TEXAS WATER COMMISSION

Joe D. Carter, Chairman
William E. Berger, Commissioner
O. F. Dent, Commissioner

Report LD-0365

INVESTIGATION OF GROUND- AND SURFACE-WATER CONTAMINATION NEAR HARROLD, WILBARGER COUNTY, TEXAS

By

Bruce E. Fink, Geologist
Ground Water Division

February 1965

TABLE OF CONTENTS

TABLES

TABLE OF CONTENTS (Cont'd.)

Page

ILLUSTRATIONS

Figures

Plates

Follows

INVESTIGATION OF GROUND- AND SURFACE-WATER CONTAMINATION NEAR HARROLD, WILBARGER COUNTY, TEXAS

INTRODUCTION

On May 20, 1964 the Texas Water Commission received a letter, forwarded by the Texas Water Pollution Control Board, from Mr. J. P. Holliman of Route 2, Vernon, Texas, which stated that salt-water seepage along China Creek east of Harrold, Wilbarger County was causing pollution to both surface and subsurface waters in the area.

A field investigation of this complaint was conducted during the period July 6 to July 9, 1964. During the study, water samples were collected from China Creek and from water wells in the area, and sources of highly mineralized brines in the nearby National oil field were investigated.

Location, Topography, and Economy

Wilbarger County is located in northern Texas (Figure 1). It is bounded on the north by the Red River and lies within the Osage Plains physiographic province. The area of investigation is located east of Harrold, a small community in the northeastern part of Wilbarger County.

Topography of the area is slightly rolling and the maximum relief in the area of investigation is about 60 feet (Figure 2). The area is drained by China Creek, which flows eastward into the Old Electra City Lake in Wichita County, which was formerly used as a municipal water supply.

The local economy is based on oil production, agriculture, and ranching.

Previous Pollution Investigations

Personnel of the District 9 office of the Texas Railroad Commission conducted a field investigation of salt-water seepage in China Creek on June 2, 1964 and July 1, 1964. These investigations consisted primarily of collecting water samples for chloride determinations and checking bradenhead pressures of oil wells and salt-water disposal wells in the National oil field.

During the study conducted by Davis (1963), surface and subsurface salt-water contamination was reported along China Creek in the National oil field area.

GENERAL GEOLOGY

Rocks exposed at the surface in the area of investigation consist primarily of shale, clay, and sandstone which belong to the Clear Fork and Wichita Groups of Permian age. Thin alluvial deposits are present along stream channels

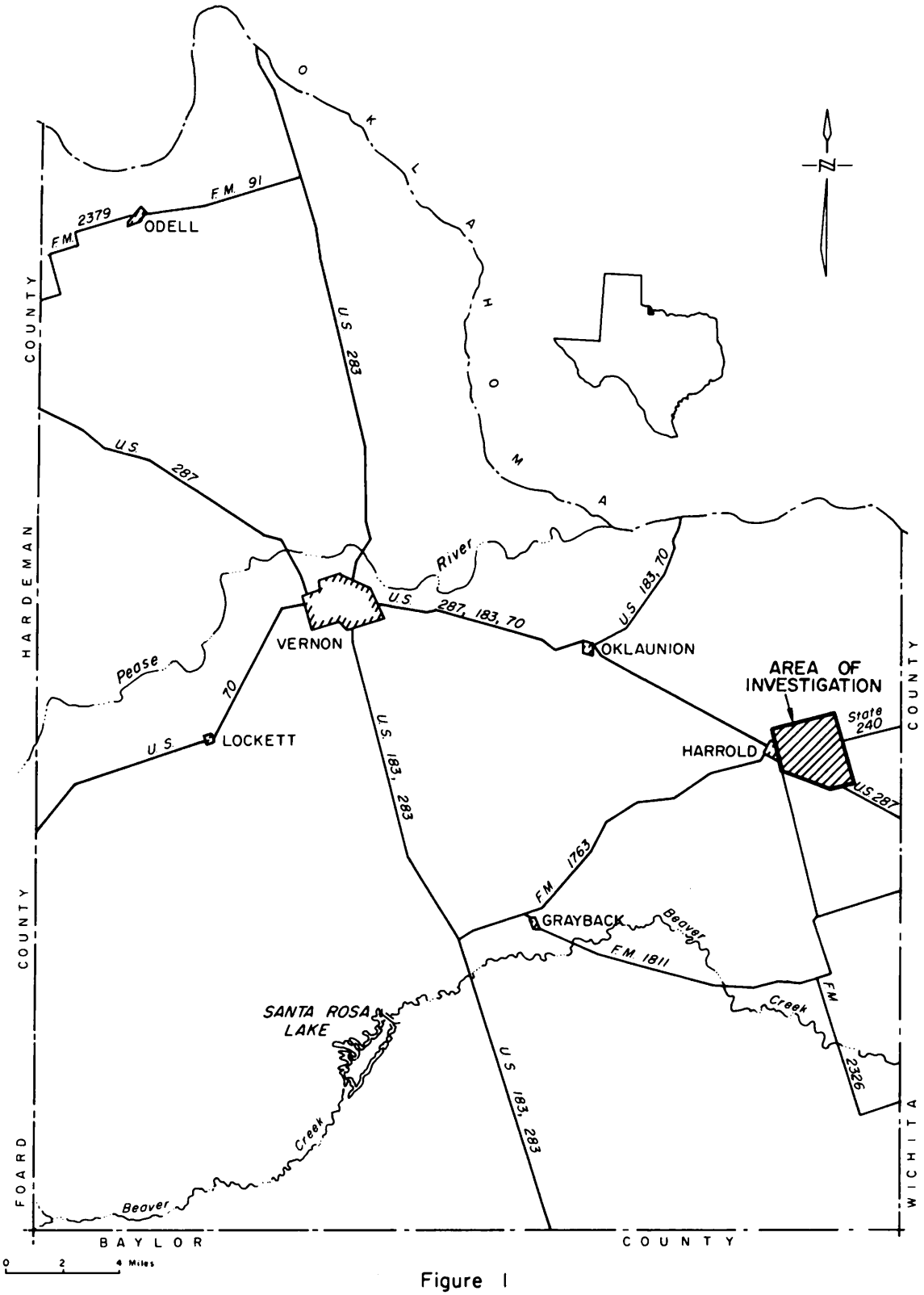
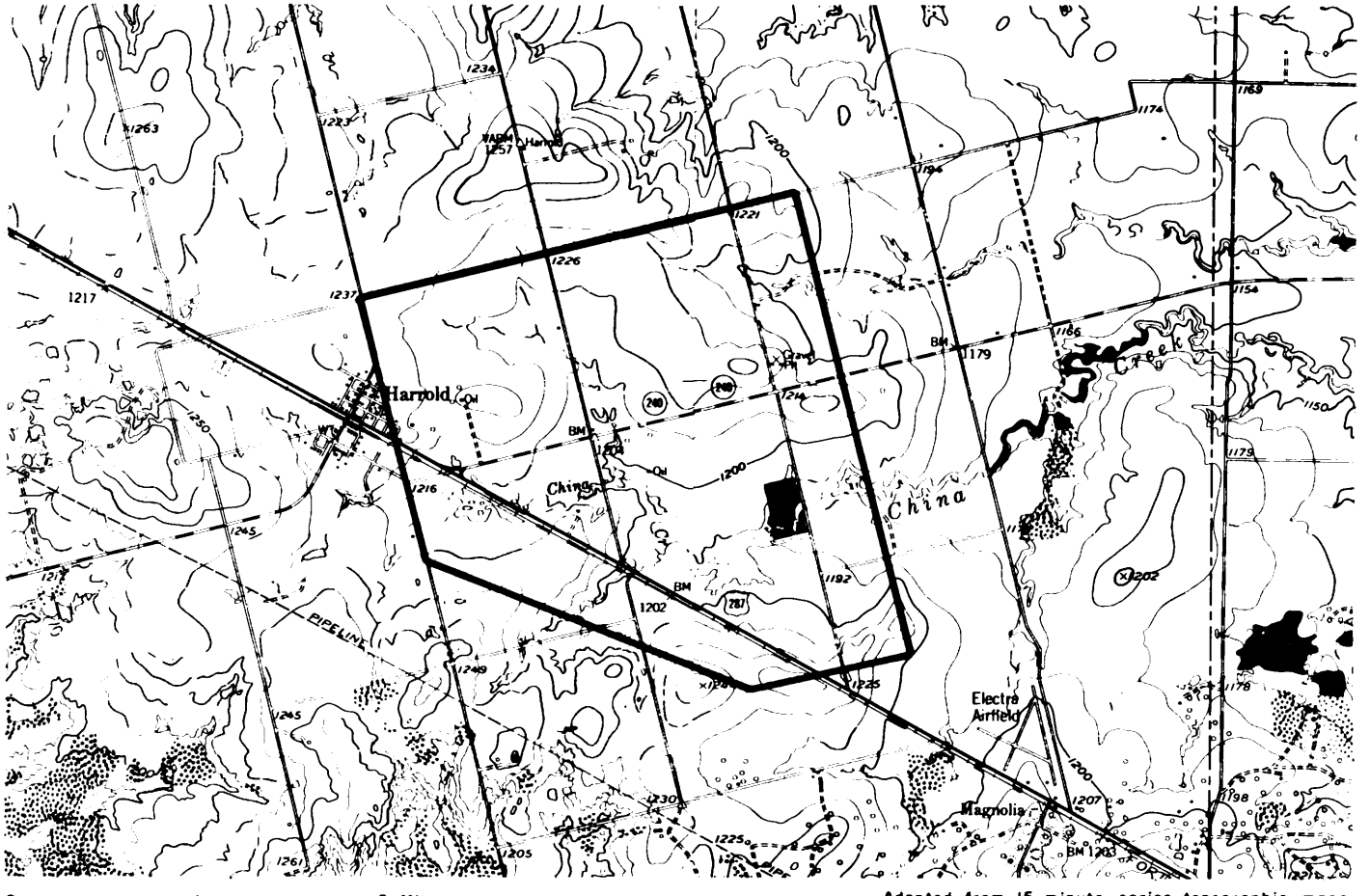


Figure 1

Index Map Showing Location of Area of Investigation

Texas Water Commission

189



Adapted from 15-minute series topographic maps prepared by the U.S. Geological Survey.
Contour interval, 10 feet.

Figure 2

Topographic Map of a Part of Wilbarger County Showing Area of Investigation

Texas Water Commission

and surface drainage ways.

A part of the stratigraphic section encountered during drilling of oil tests in the area is shown in Figure 3, which is an electric log of an oil test in the National oil field. The local oil-producing horizons are indicated on the log; the Ellenburger Limestone of Ordovician age being the oldest formation penetrated.

In general, the Permian strata in the area dip toward the west-northwest at the rate of about 40 feet per mile (Baker and others, 1963, p. 21). A large structural feature that underlies the area is the Red River uplift, which is an east-west trending anticline extending across six counties in northern Texas.

OIL AND BRINE PRODUCTION

The discovery well in the National oil field was drilled July 2, 1945, and most of the development took place during the year 1946.

Many of the oil wells in the field were plugged and abandoned by 1951; however, the June 1, 1964 Railroad Commission proration schedule indicates seven oil wells currently on production in the area. As of June, 1964, one well was producing in the National /Caddo/ field, three wells were producing in the National /Canyon Lime/ field, and three wells were producing in the National /Ellenburger/ field. Figure 3 shows the stratigraphic relationships of the producing horizons. As of January 1, 1964 a cumulative total of 1,913,488 barrels of oil had been produced from the various National fields.

The 1961 salt water inventory conducted by the Railroad Commission in cooperation with the Texas Water Commission and the Texas Water Pollution Control Board indicates that brine production for the calendar year 1961 totaled 84,250 barrels in the National oil field. Reported daily and yearly brine production for 1961 is tabulated by lease in Table 1.

OCCURRENCE OF GROUND WATER

Water wells in the area are completed in alluvial sedimentary deposits along China Creek and in thin Permian sandstone beds which lie near the surface. Most of the wells were hand dug to depths of approximately 20 feet, and are cased with brick or concrete tile. The wells yield small amounts of water which is used for domestic and stock-watering purposes (Table 3).

The static water levels in the wells range from 0 to 13 feet below land surface. The ground water occurs under water-table conditions and therefore would be expected to move in the direction of the slope of the water table. The slope of the water table, or hydraulic gradient, is controlled by the topography of the land surface and the configuration of relatively impermeable Permian shale or clay beds underlying the alluvium locally. Figure 2, the topographic map, indicates that the area of the National oil field is about 25 to 50 feet higher in elevation than the mineralized springs in China Creek. Since ground-water movement is at least partly controlled by the topography of the land surface, it would also be expected that salt water migrating into shallow fresh water zones in the oil field would eventually move into China Creek.

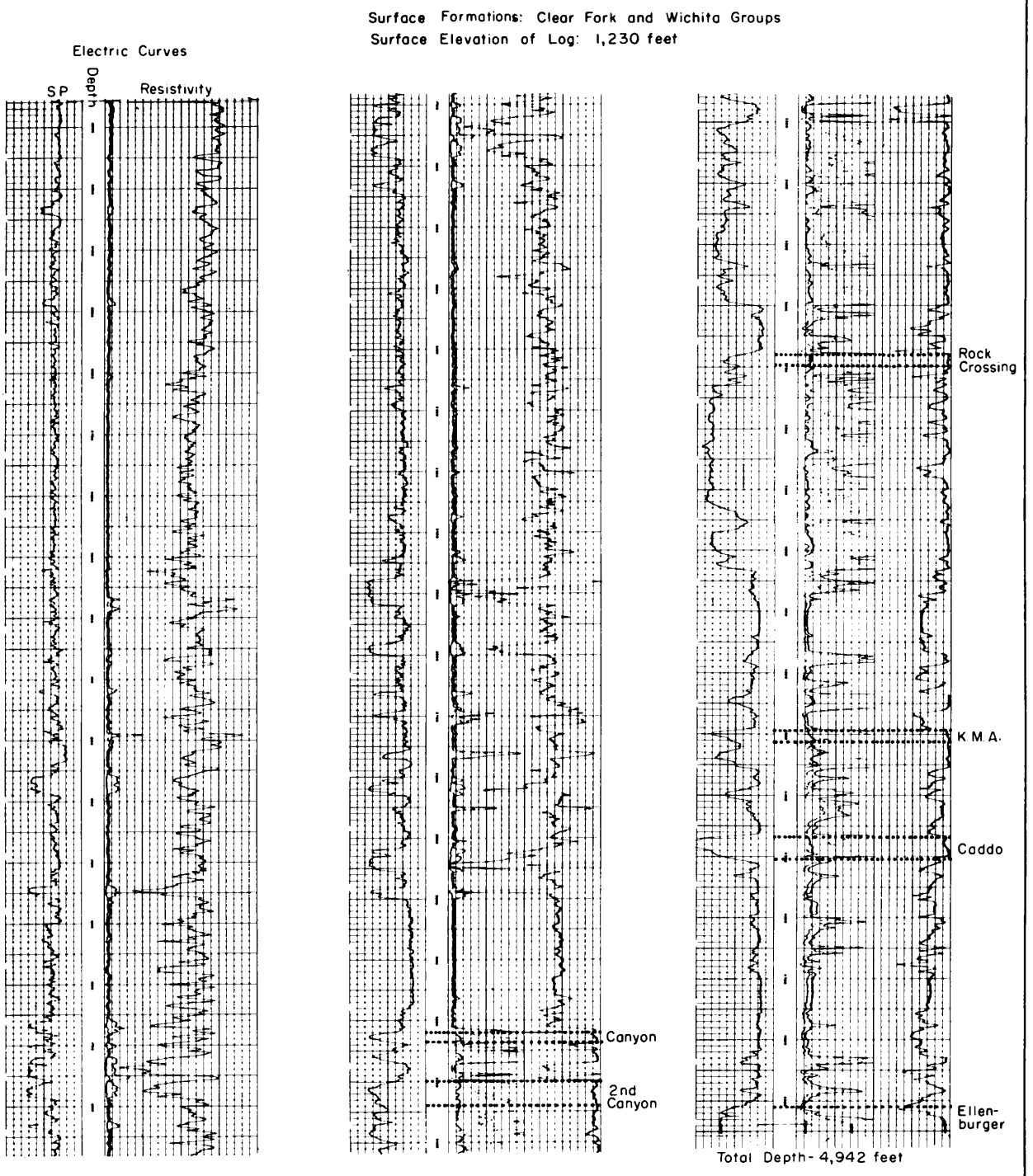


Figure 3

Electric Log Showing Typical Stratigraphic Section of Rocks Penetrated in the National Oil Field

Texas Water Commission

189

The chemical composition of the natural ground water in the area varies because water wells may produce from alluvial deposits, Permian rocks, or both. Drillers' logs of water wells are not available; therefore, the age and precise lithologic characteristics of the water-bearing formations penetrated in individual wells cannot be accurately determined. Ground water currently being used in the area is of a calcium-magnesium bicarbonate type.

Usable ground water occurs only in small quantities in the study area; therefore, surface water is an important source for livestock-watering. Electra City Lake, located on China Creek in Wichita County, was used in the past as the municipal water supply for the town of Electra. The water in this lake reportedly became too mineralized for municipal use. The town presently obtains its water supply from a new city lake located on Camp Creek in Wilbarger County and from several shallow, low capacity wells located north of Electra near the Red River. The town of Harrold presently depends entirely upon surface water for its municipal supply.

POTENTIAL SOURCES OF CONTAMINANTS

Highly mineralized contaminants in the area may be derived from any or all of three potential sources, these being; (1) subsurface disposal of produced oil-field brines, (2) inadequately cased and/or cemented oil wells or inadequately plugged abandoned oil wells, and (3) seepage from unlined earthen pits used in the past for the disposal of produced brines.

Subsurface Injection

There are six brine-disposal wells currently being used in the National oil field (see Plate 1). Four other wells were formerly used for brine disposal purposes during the years 1947 to 1951, but were abandoned and plugged in 1951.

Table 2 gives completion data and operating conditions of each disposal well, as reported by operators in the original permit application to the Railroad Commission. Brine is injected through the long string into zones ranging from 1,150 feet to 4,453 feet deep in three of the disposal wells; however, application forms do not indicate the presence of cement above the injection zones in two of these wells. This suggests that injected brines are free to migrate up the bore holes outside the long string. In one disposal well, brine is injected through tubing into a zone 4,880 feet deep; however, a tubing packer was not used to prevent brine from rising in the long string where possible corrosion could allow fluids to escape at shallower depths. Brine is injected through the surface casing-long string annulus in two wells at depths of 133 feet and 155 feet respectively. Shallow annular disposal wells and other completions that allow brine to migrate freely in the surface casing-long string annulus are hazards to ground-water resources since the horizons which receive the injected brine are generally not known. Injected brine can migrate into the fresh water-bearing horizons, either upward behind the surface casing, if it is not adequately cemented, or through the surface casing as a result of corrosion.

During the month of June, 1964, personnel from the Texas Railroad Commission office at Wichita Falls recorded bradenhead pressures in producing oil wells and brine disposal wells in the National oil field. The recorded bradenhead pressure in the Sam Kelly "A" Well No. 6 was 25-35 psi (pounds per square inch), and in the Sam Kelly "C" Well No. 3 was 5 psi (estimated). Bradenhead pressure in the other wells were recorded as zero. These data suggest that brine disposal wells in the area are not causing abnormally high pressures to develop in the various horizons exposed in the well bores.

Inadequately Plugged Wells

Railroad Commission plugging reports (Table 5) indicate that the majority of the oil wells were plugged with "mud-laden fluid and cemented hole", and no down-hole cement plugs were used. Records of about 30 wells were not specific as to whether or not casing was left in the wells upon abandonment or if the surface casing was cemented in place. If the surface casing has been pulled from these wells, then fresh water-bearing zones could be exposed to salt water which may be rising in the bore holes due to the subsurface injection operations in the area.

Surface Pits

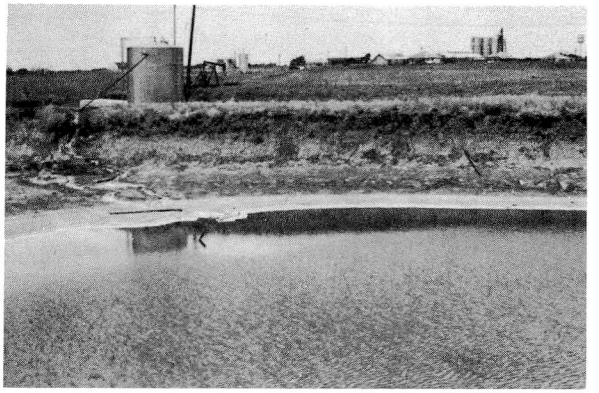
Unlined earthen surface pits are very obvious sources of contamination; however, there are presently only two pits located in the National oil field (Plate 1), and both were reported as not being in use. At the time of this investigation, a pit located on the Sam Kelly "C" lease contained a considerable quantity of salt water which reportedly was discharged into the pit while an injection well pump was being repaired (Figure 4a).

Several surface pits reported to have previously existed in the area have been abandoned and covered, but these pits may have been used for brine disposal in the past. The length of time these pits were used or the amount of brine discharged into them is not known; however, it is possible that these discharges could be a substantial contributor to the current pollution problem in the area.

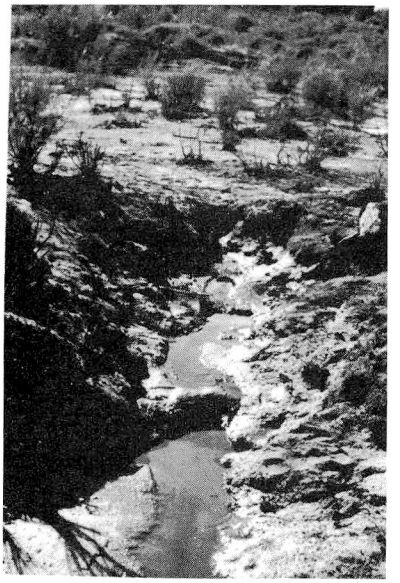
RESULTS OF INVESTIGATION

Samples of water for chemical analysis by the State Department of Health were obtained from seven water wells, two oil wells, and ten sites along China Creek. Analyses of these samples are given in Table 4. Surface water samples 1, 2, and 3 (Plate 1) are relatively low in dissolved solids content as compared to samples 4 through 10. Samples 1, 2, and 3 were taken from earthen stock ponds on China Creek which are presently being used to water livestock. Surface water sample 4 was collected from a small pool in China Creek at the base of a stock tank dam. This sample contained 5,600 ppm (parts per million) chloride, whereas samples 2 and 3, taken from the pond surface contained only 13 ppm chloride. This suggests that the surface water impounded in the stock pond creates sufficient head to prevent the mineralized ground water from discharging into China Creek upstream from the dam.

Figure 4



(a) Brine Disposal Pit Located on the Sam Kelly "C" Lease. View is west.



(b) Salt-Water Spring in China Creek at Sample Site 6.

(c) View of China Creek Looking Northeast From Sample Site 8.

Sample 5 was taken from a small earthen pond which was used for stock-watering purposes several years ago; however, at present cattle will not drink the water.

Sample 6 was taken from a spring in China Creek (Figure 4b) near a garden which was cultivated several years ago. This water contained 22,400 ppm chloride. The garden area is barren of vegetation, and mineral precipitates were present on the soil surface at the time of this investigation. Springs and seeps currently present in this area were reportedly not present in the past.

China Creek reportedly had a constant flow during the summer of 1963 and winter of 1963-64; however, water did not flow in the creek upstream from the large earthen tank. This indicates that the source of the water was from the springs and seeps downstream from sample site 4. It was also reported that the amount of rainfall in the immediate area had been less than normal during the past two years prior to this investigation; however, the "salt water" springs continued to flow.

Samples 7 and 9 were taken from small earthen pits constructed to impound water which was used in the past to irrigate cotton crops. It was reported that about 7 or 8 years ago the use of water from these pits was discontinued because the water caused the soil to become unproductive, and the land lay dormant for three years before the soil would again produce cotton growth.

Nine water wells were located in the area of investigation and seven were sampled for chemical analyses. The analyses indicate that five wells (wells 1, 2, 4, 6, & 9) are contaminated and that two wells (wells 5 & 7) still yield natural water. Water from well 3 was not analyzed, however, it was reported that livestock would not drink this water. Wells 2 and 3 reportedly became highly mineralized "several years ago", and the water from well 1 was used for stock-watering and domestic purposes until the use of this well was discontinued recently because of the high mineral content. Well 2 is a hand dug well more than forty years old and was used as a source of water supply by many of the early settlers in the area. The well has been partially filled with rock, and highly mineralized water (12,900 ppm chloride) was flowing at the surface when observed during this investigation.

Figure 4c illustrates current conditions along China Creek at sample site 8. This photo shows the salt cedar growth present on the south side of the creek and the barren north side of the creek, suggesting that highly mineralized ground water is apparently moving from a northerly direction causing the north creek bank to become too brine saturated for salt cedar growth.

The chemical relationships of the water samples are represented on Plate 1 by means of patterns plotted on radial coordinates. In comparing the patterns, it is evident that the patterns produced by surface water samples 4 through 10, and samples from wells 1 and 2, are similar to the patterns of oil-field brine. In addition, samples from wells 4 and 6 contain high concentrations of chloride, but the percentage of sodium relative to calcium and magnesium is significantly different from that of the oil-field brine. This may be explained by a chemical process known as base exchange, where sodium in the brine is exchanged for calcium and magnesium which is present in the rocks through which the water moves.

In Figure 5, each analysis collected during the investigation is also represented by three points plotted in a combination trilinar diagram. In this illustration the principal cations and anions are plotted in separate fields, while the third point plotted in the upper diamond-shaped field indicates the character of the water as represented by the relationship among the Na + K, Ca + Mg, CO_3 + HCO_3, and Cl + SO_4 ions. Theoretically, where analyses represent two original sources and a mixture, all analyses should plot on a straight line. In practice, however, straight line plots are seldom attained because of ion exchange mechanisms (particularly the cations) in ground-water aquifers. The tendency of the points in the cation and anion triangles to approach a straight-line plot demonstrates the similarity of the waters; the position of the analyses in the central field suggests that base exchange reactions have taken place.

SUMMARY OF CONCLUSIONS

Ground- and surface-water contamination in the area of investigation is considered to be derived from any or all of three potential sources as outlined below.

(1) Several disposal wells are presently injecting brine at shallow depths. Upward migration of brine injected into these wells could possibly reach the water-bearing zones, and ground-water movement toward the southeast, due to the configuration of the land surface, could carry contaminants toward the contaminated area. Possible corrosion of the surface casing in these wells may allow injected brine to flow directly into the fresh water-bearing zones.

(2) Brine injected into the subsurface may be rising or causing natural reservoir fluids to rise in inadequately plugged, abandoned oil wells in the area. These fluids may subsequently discharge into shallow water-bearing zones.

(3) Brine discharged into unlined surface pits in the past perhaps represents a significant contribution to the current contamination problem.

RECOMMENDATIONS

1. Injection of oil-field brine into the subsurface through the surface casing-long string annulus in any existing oil well in the National oil field should be prohibited. Injection of brine into wells that fail to confine injected brine to the injection zone, and allow upward migration in the bore hole, should also be prohibited.

2. The use of unlined surface disposal pits in the National oil field should be prohibited, and all existing surface pits should be destroyed.

3. Tracer surveys should be conducted on all disposal wells in an attempt to determine if these operations are contributing to the contamination problem in the area.

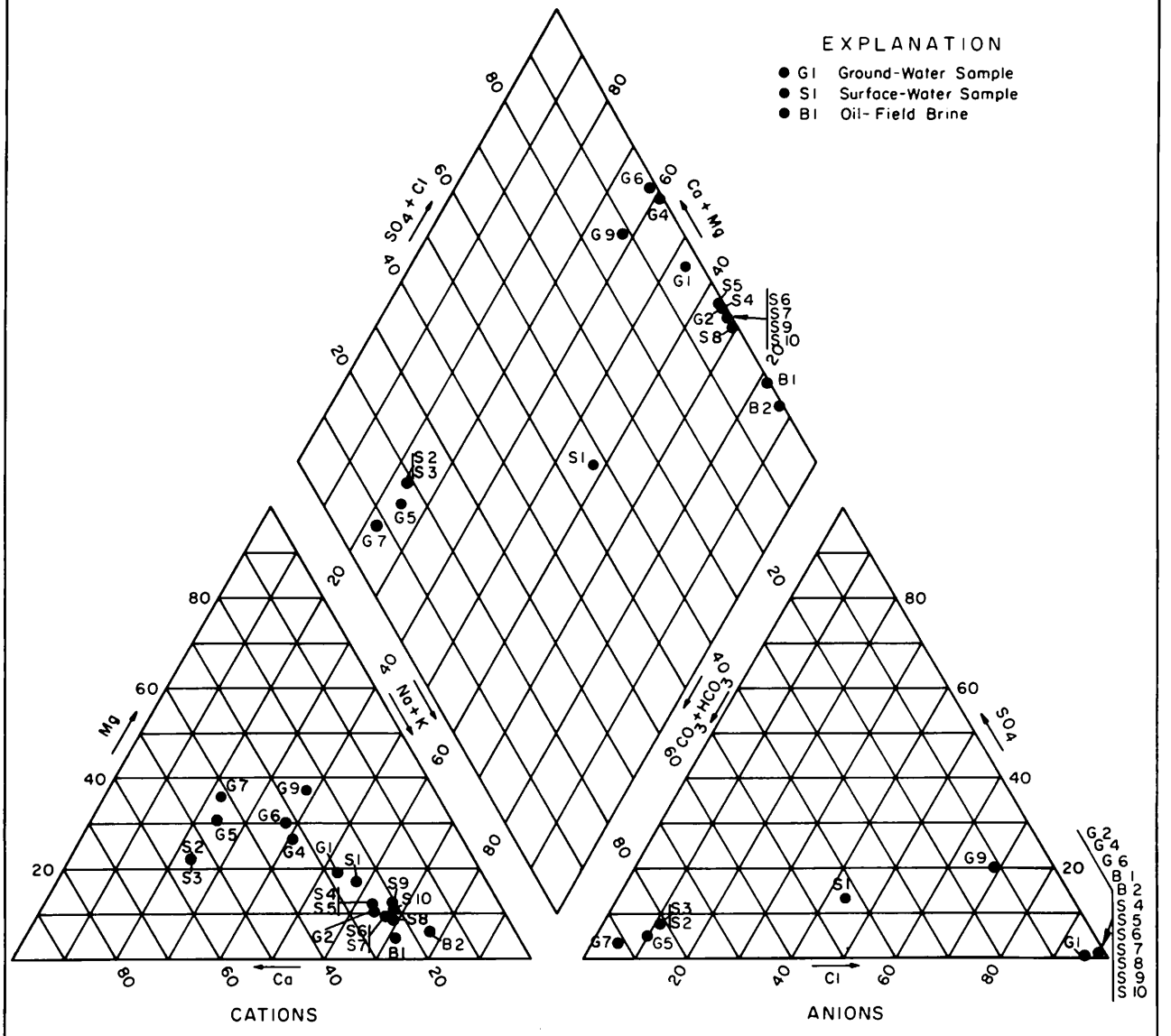


Figure 5

Analyses of Water in the Area of Investigation Represented by Three Points Plotted in Trilinear Diagram

(After A. M. Piper)

Texas Water Commission

189

SELECTED REFERENCES

A statistical analysis of data on oil-field brine production and disposal in Texas for the year 1961 from an inventory conducted by the Texas Railroad Commission, 1963: Prepared by the Texas Water Commission--Ground Water and Electronic Data Processing Divisions-and Texas Water Pollution Control Board, 17 vols.

Baker, E. T., Jr., Long, A. T., Jr., Reeves, R. D. and Wood, L. A., 1963, Reconnaissance investigation of the ground-water resources of the Red River, Sulphur River, and Cypress Creek Basins, Texas: Texas Water Commission Bull. 6306, 127 p.

Davis, John R., 1963, Salinity-alleviation study of oil-field brine conditions in the Red River Basin of Texas: Unpublished report in technical file of Ground Water Division, Texas Water Commission.

Hem, J. D., 1959, Study and interpretation of the chemical characteristics of natural water: U. S. Geological Survey Water-Supply Paper 1473, 269 p.

Piper, Arthur M., 1945, A graphic procedure in the geochemical interpretation of water-analyses: National Research Council, American Geophysical Union Transactions of 1944 Part VI, p. 914-928.

Table 1.--Records of reported brine production and disposal in the National oil field

(Source of data--1961 salt-water inventory, Texas Railroad Commission and Texas Water Commission files, and field notes)

Current operator	Lease	Well Nos.	Producing horizon (s)	Reported brine production 1961 (bbls/day)	Method of brine disposal 1961	Total reported brine for 1961 (bbls)	Current methods of brine disposal	Depth of Injection interval (ft.)	Maximum injection pressure (pounds per square inch)	Remarks
Prince Bros. Drilling Co.	Sam Kelly Estate	3 & 4	Ellenburger	8	Steel tank	300	Injection well	4880-4888 1236-1390	600 175	Disposal into injection wells on Sam Kelly Estate "C" lease. Disposal into steel tank prior to completion of injection well.
Otto Bendorf	Sam Kelly Estate "A"	4	Caddo	20	Injection well	7,300	Injection well	133-2203	50	Disposal into injection well on Sam Kelly Estate "A" lease.
Do.	do	6	Canyon Lime	70	Injection well	25,550	Injection well	133-2203	60	Disposal into injection well on Sam Kelly Estate "A" lease.
Do.	Sam Kelly Estate "C"	1 & 5	Canyon Lime	40	Injection well	14,600	Injection well	155-3061	60	Disposal into injection well on Sam Kelly Estate "C" lease.
Do.	W. J. Sheldon	3	Ellenburger	60	Injection well	21,900	Injection well	1150-2500	60	Disposal into injection well on W. J. Sheldon lease.

Table 2.--Reported completion methods of brine-disposal wells in the National oil field

(Data taken from Texas Railroad Commission and Texas Water Commission files)

	Humble Oil Cora King No. 8	Otto Bendorf Sam Kelly Estate "A" No. 6	National Assoc. Pet. Co. Sam Kelly Estate "B" No. 6	National Assoc. Pet. Co. Sam Kelly Estate "A" No. 3	National Assoc. Pet. Co. Oscar Havens No. 5	Otto Bendorf W. J. Sheldon No. 1	Otto Bendorf Sam Kelly Estate "C" No. 1	Otto Bendorf Sam Kelly Estate "C" No. 3	Prince Bros. Drilling Co. Kelly Estate No. 1	Prince Bros. Drilling Co. Kelly Estate No. 2
Depth to top of injection zone, below land surface (in feet)	3504	133	?	?	3400	1150	155	4453	1236	4880
Depth to base of injection zone. below land surface	3566	2203	?	?	3500	2500	3061	4475	1390	4888
Size of surface casing (inches)	10-3/4	10-3/4	10-3/4	10-3/4	10-3/4	10-3/4	10-3/4	10-3/4	10-3/4	10-3/4
Length of surface casing (feet)	152	133	160	163	160	138	155	136	154	149
Sacks of cement behind surface casing	80	100	125	125	125	125	125	100	100	100
Size of long string (inches)	7	7	5-1/2	7	5-1/2	2-7/8	5-1/2	5-1/2	7	5-1/2
Length of long string (feet)	3684	3649	4929	3400	5051	3321	4895	4453	3774	4935
Number of sacks cement behind long string	110	200	600	250	600	150	700	250	200	290
Size of tubing	-	-	-	-	-	-	-	-	-	2-1/2
Length of tubing	-	-	-	-	-	-	-	-	-	4880
Maximum anticipated volume of brine to be injected daily and maximum injection pressure stated on application by operator to RRC	-	100 bbls 60 psi	-	-	-	155 bbls 400 psi	100 bbls 80 psi	100 bbls 60 psi	100 bbls 600 psi	150 bbls 175 psi
Date application filed with Texas Railroad Commission	1-20-47	1-4-61	-	-	-	7-24-62	1-16-61	1-16-61	4-62	9-14-62
Remarks	Injection through 7" long string; apparently used 1947-51	Injection through surface casing-long string annulus.	Apparently used 1947-1951.	Apparently used 1947-1951.	Used 1947-1948.	Injection through 2-7/8" long string. Application does not indicate any cement above injection zone.	Injection through surface casing-long string annulus.	Injection through 5-1/2 " long string..	Injection through 7" long string. Application does not indicate any cement above injection zone.	Injection through tubing; No packer.

Table 3.--Records of water wells in area of investigation

Method of lift and type of power: S, submersible; C, cylinder; E, electric; N, none
Use of water: D, domestic; P, public supply; S, stock; N, none

Well No.	Owner	Date completed	Depth of well (ft.)	Casing		Water Level		Method of lift	Use of Water	Remarks
				Diameter (in.)	Depth (ft.)	Below land surface datum (ft.)	Date of Measurement			
1	J. P. Holliman	1940?	15	24	20	13.2	7-7-64	S,E	N	Used for domestic and stock in past.
2	do	1920?	-	60	-	0	7-7-64	N	N	Flows.
3	do	-	15	36	15	6	7-7-64	N	N	Abandoned windmill.
4	T. H. Parmelly, etal.	-	20	30	20	12.8	7-7-64	S,E	S	
5	Prince Bros. Estate	-	14	36	14	10.2	7-8-64	C	D,S	
6	-	-	27	36	27	9.6	7-8-64	N	N	Abandoned.
7	Charles Tirey	-	-	30	-	10.6	7-8-64	S,E	P	Supplies water for service station and restaurant.
8	-	-	-	36	-	-	-	N	N	Abandoned.
9	State Highway Dept.	old	15	60	-	8.6	7-8-64	N	N	Abandoned.

Table 4.--Analyses of water samples, Wilbarger County, Texas[1]
(Analyses given are in parts per million except specific conductance, pH, and SAR).

Well	Owner	Depth of well (ft)	Date of collection	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	ABS	Specific conductance (Micromhos at 25°C.)	pH	SAR
1	J. P. Holliman	15	7-7-64	16	970	409	2,120	295	27	5,900	0.7	0.4	9,600	4,100	0.2	21,624	7.0	-
2	do	-	7-7-64	15	860	464	5,500	234	67	12,900	0.8	0.4	20,900	6,600	0.2	47,328	7.3	-
4	T. H. Parmelly	20	7-7-64	34	2,000	1,020	2,900	229	171	10,700	2.4	0.4	17,000	9,200	-	39,984	6.8	-
5[2]	Prince Bros. Estate	14	7-8-64	24	93	40	56	560	24	38	0.7	0.4	570	395	-	1,085	7.9	-
6	Charles Tirey	27	7-8-64	20	3,300	1,880	4,510	192	270	17,800	1.0	0.4	27,900	16,000	-	65,484	7.0	-
7	Charles Tirey	-	7-8-64	16	69	37	40	451	16	13	0.8	0.4	414	324	-	792	7.6	-
9	State Highway Dept.	15	7-8-64	22	380	339	650	500	750	1,880	1.0	0.4	4,270	2,340	-	9,307	7.3	-
Analyses of Surface Water																		
Sample No. 1	J. P. Holliman	-	7-7-64	8	27	11	71	138	33	82	0.7	4.0	305	114	-	612	7.4	-
2	do	-	7-7-64	13	38	9	18	168	12	13	0.7	3	190	133	-	353	7.4	-
3	do	-	7-7-64	11	38	9	18	168	13	13	0.5	5	191	131	-	353	7.5	-
4	do	-	7-7-64	8	770	248	2,420	63	55	5,600	1.0	0.4	9,100	2,950	0.2	20,706	6.6	-
5	do	-	7-7-64	5	1,380	366	3,860	62	69	9,500	0.8	0.4	15,200	4,950	0.2	34,425	6.8	-
6	do	-	7-7-64	8	2,900	700	9,800	81	91	22,400	1.0	0.4	35,900	10,100	0.2	81,600	6.9	-
7	do	-	7-7-64	11	4,140	980	13,600	62	115	32,000	1.1	0.4	51,000	14,400	0.2	113,322	6.8	-
8	do	-	7-7-64	17	12,400	3,050	46,500	34	358	101,000	3.0	0.4	163,000	43,500	0.2	363,324	6.9	-
9	do	-	7-7-64	18	3,960	1,430	14,300	57	421	33,000	1.6	0.4	53,000	15,800	0.2	120,054	6.8	-
10[3]	James McKinnell	-	4-6-64	-	2,248	842	4,968	104	1219	20,022	-	-	-	-	-	-	6.5	22.7
10	do	-	7-8-64	3	3,620	1,150	12,700	48	431	28,400	1.9	0.4	46,300	13,800	-	104,346	6.4	-
Analyses of Oil-Field Brine																		
Source	Producing horizon																	
Kelly "C" lease	Ellenburger	-	7-8-64	4	24,600	3,540	91,000	18	417	195,000	2.4	0.4	315,000	76,000	-	702,270	6.2	-
Kelly "A" lease	Composite of samples from Caddo & Canyon Lime	-	7-18-64	-	12,400	2,440	64,000	-	670	125,000	1.6	0.4	205,000	41,000	-	447,474	5.1	-

1/ Samples analyzed by the Texas State Department of Health
2/ Potassium (K) is 21 ppm
3/ Percent sodium is 54.3

Table 5.--Records of plugging methods of abandoned oil wells in the National oil field
(All data from files of Texas Railroad Commission, Austin)

Operator	Lease	Well No.	Date Well Plugged	Casing Left In Well						Method of Plugging (Depths given in feet below land surface datum)	Remarks
				Surface Casing			Long String				
				length (ft.)	size (in.)	cement (sacks)	depth (ft.)	size (in.)	cement (sacks)		
Humble Oil & Refining Co.	Cora King	1	10- 6-50	149	10-3/4	105	-	5-1/2	650	Cement plug at 4920-4838 (8 sacks) do 160 (48 sacks) do surface (2 sacks)	Long string set at 4893' with 650 sacks of cement. Shot off at undetermined depth.
Do.	do	2	11-26-51	153	10-3/4	100	2435 to 4876	5-1/2	650	Cement plug at 4918-4882 do 200 (50 sacks) do surface (5 sacks)	
Do.	do	3	11-18-49	146	10-3/4	100	2680 to 4906	5-1/2	600	Cement plug at 200 (50 sacks) do surface (10 sacks)	
Do.	do	4	10- 6-50	137	10-3/4	100	-	5-1/2	575	Cement plug at 4902-4767 (15 sacks) do 160 (48 sacks) do surface (2 sacks)	Long string set at 4890' with 575 sacks of cement. Shot off at undetermined depth.
Do.	do	5	11-18-49	138	10-3/4	80	2010 to 3674	7	125	Cement plug at 200 (50 sacks) do surface (10 sacks)	
Do.	do	6	12-13-48	149	10-3/4	80	2659 to 3668	7	125	Cement plug at surface (3 sacks)	
Do.	do	7	11-18-49	156	10-3/4	75	2797 to 3682	7	125	Cement plug at 200 (50 sacks) do surface (10 sacks)	
Do.	do	8	10-19-46	152	10-3/4	80	3684	7	110		Apparently used for salt water disposal 1947-1951.
National Associated Petroleum Co.	Sam Kelly Estate "A"	1	11- 9-51	-	-	-	-	5-1/2	700	No plugs. "Mud-laden fluid & cemented hole".	Plugging record does not indicate casing left in well. 130 feet of 10-3/4 inch surface casing and 4905 feet of 5-1/2 inch long string originally set in well.
Do.	do	2	2- 1-48	156	10-3/4	125	2400 to 3756	7	325	Cement plug at 161 (25 sacks)	
							3700 to 4944	4-1/2	200		
Do.	do	3	12-1-51	-	10-3/4	-	-	7	250	No plugs. "Mud-laden fluid & cemented hole".	Plugging record does not indicate casing left in well. 163 feet of 10-3/4 inch surface casing and 3400 feet of 7 inch long string originally set in well. Apparently used for salt water disposal 1947-1951.

Table 5.--Records of plugging methods of abandoned oil wells in the National oil field (Cont'd.)

Operator	Lease	Well No.	Date Well Plugged	Casing Left In Well						Method of Plugging (Depths given in feet below land surface datum)	Remarks
				Surface Casing			Long String				
				length (ft.)	size (in.)	cement (sacks)	depth (ft.)	size (in.)	cement (sacks)		
National Associated Petroleum Co.	Sam Kelly Estate "A"	5	10- 7-51	-	-	-	-	5-1/2	125	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 149 feet of 10-3/4 inch surface casing and 3651 feet of 5-1/2 inch long string originally set in well.
Do.	Sam Kelly Estate "B"	1	3-22-49	-	-	-	-	-	-	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 125 feet of 10-3/4 inch surface casing and 3677 feet of 7 inch long string originally set in well.
Do.	do	2	11-25-51	-	-	-	-	-	-	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 156 feet of 10-3/4 inch surface casing and 4882 feet of 5-1/2 inch long string originally set in well.
Do.	do	3	12-16-47	135	10-3/4	125	1594 to 3694	-	325	Cement plug in surface casing. (20 sacks)	
Do.	do	4	3-20-49	-	-	-	-	5-1/2	700	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 125 feet of 10-3/4 inch surface casing and 3739 feet of 7 inch long string originally set in well.
Do.	do	5	11-18-51	-	-	-	-	5-1/2	700	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 180 feet of 10-3/4 inch surface casing and 4884 feet of 5-1/2 inch long string originally set in well.
Do.	do	6	11-27-51	-	10-3/4	125	-	5-1/2	600	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 160 feet of 10-3/4 inch surface casing and 4929 feet of 5-1/2 inch long string originally set in well. Apparently used for salt water disposal 1947-1951.
Do.	do	8	11-11-51	-	-	-	-	5-1/2	250	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 162 feet of 10-3/4 inch surface casing and 3668 feet of 5-1/2 inch long string originally set in well.

Table 5.--Records of plugging methods of abandoned oil wells in the National oil field (Cont'd.)

Operator	Lease	Well No.	Date Well Plugged	Casing Left In Well						Method of Plugging (Depths given in feet below land surface datum)	Remarks
				Surface Casing			Long String				
				length (ft.)	size (in.)	cement (sacks)	depth (ft.)	size (in.)	cement (sacks)		
National Associated Petroleum Co.	Sam Kelly Estate "B"	9	4-19-51	-	-	-	-	7	250	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 162 feet of 10-3/4 inch surface casing and 3675 feet of 7 inch long string originally set in well.
Do.	do	11	12- 3-51	-	-	-	-	5-1/2	600	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 137 feet of 10-3/4 inch surface casing and 4908 feet of 5-1/2 inch long string originally set in well.
Do.	do	12	11-20-51	-	-	-	-	5-1/2	250	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 138 feet of 10-3/4 inch surface casing and 3682 feet of 5-1/2 inch long string originally set in well.
Do.	do	13	12-18-47	137	10-3/4	125	2100 to 3660	5-1/2	250	Cement plug in surface casing (10 sacks)	
Do.	do	14	11-23-51	-	-	-	-	5-1/2	600	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 135 feet of 10-3/4 inch surface casing and 4884 feet of 5-1/2 inch long string originally set in well.
Do.	do	15	3-21-49	-	-	-	-	-	-	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 125 feet of 10-3/4 inch surface casing and 3699 feet of 7 inch long string originally set in well.
Do.	Sam Kelly Estate "C"	2	11- 5-51	-	-	-	-	-	-	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 163 feet of 10-3/4 inch surface casing and 3668 feet of 5-1/2 inch long string originally set in well.
Do.	do	4	1-20-49	-	-	-	-	-	-	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 138 feet of 10-3/4 inch surface casing and 4880 feet of 5-1/2 inch long string originally set in well.

Table 5.--Records of plugging methods of abandoned oil wells in the National oil field (Cont'd.)

Operator	Lease	Well No.	Date Well Plugged	Casing Left In Well						Method of Plugging (Depths given in feet below land surface datum)	Remarks
				Surface Casing			Long String				
				length (ft.)	size (in.)	cement (sacks)	depth (ft.)	size (in.)	cement (sacks)		
National Associated Petroleum Co.	Oscar Havens	1	11-10-51	-	10-3/4	125	-	-	325	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 169 feet of 10-3/4 inch surface casing and 3703 feet of long string originally set in well.
Do.	do	2	11-30-51	-	-	-	-	-	-	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 159 feet of 10-3/4 inch surface casing and 4868 feet of 5-1/2 inch long string originally set in well.
Do.	do	3	11-17-51	-	-	-	-	7	325	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 150 feet of 10-3/4 inch surface casing and 3652 feet of 7 inch long string originally set in well.
Do.	do	4	11-16-51	-	-	-	-	-	-	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 148 feet of 10-3/4 inch surface casing and 3649 feet of 7 inch long string originally set in well.
Do.	do	5	8-19-48	159	10-3/4	125	2750 to 5051	5-1/2	600	Cement plug in surface casing (20 sacks)	Used for salt water disposal 1947-1948.
Do.	do	6	11-29-51	-	-	-	-	-	-	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 143 feet of 10-3/4 inch surface casing and 4857 feet of 5-1/2 inch long string originally set in well.
Do.	J. E. Prince Estate "A"	1	2- 2-49	-	-	-	-	-	-	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. Casing record unavailable.
Do.	do	2	11- 5-51	153	10-3/4	125	-	5-1/2	600	No plugs. "Mud-laden fluid & cemented hole"	Plugging record indicates 4899 feet of 5-1/2 inch long string to be pulled.
Do.	do	3	4-18-51	-	-	-	-	-	-	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 153 feet of 10-3/4 inch surface casing and 3661 feet of 7 inch long string originally set in well.

Table 5.--Records of plugging methods of abandoned oil wells in the National oil field (Cont'd.)

Operator	Lease	Well No.	Date Well Plugged	Casing Left In well						Method of Plugging (Depths given in feet below land surface datum)	Remarks
				Surface Casing			Long String				
				length (ft.)	size (in.)	cement (sacks)	depth (ft.)	size (in.)	cement (sacks)		
National Associated Petroleum Co.	J. E. Prince Estate "A"	4	2- 5-49	-	-	-	-	-	-	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 172 feet of 10-3/4 inch surface casing and 4943 feet of 5-1/2 inch long string originally set in well.
Do	do	5	2-18-49	-	-	-	-	-	-	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 130 feet of 10-3/4 inch surface casing and 3656 feet of 5-1/2 inch long string originally set in well.
Do.	J. E. Prince Estate "B"	1	11- 8-51	-	-	-	-	5-1/2	200	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 138 feet of 10-3/4 inch surface casing and 3668 feet of 5-1/2 inch long string originally set in well.
Do.	do	2	12- 4-51	-	-	-	-	7	200	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 142 feet of 10-3/4 inch surface casing and 3661 feet of 7 inch long string originally set in well.
Do.	W. J. Sheldon et al.	2	4-21-51	-	-	-	-	-	-	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 136 feet of 10-3/4 inch surface casing and 3668 feet of 5-1/2 inch long string originally set in well.
Do.	do	4	4-21-51	-	-	-	-	5-1/2	350	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 137 feet of 10-3/4 inch surface casing and 4875 feet of 5-1/2 inch long string originally set in well.
Do.	do	5	2- 5-49	-	-	-	-	-	-	No plugs. "Mud-laden fluid & cemented hole".	Plugging record does not indicate casing left in well. 139 feet of 10-3/4 inch surface casing and 4718 feet of 5-1/2 inch long string originally set in well.
Do.	A. C. Smith et al.	1	4-15-51	-	-	-	-	-	-	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. 129 feet of 10-3/4 inch surface casing and 3649 feet of 7 inch long string originally set in well.
Do.	do	2	3-19-49	-	-	-	-	-	-	No plugs. "Mud-laden fluid & cemented hole"	Plugging record does not indicate casing left in well. Casing record unavailable.
Do.	do	3	10-18-47	139	10-3/4	-	-	-	-	Cement plug in surface casing (10 sacks)	Casing record unavailable.

Table 5.--Records of plugging methods of abandoned oil wells in the National oil field (Cont'd.)

Operator	Lease	Well No.	Date Well Plugged	Casing Left In Well						Method of Plugging (Depths given in feet below land surface datum)	Remarks
				Surface Casing			Long String				
				length (ft.)	size (in.)	cement (sacks)	depth (ft.)	size (in.)	cement (sacks)		
National Associated Petroleum Co.	A. C. Smith et al.	4	10-15-57	136	10-3/4	125	3000 to 3655	7	200	Cement plug in surface casing (10 sacks)	
Do.	Mrs. Cora King	1	10-16-46	135	10-3/4	100	-	-	-	Cement plug 90-150 feet (20 sacks) Cement plug at surface (5 sacks)	
Otto Bendorf	W. J. Sheldon et al.	2-A	-	-	-	-	-	-	-		Plugging record unavailable.
Prince Brothers Drilling Co.	T. H. Parmley	1	-	-	-	-	-	-	-		Plugging record unavailable. 169 feet of 10-3/4 inch surface casing and 3283 feet of 5-1/2 inch long string originally set in well.
Do.	Mrs. M. E. Prince	1	12-13-52	154	10-3/4	50	2500 to 3698	7	126	"Cement", Mud-laden fluid	
Do.	do	2	12-13-52	150	10-3/4	-	2600 to 3730	7	-	"Cement", Mud-laden fluid	
Do.	do	3	10-27-52	-	-	-	-	-	-		Plugging record unavailable. 156 feet of 10-3/4 inch surface casing and 3676 feet of 7 inch long string originally set in well.
Do.	do	4	1948	151	10-3/4	-	-	-	-		Plugging record unavailable.
H. F. Snebold	A. Smith	1	7-29-55	76	10-3/4	60	-	-	-	"Heavy-mud"	

H. & T. C. R. R.

BLK. 13

36

37

31

30

LAKE

F. W. B. D. C. R. R.

U. S. HWY. 10 & 287

Creek

Reservoir

Blair

Oscar Haven

Cora King

J. E. Prince Estate

Mrs. K. (Sam) Kelly Est

W. J. Sheldon et al

T. H. Parmelly

Douglas Estate

W. C. B. D. Co.

H. C. Wells

Small Tracts

Sam Kelly

A. Smith

EXPLANATION

- Producing oil well and well number
- Abandoned oil well
- Dry and abandoned hole
- Brine-disposal well (Symbol "A" over well signifies annulus injection)
- Abandoned brine-disposal well
- Tank battery
- Treator
- Collection tank for disposal well
- Surface pit
- Reported site of destroyed surface pit
- Domestic and livestock water well, and well number
- Public supply water well
- Abandoned water well
- Surface-water sample site

Graphic illustration of analyses of water shown in percent of equivalents per million

5600 Chloride concentration, in parts per million

SCALE

1" = 500'

0 500 1000 1500 2000 2500

Plate I

Plat of National Oil Field Showing Property Ownership, Surface Drainage, Producing Oil Wells, Abandoned Oil Wells, Brine Disposal Wells and Pits, Water Wells, Surface Water Sample Sites, and Water Analyses Represented by Pattern Diagrams

Texas Water Commission