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Petroleum Storage Potential of the Chacahoula Salt Dome, Louisiana

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PETROLEUM STORAGE POTENTIAL OF THE CHACAHOULA SALT DOME, LOUISIANA

Preliminary Site Characterization

by

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Amherst, New York

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ABSTRACT

Chacahoula salt dome, eight miles southwest of Thibodaux, LA, could be solution mined to create caverns for storing as much as 500 million barrels (MMB) of crude oil, should the Strategic Petroleum Reserve (SPR) require additional storage volume. The salt mass geometry is confirmed by more than 50 oil wells, and also from previous exploratory drilling for sulphur. Top of salt occurs at -1100 ft, and some 1300 acres exist within the -2000 ft salt contour. Frasch mining of 1.35 million long tons of sulphur caused the surface to subside about one foot on the northeastern part of the dome. Creep-induced subsidence averaging ~2.7 ft over 30 yrs is estimated for a 200 MMB cavern array, which would require perimeter diking to control localized perennial flooding. Earthquakes approaching intensity MM 6 have occurred nearby and are expected to recur on the order of ~100 yrs but would not affect cavern stability. Additional study of brine disposal methods and hurricane surge probabilities are needed to establish design parameters and cost estimates for storage.

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Introduction and Purpose

Chacahoula salt dome, near Thibodaux, LA, was identified in 1975 by the Federal Energy Administration (now DOE) as one of five sites for detailed prototype analysis of crude oil storage feasibility for the Strategic Petroleum Reserve (SPR). When Capline/St. James sites were chosen for the SPR, Weeks Island and Bayou Choctaw salt domes were the only southeastern Louisiana sites chosen for storage. The site selection process is described in the Environmental Impact Statement issued in 1978 [Ref. 1]. The basic dome geometry that was used to assess the potential for cavern emplacement was obtained from the June, 1961, publication of the New Orleans Geological Society. These data are now nearly thirty years old and new wells have made the earlier maps and assessments obsolete.

In 1988 Congress asked DOE to examine options for enlarging the SPR storage capacity from the presently authorized 750 million barrels (MMB) to one billion barrels (1000 MMB) [Ref. 2]. Chacahoula dome once again emerged as a possible candidate for cavern storage. An examination of well logs showed that some revisions to the earlier maps were needed, especially those showing salt contours, and thus suitable cavern areas.

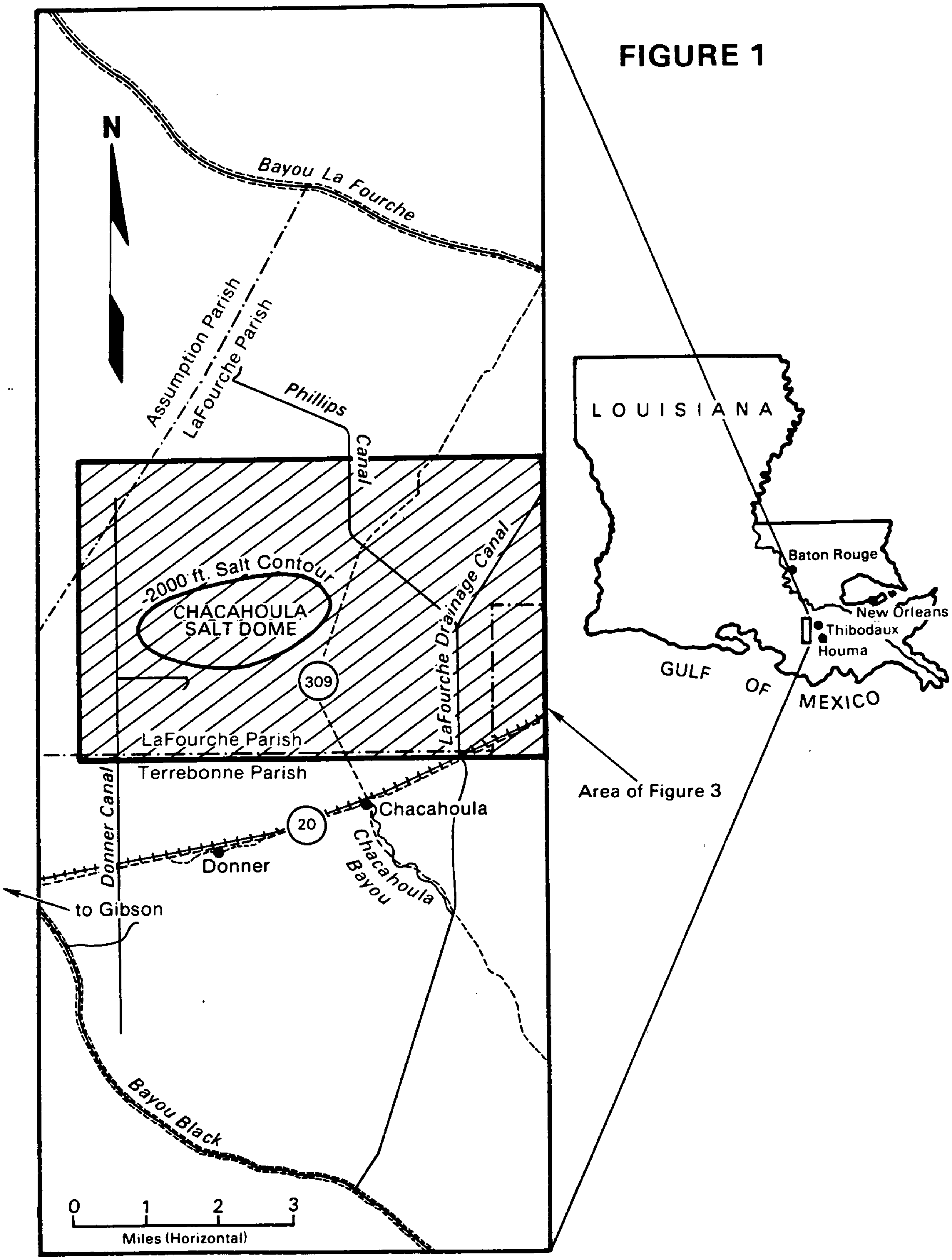
This report summarizes the principal attributes which would affect using this dome for oil storage in leached caverns. It is not as rigorous as the site characterization that was conducted for existing sites, but rather a validation of the potential. In the event that Congress elects to expand the SPR, the essential information about the Chacahoula dome will be available to make rational decisions concerning cavern development and storage.

General Information and Site History

<u>Location</u>

Chacahoula dome is located in northwestern LaFourche Parish, approximately 72 mi south and east of Baton Rouge, and 66 mi west and south of New Orleans (Fig. 1). It is three miles northwest of the crossroads village of Chacahoula and is immediately west of State Route 309. The dome is 20 mi south of the St. James terminal on the Mississippi River and 40 mi north of the Gulf of Mexico. The pipeline route identified in Ref. [2] extends almost due south some 57-60 mi across swamp and marshland to an offshore point at 30 ft depth, a substantial distance for brine disposal. This distance could be a major impediment to discourage use by the SPR; however, there may be ways to reduce this concern, and these are given particular attention in this report.

FIGURE 1


N
Bayou La Fourche
Assumption Parish
LaFourche Parish
Phillips Canal
-2000 ft. Salt Contour
CHACAHOULA SALT DOME
309
LaFourche Drainage Canal
LaFourche Parish
Terrebonne Parish
Donner Canal
Chacahoula
20
Donner
Chacahoula Bayou
to Gibson
Bayou Black
0 1 2 3
Miles (Horizontal)
Area of Figure 3
LOUISIANA
Baton Rouge
New Orleans
Thibodaux
Houma
GULF OF MEXICO

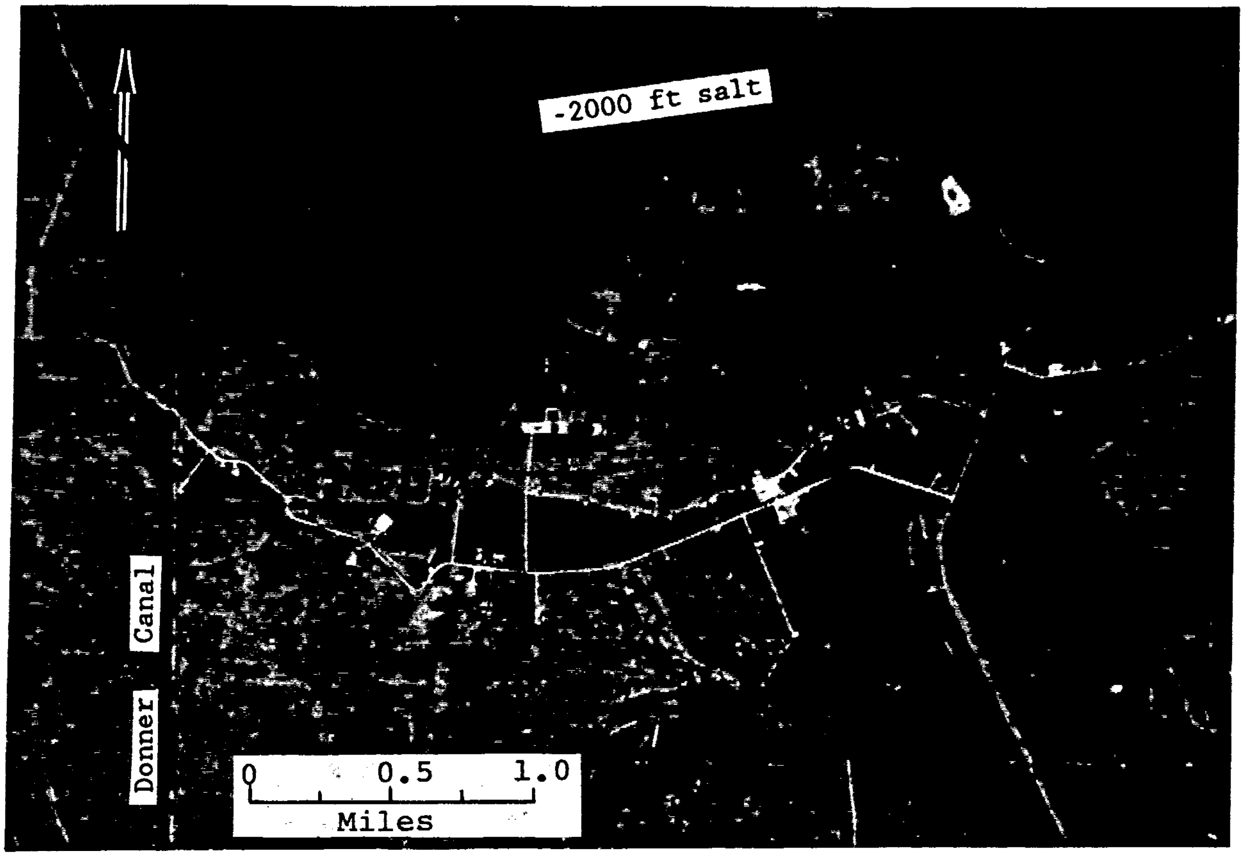
Surface Features

The dome shows practically no surface expression, varying little from the 6-7 ft elevation, and is unlike many other domes in southern Louisiana that have positive relief or other dome features such as ponds. Bubbling Bayou crosses the dome, betraying the presence of gas seeps associated with salt intrusion. Bald cypress, water tupelo, and emergent macrophytes such as duckweed are typical of the swampland. Abundant bird species, small fur-bearing animals, fish, and aquatic species inhabit the area. A typical view of the swampland forest is shown in Fig. 2; topography is shown on the map in Fig. 3.

A single road to the former sulphur mining area crosses part of the dome; shell-gravel roads flank the southern and western perimeter and provide access to oil and gas wells. The Donner barge canal traverses the western perimeter and provides interior access from rail connections several miles south. The Terrebonne-Lafourche drainage canal is about two miles east of the site and also connects with the Southern Pacific Railroad. These canals have abundant water, but very intensive withdrawals could be environmentally questionable. The more significant raw water source for leach operations is Bayou Lafourche, seven miles northeast of the dome. The Texas Brine Company operates three brine caverns along the south-central portion of the dome; this operation is accessed from the southern perimeter road. The area along the northeastern part of the dome was previously mined for sulphur and appears to be somewhat wetter and lower in elevation, probably reflecting ponding caused by subsidence.

Previous Activity

Chacahoula salt dome was discovered in 1926 by the Gulf Oil Corporation using refraction seismic data. Exploratory drilling penetrated caprock the following year, and salt was confirmed in 1930 in Gulf Well No. 25 Starks [Ref. 1]. The production of hydrocarbons, brine, and sulphur are the principal extractive operations that have taken place at the dome. The latter occurred between 1955-62 and 1967-70 and involved 1.35 MLT production. This amount of sulphur was calculated to represent a 0.8 ft average thickness over the area involved; consequently, little surface subsidence has occurred. The area involved is subject to ponding and it seems likely that a foot or more of subsidence has taken place locally. Texas Brine Company currently operates three brine caverns in the south-central part of the dome to depths of -6500 ft. The total volume was some 3 MMB in 1988, according to State of Louisiana records. Sun Oil Co. made the first discovery of petroleum in 1938 and production of oil and gas continues to the present. More than 30 MMB have been produced, principally from the southern and north-eastern flanks. With the exception of the brining



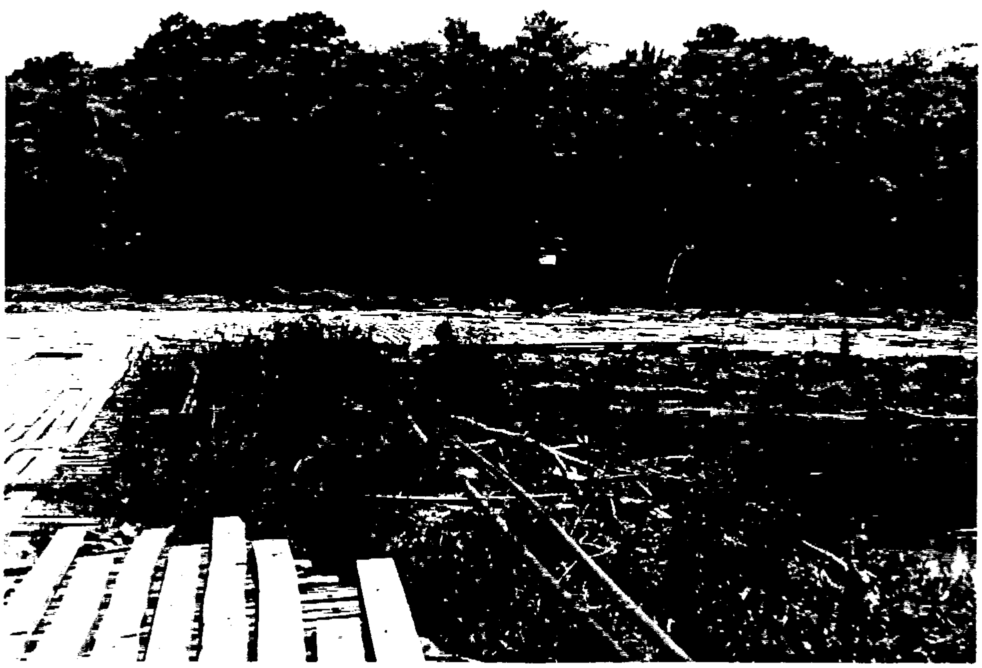


Figure 2. Top: Aerial photo showing -2000 ft salt contour and oil well access road along southern perimeter. Bottom: Oil wellpad along southern flank; soil infill and wood planking allow access through the swamp forest, adjacent to the shell road.

operations, there are presently no activities within the -2000 ft salt contour. Because of available land at the west end of the dome, it seems prudent to avoid the former sulphur area for possible SPR operations, even though there is probably no compelling reason why it could not be used.

Geologic Aspects

Regional Geology

The dome is near the center of the Holocene Mississippi Delta, which has created what land there is in South Louisiana, between the old Lafourche and Teche distributary channels. This sediment pile being dumped off the edge of the North American continent since at least the Miocene has deformed the underlying Jurassic Louann salt into ridges and domes of which Chacahoula is one of the largest.

The dome is at the south end of a trend of large domes which runs from Bayou Bleu through White Castle and Napoleonville. This salt trend or ridge is parallel to the deltaic distributary channels and the larger feature to the west: the Five Island chain with Weeks Island in the center and its parallel Iberia trough.

South of Chacahoula is the largest area in South Louisiana free of salt domes, the Houma embayment, bounded by concentric growth faults with more than two miles of vertical displacement at depth. The salt from this area is believed to have moved south as a sill, flowing into the east-west Terrebonne trough with its large bounding salt domes on both sides [Ref. 3].

The outer edge of the shelf grew southward past Chacahoula in lower Miocene time, with the lowermost Siphonina davisi expansion zone (the trend of active growth faults marking the outer edge of the shelf where sediment accumulation is in unstable foreset beds) lying just north of the dome. Sediments below this expansion zone are deep-water shales including the Abbeville facies now found in the diapiric sheath on the north side of the dome.

Most of the oil and gas on the flanks of the dome are found in the lower Miocene (Robulus) zones where they are expanded on the down side of these growth faults. Next to the salt, shallower middle and upper Miocene sands produce as well. These biostratigraphic markers are shown on the cross-sections (Figs. 4, 5, 6) and further delineated in Ref. [4].

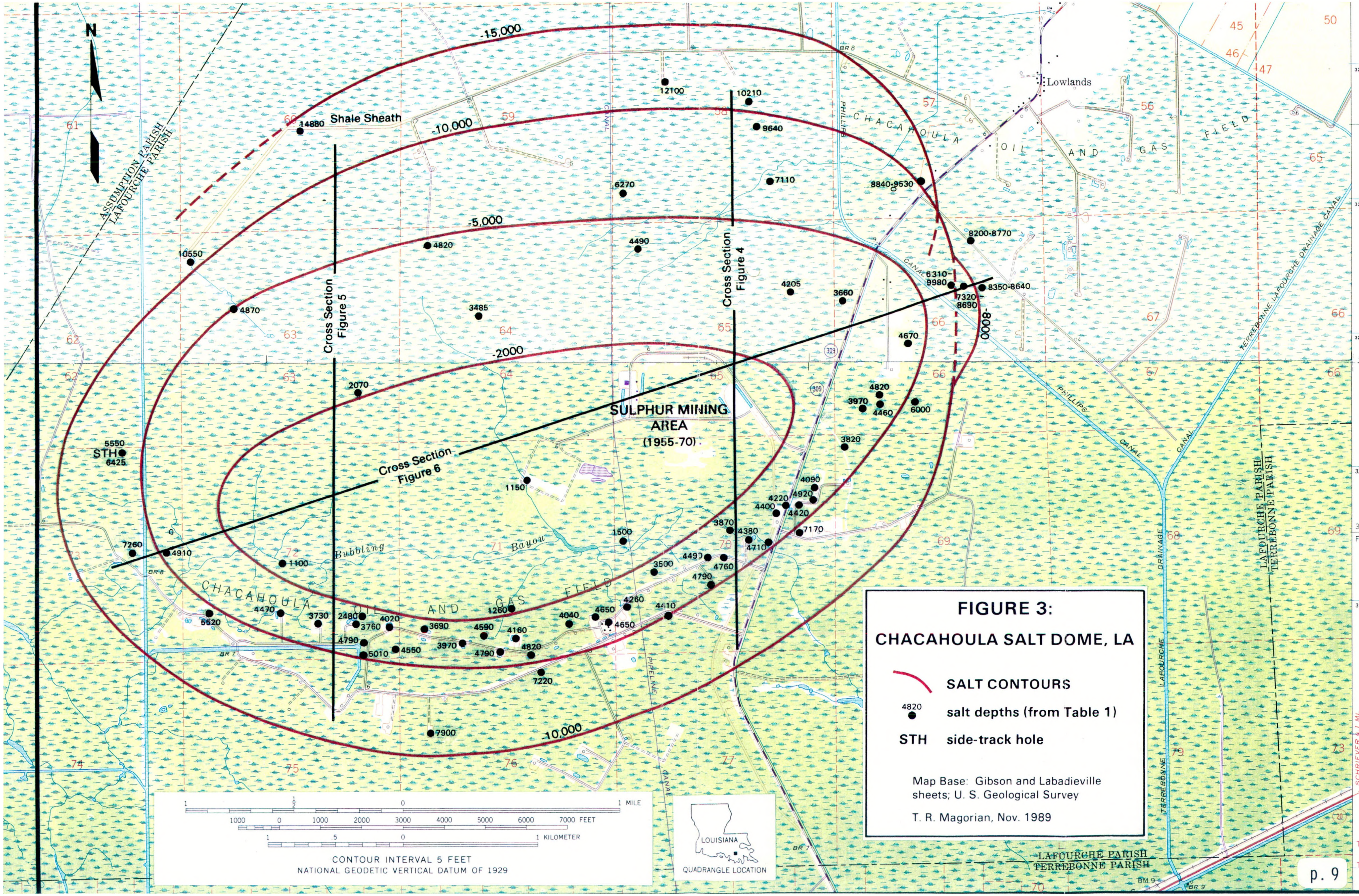


FIGURE 3:
CHACAHOULA SALT DOME, LA
SALT CONTOURS
4820 salt depths (from Table 1)
STH side-track hole
Map Base: Gibson and Labadieville sheets; U. S. Geological Survey
T. R. Magorian, Nov. 1989
N
-15,000
-10,000
-5,000
-2000
-8000
Shale Sheath
Cross Section Figure 5
Cross Section Figure 4
Cross Section Figure 6
SULPHUR MINING AREA (1955-70)
ASSUMPTION PARISH
LAFOURCHE PARISH
TERREBONNE PARISH
CHACAHOULA OIL AND GAS FIELD
Lowlands
Bubbling Bayou
PHILLIPS CANAL
TERREBONNE LAFOURCHE DRAINAGE CANAL
CONTOUR INTERVAL 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
1 MILE
7000 FEET
1 KILOMETER
LOUISIANA
QUADRANGLE LOCATION
29°45′
3293000mN
390 000 FEET
14880
12100
10210
9640
7110
8840-9530
6270
8200-8770
10550
4820
4490
6310-9980
8350-8640
7320-8690
4205
3660
4870
3485
4670
2070
4820
3970
4460
6000
5550
STH
6425
3820
1150
4090
4220
4920
4400
4420
3870
4380
7170
1500
4710
7260
4910
1100
4493
4760
3500
4790
4260
4410
5520
4470
3730
2480
3760
4020
3690
1260
4590
4160
4040
4650
4650
4790
3970
4790
4820
5010
4550
7220
7900

Table 1. SALT PENETRATIONS. Wells are shown on Figure 3 by salt depth.

Sec.	Operator	Lease	Well	BHL	Salt Depth
57	Markley	Mire	1	830N 2972W	8840-9530
58	Sun	Levert-Morvant	1		10210
			3	1985S 1300E	12100
		"	1		7110 OH
					7950 STH
			2		9640
	Lucerne		1	600N 330E	6270
60	Sun	D	57	3007S 2310W	sheath 14880
63			2	2280S 940E	4205
		(Freeport)	6		2070
			65		10550
			76	1760S 1140W	4870
64	Elsbury	Mecom	1		4820
	Gulf		25		3485
65	Wrightman	Lotham	2	660S 660E	4490
	Sun	Dodge	1		4205
66		Lyric Parking	5	626S 1948W	8200-8770
			6	2014S 1796W	7320-8690
			16	2205S 1538W	8350-8640
		" -Drexler	1	1901S 2460W	6310-9980
		"	1		3660
	Tex.Gulf		2		6000
	Brock		1	850N 925E	3970
		Bernard	2	1000N 1280E	4820
	Dynamic		1	990N 1280E	4460
	Shoreline	Linay	1	2161N 1754E	4670
69	Sun	Mire	3		3820
70		D	A1		1500
			9	2760N 720W	7170
			12		4790
			19		4380
			20	1998N 2597W	4760
			22		4790
			23		3870
			24		4480 OH
					4650 STH
			25		4260 OH
					4410 STH
			28		3500
			53		4710
			57	1784S 950W	4420
			59		4490
			72	515W	4920
			74	1115S 350W	4090
			83	2011S 1420W	4220
			94	1789N 1025E	4400
71	Sun	D	2		1260
			10		1150
			52	460N 1120W	4040 OH
					4920 STH
			54		4650
			56	230N 1599W	4820
			62		4790 OH
					4680 STH
			67		3690 OH
					3780 STH
			68	250N	3970 OH
					4640 STH
			80		4160
			93	360N 1440E	4550
			95	510N 484E	4790
			108		4590
72			61	330N 900W	5010 OH
					4480 STH
			63	700N 300W	4020
			66		3760
			69	776N 2085W	3730
			71	1060N 2265W	4470 OH
					3655 STH
			79	1249N 900W	2480 OH
					3220 STH
			NK	2250E 2550N	1100
73			26		7260
			42		4910
			75		6425 OH
					5550 STH

Abbreviations:

BHL Bottom-hole location in feet from section corner
D Dibert, Stark & Brown
NK Not Known
OH Original hole
STH Side-track hole

Geometry of the Salt Dome

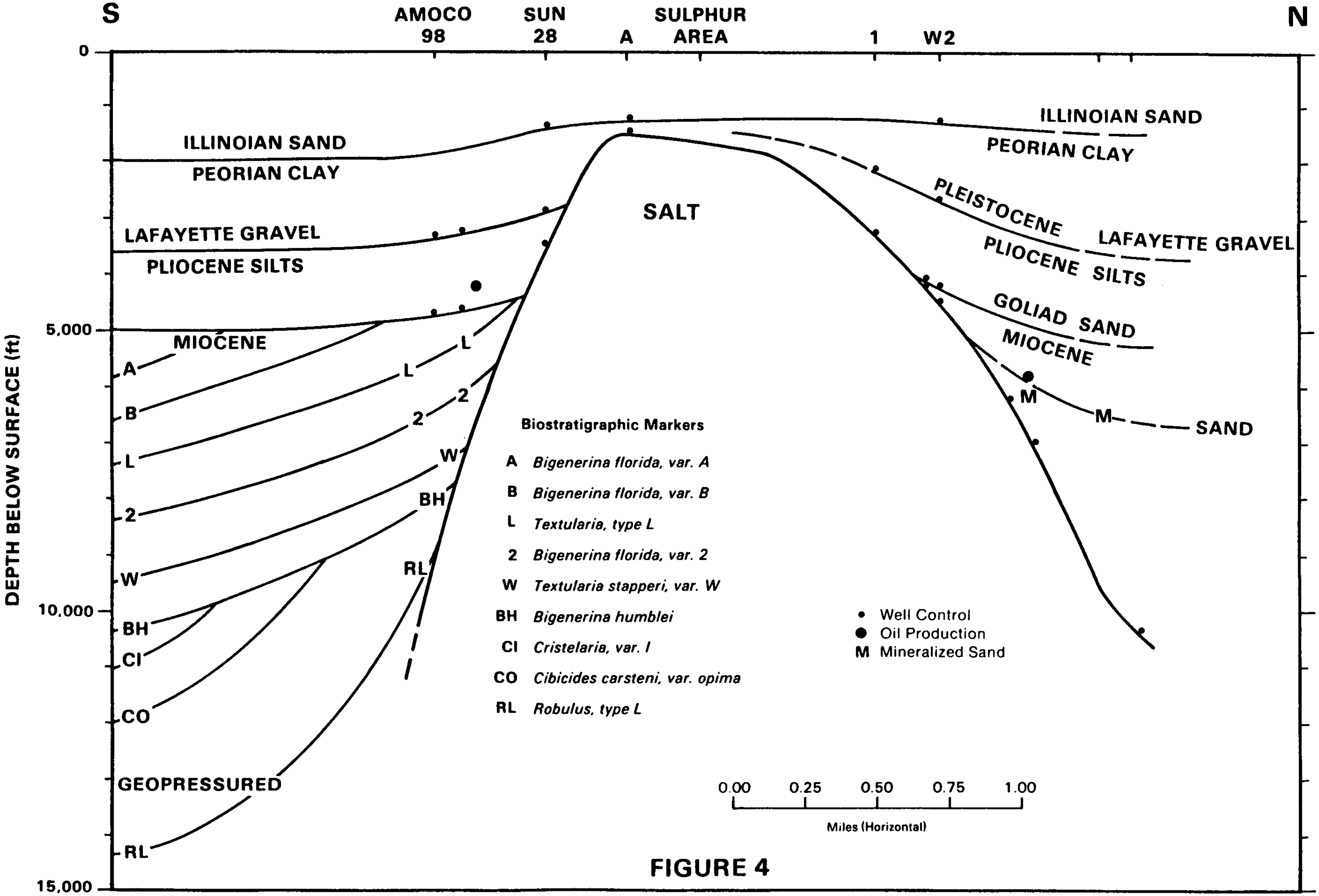
Chacahoula dome has about the best subsurface control of any salt dome in the Gulf Coast (Table 1). It is more than four miles long (E-W) and nearly three miles wide (N-S), inside the -10,000 ft salt contour (Fig. 3). Inside the -2000 ft salt contour there are some 1300 acres, which would allow as much as 500 MMB of leached-cavern storage. Thus, Chacahoula is among the larger of the some 550 Gulf Coast domes.

The limited shallow salt control above -2000 ft shows that over the top of the dome, the salt is covered by up to 100 ft of Peorian (middle Pleistocene) clay under 250 ft or more of Illinoian sands containing saturated brine. These are overlain by 400 ft of Sangamon clay, then 400 ft of massive fresh-water Wisconsin sand (brackish to saline at the base), overlain by 100 ft or more of Holocene peat and muck. The latter unit is the surficial material upon which drillpads, shell roads, and surface facilities must be engineered. Shallow unit correlations are shown at Table 2.

Table 2. SHALLOW CORRELATIONS. Depths below surface in feet.

Section: Well:	71 10	70 A1	 94	66 Drex.	42T16S Humble
Recent Atchafalaya peat & muck					
Wisconsin sand	140	140		140	
Sangamon clay & silt	445	610	680	880	890
Illinoian sand	800	1130	990	1210	1270
Peorian clay	1060	1370	1320	1610	1620
Kansan sand	1120	1410	2350	1990	2290
oil sands			3800	4150	11490
salt	1150	1500	4400	3660	NR

Caprock is thin or absent over much of the dome, but enough thickness exists in the northeast corner to have enabled minor sulfur extraction (Figs. 3, 4). Caprock is not shown on the cross-sections, because it was not specifically identified in company well records. Presumably it is very thin even in the sulphur mining area.



S
N
AMOCO 98
SUN 28
A
SULPHUR AREA
1
W2
DEPTH BELOW SURFACE (ft)
0
5,000
10,000
15,000
ILLINOIAN SAND
PEORIAN CLAY
LAFAYETTE GRAVEL
PLIOCENE SILTS
MIOCENE
SALT
PLEISTOCENE
GOLIAD SAND
SAND
GEOPRESSURED
A
B
L
2
W
BH
CI
CO
RL
M
Biostratigraphic Markers
A Bigenerina florida, var. A
B Bigenerina florida, var. B
L Textularia, type L
2 Bigenerina florida, var. 2
W Textularia stapperi, var. W
BH Bigenerina humblei
CI Cristelaria, var. I
CO Cibicides carsteni, var. opima
RL Robulus, type L
Well Control
Oil Production
M Mineralized Sand
0.00
0.25
0.50
0.75
1.00
Miles (Horizontal)

FIGURE 4

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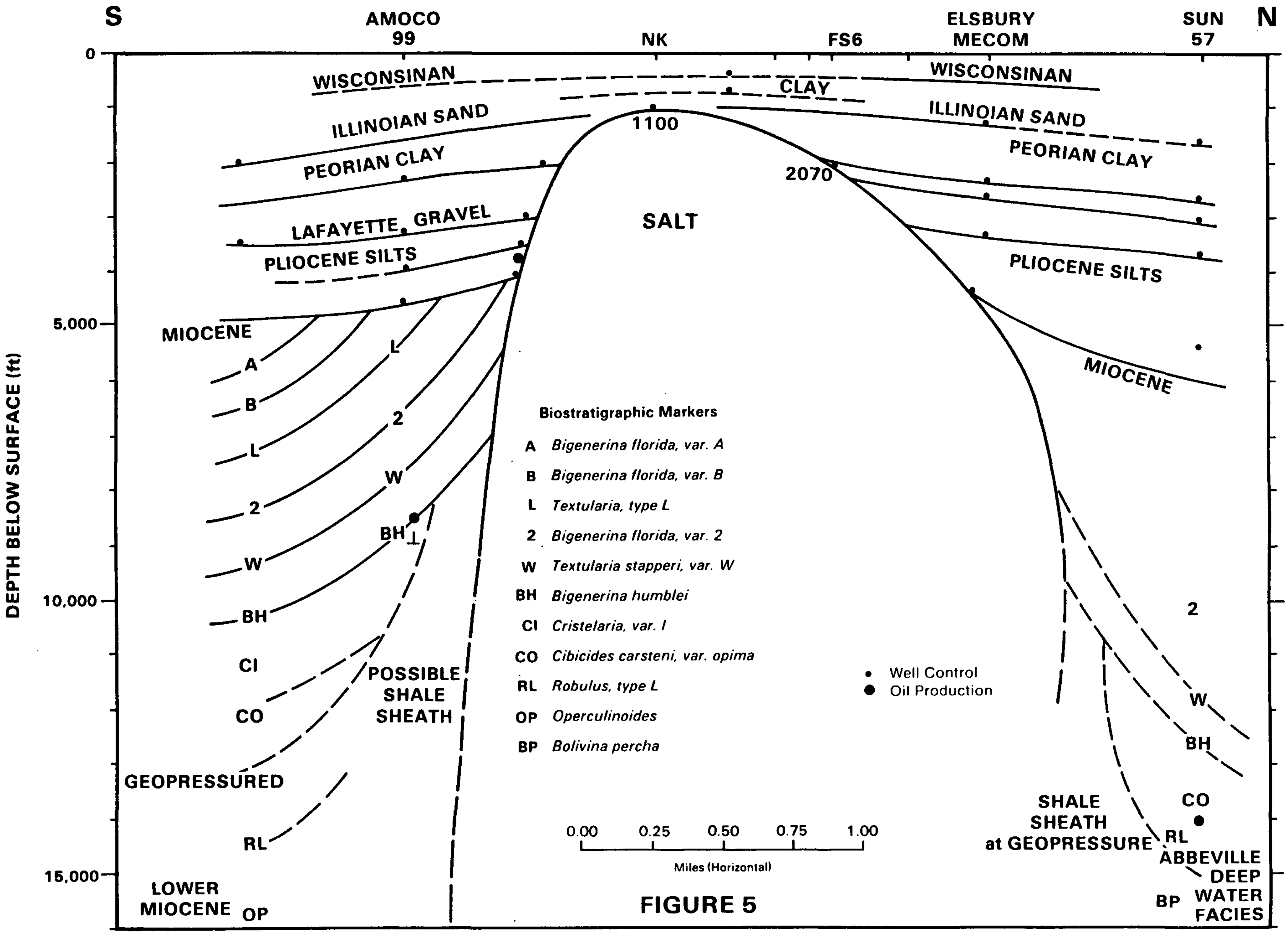
S
N
AMOCO 99
NK
FS6
ELSBURY MECOM
SUN 57
DEPTH BELOW SURFACE (ft)
0
5,000
10,000
15,000
WISCONSINAN
CLAY
ILLINOIAN SAND
PEORIAN CLAY
LAFAYETTE GRAVEL
PLIOCENE SILTS
MIOCENE
1100
2070
SALT
A
B
L
2
W
BH
CI
CO
GEOPRESSURED
RL
LOWER MIOCENE
OP
POSSIBLE SHALE SHEATH
SHALE SHEATH at GEOPRESSURE
ABBEVILLE DEEP WATER FACIES
BP
Biostratigraphic Markers
A Bigenerina florida, var. A
B Bigenerina florida, var. B
L Textularia, type L
2 Bigenerina florida, var. 2
W Textularia stapperi, var. W
BH Bigenerina humblei
CI Cristelaria, var. I
CO Cibicides carsteni, var. opima
RL Robulus, type L
OP Operculinoides
BP Bolivina percha
Well Control
Oil Production
0.00 0.25 0.50 0.75 1.00
Miles (Horizontal)

FIGURE 5

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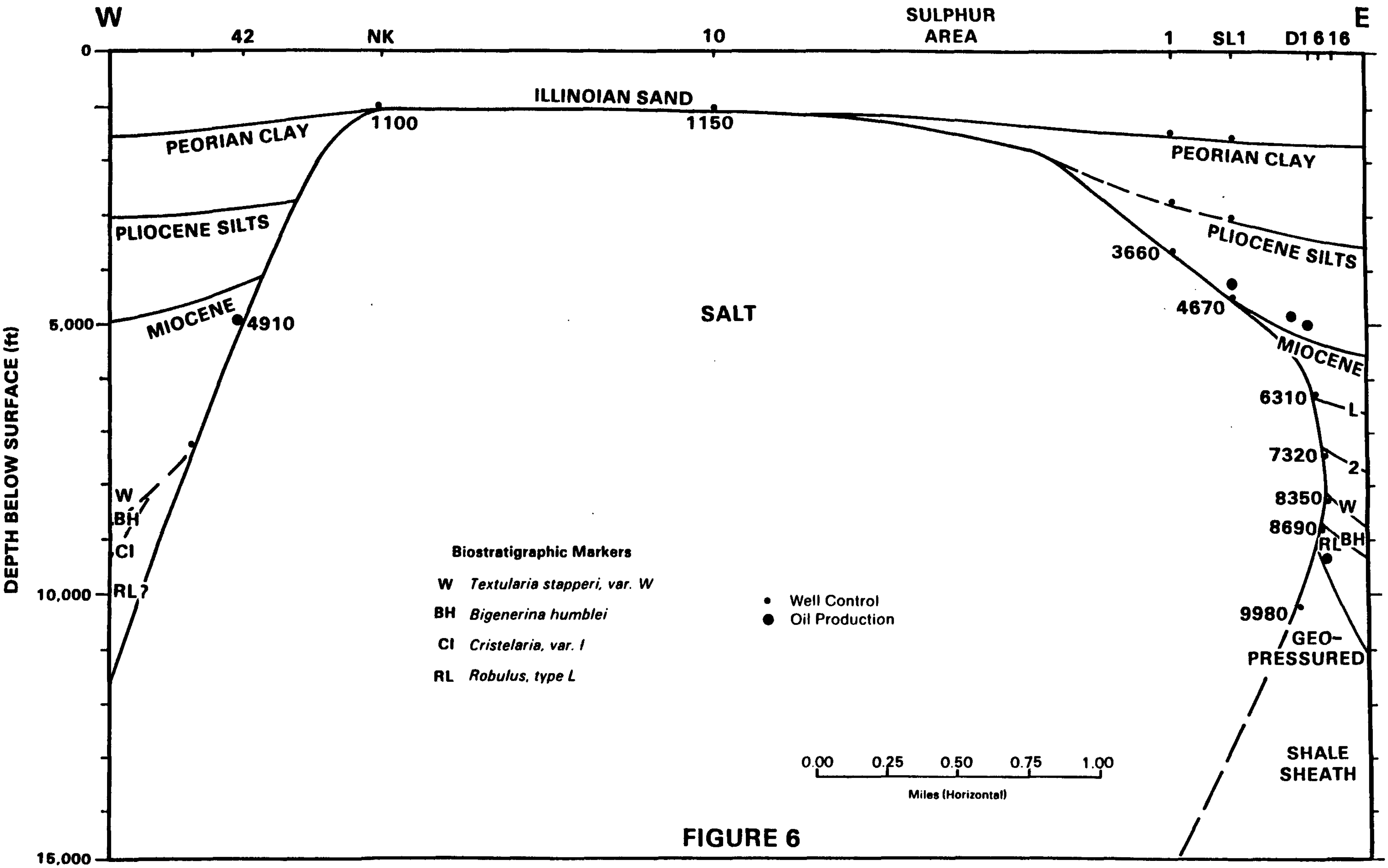

W
E
42
NK
10
SULPHUR
AREA
1
SL1
D1 6 16
0
5,000
10,000
15,000
DEPTH BELOW SURFACE (ft)
ILLINOIAN SAND
1100
1150
PEORIAN CLAY
PEORIAN CLAY
PLIOCENE SILTS
PLIOCENE SILTS
MIOCENE
MIOCENE
4910
3660
4670
SALT
6310
L
7320
2
8350
W
8690
RL
BH
9980
W
BH
CI
RL ?
GEO-
PRESSURED
SHALE
SHEATH
Biostratigraphic Markers
W Textularia stapperi, var. W
BH Bigenerina humblei
CI Cristelaria, var. I
RL Robulus, type L
Well Control
Oil Production
0.00 0.25 0.50 0.75 1.00
Miles (Horizontal)

FIGURE 6

Most of the salt control is at about -4500 ft, because the -4200 ft sand is the shallowest with extensive production. This is associated with the major unconformity at the top of the Miocene, below the massive basal-Pliocene (Goliad of Texas) sand and gravel. This dense control delimits the entire south flank of the dome, where Sun Oil Company has found many productive sands immediately above the uniformly-sloping salt margin.

The north flank is poorly controlled; the top of the salt slopes more gently down to -5000 ft but then steepens with a shale sheath present, at least in Sec. 60 to the northwest (Figs. 3, 5).

A small overhang occurs at the eastern tip of the dome from -5000 to -10,000 ft, delineated by five well penetrations (Fig. 6). The overhang is restricted to the north half of Sec. 66 and the south half or less of Sec. 57. There is no indication that it has any impact on possible storage areas of the dome, inside the -2000 ft salt contour.

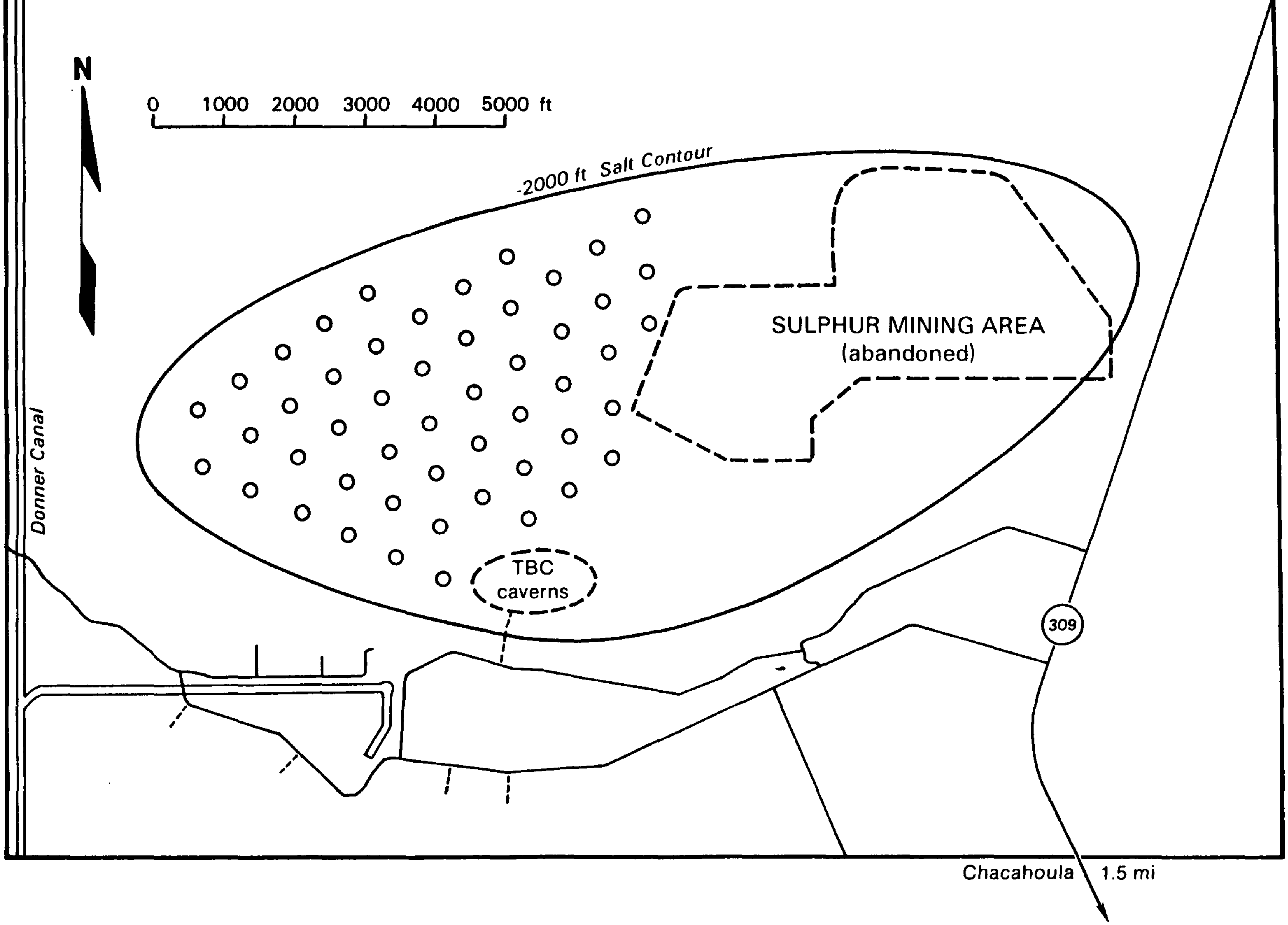
In east-west elongate domes like Chacahoula and West Hackberry, the salt flow may occur in widely-separated spines within the salt mass. We do not have enough control within the salt yet to define these spines nor any shear zones or areas of more anhydrite which may separate them. Exploratory drilling should be planned to delineate these features of the salt mass.

SPR System Aspects

Cavern Layout Considerations

The area within the -2000 ft salt contour at the western end of the dome is the principal location that is available and most suitable for cavern development (Fig. 7). The 50 cavern locations shown on Fig. 7 adhere to criteria currently used at Big Hill, with centers 750 ft apart and diameters of ~200 ft [Ref. 5]. While extensive areas still remain east of this area, they are either fragmented or within the former sulphur mining area, which is considered less favorable. Nonetheless, some 100 MMB and more of additional volume could be made available, if needed. There is little, if any, physiographic difference at the surface inside and outside the -2000 ft contour; consequently, the siting of surface operating facilities outside the contour would not take up prime cavern space.

FIGURE 7: POSSIBLE CAVERN LOCATIONS



Brine Disposal by Pipeline to the Gulf of Mexico

Barge and pipeline canals enter the site from the southwest. It would be possible to lay a large-diameter brine pipeline in the bottom of these canals at a minimal cost/mile (although the route would be slightly longer) all the way out to Atchafalaya Bay and avoid any dredging of sensitive marsh or swamp. Such a route would follow the pipeline canals to Gibson and Bayou Black, and from there to Bayou Chene, both of which are wide navigable waterways serving large shipbuilding facilities. It would also be possible to lay the pipe in the pipeline ditch right-of-way which follows the Southern Pacific railroad from the canal at Donner or Gibson to the shipping lanes.

The total cost of such a brine pipeline using lay barges could be as low as $30 million, even for the large diameter required. The line must be carefully designed for the abrasive nature of the insoluble sand carried along the bottom at high velocities.

Brine Disposal by Well Injection

At Chacahoula, the cheapest disposal area would be to the northwest of the dome where there has been minimal oil and gas development. However, disposal would be feasible in shallow sands above -3800 ft on any flank of the dome. Although no 500-foot thick sands are present, the massive 200+ foot-thick Illinoian sand aquifer at -1000 to -1300 ft depth is not fully saturated with salt and may have some use as an industrial water supply. However, the equally thick basal Pleistocene sand, often referred to as the Lafayette gravel, at or above -3000 ft is saturated and nearly ideal for brine disposal. Disposal above the salt cannot be recommended because much of the brine is unsaturated. Shallow unconsolidated units and respective depth correlations in selected wells are shown on Table 2 and the cross sections (Figs. 4-6).

The injection wells at Bayou Choctaw have functioned adequately, but often under difficult operating conditions. The Sulphur Mines wells have been a success commercially. At other sites, where deviated holes were included, the injection wells have not been deemed to meet the requirements of the program.

Adequate filtration of the brine has not been applied consistently. The rigidity of the SPR schedule has greatly increased the number of injection wells included in the program. The wells can be drilled and completed with large-diameter tubing and screens capable of more than 50,000 barrels/day for less than $1 million/well (1990). With good filtration and regular screen maintenance, only a few spare wells should be required. However, at a large site with high leach rates, the cost advantage of disposal wells over pipelines during the life of the site is marginal.

Anticipated Natural Hazards

Of potential hazards at the Chacahoula site, three that quickly come to mind are hurricanes and associated flooding, subsidence resulting from solution mining, and seismicity.

Hurricanes and Flooding Potential

Chacahoula dome is about 25 mi from the Gulf of Mexico and because of its already low elevation at 6-7 ft could be vulnerable to storm surges associated with hurricanes. The Louisiana Office of Emergency Preparedness has prepared an atlas of storm surge predictions which includes Chacahoula dome [Ref. 6]. The predictions are based on historical data and the SLOSH (Sea, Lake, Overland Surge from Hurricanes) computer model of the National Weather Service.

These predictions show that storm surges associated with the strongest hurricanes (Category IV : 133-155 mph; Category V : >155 mph) moving slowly (avg 5 mph) in a northeasterly direction would produce inundation levels at the site which approach 15 ft AGL (above ground level).

A similar slow-moving storm from a more southerly direction would produce inundation levels of 12-13 ft AGL. For fast-moving storms (avg 15 mph) of the same magnitude, surge levels do not have time to pile up water as high as in the slow-moving case, and the predicted inundation levels range from 5-12 ft AGL, depending on storm direction and other factors.

More moderate hurricanes in the 100 mph range (Category II: 96-111 mph) when slow moving in a northeasterly direction could yield inundation levels of ~4 ft at Chacahoula. These values indicate that hurricanes of any strength moving slowly in a northeasterly direction would be a serious threat. The most severe threats would require complete evacuation from the site and probably damage or destroy many conventional surface structures, whereas the lesser hurricanes could still produce much damage and inconvenience.

Probability values for the events described above are extremely low and would probably be expected in the 1000 yr return range, according to Corps of Engineers personnel. Thus, it would be unreasonable to design for 15 ft AGL surge heights. More realistic flood potential values for this site come from the Federal Emergency Management Agency's

Flood Insurance Rate Maps which show 10 yr and 500 yr flood elevations of 5.8 and 6.2 ft, respectively [Ref. 7]. This indicates that flooding would not be a problem under normal circumstances; however, induced subsidence could alter this condition.

Subsidence

Subsidence induced by the emplacement of leached caverns at Chacahoula deserves special attention because of the already low surface elevation of 6-7 ft. Subsidence estimates can be derived from experience and from theory, relying on reasonably well understood principles of salt creep. The former is thought to be more reliable, as some eight years of measurement history is available from five SPR sites, from about 350 repetitively-surveyed stations [Ref. 8].

Theoretically, if Chacahoula cavern tops were emplaced at ~-2000 ft and bottoms at ~-4000 ft, the salt creep environment should be less severe than that occurring at West Hackberry, where cavern bottoms are at ~-4500 ft. The proposed depth interval at Chacahoula is similar to that existing at Bryan Mound, but caution should be used in extrapolating creep/subsidence data, especially in view of the exceptionally low creep rates observed experimentally in Bryan Mound Salt. No salt samples have been obtained from Chacahoula for testing, so a reasonable middle value between the West Hackberry and Bryan Mound subsidence rates (63 vs 9 mm/yr, respectively) seems conservative; thus, the average value of 27 mm/yr is used here for estimating subsidence, an amount not too dissimilar to rates observed at the remaining SPR sites. The average subsidence at Bayou Choctaw, the nearest site, was 19 mm/yr, but the data are of questionable reliability.

A hexagonal array of nineteen 10.5 MMB caverns was configured for Chacahoula, which would allow total storage of 200 MMB (Fig. 8). A rule-of-thumb 10% volume loss over 30 years owing to cavern creep closure would result in 11.24E7 cu ft loss; 50% of this (an approximate amount attributable to subsidence) leads to a total subsidence volume of 5.62E7 cu ft distributed over 260 acres. The calculated total subsidence averages 4.96 ft, which seems excessive -- more than observed at most sites, and nearly the value at West Hackberry, the greatest of any site. The intermediate value of 27 mm/yr, as estimated from other sites and described above, results in an average 30-yr value of 31.9 inches (2.66 ft). Assuming that the latter value of ~2.7 ft is the better approximation for Chacahoula, a conical depression would likely be about five feet deep at the center of the array, tapering more or less uniformly to a foot and less at the edges.

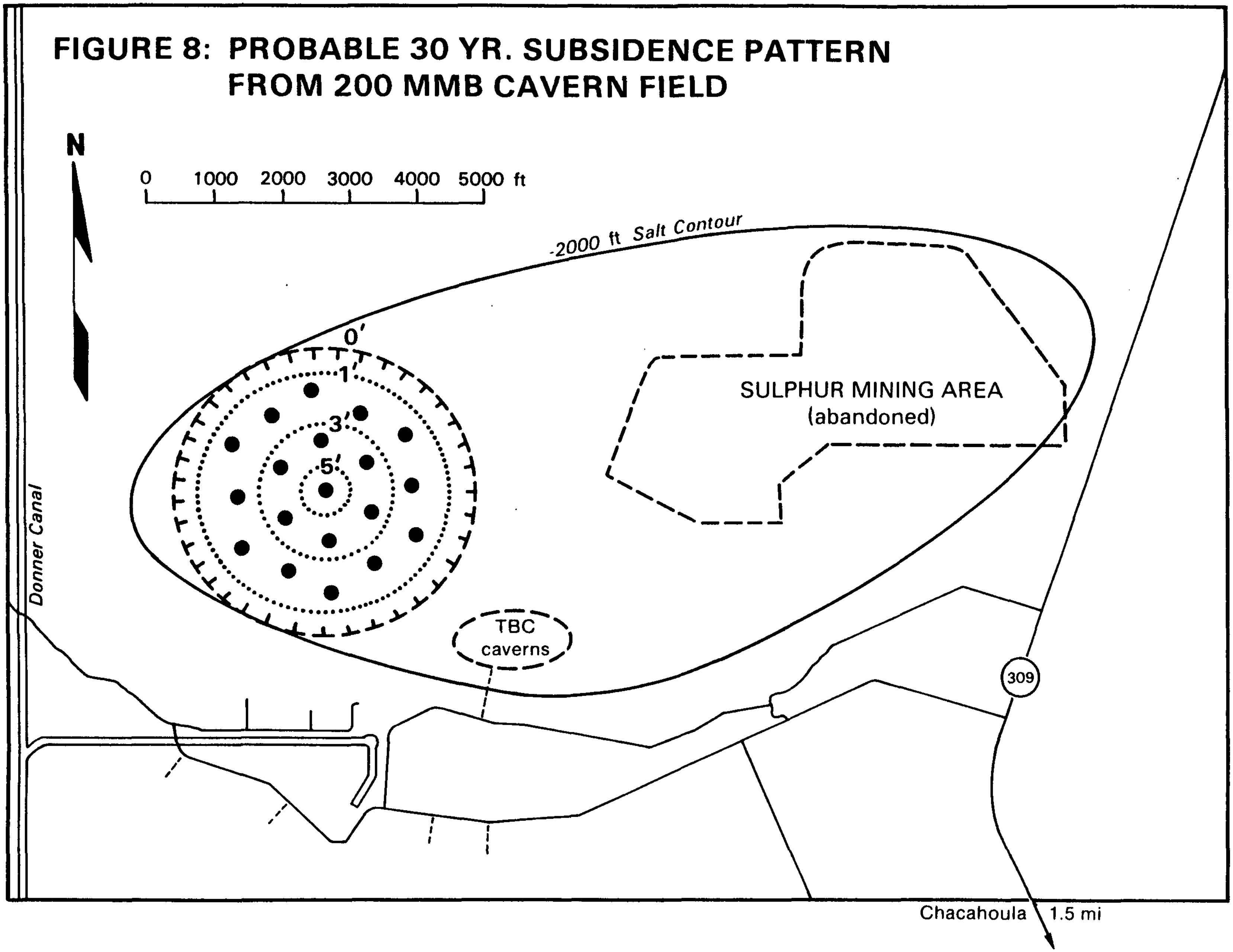


FIGURE 8: PROBABLE 30 YR. SUBSIDENCE PATTERN
FROM 200 MMB CAVERN FIELD
N
0 1000 2000 3000 4000 5000 ft
-2000 ft Salt Contour
0'
1'
3'
5'
SULPHUR MINING AREA
(abandoned)
TBC
caverns
Donner Canal
309
Chacahoula 1.5 mi

Such a depression would lead to perennial flooding at some point unless preventive measures were employed. Diking and/or infilling would be a necessary solution to subsidence-induced flooding.

Seismicity

The southern Louisiana area in which Chacahoula dome is located is one of infrequent and low seismicity. Seismic risk analyses that have been conducted for existing and proposed (e.g., River Bend Station (RBS) and Waterford) nuclear power plants provide in-depth information for the seismic environment within a 100 mi radius, which includes Chacahoula [Ref. 9]. The largest historical earthquake experienced at the RBS site was the October 19, 1930, event near Donaldsonville, LA, with a Modified Mercalli intensity greater than V but less than VI (assigned Richter Magnitude 4.7). The epicenter of this earthquake is about 17 mi north and slightly west of the potential Chacahoula site; because it is also effectively the design basis earthquake for the RBS, it is instructive to detail its effect on the site.

The epicentral location of the Donaldsonville event is about 30 N; 91 W, based on locally felt intensities and on estimates from the Georgetown University seismograph in Washington, D. C.; the stations at Loyola University (New Orleans) and Spring Hill College (Mobile, AL) were inoperative at the time. The source of this earthquake is unclear but may originate in deep basement faults that haven't been mapped, and/or in combination with relatively shallow growth faults that are common on the coastal plain. This source mechanism is attributed to the magnitude 3.8 Lake Charles earthquake of October 16, 1983, [Ref. 10]. The Baton Rouge Fault, although largely to the north of the site, probably extends southward as a step system. For these reasons, most geophysicists agree that such an event could occur anywhere along the southern Louisiana coast; this would produce a maximum horizontal acceleration at the surface of ~0.07 g. The acceleration would result largely from body-wave motion, associated with high frequencies of several cycles per second or more and should be of short duration, on the order of several seconds. This does not present any particular design challenge for conventional structures, such as SPR surface facilities, and would be of even less concern at nominal cavern depths in solid salt within the dome because SPR cavern storage is not earthquake-sensitive. That is because mine openings experience no damage at localities subject to surface accelerations up to about MM VIII [Ref. 11], which is greater than would be expected along the Gulf Coast.

The nuclear industry has further considered a New Madrid event (1811-12; M 8+); peak acceleration would be less than a repeat Donaldsonville event at the distance of Chacahoula. Also, several earthquakes have occurred with epicenters offshore in the Gulf with Richter magnitudes between 4.5 and 5.0. The largest not associated with a known geologic structure was M 4.8. This brief summary demonstrates that the conservative peak acceleration value of 0.1 g used by the nuclear power industry in south Louisiana presents no problem for SPR. Finally, this value represents an earthquake with a return period on the order of 100 years.

Summary of Significant Aspects Affecting SPR Development

Space exists potentially for as much as 500 MMB of cavern volume within the Chacahoula salt mass at depths in the -2000 ft to -4000 ft range. Additional space beneath the former sulphur area could be used but minor subsidence has already occurred, and the low site elevation combined with caprock voids make it less favorable. The salt mass is well defined, owing to abundant control from oil wells and sulphur exploration.

Estimates of 30-yr subsidence from a hexagonal array of nineteen 10.5 MMB (200 MMB total) caverns resulted in a conical-shaped subsidence bowl about five feet deep at the center. Because of the already low surface elevation (6-7 ft), this would lead to perennial flooding unless perimeter diking were in place.

Major hurricane flood-surge heights could exceed 10 ft at Chacahoula, especially with slow-moving Category V storms from the south and southwest. However, the return period probabilities for such events would be so low that facility design would be virtually unaffected.

Seismicity is of virtually no concern, even though very small earthquakes in the range MM III-V may occur.

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