

**KANSAS GEOLOGICAL SURVEY
OPEN-FILE REPORT 77-24**

**CONSIDERATION OF KANSAS SALT MINES FOR POTENTIAL
STORAGE OF CRUDE PETROLEUM**

by

L. L. Brady

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KGS
OF
77-29

CONSIDERATION OF KANSAS SALT MINES FOR
POTENTIAL STORAGE OF CRUDE PETROLEUM

by

Lawrence L. Brady

Kansas Geological Survey

Summary

In Kansas there are four inactive salt mines that have a total mine volume of 118.3 million cubic feet or the potential storage of 21 million barrels of petroleum. These four mines include the Crystal and Royal Mines at Kanopolis (Ellsworth County), Carey Mine at Lyons (Rice County) and the Kingman Mine at Kingman (Kingman County). A fifth inactive mine is presently being utilized for storage of propane and ethane.

Three active salt mines are present in the state having a combined volume of 419 million cubic feet or the equivalent of nearly 75 million barrels of petroleum. Utilization of this space with active mining, if possible, would require some very careful engineering.

In addition to the salt mines, several areas having large solution cavities might also be considered for petroleum storage. These include two inactive solution well fields - one in Barton County near Pawnee Rock, and the second near Hutchinson in Reno County.

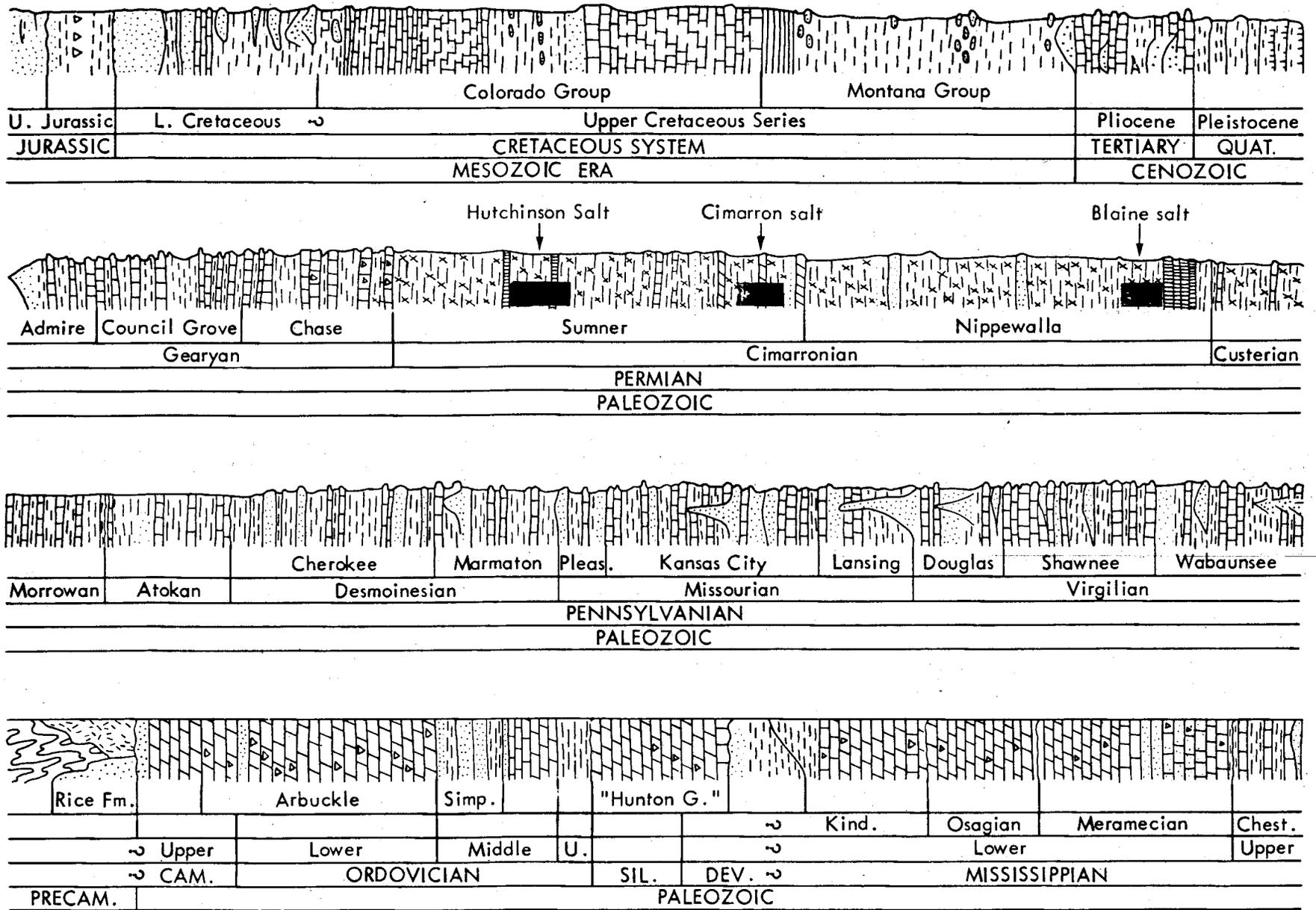
May 1977

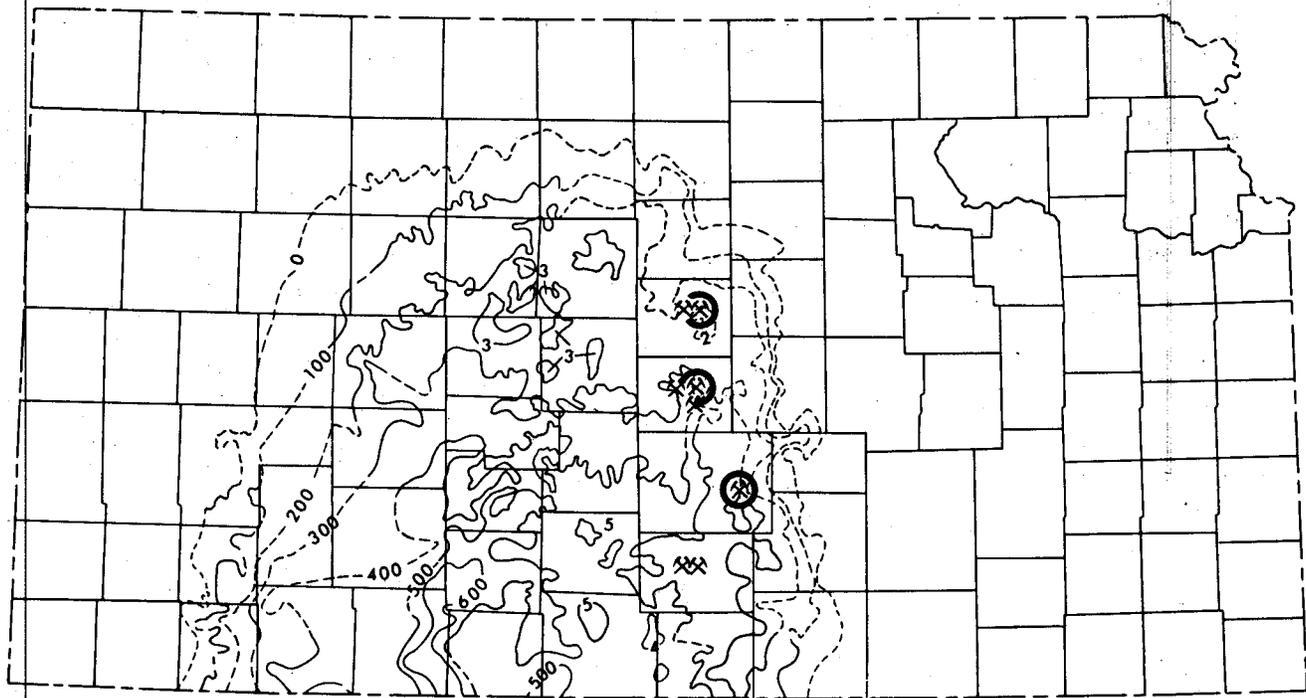
Introduction

Deposits of salt in Kansas are present at three different intervals in the Permian rocks in the western two-thirds of Kansas. The only unit of importance for salt production in the past has been from the Hutchinson Salt Member of the Wellington Formation (Figure 1). All of the active and inactive salt mines in Kansas worked this salt unit. Distribution and thickness of the Hutchinson Salt Member and locations of the salt mines in the unit are shown in Figure 2.

There are nine underground mines in the salt that are presently known. These mines are all located in the central part of the state with three mines in Ellsworth County, three in Rice, two in Kingman, and one in Reno County. Of this total, three mines are presently in operation and producing a total of over 600 thousand tons of rock salt annually.

Figure 1 -- Position of salt beds in the Kansas stratigraphic column (from Bayne, 1972).





EXPLANATION

- - - - Information based on cable tool logs, drillers' logs, or logs showing presence of salt, but thickness data unreliable
- Information based on electric logs

- ⊗ Active Mine
- ⊗ Inactive Mine

Contour interval = 100'

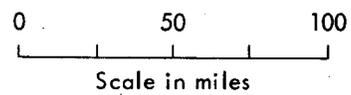


Figure 2 -- Thickness and limits of the Hutchinson salt member and location of salt mines (modified from Bayne, 1972).

Mine Size and Condition

With six inactive mines and three active mines in Kansas all mining the Hutchinson Salt Member, there are only minor differences between the mines. Other than volume mined, all the mines used the room and pillar technique of mining and extracted approximately 75% of the salt. Several of the mines are now flooded or partially flooded from water entering the mine primarily from the shaft opening. Depth of the mines vary from about 650 to 1050 feet from the surface.

Most of the information on the mines was obtained from Jewett (1956), with additional information from Walters (1976). Volumes of operating mines and recent developments of the mines were updated from Jewett's report.

In this report a conversion factor for volume measurement of 1 gal. = .1337 cubic foot was used or a 42 gallon barrel of petroleum would be equal to 5.6154 cubic feet. For update of volume of working mines from the report of Jewett (1956) a specific gravity measurement for salt of 2.16 was used. Based on this figure one short ton of salt mined would be equal to a void of 14.84 cubic feet. Therefore, reported tonnages of salt mined from 1956-1976 was converted to volume of new space in the mine.

Inactive mines, then the active mines, will be covered in this report and summarized in the accompanying table.

SUMMARY DATA¹ ON KANSAS SALT MINES

Name	County	Mine Volume million ft ³	Potential Volume million bbl (42 gal. bbl)	Depth Ave ht.	Condition of the Mine
<u>INACTIVE MINES</u>					
Little River	Rice Sec 18, T19S, R6W	11.2	1.99	796' 11'	Shaft grouted shut and presently used for propane & ethane storage; mining ceased 1926.
Crystal-Royal	Ellsworth Sec 27, 25, T15S, R8W	62.4	11.11	810'-816' 9'	Shaft in Crystal mine collapsed; mines partly filled w/water; closed 1948
Kingman Mine	Kingman Sec 29, T27S, R7W	11.0	1.96	? ?	Mine closed in 1913; flooded
Carey Salt - Lyons	Rice Sec 34, T19S, R8W	44.9	8.00	1024' 10'	Mine closed in 1948; dry but in stand-by cond.; used for AEC studies
<u>ACTIVE MINES</u>					
Independent Salt	Ellsworth Sec 29, 20, 21, 28 T15S, R8W	248 (est)	44.16	846' 9'	Largest producer of rock salt in Kansas; active 1977
American Salt	Rice Sec 10, T20S, R8W	46 (est)	8.19	993' 9'	Active 1977
Carey Salt - Hutchinson	Reno Sec 16, 15, 22, T23S, R5W	125 (est)	22.26	645' 9'	Active 1977; possibly a volume of 175 million cu. ft.

¹ Most of the data from Jewett (1956)

Little River Mine - This mine is located in the NE 1/4, NE 1/4 Section 18, T19S, R6W, Rice County. Depth to the mine floor is 798 feet with an average ceiling height in the mine of 11 feet. Mined by room and pillar methods the shaft was 7' x 17' in size. The mine was owned by the Morton Salt Company, but mining ceased in 1926 and the shaft was plugged in 1937. Walters (1976, p. 49-50) describes a collapse in 1963 of the lower part of the shaft. Deterioration of the shaft was due to fresh water seepage. In 1975 the shaft area was grouted shut and the mine is presently being used for propane and ethane storage by the Sentry Underground Storage Company.

Volume of the mine is estimated at 11.23 million cubic feet or the volume equivalent of 1.99 million barrels of petroleum.

With the apparent successful use of the mine for the LPG storage, the mine would not be available for use in the crude oil storage program.

Kingman Mine - Sketchy information is available on only one mine near Kingman, although there were two mines operating in Kingman County in the late 1800's. One mine began operation in 1889 and closed in 1891. A second mine began operation in 1891 but ceased operation in 1893 (Lane, 1960, p. 15). Jewett (1956) lists the Kingman Mine as closing in 1911-12. Perhaps one of the mines was reopened and later closed. Data on the Kingman Mine is taken from the Jewett report.

The Kingman Mine is located near the NE city limits of Kingman in E 1/2, SE 1/4, Section 29, T27S, R7W, Kingman County. The mine had a shaft 7' x 16' in size and was mined by room and pillar methods. Ceiling height and depth to the bottom of the mine shaft are unknown. It is

my estimate that the ceiling height was probably 8' to 9' high and the mine was at a depth of approximately 600 feet.

The mine is flooded and the shaft could still be open. Volume is estimated at 11.00 million cubic feet or equivalent to 1.96 million barrels of petroleum.

After the water is removed from the mine the space should provide adequate storage of petroleum. However, a good evaluation of the mine would be necessary to determine possible collapse.

Kingman, Kansas is presently served by a five mile gas pipeline owned by Kansas Power and Light Company that connects with a large Kansas Power and Light Company gas pipeline.

Crystal Mine - Royal Mine - These two mines are interconnected and will be discussed together in this report. Both mines are located in the east limits of Kanopolis and part of mine workings could underlie part of the town. The Crystal and Royal Mines are located in Sections 25 and 30, T15S, R8W, Ellsworth County. The mines are partly flooded and the main shaft of the Crystal Mine has cratered in 1972 from weakened mine timbers. The size of the crater is 129' x 95'. The crater is approximately 50 feet deep and filled in part with water. The original shaft of the Crystal Mine was 8' x 16' and was sealed in 1948. A second shaft 8' x 8' at the Crystal Mine is also plugged, while a plugged 8' x 16' shaft exists in the Royal Mine. Average ceiling height at both mines was 9 feet and depth of the mines was 810 feet at the Crystal Mine and 816 feet at the Royal Mine. Volume of mined area in the two mines is estimated by Jewett (1956) as 62.44 million cubic feet. This volume is equivalent to 11.11 million barrels of petroleum.

Both mines were worked by room and pillar methods by the Morton Salt Company and were closed in 1948. Two - 8 inch product pipelines pass through Kanopolis that are owned by Hydrocarbon Transportation, Inc. In addition, an 8 inch and 12 inch natural gas pipeline owned by Cities Service Gas Company also passed through Kanopolis.

Carey Mine - Lyons - The mining operations in this mine owned by the Carey Salt Company were discontinued in 1948. Location of the mine is Section 34, T19S, R8W in Rice County, and the mine has remained open and in a standby condition by the Carey Company. The original mine had one shaft 7' x 16' in size that extended to a depth of 1,024 feet. Mining was by room and pillar methods and an average ceiling height of 10 feet. Volume of space as indicated by Jewett (1956) is 44.88 cubic feet, or an equivalent of 8.00 million barrels of petroleum.

The mine was used by the U.S. Atomic Energy Commission for Project Salt Vault from 1963-67. During this period the salt was studied for information on the effects of heat and radiation on salt. This study is now discontinued.

This mine appears to be a good mine possibility for potential storage of petroleum. The standby status of the mine could result in the hesitancy of the company about allowing its use for a petroleum storage.

A Cities Service gas pipeline passes just east of the mine area. Three crude oil pipelines are located about two miles south of the mine area. These three lines are owned by Jayhawk Pipeline Corporation, Phillips Pipeline Company and the Kaw Pipeline Company. A petroleum products pipeline owned by the Skelly Pipeline Company is located just south of the mine.

Carey Mine - Hutchinson - Located on the east edge of Hutchinson in Sections 16, 15, 22, T23S, R5W, the Carey Mine is an operating salt mine. The mine is worked by room and pillar methods and has an average ceiling height of 9 feet and a depth of 645 feet. One shaft is used at the mine with dimensions of 11 1/2' x 11 1/2'.

Space in the mine is estimated at 125 million cubic feet or equivalent to 22.26 million barrels of petroleum. This figure is based on the volume estimate of Jewett (1956) and calculation of the subsequent mined area based on tonnage. This volume amount is probably lower than the actual volume amount.

A portion of the mine space is presently used for storage of critical documents.

Numerous gas pipelines are present in the area of the Carey Mine at Hutchinson including gas lines of Arkansas-Louisiana Gas Company, Cities Service Gas Company, and the Kansas Power and Light Company. An 8 inch petroleum products line of the Champlain Petroleum Company passes just east of the mine.

Independent Salt Company Mine - The largest mine in the state is the salt mine at Kanopolis owned by the Independent Salt Company. This mine is located in Sections 29, 20, 21, 28, T15S, R8W in Ellsworth County. Depth to the mine floor is 846 feet with an average ceiling height of nine feet. There are two shafts in the mine, a 7' x 16' operating shaft and a 9' x 18' escape shaft. Volume of the mine is estimated at 248 million cubic feet or equivalent of 44.16 million barrels of petroleum. This mine is presently the largest producer of rock salt in Kansas.

Adjacent to the Independent Salt Company mine on the west is the abandoned Crystal and Royal Salt Mines. Pipelines located near the mine were discussed in the section on the Crystal - Royal mines.

American Salt Corporation Mine - The third operating rock salt mine in Kansas is owned by the American Salt Corporation near Lyons, Kansas in Sections 3 and 10, T20S, R8W, Rice County. Room and pillar methods of mining were used with an average ceiling height of nine feet. Depth to the floor of the mine is 993 feet, and one shaft (8' x 16') is used. Volume of the mine is estimated to be 46 million cubic feet or volume of petroleum equivalent to 8.19 million barrels.

Three crude petroleum pipelines are adjacent to the mine site. These pipelines are owned by the Jayhawk Pipeline Corporation, Phillips Pipeline Company and the Kaw Pipeline Company.

Other Petroleum Storage Possibilities in Salt Formations

At the present time there are over 50 million barrels of LPG storage in salt caverns in Kansas (Gas Processors Association, 1976). Most of the salt caverns utilized were solution mined especially for light hydrocarbon storage. These cavities are presently filled, however, other salt solution areas are present in the state that have the potential for petroleum storage. Solution well fields exist in four counties that are or were developed by salt and chemical companies for the salt (Figure 3).

These solution well fields are listed by Walters (1976) as follows:

American Salt Company
Sec. 15, T20S, R8W, Rice County

Carey Salt Company
Sec. 17, T23S, R6W, Reno County

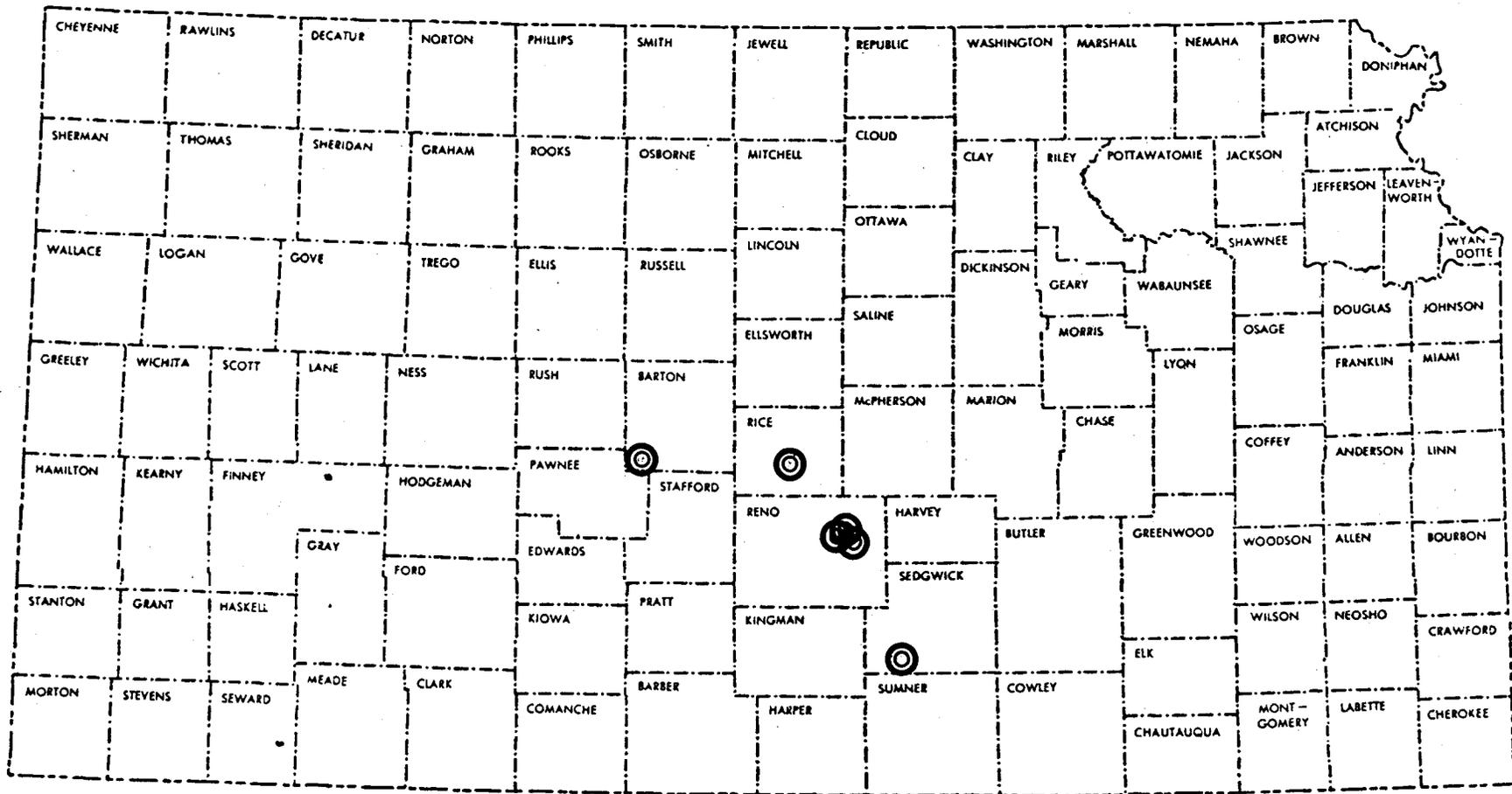
Cargill, Inc.
Sec. 19, T23S, R6W, Reno County

Morton Salt Company
Sec. 17, T23S, R6W, Reno County

Vulcan Materials Company
Sec. 20, T29S, R2W, Sedgwick County

In addition there is an abandoned field near Pawnee Rock in Barton County that was developed by the Carey Salt Company, later used by Cargill, Inc., and is located in Section 28, T20S, R15W.

From a discussion with Mr. Ralph O'Connor, District Geologist with the Kansas Department of Health and Environment, it was determined that several of the companies use the solution cavities previously formed for salt for disposal of undesirable salts. Some of the salts obtained other than sodium chloride are disposed in the cavities, therefore, these fields may not be available for petroleum storage purposes.



⊙ solution well field

Figure 3 -- Index map of solution well fields (adapted from Walters, 1976, p. 8).

However, Vulcan Materials Company near Wichita and Carey Salt Company at Hutchinson are not believed to be using the older cavities. In addition the Pawnee Rock solution field and the Cargill field at Hutchinson, where collapse of one cavity occurred, are now abandoned.

Possible evaluation of these cavities that are not being presently used for disposal could result in some potential petroleum storage areas. Disposal of the brine presently in the cavities could be made in the Arbuckle Group (Ordovician). Disposal of salt water in the solution mining operations and also oil field brines is commonly injected into the Arbuckle rocks.

No volumes of these solution areas are known by Mr. O'Connor or the author. However, it is anticipated that the operating companies have a close approximation of the volumes of these solution cavities.

Any company planning to store hydrocarbons either in the mines or the solution cavities must have a permit from Mr. Bruce Latta, Chief Geologist and Director of the Oil Field and Environmental Geology Section of the Kansas Department of Health and Environment, Topeka, Kansas, before the space can be used.

Potential Problems with Petroleum Storage in Salt Mines

Utilization of the Little River Mine by the Sentry Underground Storage Company for storage of propane and ethane indicates that the problem of storage of hydrocarbons can be safely handled. This mine had a collapsed shaft that was safely grouted and utilized, and the mine had to be drained of water that had filled the cavity since it was closed.

Salt water in oil field operation is commonly disposed into the Arbuckle rocks in many areas of the state and would be the most likely disposal zone for the mine water. This fact would have to be adequately checked before the mine is given further consideration for storage.

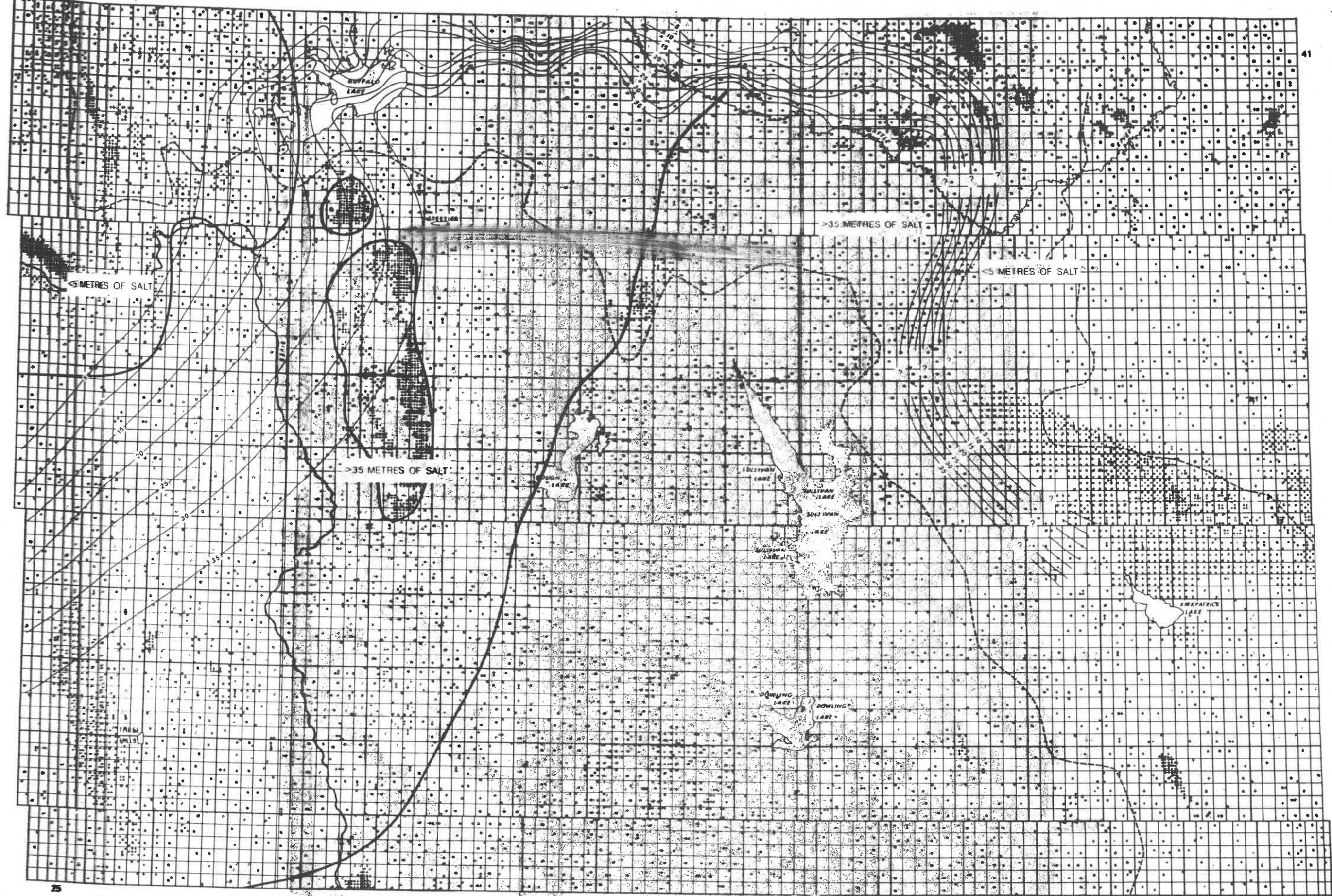
The floor of individual mines are not at a constant elevation, but vary within the mine. The elevation differences of the floor must be accurately determined either from existing mine survey data and maps or new surveys should be required. This information would be needed primarily for retrieval of the petroleum at time of utilization.

It might be possible to seal off areas of operating mines and utilize this space for storage. This type of operation would require good engineering to adequately key the seal into the mine wall to withstand the fluid pressures involved both at filling and in the static storage.

Environmental problems of transportation, unloading, injection, and retrieval of the petroleum are all factors which must be considered in this type of storage operation.

References Cited

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- Gas Processors Association, 1976, North American storage capacity for light hydrocarbons: Gas Processors Association, Tulsa, Oklahoma.
- Jewett, J.M., 1956, Kansas in Underground storage of liquid petroleum hydrocarbons in the United States: Interstate Oil Compact Commission, Oklahoma City, Oklahoma, p. 26-34.
- Lane, C.W., 1960, Geology and ground-water resources of Kingman County, Kansas: Kansas Geol. Survey Bull. 144, 174 p.
- Walters, R.F., 1976, Land subsidence in central Kansas related to salt dissolution: Solution Mining Research Institute, Inc., Flossmoor, Illinois, 144 p.



<5 METRES OF SALT

>35 METRES OF SALT

<5 METRES OF SALT

>35 METRES OF SALT

TARB

BUFFALO LAKE

SULLIVAN LAKE

SULLIVAN LAKE

SULLIVAN LAKE

DOWLING LAKE

DOWLING LAKE

ST. PATRICK'S LAKE

25

41

30

8



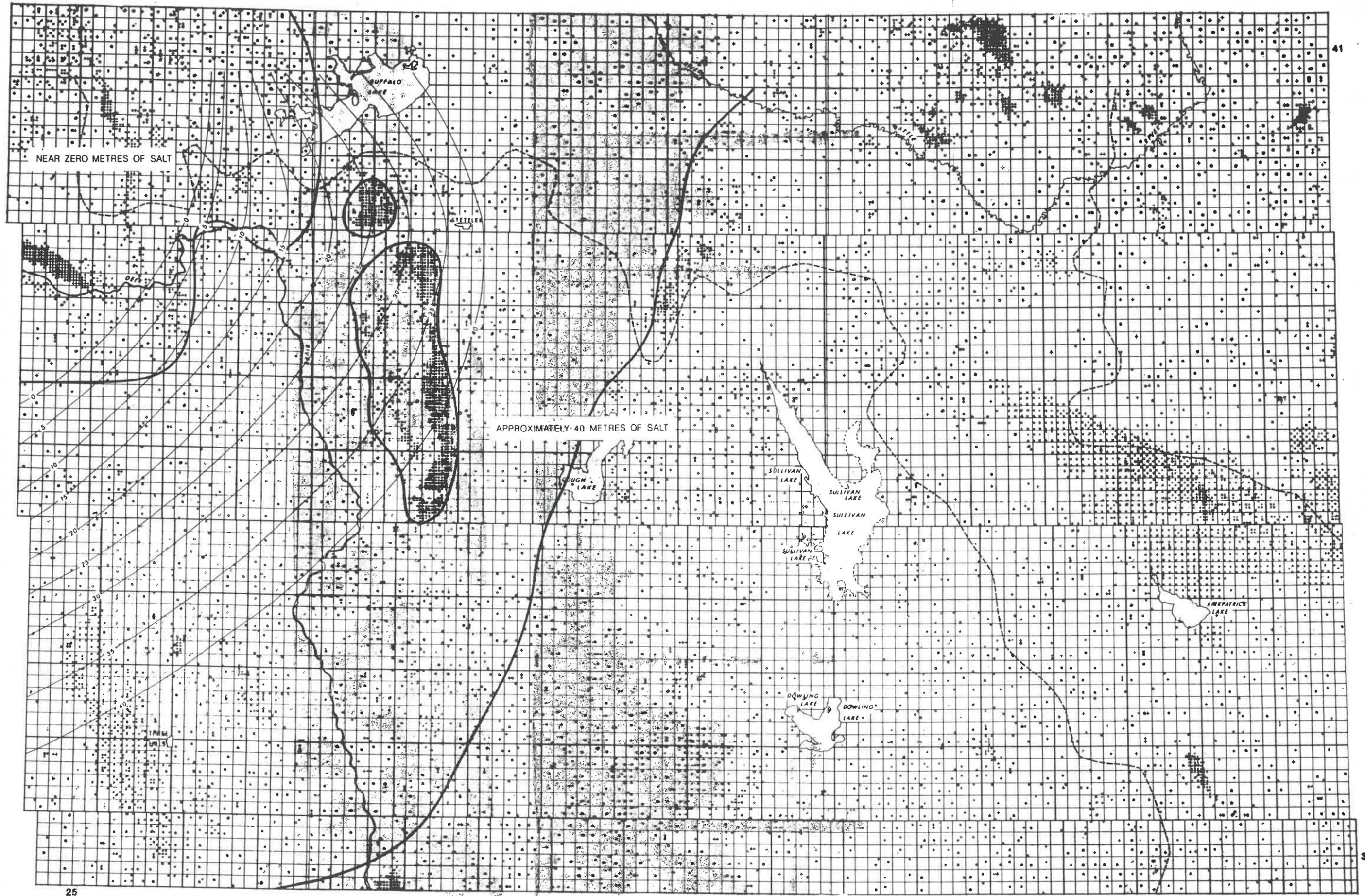


FIGURE 5



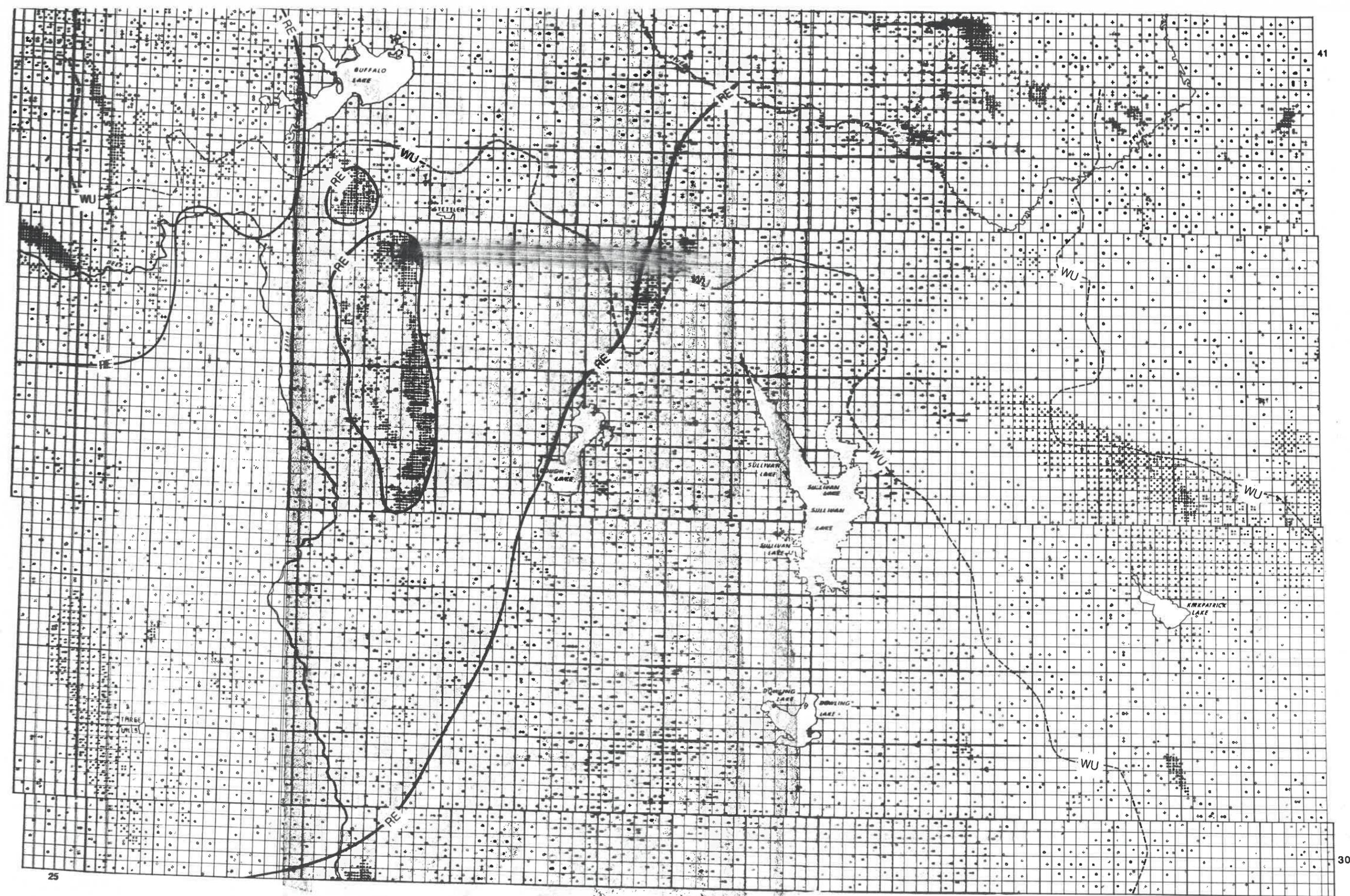


FIGURE 4



STATE OF KANSAS
ENERGY OFFICE

503 KANSAS, TOPEKA, KANSAS 66603



January 14, 1976

Dr. William W. Hambleton, Director
Kansas Geological Survey
The University of Kansas
1930 Avenue "A", Campus West
Lawrence, Kansas 66045



Dear Bill:

I know you are aware, as am I, of the fact that FEA Region VII is investigating the possibility of establishing a regional petroleum reserve, and probably and logically, are looking hardest at Kansas. It strikes me, that since the new Energy Act does little to reduce our dependence on foreign oil, there is a strong probability that strategic petroleum reserves as provided for in the Act will come to pass.

If FEA officials are going to attempt to promote regional reserves in Kansas, I believe we should have an opportunity to influence their efforts. In fact, I think it would be wise for us to do so. If you agree, I intend to ask the Regional Administrator to coordinate their investigations with the Geological Survey, at least as far as the technical aspects are concerned. In this manner, Region VII will benefit from your expertise and previous related work with regard to storage. At the same time, we will be able to exert our influence wherever appropriate for the benefit of the State. I have asked the Kansas Petroleum Council and KIOGA informally to give me an assessment of what the impact of the establishment of regional reserves might be to the petroleum industry in the State.

If funds are necessary to finance any support the Survey is called upon to render, I am sure it would be forthcoming from the FEA, and if not from them, perhaps my reimbursement funds could be used. Would you please give consideration to this matter? I will wait to hear from you before contacting Region VII.

Sincerely,

A handwritten signature in dark ink, appearing to read "Lamar Weaver, Jr.".

Lamar Weaver, Jr., Director

LW:fe

FEDERAL ENERGY ADMINISTRATION

WASHINGTON, D.C. 20461

7 JUN 1977

Mr. Lawrence L. Brady
Chief
Mineral Resources Section
Kansas Geological Survey
1930 Avenue "A", Campus West
The University of Kansas
Lawrence, Kansas 66044

Dear Mr. Brady:

Thank you for your letter of May 25, 1977, and the enclosed report entitled "Consideration of Kansas Salt Mines For Potential Storage of Crude Petroleum."

Your report is the most descriptive piece of work which we have on the salt deposits of Kansas and those which might be considered for crude petroleum storage.

In the event that we extend our storage program to accommodate specific regional requirements which cannot be satisfied by the present Gulf Coast sites, these salt deposits will be reviewed again for possible storage.

I appreciate having your report available to respond to inquiries regarding storage in Kansas.

Sincerely,



Richard E. Smith
Chief, Technical Support Division
Facilities Construction Office
Strategic Petroleum Reserve

KANSAS GEOLOGICAL SURVEY
Mineral Resources Section

1930 Avenue "A", Campus West
The University of Kansas
Lawrence, Kansas 66044
913-864-4991

June 13, 1977

MEMORANDUM

TO: W. W. Hambleton

FROM: L. L. Brady

SUBJECT: Letter covering salt storage of strategic petroleum

The attached letter is from Mr. Smith of the F.E.A. in answer to a letter and a copy of the salt report I sent him concerning strategic petroleum storage in Kansas that I compiled for the House Committee on Interior and Insular Affairs. While I was conducting the study, I contacted Acres American, an engineering consultant firm who had previously telephoned me about data on the salt mines for a report for the F.E.A. Acres contacted Mr. Smith who then contacted me since the report had not been released to the public yet. He did send me the brief portion on Kansas. Mr. Smith also sent a copy of the Committee Report on "Strategic Petroleum Reserve Plan" put out by the Senate Committee on Interior and Insular Affairs.

Since the F.E.A. report seemed so brief on Kansas, I sent Mr. Smith a copy of my report. From his reply, apparently he was glad to receive it.