TEXAS WATER COMMISSION

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BACTERIOLOGICAL POLLUTION OF GROUND WATER IN THE BIG SPRING AREA, HOWARD COUNTY, TEXAS

By

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BACTERIOLOGICAL POLLUTION OF GROUND WATER IN THE BIG SPRING AREA, HOWARD COUNTY, TEXAS

INTRODUCTION

On January 2, 1963, the Texas Water Commission received a request from Mr. Jim C. Harper for assistance in determining the source of bacteriological contamination in the domestic water well at his home north of Big Spring, Howard County, Texas. According to Mr. Harper, the water from the well became highly unpalatable with a very offensive odor in November 1961, and subsequent bacteriological analyses of the water confirmed the presence of coliform organisms. Mr. Harper felt that the problem was caused by a slaughter house, which is disposing of kill floor effluent into unlined surface pits located approximately 200 yards from his well.

The complaint was forwarded to the Texas Water Pollution Control Board by the Texas Water Commission on January 10, 1963. The Pollution Board requested that a joint investigation of the complaint be made by the Water Commission and the Division of Water Pollution Control, State Department of Health, and this investigation was conducted during the week of February 4, 1963.

A field investigation was made by the staff of the Waste Disposal Section, Ground Water Division, Texas Water Commission, to determine the occurrence, movement, and quality of ground water in the local area, and the possible source of contamination. The field investigation was made during the period February 4 through February 10, 1963, in conjunction with an investigation by James C. Willmann of the State Department of Health.

LOCATION AND ECONOMY

The area covered by the investigation centers at the common corners of sections 31, 32, 41 and 42, Block 32, TWP 1 N, T & P RR Survey, Howard County, Texas. The Jim C. Harper residence is located in the southwest corner of section 32, about one-half mile north of the Big Spring city limits on the north side of Hill Top Road east of State Highway 350. (See Figure 4.) The area has developed rapidly in the past several years into a suburban residential district with varied industrial development along State Highway 350.

TOPOGRAPHY AND DRAINAGE

The area of investigation is on the eastern edge of the Southern High Plains. The topography is flat to rolling and slopes to the south towards Beals Creek.

Beals Creek is the major drainage in this area of Howard County. It is an intermittent stream that flows east through Big Spring, adjacent to the Texas and Pacific Railroad. Surface water accumulating in Beals Creek ordinarily flows for only a short distance before being lost by seepage and evaporation.

Secondary drainage in the immediate area of investigation is developed in the form of a draw which heads about one-half mile north of the area, trends in a southerly direction on the east side of the Harper residence, and joins Beals Creek in Big Spring about one mile south of the area. During periods of heavy rainfall, runoff flows through the draw. However, surface water accumulating in the draw is normally lost by seepage and evaporation before reaching Beals Creek.

CLIMATE

The climate of the area is semiarid, characterized by low precipitation and relatively high evaporation. The annual precipitation rate for the period 1931-60 is approximately 17 inches; the mean annual temperature is 63°F; and the average net annual evaporation rate from a fresh, free-water surface for the period 1940-57 is about 65 inches (data from the Surface Water Division, Texas Water Commission). Most of the rainfall occurs in the period April to October, during which time the monthly average is fairly uniformly distributed. The rain is often torrential and occurs largely as local storms. During the summer the prevailing winds are from the south and are hot and dry, and the rate of evaporation is very high.

METHOD OF INVESTIGATION

During the course of this investigation, 36 water wells were inventoried and water samples were collected from 22 water wells for chemical analysis. Elevations were determined with a Paulin Altimeter in conjunction with the U. S. Geological Survey Big Spring North 15-Minute Quadrangle topographic map.

Data pertaining to previous bacteriological analyses of water samples from the Harper well were obtained from Mr. Lige Fox of the Big Spring Health Department. Mr. James C. Willmann of the State Department of Health collected water samples for bacteriological analysis as part of this joint investigation and submitted a report of his investigation to Mr. D. F. Smallhorst, Director, Division of Water Pollution Control, State Department of Health.

Included in this report are: a plat showing the location of water wells in the area (Figure 3); a plat of the immediate area of contamination showing the location of possible sources of contamination and direction of movement of ground water in the area (Figure 4); a table of records of wells inventoried during the investigation (Table 1); a table of chemical analyses of water samples (Table 2); and a table of bacteriological analyses of water samples (Table 3).

GENERAL GEOLOGY AND OCCURRENCE OF GROUND WATER

Geology

This report deals only with rocks penetrated in the drilling of water wells in the area. These are the Tertiary Ogallala Formation, which crops out in the area, and the Triassic Dockum Group, which immediately underlies the Ogallala.

The Triassic rocks crop out east of the area of investigation and dip westward into a large depositional basin which coincides roughly with the Permian Basin. On the outcrop the Triassic sediments are mainly dark red to maroon shales that usually contain small flakes of mica as well as some flakes of gypsum. Lenticular beds of sandstone that are usually gray to red, cross-bedded, and very micaceous are present within the red shale at many localities.

Sediments which crop out in the area of investigation lie unconformably on the Triassic red beds and have been mapped on the U. S. Geological Survey Geologic Map of Texas, 1937, as the Ogallala Formation. In general, the Ogallala section is not well exposed and well logs are about the only means of determining the lithology and thickness of the formation. Drillers' logs in the area indicate that the formation consists of clay, caliche, and unconsolidated sand and gravel, erratically distributed throughout the section. The thickness of the Ogallala Formation depends largely on the relief of the underlying Triassic surface; therefore, thicker sections are found in lows in the Triassic surface. In the area of investigation the Ogallala ranges generally from 60 to 100 feet in thickness, although a red clay bed that occurs locally near the base of the formation makes it difficult to pick the base in some wells. The base of the Ogallala slopes generally to the southeast with no known structural interruptions.

Occurrence of Ground Water

The Ogallala Formation is the principal water-bearing formation in the area of investigation. Ground water occurs generally in the Ogallala under water-table conditions. Slight artesian pressure may exist locally where the water-saturated sand is confined beneath relatively impermeable strata.

The principal sources of ground-water recharge to the Ogallala Formation in the Southern High Plains of Texas are underflow from the Ogallala in New Mexico and precipitation on the land surface in Texas. Available information indicates that the regional movement of the ground water in the Ogallala is to the east-southeast. Contour lines on the approximate altitude of the water table in the area of investigation indicate the direction of ground-water movement. (See Figure 4.) East of the well designated as Well No. 1, the contours indicate that the water table slopes to the west-southwest on the east side of the surface drainage and to the east-southeast on the west side, although the regional movement in the area is to the east-southeast towards Beals Creek.

Drillers' logs obtained during the investigation indicate that some of the wells in the area are possibly screened in sands in the upper part of the Triassic. Outcrop data indicate that these Triassic sands are lenticular and limited in areal extent. The possibility exists that some of these lenticular sands are hydraulically connected with the overlying Ogallala Formation as there does not appear to be a water-level differential between the wells that are believed to be completed in the Triassic and the wells completed in the Ogallala.

Quality of Ground Water

Chemical analyses of water from wells producing from the Ogallala indicate that the quality varies widely within relatively short distances in the area of investigation. (See Table 2.) Most of the analyses indicate that the quality of the water sampled does not conform to the limits of the U. S. Public Health Service for drinking water used by interstate carriers. However, the usability of water varies in many areas of Texas according to the water which is available in the area.

No data is available on the quality of water in the Triassic. Analyses of water from wells that are apparently screened in part in the Triassic sands are compatible in quality with analyses of samples from wells completed in the Ogallala Formation. This similarity in quality lends support to the idea that the lenticular Triassic sands are hydraulically connected with the Ogallala.

The bacteriological quality of the ground water was not determined in this investigation for the entire area. Periodic analysis of water sampled from the Harper well over a 1-year period indicates that the water is contaminated by coliform organisms. The bacteriological analysis of water sampled from the Carl Hailey well (Well No. 2, Figure 4) during the investigation indicates the water is free of coliform organisms. Table 3 shows the results of bacteriological analysis on water from these two wells.

The Texas State Department of Health uses the multiple-tube fermentation technique (Presumptive Test and Confirmed Test) for bacteriological analyses to determine the sanitary quality of water. This technique consists of ascertaining the incidence of coliform organisms considered to be characteristic of human or animal intestinal origin. Water of satisfactory bacteriological quality should be free from coliform organisms and the Health Department considers a confirmed test of one (1) tube in five (5) on water well samples to be an indication of pollution.

SUMMARY OF CURRENT INVESTIGATION

On February 5, 1963, Mr. Lige Fox, Big Spring Health Department and Mr. James C. Willmann, State Department of Health, were contacted in Big Spring to discuss the contamination of the Jim C. Harper water well. An inspection was made of the Harper water well and the Casey Packing Company plant area, and Mr. Harper and Messrs. Mike and Bill Casey were interviewed regarding the complaint.

The water from the Harper well had a very unpleasant sewage-type odor. Mr. Willmann stated in his report that the sample collected from this well for bacteriological analysis contained small dark flakes in clear water; however, when submitted for analysis the sample had turned completely brown in color. Mr. Willmann was informed by Mr. Kenneth Scott, Regional Laboratory Director, State Department of Health, that the sample showed visual indication of iron bacteria contamination which would account for the strong odor. No detectable odors were noticed or reported in water samples collected for chemical analysis from other wells in the area.

The bacteriological analysis of the water sample from Mr. Harper's well, which was run on April 3, 1962, was free of coliform organisms. However, this sample was collected following chlorination of the well with one pound of HGH and reportedly the unpleasant odor persisted after the treatment.

Possible sources of bacteriological contamination of the water well are: (1) the septic tank which is located on the east side of the Harper house and downhill from the water well; (2) a neighbor's outdoor toilet which is located about 100 feet west and slightly uphill from the water well; (3) a small stock pen which is located between the two houses; and (4) the Casey Packing Company disposal pits which are located approximately 200 yards northwest of the Harper residence.

The septic tank drainfield at the Harper residence is in the draw on the east side of the house, and, as indicated by the contours on the water table, it is located down the hydraulic gradient from the contaminated water well. (See Figure 4.) This tank is used only for domestic waste effluent from the Harper residence. Because of the small volume of effluent, the high evaporation rate in this area, the location of the septic tank in relation to the contaminated water well, and the direction of movement of ground water, it is improbable that the septic tank has contributed to the contamination of the Harper well.

The outdoor toilet which is west of the Harper well is located so that lateral movement of the waste fluid not parallel with the regional ground-water movement would be necessary for the contaminant to reach the well. (See Figure 4.) However, the very small amounts of fluid waste, the high evaporation rate, the distance between the two locations and the direction of local movement of ground water do not indicate that this facility is a source of contamination to the Harper well.

The stock pen is located slightly southwest of the Harper well. (See Figure 4.) The size of the pen indicates that only a few head of cattle could be kept at one time and that the waste volume would be very small. The high evaporation rate and the local direction of movement of ground water does not indicate that the stock pen would be a likely source of contamination.

The Casey Packing Company Plant is located approximately 200 yards slightly northwest of the Harper residence. Approximately 60 to 80 head of cattle are now slaughtered each week, although previous maximum kills have been 400 to 450 head per month. All wash water and blood from the kill floor flows into a 6 ft. by 6 ft. by 6 ft. tile and concrete settling tank. From the settling tank the effluent flows into unlined earthen trenches which are about 30 inches wide, 4 feet deep, up to 100 feet long, and are covered with tin and sand. All solid waste is hauled from the plant.

The disposal area is located on the south side of the plant and covers an area approximately 100 ft. by 200 ft. The operator originally attempted to dig deeper trenches, but the extra depth was lost due to slumpage of the unconsolidated sand from the sides of the trench. During normal operation, one trench is reported to last about 60 days, after which a new one is dug. The fact that a pit will only last about 60 days is probably due to slumpage of the pit walls and the nature and volume of the disposal fluid waste. The settling tank is pumped out every 3 to 6 months depending on the number of cattle slaughtered. The operators have constructed an open trench about 2 feet deep and 1 foot wide on the west side of the disposal area to prevent surface drainage from washing out the disposal area during times of heavy rainfall. These surface disposal facilities have been in use for about 6 years.

UNLINED SURFACE PITS AS A MEANS OF WASTE DISPOSAL

Disposal of sewage or other man-made wastes into open, unlined, earthen pits has been reported in many instances where ground-water contamination has taken place. Usually the contamination has occurred where the depth to ground water is not great and where unconsolidated materials such as sand, gravel and lenticular clay are the principal porous media through which the fluid must move.

Figure 1 shows a disposal pit constructed in the unsaturated zone. It is assumed that the porous material for both the saturated and unsaturated zone is a uniform medium sand. As fluid wastes are discharged into the pit, some fluid seeps through the pit bottom and moves toward the water table as suggested by the vertical arrows. In this idealized setting, little lateral movement of the fluid occurs and most of the fluid moves downward to the water table directly under the disposal pit.

In some areas the unsaturated zone is not a uniformly porous media but is interrupted by clay lenses, caliche beds, or other media that retard the downward migration of the seepage fluid. Figure 2 is an idealized cross section of a disposal pit constructed in an unsaturated zone that contains clay lenses. From this cross section it can be seen that the fluid moves downward from the disposal pit until it encounters an impermeable zone. A perched zone of saturation occurs on the upper surface of the clay lens and the fluid then moves laterally until it finds a way around the lens; the fluid then continues downward to the water table or the cycle is repeated at a new clay lens. In this case it can be seen that when the seepage fluid arrives at the water table it may have traveled a significant distance laterally from the disposal pit.

The seepage fluid which percolates into the water table mixes with the ground-water body and ultimately emerges at points of artificial or natural discharge. Numerous studies by ground-water hydrologists have led to the belief that once the pollutant enters the water table, underground mixing proceeds very slowly in contrast to relatively fast mixing that takes place in surface streams, and that movement of foreign water through ground-water aquifers is confined to rather narrow zones or belts.

In summary, it can be seen that a number of hydrologic factors control the movement of the seepage fluid from the disposal pit. Though the discussion has been limited and simplified, it should be recognized that fluid waste types and volumes, rock type, infiltration rate, evaporation and transpiration, flow through saturated and unsaturated zones, permeability and nonuniformity of porous media all play an important roll in the movement of the contaminant from the disposal pit.

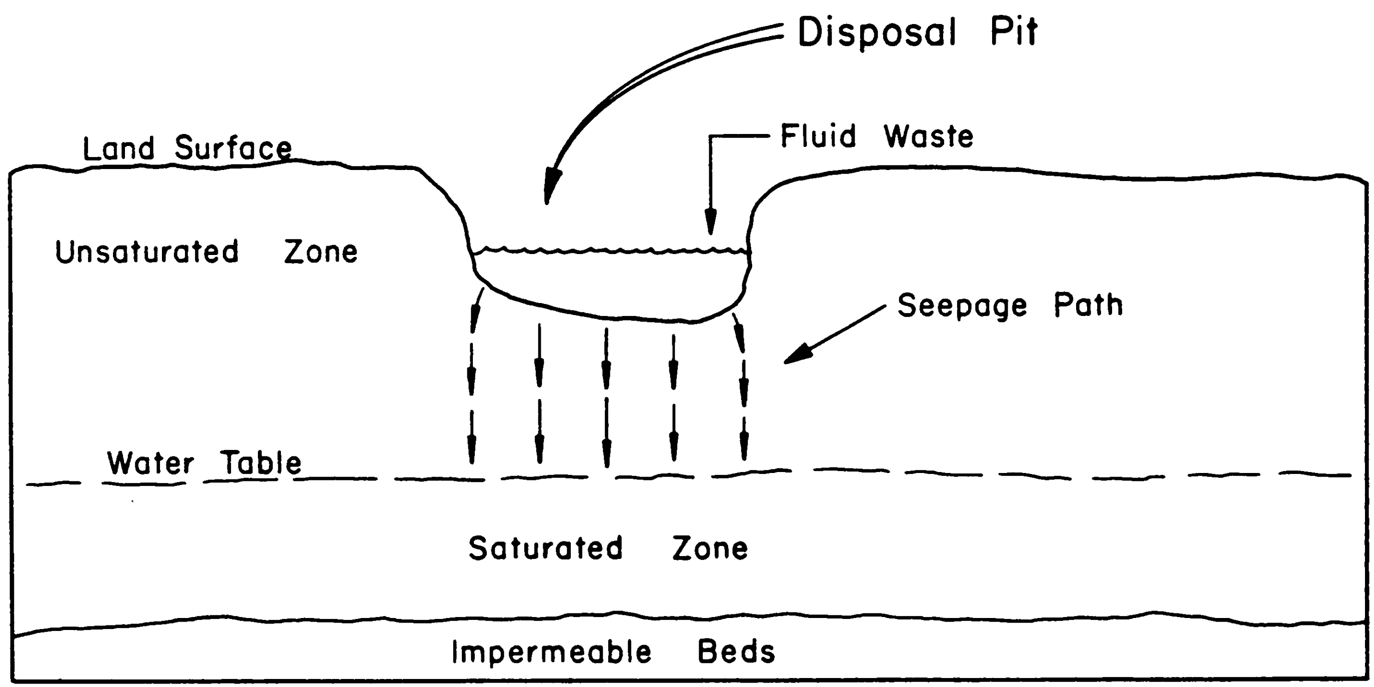

Figure I

Cross Section of a Disposal Pit Showing Seepage Through an Idealized Unsaturated Zone

(Adapted from Brown, R. H., 1961, Hydrologic factors pertinent to ground water contamination: The Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, Technical Report W61-5.)

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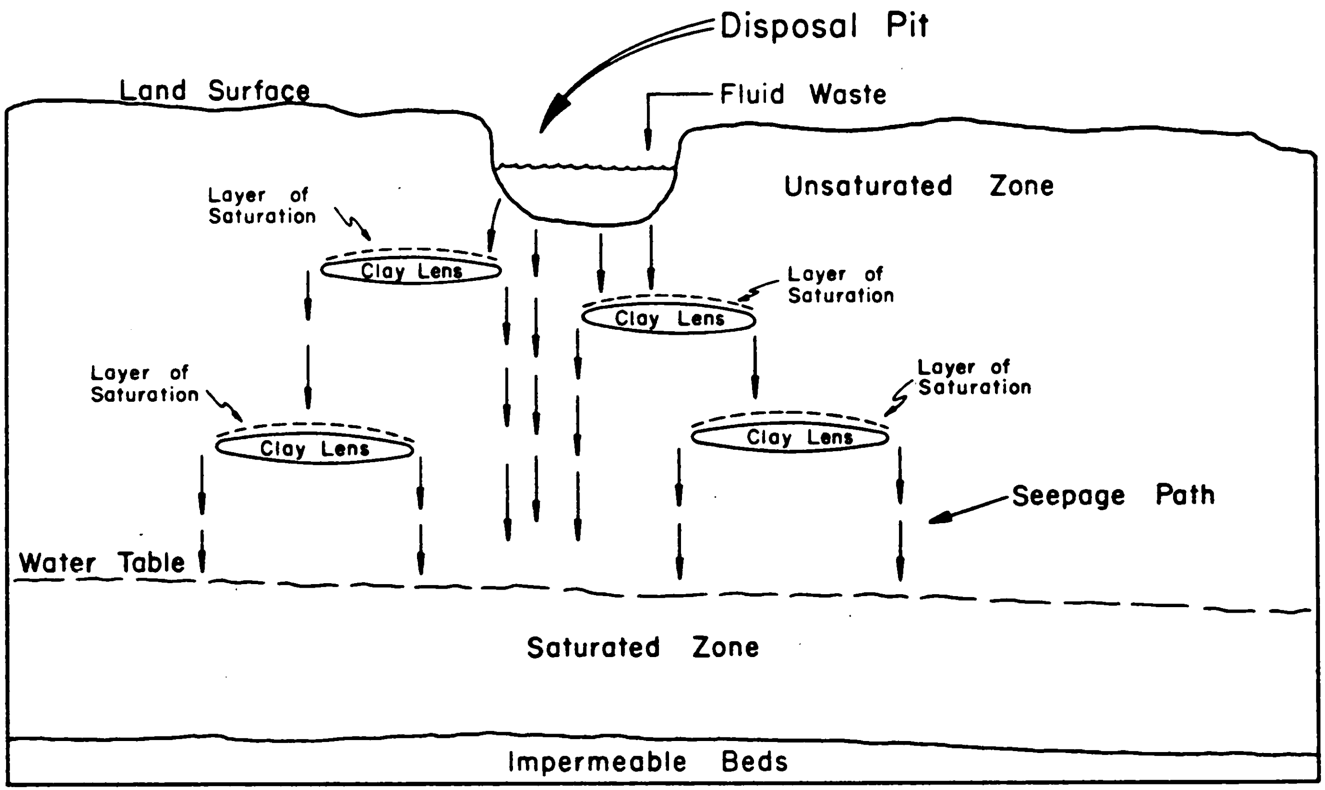

Figure 2

Cross Section of a Disposal Pit Showing Seepage Through an Unsaturated Zone With Clay Lenses

(Adapted from Brown, R. H., 1961, Hydrologic factors pertinent to ground water contamination: The Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, Technical Report W61-5.)

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CONCLUSIONS

(1) The limited scope of this investigation does not conclusively determine the source of contamination of the Harper water well. However, geologic, hydrologic, and bacteriologic data collected does indicate that surface disposal of packing-plant waste is a probable source of contamination to the ground-water supplies in the area.

(2) Mr. Harper's septic tank, his neighbor's outdoor toilet, and the small livestock pen do not appear to have any influence on the problem. Their location relative to the contaminated well, the local movement of ground water, the small amounts of fluid waste and high evaporation rates practically preclude any movement of the fluid waste from these sources into the well.

(3) Subsurface geologic data in the vicinity of the Harper well indicate a continuous sequence of sand or sandy shale from the surface to a depth of about 100 feet. Porous material of this type provides an avenue for seepage of disposed fluids from unlined, earthen disposal pits.

(4) Water-level data in the area indicate that the water table is relatively shallow, and that the hydraulic gradient is to the west-southwest on the east side of the draw and to the east-southeast on the west side. The regional hydraulic gradient is to the east-southeast.

(5) Fluids with waste from human or animal sources contain coliform organisms. When this type fluid is stored untreated it is conducive to the growth of these coliform organisms and may create a health hazard.

(6) The Casey Packing Company has constructed unlined, earthen disposal pits approximately 200 yards northwest of the contaminated water well. Contaminated waste water flows from the company's settling tank into the pits. The pits are covered with tin and sand which suggests that direct evaporation of the fluid is negligible.

(7) The permeable nature of the material in which the pits are dug and the apparent lack of evaporation of the waste fluid indicate that the fluid is leaving the pits by seepage. As the fluid moves through the unsaturated zone some of it is probably lost by evapotranspiration and the remainder migrates downward to the water table. Upon reaching the water table the contaminated fluid would move in the direction of the hydraulic gradient.

(8) The location of the contaminated water well with respect to the disposal pits, the direction of movement of the ground water, and the nature and volume of the waste fluid indicate that the disposal pits are a probable source of contamination of ground water in the area.

RECOMMENDATIONS

It is recommended that the uses of the unlined pits at the Casey Packing Company be eliminated to insure the proper protection of ground water of usable quality in the area from further contamination.

Table 1.--Records of wells

Method of lift and type of power : C, cylinder; E, electric; J, jet; N, none; Sub, Submersible; W, wind.
Use of water : D, domestic; Irr, irrigation; N, none; S, stock.

Field well no.	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Altitude of land surface (ft.)	Water Level: Below land surface datum (ft.)	Water Level: Date of Measurement	Method of lift	Use of Water
1	Jim C. Harper	M. Murdock	--	109	--	--	2,499	47.05	Feb. 5, 1963	C,W	N
2	C. Haley	M. Murdock	--	89	7	89	2,503	51.60	Feb. 5, 1963	J,E	D
3	O. R. Bolinger	--	1962	24	6	24	2,448	9.90	Feb. 6, 1963	J,E	Irr
4	O. R. Bolinger	--	--	Spring	--	--	2,445	--	--	--	S
5	O. R. Bolinger	--	--	56	7	54	2,522	38.50	Feb. 6, 1963	J,E	Irr
6	R. G. Lloyd	--	1961	68	7	68	2,442	45.25	do	N	N
7	W. Robinson	--	--	41	--	--	2,429	34.20	Feb. 7, 1963	J,E	D
8	A. Bates	--	--	168	7	168	2,515	78.20	do	C,W	D
9	J. L. Turner	--	1957	60	--	--	2,509	--	--	J,E	D
10	H. A. Rogers	A. B. English	1960	130	--	--	2,510	60.60	Feb. 7, 1963	Sub,E	D
11	S. P. Corcoran	F. Smith	1957	60	5	60	2,512	52.75	do	J,E	D
11-A	S. P. Corcoran	A. B. English	1960	127	5	127	2,512	52.60	do	Sub,E	D
12	William Carter	M. Murdock	1957	103	7	103	2,518	62.50	do	Sub,E	D
13	A. J. Bailey	--	1956	119	6	115	2,505	54.45	do	Sub,E	D
14	W. R. Bunn	--	1961	93	6	--	2,501	49.40	do	J,E	D
15	J. Worthy	--	--	120	6	--	2,527	79.10	Feb. 8, 1963	C,E	D
17	Smith Butane Co.	M. Crawford	1962	137	7	137	2,522	--	--	--	D
18	M. H. Tate	M. Murdock	1958	145	7	--	2,532	85.40	Feb. 8, 1963	Sub,E	D
19	M. Daniels	--	1953	84	6	--	2,542	36.85	do	J,E	D
20	W. Watson	--	1955	90	N	--	2,504	42.00	Feb. 9, 1963	Sub,E	D
20-A	W. Watson	--	--	100	--	--	--	--	--	J,E	D
21	A. Pettus	M. Crawford	1962	86	7 5-1/2	76 47	2,521	59.20	Feb. 9, 1963	N	N
22	M. D. Cross	D. C. English	1961	89	4	89	2,542	41.30	do	J,E	D
23	Crestview Baptist Ch.	A. B. English	1961	120	6	--	2,530	69.85	do	Sub,E	D
24	D. B. Atkinson	O. William	1959	105	6	90+	2,502	42.90	do	J,E	D
25	J. I. Balch	M. Crawford	--	50	7	50	2,517	35.80	Feb. 10, 1963	Sub,E	S
26	J. Minchew	Roberts	1963	62	6	62	2,538	42.30	do	N	N
27	J. I. Balch	M. Crawford	--	94	7	94	2,530	--	--	--	N
28	Ace Wrecking Yard	M. Crawford	--	125	7	70	2,547	--	--	--	D
29	Ted Smith	M. Crawford	--	110	6-5/8	110	2,515	--	--	--	D
30	S. C. Fraizer	M. Crawford	--	108	7	108	2,515	--	--	--	D
31	Ralph Hize	M. Crawford	--	102	6-5/8	102	--	--	--	--	D
32	A. Kinard	M. Crawford	1962	79	7	79	--	--	--	Sub,E	Irr
33	A. Kinard	M. Crawford	1962	80	7	80	--	--	--	Sub,E	Irr
34	Jack Lewis	M. Crawford	1962	72	--	--	--	--	--	--	--
35	Jack Lewis	M. Crawford	1962	77	6-5/8	77	--	--	--	--	D

Table 2.--Chemical analyses of water samples

(Analyses are in parts per million except specific conductance and pH)

Samples analysed by Texas State Department of Health

Well	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Cal-cium (Ca)	Magne-sium (Mg)	Sodium and potassium (Na + K)	Bicar-bonate (HCO_3)	Sul-fate (SO_4)	Chlo-ride (Cl)	Fluor-ide (F)	Ni-trate (NO_2)	Dis-solved solids	Total hardness as $CaCO_3$	Specific conductance (micromhos at 25° C.)	pH
1	J. C. Harper	109	July 13, 1962*	--	252	98	244	276	533	485	2.0	49	2,250	1,040	3,750	7.2
			Feb. 5, 1963	69	324	141	261	254	814	639	2.0	33	2,537	1,389	3,450	7.1
2	Carl Haley	89	do	8	216	110	277	242	599	525	2.2	102	2,081	989	2,950	7.2
3	O. R. Bolinger	24	Feb. 6, 1963	79	178	48	325	503	700	152	1.7	12	1,999	640	2,350	7.3
4	O. R. Bolinger	Spring	do	37	216	51	213	155	544	411	0.8	<0.4	1,628	750	2,350	7.7
6	Gage Lloyd	68	do	6	11	8	207	300	173	59	6.0	<0.4	770	61	1,025	8.0
7	W. Robinson	41	Feb. 7, 1963	73	100	80	486	387	507	519	6.0	78	2,236	580	3,100	7.5
8	Alvin Bates	168	do	50	132	51	279	257	380	394	3.0	31	1,577	539	2,260	7.6
9	J. L. Turner	--	do	70	64	17	94	290	75	39	3.0	85	737	232	850	7.8
10	H. A. Rogers	130	do	35	40	22	340	362	211	286	2.0	9	1,307	192	1,840	8.0
11	S. P. Corcoran	57	do	67	64	13	166	307	118	76	5.0	101	917	213	1,140	7.7
11-A	S. P. Corcoran	127	do	71	94	26	134	309	219	85	1.5	51	991	342	1,200	7.6
12	W. Carter	103	do	71	87	30	179	384	219	128	2.0	35	1,135	339	1,400	7.6
13	A. J. Bailey	119	do	70	272	95	151	196	399	548	2.0	85	1,818	1,068	2,660	7.3
14	W. R. Bunn	93	do	67	361	142	319	228	806	763	2.6	126	2,815	1,484	3,830	7.3
15	J. Worthy	120	Feb. 8, 1963	48	52	34	75	229	108	100	1.5	7	665	271	875	7.5
17	Smith Butane Co.	137	Dec. 1961†	--	248	115	405	217	608	745	4	44	2,670	1,100	4,450	7.4
18	M. H. Tate	140	Feb. 8, 1963	33	24	13	127	229	76	86	3.1	<0.4	591	113	786	8.2
19	M. Daniels	84	do	73	278	98	403	240	564	624	2.5	33	2,516	1,094	3,660	7.6
20-A	W. Watson	90	Feb. 9, 1963	75	148	63	314	312	528	309	3.4	99	1,851	628	2,500	7.4
22	M. D. Cross	89	do	62	425	176	641	160	1,023	1,385	1.4	40	3,913	--	5,630	7.3
23	Crestview Baptist Ch.	120	do	65	303	120	280	246	584	715	1.0	43	2,357	1,250	3,400	7.1
24	D. B. Atkinson	105	do	81	379	135	613	245	907	1,809	3.1	33	3,605	1,501	5,000	7.3

* Iron (Fe) 1.1 ppm; Manganese (Mn) less than 0.05 ppm.
† Iron (Fe) 0.18 ppm.

Table 3.--Bacteriological analyses of water samples

Samples analysed by Texas State Department of Health

Well	Owner	Date	Presumptive test 24-hr.*	Presumptive test 48-hr.*	Confirmed test*	Coliform organisms	Remarks
1	J. C. Harper	Feb. 27, 1962	5	5	5	yes	--
1	J. C. Harper	Apr. 3, 1962	--	--	--	no	--
1	J. C. Harper	June 22, 1962	--	5	5	yes	Sample submitted under the name of Clyde E. Thomas, M.D.
1	J. C. Harper	July 13, 1962	5	5	5	yes	--
1	J. C. Harper	Oct. 2, 1962	--	5	5	yes	--
1	J. C. Harper	Feb. 9, 1963	--	5	5	yes	Hematest negative for blood.
2	Carl Haley	Feb. 9, 1963	--	--	--	no	--

* Number of tubes showing coliform organisms.

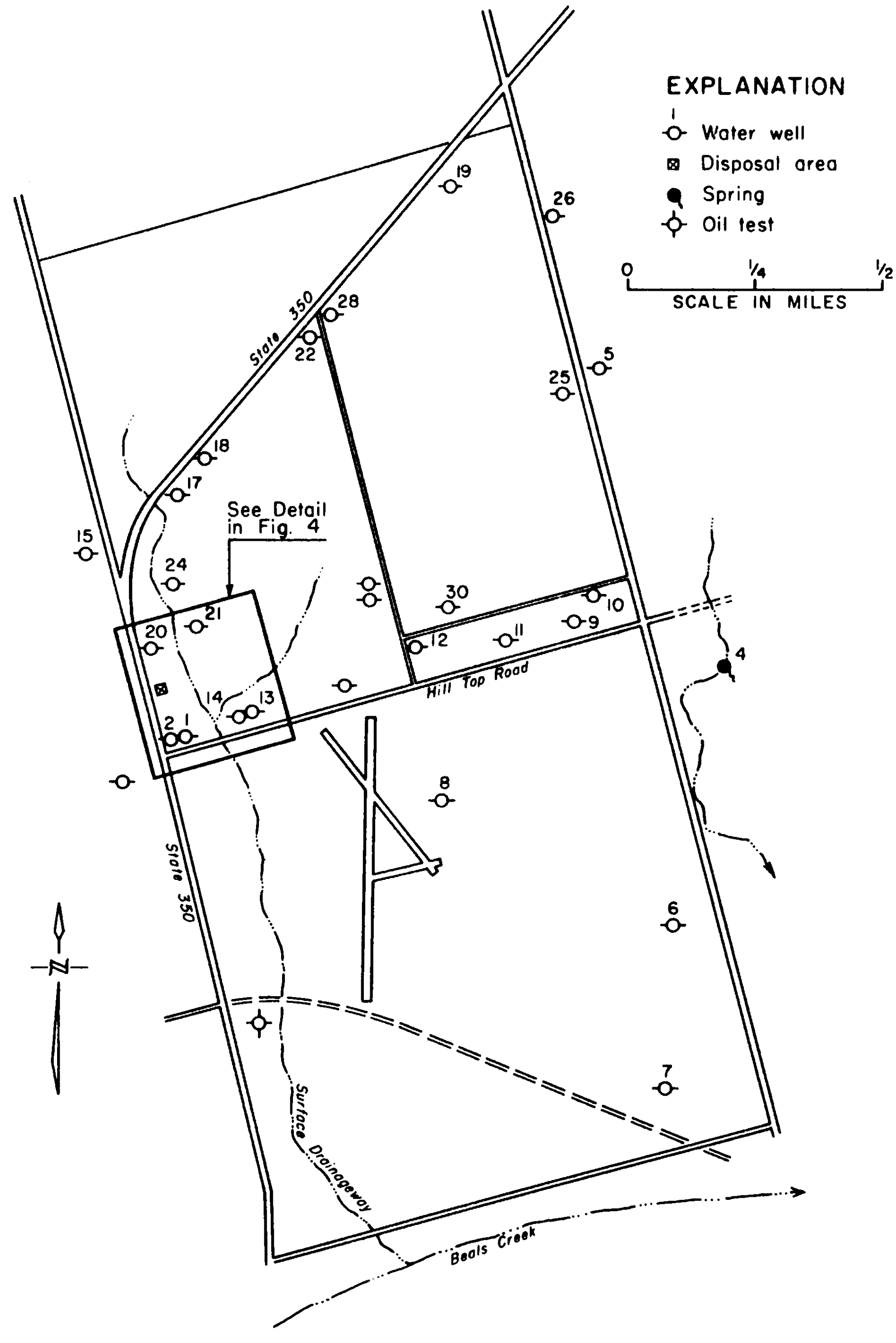

Figure 3

Plat Showing Location of Water Wells in the Area North of Big Spring, Howard County, Texas

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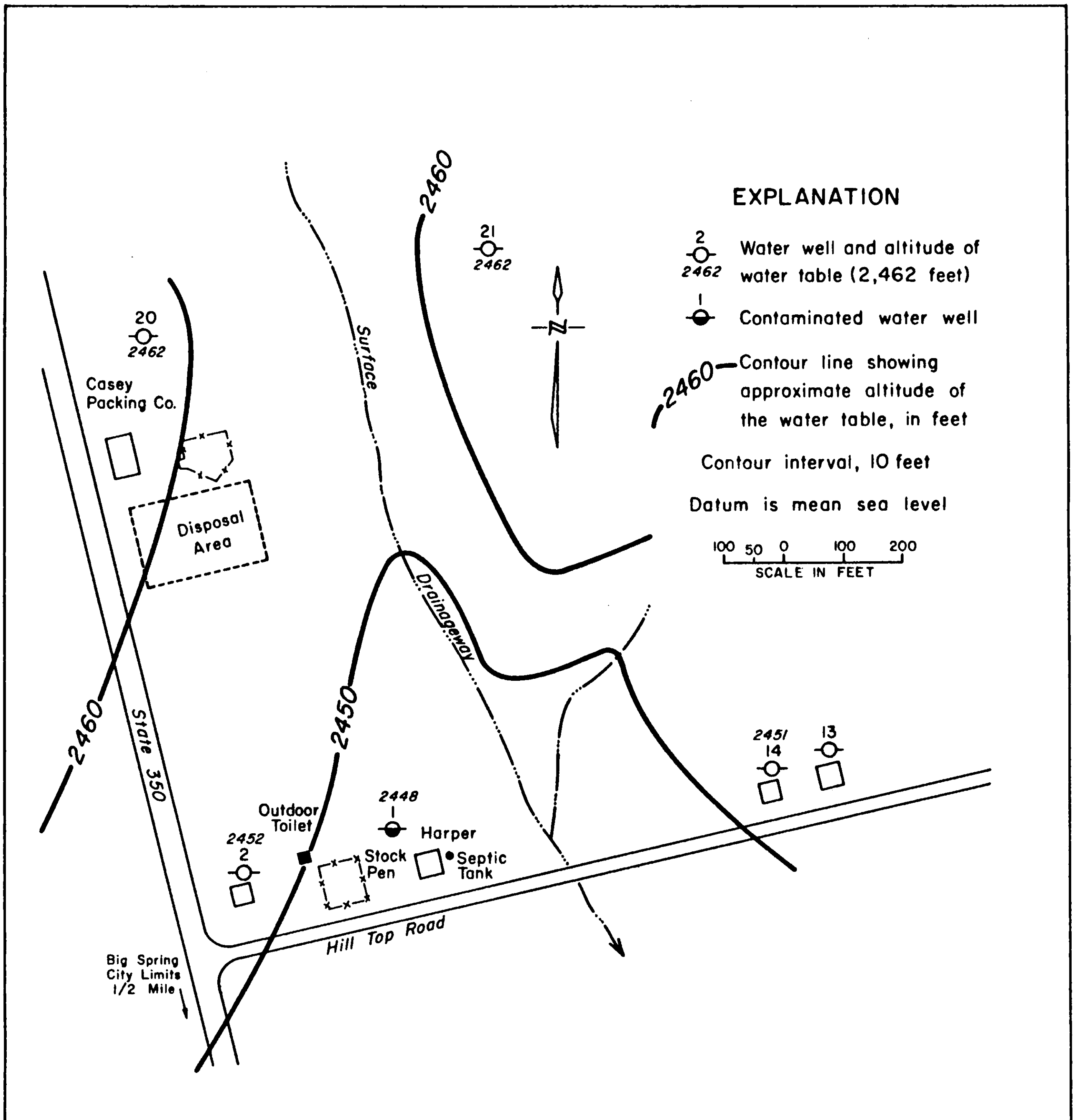

Figure 4

Plat of Area of Contamination Showing Altitude of Water Table and Possible Sources of Contamination, Big Spring Area, Howard County, Texas, 1963

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