AN ENVIRONMENTAL ASSESSMENT OF PROPOSED GEOTHERMAL WELL TESTING IN THE TIGRE LAGOON OIL FIELD, VERMILION PARISH, LOUISIANA

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DISCLAIMER

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I. INTRODUCTION

Purpose

This report is an environmental assessment of the proposed testing of two geopressured, geothermal aquifers in central coastal Louisiana. The testing will be done by Osborn, Hodges, and Roberts Engineering, Lafayette, La., under contract with the Energy Research and Development Administration (E.R.D.A.). On the basis of an analysis of the environmental setting, subsurface characteristics, and the proposed action, potential environmental impacts are determined and evaluated together with potential conflicts with federal, state, and local programs.

Oil and gas wells in coastal Louisiana have penetrated a potentially productive geothermal zone of abnormally high-pressured aquifers that also yield large volumes of natural gas. To evaluate the extent to which the geothermal-geopressured water can be used as an alternative energy source and to what extent withdrawal of geopressured water can enhance gas production, it is necessary that flow rates, composition and temperature of fluids and gases, recharge characteristics, pressures, compressibilities, and other hydrodynamic and boundary conditions of the reservoir be determined by means of production tests. Tests are further necessary to evaluate and seek solutions to technological problems.

General Project Description

With regard to possible impacts and benefits, the proposed project involves four major actions. These are: 1) site preparation, including limited bucket dredging of the existing well slip to provide for movement of barge-mounted drilling equipment to the well site, spoil disposal, and shell placement around the immediate well site; 2) drilling of a saltwater disposal well to a depth of approximately 2,500 feet and workover of an abandoned well which will be utilized as the test well to the total depth of 13,300 feet; 3) the actual flow testing; and 4) plugging and abandonment of the well, clean-up operations, and removal of rig and service equipment. A more detailed description of the project actions is given in Section II and Appendix A of this report.

General Area Description

The well to be utilized for testing is the Coastal States' Edna Delcambre #1, located in a well slip of the Tigre Lagoon Oil and Gas Field, Section 5, T. 14 S, R. 5 E., in Vermilion Parish, Louisiana (Figures I-1, I-2, I-3, I-4, and I-5). At the surface, the oil field is characterized by a network of spoil-bounded pipeline and access canals that dissect brackish coastal marshes fringing the Vermilion Bay estuary. These marshes are part of a continuous belt of fresh to saline marshes and swamps that extend coastwise along the full 400-mile extent of Louisiana's Gulf Coast, varying in width from 10 to 50 miles. The Tigre Lagoon field may be considered a typical example of the many changes that have occurred in Louisiana's coastal wetlands as a result of exploration and production of the vast hydrocarbon reservoirs that underly the area.

Benefits

Corresponding to the main objective of the project, anticipated primary benefits are mainly the acquisition of knowledge pertaining to ambient conditions and test-induced changes in the geopressured-geothermal aquifers and to fluid withdrawal technology. Although the proposed operation is a pilot project, it should be realized that acquired knowledge may represent a major contribution to evaluation of the Gulf Coast's geothermal energy potential and realization of its use as a supplemental energy source.

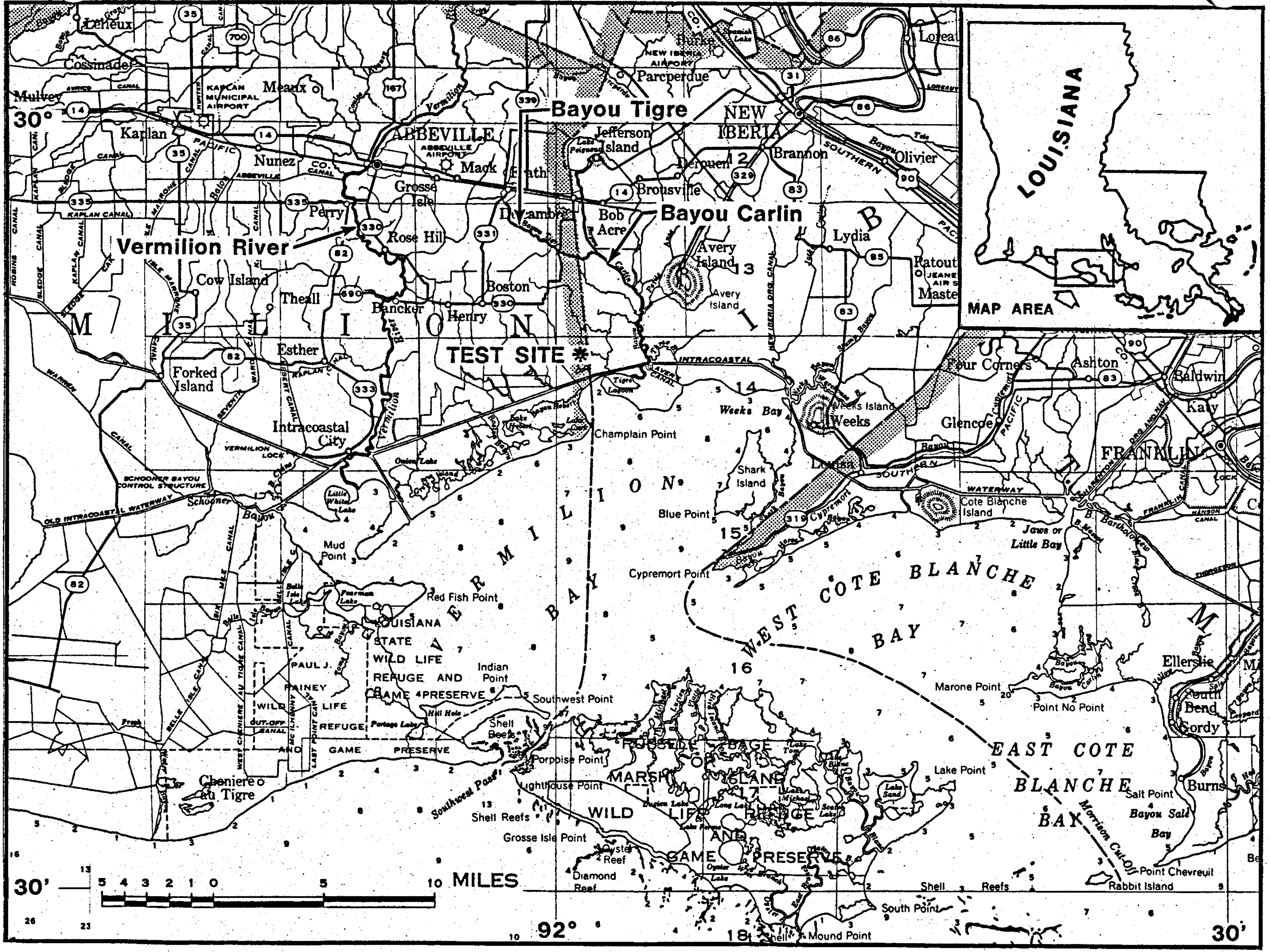
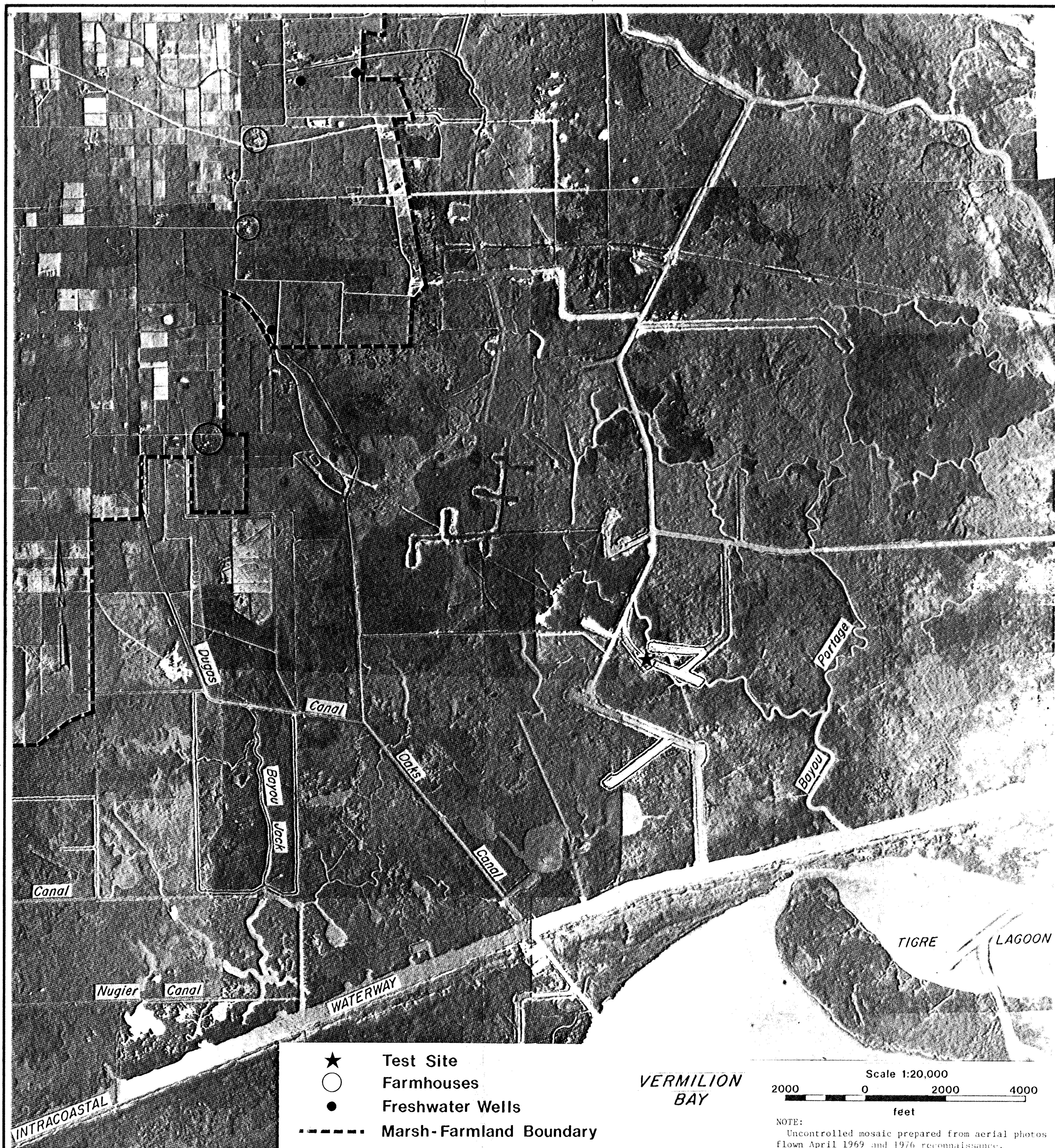


Figure I-1. General Location of Well Site in Central Coastal Louisiana.



Dugas
Canal
Bayou
Jack
Oaks
Canal
Portage
Bayou
Canal
Nugier
Canal
WATERWAY
INTRACOASTAL
TIGRE
LAGOON
Test Site
Farmhouses
Freshwater Wells
Marsh-Farmland Boundary
VERMILION
BAY
Scale 1:20,000
2000
0
2000
4000
feet
NOTE:
Uncontrolled mosaic prepared from aerial photos flown April 1969 and 1976 reconnaissance.

Figure I-3. Aerial view of test-well locale looking south toward GIWW and Vermilion Bay. Test-well location is indicated by arrow: February, 1976.

Figure I-4. Aerial view of test-well looking west toward farmlands. Test-well is indicated by arrow: February, 1976.

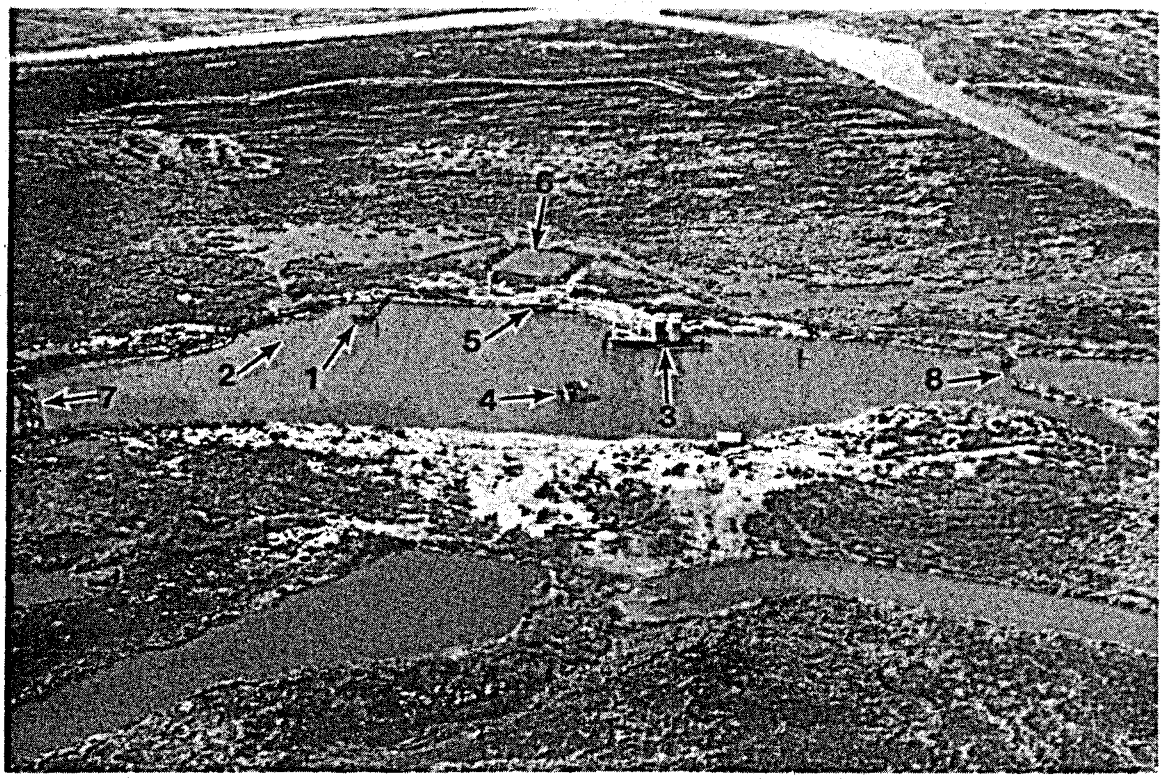


Figure I-5. Aerial view of test-well slip looking to the southwest. Indicated are: the test-well (1), location of disposal well (2), tanks to be removed for conversion of platform to heli-pad (3), plugged well Delcambre #4 (4), platform for condensate storage tank (5), sludge pit (6), dam (7), and bulk heads to be removed (8). White area along edge of slip is unvegetated spoil, the water levels are low and tidal mudflats within marsh are exposed such as to the left and right of the sludge pit.

II. PROJECT DESCRIPTION

Site Preparation, Drilling, and Workover

Maintenance dredging of the existing well slip is required prior to moving the workover rig into the location. The dredging will remove from the canal approximately 3,000 cubic yards of spoil, which will be deposited along the existing spoil banks (Figures II-1 and II-2).

Upon completion of the site work, the workover rig will be moved into place for the drilling of the disposal well. It will be drilled to an approximate depth of 2,500 feet and cased with 7-5/8 inch casing to protect the freshwater sands (Figure II-3). After the well has been completed, tests will be conducted to determine the volume of water the disposal well can accept.

Workover operations on the Edna Delcambre #1 (Figure II-4) will commence following the testing of the disposal well. First, to counterbalance the formation pressure, heavy mud will be pumped into the tubing. When the pressure has been stabilized to zero at the surface, the tubing will be pulled out of the well. Next, it will be necessary to seal off the existing perforations with a combination of bridge plugs and cement to prevent the entrance into the well bore of any formation fluids from this interval. New tubing consisting of 12,000 feet of 3-1/2 inch and 1,150 feet of 2-7/8 inch will be run in the hole (Figure II-5). After the new tubing has been set in place, the Number 3 Sand will be perforated. Sampling of the reservoir, fluids, and flow testing will begin.

Testing

The flow tests are designed to determine the capacity of the reservoir and the rates at which the reservoir can be produced without a breakdown of the formation. For those flow tests, the water will be flowed from the formation through the tubing to the surface test equipment (Figure II-6). At the surface, the water will go into a three-phase separator which will separate the natural gas, the condensate, and the water. The natural gas will be burned; the condensate, stored; and the water, used to drive a geopressure hydraulic turbine-generator. The turbine-generator will convert the hydraulic energy of the water into electrical power that can be used as an alternate source of power for lighting the heliport. The exhausted water from the turbine will then be disposed of in the disposal well.

Two geopressured aquifers, the Number 1 Sand and the Number 3 Sand, of the Planulina formations will be tested for approximately ten days each. Flow rates of 15,000 barrels per day of water containing 84,000 parts per million (ppm) chlorides are expected. The total anticipated water production is 300,000 barrels. This water will be disposed of in a saltwater-bearing sand with chloride content in the range of 20,000 - 40,000 ppm at an approximate depth of 2,500 feet.

The natural gas which will be separated from the water is expected to be approximately 25-35 standard cubic feet per barrel of water. At 35 standard cubic feet per barrel, the total volume of natural gas that would be flared is 10.5 million cubic feet.

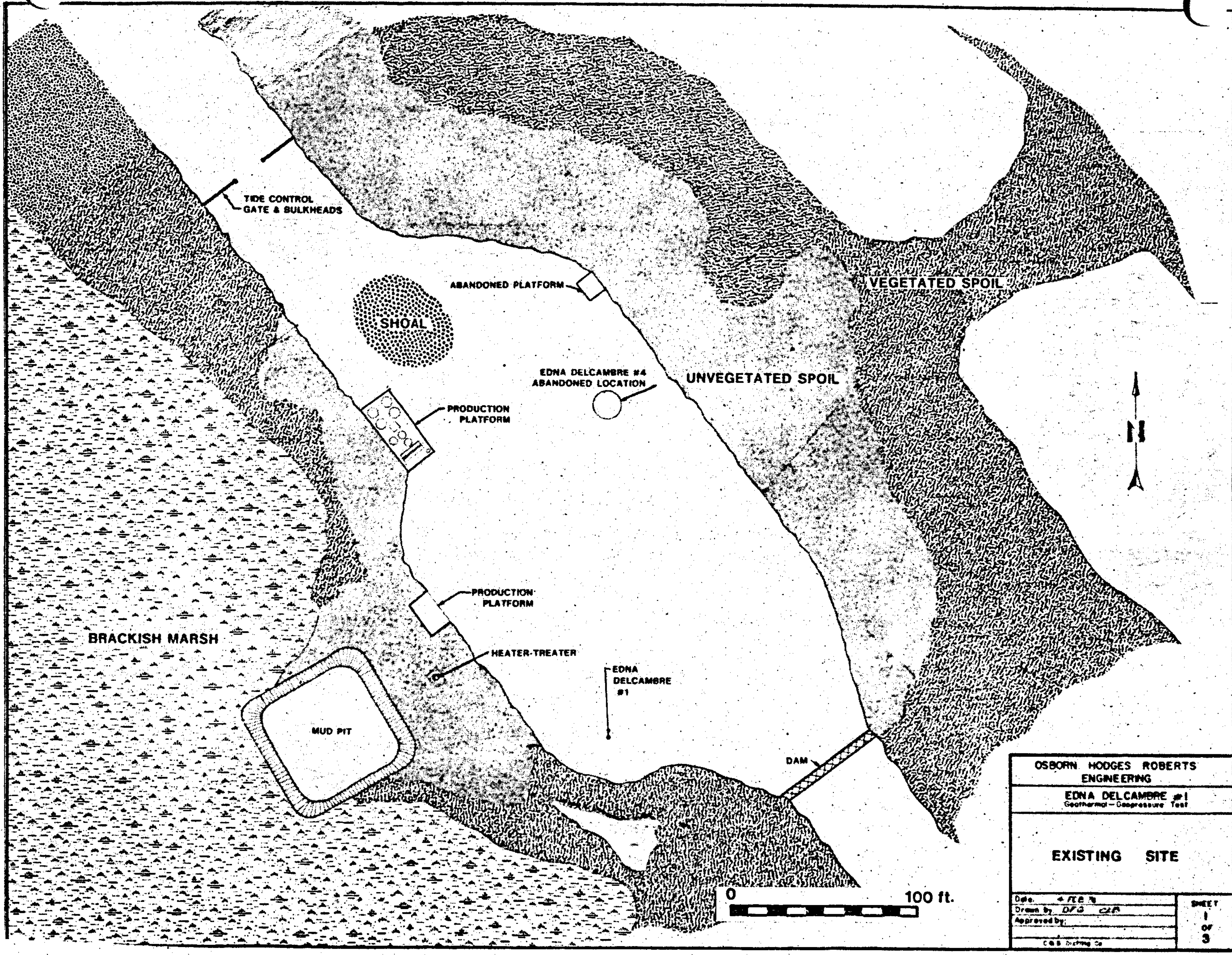


Figure II-1. Existing Site Diagram, Edna Delcambre #1.

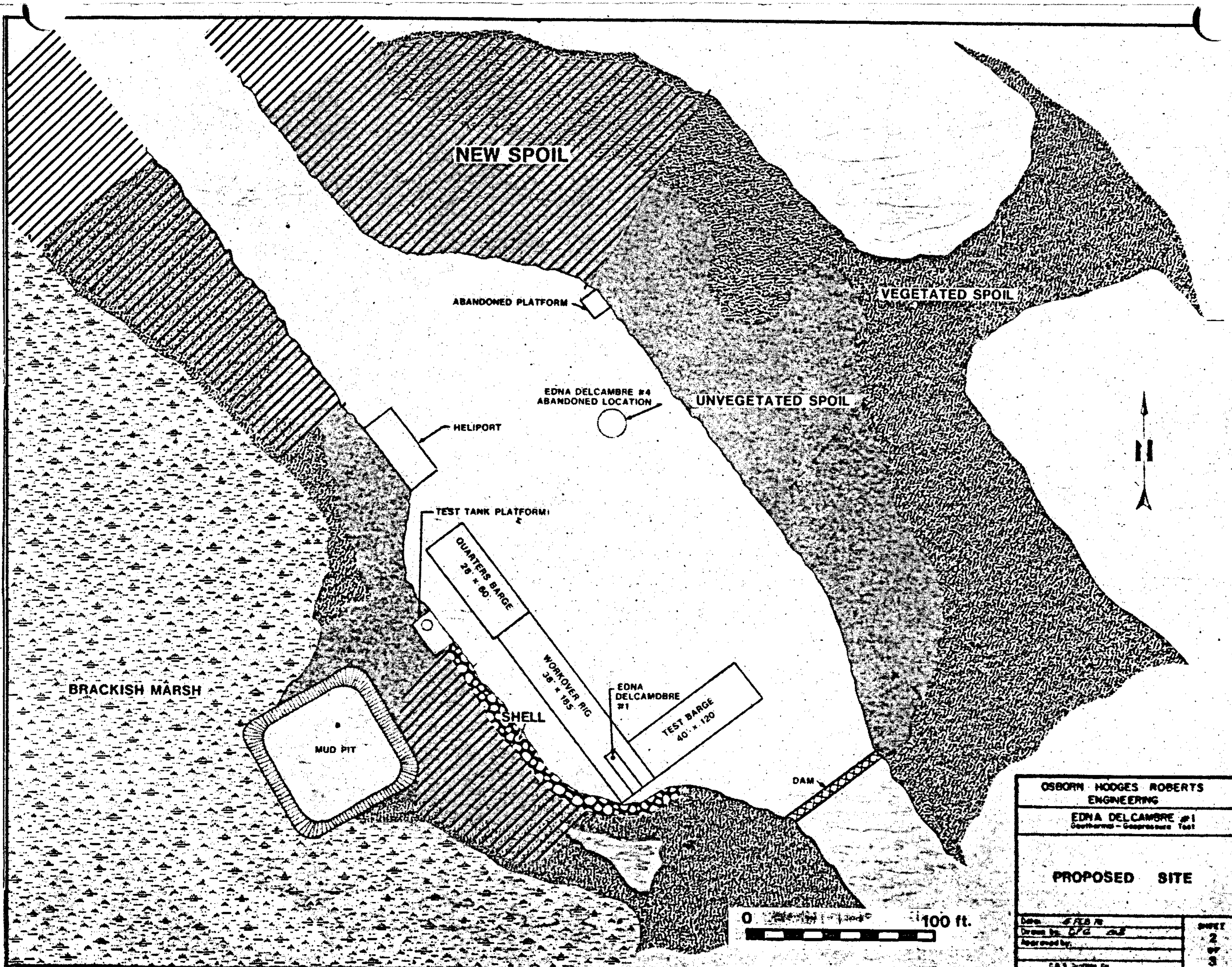


Figure II-2. Spoil Placement Diagram, Edna Delcambre #1.

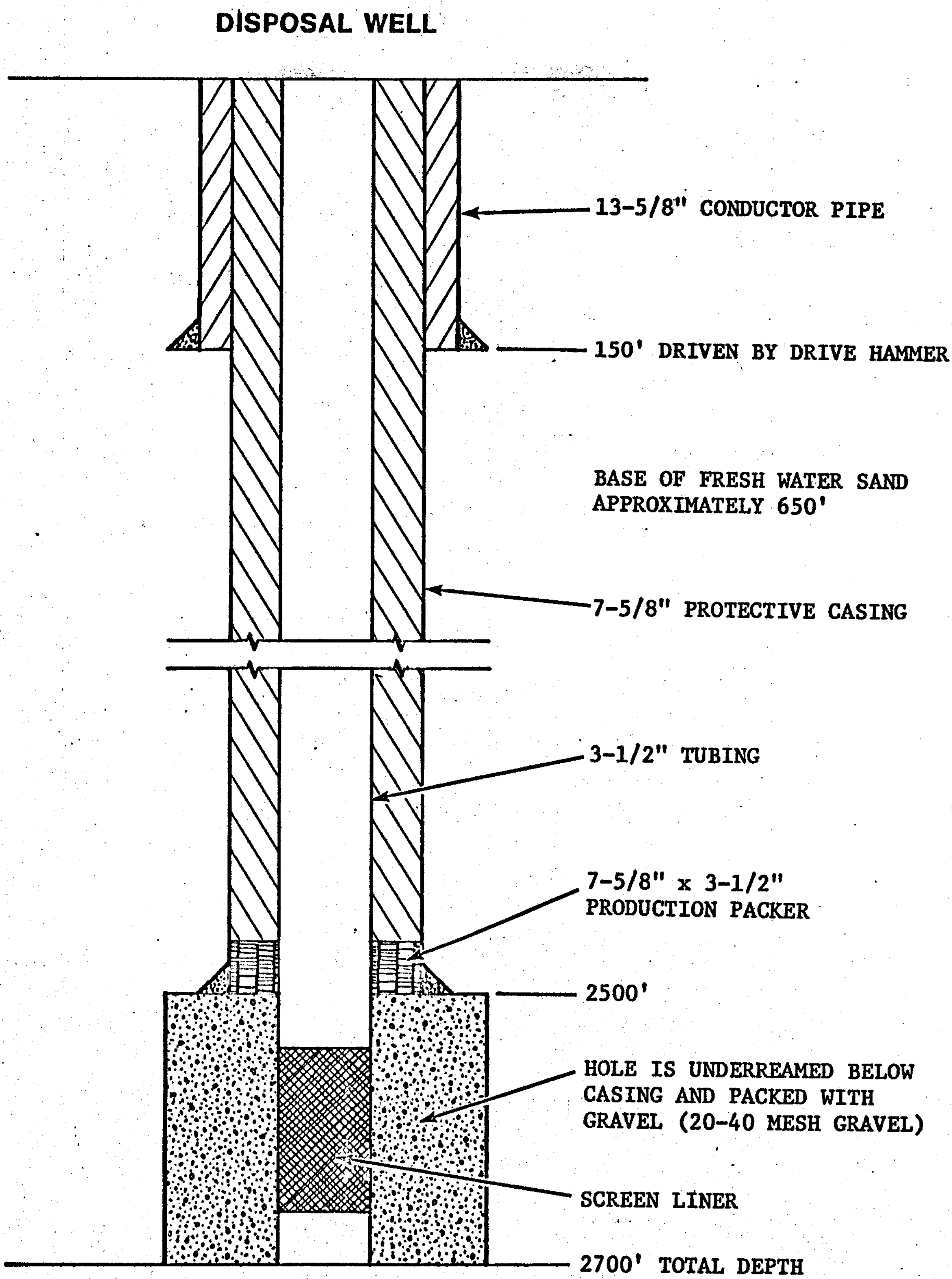


Figure II-3. Wellbore Diagram of Saltwater Disposal Well.

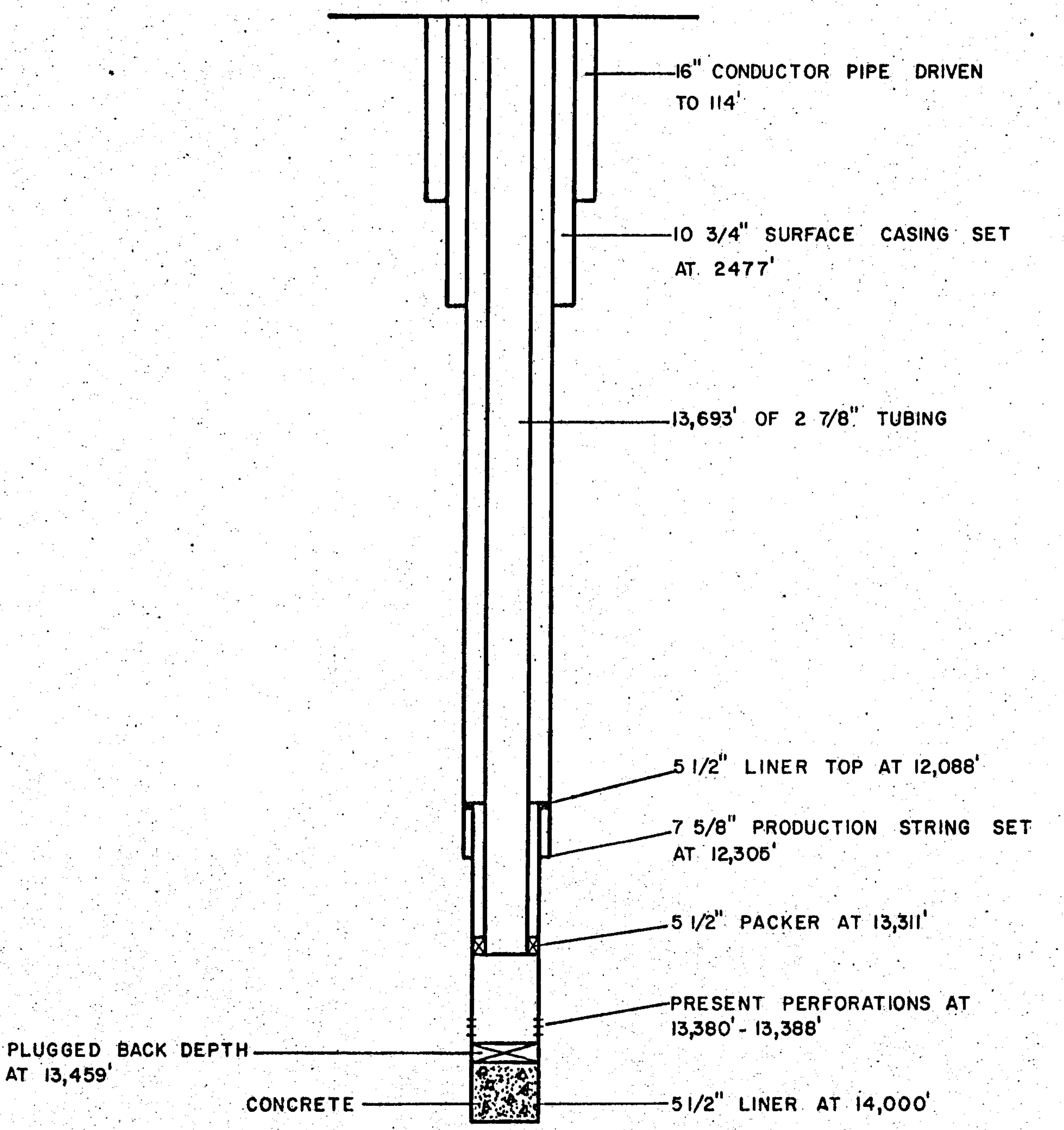


Figure II-4. Edna Delcambre #1, Present Wellbore Diagram, Tigre Lagoon, Vermilion Parish, Louisiana

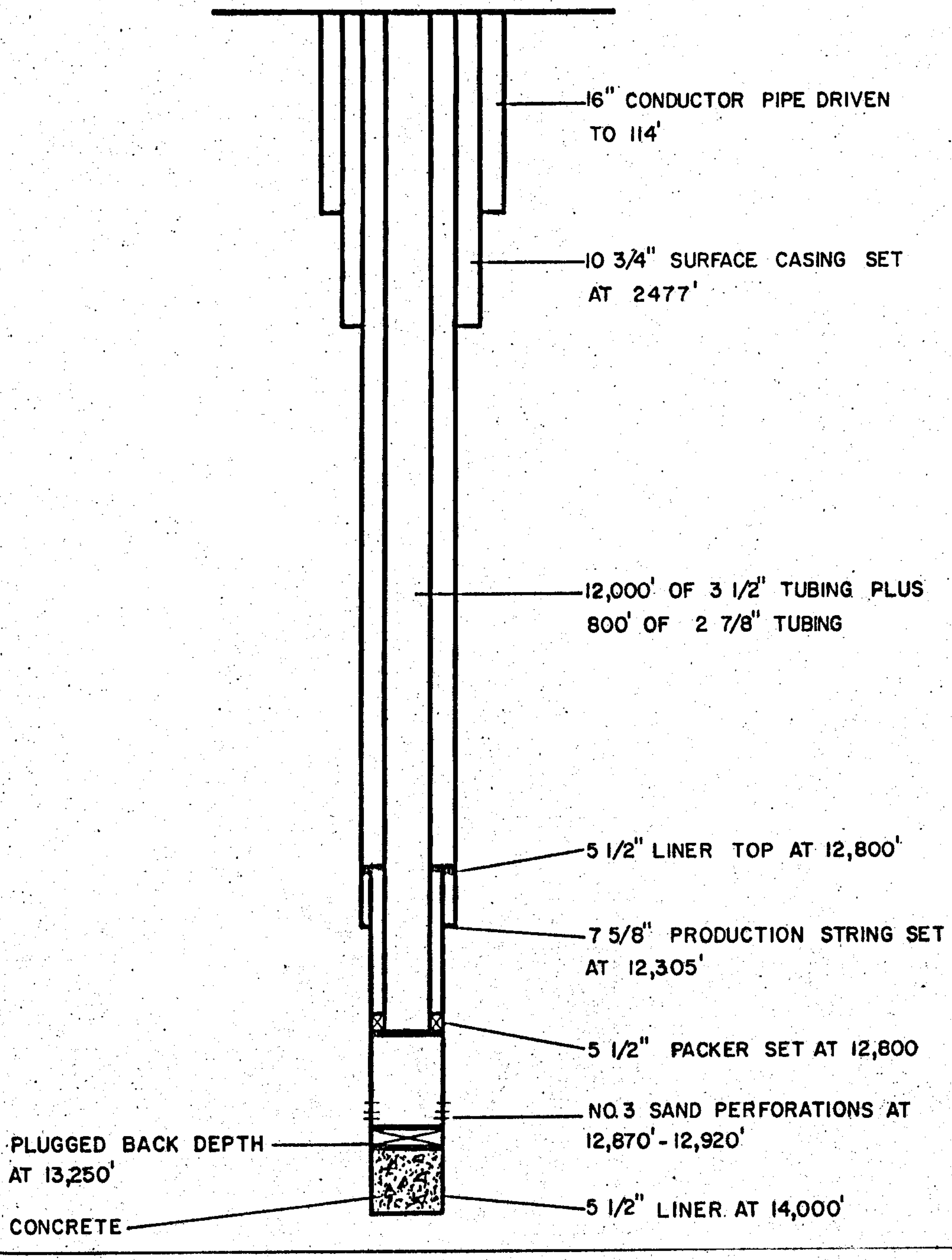


Figure II-5. Edna Delcambre #1, Geothermal Test Wellbore Diagram, Tigre Lagoon, Vermilion Parish, Louisiana.

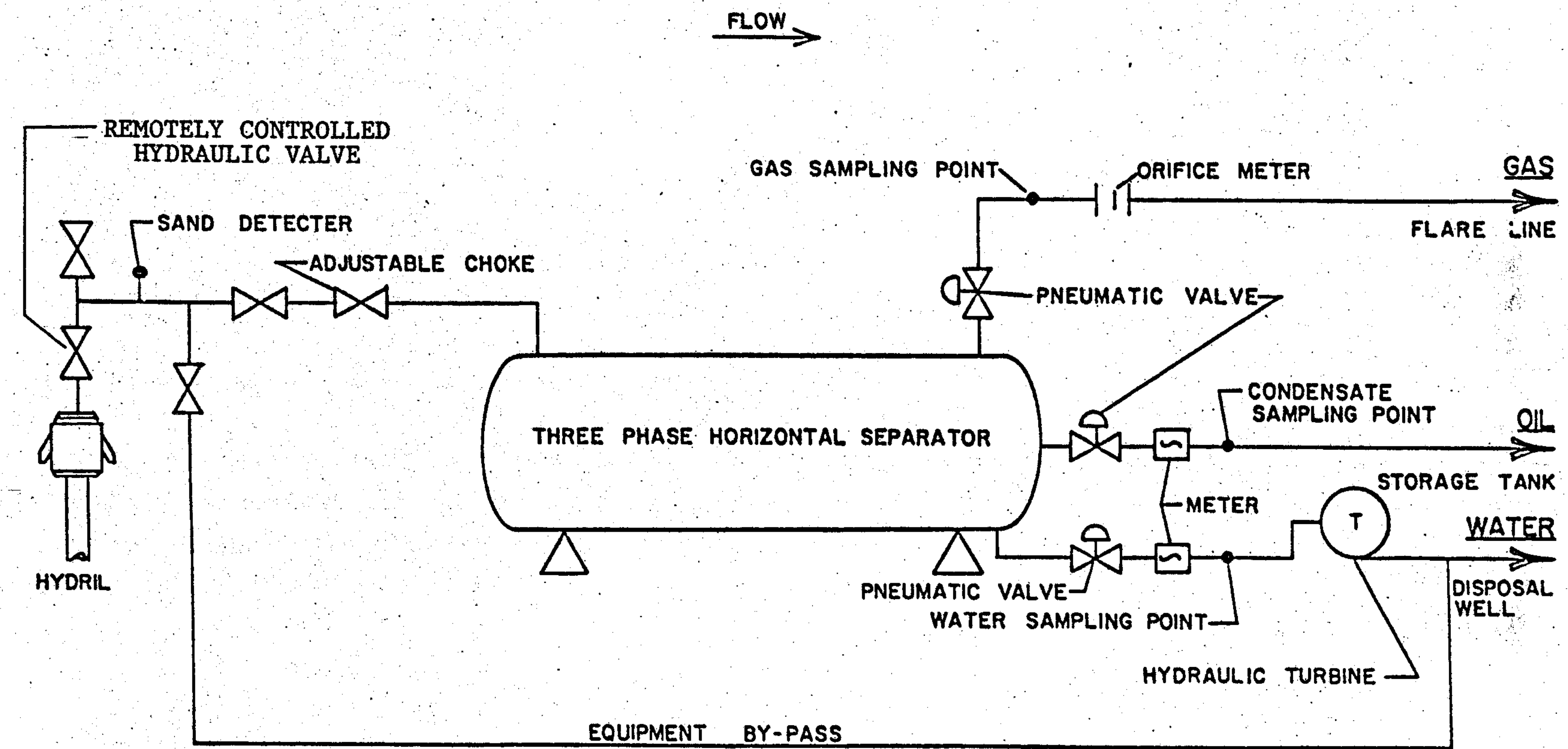


Figure II-6. Edna Delcambre #1 Surface Dynamic Test Equipment, Tigre Lagoon, Vermilion Parish, Louisiana.

Little condensate is anticipated. Whatever quantity is produced will be stored in a storage tank and sold at the end of the testing. The quantity is not expected to be greater than 50 barrels in total volume.

Precautionary Measures

The major concern in working over a well is the possibility of having a blowout. There are several safety precautions that have been taken for this project that will minimize this potential danger. It should be pointed out that the reservoirs in which the work will be performed are water cones. Because of this, there is very little fire hazard. Little or no oil or condensate is expected, which reduces the potential of long-term damage in the event of a blowout.

The precautions taken to prevent a blowout are as follows:

1) The blowout preventers, four in all, are rated at 10,000 pounds per square inch (psi) working pressure.

2) The tubing has a pressure rating of 19,000 psi working pressure.

3) The test tree has a rating of 10,000 psi working pressure.

4) The safety valves can be closed from a remote location.

5) A high pressure mud pump with the capability of pumping mud into the well against a pressure of 10,000 psi will be on location.

6) In addition to the drilling engineer, a special high pressure consultant will be on location at all times.

The equipment used to control the pressure at the surface has a working pressure rating that is twice the maximum anticipated pressure of 5,000 psi. Materials selected for tubing and piping have wall thicknesses to adequately handle the pressures encountered after having undergone erosion caused by the abrasive sand particles that will be in the flow stream.

Erosion is expected to be the major problem during the flow tests. For this reason, a sonic sand detector and precision orifice plates will be placed in the flow stream. The presence of sand particles in the flow stream will be continuously monitored. The orifice plates will be changed periodically and measured to determine the amount of erosion that has taken place over a given time period. These indicators will provide data to be used as a basis for estimating the life expectancy of the surface piping. The tubing will be internally plastic-coated to minimize the abrasive effects of the sand particles.

To prevent the rupture of any of the piping or test equipment, safety valves have been specified in the system design. As the line pressure increases to above the desired working pressure, a safety relief valve will open and divert the flow stream to the mud pit (Figure II-7). The master valve on the well will then be slowly closed and the problem corrected.

The only anticipated pollution to the water could come from hydraulic fluid dripping from the actuator of the safety valve at the well head. The

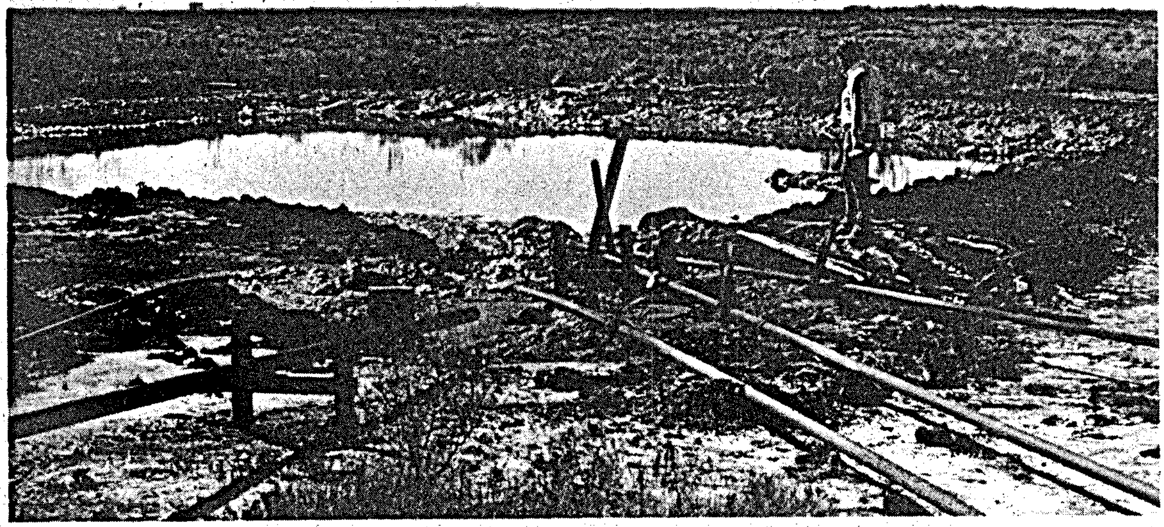


Figure II-7. S Sludge pit originally used for disposal drilling mud and cutting waste. Pit is surrounded by oil coated spoil.

key slot of the rig might be noted. A special gate to contain the hydraulic fluid or any lubricants that might fall into the water will be attached across the key slot. A skimmer or absorbing material will be used to remove the fluid from the water surface.

The rig has on board a Spill Prevention Control and Countermeasure plan as required by federal law. All personnel will be briefed on the plan of action should any hydrocarbon be spilled into the water.

In the event of a leak in the surface equipment, the safety valves will be closed immediately. Allowing a 15-minute reaction time, the amount of water that would be lost at a daily rate of 15,000 barrels per day would be 150 barrels of brine water.

At the termination of the testing program, the source well and the disposal well will be abandoned and the surface location cleaned up. Prior to abandonment of the disposal well, the mud pit will be drained of free water by the rig mud pumps, and this water will be pumped into the disposal well. The mud pit will be filled with the spoil around it and along the edge of the canal. All possible efforts will be made to leave the area in as natural a condition as possible. A step-by-step description of the proposed action is given in Appendix A.

III. ENVIRONMENTAL SETTING

Geology

Since it is felt that possible major impacts such as subsidence, seismic processes, and freshwater aquifer contamination are related to geological characteristics of an area, the geology of the test site is described in some detail.

Regional Geology

Regional geology is dominated by the Gulf Coast geosyncline which extends from Florida to northeast Mexico (Figure III-1). In Louisiana, the axis of downwarping and sedimentation is approximately beneath the coastline (Figure III-2), with the result that the formations of the state are part of a south-dipping monocline which has a regional dip of about 150 feet per mile at 10,000 to 12,000 feet (Dobie, 1970). Regional dip is modified by the diapiric intrusion of salt and the subsidence of adjacent areas. A series of residual highs and salt-withdrawal synclines occurs throughout the subsurface of Louisiana (Figure III-3). The Tiger Lagoon oil field, the study area, is an excellent example of the consequences of this type of salt movement.

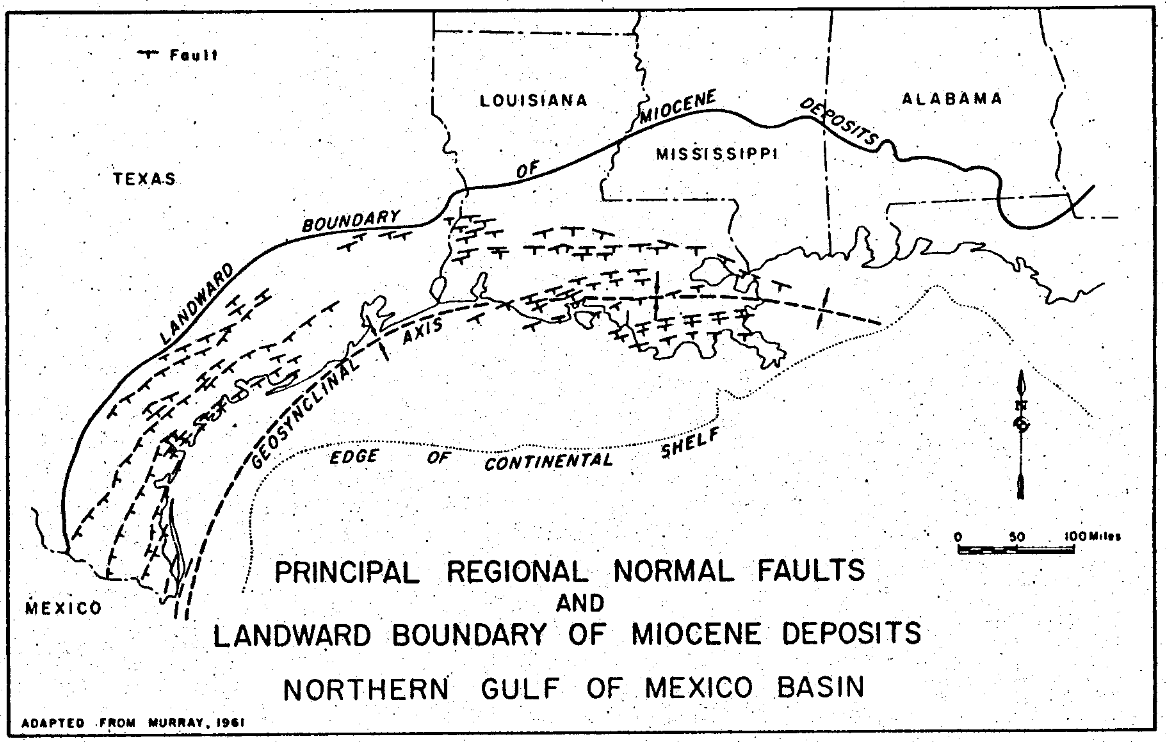


Figure III-1. Outline of Gulf Coast Geosyncline Across Texas to Florida.

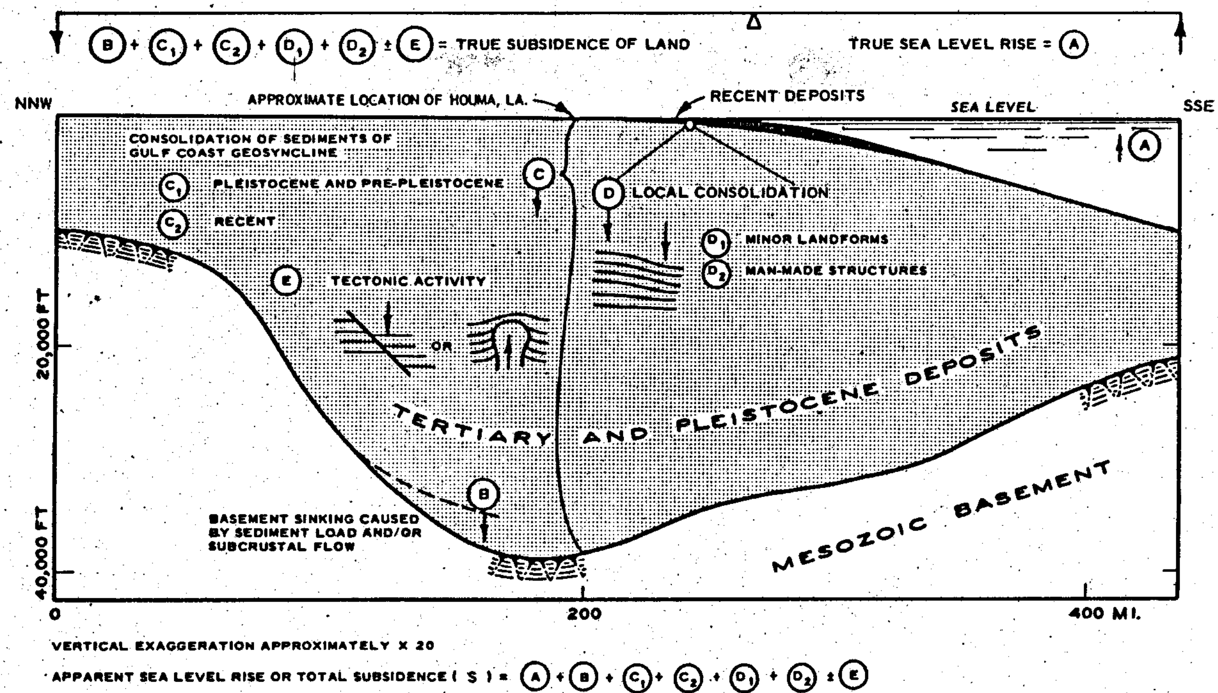


Figure III-2. Cross Section of Gulf Coast Geosyncline.

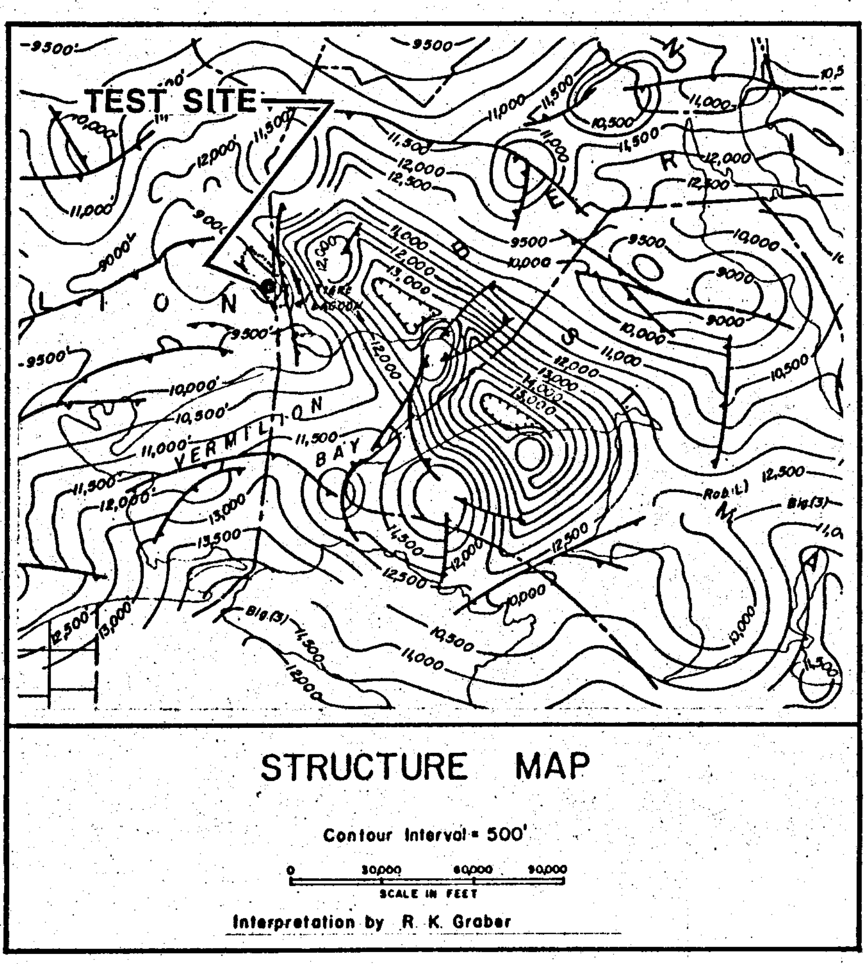


Figure III-3. The Five Islands Trough Area. The Residual Highs and Salt Withdrawal Synclines (Modified from Dobie, 1970).

Sloane (1971) describes the field as "a relatively young uplift on the flank of a much older rim anticline associated with the Five Island trend" (Figure III-4). The field is an anticline which trends northwest-southeast and has overall dimensions of six miles by three miles (Chadeayne, 1970). The major fault strikes north-south along the east flank of the structure (Figures III-3 and III-4). Displacement is normal with the down-thrown block to the east. Displacement increases with depth from 175 feet at 11,225 feet, to 200 feet at 11,550 feet, to approximately 350 feet at 11,800 feet.

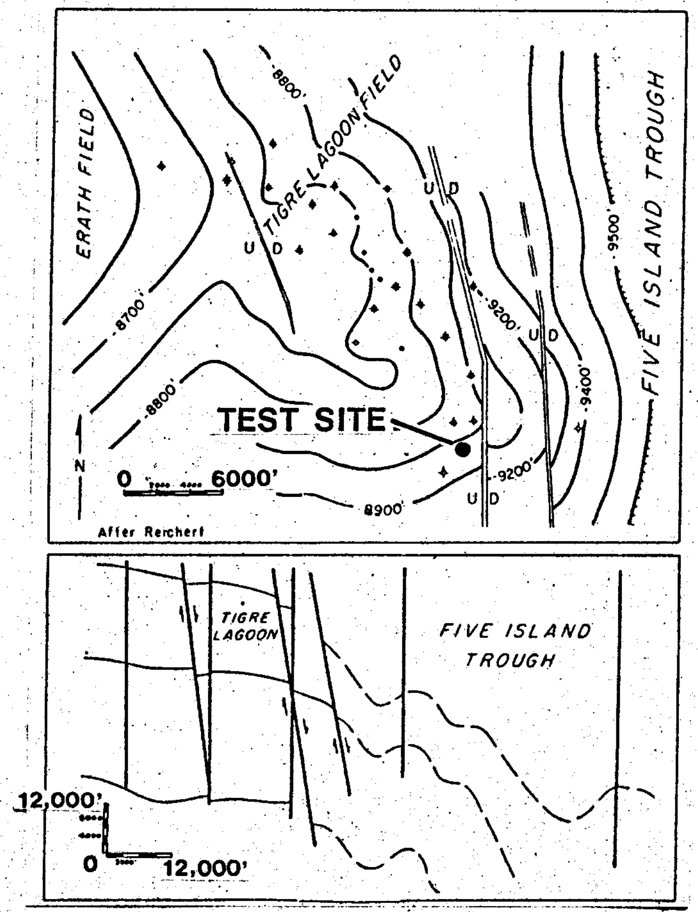


Figure III-4. East-West Cross Section of Tigre Lagoon Field (After Limes and Stipe, 1959).

The stratigraphic column for the study area is shown in Table III-1. Chadeayne (1970) lists the principal producing sands of the Tigre Lagoon field as the Planters (Figure III-5), the Landry (Figure III-6), and the Siphonina davisi (Figure III-7). A north-south cross section of the Tigre Lagoon field is shown on Figure III-8. Figure III-9 shows another important gas-producing strata, the Planulina sands. The Planters sands are the boundary between the Middle and Lower Miocene. The Landry, Siphonina davisi, and Planulina sands are all Lower Miocene in age. Figure III-10 is the type electric log for the Tigre Lagoon field (Chadeayne, 1970).

Table III-1. Geologic Column of the Study Area

EPOCH	GROUP	FORMATION	LITHOLOGY	INDEX FOSSILS
Holocene	River deposits	Meander belts and deltaic plain deposits, alluvium	See Section on Quaternary	
Plio-Pleistocene	Terraces	Citronelle	Basal sands and gravels, clays and silts above Citronelle - sandy pebble conglomerates; fine and medium sandstone; some red or purple shale and mudstone; cherts and orthoquartzites from Appalachian or Ouachita Mountains; crossbedding, channeling, cut and fill structures	
		Prairie	Clayey sandstones, fine to very fine sandy siltstones; sandy pebble conglomerates; fluvial sedimentary structures; light grey, light brown, yellowish orange in color; more finely grained than Citronelle, quartzose, chert, hematite, authigenic pyrite	

Source: U.S. Army Corps of Engineers, 1974 Preliminary Draft Environmental Statement, Atchafalaya Basin Floodway, Louisiana, New Orleans District.

Table III-1. Geologic Column of the Study Area

EPOCH	GROUP	FORMATION	LITHOLOGY	INDEX FOSSILS
Miocene	Grand Gulf Group	Fleming/ 1 Harang Fauna (downdip)	interfingering sands, silts and clays of deltaic origin; brackish water silts and clays	upper portion *Rangia* (*Miorangia*) *microjohnsoni* {mollusk} *Rotalia beccarii* (A) upper portion - downdips *Lenticulina vaughani* {="*Robulus* E"} *Bigenerina floridana* *Textularia stapperi*
		Catahoula	fresh water sands and silts, petrified wood fragments; root tubes, fossilized grasses; silty clays with leaf-bearing beds	middle portion - *Potamides matsoni* {mollusk} middle portion - downdips *Bigenerina humblei* *Globarotalia fohsi* *Uvigerina lirettensis*
		Chicka-sawhay	shale beds, deltaic deposits	lower portion - *Amphistegina* "B" *Operculinoides* sp. *Robulus chambersi* lower and middle portion - farthest downdy's *Cibicides opima* Harang fauna *Planulina harangensis* *Liebusella* sp. *Cyclammina* sp. basal portion *Marginulina ascensionensis* *Siphonina davisi*

Source: U.S. Army Corps of Engineers, 1974 Preliminary Draft Environmental Statement, Atchafalaya Basin Floodway, Louisiana, New Orleans District.

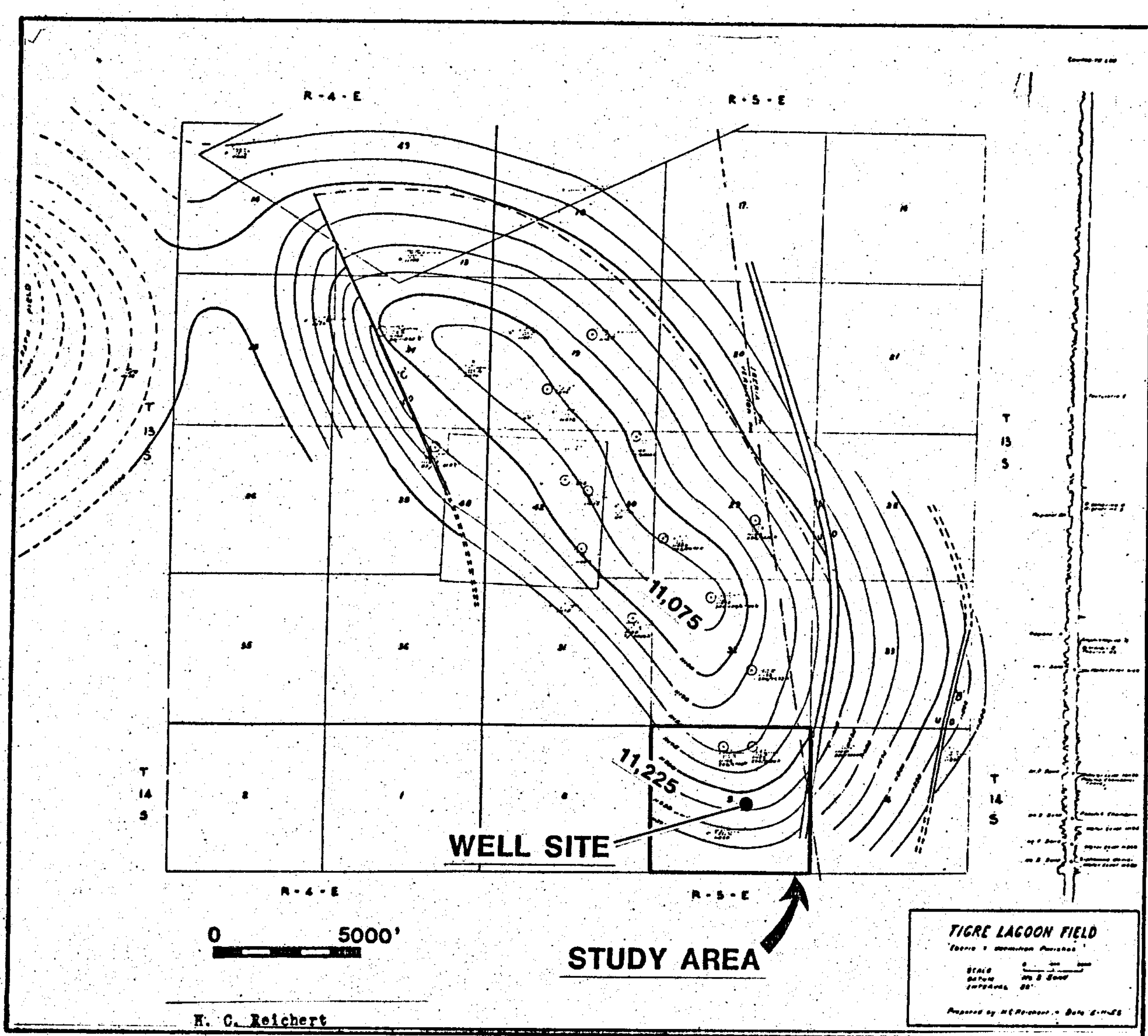


Figure III-5. The Planter's Sands (After Reichert, 1955).

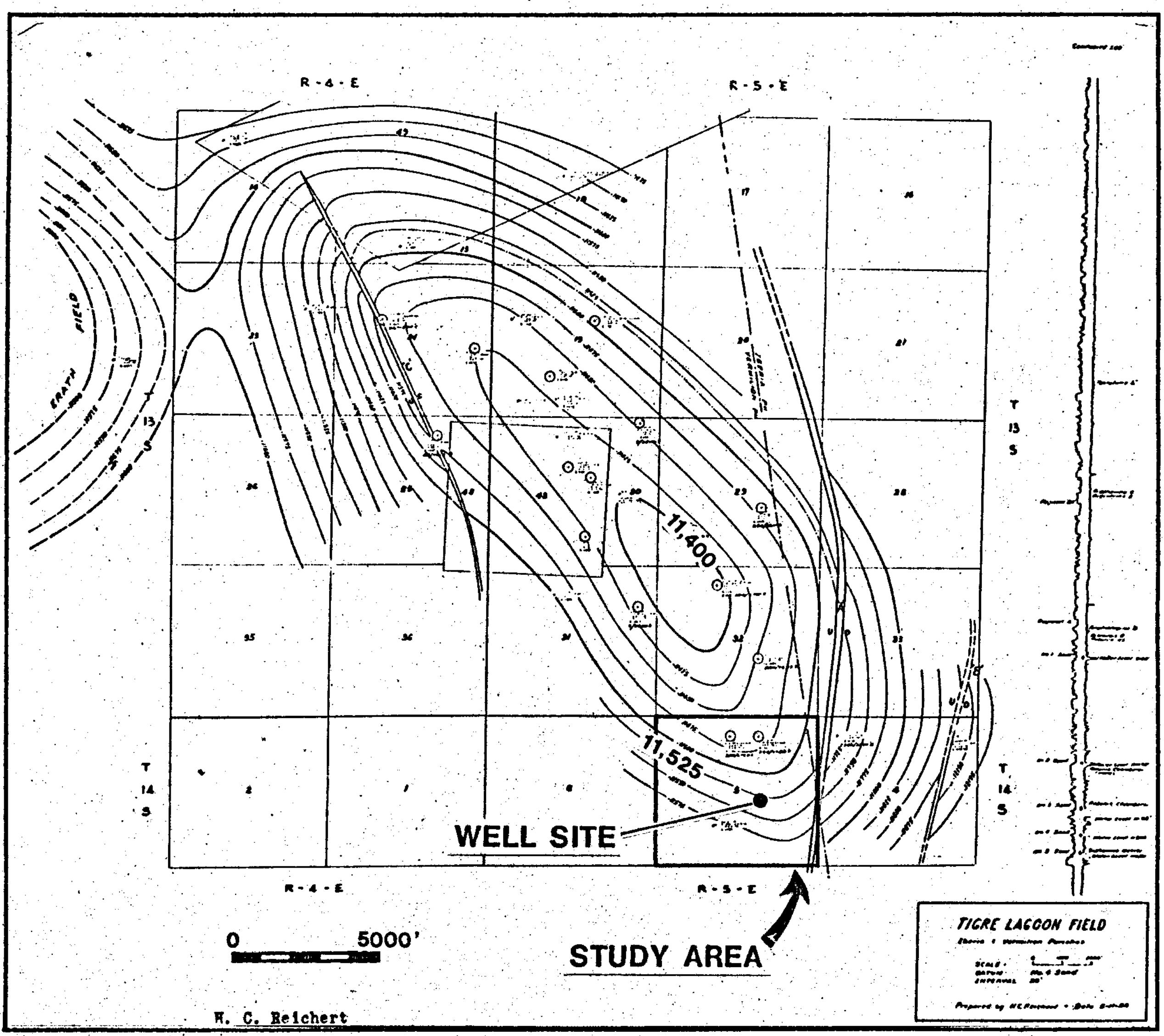


Figure III-6. The Landry Sands (After Reichert, 1955).

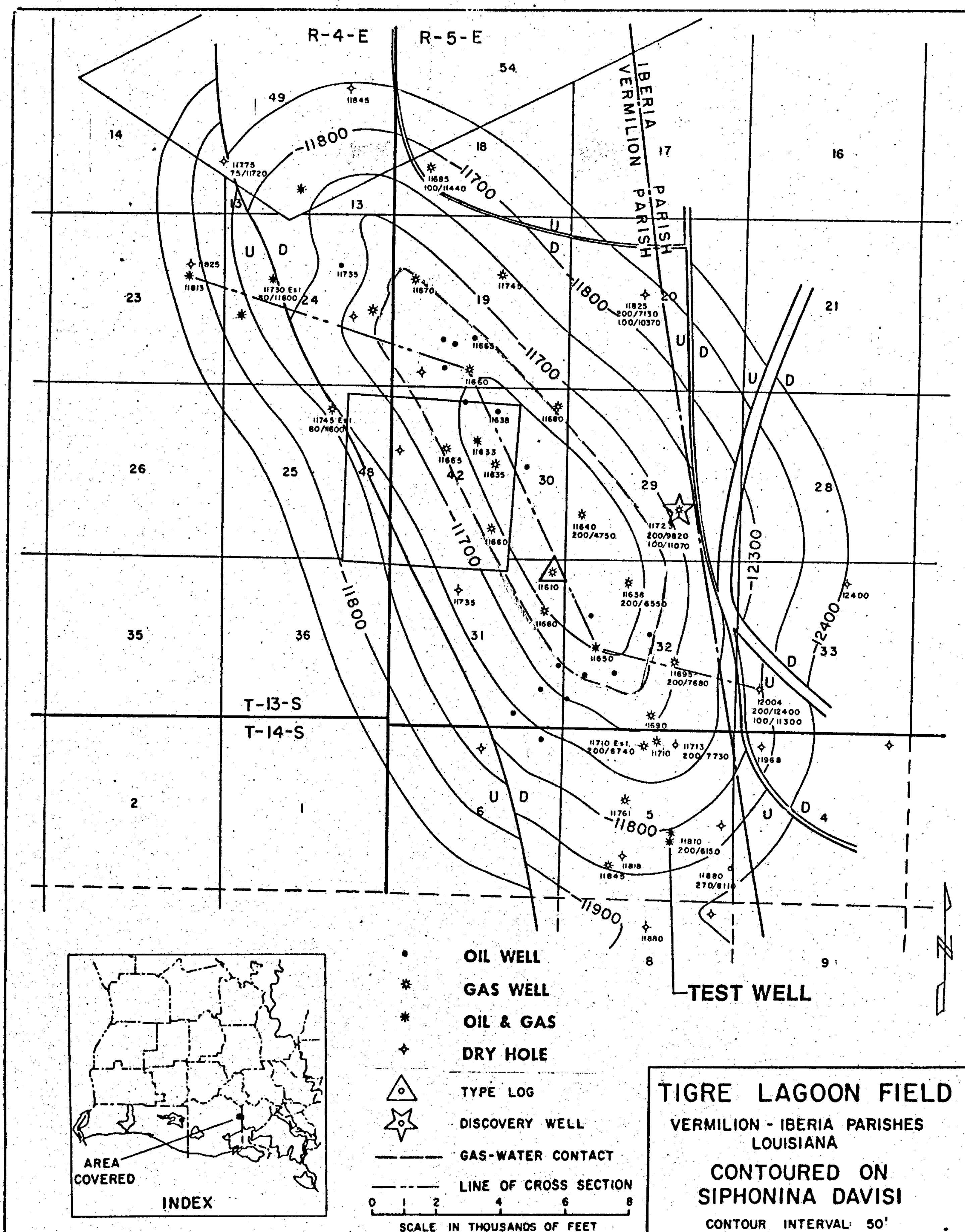


Figure III-7. The Siphonina davisi Sands (After Chadeayne, 1970).

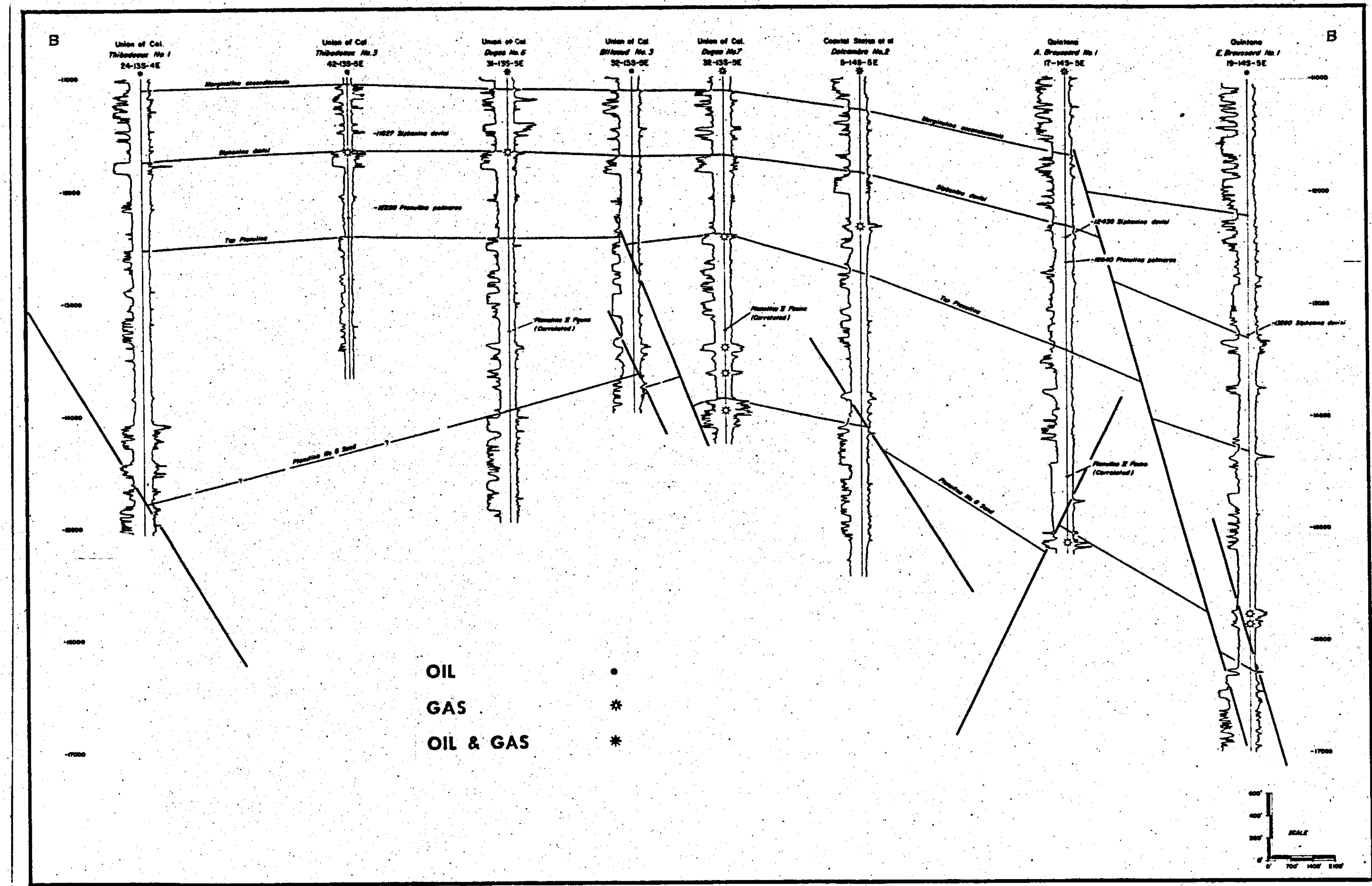


Fig. III-8. North-South Cross Section of Tigre Lagoon Field Section Line Shown on Figure 11 (After Sloane, 1971).

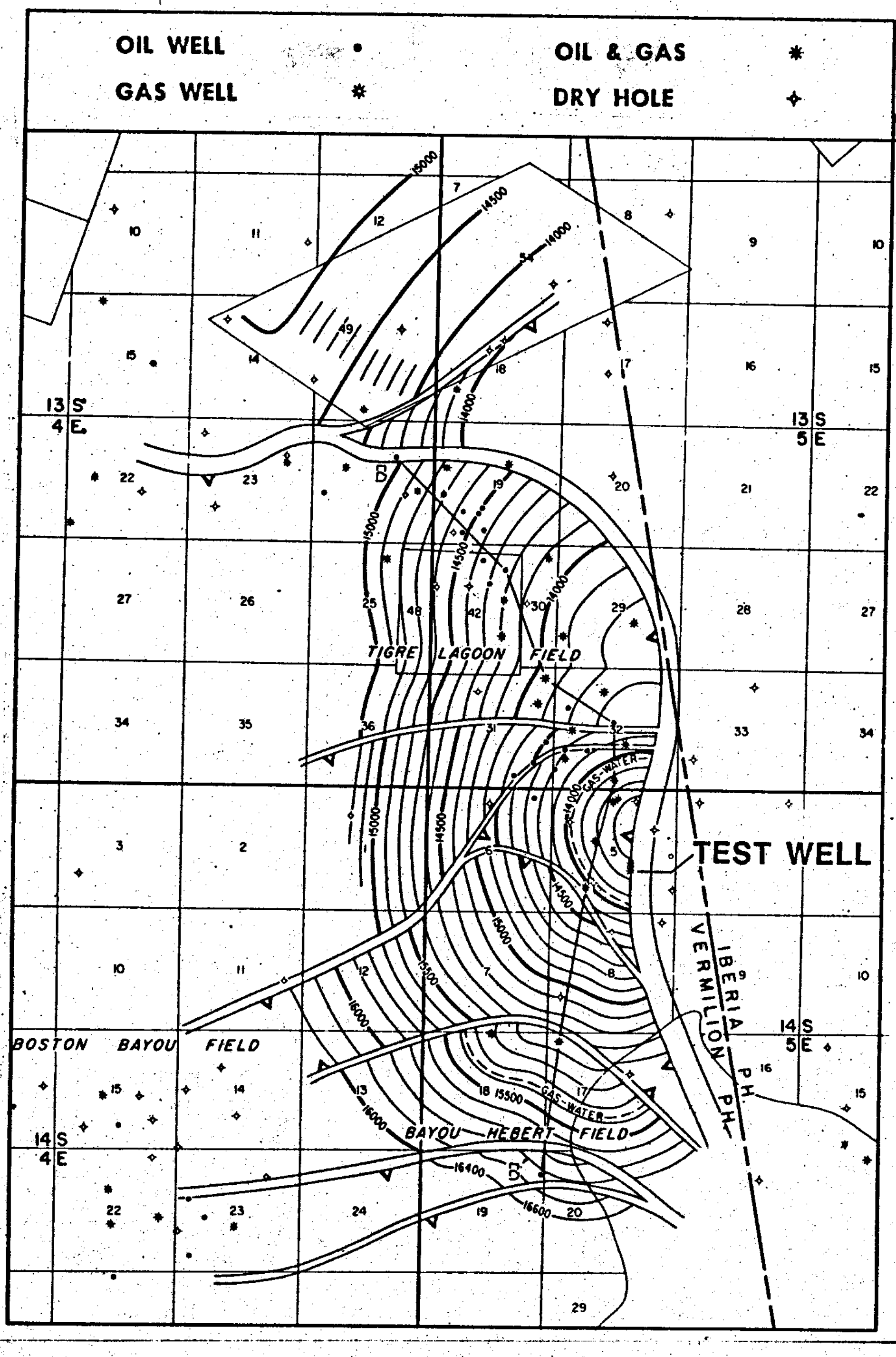


Figure III-9. The Planulina Sands (After Sloane, 1971).

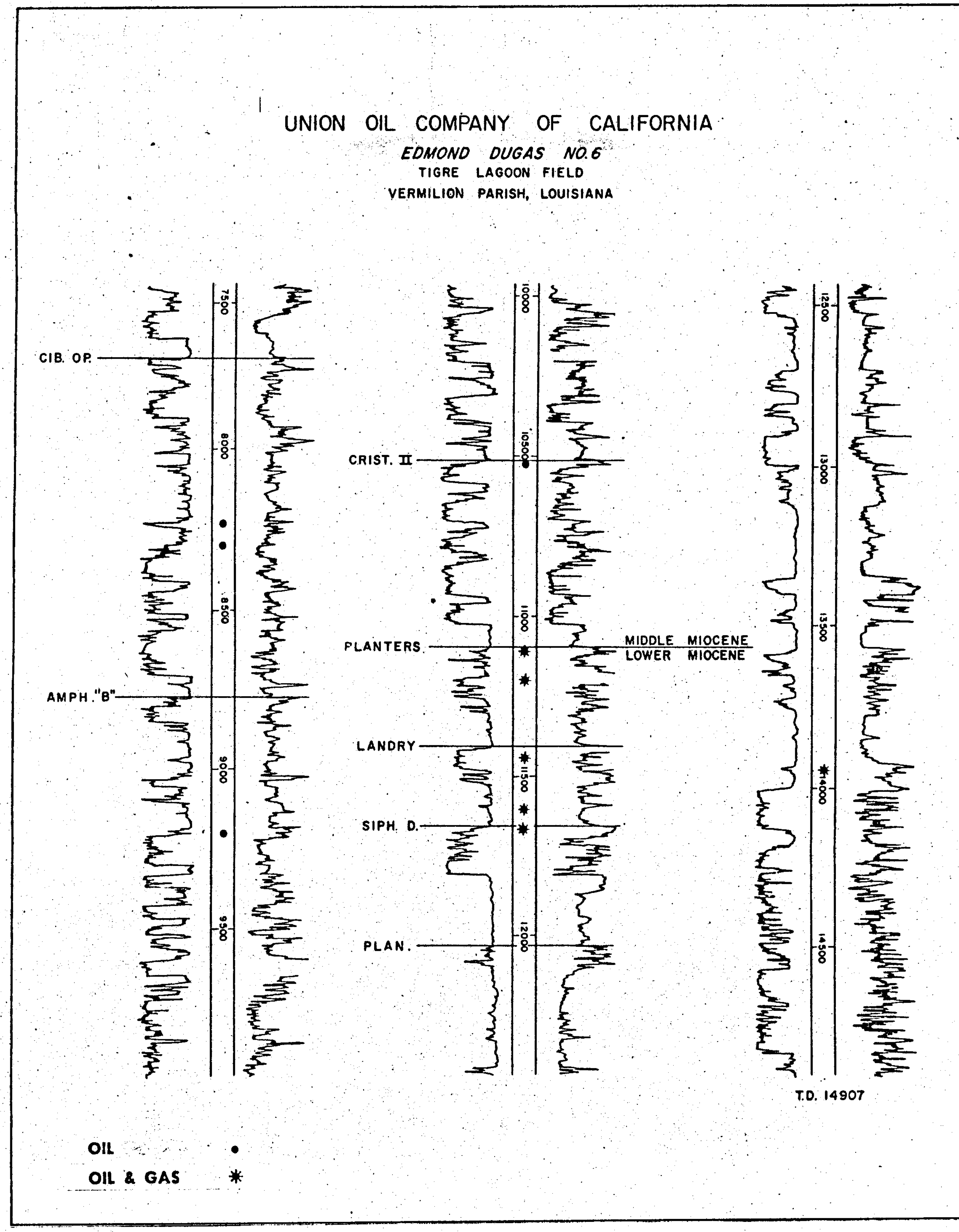


Figure III-10. Type Electric Log of the Tigre Lagoon Field (After Chadeayne, 1970).

With regard to the present report, the most important geological feature is occurrence of a geothermal, geopressured aquifer system composed of alternating sand and shale beds of lower Miocene age. The system extends along the entire northwestern Gulf of Mexico coastal plain (Figure III-11; Jones, 1975). Depth of occurrence of the geopressured zone in the project area is approximately 12,500 feet (Jones, unpublished maps). The two aquifers to be tested are sand beds referred to as the #1 and #3 sands, which are part of the Planulina formation. The following table (III-2) and Figure III-12 give their respective characteristics. Lateral distribution of the #3 sand is shown in Figure III-13. Pay sands from which 13167.2 thousand cubic feet (mcf) of gas have been produced through the Edna Delcambre #1 well lie immediately below the test aquifers at depths from 13,300 to 13,800 feet. None of the aquifers to be tested has been tapped for oil or gas, but it must be assumed that geopressured water is methane-saturated on the basis of geophysical data from well logs, the absence of a pressure decline, and occurrence of a 40-feet gas cap in the #1 sand at the Union Oil Dugas #7 well, located one mile due north of the test well (Figure III-13).

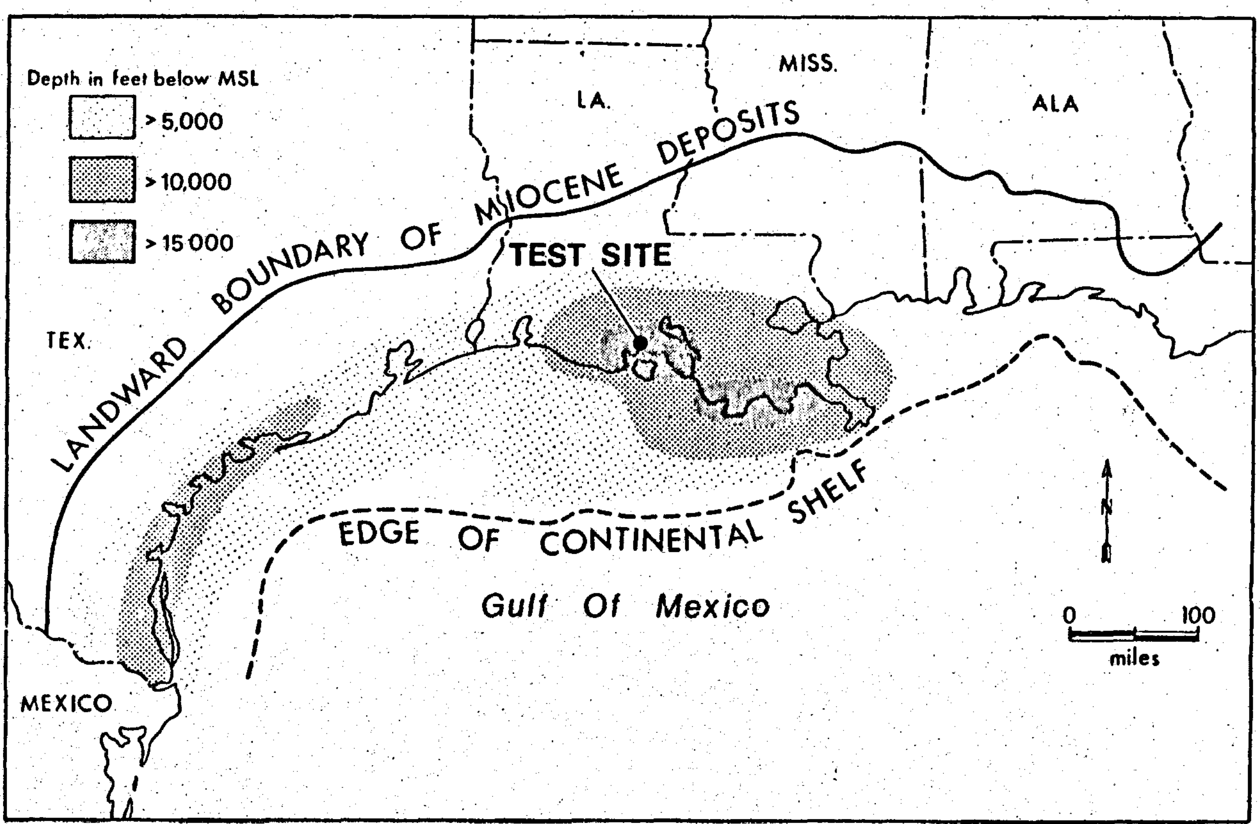


Figure III-11. Geopressured Zone in Neogene Deposits, Northern Gulf of Mexico Basin (From Jones, 1975).

Boundaries of the reservoir have been established partly on the basis of data from adjacent oil and gas wells. The data reveals the presence of bounding faults (Figure III-13) that are part of the growth fault system shown in Figure III-9 and along which vertical displacements of up to 500 feet (Dr. Paul Jones, 1976; Oral Communication) have been identified in the Miocene deposits. A minimal area of the reservoir has been estimated as 50,000 acres (Dr. Paul Jones, 1976; Oral Communication).

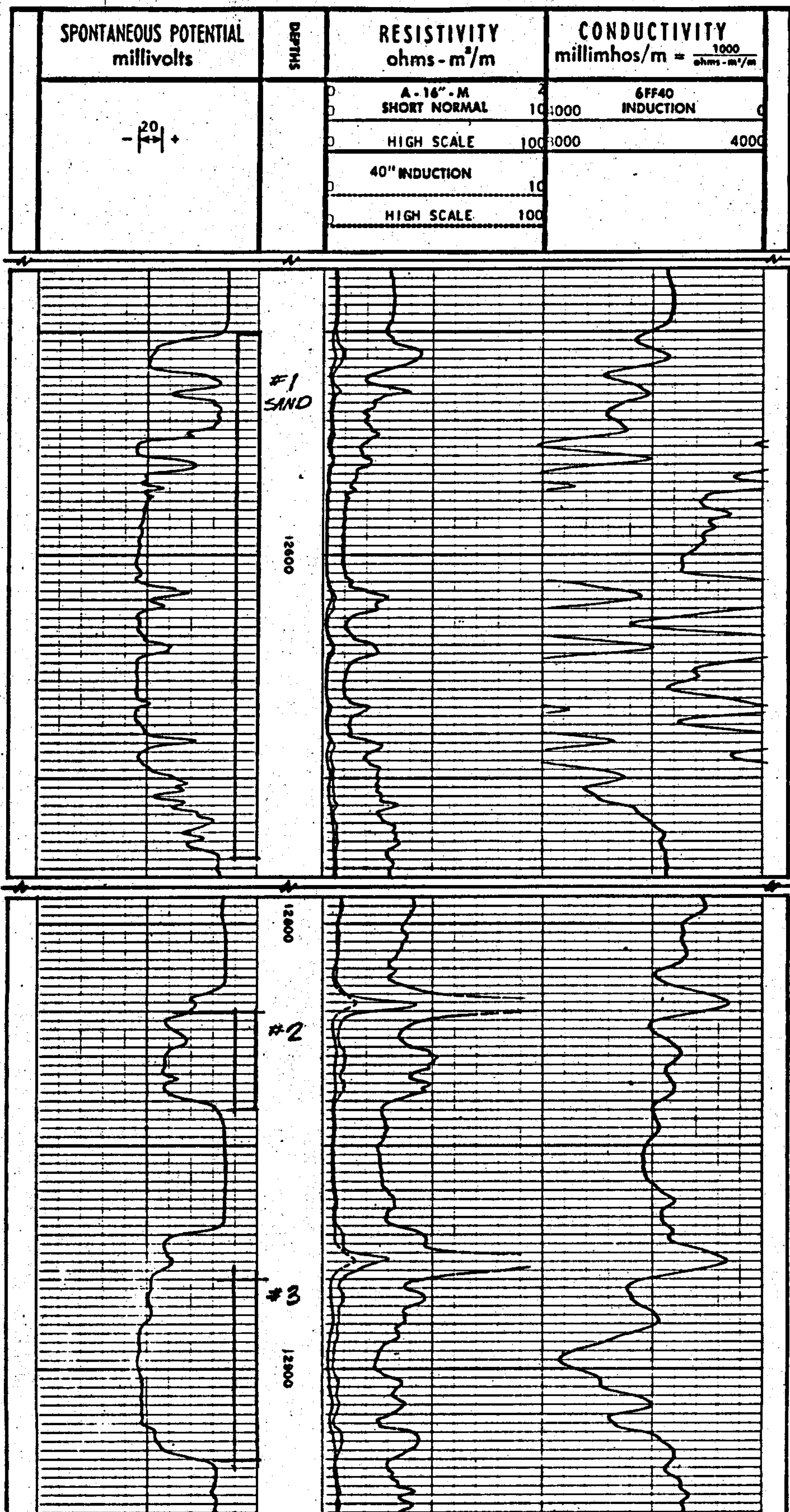


Figure III-12. The Electric Log of the Coastal States' Delcambre No. 1 Well Showing the Planulina Formation

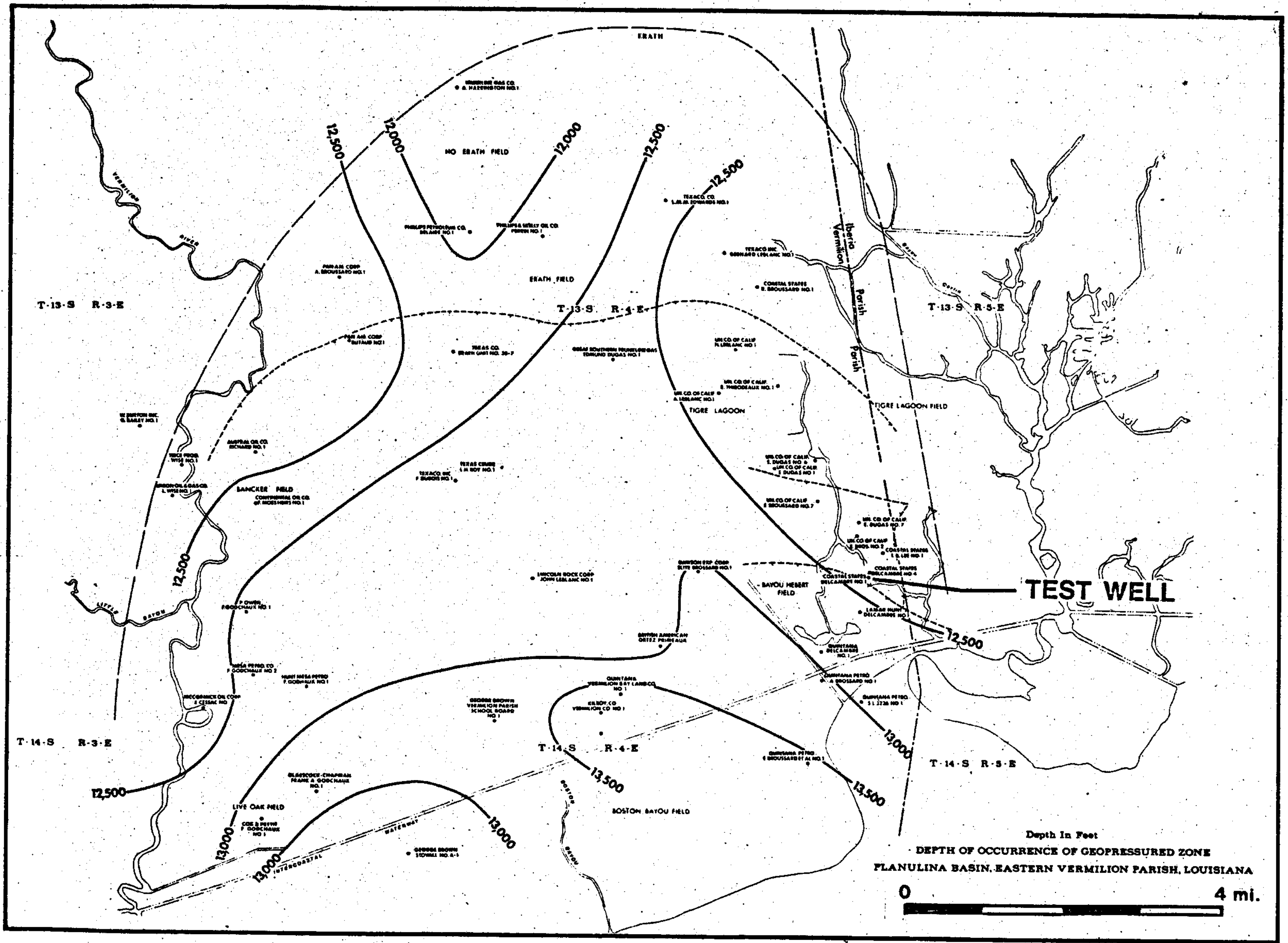


Figure III-13. The Distribution of the Number 3 Sands Across the Study Area.

Table III-2. Characteristics of Aquifer Sands to be Tested.

	Sand #1	Sand #3
Depth (ft)	12550 - 12668	12880 - 12920
Porosity	0.35	0.26
Temperature	± 235°F	± 240°F
Pressure	± 11000 psi	± 11000 psi

Quaternary Geology

The test well is located in the five islands area of the Louisiana coastal zone between the Mississippi River deltaic plain to the east and the Chenier Plain to the west (Figure III-14). The basic elements of the surface and near-surface geology in the general vicinity fall into three groups: 1) salt dome islands, 2) Pleistocene terraces and deposits, and 3) Holocene coastal features and deposits. The geological history and physical characteristics of these elements have been studied by a number of workers, and consequently, there is a considerable amount of published data to draw from as background for the present assessment.

Salt Dome Islands

Lying north and east of the proposed test well site are three of a trend of five salt domes that have surface expression (Figure III-14, Jefferson Island, Avery Island and Weeks Island). The unusual elevation and relief of the domes (Avery Island reaches elevations above 150 feet) stand in sharp contrast to the virtually flat terrain of the surrounding terrace and marshes (Figure III-15). For this reason, they have been called islands.

The rock salt cones of the domes lie at relatively shallow depths (approximately ten feet at Avery Island), and consequently, each has a long history of mining activity. Surface deposits on the domes consist largely of Pleistocene sediments, but there are also Tertiary exposures and areas of Holocene sediment accumulation.

Although these features are interesting geologically, they have little bearing on the assessment of the test well site. It should be noted, however, that while the domes do represent major tectonic elements, there is no evidence of seismic activity associated with the features. The islands have been utilized since colonial times (circa 1800 A.D.), and there are no known reports of seismic tremors or other effects. Furthermore, detailed archeological and stratigraphic studies at Salt Mine Valley, Avery Island, suggest stability for the past 12,000 years (Gagliano, 1967; 1970). The geologic data suggests that the relative uplift of the domes has been slow and imperceptible over long periods of geologic time.

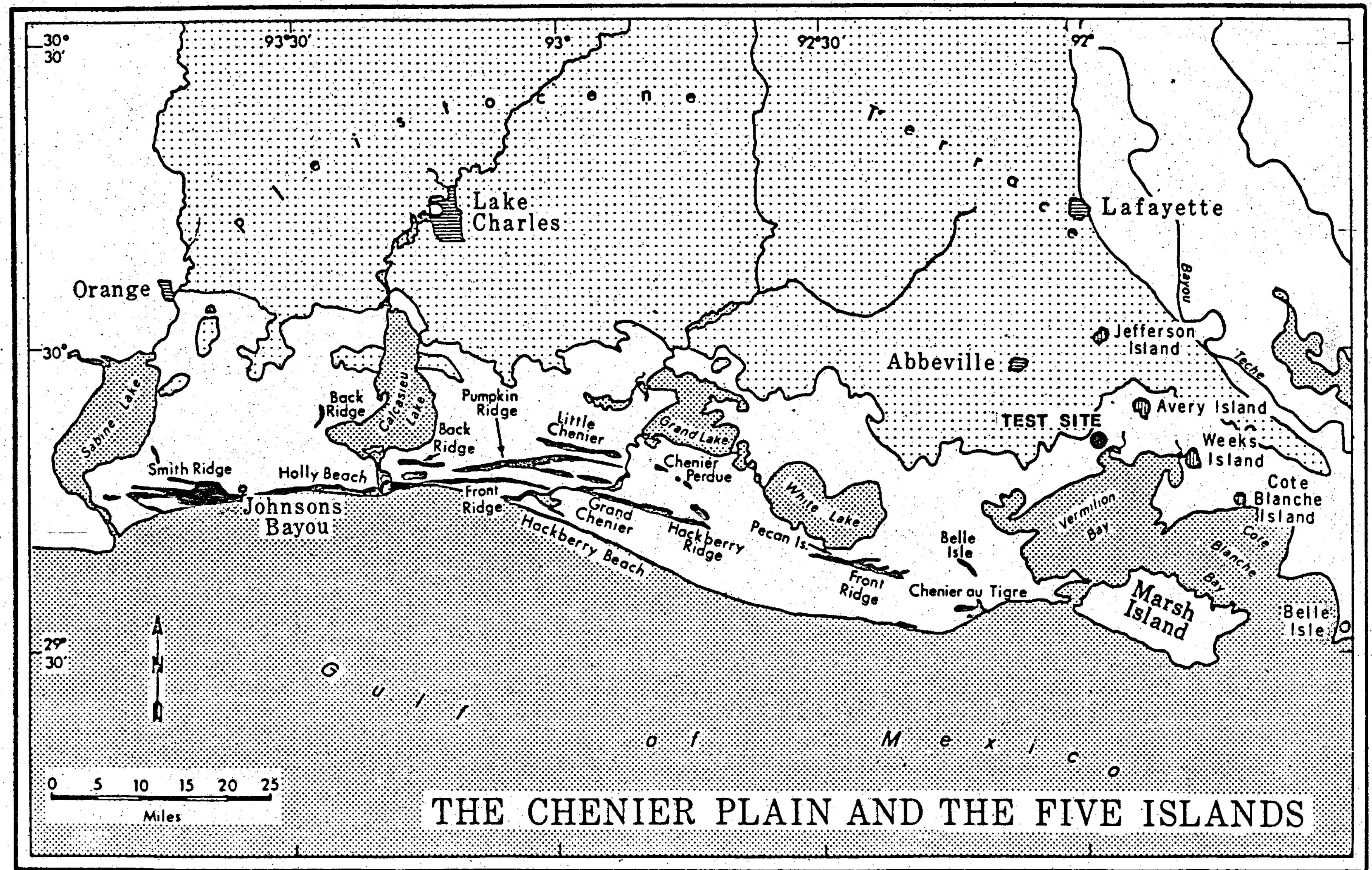


Figure III-14. The Chenier Plain and the Five Islands of Southwest Louisiana.

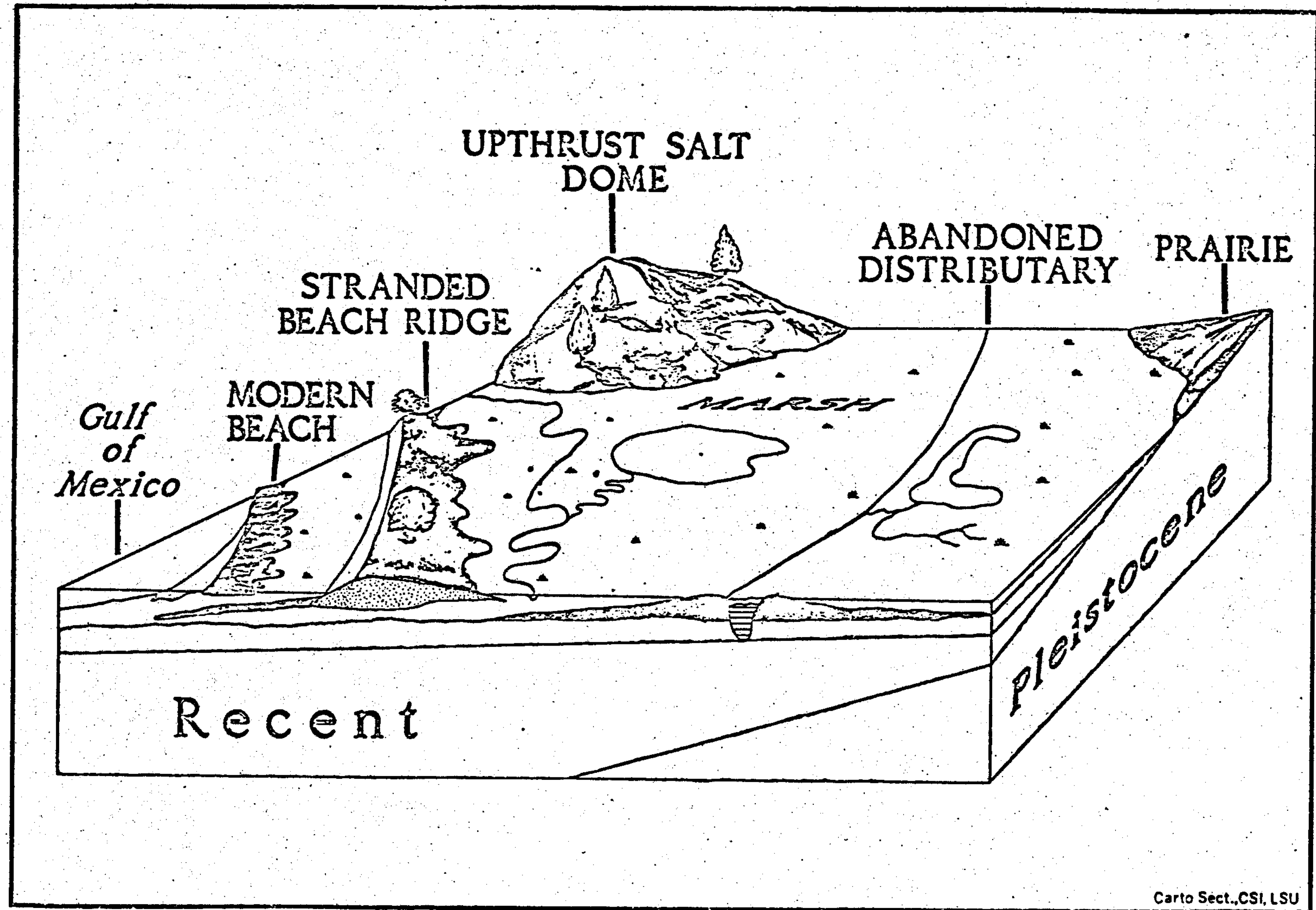


Figure III-15. Block Diagram and Schematic Representation of Avery Island in Relation to the Nearby Pleistocene and Surrounding Wetlands.

Another aspect of the islands in reference to the present study is that the best evidence of extinct, Pleistocene vertebrates which occurs in the region and which may be associated with shallow, Pleistocene deposits at the test well site comes from Salt Mine Valley. Arata (1964) reports eleven extinct forms from the valley. While Pleistocene deposits may be encountered in the maintenance dredging at the well site, the probability of vertebrate fossil occurrence is relatively low. As discussed in the archeological section of this assessment, inspection of the present spoil bank deposits at the well site failed to disclose any vertebrate fossils.

Pleistocene Terraces and Deposits

The test well site lies approximately 1.3 miles southeast of the surface contact between the late Pleistocene Prairie Terrace and the overlying wedge of Holocene deposits (Figure III-16). The Prairie Terrace represents a late Pleistocene floodplain and deltaic plain of the Mississippi River. Both the characteristics of the relict surface topography and the nature of the terrace deposits reflect this origin. The most prominent relict features are related to a major meander belt of the Mississippi River (the Lafayette meander belt), which trends through the present cities of Lafayette and Abbeville (see Figure III-17). The meander belt is distinguished by natural levee ridges, point bars, channel scars, and attendant features. Sands and gravels deposited in point bars and channels constitute one of the major surface aquifers of the area, extending to depths of over 150 feet. Marginal to the old meander belt are backswamp deposits. The test well is located in an area of fine-grained, late Pleistocene, backswamp deposits.

As indicated in Table III-3, subsequent to its abandonment by the Mississippi River in late Pleistocene times, the alluvial valley and deltaic plain associated with the Lafayette meander belt became tilted. While the upper part of the surface became uplifted and drained, the seaward ends were downwarped and drowned. The fulcrum upon which the tilting occurred is approximated by the Pleistocene-Holocene surface contact. It is significant that the test well is situated in close proximity to this "hinge line."

The uplifted part of the terrace to the north constitutes the rich, agricultural prairie lands of southwestern Louisiana, while south of the hinge line the surface has been drowned by the sea and partially buried by Holocene sediment. Prominent bulges on the continental shelf mark the positions of the deltaic lobes associated with the late Pleistocene delta system (see Frazier, 1974; Gagliano, et al., 1975).

Pleistocene exposed in the spoil banks at the test well site is indicative of the shallow depth of burial. The spoil material consists of silty clays that are oxidized and deeply weathered. Pleistocene deposits continue to depths of approximately 2,000 feet in the vicinity of the test well. Below the sequence related to the Lafayette meander belt, in order of increasing depths and age, are older Prairie, Montgomery, Bentley, and Williana Formations. Each of these formations is of fluvial deltaic origin, having a history not unlike that described above for the late Quaternary. The deposit consists of channel and point bar sands and gravels, interbedded with floodplain and shallow marine sequences consisting largely of clays and silty clays. In the vicinity of the test well, sands and gravels are well developed in the upper half of the Pleistocene section. It is

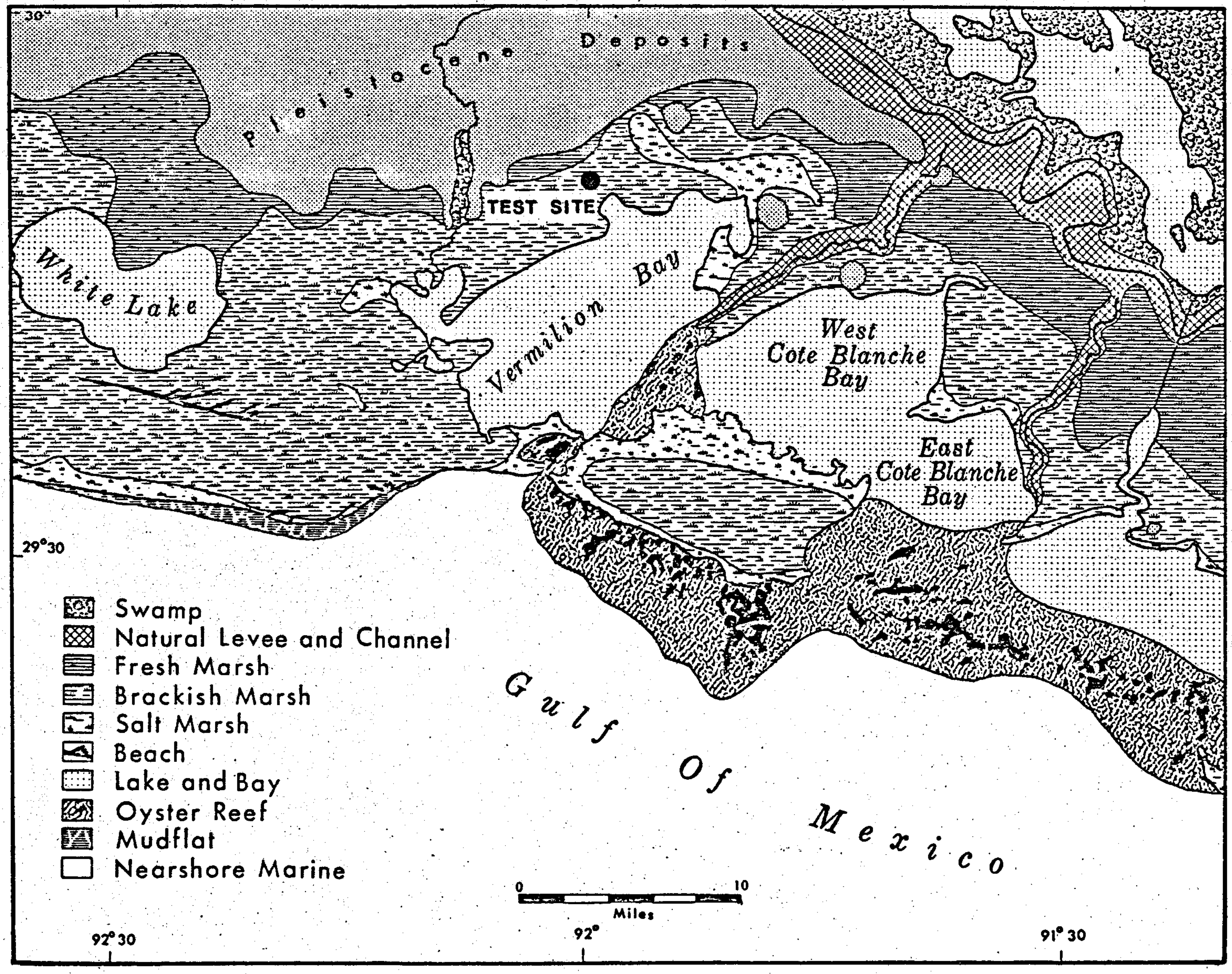


Figure III-16. The Physiography of the Study Area.

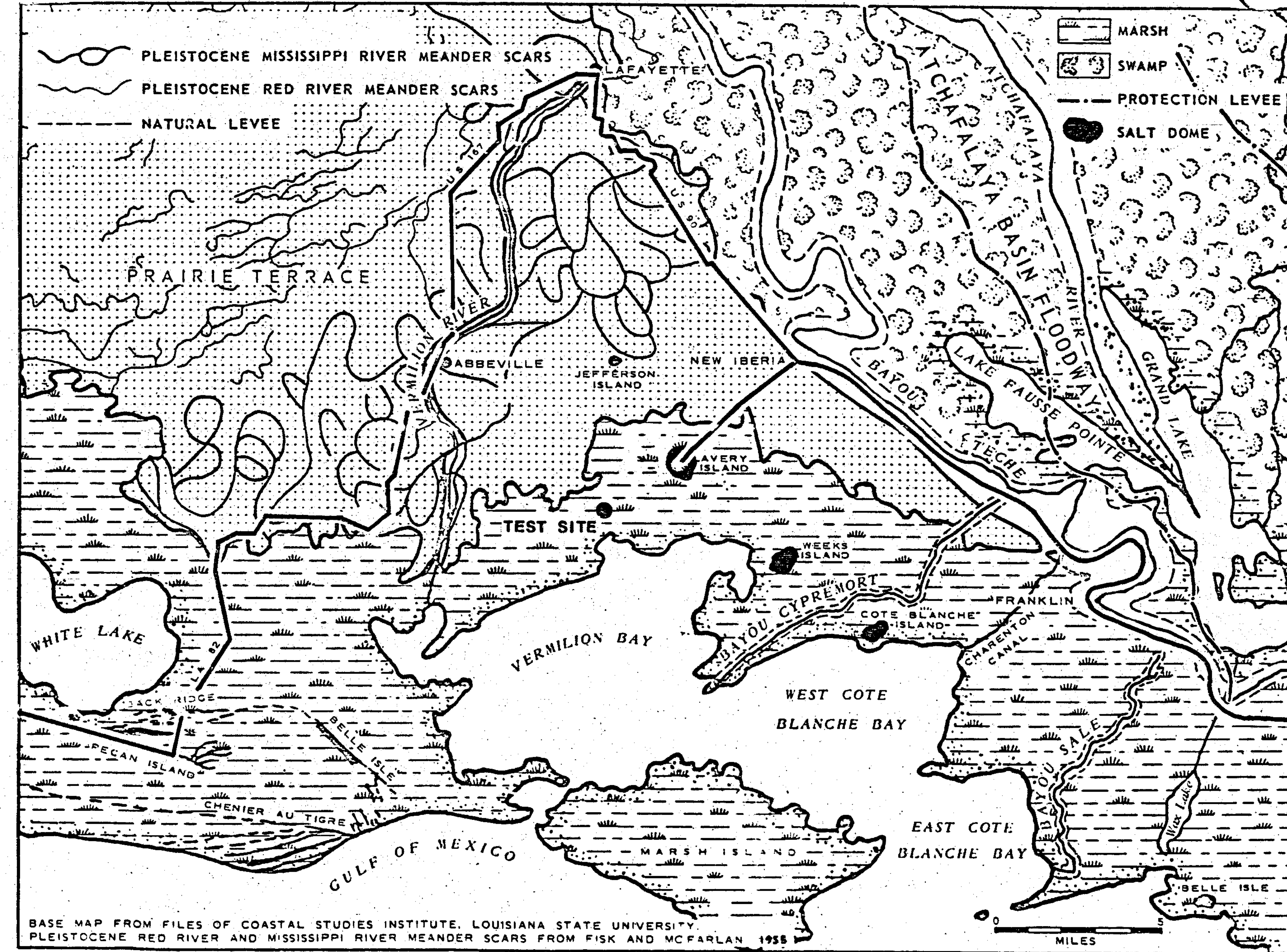


Figure III-17. The Pleistocene Meander Belts on the Prairie Terrace.

Table III-3. Late Quaternary Events of the Study Area.

Late Pleistocene

Lafayette meander belt and associated delta lobe of Mississippi River active. Deposition of Prairie terrace deposits in alluvial valley and deltaic environments.

Sea level lowered. Lafayette meander belt abandoned. Surface tilted. Uplifted portion drained and weathered.

Holocene

<u>7300 - 6200 Years B.P.</u>

Sea level rising, Maringouin Delta Complex active, delta lobe on present continental shelf southeast of Marsh Island.

<u>5800 - 3800 Years B.P.</u>

Sea level rising, Teche Delta Complex active immediately south and east of test well site.

<u>3500 - 30 Years B.P.</u>

Present sea level attained with only very minor fluctuations. Teche Lobe abandoned, supply of Mississippi fresh water and sediment cut off from study area. Coastal erosion is dominant; area took on more estuarine character.

<u>30 Years - Present</u>

New cycle of Mississippi River delta building developing in Atchafalaya Bay to east, resulting in new influx of fresh water and sediment which will become more pronounced during next few decades.

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these sands and gravels which form the Chicot Reservoir, discussed in the groundwater section of this assessment.

Each of the Pleistocene formations slope gently seaward. Thus, the outcrop area of each lies to the north.

Holocene Coastal Features and Deposits

The seaward-thickening prism of Holocene sediment lying above the Pleistocene is a result of events that have occurred during the Holocene transgression and since sea level stabilized at its present stand approximately 3,500 years ago (see Table III-3). These events have been interpreted through analysis of samples taken from hundreds of shallow borings made in the general area of the test well (van Lopik, 1955; Gould and McFarlan, 1959; Gould and Morgan, 1962; Coleman, 1966; and Frazier, 1974).

Much of the section is dominated by sediments related to the Maringouin and Teche Delta complexes of the Mississippi River (Coleman, 1966; Frazier, 1974). Relict features related to the abandoned distributaries of the Teche Complex can be traced through surface expression and boring samples (see Figure III-18). Radiocarbon dating of buried, brackish-marsh, peat deposits, which accumulated at approximately mean Gulf level, by Coleman (1966) and others have contributed greatly to an understanding of depositional and post-depositional events of the Holocene (Figure III-19).

Following abandonment of the Teche Delta Complex about 3,800 years ago, the area gradually reverted to a more estuarine condition, and the present surface environments evolved (Figure III-16). The Holocene deposits at the test well site, consisting predominantly of peat and organic silts and clays, are related only to these final events (Figure III-19).

Hydrologic Elements

General Hydrology

The project area is part of a hydrologic unit extending perpendicular to the coast between the Vermilion River to the west and Bayou Carlin - Bayou Tigre to the east (Figure I-1). Water movement is generally from north to south in response to surface gradient. In the southern part of the unit, a 5-mile wide zone of marshes forms an interactive zone where fresh water discharged from farmed uplands to the north and diverted from adjacent streams mixes with the brackish waters introduced from Vermilion Bay to the south through tidal variation and wind stress.

Water movement in the marsh area in which the project site is located is highly disorganized and unpredictable as a result of the absence of relief, numerous interconnecting tidal streams and ponds, and a complex network of mineral industry canals and associated spoil banks. Exchange of water with Vermilion Bay is further complicated by the intercepting action of the Gulf Intracoastal Waterway (GIWW), which extends in an east-west direction across the hydrographic grain of the area (Figure I-2) and connects Bayou Carlin and the Vermilion River.

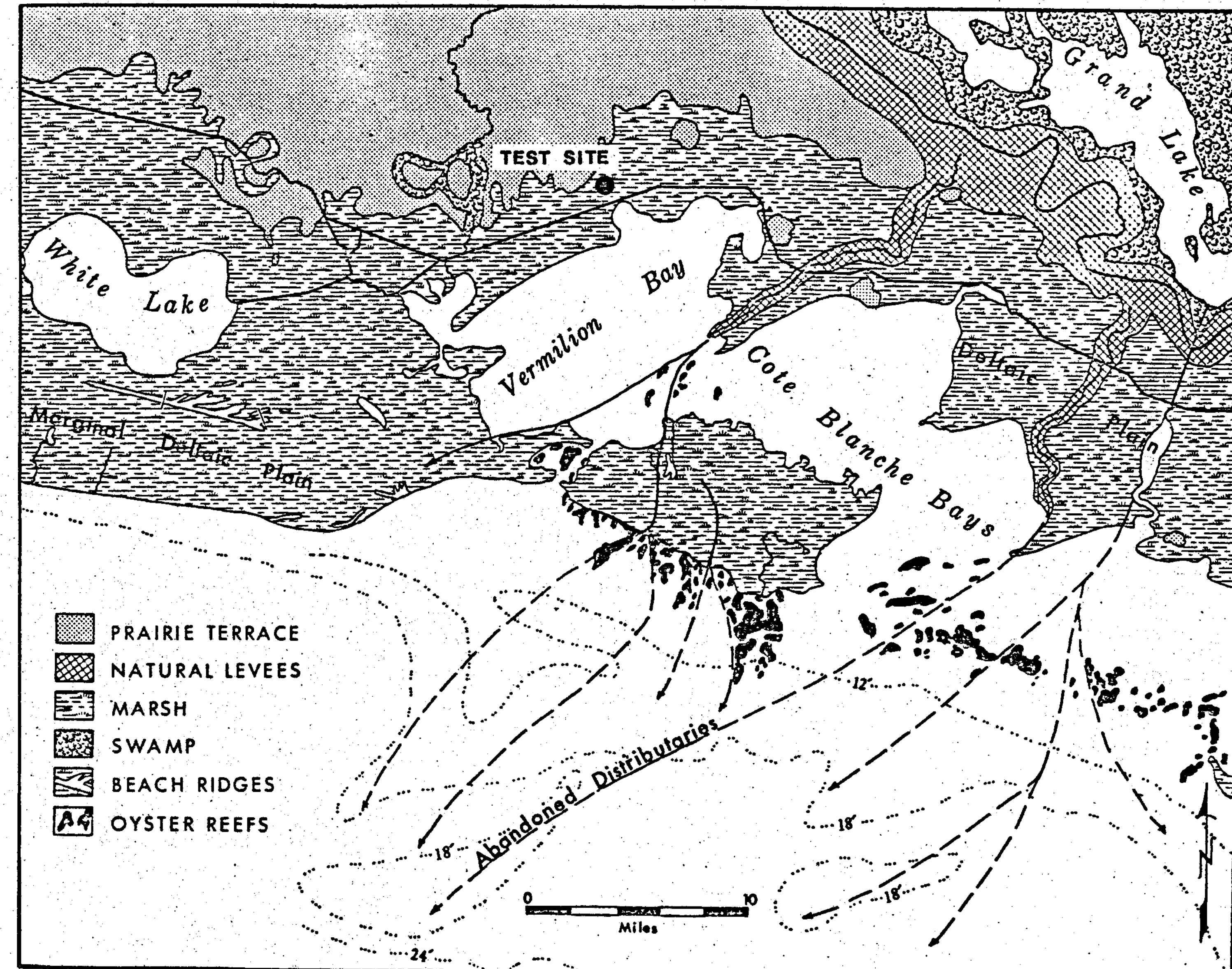


Figure III-18. The Abandoned Distributary Systems Which Form the Holocene Surface.

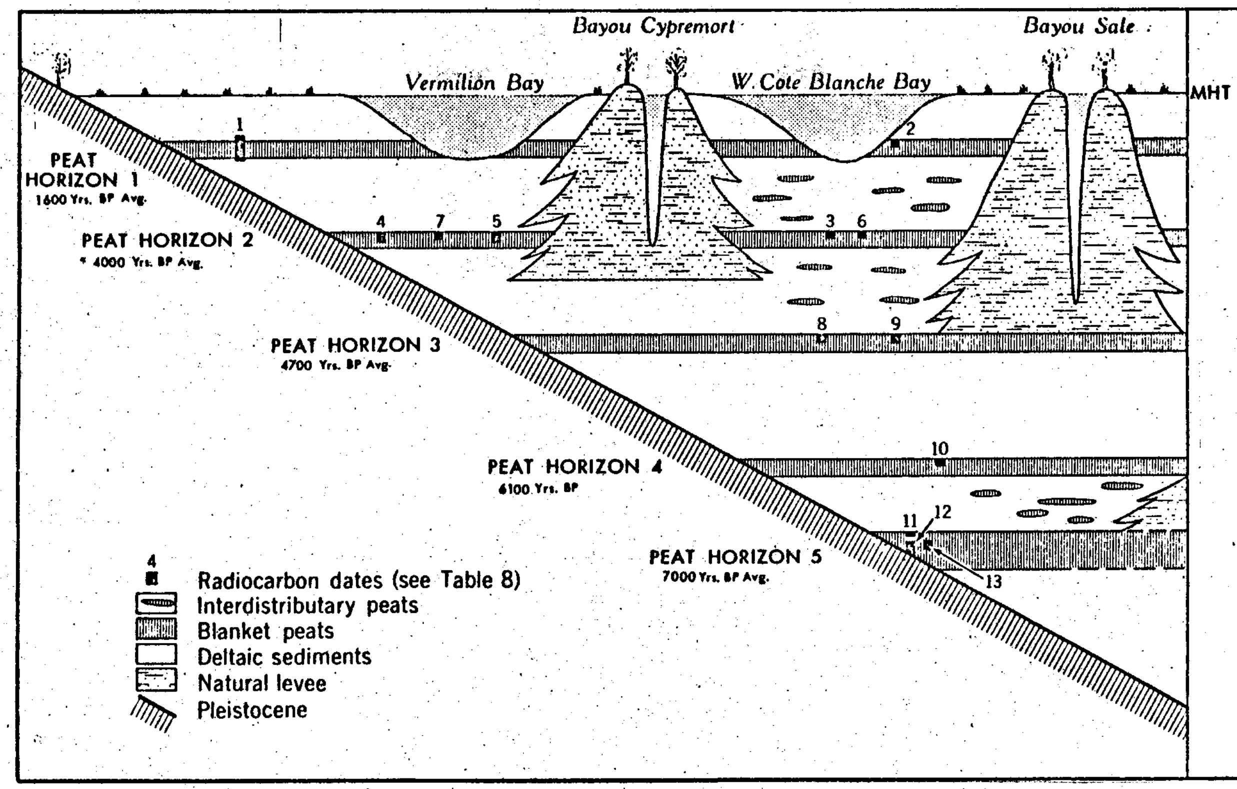


Figure III-19. Cross Section of the Depositional Sequence of the Study Area for the Last 7,000 Years.

Hydrology of the Project Area

The well to be utilized for the present test project is located in a drilling slip that measures 300 x 160 feet and has an average depth of eight feet. Water exchange from the slip with the surrounding wetland environment occurs through a number of canals and streams (Figure I-2). All canals are bounded by spoil banks, which eliminate overbank water exchange with adjacent marshes, and serve mainly as conduits. Due to their hydrologic efficiency, the canals carry most of the flow and are the main elements in water exchange between the hydrologic subsystem of which the test site is a part and Vermilion Bay. Through connection with the canals, the natural tidal streams and associated distributaries - tributaries function as the main dispersal system. Water within the marshes is exchanged through this branching network of smaller channels and through overbank flow during the higher tidal passes.

From Figure III-20, it can be observed that the main elements in the site hydrology are the GIWW, the four-mile long canal (A) extending northward from the GIWW past the site access canal toward Bayou Tigre, the canal (B) connecting (A) and Bayou Carlin to the west, and the canal (C) extending westward from canal (A) near the project site. In a number of locations, each of the canals intersects natural tidal streams, allowing water exchange with adjacent marshes. Possible flow routes for water exchange with the test site are indicated in Figure III-20. It should be noted that the test slip is separated from its southwestward extension by a dam containing a six-foot wide sill at approximately mean sea level (Figure I-5) that limits direct exchange with Bayou Portage.

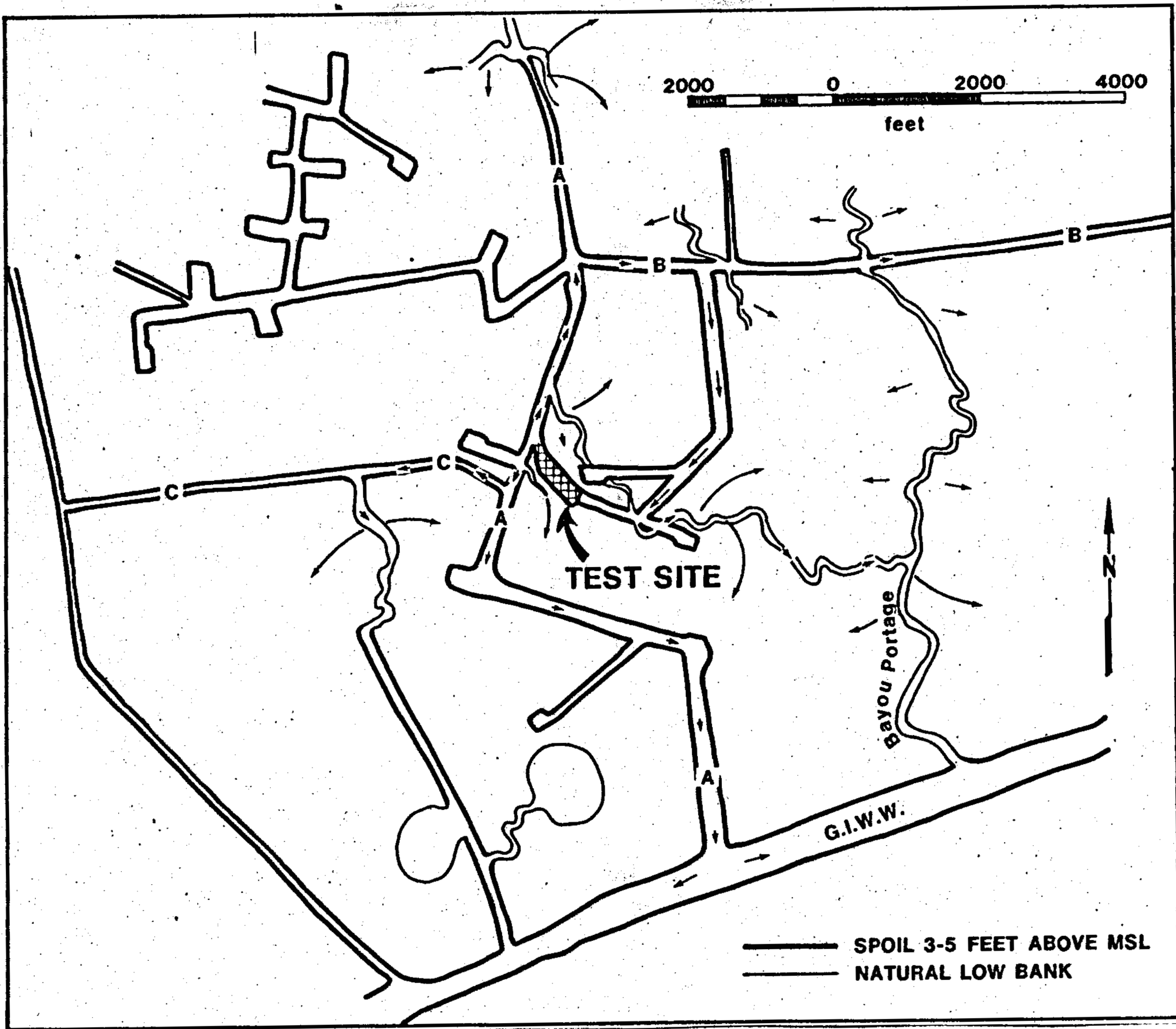


Figure III-20. Water Exchange Between Test Slip and Adjacent Environments.

Quality of Surface Waters

No water quality data is available for the immediate test area for normal conditions except for a mean salinity of about 5 ppt as based on the local salinity gradient (Palmisano, 1971). Mean salinity conditions are shown in Figure III-21 . In view of the proximity to Vermilion Bay and unimpeded exchange of water, the most representative data available are those from the western edge of the bay, ten miles to the southwest (Figure III-21; Louisiana Wild Life and Fisheries Commission, 1970). This data is summarized in Table III-4. An indication of water quality problems exists in observations made by the U.S. Army Corps of Engineers (1973) at the entrance to the GIWW from West Cote Blanche Bay, 15 miles to the east. These show high oil and grease concentrations (82 mg/l), high mercury content (> 10 mg/l), and Aldrin residue concentrations up to 152×10^{-6} mg/l.

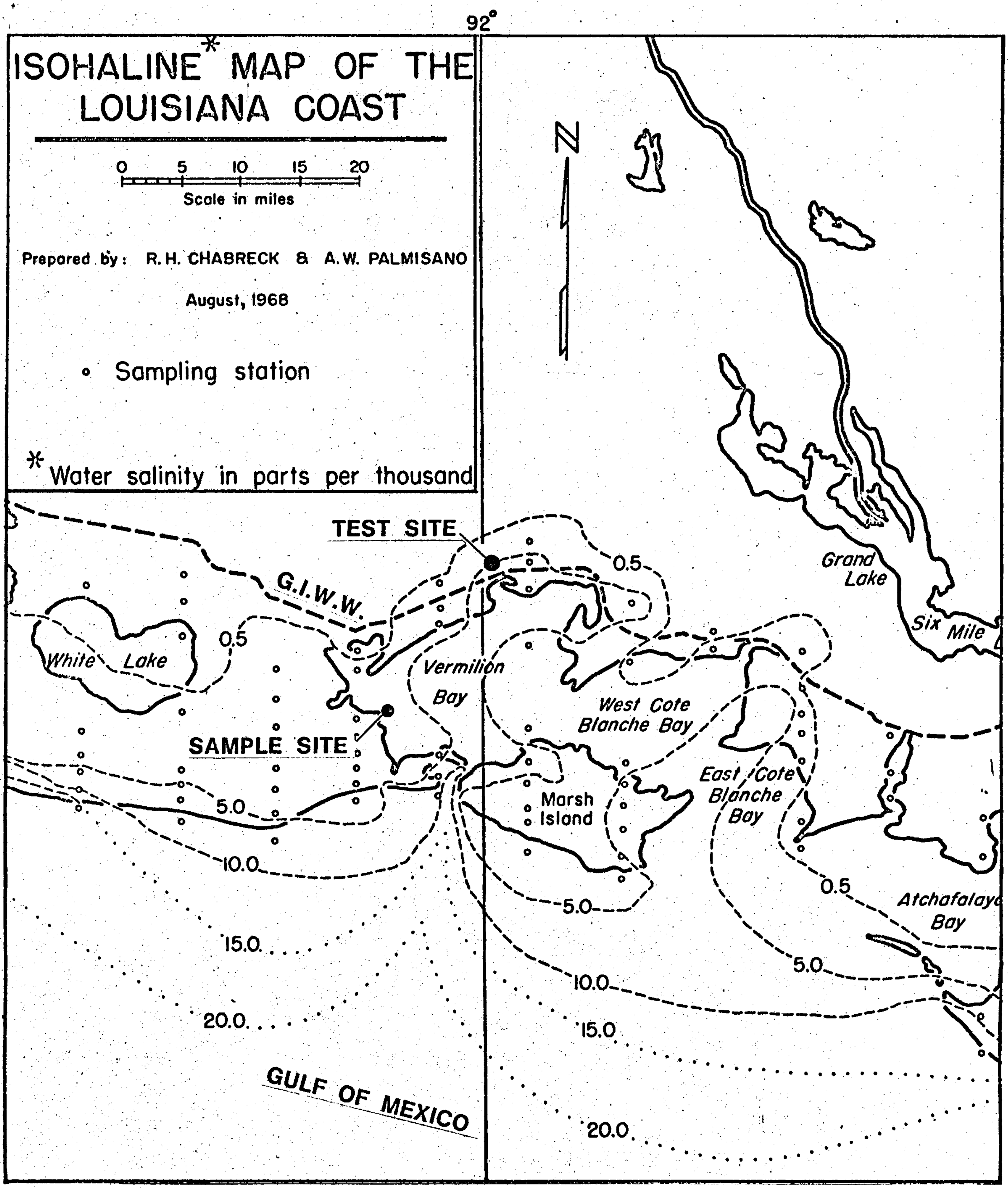


Figure III-21. Isohalines in the Vermilion Bay Area (After Chabreck et al., 1968).

Table III-4. Water Quality Observations in Western Vermilion Bay (Louisiana Wild Life and Fisheries Commission, 1970).

AREA 6 WESTERN COASTAL LOUISIANA

STATION 2 WESTERN VERMILION BAY

YR MO DAY	TEMP*	SAL	OXYGEN	TURBID	NITRATE	NITRITE	PO4	TOTAL P
67 12 29	8.50	2.00			23.10	0.30		
68 1 17	7.90	1.00	8.10	0.20	9.40	0.38	0.52	0.92
68 2 8	7.70	4.90	12.50	0.0	13.14	0.20	0.91	4.76
68 3 6	11.60	5.30		0.0	0.08	0.81	0.42	2.86
68 4 2	21.70	10.50	8.20		2.20	0.55	0.26	3.51
68 5 17	26.80	3.00	7.50		27.62	3.90	1.28	3.46
68 6 21	29.60	1.90	7.30	1.00	61.56	1.25	1.33	3.54
68 7 10	33.10	2.70	7.00	4.40	71.00	0.65	2.05	1.29
68 8 7	34.90			0.20	5.70	0.15	1.98	3.75
68 9 12	24.00	0.0	10.20	0.0	1.67	0.24	2.42	2.67
68 10 9	25.90	3.80	7.00	2.00	3.47	0.18	2.32	3.14
68 11 8				0.40	1.25	0.12	0.97	5.86
68 12 8	6.10	3.70	8.10	0.20	20.18	0.28	1.52	4.92
69 1 14	8.40	4.70	10.30	0.80	21.45	0.86	1.81	3.52
69 2 5	10.70	1.80	9.10	0.60	25.73	1.63	1.31	7.03
69 3 19	16.00	1.20	6.00	0.40	20.12	0.36	0.98	2.81
69 4 11	24.10	1.70	7.00	0.40	15.97	1.24	2.03	4.36
69 5								
69 6								
MEAN 68	20.85	3.68	8.43	0.84	18.11	0.73	1.33	3.39
MAX 68	34.90	10.50	12.50	4.40	71.00	3.90	2.42	5.86
MIN 68	6.10	0.0	7.00	0.0	0.08	0.12	0.26	0.92
MEAN WS 68	14.03	4.45			12.59	1.02	0.68	3.10
MEAN SA 68	29.50			1.33	24.11	0.43	1.84	3.37
MEAN WS 69	13.06	2.62	8.10	0.48	20.69	0.87	1.53	4.53

*Temperature - C°
Salinity - ppt

Oxygen - ppm
Turbidity - feet visibility

Nitrate - micrograms-atoms/litre
Nitrite - micrograms-atoms/litre
Reactive phosphorus - micrograms-atoms/litre
Total phosphorus - micrograms-atoms/litre

Water Levels

Water level variation at the test locale is important since the marsh floor and spoil banks have elevations of only one foot above MSL and five to ten feet above MSL, respectively. Variation is controlled largely by tides in the Gulf of Mexico, although local runoff may have some influence. Tidal variation along the northern Gulf Coast is characterized by a cycle of 24 hours and 50 minutes (Marmer, 1954). Normal maximum fluctuation is 26 inches (Gunter, 1967), occurring once a month, and minimum fluctuation is two to three inches. Tidal fluctuation as monitored at Marsh Island, directly south of the project site, is summarized in Table III-5 and can be considered typical since no tropical storms affected the area during the period of observation.

Month	Mean High Tide	Mean Low Tide	Mean Water Level	Highest Individual Tide	Lowest Individual Tide
	- - - - - -	- - - - - -	Feet	- - - - - -	- - - - - -
January	.39	-.35	.02	1.5	-2.0
February	.56	-.26	.15	1.6	-1.8
March	.60	-.18	.21	1.3	-1.5
April	.78	.09	.43	1.2	- .7
May	1.13	.40	.76	2.4	- .7
June	1.19	.18	.69	1.7	- .7
July	.83	-.06	.39	1.5	-1.0
August	.83	.11	.47	1.6	- .8
September	1.26	.69	.97	2.6	- .2
October	1.06	.39	.72	1.8	- .5
November	.85	.07	.46	1.5	-2.1
December	.37	-.62	-.12	1.4	-2.2
Annual	.82	.04	.43	2.6	-2.2

Table III-5. Monthly Tide Levels (feet,MSL) Along the Central Louisiana Coast, 1958 - 1959 (From Chabreck and Hoffpauir, 1962).

Water levels can be strongly influenced by meteorological conditions. Periods of prolonged onshore spring and early summer winds can result in temporary inundation of the marshes to depths of about one to two feet. Likewise, prolonged northerly winds in winter lower water levels as much as two feet below normal levels (Chabreck, 1972).

Most severe changes result from tropical storms and hurricanes. The Poisson probability of at least one hurricane or tropical storm passing through the study area in any given year is 0.45 (Hope and Neuman, 1971). Figure III-22 gives the temporal frequency distribution for the area together with direction and speeds. In 1964, Hurricane Hilda made landfall 25 miles east of the test site, with winds up to 125 mph (U.S.C.E., 1966). At the coast, levels were raised by ten feet, but due to counter-clockwise atmospheric circulation around the hurricane center, flooding in the area of the site was only 3.5 feet (U.S.C.E., 1966). Inundation by seven to eight feet of water occurred over the marshes immediately east of the point of landfall.

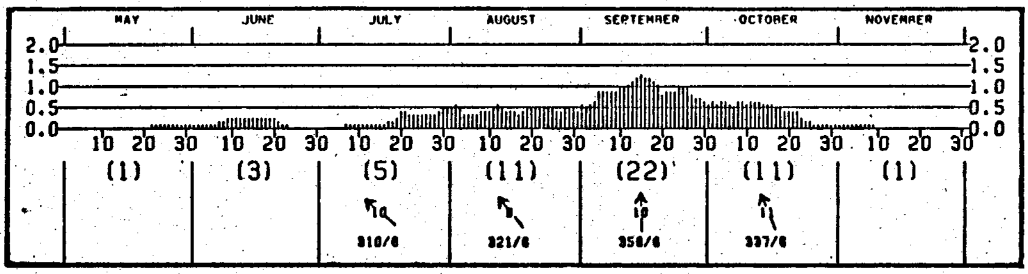


Figure III-22. Bargraph Gives the Daily Distribution of the 54 Storms Which Passed Through the Test Area in Units of Percent of Days. Numbers in Parentheses Give Monthly Storm Count. When Count is 5 or More, Arrow Shows Monthly Mean Vector Direction and Mean Scalar Speed of These Storms. Numbers Below Arrow Give Mean Vector Direction and Mean Vector Speed in Knots (After Hope and Neuman, 1971).

Climate

Climate for the area under consideration is subtropical marine. Monthly temperature means and extremes for the nearest long-term weather station (Lake Charles) are given in Table III-6. Precipitation averages between 50 and 60 inches annually. Winter precipitation, and to a large extent, summer rainfall, are frontal. Convective-type showers and thunderstorms occur about 70 times per year, mostly during the four warmest months. Average monthly distribution of rainfall for Morgan City is given in Table III-7. Wind conditions for the coast are summarized in the wind rose of Figure III-23 (U.S.C.E., 1975).

Ground Water

Fresh, ground water is a vitally important resource to the general area of the project because of irrigation needs for rice farming, in addition to domestic and stock uses. Because of this importance and because of problems of saltwater encroachment related in part to heavy pumping, extensive studies have been made of the ground water situation in southwest Louisiana, including the project area (Jones, et al., 1956; Jones, et al., 1954; Harder, et al., 1967; Fader, 1957).

The principle source of fresh, ground water in southwest Louisiana is the Chicot Reservoir, which is coincident with the southward-dipping beds of sand, gravel, silt, and clay of Pleistocene age described earlier. Recharge of the Chicot aquifer system takes place in the surface outcrop extending coastwise 40 miles to the north of the project area and in filled channel scours 20 miles to the northwest. Water moves generally south from the recharge area in the dip direction. However, in the coastal area, the direction of movement has been reversed as a result of intensive pumping for irrigation, and salty water from deeper aquifers moving into the Chicot Reservoir is increasing (Harder, et al., 1967).

Table III-6. Monthly Temperature Mean and Extremes* at Lake Charles, Louisiana, 1941 - 1970.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Daily Maximum	62.3	65.0	71.3	77.7	84.5	89.3	90.5	90.5	87.5	80.6	69.4	63.1	77.6
Daily Minimum	45.0	47.6	50.8	58.1	66.6	73.1	74.0	73.8	69.9	60.3	49.8	46.0	59.6
Normal	53.7	56.3	61.1	67.9	75.6	81.2	82.3	82.2	78.7	70.5	59.6	54.6	68.6

*All temperatures in degrees Fahrenheit.

Table III-7. Normal Precipitation (Inches) for Morgan City, Louisiana, near the Gulf of Mexico (1941 - 1970).

Town	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Morgan City	4.46	4.92	4.51	4.43	4.81	5.66	8.36	7.10	7.03	3.67	4.14	5.24	64.33

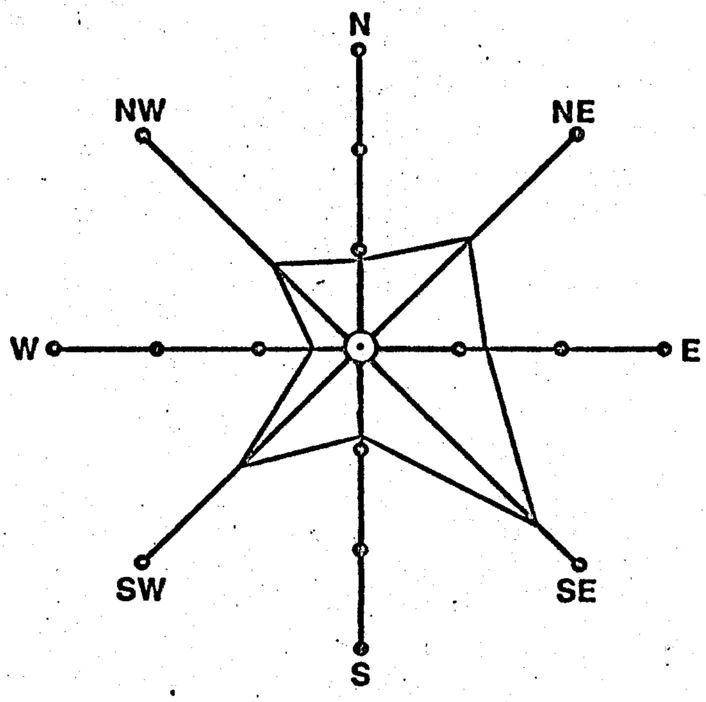


Figure III-23. Eight-Year Averaged Annual Wind Rose, Grande Isle, Louisiana, 1944 - 1951.

Scale: 1/2" = 10%   Calm (0-3 mph) - 0.7%

The aquifer system is best generally described by the cross sections in Figures III-24 and III-25, which are located 10 miles west and 20 miles east of the project site, respectively. The diagrams show that in the project area, the total reservoir is approximately 1700 feet thick and is comprised of a number of alternating sand and clay beds of varying thickness. Clay beds serve as aquitards. With regard to the fresh, ground water resource, only the upper part of the reservoir is of interest, since the base of fresh water in the project area lies at approximately 650 feet (Figure III-26). This fresh water is contained in the so-called "upper sands" (Whitman, et al., 1963) which extend downward from about 250 feet to about 800 feet below sea level. The lower part of this unit bears salt water as a result mainly of encroachment from south to north. Chloride concentrations at the bottom of the upper sand are in the order of 1000 ppm (Harder, et al., 1967). The entire unit is capped by massive clays that prevent saltwater intrusion from surface waters, with one exception to be mentioned. Thickness of the clay in the project area is about 200 feet. Wells nearest to the project draw water for stock and domestic use from between 300 and 350 feet and are marked in the northwest quarter of Figure I-2.

As indicated by Figure III-26, a problem of saltwater contamination of the principal aquifer exists in the lower Vermilion River basin 15 miles to the west of the project site. The channel of the Vermilion River lies in sand and gravel deposits related to late Pleistocene valley scour during low sea level stands. The scour trench cuts through the protective, coastal marine clay bed into the Chicot aquifer so that the latter is connected with the sand and gravel deposits of the valley fill aquifer. Consequently, water of the Vermilion River moves freely in and out of the Chicot aquifer.

As a result of the saltwater intrusion of surface waters up the Vermilion River for over 34 miles during the irrigation season and low discharges, saltwater contamination has occurred regularly for at least 40 years (Dr. P.H. Jones, personal communication, 1976; Jones, et al., 1956). Since 1962, the stream level has been higher than the level in the aquifer (Harder, et al., 1967).

Biology and Ecology

Vegetation

Figure III-27 is a blow-up of the vegetative type map of the Louisiana coastal marshes for the portion of the coast which includes the project area. Saline marshes are absent or very scant along this portion of the coast because of the freshening influence of Atchafalaya River discharge which sweeps westward towards Cote Blanche and Vermilion Bays. The common, dominant plant species growing in the different marsh types are given in the legend of the figure.

The geothermal well site is located in an area of brackish marsh composed predominantly of wiregrass (*Spartina patens*), coco (*Scirpus robustus*), and saltgrass (*Distichlis spicata*). Dwarf spikerush (*Eleocharis parvula*)

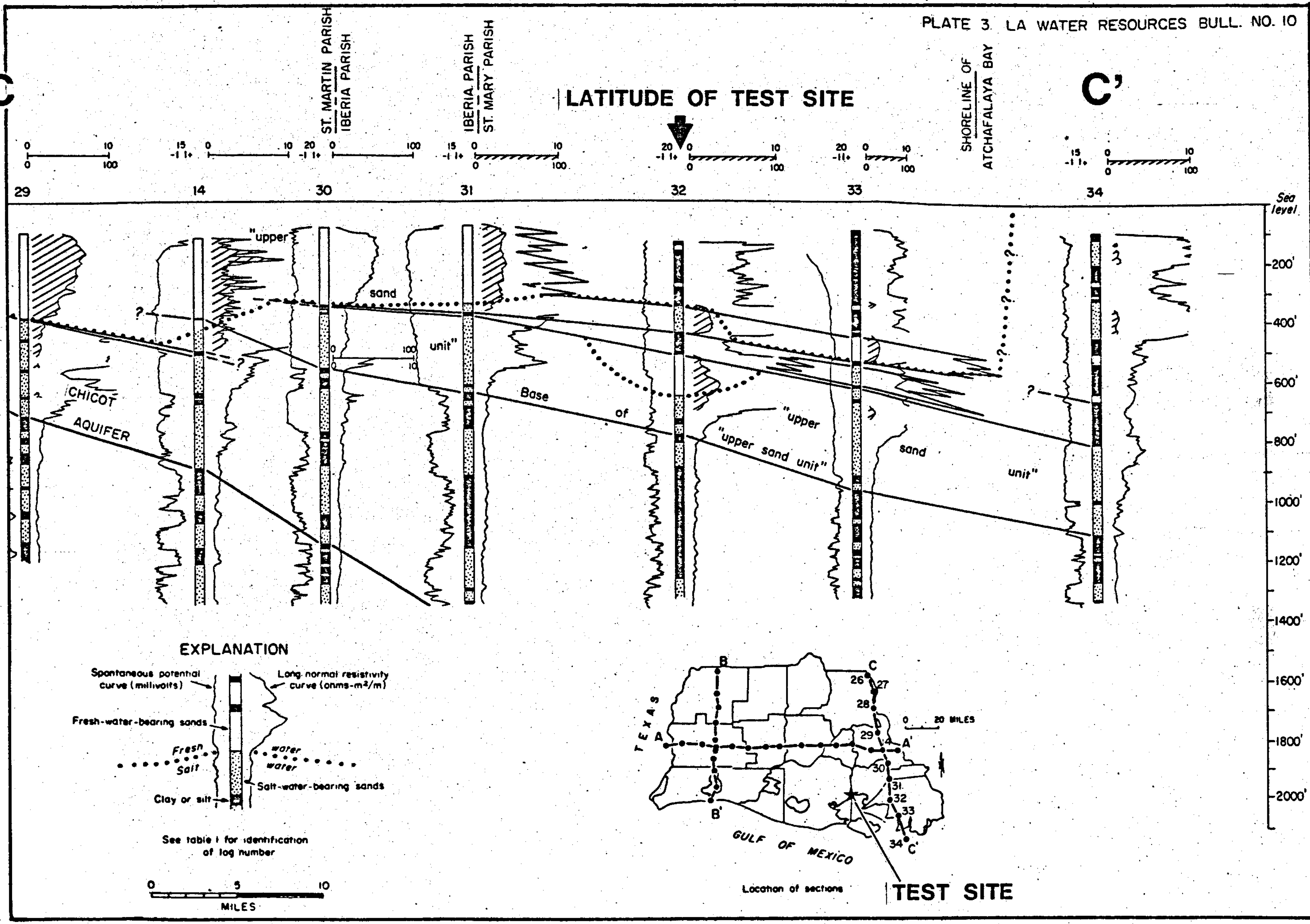


Fig. III-24. Geohydrologic Section Located 15 Miles to the West of Test Site (See Inset).

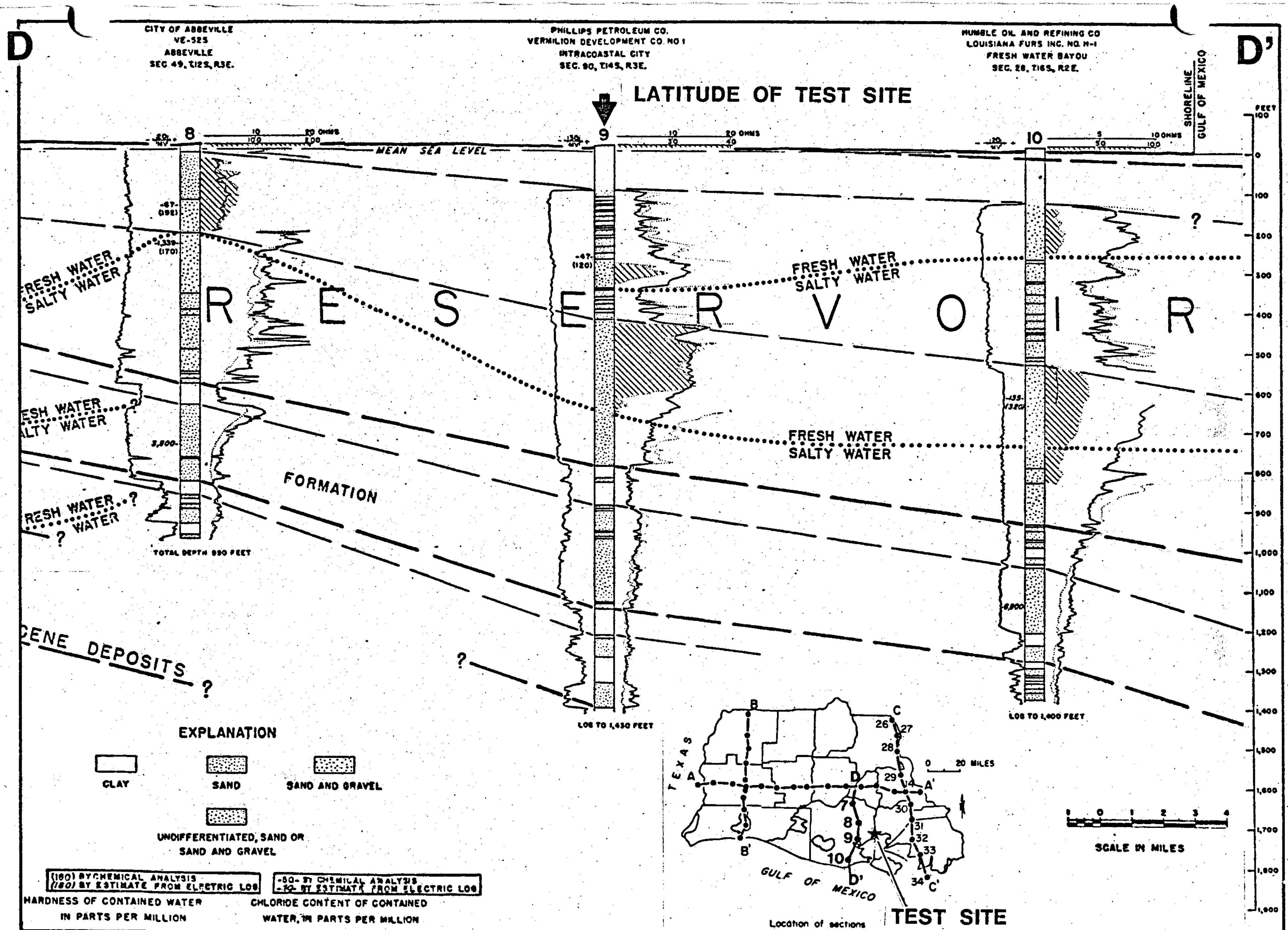


Figure III-25: Geohydrologic Section Located 20 Miles to east of Test Site (See Inset).

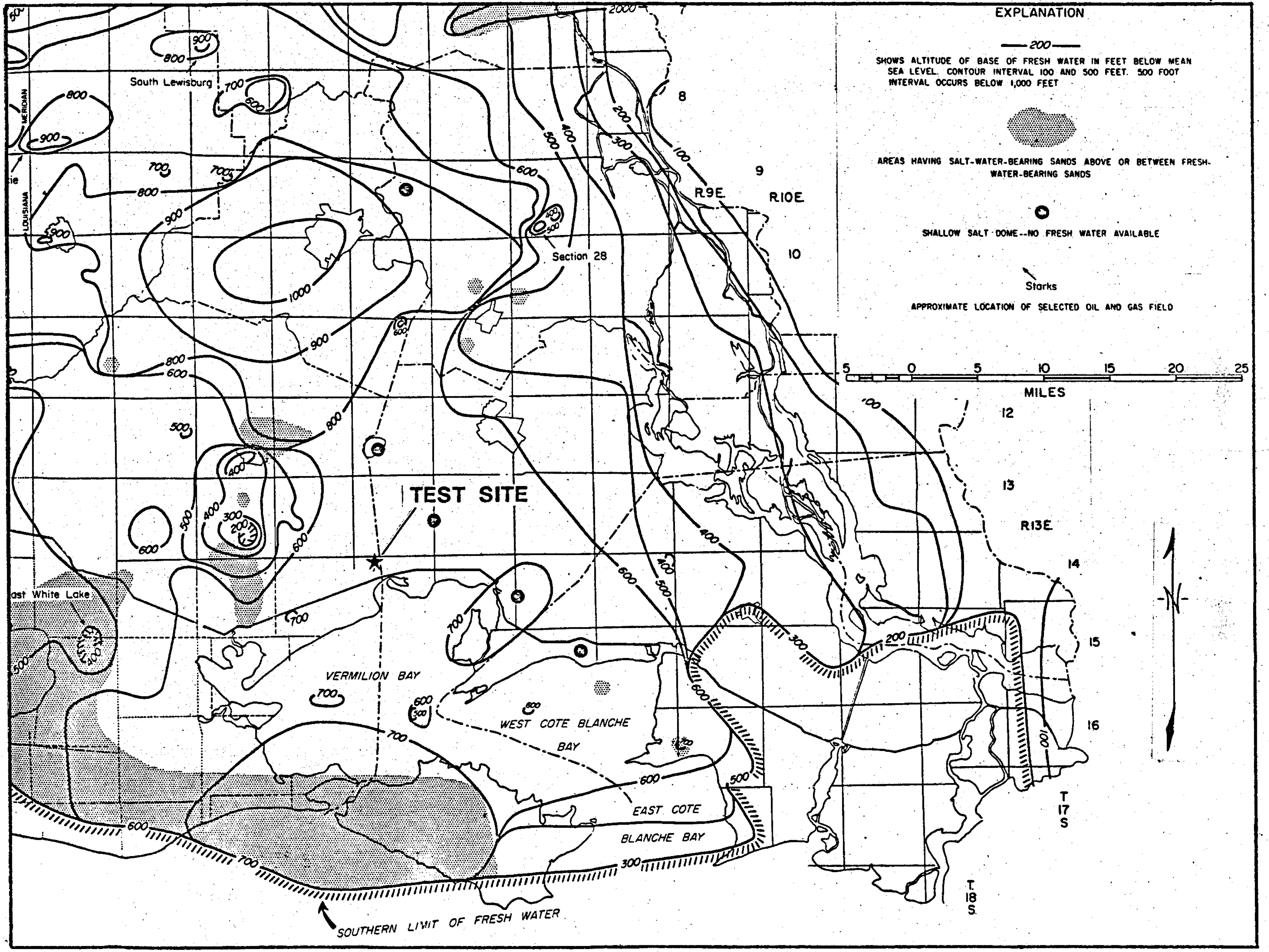
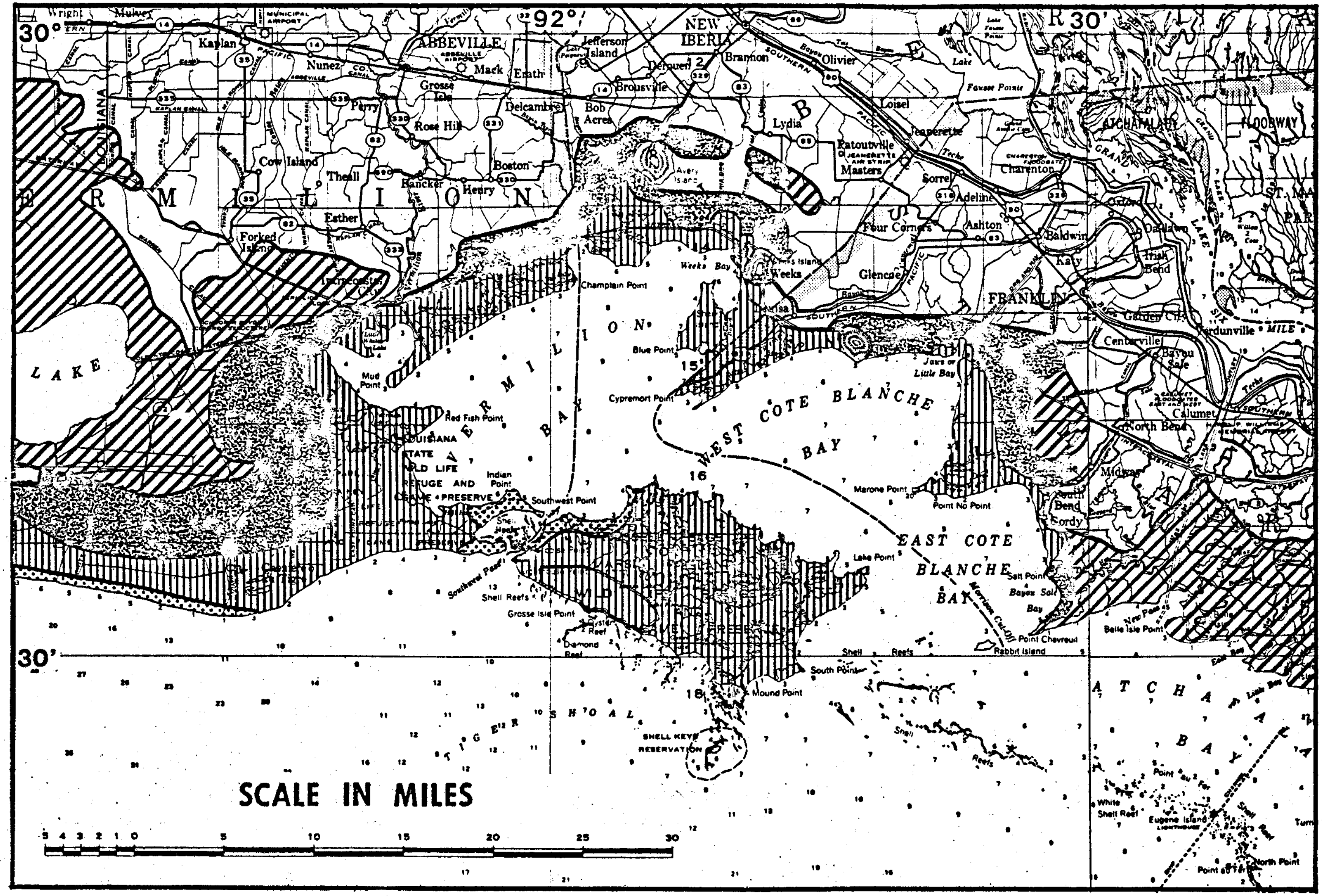
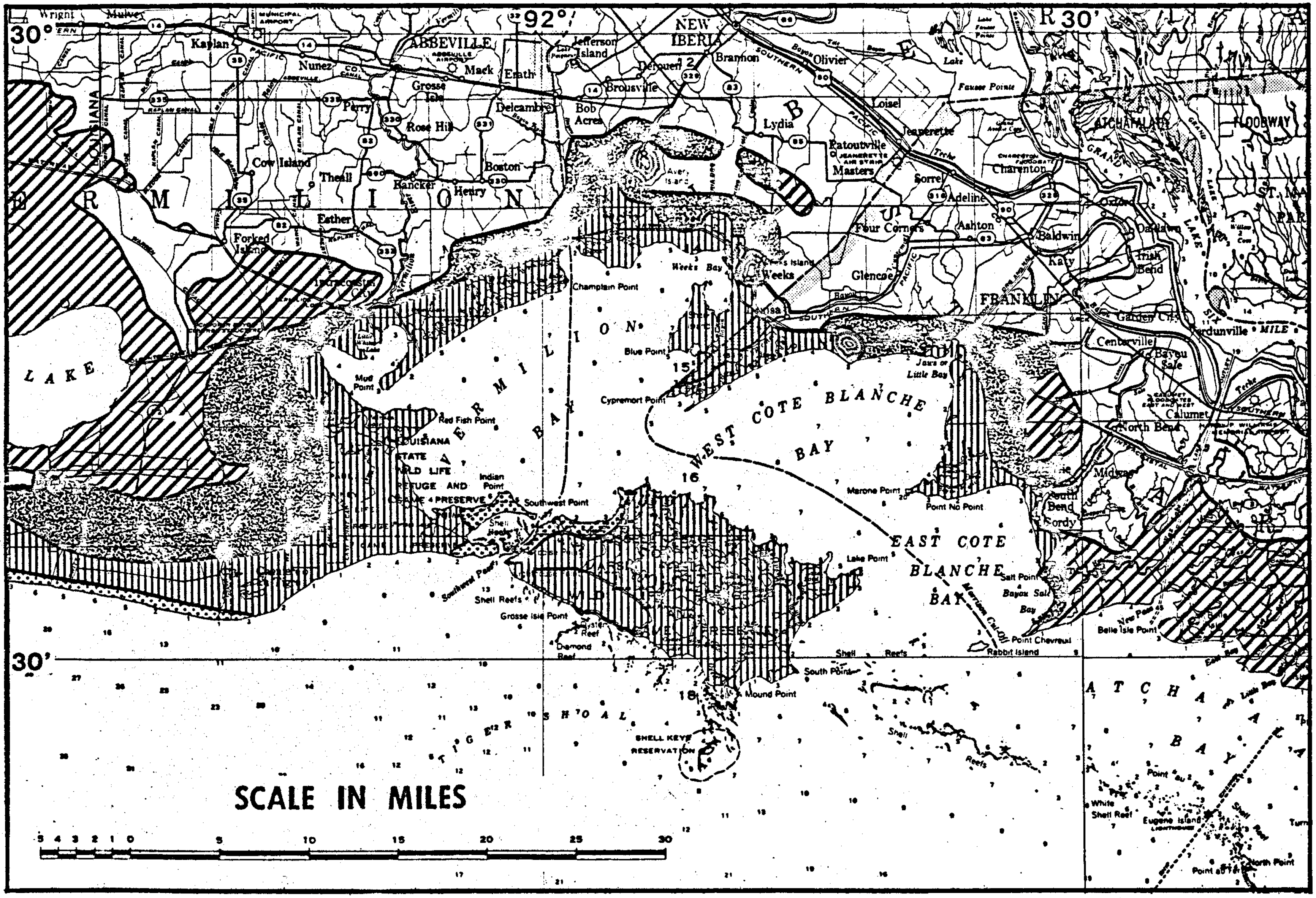


Figure III-26. Altitude of Base of Fresh Water.


30°
92°
30'
R 30'
Kaplan
Abbeville
Nunez
Mack
Erath
Jefferson Island
New Iberia
Delcambre
Bob Acres
Perry
Rose Hill
Cow Island
Theall
Bancker
Henry
Boston
Esther
Forked Island
Intracoastal City
Avery Island
Weeks Island
Weeks
Weeks Bay
Lydia
Olivier
Loisel
Jeanerette
Ratoutville
Masters
Sorrel
Adeline
Charenton
Four Corners
Ashton
Baldwin
Glencoe
Franklin
Garden City
Centerville
Bayou Sale
Calumet
North Bend
Midway
Ricohoc
Irish Bend
Oaklawn
Oxford
Verdunville
Atchafalaya
Floodway
Lake
Vermilion Bay
Champlain Point
Blue Point
Cypremort Point
Mud Point
Red Fish Point
Louisiana State Wild Life Refuge and Game Preserve
Indian Point
Southwest Point
West Cote Blanche Bay
Jaws or Little Bay
Marone Point
Point No Point
East Cote Blanche Bay
Lake Point
Salt Point
Bayou Sale Bay
Point Chevreuil
Rabbit Island
Belle Isle Point
Shell Reefs
Grosse Isle Point
Oyster Reef
Diamond Reef
South Point
Mound Point
Shell Keys Reservation
Tiger Shoal
Atchafalaya Bay
Point au Fer
White Shell Reef
Eugene Island
North Point
SCALE IN MILES
5 4 3 2 1 0 5 10 15 20 25 30


30°
92°
30'
ABBEVILLE
NEW IBERIA
Kaplan
Nunez
Mack
Erath
Jefferson Island
Delcambre
Bob Acres
Brousville
Derouen
Brannon
Olivier
Loisel
Jeanerette
Lydia
Patoutville
Masters
Sorrel
Charenton
Adeline
Ashton
Four Corners
Baldwin
Glencoe
Weeks
Weeks Bay
Weeks Island
FRANKLIN
Katy
Oxford
Irish Bend
Garden City
Centerville
Bayou Sale
Calumet
North Bend
Midway
Cow Island
Theall
Rancker
Henry
Boston
Esther
Forked Island
Perry
Rose Hill
Grosse Isle
Delcambre
LAKE
V E R M I L I O N
VERMILION BAY
Champlain Point
Blue Point
Cypremort Point
Mud Point
Red Fish Point
LOUISIANA STATE WILD LIFE REFUGE AND GAME PRESERVE
Indian Point
Southwest Point
Shell Reefs
Grosse Isle Point
Diamond Reef
WEST COTE BLANCHE BAY
EAST COTE BLANCHE BAY
Marone Point
Point No Point
Lake Point
Salt Point
Bayou Sale Bay
Point Chevreuil
Rabbit Island
Shell Reefs
South Point
Mound Point
SHELL KEYS RESERVATION
TIGER SHOAL
Belle Isle Point
ATCHAFALAYA BAY
White Shell Reef
Eugene Island
North Point
ATCHAFALAYA
FLOODWAY
GRAND LAKE
SCALE IN MILES
5 4 3 2 1 0 5 10 15 20 25 30

SALINE MARSHES - Typical vegetation is oystergrass (*Spartina alterniflora*), *Salicornia sp.*, black rush (*Juncus roemerianus*), *Batis maritima*, black mangrove (*Avicennia nitida*), and saltgrass (*Distichlis spicata*)

FRESH MARSHES - Typical vegetation is maiden cane (*Panicum hemitomon*), Hydrocotyl sp., water hyacinth (*Eichhornia crassipes*), pickerelweed (*Pontederia cordata*), alligatorweed (*Alternanthera philoxeroides*), and bulltongue (*Sagittaria sp.*)

BRACKISH MARSHES - Marshes of moderate salinity with typical vegetation consisting of wiregrass (*Spartina patens*), three-cornered grass (*Scirpus olneyi*), coco (*Scirpus robustus*), and widgeongrass (*Ruppia maritima*)

INTERMEDIATE MARSHES - Marshes of low salinity with typical vegetation consisting of wiregrass, deer pea (*Vigna repens*), bulltongue, wild millet (*Echinochloa walteri*), bullwhip (*Scirpus californicus*) and sawgrass (*Cladium jamaicense*)

NON-MARSH AREAS

Figure III-27. Vegetative Type Map and Legend of the Louisiana Coastal Marshes for the Portion of the Coast Including the Project Area (After Chabreck, Joanen, and Palmisano, 1968).

makes a low groundcover near small ponds. Smartweed (Polygonum sp.) also occurs in small amounts and is locally concentrated in some areas, indicating that the marsh has some freshwater or intermediate characteristics. Figure III-28 shows a typical view of the marsh in the project area.

Figure III-28. General View of Brackish Marsh Immediately West of Test Site. Foreground is Contact of Unvegetated Spoil and Marsh. Vegetation is Largely Wiregrass (Spartina patens) and Coco (Scirpus robustus), with Light-Colored Stalks. Small Channel Drains Tidal Flat and Marsh (Upper Left). Marsh Elder (Iva frutescens) Appears on Right and Covers Spoil Bank Behind Marsh.

The well site is located in a dredged channel which is lined on both sides by spoil banks. Vegetation on the spoil banks consists mostly of marsh elder (Iva frutescens), groundsel bush (Baccharis halimifolia), and goldenrod (Solidago sp.). Certain sections of older, somewhat subsided spoil banks in the area have been recolonized by the marsh plant Spartina patens. Some areas of spoil banks near the well site are barren of vegetation, which may be attributed in part to the fairly recent placement of newly dredged spoil material on top of existing spoil banks and, possibly, to the effects of herbicide applications during the production period of the Edna Delcambre #1 well. No living macroscopic aquatic vegetation was observed in the canals and water ways near the well site. Dead water hyacinth (Eichornea crassipes) stems and floats, however, were noted near canal banks, indicating that this floating macrophyte is sometimes present.

The generalized pattern of the vegetation in the project area is shown in Figure III-29.

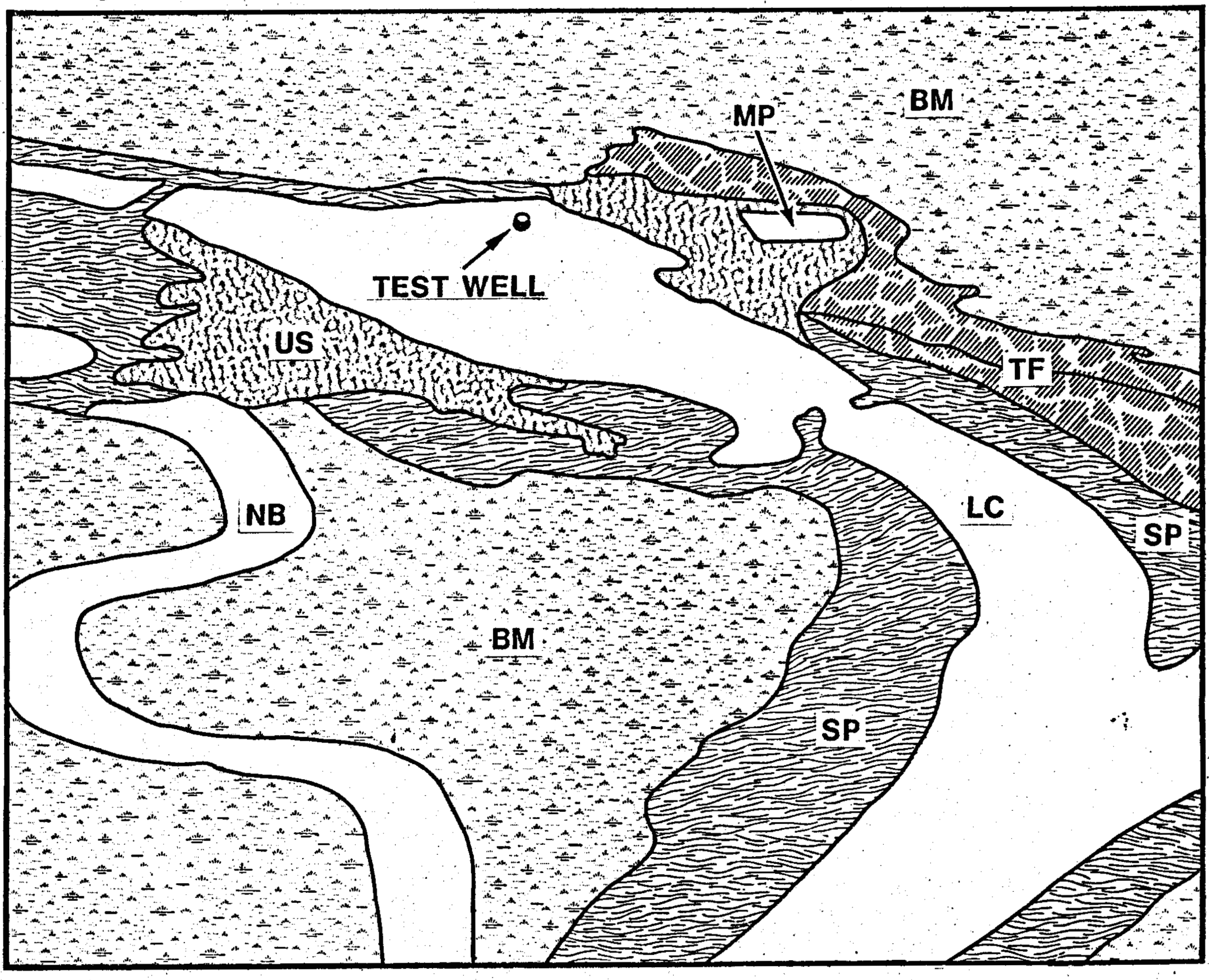


Figure III-29. Schematic Vegetation Map of Well Site Area. BM - Brackish Marsh; LC - Location Canal; MP - Mud Pit; NB - Natural Bayou; SP - Spoil Bank Vegetation; TF - Tidal Flat; US - Unvegetated Spoil.

Fish and Wildlife

In general, the coastal marshes and associated waterbodies of south Louisiana are rich in fish and wildlife resources. The marsh-estuarine ecosystem is well known for its role in the sustenance of the early life history stages of marine shrimp, crabs, and fishes, which as adults are the object of much of the northern Gulf of Mexico fisheries (Gunter, 1967). The brackish, intermediate, and fresh marshes are similarly of great importance as a wintering range for a large migratory waterfowl population and as a year-round habitat for fur-bearing animals.

Field inspection of the geothermal well site revealed it to be located in a productive fish and wildlife habitat. The canals, bayous, and small tidal channels in the area are hydrologically connected with Vermilion Bay and the Gulf of Mexico. Fish populations in Vermilion Bay have been studied by Norden (1966), Perret and Caillouet (1974) and Juneau (1975). Common fish species collected in Vermilion Bay included important commercial and sport fishes such as spotted seatrout (Cynoscion nebulosus), red drum (Sciaenops ocellata), Atlantic croaker (Micropogon undulatus), spot (Leiostomas xanthurus), Gulf menhaden (Brevoortia patronus), and southern flounder (Paralichthys lethostigma). Commercial shrimp (Peneaus aztecus and Peneaus setiferus) and crabs (Callinectes sapidus) were also present. Ecologically important fish species, such as the bay anchovy (Anchoa mitchilli), striped mullet (Mugil cephalus), and the tidewater silverside (Menidia beryllina), which are utilized as food by sport and commerical species, were also taken in the Vermilion Bay collections. All of these fish and shellfish species are characteristic inhabitants of estuaries on the Louisiana coast and indeed are estuarine dependent; they require low salinity areas during all or a portion of their life cycle.

Water salinities (average < 5 ppt) near the geothermal well site and the hydrologic connections between the well site area and Vermilion Bay suggest that estuarine fishes could and undoubtedly do utilize the aquatic habitats within the project area.

Benthic invertebrates characteristic of both fresh and brackish waters may be expected to occur in the bottom muds of canals and bayous in the project area. Commonly occurring organisms in habitats with similar salinity characteristics include various dipteran larvae, polychaete worms, amphipods, and certain bivalve mollusks. Benthic invertebrates are important food organisms for many game and commercial fish.

The average water salinities in the area of the well site, on the other hand, are not high enough to preclude the occurrence of certain freshwater fish species. Blue catfish (Ictalurus furcatus) regularly occur in waters of up to 5 ppt salinity, although they prefer lower salinities of less than 2 ppt (Kelly, 1965; Lindall, et al., 1972). Large numbers of blue catfish are caught by commercial fishermen in the Gulf Intracoastal Waterway. Freshwater game species, particularly the largemouth bass (Micropterus salmoides) and the warmouth (Chaenobryttus gulosus), are caught in certain low salinity areas along the Louisiana coast, often in the same water body as estuarine species, such as red drum and spotted seatrout. Salinities in the project area are low enough to suggest that these species may be present, at least temporarily, during low salinity periods.

The major wildlife values of the marshes in the project area are as a seasonal habitat for migratory waterfowl and as a permanent habitat for valuable fur-bearing mammals. Many ducks were observed in the project area on aerial inspections of the site. Major species of waterfowl which may be expected to utilize the marsh and marsh pond habitats in the vicinity of the well site include American coots (Fulica americana), mallards (Anas platyrhynchos), pintails (Anas acuta), gadwalls (Anas strepera), American wigeons (Anas crecca), blue-winged teal (Anas discors), mottled ducks (Anas fulvigula), and ring-necked ducks (Aythya collaris). Geese, notably snow geese (Chen caerulescens), white-fronted geese (Anser albifrons), and occasionally Canada geese (Branta canadensis), may be expected to occur in the project area periodically. Nearby rice fields also attract waterfowl to the area.

Other than waterfowl, the marshes provide habitat for smaller game birds, such as rails (Rallus sp.) and snipe (Capella gallinago). Non-game birds which are common in the marsh include many egrets and herons, blackbirds, and grackles.

Spoil bank vegetation is utilized as a habitat by various songbirds, especially during migration periods. Several marsh hawks were observed near the project area.

The marshes near the well site also provide habitat for fur-bearing mammals. Muskrat houses were evident in the marsh only a hundred yards or so away from the well site (Figure III-30). Fur-trapping is a major winter activity in and near the project area. One trapper was operating out of an anchored shrimp boat within a half-mile of the well site, and numerous skinned carcasses were observed in the area. The most abundant furbearers in the marshes are nutria (Myocastor coypus) and muskrats (Ondatra zibethicus). These two furbearers constitute the largest portion of the trapper's catch. Racoons (Procyon lotor) are also common in the area and are included in the catch. Mink (Mustela vison) and otter (Lutra canadensis) are present, but in lesser numbers and are only a small part of the catch of individual trappers.

Trappers in the area periodically burn the marshes to create better food conditions for furbearers. Proper burning at the right time burns only the top portions of the marsh plants and results in rapid, renewed growth of tender shoots. Burning also encourages the growth of three-cornered grasses (Scirpus sp.), which are preferred muskrat foods. The dominant marsh grass near the well site is wiregrass (Spartina patens). Muskrats eat wiregrass, but do not develop high populations in a wiregrass marsh. Burning allows the sub-dominant Scirpus sp., which grow more rapidly than wiregrass, to come in temporarily and make a good stand, often resulting in locally high muskrat populations. The three-cornered grasses are gradually replaced by the dominant wiregrass, and the marsh may again be burned. Marsh burning is also a common practice in waterfowl habitat management.

Swamp rabbits (Sylvilagus aquaticus) are abundant, small-game mammals in the marsh. They also utilize the spoil banks heavily. White-tailed deer (Odocoileus virginianus) also occur in the fresher marshes, but there is little information available on their abundance or exact distribution. Tracks of deer were observed near the test site.

Endangered Species

Three animal species, the American alligator, the peregrine falcon, and the red wolf, which are included on the United States List of Endangered Fauna (U.S. Department of the Interior, 1974) are likely to occur, at least occasionally, in the project area. In addition, the bald eagle (Haliaeetus leucocephalus) may sometimes fly over the project area, but it is not a primary habitat for eagles. Bald eagles occur in Louisiana in the winter months, where some nest. Eagles are most often found in Louisiana near large lakes in forested areas where they perch or nest in (usually) tall trees. The lack of trees in the project area precludes its use as a nesting habitat by eagles, although an eagle might occasionally fly over the test area. Bald eagles are largely fish eaters and may at times fish in Vermilion Bay, although they more commonly occur around large inland lakes.

The American alligator (Alligator mississippiensis) occurs in some abundance in the fresh to brackish marshes of coastal Louisiana. Although the alligator is included on the Department of the Interior's Endangered Species list, the Louisiana Wild Life and Fisheries Commission does not

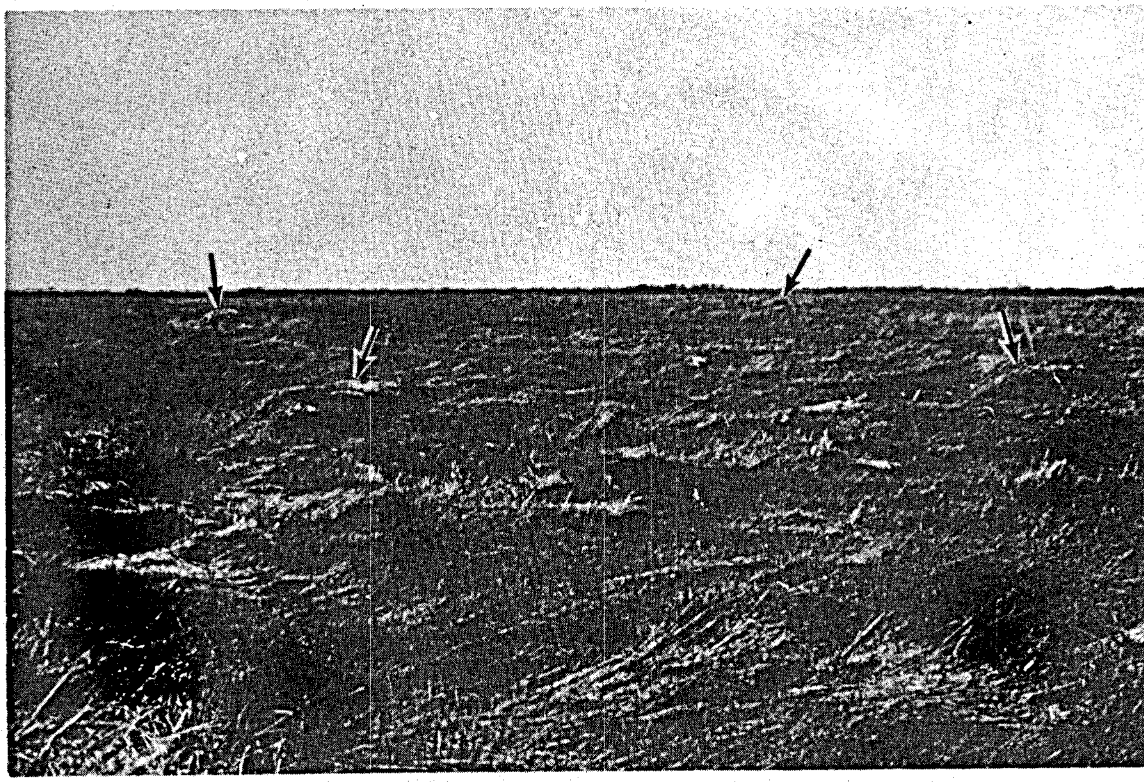


Figure III-30. Muskrat houses in recently burned marsh near the wellsite. Trappers periodically burn marshes to encourage growth of three-cornered grasses (Scirpus spp.) which are preferred muskrat foods. This marsh was probably burned sometime before the 1974-75 trapping season.

consider the alligator to be endangered within the State of Louisiana. Alligators are particularly abundant in the marshes of southwest Louisiana, where experimental, controlled hunting seasons were allowed in recent years. Rockefellar Wildlife Refuge, located in western Vermilion Parish and adjoining Cameron Parish, has long been a center of research on the life history and management of the alligator (Chabreck, 1971; Joanen, 1969).

The American peregrine falcon (Falco peregrinus) has always been a "rather scarce bird" in Louisiana (Lowery, 1974). It is a migratory species, and reported sightings are mostly in the winter months. Peregrine falcons are predators mostly on other birds, such as gulls, terns, and ducks. Thus, it is most likely to be seen in Louisiana in the coastal area, with its abundance of waterfowl and shorebirds. The project area appears to be a suitable hunting territory for peregrine falcons and, although the birds range widely, their occurrence there on occasion during the winter months is a distinct possibility.

The project area is within the range of the red wolf (Canis rufus) as given by Lowery (1974). The red wolf, now extremely limited in range, is thought to occur in pure form only in southwest Louisiana in Vermilion and Cameron Parishes and in adjoining counties in southeast Texas. Elsewhere, the red wolf is reportedly hybridizing with domestic dogs and coyotes, although it is suspected of hybridizing with coyotes in southwest Louisiana and southeast Texas also. Unfortunately, the red wolf, even in pure form, resembles the coyote and occasionally is shot by ranchers for depredations on livestock. Some wolves are caught each year in traps set for muskrats or nutria. Red wolves or hybrid animals with the genetic background of red wolves should be expected to range through the project area.

Ecological Considerations

Although the plants and the various animals that occur near the test site are separated for purposes of discussion, the marsh and its associated fauna (aquatic and terrestrial) are best considered as a single unit, or ecosystem. The marsh grasses, assimilating organic material from inorganic nutrients and carbon dioxide with the energy of sunlight, are the primary producers in the system. This production is distributed into terrestrial and aquatic pathways. Some terrestrial herbivores (muskrats, nutria, waterfowl) consume the grasses while they are alive. However, much plant material is left uneaten by herbivores, and this plant matter eventually dies and falls to the marsh floor. Here, in the fresh marshes that are unaffected by the tides, the plant detritus simply accumulates, forming a peaty soil. In tidal marshes, however, the marsh floor is periodically flooded by the tides, which washes away much of the detrital material. This portion of the marsh grass production then drives a large part of the aquatic phase of the system as the detritus is fed upon by various planktonic organisms, young shellfishes, and fishes. The various pathways in the distribution of the marsh grass production are schematically shown in Figure III-31.

Economic and Cultural Resources

Land Use

The Louisiana State Planning Office has compiled a map of existing land uses in the vicinity of the proposed well site. A section of this map which

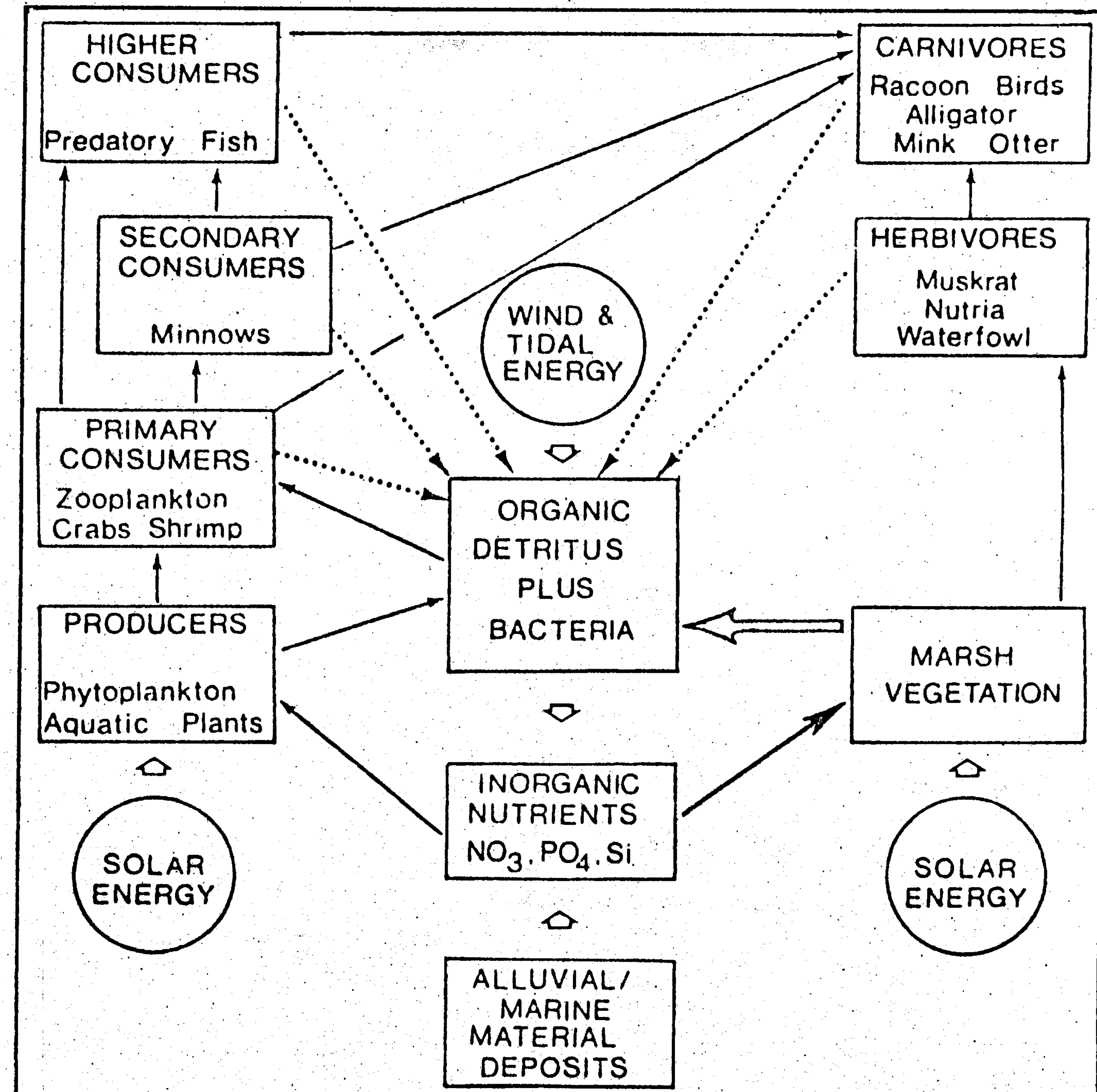


Figure III-31. Two-Phase Function of Marsh Vegetation in the Marsh-Estuary Ecosystem (After Palmisano, 1971).

cover the study area appears as Figure III-32. The test site is approximately in the center of a zone classified as extractive, a zone which generally defines the Tigre Lagoon Oil Field. The nearest cropland and pasture classification is 7000 feet to the west; however, the nearest open space which appears to be actively used for grazing and rice fields is an additional 4000 feet further west. The closest house to the site is 12,200 feet to the northwest. Houses are indicated by circles in Figure I-2. The nearest population center is Delcambre, a fishing and trade community of 1,975 people. Delcambre is six and one-half miles due north of the well site at the intersection of the Delcambre Canal and Louisiana Highway 14. Avery Island, a salt mine and Tabasco sauce production center, has a population of between 400 and 500 people and is located five miles to the northeast of the well site. The island maintains a bird sanctuary and botanical exhibit. Non-forested wetlands occupy the area between the well site and Avery Island.

The area contains a number of major oil and gas fields (Figure III-33) that have been producing for many years. The test site is located within the Tigre Lagoon Field. Yields from this field are shown for the years 1970 through 1973 in Table III-8 (Louisiana Department of Conservation, Annual Reports).

Table III-8. Production of Tigre Lagoon Field.

Year	Crude	Condensate	Casinghead Gas	Natural Gas
1970	972,356[a]	507,459[a]	615,653[b]	28,604,605[b]
1971	1,191,917	353,210	718,845	21,109,009
1972	1,105,499	259,764	509,369	17,385,933
1973	907,954	159,746	462,405	11,570,340
Accumulated Total Since Discovery	10,502,906	9,083,532	7,059,426	438,974,515

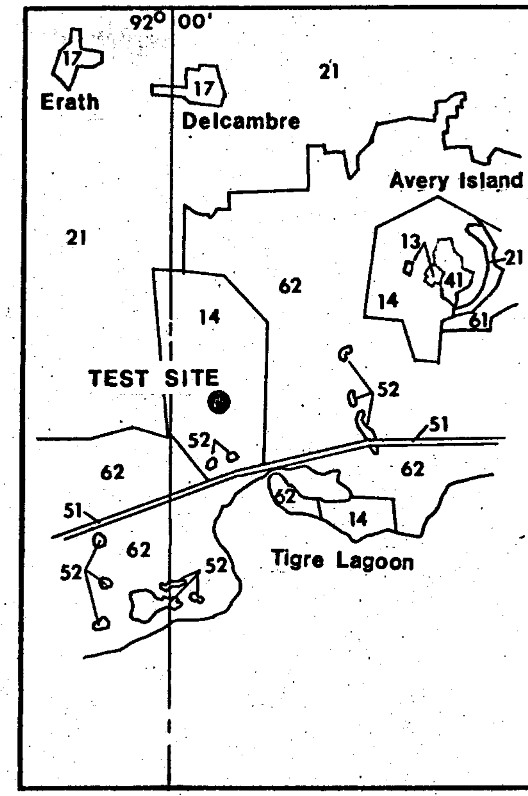
[a] Barrels
[b] mcf (Thousand Cubic Feet)

Recreational Elements

The major recreational activities in the coastal marsh area of Louisiana are sport hunting and fishing. The Louisiana Wild Life and Fisheries Commission (1972) has estimated the value of these recreational activities for the entire coastal marsh zone (4.2 million acres). Their estimates are presented in Table III-9. The recreational value of each acre of marsh, based on these estimates, is $21.90.

Figure III-32. Land Use in the Vicinity of the Study Area.

Source: Louisiana State Planning Office



SCALE 1:250,000

Based on U.S. Geological Survey, 1974

Minimum parcel sizes are 10 acres for urban, 40 acres for all other categories

URBAN AND BUILT UP LAND
- 11 Residential
- 12 Commercial and Services
- 13 Industrial
- 14 Extractive
- 15 Transportation, Communications, and Utilities
- 16 Institutional
- 17 Strip and Clustered Settlement
- 18 Mixed
- 19 Open and Other

AGRICULTURAL LAND
- 21 Cropland and Pasture
- 22 Orchards, Groves, Bush Fruit, Vineyards, and Horticultural
- 23 Feeding Operations
- 24 Other

FOREST LANDS
- 41 Deciduous
- 42 Evergreen (Coniferous and Other)
- 43 Mixed

WATER
- 51 Streams and Waterways
- 52 Lakes
- 53 Reservoirs
- 54 Bays and Estuaries

WETLAND
- 61 Forested
- 62 Non-forested

BARREN LAND
- 71 Salt Flats
- 72 Beaches
- 73 Sand Other Than Beaches
- 74 Bare Exposed Rock
- 75 Other

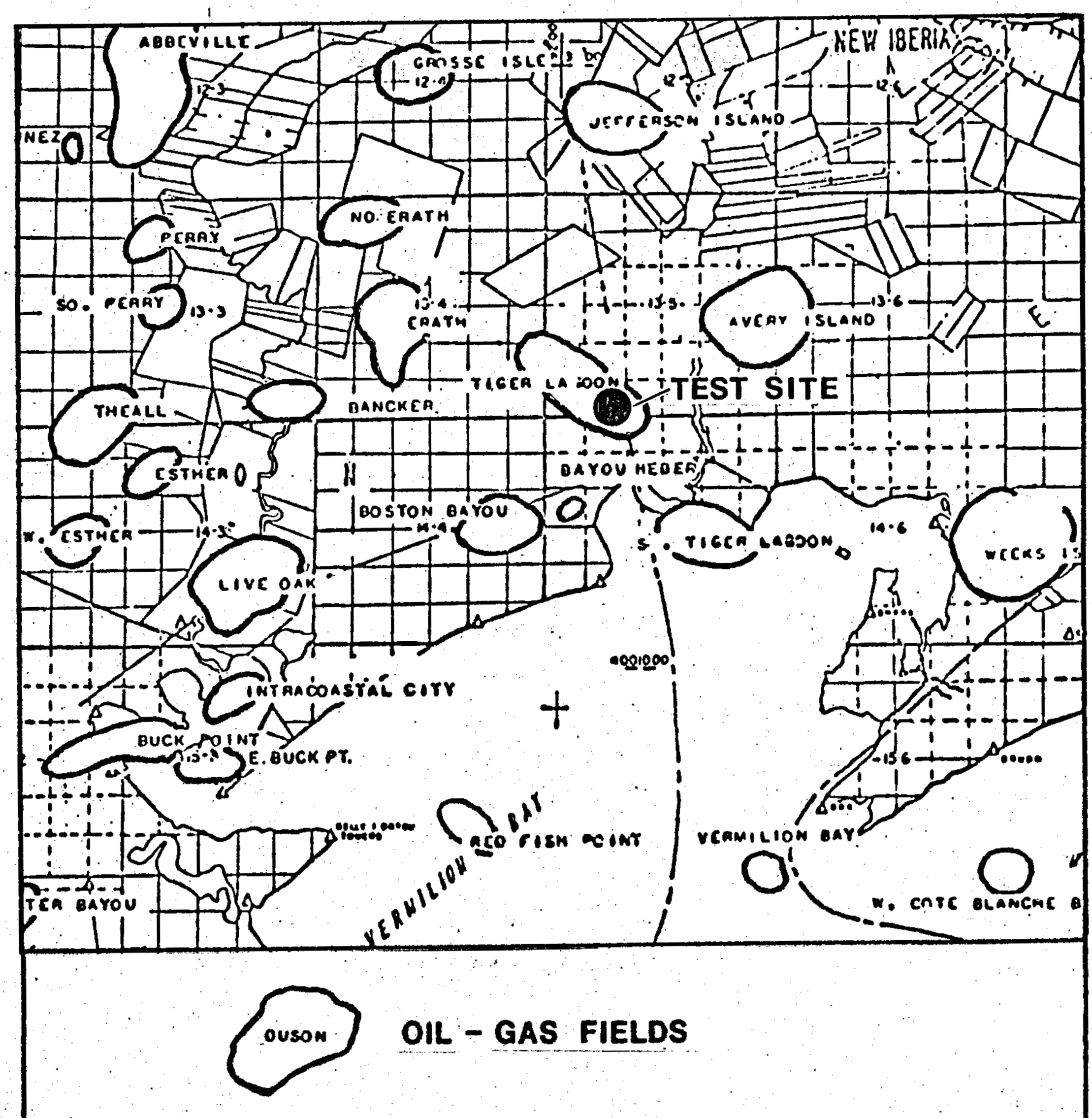


Figure III-33. Oil and Gas Fields in Vicinity of Project Site.

Table III-9. Value of Louisiana's Coastal Marshes for Fishing and Hunting Recreation.

Activity	Hunting Efforts	Value
Waterfowl and Coot Hunting	732,000	$ 7,127,000
Deer Hunting	83,800	$ 590,000
Small Game Hunting (Rabbits, Snipe, Gallinules, and Other Species)	389,000	$ 2,880,000
Fishing, Crabbing, and Crawfishing	7,939,000	$ 81,361,000
TOTAL	9,093,800	$ 91,958,000

Recreational fishing and hunting near the project area are somewhat limited, however, by lack of accessibility. Good information is unavailable concerning sport fishing and hunting near the area of the well site. However, the number of ducks observed on flyovers of the well site should be sufficient attraction for duck hunters, and the area is probably utilized by many local hunters from nearby towns. Recreational housing (fishing camps) are present 6000 feet to the south of the GIWW.

Cultural Resources

Considerable work has been done on the archeology of the area in the general vicinity of the proposed test site in recent decades, and consequently, the prehistory is reasonably well known (Table III-10). Most notable work in the area is that of McIntire (1958), Gagliano (1963, 1967, and 1970), Byrd (1974), Neuman (1973), and Gagliano, et al., (1975). The locations of known prehistoric and historic sites and fossil bone locales are shown in Figure III-34.

Archeological sites in the area contain a rich record extending from Paleo-Indian times (about 12,000 years before present) through historic times. Nineteen prehistoric sites and six historic sites of note are known from the general area. Fossils of extinct vertebrates are also relatively common in the surface and near-surface Pleistocene deposits of the area. Site data and locations are given in Table III-11, and in Figure III-34. Several of the sites are of the caliber to be considered for recognition in the National Register of Historic Places. These include: 1) Avery Island Salt Mine Valley (16 IB 23), 2) Banana Bayou Mound (16 IB 24), 3) Morton Shell Heap on Weeks' Island Site (16 IB 3), 4) McIlhenny Tabasco Factory, Avery Island, and 5) Bird City, Avery Island.

During historic times, the area was under the influence of the Atakapa Indians. As reported by Swanton (1909), the nearest Atakapa village was located on the Vermilion River, near the present city of Lafayette.

Table III-10. Coastal Louisiana Culture Sequence.

STAGE	Period	Phase	Interval
Formative	Historic	Various Tribes	1700 A.D. -
	Mississippian	Delta Natchezan[7]	1400 A.D. - 1700 A.D.
		Bayou Petrie[1]	1400 A.D. - 1700 A.D.
	Plaquemine	Medora[2]	1000 A.D. - 1400 A.D.
	Coles Creek	Bayou Cutler[1]	700 A.D. - 1000 A.D.
	Troyville	Whitehall[7]	300 A.D. - 700 A.D.
	Marksville	Magnolia[7]	100 B.C. - 300 A.D.
		Mandalay[7]	100 B.C. - 300 A.D.
		Veazey[7]	100 B.C. - 300 A.D.
		Labranche[7]	100 B.C. - 100 A.D.
	Tchefuncte	Pontchartrain[3]	500 B.C. - 100 B.C.
		Grand Lake[4]	500 B.C. - 100 B.C.
		Lafayette[7] (Teche[3])	500 B.C. - 100 B.C.
Archaic	Poverty Point	Bayou Jasmine[5]-Garcia[5]	1500 B.C. - 500 B.C.
		Rabbit Island[7]	1500 B.C. - 500 B.C.
	"Late" Archaic	Copell[3]	3000 B.C. - 1500 B.C.
		Pearl River[6]	3000 B.C. - 1500 B.C.
	"Middle" Archaic	Monte Sano Bayou	5000 B.C. - 3000 B.C.
		Amite River[6]	5000 B.C. - 3000 B.C.
	"Early" Archaic	(Kirk Points)	6000 B.C. - 5000 B.C.
Lithic	Paleo-Indian	Vatican	8000 B.C. - 6000 B.C.
		Avery Island[8]	10000 B.C. - 8000 B.C.
	"Early" Lithic (Pre-projectile Point)		? - 10000 B.C.

1. Kniffen, 1935.
2. Quimby, 1950.
3. Ford and Quimby, 1945.
4. McIntire, 1958.
5. Gagliano and Saucier, 1963.
6. Gagliano, 1963.
7. Phillips, 1970.
8. Gagliano, 1967.

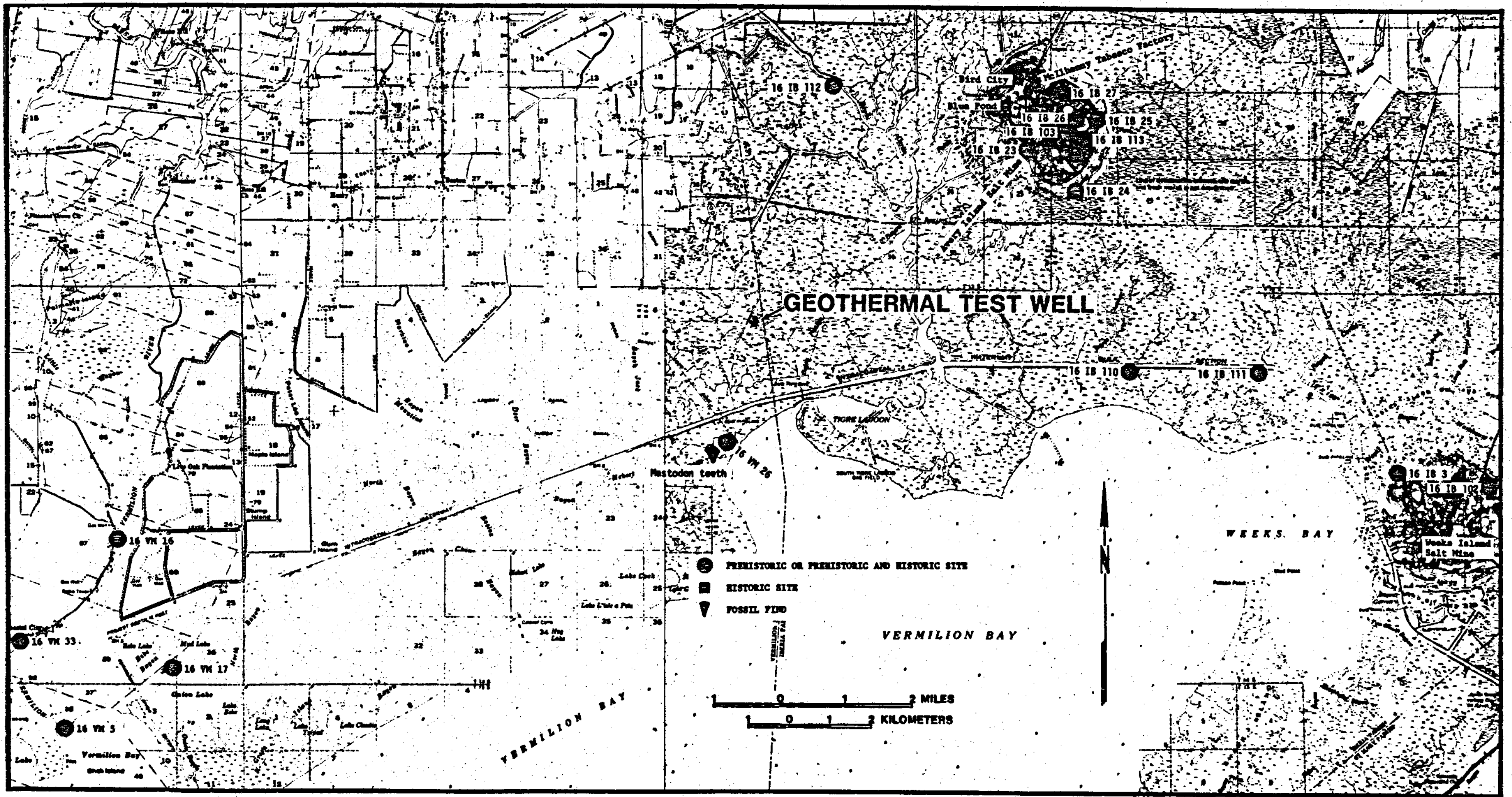


Figure III-34. Archeological and Historical Sites in the Vicinity of the Proposed Test Well.

Table III-11. Archeological and Historical Sites in the General Vicinity of the Proposed Test Well.

Site No.	Site Name	Type	Reference	Culture Periods
16 IB 3*	Weeks Island	Rangia shell midden	See Neuman, 1972, Byrd 1974	Poverty Point - Plaquemine
16 IB 23*	Salt Mine Valley	Complex stratified	See Gagliano, 1967	Paleo-Indian - Plaquemine
16 IB 24*	Banana Bayou Mound	Shell midden and earth mound	See Gagliano, 1967	Archaic
16 IB 25*	DeVance's Pond	Camp	See Gagliano, 1967	Archaic - Plaquemine
16 IB 26*	Haynes Pond	Camp	See Gagliano, 1967	Archaic - Plaquemine
16 IB 27*	Prospect Hill	Mound	No data	No data
16 IB 100	Lake Peigneur	Shell midden	See Gagliano, et al., 1975	Marksville - Plaquemine
16 IB 102*	North Hill	No data	No data	No data
16 IB 103*	Vaughn's Clearing	Camp	No data	Plaquemine

*Locations shown in Figure III-34.

Table III-11. Continued.

Site No.	Site Name	Type	Reference	Culture Periods
16 IB 110*	B. Cassmer - GIWW	Small Rangia and Ostrea midden	See Gagliano, et al., 1975	No data
16 IB 111*	GIWW Bend	Small Rangia midden	See Gagliano, et al., 1975	Coles Creek
16 IB 112*	Bayou Carlin	Large midden, Rangia and earth	See Gagliano, et al., 1975	Coles Creek - Plaquemine
16 IB 113*	South - DeVance's Pond	Small shell midden	See Gagliano, 1967	Coles Creek - Plaquemine
	Bob Acres and Jefferson Island Salt Mine	Structures and features	See EARI, 1973	Historic (modern)
	Bird City*	Park	See EARI, 1973	Historic (modern)
	McIlhenny Tabasco Factory*	Structures and grounds	See EARI, 1973	Historic (post-Civil War)
	Blue Pond *	Grounds and features	See EARI, 1973	Historic (Civil War, post-Civil War)

*Locations shown in Figure III-34.

Table III-11. Continued.

Site No.	Site Name	Type	Reference	Culture Periods
	Avery Island* Salt Mine	Structures and features	See EARI, 1973	Historic (Colonial - modern)
	Weeks Island * Salt Mine	Structures and features	See EARI, 1973	Historic (post-Civil War - modern)
	Mastodon teeth*	Fossil locale	See Gagliano, et al., 1975	Late Pleistocene
16 VM 5*	Vermilion Bayou	Beach deposit	See Gagliano, et al., 1975	No data
16 VM 16*	Vermilion Bayou	Rangia shell midden	See Gagliano, et al., 1975	Coles Creek - Plaquemine
16 VM 17*	Onion Lake	Rangia shell midden	See Gagliano, et al., 1975	No data
16 VM 26*	Bayou Hebert	Rangia shell midden	See Gagliano, et al., 1975	
16 VM 33*	Intracoastal City	Eroded bank deposit	See Gagliano, et al., 1975	Coles Creek - Mississippian
16 VM 35	Vermilion River - GIWW I	Scattered shell	See Gagliano, et al., 1975	No data

*Locations shown in Figure III-34.

IV. IMPACTS

The following sections consider first the possible adverse effects related to successive phases of the operation and their relationship to the environmental setting. Subsequently, the identified possible effects are evaluated in terms of identifiable impact or lack of impact on the various resources of the area.

Spoil Disposal

The area to be covered with spoil (34,000 sq.ft.) is limited to existing spoil banks surrounding the well slip. Only half of the spoil disposal area (17,000 sq. ft.) is vegetated (see Figures II-1 and II-2). Because vegetated spoil banks are habitats providing food and cover for rabbits, nutria, small birds, and other common wildlife, these qualities will be temporarily lost in the affected areas as a result of spoil deposition. The 17,000 sq. ft. area of spoil bank affected is small in relation to total identical habitat avialable in the area of the test well. All canals (Figure I-1) in the area are bounded by such spoil banks. Natural revegetation of the newly spoiled areas will begin immediately, however. Within one to two years after spoil deposition, the affected areas should be substantially revegetated by marsh elder, broomsedge, goldenrod, and other species originally present (personal observation, James W. Smith). After five years, the affected areas will have essentially reverted to their original condition. In consideration of the small area of spoil bank habitat to be temporarily lost as a result of spoil deposition, the environmental impact is considered to be minor.

Subsidence

Large-scale withdrawal of fluids from the hydropressured sedimentary zone can cause major subsidence, as evidenced in the Houston, Texas area (Herrin and Goforth, 1975). On the basis of calculations of large-scale geothermal production from an idealized reservoir (Papadopulos, 1975) and on other studies related to past withdrawals of water or petroleum (Hunt, 1970; Poland and Davis, 1969), it must also be taken into consideration that with production from the geopressured zone may come significant subsidence if production is long term and if vast quantities are withdrawn. Subsidence would result from compaction of aquifer-bounding shales due to leakage and/or elastic compression of the aquifer in response to large drawdowns if compaction and compression are transmitted to the surface.

On the basis of analogies and calculations, it must be concluded that subsidence, if it occurs at all, from the proposed testing will be too small to measure and does not represent an adverse impact. Analogies involve the above-cited calculations (Papadopulos, 1975), calculations made by Hise (personal communication, 1976), and withdrawal of large quantities of petroleum, gases, and brine water associated with long-term oil and gas production from sands of the same formation as the study area.

As a result of short duration of the test (two months), leakage from bounding shales may be neglected due to limited response time, as shown by Papadopulos (1975, Figure 9). Remaining, then, is possible elastic compression of the aquifer due to drawdown. Based on calculations, testing of the Number 1 sand could reasonably lead to subsidence of 0.02 mm (Hise, 1976, personal communication). Additional subsidence as a result of equal withdrawal from the Number 3 sand should be of the same magnitude, so that total subsidence would be in the order of 0.05mm.

Many important parameters for the aquifer to be tested are unknown, and calculations require a large number of experience-based assumptions. The hydrodynamics of sand-bed aquifer systems in the geopressured zone are not yet fully understood, and several factors must be considered and evaluated. Shale-water influx as pressure declines with production, elastic expansion of gas-saturated water in the reservoir tapped, and exsolution of gas from reservoir waters as pressure declines are some of the things that must be considered.

In view of the above, the statement of no impact should be further corroborated. This can be done on the basis of records of past withdrawal of oil, gas, and formation water from the same formations throughout Louisiana, including the Tigre Lagoon oil field (Hise, 1976 and Jones, 1976; personal communication).

Geopressured natural gas reservoirs, some 8,000 of which are now in production, have yielded five to seven trillion standard cubic feet (scf) of gas each year from beneath the Louisiana and Texas coasts. The Edna Delcambre Well No. 1 produced some six million scf per day for almost five years. At a conversion factor of 1,000 scf = 1 barrel (bbl) of liquid, this is about 6,000 bbl/day liquid equivalent production from a sand tapped by this well. There exists no evidence for subsidence due to fluid withdrawal from the geopressured sands tapped by this well. The effect of the proposed production of 15,000 bbl/day of formation water, to a total of 300,000 bbl, will be about equal to fifty days production of natural gas at the rate mentioned above.

It should be stressed also that subsidence of the area is a natural phenomenon related to regional geology. Based on carbon dating of peats and sea level considerations, Coleman and Smith (1964) show that natural subsidence rates for the test area are in the order of 0.75 millimeters annually, or an order of magnitude larger than could reasonably be estimated to result from the test. Related to Mississippi River delta building, the area has been fully able to cope with this rate. In the natural framework, subsidence has been a major contributor to Louisiana's estuarine productivity.

Seismic Effects

Although faulting is and has been extremely active throughout Tertiary and Quaternary history of the Gulf Coastal plain, the area is not a seismic one (Herrin and Goforth, 1975). This is because there can be no buildup of stress in the soft and geopressured deposits of the basin; strain occurs as stress occurs, and movement is continuous or nearly so where conditions of stress exist. There is no evidence for any risk of well blowout due to seismic risk for the Gulf Coastal plain of Louisiana.

With regard to induced seismicity as a result of pressure decreases from withdrawal, the same analogy as for subsidence holds true. In view of the small amount of withdrawal, the absence of any evidence of seismic shock related to vast fluid production from geopressured aquifers, or otherwise, in the Louisiana Gulf Coastal plain, the risk of induced seismicity can be neglected.

Ground Water

Ground water resources can be affected through subsurface and surface introduction of fluids whose characteristics deviate from ambient conditions. Introduction through the disposal well of pressured brine water having a salinity of approximately 150 ppt into aquifers where salinity is in the order of 35 - 50 ppt falls in the first category. This should be viewed in terms of overall subsurface hydrology of the area, where highly saline waters move upward from the geopressure into the hydropressure zone along growth fault planes, resulting in an upward increase in salinities from the bottom formation of the hydropressure zone to depths of about 3,000 feet (Jones, 1975). Salinity values thereafter drop due to mixing with fresher surface waters, introduced through aquifer surface outcrops. When taking these processes into account together with a disposal volume of water that is very small relative to the volumes present, as well as those being withdrawn for use from upper Pleistocene formations in the region (56 million bbl/day; Harder et al., 1967), distance to the nearest freshwater well, the fact that massive, impermeable clay beds separate the point of introduction and the freshwater production aquifer, it must be concluded that fluid disposal through injection will have no impact on ground water resources of the area.

Contamination of fresh, ground water resources via the surface route can equally be disregarded on the basis of the clay cap separating the freshwater production reservoir from surface waters. Distance to the nearest surface water aquifer contact is at least 15 miles to the northwest. Effects of possible surface water contamination will not extend over that distance (see next section on surface water).

Noise

Highest noise production will be from the drilling rig of the disposal well, workover of the existing well, and plugging of the test well. The noise level for a typical drilling rig at a distance of 20 ft. from the engine room was measured to be 90 dBA (data from Atlantic Richfield Oil Company, Mr. Roy McKay). Recognizing flatness of the terrain and absence of sound barriers, reduction of A-scale sound level (R_d) from a point source relative to 20 ft. distance, using the drop-off rate of 6 dBA per double distance and taking into account molecular absorption (1 dBA/1000 ft.) and atmospheric effects (1 dBA/1000 ft.) after the first 2000 and 1000 ft., respectively, can be expressed as a function of distance (D):

$$R_d = 20 \log \frac{D}{20} + \left(\frac{D - 1000}{1000} \right) + \left(\frac{D - 2000}{1000} \right)$$ (Anderson et al., 1973).

At the nearest house, a distance of 12,000 ft., noise of the drilling rig would be reduced to 13.4 dBA. Recreational housing (fishing camps) at a distance of 6,000 ft. to the south will be affected by a level of 31.4 dBA. In both cases, the anticipated noise levels are well below day and night time criteria proposed by the federal government with regard to geothermal operations (U.S. Dept. of the Interior, 1975). These criteria are shown in Table IV-1. Night and daytime levels for uninhabited areas (marsh) are exceeded up to distances of 630 ft. and 200 ft., respectively.

Table IV-1. Noise Criteria Not to be Exceeded For Geothermal-Related Activities (U.S. Dept. of the Interior, 1975).

Land Use	Daytime	Evening	Night
Residential (Rural)	45 dBA	40 dBA	30 dBA
Agricultural	70 dBA	65 dBA	55 dBA
Recreational	45 dBA	40 dBA	30 dBA
Uninhabited or Rangelands	70 dBA	65 dBA	60 dBA

Noise from additional or alternate sources during various phases of the operation include that of the dredge (one day), small crew boats (20 feet), helicopters, turbine, flow of pressured fluids through piping, and other lesser sources such as tools. Each of these sources has been or is already temporarily present in the general area as a result of oil and gas development. Their contribution to the overall noise level of the area and to that of the test site during drilling operations can be considered acceptable for the two months of the test duration.

The effect of noise on wildlife under natural conditions is largely unknown. Most studies have dealt with the effects of noise on domestic animals confined to the laboratory. Noise generators of various types have been utilized successfully to frighten animals, such as deer or birds, from areas where they are feeding on crops or creating a nuisance. The general effect of project noise on terrestrial animals in the marsh is likely to be one of avoidance of the immediate project area.

Air

Combustion engines used in the site preparation, drilling, testing, and cleanup phases of the project do not represent abnormal additional sources of pollution. All have been and are used in the immediate area of the well in conjunction with oil and gas production. They cannot be considered to add significantly to ambient levels of air pollutants.

Flaring of gas is also a frequently occurring action. No monitoring of resultant air pollution has been done, although regulations are in preparation (U.S. Environmental Protection Agency, Region IV, Dallas, Texas). A major common and harmful constituent in the gas to be burned is H_2S. Data provided by Coastal States concerning gas delivered to a trunkline and produced from the same sand series and well is given in Table IV-2.

Maximum measured hydrogen sulfide concentration is seen to be 0.095 grains/100 cu. ft., or 3.1 ppm by weight, which represents a low concentration relative to natural gas from other areas. The H_2S is not anticipated to have a harmful toxic or obnoxious odor effect since the gas will be flared. Burning of the gas will result in oxidation of the H_2S to SO_2 (sulphur dioxide). SO_2 is a common temporary constituent in air, but is generally considered a contaminant. It is soluble in water and is washed out by rain. On the basis of the low H_2S concentration, no adverse effects are expected from resulting SO_2.

The expected volume of 10.5×10^6 cu. ft. of gas would yield 620 grams of H_2S for a concentration of 3.1 ppm. Oxidation would produce 1136 grams of SO_2 over the 20 days of gas flaring, or a production rate of 0.66 mg/sec. Using the U.S. Environmental Protection Agency Standard Gaussian plume diffusion model, resulting concentration of SO_2 at the nearest house was calculated for average atmospheric conditions (wind direction - southeast; wind speed - five m/sec; neutral atmospheric stability), and flare stack height of five ft. above ground level. This calculation yielded a maximum SO_2 concentration of 0.007 $\mu g/m^3$ at the nearest house, 12,000 ft. to the northwest. This is far below the ambient air quality standard of 60 $\mu g/m^3$ (annual geometric mean) maintained by the Louisiana Air Control Commission.

Surface Water Quality

Possible temporary reduction of water quality relates to dredging, boat traffic, drilling, and blowout. The dredging operation is not anticipated to require more than one day's time. During the dredging period, the turbidity of the water in the channel will be temporarily increased due to disturbance of the channel bottom.

Case studies of dredging (Mackin, 1971) show that for the type of dredge to be used, turbidities generated do not exceed those attained under natural conditions (20 - 200 ppm) beyond a distance of 100 ft. from the dredge. In shallow bays, such as those present in the study area, natural turbidities may be as high as 500 ppm. Measurements during the above study showed futhermore that turbidity increases did not extend beyond 1,300 ft. from the working dredge.

Hydrology of the test site will tend to ameliorate the dredging effect. Presence of a dam at the southern end of the well slip limits circulation, allowing only tide-related inflow and outflow. Based on tidal range, volume exchanged, and cross-sectional area, velocities should be only in the order of 16^{-3} ft./sec. Turbidity increases should therefore be confined to the well slip, and lack of turbulence should allow rapid settling of suspended material. On the basis of settling velocity (Schultz, et al., 1954), it must be anticipated that water will have returned to normal turbidities within 24 hours after dredging has been terminated.

Table IV-2. Gas Constituents Determined From Gas From Same Field and Formation as Test Well Production.

Sample Marked: "Coastal States Gas Producing Company, Tigre Lagoon Field, Sales Gas to Trunkline, sampled @ 950 PSIG & 95° F., on September 15, 1970".

Submitted by: Southern Petroleum Labs., Inc. (Ray Calais)

for: Coastal States Gas Producing Co.
P. O. Box 52088, OCS
Lafayette, Louisiana 70501

September 16, 1970

Chromatograph Analysis:	Mol %	GPM @ 15.025 psia
Carbon Dioxide	0.66	
Nitrogen	0.12	
Methane	93.98	
Ethane	3.20	0.824
Propane	1.03	0.289
Iso-butane	0.26	0.087
N-butane	0.26	0.084
Iso-pentane	0.11	0.041
N-pentane	0.08	0.030
Hexanes	0.09	0.038
Heptanes Plus	0.21	0.099
	100.00	1.492

SAMPLING DATE:

9-3-70 SAMPLE FROM COASTAL STATES GAS PRODUCING COMPANY'S TIGRE LAGOON FIELD @ TRUNKLINE'S ON SHORE PIPELINE

PARAFFIN IN GAS	4.938
HYDROGEN SULFIDE GRAINS/100 CU. FT.	0.042

9-4-70 SAMPLE @ COASTAL STATES GAS PRODUCING COMPANY'S TIGRE LAGOON FIELD SALES TO TRUNKLINE SAMPLED @ METER RUN IN FIELD.

PARAFFIN IN GAS	20.661
HYDROGEN SULFIDE GRAINS/100 CU. FT.	0.093

In summary, it must be stated that the increase in turbidity associated with dredging is too localized in area and too short in duration to have any significant impact.

Boat traffic is not anticipated to contribute measurably to volume and density presently occurring in the area, and, therefore, should not raise levels of turbidity and/or traffic-related pollutants above ambient levels to any degree of significance. Equipment will be moved only twice, in and then out. A crew boat (20 to 30 feet in length) will need to make only one trip daily. This should be compared to traffic on the Gulf Intracoastal Waterway, which is only one mile to the south, and with local boat traffic for the purpose of maintaining oil and gas installations.

Proper operation during the drilling phase should not affect water quality to a measurable degree. The main source of contaminants is at the well head in the form of hydraulic fluid and lubricants. To prevent dispersion of these bouyant materials, the key hole of the rig is provided with a gate so that the fluids are contained and can be recovered from the water.

Among the possible, but highly improbable, impacts, that of a well blowout would be the most severe. The effects on water quality of such a blowout can be described to some extent as a result of water samples collected by the U.S. Environmental Protection Agency during discharge following a blowout of the Coastal States' well Edna Delcambre #4. Samples were also collected by Coastal States when a leak developed in the same well eight months after the blowout referred to. Data collected by the U.S. Environmental Protection Agency during brine discharge following the blowout is presented in Table IV-3. Sampling sites within the study area are shown in Figure IV-1. Based on the above salinity data and the distance of sampling sites to the point source, Figure IV-2 was constructed, indicating an ambient salinity level of 3.0 ppt and allowing the following conclusions.

Due to greater density, the gradually diluted brine water (initial salinity $\pm$ 150 ppt) moved largely as a wedge, affecting bottom water the most. In the immediate vicinity of the discharging well (E.P.A. Station 2), salinities of bottom and surface water were measured to be eight and four ppt, respectively. Bottom water effects extended outward from the well slip to distances between 3,600 and 7,200 ft., according to directions taken from the point source. Surface and mid-depth waters were affected about equally to distances of between 4,400 and 2,600 ft. Effects of the blowout thus extended over a radius of approximately one mile with regard to salinity. Surface and mid-depth salinities outside the slip (Stations 3 through 7), however, were all within the range of annual variation.

Table IV-3. Water Quality Data Collected by the Environmental Protection Agency during Brine Discharge in 1971.

Station Number*	Approximate Location	Total Depth		Salinity 0/00 PPT	Temperature°C
1.	Union Oil Co. Docks	12'	surface	2.6	27.9
			mid-depth	2.7	27.8
			bottom	2.9	27.7
2.	200' East of Injection Point	12'	surface	7.2	26.7
			mid-depth	10.5	26.7
			bottom	11.2	26.8
3.	½ Mile NE of Injection Point	12'	surface	6.2	26.8
			mid-depth	7.1	26.7
			bottom	8.2	26.9
4.	1 Mile NE of Injection Point	12'	surface	3.0	28.0
			mid-depth	3.6	27.4
			bottom	7.9	27.3
5.	1/8 Mile West of Injection Point	12'	surface	3.8	27.2
			mid-depth	5.6	27.0
			bottom	9.8	26.8
6.	1 Mile from Injection Point Midway between Injection Point and Intercoastal Canal	12'	surface	2.4	27.7
			mid-depth	2.7	27.2
			bottom	2.6	27.4
7.	Intercoastal Canal West of Confluence of Entrance Canal to Injection Point	12'	surface	3.1	26.9
			mid-depth	3.1	27.0
			bottom	3.1	26.6
8.	Intercoastal Canal, East 2nd of Vermilion Locks Right Bank Looking Downstream	4'	surface	0.2	27.5
			bottom	nil	27.4

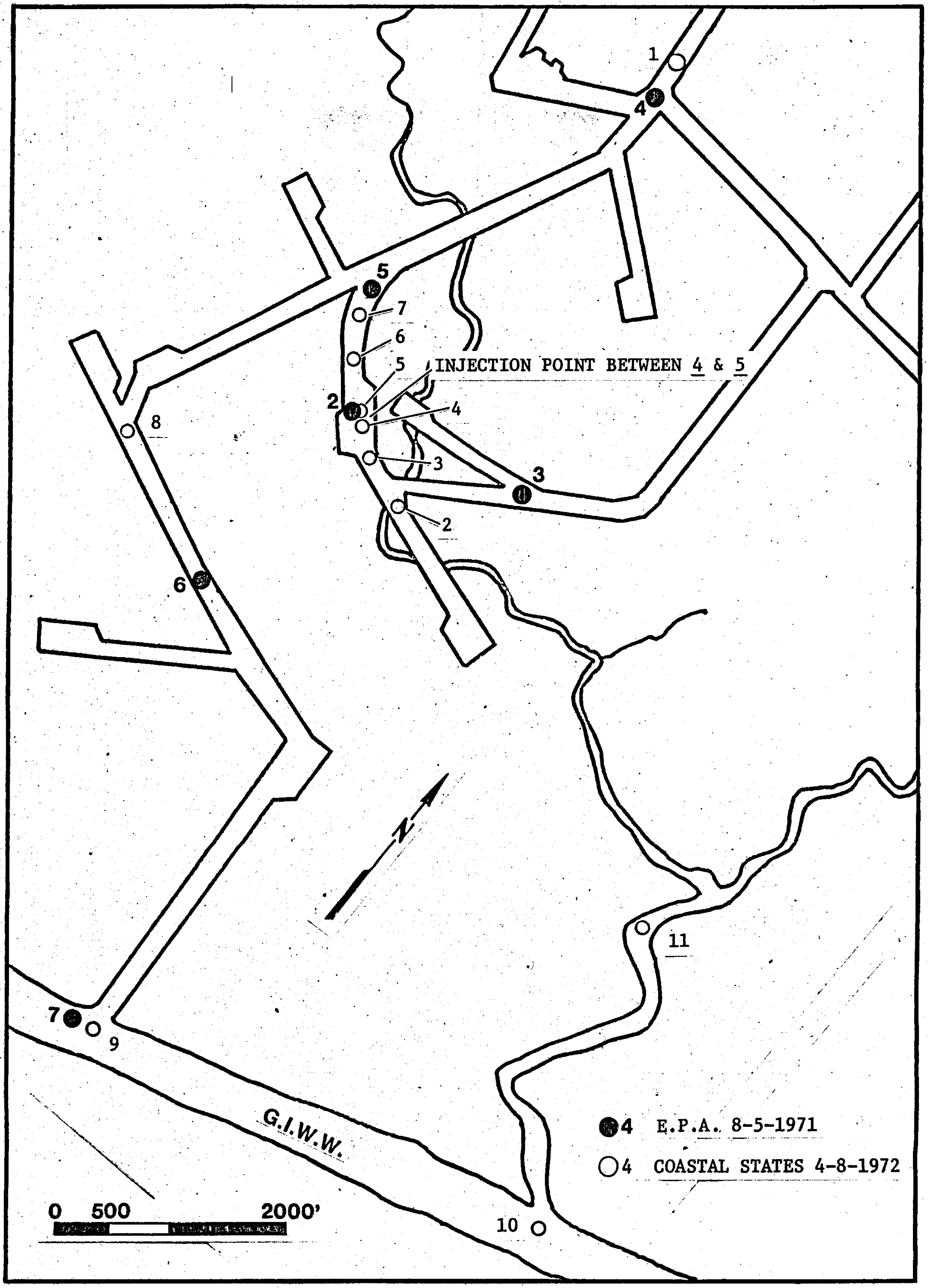


Figure IV-1. Sampling Sites during Brine Discharge in 1971 and 1972.

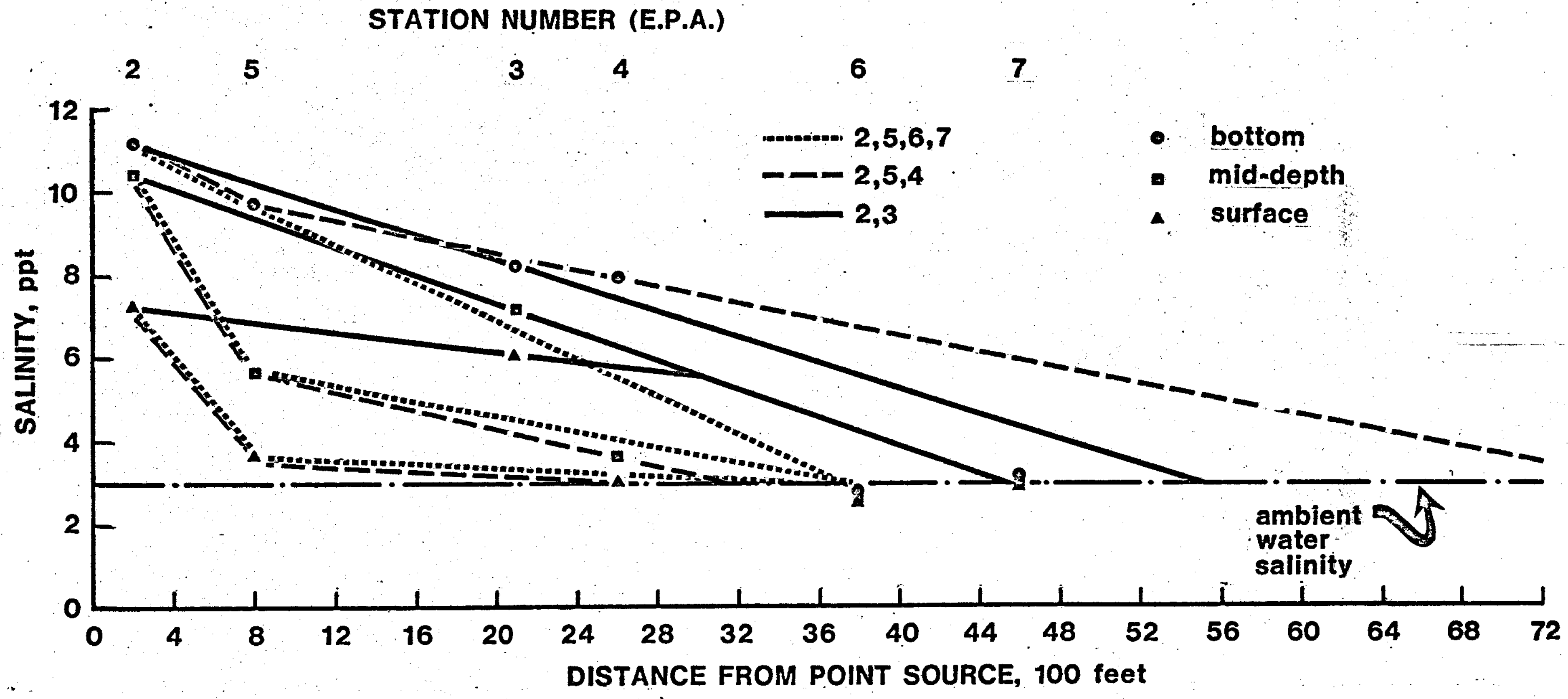


Figure IV-2. Salinity Gradients Away from Brine Point Source in Test Well Slip, 1971.

The effect of temperature appears to be confined to the well slip. There appears to have been a drop in temperature of about one degree Centigrade, which may be attributed to expansion of the geopressured fluid and gases.

Following the above procedure for the Coastal States' data (Table IV-4 and Figure IV-1) under discharge conditions of 8,000 bbl of water/day, with a salinity of 150 ppt, it was found that total effects extended outward over a distance of only 4,000 feet. However, salinity data does not show a major salinity increase anywhere.

Leakage of pressure lines at the surface is a remote possibility that would have surface water effects that are several orders of magnitude smaller than that of blowout and may therefore be disregarded.

Discharge of large volumes of highly saline formation fluids into the well slip, as would occur during a blowout, may be expected to cause a rapid increase in salinities in the slip. Such a sudden increase in salinity could be expected to adversely affect fishes and other aquatic organisms. However, an examination of data collected on the blowout of the Edna Delcambre #4 well indicates that the adverse effects of salinity increases are less than what might be expected.

Firstly, highest salinities were measured near the bottom of the channel. Surface water salinities were increased much less above ambient conditions. Motile aquatic organisms, such as fishes, could escape from the highest salinities in the deeper waters and exit from the area affected by the blowout by utilizing the surface waters. Secondly, even the highest salinities recorded were well within the range of tolerance of estuarine species present. Estuaries are zones of fluctuating salinities which are often quite rapid, depending on wind and tidal action and freshwater input. Estuarine organisms are adapted to such conditions. In consideration of these factors, it is reasonable to conclude that a large fish kill resulting from a blowout would be an unlikely event.

Since the highest salinities caused by discharge of brine waters during a blowout occur in the bottom waters, sessile, or relatively non-motile, benthic organisms may be expected to be the most seriously affected. Again, estuarine organisms among the benthic community would be least affected since they are adapted to changing salinity conditions. It is unlikely, considering the diluting effects of the receiving waters, that salinity changes would occur so suddenly as to cause mortalities among estuarine benthic animals. Since ambient salinities in the project area are low enough to allow the presence of freshwater species, such as insect larvae and mollusks, these organisms, being less tolerant of salinity increases and unable to move out of the affected area, would be most likely to suffer heavy mortalities as a result of a blowout.

Pollution of surface waters from oil or condensate as a result of a blowout on the geothermal well is likely to be of only a very minor nature, since the test zones are largely free of liquid hydrocarbons. Any oil or condensate lost into the location canal would be contained in the immediate area of the well by flotation collars.

Table IV-4. Water Quality Data Collected by Coastal States During Brine Discharge in 1972.

Station Number*	Approximate Location	Sample Depth	Salinity ppt A.M.	Salinity ppt P.M.
1	3000' North of Injection Point	Surface	0.9	1.0
		5' below Suface	0.9	1.0
2	300' East of Injection Point	Surface	0.8	1.0
		5' below Surface	0.9	1.0
3	100' East of Injection Point	Surface	0.9	1.0
		5' below Surface	1.0	1.0
4	10' East of Injection Point	Surface	1.1	1.1
		5' below Surface	1.4	1.1
5	10' West of Injection Point	Surface	1.2	1.3
		5' below Surface	1.6	1.3
6	100' West of Injection Point	Surface	1.1	1.4
		5' below Surface	1.2	1.4
7	300' West of Injection Point	Surface	1.2	1.1
		5' below Surface	1.3	1.3
8	3000' South of Injection Point	5' below Surface	1.0	1.0
9	Entrance to Intercoastal Canal	Surface	0.9	0.9
		5' below Surface	0.8	0.9
10	Entrance to Intercoastal Canal	Surface	0.7	0.7
		5' below Surface	0.7	0.7
11	4000' Southeast of Injection Point	5' below Surface	0.9	0.7

Related to the effect of surface water quality is the potential impact of precipitation of highly saline water on nearby vegetation. During both the first and second blowout of the Edna Delcambre #4 well, saline (± 150 ppt) formation fluid was blown about 100 feet vertically into the air. As a result of wind stress on the water spout, fallout of the brine occurred partially on land. Figure IV-3 shows the spray fallout zone associated with the 1971 blowout. No such information is available for the 1972 blowout. On field

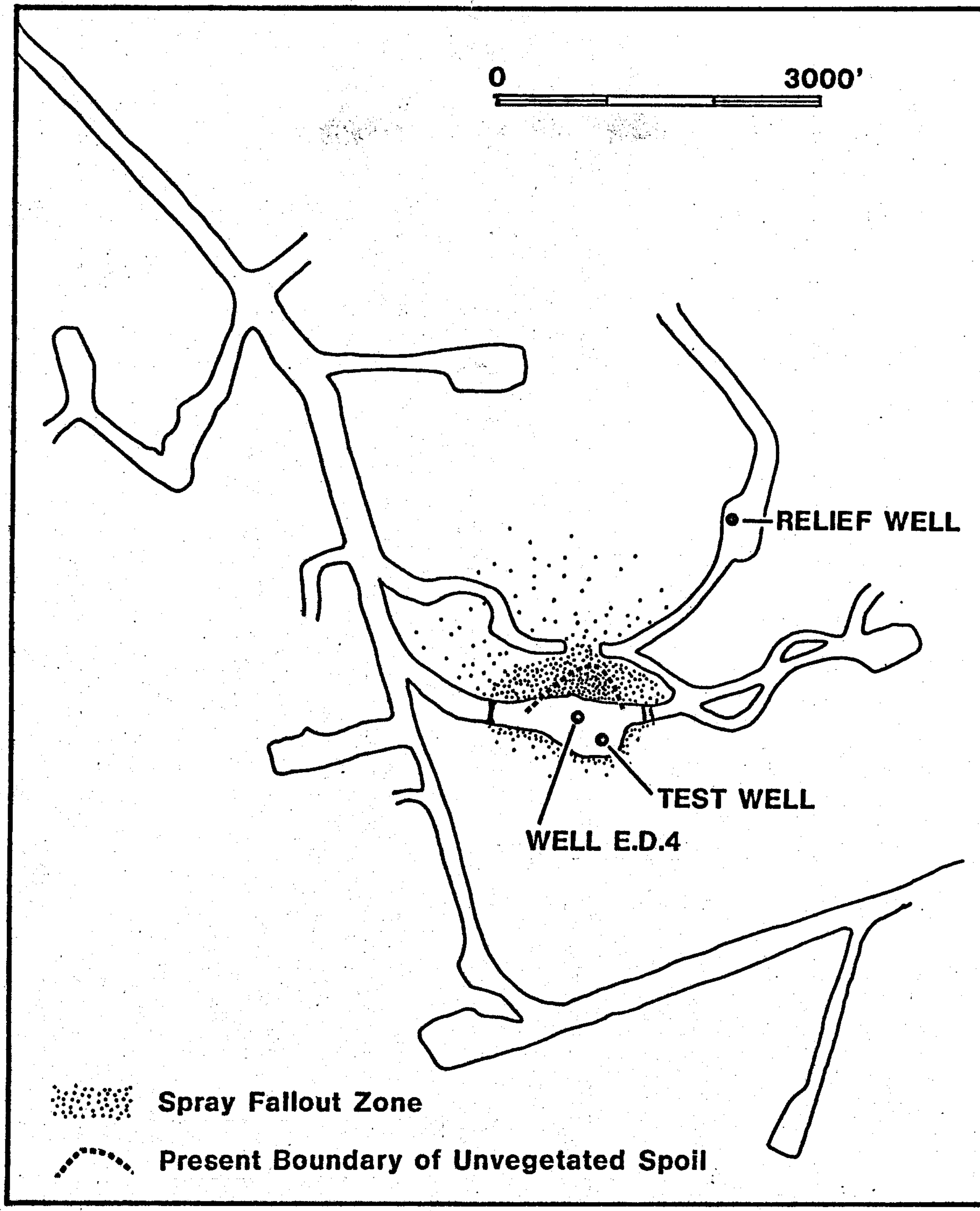


Figure IV- 3. Distribution of Brine Fallout from Spout During 1971 Blow-out of the Edna Delcambre #4 Well. Source: Environmental Protection Agency, Region VI, Dallas, Texas.

inspection of the well site for the present report, it was found that spoil along the northeast bank of the well slip was unvegetated in an area that was coincident with the area of maximum fallout shown in Figure IV-3. Though conclusive evidence would require extensive sampling of soil, the coincidence may indicate soil salinities that are still too high despite flushing by local precipitation. No evidence of lasting impact could be detected beyond the area of unvegetated spoil, including the marsh surrounding the spoil.

Well Blowout

By standards of normal oil field operation, extraordinary precautions will be taken in the proposed project to prevent blowout of the test well as discussed in Section II (blowout prevention, pipe quality, supervision). Yet the possibility of a blowout should be considered in view of the high pressures anticipated in the geopressured zone and of previous blowout of an adjacent well (Edna Delcambre #4) located within the same slip (Figure I-1).

Some documentation exists on blowout occurrences at various geothermal fields (Bolton, 1964; Stillwell, 1970; U.S. Department of the Interior, 1975). These reports show that blowouts are primarily associated with the drilling phase. This reduces probability in the present case since an existing well will be re-entered. Some notion concerning general probability of well blowout can be obtained from data collected by the Louisiana Conservation Department during 1975. This data shows a total of 3,286 drilling permits granted (including 513 wildcats) and a total of 11 blowouts. If representative, this would mean a probability of 0.003.

Blowout of the Edna Delcambre #4 gas well took place on July 13, 1971, and resulted from negligence during workover as rams were changed on the blowout preventers. Documents concerning the blowout could not be located and have either been lost or destroyed except for an investigative report covering the period of July 14 to July 25, 1971, by Mr. Joseph C. Alleman of the Louisiana State Mineral Board to the Environmental Protection Agency, Dallas, Texas.

From this report, personal communications with Mr. Charles Page, Coastal States Gas Producing Company, and correspondence between Coastal States Gas and the Louisiana Department of Conservation, the following information was obtained.

Depth of the producing interval at the time of blowout (July 13, 1971) was between 13,380 and 13,880 feet, with three to four thousand pounds flowing pressure. The well caught fire ten hours after blowout. Efforts to extinguish the fire failed, but flames went out on July 23 as the burned drilling barge was pulled off the well head. This allowed evaluation of damage to well casing, and the decision was made that the well could not be capped, but that a relief had to be drilled. At the same time, a flare pipe was installed on the casing and the well was re-ignited. The well burned for approximately ten days. Discharge of the highly saline ($\pm$ 150 ppt) formation fluid continued, however, for approximately three months until the well was made inactive. The relief well was killed through directional drilling of a relief well, begun on July 26, 1971, at a location 800 - 1000 feet to the east of Edna Delcambre #4. The well was plugged and abandoned on November 4, 1971, by pumping cement through the relief well into the Edna Delcambre #4 well.

Plugging of the well appears to have been insufficient since on March 7, 1972 the well started flowing salt water. Despite remedial measures, the well blew out on March 11, 1972, resulting in a saltwater spout 80 feet high at an estimated discharge of 3 - 5 barrels per minute. No gas or condensate were present. Further measures were also ineffective, and blowing of salt water continued to some time between March 23, 1972 and June 8, 1972, when a protective cap was placed on the well to prevent salt water from spraying onto the surrounding land. Discharge of salt water continued, however, directly into the well slip until July 31, 1973. At that time, the relief well was worked over and used to pump 11,000 sacks of cement into the Edna Delcambre #4 well, effectively killing this well.

The above blowout history is only intended to illustrate a severe case of such an event. In no way does this blowout of Edna Delcambre #4 signal any increased probability of similar problems for the adjacent test well. This is clearly corroborated by the absence of any such problem in drilling the relief well, working over the relief well, and working over the test well, Edna Delcambre #1, on two occasions after blowout of the Edna Delcambre #4. Clearly, the blowout was the result of a technical error when handling surface equipment, rather than the uncontrollable subsurface conditions.

Potential adverse impacts of the aquatic and marsh environment were discussed in the preceeding subsection of this report dealing with surface water quality, showing that the main impact resulted from the highly saline water that precipitated on nearby vegetation. Inspection of the area five years later for the purpose of the present assessment did not reveal remaining effects other than possibly that of no revegetation of some 1500 square feet of spoil along the east bank of the well slip. The absence of lasting impact has been substantiated by personal communication with Mr. Wally Cooper of the Environmental Protection Agency, Region VI, Dalls, Texas.

Adverse Impacts

The following paragraphs summarize adverse impacts as anticipated on the basis of the previous discussion.

Land Resources

Since dredging involves only maintenance of an existing well slip, it will result in no land loss. Boat traffic frequency, duration, and volume associated with the project are so low that they will not cause erosion of spoil banks along access canals. An estimated 34,000 sq. ft. of land is required for spoil disposal site corresponding to an area of previous spoil deposition. Approximately one-half of this footage is unvegetated spoil, the remaining part being vegetated spoil. No additional land modification is required for the project.

Aquatic Resources

Dredging in the well slip will result in the direct destruction of benthic invertebrates which will be removed along with the dredged bottom material in an area of approximately 5,000 square feet. Effects are not permanent since repopulation will occur over a period of one to four years, with bivalve mollusks requiring the longest period for re-establishment (Tarver and Dugas, 1973). The effects of increased turbidity and siltation on the bottom fauna are slight as compared to the direct effects of dredging. Increased turbidity for one or two days will also interfere with feeding activities of sight-feeding fishes in the immediate area of the working dredge. Such fishes will, however, move out of the affected area during the dredging period. There exists a constant turbidity at present due to exchange with ancillary turbid waters.

Dredging will include the removal of two bulkheads at the entrance to the well slip (Figure II-1). These bulkheads, probably in conjunction with a weir, functioned as a water level (tidal) control to minimize interference of the well slip and access canal with the hydrologic regime of the marsh. This was prior to subsequent dredging of a great number of additional canals and placement of a dam at the southeastern end of the well slip, severing its connection with Bayou Portage. At present, the bulkheads no longer have any affect on the hydrologic regime of the area, and removal therefore will have no impact other than that of disposal of resulting spoil as discussed under that heading.

Vegetation and Wildlife

The most severe impact of the operation results from placement of dredging material. In the area previously used for disposal, the existing plant community will be destroyed over an area of about 17,000 sq. ft. It will take about two growing seasons for natural recovery. The wildlife habitat provided by the vegetated spoil areas will be temporarily lost during this period. No marsh vegetation will be affected by spoil disposal. Effects are ameliorated by ongoing plant succession on earlier-deposited, invegetated spoil areas.

Noise increase will only lead to temporary avoidance of the area by wildlife.

Water Resources

A temporary increase in turbidity is the only identifiable adverse impact on surface water quality. No impact on ground water resources is anticipated.

Atmospheric Resources

Impact on air quality relates to the flaring of 10.5 mmcf of low sulfide (sweet) natural gas and the resulting oxidation product of sulphur dioxide. The calculated concentration remains well below the allowable ambient air quality standard. Emission of combustion engines are not above those presently occurring in the vicinity of the project site.

Economic and Cultural Resources

Natural gas from the formation fluid will be flared, resulting in a resource loss anticipated to be 10.5 mmcf, which does not have an identifiable economic impact other than loss of its monetary value (+$12,000). Existing oil and gas deposits in the area are not anticipated to be affected. Economic operation (industry, farming) and rural residential areas will not be impacted. No known archeological resources occur in the immediate area of the well site. Recreational activities are not subject to hindrance during the operations.

Remedial Action

Following the testing operation, the site will be cleared of all solid wastes. Fluids in the mud pit will be drained and disposed of in the disposal well. The mud pit will then be closed. Clean up operations represent an aesthetic benefit relative to present conditions of the site.

Benefits

Energy present in geopressured waters below the Louisiana and Texas Gulf Coasts in the form of natural gas in solution, thermal energy, and hydraulic energy represent a potential resource of national importance. Power production from geothermal energy in other areas, such as California, New Zealand, Japan, and Iceland, has been a commercial success (House, et al., 1975). The proposed action is anticipated to contribute substantially to feasibility evaluation of geothermal energy utilization along the northwestern Gulf of Mexico coast. Possible anticipated uses of geothermal energy are for sugar mills and refineries and pulp and paper mills located in Louisiana and Texas coastal regions.

Summary Statement

A thorough analysis of the proposed action, the environments possibly affected, and the probable environmental impacts indicate that the environmental impacts of the proposed project are minor in nature and short in duration. The most severe impacts the project could have would be those resulting from a well blowout. Even these impacts, except for loss of life and major injury, would not have lasting effects.

APPENDIX A

The on-site operations, under Osborn,Hodges, and Roberts Engineering Supervision, will proceed as follows:

7.0 Dredge out location then move rig-in to a location near the Edna Delcambre well. (Approximately 100 feet East)

8.0 Rig-up and prepare to drill a salt water disposal well.

9.0 Drive approximately 100 to 150 feet of 16 inch conductor pipe.

10.0 Nipple up blow-out preventers and hydril pressure test blow-out preventer to 10,000 psi and the hydril to 3000 psi.

11.0 Drill 10 5/8 inch hole to 2480 feet.

12.0 Run 2480 feet of 7 5/8 inch-24# ST&C, H-40 casing. Run cementing float shoe on bottom with appropriate scrapers.

13.0 Cement with 1200 sacks of common cement, class H with 12% gel followed by 100 sacks common cement, class H with 2% CaCl. (Check for flow back.)

14.0 Wait 18 hours for cement to set.

15.0 Drill out to 2520 feet with 6 5/8" bit.

16.0 Pull bit up into casing.

17.0 Circulate salt water to clean drill pipe of mud.

18.0 Shut well in with hydril.

19.0 Pump salt water into bottom formation to determine pressure required to put salt water away in open sand.

20.0 Ream hole and clean hole by circulating mud. Run hole-opener if required.

21.0 Pull out of the hole, lay down drill pipe.

22.0 Nipple down blow-out preventers. Nipple up tree.

23.0 Pressure test tree.

24.0 Go in hole with 3 1/2" tubing, with production packer and sand screen on bottom.

25.0 Gravel packer sand screen.

26.0 Set packer 30 feet above bottom of casing.

27.0 Hang tubing.

28.0 Pump salt water down tubing at various rates and determine tubing pressure versus flow rate.

29.0 Pump drilling barge out and prepare to skid rig.

30.0 Skid rig over Delcambre #1.

31.0 Rig up.

32.0 Run temperature log from 13,300 feet, or total depth, to 12,000 feet KB.

33.0 Kill well by circulating heavy mud.

34.0 Pull out of hole and lay down production string.

35.0 Nipple down tree, nipple up blow-out preventer and hydril and pressure test preventers to 5000 psi and hydril to 3000 psi.

36.0 Run cement Bond, Gamma Ray, Porosity, and Collar Locator logs from total depth to 12,000 feet KB.

Upon examination of the cement bond log, if it is deemed necessary, based upon the judgment of Osborn-Hodges Engineering, the sands to be tested will be squeezed with cement prior to proceeding.

37.0 Set wire line bridge plug at 13,300 feet KB.

38.0 Dump cement with cement bailer. (10 sacks class H)

39.0 Go in hole with wireline and tag bottom.

40.0 Set wireline bridge plug on top of cement.

41.0 Go in the hole with 12,000 feet of 3 1/2" tubing tailed with 1150 feet of 2 7/8" tubing and packer to a depth of 13,150 feet KB.

42.0 Circulate predetermined volume of salt water to reduce static head on bridge plug to approximately 6000 psi.

43.0 Shut-in with Hydril and Kelly valve and check for pressure build-up on casing or tubing.

44.0 If no pressure builds up, break off Kelly and check for flow back. If pressure or flow-back occurs, cement plug and bridge plugs do not have integrity. If so, go in the hole with squeeze packer and squeeze plug.

45.0 If there is "plug" integrity, circulate heavy mud around, then shut-in well with Hydril.

46.0 Pressure up tubing to equivalent static bottom hole pressure of 12,000 psi. Determine if pressure holds for 30 minutes to test integrity of casing. If pressure drops off, pull out of the hole, go in the hole with squeeze packer and determine point of leak by setting packer and pressuring up tubing. When point of leak has been determined, squeeze leak with class H cement. Wait for cement to set and then drill out and scrape casing if necessary, then re-pressure test.

47.0 Circulate mud with predetermined mud weight of approximately 0.2 to 0.3 #/gal under balance for the #3 sand; set packer.

48.0 Go in the hole with tubing gun and perforate with 3 shots, 1 shot per foot, at 12,906 to 12,909 feet KB.

49.0 Pull out of the hole with tubing gun.

50.0 Nipple up for dynamic flow testing.

The following steps describes dynamic flow test procedure:

The first phase of the testing program (steps 51 thru 65) is to accomplish two objectives. The objectives are to (1) obtain fluid samples and (2) determine the flow rate at which significant quantities of sand is produced.

The purposes of the first phases of the tests are to determine the amount of natural gas dissolved in the produced water and to analyze the composition of the fluids. Also, the determination of the flow parameters at which the reservoir sands begin to move. This will assist in defining the sand production problems.

The second phase of the testing program is designed to collect data to be used in determining some of the reservoir parameters. This information will be utilized in computer computations to determine the Kh of the reservoir and how much fluid the reservoir can produce. Also, fluid samples will be taken during this phase of the testing and the fluid will also be passed through separators to determine the volume of the gas contained therein.

The dynamic testing will be conducted as follows:

51.0 Run bottom hole pressure bomb, record bottom hole pressure.

52.0 Pull pressure bombs out of the hole.

53.0 Slowly open master valve and control well with choke. Flow at very low rate to mud pits until well has cleaned up.

54.0 Shut well in.

55.0 Run temperature log to determine that all perforations are open.

56.0 Go in the hole with bottom hole pressure bombs to record flowing bottom hole pressure, also fluid sample bombs will be run to the maximum depth possible, as dictated by the maximum pressure, the pressure bombs can withstand, to secure fluid samples at as near in-situ conditions as possible.

57.0 Divert flow stream to test equipment. Stabilize flow rates and vessel levels.

58.0 Check operation of pressure, temperature, flow rate and sand detection equipment.

59.0 Open choke and allow well to flow at a minimal rate and observe sand detecter. Slowly increase the flow, allowing several hours for each flow rate established, and check for presence of sand grains in the fluid. By adjusting the flow rate, determine the flow rate at which the reservoir sands tend to produce significant quantities of sand particles. During this flowing period, continuously monitor the quantity of gas recovered by the separating equipment and every two hours secure fluid samples to be sent to laboratories for analysis. Approximately every 24 hours collect down hole fluid sample as in item 56.0 above.

Varify findings above as follows:

60.0 Reduce flow rates and stabilize rate at point of low sand particle detection.

61.0 Increase rates slowly and note point of elevation of sand particle count.

62.0 Reduce flow rates and stabilize rate at point of low sand particle detection.

63.0 Increase rates slowly and note point of elevation of sand particle count.

64.0 Pull out of hole with bottom hole pressure bombs. Secure fluid sample, down hole, as in item 56.0 above.

65.0 Run temperature log.

66.0 Go in hole with perforation gun and perforate the entire Number 3 sand interval.

67.0 Pull out of hole with perforating gun.

68.0 Run Hewlett Packard Quarts Crystal and Amerada Hess bottom hole pressure bombs in tandum.

69.0 Flow well to mud pits for clean up.

70.0 Divert flow stream to test equipment.

71.0 Start sampling at sampling points.

72.0 Check for sand movement.

73.0 Set flow rate at predetermined rate based upon previous test data.

74.0 Start extended duration flow test. Maintain constant continuous flow rate. Observe draw down of bottom hole pressure detected by the Hewlett Packard pressure bomb. When adequate draw down has occurred shut the well in. Also, during this extended test period run down hole, fluid sample bombs as set forth in item 56.0 above. (Approximately every 24 hours).

75.0 Observe the bottom hole pressure build-up on the Hewlett Packard pressure bomb.

76.0 Notify ERDA regarding committee review as set forth below.

77.0 When adequate bottom hole pressure build-up has occurred pull the pressure bombs out of the hole. Secure, down hole, fluid sample as set forth in item 56.0 above.

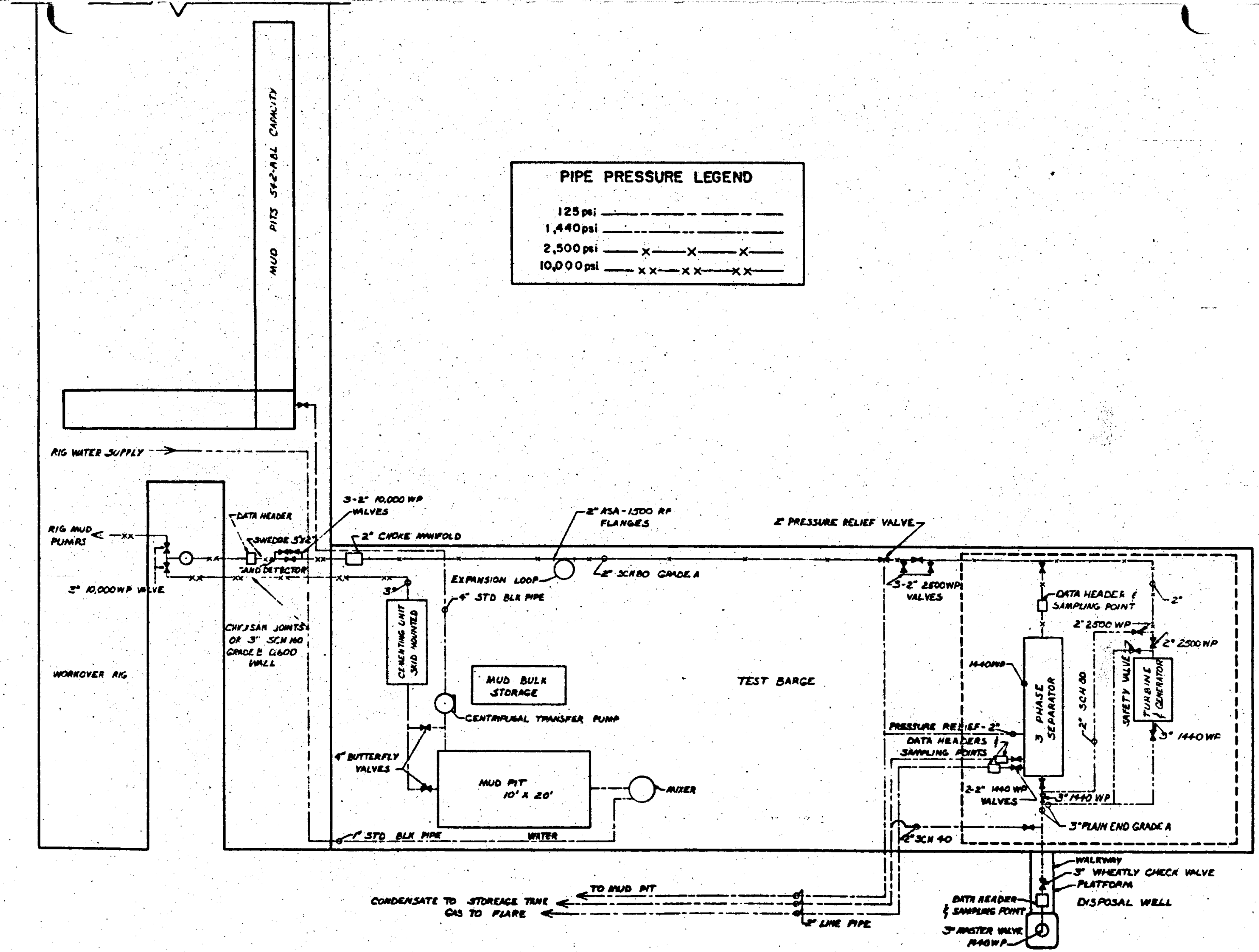
78.0 Run temperature and porosity log from 12,950 feet to 12,800 feet KB.

79.0 During the entire dynamic flow testing period continue to monitor appropriate pressures, temperatures, gas production and flow rates. Also, fluid samples will be taken approximately every two hours to be sent to laboratories for analysis. The actual number of fluid samples taken both surface and down hole, will be based upon the analysis of the first several fluid samples taken. Also, within surface flow line a precision cut orifice will be placed. The initial orifice diameter will be measured. Thereafter, when feasible, the orifice diameter will be measured to determine if sand produced with the reservoir fluid has caused significant erroding of the orifice.

It is estimated that the dynamic testing period on the Number three sand will require approximately 20 days.

Based upon certain equipment availability, engineering tasks yet to be performed, and analysis of information obtained during test, the above procedure may be altered to some degree prior to, and/or during testing.

80.0 Upon completion of the testing, the well will be plugged and abandoned per the rules and regulations of the Conservation Commission of the State of Louisiana. Upon completing the plugging of the well, the rig and other service equipment will be released and the well-site will be cleaned up.


PIPE PRESSURE LEGEND
125 psi
1,440 psi
2,500 psi
10,000 psi
MUD PITS 542-BBL CAPACITY
RIG WATER SUPPLY
RIG MUD PUMPS
2" 10,000 WP VALVE
DATA HEADER
SWEDGE 3x2"
SAND DETECTOR
CHIKSAN JOINTS OF 3" SCH 160 GRADE B 0.600 WALL
WORKOVER RIG
3-2" 10,000 WP VALVES
2" CHOKE MANIFOLD
2" ASA-1500 RF FLANGES
2" PRESSURE RELIEF VALVE
EXPANSION LOOP
2" SCH 80 GRADE A
4" STD BLK PIPE
3"
CEMENTING UNIT SKID MOUNTED
MUD BULK STORAGE
CENTRIFUGAL TRANSFER PUMP
4" BUTTERFLY VALVES
MUD PIT 10' X 20'
MIXER
1" STD BLK PIPE
WATER
TEST BARGE
3-2" 2500 WP VALVES
DATA HEADER & SAMPLING POINT
2"
2" 2500 WP
2" 2500 WP
1440 WP
3 PHASE SEPARATOR
2" SCH 80
SAFETY VALVE
TURBINE & GENERATOR
3" 1440 WP
PRESSURE RELIEF - 2"
DATA HEADERS & SAMPLING POINTS
2-2" 1440 WP VALVES
3" 1440 WP
3" PLAIN END GRADE A
2" SCH 40
WALKWAY
3" WHEATLY CHECK VALVE
PLATFORM
DISPOSAL WELL
DATA HEADER & SAMPLING POINT
3" MASTER VALVE 1440 WP
TO MUD PIT
CONDENSATE TO STORAGE TANK
GAS TO FLARE
2" LINE PIPE

APPENDIX B

Identification of Conflicts

Through review of active and proposed plans and regulations of the various federal, state, and local agencies, no conflicts or potential conflicts to result from the proposed action could be identified. To substantiate this conclusion, a letter communicating the exact nature of the project was sent to the following persons and agencies:

Louisiana Office of State Planning
P.O. Box 44425
Baton Rouge, Louisiana 70804

U.S. Army Corps of Engineers
New Orleans District
P.O. Box 60267
New Orleans, Louisiana 70160

U.S. Fish and Wildlife Service
Regional Office
Box 4753
University of Southwestern Louisiana
Lafayette, Louisiana 70501

Louisiana Department of Conservation
P.O. Box 44275
Capitol Station
Baton Rouge, Louisiana 70804

Louisiana Advisory Commission on
Coastal and Marine Resources
810 Jefferson Street
Room 230
Lafayette, Louisiana 70501

The Honorable Edwin W. Edwards
Office of the Governor
State Capitol
P.O. Box 44004
Baton Rouge, Louisiana 70804

Evangeline Economic Development
District Council
P.O. Box 3322
Lafayette, Louisiana 70501

Louisiana State Mineral Board
P.O. Drawer 2827
Baton Rouge, Louisiana 70821

Louisiana Geological Survey
Louisiana State University
Baton Rouge, Louisiana 70893

Louisiana Stream Control Commission
Director
P.O. Drawer FC
University Station
Baton Rouge, Louisiana 70893

Air Pollution Control Commission
P.O. Box 60630
New Orleans, Louisiana 70160

Vermilion Parish Police Jury
P.O. Box 430
Abbeville, Louisiana 70510

Louisiana Wildlife and Fisheries
Commission
400 Royal Street
New Orleans, Louisiana 70130

Agency responses received so far are included here and corroborate the conclusion of no conflict. Additional responses will be forwarded immediately upon receipt.

R. T. SUTTON
COMMISSIONER

State of Louisiana

DEPARTMENT OF CONSERVATION
BATON ROUGE 70804

P. O. BOX 44275

March 4, 1976

Mr. James W. Smith
Coastal Environments, Incorporated
1260 Main Street
Baton Rouge, Louisiana 70802

Re: Your letter dated February 19, 1976
McNeese State University Geopressure
Resource Test

Dear Mr. Smith:

The proposal outlining the major features of the McNeese Geopressure Geothermal Test of the Edna Delcambre No. 1 Well, Tigre Lagoon Field, Vermillion Parish does not appear to present any conflict or potential conflict with any of our plans, projects or standards.

Sincerely,

R. T. Sutton, Commissioner

RTS:ACC:kcm

cc: Governor Edwin Edwards

COASTAL RESOURCES PROGRAM
STATE PLANNING OFFICE

EDWIN EDWARDS
GOVERNOR

HARLES E. ROEMER, II
COMMISSIONER OF
ADMINISTRATION

February 27, 1976

Mr. James W. Smith
Coastal Environments, Inc.
1260 Main Street
Baton Rouge, LA 70802

Dear Jim:

I am in receipt of your letter of February 19, 1976 which explains your proposed actions concerning the geopressure, geothermal water-sand reservoir in central coastal Louisiana.

The coastal management program in Louisiana has not yet reached the level of specificity which would tell us whether your project has any conflicts or potential conflicts with our plans. However, I think it is safe to assume that what you have proposed is not in conflict with Louisiana's Coastal Management Program. If I can be of any further assistance to you, please let me know.

Sincerely,

Paul

Paul H. Templet
Program Coordinator

PHT:mld

PATRICK W. RYAN
EXECUTIVE DIRECTOR
ATE PLANNING OFFICE

PAUL H. TEMPLET
AM COORDINATOR

P.O. BOX 44425
CAPITOL STATION
ON ROUGE, LA. 70804
(504) 389-7041

STATE OF LOUISIANA
STREAM CONTROL COMMISSION
P. O. DRAWER FC
UNIVERSITY STATION
BATON ROUGE, LOUISIANA 70803

February 25, 1976

Coastal Environments, Inc.
1260 Main Street
Baton Rouge, Louisiana 70802

Attention: Mr. James W. Smith

Gentlemen:

Reference is made to your letter dated February 19, 1976, relative to the proposed project involving the experimental test of a geopressured geothermal water-sand reservoir in central coastal Louisiana.

After carefully reading your letter relative to pollution control measures to be implemented, I have only one comment: That the dredging of the existing canal be performed in such a manner as to control turbidity in public waters to a practicable minimum.

Very truly yours,

Robert A. Lafleur
Executive Secretary

fbr

THE LOUISIANA COASTAL COMMISSION

LAFAYETTE, LOUISIANA 70504

Office of the Director

41006
P. O. BOX [redacted] U.S.L.
318/235-3318

February 25, 1976

PLEASE NOTE CHANGE OF ADDRESS

Dr. James W. Smith
Coastal Environments, Inc.
1260 Main Street
Baton Rouge, LA 70802

Dear Dr. Smith:

With regard to your letter concerning the geothermal test, the Coastal Commission has no objection to your testing provided the procedures outlined in your letter of February 19 are strictly adhered to.

Sincerely yours,

VERNON BEHRHORST
Director

/ctc

VI. LIST OF REFERENCES

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