Case 5899

AN EVALUATION OF GRAVEL PITS FOR SALT WATER DISPOSAL

EUNICE AREA

LEA COUNTY, NEW MEXICO

PREPARED FOR

WALLACH BROTHERS

EUNICE & HOBBS, NEW MEXICO

ED L. REED & ASSOCIATES

CONSULTING HYDROLOGISTS

MIDLAND AND SAN ANGELO, TEXAS

FEBRUARY, 1977

EXHIBIT 7

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AN EVALUATION OF THE FEASIBILITY OF USING
GRAVEL PITS FOR SALT WATER DISPOSAL

INTRODUCTION

This firm has examined gravel pits located in the southwestern quarter of Section 29, T. 21 S., R. 38 E., Lea County, New Mexico, to evaluate their potential usefulness as disposal sites for salt water. The gravel pits lie on a surface that slopes west and south towards Monument Draw (figure 1). This report summarizes our evaluation and recommendations.

GEOLOGIC INVESTIGATION

The surface in this area is underlain by sands and gravels of the Ogallala Formation. The thickness of the sands and gravels ranges from 0 to about 20 feet. In places silty, yellow clay is present at the base of the Ogallala. The Ogallala overlies generally silt-free, green and red clays of the Triassic red beds. The Cretaceous sediments which normally overlie the Triassic have been largely removed although large blocks of Cretaceous limestone are present within the basal Ogallala. The Triassic dips regionally to the south-southwest. A linear depression is developed in the Triassic in the immediate area of the pits, probably due to channeling during Ogallala time.

Seventy-six test holes were drilled through the Ogallala into underlying Triassic around the margin and within the pits. These test holes, as well as Triassic exposures present in the pit walls, pit rims, and floors were mapped with a plane table and alidade. The resulting maps show the configuration of the top of the Triassic (figure 2) and the general topography of the floor of the pits (figure 3). These data verify that a linear depression in the Triassic trending east-northeast underlies most of the pits. The regional dip is interrupted by this depression; it resumes south of the depression.

UTILIZATION OF PITS FOR DISPOSAL PONDS

The Triassic map generated in this study shows that the linear depression in the red beds does not form a completely enclosed basin. Three openings in the linear depression could allow waste water to escape unless modified: the east side of pit 3, the west side of pit 4, and a small swale south of pit 1. The following discussion summarizes the suitability and modifications of each pit.

Pit 1: Before contaminants could be adequately contained within pit 1, three dikes/core trenches would be required (figures 2 and 4): on the west side, a dike (A) of compacted clay generally not over 7 feet high; a core trench south of pit 1 (B) in which the vertical thickness of compacted clay would range between 0 and 5 feet; a combination core trench and dike across the eastern end (C) which would require an average vertical thickness of about 10 feet of clay within the pit. The elevation of the top of the dikes and core trenches around pit 1 should be 3451 feet above sea level. The water level in pit 1 should not exceed a sea level elevation of 3447 feet to maintain a 4 foot freeboard (figures 2 and 4). Assuming an average depth of water of 2 feet in pit 1, approximately 15 acre feet or about 116,000 bbls could be stored within this pit (table 1).

Pit 2: Pit 2 is unusable in its present configuration, primarily because its floor slopes upward toward the north. This pit could be used as a source of clay for the dikes and core trenches. The floor, therefore, could be lowered to an elevation similar to pit 1. No additional diking or core trenching other than that required for pit 1 would be required. The water level should not exceed an elevation of 3447. Again, assuming an average water depth of 2 feet, about 2.5 acre feet or 20,000 bbls could be stored within this pit.

Pit 3: This pit may be undesirable because extensive core trenching is required. Prior to utilization of this pit, a core trench should be constructed around the south, east and northeast sides (D, figure 2). If the top of the clay in this core trench was at an elevation of 3445 feet, the impounded water should not rise above an elevation of 3441 feet. In its present configuration (figure 3) approximately 0.6 acre foot or 4700 bbls could be stored in pit 3 with an average depth of 1 foot. Again, if core trenching materials were removed from this pit such that the floor was essentially flat at an elevation of 3440 or less, the storage capacity would be increased to over 2 acre feet or about 18,000 bbls (table 1).

Pit 4: This pit will require a core trench around its west side (figures 2 and 4). Were the top of the clay in the core trench constructed to an elevation of 3439, water could be stored to a maximum elevation of 3435. Once this core trench has been constructed, approximately 19.5 acre feet (151,000 bbls) could be stored below the 3435 contour if the average depth is 15 feet.

Pit 5: This pit appears to be useable in its present configuration, if the water does not exceed an elevation of 3444. Assuming an average 5 foot depth, approximately 3 acre feet (23,000 bbls) could be stored in this pit.

Pits 6 and 7: These pits would require that dikes and core trenches almost completely enclose them before they could be considered as disposal sites. For this reason, they are not recommended at this time.

EVAPORATION POTENTIAL

We have calculated the net evaporation from records at the Red Bluff Dam approximately 60 miles southwest of this site (tables 2 and 3). Table 2 shows the average net evaporation that could be expected in each of the pits. These data are based on monthly evaporation and precipitation averaged for 15 years of records at Red Bluff Dam. Table 3 lists the net evaporation that could be expected in a year of unusually high rainfall and low evaporation.

To prevent excessive accumulation during low evaporation months, not over 0.41 feet (3180 bbls) should be applied per month per acre (table 4).

Table 4 shows that an accumulation of 2.5 feet would be expected during 20 consecutive months of low evaporation and high rainfall.

Table 5 lists the average monthly volumes which can be applied to each of the pits such that a rate of 3180 bbls per acre is not exceeded. We recommend that one of the pits, preferably one with high storage and low evaporation potential such as pit 4, be dedicated to emergency storage. For instance, should there be several consecutive years of low evaporation and high rainfall, the maximum recommended water elevation in the pits would be exceeded unless additional unused storage was available.

DIKES

Dikes should be constructed in the following manner.

1. A shallow trench should be dug at least two feet into the Triassic.
2. Red bed material brought in from other pits should be laid down in 6 to 8 inch layers.
3. Water should be sprayed on this layer to increase the moisture content to optimum conditions.
4. This layer should be compacted using some device such as a sheepsfoot.
5. This procedure should be repeated until the dike has reached its designated elevation. A 2:1 slope on the sides is recommended.

CORE TRENCHES

Core trenches should be designed in the following manner.

1. A trench should be dug through the Ogallala at least two feet into the Triassic. The trench should be dug with a bulldozer, because of depths and need for compaction of clay backfill.
2. Six to eight inch layers of clay should be laid down in this trench to optimum conditions.
3. Water should be sprayed on each layer to increase its moisture content.
4. Each layer should then be compacted.
5. This procedure should be repeated until the core trench

has reached its designated elevation.

Table 6 lists the approximate volumes of material that will have to be moved to construct dikes and core trenches. To build dikes/core trenches for pit 1, for instance, would require moving between 6,000 and 7,000 cubic yards of material.

PERMEABILITY

Fifteen core holes were drilled to provide material on which to run in situ permeability tests. These holes (figure 2) were drilled with an air rotary rig into the top of the Triassic, and shelby tube samples were collected. Table 7 lists the in-place permeabilities and Atterburg limits of these samples. In addition, two samples near the top of the Triassic in two holes were remolded for permeability tests. These data, also shown in table 7, show the permeability that could be expected of the core trench and dike material. With the exception of two samples, both near the top (weathered) part of the Triassic, all permeabilities are less than 1×10^{-7} cm/sec. One of these (CH-1, 1-2') has a high liquid limit which suggests that the 1.4×10^{-6} permeability calculated for this sample may be too high. The other (8A, 3-4') contains some silt which accounts for the slightly higher permeability and lower liquid limit. This silty zone is underlain by silt-free red clay which would have a lower permeability.

The two remolded samples (CH-6, 0-5' and CH-11, 3.5-5') have permeabilities between 2.8×10^{-8} and 8.5×10^{-9} cm/sec, essentially one order of magnitude less permeable than the in situ clay. These data indicate that the recompacted clay that will be used for dikes or core trenches will have permeabilities similar to or less than the pit bottoms.

MONITORING

Monitor wells should be constructed around the periphery of all pits to be used (figure 4). These monitor holes should be drilled 6 inches in diameter 5 feet into the Triassic and cased with 4 inch PVC. The PVC should be perforated with at least 8 holes per foot from the bottom of the hole to 4 feet above the maximum water level expected in the pit to be monitored. The PVC should be cemented from the surface to five feet below the surface, or to the top of the perforations, whichever is less. For instance, a monitor well drilled in the vicinity of Test Hole 160 to monitor pit 1 should be drilled to an elevation of 3441 feet and the casing should be perforated to an elevation of 3451 feet.

The monitor wells should be checked for fluids once a month for the first two years of operation, and quarterly thereafter. This monitoring program will allow early detection of leakage from the pits. Should there be leakage, a trench could be dug to the top of the Triassic that would intersect all water moving from the pit; this water could be pumped from the trench, thereby not allowing it to continue down gradient.

RUNOFF DIVERSION

It is recommended that diversion terraces be constructed on the uphill side of the pits (where high spoil banks are not present) to divert runoff around the pits. A ridge 2 to 3 feet high (which does not have to be constructed of clay) would be sufficient, but actual heights required will be determined by surveying.

OPERATIONAL PROCEDURES

Oil field brines may contain small amounts of oil which would severely reduce the evaporation potential of the pits. It is recommended that this brine be run through at least two tanks to prohibit oil from being discharged into the pits. This involves, quite simply, pumping the brine into the top of a tank and pulling the brine from the bottom of the tank. If two tanks are used in series, the brine pulled from the second tank and discharged into the pits should be oil free.

One of the pits, preferably pit 5, could be used to contain BS from tank bottoms. The BS, or any fluids derived from it should not be mixed with material in the evaporating ponds. Hence it becomes doubly important to divert runoff around this pit to prevent overflow into one of the other pits.

SALT ACCUMULATION

We have calculated the length of time required to deposit one foot of salt on the floor of a pit using various anticipated salinities and a maximum discharge rate. The rate of salt accumulation for a given salinity is derived from the Texas Water Commission Report LD-0764 (1964).

Table 8 shows the estimated salinities for various oil-producing formations in western Andrews County (Texas Water Development Board Report 157, v.1, 1972). Table 9 shows the estimated number of years required to deposit one foot of salt in the bottom of a pit using a maximum discharge of 0.4 foot/month/acre for various salinities. We would anticipate that the brines discharged into the pits will range from 50,000 to 100,000 ppm. Assuming this figure is reasonable, it would require approximately six years to build up one foot of salt in the bottom of a pit if

0.4 foot of brine were discharged into the pit each month.

This accumulation rate may encourage the deepening of some pits (such as pit 1) to extend its lifetime. This deepening can be accomplished in conjunction with the removal of material needed to construct core trenches and dikes. Removal of one foot of clay from the bottom of pit 1, for example, would provide about 12,000 cubic yards of clay. Half of this clay could be utilized for core trenches or dikes. Two things should be kept in mind before brine is discharged into the pits: (1) every foot removed from the bottom of the pits should increase their life about six years and (2) removal of salt from the bottom of the pits is usually impractical because it presents an additional disposal problem.

SUMMARY

Our study has shown that only one pit can be used for salt water disposal in its present configuration. Modification in the form of core trenches or dikes would be required before disposal in the other pits would be possible. However, these modifications would provide a large area into which salt water could be discharged.

Respectfully submitted,

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Table 1. Storage Capacity

Pit	Max. Elev.	Dike Elev.	Average Max.Depth	Area (Acres)	Storage Capacity AF	bbls
1	3447	3451	2	7.5	15.0	116,375
2 (modified)	3447	3451	2	1.3	2.6	20,000
3	3441	3445	1	0.6	0.6	4,700
3 (modified)	3441	3445	1	2.3	2.3	18,000
4	3435		15(?)	1.3	19.5	151,288
5	3445		5(?)	0.6	3	23,000

Table 2. Potential Evaporation.

	Average of 15 years Red Bluff Dam Net Evap. (inches)	Pit #1 7.5A		Pit #2 Floor Modified 1.3A		Pit #3 Floor Unmodified 0.6A		Pit #3 Floor Modified 2.3A		Pit #4 1.3A		Pit #5 0.6A	
		AF	bbl	AF	bbl	AF	bbl	AF	bbl	AF	bbl	AF	bbl
Jan.	2.18	1.36	10,570	0.24	1,846	0.11	846	0.42	3,242	.24	1,832	0.11	846
Feb.	3.01	1.88	14,595	0.33	2,549	0.15	1,168	0.58	4,476	0.33	2,530	0.15	1,168
Mar.	5.32	3.33	25,796	0.58	4,506	0.27	2,064	1.02	7,911	0.58	4,471	0.27	2,064
Apr.	7.97	4.98	38,646	0.87	6,750	0.40	3,092	1.53	11,852	0.86	6,700	0.40	3,092
May	8.87	5.54	43,010	0.97	7,512	0.44	3,441	1.7	13,190	0.96	7,455	0.44	3,441
June	8.55	5.34	41,459	0.93	7,241	0.43	3,317	1.64	12,714	0.93	7,186	0.43	3,317
July	8.4	5.25	40,731	0.92	7,114	0.42	3,259	1.61	14,491	0.91	7,060	0.42	3,259
Aug.	7.1	4.44	34,428	0.78	6,013	0.36	2,754	1.36	10,558	0.77	5,967	0.36	2,754
Sept.	4.67	2.92	22,645	0.51	3,955	0.23	1,812	0.90	6,944	0.51	3,925	0.23	1,812
Oct.	3.59	2.24	17,408	0.39	3,041	0.18	1,393	0.69	5,338	0.39	3,017	0.18	1,393
Nov.	2.79	1.74	13,529	0.30	2,363	0.14	1,082	0.53	4,149	0.30	2,345	0.14	1,082
Dec.	2.15	1.34	10,425	0.23	1,821	0.11	834	0.41	3,197	0.23	1,807	0.11	834
Total/ year	64.60	40.36	313,243	7.05	54,713	3.23	25,060	12.38	96,061	7.01	54,295	3.23	25,060

AF = Acre feet

bbl = barrels

Table 3. Low net evaporation year.

	1941 Red Bluff Dam Net evap. (inches)	Pit #1 7.5A		Pit #2 Floor Modified 1.3A		Pit #3 Floor Unmodified 0.6A		Pit #3 Floor Modified 2.3A		Pit #4 1.3A		Pit #5 0.6A	
		AF	bbl	AF	bbl	AF	bbl	AF	bbl	AF	bbl	AF	bbl
Jan.	1.17	0.73	5,673	0.13	983	0.06	454	0.22	1.740	0.13	983	.06	454
Feb.	2.08	1.30	10,086	0.23	1,748	0.10	807	0.40	3,093	0.23	1,748	0.1	807
Mar.	3.92	2.45	19,008	0.42	3,295	0.2	1,521	0.75	5,8[illegible]9	0.42	3,295	0.2	1,521
Apr.	4.81	3.01	23,323	0.52	4,043	0.24	1,866	0.92	7,[illegible]3	0.52	4,043	0.24	1,866
May	1.81	1.13	8,777	0.20	1,521	0.09	702	0.35	2,[illegible]2	0.20	1,521	0.09	702
June	5.2	3.25	25,215	0.56	4,371	0.26	2,017	1.0	7,732	0.56	4,371	0.26	2,017
July	6.35	3.97	30,791	0.69	5,337	0.32	2,463	1.22	9,443	0.69	5,337	0.32	2,463
Aug.	6.88	4.30	33,361	0.75	5,783	0.34	2,669	1.32	10,231	0.75	5,783	0.34	2,669
Sep.	2.22	1.39	10,765	0.24	1,866	0.11	861	0.43	3,301	0.24	1,866	0.11	861
Oct.	0.67	0.42	3,249	0.07	563	0.03	260	0.13	996	0.07	563	0.03	260
Nov.	2.55	1.59	12,365	0.28	2,143	0.13	989	0.49	3,792	0.28	2,143	0.13	989
Dec.	1.91	1.19	9,262	0.21	1,605	0.10	741	0.37	2,840	0.21	1,605	0.10	741
Total	39.57	24.73	191,873	4.29	33,258	1.98	15,350	7.58	58,841	4.30	33,258	1.98	15,350

AF = Acre feet

bbl = barrels

Table 4.

	Net Evap. (ft/mo)	*Average Accumulation (feet)	Net evap. for 1941 (feet)	*Accumulation
Jan.	0.18	0.23	0.10	0.31
Feb.	0.25	0.39	0.17	0.55
Mar.	0.44	0.36	0.33	0.63
Apr.	0.66	0.11	0.40	0.64
May	0.74	0	0.15	0.90
June	0.71	0	0.43	0.88
July	0.70	0	0.53	0.76
Aug.	0.59	0	0.57	0.60
Sep.	0.39	0.02	0.19	0.82
Oct.	0.30	0.13	0.06	1.17
Nov.	0.23	0.31	0.21	1.37
Dec.	0.18	0.54	0.16	1.62
Jan.	0.18	0.77	0.10	1.93
Feb.	0.25	0.93	0.17	2.17
Mar.	0.44	0.90	0.33	2.25
Apr.	0.66	0.65	0.40	2.26
May	0.74	0.32	0.15	2.52
June	0.71	0.02	0.43	2.50
July	0.70	0	0.53	2.38
Aug.	0.59	0	0.57	2.22

*This accumulation is based on an application of 0.41 feet of water (3180 bbls per acre) each month.

Table 5. Proposed maximum monthly rate of disposal. Discharge rate will place 0.41 feet of water per month into each of the pits.

Pit #	AF/mo.	bbls/mo.	
1	3.08	23,857	
2 (modified)	0.53	4,112	
3 (unmodified)	0.24	1,862	
3 (modified)	0.95	7,370	
4	0.53	4,135	
5	0.24	1,862	
		43,198	Total

Table 6. Estimated volumes of material to be moved.

Dike or Core trench	Volume of clay for structure (cubic yards)	Volume of overburden (cubic yards)
A	1,600	
B	800	2,800
C	1,600	
D	1,500	2,500
E	700	1,800

Table 7. Permeability of the pit floors.

SOUTHWESTERN LABORATORIES

SUMMARY OF TEST

PROJECT: PROPOSED SALT WATER DISPOSAL PIT - EUNICE, NEW MEXICO

CLIENT: Ed L. Reed and Associates

DATE: 2-10-77

BORING NUMBER	DEPTH (FEET)	TYPE OF MATERIAL (By ELR&A)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	ATTERBURG LIMITS			LINEAR SHRINKAGE (%)	Coefficient of Permeability cm/sec
					LL	PL	PI		
1	1-2	Red clay, little to no silt.	15	118	51	25	26	13	1.4×10^{-6}
2	4-5	Green clay, dense, some silt.	12	120	38	16	22	11	5.6×10^{-8}
2	7-7.5	Red clay, little to no silt.	12		49	21	28	13	8.4×10^{-10}
3	0.5-1.5	Red clay, no silt.	27	95	58	24	34	16	5.0×10^{-7}
4	7-8.5	Red clay, no silt. Minor green clay.	17	112	58	22	36	17	6.5×10^{-8}
5	2-3.5	Red clay, no silt.	25	96	59	25	34	16	4.3×10^{-8}
6	1.5-2	Mottled red clay, minor silt and sand.	10	123	29	15	14	6	1.7×10^{-7}
6	6-6.5	Green clay, some silt.	7		27	12	15	7	2.6×10^{-7}
7	4-5.5	Green clay, little to no silt.	19	109	56	21	35	16	8.4×10^{-10}

SWL FORM 8-K2

SOUTHWESTERN LABORATORIES

SUMMARY OF TEST

PROJECT: PROPOSED SALT WATER DISPOSAL PIT - EUNICE, NEW MEXICO

CLIENT: Ed L. Reed and Associates

DATE: 2-10-77

BORING NUMBER	DEPTH (FEET)	TYPE OF MATERIAL (By ELR&A)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	ATTERBURG LIMITS LL	PL	PI	LINEAR SHRINKAGE (%)	Coefficient of Permeability cm/sec
8A	3-4	Green and red mottled clay, minor silt.	9		27	12	15	7	3.4×10^{-6}
9	1-2.5	Red clay, no silt.	23	100	57	22	35	17	3.9×10^{-8}
10	2-2.5	Red clay, minor silt.	9		36	16	20	9	LESS THAN 10^{-8}
11	3.5-5	Red clay, little to no silt; Minor green clay.	15	116	40	20	20	11	1.9×10^{-7}
11	14-15	Red clay, little to no silt.	16	115	47	22	25	13	1.9×10^{-7}
12	6-7.5	Red clay, little to no silt. Minor green clay.	11	124	42	17	25	13	3.8×10^{-10}
13	1-2	Red clay, little to no silt.	12	123	40	16	24	11	7.4×10^{-8}
14	11-12.5	Red and green clay, little to no silt.	16	114	42	15	27	14	2.9×10^{-9}
6	0-5	Remolded red and green clay, silty clay, minor clay silt.	30	90					8.5×10^{-9}
11	3.5-5	Remolded red clay, little to no silt, minor green clay.	29	92					2.8×10^{-8}

SWL FORM 8-82

Table 8. Approximate salinities of oil field brines in western Andrews County, Texas. (Texas Water Development Board Report 157, v. 1, 1972).

Formation/Age	Salinity (ppm)
Ellenberger	50,000
Siluro-Devonian	50,000
Mississippian	50,000
Pennsylvanian	50,000 - 100,000
Wolfcamp	50,000 - 100,000
Leonard	50,000 - 100,000
San Andres	50,000 - 100,000
U. Guadalupe	150,000 - 250,000

Table 9. Estimated years required to accumulate one foot of salt at various salinities, and a maximum rate of discharge of 0.41 ft/month.

Salinity	Foot of salt/ foot of water	Salt accumulation per year (feet)	No. years/ 1 foot salt
50,000	0.023	0.113	8.9
75,000	0.036	0.177	5.6
100,000	0.050	0.26	4.1
150,000	0.076	0.374	2.7

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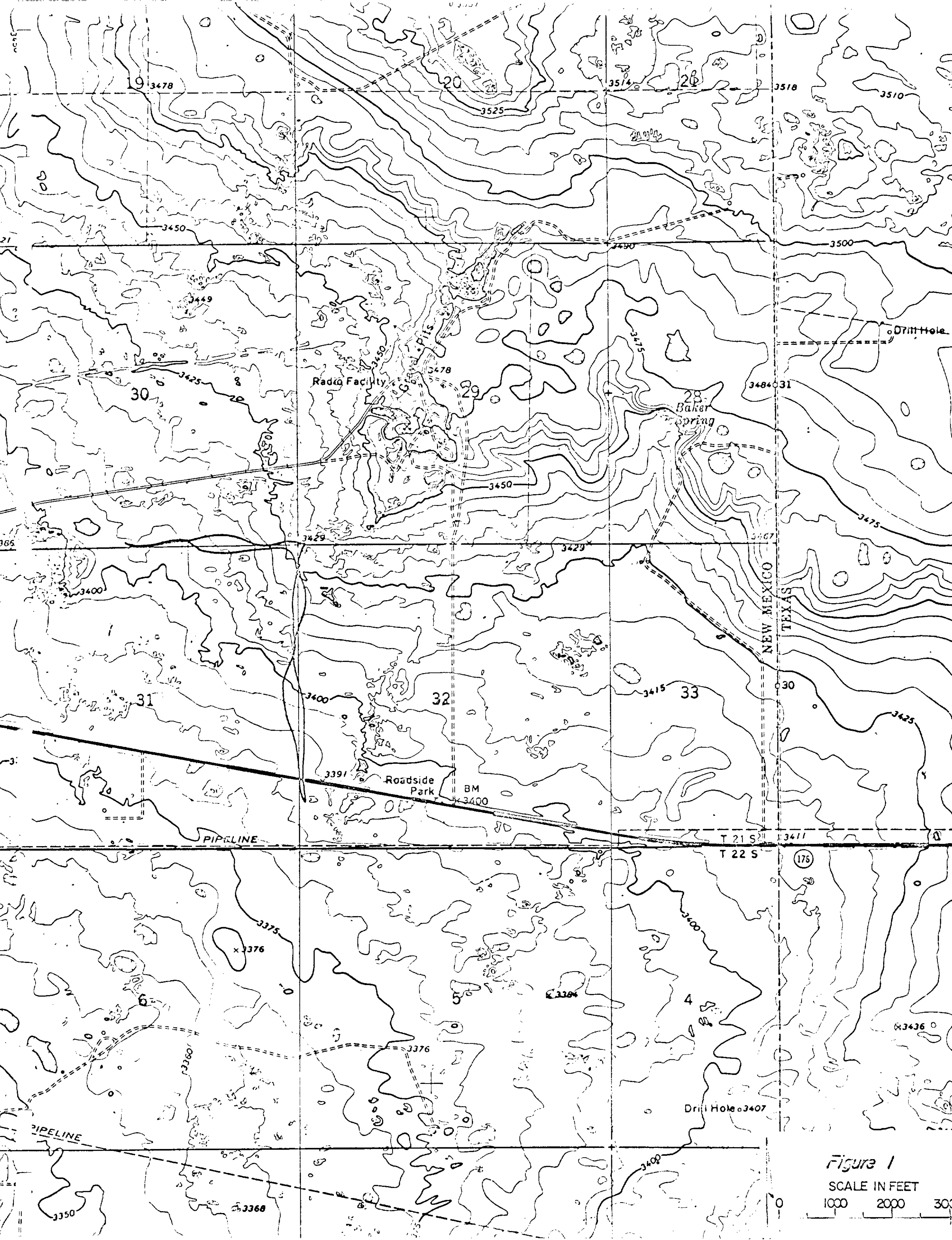

Figure 1

SCALE IN FEET

0 1000 2000 30