REPORT OF THE

BURRTON TASK FORCE

to the

CHIEF ENGINEER-DIRECTOR

of the

KANSAS STATE BOARD OF AGRICULTURE
DIVISION OF WATER RESOURCES

Concerning the

PROPOSED BURRTON INTENSIVE GROUNDWATER USE CONTROL AREA

February 21, 1984

MEMBERS OF THE BURRTON TASK FORCE

Equus Beds Groundwater Management District No. 2

Kansas Corporation Commission (Conservation Division)

Kansas Department of Health and Environment
Division of Environment
Bureau of Oil Field and Environmental Geology

Kansas Geological Survey

Kansas Independent Oil and Gas Association

Kansas Water Authority

Kansas Water Office

<u>TABLE OF CONTENTS</u>

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF TABLES

CONCLUSIONS

1. The geology of the area consists of unconsolidated Pleistocene and some Pliocene sands, gravels, silts, and clays of the Equus Beds. The proposed Intensive Groundwater Use Control Area (IGUCA) is underlain by Wellington Shale and a portion of the Wellington Aquifer.

2. Clay layers beneath the area range from 1 to 75 feet thick and are discontinuous. The clay layers tend to disperse the chlorides in the groundwater. As salt water travels downward in the aquifer and meets a clay layer, it tends to disperse laterally until it reaches the edge of the clay layer and can continue its downward trend. The basal part of the Equus Beds aquifer contains water of lower chloride concentration in some areas of the Burrton IGUCA than shallower groundwater in the same areas.

3. The concentrations of chloride greater than 1000 mg/l in the groundwater have a smaller areal extent at less than 50 feet deep than in the deep groundwater, because the clay layers tend to disperse the chloride with depth.

4. Municipal usage in the proposed Intensive Groundwater Use Control Area averaged 3,936 acre-feet per year from 1977 through 1982. Irrigation usage averaged 1,854 acre-feet and industrial usage averaged 231 acre-feet per year for the same period.

5. Chloride concentrations in the Burrton area ranged from 10 to 100 mg/l prior to 1931 and oil field activity. By 1948, chloride concentrations ranged to greater than 1,000 mg/l. Currently chloride concentrations range up to 2450 mg/l.

6. From 1931 to 1943, brine was disposed into brine ponds. From 1943 to the mid 1950's, 95% of the brine was disposed through deep disposal wells and 5% was disposed through ponds. Currently all brine is disposed through deep disposal and enhanced recovery wells.

7. A large percentage of the estimated 1.9 million tons of salt produced in brine from 1931 to 1943 entered the groundwater in the area.

8. The majority of the groundwater pollution in the Burrton area occurred through brine disposal ponds from 1931 to 1943. The second most predominant source of saltwater pollution was the use of shallow brine disposal wells, many under pressure, into the "lost circulation zone" of the Wellington Formation. The injection pressures forced salt water up into the Equus Beds through unplugged or improperly plugged test holes and improperly constructed wells. The major source of pollution in the last 15 years has been from steady leaks, massive brine line breaks, saltwater tank leaks, overflows, and malfunctioning disposal wells.

9. The average chloride concentration of brine disposed into ponds in the 1930's and early 1940's is estimated to have been 96,000 mg/l.

10. All the known shallow disposal wells into the "lost circulation zone" of the Wellington Formation in the Burrton area have had their permits cancelled and the wells have been plugged. If these wells are properly plugged, no new additions of oil brine to the Wellington saltwater aquifer should occur, which could increase the hydraulic head and cause salt water to flow into the overlying freshwater aquifer (Equus Beds).

11. Saltwater brine is being transported in the Burrton area through several types of pipelines, including asbestos-cement Transite, steel, vitrified clay, and Orangeburg sewer line pipe. It is estimated the condition of many of these lines is poor.

12. Depth to bedrock in the proposed Burrton Intensive Groundwater Use Control Area ranges from 100 to 250 feet. A bedrock high, just south of Burrton, seems to influence the deep brine-plume movement.

13. The predominant source of high chlorides in the groundwater in the proposed Burrton Intensive Groundwater Use Control Area is oil-field brine. This conclusion is primarily based upon bromide/chloride versus chloride ratios of the groundwater in the area. South and southwest of the proposed Burrton Intensive Groundwater Use Control Area, the source of chloride is from halite solution. Iodide/chloride ratios suggest the salt water originated at or near the surface and flowed downwards.

14. A mass transport model of the salt water in the Burrton area estimates that the 250 mg/l iso-chlore will move approximately one mile south and east by the year 2000, assuming no additional appropriations.

15. The mass transport model of the proposed IGUCA estimates that the average chloride concentration of the groundwater in Sec. 4-T24S-R3W., in the vicinity of Application 35887 (Regier, Inc.), will be approximately 409 mg/l in the year 2000. The model estimates that the approval of Application 35887 in the proposed Burrton IGUCA area will produce insignificant change in the chloride concentration of the groundwater in the area.

RECOMMENDATIONS

Recommendation 1. Move Entire Proposed Intensive Groundwater Use Control Area West One Mile

Based upon the results and conclusions of this study by the Burrton Task Force, the Task Force recommends that the proposed 36 square-mile Intensive Groundwater Use Control Area be moved west one mile. Moving the proposed control area west one mile means that the following sections would be deleted on the east side of the currently proposed area: Sections 14, 23, 26, and 35, Township 23 South, Range 3 West, and Sections 2 and 11, Township 24 South, Range 3 West. Moving the proposed control area west one mile would mean adding the following six sections along the west side of the currently proposed area: Sections 14, 23, 26, and 35, Township 23 South, Range 4 West, and Sections 2 and 11, Township 24 South, Range 4 West.

Information gathered from the six sections west of the currently proposed control area indicate high chlorides ranging up to 1000 mg/l in those sections. Therefore, it is suggested those sections be included in the control area.

Kansas Geological Survey modelling of the area predicted water quality and chloride movement in the area to the year 2000. The model predicted only one of the six sections on the east side of the currently proposed control area (Section 26) would have chloride ranging from 100 to 500 mg/l chloride. All other sections along the east side are estimated to have chloride concentrations of less than 100 mg/l. Therefore, the Task Force is recommending that the eastern six sections in the currently proposed Intensive Groundwater Use Control Area be deleted.

Recommendation 2. Check Integrity of Saltwater Lines

The saltwater disposal and gathering line systems have been in operation since the mid 1940's. Although the exact date of installation of each system is not known, a map dated December 1940 showed some of the systems in place at that time. Other maps used for reference were not dated. The integrity of these lines at any point from 1940 to present is not known and continual chloride contamination could be occurring if corroded lines, leaking joints and collars exist. The contribution of chloride to the groundwater from these services, if they exist, is an unknown factor that will have a decided effect on the assumptions made in developing a mass transport model for the area.

The majority of the lines for the North Burrton Salt Water Disposal Association and Resource Recovery Corporation lie in the eastern part of T23S-R4W and the western part of T23S-R3W. Samples of water from wells collected from these areas had high chloride concentrations and Dr. Whittemore's study determined were contaminated by brine. Brine line leakage could be one source of chloride contamination in these wells.

Brine lines of various sizes and materials were used in the Burrton Oil Field. Transite lines of resistant material were present, as were separate lines of non-resistant material. Sizes of the lines ranged from 2 to 7 inches and most of the Transite lines and other lines of resistant materials were 3 inches in diameter. The lead line sizes were not recorded on the maps, however, it is assumed all are made of steel.

Numerous lines were made of "non-resistant" (probably steel) material and many were of rather short length leading from the tank battery to the disposal well. These lines are corrosion prone and have leaked at sometime.

Transite lines are resistant to corrosion, however, they are somewhat porous and probably not water tight. The rubber rings used in the collars as a seal may have broken down and become brittle with time.

The integrity of the disposal systems should be checked. All leaking lines should be repaired and those that have been repaired numerous times, replaced. Larger diameter lines could possibly have smaller liners installed inside if found to be leaking. This will be the responsibility of KCC-KDHE to work with all the saltwater disposal associations to check their lines for leakage.

Recommendation 3. Check Competency of Cement-Lined Saltwater Pits

The water retention compentency of the cement-lined saltwater pits should be evaluated. Sealed ponds which are leaking represent a continuous pollution source to groundwater resources. Pond overflows are another source of intermittent pollution. Each of these ponds should be field checked and evaluated. A sampling of the observation wells surrounding the pits as well as the competency of the pits will be done by KDHE.

Recommendation 4. Conduct Detailed Lease Investigations

A detailed lease inspection should be run on all leases which water quality data indicates may be potential water pollution contributors. Such inspections should look for abandoned wells not on the inventories, abandoned wells not plugged, injection wells not authorized, and any suspicious potential water pollution situations.

Recommendation 5. Investigate Integrity of Plugs In Wells Suspected Of Leaking

Plugged abandoned wells, which water sampling data indicates are potential pollution sources, should be drilled out and replugged. As much data as practical should be obtained during the drilling out of the plugged hole relative to water and mud qualities, cement quality and possibility of vertical fluid movement in the hole.

Recommendation 6. Conduct Mechanical Integrity Tests On All Injection Or Disposal Wells In Area

The new Underground Injection Control (UIC) regulations require that all injection and disposal wells have a mechanical integrity test every five years. This is a new program that is just beginning. The Task Force recommends that the Burrton area be placed very high in the order of testing and that priority be given by testing the injection and disposal wells in the proposed Burrton Intensive Groundwater Use Control Area.

Recommendation 7. Sample Soil Of Area Of Several Abandoned Saltwater Ponds

The majority of the pollution to this area has been caused by past and present oil field activities. One past activity that contributed significant pollution was the oil field saltwater ponds. Residual leachate from these pond areas could still be contributing to the observed pollution levels because of the amount and concentrations of brines that were disposed into them during their years of usage. They could possibly add enough chloride to the groundwater to retard the rate of dilution.

KDHE proposes locating at least one of these abandoned and filled in salt water ponds for the purpose of taking continuous split-spoon core samples from the surface down to at least three feet below the base of the filled in pond excavation. The soil samples would require analysis for residual salts. The purpose is to ascertain if the old saltwater ponds are a present contributor to pollution, and if so, the level of pollution contributions that exist.

Recommendation 8. Establish Deeper Aquifer Monitoring Wells

Locations for additional deep monitoring wells, 100-to-250 feet deep, should be selected to the immediate west and southwest of the City of Burrton. Please refer to Figures 14 and 19. No specific locations are recommended because there may be wells in this area that may meet the location and depth criteria assigned by the task force, thus the drilling of additional wells may not be necessary. Any new monitoring wells should be constructed to exclude any groundwater above the screened interval. The well diameter should be conducive for pumped samples.

Recommendation 9. Utilize Polluted Groundwater For Enhanced Recovery Of Oil

Resource Recovery's water well is located in the SWSWSE 19-23W-3W. The depth of this well is 124 feet and is used as a source of fresh water for injection into wells for enhanced recovery of oil. The groundwater from this well contains 401 mg/L chloride.

Located immediately to the east of the above well in the SESESE 19-23S-3W, are wells showing groundwater chloride concentrations from 1480 mg/L to 1830 mg/L. The depths from which these samples were collected are 60 feet and 110 feet, respectively. Please refer to Figures 13 and 14 and Table 3.

The task force responsibilities are to evaluate the existing groundwater pollution, the past and present sources of that pollution, and to make recommendations to the Chief Engineer of the Division of Water Resrouces as to whether an intensive groundwater control area should be established on the basis of deteriorating groundwater quality.

From a groundwater management standpoint, Resource Recovery or any other oil company who presently is using or will be using groundwater for water flood injection, should be required to use polluted groundwater for enhanced recovery purposes. Utilizing the polluted groundwater will help remove the contaminants from the aquifer and, if the well is appropriately located, may also help retard their migration down gradient. Resource Recovery should consider installing a water well to a depth of around 120 feet in the SESESE 19-23S-3W to intercept and use this polluted groundwater for use in their secondary recovery project. Chemical analyses would determine if the polluted groundwater would be compatible with the brine in the producing formation.

<u>Recommendation 10. Recommend Continuous Monitoring Program In Area</u>

Continuous monitoring and research of the groundwater quality in the proposed IGUCA and adjacent areas is recommended until quality and movement improves to meet State and groundwater management standards.

<u>Recommendation 11. Educate Public In Area About Problem And Future Salinity Trends</u>

Educate the water users and the public in the area about the seriousness of the present and future salinity trends.

Recommendation 12. Continue Appropriating Water Under Safe Yield Policy By Considering Applications On An Individual Basis

Consider remedial actions. Given that no present pollution sources exist and that most pollution sources are oil-field brine related, continuation of usual water rights appropriation policies may not be a bad policy in the long term, provided that the irrigators are educated as to what to expect. This is because additional pumpage will speed up aquifer restoration to natural water quality, although in the short run it may divert marginal quality water to the pumping centers. Interception of the brine plume could be considered, if economically feasible. KGS is currently investigating this approach.

Any new application for beneficial use of water should be evaluated on an individual basis to ascertain if the proposed point of diversion will meet district and State management standards.

Recommendation 13. Implement Additional Water Well Construction Standards

All future water wells constructed, reconstructed or plugged within the proposed IGUCA should be evaluated for their construction, reconstruction or plugging prior to the actual work being done by the Kansas Department of Health and Environment. This is to prevent cross communication of waters of differing quality.

INTRODUCTION
by
Equus Beds Groundwater Management District

For many years it has been known that salt water contamination of the groundwater exists in western Harvey and eastern Reno counties of south central Kansas. The contamination has been associated with the Burrton Oil Field and is in large part the result of oil field practices.

In 1977, the Equus Beds Groundwater Management District became interested in a project to monitor and better define the nature and extent of the salt water pollution. The district approached the Harvey County Economic Development Commission for funding of the project. The Commission recommended the project be funded by the Harvey County Commissioners who subsequently did so.

Over the next several years, 84 monitoring wells were installed in western Harvey and eastern Reno counties to monitor the chlorides in the groundwater. Harvey County provided funds to purchase materials such as casing, cement, etc. while the Wichita Water Department provided a drilling rig and crews to install the wells. Two small-diameter (1¼ inch to 2 inch) monitoring wells were installed at most locations, one shallow and one deep. The shallow well was drilled to the first producible formation below the top of the water table. The deep well was designed to be installed to the base of the Equus Beds just above the shale in the Wellington Formation. However, in most instances the deep well could be described as monitoring a middle zone between the very upper and very lower parts of the aquifer.

With increased water quality data from the area, the nature and extent of the salt water plume was better defined. Because irrigation development was continuing to take place in the Equus Beds Groundwater Management District, the district became concerned about the long-term effects of increased groundwater development in the Burrton area. The concern was raised that increased pumping of fresh groundwater down-gradient from the area (generally east and southeast) would cause the salt water plume to move southeast into fresh water areas, degrading fresh groundwater supplies.

On January 18, 1982, Application for the Beneficial Use of Water No. 35887 was filed by Regier, Inc. with the Division of Water Resources in Topeka. The proposed well location was just southeast of the known salt water plume in the Burrton area. On March 22, 1982, the Equus Beds Groundwater Management District recommended the Division of Water Resources take no action on the application pending an investigation of the water quality in the area and the impact of the proposed well on the quality of the water in adjacent wells. Subsequently, the Division of Water Resources requested the Kansas Geological Survey study the situation and provide the Division of Water Resources with information about the effect of the proposed well.

In a letter from the Kansas Geological Survey to the Division of Water Resources dated April 26, 1982, Dr. Marios Sophocleous wrote that projections showed the water quality in the area of the proposed well would degrade to the point of being questionable for irrigation use in the next five to ten years whether the well was installed or not. Based upon this information and the other data collected in the Burrton area over the previous years, on June 8, 1982, the Board of Directors of the Equus Beds Groundwater Management District requested the Chief Engineer-Director (hereinafter referred to as Chief Engineer) of the DWR initiate the proceedings for the designation of an Intensive Groundwater Use Control Area (IGUCA) in a 36 square mile area around Burrton. On August 4, 1982, a public hearing was held by the Chief Engineer in Burrton to gather information upon which to base a decision concerning a control area.

Following the hearing, the Chief Engineer continued the hearing for one year to allow additional data to be gathered from the area. In addition, the Chief Engineer appointed a task force to study the area and report the results to the Chief Engineer in one year with recommendations about the need, extent, and nature of any controls in the proposed intensive groundwater use control area. The task force is composed of a member from the Kansas Department of Health and Environment, the Equus Beds Groundwater Management District, the Kansas Water Office, the Kansas Corporation Commission, the Kansas Water Authority, the Kansas Geological Survey, and a representative of the Kansas Independent Oil and Gas Association. The manager of the Equus Beds Groundwater Management District was designated chairman of the task force. In addition, the Chief Engineer said he would accept but not process any applications to appropriate water for a beneficial use except applications for domestic use and temporary permits in the proposed control area subsequent to the date of the hearing.

This study is a result of a one year effort by the task force to provide additional data about the nature, source, and extent of the salt water pollution in the groundwater in the proposed control area. The purposes of this study, as outlined by the task force at an earlier meeting, are as follow:

1. determine the need for an intensive groundwater use control area and if so, define the boundaries of the area; and
2. make recommendations to the Chief Engineer concerning the area.

Specific Technical objectives of the study are as follow:

1. define the source or sources of pollution;
2. define the extent of the pollution;
3. inventory information from the area;
4. develop management alternatives; and
5. prepare a groundwater model for the area.

This report is a summary of the first year's study by the Task Force. It describes the information about the area assembled by the Task Force and makes recommendations concerning a proposed Intensive Groundwater Use Control Area.

METHODS OF INVESTIGATION

by

Equus Beds Groundwater Management District

The Burrton Task Force met several times throughout the course of this first year's study. With some exceptions, a large part of this information has been compiled from data in existing agency files and records. However, other information presented here is the result of field work in the area during the course of this year's study.

The data presented by the Kansas Department of Health and Environment is a combination of information from files and from direct field work. The history of the area and existing oil field data were supplied by records. A portion of the water quality data was collected during a mass sampling of water wells in December, 1982.

The modelling and water quality information presented by the Kansas Geological Survey was a combination of work done for this study and work done for two other studies. Dr. Don Whittemore had previously been developing a method to determine the source of chloride in water samples. A portion of the information presented here was prepared for an earlier study while a portion of the work was done directly for this study. The computer modelling of water quality in the Burrton area was made for an independent study, knowing there was a problem in the Burrton area. The study happened to be completed during this first year's study by the Burrton Task Force and meshed very well with this study.

A great deal of the water quality information used in the modelling and other portions of this study was generated by the Equus Beds Groundwater Management District. The water rights and water use information was prepared from the Equus Beds Groundwater Management District and the Division of Water Resources files. The summary of oil and gas activities and status of oil and gas wells in the area was prepared by the Kansas Corporation Commission from their records and files.

HYDROGEOLOGY

by

Kansas Geological Survey and Kansas Department of Health and Environment

Hydrogeologic Setting of the Burrton Study Area

The study area consists of unconsolidated deposits of Pleistocene age in the upper part and occassionally Pliocene age in the lower part (Stramel, 1967) overlying the bedrock, which consists of consolidated Permian rocks (Wellington Formation and Ninnescah Shale). The Wellington Formation (Fig. 1), which is the predominant bedrock unit in the study area, can be divided (Leonard and Kleinschmidt, 1976) into an upper member consisting mainly of shale with minor amounts of gypsum, anhydrite, dolomite, and siltstone; a middle unit which, in the western part of the study area, is the Hutchinson Salt Member consisting of salt interbedded with minor amounts of shale, gypsum, and anhydrite; and a lower member consisting mostly of shale with abundant anhydrite and some gypsum and dolomite. Differential dissolution of large portions of the salt resulted in the development of a permeable unit known as the "lost circulation zone" (LCZ) or Wellington aquifer. The areal extent of the "lost circulation zone" is shown in Figure 2. The unconsolidated rocks, of fluvial origin, consist of gravel, sand, silt, and clay in various proportions. The sand and gravel beds generally lie between lenses of silt, clay, and sandy clay. For the most part, the fluvial deposits are buried beneath a mantle of wind-deposited sand, silt, and clay. A large area of sand dunes, mostly underlain by discontinuous clay lenses, exists north of Burrton (Fig. 3).

Geologic Cross Sections Of Unconsolidated Deposits In The Burrton Study Area

Drilling logs of water well records for the Burrton Study Area, Harvey County 23S-3W, 24S-3W and Reno County 23S-4W, 24S-4W, were reviewed to locate the presence of clay layers and to compare the stratigraphic continuity and orientation of these layers. This evaluation was also employed as a method of investigating the geology of the area.

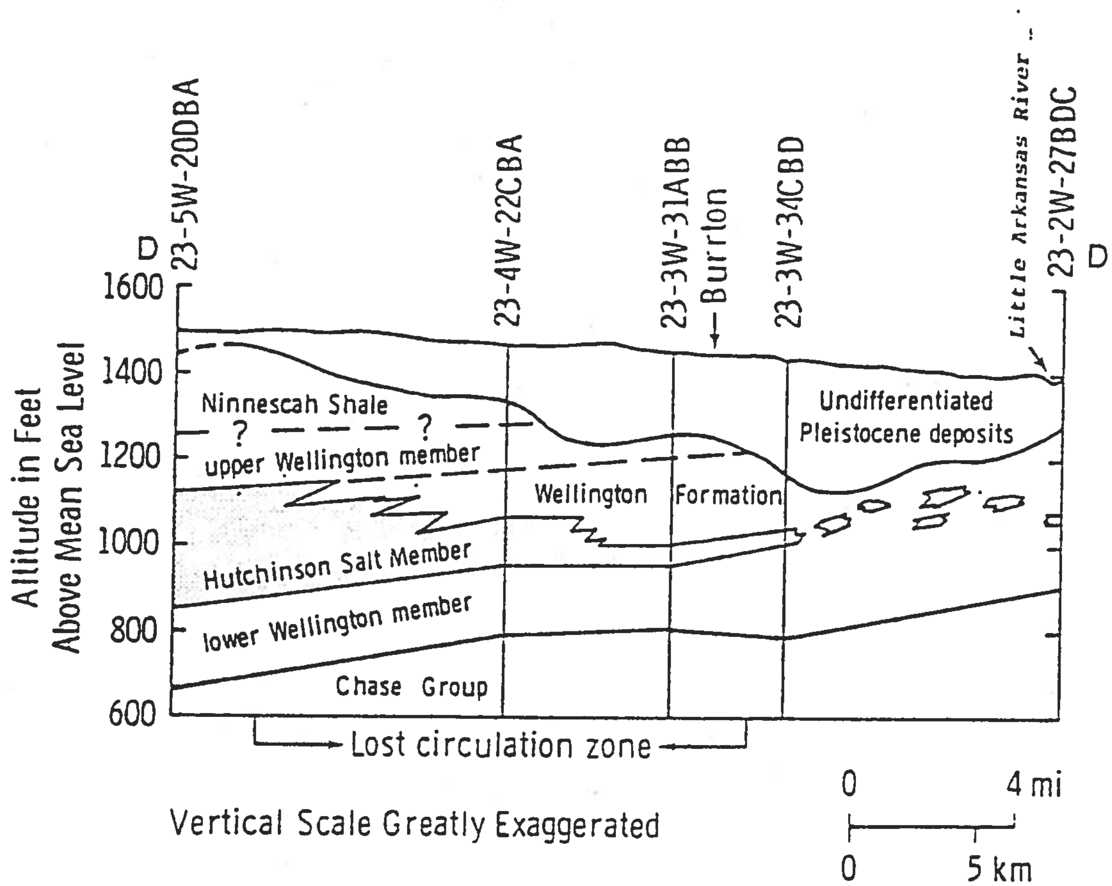


Figure 1. Geologic cross section in the vicinity of Burrton. (Adapted from Gogel, 1981)

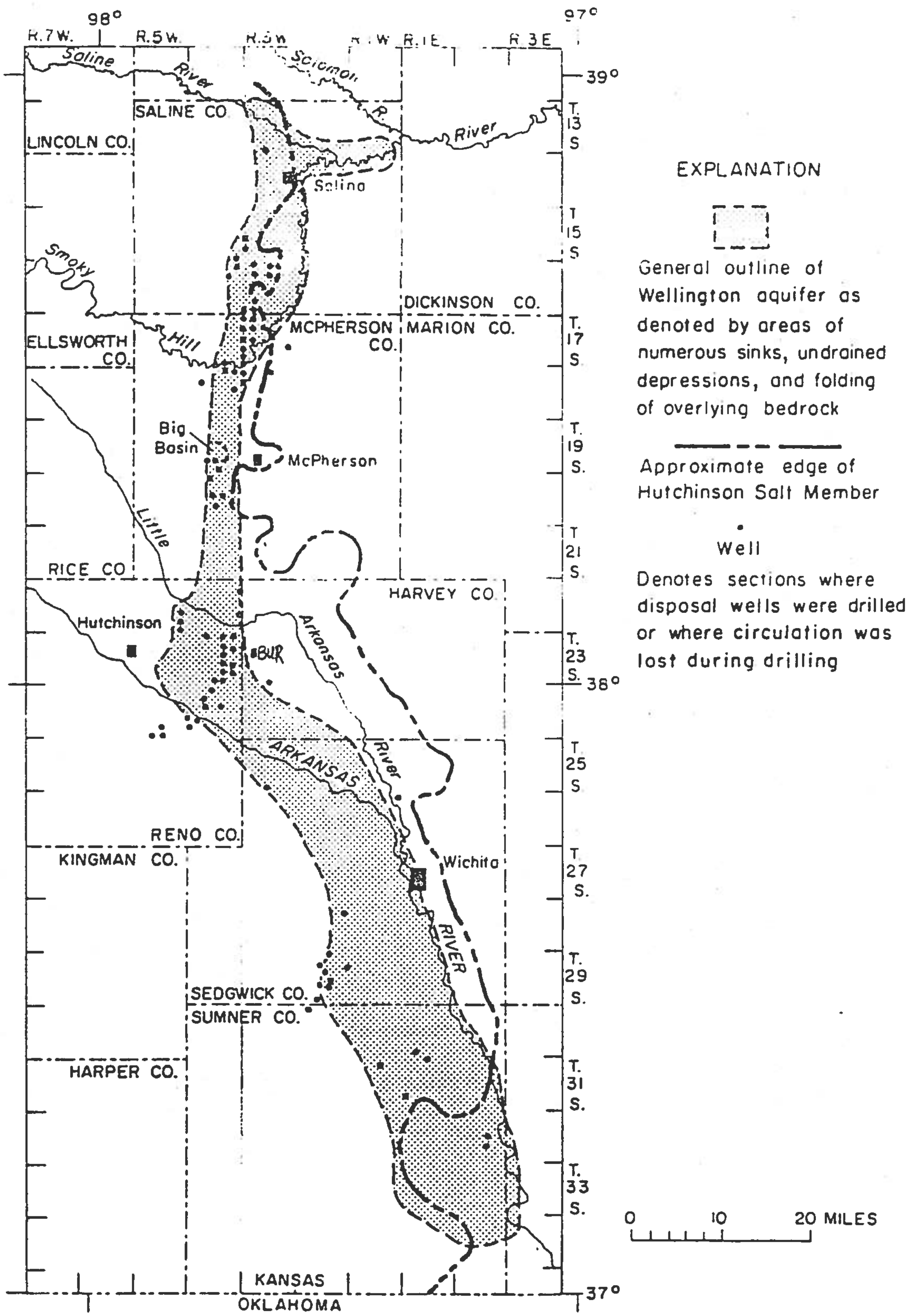


Figure 2.--General outline of Wellington aquifer as denoted by areas of sinks and undrained depressions, locations of disposal wells, and areas where lost circulation was reported.
(From Gogel, 1981)

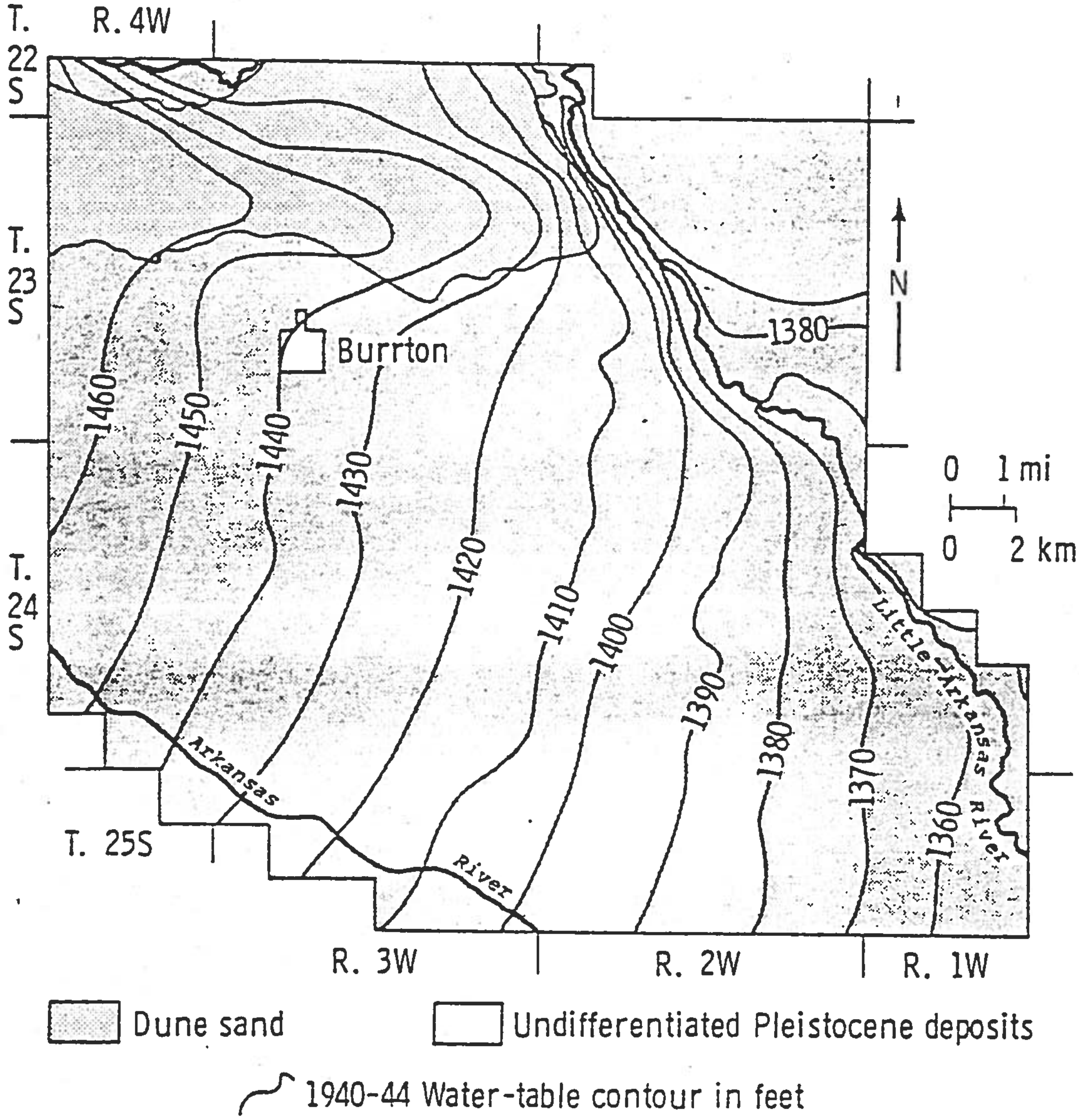


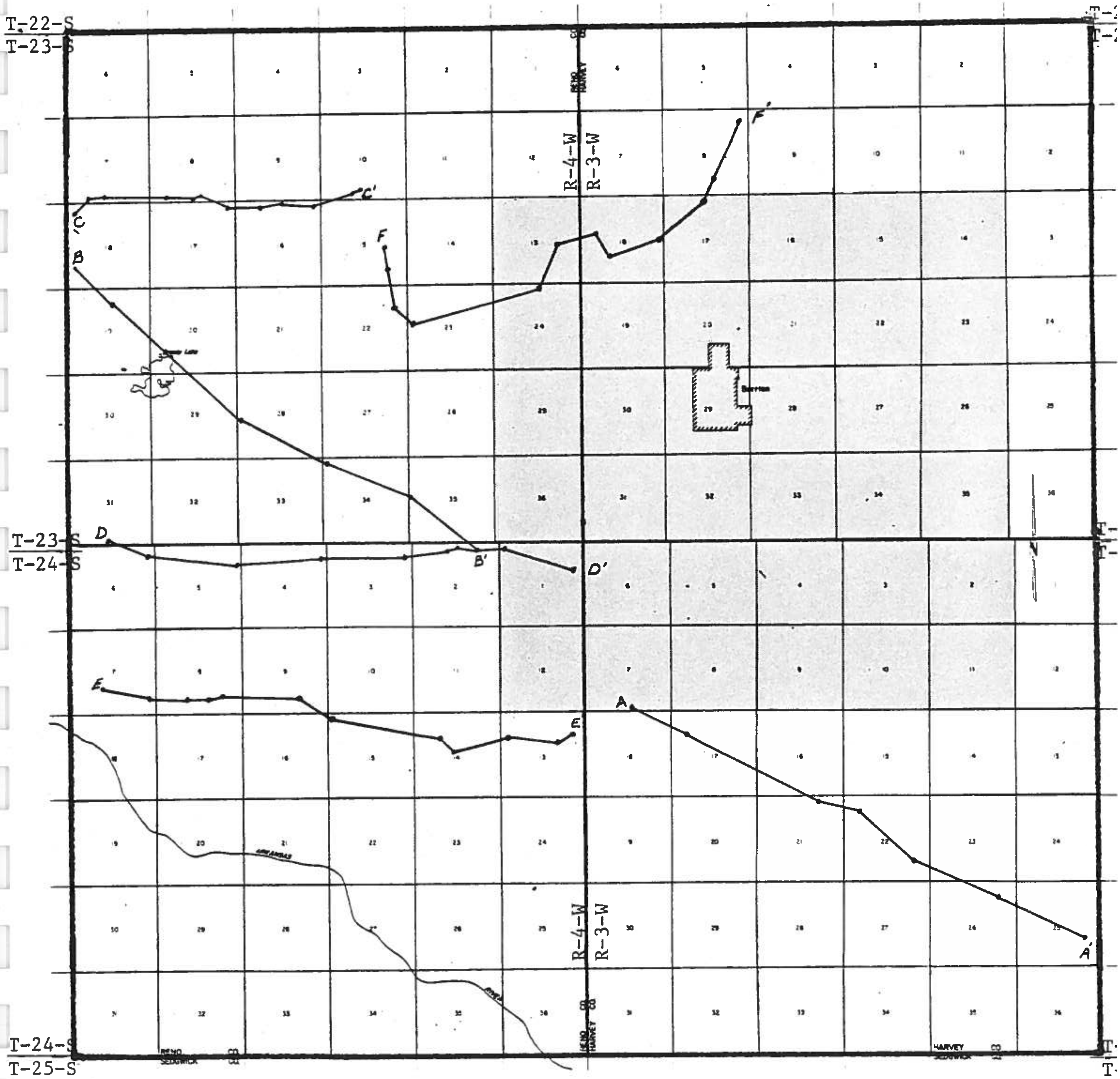
Figure 3. Surficial geology and 1940-44 water-table configuration. (Modified from Williams and Lohman, 1949)

The investigation confirmed the existence of clay layers in the Equus Beds aquifer and recent alluvium (Figures 4 through 9). The most substantial layers found in the logs were 35-75 feet thick (see Fig. 9, cross section F-F'); the thinnest clay layer was 1-5 feet thick (see Fig. 7, cross section C-C' and Fig. 8, cross section D-D'). Interpretation of the driller's logs indicates the clay layers are not connected or continuous. The clay layers tend to be interbedded with silty sand, sand and gravel, and contain sandy clay in some localized areas. The logs also indicate the lateral extent of these layers to be as much as two miles wide.

These findings support the contention that the entire formation is hydrologically connected as an unconfined, unconsolidated aquifer containing clay lenses which act as barriers and aquitards. Because of their vertical and lateral discontinuity, the clay layers are not effective in restricting the spread of pollutants. In fact the clay layers have served to disperse the pollution over a greater area. The salt water pollution has traveled downward and laterally until it contacts a clay deposit which serves as a barrier or aquitard, dispersing the pollution plume both vertically and laterally. The contaminants then continue their downward migration until the next clay layer is reached. Due to this "stair-step" effect, pollution fronts may be found at varying distances and at various depths from sources. Consequently, chloride concentrations are much different from those concentrations at the initial pollution source. High chloride concentrations may be the result of pollution that has migrated some distance from its originating source. This "stair-step" effect may also help explain the reason why the chloride levels of the deep wells are higher and extend over a larger area than the shallow well chloride levels. The actual source(s) of the chloride pollution could possibly be a mile or more away and in a different direction from the location where the saltwater pollution is finally showing up in the groundwater.

Figure 4

MAP SHOWING LOCATIONS OF CROSS SECTIONS OF CLAY LAYERS



Section Cut Lines For Cross Sections

Proposed IGUCA

Scale 1 0 1 2 MILES

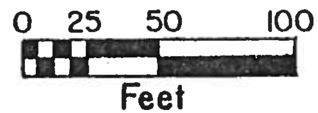
Figure 5

EXPLANATION TO CROSS SECTIONS OF CLAY LAYERS

LEGEND

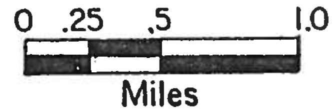
Water Wells

Vertical Scale



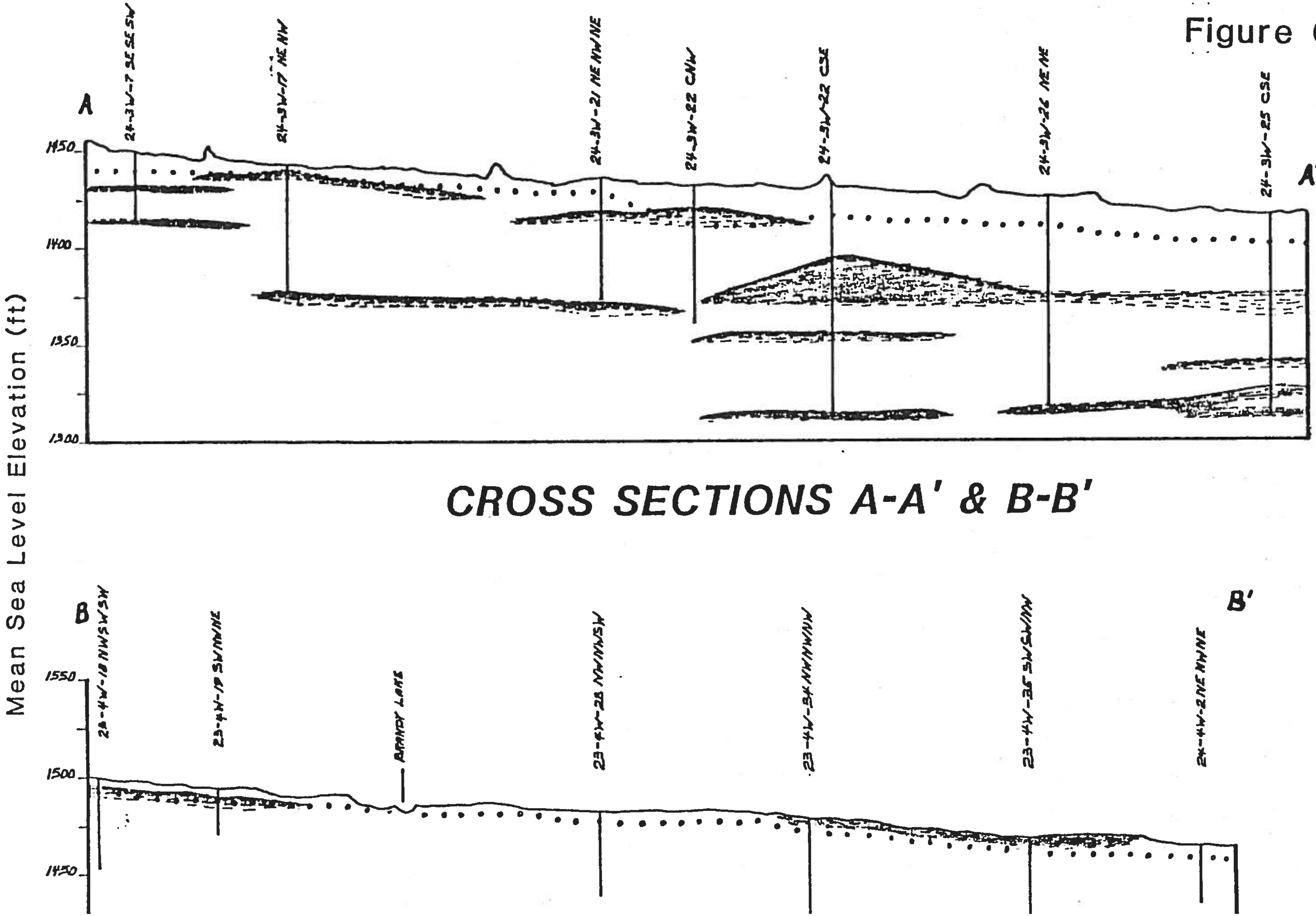
Water Level

Horizontal Scale



Clay Layers

Figure 6



CROSS SECTIONS A-A' & B-B'

Figure 7

CROSS SECTION C-C'

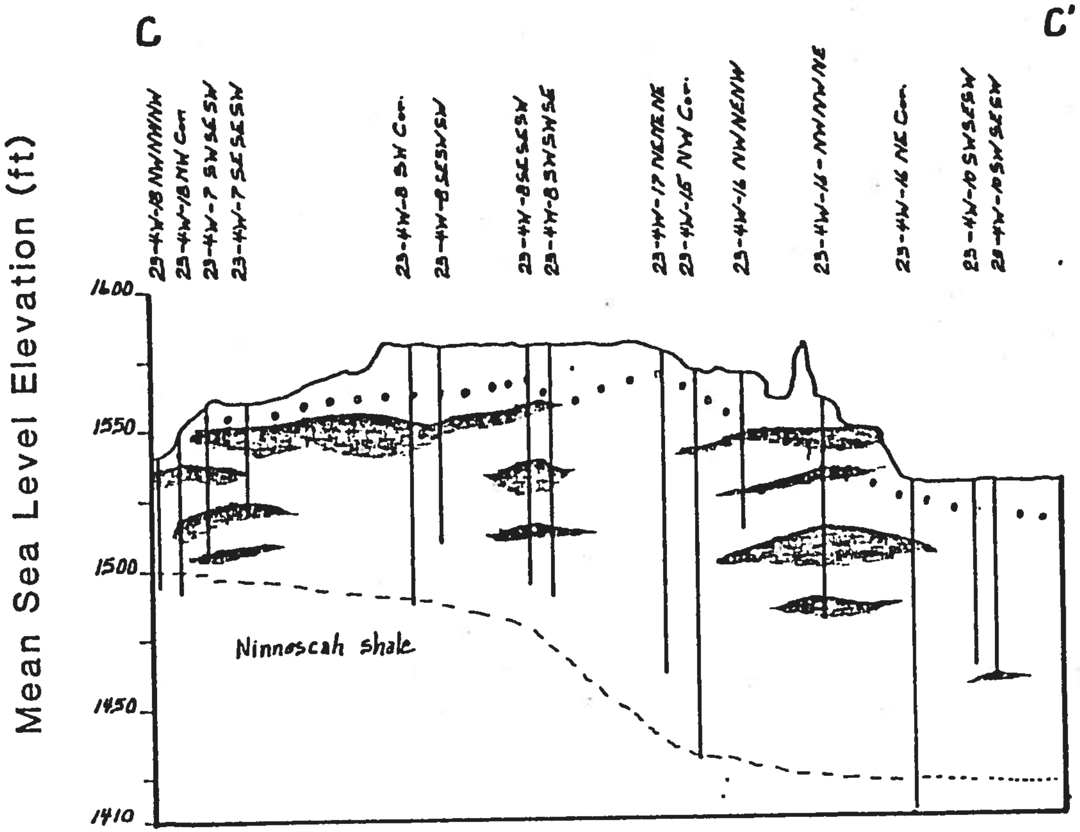
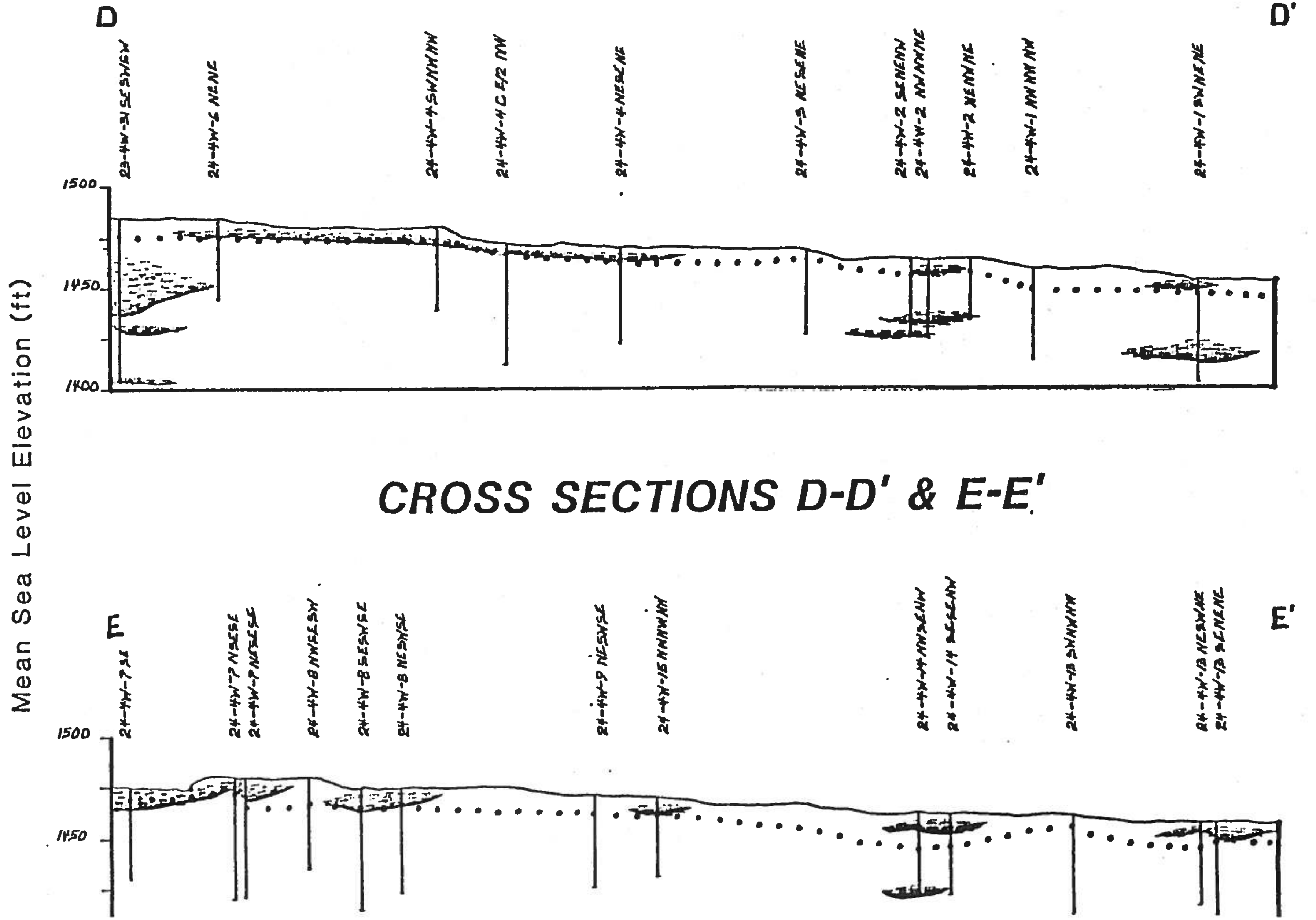


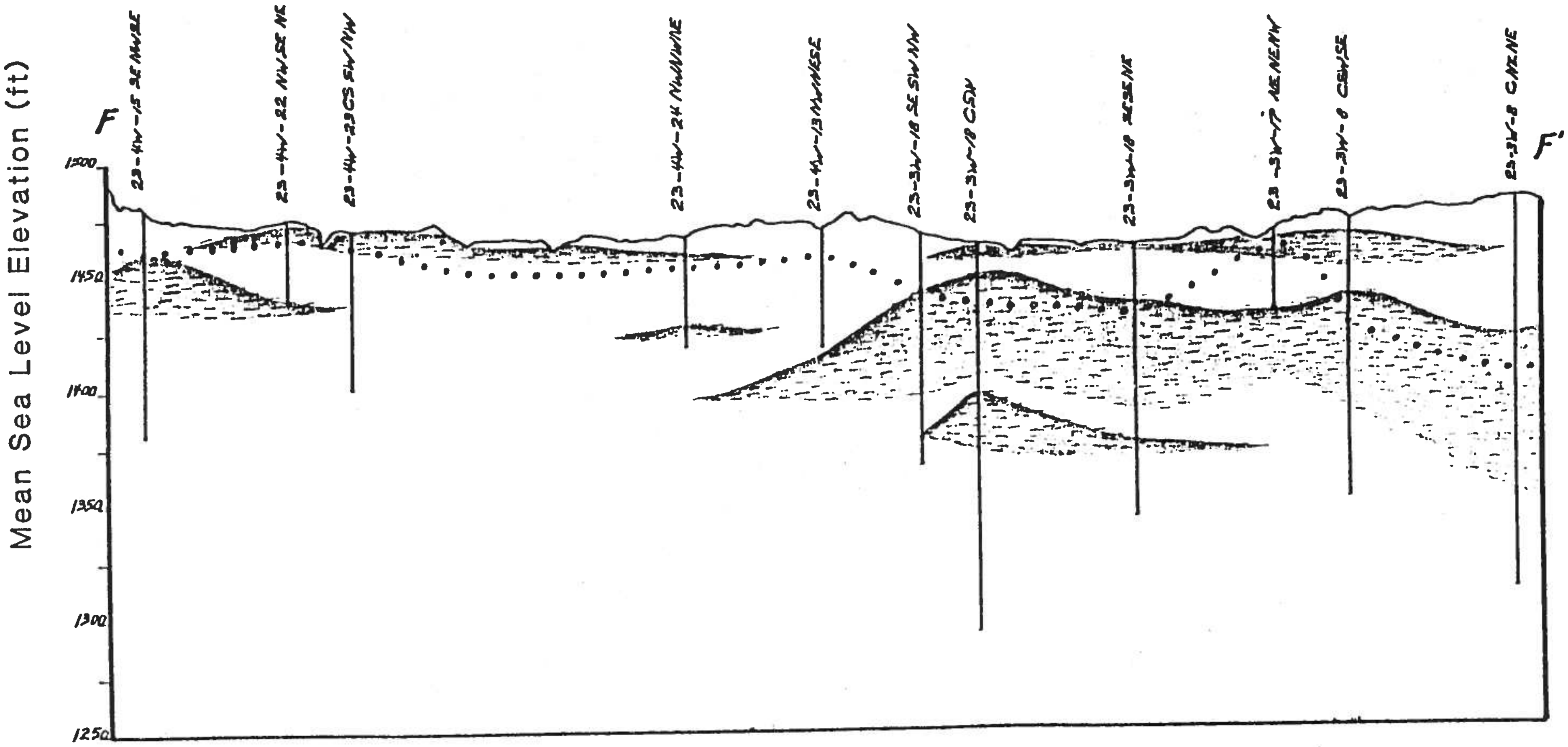
Figure 8



D
D'
1500
1450
1400
Mean Sea Level Elevation (ft)
CROSS SECTIONS D-D' & E-E'
E
E'
1500
1450

Figure 9

CROSS SECTION F-F'



SUMMARY OF WATER RIGHTS AND WATER USE

by

Equus Beds Groundwater Management District

Tables 1 and 2 are summaries of water use and water rights information for the proposed Burrton Intensive Groundwater Use Control Area. Table 1 shows municipal, industrial, and irrigation use in the area from 1977 through 1982. Total useage in the proposed control area averages 6,021 acre-feet per year.

The average yearly useage is as follows: municipal - 3,936 acre-feet; industrial - 231 acre-feet; and irrigation - 1,854 acre-feet. Almost all of the municipal useage comes from the City of Wichita. Wichita has four water wells in the very southeast section of the proposed control area. Burrton averages 99 acre-feet per year while Wichita averages 3,837 acre-feet per year.

Approximately 40 percent of the industrial useage is for secondary recovery of oil. The remaining 60 percent is a sand and gravel operation. The irrigation useage averages 1,854 acre-feet per year and represents a combination of both flood and center pivot sprinkler irrigation.

Water right appropriations in the area total as follow: municipal - 3,048 acre-feet per year; industrial - 1,042 acre-feet per year with 265 acre-feet pending in three applications; irrigation - 4,783 acre-feet per year with 136 acre-feet pending on one application. Total water rights in the proposed control area are 9,274 acre-feet including pending applications.

Table 1

Reported Water Use by Category for the
Proposed Burrton Intensive Groundwater Use Control Area
Equus Beds Groundwater Management District No. 2
(Acre-feet)

Year	Municipal	Industrial	Irrigation	Total
1977	3,315	136	857	4,308
1978	4,011	220	2,246	6,477
1979	4,350	393	1,730	6,473
1980	4,267	351	3,247	7,865
1981	3,917	48	1,686	5,651
1982	3,755	240	1,359	5,354
	23,615	1,388	11,125	36,128
Average	3,936	231	1,854	6,021

Table 2
SUMMARY OF WATER RIGHT APPROPRIATIONS
AND REPORTED WATER USE FOR THE BURRTON AREA
EQUUS BEDS GROUNDWATER MANAGEMENT DISTRICT NO. 2

Application Number		Applicant	Location Section-Township-Range	Water Right A/FT	Water Right Status[a]	Reported Use (A/FT)[b] 1982	1981	1980	1979	1978	1977	Average Use (A/FT)
		MUNICIPAL USE										
H-5		City of Burrton	SW NE SE 29 23 3W	See 17756	VR	--	--	--	--	--	--	0
&			SE NW SE 29 23 3W			--	--	--	--	--	--	0
1497		City of Burrton	Lot 6 Blk 51 29 23 3W	See 17756	VR	--	--	--	--	--	--	0
17756		City of Burrton	NW NW NW 16 23 3W	140	NP	108	1	--	126	132	129	99
1006	#41	City of Wichita	NE NE NE 11 24 3W	727		1364	1193	1428	1455	1173	1130	1291
	#42		SE SE NE 11 24 3W	727		647	725	631	661	662	427	626
	#43		SE SE SE 11 24 3W	727		634	760	1037	677	936	845	815
	#44		SW SW SE 11 24 3W	727		1002	1238	1171	1431	1108	784	1122
		INDUSTRIAL USE										
9057		Recovery Resources	SE NE SE 18 23 3W	823	NP	196	48	150	147	73	136	125
			SW SW SE 19 23 3W			NU	NU	--	--	--	--	0
31465		Bryant Sand Company	SE NE SE 27 23 3W	206	NP	44	--	201	246	147	--	160
34332		Independent Fuels, Inc.	SE SW SE 23 23 3W	13	P	--	--	--	--	--	--	0
34374		Burnice Hill (Thatch Sand, Inc.)	NCO SE SE 27 23 3W	22	A	WND	--	--	--	--	--	0
34375		Burnice Hill (Thatch Sand, Inc.)	NCO S½ SE 27 23 3W	221	A	WND	--	--	--	--	--	0
34376		Burnice Hill (Thatch Sand, Inc.)	NCO SE SE 27 23 3W	22	A	WND	--	--	--	--	--	0
		IRRIGATION USE										
3036		Donna A. Darling	NCO NE 14 23 3W	132	C	55	57	125	43	47	40	61
5785		Harry Nitengale	NCO NE 19 23 3W	240	NP	--	--	--	--	--	--	0
7742		Weber Brothers	NCO NE 26 23 3W	See 33810	C	--	--	--	--	59	164	112
14844		V. Jerry Blue	NCO SE 22 23 3W	231	C	156	150	--	--	177	40	131
14845		Linford Holdeman	SW NW SW 23 23 3W	120	NP	206	155	239	110	177	35	154

Table 2 (Continued)
SUMMARY OF WATER RIGHT APPROPRIATIONS
AND REPORTED WATER USE FOR THE BURRTON AREA
EQUUS BEDS GROUNDWATER MANAGEMENT DISTRICT NO. 2

Application Number	Applicant	Location Section-Township-Range	Water Right A/FT	Water Right Status[a]	Reported Use (A/FT)[b] 1982	1981	1980	1979	1978	1977	Average Use (A/FT)
		I R R I G A T I O N U S E									
19499	KWK Farms	NW NW SW 22 23 3W	See 30130	NP	--	--	--	--	--	--	0
21059	Comanche West, Inc.	NCO N½ NE 22 23 3W	120	NP	42	11	74	100	92	14	56
24585	Comanche West, Inc.	SW NE SW 16 23 3W	240	NP	106	133	340	200	124	19	134
25337	Don Valdois	NCO S½ SE 3 24 3W	120	NP	--	--	120	36	91	31	70
26496	KWK Farms	NCO SE 16 23 3W	237	NP	125	124	160	126	237	181	159
26497	KWK Farms	NCO Ws SE NE 21 23 3W	180	NP	67	85	246	160	230	47	139
26531	Milton C. Boyle	NCO SW SE 8 24 3W	240	NP	53	41	155	--	137	27	83
26561	Regier, Inc.	NCO NE 5 24 3W	234	NP	--	234	234	108	146	12	147
27416	Melvin F. Kincaid	NCO NE 1 24 4W	240	NP	78	59	115	87	240	24	100
27803	John Stutzman	NCO W½ SE 11 24 3W	240	NP	--	227	300	188	250	114	216
		NW NW SE 11 24 3W			--	--	--	--	--	--	0
28063	James H. Siemens	NE SE NE 17 23 3W	227	NP	8	17	18	12	11	5	12
30130	KWK Farms	NW NW SW 22 23 3W	120	NP	136	165	118	162	228	77	148
30425	Milton C. Boyle	NCO SE 8 24 3W	120	NP	NU	NU	150	83	NU	27	87
32719	John Stutzman	NCO NE 11 24 3W	102	NP	--	--	WND	--	--	--	0
32760	Don Weninger	NCO NE 3 24 3W	240	NP	15	--	221	WND	--	--	118
32843	Warren R. Schmitt	NCO NW 26 23 3W	201	NP	78	120	172	14	--	--	96
32903	Lawrence J. Baalmann	NCO NW 2 24 3W	240	NP	--	--	63	WND	--	--	63
33104	Eldon W. Baumann	NW SE SE 12 24 4W	71	NP	NU	--	NU	WND	--	--	0
33267	Allen Baumann	NCO N½ SE 12 24 3W	57	NP	--	1	166	54	--	--	74
		NCO N½ SW 7 24 4W	56	NP	--	--	44	30	--	--	37
33495	Lloyd W. Boyle	NCO SW 9 24 3W	240	NP	53	44	--	WND	--	--	49
33810	Weber Brothers	NCO NE 26 23 3W	171	NP	89	63	187	217	--	--	139
34987	Warren F. Miller	NCO NW 25 23 4W	179	P	WND	--	--	--	--	--	0
35035	Duane Goering	NCO SE 5 24 3W	185	NP	92	WND	--	--	--	--	92
35887	Regier, Inc.	NE SW SW 4 24 3W	136	A	WND	--	--	--	--	--	0
			9,274		5,354	5,651	7,865	6,473	6,477	4,308	

[a]Water Right-Status: VR - Vested Right; A - Application; P - Permit; NP - Notice & Proof; C - Certificate

[b]Reported Use: -- No Report; NU - No Water Used (Has well); WND - Well Not Drilled
Source; Equus Beds Groundwater Management District and Division of Water Resources

WATER QUALITY

Historical Water Quality by Kansas Department of Health and Environment

Prior to discovery of the Burrton Oil Field in 1931, records of the Kansas Department of Health and Environment indicate that the overall water quality in the Burrton area was very good. Chloride concentrations within the Burrton Oil Field area ranged from 10 to 100 mg/l before oil field development (Figure 10). The widespread use of brine disposal ponds during the early life of the field coupled with leaks, brine line distribution systems, and pressurized shallow "lost circulation zone" disposal wells, caused the quality of the groundwater to deteriorate. Chloride concentrations in water wells in 1948, as documented in KGS Bulletin 79 (1949) and from KDHE records are shown in Figures 11 and 12. The 1948 iso-chloride maps (Figures 11 and 12) and the 1983 iso-chloride maps (Figures 13 and 14), both show an elongated north-south pollution plume. The 1948 groundwater pollution front is associated with the Burrton Oil Field, however, the southeastward migration of this pollution plume has probably combined with other chloride pollution fronts within the Burrton Oil Field, resulting in the pollution body configuration shown in the groundwater quality maps in Figures 11 and 12. These figures graphically indicate the chloride concentration patterns which resulted from a group of merging pollution fronts.

History of Brine Disposal for the Burrton Oil Field

The brine disposal methods most commonly used during the first 14 years following the discovery of the Burrton Oil Field in early 1931, were brine disposal ponds and shallow disposal wells in the Wellington "lost circulation zone". Since the North and South Burrton Disposal Associations were not formed until late 1943, it can be assumed that for approximately 12 years, the majority of the brine was disposed through one of these two methods. KGS Bulletin 79 states that in 1939, an average of 44,047 barrels of brine were produced daily by leases in the Burrton Oil Field. Using this average rate of brine production for a twelve year period and assuming the average concentration of chloride in the brine was 96,000 mg/l, the estimated total tons of salt produced and placed into brine ponds was 1.9 million tons. Because the annual rainfall in the Burrton area is 32 inches per year

Explanation For Figure 10

Figure 10 was prepared in 1938 (August, September, and October) by staff of the Kansas State Board of Health. Its historical significance is revealed by the chloride analyses that were conducted on the water from water wells, salt water ponds, creeks and rivers within the Burrton Oil Field. Figure 10 is located inside the back cover.

Concentration of chloride in groundwater from the water wells varies from 4 to over 2000 mg/l.

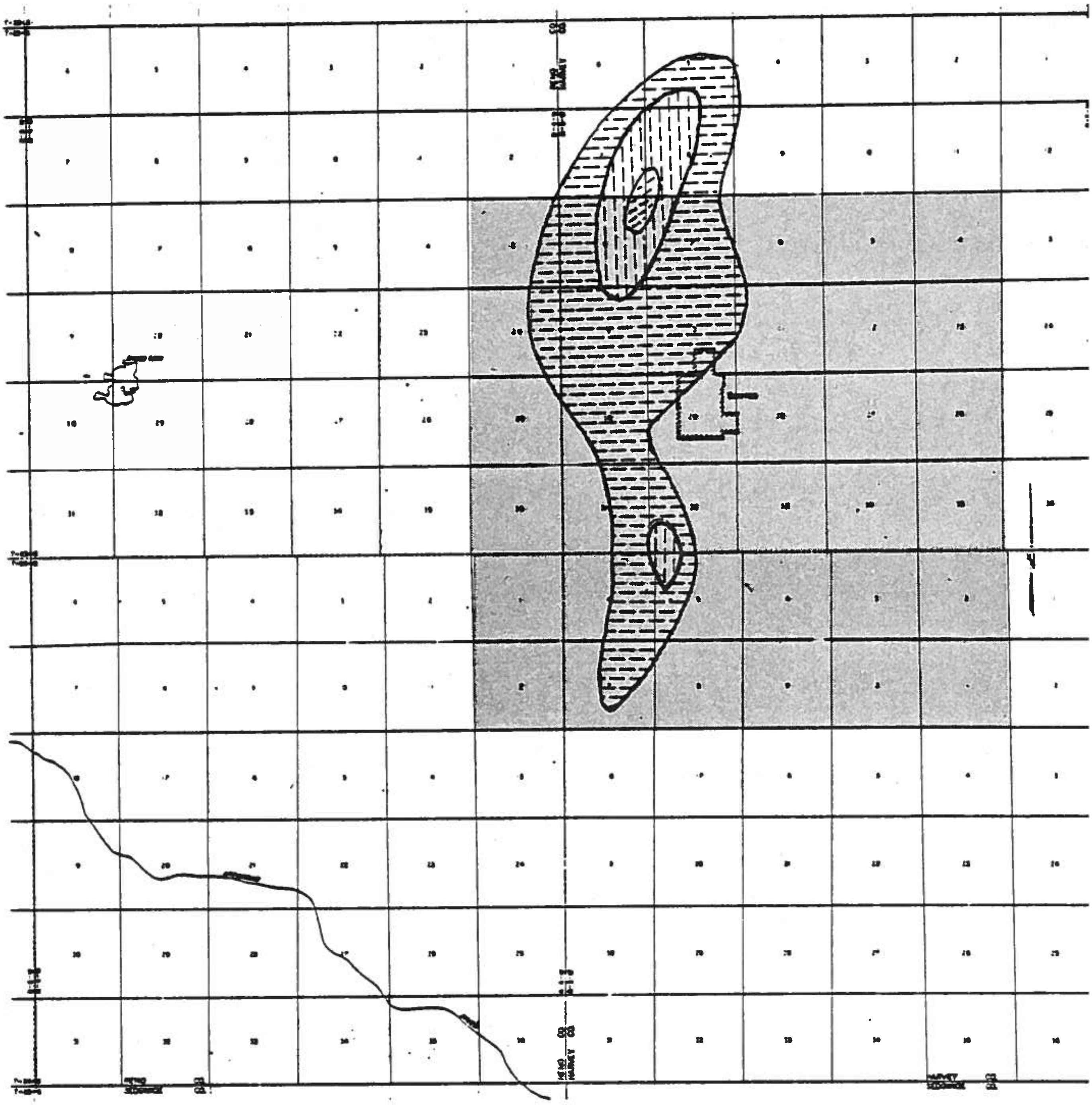
Kisiwa Creek waters and its tributaries showed chloride concentrations ranging from 1030 up to over 83,000 mg/l (SE NW 26-23-4W, Reno Co.).

Arkansas River water showed chloride concentrations ranging from 1000 (NW 18-35-4W, Reno Co.) to 1330 mg/l (SW 21-24-4W, Reno Co.).

Figure 10 shows the most accurate description of where wells were located and shows the location of the salt water disposal wells. Most of these early disposal wells were disposing brine into the "lost circulation zone" of the Hutchinson Salt Member of the Wellington Formation.

Figure 1

1948 CHLORIDE DATA



From wells less than 50' deep

Proposed IGUCA

FROM 1948 KDHE FILES

mg/l

Greater than 1,000 Cl

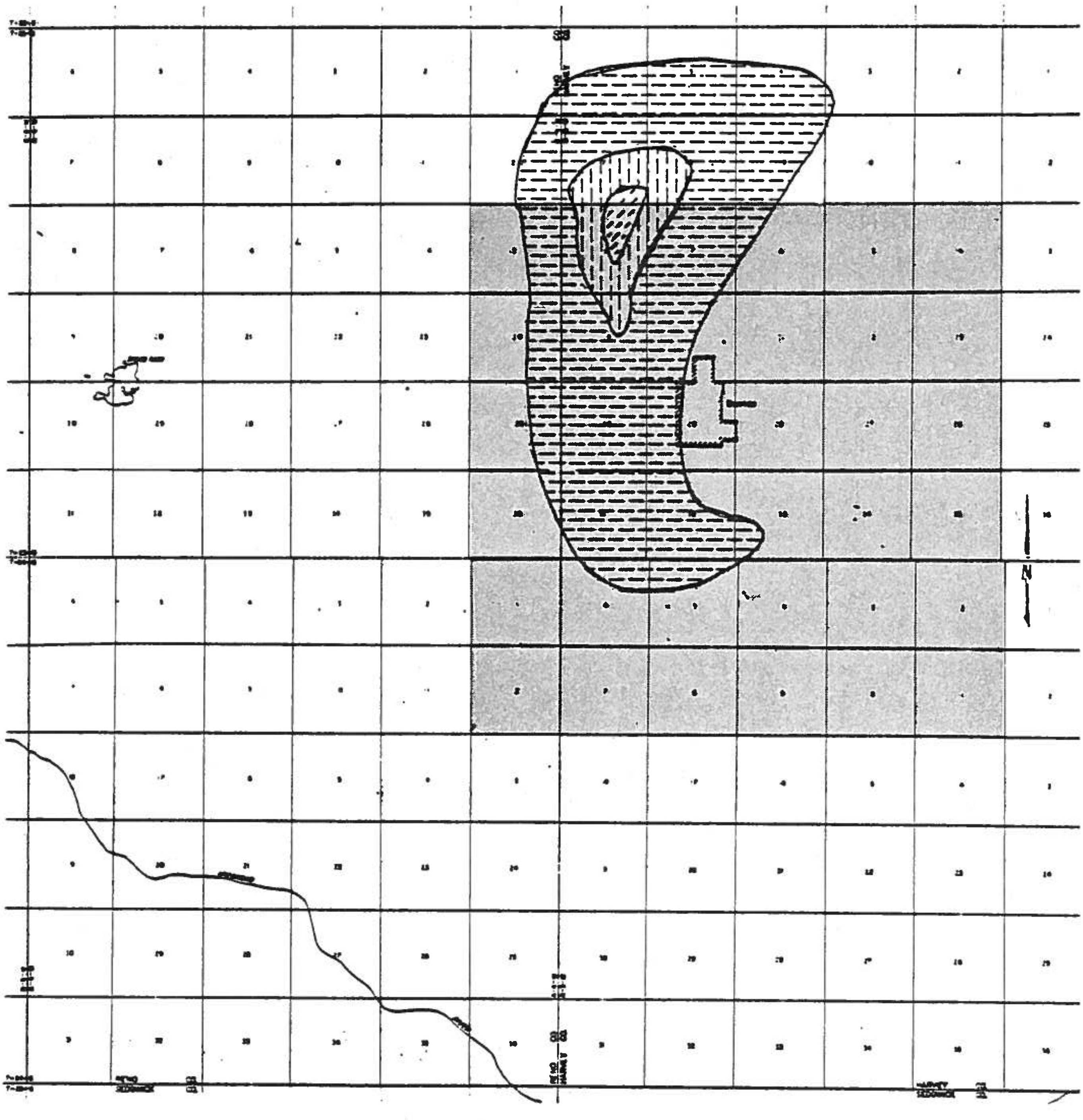
Greater than 500 Cl

Greater than 250 Cl

KDHE 4/83

Figure 12

1948 CHLORIDE DATA



From wells deeper than 50'

Proposed IGUCA

FROM 1948 KDHE FILES

mg/l	
Greater than 1,000 Cl	
Greater than 500 Cl	
Greater than 250 Cl	

KDHE 4/83

and because the average annual evaporation rate is 61 inches per year, the concentration of chloride in the brine ponds was probably considerably higher than 96,000 mg/l during certain parts of the year. It can be assumed that a large percentage of the 1.9 million tons of salt produced has entered the groundwater, with some unknown amount being tied up in the soil due to closure of the brine ponds. Evaporation of the brine would have taken place only in those areas where the soil was tight enough to retard seepage.

By late 1944 and early 1945, approximately 95% of the daily brine production was being disposed by deep disposal wells. The remaining 5% was being disposed by brine disposal ponds and shallow (LCZ) disposal wells. By the mid 1950's, almost all of the brine produced was being disposed by deep wells.

The majority of the groundwater pollution in the Burrton area apparently occurred during the period from 1931 to 1944 when the brine ponds and shallow (LCZ) wells were being used exclusively for brine disposal. However, the shallow groundwater iso-chloride map (Figure 13) indicates more recent pollution. The pollution in the shallow aquifer (less than 50 feet) can probably be related to losses of brine from spillage, tank overflows, numerous brine leaks and massive brine line failures. Most of these sources have become active during the last fifteen years. However, historical brine pollution has not moved out of the area.

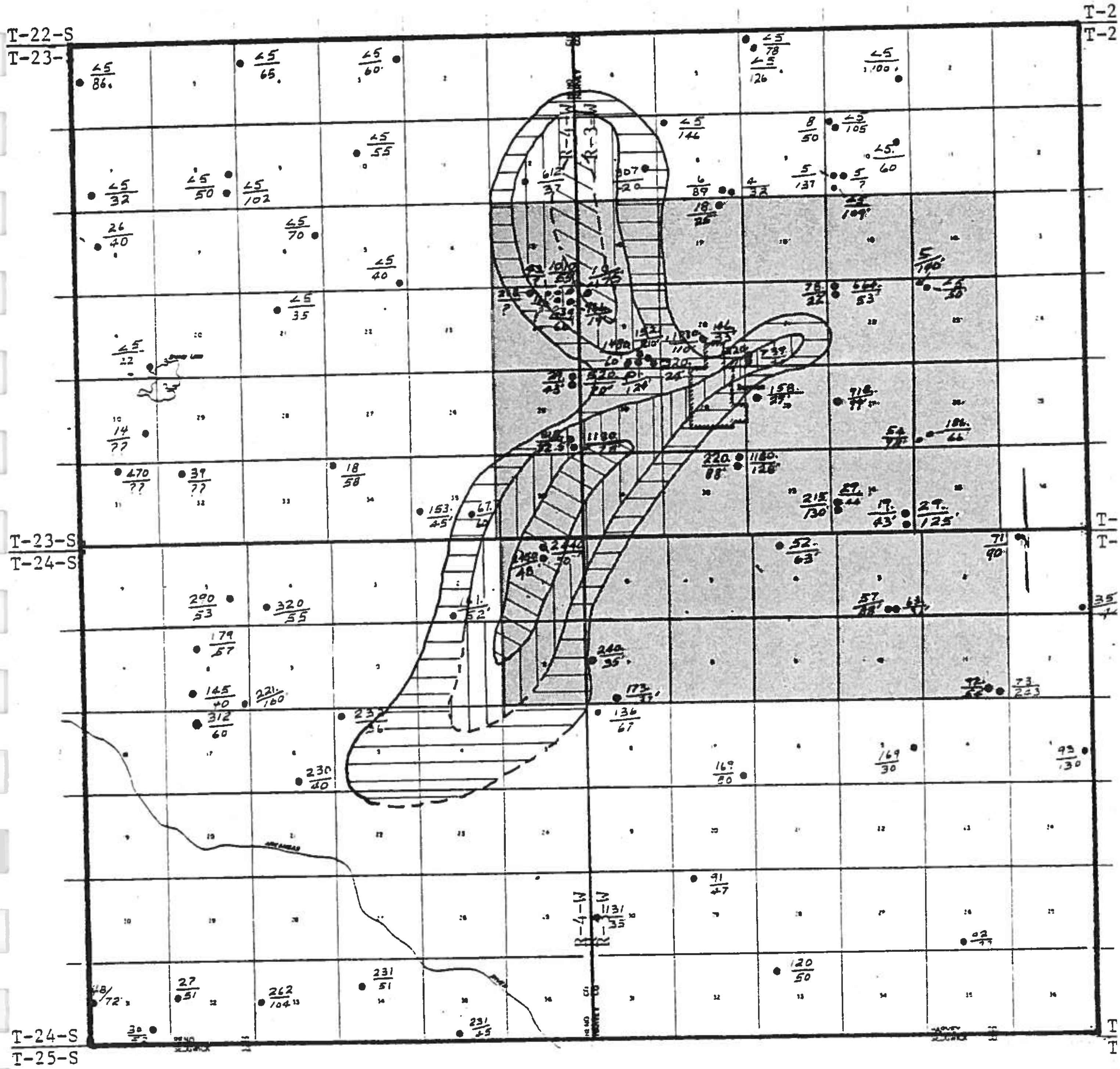
Without question, the major source of chloride contamination of the groundwater has resulted from the use of many brine ponds over a number of years. The second most serious source of chloride contamination has resulted from the use of the Wellington "lost circulation zone" for disposal. This is especially true where the shallow LCZ wells were operated under wellhead pump pressure. Other point sources of chloride pollution over the years are drill pits, leaks, brine line breaks, salt water tank leaks and overflows, and the malfunctioning of disposal wells.

<u>Current Water Quality by Kansas Department of Health and Environment and Kansas Geological Survey</u>

The Kansas Department of Health and Environment initially selected 176 water-well sites for sampling located in a 144 square mile area comprised of 4 townships (T.23S., R.3W. and R.4W., and T.24S., R.3W. and R.4W.) around the Burrton area.

Figure 1

WATER WELL SAMPLING
DECEMBER 1982



CONTOURS BASED ON DATA FROM WELLS LESS THAN 50 FEET DEEP

WELL ● CHLORIDE 120 (MG/L)
WELL DEPTH 50 (FT)

SCALE
MILES 1 0 1 2

Cl CONTOUR INTERVALS >1000
1000 --- >500
500 --- >250

PROPOSED IGUCA

KDHE-- 4/83

Groundwater samples were collected from 81 of these wells in December, 1982, and one well in January 1983. Chloride concentration was determined in all samples. Waters with high chloride concentrations were further analyzed for certain major and minor dissolved constituents (Table 3).

The Equus Beds Groundwater Management District sampled the monitoring well network and several irrigation and domestic wells in the Equus Beds from September through December, 1982. Chloride determinations made by the Kansas Geological Survey for the Groundwater Management District samples appear in Table 3. In addition, data for a few observation well waters collected by the U.S. Geological Survey and analyzed by either the U.S. or Kansas Survey are listed. Many of the wells sampled by the District and the U.S. Survey were also sampled by the Department of Health and Environment.

Maps with chloride concentration contours were prepared using the data in Table 3. Figure 13 shows the iso-chloride lines for shallow water wells (up to 50 feet deep) in the Burrton area. The map shows that most shallow wells sampled in the 144 square mile area have a chloride concentration of less than 250 mg/l. This is within safe drinking water standards. The horizontal lines represent the area with shallow well waters containing chloride concentrations between 250 and 500 mg/l. The areas shaded with vertical and diagonal lines indicate chloride values between 500 and 1000 mg/l and over 1000 mg/l, respectively. Of 40 shallow wells sampled, 10 had chloride concentrations over 250 mg/l. The highest values were in groundwaters in the immediate vicinity of Burrton and in an elliptically-shaped area just to the west of Burrton.

Iso-chloride lines for deep water wells (over 50 feet in depth) are shown in Figure 14 with the same concentration ranges as in Figure 13. Figure 14 shows that the groundwaters with the highest chloride content lie within a 2.5 mile radius of Burrton. In general, the deeper wells yield waters higher in chloride than the shallow wells. Thus, the area affected by higher chloride groundwaters (>500 mg/l) is larger than that for shallow wells.

The locations of the iso-chloride lines are dependent on both the depth division selected between shallow and deep wells and the amount of data available. The lines could be appreciably moved in Figures 13 and 14 with additional information.

TABLE 3

Description and Analyses of Well Waters Sampled During 1982 and 1983 by GMD No. 2, KGS, USGS and KDHE for Burrton Study

Legal Location[a]		Date Collected	Well Depth Feet[b]	Well Type[c]	KDHE Lab No.[d]	pH	Total Hard. $CaCO_3$[e]	Ca	Mg	Na	Total Alk., $CaCO_3$[f]	Cl[g]	SO_4	NO_3 as N	Br	Estd. EC, mmho/cm[h]	Sol. Na %[i]	Na/Cl	SO_4/Cl	Br/Cl x 10^4
NENESE	3-23-3W	12-14-82	100+	OWS	1280							<5				<0.5				
NWNWNW	4-23-3W	10-15-82	78	P34								3			0.05	<0.5				180
NWNWNW	4-23-3W	10-15-82	126	P34A								2			0.05	<0.5				230
NENESE	7-23-3W	12-14-82	20	DOM	1281	7.3	407	127	22	39	26	307	6.5	2.2	1.2	1.0	17.2	0.127	0.021	39
NWNWNW	8-23-3W	10-15-82	145.5	EB32								4				<0.5				
SESESE	8-23-3W	10-15-82	89.0	P32A								6				<0.5				
SESESE	8-23-3W	12-14-82	89.0	P32A	1282							6				<0.5				
SESESE	8-23-3W	12-14-82	32.0	P32	1283							4				<0.5				
NWNWNW	10-23-3W	10-15-82	49.6	EB22A								1				<0.5				
NWNWNW	10-23-3W	12-14-82	49.6	EB22A	1284							8				<0.5				
NWNWNW	10-23-3W	10-15-82	105.0	EB22B								2				<0.5				
NWNWNW	10-23-3W	12-14-82	105.0	EB22B	1285							<5				<0.5				
SESENE	10-23-3W	12-14-82	60	DOM	1286							<5				<0.5				
NWSWSW	10-23-3W	10-15-82	109.4	EB21A								4				<0.5				
NWSWSW	10-23-3W	10-15-82	136.8	EB21B								5				<0.5				
NWSWSW	10-23-3W	10-15-82	?	IRR								5			0.03	<0.5				65
NWNENE	17-23-3W	12-14-82	25	?	1287	7.2	12	35	6.0	13	35	18	28	12.0		0.3	20.2	0.72	1.56	
NWNWNW	19-23-3W	10-23-82	175	DOM								10			<0.03	0.5				
SESESE	19-23-3W	7-08-82	210	USGS								146				1.0				
SESESE	19-23-3W	10-07-82	210	USGS								142				1.0				
SESESE	19-23-3W	10-12-82	210	USGS								144				1.0				
SESESE	19-23-3W	12-14-82	210	USGS	1288	11	327	131	0.0	98	98	152	74	0.3	.22	1.1	39.5	0.645	0.487	14
SESESE	19-23-3W	7-08-82	110	USGS								1950			7.5	6.3				38
SESESE	19-23-3W	12-14-82	110	USGS	1290	6.7	1670	518	93	493	60	1830	54	0.0	7.2	5.5	39.0	0.269	0.0295	39
SESESE	19-23-3W	7-08-82	24	USGS								450			1.7	1.8				38
SESESE	19-23-3W	12-14-82	24	USGS	1291	7.4	333	99	21	137	102	320	49	2.0	1.2	1.3	47.2	0.428	0.153	38
SESESE	19-23-3W	10-12-82	60	DOM								1420			5.7	4.6				40
SESESE	19-23-3W	12-14-82	60	DOM	1289	7.5	1110	332	68	524	67	1480	52	0.0	6.1	4.5	50.7	0.354	0.0351	41
SWSWSE	19-23-3W	1-20-83	124	OWS	1484	7.4	472	143	28	132	141	401	36	0.5		1.5	37.8	0.329	0.090	
SWNWSE	20-23-3W	12-14-82	33	?	1292							146			0.52	1.0				36
SWSWSW	21-23-3W	10-15-82	39.9	P31								753			3.2	2.6				42

TABLE 3 (cont.)

Description and Analyses of Well Waters Sampled During 1982 and 1983 by GMD No. 2, KGS, USGS and KDHE for Burrton Study

Legal Location[a]		Date Collected	Well Depth Feet[b]	Well Type[c]	KDHE Lab No.[d]	pH	Total Hard., CaCo3[e]	Ca	Mg	Na	Total Alk., CaCO3[f]	Cl[g]	SO4	NO3 as N	Br	Estd. EC, mmho/cm[h]	Sol. Na %[i]	Na/Cl	SO4/Cl	Br/Cl x 10^4
SWSWSW	21-23-3W	12-14-82	39.9	P31	1293	7.3	602	182	36	281	104	739	37	0.0	3.1	2.4	50.4	0.380	0.050	42
SWSWSW	21-23-3W	10-15-82	67.6	P31A								1280			5.3	4.2				41
SWSWSW	21-23-3W	12-14-82	67.6	P31A	1294	7.2	825	245	52	484	81	1220	32	0.0	5.2	3.8	56.1	0.397	0.0262	42
NWNWNW	22-23-3W	12-14-82	22.0	EB10A	1295							78				0.8				
NWNWNW	22-23-3W	11-08-82	53.0	EB10B								678			2.7	2.4				40
NWNWNW	22-23-3W	12-14-82	53.0	EB10B	1296	7.3	526	168	26	238	49	664	25	5.0	2.6	2.1	49.6	0.358	0.038	39
NWNWNW	23-23-3W	10-15-82	49.8	EB17A								3				<0.5				
NWNWNW	23-23-3W	10-15-82	140.0	EB17B								5				<0.5				
SWSWSW	26-23-3W	10-14-82	66.2	EB15A								186			0.74	1.1				40
SWSWSW	26-23-3W	10-14-82	97.9	EB15B								54			0.20	0.7				37
SWSWNW	27-23-3W	10-14-82	99.8	EB9B								958			3.8	3.2				39
SWSWNW	27-23-3W	12-14-82	99.8	EB9B	1297	7.5	649	201	36	382	101	918	52	0.1	3.9	3.0	56.1	0.412	0.056	42
CSWNW	28-23-3W	12-14-82	29	OWS	1298	7.6	274	80	18	77	150	158	63	2.6	0.45	0.9	38.0	0.487	0.399	28
NENENE	32-23-3W	12-14-82	88.0	P30	1299							220				1.2				
NENENE	32-23-3W	12-14-82	128.0	P30A	1300	7.2	973	296	57	433	171	1180	32	0.2	5.2	3.8	49.2	0.367	0.0271	44
NWNWSW	34-23-3W	10-14-82	44.3	EB8A								31			0.20	0.6				65
NWNWSW	34-23-3W	12-14-82	44.3	EB8A	1301							29				0.6				
NWNWSW	34-23-3W	10-14-82	129.7	EB8B								338			1.4	1.5				43
NWNWSW	34-23-3W	12-14-82	129.7	EB8B	1302	7.6	380	116	22	67	194	215	39	0.0	1.4	1.0	27.7	0.322	0.188	65
SESESE	34-23-3W	10-14-82	43.0	EB14A								20			0.09	0.5				45
SESESE	34-23-3W	12-14-82	43.0	EB14A	1303							19				0.5				
SESESE	34-23-3W	10-14-82	125.3	EB14B								29			0.16	0.6				54
SESESE	34-23-3W	12-14-82	125.3	EB14B	1304							29				0.6				
SENENE	3-23-4W	12-14-82	60	DOM	1305							<5				<0.5				
SWNWNW	4-23-4W	12-14-82	65	DOM	1306							<5				<0.5				
CWLSWSWNW	6-23-4W	12-14-82	86	DOM	1307							<5				<0.5				
NESWSW	7-23-4W	12-14-82	32	DOM	1308							<5				<0.5				
NENESE	8-23-4W	12-14-82	50	DOM	1309							<5				<0.5				
SENESE	8-23-4W	12-14-82	102	DOM	1310							<5				<0.5				
SESENW	10-23-4W	12-14-82	55	DOM	1311							<5				<0.5				
SENESW	12-23-4W	12-14-82	37	OWS	1312	7.7	467	146	25	267	66	612	75	0.8	1.7	2.1	55	0.433	0.122	28

TABLE 3 (cont.)

Description and Analyses of Well Waters Sampled During 1982 and 1983 by GMD No. 2, KGS, USGS and KDHE for Burrton Study

Legal Location[a]	Date Collected	Well Depth Feet[b]	Well Type[c]	KDHE Lab No.[d]	pH	Total Hard. CaCo$_3$[e]	Ca	Mg	Na	Total Alk., CaCO$_3$[f]	Cl[g]	SO_4	NO_3 as N	Br	Estd. EC, mmho/cm[h]	Sol. Na %[i]	Na/Cl	SO_4/Cl	Br/Cl x 10^4
CSESESE 15-23-4W	12-14-82	39.8	?	1313	7.9	76	23	4.5	21	84	<5	14	2.6		0.2	37.6	>4	>3	
NESENE 16-23-4W	12-14-82	70	DOM	1314							<5				<0.5				
SWSENW 18-23-4W	12-14-82	40	DOM	1315							26				0.6				
SESESE 19-23-4W	12-14-82	22	DOM	1316							<5				<0.5				
SENENW 21-23-4W	12-14-82	35	?	1317							<5				<0.5				
NENENW 24-23-4W	12-14-82	?	?	1318	7.7	349	107	20	93	106	268	26	6.8		1.1	36.7	0.347	0.097	
NWNENE 24-23-4W	12-23-82	?	DOM								166			0.64	1.1				39
NWNENE 24-23-4W	12-23-82	60?	DOM								234			0.93	1.3				40
NENWNE 24-23-4W	12-23-82	?	DOM								43			0.17	0.7				39
NENENE 24-23-4W	11-08-82	18.9	EB5A								966			3.8	3.3				39
NENENE 24-23-4W	11-08-82	55.1	EB5B								1010			3.7	3.4				37
NENENE 25-23-4W	11-22-82	43.0	EB4A								21			0.16	0.6				76
NENENE 25-23-4W	12-14-82	43.0	EB4A	1319							29				0.6				
NENENE 25-23-4W	11-22-82	70.0	EB4B								537			2.1	2.0				39
NENENE 25-23-4W	12-14-82	70.0	EB4B	1320	7.5	542	163	33	173	107	520	44	0.1	2.0	1.8	41.0	0.333	0.085	39
SESESE 25-23-4W	12-14-82	32.5	EB3A	1321	7.6	277	83	17	458	41	818	56	0.0	3.6	2.6	78.3	0.560	0.068	44
SESESE 25-23-4W	9-22-82	78.0	EB3B								1210			4.7	4.0				39
SESESE 25-23-4W	12-14-82	78.0	EB3B	1322	7.6	853	261	49	484	160	1180	30	0.0	4.9	3.8	55.3	0.410	0.0254	42
CE/2NESE 30-23-4W	12-14-82	?	DOM	1323							14				0.5				
NENENW 31-23-4W	12-14-82	?	DOM	1324	8.1	695	196	50	262	405	470	141	4.4	0.22	2.5	45.1	0.557	0.300	4.8
CN/2NW 32-23-4W	12-14-82	?	DOM	1325							39				0.7				
NWNWNW 34-23-4W	12-14-82	58	OWS	1326							18				0.5				
SENWSE 35-23-4W	12-14-82	60	OWS	1327							67				0.8				
CW/2NWSW 35-23-4W	12-14-82	45	OWS	1328							153				1.0				
NENWNW 1-24-3W	12-14-82	90	DOM	1329							71				0.8				
SESESESE 1-24-3W	12-14-82	44	?	1330							35				0.6				
SWSESE 3-24-3W	12-14-82	31.0	EB13A	1331							63				0.8				
SWSESE 3-24-3W	12-14-82	87.6	EB13B	1332							57				0.7				
NENENW 4-24-3W	12-14-82	63	DOM	1333							52				0.7				
SWSWNW 7-24-3W	12-13-82	35	DOM	1334	8.0	1050	344	47	121	303	240	226	105	0.43	2.6	2.0	0.504	0.942	18
SESESW 7-24-3W	12-14-82	37	DOM	1335							173				1.1				

TABLE 3 (cont.)

Description and Analyses of Well Waters Sampled During 1982 and 1983 by GMD No. 2, KGS, USGS and KDHE for Burrton Study

Legal Location[a]		Date Collected	Well Depth Feet[b]	Well Type[c]	KDHE Lab No.[d]	pH	Total Hard., CaCO$_3$[e]	Ca	Mg	Na	Total Alk., CaCO$_3$[f]	Cl[g]	SO$_4$	NO$_3$ as N	Br	Estd. EC, mmho/cm[h]	Sol. Na %[i]	Na/Cl	SO$_4$/Cl	Br/Cl x 10^4
SESESESE	11-24-3W	12-14-82	54	?	1336							92				0.9				
SESESESE	11-24-3W	12-14-82	243	?	1337							73				0.8				
NENESE	13-24-3W	12-13-82	130	DOM[j]	1338	8.1	5.0	2.0	0.0	226	236	93	154	0.6	0.13	1.0	99.0	2.43	1.66	14
NENESE	15-24-3W	12-14-82	30.0	EB19A	1339	9.0	30	9.5	1.5	130	20	169	79	0.0	0.60	0.6	90.5	0.802	0.488	38
SESESE	17-24-3W	12-13-82	80.0	EB11B	1340	7.8	193	56	13	95	114	169	39	0.9	0.28	0.8	51.7	0.572	0.235	17
NWNWNW	18-24-3W	12-20-82	67.4	P27								136				1.0				
SESESW	26-24-3W	12-14-82	?	DOM	1341							92				0.9				
NENWNW	29-24-3W	12-14-82	47	DOM	1342							91				0.9				
NWNWSW	30-24-3W	12-14-82	35	DOM	1343	8.1	357	115	17	83	230	131	77	9.0		1.1	33.6	0.634	0.588	
SENWNW	33-24-3W	12-14-82	50	DOM	1344							120				1.0				
CNL	1-24-4W	9-22-82	48.0	EB2A								2450			9.7	7.9				40
CNL	1-24-4W	11-22-82	50.0	EB2B								2420			9.4	7.8				39
CNL	1-24-4W	12-14-82	50.0	EB2B	1345	7.6	1430	443	78	1018	180	2440	51	0.3	9.8	7.3	60.8	0.417	0.0209	40
CSL	2-24-4W	12-14-82	52.0	EB1A	1346							161				1.1				
CSL	2-24-4W	12-20-82	52.0	EB1A								158			0.59	1.1				37
NESWSW	4-24-4W	12-14-82	55	OWS	1347	8.1	465	150	22	158	217	320	91	3.0	0.33	1.6	42.5	0.506	0.292	10
NESE	5-24-4W	12-14-82	53	OWS	1348							290				1.4				
SESESE	8-24-4W	7-08-82	160	USGS								221			0.26	1.2				12
SENESW	8-24-4W	12-14-82	40	OWS	1349							145				1.0				
SENENW	8-24-4W	12-14-82	57	OWS	1350							179				1.1				
NWNWNW	15-24-4W	12-14-82	36	DOM	1351	8.0	450	144	22	103	249	232	59	7.2		1.4	33.3	0.444	0.254	
SWNWSE	16-24-4W	12-14-82	40	OWS	1352							230				1.3				
CNENW	17-24-4W	12-14-82	60	OWS	1353	8.2	328	107	15	187	193	312	67	2.6	0.29	1.5	55.3	0.599	0.215	9.3
SWSWNW	31-24-4W	12-14-82	72	DOM	1354							48				0.7				
C/SE	31-24-4W	12-14-82	52	DOM	1355							30				0.6				
SWSWNW	32-24-4W	12-14-82	51	DOM	1356							27				0.6				
SWSWNW	33-24-4W	12-14-82	104	IRR	1357	7.7	490	160	22	162	380	262	23	7.6	0.87	1.7	41.9	0.618	0.088	33
SWNENW	34-24-4W	12-14-82	51	DOM	1538	8.1	354	114	17	191	290	231	152	0.1		1.5	54.0	0.827	0.658	
SESESW	35-24-4W	12-14-82	45	DOM	1359	8.1	320	102	16	185	275	231	111	0.0		1.4	55.7	0.801	0.481	

TABLE 3 (cont.)

Description and Analyses of Well Waters Sampled During 1982 and 1983 by GMD No. 2, KGS, USGS and KDHE for Burrton Study

Explanation

Legal Location[a]	Date Collected	Well Depth Feet[b]	Well Type[c]	KDHE Lab No.[d]	pH	Total Hard. CaCo$_3$[e]	Ca	Mg	Na	Total Alk., CaCO$_3$[f]	Cl[g]	SO_4	NO_3 as N	Br	Estd. EC, mmho/cm[h]	Sol. Na %[i]	Na/Cl	SO_4/Cl	Br/Cl x 10^4

[a]Quarter-quarter-quarter section, quarter-quarter section, quarter section, section-township-range

[b]Depths of wells are the reported depths to KDHE on Water Well Records. Some of these depths are different by a few feet (±) than the actual depths measured by Equus Beds GWMD No. 2 for the EB and P observation wells

[c]Type: DOM, domestic; IRR, irrigation; OWS, Oil-field water supply; EB, P, and USGS, observation

[d]Waters without Department of Health and Environment number were sampled by Equus Beds GWMD No. 2 or the U.S. Geological Survey and analyzed by the Kansas Geological Survey

[e]Total hardness expressed as mg/L CaCo$_3$

[f]Total alkalinity expressed as mg/L $CaCO_3$; multiply by 1.22 to obtain mg/L HCO_3

[g]Some Cl values are an average between Department of Health and Environment and Kansas Geological Survey determinations

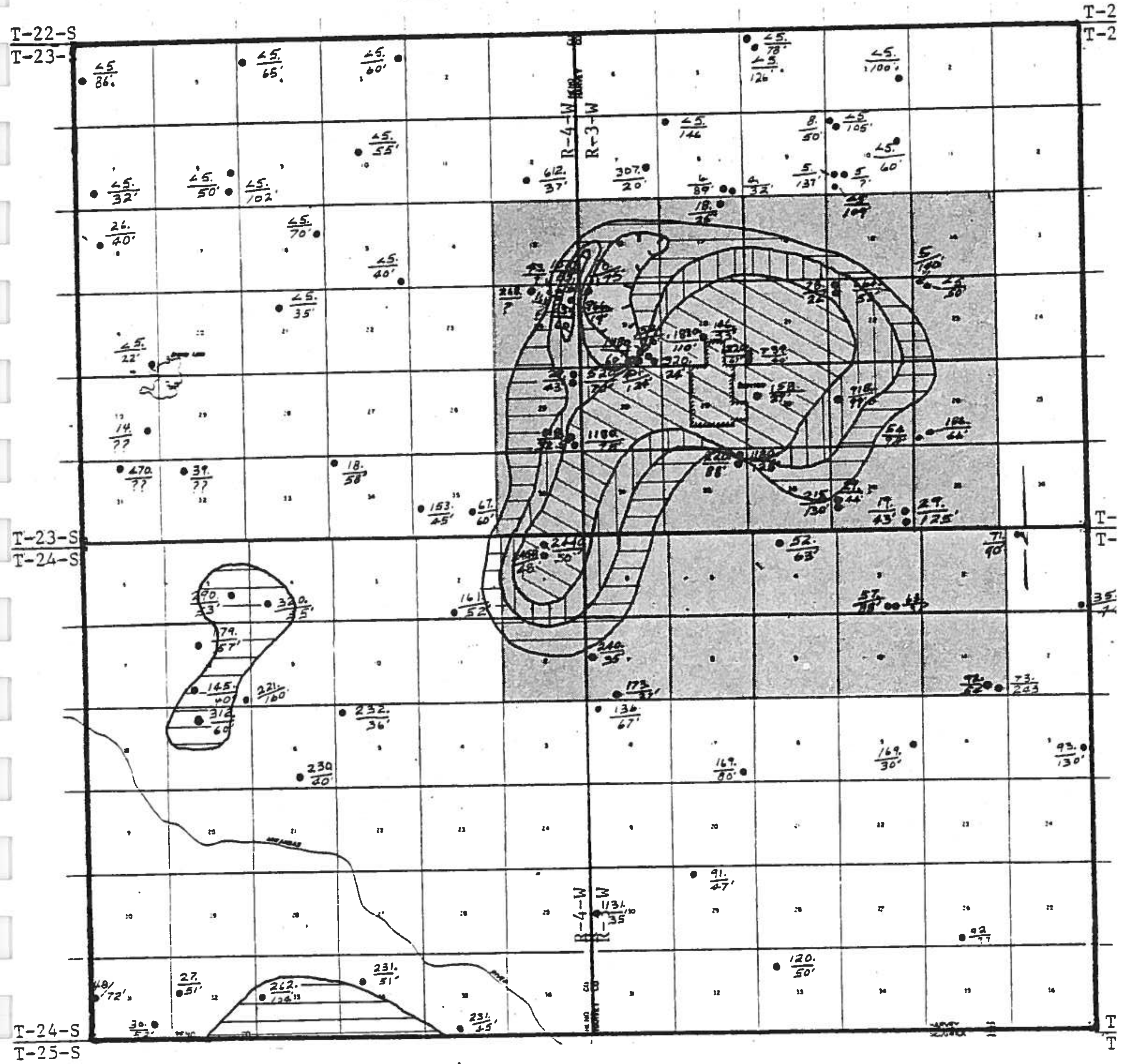
[h]EC: Electrical (specific) conductance in mmho/cm at 25°C estimated from (Ca+Mg+Na in meq/l)/10 for samples with cation analyses and from a specific conductance versus chloride concentration curve for other samples

[i]Soluble Sodium Percentage: [Na in meq/l/(Ca+Mg+Na in meq/l)]100

[j]This analysis shows the water was softened, which may have also effected the bromide/chloride ratio

Figure 14

WATER WELL SAMPLING DECEMBER 1982



CONTOURS BASED ON DATA FROM WELLS GREATER THAN 50 FEET DEEP

WELL ● CHLORIDE 120 (MG/L) / WELL DEPTH 50 (FT)

SCALE 1 0 1 2 MILES

Cl CONTOUR INTERVALS >1000; 1000 --- >500; 500 --- >250

PROPOSED IGUCA

KDHE-- 4/83

Also, chloride concentrations in groundwaters at nearby sites change markedly with depth even within the same depth classification used for the figures. For example, dissolved chloride values for waters from Equus Bed observation wells EB10A and EB10B (both located at NWNWNW Section 22, T.23S., R.3W.) were 78 and 664 mg/l, respectively, in December, 1982. Both of these wells are close to 50 feet deep (EB10A, 24 feet; EB10B, 53 feet in depth). The very limited chemical data for wells deeper than 150 feet indicates that groundwaters are fresh beneath the high chloride zones near Burrton shown in Figure 14. This suggests that deep clay layers retard the movement of shallower, poorer quality groundwaters to the underlying freshwater aquifer.

The electrical conductivity and soluble sodium percentage were estimated and calculated, respectively, for the current water-quality data and are listed in Table 3. These values are useful for determining the quality of the water for irrigation as described in a brochure available from the Cooperative Extension Service at Kansas State University (Jacobs and Whitney, 1975). The electrical conductivity is a measure of the total soluble salt content of a water and is used to rank its salinity hazard for irrigation. High sodium content in soil water decreases crop yield; salt tolerence depends on the particular crop. The more scientific term for electrical conductivity is specific conductance (in units of mmho/cm at 25°C) as given in reports of the Kansas and U.S. Geological Surveys. Some of the electrical conductivities in Table 3 were estimated from an equation given in the Cooperative Extension Service brochure, the others from a graph of measured specific conductance versus chloride concentration for samples from the Equus Beds aquifer collected in previous years. The soluble sodium percentage is used to predict the potential of an irrigation water for causing sodium accumulation in the soil. High amounts of sodium absorbed on clays in soils disperses soil aggregates and appreciably reduces permeability, resulting in poor crop growth. Both the salinity and sodium hazards of an irrigation water are dependent not only on the measure used to predict them, but also on the texture of the soil. Thus, the data in Table 3 should be used with the appropriate figure for soil type (sandy, loamy, or clayey soil) in the Extension Service publication to correctly rank its potential hazards for irrigation.

HISTORY OF OIL FIELD DEVELOPMENT AND BRINE DISPOSAL

by

Kansas Department of Health and Environment

Methods of Investigation

The methods KDHE used to investigate the portions of the Task Force study assigned to it followed four courses of action:

(1) Review and compilation of pertinent information from KDHE district and Topeka office files.

(2) Review of literature and historical information on the Burrton Oil Field relevant to oil producing and brine handling facilities.

(3) Presentation of data on maps, cross sections and in tables on the geology, hydrogeology and historical water quality of subsurface formations.

(4) Conduction of a water well sampling program to provide better data point coverage for groundwater quality and hydrogeologic characteristics.

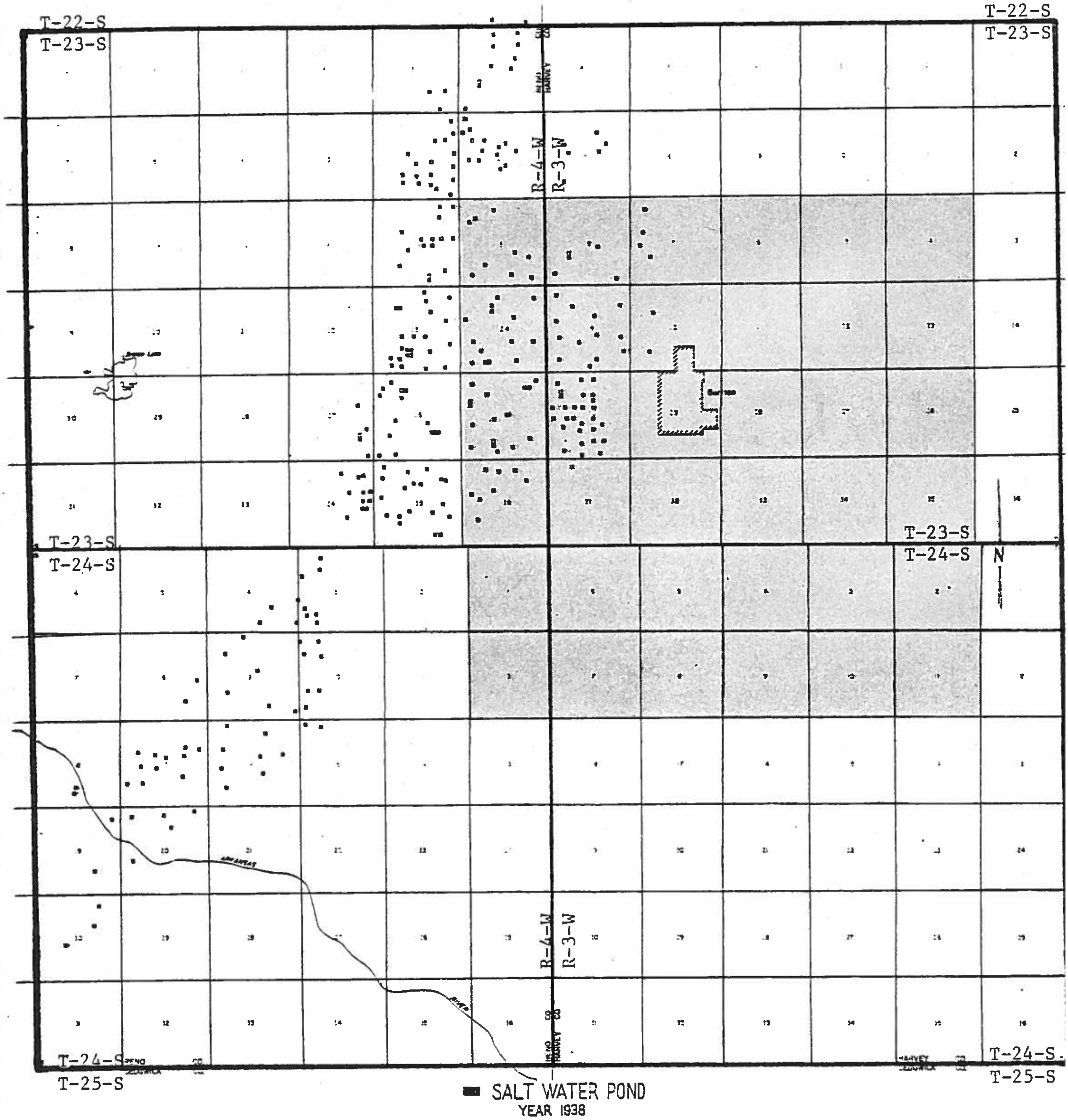
State regulatory agencies often have considerably more information in files to develop data bases for research projects than they believe possible. There are gaps in the historical record of the Burrton Oil Field because the major sources of pollution (unsealed brine disposal ponds and shallow Wellington "lost circulation zone" (LCZ) disposal wells) were discontinued. Thus the monitoring of water from salt water contaminated wells also discontinued, unless there was a complaint. Much analysis of existing groundwater quality data took place during the information collecting phase so base maps and cross sections could be developed and information added as more information became available.

Brine Disposal Ponds

Figure 15 shows the locations of brine disposal ponds in the Burrton Oil Field in 1938. It was produced from 7.5 minute quadrangle maps prepared by Jay Gillespie

LOCATION OF BRINE DISPOSAL PONDS IN 193

Figure 1



PREPARED FROM MAPS FURNISHED TO KDHE BY JAY GILLESPIE, USGS, LAWRENCE, KS.
BASE DATA FROM 1938 DEPT. OF AGRICULTURE AERIAL PHOTOGRAPHS.
---- LARGER SCALE MAP AVAILABLE FROM KDHE

PROPOSED IGUCA

MILES SCALE 1 0 1 2

KDHE 4/83

of the U.S. Geological Survey in Lawrence. Mr. Gillespie obtained the information from 1938 Department of Agriculture aerial photographs as part of an unpublished Equus Beds study. At this time the information is interpretive. The locations of the salt water ponds, used in 1938 by the oil industry to dispose of the produced brine waters are shown.

Figure 16 shows the location of salt water ponds, reported barrels of salt water disposed into the ponds per day, and estimated chloride concentration of the brine waters. This information was taken from KDHE files and spans the years from 1940 to 1967. Figure 16 does not cover the entire proposed IGUCA because information was not available for the remainder of the area.

<u>Salt Water Disposal Into the Wellington "Lost Circulation Zone" (LCZ)</u>

The map of Wellington LCZ saltwater disposal wells (Figure 17) shows the location of wells that were known to be completed for disposal into the Wellington LCZ. A list of the wells with brief remarks on the company, lease name, depth and status is included in Table 4 as support information for the wells shown in Figure 17.

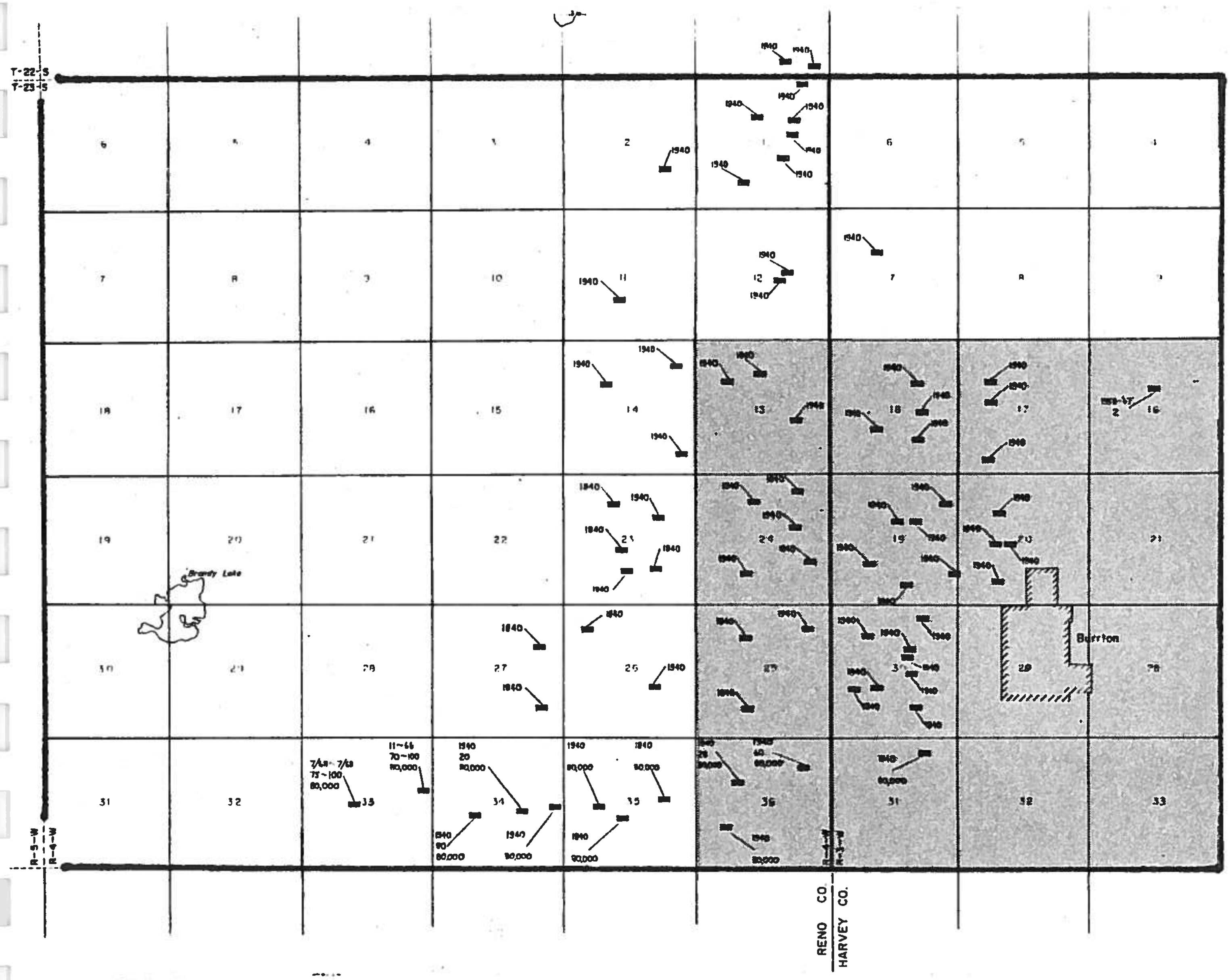
Few applications for the wells were found in the files at the Topeka-KDHE office. Most of the information was obtained from old pressure check cards from the KDHE Wichita District office. Some of the plugging records for these wells were found at the Wichita-KCC office.

All of the known shallow wells in the study area have been plugged or have had the permit cancelled. Only those wells, for which there are plugging reports, are indicated as plugged on Figure 17. It is possible that the wells shown only as having cancelled permits are also plugged. A field check should be conducted to determine if these wells have been plugged. If wells are found abandoned and not plugged, immediate action should be taken to plug them.

The Montford #1 well in Section 12-23-4W was approved for disposal in December of 1972 (well #5, Fig. 17). Several field inspections were made and the well was reported as being not completed or abandoned and not plugged. During a recent lease inspection, this well was found to be plugged and further investigation proved the well to have been plugged in December of 1982. It should be noted that

Figure 1

CHLORIDE CONCENTRATION OF BRINE DISPOSAL WATERS IN PONDS IN A PORTION OF THE BURRTON OIL FIEL



SOURCE:

KDHE SALTWATER POND FILE 1940-1967

PROPOSED IGUCA

SALT WATER POND

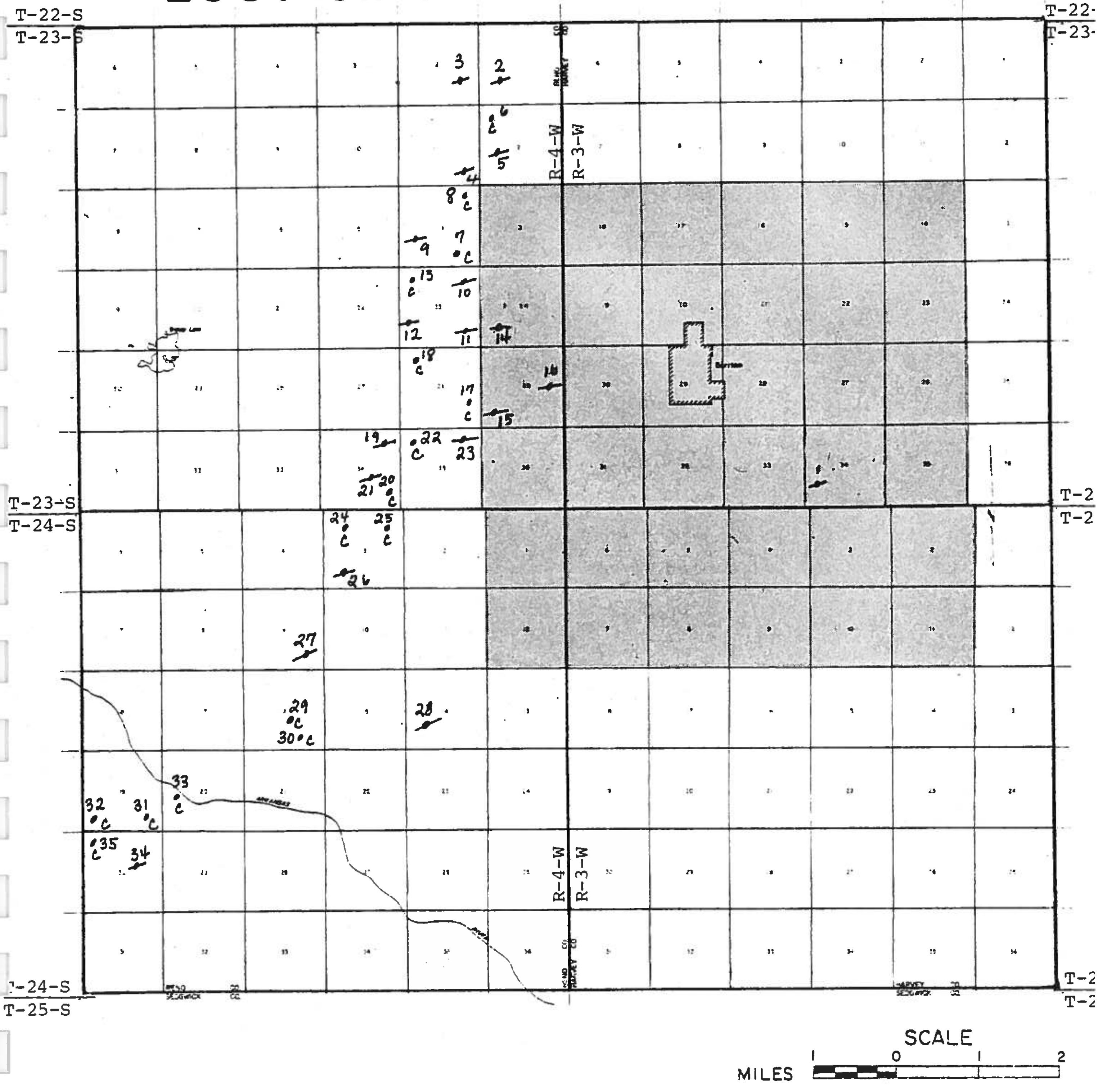
1950 Year
200 Bbls. Saltwater Disposal per Day
80,000 Est. Cl Con. mg/l

SCALE
MILES 1 0 1 2

KDHE/83

Figure 17

LOCATIONS OF SHALLOW SALTWATER DISPOSAL WELLS INTO THE WELLINGTON "LOST CIRCULATION ZONE" (LCZ)



WELLINGTON LCZ SALTWATER DISPOSAL WELLS

PLUGGED WELL
WELL WITH CANCELLED PERMIT
REFERENCE NUMBER, SEE TABLE 4

PROPOSED IGUCA

KDHE 7/83

TABLE 4

Burrton Study
Shallow Disposal Wells

Reference Number	Location	Remarks
1).	SW 34-23-3W Harvey Co.	Skelly Oil Co., Burrton Pump Station, Disposal Well, 460' deep, application 1958, plugged.
2)	1-23-4W Reno Co.	Tomlinson-Kathol, Inc., Haury lease, Well, 470' deep application 1957, plugged 1982.
3)	SE 2-23-4W Reno Co.	Merritt Oil Co., White lease, disposal well, 500' de application 1961, plugged.
4)	NW Ctr, SE SE 11-23-4W Reno Co.	Barnsdall Oil Co., Martha Sabin "C" lease, Well 13, 431' deep, application 1935, cancelled 1961, plugged 1941.
5)	C N/2 N/2 SW 12-23-4W Reno Co.	Merritt Oil Co., Montford lease, Well 1, 1022' deep, drilled in 1937, application 1972, plugged Dec. 1982. (Probably completed into the Ft. Riley format
6)	N/2 NW 12-23-4W Reno Co.	Ledo Oil Co. & Bearmore Drilling Co., Neufeldt lease Well 5, 447' deep, application 1940, cancelled 1940.
7)	W/2 SE 14-23-4W Reno Co.	Derby Oil Co., Mary C. & Arthur L. Ackley lease, Wel 2, 370' deep, application 1936, cancelled 1940.
8)	NE 14-23-4W Reno Co.	Olson Oil Co., E. R. Downie lease, Well 1, 432' deep application 1935, cancelled 1940.
9)	SW 14-23-4W Reno Co.	Sinclair Prairie Oil Co., Geo. M. Harner lease, Well 426' deep, application 1935, cancelled 1940, plugged 1948.
10)	NE 23-23-4W Reno Co.	Olson Oil Co., F. Duckworth lease, Well 1, 422' deep application 1935, cancelled & plugged 1939.
11)	SE & S/2 SW 23-23-4W Reno Co.	Olson Oil Co., M. B. Blake lease, Well 1, 423' deep, application 1935, cancelled 1940, plugged 1939.
12)	W/2 SW 23-23-4W Reno Co.	Amerada Petroleum Corp., H. Wilson lease, Well 1, 38 deep, application 1935, plugged 1952.
13)	NW 23-23-4W Reno Co.	Marathon Oil Co., S. F. VanSickle lease, Well 1, 415 deep, application 1935, cancelled 1940.
14)	C SW 24-23-4W Reno Co.	Classen Oil Co. et al., Rudicel lease, Well 1, 500' deep, application 1963, plugged 1964.

TABLE 4 (continued)

Reference Number	Location	Remarks
15)	SW SW 25-23-4W Reno Co.	Olson Oil Co., P. C. Roberts lease, Well 1, 449' deep application 1935, cancelled 1939, plugged 1939.
16)	E/2 25-23-4W Reno Co.	Olson Oil Co., J. Fast lease, Well 1, 400' deep, appl cation 1936, cancelled 1939, plugged 1939.
17)	SE 26-23-4W Reno Co.	Sinclair Prairie Oil Co., Adam T. Base lease, Well 1, 407' deep, application 1936, cancelled 1940.
18)	E/2 NW 26-23-4W Reno Co.	Olson Oil Co., E. Krehbiel lease, Well 1, 393' deep, application 1935, cancelled 1939.
19)	E/2 NE 34-23-4W Reno Co.	Barnsdall Oil Co., C. Baughman lease, Well 1, 450' deep, application 1935, cancelled 1940, plugged 1947.
20)	E/2 SE 34-23-4W Reno Co.	T. M. Deal Oil & Gas Co., McElwain lease, Well 1, 450 deep, application 1935, cancelled 1940.
21)	W/2 SE 34-23-4W Reno Co.	Olson Oil C., E. J. England lease, Well 1, 498' deep, application 1935, plugged 1939, cancelled 1939.
22)	NW 35-23-4W Reno Co.	Olson Oil Co., J. H. Goering "B" lease, Well 1 398' deep, application 1935, cancelled 1961.
23)	NW NE 35-23-4W Reno Co.	Gypsy Oil Co., Lena Krehbiel lease, Well A, 408' deep application 1935, plugged 1938.
24)	NW 3-24-4W Reno Co.	Gypsy Oil Co., John Myers lease, Well 1, 495' deep, application 1936, cancelled 1940.
25)	W/2 NE 3-24-4W Reno Co.	Dickey Oil Co., J. Baughman lease, Well 1, 400' deep, application 1936, cancelled 1941.
26)	E/2 SW 3-24-4W Reno Co.	Sinclair Prairie Oil Co., Guy T. Matlock lease, Well 525' deep, application 1936, cancelled 1940, plugged 1948.
27)	S/2 SE 9-24-4W Reno Co.	Shell Petroleum Co., J. H. Flory lease, Well 1-W, 450 deep, application 1936, cancelled 1940, plugged 1937.
28)	14-24-4W Reno Co.	Disposal Well, 563' deep, application 1939, cancelled 1961.
29)	NW SE 16-24-4W Reno Co.	Disposal Well, 450' deep, application 1936, cancelled 1961.
30)	SW SE 16-24-4W Reno Co.	Ohio Oil Co., V. Priddle, Well 1, 338' deep, application 1936, cancelled 1940.

TABLE 4 (continued)

Reference Number	Location	Remarks
31)	SE 19-24-4W Reno Co.	Barnsdall Oil Co., F. Westfahl "A & B", Well A-7, 40 deep, application 1938, cancelled 1940.
32)	SW 19-24-4W Reno Co.	Carter Oil Co., Ella Hogan lease, Well 8, 381' deep, application 1938, cancelled 1940.
33)	SW NW 20-24-4W Reno Co.	Bridgeport Machine Co., Tucker lease, Well J, 504' deep, application 1939, cancelled 1940.
34)	SW NE 30-24-4W Reno Co.	Marathon Oil Co., Wm. Mueller, Jr., Well 1, 456' dee application 1936, cancelled 1940, plugged 1946.
35)	C N/2 NW NW 30-24-4W Reno Co.	Fell & Wolfe Oil Co., Mueller "B" lease, Well 3, 546 deep, application 1961, plugged 1972.

the disposal zone approved for this well is actually not the Wellington LCZ. The well is 1022 feet deep and the disposal zone would have been in the Ft. Riley Limestone below the Wellington LCZ.

Disposal and Enhanced Recovery Wells and Distribution Lines

All known disposal wells and lines of the North Burrton Salt Water Disposal Association and the water flooding operations of Recovery Resources Corporation are shown on Figure 18.

The information was obtained from an old 1940 map of the North Burrton Salt Water Disposal Association found in the KDHE Wichita District office and a map prepared in 1983 by Recovery Resources Corp. Because of the age of the North Burrton information, it is not certain if all the lines and wells illustrated are active. An updated map of the South Burrton Salt Water Disposal Association disposal lines and wells has been requested.

Most of the wells and lines of both systems were concentrated in the eastern portion of 23-4W and an area in the western part of 23-3W north and west of the City of Burrton.

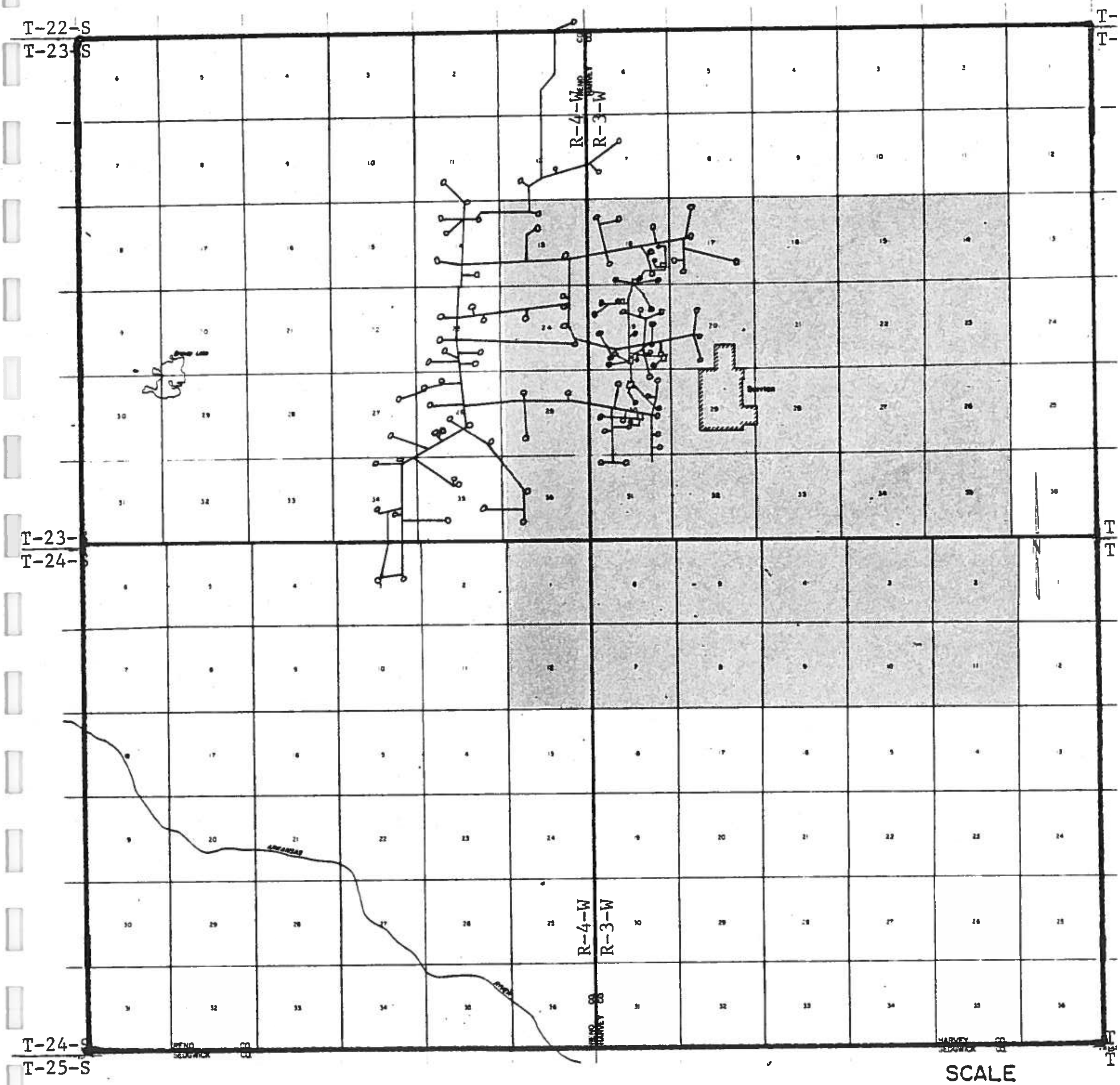
The only information available on the sizes of the lines and their composition is a 1940 map prepared for the Kansas State Board of Health and notes from field observations. It shows resistant and non-resistant materials. Of the resistant lines, Transite or cement-asbestos pipes are mentioned. Also, it was observed, during field checks, that some of the lines were of vitrified clay pipe. These 'resistant' materials are somewhat porous and not water tight. They have a tendency to leak at the joints and collars and the rubber seals may have deteriorated, also causing leakage. It is assumed that the non-resistant lines were made of steel and are susceptible to corrosion.

Deep Well Locations Not Sampled and Area Needing Evaluation For Deep Well Locations For Further Sampling

Figure 19 shows the location of water wells on record with KDHE that are 100 feet or more in depth and have not been sampled. KDHE and KGS recommend these wells be

Figure 18

MAP OF DISPOSAL & ENHANCED RECOVERY WELLS & DISTRIBUTION LINE



SCALE
MILES 0 1 2

DISPOSAL WELLS & LINES

North Burrton Salt Water Disposal Assoc.

Recovery Resources Corp.

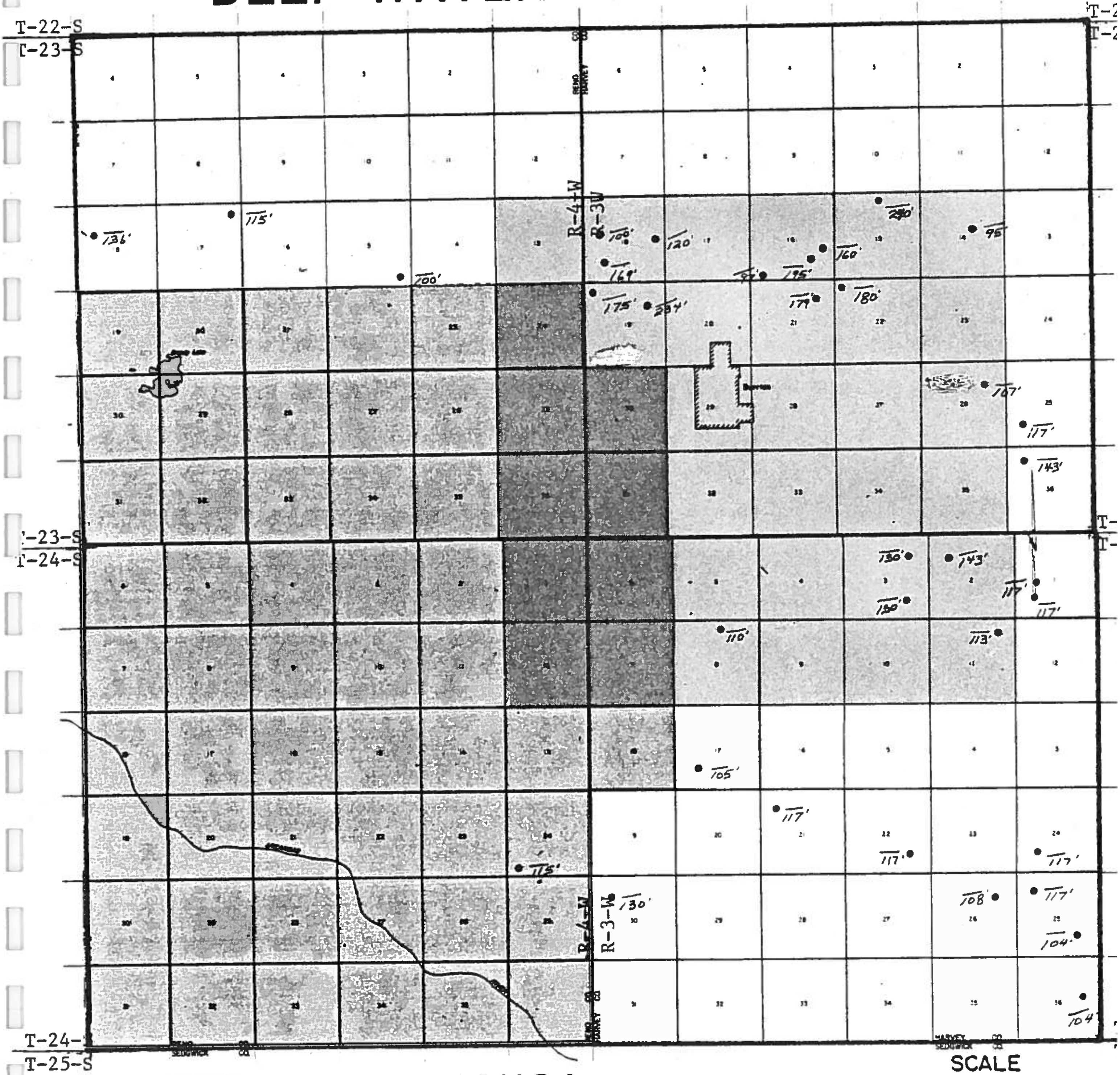
Proposed IGUCA

52

KDHE- 4/83

Figure 1

DEEP WATER WELLS (>100ft) NOT SAMPLED & AREA NEEDING ADDITIONAL DEEP WATER WELL SAMPLING



Proposed IGUCA

SCALE

MILES 1 0 1 2

• Deep (100+ ft.) Water Wells to be Sampled

Area Needing Location and Sampling of Deep Water Well

$\overline{125}$ (ft) Depth of Well

KDHE-- 4/83

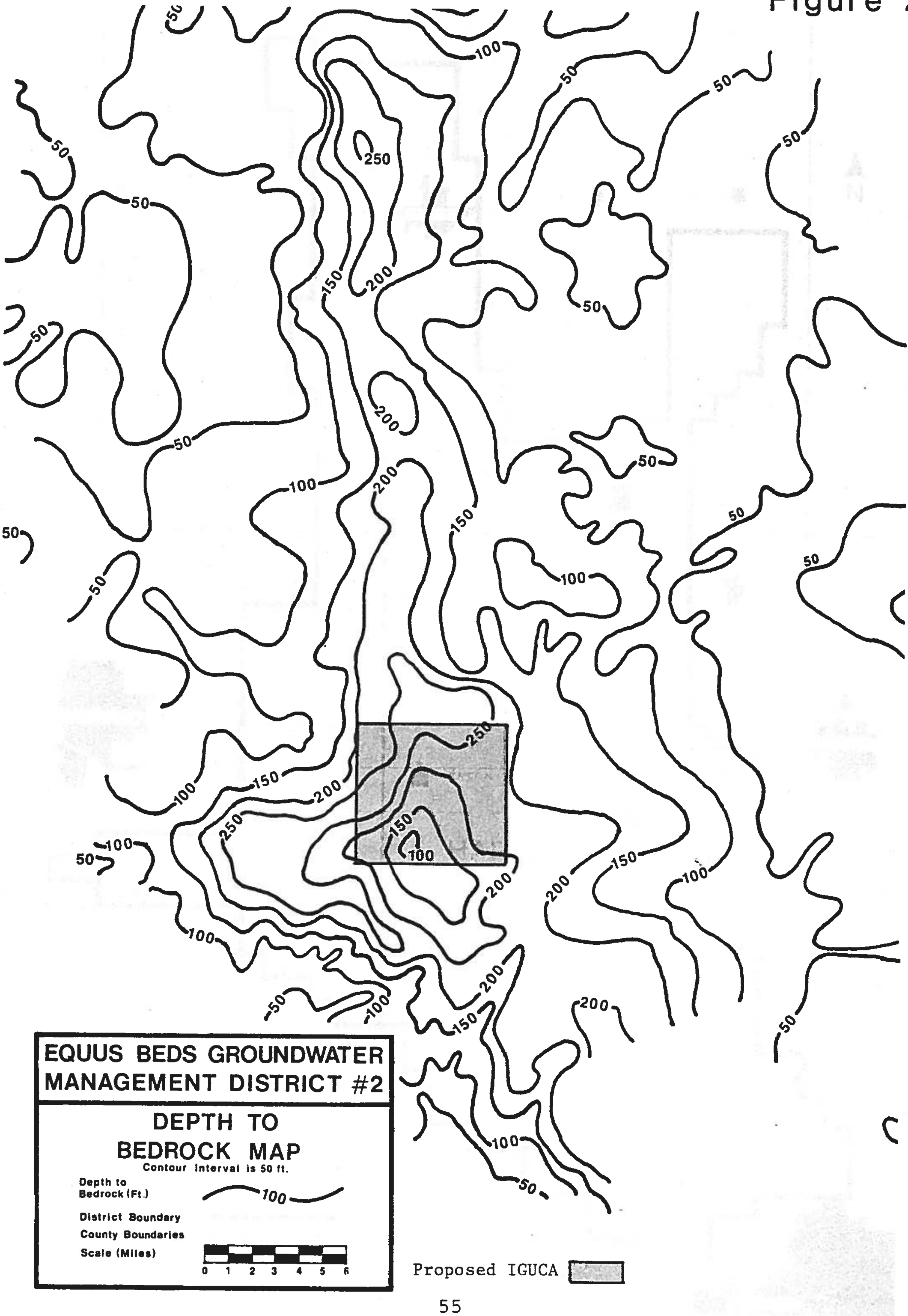
sampled and analyses made for the customary major constitutents included in most partial chemical analyses (pH, calcium, magnesium, sodium, alkalinity, chloride, sulfate, nitrate, and fluoride), and for bromide.

The shaded area on this map outlines those areas where KDHE files have insufficient information on water wells over 100 feet deep. Groundwater Management District Number 2 and the Division of Water Resources should search their files for water wells reportedly 100 feet or more in depth so ground water samples may be collected for partial chemical analysis, and to determine bromide. The bromide results obtained to date indicate the importance of determining whether deeper groundwaters are being influenced by either oil field brines or halite solution brines. We suggest the Groundwater Management District consider placing in their Newsletter a solicitation to the citizens in this area for help in locating water wells known to be 100 feet or more in depth and for the submission of water samples from these wells to the GMD office for transference to KDHE and KGS where appropriate analyses will be run.

Bedrock Configuration and Apparent Influence

A depth-to-bedrock map of GMD #2, with an outline of the proposed Burrton IGUCA, is shown in Figure 20. A comparison of Figure 15 (on page 44) with Figure 20 indicates that the bedrock high, located approximately three miles south of the City of Burrton, has apparently influenced the deep brine-plume movement.

Figure 2



Proposed IGUCA

OIL AND GAS INVENTORY

by

Kansas Corporation Commission

Oil and Gas Well Inventory

The Kansas Corporation Commission collected and tabulated all existing and abandoned oil and gas well data available in the Burrton Task Force study area. Files of plugging records, scout cards, salt water disposal, and repressuring applications were reviewed and well records with approriate plat maps were obtained. From this information, detailed summary sheets with corresponding plat maps were prepared for each section (48 total) in the Burrton study area. Summary sheets identified each well by lease name, type of well, well number, date drilled, date plugged, and total depth. Accompanying the summary sheets are the best available plat maps with well name and number plotted accordingly. Table 5 compiles all well date for the Burrton Task Force study area.

A map of the Burrton Task Force study area was prepared to show well locations and status (Figure 21). The map was prepared at 2" per mile and is presented on a 1" per mile scale. All plugging records, scout cards and original plat maps have been photo-copied and compiled from the Commission's Conservation Division files.

Lost Circulation Zone Wells

An additional classification of wells was keyed on the summary sheet for lost holes and "lost circulation zone" holes. The Burrton Task Force Committee requested the KCC staff research the cause of lost circulation or lost holes more extensively. This information was researched and showed that only three of eighteen recorded lost holes were truly large volume "lost circulation zone" or sink-hole type situations. All of these wells have been plugged to date and are color-coded red in Figure 21. From this data, Table 6 was prepared. Table 7 is a detailed inventory of oil and gas wells.

In the Hutchinson Salt Member of the Wellington Formation, frequently drillers report a loss of drilling fluid into voids as they penetrate the dissolution interval that comprises the aquifer. As a result, drillers have applied the name

TABLE 5

KCC OIL AND GAS INVENTORY SUMMARY

Legal Location Sec.Twp.Rge.	Number of NO Well Records	Total Wells: Oil Well	Total Wells: Gas Well	Total Wells: Salt Water Disposal	Total Wells: Enhanced Recovery	Total Wells Plugged	Active Wells: Oil Well	Active Wells: Gas Well	Active Wells: Salt Water Disposal	Active Wells: Enhanced Recovery
14-23S-3W		4	1			2	2	1		
15-23S-3W		2	4	1		4		2	1	
16-23S-3W		5	2			5		2		
17-23S-3W		21	1		7	27	2			
18-23S-3W	1	18		1	3	17	4		1	
19-23S-3W	10	9			10	15				4
20-23S-3W		13			6	19				
21-23S-3W			7			3		4		
22-23S-3W		6				5	1			
23-23S-3W				1					1	
26-23S-3W		NO WELL RECORDS IN THIS SECTION								
27-23S-3W		NO WELL RECORDS IN THIS SECTION								
28-23S-3W		3		1		3			1	
29-23S-3W		4			1	5				
30-23S-3W	9	32			12	38	2			4
31-23S-3W		16		2	2	19			1	
32-23S-3W		1				1				
33-23S-3W		NO WELL RECORDS IN THIS SECTION								
34-23S-3W		NO WELL RECORDS IN THIS SECTION								
35-23S-3W		1				1				
13-23S-4W		10				10				
14-23S-4W		23	1	3		26			1	
15-23S-4W		1				1				
22-23S-4W		15			1	7	9			
23-23S-4W		30		5		27	6		2	
24-23S-4W		17				16	1			
25-23S-4W		19		2		21				
26-23S-4W		27		5		27	3		1	
27-23S-4W		23				10	12			
34-23S-4W	5	43		5		36	9		1	
35-23S-4W	2	34		3	1	35	3			
36-23S-4W	9	9		1	1	9	2			
2-24S-3W		NO WELL RECORDS IN THIS SECTION								
3-24S-3W		NO WELL RECORDS IN THIS SECTION								
4-24S-3W		NO WELL RECORDS IN THIS SECTION								
5-24S-3W		NO WELL RECORDS IN THIS SECTION								
6-24S-3W		NO WELL RECORDS IN THIS SECTION								
7-24S-3W		1				1				
8-24S-3W		1				1				
9-24S-3W		NO WELL RECORDS IN THIS SECTION								
10-24S-3W		7		1		5	2		1	

TABLE 5 (continued)

KCC OIL AND GAS INVENTORY SUMMARY

		Well Designation									
	Number	Total Wells					Active Wells				
Legal Location Sec.Twp.Rge.	of NO Well Records	Oil Well	Gas Well	Salt Water Disposal	Enhanced Recovery	Total Wells Plugged	Oil Well	Gas Well	Salt Water Disposal	Enhance Recover
11-24S-3W		1				1				
1-24S-4W		7				5	2			
2-24S-4W		3					2			
3-24S-4W	5	36		3	3	39	3			
10-24S-4W		13			4	14	3			
11-24S-4W		1				1				
12-24S-4W		NO WELL RECORDS IN THIS SECTION								
TOTALS	41	456	16	34	51	456	68	9	11	8

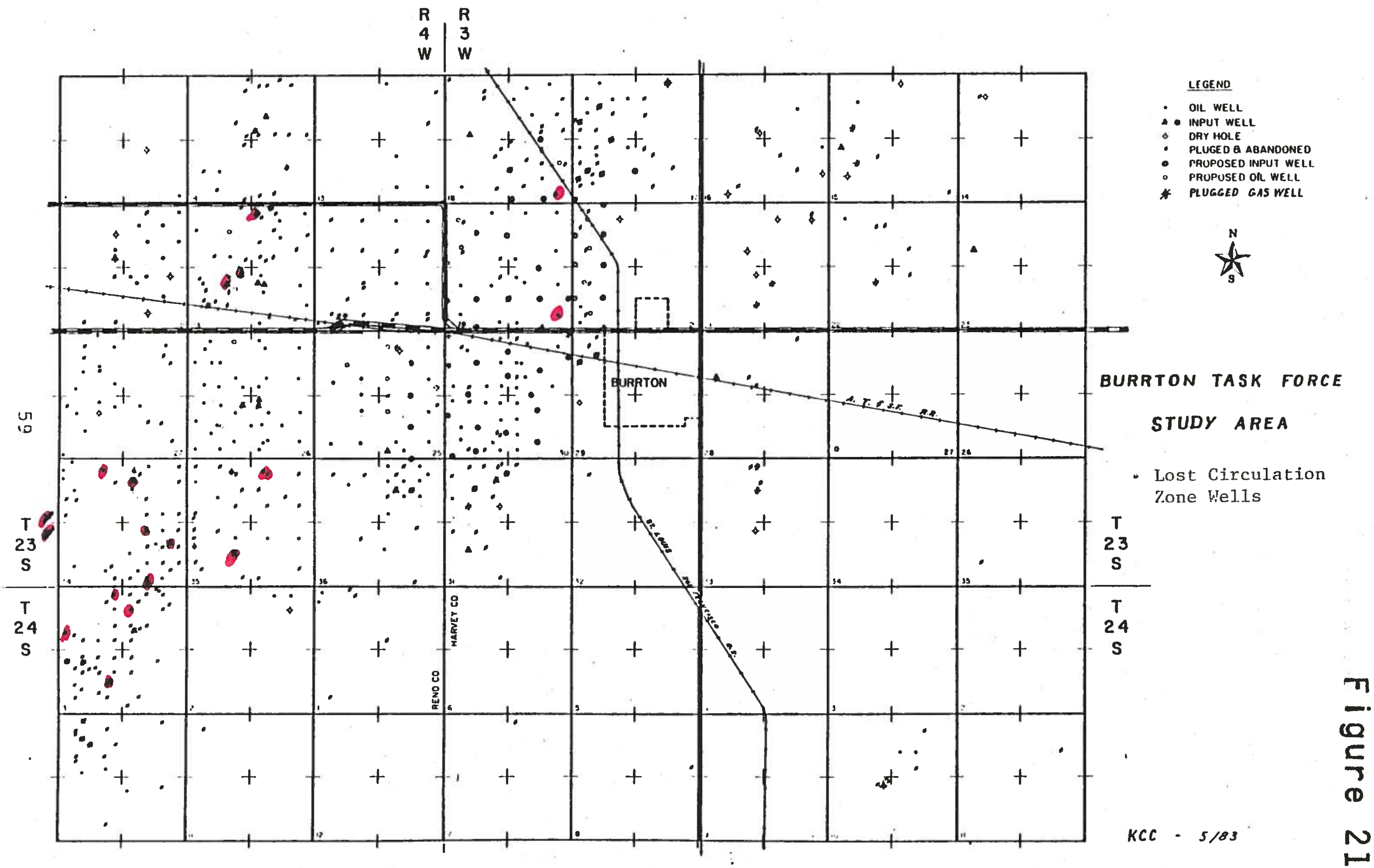


Figure 21

STATUS of OIL and GAS WELLS IN THE BURRTON TASK FORCE AREA

TABLE 6

KCC LIST OF LOST CIRCULATION HOLES AND LOST HOLES

Lease Name	Well Identification Number	Legal Location	Depth In Feet	Problem or Formation
*1. F. Duckworth	SWD	CN$\frac{1}{2}$-23-23S-4W	440	Hutchinson Salt
*2. H. Wilson	SWD	SW$\frac{1}{4}$-23-23S-4W	463	Wellington Fm.
*3. M.B. Blake	SWD	SW$\frac{1}{4}$-23-23S-4W	446	Hutchinson Salt
*4. C. Baughman	SWD	NE$\frac{1}{4}$-34-23S-4W	467	Hutchinson Salt-Wellington Fm.
5. H. Graber	#6	NW$\frac{1}{4}$-34-23S-4W	592	Wellington Fm.
*6. Mc. Elwain	#1-SWD	SE$\frac{1}{4}$-34-23S-4W	493	Wellington Fm.
*7. E.J. England	#1-SWD	SE$\frac{1}{4}$-34-23S-4W	483	Hutchinson Salt
*8. E.J. England	#2-SWD	SE$\frac{1}{4}$-34-23S-4W	500	Anhydrite
*9. J.H. Goering	#1-SWD	SW$\frac{1}{4}$-35-23S-4W	450	Hutchinson Salt
10. L. Krehbiel	#1-SWD	NE$\frac{1}{4}$-35-23S-4W	467	Hutchinson Salt
*11. John Myers	#1	NW$\frac{1}{4}$-3-24S-4W	535	Ninnescah Shale
*12. John Myers	#9	NW$\frac{1}{4}$-3-24S-4W	288	Iron junk in bottom of hole
*13. Baughman "F"	SWD	NE$\frac{1}{4}$-3-24S-4W	585	Hutchinson Salt
*14. Guy Matlack	#1-SWD	SW$\frac{1}{4}$-3-24S-4W	525	Wellington Fm.
15. Pierce	#6	NE$\frac{1}{4}$-33-23S-4W	376	Hutchinson Salt (lost 351 ft. of drill pipe)
*16. Pierce	#5-SWD	NE$\frac{1}{4}$-33-23S-4W	548	Cheyenne Ss.
*17. Cunningham	#W-4	SE$\frac{1}{4}$-19-23S-3W	985	Ninnescah Shale (?) @ 620 ft. Lost hole Wellington Fm.
*18. LeClerc	#0-1	SE$\frac{1}{4}$-18-23-3W	258	Collapsed Surface pipe

*These wells quit taking water or were abandoned leases. Certain holes would not readily circulate water or cement when abandoned.

NOTE: All truly lost circulation holes are in the "lost circulation zone" of the Hutchinson Salt Member of the Wellington Formation.

"lost circulation zone" to the interval (Gogel, 1981). When a drill hole is drilled into a "lost circulation zone", and fluid loss is noted, the hole is described as a lost circulation hole.

Abandoned Well Plugging

Plugging records were reviewed by the KCC to determine the method of plugging in the past verses the present. Examples of past plugging procedures are:

Example a.

O. Chesshire #3 Oil Well in the SE¼ Sec. 3, T24S, R4W, Reno County: Status = Abandoned oil well; Total depth of well = 3373'; Date Plugged = June 30, 1943.
Plug #1: 8 sacks of cement spotted at 3315' depth.
Plug #2: 20 sacks of cement spotted at 300' depth.
Plug #3: 8 sacks of cement spotted at the base of the cellar.
This well bore was filled with high viscosity drilling mud between the above plugs.

Example b.

A.A. Goering #1 Oil Well in the NW¼ Sec. 14, T23S, R3W, Harvey County: Status = Abandoned oil well; Total depth of well = 3350'; Date Plugged = February 20, 1963. Filled hole with sand from total depth 3350' to 3290'.
Plug #1: Spotted 5 sacks of cement at 3290' with a dump bailer. Shot off and pulled 4" casing. Filled hole with drilling mud from 3255' to 240'.
Plug #2: At 240', set a 10' rock bridge and spotted 20 sacks of cement from 230' to 160'. Filled the hole with drilling mud from 160' to 30'.
Plug #3: At 30' set a 5' rock bridge and spotted 8 sacks of cement from 25' to 0' (ground surface).

Example c.

Devenpeck #1 in the SE¼ Sec. 7, T24S, R3W, Harvey County: Status = Dry & Abandoned; total depth of well = 3960'; Date Plugged = February 16, 1982. Filled hole with high viscosity drilling mud from 3960' to 660'.

Plug #1: Spotted 30 sacks of cement at 660' in depth. Filled hole with high viscosity drilling mud to 240'.

Plug #2: Spotted 20 sacks of cement at 240' in depth. Filled hole with high viscosity drilling mud to near surface.

Plug #3: Spotted 15 sacks of cement at the bottom of the cellar to land surface.

The three wells given as examples were plugged approximately 20 years apart. The deeper plugs (described as plug #1 in Example a. and Example b. were placed in production wells which were abandoned. Example c. is for a dry and abandoned well with no production intervals detected. Therefore, a bottom plug was not placed. Heavy viscosity drilling mud is placed between cement plugs in all examples as well as 50' or greater plugs above the Hutchinson Salt Member of the Wellington Formation.

<u>TABLE 7</u>

KCC OIL AND GAS INVENTORY

Legal Location Sec.Twp.Rge.	Lease Name	Well Number	Date Drilled	Total Depth in Ft.	Type of Well[a]	Status of Well[b]	Date Plugged
14-23S-3W	Matthew	1	7/6/79	3325	Oil	D/A	7/9/79
	A.A. Goering	1	6/24/60	3350	Oil		2/12/63
	B.A. Hill	1	6/12/78	3375	Gas		
	Darling	1	6/17/80	3317	Oil		
	Emerson	1	4/13/79	3300	Oil		
15-23S-3W	Epp	1 SWD	1/28/78	3329	SWD		
	Epp	1 GAS	10/15/49	3350	Gas	D/A	1/12/53
	Epp	1 OIL	11/20/58	3294	Oil	D/A	3/17/67
	Epp	1	7/3/37	3915	Oil	D/A	8/7/37
	Epp	2	7/3/78	3296	Gas		
	Howard	1	1/18/49	3378	Gas	D/A	1/17/53
	Howard	1	2/8/78	3325	Gas		
16-23S-3W	Warkentine	1	7/12/49	3370	Oil	D/A	11/8/69
	Warkentine	1 TWIN	6/18/70	3315	Gas		
	Hook	1	8/19/50	3636	Oil	D/A	9/10/50 7/3/67
	Hook	2	5/23/59	3308	Oil	D/A	4/21/60
	Payne	1	10/15/49	3375	Oil	D/A	2/4/50
	Comanche West	1	9/18/80	3361	Oil	D/A	
	KWK Farms	1A	2/14/77	3350	Gas		
17-23S-3W	T. Harms	1	12/14/78	3395	Oil		
	Siemens	2	9/7/52	3367	Oil		3/19/63
	Siemens	1	3/11/80	3371	Oil	D/A	3/19/80
	Siemens	1 GAS	9/1/67	3363	Gas	D/A	4/21/78
	Siemens	1 SW/NE	8/14/52	3364	Oil	D/A	4/1/53
	Howell	W-2	1/16/41	3367	E.R.		1/12/77
	Howell	W-52	10/19/63	3374	E.R.		8/2/76
	Howell	W-51	10/12/63	3373	E.R.		8/5/76
	Howell	1	11/7/39	3370	Oil	D/A	1/12/77
	Howell	2	?	?	Oil		
	Howell	3	2/29/48	3363	Oil	D/A	1/12/77
	Howell	4	8/9/48	3345	Oil	D/A	1/12/77
	Saylor "A"	W-19	6/15/63	3366	E.R.		8/14/69
	Saylor "A"	W-46	8/12/63	3366	E.R.		9/2/71
	Saylor "A"	1	7/16/40	3366	Oil	D/A	8/12/70
	Saylor "A"	W-25	4/18/63	3366	E.R.		7/23/76
	Saylor "B"	1	12/24/48	3363	Oil	D/A	10/4/69
	Saylor "B"	2	?	3405	Oil		10/29/4
	Saylor "B"	0-19	8/21/63	3363	Oil		9/29/69
	Saylor "B"	0-23	4/1/64	3364	Oil		8/8/69
	Saylor "B"	W-43	8/5/63	3365	Oil		7/31/69
	Frederick	"A" 1	9/9/39	3371	Oil	D/A	1/13/77
	Frederick	2	2/3/43	3397	Oil	D/A	7/3/43
	Frederick	3	3/26/49	3366	Oil	D/A	10/4/69

TABLE 7 (continued)

KCC OIL AND GAS INVENTORY

Legal Location Sec.Twp.Rge.	Lease Name	Well Number	Date Drilled	Total Depth in Ft.	Type of Well[a]	Status of Well[b]	Date Plugged
17-23S-3W	Frederick A	W-20	6/12/63	3370	E.R.		10/24/7
	Havely	1	8/18/49	3374	Oil	D/A	8/18/49
	H.B. Havely	1	5/22/43	3364	Oil	D/A	5/14/48
	J.B. Havely	2	8/27/43	3372	Oil	D/A	12/7/47
	M. Redenbaugh	1	?	3326	Oil	D/A	5/8/69
18-23-3W	Pizinger	2	1/29/80	3409	Oil	D/A	6/27/80
	Pizinger Prospect	1	11/27/78	3470	SWD		
	Martindale	W-31	9/2/63	3369	E.R.		7/13/70
	Martindale	W-49	2/3/64	3371	E.R.		7/10/70
	Martindale	W-50	12/10/63	3370	E.R.		7/15/70
	Martindale	4	2/18/41	3362	Oil	D/A	4/19/50
	Martindale	2	7/29/39	3369	Oil	D/A	8/17/63
	Martindale	5	9/2/42	3364	Oil	D/A	9/7/71
	Short	1	4/14/41	3373	Oil	D/A	9/11/68
	Short	2	12/3/49	3373	Oil	D/A	9/9/68
	Sabin "C"	1	NO RECORDS				
	Sabin "C"	2	5/16/49	3320	Oil	D/A	9/4/73
	Sabin "C"	3	12/17/63	3375	Oil	D/A	9/10/73
	Sabin "C"	4	1/24/64	3380	Oil	D/A	4/11/71
	Hurty	1	3/29/41	3381	Oil	D/A	10/2/67
	Hurty	2	10/2/48	3387	Oil	D/A	10/27/6
	Wiley	1	6/13/39	3372	Oil	D/A	11/10/4
	Wiley	2	11/8/39	3396	Oil	D/A	8/17/63
							6/19/41
	Wiley	3	?	?	Oil		
	Wiley	4	?	?	Oil		
	Wiley	5	10/23/73	3363	Oil		
	Wiley	6	7/24/75	3360	Oil		
	LeClerc	O-1	2/22/63	258	Oil	(L.C.)	2/22/63
19-23S-3W	Cunningham	1					
	Cunningham	2					
	Cunningham	W-4	10/16/62	620	E.R.	(L.C.)	10/18/6
	Cunningham	W-9	2/14/63	3364	E.R.		6/30/78
	Gouldner	1	NO RECORDS				
	Gouldner	2	NO RECORDS				
	Gouldner	3	NO RECORDS				
	Gouldner	W-8			E.R.		
	Gouldner	W-28			E.R.		
	Krehbiel	1	NO RECORDS				
	Krehbiel	2	NO RECORDS				
	Krehbiel	3	NO RECORDS				
	J.J. Krehbiel	4	9/5/38	3361	Oil	D/A	6/20/41
	Krehbiel	W-3			E.R.		

TABLE 7 (continued)

KCC OIL AND GAS INVENTORY

Legal Location Sec.Twp.Rge.	Lease Name	Well Number	Date Drilled	Total Depth in Ft.	Type of Well[a]	Status of Well[b]	Date Plugged
19-23S-3W	Krehbiel	W-35	10/4/64	3365	E.R.		9/10/71
	Krehbiel	W-7			E.R.		
	Krehbiel	W-2	5/12/63	3328	E.R.		12/18/8
	Dick	1	NO RECORDS				
	Dick	2	NO RECORDS				
	Day "A"	W-1	5/1/63	3370	E.R.		7/1/80
	Day	A-1	7/4/32	3372	Oil	D/A	8/21/63
	Ada Day "B"	W-33	10/12/63	3371	E.R.		7/1/80
	A.M. Day	1	8/3/32	3372	Oil	D/A	5/22/42
	Ada Day	2	7/24/33	3367	Oil	D/A	6/8/63
							6/7/38
	A.M. Day	2	6/1/38	3375	Oil	D/A	6/7/38
20-23S-3W	Dole	1	4/21/53	1000	Oil		4/23/53
	Dole	1	6/19/38	3428	Oil		8/22/49
	Sanders	1	11/4/37	3371	Oil		2/19/50
	Hullman	1	11/9/43	3332	Oil	D/A	12/14/4
	Morton	0-18	7/11/63	3363	E.R.		5/15/78
	Morton	W-47	7/18/64	3364	Oil		8/30/69
	Hitch	1	6/19/52	965	Oil	D/A	6/19/52
	Hitch	0-17	7/17/63	3364	Oil		6/12/69
	Wilson	3	7/29/48	3340	Oil		8/29/50
	Wilson	2	12/7/39	3362	Oil		8/8/51
	Wilson	1	4/13/38	3400	Oil		8/31/49
	Wilson	1-B	1/8/45	3370	Oil	D/A	1/25/45
	Wilson	W-26	5/9/63	3366	E.R.		7/28/76
	Wilson	W-27	6/10/63	3365	E.R.		7/26/76
	Wilson	0-2	4/10/63	3366	Oil		9/22/69
	Wilson	0-16	7/31/63	3365	Oil		9/19/69
	Wilson	W-18	4/26/63	3365	E.R.		8/19/69
	Wilson	W-44	8/7/63	3364	E.R.		8/23/69
	Wilson	W-45	7/25/63	3364	E.R.		8/28/69
21-23S-3W	E. Jones	1	11/30/79	3360	Gas		3/5/81
							4/6/81
	Becker	1	7/24/78	3308	Gas		
	KWK Farms	1-B	2/21/77	3359	Gas		
	Webb	1	8/15/63	3357	Gas	D/A	8/15/63
	Frederick	1	2/5/79	3354	Gas		
	A. Unruh	1	10/28/78	3385	Gas		8/26/82
	T. Jones	1	5/5/78	3310	Gas		
22-23S-3W	Sanders	1	8/5/65	3305	Oil	D/A	8/5/65
	Bontranger	1	11/25/65	3300	Oil	D/A	6/29/67
	Bontranger	2	7/29/80	3320	Oil	D/A	3/27/81
	Bontranger	1	9/7/78	3297	Oil		
	C.A. Carbough	1	12/7/59	3396	Oil	D/A	2/1/67
	M. LeFever	1	9/22/64	3295	O & G	D/A	12/9/70

TABLE 7 (continued)

KCC OIL AND GAS INVENTORY

Legal Location Sec.Twp.Rge.	Lease Name	Well Number	Date Drilled	Total Depth in Ft.	Type of Well[a]	Status of Well[b]	Date Plugged
23-23S-3W	A.J. Becker	2 SWD	2/11/80	3610	SWD		
26-23S-3W	NO WELL RECORDS IN THIS SECTION						
27-23S-3W	NO WELL RECORDS IN THIS SECTION						
28-23S-3W	A.J. Becker	1	5/5/77	3348	Oil		8/15/7
	A.J. Becker	2	2/18/80	?	SWD		
	Becker	1	9/19/56	3381	Oil		4/6/57
	Stelbar	1	8/8/60	3345	Oil		2/16/6
29-23S-3W	Graebeck	W-48	1/26/64	3363	E.R.		9/10/6
	Graebeck	W-54	10/20/64	3364	Oil	D/A	10/21/
	Graebeck	0-20	1/2/64	3364	Oil		9/10/6
	Ashmon	1	3/8/39	3371	Oil		10/29/
	Wilson	1	6/1/38	3389	Oil	D/A	6/3/3
30-23S-3W	Nelson	W-21	6/25/63	3364	E.R.		7/2/70
	Nelson	W-36	9/21/63	3370	E.R.		1/22/8
	Nelson	1	9/1/32	3370	Oil		3/17/4
	Nelson	2	NO RECORDS				
	Nelson	3	NO RECORDS				
	Nelson	4	NO RECORDS				
	Nelson	5	6/29/37	3365	Oil		7/31/6
	Nelson	6	NO RECORDS				
	Nelson	7	NO RECORDS				
	Nelson	W-5	6/23/63	3368	E.R.		
	Nelson	W-14	6/11/63	3371	E.R.		
	Nelson	W-37	10/2/63	3369	Oil		7/31/7
	Nelson	0-6	5/25/63	3660	Oil		8/20/7
	Nelson	W-12	6/1/63	3367	E.R.		7/2/70
	Short	1	4/14/41	3373	Oil		8/15/6
	Short	2	5/20/38	3365	Oil		10/14/
	Short	3	10/6/37	3369	Oil		8/8/63
	Short	0-4	5/31/63	3365	Oil		
	Short	0-14	7/4/63	3367	Oil		
	Short	W-10	2/19/63	3365	E.R.		10/17/
	Short	W-22	6/20/63	3365	E.R.		
	Short	W-53	10/5/63	3365	E.R.		10/19/
	Schrag A	/	NO RECORDS				
	Schrag A	2	7/25/37	3365	Oil		10/1/6
	Schrag A	3	9/7/37	3360	Oil		8/15/7
	J. Schrag Jr.	4	9/18/37	3360	Oil		8/16/4
	Schrag A	5	NO RECORDS				
	Schrag A	6	6/18/63	3367	Oil		7/2/70
	Schrag A	0-7	3/15/63	3365	Oil		7/1/70
	Schrag A	W-6	3/21/63	2730	Oil		3/26/6
	Schrag A	W-16	2/6/63	3374	Oil		7/1/70
	Schrag A	W-17	6/15/63	3366	Oil		6/8/70
	Norris	1	1/29/37	3372	Oil		12/23/

TABLE 7 (continued)

KCC OIL AND GAS INVENTORY

Legal Location Sec.Twp.Rge.	Lease Name	Well Number	Date Drilled	Total Depth in Ft.	Type of Well[a]	Status of Well[b]	Date Plugged
30-23S-3W	Norris	2	6/12/37	3373	Oil		7/26/63
	Norris	3	NO RECORDS				
	Norris	4	11/15/48	3362	Oil		10/24/7
	Norris	0-9	4/26/63	3367	Oil		10/14/7
	Norris	W-38	8/20/63	3367	E.R.		10/12/7
	Norris	W-23	3/14/63	3342	Oil		6/10/68
	Jerome	W-15	6/18/63	3362	E.R.		
	Jerome	1	9/12/37	3359	Oil		8/5/76
	Jerome	0-22	4/26/64	3357	Oil		7/3/70
	Hancock	1	8/18/37	3365	Oil		12/22/8
	Hancock	W-39	6/20/63	3363	E.R.		6/29/70
	Hancock	1-W	12/19/81	3385	Oil		12/22/8
	Murphy	1	7/22/37	3360	Oil		7/10/68
	Murphy	2	9/10/37		Oil		8/5/70
	Murphy A	W-40	6/16/63	3365	E.R.		7/21/70
	Murphy "B"	1	?	3365	Oil		7/30/44
	Divine	1	NO RECORDS				
	Divine	0-8	1/19/64	3372	Oil		9/3/71
	Murphy A	0-24	3/24/64	3364	Oil		7/18/70
	Schrag "A"	6-A	11/27/37	3354	Oil		8/5/63
31-23S-3W	Base "B"	3	10/18/67	3400	Oil	D/A	10/18/6
	Base "B"	2	7/25/75	3355	SWD		
	Base "B"	1	1/3/65	3352	Oil	D/A	7/21/66
	Base "A"	1	9/4/63	3340	Oil	D/A	5/2/67
	Base	1	?	3400	Oil		3/12/74
	Base	3	?	3400	Oil	D/A	10/18/6
	Schrag "B"	0-10	3/13/63	3364	Oil	D/A	6/12/68
	Schrag "B"	W-41	6/22/63	3363	E.R.		6/7/68
	Schrag "B"	1	8/23/62	3373	Oil	D/A	6/12/75
							6/5/68
	Schrag	2	9/29/37	3358	Oil	D/A	2/15/45
	Brilhart	1	9/12/37	3362	Oil	D/A	7/5/68
	Brilhart "B"	W-42	6/15/63	3365	E.R.		6/25/68
	Brilhart "B"	0-15	7/12/63	3365	Oil	D/A	6/24/68
	Graham	1	6/21/40	3350	Oil	D/A	8/23/40
	Schrag	1	?	3373	Oil		6/12/75
	Schrag "A"	1	9/16/67	3366	Oil	D/A	3/12/74
							10/3/81
	Schrag	1-SWD	3/25/44	501	SWD		3/26/44
	Schrag	1	9/29/37	3358	Oil	D/A	9/28/56
	J.G. Schrag	East-1	12/8/62	3353	Oil	D/A	7/2/74
32-23S-3W	Morris	1	9/10/38	3317	Oil	D/A	9/10/38
33-23S-3W		NO WELL RECORDS IN THIS SECTION					
34-23S-3W		NO WELL RECORDS IN THIS SECTION					
35-23S-3W	Howard	1	2/8/78	3930	Oil	D/A	1/12/78

TABLE 7 (continued)

KCC OIL AND GAS INVENTORY

Legal Location Sec.Twp.Rge.	Lease Name	Well Number	Date Drilled	Total Depth in Ft.	Type of Well[a]	Status of Well[b]	Date Plugged
13-23S-4W	M.E. Sabin "B"	5	8/15/36	3408	Oil		10/12/7
	Sabin "B"	3	4/27/36	3381	Oil		10/4/73
	M.E. Sabin "B"	B-1	6/16/33	3379	Oil		5/17/7
	Sabin	6	11/16/67	3343	Oil		8/12/6
	M.E. Sabin "B"	4	7/17/36	3374	Oil		12/19/4
	M.E. Sabin "B"	2	12/16/35	3404	Oil		11/11/4
	M.E. Sabin	1	3/2/35	3378	Oil		6/6/43
	Sabin	3	8/22/40	3393	Oil		5/19/5
	Sabin	5	4/10/50	3641	Oil		9/18/5
	Sabin "B"	6	?	3354	Oil		8/10/6
14-23S-4W	Ackley	1	9/19/34	3275	Gas	D/A	10/2/4 10/8/3
	Ackley	2	11/16/34	3598	Oil	D/A	1/19/4 8/9/46
	Ackley	3	1/21/35	3610	Oil	D/A	12/14/4 8/17/4
	Ackley	4	3/15/35	3360	Oil	D/A	11/1/3 9/25/4
	Ackley	1	9/17/34	3601	Oil	D/A	9/1/35
	Ackley	4	3/15/35	3593	Oil	D/A	8/25/4
	Hensley	1	4/17/67	3720	Oil	D/A	12/14/6
	Hensley	1	?	3590	Oil	D/A	3/29/67
	E.R. Downie	1	7/2/38	3725	Oil	D/A	12/31/4
	E.R. Downie	2	11/28/34	3604	Oil	D/A	12/12/4
	E.R. Downie	3	1/27/35	3606	Oil	D/A	1/16/47
	E.R. Downie	SWD	4/29/35	451	SWD		12/1/3
	Downie	4	1/21/35	4572	Oil	D/A	5/16/5
	E.R. Downie	5	3/29/35	3837	Oil	D/A	12/4/4
	E.R. Downie	6	2/21/35	3614	Oil	D/A	10/8/4
	E.R. Downie	7	3/7/35	3610	Oil	D/A	1/13/4
	Downie	10	10/24/35	500	Oil	SWD	8/14/4
	Downie	SWD	6/16/80	3722	SWD		
	Harner	1	5/31/65	3580	Oil	D/A	5/31/6
	Harner	1-A	9/28/46	3618	Oil	D/A	10/6/4
	G.M. Harner	2	2/26/35	3625	Oil	D/A	12/12/4
	G.M. Harner	3	4/24/35	3626	Oil	D/A	9/9/40
	Geo. M. Harner	1-B	1/12/35	3614	Oil	D/A	8/3/44
	Geo. Harner	2-A	1/26/35	3611	Oil	D/A	9/6/45
	Geo. M. Harner	4	5/2/35	3808	Oil	D/A	5/8/35
	Harner	5	7/8/75	3410	Oil		2/12/7
	G.M. Harner	1 SWD	?	500	SWD		8/14/4
15-23S-4W	Nelson "A"	1	11/3/78	3440	Oil	D/A	7/6/79
22-23S-4W	Miller "A"	6	3/30/72	3430	Oil		4/4/74
	Miller "A"	5	3/16/73	3667	Oil		
	Miller "A"	4	3/10/72	3400	Oil		

TABLE 7 (continued)

KCC OIL AND GAS INVENTORY

Legal Location Sec.Twp.Rge.	Lease Name	Well Number	Date Drilled	Total Depth in Ft.	Type of Well[a]	Status of Well[b]	Date Plugged
22-23S-4W	Miller "A"	3	2/10/72	3415	Oil		
	Miller "A"	2	2/10/72	3410	Oil		
	Miller "A"	1	9/22/71	3400	Oil		
	Dillingham	1	6/3/76	3430	Oil		2/10/78
	Dillingham	1	1/21/69	3412	Oil	D/A	1/27/7
	Strawn	1	9/5/68	3445	E.R.		10/13/7
	Regier	1	11/18/74	3415	Oil	D/A	11/18/7
	Regier	1	12/14/70	3377	Oil	D/A	12/27/7
	Hilda	2	9/27/74	3400	Oil		12/23/7
	Sabin	1	1/8/69	3445	Oil		
	Sabin "A"	2	9/13/73	3355	Oil		
	Sabin "A"	1	4/13/73	3401	Oil		
	Sabin "A"	3	8/18/79	3355	Oil		
23-23S-4W	Evans	1	1/5/67	3246	Oil		
	Evans	2	1/5/67	3617	Oil		
	Evans	3	1/5/67	3253	Oil		
	Evans	4	12/6/66	3349	Oil	D/A	10/22/6
	Evans	5	1/26/67	3354	Oil		
	Evans	B-6	10/1/67	3599	Oil	D/A	4/11/69
	Evans	B-7	7/30/68	3400	Oil	D/A	9/20/74
	Evans	8	12/15/68	3325	Oil	D/A	8/23/79
	Evans	9	4/8/69	3320	Oil	D/A	8/29/69
	F. Duckworth	1	7/8/32	3377	Oil	D/A	10/29/3
	F. Duckworth	2	11/21/34	3325	Oil	D/A	11/12/4
	F. Duckworth	3	3/13/35	3606	Oil	D/A	8/23/46
	F. Duckworth	4	3/17/35	3613	Oil	D/A	12/2/46
	F. Duckworth	5	1945 ?	4000	Oil	D/A	11/25/4
	F. Duckworth	SWD	5/10/35	440	SWD	L.H.	12/1/39
	F. Duckworth	6	4/17/35	3606	Oil	D/A	10/6/41
	H. Wilson	1-SWD	7/9/35	463	SWD	L.H.	6/22/52
	H. Wilson	1	11/17/34	3304	Oil	D/A	4/2/44
							11/1/68
	H. Wilson	2	1/20/35	3607	Oil	D/A	4/21/44
	H. Wilson	3	3/20/35	3619	Oil	D/A	4/28/52
	H. Wilson	4	3/24/35	3619	Oil	D/A	5/6/52
	H. Wilson	1		3610			4/22/44
	M.B. Blake	SWD	6/17/35	446	SWD	L.H.	12/1/39
	M.B. Blake	9	3/26/35	3604	Oil	D/A	10/11/7
	M.B. Blake	5	3/8/35	3614	Oil	D/A	1/16/45
	M.B. Blake	1	3/13/33	3378	Oil	D/A	11/28/7
	VanSickle	1	1/2/35	3600	Oil	D/A	9/13/40
	VanSickle	2	1/18/35	3621	Oil	D/A	9/22/73
	VanSickle	3					
	VanSickle	4	3/29/35	3605	Oil	D/A	7/4/54
	VanSickle	5	7/9/35	3875	Oil	D/A	7/1/71

TABLE 7 (continued)

KCC OIL AND GAS INVENTORY

Legal Location Sec.Twp.Rge.	Lease Name	Well Number	Date Drilled	Total Depth in Ft.	Type of Well[a]	Status of Well[b]	Date Plugged
23-23S-4W	VanSickle	6	12/26/71	3617	Oil		
	Krehbiel	1	10-20-53	3628	Oil	D/A	9/20/53
	Blake	10	3/4/81	4563	SWD		
	Blake	10-A	5/8/55	3820	SWD		
	Blake	11	10/27/77	3400	Oil		
	Blake	1		3386	Oil		11/28/7
24-23S-4W	M.E. Sabin "A"	1	7/3/32	3373	Oil	D/A	4/15/51
	M.E. Sabin "A"	2	4/11/36	3375	Oil	D/A	3/21/69
	Sabin "A"	3	12/7/63	3372	Oil	D/A	9/20/73
	O. Johnson	1	3/25/32	3354	Oil	D/A	1/3/46
	O. Johnson	2	4/6/35	3368	Oil	D/A	4/19/40
	O. Johnson	3	3/30/36	3370	Oil	D/A	10/20/7
	O. Johnson	4	5/26/36	3375	Oil	D/A	7/19/41
	Regier	1	4/29/32	3375	Oil	D/A	1/10/38
	Regier	2	3/2/36	3374	Oil	D/A	10/25/3
	A. Regier	3	12/20/63	3363	Oil	D/A	4/10/72
	A. Regier	4	2/20/66	3342	Oil	D/A	3/23/72
	Rudicel	1	4/22/63	3388	Oil	D/A	8/15/64
	C.E. Rudicel	1	7/27/32	3338	Oil	D/A	12/12/3
	C.E. Rudicel	2	12/12/32	3386	Oil	D/A	11/5/39
	C.E. Rudicel	3	2/20/36	3362	Oil	D/A	11/10/3
	C.E. Rudicel	4	3/24/36	3372	Oil	D/A	8/2/40
	VanSickle "A"	1	7/3/78	3410	Oil		
25-23S-4W	Roberts	9	12/2/65	3300	Oil		8/4/76
	P.C. Roberts	SWD	7/6/35	450	SWD		12/1/39
	Roberts	8	11/25/65	3300	Oil		11/8/74
	Roberts	6	12/20/35	3641	Oil		12/1/38
	P.C. Roberts	1	5/31/32	3417	Oil		12/30/4
	Roberts	7	11/29/36	3374	Oil		11/19/5
	Roberts	10	12/23/65	3323	Oil		4/10/72
	Roberts	11	1/5/66	3320	Oil		6/22/74
	P.C. Roberts	3	6/2/34	3374	Oil		8/15/74
	P.C. Roberts	4	3/18/34	3367	Oil		3/2/39
	J. Fast	5	4/9/37	3359	Oil	D/A	10/16/3
	C.J. Fast	3	1/19/36	3366	Oil		3/9/40
	J. Fast	SWD	4/8/36	480	SWD		11/30/3
	J. Fast	6	8/11/37	3392	Oil	D/A	10/9/37
	J. Fast	4	1/13/37	3377	Oil		3/15/47
	J. Fast	2	5/1/36	3370	Oil		8/2/63
	Fast	8	10/6/63	3374	Oil		10/18/7
	Fast	14	12/10/65	3318	Oil		5/5/72
	Fast	7	?	3376	Oil		10/23/6
	Fast	9	10/31/63	3376	Oil		10/26/6
	W.L. Adkins	3	3/11/35	3371	Oil		11/25/6

TABLE 7 (continued)

KCC OIL AND GAS INVENTORY

Legal Location Sec.Twp.Rge.	Lease Name	Well Number	Date Drilled	Total Depth in Ft.	Type of Well[a]	Status of Well[b]	Date Plugged
26-23S-4W	A.T. Base	1-SWD	4/5/35	550	SWD		8/11/48
	Base	6	5/22/35	4492	SWD		10/30/5
	Base	1	4/15/50	430	Oil	D/A	4/15/50
	A.T. Base	1	3/19/33	3591	Oil		1/31/39
	Base "A"	1	4/28/50	3345	Oil		5/28/56
	Base (Wash-Down)	1	3/19/33	2460	Oil	OWWO	4/26/66
	A.T. Base	2	4/11/33	3361	Oil	OWWO	4/30/47
	A.T. Base	5	8/11/34	3362	Oil		2/13/40
	A.T. Base	4	5/9/34	3374	Oil		5/24/47
	A.T. Base	3	4/25/34	3367	Oil		2/26/40
	A.T. Base	2	4/11/33	3361	Oil		5/15/47
	Pankratz	1	4/25/34	3356	Oil	OWWO	8/30/67
	E. Krehbiel "A"	6	6/15/35	3595	Oil		4/22/69
	E. Krehbiel "A"	5	5/9/35	3583	Oil		9/12/70
	E. Krehbiel "B"	3	12/1/35	3618	Oil		4/21/71
	E. Krehbiel "A"	SWD	6/1/35	471	SWD		12/4/39
	E. Krehbiel "A"	4	2/22/35	3614	Oil		4/17/69
	E. Krehbiel "A"	3	8/11/34	3368	Oil		1/18/69
	E. Krehbiel "A"	2	5/1/33	3310	Oil		5/3/46
	E. Krehbiel "A"	1	6/2/32	3384	Oil		7/8/44
	Krehbiel "A-B"	2	4/28/78	3592	Oil		
	D.M. Vogt	3	5/5/35	3593	Oil		6/28/41
	D.M. Vogt	1	UNKNOWN	3375	Oil		11/??/4
	D.M. Vogt	2	3/23/34	3375	Oil		1/24/47
	J.H. Goering "A"	9	7/18/37	3584	Oil		1/13/47
	J.H. Goering "A"	4	6/22/35	3380	Oil		1/10/41
	J.H. Goering "A"	1	4/11/32	3332	Oil		1/11/41
	J.H. Goering "A"	5	4/23/35	4497	SWD		8/4/58
	J.H. Goering "A"	10	5/27/75	3574	Oil		
	J.H. Goering "A"	11	11/1/77	3567	Oil		
	Base	6-B TWIN	2/9/81	4462	SWD		
	Base	1	8/15/68	3597	Oil	D/A	(?)
27-23S-4W	O'Neal	2	2/1/70	3345	Oil	D/A	1/3/73
	O'Neal	1	2/7/69	3420	Oil		
	Copper	1	8/4/74	3378	Oil	D/A	6/13/75
	Copper	1-A	6/16/68	3405	Oil	D/A	6/15/69
	Banz	1	9/5/66	3675	Oil	D/A	9/5/66
	Banz	1-A	8/10/67	3665	Oil		
	Banz	2	2/8/68	3425	Oil		
	Banz	3	6/17/68	3430	Oil		
	L. Hill	1	7/21/61	3905	Oil	D/A	7/21/61
	Banz	4	3/19/70	3348	Oil		
	J.J. Penner	1	2/13/36	3370	Oil	D/A	5/21/69
	J.J. Penner	2	2/6/69	3325	Oil	D/A	6/22/74
	J.J. Penner	3	8/15/69	3353	Oil		

TABLE 7 (continued)

KCC OIL AND GAS INVENTORY

Legal Location Sec.Twp.Rge.	Lease Name	Well Number	Date Drilled	Total Depth in Ft.	Type of Well[a]	Status of Well[b]	Date Plugged
27-23S-4W	M. Querfield	2	10/4/34	3609	Oil	D/A	2/17/44
	M. Querfield	3	1/21/47	3618	Oil	D/A	1/21/47
	Hill	1	1961	3903	Oil		8/25/66 1/18/68
	Hill	2	2/8/68	3331	Oil		
	Hill	3	5/23/68	3391	Oil		
	Harper	1	12/7/67	3425	Oil		
	Harper	2	6/30/69	3341	Oil		
	E. Miller	1	11/23/67	3339	Oil	D/A	(?)
	E. Miller	2	8/27/75	3346	Oil		
	Hill	4	8/3/68	3430	Oil		
34-23S-4W	Rudicel	2	3/18/82	3375	Oil	D/A	3/19/82
	Baughman	4	2/8/35	3593	Oil	D/A	3/9/70
	C. Baughman	3	12/23/34	3590	Oil	D/A	4/7/75
	C. Baughman	2	10/30/34	3587	Oil	D/A	4/7/75
	C.W. Grandon	1	3/18/35	3603	Oil	D/A	6/4/40
	C.W. Grandon	2	4/13/35	3358	Oil	D/A	3/8/40
	C.W. Grandon	3	NO RECORDS				
	C. Baughman	1	9/8/34	3595	Oil	D/A	11/30/4
	C. Baughman	SWD	6/26/35	467	SWD	L.H.	3/13/47
	C. Baughman	1	10/18/67	3340	Oil	D/A	9/6/77
	E. Miller	2	12/20/67	3342	Oil	D/A	10/15/7
	Baughman	1	8/30/32	3390	Oil	D/A	4/10/41
	Baughman	2	4/20/35	3516	Oil	D/A	4/2/41
	Baughman	3	NO RECORDS				
	Graber	1	4/4/69	3425	Oil	D/A	8/10/69
	Graber	2	10/21/81	3623	Oil	D/A	10/21/8
	Graber	3	NO RECORDS				
	Graber	4			Oil	D/A	(?)
	Graber	5	NO RECORDS				
	Graber	6	12/20/82	592	Oil	L.H.	12/21/8
	Graber	1-SWD	9/19/67	3362	SWD		12/13/7
	Graber "A"	1-SWD	8/30/32	3390	SWD		
	Myers	1	5/10/35	3680	Oil	D/A	8/26/40
	McElwain	1-SWD	9/12/50	493	SWD	L.H.	11/8/51
	E.J. England	1	4/8/39	483	Oil	L.H.	12/8/39
	E.J. England	1		3370	Oil	D/A	8/24/43
	England	1	12/19/34	3601	Oil	D/A	8/21/43 11/20/6
	England	1	1/19/72	3600	Oil		
	E.J. England	2	3/25/35	3604	Oil	D/A	1/7/46
	E.J. England	3	4/7/35	3604	Oil	D/A	12/29/4
	E.J. England	4	4/13/35	3604	Oil	D/A	12/18/4
	E.J. England	5	4/21/35	3604	Oil	D/A	12/11/4
	E.J. England	6	NO RECORDS				

TABLE 7 (continued)

KCC OIL AND GAS INVENTORY

Legal Location Sec.Twp.Rge.	Lease Name	Well Number	Date Drilled	Total Depth in Ft.	Type of Well[a]	Status of Well[b]	Date Plugged
34-23S-4W	E.J. England	2-SWD	11/11/35	500	SWD	L.H.	12/15/3
	E.J. England	1-A	5/15/69	3601	Oil		
	McElwain	1	12/21/34	3393	Oil	D/A	7/27/67
							10/7/50
	McElwain	2	12/21/34	3593	Oil	D/A	8/23/50
	McElwain	3	1/13/35	3595	Oil		10/20/5
							10/22/7
	McElwain	4	3/30/35	3588	Oil	D/A	10/26/5
	McElwain	5	7/14/36	3594	Oil	D/A	9/22/50
	McElwain	6	4/26/35	3593	Oil	D/A	8/11/43
	McElwain	7	8/15/36	3360	Oil	D/A	9/3/50
	McElwain	8	10/7/36	3371	Oil	D/A	9/8/50
	McElwain	1-A	7/14/71	3725	Oil		
	McElwain	1		3379	Oil		10/7/50
	Eash-Miller	1	1/11/68	3340	Oil		
	Eash-Miller	2	2/22/68	3347	Oil		
	Eash-Miller	4	2/20/68	3400	Oil		
	Eash-Miller	3	9/5/68	3340	Oil		
	Eash-Miller	5	9/15/80	3353	Oil	T/A	5/16/80
	Graber	1-A	8/12/67	3279	Oil		
	McElwain	3	10/22/77	3588	Oil		
	McElwain	2	10/17/75	3595	Oil	D/A	(?)
35-23S-4W	J.W. Stanley	1	6/21/33	3358	Oil	D/A	4/16/39
	J.W. Stanley	2	6/3/34	3375	Oil	D/A	10/22/3
	Rudicel	1	3/18/82	3375	Oil	D/A	3/19/82
							10/17/8
	C. Gorvin	2	10/15/33	3371	Oil	D/A	7/18/44
	L. Krehbiel	7	10/23/67	3383	Oil	D/A	9/13/68
	L. Krehbiel	1	11/30/32	3370	Oil	D/A	10/24/6
	L. Krehbiel	2	11/22/33	3370	Oil	D/A	8/18/43
	L. Krehbiel	3	3/9/34	3370	Oil	D/A	8/12/43
	L. Krehbiel	4	7/22/34	3590	Oil	D/A	9/11/46
	L. Krehbiel	5	2/18/35	3369	Oil	D/A	11/8/51
	L. Krehbiel	6	5/1/35	3593	Oil	D/A	10/8/68
	J.H. Goering	1-SWD	6/19/35	450	SWD	L.H.	12/8/39
	L. Krehbiel	1	5/26/38	467	SWD	L.H.	5/26/38
	W.L. Adkins	1	12/22/45	3374	Oil	D/A	12/28/4
	W.L. Adkins	2	6/16/33	3375	Oil	D/A	1/3/46
	W.L. Adkins	3	NO RECORDS				
	W.L. Adkins	4	2/19/35	3626	Oil	D/A	8/15/72
	W.L. Adkins	5	11/18/36	3317	Oil	D/A	9/18/43
	W.L. Adkins	6	12/19/36	3371	Oil	D/A	10/17/4
	W.L. Adkins	7	4/29/72	3588	Oil	D/A	8/25/72
	J.H. Goering "B"	1	5/25/32	3322	Oil	D/A	8/7/48
	J.H. Goering "B"	2	6/2/34	3589	Oil	D/A	1/8/69

TABLE 7 (continued)

KCC OIL AND GAS INVENTORY

Legal Location Sec.Twp.Rge.	Lease Name	Well Number	Date Drilled	Total Depth in Ft.	Type of Well[a]	Status of Well[b]	Date Plugged
35-23S-4W	J.H. Goering "B"	3	8/27/34	3593	Oil	D/A	11/1/73
	J.H. Goering "B"	4	NO RECORDS				
	J.H. Goering "B"	5	4/28/35	3593	Oil	D/A	4/5/69
	J.H. Goering "B"	6	12/20/34	3590	Oil	D/A	12/30/7
	J.H. Goering "B"	7	1/11/35	3363	Oil	D/A	12/16/7
	J.B. Goering "B"	8	8/29/35	3804	Oil	D/A	7/10/50
	J.H. Goering "B"	9	4/30/72	3583	Oil		
36-23S-4W	Base	1	12/12/63	3340	Oil	D/A	12/12/6
	Base	2	NO RECORDS				
	Base	3	NO RECORDS				
	Base	4	NO RECORDS				
	Smith	1	NO RECORDS				
	Smith	2	NO RECORDS				
	Smith	3	NO RECORDS				
	C. Base	1	9/17/34	3376	Oil	D/A	7/9/40
	C. Base	2	NO RECORDS				
	C. Base	3	NO RECORDS				
	C. Base	4	NO RECORDS				
	C. Base	5-W	3/1/65	3388	E.R.		7/18/70
	Hoskinson	1	12/16/65	3309	Oil	D/A	1/30/71
	R.J. Stucky	1	2/10/34	3662	Oil	D/A	4/19/41
	R.J. Stucky	2	8/12/34	3370	Oil	D/A	3/30/43
	Siemens	5	5/10/75	3401	Oil		
	W. Marr	1	10/17/34	3374	Oil	D/A	4/17/37
	McElwain	3	5/13/76	3422	Oil		
	M. Stalcup	1-SWD	9/26/35	899	SWD		8/30/48
	Craven	1	12/15/57	3365	Oil	D/A	12/17/5
2-24S-3W		NO WELL RECORDS IN THIS SECTION					
3-24S-3W		NO WELL RECORDS IN THIS SECTION					
4-24S-3W		NO WELL RECORDS IN THIS SECTION					
5-24S-3W		NO WELL RECORDS IN THIS SECTION					
6-24S-3W		NO WELL RECORDS IN THIS SECTION					
7-24S-3W	Devenpeck	1	1/28/48	3960	Oil	D/A	2/1/82
							1/29/48
8-24S-3W	J. McNew	1	9/24/59	4030	Oil	D/A	9/24/59
9-24S-3W		NO WELL RECORDS IN THIS SECTION					
10-24S-3W	Schrag	1	11/13/80	3951	Oil		
	Schrag	2	5/6/81	3030	Oil		
	Schrag	3	10/12/81	3015	Oil	D/A	10/19/8
	Schrag	4	4/12/82	465	Oil	D/A	10/19/8
	Loyd	1-B	2/7/81	550	Oil	D/A	2/7/81
	Loyd	1-A	2/3/81	2982	Oil	D/A	2/17/81
	Loyd	1-SWD	5/18/81	3445	SWD		
	Loyd	1-B TWIN	2/5/81	2981	Oil	D/A	2/7/81
11-24S-3W	Frantz	1	10/7/47	4029	Oil	D/A	10/9/47

TABLE 7 (continued)

KCC OIL AND GAS INVENTORY

Legal Location Sec.Twp.Rge.	Lease Name	Well Number	Date Drilled	Total Depth in Ft.	Type of Well[a]	Status of Well[b]	Date Plugged
1-24S-4W	McElwain	1	1/20/81	3350	Oil		
	McElwain	2	3/25/81	3363	Oil	T/A	
	Kincaid	1	9/5/67	3545	Oil	D/A	8/5/68
	Seeley	1	10/22/56	3800	Oil	D/A	10/29/5
	Seeley	1-A	4/18/57	3498	Oil	D/A	5/10/57
	Valdois	1	4/30/63	3445	Oil	D/A	5/1/63
2-24S-4W	McElwain	1	8/15/81	3354	Oil		
	McElwain	1-A	5/22/69	3424	Oil	D/A	(?)
	Matlack	1	5/27/81	3320	Oil		
3-24S-4W	J. Myers	1	12/17/35	535	Oil	L.H.	7/21/37
	J. Myers	2	6/11/73	4756	Oil	D/A	6/11/73
							5/20/52
3-24S-4W	J. Myers	3	NO RECORDS				
	J. Myers	4	NO RECORDS				
	J. Myers	5	1/8/36	3354	SWD		12/4/58
	J. Myers	6	NO RECORDS				
	J. Myers	7	6/23/58	3604	Oil	D/A	7/11/58
	J. Myers	8	12/20/65	3398	Oil	D/A	1/8/66
	J. Myers	9	3/12/82	288	Oil	L.H.	3/12/82
	Rimbey	1	4/16/82	3375	Oil	D/A	4/16/82
	M. Collins	0-9	7/16/63	3371	Oil	D/A	8/14/68
	M. Collins	4	5/1/38	3379	Oil	D/A	10/17/4
	M. Collins	5	5/1/38	3379	Oil	D/A	10/9/48
	Grandon	1	3/15/35	3817	Oil	D/A	3/26/44
	Grandon	2	8/15/35	3361	Oil	D/A	4/12/44
	M. Collins	2	7/23/36	3606	Oil	D/A	2/23/61
	Collins	1	12/9/35	3606	Oil	D/A	2/21/61
	M. Collins	3	5/1/38	3360	Oil	D/A	7/7/49
	Baughman "F"	1	3-10-35	3605	Oil	D/A	1/30/50
	Baughman "F"	2	4/11/35	3604	Oil	D/A	11/30/4
	Baughman "F"	3	5/18/35	3365	Oil	D/A	12/15/4
	Baughman "F"	4	7/27/35	3603	Oil	D/A	12/7/49
	Baughman "F"	5	1/16/36	3370	Oil	D/A	7/31/49
	Baughman	6	3/22/36	3361	Oil	D/A	8/16/49
	Baughman "F"	SWD	8/3/49	585	SWD	L.H.	8/4/49
	Symns	1	5/24/65	3315	Oil	D/A	8/24/67
	Symns	1-A	5/28/68	1743	Oil	D/A	5/20/69
	Symns	2	3/22/36	3362	Oil	D/A	8/28/67
	G. Matlack	1	12/5/35	3601	Oil	D/A	10/2/47
	G.T. Matlack	2	NO RECORDS				
	G.T. Matlack	3	6/3/36	3602	Oil	D/A	5/5/44
	G.T. Matlack	4	8/29/36	3361	Oil	D/A	5/15/44
	G.T. Matlack	5	NO RECORDS				
	G.T. Matlack	6	2/15/37	3834	Oil	D/A	7/18/44
	G.T. Matlack	1-SWD	6/23/36	525	SWD	L.H.	8/30/48

TABLE 7 (continued)

KCC OIL AND GAS INVENTORY

Legal Location Sec.Twp.Rge.	Lease Name	Well Number	Date Drilled	Total Depth in Ft.	Type of Well[a]	Status of Well[b]	Date Plugged
3-24S-4W	Matlack	4	5/6/36	3411	Oil		
	G. Matlack	7	5/4/72	3594	Oil		
	M. Collins	W-15	10/22/63	3372	E.R.		8/30/67
	M. Collins	W-16	12/5/63	3374	E.R.		9/1/67
	M. Collins	O-17	4/28/64	3362	Oil	D/A	9/8/67
	M. Collins	W-18	11/29/63	3369	E.R.		9/6/67
	Smith	1	1/4/49	3300	Oil	D/A	5/19/49
	Smith	2	6/19/49	3352	Oil	D/A	7/7/50
	O. Chesshire	1	1/9/36	3370	Oil	D/A	6/21/43
	O. Chesshire	2	11/5/36	3343	Oil	D/A	9/3/42
	O. Chesshire	3	1/3/37	3373	Oil	D/A	6/30/43
	Collins	1	10/19/71	3806	Oil		
10-24S-4W	Baker	1	8/19/55	3388	Oil	D/A	10/22/5
	Brown	1	5/10/50	3428	Oil	D/A	6/2/50
	H. Brown	1	2/17/36	3388	Oil	D/A	12/15/4
	H. Brown	2	11/5/36	3369	Oil	D/A	9/29/44
	E. Mardis	1	6/15/36	3390	Oil	D/A	11/3/48
	E. Mardis	2	5/24/43	3396	Oil	D/A	5/25/43
	VanSickle	W-13	3/15/64	3377	E.R.		7/19/68
	VanSickle	O-4	12/22/62	3410	Oil	D/A	8/5/68
	VanSickle	O-5	4/3/63	3381	Oil	D/A	2/27/75
	VanSickle	W-14	12/19/63	3370	E.R.		7/21/68
	VanSickle	W-20	3/17/64	3375	E.R.		7/15/68
	VanSickle	W-22	12/17/63	3369	E.R.		7/12/68
	State Bank	1	3-20-43	3380	Oil	D/A	3/20/43
	C.L. McElwain	1	2-23-36	3385	Oil	D/A	9/21/38
	Kincaid	1	5/29/79	3365	Oil		
	Johnson	1	9/14/67	3425	Oil		
	Miller	4	7/24/67	3290	Oil		
11-24S-4W	Johnson	1	10/29/68	1975	Oil	D/A	12/15/6
12-24S-4W		NO WELL RECORDS IN THIS SECTION					

Explanation of Table 7:

[a]OIL is oil well; GAS is gas well; O & G is an oil and gas well; SWD is a saltwater disposal well; E.R. is an oil and gas enhanced recovery well.

[b]D/A is a dry and abandoned well; T/A is a temporarily abandoned well; OWWO is an old well work over; SWD is a saltwater disposal well; L.C. means lost circulation; L.H. means lost hole.

CEMENT-LINED SALTWATER PITS

by

Kansas Department of Health and Environment

Several permitted and active cement lined saltwater ponds exist and are actively used in the outlined study area. The oldest of these was permitted in 1961 while the youngest was permitted in 1977. These ponds are permitted to receive from 35 to 6000 barrels brine per day (Table 8).

Field inspections have revealed that the cement liners in ponds on the Goering and Blake leases are deteriorating and the reinforcing bars are visible in places.

All five permitted ponds have observation wells around them to detect leakage. Data obtained from the Wichita-KDHE office are assembled in Table 8. The wells are 40 to 50 feet deep and screened from 10 feet to total depth. High chlorides have been reported for several of the wells, especially those near the Blake and Goering 'A' leases and the S. Burrton SWDS pond in NE 20-24-4W. This is an indication that the ponds may be leaking. The concentrations in some of the wells changed significantly from each sampling time. Precipitation changes may have caused these differences.

The last sampling effort for most of these monitoring wells occurred in June of 1980. The S. Burrton SWDS wells in NE 20-24-4W have not been checked since July 1979.

TABLE 8

Permitted Saltwater Ponds

Company (yr. permitted)	Lease	Description	bbls/day	Cl(ppm)	Liner
Fell & Wolfe Oil Co. (1961)	Mueller 'B'	NW 30-24-4W	35	92,000	Cement
Louis Kahan (1963)	Blake	E/2 SW 23-23-4W	1000	110,850	Cement
Louis Kahan (1963)	Goering 'A'	SW 26-23-4W	1000	111,000	Cement
Excalibur Production Co. Inc. (1975)	S. Burrton SWDS	NW 15-24-4W	6000	110,650	Cement
S. Burrton SWD Assn. (1977)	S. Burrton SWDS	SW NE 20-24-4W	2500	40,100	Cement

Source: Saltwater Pond and Injection Well printout as of January 1, 1983, Kansas Department of Health and Environment.

Data of Observation Wells Around Permitted Saltwater Ponds

Pond Location and Lease	Date Sampled	Well Location	Chlorides	Remarks
SW 23-23-4W	11/77	West side	100	Well depth = 50';
Blake lease	11/77	East side	1200	Screened from 10'-50';
	7/79	West side	4500	2 wells to monitor
	7/79	East side	875	ponds.
	6/80	West side	180	
	6/80	East side	1160	
SW 26-23-4W	11/77	West side	150	Well depth 50';
Goering 'A'	11/77	East side	150	screened 10'-50';
	7/79	West side	6000	2 wells.
	7/79	East Side	3000	
	6/80	West side	1720	
	6/80	East side	460	
NW 15-24-4W	6/78	NW side	250	2 wells, depth 40';
S. Burrton SWDS	6/78	SE side	660	screened 10'-40'.
	7/79	NW side	200	
	7/79	SE side	375	
	6/80	NW side	340	
	6/80	SE side	360	
NE 20-24-4W	11/77	West side	600	2 wells, depth 50';
S. Burrton SWDS	11/77	East side	1125	screened 10'-50'.
	7/79	West side	375	
	7/79	East side	700	
NW 30-24-4W	10/78	NE side	300	1 well, depth 40';
Mueller 'B'	7/79	NE side	650	screened 10'-40'.
	6/80	NE side	440	

DISCUSSION OF SOURCES OF CHLORIDE CONTAMINATION

by

Kansas Geological Survey

Introduction

The two major sources of salt water which could have produced the saline groundwaters in the Burrton area are oil-field brine and solutions of halite (rock salt) in Permian formations. Weight ratios of sodium/chloride have been used in the past to identify saltwater sources, based on the values for oil-field brines in Kansas versus those for solutions of halite. While this ratio is often useful for differentiating these sources in surface waters, ion exchange reactions can lower the value when salt waters flow into aquifers containing fresh or appreciably less saline water. In many cases the ratio sulfate/chloride may be better for differentiating between oil-field-brine and evaporite-solution sources of salt water.

The best method for distinguishing saltwater sources in Kansas is based on plots of the ratio bromide/chloride versus chloride concentration (Whittemore, et al., 1981; Whittemore, 1983). Graphs of iodide/chloride versus chloride concentration also provide useful information concerning salinity sources. The origin of high chloride concentrations in Burrton area groundwaters was identified based on these methods in an initial report for the Equus Beds Groundwater Management District (Whittemore and Basel, 1982).

Additional well-water samples collected by the Groundwater Management District, the Department of Health and Environment, and the U.S. Geological Survey were analyzed for dissolved bromide and chloride contents to further delineate the salinity sources in the Burrton area. This subsection presents the results and interpretation of these analyses integrated with those from the initial report.

Procedures

Water samples from the Equus Beds monitoring well network were obtained from the Equus Beds GMD during 1979, 1980, and 1982. Samples from several U.S. Geological

Survey test wells in the Equus Beds and the alluvium of the Arkansas River valley were provided by J.B. Gillespie and Michael Haley. Groundwaters sampled by the Kansas Department of Health and Environment in 1982 from both water-supply and observation wells were also provided. Major dissolved constituents were determined at the Kansas Geological Survey, Department of Health and Environment, and the district office of the U.S. Geological Survey (chloride only). Kansas Geological Survey determinations involved inductively coupled plasma spectrophotometry for cations (by Truman Waugh), automated methods on a Technicon AutoAnalyzer for chloride and sulfate (by Karmie Galle and David Leavitt), and argentometric titration for chloride in selected samples (by Donald Whittemore). Bromide concentrations were measured by an automated phenol red method on the AutoAnalyzer (Basel, et al., 1982). This method gives results which agree excellently with bromide determinations made using x-ray fluorescence spectrophotometry (by Gerald James, Kansas Geological Survey), and ion-chromatography (by Kirk Nordstrom, U.S. Geological Survey, Menlo Park, California). Iodide was determined by an automated colorimetric method in which iodide catalyzes the reduction of ceric ions by arsenious acid. Donald Whittemore and Chris Basel conducted the bromide and iodide determinations.

Results and Discussion

Concentrations of dissolved constituents are listed in Table 3 with selected weight ratios for well waters collected during 1982 and early 1983 in townships T.23S., R.3W. and R.4W., and T.24S., R.3W. and R.4W. Chloride concentrations ranged from 2 to 2450 mg/l with the highest values within a 3 mile radius from the southwest corner of the town of Burrton.

Weight ratios of sodium/chloride ranged from 0.13 to 0.62 for samples with chloride contents exceeding 250 mg/l in the Burrton area. The sodium/chloride ratio expected for halite-solution brine is 0.65. The ratios observed for brines (> 19,000 mg/l chloride) naturally occurring within the Wellington saltwater aquifer in Kansas and mineralized waters (> 5,000 mg/l chloride) deriving their salinity from these brines average 0.65 and range from 0.63 to 0.68 (Whittemore, et al., 1981). Oil-field brines in Kansas generally have sodium/chloride ratios of 0.5 ± 0.1 (Whittemore and Pollock, 1979; Whittemore, et al., 1981; Leonard, 1964). The ratios for 11 oil brines from the Burrton Field for which both sodium and chloride concentrations had been determined (listed in the Kansas Geological Survey computer printout for Kansas brines) ranged from 0.50 to 0.53 and averaged 0.51. Thus, the observed ratios suggest that the main source of salt water in the Burrton area was oil-field brine pollution. It is noted, however, that exchange of sodium for calcium and magnesium ions on clays in sediments can lower the sodium/chloride ratio of groundwater containing a high sodium concentration that moves into an aquifer with fresh or less saline water. This explains the low sodium/chloride values (less than in oil-field brine) occurring in some of the groundwaters. Saline water with a ratio near 0.65 would indicate that halite-solution brine had been the salinity source for many years in order for the ion exchange in the sediments to come into equilibrium with the water composition; influx of halite solutions over a shorter period related to anthropogenic activities could result in sodium/chloride less than 0.63. Thus, additional, more conclusive identification of the saltwater source(s) was needed.

Plots of the ratio bromide/chloride versus chloride concentration have been found to best distinguish between oil-field and halite-solution brines and waters contaminated with these brines. Such a plot for the groundwaters of the Burrton area (the entire area of Figure 22) is shown in Figure 23 along with curves that are the boundaries of mixing zones of freshwaters with oil-field brines and halite solutions (Permian brines). Several values for water samples collected from observation wells in 1980 are included along with those for the 1982 samples. Point A on Figure 23 is for a 1980 sample from a U.S. Geological Survey observation well drilled to a depth of 160 feet about 6 miles west of Hutchinson (SWSWSW Section 2, T.32S., R.7W.). The chemistry of groundwater at this site is affected by salt water from Lower Permian strata above the Wellington Formation. The saline groundwater, which is in alluvium of the Arkansas River valley, could be a source of saline water farther downgradient in the alluvial valley to the southwest of Burrton. The other points falling in the freshwater and halite-solution-brine mixing zone are for groundwaters occurring to the west and south of Burrton (Figure 22). Sodium/chloride ratios for waters in this zone with chloride concentrations greater than 250 mg/l ranged from 0.51 to 0.60.

Nearly all of the groundwaters plotting within the freshwater and oil-field-brine mixing zone on Figure 23 are located within a few miles of Burrton. Sodium/chloride ratios for samples in this group ranged from 0.13 to 0.62. Two waters

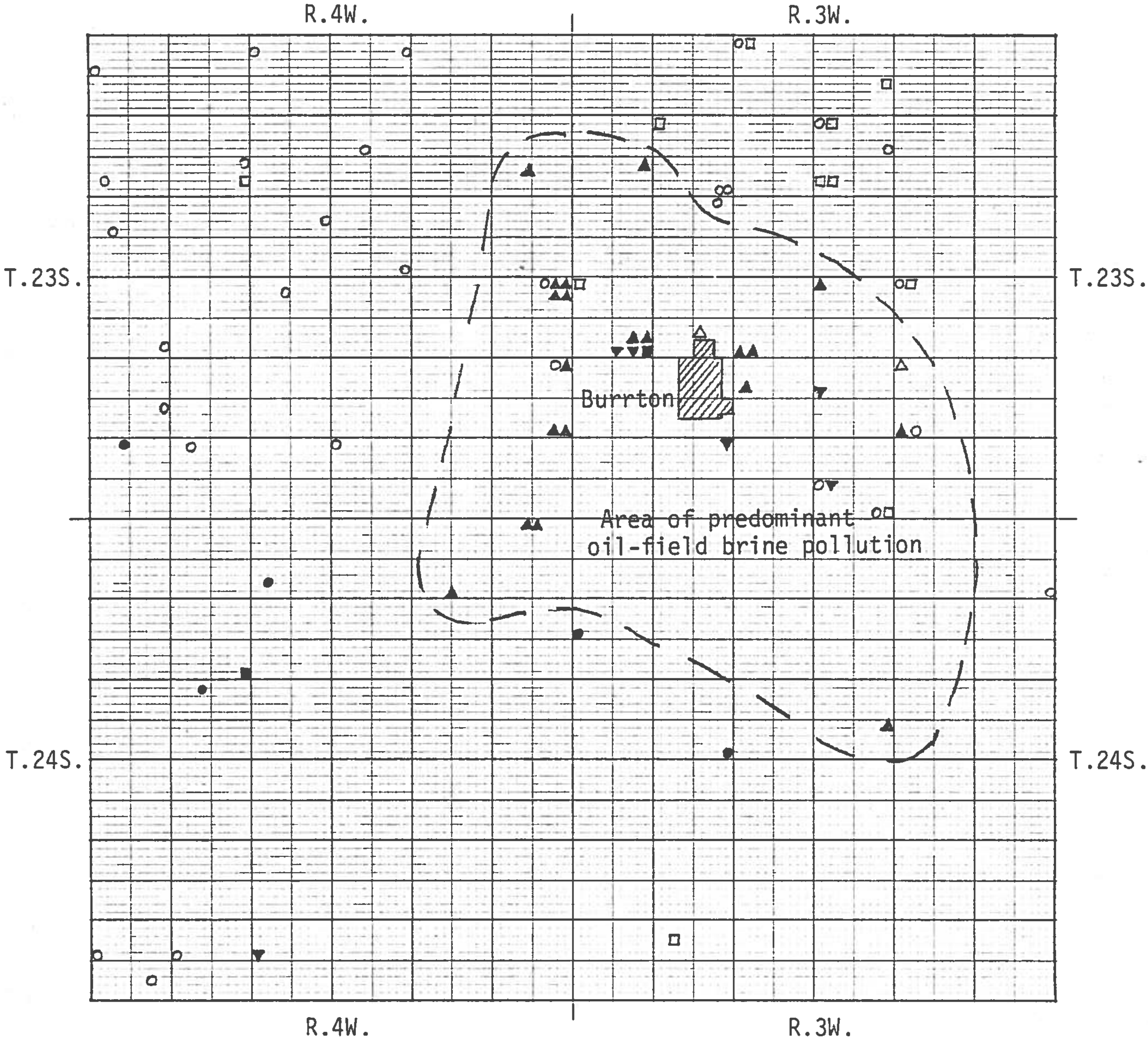


Figure 22. Source of Chloride in Groundwater in the Burrton Area. Only wells for which a bromide/chloride ratio was determined (which was used in identifying the major chloride source based on Figure 23) or which had a chloride concentration <50 mg/L (which was assumed to be primarily derived from other sources than oil-field brine) are shown. Symbols: △▲▽▼ predominant source of chloride is oil-field brine; ○●□■ predominant source of chloride is halite-solution brine (and/or sources other than oil-field brine for waters with chloride contents <50 mg/L); △▲○● well depths <100 feet; ▽▼□■ well depths ≥100 feet; △▽○□ chloride concentrations <150 mg/L; ▲▼●■ chloride concentrations ≥150 mg/L.

VARIATION IN THE WEIGHT RATIO BROMIDE/CHLORIDE WITH CHLORIDE CONCENTRATION IN THE BURRTON AREA

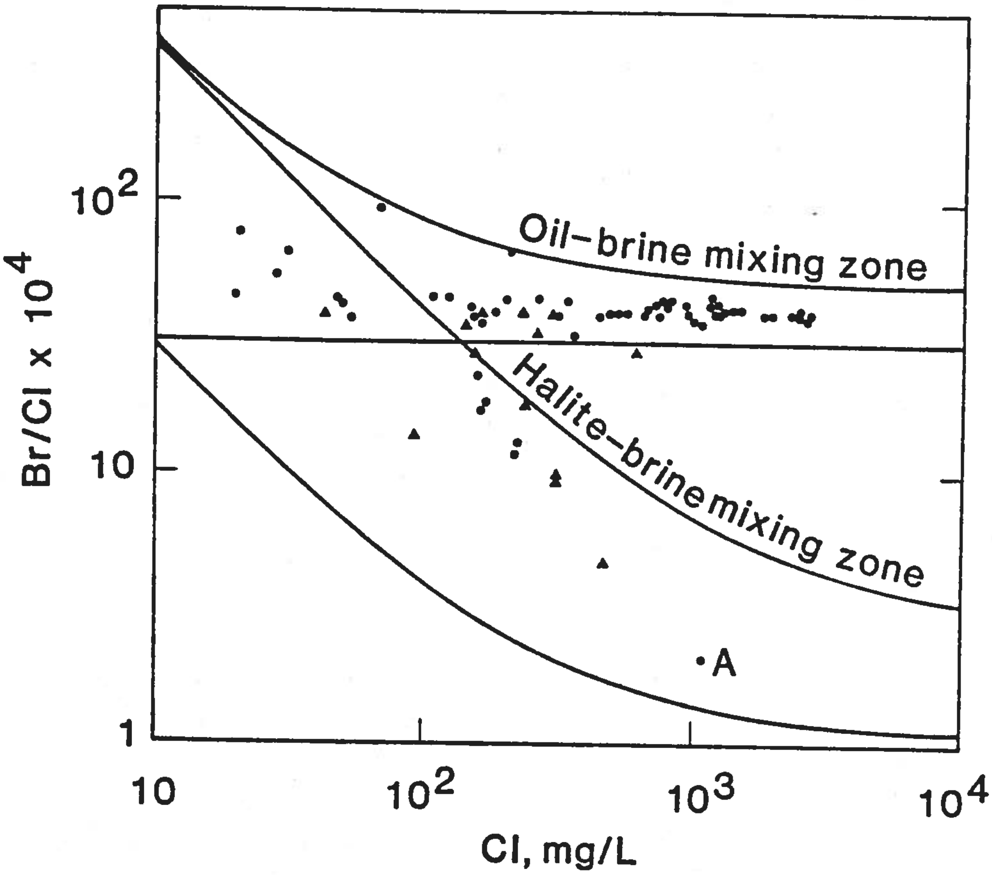


Figure 23. Variation in the Weight Ratio Bromide/Chloride with Chloride Concentration in the Burrton Area. Symbols: ▲ irrigation or water supply well, ● observation well.

could have derived their chloride from mixtures of varying proportions of freshwater, oil-field brine, and halite solution. A well to the northwest of Burrton (SENESW Section 12, T.23S., R.4W.) yielded water with 617 mg/l chloride mainly derived from oil-field brine, but possibly partially from halite solution. Both types of salinity sources could have also contributed to the dissolved chloride (158 mg/l) in the well just east of Burrton (CSWNW Section 28, T.23S., R.3W.) although oil-field brine is probably the main source. Samples collected in 1982 from monitoring wells EB5A and EB5B (NENENE Section 24, T.23S., R.4W.) at shallow and moderate depths, respectively, plotted within the oil-field-brine mixing zone. However, samples obtained from the same wells in 1980 (not plotted on Figure 23) fell approximately midway between the oil-brine and halite-solution mixing zones. At that time a mixture of the two saltwater sources was indicated. A disposal line break occurred in early 1982 probably causing the rises in chloride concentrations at these wells (from 950 and 960 mg/l in the fall of 1980 to 966 and 1010 mg/l in the fall of 1982 for EB5A and EB5B, respectively) as well as increased bromide/chloride ratios.

Sulfate/chloride ratios can often be useful as supporting data for distinguishing oil brine from Permian saltwater sources. Values of sulfate/chloride are generally low (<0.1) for brines associated with oil in Kansas; the average value for 39 saltwater analyses from the Burrton Field (data from Kansas Geological Survey brine printout) is 0.0045. The mean chloride concentration for these same brines is 95,800 mg/l. Gypsum and anhydrite are commonly associated with halite in Permian formations in Kansas, thus sulfate/chloride ratios for solutions of these evaporites are usually above 0.07 for dissolved chloride of less than 80,000 mg/l. The solubility of gypsum decreases with increasing chloride concentration greater than 80,000 mg/l, causing the sulfate/chloride ratios in Wellington aquifer brines to drop to 0.01 to 0.05 in solutions near saturation with respect to halite (based on data in Whittemore, et al., 1981; Gogel, 1981; Leonard and Kleinschmidt, 1976). In the Burrton area all groundwaters for which the bromide/chloride data indicated an oil-brine source had sulfate/chloride ratios of less than 0.2 if the chloride content exceeded 200 mg/l, and less than 0.05 if the chloride was greater than 1,000 mg/l. Sulfate/chloride ratios ranged from 0.22 to 0.94 for the groundwaters (with >200 mg/l chloride) identified to have a halite-solution source.

Graphs of iodide/chloride versus chloride concentration similar to that in Figure 23 have been used successfully to differentiate between oil-field and halite-solution brines (Whittemore, et al., 1981). However, unlike bromide, some iodide in saline waters can be adsorbed in clays and iron oxyhydroxides in sediments. Therefore, as a brine is dispersed through a freshwater aquifer, ratios of iodide/chloride may decrease relative to those of bromide/chloride. Values of iodide/chloride for waters containing chloride concentrations exceeding 250 mg/l in shallow monitoring well in the Burrton area sampled in 1979 and 1980 generally plotted within a freshwater and oil-field-brine mixing zone. Deep well waters gave lower iodide/chloride ratios falling below the mixing zone. This suggests that oil-brine pollution originated primarily at shallow depths in the aquifer and moved downwards with time. Such evidence supports past leakage from surface disposal ponds and near surface pipes carrying oil brine as the major saltwater source. Samples collected in 1980 from wells EB5A and EB5B in the northwestern part of the proposed control area had even lower iodide/chloride ratios at similar chloride concentrations than the deeper group of other wells. Again, this suggested that halite-solution brine had contributed to the dissolved solids of groundwaters at this location.

Conclusions

Geochemical evidence based primarily on bromide/chloride ratios and supported by sodium/chloride, sulfate/chloride, and iodide/chloride ratios indicates that the main source of salinity in Equus Beds groundwaters near Burrton is oil-field brine. Iodide/chloride ratios suggest that the saltwater originated at or near the surface and flowed downwards through the freshwater aquifer. This supports the belief that old surface disposal ponds were the primary source of pollution. A mixture of oil brine and halite-solution brine appears to have been the origin of saline water from Equus Beds monitoring wells EB5A and EB5B in the northwestern part of the Burrton area in 1980. The mixture could have been derived from saltwater in the "lost circulation zone" of the Wellington Formation. During the 1930's, pressure injection of oil brine into disposal wells in this formation forced salt water up nearby boreholes to the surface. The water collected from wells EB5A and EB5B in 1982 was identified as predominantly oil-field brine, suggesting that a nearby disposal line break appreciably affected the groundwater.

Saline waters to the west and south of the Burrton area and near or in the Arkansas River valley derive most of their salinity from salt water with geochemical characteristics of halite solution. The source of this salt water is probably in Permian strata above the Wellington Formation to the west of the Burrton area.

GROUNDWATER QUALITY MODELING OF THE EQUUS BEDS AQUIFER IN THE BURRTON AREA

by

Kansas Geological Survey

Modeling Approach

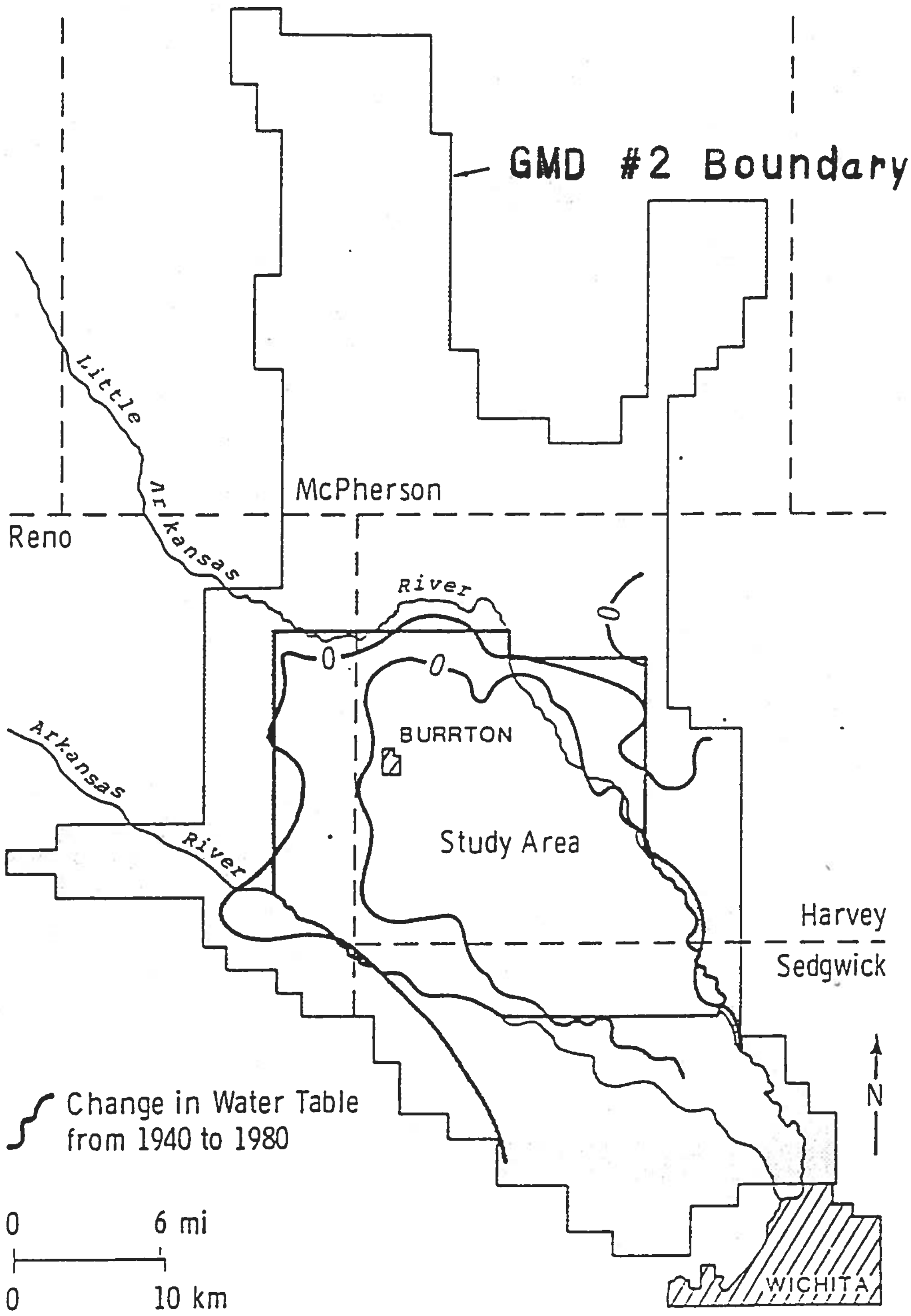
An area of the Equus Beds aquifer encompassing the 36 mi^2 proposed intensive groundwater use control area (IGUCA) was selected for the purpose of modeling groundwater flow and brine plume movement. Because the selected model area does not encompass the entire Equus Beds aquifer and its natural boundaries, it is important in such studies that meaningful boundary conditions be applied to the selected area. A hydrogeologic study of the region indicated that a 240 mi^2 area in the vicinity of Burrton has been enclosed by a zero water-level decline since 1940 and is surrounded by the two major streams in the area (Fig. 24). Thus, constant head boundary conditions could be safely applied for the boundaries of the selected model area.

Because the model area, and especially the proposed IGUCA, have not yet experienced any serious water-level decline problems since the 1940s, it was decided that the area's steady-state groundwater velocity field which existed since the 1940s would still be a satisfactory approximate flow distribution. Thus, in a transient brine plume transport simulation we can examine how the brine is spreading in space and time given that average groundwater velocity field.

It is important to realize that the direction and velocity of pollutant transport generally is assumed to be identical to that of groundwater. Therefore, a thorough understanding of the hydrogeological setting and the groundwater velocity field is essential, because an accurate prediction of solute transport cannot be made without first fully understanding the fluid flow system. Therefore, special emphasis is given to obtaining a calibrated model of the groundwater flow field.

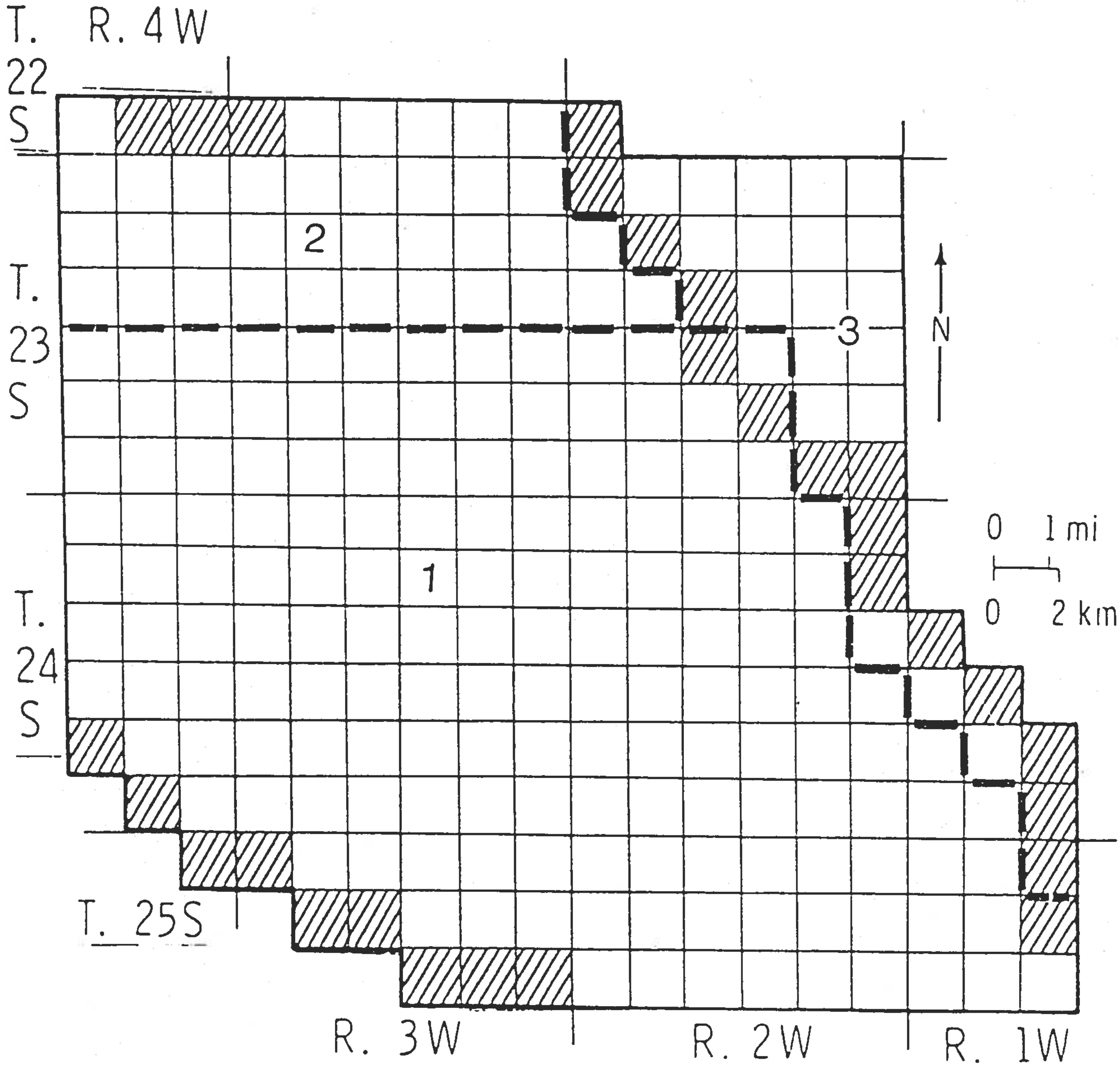
The multiple regression procedure used in calibrating the groundwater flow model is described in Sophocleous (1983, 1984). In the course of this calibration, the model area is divided into three subareas of uniform hydrogeologic parameters based on the hydrogeology of the area (Fig. 25). Thus, zone 1 which encompasses

Figure 24



1940-1980 ZERO WATER-LEVEL DECLINE CONTOURS FOR THE STUDY AREA.

HYDROGEOLOGIC ZONATION OF THE STUDY AREA.



Hydrogeologic zonation of the study area.

the most productive part of the Equus Beds aquifer is characterized by high values of transmissivity compared to the other zones; zone 2, which coincides with the sand dune area, is characterized by much higher recharge than in the other zones; and zone 3 which is outside the proposed IGUCA is characterized by low values at both recharge and transmissivity.

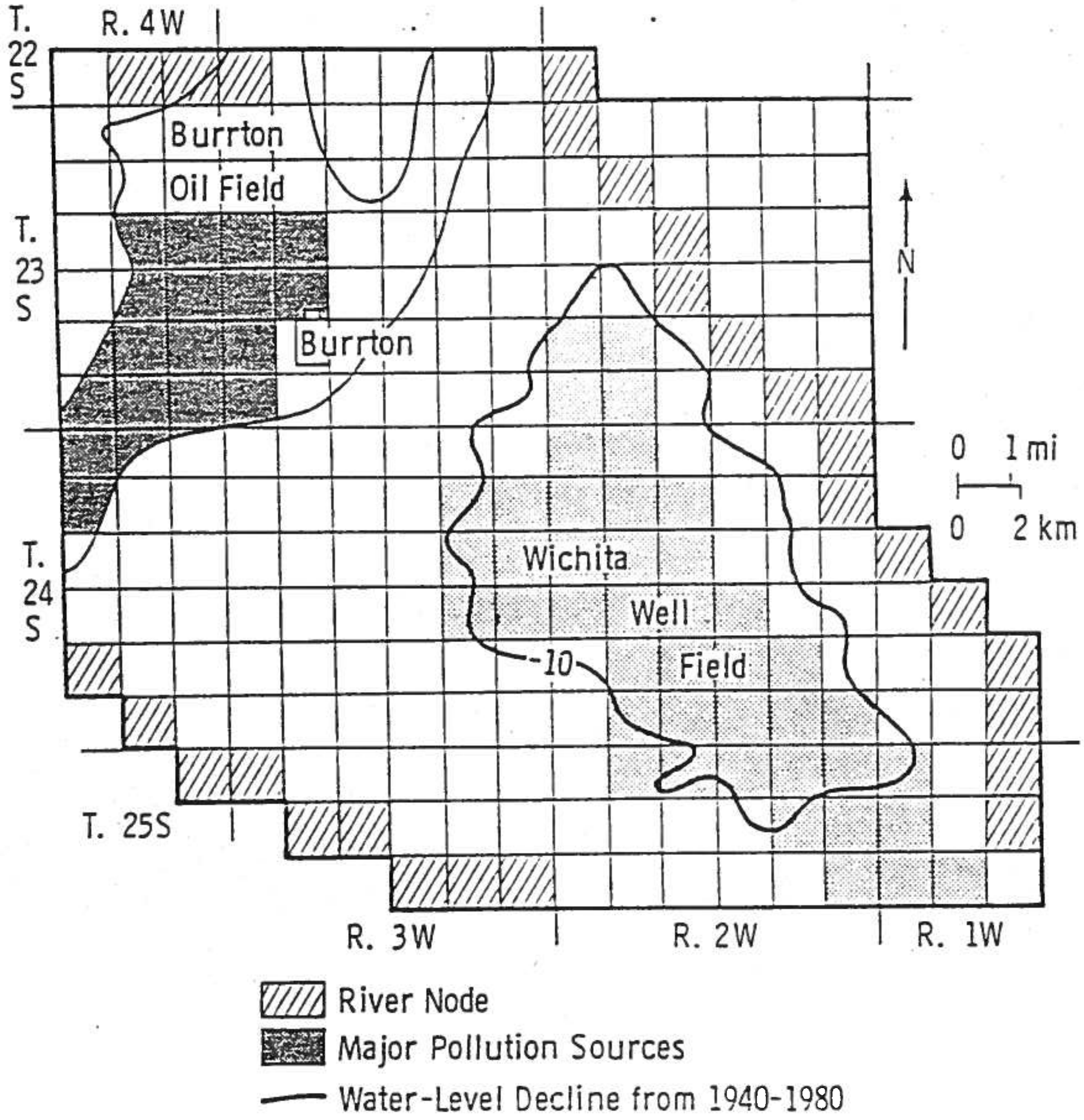
Results of this calibration effort showed that the fit of the model-calculated and observed (measured) values of water levels is very good, as indicated by the high value of the correlation coefficient of approximately 99 percent. Analysis of the residuals (the differences between the calculated and observed values of water levels) indicated that the model used is appropriate for the available data. Specific details are reported in Sophocleous (1983).

Once the groundwater flow model was successfully calibrated, the next step was the formulation of a brine transport model. It should be mentioned that serious data deficiencies were experienced during this phase of the study. An evaluation of the historical water quality data revealed a comprehensive description of water quality in the aquifer would be very difficult because of methods used to collect and analyse water samples, according to Leonard and Kleinschmidt (1976) and Larry Hathaway (1981, oral communication). For example, analyses were erratically distributed in time and space; methods of collection and analysis of the samples varied widely; many sampling locations were poorly or inaccurately recorded; and the depth of the zones sampled were poorly defined. Not until the recent establishment of the saltwater-monitoring well network by the Equus Beds Groundwater Management District could definite chloride patterns be easily recognized in the area.

The sources and rates of brine entry into the groundwater flow system are not well understood. However, an unpublished map of old surface disposal ponds with an approximate average rate of brine disposal was obtained from the Kansas Department of Health and Environment (R. O'Connor, 1982, personal communication). This map was verified and supplemented by studying old aerial photos of the area and identifying the disposal ponds (J.P. Gillespie, 1982, personal communication). Figure 26 shows the general area of major concentration of disposal ponds, although such ponds also existed to the north of the indicated area. The life of operation of each of those ponds is practically unknown, although a figure of approximately 10

Figure 26

LOCATION OF MAJOR POLLUTION SOURCES AND EXTENT OF THE 1940-80 THREE-METER WATER LEVEL AREAL DECLINE



Location of major pollution sources and extent of the 1940-80 three-meter water level areal decline.

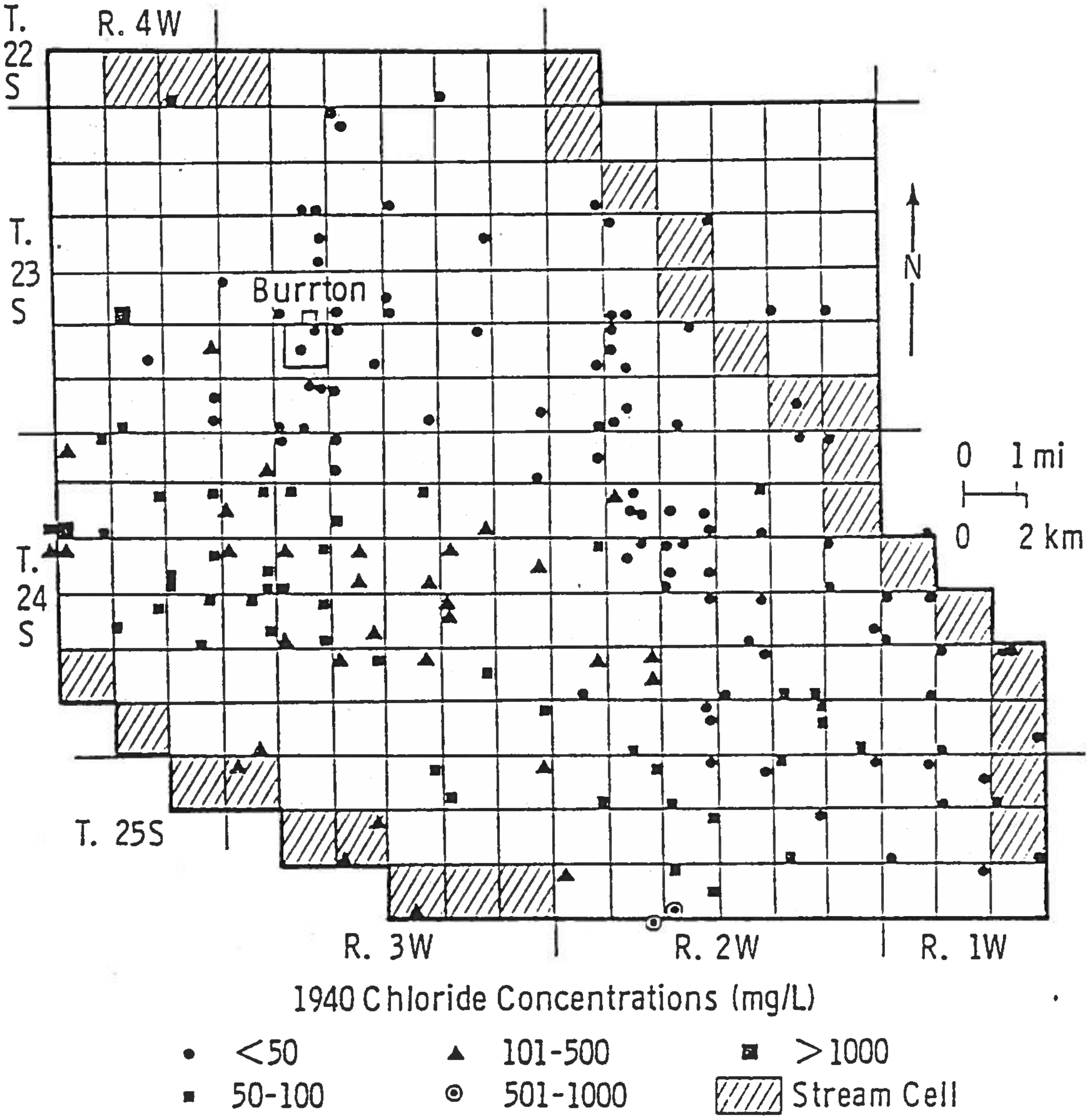
years seems to be the right order of magnitude (R. O'Connor, 1982, personal communication). Brine pollution from other sources such as improperly plugged old holes, natural salt dissolution and other sources constitutes a complex problem. In this study we assume that all brine pollution is lumped into the disposal ponds. The chloride concentration of brines produced from the Burrton Oil Field (Schoewe, 1943; Rall and Wright, 1953) averages approximately 96,000 mg/l. Given the sandy nature of the surface deposits in the Burrton area and the very shallow water-level depths in the area, we believe that this chloride concentration entered the groundwater system very quickly and was not greatly diluted.

Despite the previously mentioned data deficiencies, we proceeded with a preliminary chloride transport modeling effort believing that if we could reproduce the presently observed pattern of chloride concentration, we could have a fairly satisfactory tool for predicting the spatial and temporal chloride patterns, as well as average concentrations in different areas of the aquifer; and that through sensitivity analysis we would be able to evaluate the effect of the various unknown parameters. Although the results of the groundwater flow model may have been adequate as a first-hand approximation for the general direction and travel time of the chloride solutes, the disposal-pond seepage of varied intensity and lifetime, significantly complicates mass transport predictions. This fact necessitated the mass transport modeling approach.

Therefore, using the calibrated steady state flow model parameters mentioned previously, the detailed 1940 chloride distribution map of the Equus Beds aquifer by Williams and Lohman (1949) as the initial condition (Fig. 27), and the locations of surface disposal ponds (Fig. 26) as the sources of contamination, we used a well known solute transport model (Konikow and Bredehoeft, 1978), suitably modified, in our attempts to simulate the water quality degradation problems of the area. Various water quality data were collected over the years, but because of the problems mentioned previously with regard to the quality of these records, we used only recent (1980) water quality data as benchmark data for comparing observed and simulated chloride distributions. Sensitivity analysis, the results of which will be presented next, proved to be instructive in selecting mass transport parameters.

Figure 27

1940 CHLORIDE CONCENTRATION OF GROUNDWATER IN THE STUDY AREA



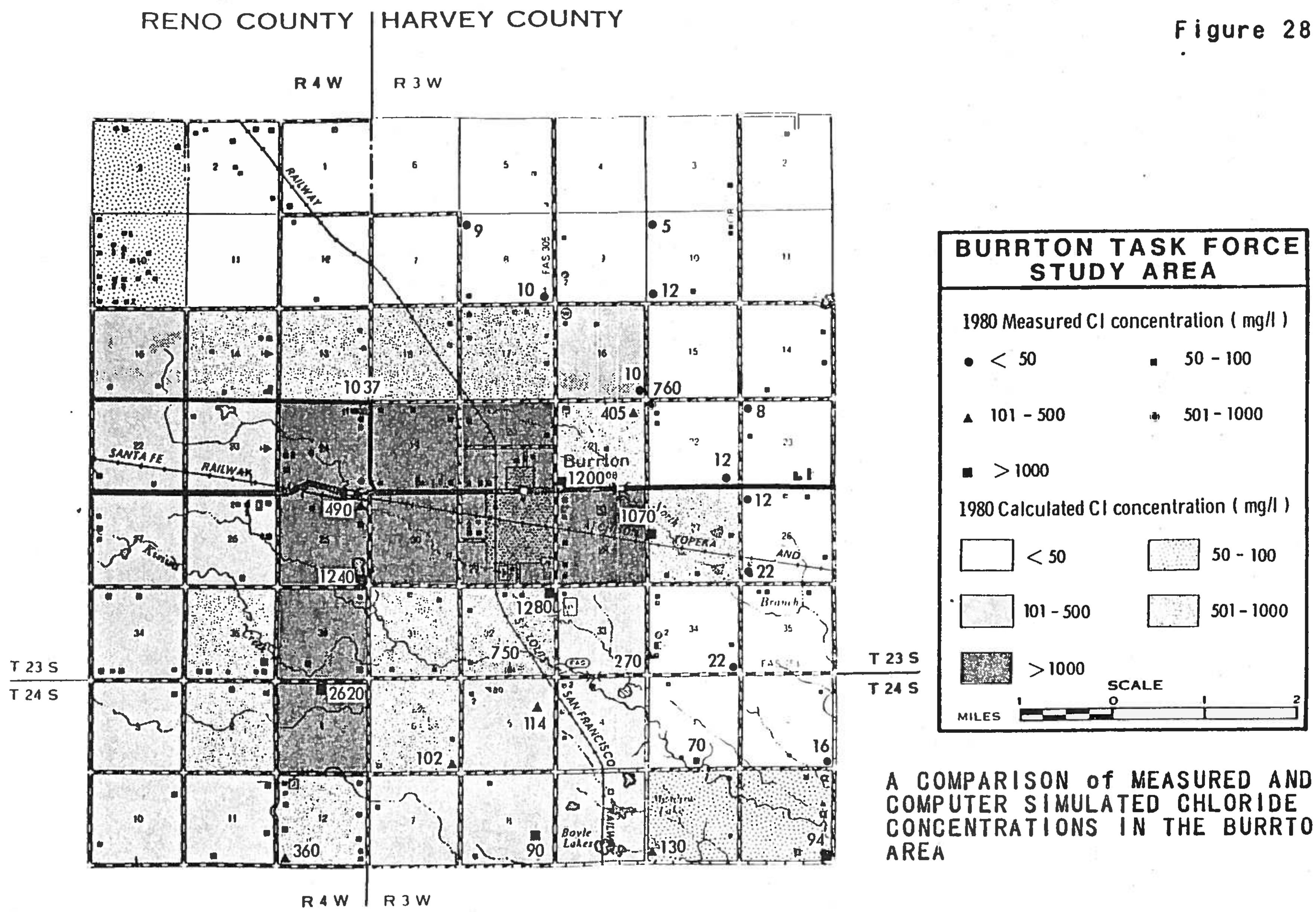
1940 chloride concentration of groundwater in the study area.

Several computer runs were executed to check the sensitivity of the adopted model to various solute transport parameters and pollutant sources. The model is shown to be very sensitive to the effective porosity value used, relatively sensitive to the longitudinal dispersivity value, but not very sensitive to the ratio of transverse to longitudinal dispersivity. As the value of dispersivity and porosity increased, the chloride solute moved farther through the flow system and the concentration gradient decreased. Several values of porosity, longitudinal dispersivity, and ratio of transverse to longitudinal dispersivity were employed and the chloride distribution was computed after 40 years of simulation. More than 45 laboratory porosity determinations from several areas of the Equus Beds aquifer (Williams and Lohman, 1949) indicated that the average value of effective porosity of 0.30 employed in this model is of approximately the right value. A study of the chloride distribution, both during the present and during the early 1940s, shows high chloride concentration contrasts in nearby locations, indicating relatively low dispersivity values. The value of 100 ft for the longitudinal dispersivity produced a satisfactory match between observed and calculated chloride distributions.

It was also found that the simulated chloride distribution was very sensitive to the brine concentration entering the groundwater system as well as to the rate of disposal-pond seepage. Of course the initial concentration distribution, as well as the location of disposal ponds, is very important. For further details, the reader is referred to Sophocleous (1983, 1984).

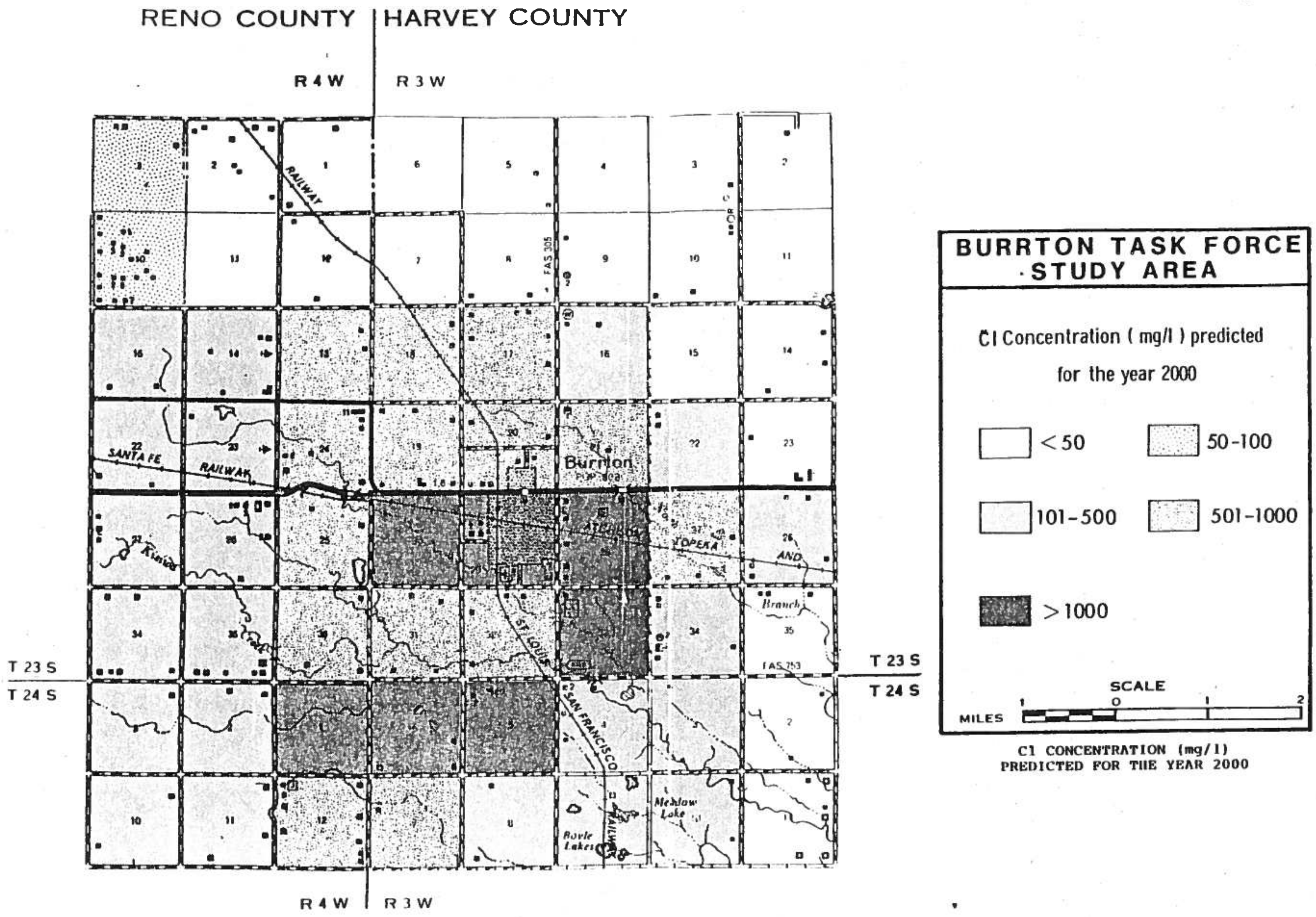
Given the above results, and having obtained a calibrated groundwater flow model, an effective way to reproduce the present chloride concentration is to manipulate the sources of pollution by adjusting, within limits, both the concentration of the brine entering the aquifer and the rate of brine percolation. A comparison of measured and simulated results is shown in Figure 28. The match between observed and calculated results seems to be satisfactory, given that the model predicts average concentrations over a square-mile area. Once a match to the historical data was obtained, chloride concentration projections for the year 2000 were made (Fig. 29). A detailed prediction of the chloride concentration distribution for the year 2000, together with the initial and present chloride distributions, are shown in Appendix A. This projection shows that the brine plume, in a relatively diluted form, would barely reach to within a mile of the westernmost edge of the Wichita well field by the year 2000.

Figure 28



A COMPARISON of MEASURED AND COMPUTER SIMULATED CHLORIDE CONCENTRATIONS IN THE BURRTON AREA

Figure 29



Cl CONCENTRATION (mg/l)
PREDICTED FOR THE YEAR 2000

Conclusions From the Modeling Study

1) Many input data are required for the groundwater flow and mass transport models and the reliability of the modeling results is affected by the accuracy of these data. A sensitivity analysis helps in the definition of accuracy requirements for each of the input parameters.

2) The models employed in this study performed satisfactorily despite data deficiencies and modeling errors. Although the present solute transport model should be regarded only as an approximation of reality, the overall water-quality patterns of the observed and calculated data are in fairly good agreement. Changes in the chloride concentration of the groundwater were predominantly controlled by past oil-field-brine disposal practices, convective transport, and mixing and dilution with recharge water of low chloride concentration.

3) The water-quality modeling results indicate that the chloride concentration of the Wichita well field waters will not have deteriorated from their present condition by the year 2000. However, the brine plume is shown to be moving southeastward in a relatively diluted form (Fig. 29 and Appendix A), but still rendering the chloride concentration of groundwaters in that general direction above the recommended drinking limits. Therefore, it would be prudent to continue saltwater monitoring efforts.

4) The predictive capability of the model can be helpful in future expansion of the present saltwater monitoring network. By indicating the most probable and least probable areas of future contamination and the rate of spreading, optimal locations and sampling frequencies of observation wells can be determined. It may also be both physically and economically feasible to institute a reclamation program to improve or control the quality of groundwater. An accurate model of flow and solute transport in the aquifer could be an invaluable tool for planning an efficient and effective water-management plan.

REFERENCES

Basel, C.L., Defreese, J.D., and Whittemore, D.O., 1982, Interferences in automated phenol red method for determination of bromide in water: Analytical Chemistry 54, 2090-2094.

Gogel, T., 1981. Discharge of salt water from Permian rocks to major stream-aquifer systems in central Kansas. Kansas Geological Survey Chemical Quality Series 9, Lawrence, Kansas, 60 p.

Jacobs, H.S., and Whitney, D.A., 1975, Determining water quality for irrigation: Report C-396, Cooperative Extension Service, Kansas State University, Manhattan, Kansas, 8 p.

Konikow, L.F. and Bredehoeft, J.D., 1978. Computer model of two-dimensional solute transport and dispersion in groundwaters. Techniques of Water Resources Investigations, U.S. Geological Survey, Book 7, Chapter 22, 40 p.

Leonard, R.B., 1964, A method for evaluating oil-field-brine pollution of the Walnut River in Kansas: U.S. Geol. Survey Prof. Paper 501-B, B173-B176.

Leonard, R.B. and Kleinschmidt, M.K., 1976. Saline water in the Little Arkansas River Basin area, south-central Kansas. Kansas Geological Survey Chemical Quality Series 3, Lawrence, Kansas, 24 p.

Rall, C.G. and Wright, T., 1953. Analyses of formation brines in Kansas: U.S. Bureau of Mines, Report of Investigations 4974, 40 p.

Schoewe, W.H., 1943. Kansas oil field brines and their magnesium content: Kansas Geological Survey Bulletin 47(2):37-76.

Sophocleous, M.A., 1983. Water quality modeling of the Equus Beds aquifer in south-central Kansas. Kansas Geological Survey Open-File Report 83-1, 68 p.

Sophocleous, M.A., 1984. Groundwater flow parameter estimation and water quality modeling of the Equus Beds aquifer in Kansas. Journ. of Hydrology 69 (1/4):197-222.

Whittemore, D.O., and Pollock, L.M., 1979, Salinity sources in water resources of Kansas by minor alkali metal and halide chemistry: Kansas Water Resources Research Institute Contribution No. 208, Manhattan, Kansas, 28 p.

Whittemore, D.O., Basel, C.L., Galle, O.K., and Waugh, T.C., 1981, Geochemical identification of saltwater sources in the Smoky Hill River valley, McPherson, Saline, and Dickinson counties, Kansas: Kansas Geological Survey Open-File Rep 81-6, 78 p.

Whittemore, D.O. and Basel, C.L., 1982. Identification of saltwater sources affecting groundwater in the Burrton area, Harvey County, Kansas. Kansas Geological Survey Open-File Report 82-5, 11 p.

Whittemore, D.O., 1983, Geochemical identification of salinity sources: International Symposium on State-of-the-Art Control of Salinity, Salt Lake City (in preparation).

Williams, C.C. and Lohman, S.W., 1949. Geology and groundwater resources of a part of south-central Kansas with special reference to the Wichita municipal water supply. Kansas Geological Survey Bulletin 79, Lawrence, Kansas, 455 p.

APPENDIX A

APPENDIX A: MODEL OUTPUTS FOR INITIAL (1940), PRESENT (1980), AND FUTURE (YEAR 2000) CHLORIDE CONCENTRATIONS

Note: In all chloride concentration outputs that follow, the value characterizing the section where the town of Burrton is located is outlined by a rectangle. Each indicated value represents the chloride concentration at the center of a section (1 mi^2).

65	65	65	65	20	20	20	20	20	20	0	0	0	0	0	0	0	0
65	65	65	65	65	66	20	20	20	20	20	20	20	20	20	0	0	0
65	20	20	20	20	20	43	20	20	6	20	20	20	20	20	0	0	0
365	75	70	20	20	22	20	20	29	20	20	11	20	20	20	0	0	0
365	1825	20	7	20	13	6	20	20	20	13	20	20	11	13	0	0	0
365	18	218	20	20	44	44	11	20	33	8	9	20	20	20	0	0	0
478	58	26	20	19	27	26	20	40	16	15	7	20	20	20	0	0	0
478	140	200	138	19	49	26	20	14	10	48	20	20	20	11	0	0	0
200	87	90	136	100	92	73	94	20	20	111	14	99	20	20	0	0	0
200	180	135	183	139	128	100	163	128	61	37	44	20	20	10	20	0	0
200	68	95	97	160	124	110	110	77	41	20	38	44	20	39	27	20	0
200	200	140	140	140	86	107	79	75	145	118	20	42	69	20	32	33	20
0	200	200	308	150	100	75	75	85	75	92	28	20	121	78	20	34	20
0	0	200	200	140	200	76	66	123	78	52	73	10	100	28	41	5	20
0	0	0	0	365	365	200	140	140	75	75	84	75	58	40	33	20	20
0	0	0	0	0	0	500	365	365	365	365	240	40	40	40	20	30	20

Initial (1940) chloride concentrations (mg/l)

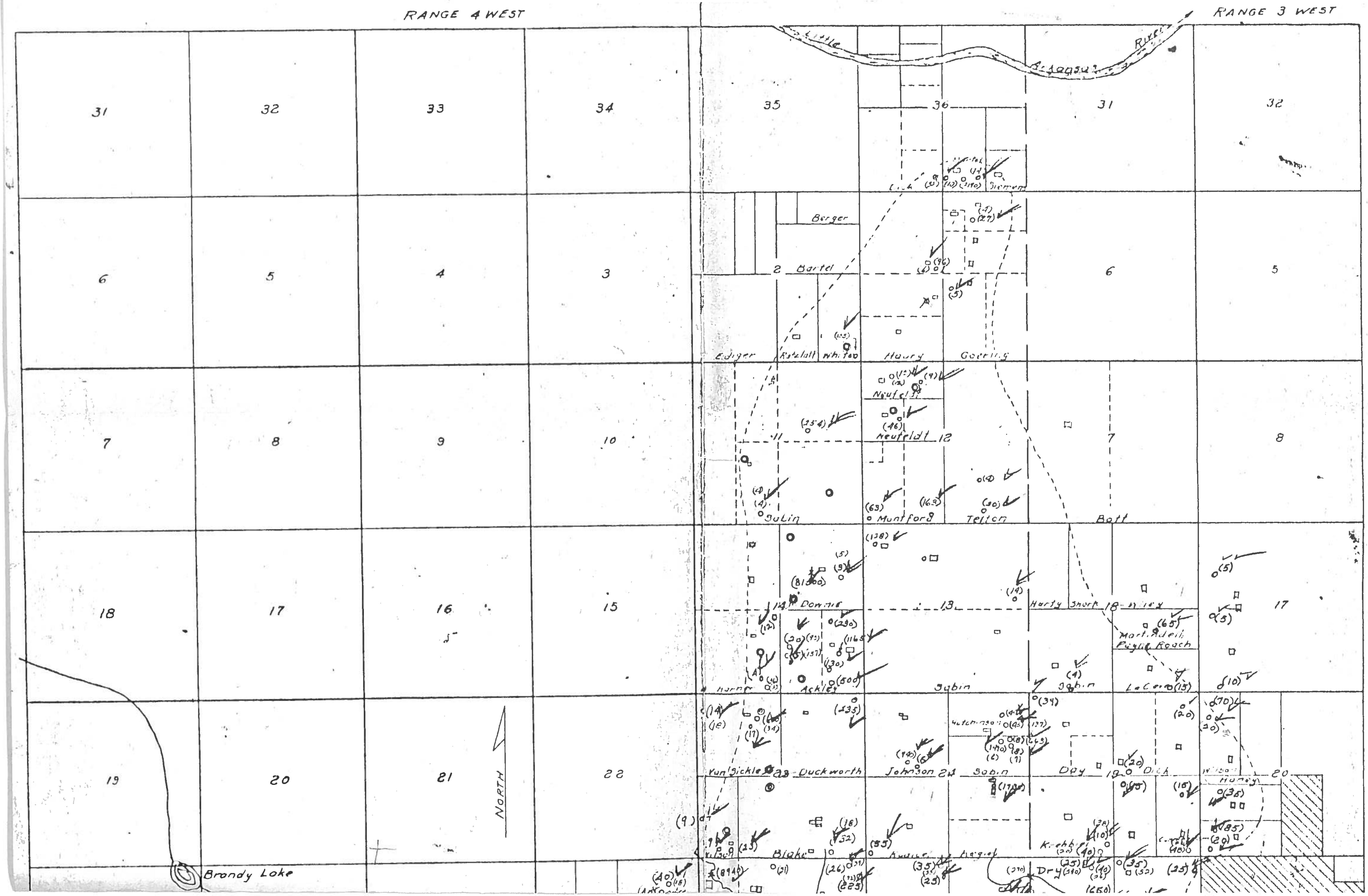
65	65	65	65	20	20	20	20	20	20	0	0	0	0	0	0	0	0
65	41	37	40	49	48	17	17	16	20	20	20	20	20	20	0	0	0
65	26	18	18	19	18	34	22	17	13	20	20	18	18	20	0	0	0
365	562	767	655	638	124	17	17	22	19	17	11	17	18	20	0	0	0
365	351	1189	1037	1022	736	28	23	19	22	19	20	20	15	13	0	0	0
365	353	1443	1121	1542	1190	531	30	19	17	21	28	20	20	20	0	0	0
478	565	1418	850	978	476	31	31	23	26	28	16	16	20	20	0	0	0
478	657	1199	724	280	197	26	29	22	19	12	31	33	19	11	0	0	0
200	295	530	166	162	123	51	56	60	34	18	72	44	14	20	0	0	0
200	194	112	105	89	118	97	86	111	99	58	52	40	31	10	20	0	0
200	193	134	119	128	157	128	108	110	101	60	32	34	39	24	27	20	0
200	193	106	102	98	87	138	110	100	79	81	71	37	35	43	40	33	20
0	200	192	151	166	148	124	77	89	71	95	104	49	29	52	76	45	20
0	0	200	200	220	164	115	86	74	68	73	72	52	26	59	94	70	20
0	0	0	0	365	365	262	123	71	65	89	65	65	44	53	89	27	20
0	0	0	0	0	0	500	365	365	365	365	240	40	40	40	20	30	20

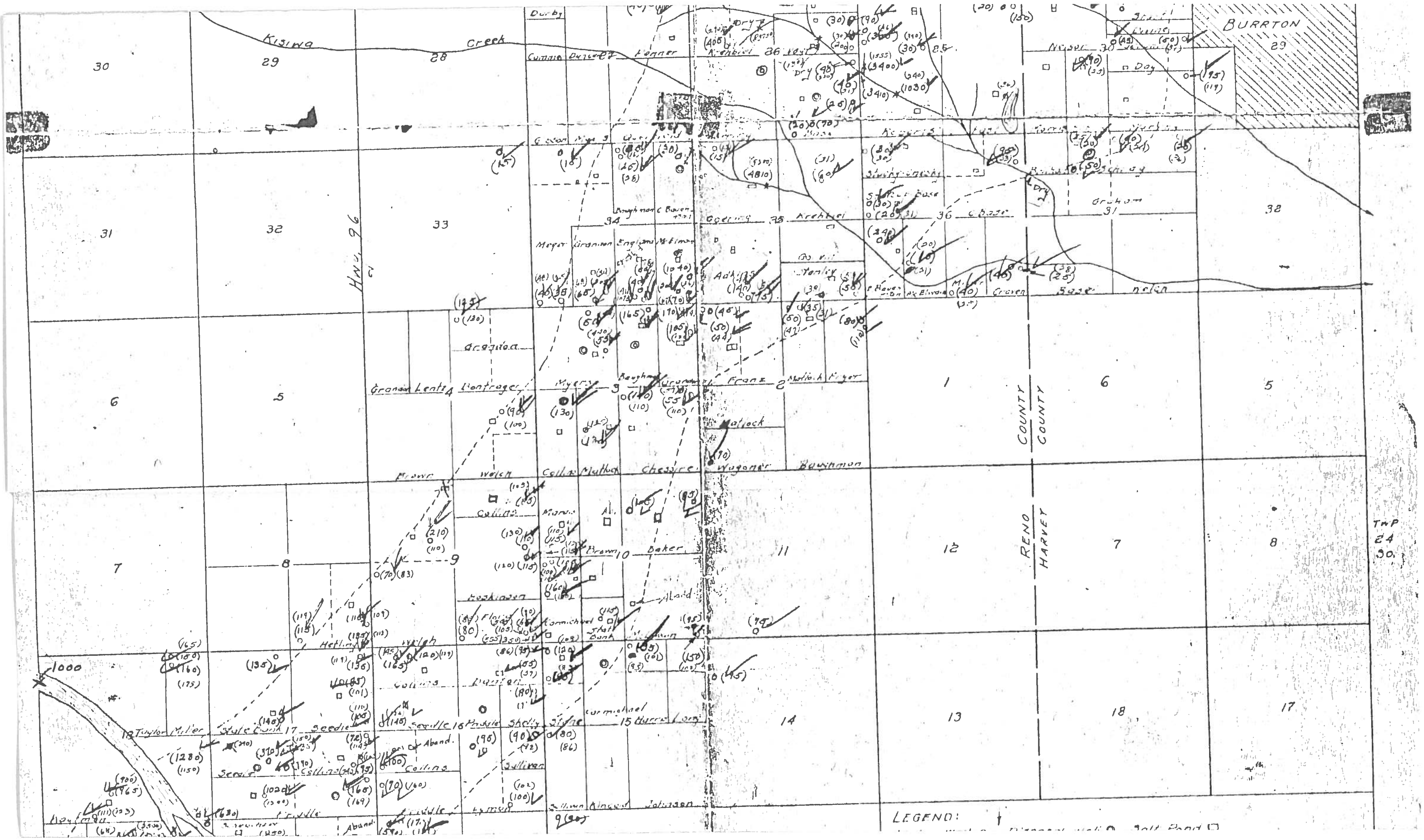
Present (1980) chloride concentrations (mg/l)

65	65	65	65	20	20	20	20	20	20	0	0	0	0	0	0	0	0
65	42	29	31	30	31	16	19	15	20	20	20	20	20	20	0	0	0
65	30	17	18	18	17	27	21	16	14	20	20	18	17	20	0	0	0
365	355	629	560	542	234	16	16	19	18	15	11	16	17	20	0	0	0
365	395	739	845	779	693	369	34	20	20	21	20	20	14	13	0	0	0
365	358	648	1383	1297	1348	897	132	24	17	17	18	20	20	20	0	0	0
478	457	756	856	813	1164	358	41	34	21	27	24	24	20	20	0	0	0
478	467	1179	1394	1008	409	166	30	27	19	20	11	37	30	11	0	0	0
200	216	540	772	167	178	123	27	43	51	18	17	94	15	20	0	0	0
200	191	134	83	86	113	114	88	73	103	66	37	64	46	10	20	0	0
200	191	174	160	109	101	127	109	98	123	87	51	30	36	38	27	20	0
200	191	124	66	90	89	129	124	102	97	70	73	41	32	35	38	33	20
0	200	192	163	120	115	98	125	91	81	68	126	105	20	35	44	58	20
0	0	200	200	210	220	127	113	73	84	68	69	82	27	21	59	98	20
0	0	0	0	365	365	272	132	101	69	66	79	52	65	12	51	90	20
0	0	0	0	0	0	500	365	365	365	365	240	40	40	40	20	30	20

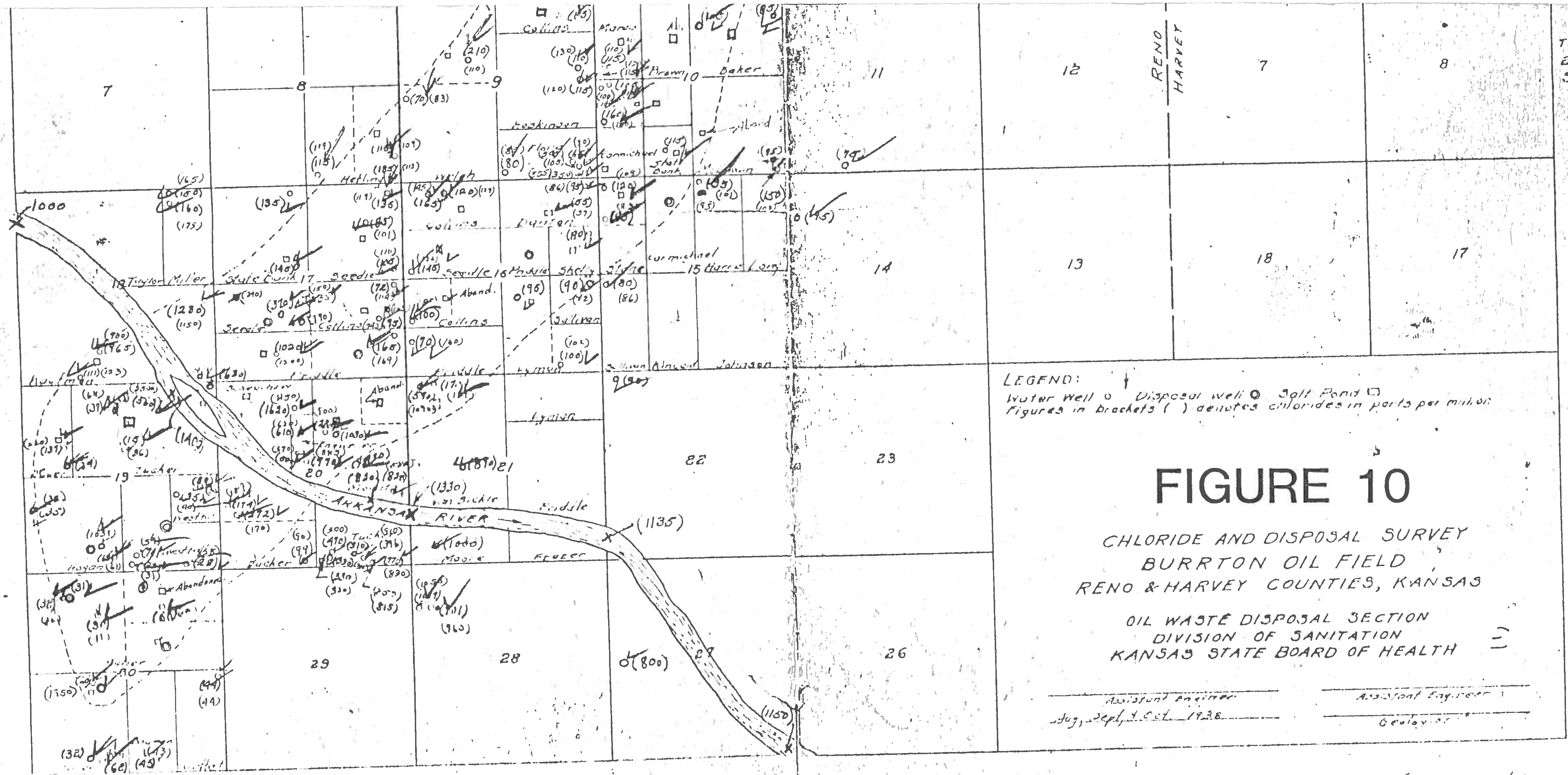
Predicted (year 2000) chloride concentrations (mg/l)

BURRTON STUDY FIGURE 10





BURRTON
Kisiwa Creek
Hwy. 96
RENO COUNTY
HARVEY COUNTY
TWP 24 30.
LEGEND:


LEGEND:
Water Well ○ Disposal Well ◉ Salt Pond □
Figures in brackets ( ) denotes chlorides in parts per million
FIGURE 10
CHLORIDE AND DISPOSAL SURVEY
BURRTON OIL FIELD
RENO & HARVEY COUNTIES, KANSAS
OIL WASTE DISPOSAL SECTION
DIVISION OF SANITATION
KANSAS STATE BOARD OF HEALTH
Assistant Engineer
Aug., Sept, & Oct. 1938
Assistant Engineer
Geologist
RENO
HARVEY
TWP 24
ARKANSAS RIVER