977	Hour (MST)	time (min) t	Meter (gal)	discharge (gal)	average (gpm)	ΔQ (gal)	Δt (min)	ΔQ/Δt (gpm)	Comments
10	1330	0	328.95						
						11.90	7.75	1.54	
	1337.75	7.75	340.85	11.90	1.54				
						9.15	4.25	2.15	
	1342	12	350.00	21.05	1.75				
						11.85	3.45	3.43	
	1345.45	15.45	361.85	32.90	2.13				
						8.50	3.55	2.39	
	1349	19	370.35	41.40	2.18				
						19.65	6.25	3.14	
	1355.25	25.25	390.00	61.05	2.42				
						50.85	15.75	3.23	
	1411	41	440.85	111.90	2.73				
						24.45	8.00	3.06	
	1419	49	465.30	136.35	2.78				
						15.95	10.00	1.60	
	1429	59	481.25	152.30	2.58				average Q 1st step = 2.58 gpm
	1435.5	0	509.00						
						14.75	4.00	3.69	
	1439.5	4	523.75	14.75	3.69				
						22.60	3.50	6.46	
	1443	7.5	546.35	37.35	4.98				
						1.50	2.00	.75	
	1445	9.5	547.85	38.85	4.09				
						31.00	7.00	4.43	
	1452	16.5	578.85	69.85	4.23				average Q 2nd step = 4.23 gpm

Appendix I-3.--CNW-4--Temperature and conductance of discharged water.

Date January 1977	Hour (MST)	Temp. (°C)	Specific conductance (µmhos) obs	@ 25°C
10	1343	14.5	830	1022
	1348	14	800	955
	1353	14	810	1008
	1358	14	800	995
	1403	14	800	995
	1408	14	810	1008
	1413	14.5	790	972
	1418	14	800	995
	1423	13.9	800	998
	1428	13.8	800	1000
	1433	14.1	810	1006
	1438	13.9	810	1010
	1443	13.9	800	998
	1448	13.9	800	998
	1453	12.8	790	1010
	1458	13.0	790	1006
	1503	13.0	790	1006
	1508	13.0	790	1006
	1536	13.2	800	1014
	1608	11.5	790	1043
	1648	10.2	750	1024
	1718	10	700	962
	1728	10	720	989

Appendix I-4.--Slug Test Data

Appendix I-4. -- Slug test of CNC-3(P).

Date		Elapsed	Depth to water		
December 1976	Hour (MST)	time (min) t_0	below measuring point (ft)*	s (ft)	Comments
18	1100		49.43		
	1101				inject 1 gal in 15 secs
	1101.25	0			
	1102	.75	48.10	1.33	
	1103	1.75	48.07	1.36	
	1104	2.75	48.06	1.37	
	1105	3.75	48.06	1.37	
	1106	4.75	48.05	1.38	
	1107	5.75	48.04	1.39	
	1108	6.75	48.05	1.38	
	1109	7.75	48.04	1.39	
	1110	8.75	48.04	1.39	
	1111	9.75	48.04	1.39	
	1112	10.75	48.05	1.38	
	1114	12.75	48.05	1.38	
	1116	14.75	48.05	1.38	
	1118	16.75	48.04	1.39	
	1120	18.75	48.05	1.38	
	1122	20.75	48.05	1.38	
	1124	22.75	48.05	1.38	
	1126	24.75	48.05	1.38	
	1128	26.75	48.05	1.38	
	1130	28.75	48.05	1.38	
	1132	30.75	48.05	1.38	
	1137	35.75	48.04	1.39	
	1142	40.75	48.04	1.39	
	1147	45.75	48.05	1.38	
	1152	50.75	48.05	1.38	
	1157	55.75	48.04	1.39	
	1202	60.75	48.05	1.38	

*Measuring point = 5.10 ft above ground surface

Appendix I-4. -- Slug test of CNC-7(P).

Date December 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
9	1415		34.26		
	1416				inject 1 gal in 20 secs
	1416.33	0			
	1417	.67	32.28	1.98	
	1418	1.67	32.68	1.58	
	1419	2.67	33.29	.97	
	1420	3.67	33.59	.67	
	1421	4.67	33.76	.50	
	1422	5.67	33.94	.32	
	1423	6.67	34.05	.21	
	1424	7.67	34.12	.14	
	1425	8.67	34.17	.09	
	1426	9.67	34.23	.03	
	1427	10.67	34.23	.03	
	1429	12.67	34.26	0	
	1431	14.67	34.26	0	
	1433	16.67	34.26	0	
	1435	18.67	34.26	0	
	1437	20.67	34.26	0	
	1439	22.67	34.26	0	
	1441	24.67	34.26	0	
	1443	26.67	34.26	0	
	1445	28.67	34.26	0	
	1447	30.67	34.25	.01	
	1452	35.67	34.26	0	
	1457	40.67	34.26	0	
	1502	45.67	34.25	.01	
	1507	50.67	34.26	0	
	1512	55.67	34.26	0	
	1517	60.67	34.26	0	

* Measuring point - 3.50 ft above ground surface

Appendix I-4. -- Slug test of CNG-2(P).

Date		Elapsed	Depth to water		
December 1976	Hour (MST)	time (min) t_0	below measuring point (ft)*	s (ft)	Comments
17	1500		49.97		
	1501				inject 1 gal in 10 secs
	1501.17	0			
	1502	.83	44.40	5.57	
	1503	1.83	44.39	5.58	
	1504	2.83	44.26	5.71	
	1505	3.83	44.26	5.71	
	1506	4.83	44.25	5.72	
	1507	5.83	44.24	5.73	
	1508	6.83	44.24	5.73	
	1509	7.83	44.23	5.74	
	1510	8.83	44.23	5.74	
	1511	9.83	44.23	5.74	
	1512	10.83	44.23	5.74	
	1514	12.83	44.23	5.74	
	1516	14.83	44.23	5.74	
	1518	16.83	44.23	5.74	
	1520	18.83	44.23	5.74	
	1522	20.83	44.23	5.74	
	1524	22.83	44.23	5.74	
	1526	24.83	44.24	5.73	
	1528	26.83	44.25	5.72	
	1530	28.83	44.24	5.73	
	1532	30.83	44.25	5.72	
	1537	35.83	44.26	5.71	
	1542	40.83	44.28	5.69	
	1547	45.83	44.29	5.68	
	1552	50.83	44.30	5.67	
	1557	55.83	44.31	5.66	
	1602	60.83	44.32	5.65	

*Measuring point = 4.10 ft above ground surface

Appendix I-4. -- Slug test of CNP-3(P).

Date November 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
19	1258		92.04		
	1300				inject 1 gal in 20 secs
	1300.33	0			
	1301	.67	89.14	2.90	
	1302	1.67	89.00	3.04	
	1303	2.67	88.98	3.06	
	1304	3.67	88.96	3.08	
	1305	4.67	88.94	3.10	
	1306	5.67	88.96	3.08	
	1307	6.67	88.94	3.10	
	1308	7.67	88.95	3.09	
	1309	8.67	88.96	3.08	
	1310	9.67	88.95	3.09	
	1311	10.67	88.95	3.09	
	1313	12.67	88.93	3.11	
	1315	14.67	88.93	3.11	
	1317	16.67	88.93	3.11	
	1319	18.67	88.93	3.11	
	1321	20.67	88.93	3.11	
	1323	22.67	88.95	3.09	
	1325	24.67	88.92	3.12	
	1327	26.67	88.90	3.14	
	1329	28.67	88.92	3.12	
	1334	33.67	88.91	3.13	
	1339	38.67	88.90	3.14	
	1344	43.67	88.91	3.13	
	1349	48.67	88.91	3.13	
	1354	53.67	88.91	3.13	
	1359	58.67	88.90	3.14	
	1404	63.67	88.89	3.15	

* Measuring point = 6.10 ft above ground surface

Appendix I-4. -- Slug test of CNP-3B(P).

Date		Elapsed	Depth to water		
December 1976	Hour (MST)	time (min) t_0	below measuring point (ft)*	s (ft)	Comments
15	1452		37.42		
	1453				inject 1 gal in 15 secs
	1453.25	0			
	1454	.75	31.77	5.65	
	1455	1.75	31.70	5.72	
	1456	2.75	31.68	5.74	
	1457	3.75	31.69	5.73	
	1458	4.75	31.69	5.73	
	1459	5.75	31.69	5.73	
	1500	6.75	31.71	5.71	
	1501	7.75	31.72	5.70	
	1502	8.75	31.72	5.70	
	1503	9.75	31.71	5.71	
	1504	10.75	31.74	5.68	
	1506	12.75	31.75	5.67	
	1508	14.75	31.78	5.64	
	1510	16.75	31.80	5.62	
	1512	18.75	31.83	5.59	
	1514	20.75	31.85	5.57	
	1516	22.75	31.87	5.55	
	1518	24.75	31.89	5.53	
	1520	26.75	31.89	5.53	
	1522	28.75	31.92	5.50	
	1524	30.75	31.94	5.48	
	1529	35.75	32.01	5.41	
	1534	40.75	32.07	5.35	
	1539	45.75	32.13	5.29	
	1544	50.75	32.15	5.27	
	1549	55.75	32.21	5.21	
	1554	60.75	32.25	5.17	

* Measuring point = 4.03 ft above ground surface

Appendix I-4. -- Slug test of CNP-4(P).

Date November 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
16	1430		68.51		
	1432				inject 1 gal in 20 secs
	1432.33	0			
	1433	.67	63.26	5.25	
	1434	1.67	63.26	5.25	
	1435	2.67	63.24	5.27	
	1436	3.67	63.24	5.27	
	1437	4.67	63.18	5.33	
	1438	5.67	63.18	5.33	
	1439	6.67	63.19	5.32	
	1440	7.67	63.17	5.34	
	1441	8.67	63.19	5.32	
	1442	9.67	63.21	5.30	
	1443	10.67	63.20	5.31	
	1444	11.67	63.22	5.29	
	1446	13.67	63.24	5.27	
	1448	15.67	63.27	5.24	
	1450	17.67	63.28	5.23	
	1452	19.67	63.30	5.21	
	1454	21.67	63.32	5.19	
	1456	23.67	63.35	5.16	
	1458	25.67	63.37	5.14	
	1500	27.67	63.38	5.13	
	1505	32.67	63.45	5.06	
	1510	37.67	63.51	5.00	
	1515	42.67	63.55	4.96	
	1520	47.67	63.62	4.89	
	1525	52.67	63.67	4.84	
	1530	57.67	63.72	4.79	

* Measuring point = 4.80 ft above ground surface

Appendix I-4. -- Slug test of CNP-4B(P).

Date		Elapsed time (min)	Depth to water below measuring point (ft)*		
December 1976	Hour (MST)	t_0		s (ft)	Comments
15	1339		58.83		
	1340				inject 1 gal in 15 secs
	1340.25	0			
	1341	.75	53.19	5.64	
	1342	1.75	53.07	5.76	
	1343	2.75	53.02	5.81	
	1344	3.75	52.97	5.86	
	1345	4.75	52.96	5.87	
	1346	5.75	52.94	5.89	
	1347	6.75	52.95	5.88	
	1348	7.75	52.94	5.89	
	1349	8.75	52.94	5.89	
	1350	9.75	52.95	5.88	
	1351	10.75	52.94	5.89	
	1353	12.75	52.93	5.90	
	1355	14.75	52.94	5.89	
	1357	16.75	52.93	5.90	
	1359	18.75	52.93	5.90	
	1401	20.75	52.93	5.90	
	1403	22.75	52.93	5.90	
	1405	24.75	52.93	5.90	
	1407	26.75	52.94	5.89	
	1409	28.75	52.95	5.88	
	1411	30.75	52.95	5.88	
	1416	35.75	52.93	5.90	
	1421	40.75	52.94	5.89	
	1426	45.75	52.94	5.89	
	1431	50.75	52.95	5.88	
	1436	55.75	52.93	5.90	
	1441	60.75	52.93	5.90	

*Measuring point = 4.66 ft above ground surface

Appendix I-4. -- Slug test of CNP-5(P).

Date December 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
4	1354		51.20		
	1355				inject 1 gal in 20 secs
	1355.33	0			
	1356	.67	45.96	5.24	
	1357	1.67	45.98	5.22	
	1358	2.67	46.00	5.20	
	1359	3.67	46.02	5.18	
	1400	4.67	46.04	5.16	
	1401	5.67	46.11	5.09	
	1402	6.67	46.17	5.03	
	1403	7.67	46.24	4.96	
	1404	8.67	46.30	4.90	
	1406	10.67	46.43	4.77	
	1408	12.67	46.55	4.65	
	1410	14.67	46.66	4.54	
	1412	16.67	46.81	4.39	
	1414	18.67	46.90	4.30	
	1416	20.67	47.00	4.20	
	1418	22.67	47.14	4.06	
	1420	24.67	47.22	3.98	
	1422	26.67	47.33	3.87	
	1424	28.67	47.42	3.78	
	1426	30.67	47.51	3.69	
	1431	35.67	47.78	3.42	
	1436	40.67	47.93	3.27	
	1441	45.67	48.11	3.09	
	1446	50.67	48.26	2.94	
	1451	55.67	48.43	2.77	
	1456	60.67	48.58	2.62	

* Measuring point = 2.20 ft above ground surface

Appendix I-4. -- Slug test of CNP-6(P).

Date November 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
22	1424		15.54		
	1425				inject 1 gal in 20 secs
	1425.33	0			
	1426	.67	10.74	4.80	
	1427	1.67	11.11	4.43	
	1428	2.67	11.13	4.41	
	1429	3.67	11.51	4.03	
	1430	4.67	11.68	3.86	
	1431	5.67	11.91	3.63	
	1432	6.67	12.10	3.44	
	1433	7.67	12.25	3.29	
	1434	8.67	12.40	3.14	
	1435	9.67	12.55	2.99	
	1436	10.67	12.68	2.86	
	1438	12.67	12.95	2.59	
	1440	14.67	13.18	2.36	
	1442	16.67	13.40	2.14	
	1444	18.67	13.59	1.95	
	1446	20.67	13.75	1.79	
	1448	22.67	13.92	1.62	
	1450	24.67	14.03	1.51	
	1452	26.67	14.15	1.39	
	1454	28.67	14.25	1.29	
	1456	30.67	14.38	1.16	
	1501	35.67	14.55	.99	
	1506	40.67	14.77	.77	
	1511	45.67	14.92	.62	
	1516	50.67	15.00	.54	
	1521	55.67	15.11	.43	
	1526	60.67	15.14	.40	

* Measuring point = 4.70 ft above ground surface

Appendix I-4. -- Slug test of CNP-6A(P).

Date		Elapsed	Depth to water		
December 1976	Hour (MST)	time (min) t_0	below measuring point (ft)*	s (ft)	Comments
11	1131		11.22		
	1132				inject 1 gal in 15 secs
	1132.25	0			
	1133	.75	10.52	.70	
	1134	1.75	11.12	.10	
	1135	2.75	11.19	.03	
	1136	3.75	11.22	0	
	1137	4.75	11.23	-.01	
	1138	5.75	11.25	-.03	
	1139	6.75	11.23	-.01	
	1140	7.75	11.25	-.03	
	1141	8.75	11.26	-.04	
	1142	9.75	11.24	-.02	
	1143	10.75	11.24	-.02	
	1145	12.75	11.25	-.03	
	1147	14.75	11.22	0	
	1149	16.75	11.23	-.01	
	1151	18.75	11.23	-.01	
	1153	20.75	11.22	0	
	1155	22.75	11.23	-.01	
	1157	24.75	11.24	-.02	
	1159	26.75	11.23	-.01	
	1201	28.75	11.24	-.02	
	1203	30.75	11.23	-.01	
	1208	35.75	11.23	-.01	
	1213	40.75	11.25	-.03	
	1218	45.75	11.23	-.01	
	1223	50.75	11.24	-.02	
	1228	55.75	11.23	-.01	
	1233	60.75	11.22	0	

*Measuring point = 3.94 ft above ground surface

Appendix I-4. -- Slug test of CNP-6B(P).

Date		Elapsed	Depth to water		
December 1976	Hour (MST)	time (min) t_0	below measuring point (ft)*	s (ft)	Comments
11	1243		29.17		
	1244				inject 1 gal in 15 secs
	1244.25	0			
	1245	.75	28.02	1.85	
	1246	1.75	28.84	.33	
	1247	2.75	29.09	.08	
	1248	3.75	29.18	-.01	
	1249	4.75	29.21	-.04	
	1250	5.75	29.24	-.07	
	1251	6.75	29.26	-.09	
	1252	7.75	29.27	-.10	
	1253	8.75	29.28	-.11	
	1254	9.75	29.28	-.11	
	1255	10.75	29.32	-.15	
	1257	12.75	29.28	-.11	
	1259	14.75	29.26	-.09	
	1301	16.75	29.24	-.07	
	1303	18.75	29.24	-.07	
	1305	20.75	29.24	-.07	
	1307	22.75	29.23	-.06	
	1309	24.75	29.23	-.06	
	1311	26.75	29.23	-.06	
	1313	28.75	29.22	-.05	
	1315	30.75	29.23	-.06	
	1320	35.75	29.22	-.05	
	1325	40.75	29.22	-.05	
	1330	45.75	29.23	-.06	
	1335	50.75	29.23	-.06	
	1340	55.75	29.22	-.05	
	1345	60.75	29.23	-.06	

*Measuring point = 4.29 ft above ground surface

Appendix I-4. -- Slug test of CNP-7(P).

Date December 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
7	1505		84.38		
	1506				inject 1 gal in 15 secs
	1506.25	0			
	1507	.75	79.83	4.55	
	1508	1.75	79.51	4.87	
	1509	2.75	79.41	4.97	
	1510	3.75	79.34	5.04	
	1511	4.75	79.34	5.04	
	1512	5.75	79.34	5.04	
	1513	6.75	79.31	5.07	
	1514	7.75	79.39	4.99	
	1515	8.75	79.41	4.97	
	1516	9.75	79.38	5.00	
	1517	10.75	79.37	5.01	
	1519	12.75	79.38	5.00	
	1521	14.75	79.38	5.00	
	1523	16.75	79.42	4.96	
	1525	18.75	79.41	4.97	
	1527	20.75	79.44	4.94	
	1529	22.75	79.45	4.93	
	1531	24.75	79.47	4.91	
	1533	26.75	79.50	4.88	
	1535	28.75	79.55	4.83	
	1537	30.75	79.62	4.76	
	1542	35.75	79.95	4.43	
	1547	40.75	80.26	4.12	
	1552	45.75	80.52	3.86	
	1557	50.75	80.65	3.73	
	1602	55.75	80.73	3.65	
	1607	60.75	80.80	3.58	

*Measuring point = 4.88 ft above ground surface

Appendix I-4. -- Slug test of CNP-8(P).

Date December 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
7	1323		28.30		
	1324				inject 1 gal in 20 secs
	1324.33	0			
	1325	.67	26.07	2.23	
	1326	1.67	26.85	1.45	
	1327	2.67	27.17	1.13	
	1328	3.67	27.38	0.92	
	1329	4.67	27.50	0.80	
	1330	5.67	27.63	0.67	
	1331	6.67	27.72	0.58	
	1332	7.67	27.75	0.55	
	1333	8.67	27.80	0.50	
	1334	9.67	27.85	0.45	
	1335	10.67	27.88	0.42	
	1337	12.67	27.96	0.34	
	1339	14.67	28.01	0.29	
	1341	16.67	28.03	0.27	
	1343	18.67	28.05	0.25	
	1345	20.67	28.10	0.20	
	1347	22.67	28.10	0.20	
	1349	24.67	28.13	0.17	
	1351	26.67	28.13	0.17	
	1353	28.67	28.15	0.15	
	1355	30.67	28.16	0.14	
	1400	35.67	28.18	0.12	
	1405	40.67	28.18	0.12	
	1410	45.67	28.19	0.11	
	1415	50.67	28.20	0.10	
	1420	55.67	28.20	0.10	
	1425	60.67	28.20	0.10	

* Measuring point = 2.80 ft above ground surface

Appendix I-4. -- Slug test of CNP-8A(P).

Date November 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
23	1233		28.58		
	1234				inject 1 gal in 20 secs
	1234.33	0			
	1235	.67	26.94	1.64	
	1236	1.67	27.15	1.43	
	1237	2.67	27.25	1.33	
	1238	3.67	27.55	1.03	
	1239	4.67	27.68	.90	
	1240	5.67	27.83	.75	
	1241	6.67	27.94	.64	
	1242	7.67	28.01	.57	
	1243	8.67	28.14	.44	
	1244	9.67	28.07	.51	
	1245	10.67	28.14	.44	
	1247	12.67	28.22	.36	
	1249	14.67	28.26	.32	
	1251	16.67	28.30	.28	
	1253	18.67	28.35	.23	
	1255	20.67	28.35	.23	
	1257	22.67	28.39	.19	
	1259	24.67	28.41	.17	
	1301	26.67	28.44	.14	
	1303	28.67	28.47	.11	
	1305	30.67	28.48	.10	
	1310	35.67	28.49	.09	
	1315	40.67	28.50	.08	
	1320	45.67	28.51	.07	
	1325	50.67	28.51	.07	
	1330	55.67	28.52	.06	
	1335	60.67	28.53	.05	

* Measuring point = 2.18 ft above ground surface

Appendix I-4. -- Slug test of CNP-9(P).

Date		Elapsed	Depth to water		
December 1976	Hour (MST)	time (min) t_0	below measuring point (ft)*	s (ft)	Comments
6	1500		28.67		
	1501				inject 1 gal in 15 secs
	1501.25	0			
	1502	.75	27.74	.93	
	1503	1.75	28.45	.22	
	1504	2.75	28.57	.10	
	1505	3.75	28.63	.04	
	1506	4.75	28.66	.01	
	1507	5.75	28.68	-.01	
	1508	6.75	28.70	-.03	
	1509	7.75	28.69	-.02	
	1510	8.75	28.71	-.04	
	1511	9.75	28.70	-.03	
	1512	10.75	28.71	-.04	
	1514	12.75	28.69	-.02	
	1516	14.75	28.68	-.01	
	1518	16.75	28.69	-.02	
	1520	18.75	28.68	-.01	
	1522	20.75	28.66	.01	
	1524	22.75	28.66	.01	
	1526	24.75	28.66	.01	
	1528	26.75	28.67	0	
	1530	28.75	28.66	.01	
	1532	30.75	28.68	-.01	
	1537	35.75	28.67	0	
	1542	40.75	28.66	.01	
	1547	45.75	28.67	0	
	1552	50.75	28.66	.01	
	1557	55.75	28.66	.01	
	1602	60.75	28.66	.01	

*Measuring point = 5.42 ft above ground surface

Appendix I-4. -- Slug test of CNS-2(P).

Date December 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
17	1607		51.28		
	1608				inject 1 gal in 15 secs
	1608.25	0			
	1609	.75	45.63	5.65	
	1610	1.75	45.55	5.73	
	1611	2.75	45.55	5.73	
	1612	3.75	45.55	5.73	
	1613	4.75	45.57	5.71	
	1614	5.75	45.55	5.73	
	1615	6.75	45.56	5.72	
	1616	7.75	45.55	5.73	
	1617	8.75	45.57	5.71	
	1618	9.75	45.57	5.71	
	1619	10.75	45.58	5.70	
	1621	12.75	45.58	5.70	
	1623	14.75	45.58	5.70	
	1625	16.75	45.58	5.70	
	1627	18.75	45.59	5.69	
	1629	20.75	45.61	5.67	
	1631	22.75	45.61	5.67	
	1633	24.75	45.62	5.66	
	1635	26.75	45.61	5.67	
	1637	28.75	45.62	5.66	
	1639	30.75	45.64	5.64	
	1644	35.75	45.65	5.63	
	1649	40.75	45.66	5.62	
	1659	50.75	45.67	5.61	
	1704	55.75	45.68	5.60	
	1709	60.75	45.69	5.59	

*Measuring point = 1.80 ft above ground surface

Appendix I-4. -- Slug test of CNS-3(P).

Date November 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
21	1156		26.35		
	1157				inject 1 gal in 20 secs
	1157.33	0			
	1158	.67	20.68	5.67	
	1159	1.67	20.69	5.66	
	1200	2.67	20.70	5.65	
	1201	3.67	20.71	5.64	
	1202	4.67	20.72	5.63	
	1203	5.67	20.73	5.62	
	1204	6.67	20.75	5.60	
	1205	7.67	20.77	5.58	
	1206	8.67	20.79	5.56	
	1207	9.67	20.81	5.54	
	1208	10.67	20.83	5.52	
	1210	12.67	20.85	5.50	
	1212	14.67	20.87	5.48	
	1214	16.67	20.88	5.47	
	1216	18.67	20.92	5.43	
	1218	20.67	20.96	5.39	
	1220	22.67	20.99	5.36	
	1222	24.67	21.00	5.35	
	1224	26.67	21.03	5.32	
	1226	28.67	21.08	5.27	
	1228	30.67	21.08	5.27	
	1233	35.67	21.14	5.21	
	1238	40.67	21.20	5.15	
	1243	45.67	21.26	5.09	
	1248	50.67	21.30	5.05	
	1253	55.67	21.35	5.00	
	1258	60.67	21.41	4.94	

* Measuring point = 5.35 ft above ground surface

Appendix I-4. -- Slug test of CNS-4(P).

Date November 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
19	1429		41.80		
	1430				inject 1 gal in 20 secs
	1430.33	0			
	1431	.67	36.60	5.20	
	1432	1.67	36.82	4.98	
	1433	2.67	37.10	4.70	
	1434	3.67	37.19	4.61	
	1435	4.67	37.35	4.45	
	1436	5.67	37.33	4.47	
	1437	6.67	37.52	4.28	
	1438	7.67	37.60	4.20	
	1439	8.67	37.62	4.18	
	1440	9.69	37.60	4.20	
	1441	10.67	37.62	4.18	
	1443	12.67	37.65	4.15	
	1445	14.67	37.71	4.09	
	1447	16.67	37.72	4.08	
	1449	18.67	37.72	4.08	
	1451	20.67	37.77	4.03	
	1453	22.67	37.80	4.00	
	1455	24.67	37.85	3.95	
	1457	26.67	37.87	3.93	
	1459	28.67	37.88	3.92	
	1501	30.67	37.90	3.90	
	1506	35.67	37.94	3.86	
	1511	40.67	38.01	3.79	
	1516	45.67	38.04	3.76	
	1521	50.67	38.12	3.68	
	1526	55.67	38.17	3.63	
	1531	60.67	38.18	3.62	

* Measuring point = 1.65 ft above ground surface

Appendix I-4. -- Slug test of CNS-5(P).

Date November 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
19	1615		32.42		
	1616				inject 1 gal in 20 secs
	1616.33	0			
	1617	.67	30.57	1.85	
	1618	1.67	31.11	1.31	
	1619	2.67	31.68	.74	
	1620	3.67	32.11	.31	
	1621	4.67	32.54	-.12	
	1622	5.67	32.75	-.33	
	1623	6.67	32.93	-.51	
	1624	7.67	33.11	-.69	
	1625	8.67	33.24	-.82	
	1626	9.67	33.38	-.96	
	1627	10.67	33.42	-1.00	
	1629	12.67	33.53	-1.11	
	1631	14.67	33.57	-1.15	
	1633	16.67	33.60	-1.18	
	1635	18.67	33.62	-1.20	
	1637	20.67	33.67	-1.25	
	1639	22.67	33.70	-1.28	
	1641	23.67	33.70	-1.28	
	1643	25.67	33.68	-1.26	
	1645	27.67	33.67	-1.25	
	1650	29.67	33.65	-1.23	
	1655	34.67	33.63	-1.21	
	1700	39.67	33.62	-1.20	
	1705	44.67	33.62	-1.20	
	1710	49.67	33.63	-1.21	
	1715	54.67	33.63	-1.21	

* Measuring point = 2.00 ft above ground surface

Appendix I-4. -- Slug test of CNS-5(P).

Date		Elapsed time (min)	Depth to water below measuring point (ft)*	s (ft)	Comments
December 1976	Hour (MST)	t_0			
20	1150		33.94		
	1152				inject 1 gal in 20 secs
	1152.33	0			
	1153	.67	29.55	4.39	
	1154	1.67	29.92	4.02	
	1155	2.67	30.37	3.57	
	1156	3.67	30.73	3.21	
	1157	4.67	31.10	2.84	
	1158	5.67	31.34	2.60	
	1159	6.67	31.68	2.26	
	1200	7.67	31.91	2.03	
	1201	8.67	32.23	1.71	
	1202	9.67	32.35	1.59	
	1204	11.67	32.78	1.16	
	1206	13.67	32.77	1.17	
	1208	15.67	33.12	0.82	
	1210	17.67	33.18	0.76	
	1212	19.67	33.26	0.68	
	1214	21.67	33.56	0.38	
	1216	23.67	33.41	0.53	
	1218	25.67	33.49	0.45	
	1222	29.67	33.46	0.48	
	1224	31.67	33.44	0.50	
	1229	36.67	33.47	0.47	
	1234	41.67	33.49	0.45	
	1239	46.67	33.50	0.44	
	1244	51.67	33.49	0.45	
	1249	56.67	33.49	0.45	
	1254	61.67	33.49	0.45	

* Measuring point = 2.00 ft above ground surface

Appendix I-4. -- Slug test of CNS-7(P).

Date November 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
17	1104		37.88		
	1105				inject 1 gal in 20 secs
	1105.33	0			
	1106	.67	32.92	4.96	
	1107	1.67	32.93	4.95	
	1108	2.67	32.94	4.94	
	1109	3.67	32.94	4.94	
	1110	4.67	32.93	4.95	
	1111	5.67	32.94	4.94	
	1112	6.67	32.94	4.94	
	1113	7.67	32.95	4.93	
	1114	8.67	32.96	4.92	
	1115	9.67	32.97	4.91	
	1116	10.67	32.98	4.90	
	1118	12.67	33.00	4.88	
	1120	14.67	33.02	4.86	
	1122	16.67	33.03	4.85	
	1124	18.67	33.05	4.83	
	1126	20.67	33.07	4.81	
	1128	22.67	33.09	4.79	
	1130	24.67	33.12	4.76	
	1132	26.67	33.14	4.74	
	1134	28.67	33.14	4.74	
	1139	33.67	33.19	4.69	
	1144	38.67	33.23	4.65	
	1149	43.67	33.25	4.63	
	1154	48.67	33.28	4.60	
	1159	53.67	33.30	4.58	
	1204	58.67	33.37	4.51	
	1209	63.67	33.38	4.50	

* Measuring point = 5.10 ft above ground surface

Appendix I-4. -- Slug test of CNS-10(P).

Date November 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
22	1124		30.21		
	1125				inject 1 gal in 20 secs
	1125.33	0			
	1126	.67	28.72	1.49	
	1127	1.67	29.22	.99	
	1128	2.67	29.52	.69	
	1129	3.67	29.61	.60	
	1130	4.67	29.71	.50	
	1131	5.67	29.72	.49	
	1132	6.67	29.67	.54	
	1133	7.67	29.70	.51	
	1134	8.67	29.72	.49	
	1135	9.67	29.72	.49	
	1136	10.67	29.74	.47	
	1137	11.67	29.74	.47	
	1139	13.67	29.73	.48	
	1141	15.67	29.73	.48	
	1143	17.67	29.74	.47	
	1145	19.67	29.74	.47	
	1147	21.67	29.73	.48	
	1149	23.67	29.74	.47	
	1151	25.67	29.73	.48	
	1153	27.67	29.73	.48	
	1155	29.67	29.72	.49	
	1200	34.67	29.70	.51	
	1205	39.67	29.70	.51	
	1210	44.67	29.68	.53	
	1215	49.67	29.69	.52	
	1220	54.67	29.69	.52	
	1225	59.67	29.73	.48	

* Measuring point = 4.02 ft above ground surface

Appendix I-4. -- Slug test of CNS-11(P).

Date November 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
16	1212		45.19		
	1218				inject 1 gal in 20 secs
	1218.33	0			
	1219	.67	44.14	1.05	
	1220	1.67	45.00	.19	
	1221	2.67	45.01	.18	
	1222	3.67	45.06	.13	
	1223	4.67	45.07	.12	
	1224	5.67	45.08	.11	
	1225	6.67	45.09	.10	
	1226	7.67	45.09	.10	
	1227	8.67	45.10	.09	
	1228	9.67	45.09	.10	
	1229	10.67	45.11	.08	
	1231	12.67	45.13	.06	
	1233	14.67	45.17	.02	
	1235	16.67	45.18	.01	
	1237	18.67	45.18	.01	
	1239	20.67	45.19	0	
	1241	22.67	45.21	-.2	
	1243	24.67	45.22	-.3	
	1245	26.67	45.21	-.2	
	1250	31.67	45.23	-.4	
	1255	36.67	45.22	-.3	
	1300	41.67	45.24	-.5	
	1305	46.67	45.22	-.3	
	1310	51.67	45.23	-.4	
	1315	56.67	45.22	-.3	
	1320	61.67	45.21	-.2	

* Measuring point = 5.66 ft above ground surface

Appendix I-4. -- Slug test of CNS-11(P).

Date		Elapsed	Depth to water		
December 1976	Hour (MST)	time (min) t_0	below measuring point (ft)*	s (ft)	Comments
20	1040		45.15		
	1041				inject 1 gal in 15 secs
	1041.25	0			
	1042	.75	44.87	.28	
	1043	1.75	45.06	.09	
	1044	2.75	45.05	.10	
	1045	3.75	45.04	.11	
	1046	4.75	45.03	.12	
	1047	5.75	45.07	.08	
	1048	6.75	45.11	.04	
	1049	7.75	45.15	0	
	1050	8.75	45.20	-.05	
	1051	9.75	45.21	-.06	
	1052	10.75	45.20	-.05	
	1054	12.75	45.21	-.06	
	1056	14.75	45.22	-.07	
	1058	16.75	45.23	-.08	
	1100	18.75	45.27	-.12	
	1102	20.75	45.28	-.13	
	1104	22.75	45.27	-.12	
	1106	24.75	45.29	-.14	
	1108	26.75	45.26	-.11	
	1110	28.75	45.21	-.06	
	1112	30.75	45.24	-.09	
	1117	35.75	45.24	-.09	
	1122	40.75	45.24	-.09	
	1127	45.75	45.22	-.07	
	1132	50.75	45.24	-.09	
	1137	55.75	45.24	-.09	
	1142	60.75	45.24	-.09	

*Measuring point = 5.66 ft above ground surface

Appendix I-4. -- CNS-12(P).

Date November 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
17	1245		48.16		
	1302				inject 1 gal in 20 secs
	1302.33	0			
	1303	.67	42.88	5.28	
	1304	1.67	43.51	4.65	
	1305	2.67	43.82	4.34	
	1306	3.67	44.28	3.88	
	1307	4.67	44.78	3.38	
	1308	5.67	45.14	3.02	
	1309	6.67	45.57	2.59	
	1310	7.67	45.87	2.29	
	1311	8.67	46.15	2.01	
	1312	9.67	46.34	1.82	
	1313	10.67	46.50	1.66	
	1315	12.67	46.89	1.27	
	1317	14.67	47.13	1.03	
	1319	16.67	47.34	.82	
	1321	18.67	47.48	.68	
	1323	20.67	47.64	.52	
	1325	22.67	47.71	.45	
	1327	24.67	47.78	.38	
	1329	26.67	47.82	.34	
	1331	28.67	47.88	.28	
	1336	33.67	47.99	.17	
	1341	38.67	48.04	.12	
	1346	43.67	48.09	.07	
	1351	48.67	48.14	.02	
	1356	53.67	48.16	0	
	1401	58.67	48.16	0	
	1406	63.67	48.16	0	

* Measuring point = 5.95 ft above ground surface

Appendix I-4. -- Slug test of CNS-13(P).

Date December 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
14	1551		34.65		
	1552				inject 1 gal in 15 secs
	1552.25	0			
	1553	.75	33.41	1.24	
	1554	1.75	33.49	1.16	
	1555	2.75	33.52	1.13	
	1556	3.75	33.49	1.16	
	1557	4.75	33.52	1.13	
	1558	5.75	33.51	1.14	
	1559	6.75	33.50	1.15	
	1600	7.75	33.49	1.16	
	1601	8.75	33.49	1.16	
	1602	9.75	33.50	1.15	
	1603	10.75	33.51	1.14	
	1605	12.75	33.51	1.14	
	1607	14.75	33.52	1.13	
	1609	16.75	33.50	1.15	
	1611	18.75	33.50	1.15	
	1613	20.75	33.50	1.15	
	1615	22.75	33.50	1.15	
	1617	24.75	33.53	1.12	
	1619	26.75	33.51	1.14	
	1621	28.75	33.51	1.14	
	1623	30.75	33.52	1.13	
	1628	35.75	33.53	1.12	
	1633	40.75	33.51	1.14	
	1638	45.75	33.52	1.12	
	1643	50.75	33.52	1.12	
	1648	55.75	33.52	1.12	
	1653	60.75	33.54	1.11	

*Measuring point = 4.70 above ground surface

Appendix I-4. -- Slug test of CNS-18(P).

Date November 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
21	1443		33.65		
	1444				inject 1 gal in 20 secs
	1444.33	0			
	1445	.67	28.29	5.36	
	1446	1.67	28.43	5.22	
	1447	2.67	28.57	5.08	
	1448	3.67	28.67	4.98	
	1449	4.67	28.78	4.87	
	1450	5.67	28.84	4.81	
	1451	6.67	28.94	4.71	
	1452	7.67	29.01	4.64	
	1453	8.67	29.06	4.59	
	1454	9.67	29.13	4.52	
	1455	10.67	29.21	4.44	
	1457	12.67	29.36	4.29	
	1459	14.67	29.47	4.18	
	1501	16.67	29.57	4.08	
	1503	18.67	29.61	4.04	
	1505	20.67	29.81	3.84	
	1507	22.67	29.88	3.77	
	1509	24.67	29.97	3.68	
	1511	26.67	30.05	3.60	
	1513	28.67	30.14	3.51	
	1515	30.67	30.21	3.44	
	1520	35.67	30.37	3.28	
	1525	40.67	30.54	3.11	
	1530	45.67	30.67	2.98	
	1535	50.67	30.80	2.85	
	1540	55.67	30.93	2.72	
	1545	60.67	31.02	2.63	

* Measuring point = 1.30 ft above ground surface

Appendix I-4. -- Slug test of CNS-19(P).

Date November 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
21	1320		41.93		
	1321				inject 1 gal in 20 secs
	1321.33	0			
	1322	.67	36.90	5.03	
	1323	1.67	37.25	4.68	
	1324	2.67	37.26	4.67	
	1325	3.67	37.28	4.65	
	1326	4.67	37.29	4.64	
	1327	5.67	37.38	4.55	
	1328	6.67	37.45	4.48	
	1329	7.67	37.47	4.46	
	1330	8.67	37.46	4.47	
	1331	9.67	37.42	4.51	
	1332	10.67	37.38	4.55	
	1334	12.67	37.36	4.57	
	1336	14.67	37.46	4.47	
	1338	16.67	37.51	4.42	
	1340	18.67	37.54	4.39	
	1342	20.67	37.57	4.36	
	1344	22.67	37.65	4.28	
	1346	24.67	37.68	4.25	
	1348	26.67	37.73	4.20	
	1350	28.67	37.78	4.15	
	1352	30.67	37.82	4.11	
	1357	35.67	37.93	4.00	
	1402	40.67	38.05	3.88	
	1407	45.67	38.13	3.80	
	1412	50.67	38.24	3.69	
	1417	55.67	38.34	3.59	
	1422	60.67	38.42	3.51	

* Measuring point = 2.80 ft above ground surface

Appendix I-4. -- Slug test of CNS-21(P).

Date November 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
22	0945		44.91		
	0946				inject 1 gal in 20 secs
	0946.33	0			
	0947	.67	39.81	5.10	
	0948	1.67	40.41	4.50	
	0949	2.67	41.07	3.84	
	0950	3.67	41.53	3.38	
	0951	4.67	42.08	2.83	
	0952	5.67	42.43	2.48	
	0953	6.67	42.72	2.19	
	0954	7.67	42.97	1.94	
	0955	8.67	43.14	1.77	
	0956	9.67	43.31	1.60	
	0957	10.67	43.45	1.46	
	0959	12.67	43.64	1.27	
	1001	14.67	43.75	1.16	
	1003	16.67	43.82	1.09	
	1005	18.67	43.90	1.01	
	1007	20.67	43.93	.98	
	1009	22.67	43.97	.94	
	1011	24.67	43.99	.92	
	1013	26.67	44.01	.90	
	1015	28.67	44.04	.87	
	1017	30.67	44.05	.86	
	1022	35.67	44.11	.80	
	1027	40.67	44.13	.78	
	1032	45.67	44.17	.74	
	1037	50.67	44.19	.72	
	1042	55.67	44.21	.70	
	1047	60.67	44.25	.66	

* Measuring point = 3.00 ft above ground surface

Appendix I-4. -- Slug test of CNS-22(P).

Date November 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
18	1330		44.92		
	1331				inject 1 gal in 20 secs
	1331.33	0			
	1332	.67	39.42	5.50	
	1333	1.67	40.90	4.02	
	1334	2.67	41.04	3.88	
	1335	3.67	41.09	3.83	
	1336	4.67	41.14	3.78	
	1337	5.67	41.16	3.76	
	1338	6.67	41.21	3.71	
	1339	7.67	41.23	3.69	
	1340	8.67	41.23	3.69	
	1341	9.67	41.24	3.68	
	1343	11.67	41.24	3.68	
	1345	13.67	41.25	3.67	
	1347	15.67	41.29	3.63	
	1349	17.67	41.31	3.61	
	1351	19.67	41.28	3.64	
	1353	21.67	41.30	3.62	
	1355	23.67	41.31	3.61	
	1357	25.67	41.31	3.61	
	1359	27.67	41.32	3.60	
	1401	29.67	41.34	3.58	
	1406	34.67	41.35	3.57	
	1411	39.67	41.36	3.56	
	1416	44.67	41.39	3.53	
	1421	49.67	41.39	3.53	
	1426	54.67	41.41	3.51	
	1431	59.67	41.40	3.52	

* Measuring point = 4.60 ft above ground surface

Appendix I-4. -- Slug test of CNS-23(P).

Date: November 1976	Date: Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
16	1520		69.23		
	1521				inject 1 gal in 10 secs
	1521.17	0			
	1522	.83	65.43	3.80	
	1523	1.83	65.62	3.61	
	1524	2.83	65.75	3.48	
	1525	3.83	65.78	3.45	
	1526	4.83	65.83	3.40	
	1527	5.83	65.85	3.38	
	1528	6.83	65.89	3.34	
	1529	7.83	65.89	3.34	
	1530	8.83	65.90	3.33	
	1531	9.83	65.90	3.33	
	1532	10.83	65.91	3.32	
	1534	12.83	65.91	3.32	
	1536	14.83	65.90	3.33	
	1538	16.83	65.91	3.32	
	1540	18.83	65.90	3.33	
	1542	20.83	65.90	3.33	
	1544	22.83	65.90	3.33	
	1546	24.83	65.90	3.33	
	1548	26.83	65.91	3.32	
	1550	28.83	65.91	3.32	
	1552	30.83	65.91	3.32	
	1557	35.83	65.91	3.32	
	1602	40.83	65.92	3.31	
	1607	45.83	65.92	3.31	
	1612	50.83	65.90	3.33	
	1617	55.83	65.92	3.31	
	1622	60.83	65.91	3.32	

*Measuring point = 3.50 ft above ground surface

Appendix I-4. -- Slug test of CNS-25(P).

Date December 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
16	1343		58.90		
	1344				inject 1 gal in 10 secs
	1344.17	0			
	1345	.83	53.49	5.41	
	1346	1.83	53.36	5.54	
	1347	2.83	53.31	5.59	
	1348	3.83	53.33	5.57	
	1349	4.83	53.34	5.56	
	1350	5.83	53.35	5.55	
	1351	6.83	53.32	5.58	
	1352	7.83	53.37	5.53	
	1353	8.83	53.36	5.54	
	1354	9.83	53.32	5.58	
	1355	10.83	53.39	5.51	
	1357	12.83	53.39	5.51	
	1359	14.83	53.43	5.47	
	1401	16.83	53.41	5.49	
	1403	18.83	53.43	5.47	
	1405	20.83	53.47	5.43	
	1407	22.83	53.70	5.20	
	1409	24.83	53.47	5.43	
	1411	26.83	53.49	5.41	
	1413	28.83	53.46	5.44	
	1415	30.83	53.50	5.40	
	1420	35.83	53.52	5.38	
	1425	40.83	53.48	5.42	
	1430	45.83	53.47	5.43	
	1435	50.83	53.60	5.30	
	1440	55.83	53.55	5.35	
	1445	60.83	53.56	5.34	

*Measuring point = 6.35 ft above ground surface

Appendix I-4. -- Slug test of CNS-26(P).

Date		Elapsed	Depth to water		
December 1976	Hour (MST)	time (min) t_0	below measuring point (ft)*	s (ft)	Comments
15	1610		52.26		
	1611				inject 1 gal in 15 secs
	1611.25	0			
	1612	.75	46.95	5.31	
	1613	1.75	46.87	5.39	
	1614	2.75	46.86	5.40	
	1615	3.75	46.86	5.40	
	1616	4.75	46.84	5.42	
	1617	5.75	46.79	5.47	
	1618	6.75	46.81	5.45	
	1619	7.75	46.78	5.48	
	1620	8.75	46.79	5.47	
	1621	9.75	46.78	5.48	
	1622	10.75	46.76	5.50	
	1624	12.75	46.78	5.48	
	1626	14.75	46.76	5.50	
	1628	16.75	46.75	5.51	
	1630	18.75	46.76	5.50	
	1632	20.75	46.81	5.45	
	1634	22.75	46.76	5.50	
	1636	24.75	46.76	5.50	
	1638	26.75	46.79	5.47	
	1640	28.75	46.75	5.51	
	1642	30.75	46.77	5.49	
	1647	35.75	46.81	5.45	
	1652	40.75	46.77	5.49	
	1657	45.75	46.76	5.50	
	1702	50.75	46.81	5.45	
	1707	55.75	46.77	5.49	
	1712	60.75	46.75	5.51	

*Measuring point = 5.97 ft above ground surface

Appendix I-4. -- Slug test of CNS-29(P).

Date December 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
10	1520		39.56		
	1521				inject 1 gal in 20 secs
	1521.33	0			
	1522	.67	33.50	6.06	
	1523	1.67	34.93	4.63	
	1524	2.67	36.29	3.27	
	1525	3.67	37.30	2.26	
	1526	4.67	37.80	1.76	
	1527	5.67	38.31	1.25	
	1528	6.67	39.56	0	
	1529	7.67	39.62	-0.06	
	1530	8.67	39.62	-0.06	
	1531	9.67	39.62	-0.06	
	1532	10.67	39.62	-0.06	
	1534	12.67	39.56	0	
	1536	14.67	39.56	0	
	1538	16.67	39.59	-0.03	
	1540	18.67	39.59	-0.03	
	1542	20.67	39.56	0	
	1544	22.67	39.56	0	
	1546	24.67	39.59	-0.03	
	1548	26.67	39.56	0	
	1550	28.67	39.58	-0.02	
	1552	30.67	39.56	0	
	1557	35.67	39.59	-0.03	
	1602	40.67	39.59	-0.03	
	1607	45.67	39.56	0	
	1612	50.67	39.59	-0.03	
	1617	55.67	39.59	-0.03	
	1622	60.67	39.59	-0.03	

* Measuring point = 1.80 ft above ground surface

Appendix I-4. -- Slug test of CNS-30(P).

Date December 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
9	1536		43.49		
	1537				inject 1 gal in 20 secs
	1537.33	0			
	1538	.67	37.66	5.83	
	1539	1.67	37.67	5.82	
	1540	2.67	37.65	5.84	
	1541	3.67	37.67	5.82	
	1542	4.67	37.65	5.84	
	1543	5.67	37.67	5.82	
	1544	6.67	37.63	5.86	
	1545	7.67	37.61	5.88	
	1546	8.67	37.62	5.87	
	1547	9.67	37.65	5.84	
	1548	10.67	37.67	5.82	
	1550	12.67	37.65	5.84	
	1552	14.67	37.65	5.84	
	1554	16.67	37.65	5.84	
	1556	18.67	37.67	5.82	
	1558	20.67	37.67	5.82	
	1600	22.67	37.65	5.84	
	1602	24.67	37.63	5.86	
	1604	26.67	37.64	5.85	
	1606	28.67	37.64	5.85	
	1608	30.67	37.63	5.86	
	1613	35.67	37.63	5.86	
	1618	40.67	37.65	5.84	
	1623	45.67	37.65	5.84	
	1628	50.67	37.63	5.86	
	1633	55.67	37.65	5.84	
	1638	60.67	37.65	5.84	

* Measuring point = 2.95 ft above ground surface

Appendix I-4. -- Slug test of CNS-31(P).

Date: December 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
8	1505		28.40		
	1506				inject 1 gal in 20 secs
	1506.33	0			
	1507	.67	28.40	0	
	1508	1.67	28.44	-.04	
	1509	2.67	28.45	-.05	
	1510	3.67	28.45	-.05	
	1511	4.67			inject 1 gal in 20 secs
	1512	5.67	28.44	-.04	
	1513	6.67	28.46	-.06	
	1514	7.67	28.46	-.06	
	1515	8.67	28.45	-.05	
	1516	9.67	28.45	-.05	
	1517	10.67	28.46	-.06	
	1518	11.67	28.45	-.05	
	1519	12.67	28.46	-.06	
	1520	13.67	28.45	-.05	
	1521	14.67	28.47	-.07	
	1522	15.67	28.45	-.05	
	1524	17.67	28.45	-.05	
	1526	19.67	28.45	-.05	
	1528	21.67	28.46	-.06	
	1530	23.67	28.45	-.05	
	1532	25.67	28.45	-.05	
	1534	27.67	28.46	-.06	
	1536	29.67	28.45	-.05	
	1538	31.67	28.44	-.04	
	1540	33.67	28.45	-.05	
	1542	35.67	28.46	-.06	
	1547	40.67	28.45	-.05	
	1552	45.67	28.47	-.07	
	1557	50.67	28.46	-.06	
	1602	55.67	28.46	-.06	
	1607	60.67	28.47	-.07	
	1612	65.67	28.47	-.07	

*Measuring point = 2.83 ft above ground surface

Appendix I-4. -- Slug test of CNS-31(P).

Date December 1976	Hour (MST)	Elapsed time (sec) t	Depth to water below measuring point (ft)*	s (ft)	Comments
29	1214		28.32		
	1231		29.26		
	1232		29.18		
	1232.5		29.18		
	1234		29.16		
	1234.5		29.17		
	1241	0	29.17	0	
		20	28.44	.73	inject 1 gal
		35	29.12	.05	
		45	29.18	-.01	
		100	29.17	0	
	1315	0	29.17	0	
		20			inject 1 gal
		25	28.68	.49	
		33	29.05	.12	
		40	29.14	.03	
		50	29.15	.02	
		60	29.06	.11	
		65	29.16	.01	
		75	29.17	0	
		85	29.17	0	
	1320	0	29.17	0	
		13			inject 1 gal
		25	28.91	.26	
		35	29.18	-.01	
		43	29.15	.02	
		50	29.14	.03	
		60	29.17	0	
		70	29.17	0	
	1328	0	29.18	.01	
		13			inject 1 gal
		25	29.04	.13	
		34	29.13	.04	
		43	29.14	.03	
		51	29.16	.01	
		60	29.16	.01	
		67	29.17	0	
		75	29.17	0	
		85	29.18	.01	

Appendix I-4. -- Slug test of CNS-31(P). (cont)

Date December 1976	Hour (MST)	Elapsed time (sec) t	Depth to water below measuring point (ft)*	s (ft)	Comments
29	1330	0	29.18	.01	
		20			inject 1 gal
		25	28.45	.72	
		32	28.95	.22	
		37	29.18?	-.01	
		45	29.16	.01	
		53	29.15	.02	
		60	29.16	.01	
		65	29.17	0	
		75	29.17	0	
		80	29.17	0	
		88	29.17	0	
		95	29.17	0	
		105	29.18	-.01	

*Measuring point = 2.83 ft above ground surface

Appendix I-4. -- Slug test of CNS-32(P).

Date December 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
8	1350		31.83		
	1351				inject 1 gal in 20 secs
	1351.33	0			
	1352	.67	29.50	2.33	
	1353	1.67	30.27	1.55	
	1354	2.67	30.60	1.23	
	1355	3.67	30.89	0.94	
	1356	4.67	31.04	0.79	
	1357	5.67	31.18	0.65	
	1358	6.67	31.25	0.58	
	1359	7.67	31.30	0.53	
	1400	8.67	31.33	0.50	
	1401	9.67	31.36	0.47	
	1402	10.67	31.37	0.46	
	1404	12.67	31.41	0.42	
	1406	14.67	31.43	0.40	
	1408	16.67	31.46	0.37	
	1410	18.67	31.46	0.37	
	1412	20.67	31.50	0.33	
	1414	22.67	31.50	0.33	
	1416	24.67	31.52	0.31	
	1418	26.67	31.53	0.30	
	1420	28.67	31.53	0.30	
	1422	30.67	31.54	0.29	
	1427	35.67	31.55	0.28	
	1432	40.67	31.54	0.29	
	1437	45.67	31.55	0.28	
	1442	50.67	31.55	0.28	
	1447	55.67	31.56	0.27	
	1452	60.67	31.56	0.27	

* Measuring point = 2.95 ft above ground surface

Appendix I-4. -- Slug test of CNS-34(P).

Date December 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
14	1440		41.92		
	1441				inject 1 gal in 20 secs
	1441.33	0			
	1442	.67	37.39	4.53	
	1443	1.67	38.70	3.22	
	1444	2.67	39.00	2.92	
	1445	3.67	29.38	2.54	
	1446	4.67	39.87	2.05	
	1447	5.67	40.35	1.57	
	1448	6.67	40.57	1.35	
	1449	7.67	40.81	1.11	
	1450	8.67	41.04	0.88	
	1451	9.67	41.15	0.77	
	1452	10.67	41.28	0.64	
	1454	12.67	41.52	0.40	
	1456	14.67	41.63	0.29	
	1458	16.67	41.71	0.21	
	1500	18.67	41.79	0.13	
	1502	20.67	41.87	0.05	
	1504	22.67	41.91	0.01	
	1506	24.67	41.95	-0.03	
	1508	26.67	41.98	-0.06	
	1510	28.67	42.01	-0.09	
	1512	30.67	42.04	-0.12	
	1517	35.67	42.07	-0.15	
	1522	40.67	42.09	-0.17	
	1527	45.67	42.10	-0.18	
	1532	50.67	42.11	-0.19	
	1537	55.67	42.12	-0.20	
	1542	60.67	42.12	-0.20	

* Measuring point = 3.70 ft above ground surface

Appendix I-4A. -- Slug test of CNC-6-1 -- open hole.

Date December 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
6	1547	0	77.30		inject 30 gal in 30 secs
	1547:30	.5	29.82		
	1549:25	2.42	31.70		
	1551:30	4.50	32.10		
	1552:25	5.42	34.35		
	1554:08	7.13	36.02		
	1555:30	8.50	38.55		
	1557:27	10.45	42.11		
	1559:13	12.22	45.15		
	1600:37	13.62	47.90		
	1603:57	16.95	53.70		
	1605:21	18.35	53.70		
	1607:47	20.78	53.70		
	1609:38	22.63	53.70		
	1611:07	24.12	53.68		
	1616:00	29.00	53.70		
	1621:00	34.00	53.66		
	1626:00	39.00	53.65		
	1631:00	44.00	53.65		
	1636:00	49.00	53.65		
	1641:00	54.00	53.60		
	1646:00	59.00	53.56		

*Measuring point = 4.5' above ground surface

Appendix I-4A. -- Slug test of CNC-8-1 -- open hole.

Date: December 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
1	1030		27.30		
	1030:50	0	22.05	5.25	inject 10 gal in 50 secs
	1031	.17	22.02	5.28	
	1032	1.17	22.03	5.27	
	1033	2.17	22.03	5.27	
	1034	3.17	22.02	5.28	
	1035	4.17	22.02	5.28	
	1036	5.17	22.02	5.28	
	1037	6.17	22.02	5.28	
	1038	7.17	22.02	5.28	
	1039	8.17	22.03	5.27	
	1040	9.17	22.03	5.27	
	1045	10.17	22.04	5.26	
	1050	19.17	22.06	5.24	
	1055	24.17	22.07	5.23	
	1100	29.17	22.08	5.22	
	1105	34.17	22.10	5.20	
	1110	39.17	22.11	5.19	
	1115	44.17	22.12	5.18	
	1120	49.17	22.14	5.16	
	1125	54.17	22.15	5.15	
	1130	59.17	22.16	5.14	

*Measuring point = 5.3' above ground surface

Appendix I-4A. -- Slug test of CNC-8-2 -- open hole.

Date December 1976	Hour (MST)	Elapsed time (min) t_0	Depth to water below measuring point (ft)*	s (ft)	Comments
2	1225:00	0	48.39		inject 5 gal in 30 secs
	1225:30	.5	44.83		
	1226:00	1.0	44.74		
	1227:00	2.0	44.72		
	1229:00	4.0	44.72		
	1230:00	5	44.70		
	1231:00	6	44.70		
	1232:00	7	44.70		
	1233:00	8	44.70		
	1234:00	9	44.70		
	1235:00	10	44.70		
	1240:00	15	44.68		
	1245:00	20	44.69		
	1250:00	25	44.68		
	1255:00	30	44.68		
	1300:00	35	44.68		
	1305:00	40	44.67		
	1310:00	45	44.68		
	1315:00	50	44.68		
	1320:00	55	44.68		
	1325:00	60	44.68		

*Measuring point = 5.3' above ground surface

Appendix I-5.--Pressure-Injection Test Data

Appendix I-5. -- Pressure-injection test data.

Hole No. CNA-1 Test No. 1 Total depth 29:5 feet, uncased interval 19.2' to 144.3' below MP

Air Released: yes X No ____ Measuring point: top of casing 1.8' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
12	9	0921:00	0	0	0	0		
		0922:00	1	1.0	2.31	6.40		
		0923:00	2	1.0	2.31	14.00		
		0924:00	3	1.0	2.31	21.80		
		0925:00	4	1.0	2.31	31.10		
		0926:00	5	1.0	2.31	40.10		
		0927:00	6	1.0	2.31	49.00		
		0928:00	7	40.0	92.40	50.30		full
		0929:00	8	10.0	23.10			
		0930:00	9	7.0	16.17			
		0931:00	10	5.2	12.01			
		0932.00	11	4.0	9.24			
		0933:00	12	3.0	6.93			
		0934:00	13	2.0	4.62			
		0935:00	14	1.0	2.31			

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNA-1 Test No. 2 Total depth 50.0 feet, uncased interval 19.2' to 144.3' below MP

Air Released: yes X No ____ Measuring point: top of casing 1.8' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
12	9	1058:00	0	0	0	0		
		1059:00	1	3.0	6.93	18.10		
		1100:00	2	3.0	6.93	37.4		
		1101:00	3	3.0	6.93	56.6		
		1102:00	4	3.0	6.93	75.7		
		1102:20	4.3	47.0	108.57	79.7		
		1102:37	4.6	0	0	0		

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNA-1 Test No. 3 Total depth 7.05 feet, uncased interval 19.2' to 144.3' below MP

Air Released: yes X No ____ Measuring point: top of casing 1.8' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
12	9	1403:00	0	0	0	0		
		1404:00	1	3.0	6.93	18.2		
		1405:00	2	3.0	6.93	36.4		
		1406:00	3	3.0	6.93	55.9		
		1407:00	4	3.0	6.93	74.6		
		1408:00	5	3.0	6.93	92.9		
		1409:00	6	40.0	92.4	109.7		full
		1409:09	6.15	0	0	0		
		1413:00	10				0.87	
		1414:00	11				1.10	
		1415:00	12				1.40	
		1416:00	13				1.71	
		1417:00	14				2.00	
		1418:00	15				2.36	
		1419:00	16				2.70	

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNA-1 Test No. 4 Total depth 91.0 feet, uncased interval 19.2' to 144.3' below MP

Air Released: yes X No ____ Measuring point: top of casing 1.8' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
12	10	0829:00	0	0	0	0		
		0830:00	1	3.0	6.93	17.0		
		0831:00	2	3.0	6.93	35.7		
		0832:00	3	3.0	6.93	54.1		
		0833:00	4	3.0	6.93	72.6		
		0834:00	5	3.0	6.93	91.2		
		0835:00	6	3.0	6.93	110.3		
		0836:00	7	3.0	6.93	128.3		full
		0837:00	8	39.0	90.09	144.3		
		0838:00	9	33.0	76.23	159.7		
		0839:00	10	32.0	73.92	176.3		
		0840:00	11	30.0	69.3	194.3		
		0841:00	12	28.5	65.84	211.5		
		0842:00	13	25.0	57.75	229.6		
		0843:00	14	24.3	56.13	247.9		
		0844:00	15	22.0	50.82	266.3		
		0845:00	16	21.2	48.97	284.5		
		0846:00	17	20.4	47.12	302.8		
		0847:00	18	19.8	45.74	320.9		
		0848:00	19	19.2	44.35	339.1		
		0849:00	20	18.7	43.20	357.1		
		0850:00	21	18.5	42.74	375.1		
		0851:00	22	18.0	41.58	393.3		
		0852:00	23	18.0	41.58	411.0		
		0853:00	24	17.9	41.35	429.1		
		0854:00	25	17.9	41.35	447.0		
		0857:20	28.3				4.15	
		0859:20	30.3				7.45	
		0901:00	32				9.9	
		0902:00	33				11.1	
		0903:00	34				12.05	
		0904:00	35				12.85	
		0905:00	36				13.55	

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNA-1 Test No. 5 Total depth 111.5 feet, uncased interval 19.2' to 144.3' below MP

Air Released: yes X No ___ Measuring point: top of casing 1.8' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
12	10	1145:00	0	0	0	0		
		1146:00	1	3.0	6.93	19.5		
		1147:00	2	3.0	6.93	39.7		
		1148:00	3	3.0	6.93	59.8		
		1149:00	4	3.0	6.93	79.7		
		1150:00	5	3.0	6.93	99.6		
		1151:00	6	3.0	6.93	119.5		
		1152:00	7	3.0	6.93	139.4		
		1153:00	8	3.0	6.93	159.2		
		1153:28	8.5			168.4		full
		1154:00	9	35.8	82.7	176.5		
		1155:00	10	28.8	66.53	194.7		
		1156:00	11	26.0	60.06	214.5		
		1157:00	12	25.0	57.75	234.1		
		1158:00	13	25.0	57.75	253.5		
		1159:00	14	24.9	57.52	272.8		
		1159:36	15.6			284.5		
		1202:00	18				2.15	
		1203:00	19				3.8	
		1204:00	20				5.4	
		1205:00	21				6.8	
		1206:00	22				8	
		1207:00	23				9	
		1208:00	24				10.15	
		1209:00	25				11.2	

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNA-1 Test No. 6 Total depth 132.0 feet, uncased interval 19.2' to 144.3' below MP

Air Released: yes X No ____ Measuring point: top of casing 1.8' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
12	10	1517:00	0	0	0	0		
		1518:00	1	3.0	6.93	19.20		
		1519:00	2	3.0	6.93	39.1		
		1520:00	3	3.0	6.93	58.8		
		1521:00	4	3.0	6.93	78.4		
		1522:00	5	3.0	6.93	98.1		
		1523:00	6	3.0	6.93	117.7		
		1524:00	7	3.0	6.93	137.4		
		1525:00	8	3.0	6.93	157.2		
		1526:00	9	3.0	6.93	176.4		
		1527:00	10	3.0	6.93	196.0		full
		1527:28	10.5	35.0	80.85	203.6		
		1528:00	11	32.3	74.61	212.2		
		1529:00	12	29.0	66.99	230.1		
		1530:00	13	27.0	62.37	249.4		
		1431:00	14	26.5	61.22	268.5		

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNA-1 Test No. 7 Total depth 142.5 feet, uncased interval 19.2' to 144.3' below MP

Air Released: yes X No ____ Measuring point: top of casing 1.8' above land surface

Date				Applied Pressure				
Mo	Day	Hour	Elapsed time (min)	(psi)	(Feet of water)*	Input Volume (gal)	Depth to Water (ft)**	Comments
12	14	1116:00	0	0	0	0		
		1117:00	1	3.0	6.93	18.8		
		1118:00	2	3.0	6.93	38.3		
		1119:00	3	3.0	6.93	57.8		
		1120:00	4	3.0	6.93	77.2		
		1121:00	5	3.0	6.93	96.8		
		1122:00	6	3.0	6.93	116.1		
		1122:44	6.7			130.2		full
		1123:00	7	29.0	66.99	134.3		
		1124:00	8	35.0	80.85	150.8		
		1125:00	9	35.3	81.54	167.3		
		1126:00	10	34.9	80.62	183.9		
		1127:00	11	33.9	78.31	200.8		
		1128:00	12	32.8	75.77	217.9		
		1129:00	13	31.9	73.69	235.3		
		1130:00	14	31.5	72.76	252.6		
		1131:00	15	31.1	71.84	270.6		
		1132:00	16	30.9	71.38	287.5		
		1133:00	17	30.6	70.69	305.0		
		1134:00	18	30.3	69.99	322.5		
		1135:00	19	30.1	69.54	340.0		
		1136:00	20	30.0	69.3	357.5		
		1137:00	21	30.0	69.3	374.9		
		1138:00	22	29.9	69.07	392.4		
		1139:00	23	29.9	69.07	409.8		
		1140:00	24	29.8	68.84	427.1		
		1141:00	25	29.8	68.84	444.4		
		1142:00	26	29.6	68.38	461.8		
		1142:30	26.5	6.0	13.86			
		1143:00	27	3.2	73.92			
		1143:30	27.5	1.5	3.46			

Hole No. CNA-1 Test No. 7 Total depth 142.5 feet, uncased interval 19.2' to 144.3' below MP

Air Released: yes X No ____ Measuring point: top of casing 1.8' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
12	14	1145:00	29				0.85	
		1146:00	30				2.02	
		1147:00	31				3.22	
		1148:00	32				4.44	
		1149:00	33				5.65	
		1150:00	34				6.75	
		1151:00	35				8.00	

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNA-2 Test No. 1 Total Depth 28.8 feet, uncased, interval 19.0' to 153.8' below MP

Air Released: yes X no ____ Measuring point: top of casing 2.0' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft) **	Comments
12	15	0933:00	0	0	0	0		
		0934:00	1	2.0	4.62	33.6		
		0935:00	2	2.0	4.62	40.5		
		0936:00	3	2.0	4.62	47.5		
		0937:00	4	2.0	4.62	54.3		
		0938:00	5	2.0	4.62	61.2		
		0939:00	6	2.0	4.62	68.1		full
		0940:00	7	43.0	99.33	74.1		
		0940:20	7.3	21.0	48.51			
		0940:40	7.7	14.5	33.50			
		0941:00	8	11.4	26.33			
		0941:20	8.3	9.0	20.79			
		0941:40	8.7	8.0	18.48			
		0942:00	9	7.0	16.17			
		0942:20	9.3	6.2	14.32			
		0942:40	9.7	5.5	12.71			
		0943:00	10	5.0	11.55			
		0943:20	10.3	4.8	11.09			
		0943:40	10.7	4.4	10.16			
		0944:00	11	4.2	9.70			
		0944:20	11.3	4.0	9.24			
		0944:40	11.7	3.8	8.78			
		0945:00	12	3.4	7.85			

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNA-2 Test No.2 Total Depth 49.3 feet, uncased interval 19.0' to 153.8' below MP

Air Released: yes X no ____ Measuring point: top of casing 2.0' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	Comments
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft) **	
12	15	1131:00	0	0	0	0	0	
		1132:00	1	2.0	4.62	17.6		
		1133:00	2	2.0	4.62	36.5		
		1134:00	3	2.0	4.62	55.3		
		1135:00	4	2.0	4.62	74.2		
		1135:10	4.2	48.0	110.88	77.3		stop
		1135:30	4.5	5.0	11.55			
		1135:40	4.7	0	0			
		1138:00	7				.14	
		1139:00	8				.24	
		1140:00	9				.39	
		1141:00	10				.53	
		1142:00	11				.69	
		1143:00	12				.87	
		1144:00	13					missed
		1145:00	14				1.30	
		1146:00	15				1.50	
		1147:00	16				1.80	
		1148:00	17				2.15	
		1149:00	18				2.65	
		1150:00	19				3.20	
		1151:00	20				3.85	
		1152:00	21				4.45	
		1153:00	22				5.30	
		1154:00	23				6.20	
		1155:00	24				7.04	
		1156:00	25				8.05	

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNA-2 Test No. 3 Total Depth 69.8 feet, uncased interval 19.0' to 153.8' below MP

Air Released: yes X no ____ Measuring point: top of casing2.0' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	Comments
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft) **	
12	15	1412:00	0	0	0	0		
		1413:00	1	3.0	6.93	17.9		
		1414:00	2	3.0	6.93	37.4		
		1415:00	3	3.0	6.93	56.7		
		1416:00	4	3.0	6.93	76.1		
		1417:00	5	3.0	6.93	95.6		
		1418:00	6	3.0	6.93	114.3		
		1418:32	6.5	40.0	92.40	124.3		
		1419:00	7	27.0	62.37	129.4		
		1420:00	8	24.5	56.60	148.1		
		1421:00	9	24.5	56.60	166.4		
		1422:00	10	24.8	57.29	184.5		
		1423:00	11	24.7	57.06	202.6		
		1424:00	12	24.9	57.52	220.2		
		1425:00	13	25.0	57.75	237.7		
		1426:00	14	24.0	55.44	254.6		
		1427:00	15	23.5	54.29	270.3		
		1428:00	16	22.4	51.74	285.8		
		1429:00	17	22.0	50.82	301.0		
		1430:00	18	21.5	49.67	316.1		
		1431:00	19	21.0	48.51	330.9		
		1432:00	20	20.5	47.36	345.2		
		1433:00	21	20.0	46.20	359.1		
		1434:00	22	19.8	45.74	373.1		
		1435:00	23	18.9	43.66	385.7		
		1436:00	24	18.5	42.74	398.4		
		1437:00	25	18.5	42.74	410.9		
		1438:00	26	18.3	42.27	423.2		

Hole No. CNA-2 Test No. 3 Total Depth 69.8 feet, uncased interval 19.0' to 153.8' below MP

Air Released: yes __X__ no _____ Measuring point: top of casing 2.0' above land surface

Date: Mo	Date: Day	Date: Hour	Elapsed time (min)	Applied Pressure (psi)	Applied Pressure (Feet of water)*	Input Volume (gal)	Depth to Water (ft) **	Comments
12	15	1438:00	26	18.3	42.27	423.2		
		1439:00	27	18.9	43.66	435.6		
		1440:00	28	18.5	42.74	448.2		
		1441:00	29	18.2	42.04	460.6		
		1442:00	30	18.0	41.58	472.9		
		1443:00	31	18.2	42.04	485.1		
		1444:00	32	18.2	42.04	497.6		
		1445:00	33	18.2	42.04	510.0		
		1446:00	34	18.1	41.81	522.5		
		1447:00	35	18.1	41.81	535.0		
		1448:00	36	18.1	41.81	547.5		
		1449:00	37	18.0	41.58	560.0		
		1450:00	38	16.0	36.96	572.5		
		1451:00	39	16.0	36.96	583.1		
		1452:00	40	15.9	36.73	594.7		
		1452:10	40.2	0	0			
		1454:00	42				4.00	
		1454:30	42.5				5.31	
		1455:00	43				6.60	
		1455:30	43.5				7.71	

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNA-2 Test No. 4 Total Depth 90.3 feet, uncased interval 19.0' to 153.8' below MP

Air Released: yes X no ____ Measuring point: top of casing 2.0' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft) **	Comments
12	16	0849:00	0	0	0	0		
		0850:00	1	3.0	6.93	17.5		
		0851:00	2	3.0	6.93	36.7		
		0852:00	3	3.0	6.93	55.6		
		0853:00	4	3.0	6.93	74.6		
		0854:00	5	3.0	6.93	94.3		
		0855:00	6	3.0	6.93	112.6		
		0856:00	7	3.0	6.93	131.4		
		0857:48	7.8	25.0	57.75	149.5		full
		0858:00	9	31.5	72.77	167.0		
		0859:00	10	30.2	69.76	183.9		
		0900:00	11	30.2	69.76	200.8		
		0901:00	12	30.1	69.53	217.6		
		0902:00	13	30.2	69.76	234.4		
		0903:00	14	30.2	69.76	250.7		
		0904:00	15	30.1	69.53	266.8		
		0905:00	16	29.9	69.07	282.4		
		0906:00	17	29.9	69.07	297.7		
		0907:00	18	29.8	68.84	312.9		
		0908:00	19	29.2	67.45	328.1		
		0909:00	20	29.0	66.99	343.0		
		0910:00	21	28.8	66.53	357.7		
		0911:00	22	28.8	66.53	372.3		
		0912:00	23	28.8	66.53	387.3		stop
		0912:30	23.5	5.0	11.55			
		0913:00	24	0	0			
		0915:00	26				3.18	
		0915:30	26.5				4.21	

Appendix I-5. -- Pressure-injection test data. (cont)

Hole No. CNA-2 Test No. 4 Total Depth 90.3 feet, uncased interval 19.0' to 153.8' below MP

Air Released: yes X no ____ Measuring point: top of casing 2.0' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	Comments
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft) **	
12	16	0916:00	27				5.21	
		0916:30	27.5				6.20	
		0917:00	28				7.20	
		0917:30	28.5				8.10	

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNA-2 Test No. 5 Total depth 110.8 feet, uncased interval 19.0' to 153.8' below MP

Air Released: yes X no ____ Measuring point: top of casing 2.0' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	Comments
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft) **	
12	16	1138:00	0	0	0	.0		
		1139:00	1	3.0	6.93	17.6		
		1140:00	2	3.0	6.93	36.5		
		1141:00	3	3.0	6.93	55.3		
		1142:00	4	3.0	6.93	74.2		
		1143:00	5	3.0	6.93	92.9		
		1144:00	6	3.0	6.93	112.3		
		1145:00	7	3.0	6.93	129.2		
		1146:00	8	3.0	6.93	147.1		
		1147:00	9	3.0	6.93	165.1		
		1147:18	9.3			170.5		full
		1148:00	10	30.1	69.53	181.6		
		1149:00	11	29.8	68.84	198.0		
		1150:00	12	29.0	66.99	214.1		
		1151:00	13	28.3	65.37	230.1		
		1152:00	14	28.0	64.68	245.8		
		1153:00	15	27.9	64.45	261.2		
		1154:00	16	27.8	64.22	276.4		
		1155:00	17	27.8	64.22	291.5		
		1156:00	18	27.3	63.06	306.8		
		1157:00	19	27.0	62.37	321.9		
		1158:00	20	26.6	61.45	336.6		
		1159:00	21	25.5	58.91	351.2		
		1200:00	22	25.7	59.37	365.6		
		1201:00	23	25.2	58.21	379.2		
		1202:00	24	24.9	57.52	392.7		
		1203:00	25	24.7	57.06	405.9		
		1204:00	26	24.3	56.13	418.9		
		1205:00	27	24.2	55.90	431.9		
		1206:00	28	24.2	55.90	444.7		
		1207:00	29	24.2	55.90	457.5		
		1208:00	30	24.3	56.13	470.2		
		1209:00	31	24.8	57.29	482.9		

Hole No. CNA-2 Test No. 5 Total depth 110.8 feet, uncased interval 19.0' to 153.8' below MP

Air Released: yes x no ____ Measuring point: top of casing 2.0' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft) **	Comments
12	16	1210:00	32	24.5	56.60	495.8		
		1211:00	33	24.5	56.60	508.6		
		1212:00	34	24.3	56.13	521.3		
		1213:00	35	24.5	56.60	534.0		
		1214:00	36	24.0	55.44	546.6		
		1215:00	37	23.9	55.21	559.0		
		1216:00	38	24.0	55.44	571.4		
		1217:00	39	24.0	55.44	583.9		
		1218:00	40	24.0	55.44	597.3		
		1218:20	40.3	14.0	32.34			
		1218:40	40.7	10.5	24.26			
		1219:00	41	8.1	18.71			
		1219:20	41.3	6.0	13.86			
		1219:40	41.7	4.1	9.47			
		1220:00	42	2.6	6.01			
		1220:20	42.3	0.5	1.16			
		1221:30	43.7				1.25	
		1222:00	44				1.93	
		1222:30	44.5				2.66	
		1223:00	45				3.45	
		1223:30	45.5				4.17	
		1224:00	46				4.90	
		1224:30	46.5				5.67	
		1225:00	47				6.40	
		1225:30	47.5				7.10	
		1226:00	48				7.78	

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNA-2   Test No. 6   Total depth 131.3 feet, uncased interval 19.0' to 153.8' below MP

Air Released: yes X no ___   Measuring point: top of casing 2.0' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft) **	Comments
12	16	1526:00	0	0	0	.0		
		1527:00	1	3.0	6.93	12.6		
		1528:00	2	3.0	6.93	30.3		
		1529:00	3	3.0	6.93	48.2		
		1530:00	4	3.0	6.93	66.1		
		1531:00	5	3.0	6.93	83.7		
		1532:00	6	3.0	6.93	101.5		
		1533:00	7	3.0	6.93	119.0		
		1534:00	8	3.0	6.93	136.3		
		1535:00	9	3.0	6.93	154.4		
		1536:00	10	3.0	6.93	171.1		
		1537:00	11	3.0	6.93	188.4		
		1537:30	11.5			197.0		full
		1538:00	12	26.0	60.06	204.8		
		1539:00	13	26.3	60.75	221.9		
		1540:00	14	25.4	58.67	239.2		
		1541:00	15	25.4	58.67	256.2		
		1542:00	16	25.2	58.21	273.1		
		1543:00	17	25.0	57.75	289.9		
		1544:00	18	24.9	57.52	306.5		
		1545:00	19	24.8	57.29	323.0		
		1546:00	20	24.8	57.29	339.2		
		1547:00	21	24.8	57.29	355.5		
		1548:00	22	24.5	56.60	371.8		
		1549:00	23	24.0	55.44	388.0		
		1550:00	24	24.0	55.44	404.3		
		1551:00	25	23.9	55.21	420.1		
		1551:20	25.3	16.2	37.42			
		1551:40	25.7	13.5	31.19			
		1552:00	26	11.0	25.41			
		1552:20	26.3	8.5	19.64			

Appendix I-5. -- Pressure-injection test data. (cont)

Hole No. CNA-2 Test No. 6 Total depth 131.3 feet, uncased interval 19.0' to 153.8' below MP

Air Released: yes X no ____ Measuring point: top of casing 2.0' above land surface

Date Mo	Day	Hour	Elapsed time (min)	Applied Pressure (psi)	Applied Pressure (Feet of water)*	Input Volume (gal)	Depth to Water (ft) **	Comments
12	16	1552:40	26.7	6.3	14.55			
		1553:00	27	4.2	9.70			
		1553:20	27.3	2.7	6.24			
		1553:40	27.7	0.5	1.16			
		1555:00	29				1.43	
		1555:30	29.5				2.10	
		1556:00	30				2.88	
		1556:30	30.5				3.71	
		1557:00	31				4.56	
		1557:30	31.5				5.40	
		1558:00	32				6.24	
		1558:30	32.5				7.05	
		1559:00	33				7.83	

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNA-2 Test No. 7 Total depth 151.8 feet, uncased interval 19.0' to 153.8' below MP

Air Released: yes X no ____ Measuring point: top of casing 2.0' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft) **	Comments
12	17	1509:00	0	0	0	.0		
		1510:00	1	3.0	6.93	13.5		
		1511:00	2	3.0	6.93	28.1		
		1512:00	3	3.0	6.93	42.6		
		1513:00	4	3.0	6.93	57.1		
		1514:00	5	3.0	6.93	71.5		
		1515:00	6	3.0	6.93	85.9		
		1516:00	7	3.0	6.93	100.2		
		1517:00	8	3.0	6.93	114.4		
		1518:00	9	3.0	6.93	128.7		
		1519:00	10	3.0	6.93	142.7		
		1520:00	11	3.0	6.93	156.6		
		1521:00	12	3.0	6.93	170.7		
		1522:00	13	3.0	6.93	184.6		
		1523:00	14	3.0	6.93	198.6		
		1524:00	15	3.0	6.93	212.5		
		1524:35	15.6			220.6		full
		1531:00	0			226.8		restart
		1531:14	0.2			240.1		full
		1541:00	0			248.5		restart
		1541:00	0			260.5		full
		1549:00	0			272.4		restart
		1549:07	0.1			284.6		

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNA-2 Test No. 8 Total depth 151.8 feet, uncased interval 19.0' to 153.8' below MP

Air Released: yes X no ____ Measuring point: top of casing 2.0' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	Comments
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft) **	
12	20	1253:00	0	0	0	.0		
		1254:00	1	2.0	4.62	14.7		
		1255:00	2	2.0	4.62	30.5		
		1256:00	3	2.0	4.62	46.4		
		1257:00	4	2.0	4.62	62.1		
		1258:00	5	2.0	4.62	77.9		
		1258:46	5.8			90.0		full
		1259:00	6	18.0	41.58	93.0		
		1300:00	7	24.0	55.44	108.3		
		1301:00	8	23.6	54.52	124.2		
		1302:00	9	23.1	53.36	140.0		
		1303:00	10	23.0	53.13	155.8		
		1304:00	11	22.9	52.90	171.4		
		1305:00	12	22.7	52.44	187.3		
		1306:00	13	22.7	52.44	208.0		
		1307:00	14	22.5	51.98	219.3		
		1308:00	15	22.3	51.51	234.3		
		1308:20	15.3	14.0	32.34			
		1308:40	15.7	11.0	25.41			
		1309:00	16	8.5	19.64			
		1309:20	16.3	5.8	13.40			
		1309:40	16.7	3.1	7.16			
		1310:00	17	0.5	1.16			
		1312:30	19.5				4.59	
		1313:00	20				5.65	
		1313:30	20.5				6.72	
		1314:00	21				7.75	

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNA-3 Test No. 1 Total depth 29.0 feet, uncased interval 18.5' to 154.5' below MP

Air Released: yes __x__ No _____ Measuring point: top of casing 2.5' above land surface

Date			Elapsed	Applied Pressure			Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
12	20	1340:00	0	0	0	0		
		1341:00	1	3.0	6.93	18.2		
		1342:00	2	3.0	6.93	37.3		
		1342:40	2.7					full
		1342:55	2.9	55.0	127.05	51.1		
		1343:00	3	22.0	50.82			
		1343:20	3.3	15.5	35.81			
		1343:40	3.7	12.0	27.72			
		1344:00	4	11.8	27.26			
		1344:20	4.3	10.2	23.56			
		1344:40	4.7	9.0	20.79			
		1343:00	5	8.2	18.94			
		1345:20	5.3	7.2	16.63			
		1345:40	5.7	7.0	16.17			
		1346:00	6	6.6	15.25			
		1346:20	6.3	6.1	14.09			
		1346:40	6.7	5.9	13.63			
		1347:00	7	5.4	12.47			
		1347:20	7.3	5.1	11.78			
		1347:40	7.7	5.0	11.55			
		1348:00	8	4.8	11.09			
		1348:20	8.3	4.6	10.63			
		1348:40	8.7	4.3	9.93			
		1349:00	9	4.1	9.47			

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNA-3 Test No. 2 Total depth 49.5 feet, uncased interval 18.5' to 154.5' below MP

Air Released: yes X No ____ Measuring point: top of casing 2.5' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
12	20	1459:00	0	0	0	0		
		1500:00	1	3.0	6.93	16.8		
		1501:00	2	3.0	6.93	36.1		
		1502:00	3	3.0	6.93	55.4		
		1503:00	4	3.0	6.93	74.7		
		1503:22	4.37			81.9		full
		1503:40	4.67	45.0	103.95	86.6		
		1504:00	5	32.0	73.92	90.4		
		1505:00	6	19.8	45.74	109.7		
		1506:00	7	17.0	39.27	129.1		
		1507:00	8	15.2	35.11	148.0		
		1508:00	9	15.3	35.34	167.0		
		1509:00	10	14.8	34.19	185.8		
		1510:00	11	13.9	32.11	204.3		
		1511:00	12	12.8	31.88	222.7		
		1512:00	13	13.4	30.95	240.8		
		1513:00	14	12.5	28.88	258.8		
		1514:00	15	12.5	28.88	276.8		
		1515:00	16	12.0	27.72	294.7		
		1516:00	17	11.8	27.14	312.5		
		1517:00	18	11.7	27.03	330.4		
		1518:00	19	11.6	26.80	348.1		
		1519:00	20	11.7	27.03	366.6		
		1519:20	20.3	0	0			
		1521:00	22				5.70	
		1521:30	22.5				5.70	
		1522:00	23				7.50	

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNA-3 Test No. 3 Total depth 70.0 feet, uncased interval 18.5' to 154.5' below MP

Air Released: yes __X__ No _____ Measuring point: top of casing 2.5' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
12	21	0841:00	0	0		0		
		0842:00	1	2	4.62	17.9		
		0843:00	2	2	4.62	36.7		
		0844:00	3	2	4.62	55.2		
		0845:00	4	2	4.62	73.8		
		0846:00	5	2	4.62	85.3		generator trouble
		0847:00	6	3	6.93	92.8		generator trouble
		0848:00	7	3	6.93	100.0		generator trouble
		0849:00	8	3	6.93	117.6		
		0849:26	8.4			125.2		full
		0850:00	9	25.5	58.91	134.8		
		0851:00	10	21.5	49.67	153.1		
		0852:00	11	19.6	45.28	171.3		
		0853:00	12	18.5	42.74	189.4		
		0854:00	13	17.5	40.43	208.8		
		0855:00	14	16.8	38.81	225.2		
		0856:00	15	16.0	36.96	244.5		
		0857:00	16	15.3	35.34	259.6		
		0858:00	17	14.9	34.42	276.5		
		0859:00	18	14.5	33.50	293.3		
		0900:00	19	14.3	33.03	310.4		
		0901:00	20	14.0	32.34	327.3		
		0902:00	21	13.3	30.72	342.1		
		0903:00	22	13.5	31.19	357.8		
		0904:00	23	13.2	30.49	373.2		
		0905:00	24	10.0	23.10	382.6		
		0906:00	25	14.1	32.57	399.5		water froze
		0906:40	25.7	0	0	0		
		0908:30	27.5				4.32	
		0909:00	28				5.61	
		0909:30	28.5				6.75	
		0910:00	29				7.75	

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNA-3 Test No. 4 Total depth 90.5 feet, uncased interval 18.5' to 154.5' below MP

Air Released: yes X No ____ Measuring point: top of casing 2.5' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
12	21	1119:00	0	0	0	0		
		1120:00	1	3	6.93	19.0		
		1121:00	2	3	6.93	38.0		
		1122:00	3	3	6.93	57.1		
		1123:00	4	3	6.93	75.9		
		1124:00	5	3	6.93	94.7		
		1125:00	6	3	6.93	113.6		
		1126:00	7	3	6.93	131.7		
		1127:00	8	3	6.93	149.6		
		1127:31	8.5			158.8		full
		1128:00	9	14.0	32.34	166.6		
		1129:00	10	15.3	35.34	184.0		
		1130:00	11	14.3	33.03	201.5		
		1131:00	12	14.1	32.57	218.9		
		1132:00	13	13.8	31.88	235.8		
		1133:00	14	13.5	31.19	252.8		
		1134:00	15	13.0	30.03	269.8		
		1135:00	16	12.9	29.80	286.7		
		1136:00	17	12.7	29.34	303.4		
		1137:00	18	12.3	28.41	319.5		
		1138:00	19	11.8	27.26	335.9		
		1139:00	20	11.2	25.87	351.4		
		1140:00	21	11.0	25.41	366.9		
		1141:00	22	10.0	23.10	381.7		
		1142:00	23	9.8	22.64	396.6		
		1143:00	24	9.8	22.64	411.4		
		1143:15	24.3	0	0			
		1145:00	26					
		1145:30	26.5				4.94	
		1146:00	27				6.40	
		1146:30	27.5				7.72	

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNA-3 Test No. 5 Total depth 111.0 feet, uncased interval 18.5' to 154.5' below MP

Air Released: yes x No ____ Measuring point: top of casing 2.5' above land surface

Date Mo	Day	Hour	Elapsed time (min)	Applied Pressure (psi)	Applied Pressure (Feet of water)*	Input Volume (gal)	Depth to Water (ft)**	Comments
12	21	1415:00	0	0	0	0		
		1416:00	1	3	6.93	16.7		
		1417:00	2	3	6.93	35.4		
		1418:00	3	3	6.93	54.2		
		1419:00	4	3	6.93	72.7		
		1420:00	5	3	6.93	91.2		
		1421:00	6	3	6.93	109.6		
		1422:00	7	3	6.93	128.2		
		1423:00	8	3	6.93	146.6		
		1424:00	9	3	6.93	164.7		
		1425:00	10	3	6.93	182.7		
		1425:32	10.5			192.3		full
		1426:00	11	12.0	27.72	200.0		
		1427:00	12	12.4	28.64	217.5		
		1428:00	13	13.0	30.03	235.1		
		1429:00	14	12.9	29.80	252.6		
		1430:00	15	12.6	29.11	269.8		
		1431:00	16	12.2	28.18	286.8		
		1432:00	17	12.1	27.95	302.8		water at surface
		1433:00	18	12.0	27.72	320.4		
		1434:00	19	12.0	27.72	337.4		
		1435:00	20	12.0	27.72	354.2		
		1436:00	21	11.5	26.57	370.7		
		1437:00	22	11.4	26.33	387.3		
		1438:00	23	11.2	25.87	403.9		
		1439:00	24	11.1	25.64	420.7		
		1444:30	25.5				3.39	
		1441:00	26				5.17	
		1441:30	26.5				6.80	
		1442:00	27				8.25	

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNA-3 Test No. 6 Total depth 131.5 feet, uncased interval 18.5' to 154.5' below MP

Air Released: yes X No ____ Measuring point: top of casing 2.5' above land surface

Date Mo	Day	Hour	Elapsed time (min)	Applied Pressure (psi)	Applied Pressure (Feet of water)*	Input Volume (gal)	Depth to Water (ft)**	Comments
12	22	0849:00	0	0	0			
		0850:00	1	3.0	6.93	17.4		
		0851:00	2	3.0	6.93	39.1		
		0852:00	3	3.0	6.93	54.4		
		0853:00	4	3.0	6.93	72.7		
		0854:00	5	3.0	6.93	91.3		
		0855:00	6	3.0	6.93	109.8		
		0856:00	7	3.0	6.93	127.7		
		0857:00	8	3.0	6.93	146.0		
		0858:00	9	3.0	6.93	164.3		
		0859:00	10	3.0	6.93	182.2		
		0900:00	11	3.0	6.93	200.0		
		0900:04	11.07			201.2		full
		0901:00	12	16.0	36.96	216.9		
		0902:00	13	16.2	37.42	234.4		
		0903:00	14	16.4	37.88	251.8		
		0904:00	15	15.5	35.81	269.2		
		0905:00	16	15.5	35.81	286.6		
		0906:00	17	16.5	38.12	304.1		
		0907:00	18	17.0	39.27	321.3		
		0908:00	19	16.9	39.04	338.2		
		0909:00	20	17.0	39.27	355.9		
		0910:00	21	17.0	39.27	373.5		
		0911:00	22	17.1	39.50	390.9		
		0912:00	23	17.5	40.43	408.1		
		0913:00	24	17.9	41.35	425.0		
		0914:00	25	20.0	46.20	442.4		
		0915:00	26	21.8	50.36	460.3		
		0916:00	27	24.9	57.52	474.6		no water at surface
		0917:00	28	18.0	41.58	491.1		

Appendix I-5. -- Pressure-injection test data. (cont)

Hole No. CNA-3 Test No. 6 Total depth 131.5 feet, uncased interval 18.5' to 154.5' below MP

Air Released: yes X no ____ Measuring point: top of casing 2.5' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft) **	Comments
12	22	0918:00	29	17.9	41.35	507.1		
		0919:00	30	14.2	32.34	523.2		
		0920:00	31	12.8	29.57	539.4		
		0921:00	32	12.1	27.95	555.3		
		0922:00	33	10.0	23.10	569.7		

* above measuring point

** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNA-3 Test No. 7 Total depth 152.0 feet, uncased interval 18.5' to 154.5' below MP

Air Released: yes X No ____ Measuring point: top of casing 2.5' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
12	22	1253:00	0	0	0			
		1257:00	0	0	0	15.1		
		1258:00	1	3.0	6.93	32.9		
		1259:00	2	3.0	6.93	52.4		
		1300:00	3	3.0	6.93	71.9		
		1301:00	4	3.0	6.93	91.4		
		1302:00	5	3.0	6.93	110.9		
		1303:00	6	3.0	6.93	130.4		
		1304:00	7	3.0	6.93	149.9		
		1305;00	8	3.0	6.93	169.5		
		1306:00	9	3.0	6.93	189.1		
		1307:00	10	3.0	6.93	208.3		
		1308:00	11	3.0	6.93	227.5		
		1309:00	12	3.0	6.93	246.6		
		1310:00	13	3.0	6.93	265.7		
		1311:00	14	3.0	6.93	284.8		
		1312:00	15	3.0	6.93	303.8		
		1313:00	16	3.0	6.93	322.9		
		1314:00	17	3.0	6.93	341.9		
		1314:55	17.9			359.3		
		1315:00	18	4.0	9.24	360.5		
		1316:00	19	4.2	9.70	380.0		
		1317:00	20	4.5	10.40	399.4		
		1318:00	21	4.5	10.40	418.3		
		1319:00	22	4.6	10.63	436.9		
		1320:00	23	4.6	10.63	455.6		
		1321:00	24	4.0	9.24	474.4		
		1322:00	25	3.8	8.78	493.2		
		1323:00	26	3.5	8.09	511.9		
		1324:00	27	3.4	7.85	530.7		

Appendix I-5. -- Pressure-injection test data. (cont)

Hole No. CNA-3 Test No. 7 Total depth 152.0 feet, uncased interval 18.5' to 154.5' below MP

Air Released: yes X No ____ Measuring point: top of casing 2.5' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
12	22	1325:00	28	3.2	7.39	549.3		
		1326:00	29	3.0	6.93	566.8		
		1327:00	30				8.3	
		1329:14	32.2					
		1329:20	32.3					

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNC-1 Test No. 1 Total depth 88.7 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes ____ No _X_ Measuring point: top of casing 0.7' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
10	18	1544:00	0	0	0		0	small leak at casing head
		1545:00	1	5.4	12.47	7.10		
		1546:00	2	5.5	12.71	27.70		
		1547:00	3	6.0	13.86	44.00		
		1548:00	4	12.3	28.41	65.10		
		1549:00	5	21.0	48.51	85.00		
		1550:00	6	43.0	99.33	104.70		
		1551:00	7	44.0	101.64			
		1552:00	8	45.0	103.95			
		1553:00	9	45.5	105.11			
		1554:00	10	46.0	106.26			
		1555:00	11	46.0	106.26			
		1556:00	12	46.0	106.26			
		1557:00	13	46.0	106.26			
		1558:00	14	46.0	106.26			
		1559:00	15	45.8	105.80			
		1600:00	16	45.8	105.80			
		1601:00	17	45.6	105.34			
		1602:00	18	45.2	104.41			
		1603:00	19	45.1	104.18			
		1604:00	20	45.0	103.95			
		1605:00	21	45.0	103.95			
		1606:00	22	44.9	103.72			
		1607:00	23	44.8	103.49			
		1608:00	24	44.3	102.33			
		1609:00	25	44.2	102.10			
		1610:00	26	44.1	101.87			
		1611:00	27	44.1	101.87			
		1612:00	28	44.0	101.64			
		1613:00	29	43.9	101.41			
		1614:00	30	43.8	101.18			

Appendix I-5. -- Pressure-injection test data. (cont)

Hole No. CNC-1 Test No. 1 Total depth 88.7 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes _____ No X

Measuring point: top of casing 0.7' above land surface

Date Mo	Day	Hour	Elapsed time (min)	Applied Pressure (psi)	Applied Pressure (Feet of water)*	Input Volume (gal)	Depth to Water (ft)**	Comments
10	18	1615:00	31	43.6	100.72			
		1616:00	32	43.3	100.02			
		1617:00	33	43.1	99.56			
		1618:00	34	43.0	99.33			
		1619:00	35	43.0	99.33			

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNC-1 Test No. 2 Total depth 108.7 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes ____ No __X__ Measuring point: top of casing 0.7' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	Comments
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	
10	19	1518:00	0	0	0			vol. gauge not working
		1519:00	1	6.0	13.86	18.9		
		1520:00	2	7.5	17.32	37.8		
		1521:00	3	10.2	24.00	54.2		
		1522:00	4	14.5	33.50	71.8		small leaks
		1523:00	5	20.2	46.66	79.6		
		1524:00	6	30.5	70.45	91.7		
		1525:00	7	48.0	110.88	106.3		
		1526:00	8	48.0				
		1527:00	9	47.0	108.57			
		1528:00	10	46.2	106.72			
		1529:00	11	45.8	105.80			
		1530:00	12	45.0	103.95			
		1531:00	13	44.3	102.33			
		1532:00	14	43.8	101.17			
		1533:00	15	43.0	99.33			
		1534:00	16	42.8	98.87			
		1535:00	17	42.0	97.02			
		1536:00	18	41.3	95.40			
		1537:00	19	40.5	94.00			
		1538:00	20	40.0	92.40			
		1539:00	21	39.2	90.55			
		1540:00	22	38.8	89.62			
		1541:00	23	38.0	87.78			
		1542:00	24	37.4	86.39			
		1543:00	25	36.9	65.23			
		1544:00	26	36.2	83.62			
		1545:00	27	35.4	81.77			
		1546:00	28	35.0	80.85			
		1547:00	29	34.2	79.00			
		1548:00	30	33.9	78.30			
		1549:00	31	33.1	76.46			

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNC-1 Test No.3 Total depth 128.7 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes _____ No X Measuring point: top of casing 0.7' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
10	20	1400:00	0	0			0	very slight leak
		1401:00	1	6.0	6.0	20.9		
		1402:00	2	7.5	17.32	41.4		
		1403:00	3	9.0	20.79	61.7		
		1404:00	4	12.0	27.72	81.3		
		1405:00	5	16.0	36.96	101.0		
		1406:00	6	22.5	51.98	121.5		
		1407:00	7	33.3	76.92	139.1		
		1408:00	8	49.0	113.19	152.8		
		1409:00	9	48.9	113.00			
		1410:00	10	48.9	113.00			
		1411:00	11	48.9	113.00			
		1412:00	12	48.9	113.00			
		1413:00	13	48.9	113.00			
		1414:00	14	48.9	113.00			
		1415:00	15	48.9	113.00			
		1416:00	16	48.8	112.72			
		1417:00	17	48.2	111.34			
		1418:00	18	48.2	111.34			
		1419:00	19	48.1	111.11			
		1420:00	20	48.1	111.11			
		1421:00	21	48.1	111.11			
		1422:00	22	48.0	110.88			
		1423:00	23	48.0	110.88			
		1424:00	24	47.8	110.41			
		1425:00	25	47.6	110.00			
		1426:00	26	47.2	109.03			
		1427:00	27	47.1	108.80			
		1428:00	28	47.0	108.57			
		1429:00	29	46.9	108.33			
		1430:00	30	46.6	107.64			
		1431:00	31	46.2	106.72			
		1432:00	32	46.1	106.49			

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNC-1 Test No. 4 Total depth 148.5 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes _____ No _X___ Measuring point: top of casing 0.7' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
10	21	1543:00	0	0	0	0	0	large leaks
		1544:00	1	5.9	13.62	21.4		
		1545:00	2	6.9	15.93	41.1		
		1546:00	3	8.5	19.63	61.4		
		1547:00	4	10.5	24.25	81.7		
		1548:00	5	13.0	30.03	101.6		
		1549:00	6	17.0	39.27	121.2		
		1550:00	7	23.0	53.13	141.1		
		1551:00	8	31.5	73.00	158.9		
		1552:00	9	43.0	99.33	174.6		
		1553:00	10	42.0	97.02			
		1554:00	11	38.0	88.00			
		1555:00	12	36.0	83.16			
		1556:00	13	35.0	80.85			
		1557:00	14	33.0	76.23			
		1558:00	15	31.0	71.61			
		1559:00	16	28.5	65.83			
		1600:00	17	26.0	60.06			

* above measuring point
** below masuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNC-1 Test No. 6 Total depth 148.5 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes _____ No __X__ Measuring point: top of casing 0.7' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
10	22	953:00	0	0	0	0		
		954:00	1	5.0	11.55	19.2		
		955:00	2	5.6	12.93	37.7		
		956:00	3	7.0	16.17	55.6		
		957:00	4	8.0	18.48	72.6		
		958:00	5	9.6	22.17	87.7		
		959:00	6	11.5	27.00	101.3		
		1000:00	7	14.0	32.34	114.4		
		1001:00	8	17.2	39.73	126.7		
		1002:00	9	21.2	49.00	138.8		
		1003:00	10	26.5	61.21	149.8		
		1004:00	11	31.5	73.00	158.0		
		1005:00	12	34.5	78.00	162.7		
		1006:00	13	35.0	80.85	162.8		
		1007:00	14	35.0	80.85			
		1008:00	15	35.0	80.85			
		1009:00	16	35.0	80.85			
		1010:00	17	35.0	80.85			
		1011:00	18	35.0	80.85			
		1012:00	19	35.0	80.85			
		1013:00	20	35.0	80.85			
		1014:00	21	35.0	80.85			
		1015:00	22	35.0	80.85			
		1016:00	23	35.0	80.85			
		1017:00	24	35.0	80.85			
		1018:00	25	34.8	80.38			
		1019:00	26	34.8	80.38			
		1020:00	27	34.8	80.38			
		1021:00	28	34.8	80.38			
		1022:00	29	34.8	80.38			
		1023:00	30	34.8	80.38			

Hole No. CNC-1 Test No. 6 Total depth 148.5 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes _____ No X Measuring point: top of casing 0.7' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	Comments
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	
10	22	1024:00	31	34.8	80.38			
		1025:00	32	34.8	80.38			
		1026:00	33	34.8	80.38			
		1027:00	34	34.8	80.38			
		1028:00	35	34.8	80.38			
		1029:00	36	34.8	80.38			

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNC-1 Test No. 7 Total depth 168.4 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes ____ No X.

Measuring point: top of casing 0.7' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
10	25	1243:00	0	0	0	0		
		1244:00	1	4.8	11.08	21.1		
		1245:00	2	5.5	12.70	41.5		
		1246:00	3	7.8	18.01	62.0		
		1247:00	4	9.0	20.79	82.9		
		1248:00	5	9.0	20.79	93.1		out of fuel
		1249:00	6	13.8	31.87	112.9		
		1250:00	7	18.4	42.50	133.1		
		1251:00	8	23.8	55.00	152.2		
		1252:00	9	33.0	76.23	171.7		
		1253:00	10	47.0	108.57	187.4		
		1254:00	11	46.8	108.10			
		1255:00	12	46.8	108.10			
		1256:00	13	46.8	108.10			
		1257:00	14	46.8	108.10			
		1258:00	15	46.8	108.10			
		1259:00	16	46.8	108.10			
		1300:00	17	46.8	108.10			
		1301:00	18	46.8	108.10			
		1302:00	19	46.8	108.10			
		1303:00	20	46.8	108.10			
		1304:00	21	46.8	108.10			
		1305:00	22	46.8	108.10			
		1306:00	23	46.8	108.10			
		1307:00	24	46.8	108.10			
		1308:00	25	46.8	108.10			
		1309:00	26	46.8	108.10			
		1310:00	27	46.8	108.10			
		1311:00	28	46.8	108.10			
		1312:00	29	46.8	108.10			
		1313:00	30	46.8	108.10			

Hole No. CNC-1 Test No. 7 Total depth 168.4 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes _____ No __X__ Measuring point: top of casing 0.7' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	Comments
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	
10	25	1314:00	31	46.8	108.10			
		1315:00	32	46.8	108.10			
		1316:00	33	46.8	108.10			
		1317:00	34	46.8	108.10			
		1319:00	35	46.8	108.10			
		1320:00	36	46.8	108.10			

* above measuring point

** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNC-1 Test No. 8 Total depth 188.2 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes ______ No __X__ Measuring point: top of casing 0.7' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
10	26	0916:00	0	0	0			
		0917:00	1	4.0	9.24	18.8		
		0918:00	2	5.3	12.24	39.9		
		0919:00	3	6.5	15.01	59.9		
		0920:00	4	8.0	18.48	81.0		
		0921:00	5	9.7	22.40	100.7		
		0922:00	6	12.2	28.18	121.1		
		0923:00	7	15.5	35.80	140.9		
		0924:00	8	20.2	46.66	161.0		
		0925:00	9	27.2	62.83	180.2		
		0926:00	10	38.0	87.78	199.8		
		0927:00	11	37.8	87.31			
		0928:00	12	37.8	87.31			
		0929:00	13	37.8	87.31			
		0930:00	14	38.0	87.78			
		0931:00	15	38.0	87.78			
		0932:00	16	38.0	87.78			
		0933:00	17	38.0	87.78			
		0934:00	18	38.0	87.78			
		0935:00	19	38.0	87.78			
		0936:00	20	38.0	87.78			
		0937:00	21	38.0	87.78			
		0938:00	22	38.5	88.93			
		0939:00	23	38.5	88.93			
		0940:00	24	38.5	88.93			
		0941:00	25	38.5	88.93			
		0942:00	26	38.5	88.93			
		0943:00	27	38.5	88.93			
		0944:00	28	38.5	88.93			
		0945:00	29	38.5	88.93			
		0946:00	30	38.5	88.93			

Hole No. CNC-1 Test No. 8 Total depth 188.2 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes ____ No X Measuring point: top of casing 0.7' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	Comments
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	
10	26	0947:00	31	38.5	88.93			
		0948:00	32	38.5	88.93			
		0949:00	33	38.5	88.93			
		0950:00	34	38.5	88.93			
		0951:00	35	38.5	88.93			

* above measuring point

** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNC-1 Test No. 9 Total depth 204.4 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes X No ____ Measuring point: top of casing 0.7' above land surface

Date			Elapsed time (min)	Applied Pressure		Input Volume (gal)	Depth to Water (ft)**	Comments
Mo	Day	Hour		(psi)	(Feet of water)*			
10	27	1055:00	0	0				
		1056:00	1	2.5	5.78	27.8		
		1057:00	2	2.5	5.78	46.7		
		1058:00	3	2.5	5.78	65.8		
		1059:00	4	2.5	5.78	84.5		
		1100:00	5	2.5	5.78	93.8		
		1101:00	6	3.0	6.93	112.9		
		1102:00	7	3.0	6.93	130.5		
		1103:00	8	3.0	6.93	148.9		
		1104:00	9	3.0	6.93	167.1		
		1105:00	10	3.0	6.93	185.9		
		1106:00	11	3.0	6.93	203.8		
		1107:00	12	3.0	6.93	222.0		
		1108:00	13	3.0	6.93	240.3		
		1109:00	14	3.0	6.93	258.5		
		1109:20	14.3	44.0	101.64	274.0		full
		1110:00	15	41.0	94.71			
		1111:00	16	40.0	92.40			
		1112:00	17	38.5	88.93			
		1113:00	18	35.0	80.85			
		1114:00	19	32.4	74.84			
		1115:00	20	30.5	70.45			
		1116:00	21	29.0	67.00			
		1117:00	22	28.0	64.68			
		1118:00	23	27.8	64.21			
		1119:00	24	26.5	61.21			
		1120:00	25	25.6	59.13			
		1121:00	26	25.0	57.75			
		1122:00	27	24.3	56.13			
		1123:00	28	23.8	55.00			
		1124:00	29	23.0	53.13			
		1125:00	30	22.3	51.51			

Hole No. CNC-1 Test No. 9 Total depth 204.4 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes X No ____ Measuring point: top of casing 0.7' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
10	27	1126:00	31	21.9	50.58			
		1127:00	32	21.3	49.20			
		1128:00	33	21.0	48.51			
		1129:00	34	20.6	47.58			
		1130:00	35	20.8	48.04			

* above measuring point

** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNC-1 Test No. 9A Total depth 204.4 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes ____ No __X__ Measuring point: top of casing 0.7' above land surface

Date Mo	Date Day	Date Hour	Elapsed time (min)	Applied Pressure (psi)	Applied Pressure (Feet of water)*	Input Volume (gal)	Depth to Water (ft)**	Comments
10	23	1308:00	0	0				
		1309:00	1	2.5	5.8	18.4		
		1310:00	2	4.5	10.39	37.0		
		1311:00	3	5.0	11.55	55.5		
		1312:00	4	6.3	14.55	74.0		
		1313:00	5	7.8	18.01	92.4		
		1314:00	6	9.5	21.94	110.7		
		1315:00	7	11.5	27.00	128.8		
		1316:00	8	13.0	30.03	139.1		
		1317:00	9	14.8	34.18	161.6		
		1318:00	10	17.2	39.73	164.2		
		1319:00	11	20.2	46.66	176.3		
		1320:00	12	24.0	55.44	187.8		
		1321:00	13	28.6	66.00	199.3		
		1322:00	14	34.3	79.00	209.8		
		1323:00	15	40.0	92.40	219.0		
		1324:00	16	40.0	92.40			
		1325:00	17	39.9	92.16			
		1326:00	18	39.9	92.16			
		1327:00	19	39.9	92.16			
		1328:00	20	39.9	92.16			
		1329:00	21	39.9	92.16			
		1330:00	22	39.9	92.16			
		1331:00	23	39.9	92.16			
		1332:00	24	39.9	92.16			
		1333:00	25	39.9	92.16			
		1334:00	26	39.9	92.16			
		1335:00	27	39.9	92.16			
		1336:00	28	39.9	92.16			
		1337:00	29	39.9	92.16			
		1338:00	30	39.9	92.16			

Hole No. CNC-1 Test No. 9A Total depth 204.4 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes ____ No X

Measuring point: top of casing 0.7' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	Comments
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	
10	27	1339:00	31	39.9	92.16			
		1340:00	32	39.9	92.16			
		1341:00	33	39.9	92.16			
		1342:00	34	39.9	92.16			
		1343:00	35	39.9	92.16			
		1344:00	36	39.9	92.16			
		1345:00	37	39.9	92.16			

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNC-1 Test No. 10 Total depth 223.5 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes _x_ no _x_ Measuring point: top of casing 0.7'above land surface

Date Mo	Day	Hour	Elapsed time (min)	Applied Pressure (psi)	Applied Pressure (Feet of water)*	Input Volume (gal)	Depth to Water (ft) **	Comments
10	28	1052:00	0	0	0	0		air released partially
		1053:00	1	3.0	6.93	29.6		
		1054:00	2	3.0	6.93	49.0		
		1055:00	3	4.0	9.24	58.2		
		1056:00	4	5.0	11.55	77.4		
		1057:00	5	5.5	12.71	97.2		
		1058:00	6	5.5	12.71	116.8		
		1059:00	7	6.5	15.02	134.4		
		1100:00	8	7.5	17.33	153.4		
		1101:00	9	8.5	19.64	171.9		
		1102:00	10	9.5	21.95	190.5		
		1103:00	11	10.0	23.10	208.9		
		1104:00	12	11.5	26.57	227.0		
		1105:00	13	13.5	31.19	244.9		
		1106:00	14	16.0	36.96	262.8		
		1107:00	15	20.5	47.36	280.4		
		1108:00	16	39.0	90.09	297.0		
		1109:00	17	50.0	115.50	301.0		
		1110:00	18	12.0	27.72			
		1111:00	19	5.5	12.71			
		1112:00	20	4.5	10.40			
		1113:00	21	4.0	9.24			
		1114:00	22	4.0	9.24	301.0		repressure
		1114:02	22.02	50.0	115.50	301.3		
		1115:00	23	25.0	57.75			
		1116:00	24	19.0	43.89			
		1117:00	25	15.5	35.81			

Appendix I-5. -- Pressure-injection test data. (cont)

Hole No. CNC-1 Test No. 10 Total depth 223.5 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes X no X Measuring point: top of casing 0.7' above land surface

Date			Elapsed time (min)	Applied Pressure (psi)	Applied Pressure (Feet of water)*	Input Volume (gal)	Depth to Water (ft) **	Comments
Mo	Day	Hour						
10	28	1118:00	26	14.0	32.34			
		1119:00	27	13.5	31.19			
		1120:00	28	12.9	29.80			
		1121:00	29	12.0	27.72			
		1122:00	30	11.5	26.57			
		1123:00	31	11.0	25.41			
		1124:00	32	10.5	24.26			
		1134:00	42				0.42	
		1136:00	44				0.47	

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNC-1 Test No. 11 Total depth 242.3 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes _____ No __X__ Measuring point: top of casing 0.7' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
10	29	1006:00	0	0	0			
		1007:00	1	4.0	9.24	27.6		
		1008:00	2	4.5	10.40	37.1		
		1009:00	3	5.0	11.55	55.2		
		1010:00	4	6.2	14.32	73.1		
		1011:00	5	7.0	16.17	100.7		
		1012:00	6	8.5	19.64	108.0		
		1013:00	7	10.0	23.10	125.3		
		1014:00	8	11.8	27.26	142.2		
		1015:00	9	14.2	32.80	158.9		
		1016:00	10	15.5	35.81	175.5		
		1017:00	11	19.0	43.89	193.0		
		1018:00	12	21.5	49.67	218.2		
		1019:00	13	28.0	64.68	224.1		
		1020:00	14	32.0	73.92	247.8		
		1021:00	15	38.5	88.94	250.0		
		1022:00	16	44.0	101.64	258.7		
		1023:00	17	44.0	101.64			
		1024:00	18	44.0	101.64			
		1025:00	19	44.0	101.64			
		1026:00	20	44.1	101.87			
		1027:00	21	44.2	102.10			
		1028:00	22	44.2	102.10			
		1029:00	23	44.2	102.10			
		1030:00	24	44.2	102.10			
		1031:00	25	44.2	102.10			
		1032:00	26	44.2	102.10			
		1033:00	27	44.2	102.10			
		1051:00	45	0	0	258.7		filling with water
		1052:00	46			279.6		
		1053:00	47			300.1		open hole

Appendix I-5. -- Pressure-injection test data. (cont)

Hole No. CNC-1 Test No. 11 Total depth 242.3 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes _____ No X

Measuring point: top of casing 0.7' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
10	29	1054:00	48			313.9		
		1055:00	49			323.1		
		1056:00	50				0.01	
		1057:00	51				0.02	
		1058:00	52				0.03	
		1059:00	53				0.05	

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNC-1 Test No. 12 Total depth 260.0 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes X No ____ Measuring point: top of casing 0.7' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
11	1	1139:00	0	0	0			
		1140:00	1	3.5	8.09	19.4		
		1141:00	2	3.5	8.09	38.6		
		1142:00	3	3.5	8.09	57.6		
		1143:00	4	3.5	8.09	76.6		
		1144:00	5	3.5	8.09	95.5		
		1145:00	6	3.5	8.09	114.5		
		1146:00	7	3.5	8.09	133.4		
		1147:00	8	3.5	8.09	152.3		
		1148:00	9	3.5	8.09	181.2		
		1149:00	10	3.5	8.09	199.4		
		1150:00	11	3.5	8.09	207.1		
		1151:00	12	3.5	8.09	224.8		
		1152:00	13	3.5	8.09	242.3		
		1153:00	14	3.5	8.09	259.8		
		1154:00	15	3.5	8.09	277.0		
		1155:00	16	3.5	8.09	294.1		
		1156:00	17	3.5	8.09	311.0		
		1157:00	18	3.5	8.09	327.9		
		1157:48	18.8	50	115.50	342.5		full
		1158:00	19	15	34.65			
		1159:00	20	11.2	25.87			
		1200:00	21	10.2	23.56			
		1201:00	22	9.9	22.87			
		1202:00	23	9.5	21.95			
		1203:00	24	9.0	20.79			
		1204:00	25	8.8	20.33			
		1205:00	26	8.5	19.64			
		1206:00	27	8.2	18.94			
		1207:00	28	8.0	18.48			
		1208:00	29	7.9	18.25			

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data. (cont)

Hole No. CNC-1 Test No. 12 Total depth 260.0 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes X No ____ Measuring point: top of casing 0.7' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
11	1	1209:00	30	7.5	17.33			
		1210:00	31	7.4	17.09			
		1211:00	32	7.3	16.86			
		1212:00	33	7.2	16.63			
		1213:00	34	6.8	15.71			
		1213:00	0				0.23	
		1219:00	40				0.27	

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNC-1 Test No. 13 Total depth 279.6 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes X No ____ Measuring point: top of casing 0.7' above land surface

Date Mo	Day	Hour	Elapsed time (min)	Applied Pressure (psi)	Applied Pressure (Feet of water)*	Input Volume (gal)	Depth to Water (ft)**	Comments
11	2	1036:00	0	0				
		1037:00	1	4.0	9.24	18.8		
		1038:00	2	4.0	9.24	38.3		
		1039:00	3	4.0	9.24	57.6		
		1040:00	4	4.0	9.24	76.8		
		1041:00	5	4.0	9.24	96.0		
		1042:00	6	4.0	9.24	115.2		
		1043:00	7	4.0	9.24	134.5		
		1044:00	8	4.0	9.24	153.7		
		1045:00	9	4.0	9.24	172.3		
		1046:00	10	4.0	9.24	190.9		
		1047:00	11	4.0	9.24	209.5		
		1048:00	12	4.0	9.24	227.9		
		1049:00	13	4.0	9.24	246.9		
		1050:00	14	4.0	9.24	264.1		
		1051:00	15	4.0	9.24	281.9		
		1052:00	16	4.0	9.24	299.6		
		1053:00	17	4.0	9.24	316.8		
		1054:00	18	4.0	9.24	334.1		
		1055:00	19	4.0	9.24	351.3		
		1056:00	20	4.0	9.24	368.6		
		1056:10	20.2	50.0	115.50	370.1		full
		1057:00	21	24.8	57.29			
		1058:00	22	18.2	42.04			
		1059:00	23	14.2	32.80			
		1100:00	24	10.9	25.18			
		1101:00	25	7.8	18.02			
		1102:00	26	5.5	12.71			
		1103:00	27	3.5	8.09			
		1104:00	28	2.0	4.62			

Appendix I-5. -- Pressure-injection test data. (cont)

Hole No. CNC-1 Test No. 13 Total depth 279.6 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes X No ____ Measuring point: top of casing 0.7' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
11	2	1107:00	31				0.15	
		1109:00	33				0.17	
		1111:00	35				0.17	
		1131:00	55				0.20	

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNC-1 Test No. 14 Total depth 350.0 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes X No ______ Measuring point: top of casing 0.7' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
11	3	1520:00	0	0				
		1521:00	1	4.5	10.40	19.8		
		1522:00	2	4.5	10.40	39.5		
		1523:00	3	4.5	10.40	58.8		
		1524:00	4	4.5	10.40	78.3		
		1525:00	5	4.5	10.40	97.3		
		1526:00	6	4.5	10.40	116.7		
		1527:00	7	4.5	10.40	136.0		
		1528:00	8	4.5	10.40	155.1		
		1529:00	9	4.5	10.40	174.1		
		1530:00	10	4.5	10.40	193.0		
		1531:00	11	4.5	10.40	211.9		
		1532:00	12	4.5	10.40	230.9		
		1533:00	13	4.5	10.40	259.5		
		1534:00	14	4.5	10.40	270.3		
		1535:00	15	4.5	10.40	285.9		
		1536:00	16	4.5	10.40	303.8		
		1537:00	17	4.5	10.40	321.7		
		1538:00	18	4.5	10.40	349.3		
		1539:00	19	4.5	10.40	360.4		
		1540:00	20	4.5	10.40	374.3		
		1541:00	21	4.5	10.40	391.3		
		1542:00	22	4.5	10.40	408.2		
		1543:00	23	4.5	10.40	424.9		
		1544:00	24	4.5	10.40	441.7		
		1545:00	25	4.5	10.40	458.4		
		1546:00	26	4.5	10.40	474.9		
		1546:05	26.1	45.0	103.95	477.0		full

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Appendix I-5. -- Pressure-injection test data. (cont)

Hole No. CNC-1 Test No. 14 Total depth 350.0 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes X No ____ Measuring point: top of casing 0.7' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
11	3	1547:00	27	25.0	57.75			
		1548:00	28	18.2	42.04			
		1549:00	29	16.0	36.96			
		1550:00	30	14.9	34.42			
		1551:00	31	13.2	30.49			
		1552:00	32	12.0	27.72			
		1553:00	33	11.5	26.57			
		1554:00	34	11.0	25.41			
		1555:00	35	10.2	23.56			
		1556:00	36	10.0	23.10			
		1557:00	37	9.8	22.64			
		1558:00	38	9.0	20.79			
		1559:00	39	8.5	19.64			
		1600:00	40	8.0	18.48			
		1601:00	41	7.6	17.56			
		1602:00	42	7.1	16.40			
		1603:00	43	6.8	15.71			
		1604:00	44	6.7	15.48			
		1606:00	46				0.17	
		1615:00	51				0.18	
		1625:00	61				0.19	

* above measuring point

** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNC-1 Test No. 15 Total depth 400.0 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes X No ____ Measuring point: top of casing 0.7' above land surface

Date			Elapsed time (min)	Applied Pressure (psi)	Applied Pressure (Feet of water)*	Input Volume (gal)	Depth to Water (ft)**	Comments
Mo	Day	Hour						
11	4	1103:00	0	0				
		1104:00	1	1.0	2.31	17.8		
		1105:00	2	5.0	11.55	35.6		
		1106:00	3	5.0	11.55	53.4		
		1107:00	4	5.0	11.55	71.2		
		1108:00	5	5.0	11.55	89.0		
		1109:00	6	5.0	11.55	107.1		
		1110:00	7	5.0	11.55	125.2		
		1111:00	8	5.0	11.55	144.5		
		1112:00	9	5.0	11.55	161.0		
		1113:00	10	5.0	11.55	179.1		
		1114:00	11	5.0	11.55	196.6		
		1115:00	12	5.0	11.55	214.6		
		1116:00	13	5.0	11.55	232.2		
		1117:00	14	5.0	11.55	249.9		
		1118:00	15	5.0	11.55	267.2		
		1119:00	16	5.0	11.55	284.3		
		1120:00	17	5.0	11.55	301.3		
		1121:00	18	5.0	11.55	318.2		
		1122:00	19	5.0	11.55	335.0		
		1123:00	20	5.0	11.55	352.0		
		1124:00	21	5.0	11.55	368.6		
		1125:00	22	5.0	11.55	385.2		
		1126:00	23	5.0	11.55	401.6		
		1127:00	24	5.0	11.55	417.9		
		1128:00	25	5.0	11.55	434.1		
		1129:00	26	5.0	11.55	450.4		
		1130:00	27	5.0	11.55	466.6		
		1131:00	28	5.0	11.55	482.8		
		1132:00	29	5.0	11.55	498.6		
		1133:00	30	5.0	11.55	513.3		

Appendix I-5. -- Pressure-injection test data. (cont)

Hole No. CNC-1 Test No. 15 Total depth 400.0 feet, uncased interval 60.7' to 400.0' below MP

Air Released: yes X No ____ Measuring point: top of casing 0.7' above land surface

Date Mo	Day	Hour	Elapsed time (min)	Applied Pressure (psi)	Applied Pressure (Feet of water)*	Input Volume (gal)	Depth to Water (ft)**	Comments
11	4	1134:00	31	5.0	11.55	529.9		
		1135:00	32	5.0	11.55	545.5		
		1136:00	33	5.0	11.55	561.1		
		1136:50	33.8	55.0	127.05	567.2		
		1137:00	34	32.0	73.92			
		1138:00	35	29.8	68.84			
		1139:00	36	27.5	63.53			
		1140:00	37	25.9	59.83			
		1141:00	38	24.5	56.60			
		1142:00	39	23.0	53.13			
		1143:00	40	21.5	49.67			
		1144:00	41	20.2	46.66			
		1145:00	42	19.8	45.74			
		1146:00	43	18.9	43.66			
		1147:00	44	17.5	40.43			
		1148:00	45	17.0	39.27			
		1149:00	46	16.0	36.96			
		1150:00	47	15.2	35.11			
		1151:00	48	14.2	32.80			
		1152:00	49	13.7	31.65			
		1153:00	50	13.0	30.03			
		1154:00	51	12.3	28.40			
		1155:00	52	11.9	27.50			
		1156:00	53	11.2	25.87			
		1157:00	54	10.9	25.18			
		1200:00	57				0.12	
		1215:00	72				0.14	
		1230:00	87				0.17	

* above measuring point
** below measuring point

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Appendix I-5. -- Pressure-injection test data.

Hole No. CNC-4 Test No. 1 Total depth 26.7 feet, uncased interval 50.6' to 53.3' below MP

Air Released: yes X No ____ Measuring point: top of casing 0.8' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
11	24	1115:00	0	0	0	0		
		1116:00	1	4.0	9.24	5.0		
		1117:00	2	4.0	9.24	9.8		
		1118:00	3	5.0	11.55	15.5		
		1119:00	4	6.3	14.55	24.4		
		1120:00	5	8.1	18.71	32.4		Packer seal broken
		1140:00	25				14.30	
		1150:00	35				14.50	
		1200:00	45				14.45	
		1220:00	65				14.60	
		1230:00	75				14.63	
		1245:00	90				14.65	

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNC-6 Test No. 1 Total depth 21.3 feet, uncased interval 93.6' to 96.3' below MP

Air Released: yes x no ____ Measuring point: top of casing 0.5' above land surface

Date Mo	Day	Hour	Elapsed time (min)	Applied Pressure (psi)	Applied Pressure (Feet of water)*	Input Volume (gal)	Depth to Water (ft) **	Comments
12	2	1114:00	0	0	0		0	
		1115:00	1	2.0	4.62	5.90		
		1116:00	2	2.0	4.62	11.30		
		1117:00	3	2.0	4.62	16.50		
		1118:00	4	2.0	4.62	21.70		
		1119:00	5	2.0	4.62	26.90		
		1120:00	6	50.0	115.50	31.50		
		1121:00	7	1.0	2.31			
		1124:00	10				0.15	
		1125:00	11				0.16	
		1126:00	12				0.17	
		1127:00	13				0.18	
		1128:00	14				0.19	
		1129:00	15				0.19	
		1130:00	16				0.20	
		1131:00	17				0.20	
		1132:00	18				0.21	
		1133:00	19				0.21	
		1134:00	20				0.21	
		1139:00	25				0.24	
		1144:00	30				0.28	
		1149:00	35				0.30	
		1154:00	40				0.33	
		1159:00	45				0.36	
		1204:00	50				0.39	
		1209:00	55				0.41	
		1214:00	60				0.45	

* above measuring point

** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNC-6 Test No. 2 Total depth 50.3 feet, uncased interval 93.6' to 96.3' below MP

Air Released: yes X No ____ Measuring point: top of casing 0.5' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
12	3	1052:00	0	0	0		0	
		1053:00	1	1	2.31	11.60		
		1054:00	2	1	2.31	23.20		
		1055:00	3	1	2.31	34.40		
		1056:00	4	1	2.31	47.40		
		1057:00	5	2	4.62	58.10		
		1058:00	6	20.0	46.20	76.80		
		1059:00	7	19.0	43.89	95.60		
		1100:00	8	15.0	34.65	112.70		
		1101:00	9	17.0	39.27	130.70		
		1102:00	10	17.5	40.43	150.50		
		1103:00	11	17.8	41.12	170.00		
		1104:00	12	17.5	40.43	189.70		
		1105:00	13	17.2	39.73	209.40		
		1106:00	14	17.4	40.19	229.20		
		1107:00	15	17.0	39.27	248.70		
		1108:00	16	17.0	39.27	267.90		
		1110:00	18				1.45	
		1110:30	18.5				2.21	
		1111:00	19.0				2.78	
		1111:30	19.5				3.60	
		1112:00	20				4.32	
		1113:00	21				5.45	
		1114:00	22				6.40	
		1115:00	23				7.30	
		1116:00	24					
		1117:00	25				8.30	
		1118:00	26				8.70	
		1119:00	27				9.04	
		1120:00	28				9.38	
		1122:00	30				9.89	

Appendix I-5. -- Pressure-injection test data. (cont)

Hole No. CNC-6 Test No. 2 Total depth 50.3 feet, uncased interval 93.6' to 96.3' below MP

Air Released: yes x No ____ Measuring point: top of casing 0.5' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	Comments
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	
12	3	1124:00	32				10.22	
		1125:00	34				10.48	
		1128:00	36				10.71	
		1131:00	39				11.00	
		1134:00	42				11.25	
		1137:00	45				11.45	
		1140:00	48				11.60	
		1143:00	51				11.75	
		1147:00	55				11.91	
		1151:00	59				12.04	
		1155:00	63				12.16	
		1159:00	67				12.27	
		1203:00	71				12.37	
		1218:00	86				12.69	
		1241:00	109				13.20	

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNP-8 Test No. 1 Total depth 54.0 feet, uncased interval 51.3' to 54.0' below MP

Air Released: yes ____ No X Measuring point: top of casing 2.15 above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
12	8	1230:00	0	0	0	0	27.65	
		1231:00	1.0	21.2	48.97	10.0		
		1235:00	5.0	3.0	6.93	10.1		
		1235:36	5.6	40.0	92.4	22.4		repressure
		1236:00	6.0	18.0	41.58			
		1236:10	6.17	15.0	34.65			
		1236:20	6.3	13.0	30.03			
		1236:30	6.5	11.0	25.41			
		1236:40	6.67	9.5	21.95			
		1236:50	6.83	8.5	19.64			
		1237:00	7.0	7.9	18.25			
		1237:10	7.17	7.0	16.17			
		1237:20	7.3	6.5	15.02			
		1237:30	7.5	6.0	13.86			
		1237:40	7.67	5.8	13.40			
		1237:50	7.83	5.2	12.01			
		1238:00	8.0	5.0	11.55			
		1238:10	8.17	4.9	11.32			
		1238:20	8.3	4.8	11.09			
		1238:30	8.5	4.5	10.40			
		1238:40	8.67	4.2	9.70			

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNP-8A   Test No. 1   Total depth 19.5 feet, uncased interval 16.8' to 19.5' below MP

Air Released: yes ____ No __X__   Measuring point: top of casing 4.45' above land surface

Date: Mo	Date: Day	Date: Hour	Elapsed time (min)	Applied Pressure (psi)	Applied Pressure (Feet of water)*	Input Volume (gal)	Depth to Water (ft)**	Comments
12	8	1214:00	0	0			0	
		1215:00	1	11.5	26.57	15.40		
		1216:00	2	12.0	27.72	29.60		
		1217:00	3	11.8	27.26	43.40		
		1218:00	4	14.0	32.34	56.90		
		1219:00	5	15.0	34.65	70.00		
		1220:00	6	19.8	45.74	83.80		
		1221:00	7	25.0	57.75	97.10		
		1221:02	7.03	0				
		1223:15	9.2				0	

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data.

Hole No. CNS-4 Test No. 1 Total depth 50.0 feet, uncased interval 47.3'to 50.0' below MP

Air Released: yes ____ No __X__ Measuring point: top of casing 1.64' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
12	14	1412:00	0	0	0		42.30	
		1413:00	1	42.0	97.02	6.7		
		1413:20	1.3	36.0	83.16			
		1413:40	1.7	31.9	73.69			
		1414:00	2	29.2	67.45			
		1414:20	2.3	27.0	62.37			
		1414:40	2.7	25.4	58.67			
		1415:00	3	24.3	56.13			
		1415:20	3.3	23.5	54.28			
		1415:40	3.7	22.3	51.51			
		1416:00	4	21.8	50.35			
		1416:20	4.3	21.1	48.74			
		1416:40	4.7	20.9	48.27			
		1417:00	5	20.2	47.00			
		1417:20	5.3	20.0	46.20			
		1417:40	5.7	19.8	45.73			
		1418:00	6	19.2	44.35			
		1418:20	6.3	19.0	43.89			
		1418:40	6.7	18.8	43.42			
		1419:00	7	18.5	42.73			
		1419:20	7.3	18.0	41.58			
		1419:40	7.7	17.9	41.34			
		1420:00	8	17.5	40.42			
		1420:20	8.3	17.2	39.73			
		1420:40	8.7	17.0	39.27			
		1421:00	9	16.9	39.03			
		1423:00	11				17.72	
		1425:00	13				17.85	
		1426:00	14				17.96	

Hole No. CNS-4 Test No. 1 Total depth 50.0 feet, uncased interval 47.3' to 50.0' below MP

Air Released: yes ____ No _x__ Measuring point: top of casing 1.64' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	Comments
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	
12	14	1427:00	15				18.03	
		1428:00	16				18.14	
		1430:00	18				18.30	
		1432:00	20				18.46	
		1434:00	22				18.64	
		1436:00	24				18.84	
		1438:00	26				19.04	
		1440:00	28				19.28	
		1445:00	33				21.05	
		1450:00	38				21.09	
		1455:00	43				22.37	
		1500:00	48				23.90	

* above measuring point
** below measuring point

Appendix I-5. -- Pressure-injection test data. (cont)

Hole No. CNS-30 Test No. 1 Total depth 74. 5 feet, uncased interval 71.8' to 74.5' below MP

Air Released: yes _____ No __x__ Measuring point: top of casing 1.32' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
12	14	1307:00	0	0			37.29	
		1308:00	1	45.0	103.95	6.5		
		1308:20	1.3	33.0	76.23			
		1308:40	1.7	27.4	63.29			
		1309:00	2	24.5	56.60			
		1309:20	2.3	21.5	49.67			
		1309:40	2.7	19.4	44.81			
		1310:00	3	17.7	40.89			
		1310:20	3.3	16.1	37.19			
		1310:40	3.7	15.0	34.65			
		1311:00	4	14.0	32.34			
		1311:20	4.3	13.1	30.26			
		1311:40	4.7	12.5	28.88			
		1312:00	5	12.0	27.72			
		1312:20	5.3	11.2	25.87			
		1312:40	5.7	10.8	24.95			
		1313:00	6	10.2	23.56			
		1313:20	6.3	9.9	22.87			
		1313:40	6.7	9.7	22.41			
		1314:00	7	9.2	21.25			
		1314:20	7.3	9.0	20.79			
		1314:40	7.7	8.5	19.64			
		1315:00	8	8.2	18.94			
		1315:20	8.3	8.0	18.48			
		1315:40	8.7	7.9	18.25			
		1316:00	9	7.6	17.56			
		1316:20	9.3	7.2	16.63			
		1316:40	9.7	7.1	16.40			
		1317:00	10	7.0	16.17			

Appendix I-3. Pressure injection test data.

Hole No. CNS-30 Test No. 1 Total depth 74.5 feet, uncased interval 71.8' to 74.5' below MP

Air Released: yes _____ No _X___ Measuring point: top of casing 1.32' above land surface

Date			Elapsed	Applied Pressure		Input	Depth to Water	
Mo	Day	Hour	time (min)	(psi)	(Feet of water)*	Volume (gal)	(ft)**	Comments
12	14	1317:20	11.3	6.9	15.94			
		1317:40	11.7	6.5	15.02			
		1318:00	12	6.4	14.78			
		1318:20	12.3	6.1	14.09			
		1318:40	12.7	6.0	13.86			
		1319:20	13	5.9	13.63			
		1320:36	1					
		1321:00	14					
		1322:00	15				25.79	
		1323:00	16				25.30	
		1324:00	17				25.44	
		1326:00	19				25.57	
		1327:00	20				25.71	
		1328:00	21				25.84	
		1329:00	22				25.99	
		1330:00	23				26.10	
		1331:00	24				25.25	
		1332:00	25				26.37	
		1333:00	26				26.48	
		1334:00	27				26.62	
		1335:00	28				26.74	
		1336:00	29				26.86	
		1337:00	30				26.98	
		1345:00	38				27.89	
		1350:00	43				28.05	

* above measuring point
** below measuring point

Appendix I-6.--Air Pressure at Cimmaron, New Mexico

Appendix I-6. -- Air pressure at Cimarron, New Mexico

Date	Hour	Barometer (in Hg)
11- 5-76	1800	30.13
11- 6-76	0000	30.13
	0600	30.12
	1200	30.15
	1800	30.30
11- 7-76	0000	30.41
	0600	30.42
	1200	30.42
	1800	30.33
11- 8-76	0000	30.30
	0600	30.20
	1200	30.15
	1800	30.11
11- 9-76	0000	30.11
	0600	30.10
	1200	30.09
	1800	30.07
11-10-76	0000	30.14
	0600	30.09
	1200	30.02
	1800	29.94
11-11-76	0000	30.03
	0600	30.07
	1200	30.10
	1800	30.10
11-12-76	0000	30.12
	0600	30.16
	1200	30.16
	1800	30.16
11-13-76	0000	30.14
	0600	30.09
	1200	29.97
	1800	29.93
11-14-76	0000	29.89
	0600	29.90
	1200	29.85
	1800	29.82
11-15-76	0000	29.87
	0600	29.93
	1200	29.97
	1800	29.98
11-16-76	0000	29.98
	0600	30.04
	1200	30.16
	1800	30.22

Appendix I-6. -- Air pressure at Cimarron, New Mexico (cont)

Date	Hour	Barometer (in Hg)
11-17-76	0000	30.26
	0600	30.26
	1200	30.22
	1800	30.21
11-18-76	0000	30.18
	0600	30.10
	1200	30.03
	1800	29.99
11-19-76	0000	30.04
	0600	30.00
	1200	29.92
	1800	29.93
11-20-76	0000	30.00
	0600	30.03
	1200	29.97
	1800	30.02
11-21-76	0000	30.17
	0600	30.20
	1200	30.14
	1800	30.13
11-22-76	0000	30.13
	0600	30.10
	1200	30.05
	1800	30.02
11-23-76	0000	30.07
	0600	30.16
	1200	30.19
	1800	30.17
11-24-76	0000	30.18
	0600	30.14
	1200	30.09
	1800	30.02
11-25-76	0000	29.94
	0600	29.83
	1200	29.71
	1800	29.66
11-26-76	0000	29.62
	0600	29.58
	1200	29.63
	1800	29.87
11-27-76	0000	29.94
	0600	29.95
	1200	29.95
	1800	29.96

Appendix I-6. -- Air pressure at Cimarron, New Mexico (cont)

Date	Hour	Barometer (in Hg)
11-28-76	0000	29.98
	0600	29.98
	1200	29.99
	1800	29.97
11-29-76	0000	30.00
	0600	29.99
	1200	30.00
	1800	30.07
11-30-76	0000	30.12
	0600	30.10
	1200	30.06
	1800	29.97
11- 1-75	0000	30.03
	0600	30.17
	1200	30.23
	1800	30.26
12- 2-76	0000	30.25
	0600	30.26
	1200	30.22
	1800	30.12
12- 3-76	0000	30.09
	0600	30.07
	1200	30.07
	1800	30.06
12- 4-76	0000	30.08
	0600	30.07
	1200	30.06
	1800	29.97
12- 5-76	0000	29.96
	0600	29.86
	1200	29.80
	1800	29.90
12- 6-76	0000	30.00
	0600	29.97
	1200	30.02
	1800	30.02
12- 7-76	0000	29.96
	0600	29.93
	1200	30.02
	1800	30.03
12- 8-76	0000	30.04
	0600	30.01
	1200	30.00
	1800	29.96

Appendix I-6. -- Air pressure at Cimarron, New Mexico (cont)

Date	Hour	Barometer (in Hg)
12- 9-76	0000	29.93
	0600	29.86
	1200	29.83
	1800	29.87
12-10-76	0000	29.91
	0600	30.02
	1200	30.15
	1800	30.18
12-11-76	0000	30.18
	0600	30.12
	1200	30.09
	1800	30.03
12-12-76	0000	30.02
	0600	30.16
	1200	30.22
	1800	30.24
12-13-76	0000	30.28
	0600	30.21
	1200	30.11
	1800	30.08
12-14-76	0000	30.04
	0600	30.01
	1200	30.05
	1800	30.08
12-15-76	0000	30.07
	0600	30.08
	1200	30.15
	1800	30.19
12-16-76	0000	30.23
	0600	30.17
	1200	30.13
	1800	30.14
12-17-76	0000	30.13
	0600	30.10
	1200	30.02
	1800	29.97
12-18-76	0000	29.97
	0600	29.93
	1200	29.89
	1800	29.88
12-19-76	0000	29.92
	0600	29.98
	1200	30.05
	1800	30.15

Appendix I-6. -- Air pressure at Cimarron, New Mexico (cont).

Date	Hour	Barometer (in Hg)
12-20-76	0000	30.23
	0600	30.25
	1200	30.18
	1800	30.16
12-21-76	0000	30.11
	0600	30.03
	1200	29.92
	1800	29.84
12-22-76	0000	29.91
	0600	29.95
	1200	29.99
	1800	29.99
12-23-76	0000	30.04
	0600	30.06
	1200	30.00
	1800	29.90
12-24-76	0000	29.85
	0600	29.76
	1200	29.74
	1800	29.76
12-25-76	0000	29.89
	0600	29.98
	1200	30.03
	1800	30.08
12-26-76	0000	30.10
	0600	30.09
	1200	30.09
	1800	30.02
12-27-76	0000	29.99
	0600	29.84
	1200	29.69
	1800	29.79
12-28-76	0000	29.88
	0600	29.97
	1200	29.97
	1800	29.93
12-29-76	0000	29.92
	0600	29.87
	1200	29.79
	1800	29.72
12-30-76	0000	29.68
	0600	29.66
	1200	29.78
	1800	29.80

Appendix I-6. -- Air pressure at Cimarron, New Mexico (cont)

Date	Hour	Barometer (in Hg)
12-31-76	0000	29.80
	0600	29.75
	1200	29.70
	1800	29.75
1- 1-77	0000	29.82
	0600	29.86
	1200	29.82
	1800	29.82
1- 2-77	0000	29.81
	0600	29.80
	1200	29.80
	1800	29.81
1- 3-77	0000	29.81
	0600	29.70
	1200	29.61
	1800	29.56
1- 4-77	0000	29.59
	0600	29.68
	1200	29.73
	1800	29.81

Appendix I-7.--Stream Flow Measurements

Appendix I-7. -- Stream-flow measurements for VB-1

Date	Hour	Discharge CFS	Discharge GPM	Comments
10-22-76	1230	.039	17.5	installed 90°v-north weir
10-23-76		.045	20.2	breached
10-24-76	1350	.039	17.5	breached
10-25-76		.051	22.9	breached
10-26-76		.057	25.6	breached
10-27-76		.078	35.0	stabilized
10-28-76	1045	.086	38.6	stabilized
10-29-76		.086	38.6	
10-30-76		.086	38.6	
10-31-76		.086	38.6	
11- 1-76		.086	38.6	
11- 2-76		.095	42.6	
11- 3-76		.095	42.6	
11- 4-76		.095	42.6	
11- 5-76		.096	42.6	
11- 6-76		.095	42.6	
11- 7-76		.095	42.6	
11- 8-76		.095	42.6	
11- 9-76		.095	42.6	
11-10-76		.095	42.6	
11-11-76		.095	42.6	
11-12-76		.095	42.6	freezing
11-13-76		.104	46.7	snowing
11-14-76		.134	60.1	frozen with runoff
11-15-76		.134	60.1	runoff
11-16-76		.123	55.2	
11-17-76		.113	50.7	
11-18-76		.113	50.7	
11-19-76		.094	42.6	run over by dozer rebuilt dam
11-20-76		.113	50.7	breached
11-21-76		.113	50.7	breached
11-22-76		.113	50.7	breached
11-23-76		.113	50.7	breached
12- 2-76		---	---	frozen - 2 inch ice

Appendix I-7. -- Stream-flow measurements for VB-2.

Date	Hour	Discharge CFS	Discharge GPM	Comments
10-13-76		.015	6.73	extreme underflow
10-15-76	1230	.026	11.7	dam breached and repaired less underflow
10-16-76		.026	11.7	dam breached and repaired less underflow
10-17-76		.026	11.7	dam breached and repaired less underflow
10-18-76		.026	11.7	dam breached and repaired less underflow
10-19-76	1615	.104	46.7	underflow reduced
10-21-76		.104	46.7	
10-22-76		.104	46.7	
10-23-76		.104	46.7	
10-24-76		.104	46.7	
10-25-76	1342	.108	48.5	
10-26-76		.113	50.7	
10-27-76		.113	50.7	
10-28-76	1025	.113	50.7	
10-29-76		.113	50.7	
10-30-76		.104	46.7	
10-31-76		.104	46.7	
11- 1-76		.104	46.7	
11- 2-76		.113	50.7	
11- 3-76		.104	46.7	
11- 4-76		.113		
11- 5-76		.113	50.7	
11- 6-76		.113	50.7	
11- 7-76		.113	50.7	
11- 8-76		.118	53.0	
11 -9-76		.113	50.7	
11-10-76		.113	50.7	
11-11-76		.113	50.7	
11-12-76		.118	53.0	
11-13-76		.118	53.0	frozen
11-14-76		.145	65.1	
11-15-76		.145	65.1	breached
11-16-76		.123	55.2	breached
11-17-76		.113	50.7	breached
11-18-76		.086	38.6	breached

Appendix I-7. -- Stream-flow measurements for VB-2

Date	Hour	Discharge CFS	Discharge GPM	Comments
11-19-76		.095	42.6	breached
11-20-76		.095	42.6	breached
11-21-76		.095	42.6	breached
11-22-76		.104	46.7	breached
11-23-76		.095	42.6	breached
12- 2-76		--	--	frozen - 2 inch ice

Appendix I-7. -- Stream-flow measurements for VB-3

Date	Hour	Discharge CFS	Discharge GPM	Comments
10-13-76		.030	13.5	built dam
10-14-76		.030	13.5	dam smashed by cattle rebuilt
10-15-76		.030	13.5	dam smashed by cattle rebuilt
10-16-76	1045	.034	15.3	dam smashed by cattle rebuilt
10-17-76		.034	15.3	
10-18-76		.030	13.5	
10-19-76	1530	.026	11.7	dam smashed by cattle rebuilt
10-21-76		.030	13.5	
10-22-76		.026	11.7	dam smashed by cattle rebuilt
10-23-76		.026	11.7	
10-24-76		.030	13.5	
10-25-76	1320	.034	15.3	rebuilt dam
10-26-76		.030	13.5	rebuilt dam
10-27-76		.030	13.5	rebuilt dam
10-28-76	1010	.032	14.4	rebuilt dam
10-29-76		.030	13.5	rebuilt dam
10-30-76		.026	11.7	rebuilt dam
10-31-76		.026	11.7	rebuilt dam
11- 1-76		.026	11.7	
11- 2-76		.030	13.5	
11- 3-76		.026	11.7	
11- 4-76		.030	13.5	
11- 5-76		.045	20.2	cows gone-dam holding
11- 6-76		.039	17.5	cows gone-dam holding
11- 7-76		.039	17.5	cows gone-dam holding
11- 8-76		.034	15.3	cows broke dam
11- 9-76		.034	15.3	cows broke dam
11-10-76		.034	15.3	cows broke dam
11-11-76		.039	17.5	cows broke dam
11-12-76		.039	17.5	dam bolding-not breached
11-13-76		.057	25.6	frozen
11-14-76		.145	65.0	dam badly breached couldn't keep up with water level
11-15-76		.134	60.1	
11-16-76		.063	28.3	
11-17-76		.045	20.2	
11-18-76		.057	25.6	stable-cows removed from pasture

Appendix I-7. -- Stream-flow measurements for VB-3 (cont)

Date	Hour	Discharge CFS	Discharge GPM	Comments
11-19-76		.078	35.0	
11-20-76		.063	28.3	breached
11-21-76		.063	28.3	breached
11-22-76		.057	25.6	breached
11-23-76		.057	25.6	breached
12- 2-76				frozen breached
12-28-76		.071	31.9	
12-29-76	1550	.086	38.6	
12-30-76	1420	.086	38.6	

Appendix I-7. -- Stream-flow measurements for VB-4

Date	Hour	Discharge CFS	Discharge GPM	Comments
10-14-76	1630	.057	25.6	installed 1630
10-15-76		.060	26.9	
10-16-76	1337	.060	26.9	
10-17-76		.060	26.9	
10-18-76		.060	26.9	
10-19-76	1815	.060	26.9	
10-21-76	1830	.060	26.9	
10-22-76		.060	26.9	
10-23-76		.060	26.9	
10-24-76	1700	.060	26.9	
10-25-76		.060	26.9	
10-26-76		.060	26.9	
10-27-76		.060	26.9	
10-28-76		.060	26.9	
10-29-76		.060	26.9	
10-30-76		.060	26.9	
10-31-76		.060	26.9	
11- 1-76		.060	26.9	
11- 2-76		.057	25.6	
11- 3-76		.057	25.6	
11- 4-76		.057	25.6	
11- 5-76		.057	25.6	
11- 6-76		.057	25.6	
11- 7-76		.060	26.9	
11- 8-76		.060	26.9	
11- 9-76		.057	25.6	
11-10-76		.057	25.6	
11-11-76		.057	25.6	
11-12-76		.063	28.3	freezing and snowing
11-13-76		.067	30.1	snowing
11-14-76		.134	60.1	melted snow runoff
11-15-76		.123	55.2	
11-16-76		.071	31.9	
11-17-76		.063	28.3	
11-18-76		.057	25.6	
11-19-76		.057	25.6	
11-20-76		.054	24.2	
11-21-76		.051	22.9	
11-22-76		.045	20.2	
11-23-76		.045	20.2	
12- 2-77				frozen - 2 inch ice
12- 3-77				frozen - 2 inch ice

Appendix I-7. -- Stream-flow measurements for VV-1

Date	Hour	Discharge CFS	Discharge GPM	Comments
10-24-76		.403	180.9	installed 90°v-north weir - below Vermejo River
10-25-76		.403	180.9	washed out
10-26-76		.403	180.9	washed out
10-27-76		.403	180.9	weir gone
11-18-76		.336	150.8	installed 120°v notch large amount of under-flow
11-19-76		.315	141.4	washed out
11-20-76		.336	150.8	washed out
11-21-76		.336	150.8	washed out
11-22-76		.347	155.8	staked in
11-23-76		.357	160.2	washed out-replaced
12- 2-76		.269	120.7	breached
12- 3-76		.315	141.4	breached
12- 4-76		.315	141.4	extreme underflows
12- 5-76		.315	141.4	extreme underflows frozen
12- 6-76		.315	141.4	extreme underflows frozen
12- 7-76		.315	141.4	extreme underflows frozen
12- 8-76		.315	141.4	extreme underflows frozen

Appendix I-7. -- Strem-flow measurements for VV-2.

Date	Hour	Discharge CFS	GPM	Comments
11-17-76		.192	86.2	installed 120°v-north weir - 300' N of Road Bridge (U.S. 64)E of Colfax
11-18-76		.192	86.2	very rapid river
11-19-76		.192	86.2	
11-20-76		.178	79.9	
11-21-76		.192	86.2	
11-22-76		.192	86.2	
11-23-76		.192	86.2	
12- 2-76		.164	73.2	slight freezing-not breached
12- 3-76		.164	73.2	slight freezing-not breached
12- 4-76		.164	73.2	slight freezing-not breached
12- 5-76		.178	79.9	slight freezing-not breached
12- 6-76		.164	73.2	slight freezing-not breached
12- 7-76		--	--	frozen

Appendix I-8.--In-situ Temperature and Conductivity

Appendix I-8.--In-situ temperature and conductivity--CNC-3(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (µmhos) obs	Conductivity (µmhos) @ 25°C	Comments
8	6223 water level				slug tested 12-18-76
	~6222.5	11.5	1520	2006	end of point
23	6223 water level				
	6221	12.9	1130	1442	end of point

Appendix I-8.--In-situ temperature and conductivity--CNC-4.

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (μmhos)		Comments
			obs	@ 25°C	
23	6241 water level				
	6240	12.4	720	929	end of point

Appendix I-8.--In-situ temperature and conductivity--CNC-6.

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (μmhos) obs	Conductivity (μmhos) @ 25°C	Comments
28	6190	water level			slug tested 12-6-76
	6188	13.3	3510	4437	
	6185	13.8	3590	4487	
	6180	13.9	3600	4490	
	6175	14.0	3620	4505	
	6170	14.0	3650	4542	
	6165	14.0	3650	4542	
	6160	14.0	3680	4579	
	6155	14.1	3700	4594	
	6150	14.1	3700	4594	
	6145	14.2	3700	4584	
	6140	14.2	3700	4584	
	6135	14.3	3710	4586	
	6130	14.5	3750	4616	end of point

Appendix I-8.--In-situ temperature and conductivity--CNC-7(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (umhos) obs	Conductivity (umhos) @ 25°C	Comments
8	6179	water level			slug tested 12-9-76
	6177	12.8	1290	1649	
	6174	13.5	1310	1648	
	6169	14.0	1320	1642	
	6164	14.2	1910	2366	
	6159	14.2	2010	2490	
	6157	14.3	2070	2558	end of point
23	6179	water level			
	6177	13.0	510	649	
	6174	13.1	610	775	
	6169	13.2	680	864	
	6164	13.2	820	1039	
	6159	13.2	870	1102	end of point
28	6178	water level			
	6176	13.2	660	836	
	6173	13.2	660	836	
	6168	13.2	690	876	
	6163	13.2	700	887	
	6159	13.5	820	1032	

Appendix I-8.--In-situ temperature and conductivity--CNG-2(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (μmhos) obs	Conductivity (μmhos) @ 25°C	Comments
8	6196	water level			slug tested 12-17-76
	6194	14.0	1750	2177	
	6191	14.1	1780	2210	
	6186	14.2	1810	2242	
	6181	14.2	1810	2242	
	6176	14.2	1800	2230	end of point
23	6196	water level			
	6194	13.1	308	391	
	6191	13.2	480	608	
	6186	13.2	1050	1330	
	6181	13.5	1030	1296	end of point

Appendix I-8.--In-situ temperature and conductivity--CNP-2(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (μmhos) obs	Conductivity (μmhos) @ 25°C	Comments
23	6186	water level			
	6184	13.3	1110	1403	
	6181	13.4	1120	1413	
	6176	13.3	1160	1466	
	6171	13.3	1290	1631	
	6166	13.3	1290	1631	
	6161	13.5	1300	1636	
	6156	13.6	1300	1632	
	6151	13.7	1310	1641	
	6146	13.7	1310	1641	
	6141	13.8	1320	1650	
	6136	13.8	1330	1662	
	6131	13.8	1330	1662	
	6126	13.8	1330	1662	
	6121	13.9	1330	1659	
	6116	14.0	1470	1829	
	6111	14.0	1510	1879	
	6106	14.1	1620	2011	
	6101	14.1	1680	2086	
28	6186	water level			
	6184	13.9	910	1135	
	6181	13.9	910	1135	
	6176	13.8	990	1237	
	6171	13.5	1090	1372	
	6166	13.8	1110	1387	
	6161	13.8	1140	1425	
	6156	13.8	1150	1437	
	6151	13.8	1150	1437	
	6146	13.9	1150	1434	
	6141	13.9	1170	1459	
	6136	13.9	1170	1459	
	6131	14.0	1190	1481	
	6126	14.0	1200	1493	
	6121	14.0	1200	1493	
	6116	14.0	1210	1506	
	6111	14.0	1320	1643	
	6106	14.0	1450	1804	
	6101	14.1	1490	1850	

Appendix I-8.--In-situ temperature and conductivity--CNP-3.

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (µmhos) obs	Conductivity (µmhos) @ 25°C	Comments
8	6138	water level			slug tested 11-19-76
	6136	14.8	1150	1406	
	6133	15.0	1500	1826	
	6128	15.0	2400	2922	end of point
23	6138	water level			
	6136	13.7	380	476	
	6133	13.9	680	848	
	6128	14.0	1600	1991	end of point
28	6138	water level			
	6136	13.9	310	387	
	6131	14.0	452	562	
	6126	14.0	1200	1493	
	6123	14.0	1100	1369	end of point

Appendix I-8.--In-situ temperature and conductivity--CNP-3B.

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (μmhos) obs	Conductivity (μmhos) @ 25°C	Comments
8	6185	water level			slug tested 12-15-76
	6183	14.3	2150	2657	
	6180	14.5	2150	2646	
	6175	14.5	2110	2597	
	6170	14.5	2100	2584	
	6165	14.6	2090	2567	
	6160	14.8	2080	2543	
	6155	14.8	2080	2543	
23	6183	water level			
	6181	13.2	270	342	
	6178	13.3	395	499	
	6173	13.4	1360	1715	
	6168	13.5	1360	1711	
	6163	13.6	1360	1707	
	6158	13.7	1350	1691	
	6153	13.8	1350	1687	
	6151	13.8	1350	1687	
28	6183	water level			
	6181	13.3	245	310	
	6178	13.5	418	526	
	6173	13.5	1000	1258	
	6168	13.5	1000	1258	
	6163	13.8	1010	1262	
	6158	13.9	1010	1260	
	6153	13.9	1010	1260	
	6151	13.9	1010	1260	

Appendix I-8.--In-situ temperature and conductivity--CNP-4.

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (µmhos) obs	Conductivity (µmhos) @ 25°C	Comments
8	6175	water level			slug tested 11-16-76
	6173	13.8	1310	1637	
	6170	14.0	3000	3733	
	6165	14.2	7000	8672	
	6160	14.6	7000	8597	
	6155	14.8	7100	8683	
	6150	14.8	7500	9172	
	6145	14.8	8100	9906	
	6140	14.8	8100	9906	
23	6175	water level			
	6173	13.5	1560	1963	
	6170	13.7	5300	6639	
	6165	13.8	6800	8499	
	6160	13.8	6900	8624	
	6155	13.9	7050	8792	
	6150	14.0	7900	9830	
	6145	14.0	7900	9830	
	6140	14.0	7900	9830	
	6135	14.0	7850	9768	
28	6175	water level			
	6173	13.1	1450	1841	
	6170	13.5	2470	3108	
	6165	13.7	5100	6389	
	6160	13.9	5900	7358	
	6155	13.9	6000	7483	
	6150	14.0	6500	8088	
	6145	14.0	6800	8462	
	6140	14.0	6900	8586	
	6135	14.0	6900	8586	

Appendix I-8.--In-situ temperature and conductivity--CNP-4B.

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (μmhos) obs	Conductivity (μmhos) @ 25°C	Comments
8	6187	water level			slug tested 12-15-76
	6185	14.5	2500	3077	
	6182	14.6	2500	3070	
	6177	14.6	2500	3070	
	6172	14.6	2600	3193	end of point
23	6187	water level			
	6185	13.2	320	405	
	6182	13.5	320	403	
	6177	13.5	1550	1950	
	6172	13.8	1550	1937	
	6169	13.8	1590	1987	end of point
28	6187	water level			
	6185	13.1	310	394	
	6182	13.5	492	619	
	6177	13.8	1380	1725	
	6172	13.9	1380	1721	
	6167	14.0	1540	1916	
	6165	14.0	1500	1867	end of point

Appendix I-8.--In-situ temperature and conductivity--CNP-5.

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (μmhos) obs	Conductivity (μmhos) @ 25°C	Comments
8	6169	water level			slug tested 12-4-76
	6167	14.8	1680	2055	
	6164	14.8	1680	2055	
	6159	14.8	5000	6115	
	6154	14.8	5000	6115	
	6149	14.8	5100	6237	
	6144	14.8	5100	6237	
	6142	14.8	5100	6237	end of point
23	6169	water level			
	6167	13.2	1720	2179	
	6164	13.8	1720	2150	
	6159	13.9	4600	5737	
	6154	13.9	4620	5762	
	6149	13.9	4620	5762	
	6145	14.0	4650	5786	end of point
28	6170	water level			
	6168	13.5	1520	1913	
	6165	13.9	1610	2008	
	6160	14.0	4000	4977	
	6155	14.0	4030	5015	
	6150	14.0	4050	5040	
	6145	14.0	4060	5052	end of point

Appendix I-8.--In-situ temperature and conductivity--CNP-6(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (μmhos) obs	Conductivity (μmhos) @ 25°C	Comments
8	6131	water level			slug tested 12-6-76
	6129	12.0	13500	17597	
	6126	13.0	13900	17692	
	6121	14.0	14100	17946	
	6116	14.0	14300	17794	
	6111	13.6	14800	18580	
	6106	13.1	15100	19174	
	6101	13.1	15500	19682	
	6096	13.1	15800	20063	
	6091	13.1	15900	20190	
23	6131	water level			
	6129	9.7	12800	17732	
	6126	10.6	13100	17701	
	6121	12.8	13800	17647	
	6116	13.0	13800	17565	
	6111	12.9	14000	17861	
	6106	12.7	14200	18201	
	6101	12.4	14500	18719	
	6096	12.4	14800	19106	

Appendix I-8.--In-situ temperature and conductivity--CNP-6A(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (μmhos) obs	Conductivity (μmhos) @ 25°C	Comments
8.	6134	water level			slug tested 12-11-76
	6132	14.1	1190	1478	
	6129	14.8	1200	1468	
	6124	14.8	1210	1480	
23	6134	water level			
	6132	12.2	380	493	
	6129	13.0	385	490	

Appendix I-8.--In-situ temperature and conductivity--CNP-6B(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (μmhos) obs	Conductivity (μmhos) @ 25°C	Comments
8	6129	water level			slug tested 12-11-76
	6127	12.8	1100	1406	
	6124	13.2	1120	1418	
	6119	13.2	1150	1456	end of point
23	6136	water level			
	6134	12.8	290	371	
	6131	12.9	335	427	
	6130	12.9	680	868	end of point

Appendix I-8.--In-situ temperature and conductivity--CNP-7(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (μmhos) obs	Conductivity (μmhos) @ 25°C	Comments
8	6148	water level			slug tested 12-7-76
	6146	13.9	480	598	
	6143	13.9	790	985	end of point
23	6148	water level			
	6146	13.2	720	912	
	6141	13.3	1460	1845	

Appendix I-8.--In-situ temperature and conductivity--CNP-8(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (µmhos) obs	Conductivity (µmhos) @ 25°C	Comments
8	6096	water level			slug tested 12-7-76
	6094	12.8	1310	1675	
	6091	13.0	1320	1680	
	6086	13.0	1340	1705	
	6081	13.1	1810	2298	
	6076	13.1	2010	2552	
	6071	13.1	2100	2666	
	6069	13.1	2150	2730	end of point
23	6096	water level			
	6094	12.8	1090	1394	
	6091	12.9	1090	1391	
	6086	13.0	1080	1375	
	6081	13.0	1080	1375	
	6076	13.0	1080	1375	
	6071	13.1	2340	2971	end of point

Appendix I-8.--In-situ temperature and conductivity--CNP-9(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (μmhos) obs	Conductivity (μmhos) @ 25°C	Comments
8	6042	water level			slug tested 12-6-76
	6040	13.1	460	584	
	6033	13.5	740	931	
23	6043	water level			
	6041	12.9	270	344	
	6039	13.1	730	927	end of point

Appendix I-8.--In-situ temperature and conductivity-- CNS-2(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (μmhos) obs	Conductivity (μmhos) @ 25°C	Comments
8	6190	water level			slug tested 12-17-76
	6188	14.7	2950	3615	
	6185	14.8	3050	3730	
	6180	14.8	3650	4463	
	6175	14.8	3650	4463	
	6170	14.8	3650	4463	
	6167	14.8	3600	4403	end of point
23	6189	water level			
	6187	13.2	270	342	
	6184	13.3	720	910	
	6179	13.5	2010	2529	
	6174	13.6	2000	2511	
	6169	13.8	2000	2500	
	6164	13.8	2000	2500	end of point

Appendix I-8.--In-situ temperature and conductivity-- CNS-3(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (umhos)		Comments
			obs	@ 25°C	
8	6263	water level			slug tested 11-21-76
	6261	14.2	910	1127	
	6278	14.5	920	2006	
	6253	14.2	2100	2601	
	6248	14.3	2380	2942	
	6243	14.2	2380	2948	end of point
23	6263	water level			
	6261	13.3	460	581	
	6258	13.3	460	581	
	6253	13.2	810	1026	
	6248	13.2	890	1128	
	6246	13.2	900	1140	

Appendix I-8.--In-situ temperature and conductivity--CNS-4(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (μmhos) obs	Conductivity (μmhos) @ 25°C	Comments
8	6202	water level			slug tested 11-19-76
	6200	13.9	1050	1309	
	6297	14.0	3000	3733	
	6294	14.0	4100	5101	end of point
23	6202	water level			
	6200	13.0	830	1056	
	6297	13.1	820	1041	
	6294	13.2	1000	1267	end of point

Appendix I-8.--In-situ temperature and conductivity-- CNS-5(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (µmhos) obs	Conductivity (µmhos) @ 25°C	Comments
8	6225	water level			slug tested 11-19-76
	6223	13.9	1850	2307	slug tested 12-20-76
	6220	14.0	1900	2364	
	6215	14.1	2050	2545	
	6210	14.2	2150	2663	
	6208	14.2	2200	2725	end of point
23	6224	water level			
	6222	13.0	275	350	
	6219	13.1	900	1143	
	6214	13.2	900	1140	
	6209	13.5	910	1145	

Appendix I-8.--In-situ temperature and conductivity-- CNS-7(P).

Date December 1976	Altitude of measurement (ft)		Observed temperature (°C)	Conductivity (µmhos) obs	Conductivity (µmhos) @ 25°C	Comments
8	6246	water level				slug tested 11-17-76
	6244		13.9	1300	1621	
	6241		14.0	3000	3733	
	6240		14.0	2950	3670	end of point
23	6246	water level				
	6244		12.9	680	868	
	6239		13.1	3900	4952	end of point
28	6246	water level				
	6244		13.0	840	1069	
	6241		13.5	2642	3324	
	6238		13.5	3460	4354	end of point

Appendix I-8.--In-situ temperature and conductivity-- CNS-10(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (μmhos) obs	Conductivity (μmhos) @ 25°C	Comments
8	6201	water level			slug tested 11-22-76
	6199	14.1	1500	1862	
	6196	14.3	3010	3720	
	6194	14.3	3710	4586	end of point
23	6201	water level			
	6199	12.9	1630	2080	
	6196	13.0	3500	4465	
	6194	13.0	6000	7637	end of point
28	6201	water level			
	6199	13.2	1840	2331	
	6196	13.3	4100	5183	
	6194	13.5	6110	7688	end of point

Appendix I-8.--In-situ temperature and conductivity-- CNS-11(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (μmhos) obs	@ 25°C	Comments
8	6200	water level			slug tested 11-16-76
	6198	13.6	1600	2008	slug tested 12-20-76
	6195	13.8	1600	1999	
	6193	13.8	1600	1999	end of point
23	6200	water level			
	6198	12.5	350	451	
	6195	13.0	369	470	end of point
28	6200	water level			
	6198	13.0	360	458	
	6195	13.1	373	474	end of point

Appendix I-8.--In-situ temperature and conductivity-- CNS-12(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (μmhos) obs	Conductivity (μmhos) @ 25°C	Comments
8	6211	water level			slug tested 11-17-76
	6209	13.7	1260	1578	
	6206	13.8	1260	1574	
	6201	13.8	1710	2137	
	6196	14.0	1720	2140	
	6194	14.0	1790	2227	end of point
23	6212	water level			
	6210	12.6	390	501	
	6217	12.9	388	495	
	6202	13.0	780	993	
	6197	13.1	800	1016	
	6195	13.1	850	1079	end of point
28	6211	water level			
	6209	13.6	410	516	
	6206	13.0	510	649	
	6201	13.1	790	1003	
	6296	13.1	890	1130	
	6294	13.1	910	1156	end of point

Appendix I-8.--In-situ temperature and conductivity-- CNS-13(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (µmhos) obs	Conductivity (µmhos) @ 25°C	Comments
8	6209	water level			slug tested 12-14-76
	6207	14.1	7100	8815	end of point
23	6208	water level			
	6206	12.9	7000	8930	
	6204	12.9	6800	8675	end of point
28	6209	water level			
	6207	13.0	4180	5320	
	6205	13.1	6500	8000	end of point

Appendix I-8.--In-situ temperature and conductivity-- CNS-18(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (μmhos) obs	Conductivity (μmhos) @ 25°C	Comments
8	6213	water level			slug tested 11-21-76
	6211	14.5	1050	1292	
	6206	14.6	4500	5526	
	6203	14.6	4610	5662	
	6198	14.5	5200	6400	end of point
23	6214	water level			
	6212	13.1	370	470	
	6209	13.1	1050	1333	
	6204	13.2	3810	4827	
	6199	13.3	3820	4829	
	6197	13.3	3820	4829	

Appendix I-8.--In-situ temperature and conductivity--CNS-19p.

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (µmhos) obs	Conductivity (µmhos) @ 25°C	Comments
8	6219	water level			slug tested 11-21-76
	6217	1.8	1070	2174	
	6214	2.0	2530	5039	
	6209	3.1	4030	7348	end of point
23	6219	water level			
	6217	13.1	340	432	
	6214	13.2	1710	2166	
	6211	13.3	3090	3906	end of point

Appendix I-8.--In-situ temperature and conductivity--CNS-21(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (µmhos) obs	Conductivity (µmhos) @ 25°C	Comments
8	6218	water level			slug tested 11-22-76
	6216	13.8	1010	1262	
	6213	14.0	1010	1256	
	6208	14.0	1100	1368	
	6203	14.1	1150	1427	
	6198	14.1	1280	1589	
	6196	14.2	1320	1635	end of point
23	6217	water level			
	6215	12.8	248	317	
	6212	13.0	248	316	
	6207	13.1	253	321	
	6202	13.5	260	327	
	6197	13.7	3750	4697	
	6195	13.8	3300	4125	end of point
28	6217	water level			
	6215	13.0	265	337	
	6212	13.2	262	332	
	6207	13.5	265	252	
	6202	13.6	300	377	
	6197	13.6	3900	4896	
	6195	13.6	3090	3879	end of point

Appendix I-8.--In-situ temperature and conductivity--CNS-22(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (umhos) obs	Conductivity (umhos) @ 25°C	Comments
8	6182	water level			slug tested 11-18-76
	6180	13.8	1310	1637	
	6177	14.0	3000	3733	
	6172	14.2	7000	8672	
	6167	14.6	7000	8597	
	6162	14.8	7100	8683	
	6157	14.8	7500	9172	
	6152	14.8	8100	9906	
	6147	14.8	8100	9906	end of point
23	6181	water level			
	6179	13.0	305	388	
	6176	13.1	1290	1638	
	6173	13.2	2720	3446	end of point
28	6181	water level			
	6179	13.5	377	474	
	6176	13.2	1039	1316	
	6173	13.5	2794	3516	end of point

Appendix I-8.--In-situ temperature and conductivity-- CNS-23(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (µmhos)		Comments
			obs	@ 25°C	
8	6133	water level			slug tested 11-16-76
	6131	14.1	7000	8691	
	6128	14.5	7100	8739	
	6123	14.6	7200	6828	end of point
23	6133	water level			
	6131	13.3	410	518	
	6128	13.7	1730	2167	
	6126	13.8	3400	4250	end of point
28	6133	water level			
	6131	13.5	435	547	
	6128	13.8	1050	1312	
	6125	13.9	1950	2432	end of point

Appendix I-8.--In-situ temperature and conductivity-- CNS-25(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (μmhos) obs	Conductivity (μmhos) @ 25°C	Comments
8	6165	water level			slug tested 12-16-76
	6163	14.1	5500	6828	
	6160	14.1	5300	6580	end of point
23	6165	water level			
	6163	12.9	370	506	
	6160	13.1	1970	2685	
	6155	13.2	4250	5780	end of point
29	6165	water level			
	6163	13.0	399	508	
	6160	13.2	1300	1647	
	6155	13.2	3100	3928	
	6153	13.2	3160	4004	end of point

Appendix I-8.--In-situ temperature and conductivity-- CNS-26(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (μmhos) obs	Conductivity (μmhos) @ 25°C	Comments
8	6180	water level			slug tested 12-15-76
	6178	14.0	2000	2488	
	6175	14.1	2000	2483	end of point
23	6180	water level			
	6178	12.9	210	268	
	6173	13.2	360	456	
	6170	13.3	1180	1492	
	6165	13.5	1180	1485	end of point
29	6179	water level			
	6177	13.2	250	317	
	6174	13.2	279	354	
	6169	13.5	1000	1258	
	6164	13.5	1000	1258	end of point

Appendix I-8.--In-situ temperature and conductivity-- CNS-29(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (µmhos) obs	Conductivity (µmhos) @ 25°C	Comments
8	6197	water level			slug tested 12-10-76
	6195	12.8	1150	1470	
	6192	13.0	1180	1501	end of point
23	6196	water level			
	6194	13.0	910	1158	
	6191	13.1	970	1232	end of point
28	6196	water level			
	6194	13.0	950	1209	
	6190	13.2	990	1254	end of point

Appendix I-8.--In-situ temperature and conductivity-- CNS-30(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (µmhos)		Comments
			obs	@ 25°C	
8	6188	water level			slug tested 12-9-76
	6186	13.3	1460	1845	
	6183	13.7	1480	1853	
	6178	13.9	1520	1895	end of point
23	6188	water level			
	6186	12.9	770	982	
	6183	13.0	770	980	
	6178	13.1	780	990	
	6173	13.2	790	1003	
	6168	13.4	790	996	
	6163	13.6	800	1004	
	6158	13.7	800	1002	
	6153	13.8	805	1006	
	6149	13.8	810	1012	end of point
28	6188	water level			
	6186	13.0	790	1006	
	6183	13.1	750	952	
	6178	13.1	750	952	
	6173	13.2	750	950	
	6168	13.5	760	956	
	6163	13.5	770	969	
	6158	13.8	780	975	
	6153	13.8	780	975	
	6148	13.9	750	935	
	6144	14.0	590	734	

Appendix I-8.--In-situ temperature and conductivity--CNS-31(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (µmhos) obs	Conductivity (µmhos) @ 25°C	Comments
8	6174	water level			slug tested 12-8-76
	6172	16.1	1480	1762	slug tested 12-29-76
	6169	15.0	1410	1717	
	6164	14.5	1400	1723	
	6159	14.3	1380	1705	end of point
23	6174	water level			
	6172	13.2	1000	1267	
	6169	13.1	950	825	
	6164	13.1	960	1219	
	6162	13.1	1000	1270	end of point

Appendix I-8.--In-situ temperature and conductivity--CNS-32(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (µmhos) obs	Conductivity (µmhos) @ 25°C	Comments
8	6137	water level			slug tested 12-8-76
	6135	13.7	1390	1741	
	6132	13.9	1510	1883	
	6127	14.0	3230	4019	end of point
23	6174	water level			
	6172	12.9	1390	1773	
	6169	13.1	2210	2806	
	6164	13.2	3530	4472	
	6159	13.2	3680	4662	
	6154	13.3	3700	4677	
	6149	13.5	3710	4668	
	6144	13.5	3710	4668	
	6139	13.6	3720	4670	
	6134	13.8	3720	4649	
	6132	13.9	3600	4490	end of point
28	6174	water level			
	6172	13.1	1310	1664	
	6169	13.3	1800	2275	
	6164	13.3	3080	3893	
	6159	13.5	3280	4127	
	6154	13.6	3300	4143	
	6149	13.6	3300	4143	
	6144	13.8	3300	4125	
	6139	13.8	3300	4125	
	6134	14.0	3310	4119	end of point

Appendix I-8.--In-situ temperature and conductivity-- CNS-34(P).

Date December 1976	Altitude of measurement (ft)	Observed temperature (°C)	Conductivity (µmhos) obs	Conductivity (µmhos) @ 25°C	Comments
8	6201	water level			slug tested 12-14-76
	6199	13.8	1400	1749	
	6196	14.0	1380	1717	
	6191	14.0	1390	1729	
	6186	14.0	1400	1742	end of point
23	6201	water level			
	6199	12.9	330	421	
	6196	12.9	435	555	
	6191	13.0	830	1056	
	6186	13.1	880	1117	end of point
28	6201	water level			
	6199	13.0	380	484	
	6196	13.0	384	489	
	6191	13.1	800	1016	
	6189	13.2	870	1102	end of point

Appendix I-9.--Infiltration Studies

Appendix I-9 Infiltration Studies

A double ring infiltrometer was used to determine the infiltration rate, in inches per hour, at various locations within the proposed site. Following the completion of the infiltration test, excavation of the soil at the test site permitted a cross-sectional view of the wetted profile and evaluation of the subsurface material.

Apparatus (See diagram 1)

The double ring infiltrometer consists of two open ended metal cylinders, one 12 inch diameter cylinder placed centrally inside a 24 inch diameter cylinder. Each cylinder has an opening to an external water supply (Mariotte tube) and a hook gage. The Mariotte tubes are volumetric cylinders mounted on metal rods.. Arrangement of valves and tubes in the Mariotte cylinders allow a predetermined water level to be maintained in the infiltrometer rings. The hook gages are pointed metal rods used for visual observation of water level changes in the infiltrometer rings.

Procedure

Eight tests were run. The procedure for seven of the tests was to drive the infiltrometer rings 4 to 6 inches into the undisturbed ground surface, fill each ring with water to a depth of one foot, and record the volumes of water needed to maintain the one foot water level. In the eighth test the infiltrometer rings were driven into a brown clay exposed after approximately two feet of surface soil and vegetation were removed. After emplacement of the rings in the eighth test, the procedure followed was the same as in the other seven tests. Water volumes were recorded at fifteen minute intervals for a period of six hours for each test.

After six hours, the infiltrometer rings were removed and a trench was dug at each site. The trench permitted measurement of the area affected by the test (wetted profile), and examination of the subsurface material.

Calculations and Data Report

The water used during each fifteen minute interval was converted to depth of water per unit of time (inches per hour) and plotted graphically. Included with each graph for the 24 inch diameter ring is a cross section of the moist area and a soil profile description.

Diameter of Ring (Inches)	Area of Inner Ring (Sq. In.)	Area of Outer Ring (Sq. In.)	Volume of Water (In Milliliters) Providing 1 Inch Depth	Conversion Factor (Mls. to Depth of Water)
12	113.1		1854	5.39×10^{-4}
24		339.3	5561	1.80×10^{-4}

EXAMPLE: (Inner Ring)

$$\text{Milliliters used} \times \text{Conversion Factor} \div \text{Time Period} = \text{Inches/Time Period}$$

$$2000\ \text{ML.} \times 5.39 \times 10^{-4} \div 1\ \text{Hour} = 1.078\ \text{Inches/Hour}$$

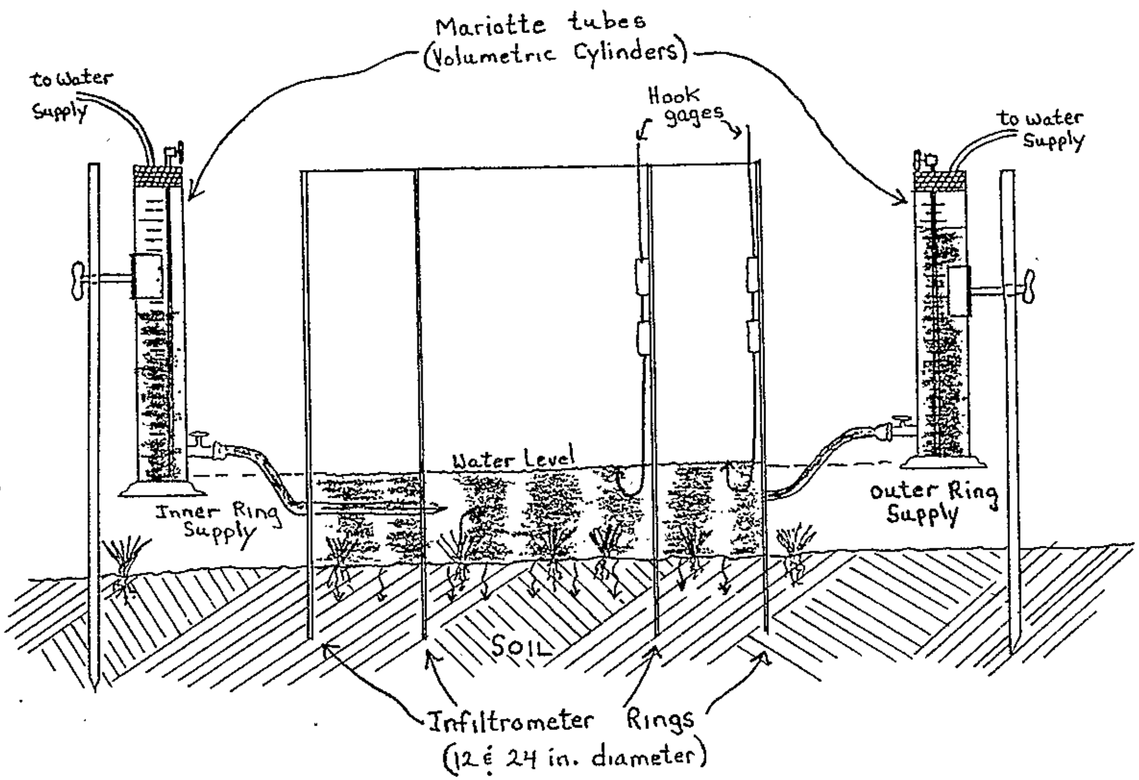
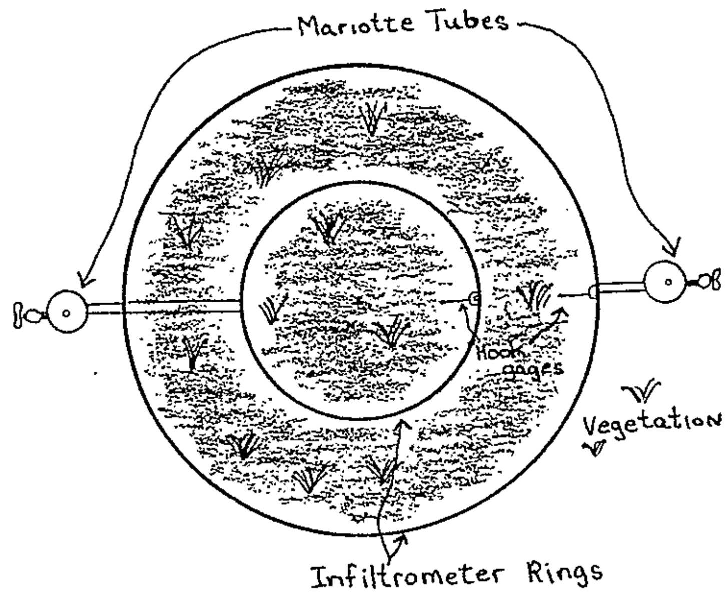


Diagram 1 A. Cross Sectional View of apparatus.



B. Top View of apparatus

Test Locations and Comments

Test #1 - (Location - N2,028,375 E378,635)

Large cobbles prevented proper emplacement of the infiltrometer rings. The water levels could not be maintained. Test No. 1 was abandoned after 3½ hours.

Test #2 - (Location - N2,026,970 E380,985)
Test #3 - (Location - N2,028,700 E381,280)
Test #4 - (Location - N2,026,815 E379,070)
Test #5 - (Location - N2,027,755 E378,160)
Test #6 - (Location - N2,026,875 E377,325)
Test #7 - (Location - N2,030,260 E383,240)

Test #8 - (Location - N2,029,397 E379,492)

A two foot hole was dug prior to the emplacement of the infiltrometer rings. The purpose of the hole was to eliminate the effects of the surface soil and vegetation, and to determine the infiltration rate of a brown clay that is present over a large area of the disposal site.

The infiltration rate in the clay was very slow. The infiltrometer rings were covered to eliminate water loss by evaporation. The amount of water infiltrating the clay was so small that it could not be recorded accurately. The amount of water used per time interval was recorded as less than 10 ml.

GORDON HERKENHOFF & ASSOCIATES, INC.
302 Eighth Street, N.W.
Albuquerque, New Mexico 87102
(505) 247-0294

Description: water Infiltration test #2 outer ring and soil moisture profile
Location — N2026970 E378635

Date: 18 OCT 1976

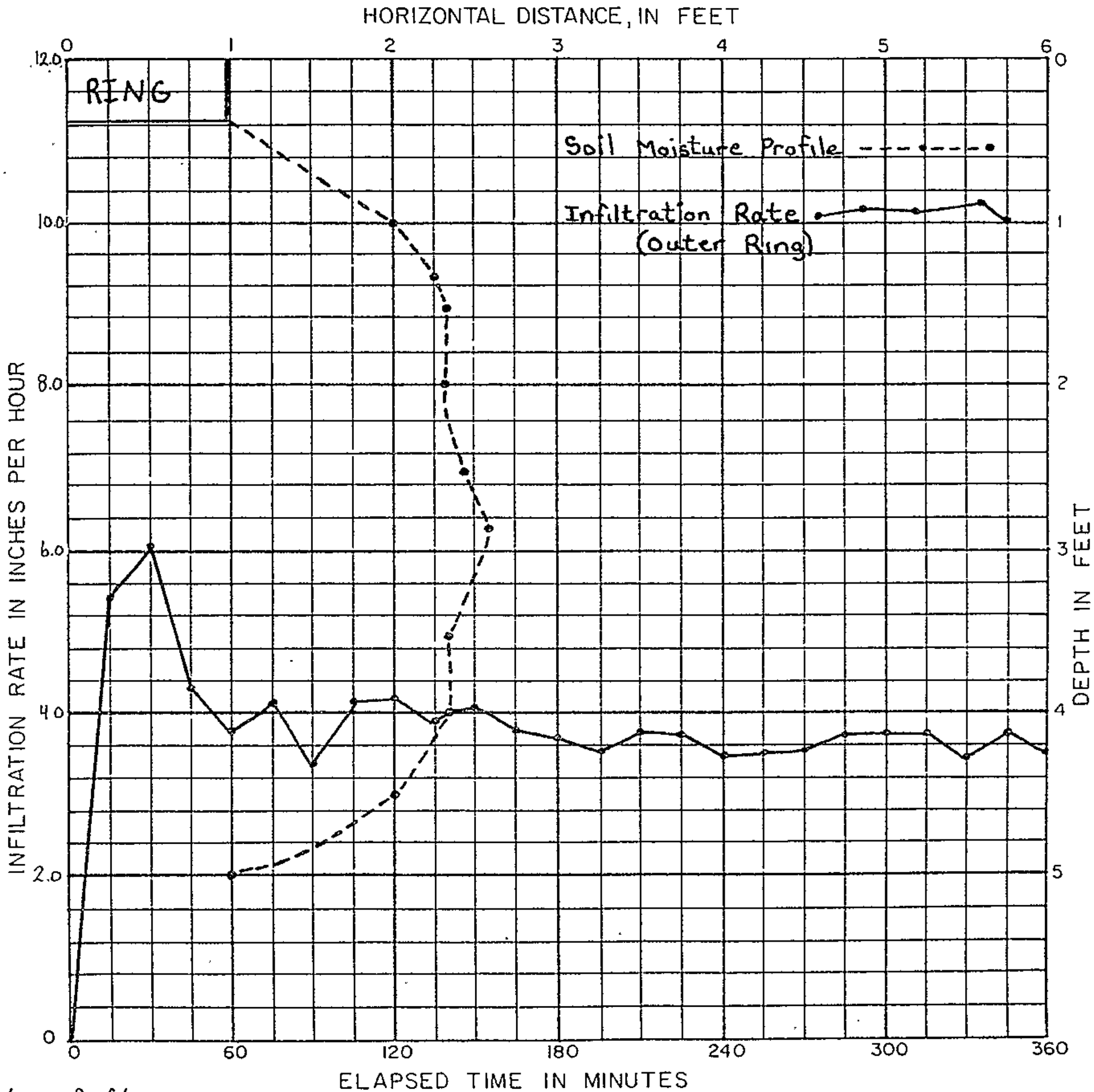
Drawing No.

Page: 1

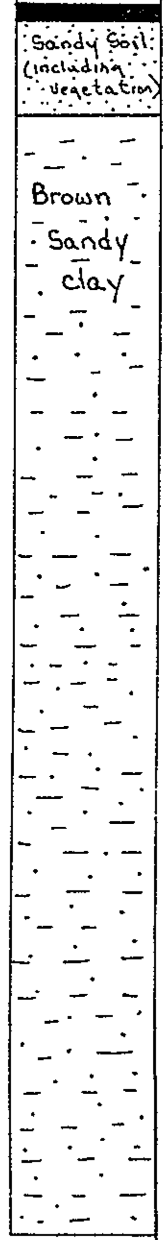
ELAPSED TIME (MINS.)	QUANT. OF WATER (MIL.)	INFIL. (IN.PR.HR)
15	7600	5.48
30	8400	6.04
45	6000	4.32
60	5300	3.80
75	5820	4.16
90	4700	3.40
105	5800	4.16
120	5900	4.24
135	5500	3.96
150	5600	4.04
165	5300	3.80
180	5100	3.68
195	4950	3.56
210	5250	3.80
225	5200	3.76
240	4850	3.48
255	5050	3.56
270	4950	3.56
285	5150	3.72
300	5250	3.80
315	5200	3.76
330	4850	3.48
345	5150	3.72
360	4950	3.56

Test #2
(Outer Ring) + Moisture Profile

CROSS SECTION OF MOIST AREA AND GRAPH OF INFILTRATION RATE



SOIL PROFILE DISCRPTION



GORDON HERKENHOFF & ASSOCIATES, INC.
302 Eighth Street, N.W.
Albuquerque, New Mexico 87102
(505) 247-0294

Description: Water Infiltration Test #2 Inner Ring

Date: 18 Oct 76

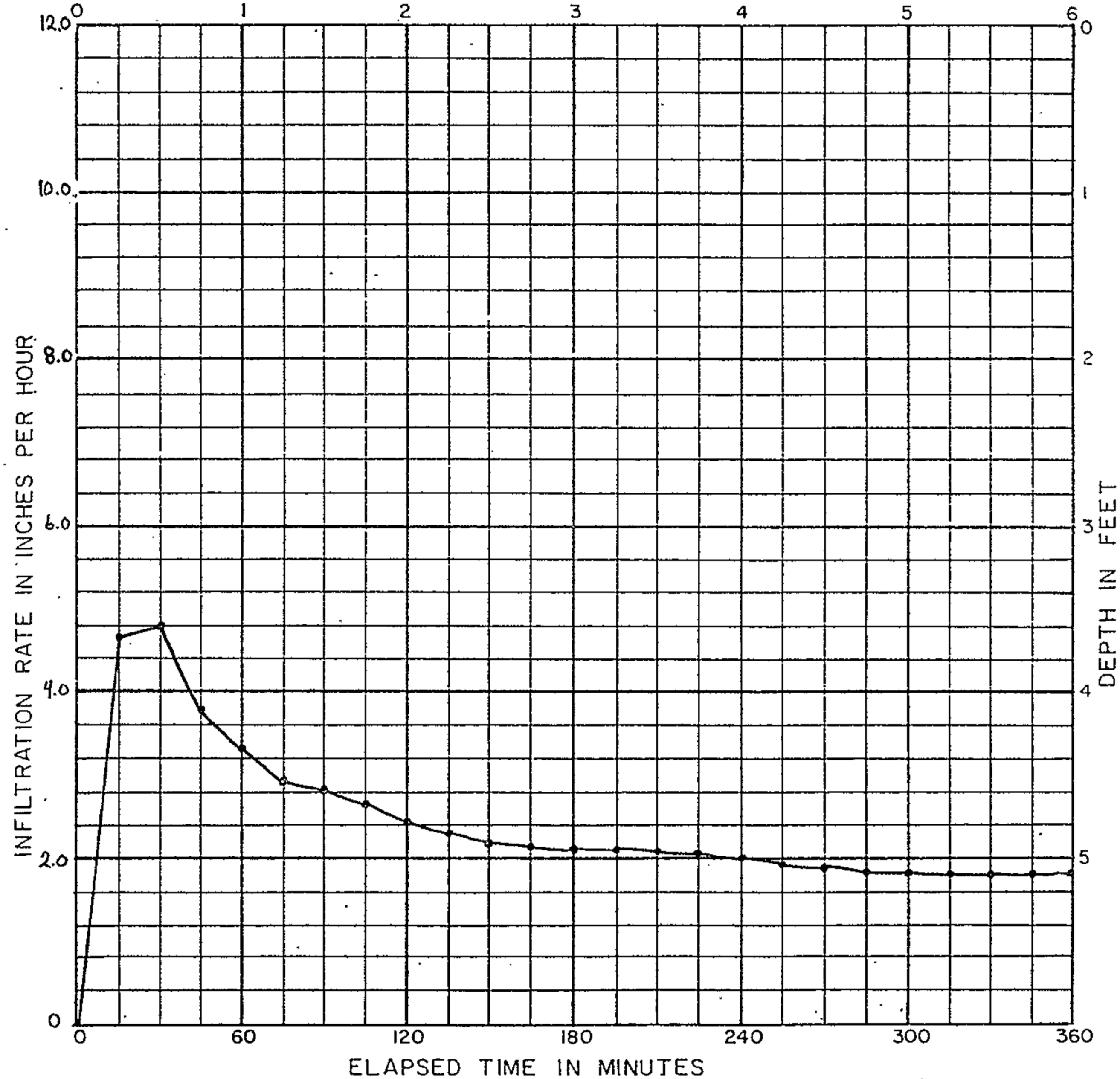
Drawing No.

Page: 2

ELAPSED TIME (MINS.)	QUANT. OF WATER (MIL.)	INFIL. (IN.PR.HR)
15	2150	4.64
30	2230	4.80
45	1760	3.80
60	1560	3.36
75	1400	3.00
90	1320	2.84
105	1240	2.68
120	1140	2.44
135	1100	2.36
150	1040	2.24
165	1000	2.16
180	1000	2.16
195	980	2.12
210	965	2.08
225	945	2.04
240	920	2.00
255	905	1.96
270	8.90	1.92
285	880	1.88
300	845	1.84
315	860	1.84
330	845	1.84
345	845	1.84
360	845	1.84

Test #2 Inner Ring

CROSS SECTION OF MOIST AREA AND GRAPH OF INFILTRATION RATE



SOIL PROFILE DISCRPTION

See Outer Ring Sheet

GORDON HERKENHOFF & ASSOCIATES, INC.
302 Eighth Street, N.W.
Albuquerque, New Mexico 87102
(505) 247-0294

Description: Water Infiltration Test #3
Outer Ring and moisture profile
Location – N2028700 E381280

Date: 19 Oct 1976

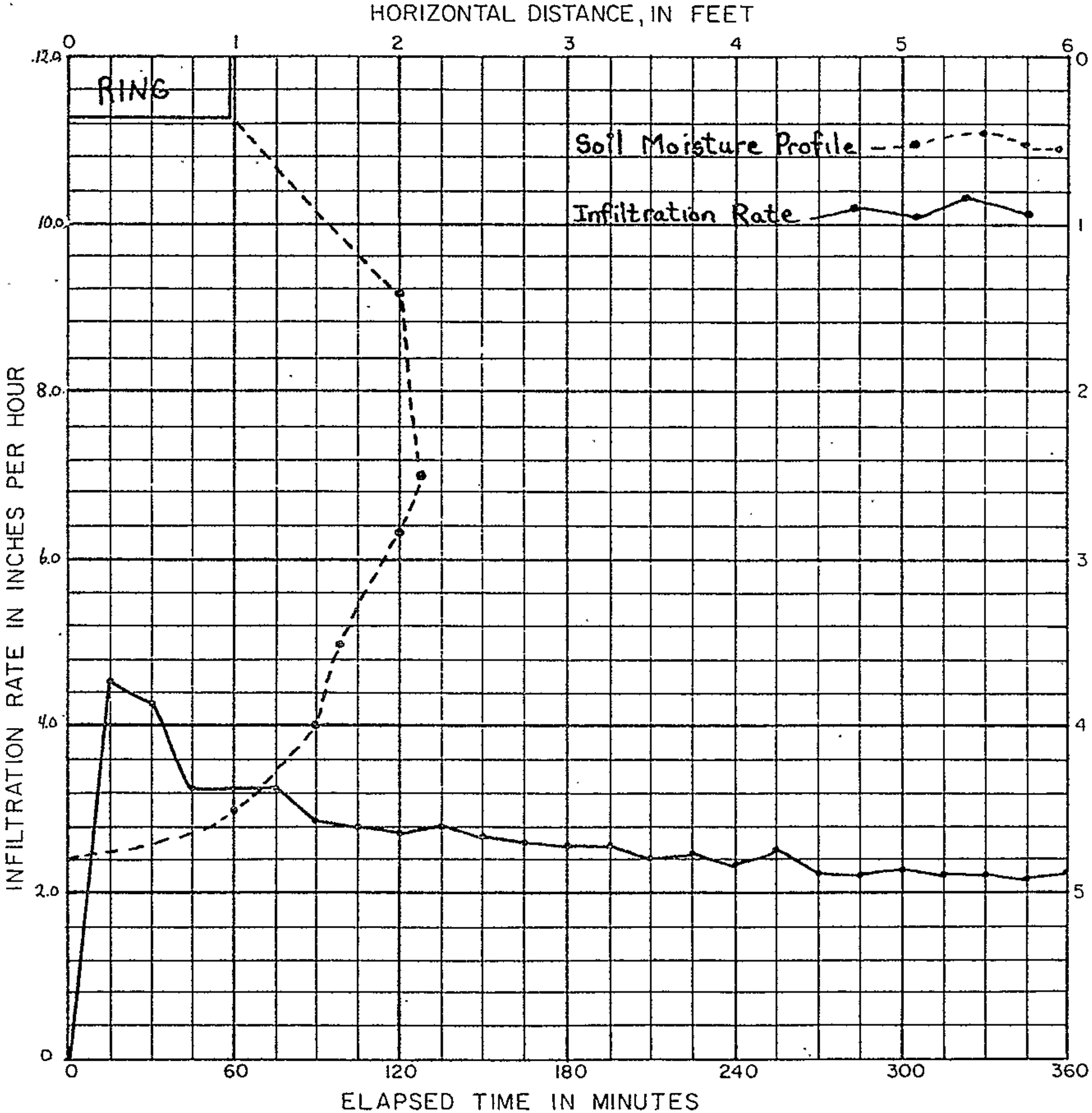
Drawing No.

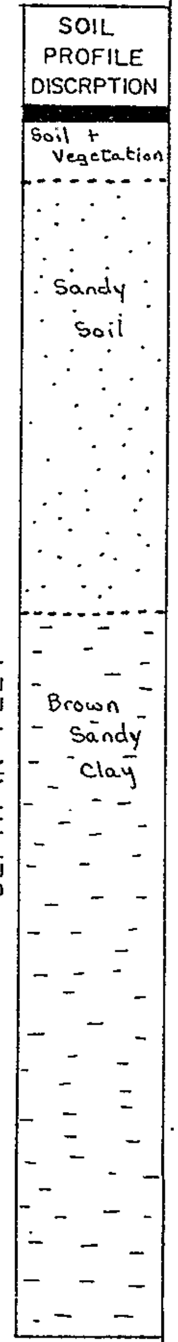
Page 3

ELAPSED TIME (MINS.)	QUANT. OF WATER (MIL.)	INFIL. (IN.PR.HR.)
15	6400	4.60
30	6000	4.32
45	4500	3.24
60	4500	3.24
75	4500	3.24
90	4000	2.88
105	3900	2.80
120	3800	2.72
135	3900	2.80
150	3700	2.68
165	3600	2.60
180	3600	2.60
195	3675	2.64
210	3325	2.40
225	3400	2.44
240	3200	2.32
255	3500	2.52
270	3150	2.28
285	3100	2.24
300	3200	2.32
315	3100	2.24
330	3100	2.24
345	2900	2.08
360	3050	2.20

Test #3
Outer Ring and
Moisture Profile

CROSS SECTION OF MOIST AREA AND GRAPH OF INFILTRATION RATE





GORDON HERKENHOFF & ASSOCIATES, INC.
302 Eighth Street, N.W.
Albuquerque, New Mexico 87102
(505) 247 - 0294

Description: Water Infiltration test. #3 Inner Ring

Date: 19 Oct. 1976

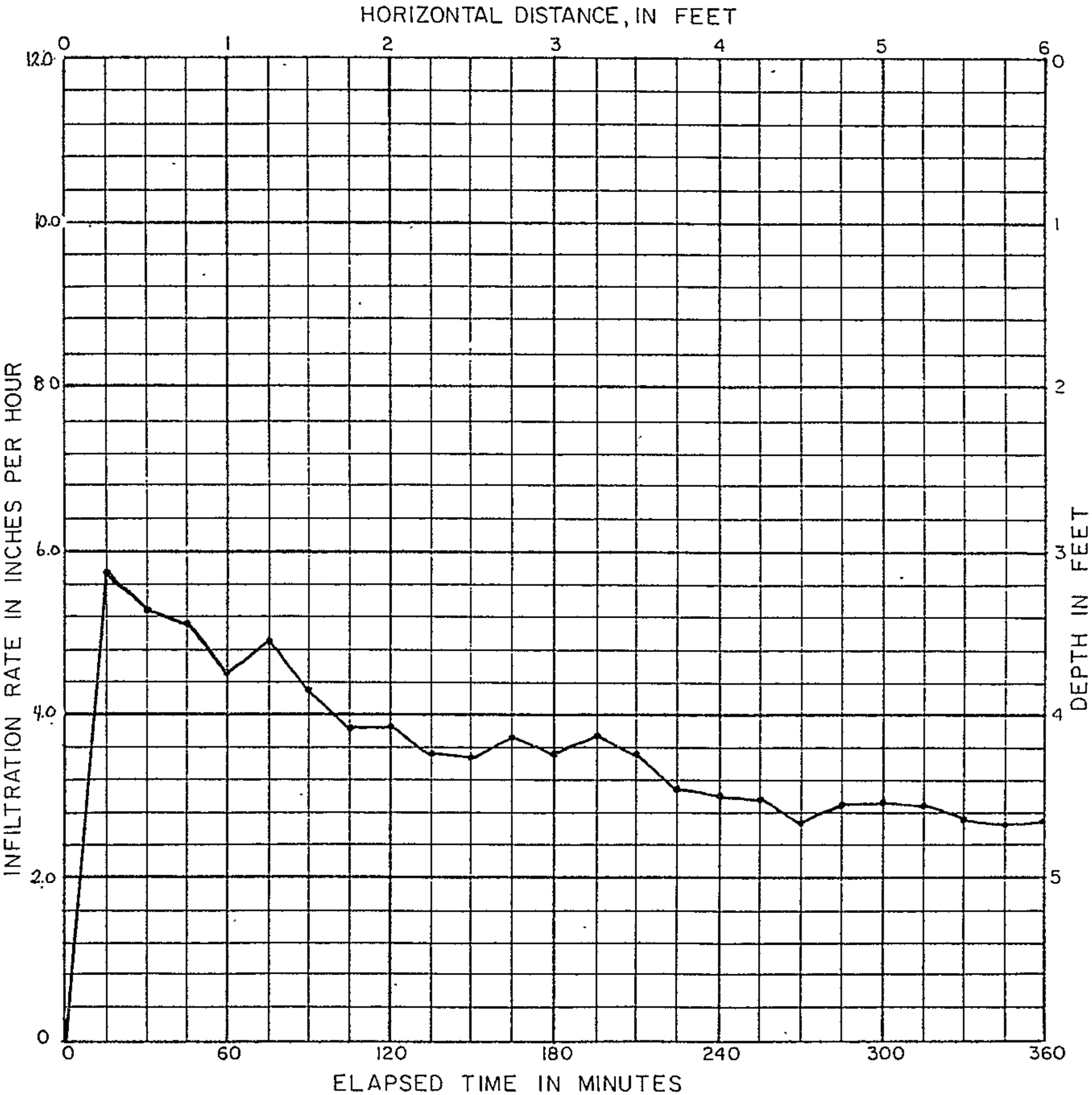
Drawing No.

Page: 4

ELAPSED TIME (MINS.)	QUANT. OF WATER (MIL.)	INFIL. (IN.PR.HR)
15	2860	5.76
30	2440	5.28
45	2400	5.16
60	2100	4.52
75	2280	4.92
90	2000	4.32
105	1780	3.84
120	1800	3.88
135	1650	3.56
150	1625	3.52
165	1720	3.72
180	1645	3.56
195	1720	3.72
210	1645	3.56
225	1420	3.08
240	1415	3.04
255	1400	3.00
270	1240	2.68
285	1340	2.88
300	1360	2.92
315	1340	2.88
330	1300	2.76
345	1260	2.72
360	1250	2.68

Test #3
Inner Ring

CROSS SECTION OF MOIST AREA AND GRAPH OF INFILTRATION RATE



SOIL PROFILE DISCRPTION
See Outer Ring Sheet

GORDON HERKENHOFF & ASSOCIATES, INC.
302 Eighth Street, N.W.
Albuquerque, New Mexico 87102
(505) 247 - 0294

Description: Water Infiltration Test #4 outer ring and moisture profile
Location-T/2026815 E379070

Date: 20 oct. 1976

Drawing No.

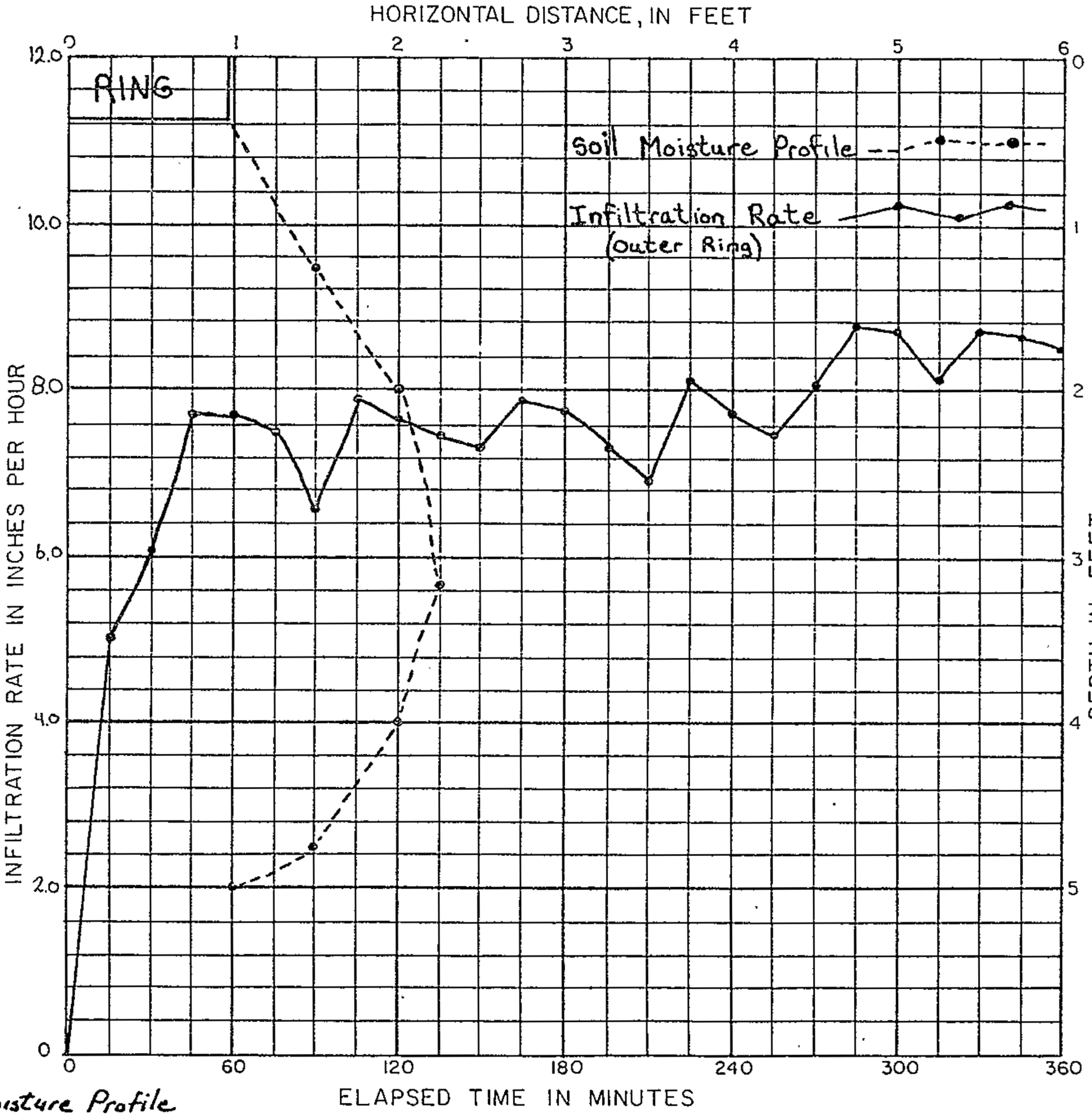
Page 5

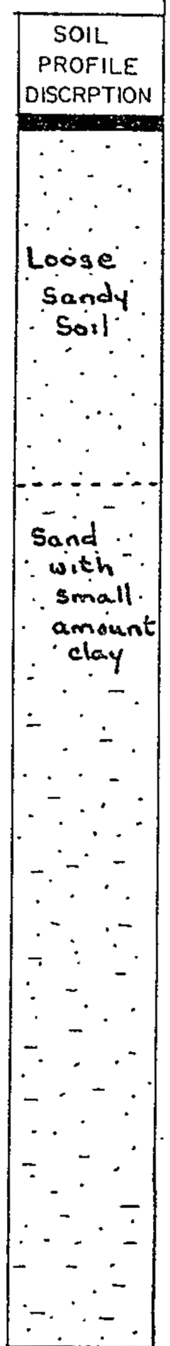
8

ELAPSED TIME (MINS.)	QUANT. OF WATER (MIL.)	INFIL. (IN.PR.HR)
15	7075	5.08
30	8450	6.08
45	10800	7.76
60	10780	7.76
75	10500	7.56
90	9200	6.64
105	11,000	7.92
120	10700	7.72
135	10400	7.48
150	10200	7.36
165	11000	7.92
180	10900	7.84
195	10200	7.36
210	9600	6.92
225	11350	8.16
240	10900	7.84
255	10500	7.56
270	11150	8.04
285	12200	8.80
300	12100	8.72
315	11300	8.12
330	12100	8.72
345	12100	8.72
360	11800	8.48

TEST #4
Outer Ring and Moisture Profile

CROSS SECTION OF MOIST AREA AND GRAPH OF INFILTRATION RATE





GORDON HERKENHOFF & ASSOCIATES, INC.
302 Eighth Street, N.W.
Albuquerque, New Mexico 87102
(505) 247-0294

Description: Water Infiltration Test #4 Inner Ring

Date: 20 Oct. 1976

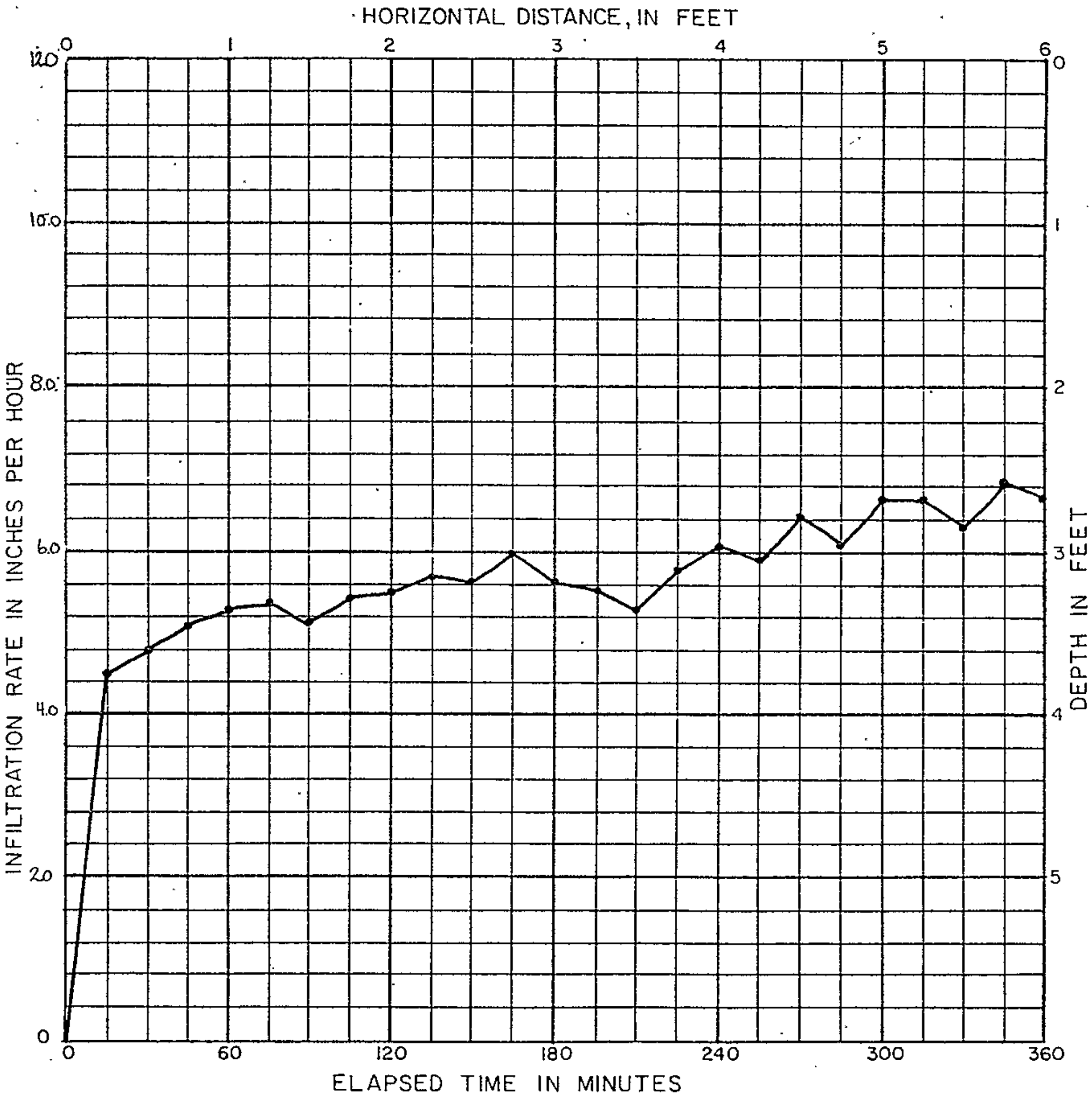
Drawing No.

Page: 6

ELAPSED TIME (MINS.)	QUANT. OF WATER (MIL.)	INFIL. (IN.PR.HR)
15	2100	4.52
30	2220	4.80
45	2380	5.12
60	2450	5.28
75	2500	5.40
90	2400	5.16
105	2540	5.48
120	2560	5.52
135	2645	5.72
150	2620	5.64
165	2780	5.00
180	2625	5.64
195	2580	5.56
210	2460	5.32
225	2700	5.84
240	2820	6.08
255	2740	5.92
270	3000	6.48
285	2840	6.12
300	3100	6.68
315	3100	6.68
330	2940	6.32
345	3180	6.84
360	3100	6.68

Test #4
Inner Ring

CROSS SECTION OF MOIST AREA AND GRAPH OF INFILTRATION RATE



SOIL PROFILE DISCRPTION

See Outer Ring Sheet

GORDON HERKENHOFF & ASSOCIATES, INC.
302 Eighth Street, N.W.
Albuquerque, New Mexico 87102
(505) 247 - 0294

Description: Water Infiltration Test #5
Outer Ring and Moisture Profile
Location — N2027755 E 378160

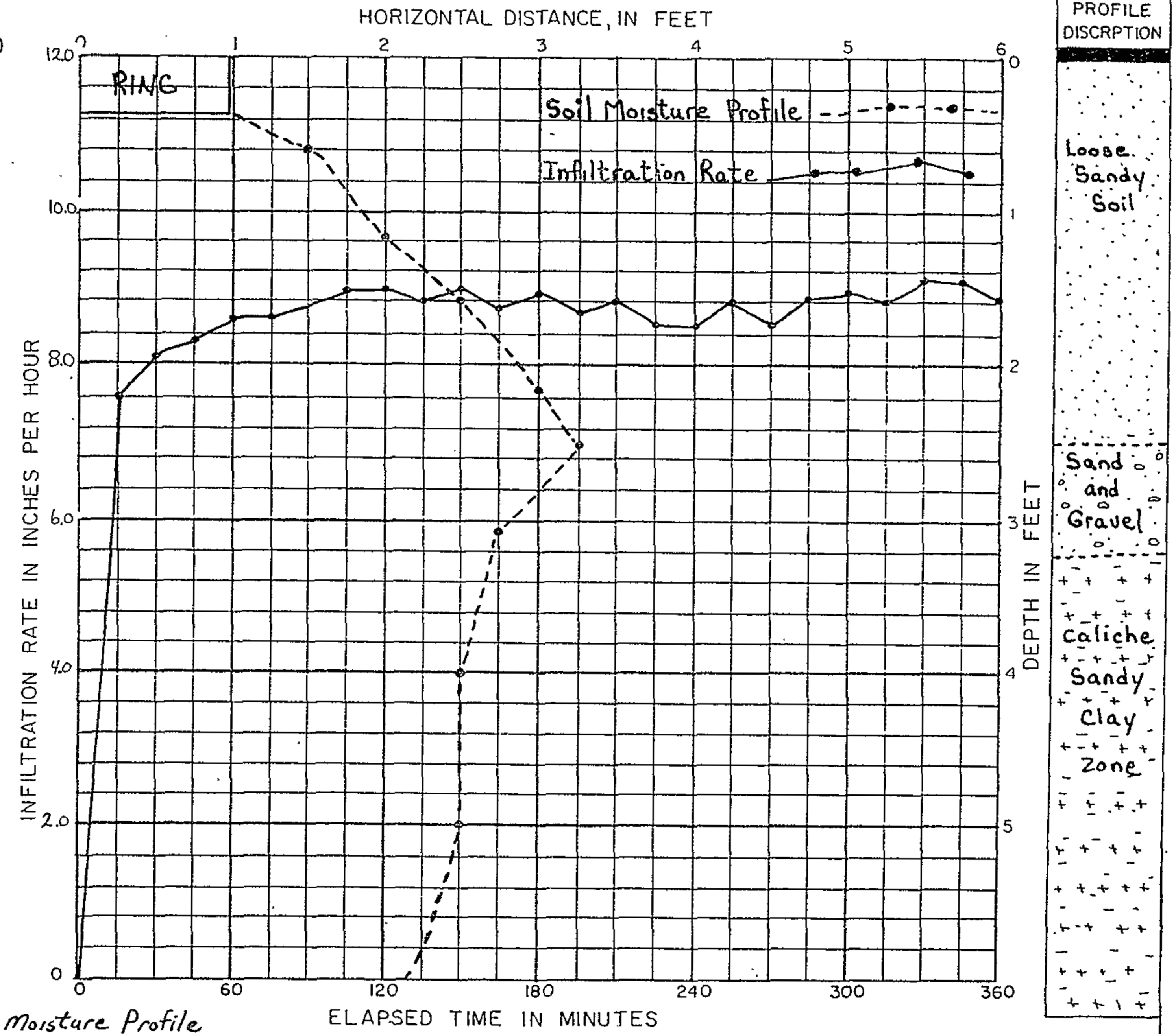
Date: 21 Oct. 76

Drawing No.

Page 7

ELAPSED TIME (MINS.)	QUANT. OF WATER (MIL.)	INFIL. (IN.PR.HR)
15	10560	7.60
30	11200	8.08
45	11600	8.36
60	12000	8.64
75	12000	8.64
90	–	–
105	12400	8.92
120	12450	8.96
135	12250	8.80
150	12375	8.92
165	12100	8.72
180	12400	8.92
195	12000	8.64
210	12250	8.80
225	12000	8.64
240	12000	8.64
255	12200	8.80
270	11900	8.56
285	12,300	8.84
300	12450	8.96
315	12200	8.80
330	12700	9.16
345	12650	9.12
360	12300	8.84

CROSS SECTION OF MOIST AREA AND GRAPH OF INFILTRATION RATE



Test #5
Outer Ring and Moisture Profile

10

GORDON HERKENHOFF & ASSOCIATES, INC.
302 Eighth Street, N.W.
Albuquerque, New Mexico 87102
(505) 247 - 0294

Description: Water Infiltration Test #5 Inner Ring

Date: 21 Oct. 76

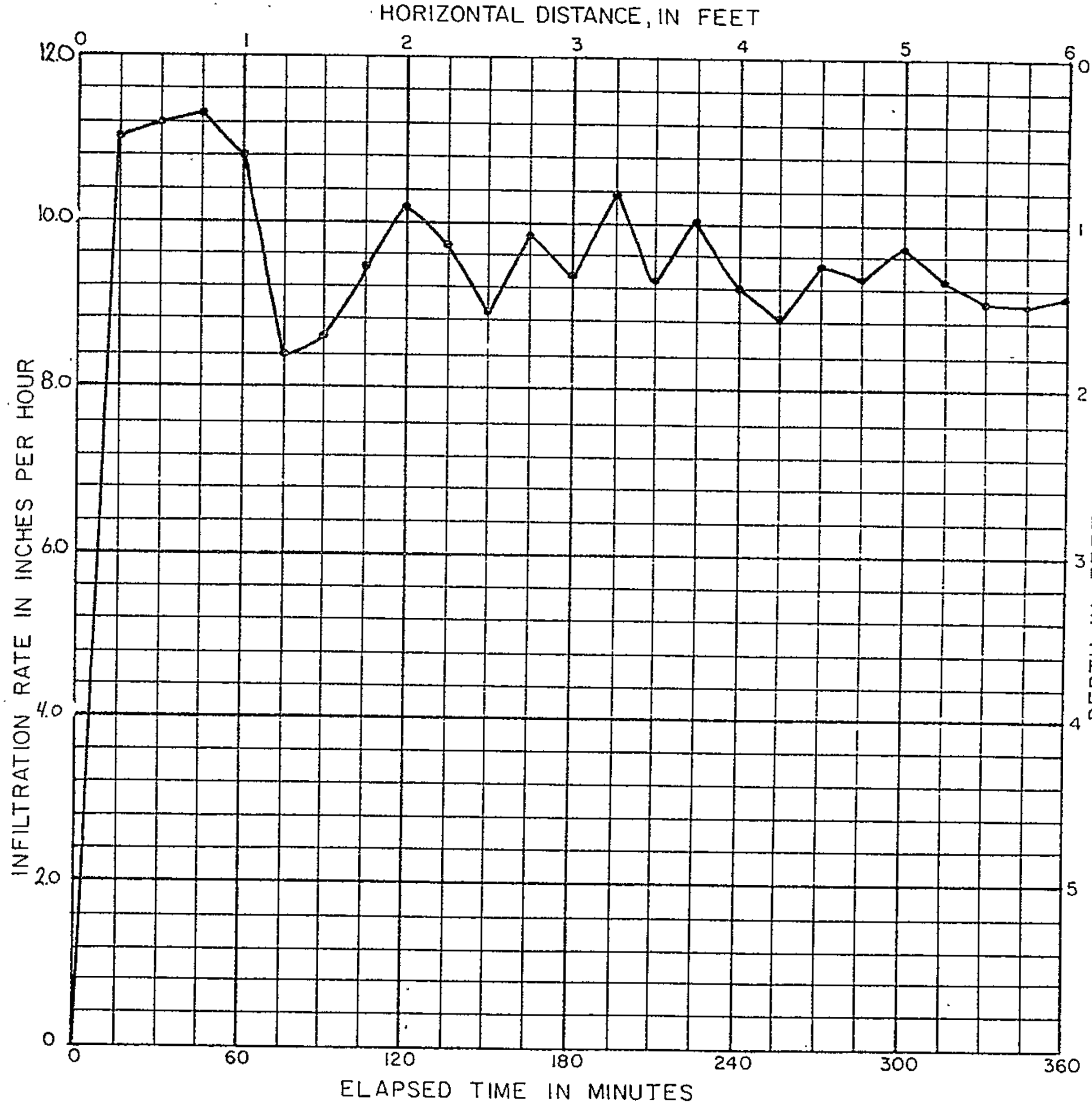
Drawing No.

Page 8

ELAPSED TIME (MINS.)	QUANT. OF WATER (MIL.)	INFIL. (IN.PR.HR.)
15	5150	11.12
30	5200	11.20
45	5250	11.32
60	5000	10.80
75	3900	8.40
90	-	-
105	4000	8.64
120	4400	9.48
135	4750	10.24
150	4520	9.76
165	4120	8.88
180	4580	9.88
195	4360	9.40
210	4830	10.40
225	4300	9.28
240	4650	10.04
255	4275	9.20
270	4100	8.84
285	4400	9.48
300	4350	9.36
315	4535	9.76
330	4350	9.36
345	4200	9.04
360	4250	9.16

Test #5
Inner Ring

CROSS SECTION OF MOIST AREA AND GRAPH OF INFILTRATION RATE

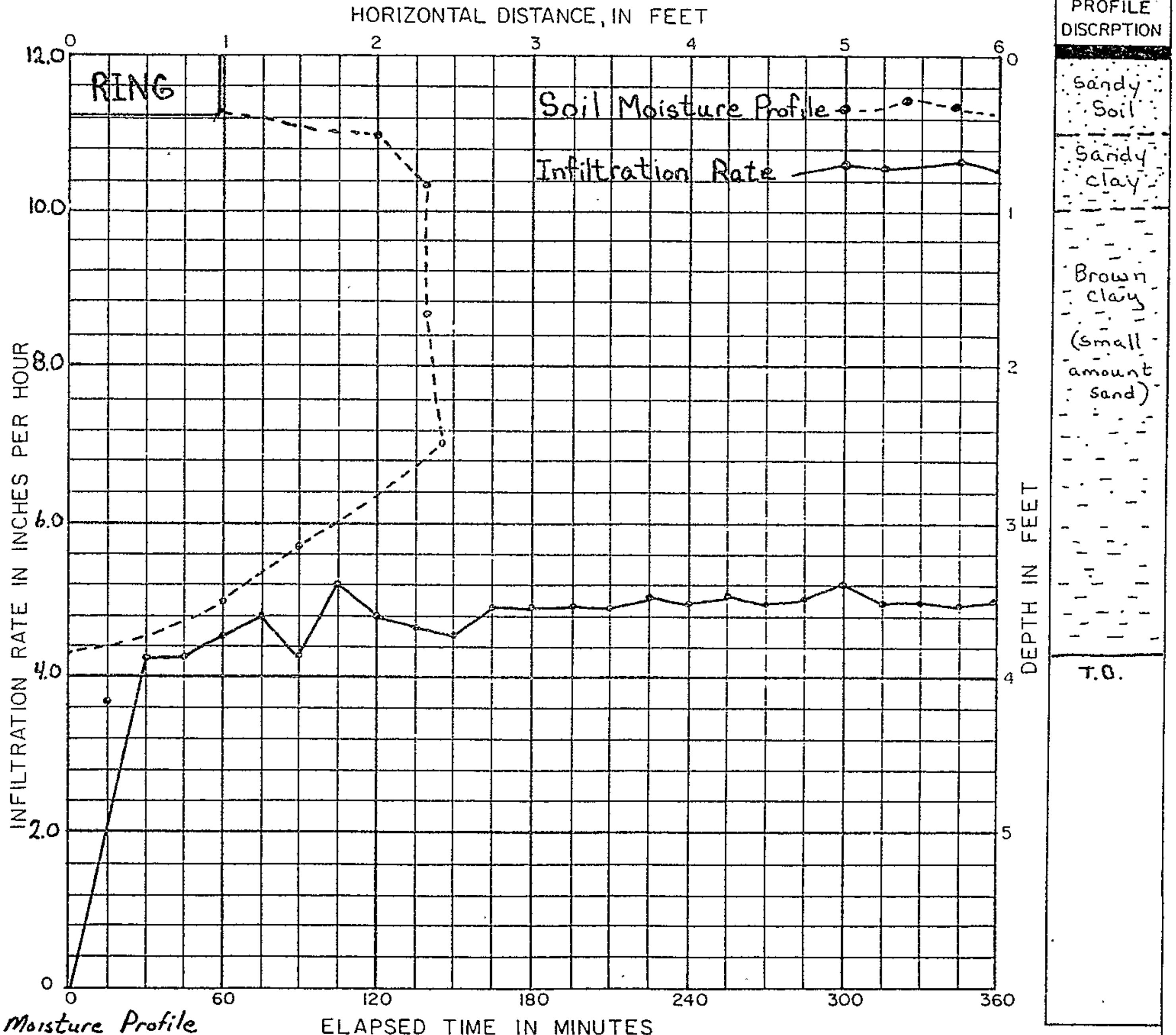


SOIL PROFILE DISCRPTION
See Outer Ring Sheet

ELAPSED TIME (MINS.)	QUANT. OF WATER (MIL.)	INFIL. (IN.PR.HR)
15	5065	3.64
30	5950	4.28
45	5980	4.32
60	6320	4.56
75	6660	4.80
90	5940	4.28
105	7200	4.00
120	6680	4.80
135	6550	4.72
150	6400	4.60
165	6840	4.92
180	6840	4.92
195	6880	4.96
210	6820	4.92
225	7100	5.12
240	7000	6.40
255	7100	5.12
270	6820	4.92
285	7000	5.04
300	7200	5.20
315	6920	4.80
330	7000	5.04
345	6880	4.96
360	6940	5.00

Test #6
Outer Ring and Moisture Profile

CROSS SECTION OF MOIST AREA AND GRAPH OF INFILTRATION RATE



GORDON HERKENHOFF & ASSOCIATES, INC.
302 Eighth Street, N.W.
Albuquerque, New Mexico 87102
(505) 247 - 0294

Description: Water Infiltration Test #6 Outer Ring and moisture Profile
Location — N2026875 E377325

Date: 30 Oct. 76

Drawing No.

Page: 9

12

GORDON HERKENHOFF & ASSOCIATES, INC.
302 Eighth Street, N.W.
Albuquerque, New Mexico 87102
(505) 247 - 0294

Description: *Water Infiltration Test #6 Inner Ring*

Date: *30 Oct. 76*

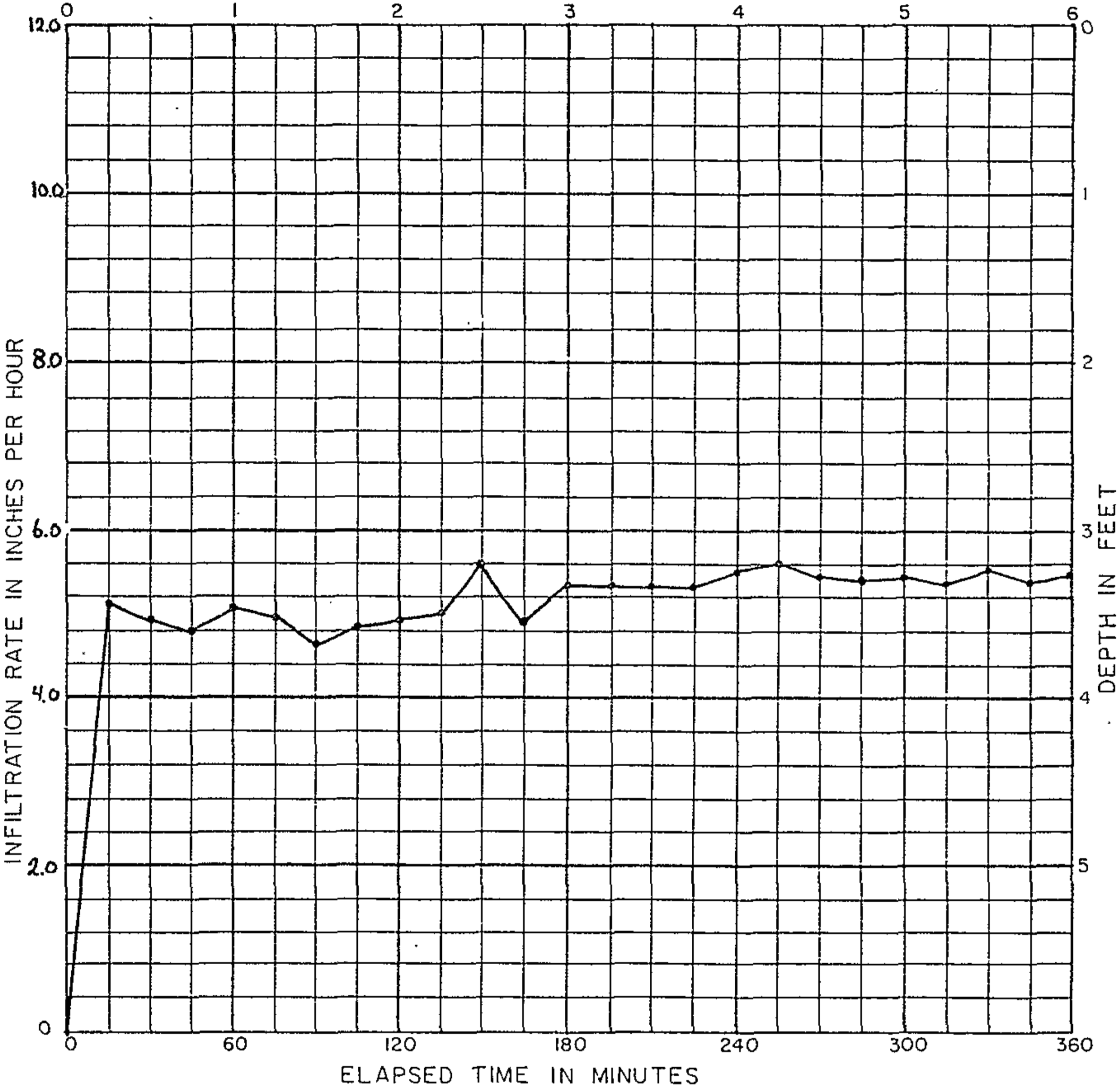
Drawing No.

Page: *10*

ELAPSED TIME (MINS.)	QUANT. OF WATER (MIL.)	INFIL. (IN.PR.HR)
15	2400	5.16
30	2300	4.96
45	2220	4.80
60	2360	5.08
75	2300	4.96
90	2150	4.64
105	2250	4.84
120	2280	5.20
135	2330	5.04
150	2600	5.60
165	2300	4.96
180	2500	5.40
195	2500	5.40
210	2500	5.40
225	2460	5.32
240	2580	5.56
255	2600	5.60
270	2560	5.52
285	2540	5.48
300	2510	5.40
315	2570	540
330	2570	5.56
345	2520	5.40
360	2560	5.60

Test #6
Inner Ring

CROSS SECTION OF MOIST AREA AND GRAPH OF INFILTRATION RATE



SOIL PROFILE DISCRPTION
See Outer Ring Sheet

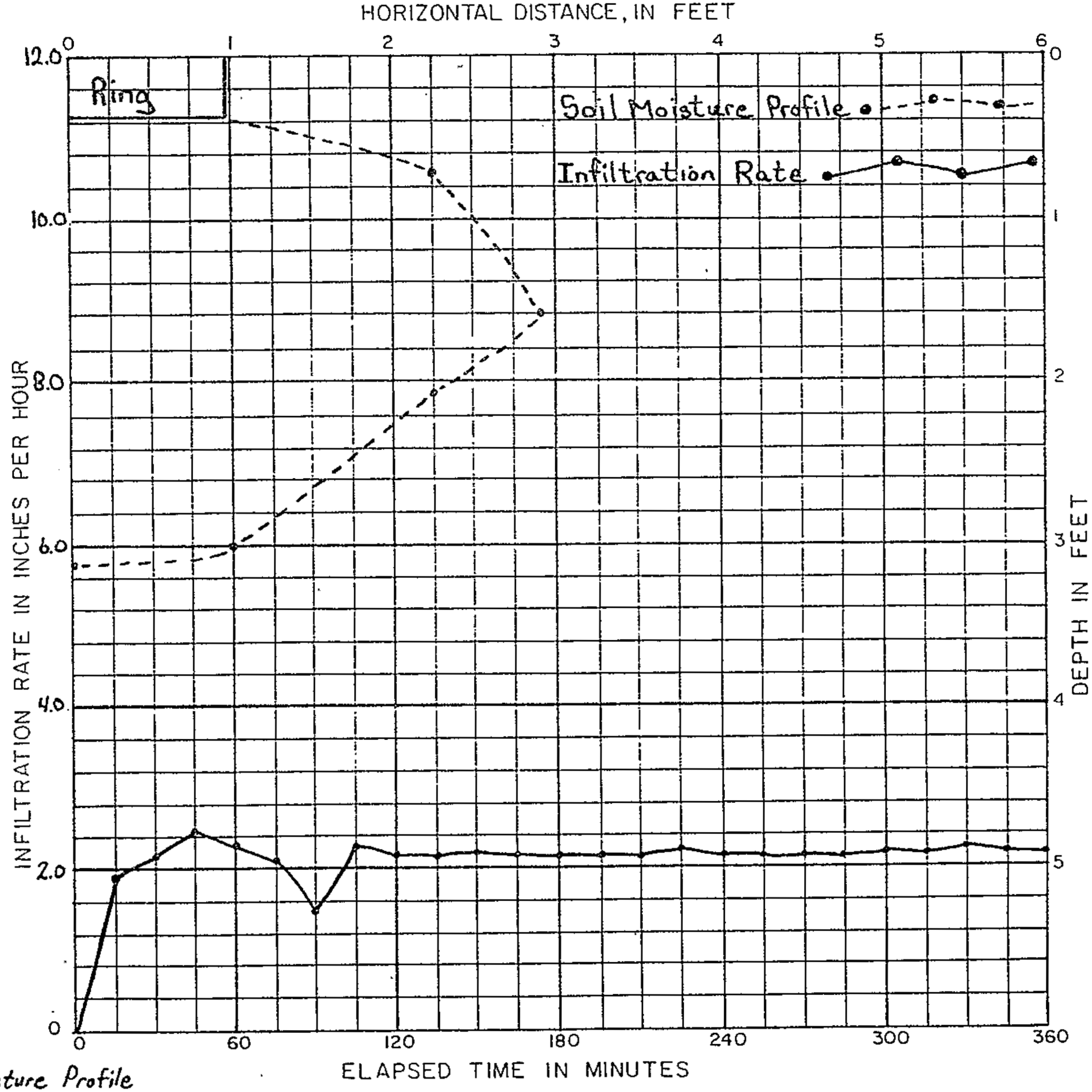
GORDON HERKENHOFF & ASSOCIATES, INC.
302 Eighth Street, N.W.
Albuquerque, New Mexico 87102
(505) 247 - 0294

Description: Water Infiltration Test #7
Outer Ring and Moisture Profile
Location - N 2030260 E 383240

Date: 31 Oct. 1976
Drawing No.
Page: 11

ELAPSED TIME (MINS.)	QUANT. OF WATER (MIL.)	INFIL. (IN.PR.HR.)
15	2660	1.92
30	3060	2.20
45	3400	2.44
60	3220	2.32
75	2880	2.08
90	2850	1.48
105	3160	2.28
120	3060	2.20
135	3020	2.16
150	3180	2.28
165	3000	2.16
180	2960	2.12
195	2960	2.12
210	2940	2.12
225	3120	2.24
240	3020	2.16
255	2950	2.12
270	3010	2.16
285	3100	2.24
300	3090	2.24
315	2990	2.16
330	3160	2.28
345	3040	2.20
360	3060	2.20

CROSS SECTION OF MOIST AREA AND GRAPH OF INFILTRATION RATE



SOIL PROFILE DISCRPTION
Sandy Soil
Brown Slightly Sandy Clay
T.O.

Test # 7
Outer Ring and Moisture Profile

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GORDON HERKENHOFF & ASSOCIATES, INC.
302 Eighth Street, N.W.
Albuquerque, New Mexico 87102
(505) 247-0294

Description: Water Infiltration Test #7. Inner Ring

Date: 31 Oct. 1996

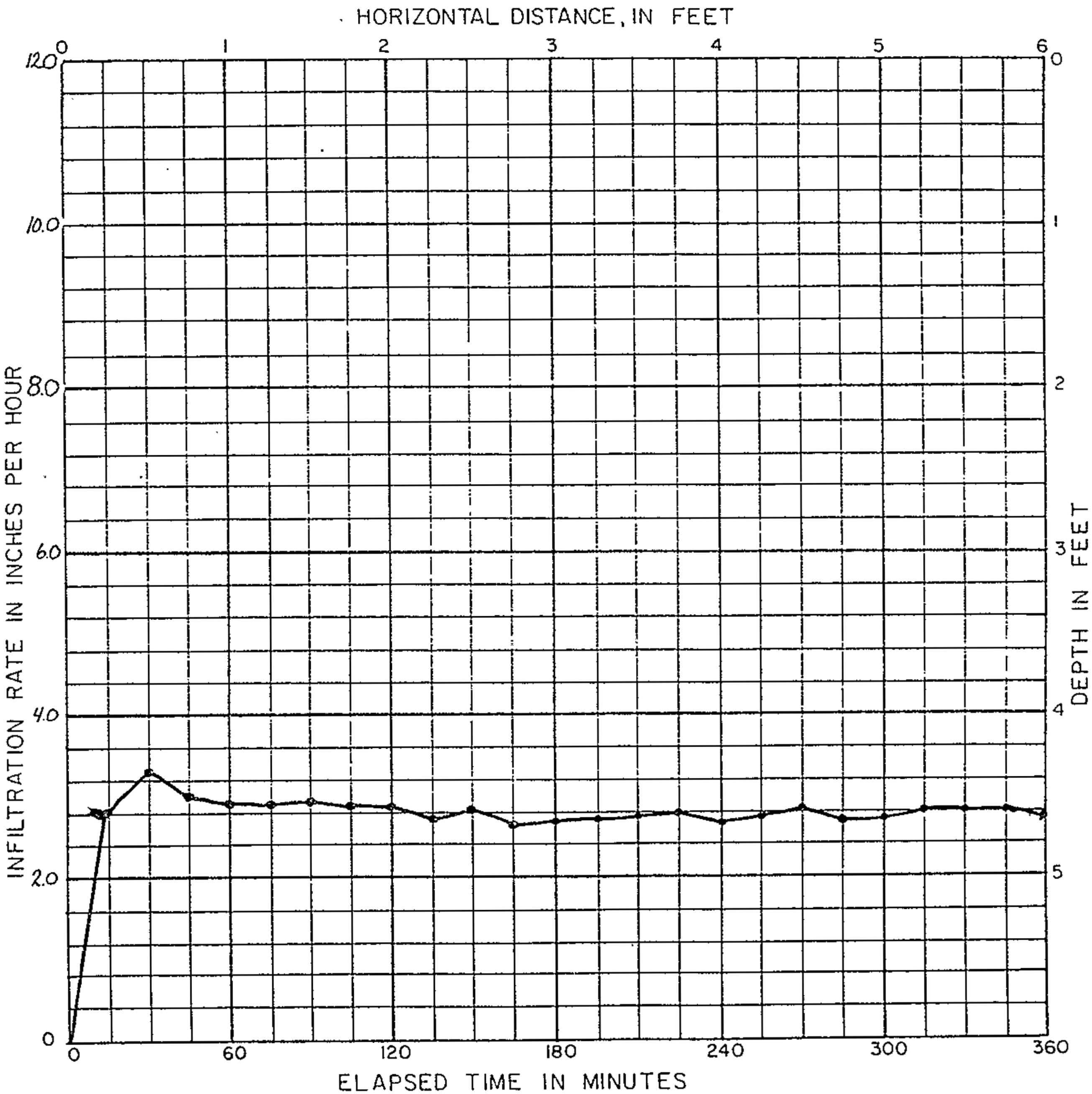
Drawing No.

Page: 12

ELAPSED TIME (MINS.)	QUANT. OF WATER (MIL.)	INFIL. (IN.PR.HR)
15	1360	2.92
30	1540	3.32
45	1400	3.00
60	1350	2.92
75	1360	2.92
90	1370	2.96
105	1320	2.84
120	1340	2.88
135	1260	2.72
150	1320	2.84
165	1240	2.68
180	1260	2.72
195	1280	2.76
210	1300	2.80
225	1300	2.80
240	1240	2.68
255	1280	2.76
270	1310	2.84
285	1240	2.68
300	1290	2.76
315	1300	2.80
330	1320	2.84
345	1300	2.80
360	1290	2.76

Test #7
Inner Ring

CROSS SECTION OF MOIST AREA AND GRAPH OF INFILTRATION RATE

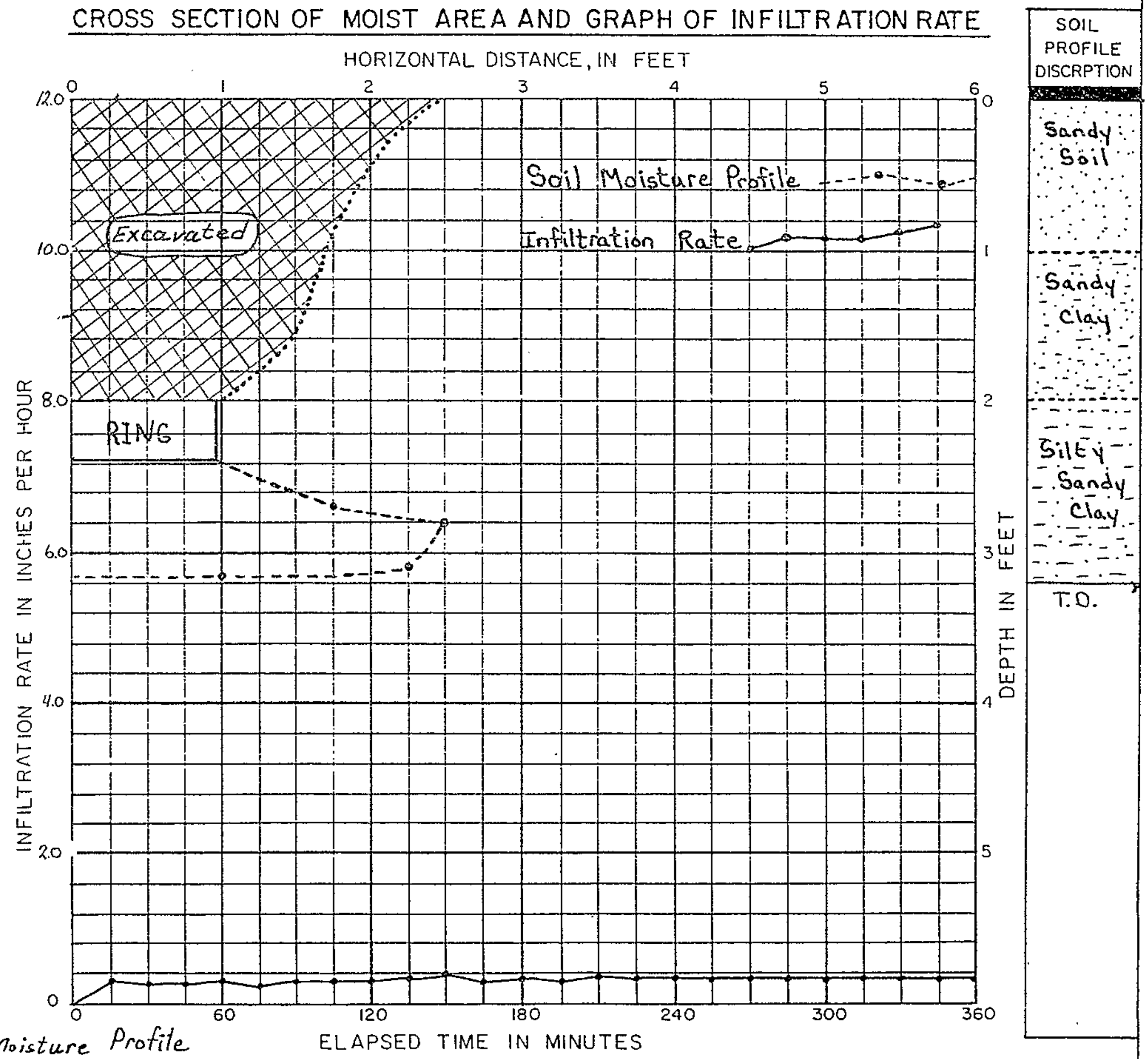


SOIL PROFILE DISCRPTION

See Outer Ring Sheet

ELAPSED TIME (MINS.)	QUANT. OF WATER (MIL.)	INFIL. (IN.PR HR)
15	425	.32
30	405	.28
45	410	.28
60	395	.28
75	400	.28
90	350	.24
105	415	.28
120	380	.28
135	425	.32
150	420	.32
165	460	.32
180	480	.36
195	570	.40
210	425	.32
225	510	.36
240	460	.32
255	505	.36
270	505	.36
285	520	.36
300	485	.36
315	510	.36
330	515	.36
345	490	.36
360	505	.36

Test # 8
Outer Ring + Moisture Profile



GORDON HERKENHOFF & ASSOCIATES, INC.
302 Eighth Street, N.W.
Albuquerque, New Mexico 87102
(505) 247 - 0294

Description: Water Infiltration Test #8 Outer Ring and Moisture Profile
Location - N 2029397 E 379492

Date: 1 Nov. 76

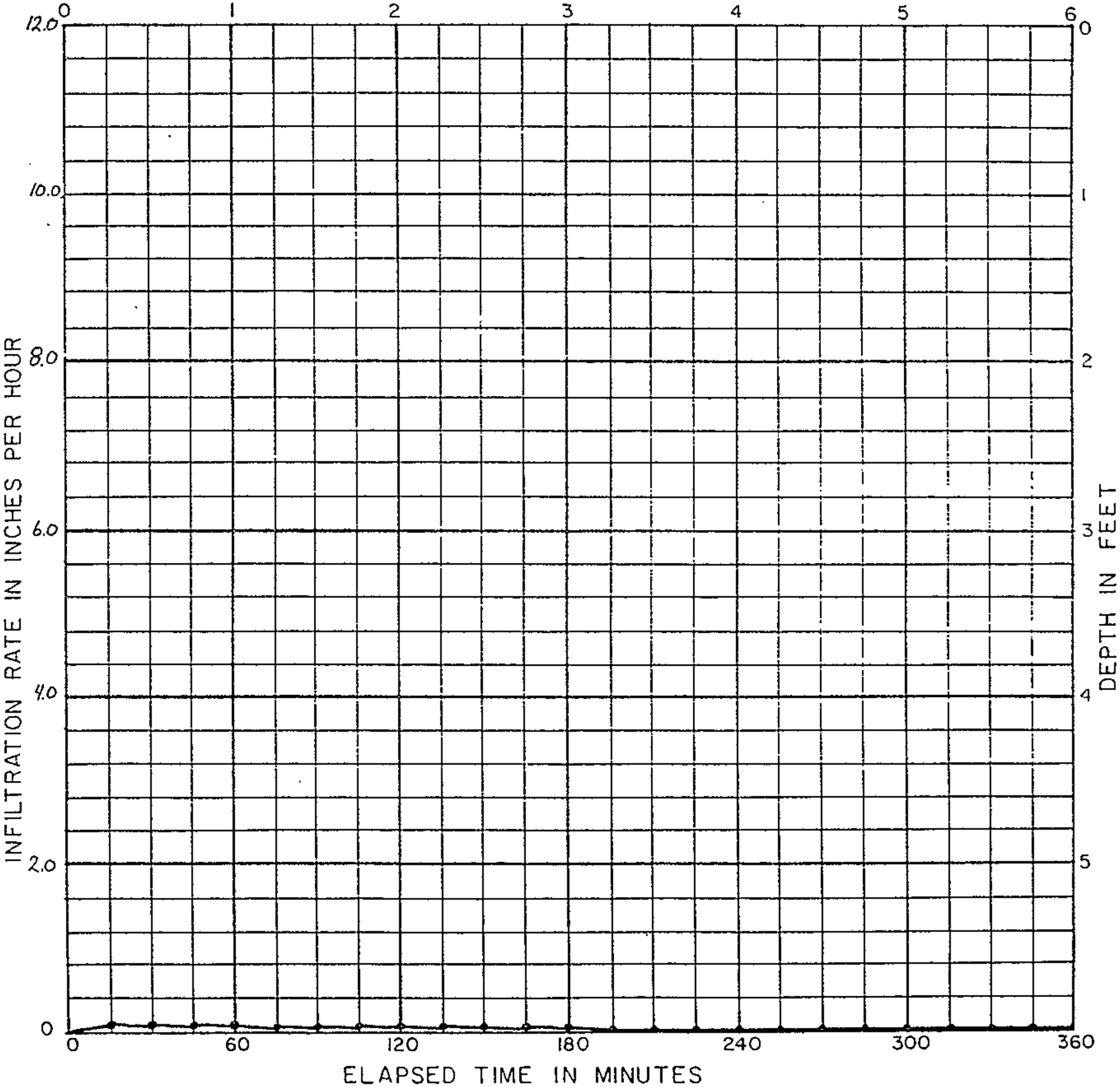
Drawing No.

Page: 13

CROSS SECTION OF MOIST AREA AND GRAPH OF INFILTRATION RATE

ELAPSED TIME (MINS.)	QUANT. OF WATER (MIL.)	INFIL. (IN.PR.HR)
15	25	.052
30	45	.096
45	55	.120
60	40	.090
75	35	.080
90	25	.05
105	25	.05
120	30	.06
135	35	.08
150	30	.06
165	45	.09
180	35	.08
195	20	.04
210	15	.03
225	10	.02
240	<10	.02
255	<10	.02
270	<10	.02
285	<10	.02
300	<10	.02
315	<10	.02
330	<10	.02
345	<10	.02
360	<10	.02

Test #8
Inner Ring



SOIL PROFILE DISCRPTION

See Outer Ring Sheet

GORDON HERKENHOFF & ASSOCIATES, INC.
302 Eighth Street, N.W.
Albuquerque, New Mexico 87102
(505) 247-0294

Date: 1 Nov 76

Description: Water Infiltration Test #8

Drawing No.

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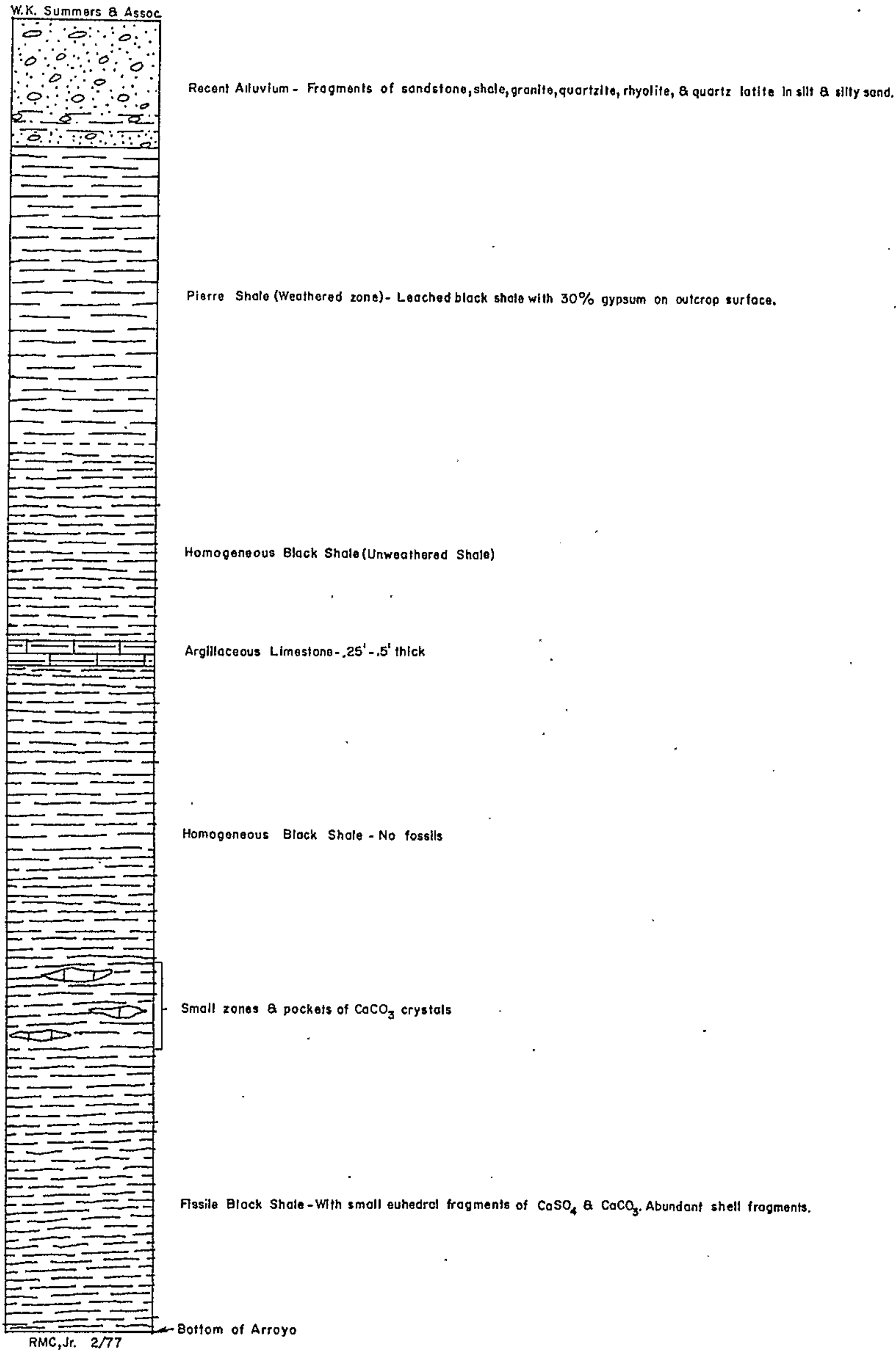
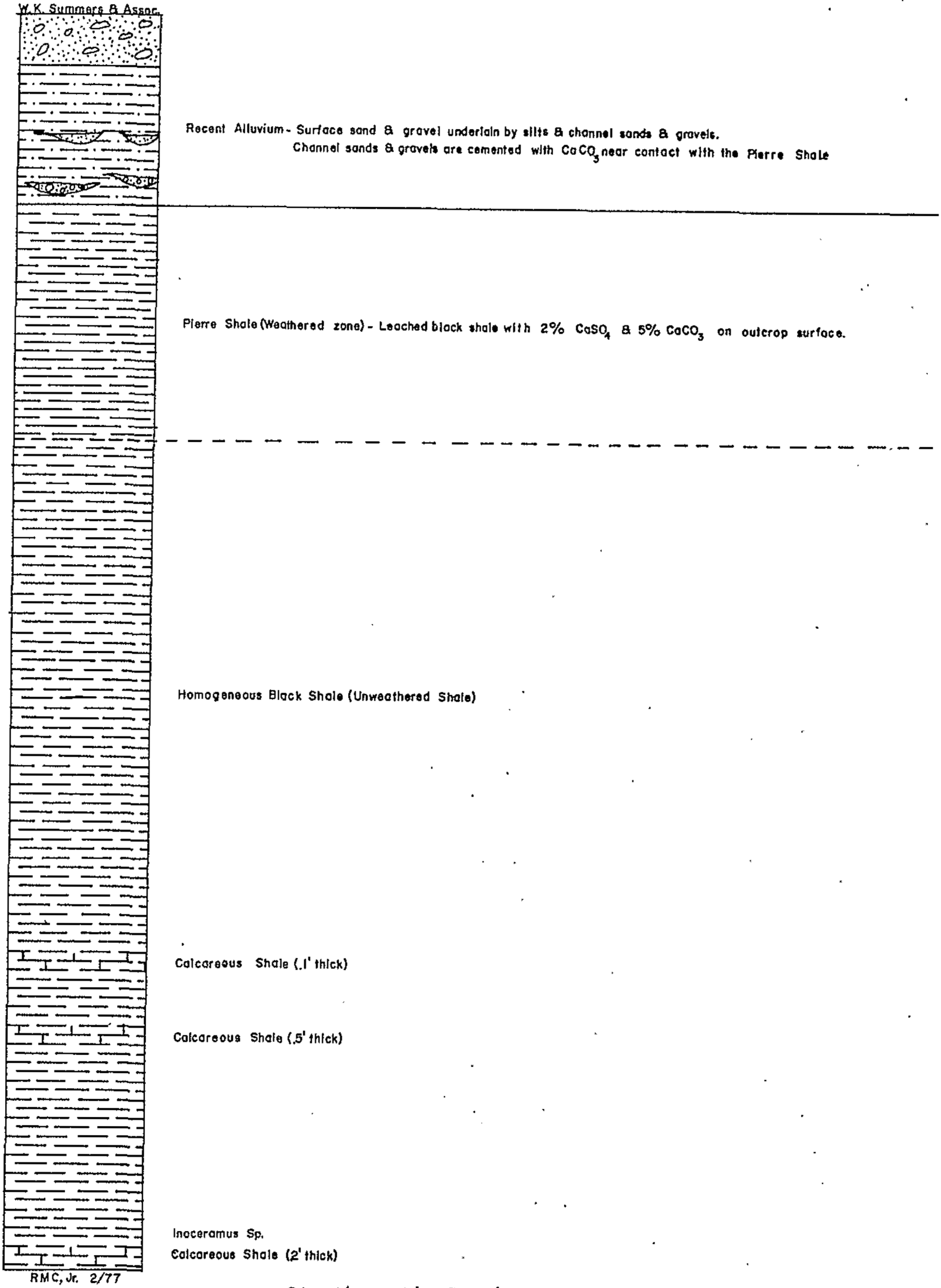
Appendix I-10.--Stratigraphic sections.

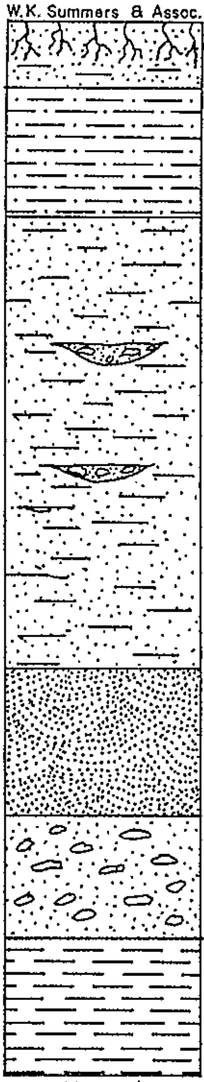


Stratigraphic Section 1
Scale: 1 inch = 3 feet



Stratigraphic Section 2
Scale-1 inch = 6 feet

W.K. Summers & Assoc.



Silty Soil with plant roots

Silt- Dark gray silt with 10% fine grained sand.

Sandy Silt - Unconsolidated, light gray silt with channel conglomerates.

Sand- Fine grained cross-bedded sand.

Conglomerate- Composed of cobbles of buff-brown sandstone, fragments of black shale & coarse grained sand.

ALLUVIUM

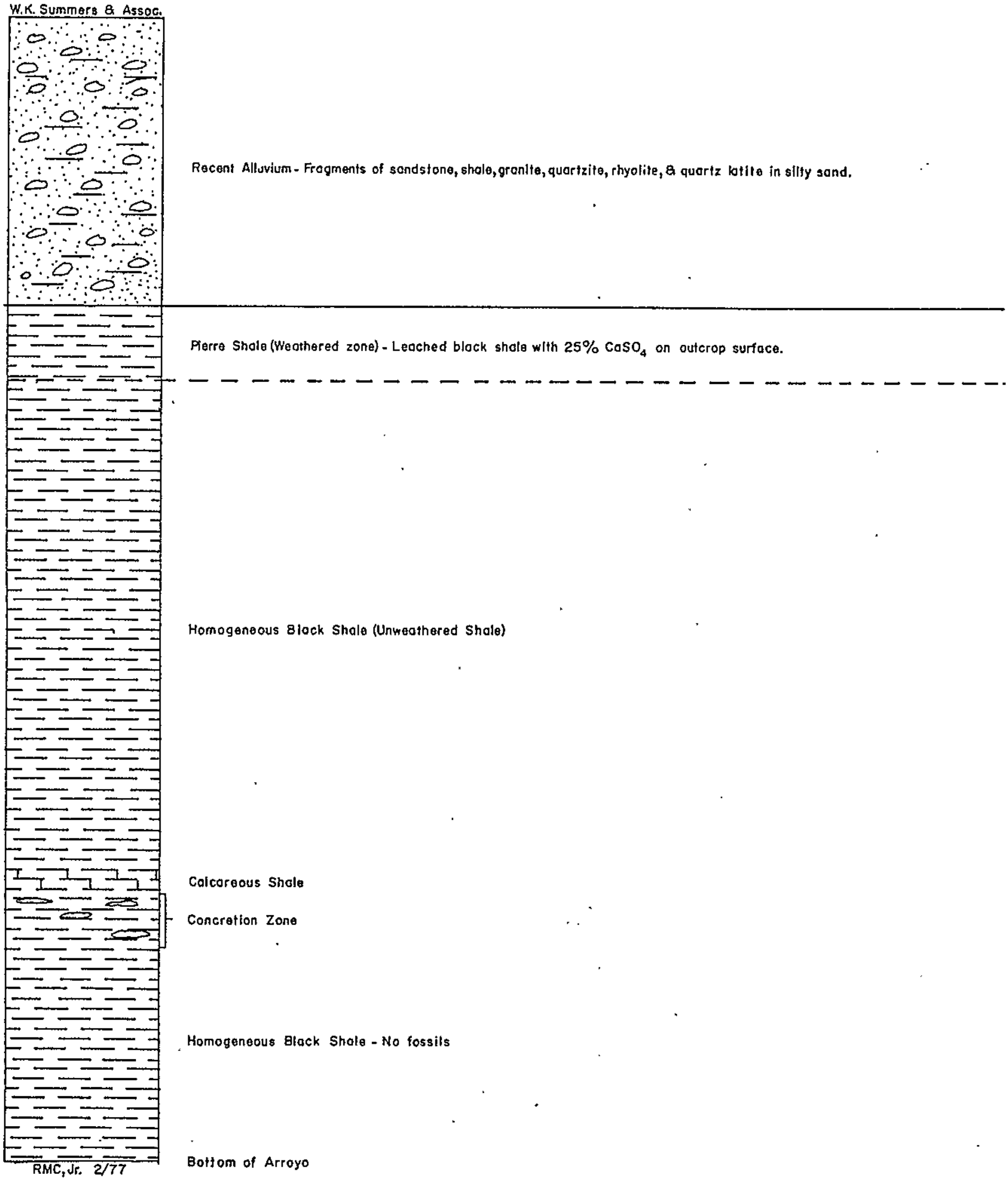
PIERRE SHALE

Homogeneous Black Shale

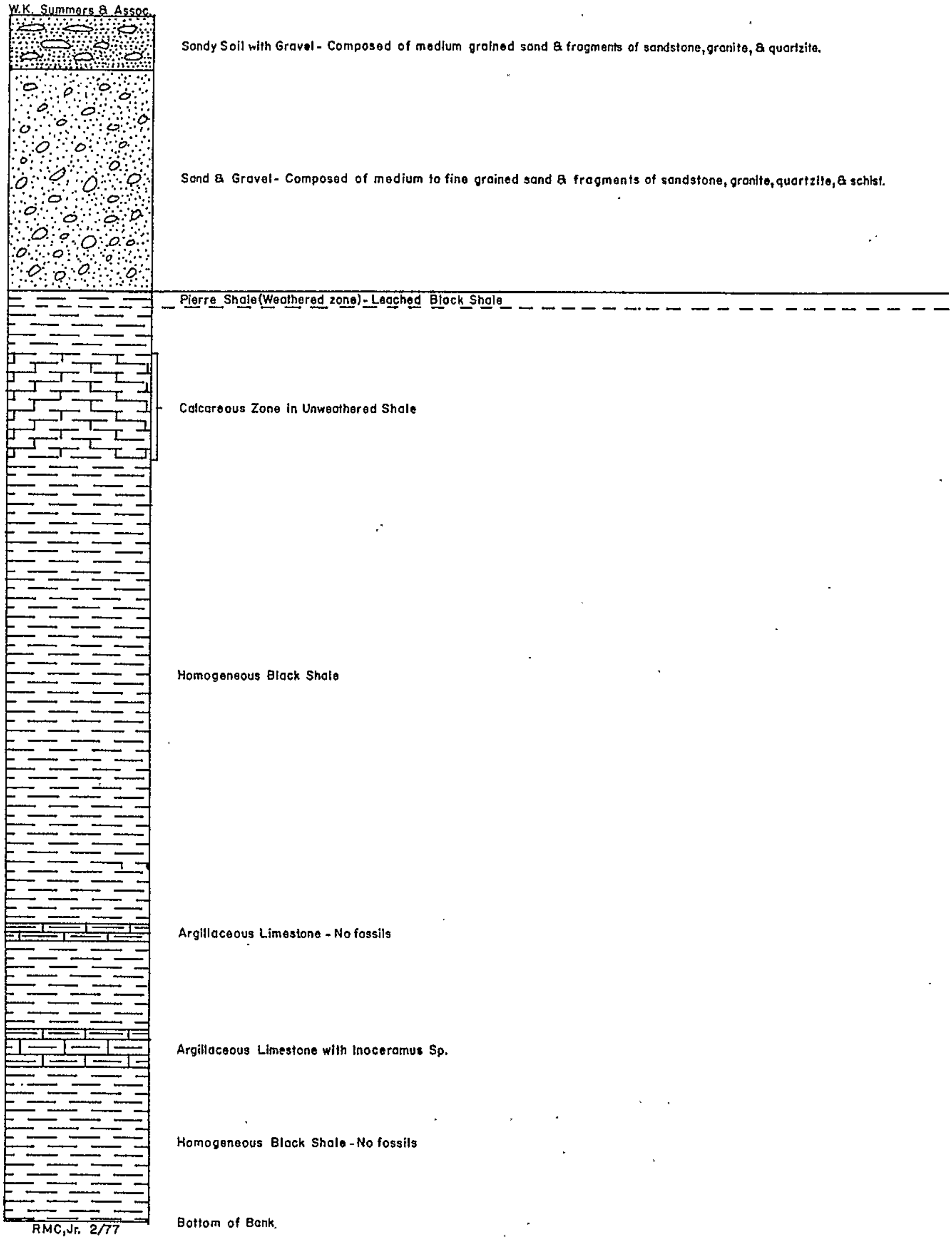
Inoceramus Sp.
Bottom of Van Bremmer Creek

RMC, Jr. 2/77

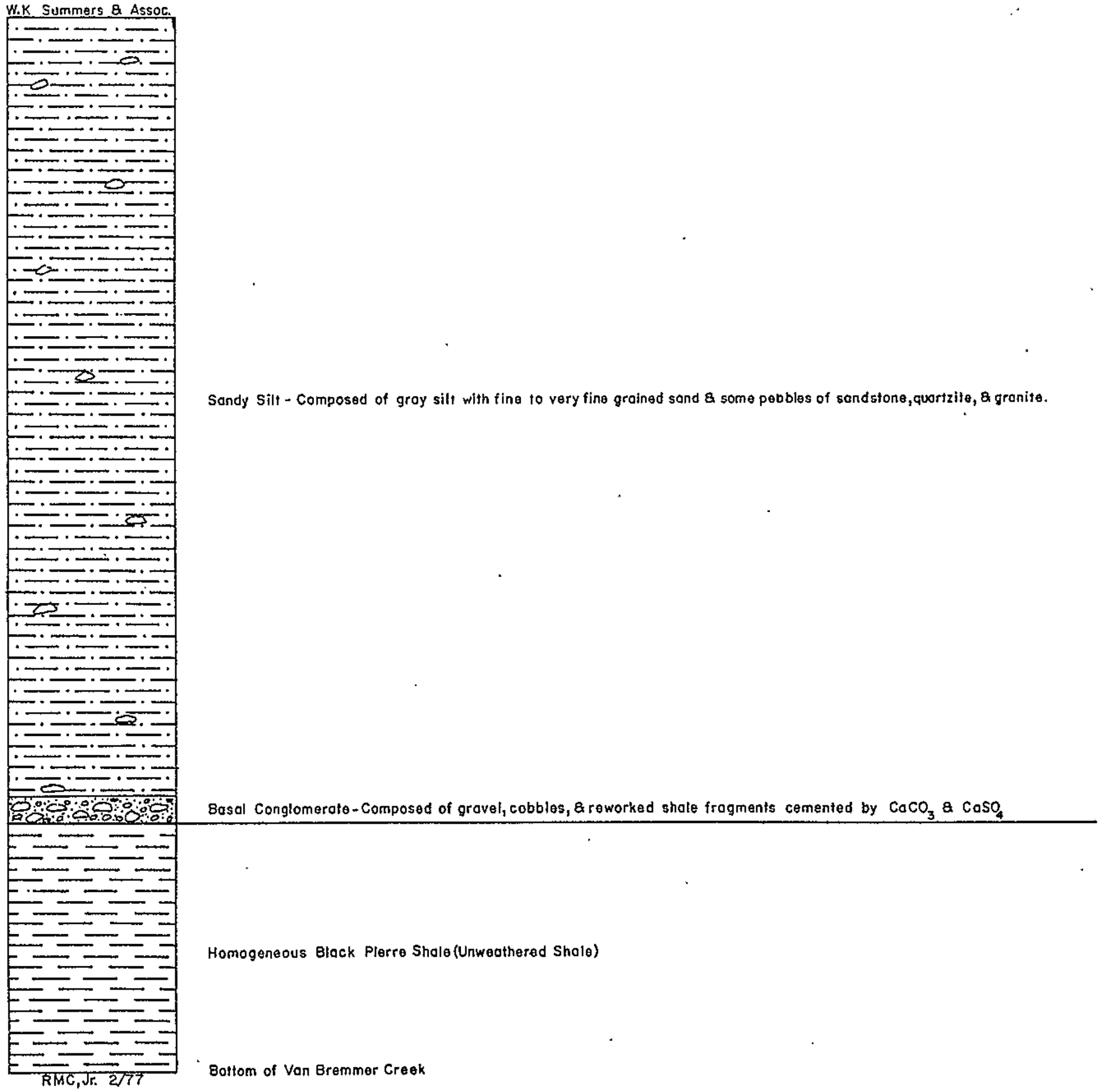
Stratigraphic Section 3
Scale - 1 inch = 3 feet



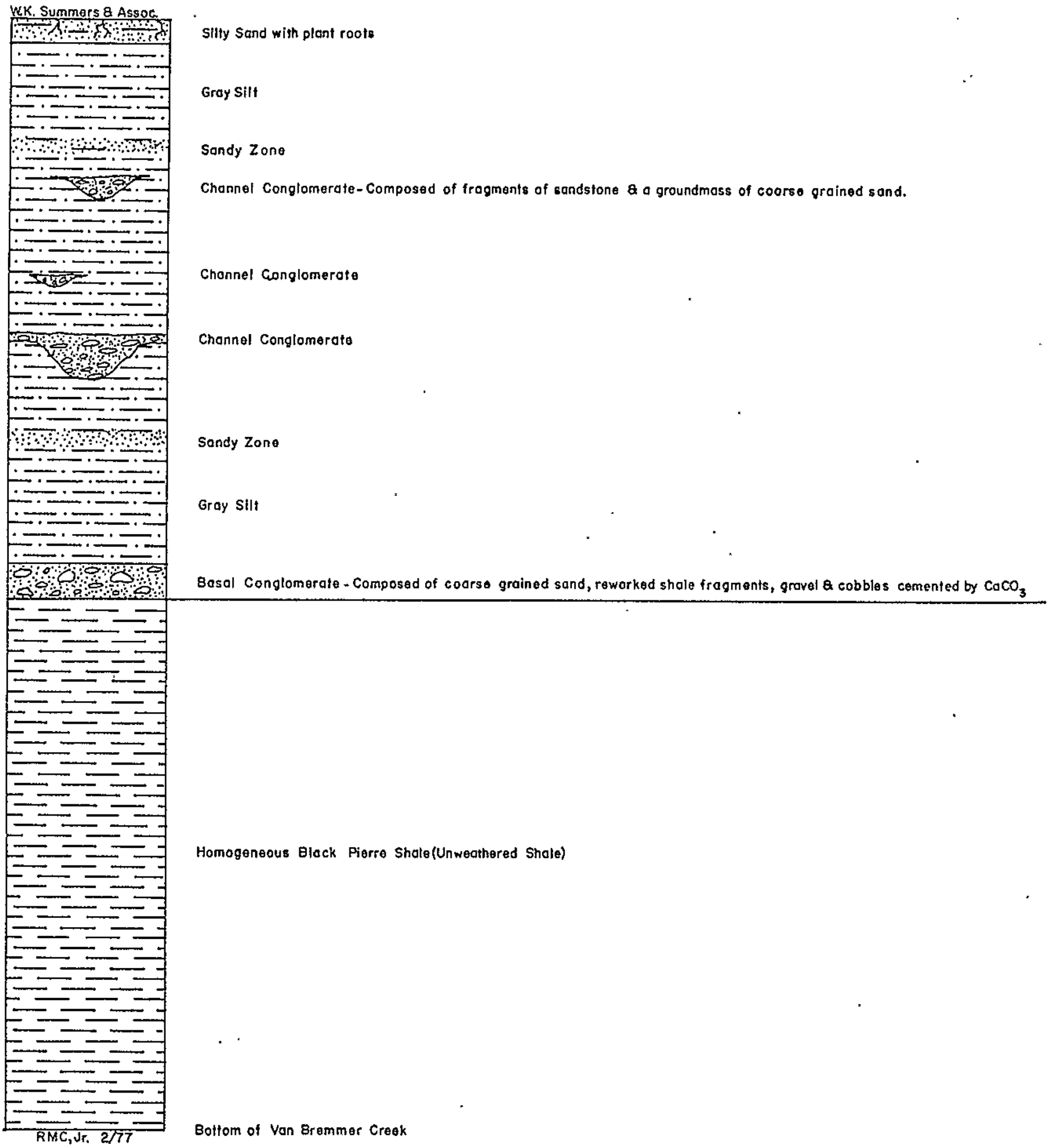
Stratigraphic Section 4
Scale-1 inch=4 feet



Stratigraphic Section 5
Scale - 1 inch = 4 feet

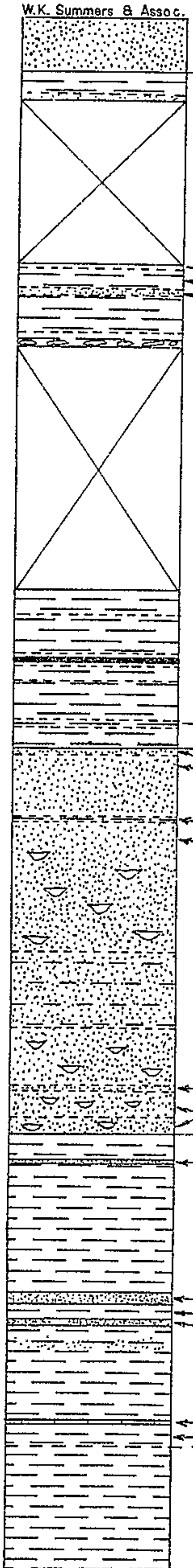


Stratigraphic Section 6
Scale-1 inch=3 feet



Stratigraphic Section 7
Scale - 1 inch = 3 feet

W.K. Summers & Assoc.



Top of Cliff
White to gray, medium grained friable sandstone.

RATON(?) FORMATION
VERMEJO FORMATION

Gray mudstone with 20% medium grained sand.
Sandy Lavender mudstone.

Interval covered by silt, plants & cobbles of sandstone. No outcrop exposed.

Gray mudstone with palm leaves.
Brown mudstone with petrified wood.
Sandy Gray mudstone
Lavender brown mudstone.
Gray mudstone with ironstone concretions

Interval covered by silt, plants & cobbles of sandstone. No outcrop exposed.

Gray mudstone

Lavender brown mudstone with petrified wood & abundant carbonaceous material. Also contains thin gray mudstone beds.

1.0' thick coal seam with a 1.0' thick lavender brown mudstone below & a 1.5' thick gray mudstone above.
Gray mudstone with petrified wood.

Lavender brown mudstone with 0.5% muscovite mica & a 0.1' thick coal seam.

Gray mudstone with petrified wood.
Lavender brown mudstone petrified wood.

VERMEJO FORMATION
TRINIDAD SANDSTONE

Sandstone with brown mud.
Gray sandstone with 25% dark minerals.

White to light gray, medium grained sandstone with Ophiomorpha Sp. burrows.

Brown micaceous siltstone.

White to light gray, medium grained sandstone with 0.5% white clay and $CaCO_3$ cement.

Gray, medium grained sandstone with $CaCO_3$ cement & Ophiomorpha Sp. burrows. Also contains lenticular brown sandstones.

White to buff, medium to fine grained, silty sandstone.

Gray, medium grained sandstone with $CaCO_3$ cement & Ophiomorpha Sp. burrows. Also contains lenticular brown sandstones.

Brown, medium grained sandstone with Fe_2O_3 cement.

Gray sandstone with lenticular brown micaceous sandstones.

TRINIDAD SANDSTONE
PIERRE SHALE

Gray, brown, & black shale.
Grayish brown, medium grained sandstone.

Brown shale with silty zones.

Buff to white, medium grained sandstone with Ophiomorpha Sp. burrows.
Brown sandy shale.
Buff, medium grained, sandstone.

Brown shale with sandy zones.

Brown argillaceous limestone.
Brown sandy shale.

Homogeneous black shale with occasional small concretions & fragments of Inoceramus Sp.

Bottom of Arroyo

RMC, Jr. 2/77

Stratigraphic Section 8

SCALE = 1 inch = 60 feet

FROM - (N = 2,037,250 ft. E = 363,250 ft. Alt. = 6610 ft.) TO - (N = 2,038,000 ft. E = 363,900 ft. Alt. = 7210 ft.)

APPENDICES TO

GEOLOGY AND HYDROLOGY OF A SITE PROPOSED FOR BURIAL OF LOW-LEVEL SOLID RADIOACTIVE WASTE

WESTERN COLFAX COUNTY, NEW MEXICO

APPENDIX II LABORATORY STUDIES

III CONSULTANTS REPORTS

IV DATA & PUBLISHED REPORTS

V FIELD PROCEDURES

VI BIBLIOGRAPHY

PREPARED FOR

CHEM—NUCLEAR NEW MEXICO, INC.
2403 SAN MATEO N.E., SUITE 9 WEST
ALBUQUERQUE, NEW MEXICO 87110

PREPARED BY

GORDON HERKENHOFF & ASSOCIATES, INC.
302 Eighth Street, N.W.
Albuquerque, New Mexico 87102

W.K. SUMMERS & ASSOCIATES
Box 684
Socorro, New Mexico 87801

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Appendix II-1.--Water Samples, Chemical Analysis

Appendix II-1. --

Chemical Analysis

CNP-3
N2,028,490
E383,100

Data collected 11-4-76

Data analysis complete 11-11-76

Laboratory Orlando Laboratories, Inc. Lab. No. 12490-23

Source of Data Orlando Laboratories, Inc.

Remarks CO_2 = 9.1 mg/L
Cu = <.1 mg/L

Constituent	Concentration mg/l		mel	%
SiO_2	15			*
Fe^{+3}/total	600			*
Mn^{+2}	12.20			
Ca^{+2}	20		1.00	3.93
Mg^{+2}	9.7		.80	3.14
Na^{+1}	540		23.49	92.23
K^{+1}	7.2		.18	.71
		Σ cations	25.47	100.01
HCO_3	531		8.70	34.74
CO_3	0		0	0
SO_4	690		14.37	57.39
Cl	65		1.83	7.31
F	2.6		.14	.56
B				
PO_4	< .1		0	
NO_3				
		Σ anions	25.04	100.00

Σ dissolved solids 2223

$\frac{\text{Cations-Anions}}{\text{Cations+Anions}}$ X 100 = .85%

Residue @ ______ 1750

	Lab	Date	Field	Date
pH	8.0			
Sp.Cond.	2350		2000	11-4-76
Discharge rate				

*excluded from computations

W. K. Summers & Associates

Appendix II-1. --

Chemical Analysis

CNP-4
N2,025,940
E383,080

Data collected 11-4-76

Data analysis complete 11-11-76

Laboratory Orlando Laboratories, Inc. Lab. No. 12490-15

Source of Data Orlando Laboratories, Inc.

Remarks CO_2 = 18 mg/L
Cu = <.1

Constituent	Concentration mg/l		mel	%
SiO_2	6.0			
Fe^{+3}/total	1.90		.10	.12
Mn^{+2}	.10		0	0
Ca^{+2}	56		2.80	3.31
Mg^{+2}	34		2.80	3.31
Na^{+1}	1800		78.30	92.54
K^{+1}	24.0		.61	.72
		Σ cations	84.61	100.00
HCO_3	1330		21.80	25.65
CO_3	0		0	0
SO_4	255		5.31	6.25
Cl	2050		57.83	68.04
F	1.0		.05	.06
B				
PO_4	< .1		0	
NO_3				
		Σ anions	84.99	100.00

Σ dissolved solids 4882

Residue @ ________ 5500

$\frac{\text{Cations-Anions}}{\text{Cations+Anions}}$ X 100 = .22%

	Lab	Date	Field	Date
pH	8.1			
Sp.Cond.	8350		6400	11-4-76
Discharge rate				

Appendix II-1. --

Chemical Analysis

CNS-3(P)
N2,029,460
E379,600

Data collected 11-4-76

Data analysis complete 11-11-76

Laboratory Orlando Laboratories, Inc. Lab. No. 12490-13

Source of Data Orlando Laboratories, Inc.

Remarks CO_2 = 25 mg/L
Cu = <.1

Constituent	Concentration mg/l		mel	%
SiO_2	9.6			
Fe^{+3}/total	.30		.02	.13
Mn^{+2}	1.31		.05	.33
Ca^{+2}	116		5.80	37.91
Mg^{+2}	39		3.21	20.98
Na^{+1}	140		6.09	39.80
K^{+1}	5.2		.13	.85
		Σ cations	15.30	100.00
HCO_3	476		7.80	52.07
CO_3	0		0	
SO_4	295		6.14	40.99
Cl	35		.99	6.61
F	1.0		.05	.33
B				
PO_4	< .1		0	
NO_3				
		Σ anions	14.98	100.00

Σ dissolved solids 876

Residue @ ______ 1000

$\frac{\text{Cations-Anions}}{\text{Cations+Anions}}$ X 100 = 1.06%

	Lab	Date	Field	Date
pH	7.5			
Sp.Cond.	1280		900	11-4-76
Discharge rate				

Appendix II-1. --

Chemical Analysis

CNS-4(P)
N2,028,720
E381,330

Data collected 11-4-76

Data analysis complete 11-11-76

Laboratory Orlando Laboratories, Inc. Lab. No. 12490-22

Source of Data Orlando Laboratories, Inc.

Remarks CO_2 = 23
Cu = <.1

Constituent	Concentration mg/l		mel	%
SiO_2	10			
Fe^{+3}/total	.43		.02	.03
Mn^{+2}	5.00		.18	.28
Ca^{+2}	524		26.18	40.82
Mg^{+2}	228		18.76	29.25
Na^{+1}	430		18.71	29.17
K^{+1}	11.2		.29	.45
		Σ cations	64.14	100.00
HCO_3	634		10.39	16.08
CO_3	0		0	0
SO_4	2550		53.09	82.16
Cl	35		.99	1.53
F	2.8		.15	.23
B				
PO_4	< .1		0	
NO_3				
		Σ anions	64.62	100.00

Σ dissolved solids 4108

Residue @ ______ 4000

$\frac{\text{Cations-Anions}}{\text{Cations+Anions}} \times 100 =$ .37%

	Lab	Date	Field	Date
pH	7.7			
Sp.Cond.	5000		6400	11-4-76

Discharge rate

Appendix II-1. --
Chemical Analysis

CNS-5
N2,027,030
E381,030

Data collected 11-4-76

Data analysis complete 11-11-76

Laboratory Orlando Laboratories, Inc.

Lab. No. 12490-20

Source of Data Orlando Laboratories, Inc.

Remarks CO_2 = 29 mg/L
Cu = < .1 mg/L

Constituent	Concentration mg/l		mel	%
SiO_2	12			
Fe^{+3}/total	.47		.03	.19
Mn^{+2}	.88		.03	.19
Ca^{+2}	74		3.70	22.98
Mg^{+2}	22		1.81	11.24
Na^{+1}	240		10.44	64.84
K^{+1}	3.4		.09	.56
		Σ cations	16.10	100.00
HCO_3	811		13.29	83.69
CO_3	0		0	0
SO_4	100		2.08	13.10
Cl	15		.42	2.64
F	1.8		.09	.57
B				
PO_4	< .1			
NO_3				
		Σ anions	15.88	100.00

Σ dissolved solids 868

Residue @ ____ 1100

$$\frac{\text{Cations-Anions}}{\text{Cations+Anions}} \times 100 = .69\%$$

	Lab	Date	Field	Date
pH	7.7			
Sp.Cond.	1330		1200	11-4-76
Discharge rate				

Appendix II-1. --

Chemical Analysis

CNS-7
N2,027,140
E377,450

Data collected 11-4-76

Data analysis complete 11-11-76

Laboratory Orlando Laboratories, Inc. Lab. No. 12490-11

Source of Data Orlando Laboratories, Inc.

Remarks CO_2 = 13 mg/L
Cu = <.1 mg/L

Constituent	Concentration mg/l		mel	%
SiO_2	3.0			
Fe^{+3}/total	.86		.05	.06
Mn^{+2}	2.65		.10	.13
Ca^{+2}	462		23.08	29.28
Mg^{+2}	247		20.32	25.78
Na^{+1}	800		34.80	44.15
K^{+1}	18.3		.47	.60
		Σ cations	78.82	100.00
HCO_3	146		2.39	3.04
CO_3	0		0	0
SO_4	3450		71.83	91.48
Cl	150		4.23	5.39
F	1.4		.07	.09
B				
PO_4	< .1		0	0
NO_3				
		Σ anions	78.52	100.00

Σ dissolved solids 5207

Residue @ ______ 4700

$\frac{\text{Cations-Anions}}{\text{Cations+Anions}} \times 100 =$ .19%

	Lab	Date	Field	Date
pH	7.3			
Sp.Cond.	5750		4900	11-4-76

Discharge rate ______

Appendix II-1. --

Chemical Analysis

CNS-11
N2,024,480
E376,880

Data collected 11-4-76

Data analysis complete 11-11-76

Laboratory Orlando Laboratories, Inc.

Lab. No. 12490-4

Source of Data Orlando Laboratories, Inc.

Remarks CO_2 = 10 mg/L
Cu = <.1 mg/L

Constituent	Concentration mg/l		mel	%
SiO_2	3.4			
Fe^{+3}/total	2.10		.11	.92
Mn^{+2}	.80		.03	.25
Ca^{+2}	60		3.00	25.02
Mg^{+2}	19		1.56	13.01
Na^{+1}	164		7.13	59.47
K^{+1}	6.3		.16	1.33
		Σ cations	11.99	100.00
HCO_3	232		3.80	31.51
CO_3	0			
SO_4	340		7.08	58.71
Cl	40		1.13	9.37
F	.9		.05	.41
B				
PO_4	< .1			
NO_3				
		Σ anions	12.06	100.00

Σ dissolved solids 751

Residue @ ______ 815

$\frac{\text{Cations-Anions}}{\text{Cations+Anions}}$ X 100 = .29%

	Lab	Date	Field	Date
pH	7.6			
Sp.Cond.	1095		1100	12-4-76
Discharge rate				

Appendix II-1. --

Chemical Analysis

CNS-19(P)
N2,028,110
E380,610

Data collected 11-4-76

Data analysis complete 11-11-76

Laboratory Orlando Laboratories, Inc. Lab. No. 12490-14

Source of Data Orlando Laboratories, Inc.

Remarks CO_2 = 65 mg/L
Cu = <.1 mg/L

Constituent	Concentration mg/l		mel	%
SiO_2	12			
Fe^{+3}/total	1.46		.08	.14
Mn^{+2}	4.00		.15	.26
Ca^{+2}	536		26.78	46.21
Mg^{+2}	156		12.83	22.14
Na^{+1}	410		17.84	30.79
K^{+1}	10.4		.27	.47
		Σ cations	57.95	100.01
HCO_3	756		12.39	21.21
CO_3	0		0	0
SO_4	2150		44.76	76.63
Cl	40		1.13	1.93
F	2.4		.13	.22
B				
PO_4	< .1		0	
NO_3				
		Σ anions	58.41	99.99

Σ dissolved solids ______

Residue @ ______ 3600

$\frac{\text{Cations-Anions}}{\text{Cations+Anions}}$ X 100 = .40%

	Lab	Date	Field	Date
pH	7.3			
Sp.Cond.	4150		3300	11-4-76
Discharge rate				

W. K. Summers & Associates

Appendix II-1. --

Chemical Analysis

W.S. #13 Vermejo Ditch
1460.0' East of Vermejo River
N2,032,590
E386,700

Data collected 10-5-76

Data analysis complete 11-11-76

Laboratory Orlando Laboratories, Inc. Lab. No. 12490-21

Source of Data Orlando Laboratories, Inc.

Remarks CO_2 = 6.8 mg/L
Cu = <.1 mg/L

Constituent	Concentration mg/l		mel	%
SiO_2	7.3			
Fe^{+3}/total	.40		.02	.17
Mn^{+2}	.10		0	0
Ca^{+2}	120		6.00	51.55
Mg^{+2}	22		1.81	15.55
Na^{+1}	86		3.74	32.13
K^{+1}	2.8		.07	.60
		Σ cations	11.64	100.00
HCO_3	293		4.80	41.03
CO_3	0		0	0
SO_4	315		6.56	56.07
Cl	10		.28	2.39
F	1.1		.06	.51
B				
PO_4	<.1		0	
NO_3				
		Σ anions	11.70	100.0C

Σ dissolved solids 709

Residue @ ______ 780

$\frac{\text{Cations-Anions}}{\text{Cations+Anions}}$ X 100 = .26%

	Lab	Date	Field	Date
pH	7.9			
Sp.Cond.	1000		900	10-5-76
Discharge rate				

Appendix II-1. --

Chemical Analysis

W.S. #12 Vermejo Ditch
3950.0' East of Vermejo River
N2,027,500
E393,130

Data collected 10-5-76

Data analysis complete 11-11-76

Laboratory Orlando Laboratories, Inc. Lab. No. 12490-18

Source of Data Orlando Laboratories, Inc.

Remarks CO_2 = 6.9 mg/L
Cu = <.1 mg/L

Constituent	Concentration mg/l		mel	%
SiO_2	7.3			
Fe^{+3}/total	.05		0	
Mn^{+2}	<.05		0	
Ca^{+2}	104		5.20	44.98
Mg^{+2}	32		2.63	22.75
Na^{+1}	84		3.65	31.57
K^{+1}	3.2		.08	.69
		Σ cations	11.56	99.99
HCO_3	305		5.00	41.74
CO_3	0		0	
SO_4	320		6.66	55.59
Cl	10		.28	2.34
F	.8		.04	.33
B				
PO_4	< .1		0	
NO_3				
		Σ anions	11.98	100.00

Σ dissolved solids ______

Residue @ ______ 780

$$\frac{\text{Cations-Anions}}{\text{Cations+Anions}} \times 100 = 1.78\%$$

	Lab	Date	Field	Date
pH	7.9			
Sp.Cond.	995		800	10-5-76
Discharge rate				

Appendix II-1. --

Chemical Analysis

W.S. #16 Vermejo River
26,600.0' above confluence
N2,037,360
E381,360

Data collected 10-5-76

Data analysis complete 11-11-76

Laboratory Orlando Laboratories, Inc.

Lab. No. 12490-2

Source of Data Orlando Laboratories, Inc.

Remarks CO_2 = 9.7 mg/L
Cu = <.1 mg/L

Constituent	Concentration mg/l		mel	%
SiO_2	3.9			
Fe^{+3}/total	.25		.01	.07
Mn^{+2}	<0.05		0	0
Ca^{+2}	132		6.59	43.61
Mg^{+2}	39		3.21	21.24
Na^{+1}	120		5.22	34.55
K^{+1}	3.2		.08	.53
		Σ cations	15.11	100.00
HCO_3	342		5.61	36.64
CO_3	0			
SO_4	450		9.37	61.20
Cl	10		.28	1.83
F	1.0		.05	.33
B				
PO_4	<0.1		0	
NO_3				
		Σ anions	15.31	100.00

Σ dissolved solids 928

Residue @ ______ 995

$\frac{\text{Cations-Anions}}{\text{Cations+Anions}} \times 100 =$ 1.18%

	Lab	Date	Field	Date
pH	7.4			
Sp.Cond.	1270		1200	10-5-76
Discharge rate				

Appendix II-1. --

Chemical Analysis

W.S. #14 Vermejo River
16,800' above confluence
N2,031.800
E385,630

Data collected 10-5-76

Data analysis complete 11-11-76

Laboratory Orlando Laboratories, Inc. Lab. No. 12490-12

Source of Data Orlando Laboratories, Inc.

Remarks CO_2 = 8.2 mg/L
Cu = <.1 mg/L

Constituent	Concentration mg/l		mel	%
SiO_2	6.4			
Fe^{+3}/total	.24		.01	.08
Mn^{+2}	<.05		0	0
Ca^{+2}	68		3.40	28.64
Mg^{+2}	63		5.18	43.64
Na^{+1}	74		3.22	27.13
K^{+1}	2.4		.06	.51
		Σ cations	11.87	100.00
HCO_3	299		4.90	41.21
CO_3	0		0	
SO_4	320		6.66	56.01
Cl	10		.28	2.35
F	1.0		.05	.42
B				
PO_4	<.1		0	
NO_3				
		Σ anions	11.89	99.99

Σ dissolved solids 692

Residue @ ______ 820

$\frac{\text{Cations-Anions}}{\text{Cations+Anions}}$ X 100 = .08%

	Lab	Date	Field	Date
pH	7.8			
Sp.Cond.	1140		1000	10-5-76
Discharge rate				

Appendix II-1. --

Chemical Analysis

W.S. #15 Vermejo River
15,800' above confluence
N2,030,900
E385.950

Data collected 10-5-76

Data analysis complete 11-11-76

Laboratory Orlando Laboratories, Inc.

Lab. No. 12490-3

Source of Data Orlando Laboratories, Inc.

Remarks CO_2 = 19 mg/L
Cu = <.1 mg/L

Constituent	Concentration mg/l		mel	%
SiO_2	2.8			
Fe^{+3}/total	.10		.01	.04
Mn^{+2}	< .05		0	0
Ca^{+2}	228		11.39	45.04
Mg^{+2}	83		6.83	27.01
Na^{+1}	160		6.96	27.52
K^{+1}	3.8		.10	.40
		Σ cations	25.29	100.01
HCO_3	293		4.80	19.10
CO_3	0		0	0
SO_4	960		19.99	79.54
Cl	10		.28	1.11
F	1.2		.06	.24
B				
PO_4	<0.1		0	0
NO_3				
		Σ anions	25.13	99.99

Σ dissolved solids 1593

Residue @ ______ 1520

$\frac{\text{Cations-Anions}}{\text{Cations+Anions}}$ X 100 = .32%

	Lab	Date	Field	Date
pH	7.4	11-11-76		
Sp.Cond.	1900	11-11-76	1700	10-5-76

Discharge rate ______

Appendix II-1. --

Chemical Analysis

Vermejo River
1600' above confluence
N2,022,480
E393,900

Data collected 11-2-76

Data analysis complete 11-11-76

Laboratory Orlando Laboratories, Inc. Lab. No. 12490-7

Source of Data Orlando Laboratories, Inc.

Remarks CO_2 = 8.5 mg/L
Cu = <.1 mg/L

Constituent	Concentration mg/l		mel	%
SiO_2	3.0			
Fe^{+3}/total	.06		0	
Mn^{+2}	< .05		0	
Ca^{+2}	216		10.79	45.42
Mg^{+2}	74		6.09	25.63
Na^{+1}	156		6.79	28.58
K^{+1}	3.4		.09	.38
		Σ cations	23.76	100.01
HCO_3	305		5.00	20.76
CO_3	0		0	0
SO_4	900		18.74	77.82
Cl	10		.28	1.16
F	1.1		.06	.25
B				
PO_4	< .1		0	
NO_3				
		Σ anions	24.08	99.99

Σ dissolved solids 1514

Residue @ ____ 1450

$\frac{\text{Cations-Anions}}{\text{Cations+Anions}}$ X 100 = .67%

	Lab	Date	Field	Date
pH	7.8			
Sp.Cond.	1750		1500	11-2-76
Discharge rate				

Appendix II-1. --
Chemical Analysis

Van Bremmer Creek
32,800' above confluence
N2,029,260
E370,320

Data collected 11-2-76

Data analysis complete 11-11-76

Laboratory Orlando Laboratories, Inc. Lab. No. 12490-6

Source of Data Orlando Laboratories, Inc.

Remarks CO_2 = 4.0 mg/L
Cu = <.1 mg/L

Constituent	Concentration mg/l		mel	%
SiO_2	.2			
Fe^{+3}/total	.05		0	0
Mn^{+2}	< .05		0	0
Ca^{+2}	62		3.10	27.12
Mg^{+2}	21		1.73	15.14
Na^{+1}	150		6.53	57.09
K^{+1}	2.7		.07	.61
		Σ cations	11.43	99.96
HCO_3	354		5.80	50.61
CO_3	0		0	
SO_4	243		5.06	44.15
Cl	20		.56	4.89
F	.8		.04	.35
B				
PO_4	< .1		0	0
NO_3				
		Σ anions	11.46	100.00

Σ dissolved solids 674

Residue @ ______ 760

$\frac{\text{Cations-Anions}}{\text{Cations+Anions}}$ X 100 = .13%

	Lab	Date	Field	Date
pH	8.2			
Sp.Cond.	960		900	11-2-76

Discharge rate

Appendix II-1. --

Chemical Analysis

Van Bremmer Creek
22,800' above confluence
N2,022,800
E376,800

Data collected 11-2-76

Data analysis complete 11-11-76

Laboratory Orlando Laboratories, Inc, Lab. No. 12490-16

Source of Data Orlando Laboratories, Inc.

Remarks CO_2 = 4.7 mg/L
Cu = <.1 mg/L

Constituent	Concentration mg/l		mel	%
SiO_2	2.9			
Fe^{+3}/total	.17		.01	.07
Mn^{+2}	< .05		0	0
Ca^{+2}	78		3.90	26.37
Mg^{+2}	18		1.48	10.01
Na^{+1}	200		8.70	58.82
K^{+1}	27.2		.70	4.73
		Σ cations	14.79	100.00
HCO_3	415		6.80	47.79
CO_3	0		0	0
SO_4	280		5.83	40.97
Cl	50		1.41	9.91
F	.9		.05	.35
B				
PO_4	4.3		.14	.98
NO_3				
		Σ anions	14.23	100.00

Σ dissolved solids 865.53

Residue @ ______ 955

$\frac{\text{Cations-Anions}}{\text{Cations+Anions}} \times 100 =$ 1.93%

	Lab	Date	Field	Date
pH	7.2			
Sp.Cond.	1235		600	11-2-76
Discharge rate				

W. K. Summers & Associates

Appendix II-1. --

Chemical Analyses

Van Bremmer Creek
17,800' above confluence
N2,021,120
E380,920

Data collected 10-4-76

Data analysis complete 11-11-76

Laboratory Orlando Laboratories, Inc. Lab. No. 12490-1

Source of Data Orlando Laboratories, Inc.

Remarks CO_2 = 10 mg/L
Cu = <.1 mg/L

Constituent	Concentration mg/l		mel	%
SiO_2	4.6			
Fe^{+3}/total	.27		.01	.08
Mn^{+2}	.53		.02	.16
Ca^{+2}	80		4.00	31.67
Mg^{+2}	19		1.56	12.35
Na^{+1}	160		6.96	55.11
K^{+1}	3.1		.08	.63
		Σ cations	12.63	100.00
HCO_3	366		6.00	49.75
CO_3	0		0	
SO_4	275		5.73	47.51
Cl	10		.28	2.32
F	.9		.05	.41
B				
PO_4	<0.1		0	0
NO_3				
		Σ anions	12.06	99.99

Σ dissolved solids 734

Residue @ ______ 845

$\frac{\text{Cations-Anions}}{\text{Cations+Anions}} \times 100 = 2.31\%$

	Lab	Date	Field	Date
pH	7.8	11-11-76		
Sp.Cond.	1095	11-11-76	1100	10-4-76
Discharge rate				

Appendix II-1. --

Chemical Analysis

W.S. #11 Van Bremmer Creek
3600' above confluence
N2,020,380
E392,620

Data collected 10-14-76

Data analysis complete 11-11-76

Laboratory Orlando Laboratories, Inc. Lab. No. 12490-10

Source of Data Orlando Laboratories, Inc.

Remarks CO_2 =
Cu =

Constituent	Concentration mg/l		mel	%
SiO_2	3.9			
Fe^{+3}/total	.05		0	
Mn^{+2}	< .05		0	
Ca^{+2}	48		2.40	15.12
Mg^{+2}	36		2.96	18.65
Na^{+1}	240		10.44	65.78
K^{+1}	2.7		.07	.44
		Σ cations	15.87	99.99
HCO_3	378		6.20	38.85
CO_3	0		0	0
SO_4	425		8.85	55.45
Cl	30		.85	5.33
F	1.1		.06	.38
B				
PO_4	<.1		0	
NO_3				
		Σ anions	15.96	100.01

Σ dissolved solids 973

Residue @ ______ 1070

$\frac{\text{Cations-Anions}}{\text{Cations+Anions}}$ X 100 = .28%

	Lab	Date	Field	Date
pH	8.2			
Sp.Cond.	1400		1400	10-14-76
Discharge rate				

W. K. Summers & Associates

Appendix II-1. --

Chemical Analysis

Stock well (windmill)
N2,033,250
E364,200

Data collected 10-4-76

Data analysis complete 11-11-76

Laboratory Orlando Laboratories, Inc. Lab. No. 12490-9

Source of Data Orlando Laboratories, Inc.

Remarks CO_2 = 7.7 mg/L
Cu = <.1 mg/L

Constituent	Concentration mg/l		mel	%
SiO_2	2.8			
Fe^{+3}/total	.70		.04	.13
Mn^{+2}	<.05		0	0
Ca^{+2}	4.8		.24	.79
Mg^{+2}	1.9		.16	.53
Na^{+1}	680		29.58	97.85
K^{+1}	8.1		.21	.69
		Σ cations	30.23	99.99
HCO_3	781		12.80	42.51
CO_3	37		1.23	4.09
SO_4	60		1.25	4.15
Cl	520		14.67	48.72
F	3.0		.16	.53
B				
PO_4	< .1		0	
NO_3				
		Σ anions	30.11	100.00

Σ dissolved solids 1702

Residue @ ______ 2000

$\frac{\text{Cations-Anions}}{\text{Cations+Anions}}$ X 100 = .20%

	Lab	Date	Field	Date
pH	8.3			
Sp.Cond.	2850		2600	10-4-76
Discharge rate				

Appendix II-1. --

Chemical Analysis

W.S. #9 Stock Pond
N2,023,650
E366,000

Data collected 10-4-76

Data analysis complete 11-11-76

Laboratory Orlando Laboratories, Inc. Lab. No. 12490-17

Source of Data Orlando Laboratories, Inc.

Remarks CO_2 = 8.8 mg/L
Cu = <.1 mg/L

Constituent	Concentration mg/l		mel	%
SiO_2	3.9			
Fe^{+3}/total	19.6			*
Mn^{+2}	<.05		0	0
Ca^{+2}	32		1.60	48.34
Mg^{+2}	7.3		.60	18.13
Na^{+1}	21		.91	27.49
K^{+1}	8.0		.20	6.04
		Σ cations	3.31	100.00
HCO_3	153		2.51	84.23
CO_3	0		0	
SO_4	16		.33	11.07
Cl	5		.14	4.70
F	<.1			
B				
PO_4	<.1			
NO_3				
		Σ anions	2.98	100.00

Σ dissolved solids 188

Residue @ ______ 240

$\frac{\text{Cations-Anions}}{\text{Cations+Anions}}$ X 100 = 5.25%

	Lab	Date	Field	Date
pH	7.5			
Sp.Cond.	375		200	10-4-76
Discharge rate				

* Excluded from computations

Appendix II-1. --

Chemical Analysis

Domestic well
N2,029,220
E370,000

Data collected 11-2-76

Data analysis complete 11-11-76

Laboratory Orlando Laboratories, Inc.

Lab. No. 12490-8

Source of Data Orlando Laboratories, Inc.

Remarks CO_2 = 14 mg/L
Cu = <.1 mg/L

Constituent	Concentration mg/l		mel	%
SiO_2	4.3			
Fe^{+3}/total	.32		.02	.14
Mn^{+2}	<.05		0	0
Ca^{+2}	80		4.0	28.90
Mg^{+2}	29		2.39	17.27
Na^{+1}	170		7.40	53.47
K^{+1}	1.2		.03	.22
		Σ cations	13.84	100.00
HCO_3	403		6.61	45.90
CO_3	0		0	
SO_4	345		7.18	49.86
Cl	20		.56	3.89
F	1.0		.05	.35
B				
PO_4	<.1			
NO_3				
		Σ anions	14.40	100.00

Σ dissolved solids 849

Residue @ ______ 960

$\frac{\text{Cations-Anions}}{\text{Cations+Anions}} \times 100 =$ 1.98%

	Lab	Date	Field	Date
pH	7.7			
Sp.Cond.	1245		1000	11-2-76
Discharge rate				

Appendix II-1. --

Chemical Analysis

CNW-2
N2,024,050
E379,970

Data collected ______________________

Data analysis complete January 17, 1977

Laboratory Orlando Laboratories, Inc.

Lab. No. 12753

Source of Data Orlando Laboratories, Inc.

Remarks

CO_2 = 8.0 mg/L

Cu = <.1 mg/L

Constituent	Concentration mg/L		mel	%
SiO_2	12			
Fe^{+3}/total	.60		.032	.296
Mn^{+2}	<.05		0	0
Ca^{+2}	26		1.299	12.004
Mg^{+2}	8.7		.716	6.617
Na^{+1}	200		8.700	80.399
K^{+1}	2.9		.074	.684
		Σ cations	10.821	100.000
HCO_3	178		2.917	30.341
CO_3	0		0	0
SO_4	315		6.558	68.213
Cl	25.		.071	.739
F	1.1		.058	.603
B	--		--	--
PO_4	.31		.010	.104
NO_3	--		--	--
		Σ anions	9.614	100.000

Σ dissolved solids 679

Residue @ ______ 790

$\frac{\text{Cations-Anions}}{\text{Cations+Anions}} \times 100 = 5.91$

	Lab	Date	Field	Date
pH	7.6			
Sp.Cond.	1238			
Discharge rate				

Chemical Analysis

CNW-4
N2,021,790
E379,370

Data collected ______

Data analysis complete January 24, 1977

Laboratory Orlando Laboratories, Inc. Lab. No. 12782

Source of Data Orlando Laboratories, Inc.

Remarks

CO_2 = 9.8 mg/L

Cu = <0.1 mg/L

Constituent	Concentration mg/L		mel	%
SiO_2	6.4			
Fe^{+3}/total	2.20		.118	1.080
Mn^{+2}	.05		0	0
Ca^{+2}	55		2.748	25.142
Mg^{+2}	19		1.563	14.300
Na^{+1}	148		6.438	58.902
K^{+1}	2.47		.03	.576
		Σ cations	10.930	100.000
HCO_3	285		4.671	46.561
CO_3	0		0	0
SO_4	235		4.893	48.774
Cl	15		.423	4.217
F	.8		.042	.419
B	--		--	--
PO_4	.09		.003	.030
NO_3	--		--	--
		Σ anions	10.032	100.000

Σ dissolved solids 624

Residue @ ______ 680

$\frac{\text{Cations-Anions}}{\text{Cations+Anions}} \times 100 = 4.28$

	Lab	Date	Field	Date
pH	7.7			
Sp.Cond.	1000			
Discharge rate				

Appendix II-2.--Radiochemistry

ALBUQUERQUE LABORATORY

REPORT OF ANALYSIS

CUSTOMER GORDON HERKENHOFF & ASSOCIATES
ATTENTION Mr. W. K. Summers
ADDRESS 302 Eighth Street, N. W.
CITY Albuquerque, New Mexico 87102
S.O. NO. 5323

TYPE OF ANALYSIS DETERMINATION of TRITIUM, Sr-90 & Ra-226 in WATER SAMPLES

CUSTOMER ORDER NUMBER

SAMPLES RECEIVED 11/10/76

Sample Identification	Sample Number	Total Volume (ml)	pCi/ml Tritium	pCi/l Sr-90	pCi/l Ra-226
Water	CNS-3	3000	0.0 ± 1.0	0.0 ± 1.0	0.09 ± 0.02
Water	CNP-4	3000	0.0 ± 1.0	0.0 ± 1.0	0.07 ± 0.02
Water	CNS-4	3000	0.0 ± 1.0	0.0 ± 1.0	0.03 ± 0.02
Water	CNS-5	3000	0.0 ± 1.0	0.0 ± 1.0	0.12 ± 0.02
Water	CNS-11	3000	0.0 ± 1.0	0.0 ± 1.0	0.38 ± 0.04

☐ REPORTED VIA TELEPHONE

☐ REPORTED VIA TWX

PAGE 1 OF 1 PAGE

EBERLINE INSTRUMENT CORPORATION
P.O. BOX 3874 ALBUQUERQUE, NEW MEXICO 87110
PHONE (505) 345-3461 TWX: 910-985-0678

APPROVED BY Kathy Burnham DATE 12/27/76

Kathy Burnham, Environmental Reports
Albuquerque Laboratory

ALBUQUERQUE LABORATORY

REPORT OF ANALYSIS

STOMER GORDON HERKENHOFF & ASSOCIATES
ENTION Mr. W. K. Summers
DDRESS 302 Eighth Street, N. W.
CITY Albuquerque, New Mexico 87102
S.O. NO. 5324

PE OF ANALYSIS DETERMINATION of GAMMA ISOTOPIC in WATER SAMPLES

CUSTOMER ORDER NUMBER

SAMPLES RECEIVED 11/10/76

Sample Identification	Sample Number	pCi/l K-40
Water	CNS-3	< MDA
Water	CNP-4	98 ± 77
Water	CNS-4	75 ± 72
Water	CNS-5	< MDA
Water	CNS-11	120 ± 90

* All other gamma emitters were below minimum delectable activity concentrations shown in the attached table.

EPORTED VIA TELEPHONE

EPORTED VIA TWX

PAGE 1 OF 1 PAGE

EBERLINE INSTRUMENT CORPORATION
P.O. BOX 3874 ALBUQUERQUE, NEW MEXICO 87110
PHONE (505) 345-3461 TWX: 910-985-0678

APPROVED BY Kathy Burnham DATE 12/27/76

Kathy Burnham, Environmental Reports
Albuquerque Laboratory

ALBUQUERQUE LABORATORY

REPORT OF ANALYSIS

USTOMER GORDON HERKENHOFF & ASSOCIATES
TTENTION Glenn Hammock
ADDRESS 302 Eighth Street, N. W.
CITY Albuquerque, New Mexico 87102
S.O. NO. 5488

YPE OF ANALYSIS DETERMINATION of TRITIUM in WATER SAMPLES

CUSTOMER ORDER NUMBER

SAMPLES RECEIVED 01/19/77

Sample Identification	Sample Number	Date Collected	Total Volume (ml)	pCi/ml*
Resample	CNS-5	01/05/77	3800	0.0 ± 1.0
Van Bremmer CRK.	Weir #3	01/05/77	3800	0.0 ± 1.0
Water Sample	CNW-2	01/19/77	3800	0.0 ± 1.0

REPORTED VIA TELEPHONE 01/21/77

REPORTED VIA TWX

PAGE 1 OF 1 PAGE

EBERLINE INSTRUMENT CORPORATION
P.O. BOX 3874 ALBUQUERQUE, NEW MEXICO 87110
PHONE (505) 345-3461 TWX: 910-985-0678

APPROVED BY Kathy Burnham DATE 01/26/77
Kathy Burnham, Environmental Reports
Albuquerque Laboratory

GAMMA SENSITIVITIES

EIC GeLi SYSTEM

Nuclide	Energy Used to Quantify (KeV)	MDA* pCi/Sample	MDA** pCi/Sample
Co-57	122	4.3	13
Ce-144	134	35	100
Ce-141	145	8.5	23
Ra-226	186	110	280
Hg-203	279	4.8	11
Cr-51	320	40	91
I-131	364	4.4	9.7
Sb-125	427	14	28
Be-7	477	32	70
La-140	487	9.4	19
Ru-103	497	4.0	8.4
Ba-140	537	15	30
Cs-134	605	4.8	10
Ru-106	622	11	69
Cs-137	662	4.5	9.7
Zr-95	724	7.7	15
Nb-95	765	4.0	9.4
Co-58	810	4.3	8.7
Mn-54	835	4.3	7.9
Zn-65	1115	8.4	19
Co-60	1173	4.7	8.5
Na-22	1275	3.9	7.6
K-40	1460	43	84

*Minimum detectable activity for 100 mm diameter x 19 mm deep Petri dish geometry and 200-minutes counting time.

**Minimum detectable activity for 550 ml Marinelli beaker geometry and 200-minutes counting time.

Appendix II-3.--Clay mineralogy

Southern Illinois
University at Carbondale
Carbondale, Illinois 62901

Department of Geology
December 10, 1976

Dr. Charles W. Walker
P.O. Box 224
Cimmaron, NM 87714

Dear Buzz,

Here are the x-ray analyses of the seven shale and clay samples as well as the three sand samples.

Four separate x-ray scans were made on each shale and clay sample and one scan was made on each sand sample. The details of our experimental procedure and the x-ray strip charts are included along with our interpretations.

We hope that you will find this data useful in your study. If you have any questions about the identifications or methods used please feel free to call.

Sincerely,

Paul

Paul D. Robinson
Assistant Professor of Geology

William C. Hood
Associate Professor of Geology

X-RAY STUDY OF SHALES AND SANDS

Submitted to:

Charles W. Walker

by

Paul D. Robinson, M.S.
1807 W. Freeman
Carbondale, Il

and

William C. Hood, Ph.D.
202 N. Oakland St.
Carbondale, Il
C.P.G. No. 2185

Introduction and Authorization

At the request of Charles W. Walker, x-ray diffraction identifications were made of the minerals present in ten shale, clay and sand samples from an unspecified area. Identification of clay minerals were made by Dr. William C. Hood, Certified Professional Geologist and Charter Member of the Clay Minerals Society. Identifications of silts and sands were made by Paul D. Robinson, X-ray Crystallographer.

SAMPLE PREPARATION

I. Sands

The sands were crushed and then ground to less than 200 mesh using an automatic mortar and pestle.

II. Silt Size Fraction

The silt size fractions from the clay samples were dried in an oven and ground to less than 200 mesh in an automatic mortar and pestle.

III. Oriented Clay Slides

The clay size materials were separated from shale samples by first crushing the shales with a cast iron mortar and pestle, followed by grinding with a mechanical mortar and pestle. Each pulverized shale was placed in a beaker with water adjusted to pH 9.5 with sodium carbonate, and the slurry subjected to ultrasonic disaggregation for twenty minutes. Following disaggregation, the slurrys were transferred to sedimentation cylinders where the clay size fractions were separated from coarser materials by differential sedimentation rates. The sedimentation step was repeated until most of the clay was separated from the silts. The clay was then concentrated into a convenient volume by centrifuge.

The concentrated clays were then saturated with magnesium by suspension in magnesium chloride solution, again centrifuged, rinsed to remove excess magnesium chloride and resuspended. From this suspension, three oriented samples of each clay were prepared:

a) Untreated magnesium-saturated clay

b) Ethylene glycol-saturated clay

c) Clay heated to 600° C for one hour

The procedure for preparing the oriented clay slides involves placing the clay slurry on three glass slides and allowing them to air dry. One slide is then heat treated, the second is glycolated and the third receives no further treatment. This procedure produces oriented samples of clay which allows x-ray identification of most common clay minerals by use of their basal plane spacings. To better ascertain the identity of a minor phase that appeared in some of the patterns, a fourth treatment, potassium saturation, was also used.

X-RAY EQUIPMENT

All samples were run with a Norelco wide-angle powder diffractometer using CuK radiation, a graphite monochromator and a scintillation detector. Clay samples were scanned over the range 3 to 40° two-theta. Silts and sands were packed in standard aluminum sample holders and scanned over the range 10 to 80° two-theta. In the silt scans, the quartz peak was purposely allowed to go off scale in order to enhance the peaks of any other minerals present.

INTERPRETATION

I. Clays

Clay minerals recognized include illite, kaolinite, mixed layer illite /montmorillonite, quartz, a very small amount of discrete montmorillonite, and chlorite. The chlorite merits special mention due to its somewhat unusual behavior. The basal spacing of chlorite is approximately 14 A, and is often weak. The second and fourth order peaks coincide with kaolinite which results in an identification problem. The usual method for identification is heat treatment, which destroys the kaolinite and enhances the chlorite x-ray peaks. In the samples under investigation, both the kaolinite peaks and the 14 A peak disappeared with heat treatment. This is atypical behavior for chlorite and suggested the 14 A peak might be vermiculite. Potassium saturation, which collapses the 14 A vermiculite peak to 10 A, was then tried with negative results. There are some poorly crystallized chlorites with low thermal stability that appear to form within sedimentary rocks. It appears that the chlorite present in these shales is such a mineral.

II. Silt Size Fraction and Sands

All x-ray peaks were checked against the J.C.P.D.S. powder diffraction file in order to affect identification of each species present. In the case of the sands the peak height of the largest quartz peak was divided into the peak height of the feldspar peaks in order to get a general impression of their relative abundances.

MINERAL IDENTIFICATIONS

Sample No. 1. CNC-1 253.5' Core sample. Unweathered Pierre shale.

Clay size fraction	Relative abundance
Illite	5
Kaolinite	3
Mixed layer illite/montmorillonite	3
Chlorite	1
Quartz	1
Silt size fraction	
Quartz	5
Calcite	3
Dolomite	2-3
Plagioclase	2

Sample No. 2. CNC-2 22.5' Core sample. Weathered Pierre shale approximately 10' above unweathered shale.

Clay size fraction	Relative abundance
Illite	4
Kaolinite	3
Mixed layer illite/montmorillonite	3
Montmorillonite	1
Silt size fraction	
Quartz	5
Plagioclase	3
Dolomite	2-3
Potassium feldspar	1
Calcite (?)	

Sample No. 3. CNC-2 32.9' Core sample. Unweathered Pierre shale approximately 0.4' below weathered zone.

Clay size fraction	Relative abundance
Illite	3
Kaolinite	3
Mixed layer illite/montmorillonite	3
Chlorite	2
Quartz	3
Silt size fraction	
Quartz	5
Dolomite	3
Plagioclase	2
Calcite	1

Sample No. 4. CNP-2 20' Drill cuttings from 5' interval of sand and gravel. Less than 75 um washed out.

Sand size fraction	Relative abundance
Quartz	5
Plagioclase	3
Potassium feldspar	3
Calcite	2

Approximate abundance of feldspar relative to quartz, based on peak height ratios

Potassium feldspar	28%
Plagioclase	26%

Sample No. 5. CNS-29 20' Drill cuttings from 8' interval of sandy clay. Approximately 12% moisture.

Clay size fraction	Relative abundance
Illite	3
Kaolinite	3
Mixed layer illite/montmorillonite	3
Chlorite	2
Quartz	4

Silt size fraction	
Quartz	5
Plagioclase	3-4
Potassium feldspar	3-4
Calcite	1

Sample No. 6. CNS-29 40' Drill cuttings from 9' interval of sand and gravel. Water producer. Less than 75 um washed out.

Sand size fraction	Relative abundance
Quartz	5
Plagioclase	3
Potassium feldspar	2
Calcite	1

Approximate abundance of feldspar relative to quartz, based on peak height ratios.

Plagioclase	15%
Potassium feldspar	7%

Sample No. 7. Outcrop sample. Unweathered Pierre shale. From Vermejo River valley, A.T.S.F. RR cut.

Clay size fraction	Relative abundance
Illite	4
Kaolinite	3
Mixed layer illite/montmorillonite	3
Chlorite	2
Quartz	3
Silt size fraction	
Quartz	5
Calcite	3
Plagioclase	3
Dolomite	2

Sample No. 8. Outcrop sample. Weathered Pierre shale. From Vermejo River valley, A.T.S.F. RR cut.

Clay size fraction	Relative abundance
Illite	3
Kaolinite	3
Mixed layer illite/montmorillonite	4
Chlorite	2
Quartz	2
Silt size fraction	
Quartz	5
Calcite	3
Plagioclase	2-3
Dolomite	2

Sample No. 9. Outcrop sample. Unweathered Pierre shale. From 100' below the Trinidad sandstone contact on west face of ridge dividing Van Bremmer Creek and Vermejo River.

Clay size fraction	Relative abundance
Illite	3
Kaolinite	4
Mixed layer illite/montmorillonite	3
Chlorite	2
Quartz	3

Silt size fraction	
Quartz	5
Plagioclase	2-3
Dolomite	2
Potassium feldspar	1

Sample No. 10. Outcrop sample. Trinidad sandstone. Composite lithology. From west face of ridge dividing Van Bremmer Creek and Vermejo River.

Sand size fraction	
Quartz	5
Plagioclase	3
Calcite	3
Potassium feldspar	2

Approximate abundance of feldspar relative to quartz, based on peak heigth ratios.

Plagioclase	40%
Potassium feldspar	10%

RELATIVE ABUNDANCE CODE

5. The predominant phase present in the X-ray pattern. Peak height suggests it is by far the most abundant material present, probably exceeding 70 percent of the total.

4. The main phase present, but not so outstandingly more abundant than the other minerals present as 5 (above). Approximately 40 to 70 percent of the total.

3. An important phase, easily recognized on the X-ray pattern. Peak height suggests the mineral might constitute on the order of 10 to 40 percent of the total.

2. Minor phase. Main peak recognizable, but probably not over 10 percent of the total sample.

1. Trace amount. Peak recognizable but very small.

Sample No. 11. CNC-1 400.0' Pierre shale, cuttings.

Clay size fraction	Relative abundance
Illite	3
Kaolinite	3
Mixed layer illite/montmorillonite	4
Chlorite	2
Silt size fraction	
Quartz	5
Plagiclase	2
Dolomite	2
Pyrite	1

Sample No. 12 CNC-5 46' Pierre shale, altered. Core sample

Clay size fraction	Relative abundance
Illite	1
Kaolinite	5
Mixed layer illite/montmorillonite	1
Chlorite	1
Quartz	1
Silt size fraction	
Kaolinite	4
Quartz	3
Pyrite	2

Sample No. 13. CNC-6 65.3' Pierre shale, core.

Clay size fraction	Relative abundance
Illite	3
Kaolinite	3
Mixed layer illite/montmorillonite	3
Chlorite	1
Quartz	2
Calcite	2

Silt size fraction	
Quartz	5
Calcite	3
Dolomite	3
Plagioclase	2
Potassium Feldspar (?)	-
Pyrite	1

Sample No. 14. CNC-8 41.0 Pierre shale, core.

Clay size fraction	
Illite	3+
Kaolinite	3
Mixed layer illite/montmorillonite	3+
Chlorite	1
Quartz	2

Silt size fraction	
Quartz	5
Calcite	2-3
Dolomite	2
Plagioclase	2
Pyrite (?)	-

Sample No. 15 CNG-2 58.5' Pierre shale, core.

Clay size fraction	Relative abundance
Illite	4
Kaolinite	3
Mixed layer illite/montmorillonite	3
Chlorite	2
Quartz	1

Silt size fraction	
Quartz	5
Dolomite	3
Plagioclase	2

Sample No. 16 CNC-6 14.5' Weathered Pierre shale, core.

Clay size fraction	
Illite	3
Kaolinite	3
Mixed layer illite/montmorillonite	4
Chlorite	2
Quartz	2

Silt size fraction	
Quartz	5
Plagioclase	3
Potassium Feldspar	2
Calcite (?)	-

Sample No. 17 CNC-8 15.0' Weathered Pierre shale, cuttings.

Clay size fraction	Relative Abundance
Illite	3
Kaolinite	3
Mixed layer illite/montmorillonite	4
Chlorite	1
Quartz	1

Silt size fraction	
Quartz	5
Plagioclase	2
Dolomite	2
Calcite	1

Sample No. 18 CNS-34 20.0' Brown sandy clay, cuttings.

Clay size fraction	
Illite	3+
Kaolinite	2
Mixed layer illite/montmorillonite	3+
Chlorite	1
Quartz	2

Silt size fraction	
Quartz	5
Plagioclase	1-2
Dolomite	1
Potassium Feldspar	1-

Sample No. 19 CNG-2 45.0' Weathered Pierre shale, cuttings.

Clay size fraction

Illite	3
Kaolinite	3
Mixed layer illite/montmorillonite	3
Chlorite	2-3

Silt size fraction

Quartz	5
Calcite	2
Plagioclase	2
Dolomite	2
Potassium Feldspar (?)	-

Sample No. 20 GNG-2 50.0' Partially weathered Pierre shale, cuttings.

Clay size fraction

Illite	3
Kaolinite	3
Mixed layer illite/montmorillonite	3
Chlorite	2
Quartz	1

Silt size fraction

Quartz	5
Dolomite	2-3
Plagioclase	2
Calcite	2
Pyrite	1
Potassium Feldspar (?)	-

Sample No. 21 CNP-1 5.0' Sand and gravel, cuttings

Sand size fraction	Relative abundance
Quartz	5
Potassium feldspar	3
Plagioclase	3
Calcite (?)	-

Approximate abundance of feldspar relative to quartz, based on peak height ratios.

Plagioclase	28%
Potassium feldspar	43%

Sample No. 22 CNP-6 15' Sand and gravel, cuttings.

Sand size fraction	Relative abundance
Quartz	5
Potassium feldspar	3
Plagioclase	3
Illite	1
Kaolinite or chlorite	1

Approximate abundance of feldspar relative to quartz, based on peak height ratios.

Potassium feldspar	31%
Plagioclase	25%

Sample No. 23 CNG-2 25' Sand and gravel, cuttings

<u>Sand size fraction</u>	Relative abundance
Quartz	5
Plagioclase	3
Potassium Feldspar	3
Kaolinite or Chlorite (?)	-

Approximate abundance of feldspar relative to quartz, based on peak height ratios.

Plagioclase	44%
Potassium Feldspar	34%

Appendix II-4.--Whole rock chemical analyses

DEPARTMENT OF GEOLOGY

THE UNIVERSITY OF NEW MEXICO

DATE: March 15, 1977

TO: C. W. Walker

FROM: John Husler

SUBJECT: Rock Analysis Procedure

Silica was determined gravimetrically by fusion with sodium carbonate. Sulfur was determined on the filtrate by precipitation with barium chloride and weighing as barium sulfate.

Total Fe, Al_2O_3, MgO, CaO, Na_2O, K_2O, TiO_2, MnO, and SrO were determined by atomic absorption spectrophotometry by a method developed at UNM. Calibration curves were prepared from in-house standards prepared from USGS standard rocks. The P_2O_5 was determined colorimetrically by an adaptation of the Molybdenum Blue Method. The $H_2O(-)$ was determined by weight loss at 110°C, and the organic matter was estimated by weight loss between 110°C and 500°C. The $H_2O(+)$ remaining after 500°C was estimated by ignition loss at 1,000°C, taking into account the change in weight due to Fe oxidation by $K_2Cr_2O_7$ titration of ferrous iron in both the ignited and unignited sample.

Trace metals were determined by atomic absorption using a portion of the filtrate from the silica fusion, or by HF - HNO_3 - $HClO_4$ dissolution using larger sample amounts than those used for the major oxides.

John Husler
Staff Chemist

DATE: March 15, 1977

TO: C. W. Walker

FROM: John Husler

SUBJECT: Whole Rock Analyses

	CNC-6 (14.0-14.5)	CNC-6 (65.8)	CNS-29@ 20' intervals	CNG-2 (58.5)
SiO_2	64.49	54.37	68.09	59.84
Al_2O_3	18.2	13.5	13.9	14.6
Fe_2O_3	2.86	1.34	3.56	1.47
FeO	0.59	3.12	0.41	2.08
MgO	1.70	2.58	1.07	2.76
CaO	1.08	6.98	1.80	3.29
Na_2O	0.80	1.02	1.23	0.89
K_2O	2.89	2.61	2.52	2.65
H_2O+	5.99	12.12	4.74	10.27
H_2O-	0.06	0.66	2.19	0.76
TiO_2	0.54	0.51	0.52	0.54
P_2O_5	0.16	0.19	0.10	0.15
MnO	0.018	0.030	0.054	0.023
SrO	0.014	0.027	0.014	0.014
BaO	0.146	0.044	0.082	0.029
S	< 0.1	0.63	< 0.1	0.82
TOTAL	99.54	99.73	100.28	100.19
Total Fe (as Fe_2O_3)	3.52	4.81	4.02	3.78
L.O.I.	5.93	11.77	4.69	10.04
FeO after L.O.I.	0.0	0.0	0.0	0.0
110-500^{o}C (approx. organic content)	3.63	4.33	2.58	4.38
500-1000^{o}C	2.30	7.44	2.11	5.66

3/9/77

TO: C. W. Walker

FROM: John Husler, Virginia Glugla

SUBJECT: Trace element analyses, PARTS PER MILLION

ELEMENT	SAMPLE			
	CNC-6 (14-14.5')	CNC-6 (65.8)	CNS-29 @ 20' interval	CNG-2 (58.5')
Co	*	*	*	*
Cu	38	34	26	40
Pb	34	42	46	22
Zn	128	114	86	116
Ni	< 60	< 60	< 60	< 60
V	< 120	< 120	< 120	< 120
Cd	2.4	2.4	1.8	2.2
Li	98	57	29	71
Cr	94	80	42	84

* Cobalt is not reported due to contamination from binder in tungsten carbide capsule used for grinding.

Appendix II-5.--Particle Size Analysis

Las Cruces, March 21,1977

Dr.W.K.Summers,
P.O.Box 684
Socorro, New Mexico, 87801

Dear Kelly,

Please find enclosed the results of the mechanical analysis of the samples you send me.
Except for no.10 most soils are rather light textured.
The soils should have a good infiltration rate.
I hope this is the information you wanted. If there is anything else you need, please let me know.

Best ~~wishes~~,

Peter

Appendix II-5a.--Particle size analyses.

SUBJECT: Mechanical Analysis of Geological Soil Samples (1-14).

Sample	% Sand	% Silt	% Clay	Texture
1	67.2	8.4	24.4	Sandy clay loam
2	70.0	6.4	23.6	Sandy clay loam
3	54.8	23.8	21.4	Sandy loam
4	82.6	5.4	12.0	Loamy sand
5	65.0	16.6	18.4	Sandy loam
6	55.6	18.4	26.0	Sandy clay loam
7	46.8	28.8	24.4	Loam
8	73.6	6.4	20.0	Sandy loam
9	80.4	5.0	14.6	Sandy loam
10	35.6	31.0	33.4	Clay loam
11	54.4	19.0	26.6	Sandy clay loam
12	53.6	20.0	26.4	Sandy clay loam
14	80.8	4.8	14.4	Loamy sand

Analyses by P.J. Wierenga, Agronomy Dept., New Mexico State Univ.

Appendix II-5b.--Particle-size distribution analyses*, sample no. 1
[see pit diagram for location].

Sieve no.		Size retained		Percent retained	Cumulative percent retained
USA	Tyler	inches	mm		
		1	25.0	0	0
		.5	12.5	0	0
4	4	.187	4.76	0	0
10	9	.07	2.00	0	0
20	20	.0331	.850	.6	.6
40	35	.0165	.425	5.2	5.8
80	80	.0070	.180	29.4	35.2
100	100	.0059	.150	8.0	43.2
200	200	.0029	.075	17.4	60.6
325	325	.0017	.044	5.8	66.4
Pan				33.6	100.0

*Analysis by Dennis Engineering Co.

Appendix II-5b.--Particle-size distribution analyses*, sample no. 2
[see pit diagram for location].

Sieve no. USA	Sieve no. Tyler	Size retained inches	Size retained mm	Percent retained	Cumulative percent retained
		1	25.0	0	0
		.5	12.5	0	0
4	4	.187	4.76	0	0
10	9	.07	2.00	0	0
20	20	.0331	.850	.1	.1
40	35	.0165	.425	1.9	2.0
80	80	.0070	.180	25.7	27.7
100	100	.0059	.150	8.6	36.3
200	200	.0029	.075	27.0	63.3
325	325	.0017	.044	7.2	70.5
Pan				29.6	100.1

*Analysis by Dennis Engineering Co.

Appendix II-5b.--Particle-size distribution analyses*, sample no. 3 [see pit diagram for location].

Sieve no. USA	Sieve no. Tyler	Size retained inches	Size retained mm	Percent retained	Cumulative percent retained
		1	25.0	0	0
		.5	12.5	0	0
4	4	.187	4.76	0	0
10	9	.07	2.00	0	0
20	20	.0331	.850	.2	.2
40	35	.0165	.425	.6	.8
80	80	.0070	.180	12.1	12.9
100	100	.0059	.150	5.5	18.4
200	200	.0029	.075	23.8	42.2
325	325	.0017	.044	15.1	57.3
Pan				42.6	99.9

*Analysis by Dennis Engineering Co.

Appendix II-5b.--Particle-size distribution analyses*, sample no. 4 [see pit diagram for location].

Sieve no.		Size retained		Percent retained	Cumulative percent retained
USA	Tyler	inches	mm		
		1	25.0	0	0
		.5	12.5	0	0
4	4	.187	4.76	0	0
10	9	.07	2.00	0	0
20	20	.0331	.850	0	0
40	35	.0165	.425	3.0	3.0
80	80	.0070	.180	54.2	57.2
100	100	.0059	.150	14.0	71.2
200	200	.0029	.075	24.4	95.6
325	325	.0017	.044	2.8	98.4
Pan				1.6	100.0

*Analysis by Dennis Engineering Co.

Appendix II-5b.--Particle-size distribution analyses*, sample no. 5 [see pit diagram for location].

Sieve no. USA	Sieve no. Tyler	Size retained inches	Size retained mm	Percent retained	Cumulative percent retained
		1	25.0	0	0
		.5	12.5	0	0
4	4	.187	4.76	0	0
10	9	.07	2.00	0	0
20	20	.0331	.850	0	0
40	35	.0165	.425	3.1	3.1
80	80	.0070	.180	42.6	45.7
100	100	.0059	.150	10.2	55.9
200	200	.0029	.075	29.1	85.0
325	325	.0017	.044	8.5	93.5
Pan				6.6	100.1

*Analysis by Dennis Engineering Co.

Appendix II-5b.--Particle-size distribution analyses*, sample no. 6 [see pit diagram for location].

Sieve no.		Size retained		Percent retained	Cumulative percent retained
USA	Tyler	inches	mm		
		1	25.0	0	0
		.5	12.5	0	0
4	4	.187	4.76	0	0
10	9	.07	2.00	0	0
20	20	.0331	.850	.3	.3
40	35	.0165	.425	2.9	3.2
80	80	.0070	.180	17.4	20.6
100	100	.0059	.150	5.7	26.3
200	200	.0029	.075	19.2	45.5
325	325	.0017	.044	10.6	56.1
Pan				43.9	100.0

*Analysis by Dennis Engineering Co.

Appendix II-5b.--Particle-size distribution analyses*, sample no. 7 [see pit diagram for location].

Sieve no. USA	Sieve no. Tyler	Size retained inches	Size retained mm	Percent retained	Cumulative percent retained
		1	25.0	0	0
		.5	12.5	0	0
4	4	.187	4.76	0	0
10	9	.07	2.00	.2	.2
20	20	.0331	.850	.2	.4
40	35	.0165	.425	4.1	4.5
80	80	.0070	.180	12.7	17.2
100	100	.0059	.150	2.8	20.0
200	200	.0029	.075	11.6	31.6
325	325	.0017	.044	11.8	43.4
Pan				56.6	100.0

*Analysis by Dennis Engineering Co.

Appendix II-5b.--Particle-size distribution analyses*, sample no. 8 [see pit diagram for location].

Sieve no. USA	Sieve no. Tyler	Size retained inches	Size retained mm	Percent retained	Cumulative percent retained
		1	25.0	0	0
		.5	12.5	0	0
4	4	.187	4.76	2.2	2.2
10	9	.07	2.00	1.3	3.5
20	20	.0331	.850	1.8	5.3
40	35	.0165	.425	7.8	13.1
80	80	.0070	.180	9.5	22.6
100	100	.0059	.150	6.5	29.1
200	200	.0029	.075	17.6	46.7
325	325	.0017	.044	7.0	53.7
Pan				46.2	99.9

*Analysis by Dennis Engineering Co.

Appendix II-5b.--Particle-size distribution analyses*, sample no. 9 [see pit diagram for location].

Sieve no.		Size retained		Percent retained	Cumulative percent retained
USA	Tyler	inches	mm		
		1	25.0	17.2	17.2
		.5	12.5	7.4	24.6
4	4	.187	4.76	6.6	31.2
10	9	.07	2.00	2.4	33.6
20	20	.0331	.850	9.4	43.0
40	35	.0165	.425	8.6	51.6
80	80	.0070	.180	17.7	69.3
100	100	.0059	.150	3.9	73.2
200	200	.0029	.075	10.5	83.7
325	325	.0017	.044	7.9	91.6
Pan				8.5	100.1

*Analysis by Dennis Engineering Co.

Appendix II-5b.--Particle-size distribution analyses*, sample no. 10 [see pit diagram for location].

Sieve no.		Size retained		Percent retained	Cumulative percent retained
USA	Tyler	inches	mm		
		1	25.0	26.7	26.7
		.5	12.5	3.8	30.5
4	4	.187	4.76	12.1	42.6
10	9	.07	2.00	8.7	51.3
20	20	.0331	.850	4.0	55.3
40	35	.0165	.425	3.2	58.5
80	80	.0070	.180	13.0	71.5
100	100	.0059	.150	3.4	74.9
200	200	.0029	.075	8.3	83.2
325	325	.0017	.044	4.9	88.1
Pan				12.0	100.1

*Analysis by Dennis Engineering Co.

Appendix II-5b.--Particle-size distribution analyses*, sample no. 11 [see pit diagram for location].

Sieve no.		Size retained		Percent retained	Cumulative percent retained
USA	Tyler	inches	mm		
		1	25.0	0	0
		.5	12.5	0	0
4	4	.187	4.76	.1	.1
10	9	.07	2.00	0	.1
20	20	.0331	.850	0	.1
40	35	.0165	.425	.9	1.0
80	80	.0070	.180	7.8	8.8
100	100	.0059	.150	2.9	11.7
200	200	.0029	.075	12.2	23.9
325	325	.0017	.044	10.5	34.4
Pan				65.5	99.9

*Analysis by Dennis Engineering Co.

Appendix II-5b.--Particle-size distribution analyses*, sample no. 12 [see pit diagram for location].

Sieve no.		Size retained		Percent retained	Cumulative percent retained
USA	Tyler	inches	mm		
		1	25.0	0	0
		.5	12.5	0	0
4	4	.187	4.76	1.4	1.4
10	9	.07	2.00	.5	1.9
20	20	.0331	.850	.5	2.4
40	35	.0165	.425	1.8	4.2
80	80	.0070	.180	14.7	18.9
100	100	.0059	.150	4.0	22.9
200	200	.0029	.075	17.9	40.8
325	325	.0017	.044	11.0	51.8
Pan				48.1	99.9

*Analysis by Dennis Engineering Co.

Appendix II-5b.--Particle-size distribution analyses*, sample no. 13 [see pit diagram for location].

Sieve no.		Size retained		Percent retained	Cumulative percent retained
USA	Tyler	inches	mm		
		1	25.0	36.0	36.0
		.5	12.5	10.5	46.5
4	4	.187	4.76	9.0	55.5
10	9	.07	2.00	7.2	62.7
20	20	.0331	.850	3.6	66.3
40	35	.0165	.425	3.6	69.9
80	80	.0070	.180	11.9	81.8
100	100	.0059	.150	2.8	84.6
200	200	.0029	.075	6.0	90.6
325	325	.0017	.044	2.0	92.6
Pan				7.3	99.9

*Analysis by Dennis Engineering Co.

Appendix II-5b.--Particle-size distribution analyses*, sample no. 14 [see pit diagram for location].

Sieve no.		Size retained		Percent retained	Cumulative percent retained
USA	Tyler	inches	mm		
		1	25.0	0	0
		.5	12.5	0	0
4	4	.187	4.76	1.7	1.7
10	9	.07	2.00	.5	2.2
20	20	.0331	.850	.2	2.4
40	35	.0165	.425	2.0	4.4
80	80	.0070	.180	18.3	22.7
100	100	.0059	.150	6.1	28.8
200	200	.0029	.075	17.1	45.9
325	325	.0017	.044	8.3	54.2
Pan				45.9	100.1

*Analysis by Dennis Engineering Co.

Appendix II-5b.--Particle-size distribution analyses*, sample no. 15 [see pit diagram for location].

Sieve no. USA	Sieve no. Tyler	Size retained inches	Size retained mm	Percent retained	Cumulative percent retained
		1	25.0	15.8	15.8
		.5	12.5	3.4	19.2
4	4	.187	4.76	4.6	23.8
10	9	.07	2.00	2.2	26.0
20	20	.0331	.850	1.4	27.4
40	35	.0165	.425	4.9	32.3
80	80	.0070	.180	35.5	67.8
100	100	.0059	.150	9.4	77.2
200	200	.0029	.075	18.1	95.3
325	325	.0017	.044	2.8	98.1
Pan				1.8	99.9

*Analysis by Dennis Engineering Co.

Appendix II-5b.--Particle-size distribution analyses*, sample no. 16 [see pit diagram for location].

Sieve no.		Size retained		Percent retained	Cumulative percent retained
USA	Tyler	inches	mm		
		1	25.0	0	0
		.5	12.5	0	0
4	4	.187	4.76	0	0
10	9	.07	2.00	.3	.3
20	20	.0331	.850	.4	.7
40	35	.0165	.425	2.1	2.8
80	80	.0070	.180	42.6	45.4
100	100	.0059	.150	15.2	60.6
200	200	.0029	.075	31.4	92.0
325	325	.0017	.044	5.1	97.1
Pan				2.8	99.9

*Analysis by Dennis Engineering Co.

Appendix II-6.--Physical tests of cores

PHYSICAL TEST SAMPLES

CNC-1A	Core 1.0' long	63.1-64.1	(shale)
CNC-1B	Core 0.9' long	147.1-148.0	(shale)
CNC-1C	Core 1.0' long	215.5-216.5	(shale)
CNC-1D	Core 1.0' long	285.0-286.0	(shale)
CNC-4A	Core 1.0' long	40.0-41.0	(shale)
CNC-5A	Core 1.0' long	35.0-36.0	(shale)
CNC-6A	Core 1.0' long	14.5-15.5	(weathered shale)
CNC-2A	Core 1.0' long (2 pieces)	26.1-27.1	(weathered shale)
CNC-4B	Core 0.9' long (4 pieces)	24.1-25.0	(weathered shale)
CNC-6B	Core 0.9' long (2 pieces)	64.3-65.2	(shale)

Box #1
CNC-6A, CNC-5A, CNC-4A, CNC-4B, CNC-2A

Box #2
CNC-6B, CNC-1A, CNG-1B, CNC-1C, CNC-1D

Samples sent 12/7/76 via bus to Terra Tek

MATERIAL PROPERTIES OF CLAY AND SHALE

FOR SUMMERS AND ASSOCIATES

by

D. O. Enniss
S. W. Butters

Submitted to

Mr. W. K. Summers
Summers & Associates
P.O. Box 684
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Submitted by

Terra Tek, Inc.
University Research Park
420 Wakara Way
Salt Lake City, Utah 84108

TR 77-13
February 1977

INTRODUCTION

Material properties determined for ten cores, Table 1, extracted from the potential nuclear waste storage site in northeastern New Mexico are outlined below. Tests were performed to evaluate physical properties, gas permeability, brine permeability, ultrasonic velocity and hydrostatic compression.

TABLE 1

Cores Received

SAMPLE DESIGNATION	MATERIAL
(1) CNC-1A	Shale
(2) CNC-1B	Shale
(3) CNC-1C	Shale
(4) CNC-1D	Shale
(5) CBC-2A	Clay
(6) CNC-4A	Shale
(7) CNC-4B	Clay
(8) CNC-5A	Shale
(9) CNC-6A	Clay
(10) CNC-6B	Shale

The material consisted of both weathered and non-weathered shale. All of the non-weathered shale were extensively layered, but were competent and cored easily. The weathered shale (clay) samples were much less competent. One sample of the weathered shale (CNC-6A), for example, was so friable that it crumbled during handling. Tests with this core were limited due to sample preparation difficulties.

This report contains a summary of the test data obtained from each of the five test programs. The appendix contains a brief description of each test series.

TEST RESULTS AND DISCUSSION

A summary of the physical properties data is contained in Table 2. The samples containing significant amounts of clays, CNC-2A, CNC-4B, CNC-6A, demonstrated slightly lower bulk densities than the other shale type materials. The low bulk density for sample CNC-6A reflects the extensive amount of inter-layer fracturing present within the core. This particular material had very little cohesion between layers and was extremely friable.

The moisture contents of the material are consistently below 3% with the exception of the CNC-4B and CNC-6A footages which contain moisture contents of 6.9% and 7.8% respectively.

Effective porosity measurements were made on all footages with the exception of the CNC-6A footage. The state of the CNC-6A prevented the type of sample preparation necessary for a meaningful test. Effective porosity values ranged from a low of 2.5%, sample CNC-1C, to a high of 14.0%, sample CNC-4B.

The results of the permeability tests are contained in Table 3. The water permeabilities are consistently lower than the gas permeabilities. The values determined for the lateral gas permeability are significantly higher than the vertical gas permeabilities. The flow in the lateral case, however, appears to be principally via cracks opened in the horizontal bedding planes.

A summary of the ultrasonic test results is also contained in Table 3. The shale test samples show consistently higher velocities than the clay samples. Typical shale p-wave velocities are approximately 10,000 ft/sec while the clay samples were approximately 5,000 ft/sec.

TABLE 2

Physical Property Test Summary

SAMPLE DESIGNATION	BULK DENSITY (gm/cc)	DRY DENSITY (gm/cc)	GRAIN DENSITY (gm/cc)	WATER CONTENT (%)	TOTAL POROSITY (%)	EFFECTIVE GAS POROSITY (%)	SATURATION (%)	AIR VOIDS (%)
CNC-1A	2.51	2.43	2.72	3.2	10.9	5.0	73.4	2.9
CNC-1B	2.52	2.45	2.69	2.9	9.0	5.8	80.7	1.7
CNC-1C	2.50	2.43	2.66	2.9	8.6	2.5	83.5	1.4
CNC-1D	2.58	2.51	2.70	2.4	7.1	5.0	87.6	0.9
CNC-2A	2.40	2.33	2.72	2.9	14.1	13.4	49.9	7.1
CNC-4A	2.54	2.47	2.74	2.9	9.8	6.0	75.7	2.4
CNC-4B	2.32	2.16	2.76	6.9	21.8	14.0	73.1	5.9
CNC-5A	2.52	2.45	2.71	3.0	9.5	5.8	78.8	2.0
CNC-6A	1.85	1.70	2.73	7.8	27.5	--	38.5	23.1
CNC-6B	2.58	2.52	2.74	2.2	8.1	7.6	71.6	2.3

Accuracy:

Bulk Density	±0.002 gm/cc	Total Porosity	±0.2%
Dry Density	±0.002 gm/cc	Eff. Gas Porosity	±0.5%
Grain Density	±0.04 gm/cc	Saturation	±0.6%
Water Content	0.1%	Air Voids	±0.4%

TABLE 3

Permeability and Ultrasonic Velocity Test Summary

SAMPLE DESIGNATION	PERMEABILITIES			VELOCITIES	
	GAS (10^{-6} DARCIES)	WATER (10^{-6} DARCIES)	LATERAL GAS (10^{-3} DARCIES)	P-WAVE (FT/SEC)	S-WAVE (FT/SEC)
CNC-1A	96	40	17	9,610	4,175
CNC-1B	24	18	--	10,940	6,040
CNC-1C	3	2	--	9,595	4,465
CNC-1D	10	8	--	10,680	4,615
CNC-2A	74	56	--	5,470	3,405
CNC-4A	92	91	--	10,010	6,495
CNC-4B	10	5	69	4,965	3,055
CNC-5A	11	4	--	7,000	3,340
CNC-6A	--	--	--	--	--
CNC-6B	4	3	--	9,970	6,860

Accuracy: Permeabilities repeatable to within 20%
Velocities ±1%

One clay sample and one shale sample were tested to determine the material's response to hydrostatic pressure. The results of these tests are contained in Figures 1 and 2.

Both samples demonstrated anisotropic behavior. The axial deformation in both instances was much larger than the lateral strain. This was apparently caused by the extensive horizontal bedding present in both samples. The clay contained more bedding than the shale as verified by the larger axial strain during the clay test.

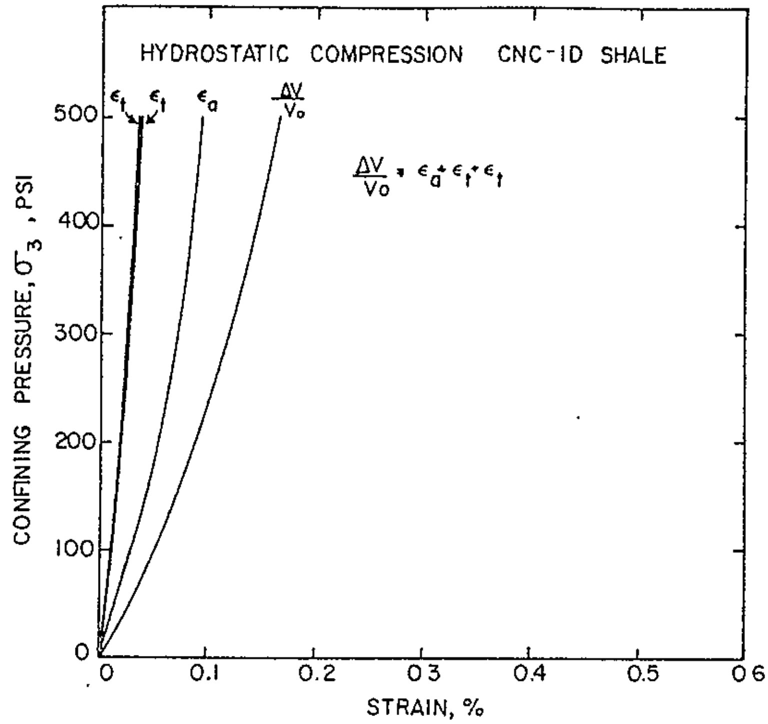

Figure 1. Hydrostatic Compression of Sample CNC-1D.

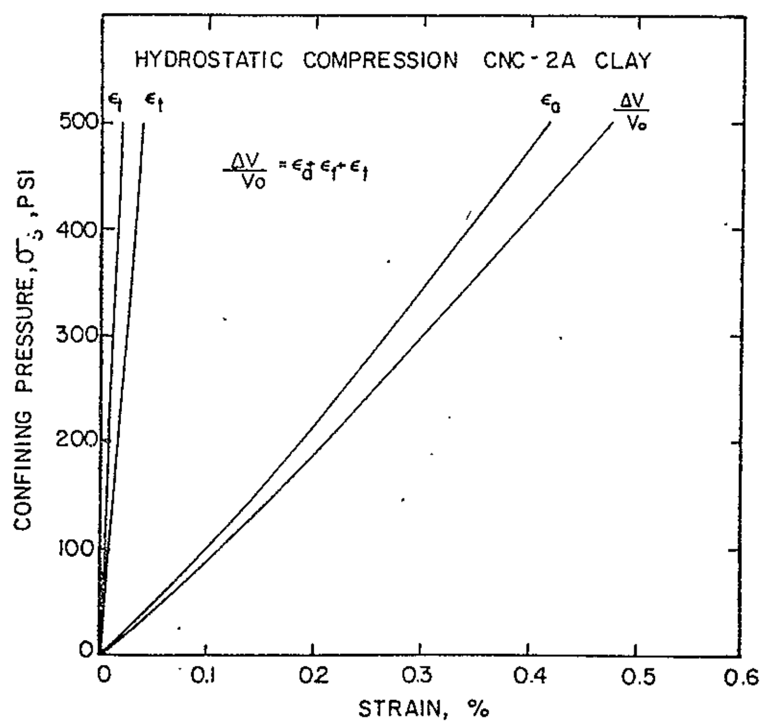

Figure 2. Hydrostatic Compression of Sample CNC-2A.

--APPENDIX--

PHYSICAL PROPERTIES TEST PROGRAM

Physical property tests were performed to determine the bulk density, moisture content by wet weight, grain density, and effective gas porosity of each footage. From these values the dry density, total porosity, percent saturation and percent air voids were calculated. Samples for the physical properties measurements were obtained from the wrapped and waxed sealed cores. Two fragments of approximately 30 to 50 cc in volume were broken from each of the cores. The cores were then re-sealed to maintain "as-received" moisture content.

The bulk density represents the "as-received" density of the core. These measurements were made using the Ruska Mercury Porometer which determines volumes by mercury displacement. The densities obtained in this manner are accurate to ±0.002 gm/cc.

The moisture content is expressed as a percent of the wet-weight and is determined by measuring the weight loss of a crushed sample during oven drying for 24 hours at 105°C. The weight lost can be measured to 0.1% of the total weight.

The grain density represents the density of the actual crystals or particles that make up the rock structure. To determine this, a sample weighing approximately 50 gms is first ground to a -100 mesh particle size. The pulverized material is then dried in a forced convection oven at 105°C for 24 hours. Approximately 25 gms of dried material are placed into a calibrated 50 ml flask and weighed. A vacuum is first drawn on the flask to remove any entrapped air, then the flask is filled with water and weighed.

The water weight and the oven dried sample weight are then used to determine the grain density. Densities obtained by this method are repeatable to ±0.04 gm/cc.

The total porosity, percentage saturation, and percentage air-filled voids are determined arithmetically from the bulk and grain densities, and moisture content. The total porosity represents the total amount of pore volume, both accessible and occluded, present within the material. Total porosity values are accurate to ±0.2%. The air-filled void content is the amount of pore volume not occupied by pore fluids. These values are accurate to ±0.4% of total pore volume. Saturation is a measure of the total pore volume filled with pore fluid. Saturation values have a ±0.6% accuracy.

The effective porosity determinations were made with a Beckman Gas Pycnometer on samples oven dried at 105°C. The effective porosity is a measure of the connected pore volume. The Beckman technique uses helium gas to impregnate the sample and measure the volume of the connected accessible pores. By using this technique, effective porosity measurements accurate to ±0.5% porosity are obtained.

PERMEABILITY TEST PROGRAM

Vertical gas and water permeabilities (i.e. gas flow perpendicular to bedding planes) were determined for all footages with the exception of the CNC-6A footage. Additionally, lateral gas permeabilities (i.e. gas flow parallel to the bedding planes) were determined on samples CNC-1A and CNC-4B. All tests were performed with the transient pressure test method.

The gas permeability tests were conducted on unconfined samples in the "as-received" state. The samples were 0.990 ± 0.005" (2.51 cm ± 0.013 cm) in diameter and 0.30" (0.76 cm) in length. The tests employed nitrogen gas as a permeating fluid and were conducted at room temperature, 20°C.

The water permeability tests were made on samples saturated in an aqueous brine. The principal ionic constituents of this brine were calcium, sodium, bicarbonate and sulfate ions. The concentration of these ions was manipulated to achieve a fluid conductivity of 1000 $\frac{\mu mhos}{cm}$ while maintaining roughly equal proportions. This water make-up was an approximation to the *in situ* ground water chemistry.*

The water permeability samples were sealed and confined at a pressure equal to 1 psi per foot of overburden -- the clay samples were confined at 25 psi and the shale samples were confined at 50 psi.

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* Private communication with W. K. Summers, December, 1976.

ULTRASONICS VELOCITY TEST PROGRAM

The technique used to measure the ultrasonic velocities of the various footages is best described as the "through transmission system". It has the capability of determining small delay times to a high degree of accuracy. A schematic of this system is shown in Figure 3.

The frequency synthesizer is extremely stable with a signal error of ±1 part in 10^7/month. The signal passing through the test sample is compared with the signal coming directly from the synthesizer. The delay experienced by the signal coming through the sample is then determined by comparing wave forms on an oscilloscope. The path length divided by the elapsed time of the signal passing through the sample sives the resulting acoustic velocity for that medium. The designation "p-wave" is given the longitudinal wave while the term "s-wave" is applied to the shear wave.

The samples tested were 1.00 ± 0.005" (2.54 ± 0.013 cm) diameter with lengths ranging from 0.30" (0.76 cm) to 1.00" (2.54 cm). In each case the length represented the maximum length obtainable from that core. The samples were tested in the "as-received" state at room temperature and pressure. The ultrasonic velocities are accurate to ±1%.

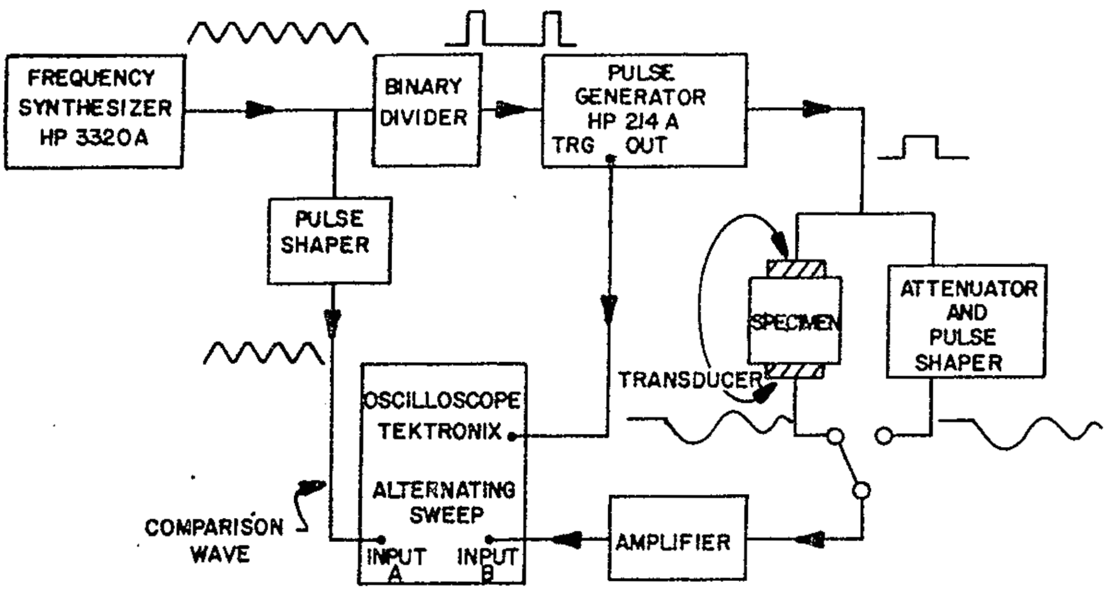

Figure 3. Ultrasonic Velocity Test Schematic.

HYDROSTATIC COMPRESSION TEST PROGRAM

One shale sample and one clay sample were tested to determine the volume strain as a function of hydrostatic pressure. From the slope of this curve, the bulk modulus can be obtained.

The samples tested were CNC-1D, a shale, and CNC-2A, a clay. Both samples were 1.0" (2.54 cm) diameter and 1.0" (2.54 cm) in length. The samples were sealed within a urethane jacket, to prevent contact with the confining fluid, and mounted to steel endcaps. The jacket is then sealed to the endcaps with several turns of lockwire.

The sample is then subjected to hydrostatic pressurization within a pressure vessel while the strains of the sample are monitored. The confining pressure measurement is accurate to within 5 psi. The axial and transverse strains of the sample, designated E_a and E_t, respectively, are measured inside the vessel by a strain gauged cantilever system. Lateral strain measurements are accurate to 0.04% strain and axial strains are accurate to 0.05% strain.

Appendix II-7.--Cation exchange.

Cation Exchange

Well #	Depth (feet)	Sample Description	Comments
CNC-1	231.5	Pierre shale	core
CNC-1	400.0	Pierre shale	cuttings
CNP-2	400.0	Pierre shale	cuttings
CNC-5	46.0	Pierre shale (rotten)	core
CNC-8	41.0	Pierre shale	core
CNG-2	58.5	Pierre shale	core
CNG-2	50.0	partially weathered Pierre shale	cuttings
CNG-2	45.0	weathered Pierre	cuttings
CNS-34	20.0	brown sandy clay	cuttings
CNC-8	15.0	weathered Pierre	cuttings
CNC-2	22.5	weathered Pierre	core

GEOCHEMICAL EXPLORATION
POLLUTION ANALYSIS (UMPIRE)
SOILS AND FERTILIZERS
METALS
SALTS AND BRINES
BIOCHEMICAL
ENVIRONMENTAL BACKGROUND
CROPS AND PLANTS
COKES AND COALS
WATERS AND EFFLUENTS
GASES

March 3, 1977

Mr. W. K. Summers
W. K. Summers and Associates
Box 684
Socono, NM 87801

Dear Mr. Summers:

As per your request, I am including a brief description of our "Cation Exchange Capacity" (CEC) procedure.

A screened (8 mesh), air-dried sample is mixed with sodium acetate solution to displace exchangeable cations from the soil solution, clay lattice, and organic material within the soil.

The extraneous ions are then washed free with ethanol. The exchanged sodium is then displaced by addition of ammonium acetate solution and collected in a volumetric flask.

The exchanged and subsequently displaced sodium is determined by atomic absorption or flame emission and reported in Meq. Na/100 g. soil (= CEC).

To determine the extraneous ions which make up the CEC in the soil it is necessary to combine the sodium acetate and ethanol wash solutions and determine the quantities of each of the ions present.

This procedure is one of many approved for use by the Association of Official Agricultural Chemists (AOAC) for Western Soils. We have made slight modifications on the procedure to enhance the reproducibility of the results. Some changes have also been made in order to allow for a

American Chemical & Research Laboratories

32 EAST 3335 SOUTH • SALT LAKE CITY, UTAH 84115 • TELEPHONE (801) 467-7922

particular analytical procedure on some of the cations (Cs, Ca, and Mg).

I hope this is adequate for your purpose. We are not in the habit of providing customers with detailed procedures (volumes, concentrations, and weights) for the obvious reasons.

Thank you for your patronage.

Sincerely,

V. B. Benson

V. Brent Benson
American Chemical & Research Labs

VBB:sw

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W. K. Summers and Associates
Box 684
Socono, NM 87801

American Chemical Research Laboratories

CERTIFICATE OF ANALYSIS 16 February 1977

Description	Analysis						
le No. and Description	Cation Exchange Capacity	ppm K	ppm Ca	ppm Mg	ppm Co	ppm Sr	ppm Cs
CNC-1 231.5' Pierre Shale Core	26.9	376	3200	144	76	138	10.0
CNC-1 400.0' Pierre Shale Cuttings	27.0	368	1820	164	76	179	10.0
CNP-2 400.0' Pierre Shale Cuttings	16.5	244	640	183	80	144	10.0
CNC-5 46.0' Pierre Shale (rotten) Core	30.4	276	4080	676	72	172	10.0
CNC-8 41.0' Pierre Shale Core	24.4	576	3400	436	72	186	10.0
CNG-2 58.5' Pierre Shale Core	23.5	512	2240	552	73	164	10.0
CNG-2 50.0' Partially weathered Pierre cut.	20.0	256	2080	664	72	42	10.0
CNG-2 45.0' Weat. Pier. Cuttings	22.6	232	3040	664	80	48	10.0
CNS-34 20.0' Brown Sandy Clay Cuttings	29.6	452	3440	528	74	42	10.0
CNC-8 15.0' Weat. Pier. Cuttings	27.0	396	2840	520	76	48	10.0
CNC-2 22.5' Weat. Pier. Core	25.2	260	1802	584	72	36	10.0

Thank you for your patronage.

V. Brent Benson

V. Brent Benson
American Chemical & Research Labs

Appendix II-8a.--Sorption studies

Radioisotope Exchange

Well #	Depth (feet)	Sample Description	Comments
CNC-1	173.2	unweathered Pierre shale	
CNC-1	231.5	unweathered Pierre shale	
CNC-5	46.0	unweathered Pierre shale (rotten zone)	
CNC-8	41.0	unweathered Pierre shale	
CNC-2	21.2	weathered Pierre shale	
CNC-4	17.5	weathered Pierre shale	
CNC-5	18.8	weathered Pierre shale	
CNC-6	11.8	weathered Pierre shale	

eberline

February 14, 1977

W. K. Summers and Associates
P. O. Box 684
Socorro, New Mexico 87801

Dear Kelly:

Please excuse the "bare data" we sent. I felt that time was of the essence and that our conversation was enough of a precursor. To reconfirm, all exchanges were in a static condition for 24 hours. The solution volumes were all 1.0 liter with the exception of the wet case for the solid configurations. Those were not reported since the wet case resulted in breaking up to nonspecific surface areas before exchange was permitted.

The percentage tables are straight forward and should be relatively nonconfusing. Two of the pages of tables deserve some clarification.

That page labelled Powdered, Wet Weight and with the second set of data headed Dry Weight, deserves clarification. The first line under each of the respective isotopes, shown as "Avail.", indicates the total activity in the one liter available for exchange into the shale. The second line "Conc.", indicates the concentration in that solution. The numbers in the left column are our specific sample numbers. They are cross referenced on other tables. For examples, 0735 is CNC-1 at 173.2 ft. The second column gives the sample wet weight or the weight of the shale after soaking in deionized water. Under each isotope, the concentration, in pCi/g, is the resultant concentration in the shale. The numbers, given in ten's of thousands, show the total quantity absorbed in each specific shale sample. One error that did occur was in the Co-57 data. Instead of 47,200 and 42.9 pCi/ml, it should be 94,400 pCi and 85.8 pCi/ml. A factor of two was dropped during calculation.

Please excuse the indistinct report. We knew you were in a hurry for the data. I was called out of town on a rush job and my secretary had to work from my data sheets. I asked her to send the data although I could not proof read the result. This is not normal procedure.

Please call for any additional clarification that might be helpful.

Very truly yours,

EBERLINE INSTRUMENT CORPORATION

Stanley J. Waligora, Jr.
Southeastern Facility, Manager

SJW/bs

PLEASE REPLY TO: SOUTHEASTERN FACILITY 312 MIAMI STREET WEST COLUMBIA, SOUTH CAROLINA 29169 PHONE (803) 796-3604

EBERLINE INSTRUMENT CORPORATION, PO BOX 2108 SANTA FE, NEW MEXICO 87501 TELEPHONE (505) 471-3232, TWX 910-985-0678

Fraction Absorbed or Adsorbed
Powdered Material
(Percent)

Wet Case	Cs-137	Sr-85	Co-57
CNC-1 173.2 ft. Unweathered pierre shale (0735)	52.7	32.3	50.8
CNC-1 231.5 ft. Unweathered pierre shale (0736)	47.6	31.4	40.2
CNC-5 46.0 ft. Unweathered pierre shale (0737)	50.7	31.3	49.1
CNC-8 41.0 ft. Unweathered pierre shale (0738)	76.1	44.9	76.4
CNC-2 21.2 ft. Weathered pierre shale (0739)	60.3	35.7	66.9
CNC-4 17.5 ft. Weathered pierre shale (0740)	55.4	29.9	66.9
CNC-5 18.8 ft Weathered pierre shale (0741)	81.2	37.9	92.2
CNC-6 11.8 ft. Weathered pierre shale (0742)	64.7	33.1	71.5

Fraction Absorbed or Adsorbed
Powdered Material
(percent)

Dry Case	Cs-137	Sr-85	Co-57
CNC-1 173.2 ft. Unweathered pierre shale (0735)	66.1	35.3	64.4
CNC-1 231.5 ft. Unweathered pierre shale (0736)	51.3	35.9	42.5
CNC-5 46.0 ft. Unweathered pierre shale (0737)	71.8	40.3	72.0
CNC-8 41.0 ft. Unweathered pierre shale (0738)	69.4	39.0	64.1
CNC-2 21.2 ft. Weathered pierre shale (0739)	49.7	35.1	54.7
CNC-4 17.5 ft. Weathered pierre shale (0740)	59.0	36.0	61.3
CNC-5 18.8 ft. Weathered pierre shale (0741)	84.6	39.4	88.8
CNC-6 11.8 ft. Weathered pierre shale (0742)	76.0	34.9	81.3

Fraction Absorbed or Adsorbed
Solid Chunks
(Percent)

	Cs-137	Percent Per cm^2	Sr-85	Percent Per cm^2	Co-57	Perce Per c
NC-1 173.2 ft. nweathered pierre shale 0735)	72.8	0.32	34.6	0.15	18.7	0.08
NC-1 231.5 ft. nweathered pierre shale 0736)	79.5	0.35	45.6	0.20	16.3	0.07
NC-5 46.0 ft. nweathered pierre shale (0737)	34.2	0.26	41.6	0.32	17.5	0.13
NC-8 46.0 ft. nweathered pierre shale (0738)	58.1	0.45	49.6	0.38	19.1	0.15
NC-2 41.0 ft. eathered pierre shale (0739)	69.9	0.27	55.6	0.21	74.7	0.29
NC-4 17.5 ft. eathered pierre shale (0740)	65.4	0.20	52.1	0.16	57.3	0.18
NC-5 18.8 ft. eathered pierre shale (0741)	61.4	0.19	41.3	0.13	61.3	0.19
NC-6 11.8 ft. eathered pierre shale (0742)	27.9	0.09	36.1	0.11	29.6	0.09

Powdered
Wet weight
picocuries per gram

	Wet Weight	Cs-137		Sr-85		Co-57	
		Avail. 48,400 pCi Conc. 44.0 pCi/ml		43,100 39.2 pCi/ml		47,200 pCi 42.9 pCi/ml	
5	160 g	160 ± 10	25,600	87 ± 1	13,920	300 ± 10	48,000
6	165	140 ± 10	23,100	82 ± 2	13,530	230 ± 10	37,950
7	145	170 ± 10	24,650	93 ± 2	13,485	320 ± 10	46,400
8	176	210 ± 10	36,960	110 ± 10	19,360	410 ± 10	72,160
9	154	190 ± 10	29,260	100 ± 10	15,400	410 ± 10	63,140
0	117	230 ± 10	26,910	110 ± 10	12,870	540 ± 10	63,180
1	136	290 ± 10	39,440	120 ± 10	16,320	640 ± 10	87,040
2	157	200 ± 10	31,400	91 ± 2	14,287	430 ± 10	67,510

Dry Weight

	Dry Weight						
		Avail. 48,400 pCi Conc. 48,4 pCi/ml		43,100 43.1		47,200 47.2	
5	160 g	200 ± 10	37,000	95 ± 2	15,200	380 ± 10	60,800
6	191	130 ± 10	24,830	81 ± 1	15,471	210 ± 10	40,110
7	158	220 ± 10	34,760	110 ± 10	17,380	430 ± 10	67,940
8	224	150 ± 10	33,600	75 ± 1	16,800	270 ± 10	60,480
9	172	140 ± 10	24,080	88 ± 2	15,136	300 ± 10	51,600
0	152	188 ± 3	28,576	102 ± 2	15,504	381 ± 3	57,912
1	195	210 ± 10	40,950	87 ± 1	16,965	430 ± 10	83,850
2	160	230 ± 10	36,800	94 ± 2	15,040	480 ± 10	76,800

Chunks
Dry only
picocuries per gram

	Dry weight	Cs-137		Sr-85		Co-57	
35	135.5 g	260 ± 10	35,230	110 ± 10	14,905	130 ± 10	17,615
36	85.5 g	450 ± 10	38,475	230 ± 10	19,665	180 ± 10	15,390
37	138.0 g	120 ± 10	16,560	130 ± 10	17,940	120 ± 10	16,560
38	112.5 g	250 ± 10	28,125	190 ± 10	21,375	160 ± 10	18,000
39	141.0 g	240 ± 10	33,840	170 ± 10	23,970	500 ± 10	70,500
40	132.0 g	240 ± 10	31,680	170 ± 10	22,440	410 ± 10	54,120
41	148.5 g	200 ± 10	29,700	120 ± 10	17,820	390 ± 10	57,915
42	155.5 g	87 ± 10	13,528	100 ± 10	15,550	180 ± 10	27,990

Initial Surface Area
picocuries per squared centimeters

		Cs-137	Sr-85	Co-57
35	226 cm^2	158	65	80
36	226	168	88	68
37	129	133	144	125
38	129	214	164	139
39	258	133	95	274
40	322	99	71	169
41	322	91	57	182
42	322	42	49	88

eberline

February 17, 1977

W. K. Summers & Associates
P. O. Box 684
Socorro, New Mexico 87801

Dear Mr. Summers:

This is to define the details of our tests of cesium, cobalt, and strontium absorption and/or adsorption into the shale samples you forwarded.

The stock solutions used were purchased from New England Nuclear and consisted of soluble salts (in solution) of cobalt-57, strontium-85, and cesium-137. All three were in separate dilute hydrochloric acid solutions and radiochemical purity was greater than 99 percent. Cobalt-57 was used as the exact chemical analog for cobalt-60 (given the same chemical form) since a pure solution was more immediately available and the characteristic gamma ray (122 kev) is readily measured. Cesium-137 is an isotope of interest for this study. Strontium-85 was selected as the exact chemical analog of strontium-90 (given the same chemical form). The use of strontium-85 avoided the extensive radiochemistry required to analyze strontium-90 and use of the characteristic gamma ray (514 kev) permitted simultaneous measurement off all three isotopes through a single gamma determination for each sample.

Upon receipt of the stock solutions, each was carefully caligrated for a fixed point source geometry which has been accurately calibrated and re-verified during the past four years. The basic standards used for this calibration are, in our judgement, the best available. Standards used were obtained from the U.S. National Bureau of STandards and the Radiochemical Centre in Amersham England. These standards were provided in flame sealed glass ampules and have never been opened.

Once calibrated, the solutions were carefully transferred to 500 ml volumetric flasks and diluted up to that volume. The exchange test solutions were prepared by transferring one ml of each of the three stock solutions, by accurate pipetting, with dilution up to either 1000 ml or 1100 ml. The basic test included static soaking of the sample in the solution for a 24.0 hour period.

Although four cases were to be tested, only three were conducted due to problems initially encountered. The first two of the four were to be solid pieces of the shale, in one case wetted and in the other dry, with measurable surface area. Upon contact, in the fry case, the solid pieces slumped and fractured with a great increase in real surface area. Those data were reported however the results, in terms of initial surface area, do not represent reality.

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For maximum potential uptake of the three isotopes in shale, samples were ground and sieved to fine dust-like particulate. Both the wet and dry cases were tested. Results were reported in relation to both the activity taken into the shale as well as the percentage of that available for uptake.

The gamma spectrometry system used for work consists of a Nuclear Data 4420 with ND 812 Computer with 20 K memory for acquisition, storage, manipulation of spectra and programs. The Ge-Li detector is a right circular cylinder with a 40 mm diameter, drifted coaxially with an open end. The "P" core diameter is 6 mm and "N" layer thickness of 0.5 mm. An active area of 12.3 cm^2 faces the thin aluminum window which permits analysis of photon energies as low as 35 kev. The resolution if 2.2 kev for the 1170 kev peak of Co-60 and the peak-to-compton ratio is 32.1 for Co-60 gamma.

I trust the above information, with the attached Reports of Analysis provide the information sought. If you have any further question, please do not hesitate to call upon me.

Very truly yours,

EBERLINE INSTRUMENT CORPORATION

Stanley J. Waligora, Jr.
Southeastern FAcility, Manager

SJW/bs

ENTION Kelly Summers

RESS P. O. Box 684

CITY Socorro, New Mexico 87801

. NO.

REPORT OF ANALYSIS

E OF ANALYSIS | CUSTOMER ORDER NO. | SAMPLES REC'D

Total picocuries

	wet weight (grams)	Cs-137	Sr-85	Co-57
735	160	25,600	13,280	51,200
736	165	23,100	13,200	42,900
737	145	26,100	13,920	55,100
738	176	38,720	19,360	80,960
739	154	30,800	15,400	64,680
740	117	25,740	11,700	60,840
741	136	32,640	14,960	70,720
742	157	31,400	13,816	65,940

	Dry weight (grams)	Cs-137	Sr-85	Co-57
735	160	36,800	15,680	73,600
736	191	26,740	14,898	47,750
737	158	34,760	17,380	66,360
738	224	35,840	16,352	69,440
739	172	27,520	15,136	60,200
740	152	27,360	14,440	59,280
741	195	54,600	15,795	66,300
742	160	32,000	14,240	62,400

EBERLINE INSTRUMENT CORPORATION
312 MIAMI ST.
WEST COLUMBIA, S.C. 29169
(803)796-3604

HOW REPORTED:

PAGE 1 OF 1 PAGES

BY [signature] DATE 2-16-77

Stanley J. Waligora, Jr., Manager

ATTENTION Mr. Kelly Summers

ADDRESS P.O. Box 684

CITY Socorro, New Mexico 87801

ACK. NO.

REPORT OF ANALYSIS

TYPE OF ANALYSIS	CUSTOMER ORDER NO.	SAMPLES REC'D

Picocuries per gram

	Wet Weights	Cs-137	Sr-85	Co-57
0735	160 g	1.6 ± 0.1 E+02	8.3 ± 0.2 E+01	3.2 ± 0.1 E+02
0736	165	1.4 ± 0.1 E+02	8.0 ± 0.2 E+01	2.6 ± 0.1 E+02
0737	145	1.8 ± 0.1 E+02	9.6 ± 0.2 E+01	3.8 ± 0.1 E+02
0738	176	2.2 ± 0.1 E+02	1.1 ± 0.1 E+02	4.6 ± 0.1 E+02
0739	154	2.0 ± 0.1 E+02	1.0 ± 0.1 E+02	4.2 ± 0.1 E+02
0740	117	2.2 ± 0.1 E+02	1.0 ± 0.2 E+02	5.2 ± 0.1 E+02
0741	136	2.4 ± 0.1 E+02	1.1 ± 0.2 E+02	5.2 ± 0.1 E+02
0742	157	2.0 ± 0.1 E+02	8.8 ± 0.2 E+01	4.2 ± 0.1 E+02

	Dry Weights	Cs-137	Sr-85	Co-57
0735	160 g	2.3 ± 0.1 E+02	9.8 ± 0.2 E+01	4.6 ± 0.1 E+02
0736	191	1.4 ± 0.1 E+02	7.8 ± 0.1 E+01	2.5 ± 0.1 E+02
0737	158	2.2 ± 0.1 E+02	1.1 ± 0.1 E+02	4.2 ± 0.1 E+02
0738	224	1.6 ± 0.1 E+02	7.3 ± 0.1 E+01	3.1 ± 0.1 E+02
0739	172	1.6 ± 0.1 E+02	8.8 ± 0.2 E+01	3.5 ± 0.1 E+02
0740	152	1.8 ± 0.1 E+02	9.5 ± 0.2 E+01	3.9 ± 0.1 E+02
0741	195	2.8 ± 0.1 E+02	8.1 ± 0.1 E+01	3.4 ± 0.1 E+02
0742	160	2.0 ± 0.1 E+02	8.9 ± 0.2 E+01	3.9 ± 0.1 E+02

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(803) 796-3604

HOW REPORTED:

BY Stanley J. Waligora, Jr., Manager

DATE 2-16-77

ENTION Kelly Summers

RESS P. O. Box 684

CITY Socorro, New Meixco 87801

NO.

REPORT OF ANALYSIS

E OF ANALYSIS

CUSTOMER ORDER NO.

SAMPLES REC'D

CORRECTED REPORT

Fraction Absorbed or Adsorbed
Powdered Material (Percent)

et Case	Avail. 48,400 pCi Cs-137	Avail. 43,100 pCi Sr-85	Avail. 94,400 pCi Co-57
735	52.9	30.8	54.2
736	47.7	30.6	45.4
737	53.9	32.3	58.4
738	80.0	44.9	85.8
739	63.6	35.7	68.5
740	53.2	27.1	64.4
741	67.4	34.7	74.9
742	64.9	32.1	69.8

ry Case			
735	76.0	36.4	78.0
736	55.2	34.6	50.6
737	71.8	40.3	70.3
738	74.0	37.9	73.5
739	56.8	35.1	63.8
740	56.5	33.5	62.8
741	84.6	36.6	70.2
742	66.1	33.0	66.1

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(803) 796-3604

HOW REPORTED:

PAGE 1 OF 1 PAGES

BY Stanley J. Waligora, Manager DATE 3-18-77

eberline

March 24, 1977

Mr. Kelly Summers
W. K. Summers & Associates
P.O. Box 684
Socorro, New Mexico 87801

Dear Kelly:

Considering the simplicity of our approach to the pragmatic exchange of strontium, cesium and cobalt, we merely assured that any stable isotopes present were in very low concentrations. Since question arose regarding the lower than expected uptake of cesium, we took steps to specifically determine the total cesium concentration in the exchange solutions. We obtained stock solution with very high radiochemical purity and with further qualification of "carrier free". The degree of that latter label can vary based upon the production and separation technique for the isotope.

The actual quantity of cesium-137 was determined on the basis of its radiological-physical property (specific activity) and the total cesium was determined through precipitation (drying down) and measurement of cesium chloride. The results showed:

mass of cesium-137 = 5.8×10^{-10} g/solution

mass of cesium^{+1} = 4×10^{-6} g/solution

These represent very small quantities of cesium, but the isotope dilution is on the order of 10^{+4}.

This fact does not alter the data we reported since both the absolute and relative values given are not altered by the isotopic dilution.

One might, however, be mis-lead if an attempt to calculate the mass of cesium absorbed per mass of shale, solely on ths basis of the specific activity of cesium-137. For example, 60% absorption of cesium-137 onto a shale sample from this very dilute cesium chloride solution would mean that

3.5×10^{-10} g of Cs-137 was absorbed but also that

2.4×10^{-6} g of total cesium was absorbed.

This is tha same type of determination used by many investigators who "tag" a stable metal with a measurable radioisotope of that same metal to determine the relative quantities of the metal that interact in different chemical and physical environments. One may deem it desirable to add additional stable cesium carrier to the exchange solution in order to challenge the total absorption capacity of the shale. I do not recommend this unless the nature

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of the waste or the environmental geology indicate an abundance of stable cesium or an interfering element.

We have proceeded to repeat the 24 hour exchange procedure with three samples of shale (unused aliquots) that were previously tested. These three were constantly stirred for the 24 hour period instead of the static method performed on all the previously tested shale samples. Results show:

DYNAMIC EXCHANGE

		Cs-137	Sr-85	Co-57
Activity Avail.	(pCi)	4.84 E+04	2.73 E+04	8.46 E+04
		Shale concentration	(pCi/g)	
CNC-4 (0740E)	152 g	1.5 ± 0.1 E+02	6.8 ± 0.1 E+01	2.4 ± 0.1 E+02
CNC-5 (0741E)	150 g	2.3 ± 0.1 E+02	7.4 ± 0.1 E+01	4.6 ± 0.1 E+02
CNC-6 (0742E)	136 g	2.6 ± 0.1 E+02	7.9 ± 0.2 E+01	2.6 ± 0.1 E+02

The table below compares the dynamic and static results on a percentage basis.

Percent Absorbed - Dry Powder

	Cs-137	Sr-85	Co-57
CNC-4			
Static	56.5	33.5	62.8
Dynamic	47.1	37.7	43.1
CNC-5			
Static	84.6	36.6	70.2
Dynamic	71.3	40.6	81.6
CNC-6			
Static	66.1	33.0	66.1
Dynamic	73.1	39.2	41.4

All one can say is that there is relative agreement and only the strontium, within the obvious uncertainties, shows higher absorption in the dynamic case. It is important to note that particle size (surface area) of the powdered shale could have a great bearing upon absorption/adsorption of the metals. One can easily prepare samples with graded particle size distributions however we did not make this separation. In terms of the maximum particle size, all samples were screened through a No. 12 U.S. standard testing sieve (Tyler Equivalent 10 Mesh). Particle sizes were substantially smaller than the 1.7 mm openings.

The properities of the other stock solutions, cobalt-57 and strontium-85 were also investigated for definition. The cobalt-57 is accelerator produced with a different target element, so there is essentially negligible isotopic dilution. On a weight percent basis, there is:

0.18 percent cabalt-56
0.059 percent cobalt-58

The specific activity of the strontium-85 used in the solution is 6.16 Ci/g compared to the expected specific activity of 2.29×10^4 Ci/g. This indicates an isotopic dilution of 3.7×10^3; there is that much more strontium than strontium-85. The situation is therefore similar to that for cesium-137. As stated earlier, the reported percentages absorbed remain the same however these factors must be considered when attempting to determine the masses of cesium and strontium absorbed by the shale.

I trust this information is sufficient to clear up any ambiguities however request any other information that may be helpful. I look forward to roaming the mesa with you one day.

Very truly yours,

Stanley J. Waligora, Jr.
Southeastern Facility

SJW/dlr

cc: Eric Geiger
Chuck Schwarz

Appendix II-8b.--Sorption studies

Batch Tests

Well	Depth (feet)	Sample Description	Comments
CNC-1	69.5	black Pierre shale	core
CNC-1	153.4	rotten Pierre shale	core
CNC-1	253.6	black Pierre shale	core
CNC-1	400.0	black Pierre shale	cuttings
CNC-2	21.25	gray-brown clay-shale	core
CNC-2	32.5	interface between gray-brown and black shale	core
CNC-2	33.0	black Pierre shale	core
CNP-2	25.0	gray-brown shale	cuttings
CNP-2	50.0	black Pierre shale	cuttings
CNP-2	200.0	black Pierre shale	cuttings
CNP-2	400.0	black Pierre shale	cuttings
CNS-34	20.0	brown-sandy clay	cuttings

W.K. SUMMERS
& Associates

Box 684
Socorro, N.M. 87801 505-835-2095

Ion Exchange Experiments

All samples were ground so that they would go through a 200 mesh screen.

Exchange #1

2.0 grams of sample was shaken with 50.0 mls of solution containing 25.0 ppm Sr and Co in distilled water at a pH of 7.0. Sr was put into solution as the chloride and Co as the nitrate.

Exchange #2

2.0 grams of sample was shaken with 50.0 mls of solution containing 50.0 ppm Sr and Co in distilled water at a pH of 7.0.

Exchange #3

2.0 grams of sample was shaken with 50.0 mls of solution containing 50.0 ppm Sr and Co and saturated with $CaSO_4$ at a pH of 7.0.

Exchange #4

2.0 grams of sample was shaken with 50.0 mls of solution containing 50.0 ppm Sr and 50.0 ppm Co in distilled water at a pH of 5.0.

Exchange #5

Same as previous exchange except at a pH of 9.0.

All samples were shaken 24±2 hours and filtered through a glass to remove particles from the solution before determining the final concentration by atomic absorption. (Co at a wavelength of 240.7 nm and Sr at 460.7 nm).

Whenever pH adjustments proved necessary they were made with either H_2SO_4 or NaOH.

Change in Concentration of Co in ppm (Initial-Final)

Sample		#1	#2	#3	#4	#5
CNC-1	69.5	>24.9	48.5	39.8	22.0	>49.9
	153.4	>24.9	49.5	--	32.2	49.6
	256.6	>24.9	48.6	44.0	33.3	49.7
	400.0	>24.9	49.3	39.8	30.6	>49.9
CNC-2	21.25	22.1	37.9	36.0	16.6	46.8
	32.5'	23.9	40.4	35.7	30.6	46.2
	33.0'	>24.9	44.1	40.0	27.9	44.4
CNP-2	25.0'	>24.4	48.5	40.4	28.7	49.8
	50.0'	>24.9	48.5	40.1	23.4	49.9
	200.0'	>24.9	49.1	39.4	14.5	49.9
	400.0'	>24.9	40.3	34.2	10.7	49.7
CNS-34	20.0'	>24.9	47.0	9.2	20.0	49.8

Change in concentration of Sr in ppm (Initial-Final)

Sample		#1	#2	#3	#4	#5
CNC-1	69.5'	17.6	31.0	18	31.0	34.0
	153.4'	24.9	48.1	--	41.4	49.0
	256.6'	21.9	37.0	30	38.6	46.2
	400.0'	17.9	45.5	14	37.3	48.9
CNC-2	21.25'	17.1	36.8	13	39.0	38.8
	32.5'	20.1	38.5	21	38.0	42.1
	33.0'	15.2	28.3	17	31.2	48.1
CNP-2	25.0'	20.7	35.5	19	36.6	39.5
	50.0'	23.0	36.8	28	34.9	41.5
	200.0'	>24.9	46.1	17	40.7	48.9
	400.0'	20.4	35.0	21	35.3	38.1
CNS-34	20.0'	21.4	38.0	19	22.4	39.6

Appendix II-8c.--Sorption studies

Albuquerque Assay Laboratory

Well #	Depth (feet)	Sample Description
CNC- 1	20	sandy clay
	25	weathered Pierre Shale
	30	" " "
	35	" " "
	40	" " "
	45	" " "
	50	" " "
	55	Pierre shale
	60	" "
	300	" "
	330	" "
CNC- 3	30	sandy clay
	35	" "
	40	gravel and sand
	45	Pierre shale
CNC- 6	10	weathered Pierre shale
CNS-15	15	slightly sandy clay
	25	weathered Pierre shale
	40	Pierre shale
CNS-16	20	weathered Pierre shale
	30	" " "
	40	Pierre shale
CNS-17	10	clay
	20	weathered Pierre shale
	30	Pierre shale
CNS-18	25	weathered Pierre shale
	35	" " "
	50	Pierre shale

Albuquerque Assay Laboratory

Trench #	Sieve fraction	Sample Description
2	all	clayey sand
	80	
	100	
	200	
	325	
8	all	sand
	40	
	80	
	100	
	200	
	325	
11	all	sandy clay
	80	
	100	
	200	
	325	

W.K. Summers & Associates

PLEASE REFER TO ABOVE NUMBER ON ALL CORRESPONDENCE.

DATE: 27 March 1977

ALBUQUERQUE ASSAY LAB

4115 SILVER S.E.
Albuquerque, New Mexico 87108
Phone: (505) 268-5776

SAMPLE IDENTIFICATION	GOLD Troy oz/ton	SILVER Troy oz/ton	COPPER %	Cesium ppm	Strontium ppm	Cobalt ppm	
CNS-15-25'				32.6	79.0	47.4	
CNS-15-40'				45.0	86.0	49.6	
CNS-16-20'				37.6	80.0	47.6	
CNS-16-30'				38.2	80.6	56.0	
CNS-16-40'				48.0	89.2	42.0	
CNS-17-10'				44.0	83.2	49.4	
CNS-17-20'				40.0	84.4	51.0	
CNS-17-30				48.0	86.8	39.4	
CNS-18-25'				37.8	78.4	50.4	
CNS-18-35'				37.4	78.6	57.0	
CNC-1-20'				42.8	83.4	56.8	
CNC-1-25'				33.4	78.0	54.8	
CNC-1-30'				36.0	80.4	47.8	
CNC-1-35'				30.4	76.6	50.6	
CNC-1-40'				28.4	74.6	52.0	
CNC-1-45'				27.4	79.6	46.6	
CNC-1-50'				32.0	79.4	46.0	
CNC-1-55'				44.0	85.0	58.0	
CNC-1-60'				61.2	94.4	68.0	

COMMENTS: for initial concentrations, see blank on first page.

THANK YOU

CHARGES $

BY David A. Schwab (signature)
ASSAYER–CHEMIST

GEOCHEMICAL - BIOCHEMICAL - ENVIRONMENTAL RESEARCH

CUSTOMER:

W.K. Summers & Associates

AAL IDENTIFICATION NO. 7435
PLEASE REFER TO ABOVE NUMBER ON ALL CORRESPONDENCE.

DATE: 27 March 1977

ALBUQUERQUE ASSAY LAB

4115 SILVER S.E.
Albuquerque, New Mexico 87108
Phone: (505) 268-5776

SAMPLE IDENTIFICATION	GOLD Troy oz/ton	SILVER Troy oz/ton	COPPER %	Cesium ppm	Strontium ppm	Cobalt ppm	
CNC-1-300'				56.8	93.4	64.6	
CNC-1-330'				42.2	90.4	53.0	
CNC-3-30'				44.8	88.2	49.0	
CNC-3-35'				39.0	88.0	45.6	
CNC-3-40'				63.0	98.0	55.4	
CNC-3-45'				41.6	85.2	51.4	
CNC-6-10'				38.0	82.0	48.4	

COMMENTS: for initial concentrations, see blank on first page.

THANK YOU

CHARGES $

BY [signature]
ASSAYER–CHEMIST

GEOCHEMICAL - BIOCHEMICAL - ENVIRONMENTAL RESEARCH

W.K. Summers & Associates

AAL IDENTIFICATION NO. ____
PLEASE REFER TO ABOVE NUMBER ON ALL CORRESPONDENCE.

DATE: 27 March 1977

ALBUQUERQUE ASSAY LAB
4115 SILVER S.E.
Albuquerque, New Mexico 87108
Phone: (505) 268-5776

SAMPLE IDENTIFICATION	GOLD Troy oz/ton	SILVER Troy oz/ton	COPPER %	Cesium ppm	Strontium ppm	Cobalt ppm	
Trench 2 (all)				44.8	90.6	67.4	
Trench 8 (all)				34.8	88.8	63.4	
Trench 11 (all)				29.0	80.0	56.6	
Trench 2- #80				84.0	97.6	92.0	
- #100				78.4	98.4	93.8	
- #200				78.4	97.2	91.0	
- #325				80.0	98.4	92.0	
Trench 8- #40				81.6	100.0	93.6	
- #80				83.8	98.6	92.0	
- #100				80.2	98.8	89.0	
- #200				80.0	98.0	90.4	
- #325				68.4	96.0	81.0	
Trench 11- #80				92.4	100.0	92.0	
- #100				88.2	98.8	92.0	
- #200				80.0	97.6	90.4	
- #325				72.0	95.0	86.0	

COMMENTS: for initial concentrations, see blank on first page.

THANK YOU

CHARGES $ 381.55 (on account)

BY David Richhart
ASSAYER--CHEMIST

CUSTOMER:

W.K. Summers and Associates
P.O. Box 684
Socorro, New Mexico 87801

Page 1 of 3

AAL IDENTIFICATION NO. [illegible]
PLEASE REFER TO ABOVE NUMBER ON ALL CORRESPONDENCE

DATE April 1, 1977

ALBUQUERQUE ASSAY LAB

4115 SILVER S.E.
Albuquerque, New Mexico 87108
Phone: (505) 268-5776

Sample Identification					Cesium ppm	Strontium ppm	Cobalt ppm	
CNS-15- 15'					3.8	14.2	3.6	
CNS-15- 25'					2.4	15.3	4.0	
CNS-15- 40'					5.6	17.2	4.0	
CNS-16- 20'					4.4	15.4	[illegible]	
CNS-16- 30'					3.0	15.8	1.6	
CNS-16- 40'					4.6	17.4	3.2	
CNS-17- 10'					3.6	16.0	3.4	
CNS-17- 20'					3.0	16.6	3.6	
CNS-17- 30'					4.4	17.0	[illegible]	
CNS-18- 25'					3.4	14.8	[illegible]	
CNS-18- 35'					2.8	14.8	3.5	
CNS-18- 50'					4.9	17.2	[illegible]	
CNC-1- 20'					3.8	[illegible]	[illegible]	
CNC-1- 30'					1.9	14.6	[illegible]	
CNC-1- 40'					1.5	14.4	3.0	
CNC-1- 50'					1.6	14.8	3.6	
CNC-1- 60'					7.0	18.0	8.2	
CNC-3- 30'					5.8	16.2	4.2	
CNC-3- 35'					5.0	14.8	4.0	
CNC-3- 40'					8.4	17.8	3.0	
CNC-3- 45'					4.0	15.6	3.0	

COMMENTS: Specific Conductance 1375; Initial concentration
pH 7.37
Cesium 19.0 ppm
Strontium 22.4 ppm
Cobalt 19.8 ppm

THANK YOU

CHARGES $ ____________

BY [signature]
ASSAYER-CHEMIST

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Page 2 of 3

PLEASE REFER TO ABOVE NUMBER ON ALL CORRESPONDENCE.

DATE: April 1, 1977

ALBUQUERQUE ASSAY LAB

4115 SILVER S.E.
Albuquerque, New Mexico 87108
Phone: (505) 268-5776

ple Identification					Cesium ppm	Strontium ppm	Cobalt ppm
CNS-15- 15'					10.0	26.4	8.4
CNS-15- 25'					6.8	27.4	10.0
CNS-15- 40'					14.0	30.6	10.8
CNS-16- 20'					11.4	27.4	10.6
CNS-16- 30'					8.8	28.8	11.0
CNS-16- 40'					13.3	32.0	7.4
CNS-17- 10'					10.8	29.0	11.0
CNS-17- 20'					9.6	30.2	14.0
CNS-17- 30'					13.1	31.0	8.4
CNS-18- 25'					10.4	27.0	12.6
CNS-18- 35'					9.4	26.8	15.4
CNS-18- 50'					14.4	32.0	13.2
CNC-1- 20'					12.1	26.4	13.8
CNC-1- 30'					7.4	26.4	10.4
CNC-1- 40'					6.2	25.8	12.2
CNC-1- 50'					7.1	27.2	10.4
CNC-1- 60'					19.9	32.0	22.0
CNC-3- 30'					15.4	28.6	12.4
CNC-3- 35'					12.6	27.6	10.4
CNC-3- 40'					14.6	33.6	12.6
CNC-3- 45'					12.4	22.0	14.8

MENTS: Specific Conductance 1340; Initial Concentrations
pH 7.27
Cesium 38.0 ppm
Strontium 40.0 ppm
Cobalt 40.0 ppm

THANK YOU

CHARGES $

BY David A. Schwab
ASSAYER–CHEMIST

W.K. Summers & Associates

AAL IDENTIFICATION NO. [illegible]
PLEASE REFER TO ABOVE NUMBER ON ALL CORRESPONDENCE.

DATE: April 1, 19[illegible]

ALBUQUERQUE ASSAY LAB

4115 SILVER S.E.
Albuquerque, New Mexico 87108
Phone: (505) 268-5776

SAMPLE IDENTIFICATION	GOLD Troy oz/ton	SILVER Troy oz/ton	COPPER %			
	Initial Concentration			Final Concentration		
	Cesium ppm	Strontium ppm	Cobalt ppm	Cesium ppm	Strontium ppm	Cobalt ppm
Solution 1K20	A Specific Conductance of 920 and a pH of [illegible]					
CNS-15- 15'	18.8	20.4	19.2	3.6	10.0	[illegible]
CNS-18- 50'	18.8	20.4	19.2	4.4	12.7	4.6
Solution 1K40	A Specific Conductance of 600 and a pH of 6.32					
CNS-15- 15'	39.4	39.4	38.8	9.0	19.6	4.0
CNS-18- 50'	39.4	39.4	38.8	12.4	26.0	5.0
Solution 3K20	A Specific Conductance of 2500 and a pH of 7.10					
CNS-15- 15'	21.4	27.2	21.0	5.6	20.8	5.6
CNS-18- 50'	21.4	27.2	21.0	7.1	23.2	9.6
Solution 3K40	A Specific Conductance of 2300 and a pH of 6.90					
CNS-15- 15'	39.8	46.2	39.8	12.5	32.6	13.0
CNS-18- 50'	39.8	46.2	39.8	17.8	39.2	[illegible]

COMMENTS:

THANK YOU

CHARGES $ 312.50 (on account)

BY [illegible]
ASSAYER - CHEMIST

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CUSTOMER: W.K. Summers & Associates

AAL IDENTIFICATION NO. [illegible]
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DATE: April 7, 1977

Page 2 of 2

ALBUQUERQUE ASSAY LAB

4115 SILVER S.E.
Albuquerque, New Mexico 87108
Phone: (505) 268 5776

Sample Identification					Cesium ppm	Strontium ppm	Cobalt ppm
CNS-15- 15'					<0.05	2.48	<0.05
CNS-15- 25'					<0.05	3.10	<0.05
CNS-15- 40'					<0.05	3.56	<0.05
CNS-16- 20'					<0.05	3.26	<0.05
CNS-16- 30'					<0.05	3.20	<0.05
CNS-16- 40'					0.06	3.24	<0.05
CNS-17- 10'					<0.05	3.16	<0.05
CNS-17- 20'					<0.05	4.02	<0.05
CNS-17- 30'					<0.05	3.60	<0.05
CNS-18- 25'					<0.05	3.24	<0.05
CNS-18- 35'					<0.05	3.14	<0.05
CNS-18- 50'					<0.05	4.06	<0.05
CNC-1- 20'					<0.05	2.94	<0.05
CNC-1- 30'					<0.05	3.14	<0.05
CNC-1- 40'					<0.05	3.44	<0.05
CNC-1- 50'					<0.05	3.60	<0.05
CNC-1- 60'					0.06	4.26	<0.05
CNC-3- 30'					<0.05	4.20	<0.05
CNC-3- 35'					<0.05	4.30	<0.05
CNC-3- 40'					<0.05	4.50	<0.05
CNC-3- 45'					<0.05	4.02	<0.05

COMMENTS: Specific Conductance 1280; pH 7.08

Initial Concentrations: < is less than.
Cesium 1.00 ppm
Strontium 4.80 ppm
Cobalt 1.00 ppm
4 grams

THANK YOU

CHARGES $ 262.71 (on account)

BY David [signature]
ASSAYER CHEMIST

GEOCHEMICAL - BIOCHEMICAL - ENVIRONMENTAL RESEARCH

W.K. Summers & Associates
P.O. Box 684
Socorro, New Mexico 87801

PLEASE REFER TO ABOVE NUMBER ON ALL CORRESPONDENCE.

DATE: April 7, 1977

ALBUQUERQUE ASSAY LAB

4115 SILVER S.E.
Albuquerque, New Mexico 87108
Phone: (505) 268-5776

Sample Identification					Cesium ppm	Strontium ppm	Cobalt ppm	
CNS-15- 15'					0.14	4.04	[illegible]	
CNS-15- 25'					0.20	4.76	0.20	
CNS-15- 40'					0.30	[illegible]	[illegible]	
CNS-16- 20'					0.22	4.94	[illegible]	
CNS-16- 30'					0.22	[illegible]	[illegible]	
CNS-16- 40'					0.26	[illegible]	[illegible]	
CNS-17- 10'					0.20	[illegible]	0.26	
CNS-17- 20'					0.22	6.22	0.24	
CNS-17- 30'					0.24	5.56	0.24	
CNS-18- 25'					0.22	4.86	0.22	
CNS-18- 35'					0.24	4.80	0.28	
CNS-18- 50'					0.28	6.12	0.40	
CNC-1- 20'					0.20	4.74	[illegible]	
CNC-1- 30'					0.14	4.76	[illegible]	
CNC-1- 40'					0.12	5.00	0.18	
CNC-1- 50'					0.18	[illegible]	[illegible]	
CNC-1- 60'					0.54	6.40	0.40	
CNC-3- 30'					0.34	6.64	0.44	
CNC-3- 35'					0.24	6.70	[illegible]	
CNC-3- 40'					0.74	7.46	0.42	
CNC-3- 45'					0.30	6.30	0.48	

COMMENTS: Specific Conductance 1280, Initial Concentration
pH 7.10
Cesium 5.00 ppm
Strontium 8.42 ppm
Cobalt 4.98 ppm
4 grams

CHARGES $ ____

THANK YOU

BY [signature]
ASSAYER CHEMIST

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Appendix III-1.--Photogeologic study

GENE D. WILSON & ASSOCIATES
PHOTOGEOLOGISTS
301-B GRACELAND DRIVE, S.E. ◦ ALBUQUERQUE, NEW MEXICO ◦ TELEPHONE 268-9570

January 24, 1977

Mr. Glenn Hammock
Gordon Herkenhoff & Associates
302 Eighth Street N.W.
Albuquerque, N.M.

Dear Mr. Hammock:

Attached hereto is a photogeologic map of the ChemNuclear Cimarron site.

PURPOSE

The purpose of this study was to map all the faults, fractures and other pertinent geologic data that could be seen on aerial photographs to see if a photogeologic study could possibly be of some help in evaluating this area for use as a possible radioactive waste disposal site.

METHOD

51 aerial photographs of the proposed disposal site and surrounding area were studied in detail, both stereoscopically and individually. All fractures were delineated and mapped, all those that appeared to have offset were mapped as faults. All anomalous areas such as covered outcrops, stream offsets, inferred anticlines and synclines were mapped. All data were plotted on a 1" = 500' mosaic, then copied onto a base map of the same scale.

RESULTS

The area appears to be severely faulted and fractured and possibly folded beneath the Quaternary terrace gravels. There appear to be several faults with recent movement. The northwest-southeast fractures are best exhibited because of the drainage direction.

The relatively straight outcrop pattern in the south central part of the area suggests dips of 10° to 20° magnitude. There appear to be several structural undulations in the central part of the area.

A clue to the complexity of the area can be seen in the streams surrounding the proposed site. They have adjusted to the apparrently rather large faults and structural trends in the Pierre-Niobrara bedrock. Since the same forces were acting all over the area, it would seem safe to assume that the bedrock beneath the proposed disposal site has been similarly affected.

CONCLUSIONS

The photogeological study indicates that there is a high probability of structural complexity in this area and due caution should be observed.

Very truly yours:

Gene D. Wilson APGS

Appendix III-2.--Geophysical log analyses.

N

EXPLANATION

Faults .... U D
Fractures ....
Inferred Anticline ....
Inferred Syncline ....
Covered Outcrop (Inferred) ....
Sale Line ....
Reference Points .... △
Elev Pts x

GENE D. WILSON & ASSOCIATES

PHOTOGEOLOGISTS

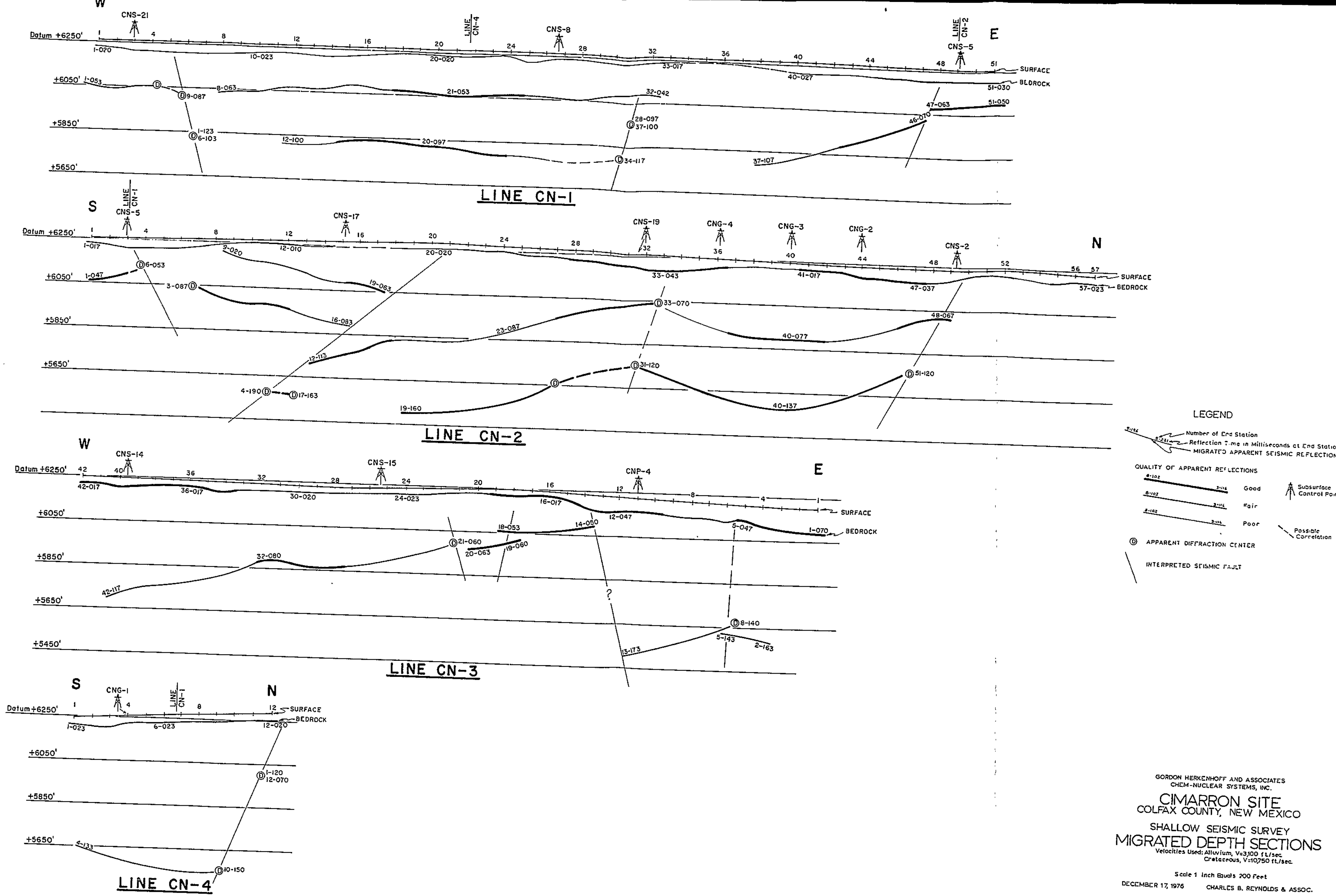
ALBUQUERQUE, NEW MEXICO

PREPARED FOR

GORDON HERKENHOFF

& ASSOCIATES

CHEM-NUCLEAR
CIMARRON SITE
COLFAX COUNTY
NEW MEXICO



GORDON HERKENHOFF AND ASSOCIATES
CHEM-NUCLEAR SYSTEMS, INC.

CIMARRON SITE
COLFAX COUNTY, NEW MEXICO

SHALLOW SEISMIC SURVEY
MIGRATED DEPTH SECTIONS

Velocities Used: Alluvium, V=3,100 ft./sec.
Cretaceous, V=10,750 ft./sec.

Scale 1 Inch Equals 200 Feet

DECEMBER 17, 1976 CHARLES B. REYNOLDS & ASSOC.

CNP-2 and CNC-1 Log Analyses

The rock material is reasonably uniform as exhibited by the small variations in measured parameters (ρ_β, Δt, resistivity, etc.) There are slight variations but the magnitudes are small. Standard deviations in measured parameters vary in the 4 to 10% range.

The rocks logged are shales as evidenced by density, neutron, and sonic response. Two calculated parameters called M and N plot in the mineral identification graphs as shales. The apparent average matrix properties (Δtmə)a and (ρmə)a suggest a slight difference in mineralogy between two wells.

Well	(Δtma)a μsec/ft	(ρma)a gm/cc
CNP-2	51.6	2.89
CNC-1	56.3	2.87

The mineralogy of CNP-2 probably contains less heavy minerals than CNC-1. The basic mineralogy is a mixture of quartz, dolomite, and other "heavier minerals".

Each data point examined suggests a model of porosity, solid matrix, and something akin to "suspended fines". The latter are probably solid particles which are not part of the rocks' matrix in that they do not support weight of the overburden rocks. Average fractions of total porosity, effective porosity, and "suspended fines" (mean values) are as follows:

Well	Total Porosity	Effective porosity	"U_{fn}"
CNP-2	.288	.187	.102
CNC-1	.277	.163	.114

Mechanical properties of the shales (mean values) are:

	CNP-2	CNC-1
Poisson's Ratio	.314	.321
Bulk Modulus	2.63×10^6 psi	2.60×10^6 psi
Bulk Compressibility	3.80×10^{-7} psi^{-1}	3.85×10^{-7} psi^{-1}
Young's Modulus	2.93×10^6 psi	2.80×10^6 psi
Shear Modulus	11.1×10^5 psi	10.5×10^5 psi

Individual values of these parameter at each data point indicate that the shales are in compression in the vertical direction with the degree or amount of compression increasing with depth (generally) and compression laterally from the well bore.

Mean values of specific storage are:

Well	Specific Storage (Ft^{-1})	Std. Dev. (Ft^{-1})
CNP-2	4.0×10^{-7}	$.33 \times 10^{-7}$
CNC-1	3.7×10^{-7}	$.30 \times 10^{-7}$

The specific storage values are reasonably uniform as shown by the standard deviations (only about 8%). Specific storage was calculated by using bulk compressibility as follows:

$$S_s = \rho g \; (\beta\phi + (1-\phi)\alpha)$$

where: ρg = specific wt. H_2O = 62.4 lbs./ft^3
β = compressibility H_2O = 3.3×10^{-6} psi^{-1}
ϕ = porosity
α = bulk compressibility

see: Bear, 1972, p. 213

The shales do exhibit some permeability as evidenced by SP and invasion profiles. Average depths of invasion, calculated from the resistivity logs, from the side of the well bore are as follows:

Well	Depth Invasion (in.)	Std. Dev. (in.)
CNP-2	15.0	3.0
CNC-1	15.5	4.6

Date:

R. M. Brimhall
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Ground-water Hydrologist

Appendix III-3.--Earthquake risk study.

EARTHQUAKE RISK IN THE CIMARRON SITE AREA

The Cimarron site falls within one of the two principal seismically active belts in New Mexico (Sanford et al, 1976). This belt of seismic activity extends southwestward from the northeast corner of the state to the Grants area. The other main seismic belt follows the Rio Grande valley west of the Cimarron site.

Northrop (1976) lists seven earthquakes with epicenters near the Cimarron site during the period 1878-1970. Two of these, in 1878 and 1952, occurred before permanent seismograph installations were established in New Mexico (1960). These two have been assigned Modified Mercalli intensities of III and V respectively (Northrop, personal communication, January 6, 1977). The remaining five, which were instrumentally recorded, are tabulated by Sanford and Cash (1969) and by Northrop and Sanford (1972). The first of these occurred in 1963, with an epicenter south of Raton and about 19-20 miles east-northeast of the Cimarron site and was measured at a Richter magnitude of 3.7. The others took place in 1966, with epicenters west of Cimarron and 15-20 miles west-southwest of the Cimarron site area. These earthquakes had Richter magnitudes of 3.4 to 3.8. Additional earthquakes may have been recorded in the Cimarron-Raton area since 1970, but this information is not yet ready for release or publication (Sanford, personal communication, January 7, 1977).

A number of earthquakes originating elsewhere in New Mexico or in nearby parts of Texas and Colorado have been felt in the Cimarron-Raton area (Northrop, 1976). Several of these have had magnitudes exceeding 4 on the Richter scale, though in the vicinity of the Cimarron site they have exhibited Mercalli intensities of IV or less.

Richter (1959) in a seismic regionalization map of the United States, showed the Cimarron area as possibly occasionally subject to earthquakes of intensity VIII. Algermissen (1969) produced a similar map showing the area subject to earthquakes of intensity V and VI. Sanford et al (1972) analyzed the information available for the Rio Grande valley and concluded that Richter's estimate appeared too high and Algermissen's too low. This might be taken as suggesting that the Cimarron site area can be regarded as subject to earthquakes of intensity VI-VII (roughly magnitude 5).

Consideration of the available information leads to the conclusion that the Cimarron site area is in a seismically active belt definitely subject to earthquakes of magnitude 3-4 and intensity III-V, and probably subject to earthquakes of magnitude 4-5 and intensity VI-VIII over a longer period of time (say 100 years). More powerful earthquakes of magnitude 5-6 and intensity VII-VIII are a possibility during a period of 200-400 years. This translates into the possibility of an earthquake (during the period of significant radioactivity of the materials proposed for disposal) which could cause considerable damage in ordinary substantial buildings or excavations. By comparison

Northrop (1976) states that a shock of magnitude 6 and intensity VII-VIII is expectable once every 100 years between Socorro and Albuquerque. The Cimarron site area is clearly subject to earthquakes, but less frequently than the Socorro-Albuquerque area, and of moderate intensity as compared with earthquakes recorded in California and other highly active seismic areas.

Two principal affects of earthquakes of magnitude as great as 6 on the disposal site shoud be considered. First and most obvious is the possibility of collapse of the excavation walls. Second and less obvious is the possibility that such an earthquake might open new or existing fractures in the shale, producing fluid conduits leading to or from the trenches.

Embankments or excavation walls sometimes collapse if built at too steep an angle for the rock or soil material in which they are cut. This can be agravated by the shaking caused by an earthquake shock, requiring that the excavation walls slope more gently if they are to survive earthquakes without collapse. An advantage can be gained by seating the trenches in bedrock (here, Cretaceous Pierre shale) rather than in the overlying alluvium. This is because the relative intensity of earthquake motion and damage in unconsolidated alluvium can be two or more times greater than in consolidated rock (Legget, 1962, pp.395-403).

The experience of the New Mexico Highway Department is that excavation walls in the Pierre shale should be cut at slopes of 2:1 or 2½:1 to stand for long periods without collapsing, especially if fractured or dipping more than a few degrees (i.e., bedding planes sloping more than a few degrees).

In the writer's opinion the greatest danger consequent upon earthquake-induced partial collapse of the rock walls of a filled trench is that of unequal fill subsidence leading to erosion and unearthing of the buried radioactive material. The presence of the fill material would, of course, retard the collapse. Two different approaches to control of this situation are suggested. The trenches could be so constructed as to withstand the greatest predictable earthquake motion. This might require slopes as gentle as 3:1 for the walls of the excavations, or artificial bracing of the walls. It would also produce an excavation 230 feet wide at the top to provide a disposal trench 30 feet deep and 50 feet wide at the bottom. Alternatively, the trenches could be excavated with walls only sloped enough to stand safely during the short periods while they are being filled (1:1, for example). They could then be watched for erosion-provoking subsidence caused by earthquake-induced or other collapse and corrective reconstruction of the surface undertaken. The first approach would be more stable, but would require a larger surface area per trench and would necessitate more than twice as much excavation per trench. It would also require a much larger protective earth mound over each filled trench which would in itself invite erosion, and therefore would still need to be monitored and maintained during the redioactive life of the buried material.

The second approach would require less surface area per trench, less excavation per trench, and would probably require no more maintenance. The probability of earthquake-produced collapse of a trench before it is filled and while people are working in it would seem minute.

Earthquake shocks sometimes create new springs or dry up old ones along existing faults or fractures. This shows that earthquakes can alter the ability of fractures to serve as fluid conduits. Relatively rigid rocks such as granite are much more subject to such effects than are the less brittle rocks such as the Pierre shale. The possibility of an earthquake of the predictable intensity opening a fracture sufficient to serve as a significant fluid conduit in the Cimarron site area is probably small because the plastic nature of the shale tends to keep fractures closed in the absence of high fluid pressures. The absence of springs in the near vicinity of the site supports this, as does the fact that none of the numerous holes drilled into the shale in the site area produced large amounts of water. Pressure tests conducted in some of the holes showed that fractures in the shale could be opened by high fluid pressures, but closed again upon release of the pressure, expelling the fluid. (W. K. Summers, oral communication, February 3, 1977).

<u>Conclusions</u> - 1. The Cimarron site lies within a northeast-southwest belt of seismic activity subject in the short term to earthquakes of Richter magnitude 3-4, and Mercalli intensity III-V, probably subject over longer periods (such as 100 years) to earthquakes of magnitude 4-5 and intensity VI-VII, and possibly subject over still longer periods (such as 200-400 years) to earthquakes of magnitude 5-6 and intensity VII-VIII.

2. Partial collapse of the rock walls of the trenches into the softer fill material as a result of earthquake shocks is possible.

3. The opening of previously existing or new fractures which might serve as fluid conduits in the area is unlikely because of the plastic nature of the shale, the moderate intensity of the expectable earthquakes, and the apparent absence of high fluid pressures and open fractures at shallow depths in the shale of the area.

<u>Recommendations</u> - 1. Trenches for waste disposal should be seated in the Cretaceous shale bedrock rather than in the overlying alluvium, because of the much greater motion and damage caused in unconsolidated alluvium by earthquake shocks.

2. The earth mounds over filled trenches should be carefully monitored and maintained to prevent erosion resulting from earthquake-induced partial collapse of the rock

trench walls into the softer fill of the trench and consequent uneven fill subsidence. This problem could be minimized by cutting the walls of the trenches to gentler slopes (perhaps 3:1) but only at the cost of greatly increased excavation.

Respectfully submitted,

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REFERENCES

1. Algermissen, S. T., 1969, Seismic risk studies in the United States: Fourth World Conference on Earthquake Engineering, Santiago, Chile.

2. Legget, Robert F., 1962, Geology and engineering: McGraw-Hill, New York.

3. Northrop, Stuart A., and Sanford, Allan R., 1972, Earthquakes of northeastern New Mexico and the Texas Panhandle: in N. M. Geol. Soc. Guidebook of East-Central New Mexico.

4. Northrop, Stuart A., 1976. New Mexico's earthquake history, 1849-1975: in New Mex. Geol. Soc., Spec. Publ. No. 6.

5. Richter, C. F., 1959, Seismic regionalization: Seismol. Soc. Amer., Bull., V. 49.

6. Sanford, Allan R., and Cash, Daniel J., 1969, An instrumental study of New Mexico earthquakes, July 1, 1964, through Dec. 31, 1967: N. M. Bureau Mines and Min. Res., Circular 102.

7. Sanford, A. R., Budding, A. J., Hoffman, J. P., Alpetkin, O. S., Rush, C. A. and Toppozada, T. R., 1972, Seismicity of the Rio Grande rift in New Mexico: N. M. Bureau Mines and Min. Res., Circular 120.

8. Sanford, Allan R., Toppozada, Tousson R., Ward, Roger M., and Wallace, Terry C., 1976, The seismicity of New Mexico: Abstr. in Geol. Soc. Amer., Abstracts with Programs, Vol. 8, No. 5.

Appendix III-4.--Shallow seismic survey.

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FINAL REPORT

SHALLOW SEISMIC SURVEY

CIMARRON SITE, COLFAX COUNTY, NEW MEXICO

SUMMARY

I. Introduction - A shallow seismic survey consisting of two reversed refraction probes and four short reflection lines totalling about 2.5 miles in length was carried out October 20-21, 1976, in the Cimarron site area. The principal purpose was to obtain structural geologic information, especially with regard to possible fault or fracture zones.

II. Method - A single-vehicle operation was used. The seismic energy source was a 150 lb. shot bag dropped four feet. The reflection receiver array was a drag cable with six geophone cases spaced four meters apart and towed behind the vehicle. Recording was by a single-channel engineering-type seismograph with programmed gain expansion, frequency filters, and a paper recorder. The refraction probes were fully reversed and used a single buried geophone.

III. Results - Apparent reflections of good to very poor quality and ranging from about 20 to about 1000 feet in depth were recorded. One of the refraction probes recorded a bedrock refraction, the other apparently did not.

IV. Interpretation - Attempts were made to identify and trace a reflection from the top of bedrock and reflections from within the Cretaceous shale bedrock. Migrated depth sections of the reflection lines were constructed.

V. Conclusions - The bedrock surface appears to be a buried landscape possibly in early maturity with an integrated drainage system which may have been influenced by faulting and fracturing. The Cretaceous shale bedrock has apparently been affected by small-scale Laramide folding, probably of the flowage type and perhaps confined entirely to the thick shale unit. Faulting and probably fracturing also appear to be present. The faults, which may be mostly high-angle reverse faults, do not appear to cut the overburden. Tectonic strike may be east-southeast.

VI. Recommendations - An effort should be made to detect and trace the main fault, fracture and fold systems by photogeology, seismic reflection, or other means.

FINAL REPORT

SHALLOW SEISMIC SURVEY

CIMARRON SITE, COLFAX COUNTY, NEW MEXICO

I. Introduction - A shallow seismic survey was carried out October 20 and 21, 1976, in an area about two miles south of the ghost town of Colfax, New Mexico, for Gordon Herkenhoff and Associates, consulting engineers. The study consisted of two shallow reversed seismic refraction probes and four short reflection seismic lines totalling about 2.5 miles in length (see enclosed Location Map). The purposes of the survey were to obtain rock velocity information for its bearing on rock conditions, and to obtain structural geologic information, especially with regard to possible faulting or fracture zones.

II. Method - The four shallow seismic reflection lines are shown on the location map. A 150 lb. weight (shot-filled leather bag) was dropped four feet as the energy source. The receiver array was a drag cable with six geophone cases, each containing two 10 Hz digital-grade geophones, spaced four meters apart and towed behind the weight-drop truck. Recording was by a single-channel Seaman Nuclear Corp. engineering-type seismograph with digital memory and modified to utilize frequency filters, programmed gain expansion, and a paper strip-chart recorder. Station spacing was 25 meters (82 feet).

The two refraction probes were located on reflection lines CN-1 and CN-2 (see Location Map, Enclosure No. 1). The refraction probe locations were selected by examination of drill data and reflection lines to have bedrock shallow enough to measure the propagation velocity of the bedrock (upper Cretaceous shale). At each probe location the following procedure was used. An 8 Hz refraction geophone was buried at one end of the refraction line and the weight-drop truck moved away from the geophone, dropping the weight at distances of 12.5M (41 ft.), 25M (82 ft.), 37.5M (123 ft.), 50M (164 ft.), 62.5M (205 ft.), 75M (246 ft.), and 87.5M (287 ft.) from the geophone. The geophone was then buried at the opposite end of the refraction line and the procedure repeated in the other direction, yielding a fully reversed refraction probe.

III. Results - Time-depth plots for the two shallow refraction probes are shown by Figure No. 1. A time correction of -0.012 second has been applied to correct from the first trough of each trace to the first energy arrival.

Refraction probe CN-1-44 does not appear likely to have reached bedrock. The deepest refractor indicated appears to have a velocity of about 7,300 ft/sec, slow enough to be more likely within the Cenozoic overburden than Cretaceous shale bedrock. The layer above this refractor appears to be very different in velocity at the two ends of the refraction probe. The refractor, which is probably a sand or gravel bed above bedrock, evidently dips west.

Refraction probe CN-2-24 appears to have reached true bedrock. The bedrock refractor has a velocity of about 10,400 ft/sec, which is compatible with the velocities indicated by the sonic logs which were run in the CNC-1 and CNP-2 drill holes. The overburden velocity appears to increase with depth, probably averaging about 2,500 ft/sec. A depth section (horizontal and vertical scales equal) for refraction probe CN-2-24 is shown by Figure No. 1. This section, made by wavefront reconstruction, shows about ten feet of buried topographic relief on bedrock along the length of subsurface coverage, including a shallow depression. The depth range to bedrock shown (30-40 feet) is compatible with drill hole and reflection seismic data.

The locations of the four short seismic reflection lines are shown by the Location Map (Enclosure No. 1). The resulting data are included with this report as variable area record sections (Enclosures Nos. 2 and 3). Seismic events believed to be reflections range from about 20 feet to nearly 1000 feet in depth. Scattered, fragmentary later events which may be reflections are as deep as 2000 feet, but are regarded as too poor to be usable. Reflection data quality varies locally from good to very poor, and is generally fair in the top 500 feet or so.

IV. Interpretation - Enclosures Nos. 4 and 5 show the interpretation of the variable area record sections. The horizon marked in red is believed to be a reflection from the overburden-bedrock contact. This reflection traverse is controlled by a total of 14 drillholes on or very near the seismic lines. The criterion used to trace this reflection along the lines (and the most accurate of the several tried) is simply to pick the onset of the earliest coherent event. This is not everywhere clear on the data; there are half a dozen places where the reflection does not appear to be present. In such places the red horizon is very questionable for distances as great as two hundred yards.

The seismic events marked in yellow on Enclosures Nos. 4 and 5 are those thought likely to be bedding-plane reflections from within the Cretaceous shales. They suggest small-scale folding and faulting of a sort not uncommonly seen within thick shale sections near major uplifts. This was an unexpected result, and caused us to question its correctness. If these events are not reflections, the most likely explanation is that they are reflected refractions. This seems unlikely, as the good event at the intersection of CN-1 and CN-2 has far too high an apparent velocity (more than 30,000 ft/sec) to be a refraction from any rocks known to be present in the vicinity. Further, experience indicates that internal reflections from shale units are much more common than are internal refractions. Therefore these events should be considered reflections unless proven otherwise.

The seismic events marked in purple are believed to be diffractions or reflected refractions. These are seismic event types which commonly provide evidence of the presence of faults or fracture zones. The interpreted possible faults or fracture zones are shown in green on Enclosures Nos. 4 and 5.

The seismic events shown in color on Enclosures Nos. 4 and 5 have been converted to migrated depth sections or structure sections by the point-arc method, which is explained by Figure No. 2. The velocities used were 3100 ft/sec through the overburden and 10,750 ft/sec within the Cretaceous shales. The overburden velocity of 3100 ft/sec was obtained by determining what average velocity gave the best average tie between the known depth of bedrock in the 14 drill holes and the depth computed from the bedrock reflection. This velocity may be about 2% too fast; a velocity of 3050 ft/sec would improve the resulting depth ties to the drill holes slightly. The Cretaceous shale velocity was determined by averaging the velocities indicated by the sonic logs from the CNP-2 and CNC-1 drill holes. This velocity is also inclose agreement with that determined by the CN-2-24 refraction probe (10,400 ft/sec).

The resulting migrated depth sections are included as Enclosure No. 6. Both horizontal and vertical scales are one inch equals 200 feet. Reflection quality grading is indicated by line width of the reflecting horizons.

Because the overburden velocity is so much slower than the Cretaceous velocity, it was necessary to correct for variations in the overburden thickness. Without this correction, the deeper apparent reflections from within the Cretaceous would have been considerably distorted. For this reason a good deal of time and care were spent in deciding where the bedrock reflection must be on the record sections, in determining the overburden velocity, and in migrating (plotting) the bedrock reflection on the migrated depth sections. As a result of this and the considerable amount of drill hole control, the bedrock horizon shown is considered to be reasonably accurate. The average mistie to the drill holes is seven feet, at least part of which must be due to variations in overburden velocity. The greatest error, 13 feet at CNS-19, is probably also partly due to some uncertainty in the exact position of the drill hole relative to the seismic line. The bedrock horizon as shown is thus evidently accurate within about 16%. Two steps could improve this accuracy figure in future. First, the quality of the reflection data at this depth must and can be improved. Second, determination of the overburden velocity in the drill holes would also help greatly in increasing the accuracy of such a bedrock profile.

Despite this somewhat disappointing accuracy figure, there appears to be little doubt that the features indicated (such as buried bluffs, ridges and channels) actually exist. This does not, of course, mean that they can always be correctly interpreted the first time. One steeply dipping event on Line CN-4, initially interpreted as possibly the north side of a deep channel, was subsequently proven by drill hole CNG-1 and event migration to be a diffraction probably related to a fault or fracture zone near the north end of Line CN-4.

The bedrock horizon shown on the migrated section suggests a buried landscape perhaps in early maturity, no doubt with an integrated drainage system. The largest buried drainage indicated is shown by the east end of Line CN-3 (east of Station 16). This buried valley evidently deepens eastward, presumably toward an ancestral Vermejo River. This valley is apparently bounded on the west by a low bluff which may have been localized by a bedrock fault. If this fault exists, however, possible faint deeper reflections suggest it does not extend downward to cut strata at the base of the thick Cretaceous Pierre shale.

Lesser buried channels presumably represent members of varied size of the buried fossil drainage system. Notable are three shown by Line CN-2. These center at about Stations 5, 33 and 47. All three channels and the elevated interfluvial areas between have been penetrated by drill holes, as shown by the migrated section. These channels were probably short (about 1-3 miles) east-flowing tributaries of the ancestral Vermejo River. All three appear to be located over faulted small anticlines, and may well have been localized by the reduced erosion resistance of these features, especially the faults.

The buried channel on the east end of Line CN-1 (east of Station 36) is evidently continuous with the channel centered about Station 5 on Line CN-2. This was probably a divide position, however, between east-running and southwest-running watercourses draining the northwest to southeast ridge crossing the area. The broad, compound buried channel near the west end of Line CN-1 (between Stations 1 and 20) may represent a longer drainage running from northwest to southeast, which presumably was a tributary of an ancestral Van Bremmer Creek to the south. Like the other buried channels observed here, this one may have been at least partly controlled by a small fault crossing Line CN-1 at about Station 6.

Still smaller buried channels are also indicated, such as those on Line CN-3 at Stations 34 and 40, Line CN-4 at Station 3, and Line CN-1 at Station 25. These lesser features show no sign of any relationship to faulting. If their location was influenced by any structural element, it would most likely have been bedrock jointing.

As mentioned earlier, the geologic structure within bedrock suggested by the seismic data consists mainly of a series of faulted assymetric anticlines and synclines, best seen on Line CN-2. These appear to be compressive features; the faults seem mostly to be small, high-angle reverse faults.

The wavelength of the small faulted folds on Line CN-2 appears to be about 1,000-2,000 feet. This is probably exaggerated, as the small amount of seismic data does not allow us to determine the trends of the folds. They are probably not at right angles to the line. We can, however, make some deductions as to their probable trend.

Both the Tectonic Map of the United States (Cohee et al, 1962) and Foster and Stipp (1961) show the Cimarron site area at basement depth as being located low on the east flank of the Sangre de Cristo uplift and west of the saddle between the Raton Basin to the northeast and the Las Vegas Basin to the southeast. Regional dip on the top of Precambrian rocks at this location is shown as about 100 feet per mile toward the Raton Basin to the northeast. A petroleum wildcat well drilled a few miles to the southwest in 1946 (Amer. Mfg. No. 1 Ranch, Sec. 1, T 26 N, R 20 E) reached Precambrian rocks at a depth of 3,814 feet. The total thickness of the sedimentary rocks at the Cimarron site is thus probably about 4,300 feet, much of it Cretaceous. Griggs (1948) shows the dip in the area to be less than one degree to the northwest at the top of the Dakota formation. He shows the axis of the Raton Basin to be northwest of the Cimarron site. Neither this study (Griggs, 1948) nor the earlier cited maps (Foster and Stipp, 1961, and Cohee et al, 1963) have enough subsurface control to determine either the position of the Raton Basin axis or the direction and amount of regional dip accurately in the Cimarron site area.

The nearest intense tectonic activity indicated by surface geology is 15-20 miles to the southwest, where folding, thrusting and igneous intrusion of Laramide age affect the Cretaceous strata (Dane and Bachman, 1965). Here the tectonic strike wraps around the Urraca salient, which juts eastward toward the saddle between the Raton and Las Vegas Basins. On the side nearest the Cimarron site area, the tectonic strike is east-southeast. Quaternary dikes in both this area and to the northeast of the Cimarron site also mostly strike east-southeast. On the assumption, which is probably reasonably safe, that the flowage folds indicated in the Cimarron site area are also of Laramide age and genetically related to the formation of the Sangre de Cristo uplift, Urraca salient, and Raton Basin, it seems reasonable to assume that they also trend approximately east-southeast. If this is correct, their true wavelength is probably of the order of 700-1500 feet. Such small folds in a thick shale section, in the writer's experience, are likely to be confined entirely to the shale unit, as are the associated high-angle reverse faults. Mechanically they may represent one means by which the shale thickened in response to compressional shortening in the Raton Basin. Presumably the compressional stress which produced them ceased after Laramide time, so that they can now probably be safely presumed stable. The basalt dikes to the northeast and southwest of the Cimarron site area suggest that by Quaternary time the compressional stress had relaxed enough for the east-southeast trend to be subject to magma injection.

In such folds faulting and fracturing sometimes tend to be concentrated near the axes of the folds. The fracturing encountered in the CNC-1 drill hole, for instance, may suggest that this drill hole was located near the crest of one of the small anticlines. Some possible support for this may be present in a possible log correlation between the CNC-1 and CNP-2 drill holes which suggests that CNC-1 might be about 140 feet structurally higher within the Cretaceous shale than CNP-2. The faults or fracture zones and their possible relationship to the small folds may be detectable by an experienced photogeologist. If not, the principal other means of tracing them would be a detail seismic survey.

V. <u>Conclusions</u> - A. The bedrock surface in the Cimarron site area appears to be a buried landscape possibly in early maturity with an integrated drainage system. The locations of at least some of the streams may have been influenced by bedrock faulting or fracturing, and possibly by folding.

B. The Cretaceous shale bedrock evidently has been subjected to small-scale folding, probably as a result of compressional thickening of the shale in the Raton Basin. The folds may be entirely confined to the thick shale unit and may not affect underlying or overlying more competent units.

C. Faulting, and probably fracturing as well, appear to occur mainly near the axes of the small folds. Most of the faults appear to be small high-angle reverse faults.

D. Tectonic strike in the area may be east-southeast.

VI. Recommendation - An effort should be made to detect and trace the main fault and fracture systems of the area by photogeology, reflection seismic methods, or other means.

Respectfully submitted,

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References:

Cohee, George V. et al, 1962, Tectonic map of the United States: U. S. Geol. Survey and Am. Assoc. Petroleum Geologists. Scale 1:2,500,000.

Dane, Carle H. and Bachman, George O., 1965, Geologic map of New Mexico: U. S. Geol. Survey. Scale 1:500,000.

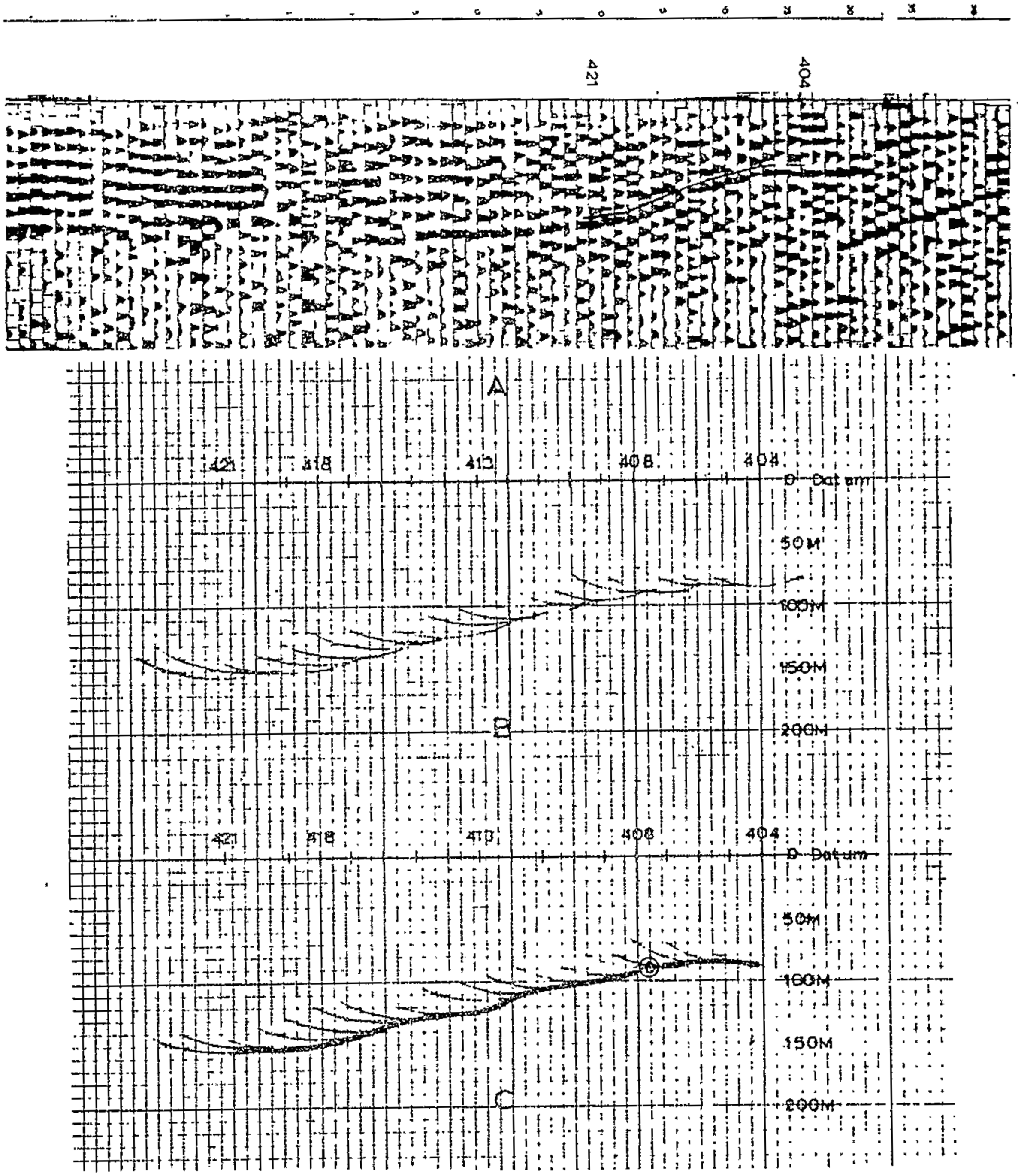
Foster, Roy W. and Stipp, Thomas F., 1961, Preliminary geologic and relief map of the Precambrian rocks of New Mexico: Circular 57, N. M. Bur. Mines and Min. Res..

Griggs, Roy L., 1948, Geology and groundwater resources of the eastern part of Colfax County, New Mexico: Groundwater Report 1, N. M. Bur. Mines and Min. Res..

Enclosures:

No. 1 - Station Location Map, Scale 1 inch equals 500 ft.
No. 2 - Variable Area Record Sections, Lines CN-1 and CN-2
No. 3 - " " " " " CN-3 and CN-4
No. 4 - " " " " Interpreted, Lines CN-1 and CN-2
No. 5 - " " " " " " CN-3 and CN-4
No. 6 - Migrated Depth Sections

Two Figures



POINT-ARC METHOD OF MIGRATION OF
SHALLOW SEISMIC REFLECTION DATA

In the point-arc method of migration or depth conversion, a given seismic event is first selected ("picked") and its time of arrival on each trace determined. In this example the event marked in red from Station 404 to Station 421, Figure A, has been picked and timed. Next all these times are converted to depth using a known or assumed velocity (in this example V=2000 M/sec). A circular arc with radius equal to each computed depth is then drawn with its center at the corresponding station on the datum (Figure B). Note that the horizontal and vertical scales on the depth section must be equal. Lastly, a curve is drawn tangent to the successive circles (Figure C). This gives a good approximation of the form of the reflector. Where three or more arcs intersect in a point, as at the point marked Ⓓ on the curve of Figure C, a diffraction or point reflection is suggested - possible fault evidence.

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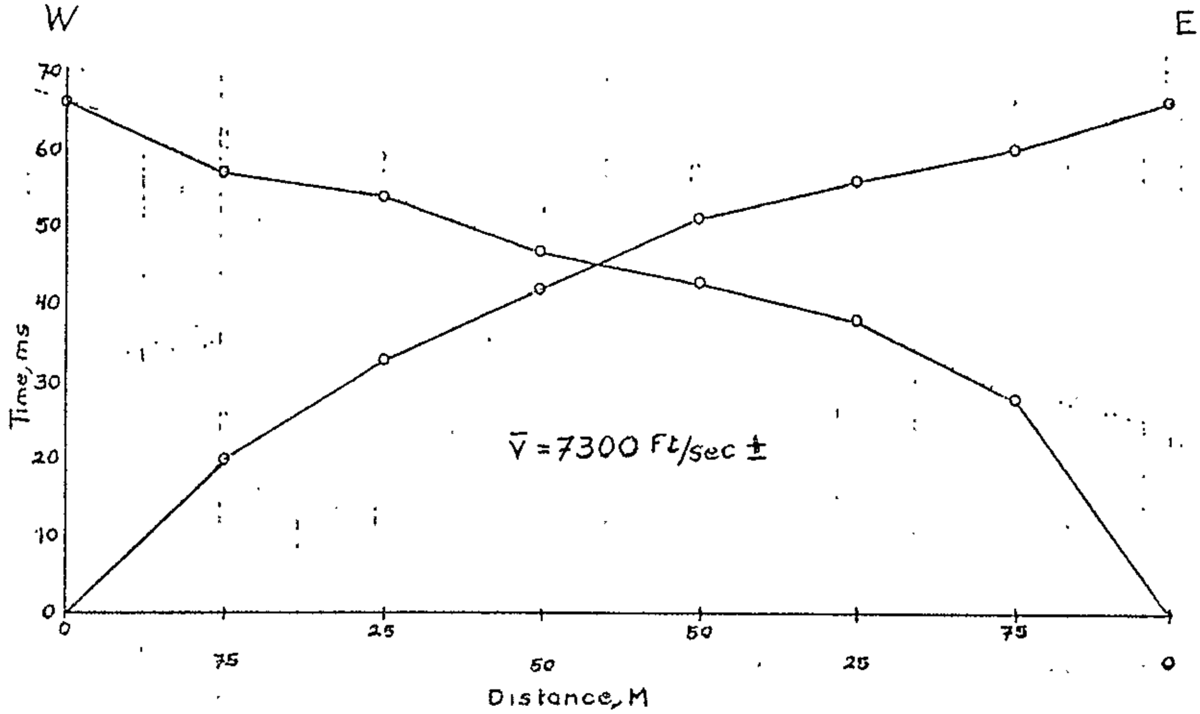
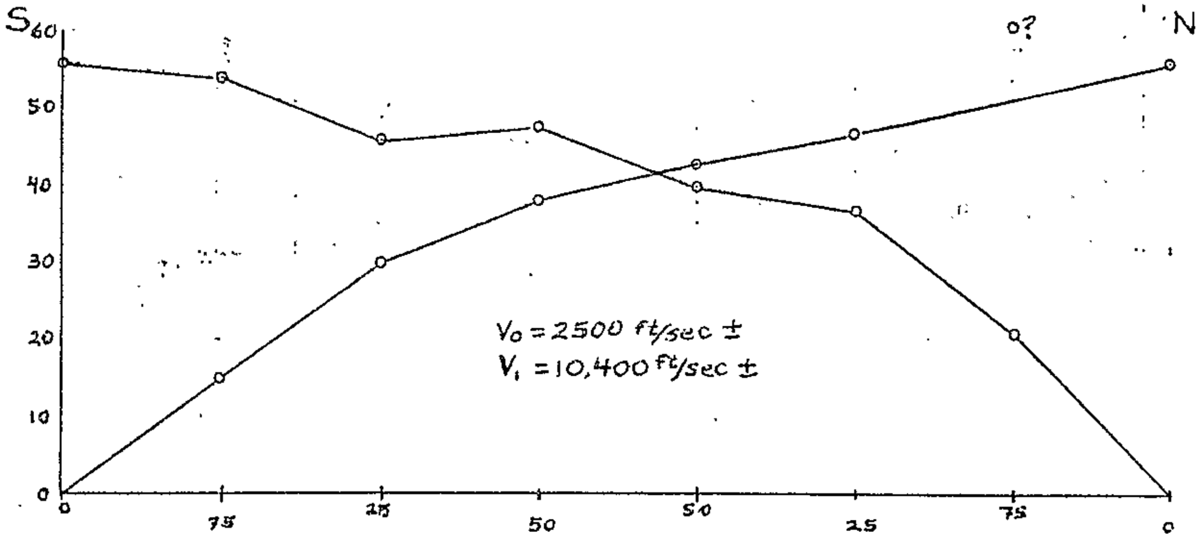
FIGURE NO. 1

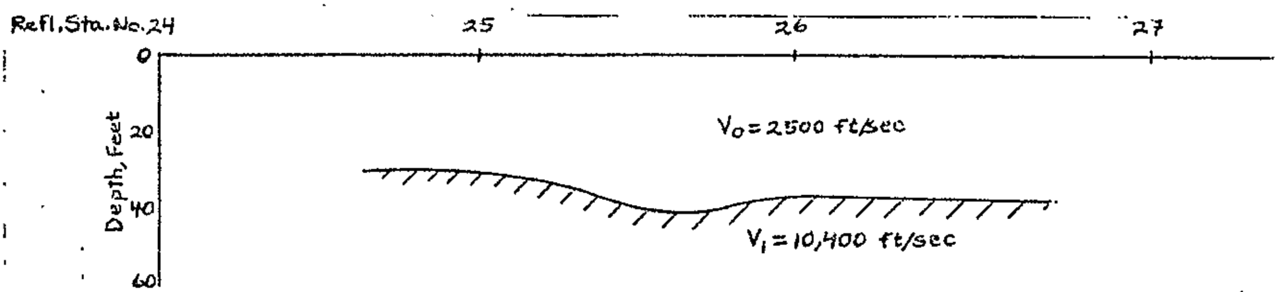
FIGURE NO. 1



Time-Distance Plot, Refraction Probe CN-1-44

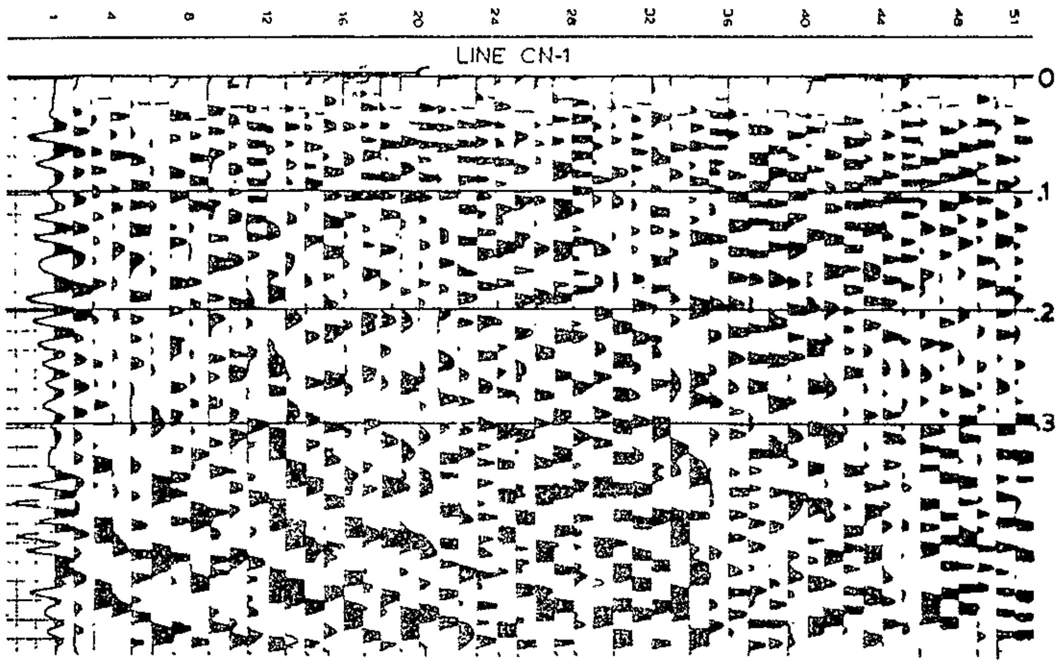


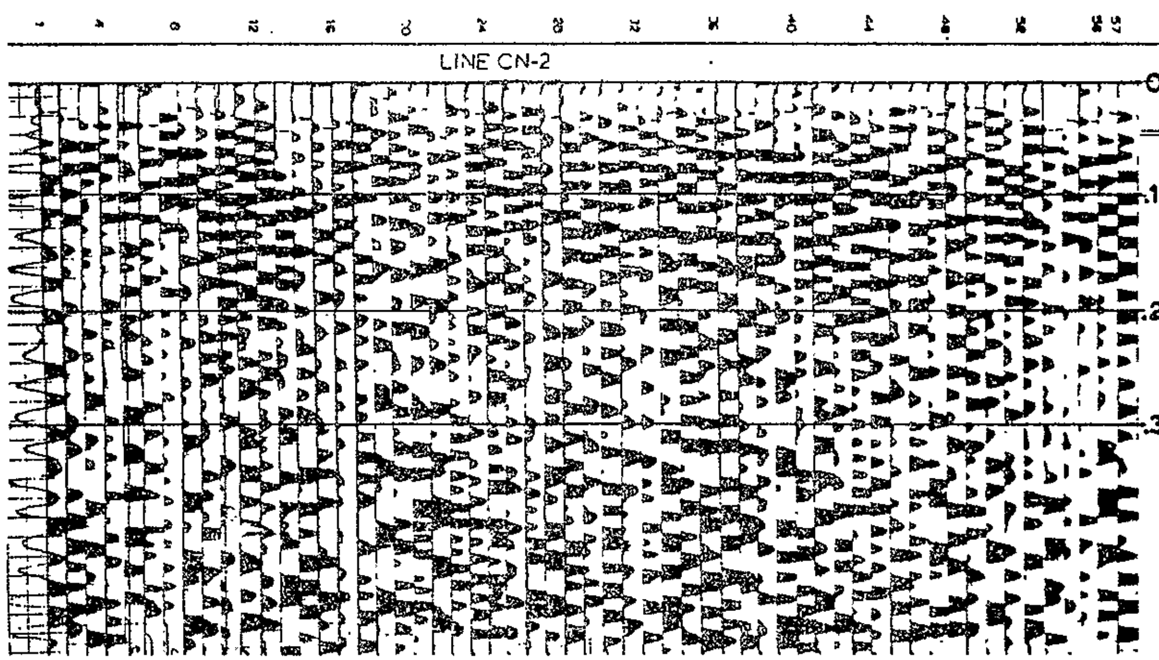
Time-Distance Plot, Refraction Probe CN-2-24



Refraction Depth Section (Wavefront Reconstruction), Refraction Probe CN-2-24

FIGURE NO. 2

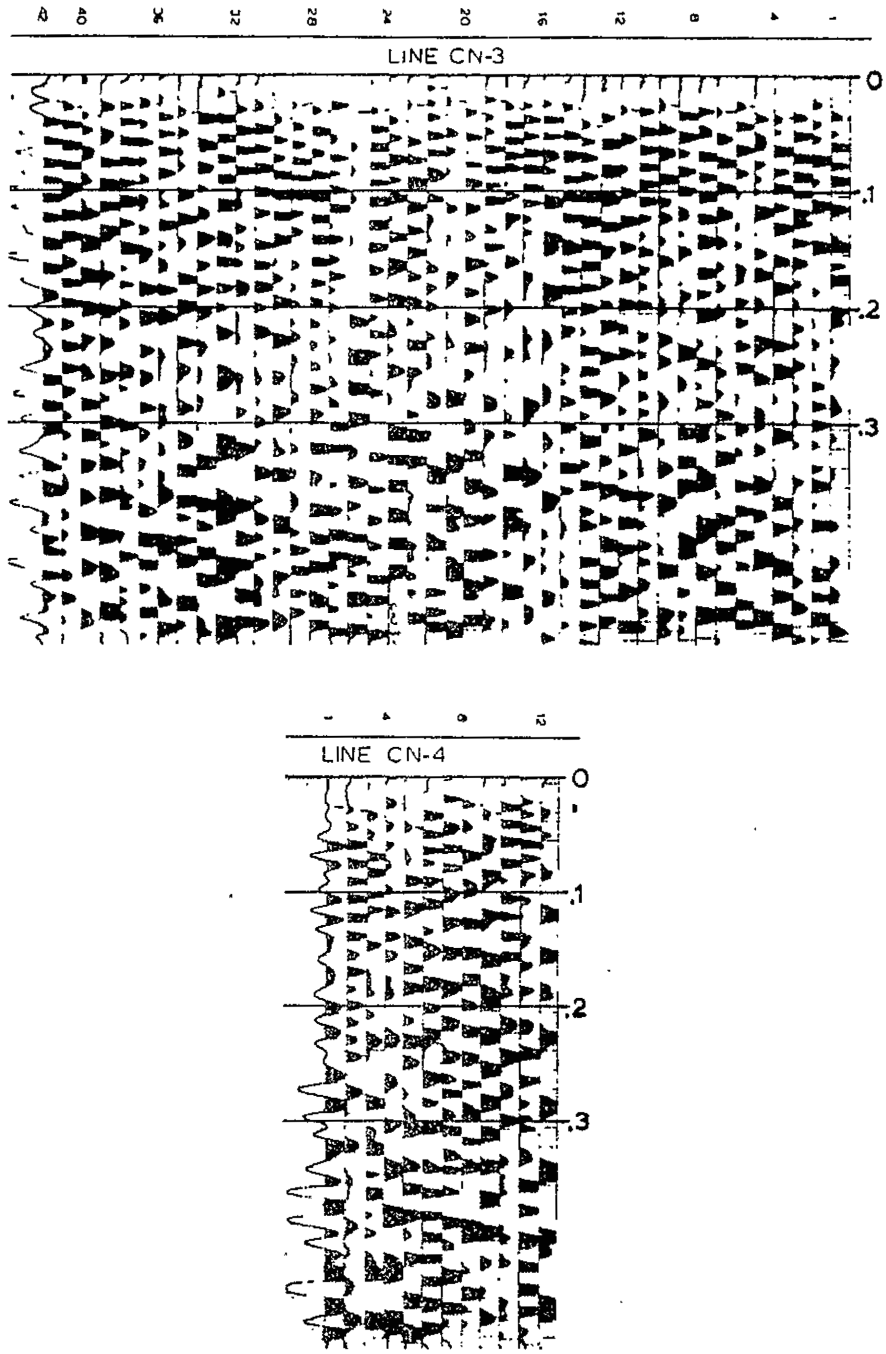




Variable Area Record Sections, Seismic Reflection Lines CN-1 and CN-2, Cimarron Site, Colfax County, New Mexico.

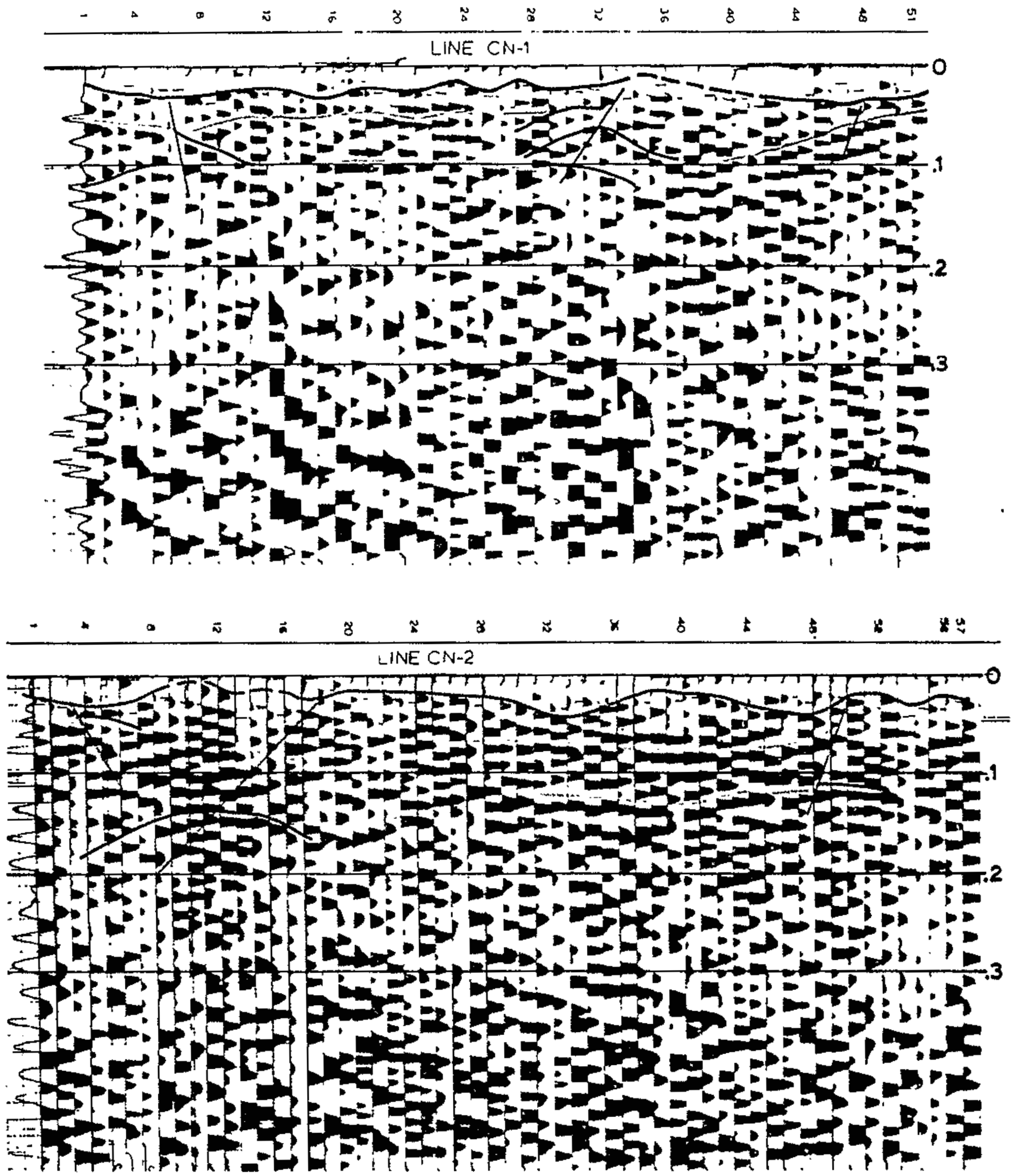
Seismic energy source 150 lb. weight dropped four feet. Receiver array six geophones spaced four meters apart inline. Source impact point four meters inline from first geophone. Average number of drops 1.5 per station. Single channel recording for 0.5 second using programmed gain and 20-60 Hz filters. Station spacing 25 meters.

Enclosure No. 2



Variable Area Record Sections, Seismic Reflection Lines CN-3 and CN-4, Cimarron Site, Colfax County, New Mexico.

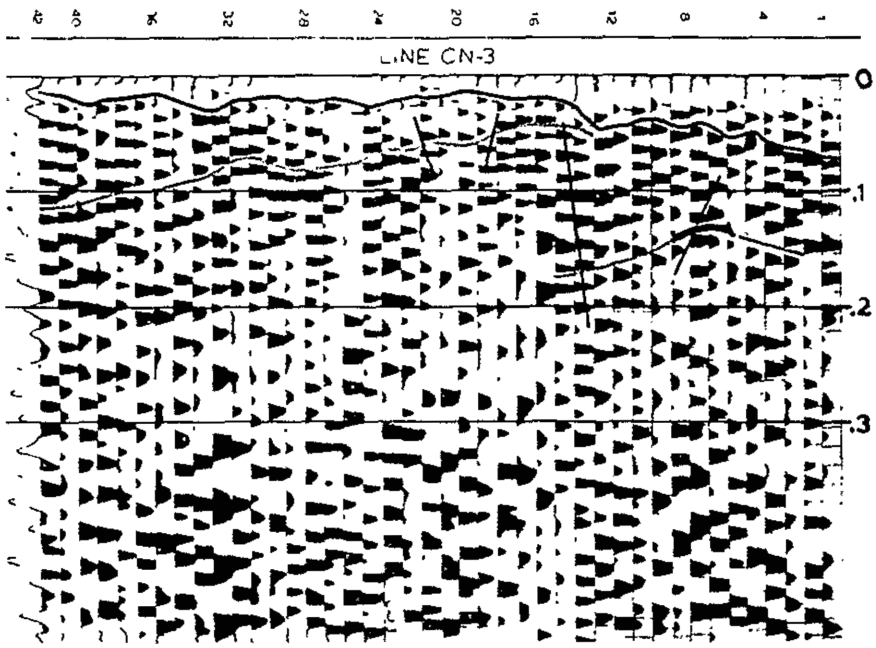
Seismic energy source 150 lb. weight dropped four feet. Receiver array six geophones spaced four meters apart inline. Source impact point four meters inline from first geophone. Average number of drops 1.5 per station. Single channel recording for 0.5 second using programmed gain and 20-60 Hz filters. Station spacing 25 meters.

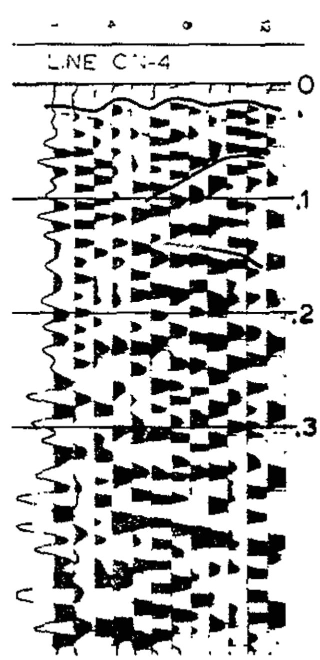


Variable Area Record Sections, Seismic Reflection Lines CN-1 and CN-2, Cimarron Site, Colfax County, New Mexico.

Seismic energy source 150 lb. weight dropped four feet. Receiver array six geophones spaced four meters apart inline. Source impact point four meters inline from first geophone. Average number of drops 1.5 per station. Single channel recording for 0.5 second using programmed gain and 20-60 Hz filters. Station spacing 25 meters.

Enclosure No. 4



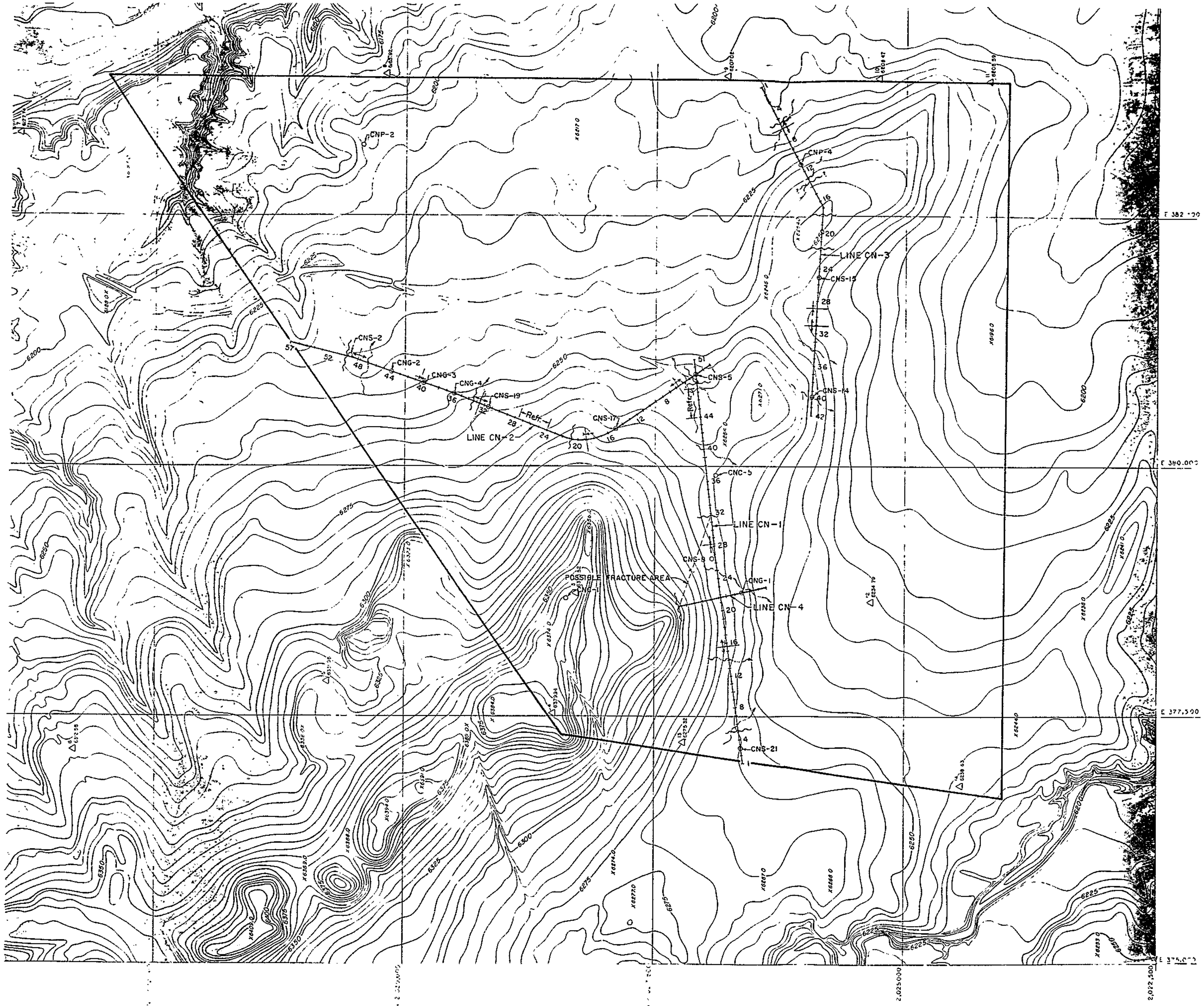


Variable Area Record Sections, Seismic Reflection Lines CN-3 and CN-4, Cimarron Site, Colfax County, New Mexico.

Seismic energy source 150 lb. weight dropped four feet. Receiver array six geophones spaced four meters apart inline. Source impact point four meters inline from first geophone. Average number of drops 1.5 per station. Single channel recording for 0.5 second using programmed gain and 20-60 Hz filters. Station spacing 25 meters.

Enclosure No. 5

Appendix III-5.--Denudation study.



N

LEGEND

Seismic Line Location-Numbered Stations Staked

Geologic Drill Hole

Location of Possible Fault or Fracture Zone Interpreted from Seismic Data; Possible Folds

Location of Buried Channel Interpreted from Seismic Data

GORDON HERKENHOFF AND ASSOCIATES
CHEM-NUCLEAR SYSTEMS, INC.

CIMARRON SITE
COLFAX COUNTY, NEW MEXICO

SHALLOW SEISMIC SURVEY

STATION LOCATION MAP

SHOWING PRINCIPAL GEOLOGIC FEATURES INDICATED BY SEISMIC DATA

Scale 1 Inch Equals 1000 Feet

DECEMBER 17, 1976 — CHARLES B. REYNOLDS & ASSOC.

GEOMORPHOLOGY OF THE CHEM-NUCLEAR SYSTEMS

PROPOSED WASTE DISPOSAL SITE

COLFAX COUNTY, NEW MEXICO

DESCRIPTION

Topography--The site is rolling grassland of gentle slopes (mostly less than 5%). It lies on the drainage divide between Vermejo and Van Bremmer Creeks, 3 miles southeast of a northeast-southeast trending escarpment capped by resistant sandstone. The site is underlain by Pierre shale, which dips gently to the northwest, perpendicular to the escarpment. The major streams drain to the southeast.

Elevations at the site range from 6100 feet along Vermejo Creek, to 6400 feet at the divide. The escarpment to the northwest rises to 7200 feet.

Soils--Maker et. al. (1972) have classified soils at the site as belonging to either the Colmor-Swastika-Kim association or the Vermejo-Litle-Midway association. Both soil associations have medium to fine texture and form on sedimentary rock or alluvium derived principally from sedimentary rock. They have low to medium permeability and low strength when wet.

Unusual topographic features--Several small undrained depressions ("pot-holes" or "buffalo wallows") occur on the site. The one visited (located on Plate 1) is some 200 feet across and 10 feet deep. It contains no standing water and the bottom is vegetated. I saw no evidence of human modification.

The undrained depressions probably formed by wind deflation at some time in the past. I saw no evidence that would link them to slumping or mud flow phenomena. It is possible, however, that they are sag ponds resulting from faulting. To the southwest of the disposal site a linear arrangement of small ponds may be seen on the Koehler and Cimarron 15-minute quadrangles, trending ENE, roughly parallel to the escarpment. A linear arrangement suggests a relationship to underlying structure, and may indicate the presence of an active fault.

PLEISTOCENE GRAVELS AND SOILS

Upper gravel--A series of hills capped by gravel occupies the central ridge of the site (Plate 1). The cobbles are of igneous and metamorphic rock, the nearest source of which is 40 miles upstream near the headwaters of Vermejo Creek. Maximum diameter of the cobbles is in excess of 1 foot. The gravel has been extremely weathered since deposition; many of the cobbles show a weathering rind up to 1 inch thick, and others have entirely lost their original stream-worn surface. The Pierre shale is weathered to a gray color beneath the gravel. An exposure of this weathered zone occurs along U. S. highway 64 (C-1 in Plate 1), and indicates that the depth of gray weathering may be on the order of 50 feet.

Judging from the state of weathering of the individual cobbles, the upper gravel is older than Wisconsinan, and may be mid to early Pleistocene in age. For the purposes of further discussion it may be assigned a minimum age of 200,000 years.

Intermediate gravels--Deposits of gravel cap several hills which are intermediate in elevation between the higher and lower gravels (Plate 1). These are probably deposits reworked from the older gravels during erosional lowering of the landscape.

Lower gravel--Along the valley margins of Vermejo and Van Bremmer Creeks lies a continuous bed of gravel about 50 feet above the modern valley floors (Plate 1). Individual cobbles show somewhat less weathering than do those of the upper gravel. Away from the valley margins the gravel is covered by slope wash; its subsurface extent will have to be determined by drilling. Several good exposures along the Santa Fe Railroad on the west side of Vermejo Creek (Plate 1) show black Pierre shale overlain by 5 feet of gray weathered shale, beneath 5 to 8 feet of gravel (Figure 1). The contact between the weathered zone and the unweathered black shale is sharp; the colqr change takes place within a very few inches. The age of the lower gravel is probably Wisconsinan, but could be older.

Modern Valley--The present valley of Vermejo Creek has been eroded into these deposits, truncating not only the lower gravel, but the 5-foot weathered zone beneath it. Truncation of the weathered zone suggests that it is an ancient soil, and that its formation was largely complete before downcutting of Vermejo Creek to its present level.

The valleys of Vermejo and Van Bremmer Creeks contain alluvial fill which is probably Holocene in age. Both creeks show evidence of arroyo cutting during the last century.

RATE OF LANDSCAPE DENUDATION

Assuming a minimum age of 200,000 years for the higher gravel, it follows that Vermejo Creek has eroded downward 300 feet in no less than 200,000 years. On the average, therefore, landscape denudation has proceeded locally at no more than 1½ feet per thousand years. Figure 2 illustrates the probable stages in this process.

MODERN EROSION

Arroyos--Van Bremmer lies at the bottom of a 15-foot arroyo throughout its length adjacent to the disposal site. The arroyo is cut into holocene alluvium, and is cut to bedrock only near the sides of the valley. Its width, depth, and the state of decay of the walls indicate that it is from 50 to 75 years in age. Although rapid downcutting has occurred along major drainages, downcutting has not progressed headward along smaller tributaries beyond the limits of the alluvial fill in the stream valleys. The upland area of the disposal site is therefore unaffected by arroyo cutting.

Hill-side gullies--Several short discontinuous hillside gullies occur in the upland area of the disposal site. All are on slopes greater than 5%, and all appear to be associated with cattle trails or the traces of abandoned roads. The deepest observed on the site is at B-1 (Plate 1) where the overlying colluvial soil has been stripped down to weathered-in-place bedrock at a depth of 12 feet (Figure 3). Gravel concentrates in the soil indicate that similar cycles of erosion have occurred in the past to depths of at least 5 feet.

The deepest gully noted follows the trace of an abandoned road to the southeast of the site, just east of the junction of Vermejo and Van Bremmer Creeks. This gully is cut 15 feet into the alluvium along the valley margin.

Creep and wash--Hillslope surface creep and slopewash undoubtedly play a part in moving material short distances downslope on the steeper parts of the site. However the low gradient that separates the upland areas from the stream valleys indicates that very little material is lost this way.

Slumping--On the escarpment to the northwest of the disposal site several large slump blocks indicate massive slides due to failure within the Pierre shale. Slumping occurs only in areas of much higher relief (800 feet) and on slopes much steeper (50% grade) than those found at the disposal site.

At the disposal site itself I saw no evidence of either past or present slumping. With the possible exception of the unexplained depressions, I saw neither topographic or stratigraphic evidence of large-scale mass movement of material. In all exposures, bedrock appears undisturbed, conforming to the regional dip.

Mudflow--I saw no topographic or stratigraphic evidence that low-gradient mudflows have occurred, either on the site or nearby.

Wind erosion--I saw no evidence of the removal of material by wind from the site in significant amounts, except from the access roads that are recent and temporary features. The existance of small undrained depressions suggest that wind erosion may have occurred in the past, although the absence of dunes argues against the transport of large quantities of material by wind.

LANDSCAPE STABILITY

All the evidence indicates that the upland at the proposed disposal site has eroded very little since the end of the Pleistocene (10,000 years before the present). The weathered zone in the shale, with thicknesses of 5 feet under the lower gravel and as much as 50 feet under the upper gravel, indicates substantial age.

The valleys of Vermejo and Van Bremmer Creeks are the most recent landscape features dating from late Pleistocene or Holocene time. Insets of alluvial fill probably range in age from 500 to 2000 years.

The characteristics of stability of the upland are to a combination of gentle slopes, sandy or gravelly topsoil of high porosity, and the existence of the grassland.

PROJECTIONS REGARDING FUTURE EROSION

Modern erosion on the upland is associated almost entirely with disturbances that have removed or damaged the grassland, particularly roads and cattle trails. In the absence of disturbance, erosion should be at a minimum.

The greatest erosional risk is the development of hillside gullies. The maximum depth of present gullies on the site is 12 feet. They are ephemeral features and appear to have developed in abandoned roads during the last century. If left alone, they will probably disappear by bank sloughing and aggradation within another century.

These projections are based on present conditions of soil, topography, and vegetation. The burial of waste will involve disturbance of the site and will alter some of these characteristics.

RECOMMENDATIONS FOR MINIMIZING THE CHANCE OF ESCAPE OF BURIED WASTE BY EROSION

1) Depth of burial should be in excess of 15 feet (12-foot gully depth, and 3-foot safety margin.)
2) The present topography of the site should be preserved or restored as nearly as possible. Hillsides downslope from the burial sites should be graded to less than 5%. The location of existing drainages and divides should be preserved, to minimize disruption of the graded profile of landscape drainage.
3) Sandy or gravelly topsoil should be saved and replaced to provide a permeable, low-strength surface cover to minimize the development of gullies and to encourage the regrowth of the grassland.
4) Following disposal, the areas should be revegetated and protected from possible damage by overgrazing or travel by vehicles which might weaken the vegetative cover.

Benjamin L. Everitt

November 19, 1976

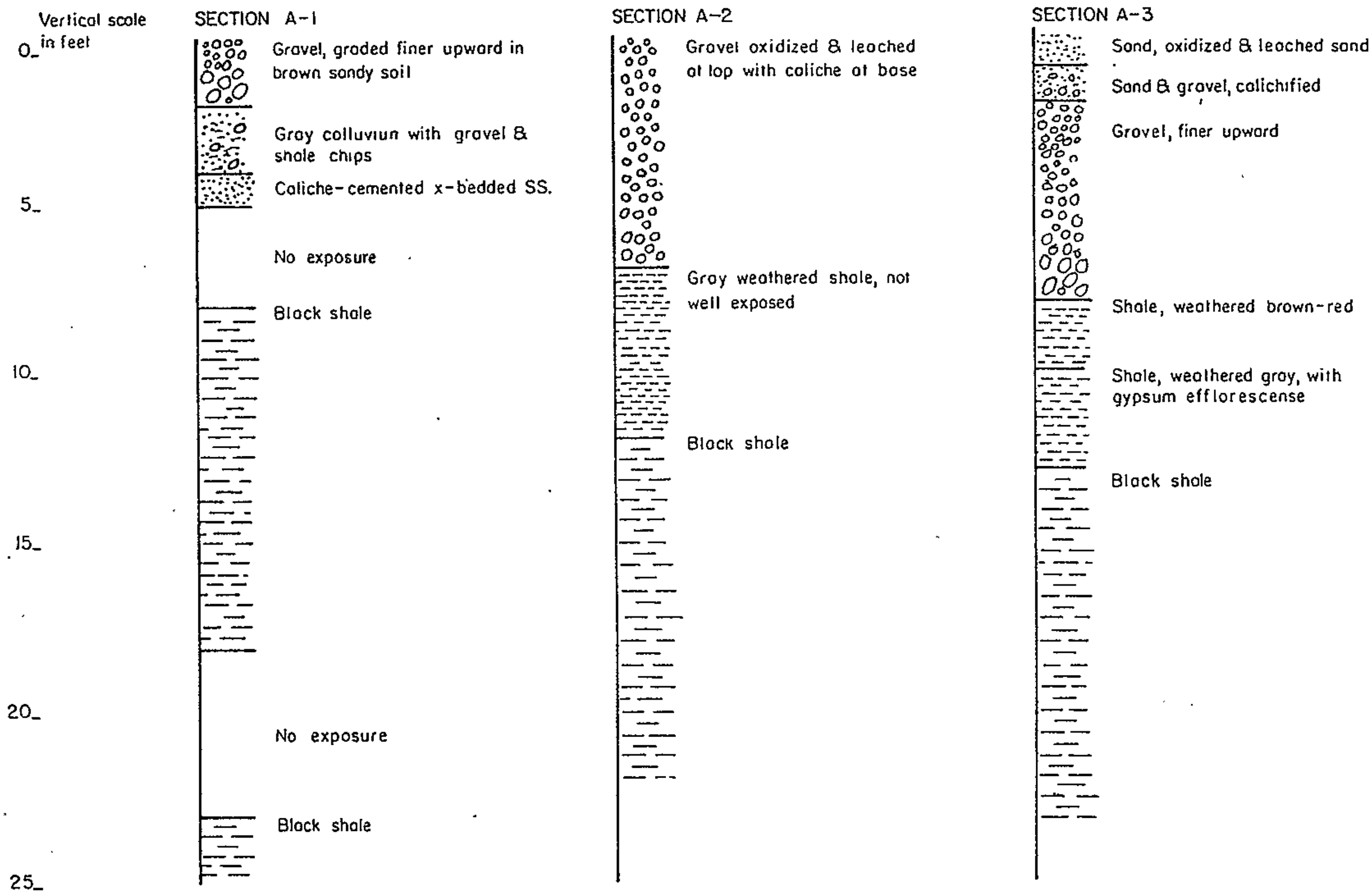


Figure 1 Exposure of Pleistocene gravel overlying Pierre Shale, west edge of Vermejo River Valley, in gully (A-1) and in Santa Fe Railroad cuts (A-2 & A-3)

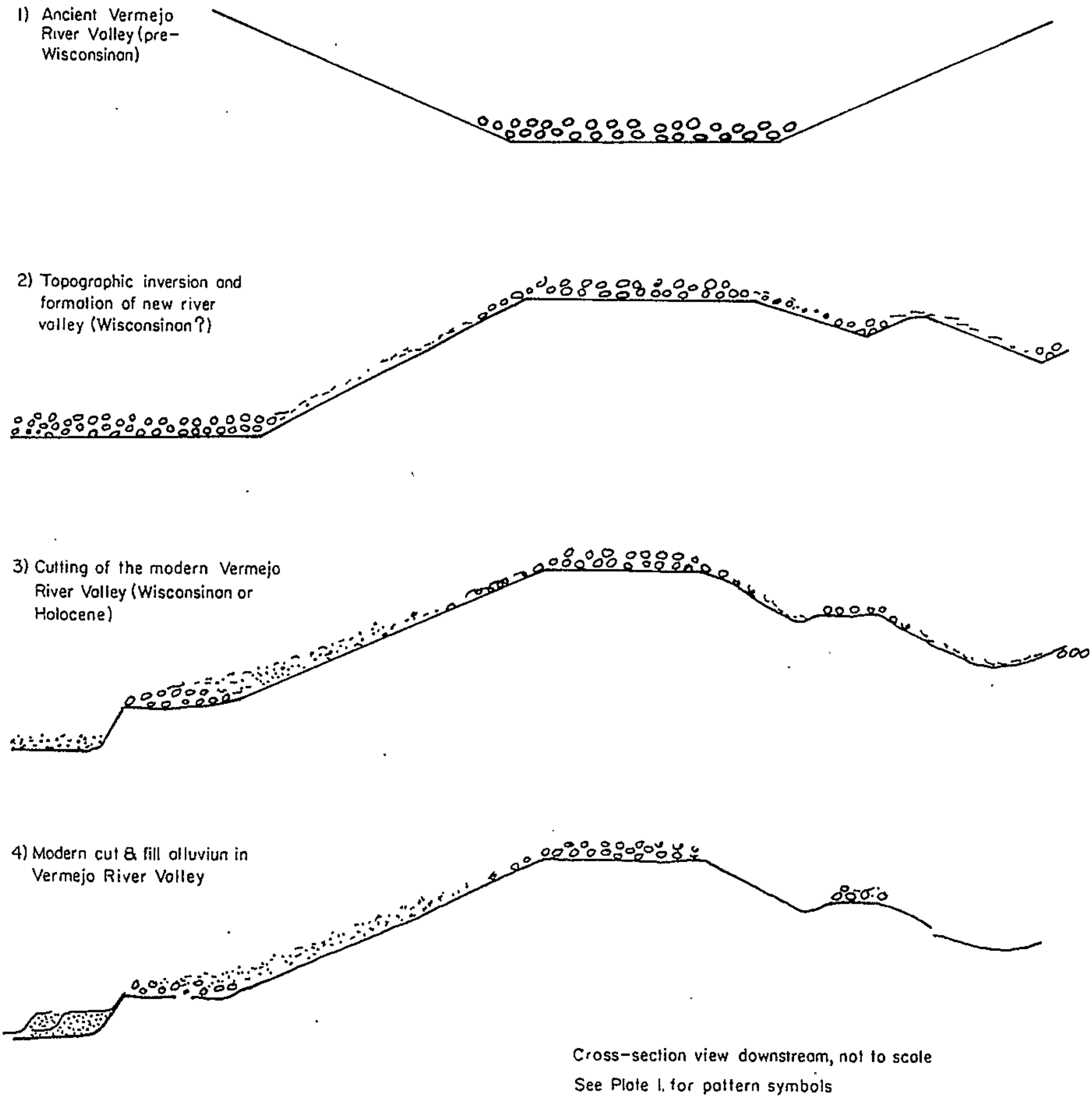


Figure 2 Hypothetical sequence of events in the evolution of the landscape of the disposal site.

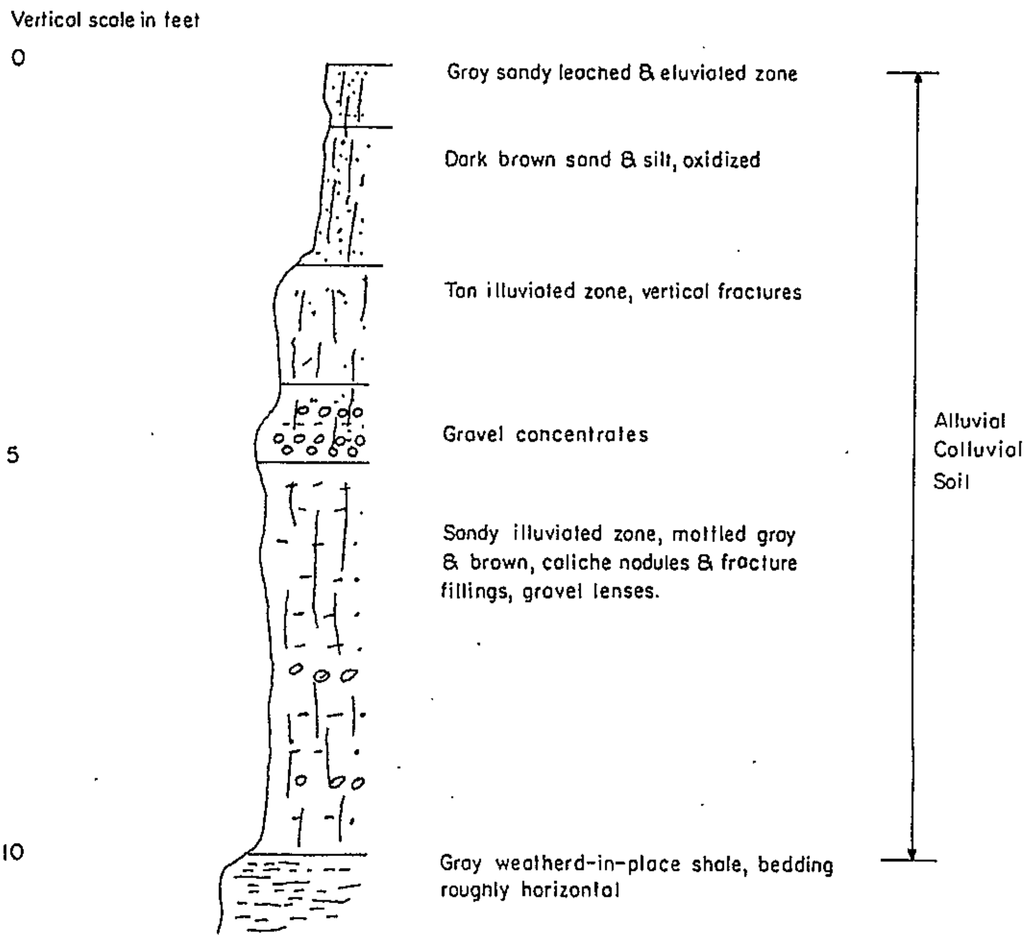


Figure 3 Profile of soil exposed in hillside gully at site B-1

REFERENCES

Maker, H. J., G. W. Anderson, and J. U. Anderson, 1972, Soil associations and land classification for irrigation, Colfax County: Agricultural Experiment Station Research Report 239, New Mexico State University, Las Cruces.

Appendix III-6.--Rb/Sr geochronologic investigation.

Rb-Sr Geochronologic and Uranium Abundance Study of Peirre Shale

Submitted to:

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c/o W.K. Summers and Associates
Box 684
Socorro, New Mexico 87801

By:

Douglas G, Brookins
12536 Elaine Pl., NE
Albuquerque, NM 87112

Introduction and Authorization

At the request of Mr. W.K. Summers, nine samples of Pierre Shale have been analyzed for their Rb-Sr systematics; these and eight additional samples have been analyzed for their uranium content. Samples were provided by Mr. C.W. Walker after discussions with W.K. Summers and D.G. Brookins.

X-ray data (Report by P.D. Robinson and W.C. Hood to C.W. Walker) were made available; these were from separate parts of the core provided. Mr. W.K. Summers provided Ion Exchange and CNP-2 and CNC-1 Log Experiment Data to D.G. Brookins as well.

Analytical Techniques

After preliminary analysis of samples for their Rb and Sr contents ten samples were selected for Rb, Sr and Sr isotopic study. Approximately one gram of each sample was dissolved in a 25 ml:3 ml mix of reagent HF and vycor distilled $HClO_4$ with a second volume of 25 ml HF added to each to ensure complete dissolution. ^{87}Rb-enriched and ^{84}Sr-enriched spikes were added prior to dissolution. When near dryness was obtained the samples were digested in 100 ml of a 50:50 mixture of vycor distilled 2N HCl and deionized H_2O and evaporated to near dryness (about 5 ml). The samples were then cooled for eight to ten hours, filtered, and Rb and Sr separated by ion exchange chromatography. The Rb-and Sr rich fractions were then concentrated, transferred to vycor beakers, and fused to drive off resin or other organic matter which may have passed through the exchange columns. Total Rb and Sr and the isotopic composition of Sr were determined by use of a Nuclide 1290 (Nier Design) mass spectrometer with thermionic emission, Faraday cup collection, DC amplification, strip chart recording. These are standard laboratory procedures and contamination from various reagents negligible when samples contain more than 2 ppm either Rb or Sr (based on a one gram sample).

Uranium analyses were carried out by the delayed neutron activation analysis method; this method has been demonstrated to be the most reliable (except for isotope dilution) in the 0.5 to 20 ppm range relative to other methods (See Stuckless et al., 1977, U.S.G.S. Jour. Res., v. 5, n. 1, p. 83-92.).

Table 1

Rb - Sr Data

Sample (footage)	Rb (ppm)	Sr (ppm)	$^{87}Sr/^{86}Sr$	$^{87}Rb/^{86}Sr$
I. Unweathered samples				
CNC-4 (34)	126.1	277.4	0.7141	1.32
CNC-5 (45)	159.6	192.0	0.7190	2.41
CNC-6 (65.8)	118.6	325.3	0.7438*	1.06
CNC-6 (82)	113.7	370.1	0.7145	0.89
CNC-8 (51.8)	100.9	144.5	0.7218	2.02
CNG-2 (58.5)	125.8	164.5	0.7185	2.22
LL. Weathered samples				
CNC-5 (19.9-20.5)	129.8, 133.1	237.3	0.7170	1.60
CNC-6 (14-14.5)	83.5	114.8	0.7215	2.11
CNC-8 (25-25.5)	195.0	212.5	0.7184	2.66

----

*The very high $^{87}Sr/^{86}Sr$ ratio for CNC-6 (65.8) may possibly be explained in view of its complex mineralogy (Re: Report to C.W. Walker by Robinson and Hood; data for core from 65.3 feet); i.e. the sample contains both authigenic and allogenic calcite and possibly K-feldspar. The effect of the calcite would be to lower the Rb/Sr ratio and the effect of the K-feldspar would be to increase the $^{87}Sr/^{86}Sr$ ratio. The sample is clearly anomalous relative to the others.

Table 2

Uranium Data

Sample (footage)	U (ppm)
A. Unweathered samples	
CNC-1(70)	4.41
CNC-1(153)	3.83
CNC-1(253)	4.14
CNC-2(33.4)	4.35
CNC-4(34)	4.70
CNC-5(46-46.5)	6.03
CNC-6(65.8)	3.91
CNC-6(82)	4.28
CNC-8(51.2)	7.13
CNG-2(58.5)	4.25
CNG-1(38.2-38.3)	7.23

Sample (footage)	U (ppm)
B. Weathered samples	
CNC-4(23.8)	4.12
CNC-6(14-14.5a)*	3.44
CNC-6(14-14.5b)*	4.44
CNC-6(14-14.5c)*	4.90
CNC-5(19.9-20.5)	6.42
CNC-8(25-25.5)	7.92

*a,b,c for CNC-6(14-14.5) refer to three separate shale samples; not splits of one sample.

Note: Reproducibility of uranium data is ± 2 percent (1σ) of the reported value.

The Rb-Sr Isochron Diagram

Two reference isochrons are shown in Figure One; for t = 150 million years (m.y.) and for t = 250 m.y. The initial $^{87}Sr/^{86}Sr$ ratio is 0.7130 based on a least squares regression of all data except that for sample CNC-6 (65.8) which is clearly anomalous. Further, sample CNC-8 (51.8), unweathered, may contain allogenic calcite (note: Robinson and Hood report allogenic calcite for CNC-8 (41)) and sample CNC-6 (14), weathered, contains both allogenic K-feldspar and some calcite. These two samples weight the 250 m.y. isochron; if they are omitted then the remaining six data define the 150 m.y. isochron.

For purposes of age calculation the following equation was used:

$$t = \frac{(^{87}Sr/^{86}Sr)_m - (^{87}Sr/^{86}Sr)_i}{(^{87}Rb/^{86}Sr)_c\ (\lambda)}$$

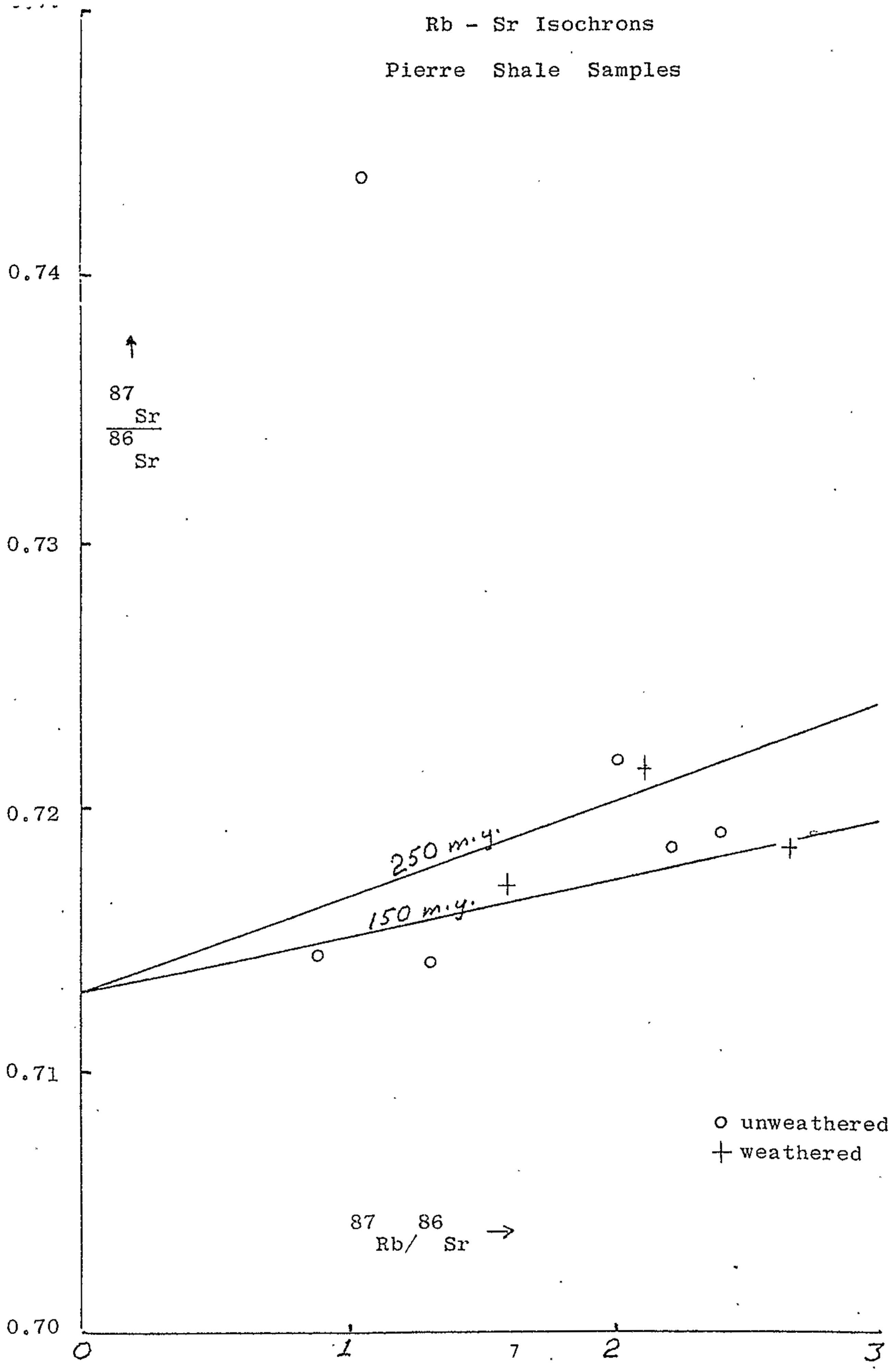
where m = measured

i = initial

c = calculated (from the Rb/Sr weight ratio)

λ = the decay constant for $^{87}Rb = 1.42 \times 10^{-11}/y$

The reproducibility of an individual $^{87}Sr/^{86}Sr$ measurement is $\pm$ 0.0001 (2σ) for all reported values; the reproducibility of an individual $^{87}Rb/^{86}Sr$ ratio is $\pm$ 0.8 percent of the reported value (1σ). The Eimer and Amend Standard $SrCO_3$ was analyzed once as these samples were analyzed with a measured value of $^{87}Sr/^{86}Sr$ = 0.7082 being obtained which is within the limits of our error limits of 0.7081 $\pm$ 0.0001 for this standard. All Rb(ppm) and Sr(ppm) values were determined by isotope dilution using ^{87}Rb-enriched and ^{84}Sr-enriched spikes.


Rb - Sr Isochrons
Pierre Shale Samples
0.74
0.73
0.72
0.71
0.70
87 Sr / 86 Sr
250 m.y.
150 m.y.
o unweathered
+ weathered
87 Rb / 86 Sr
0
1
2
3

Interpretation of the Data

The Rb-Sr data for the eight samples of Pierre Shale used for the construction of isochrons in Figure One (Note: Sample CNC-6 (65.8) has been omitted for reasons explained elsewhere) yield internally consistent pre-sedimentation dates. The Pierre Shale cannot be older than about 70 to 80 m.y.; hence the 150 m.y. (best fit) isochron probably reflects systematic mixing of authigenic minerals with earlier Mesozoic (or possibly Triassic) allogenic minerals. Sample CNC-6 (68.5) may contain Precambrian detrital material but this remains to be domonstrated. Comments below refer to all samples except CNC-6 (68.5).

What is clear from the data is the lack of disturbance of the Pierre Shale since deposition; even the three weathered samples yield Rb, Sr and $^{87}Sr/^{86}Sr$ values in the range of the unweathered samples. Comments over possible migration of the highly radioactive isotopes ^{90}Sr and ^{137}Cs can be obtained from the data presented. I have measured Sr (for ^{90}Sr discussion) and Rb (as analog for Cs) and find that both have not migrated to any significant degree in the Pierre Shale samples analyzed, even for weathered samples. Had ages for either the weathered or the unweathered (or both) samples been obtained then it could be argued that either radiogenic ^{87}Sr loss or Rb gain (or both) had occurred; as this is not the case then I urge consideration of the data as supporting the suitability of the Peirre Shale from the site of the CNC and CNG samples for retention of alkali and alkaline earth elements (i.e. especially ^{90}Sr and ^{137}Cs). Further, the x-ray report by Robinson and Hood indicates a mix of authigenic illite, kaolinite, mixed layer illite-montmorillonite and chlorite as representative of the clay mineral assemblage. This mixture is well suited for absorption of any Sr and/or Cs which might otherwise tend to migrate (e.g. See Kharaka and Berry, 1973, Geochim. Cosmochim. Acta, v. 37, p. 2577-2604.). As a point of interest or clarification, Robinson and Hood (op. cit. p. 4) mention the possibility of poorly crystallized chlorite in the samples of Pierre Shale analyzed versus vermiculite. This is exactly what one would predict when authigenic illite and/or mixed layer illite-montmorillonite occur in the presence of organic matter as the reactions:

illite + organic acids + rock detritus = chlorite ($\pm$ pyrite)

and montmorillonite + organic acids + rock detritus = chlorite ($\pm$ pyrite) both yield large (-100 kcal.) free energies of reaction (See Brookins, 1976, GJO-1636-1, 136 p.; also Leone et al., 1975, Jour. Sed Pet., V. 45, p. 618-628; Sieve and Kastner, 1972, Jour. Sed. Pet., v. 42, p. 235-355.). The result of the chlorite formation as proposed above is twofold: (1) The poorly crystallized chlorite absorbs Cs and Sr preferentially relative to K and Mg, Ca respectively; (2) Vermiculite formation is inhibited (i.e. vermiculites are readily stripped of many ions in an unpredictable fashion whereas chlorites are not).

As all samples studied apparently contain authigenic kaolinite, this indicates that the Peirre Shale is essentially buffered with respect to alkali and alkaline earth migration as the three phase assemblage illite-montmorillonite-kaolinite is very restrictive in terms of activities of K, Mg, dissolved silica (as H_4SiO_4) and pH and the four phase assemblage illite-montmorillonite-kaolinite-chlorite even more restrictive in terms of these components (See Brookins, 1976, N.M. Geol. Soc. Spec. Pub. No. 6, p. 158-166; Fig. 3).

The clay mineral data together with the Rb-Sr data argue for retention (i.e. even if by very local fixation in Pierre Shale) of Sr and/or Cs. Further, calcite present not only further buffers the system but helps retain Sr as well.

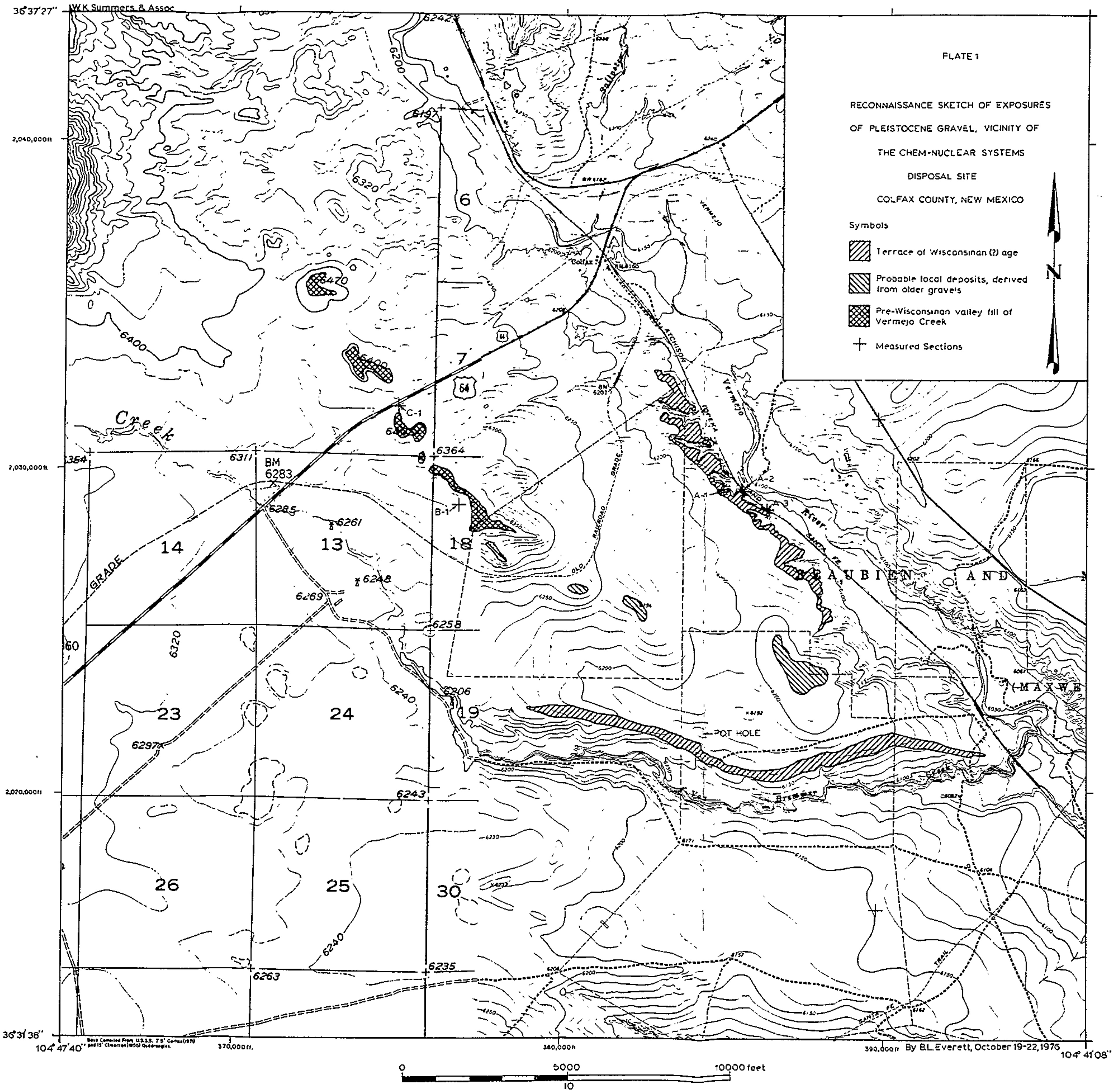
Further, uranium analyses of all sixteen samples provided to me by C.W. Walker range from 3.8 to 7.9 ppm with no significant difference between weathered and unweathered samples (Table 2). The arithmetic mean of 5.0 ppm is in good agreement with uranium values for other Middle and Upper Cretaceous sedimentary rocks from the San Juan Basin from unmineralized areas. The uranium data support the Rb-Sr data in suggesting no widespread movement of mobile elements (i.e. as it takes less energy to oxidize U(IV), insoluble, to U(VI), soluble, than it does Fe(II) to Fe(III) then when hematitic staining is noted U has usually been mobile to some extent. As no anomalously high or low U values are obtained then the samples of Pierre Shale analyzed appear to reflect a very inert environment with respect to possible U migration).

Suggestions for further work

More whole rock samples of the Peirre Shale (i.e. on hand, See Tables 1 and 2) can be analyzed to increase the data for Figure One; I shall await your advice on this and other matters.

If it is deemed desirable, the minus two micron fraction for the Pierre Shales can be separated and a more precise Rb-Sr age determined; uranium can be determined for both the plus- and minus-two micron fractions. Further, more detailed x-ray study of the minus-two micron fraction (i.e. identification of illite polytypes, etc.) can be carried out(Note: I am familiar with the work of both Robinson the Hood and have confidence in their abilities as clay mineralogists and x-ray analysts.).

One study which may be desirable would be to examine Rb and/or Sr (including $^{87}Sr/^{86}Sr$ measurements) for soils in the vicinity of the CNC drill sites. Now that a reference base for the Pierre Shale has been determined deviation of Rb-Sr systematics from this base can be examined, the data synthesized, and an interpretation (backed by x-ray study) realized. This may be of benefit to all concerned with the porject.


W.K. Summers & Assoc.
PLATE 1
RECONNAISSANCE SKETCH OF EXPOSURES
OF PLEISTOCENE GRAVEL, VICINITY OF
THE CHEM-NUCLEAR SYSTEMS
DISPOSAL SITE
COLFAX COUNTY, NEW MEXICO
Symbols
Terrace of Wisconsinan (?) age
Probable local deposits, derived from older gravels
Pre-Wisconsinan valley fill of Vermejo Creek
Measured Sections
N
36°37'27"
36°31'38"
104° 47'40"
104° 41'08"
2,040,000ft
2,030,000ft
2,070,000ft
370,000ft.
380,000ft
390,000ft
Creek
Vermejo
Colfax
BEAUBIEN AND
(MAXWE
POT HOLE
GRADE
OLD RAILROAD GRADE
ATCHISON TOPEKA AND SANTA FE
River
64
BM 6283
C-1
B-1
A-1
A-2
6
7
13
14
18
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23
24
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26
30
6364
6311
6285
6261
6248
6269
6258
6306
6297
6243
6263
6235
6320
6400
6470
6240
6200
Base Compiled From U.S.G.S. 7.5' Colfax (1970) and 15' Cimarron (1956) Quadrangles.
By B.L. Everett, October 19-22, 1976
0
5000
10000 feet
10

Appendix III - 7 Radiological Background

RADIOLOGICAL BACKGROUND
PROPOSED CHEM-NUCLEAR WASTE DISPOSAL SITE
Cimarron, New Mexico
First Quarter, 1977

Introduction

The Radiological Environmental Surviellance Program for the Proposed waste disposal site is described in Volume I of the Chem-Nuclear application for a license. The program was implemented by Eberline during the first calendar quarter of 1977. The first quarter results of field measurements of direct radiation levels and laboratory measurements of radioactivity in environmental media, summarized in this report, provide an indication of radiological background characteristics at the proposed site.

Direct Radiation Survey

Direct radiation levels were measured on January 18-19, 1977, with an Eberline MS-2 scaler and a SPA-3 scintillation detector. A portable battery pack provided power. This instrument was calibrated so that 1,100,000 cpm corresponded to 1 mR/hr referenced to Cs-137. To permit direct comparison of pre-operational background readings with those obtained after waste is buried at the site, twenty-one locations were selected as indicated in Figure 1. These locations were selected to encircle the proposed inner burial area and the outer exclusion or buffer zone. Sample locations one through ten delineate the burial area. Sample locations eleven through twenty-one defind the exclusion zone. These locations were selected in January 1977 before plans for the site had been finalized and some shifting of the locations will be necessary. Results of this survey are provided in Table 1. A relatively constant background of 0.014 ± 0.001 mR/hr was observed everywhere except location number 15 where 0.018 mR/hr was measured. This difference is not considered significant and no apparent reason for this anomaly is evident.

A more rugged but less sensitive Eberline E-400 radiation survey meter was continually turned on while personnel drove over the site to monitor for unusually high background dose rates. No irregularities were detected.

Lithium floride thermoluminescent dosimeters (TLD) were used to measure integrated radiation dose. An environmental TLD packet was taped to a fence post at each location. The last two digits of the identification number on the badge represent the sample location number. These badges integrate direct gamma radiation exposure and will be exchanged and read out quarterly. Two off-site sample locations were selected to monitor the ambient background radiation levels. Only TLD's were set out at these stations; soil samples and background survey readings were not obtained. TLD number 22 is mounted at the locked gate to the Vermejo Ranch near U. S. Highway 64, approximately 1.1 miles west of the site. TLD number 23 is located at the office trailer. The TLD results for the first calendar quarter of 1977 are summarized in Table 1.

Soil Samples

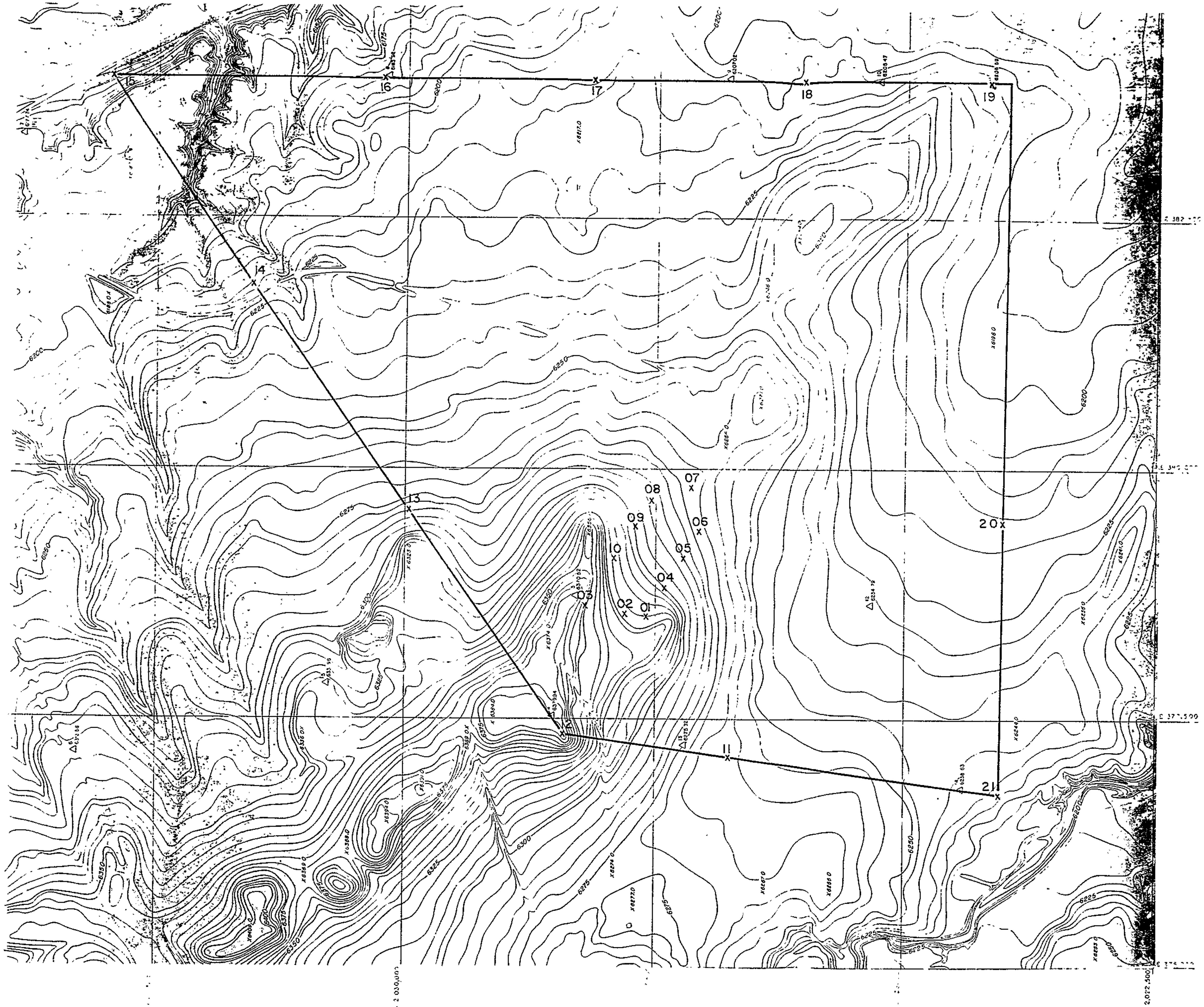
Soil samples were collected from each of the 21 locations shown in Figure 1. An auger was used to sample a 50 cm^2 area to a depth of 22 cm. Each sample will be analyzed by high resolution gamma spectrometry and for Sr-90. The analytical results are summarized below. The Eberline "Report of Analysis" data sheets are attached.

Natural radioactivity is predominant and is uniformly distributed in the soil. Naturally occurring ^{40}K is the most abundant radionuclide in both soil and vegetation, the concentration being about an order of magnitude higher than for any other radionuclide. The ^{40}K concentration in soil is extremely uniform, the average for 21 samples being 15.6 pCi/g with a standard deviation of only 1.6 pCi/g. The concentration of ^{137}Cs, which is chemically and radiologically similar to ^{40}K, averaged only 2% of the ^{40}K concentration in the top 22 cm of soil.

Decay products of natural uranium and natural thorium also were measurable in all samples. The ^{214}Pb and ^{214}Bi decay products in the uranium decay series indicate that at least ^{226}Ra is present at about 1 pCi/g concentration. The average concentrations of ^{214}Pb and ^{214}Bi were 1.0 ± 0.2 and 0.9 ± 0.2 pCi/g, respectively. We can assume that all decay products in the uranium series (including ^{226}Ra, ^{230}Th, ^{234}U, ^{238}U, ^{210}Pb and ^{210}Po) are present, each at about this 1 pCi/g concentration.

The ^{228}Ac and ^{212}Pb decay products of thorium also were measured in soil, with average concentrations of 1.0 ± 0.3 and 0.9 ± 0.2 pCi/g, respectively. The ^{228}Ac occurs early in the natural thorium series and ^{212}Pb occurs near the end of the series. Therefore, we can assume that each radionuclide in the natural thorium decay chain is present at a concentration of 1 pCi/g. This includes ^{232}Th, ^{228}Ra and ^{228}Th.

Strontium 90 also was measured in all soil samples, with an average concentration similar to ^{137}Cs, (0.42 ± 0.26 and 0.33 ± 0.19 for ^{90}Sr and ^{137}Cs, respectively).



LEGEND

02
x = Sample Location and Number

SCALE : 1" = 1000'

0 500 1000 2000

MONITORING LOCATIONS
FIGURE 1

Long half-life radionuclides in the top 22cm of soil can be summarized as follows:

RADIONUCLIDE	CONCENTRATION, pCi/g
^{40}K	15.6 ± 1.6
^{232}Th	1.0 ± 0.3
^{228}Th	1.0 ± 0.3
^{228}Ra	1.0 ± 0.3
^{226}Ra	1.0 ± 0.2
^{230}Th	about 1
^{234}U	about 1
^{238}U	about 1
^{210}Pb	about 1
^{210}Po	about 1
^{90}Sr	0.42 ± 0.26
^{137}Cs	0.33 ± 0.19
Total naturally occurring	about 25.
Total man-made (fallout)	about 0.8

Water Samples

Water from five test wells (CNS-3, CNP-4, CNS-4, CNS-5 and CNS-11) were submitted to Eberline in November 1976 by W. K. Summers for radiochemical analysis, as part of the hydrological testing program. Three additional samples were submitted later from two test wells (CNS-5 and CNW-2) and from Van Bremmer Creek. Additional samples were collected on March 31, and April 1, 1977 from Van Bremmer Creek, Vermejo River and five of the test wells. Results are summarized below. The Eberline "Report of Analysis" data sheets are attached.

Tritium concentrations were below routine detectable levels (1 pCi/ml) for liquid scintillation counting. The special well samples from W. K. Summers and one surface water sample from Van Bremmer Creek were subsequently analyzed in the Eberline Midwestern Facility by tritium enrichment techniques.

The concentrations of ^{90}Sr were below the minimum detectable activity (MDA) value of 1 pCi/1.

Natural ^{226}Ra was measured in all but one of the samples, with concentrations ranging from 0.03 ± 0.02 to 0.38 ± 0.04 pCi/1.

Traces of naturally occurring gamma emitters (^{40}K and decay products of U and Th) were detected in some of the water samples, but these slightly positive results are attributed to insoluble material that settles out in the container prior to and during gamma isotopic analysis. Gross alpha and gross beta results indicate that most of the natural radioactivity is associated with the insoluble fraction. In the future, all analysis will be performed on the soluble fraction. Additional gamma isotopic analysis of water samples will be performed only when gross beta results exceed 30 pCi/l.

Vegetation Samples

A two gallon sample of dead, dry grass was gathered near the center of the site on January 19, 1977. This sample was analyzed by high resolution gamma spectrometry and for ^{90}Sr. The predominant gamma emitting radionuclide in this sample was naturally occurring ^{40}K at 3.8 ± 2.3 pCi/g (dry). A trace of ^{95}Zr (0.39 ± 0.24 pCi/g) was also detected. The concentration of ^{90}Sr was 0.19 ± 0.08 pCi/g (dry).

Airborne Particulate

AC 110 volt power is not yet available at the site; therefore, an air sampler was operated at the Chem-Nuclear Office trailer in Cimarron. Gross alpha was not detected (0.00 ± 0.01 pCi/m^3). Gross beta was detected in each filter sample with results in the 0.1 to 0.3 pCi/m^3 range. Gamma isotopic analysis of quarterly composite filters gave the following results:

NUCLIDE	pCi/m^3
Ru-103	0.022 ± 0.006
Be-7	0.154 ± 0.062
Ce-144	0.054 ± 0.028
Nb-95	0.041 ± 0.008
Zr-95	0.028 ± 0.008

A few on-site samples were obtained with a battery operated air sampler. The results were not significantly different from those obtained at the office trailer in Cimarron.

Eric L. Geiger

ERIC L. GEIGER
Certified Health Physicist
Eberline Instrument Corporation

TABLE I

Sample Location Number	Initial Radiation Survey Results		Environmental TLD Results January 18 to April 1, 1977	
	Counts Per Minute *	mR/hr	mrad total	mrad/week
1	15,417	0.014	35.2 ± 2.6	3.2
2	16,126	0.015	37.0 ± 3.2	3.4
3	14,692	0.013	38.4 ± 4.1	3.5
4	15,087	0.014	35.6 ± 3.0	3.2
5	15,016	0.014	34.8 ± 3.6	3.2
6	15,516	0.014	36.2 ± 1.7	3.3
7	14,976	0.014	34.6 ± 2.3	3.2
8	15,175	0.014	35.0 ± 3.2	3.2
9	14,969	0.014	41.0 ± 2.4	3.7
10	16,112	0.015	35.6 ± 1.1	3.2
11	15,880	0.014	44.2 ± 3.0	4.0
12	15,481	0.014	42.0 ± 2.0	3.8
13	16,389	0.015	39.6 ± 5.9	3.6
14	16,476	0.015	42.0 ± 1.4	3.8
15	19,770	0.018	45.2 ± 3.8	4.1
16	15,749	0.014	46.0 ± 5.3	4.2
17	15,314	0.014	37.2 ± 2.6	3.4
18	15,177	0.014	37.0 ± 1.4	3.4
19	15,604	0.014	48.6 ± 2.7	4.4
20	15,718	0.014	39.2 ± 4.8	3.6
21	15,678	0.014	36.6 ± 3.6	3.3
22			32.0 ± 3.2	2.9
23			30.6 ± 2.7	2.8

*The cpm reading was measured at approximately 12 inches above the ground.

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S.O. NO. 5500

REPORT OF ANALYSIS

TYPE OF ANALYSIS DETERMINATION of STRONTIUM-90 and GAMMA ISOTOPIC by GeLi in SOIL SAMPLES

CUSTOMER ORDER NUMBER

SAMPLES RECEIVED 01/24/77

Sample Identification:	1	2	3	4	5
Date Collected:	01/18/77	01/18/77	01/18/77	01/18/77	01/18/77

Nuclide	pCi/g (Dry)				
K-40	16 ± 3	12 ± 3	16 ± 3	17 ± 3	16 ± 3
Cs-137	0.14 ± 0.08	< 0.14	0.26 ± 0.12	0.20 ± 0.11	< 0.14
Bi-214	0.83 ± 0.31	1.0 ± 0.3	0.66 ± 0.29	1.1 ± 0.3	0.58 ± 0.31
Pb-214	1.1 ± 0.3	0.80 ± 0.36	0.66 ± 0.32	0.91 ± 0.36	1.2 ± 0.3
Tl-208	0.22 ± 0.13	0.25 ± 0.13	0.26 ± 0.12	0.23 ± 0.14	0.31 ± 0.15
Ac-228	0.68 ± 0.61	0.78 ± 0.60		0.91 ± 0.62	0.84 ± 0.57
Pb-212	0.88 ± 0.29	1.0 ± 0.3	0.58 ± 0.30	0.82 ± 0.33	0.82 ± 0.32
Bi-212				1.3 ± 1.2	
Sr-90	0.15 ± 0.04	0.14 ± 0.04	0.31 ± 0.04	0.37 ± 0.07	0.33 ± 0.05

c.c Nels Johnson
Eric Geiger

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DATE 03/21/77

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CUSTOMER ORDER NUMBER

SAMPLES RECEIVED 01/24/77

Sample Identification:	6	7	8	9	10
Date Collected:	01/18/77	01/18/77	01/18/77	01/18/77	01/18/77
Nuclide	pCi/g (Dry)				
K-40	15 ± 3	16 ± 3	16 ± 3	15 ± 3	18 ± 3
Cs-137		0.38 ± 0.11	< 0.15	0.24 ± 0.19	0.18 ± 0.11
Bi-214	0.92 ± 0.33	0.69 ± 0.30	0.80 ± 0.37	1.0 ± 0.3	0.84 ± 0.35
Pb-214	0.85 ± 0.30	1.1 ± 0.3	0.94 ± 0.35	0.96 ± 0.33	1.1 ± 0.3
Tl-208	0.31 ± 0.13	< 0.20	0.41 ± 0.15	0.26 ± 0.14	< 0.20
Ac-228	1.2 ± 0.6	1.2 ± 0.6	0.82 ± 0.58	0.94 ± 0.56	0.62 ± 0.57
Pb-212	1.1 ± 0.3	0.90 ± 0.30	1.2 ± 0.3	0.67 ± 0.32	0.70 ± 0.31
Bi-212		1.5 ± 1.0			
Sr-90	0.20 ± 0.04	0.42 ± 0.05	0.39 ± 0.05	0.51 ± 0.06	0.65 ± 0.07

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CUSTOMER ORDER NUMBER

SAMPLES RECEIVED 01/24/77

Sample Identification:	11	12	13	14	15
Date Collected:	01/18/77	01/18/77	01/18/77	01/18/77	01/18/77
Nuclide	pCi/g (Dry)				
K-40	17 ± 3	14 ± 3	13 ± 3	18 ± 3	15 ± 3
Cs-137		0.16 ± 0.10	< 0.15	0.35 ± 0.12	0.64 ± 0.16
Bi-214	0.76 ± 0.32	0.99 ± 0.30	0.80 ± 0.33	0.95 ± 0.37	1.2 ± 0.3
Pb-214	0.84 ± 0.33	1.2 ± 0.3	0.94 ± 0.32	1.4 ± 0.3	1.5 ± 0.4
Tl-208	0.25 ± 0.13	0.27 ± 0.13	0.24 ± 0.10	0.20 ± 0.14	0.22 ± 0.14
Ac-228	0.78 ± 0.54	1.6 ± 0.5	1.0 ± 0.5	1.5 ± 0.6	1.5 ± 0.6
Pb-212	1.0 ± 0.3	0.89 ± 0.30	1.2 ± 0.3	0.93 ± 0.32	< 0.57
Bi-212	1.6 ± 1.0		1.2 ± 1.1		
Sr-90	0.37 ± 0.02	0.30 ± 0.02	0.10 ± 0.02	0.43 ± 0.05	0.68 ± 0.05

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CUSTOMER ORDER NUMBER

SAMPLES RECEIVED 01/24/77

Sample Identification:	16	17	18	19	20
Date Collected:	01/19/77	01/19/77	01/19/77	01/19/77	01/19/77

Nuclide	pCi/g (Dry)				
K-40	15 ± 3	17 ± 3	17 ± 3	13 ± 3	15 ± 3
Cs-137	0.50 ± 0.13	0.68 ± 0.14	0.52 ± 0.13	0.50 ± 0.15	0.29 ± 0.12
Bi-214	1.2 ± 0.4	0.80 ± 0.29	0.78 ± 0.25	0.78 ± 0.27	0.68 ± 0.30
Pb-214	0.94 ± 0.34	1.1 ± 0.3	0.82 ± 0.31	0.84 ± 0.33	0.89 ± 0.31
Tl-208	0.30 ± 0.13	0.21 ± 0.12	0.28 ± 0.13	0.29 ± 0.12	0.25 ± 0.13
Ac-228	1.4 ± 0.6	0.87 ± 0.54	0.61 ± 0.57	1.2 ± 0.5	0.74 ± 0.56
Pb-212	0.73 ± 0.31	0.98 ± 0.30	0.50 ± 0.30	0.69 ± 0.31	1.0 ± 0.3
Bi-212	1.8 ± 1.2		1.2 ± 0.9		
Sr-90	0.36 ± 0.05	0.32 ± 0.04	0.34 ± 0.04	1.2 ± 0.1	0.36 ± 0.04

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PAGE 1 OF 1 PAGE

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REPORT OF ANALYSIS

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CUSTOMER ORDER NUMBER

SAMPLES RECEIVED 01/24/77

Sample Identification: 21

Date Collected: 01/19/77

Nuclide	pCi/g (Dry)
K-40	16 ± 3
Cs-137	0.64 ± 0.15
Bi-214	0.99 ± 0.30
Pb-214	0.93 ± 0.33
Tl-208	0.20 ± 0.13
Ac-228	0.84 ± 0.60
Pb-212	0.96 ± 0.31
Sr-90	0.95 ± 0.08

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REPORT OF ANALYSIS

TYPE OF ANALYSIS DETERMINATION of GROSS ALPHA & BETA, TRITIUM, Sr-90 and RADIUM-226 in WATER SAMPLES

CUSTOMER ORDER NUMBER

SAMPLES RECEIVED 04/04/77

Sample Identification	Date Collected	Total Volume (ml)	Analysis	pCi/ml	pCi/L
Van Bremmer Creek-Upstream	03/31/77	1000	Alpha		0.0 ± 2.5
			Beta		5.0 ± 4.8
			Tritium	0.0 ± 1.0	
			Sr-90		0.0 ± 1.0
			Ra-226		0.17 ± 0.04
Van Bremmer Creek-Downstream	04/01/77	1000	Alpha		0.0 ± 2.5
			Beta		0.0 ± 2.0
			Tritium	0.0 ± 1.0	
			Sr-90		0.0 ± 1.0
			Ra-226		0.19 ± 0.05
Vermejo River	04/01/77	1000	Alpha		0.0 ± 2.5
			Beta		0.0 ± 2.0
			Tritium	0.0 ± 1.0	
			Sr-90		0.0 ± 1.0
			Ra-226		0.00 ± 0.05
Water CNS-3	03/31/77	1000	Alpha		0.0 ± 2.5
			Beta		5.5 ± 4.9
			Tritium	0.0 ± 1.0	
			Sr-90		0.0 ± 1.0
			Ra-226		0.08 ± 0.04
Water CNS-4	03/31/77	1000	Alpha		0.0 ± 2.5
			Beta		0.0 ± 2.5
			Tritium	0.0 ± 1.0	
			Sr-90		0.0 ± 1.0
			Ra-226		0.14 ± 0.04
Water CNS-5*	03/31/77	1000	Alpha (Total)		46 ± 25
			Beta (Total)		28 ± 6
			Alpha (Diss:)		12 ± 9
			Beta (Diss:)		0.0 ± 2.0
			Tritium	0.0 ± 1.0	
			Sr-90		0.0 ± 1.0
			Ra-226		0.21 ± 0.07

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REPORT OF ANALYSIS

TYPE OF ANALYSIS: DETERMINATION of GROSS ALPHA & BETA, TRITIUM, Sr-90 and RADIUM-226 in WATER SAMPLES

CUSTOMER ORDER NUMBER

SAMPLES RECEIVED 04/04/77

Sample Identification	Date Collected	Total Volume (ml)	Analysis	pCi/ml	pCi/L
Water CNS-7	03/31/77	1000	Alpha		0.0 ± 2.5
			Beta		13 ± 5
			Tritium	0.0 ± 1.0	
			Sr-90		0.0 ± 1.0
			Ra-226		0.13 ± 0.06
Water CNS-22	03/31/77	1000	Alpha		0.0 ± 2.5
			Beta		5.2 ± 4.8
			Tritium	0.0 ± 1.0	
			Sr-90		0.0 ± 1.0
			Ra-226		0.30 ± 0.10

c.c. Kenneth Flaig
Nels Johnson
Eric Geiger

* Sample contained a considerable amount of sediment which accounts for the high alpha and beta values reported as total. Sample was filtered and analyzed for alpha and beta and reported for dissolved fraction. The sample was also filtered prior to analysis for Tritium, Strontium-90 and Radium-226.

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APPROVED BY Kathy Burnham 04/18/77
Kathy Burnham, Environmental Reports DATE
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CUSTOMER CHEM-NUCLEAR SYSTEMS, INC.
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S.O. NO. 1168

REPORT OF ANALYSIS

TYPE OF ANALYSIS DETERMINATION of GAMMA ISOTOPIC by GeLi in WATER SAMPLES

CUSTOMER ORDER NUMBER

SAMPLES RECEIVED 04/04/77

Sample Identification:	Van Bremmer Creek-Upstream	Van Bremmer Creek-Downstream	Vermijo River	CNS-3
Date Collected:	03/31/77	04/01/77	04/01/77	03/31/77
Nuclide:	pCi/L			
Bi-214	< 26			
Tl-208	< 9	< 10	< 10	< 10
Pb-212	< 24	< 23	< 23	< 24
Cs-137	< 7	< 6	< 6	< 6
Pb-214			< 30	< 28
Ac-228				< 59

c.c. Kenneth Flaig
Nels Johnson
Eric Geiger

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APPROVED BY Kathy Burnham, Environmental Reports DATE 04/18/77
Albuquerque Laboratory

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S.O. NO. 1168

REPORT OF ANALYSIS

TYPE OF ANALYSIS DETERMINATION of GAMMA ISOTOPIC by GeLi in WATER SAMPLES
CUSTOMER ORDER NUMBER
SAMPLES RECEIVED 4/4/77

Sample ID:	CNS-4	CNS-5 *	CNS-7	CNS-22
Date Collected:	3-31-77	3-31-77	3-31-77	3-31-77
Nuclide	pCi/1			
K-40		820 ± 290		
Nb-95	< 8			
Cs-137	< 6	< 15	< 10	< 10
Bi-214	< 27	< 55		
Pb-214	< 29	69 ± 44		
Pb-212	< 24	76 ± 42	< 23	< 25
Zr-95	< 12			
Bi-212		170 ± 130		
Tl-208		19 ± 15		
AC-228		110 ± 100		

c.c. Kenneth Flaig
Nels Johnson
Eric Geiger

*Sample contained a considerable amount of sediment which accounts for the elevated amounts of natural activity reported.

☐ REPORTED VIA TELEPHONE
☐ REPORTED VIA TWX

EBERLINE INSTRUMENT CORPORATION
P.O. BOX 3874 ALBUQUERQUE, NEW MEXICO 87110
PHONE (505) 345-3461 TWX: 910-985-0678

APPROVED BY Kathy Burnham DATE 4/18/77
KATHY BURNHAM, Environmental Reports
Albuquerque Laboratory

CUSTOMER CHEM-NUCLEAR SYSTEMS, INC.
ATTENTION J. Stewart Corbett
ADDRESS P. O. Box 1866
CITY Bellevue, Washington 98009
S.O. NO. 1169

REPORT OF ANALYSIS

TYPE OF ANALYSIS AIR PARTICULATE COMPOSITE in STRONTIUM-90 & GAMMA ISOTOPIC by GeLi

CUSTOMER ORDER NUMBER

SAMPLES RECEIVED 04/04/77

Sample Identification	Date Collected	Total Volume(m^3)	Nuclide	pCi/m^3
Office	1st Qtr. 1977	1301	Ru-103	0.022 ± 0.006
			Be-7	0.154 ± 0.062
			Ce-144	0.054 ± 0.028
			Nb-95	0.041 ± 0.008
			Zr-95	0.028 ± 0.008
			Sr-90	*

* To be reported at a later date.

c.c. Kenneth Flaig
Nels Johnson
Eric Geiger

☐ REPORTED VIA TELEPHONE
☐ REPORTED VIA TWX

PAGE 1 OF 1 PAGE

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APPROVED BY Kathy Burnham, Environmental Reoprts Albuquerque Laboratory DATE 04/18/77

Appendix IV-1.--Climatologic Data

Appendix IV-1.--Climatologic data.

Station Abbott | County Colfax | Index No. 0022

Latitude 36°11' | Longitude 104°20' | Elevation 5771 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	41	41	41	41	40	40	40	39	38	40	40	40	34
Mean	.31	.38	.58	1.01	1.88	1.94	2.48	2.96	1.83	1.29	.45	.35	15.25/ 15.46
Temp													
Years of record													
Mean													
PE													
Surplus													
Deficit													

Appendix IV-1.--Climatologic data.

Station Abbott A County Colfax Index No. 0022

Latitude 36°18' Longitude 104°15' Elevation 6040 ft

Precip	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Years of record	24	22	23	24	24	24	24	24	24	24	25	25	21
Mean	.16	.24	.40	.55	1.86	1.29	3.02	3.22	1.20	.97	.31	.26	14.01/ 13.48

Temp													
Years of record													
Mean													
PE													
Surplus													
Deficit													

Appendix IV-1.--Climatologic data.

Station Aurora County Colfax Index No. 0646

Latitude 36°19' Longitude 105°06' Elevation 9100 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	37	37	36	36	36	35	37	37	37	37	37	37	35
Mean	.59	.82	1.25	1.65	1.94	2.36	3.74	3.62	2.30	1.40	.74	.60	21.23/ 21.01
Temp													
Years of record													
Mean													
PE													
Surplus													
Deficit													

Appendix IV-1--Climatologic data.

Station Aurora A County Colfax Index No. 0646

Latitude 36°16' Longitude 105° 03' Elevation 8130 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	13	12	15	15	15	15	15	14	13	13	14	13	11
Mean	.56	.43	.86	.99	2.14	1.50	3.62	3.55	.99	1.42	.74	.52	17.42/ 17.32
Temp													
Years of record													
Mean													
PE													
Surplus													
Deficit													

Appendix IV-1.--Climatologic data.

Station Black Lake County Colfax Index No. 1000

Latitude 36°18' Longitude 105°16' Elevation 8338 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	58	58	58	58	58	58	59	59	59	58	58	58	57
Mean	.54	.63	.92	1.07	1.53	1.76	3.28	3.34	1.48	1.19	.61	.50	16.80/ 16.85
Temp													
Years of record													
Mean													
PE													
Surplus													
Deficit													

Appendix IV-1.--Climatologic data.

Station Black Lake A County Colfax Index No. 1000

Latitude 36°18' Longitude 105°17' Elevation 8358 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	7	7	7	7	7	7	7	7	7	8	8	8	7
Mean	.92	.63	1.56	1.18	1.49	1.44	4.12	2.87	2.11	1.47	1.10	.73	19.91/ 19.62
Temp													
Years of record													
Mean													
PE													
Surplus													
Deficit													

Appendix IV-1.--Climatologic data.

Station Cimarron County Colfax Index No. 1813

Latitude 36°31' Longitude 104°55' Elevation 6427 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	67	67	67	67	68	68	68	68	68	68	68	68	67
Mean	.34	.52	.86	1.31	1.92	1.61	2.70	2.58	1.48	1.23	.55	.40	15.44/ 15.50
Temp													
Years of record	66	66	66	66	67	67	67	67	67	66	66	66	65
Mean	32.3	35.2	40.3	48.4	56.5	65.1	68.9	67.3	61.4	52.5	40.5	33.3	50.3/ 50.1
PE	.42	.53	1.10	2.21	3.96	5.87	6.74	5.72	3.81	2.21	.85	.43	33.85
Surplus													.00
Deficit	.08	.01	.24	.90	2.04	4.26	4.04	3.14	2.33	.98	.30	.03	18.35

Appendix IV-1.--Climatologic data.

Station Cimarron 4SW County Colfax Index No. 1813

Latitude 36°28' Longitude 104°57' Elevation 6540 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	4	4	4	4	4	4	4	4	4	4	4	4	4
Mean	.17	.38	1.32	.63	1.68	1.31	2.75	2.12	2.97	1.01	.62	.55	15.50/ 15.51
Temp													
Years of record	4	4	4	4	4	4	4	4	4	3	4	4	3
Mean	29.5	33.2	40.4	44.1	54.4	63.6	66.4	64.3	57.3	50.8	37.0	31.4	47.7/ 47.7
PE	.39	.50	1.10	1.74	3.64	5.59	6.13	5.14	3.22	2.03	.66	.41	30.55
Surplus			.22									.14	.36
Deficit	.22	.12		1.11	1.96	4.28	3.38	3.02	.25	1.02	.04		15.40

Appendix IV-1.--Climatologic data.

Station Cimarron 8SE County Colfax Index No. 1819

Latitude 36°28' Longitude 104°48' Elevation 6200 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	12	12	13	13	13	13	13	12	12	12	12	12	11
Mean	.23	.25	.48	.75	1.94	1.52	2.58	3.04	.81	.52	.49	.24	12.77/ 12.85
Temp													
Years of record													
Mean													
PE													
Surplus													
Deficit													

Appendix IV-1.--Climatologic data.

Station Colmor County Colfax Index No. ______

Latitude 36°13' Longitude 104°38' Elevation 5931 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	3	3	3	2	2	3	3	3	3	3	3	3	2
Mean	.25	1.62	1.62	.15	1.79	1.48	1.90	2.90	1.14	.93	.45	.73	11.22/ 14.96
Temp													
Years of record	3	3	3	2	2	3	3	3	3	3	3	3	2
Mean	24.8	36.6	37.8	49.6	58.0	67.8	71.5	69.0	61.8	49.3	38.6	26.1	51.5/ 49.2
PE	.33	.59	.92	2.35	4.24	6.48	7.30	6.06	3.89	1.90	.73	.34	35.13
Surplus		1.03	.70									.39	2.12
Deficit	.08			2.20	2.45	5.00	5.40	3.16	2.75	.97	.28		22.29

Appendix IV-1.--Climatologic data.

Station Colmor A County Colfax Index No. ___

Latitude 36°15' Longitude 104°43' Elevation 6200 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	5	5	5	6	6	6	6	5	5	5	5	5	5
Mean	.02	.53	.67	1.09	3.15	1.99	3.31	3.16	2.04	1.12	.68	.23	18.99/ 17.99
Temp													
Years of record	0	0	0	1	1	1	1	1	1	0	0	0	0
Mean													
PE													
Surplus													
Deficit													

Appendix IV-1.--Climatologic data.

Station Colmor B County Colfax Index No. ______

Latitude 36°13' Longitude 104°38' Elevation 5931 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	1	1	1	1	1	1	1	2	1	1	1	1	0
Mean	.46	.41	.59	.94	3.97	1.39	1.18	3.83	3.43	1.25	.30	.00	17.75/
Temp													
Years of record													
Mean													
PE													
Surplus													
Deficit													

Appendix IV-1.--Climatologic data.

Station Cunico Ranch County Colfax Index No. 2321

Latitude 36°41' Longitude 104°14' Elevation 6500 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	2	2	2	2	2	2	3	2	2	1	2	2	1
Mean	.05	.01	1.37	4.62	2.01	2.16	2.81	3.81	3.94	2.37	1.33	.18	25.85/ 24.66
Temp													
Years of record													
Mean													
PE													
Surplus													
Deficit													

Appendix IV-1.--Climatologic data.

Station Cunico Ranch A County Colfax Index No. 2321

Latitude 36°41' Longitude 104°07' Elevation 6820 ft

Precip	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Years of record	29	29	29	29	29	28	29	29	27	28	28	28	26
Mean	.29	.24	.41	.69	1.81	1.57	3.54	2.84	1.08	1.14	.29	.25	14.64/ 14.15
Temp													
Years of record													
Mean													
PE													
Surplus													
Deficit													

Appendix IV-1.--Climatologic data.

Station Dawson County Colfax Index No. 2384

Latitude 36°40' Longitude 104°47' Elevation 6400 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	50	50	51	50	52	52	52	52	52	51	52	52	49
Mean	.32	.49	.67	1.26	2.05	1.78	2.92	2.77	1.39	1.46	.49	.35	16.01/ 15.95
Temp													
Years of record	35	38	37	36	37	39	37	38	38	38	36	36	30
Mean	31.1	35.6	40.8	49.3	57.4	65.9	69.8	68.0	61.8	52.0	40.3	33.1	53.8/ 50.4
PE	.41	.53	1.14	2.34	4.15	6.10	6.92	5.85	3.89	2.19	.82	.43	34.77
Surplus													.00
Deficit	.09	.04	.47	1.08	2.10	4.32	4.00	3.08	2.50	.73	.33	.08	18.82

Appendix IV-1.--Climatologic data.

Station Dorsey (Val Verde Ranch) County Colfax Index No. ______

Latitude 36°41' Longitude 104°34' Elevation 6200 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	4	4	4	4	4	4	5	4	4	4	4	4	3
Mean	.10	.62	.83	2.07	.72	3.51	2.40	2.09	2.37	.25	.76	.28	16.50/ 16.00
Temp													
Years of record	4	4	4	4	4	4	5	4	4	4	4	4	3
Mean	31.3	32.1	41.6	47.1	55.8	64.9	68.1	68.8	61.5	50.6	41.4	32.4	49.5/ 49.6
PE	.41	.48	1.22	2.07	3.85	5.86	6.52	6.05	3.82	2.02	.89	.42	33.61
Surplus		.14		.00									.14
Deficit	.31		.39	.00	3.13	2.35	4.12	3.96	1.45	1.77	.13	.14	17.75

Appendix IV-1.--Climatologic data.

Station Dorsey (Val Verde Ranch) A   County Colfax   Index No. ______

Latitude 36°39'   Longitude 104°27'   Elevation 6200 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	2	2	4	4	4	4	4	5	4	4	3	3	0
Mean	.09	.90	.13	1.04	2.87	2.32	2.14	4.23	.88	.67	.33	.04	15.64/
Temp													
Years of record	3	2	4	4	4	4	4	4	4	4	3	3	1
Mean	35.7	34.7	44.4	48.6	54.8	66.0	70.7	68.2	62.9	50.7	40.5	34.1	49.6/ 50.9
PE	.47	.52	1.43	2.26	3.67	6.11	7.16	5.93	4.01	2.03	.85	.44	34.88
Surplus		.38											.38
Deficit	.38		1.30	1.22	.80	3.79	5.02	1.70	3.13	1.36	.52	.40	19.62

Appendix IV-1.--Climatologic data.

Station Eagle Nest (Therma) County Colfax Index No. 2700

Latitude 36°30' Longitude 105°17' Elevation 8219 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	0	0	0	3	4	3	3	3	3	3	1	0	0
Mean													
Temp													
Years of record	0	0	0	2	3	3	3	3	3	2	1	0	0
Mean													
PE													
Surplus													
Deficit													

Appendix IV-1.--Climatologic data.

Station Eagle Nest (Therma) A County Colfax Index No. 2700

Latitude 36°28' Longitude 105°16' Elevation 8225 ft

Precip	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Years of record	1	0	0	1	1	2	2	2	2	2	2	2	0
Mean													
Temp													
Years of record	1	0	0	1	1	2	2	2	2	2	2	2	0
Mean													
PE													
Surplus													
Deficit													

Appendix IV-1.--Climatologic data.

Station Eagle Nest (Therma) B   County Colfax   Index No. 2700

Latitude 36°33'   Longitude 105°16'   Elevation 8280 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	41	41	42	39	39	39	40	41	41	41	41	42	37
Mean	.70	.65	.90	.93	1.33	1.06	2.75	2.69	1.28	.87	.69	.70	14.61/ 14.55
Temp													
Years of record	41	41	41	39	39	41	39	39	40	41	40	40	33
Mean	18.9	23.2	30.0	38.8	46.7	54.4	59.1	57.9	51.2	42.1	30.0	21.7	39.7/ 39.5
PE	.25	.35	.65	1.23	2.43	3.81	4.67	4.00	2.42	1.23	.48	.28	21.80
Surplus	.45	.30	.25								.21	.42	1.63
Deficit				.30	1.10	2.75	1.92	1.31	1.14	.36			8.88

Appendix IV-1.--Climatologic data.

Station Elizabethtown County Colfax Index No. 2860

Latitude 36°37' Longitude 105°17' Elevation 8465 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	45	43	44	43	43	43	41	41	42	42	43	43	39
Mean	.79	.97	1.42	1.44	1.31	1.07	2.90	2.90	1.32	1.12	.70	.72	17.20/ 16.66
Temp													
Years of record	41	40	40	39	39	39	37	39	40	40	40	39	36
Mean	18.8	23.0	30.3	37.9	45.8	52.3	57.5	56.5	50.5	40.7	28.2	20.2	38.8/ 38.5
PE	.25	.34	.65	1.13	2.34	3.44	4.35	3.73	2.34	1.13	.45	.26	20.41
Surplus	.54	.63	.77	.31							.25	.46	2.96
Deficit					1.03	2.37	1.45	.83	1.02	.01			6.71

Appendix IV-1.--Climatologic data.

Station Farley | County Colfax | Index No. 3117

Latitude 36°21' | Longitude 104°02' | Elevation 5800 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	6	5	5	7	7	7	9	9	9	6	6	6	4
Mean	.46	.65	.57	1.89	1.68	1.51	3.20	2.31	2.25	.79	.59	.32	18.85/ 16.22
Temp													
Years of record													
Mean													
PE													
Surplus													
Deficit													

Appendix IV-1.--Climatologic data.

Station Hennigan Ranch County Colfax Index No. 3925

Latitude 36°38' Longitude 104°08' Elevation 6940 ft

Precip	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Years of record	0	0	0	0	0	0	1	1	0	1	1	0	0
Mean													
Temp													
Years of record													
Mean													
PE													
Surplus													
Deficit													

Appendix IV-1.--Climatologic data.

Station Johnson Park (Meloche Ranch) County Colfax Index No. ____

Latitude 36°48' Longitude 104°15' Elevation 6550ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	11	12	11	12	12	11	11	11	11	11	10	10	9
Mean	.16	.43	.67	1.59	2.44	2.53	3.47	2.45	1.12	1.31	.35	.58	17.20/ 17.10
Temp													
Years of record													
Mean													
PE													
Surplus													
Deficit													

Appendix IV-1.--Climatologic data.

Station Lake Alice (Nr) County Colfax Index No. 4728

Latitude 36°57' Longitude 104°23' Elevation 6950 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	29	30	31	30	30	31	32	32	31	31	30	27	24
Mean	.57	.77	1.32	1.99	2.56	2.15	2.89	3.14	2.11	1.56	.70	.65	18.82/ 20.41
Temp													
Years of record	9	12	13	11	12	11	12	12	12	12	11	8	5
Mean	30.6	33.6	37.9	45.8	53.7	62.2	67.1	66.0	59.5	50.1	37.9	32.3	48.3/ 48.1
PE	.40	.50	.92	1.93	3.54	5.28	6.36	5.48	3.55	1.96	.69	.42	31.03
Surplus	.17	.27	.40	.06							.01	.23	1.14
Deficit					.98	3.13	3.47	2.34	1.44	.40			11.76

Appendix IV-1.--Climatologic data.

Station Lake Maloya   County Colfax   Index No. 4742

Latitude 36°59'   Longitude 104°22'   Elevation 7400 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	32	32	32	33	33	33	33	33	34	34	34	34	31
Mean	.88	1.21	1.58	1.72	3.11	2.22	3.55	3.16	1.33	1.39	1.30	1.08	22.34/ 22.53
Temp													
Years of record	31	31	32	33	33	32	32	32	34	34	34	32	23
Mean	26.1	28.4	33.2	42.2	50.7	59.1	59.4	62.2	55.8	47.1	35.4	28.2	44.0/ 44.0
PE	.34	.42	.71	1.56	3.02	4.69	4.70	4.73	3.01	1.68	.57	.36	25.79
Surplus	.54	.79	.87	.16	.09						.73	.72	3.90
Deficit						2.47	1.15	1.57	1.68	.29			7.16

Appendix IV-1.--Climatologic data.

Station Maxwell County Colfax Index No. 5490

Latitude 36°33' Longitude 104°33' Elevation 5909 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	27	27	27	28	26	26	26	26	28	28	28	27	23
Mean	.23	.27	.44	.81	1.51	1.48	2.67	3.07	1.47	1.18	.51	.32	13.90/ 13.96
Temp													
Years of record	22	23	23	22	23	23	22	23	24	23	22	22	17
Mean	28.5	32.1	37.7	46.9	56.5	65.5	70.0	67.9	60.9	50.6	35.9	29.7	48.6/ 48.5
PE	.37	.48	.92	2.07	3.96	5.98	7.01	5.84	3.73	2.02	.58	.39	33.35
Surplus													.00
Deficit	.14	.21	.48	1.26	2.45	4.50	4.34	2.77	2.26	.84	.07	.07	19.39

Appendix IV-1.--Climatologic data.

Station Maxwell A County Colfax Index No. 5490

Latitude 36°34' Longitude 104°35' Elevation 5959 ft

Precip	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Years of record	28	29	29	28	29	29	29	29	28	27	26	26	25
Mean	.22	.26	.62	1.08	1.82	1.77	2.70	2.97	1.35	.90	.26	.33	14.30/ 14.28
Temp													
Years of record	6	7	7	6	6	6	6	6	6	6	4	5	3
Mean	26.5	31.0	36.1	47.3	55.0	63.9	68.2	67.3	60.9	51.6	35.3	30.4	48.0/ 47.8
PE	.35	.46	.80	2.07	3.74	5.62	6.60	5.72	3.73	2.14	.57	.40	32.20
Surplus													.00
Deficit	.13	.20	.18	.99	1.92	3.85	3.90	2.75	2.38	1.24	.31	.07	17.92

Appendix IV-1.--Climatologic data.

Station Miami County Colfax Index No. 5691

Latitude 36°21' Longitude 104°46' Elevation 6300 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	51	52	50	49	49	49	49	51	50	50	50	51	42
Mean	.32	.43	.79	1.20	2.24	1.71	2.51	2.67	1.42	1.47	.59	.35	15.70/ 15.70
Temp													
Years of record	51	50	51	49	49	48	49	51	50	49	49	51	41
Mean	31.3	33.9	39.5	47.5	57.9	64.3	67.9	66.6	61.0	50.9	39.2	32.1	49.0/ 49.3
PE	.41	.51	1.05	2.12	4.24	5.72	6.49	5.59	3.74	2.07	.76	.42	33.12
Surplus													.00
Deficit	.09	.08	.26	.92	2.00	4.01	3.98	2.92	2.32	.60	.17	.07	17.42

Appendix IV-1.--Climatologic data.

Station Raton County Colfax Index No. 7277

Latitude 36°54' Longitude 104°26' Elevation 6676 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	32	33	34	31	30	29	31	29	27	29	27	30	24
Mean	.29	.59	.59	1.66	1.81	1.73	3.21	3.22	1.62	.90	.35	.46	15.79/ 16.43
Temp													
Years of record	30	31	32	32	30	28	29	28	28	28	27	29	24
Mean	31.5	33.0	38.9	47.4	55.9	64.7	68.6	67.8	60.9	51.1	40.7	31.6	49.1/ 49.3
PE	.41	.49	1.00	2.12	3.87	5.85	6.65	5.83	3.73	2.08	.85	.41	33.29
Surplus		.10										.05	.15
Deficit	.12		.41	.46	2.06	4.12	3.44	2.61	2.11	1.18	.50		17.01

Appendix IV-1.--Climatologic data.

Station Raton A County Colfax Index No. 7277

Latitude 36°52' Longitude 104°25' Elevation 6485 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	24	23	24	24	25	25	25	25	25	25	24	25	22
Mean	.43	.47	.92	1.12	2.28	1.71	2.53	2.33	2.32	1.32	.77	.41	16.86/ 16.61
Temp													
Years of record	24	24	22	23	25	25	25	24	25	25	24	25	21
Mean	28.4	32.8	38.7	46.7	55.5	64.8	69.2	67.4	60.7	50.4	38.4	30.8	48.7/ 48.7
PE	.37	.49	1.00	2.01	3.84	5.86	6.79	5.73	3.72	2.01	.72	.40	32.94
Surplus	.06										.05	.01	.12
Deficit		.02	.08	.89	1.56	4.15	4.26	3.40	1.40	.69			16.45

Appendix IV-1.--Climatologic data.

Station Raton Filter Plant County Colfax Index No. 7279

Latitude 36°55' Longitude 104°26' Elevation 6933 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	21	21	21	21	21	21	21	21	21	23	23	23	22
Mean	.39	.53	.88	.87	2.29	1.86	3.26	3.03	1.29	1.22	.72	.57	16.19/ 16.91
Temp													
Years of record	21	21	21	21	21	21	21	21	22	22	21	21	20
Mean	31.9	33.8	37.7	46.2	55.6	64.4	68.6	67.0	60.8	51.9	40.2	33.5	49.3/ 49.3
PE	.42	.50	.92	1.99	3.84	5.76	6.66	5.70	3.73	2.14	.82	.43	32.91
Surplus		.03										.14	.17
Deficit	.03		.04	1.12	1.55	3.90	3.40	2.67	2.44	.92	.10		16.17

Appendix IV-1.--Climatologic data.

Station Raton Weather Bureau Airport County Colfax Index No. 7283

Latitude 36°45' Longitude 104°30' Elevation 6379 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	26	26	26	26	26	26	26	26	25	25	26	25	24
Mean	.34	.30	.48	1.01	1.84	2.05	2.66	2.90	1.38	.95	.37	.29	14.71/ 14.57
Temp													
Years of record	26	26	26	26	26	26	26	26	25	25	25	24	24
Mean	28.5	32.3	37.1	46.7	55.8	65.1	69.2	67.8	60.9	50.9	37.8	30.5	48.5/ 48.6
PE	.37	.48	.88	2.01	3.86	5.89	6.79	5.83	3.73	2.07	.69	.40	33.00
Surplus													.00
Deficit	.03	.18	.40	1.00	2.02	3.84	4.13	2.93	2.35	1.12	.32	.11	18.43

Appendix IV-1.--Climatologic data.

Station Shoemaker Ranch County Colfax Index No. 8289

Latitude 36°27' Longitude 104°39' Elevation 6200 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	15	16	16	16	16	16	16	16	16	17	15	16	14
Mean	.39	.31	.53	1.24	2.02	1.83	2.24	2.57	2.42	.95	.51	.28	15.34/ 15.29
Temp													
Years of record	15	16	15	15	15	16	15	15	15	16	14	14	12
Mean	29.0	34.4	43.5	52.2	61.0	65.6	69.5	68.4	62.0	52.4	39.6	32.7	50.2/ 50.9
PE	.38	.51	1.37	2.70	4.79	5.99	6.88	5.95	3.90	2.21	.79	.43	35.90
Surplus	.01												.01
Deficit		.20	.84	1.46	2.77	4.16	4.64	3.38	1.48	1.26	.28	.15	20.62

Appendix IV-1.--Climatologic data.

Station Springer 2NW County Colfax Index No. 8501

Latitude 36°22' Longitude 104°36' Elevation 5917 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	77	81	83	85	84	83	81	84	83	83	81	81	69
Mean	.31	.35	.58	.98	1.79	1.58	2.79	2.81	1.49	1.10	.50	.42	14.86/ 14.70
Temp													
Years of record	70	75	77	80	80	79	77	78	79	78	76	76	58
Mean	29.2	33.7	40.4	49.4	58.7	67.5	71.0	70.4	62.7	51.9	39.4	30.7	48.9/ 50.4
PE	.38	.50	1.10	2.34	4.36	6.38	7.18	6.33	4.00	2.15	.79	.40	35.91
Surplus												.02	.02
Deficit	.07	.15	.52	1.36	2.57	4.80	4.39	3.52	2.51	1.05	.29		21.23

Appendix IV-1.---Climatologic data.

Station Taylor County Colfax Index No. ______

Latitude 36°20' Longitude 104°30' Elevation 5661 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	21	21	21	21	21	21	22	22	22	22	22	22	21
Mean	.27	.50	.78	1.03	2.11	1.81	2.86	2.81	1.40	1.34	.48	.48	15.56/ 15.87
Temp													
Years of record	20	20	20	20	20	21	19	19	18	19	18	20	17
Mean	28.9	35.4	39.7	49.3	58.1	67.0	67.9	69.5	63.0	51.4	39.3	29.8	50.4/ 49.9
PE	.38	.53	1.05	2.33	4.25	6.33	6.49	6.18	4.07	2.13	.78	.39	34.91
Surplus												.09	.09
Deficit	.11	.03	.27	1.30	2.14	4.52	3.63	3.37	2.67	.79	.30		19.13

Appendix IV-1.--Climatologic data.

Station Vermejo Park　County Colfax　Index No. 9448

Latitude 36°53'　Longitude 104°57'　Elevation 7550 ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	31	30	28	27	29	27	30	30	30	28	28	30	22
Mean	.41	.52	.88	1.50	1.38	1.52	4.00	3.37	1.47	1.03	.58	.58	17.79/ 17.24
Temp													
Years of record	27	27	23	25	25	24	28	27	26	27	27	26	19
Mean	29.5	31.1	35.4	43.1	50.8	59.8	63.5	62.0	56.1	46.6	36.8	28.8	45.6/ 45.3
PE	.39	.46	.76	1.63	3.03	4.81	5.52	4.72	3.07	1.63	.63	.37	27.02
Surplus	.02	.06	.12									.21	.41
Deficit				.13	1.65	3.29	1.52	1.35	1.60	.60	.05		10.19

Appendix IV-2.--Climatologic Data

Appendix IV-2. -- Precipitation, potential evapotranspiration, surplus, and deficit by station for the 5500-5999 feet altitude interval for Colfax County, New Mexico.

	Precipitation			PE		Surplus		Deficit	
Station	yrs	total (in)	yrs	x(in) =	total (in)	x(in) =	total (in)	x(in) =	total (in)
Abbott	34	518.52	-	-	-	-	-	-	-
Colmor	2	22.43	2	35.13	70.26	2.12	4.24	22.29	44.58
Colmor B	1	17.75	-	-	-	-	-	-	-
Farley	4	75.40	-	-	-	-	-	-	-
Maxwell	23	319.62	17	33.35	566.95	.00	.00	19.39	329.63
Maxwell A	25	357.48	3	32.20	96.60	.00	.00	17.92	53.76
Springer	69	1025.14	58	35.91	2082.78	.02	1.16	21.23	1231.34
Taylor	21	326.83	17	34.91	593.47	.09	1.53	19.13	325.21
Total	179	2663.17	97		3410.06		6.93		1984.52
Mean		14.88			35.16		.07		20.46

Appendix IV-2. -- Precipitation, potential evapotranspiration, surplus, and deficit by station for the 6000-6499 feet altitude interval for Colfax County, New Mexico.

Station	Precipitation yrs	Precipitation total (in)	yrs	PE x(in) =	PE total (in)	Surplus x(in) =	Surplus total (in)	Deficit x(in) =	Deficit total (in)
Abbott 2 SE	21	294.24	-	-	-	-	-	-	-
Cimarron	67	1034.68	65	33.85	2200.25	-	-	18.35	1192.75
Cimarron 7 SE	11	140.51	-	-	-	-	-	-	-
Colmor A	5	94.94	0	-	-	-	-	-	-
Dawson	49	784.34	30	34.77	1043.10	-	-	18.82	564.60
Dorsey (Val Verde Ranch)	3	49.50	3	33.61	100.83	.14	.42	17.75	53.25
Dorsey (Val Verde Ranch) A	2	31.28	1	34.88	34.88	.38	.38	19.62	19.62
Miami	42	659.26	41	33.12	1357.92	.00	.00	17.42	714.22
Raton A	22	370.94	21	32.94	691.74	.12	2.52	16.45	345.45
Raton Weather Bureau	24	353.12	24	33.00	792.00	.00	.00	18.43	442.32
Shoemaker Ranch	14	214.76	12	35.90	430.80	.01	.12	20.62	247.44
Total	260	4027.57	197		6651.52		3.44		3579.65
Mean		15.49			33.76		.02		18.17

Appendix IV-2. -- Precipitation, potential evapotranspiration, surplus, and deficit by station for the 7000-7499 feet altitude interval for Colfax County, New Mexico.

Station	Precipitation yrs	Precipitation total (in)	yrs	PE x(in)	=	PE total (in)	Surplus x(in)	=	Surplus total (in)	Deficit x(in)	=	Deficit total (in)
Lake Maloya	31	692.56	23	25.79		593.17	3.90		89.70	7.16		164.68
Total	31	692.56	23			593.17			89.70			164.68
Mean		22.34				25.79			3.90			7.16

Appendix IV-2. -- Precipitation, potential evapotranspiration, surplus, and deficit by station for the 6500-6999 feet altitude interval for Colfax County, New Mexico.

	Precipitation			PE		Surplus		Deficit	
Station	yrs	total (in)	yrs	x̄(in) =	total (in)	x̄(in) =	total (in)	x̄(in) =	total (in)
Cimarron 4 SW	4	61.99	3	30.55	91.65	.36	1.08	15.40	46.20
Cunico Ranch	1	25.85	-	-	-	-	-	-	-
Cunico Ranch A	26	380.55	-	-	-	-	-	-	-
Johnson Park (Melache Ranch)	9	154.76	-	-	-	-	-	-	-
Lake Alice (Sugarite)	24	451.74	5	31.03	155.15	1.14	5.70	11.76	58.80
Raton	24	379.07	24	33.29	798.96	.15	3.60	17.01	408.24
Raton Filter Plant	22	356.23	20	32.91	658.20	.17	3.40	15.16	303.20
Total	110	1810.19	52		1703.96		13.78		816.44
Mean		16.46			32.77		.27		15.70

Appendix IV-2. -- Precipitation, potential evapotranspiration, surplus, and deficit by station for the 7500-7999 feet altitude interval for Colfax County, New Mexico.

	Precipitation			PE			Surplus			Deficit		
Station	yrs	total (in)	yrs	x(in)	=	total (in)	x(in)	=	total (in)	x(in)	=	total (in)
Philmont Scout Ranch	12	174.11	5	29.81		149.05	.08		.40	14.32		71.60
Vermejo Park	22	391.32	19	27.02		513.38	.41		7.79	10.19		193.61
Total	34	565.43	24			662.43			8.19			265.21
Mean		16.63				27.60			.34			11.05

Appendix IV-2. -- Precipitation, potential evapotranspiration, surplus, and deficit by station for the 8000-8499 feet altitude interval for Colfax County, New Mexico.

	Precipitation			PE		Surplus		Deficit	
Station	yrs	total (in)	yrs	x(in) =	total (in)	x(in) =	total (in)	x(in) =	total (in)
Aurora	11	191.67	-	-	-	-	-	-	-
Black Lake	57	957.33	-	-	-	-	-	-	-
Eagle Nest (Therma)	0	-	0	-	-	-	-	-	-
Eagle Nest (Therma) A	0	-	0	-	-	-	-	-	-
Eagle Nest (Therma) B	37	540.39	33	21.80	719.40	1.63	53.79	8.88	293.04
Elizabethtown	39	670.70	36	20.41	734.76	2.96	106.56	6.71	241.56
Total	144	2360.09	69		1454.16		160.35		534.60
Mean		16.39			21.07		2.32		7.75

Appendix IV-2. -- Precipitation, potential evapotranspiration, surplus, and deficit by station for the 8500-8999 feet altitude interval for Colfax County, New Mexico.

	Precipitation			PE			Surplus			Deficit		
Station	yrs	total (in)	yrs	x(in)	=	total (in)	x(in)	=	total (in)	x(in)	=	total (in)
Black Lake A	7	139.39	-	-		-	-		-	-		-
Total	7	139.39	-			-			-			-
Mean		19.91	-			-			-			-

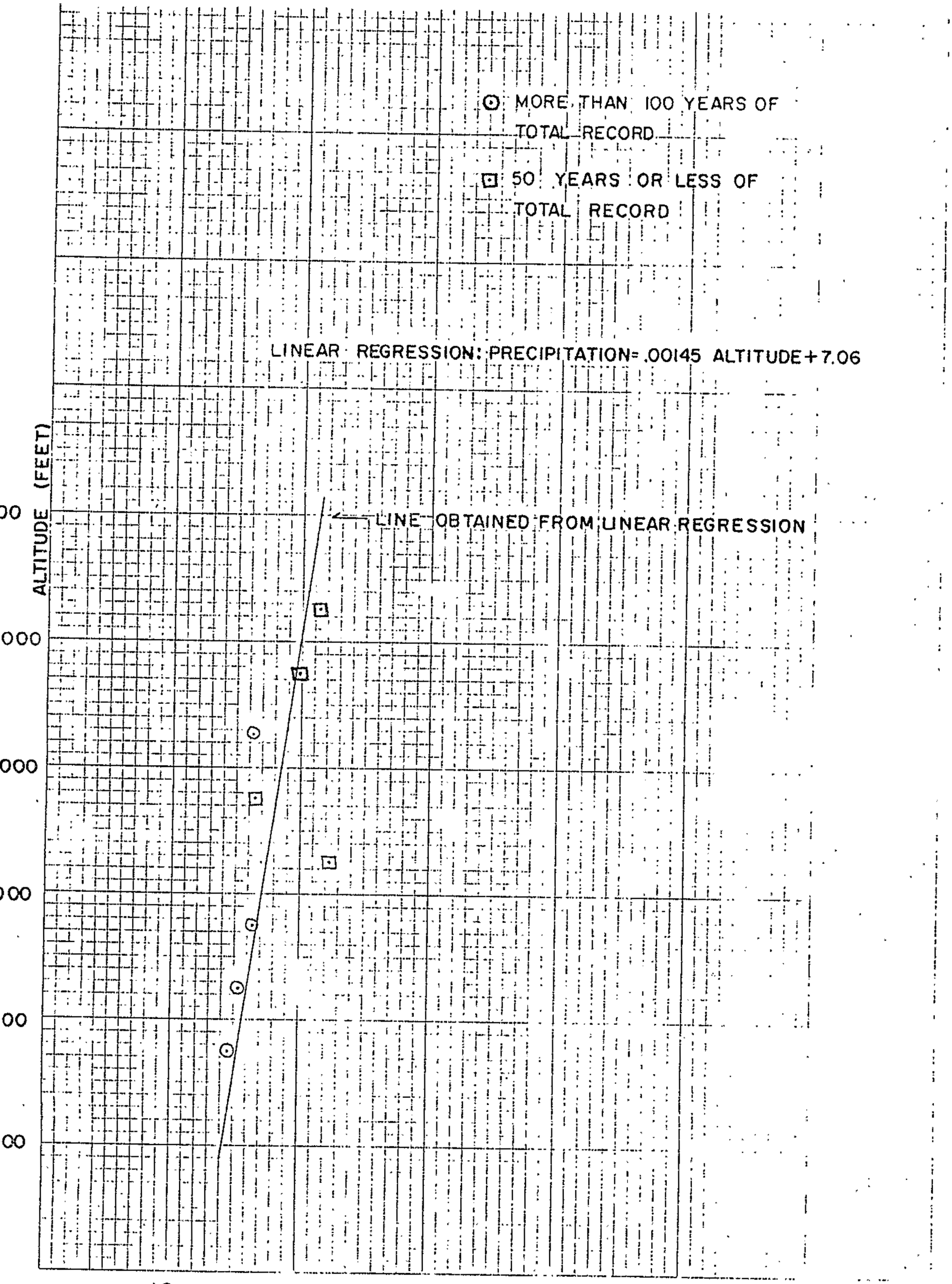
Appendix IV-2. -- Precipitation, potential evapotranspiration, surplus, and deficit by station for the 9000-9499 feet altitude interval for Colfax County, New Mexico.

	Precipitation			PE			Surplus			Deficit		
Station	yrs	total (in)	yrs	x(in)	=	total (in)	x(in)	=	total (in)	x(in)	=	total (in)
Aurora	35	743.17	-	-		-	-		-	-		-
Total	35	743.17	-			-			-			-
Mean		21.23	-			-			-			-

Appendix IV-3.--Climatologic Data

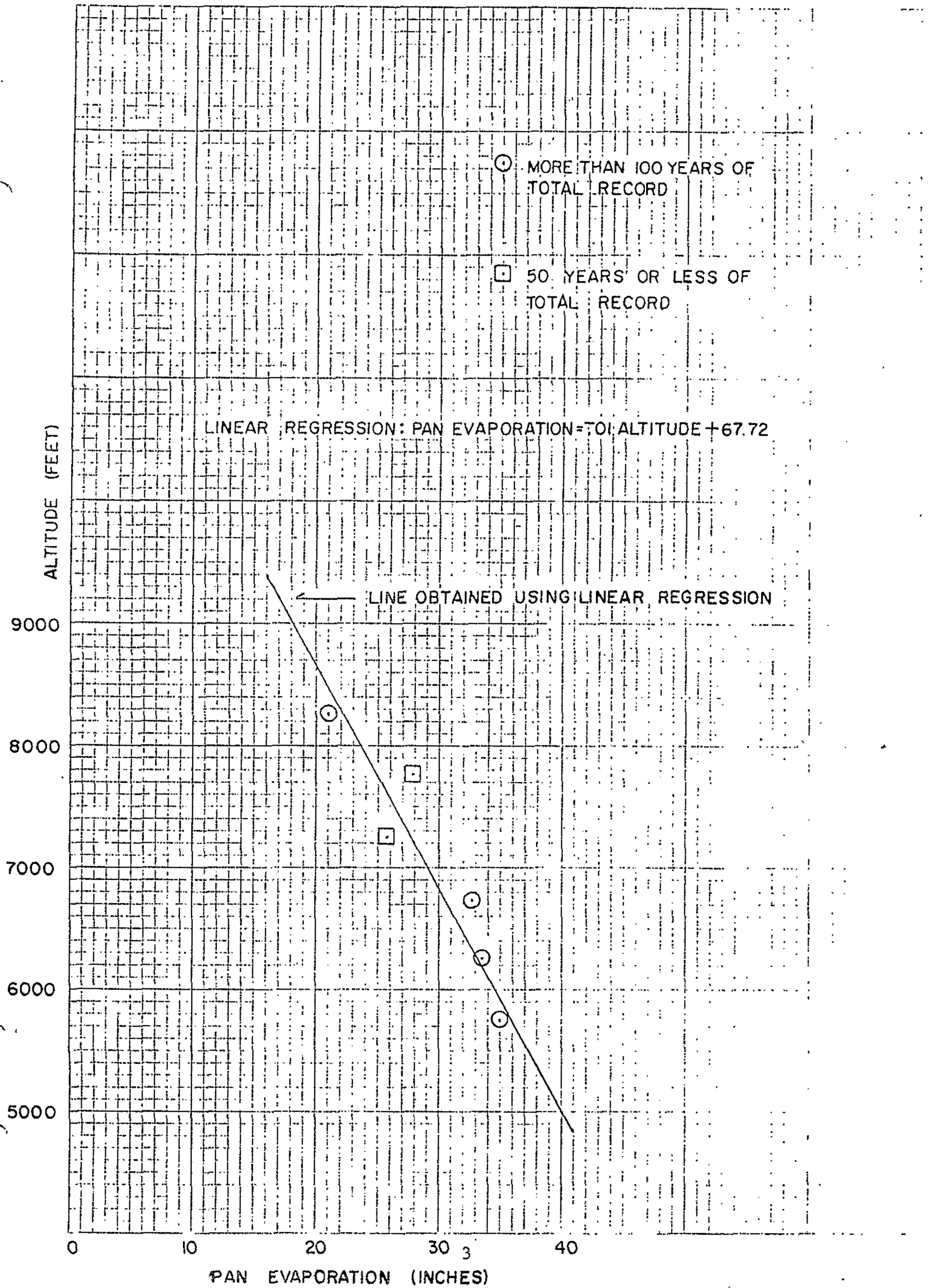
Appendix IV-3 . -- Precipitation, potential evapotranspiration, surplus, and deficit by altitude interval for Colfax County, New Mexico.

Altitude interval	Total number years of record	Mean precipitation (in)	Mean potential evapotranspiration (in)	Mean surplus (in)	Mean deficit (in)
5500-5999	179	14.88	35.16	.07	20.46
6000-6499	260	15.49	33.76	.02	18.17
6500-6999	110	16.46	32.77	.27	15.70
7000-7499	31	22.34	25.79	3.90	7.16
7500-7999	34	16.63	27.60	.34	11.05
8000-8499	144	16.39	21.07	2.32	7.75
8500-8999	7	19.91	-	-	-
9000-9499	35	21.23	-	-	-



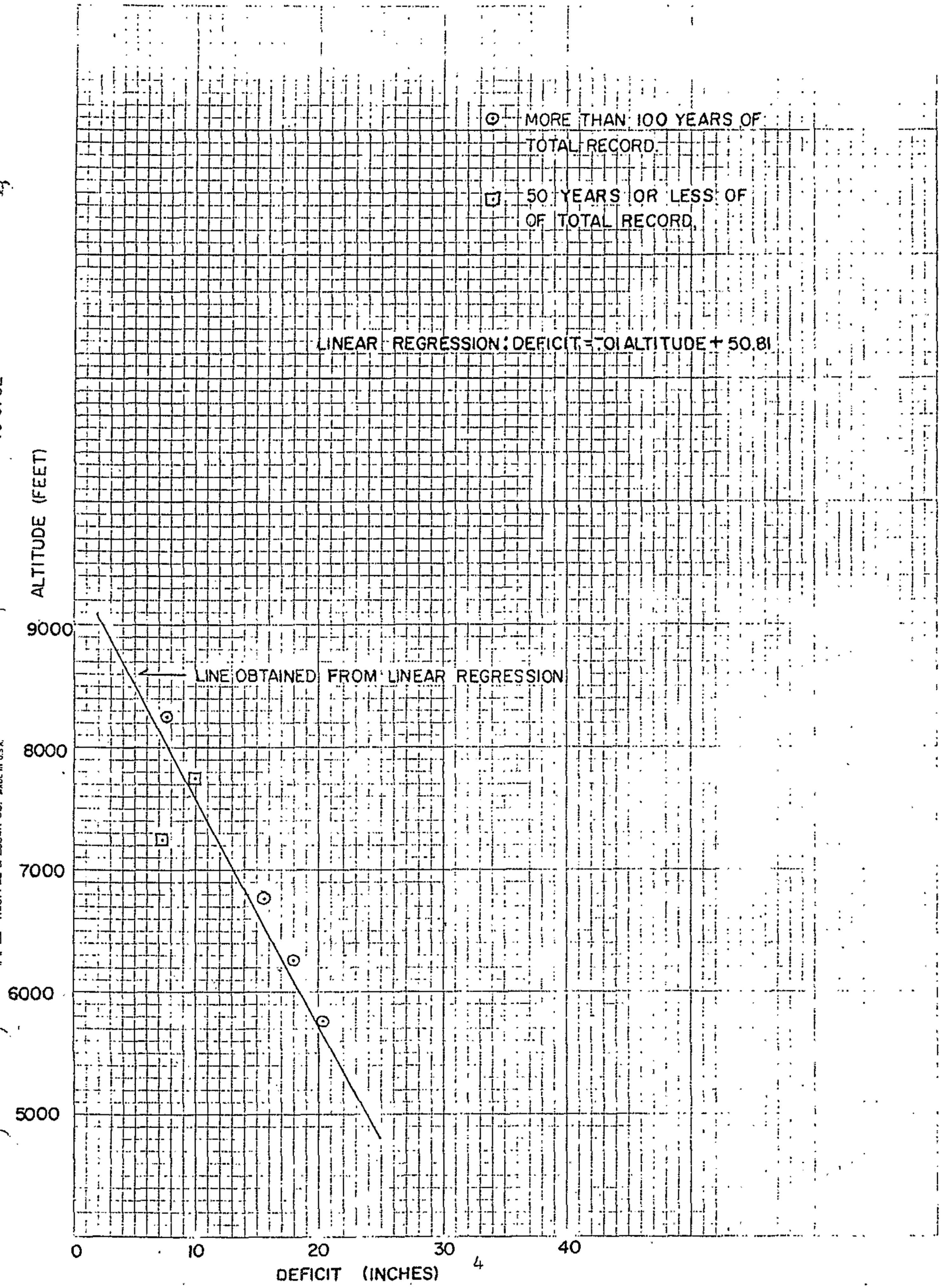
MORE THAN 100 YEARS OF TOTAL RECORD
50 YEARS OR LESS OF TOTAL RECORD
LINEAR REGRESSION: PRECIPITATION=.00145 ALTITUDE+7.06
LINE OBTAINED FROM LINEAR REGRESSION
ALTITUDE (FEET)
10
20
30
40
PRECIPITATION (INCHES)

2

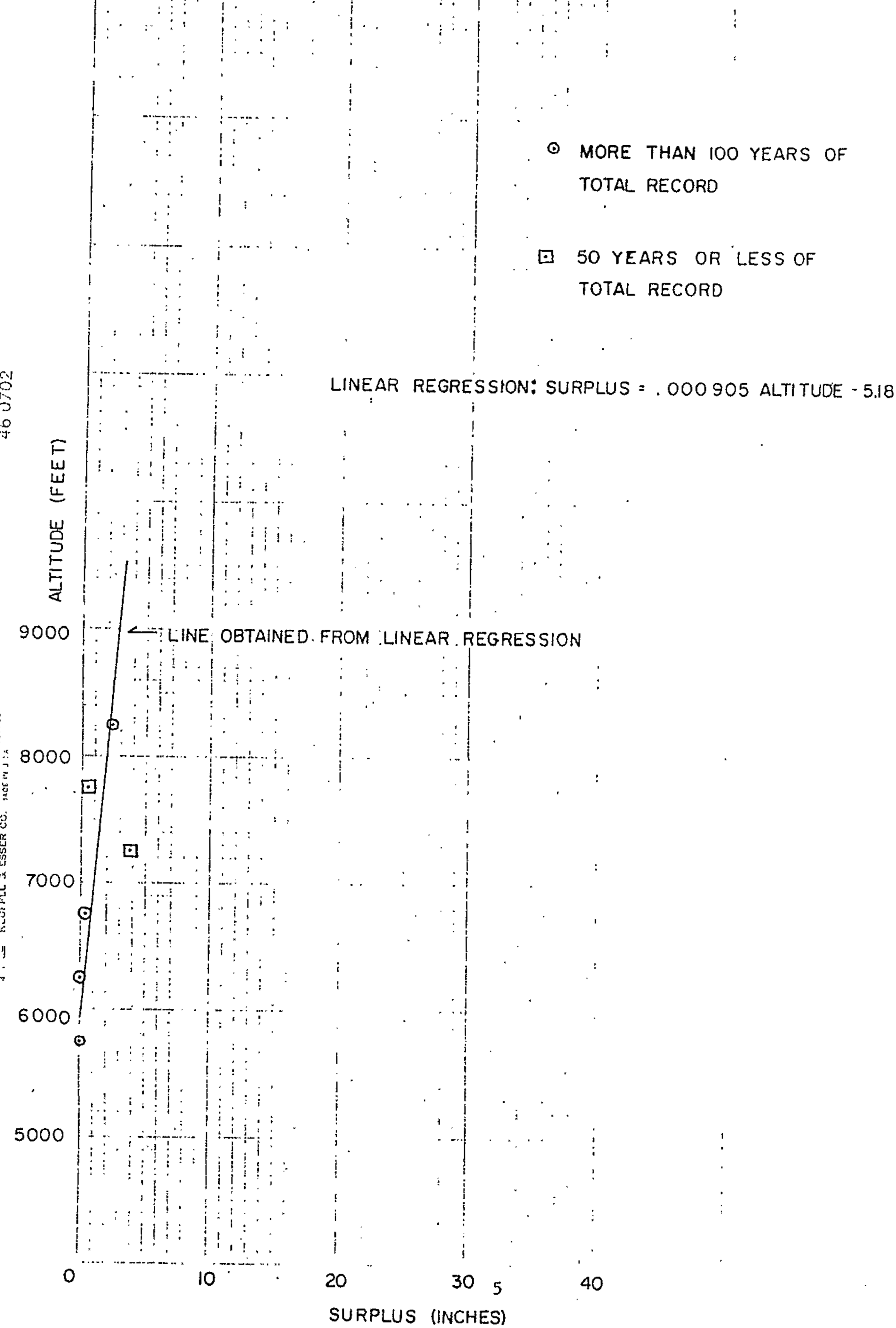


MORE THAN 100 YEARS OF TOTAL RECORD
50 YEARS OR LESS OF TOTAL RECORD
LINEAR REGRESSION: PAN EVAPORATION=-.001 ALTITUDE +67.72
LINE OBTAINED USING LINEAR REGRESSION
ALTITUDE (FEET)
9000
8000
7000
6000
5000
0
10
20
30
40
PAN EVAPORATION (INCHES)

3



MORE THAN 100 YEARS OF TOTAL RECORD.
50 YEARS OR LESS OF OF TOTAL RECORD.
LINEAR REGRESSION: DEFICIT = .01 ALTITUDE + 50.81
LINE OBTAINED FROM LINEAR REGRESSION
ALTITUDE (FEET)
9000
8000
7000
6000
5000
0
10
20
30
40
DEFICIT (INCHES)


MORE THAN 100 YEARS OF TOTAL RECORD
50 YEARS OR LESS OF TOTAL RECORD
LINEAR REGRESSION: SURPLUS = .000905 ALTITUDE - 5.18
LINE OBTAINED FROM LINEAR REGRESSION
ALTITUDE (FEET)
9000
8000
7000
6000
5000
0
10
20
30
40
SURPLUS (INCHES)

Appendix IV-4. Precipitation Data

Appendix IV-4. -- Annual precipitation, departure from mean precipitation, cumulative departure from mean precipitation, 3-year running average precipitation, and 5-year running average at Cimarron, N.M. [36°31'N, 104°55'W, Elev. 6427, NOAA Environmental Data Service Station No. 1813].

Year	Annual average precipitation (inches)	Departure from mean precipitation of 15.44 (inches)	Cumulative departure from mean (inches)	3-year running average (inches)	5-year running average (inches)
1905	21.34	+5.90	+5.90		
1906	14.81	-0.63	+5.27		
1907	13.09	-2.35	+2.92	16.41	
1908	10.10	-5.34	-2.42	12.67	
1909	13.80	-1.64	-4.06	12.33	14.63
1910	10.72	-4.72	-8.78	11.54	12.50
1911	22.95	+7.51	-1.27	15.82	14.13
1912	14.15	-1.29	-2.56	15.94	14.34
1913	18.77	+3.33	+0.77	18.62	16.08
1914	23.99	+8.55	+9.32	18.97	18.12
1915	20.58	+5.14	+14.46	21.11	20.09
1916	14.59	-0.85	+13.61	19.72	18.42
1917	11.42	-4.02	+9.59	15.53	17.87
1918	19.23	+3.79	+13.38	15.08	17.96
1919	26.84	+11.40	+24.78	19.16	18.53
1920	18.31	+2.87	+27.65	21.46	18.08
1921	20.54	+5.10	+32.75	21.89	19.27
1922	10.55	-4.89	+27.86	16.46	19.09
1923	19.09	+3.65	+31.51	16.72	19.07
1924	9.44	-6.00	+25.51	13.03	15.59
1925	13.60	-1.84	+23.67	14.04	14.64
1926	14.64	-0.80	+22.87	12.56	13.46
1927	11.64	-3.80	+19.07	13.29	13.68
1928	14.16	-1.28	+17.79	13.48	12.69
1929	21.37	+5.93	+23.72	15.72	15.08
1930	19.41	+3.97	+27.69	18.31	16.24
1931	12.76	-2.68	+25.01	17.85	15.87
1932	12.10	-3.34	+21.67	14.76	15.96
1933	15.56	+0.12	+21.79	13.47	16.24
1934	10.02	-5.42	+16.37	12.56	13.97
1935	13.84	-1.60	+14.77	13.14	12.86
1936	10.68	-4.76	+10.01	11.51	12.44
1937	12.18	-3.26	+6.75	12.23	12.45
1938	17.05	+1.61	+8.36	13.30	12.75
1939	9.99	-5.45	+2.91	13.07	12.75
1940	17.56	+2.12	+5.03	14.87	13.49

Appendix IV-4. -- Annual precipitation, departure from mean precipitation, cumulative departure from mean precipitation, 3-year running average precipitation, and 5-year running average at Cimarron, N.M. [36°31'N, 104°55'W, Elev. 6427, NOAA Environmental Data Service Station No. 1813]. (cont)

Year	Annual average precipitation (inches)	Departure from mean precipitation of 15.44 (inches)	Cumulative departure from mean (inches)	3-year running average (inches)	5-year running average (inches)
1941	23.66	+8.22	+13.25	17.07	16.09
1942	18.66	+3.22	+16.47	19.96	17.38
1943	13.65	-1.79	+14.68	18.66	16.70
1944	14.94	-0.50	+14.18	15.75	17.69
1945	11.81	-3.63	+10.55	13.47	16.54
1946	16.41	+0.97	+11.52	14.39	15.0[illegible]
1947	13.16	-2.28	+9.24	13.79	1[illegible].99
1948	15.31	-0.13	+9.11	14.96	14.33
1949	16.75	+1.31	+10.42	15.07	14.69
1950	10.62	-4.82	+5.60	14.23	14.45
1951	14.93	-0.51	+5.09	14.10	14.15
1952	13.82	-1.62	+3.47	13.12	14.28
1953	12.16	-3.28	+0.19	13.64	13.65
1954	10.89	-4.55	-4.36	12.29	12.48
1955	15.27	-0.17	-4.53	12.77	13.41
1956	9.02	-6.42	-10.95	11.73	12.23
1957	20.64	+5.20	-5.75	14.98	13.59
1958	19.99	+4.55	-1.20	16.55	15.16
1959	17.37	+1.93	+0.73	19.33	16.46
1960	18.44	+3.00	+3.73	18.60	17.09
1961	16.05	+0.61	+4.34	17.29	18.50
1962	10.42	-5.02	-0.68	14.97	16.45
1963	17.95	+2.51	+1.83	14.81	16.05
1964	8.67	-6.77	-4.94	12.35	14.31
1965	23.34	+7.90	+2.96	16.65	15.29
1966	11.77	-3.67	-0.71	14.59	14.43
1967	17.50	+2.06	+1.35	17.54	15.85
1968	14.01	-1.43	-0.08	14.43	15.06
1969	18.99	+3.55	+3.47	16.83	17.12
1970	11.07	-4.37	-0.90	14.69	14.67
1971	**E16.54	+1.10	+0.20	15.53	15.62
1972*	E20.65	+5.21	+5.41	16.09	16.25
1973	E13.91	-1.53	+3.88	17.03	16.23
1974	12.80	-2.64	+1.24	15.79	14.99
1975	E14.63	-0.81	+0.43	13.78	15.71

* Station moved to 36°28'N, 104°57'E, Elev. 6540.
**E Estimate made by NOAA Environmental Data Service.

Appendix IV-4. -- Annual precipitation, departure from mean precipitation, cumulative departure from mean precipitation, 3-year running average precipitation, and 5-year running average at Raton, N.M. [36°54'N, 105°26'W, Elev. 6660, NOAA Environmental Data Service].

Year	Annual average precipitation (inches)	Departure from mean precipitation of 15.79 (inches)	Cumulative departure from mean (inches)	3-year running average (inches)	5-year running average (inches)
1942	29.53	+13.74	+13.74		
1943	12.53	-3.26	+10.48		
1944	18.96	+3.17	+13.65	20.34	
1945	13.44	-2.35	+11.30	14.98	
1946	16.30	+0.51	+11.81	16.23	18.15
1947	16.13	+0.34	+12.15	15.29	15.47
1948	*(17.41)	+1.62	+13.77	16.61	16.45
1949	(16.37)	+0.58	+14.35	16.64	15.93
1950	12.57	-3.22	+11.13	15.45	15.76
1951	(17.10)	+1.31	+12.44	15.35	15.92
1952	12.30	-3.49	+8.95	13.99	15.15
1953**	(15.76)	-0.03	+8.92	15.05	14.82
1954	9.73	-6.06	+2.86	12.60	13.49
1955	24.43	+8.64	+11.50	16.64	15.86
1956	11.93	-3.86	+7.64	15.36	14.83
1957	23.27	+7.48	+15.12	19.87	17.02
1958	22.71	+6.92	+22.04	19.30	18.41
1959	17.75	+1.96	+24.00	21.24	20.02
1960	16.55	+0.76	+24.76	19.00	18.44
1961	15.09	-0.70	+24.06	16.46	19.07
1962	11.14	-4.65	+19.41	14.26	16.65
1963	12.62	-3.17	+16.24	12.95	14.63
1964	11.14	-4.65	+11.59	11.63	13.31
1965	23.45	+7.66	+19.25	15.74	14.69
1966	14.29	-1.50	+17.75	16.29	14.53
1967	16.95	+1.16	+18.91	18.23	15.69
1968	12.64	-3.15	+15.76	14.63	15.69
1969	21.28	+5.48	+21.24	16.96	17.72
1970	***E17.18	+1.39	+22.63	17.03	16.47
1971	16.03	+0.24	+22.87	18.16	16.82
1972	17.00	+1.21	+24.08	16.74	16.83
1973	17.59	+1.80	+25.88	16.87	17.82
1974	11.04	-4.75	+21.13	15.21	15.77
1975	12.78	-3.01	+18.12	13.80	14.89

* ( ) parenthesis indicates estimate based on data from nearby stations.

** Station moved to 36°55'N, 104°26'W, Elev. 6933.

***E Estimate made by NOAA Environmental Data Service.

Appendix IV-4.-- Annual precipitation, departure from mean precipitation, cumulative departure from mean precipitation, 3-year running average precipitation, and 5-year running average at Springer, N.M. [36°23'N, 104°36'W, Elev. 5857, NOAA Environmental Data Service Station No. 8501].

Year	Annual average precipitation (inches)	Departure from mean precipitation of 14.86 (inches)	Cumulative departure from mean (inches)	3-year running average (inches)	5-year running average (inches)
1905	14.15	-0.71	-0.71		
1906	13.47	-1.39	-2.10		
1907	9.95	-4.91	-7.01	12.52	
1908	11.77	-3.09	-10.10	11.73	
1909	*(20.03)	+5.17	-4.93	13.92	13.87
1910	(9.37)	-5.49	-10.42	13.73	12.92
1911	13.00	-1.86	-12.28	14.14	12.82
1912	9.70	-5.16	-17.44	10.70	12.77
1913	12.55	-2.31	-19.75	11.76	12.93
1914	15.98	+1.12	-18.63	12.75	12.12
1915	15.30	+0.44	-18.19	14.62	13.31
1916	10.19	-4.67	-22.86	13.83	12.74
1917	(12.29)	-2.57	-25.43	12.60	13.26
1918	16.41	+1.55	-23.88	12.97	14.03
1919	17.88	+3.02	-20.86	15.54	14.41
1920	11.90	-2.96	-23.82	15.41	13.73
1921	17.32	+2.46	-21.36	15.71	15.16
1922	14.09	-0.77	-22.13	14.45	15.52
1923	22.35	+7.49	-14.64	17.93	16.71
1924	11.79	-3.07	-17.71	16.09	15.49
1925	14.18	-0.68	-18.39	16.12	15.95
1926	14.53	-0.33	-18.72	13.51	15.39
1927	(13.74)	-1.12	-19.84	14.16	15.32
1928	13.52	-1.34	-21.18	13.94	13.55
1929	(17.31)	+2.45	-18.73	14.87	14.66
1930	(18.19)	+3.33	-15.40	16.35	15.46
1931	14.38	-0.48	-15.88	16.64	15.43
1932	10.48	-4.38	-20.26	14.36	14.78
1933	17.42	+2.56	-17.70	14.10	15.56
1934	8.33	-6.53	-24.23	12.09	13.76
1935	17.73	+2.87	-21.36	14.50	13.67
1936	9.45	-5.41	-26.77	11.85	12.68
1937	11.58	-3.28	-30.05	12.93	12.90
1938	(18.95)	+4.09	-25.96	13.34	13.21
1939	13.47	-1.39	-27.35	14.68	14.24
1940	15.23	+0.37	-26.98	15.89	13.74
1941	29.42	+14.56	-12.42	19.38	17.73

Appendix IV-4.-- Annual precipitation, departure from mean precipitation, cumulative departure from mean precipitation, 3-year running average precipitation, and 5-year running average at Springer, N.M. [36°23'N, 104°36'W, Elev. 5857, NOAA Environmental Data Service Station No. 8501].(cont)

Year	Annual average precipitation (inches)	Departure from mean precipitation of 14.86 (inches)	Cumulative departure from mean (inches)	3-year running average (inches)	5-year running average (inches)
1942	25.49	+10.63	-1.79	23.39	20.51
1943	12.14	-2.72	-4.51	22.36	19.15
1944	14.25	-0.61	-5.12	17.30	19.31
1945	(10.51)	-4.35	-9.47	12.31	18.36
1946	20.67	+5.71	-3.76	15.15	16.61
1947	14.88	+0.02	-3.74	15.36	14.49
1948	16.95	+2.09	-1.65	17.51	15.45
1949	18.59	+3.73	+2.08	16.82	16.[illegible]
1950	13.12	-1.74	+0.34	16.23	16.[illegible]1
1951	14.25	-0.61	-0.27	15.33	[illegible]
1952	12.59	-2.27	-2.54	13.33	15.1[illegible]
1953	11.88	-2.98	-5.52	12.92	14.[illegible]
1954	10.68	-4.18	-9.70	11.73	12.56
1955	19.30	-4.44	-14.14	13.96	13.74
1956	5.82	-9.04	-23.18	11.94	12.05
1957	22.35	+7.49	-15.69	15.82	14.01
1958	19.29	+4.43	-11.26	15.82	15.49
1959	18.89	+4.03	-7.23	20.18	17.13
1960	19.70	+4.84	-2.39	19.29	17.21
1961	18.64	+3.78	+1.39	19.08	19.77
1962	8.06	-6.80	-5.41	15.47	1[illegible].92
1963	13.87	-0.99	-6.40	13.52	15.83
1964	9.64	-5.22	-11.62	10.52	13.98
1965	15.86	+1.00	-10.62	13.12	13.21
1966	15.39	+0.53	-10.09	13.63	12.56
1967	19.53	+4.67	-5.42	16.93	14.86
1968	10.65	-4.21	-9.63	15.19	14.21
1969	23.19	+8.33	-1.30	17.79	16.92
1970	**E11.99	-2.87	-4.17	15.28	16.15
1971	14.43	-0.43	-4.60	16.54	15.96
1972	18.25	+3.39	-1.21	14.89	15.70
1973	E13.58	-1.28	-2.49	15.42	16.29
1974	E12.96	-1.90	-4.39	14.93	14.24
1975	13.04	-1.82	-6.21	13.19	14.45

*( ) parenthesis indicates estimate based on data from nearby stations.

**E estimate made by NOAA Environmental Data Service.

Appendix IV-4. -- Annual precipitation, departure from mean precipitation, cumulative departure from mean precipitation, 3-year running average precipitation, and 5-year running average at Eagle Nest(Therma) B, N.M. [36°33'N, 105°16'W, Elev. 828[illegible]. NOAA Environmental Data Service].

Year	Annual average precipitation (inches)	Departure from mean precipitation of 14.61 (inches)	Cumulative departure from mean (inches)	3-year running average (inches)	5-year running average (inches)
1934	13.75	-0.86	-0.86		
1935	20.81	+6.20	+5.34		
1936	19.91	+5.30	+10.64	18.16	
1937	18.52	+3.91	+14.55	19.75	
1938	16.09	+1.48	+16.03	18.17	17.82
1939	10.45	-4.16	+11.87	15.02	17.16
1940	18.89	+4.28	+16.15	15.14	16.77
1941	19.00	+4.39	+20.54	16.11	16.59
1942	16.04	+1.43	+21.97	17.98	16.09
1943	*(15.53)	+0.92	+22.89	16.86	15.98
1944	13.97	-0.64	+22.25	15.18	16.69
1945	14.02	-0.59	+21.66	14.51	15.71
1946	14.05	-0.56	+21.10	14.01	14.72
1947	14.04	-0.57	+20.53	14.04	14.32
1948	(15.88)	+1.27	+21.80	14.66	14.39
1949	14.67	+0.01	+21.81	14.85	14.52
1950	12.52	-2.09	+19.72	14.34	14.22
1951	13.92	-0.69	+19.03	13.69	14.20
1952	11.95	-2.66	+16.37	12.80	13.78
1953	12.00	-2.61	+13.76	12.62	13.00
1954	9.20	-5.41	+8.35	11.05	11.92
1955	13.16	-1.45	+6.90	11.45	12.05
1956	6.94	-7.67	-0.77	9.77	10.65
1957	19.92	+5.31	+4.54	13.34	12.24
1958	10.11	-4.50	+0.04	12.32	11.87
1959	15.99	+1.38	+1.42	15.34	13.22
1960	(16.06)	+1.45	+2.87	14.05	13.80
1961	(17.88)	+3.27	+6.14	16.64	15.99
1962	**E 9.89	-4.72	+1.42	14.61	13.99
1963	E16.11	+1.50	+2.92	14.63	15.19
1964	E16.91	+2.30	+5.22	14.30	15.37
1965	E16.98	+2.37	+7.59	16.67	15.55

Appendix IV-4. -- Annual precipitation, departure from mean precipitation cumulative departure from mean precipitation, 3-year running average precipitation, and 5-year running average at Eagle Nest (Therma) B, N.M. [36°33'N, 105°16'W, Elev. 8280, NOAA Environmental Data Service].(cont)

Year	Annual average precipitation (inches)	Departure from mean precipitation of 14.61 (inches)	Cumulative departure from mean (inches)	3-year running average (inches)	5-year running average (inches)
1966	E14.48	-0.13	+7.46	16.12	14.87
1967	E16.70	+2.09	+9.55	16.05	16.24
1968	E11.12	-3.49	+6.06	14.10	15.24
1969	21.76	+7.15	+13.21	16.53	16.21
1970	10.42	-4.19	+9.02	14.43	14.89
1971	12.99	-1.62	+7.40	15.06	14.60
1972	12.06	-2.55	+4.85	11.82	13.67
1973	E12.76	-1.85	+3.00	12.60	14.00
1974	E15.91	+1.30	+4.30	13.58	12.83
1975	E14.43	-0.18	+4.12	14.37	13.63

*(   ) parenthesis indicates estimate based on data from nearby stations.

**E estimate made by NOAA Environmental Data Service.

Appendix IV-5.--Drill Hole Logs

Appendix IV-5.

NEW MEXICO OIL CONSERVATION COMMISSION J #7493

Company: Columbine Oils, Inc. Well No.: 1 Lease: George S-T-R: 13-23N-21E

Location: 1980 Fr. S L 1980 fr. E L

County: Colfax

Spud: 3-16-58 Comp. 03-58

Field: Wildcat

Total Depth: 1507' od P. B. Top Pay

CSG. RECORD

Size	Depth	Sax
7	65	20

I. P.

Ch. on Tbg. @ Press: T.

C. Pkr. Gor. Gr.

Wtr well for rancher
wtr at 945-1120

Shows: G/sul G above 1000' depth not reported

Treatments

FORMATION RECORD

Elev. ?DF T

T Greenhorn 716'
T Dakota 1060'
BX T
T Morrison 1120'
T T
T T
T T
T TGr.

6259 — Artesia Printing Co.

Appendix IV-5.

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

WELL LOG DIVISION

LOG NO. 7493
COUNTY: Colfax
FIELD: Wildcat
COMPANY: Columbine Oils, Inc.
LEASE: George Well No. 1
LOCATION (1/4) C-NW SE
1980 feet from the South line and
1980 feet from the East line
SEC. 13, T. 23 N., R. 21 E.
COMMENCED: d March 16, 1958
COMPLETED: April 16, 1958
ABANDONED:
REMARKS: Rotary tools were used from surface to 1607 feet TOTAL DEPTH.

ELEVATION: ?
IP: Completed as a Water Well

CASING RECORD Diam. in./ Bottom		
7	65	20

FORMATION	BOTTOM, FEET
Topsoil	2
Clay, brown	23
Shale, Niobrara	742
Lime, Timpas	764
Shale, Carlile	945
Sandstone, Dakota	1120
Sandy, variegated shale, Morrison	1520
Hard, tight sandstone, Entrada	1580
Red sandy shale, Chinle -- T. D. --	1607

LOG NO. 9023

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD Diam. in/Bottom	
7	120
4 1/2	1171

ELEVATION: 5984 Grd.
IP: D & A

COUNTY: Colfax
FIELD: Wildcat
COMPANY: Kelly Bell
LEASE: 1 Fernandez Montoya
LOCATION: 1980 from S line
1980 from E line
SEC: 14 T. 23N R. 21E
COMMENCED: 12-13-72
COMPLETED: 1-11-73
Remarks: Rotary Tools 0-1171'

FORMATION	BOTTOM, FEET
Surf sh and sand	352
Niobrara shale	510
Ft. Hays lm & shale	565
Gray shale	748
Greenhorn	810
Carb. shale	966
Dakota sand & shale	1146
Morrison and shale	1171 T.D.

GEOLOGIC TOPS

FORMATION	BOTTOM, FEET
B. Greenhorn	810
Dakota	966
Morrison	1146

Appendix IV-5.

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES LOG 57

COMPANY	WELL NO.	LEASE	S-T-R
The California Co.	1	Floersheim-State	15-23N-24E

Location 250 fr. S L 250 fr. W L

Spud 7-5-24 Comp. 1-22-25

Total Depth 2556 P. B. Top Pay

I. P. Abd. per day

Remarks: Water at 151, 204, 360, 600, 627, 1509, 1979.

CO_2 — $\frac{1}{4}$ million cu. ft./24 at 1510'

$\frac{1}{2}$ million cu. ft./24 1510'-1560'

67% CO_2, 28.7% N, 4.1% O, .2% Helium

USGS shows operator as Std. of California

Kir
PE

Shot or Acid:

T PC Granite 2095

Samples No Spl. Desc. 0-2157 Stanolind

Tops from Prelim. Map 141

County Colfax

Field Jaritas Dome

CSG. RECORD

Size	Depth	Sax
20	159	
15½	497	
12½	1361	

Tbg. at

FORMATION RECORD

Elev. 5823 Est.

K	Graneros	0-35'
T	Dakota	35'
T	Purgatoire	72'
T	Morrison	218'
T	Wanakah	550'
T	Ocate	580'
T	Dockum	640'
T	Sangre de Cris	1710'

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD Diam. in	Bottom
20	159'
15 1/2	497'
12 1/2	1361'

ELEVATION:
IP: D&A

COUNTY: Colfax
FIELD: Wildcat
COMPANY: The California Com.
LEASE: Floersheim St. Propt. #1
LOCATION: SW 1/4 from Line
Cor. SW 1/4 from Line
SEC: 15 T. 23N R. 24E
COMMENCED: 7-5-24
COMPLETED: 1-22-25
ABANDONED: 3-2-25

FORMATION	BOTTOM, FEET
Yellow clay Dakota	15
Dark blue clay	25
Yellow and blue clay	30
Dark sandy shale	35
Dark sand and lime	38
Hard sand and pyrites of iron	44
Hard white sand	52
White sand	74
Dark clay	87
Sandy shell	90
Hard sand	96
White sand, hard	100
Gray sand	115
Blue clay	118
Hard white sand	146
Dark slate	151
Dark slate and gravel making 30 barrels fresh water per 24 hours	154
Hard white sand	204
Blue sandy shale making 1 barrel of water	212
White sandy lime	220
Broken lime	225
Sandy blue shale and shells	237
Sandy blue shale and hard shells	257
Blue and brown shale and shells	285
Hard sand	294
Blue sandy shale and hard shells	300
Hard sand	305
Blue sandy shale and hard shells	325
Brown shale	330
Brown shale and hard shells	335
Blue shale and hard shells	345
Brown shale and hard shells	360
Blue shale and sandy shells, water	368
Brown shale and hard shells	395
Brown and blue shale and hard shells	481
Brown and blue shale	492
Brown shale and hard shells	497
Brown and blue shale and hard shells	600
Soft white sand, water	627
Soft pink sand, water Wingate	705
Red bed and hard shells	840
Hard gray sand	890
Red bed and hard shells	997
Red bed and mud	1009
Red bed and hard shells	1025
Blue slate	1027
Brown shale	104[illegible]
Hard shell	10[illegible]
Red bed	1070
Hard shells	1073
Blue sand, hard	1115
Hard blue sand	1118
Red bed	1140
Red sand, hard	1143
Red bed	1146
Red bed and hard shells	1149
Red bed	1268
Shell	1270
Red bed	1275
Red bed and hard shells	1287
Blue and brown shale	1298
Red beds and hard shells	1394
Hard white sand, sharp (Encountered dry gas at 1509' making about 1/4 M. cubic feet)	1509
Light gray sandy containing water and some gas (water flowing about 1000 bbls. fresh water per 24 hours)	1510

FORMATION	BOTTOM, FEET	FORMATION	BOTTOM, FEET
Light gray sand	1523		
Hard white sand	1560		
Soft white sand	1603		
Hard white sand	1710		
Very hard white sand	1718		
Hard gray sandy lime	1755		
Very hard white sand	1779		
Hard gray sandy lime	1800		
Hard sandy red bed	1915		
Hard gray lime	1920		
Hard light brown sand	1967		
Hard pink sand	1979		
Hard light brown sand, some water, slightly salty	1984		
Hard light pink sand	2045		
Very hard light pink sand	2119		
Hard gray sand	2123		
Hard light pink sand	2130		
Very hard light pink sand	2137		
Hard light pink sand	2195		
Very hard light pink sand	2345		
Hard light pink sand	2430		
Dark gray sand, limy	2432		
Hard light pink sand	2529		
Very light pink hard sand	2537		
Hard light pink sand	2556 T.D.		

A gas bearing formation was encountered from 1509' to 1510' making about 1/4 million cubic feet of dry, noninflammable gas per 24 hours. As the depth increased the flow of Gas increased until the well was making 1/2 million cubic feet per day, at a depth of1560! With further increases in depth, the flow decreased in volume.

Water was encountered at 151'-204'-360'-600'-627'-1509'-1979'.

Pink sands determined as granite.

Appendix IV-5.

MCDANIEL OIL LEASE TRUST #1 McDaniel & Sons, Inc. 32-24N-20E

COMPANY WELL NO. LEASE S T R

Loc. 660 fr. N L 660 fr. E L County Colfax

Spud. 8-5-66 Comp. 9-9-66 Field Wildcat

T.D. 5204 P.B. T.Pay

I.P. P & A

Remarks: Drilled with rotary tools

[illegible]

Treatment:

CSG. RECORD

Size	Depth	Sax
13-3/8	196	20[illegible]
9-5/8	1542	10[illegible]

Tbg. at

FORMATION RECORD

Elev. 6342

T. Nibbrara	Surf.
T. Smokey Hills Mem.	"
T. Timpas Member	326
T. Carlile Shale	422
T. Greenhorn	598
T. Graneros	660
T. Dakota	832
T. Upper Dakota	832
T. Middle Dakota	876

Appendix IV-5.

Information From: C-101
" C-105

Lower Dakota	919
Morrison	988
Upper Morrison	988
Middle Morrison	1167
Lower Morrison	1328
Entrada	1368
Chinle	1435
Santa Rosa	1972
Bernal	2130
Glorieta Sandstone	2198
Sangre de Cristo	2414
Magdalena Group	3817

Appendix IV-5.

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES. LOG 59

COMPANY	WELL NO.	LEASE	S-T-R
Frontier Oil Co.	1	Chico	6-24N-25E

Location 1250 fr. N L 600 fr. W L

Spud 6-2-27 Comp. 10-5-27

Total Depth 1326 P. B. Top Pay

I. P. Abd. per day

Remarks: Water 560', salt water at 735'

Shot or Acid:

Tops from Prelim Map 1141

County Colfax

Field Chico Dome

CSG. RECORD

Size	Depth	Sax

Tbg. at

FORMATION RECORD

Elev. 6186 GL

	Formation	Depth
X	Graneros	0-180
T	Dakota	180
T	Purgatoire	240
T	Morrison	300
T	Wanakah	680
T	Ocate	735
T	Dockum	760
T	PC- Granite	1302

Appendix IV-5. LOG NO. 59

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD
Diam. in/Bottom

ELEVATION:
IP: D&A

COUNTY: Colfax
FIELD: Wildcat
COMPANY: Fletcher Oil Co. (Frontier Oil Co.)
LEASE: Chico Structure #1
LOCATION: NW 1/4 from Line
NW 1/4 from Line
SEC: 6 T. 24N R. 25E
COMMENCED:
COMPLETED:

FORMATION	BOTTOM, FEET	FORMATION	BOTTOM, FEET
Clay to rock	18	Pink lime	535
Shell	20	White sandy lime	550
Brown mud	24	Sandy lime	560
Shell	26	Water sand	570
Brown mud	34	Lime	575
Hard shale	40	Pink lime	580
Hard brown shale	50	Shale	585
Hard brown shale	70	Pink lime	600
Hard brown shale	80	Pink lime	630
Brown shale	110	Pink lime	660
Brown shale	125	Sandy shale	680
Brown shale	140	Brown lime	695
Brown shale	148	Pink lime	735
Shell	150	Salt water sand, carrying	
Brown shale	160	strong salt water	760
Brown shale	180	Red rock	800
Sand and hard shale	190	Red rock	840
Sand	205	Pink lime	850
Hard sand	215	Red rock	880
Hard sand	230	Gray shale	900
Hard sand	235	Gray lime	915
Soft shale	240	Red rock	1060
Hard sand	250	Pink lime	1085
Hard sand, very sharp	270	Pink lime	1100
Hard sand	290	Gray lime	1104
Shale	295	Red rock	1205
Sand	300	Red rock mud	1207
Sandy lime	330	Shell	1214
Blue shale	445	Red rock	1231
Sandy lime	460	Pink lime	1237
Hard shell	466	Gray shale	1245
Sandy lime	475	Variegated shales	1260
Red rock	480	Blue clay	1265
Sandy lime	490	White clay	1268
Water sand	495	White mud	1275
Blue shale	500	Light sandy lime	1295
Hard shell	505	Lime shell	1297
Blue lime	515	Blue and black shale	1300
Sandy lime	520	Sandy lime shell	1302
Soft white lime	525	Light pink granite	1326 T.D.

Appendix IV-5.

LOG NO. 9214

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD
Diam. in/Bottom

8 5/8	320
4 1/2	2325

ELEVATION: 6172'RAB
IP: P & A

COUNTY: Colfax
FIELD: Wildcat
COMPANY: Amoco Production Company
LEASE: 1 State FA
LOCATION: 1980 from N line
660 from W line
SEC: 29 T. 24N R. 27E
COMMENCED: 7-13-73
COMPLETED: 9-3-74
Remarks: Rotary Tools 0 - 2325

FORMATION	BOTTOM, FEET	
Surface	300	
Sand & Shale	1835	
Shale & Dolomite	1920	
Shale & Sand	2135	
Sand	2325	T.D.

GEOLOGIC TOPS

FORMATION	BOTTOM, FEET
San Rosa	1380
San Andres	1765
Glorieta	1832
Gr. Wash	2280
Granite	2300

Appendix IV-5.

NEW MEXICO OIL CONSERVATION COMMISSION

Orris R. Hodges & Helen S. Mackie — Well No. 1 — Lease: McDaniel Investment Co.-MB — S-T-R: 36-25N-18E

Location	660'	Fr. N. L	660'	fr. E. L	County: Colfax
Spud	8-15-56	Comp.	9-23-56		Field: Wildcat
Total Depth	657' sd	P. B.		Top Pay	
I. P.					
Ch.	on	Tbg. @		Press: T.	
C.	Pkr.	Gor.		Gr.	

CSG. RECORD

Size	Depth	Sax
13 3/8	29	17

WATER WELL

String of Tools in hole. Completed as water well

Treatments

FORMATION RECORD

Elev. 6892'	T
T	T
T	T
BX	T
T	T
T	T
T	T
T	T
T	T Gr.

5175 — Artesia Printing Co.

Appendix IV-5.

NEW MEXICO OIL CONSERVATION COMMISSION

Company	Well No.	Lease	S-T-R
Orris R. Hodges	1	McDaniel-Mackie	18-25N-20E

Location 2740' Fr. S. L 330' fr. W. L — County Colfax

Spud 7-15-56 Comp. 9-23-56 — Field Wildcat

Total Depth 1423' el P. B. Top Pay

I. P.

Ch. on Tbg. @ Press: T.

C. Pkr. Gor. Gr.

TEMPORARILY ABANDONED

No DST'S or Cores

Treatments

CSG. RECORD

Size	Depth	Sax
13 3/8	28	set

FORMATION RECORD

Elev. 6735' T

Dakota 1397'

T T

BX T

T T

T T

T T

T T

T T Gr.

5175 — Artesia Printing Co.

over

Appendix IV-5.

SEP 26 1966

Field check of This well by J. A. Smythe, Denver
consulting Geologist revealed This information July 1962
Location: 2625' N, 275' W. lines Sec. 18
Elevation: Ground 6365' ASL.
Bottom in Dakota, 1225' of water standing in hole.
well stands Plugged & Abandoned.

SAMPLES 30 - 1423

Appendix IV-5. LOG NO. 9021

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD Diam. in/Bottom		ELEVATION:	5974 Grd.		
7	90	IP:	D & A		

COUNTY: Colfax
FIELD: Wildcat
COMPANY: Kelly Bell
LEASE: #1 C.S. Cattle Company
LOCATION: 1980 from S line
1980 from E line
SEC: 21 T. 25N R. 21E
COMMENCED: 12-13-72
COMPLETED: 1-6-73
Remarks: Rotary Tools 0-1216

FORMATION	BOTTOM, FEET	
Surf sh & sand	100	
Gray sh	384	
Niobrara sh	554	
Ft. Hays	590	
Gray sh	778	
Greenhorn	832	
Graneros sh	1010	
Dalota sand & sh	1187	
Morrison sand & sh	1216	T.D.

GEOLOGIC TOPS

FORMATION	BOTTOM, FEET
Base Greenhorn	832
Dakota	1010
Morrison	1187

Appendix IV-5.

NEW MEXICO OIL CONSERVATION COMMISSION

Company: Lyle A. Carner	Well No.: 1	Lease: Mesa Ranch Co.	S-T-R: 27-25N-21E
Location: 1650 Fr. N L, 990 fr. W L		County: Colfax	
Spud: 4-16-57	Comp.: 4-26-57	Field: Wildcat	
Total Depth: 1186' sh	P. B.	Top Pay	
I. P.			
Ch.	on	Tbg. @	Press: T.
C.	Pkr.	Gor.	Gr.

CSG. RECORD

Size	Depth	Sax
8 5/8	92	50

Core 1036-1121 rec 35' sd & sh, Core 1146-86, rec 40' sh.

Rancher is to take this well over for a water well.

Treatments

FORMATION RECORD

Smpl.
Elev. 6000'? T
Dakota 1060'
T T
BX T
T T
T T
T T
T T
T TGr.

5175 — Artesia Printing Co.

Appendix IV-5.

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

WELL LOG DIVISION

Log No. 7409

COUNTY Colfax
POOL Wildcat
COMPANY Lyle A. Garner
LEASE Mesa Ranch Co. Well No. 1
LOCATION (¼) SE NW
SEC. 27, T. 25 N., R. 21 E.
1650 feet from North line and
990 feet from West line.
COMMENCED April 18, 1957
COMPLETED April 27, 1957
ABANDONED
REMARKS: Plugged & Abandoned

CASING RECORD
Diam. in/Bottom

8-5/8" 92' 50

Elev. 6000'
IP: none

FORMATION	BOTTOM, FEET	FORMATION	BOTTOM, FEET
Hard sandy shale - brown color	255		
Sand	350		
Hard dark shale	1086		
Sand & green shale	1148		
Green shale & grey sand with red streaks to bottom 1186	1186		

Note -- This well was converted to water well by land owner.

Appendix IV-5.

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES LOG 5022.

Winston Marks	1	Sierracita State	5-25N-24E
COMPANY	WELL NO.	LEASE	S-T-R

Location 1980 fr. N L 1980 fr. W L

Spud 2-7-38 Comp. 3-31-39

Total Depth 1650 P. B. Top Pay

I. P. Abd. per day

Remarks:

Water 1056'

SO 660-65, 905-10, 990-1025

SG 1535-43

Shot or Acid:

Spl. 0-1570 skippy Spl. Desc. 0- 1570RLB

County Colfax

Field Rita del Plano Ant

CSG. RECORD

Size	Depth	Sax

Tbg. at

FORMATION RECORD

Elev. 6109

T See back of card

T for tops.

T

T

T

T

T

T

Appendix IV-5.

Tops by RLB

Timpas	0-45
Carlile	45
Greenhorn	265
Graneros	295
Dakota	420
Morrison	590?
Navajo	755
Wingate	955?
Chinle	1040?

[illegible] 0 – 15-70

LOG NO. 5022

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD
Diam. in/Bottom

ELEVATION: 6109'
IP: P&A

COUNTY: Colfax
FIELD: Wildcat
COMPANY: Winston-Marks
LEASE: State #1
LOCATION: 1980 from N Line
1980 from W Line
SEC: 5 T. 25N R. 24E
COMMENCED: 2-7-38
COMPLETED: 5-1940

FORMATION	BOTTOM, FEET
Top Dakota	415
Top Sundance	990
Lime	992
Brown sand	1003
Gray lime	1029
Red rock	1056
Lime, water	1060
Lime, caving	1062
	1073
Red beds and lime	1125
Sandy lime	1135
Red beds	1138
Hard sand	1155
Black slate	1160
Black slate and lime	1180
Red bed and lime	1215
Red beds	1265
Red rock and lime	1305
Red rock	1312
Brown sandy lime	1330
Hard sandy lime	1345
Gray lime	1395
Red rock	1400
Gray lime	1414
Gray lime and broken red rock	1440
Red rock	1460
Red beds and lima shale	1470
Red rock, caving	1485
White sand	1490
Red beds and lime shale	1515
Gray lime, SG	1543
Gray lime	1560
Gray sandy lime	1575
	1650 T.D.

Formation Tops by Driller.

LOG NO. 9020

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD Diam. in/Bottom	
7	150

ELEVATION: 6067 Grd.
IP: D & A

COUNTY: Colfax
FIELD: Wildcat
COMPANY: Kelly Bell
LEASE: #1 New Mexico State
LOCATION: 1980 from S line
1980 from E line
SEC: 6 T. 25N R. 24E
COMMENCED: 1-12-73
COMPLETED: 2-14-73
Remarks: Rotary Tools 0-1565'

FORMATION	BOTTOM, FEET
Ft Hays sh & li	20
Gray sh	214
Greenhorn	266
Graneros sh.	430
Dakota and sh	595
Morrison snd & sh	986
Entrada sand	1070
Dookum sand & sh	1208
Red sh	1398
Dolomite	1418
Purple sh. sand, anhy	1565 T.D.

GEOLOGIC TOPS

FORMATION	BOTTOM, FEET
B. Greenhorn	266
Dakota	430
Morrison	595
Entrada	986

Appendix IV-5.

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NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES — LOG 61

COMPANY	WELL NO.	LEASE	S-T-R
W. D. Weathers et al	1		7-25N-24E

Location SE¼ SW¼ fr. L fr. L

Spud 3-4-27 Comp. 6-25-27

Total Depth 1097' P. B. Top Pay

I. P. D & A per day

Remarks: Water 1012, 1078

Also known as Fargo Western Oil Co. #1 Weathers

County Colfax

Field Rita del Plano Ant.

CSG. RECORD

Size	Depth	Sax
5 3/16	612	

Tbg. at

Shot or Acid:

Tops-Source unknown

Apishapa	Surface
Mancos	35'
Dakota	431
Purgatoire	613
Morrison	673
Wingate & Navajo	747
Chinle	860
Santa Rosa	1012

FORMATION RECORD

Elev. 6050

Carlile	0-188'
Greenhorn	188
Graneros	227
Dakota	430
Purgatoire	558
Morrison	620
Wanakah	958
Ocate	1012

LOG NO. 61

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD	
Diam. in/Bottom	
5 3/16	612'

ELEVATION:
IP: D&A

COUNTY: Colfax
FIELD: Rito del Piano
COMPANY: W.D. Weathers et al
LEASE: #1
LOCATION: SE SW from Line
from Line
SEC: 7 T. 25N R. 24E
COMMENCED: 3-4-27
COMPLETED: 6-25-27

FORMATION	BOTTOM, FEET
Surface	5
Gray shale	35
Black shale, partings of lime	100
Black shale, partings of lime	421
Hard black shale, top of Dakota	431
Hard gray coarse sand	457
Black shale	467
White sandstone	472
Black shale and streaks of White sand	507
White coarse sandstone	528
Black shale and streaks of sandstone	562
White sandstone soft in spots	612
White almost crystallized sandstone (set 612' 5-3/16" casing)	613
Sandstone, shaley and limy in spots	629
Sandy shale	639
Shale	643
Gray sandy shale	644
Red shale and sand conglomerate	648
Blue sandy shale	651
Shaley sandstone	660
Sandy shale	667
Sandy lime	673
Soft pink shale	679
Lime	682
Pink sandy shale	683
Gray sandy shale	684
Pink sandy shale	685
Gray sandy shale	687
Pink sandy shale	697
Shaley sandstone	709
Blue shaley sandstone	710
Gray sandstone with partings of lime	712
Blue shale and streaks of sand	715
Lime	718
Gray sandy shale	721
Gray limey shale	734
Gray lime	738
Red shale	741
Gray limey shale	747
Hard white sandstone	759
Hard white sandstone, streaks of shale	784
Hard crystallized sandstone, streaks of red shale	802
Hard sandy shale	807
Sandstone with red shale in small streaks	819
Hard crystallized sandstone	822
Hard broken-up sand, crystallized	833
Hard sand	837
Blue sandy shale	841
Hard crystallized sandstone	849
Hard crumbly white sand	850
Hard crystallized sandstone	860
Red sandy shale	867
Red sandy shale and streaks of hard white sandstone	958
Red and gray sandy shale with few gypsum streaks	990
Sandy gray shale, top of Morrison	1012
Soft white sandstone bearing water	1078
Soft white sandstone bearing water	1088
Sandstone becoming harder and seemingly dier.	1097
Hole abandoned	1097 T.D.

Drilling Contractor:
Mineral Exploration Company
Denver, Colorado.
Tools used: Core Diamond Drill.

LOG NO. 9168

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD
Diam. in/Bottom

Diam. in	Bottom
8 5/8	317
4 ½	2238

ELEVATION: 6609 KB
IP: P.B to 650' and left as a water well.

COUNTY: Colfax
FIELD: Wildcat
COMPANY: Amoco Production Company
LEASE: 1 State EX
LOCATION: 1980 from N line
660 from E line
SEC: 14 T. 25N R. 25E
COMMENCED: 7-22-73
COMPLETED: 9-2-74
Remarks: Rotary Tools 0 - T.D.

FORMATION	BOTTOM, FEET
Sand & Shale	1024
Lime & Shale	1255
Sand & Shale	1820
Sand	1829
Core	2026
Sand	2113
Sand & Shale	2240 T.D.

GEOLOGIC TOPS

FORMATION	BOTTOM, FEET
Dakota	586
San. Rosa	1462
Permian	1635
Glorieta	173
Yeso	2025
Gr. Wash	2202
Granite	2215

Appendix IV-5.

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NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES LOG

COMPANY	WELL NO.	LEASE	S-T-R
Decker et. al	1		26-25N-25E

Location NW¼ SE¼ fr. L fr. L	County Colfax
Spud Comp. 1924	Field
Total Depth 640' P. B. Top Pay	CSG. RECORD
I. P. D & A per day	Size Depth Sax
Remarks:	
	Tbg. at
	FORMATION RECORD
	Elev.
	T
	T
	T
	T
Shot or Acid:	T
	T
	T
	T

Appendix IV-5.

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NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES LOG 4994

COMPANY	WELL NO.	LEASE	S-T-R
American Mfg. Co. of Texas	1	W. S. Ranch	1-26N-20E

Location 975 fr. N L 302 W. L

Spud 12-16-45 Comp. 5-23-46

County Colfax

Field

Total Depth 3825 P. B. Top Pay

I. P. P & A per day

Remarks:

6" of solid granite was reported to have been cored at 3824½-25

Shot or Acid:

Samples 200-3314

Spl. Desc. 0-3314 Spl. log plotted

CSG. RECORD

Size	Depth	Sax
10 3/4	200	

Tbg. at

FORMATION RECORD

Elev. 6400 log

T For tops see back of card.

T

T

T

T

T

T

T OVER

	RCN	Perm. Basin Spl. Lab.	
Pierre	surface		0-1325
Apishipa	1355	Niobrara	1325
Timpas	1799		
Carlisle	1865		
Greenhorn	2020		2030
Graneros	2068		2070
Dakota	2230		2225
Morrison	2430	Purgatoire	2470
Todilto	2750	Morrison	2510
Wingate	2790	Todilto	2750
Chinle	2880	Wingate	2770
Santa Rosa	3120	Chinle	2880

Source unknown

Granite wash	3806
Granite	3814

Samples 200 - 3314

Appendix IV-5.

Log. No. 4994

New Mexico School of Mines
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

WELL LOG DIVISION

Casing Record	
Diam.in.	Bottom
10-3/4"	200'

Elevation 6400' Feet
Initial Daily Production:

Open	P & A	Bbls. Oil
Open		Cu.ft.Gas
Tbg.		Bbls. Oil
Tbg.		Cu.ft.Gas

County Colfax
Field Wildcat
Company American Mfg. Co. of Texas
Lease W. S. Ranch Well No. 1
Location(¼) NE
Sec. 1 T26N R20E
974.9 feet from North line and
1377.6 feet from East line of Sec.
Commenced: 12-16-45
Completed: 5-23-46
Abandoned:
Remarks:

FORMATION	BOTTOM, FEET	FORMATION	BOTTOM, FEET
Shale	1713		
Sticky shale	1743		
Shale	2224		
Hard sandy lime	2252		
Sand	2454		
Hard green sand	2537		
Sand and shale	2629		
Sandy lime	2670		
Sandy and shale	2701		
Sand, shale & lime	2774		
Soft white sand & shale	2883		
Sand and red shale	2900		
Red shale	2916		
Sand shale and lime	2924		
Hard sandy lime	2936		
Sandy lime	2994		
Sandy lime and shale	3010		
Red shale	3109		
Red & black shale & sandy lime	3128		
Sandy lime	3194		
Sand	3200		
Red shale & white green sand	3215		
Sand and red shale	3289		
White sand & shale	3293		
Sand, chert	3302		
Hard red shale and lime	3312		
Hard brown shale and lime	3315		
Hard brown chert & lime	3325		
Sand and shale	3354		
Red sand	3364		
Red sand and green	3390		
Shale and lime	3406		
Green shale and sandy lime	3445		
Red sand and green shale	3454		
Sandy lime	3481		
Sand and shale	3511		
Sand and gyp	3560		
Lime and shale	3580		
Lime and sand	3705		
Lime and shale	3728		
Chert and lime	3806		
Granite wash	3814 T.D.		

Appendix IV-5.

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NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES — LOG..............

COMPANY	WELL NO.	LEASE	S-T-R
Neill & Alexander	2	Sauble	1-26N-24E

Location	1980	fr. S L	1980	fr. E L	County	Colfax		
Spud	2-2-47	Comp.	6-?-47		Field			
Total Depth	1755	P. B.	Top Pay		CSG. RECORD			
I. P.	Abd.		per day		Size	Depth	Sax	

Remarks:

Prelim. Map 141 gives location as Sec. 2

Tops by RCN

Morrison	555
Todilto	916
Wingate	924
Chinle	1007

Tops from Prelim. Map 141

Shot or Acid:

Samples 430-1188, 1471-1737

Spl. Desc. 430-1737 RCN

Spl. log plotted

Tbg. at

FORMATION RECORD

Elev. 6418 USGS

X	Niobrara	Surface
T	Dakota	430
T	Purgatoire	504
T	Morrison	575
T	Wanakah	908
T	Ocate	935
T	Dockum	1002
T		

Appendix IV-5.

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES — LOG 1097

COMPANY	WELL NO.	LEASE	S-T-R
York Denton et al	1	Tex-Mex	2-26N-24E

Location 400 fr. N L 400 fr. W L

County: Colfax

Spud 10-1-37 Comp. 10-18-39

Field

Total Depth 1525 P. B. 1511' Top Pay

I. P. per day

Remarks: CO_2 250 MCF/24 hrs. 1515-25 99.85% CO_2
PB 1515 gas vol reduced to 153 MCF

Water 432, 539, 777 Sulfur water 28'

SO 327, 387, 415, 432, 478, 499, 603, 688, 725, 784, 793, 1025, 1046, 1092, 1108, 1140, 1245-86, 1328, 1365, 1416, 1451, 1484

SG 62, 387, 488, 1513. CO_2 1147, 1515

*Change in ownership from Colfax Carbide To F.E. Sauble on May 1, 1942.

Shot or Acid: 53 qts. 786'

Samples 0-170, 786-1513

Spl. Desc. 786-1304 G.V. & FLB

CSG. RECORD

Size	Depth	Sax
8	57	
6 5/8	652	3
5 3/16	1175	
3½	1500	11

Tbg. at

FORMATION RECORD

Elev. 6264 L & S

T	Source unknown	
T	Ft. Hays	0-44
T	Carlile	44
T	Santa Rosa	965
T		
T		
T		
T		

Tops by RLB

Ft. Hays	0-44
Carlile	44
Greenhorn	200
Graneros	385
Dakota	435
Purgatoire	488
Morrison	598
Navajo	775
Wingate	965
Chinle	1025

Santa Rosa
Glorieta Possibly present

Samples 0-1513

Appendix IV-5. LOG NO. 1097

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD
Diam. in/Bottom
8" 57'2"
6-5/8 652'
5-3/16 1175'

ELEVATION: 6250
IP: Open 150 M CO_2

COUNTY: Colfax
FIELD: Wildcat
COMPANY: Colfax Carbon-Dioxide Corp.
LEASE: Tex-Mex Cattle Co. #1
LOCATION: 400 from N Line
400 from W Line
SEC: 2 T. 26N R. 24E
COMMENCED: 10-6-37
COMPLETED: 12-6-41

FORMATION	BOTTOM, FEET
Hard lime	14
Hard lime, sulphur water at 28'	30
Hard lime	44
Shale	62
Black shale - enough gas to burn, oil color	87
Black shale, lime breaks	100
Blue gumbo	114
Shale and gumbo	180
Shale	199
Lime with shale breaks	265
Hard lime	279
Hard lime	281
Hard lime	327
Broken lime, oil showing	334
Lime with shale breaks	367
Broken lime, gas & oil showing	387
Black shale	412
Hard lime	415
Lime, oil showing	416
Shale and lime	432
Dakota sand, oil showing, water	460
Hard shale	468
Hard gray sand	478
Hard gray sand, little oil show	488
Lime and gumbo, most gas at 488	499
Hard sand and broken shale, oil showing	523
Black shale	527
Very hard sand	529
Black shale and gumbo	535
Lime and shale	539
White sand, lots of water	584
White sand	589
White Sand	593
Blue shale	594
Hard sand	599
Red shale	603
Gray sand, oil showing	608
Pink shale	610
Pink shale	613
Blue shale	616
White sand	630
Blue shale	635
Sandy red shale	648
Shale and lime water shut off	660
Lime	666
Lime and pink shale breaks	688
Blue lime, little oil showing	694
Gray lime and pink shale	714
Gray sand and lime	718
Pink lime	721
Lime	725
Lime, oil showing	730
Pink shale and shells	739
Hard lime	745
Red shale and lime	760
Red shale and lime	777
White water sand	780
Red shale and lime oil	784
Dolomite sand, hard, showing	786
Lime and sand; plugged up to 786 shot 53 qts. glycerin	793
Hard sand, little oil showing	810
Red shale and lime	845
Lime	860
Broken lime and shale	948
Lime	955
Black shale	965
White sand, presumable Dakota sands	1000
Brownish sand	1025

FORMATION	BOTTOM, FEET
Lime and red shale, oil showing	1046
Red shale breaks and lime, oil showing	1066
Red shale breaks and sandy lime	1092
Lime and chovolate shale, oil showing	1098
Brown shale	1108
Brown sand, oil.showing	1140
Gray sand showing oil	1147
Little CO_2 gas, brown sand carrying water	1166
White lime	1177
Gray lime	1186
Lime conglomerate	1190
Pink shale and lime	1208
Lime and pink shale	1224
Brown sand	1228
Hard lime	1245
Pink lime, showing oil	1260
" " " "	1276
"" " " "	1282
Pink lime, good showing of oil	1286
Brown lime	1293
Gray lime	1295
Pink lime	1301
Brown and pink sand	1313
Pink lime	1328
Gray and pink lime showing oil	1340
Lime and shells	1345
Gray lime and pink shells	1353
" " " " "	1357
" " " " "	1365
Sandy lime, oil showing	1374
Gray lime	1379
Shale and lime	1399
Gray lime	1416
Brown lime, good oil showing	1433
Shale and lime	1451
Red beds, soft, little oil show.	1480

FORMATION	BOTTOM, FEET
Gray shale and gypsum	1484
Hard gray sand, oil showing in slush	1513
Gray and pink sand, blew in CO_2 gas 253 M cu. ft.	1515
Brown water sand	1517
Brown water sand	(T.D.)1520 1/2

Plugged back up to 1515 with lead wool, shut out the water below; in plugging back we reduced the gas volume to about 153 M. cu. ft. Well was completed and put on valve. Gas CO_2, purity 99.85.

Appendix IV-5.

√

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES — LOG 5651

Company	Well No.	Lease	S-T-R
Neill & Knapp	1	Herrera	3-26N-24E

Location 660 fr. N L 1980 fr. E L

Spud 12-21-47 Comp. 5-26-48

Total Depth 1552 P. B. Top Pay

I. P. D. & A. per day

Remarks:

County Colfax

Field

CSG. RECORD

Size	Depth	Sax
8½	854	
7	1161	

Tbg. at

Tops by RCN

Greenhorn	275
Dakota	450
Morrison	600
Todilto	968
Wingate	976
Triassic	1048

Shot or Acid:

Samples 150-1552

Spl. Desc. 150-1552 RCN

Spl. log plotted

FORMATION RECORD

Elev. 6242 Neill

6420 Log

Niobrara	Surface
Dakota	450
Purgatoire	545
Morrison	600
Wanakah	945
Ocate	976
Dockum	1048

LOG NO. 5651

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD

Diam. in/Bottom	
8-1/4	854
7	1161

ELEVATION: 6420
IP:

COUNTY: Colfax
FIELD: Wildcat
COMPANY: Neill and Knapp
LEASE: Herrera #1
LOCATION: 660 from N Line
1980 from E Line
SEC: 3 T. 26N R. 24E
COMMENCED: 12-21-47
COMPLETED: 5-26-48

FORMATION	BOTTOM, FEET
Clay	20
Lime	25
Black shale	288
Shale and lime shells	452
Sand	500
Black shale	508
Sand	665
Sand and shale	670
Blue lime	676
Blue lime and shale	765
Shale	815
Sand	925
Lime	945
Congolmerate	976
Sand	1053
Lime	1134
Sand	1205
Lime and shale	1460
Conglomerate	1552 T.D.

Appendix IV-5.

√

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES

LOG 5487

Neill & Steffan	3	Sauble	3-26N-24E
COMPANY	WELL NO.	LEASE	S-T-R

Location 1980 fr. S L 660 fr. E L

Spud 2-18-47 Comp. 12-12-47

Total Depth 1560 P. B. 1539 Top Pay

I. P. per day

Remarks:

CO_2 133,000 cu. ft./24 hrs. 1525-60

Initial R.P. 145 PSI

Shot or Acid:

County Colfax

Field

CSG. RECORD

Size	Depth	Sax
$5\frac{1}{2}$	1525	

Tbg. at

FORMATION RECORD

Elev. 6203 Opr.

T Dakota 420

T Santa Rosa 1522

T

T

T

T

T

T

Appendix IV-5. LOG NO. 5487

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD
Diam. in/Bottom
5-1/2 1525

ELEVATION: ?
IP: 133,000

COUNTY: Colfax
FIELD: Maxwell
COMPANY: Neill and Steffan
LEASE: Sauble #3
LOCATION: 1980 from N Line
660 from E Line
SEC: 3 T. 26N R. 24E
COMMENCED: 2-18-47
COMPLETED: 12-12-47
REMARKS: Cable tools Top to 1560'

FORMATION	BOTTOM, FEET
Clay	12
Lime	62
Black lime	104
Blue shale	118
Shale	200
Lime and shale	272
Lime and shale	416
Sand	490
Sandy shale	539
White sand	593
Sandy shale	694
Sandy shale	777
Sandy shale	786
Sandy lime	793
Sandy shale	965
White sand	1008
Brown sandy lime	1033
Sandy shale	1143
Sandy lime	1160
White lime	1177
Grey lime & red shale	1319
Grey lime & red shale	1395
Red rock	1410
Red shale	1444
Sandy lime	1477
Red sand	1491
Red lime	1506
Brown sandy lime	1518
Grey sand	1522
Grey & pink sand very hard CO_2 showing at 1528 feet	1529
Gas sand	1557
Gas sand	1560 T.D.

Water showing. Plugged back 21 feet.
Shut in 145# pressure.

Appendix IV-5.

WILLARD C. FRANKS	#1	LaRoe	19-27N-22E
COMPANY	WELL NO.	LEASE	S T R
Loc. 1980' fr. N L 1980' fr. W L		County Colfax	
Spud. 5-10-63 Comp. 11-20-65		Field Wildcat	
T.D. 1825' P.B. T.Pay		CSG. RECORD	
I.P. D & A		Size Depth Sax	
		8-5/8 90 25	
Remarks: No cores or tests; had sli show gas @ 1200'			
		Tbg. at	
		FORMATION RECORD	
		Elev. NR	
		T. Dakota 1790	
		T.	
		T.	
		T.	
Treatment:		T.	
		T.	
		T.	
		T.	
		T.	

Appendix IV-5.

WILLARD C. FRANKS	#2	LaRoe		19-27N-22E
COMPANY	WELL NO.	LEASE		S T R
Loc. 1650' fr. S L 330' fr. W L			County Colfax	
Spud. 3-7-66 Comp. 3-25-66			Field Wildcat	
T.D. 1809' P.B. T.Pay			CSG. RECORD	
I.P. D & A (First Report & Completion)			Size Depth Sax	
			8-5/8 60 31	
Remarks: Crd 1789-1809', rec 8' sd, no desc.				
			Tbg. at	
			FORMATION RECORD	
			Elev. NR	
			T. NR	
			T.	
			T.	
			T.	
Treatment:			T.	
			T.	
			T.	
			T.	
			T.	

Appendix IV-5.

LOG NO. 9022

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD Diam. in/Bottom		ELEVATION:	6092' Grd.	COUNTY:	Colfax
		IP:	D & A	FIELD:	Wildcat
				COMPANY:	Kelly Bell
7	120			LEASE:	1 Sam Laroe
				LOCATION:	660' from N line 660' from W line
				SEC:	19 T. 27N R. 22E
				COMMENCED:	2-21-73
				COMPLETED:	2-25-73
				Remarks:	Rotary Tools 0-1951'

FORMATION	BOTTOM, FEET		FORMATION	BOTTOM, FEET
Surf sh and sand	120		GEOLOGIC TOPS	
Gray sh	1160			
Niobrara shale	1303		Dakota	1574
Ft. Hays	1363		Morrison	1746
Gray shale	1519		Todilto	1900
Greenhorn	1574			
Carbonaceous shale	1746			
Dakota sand & shale	1900			
Morrison sand and shale	1951	T.D.		

Appendix IV-5.

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES — LOG 4718

COMPANY	WELL NO.	LEASE	S-T-R
Kates & Sidwell	1-A	Sauble	35-27N-24E

Location 330 fr. S L 1650 fr. W L

County Colfax

Spud 11-21-44 Comp. 3-22-45

Field

Total Depth 2520 P. B. Top Pay

I. P. D & A per day

Remarks:

Shot or Acid:

Samples 0-2520

Spl. Desc. 0-2520 RCN

Spl. log plotted

CSG. RECORD

Size	Depth	Sax
13	61	
10-3/4	800	
8 5/8	1442	

Tbg. at

FORMATION RECORD

Elev. 6254 Kates & Sid.

T See back of card

T for tops.

T

T

T

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T

T

Appendix IV-5.

	Prelim. Map 141	RCN	Quigley of Texas Co.
Niobrara	Surface	----	-----
Timpas	----	----	10
Ft. Hays	50-80	----	-----
Greenhorn	290	290	290
Graneros	320	----	----
Dakota	450	460	460
Purgatoire	530	----	----
Morrison	595	620	620
Navajo	----	800	800
Wanakah	940	----	----
Todilto	----	970?	970
Wingate	----	980	980
Ocate	990	----	----
Dockum (Chinle)	1030	1030	1030
Permian	-----	-----	1560
Glorieta	-----	1560	-----
Gangre de Cristo	2060	2060	-----
PC-Granite	2480	2490?	

Samples 0-2520

Appendix IV-5.

New Mexico School of Mines
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

WELL LOG DIVISION

Log. No. 4718

County Colfax
Field Wildcat
Company Tex-Well Corporation*
Lease Sauble "A" Well No. 1
Location(4) SE SW
Sec. 35 T27N R24E
330 feet from South line and
2310 feet from West line of Sec.
Commenced: 11-21-44
Completed: 3-21-45
Abandoned:
Remarks: *Also known as Kates and Sidwell

Elevation 6254 Feet

Casing Record	
Diam.in.	Bottom
13	61'
10-3/4"	800'
8-5/8"	1442'

Initial Daily Production:

Open	P & A	Bbls. Oil
Open		Cu.ft.Gas
Tbg.		Bbls. Oil
Tbg.		Cu.ft.Gas

FORMATION	BOTTOM, FEET
Soil	3
Doby C Mud	25
B Shale	38
Lime	58
Shale	60
Lime	73
Shale and shells	90
Shale	275
Lime	315
Shale	318
Lime shells and shale	340
Shale	350
Lime and shale	370
Lime, gray	400
Broken lime	440
Sandy lime	450
Lime and shale	459
Dakota sand, hard	499
Broken lime and shells	500
Pink lime	530
Lime, hard	550
Lime	565
Lime and white sand	600
Sand, hard	615
Sand, hard, white	628
Pink shale	640
Pink lime, hard	680
Lime, hard	720
Lime, pink	742
Red shale	745
Lime shells	750
Pink lime	760
Blue lime	773
Red shale and shells	780
Brown lime	800
Lime	815
Sand, hard and sharp	840
Pink lime	880
Lime	910
Broken lime and shells	920
Brown lime	930
Lime shells, gray	950
White lime	955
Blue shale	960
Lime	965
Pink shale	980
Blue and pink shale	990
Shale	995
Shells	1010
White sandy lime	1020
White sand	1040
Red shale	1050
Hard lime	1075
Hard red lime	1105
Brown shale	1107
Broken lime	1120
Hard lime	1135
Red broken lime	1140
Red hard lime	1195
Broken lime shells	1215
Lime	1235
Broken shells	1245
Lime	1265
Lime and shale	1330
Lime	1345
Pink lime	1370
Lime	1380
Pink lime	1440
Red shale and lime	1450
Lime	1454
Red rock, shells and shale	1477
Lime, gray	1510
Red rock shells	1535
Lime	1585
Sandy lime, gray	1695
Sand, hard, gray	1750
Sandy lime, gray	1780
White sand rock	1810
Sandy lime, gray	1865
Red and brown lime	1890
Gray lime	1905
Hard sand	1930
Hard brown sand	1945
Brown sand, medium	1970
Red lime	2000
Red sandy lime	2010
Medium red lime	2055
Brown speckled sand	2075
Light glassy sand	2135
Red rock and lime shells	2160
Sand, granite wash	2170
Light sand	2215
Granite wash	2400
Red sand	2435
Granite wash	2500
Sandy lime and granite, very hard	2520 T.D.

Appendix IV-5.

o 8718

PAN AMERICAN PET. | #1 | Phelps-Dodge | 11-28N-20E
COMPANY | WELL NO. | LEASE | S T R

Loc. 990 fr. S L 1642 fr. E L | County Colfax
Spud. 10-16-68 Comp. 12-1-68 | Field Wildcat
T.D. 5810 P.B. Surface T.Pay

I.P. D & A

Remarks: (Tight Hole) Will be re-issued when data available.

Treatment:

Niobrara 2055'
Timpoas 2748'
Carille 2786'
Glor. 4186'

CSG. RECORD

Size	Depth	Sax
10-3/4"	469'	400

Tbg. at

FORMATION RECORD

Elev. 6327' RDB
T. B/Grnhrn 3014'
T. Dakota 3197'
T. Morrison 3384'
T. Todilto 3670'
T. Entrada 3720'
T. Chinle 3816'
T. Granite 4702'
T. Pre Camb. 5708'
T. Hygiene 1282'
1333'

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD
Diam. in/Bottom
10-3/4" 469'

ELEVATION: 6327' RDB
IP: Dry

COUNTY: Colfax
FIELD: Wildcat
COMPANY: Pan American Pet Co.
LEASE: Phelps-Dodge #1
LOCATION: 990' from South line
1642' from East line
SEC:11 T. 28S R. 20E
COMMENCED: 10-16-68
COMPLETED: 12-1-68
Remarks: O-TD Rotary Tools

FORMATION	BOTTOM, FEET
Surface, Sn, Blue Sh, Water Sn	141
Coal	165
Water sand, Sh	300
Sh	469
Lm-Sh	501
Sh	750
Sn, Sh, Stks	1035
Lm Stks, Sh	1315
Lm-Sh	1420
Sh	1450
Lm-Sh	2220
Sn Stks-Sh	2300
Lm-Sh	3209
Sndy-Lm, Int Shale Stks	3358
Sndy-Lm, Sh	3760
Sn	3814
Sn-Lm	3856
Sn-Lm, Sh	4006
Lm-Sh	4073
Sn, Lm, Sh	4400
Sn, Sh	4435
Sn Lm, Sh	4543
Lm. Sh Sn	4857
Lm Sh	5207
Lm, Sh, Sn	5668
Wash	5810 TD

TOPS	
B/Greenhorn	3014
Dakota	3197
Morrison	3384
Todilto	3670
Entrada	3720
Chinle	3816
Granite	4702
Pre-Camb.	5708
Hygiene	1283
Niob.	2055
Timpas	2748
Carille	2786
Glor.	4186

Appendix IV-5.

NEW MEXICO OIL CONSERVATION COMMISSION — Lg 6970

Company	Well No.	Lease	S-T-R
Continental Oil Co.	1 H	Springer	11-28N-21E

Location 1980' fr. N. L 660' fr. E. L — County Colfax

Spud 4-15-55 — Comp. 4-25-55 — Field Wildcat

Total Depth 2900' Sd. — P. B. — Top Pay

I. P. per day

Ch. on Tbg. @ Press: T.

C. Pkr. Gor. Gr.

CSG. RECORD

Size	Depth	Sax
10 3/4	294	375

PLUGGED AND ABANDONED.
No DST'S.
C 2800-55 rec 42.9 blk sh
C 2855-2867.5 rec 12½' sh & sd w/gas odor
C 2873-74 rec ½' sd, sptd oil stain & gas odor

Treatments:

FORMATION RECORD

Elev. 6523' Grd

Apishapa	T	1720
Timpas	T	2445
Carlile	T	2527
Greenhorn	T	2635
Graneros	T	2700
Dakota	T	2870
T	T	
T	TGr.	

Appendix IV-5.

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

Log No. 6990

WELL LOG DIVISION

COUNTY Colfax
FIELD Wildcat
COMPANY Continental Oil Co.
LEASE Springer Well No. 1
LOCATION ($\frac{1}{4}$) SE NE
SEC. 11 T. 28N R. 21E
1980 feet from north line and
660 feet from east line of section
COMMENCED 4-18-55
COMPLETED 4-25-55
ABANDONED P & A
REMARKS

CASING RECORD	
Diam.in	Bottom
10-3/4"	282

ELEVATION 6523 FEET
Initial Daily Production:
P & A

FORMATION	BOTTOM, FEET	FORMATION	BOTTOM, FEET
Tops in lieu of driller's log:			
Dakota	2870		
	2900 T.D.		

Appendix IV-5.

NEW MEXICO OIL CONSERVATION COMMISSION

NM Log 6944

Continental Oil Co.		1	Maxwell Land Grant	11-28N-22E
Company	C&O 5 of W	Well No.	Lease	S-T-R
Location	660 fr. S. L	660 fr. W. L	County	Colfax
Spud	5-30-54	Comp. 6-24-54	Field	Wildcat

Total Depth 2947' Gran. P. B. Top Pay

I. P. per day

Remarks: Plugged & Abandoned

DST 1782-1823 op 1 hr rec 120' fresh wtr
Fp 80# SIP 15 min 80#

DST 2775-2820 op 1 hr rec 90' mud Fp 0#
SIP 15 min 580#

Shot or Acid:

CSG. RECORD

Size	Depth	Sax
13 3/8	195	100

Tbg. @

FORMATION RECORD

S/J Elev. 6101'

Timpas	1350 T	Glo	2768
Carlile	1437 T	Dakota	
Greenhorn	1575 T		1773
Graneros	1610 T		
Morrison	1924 T		
Todilto	2260 T		
Entrada	2312 T		
Chinle	2360 TGr.		

LOG NO. 6944

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD
Diam. in/Bottom
10-3/4" 186

ELEVATION: 6181
IP:

COUNTY: Colfax
FIELD: Raton Basin - Wildcat
COMPANY: Continental Oil Company
LEASE: Maxwell Land Grant #1
LOCATION: 660 from S Line
660 from W Line
SEC: 11 T. 28N R. 22E
COMMENCED: 5-30-54
COMPLETED: 6-23-54
ABANDONED: P&A

FORMATION	BOTTOM, FEET
Pierre shale	0
Apishipa	520
Timpas	1350
Carlile	1437
Greenhorn	1575
Graneros	1610
Dakota	1778
Morrison	1923
Todilto	2260
Entrada	2305
Chinle	2360
Glorietta	2755
Pre-Cambrian	2928 T.D.

Appendix IV-5.

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES — LOG 7427

COMPANY	Howard & O'Hern et al
WELL NO.	1
LEASE	Moore
S-T-R	8-28N-2[illegible]
Location	fr. L fr. L
Spud	9-19-57
Comp.	1-15-58
Total Depth	1478
P. B.	
Top Pay	
I. P.	D & A per day
County	Colfax
Field	Wildcat Water well

Remarks: Good s/o 1421-22, s/o 1434-53
700-TD enough gas to kick mud
pkr set @ 1344, 5½" btm 44' slotted liner

3 hr. test--bailed 25 gal. wtr per min & 4-5 gal oil.

Not on Scout Report- Data from log

Shot or Acid:

CSG. RECORD

Size	Depth	Sax
5½	1449	
8	239	

Tbg. at

FORMATION RECORD

Elev.

T Dakota 1341
T Cheyene 1445
T
T
T
T
T
T

LOG NO. 7427

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD	
Diam. in	Bottom
5-1/2	1449
8	239

ELEVATION:
IP: D&A

COUNTY: Colfax
FIELD: Wildcat Water Well
COMPANY: Howard & O'Hern et al
LEASE: Moore #1
LOCATION: from Line
from Line
SEC: 8 T. 28N R. 24E
COMMENCED: 9-19-57
COMPLETED: 1-15-58

FORMATION	BOTTOM, FEET
No Log	1400
sdy ls hd	1406
sdy ls gry	1408
shale	1412
sdy ls hd gry	1415
white sd soft	1421
white sd, hd showing of oil	1429
sdy ls hd	1434
white sd, with s/o	1438
white sd, with s/o	1445
gry sd, with s/o	1449
white sd, with s/o	1453
white sd, hd, N/S	1458
white sd, soft N/S	1461
white sd, med hd, N/S	1469
white sd, hd, N/S -- T.D.--	1478

Appendix IV-5.

J

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES

LOG

COMPANY	WELL NO.	LEASE	S-T-R
Red Feather Oil Co.	1	Landon Moore	10-28N-26E

Location NW¼ SW¼ fr. L fr. L

Spud 1-23-26 Comp. 10-24-26

Total Depth 975' P. B. Top Pay

I. P. Abd. per day

Remarks:

Shot or Acid:

County Colfax

Field Capulin Anticline

CSG. RECORD

Size	Depth	Sax

Tbg. at

FORMATION RECORD

Elev. [illegible] Gr.

T Dakota 435'

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Appendix IV-5.

NEW MEXICO OIL CONSERVATION COMMISSION

[illegible]

Company	Well No.	Lease	S-T-R
Magnolia Pet. Co.	1	T. O. Ranch	10-25N-26E

Location	1980' fr. S. L	660' fr. W. L		County	Colfax
Spud	8-16-54	Comp.	8-26-54	Field	Wildcat
Total Depth	715' granite	P. B.	Top Pay		
I. P.		per day			

CSG. RECORD

Size	Depth	Sax
10 3/4	209	250

Tbg. @

Remarks: Plugged and Abandoned.
No DST's.
C 705-715 rec 10' granite NS

Shot or Acid:

Grl. FORMATION RECORD

Elev.	7114'	T
Greenhorn	90	T
Graneros	120	T
Dakota	238	T
Morrison	377	T
Granite	701	T
T		T
T		T
T		TGr.

Appendix IV-5. LOG NO. 6928

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD				
Diam. in/Bottom		ELEVATION: 7114'		COUNTY: Colfax
10-3/4	249'	IP: Open----	bbls. Oil	FIELD: Wildcat
		Open	cu.ft. Gas	COMPANY: Magnolia Petroleum Com.
		Tbg.	bbls. Oil	LEASE: T.O. Ranch #1
		Tbg.	cu.ft. Gas	LOCATION: 1930 from S Line; 660 from W Line
				SEC: 10 T. 28N R. 26E
				COMMENCED: 8-16-54
				COMPLETED: 8-26-54
				ABANDONED: P&A

FORMATION	BOTTOM, FEET
Brown & Gray Shale	45
Shale, Lime & Anhydrite	148
Shale	178
Dolomite, Anhydrite, Brown & Gray Shale	208
Brown Shale & Sand	237
Shale, Brown & Gray Bentonite	244
Hard Sand	252
Sandy Shale	310
Shale & Sand	365
Hard Sand	408
Green Sandy Shale	466
Sand & Shale	558
Green & Redish Brown Sandy Shale	699
Rock & Sandy Shale	705
Igneous Rock	715 T.D.

GEOLOGIC TOPS - BY DRILLER

T. Greenhorn	90
T. Graneros	120
T. Dakota	238
T. Morrison	377
T. Granite	701

Appendix IV-5.

NEW MEXICO OIL CONSERVATION COMMISSION

Continental Oil Co. — Company

5 — Well No.

St. Louis Rocky Mt. & P. Co. Co. — Lease

14-[illegible] — S-T-R

Location	1980' fr. N. L	660' fr. W. L		County	Colfax
Spud	2-21-55	Comp.	3-21-55	Field	Wildcat
Total Depth	2890' sd.	P. B.	Top Pay		
I. P.			per day		
Ch.	on	Thr. @	Press: T.		
C.	Pkr.	Gor.	Gr.		

CSG. RECORD

Size	Depth	Sax
10 3/4	230	175

PLUGGED AND ABANDONED.
DST 2668-2709 op 2 hrs, rec 120' mud & 360' sl fresh wtr, FP 290#, 30min SIP 800#
DST 2700-2720 straddle pkr test, op 2 hrs, rec 240' wtr c mud, FP 120#, 30 min SIP 930#
DST 2615-2640 straddle pkr test, op 2½ hrs,
Treatment: rec 2000' wtr c mud, pkr failed, no press. recorded.

S/J FORMATION RECORD

Elev. 6464' Gr.

T Timpas		T	2200
T Carlile		T	2283
T Greenhorn		T	2304
T Graneros		T	2450
T Dakota		T	2610
T Morrison		T	27[illegible]
T		T	
T		TGr.	

Appendix IV-5.

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

WELL LOG DIVISION

Log No. 6991

COUNTY Colfax
FIELD Wildcat
COMPANY Continental Oil Co.
LEASE St. Louis Rocky Mtn. & Pac.
LOCATION ($\frac{1}{4}$) NW SW Well No. 5
SEC. 16 T. 29N R. 22E
660 feet from west line and
1980 feet from north line of section
COMMENCED 2-21-55
COMPLETED 3-21-55
ABANDONED
REMARKS

CASING RECORD ELEVATION 6464 FEET

Diam.in	Bottom
10-3/4"	230

FORMATION	BOTTOM, FEET
Tops in lieu of driller's log:	
Dakota	2610
Morrison	2780
	2890 T.D.

Appendix IV-5.

NEW MEXICO OIL CONSERVATION COMMISSION

Company	Continental Oil Co.	Well No.	6 St. Louis Rocky [illegible]
S-T-R	[illegible]		
Location	[illegible] fr. [illegible] L [illegible] fr. [illegible] L	County	Colfax
Spud	[illegible] Comp. 11-2[illegible]	Field	Wildcat
Total Depth	[illegible] P. B. [illegible] Top Pay		
I. P.	per day		

CSG. RECORD

Size	Depth	Sax
[illegible]	[illegible]	[illegible]
5 1/2	[illegible]	200

Tbg. @

Remarks: [illegible]
DST 1917-[illegible] op 1 hr 30 min, rec 20' mud all pressures 0#
DST 2793-2843 op 3 hrs, rec 195' [illegible] FP 0#, 30 min SIP 190#
DST 2771-95 op 2 hrs rec 20' mud, FP 0#, 30 min SIP 80#

Shot or Acid:

FORMATION RECORD

Elev. [illegible]
[illegible] [illegible] [illegible] 3737
[illegible] [illegible] Cerro do Cristo 3941
[illegible] 2760 [illegible] 4330
[illegible] 2778 [illegible]
[illegible] [illegible] [illegible] 4550
[illegible] [illegible] Intrusive
T [illegible] 3625 T 4602
T TGr.

Appendix IV-5.

LOG NO. 6965

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD Diam. in/Bottom		ELEVATION: 6542		
13 3/8	214	IP:	COUNTY:	Colfax
5 1/2	2874		FIELD:	Wildcat
			COMPANY:	Continental Oil Co.
			LEASE:	St. Louis, Rocky Mtn. & Pacif
			LOCATION:	(½) NE SW Well No. 4 1880 W & 1770 S
			SEC: 17	T. 29N R. 22E
			COMMENCED:	8/15/54
			COMPLETED:	11/21/54
			Remarks:	P & A

ORMATION	BOTTOM, FEET	FORMATION	BOTTOM, FEET
GEOLOGIC TOPS		SHOT OR ACID	
. Pierre	0	2500 g	2820 - 26
. Apishipa	1600	5000 g	2792 - 2806
. Timpas	2360		
. Carlile	2447		
. Greenhorn	2550		
. Graneros	2592		
. Dakota	2760		
. Morrison	2978		
. Todilto	3280		
. Entrada	3318		
. Chinle	3354		
. San Andres	3600		
. Glorietta	3737		
. Sangre de Cristo	3941		
. Madera	4248		
Intrusive	4602		

RECORD OF DRILL-STEM AND SPECIAL TESTS

ST # 1 Set packer at 1919'. Plugged back T.D. 2001'. Open 1 hr. Very slight blow for 12 min. Reset packer. Open 30 min. SI 20 min. Rec. 20' mud. FP 0; SIP 0; HP 920#.

ST # 2 Set packer at 2771'. T.D. 2793'.Open 2 hrs. SI 30 min. Rec. 20' of drilling mud. Slightly water cut. FP 0; SIO 80#; HP 1350#.

ST # 3 Set packer at 2793. T.D. 2843'. Open 3 hrs., SI 30 min. Light blow for 1 hr. & 30 min. Slight blow by heads for remainder of test. Rec. 195' of slightly high gravity oil cut mud. FP 0; SIP 190#; HP 1380#. There is a possibility that the tool was plugged.

ORE # 1 Recovered 7' - 2775-2782'
1' Ss., wh., m. g., well r., well sorted, well cem. qtz. g., hd., sl. por., sl. wet., gassy odor on fresh surface, few pyr. concretions & styl. partings sl. oil st.
6' Ss., wh., m. to f. g., cross-bedded, well cem., sorted, well r., qtz., g., hd., sl. por., sl. gassy odor, dry. Styl. parting.

FORMATION	BOTTOM, FEET	FORMATION	BOTTOM, FEET

CORE # 2 — 2782-2795' Rec. 11'6"
2' Ss., wh., f. g., well sorted, well cem., well r., qtzose, sl. qtzitic., sl. por., hd. wet, few sh. partings.
1' Ss., as ab., spotty oil st., pale yel-grn. fluor., good odor on fresh fracture, quickly dissipated.
8½' Ss., as ab., m. to f. g., hd., sl. por., wet, sl. qtzitic., w/few sh. partings.

CORE # 3 — Recovered 50' - 2793-2843'
27' Ss., f. to m. g., hd., por., well sorted, well r., some cross-bedded, v. good odor, bleeding free oil.
7' Ss., m. g., soft, por., well sorted, well r., fair to good odor, staining.

CORE # 4 — 2843-2893 Rec. 36'
25' Ss., f. to m. g., gr., s&p, hd. & tight to hd. & sl. por., well sorted, few thin sh. breaks, pyr. nod. & carb. inclusions. Wet w/brackish water.
8' sh., blk.
1' Ss., v. soft, chalky gr., clayey, nearly unconsolidated, poorly sorted, tight, fri. No shows.

CORE # 5 — 2893-2916' Rec. 23'
23' Ss., wh., f. g., well sorted, hd. to soft, por. to v. tight, few pale grn. waxy sh. breaks & pale grn. sh. inclusions. Wet.

CORE # 6 — 2916-2948' Rec. 32'
32' Ss., wh., f. g., well sorted, hd. to soft, por. to v. tight, few pale grn. waxy sh. breaks & pale grn. sh. inclusions, Wet.

CORE # 7 — 3120-3170' Rec. 50'
8' Sh., gr-grn., hd. slty.
3' Qtzite., grn., pyr.
3' Sh., grn., waxy.
8' Sltst., grn., shly., hd., v. tight, sdy, in spots.
14' Sh., red, brn. & grn. var., hd., slty in part, some waxy.
4' Ss., gr-grn., hd., tight, qtzitic., v. f. g., few scattered grn. ch. inclusions.
10' Sh., red. grn. & reddish-brn. var. slity in part, some waxy.

CORE # 8 — 3172-3221' Rec. 49'
1' Sh., gr., hd., silty
5' Ss., gr-grn., v. hd., tight, v.f.g., well sorted, qtzitic.
9' Sh., vluish-gr. & red var., hd.
15' Ss., hd., tight, f.g., well sorted, qtzitic., gr-grn.
Bottom 1' w/grn. sh. inclusions.
4' sh., gr., hd., silty.
12 Ss., gr-grn., v.f.g., v. hd., tight, well sorted qtzitic, some w/thin sh. inbds., m. g. near base.
3' Qtzite, tan, extremely hd., f. g.

Appendix IV-5.

√

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES — LOG

COMPANY	WELL NO.	LEASE	S-T-R
Inflow Oil Co.	1	Brown	3-29N-24E

Location NE NE NE fr. L fr. L

County Colfax

Spud 192? Comp.

Field

Total Depth 260' P. B. Top Pay

I. P. per day

CSG. RECORD

Size Depth Sax

Remarks: SO 240-60

Tbg. at

FORMATION RECORD

Elev. 6275 Est.

T

T

T

T

T

T

T

T

Shot or Acid:

Appendix IV-5.

√NEW MEXICO OIL CONSERVATION COMMISSION

Company	Well No.	Lease	S-T-R
[illegible] & Reynolds Drlg Co.	1 P	[illegible] T. Moore	[illegible]-29N-24E

Location 660 fr. S L 656 fr. E L		County Colfax	
Spud 6-17-54	Comp. 6-7-55	Field Wildcat	
Total Depth 243 11	P. B.	Top Pay	CSG. RECORD
I. P.		per day	
Ch.	on	Tbg.	Press: T.
C.	Pkr.	Gor.	Gr.

CSG. RECORD

Size	Depth	Sax
8 5/8	226	75

TEMPORARILY ABANDONED

Treatments:

FORMATION RECORD

Elev.	T
T	T
T	T
BX	T
T	T
T	T
T	T
T	T
T	TGr.

Appendix IV-5.

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES — LOG 58

COMPANY	Eureka Oil Co.
WELL NO.	1
LEASE	Cora B. Moore
S-T-R	10-29N-24E
Location	NW¼ SW¼ fr. L fr. L
County	Colfax
Spud	
Comp.	12-6-27
Field	
Total Depth	4083
P. B.	
Top Pay	
I. P.	per day

Remarks:

Water 30, 1440, 2955. Salt water 2345
SG 180, ½ MCF 270-90, 980, 1465, 2885, 2938,
2 MCF 3142--1040 pressure.
SO 1745, 1840, 1950, 2095, 2345, 2885, 2938,
3022, 3260--52 gravity, 3876.

Shot or Acid:

CSG. RECORD

Size	Depth	Sax
15½	50	
10	1542	
8¼	2110	
6 5/8	2460	
5 3/16	Tbg. 2938 at	

FORMATION RECORD

Elev. 6275 Est.

Formation	Depth
Niobrara	Surface
Ft. Hays	?-1000
Carlile	1000
Dakota	1365
Purgatoire	1485
Morrison	1525
Wanakah	1800
Ocate	1840
Dockum	1920
Sang de Cristo	2885

Appendix IV-5.

√ NEW MEXICO OIL CONSERVATION COMMISSION — D

Company	Well No.	Lease	S-T-R
Melvin B. Condron	1	Moore	10-22N-24E

Location 660' fr. N. L 657' fr. W. L

Spud 2-19-56 Comp. 3-11-56

Total Depth 4075' granite P. B. Top Pay

I. P.

Ch. on Tbg. @ Press: T.

C. Pkr. Gor. Gr.

County Colfax

Field Wildcat

CSG. RECORD

Size	Depth	Sx
10 3/4	314	225

PLUGGED AND ABANDONED

Cored 1471-1501, rec 30' white porous sand
Cored 2440-46, rec 6' quartzite, Cored
2446-68, rec 22' quartzite

Water Sands: 240-264
450-670
970-990
1460-1500

Treatments:

FORMATION RECORD

Elev. 6550' ? T 6255'?

T Dakota 1362

T Purgatoire 1463

BX T

T T

T T

T T

T T

T TGr.

4301 — Artesia Printing Co.

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD Diam. in/Bottom	
15 1/2	50'
10"	1542'
5-3/16"	2938'
6-5/8	2460
8-1/4	2110

ELEVATION:
IP: D&A

COUNTY: Colfax
FIELD: Wildcat
COMPANY: Eureka Oil Co.
LEASE: Cora B. Moore #1
LOCATION: NW cor. from Line
SW from Line
SEC: 10 T. 29N R. 24E
COMMENCED:
COMPLETED: 12/6/27

FORMATION	BOTTOM, FEET
Soil	30
WATER- gravel	40
Black shale	180
Hard sand - show GAS	190
Dark shale	270
Hard sand - 1/2M. Gas 270-290	290
Black shale	415
Gray lime	425
Dark shale	790
Gray lime - GAS at 980'	1000
Brown shale	1225
Sand	1235
Gray shale	1345
Lime	1350
Black shale	1365
Sandy lime	1378
Raton sand (Dakota)	
WATER 1440- GAS 1465	1485
Sandy lime	1500
Hard sand	1525
Green sand	1545
Pink lime	1562
Gray sand	1585
Dark lime	1598
Sand	1625
Red shale	1632
Dark sand	1740
Gray lime - OIL show 1745'	1750
Gray sand	1800
Dark shale	1840
Gray sand - showing of OIL	1920
Dark shale	1950
Dark sand - showing of OIL	1960
Dark shale	2000
Sand	2050
Gray lime	2095
Light sand - showing of OIL	2240
Light sand	2300
Sandy shale	2345
Hard sand - salt WATER & OIL	2885
Coarse sand - OIL & GAS	2938
Hard sand and lime	2955
Gray sand (LAST WATER)	3010
Lime 60%	3022
Sand, white (OIL SHOW)	3055
Dark sand	3071
Shale	3077
Gray sand	3142
Red sand (2,000,000)(1040)	3172
Gray sand pressure	3242
Pink sand	3260
Gray sand - showing of OIL	3530
Red sand	3567
Gray sand	3756
Gray, red mixed sand	3874
Dark shale - Test above 52 specific gravity	3876
Gray sand - very hard, good OIL show	3928
Sand	3966
Pink lime	3970
Dark shale - full of parafine	3971
Hard sand - limy and hard	3974
Gray sand	4077
Light sand	4083 T.D.

Appendix IV-5.

NEW MEXICO OIL CONSERVATION COMMISSION

Company: W. J. Gourley	Well No.: 1	Lease: Vermejo Park	S-T-R: 27-30N-17E
Location: 2003 Fr. S L 330 fr. W L		County: Colfax	
Spud: 5/27/62	Comp.: 7/26/62	Field: Wildcat	
Total Depth: 6012'	P. B.	Top Pay	
I. P.			
Ch. on	Tbg. @	Press: T.	
C. PLUGGED AND ABANDONED	Gor.	Gr.	

CSG. RECORD

Size	Depth	Sax
8-5/8	210	100

SWC: @ 5209, rec. med grey fine grain tite sand, NS.
SWC: @ 5339, rec. med grey fine grain tite sd NS.
SWC: @ 5372, rec. lite grey fine-med. grain sd. no show.
SWC: @ 5376, rec. same.
SWC: @ 5404, no rec.
SWC: @ 5406, rec. sd & sh, med grain, NS.
SWC: @ 5526, no rec.
SWC: @ 5556, rec. brown sh., very sandy.
SWC: @ 5636, no rec.
SWC: @ 5778, rec. sand, slty fine grain.

FORMATION RECORD

Elev. L/T

Trinidad	T	Greenhorn	4920
T	1330	Graneros	4970
T. Pierre	1506	Dakota	5170
Niobrara	T 3965	Morrison	5315
Fort Hays	T 4710	Entrada	5644
Carlisle	4750	Chinle	5876

7336 — ARTESIA PRINTING CO.

Appendix IV-5. LOG NO. 9024

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD Diam. in/Bottom		ELEVATION:	8027' Grd.	COUNTY:	Colfax
9 5/8	120	IP:	D & A	FIELD:	Wildcat
7	2143			COMPANY:	Universal Res. & Odessa Nat.
				LEASE:	#1-16 Vermejo
				LOCATION:	938 from S line 514 from E line
				SEC: 16 T. 30N R. 18E	
				COMMENCED:	10-6-72
				COMPLETED:	10-24-72
				Remarks:	Rotary Tools 0-2281'

FORMATION	BOTTOM, FEET	FORMATION	BOTTOM, FEET
Sand and shale	560		
Sand and shale	909		
Shale and sand	1335		
Shale and sand	1675		
Sand, shale & coal	2169		
Shale and silt	2281 T.D.		

LOG NO. 8733

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD
Diam. in/Bottom

8-5/8 233

ELEVATION: 7200 GL
IP: Dry & Abandoned

COUNTY: Colfax
FIELD: Wildcat
COMPANY: W. J. Gourley
LEASE: #2 Vermejo Park
LOCATION: 820.7 from E Line
864.4 from N Line
SEC: 16, T. 30N, R. 19E.
COMMENCED: 6-22-67
COMPLETED: 7-26-67
REMARKS: Rotary Tools Used 0-5426' TD.

FORMATION	BOTTOM, FEET	TOPS
Surface & Soil	15	
Sandstone, Shale Streaks	1220	
Coal & Shale	1250	
Shale, Sand Streaks	1390	
Shale (Pierre)	4070	
Shale (niobrare)	4683	
Fort Hayes Ls. & Shale	4930	
Greenhorn Ls.	4956	
Graneros Shale	5145	
Dakota Sand, Shale	5333	
Morrison Sand, s.	5350	
Shale, Total Depth	5426	

Appendix IV-5.

P. L. APR 1 9 1973
W. & L. MAR 3 1 1973

Cmp 9-30-72' Acid (4910-5026') 1500 gals
Swbd gas cut AW (4910-5026') Frac (4910-5026') 60,000 gals
wtr + 50,000# sd. Swbd gas cut LW (4910-5026')
Frac (4910-5026') 8900 gals wtr + 5600# sd. Swbd gas cut
LW (4910-5026')

SAMPLES 900 - 4960

LOG NO. 9019

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD Diam. in/Bottom	
13 3/8	143
9 5/8	1561
7	4887

ELEVATION: 7079' Grd.
IP: D & A

COUNTY: Colfax
FIELD: Wildcat
COMPANY: Odessa Natural Corp.
LEASE: #1 W.S. Ranch
LOCATION: 1829 from N line
380 from W line
SEC: 30 T. 30N R. 20E
COMMENCED: 2-2-73
COMPLETED: 2-17-73
Remarks: Rotary Tools 0-5160

FORMATION	BOTTOM, FEET
Raton	1032
Vermejo	1198
Trinidad	1350
Pierre	4245
Niobrara	4526
Carlile	4700
Greenhorn	4764
Graneros	4942
Dakota	5118
Morrison	5160 T.D.

GEOLOGIC TOPS

FORMATION	BOTTOM, FEET
Raton	0
Vermejo	1032
Trinidad	1198
Pierre	1350
Carlile	4526
Greenhorn	4764
Dakota	4942
Morrison	5118

Appendix IV-5.

NEW MEXICO OIL CONSERVATION COMMISSION D

Continental Oil Co.	3	St. Louis Ritz. [illegible] & 12-30N-22E
Company	Well No.	Pacific Lease S-T-R

Location 660'	fr. N. L	330'	fr. W. L	County	Colfax
Spud 6-30-54		Comp.	9-9-54	Field	Wildcat
Total Depth 5500' [illegible]	P. B.	Top Pay		CSG. RECORD Size / Depth / Sax	
I. P.			per day	13 3/8 534 400	

Remarks: Plugged and Abandoned,

DST 1321-91 op 1 hr rec 10' mud all press 0#

DST 1722-87 op 1 hr rec 10' mud [illegible] all press 0#

DST 692-500 op 3 hrs rec 60' mud No Press

DST 4539-91 op 2 hrs 30 min rec 840' mc wtr FP 375# 30 min SIP 875#

DST 5327-5477 op 1 hr rec 1090' mud FP 1000-1550# 15 min SIP 1675#

DST 5321-5477 op 2 hrs rec 330' mud + 300' [illegible]

Shot or Acid: FP 410# 30 min SIP 920#

Tbg. @

S/J FORMATION RECORD

Elev.	7972	[illegible]	4374
Vermejo	1298	[illegible]	3373
Trin	1332	[illegible]	4996
[illegible]	1443	[illegible]	5367
[illegible]	1002	[illegible]	5014
[illegible]	4125	[illegible]	5073
Dakota	4471	T. [illegible]	
[illegible]	4276	T	5295
Morrison	4025	TGr.	

LOG NO. 6966

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD
Diam. in/Bottom

13 3/8	534
7	4009

ELEVATION: 7972 DF
IP: P & A

COUNTY: Colfax
FIELD:
COMPANY: Continental Oil Co.
LEASE: St. Louis, Rocky Mtn. & Paci
LOCATION: 1309 from N line (¼) NE NW
1482 from W line
SEC: 18 T. 30N R. 22E
COMMENCED: 6/30/54
COMPLETED: 9/10/54
Remarks:

FORMATION	BOTTOM, FEET	FORMATION	BOTTOM, FEET
GEOLOGIC TOPS			
T. Raton	0		
T. Vermejo	1210		
T. Trinidad	1330		
T. Pierre Shale	1450		
T. Apishipa	3380		
T. Timpas	4080		
T. Carlile	4135		
T. Greenhorn	4284		
T. Graneros	4317		
T. Dakota	4470		
T. Morrison	4665		
T. Todilto	4975		
T. Entrada	5008		
T. Chinle	5093		
T. Glorietta	5387		

CORE RECORD & D.S.T. RECORD

DST # 1 Set packer at 638'. TD 800'. Open 3 hrs, SI 30 min. Rec. 60' drilling mud. FP 190#; SIP 150#; HP 420#. Subsequent re-interpretation of charts indicated tool was plugged.

CORE # 1 1346-1392 Recovered 45'. Dips flat.
Top 45' Ss., lt. gry., f. g., hd., tight, poorly sorted, a. to sub-a., sl. s&p. Dry. No shows.

DST # 2 Set packer at 1321'. TD 1391'. Open 15 min. Reset packer. Open 45 min. SI 15 min. Rec. 10 drilling mud. FP 0#; SIP 0#; HP 700#

CORE # 2 1775-1787' No recovery.

DST # 3 Set packer at 1722'. TD 1787'. Open 30 min. Very slight blow. Dead in 10 min. Rec. 10' drilling mud. FP 0#; SIP 0#; HP 890#.

FORMATION	BOTTOM, FEET	FORMATION	BOTTOM, FEET

CORE #3 — 4474-4499' Recovered 25'.
Top 3' Ss., gry., m. g., well sorted, soft, por. Bleeding gas & water.
22' Ss., gry., f. g., hd., tight, well sorted. Wet. Numerous stylite partings throughout core. Vertical fracturing near base.

CORE # 4 — 4499-4549' Recovered 50'
Top 4' Ss., gry., f. g., hd., tight. Wet.
7' Sh., blk., w/sdy. strs.
7' Ss., gry., m. g., moderately tight,hd., well sorted. Wet.
16' Sh., dk. gry., to blk., w/sdy. strs.
16' Ss., gry., f. g., hd., tight, well sorted, sl. qtzitic. in places. Wet.

CORE #5 — 4550-4581' Recovered 31'
Top 14' Ss., gry-grn., hd., tight, f. g., well sorted, few scattered ch. pebs. Numerous calcite filled cavities. Some Vertical frac. Wet
1' Ss., gry-grn., m. g., hd., tight, w/pyr. nod. Wet
2' Sh., blk., w/sdy. strs.
14' Ss., gry-grn., m. to f. g., hd., tight to moderately por., well sorted, some s&p. Wet.

DST #4 — Set packer at 4539'. Open 2½ hrs. SI 30 min. Rec. 840' muddy water. FP 150-375#; SIP 875#; HP 2200#. T.D. 4591'

CORE # 6 — 4591-4597' Recovered 6'.
Top 6' Ss., f. g., hd., tight, qtzitic.

CORE # 7 — 4597-4609' Recovered 10'.
Top 4' Ss., lt. gry., f. g., extremely hd., tight qtzitic.
6' Ss., gry., soft, fri., f. g., well sorted. Wet.

DST # 5 — Set packer at 5327'. Plugged back TD 5477'. Open 1 hr. SI 15 min. Hd. blow gradually decreasing. Dead in 50 min. Rec. 1030' mud. FP 1000-1550#; SIP 1675#; HP 2450#. Tool plugged after 50 min.

DST #6 — Set packer at 5321'. Plugged back TD 5477'. Open 2 hrs. SI 20 min. Good blow gradually decreasing. Dead in 1 hr. 15 min. Rec. 390' mud and 300' heavily non-inflammable gas cut mud. FP 140#; SIP 920#; HP 245#. Tool plugged.

Appendix IV-5.

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

Log No. 6992

WELL LOG DIVISION

COUNTY Colfax
FIELD Wildcat
COMPANY Continental Oil Co.
LEASE St. Louis Rocky Mtn. & Pac.
LOCATION (¼) SE SE Well No. 6
SEC. 26 T. 30N R. 22E
660 feet from south line and
660 feet from east line of section
COMMENCED 3-24-55
COMPLETED 4-16-55
ABANDONED P & A

CASING RECORD ELEVATION 6762 FEET

Diam.in	Bottom
10-3/4"	508'
7	3028

FORMATION	BOTTOM, FEET	FORMATION	BOTTOM, FEET
Tops in lieu of driller's log:			
Dakota	3100		
Morrison	3285		
Entrada	3642		
	3675 T.D.		

Appendix IV-5.

NEW MEXICO OIL CONSERVATION COMMISSION

R 27-30N-23E

Company: Dorfman Prod. Co.	Well No.: 1	Lease: Maxwell Land Grant Co.	S-T-R
Location: 1530 Fr. S L	2310' fr. W L	County: [illegible]	
Spud: 3-18-62	Comp.: 3-29-62	Field: [illegible]	
Total Depth: 2312	P. B.	Top Pay	
I. P.			
Ch.	on	Tbg. @	Press: T.
C.	Pkr.	Gor.	Gr.

PLUGGED & ABANDONED
Core 2245-60 recovered 8½' being 4½' grey [illegible] 3' shale, 1' coal.

Treatments

CSG. RECORD

Size	Depth	Sax
8-5/8	105	35

L/T FORMATION RECORD

Elev. 6417 Gr.

Formation		Top	
Niobrara	T	1023	T
Ft. Hays	T	1822	T
Greenhorn	BX	2043	T
Graneros	T	2117	T
Callun	T	2000	T
Dakota	T	2233	T
2nd Dakota	T	2285	T
	T		T Gr.

7336 — ARTESIA PRINTING CO.

Appendix IV-5.

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES

LOG 60

COMPANY	WELL NO.	LEASE	S-T-R
Union Oil Co. of California	1	Bartlett	23-31N-18E

Location 775 fr. N L 2640 fr. W L

Spud 7-10-24 Comp. 2-10-26

Total Depth 4411 P. B. Top Pay

I. P. D & A per day

Remarks:

Water 22

SG 115

Shot or Acid:

Drillers Log Plotted

County Colfax

Field Vermejo Park

CSG. RECORD

Size	Depth	Sax
15½	74	
12½	804	
10	1966	
8¼	2700	

Tbg. at

FORMATION RECORD

Elev. 7200

T Ft. Hays	3210
T Carlile	3291
T	
T	
T	
T	
T	3740
T PC-Granite	3740

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD

Diam. in/Bottom	
15 1/2	74'
12 1/2	804'
10	1966
8 1/4	2700'

ELEVATION:
IP: P&A

COUNTY: Colfax
FIELD: Wildcat
COMPANY: Union Oil Co. of Calif.
LEASE: Bartlett
LOCATION: N 1/2 from Line
N 1/2 from Line
SEC: 23 T. 31 R. 18E
COMMENCED: 7-10-24
COMPLETED: 2-10-26
Remarks: On Vermejo Park dome

FORMATION	BOTTOM, FEET
Surface	11
Coarse gravel	12
Blue shale	22
Gravel - small water	23
Blue shale	29
Hard blue shale	34
Blue shale - showing of Gas at 115	170
Blue lime	180
Hard blue shale	535
Hard blue shell	540
Hard shell	550
Hard blue shale, hole caving 575	820
Hard gray shell	830
Hard dark shale	920
White and black conglomerate	935
Hard black shale	985
Dark shale	1420
Hard gray shale	1635
Blue shale	1805
Soft blue shale	1865
Blue shale	1938
Hard shell (Sill?)	1942
Shale	1969
Hard blue shale	1970
Hard white lime	1974
Hard white lime	1975
Hard black and white sand (Sill? 1975-1990)	1978
Hard black shale	1982
Hard dark sand	1986
Hard light sand	1990
Hard black slate	1995
Hard black and white shell	1998
Blue shale	2385
Hard blue shale	2495
Blue shale	2610
Hard blue shale	2660
Very hard blue shale	2680
Hard blue shale	2700
Hard black limy shale	2875
Hard blue shell	2879
Hard blue limy shale	2881
Hard blue shell	2890
Hard black limy shale	2920
Hard blue limy shale	2928
Hard blue shale	2930
Hard black limy shale	2965
Hard black shell	2968
Soft blue shale	2971
Black limy shale	3024
Hard black limy shell	3044
Hard black limy shale	3070
Hard black shale	3080
Hard black shale - no lime	3083
Hard gray limestone in black shale	3091
Hard black shale - some lime	3102
Hard black shale	3106
Hard black shale, some pyrite	3110
Hard black shale	3127
Black shale	3129
Very hard, fine black shale	3150
Coarse blue shale	3152
Hard black shale	3170
Hard dark shell	3171
Hard white sand	3173
Hard black shale	3182
Hard black limy shale	3208
Hard black shale	3210
White limestone	3214
Acid sill. 2850' water in hole	3291
Slate limy dark gray and quartzite sand by microscopic examination	3295
Igneous rock	4411 T.D.

Appendix IV-5.

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NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES LOG 1339

Union Oil Co. of California	2	Bartlett	23-31N-18E
COMPANY	WELL NO.	LEASE	S-T-R

Location 1000 fr. S L 80 fr. W L

Spud 6-3-26 Comp. 9-1-26

Total Depth 3265 P. B. Top Pay

I. P. D & A per day

Remarks:

Water 130-40, 1760, 1801, 3220

SSG 2000-10

Shot or Acid:

Drillers Log Plotted

County Colfax

Field Vermejo Park

CSG. RECORD

Size	Depth	Sax
15½	72	
12½	874	
10	1901	

Tbg. at

FORMATION RECORD

Elev.

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T PC-Granite 3218

Appendix IV-5.

Log. No. 1339

New Mexico School of Mines
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

WELL LOG DIVISION

County Colfax
Field Wildcat
Company Union Oil of California
Lease Bartlett Well No. 2
Location(¼) NW SW SW
Sec. 23 T31N R18E
1000 feet from South line and
80 feet from West line of Sec.
Commenced: 6-3-26
Completed: 9-4-26
Abandoned:
Remarks:

Casing Record

Diam.in.	Bottom
15 1/4"	72
12 1/2	874
10	1901

Elevation Feet
Initial Daily Production:

Open	Bbls. Oil
Open D & A	Cu.ft.Gas
Tbg.	Bbls. Oil
Tbg.	Cu.ft.Gas

FORMATION	BOTTOM.FEET	FORMATION	BOTTOM.FEET
Cellar	13		
Gray shale,water about 130-140	605		
Dark gray shale	632		
Gray shale	1535		
Light gray shale	1760		
Gray shale, small water	1801		
Gray calcitic limestone,water	1811		
Gray shale	19[illegible]		
Gray lime	1946		
Gray shale,slight trace of gas from 2000 to 2010	2530		
Light blue shale	2795		
Dark slate,pyrites	2810		
Gray slatey shale	2817		
Gray shale	3040		
Extra hard gray shale	3043		
Gray shale	3130		
Fine hard black shale	3140		
Gray shale	3215		
Aplite (igneous rock)	3220		
Gray granite - Water	3265 T.D.		

Appendix IV-5.

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES — LOG

COMPANY	WELL NO.	LEASE	S-T-R
Bartlett et al	1		25-31N-18E

Location 2525' fr. S L 325 fr. E L

Spud — Comp. 1908

County Colfax

Field Vermejo Park

Total Depth 2535' P. B. — Top Pay

I. P. Abd.. per day

Remarks:

Shot or Acid:

CSG. RECORD

Size	Depth	Sax

Tbg. at

FORMATION RECORD

Elev.

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Appendix IV-5.

NEW MEXICO OIL CONSERVATION COMMISSION

Log 7041

Company: Continental Oil Co.	Well No.: 7	Lease: St. Louis Rocky MTN	S T R: 2-31N-20E
Location: 660' fr. N. L	660' fr. E. L	County: Colfax	
Spud: 9-23-55	Comp.: 11-5-55	Field: Wildcat	
Total Depth: 6081' sd	P. B.	Top Pay	
I. P.			
Ch.	on	Tbg. @	Press: T.
C.	Pkr.	Gor.	Gr.

CSG. RECORD

Size	Depth	Sax
13 3/8	135	100
9 5/8	2664	140

Plugged and Abandoned
Cored 5543-56, rec 13' black hard sh
Cored 5858-5889, rec 30', 4' black sh, 6½' sd, ½' black sh, 4' sd stone, 3' sh, 13' sd stone.
Cored 5891-5912, rec 21'
Cored 5912-5922½, rec 10½'

Treatments:

Spl.

FORMATION RECORD

S/J
Elev. 7971' T
T Bermijo 1954
T Trinndad 2120
BX T
T Pierre sh 2248
T Green Horn 5659
T Timpas 5412'
T Dakota 5860'
T Morrison 6062

4951 — Artesia Printing Co.

LOG NO. 7041

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD Diam. in/Bottom	
13 3/8	123
9 5/8	389
9 5/8	2264

ELEVATION: 7982 ft.
IP: Dry

COUNTY: Colfax
FIELD: Wildcat
COMPANY: Continental Oil Co.
LEASE: #7 St. Louis Rocky Mtn. & Paci
LOCATION: 660 Feet from N line
660 Feet from E line
SEC: 2 T. 31N R. 20E
COMMENCED: 9-23-55
COMPLETED: 11-5-55
Remarks: rotary tools used 0-6082

FORMATION	BOTTOM, FEET	FORMATION	BOTTOM, FEET
Raton	1954		
Vermejo	2120		
Trinidad	2248		
Pierre	4640		
Apishapa	5416		
Timpas	5471		
Carlisle	5660		
Greenhorn	5691		
Graneros	5858		
Dakota	6058		
Morrison	6082		

GEOLOGIC TOPS

Dakota	5858
Morrison	6058

Appendix IV-5.

√NEW MEXICO OIL CONSERVATION COMMISSION   H   69 7

Continental Oil Co. — Well No. 2 — St. Louis Rocky Mt. & Pacific Railroad Co. — S-T-R 26-31N-21E

Company	Well No.		S-T-R
Continental Oil Co.	2	St. Louis Rocky Mt. & Pacific Railroad Co.	26-31N-21E

Location	2600' fr. N. L	700' fr. E. L		County	Colfax
Spud	5-29-54	Comp.	10-9-54	Field	Wildcat
Total Depth	7268' gr.	P. B.	Top Pay		
I. P.		per day			

CSG. RECORD

Size	Depth	Sax
13 3/8	293	200
7	4610	500

Tbg. @

Remarks: Plugged and Abandoned.
DST 4889-4938 tool op 5 hrs plr failed rec 730' fresh wtr cn FP 550# NO SIP
DST 5147-73 op 2 hrs SI 30 min rec 13' mud FP 100# SIP 825#
DST 5265-5301 op 1 hr SI rec 15' mud all press. 0#
DST 6655-6715 op 45 min v sli blow air im died 11 min rec 5' drlg mud FP 0#
DST 4954-5004 op 1 hr rec 1740' mud FP 625-1000# 20 min SIP 1175#

Shot or Acid:

S/J **FORMATION RECORD**

Elev.	7751'	Chinle	5180
Vermejo	1454	Glo.	5633
Trin.	1525	St Dg. Ch.	
Pierre	1640	T	5900
Graneros	4639	Mad.	6562
Dakota	4825	Penn.	6650
Gr. H.	4650	Gr.	7195
Morr.	4940	T	
Entr.	5313	TGr.	

Appendix IV-5. LOG NO. 6967

New Mexico
Institute of Mining and Technology
STATE BUREAU OF MINES AND MINERAL RESOURCES
Socorro, New Mexico

CASING RECORD
Diam. in/Bottom

Diam. in	Bottom
13-3/8"	293'
7	4610

ELEVATION: 7761
IP:

COUNTY: Colfax
FIELD: Wildcat
COMPANY: Continental Oil Co.
LEASE: St. Louis Rocky Mtn. & Pacific
LOCATION: 1090 from S Line
630 from W Line
SEC: 26 T. 31N R. 21E
COMMENCED: 5-29-54
COMPLETED: 10-9-54
ABANDONED: P&A

FORMATION BOTTOM, FEET FORMATION BOTTOM, FEET

FORMATION	TOP	BASE	GENERAL LITHOLOGY
Raton	surface	1454	F.g.ss., gr. sh. & sltst.; some coal & basaltic still material.
Vermejo	1454	1525	sh., dk. gr.; Ss., wh. to grn.; some coal.
Trinidad	1525	1640	Ss., wh. & grn., some vcl. g., f. grn., br gr. sh. inbds.
Pierre	1640	3740?	Sh., dk. gr.; Sdy. near top.
Apiships	3740?	4320	Sh., dk. gr., calc.
Timpas	4320	4400	Ls., gr., shy., impure; sh. dk. gr., calc.
Carlile	4400	4650	Sh., dk. gr., fiss., some spl., non-calc. for most part.
Greenhorn	4650	4689	Ls., gr. to brn. hd., f. x.; Sh., blk. cal
Graneros	4689	4825	Sh., dk. gr. to blk., fiss.; some calc.
Dakota	4825	4940	Ss., f. to m. g. wh.; well sorted; mostly tight; some blk. sh. imbs.
Morrison	4940	5240	Sh., red, grn., and mar. var.; some ss. gr town., f. g. well sorted, some por.
Todilto	5240	5313	Anhydrite, wh. to lt. pk. soft w. lt. gr. brn. sh.
Entrada	5313	5420	Ss., wh. to lt. gr., m. to f. g., poorly sorted, sh., hd. to soft tight.
Chinle	5420	5683	Siltstone, lt. gr., shy., mica., hd.; Ss., as before only red. Some sdy.
Glorietta	5683	5890	Ss. salmon pk., m. g. to f. g.; some soft & fri.; hr. & tight for most part; some qt

Appendix IV-5.

NEW MEXICO OIL CONSERVATION COMMISSION

Company	Well No.	Lease	S-T-R
Continental Oil Co.	6 P	St. Louis Rocky Mt. & Pacific	26-31N-22E

Location 660' fr. S. L. 660' fr. E. L.		County	Colfax
Spud 3-28-55	Comp. 4-15-55	Field	Wildcat
Total Depth 3650'	P. B. Top Pay		

CSG. RECORD Size	Depth	Sax
10 3/4	508	320
7	3028	50

I. P. per day

Ch. on Tbg. Press: T.

C. Pkr. Gor. Gr.

Plugged and Abandoned.
DST 3358-90 op. 3 hrs rec 35' mud, NS, FP 0#, 1 hr SIP 700#
DST 3665-75 op 2 hrs rec 90' mud, NS, FP 0#, 30 min SIP 690#

Treatments:

S/J FORMATION RECORD

Elev. 6762' Gr.

Formation	Top
Apishapa	T 1960
Timpas	T 2700
Carlile	T 2775
Green Horn	T 2910
Graneros	T 2941
Dakota	T 3100
Morrison	T 3235
Todilto	T 3706
Entrada	3742

Appendix IV-5.

NEW MEXICO OIL CONSERVATION COMMISSION

Consolidated Minerals Development Corp. 1 Sarah ~~[illegible]~~ 26-31N-23E

Company | Well No. | Lease | S-T-R

Location	2634' Fr. S. L	2123' fr. E. L	County	Colfax	
Spud	9-10-56	Comp. 11-20-56	Field	Wildcat	
Total Depth	703' Li	P. B.	Top Pay	CSG. RECORD	
			Size	Depth	Sax
I. P.			16	40	set
Cn.	on	Tbg. @	Press: T.		
C.	Pkr.	Gor.	Gr.		

TEMPORARILY ABANDONED

No DST'S or Cores

FORMATION RECORD

Elev.	T
T	T
T	T
BX	T
T	T
T	T
T	T
T	T
T	T Gr.

Treatments

5175 — Artesia Printing Co.

Appendix IV-5.

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES LOG

COMPANY	WELL NO.	LEASE	S-T-R
Raton City	1		28-31N-24E

Location fr. L fr. L

Spud 1924 Comp.

Total Depth 2700' P. B. Top Pay

I. P. Abd. per day

Remarks:

Shot or Acid:

County Colfax

Field

CSG. RECORD

Size	Depth	Sax

Tbg. at

FORMATION RECORD

Elev.

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Appendix V.--Methods of Investigation

Appendix V.--Methods of investigation

INTRODUCTION

The following text briefly explains the methods and activities employed in the field at and near the proposed low-level radwaste site, Colfax County, New Mexico. It includes the investigations carried out by Gordon Herkenhoff and Associates, Inc., and W.K. Summers and Associates, as well as subcontractors procurred to do additional field work.

Drilling

Red Top Drilling Co., Inc. of Las Vegas, New Mexico furnished the necessary manpower and equipment to drill a total of 70 holes. The rig used to drill these holes was a Rotadrill, Model #64H-B with a General Motors #8V-71 engine, manufactured by Schramm, Inc. of Westchester, Pennsylvania. The rig was on location from September 27, 1976 to January 6, 1977, a total of 102 days. Rig time averaged over 40 hours a week.

All holes were drilled using the air-rotary method. Two types of drill bits were used during the drilling operation:

(1) Fifty-nine vertical holes and three 45° angle holes totaling 4,178 feet of drilling utilized a conventional tri-cone bit.

(2) Eight vertical holes used the tri-cone bit through the alluvium-colluvium overburden but used a coring bit at periodic intervals below the alluvium-colluvium.

A total of 470.3 feet of shale was cored. The coring barrel has an outside dimension of 5-1/2 inches and produces a core 4 inches in diameter. The barrel has the capability of retaining a maximum of 10 feet of core. Prior to coring, the holes were cased through the alluvium-colluvium in order to prevent sluffing; thus only the Pierre shale was cored. A diamond bit was first used in the coring process but it was later determined that a coarser carbide-tipped bit performed more satisfactorily in the shale.

The three 45° angle holes were drilled to a hole length of about 150 feet and a vertical depth of around 106 feet. Special equipment was designated and fabricated by Red Top Drilling Company to accomplish the angle-hole drilling. The use of an additional tower-winch truck was also necessary to move the drill pipe around while angle drilling.

Drill Samples

During the process of drilling, samples were examined continually. Any changes in lithology, formation, hardness, color, etc., were noted. While conventional air drilling with a tri-cone bit, samples were taken at 5-foot intervals when in the alluvium-colluvium material and weathered shale, and at 10-foot intervals in the unweathered shale. Samples were also taken at any time deemed necessary. Core samples varied from very solid and greater than four feet in length to small broken pieces no larger than one's thumbnail. Generally speaking, the weathered shale produced broken cores and the cores of the unweathered shale were fairly solid.

The drill cuttings samples were placed in 7" x 8" Ziploc storage bags. These bags were later sorted according to hole and depth interval and placed in cardboard boxes. Wooden core boxes 10 inches high, 10 inches wide and 5 feet long were made to accommodate 10 feet of core. Wood shavings from the local lumber mill were placed around the core for protection. Badly broken core was placed in Ziploc storage bags and then put into proper position in the core box. Both cores and cuttings were initially kept in Cimarron, New Mexico primarily to maintain access during the on-site testing. They were later shipped to the New Mexico Bureau of Mines and Mineral Resources in Socorro.

Sample Descriptions

Samples were described in the field according to lithology, texture, color, hardness, and any other features worth noting. The texture of the alluvium-colluvium material was described by a classification proposed by Wentworth in 1922. This scheme assumes that most deposits are gravels, sands, silts, or clays and are modified only by the introduction of an appreciable content of foreign-size material. If this foreign-size material constituted between 20 percent and 50 percent of the bulk sample, a modifying term was added. A sand, for example, would be a "clayey sand" if the clay content exceeds 20 percent. To further describe the texture, other modifiers were used such as "slightly clayey" sand, which indicates the clay content to be less than 20 percent but still detectable under field conditions.

Cores were examined very carefully for any fractures, bedding, parting, altered zones, mineralized zones, water streaks and fossils. This examination was performed a minimum of two different times: first, when the core was removed from the core barrel, and later at the time the cores were being loaded on the truck to be shipped to Socorro.

HOLE LOCATION SELECTION

Initially, we proposed that two core holes, five to nine piezometers holes, and three 45° angle holes were to be drilled. The first holes to be drilled at the site were along a near north-south line close to the eastern edge of the property and were to be drilled to an altitude of about 6,130 feet. An unexpected amount of gravel and sand was found to overlie the Pierre shale at the locations of these drill holes; thus, the drilling program was revised.

Seventeen holes were drilled with the express purpose of installing piezometers in them, and are designated on the maps and cross-sections as "CNP" holes. Nine of the piezometers are located on the site and the remaining eight piezometers are located off the property. Thirty-four holes were drilled to determine the depth to shale and the corresponding alluvium-colluvium thickness; these holes are designated "CNS". We later found that 22 of these holes had water in them and subsequently, piezometers were installed. Eight core hole sites were selected; two to be located on the crests of the highest hills on the site, five along a north-south line about in the center of the site, and one in a saddle between two small hills in the east-central portion of the site. The proposed core holes at each end of the north-south line of holes could not be cored due to large amounts of sand and gravel and were thus conventionally drilled with a tri-cone bit. Piezometer pipes were installed in these two holes as well as three core holes in which water was later detected. Core holes are designated "CNC". Four holes were drilled at the request of a geophysicist who wanted to see if he could determine what he believed were shallow seismic anomalies. Water was later found in one of these holes and a piezometer pipe installed. The four holes drilled for geophysical information are labeled "CNG". Four holes were drilled for the express purpose of being water wells. Two of the holes are located in an ancient channel at the south end of the site, but only one of these is capable of producing much water. The other two holes are located on an old terrace just north of Van Bremmer Creek, with only one of these capable of being a good water well. Holes drilled for the purpose of obtaining water are designated "CNW". Three 45° angle holes were drilled and these holes are designated "CNA'. The location of the angle holes is along the perimeter of a circle centered on a 100-foot core hole, with the angle holes being 120° from each other.

TESTS

Open Hole Tests

Pressure-injection tests were used to determine hydraulic conductivities at selected intervals during drilling. A total of 40 such tests were performed in 6 holes.

It was first necessary to set and cement casing a minimum of a few feet into the shale. The reason for this step is because the water is injected at the top of the casing; thus, leaks cannot be tolerated at the casing seat if realistic values are to be obtained.

The equipment used in the pressure-injection tests consisted of a 300-gallon stock water tank, a 2 Hp water pump capable of pumping at least 20 gpm under zero head and able to develop 60 psi pressure, a generator, flow meter and pressure gauges, casing head seal and all the necessary hoses and fittings. The first few tests were run without the capability of releasing the air from the hole as the water displaced it. We found that the air had too great a cushioning effect, which resulted in inconclusive data. This problem, however, was solved by the use of a new type of casing head seal and the addition of one valve. Figure 1 illustrates diagrammatically the set-up used for pressure-injection testing.

Generally, pressure-injection tests were performed at 20-foot intervals. It was first necessary to pull the drill string and bit out of the hole. The casing head seal was then installed and connected to the appropriate hoses, gauges, fittings, and pump. Before each test began, the time and flow-meter readings were recorded. Water was then pumped into the hole at a fast rate and the displaced air allowed to escape through a valve at the casing head seal. Both the pressure and water volume put into the hole were recorded at one-minute intervals. Upon filling the hole with water, the air release valve was closed, and pumping was continued until 40 to 50 psi pressure was obtained at the casing head. When a fracture was encountered, this pressure was not always obtained, and pumping continued until the water tank ran out, recording the pressure and volume every minute. When the 40 to 50 psi pressure was obtained, a valve was closed which isolated everything from the casing head seal except the pressure gauge. The pressure drop was then recorded at as short a time interval as practical down to a psi of around 2. The casing head seal was then removed, and the water level in the hole was measured periodically.

A similar pressure-injection test was tried using a packer mounted to the end of the drill stem. The packer was lowered into the hole and set at a predetermined depth. The drill pipe joint immediately above the ground surface was broken and a device similar to the casing head seal installed into the drill pipe. The supporting equipment was then connected. The packer seal leaked at

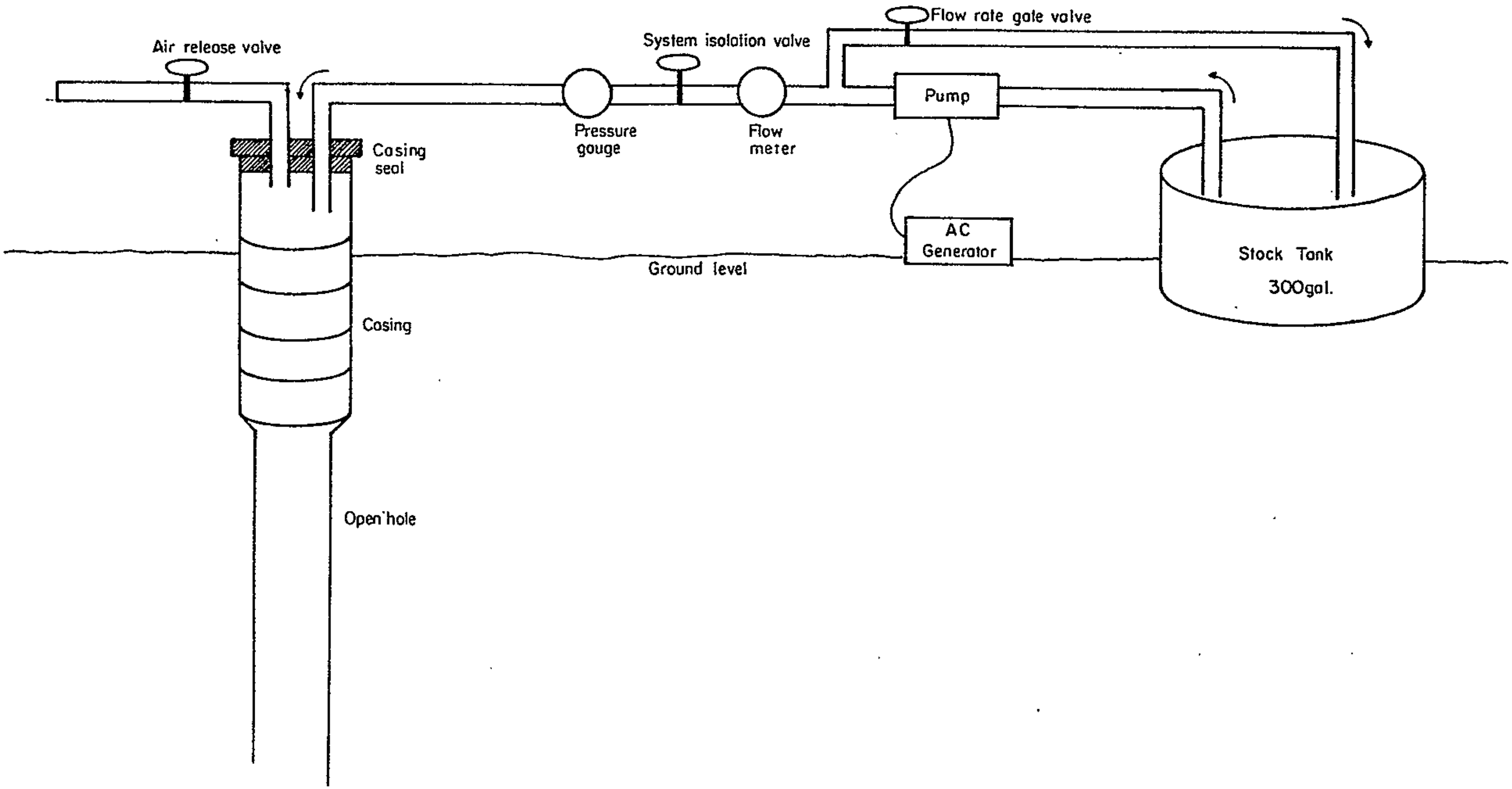

Figure I Apparatus for Pressure injection tests.

a pressure of about 8 psi, resulting in the failure of the test. It was then determined that a suitable seal could not be obtained in the shale and this method of pressure injection was abandoned.

Three slug tests were performed on two holes. In these tests, a known volume of water (10 to 30 gallons) was introduced into the dry hole as rapidly as possible. The initial water level was measured and the subsequent water level drop was recorded at appropriate intervals.

One open-hole pump test was conducted in one of the angle holes. Because of the 45^{o} angle, special equipment had to be designed and fabricated, which was done by Red Top Drilling Company. Water levels during the test were obtained from an air line mounted between the top of the pump and the surface, at which a pressure gauge and a air-input valve were mounted. Air was then pumped through the line with the resulting pressure reading at the gauge being a function of the water level in the hole. The water pumped from the hole was metered for flow volume and piped about 300 feet from the hole.

The two deep holes (400 feet each) were subjected to bore-hole geophysical surveys conducted by Schlumberger of Hobbs, New Mexico. To log the holes we filled them with water. The surveys, which took about two days to perform, resulted in the following logs: dual induction-laterology; bore-hole compensated sonic log; compensated formation density log; and the compensated neutron log. During this time it was necessary to utilize the drill rig in order to handle the logging equipment.

Cased Hole Tests

Pressure-injection tests were conducted on four piezometer holes. The procedure and apparatus used in these tests are the same as those described under "Open Hole Tests" except the water line is connected directly to the piezometer pipe and the air is not released while pumping water in. The level of water in the pipe was measured prior to the test and at adequate intervals following the test. During the test, both the pressure and flow volume were recorded at one-minute intervals.

Slug Tests

Slug tests with one exception involved the following "steps":

(1) an initial water-level measurement with electric sounder;

(2) the addition of one gallon of water (20 secs. average), t = 0 as water starts into well;

(3) water-level measurements according to the following schedule:

t(min)	Measurement interval (min)
0-10	1
10-30	2
30-60	5

The one exception involved CNS-31(P) where the elapsed time for the head to dissipate created by one gallon of water was less than 60 seconds. For piezometers, we made tests in which the water was poured in and followed by rapidly successive water-level measurements. The results of the tests were then combined.

Pumping Tests

The pumping tests consisted of making depth-to-water measurements and recording discharge periodically. They were conducted to determine the hydrologic properties of the rocks tapped by the wells.

We pumped CNW-2 from January 5, 1977, at 0828, where $t_1 = 0$, to January 7, at 1030, where $t_1=0$. In observation well CNC-7, measurements were taken from January 5, 1977, at 0942 to January 10, at 0814.

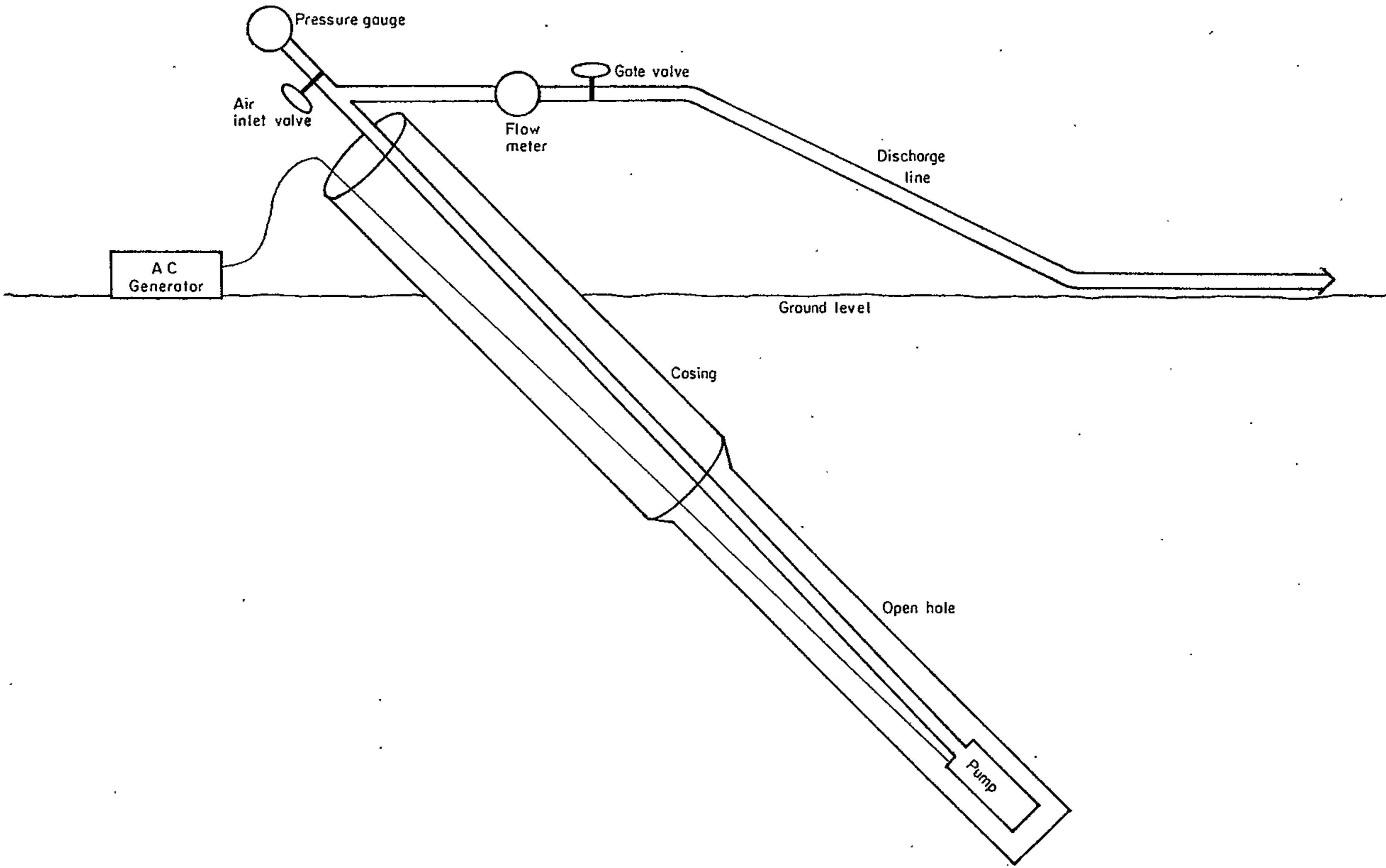

Figure 2 Apparatus for angle hole pump test.

We conducted a test on CNA-3 from January 18, at 1550 to January 18, at 1730. Actual pumping took place from 0350, where $t_1 = 0$, to 0500, where $t_1=0$ (Appendix I-3).

HOLE COMPLETION

Piezometers

As discussed previously, piezometers were installed in those holes found to have water present in them, plus additional piezometers were installed in' the unsaturated zone. In total, 44 piezometers, which used about 2,400 feet of pipe, were installed. The depths of the piezometers are variable, ranging from 11 to 106 feet, with an average depth for all piezometers of about 54 feet.

The piezometers consist of a commercial 2" x 30" or 2" x 36" drive point with number 60 gauze-size screen attached to 2-inch galvanized pipe. Metal spiders, used to keep the pipe and drive point centered in the hole, were welded to the galvanized pipe one foot above the drive point and, for deep installations, in the middle of the pipe section. The pipe and screen were then lowered into the hole by either the drill rig or the tower-winch truck. An amount of pea gravel necessary to come above one foot above the top of the drive point was added to the hole. One-half sack (about 45 pounds) of feed-grade bentonite was then poured into the hole, followed by a mixture of sand, gravel, water and cement in an amount sufficient to fill the hole. The construction of a typical piezometer is displayed in figure 3.

Water Wells

The water wells were located and constructed to provide the best quality and quantity of water available near the proposed site. The wells were first drilled with an 8½-inch tri-cone bit through the alluvium and about two feet into the shale. Eight-inch casing was then installed into the hole completely

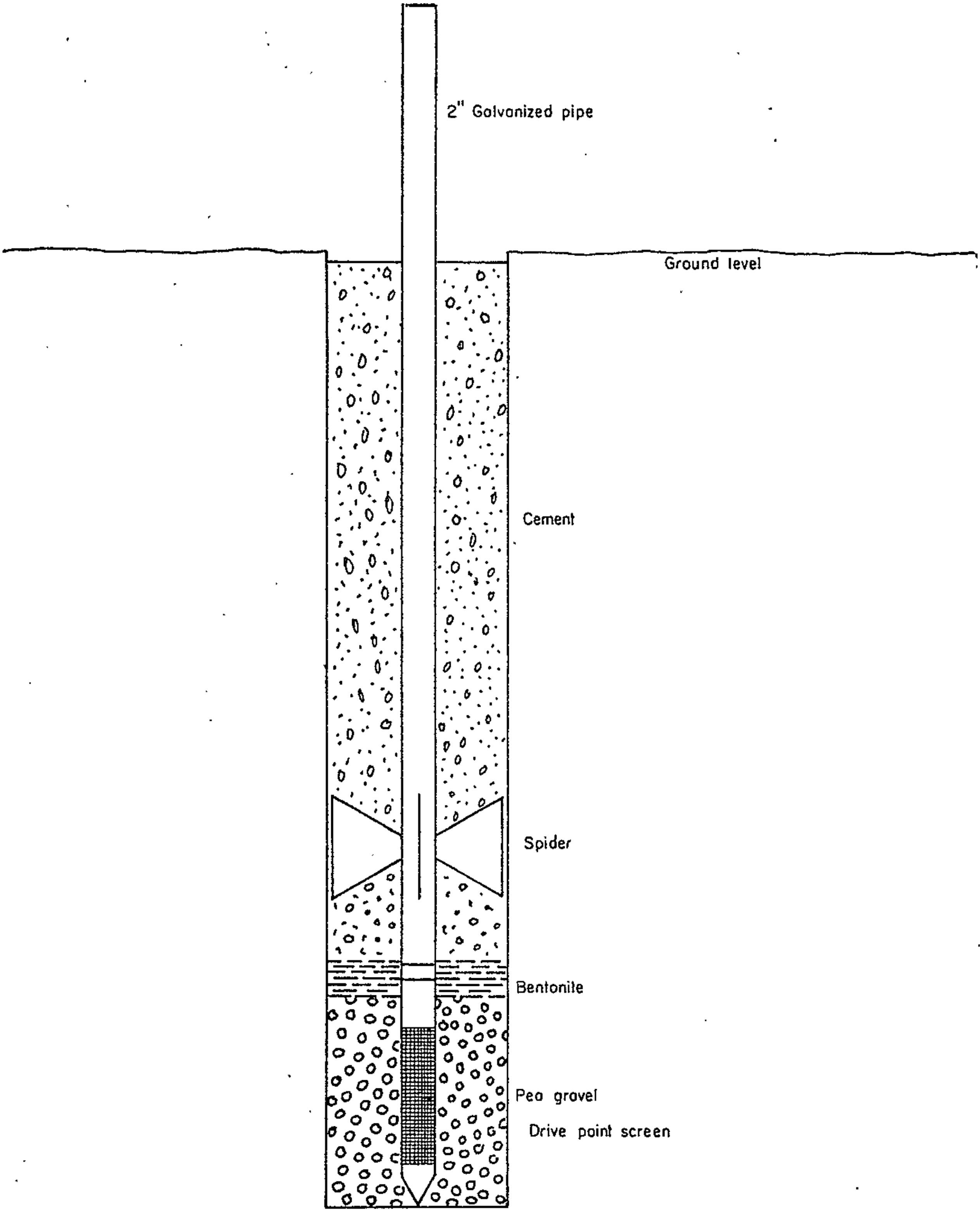

Figure 3. Typical piezometer construction.

to the bottom. Next, a 3-foot piece of 6-inch casing was welded to the bottom of the well screen (stainless steel, 6-inch diameter, 40-mesh screen) and a long length of casing was welded to the top of the screen. This assembly was then lowered down through the 8-inch casing to the bottom, and the 8-inch casing then pulled from the hole. Gravel was packed around the outside of the screen and sand was packed around the outside of the casing. The drill stem was then lowered into the hole with the compressor operating so as to blow out the water with the associated sand and silt. This was continued until just a small amount of sand and silt came up with the water, indicating an adequate gravel pack was surrounding the well screen.

Abandoned Holes

Those holes in which little or no water entered (or for some other reason were not used) were plugged. The method of plugging involved backfilling the holes with drill tailings and cement. A sandy clay soil was then placed over the top of this.

TRENCHES

Five bulldozer trenches were cut on the site at the request of a Chem-Nuclear representative. The trenches were dozed by a model D8 Caterpillar crawler tractor owned and operated by the Colfax Construction Company. Three of these trenches were cut to a depth of about 15 feet and are about 14 feet wide and 100 feet long. The remaining two trenches were cut to depths of less than two feet.

GEOLOGIC MAPPING

Geologic maps of the site and surrounding area were prepared by W.K. Summers and Associates. A topographic contour map at a scale of 1 inch to 500 feet, prepared by Gordon Herkenhoff and Associates, was used as a base for geologic mapping of the site. Regional geologic mapping was done on a topographic contour map published by the U.S. Geological Survey, at a scale of 1 inch to 2,000 feet. The geologic maps show the distribution of rock units and unconsolidated materials as they crop out at the surface.

In addition to the geologic maps, a number of columnar stratigraphic sections were prepared. These sections illustrate in more or less detail the actual succession of strata observed at an outcrop or in a bore hole. Other data, such as the altitude of the groundwater table, were added to some of the sections.

WELL AND SPRING INVENTORY

Geologists from Gordon Herkenhoff and Associates examined all accessible surface and subsurface water sources within a three-mile radius of the proposed site. The field examinations took place between November 1, 1976 and November 5, 1976. The water sources included wells, springs, creeks, and stock ponds. Each source was identified on a base map and described on a field information sheet. The field information sheet is summarized as follows:

(1) date of examination;

(2) identification of water source;

(3) location of water source;

(4) ground-level elevation;

(5) depth to water below measuring point (if applicable)

(6) measuring point;

(7) water temperature;

(8) specific conductance; and

(9) additional comments.

WATER SAMPLING PROCEDURE

Geologists from Gordon Herkenhoff and Associates collected water samples for laboratory analysis from surface and subsurface sources on or near the proposed site. The samples were collected between November 1, 1976 and November 5, 1976. Orlando Laboratories, Inc. of Orlando, Florida provided the containers for collecting and shipping the water samples. For surface sources (creeks, springs, and stock ponds), the water was transferred directly from the source to the sample containers. For subsurface sources (piezometers and wells), a down-hole bailer was used to bring the samples to the surface. Upon reaching the surface, the water was immediately transferred to the sample containers. The water samples were sent to Orlando Laboratories, Inc. for analysis. In addition, five samples collected from piezometers were delivered to Eberline Instrument Corporation, Albuquerque, New Mexico for radioactive isotope analysis.

STREAM-FLOW MEASUREMENTS

All stream-flow measurements were made with V-notch weirs.

Appendix VI. Bibliography

BIBLIOGRAPHY

Andreason, Gordon E., and Kane, Martin F., 1961, Isostatic compensation in the Sangre de Cristo Mountains, New Mexico: U.S. Geol. Surv. Prof. Paper 424-D, p. 277-281.

Andreason, Gordon E., Kane, M.F., and Zietz, Isidore, 1960, Regional geological interpretation of aeromagnetic and gravity data from the Rowe-Mora area, New Mexico, in Geological Survey research 1960 - short papers in the geological sciences: U.S. Geol. Surv. Prof. Paper 400-B, p. B238-B239, 1 fig.

__________, 1963, Aeromagnetic and gravity studies of the Precambrian in northeastern New Mexico: Geophysics, v. 27, n. 3, p. 343-358.

Anonymous, 1956 C, Guidebook of southeastern Sangre de Cristo Mountains, New Mexico: NM Geol. Soc. Guidebook, 7th Field Conf., 151 p., illus.

__________, 1967, Water Resources of New Mexico: Santa Fe, NM State Planning Office, 321 p.

Ash, Sid, and Tidwell, William D., 1976, Upper Cretaceous and Paleocene floras of the Raton Basin, Colorado and New Mexico: N.M. Geol. Soc. Guidebook, 27th Field Conf., Vermejo Park, N. Mex., p. 197-204.

Asquith, J.B., and Gilbert, J.L., 1976, Proximal and distal braided alluvial facies in the lower braided interval of the Dakota Sandstone, Northeastern New Mexico: N. Mex. Geol. Soc. Guidebook, 27th Field Conf., Vermejo Park, N. Mex., p. 153-156.

Bachman, George O. and Dane, Carle H., 1962, Preliminary geologic map of the northeastern part of New Mexico: U.S. Geol. Surv. Misc. Inv. Map I-358.

Baldwin, S. Prentiss and Collins, Robert F., 1928, Descriptive geology of northeastern New Mexico, abs.: Geol. Soc. Am. Bull., v. 39, n. 1.

Ballance, Wilbur C., 1968, Arkansas River basin - geography, geology, and hydrology, in Water Resources of New Mexico -- Occurrence development and use: Santa Fe, N. Mex. State Planning Office, p. 11-23.

Baltz, Elmer H., Jr., 1959, Distribution and facies of Pennsylvanian rocks of the Sangre de Cristo Mountains and Raton Basin, N. Mex., abs.: Am. Assoc. Petrol. Geol. Bull., v. 43, n. 5, p. 1093-1094.

__________, 1964, Tectonic and sedimentary history of Raton basin and notes on San Luis basin, abs.: Am. Assoc. Petrol. Geol. Bull., v. 48, n. 11, p. 1875.

__________, 1965, Stratigraphy and history of Raton Basin and notes on San Luis Basin, Colorado-New Mexico: Am. Assoc. Petrol. Geol. Bull., v. 49, n. 11, p. 2041-2075.

Baltz, Elmer H., Jr., and Read, Charles, B., 1960, Rocks of Mississippian and probable Devonian age in Sangre de Cristo Mountains, New Mexico: Am. Assoc. Petrol. Geol. Bull., v. 44, n. 11, p. 1749-1774.

Bedinger, M.S., and Sniegocki, R.T., 1976, Summary appraisals of the nation's groundwater resources - Arkansas-White-Red Region: U.S. Geol. Surv. Prof. Paper 813-H, 31 p.

Beetem, W.A., et al., 1962, Use of ^{137}Cs in the determination of cation exchange capacity: Geol. Surv. Bull. 1140-A.

Benjar, Craig R., and Lessard, Robert H., 1976, Paleocurrents and depositional environments of the Dakota Group, San Miguel and Mora Counties, New Mexico: N. Mex. Geol. Soc. Guidebook, 27th Field Conf., Vermejo Park, N. Mex., p. 157-164.

Bieberman, Robert A., comp., 1955, Petroleum exploration map of Colfax County, New Mexico: N. Mex. Bur. Mines Min. Res. Petrol. Expl. Map N-1, scale 1 inch to 2 miles. (Kept up to date by continuous revisions.)

Brand, John P. and Mattox, Richard B., 1972, Pre-Dakota Cretaceous formations in northwestern Texas and northeastern New Mexico: N. Mex. Geol. Soc. Guidebook, 23rd Field Conf., East-central N. Mex., p. 98-104, 4 fig.

Brooks, Lon C., 1959, Biostratigraphy of the Purgatoire formation, west-central Quay County, New Mexico: unpub. M.S. thesis, Texas Tech. Univ..

Brown, Roland, W., 1962, Paleocene flora of the Rocky Mountains and Great Plains: U.S. Geol. Surv. Prof. Paper 375, 119 p., 1 fig., 69 pl.

Burbank, W. S. and Goddard, E.N., 1937, Thrusting in Huerfano Park, Colorado, and related problems of orogeny in the Sangre de Cristo Mountains: Geo. Soc. Am. Bull., v. 48, p. 931-976.

Busby, M.W., 1966, Annual Runoff in the conterminous United States, U.S. Geol. Surv. Hydrol. Inv., Atlas HA-212.

Callender, Jonathon F., Robertson, James, M. and Brookins, Douglas G., 1976, Summary of Precambrian geology and geochronology of Northeastern New Mexico: N. Mex. Geol. Soc. Guidebook, 27th Field Conf., Vermejo Park, N. Mex., p. 129-136.

Campbell, Marius Robinson, 1917a., The coal fields of the United States; general introduction: U.S. Geol. Surv. Prof. Paper 100, p. 1-33, map.

Carter, D.A., 1956, Coal deposits of the Raton Basin, in Guidebook to the Geology of the Raton Basin, Colorado, 1956: Rocky Mt. Assoc. Geol., p. 89-92.

Cathey, C.A., 1973, Precambrian geology of the Montezuma, New Mexico, quadrangle: M.S. thesis, Texas Tech. Univ., Lubbock, Texas, 103 p.

Cave, H.S., 1954b., A geologist looks at Raton Basin: Oil and Gas J., v. 53, n. 33, p. 84-88, 6 fig.

Cazeau, Charles J., 1960, Cross-bedding directions in upper Triassic sandstones of northeastern New Mexico: Am. Assoc. Petrol. Geol. Bull., v. 44, n. 5, p. 638-640, 3 fig.

Claassen, Hans C., and Cordes, Edwin H., 1975, Two-well recirculating tracer test in fractured carbonate rock, Nevada: Hydrologic Sciences Bull., v. 20, n. 3, p. 367-382.

Clark, Kenneth F., 1966a., Geology and ore deposits of the Eagle Nest quadrangle, New Mexico: Ph.D. dissert., N. Mex. Univ., 363 p., 19 fig., 25 pl., 8 tables.

________, 1966b., Geology of the Sangre de Cristo Mountains and adjacent areas, between Taos and Raton, New Mexico, in Guidebook of the Taos-Raton-Spanish Peaks Country: N. Mex. Geol. Soc. Guidebook, 17th Field Conf., p. 56-65, 3 fig.

Clark, Kenneth F., Johnson, Ross B., Lambert, Wayne and Lisenbee, Alvis L., 1966, Road log: Sangre de Cristo Mountains and vicinity in Guidebook of the Taos-Raton-Spanish Peaks Country: N. Mex. Geol. Soc. Guidebook, 17th Field Conf., p. 11-26.

Clark, K.F., and Read, C.B., 1972, Geology and ore deposits of Eagle Nest area, New Mexico: N. Mex. Bur. Mines Min. Res., Bull. 94, 152 p., 23 fig., 4 tables, 1 pl., 2 charts, 5 maps.

Cline, L.M., 1953, Raton region, preliminary statement, in (Guidebook) Field Trip of the Raton Basin Region and the Sangre de Cristo Mountains of New Mexico: Panhandle Geol. Soc. Field Conference, p. 5-7.

Cobban, W.A., 1956, The Pierre shale and older Cretaceous rocks in southeastern Colorado: Geology of the Raton Basin: Rocky Mtn. Assoc. Geologists Guidebook, 1956, p. 25-27.

Cobban, William A., 1976, Ammonite records from the Pierre shale of Northeastern New Mexico: N. Mex. Geol. Soc. Guidebook, 27th Conf., Vermejo Park, N. Mex., p. 165-170.

Cobban, William A., and Scott, G.R., 1972, Stratigraphy and ammonite fauna of the Graneros shale and Greenhorn limestone near Pueblo, Colorado: U.S. Geol. Surv. Prof. Paper 645, 108 p.

Collins, Robert Frank and Stobbe, Helen Ruth, 1942, Extrusive and related rocks of northeastern New Mexico, abs.: Geol. Soc. Am. Bull., v. 53, n. 12, pt. 2, p. 1846.

Collins, Robert Frank, 1949, Volcanic rocks of northeastern New Mexico: Geol. Soc. Am. Bull., v. 60, n. 6, p. 1017-1040, illus. incl. geol. map.

Cordell, Lindrith, 1976, Aeromagnetic map of the Wheeler-Later-Costilla Sections of the Sangre de Cristo Mountains: N. Mex. Geol. Soc. Guidebook, 27th Field Conf., Vermejo Park, N. Mex., p. 281-282.

Cruff, R.W. and Thompson, T.H., 1967, A comparison of methods of estimating potential evapotranspiration from climatological data in arid and sub-humid environments: U.S. Geol. Surv. Water Supply Paper, 1839-M, 28 p.

Dalrymple, Tate, et al., 1939, Floods in the Canadian and Pecos River basins of New Mexico, May and June, 1937, with summary of flood discharges in New Mexico: U.S. Geol. Surv. Water Supply Paper 842, 68 p., 9 pl.

DeBuchananne, George D., 1974, Geohydrologic considerations in the management of radioactive waste: Nuclear Technology, v. 24, p. 356-361.

Dempsey, W.J. et al., 1963, Aeromagnetic map of parts of southern Colfax, northern Mora, and western Harding Counties, New Mexico: U.S. Geol. Surv. Geophys. Inv. Map GP-355.

Desjardins, Louis, 1952, (Review of) Late Cenozoic erosional history of the Raton Mesa region, by William S. Levings: Am. Assoc. Petrol. Geol. Bull., v. 36, n. 3, p. 515-517.

Dinwiddie, George A., 1964, Municipal water supplies and uses, northeastern New Mexico: N. Mex. State Engr., Tech. Rpt. 29-B, 64 p., 15 fig., 16 tables.

Dinwiddie, George A. and Cooper, James B., 1966, Water-bearing characteristics of the rocks of eastern Colfax and western Union Counties, New Mexico, in Guidebook of the Taos-Raton-Spanish Peaks Country: N. Mex. Geol. Soc. Guidebook, 17th Field Conf., p. 76-79.

Dixon, George H., 1966, Northeastern New Mexico and Texas-Oklahoma panhandles, in Paleotectonic investigations of the Permian System in the United States, Chapter D: U.S. Geol. Surv. Prof. Paper 515-D, p. 61-80, 9 fig., 1 table.

Edwards, C.L., 1975, Terrestrial heat flow and crustal radioactivity in northeastern New Mexico and southeastern Colorado: Ph.D. thesis, N. Mex. Inst. Mining and Tech.

Edwards, C.L., Reiter, Marshall A., and Shearer, Charles R., 1975a., Heat flow and crustal radioactivity in northeastern New Mexico and southern Colorado, abs.: Am. Geophys. Union Trans., v. 56, n. 12, p. 1069.

__________, 1975b., Terrestrial heat flow in northeastern New Mexico and Southeastern Colorado, abs.: Am. Assoc. Petrol. Geol. Bull., v. 59, n. 5, p. 908.

Eicher, D.L., 1965, Foraminifera and biostratigraphy of the Graneros shale: Paleontology, v. 39, p. 875-909.

Fassett, James E., 1976, What happened during late Cretaceous time in the Raton and San Juan Basins with some thought about the area in between: N. Mex. Geol. Soc. Guidebook, 27th Field Conf., Vermejo Park, N. Mex., p. 185-190.

Fenneman, N.M., 1931, Physiography of the Western United States: McGraw-Hill Book Co., Inc., 534 p.

Foster, Roy W., 1959, Petroleum exploration in northeastern New Mexico, in Guidebook of the southern Sangre de Cristo Mountains, New Mexico: Panhandle Geol. Soc. Guidebook, 7th Field Conf., 24 p., illus.

_________, 1966, Oil and gas exploration in Colfax County, in Guidebook of the Taos-Raton-Spanish Peaks Country: N. Mex. Geol. Soc., Guidebook 17th Field Conf., p. 80-87, 1 table.

Freeze, R.A., 1969, Regional groundwater flow-Old Wives Lake Drainage Basin, Saskatchewan: Dept. of Energy, Mines and Resources, Inland Waters Branch, 245 p.

Gabelman, John Warren, 1956, Tectonic history of the Raton Basin region, in Guidebook to the Geology of the Raton Basin, Colorado, 1956: Rocky Mt. Assoc. Geologists Guidebook, p. 35-39.

Goodknight, Craig S., 1973, Structure and stratigraphy of the central Cimarron Range, Colfax County, New Mexico: M.S. thesis, Univ. N. Mex., 85 p., 26 fig.

_________, 1976, Cenozoic structural geology of the Central Cimarron Range, N. Mex.: N. Mex. Geol. Soc. Guidebook, 27th Field Conf., Vermejo Park, N. Mex., p. 137-140.

Gregory, Joseph T., 1965, Triassic vertebrate fauna of the Redonda formation in northeastern New Mexico: Geol. Soc. Am., Spec.Papers. N. 82 (abs. for 1964), p. 256.

Griggs, Roy Lee, 1948, Geology and groundwater resources of the eastern part of Colfax County, New Mexico (with a section on geology by R.L. Griggs, Stuart Alvord Northop, and Gordon H. Wood, Jr.): N. Mex. School of Mines, N. Mex. Bur. Mines Min. Res., Groundwater Rpt. 1, 180 p., illus., incl. index map, geol. maps.

_________, 1954, A reconnaissance for uranium in New Mexico, 1953: U.S. Geol. Surv. Circ. 354, 9 p., 3 fig.

Griggs, R.L. and Hendrickson, G.E., 1951, Geology and groundwater resources of San Miquel County, New Mexico: N. Mex. Bur. Mines Min. Res., 121 p.

Griggs, Roy L. and Northrup, S.A., 1956, Stratigraphy of the plains area adjacent to the Sangre de Cristo Mountains, New Mexico, in Guidebook of southeastern Sangre de Cristo Mountains, New Mexico: N. Mex. Geol. Soc. Guidebook, 7th Field Conf., p. 134-138.

Grow, D.B. and Beetem, W.A., 1971, Porosity and dispersion constant calculations for fractured carbonate aquifer using the two-well tracer method: Water Resour. Res., v. 7, p. 128-134.

Hitchon, Brian, Feb. 1969, Fluid flow in the Western Canada Sedimentary Basin; 1. Effect of Topography: Water Resour. Res., v. 5, n. 1, p. 186-195.

_________, 1969, Fluid flow in the Western Canada Sedimentary Basin; 2. effects of geology: Water Resour. Res., v. 5, n. 2, p. 460-469.

Houghton, Frank E., 1972, Climatology (in Soil Associations and Land Classification for Irrigation Colfax County, N. Mex.): N. Mex. State Univ., Agri. Exp. Sta. Res. Rpt. 239, p. 7-9.

Hussey, Keith M., 1971, A K-Ar date on the Rocky Mountain pediment sequence, north-central New Mexico: Isochron/West, n. 2. p. 45.

Irwin, James H. and Morton, Robert B., 1969, Hydrogeolic information on the Glorieta Sandstone and the Ogallala Formation in the Oklahoma Panhandle and adjoining areas as related to underground waste disposal: U.S. Geol. Surv. Circ. 630, 26 p., 4 fig., 4 pl., 2 tables.

Jacka, A.D. and Brand, J.P., 1972, An analysis of the Dakota sandstone in the vicinity of Las Vegas, New Mexico and eastward to the Canadian River Valley: N. Mex. Geol. Soc. Guidebook, 23rd Field Conf., p. 105-107.

Johnson, Ross B., 1966a., Road log: Raton to Capulin Mountain National Monument, Folsom Man State Monument and return to Raton, New Mexico, in Guidebook of the Taos-Raton-Spanish Peaks Country: N. Mex. Geol. Soc. Guidebook, 17th Field Conf., p. 27-30.

_________, 1966b., Road log: Raton, New Mexico through Colorado to Questa, New Mexico via Raton Pass, Spanish Peaks, Huerfano Park, Sangre de Cristo Mountains, and San Luis Valley, in Guidebook of the Taos-Raton-Spanish Peaks Country: N. Mex. Geol. Soc. Guidebook, 17th Field Conf., p. 31-42.

_________, 1968a., Geology of the igneous rocks of the Spanish Peaks region, Colorado: U.S. Geol. Surv. Prof. Paper 594-G, 47 p., 9 fig., 1 pl., 21 tables.

_________, 1968b., Volcanic terrain adjoining the central Sangre de Cristo Mountains of Colorado and New Mexico, abs.: Colo. School of Mines Quart., v. 63, n. 3, p. 239-240.

_________, 1969, Geologic map of the Trinidad quadrangle, southcentral Colorado: U.S. Geol. Surv. Misc. Geol. Inv. Map, 1-558.

Johnson, Ross B., Dixon, G.H., and Wanek, A.A., 1956a., Late Cretaceous and Tertiary stratigraphy of the Raton Basin of New Mexico and Colorado, in Guidebook of southeastern Sangre de Cristo Mountains, New Mexico: N. Mex. Geol. Soc. Guidebook, 7th Field Conf., p. 122-133, 7 fig.

________, 1956b., Upper Cretaceous and Tertiary stratigraphy of Raton Basin of New Mexico and Colorado, abs.: Geol. Soc. Am. Bull., v. 67, n. 12, p. 1797.

________, 1966, Late Cretaceous and Tertiary stratigraphy of the Raton Basin of New Mexico and Colorado, in Guidebook of the Taos-Raton-Spanish Peaks Country: N. Mex. Geol. Soc. Guidebook, 17th Field Conf., p. 88-98, 7 fig.

Johnson, Ross B. and Roberts, A.E., 1960, Depositional environment of the coal-bearing formations of the Raton Mesa coal region, New Mexico and Colorado, abs.: Geol. Soc. Am. Bull., v. 71, n. 12, p. 1899-1900.

Johnson, Ross B. and Koogle, Richard L., 1954, Late Cretaceous and Tertiary history of the Raton Basin, Colorado and New Mexico, abs.: N. Mex. Geol. Soc., Proc., 8th Annual Mtg., Apr. 30-May 1, 1954.

Johnson, Ross B. and Wood, G.H., Jr., 1956, Stratigraphy of Upper Cretaceous rocks of Raton Basin, Colorado and New Mexico: Am. Assoc. Petrol. Geol. Bull., v. 40, n. 4, p. 707-721, 7 fig.

Jones, Lois M., Walker, Raymond L., and Stormer, John C., 1974, Isotope composition of strontium and origin of volcanic rocks of the Raton-Clayton district, northeastern New Mexico: Geol. Soc., Am. Bull., v. 85, n. 1, p. 33-36, 1 fig.

Kaufman, Erle G., 1969, Cretaceous marine cycles of the western interior: Mt. Geologist, v. 6, p. 227-245, 4 fig.

Kessler, L.G. II, 1972, Channel geometry, development, and variation, South Canadian River, eastern New Mexico and west Texas: N. Mex. Geol. Soc. Guidebook, 23rd Field Conf., East-central N. Mex., p. 165-167, 3 fig.

Knowlton, Frank H., 1913, Results of a paleobotanical study of the coal-bearing rocks of the Raton Mesa region of Colorado and New Mexico: Am. J. Sci., 4th ser., v. 35, p. 526-530.

Kudo, Albert M., 1976, A review of the volcanic history of stratigraphy of northeastern New Mexico: N. Mex. Geol. Soc. Guidebook, 27th Field Conf., Vermejo Park, p. 109-110.

Lee, Willis T., 1917, Geology of the Raton Mesa and other regions in Colorado and New Mexico: U.S. Geol. Surv. Prof. Paper. 101, p. 9-221, map.

________, 1924, Coal resources of the Raton coal field, Colfax County, New Mexico: U.S. Geol. Surv. Bull., 752, 254 p., 22 pl., 18 fig.

Lesquereux, Leo, 1981, On the fossil plants of the Cretaceous and Tertiary formations of Kansas and Nebraska (also Purgatorie Canyon and Raton Pass): U.S. Geol. Surv. Wyo. (Hayden), Prelim. Rpt. 4, p. 370-385.

Lessard, R.H. and Waldemere, Bejnar, 1976, Geology of the Las Vegas Area: N. Mex. Geol. Soc. Guidebook, 27th Field Conf., Vermejo Park, 1976, p. 103-108.

Levings, William S., 1950, Contribution to the geomorphology of the Raton Mesa area, abs.: Geol. Soc. Am. Bull., v. 61, n. 12, pt. 2, p. 1535-1556.

Lipman, Peter W., 1969, Alkalic and theoleiitic basaltic volcanism related to the Rio Grande depression, southern Colorado and northern New Mexico: Geol. Soc. Am. Bull., v. 80, p. 1343-1354, 2 fig., 2 tables.

Macachlan, M.E., 1976, Lexicon of rock - stratigraphic units in Union, Colfax, Mora and eastern Taos Counties, New Mexico: N. Mex. Geol. Soc. Guidebook, 27th Field Conf., Vermejo Park, N. Mex., p. 205-216.

Maher, J. C. and Collins, J.B., 1949, Pre-Pennsylvanian geology of southwestern Kansas, southeastern Colorado, northeastern New Mexico, and the Oklahoma Panhandle: U.S. Geol. Surv., Oil and Gas Inv. Prelim. Maps, n. 101.

Maker, H.J., Anderson, G.W., and Anderson, J.U., 1972, Soil associations and land classification for irrigation, Colfax County: N. Mex. State Univ., Agri. Exp. Sta. Res. Rpt., 239, 47 p., 8 fig., 7 tables.

Mallory, William W., ed., 1972a., Geologic Atlas of the Rocky Mountain Region: A.F. Hirschfeld Press, Denver, Colo., 331 p., 278 fig.

Mankin, C.J., 1972, Jurassic strata in northeastern New Mexico, N. Mex. Geol. Soc. Guidebook, 23rd Field Conf., p. 91-97.

Matuszczak, R.A., 1969, Trinidad Sandstone interpreted, evaluated, in Raton Basin, Colorado - New Mexico: Mt. Geologist, v. 6, n. 3, p. 119-124, 5 fig.

Mertie, John Beaver, Jr., 1911, The igenous rocks of the Raton Mesa region of New Mexico and Colorado: Thesis, John Hopkins Univ.

________, 1922, Igneous rocks (Raton, Brilliant, and Koehler quadrangles): U.S. Geol. Surv. Geol Atlas, Raton-Brilliant-Koehler folio, N. Mex.-Colo., n. 214, p. 9-12.

Miller, John P., Montgomery, Arthur and Sutherland, Patrick K., 1963, Geology of part of the southern Sangre de Cristo Mountains, New Mexico: N. Mex. Bur. Mines Min. Res. Mem. 11, 106 p.

Misaqi, F. Leo (Missaghi, Fozlallah), 1968a., Geochemical anomalies in the Philmont Ranch Region, New Mexico: N. Mex. Bur. Mines Min. Res. Circ. 92, 12 p., 6 fig., 1 pl., 1 table.

________, 1968b., Geochemical and biogeochemical studies in the Eagle Nest quandrangle, New Mexico: N. Mex. Bur. Mines Min. Res. Circ. 94, 24 p., 17 fig., 3 maps, 1 table.

Mitchell, James G., Greene, John and Gould, D.B., 1956, Catalog of stratigraphic names used in Raton Basin and vicinity, in Guidebook to the Geology of the Raton Basin, Colorado: Rocky Mt. Assoc. Geol. Guidebook, p. 131-135.

Muehlberger, William R., Baldwin, Brewster, and Foster, Roy W., 1967, High plains northeastern New Mexico, Raton-Capulin Mountain - Clayton: N. Mex. Bur. Mines Min. Res., Science trips to the geol. past, n. 7, 106 p.

Northrop, Stuart A. and Read, Charles B., ed., 1966, Guidebook of the Taos-Raton-Spanish Peaks Country: N. Mex. Geol. Soc. Guidebook, 17th Field Conf., 128 p.

Northrop, Stuart A. and Sanford, Allan R., 1972, Earthquakes of northeastern New Mexico and the Texas Panhandle: N. Mex. Geol. Soc. Guidebook, 23rd Field Conf., East-central N. Mex., p. 148-160, 8 fig., 2 tables.

Ogata, Akid, 1976, Two-dimensional steady-state dispersion in a saturated porous medium: U.S. Geo. Surv. J. of Res., v. 4, n..3, p. 277-284.

Olsen, Kenneth H. and Cash, Daniel V., 1975, Seismicity studies in northern New Mexico, abs.: Am. Geophys. Union. Trans., v. 56, n. 12, p. 1022.

Owen, Donald E., 1969, The Dakota Sandstone of the eastern San Juan and Chama basins and its possible correlation across the southern Rocky Mountains: Mt. Geol., v. 6, n. 3, p. 87-92, 2 fig., 1 table.

Papadopulas, Stavros S. and Winogrod, Issac J., 1974, Storage of low-level radioactive wastes in the ground-hydro-geologic and hydrochemical factors: E.P.A.-520/3-74-009, 43 p.

Perkins, Bobby F., 1956, Biostratigraphic studies in the Comanche (cretaceous) series of northern New Mexico and Texas: Ph.D. thesis, Mich. Univ.

Petersen, John W., 1969, Geology of the Tienditas Creek - LaJunta Canyon area, Taos and Colfax Counties, New Mexico: M.S. thesis, N. Mex. Univ., 82 p., 15 fig., 5 tables, 9 pl.

Pillmore, Charles L., 1966a., Geologic relationships of coal deposits, western Raton Basin, New Mexico: Geol. Soc. Am. and Assoc. Socs., Ann. Mtg., paper.

_________, 1969a., Geology and coal deposits of the Raton coal field, Colfax County, New Mexico: Mt. Geologist, v. 6, p. 125-142, 13 fig., 2 tables.

_________, 1969b., Coal deposits of Raton coal field, New Mexico: Am. Assoc. Petrol. Geol., Rocky Mt. Sec., 18th Ann. Mtg., Paper.

_________, 1970, Geologic map of the Casa Grande quadrangle, Colfax County, New Mexico, and Las Aminas County, Colorado: U.S. Geol. Surv. Quad. Map, GQ-823, scale 1:62,500.

Pillmore, C.L., Obradovich, J.D., and Landreth, J.O., 1973, Mid-Tertiary volcanism in the Sangre de Cristo Mountains of northern New Mexico: Geol. Soc. Am. Abs. with Programs, v. 5, p. 502.

Pillmore, Charles L., 1976, Deflation origin of Adams and Bartlett Lake Basin, Vermejo Park, New Mexico: N. Mex. Geol. Soc. Guidebook, 27th Field Conf., Vermejo Park, N. Mex., p. 121-124.

Pillmore, C.L. and Eicher, D.T., 1976, Lower part of the marine Cretaceous at Gold Creek, Vermejo Park, New Mexico: N. Mex. Geol. Soc. Guidebook, 27th Field Conf., Vermejo Park, N. Mex., p. 171-176.

Pillmore, C.L. and Maberry, J.O., 1976, The depositional environment and trace fossils of the Trinidad Sandstone, Southern Raton Basin, New Mexico: N. Mex. Geol. Soc. Guidebook, 27th Field Conf., Vermejo Park, N. Mex., p. 191-196.

Pillmore, C.L. and Scott, G.R., 1976, Pediments of the Vermejo Park Area, New Mexico: N. Mex. Geol. Soc. Guidebook, 27th Field Conf., Vermejo Park, p. 111-120.

Rabinowitz, D.D., Gross, G.W. and Holmes, C.R., 1977, Environmental tritium as a hydrometeorologic tool in the Roswell Basin, New Mexico; I. Tritium input function and precipitation - recharge relation: J. Hydrol., v. 32, p. 3-17.

________, 1977, Environmental tritium as a hydrometeorologic tool in the Roswell Basin, New Mexico; II. Tritium pattern in groundwater: J. Hydrol., v. 32, p. 19-33.

________, 1977, Environmental tritium as a hydrometeorologic tool in the Roswell Basin, New Mexico; III. Hydrologic parameters: J. Hydrol., v. 32, p. 35-46.

Read, Charles B., Wanek, Alexander A., et al., 1964, Geologic map and sections of the Philmont Ranch region, New Mexico: U.S. Geol. Surv., Misc. Geol. Inv. Map, 1-425.

Rich, John Lyon, 1921, The stratigraphy of eastern New Mexico - a correction: Am. J. Sci., 5th ser., v. 2, Nov., p. 295-298.

Ripple, C.D., et al., 1972, Estimating steady-state evaporansporation from bare soils under water table conditions: U.S. Geol. Surv. Water Supply Paper, 2019-A, 39 p.

Roberts, J.W., Barnes, J.J. and Wacker, H.J., 1976, Subsurface Paleozoic stratigraphy of the Northwestern New Mexico Basin and Arch. Complex: N. Mex. Geol. Soc. Guidebook, 27th Field Conf., Vermejo Park, p. 141-152.

Robinson, G.D., et al., 1964, Philmont Country, the rocks and landscape of a famous New Mexico ranch: U.S. Geol. Surv. Prof. Paper 505.

Schilling, John H., 1968, Taos-Red River-Eagle Nest, New Mexico circle drive, 4th ed.: N. Mex. Bur. Mines Min. Res., Scenic Trips to geol. past 2, 26 p.

Schrader, Frank C., 1906, The Durango-Gallup coal field of Colorado and New Mexico: U.S. Geol. Surv. Bull., 285, p. 241-258, 1 pl.

Schwartz, Franklin W., 1977, On radioactive waste management: model analysis of a proposed site: J. Hydrol., v. 32, p. 257-277.

Scott, Robert W., 1970, Stratigraphy and sedimentary environments of Lower Cretaceous rocks, southern western interior: Am. Assoc. Petrol. Geol. Bull., v. 54, p. 1225-1244, 5 fig., 1 table.

Shaw, Gene L., 1956, Tectonic history of Raton Basin with special reference to late Paleozoic, abs.: Am. Assoc. Petrol. Geol. Bull., v. 40, n. 4, p. 786-787.

Sidwell, Raymond G., 1945, Triassic sediments in west Texas and eastern New Mexico: J. Sed. Pet., v. 15, n. 2, p. 50-54, 2 fig.

Smith, J. Fred, Jr., and Ray Louis Lamy, 1939, Structure of the Moreno Valley, New Mexico, abs.: Geol. Soc. Am. Bull., v. 50, n. 12, pt. 2, p. 1935-193

________, 1943, Geology of the Cimarron Range, New Mexico: Geol. Soc. Am. Bull v. 54, n. 7, p. 891-024, 6 pl. incl. geol. map, 2 fig, incl. index map.

Snipes, R.J., et al., 1974, Floods of June 1965 in Arkansas River Basin, Colorad Kansas, and New Mexico: U.S. Geol. Surv. Water Supply Paper 1850D, 97 p

Speer, W.R., 1976, Oil and gas exploration in the Raton Basin: N. Mex. Geol. Soc. Guidebook, 27th Field Conf., Vermejo Park, N. Mex., p. 217-226.

Stobbe, Helen R., 1949a., Dacites from Laughlin Peak, Colfax County, New Mexico, abs.: Geol. Soc. Am. Bull., v. 60, n. 12, pt. 2, p. 1922.

________, 1949b., Petrology of volcanic rocks of northeastern New Mexico: Geol. Soc. Am. Bull., v. 60, n. 6, p. 1041-1095, illus. incl. index map.

Stokes, William L., 1944, Morrison Formation and related deposits in and adjacent to the Colorado Plateau: Geol. Soc. Am. Bull., v. 55, n. 8, p. 951-992, 5 pl., 5 fig.

Stormer, J.C., Jr., 1972a., Ages and nature of volcanic activity on the southern High Plains, New Mexico and Colorado: Geol. Soc. Am. Bull., v. 83, p. 2443-2448.

______, 1972b., Mineralogy and petrology of the Raton-Clayton volcanic field, northeastern New Mexico: Geol. Soc. Am. Bull., v. 83, p. 3299-3322.

-land, Patrick K., 1963, Precambrian structure, key to Pennsylvanian depositional history in the southern Sangre de Cristo Mountain area, New Mexico: Geol. Soc. Am., Spec. Paper, n. 73 (abs. for 1962), p. 251-252.

Y -u, Everars, Cyril E., and Widdison, Jerold G., 1969, The Climate New Mexico: State Planning Office, 159 p.

Wanek, Alexander A., 1963, Geology and fuel resources of the southwestern part of the Raton coal field, Colfax County, New Mexico: U.S. Geol. Surv., Coal Inv. Map C-45.

Week, E.P. and Sorey, M.L., 1973, Use of finite-difference arrays of observation wells to estimate evapotranspiration from groundwater in the Arkansas River Valley, Colorado: Geol. Surv. Water Supply Paper 2029-C, 27 p.

Wood, G.H. Jr., Northrop, S.A., and Griggs, R.L., 1953, Geology and stratigraphy of Koehler and Mount Laughlin quadrangles, eastern Colfax County, New Mexico: U.S. Geol. Surv. Oil and Gas Inv. Map OM-141, scale 1 inch to 1 mile, 2 sheets, text.

Woodard, Lee A., and Snyder, Don O., 1976, Tectonic map of the Southern Raton Basin, New Mexico: N. Mex. Geol. Soc. Guidebook, 27th Field Conf., Vermejo Park, N. Mex., in pocket.

________, 1976, Structural framework of the Southern Raton Basin: N. Mex. Geol. Soc. Guidebook, 27th Field Conf., Vermejo Park, N. Mex., p. 125-128.

Woodward, Lee A., 1972a., Normal faulting related to mountain-flank thrusting, northern New Mexico, abs.: Geol. Soc. Am., Abs. with Programs, v. 4, n. 3, p. 267.

GEOLOGY AND HYDROLOGY

OF A SITE

PROPOSED FOR BURIAL OF LOW-LEVEL

SOLID RADIOACTIVE WASTE

WESTERN COLFAX COUNTY, NEW MEXICO

PREPARED FOR

CHEM—NUCLEAR NEW MEXICO, INC.
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April 20, 1977

Mr. Bruce W. Johnson, President
Chem-Nuclear New Mexico
American Southwestern Plaza
2403 San Mateo Boulevard N.E.
Albuquerque, New Mexico 87110

Subject: Report of Geology and Hydrology of a Site Proposed for Burial of Low-Level Solid Radioactive Waste, Western Colfax County, New Mexico

Gentlemen:

Gordon Herkenhoff and Associates, Inc. and W. K. Summers and Associates submit herewith this report resulting from our investigation of the geology and hydrology of the proposed low-level solid radwaste burial site near Cimarron, New Mexico. We are pleased to report that, after conducting an extensive and detailed investigation, we believe that the site will safely serve as a suitable repository for low-level solid radwastes.

We especially appreciate the freedom of choice you allowed us in selecting methods and paths of investigations. We feel strongly that the studies reported herein constitute the most detailed and complete investigation made of any commercial radwaste site to date.

We are pleased to have assisted you in this investigation. If any further questions arise or assistance is needed, please call us.

GORDON HERKENHOFF AND ASSOCIATES, INC.

Gordon Herkenhoff, President
Registered Professional Engineer

Glenn Hammock
Certified Professional Geologist

W. K. SUMMERS AND ASSOCIATES

W. K. Summers
Ground-Water Geologist

We hereby certify that these documents were prepared by us,or under our direct supervision, and are true and correct to the best of our knowledge and belief.

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INTRODUCTION

Purpose and Scope

This report describes, evaluates, and discusses the hydrologic and geologic factors that determine whether or not a site in western Colfax County, New Mexico, is suitable for development into a low-level radwaste burial facility. We believe the site qualifies and is a suitable place to inter low level solid radwastes. The report presents systematically the basis for this conclusion.

The primary concern about a radwaste burial site is the potential hazard to the biosphere, especially to people. At an ideal site neither radioisotopes nor toxic non-radiogenic substances would ever reach the biosphere as a result of waste burial. We, therefore, directed our efforts at learning how closely the proposed site fits the ideal. This report deals with the hydrologic and geologic factors at, and around the proposed site that might conceivably affect the mobility of radionuclides toward the biosphere.

Federal and state authorities have not established specific criteria that qualify a site as a low-level radwaste repository. The literature, however, contains a rich assortment of suggested items. DeBuchananne (1974) reviewed these suggestions. Table 1 contains a list of the geologic and hydrologic considerations compiled from the literature.

Conceivably radionuclides may return to the biosphere by disinterment or by movement through the soil-rock container. As we shall show, the exposure

Table 1.--Geologic and hydrologic topics recommended for consideration during site evaluation for low-level radwaste disposal facility: a synopsis of the literature.

GEOLOGIC CONSIDERATIONS

A. Rock type (related to ultimate disposal/storage method(s))

   1. Stratigraphic sequence (to depths at least as deep as ground water or maximum possible migration of wastes over hazardous lifetime of facility)

   2. Structural relationships

   3. Mineral potential (economic)

   4. Historical potential (paleontological and archeological)

B. Geologic Hazards

   1. Earthquake risk

   2. Tectonics (subsidence, faults and folds)

   3. Landslide potential

   4. Volcanic potential

PHYSIOGRAPHIC CONSIDERATIONS

A. Topographic

   1. Elevation

   2. Slope

   3. Accessibility

B. Soil Types

   1. Primary disposal (storage of ultimate waste product)

      a. Erodability (texture, structure, permeability)

      b. Depth of bedrock and groundwater

      c. Sorption (suitability/capacity for hazardous materials)

Table 1.--Geologic and hydrologic topics recommended for consideration during site evaluation for low-level radwaste disposal facility: a synopsis of the literature. (cont)

2. Secondary disposal (low-level or dilute process waste streams)

    a. Depth of bedrock and ground water

    b. Sorption (suitability/capacity)

    c. Leaching potential

3. Accidental spills of process feed or waste streams

    b. Depth of bedrock and ground water

4. Engineering limitations

HYDROGEOLOGIC AND HYDROCHEMIC CONSIDERATIONS (Papadopulos and Winograd, 1974, p. 17 and 18)

1. Depth of water table, including perched water tables, if present.

2. Distance of nearest points of ground water, spring water, or surface water usage (includes well and spring inventory).

3. Ratio or pan evaporation to precipitation minus runoff (by month for period of at least 2 years).

4. Water table contour map.

5. Magnitude of annual water-table fluctuation.

6. Stratigraphy and structure to base of shallowest confined aquifer.

7. Baseflow data on perennial streams traversing or adjacent to storage site.

8. Chemistry of water in aquifers and confining beds and of leachate from the waste trenches.

9. Laboratory measurements of hydraulic conductivity, effective porosity, and mineralogy of core and grab samples (from trenches) or each lithology in unsaturated and saturated (to base of shallowest confined aquifer) zone. Hydraulic conductivity should be measured at different water contents and suctions.

Table 1.--Geologic and hydrologic topics recommended for consideration during site evaluation for low-level radwaste disposal facility: a synopsis of the literature. (cont)

10. Neutron moisture meter measurements of moisture content of unsaturated zone. Measurements to be made in especially constructed holes; at least 2 years' record needed.

11. In site measurements of soil moisture tension in upper 5-10 meters of unsaturated zone; at least 2 years record needed.

12. Three-dimensional distribution of head in all hydrostratigraphic units to base of shallowest confined aquifer.

13. Pumping, bailing, or slug tests to determine transmissivity and storage coefficients.

14. Definition of recharge and discharge areas for unconfined and shallowest confined aquifers.

15. Field measurements of dispersivity coefficients.

16. Laboratory and field determination of the movement of critical nuclides through all hydrostratigraphic units.

17. Rates of denudation and (or) slope retreat.

SITE RADIOLOGICAL BACKGROUND CONSIDERATIONS

A. Atmospheric background levels of radiation

B. Background radiation levels in local surface and ground waters

C. Background radiation levels in local soil and biota

CLIMATOLOGICAL CONSIDERATIONS

A. Diffusion characteristics

B. Extreme conditions

  1. Frequency and saverity of hurricanes, tornados, thunderstorms, other local storms and winds.

C. Potential evaporation

D. Seasonal climatology (at the site and along major transportation routes)

Table 1.--Geologic and hydrologic topics recommended for consideration during site evaluation for low-level radwaste disposal facility: a synopsis of the literature. (cont)

1. Air temperature
2. Relative humidity
3. Fog frequency
4. Solar radiation
5. Wind speed and direction (also stability conditions)
6. Precipitation

of waste by extraordinary natural events such as earthquakes or floods, after burial in the trenches we envisage, is virtually impossible. The movement of radionuclides to the biosphere by diffusion through the overburden after burial, and the trenches, designed specifically to minimize movement, is also impossible in the absence of water. We have, therefore, concentrated on the behavior of water at the site. Since the site is in a semi-arid region we focused first upon "average" conditions and then on extraordinary "wet" conditions. Prolonged droughts are an asset because they minimize the availability of water to mobilize the radionuclides.

We directed our efforts at learning about the processes that control radionuclide migration rather than merely generating statistical history. We argue:

> By understanding the processes that operate and their effects on one another, we more reliably predict the impact of events that could cause environmental distress. Simply monitoring selected hydrogeologic phenomena, without regard to the related physical or chemical processes, does not of itself improve our predictive capability. As a result, we have discounted prolonged environmental monitoring as a predictive tool.

Even so, we advocate systematic monitoring as a necessary protective measure and as a means of calibrating computer models of the facility. Therefore, a section on monitoring concepts with suggestions and recommendations for a systematic monitoring program is included.

To prepare this report we have utilized (1) field investigations (Appendix I), (2) laboratory studies (Appendix II), (3) consultants' services (Appendix III), (4) data accumulated in the files of state and federal agencies (Appendix IV), and (5) published reports as listed in the Bibliography. (Appendix V describes our field procedures).

We have made no effort to cite, in the text, all the published references used in its preparation, but have cited them in the Bibliography. The Bibliography lists, in addition to the references cited or used, additional references that we could identify as pertaining to the geology or hydrology of the region.

Summary of Field and Laboratory Studies

Introduction

Evaluation of the proposed site required extensive field and laboratory studies. We believe that the studies reported constitute the most detailed investigation of any commercial radwaste site to date. Many specialists participated to assess the potential hazard created by the buried radwaste. Based on the findings of these specialists, well-supported predictions were made concerning the behavior of the buried waste material. This intensive study of a relatively small parcel of land allows us to conclude that the site will safely inter the radwaste until by decay it becomes innocuous.

Laboratory and Field Studies

Drilling: Because the radwaste material will be stored in trenches ranging from 20 to 40 feet deep, a thorough understanding of the subsurface geology was essential. To provide a basis for complete understanding of the subsurface conditions at the site, 70 drill holes representing over 5,000 feet of drilling, were completed. Many drill holes had multiple purposes.

In addition to providing information relative to the subsurface geology at the site, the drill holes provided mechanism for additional types of studies:

A. Rock samples collected at regular intervals during the drilling operation were evaluated at the site and sent to various laboratories for analysis.

B. Core samples were collected to allow the determination of the "in-place" characteristics of the subsurface geology. (Approximately 470 ft. of core).

C. Piezometer pipes were permanently installed, allowing for continuous monitoring of ground-water characteristics. (44 piezometers)

D. "Slug Testing" of the drill holes permitted predictions of ground-water flow through the subsurface rock. (27 slug tests on separate holes).

E. "Pressure Injection Testing" permitted evaluation of ground-water flow through the subsurface rock under the influence of increased pressure. (40 pressure injection tests in 6 holes).

F. Pump testing of bore holes containing water provided additional information relative to the ground-water characteristics (one pump test in an angle hole and 2 in vertical drill holes).

G. "Slant Holes" or holes drilled at approximately 45^{o} angle were completed primarily to investigate the possibility for the existence of vertical fractures in the subsurface rock material that may not have been encountered by the vertical drill holes. (Three slant holes).

H. Variable depths of drill holes ranging from 12 to 400 feet below the surface permitted independent monitoring of ground-water characteristics at different elevations.

I. The two deepest bore holes were utilized for geophysical analysis. The geophysical surveys included: bore hole compensated sonic log; compensated neutron log; compensated formation density log; dual induction-laterolog; and caliper log. (Completed in two 400 feet deep holes).

Stream Flow: Continuous monitoring of stream flow in nearby Van Bremmer Creek permitted the determination of the influent (water flowing from ground-water into stream) and effluent (water flowing from the stream into the ground-water system) portions of the creek.

Atmospheric Pressure: Continuous monitoring of the atmospheric pressure at nearby Cimarron permitted evaluation of the ground-water characteristics that might be related to atmospheric pressure changes.

Infiltration Studies: The infiltration tests permitted the establishment of the potential infiltration rate of water at various locations throughout the site. The tests were completed under conditions that greatly exceeded expected conditions for maximum rainfall (8 infiltration tests).

Chemical and Physical Analysis of Water Samples and Earth Materials: Water samples collected from piezometers and surface sources were sent to various laboratories for complete analysis. In addition to standard chemical analysis, radiometric analysis of several samples provided a baseline of existing radiation for future reference (25 standard analyses, 5 radiometric analyses).

Earth material samples were collected from the drill cuttings and core samples. Laboratory tests included standard chemical analysis, clay mineralogy, particle size distribution, physical tests of cores, cation-exchange, and sorption studies. (4 whole rock analyses, 14 particle size analyses, 16 particle size distribution analys s, 10 core sample analys .s, 11 cation-exchange analyses, approximately 150 sorption study analyses).

Geomorphic Study: The geomorphic study permitted determination of the rate at which the site may be expected to erode. It was based on the present topography at the site and a knowledge of the processes that have occurred during recent geologic history.

Shallow Seismic Survey: The shallow seismic survey provided an evaluation of varying subsurface conditions based on the velocities of seismic waves through the ground. The survey was especially useful in determining the existence of fractures or faults within the site and changes in rock type beneath the surface.

Photogeologic Study: The photogeologic study was undertaken to evaluate surface structures that may not have been apparent on the ground. The study not only included a detailed study of the site, it also evaluated the potential for major geologic structures in the surrounding area.

Earthquake Risk Analysis: The earthquake risk analysis establishes the probability of earthquakes occurring in the vicinity of the site. Based on historic records, the potential for, and the magnitude of such earthquakes is predicted.

Climatological Studies: Examination of existing climatological data permitted evaluation of the potential maximum rainfalls for specific intervals ranging from the mean annual flood to a 1,000 year rainfall.

Geochronologic Studies: Nine samples of the Pierre Shale were analyzed for their Rb-Sr systematics and eight additional samples were analyzed for their uranium content. This analysis of the radioactive isotopes existing in the Pierre Shale provided information relative to the ages of the shale and the extent to which migration of the isotopes have occurred throughout their existence in the Pierre Shale. The study provides a basis for predicting the potential migration of radioactive elements that are contained in the waste material buried at the site.

Drill Hole Logs: Previously existing drill logs of wells drilled in Northeastern New Mexico were collected and evaluated. These logs provided basic geologic information about the geology of Northeastern New Mexico. Items such as the depth and thickness of the Pierre Shale over a wide area were especially valuable for the preparation of geologic cross sections.

Municipal Water Sources: In order to conclude that the proposed burial site does not influence municipal water sources, an investigation of the municipal water sources for many of the cities and villages in Colfax County was completed.

Discussion

All of the field and laboratory studies were compiled and evaluated independently. Each study or analysis was completed by a respected authority in his relative field of study. We feel that the various studies contribute to a complete understanding of all mechanisms by which radioactive material would become a threat to the biosphere. We feel the field and laboratory procedures undertaken at the Cimarron site are adequate to provide a sound procedural format for future site evaluations.

Conclusions

We have examined the proposed burial site to determine its suitability as a place to put low-level solid radwastes containing potentially hazardous quantities of cobalt-60, cesium-137, and strontium-90. We believe the site is safe and the short-lived isotopes cannot reach the biosphere in hazardous quantities.

Burial in properly designed trenches isolates the waste initially from the biosphere. Only two possible routes exist by which a radioactive component of the waste may re-enter the biosphere: (1) It must be exposed by disinternment (that is, we may deliberately exhume it or natural erosion may remove the cover) or, (2) the radionuclide may be transported as ions or ion complexes in water that moves through the buried wastes.

If the waste is deliberately exhumed, it will be under controlled conditions. Natural erosion rates are so slow as to be negligible. The highest land surfaces are pediments that have been stable for about 200,000 years; the lower slopes are aggrading; the streams are moving progressively farther away from the site. Even gullies seem to heal themselves. With an effective site restoration program, erosion cannot uncover the burial wastes while they are still hazardous.

Transport by water to the biosphere in periods of less than 1,000 years is precluded on a number of grounds:

(1) The site is isolated from water-bearing rocks in two ways; (A) approximately 2,000 feet of shale, with

low to zero hydraulic conductivity, lie between the trenches and the Dakota Sandstone. (The water in the Dakota Sandstone is brackish to saline and the rock yields only limited volumes of water to wells); and (B) ground-water flow systems, created by the topography of the upper Canadian River and its tributaries, provide that <u>all</u> ground-water movement at the site is contained within a local flow system that discharges to either the Vermejo River or its principal tributary, Van Bremmer Creek, upstream from their confluence.

(2) The site's situation, at the end of, or near, the top of a small ridge, totally eliminates any possiblity of flooding or surface runoff onto the site from adjacent land. It further restricts the movement of ground water beneath the site to water moving at depths of 100 feet or more below the water table in the regional and intermediate flow systems.

(3) Precipitation at the site averages about 16 inches per year and will be about 36 inches one year in a thousand. Most of the precipitation that falls on the site returns to the biosphere almost immediately via evapotranspiration. Once a trench has been backfilled, the only source of moisture is the water that infiltrates to become recharge. The average recharge rate is less

than 0.8 inch/year and may be less than .001 inch/year.

(4) Travel times through the shale from the trench area to the water courses are greater than 1,000 years so any of the radionuclides will have decayed if they were to be transported in the circulating ground-water.

(5) The sorption characteristics of the rocks (shale, weathered shale, and alluvium-colluvium) are sufficient to retain, by ion-exchange capture, and delay the movement of the radiogenic isotopes for a period sufficiently long that decay will have rendered them harmless.

(6) Dispersion characteristics of the shale are such that the radionuclide concentration will be diluted and the dispersing front will advance so slowly that decay will have rendered the radionuclides harmless.

(7) Short-circuiting of the system by flow through fractures is not a problem. Several lines of evidence show that fractures are widely spaced, of relatively short length, and most important, are closed under the pressure-head distribution observed at the site. New fractures are not likely to open due to earthquakes.

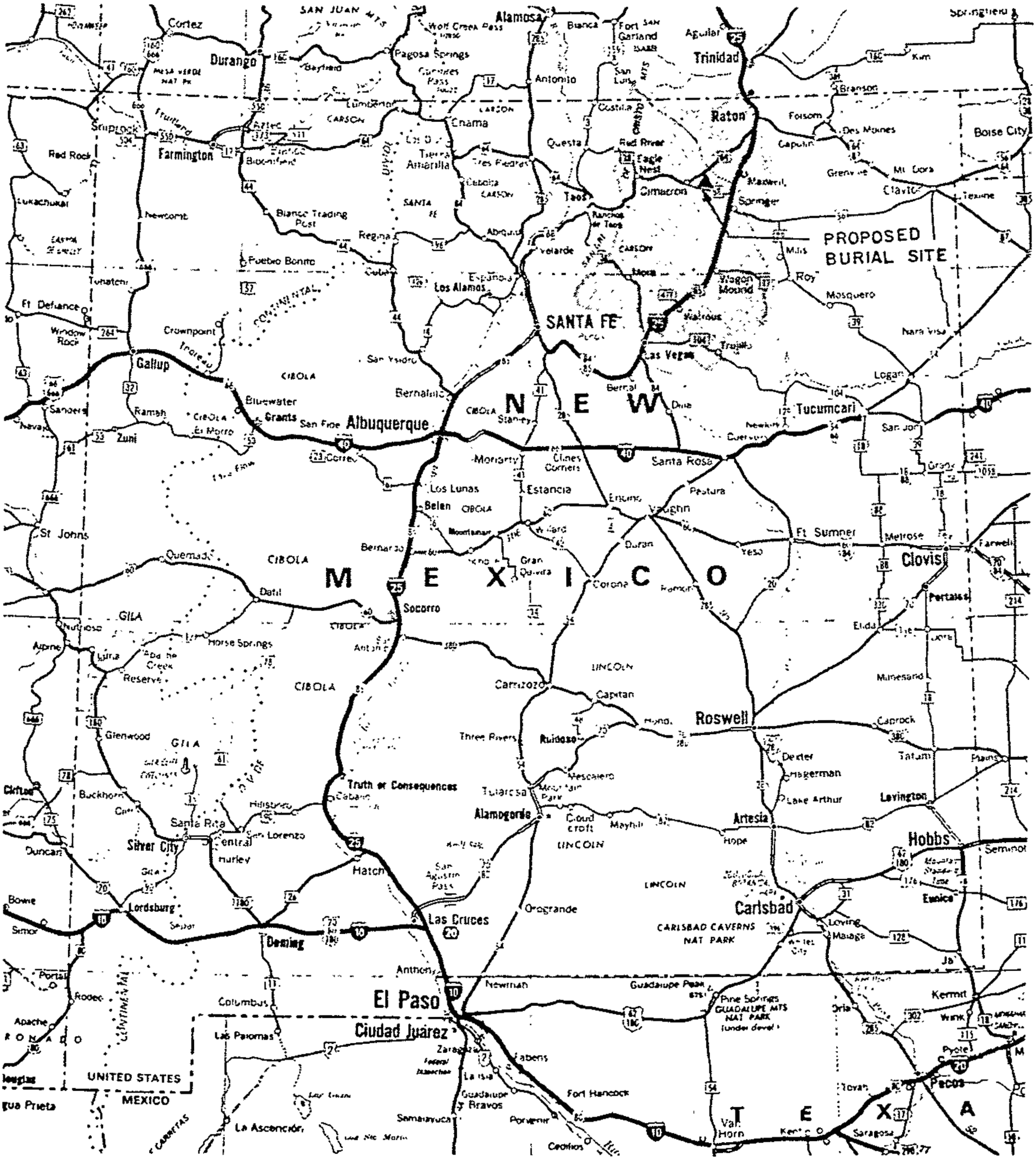
(8) Water-table changes and the amount of recharge during "wet" periods will not change the basic features of the site. The waste will be safely contained between the land surface and the water table for the full life of the radionuclides.

Location of the Site

The site occupies about 900 acres of the Maxwell Land Grant in western Colfax County, New Mexico (Fig. 1). It lies in the triangle formed by the Vermejo River, and its principal tributary, Van Bremmer Creek, and U.S. Highway 64. It is about 12 miles north of Cimarron and 8 miles west of Maxwell. It is only two miles south-southeast of the ghost town of Colfax.

The Maxwell Land Grant has not been surveyed into the General Land Office township and range system. However, extension of the nearby system would place the site in Sections 6, 17, 18, 19, and 20, T.27 N., R.21 E. The latitude of the site is about 36° 34' North. The longitude of the site is about 104° 44' West.

The site is in the upper reaches of the Canadian River basin. The Canadian River is a major tributary of the Arkansas River (confluence in Oklahoma), which in turn is tributary to the Mississippi River (confluence in Arkansas).



▲ PROPOSED BURIAL SITE

UPPER CANADIAN RIVER BASIN

LOCATION OF SITE IN NEW MEXICO

FIGURE 1

CLIMATOLOGY

Climatologic Setting

In 1972 State Climatologist for New Mexico, Franke E. Houghton, described (p. 7-9) the climate of Colfax County as follows:

> Colfax County includes both mountains and plains. The temperatures are generally cool, but the difference in elevation of the high mountain and lower plains area causes the mean annual temperature to range from 55 to 68 degrees.
>
> The average annual precipitation in most of the county is between 15 and 16 inches, but in the higher mountain area it is between 20 and 30 inches. More than one-half of the average annual precipitation falls in July and August, most as brief, but heavy thunderstorms. Raton receives an average of 75 thunderstorms a year between May and September, the period in which nearly two-thirds of the precipitation falls in the county. Occasionally hail accompanies the heavier showers. Tornadoes occur an average of less than one year in ten.
>
> The annual patterns of temperature and precipitation at Cimarron are shown in Table 2, (also Table 2 of this report) and these patterns are generally representative of most of the county below 7,000 feet. For comparison, selected climatological data from other county localities are listed in Table 3 (also Table 3 of this report). Most precipitation is derived from the moist air which reaches New Mexico from over the Gulf of Mexico in the southeasterly circulation about the Bermuda high pressure area. Diurnal heating, augmented by upslope flow of the moist air to the mountains, causes the heavy summer showers. Precipitation in winter is generally light, averaging less that one inch per month. Much of the moisture from the Pacific Ocean storms is lost as precipitation over the mountains to the west.
>
> The average number of days with precipitation of 0.10 inch or more is nearly 30 in most of the county, and more than 50 in the high mountains. Precipitation of 0.50 inch or more falls in an average of 5 to 10 days per year, except in the mountains. Precipitation totals vary greatly from month to month and year to year. June rainfall at Raton ranged from 0.05 inch in 1931 to 11.93 inches in 1965. Annual precipitation in Raton has ranged from less than 8 inches in 1896 to more than 33 inches in 1941. The greatest 24 hour precipitation in New Mexico, 11.28 inches,

Table 2.--Monthly temperatures and precipitation, Cimarron, Colfax County, New Mexico, for period of record 1904-1960 except as indicated (after Houghton, 1972, p.7).

Item	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Temperatures (F°)												
Average daily maximum	47	50	56	64	72	81	94	82	77	68	56	48
Average daily minimum	18	20	25	33	41	49	54	53	46	36	25	18
Daily mean	32	35	41	48	56	65	69	67	62	52	40	34
Extreme maximum	81	76	81	84	90	97	101	100	98	87	81	73
Extreme minimum	-22	-35	-17	- 2	15	25	40	36	23	1	-10	-16
Precipitation												
Average (inches)	.35	.51	.89	1.39	2.02	1.57	2.54	2.55	1.43	1.33	.56	.39
Average days 0.10 inch or more (no.)*	1	1	2	2	5	3	7	7	2	3	2	2
Average snowfall (inches)	4.2	6.0	6.7	4.1	1.5	0	0	0	0.1	1.3	5.0	4.8

* Period of records: 1954-1960

Table 3.--Annual averages of selected climatological data, Colfax County, New Mexico, for the period of record through 1960, except as indicated (after Houghton, 1972, p.8).

Station	Elevation (feet)	Temperatures: Mean maximum (F°)	Temperatures: Mean minimum (F°)	Temperatures: Yrs of record (number)	Precipitation: Mean annual (inches)	Precipitation: Yrs of record (number)	Last 32°F or lower in Spring (average date)	Last 32°F or lower in Fall (average date)	Time between dates (days)
Cimarron	6427	65	35	57	15.53	57	May 6	Oct 10	157
Dawson	6400	67	34	37	15.93	52	May 3	Oct 9	160
Dorsey*	6550	66	34	8	15.87	9	May 7	Oct 7	156
Eagle Nest	8240	58	21	26	14.73	29	June 25	July 30	35
Elizabethtown*	8465	55	23	41	16.92	43	June 22	Sept 9	79
Lake Alice*	6950	65	32	7	20.22	33	May 13	Oct 3	143
Lake Maloya	7400	61	29	14	22.60	10	May 26	Sept 26	123
Maxwell	5909	68	30	14	14.27	10	May 16	Sept 27	134
Miami*	6300	67	33	47	15.88	52	May 8	Oct 6	151
Philmont Ranch	7600	64	31	12	15.64	17	May 23	Sept 28	128
Raton	6676	65	33	14	17.59	14	May 17	Sept 28	134
Raton Filter Plant	6933	64	36	7	18.14	7	May 12	Oct 12	154
Raton Weather Bureau	6379	65	32	18	14.05	17	May 10	Oct 1	144
Shoemaker Ranch*	6200	67	33	13	14.92	14	May 6	Oct 8	154
Springer	5857	68	33	59	14.86	72	May 7	Oct 6	152
Taylor*	5661	67	34	20	15.79	22	May 9	Oct 10	154
Vermejo Park*	7600	62	28	18	16.88	21	May 27	Sept 23	119
Abbott	6040				15.13	52			
Aurora	8130				19.96	51			
Black Lake	8338				16.51	52			

Table 3.--Annual averages of selected climatological data, Colfax County, New Mexico, for the period of record through 1960, except as indicated (after Houghton, 1972, p.8). (cont)

Station	Elevation (feet)	Temperatures: Mean maximum (F°)	Temperatures: Mean minimum (F°)	Temperatures: Yrs of record (number)	Precipitation: Mean annual (inches)	Precipitation: Yrs of record (number)	Last 32°F or lower in Spring (average date)	Last 32°F or lower in Fall (average date)	Time between dates (days)
Cunico Ranch	6820				16.07	20			
Farley*	5800				16.42	7			
Johnson's Park*	6722				17.43	13			

* Period of record: Dorsey, through 1911; Elizabethtown, through 1948; except freeze data through 1938; Lake Alice through 1941; Miami, precipitation through 1959; Shoemaker Ranch, through 1945; Taylor, through 1932; Vermejo Park, through 1926, except freeze data through 1920; Farley, through 1949; and Johnson's Park, through 1923.

fell at Lake Maloya, May 19, 1955. Twenty-four hour totals of 6 and 7 inches fell August 31 - September 1, 1942, at Blakely Ranch, Dawson, Miami, Raton, and Springer, from the remains of a tropical storm moving inland from over the Gulf of Mexico.

Average annual snowfall has greater variability than annual precipitation because of the decrease in temperature with increase in elevation. Most lower elevations receive 20 to 35 inches of snow, but mountains receive 60 to 90 or more inches.

The average diurnal temperature range is 33 degrees. Extremes of temperature have been 104 at Springer and Taylor, and -47 degrees at Elizabethtown. Seldom is 90 degrees reached in the mountains, but occasionally 100 degrees are reached at the lower elevations. At lower elevations, up to 60 days a year reach 90 degrees. One-half the nights at lower elevations and nearly two-thirds of the nights in the mountains reach freezing. Several days a year may have temperatures of zero or lower.

The average freeze-free period below 7,000 feet is 150 days, from early May until early October, but at Eagle Nest and other high mountain valleys, the freeze-free period is only slightly more than one month.

Sunshine occurs nearly 75 percent of the possible time at Raton, or an average of near 3,200 hours a year. The percentage of sunshine is slightly less in winter, about 70 percent, and slightly greater in the fall. Forty percent of the days are clear (less than four-tenths of the sky covered with clouds) and 25 percent of the days are cloudy (more than seven-tenths of the sky covered with clouds). Fog may form a day or two a month from late fall through early spring, but rarely in summer. Average annual evaporation, as measured from a Class A pan at Blakely Ranch, was 75 inches, of which 47 inches occurred during May through October. At Eagle Nest, the May through October average pan evaporation was measured at 41 inches. At Raton Airport, winds are predominately north to northeast in winter and south to southwest in summer. Average wind speed ranges from 12 miles per hour in spring, the windy season, to 8 miles per hour in summer. Strongest winds are usually from the west quadrant. Winds exceed 24 miles per hour about seven percent of the hours.

Climate at the Site

Data

Climatological characteristics of the site can be deduced from the precipitation and temperature data collected at 34 weather stations in Colfax County. Of these stations, 21 recorded both temperature and precipitation and 13 recorded precipitation only. Three stations have less than one year's record. Appendix IV-1 contains the mean monthly and mean annual precipitation and temperatures; the mean monthly and mean annual potential evapotranspiration, surplus, and deficit have been computed according to the Blaney-Criddle method as presented in U.S. Soil Conservation Services Technical Report 21. Cruff and Thompson (1967) demonstrated the validity of this method for arid and subhumid climates.

Variables

Tuan, et al, (1969) have mapped a number of climate variables in New Mexico. They show (p. 159) the climate of the site as semi-arid. Table 4 gives some of the climate variables picked from their maps and tables that apply to the site.

Table 4.--Climatic variables for the site picked from the maps of Tuan, et al, (1969).

Average number of days without killing frost	(p. 87)	140 days
Average date of last killing frost in spring	(p. 88)	May 10
Average date of first killing frost in fall	(p. 89)	Sept. 20-30
Normal annual sunshine (percent of possible)		70%
Normal winter sunshine (percent of possible)		70% +
Normal summer sunshine (percent of possible)		70-80%
Precipitation (average annual p. 18)		16 inches
average winter (Dec., Jan., Feb., p. 30)		1.2 inches
average spring (March, April, May, p. 31)		4.2 inches
average summer (June, July, August, p. 53)		7 + inches
average fall (Sept., Oct., Nov., p. 33)		4 - inches
PE Annual (Thornthwaite Formula) (p. 123)		24.6 inches
Deficit (Thornthwaite Formula) (p. 126)		10.5 inches
Deficit (Frost-free Geason Formula) (p. 127)		8.3 inches

Annual Means

Appendix IV-2 contains the annual precipitation, potential evapotranspiration, surplus, and deficit summarized by altitude intervals for Colfax County. Figures 2, 3, 4, and 5, and Appendix IV-3 show that the relationships of precipitation, potential evapotranspiration, deficit, and surplus to altitude are linear. We may, therefore, estimate these properties for the site with confidence from these relationships as follows:

	Annual Mean (inches)			
Altitude of Site (ft.)	Precipitation	Potential Evapotranspiration	Surplus	Deficit
6,374 (maximum)	16.3	31.8	.6	16.7
6,140 (minimum)	15.9	32.9	.4	18.0

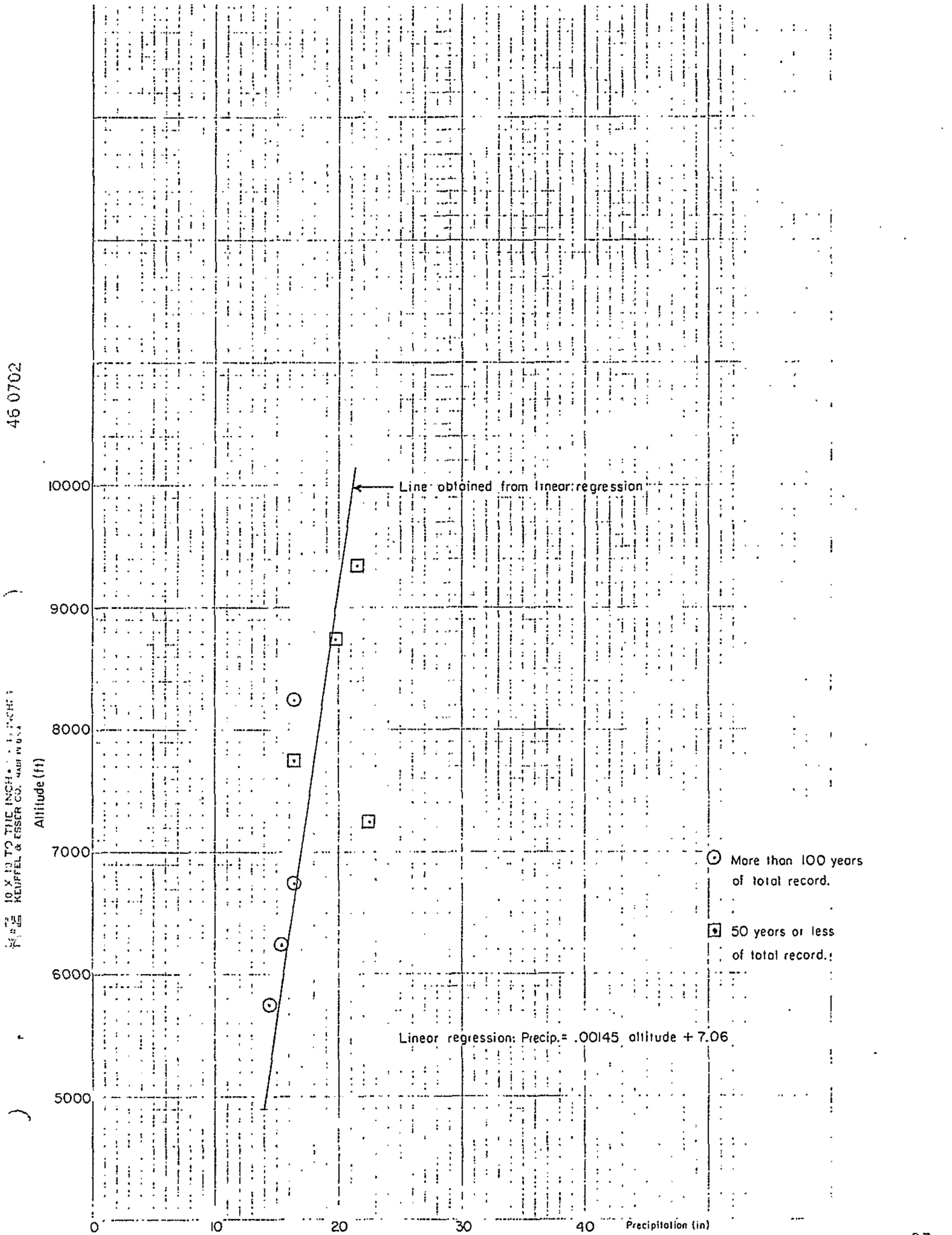


Figure 2. Relation of mean annual precipitation to altitude, Colfax Co., New Mexico.

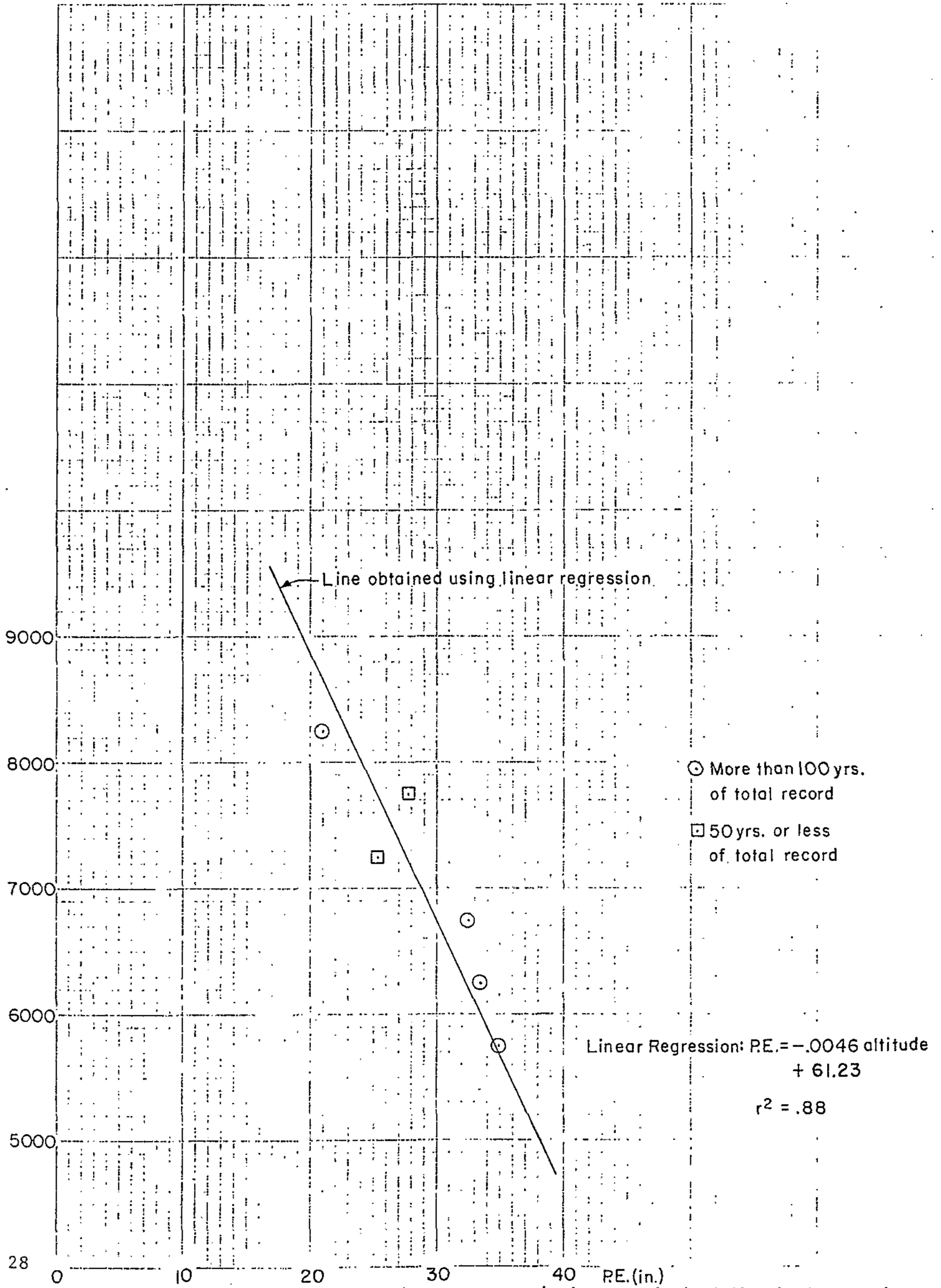


Figure 3 Relation of mean annual potential evapotranspiration to altitude, Colfax Co., New Mexico.

28

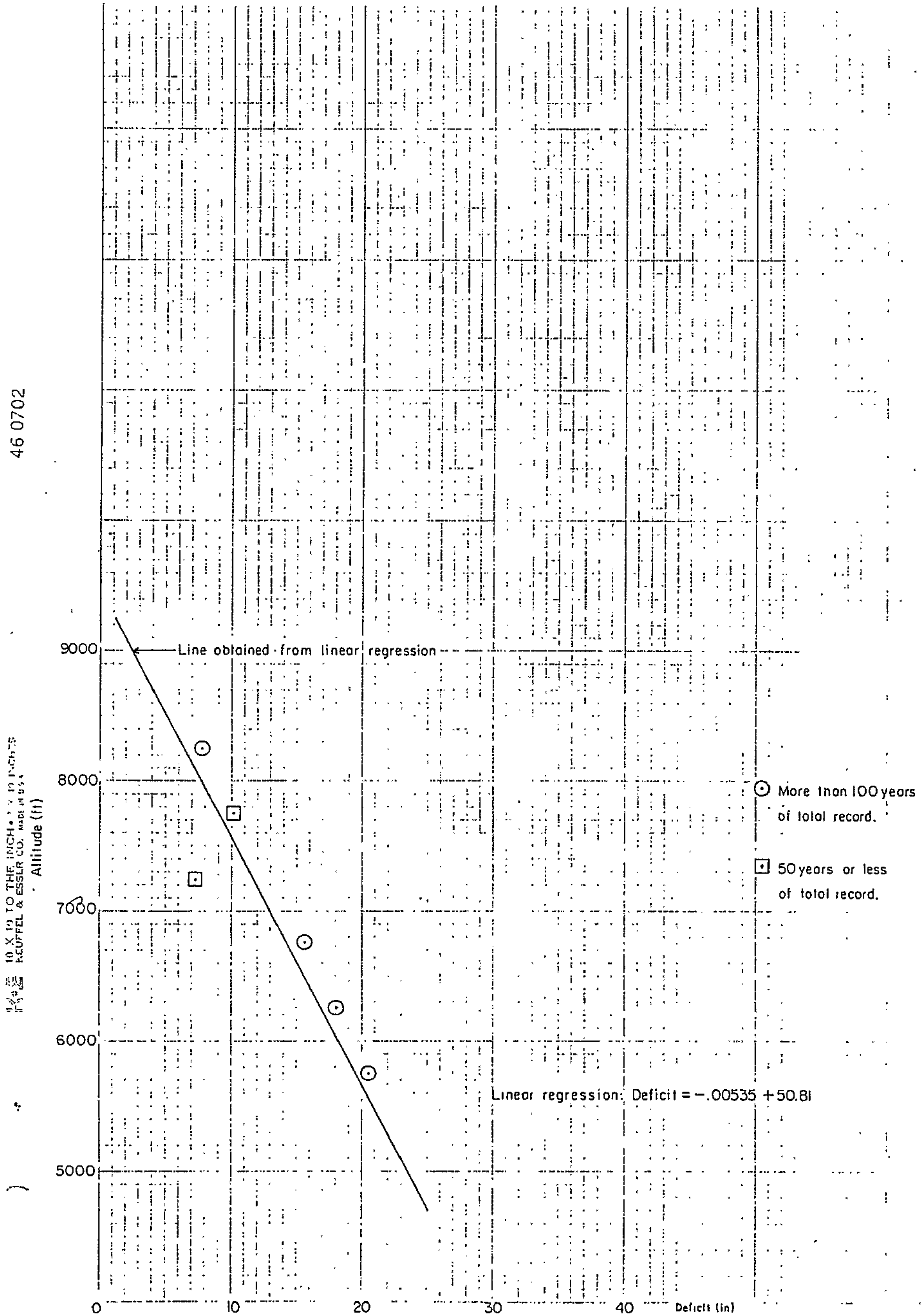


Figure 4. Relation of mean annual deficit to altitude, Colfax Co., New Mexico.

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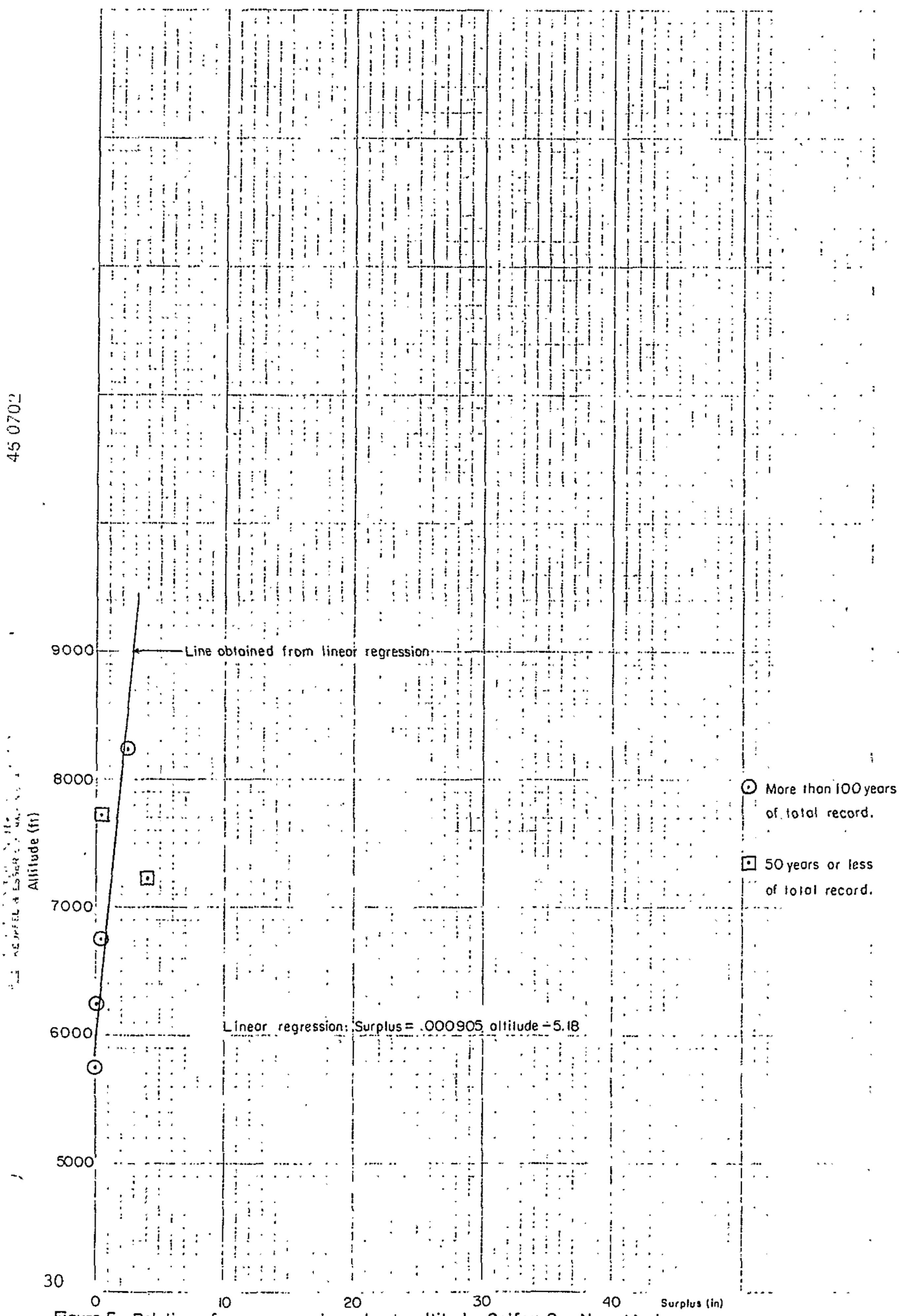


Figure 5. Relation of mean annual surplus to altitude, Colfax Co., New Mexico.

Variations During an Average Year

Precipitation

Table 5 gives the cumulative percent of mean monthly precipitation for stations in Colfax County. During a typical year the precipitation is normally distributed (Fig. 6) and the precipitation can be predicted by:

$$P = 1 - \frac{1}{\sqrt{2\pi}} e^{-Z^2/2}$$

where

P = the percent of the total precipitation by the dth day of the year, and

$$Z = \frac{d-\mu}{\sigma} ,$$

where

μ = day by which 50 percent of the precipitation has occurred, and

σ = the standard deviation (days).

For Abbott, Cimarron, Maxwell, and Raton, μ ranges from 183 to 198 days and σ ranges from 62 to 77 days. Using μ = 190 days, and σ = 75 days as representative of the site, the equation predicts the precipitation at the site during a typical year will be distributed as follows:

	J	F	M	A	M	J	J	A	S	O	N	D	Total
						Percent							
Monthly	2	2	5	9	12	16	15	16	10	7	3	3	100
Cumulative	2	4	9	18	30	46	61	77	87	94	97	100	---
						Inches							
Max. Altitude 6,374 ft.	.3	.3	.8	1.5	2.0	2.6	2.4	2.6	1.6	1.1	.8	.5	16.2
Min. Altitude 6,140 ft.	.3	.3	.8	1.4	1.9	2.5	2.4	2.5	1.6	1.1	.5	.5	15.8

Table 5.--Cumulative percent of mean monthly precipitation for stations in Colfax County, New Mexico

Station	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Abbott	2.0	4.5	8.2	14.8	26.9	39.5	55.5	74.6	86.5	94.8	97.7	100.0
Abbott 2 SE	1.2	3.0	5.9	10.0	23.8	33.4	55.8	79.7	88.6	95.8	98.1	100.0
Aurora	2.8	6.7	12.7	20.5	29.8	41.0	58.8	76.0	87.0	93.6	97.1	100.0
Aurora A	3.2	5.7	10.7	16.4	28.8	37.4	58.3	78.8	84.5	92.7	97.0	100.0
Black Lake	3.2	6.9	12.4	18.8	27.8	38.3	57.7	77.6	86.4	93.4	97.0	100.0
Black Lake A	4.7	7.9	15.9	21.9	29.5	36.8	57.8	72.4	83.2	90.7	96.3	100.0
Cimarron	2.2	5.6	11.1	19.6	31.9	42.3	59.7	76.4	85.9	93.9	97.4	100.0
Cimarron 4 SW	1.1	3.6	12.1	16.1	27.0	35.4	53.1	66.8	85.9	92.5	96.5	100.0
Cimarron 7 SE	1.8	3.7	7.5	13.3	28.4	40.2	60.3	84.0	90.3	94.3	98.1	100.0
Colmor	1.7	12.5	23.3	24.3	36.3	46.2	58.9	78.3	85.9	92.1	95.1	100.0
Colmor A	.1	3.1	6.8	12.8	30.4	41.4	59.8	77.4	88.7	94.9	98.7	100.0
Colmor B	2.6	4.9	8.2	13.5	35.9	43.7	50.4	71.9	91.3	98.3	100.0	100.0
Cunico Ranch	.2	.2	5.8	24.5	32.7	41.4	52.8	68.3	84.3	93.9	99.3	100.0
Cunico Ranch A	2.1	3.8	6.6	11.5	24.3	35.4	60.4	80.5	88.1	96.2	98.2	100.0
Dawson	2.0	5.1	9.3	17.2	30.0	41.2	59.5	76.9	85.6	94.7	97.8	100.0
Dorsey	.6	4.5	9.7	22.6	27.1	49.1	64.1	77.1	91.9	93.5	98.3	100.0
Dorsey A	.6	6.3	7.2	13.8	32.2	47.0	60.7	87.7	93.4	97.6	99.7	100.0
Eagle Nest B	4.8	9.3	15.5	21.9	31.0	38.3	57.2	75.7	84.5	90.5	95.2	100.0
Elizabethtown	4.7	10.6	19.1	27.7	35.6	42.0	59.4	76.8	84.8	91.5	95.7	100.0
Farley	2.8	6.8	10.4	22.0	32.4	41.7	61.4	75.7	89.5	94.4	98.0	100.0
Johnson Park	.9	3.5	7.4	16.7	30.9	45.7	66.0	80.4	86.9	94.6	96.6	100.0
Lake Alice	2.8	6.6	13.0	22.8	35.3	45.9	60.0	75.4	85.7	93.4	96.8	100.0
Lake Maloya	3.9	9.3	16.3	23.9	37.7	47.6	63.3	77.4	83.3	89.4	95.2	100.0
Maxwell	1.7	3.6	6.7	12.5	23.4	34.0	53.1	75.1	85.6	94.1	97.7	100.0
Maxwell A	1.5	3.4	7.7	15.3	28.0	40.4	59.3	80.1	89.6	95.9	97.7	100.0
Miami	2.0	4.8	9.8	17.5	31.7	42.6	58.6	75.6	84.7	94.0	97.8	100.0
Philmont Scout Ranch	2.1	4.2	8.0	19.7	33.7	42.8	63.3	80.1	86.5	94.4	97.8	100.0
Raton	1.7	5.4	9.0	19.1	30.1	40.6	60.1	79.7	89.6	95.1	97.2	100.0
Raton A	2.6	5.4	11.0	17.7	31.4	41.7	57.0	71.0	85.0	92.9	97.5	100.0

Table 5.--Cumulative percent of mean monthly precipitation for stations in Colfax County, New Mexico. (cont)

Station	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Raton Filter Plant	2.3	5.4	10.6	15.8	29.3	40.3	59.6	77.5	85.2	92.4	96.6	100.0
Raton Weather Bureau	2.3	4.4	7.7	14.6	27.3	41.3	59.6	79.5	89.0	95.5	98.0	100.0
Shoemaker Ranch	2.6	4.6	8.0	16.2	29.4	41.3	56.0	72.8	88.6	94.8	98.2	100.0
Springer	2.1	4.5	8.4	15.1	27.3	38.0	57.0	76.1	86.3	93.7	97.1	100.0
Taylor	1.7	4.9	9.8	16.3	29.6	41.0	59.0	76.7	85.5	94.0	97.0	100.0
Vermejo Park	2.4	5.4	10.5	19.2	27.2	36.0	59.2	78.8	87.3	93.3	96.6	100.0
Expectant	2	4	9	18	30	46	61	77	87	94	97	100

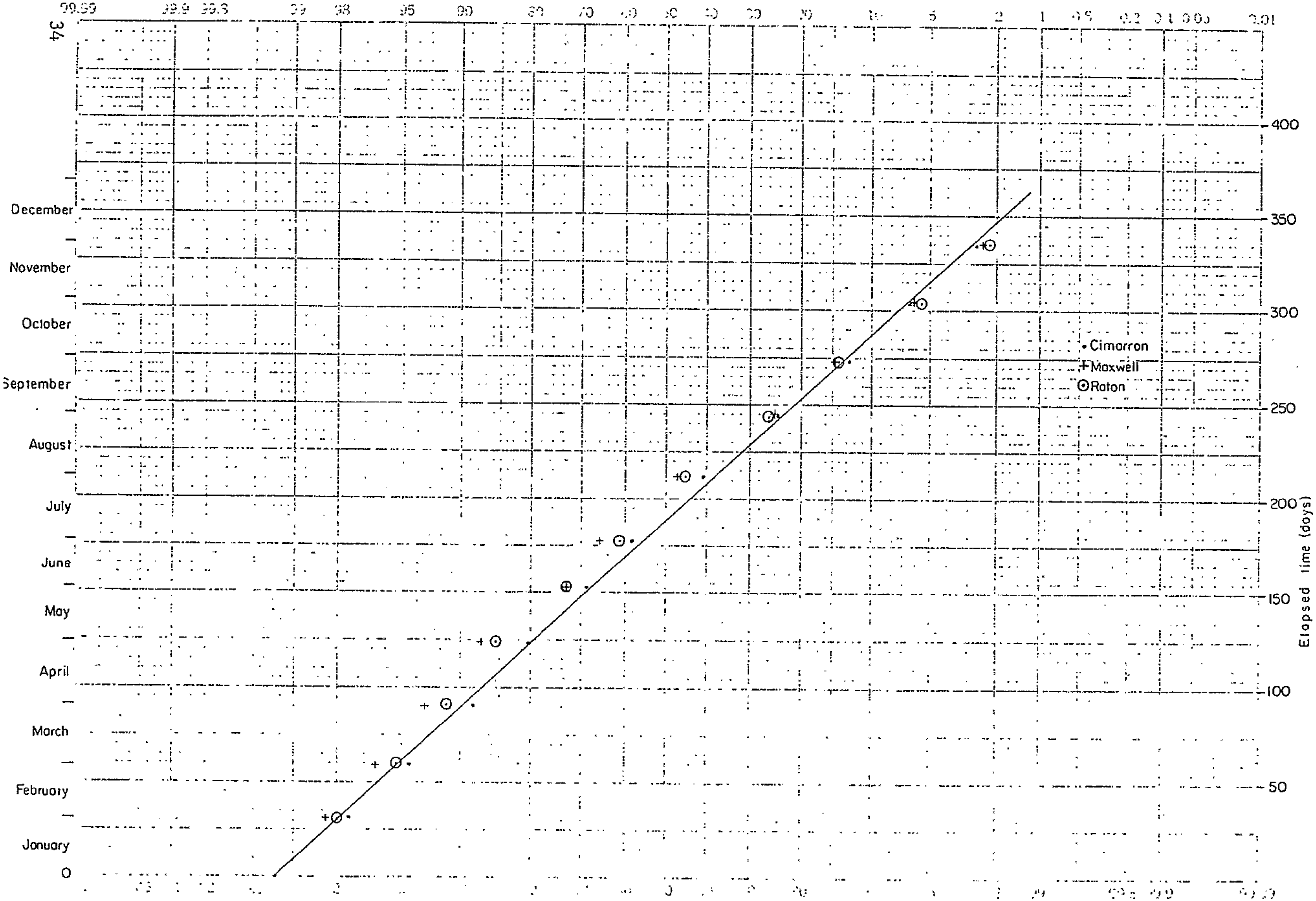


Figure-6. Elapsed days in year versus cumulative percent of precipitation.

This tabulation shows clearly that three months (June, July, and August) are "wet", accounting for nearly half (47 percent) of the total; whereas, five months (January, February, March, November, and December) are "dry", accounting for only 15 percent of the total. The Spring and Fall (April and May, and September and October) are moderately dry, accounting for 19 and 17 percent, respectively, of the annual total.

From the standpoint of precipitation we see the seasons as: Winter = November through March; Spring = April and May; Summer = June, July, and August; and Fall = September and October.

Potential Evapotranspiration, Surplus, and Deficit

Table 6 gives the cumulative percent of mean monthly potential evapotranspiration for Stations in Colfax County, New Mexico.

During an average year PE (potential evapotranspiration) is normally distributed (Fig. 7) and can be predicted by:

$$PE = 1 - \frac{1}{\sqrt{2\pi}} e^{-Z^2/2}$$

where

PE = the percent of the potential evapotranspiration by day (d), and

$$Z = \frac{d - \mu}{\sigma},$$

where μ = the number of days since December 31 required for 50 percent of the annual potential evapotranspiration to have occurred, and

σ = the standard deviation (days).

Table 6.--Cumulative percent of mean monthly potential evapotranspiration for stations in Colfax County, New Mexico.

Station	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Cimarron	1.2	2.8	6.1	12.6	24.3	41.6	61.5	78.4	89.7	96.2	98.7	100
Cimarron 4 SW	1.3	2.9	6.5	12.2	24.1	42.4	62.5	79.3	89.9	96.5	98.7	100
Colmor	.9	2.6	5.2	11.9	24.0	42.4	63.2	80.5	91.6	97.0	99.0	100
Dawson	1.2	2.7	6.0	12.7	24.7	42.2	6.1	78.9	90.1	96.4	98.8	100
Dorsey	1.2	2.7	6.3	12.4	23.9	41.3	60.7	78.7	90.1	96.1	98.8	100
Dorsey A	1.4	2.8	6.9	13.4	23.9	41.5	62.0	79.0	90.5	96.3	98.7	100
Eagle Nest B	1.2	2.8	5.7	11.4	22.5	40.0	61.4	79.8	90.9	96.5	98.7	100
Elizabethtown	1.2	2.9	6.1	11.6	23.1	39.9	61.2	79.5	91.0	96.5	98.7	100
Lake Alice	1.3	2.9	5.9	12.1	23.5	40.5	61.0	78.7	90.1	96.4	98.7	100
Lake Maloya	1.3	3.0	5.7	11.8	23.5	41.6	59.9	78.2	89.9	96.4	98.6	100
Maxwell	1.1	2.6	5.3	11.5	23.4	41.3	62.3	79.9	91.0	97.1	98.8	100
Maxwell A	1.1	2.5	5.0	11.4	23.0	40.5	61.0	78.8	90.3	97.0	98.8	100
Miami	1.2	2.8	6.0	12.4	25.2	42.4	62.0	78.7	90.2	96.4	98.7	100
Philmont Scout Ranch	1.4	3.0	6.1	11.9	23.8	41.4	61.1	78.4	89.9	96.3	98.6	100
Raton	1.2	2.7	5.7	12.1	23.7	41.3	61.3	78.8	90.0	96.2	98.8	100
Raton A	1.1	2.6	5.7	11.8	23.4	41.2	61.8	79.2	90.5	96.6	98.8	100
Raton Filter Plant	1.3	2.8	5.6	11.6	23.3	40.8	61.1	78.4	89.7	96.2	98.7	100
Raton WB	1.1	2.6	5.2	11.3	23.0	40.9	61.5	79.1	90.4	96.7	98.8	100
Shoemaker Ranch	1.1	2.5	6.3	13.8	27.2	43.8	63.0	79.6	90.5	96.6	98.8	100
Springer	1.1	2.5	5.5	12.0	24.2	41.9	61.9	79.6	90.7	96.7	98.9	100
Taylor	1.1	2.6	5.6	12.3	24.5	42.6	61.2	78.9	90.6	96.7	98.9	100
Vermejo Park	1.4	3.2	6.0	12.0	23.2	41.0	61.4	78.9	90.3	96.3	98.6	100

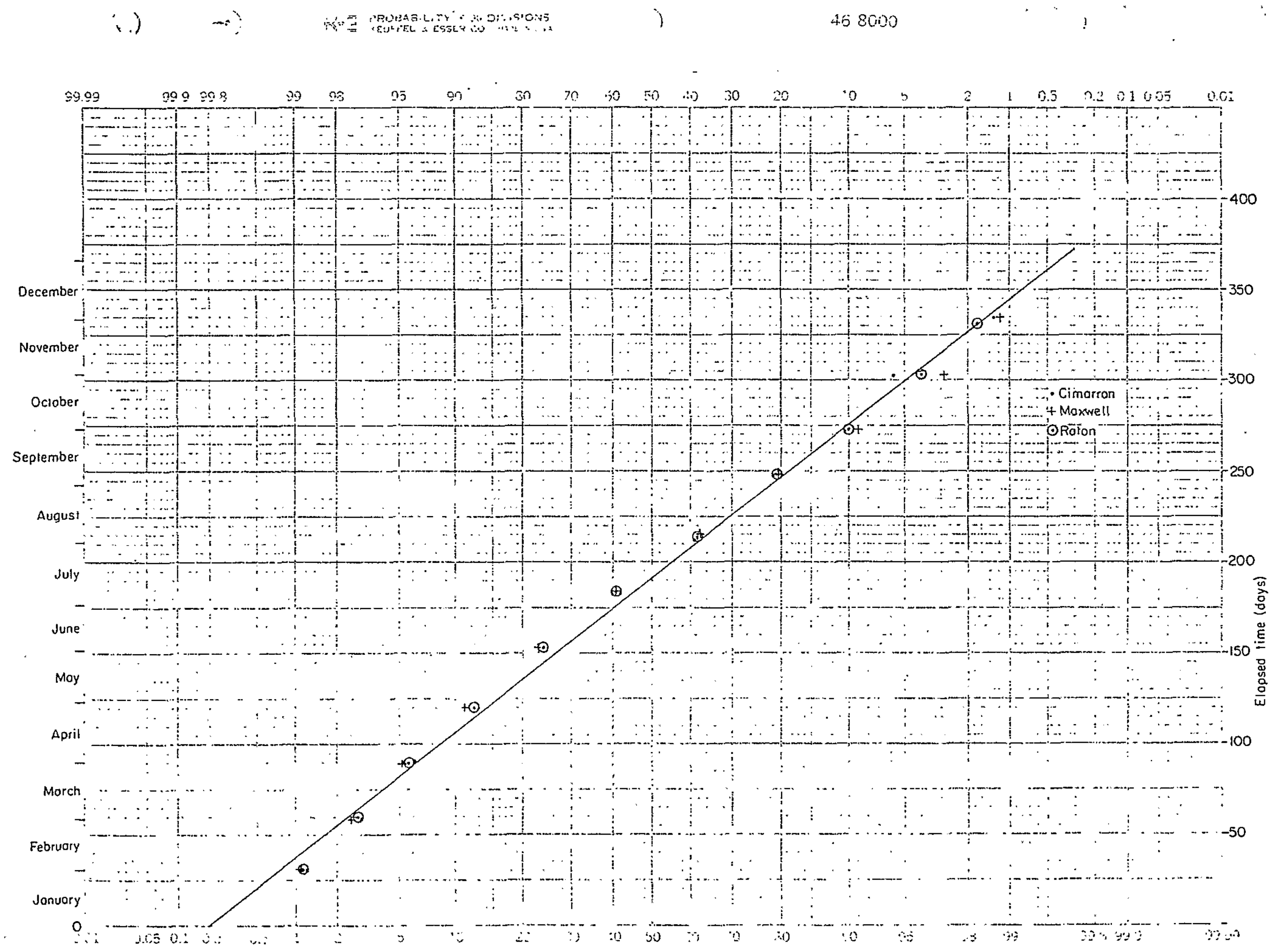


Figure-7. Elapsed days in year versus cumulative percent of potential evapotranspiration.

For Cimarron, Maxwell, and Raton the relationship is:

$$PE = 1 - \frac{1}{\sqrt{2\pi}} e^{\frac{-(d-190)^2}{67}/2}$$

The potential evapotranspiration during a typical year at the site will be distributed as follows:

	J	F	M	A	M	J	J	A	S	O	N	D	Total
							Percent						
Monthly	1	1	5	8	13	17	18	17	10	7	2	1	100
Cumulative	1	2	7	15	28	45	63	80	90	97	99	100	---
							Inches						
Max. Altitude 6,374 ft.	.3	.3	1.7	2.6	4.3	5.6	5.9	5.6	3.3	2.3	.7	.3	32.9
Min. Altitude 6,140 ft.	.3	.3	1.6	2.5	4.1	5.4	5.7	5.4	3.2	2.2	.6	.3	31.6

The estimated surplus and deficit thereby become:

							Inches						
	J	F	M	A	M	J	J	A	S	O	N	D	Total
Surplus													
6,374 ft.	0	0	0	0	0	0	0	0	0	0	0	.2	.2
6,140 ft.	0	0	0	0	0	0	0	0	0	0	0	.2	.2
Deficit													
6,374 ft.	0	0	.8	1.1	2.1	2.8	3.3	2.8	1.6	1.1	.1	0	15.8
6,140 ft.	0	0	.9	1.2	2.4	2.1	3.5	3.1	1.7	1.2	.2	0	17.3

The estimated annual surplus and deficit are less than those estimated by regresssion of the mean-annual values with altitudes. The difference is due in part to the choice of μ and σ for precipitation and potential evapotranspiration. But the difference is small and the results obtained reflect the average-annual distribution of precipitation, potential evapotranspiration, surplus, and deficit fairly well.

Discussion

The distribution of precipitation in time and space will determine whether or not infiltration into buried waste can occur. Obviously, during "dry" periods infiltration is impossible so we will ignore "dry" periods hereafter.

During an average year most precipitation at the site returns almost immediately to the atmosphere via evapotranspiration, so infiltration is negligible.

During "wet" periods the probability of infiltration increases according to the increase in precipitation. When precipitation exceeds potential evapotranspiration, the potential for infiltrating water to reach the buried waste is greatest. Surpluses can come about by either:

(1) a single episode of sustained precipitation; or

(2) long "wet" periods.

Twenty-Four Hour Precipitation

The amount of precipitation that the site might experience in the first case can be estimated by a consideration of the recurrence interval of selected precipitation rates. Figure 8 shows the recurrence intervals of the total precipitation during 6-hour and 24-hour periods for recurrence intervals of 1 to 100,000 years. This figure shows that the maximum rainfall that can be expected during a 6 hour period about one year in a thousand (under present climatologic conditions) is about 5.1 inches, and the maximum rainfall that can be expected during a 24-hour period about one year in a thousand (under present conditions) is about 6.9 inches.

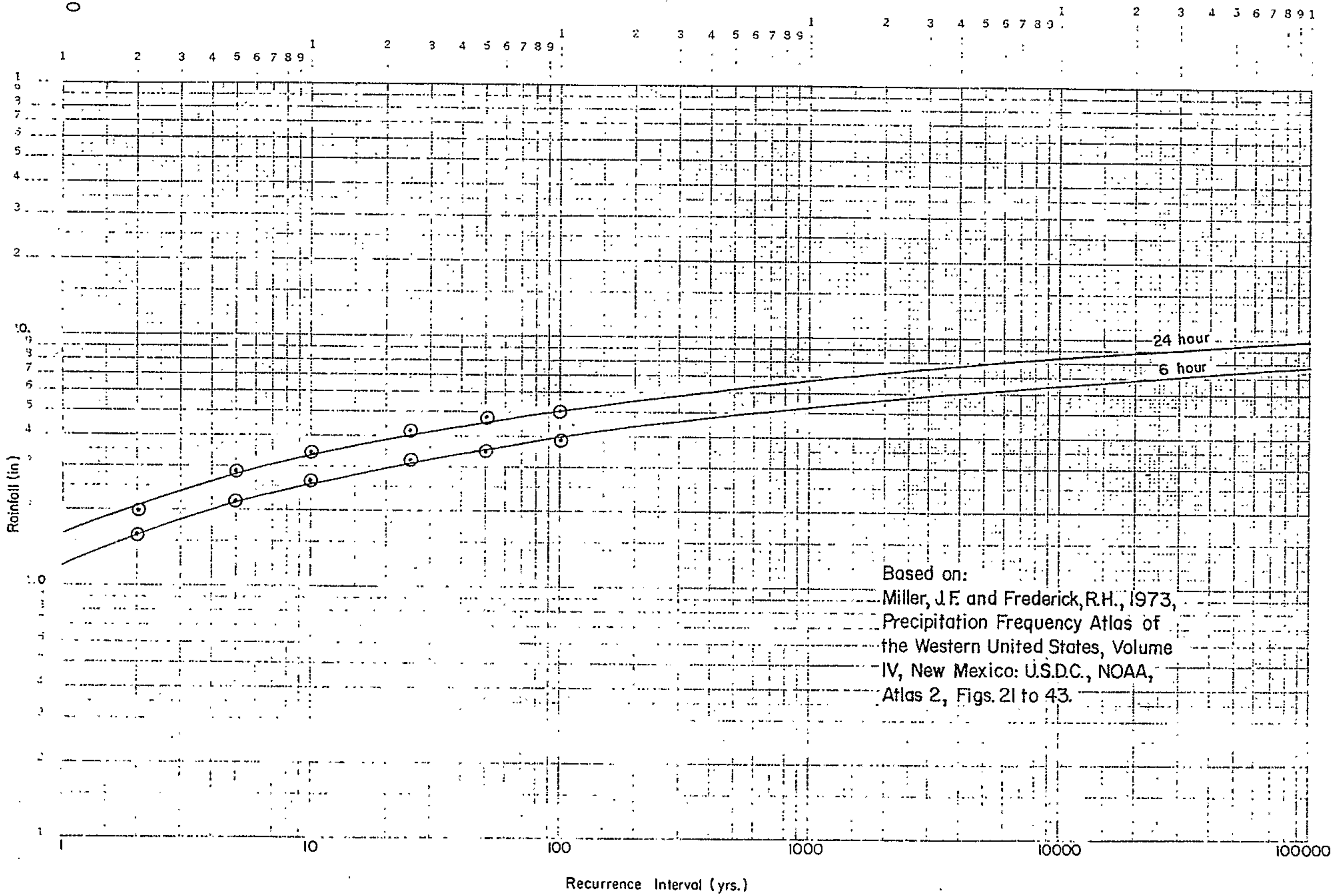


FIGURE 8. Frequency of 6-hour and 24-hour rainfall near confluence of Van Bremmer Cr. and Vermejo R., Colfax Co., New Mexico.

"Wet" Periods

Appraisals of two data suites from extant stations give insight to the potential characteristics of a sustained "wet" period. One suite is the data for the "wettest" 12 month period for the United States, including New Mexico. The other is the annual precipitation history for those stations with the longest period of record.

"Wettest"-12 Month Period

The period November 1940 through October 1941 was the wettest 12 month period in New Mexico's history (Tuan) et al, 1969, p. 143). Tables 7 to 10 summarize the data for this period from stations in Colfax County. Linear regression of station altitude versus total precipitation gives:

$$\text{Altitude} = -56.26\ (\text{precipitation}) + 8135.02$$

with a correlation coefficient (r^2) of .20 -- an extremely poor correlation of precipitation with altitude. The mean precipitation for the 11 stations was 31.18 inches (standard deviation of 4.105 inches).

Even though the total precipitation for the period on the average was nearly twice the average for the site, the precipitation for four months was at or below the average for the site (Table 7).

The mean potential evapotranspiration for the period was very close to the average potential evapotranspiration expected at the site (Table 8). The deficit was much less than the average (Table 9). The surplus was much greater than the average (Table 10).

Table 7.--Precipitation recorded by months in Colfax County during "wettest" 12-month period of record, Nov. 1940 - Oct. 1941.

	(Inches)												
	1940		1941										
Station	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Total
Abbott	4.00	.16	.46	.18	1.95	1.88	6.35	1.84	3.80	2.76	7.79	2.42	33.59
Cimarron	2.31	.53	.53	.13	3.55	2.23	4.35	2.14	3.49	.99	3.37	2.76	26.38
Cunico Ranch	2.59	.04	0	.01	2.00	2.35	3.67	2.18	2.96	4.32	5.60	2.37	28.09
Dawson	2.79	.55	.29	.30	4.25	3.00	3.92	1.14	6.07	2.11	4.44	2.77	31.52
Farley	2.95	.48	.34	.39	2.11	2.06	5.55	2.80	6.37	3.60	6.98	2.57	36.2
Lake Alice	1.44	.80	.57	.46	3.45	3.80	4.90	3.54	3.45	2.59	7.70	3.18	35.88
Miami	2.34	.40	.42	.03	3.04	3.36	4.81	1.24	3.69	1.75	4.60	1.97	27.65
Raton A	2.49	.44	.36	.32	3.61	3.01	5.22	3.77	3.14	2.88	8.00	2.72	35.96
Shoemaker Ranch	3.33	.45	.43	.04	3.25	2.57	4.73	2.48	3.52	1.90	5.07	1.91	29.68
Springer	3.66	.35	.43	.04	3.09	2.54	5.64	1.83	3.73	2.36	6.76	2.83	33.26
Vermejo Park	2.05	1.03	.46	.27	3.57	2.11	2.78	3.44	3.51	1.36	2.20	2.01	24.79
μ	2.72	.48	.39	.20	3.08	2.63	4.72	2.40	3.98	2.42	5.68	2.50	31.18 31.20
σ	.736	.271	.152	.160	.752	.599	1.01	.901	1.14	.967	1.93	.407	9.025

Table 7.--Precipitation recorded by months in Colfax County during "wettest" 12-month period of record, Nov. 1940 - Oct. 1941. (cont)

	(Inches)												
	1940		1941										
Station	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Total
"Average" for Site	.5	.5	.3	.3	.8	1.5	2.0	2.6	2.4	2.6	1.6	1.1	16.2
(μ-Ave) =	2.2	0	.1	-.1	2.8	1.1	2.7	-.2	3.6	- .2	4.0	1.4	

Table 8.--Potential evapotranspiration computed by months for stations in Colfax County during "wettest" 12-month period of record, Nov. 1940 - Oct. 1941.

	(inches)												
	1940		1941										
Station	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Total
Cimarron	.72	.45	.43	.64	1.09	2.07	4.23	5.26	6.47	5.69	3.64	1.90	32.59
Dawson	.75	.43	.44	.70	1.09	2.14	4.46	5.61	6.50	5.95	4.10	2.27	34.44
Lake Alice	-	-	.40	.52	.75	1.50	3.65	4.57	5.73	5.06	3.32	1.74	-
Miami	-	.37	.39	.64	.96	1.98	4.26	5.25	6.23	5.96	4.16	2.19	-
Raton A	.58	.44	.42	.58	.80	1.69	3.95	5.14	6.12	5.50	3.56	1.95	30.73
Shoemaker Ranch	.57	.33	.33	.54	.97	2.07	4.25	5.14	6.22	5.73	3.64	2.08	31.87
Springer	.60	.33	.34	.61	1.10	2.25	4.66	5.73	6.77	6.05	4.00	2.33	34.77
μ	.64	.39	.39	.60	.97	1.96	4.20	5.24	6.29	5.71	3.77	2.06	32.88
σ	.084	.055	.043	.063	.143	.266	.329	.375	.331	.342	.315	.214	32.22

Table 9.--Deficit computed by months for stations in Colfax County during "wettest" 12-month period of record, Nov. 1940 - Oct. 1941.

	(inches)												
	1940		1941										
Station	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Total
Cimarron	-	-	-	.51	-	-	-	3.12	2.98	4.70	.27	-	11.58
Dawson	-	-	.15	.40	-	-	.54	4.47	.43	3.84	-	-	9.83
Lake Alice			-	.06	-	-	-	1.03	2.28	2.47	-	-	
Miami		-	-	.61	-	-	-	4.01	2.54	4.21	-	-	
Raton A	-	-	.06	.26	-	-	-	1.37	2.98	2.62	-	-	7.29
Shoemaker Ranch	-	-	-	.50	-	-	-	2.66	2.70	3.83	-	.17	9.86
Springer	-	-	-	.57	-	-	-	3.90	3.04	3.69	-	-	11.20
μ	-	-	.03	.42	-	-	.08	2.94	2.42	3.62	.04	.02	9.95
σ	-	-	.057	.195	-	-	.204	1.33	.925	.810	.102	.064	9.57
"Average" for Site	.1	-	-	-	.9	1.2	2.4	3.1	3.5	3.1	1.7	1.2	17.3

Table 10.--Surplus computed by months for stations in Colfax County during "wettest" 12-month period of record, Nov. 1940 - Oct: 1941.

Station	1940 Nov	1940 Dec	1941 Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Total
	(inches)												
Cimarron	1.59	.08	.10	-	2.46	.16	.12	-	-	-	-	.86	5.37
Dawson	2.04	.12	-	-	3.16	.86	-	-	-	-	.34	.50	7.02
Lake Alice			.17	-	2.70	2.30	1.25	-	-	-	4.38	1.44	-
Miami		-	.03	-	2.08	1.38	.55	-	-	-	.44	.22	-
Raton A	1.91	-	-	-	2.81	1.32	1.27	-	-	-	4.44	.77	12.52
Shoemaker Ranch	2.76	.12	.10	-	2.28	.50	.48	-	-	-	1.43	-	9.86
Springer	3.06	.02	.09	-	1.99	.29	.98	-	-	-	2.76	.50	9.69
μ	2.27	.06	.07	-	2.50	.97	.66	-	-	-	1.97	.61	8.89
σ	.61	.057	.063	-	.420	.754	.51	-	-	-	1.90	.470	9.11
"Average" for Site	-	.2	-	-	-	-	-	-	-	-	-	-	.2

Both the deficit and the surplus showed greater variation (as revealed by standard deviation) than did either the precipitation or potential evapotranspiration.

The cumulative sum of the mean surplus (+) and mean deficit (-) for this wettest year is as follows:

	1940		1941									
	N	D	J	F	M	A	M	J	J	A	S	O
Surplus	2.27	.06	.07	-	2.50	.97	.66	-	-	-	1.97	.61
Deficit	-	-	.03	.42	-	-	.08	2.94	2.42	3.63	.04	.02
Cum Σ	2.27	2.33	2.40	1.98	4.48	5.45	6.03	3.09	.67	-2.95	-1.02	-.041

So even during this wettest 12 month period the net precipitation maintained a surplus during six months.

Sustained "Wet" Period

The probability of a sequence of "wet" years combining to temporarily increase "average" values significantly is much more difficult to approach. Few stations have long records. Of necessity, the length of a "wet" period is arbitrary.

Scrutinizing the annual precipitation at Springer, Cimarron, and Raton (Appendix IV-4) reveals that the maximum annual precipitation ranges from a low of 23.99 inches (1914, Cimarron) to a maximum of 29.53 inches (1942, Raton).

Appendix IV-4 also give the 3-year and 5-year running average for Springer, Cimarron, and Raton. The fact that these averages "peak" and "trough" at the same time indicates that "wet" years are most often "wet" throughout the area and are not usually a local phenomenon. They also show that historical 3-year "wet" sequences had running averages in excess of 22 inches; whereas, the historical 5-year "wet" sequence had only one running average greater than 21 inches (1942); but all stations reached a 5-year running average greater than 19 inches (1915, 1942, 1959, and 1961).

Figures 9, 10, and 11 show the mean annual precipitation, and 3-year and 5-year system running average versus recurrence interval at Cimarron, Raton, and Springer. Table 11 gives the estimated mean annual precipitation and 3-year and 5-year running average at selected stations for recurrence intervals of 10, 100, and 1,000 years, based on the Gumbel technique.

During the life of the site, we can reasonably expect "100-year" wet periods, which will have precipitation in the range of 28-30 inches. We can also expect at least one "1,000-year" wet period, which will have precipitation in the range of 32-38 inches. So the upper limit of one year's precipitation that we can reasonably expect to occur at the site is 32-38 inches.

We can reasonably expect "100-year" wet periods of 3 years duration to average in the range of 23-27 inches per year, and of 5 year duration to average in the range of 20-22 inches per year. A "1,000-year" wet period of 3 years duration in the range of 27-33 inches per year and of 5 years duration in the range of 24-26 inches per year is the upper limit of sustained "wet" that we can reasonably expect to occur once during the life of the site.

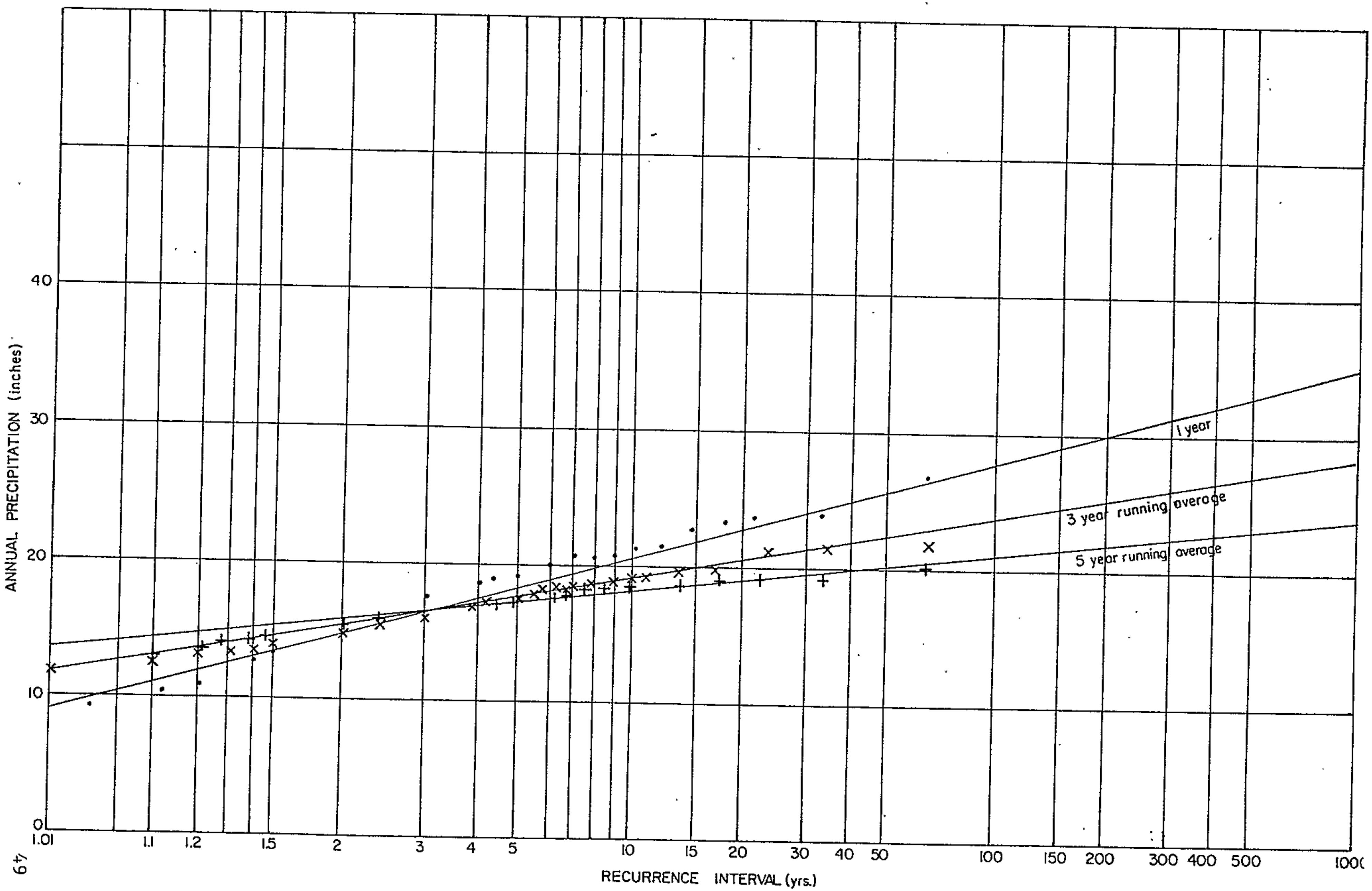


Figure 9. Frequency curves for annual, 3-year running average, and 5-year running average precipitation at Cimarron, New Mexico.

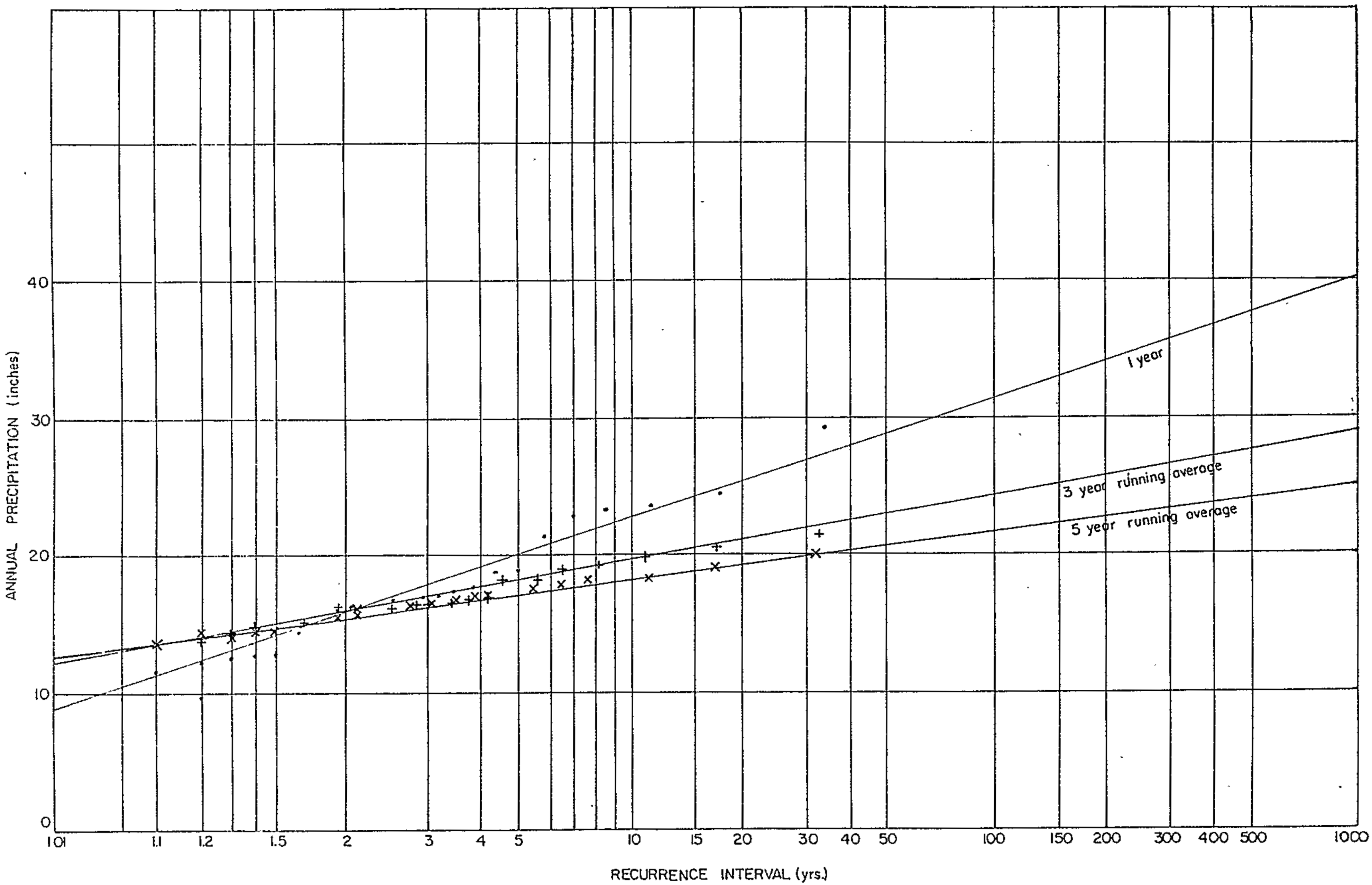


Figure 10. Frequency curves for annual, 3-year running average, and 5-year running average precipitation at Raton, New Mexico.

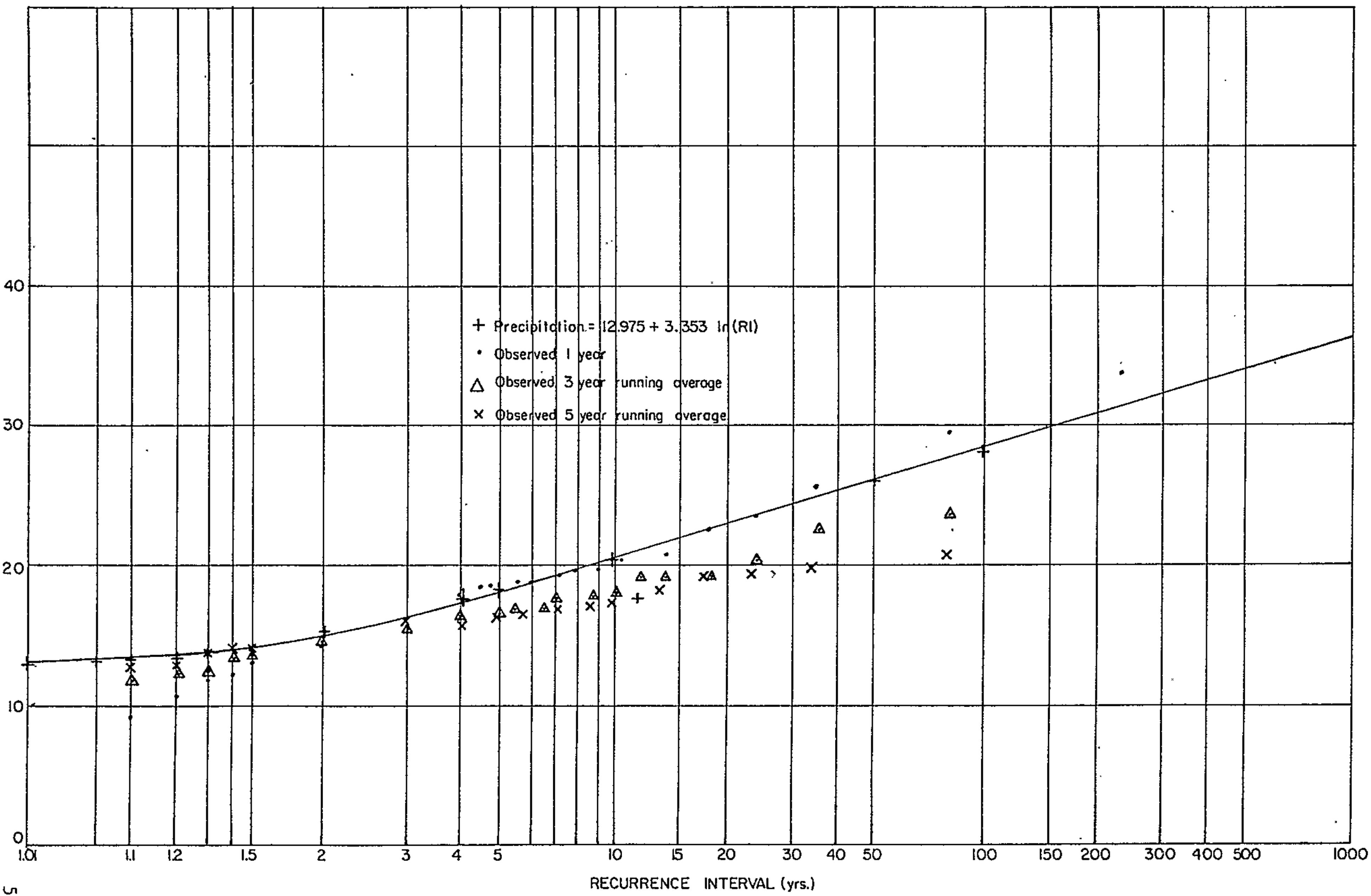


Figure 11. Frequency curves for annual, 3-year running average, and 5-year running average precipitation at Springer, New Mexico.

Table 11.--Estimated annual precipitation and 3-year and 5-year running average precipitation for recurrence intervals of 10, 100, and 1000 years for selected stations in Colfax County, N. Mex.

			(Inches)*				
					Recurrence interval (years)		
Station	Years of record	Period (years)	μ	σ	10	100	1000
Cimarron	71	1	15.45	4.166	21.06	28.54	36.03
	69	3	15.41	2.528	18.8	23.35	27.89
	67	5	15.44	1.964	18.09	21.61	25.12
Dawson	49	1	16.14	4.573	22.29	30.50	38.71
Maxwell	48	1	14.11	3.536	18.87	25.22	31.56
Raton	34	1	16.32	4.479	22.35	30.39	38.43
	32	3	16.22	2.215	19.21	23.19	27.18
	30	5	16.20	1.608	18.37	21.25	24.14
Springer	71	1	14.91	4.300	20.69	28.41	36.1
	69	3	14.91	2.473	18.24	22.68	27.12
	67	5	15.01	1.879	17.53	20.91	24.28

*Precipitation = $\mu - .45\sigma + .7797\sigma \ln$ (Recurrence interval)

REGIONAL CONSIDERATIONS

Introduction

Over most of its course the Canadian River flows eastward, but for an interval between a point a few miles south of Raton and the Conchas Reservoir, the river flows south. The site is, therefore, both west and south of the Canadian River. We limit the discussion of the regional setting to the area drained by the Canadian River above gaging station 7-2215.00 (Canadian River near Sanchez, New Mexico). This gaging station is the first long-term station maintained by the U.S. Geological Survey that is upstream from the Conchas River and the Conchas Reservoir. We call the area drained the Upper Canadian River Basin.

The Upper Canadian River Basin includes parts of Colfax, Mora, Harding, and San Miguel Counties in northern New Mexico, and a small segment of Las Animas and Costilla Counties in southern Colorado. Its shape is roughly rectangular and covers an area of 6,072 square miles. Its average east-west dimension is about 64 miles; its average north-south length is about 90 miles.

The Sangre de Cristo Moutains bound the basin on the west. The New Mexico-Colorado state line approximates the northern boundary. The eastern boundary is within a few miles of the Union County line. Its southern boundary passes a few miles north of Las Vegas.

Topography and Drainage

Altitudes in the Upper Canadian River Basin range from a maximum of 13,676 feet at Purgatoire Peak (Colorado) to 4,515 feet at the gaging station. Figure 12 (based on Table 12) shows the hypsometric curve for the basin. Fifty percent of the drainage area lies above 6,800 feet and 70 percent lies above the maximum altitude of the site.

East of the Canadian River slopes are relatively gentle, because altitudes along the eastern divide are for the most part less than 7,000 feet. West of the river slopes become very steep in the Sangre de Cristo Mountains. Surfaces with three thousand feet of relief in three or four miles are common.

The drainage basin is asymmetric. Tributary streams from the east are short, drain small areas with small relief, and are intermittent. Tributary streams from the west are much longer, drain more than 70 percent of the basin, and even intermittent streams contain some water at least 75 percent of the time.

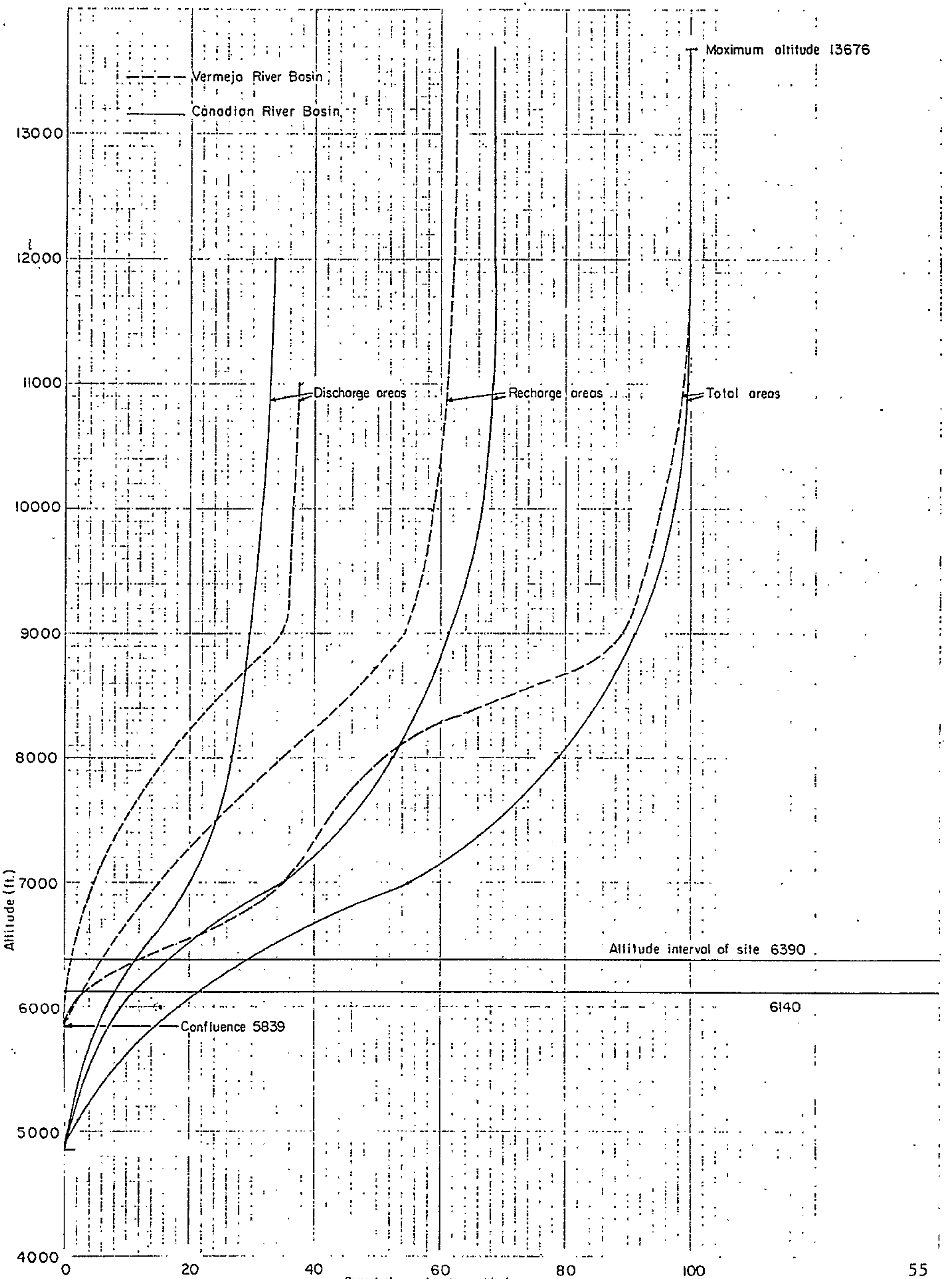


Figure 12. Hypsometric curves for the Vermejo River Basin and the Canadian River Basin above gaging station near Sanchez (07-2215.00).

Table 12.--Hypsometric data for the Canadian River Basin above gaging station 07-2215.0°

Altitude interval (ft)		Discharge Area			Recharge Area			Total		
from	to	(mi^2)	(%)	(cum %)	(mi^2)	(%)	(cum %)	(mi^2)	(%)	(cum %)
4000	5000	36.2	.60	.60	4.5	.07	.07	40.7	.67	.67
5000	6000	344.5	15.67	6.27	547.0	9.01	9.08	891.5	14.68	15.35
6000	7000	874.7	14.41	20.68	1567.5	25.82	34.90	2442.2	40.22	55.58
7000	8000	349.1	5.75	26.43	1047.5	17.25	52.15	1396.6	23.00	78.58
8000	9000	202.2	3.33	29.76	552.8	9.10	61.26	755.0	12.43	91.01
9000	10000	88.8	1.46	31.22	318.6	5.25	66.50	407.4	6.71	97.72
10000	11000	15.8	.26	31.48	102.6	1.69	68.19	118.4	1.95	99.67
11000	12000	3.2	.05	31.54	15.0	.25	68.44	18.2	.30	99.97
12000		--	--	--	1.6	.03	68.47	1.6	.03	100.00
	Total	1914.5			4157.1			6071.6		

Geology

Physiography

Physiographically the Upper Canadian River Basin extends into four of Fenneman's (1931) physiographic regions:

(1) the Southern Rocky Mountains;

(2) the Raton Mesa group;

(3) the Park Plateau; and

(4) the Las Vegas Plateau.

The Southern Rocky Mountains (Sangre de Cristo Range) includes the Costilla Lake-Cimarron Range in the northwestern part of the basin and the Pecos River-Las Vegas Range in the southwestern part of the basin.

The Raton Mesa group includes the high mesas along the north edge of the basin and the Ocate Plateau with altitudes ranging from 9,000 to 10,000 feet to the south. This group comprises the basalt-capped remnants of old erosion surfaces.

The Park Plateau is in the northwest corner of the basin. Its southern and eastern boundaries extend from Raton to Ute Park. The Plateau rises gradually from the southeast to the northwest and extends to the Sangre de Cristo Mountains on the west and into Colorado on the north. Its surface has been highly dissected by erosion and is marked by cliffs in which light colored sandstone is prominent.

The Las Vegas Plateau covers the greater part of the basin. It is largely a plains area and can be considered a western part of the Great Plains level and contain numerous pediment remnants. Those capped by lava belong to the Raton Mesa group.

Structure

The Upper Canadian River Basin includes parts of three major tectonic features (Fig. 13):

(1) the Sangre de Cristo Uplift;

(2) the Sierra Grande Uplift; and

(3) the Raton Basin.

The Sangre de Cristo Uplift, approximately equivalent to the Sangre de Cristo Mountains, consists mostly of Precambrian crystalline rocks and sedimentary rocks that range in age from Ordovician (?) to early Permian. It is nearly 200 miles long with an arcuate northerly trend, and is up to 19 miles in width, making it one of the largest positive elements of the Rocky Mountain foreland. The uplift is a structurally complex block bounded by major, high angle reverse faults and highly contorted, steeply dipping to overturned sedimentary beds. Along much of the eastern margin of the uplift crystalline Precambrian rocks are exposed in the core and are in fault contact with Paleozoic sedimentary rocks (Vermejo River Basin cross-section B-B'). The Sangre de Cristo Uplift resulted from an eastward thrusting during the Laramide orogeny. It began to rise during Late Cretaceous time and continued to rise intermittently, possibly to late Tertiary time.

The Sierra Grande Uplift is a subsurface feature. It extends northeasterly beneath the southeastern part of the Upper Canadian River Basin. It is manifested by a "high" on the structural contours in the rocks of Precambrian age. Rocks of Pennsylvania age and older flank the high; whereas, rocks of Permian and Triassic age overlap it unconformably.

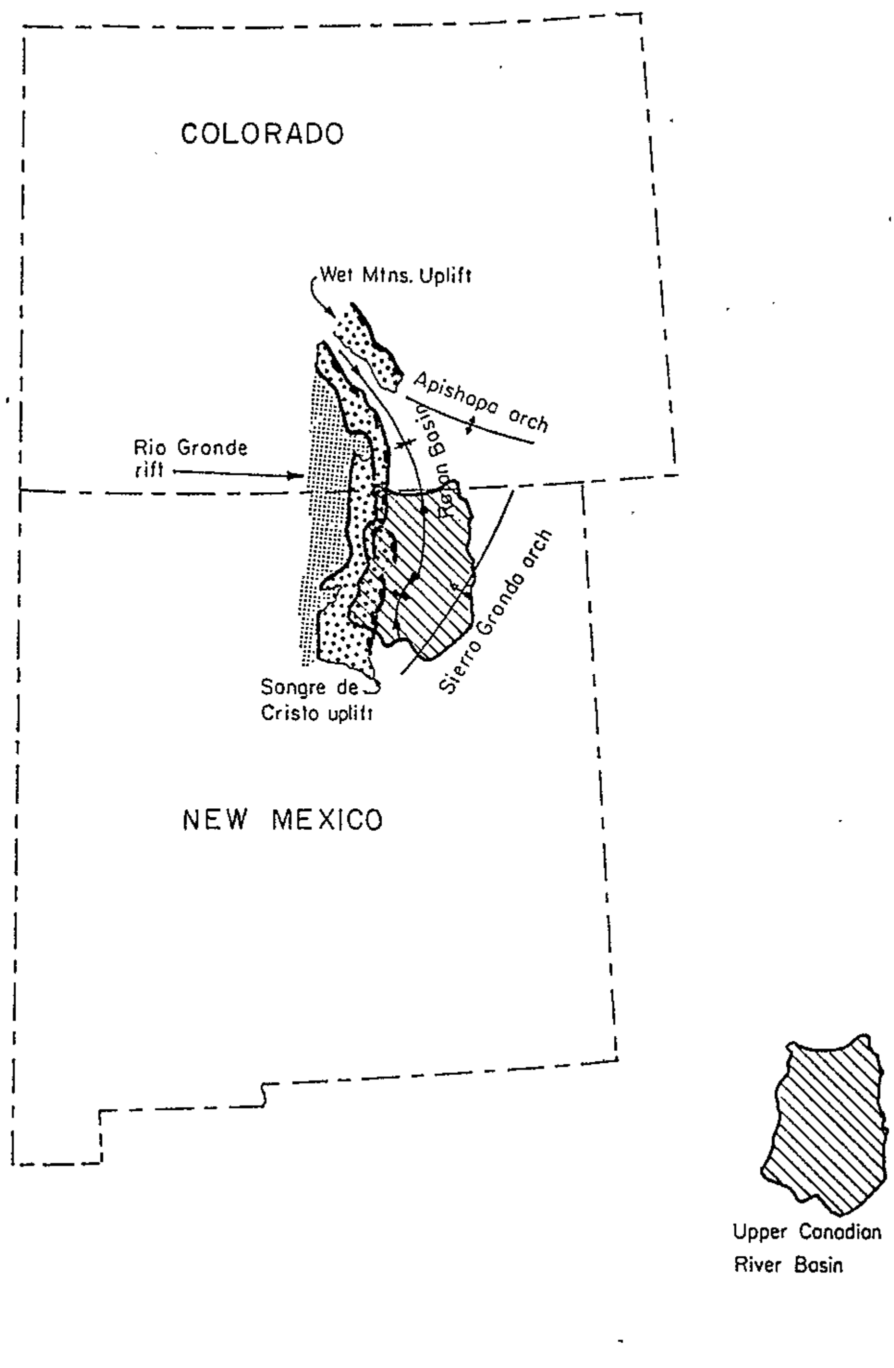


Figure 13. Tectonic setting of the Upper Canadian River Basin. After: Woodward & Snyder, 1976, p.125.

So the uplift began during Paleozoic time and the present structural arch owes its position to a Laramide rejuvenation of a portion of this Paleozoic uplift.

The Raton Basin lies between the Sangre de Cristo Uplift and the Sierra Grande Uplift. It extends about 190 miles northward from Las Vegas, New Mexico, into southern Colorado. It is asymmetrical in an east-west cross-section with the west limb dipping steeply ($>50^{\circ}$) to the east and the east limb dipping gently (1 to 5°) westward (Canadian River Basin cross-section B-B'). During most of Paleozoic time the Raton Basin area and its bounding uplifts were relatively tectonically stable. It became a basinal area during Pennsylvania time and has remained a negative element for most of its history. Geologists refer to the western part of the basin where the sedimentary rocks of Late Cretaceous and Tertiary age contain coal beds as the "Raton Coal Basin" or the "Raton Coal Field."

During Tertiary and Quaternary time igneous activity occurred along the bounding uplifts of the Raton Basin. Along the eastern margins of the Sierra Grande Uplift sills, dikes, and stocks were intruded. A pluton beneath Vermejo Park domed the overlying sedimentary rocks. Along the Sierra Grande Arch not only did intrusions of stocks and dikes occur, but also volcanic vents extruded basaltic lava that flowed into the Raton Basin.

Stratigraphy and Paleogeography

The geologic map (Fig. 14) and two cross-sections (Figs. 15a, b, and c) define and illustrate the site's relationship to the geologic features of the Upper Canadian River Basin. Table 13 is a generalized stratigraphic section of rocks present in the Upper Canadian River Basin.

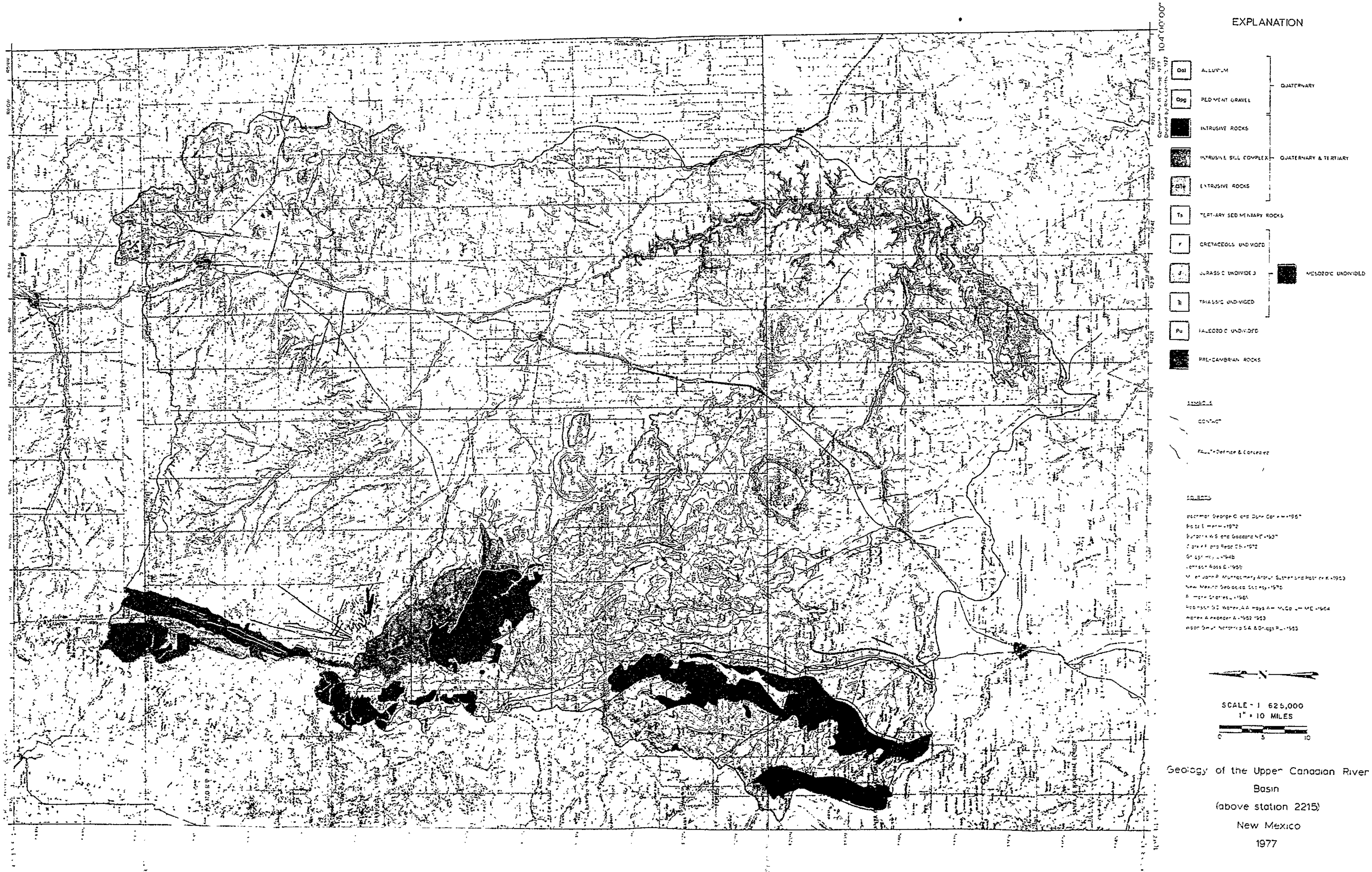
Rocks of Precambrian Age

Within the Upper Canadian River Basin rocks of Precambrian age crop out principally in the Sangre de Cristo Mountains and locally in the Moreno Valley. In the northwestern part of the basin the oldest Precambrian rocks are amphibolites, hornblende schists, mafic gneisses, and metasediments of diverse lithology. These metamorphic rocks were later intruded by an extensive body of relatively uniform microcline granite and granite gneiss. In the southwest portion of the basin, quartz-feldspar-biotite gneisses of Precambrian age are exposed northwest of Las Vegas. The youngest rocks of Precambrian age in this area are gray to pink, medium to coarse-grained granites, accompanied by pegmatite and aplite dikes and quartz veins. Radiometric dates of the rocks of Precambrian age of the basin indicate their age to be in the range of 1,800 million years to 1,100 million years before present.

The rocks of Precambrian age underlie the Raton Basin at depths of as much as 9,000 feet.

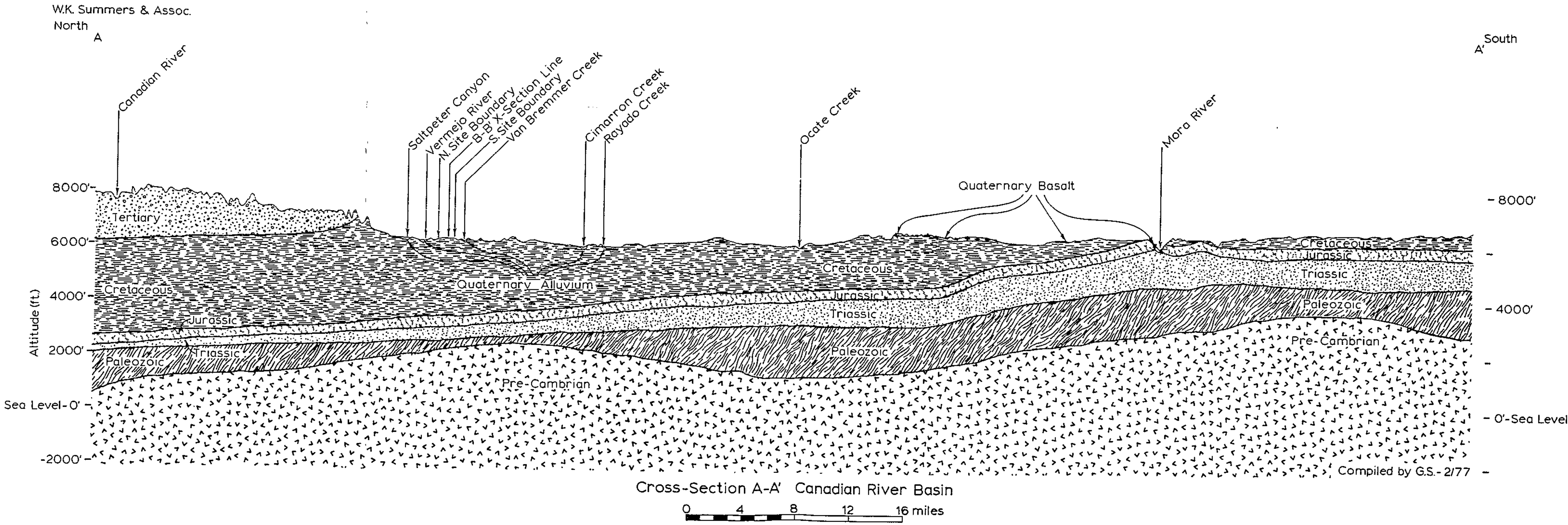
Rocks of Paleozoic Age

From Cambrian through Mississippian times the area alternated between:



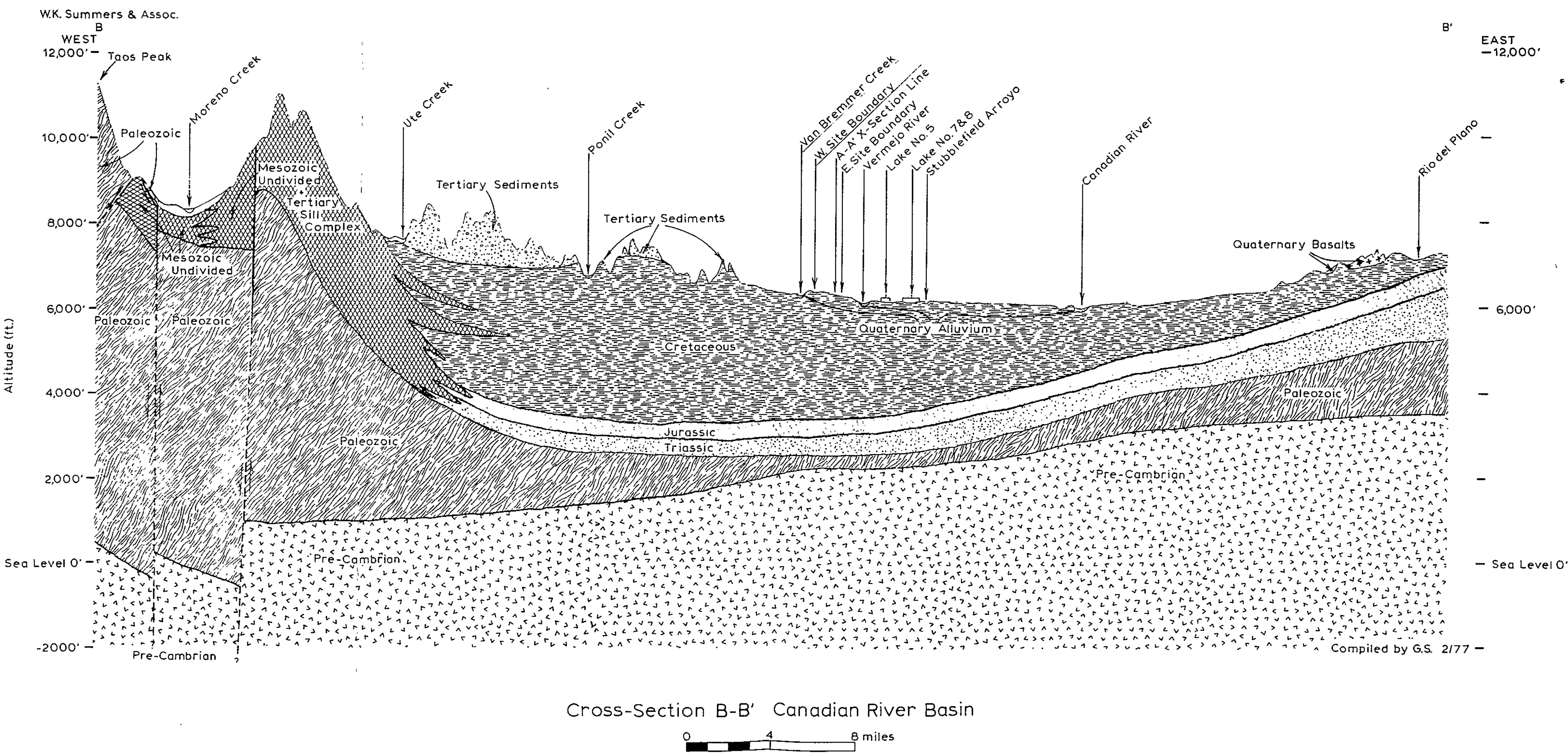
Geology of the Upper Canadian River Basin (above station 2215) New Mexico 1977

FIGURE 14



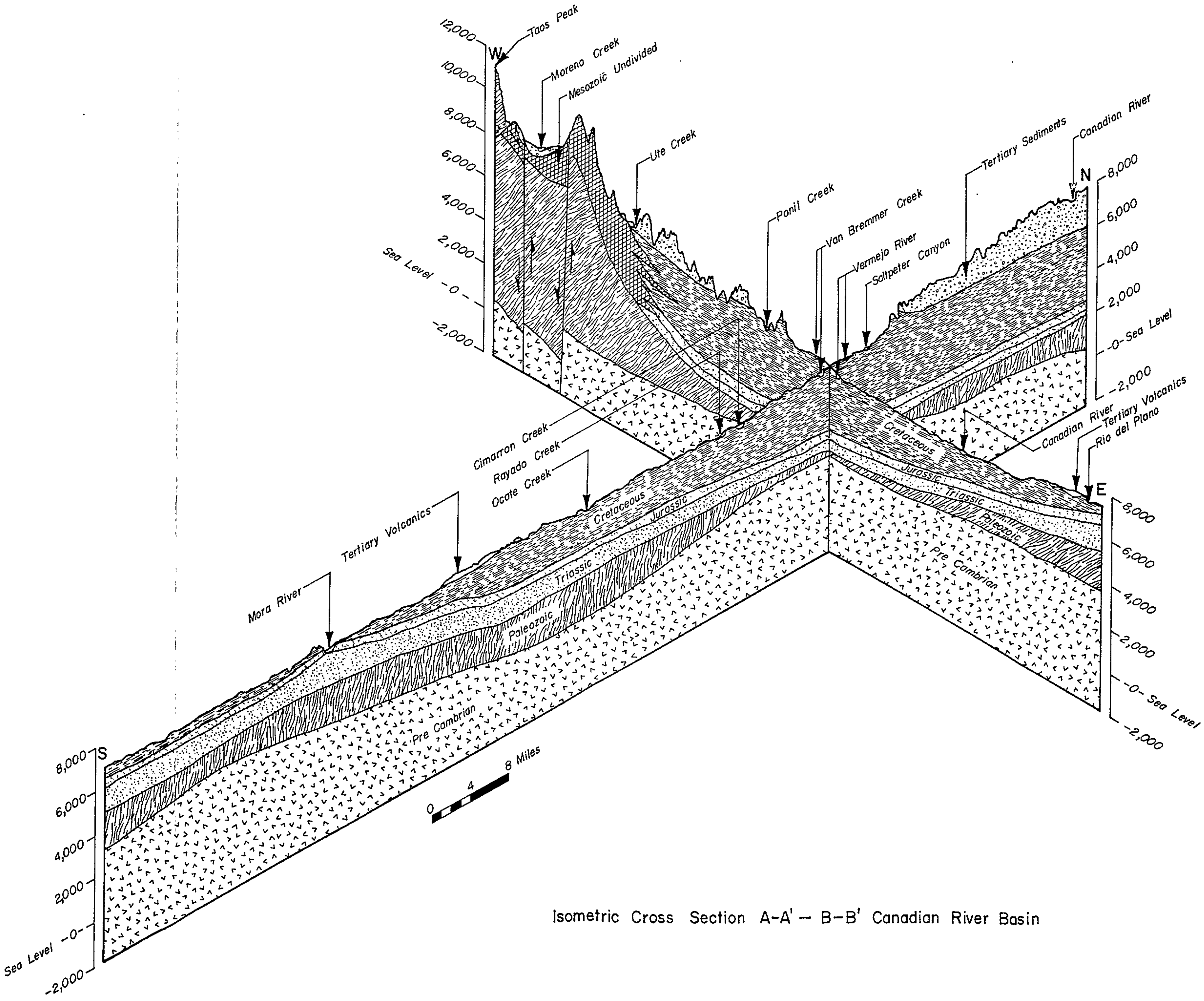
Cross-Section A-A' Canadian River Basin

FIGURE 15A



Cross-Section B-B' Canadian River Basin

FIGURE 15B



Isometric Cross Section A-A' – B-B' Canadian River Basin

FIGURE 15C

Table 13.--Generalized stratigraphic section of rocks in the Upper Canadian River Basin.

Age	Formation	General Description	Approximate thickness(ft)
Quaternary	Alluvium	Unconsolidated silt, sand, and gravel deposits in and adjacent to modern stream channels	0 - 20
	Landslide deposits	Angular blocks, soil and debris of older rocks	0 - 20
	Pediment gravel	Pediment and terrace deposits above modern stream levels; consists of sand, gravel, clay, silt, and angular to rounded fragments of older rock	0 - 50
Quaternary and Tertiary	Intrusive rocks	Includes intrusive rocks of various ages and compositions	20 +
	Intrusive sill complex	Interconnected stock of sills of granodiorite porphyry; intrusive bodies described as Christmas-tree laccoliths	10 - 4000 +
	Extrusive rocks	Includes extrusive rocks of various ages and compositions	10 - 100 +
Tertiary	Poison Canyon Formation	Sandstone, coarse to conglomeratic, beds 5ft to more than 50ft thick, interbeds of soft yellow-weathering clayey sandstone, thickens to north and west at expense of underlying rocks	500 +
	Raton Formation	Sandstone, very fine grained to fine grained, with interbeds of claystone, siltstone, and coal; commercial coal beds in upper part; lower few feet conglomeratic; intertongues with Poison Canyon to the west; generally sharp erosional contact with underlying Vermejo Formation	0 - 2000

Table 13.--Generalized stratigraphic section of rocks in the Upper Canadian River Basin. (cont)

Age	Formation	General Description	Approximate thickness (ft)
Cretaceous	Vermejo Formation	Sandstone, very fine grained to medium grained, interbedded with mudstone, carbonaceous shale, and coal; extensive thick coals top and bottom; some intertonguing with underlying Trinidad	0 - 380
	Trinidad Formation	Sandstone, very fine grained to medium grained; contains casts of Ophiomorpha sp.; intertongues both with overlying Vermejo and underlying Pierre	0 - 150
	Pierre Shale	Black shale, limestone concretions, silty in upper part; grades up to sandstone; intertongues with overlying Trinidad	1600 - 2500 +
	Niobrara Formation	Limestone and calcareous shale; consists of Smoky Hill Marl and Fort Hays Limestone members	500 +
	Carlile Formation	Black shale, gray calcareous shale, and calcarenite; consists of the upper black shale unit, and Juana Lopez, Blue Hill shale, and Fairport members	250 +
	Greenhorn Formation	Limestone and calcareous shale; consists of the Bridge Creek Limestone Member and the Hartland and Lincoln members	130
	Graneros Shale	Black shale and shaly limestone	110

Table 13.--Generalized stratigraphic section of rocks in the Upper Canadian River Basin. (cont)

Age		Formation	General Description	Approximate thickness (ft)
Cretaceous		Dakota Sandstone	Quartzitic sandstone	145
Cretaceous		Purgatoire Formation	Dark-gray silty shale of the Glencairn Shale Member equivalent and conglomeratic sandstones, about 50ft thick, that consists of granules and pebbles of pink and gray chert as large as 1 inch in diameter	70
Jurassic		Morrison and Ralston Creek (?) Formations	Red and green claystone, limestone, and sandstone with gypsiferous siltstone and claystone containing jasper	200 - 300
Jurassic		Entrada Sandstone	Fine-grained sandstone; chert granules at base	70 - 95
Triassic	Dockum Group	Johnson Gap and Chinle Formations	Beds of limestone pebble conglomerate, siltstone, and sandstone of the Johnson Gap in upper two-thirds of unit; red to grayish-purple siltstones and sandstones, white conglomeratic sandstone of the Chinle in lower part; thins to north	195 - 500
Permian		Sangre de Cristo Formation	Red and gray conglomerate and sandstone, red arkose, siltstone, conglomerate, and thin nonmarine limestone; thins to east and south	0 - 5300
Pennsylvanian		Magdalena Group	Alternating sequence of conglomerate, medium-to coarse-grained feldspathic sandstone and arkose, shale, and limestone	0 - 5000 +

Table 13.--Generalized stratigraphic section of rocks in the Upper Canadian River Basin. (cont)

Age	Formation	General Description	Approximate thickness (ft)
Mississippian & Devonian(?)	Tererro and Espiritu Santo Formations	Brown sandstone, gray lime-stone, limestone breccia, calcareous shale	0 - 80
Pre-Camb.		Gneiss, schist, quartzite, granite, diabase, migmatite	

Sources

Pillmore, Charles L., and Laurie, Craig O., 1976, Second day road log from Raton coal field via the York Canyon mine, Vermejo Park and Gold Creek, N.M. Geol. Soc., Guidebook 27th Field Conference, p. 28.

Pillmore, Charles L., 1969, Geologic map of the Casa Grande quadrangle Colfax County, New Mexico, and Los Animas County, Colorado, USGS, Map GQ-823.

Clark, Kenneth F., 1966, Geology of the Sangre de Cristo Mountains and adjacent areas, between Taos and Raton, New Mexico, NM Geol. Soc. Guidebook 17th Field Conference, p. 56-65.

Clark, R.F., and Read, C.B., 1972, Geology and ore deposits of Eagle Nest Area, New Mexico, NMBM, Bull. 94, p. 10, 27-45.

(1) relatively short periods during which it floored a shallow marine sea and received sediments; and

(2) relatively long periods during which it was the surface of an eroding land mass.

The surface upon which the rocks of Pennsylvanian age were deposited marks a profound erosional unconformity. Most of the sediments deposited earlier had been removed and their existence is demonstrated by only a few isolated remnants of uncertain age.

The oldest sedimentary rocks known to be present in the Upper Canadian River Basin consist of, at most, a few hundred feet of carbonates of Ordovician (?) age. These rocks crop out in the extreme northwestern part of the basin. The oldest identified rocks in the Raton Basin are marine sandstone and dolomitic limestone of the Espiritu Santo Formation of probable Late Devonian age. Unconformably overlying this formation are the relatively thin limestones and limestone breccias of the Tererro Formation of Mississippian age.

The first indications of the structural formation of the ancestral Raton Basin occurred during Pennsylvanian time when the Madera Formation and Permo-Pennsylvanian Sangre de Cristo Formation filled the basin. The Madera Formation of the Magdalena Group is dominantly of shallow marine origin and consists of a lower gray limestone member and an upper arkosic limestone member; whereas, the Sangre de Cristo Formation is dominantly fluvial in origin and consists of red and green shales and arkosic sandstones and conglomerates.

Shallow seas returned to the southern part of the basin, resulting in the deposition of the Yeso Formation, Glorieta Sandstone, and San Andres Limestone of Permian age. The northern part of the basin received only terrestrial sedimentation during this time. As a result, the Yeso, Glorieta, and San Andres, which are well defined to the south, interfinger with the upper beds of the Sangre de Cristo Formation and lose their identity near the Sangre de Cristo Mountains.

The total thickness of the rocks of Pennsylvanian and Permian age may exceed 7,000 feet.

Rocks of Mesozoic Age

Fluvial sands and muds of upper Triassic age rest uncomformably on the rocks of Permian age. Geologists assign the rocks of Triassic age to the Dockum Group. In the southern part of the Upper Canadian River Basin the Dockum Group includes the Santa Rosa Sandstone and Chinle Formations and may be as much as 1,200 feet thick. In Union County, it includes the Baldy Hill, Travesser, Sloan Canyon, and Sheep Pen Formations, and is 909 feet thick. In the Raton Coal Field, west and north of the site, it includes the Jackson Gap and Chinle Formations, but is only 190 feet thick. The Dockum Group consists of beds of purple, orange, gray, red, light to medium gray, and olive mudstones, silty mudstones, siltstones, and fine-grained sandstones; beds of shale and limestone-pebble conglomerate occur in some areas.

Following a period of erosion the seas returned again during late Jurassic time. Near shore eolian sediments became the basal Entrada Sandstone.

In the shallow sea the sediment that later became the Ralston Creek (Wanakah Formation or Bell Ranch Formation) built up. With the withdrawal of the sea, fluvial sands and muds that became the sandstone and shale of the Morrison Formation accumulated. The total thickness of Jurassic age sedimentary rocks ranges from 200 to 400 feet.

During Cretaceous time the Raton Basin area became a part of the Western Interior Seaway as epicontinental seas invaded the central portion of the U.S. from both the Gulf of Mexico and Arctic Ocean regions. The aggregate thickness of dominantly marine sediments deposited during this inundation may be more than 4,100 feet.

The initial transgressing sea deposited near shore sands of the Purgatoire Formation. This formation is overlain throughout the area by predominantly marine sands and interbedded shale of the Dakota Sandstone. The Graneros Shale overlies the Dakota and consists of dark gray shale with thin beds of limestone and bentonite. The Greenhorn Limestone rests conformably on the Graneros and consists of thin beds of blocky-weathering, dark gray, finely crystalline limestone interbedded with calcareous shale. The Carlile Shale conformably overlies the Greenhorn. It is a dark gray shale that contains thin limestone beds and calcareous septarian concretions. The overlying Niobrara Formation consists of a basal thin limestone and interbedded shale, the Fort Hays Limestone Member and an upper marly shale with interbedded thin limestone and sandy shale, the Smoky Hill Marl Member.

The Pierre Shale conformably overlies the Smoky Hill Marl of the Niobrara Formation. Throughout the Upper Canadian River Basin the Pierre Shale and Smoky Hill Marl are indistinguishable. The Pierre Shale has been eroded from parts of the eastern flanks of the basin and over most of its extent it is covered by pediment gravel, colluvium deposits, or soil. The Pierre is about 2,100 feet thick near the Colorado-New Mexico border and thins toward the southern margin of the northern Raton Basin to a thickness of about 1,600 feet. The Pierre is composed mainly of marine dark gray to black non-calcareous shales, but contains occasional thin beds of limestone, sandy shale and sandstone. The upper 200 to 300 feet of the Pierre are composed of interbedded dark gray shale and gray sandstone which represent a transition and intertonguing with the lowermost beds of the overlying Trinidad Sandstone. This transition zone marks the beginning of Laramide deformation. The uplift forced the strand line to retreat to the northeast. Fine sand, eroded from the uplifted areas, was deposited in the sea and on its margins as regressive beach and offshore deposits that compose the Trinidad Sandstone. Beds of the Trinidad are medium to massive and the bedding structure is most often tabular. The sea continued to retreat following the deposition of the Trinidad Sandstone, and mud, silt, sand, and carbonaceous material of the Vermejo Formation were deposited on deltas, flood plains, and swamps.

Rocks of Late Cretaceous and Tertiary Ages

Unconformably overlying the Vermejo Formation is the Raton Formation of Late Cretaceous and Paleocene ages. It consists of gray shale, carbonaceous shale, coal beds, and gray arkosic sandstone and was deposited on terrestrial flood plains and in swamps. The Raton grades upward and intertongues into the Poison Canyon Formation. The materials composing this formation were derived mainly from Precambrian terrains to the west and consist of coarse, poorly-sorted, conglomeratic arkose sandstone interbedded with thin clay siltstones.

Extensive volcanism accompanied epeirogenic uplift of the entire region during Tertiary time. Over 100 volcanic centers, mainly cinder cones and shield cones as well as hidden fissure eruptions, were formed. Intrusive igneous rocks were injected, forming sills, dikes, and laccoliths along the Sierra Grande Arch and on the west side of the Raton Basin.

Final Tertiary deposition is represented by the Ogallala Formation, which covers a portion of the southeastern corner of the Upper Canadian River Basin. The formation was deposited as a pediment and is composed of gravel, sand, silt, and clay.

Rocks and Sediments of Quaternary Age

Quaternary pediment remnants occur as mesas, tableland, and flat-topped spurs, extending out from higher topography. The highest pediment surfaces are the oldest, having been formed in past erosion cycles; and because subsequent erosion has taken place, they stand above the younger pediment surfaces. Pediment gravels are coarsest near the mountain source and may be as large as 20 feet in diameter, but the size decreases rapidly away from their source.

Alluvium occurs within present stream channels and along narrow bands adjacent to the channels. It is composed of clay, silt, sand, and gravel that has been deposited by the streams.

Water-Bearing Characteristics of the Rocks

The water-bearing characteristics of the eastern part of the Upper Canadian River Basin have been summarized by Griggs (1954) and by Dinwiddie and Cooper (1966); those of the southern part were characterized by Griggs and Hendrickson (1951). The water-bearing characteristics of the rocks of the northwestern part of the basin have not been described in detail. Robinson, et al (1964, p. 124-127) commented briefly on the water-bearing characteristics of the rocks at the Philmont Scout Ranch.

Specific information on the hydraulic conductivity, specific storage, and specific yield of the rocks is not available. Bedinger and Sniegocki (1976, p. H18) note that the hydraulic conductivity of these rocks is generally less than 10 feet per day. The rocks expected to yield water to wells are the sandstones of the Sangre de Cristo Formation, the Dockum Group, and the Entrada, Dakota, Trinidad, Raton, and Poison Canyon Formations. But in experience, their yields to wells have been small (ranging up to 40 gpm for wells in the Dakota). Alluvial sand and gravel locally yield 100 to 300 gpm to wells, but the average well appears to yield much less.

Griggs considered the Graneros Shale, the Carlile Shale, the Niobrara Shale (Smoky Hill Marl), and the Pierre Shale to be "impermeable" to "not very permeable"; that is, he believed wells in those rocks would be unlikely to produce enough water to justify their expense.

Dinwiddie and Cooper point to wells that produce less than 5 gpm in the Graneros Shale where it contains limestone, but otherwise agree that these formations are not considered "aquifers". That is, they will not yield water to wells for any purpose.

Hydrology

Introduction

Table 14 contains estimates of the mean-annual precipitation occurring in the Upper Canadian River Basin. It shows that the precipitation ranges from less than 14 inches per year at the lowest altitude to more than 25 inches per year on the highest mountains. The average (weighted by area) is about 17.4 inches per year. Most of the precipitation returns almost immediately to the atmosphere. Some infiltrates to become ground water and some runs off.

Table 14.--Average-annual precipitation on the Upper Canadian River Basin.

Altitude interval (ft)			Recharge Area			Discharge Area			Total Basin		
				Precipitation			Precipitation			Precipitation	
From	To	Precipitation (inches)*	Area (mi^2)	(cfs)	(1000 ac-ft)	Area (mi^2)	(cfs)	(1000 ac-ft)	Area (mi^2)	(cfs)	(1000 ac-ft)
4000	5000	13.6	4.5	4.5	3.3	36.2	36.3	26.3	40.8	40.9	29.6
5000	6000	15.0	547.0	604.4	437.6	344.5	380.7	275.6	891.5	985.1	713.2
6000	7000	16.5	1567.5	1905.3	1379.4	874.7	1063.2	769.7	2442.2	2968.5	2149.1
7000	8000	17.9	1047.5	1381.3	1000.0	349.1	460.3	333.3	1396.6	1841.6	1333.3
8000	9000	19.4	552.8	790.0	572.0	202.2	289.0	209.2	755.0	1079.0	781.2
9000	10000	20.8	318.6	488.2	353.4	88.8	136.1	98.5	407.4	624.3	451.9
10000	11000	22.3	102.6	168.6	122.0	15.8	26.0	18.8	118.4	194.5	140.8
11000	12000	23.7	15.0	26.2	19.0	3.2	5.6	4.0	18.2	31.8	23.0
12000	+	25.2	1.6	3.0	2.2	-	-	-	1.6	3.0	2.2
Total			4157.1	5371.5	3888.9	1914.5	2397.2	1735.4	6071.7	7768.7	5624.3

* estimated by Precipitation = .00145 Altitude + 7.06

Ground Water

Ground-Water Recharge

Of the precipitation that falls we estimate the recharge using the following relation (modified from Rabinowitz, Gross, and Holmes, 1977, p. 14):

$$R = jP\ (P-i)$$

where

R = mean-annual recharge,

P = mean-annual precipitation,

j = a terrain factor (.005 for terrain like that of the Upper Canadian River Basin), and

i = the precipitation that must be exceeded for recharge to occur (six inches in this case).

Table 15 gives the estimated recharge for the basin.

We estimated recharge area by assuming the inflection point of topography would be equal to the inflection point on the water table.

The average recharge rate on the recharge area is about one inch per year or about 4.2 percent of the total precipitation. The remainder runs off or returns almost immediately to the atmosphere via evapotranspiration.

Table 15.--Estimated average annual recharge in the Upper Canadian River Basin.

Altitude Interval (ft) From	Altitude Interval (ft) To	Area (mi^2)	Precipitation (inches)*	Estimated recharge** (in)	Estimated recharge** (cfs)	Estimated recharge** (1000 ac-ft)
4000	5000	4.5	13.6	.51	.2	.1
5000	6000	547.0	15.0	.68	27.4	19.8
6000	7000	1567.5	16.5	.87	100.4	72.7
7000	8000	1047.5	17.9	1.07	82.6	59.8
8000	9000	552.8	19.4	1.30	52.9	38.3
9000	10000	318.6	20.8	1.54	36.1	26.2
10000	11000	102.6	22.3	1.82	13.8	10.0
11000	12000	15.0	23.7	2.10	2.3	1.7
12000		1.6	25.2	2.42	.3	.2
Total		4157.1	--	--	316.0	228.8

* estimated by: Precipitation = .0145 X Altitude + 7.06

** estimated by:

Recharge = Precipitation X .005 X (Precipitation -6)

Regional Ground-Water Flow Systems

Hydrologists divide ground-water flow systems into local, intermediate, and regional systems.

In terrain similar to that of Upper Canadian River Basin (the western Canada Sedimentary Basin), Hitchon (1969 a, b), concluded that topography exerts the dominant control over the location of flow systems, whereas the effects of geology govern the rates at which water moves within systems and the volume of water contained at any time.

In the Upper Canadian River Basin we expect to find local ground-water flow systems that can be related to springs and tributaries of the river (or tributaries of tributatries), intermediate flow systems that can be related to the river or its principal tributaries, and a regional flow system that underflows the Upper Canadian River to discharge either into the lower Canadian River or directly into the Arkansas River.

In flow systems that contain rocks with both low and high hydraulic conductivities, flow through the low conductivity rocks tends to be directed dominantly upward or downward, whereas flow through the rocks with high conductivity tends to be dominantly horizontal.

By analogy with other areas, then, we expect recharge in the mountains to underflow the Upper Canadian River in a regional flow system. Recharge near the divide of the tributaries and near the non-mountain divides of the basin itself should move to the main tributaries or to the Canadian River. Recharge near the inflection line on the water table should move to the nearest stream or discharge area. Movement through shales should be dominantly normal to the bedding, whereas movement through sandstone and other rocks with large hydraulic conductivities should be dominantly parallel to the bedding.

Ground-Water Discharge

Two factors tend to mask ground-water discharge in the Upper Canadian River Basin. The streams flow in channels filled with alluvium. The alluvium has a relatively large hydraulic conductivity as compared to the underlying rock. As a result the alluvium carries a large part of the ground water discharge and Phreatophytes discharge copious quantities of ground water to the atmosphere -- ground water that in more humid climates would have been observed as the base flow of the stream. Where alluvium thins or its conductive capacity diminishes for some reason, the water flowing through the gravel emerges and flows in the surface channel, until the conductivity of the alluvium increases.

Because the potential evapotranspiration is much larger than the available precipitation, ground-water evapotranspiration discharges along stream courses are extreme.

Surface Water

Surface Runoff

According to Busby (1966) the Upper Canadian River Basin is an area of natural water deficiency and except for the mountains is an area with highly variable annual runoff.

Table 16 summarizes the flow characteristics at stream gaging stations in the Upper Canadian River Basin and gives the area drained as reported by the U.S. Geological Survey and as we obtained by planimeters using the 1:250000 topography map series. The difference between the area measurements come about for two principal reasons: (1) errors involved in locating the gaging stations and, (2) quality of the definition of the drainage area due to scale. For most of the stations the agreement is excellent.

Average-Annual Discharge

The average-annual discharge is the average of the daily-average discharge for each year of record, i.e., if Q_i is the daily-discharge for one year, then Q_y, the average-daily discharge for the year is:

$$Q_y = \Sigma Q_i/365 \text{ or } 366.$$

The average-annual discharge Q_a is then:

$$Q_a = \Sigma Q_y/n$$

where

n = the number of years of record.

In a basin where diversion uses as much of the annual water supply as

Table 16.--Flow characteristics at stream gaging stations in the Upper Canadian River Basin.

Station	Station number	Drainage area (mi²) Total area USGS	Drainage area (mi²) Total area Planimetry	Drainage area (mi²) Recharge area	(cfs) Mean-daily ground-water discharge component	(cfs) Mean-daily surface runoff component	(cfs) Median discharge	(cfs) Average-annual discharge	(cfs) Mean-annual flood
Canadian River near Hebron, NM	1990.00	228	205	123	.23	12.6	.032	7.34	320
Chicorica Creek near Yankee, NM	1996.00	32.5	34	26	.01	.08	.044	--	--
Chicorica below East Fork near Raton, NM	2000.00	71	70	56	--	--	.11	5.8	310
Una de Gato Creek below Throthe Dam near Raton, NM	2014.20	49.5	48	35	--	--	1.1	--	--
Una de Gato Creek near Hebron, NM	2015.00	224	126	88	.9	3.3	1.6	3.8	110
Chicorica Creek near Hebron, NM	2020.00	381	188	140	1.1	14	3.4	13	530
Vermejo River near Dawson, NM	2030.00	301	345	231	.9	21	7.0	20	240
Moreno Creek at Eagle Nest, NM	2040.00	73.8	87	58	.93	1.1	1.8	--	--
Cieneguilla Creek near Eagle Nest, NM	2045.00	56	51	78	--	--	2.9	--	--
Sixmile Creek near Eagle Nest, NM	2050.00	10.5	21	12	.5	2.8	1.5	2.4	14
Cimarron River below Eagle Nest Dam, NM	2060.00	167	197	123	--	--	5.2	13	100
McEvoy Creek near Eagle Nest, NM	2062.00	--	90	60	--	--	.15	--	.5
Tolby Creek near Eagle Nest, NM	2063.00	8.5	11	6.1	.47	1.8	.88	--	15

Table 16.--Flow characteristics at stream gaging stations in the Upper Canadian River Basin. (cont)

Station	Station number	Drainage area (mi^2): Total area (USGS)	Drainage area (mi^2): Total area Planimetry	Drainage area (mi^2): Recharge area	(cfs) Mean-daily ground-water discharge component	(cfs) Mean-daily surface runoff component	(cfs) Median discharge	(cfs) Average-annual discharge	(cfs) Mean-annual flood
Clear Creek near Ute Park, NM	2064.00	7.4	3.2	1.6	--	--	.60	--	15
Cimarron River near Ute Park, NM	2065.00	260	255	156	--	--	19	32	180
Cimarron River near Cimarron, NM	2070.00	294	281	174	--	--	12	21	110
Pontil Creek near Cimarron, NM	2075.00	171	189	117	.54	12	28	13	110
Rayado Creek at Sauble Ranch near Cimarron, NM	2085.00	65	61	42	.18	1.2	.62	15	110
Cimarron River at Springer, NM	2110.00	1032	1016	667	--	--	4.0	19	390
Canadian River near Taylor Springs, NM	2115.00	2850	2838	1875	5.0	81	15	115	200
Canadian River near Roy, NM	2140.00	4066	3886	2168	5.9	125	17	132	4000
Mora River near Holman, NM	2145.00	57	61	45	--	--	5.6	14	110
Vigil Canyon near Holman, NM	2146.00	2.8	6.1	5.1	--	--	.54	1.9	17
Agua Fria Creek near Holman, NM	2147.00	9.2	6.1	5.9	--	--	2.5	5.8	33
Riola Casa near Cleveland, NM	2148.00	23.0	20	15	.68	15	5.6	15	120
Mora River at La Cueva, NM	2155.00	173	188	140	--	--	11	29	230
Rito Cebolla near Golondrinas, NM	2156.00	64	67	54	2.1	7.0	4.2	5.8	90

Table 16.--Flow characteristics at stream gaging stations in the Upper Canadian River Basin. (cont).

Station	Station number	Drainage area (mi^2) Total area (USGS)	Drainage area (mi^2) Total area Planimetry	Drainage area (mi^2) Recharge area	(cfs) Mean-daily ground-water discharge component	(cfs) Mean-daily surface runoff component	(cfs) Median discharge	(cfs) Average-annual discharge	(cfs) Mean-annual flood
Mora River near Golondrinas, NM	2165.00	267	280	214	2.5	38	13	35	360
Coyote Creek below Black Lake, NM	2170.00	48	26	19	.81	4.3	1.7	4.6	38
Coyote Creek above Guadalupita, NM	2171.00	71	80	56	1.3	7.7	4.4	11	95
Coyote Creek near Golondrinas, NM	2180.00	215	263	182	1.8	9.1	5.0	12.1	120
Mora River near Watroug, NM	2181.00	521	590	435	5.4	60	40	54	800
Manuelitos Creek near Rociada, NM	2187.00	52	53	38	--	--	8.8	12	90
Sapello River at Sapello, NM	2200.00	132	140	103	--	--	7.0	25	520
Sapello River near Watroug, NM	2206.00	213	231	168	--	--	10	17	400
Mora River near Shoemaker, NM	2210.00	1104	1135	832	--	--	14	60	900
Canadian River near Sanchez, NM	2215.00	6015	6069	4195	7.4	.211	37	200	4000

possible, relationships between discharge, precipitation, and drainage areas can only be obtained with extended effort. For preliminary estimates the relationship

$$Q_a = .0336A + 7.83P - 138.23$$

where

A = the drainage area (mi^2), and

P = the precipitation at the average altitude of the drainage area.

For the most part it overestimates (24 of 30) Q_a observed by amounts as great as 800 percent; the maximum under-estimation was 27 percent. It predicts to $\pm$ 40 percent the discharge of 12 of 30 cases. We believe, however, that it probably relates to conditions without diversion fairly well, for its says, in effect, that the average precipitation on the drainage area is more important to the runoff than the area drained.

Average-Annual Runoff Per Square Mile

The average-annual runoff per square mile is a function of the terrain, but can be crudely approximated by the relationship:

$$Q/A = 5.8\ A^{-1.437}$$

(correlation coefficient $r^2 = .50$)

where

$Q = \Sigma Q_i/n$ (cfs),

Q_i = the mean daily discharge for the ith year,

n = total number of years of record available, and

A = drainage area above.

Busby (1966) showed that the average runoff ranges from as much as 10 inches per year in the moutains to less than 0.2 inches per year on the plains.

So this relationship, which is based in large part upon stations that receive runoff from the mountains, reflects the large runoff from the mountains in contrast to the low runoff of the plains. It also reflects the significant increases in evapotranspiration that occur at lower altitudes.

Mean Daily Flow Components

The mean daily discharge for surface water and ground water derives from a trial and error separation of the flow-duration curve for those stations where the two components are assumed to each have a log-normal distribution. The effects of diversion were, hopefully, first removed.

We did not try to separate the flow-duration curves for those stations which:

(a) gaged naturally intermittent streams;

(b) had records of less than five years; or

(c) could not be corrected for diversions.

The two values cited are, therefore, the mean-daily surface runoff and the mean-daily ground-water discharge passing the station for the period of record.

Figure 16 shows that the mean-daily surface runoff decreases with increasing surface area -- again showing the combined effects of decreased precipitation and increased evapotranspiration.

The sum of the mean-daily ground-water discharge and the mean-daily surface-water discharge is generally larger than the observed average annual

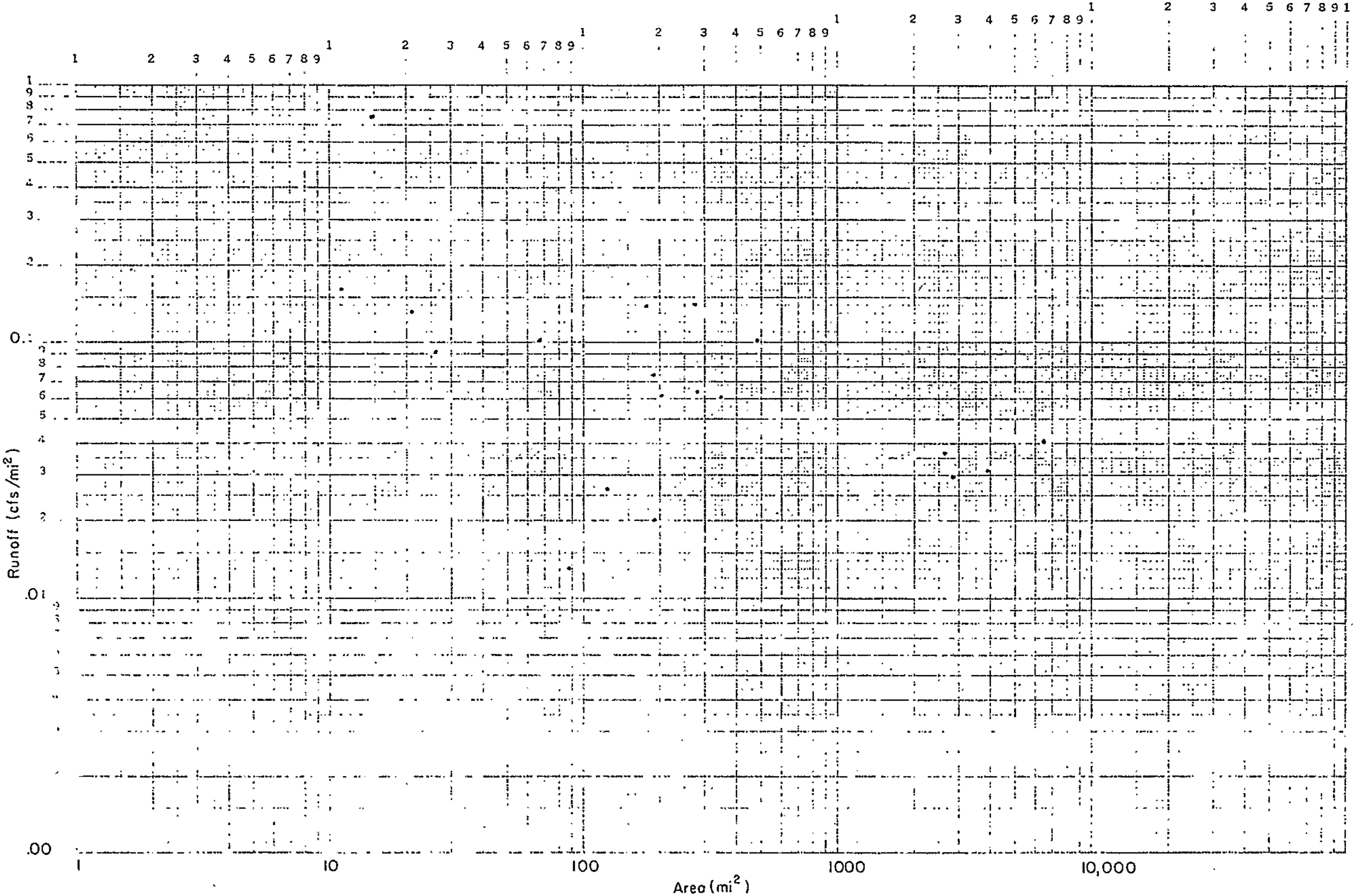


Figure 16. Relation of the estimated mean daily surface-water runoff per square mile to area drained.

discharge because these estimates took into consideration the effect of diversion.

Median Discharge

The median discharge is the discharge that is equaled or exceeded 50 percent of the time. The low discharge for more than 50 percent of the time compared to the larger mean-annual discharge can be accounted for by diversion structures and by the fact that precipitation is concentrated in five months. It also reflects the fact that most rain falls from local thundershowers of short duration.

Mean Annual Flood

The following relationship predicts the mean-annual flood:

$$Q_f = .7375\ A + 74.73$$

(correlation coefficient $r^2 = .930$)

where

Q_f = mean-annual flood (cfs), and

A = drainage area in (mi^2).

So does the expression:

$$A = 6.92\ Q_f^2 + 1.07\ Q_f.$$

Even though these relations estimate the mean-annual flood of gaging stations, no relation could be established between the observed size of the area (A) and the runoff per unit area (Q_f/A).

Relation to Ground Water

The surface-water discharge of the Upper Canadian River Basin at Sanchez averages 202 cfs or 146,300 acre-feet/year for 42 years (USGS NM-75-1), which is equivalent to 0.45 inch/year or 2.6 percent of the total precipitation. However, irrigators upstream divert water for about 56,000 acres. If this diversion is at a consumptive use rate of 1.7 feet per acre, an additional 95,200 acre-feet/year can be added to the net discharge, bringing the average discharge to about 4.3 percent of the total precipitation.

We estimate that, of the runoff passing the gaging station near Sanchez, about 15 percent derived from ground-water discharge. Adjusted to the net discharge of 241,500 acre-feet/year, only 36,225 acre-feet/year (or 50 cfs) of the estimated recharge discharges to the Canadian River or its tributaries above the station.

Figure 17 is a plot of the estimated mean ground-water discharge per unit apparent-recharge area versus apparent-recharge area. Ideally, for homogeneous isotropic media the points should plot along a curve that increases with increasing area and approaches asymptotically the average recharge rate per square mile for the basin. The failure of the points to fit such a line is due primarily to the evapotranspiration discharge of the ground water before it can pass through the gaging station.

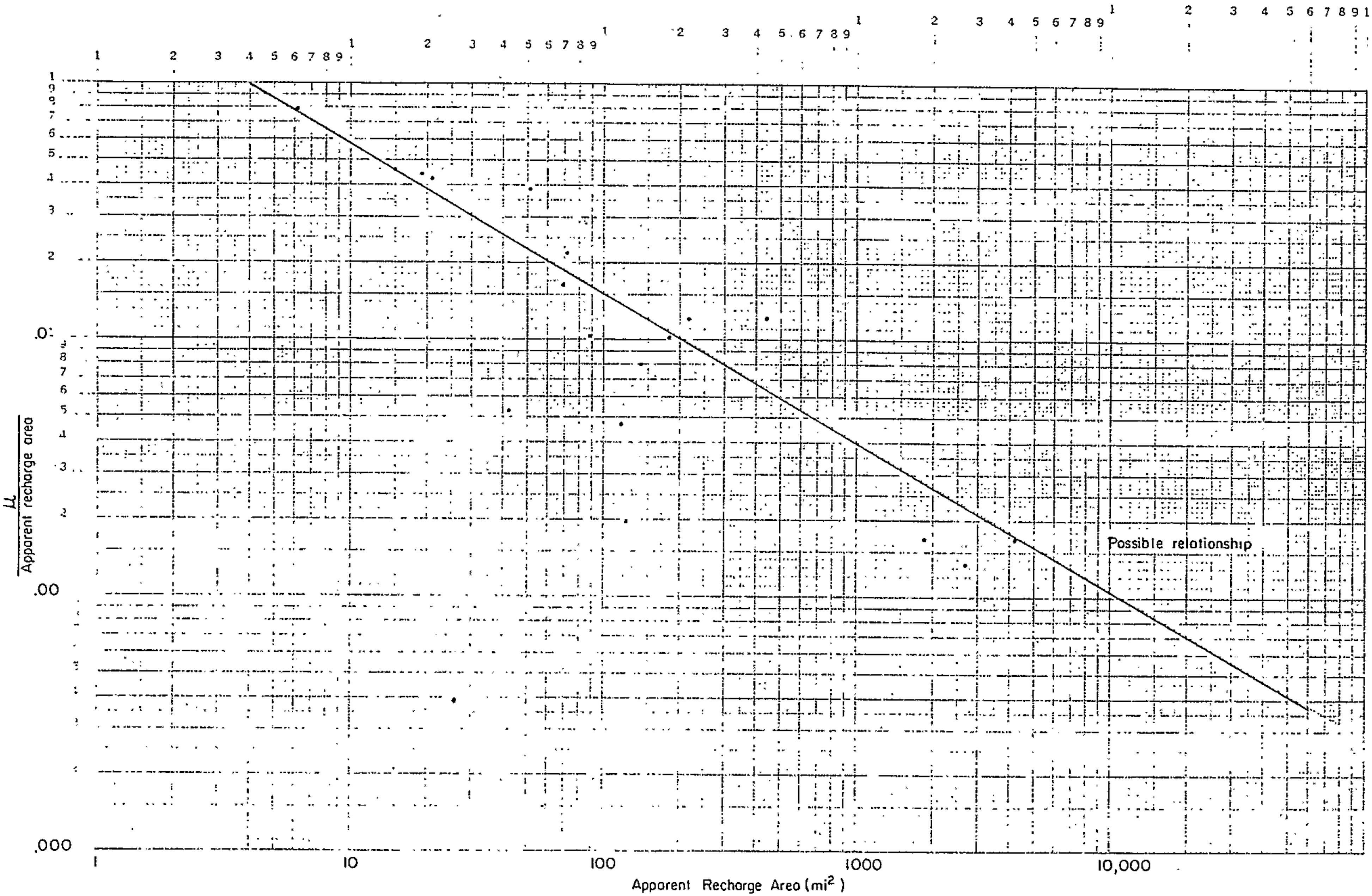


Figure 17. Relationship of the estimated mean ground-water discharge per unit apparent area to size of the apparent recharge area.

Hydrologic Budget

The mean-annual hydrologic budget for the Upper Canadian River Basin is approximately:

	Inches	
	Input	Output
Precipitation	17.4	
Ground-water recharge		1.0
Surface runoff		4.1
Immediate evapotranspiration		12.3
Recharge	1.0	
Discharge to streams and evapotranspiration		.5
Underflow		.5
Surface Runoff	4.1	
Loss to diversion and evapotranspiration		3.7
Runoff at station 2215.00		.4

These estimates are order-of-magnitude only. Even so, they show clearly that evapotranspiration ultimately accounts for about 95 percent of the precipitation that falls on the Upper Canadian River Basin.

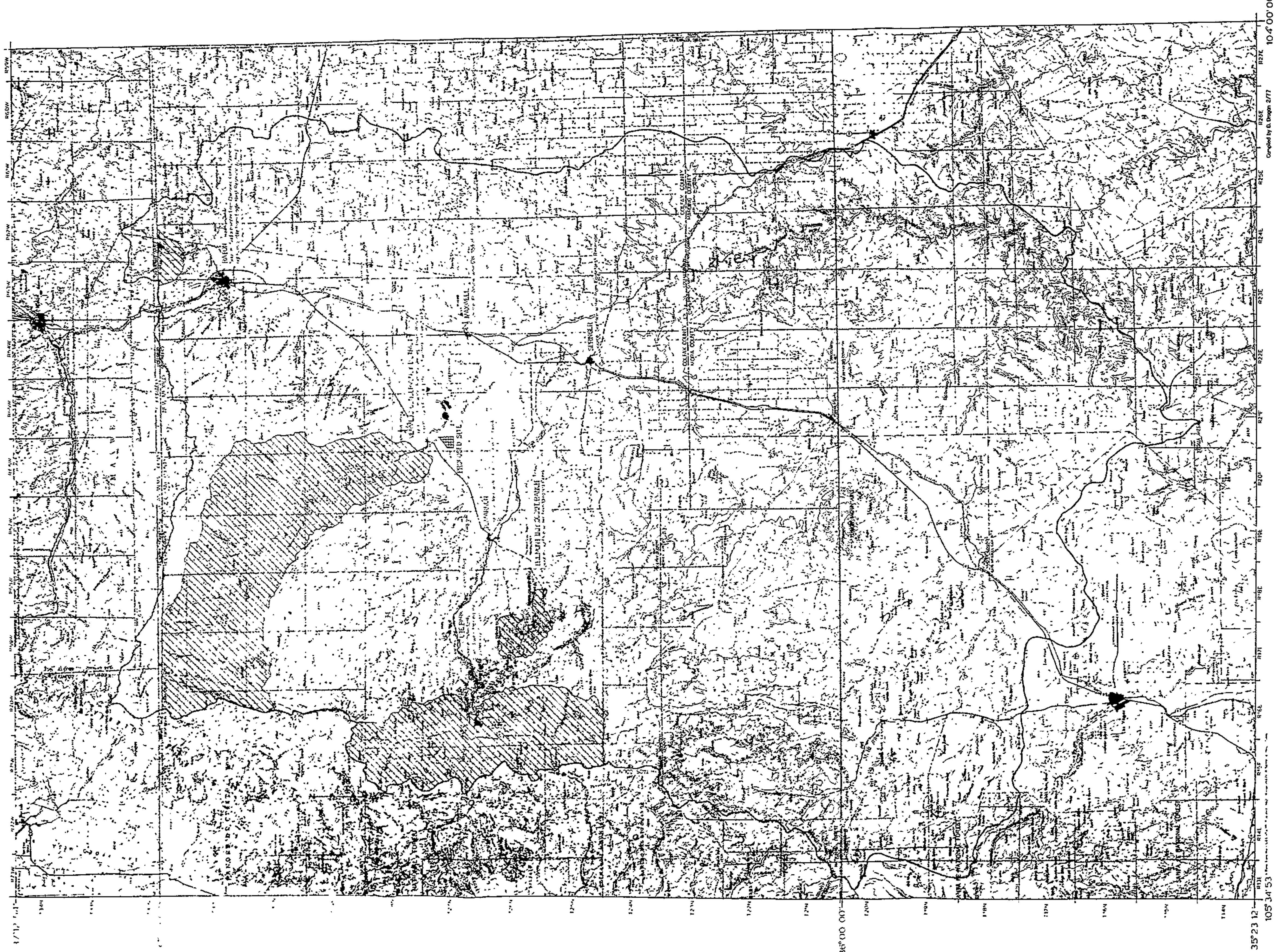
Chemical Characteristics of Water

The water discharging in the Upper Canadian River Basin east of the Trinidad escarpment is the calcium-magnesium and sulfate-chloride type and of marginal potability; west of the escarpment the discharge water is the calcium-magnesium and carbonate-bicarbonate types (Bedinger and Sniegocki), 1976, p. H23).

The State Engineer's staff report (Anonymous, 1967, p. 41 and 42), shows that the ground water beneath much of the area of the Upper Canadian River Basin contains more than 1,000 ppm (parts per million) dissolved solids, and that, through much of the area, ground water with total dissolved solid concentrations in the range of 3,000-10,000 ppm is found.

Water Use

Figure 18 shows where water in the basin (other than for domestic or stock purposes) is being used and the sources of the water. Without exception water users are either in totally different sub-basins of the Upper Canadian River Basin than the site or obtain water from sources upstream from the site. A comparison of Figure 16 with the geologic maps and the cross-sections (Figs. 14, and 15a, b, and c) shows quite clearly that operation of the site as a dry-waste repository could not have any impact on these water users.



EXPLANATION

Water Storage Dams

Drainage Areas Supplying the Storage Dams

Municipal Storage Reservoirs

Water Transmission Pipeline

Irrigation Ditches

Well Field

1 inch = 1 1/2 miles

5 0 5 10 15 20 Statute Miles

WATER RESOURCE USE IN COLFAX CO.
NEW MEXICO
1977

FIGURE 18

Discussion

The proposed site is in the Raton Basin and is east of, and downslope from, the Raton Coal Basin.

The Cretaceous rocks that underlie the site extend a long distance in every direction from the site. The rocks of the Upper Canadian River Basin at best yield low volumes of poor quality to wells. The rocks of Cretaceous age that underlie the site consist of more than 1,000 feet of shale, with low to zero hydraulic conductivity.

Recharge within the Upper Canadian River Basin is relatively low. Most precipitation leaves the basin as evapotranspiration. We believe that the site occupies within the basin a position such that it is geologically and hydrologically isolated from every lithologic unit (sandstone) that might yield water to wells, with the possible exception of alluvial sand and gravel, which is considered in detail in a later section.

The site occupies a location on the surface of the drainage basin such that the precipitation and/or runoff from it are much less than might be expected from the terrain only a few miles west. The runoff contribution from the site to the flow of the Canadian River is an infinitestimal fraction of the total flow of the river at the gaging station near Sanchez.

VERMEJO RIVER BASIN

Introduction

The proposed site lies entirely within the Vermejo River Basin, a sub-basin in the northwestern part of the Upper Canadian River Basin. The uppermost part of the sub-basin is in Los Animas and Costilla Counties, Colorado; the remainder is in Colfax County, New Mexico.

The basin's long dimension trends northwest-southeast. Its length is about 54 miles. Its average width is about 12 miles. Its area is 349 square miles.

Topography and Physiography

Altitudes in the Vermejo River Basin range from a maximum of 13,675 feet at Purgatoire Peak (Colorado) to 5,870 feet at the confluence with the Canadian River.

Most of the Vermejo River Basin lies within the Park Plateau. The higher altitudes are in the Southern Rocky Mountains; the lower quarter, including the site, lies within the Las Vegas Plateau.

Figure 12 shows the hypsometric curve of the Vermejo River Basin, based on Table 17.

Table 17.--Hypsometric data for the Vermejo River Basin, Colorado and New Mexico.

Altitude interval (ft)		Discharge Area			Recharge Area			Total Area		
from	to	(mi^2)	(%)	(cum %)	(mi^2)	(%)	(cum %)	(mi^2)	(%)	(cum %)
	7000	16.8	4.83	4.83	51.1	14.69	14.69	67.9	19.52	19.52
7000	8000	39.5	11.36	16.19	68.6	19.72	34.42	108.1	31.08	50.60
8000	9000	65.8	18.92	35.11	70.1	20.16	54.57	135.9	39.07	89.68
9000	10000	4.7	1.35	36.46	13.7	3.94	58.51	18.4	5.29	94.97
10000	11000	3.2	.92	37.38	11.2	3.22	61.73	14.4	4.14	99.11
11000		.4	.12	37.49	2.7	.78	62.51	3.1	.89	100
	Total	130.4			217.4			347.8		

Geology

The geologic map (Fig. 19) and cross-sections (Fig. 20a and b) through the site show the relation of the site to the geologic features of the Vermejo River Basin.

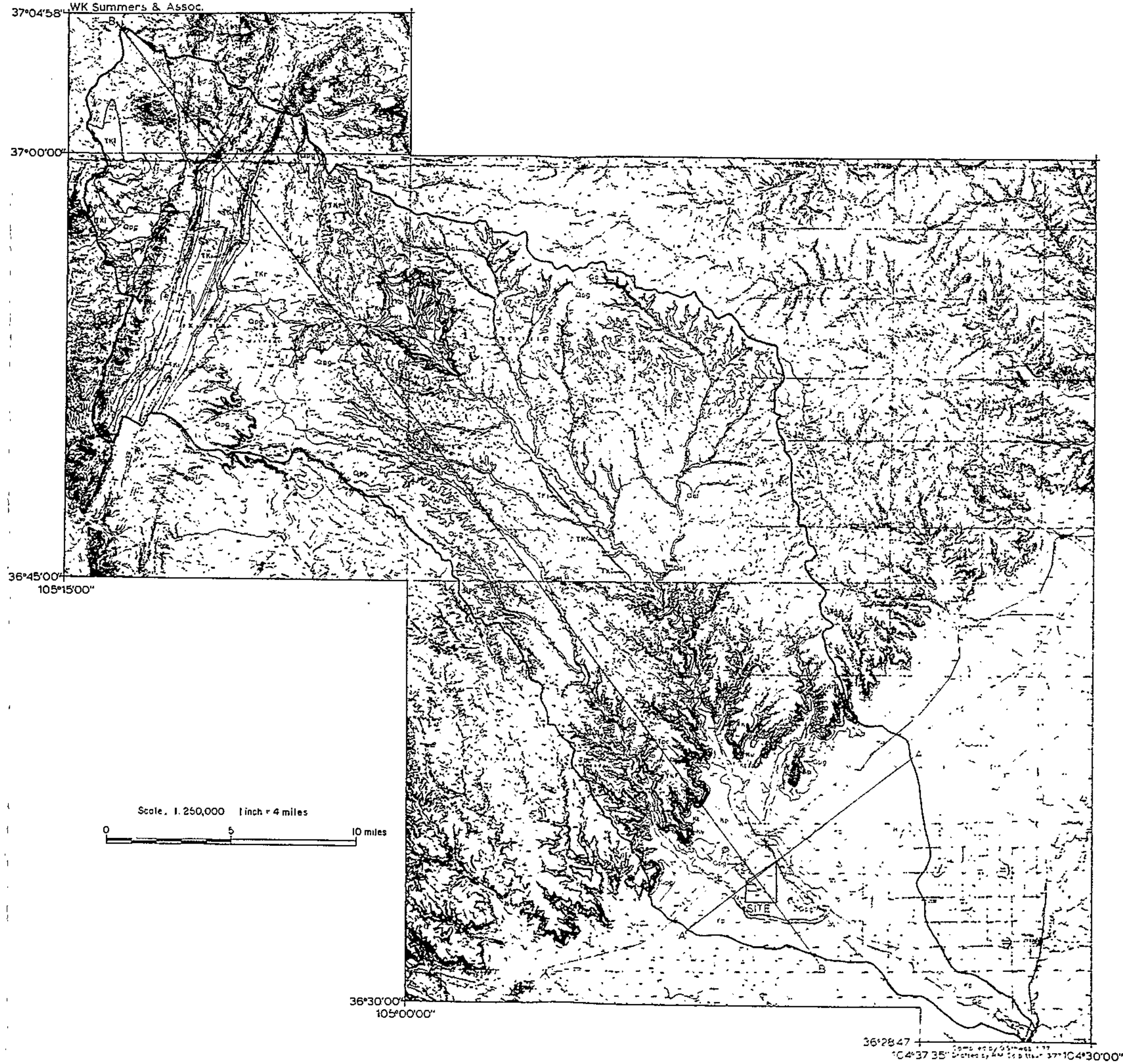
Structure

The Vermejo River Basin is situated almost entirely within the structural Raton Basin. The major positive tectonic element is the Sangre de Cristo Uplift in the northwestern segment of the basin. The Vermejo Dome is a prominent secondary structural feature formed within the Raton Basin.

The eastern margin of the Sangre de Cristo Uplift is characterized by reverse and upthrust faults that are steep at depth, but tend to flatten upward. Paleozoic sedimentary rocks are in fault contact with the uplifted Precambrian crystalline rocks which is evidence for vertical uplift. This uplift may possibly be explained by a primary vertical stress system induced by magmatism during Laramide deformation.

The Vermejo River Basin centrally lies within the Raton Basin. The synclinal axis of the structure trends in a north-northeast direction at a distance of about 20 miles from the Sangre de Cristo Uplift. There are about 14,000 feet of structural relief between the trough of the basin and the Sangre de Cristo Uplift to the west (see Vermejo River Basin Cross-Section B-B' - Fig. 20b).

The Vermejo Dome is located about halfway between the Raton Basin structural axis and the Sangre de Cristo Uplift. The dome has at least 1,400 feet



EXPLANATION

Qal	Alluvium	Quaternary		
Qls	Land Slides	Quaternary		
Qpg	Pediment Gravel	Quaternary		
Tpc	Poison Canyon Formation	Tertiary		
TKI	Intrusives of Various Ages & Compositions	Tertiary to Cretaceous		
TKr	Raton Formation	Tertiary to Cretaceous		
Kv	Vermejo Formation			Mesozoic
Kt	Trinidad Sandstone	M	Mesozoic Undivided	Mesozoic
Kp	Pierre Shale with Smokey Hill Member	M	Mesozoic Undivided	Mesozoic
K	Cretaceous Undivided (interval between the Trinidad & Dakota Ss.)	M	Mesozoic Undivided	Mesozoic
Kd	Dakota Sandstone	M	Mesozoic Undivided	Mesozoic
J	Jurassic Undivided	M	Mesozoic Undivided	Mesozoic
Tr	Triassic Undivided	M	Mesozoic Undivided	Mesozoic
PPsc	Sangre de Cristo Formation	Pa	Paleozoic Undivided	
pC	Pre-Cambrian			

SYMBOLS

Contact

Fault

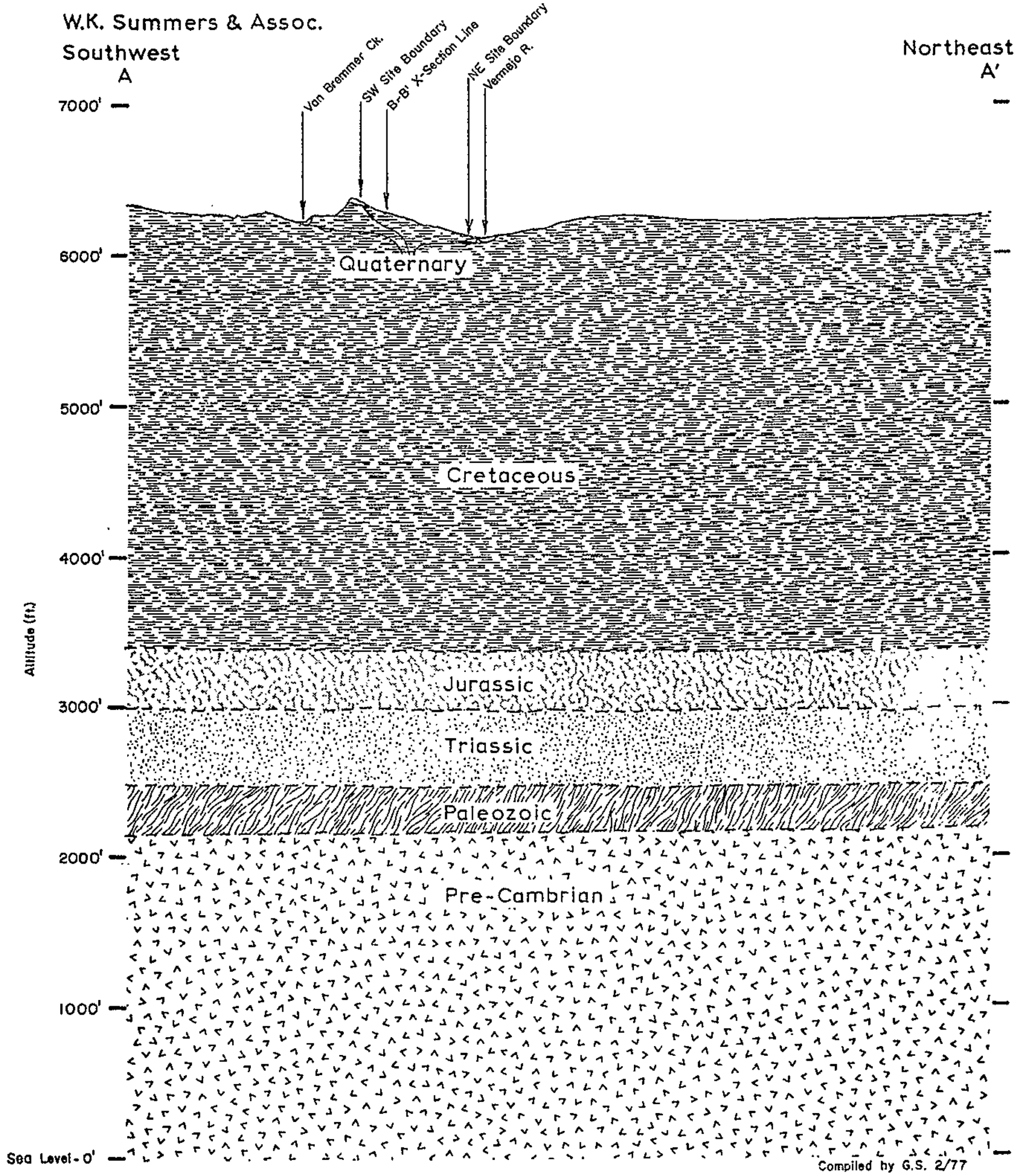
Cross-Section Line

SOURCES

Bachman, George O., & Dane, Carle H.-1962
Burbank, W.S., & Goddard E.N.-1937
Dane, Carle H., & Bachman George O.-1965
Griggs Roy L.-1948
Johnson Ross B.-1968
Pillmore, Charles L.-1969
Pillmore, Charles L., Laurie, Craig O.-1976
Wanek Alexander A.-1963

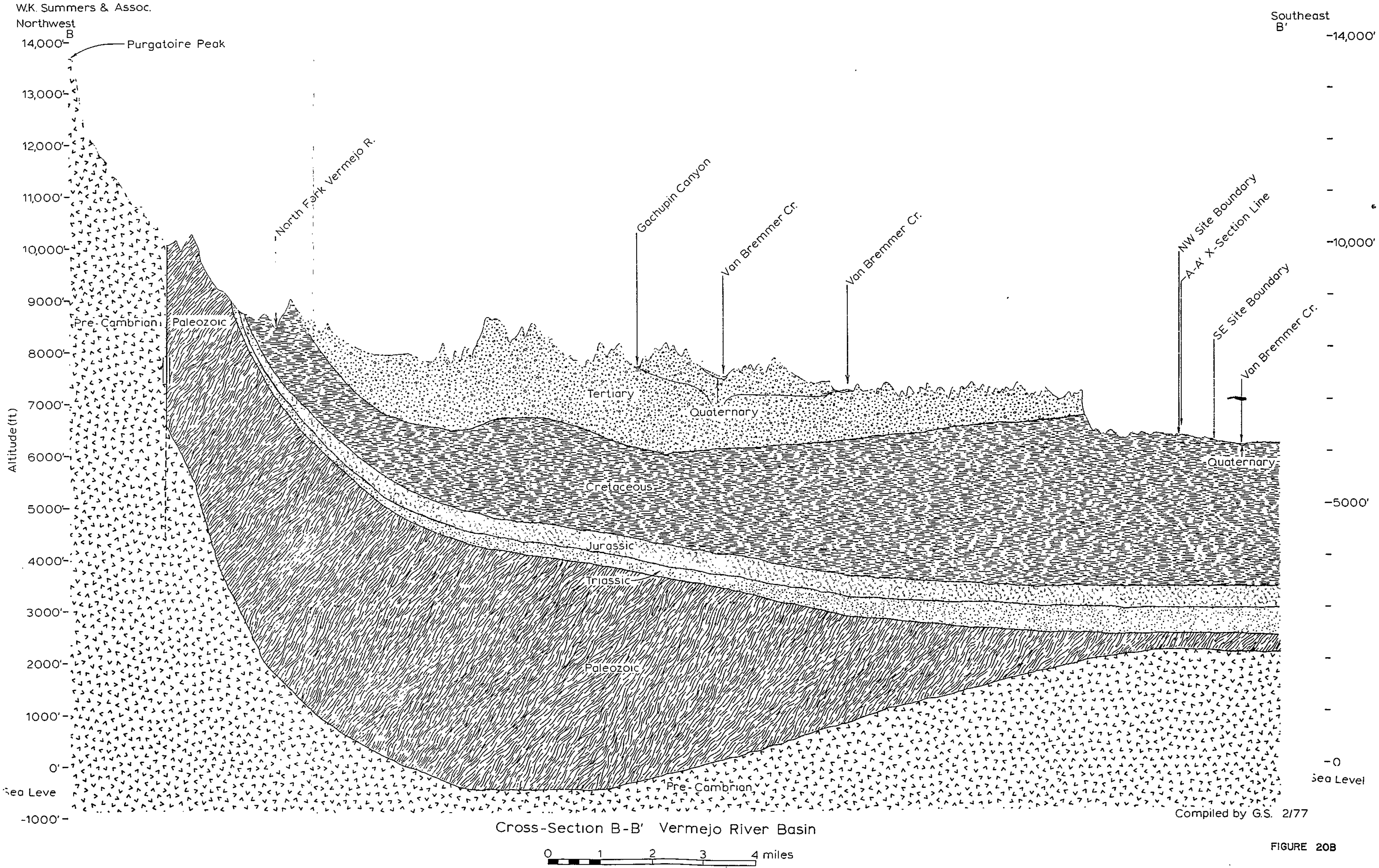
Geology of the Vermejo River Basin
New Mexico & Colorado
1977

FIGURE 19



Vermejo River Basin
Cross-Section A - A'

FIGURE 20A



Cross-Section B-B' Vermejo River Basin

FIGURE 20B

of closure with some subsidiary closure related to a northward extension. There is extremely steep dip on the flanks of the structure, but the dip flattens abruptly at a depth of about 2,000 feet. Deep-seated thrust faulting is also associated with the structure. Drilling of the Vermejo Dome has verified that its core is a Tertiary intrusive.

Stratigraphy and Paleogeography

Rocks of Precambrian Age

Precambrian rocks crop out in the Vermejo River Basin along the Sangre de Cristo Uplift and make up the eastern flank of the Costilla Massif. They are primarily granitic intrusives although some metasediments can be found. The metasediments are possibly roof pendants suspended in the granite batholith of the Costilla Massif.

Rocks of Paleozoic Age

Paleozoic rocks are in fault contact with Precambrian rocks parallel and adjacent to the Sangre de Cristo Uplift. They crop out along a narrow band (about a mile wide) and strike in a north-northeasterly direction. The oldest Paleozoic rocks consist of, at most, a few hundred feet of Ordovician (?) and Mississippian carbonates which represent erosional remnants of a regionally widespread open-shelf sea. Early Pennsylvanian time marked the initiation of basinal sedimentation in the Raton Basin. The major sediment source areas were located to the west in the Uncompahgre Highland. The sedimentary pattern was drastically altered in Late Pennsylvanian time when the Sierra Grande Uplift to the east served as the major source area. Permo-Pennsylvania time was dominated by ferruginous continental deposits of the Sangre de Cristo Formation. The formation may be as thick as 2,000 feet. The end of the Paleozoic was marked by continued terrestrial sedimentation during Leonard to Guadalupian times. The total thickness of Paleozoic rocks in the deepest part of the basin is about 4,500 feet.

Rocks of Mesozoic Age

Triassic rocks of the Vermejo River Basin range from a few feet to possibly 500 feet thick. The rocks consist of siliceous limestone conglomerates, gray and red limestone, siltstone, shale, and gray and red sandstone and belong to the Johnson Gap Formation.

A widespread blanket of shallow-marine and overlying terrestrial deposits was laid down across the entire basin during Late Jurassic time. The Entrada Sandstone, deposited on and near beaches and in near shore marine environments, lies unconformably on Triassic rocks. Overlying the Entrada is the Wanakah or Ralston Creek Formation which consists of varied facies of limestone, green and red shale, gypsum, and thin sandstone. The overlying Morrison Formation is composed of varied proportions of red, gray, and brown fluviatile sandstone and conglomerate, and interbedded red, gray, and green shale. The total thickness of Jurassic age rocks probably does not exceed 500 feet.

The Purgatoire Formation of Early Cretaceous age rests unconformably on Jurassic rocks and marks the time the area became part of the extensive Rocky Mountain geosyncline. It consists of a lower conglomeratic sandstone member and an upper member composed of gray carbonaceous shale and interbedded thin sandstone. The overlying Dakota Sandstone is mainly marine, but in the western part of the basin it contains stream channel sandstones. The Dakota is overlain by a substantial thickness of marine mudstones and silty limestones which belong to the Benton Formation. The overlying Niobrara Formation is also of marine origin and consists of a lower thin limestone and interbedded shale, the Fort Hays Limestone Member, and an upper marly shale, the Smoky Hill Marl Member.

Conformably overlying the Smoky Hill Marl is the Pierre Shale. It consists mainly of dark gray to black non-calcareous shale and occasional thin beds of limestone, sandy shale and sandstone. The Pierre accumulated as a thick marine sequence throughout much of the area now occupied by the Great Plains and the Rocky Mountains. Marine fossils collected at Vermejo Park include Placenticeras sp., Ostrea sp., Inoceramus sp., Acmae occidentales, Hosloscaphites sp., Cryptorhytis flexicostata, and Inoceramus vanuxami. The Pierre Shale becomes progressively sandier toward the top due to epeirogenic uplift which forced the stand line to retreat to the northeast, marking the beginning of Laramide deformation. Overlying and intertonguing with the Pierre is the Trinidad Sandstone. It is composed of very fine to fine-grained sand. The formation is thick bedded and massive in the upper and middle parts and thin-bedded in the lower part. Calcite cement is common as well as Ophiomorpha sp. burrows. The Trinidad intertongues with the overlying Vermejo Formation. The Vermejo consists of sandstone, siltstone, silty carbonaceous shale, and coal. Sandstone beds vary from thin to massive. Coal beds vary in thickness throughout the area and are interbedded with shale and siltstone units. The formation was deposited in swamps and on flood plains near the coast of the northeastward-retreating Cretaceous sea.

Rocks of Late Cretaceous and Tertiary Age

The Raton Formation of Late Cretaceous and Paleocene age unconformably overlies the Vermejo Formation. It consists of sandstone interbedded with siltstone, claystone, mudstone and beds of carbonaceous shale and coal. The sandstone is very fine to medium-grained and is light gray to yellowish gray. Siltstones and claystones often contain streaks of carbonaceous shale, coaly material, and plant fossils. Coal beds are individual beds or composite zones comprised of coal and partings of carbonaceous shale, claystone and impure coal. The upper beds of the Raton Formation intertongue and grade into the coarser grained rocks of the lower Poison Canyon Formation. Sandstone with interbeds of sandy claystone is characteristic of the Poison Canyon. The sandstone is conglomeratic in the upper part of the formation and medium-grained to granular in the lower part. Sediments comprising both the Raton and Poison Canyon Formations were derived from Precambrian and Paleozoic terrains to the southwest and northwest. The Raton Formation is a swamp and flood plain deposit laterally equivalent to the lower part of the Poison Canyon, whereas, the upper Poison Canyon is a pediment deposit.

During Eocene time orogenic movements of extensive major thrusting, normal faulting, and folding of the rocks took place along the northwestern margin of the basin. At this time sills of diorite and intrusive bodies of syenodiorite were intruded into the sedimentary rocks. Epeirogenic upwarping of the entire region, accompanied by the intrusion of basaltic dikes and sills, occured in late Tertiary time.

Sediments of Quaternary Age

Pediment and terrace deposits of Pleistocene age consist of gravelly alluvium composed of subangular to rounded pebbles, cobbles, and boulders of siltstone, sandstone, extrusive and intrusive igneous rocks, and metamorphic rocks derived from the mountains to the west. Holocene alluvium deposits consist of unconsolidated silt, sand, and gravel in, and adjacent to, modern stream channels.

Hydrology

Introduction

Table 18 gives the precipitation in the Vermejo River Basin. The precipitation averages about 18.6 inches. However, the average in this recharge area is about 18.5 inches.

Ground Water

Table 19 gives the estimated annual recharge for the basin. Recharge averages about 1.2 inches per year.

Ground-water flow systems include:

1) local systems that discharge to springs, tributaries of the Vermejo River, especially the Van Bremmer Creek, and the river itself;
2) intermediate systems that underflow the local systems to discharge to Van Bremmer Creek (in the mountains), the Vermejo River, and the Upper Canadian River; and
3) a regional system that underflows both the Vermejo River and the Upper Canadian River.

The regional system is manifested in deep test holes within the Maxwell Grant that have penetrated the rock beneath the Cretaceous shale, which produced non-potable water in only moderate quantities.

Table 18.--Average-annual precipitation in the Vermejo River Basin.

Altitude Interval (ft)		Precipitation	Recharge Area			Discharge Area			Total Basin		
				Precipitation			Precipitation			Precipitation	
From	To	(inches)*	Area (mi^2)	(cfs)	(1000 ac-ft)	Area (mi^2)	(cfs)	(1000 ac-ft)	Area (mi^2)	(cfs)	(1000 ac-ft)
5870	7000	16.4	51.1	61.7	44.7	16.8	20.3	14.7	67.9	82.0	59.4
7000	8000	17.9	68.6	90.5	65.5	39.5	52.1	37.7	108.1	142.5	103.2
8000	9000	19.4	70.1	100.2	72.5	65.8	94.0	68.1	135.9	194.2	140.6
9000	10000	20.8	13.7	21.0	15.2	4.7	7.2	5.2	18.4	28.2	20.4
10000	11000	22.3	11.2	18.3	13.3	3.2	5.2	3.8	14.4	23.7	17.1
11000	13676	25.0	2.7	5.0	3.6	.4	.7	.5	3.1	5.7	4.1
Total			217.4	296.7	214.8	130.4	179.6	130.0	347.8	476.3	344.8

* estimated by Precipitation = .00145 Altitude + 7.06

Table 19.--Estimated average-annual recharge in the Vermejo River Basin.

Altitude Interval (ft) From	Altitude Interval (ft) To	Area (mi^2)	Precipitation (inches)*	Estimated recharge** (in)	Estimated recharge** (cfs)	Estimated recharge** (1000 ac-ft)
5870	7000	51.1	16.4	.87	3.3	2.4
7000	8000	68.6	17.9	1.07	5.4	3.9
8000	9000	70.1	19.4	1.30	6.7	4.9
9000	10000	13.7	20.8	1.54	1.6	1.1
10000	11000	11.2	22.3	1.82	1.5	1.1
11000	13676	2.7	25.0	2.38	.5	.3
Total		217.4	--	--	19.0	13.7

* estimated by: Precipitation = .0145 X altitude + 7.06

** estimated by: Recharge = Precipitation X .005 (Precipitation -6)

The Vermejo River is a gaining stream in its upper reaches. There is clear evidence that local and intermediate flow systems exist. Studies at and around the site also confirm their existence.

The mean-daily ground-water discharge at the gaging station near Dawson is about .9 cfs from an estimated recharge area of 231 square miles. This is equivalent to an average-annual recharge of about .0053 inches per year on the recharge area.

Most of the recharge must either discharge as evapotranspiration upstream from the gage or leave the basin as underflow. Much of discharging ground water moves downstream in the alluvial gravels and is discharged by phreatophytes.

Surface Water

The average-annual runoff at the gaging station near Dawson (07-2030.00) for 51 years is 18.3 cfs (13,260 acre-feet) (USGS NM-75-1, p. 44). Diversions are for irrigation of small acreages in mountain meadows.

The mean-daily surface-water discharge component is about 21 cfs. From an area of about 345 square miles this is about 1.83 inches per square mile.

Below the gaging station, much of the water is diverted to the Vermejo Conservancy District. Downstream from the gaging station, the streams carry only water from the local or intermediate ground-water flow systems, water that is not diverted, and storm runoff from the lower basin.

Because the alluvial gravels carry much of the discharging water, the Van Bremmer Creek and the Vermejo River intermittently flow on occasion but are, in fact, perennial ground water sinks and, therefore, should be thought of as perennial streams.

Hydrologic Budget

The hydrologic budget of the basin has this form:

Precipitation	18.6	
Recharge		1.2
Surface runoff		.8
Immediate evapotranspiration discharge to atmosphere		16.0
Recharge	1.2	
Discharge to stream		.005
to underflow		.6±
to evapotranspiration		.6±

Discussion

The site lies in the lower part of the Vermejo River Basin between Van Bremmer Creek and the Vermejo River. The basin covers the western half of a broad sedimentary basin. The Pierre Shale and Smoky Hill Marl -- a major lithologic unit -- crop out and underlie the site. It consists of 1,500 to 2,000 feet of shale with low hydraulic conductivity. The water in the rocks underlying the shale moves in a regional flow system. It is not potable. The rocks through which the water moves would not yield significant volumes of saline water to wells. Potable water occurs only in the alluvial gravels.

The site straddles the inflection line on the topography, so recharge to and discharge from it can be expected to be much below the average for the altitude.

THE SITE AND ITS ENVIRONS

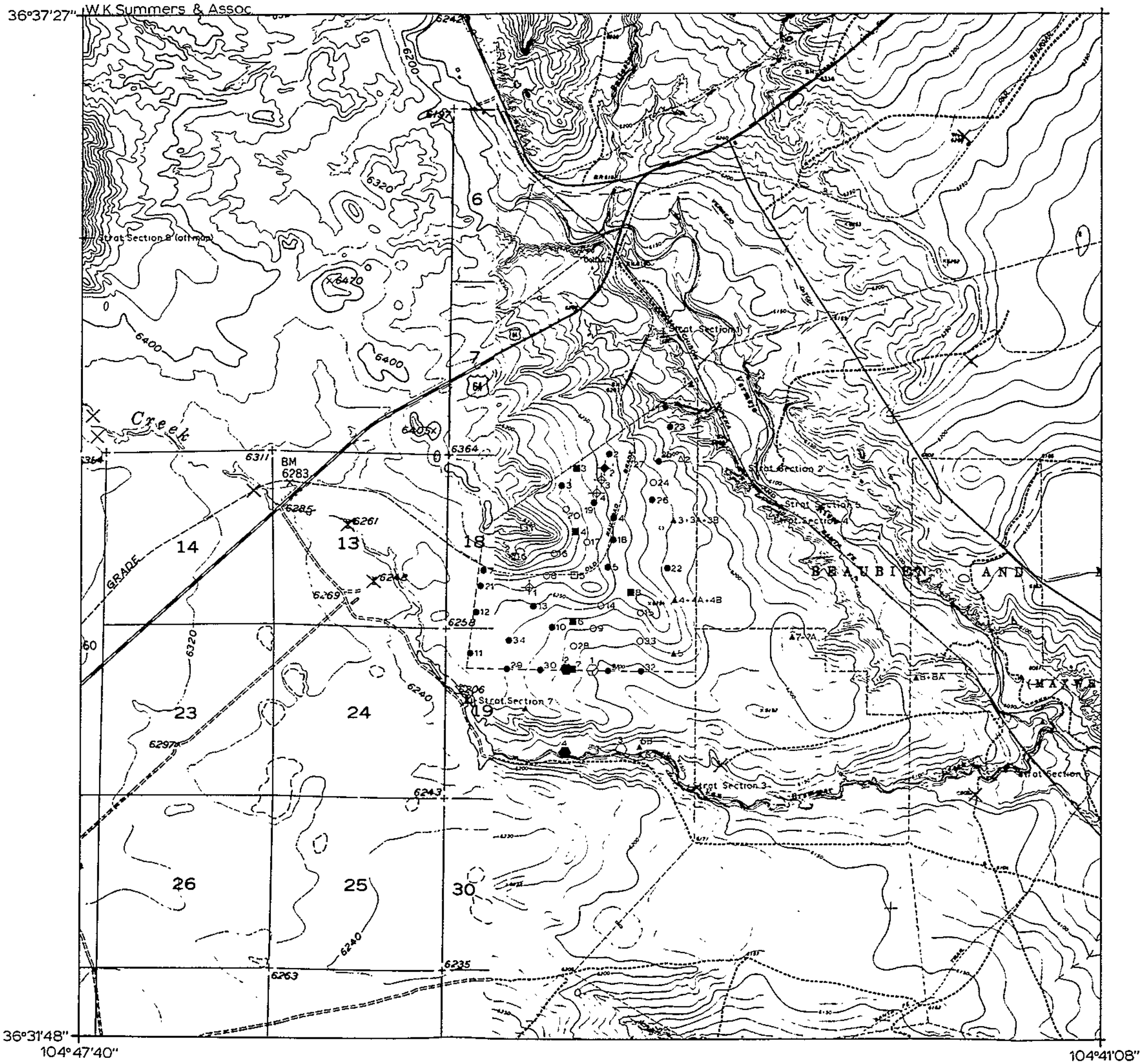
Introduction

The site consists of about 900 acres centrally located within an area bounded by latitudes 36° 31'48" and 36° 27'27" and by longitudes 104° 41'08" and 104° 47'40". It is situated between the Vermejo River on the north and Van Bremmer Creek to the south and is about 2.2 miles northwest of the confluence of the two streams. We confined our investigations to this area. Figure 21 shows the site and the locations of test holes, wells, and piezometers.

Topography and Physiography

Topographically the site is in an area that is predominantly a series of plains and remnants of plains consisting of rolling shortgrass prairie with gentle slopes. Elevations in the area range from a low of about 6,030 feet near the confluence of the Vermejo River and Van Bremmer Creek to over 6,450 feet on old pediment surfaces. The escarpment in the extreme west-northwestern part of the area rises to over 7,200 feet. The altitude of the site ranges from 6,140 to 6,374 feet. The average land slope of the site trends in a southeasterly direction at less than 80 feet per mile.

Physiographically, the area straddles the boundary between the High Plains and Southern Rocky Mountain provinces; but the site is situated on the Las Vegas Plateau, a physiographic subdivision of the Great Plains. An escarpment to the northwest marks the beginning of the Park Plateau subdivision.



Scale-1:48000 1in.=4000 ft.

5000 0 5000 feet

EXPLANATION

HOLE	PIEZOMETER	NO PIEZOMETER
CNP	▲	△
CNS	●	○
CNC	■	□
CNW	⬢	⬡
CNG	✦	✧

SYMBOLS

✕ OFF-SITE WELLS EXAMINED BY D. DRAGAN & O SIMPSON.

I STRATIGRAPHIC SECTIONS

PIEZOMETER LOCATION MAP FOR THE PROPOSED WASTE BURIAL SITE AND VICINITY

FIGURE 21

Geomorphology

Alluvial Landforms

Pediment remnants are probably the most striking geomorphic landform in the area. They stand as topographic highs, have a nearly flat surface, and slope gradually away from the mountain front. A pediment is a geomorphic surface cut by either perennial or ephemeral stream or sheet flow across both hard and soft rocks during a time of stable base level. The age of a pediment decreases from the highest to the lowest level. Each pediment in a sequence has experienced all of the natural history of all the surfaces below it. A stream, in cutting from a higher to a lower level, generally erodes downward through soft bedrock on the edges of its old valley rather than down through the gravel armor on its valley floor. As a result of this, older pediments are preserved as a steplike sequence. Thus, the oldest remnants are the highest and may only be preserved along summits between drainage lines.

The steplike sequence of pediment surfaces demonstrates episodic formation of valley landscape. It marks previous levels of valley fill and stream planation as the stream regimens changed. Tectonic movements such as regional uplift cause an increase in stream gradients and the original valley is downcut. As base level becomes increasingly stabilized, the stream begins to meander, resulting in lateral planation with the development of a new pediment surface. Climatic change may result in a change in the stream regimen. An increase in precipitation causes an increase in discharge which requires adjustments in width and depth. A decrease in rainfall can result in a decrease in density or kind of vegetative cover, which in turn may cause an increase in discharge. Flash floods may also have a great influence on pediment formation.

In the area of concern, three pediment levels can be distinguished. The highest pediment, and thus the oldest, occupies the northwest-southeast trending central ridge of the area. The ridge is armored with pebbles, cobbles, and boulders composed primarily of rhyolite and metamorphic rocks, the nearest source of which is 40 miles upstream. The thickness of this armor exceeds 20 feet in many places. The age of this pediment surface, based on spatial relationships and the extreme weathering of the gravels since their deposition, is mid to early Pleistocene. The surface stands between 210 and 250 feet above the modern Vermejo River, and belongs to the Cimarroncito low pediment group.

An intermediate pediment surface lies about 130 feet above the modern Vermejo River and belongs to the Philmont low pediment group. The gravels that form this pediment average somewhat smaller in size than those of the higher surface, but are composed of similar lithologies. The age of this deposit is probably mid to late Pleistocene.

The lowest pediment, belonging to the Rayado low pediment group, lies along the margins of Van Bremmer Creek and Vermejo River and forms an almost continuous bed of gravel about 50 feet above the modern valley floors. The gravels are somewhat less weathered than those of the higher surfaces, and their lithology is dominated by sandstone fragments. The age of this surface is probably late Pleistocene Wisconsinan. A map showing the distribution of the three pediment levels can be found in Appendix III-5.

Flood plains are also an alluvial landform and are composed of that part of the valley floor adjacent to the stream. They are underlain by sediments deposited by the activity of the stream and are covered with water when the stream overflows its banks. The flood plain of the Vermejo River is present along the entire valley on one or both sides of the stream. The valley floor is considerably wider than the stream channel. The stream course meanders, and lateral erosion is dominant over down-cutting. The valley floor is at an elevation of about 6,140 feet where it intersects with U.S. Highway 64 near Colfax and slopes down to the confluence with Van Bremmer Creek at an altitude of about 6,030 feet, at a rate of about 29 feet per mile.

The elevation of Van Bremmer Creek where it intersects U.S. Highway 64 about 2.5 miles southwest of Colfax is around 6,280 feet. This amounts to an average slope down to the confluence of about 51 feet per mile. The Van Bremmer valley is V-shaped in cross-section and the stream channel covers much of the valley floor, resulting in a very narrow flood plain. Downcutting of the valley appears to be the dominant erosion process. Based on the individual valley characteristics of the two drainages, we conclude that the valley of Van Bremmer Creek is considerably more youthful than that of the Vermejo River.

Hillslopes

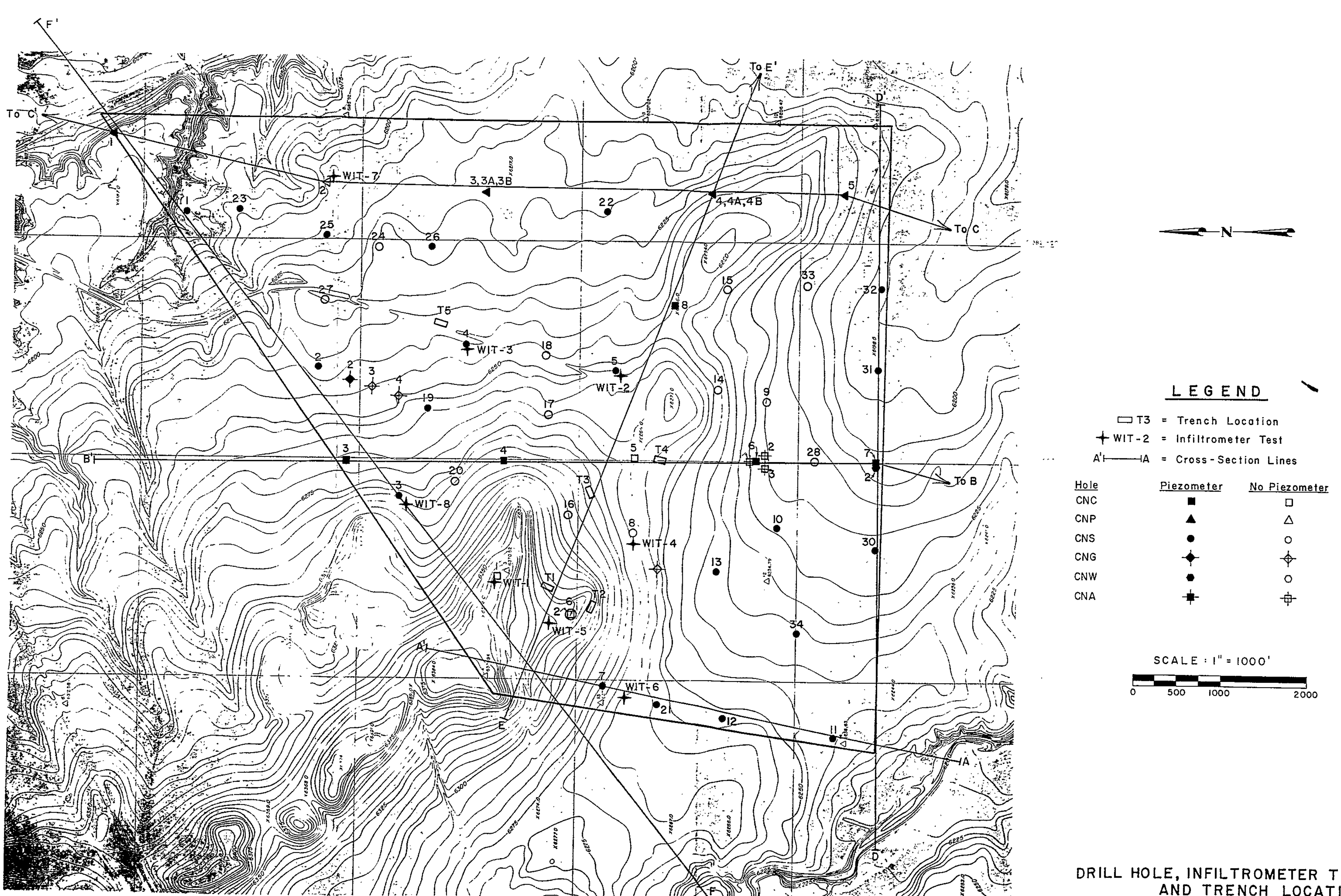
As discussed previously, the low lying hills of the area are old pediment surfaces. The shape of the hills is a result of weathering, erosion, sedimentation, and mass movement throughout their geologic history. Slope gradients seldom exceed 6° and average less than 3°. The processes on hillslopes are controlled directly by the force of gravity. Water runs off downslope, as overland flow, causing erosion and deposition only after the infiltration capacities of the soils are reached. The factors controlling erosion are the initial resistivity of the material, the cover on the hillslope, rainfall intensity, and the velocity and energy of runoff. Overland flow may be confined in rills as channel flow or unconfined as sheet flow.

Rilling (gully gravure), a more effective erosion agent than sheet wash, is a dominant process in hillslope reduction. Several short discontinuous hillside gullies occur in the upland area of the site and are restricted to slopes greater than 5°. All of the gullies appear to be associated with cattle trails or the traces of abandoned roads. Rilling is not a serious problem at the site.

Geomorphic evidence indicates that the upland area at the site has eroded very little in the last 10,000 years. The highest pediment surface is of mid to early Pleistocene in age, therefore, at least 200,000 years old. The Vermejo River has eroded downward 300 feet in no less than that time; thus, landscape denudation has proceeded locally at no more than 1.5 feet per thousand years.

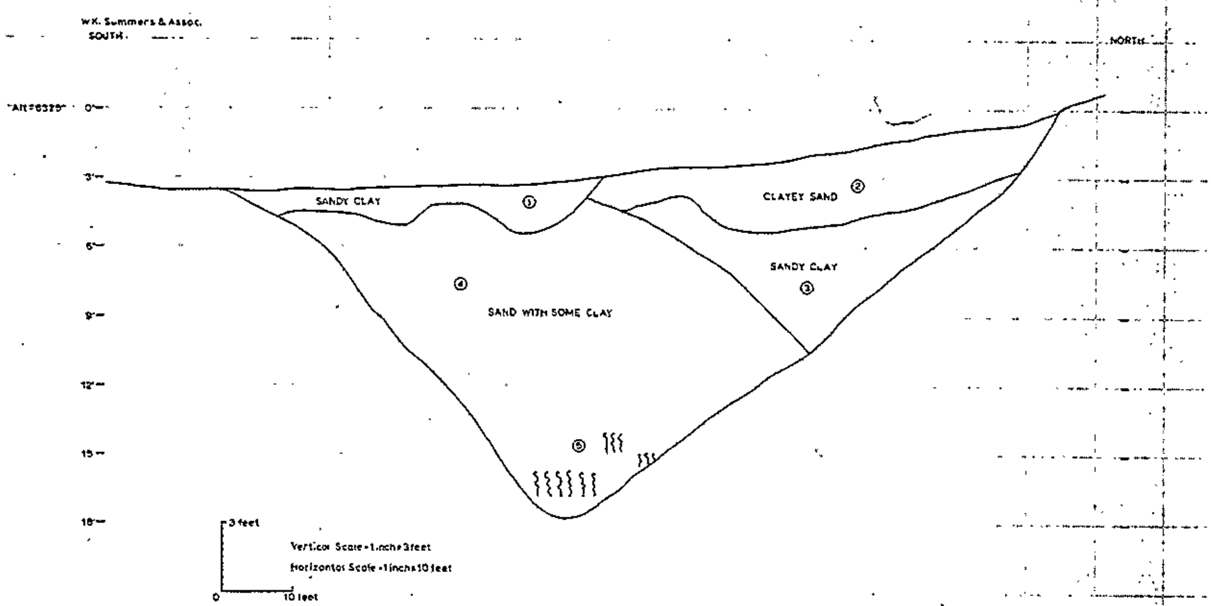
Soils

Soils of the shortgrass prairie in the area of concern have been classified as belonging to either the Colmor-Swastika-Kim association or the Vermejo-Litle-Midway association. Both soil associations have fine to medium texture and develop on sedimentary material. These soils have low to medium permeability and low strength when wet. Particle-size distribution analyses of soils in the site area indicate they differ from sample to sample in texture. For example, sample number 2 taken from Trench 1 (Fig. 22 and 23) is a clayey sandy soil in which over 70 percent of the particles are larger than 0.044 mm. The area that the sample was taken from lies in a saddle between two hills capped by pediment gravels. The parent material of the soil was probably mostly derived from the higher pediments as the finer material was winnowed out, either by wind or water, and moved downslope. Soil sample number 11 taken from Trench 5 is a sandy clay, having less than 35 percent of the particles greater than 0.0444 mm. in diameter. That trench is located on fairly flat ground away from an immediate source of coarse material. This texture-source relationship for soils in the area is generally true; however, there are many exceptions.

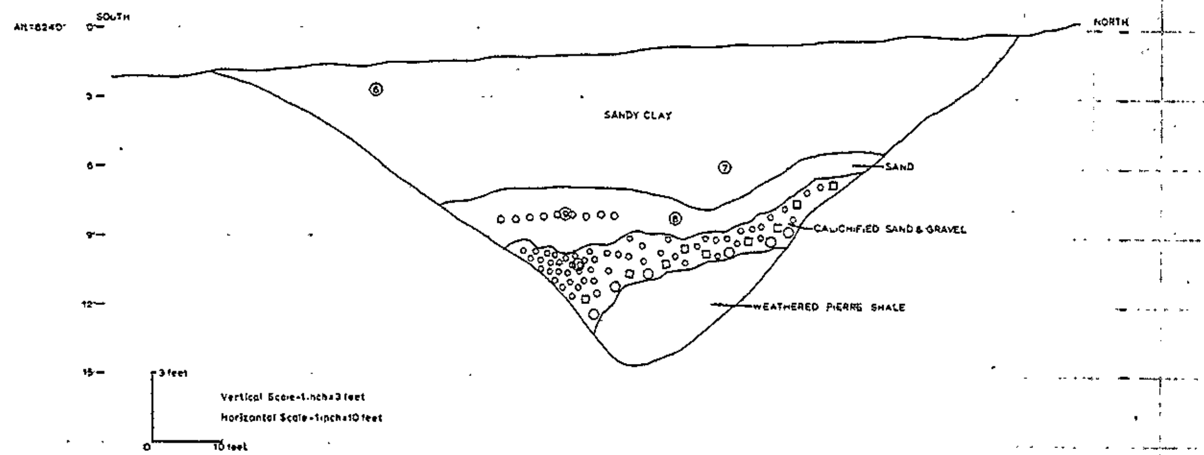


DRILL HOLE, INFILTROMETER TEST AND TRENCH LOCATIONS

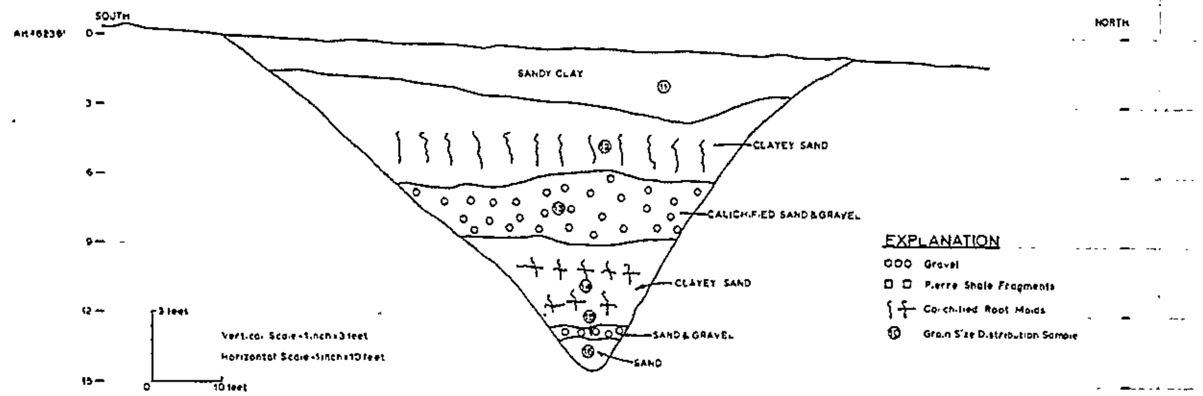
FIGURE 22



Trench 1 Long dimension=N25°E Section on west wall



Trench 4 Long dimension=N16°E Section on west wall



Trench 5 Long dimension=N16°E Section on west wall

TRENCH SECTIONS

C.W. Walker February 1977

FIGURE 23

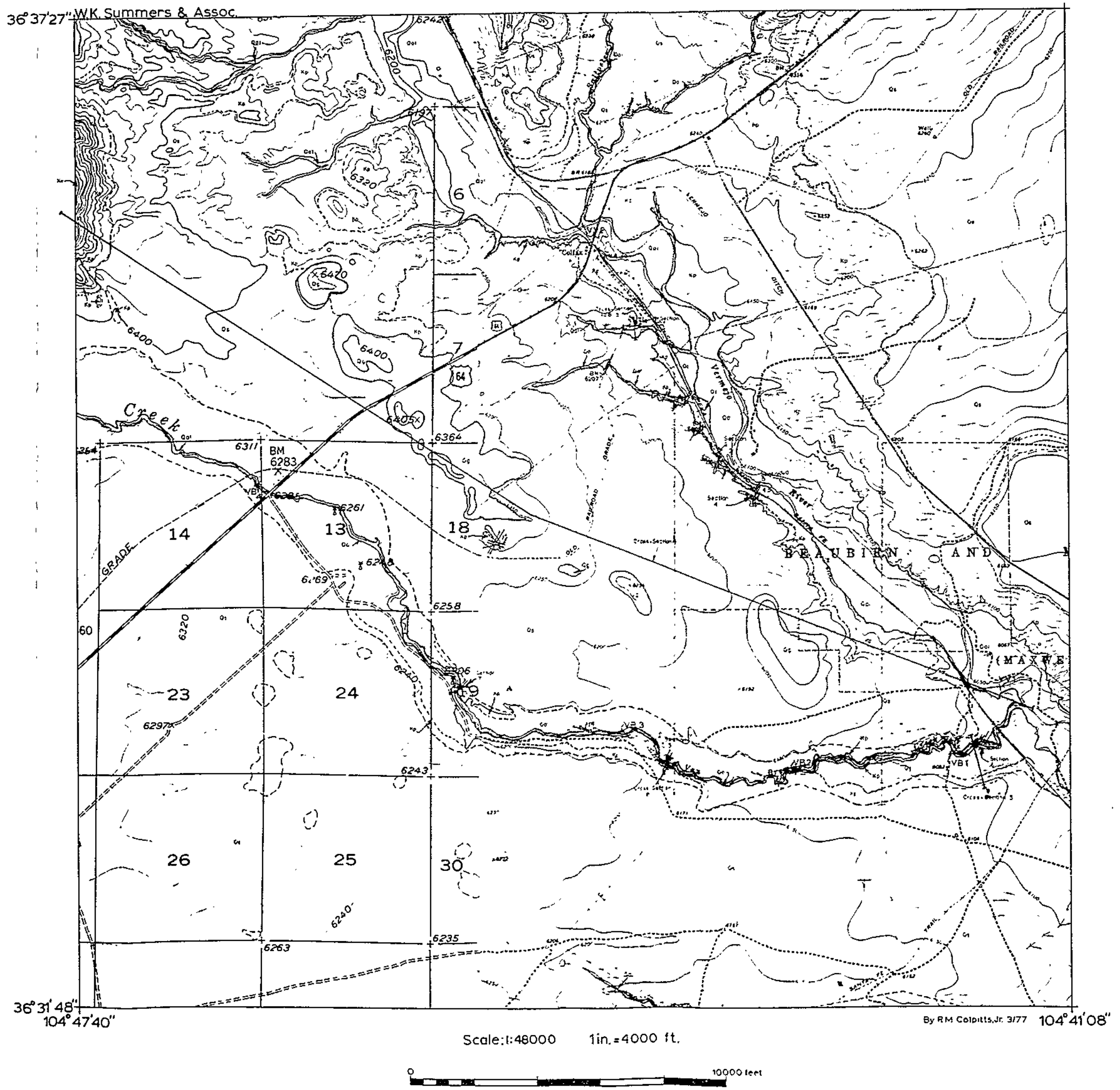
Geology

Structure

The tectonic map of the southern Raton Basin compiled by Woodward and Snyder (1976) shows that the site is about 8 miles north of the Cimarron Arch axis and about 34 miles west of the Sierra Grande Arch axis. The site is located on the southwestern flank of the structural Raton Basin about 17 miles from its synclinal axis. Structure contours drawn on top of Precambrian rocks show the regional dip in the area to be as great as 200 feet per mile toward the Raton Basin axis to the north-northwest.

A petroleum wildcat well (American Manufacturing Co., No. 1, W.S. Ranch, 1-26-20E) drilled a few miles to the southwest of the area in 1946 penetrated Precambrian granite at a depth of 3,814 feet. The Vermejo River Basin Cross-Section B-B' (Fig. 20b) indicates the total thickness of sedimentary rocks at the site to be about 4,100 feet. Of this thickness, about 2,800 feet belongs to the Cretaceous. With this above information and the information shown on the Canadian River Basin Cross-Sections A-A' and B-B' (Fig. 14, and 15a, b, and c), we estimated that the regional dip of Cretaceous strata at the site is approximately 100 feet per mile toward the northwest.

Local dips measured from outcrop range from 2° to as high as 14° in the Pierre Shale (Fig. 24). The average dip direction is toward the north-northeast. The high dip angles seem to be anomalous to the regional dip of about 1°. This anomaly may be explained by the fact that the higher dip measurements were all made on fairly steep slopes and the Pierre is very susceptible to slumping on steep slopes. This slumping is the reason



EXPLANATION

- Qal — Recent Alluvium
- Qt — Terrace Deposits
- Qs — Surface Sand and Silt
- Qg — Gravels on Ridge Tops
- Kv — Vermejo Formation
- Kt — Trinidad Sandstone
- Kp — Pierre Shale
- Boundary of Buried Valley
- Concealed Contact
- Definite Contact
- Fracture Sets
- 14 — Strike and Dip of Shale
- Cross-Section Lines

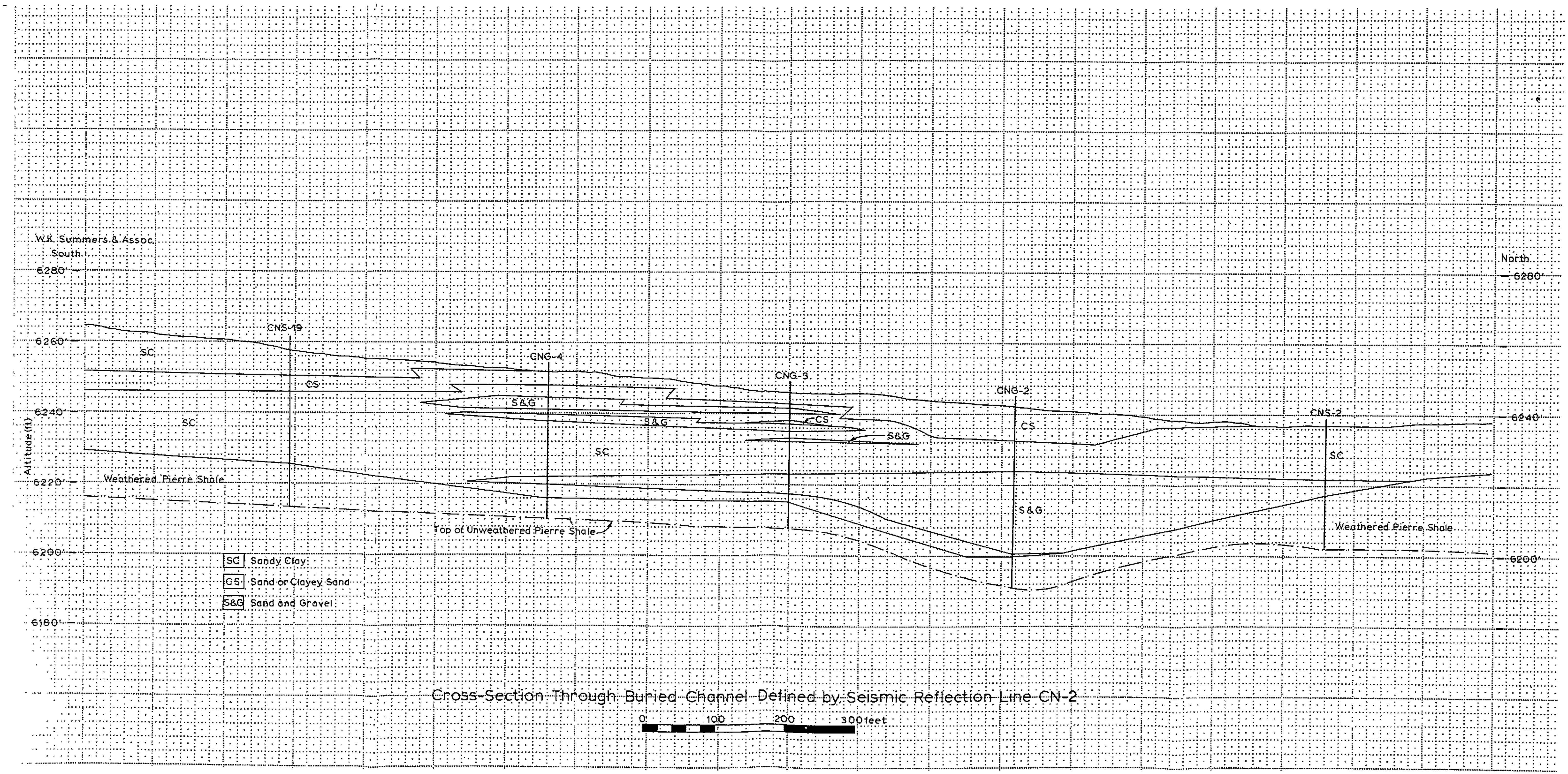
Geology of the Proposed Waste Burial Site and the Surrounding Area
Colfax Co., N. Mex.
1977

FIGURE 24

that Pierre Shale exposures are usually fair to poor. The dip direction is about 30 to 40° east of the regional dip direction. This may be due, in part, to slumping, but probably mostly reflects local structure. Measurements on core bedding (assuming that the holes were vertical) suggest an average dip of 2 to 3°.

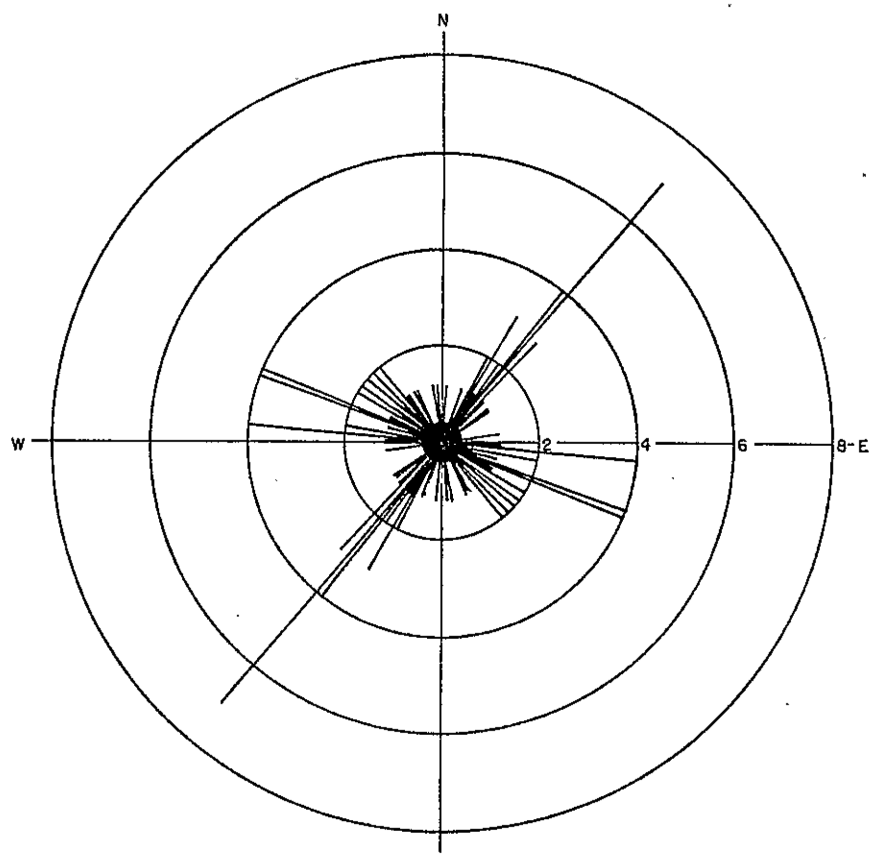
A shallow seismic survey (Appendix III-4) was conducted in the area. Seismic events were interpreted as small scale folding and faulting within Cretaceous strata, consisting mainly of a series of faulted asymmetric anticlines and synclines. The folds are thought to strike approximately east-southeast with a wavelength on the order of 700 to 1,500 feet. Small, high angle reverse faulting and fracturing, associated with compressional shortening, would be concentrated near the crests of the anticlines. At the request of the geophysicist, holes were conventionally drilled and cored through the overburden and into the shale in order to evaluate existing conditions directly. In the northern portion of the site a drill hole proved the existence of a buried channel interpreted from seismic events (Fig. 25). It was further interpreted that the channel was located over a faulted and fractured small anticline. However, a 10-foot core of the Pierre Shale taken from this hole showed no evidence of deformation of any kind.

Fracture trends in Pierre outcrop were measured at numerous locations. The trends are plotted on the circular histogram (Fig. 26) to portray distribution of the directional data. The fracture direction is plotted on the compass rose and its relative abundance is plotted with radius equal to class frequency. Two preferred orientations obviously exist as shown in the diagram. The most frequently occurring fracture direction trends about

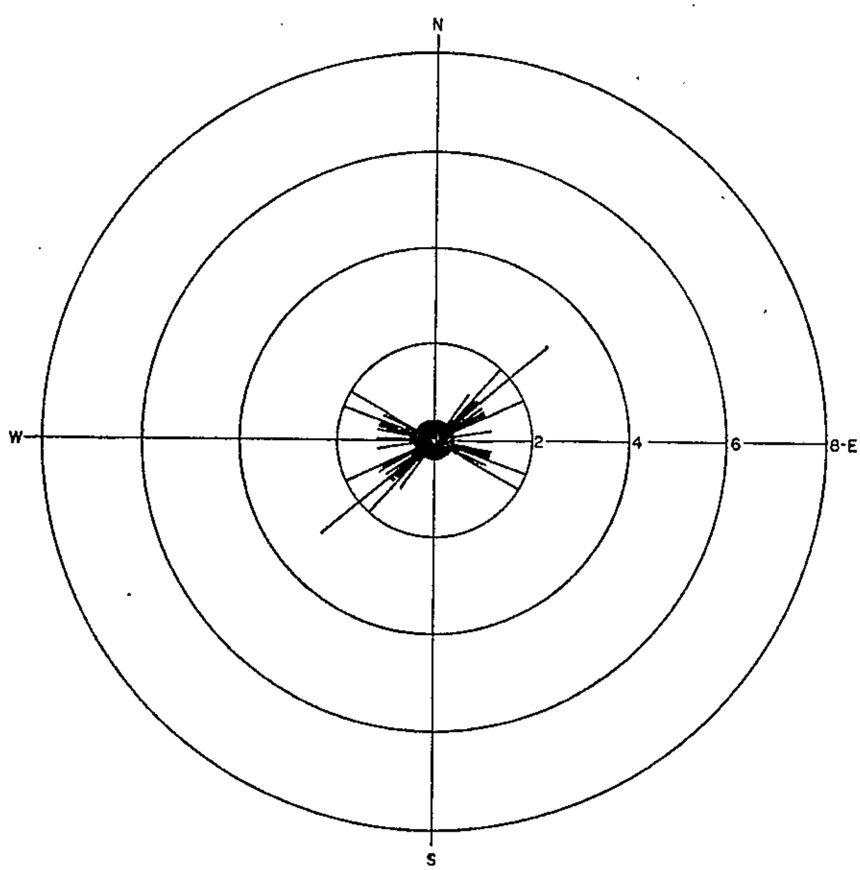


Cross-Section Through Buried Channel Defined by Seismic Reflection Line CN-2

FIGURE 25



FRACTURE TRENDS



ARROYO TRENDS

ARROYO & FRACTURE TRENDS IN THE VICINITY OF THE PROPOSED WASTE BURIAL SITE

FIGURE 26

North 40° East, a second fracture set trends about North 75° West. The circular histogram at the bottom of the figure shows the present arroyo directional trends. There appears to be a relationship between the preferred orientation of fracture trends and the preferred orientation of arroyo trends. This seems to indicate that present day arroyo development is strongly influenced by existing fracture trends.

A photogeologic study utilizing 51 aerial photographs of the proposed site and surrounding area was conducted primarily to define areas that would merit detailed investigation in the field (Appendix III-1). The photogeologist, Mr. Wilson, concluded that the area appears to be severely faulted and fractured, and possibly folded beneath the Quaternary terrace gravels. However, we believe that he misinterpreted man made features and geologic sedimentary contacts to be fractures and faults. This belief is based on the following statements and observations:

> Mr. Wilson states: "The relative straight outcrop pattern in the south central part of the area suggests dips of 10° to 20° magnitude." The area mapped as "covered outcrop" corresponds directly to a narrow zone of sandy clay bounded by zones of clayey sand. The depth to bedrock (Pierre Shale) along this "covered outcrop" zone averages over 40 feet and is 66 feet at hole CNS-12, which is located in the middle of the zone.
>
> Mr. Wilson states: "A clue to the complexity of area can be seen in the streams surrounding the proposed site. They have adjusted to the apparently rather large faults and structural trends in the Pierre-Niobrara bedrock." Mr. Wilson's map shows the interpreted faults and fractures to trend in a northwest-southeast direction; however, Van Bremmer Creek flows almost due west to east from the site to its confluence with the Vermejo River.
>
> A comparison between Mr. Wilson's map and the geologic map of the site clearly shows the close relation between the interpreted fractures and

geologic contacts which separate differing sediment types. A man made canal to the north of the site area was interpreted to be a structural feature.

No field checks at the site or surrounding area were conducted by Mr. Wilson. Field work to check photo-geologic interpretation is usually a normal part of a study such as this.

We believe that Mr. Wilson misinterpreted non-structural features to be fractures and faults. None of the detailed field work at the site, or in the surrounding area, detected any evidence to indicate the area to be severely faulted and fractured and possibly folded beneath the Quaternary terrace gravels.

Seismic evidence suggests that even if bedrock faults and fractures exist, they probably have not directly affected the more recent overburden. The structure contour map showing the altitude of the top of the Pierre Shale at the site does not indicate evidence of bedrock faulting (Fig. 27). It does show, however, that to some degree the ancient integrated drainage was influenced by the fracture trend portrayed in Figure 26.

The nearest area of intense tectonic activity lies about 18 miles southwest of the site. Here thrusting of Laramide age and igneous intrusion of Tertiary age affected the strata of Late Cretaceous and older rocks. In late Tertiary and Quaternary time volcanic rocks were extruded from vents along the Sierra Grande Arch, the nearest of these being about 17 miles northeast of the site.

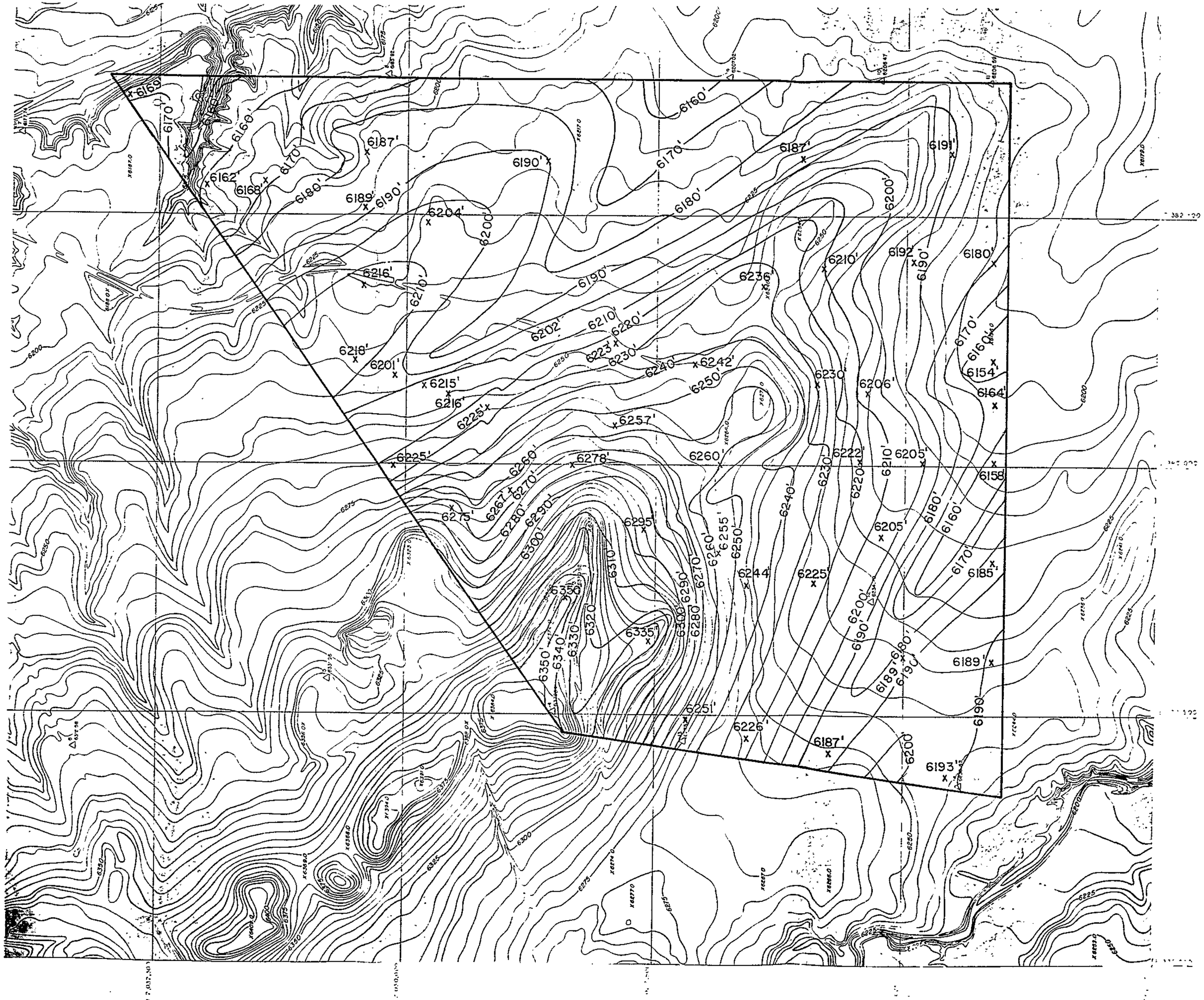
Stratigraphy and Lithology

For the immediate area of the site we recognize two stratigraphic-lithologic units in the Pierre Shale with unweathered and weathered phases in sharp contact, and the overlying alluvium-colluvium (Fig. 28). The Trinidad and Vermejo Formations crop out nearby (Fig. 24).

Pierre Shale

General Characteristics

The Pierre Shale of Late Cretaceous age is the oldest rock strata exposed at the surface in the site area. The Pierre and equivalent rocks cover an area of about 600,000 square miles in many parts of the western interior of the United States, and have an outcrop area of about 90,000 square miles. The formation accumulated as a thick marine sequence of mud and silt with minor amounts of lime and sand. Lithologically, the Pierre is a dark gray to nearly black non-calcareous shale with several thin zones of calcareous and iron carbonate concretions. Argillaceous limestones beds up to a foot or more thick occur at several horizons. The upper 120 feet of the Pierre consist of brown, occasionally sandy or silty shale intercalated with thin beds of fine to medium-grained sandstone (Appendix I-10, Stratigraphic Section 8). The thickness of the Pierre Shale in the site area is estimated to be between 1,600 to 1,700 feet where it has not been eroded. Cross-section 4 (Fig. 29a) shows the site and its relationship to the Pierre Shale and overlying formations. From this section it can be seen that the Pierre Shale has been significantly eroded in the area of the site. Assuming no dip to the Pierre, a minimum of 500 feet at the site, and 800 feet at the



N

LEGEND

x = Hole Location

6205' = Altitude of the top of the Pierre Shale rounded off to the nearest foot

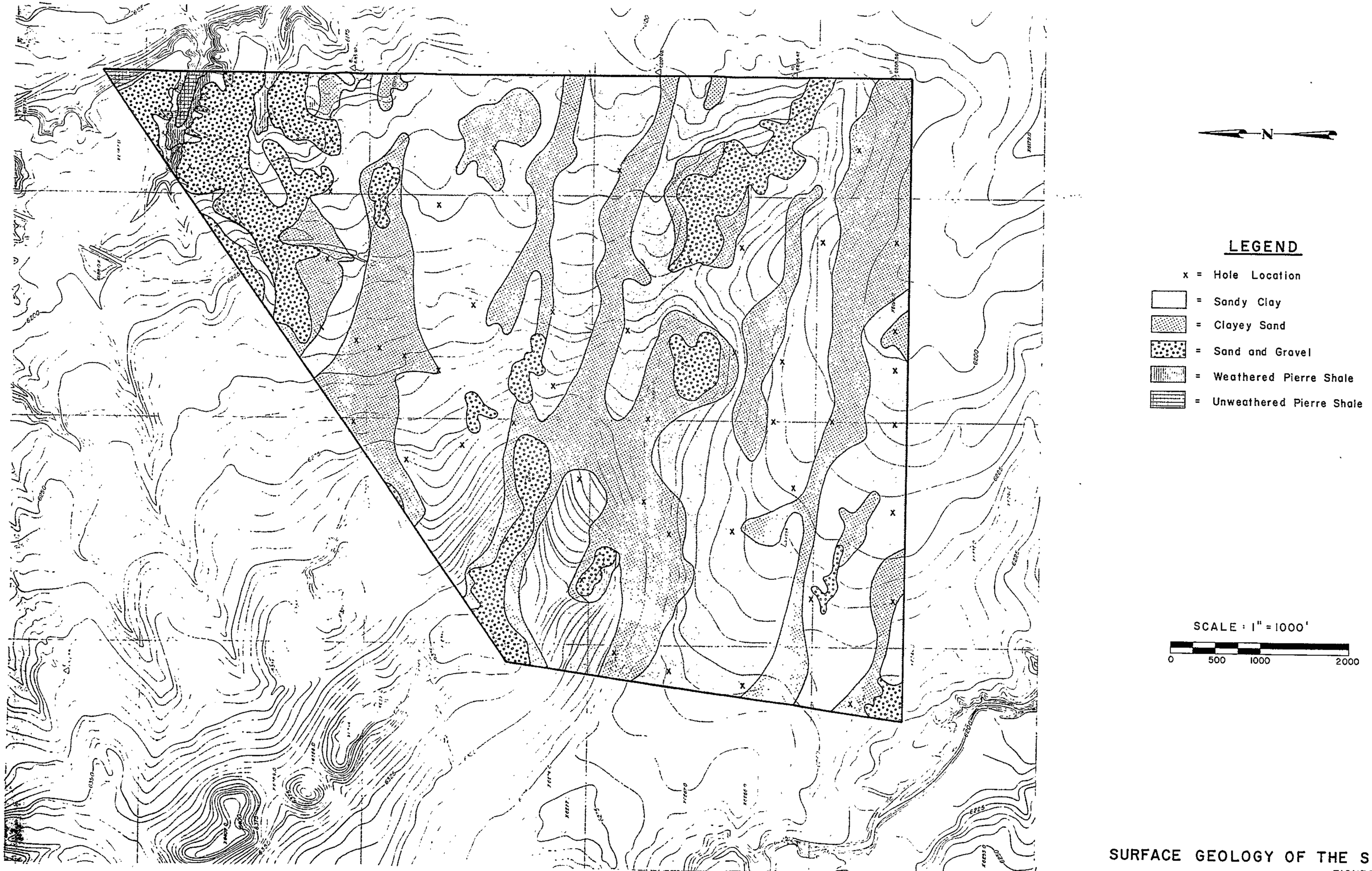
Contour Interval = 10'

SCALE: 1" = 1000'

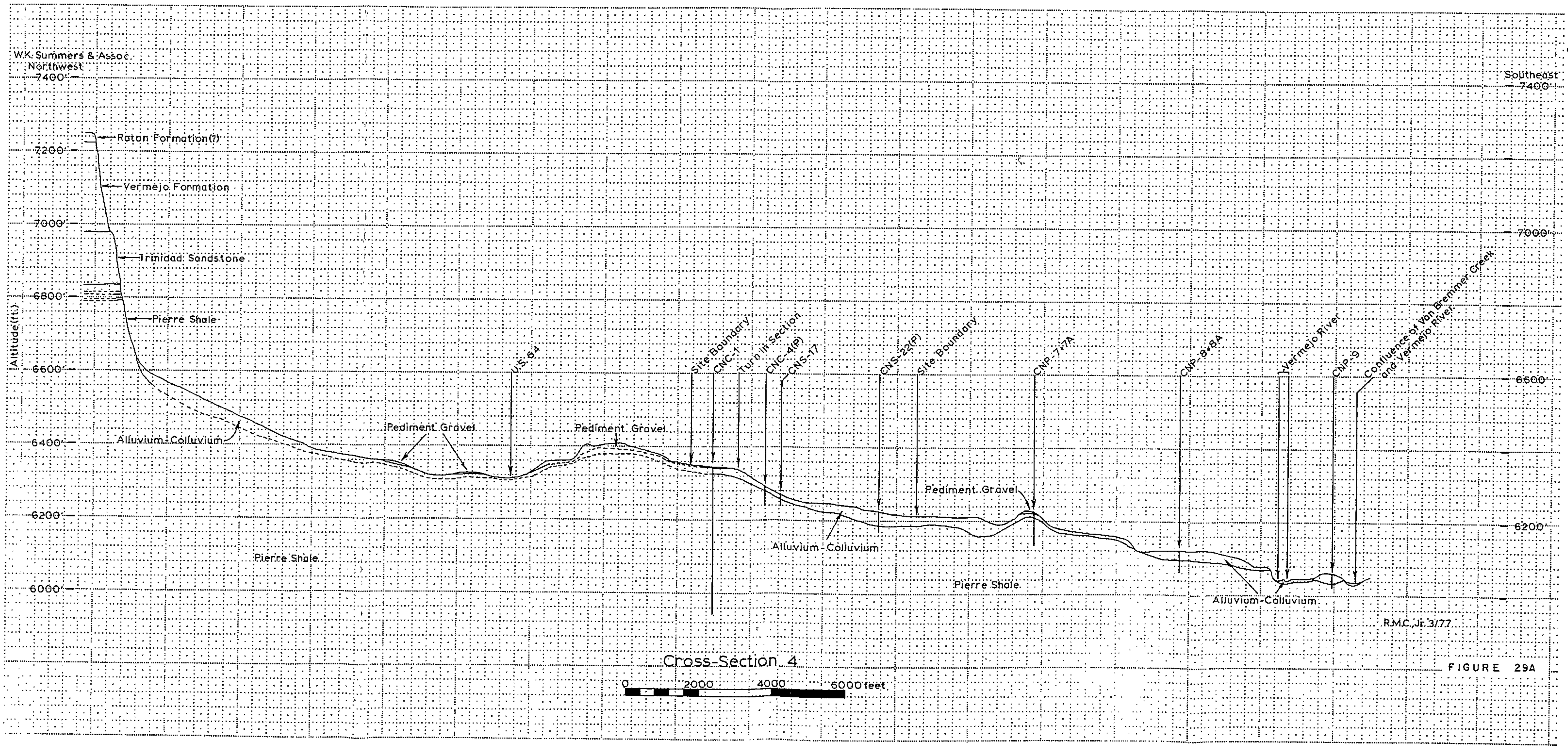
0 500 1000 2000

CONTOURS ON THE TOP OF THE PIERRE SHALE

FIGURE 27



SURFACE GEOLOGY OF THE SITE
FIGURE 28



Cross-Section 4

FIGURE 29A

confluence of Van Bremmer Creek and Vermejo River have been eroded. This means that the maximum thickness of the Pierre Shale is on the order of 1,200 feet at the site. A probable minimum thickness of about 800 feet is calculated when the regional dip of 100 feet per mile toward the northwest is considered. The true thickness of the Pierre in the site area is probably somewhere between the maximum and minimum values.

Weathered Pierre Shale

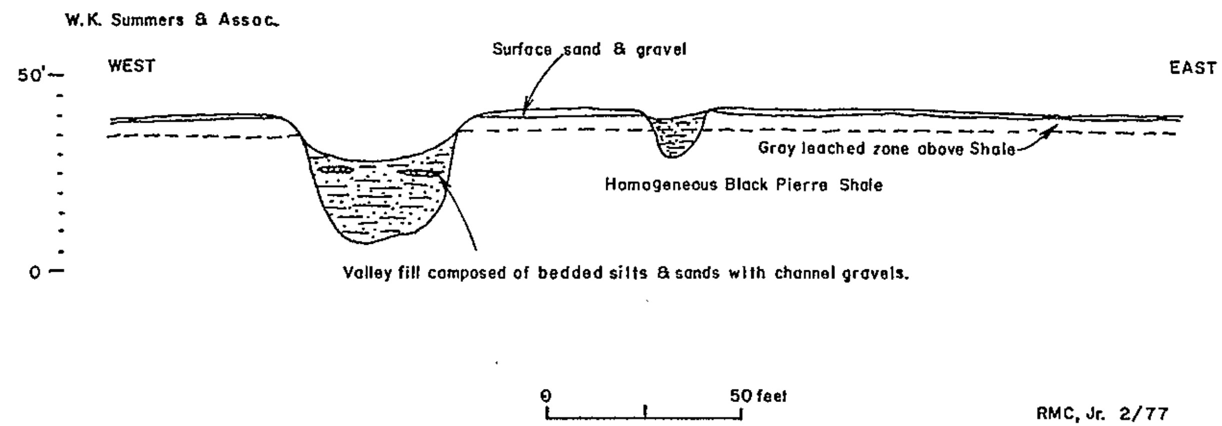
During erosion of the Pierre Shale, the uppermost beds are subjected to weathering. This weathering zone is up to 50 feet thick and probably developed over a long geologic time span prior to the Pleistocene. It is likely that most of the weathering took place under oxidizing and alkaline conditions, but locally the oxidation of sulfide-rich shales could have produced strongly acidic conditions. Erosion was much more rapid during the Pleistocene and the weathered zone was eroded away by stream action in many places. The thickest weathered zones at the site are preserved under the oldest pediment surfaces. The two modern drainages have, for the most part, cut through the weathered zone and are now eroding into the unweathered shale. Recognition of the weathered zone in both outcrop and in drilling is very easy due to its distinctive grayish-brown color. The interface between the weathered and unweathered shale is very sharp, having a narrow transition zone. Stratigraphic Section 1 (Appendix I-10) clearly illustrates both the unweathered and weathered Pierre Shale. Note that the outcrop surface of the weathered shale contains 30 percent gypsum. This gypsum resulted from water that moved toward the outcrop surface, contained calcium and sulfate in solution, and was concentrated in the surficial zone by evaporation of the solutions. Pierre Shale outcrops are, for the most part, limited to the walls of modern drainages and the deeper arroyos (Fig. 29b-e), and to man made excavations such as road and railroad cuts. On only one higher hillside slope within the site does the Pierre crop out, and this is within the weathered zone.

Mineralogy of both weathered and unweathered Pierre Shale was determined by X-ray diffraction analysis (Appendix II-3). Table 20 indicates the type and location of samples analyzed and Table 21 contains a statistical analysis of relative mineral abundance as determined by X-ray diffraction. Clay minerals recognized in this study include illite, kaolinite, mixed layer illite/montmorillonite and a very small amount of discrete montmorillonite and chlorite. The X-ray analyst found the chlorite to be poorly crystallized with low thermal stability. Brookins (Appendix III-6) states that this type of chlorite is what one would predict when authigenic illite and/or mixed layer illite/montmorillonite occurs in the presence of organic matter. He further indicates that the formation of this chlorite is twofold:

(1) the poorly crystallized chlorite absorbs Cs and Sr preferentially relative to K, Mg, and Ca respectively; and

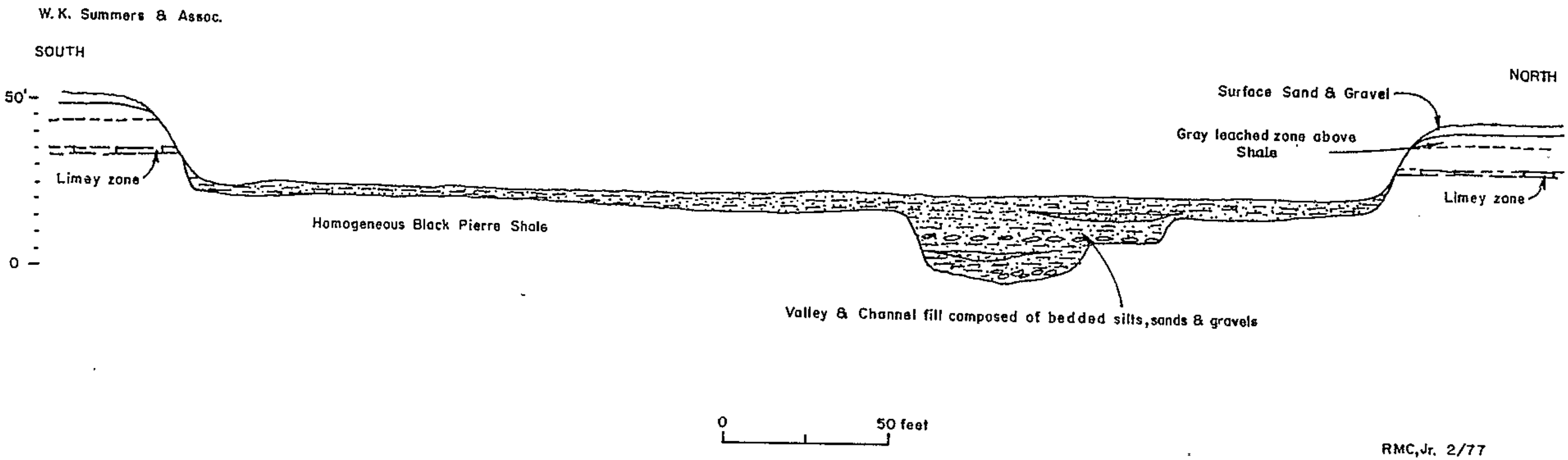
(2) vermiculite formation is inhibited, i.e., vermiculites are readily stripped of many ions in an unpredictable fashion; whereas, chlorites are not.

Figure 30a graphically displays the relative mineral abundance of the clay size fraction for both the weathered and unweathered Pierre Shale analyzed. A little surprising is the fairly large amount of kaolinite, on the order



CROSS-SECTION 1A

Figure 29b



CROSS-SECTION 1B

Figure 29c

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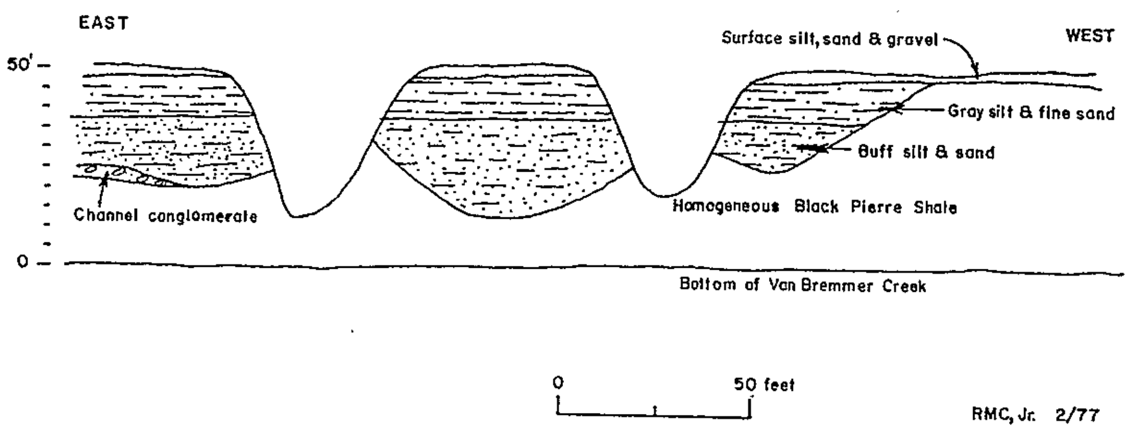
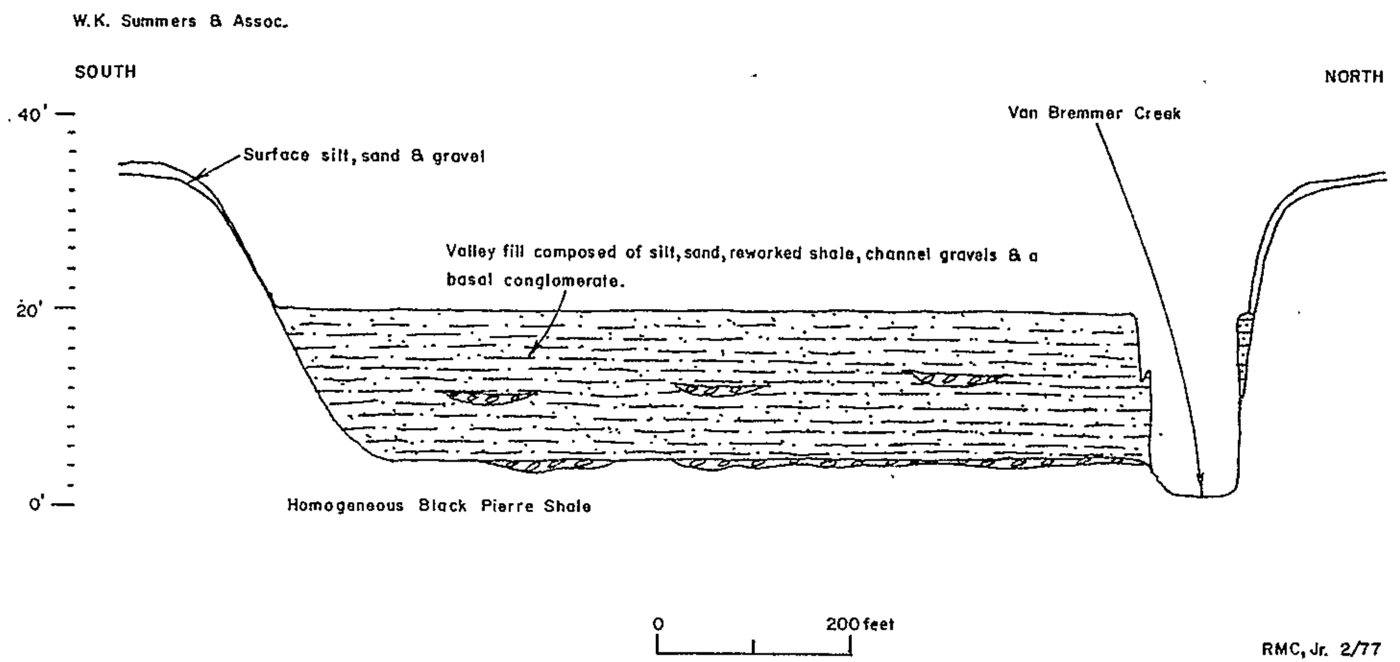


CROSS-SECTION 2



CROSS-SECTION 3

Figure 29e

Table 20.--Samples analyzed by x-ray diffraction.

Sample No.	Hole	Depth (ft)	Type	Comments
		Unweathered Pierre Shale		
1	CNC-1	253.5	core	
11	CNC-1	400	cuttings	
3	CNC-2	32.9	core	about 0.4' below weathered shale
13	CNC-6	65.3	core	
14	CNC-8	41	core	
15	CNG-2	58.5	core	
7	--	--	outcrop	along Vermejo River Valley
9	--	--	outcrop	about 100' below Trinidad sandstone
		Weathered Pierre Shale		
2	CNC-2	22.5	core	about 10' above unweathered shale
16	CNC-6	14.5	core	
17	CNC-8	15	cuttings	
19	CNG-2	45	cuttings	
20	CNG-2	50	cuttings	appears to be only partially weathered
8	--	--	outcrop	along Vermejo River Valley
		Altered Pierre Shale		
12	CNC-5	46	core	about a 1-inch thick zone
		Trinidad Sandstone		
10	--	--	outcrop	composite lithology
		Sandy Clay Alluvium-Colluvium		
5	CNS-29	20	cuttings	
18	CNS-34	20	cuttings	
		Sand and Gravel Alluvium-Colluvium		
4	CNP-2	20	cuttings	probable ancient Vermejo River source (samples 4, 21, 23, 22)
21	CNP-1	5	cuttings	
23	CNG-2	25	cuttings	
22	CNP-6	15	cuttings	
6	CNS-29	40	cuttings	probable ancient Van Bremmer Creek source

Table 21.--Relative mineral abundance as indicated by x-ray diffraction. (cont)

	Alluvium-Colluvium						
	Sandy clay (N=2)			Probable Vermejo source sands and gravels (N=4)			Probable Van Bremmer source sands and gravels (N=1)
Clay-size fraction	Average	Standard Deviation	Variance	Average	Standard Deviation	Variance	Value
Illite	3.2	0.3	0				
Kaolinite	2.5	0.7	0.2				
Mixed layer illite/ montmorillonite	3.2	0.3	0				
Chlorite	1.5	0.7	0.2				
Quartz	3.0	1.4	1.0				
Silt-size fraction							
Quartz	5.0	0	0				
Calcite	0.5	0.7	0.2				
Dolomite	0.5	0.7	0.2				
Plagioclase	2.5	1.4	1.0				
Potassium feldspar	2.2	1.8	1.6				
Sand and >sand-size fraction							
Quartz				5.0	0	0	5.0
Plagioclase				3.0	0	0	3.0
Potassium feldspar				3.0	0	0	2.0
Calcite				0.5	1.0	0.7	1.0
Potassium/plagioclase feldspar				1.1	0.3	0.1	0.5

[1]Standard deviation $= \sqrt{\text{Variance} \times \frac{N}{N-1}}$

[2]Variance $= \frac{\Sigma yi^2}{N} - \frac{(\Sigma yi)^2}{N}$

Relative mineral abundance code (based on x-ray peak heighth)

5.0 predominant phase present; probably exceeds 70% of the total
4.0 a major phase; approximately 40 to 70% of the total
3.0 an important phase; about 10 to 40% of the total
2.0 minor phase; probably not over 10% of the total
1.0 trace amount

Table 21.--Relative mineral abundance as indicated by x-ray diffraction.

	Pierre Shale						
	Unweathered (N=8)			Weathered (N=6)			
Clay-size fraction	Average	Standard Deviation[1]	Variance[2]	Average	Standard Deviation	Variance	Altered (N=1) Value
Illite	3.6	0.7	0.5	3.2	0.4	0.1	1
Kaolinite	3.1	0.3	0.1	3.0	0	0	5
Mixed layer illite/ montmorillonite	3.2	0.4	0.1	3.5	0.5	0.2	1
Chlorite	1.6	0.5	0.2	1.6	0.9	0.7	1
Quartz	1.9	1.1	1.1	1.0	0.9	0.7	1
Silt-size fraction							
Quartz	5.0	0	0	5.0	0	0	4
Calcite	1.6	1.4	1.8	1.3	1.2	1.2	0
Dolomite	2.4	0.5	0.2	1.8	0.9	0.7	0
Plagioclase	2.2	0.4	0.1	2.4	0.5	0.2	0
Potassium feldspar	0.1	0.3	0.1	0.5	0.8	0.6	0

Trinidad Sandstone Outcrop

Sand and >sand-size fraction	(N=1) Value
Quartz	5.0
Plagioclase	3.0
Potassium feldspar	2.0
Calcite	3.0
Potassium/plagioclase feldspar	0.3

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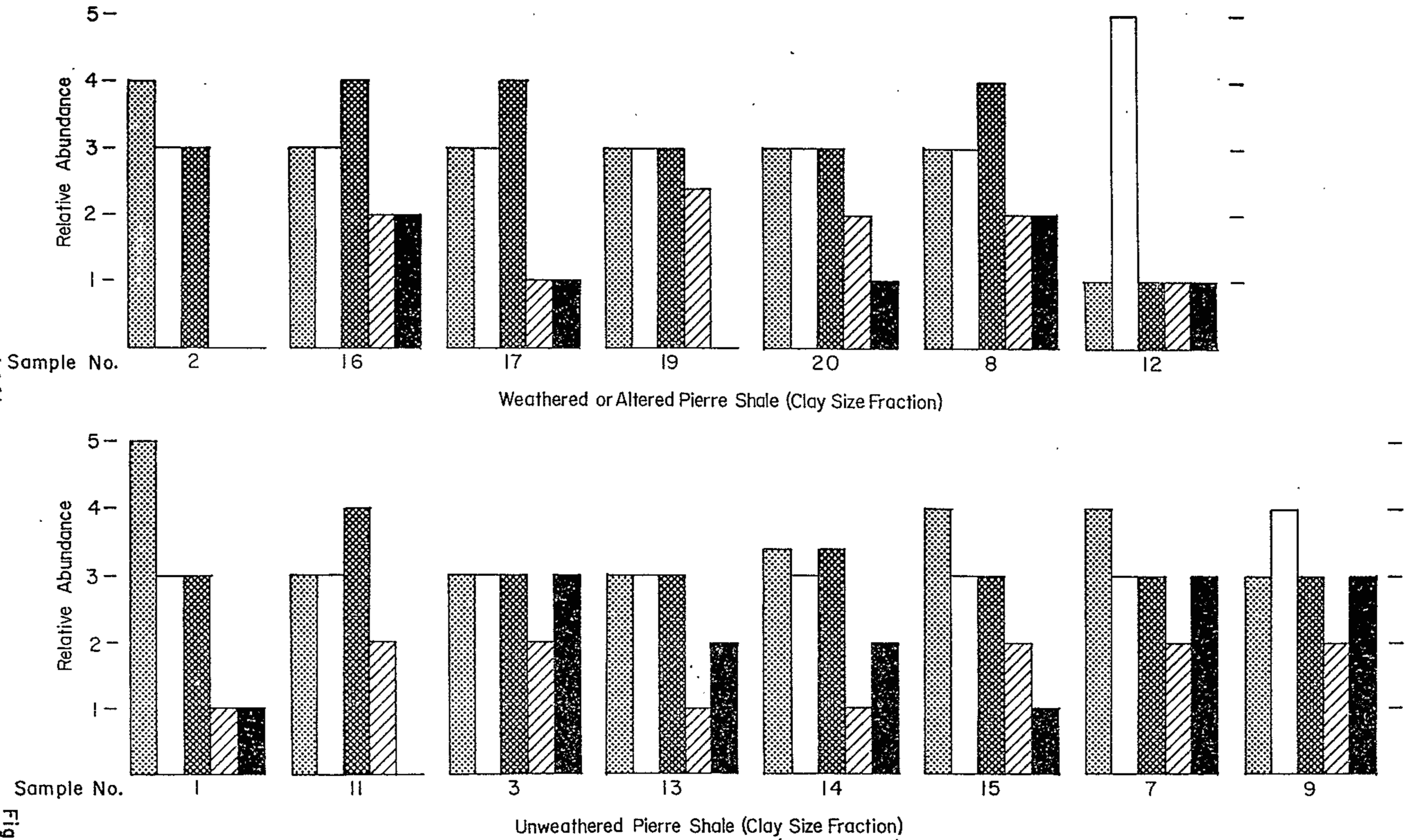

A-Pierre Shale

Figure 30a

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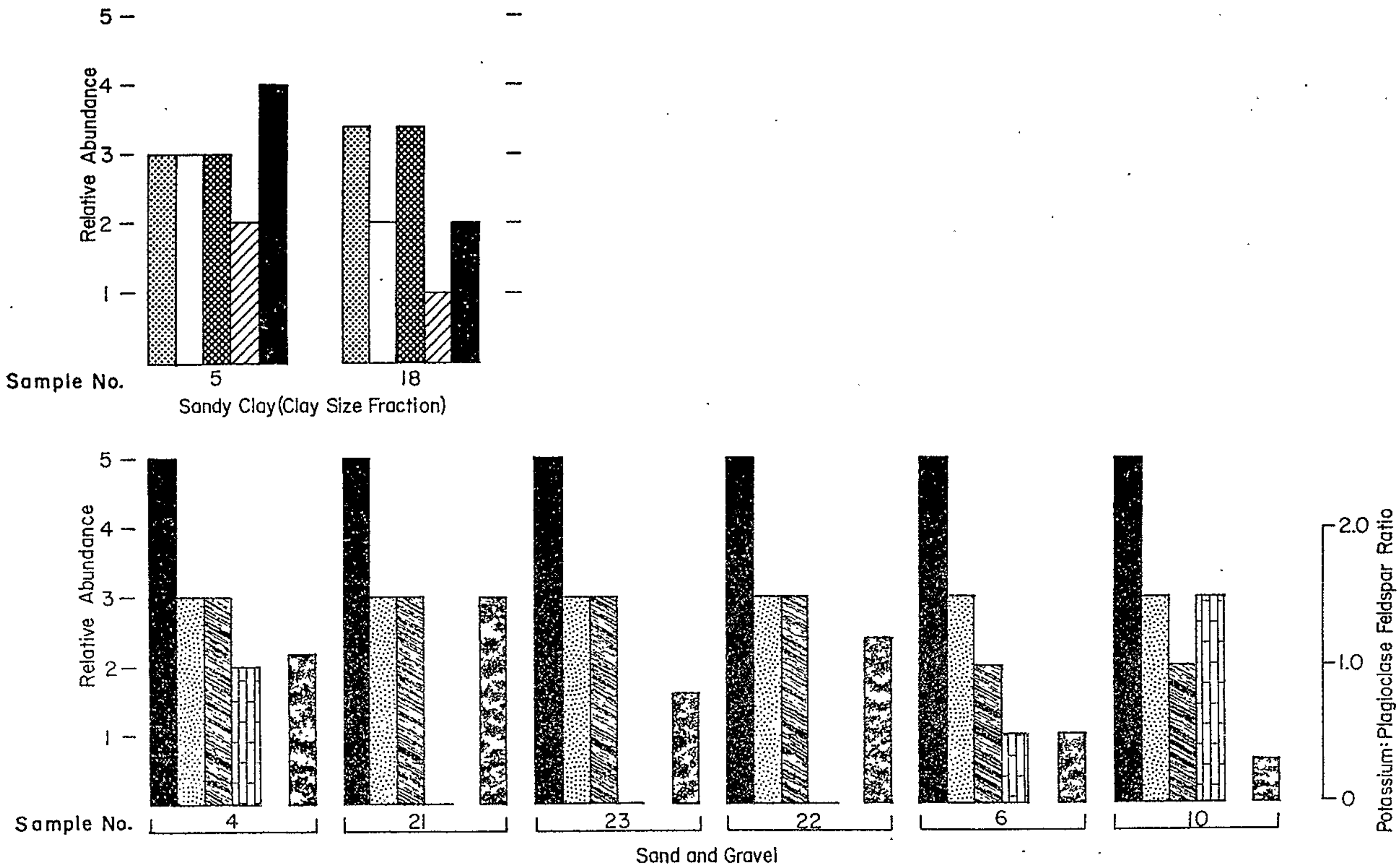
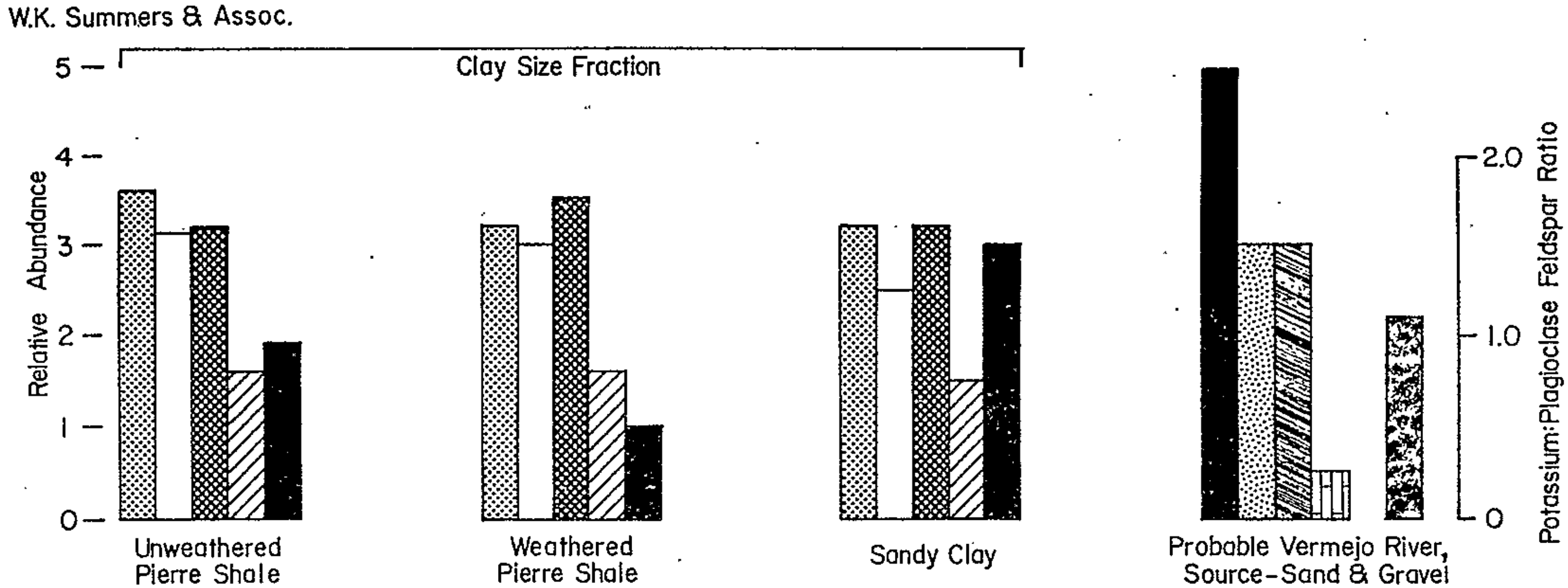


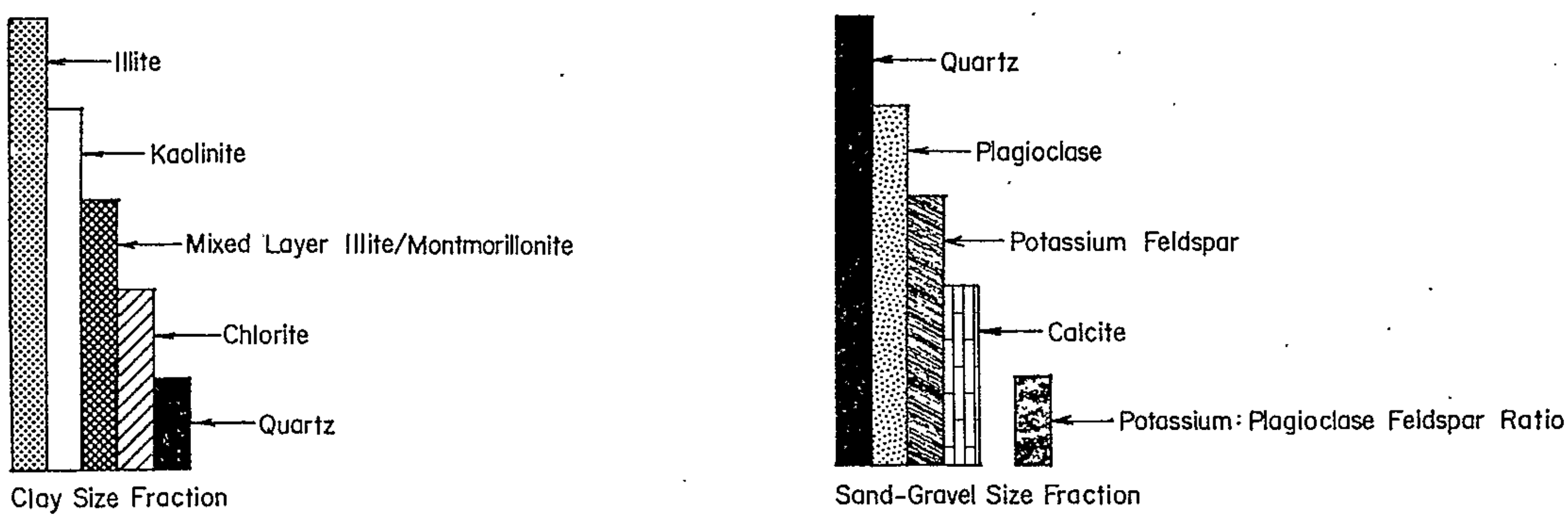
B-Alluvium-Colluvium

Figure 30b



C-Average Relative Mineral Abundance

Explanation



Relative Mineral Abundance as Indicated by X-ray Diffraction

Figure 30c

of 10 to 40 percent, in all of the samples. The Pierre Shale of Wyoming and Montana averages five percent kaolinite. Authigenic kaolinite formation is very restrictive in terms of activities of K, Mg, dissolved silica, and pH. Generally, acid solutions favor the formation of kaolinite and basic solutions the formation of montmorillonite. Perhaps, the Pierre contained more organic matter to the south, and its subsequent anaerobic decay led to increased acidity and the formation of kaolinite. Sample number 12 represents a highly altered zone about 1 inch thick occurring at a depth of about 46 feet. This sample contains over 70 percent kaolinite.

The average clay-size mineral abundance of both the weathered and unweathered Pierre is shown in Figure 30c. Great differences do not exist between the two states. The weathered shale shows a slight increase in mixed layer illite/montmorillonite at the expense of illite and kaolinite of the unweathered shale. This suggests that the weathering process took place under alkaline conditions.

The greater clay-size fraction in both the weathered and unweathered shales was dominated by quartz, followed by lesser and varied amounts of calcite, dolomite, plagioclase feldspar, and potassium feldspar. Trace amounts of pyrite were found in some of the samples.

Whole Rock Chemistry

Appendix II-4 contains chemical analyses of the whole rock for both the unweathered and weathered Pierre Shale. The gross composition of the unweathered shale is intermediate between that of granite and that of diabase.

The major chemical constituents are found mainly in the clay minerals. Almost all of the alumina occurs in the clay minerals, but some of the silica may occur as some form of quartz. Both ferric and ferrous iron are primary constituents of clay minerals; however, a small amount of ferric iron can occur in various hydrated oxides and sulfates and some ferrous iron can occur also in pyrite and organic material. Magnesium and calcim may occur as carbonates, but are essential constituents of the clay minerals. Sodium and potassium are almost entirely restricted to the clay minerals. Both phosphorous and titanium are primarily in the clay mineral structure, but a small amount of these elements may be present in finely divided heavy minerals. Manganese and strontium can occur either in the clay structure or as a carbonate or sulfate. Barium occurs chiefly as a sulfate. Sulfur is present as sulfide and sulfate minerals, and as a constituent of organic material.

The mode of occurrence of trace elements in the shale is not directly determinable, but there are four general processes by which these minor constituents can be deposited:

(1) mechanical enrichment;

(2) precipitation;

(3) adsorption and substitution; and

(4) organic processes.

Adsorption or replacement of ions in the clay minerals can account for the occurrence of most of the trace elements followed by organic processes, precipitation, and mechanical enrichment, respectively.

The Pierre weathers to a hard brownish-gray shale. Major changes in chemical composition that take place during weathering are the results of hydration, oxidation, ion-exchange reactions, and evaporation of ground moisture in surface outcrops. The analyses of CNC-6 unweathered and weathered Pierre Shale were recalculated to 100 percent after excluding water, so a geochemical comparison between the two zones could be made on a moisture free basis. The recalculated analyses show that the amount of silica and alumina increased in the weathered zone, probably resulting from the loss of the soluble constituents. Oxidation reactions during weathering cause the relative amounts of ferric and ferrous oxides to change almost reciprocally. The magnesium and calcium contents are decreased in the weathering process by very complex ion exchange reactions. The complexity of these reactions is illustrated by the fact that the concentrations of sodium and potassium remain fairly constant during weathering. This is in contrast with predictions about the relative adsorbability of different ions based on their chemical properties. These predictions indicate sodium would be easily lost in weathering and would be replaced by calcium or magnesium. The organic content is less in the weathered shale than in the unweathered zone, due to oxidation processes and possible leaching.

Cation-Exchange Capacity

The cation-exchange capacity was measured on 10 samples of the Pierre Shale (5 on unweathered shale, 4 on weathered shale, and 1 on the altered shale) with the following results:

	Shale	Weathered Shale	Altered Shale
CEC (meq/100g)	16.5- 27.0	20.0- 29.6	20.4
Ions released $\frac{meq}{l}$			
K	6.2- 14.7	5.9- 10.1	7.1
Ca	16.0- 84.8	45.0- 75.9	102
Mg	59.2-227	214 -273	278
Co	12.2- 13.6	12.2- 13.6	12.2
Sr	1.6- 2.0	.4- .6	2.0

The values of cation exchange capacity (CEC) obtained are about like those that Beetem et al (1962, p. B6) obtained for a sample of the Pierre Shale from Colorado. They are in the range one would expect for illite alone.

Distribution Coefficients

Data to obtain distribution coefficients (Kd) for cobalt, cesium, and strontium were obtained by batch tests. The tests revealed that, for cesium and cobalt, the Pierre Shale, the weathered shale, and the alluvium-colluvium were only moderately different in their sorptive characteristics.

At a pH of 9 with moderate concentrations in distilled water the clays sorbed virtually all the cobalt and much of the strontium. But the sorptive characteristics of the clay minerals in shales are known to vary according to several factors. So we extended the laboratory tests to include the specific conductive range for the ground water at the site. Table 22 gives the Kd's obtained. To predict the Kd of cobalt and cesium at low concentrations, we used a power curve regression on the data and extrapolated the results to concentrations of 10^{-10} N and 10^{-6} N. Table 23 gives the results of this effort. We conclude that for cobalt and cesium

Table 22.--Distribution coefficients obtained from batch-test data for Cobalt, Cesium, and Strontium.

COBALT

Sample	Kd (ml/g)	Specific conductance of solution (μmhos)	pH	Normality of solution (meq/ml)
		Alluvium-Colluvium		
CNC-1-20'	298.75	1280	7.1	.00016
	<237.5	1280	7.08	.000033
	93.0	1375	7.37	.00067
	47.0	1340	7.27	.0013
	18.8	1700	7.0	.0033
CNC-3-30'	143.12	1280	7.1	.00016
	<237.5	1280	7.08	.000033
	93.0	1375	7.37	.00067
	56.0	1340	7.27	.0013
	25.8	1700	7.0	.0033
CNC-3-35'	298.75	1280	7.10	.00016
	<237.5	1280	7.08	.000033
	99.0	1375	7.37	.00067
	71.0	1340	7.27	.0013
	29.6	1700	7.0	.0033
CNC-3-40'	135.7	1280	7.10	.00016
	<237.5	1280	7.08	.000033
	140.0	1375	7.37	.00067
	54.0	1340	7.27	.0013
	19.9	1700	7.0	.0033
CNS-15-15'	506.25	1280	7.10	.00016
	<237.5	1280	7.08	.000033
	110.0	1375	7.37	.00067
	94.0	1340	7.27	.0013
	215.0	920	7.37	.00067
	69.0	2500	7.37	.00067
	220.0	600	7.27	.0013
	52.0	2300	7.27	.0013
	17.2	2280	3.0	.0033
	28.8	1200	5.0	.0033
	34.8	1700	7.0	.0033
	27.5	1640	9.0	.00040
	50.3	800	7.0	.0033
	20.5	2400	-	.0033
	80.0	-	3.3	.0033
	215.0	920	7.07	.00065

Table 22.--Distribution coefficient obtained from batch-test data for Cobalt, Cesium, and Strontium. (cont)

STRONTIUM

Sample	Kd (ml/g)	Specific conductance of solution (μmhos)	pH	Normality of solution (meq/ml)
		Pierre Shale		
CNS-16-40'	5.70	1280	7.1	.00019
	3.54	1280	7.08	.00011
	7.2	1375	7.37	.00051
	6.3	1340	7.27	.00091
	4.29	1700	7.0	.0022
CNS-17-30'	6.42	1280	7.1	.00019
	4.16	1280	7.08	.00011
	7.9	1375	7.37	.00051
	7.3	1340	7.27	.00091
	5.1	1700	7.0	.0022
CNS-18-50'	4.69	1280	7.1	.00019
	2.27	1280	7.08	.00011
	7.6	1375	7.37	.00051
	6.3	1340	7.27	.00091
	15	920	7.37	.00051
	4.3	2300	7.37	.00051
	13.0	600	7.27	.00091
	4.5	2300	7.27	.00091
	4.35	2280	3.0	.0022
	4.94	1700	5.0	.0022
	5.17	1700	7.0	.0022
	7.42	1640	9.0	.0020
	13.2	800	7.0	.0020
	10.5	2400	3.3	.0020
	36.0	-	-	.0020
	2.1	920	7.07	.00046
	1.8	600	6.32	.00090
	0.60	2500	7.1	.00048
	1.5	2300	6.9	.00010

Table 22.--Distribution coefficients obtained from batch-test data for Cobalt, Cesium, and Strontium. (cont)

STRONTIUM

Sample	Kd (ml/g)	Specific conductance of solution (μmhos)	pH	Normality of solution (meq/ml)
		Weathered Pierre Shale		
CNS-17-20'	8.7	1375	7.37	.00051
	8.5	1340	7.27	.00091
	5.95	1700	7.0	.0022
CNS-18-25'	4.42	1280	7.1	.00019
	2.42	1280	7.08	.00011
	8.7	1375	7.37	.00051
	8.1	1340	7.27	.00091
	5.95	1700	7.0	.0022
CNS-18-35'	9.42	1280	7.1	.00019
	6.60	1280	7.08	.00011
	13.0	1375	7.37	.00051
	12.0	1340	7.27	.00091
	8.24	1700	7.0	.0022
		Pierre Shale		
CNC-1-55'	5.74	1700	7.0	.0022
CNC-1-60'	3.94	1280	7.1	.00019
	1.58	1280	7.08	.00011
	6.1	1375	7.37	.00051
	6.3	1340	7.27	.00091
	2.67	1700	7.0	.0022
CNC-1-300'	2.97	1700	7.0	.0022
CNC-1-330'	3.90	1700	7.0	.0022
CNC-3-45'	4.20	1280	7.1	.00019
	2.42	1280	7.08	.00011
	11.0	1375	7.37	.00051
	20.0	1340	7.27	.00091
	5.66	1700	7.0	.0022
CNS-15-40'	6.22	1280	7.1	.00019
	4.35	1280	7.08	.00011
	7.6	1375	7.37	.00051
	7.7	1340	7.27	.00091
	5.38	1700	7.0	.0022

Table 22.--Distribution coefficients obtained from batch-test data for Cobalt, Cesium, and Strontium. (cont)

STRONTIUM

Sample	Kd (ml/g)	Specific conductance of solution (μmhos)	pH	Normality of solution (meq/ml)
		Weathered Pierre Shale		
CNC-1-30'	13.0	1340	7.27	.00091
	7.49	1700	7.0	.0022
CNC-1-35'	9.11	1700	7.0	.0022
CNC-1-40'	8.55	1280	7.1	.00019
	4.94	1280	7.08	.00011
	14.0	1375	7.37	.00051
	14.0	1340	7.27	.00091
	10.0	1700	7.0	.0022
CNC-1-45'	7.82	1700	7.0	.0022
CNC-1-50'	7.89	1280	7.1	.00019
	4.16	1280	7.08	.00011
	13.0	1375	7.37	.00051
	12.0	1340	7.27	.00091
	7.9	1700	7.0	.0022
CNC-6-10'	6.86	1700	7.0	.0022
CNS-15-25'	9.61	1280	7.1	.00019
	6.85	1280	7.08	.00011
	12.0	1375	7.37	.00051
	11.0	1340	7.27	.00091
	8.07	1700	7.0	.0022
CNS-16-20'	8.80	1280	7.1	.00019
	5.9	1280	7.08	.00011
	12.0	1375	7.37	.00051
	11.0	1340	7.27	.00091
	7.66	1700	7.0	.0022
CNS-16-30'	8.97	1280	7.1	.00019
	6.25	1280	7.08	.00011
	10	1375	7.37	.00051
	9.7	1340	7.27	.00091
	7.41	1700	7.0	.0022
CNS-17-20'	4.42	1280	7.1	.00019
	2.42	1280	7.08	.00011

Table 22.--Distribution coefficients obtained from batch-test data for Cobalt, Cesium, and Strontium. (cont)

STRONTIUM

Sample	Kd (ml/g)	Specific conductance of solution (µmhos)	pH	Normality of solution (meq/ml)
		Alluvium-Colluvium		
CNC-3-35'	4.69	1700	7.0	.0022
CNC-3-40'	1.60	1280	7.1	.00019
	.83	1280	7.08	.00011
	6.5	1375	7.37	.00051
	4.8	1340	7.27	.00091
	1.66	1700	7.0	.0022
CNS-15-15'	13.55	1280	7.1	.00019
	11.69	1280	7.08	.00011
	14.0	1375	7.37	.00051
	13.0	1340	7.27	.00091
	26.0	920	7.37	.00051
	7.7	2500	7.37	.00051
	25.0	600	7.27	.00091
	10.0	2300	7.27	.00091
	9.02	2280	3.0	.0022
	9.52	1700	5.0	.0022
	10.1	1700	7.0	.0022
	13.8	1640	9.0	.0022
	23.9	800	7.0	.0022
	13.8	2400	-	.0022
	74.3	-	3.3	.0022
	3.64	920	7.07	.00046
	3.46	600	6.32	.00090
	.06	2500	7.1	.00048
	1.46	2300	6.9	.00010
CNS-17-10'	8.71	1280	7.10	.00019
	6.48	1280	7.08	.00011
	10.0	1375	7.37	.00051
	9.5	1340	7.27	.00091
	6.4	1700	7.0	.0022
		Weathered Pierre Shale		
CNC-1-25'	8.49	1700	7.0	.0022
CNC-1-30'	9.61	1280	7.1	.00019
	6.60	1280	7.08	.00011
	13.0	1375	7.37	.00051

Table 22.--Distribution coefficients obtained from batch-test data for Cobalt, Cesium, and Strontium. (cont)

CESIUM

Sample	Kd (ml/g)	Specific conductance of solution (μmhos)	pH	Normality of solution (meq/ml)
		Pierre Shale		
CNS-18-50'	210.71	1280	7.1	.00037
	<237.5	1280	7.08	.0000075
	72.0	1375	7.37	.00014
	41.0	1340	7.27	.00028
	82.0	920	7.37	.00014
	50.0	2500	7.37	.00014
	54.0	600	7.27	.00028
	31.0	2300	7.27	.00028
	32.9	2280	3.0	.00075
	34.6	1700	5.0	.00075
	33.4	1700	7.0	.00075
	37.4	1640	9.0	.00075
	36.0	800	7.0	.00075
	25.9	2400	3.3	.00075
	75.5	-	-	.00075
	11.45	920	7.07	.00014
	24.08	600	6.32	.00023
	4.3	2500	7.10	.00032
	2.94	2300	6.90	.00022

STRONTIUM

Sample	Kd (ml/g)	Specific conductance of solution (μmhos)	pH	Normality of solution (meq/ml)
		Alluvium-Colluvium		
CNC-1-20'	9.7	1280	7.1	.00019
	7.9	1280	7.08	.00011
	11.0	1375	7.37	.00051
	13.0	1340	7.27	.00091
	6.32	1700	7.0	.0022
CNC-3-30'	3.35	1280	7.1	.00019
	1.75	1280	7.08	.00011
	9.6	1375	7.37	.00051
	10.0	1340	7.27	.00091
	4.62	1700	7.0	.0022
CNC-3-35'	32.0	1280	7.1	.00019
	1.45	1280	7.08	.00011
	12.9	1375	7.37	.00051
	11	1340	7.27	.00091

Table 22.--Distribution coefficients obtained from batch-test data for Cobalt, Cesium, and Strontium. (cont)

CESIUM

Sample	Kd (ml/g)	Specific conductance of solution (μmhos)	pH	Normality of solutio (meq/ml)
		Weathered Pierre Shale		
CNS-18-35'	76.0	1340	7.27	.00028
	42.2	1700	7.0	.00075
		Pierre Shale		
CNC-1-55'	32.1	1700	7.0	.00075
CNC-1-60'	103.24	1280	7.1	.00037
	195.83	1280	7.08	.0000075
	43.0	1375	7.37	.00014
	23.0	1340	7.27	.00028
	16.1	1700	7.0	.00075
CNC-1-300'	19.2	1700	7.0	.00075
CNC-1-330'	34.5	1700	7.00	.00075
CNC-3-45'	195.83	1280	7.1	.00037
	< 237.5	1280	7.08	.0000075
	94.0	1375	7.37	.00014
	52.0	1340	7.27	.00028
	35.4	1700	7.0	.00075
CNS-15-40'	195.0	1280	7.1	.00037
	< 237.5	1280	7.08	.0000075
	60.0	1375	7.37	.00014
	43.0	1340	7.27	.00028
	30.8	1700	7.0	.00075
CNS-16-40'	227.88	1280	7.1	.00037
	195.83	1280	7.08	.0000075
	78.0	1375	7.37	.00014
	46.0	1340	7.27	.00028
	27.3	1700	7.0	.00075
CNS-17-30'	247.91	1280	7.1	.00037
	< 237.5	1280	7.08	.0000075
	83.0	1375	7.37	.00014
	48.0	1340	7.27	.00028
	27.3	1700	7.0	.00075

Table 22.--Distribution coefficients obtained from batch-test data for Cobalt, Cesium, and Strontium. (cont)

CESIUM

Sample	Kd (ml/g)	Specific conductance of solution (μmhos)	pH	Normality of solution (meq/ml)
		Weathered Pierre Shale		
CNC-1-50'	334.72	1280	7.1	.00037
	<237.5	1280	7.08	.0000075
	270.0	1375	7.37	.00014
	109.0	1340	7.27	.00028
	53.5	1700	7.0	.00075
CNC-6-10'	41.1	1700	7.0	.00075
CNS-15-25'	300.0	1280	7.1	.00037
	<237.5	1280	7.08	.0000075
	170.0	1375	7.37	.00014
	114.0	1340	7.27	.00028
	52.1	1700	7.0	.00075
CNS-16-20'	271.59	1280	7.1	.00037
	<237.5	1280	7.08	.0000075
	83.0	1375	7.37	.00014
	58.0	1340	7.27	.00028
	41.8	1700	7.0	.00075
CNS-16-30'	271.59	1280	7.1	.00037
	<237.5	1280	7.08	.0000075
	130.0	1375	7.37	.00014
	83.0	1340	7.27	.00028
	40.7	1700	7.0	.00075
CNS-17-20'	271.59	1280	7.1	.00037
	<237.5	1280	7.08	.0000075
	130.0	1375	7.37	.00014
	74.0	1340	7.27	.00028
	37.8	1700	7.0	.00075
CNS-18-25'	271.59	1280	7.1	.00037
	<237.5	1280	7.08	.0000075
	130.0	1375	7.37	.00014
	66.0	1340	7.27	.00028
	41.5	1700	7.0	.00075
CNS-18-35'	247.91	1280	7.1	.00037
	<237.5	1280	7.08	.0000075
	140.0	1375	7.37	.00014

Table 22.--Distribution coefficients obtained from batch-test data for Cobalt, Cesium, and Strontium. (cont)

CESIUM

Sample	Kd (ml/g)	Specific conductance of solution (μmhos)	pH	Normality of solution (meq/ml)
		Alluvium-Colluvium		
CNS-15-15'	70.0	1340	7.27	.00028
	106.0	920	7.37	.00014
	71.0	2500	7.37	.00014
	84.4	600	7.27	.00028
	55.0	2300	7.27	.00028
	41.8	2280	3.0	.00075
	52.8	1700	5.0	.00075
	51.1	1700	7.0	.00075
	56.3	1640	9.0	.00075
	60.1	800	7.0	.00075
	37.8	2400	-	.00075
	12.8	-	-	.00075
	105.5	920	7.07	.00014
	84.4	600	6.32	.00029
	70.5	2500	7.1	.00016
	54.6	2300	6.9	.00029
CNS-17-10'	300.0	1280	7.1	.00037
	<237.5	1280	7.08	.0000075
	110	1375	7.37	.00014
	63	1340	7.27	.00028
		Weathered Pierre Shale		
CNC-1-25'	50.2	1700	7.0	.00075
CNC-1-30'	433.92	1280	7.1	.00037
	<237.5	1280	7.08	.0000075
	230	1375	7.37	.00014
	103	1340	7.27	.00028
	44.8	1700	7.0	.00075
CNC-1-35'	57.7	1700	7.0	.00075
CNC-1-40'	508.33	1280	7.1	.00037
	<237.5	1280	7.08	.0000075
	29.0	1375	7.37	.00014
	130.0	1340	7.27	.00028
	63.5	1700	7.0	.00075
CNC-1-45'	66.7	1700	7.0	.00075

Table 22.--Distribution coefficients obtained from batch-test data for Cobalt, Cesium, and Strontium. (cont)

COBALT

Sample	Kd (ml/g)	Specific conductance of solution (µmhos)	pH	Normality of solution (meq/ml)
		Pierre Shale		
CNS-18-50'	142.0	1640	9.0	.0033
	46.4	800	5	.0033
	16.1	2400	-	.0033
	76.6	-	3.3	.0033
	11.1	920	7.07	.00065
	23.6	600	6.32	.00071
	9.62	2500	7.1	.00032
	7.21	2300	6.9	.00024

CESIUM

Sample	Kd (ml/g)	Specific conductance of solution (µmhos)	pH	Normality of solution (meq/ml)
		Alluvium-Colluvium		
CNC-1-20'	300.0	1280	7.1	.00037
	<237.5	1280	7.08	.0000075
	100.0	1375	7.37	.00014
	53.0	1340	7.27	.00028
	33.7	1700	7.0	.00075
CNC-3-30'	171.32	1280	7.1	.00037
	<237.5	1280	7.08	.0000075
	57.0	1375	7.37	.00014
	37.0	1340	7.27	.00028
	31.1	1700	7.0	.00075
CNC-3-35'	247.91	1280	7.1	.00037
	<237.5	1280	7.08	.0000075
	70.0	1375	7.37	.00014
	50.0	1340	7.27	.00028
	39.4	1700	7.0	.00075
CNC-3-40'	71.95	1280	7.1	.00037
	<237.5	1280	7.08	.0000075
	32.0	1375	7.37	.00014
	40.0	1340	7.27	.00028
	14.0	1700	7.0	.00075
CNS-15-15'	433.92	1280	7.1	.00037
	<237.5	1280	7.08	.0000075
	100.0	1375	7.37	.00014

Table 22.--Distribution coefficients obtained from batch-test data for Cobalt, Cesium, and Strontium. (cont)

COBALT

Sample	Kd (ml/g)	Specific conductance of solution (μmhos)	pH	Normality of solutio (meq/ml)
		Pierre Shale		
CNC-1-60'	11.6	1700	7.0	.0033
CNC-1-700'	13.5	1700	7.0	.0033
CNC-1-330'	21.9	1700	7.0	.0033
CNC-3-45'	117.18	1280	7.1	.00016
	<237.5	1280	7.08	.000033
	140.0	1375	7.37	.00067
	43.0	1340	7.27	.0013
	23.4	1700	7	.0033
CNS-15-40'	246.87	1280	7.1	.00016
	<237.5	1280	7.08	.000033
	8.8	1375	7.37	.00067
	68.0	1340	7.27	.0013
	25.2	1700	7.0	.0033
CNS-16-40'	270.45	1280	7.1	.00016
	195.83	1280	7.08	.000033
	130.0	1375	7.37	.00067
	110.0	1340	7.27	.0013
	34.2	1700	7.0	.0033
CNS-17-30'	247.91	1280	7.1	.00016
	<237.5	1280	7.08	.000033
	165.0	1375	7.37	.00067
	94.0	1340	7.27	.0013
	38.1	1700	7.0	.0033
CNS-18-50'	143.12	1280	7.1	.00016
	<237.5	1280	7.08	.000033
	88.0	1375	7.37	.00067
	51.0	1340	7.27	.0013
	79.0	920	7.37	.00067
	30.0	2500	7.37	.00067
	170.0	1600	7.27	.0013
	21	2300	7.27	.0013
	14.1	2280	3.0	.0033
	33.9	1700	5.0	.0033
	25.6	1700	7.0	.0033

Table 23.--Predicted distribution coefficients for dilute concentrations for Cobalt and Cesium in water with a specific conductance of 1750 µmhos.

COBALT

Sample	Equation Coefficient* a	Equation Coefficient* b	Correlation Coefficient r^2	Predicted Kd (ml/g) (10^{-6}N)	Predicted Kd (ml/g) (10^{-10}N)
		Alluvium-Colluvium			
CNC-1-20'	-559.11	-94.83	.91	751.0	1620.0
CNC-3-30'	-201.13	-39.50	.99	344.0	708.0
CNC-3-35'	-512.82	-89.75	.91	727.0	1550.0
CNC-3-40'	-201.66	-40.67	.75	360.0	734.0
CNS-15-15'	-925.15	-156.49	.85	1230.0	2670.0
CNS-17-10'	-466.43	-82.62	.96	675.0	1430.
			Arithmetic mean	681.0	1452.0
		Weathered Pierre Shale			
CNC-1-30'	-366.82	-62.91	.35	502.0	1080.0
CNC-1-40'	-620.1	-106.68	.94	853.0	1830.0
CNC-1-50'	-588.63	-102.0	.91	820.0	1760.0
CNS-15-25'	-513.93	-89.97	.91	729.0	1550.0
CNS-16-20'	-966.18	-161.83	.88	1260.0	2760
CNS-16-30'	-143.51	-42.13	.37	438.0	826.0
CNS-17-20'	-438.83	-76.73	.94	621.0	1320.0
CNS-18-25'	-480.67	-84.18	.95	682.0	1450.0
CNS-18-35'	-376.27	-66.30	.95	539.0	1150.
			Arithmetic mean	716.0	1520.
		Pierre Shale			
CNC-1-60'	-276.56	-46.16	.87	361.0	780.0
CNC-3-45'	-165.59	-34.70	.61	313.0	633.0
CNS-15-40'	-413.0	-73.34	.92	599.0	1270.0
CNS-16-40'	-406.00	-76.40	.97	640.0	1350.0
CNS-17-30'	-362.23	-70.23	.98	608.0	1250.0
CNS-18-50'	-75.80	-19.89	.34	198.0	382.0
			Arithmetic mean	453.0	944.0

Table 23.--Predicted distribution coefficients for dilute concentrations for Cobalt and Cesium in water with a specific conductance of 1750 μmhos. (cont)

CESIUM

Sample	Equation Coefficient* a	Equation Coefficient* b	Correlation Coefficient r^2	Predicted Kd (ml/g) (10^{-6}N)	Predicted Kd (ml/g) (10^{-10}N)
		Alluvium-Colluvium			
CNC-1-20'	-654.95	-90.16	.87	590.0	1420.0
CNC-3-30'	-335.25	-47.36	.81	319.0	755.0
CNC-3-35'	-499.97	-69.61	.79	461.0	1100.0
CNC-3-40'	-111.72	-17.58	.86	131.0	293.0
CNS-15-15'	-361.42	-56.14	.22	414.0	913.0
CNS-17-10'	-937.55	-120.53	.97	727.0	1830.0
			Arithmetic mean	440.0	1050.0
		Weathered Pierre Shale			
CNC-1-30'	-949.83	-133.83	.96	899.0	2130.0
CNC-1-40'	-102.00	-139.63	.63	909.0	2190.0
CNC-1-50'	-669.48	-99.99	.91	711.0	1630.0
CNS-15-25'	-556.04	-83.01	.98	590.0	1350.0
CNS-16-20'	-549.43	-76.97	.83	514.0	1220.0
CNS-16-30'	-537.03	-77.59	.95	534.0	1240.0
CNS-17-20'	-554.38	-79.26	.95	540.0	1270.0
CNS-18-25'	-547.91	-77.80	.90	527.0	1240.0
CNS-18-35'	-174.00	-32.70	.29	277.0	579.0
			Arithmetic mean	611.0	1427.0
		Pierre Shale			
CNC-1-60'	-209.15	-29.60	.90	200.0	473.0
CNC-3-45'	-376.25	-54.60	.92	378.0	881.0
CNS-15-40'	-390.98	-54.93	.83	367.0	873.0
CNS-16-40'	-485.0	-67.28	.87	444.0	1060.0
CNS-17-30'	-186.97	-31.37	.32	246.0	535.0
CNS-18-50'	-427.46	-59.97	.84	401.0	953.0
			Arithmetic mean	339.0	795.0

*Equation $\ln y = b \ln x + \ln a$

the following apply:

	(ml/g)			
	KdCs		KdCo	
	(10^{-10}N)	(10^{-6} N)	(10^{-10}N)	(10^{-6}N)
Pierre Shale	795	339	1050	504
Weathered Shale	1427	611	1500	716
Alluvium-Colluvium	1050	440	1452	681

These values are extremely conservative to take into account the high concentration of competing ions (especially sodium) in the ground water. However, they do show that sorptive characteristics of the alluvium-colluvium are about the same as the weathered shale. The unweathered shale will sorb fewer cobalt and cesium ions than the weathered shale under conditions existing at the site.

The sorptive capacity of these rocks for strontium is independent of the strontium concentration. It is, however, dependent upon the concentration of the competing ions, as Table 24 shows. Thus, for the ground water at the site, a KdSr = 8.1 ml/g is judged appropriate.

Table 24.--Summary of distribution coefficients for Strontium

pH	3.0				5.0			
Specific conductance range (μmhos)	500-1000	1000-1500	1500-2000	2000-2500+	500-1000	1000-1500	1500-2000	2000-2500+
Number of values				3			2	
Arithmetic mean (ml/g)				7.95			7.23	

pH	7.0				9			
Specific conductance range (μmhos)	500-1000	1000-1500	1500-2000	2000-2500+	500-1000	1000-1500	1500-2000	2000-2500+
Number of values	10	85	27	8			2	
Arithmetic mean (ml/g)	12.7	8.43	6.36	3.76			10.6	

Physical Properties

Velocity.-- The velocity of sound in the unweathered shale was measured in laboratory specimens, by bore-hole geophysical techniques and by seismic surveys and showed the following results:

Method	P-wave (ft/sec)	S-wave (ft/sec)
7 core specimens	7000-10940	3340-6040
Seismic survey	10460-10750	-----
Bore-hole geophysical studies	11000	-----

The velocity of sound in the weathered shale was measured as follows:

Method	P-wave (ft/sec)	S-wave (ft/sec)
2 core specimens	4965-5470	3055-3405

Density.-- The following measures of density were obtained for the shale:

	Bulk Density (gm/cc)	Dry Density (gm/cc)	Grain Density (gm/cc)
unweathered			
7 core specimens	2.51-2.58	2.43-2.52	2.66-2.74
Bore-hole geophysical studies	2.48-2.63	-----	2.86-2.93
weathered			
3 core specimens	1.85-2.40	1.70-2.33	2.72-2.76

Porosity.-- The following measurements of effective porosity of the shale were obtained.

Method	Effective Porosity (%)
unweathered	
7 core specimens	2.5- 7.6
Bore-hole geophysical studies	16.3-18.7
weathered	
3 core specimens	14.1-27.5

Others.-- From the bore-hole geophysical studies Brimhall (Appendix III-2) estimated the following:

Poisson's Ratio	.314 - .321
Bulk Modulus	2.6×10^6 psi
Bulk Compressibility	3.8×10^{-7} psi^{-1}
Young's Modulus	$2.8 \times 10^6 - 2.9 \times 10^6$ psi
Shear Modulus	$10.5 - 11.1 \times 10^5$ psi

The estimated bulk compressibility from triaxial tests of a core for confining pressures of 200 psi yielded the following:

	Bulk Modulus (psi^{-1})
weathered shale	5×10^{-6}
unweathered shale	10^{-5}

Discussion.-- The physical properties of the cores are different from those obtained by the bore-hole geophysical studies. We believe that the difference is due to expansion of the clay minerals after they were removed from the holes.

Specific Storage

The specific storage is a measure of the amount of water that will be released from a given volume of rock due to pressure change equivalent to one foot of water.

Brimhall (Appendix III-2) estimated the specific storage of the unweathered shale as 4.0×10^{-7} $ft.^{-1}$ and 3.7×10^{-7} $ft.^{-1}$.

Using the core data we obtain 2.1×10^{-6} $ft.^{-1}$ for unweathered shale and

4.2×10^{-6} ft. $^{-1}$ for weathered shale.

Hydraulic Conductivity

Introduction.-- The hydraulic conductivity of the shale depends upon the matrix properties and the degree and extent of fracturing. Drilling with air, only 2 holes, of more than 50 drilled into the shale, discharged water from the shale. The others were bone-dry during drilling, and dust and cuttings blew from the holes. However, in many holes water became evident within one to two weeks. In these holes we constructed piezometers of standard design and tested them. We also cored several holes and made pressure-injection tests to identify fractured zones. At one core hole location we drilled three mutually perpendicular holes (each hole was 45° from the horizontal and the three holes were 120° apart on the circumference of a 50-foot diameter circle). In each angle hole we ran pressure-injection tests at 20 foot intervals, and in one we ran a short pumping test.

Cores.-- Ten cores were subjected to laboratory permeability tests. One of these cores, a weathered shale, disintegrated and the results could not be used. The other results are:

	(ft/d) Vertical ($\times 10^{-6}$)		(ft/d) Horizontal ($\times 10^{-2}$)
	Gas	Water	Gas
Shale (7 cores)	7-230	5-222	4.1
Weathered Shale (2 cores)	18- 24	12-130	17

The laboratory reported that during the horizontal tests, the thin laminae parted visibly, so only one test of both the shale and weathered shale was made. In confined circumstances this probably would not happen, so we should expect field tests of the matrix only to yield hydraulic conductivities closer to the laboratory vertical values, since under extant conditions the laminae are held closed.

Pressure-Injection Tests.-- We conducted pressure-injection tests at 50 psi (115 feet of water) or less at the surface and recorded the rate at which water entered the hole. Each core hole tested had casing cemented in place and each test involved the total length of the uncased hole. Two results were obtained:

(1) the hole did not take water and the pressure injection test was treated as a slug test -- producing hydraulic-conductivity values ranging from .0079 to .55 ft./day; and

(2) the hole took water and the results were analyzed using Glover's method -- producing hydraulic-conductivity values ranging from .18 to 1.8 ft./day.

Slug Tests.-- Useful slug tests were made in 25 piezometers and in 2 core holes. These tests were analyzed by a variety of methods and the results were carefully compared to determine the validity of the methods. The slug tests gave results ranging from "nearly zero" and .00065 to 1.3 feet per day for shale and 2.0 and 2.3 for weathered shale.

Pumping Test.-- A pumping test of an angle hole (CNA-3), which took about 20 gpm at 17 psi during a pressure-injection test, yielded hole storage and less than .3 gpm for an hour before the test had to be ended. Water-level recovery following the test was extremely slow (Appendix I-3).

Matrix.-- On the strength of

(1) the laboratory tests,

(2) the number of pressure injection tests where the volumes of injected water was nil, and

(3) the shallow depth of the invaded zone noted in the bore hole geophysical studies (15.0-15.5 inches),

we believe the matrix conductivity of the shale is on the order of 10^{-5} ft./day.

Fractures.-- The hydraulic conductivity of fractures is more difficult to assess. The three angle holes crossed the same horizontal fractures at about 50 feet. Above this fracture, matrix values were observed; below, the hydraulic conductivity decreased from .6 to .2 or .3 ft./day at total depth, except for CNA-3. CNA-3 crossed vertically-oriented fractures at 30 and 160 feet.

We believe the fractures opened during the pressure injection tests because of the pressure exerted upon them, so the hydraulic conductivity calculated is extraordinarily high, whereas, pumping reduced the pressure on the fractures and the fractures closed.

A method of slug-test analysis to separate fracture hydraulic conductivity from matrix hydraulic conductivity developed by Schwartz seemed to work on a few piezometer tests. The method confirmed the matrix estimates. It also suggests that the fracture porosity is in the range of 1/3 to 2/3 that of the matrix.

Statistically, the hydraulic conductivity of the shale is randomly distributed with respect to depth, depth below the top of the shale, altitude of test interval, and altitude of the shale.

We believe the values obtained for the slug tests are representative of the rock as a flow continuum and we used them insofar as possible in preparing Figure 31. Moreover, we believe that the fractures take two forms:

(1) fractures that existed before drilling; and

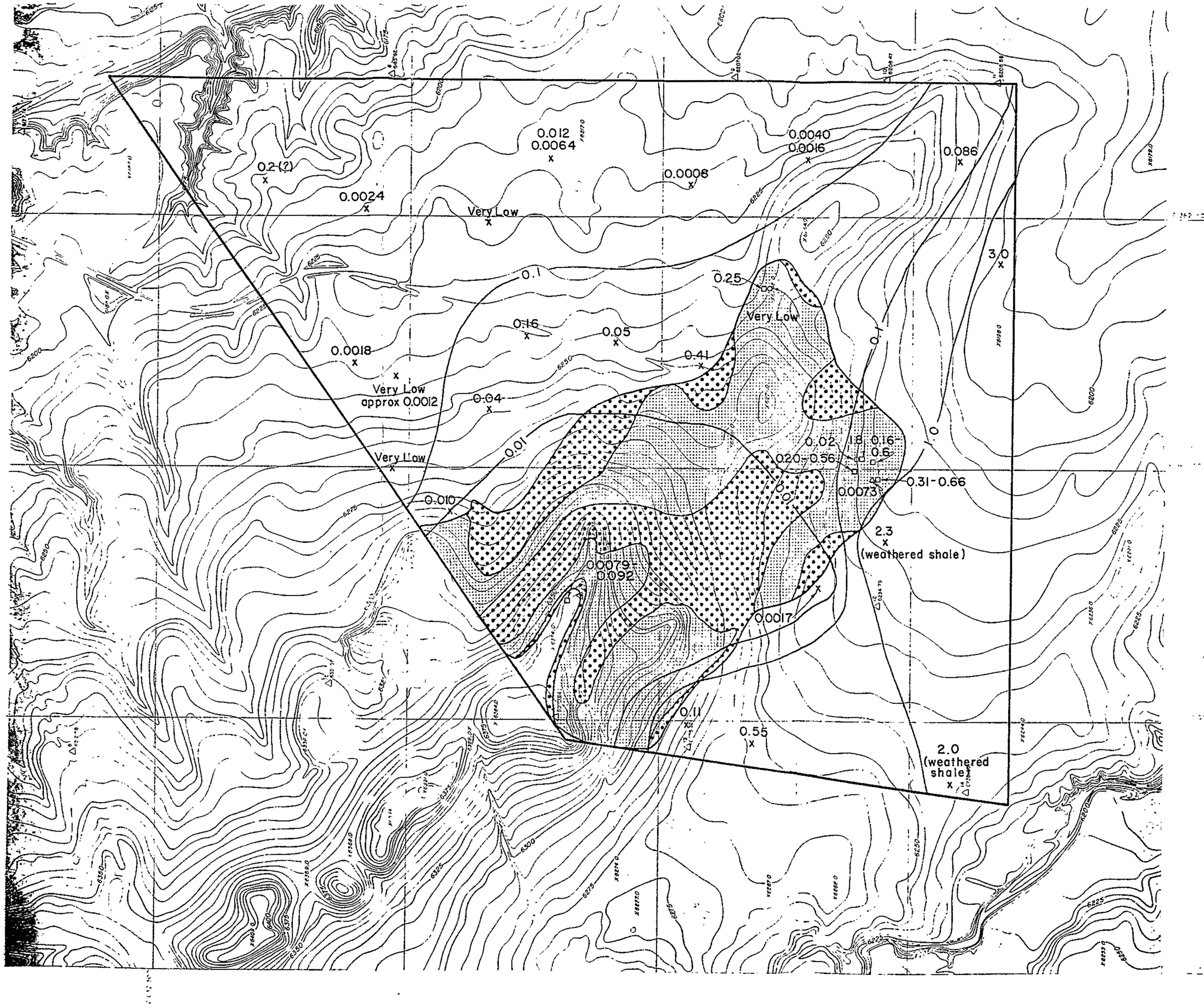
(2) spalling fractures that developed as a result of drilling the test holes and, therefore, affect only the immediate area of the holes.

The angle holes show that vertical fractures must be widely spaced; CNA-3 crossed two vertical fractures, CNA-1 and -2 did not cross any. The minimum observed distance between fractures is then about 75 feet, and the maximum distance must be greater than 130 feet. We further believe that the fractures lead to the development of existing drainage and therefore are closely spaced near drainage ways, both fossil and current, and widely spaced on the old topographic highs.

The horizontal fracture noted in the angle holes was not observed in the other drill holes or core holes with the possible exceptions of CNS-10 and -11.

Dispersivity or Mixing Length

The longitudinal (D_L) and lateral (D_T) dispersion coefficients are frequently written:



0.17
0.92
x

N

LEGEND

(fine stipple)	=	Approximately 145 Acres of 10' or less of Alluvium-Colluvium Overburden	Underlain by at least 20' of unsaturqted Pierre Shale
(coarse dots)	=	Approximately 100 Acres of 10'-17' of Alluvium-Colluvium Overburden	
x	=	Data derived from slug test of piezometer	
□	=	Data derived from pressure injection test	
o	=	Data derived from slug test of open hole	
△	=	Data derived from pump test	
0.1	=	Lines of equal hydraulic conductivity	

SCALE : 1"= 1000'

0 500 1000 2000

POTENTIAL BURIAL AREA
AND HYDRAULIC CONDUCTIVITY OF
THE SATURATED PIERRE SHALE

FIGURE 31

$$D_L = \xi v$$

$$D_T = .2\xi v$$

where

ξ = the mixing length of the flow continuum (sometimes referred to as the dispersion constant or geometric dispersivity), and

v = the ground-water velocity.

Where the Pierre Shale is fractured, the mixing length will be the average length of a fracture. On the basis of the test drilling we must conclude that though fractures are widely spaced their lengths cannot be long. The maximum length probably approaches the length of the fracture cut by the angle holes; so for the shale we believe the average length is less than 100 feet.

Rabinowitz, Gross and Holmes (1977c) found the mixing length of the San Andres Limestone in southeastern New Mexico to be 70 ± 5 feet. Others have noted mixing length values ranging from 50 to 125 feet in limestone (Claassen and Cordes, 1975; Grove and Beetem, 1971).

Limestones are brittle rocks. For a rock with the properties of the Pierre Shale -- dense but plastic -- the average fracture length sould be less. Schwartz (1977) considered 3.0 and 6.1 meters to be optimistic and pessimistic values for a mathematical model of a site in Canada that is underlain by Cretaceous shale. We agree with Schwartz's lower estimates. Ten feet would be the minimum length -- optimistically; but 40 feet would be more realistic for the upper limit.

In the proposed burial area (Fig. 31), fractures are so widely spaced that the rock may be considered as unfractured. The ratio of laboratory to field velocity is larger than 1.0, indicating the rock has sustained its integrity. In this case the mixing length should be considered the thickness of the laminae (.01 foot) for want of better criteria.

Laboratory experiments typically produce mixing-length values in the range of .003-1.5 feet.

The Trinidad and Vermejo Formations

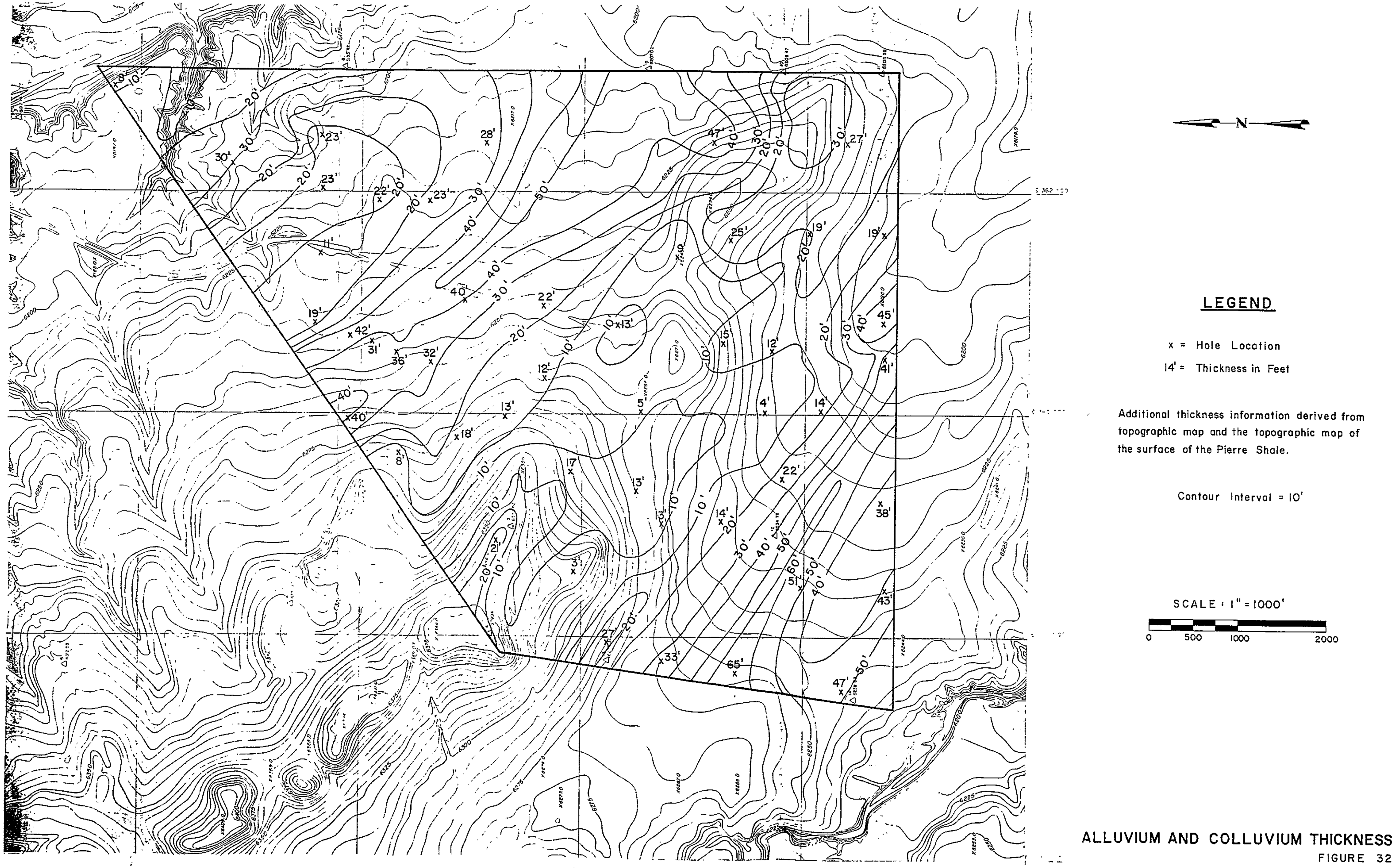
The Trinidad Formation and the overlying Vermejo Formation crop out only in the extreme northwestern corner of the area, a little over three miles from the proposed site boundary (Fig. 29e). Both formations are of Late Cretaceous age and are dominated by sandstone. A detailed description of the units can be found in the regional geology section.

Deposits of Quaternary Age

Introduction

Quaternary age deposits cover almost the entire site area and are composed of alluvium and colluvium derived materials (Fig. 28). They comprise both the old and recent pediment surfaces as well as deposits along present drainages. The thickness of these deposits is quite variable (Fig. 32), with the thickest sections related to ancient, buried channels. The vertical distribution of Quaternary deposits is illustrated in Cross-Sections A-A' through F-F' (Fig. 33a-f), Cross-Section 1 through 4 (Fig. 29a-e), Trench Sections, (Fig. 23) and Stratigraphic Sections 1 through 7 (Appendices I-I-10).

The stratigraphic-correlation diagram showing the relations of alluvium-colluvium units (Fig. 34) drawn on Cross-Section A-A' displays several features. The highest gravel and sand deposit represents the oldest pediment surface in the area. The ancient streams eroded downward and toward the south forming the buried channels shown. Subsequently these channels were filled with sand and gravel alluvial deposits and further buried by both alluvium and colluvium derived from the higher areas. The present day Van Bremmer Creek is now eroding into these older deposits in places. The figure also illustrates how the appearance of the cross-section depends on the amount of vertical exaggeration. When the vertical scale of a profile is exaggerated, the ground slopes and other lines in the section appear steeper than they actually are. Another buried channel, defined by seismic reflection line CN-1, is shown in Figure 25. This channel eroded through sandy clay sediments deposited on the weathered Pierre surface. Sandy clay deposition continued after the channel was filled with alluvial sand and gravel and was interrupted by only a few smaller channels. This was followed by the deposition of a fairly extensive clayey sand body of probably sheet wash and eolian origin.



ALLUVIUM AND COLLUVIUM THICKNESS
FIGURE 32

Lithology

Lithologically, the alluvium-colluvium deposits are composed of fragments of sandstone, shale, rhyolite and other igneous rocks, and various types of metamorphic rocks. The relative mineral abundance as indicated by X-ray diffraction of several sands and gravels and sandy clays is shown in Figure 30b. A comparison of the average relative mineral abundance in the clay size fraction between the Pierre Shale and the Quaternary sandy clay (Fig. 30c) shows that the sandy clay probably was derived primarily from the Pierre. This relationship is further documented by the chemical analyses of the two units (Appendix II-4). The source areas of the sand and gravel deposits can also be determined. The oldest gravels are characterized by fragments of rhyolite and metamorphic rocks and a lesser amount of sandstone. Younger and modern gravel deposits are composed primarily of sandstone fragments. The nearest source of material comprising the older gravel deposits is in the Sangre de Cristo Mountains at which the Vermejo River has its headwaters. Younger gravels and sand are derived mostly from the Park Plateau area in which sandstone predominates. The validity of this source analysis is further documented by the X-ray diffraction study of alluvium material (Table 21).

"Caliche"

Throughout most of the site area in the subsurface is a layer of chalky to well cemented calcareous deposit that formed in, or on, previously existing sediments. This layer is related to soil development in the upper parts of the gravelly alluvium that caps the lowest, or Rayado, pediment group, and on, or in, equivalent age sediments in the area. The carbonate horizon, characteristic of arid to semi-arid regions, is commonly known as "caliche", and for the well indurated types, "calcrete". At the site caliche was found to be present in 35 drill holes and the 3 deep bulldozer trenches. The horizon averages about one foot thick, but has been observed to be as thick as three feet. The depth to the carbonate layer is variable; it is found at the surface in some places and was noted to be as deep as 18 feet in drill hole CNS-20, but its average depth is about 8 feet. A few of the drill holes encountered two carbonate horizons, each separated by about three feet of noncalcareous sediment.

Caliche forms in the Cca soil horizon, or more recently termed K-horizon. The caliche profile has been divided into K1, K2, and K3 horizons based on percentage of K-fabric, in which fine grained, authigenic carbonate occurs as a continuous medium. The parent sediments can be either gravelly or nongravelly material, each forming morphologically different carbonate horizons. Carbonate has accumulated to such a degree in the gravelly materials that nearly all skeletal grains are continuously coated and most of the interstices between pebbles are filled or plugged with authigenic carbonate. The nongravelly soils do not have as well developed carbonate horizons as do the gravelly soils. These finer grained sediments are characterized by prominent concentrations of authigenic carbonate in the form of nodules and coatings. The matrix material is commonly reddish-brown or brown and is whitened by carbonate.

The age of this fossil caliche horizon is estimated to be at least 10,000 years and may be as much as 100,000 years. This estimate is based on the horizon's development within gravel of the lower pediment group of Wisconsin Glacial age and on its morphological character. An age of 50,000 years is given to the horizon for the sake of future discussion.

Figure 35 illustrates the caliche distribution in the site area. Two distinct belts where caliche is not present can be seen; one centrally located and trending about east-west and a second to the north which trends northwest-southeast. These belts primarily represent areas of active erosion, and to a lesser extent areas where the caliche horizon was never developed. During Wisconsin time the area was topographically similar to what it is today. The two major drainage systems, the Vermejo and Van Bremmer, occupied approximately the same position as they do today, but were about 50 feet higher in elevation as shown by terrace (pediment) deposits. Caliche formation in the paleosol probably took place at depths no greater than a couple of feet. It was probably formed during a geologically short-lived climatic reversal which resulted in more arid conditions. Most likely, only the highest areas with their steeper slopes were not subjected to caliche formation. The stratigraphic correlation diagram (Fig. 34) shows the dominant caliche horizon and its relationship to the lower pediment adjacent to Van Bremmer Creek. The figure also shows where the horizon has been truncated by erosion. When the carbonate layer is correlated throughout the site, areas of both recent deposition or erosion can be discerned. Assuming an age of 50,000 years for the caliche, one can estimate rates of recent erosion and deposition.

Erosion and Deposition Rates

It appears that the greatest rates of sedimentation take place along the north slope of the highest hill. Here the fossil caliche horizon is buried by as much as 18 feet of overburden. In assuming a depth of formation of

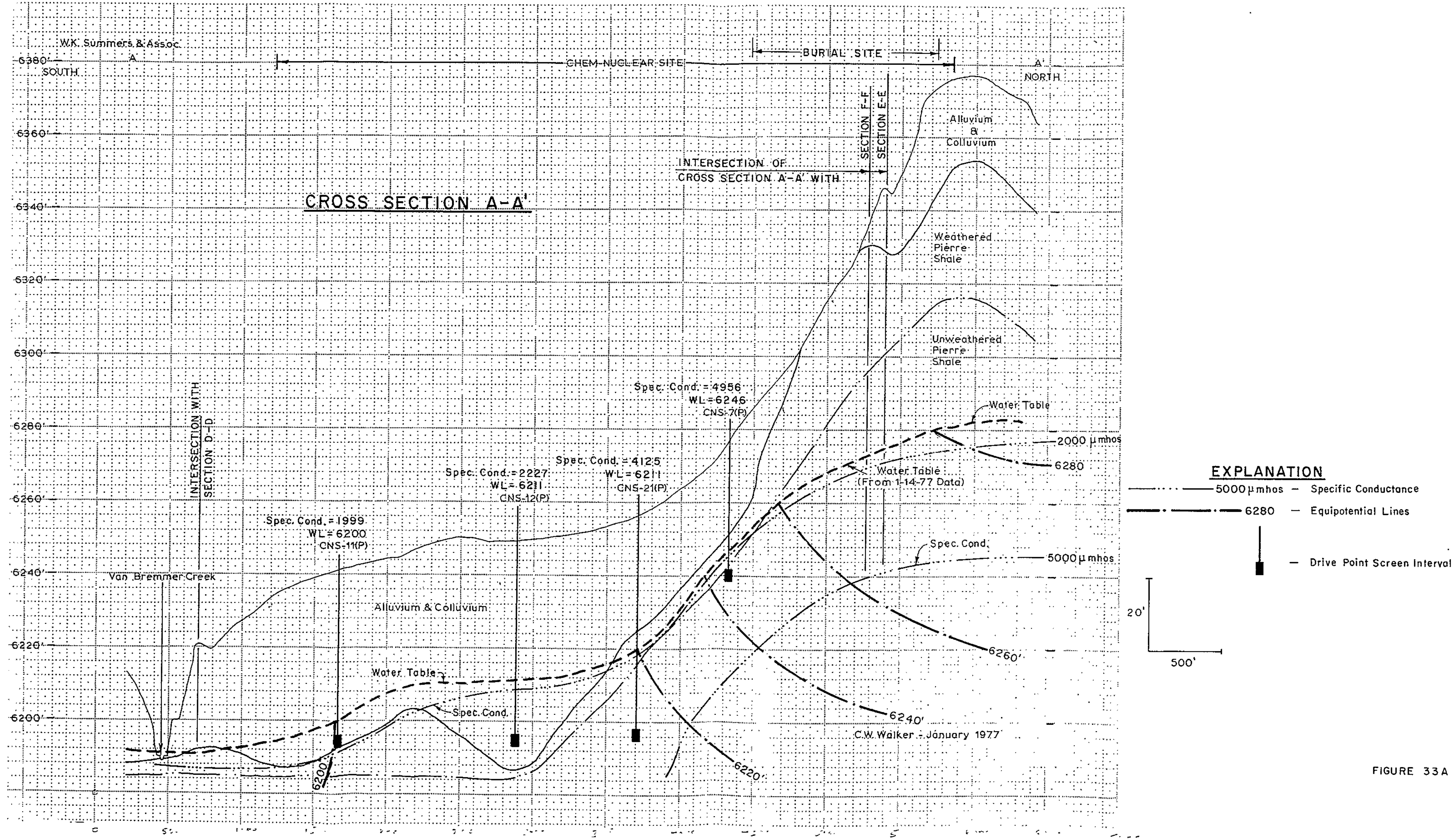

CROSS SECTION A-A'
W.K. Summers & Assoc.
A
SOUTH
A'
NORTH
CHEM-NUCLEAR SITE
BURIAL SITE
SECTION F-F
SECTION E-E
INTERSECTION OF CROSS SECTION A-A' WITH
INTERSECTION WITH SECTION D-D
6380'
6360'
6340'
6320'
6300'
6280'
6260'
6240'
6220'
6200'
Alluvium & Colluvium
Weathered Pierre Shale
Unweathered Pierre Shale
Van Bremmer Creek
Spec. Cond. = 1999
WL = 6200
CNS-11(P)
Spec. Cond. = 2227
WL = 6211
CNS-12(P)
Spec. Cond. = 4125
WL = 6211
CNS-21(P)
Spec. Cond. = 4956
WL = 6246
CNS-7(P)
Water Table
Water Table (From 1-14-77 Data)
Spec. Cond.
2000 μmhos
5000 μmhos
6280
6260'
6240'
6220'
6200
C.W. Walker - January 1977
EXPLANATION
5000 μmhos — Specific Conductance
6280 — Equipotential Lines
— Drive Point Screen Interval
20'
500'

FIGURE 33A

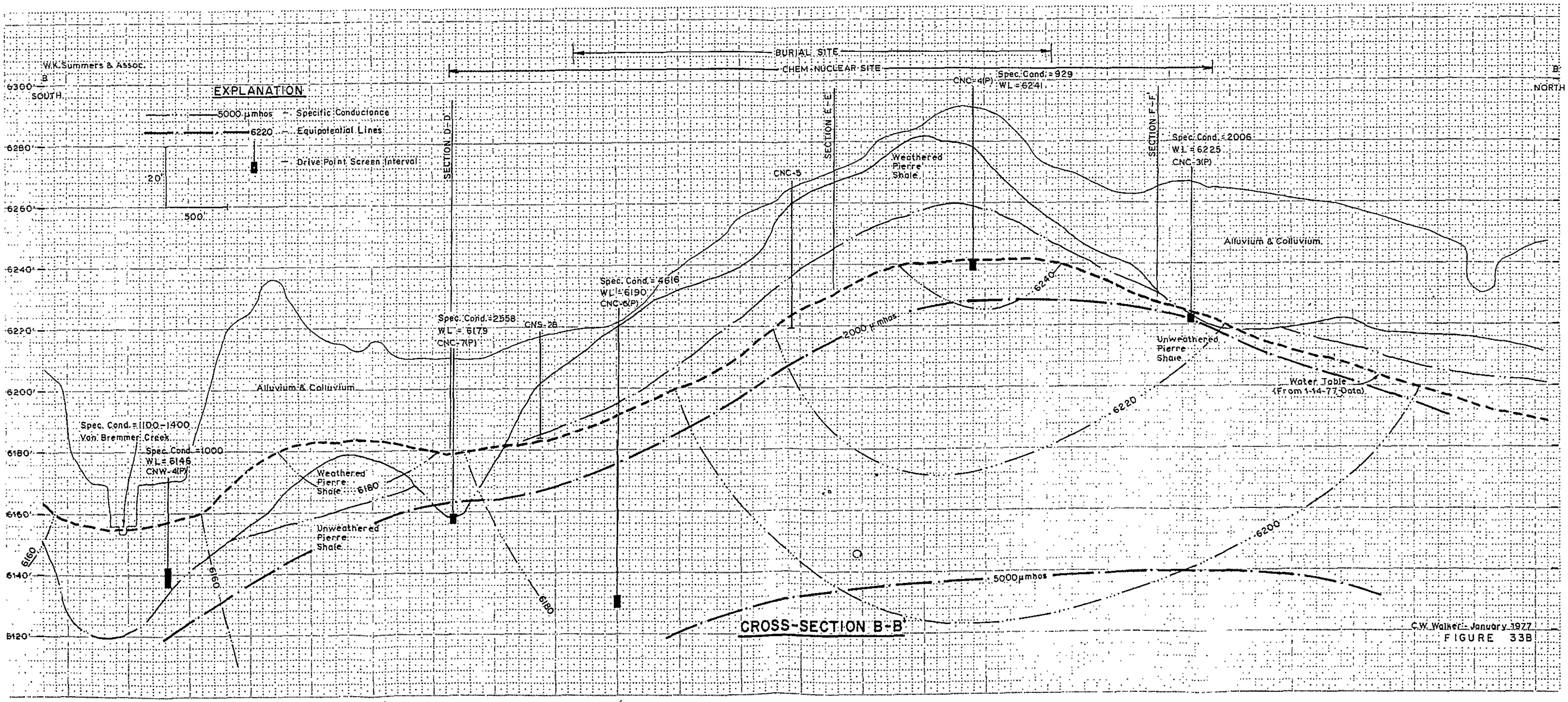
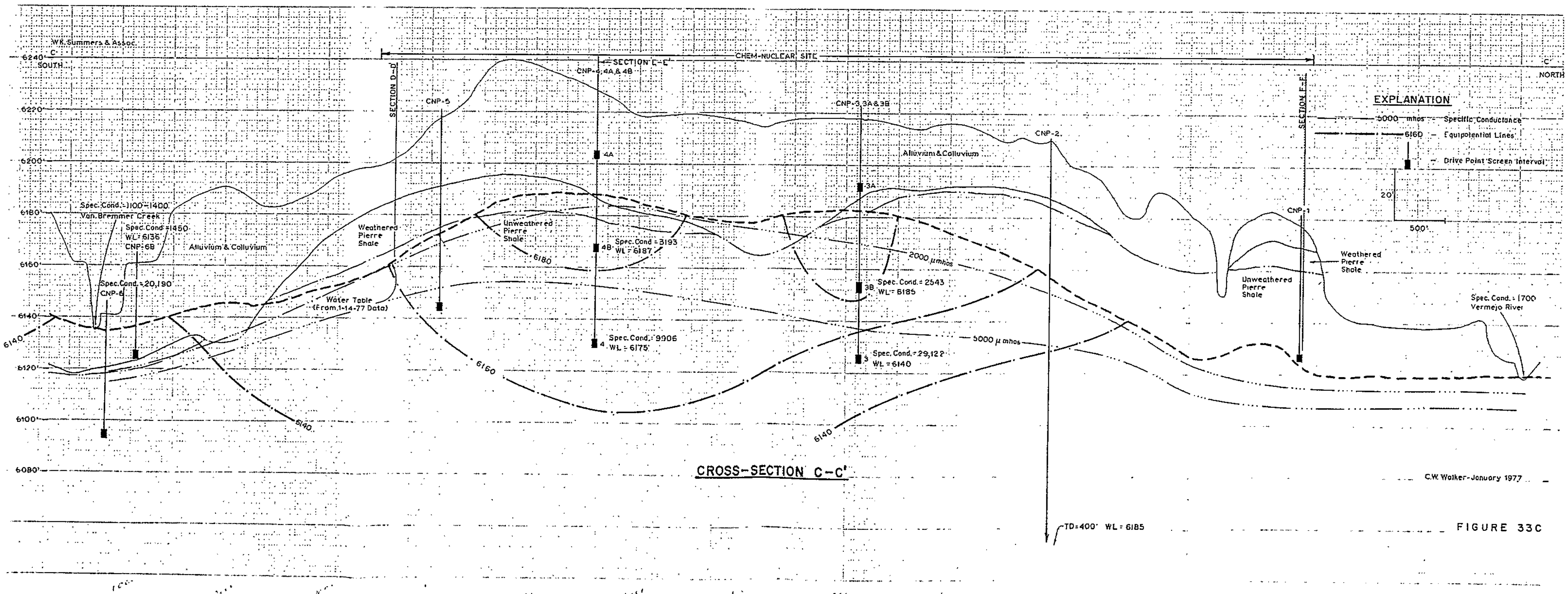

W.K. Summers & Assoc.
B
SOUTH
B'
NORTH
EXPLANATION
5000 µmhos - Specific Conductance
6220 - Equipotential Lines
- Drive Point Screen Interval
20'
500'
BURIAL SITE
CHEM-NUCLEAR SITE
SECTION D-D'
SECTION E-E'
SECTION F-F'
6300'
6280'
6260'
6240'
6220'
6200'
6180'
6160'
6140'
6120'
Spec. Cond. = 929
WL = 6241
CNC-4(P)
Spec. Cond. = 2006
WL = 6225
CNC-3(P)
CNC-5
Weathered Pierre Shale
Alluvium & Colluvium
Spec. Cond. = 4616
WL = 6190
CNC-6(P)
Spec. Cond. = 2558
WL = 6179
CNC-7(P)
CNS-28
2000 µmhos
Unweathered Pierre Shale
Water Table (From 1-14-77 Data)
Spec. Cond. = 1100-1400
Von Bremmer Creek
Spec. Cond. = 1000
WL = 6146
CNW-4(P)
Weathered Pierre Shale
6180
Unweathered Pierre Shale
6160
6240
6220
6200
5000 µmhos
CROSS-SECTION B-B'
C.W. Walker - January 1977

FIGURE 33B



CROSS-SECTION C–C'

FIGURE 33C

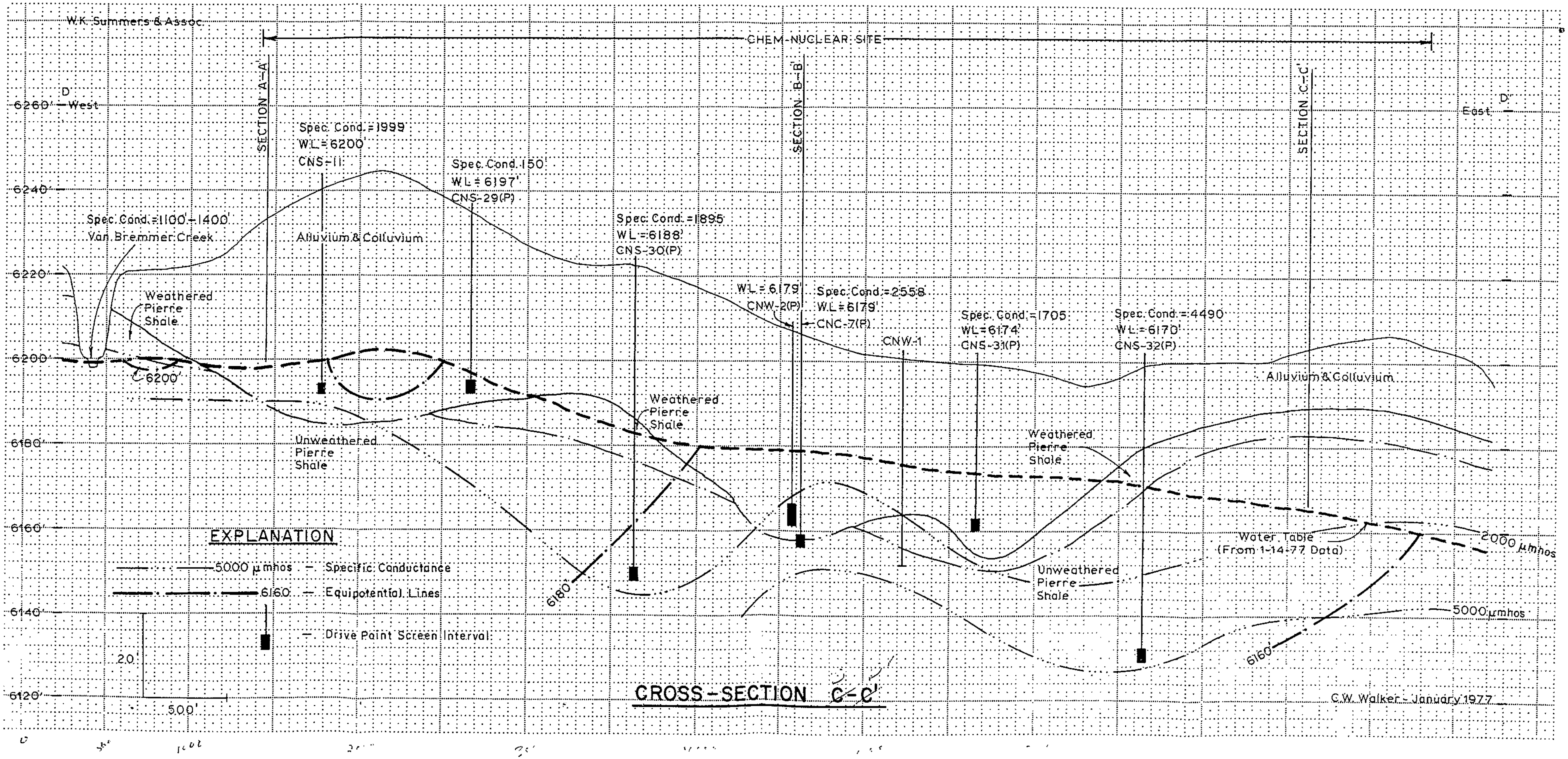
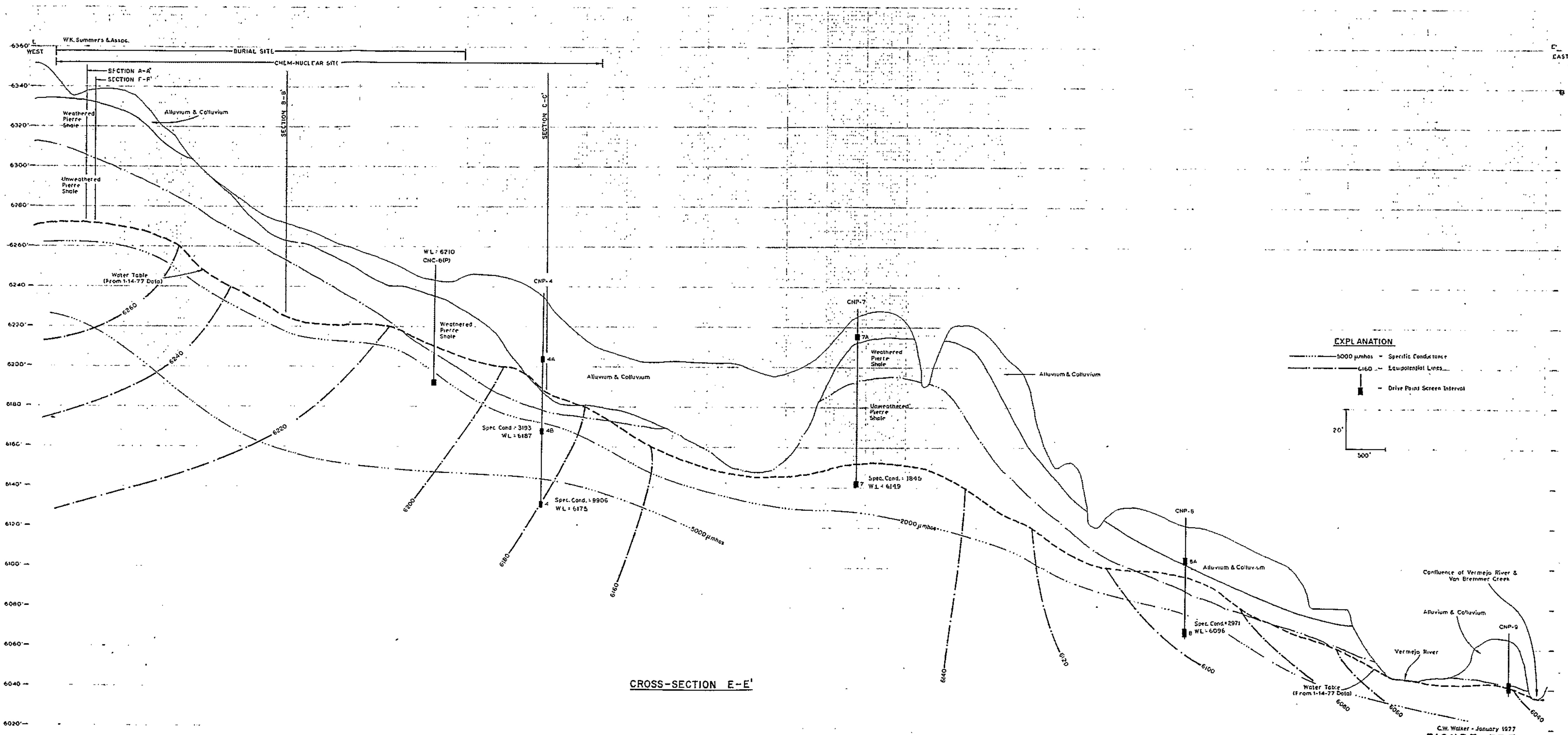
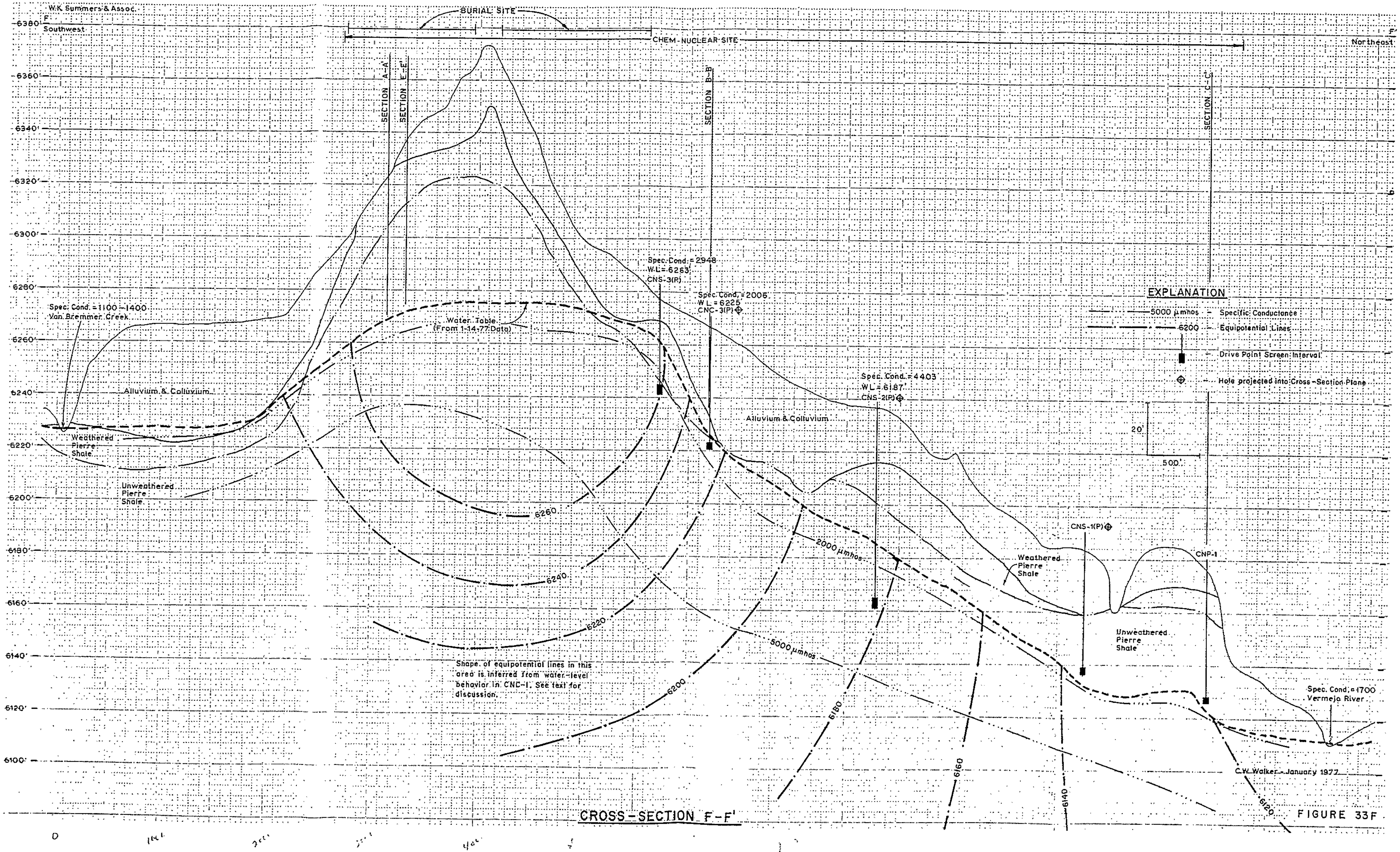

W.K. Summers & Assoc.
CHEM-NUCLEAR SITE
D
6260' — West
D'
East
SECTION A-A'
SECTION B-B'
SECTION C-C'
Spec. Cond. = 1999
W.L. = 6200'
CNS-11
Spec. Cond. 150
W.L. = 6197'
CNS-29(P)
Spec. Cond. = 1100 - 1400
Van Bremmer Creek
Alluvium & Colluvium
Spec. Cond. = 1895
W.L. = 6188'
CNS-30(P)
W.L. = 6179'
CNW-2(P)
Spec. Cond. = 2558
W.L. = 6179'
CNC-7(P)
Spec. Cond. = 1705
W.L. = 6174'
CNS-31(P)
Spec. Cond. = 4490
W.L. = 6170'
CNS-32(P)
CNW-1
Weathered Pierre Shale
Unweathered Pierre Shale
Alluvium & Colluvium
6240'
6220'
6200'
6200'
6180'
6180
6160'
6160
6140'
6120'
Water Table
(From 1-14-77 Data)
2000 µmhos
5000 µmhos
EXPLANATION
5000 µmhos — Specific Conductance
6160 — Equipotential Lines
— Drive Point Screen Interval
20'
500'
CROSS-SECTION C-C'
C.W. Walker - January 1977

FIGURE 33D



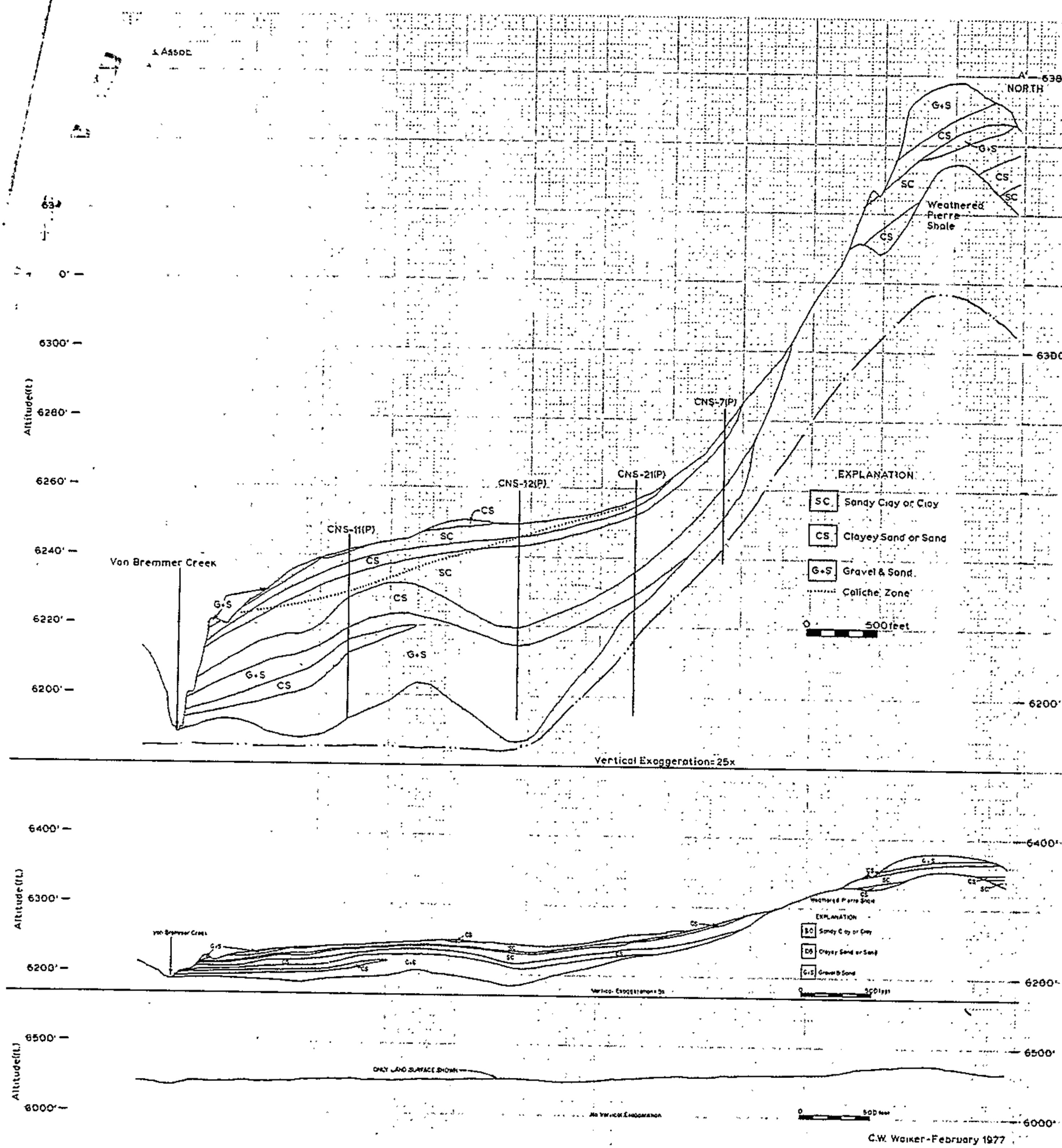
E
WEST
E'
EAST
W.K. Summers & Assoc.
BURIAL SITE
CHEM-NUCLEAR SITE
SECTION A-A'
SECTION F-F'
SECTION B-B'
SECTION C-C'
6360'
6340'
6320'
6300'
6280'
6260'
6240
6220'
6200'
6180
6160'
6140'
6120'
6100'
6080'
6060'
6040
6020'
Alluvium & Colluvium
Weathered Pierre Shale
Unweathered Pierre Shale
Water Table (From 1-14-77 Data)
WL = 6210
CNC-6(P)
CNP-4
4A
4B
4
Spec Cond = 3193
WL = 6187
Spec. Cond. = 9906
WL = 6175
CNP-7
7A
7
Spec. Cond. = 1845
WL = 6149
CNP-8
8A
8
Spec. Cond. = 2971
WL = 6096
CNP-9
5000 µmhos
2000 µmhos
6260
6240
6220
6200
6180
6160
6140
6120
6100
6080
6060
6040
Confluence of Vermejo River & Van Bremmer Creek
Vermejo River
EXPLANATION
5000 µmhos - Specific Conductance
6160 - Equipotential Lines
Drive Point Screen Interval
20'
500'
CROSS-SECTION E-E'
C.W. Walker - January 1977

FIGURE 33E.



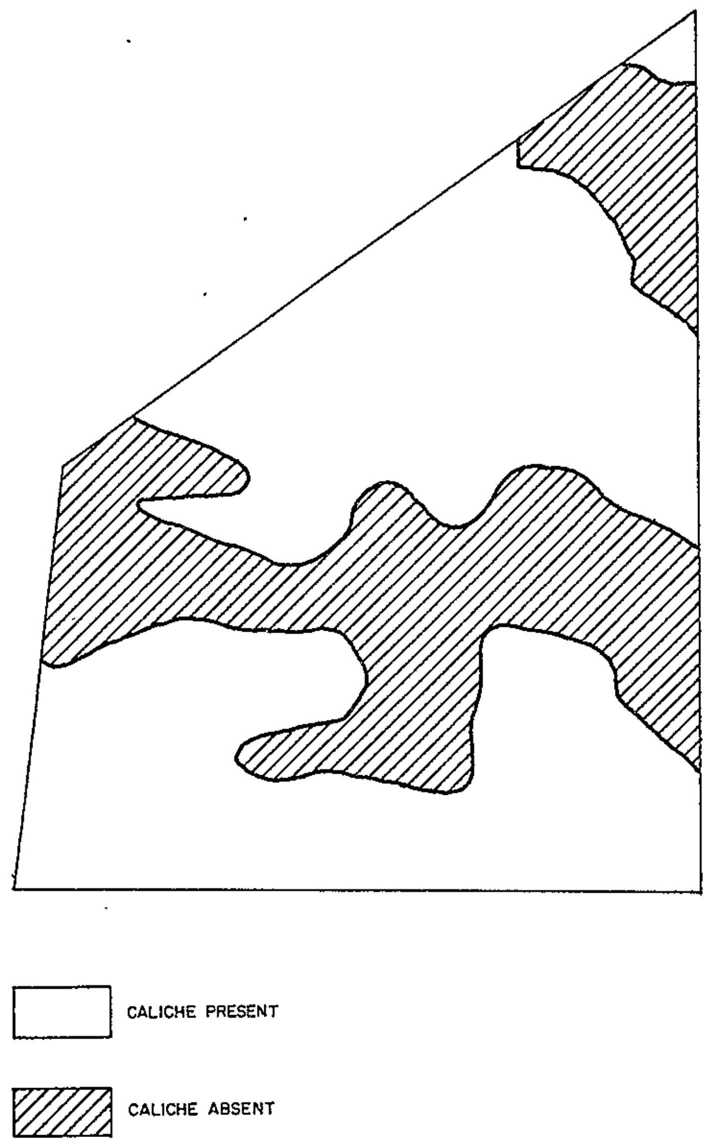
CROSS-SECTION F-F'

FIGURE 33F



Stratigraphic Correlation Diagram Showing the Relations of Alluvium-Colluvium Units.
The three diagrams show how the appearance of the profile depends on the amount of vertical exaggeration.

FIGURE 34



DISTRIBUTION OF CALICHE AT THE PROPOSED WASTE BURIAL SITE

FIGURE 35

2 feet and an age of 50,000 years, it can be estimated that the overburden was deposited at a rate of 3.2 feet per 1,000 years. However, the average depth to the horizon, where it is present, is 8 feet, which gives an average rate of deposition of 1.6 feet per 1,000 years. The greatest amount of erosion appears to be related to the arroyo development in the northernmost segment of the site. Here the erosion rate may be as high as 4.6 feet per 1,000 years. Again, most of the area undergoing erosion has lost no more than about 1.5 feet of material per 1,000 years.

Relation of Stratigraphy and Structure to Topography and Drainage

The present day configuration of the proposed site area is a result of the processes of erosion and deposition throughout geologic time. However, only 70 million years have elapsed since the beginning of Laramide time, during which the area was uplifted and the seas retreated. The bedrock has been slowly eroding since that time down to its present level in the Pierre Shale, with only minor exceptions of deposition.

As indicated earlier, topographically the site area is predominantly a series of plains and remnants of plains. This configuration has developed principally within the last 500,000 or so years. The major features contributing to this present-day configuration have been the erosion and sedimentation processes of the ancestral Vermejo River system. To a lesser extent, the processes of the ancestral Van Bremmer have influenced the topography as seen today. The highest hills of the area are the oldest remnants of the ancestral Vermejo River. As the river cut from this level to a lower level, it eroded downward through the softer weathered Pierre Shale on the edges of its old valley rather than down through the gravel armor on its valley floor. This process has resulted in the steplike sequence of pediment surfaces which mark previous levels of valley fill and stream planation as the stream regimens changed. The ancestral Van Bremmer became instrumental in landform development somewhat later than the Vermejo River.

The major directional trend of the hills and drainages in the site area is the result of regional slope of the Park Plateau to the northwest of the area. The map of the Vermejo River Basin clearly shows that its long dimension trends northwest to southeast, the same as the directional trends of landforms at the site. Present day drainages are undergoing the same processes as they have in the past; that is, primarily eroding downward and laterally through the Pierre rather than through the gravel armor on their valley floor. We believe the major directional lateral erosion is away from the oldest pediment remnants which form the summit between the two drainage lines.

The more local features, such as arroyo directional trends, appear related to fracture trends in the Pierre Shale. The smaller ancient drainage channels were probably influenced to some degree by fracture trends and possibly by small faulted folds within the bedrock which were interpreted to be present from the shallow seismic survey. However, the major buried fossil channels trend in the northwest-southeast direction, indicating this trend to be a function of the regional slope of the land, and not of any structural features.

In summary, the present topography configuration of the proposed site and surrounding area has resulted primarily from erosional and depositional processes of the ancestral Vermejo River. Later, the Van Bremmer ancestral drainage system became important in landform development. Only local topographic features can be attributed to bedrock structural features. The rates at which the landforms are changing, regardless of causes of the changes, are extremely slow.

Cation-Exchange Capacity

The cation-exchange capacity of one sample of the brown sandy clay is 29.6 meq/100g. The exchanged ions and their concentrations were:

K = 11.6 meq/l
Ca = 85.8 meq/l
Mg = 217 meq/l
Co = 12.6 meq/l
Sr = .48 meq/l

The cation-exchange characteristics of the brown sandy clay sample closely resemble those of the weathered Pierre Shale.

Physical Properties

Velocity.--The seismic survey showed that the overburden velocity increases with depth, but probably averages 2,500 feet/second. This may include the average for the weathered shale as well, but is a typical value for unsaturated sand and gravel deposits.

Particle Size Distribution.--Appendices II-5a and 5b contain the particle-size analyses that were made of samples collected at the locations noted on the trench sections (Fig. 23). Sand size or larger was the dominant size in every sample. Six samples contained more than 40 percent silt and clay. Thirteen samples contained more than 10 percent clay. For the most part the alluvium-colluvium on the trench was not well sorted.

ıulic Conductivity

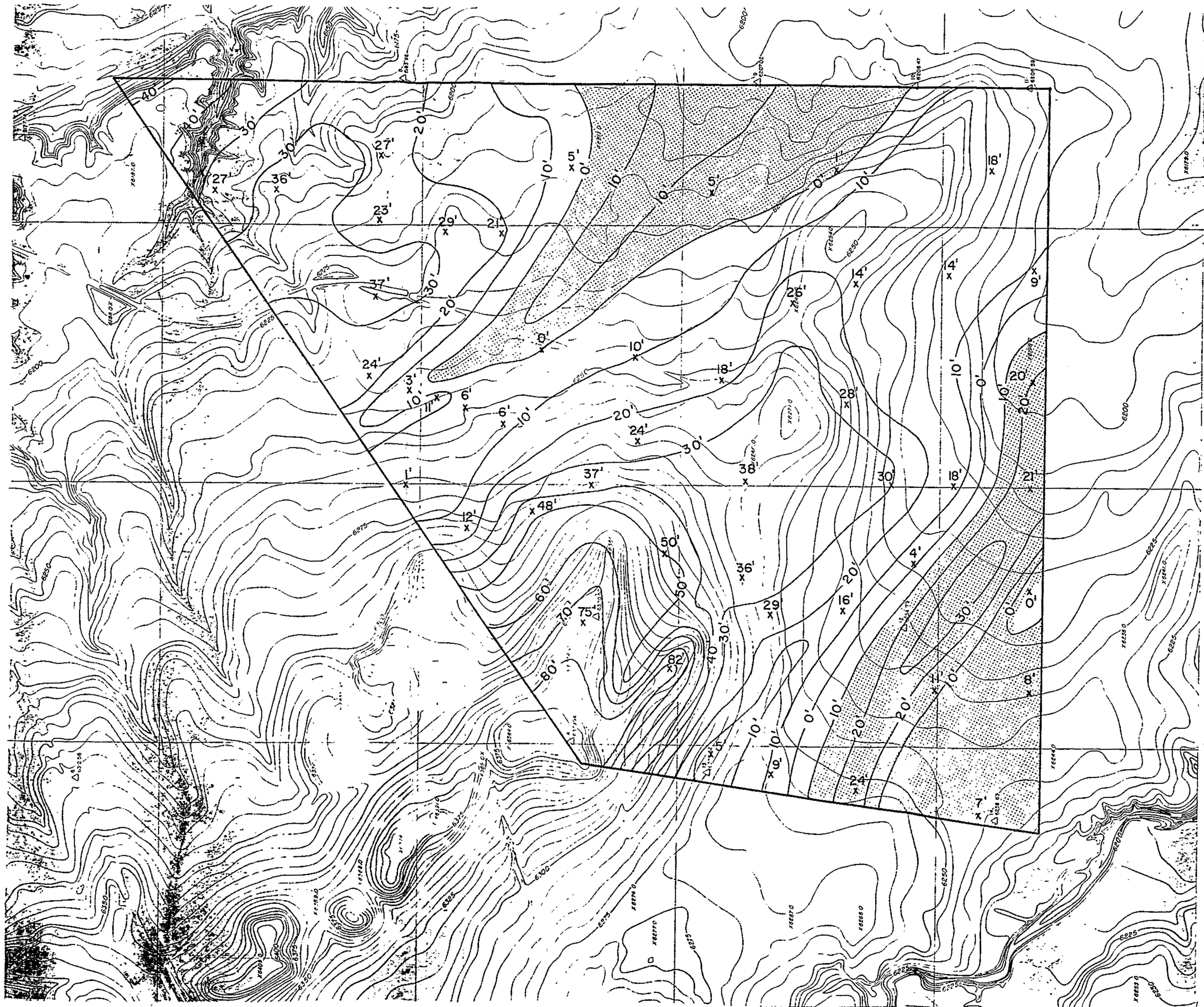
e alluvium-colluvium is saturated over a limited area. Figure 32 shows :he area and thickness of the saturated colluvium. The saturated hydraulic conductivity has been assessed directly by pumping tests of two wells and slug tests, and indirectly by grain-size distribution and infiltration tests.

Pumping Tests.-- There were two pumping tests (Appendix I-3) of wells in saturated sand and gravel (Fig. 36). Despite its higher yield, Well W-4 taps alluvium with an average hydraulic conductivity of .53 feet/day, whereas Well W-2 with a lower yield, taps alluvium with a much higher average hydraulic conductivity of 1.2 feet/day.

Slug Tests.-- Six slug tests on sand and gravel yielded hydraulic conductivity values ranging from .56 to 20 feet/day.

Grain Size Distribution.-- Using a modification of Hazen's technique (Freeze, 1969, p. 35) we estimated the saturated hydraulic conductivity of the sediments of the trenches as follows:

Trench No.	Hydraulic Conductivity (ft./d)
1	.3
2	.07
3	10
4	.3
5	.01
6	.01
7	.05
8	4
9	.05
10	.04
11	30
12	.1
13	30
14	20
15	
16	



N

LEGEND

x = Hole Location

10' = Interval (in feet) between top of the Pierre Shale and the water table

[shaded] = Top of Pierre Shale below water table (Contours represent saturated thickness of overlying alluvium and colluvium.)

Unshaded Area = Top of Pierre Shale above water table (Contours represent unsaturated thickness of overlying alluvium and colluvium.)

Contour Interval = 10'

Water table based on 1-14-77 data.

SCALE: 1" = 1000'

0 500 1000 2000

THICKNESS OF INTERVAL BETWEEN THE TOP OF THE PIERRE SHALE AND THE WATER TABLE

FIGURE 36

These are probably order-of-magnitude only, but they do compare favorably with those obtained by other means. However, they probably are the upper limits of the hydraulic conductivity of the rock type.

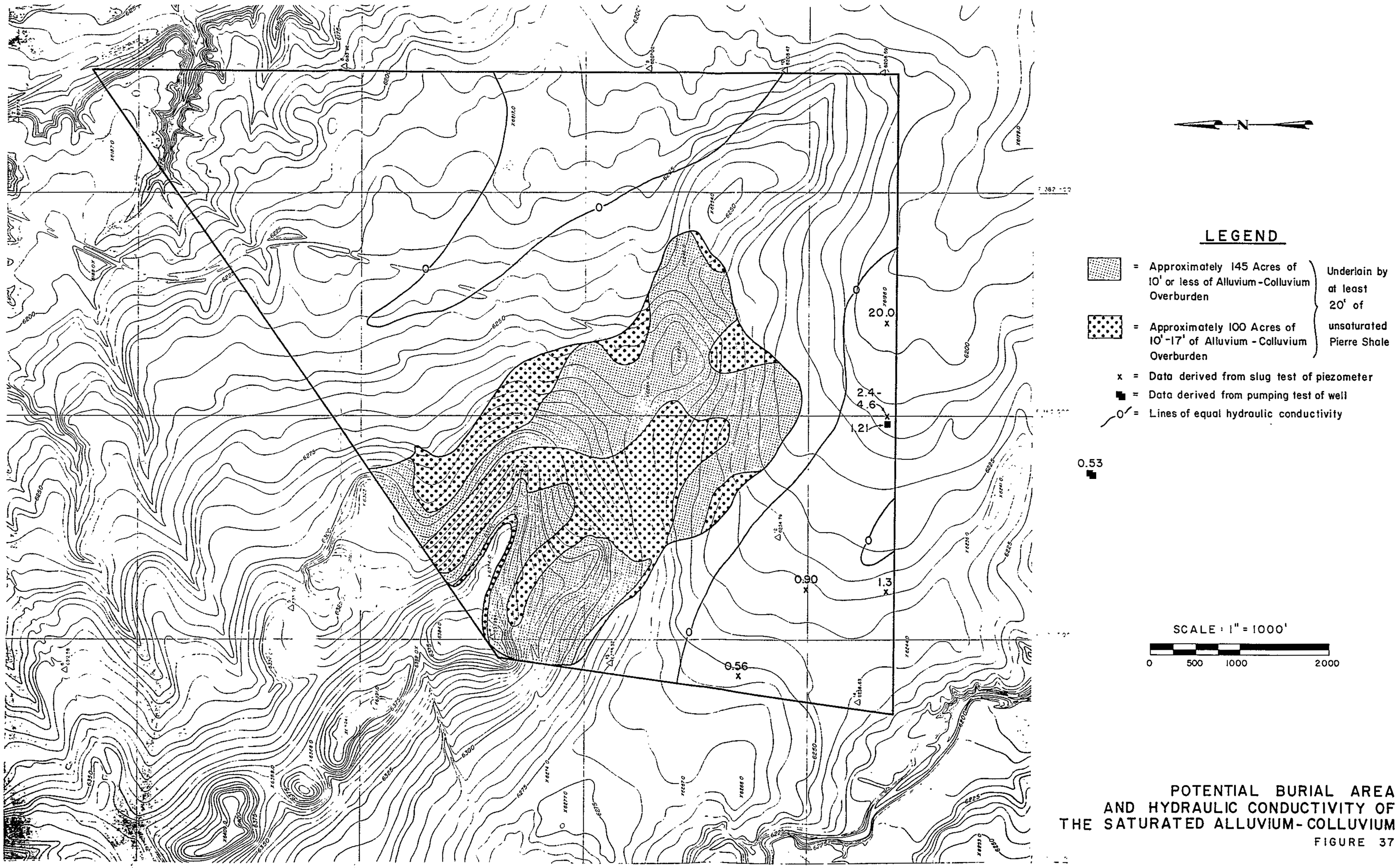
Infiltration Tests.-- Six double-ring infiltrometer (12 and 24 inches) tests at heads of one foot for six hours yielded apparent hydraulic conductivity values ranging from 3.6 to 17.6 feet/day. The infiltrating water reached wetted depths ranging from 3.1 to 6.0 feet and extended radially from 2.1 to 3.3 feet.

One test in gravel had to be aborted because the infiltration rate was too great to measure.

One test in the silty sandy clay indicated an apparent hydraulic conductivity of .2 - .8 feet/day. The wetted front reached a depth of 2.2 feet and had a radial extent of 2.5 feet.

Discussion.-- Figure 37 shows the spatial distribution of the hydraulic conductivity of the saturated alluvium-colluvium. Although the values appear to increase from northwest to southeast, the paucity of data may be misleading.

Of more importance is the range in values probably reflecting the age (compaction) of the material and the high incidence of clay. The values obtained are far below those obtained (100+ feet/day) in modern alluvial channels elsewhere.



POTENTIAL BURIAL AREA
AND HYDRAULIC CONDUCTIVITY OF
THE SATURATED ALLUVIUM-COLLUVIUM
FIGURE 37

Summary of the Geologic History of the Site Area

During early Paleozoic time (pre-Pennsylvanian) there was no strong positive structure to supply clastic sediments into the area and the environment was dominantly marine-open shelf. Uplifting of the Sierra Grande Arch during Pennsylvanian time resulted in the deposition of a thick continental and marginal marine sequence in upper Pennsylvanian and Permian strata.

After a period of non-deposition and slight erosion Triassic and Jurassic sediments were deposited as shallow marine sandstones and shale and fluvial sandstones and mudstones. During Cretaceous time the area was invaded by epicontinental seas. The transgressing sea advanced to the west and initially deposited beach and near shore sands. Continued transgression resulted in the deposition of a substantial thickness of marine mudstones, silty limestones, and occasional sandstones. The shoreline advanced further westward and a thick sequence of dark gray noncalcareous marine shales were deposited, forming the Pierre Shale. The upper portion of the Pierre marks the beginning of the Laramide Orogeny and the northeastward regression of the sea. As the coastline retreated, sands were deposited in a beach and near shore environment followed by the deposition of sands, silty shales and coal beds. Shortly thereafter, the Sangre de Cristo range to the west began to rise and supply coarse detritus to the east. During Tertiary time the Sangre de Cristo Mountains continued to rise episodically and supplied a great thickness of coarse, fluvial sediments to the adjacent area. Epeirogenic uplift of the entire area occurred in late Tertiary causing widespread erosion and was accompanied by extensive volcanism which emplaced most of the plugs, dikes and sills found in the surrounding region.

Fluvial deposition again became dominant during Pleistocene as a response to climatic changes, rather than to tectonic uplift. The ancestral Vermejo River carried boulders, as large as 3 feet in diameter, distances of over 40 miles. These gravels form the high ridges at the site and represent the oldest pediment remnants. A step-like sequence of pediment surfaces occurs at the site and demonstrates that the ancestral streams eroded downward and laterally through the Pierre Shale on the edges of its old valley, rather than down through the gravel armor on its valley floor. The present drainages are continuing with the same processes that formed the present landscape.

Hydrology

Surface Water

The hydrology conditions at the site depend, in large measure, on its topographic setting. The area proposed for waste burial is at the end of a long ridge that controls drainage. Precipitation on the site can run off, infiltrate, or evaporate, but with only trivial possible exceptions, run off from offsite can only reach the site as subsurface flow.

The bottom of the burial area is more than 80 feet above Van Bremmer Creek at the west edge of the property and much more than 80 feet above the Vermejo River.

The east edge of the proposed burial area is about 180 feet above the confluence of the two streams. The largest flood in the Upper Canadian River Basin in recorded history during June 1965 only raised the water level at Dawson (where the Vermejo River is confined within a relatively narrow valley) to a gage height of 15.25 feet (Snipes, et al, 1974, p. D73). On either side of the stream near the site area there are extensive areas that have lower altitudes than the proposed burial area. As a result the flood from the largest conceivable rainfall could not reach the burial site.

Surface runoff at the site will consist exclusively of the precipitation in excess of the soil moisture capacity.

Ground Water

Figure 38 is a map of the water table around the site. The configuration of the contours shows clearly that the two streams, together with a considerable area on either side of the streams, serve as ground-water discharge areas. An inflection line can be drawn to show that, with the exception of a strip through the southwest corner of the site, the site is a recharge area. The strip of discharge also coincides with the saturated alluvium-colluvium channel. The configuration of the water-table contours shows the shape of the discharge area and suggests that the channel, although topographically higher than the present stream channel, still carries a portion of the water moving through the alluvium of the Van Bremmer Creek.

Recharge

The recharge rate at the site can be estimated by using the water table profile and assuming that the streams are parallel drains. In this case the following relationship applies:

$$W = \frac{hk}{(a^2 + x^2)}$$

where

W = recharge required to sustain profile
h = water level difference between the streams and arbitrary point
k = hydraulic conductivity
x = distance to divide from an arbitrary point
a = distance from divide to stream

We used a line connecting the altitude of 6,150 at the Vermejo River with the altitude of 6,150 feet on the Van Bremmer Creek.

The line is 16,600 feet long, therefore,

$$a = 8,300 \text{ feet}$$

If we choose h as 50 feet, then x is half the distance between the intersections of the line with the 6,200 contour line, in this case:

$$x - 3,000 \text{ feet}$$

for

$$k = 1 \text{ ft./d}$$
$$W = 50 \times 1/(8,300^2 + 3,000^2) = 6.4 \times 10^{-7} \text{in./d or } .00023 \text{ in./yr.}$$

Other profiles give similar results.

Recharge can also be estimated by assuming a base flow (Q_b) of the two streams and by the relation:

$$Q_b = 2aW$$

The base flow of the Vermejo River at Dawson is about .9 cfs, and the stream above Dawson is about 50 miles long; so the base flow contribution per foot of stream above Dawson averages about 3.4×10^{-6} cfs/ft.

So if the base flow to the two streams from a strip one foot wide along our line is about the same, then:

$$W = \frac{3.4 \times .10^{-6} \text{cfs}}{2 \times 8300} = 2.05 \times 10^{-10} \text{ cfs/ft}^2 = .08 \text{ in./yr.}$$

Recharge in the profile can also be estimated from the average annual precipitation as:

$$R = 16 \times .005\ (16-6) = .8 \text{ in./yr.}$$

The basic assumptions underlying these relationships are not well satisfied at the site. We know that within the discharge area, recharge is nil, so from the inflection line to the divide the recharge rates must increase from 0 to some maximum value.

An estimate of the maximum recharge rate can be made using cross-sections AA'-FF'. At the water table divide:

$$W = k_v I_v$$

where

k_v = the vertical hydraulic conductivity; and
I_v = the vertical hydraulic gradient we estimate from the cross-sections (Fig. 33a-f).

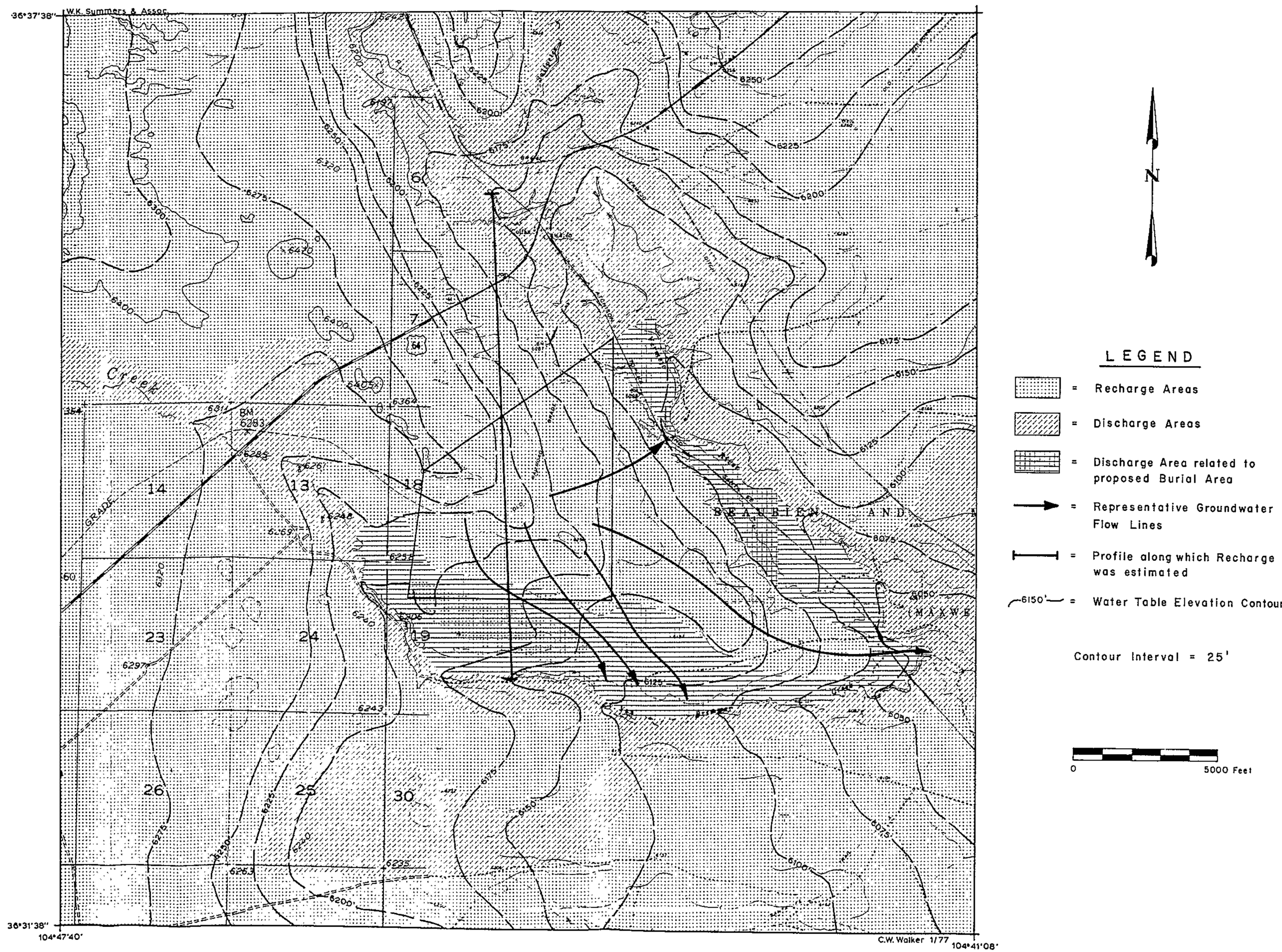
On the cross-section, I_v at the water table is about .2 ft./ft.

So

k_v = .001 ft./d
W = .001 x .2 = .0002 ft./d or .9 in./yr.

However, if we assume matrix hydraulic conductivity only, the estimate becomes .009 inches/year. If the maximum rate is .9 inches/year the average would be $\frac{0 + .9 + 0}{3}$ or 0.3 inch/year (each 0 representing the nil recharge at the inflection point of the cross-section).

The recharge rate is less than one inch a year and probably is much less.



WATER TABLE MAP
BASED ON 1-14-77 DATA
FIGURE 38

Flow Systems

The cross-sections (Fig. 33a-f) show that recharge moves to the two streams. We could also infer that a small part of the recharge underflows the streams to discharge downstream or to the Canadian River. However, the amount of underflow is probably a negligible quantity. As drawn, cross-section E-E' shows that no ground-water flows into the area in a local flow system. The water-table map supports this observation. The area proposed for burial is in, and comprises about 10 percent of, the recharge area of the local flow system. All ground-water movement derives from recharge within the area (except for the underflow of the regional flow system). An intermediate flow system may exist below a depth of 200 feet.

The depth of water in CNC-1 appears to have stabilized at about 75 feet below the water table. Two explanations can account for this great water-table -- water-level difference.

(1) the water level represents the average head for the open interval between the water table and the bottom of the hole; or

(2) the water level represents the head for a discreet point below the water level.

In either case, the head must decrease considerably with depth for the water-level observed. Such a decrease would be consistant with the pattern expected in a recharge area. The large magnitude simply reflects the large hydraulic gradient required to move water through the shale.

Ground-Water Discharge

Ground-water discharges from the site

(1) to evapotranspiration,

(2) to stream flow, including flows in the channel alluvium, and

(3) to underflow.

The discharge to evapotranspiration is difficult to measure. Weeks and Sovey (1973, p. C10-C11) measured the discharge for three small areas along the Arkansas River in Colorado where the water table was shallow for 3 years and found that the discharge ranged from 4 to 18 inches per year. Other investigators (Ripple, et al, 1972) here show that the discharge rates decrease with increasing depth-to-water table and vary with vegetation.

Although there exists a theoretical possibility that recharge from the site could underflow the confluence, the cross-section suggests that the probability is negligible.

The discharge area of the local flow system is about 2.2 square miles. If the evapotranspiration discharge averages four inches per year from the two percent of the area where the depth-to-water is five feet or less, then the average evaportranspiration discharge is 2.7×10^7 cubic feet annually. This is equivalent to a recharge rate of .06 inches/year on the recharge area. Increasing our estimation of the effective recharge area or increasing the effective discharge rate increases the estimated recharge rate. The rates will also be larger if we allow for discharge to the stream. However, the estimated discharge is within the range of estimated discharge.

In any event this estimate of discharge confirms our estimate that the mean annual recharge at the site area is less than one inch per year and could be less than 0.1 inch per year.

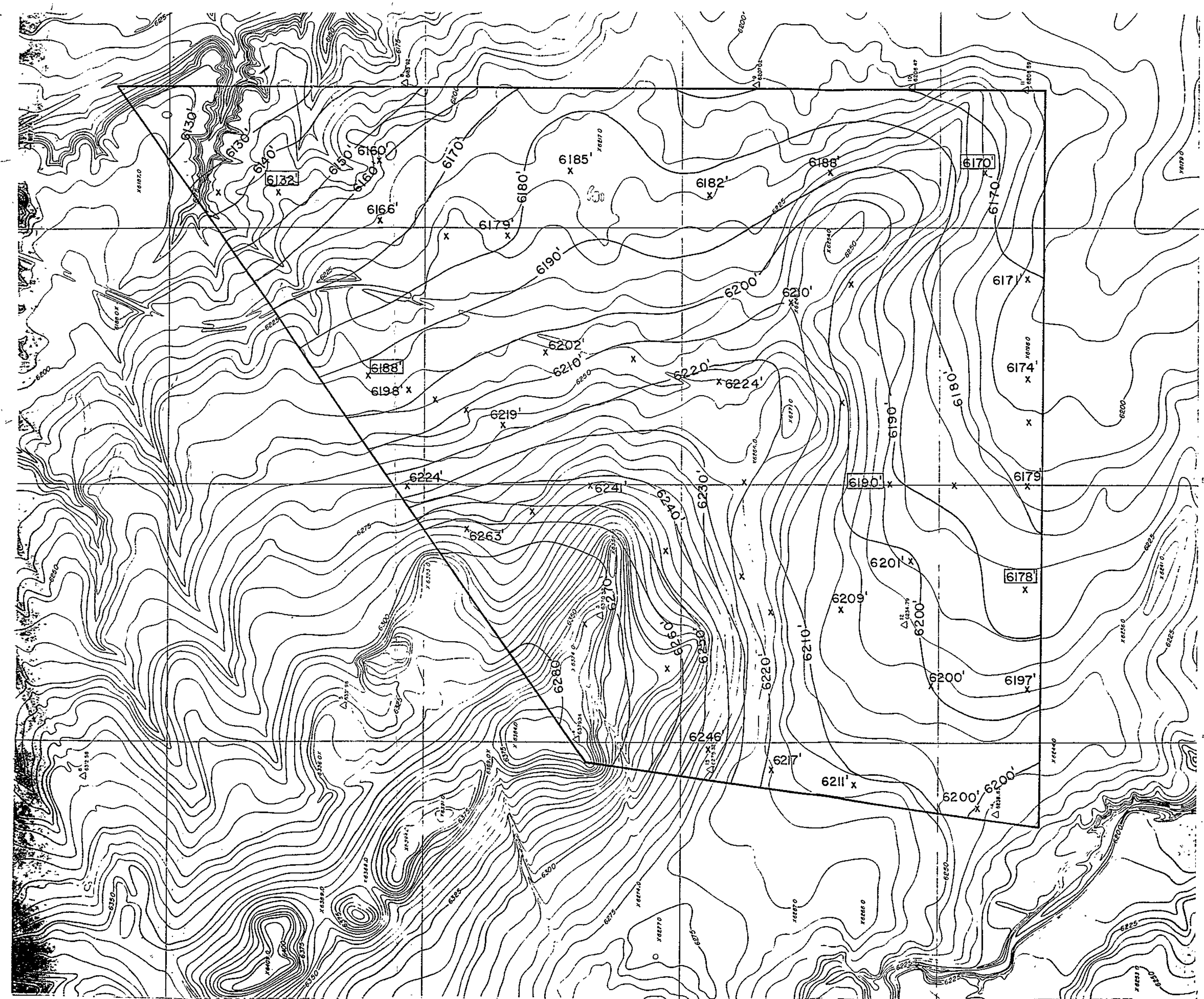
Water Table Fluctuations

Figure 39 is the water table map of the site. The amount of change one can expect on the water table in the recharge area can be estimated by using the porous volume available and an estimated recharge rate.

In the recharge area the water table is in the shale (Fig. 36). The porosity of the shale is at least five percent. To raise and maintain the water table at its maximum altitude in the area one foot, the volume of water required is .05 feet or .6 inches of extra recharge. The recharge we can expect from a 36 inch annual rain is about 5.4 inches or about 4.8 inches more recharge than average. The maximum water-level rise associated with recharge of this magnitude would be 9 feet.

For a 3-year maximum, we found the average estimated precipitation is 30 inches, and the average recharge rate would be about 3.6 inches/year with a surplus a 3.0 inches per year. So for a 3-year period the water-level rise would be 15 feet.

For a 5-year maximum wet period, the precipitation will average 25 inches, and the average annual recharge rates would be raised to about 2.4 inches a year with a surplus of 1.8 inches/year. So for a 5-year wet period the water-level rise would be about 15 feet.



N

LEGEND

x = Hole Location

6201' = Altitude of Water Table rounded off to the nearest foot

6190' = Deep Piezometer (>70') Altitude compensated for in contouring

Contour Interval = 10'

SCALE : 1" = 1000'

0 500 1000 2000

WATER TABLE ELEVATION (BASED ON 1-14-77 DATA)

FIGURE 39

The preceding analyses assume that the mechanism of moisture transfer depends exclusively on the precipitation rate and that all other mechanisms adjust accordingly.

If the porosity is more, the water-level rise will be less. We believe, therefore, that the maximum water-level rise that can occur in the shale is less than 15 feet and that this rise will occur only during the 5 year wet period with a recurrence interval of 1,000 years.

Water Chemistry

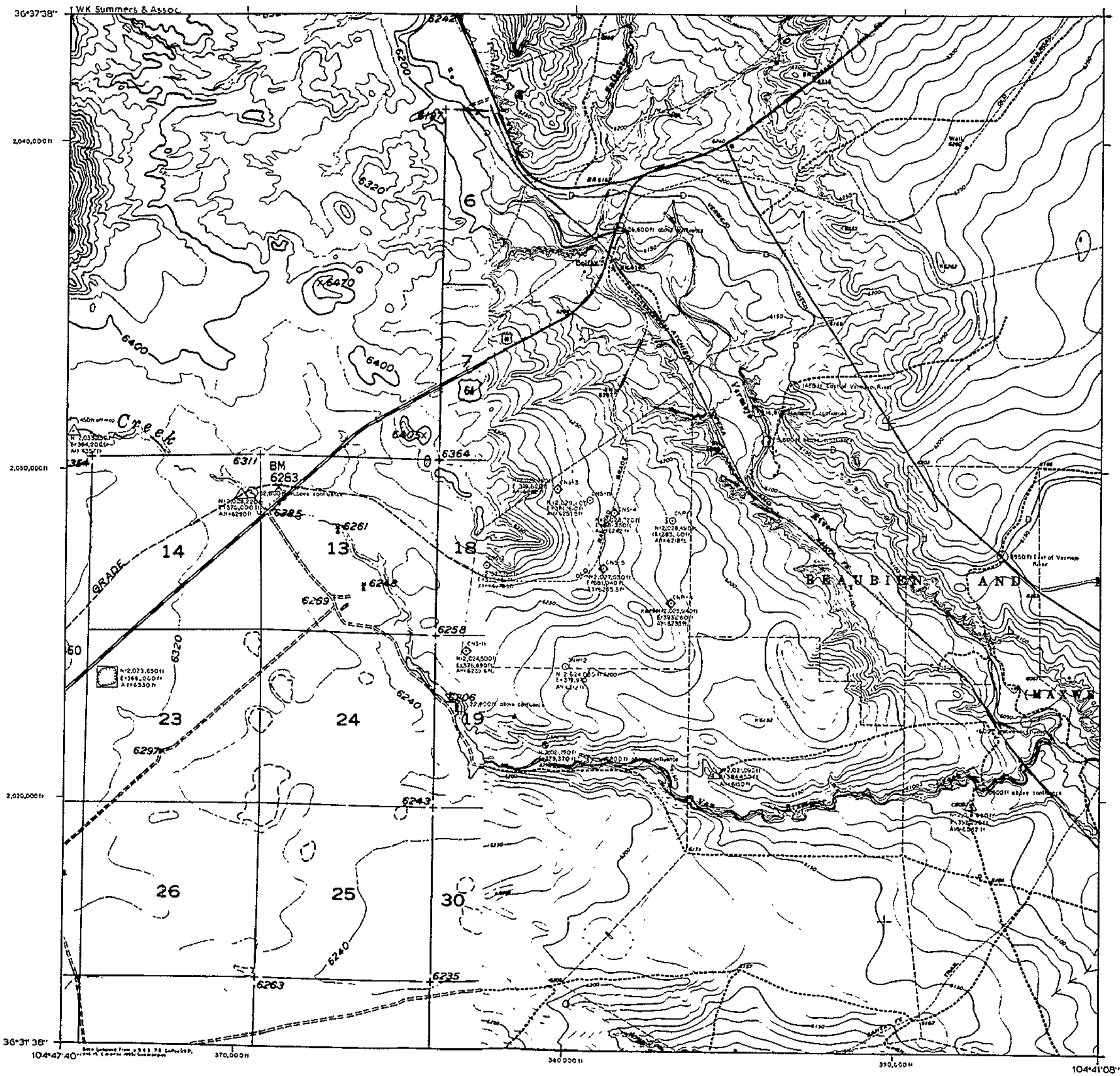
Twenty-five water samples for chemical analysis were collected at the places shown on Figure 40. The results of these analyses are given in Appendices II-1 and 2.

The total dissolved solids (residue) range from a low of 240 ppm in a sample from a range reservoir pond to more than 5,500 ppm in a sample from a deep piezometer. According to sources, the total dissolved solids are:

Source	Total dissolved solids (ppm)	Remarks
Precipitation - short runoff (pond)	240	
Vermejo Conservancy ditch and Vermejo River	780-1450	increase downstream in river
Van Bremmer Creek	760-1070	increasing downstream
Domestic and stock wells	780-3500	
Alluvium-colluvium	680-1000	
Pierre Shale	1000-5500	

The principal cations and anions are:

Source	Cations	Anions
Precipitation - short runoff (pond)	Ca>Na>Mg>K	$HCO_3>SO_4>Cl$
Vermejo Conservancy Ditch	Ca>Na>Mg>K	$SO_4>HCO_3>Cl$
Vermejo River - upstream.	Ca>Na>Mg>K	$SO_4>HCO_3>Cl$
midway	Mg>Ca>Na>K	$SO_4>HCO_3>Cl$
midway to confluence	Ca>Mg=Na>K	$SO_4>HCO_3>Cl$
Van Bremmer Creek - upstream	Ca>Na>Mg>K	$HCO_3 \simeq SO_4>Cl$
midway	Ca>Na>Mg>K	$HCO_3>SO_4>Cl$
confluence	Na>Ca≃Mg>K	$SO_4>HCO_3>Cl$
Alluvium-Colluvium	Na>Ca>Mg>K	$SO_4 \simeq HCO_3>Cl$ to $SO_4>HCO_3>Cl$
Pierre Shale	Na>Ca>Mg>K to Na>>Ca ≈ Mg>K and Ca≃Mg≃Na>K	$HCO_3 \simeq SO_4>Cl$ to $SO_4>>HCO_3>Cl$ and $SO_4>>Cl>HCO_3$ or $SO_4>>HCO_3>Cl$



Scale-1:48000 1inch=4000 feet

0 5000 10000 feet

EXPLANATION

- ⊙ On Site Piezometer Samples
- △ Off Site Well Samples
- ⬡ Off Site Stream & Ditch Samples.
- ⊡ Off Site Pond Samples
- ◇ On Site Radionuclide Sample
- D Vermejo Ditch
- ⊗ Off Site Piezometer Samples

WATER SAMPLE LOCATION MAP

FIGURE 40

The cross-sections show that the specific conductance increases from 2,000 μmhos just below the water table to 5,000 μmhos at depths less than 100 feet below the water table.

The chemical make-up of the water changes

(a) from upstream to downstream in the streams,

(b) from the shale to the colluvium to the streams, and

(c) with depth in the shale.

These changes fit with our expectations for local and intermediate flow systems. The change in the chemical characteristics downstream are due to contributions from local ground-water flow systems discharging water from the shale. The alluvium-colluvium contains a component of the stream's base flow and a component from the local flow system discharging from the shale.

An intermediate flow system in the shale contains water that ranges from:

$Ca \approx Mg \approx Na$ and $SO_4 >> HCO_3 > Cl$ to

$Na >> Mg \approx Ca$ and $SO_4 >> HCO_3 > Cl$ to

$Na >> Mg \approx Ca$ and $SO_4 >> Cl > HCO_3$

These are essentially the changes we expect in intermediate and regional flow systems.

Radioisotope Migration

Travel Time

The flow of water from the recharge area to the discharge area along the shortest path (Fig. 38) involves a distance (d) of about 4,500 feet. The hydraulic gradient (I) along this path is about 80/4,500 = .018 ft./ft. The hydraulic conductivity averages along this line about .01 ft./day (Fig. 38). The porosity (n) is no less than five percent.

Since the travel time (t) in days is given by the relationship

$$t = \frac{nd}{KI},$$

the travel time along the shortest path is

$$t = \frac{.05 \times 4500}{.01 \times .018} \text{ days} = 1{,}250{,}000 \text{ days},$$

or 3,400 years.

Other paths involving longer distances but with higher average hydraulic conductivities and probably large porosities give travel time of 1,000 years or longer.

For tritium, strontium-90, cobalt-60, and cesium-137, the principal factors of the radwaste, with half-lives of 30 years or less, travel times of 1,000 years or longer are sufficient to prevent their discharge to the biosphere. They will have undergone radioactive decay to the point where they are no longer a hazard.

Sorptive Capture

The velocity (V_i) with which an ion moves through a sorbing medium is given by

$$V_i = \frac{V_w}{1 + K_d \frac{\rho b}{n}}$$

where

V_w = the velocity of the water,

K_d = the distributive coefficient (ml/g)

ρb = the bulk density (g/cc), and

n = the porosity.

So for the Pierre Shale in the proposed burial area

$$V_w = \frac{KI}{n} = .01 \times .018/.05 = .0036$$

ρb = 2.5 g/cc and

n = .05

so

$$V_i = \frac{.0036 \text{ ft./d}}{1 + 50\ K_d}$$

For cesium in dilute concentration solutions (10^{-10} N) with a specific conductance of 1,750 μmhos

$$K_{dcs} = 795$$

so

$$V_{cs} = \frac{.0036 \text{ ft./d}}{1 + 50 \times 795} = 9.1 \times 10^{-8} \text{ ft./d or } 3.3 \times 10^{-5} \text{ ft./yr.}$$

For cesium at less dilute concentration (10^{-6} N), K_d = 339,

so

$$V_{cs} = \frac{.0036 \text{ ft./d}}{1 + 50 \times 339} = 2.1 \times 10^{-7} \text{ ft./d or } 7.8 \times 10^{-5} \text{ ft./yr.}$$

(Velocities of 2.7×10^{-3} ft./day are equivalent to 1,000 feet in 1,000 years).

For cobalt in dilute concentration (10^{-10} N) in solutions with a specific conductance of 1,750 μmhos,

$$V_{co} = \frac{.0036}{1 + 50 \times 944} \text{ ft./d} = 7.6 \times 10^{-8} \text{ ft./d or } 2.8 \times 10^{-5} \text{ ft./yr.}$$

For cobalt at less dilute concentrations

$$V_{co} = \frac{.0036}{1 + 50 \times 504} \text{ ft./d} = 1.4 \times 10^{-7} \text{ ft./d or } 5.2 \times 10^{-5} \text{ ft./yr.}$$

When the specific conductance is 1,750 μmhos the strontium

K_d = 8.1 ml/g at all dilutions

so

$$V_{sr} = \frac{.0036}{1 + 50 \times 8.1} \text{ ft./d} = 8.9 \times 10^{-6} \text{ or } 3.2 \times 10^{-3} \text{ ft./yr.}$$

Sorptive capture by the rocks at the site (both the Pierre Shale and the alluvium) will prevent cobalt-60, strontium-90, and cesium-137 from reaching the biosphere.

Dispersion

Ogata (1976) provided a complete discussion of two-dimensional steady-state dispersion in a porous medium. In his treatment he assumes horizontal flow through a region receiving that contributes a dispersant to the flow over a length (2a) that is normal to the flow. These assumptions closely approximate those at the site. If recharge through the trenches occurs, then a steady release rate of radionuclides (Co) could occur. However, to solve Ogata's equation requires a computer.

We may estimate the minimum dilution at 1,000 years by the simple, though more conservative, relationship:

$$C/Co = (H\pi Dt)^{-\frac{1}{2}} \exp- (x-vt)^2/4Dt$$

Where x is the distance from the trenches (ft.)

v is the ground-water velocity (.0036 ft./d)

t is elapsed time (3.65×10^5 days or 1,000 years)

D is the longitudinal dispersion coefficient

(.036 ft^2/d or .14 ft./day)

For the site the relationship becomes:

$$C/Co = .0025 \exp- [(x-1314)^2/52560] \text{ for } D = .036 \text{ ft.}^2/d$$

or

$$C/Co = .0012 \exp- [(x-1314)^2/20440] \text{ for } D = .14 \text{ ft.}^2/d$$

The following tabulation gives the dilution C/CO for selected (x) and D = .036 and .14 $ft.^2/d$:

x(ft)	C/CO @ 3.65×10^5 days	
	for D = .036 ft^2/d	for D = .14 ft^2/d
2,000	.02	.0001
3,000	8×10^{-27}	1×10^{-8}

Using a model developed by De Jong (personal communication, 1971) for the dilution at infinite time, we obtain dilutions as follows:

x(ft)	for D = .036 ft^2/d	for D = .14 ft^2/d
1,000	4×10^{-4}	--
2,000	less than 3×10^{-4}	6×10^{-4}
3,000	---	4×10^{-4}

Clearly the choices of model to determine dispersion is important. However, either model suggests that, for the radionuclides involved (those with half lives of 30 years or less) dispersion will preclude their passage to the biosphere within 1,000 years of burial.

Seismicity

The site is in an area where earthquakes have occurred recently. These earthquakes do not appear to be due to movements on specific fault zones. The principal effect of a large-magnitude earthquake centered near the site would be to shake the overburden. Open trenches might suffer from the collapse of the trench walls and filled trenches would probably undergo settling and possibly cracking, due to rapid compaction of the fill. Large magnitude cracks would not develop in the shale.

A comprehensive report relating to seismicity is contained in Appendix III-3.

RECOMMENDATIONS

Monitoring Program

Because recharge on the site discharges to evapotranspiration over a fairly well-defined area and to the stream, and because of the very large evapotranspiration loss of infiltrating water, size monitoring should include an extensive program of sampling soils and plants. The program should be extended to cover soils and plants in the discharge area defined in Figure 38.

Soil-moisture sampling is a must. Porous-cup lysimeters should be located in two areas around the site:

(1) five should be equally spaced around the outer perimeters of the trenches; and

(2) five should be located in the discharge area crossed by the cross-sections BB', CC', and EE' (Fig. 33b, c, and e).

This sampling program should be geared to the precipitation at the site.

Besides samples collected at routine intervals, special samples should be collected:

(1) at bi-weekly intervals following rains that exceed one inch; and

(2) in the Spring, following snow melt that produces infiltration (as indicated by soil temperatures or soil-moisture gauges).

Because the ground-water flow clearly is in a local flow system, additional piezometers should be placed along cross-sections BB', CC', and EE' (Fig. 33b, c, and e) in a rectilinear grid.

Water samples at the site should be obtained in this manner:

(1) bail the hole dry if possible (otherwise remove 10 gallons of water); and

(2) <u>two weeks later</u> obtain samples by bailing.

Surface Water

The need to measure surface discharge is not acute. At first we believed that, ground-water would discharge to streams in significant volumes and therefore streamflow measurements would go hand-in-hand with surface-water sampling. Now we believe that the need to sample soils and plants where ground-water discharge to evapotranspiration has a concentrating effect is far more necessary. Streamflow monitoring should therefore have very low priority.

Erosion Control

To prevent erosion, trench design must include runoff capability for at least the 100-year rain. Gully control practices must be implemented to prevent growth of existing gullies and incipient gullies along Van Bremmer and Vermejo River.

Additional Work

Additional work should be implemented to determine if the monitoring program is adequate. The behavior of moisture in the unsaturated zone near trenches should be appraised in greater detail once operations begin. This involves making at least five on-site measurements of the percent soil moisture at five-foot intervals to the water-table and installing and calibrating soil-moisture gauges. Monitoring of these installations would provide a basis for determining the need for additional soil-moisture samples of whether the soil-moisture monitoring program is even necessary.