INITIAL REPORT FOR I-70 SINKHOLE COMMITTEE FOR DISPOSAL WELL PRACTICES AND COMPLETION SECTIONS 1-5, 14S-15W, RUSSELL COUNTY

By

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KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT
DIVISION OF ENVIRONMENT

Topeka, Kansas

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SECTIONS 1-5, 14S-15W

RUSSELL COUNTY, KANSAS

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KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT
DIVISION OF ENVIRONMENT
TOPEKA, KANSAS

January 1985

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INITIAL REPORT FOR I-70 SINKHOLE COMMITTEE
FOR DISPOSAL WELL PRACTICES AND COMPLETION
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INTRODUCTION

Three areas of slow land subsidence are present adjacent to and across I-70 in western Russell County. The sinking has affected the roadway and an overpass bridge and frequent repairs of the road surface and shoulder have been required.

These problems have existed since the highway work began in the early '60's. The study of a 1957 aerial photo indicates subsidence was present in the area of the future interstate highway at that time.

The sinks developed by the slow dissolution of the Hutchinson salt bed of the Wellington formation which lies at a depth 1,300 feet and is an average of 255 feet thick. A portion of the salt was dissolved by the circulation of waters unsaturated as to chlorides down through the salt section in or around casings of abandoned oil wells. This water drains by gravity flow to the Gorham sand, Arbuckle formation and Reagan sand at around 3,300 feet.

The brackish water is contributed by the upper aquifers of the Dakota and from the mineralized waters of the Cheyenne and Cedar Hills formations. These formations, particularly the Cedar Hills, have been used for the disposal of large volumes of oil field brines for the past 40-50 years. The use of the Lower Dakota was eliminated in the 1940's and Cheyenne disposal was phased out nearly completely by the mid '60's. Several Cedar Hills wells, however, are currently active.

The Witt sink in C-NW NW SE 3-14-15W is the western most problem area and the major concern at this time. The sinking has recently accelerated which had caused the line of sight on the highway to be lost to drivers for a short time. The highway surface in the sink area has recently been refilled and leveled by KDOT at a cost of $566,000.

The possibility of replugging the hole is being considered by several state agencies to the extent that the KCC has established a Technical Committee. In 1979, the KDHE contracted with the Kansas Geological Survey for seismic studies of the I-70 sinkhole line to determine characteristics of the rock formations underlying the sink area. In addition, KDHE has received surface elevation information and drilling information from KDOT during a cooperative effort to chart the long term sinkhole movement. Information is available from KDHE and KCC concerning active, plugged and abandoned oil, gas, enhanced recovery and salt water disposal wells.

This report is a summary of all available data supplied by concerned agencies. Recommendations in this report have been provided to the Technical Committee of KCC and the Kansas Department of Transportation regarding the replugging of the Witt sinkhole.

DESCRIPTION OF GEOLOGY AND HYDROGEOLOGY

The area is underlain by 5 to 10 feet of soil followed by Pleistocene deposits of silt and alluvial sands of up to 75 feet in thickness. These upper deposits yield water of a satisfactory quality in most areas. Some areas have been polluted through widespread use of salt water disposal ponds in the 1940's and 1950's, leakage from improperly cased or cemented wells, surface spills of salt water and seepage from mineralized Cretaceous sandstone aquifers (Dakota and

Cheyenne). As previously stated, both the Dakota and Cheyenne were used as brine disposal zones during the 1940's and 1950's and the Cheyenne was used as late as 1970, hence some of the poor Dakota quality can be attributed to man induced sources.

Rocks of Cretaceous age, namely the Carlile shale, Greenhorn lime, Graneros shale and the Dakota formation underlie the area and outcrop nearby.

The Dakota formation is a thick, crossbedded, fluvial and channel sandstone. The formation occurs at a depth of around 170 feet and is approximately 300 feet thick. Water can be obtained from the fine grained sandstones and the more coarse channel sands in the formation. The discontinuous nature of the channel sands causes much uncertainty with the quantity and quality that can be produced from a particular zone or from a particular vertical position within the formation.

The upper part of the aquifer provides water of fairly good quality. Chloride concentrations range from 1000 to 4500 ppm. The lower portions bear mineralized water, but within the definition of usable water. Numerous shallow disposal wells were drilled into the Lower Dakota during the 30's and 40's, however, the use of these wells was phased out by the 60's.

The Dakota formation is under hydrostatic head of 140 to 150 feet below the surface at this location and is a confined artesian aquifer. With the past use of the zone for disposal of large quantities of water, and at times under pressure, the formation pressure has increased, although the actual increase is difficult to quantify. In an attempt to seek static conditions, the water drains downward through boreholes to lower aquifers. Also, injection of brine into the Lower Dakota formation polluted the usable water of the Upper Dakota because the dividing shale layers of the formation are discontinuous or not thick enough to prevent upward migration. The underlying Kiowa shale does not yield water in most cases.

The Cheyenne sandstone is a well sorted quartz sand that averages 100 + feet in thickness in the area. The Cheyenne yields water but it is highly mineralized. Many oil field brine disposal wells were completed into the Cheyenne. The use of this zone has also been phased out nearly completely. At this time, five Cheyenne wells do not have plugging records on file and one well, The Roubach #1 in SE NW 2-14-15W, was reported as active during a recent field check. (See Table 1).

The Permian Cedar Hills sandstone occurs at a depth of around 500 feet and is usually somewhat truncated by erosional unconformity from the average complete thickness of 180 feet. Cedar Hills sandstone is the uppermost zone used for salt water disposal since 1970 and several disposal wells are actively used in the area (See Table 1). However, the KDHE and KCC have been limiting both pressures and volumes of brine before permit approval is given.

The Stone Corral anhydrite lies at a depth of roughly 1000 feet. This formation can be traced laterally over a large area and is easily identified on logs and in well samples. The Stone Corral is used as a marker bed in structural and stratigraphic work. The Kansas Geological Survey conducted seismic field studies to determine the structure and attitude of the Stone Corral in the vicinity of the sinkholes. These studies indicate the anhydrite beds of the

Stone Corral have been affected by the subsidence in that they have been offset downward as much as 125 feet. The area of collapsed Stone Corral is becoming larger and Steeples (1980) suggests that the three known sinkholes may be coalescing and attempting, with time, to show up as a single topographic expression.

The top of the Hutchinson salt member of the Wellington formation is encountered at about 1300 feet and ranges in thickness from 250 - 300 feet. About one-third of the material is present in the form of insoluble shale and anhydrite beds having individual thicknesses of one foot or more. The salt is overlain by the impervious and protective Ninnescah and Upper Wellington shale which consists of 300 feet of siltstones, mudstones and shale. The penetration of this aquitard by extensive drilling of oil and gas wells has allowed less saline waters to move past this aquitard and enter the underlying salt member where salt dissolution has occurred.

The Lower Permian rocks have had shows of oil and gas but have not been developed for production. The Topeka lime formation of the Pennsylvanian, Shawnee group is an oil producing horizon in this area.

The Pennsylvanian Lansing/Kansas City group has also been developed for oil and gas production. After high initial production of the limestone, the oil reservoirs became depleted. The Lansing-KC is presently under water flood or enhanced recovery. The development of this water flood led to the discontinuance of shallow Cheyenne and Lower Dakota disposal practices due to the need for water. The Dakota formation was eliminated as a disposal horizon in the late

1940's. When production first began, there was a lack of available deep disposal formations. The development of water floods and deep producing formations provided formations capable for injecting excess brine to the water flooding activities.

The Cambrian - Ordovician Arbuckle group are important oil reservoirs. The group consists of cherty dolomites and porous and sandy dolomites underlain by a clean quartz basal sandstone at 3100 ± to 3400 ± feet below surface. The Arbuckle has the capacity to either yield or receive large quantities of water. The average chloride concentration of the water is 27,000 ppm. The great receiving capacity serves as an outlet for the disposal of large volumes of oil field brine by gravity flow. The relation of this aquifer to the land subsidence is that upper formation fresh and unsaturated saline fluids, capable of salt dissolution, can migrate from their upper aquifer origins vertically through the salt and down unplugged or improperly plugged boreholes into any lower formation which will take water, including the Arbuckle. This process has a significant bearing on the development of the Witt sinkhole.

The basement rocks are of the Pre-Cambrian age. The rock is predominately granite composed chiefly of quartz, orthoclase feldspar and biotite. The upper surface of the granitic rocks has been weathered and is termed 'granite wash' which is also used as a zone for brine disposal throughout the Central Kansas Uplift area.

Cross-section A-A' (Figure 5) shows the general subsurface geology of the study area.

DESCRIPTION OF INVESTIGATION

1. Field investigation was conducted by District Staff from the Northwest Office at Hays during December 1983 and January 1984.

   During the field investigation, all leases were checked for active disposal and injection wells. Wellhead pressures were checked and companies were contacted for information regarding casing depths, cementing, additional upper hole protection and tubing and packer settings. This additional contact was needed because:

   a) some wells found did not have an injection well permit on file;
   b) additional work records were not included with the application on file; and
   c) information on injection wells that were covered by a certain KCC docket number were not always included with the application.

2. A base map was prepared by KDHE district staff: The above data was included on the base map, Figure 1, along with all plugged oil wells for Sections 2 and 3, T14S-R15W, Russell County. The plugging reports were obtained from the State Corporation Commission. Field locations of abandoned holes were checked by KDHE and KCC staff.

   Maps of sections 1-5 were also prepared by KDHE staff. Figure 2 shows all known disposal and injection wells of sections 1-5 and the plugged oil wells of sections 2 and 3. Figure 3 has the injection well numbers and the disposal and repressuring well docket numbers included. The area and the topographic features are shown in figure 4.

Cross-section line A-A' is shown on Figure 2. The cross-section is included in Figure 5 and illustrates the dissolving of the salt and the land subsidence.

3. Files were reviewed in the KCC-KDHE Joint District Office at Hays, the KDHE Topeka Office, the Russell County Courthouse and the ASCS Office in Russell.

   All disposal and injection well related information was compiled. Frequently, an application was listed on the KDHE computer printout or referred to in a letter from the file but no applications were present. When this occurred, a clerk in the Wichita - KDHE office obtained copies of some of the applications from the KCC office in Wichita. Also, copies of some plugging reports for disposal and injection wells (sections 2 and 3) were acquired from the Wichita-KCC office.

   All the above wells were located on the base map. Only those wells recorded on KCC plugging reports or which were coded as plugged on the KDHE injection well pressure check cards and computer printout were shown on the map as plugged. It is assumed all other wells are abandoned but not plugged because no report is shown nor field inspection made to verify the absence or presence of a well.

The injection and disposal well information was compiled on Table 1. The status information of the wells (inactive, active, plugged, etc.) shown in the "remarks" column was obtained from the KDHE pressure check cards. The most recent check date was used for wells reported as active and, for inactive wells, the earliest date the well was listed as being inactive was added to the column. If a plugging report was available, "plugged by KCC" was added.

All information pertaining to the well was listed. This includes: MIT dates; flag test dates; depth intervals where any holes in the casings were found; record of flows or break-ins; whether the well was drilled out to a deeper formation; and any other problems or ideas mentioned on any correspondence in KDHE files.

Table 2 lists the general plugging practices for wells in sections 2 and 3 and Table 3 outlines problem areas throughout the entire base area. Problems such as "lost hole" locations are shown in Table 4.

Table 2 includes information from all available plugging reports. Included is data on oil, injection and disposal wells. Study of these data indicate whether pipe was salvaged from the hole and if adequate cementing material was used to isolate all water bearing formations.

Table 3 lists any flows, break-ins, complaints of unplugged holes and etc. These problems were usually mentioned in the general correspondence of the file.

Accounts of "lost holes", lost circulation and holes in casing are listed on Table 4. These data were obtained from the completion card file.

Table 5 shows the estimated volume of fluids injected into the known shallow disposal wells of the area. The figures were calculated by estimating the barrels of brine injected per day and the years that the well was reported to be active. It is evident that many barrels of fluid were injected into the wells over the years and figures included in Table 5 are probably conservative. This fluid, while containing considerable mineralization, is all capable of dissolving salt if it was permitted to contact the beds of the Wellington salt formation.

STUDIES BY OTHER AGENCIES:

Seismic studies were conducted by the Kansas Geological Survey (KGS) in 1979 and 1980 to gather data on the strata underlying the sinks. This work was done as part of a contract with KDHE. The Stone Corral anhydrite, which lies at a depth of approximately 1,000 feet, as previously mentioned, is an excellent marker bed and allows for the evaluation of the lithologic and structural condition of the formation at that depth across the sinkhole areas.

Two profiles were run in the vicinity of the I-70 sinks. The first was from .61 miles east of the Crawford sink overpass to .65 miles west of the overpass. A second profile intersects the first at right angles at the overpass and runs from .30 miles south of the north lane to .29 miles north of the north lane. Seismic energy was supplied by two Walker earth tampers and the MiniSOSIE recording process was used. Six Mark Products L-25 geophones made up the geophone groups.

The latest method used in data acquistion employed common depth point (CDP) reflection techniques. The CDP method is the equivalent of doing several surveys along the same line and adding the results in a computer after correction for geometrical differences in the distance between short points and geophone arrays.

The field data were recorded on digital tape and processed by digital techniques in a large computation facility. The data are displayed in a "record - section" format showing reflection amplitudes in a time (depth) versus horizontal distance plot. The record sections are available with the geologic sections shown in color.

From the seismic data, the structure and attitude of the Stone Corral could be determined. With the CDP methods and subsequent computer processing, it was possible to trace the Stone Corral across the sinkholes. Also, the top and bottom of the Hutchinson salt could be delineated. The conclusions from the KGS seismic study are discussed in a later section. (After Steeples (1982)).

DISSCUSSION

The maps (Figures 1 and 2) and Table 1 indicates the large number of salt water disposal wells and injection wells drilled and leases operated in this area. A large percentage (70%+) of the wells listed in Table 1 (not including injection wells) were drilled to shallow depths. The Lower Dakota at depths of 350 to 400± feet, Cheyenne sand at 440-480± feet and the Cedar Hills from 500 to 650± feet are the shallow disposal formations used in the area. Nine of the shallow wells, drilled to the Cheyenne and Cedar Hills, have no record of being plugged. Many of the shallow wells were drilled in the mid '30's and were completed with one string of pipe set to the top of the disposal interval and with 200+ feet of open hole.

Several wells were originally drilled to the Gorham formation or LKC at a depth of 3280. Information is not available on the plug back procedures used. If the plug back work was not effective, water from upper formations could escape down the back side of the casing, past the salt section, and into the lower producing horizons.

Many of the injection wells do not have casing protection extending through the upper water bearing formations such as the Dakota. The surface casing usually protected through the fresher upper water; but the lower, somewhat mineralized waters of "usable" rather than "fresh" quality are often not cased or cemented off.

The shallow wells often used pressure during their years of operation. Also, an immense amount of water was introduced into the Dakota and Cheyenne aquifers. The mixing of waters is known to produce extremely corrosive fluid which can cause both short and long term breakdown upon contact with well casing. Since the disposal of water into the shallow formations created artifically higher than normal hydrostatic pressures, pressure equalization took place through the many abandoned or poorly plugged oil wells or deep disposals. The Arbuckle and Basal Sand aquifers act as a sewer to any fluid migrating down hole. (Walters (1975)).

Of the plugging reports available for review, many did not contain sufficient detail to be of value. "Mud and cement to surface" was the general description of well plugging procedure in the late '60's and early '70's. Shallow wells had cement to surface. This was probably from the bottom of the casing to the surface, although the report did not so state. Many other well reports had mud to around 200 feet, a bridge, mud, and then a cement cap at the surface.

Most of the disposals and injection wells in sections 2 and 3 have been plugged. However, much shallow activity into Dakota, Cheyenne and Cedar Hills formations at depth of 420-900± feet took place for many years. The years of use undoubtedly caused damage that could not be corrected by simply plugging the well.

It should be noted that there probably existed more shallow wells than are indicated on the maps. Many wells were known about only by their mention in a piece of correspondence or the presence of a plugging report. Not many plugging reports were available and only two dated before 1950. Since oil activity has existed since the late '20's, many wells of earlier vintage were probably used and abandoned without any documentation of their existence.

SEISMIC STUDY:

Seismic waves are reflected and refracted by contrasts in velocity and density as they propagate through the earth. Information regarding the velocities and layer thickness can be obtained from the data by measuring the travel times of the rays.

Initially, the seismic reflection survey by the Kansas Geological Survey was to be used in the sinkhole area to determine if underground voids were present which could eventually show up as a catastropic collapse. Air or water filled cavities produce different reflections of the seismic waves. It was established that the cavity in the Wellington underlying the Witt sink is a 'rubble zone' of broken rock and not a large void area. Therefore, slow subsidence will probably continue and catastrophic collapse will most likely not occur.

On the seismic profile through the Witt area, the Stone Corral anhydrite shows to be down-dropped about 50 feet on the west side. In the area to the west of the Witt, there is competent rock to all depths to well below the salt. The study shows that in the center, the anhydrite is either down-dropped ±125 feet or its upper surface has been broken up or partially dissolved. Eastward of the center, the Stone Corral reflections indicate a broken up character for about one quarter mile. This area has future subsidence potential. Also, since most of the broken-up zone is east of the sink center, sinking in the future may be asymmetrically eastward, thus creating a different set of stress relationships on the rock than a true vertical surface - cavern matchup. (Steeples (1982)).

DRAINAGE PROBLEM:

The abandoned well bore of the Witt #1 has, until recently, been located in a rather steep gully which led from the highway. Rainwater drained directly into the area around the well and into the well itself. A temporary pond formed during heavy rains because of the interior drainage. Part of the cause for the increased rate of sinking can be placed on the very fresh rainwater that entered the well. Fresh water has a great capacity to dissolve salt.

EXTENT OF SUBSIDENCE:

The amount of subsidence in the area of the Witt #1 well needs to be addressed as a part of discussion on the feasibility of replugging the well. Prior to this discussion, two rules of thumb need to be presented:

1. If a parallel can be drawn to the subsidence experienced by the coal mining industry, surface sinking after a coal seam has been totally removed by the long-wall method will be 35 percent of the thickness of the coal bed. This observation tends to be valid independent of the depth of the coal seam.

2. The density of overburden in a collapse situation will decrease about 10 percent from the original overburden density. This means the pore space will increase by about 10 percent of the bulk volume when a collapse occurs.

Using the above guidelines the total sinking expected to take place at the Witt can be estimated. Since the Hutchinson salt bed is approximately 300 feet in thickness, sinking of around 100+ feet would be expected if all the salt were to be dissolved. This figure is obtained by using the 35 percent rule applicable to the coal industry. The overburden in the area is about 1,300 feet. The volume increase rule states that expansion of 130 feet may occur and, therefore, 170 feet of collapse would occur in a worse case scenario where the total section of salt was dissolved. After Steeples, (1984).

The seismic data from the KGS Study revealed that possibly half of the original salt thickness was remaining in 1980. Therefore, the sinking that may be expected could range from 50 feet to 85 feet over the next few decades. These estimates assume the Witt #1 hole can be replugged where half the original salt remains and that all the salt thinning to date is associated with man induced activities. The total sinking in the Witt area is 19 to 20 feet and the rate of subsidence has averaged .65 ft/year. (Wally Taylor, 1984, personal communication).

It has been observed that the diameter of individual known salt dissolution sinkholes will seldom exceed the depth to the base of the salt. Two probable reasons for this limit are:

1. The limited size of the individual sinkholes is related to the pattern of water flow within the salt. Initially, dissolution occurs in a cylindrical or spherical fashion. If the rate of dissolution is constant in the volumetric sense, the rate of lateral increase within the dissolution cavity will decrease linearly with time. This results from the fact that the volume of a sphere is proportional to radius cubed, while surface area (where actual dissolution takes place) of the same sphere is proportional to radius squared. An additional factor in the slowing down in areal growth is that as the salt dissolution front recedes in all directions from the source of unsaturated water, the water flow rate (and, hence, the dissolution rate) at the salt front decreases. At some point the ion exchange process slows to a diffusion process rather than a dissolution process, practically shutting down growth of the sinkhole. Cessation of growth occurs when the path of unsaturated water to the salt front becomes sufficiently long and arduous that its velocity might only be a few feet per year rather than perhaps inches per hour.

2. From a rock mechanics point of view, once the advance of the salt dissolution front slows substantially, the gravity slumping of material above the salt into the cavity provides additional difficulty for water flowing from the salt front to the center of the sink. The area of surface sinking is then mechanically limited by the depth of the base of the salt or the base level of the cavity. (After Steeples (1984)).

Alternate action toward estimating the amount of subsidence should be considered if the Stone Corral is found to be substantially down dropped. The mitigation effort should be different if the anhydrite is 150+ feet below normal rather than 50 feet. Some salt solution experts reason that the degree of down-drop of the Stone Corral provides a clue to the total surface sinking that can be expected.

RECOMMENDATIONS OF PLUGGING OF WITT #1

(1) Much money and time will be saved if it is possible to reenter the hole in the old casing and plug the Witt either at the base of the salt or over the base of the cavity. A major question is the condition of the old casing. It is highly probable that the pipe has collapsed or parted due to settling, or, after such a long period of time, has completely corroded away. It is possible that drilling will have to take place alongside the old hole.

The location and plugging of the old hole below the salt section with cement is very important. The use of down-hole radar should be considered to search for the old borehole when the drilling encounters the Hutchinson salt base, although formation rubble may render this recommendation infeasible.

(2) It has been suggested by Schoof (1984) that bentonite gel be used in the top part of the salt, where present, and at points above the salt. Bentonite would be favorable in this situation for two reasons:

(a) If the plugging effort below the salt proves unsuccessful, reentering the hole to perform additional work would be less complicated if bentonite were in the hole.

(b) A gel may be more likely to fill and stabilize voids and bentonite may also speed up the settling of looser formation materials to some degree.

Drilling activity may accelerate the natural settling of the area and this is a major concern, especially in reference to the safety of the drill rig and crews. (Schoof and Butcher (1984)).

(3) The success of plugging the Witt sink is difficult to predict, however, a 70 percent chance in favor is expected.(Butcher (1984)). If the attempt is successful, sinking will probably continue to take place for 5-10+ years, but at a decelerated rate. It is suggested that the highway be built to supergrade to prepare for the anticipated sinking. Planning ahead could eliminate some of the repair work that will be needed in the future. Additional drainage design measures should also be included in the overall scheme.

FUTURE CONSIDERATIONS

The attempt to plug the Witt #1, whether successful or unsuccessful, will provide valuable information to the KCC and KDHE for tackling future problems. There are two other sink areas along I-70 to the east of the Witt that may need attention in the future (See Figure 4), in particular the Roubach, where surface subsidence is in an incipient stage. There are also other subsidence areas present throughout the State. At this time, several years of data are available for the Witt sink area which include surface elevation surveys, drilling logs and seismic data. Any information gained from experiments conducted in this natural laboratory will prove valuable in future attempts to control land subsidence problems. One of the unknowns in the Witt area is the Dakota water table configuration. The drilling of three test holes in the Witt sinkhole vicinity during summer 1984 has given some indication of the downward migration of Dakota water, but the static fluid level surface was elevated across the sinkhole. The future concerns are not limited to the known sink areas. It is predicted that numerous subsidence problems will develop as a result of the many rusting casings, poor cementing jobs and inadequate or non-existent well plugging jobs that are thought to be present in the Kansas Oil Patch. These problems are inevitable and will progress during the decades ahead.

MONITORING:

Monitoring of the sink area in relation to its subsidence rate will be continuous. As continued settling is expected, surface elevation surveys will have to be conducted. Also, an overpass bridge 1/2 mile east of the Witt in the Crawford sink area has been affected by the sinking and is under tensile stress. This structure must be watched carefully to assure public safety. These stresses are currently under study by the Kansas Department of Transportation.

PLUG ABANDONED HOLES:

In an attempt to predict and abate the development of additional sink problems in the area, all known or suspected abandoned, poorly plugged or poorly cemented wells should be correctly plugged after repair or drilling out. Not only will this reduce the chances of additional sink development, but it may eliminate any complications to the plugging work of other holes caused by possible communication between wells. Any improvements made by replugging the Witt could be negated in a short time if a number of other potential problem wells are left untouched.

Remote sensing studies should be integrated into an ongoing program to detect early signs of surface sinking. The early discovery of possible problem areas would aid in the control of any subsidence at an earlier point. This is especially true if trouble were to be caused by a well not visible at the surface and vegetative stress or other remote sensing techniques can be used as early aid to detection.

FUTURE OF ONGOING WORK:

Following this initial study, a similar evaluation of a larger area of western Russell County will be conducted. Specific complaints will be taken into account to determine if surface flows and high chloride problems are related to the subsidence problems or other oil field related activities.

CONCLUSIONS

The past practice of disposal of salt water into the shallow formations of Lower Dakota and Cheyenne, and the current use of the Cedar Hills have been a contributing factor to the land subsidence problem in Russell County along I-70. Cedar Hills disposal is permitted at this time, however, careful consideration is taken before approval is given. Amounts of brine injected are reviewed and injection pressures are normally not allowed. If the well was once drilled to a deeper zone below the salt section, review of the plug back procedure is done. Also, the static fluid levels of the Cedar Hills are taken to give indication as to whether fluids are escaping downhole. The input of large volumes of water under wellhead pressure into these formations has raised the formation pressure although this has not been measured definitely. To seek static conditions, the brine will continue to drain downward through the salt section where an avenue is present. The poorly plugged wells completed into the Arbuckle provide such avenues. The replugging of the Witt well will not solve all problems in the area, however, it does address one of them. As long as wells exist in the area that are inadequately plugged, poorly cemented or have rusting casings, the potential for numerous future problems exist.

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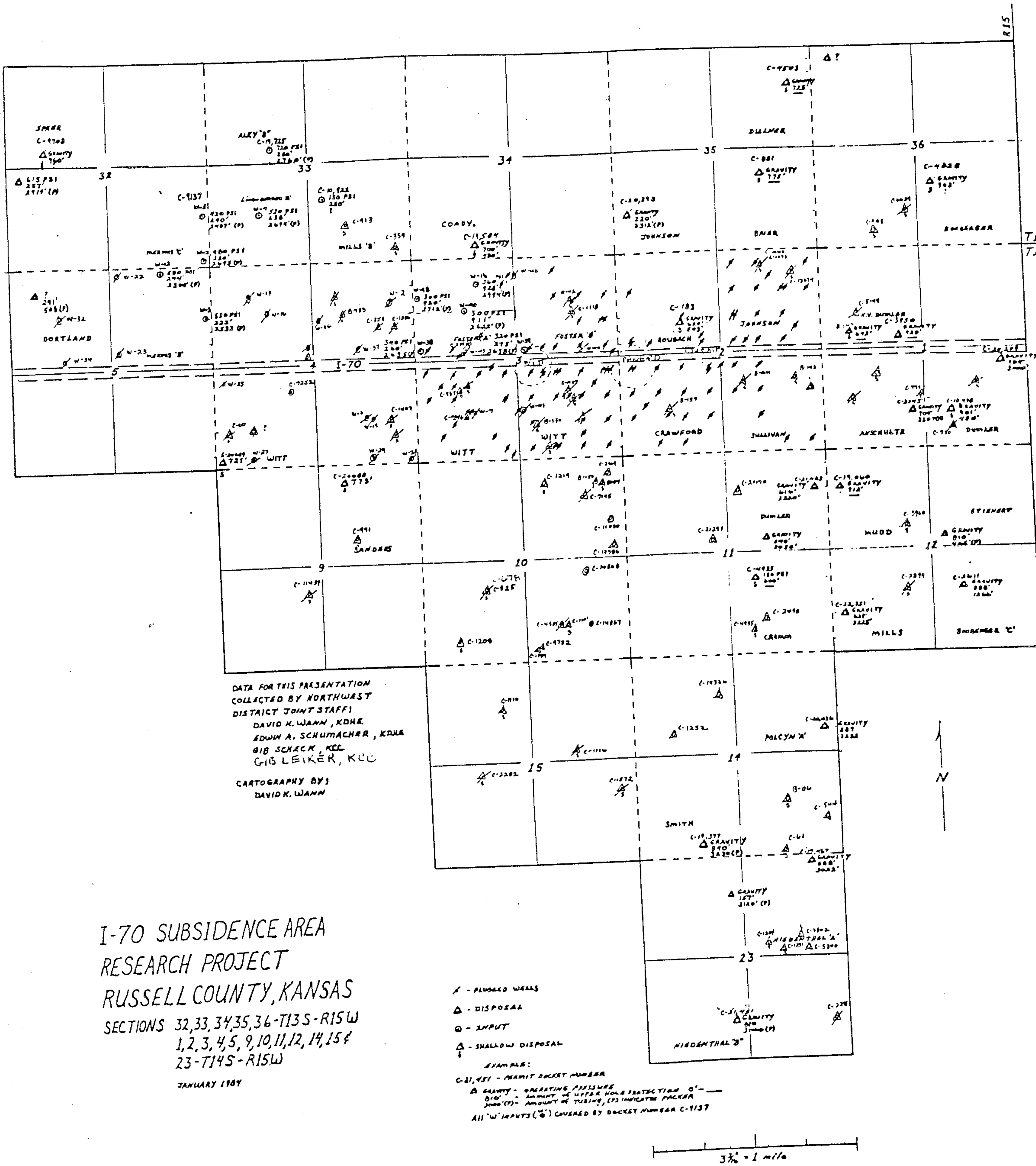
bsk/145-D

FIGURE 1



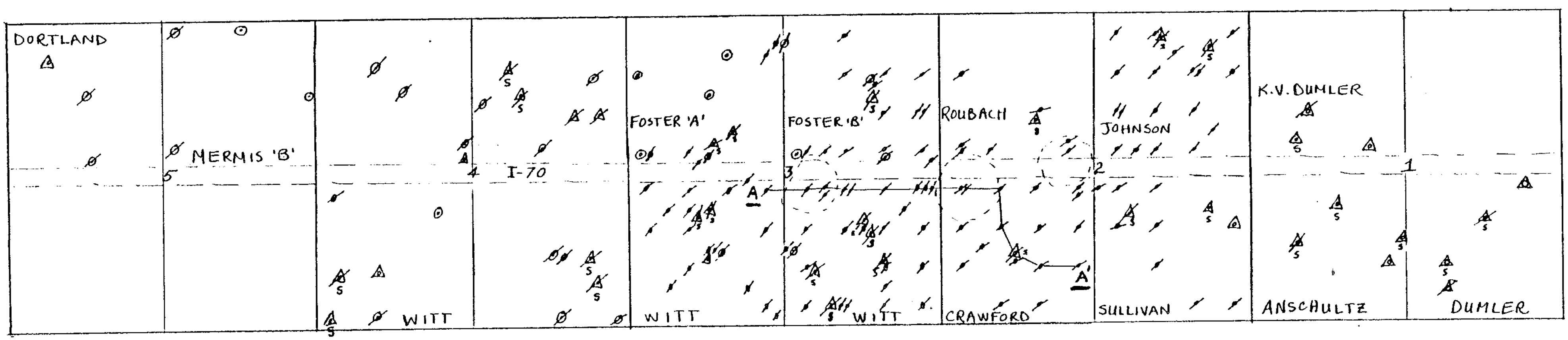
I-70 SUBSIDENCE AREA
RESEARCH PROJECT
RUSSELL COUNTY, KANSAS
SECTIONS 32, 33, 34, 35, 36-T13S-R15W
1, 2, 3, 4, 5, 9, 10, 11, 12, 14, 15 &
23-T14S-R15W

JANUARY 1984

FIGURE 2

I-70 SINKHOLE STUDY

SECTIONS 1-5, 14S-15W
RUSSELL COUNTY, KANSAS



EXPLANATION

Plugged Oil Well
Disposal Well
Plugged Disposal Well
Shallow Disposal Well
Input Well
Plugged Input Well
A ——— A' Cross Section Line A - A'

Scale

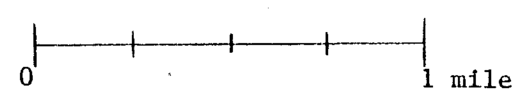
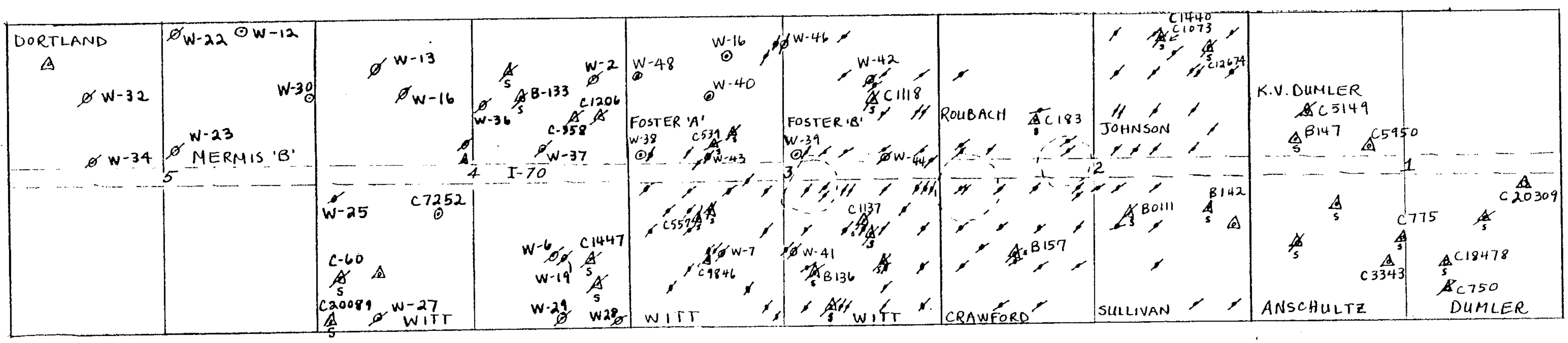


FIGURE 3

I-70 SINKHOLE STUDY
SECTIONS 1-5, 14S-15W
RUSSELL COUNTY, KANSAS



EXPLANATION

- Plugged Oil Well
- Disposal Well
- Plugged Disposal Well
- Shallow Disposal Well
- Input Well
- Plugged Input Well
- W-6 Input Well Numbers
- C3343 Disposal Well Docket Numbers

SCALE

0 — 1 mile

FIGURE 4

I-70 SINKHOLE STUDY
SECTIONS 1-5, 14S-15W
RUSSELL COUNTY, KS

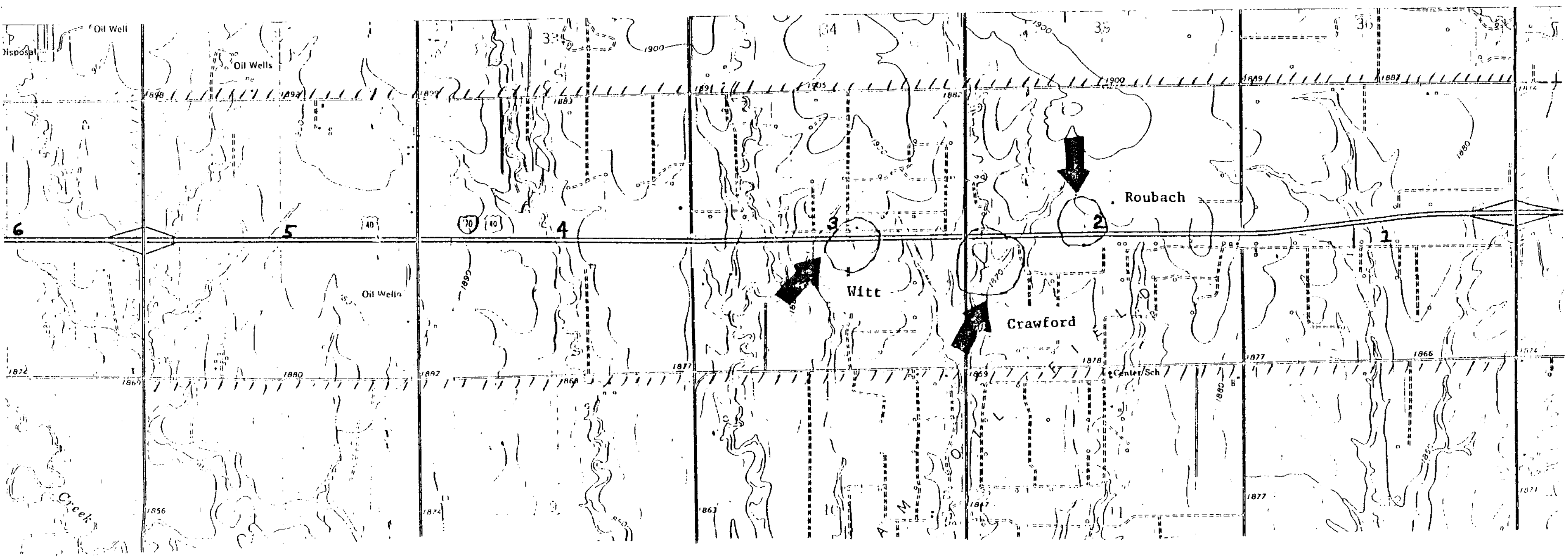


FIGURE 4: Map of study area showing topographic features.

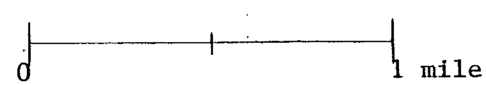
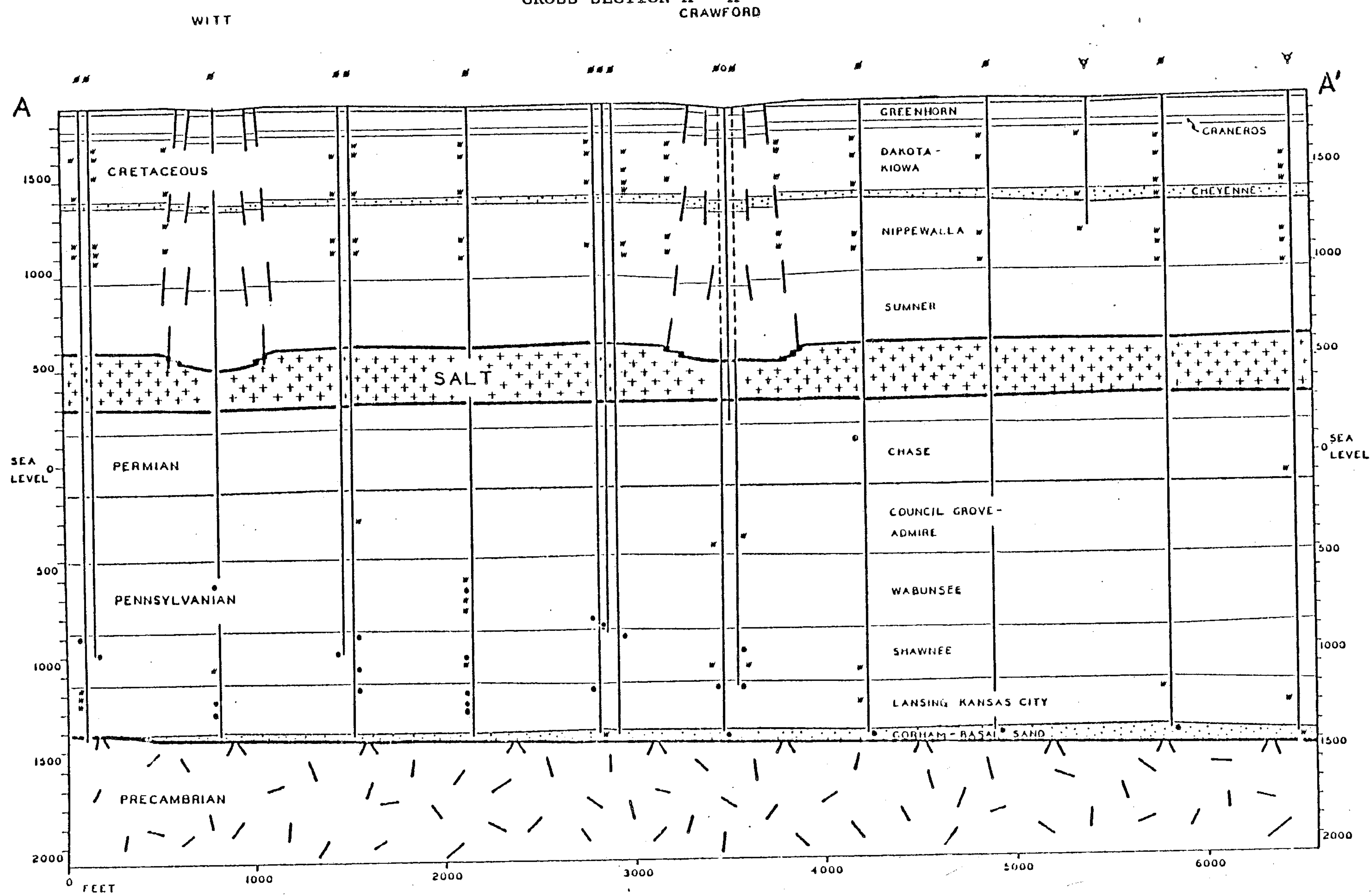


FIGURE 5

CROSS SECTION A - A'



(From Walters, 1975)

TABLE 1

T14S-R15W Russell County, Kansas

Location	Company	Well	Docket #	Inj. Fm.	Inj. Interval	Casing Information	T&P	Max. Press.	Vol. Brine	Elev.	Remarks
Sec. 1 NE SW	The Texas Co.	Anschutz #1	C-775	(Cheyenne) Cedar Hills	550-800	10 3/4 @ 375, mudded 8 5/8 @ 550, circ.		150	2500	1870	Approved 12/23/42, Inactive 5/60.
SE SW	Gulf Oil	Ehrlich #7	?	Arb.	TD-3475	16" at 340 - pulled 7" at 3358, 2893' pulled		?	?	?	Drilled as dry hole in 1937. Would deepen for SWD but well not needed so it was plugged. Mud to 3358, bridge, mud to 150, bridge and 22 sx cmt. Mud to 10', cmt. to surf. Same location as C-3343? Plugged 1939.
SW NW	Gulf Oil	Ehrlich #1 Now Dumler	B-147	Cheyenne & Cedar Hills	420-642	8 5/8 @ 422, circ. 7" liner to 642'		grav.	1500	1875	Approve 10/19/36 No p/c card. Flag test done 4/1/81, everything was ok.
NW SW	Texaco, Inc.	Anschutz 8W	?	(Chey or Kd.) Cedar Hills or Chey.		7" at 586	?	?	?	?	Completed 1/29/43. Plugged by pumping gel and cmt. to surf. Plugged 8/73.
SW SE	The Texas Co.	Dumler #1-B	C-750	Basal Sd.	3315-3365	10 3/4 @ 249 5½ @ 3295		150	2000		Approved 6/6/42. No p/c card.
CN/2 SE	Texas Co.	Dumler 'A' #5	?	(Chey or Kd.) Cedar Hills or Chey.	TD 895	7" at 546	?	?	?	?	Completed 4/15/45. Plugged by pumping 895-425' heavy mud, 425' to surf. w/cmt. Plugged 9/58.
E/2 SW	The Texas Co.	Anschutz #11	C-3343	Gorham & Granite	3320-3383	10 3/4 @ 904 7" @ 3320	2862	300	8000		Approved 1/30/53 Passed MIT. Also disposing into Plattsmouth & Reagan from 2910-3383. Active 9/79.

TABLE 1, page 2

Location	Company	Well	Docket #	Inj. Fm.	Inj. Interval	Casing Information	T&P	Max. Press.	Vol. Brine	Elev.	Remarks
SW NW	L. Mai	Dumler #1	C-5149	KC	3126-3136	5½ @ 3300 cmt. 559' to surf.		50	1000		Approve 8/21/56. No record of surf. csg.; had Kd breakin-Squeezed hole at 554, 542, 450, 430, 415. Was Gorham producer until Kd leak. P & A 9/79.
SE NW	L. Mai	Dumler 'A-2'	C-5950	Topeka	2794-2885	7" at 2794, circ. from Anhy. to surf.		300	2000		Approved 11/27/57. Not in use 5/60, plugged 7/77 gravity (?) 9/79.
SW SE	Barton Oil	Dumler B-1	C-18,478	Cedar Hills	500-875	8 5/8 @ 902; 7" @ 500, circ.	500	50	400	1867	Approve 9/10/76. Originally D & A to Granite at 3302 RTD. Active 9/79.
NE SE	A. Barton	Dumler #3	C-20309	Granite	3350-3400	8 5/8 @ 327; 5½ @ 3294	90jts	grav.	1200		Approved 10/7/81. Memo dated 10/1/81 stated 5½ perf'd at 904' and circ. to surf. No p/c card.
NE SW	Texas Co.	Dumler #5	?	Cheyenne and Perm	550-800	no info.					Approved 4/3/45.
Sec. 2 NW SE	Gulf Oil	Pierce #1	B-0111	(Kd) & Cheyenne & Cedar Hills	429-637	8¼ @ 429, circ.		grav.	800	1875	Approve 7/23/36. Plugged 9/64. Plugged by KCC 1255.
NE SE	Hartman Blair	Sullivan #1	B-142	Cheyenne	430-457	8¼ @ 430, circ.		grav.	900	1895	Approve 9/29/36 No p/c card.
SW SW	Empire Oil	Crawford	B-0157	(Kd) & Cheyenne & Cedar Hills	443-665	8¼ @ 443, circ.	462 '	grav.	1200	1880	Kd base at 480. Well checked 4/1/65 - operating at 125 psi. Letter to company 6/15/65 advising well be deepened or plugged. Inactive 3/66, P&A 6/77 Plugged by KCC 9/71 Approval order dated 11/16/36.

TABLE 1, page 3

Location	Company	Well	Docket #	Inj. Fm.	Inj. Interval	Casing Information	T&P	Max. Press.	Vol. Brine	Elev.	Remarks
NE SW	Billy Ingram	Crawford A-13	C-15765	Gorham	3302-3325	12½ @ 925 6 5/8 at 3302		30	400-500		9/2/70 well not in use. Operator told to take fluid level, run T&P; was warned about pressure and being close to sinkhole. Requested to withdraw application. Granted. 2/11/71
SE NW	Hartman-Blair	Roubach #1	C-183	Cheyenne	460-482	8¼ at 460, circ.		100	10,000	1892	Approved 8/9/38. Letter to Co. 3/25/65 advising of casing test because well appeared to be corroded. Well tested 8/3/65 holes found from 77"-436', largest at 367-436. Cheyenne top should be at 503. Inactive 3/66. Reported as active under gravity from field check for this study.
NW NE	The Texas Co.	Johnson #2	C-1073	(Cheyenne &) Perm.	500-1500	7" @ 500, circ.		500	1000	1900	Approved 5/13/46. This approval letter allowed Arb. disposal from 3321-3335. No completion info. on this. Inactive 3/61.
NW NE	The Texas Co.	Johnson #2	C-1440	(Cheyenne,) Permian, Topeka, Arb	500-3950 and 3321-3335	8/5/8 at 3064 mud to surf. 5 3/16 at 3321, mud to surf.		50	150	1900	Same location as above well. Approved 8/21/44. Order dated 5/20/46 allowed the Arb. disposal. No P/C card.
NE NE	Dreiling Oil	Johnson #1	C-12674	(Cheyenne) Cedar Hills	602-615	5½ 664, circ.		100	1000	1889	Kd base at 494. Approved 5/17/66. Plugged 7/70 Casing tested 4/18/66 - no holes found.
Sec. 3 SW SE	Central Petrol	Witt #8	B-136	(Cheyenne) Cedar Hills	760-795	10" @ 747, circ.		grav.	1000	1870	Approved 9/17/36. Plugged 10/64, from p/c card. Plugged by KCC 3/56. Originally drilled to 3319'.

Location	Company	Well	Docket #	Inj. Fm.	Inj. Interval	Casing Information	T&P	Max. Press.	Vol. Brine	Elev.	Remarks
N/2 SE	Sohio	Witt 'A'	?	Chey	520-920	7" at 520	?	?	?	?	Plugged 4/56.
S/2 NW	Central Petrol	Foster #1	C-539	(Dakota) Chey. & Cedar Hills	470-600	6 5/8 to 450, circ. 5½ liner to 610		1000	875	1885	Approved 7/26/41. Plugged 3/61.
SW SE	Sohio	Witt SWDW	?	Chey & Cedar Hills	483-880	8 5/8 at 366 5½ at 483	?	?	?	?	Plugged 1/56.
NW SW	Bridgeport Machine	Witt SWD #1	C-557	(Dakota) Chey. & Cedar Hills	440-660	7" @ 436, circ.		350	700	1870	Approved 9/13/41. Plugged 3/61.
SE SE	Sohio	Foster 'B'	?	(Cheyenne) Cedar Hills	515-930	8 5/8 at 372 5½ as 515	?	?	?	?	Plugged 1/56.
NE NE	Sohio Petrol	Foster 'B' #1	C-1118	(Cheyenne) Cedar Hills	515-945	8 5/8 @ 370, circ. 5½ @ 515, circ.		500	1500	1895	Approved 11/21/44. Plugged 3/61.
NW SW	Francis Oil	Witt SWD	?	Kd?Chey?	?	?	?	?	?	?	TD 565, Plugged 4/50.
NW SE	A.H. Witt	Witt 'A' #1 SWD	C-1137	Cheyenne & Cedar Hills	420-525	7" @ 420, circ.		500	1500	1880	Approved 12/19/44. Plugged 3/61.
SE SW	Sohio	Foster 'A' #1	?	(Cheyenne) Cedar Hills	510-915	5½ at 510	?	?	?	?	Plugged 1/56.
NE SW	Homestake Prod.	Gorham Unit #W-5	C-9846	Topeka	2750-2785	8 5/8 @ 250 4½ @ 3279, mud (rotary) to surf. from cmt. top	yes	1000	750		Note: Mtg. held 12/17/64 to discuss cmt. materials. Drlg. mud found not to be satisfactory 1. Artesian water present 2. Pipe corrosion known problem 3. Known pollution in area 4. High pressures required Operator agreed to cmt. opposite Kd and inject through tubing. Not known if this was ever done. Approved 11/16/64. Active 9/65.

TABLE 1, page 5

Location	Company	Well	Docket #	Inj. Fm.	Inj. Interval	Casing Information	T&P	Max. Press.	Vol. Brine	Elev.	Remarks
NE SW	Solar Petrol.	Witt 'B' #2 Input	C-20289	Tarkio & Elmont	2462-2674	8 5/8 at 242 5½ at 3288	2040	900	1000	1879	Never approved - has been present in 'hold' file since application rec'd 9/8/81. Latest letter of 6/30/83 requests operator cement 5½ from anhydrite to surf. to prevent the Kd, Cheyenne and Cedar Hills Waters from migrating downward to salt section.
Sec. 4 SW SW	Stanolind	Benso #19	C-060	(Dakota) Cedar Hills	520-600	17" @ 41 13 3/8 @ 515, circ. 10 3/4 slotted liner to 600	Yes	350	3500	1885	Approved 2/7/38. Permit cancelled 10/40.
4	Homestake Prod.	W-K Royalty #1 ?		Kd	TD 575	7" at 490 5¼ at 480	?	?	?	?	Completed 5/54. Pumped 5½" csg w/cmt. to surf. to plug. Plugged 3/65.
W/2 NE	W-R Royalty	Mills #1	B-133	Red Sd	500-600	6" @ 500, circ.		grav.	3000	1885	Approved 9/9/36. Plugged 2/63.
SE NW	Central Petrol.	Dortland D-2a	B-198	(Cheyenne) Cedar Hills	775-830	3 3/4 at 775, circ. w/ 40 sx cmt. (seems doubtful)		grav.	450	1870	Approved 3/26/37. No p/c card.
4	Great Bend Pipe & Supply	Witt #1	?	Cheyenne	TD 605	4½ at 605	?	?	?	?	Hulls, mud, cmt. pumped to surface. Plugging complete 12/68.
SE NE	Bridgeport Machine	J. Mills 'A' #6A	C-358	Cheyenne and Permian	520-921	10" @ 921, only lower 676 encased w/cmt.					Plugged 10/64.

Location	Company	Well	Docket #	Inj. Fm.	Inj. Interval	Casing Information	T&P	Max. Press.	Vol. Brine	Elev.	Remarks
CNLSESE	M. Billings	Witt SWD	?	Cheyenne, Cedar Hills	TD 918	10" at 24', pulled 8" at 383, pulled 7" at 507, cmt. 5" at 609, pulled	?	?	?	?	Csg. filled w/soil, cut off below plow depth and capped W/cmt. Plugged 1952.
SE NE	Francis Oil	Mills 'A' #1 SWD	C-1206	Cheyenne & Cedar Hills	450-550	7" @ 450, circ.		500	1200	1887	Approved 4/21/45. Plugged 3/61.
NE SE	Alva Billings	Witt 'A' & B #1	C-1447	Red Bed	465-904	7" @ 465, circ.		200	250	1885	Approved 5/21/46. Never completed 3/61.
NE SW	Coop Refinery Assoc.	Witt 'F' #1	C-7252	LKC	3058-3130	10 3/4 @ 914 5½ @ 3274, mud to surf.		800	1000		Approved 6/17/59. Inactive 7/77.
NE NE	Leben Drlg.	Mills 'A' #2	C-10,923	Lansing	3050-3140	8 5/8 @ 240 5½ @ 3140, mud to surf.			600		Plugged 1/82.
SW SW	Crude Producers	Witt #4 SWD	C-20,089	Cedar Hills	503-604	8 5/8 @ 265, circ. 5½ @ 727, circ.	Yes	grav.	1200	1886	Originally LKC inj. well to TD 3280. Plugged 8/22/67 Approved 5/1/81. Active 10/81.

Note: Some of the entries show formation(s) in parentheses. These are the formation names that were listed on the original applications. Don Butcher (1985) advises that the oil field nomenclature of the time included Dakota and/or Cheyenne picks to the Red Beds and sometimes Anhydrite. The formations listed near the formations in parentheses are more correct.

<u>TABLE 2</u>

Plugging Practices Along I-70 Strip.

Sections 2 and 3, 14-15W, Russell County

Location and Well	Casing Information	Details
SW 2 Rouback #11	8 5/8 at 157 5½ at 3328, 496' pulled (TD 3301)	Bridge at bottom, sand to 3290, Sand to 3290, 20SX mud and 100SX cmt to surf. Plugged 4/56.
2 Rouback #8	7" at 3045, 2500' pulled 10" at 940, 450' pulled (TD 3045)	Mud to 440, bridge at 250, mud to 8', cmt. to top. Plugged 3/47.
2 Rouback #1	5½ at 3092, 2835' pulled 8¼ at 3072, 2224' pulled 10" at 2200, 390' pulled (TD 3092)	Mud to 250', bridged, mud to 8', cmt. to top. Plugged 2/47.
2 Rouback #2	7" at 317 (TD 3296)	Bridge at 317, mud to 8', cmt. to top. Plugged 8/44.
NENW 2 Rouback #3	TD 3119	Mud (37SX to surf), cmt. 190 to surf. Plugged 2/52.
SW 2 Crawford 'A' #3	12½ at 919 7" at 3305, 2916 pulled (TD 3286)	Mud to 210, bridge at 200, mud to 30, cmt. to top. Plugged 4/51.
SENW 2 Johnson 'A' #3	20" at 19' 8 5/8 at 3058, 180' pulled 5½ at 3307, 2778 pulled (TD 3308)	Mud to 195, bridged, cmt. and mud to top. Plugged 1/53.
SENW 2 Johnson 'A' #9	8 5/8 at 242 4½ at 2606, 1811 pulled (TD 2607)	Mud to 250, bridged, mud to 25', cmt. to top. Plugged 7/54.
SENE 2 Johnson 'A' #5	7" at 3324, 2439' pulled 12½ at 940, 285' pulled (TD 3325)	Rock to 2530, mud to 225, bridged, mud to 25, cmt. to top. Plugged 10/49.
NWSE 3 Witt 'A' #1	7" at ? 5" at 3299 (TD 3305)	Tubing run to 1307, mud pumped to 552, bridged, mud to 270, cmt. to surf. Annulus cmt. w/65 SX. Plugged 6/57.
C-S/2 N/2 SE 3 Witt 'A' #1	7" at 520 (TD 920)	Tubing run to 500', cmt. thru tubing to surf. w/125 SX cmt. Plugged 4/56.
SWSE 3 Witt SWDW	8 5/8 at 366 5½ at 483 (TD 880)	Cmt. to surf. 200 SX pozmix. Plugged 1/56.

TABLE 2, page 2

Location and Well	Casing Information	Details
SESE 3 Foster 'B' SWDW	8 5/8 at 372 5½ at 515 (TD 930)	250 SX pozmix to surf. Plugged 1/56.
C-S/2 3 Witt 'E' W-41	8 5/8 to 250 4½ at 3298, 2035' pulled (TD 3298)	Plug to 2951, mud and cmt. to surf. Plugged 9/69.
SW 3 Witt 'E' W-7	8 5/8 at 228 4½ at 3045, 2095 pulled (TD 3096)	Plug to 2975, mud and cmt. to surf. Plugged 12/68.
C-East line NWSW 3 Witt SWD	TD 565, 7" cmt. to surf.	Hole filled w/125 SX cmt. Plugged 4/50.
SWC-NENE 3 Foster 'B' W-42	8 5/8 at 254 4½ at 3313, 2294 pulled	Plug to 3020, mud and cmt. to surf. Plugged 3/71.
SWSENE 3 Foster 'B' W-44	4½ at 3292, 2192 pulled (TD 3145)	Plug to 2990, gel mud and cement to surf. Plugged 7/71.
NENW 3 Foster 'B' W-46	8 5/8 at 260 4½ at 3311, 202 pulled (TD 3161)	Plug to 3020, mud and cmt. to surf. Plugged 8/68.
SESWNW 3 Foster 'A' W-43	4½ at 3189 2072' pulled (TD 3104)	Plug to 2975, 15 SX gel mud and 100 SX cmt. to surf. Plugged 7/71.
C-W/2 SENW 3 Foster 'A' SWD #1	5½ at 510 (TD 915)	200 SX cmt. to surf. Plugged 1/56.
NWNWSW 2 Crawford #12	13 5/8 at 910, 837' pulled 8 5/8 at 3039, 2633 pulled (TD 2984)	Mud to 2960, bridged, mud to 2860, bridged, mud to 285' bridged, mud to 10', cmt. to top. Plugged 6/41.
NWSW2 Crawford 'A' #16	12½ at 916, 499' pulled 7" at 3287, 569' pulled (TD 3223)	Mud to 529, mud to 400, bridged, 15 SX cement mud to 10', cmt. to surf. Plugged 1/45.
SW 2 Crawford 'A' #1 (B-157 ?)	8 5/8 at 443 (TD 653)	3 SX hulls, 10 SX gel, 100 SX cmt. Plugged 9/71.
N/2 NE 2 Johnson 'H' SWD (C-12674)	5½ at 666 (TD 666 ?)	Bridge (rock) from 315 to 325, cmt. to surf. Plugged 7/70.
C-SWNWSE 2 Pierce #1 (B-0111)	8¼ at 427 7" at 641 5½ at 637, 421' pulled	Cmt. to surf. Plugged 12/55.

TABLE 3

PROBLEM AREAS
14-15W, Russell County

Location	Lease Name	Remarks
CSWNW 1	Dumler	Unpermitted disposal well
SWNW 1	Dumler #1 #C-5149	Kd breakin - holes squeezed from 415-554. Reported P & A in 1979. Was originally Gorham producer.
SE NW 2	Rouback #1 C-183	Well tested 8/65 and holes found from 77-436'. Reported "inactive" in 1966.
SE 3	Witt	Complaint about loss of salt water during operation (3/59). No violations found. Noted that numerous Kd breakins and squeeze jobs have occurred over the years.
NW 3	Sanders 28' Stock well	Complaint about high Cl^- in well. Injection wells tested and lines checked. Have been problems with fluids in pits, overflows, etc.
W/2 4	Witt & Dortland	Complaint 5/62 about salt in ravine. Much of the problem probably stems from use of salt water ponds in past.
NW 4	Dortland	Complaint 1/46 about 3 wells on land that have not been pumped for 2 to 4 years. Salt water and oil stand in cellar to within 3' of surface.
NE 10	Polcyn	Complaint 4/59 about artesian salt water flow. A water seep in draw found W/ Cl of 32000 ppm. Noted that shallow SWDW's operating nearby w/ 300-400#. Recommended cellar of #8 well (SWD?) be dug out and checked for leaks. Was this done?
SENE 10	Polcyn #5 (C-11030)	An inspection report of 5/65 showed hole at 525 in prod. pipe. Water went out hole and entered Cheyenne at 616' under the surface casing.

Location	Lease Name	Remarks
NWSW 11	Sunray DX wells	Complaint 6/22/65 that 3 oil wells were flowing at surface out annulus of tubing and longstring. Shallow well (B-150) in NE Sec. 10 shut down but no reduction occurred in flow. Casing test done on LKC injection well (C-11030) (see previous entry) and hole found. Possibly Sunray flow occurring from injection into Nixon flood.
Center Westline SW 14	Unplugged Oil test	Report 12/20/54. When well plugged, Kd broke in and flowed. They were unable to properly plug hole. There is a salty seep out a draw near-by.
NE and NW 15	Rouback 'A' and 'B'	July 1980 - Company told to plug wells as Kd has broken in and shallow ground water is threatened.
NE 23	Neidenthal	Reported that water has broke out in SENE 23 (not location of C-1204) and flowed to Big Creek. Letter from O. Hilton 10/7/53 states that if breakin is found in this well (C-1204), the Section will rescind approval.
SE 23	Neidenthal 'SWD' (no docket #)	5-12-83 - Well plugged by KCC

13-15S

Location	Lease Name	Remarks
SENW33	Aley 'B' #1 (C-19725)	Company told several times to cement for Kd protection. Letter 9/82 stated well squeezed. No records though.
SWSW35	Johnson #2 (C-20,393)	Cedar Hills not isolated from salt w/ cement. Notified Company to cement Kd. Dept. notified that job was done - no records.

Table 3 information is from general correspondence in file.

TABLE 4

14-15W RUSSELL COUNTY

Location	Company	Well	Casing Information	Elev.	Remarks
Section 1 CSWSE	Barton Oil	Dumler 'B' #1 'OWWO'		1871	Washed down twice. Was Gorham producer. First washdown lost hole at 3405. Second washdown to Topeka. Hole in csg. in Kd zone. Set packer below Kd.
Section 2 CN/2NWSE	J. Boltin	Pierce #4	8 5/8 set to 321		Lost Circulation and could not regain.
CW/2SESENW	MIA Oper.	Rouback #14			Lost hole - RTD 742.
Section 3 N/2NWSE	H & H Prod.	Witt #9			D & A, Lost hole, TD 855.
Section 15 CN/2NENE	Don Karst	Rouback-Mermis #1			RTD 3307. Recovered too much water - not profitable.
Section 23 SESWNE	Schmidt	#9 Neidenthal 'OWWO'	8 5/8 at 247		Lost hole at 450.
CSWNW	Furthmeyer	Furthmeyer #12	8 5/8 at 217		RTD at 2650. Casing broke at? Lost hole.

Table 4 information is from the completion card file.

TABLE 5

Estimated Volumes of Brine Injected
Into Shallow Wells Along I-70 Strip

Docket	Estimated Bbls. Brine/Day	Estimated Years Well Active	Estimated Total Bbls.
C-775 (Chey)	1300	17.5	8,303,750
B-147 (Chey)	750	25?	6,843,750
C-18478 (Cedar Hills)	300	8	876,000
B-0111 (Kd, Chey)	550	19	3,814,250
B-142 (Chey)	600	?	?
B-157 (Kd, Chey)	625	30	6,843,750
C-183 (Chey)	5250	28	53,655,000
C-1073 (Chey, Perm)	1012	15	5,340,700
C-1440 ?	?	?	?
C-12674 (Chey)	525	4	766,500
C-136 (Chey)	525	20	3,832,500
C-539 (Kd)	825	20	6,022,500
C-557 (Kd)	500	20	4,066,100
C-1118 (Chey)	950	17	5,894,750
C-1137 (Chey)	775	17	4,684,775
C-60 (Kd)	2000	2	1,460,000
B-133 (Red Sd.)	1575	27	15,521,625
B-198 (Chey)	350	?	?
C-1206 (Chey)	625	16	3,650,000
C-1447 (Red Bed)	150	15	821,250
C-20089 (Cedar Hills)	700	2.5	638,750

Total: 1.33×10^8 Bbls.

or 5.6×10^9 Gals.

or 1.68×10^4 Acre-ft.