CONSERVATION DIVISION
P. O. BOX 2088
SANTA FE, NEW MEXICO 87501

Form C-103
Revised 10-1-78

SANTA FE	
FILE	
U.S.G.S.	
LAND OFFICE	
OPERATOR	

5a. Indicate Type of Lease: State [ ] Fee [X]

5. State Oil & Gas Lease No.

SUNDRY NOTICES AND REPORTS ON WELLS

(DO NOT USE THIS FORM FOR PROPOSALS TO DRILL OR TO DEEPEN OR PLUG BACK TO A DIFFERENT RESERVOIR. USE "APPLICATION FOR PERMIT —" (FORM C-101) FOR SUCH PROPOSALS.)

1. OIL WELL [ ] GAS WELL [ ] OTHER: Storage Well

7. Unit Agreement Name

2. Name of Operator: Warren Petroleum Company

8. Farm or Lease Name: Eunice Plant #161

3. Address of Operator: Box 1197 - Eunice, New Mexico 88231

9. Well No.: LPG #2

4. Location of Well: UNIT LETTER 2 G 1887 FEET FROM THE north LINE AND 1320 FEET FROM THE east LINE, SECTION 3 TOWNSHIP 22S RANGE 37-E NMPM.

10. Field and Pool, or Wildcat: Mark

15. Elevation (Show whether DF, RT, GR, etc.)

12. County

16. Check Appropriate Box To Indicate Nature of Notice, Report or Other Data

NOTICE OF INTENTION TO:

- PERFORM REMEDIAL WORK [ ]
- TEMPORARILY ABANDON [ ]
- PULL OR ALTER CASING [ ]
- PLUG AND ABANDON [ ]
- CHANGE PLANS [ ]
- OTHER [ ]

SUBSEQUENT REPORT OF:

- REMEDIAL WORK [ ]
- COMMENCE DRILLING OPNS. [ ]
- CASING TEST AND CEMENT JOB [ ]
- OTHER [ ]
- ALTERING CASING [ ]
- PLUG AND ABANDONMENT [X]

17. Describe Proposed or Completed Operations (Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work) SEE RULE 1103.

1. Pump 100 barrels fresh water down casing string.
2. Move in and rig up pulling unit. Pull 2 7/8" tubing out of hole.
3. Run bit and scraper on 2 7/8" rental tubing to 1450' depth. Pull out of hole.
4. Run cast iron bridge plug in hole on 2 7/8" rental tubing. Set bridge plug at 1400'.
5. Spot 100' cement plug on top of C.I.B.P. Pressure 5" casing to 500# for thirty minutes circulating hole with abandonment mud.
6. Pull tubing to required depth to spot second plug, approximately 490'.
7. Pump 100' to 400' of cement for second plug.
8. Spot 50" to 100" surface cement plug. Install marker.

18. I hereby certify that the information above is true and complete to the best of my knowledge and belief.

SIGNED ________ TITLE Plant Manager DATE 6-12-80

APPROVED BY ________ TITLE ________ DATE ________

CONDITIONS OF APPROVAL, IF ANY:

V. FELL
GULF OIL ; MARK LPG #1

DEVELOPMENT AND OPERATION

OF THE

SOLUTION SALT CAVITY LPG STORAGE WELL

EUNICE GASOLINE PLANT

LEA COUNTY, NEW MEXICO

JUNE, 1952

GAS AND GASOLINE DEPARTMENT
FORT WORTH PRODUCTION DIVISION
GULF OIL CORPORATION

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Figure 2 (Piping Plan), and Photographs Omitted.

I. PURPOSE

During the last two years the subject of storage of LPG in salt cavities has been of increasing interest to those engaged in the production, transportation, and marketing of the volatile liquid hydrocarbon products, butane, propane, and butane-propane mixtures. The subject has, in general, been well covered in the trade journals and technical meetings.

Gulf, during the latter part of 1951, developed and placed into operation its initial underground storage project -- the solution salt cavity LPG storage well at the Eunice Gasoline Plant, Lea County, New Mexico.

It is the purpose of this report to present the detailed information on the development and operation of this project.

II. SUMMARY AND CONCLUSIONS

The total estimated costs of the solution salt cavity storage project at the Eunice Gasoline Plant, Lea County, New Mexico, is $45,238, of which amount $24,456 was spent for drilling and completing the well, and $20,782 was spent on other facilities incidental to operation of the project.

Rotary drilling was employed and the well was drilled and completed in eight days. The well was cased with 1440' of 9-5/8" O.D. casing which was set and cemented in anhydrite. A string (1991') of 3-1/2" O.D. tubing was suspended in the well one foot off bottom.

The storage cavity has been developed by pumping water down the tubing string into the cavity where it contacts the rock salt formation in the 551' section between the casing seat and bottom of the tubing string. In general, maximum enlargement has occurred at the bottom of the well and the diameter of the cavity tapers to an estimated minimum diameter at the top of the cavity. There has been no evidence of caving in the well, but ledges or shelves in the cavity walls are indicated. In dissolving the rock salt to make the cavity, about eight barrels of water were circulated per barrel of cavity made.

In the initial filling and displacement operations, essentially 100% of the propane stored in the cavity was recovered. Operation of the well has proven very simple and the project is, in our opinion, highly successful. From the standpoint of additional plant working-storage, the project has already proven that it was well worth undertaking. In addition to its inestimable value as additional working-storage, this underground storage project should in the future enable the storage and subsequent sale of considerable quantities of propane that would otherwise have been wasted.

III. INTRODUCTION

The Eunice Gasoline Plant is located on Gulf's "Mark" Fee Lease which is a 160-acre tract comprising the NE/4 of Section 3, Township 22 South, Range 37 East, Lea County, New Mexico. It is a high pressure (850 psi) absorption type natural gasoline plant designed to process 55 million cubic feet of natural gas daily for the recovery of natural gasoline, butane, and propane.

The Plant was built by the Tulsa Division and full scale gas processing operations commenced in August, 1949. The facilities installed for storing liquid products consisted of six 1000 barrel tanks for natural gasoline, six 1000 barrel tanks for butane and eight 1000 barrel tanks for propane. Liquid products recoveries while operating at maximum gas handling capacity are as follows:

26 pound Reid Vapor Pressure Natural Gasoline	800 to 1400 Bbls/Day
Commercial Butane	300 to 500 Bbls/Day
Commercial Propane	1400 to 1600 Bbls/Day

During the summer of 1950, considerable difficulty was experienced in marketing all of the LPG products produced in plants in the West Texas and New Mexico Area, and most of the gasoline plant operators in those areas found it necessary to either recover and then burn unmarketable LPG or to reduce their recoveries of such products and allow these liquefiable hydrocarbons to remain in the vapor state and be disposed of with the residue gas. In either case, such action was, and is, very undesirable from the standpoint of both economics and conservation; and prior to the transfer of the New Mexico District to the Fort Worth Division, the Tulsa Division began a study to investigate various means for the disposition or storage of butane and propane from the Eunice Plant.

In a comprehensive report dated December 12, 1950, and entitled, Disposition of LPG Production at Gulf's Eunice Gasoline Plant, the Engineering Division of Tulsa's Production Department presented the factual data and results of their study. This study presented conclusive evidence that the best possibility for alleviating the LPG storage problem at the Eunice Plant was to utilize undergound storage created by dissolving a cavity in the Salado formation.

In May, 1951, the Fort Worth Production Division requested authority to drill and equip a well and dissolve a cavity of approximately 25,000 barrels capacity for the storage of propane at the Eunice Gasoline Plant. This undergound storage project was recommended for the following reasons:

1. To provide storage for Eunice Plant propane during the summer months when the market is weak and thereby alleviate the necessity for either reducing production or burning propane.

2. To provide sufficient day-to-day working storage for the plant because the existing propane surface storage capacity was inadequate from the standpoint of operating and marketing flexibility.

3. To gain first-hand experience and data for the Company in developing and operating a salt cavity storage project, which experience and data might be applicable and beneficial in other areas where underground storage projects are contemplated.

After receiving management approval of the project and prior to actual commencement of drilling, the Law Department made an investigation of the legal matters incident to the project and rendered the following opinions:

1. There were no legal bases upon which royalty owners could object to the drilling and operation of the storage well.

2. Since the salt that would be produced to the surface would not be commercially used or disposed of by Gulf, the royalty owners' rights would not be infringed upon and it would not be necessary to pay any royalty on the salt.

3. No royalty on the products stored would be due the owners of the royalty interests in the tract on which the storage well would be located because of the use of the tract for underground storage; and it was not deemed necessary to procure any agreement from the royalty owners with regard to use of the tract for an underground storage project.

4. Although the State of New Mexico has no statutory regulations or requirements concerning LPG storage wells, authorization from the State's Conservation Commission should be obtained for the drilling of the well.

IV. MECHANICS AND COST OF DRILLING AND COMPLETING THE FACILITY

For the drilling of the well a printed form rotary rig drilling contract was entered into with Baker and Taylor Drilling Company of Amarillo, Texas, for the drilling of a well for LPG storage. The contract specified that the hole would be drilled on a footage rate of $4.50 per foot from the surface to approximately 2000 feet, but not to exceed a depth of 2050 feet on the footage rate and all other work performed by contractor would be "day work" at a rate of $425 per day or $17.71 per hour. It was also provided that the contractor would set approximately 300' of 13-3/8" casing and approximately 1400' of 9-5/8" casing and also do "rat-holing" with a bit of reduced size.

The following is a chronological account of the drilling and completion data:

7/2/51 Started rigging up at 1:00 PM. Well location 2365' from the North line and 1320' from the East line of the NE/4 of Section 3, Township 22 South, Range 37 East, Lea County, New Mexico. Distance from top of Kelly Drive Bushing to top of ground 13'.

7/3/51 Spudded 17-1/2" hole at 2:00 AM. Made 326'. From 0 to 139' was surface sand and 139' to 326' was red shale.

7/4/51 Ran 10 joints (308.47') of 13-3/8" O.D. 8 round threads 48# H-40 new SS casing with Texas pattern guide shoe. Set and cemented 13-3/8" at 320' with 375 sacks of regular bulk cement -- plug at 294' cement circulated and the job was completed.

7/5/51 Tested casing with 1000# pressure and there was no drop in pressure. Drilled plug and cement at 3:00 AM and then the casing seat was tested with 700# pressure and there was no drop in pressure.

7/6/51 With 12-1/4" bit drilled to 1310' where salt and anhydrite were found. Changed to 8-3/4" bit and commenced drilling the anhydrite.

7/7/51 Drilled with 8-3/4" to 1500'. Anhydrite bed for locating 9-5/8" casing seat was found at 1443' - 1454'. Changed to 12-1/4" bit and reamed the 8-3/4" hole from 1310' to 1450'. Ran a Dowell Caliper Survey to determine the amount of cement to be circulated. Ran and set 9-5/8" casing as follows:

1500.00'	Bottom of hole
50.15'	Seated off bottom
1449.85'	
1.00'	One 9-5/8" O.D. 8 Rnd. Thd. Larkin Guide Shoe
1448.85'	
30.00'	One joint 9-5/8" O.D. 8 Rnd. Thd. 36# Grade J-55 SS National Casing
1418.85'	
1.57'	One 9-5/8" O.D. 8 Rnd. Thd. Larkin Float Collar
1417.28'	
1407.43'	45 joints 9-5/8" O.D. 8 Rnd. Thd. 32.30# Grade H-40 SS National Casing
9.85'	
9.85'	Distance from top of Kelly Drive Bushing to top of 9-5/8" casing

Casing cemented with 745 sacks of regular 2% Howcogel bulk cement. Ran three B&M centralizers at 1445', 1330' and 1247'. The job was completed at 3:45 PM.

7/8/51 Tested 9-5/8" casing with 1000# pressure for 1/2 hour and there was no drop in pressure.

7/9/51 Drilled the plug at 3:00 AM and tested the casing seat at 750# pressure and there was no drop in pressure. Drilled with 8-3/4" bit to 2000' and after circulating the hole for one hour, ran Dowell Caliper Survey from 1450' to 2000' to locate ledges and determine the shape and size of the hole.

7/10/51 Circulated hole for 12 hours with fresh water and then ran and set string of 3-1/2" tubing as follows:

2000.00'	Total Depth
.99'	Distance off bottom
1999.01'	
19.70'	1 joint 3-1/2" O.D. 8 Rnd. Thd. EUE 9.30# Grade N-80 SS National Tubing with bottom orange peeled and bottom foot perforated with twelve 1/2" holes.
1979.31'	
1971.21'	63 joints 3-1/2" O.D. 8 Rnd. Thd. EUE 9.30# grade N-80 SS National Tubing
8.10'	
8.10'	Distance from top of Kelly Drive Bushing to top of 13-3/8" casing

Installed Gray wellhead with slick-joint type tubing hanger and then circulated with fresh water one hour through the casing and one hour through the tubing. The rig was released at 10:00 PM on 7-10-51.

The breakdown of the cost of drilling and completing the well is as follows:

1. Outside Work

Rotary Drilling and Day Work	$ 9,721
Cementing Casing	952
Caliper Surveys	334
Grading and Leveling Road, Building Pits, Filling Pits, etc.	624
Installing Celler (including materials)	300
Outside Shop Work and Welding and Tool Rental	241
Sub-total Outside Work	$12,172

2. Materials

13-3/8" Casing	$ 1,350
9-5/8" Casing	4,183
Guide Shoes, Float Collars, etc.	140
3-1/2" Tubing (Est'd)	1,407
Gray Well Head Assembly and Casing Housing	2,000
Field Fabricated Well Head Manifold	1,600
Sub-total Well Materials	$10,680

3. Miscellaneous Costs

Company Labor, Warehouse Handling, Transportation and Supervision	$ 1,604

4. Estimated Total Cost of Drilling and Completing Well $24,456

After the drilling rig was released and moved off location the well was ready to be connected-up for enlarging the salt cavity. The Gas and Gasoline Department assumed supervision and responsibility for the project at this point. A good second-hand Type 1550, 5" x 10" Gaso-Portable Pump with Type BHT Buda gas engine drive was procured and set near the well. With a field fabricated 4" manifold mounted on the wellhead, connections were available for circulating into the tubing and out the casing or into the casing and out the tubing. Figure No. 1 is a simplified drawing of the LPG Well showing the well-head hook-up and pipe in the well.

For water to circulate through the well a 4" line was laid from the Gaso pump to the gasoline plant's water supply and connections were made to the suction and discharge lines of existing water pumps so that water could be pumped from plant water storage to the Gaso pump if flow by gravity did not provide proper suction for the pump. It developed that the well location was several feet lower than the plant site and it was not necessary to use the plant's water pumps. The gravity system worked so well that a connection was made to the plant's waste water disposal pond and waste water would flow to the Gaso pump where it could be utilized for enlarging the storage cavity. Because of the considerable quantity of plant waste water available, it was only occasionally necessary to use water from the plant water storage tanks.

In order to dispose of salt water from the well an earthen pond with a bottom area of approximately 40,000 square feet was dug near the well location. A 4" line was run from the wellhead to the salt water disposal pond and an orifice meter was installed on the line for measuring the salt water.

For handling propane, a 4" line was laid to connect the propane storage tanks in the plant yard to the Gaso pump. Connections were also made so that the existing propane loading pump in the surface storage area could be used to pump propane to the Gaso pump, however, there was sufficient pressure on the propane storage tanks to enable delivery of propane to the Gaso pump and it was not necessary to use the plant's pump. Two 2-1/2" lines were laid and connections made so that if necessary propane withdrawn from underground storage could be delivered to the plant dehydrators or fractionation equipment.

It was contemplated that high pressure plant residue gas might ultimately be used for displacing propane from the storage cavity so a connection was made within the plant yard to enable delivery of 850 psi gas through the 4" water line to the well.

Figure 2 is the piping plan showing the complete installation and the following is a summary of the expenditures for facilities over and above the cost breakdown previously given for the drilling and completing of the well.

1. Material and Equipment

Line Pipe	$ 3,849
Gaso Pump and Buda Engine	1,937
Valves, Fittings, Meters, Regulators	5,019
Paint, Lumber, Wire, Cement, etc.	2,460
Sub-Total	$13,265

2. Outside Work

Shooting and Digging and Fencing Earthen Salt Water Pond	$ 953
Laying Lines, Installing Pump, Setting Meters, Connection Work, Painting, etc.	$ 6,564
Sub-Total	$ 7,517

3. Total Expenditure for Facilities Other than the Well $\underline{\underline{\$20,782}}$

The amount of $20,782 expended for facilities for enlarging the cavity, storing brine and handling propane in and out of the storage well, when added to the $24,456 expended in drilling and completing the well, represents a grand total expenditure of $45,238 for the project. The total cost was somewhat higher than originally contemplated because of the necessity of substituting materials in several instances, and because of material shortages at that time. For example, 3" pipe and fittings would have been satisfactory, but were not readily available so 4" pipe and fittings were used, and in addition to the higher material costs, as a result of the substitutions, the installation costs were also increased.

V. ENLARGEMENT OF THE CAVITY

On the completion of the well and all the auxiliary facilities, the circulation of water for the enlargement of the salt cavity was commenced. It was originally planned to dissolve sufficient salt to give an underground storage capacity of approximately 25,000 barrels.

The water circulation on a continuous basis was begun on July 17, 1951, initially utilizing fresh water from the gasoline plant's raw water storage. All volumes of water pumped into the well and brine leaving the well were measured with standard orifice meters and accurate data were taken throughout the enlargement phase.

With a standard grade Salometer (hydrometer) having a scale for the direct reading of percent of saturation of an aqueous solution of salt brine, periodic tests were made on the brine leaving the well. These tests were used as control tests for maintaining the optimum circulation rate and also for calculating the storage capacity developed each day.

Water circulation during the initial enlargement phase expressed as barrels per day, varied from a minimum of 950 barrels the first day of circulation to a maximum of 3720 barrels on August 5, 1951. Shortly after commencing the circulation of water, it was noted that the rate of circulation, within the range that the water circulating pump was capable of operating, did not appreciably affect the percent of saturation of the brine leaving the well. It was also noted that small amounts of nitrogen were produced during the washing operation. After the first day of water circulation, the percentage of saturation was maintained within the range of approximately 85% to 95%. Water circulation was of necessity curtailed somewhat during the first week of cavity enlargement operations because of both the limited capacity of the salt water disposal pond to soak up the salt water and the tendency of the salt water to seep through the levee around the pond when the pond was filled above ground level.

All water circulation and enlargement of the cavity was conducted by pumping fresh water down through the tubing and flowing the salt water up and out of the annular space between the tubing and casing. We were of the opinion that by following this procedure there would be less likelihood of enlarging the cavity at the top of the hole where the casing was cemented than there would be if the water were circulated down the casing and the fresh water contacted the salt just below the casing seat. It was believed that by discharging the fresh water out of the tubing at the bottom of the well, lateral diffusion and travel of the fresh water upward in contact with the cavity walls would, at least during the initial stages of enlargement, result in the washing out of a cavity with maximum diameter at or near the bottom of the well and

VI. DETERMINATION OF APPROXIMATE SHAPE OF STORAGE CAVITY

As previously mentioned in the section of this report covering drilling and completion data, the drilling contractor circulated fresh water below the casing seat in the 8-3/4" well bore for 12 hours before running the string of tubing and then a Dowell Caliper Survey was run to locate ledges and enable determining the shape and size of the hole. This caliper survey indicated that by the preliminary washing action maximum enlargement of the original 8-3/4" diameter well bore had occurred approximately 30 to 40 feet below the casing seat and from that depth, where the diameter was a maximum of 16 to 17 inches, there was a gradual tapering of the hole diameter to a depth of approximately 1860 feet where the enlargement of the original well bore was negligible.

For the determination or estimation of the relative shape of the storage cavity, the procedure followed and data recorded were as follows:

1. Propane was pumped into the casing of the well in measured volumes and brine was displaced out the tubing.

2. The average percentage saturation of the brine displaced during the injection of each volume of propane was determined by physical tests.

3. After the injection of each volume of propane, the well-head static pressures on the annular space and on the tubing were recorded.

Using these test data, the well completion data and the specific gravity of propane, the depth of the propane-brine contact in the storage cavity after the injection of each volume of propane was calculated.

The general equation used in the calculation of the depth of the propane-brine contact was as follows:

$$P_1 + ax + by = cy + P_2$$

where: P_1 = Static Pressure on Annular Space — psi

P_2 = Static Pressure on Tubing — psi

x = Pressure exerted by a vertical volumn of propane per foot of column psi/ft. (For Eunice propane of specific gravity = 0.505, x = .219) minimum diameter at the casing seat. By utilizing test data obtained during the filling of the cavity with propane subsequent to the washing operation, the diameter of the hole was calculated, and it was found that the hole increased in diameter from minimum diameter at or just below the casing seat to maximum diameter at or near the depth at which the open end tubing string was suspended above the original bottom of the well. The determination of the approximate shape of the cavity is discussed in a subsequent section of this report.

On August 14, 1951, it was decided to terminate the circulation of water and the initial enlargement phase in order to utilize the well for the storage of propane because the propane market had temporarily slackened and surface storage or tank cars were not available. The following is a tabulation of the well statistics at the end of the initial enlargement phase:

Total Water Circulated	75,895 Bbls.
Total Calculated Storage Capacity including Annular Space	9,489 Bbls.
Actual Storage Capacity by Measurement of Propane Required to Fill Cavity and Annular Space	9,525 Bbls.

During the period that the LPG well was being used for working storage, the cavity was further enlarged by each injection and withdrawal cycle.

The well was completely emptied of propane in December, 1951, and water circulation for cavity enlargement resumed in January, 1952. At the writing of this report (June, 1952) the calculated storage capacity of the well is 28,666 barrels and water circulation for enlargement has been terminated. To make this storage capacity, 220,521 barrels of water were circulated. The water circulation and storage capacity statistics for the project are portrayed graphically on Figure No. 3.

y = Pressure exerted by a vertical column of brine per foot of column -- psi/ft. (specific gravity corresponding to % saturation x .433)

a = Distance from top of LPG well to propane - salt water contact in storage cavity -- feet.

b = Distance from bottom of tubing string to propane-salt water contact -- feet.

c = Length of tubing in well -- 1991 feet = a ≠ b

By substituting the numerical constants in the general equation and expressing the term "b" in terms of "a", the simplified expression is as follows:

$$a = \frac{P_1 - P_2}{y - x} \quad \text{or} \quad a = \frac{P_1 - P_2}{y - 0.219};$$

and if the tubing at the wellhead is open to atmosphere, as was generally the case, the term P_2 is ommitted from the simplified formula.

The following is a tabulation of the initial test data and calculated depths of the propane-brine contact after the pumping of each volume of propane into the cavity for the initial filling of the well when the estimated storage capacity of the well was approximately 9,489 barrels.

Test No. 1

Propane Injected Cumulative Bbls.	Static Pressure on Annular Space Psig	Tubing Pressure Psig	Sp. Gr. of Brine	Calculated Depth of Propane Brine Contact Feet
96	-	-	1.106	1440 Casing Seat
1000	440	15	1.106	1635
2000	500	25	1.163	1661
3000	550	25	1.169	1829
4000	560	14	1.181	1870
5000	585	14	1.186	1936
5995	580	0	1.193	1946
6990	589	0	1.195	1977
9525	740	170	1.199	Cavity full, propane in tubing string

During April, 1952, after approximately 26,214 barrels of storage had been developed, 7,527 barrels of propane were injected and another set of data were taken for estimation of the cavity shape. These data and the calculated propane-brine contacts were as follows:

Test No. 2

Propane Injected Cumulative Bbls.	Static Pressure on Annular Space Psig	Tubing Pressure Psig	Sp. Gr. of Brine	Calculated Depth of Propane Brine Contact Feet
96	-	-	1.138	1440 Casing Seat
1175	460	0	1.138	1679
2755	510	0	1.165	1789
3882	538	0	1.175	1855
4463	546	0	1.182	1863
6166	555	0	1.184	1888
7527	565	0	1.189	1909

To estimate the general shape of the cavity and depict the shape graphically it was assumed that each volume injected occupied a space in the cavity which had the shape of a frustrum of a right cone. The radius of the top frustrum was assumed to be the radius of the casing and then using the distances between propane-brine contacts as the altitudes for each frustrum, the radius of the base for each frustrum was calculated. The calculation of the radius of the base involves the use of the Quadratic Equation. Figure 4 is a graphical presentation of the approximate shape of the hole, using the data from test No. 2. It will be noted that, in general, the diameter increased with depth below the casing seat but apparently there were sections of the salt formation where dissolution had been accelerated due to either the physical or chemical nature of such sections and there were other sections where non-soluble or low solubility material resulted in ledges or shelves in the cavity.

VII. INJECTION AND DISPLACEMENT OF PROPANE

As mentioned in a preceding section of this report, the propane must be pumped into the well. The maximum capacity of the injection pump, with 3" liners and cups, is approximately 2000 barrels per day. Suction pressure on the pump when injecting propane was 175 psig, which is the pressure on the surface storage tanks plus the liquid head due to difference in elevation between the plant's surface storage tanks and the pump intake.

From the initial filling operation, it was found that the indication of full storage is a stoppage of brine flow out the tubing and a rapid increase in the injection pump discharge pressure. When this occurred, it was reasoned that the propane-brine contact in the cavity had reached the bottom of the tubing string and the propane had started rising in tubing string and on reaching the height where the pressure exerted by the brine column was insufficient to keep the propane in the liquid state, flash vaporization had occurred and the brine had frozen and plugged the tubing.

On reversing the flow and allowing water to gravity into the tubing string, essentially all of the propane was displaced from the cavity. To completely empty the annular space, by displacement with water, required the use of the pump and a final discharge pressure of 315 psig. During the initial test operation, approximately 1500 barrels were flowed from the well in an eight-hour period; and at this flow rate, a slight vacuum on the tubing was noted. Such a flow rate maintained over a 24-hour period would furnish all the propane the tank car and truck loading facilities could handle.

All tests conducted to-date, to determine the recovery of propane from the cavity, have indicated essentially 100% recovery, however, in only the initial test was the cavity completely filled, and at that time the capacity of the cavity was slightly less than 10,000 barrels. The other tests, conducted after the cavity capacity exceeded 25,000 barrels, involved the injection and displacement of 7,535 barrels and 5608 barrels, respectively. It is possible that with considerable enlargement of the cavity, traps or pockets could be created that would cause trapping of LPG and reduce recovery. Any dissolution or caving above the casing seat would result in trapped material.

The propane recovered by water displacement required no further processing or dehydration in order to meet sales specifications.

Tests are to be conducted on the displacement of propane with high pressure residue gas as soon as sufficient propane is available for displacing the brine and filling the cavity. The available gas pressure is not sufficient to displace the brine and, as of the writing of this report, marketing conditions have been such that there has not been sufficient propane readily available to enable conducting this test.

VIII. ECONOMICS

The estimated total expenditure on this underground storage project has been $45,238. Assuming that the ultimate storage capacity is 30,000 barrels, this expenditure represents a cost of $1.51 per barrel of storage. The estimated cost of steel surface storage tanks for propane is $16.00 per barrel and only three 1,000-barrel propane tanks (total effective storage 2400 bbls.) would have cost approximately $48,000 or considerably more than this solution salt cavity storage project which has more than ten times as much effective storage capacity and can be further enlarged with little additional expenditures.

Operating and maintenance expenses for this underground storage project are negligible because it is adjacent to the gasoline plant and operated and maintained as a part of the plant.

The "pay-out" period on this project will depend upon the quantity and price of propane stored and sold that could not have been stored and sold had this underground storage not been available. At a price of 3.5¢ per gallon, the revenue from the storage and sale of 30,774 barrels of propane would equal the cost of the project. It is estimated that approximately 15,000 barrels of propane have already been stored and sold, and about half of the cost of the project has been recovered.

Figure No 1

EUNICE PLANT L.P.G. STORAGE WELL