~~DOE/EA~~

DOE/EA-0148

ENVIRONMENTAL ASSESSMENT

Geothermal Energy Geopressure Subprogram

DOE
Lafourche Crossing No. 1

TERREBONNE PARISH & LAFOURCHE PARISH, LOUISIANA

OCTOBER, 1978

U.S. DEPARTMENT OF ENERGY

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OCTOBER, 1978

U.S. DEPARTMENT OF ENERGY
Assistant Secretary for Energy Technology
Washington, DC 20545

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GLOSSARY AND ABBREVIATIONS

point of drilling	the location of the well bore
well site	The 5 acre area on which support facilities, including separators, cooling towers, tanks and laboratories will be located; includes point of drilling
Lafourche Crossing Prime Prospect Area	an irregular shaped 9,183 ha (22,675 ac) area considered by DOE to be the most desirable zone for geopressured-geothermal resource exploration and development at this time. The Prime Prospect Area is in south central Louisiana. The Prime Prospect sands are in the Middle Miocene.
A-F/yr	acre-feet per year
API	American Petroleum Institute
cfs	cubic feet per second
BPD	barrels per day
BWPD	barrels of water per day
dBA	A-weighted sound levels taken with a sound level meter and expressed as decibels on the scale. The "A" scale approximates the frequency response of the human ear
Eh	redox potential
ERDA	Energy Research and Development Administration
FHWA	Federal Highway Administration
FIA	Federal Insurance Administration
hm^3/yr	cubic hectometers per year
Is	island
Kh	permeability in millidarcies
LOH	Louisiana Office of Highways

md	millidarcy
mgd	millions of gallons per day
MMSCF	millions of standard cubic feet
$\mu g/m^3$	micrograms per cubic meter
ppt	parts per thousand
psi	pounds per square inch
SCS	Soil Conservation Service
St.	Saint
SWLMA	State Wildlife Management Area
Tcf	trillions of cubic feet
TDS	total dissolved solids
USACE	U.S. Army Corps of Engineers
USDI	U.S. Department of the Interior
USGS	United States Geological Survey

How to Use the Impact Projecting Device and Well-Site Location Indicator (The Overlay)

The Overlay contained in the envelope inside the back cover serves two purposes: 1) to project the impacted area resulting from the proposed action and, 2) to locate a specific well site in relation to known points on similar figures and the latitude and longitude grid system. The Overlay is to be used on the photo-based figures, such as Figure 1-3 and 2-11, and on 15 minute USGS topographic maps, such as Figure 1-2. By using the intersecting lines at the center of the circles as the site of the proposed action, the circles may be placed over any point on the figure to indicate the potential area indirectly affected by the proposed action. The well-site indicator is used in reference to the latitude and longitude lines on the photo-based figures and map-based figures in this EA or to lines of latitude and longitude on 15 minute USGS topographic maps. The marginal and vertical axes are marked in meters and scaled to 1:62,500. The small square at the intersection of the axes shows 2 ha (5 ac), the size of the proposed well site, while the large square is 259 ha (640 ac). A discussion of how to use the Impact Projecting Device and Well-Site Location Indicator follows.

Example: Using the Overlay on Figure 1-2

> Using either axis, align the well-site location indicator (Overlay) to read 26 on the 90°45' line of Longitude and 23 on the 29°45' line of Latitude. With such an alignment, the 2 ha square will fall over the number 7 in Section 7, T 15 S, R 17 E.

Should this be the site of the proposed action, the site may be transferred to Figure 2-11. One may then estimate if the area to be directly affected by the installation of a well is within the 100 year flood plain.

To estimate the area which may be indirectly affected by the proposed action as a result of accidents or noise, place the intersection of the lines at the center of the circles over the well site location. Using Figure 2-11, we see what the brine disposal pattern of a blowout would be if we used the Section 7 location. Of course, this assumes a blowout of the magnitude of the Intracoastal City accident {Castle, 1975 (See References, Chapter 5)}.

Finally, the process may be reversed. We manipulate the impact device to establish a site which will have the least impact on the surrounding area. We can then locate this site and relate it to other figures.

SUMMARY

The proposed action will consist of drilling one geothermal fluid well for intermittent production testing of 284 days over a three year period. The test well will be drilled with a 21.6 cm (8.5 in) borehole to a depth of more than 3904 m (12,800 ft). Two disposal wells will initially be drilled to provide disposal of lower volume fluids produced during initial testing. Two additional disposal wells will be drilled, logged, completed, tested, and operated prior to commencement of high volume fluid production. All surface facilities will be within .8 km (½ mi) of the proposed well. Surface facilities will be constructed and installed on a 2 ha (5 ac) area. Extensive tests will be conducted on the physical and chemical composition of the fluids, their temperature, the nature of flow, fluid disposal techniques, and the reliability and performance of equipment. The objective of the proposed action is to determine the economic viability of the geopressured resource.

The Prime Prospect Area is in south central Louisiana. The physical setting is an abandoned deltaic distributary system of natural levee ridges and interdistributary basins of Recent age. The Prime Prospect Area is centered on the latitude 29°45'N and longitude 90°46'W. Within the Prime Prospect Area are the communities of Schriever and Lafourche Crossing. The nearest large town is Thibodaux, 5 km (3 mi) to the north, while the nearest city is New Orleans, 72 km (45 mi) to the northeast. Homes and some businesses are in a linear settlement pattern

along the major highways, LA 1, LA 308, LA 20, and LA 24 through the Prime Prospect Area. Although the overall character of the Prime Prospect Area is rural, mostly in sugarcane fields and swamp, the area is developing rapidly with homes and businesses. Most of the land to be used by the proposed action is in private ownership. There is a high potential for archaeological and historic sites along the crest of the distributary natural levees. There are no known archaeological sites or National Register sites in the Prime Prospect Area.

Construction of the proposed action will change the land-use of 2 ha (5 ac) for the test well and each of the injection wells from agriculture or wetlands to resource exploration. Lands will be cleared and erosion and runoff will result. During operation of the well test, the only expected impacts are from venting of gases or flaring of gases and noise. After the tests are completed, the area will be restored as much as possible to its natural condition by revegetation programs using native species. All sources of pollutants will be collected and disposed in environmentally acceptable ways. Accidents may result from this proposed action. However, numerous safeguards will be installed to reduce the probability of such an occurrence to an approved level.

If a blowout should occur, the environment may be polluted. Groundwater and surface water may be contaminated by the geothermal brines. Vegetation and possibly some wildlife will be destroyed. Homes, businesses, and churches will be evacuated, depending on the location and severity of the accident. The air quality around the well site will contain H_2S and other gases which are harmful in too great a concentration to the ecosystem.

CHAPTER ONE - DESCRIPTION OF THE PROPOSED ACTION

1.1 Introduction

This Environmental Assessment (EA) has been prepared to assess the environmental implications of the Department of Energy's (DOE's) proposal to drill, complete, and test one geopressure well located in Terrebonne and Lafourche Parishes on a 2 ha (5 ac) test site, 5 km (3 mi) south of Thibodaux, LA. (Fig. 1-1). The test well is herein referred to as DOE Lafourche Crossing No. 1. A maximum of four disposal wells will be located within .8 km (½mi) of the proposed well. The Department of Energy (DOE) and the State of Louisiana through the State University system proposes to operate the test facility for three years to evaluate the geopressure potential of the subsurface. Tests to be conducted include flow rates, fluid composition, temperature, gas content, geological characteristics, and the land subsidence potential for subsequent production. The exact location of the proposed action has not yet been determined. This EA evaluates the impacts of the proposed action on the Prime Prospect Area and will be applicable regardless of the selection process.

This EA activity falls under the broad subprogrammatic Environmental Impact Assessment, Geopressure Subprogram, EIA/GE/77-3, July 1977, Division of Geothermal Energy, Energy Research and Development Administration.

1.2 Site Location and Surface Features

1.2.1 The Region

The proposed action is located in south central Louisiana in a promising zone

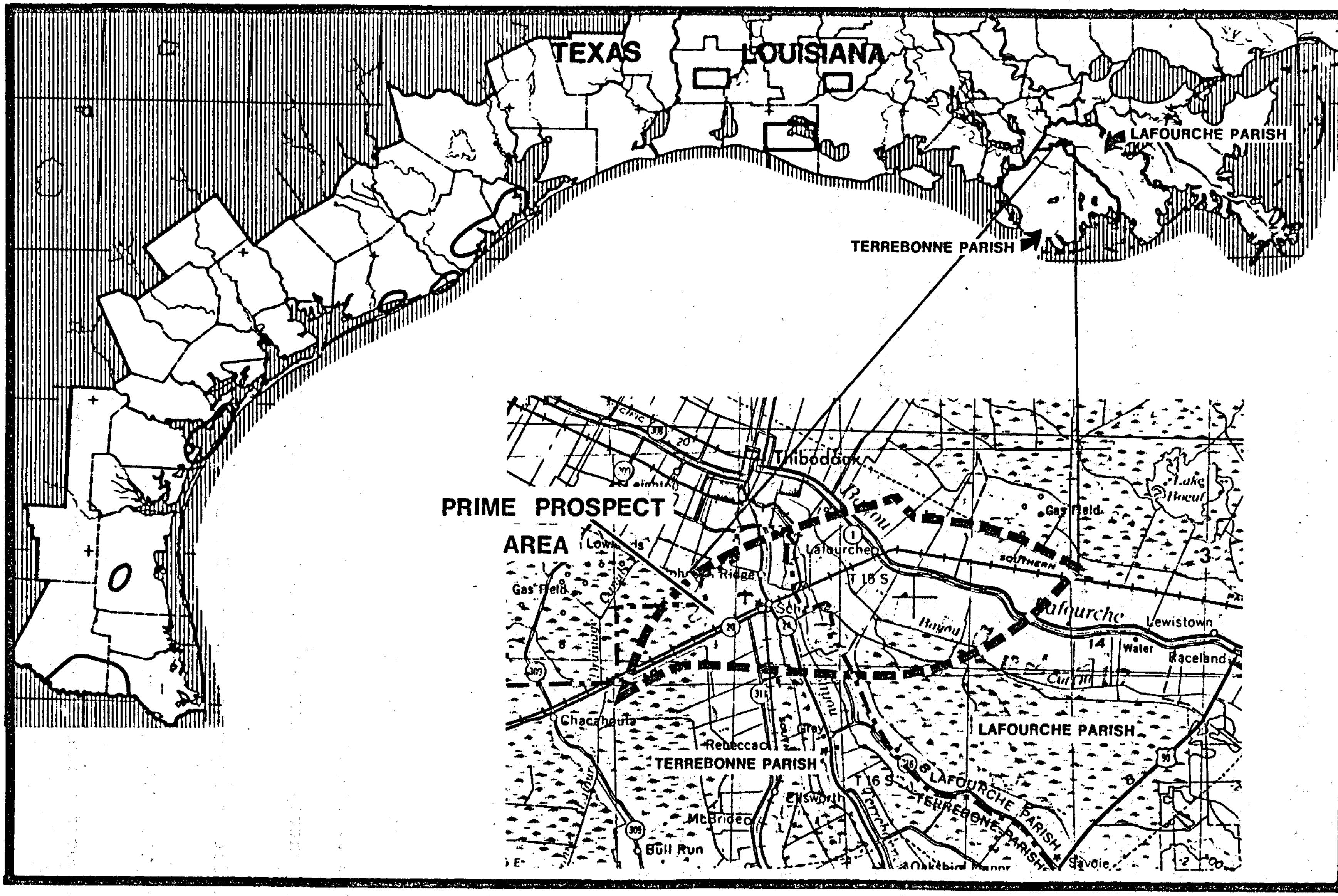


Figure 1-1. Location of the Lafourche Crossing Prime Prospect Area in relation to the Gulf Coast region.

for evaluating the physical and chemical characteristics of the resource (Fig. 1-1, 1-2, 1-3). The well will be drilled into the Middle Miocene to a depth in excess of 3904 m (12,800 ft). The geopressured interval has a maximum thickness of 259 m (850 ft).

1.2.2 Site Selection

The Prime Prospect Area was selected for resource analysis on the basis of four parameters: sand thickness, temperature, permeability, and environmental suitability for the proposed action and eventually possible full utilization of the resource. The exact well location will be determined at a later date by DOE.

1.2.3 Description of the Prime Prospect Area (Fig. 1-2 and 1-3)

All development of surface facilities and injection wells will take place within .8 km (½ mi) of the point of drilling. The physical setting is an abandoned deltaic distributary system of natural levee ridges and inter-distributary basins of Recent age. The Prime Prospect Area is centered on the latitude 29°45'N and longitude 90°46'W. Within the Prime Prospect Area are the communities of Schriever and Lafourche Crossing. The nearest large town is Thibodaux, 5 km (3 mi) to the north, while the nearest city is New Orleans, 72 km (45 mi) to the northeast. Homes and some businesses are in a linear settlement pattern along the major highways, LA 1, LA 308, LA 20, and LA 24 through the Prime Prospect Area. However, the overall character of the Prime Prospect Area is rural, most of the land-use is sugarcane fields and swamp. Most of the land to be used by the proposed action is in private ownership.

1.3 Project Description

The proposed action will consist of the drilling of one geothermal fluid

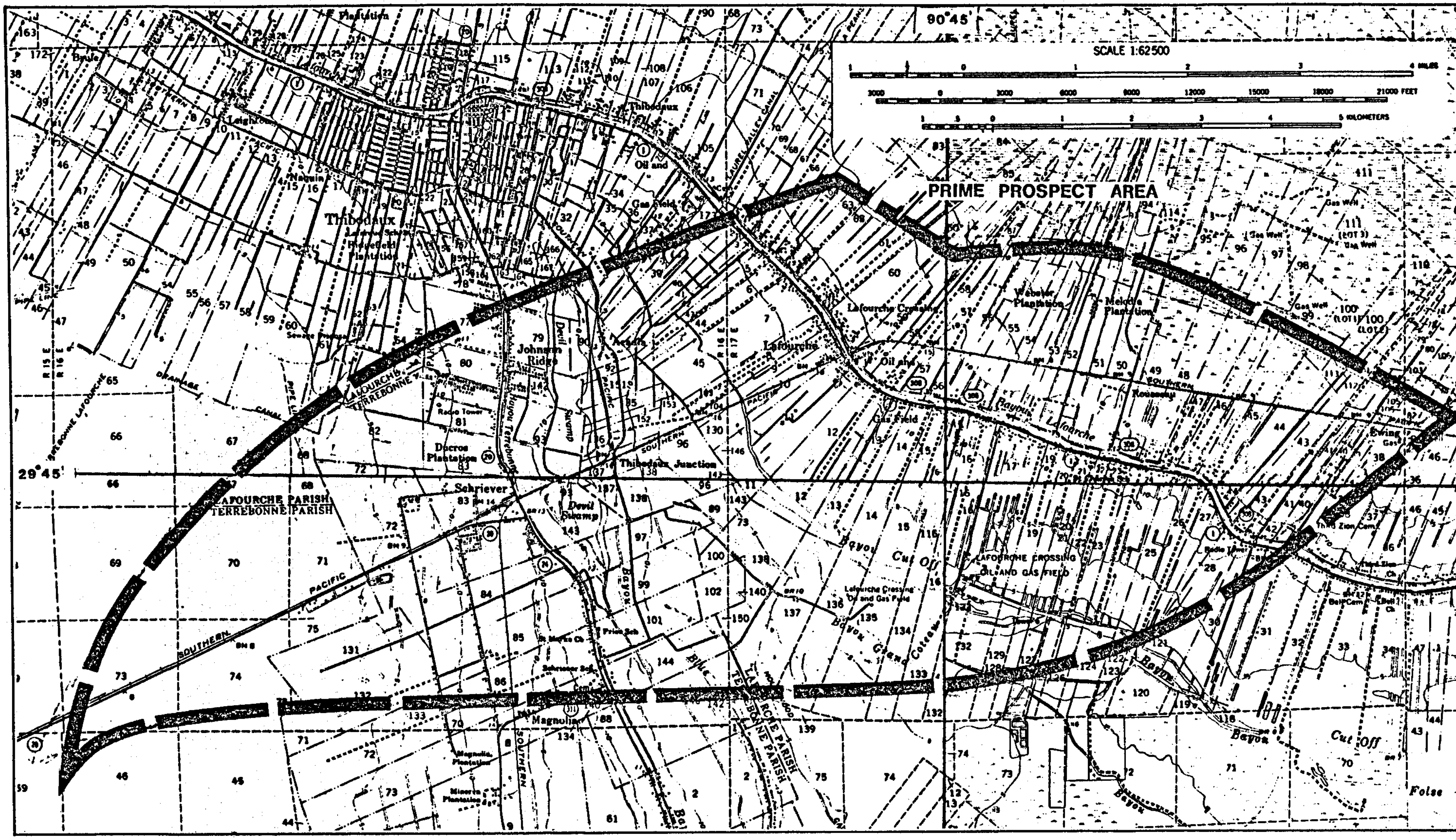


Figure 1-2. A topographic map of the Lafourche Crossing Prime Prospect Area (USGS 15' maps, Thibodaux, 1962; Lac des Allemands, 1962; Gibson, 1964; Houma, 1963).

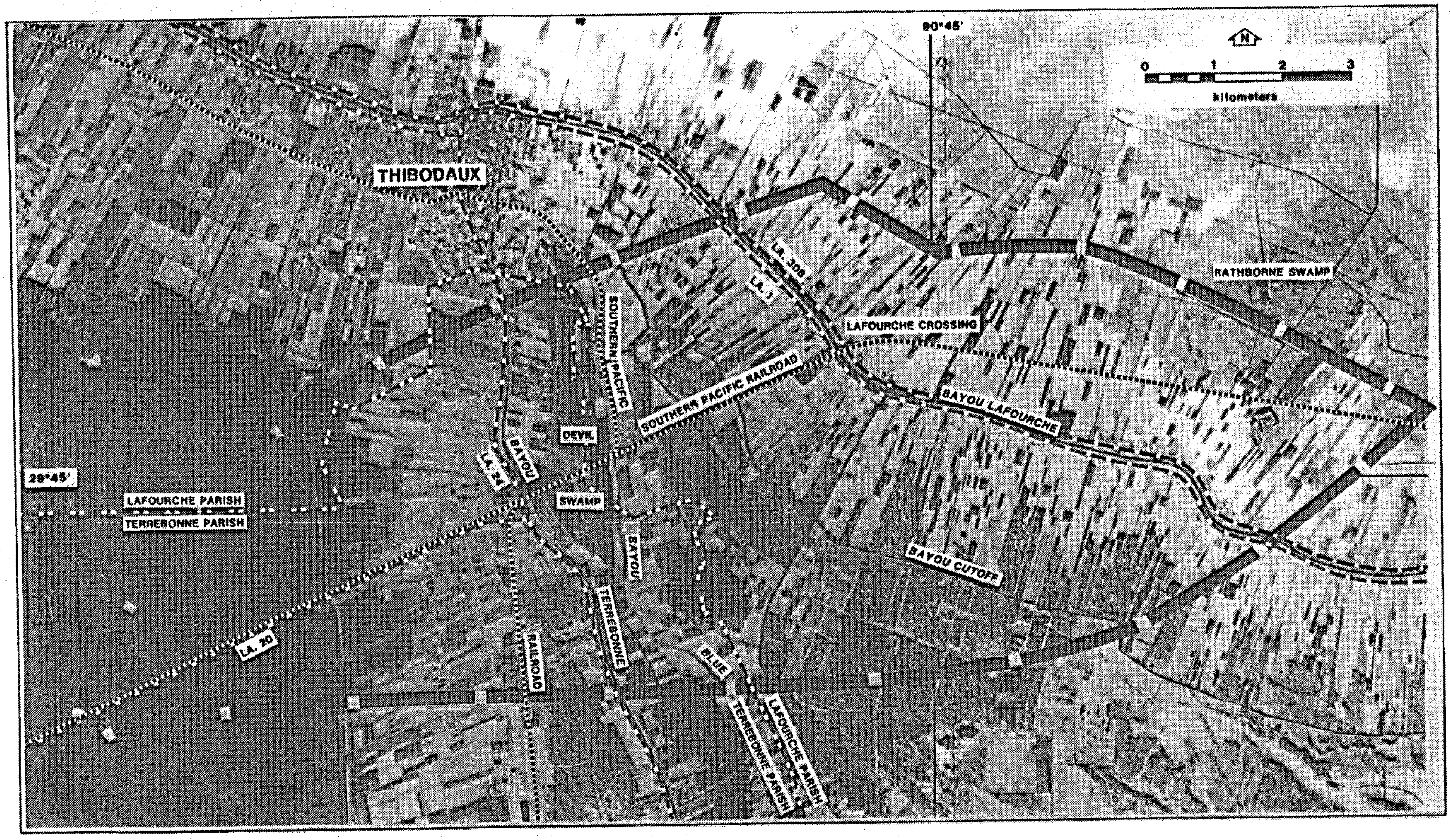


Figure 1-3. Aerial photograph of the Lafourche Crossing Prime Prospect Area (Color IR, BIN No. 7AJ5, Frames 231 and 232, Photo Identification No. 6293000800231, No. 6293000800232).

well for production testing and a maximum of four injection wells. A test well will be drilled with a 21.6 cm (8.5 in) borehole to a total depth in excess of 3904 m (12,800 ft). Two disposal wells will initially be drilled to provide disposal of lower volume fluids produced during initial testing. Two additional disposal wells will be drilled, logged, completed, tested, and operated prior to commencement of high volume fluid production. Required surface facilities will be constructed and installed in order to conduct the extensive resource tests. Over a three year period the tests will assess the economic viability of the geopressure-geothermal resource.

In this EA, the environmental implication is evaluated for the activities from well site preparation through site restoration after the testing is completed.

1.3.1 Construction and Drilling

The construction phase of the proposed action includes site and access preparation. Drilling includes both well drilling and testing.

1.3.1.1 Site and Access Preparation

Drilling activities require the construction of access roads and level drilling pads for the production well and the injection wells on the higher ground. Where possible, the access road will be constructed to disturb a minimum area by using existing roads when available, by following the natural topography, and by avoiding cut and fill operations. Roads will be 4.2 m (14 ft) wide with a disturbed area of 0.4 ha/km (1.7 ac/mi) of roadway.

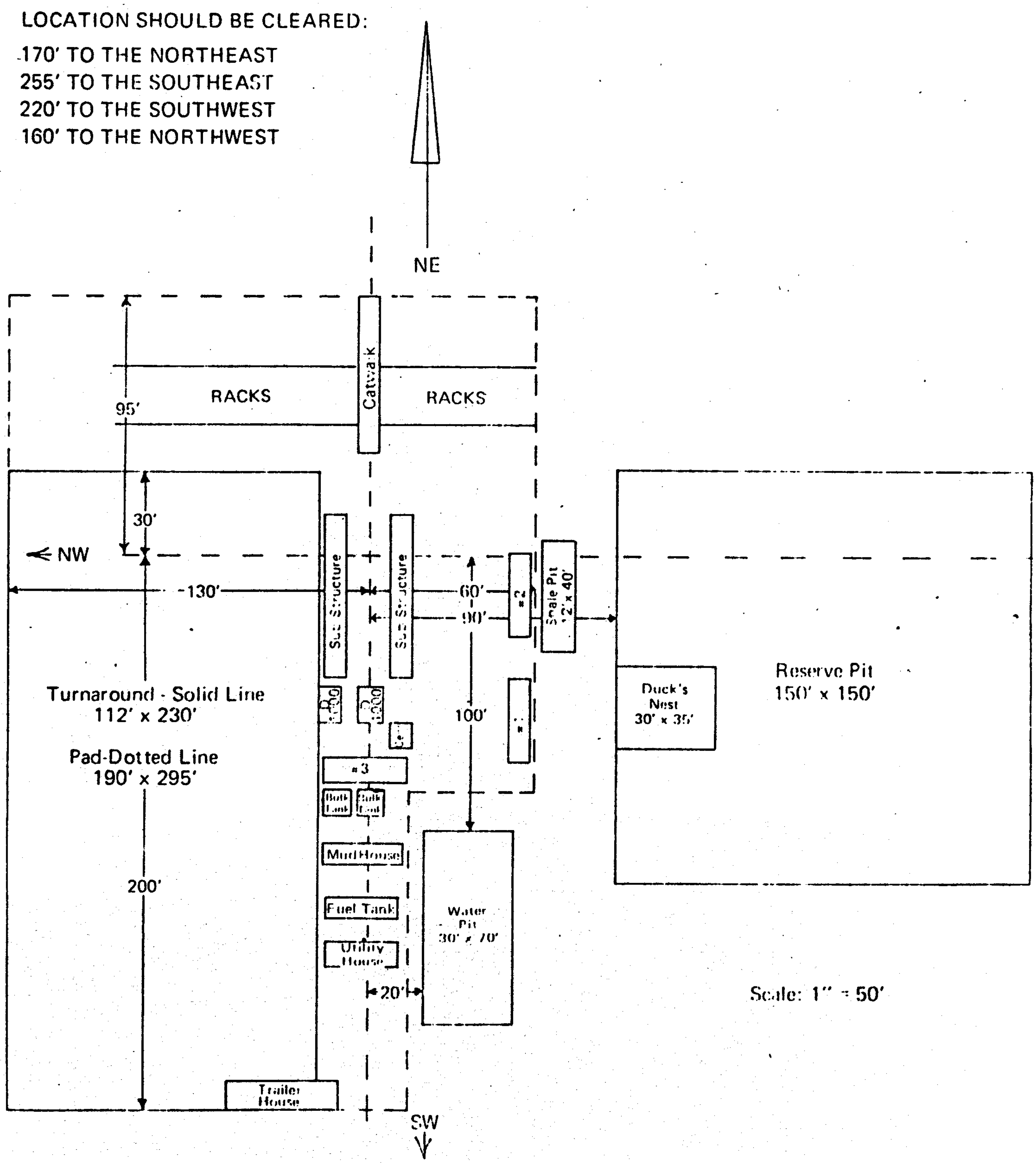


Fig. 1-4. Typical drilling site arrangement (1) (General Crude Oil Co., 1977)

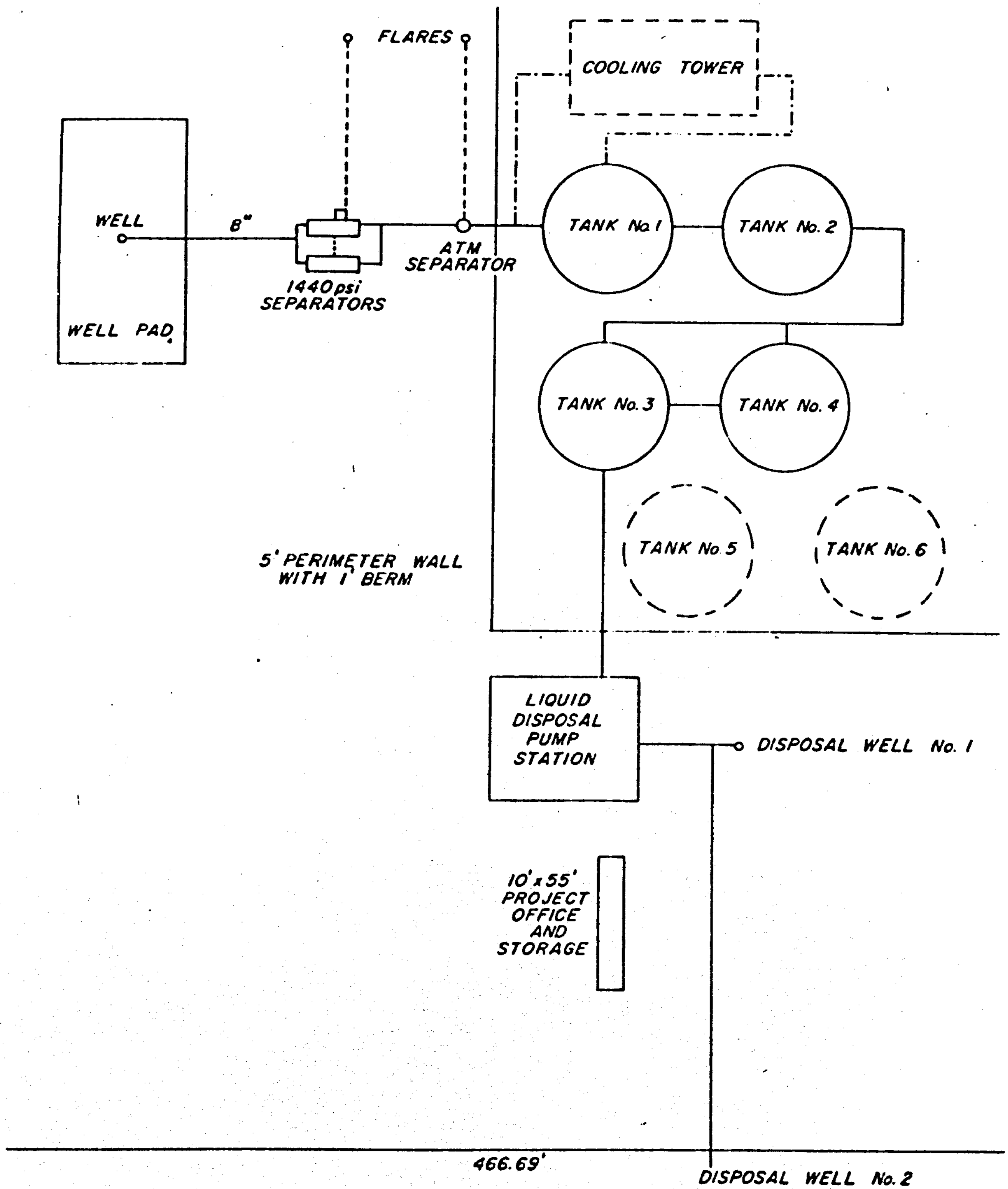


Fig. 1-6. Typical layout of well site (General Crude Oil Company, 1977).

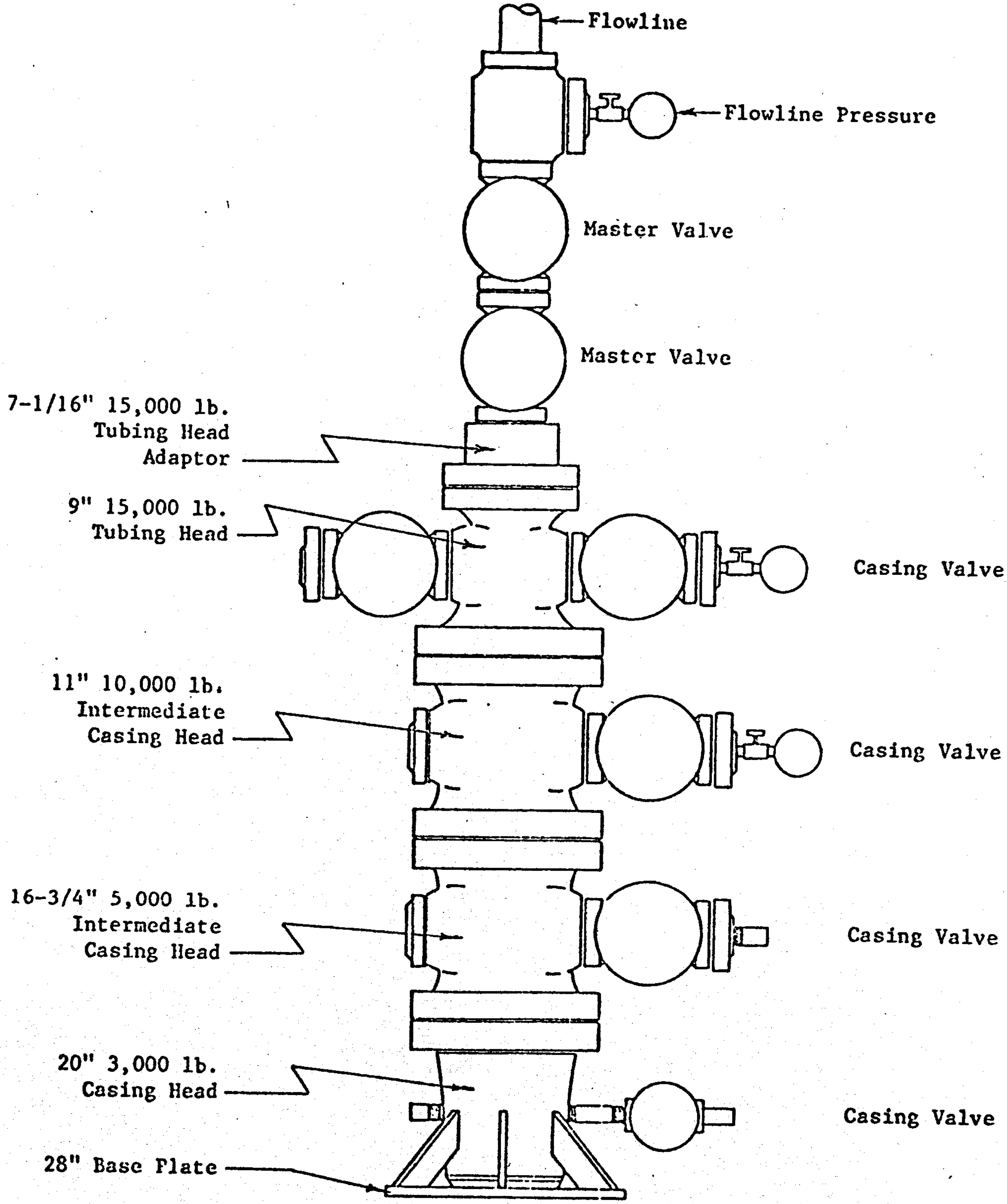


Fig. 1-8. Typical well head configuration for flow testing (General Crude Oil Company, 1977).

schedule has been formulated as shown on Table 1-1. The initial test will be the static pressure test after the well is perforated. The well will be circulated clean with saltwater and pressured up to 10,000 psi to test surface equipment. The pressure will then be bled to 5,000 psi and the hole will be logged for perforating depth control. The perforating gun will then be lowered to shoot the first permeable interval below 3904 m (12,800 ft), the geopressure zone. Perforation will continue until 38 m (125 ft) of zone is open or a permeability of about 5,000 millidarcy per foot (md/ft) is obtained based on core analysis. The total perforated interval may be increased to 67 m (220 ft) if the permeability is on the order of 10 md and the logs show the sand development to be this extensive. After perforation the well will be brought on stream in steps of 250 BWPD each day over a five day period to clean the well bore. During this period, quart samples will be taken daily and checked for sand and tracer ion concentration. If sand production is not a problem and the tracer ion concentration has changed significantly, then the well will be shut in. The well will be sampled with a bottom hole sampler, the static pressure will be measured and a high resolution thermometer log will be taken along with other logs. A continuous bottom hole pressure measuring instrument will be calibrated to agree with the static pressure test obtained. The well then will be brought on production at 1,000 BPD and increased by 1,000 BPD each day after sampling the flow stream for sand production. If sand production is detected, rate increases will be suspended while the sand production is observed. If the well cleans up, the rate of increase may stay the same, however, if the sand production stays constant or increases, the rate will be adjusted downward in 500 BPD increments until the sand production stops. Once a rate is established with less than 1/2 percent volume sand production at or below 10,000 BPD, the

well's producing pressure will be recorded for an indefinite period not to exceed 40 days. The bottom hole pressure and surface pressure should be stabalized and recorded. The well's Productivity Index can be calculated. A second dynamic test period will be run, resuming step size increases in the well production rate at 2,000 BPD increments each day up to a total rate of 20,000 BPD, and checking the flow stream for sand. This test period will also last for 40 days and the productivity index for the zone will be calculated at each rate. At the end of the second test period, the well will be shut in and the pressure allowed to stabilize while measuring the bottom hole pressure. A second set of cased hole logs will be run at this time. At this point it may be desirable to open twice as much permeable sand and test the potential of the combined zones in the same manner. Ultimately, if sand production is not a problem, the well's final flow rate should be 40,000 BPD sustained for a 30 day period to allow stabilization as determined from pressure measurements and calculations of the Productivity Index. At the end of this flow test, the well should be shut in for a second build-up to a test static pressure. The reserve pits or sumps will be lined with impervious material to prevent or reduce leaching and groundwater contamination.

During the dynamic test on reservoir production, surface samples of the produced fluid will be collected daily and checked for pH, hardness, chloride and sand cut at the test site. Once a week a sample shall be checked by a laboratory for the standard API ion analysis. The static bottom hole samples will be checked by a laboratory for the API ion analysis in addition to selected heavy metal determination with the spectrograph. Gas analysis for CO_2 and flight hydrocarbon gas content and composition may be run routinely at the test site on a weekly basis. Each month a gas sample

2) Installation of a reinjection well will require clearing of about 1.2 ha (3 ac) of land or wetland. The area required will be kept to a minimum by using the smallest feasible drilling rig and facilities configuration. If a reinjection well exists, additional wells will not be drilled, thus eliminating this impact.

3) Removal of vegetation and construction activities will result in increased runoff, erosion, and sediment concentration in streams. Drill pads and roads will be surfaced with rock or gravel where appropriate to retard runoff. Barriers will be installed to contain runoff and prevent erosion.

4) Contaminants such as lubricants from vehicles and equipment and chemicals from spills and accidents will be introduced into the environment. The degree of impact will depend on the type, amount, and duration of the spill or accident. Some species of flora will not be able to tolerate these occurrences and may be destroyed. Toxins may be picked up in the food chain and passed to herbivores and carnivores. Ponds will be lined with impervious material to reduce leaching and groundwater contamination. To prevent animals acquiring toxins in the sump area, the area should be kept dry and the vegetation should be eliminated. Portable sanitary facilities will be provided for construction crews and construction wastes will be disposed of at suitable spoil sites. Gases will be flared, blowout preventers will be installed, high pressure pipes and valves will be used, and a spill prevention control and counter-measure plan will be devised.

high pressure pipes and valves, and using weighted mud and high pressure mud pumps capable of injecting mud into the well to control pressures.

(11) Noise from machines and vehicles operating at the test site will raise the ambient noise level. This will be kept to a minimum by muffling as many machines and engines as feasible.

(12) There will be an odor associated with the release of H_2S into the atmosphere.

1.4.2 The Cultural Issues - A Summary of Adverse Impacts

(1) Some land use changes may occur as a result of the well test. The area used for the reinjection well will be modified from its present status to an energy related use. However, the extent of changes will be kept to a minimum by good planning before actual work begins.

(2) Noise from the drilling and testing operation will affect the use of surrounding areas. Mufflers will be installed and maintained on all engines and vehicles to minimize impacts.

(3) If there should be residue left from operations or accidents at the site, selected future land-uses may be limited. The chances of this will be minimized by removal of pollutants.

(4) Some archeological sites may be located in the area needed for the test program. These sites will be surveyed and evaluated for impact and mitigation.

(5) The aesthetic value of an area will be reduced by the presence of a drilling operation.

REFERENCES

General Crude Oil Company, Personel Communication with Charles Jones, Chief Geologist, 1977.

CHAPTER TWO - DESCRIPTION OF THE EXISTING ENVIRONMENT

2.1 Introduction

All development of surface facilities and injection wells will take place within .8 km (½ mi) of the point of drilling. Most of the land within the Lafourche Crossing Prime Prospect Area is in private ownership. The Prime Prospect Area is centered on latitude 29°45'N and longitude 90°46'W. The region is part of the abandoned Lafourche-Mississippi Deltaic lobe of natural levee ridges and interdistributary basins. The natural levees have been cleared for sugarcane fields while cypress-tupelo gum swamps form the basins. Homes and businesses are in linear settlements along Bayou Lafourche, Bayou Terrebonne, and Bayou Blue; however, subdivisions are rapidly expanding across agricultural fields. The nearest town is Thibodaux, 5 km (3 mi) to the north, while the nearest city is New Orleans, 72 km (45 mi) to the northeast. The following sections describe the existing environments of the Prime Prospect Area in sufficient detail to permit a discussion of impacts of the proposed action on the environmental system.

2.1.1 Physiography

The Lafourche Crossing Prime Prospect Area is centered on latitude 29°45'N and longitude 90°46'W, or on the deltaic plain of the Mississippi River. The Prime Prospect Area is in Terrebonne and Lafourche Parishes. The physiography is related to the sequence of delta building and abandonment under conditions of continuing subsidence. Approximately 3500 years ago, the region began to build as part of the Lafourche delta complex, overlapping

2.1.2 Geology

Drilling in the Prime Prospect Area will be into the Middle Miocene Formation, between the top of the Robulus "L" 43 section and the base of the Operculinoides Plater Sand Series (Fig. 2-1 and 2-2). The gross sand isopach for the Prime Prospect Area is shown on Figure 2-3.

Sedimentation in Louisiana is dominated by the Gulf Coast Geosyncline whose east to west trending axis is just seaward of the coastline (Fig. 2-4). Numerous large deltas of the Mississippi River prograded into the geosyncline. Transgressions and regressions of the Gulf of Mexico left alternating sections of sands, silts, and clays of continental and marine origin. The Prime Prospect Area's sands are mostly deltaic sands separated by near-shore and lagoonal sands (Rainwater, 1964). Table 2-1 shows the geologic column for the Prime Prospect Area.

Jones (in press), Papadopulas et al., 1975, and Bernard (1978) discuss the resource characteristics in the region containing the Prime Prospect Area. Figures 2-5 and 2-6 are logs in the Prime Prospect Area. Similar facies have been correlated to form two cross-sections through the Prime Prospect Area. Figure 2-3 shows the total sand thickness in the principal sand zone under the Prime Prospect Area and the known faults which bound the Prime Prospect Area.

Characteristics of the Lafourche Crossing Prime Prospect Area have been developed by Bernard (1978). The top of the geopressured zone is at 3904 m (12,800 ft). The geopressure interval is 259 m (850 ft). Average sand thickness is 92 m (300 ft). Total sand volume for the Area is 6.26 km^3 (1.5 cu mi). Temperatures range from 134°C to 164°C (273°F-327°F).

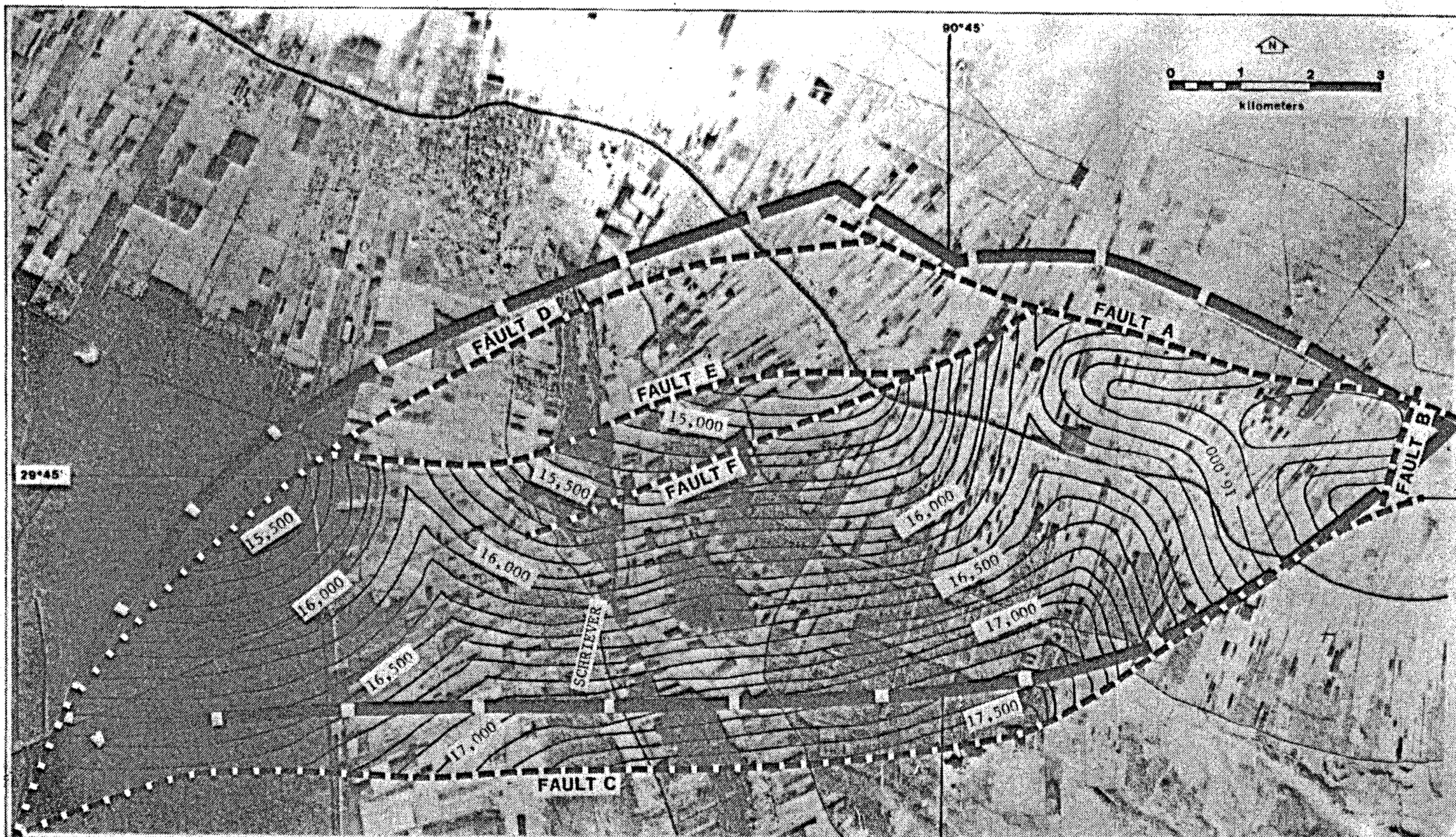
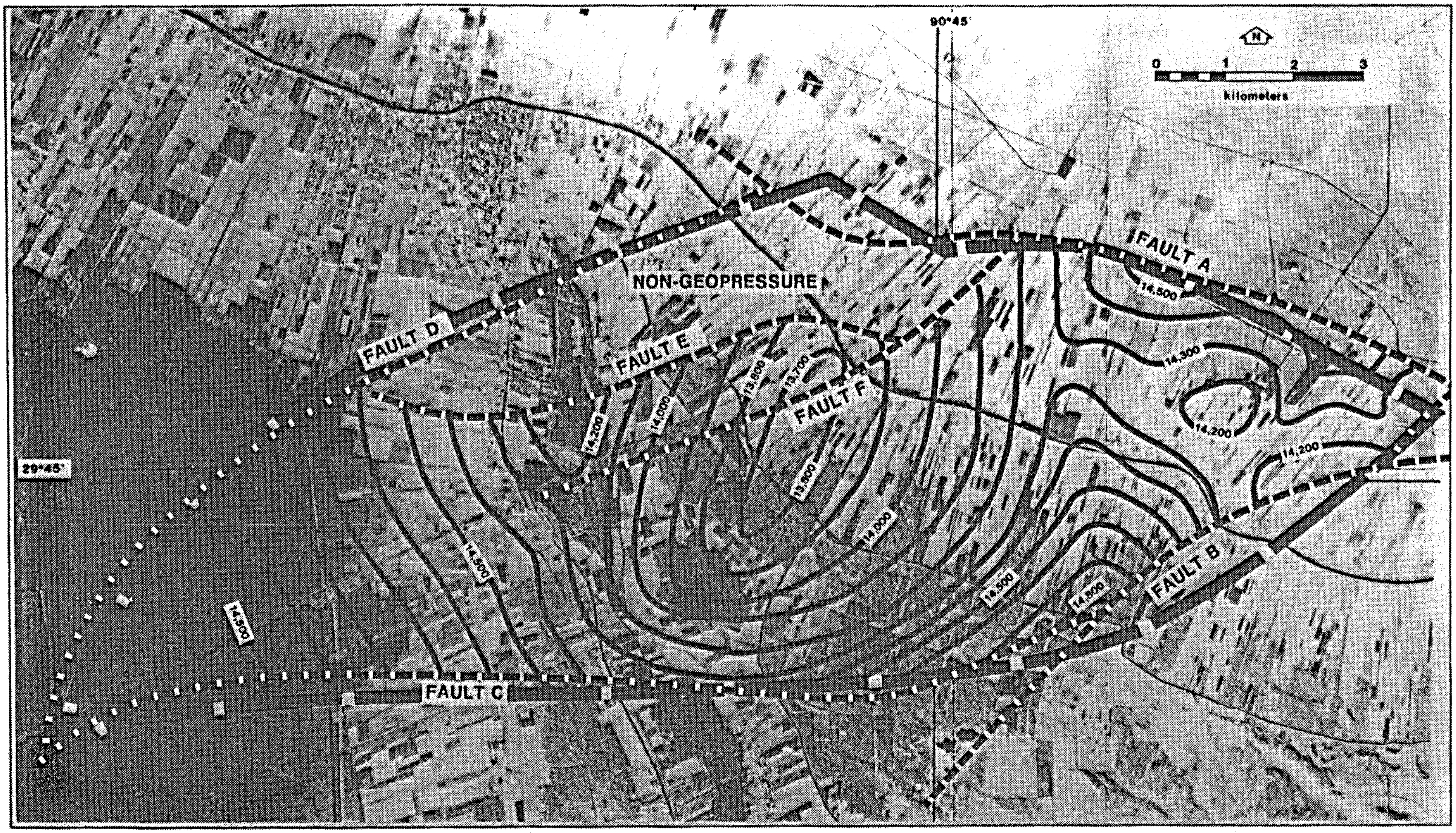
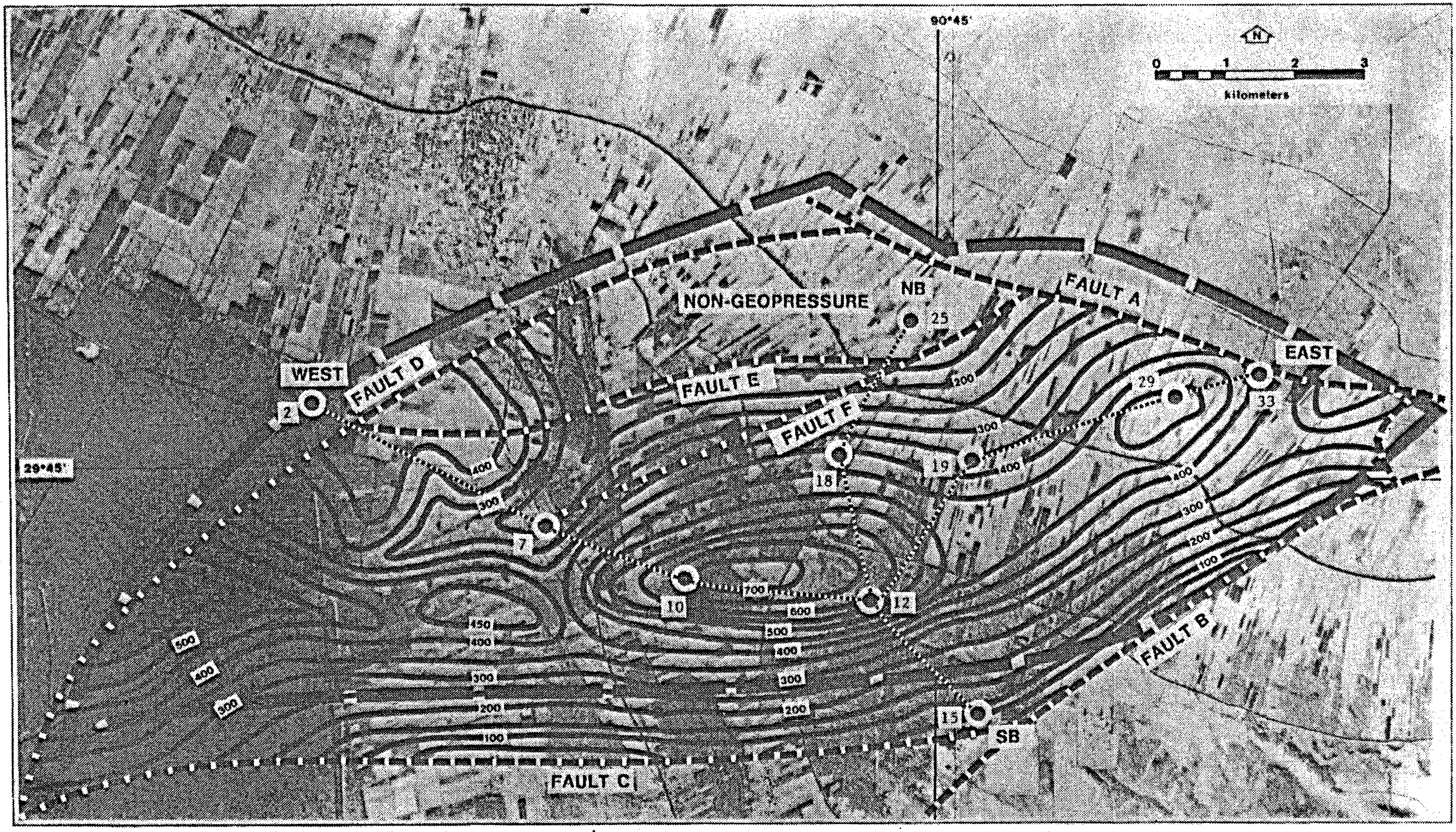


Figure 2-1. Structure Map - base of the Operculenoides Plater Sand Series (After Bernard, 1978).



CONTOUR INTERVAL = 100'

Figure 2-2. Structure Map - top of Robulus "L" 43 (After Bernard, 1978).



19 WELL CODE NO.

WELL LOCATION

GROSS SAND ISOPACH CONTOUR INTERVAL = 50 FEET

Figure 2-3. Gross sand isopach map of the Prime Prospect Area sands (After Bernard, 1978).

Table 2-1. Geologic Column for the Lafourche Crossing Prime Prospect Area.

AGE	SERIES	GROUP/FORMATION	DESCRIPTION
Quaternary	Recent	Undifferentiated	Deltaic deposits
	Pleistocene	Terraces	Alluvial and deltaic deposits
	Pliocene	Citronelle	
Tertiary		Upper	Interfingering deltaic sands, silts and clays; brackish water silts and clays.
	Miocene	Middle	Massive deltaic sands, non-marine silt stones.
		Lower	Silty clays, lenticular sands, silty clays.

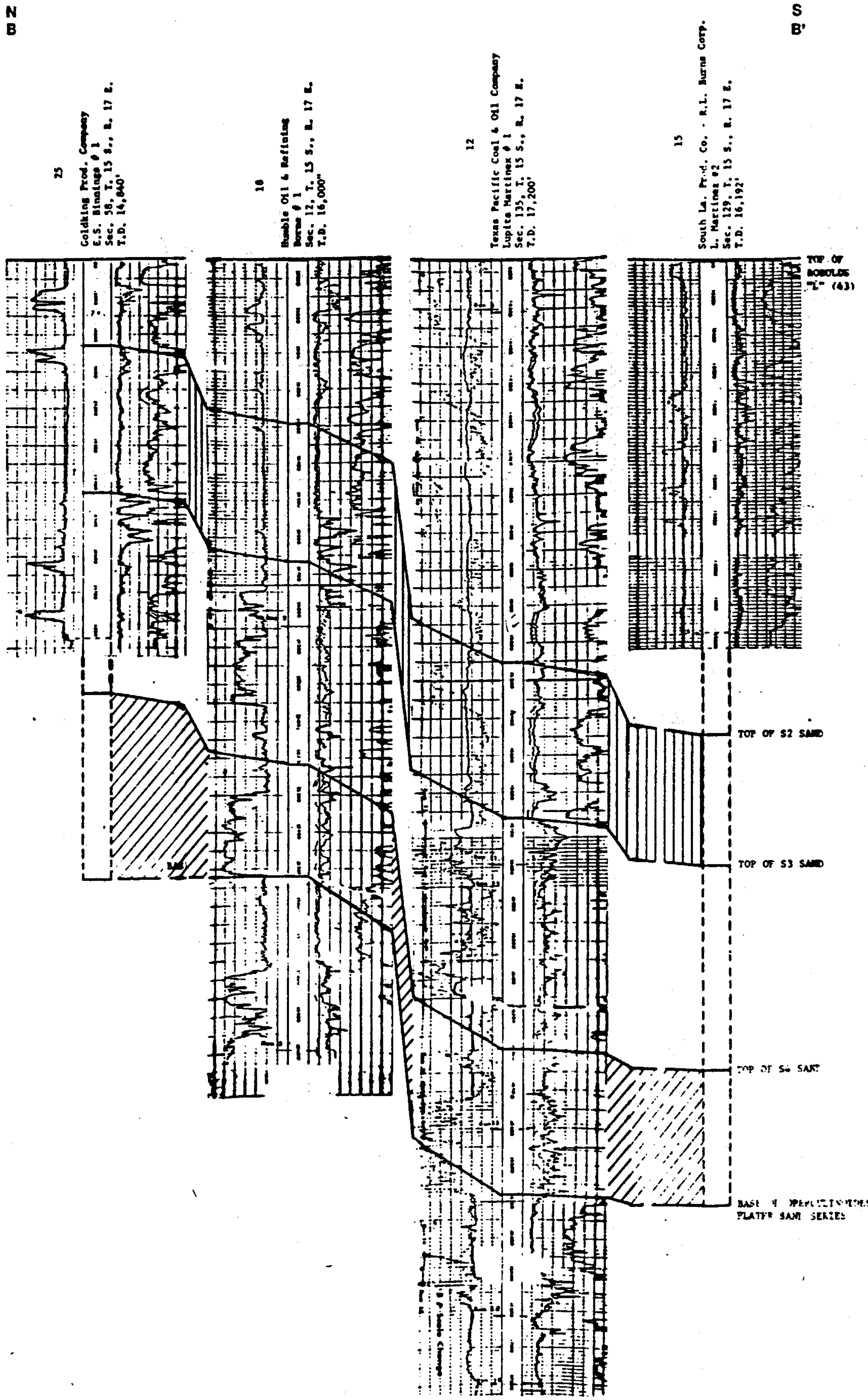


Figure 2-5. Stratigraphic cross-section of Lafourche Crossing Prime Prospect Area (N-B - S-B').

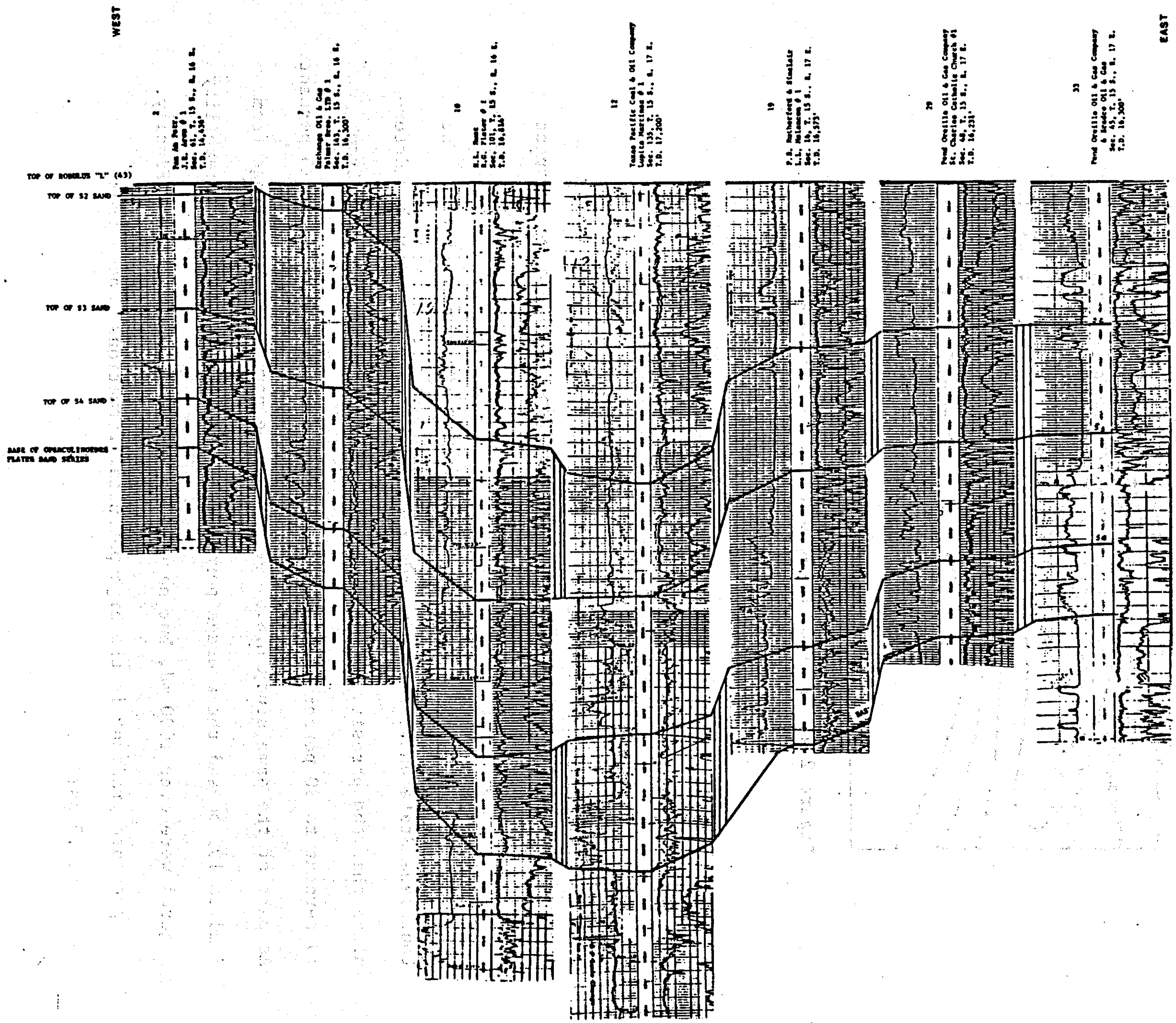


Figure 2-6. Stratigraphic cross-section of Lafourche Crossing Prime Prospect Area (West-East)

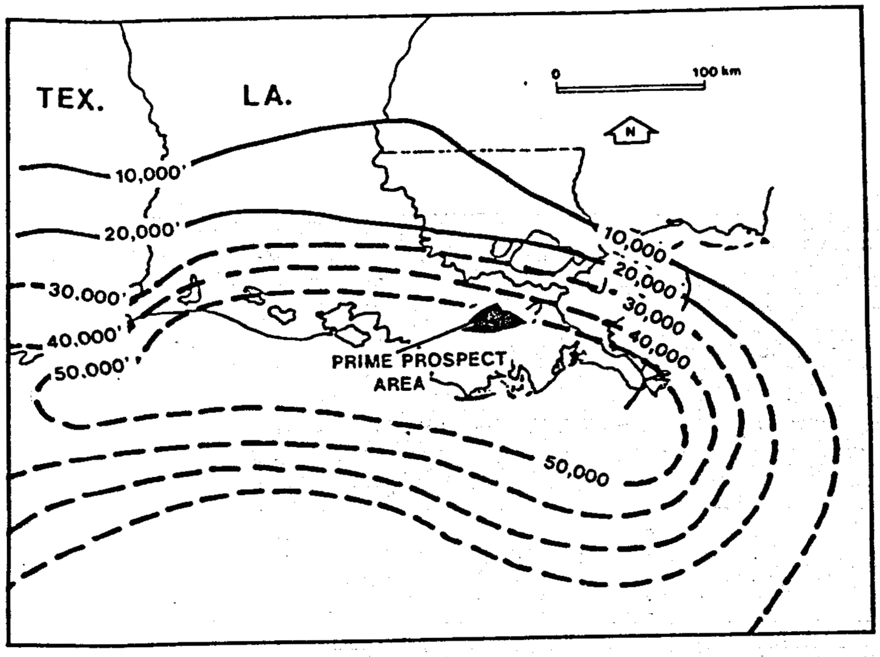


Figure 2-4. Gulf Coast Geosyncline: approximate thickness of the Cenozoic of Louisiana (After Hardin, 1962).

The porosity, permeability, and pressure gradient of the prime prospect zone under the Lafourche Crossing Prime Prospect Area have been determined by analyzing cores from oil wells in the region (Bassiouni, 1978). The Louisiana State University Department of Petroleum Engineering has determined that the porosity of the geopressured zone formations range from 19 percent to 30 percent, and that an average porosity estimate is 25 percent. As part of the same study, L.S.U. estimates the permeability to range from 7 md to 199 md and the average permeability to be 70 md. Some permeability figures were over 1000 md, but have been discarded as anomalies. Finally, the pressure gradient in the high potential formations ranges from .8 psi to .9 psi/ft.

2.1.3 Land Subsidence

There are no known calculations of land subsidence through the Prime Prospect Area. Evaluation of existing survey lines across the area do not provide a sufficient number of points to accurately project subsidence (Smith, 1978). However, historic map studies of south-central Louisiana (Gagliano et al, 1973) have documented land loss in the region due to subsidence, but do not establish rates. Subsidence is the result of regional settling and the reduction of sediment into the subdelta which maintained surface elevations and vegetation cover. Overbank flooding and sediment deposition no longer occur because of the artificial levees and flood control structures of the U.S. Army Corps of Engineers.

2.1.4 Tectonic Activity

Figure 2-7 shows the regional tectonic setting around the Lafourche Crossing Prime Prospect Area. Two regional faults cross the Prime Prospect Area and are downthrown to the south. The rate of movement along these faults is not known.

Seismic hazard in the study area is very low to non-existent (Algermissen, 1969; Alermissen and Perkins, 1976). Potential for seismic risk is described on a scale of 0 to 3 where Zone 0 means no damage, Zone 1 means minor damage, Zone 2 means moderate damage, and Zone 3 means major damage. Such a scale is based on historical data which considers only the intensity of the earthquake, not the frequency. The Lafourche Crossing Prime Prospect Area has a seismic potential of zero (Algermissen and Perkins, 1976), even though there have been two recent earthquakes in

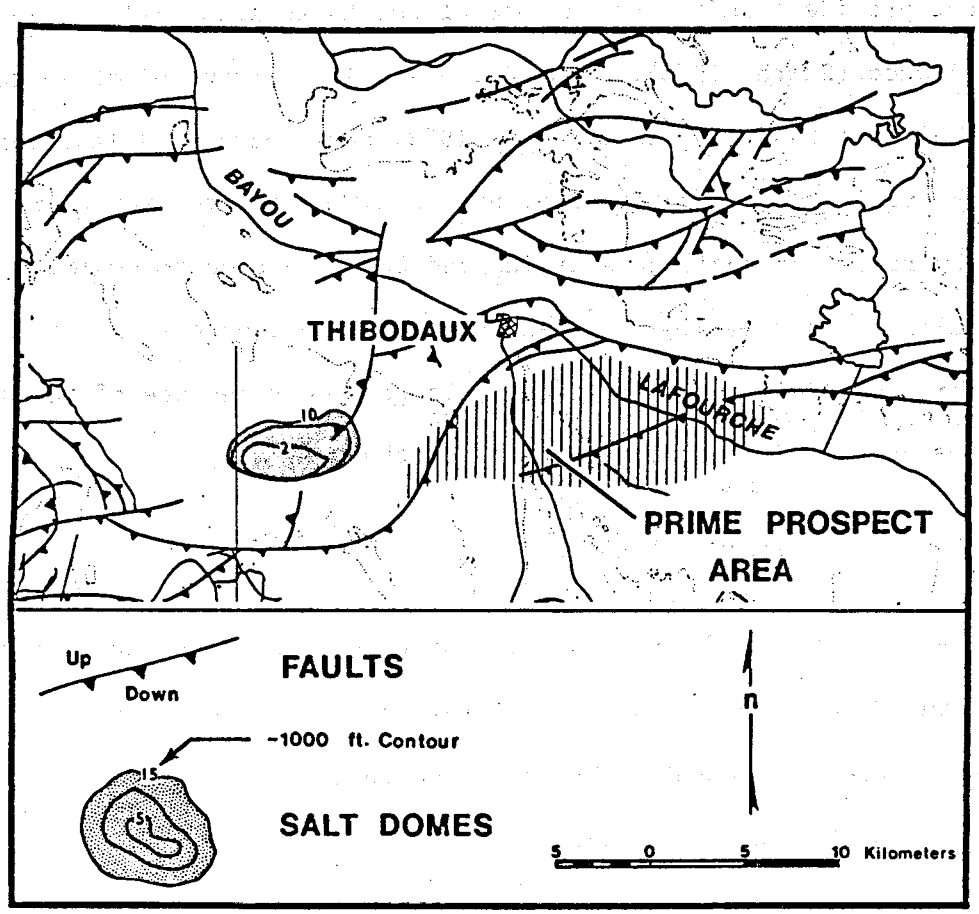


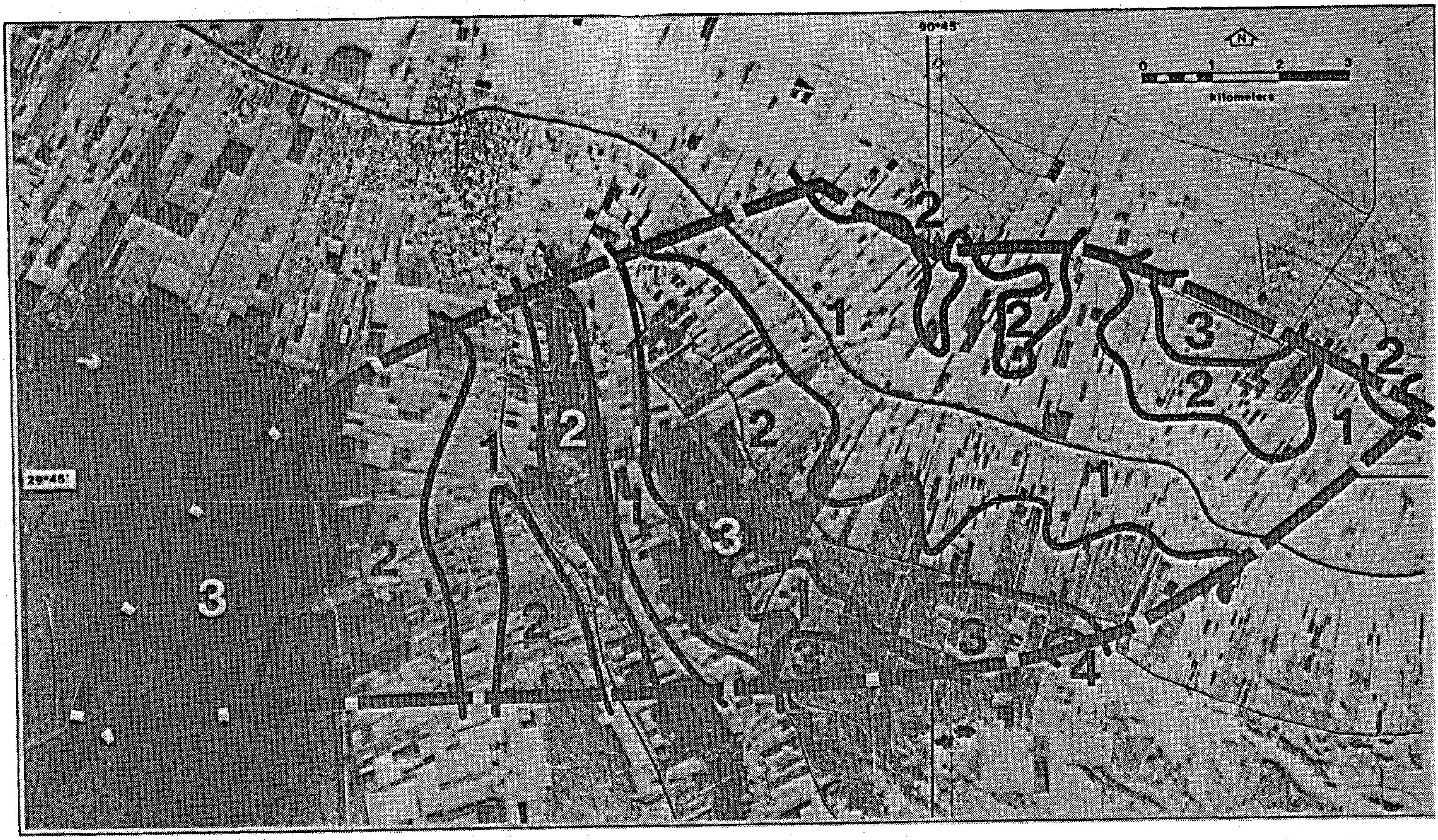
Figure 2-7. Regional tectonic map of the Lafourche Crossing Prime Prospect Area (After Gagliano et al., 1973).

Louisiana. On October 19, 1930, an intensity VI [Modified Mersalli (MM) scale] earthquake was centered south of Donaldsonville at approximately 30°N Latitude and 91°W Longitude or 32 km (20 mi) north of the Prime Prospect Area. Some brick chimneys were cracked or the tops knocked down in Gonzales, Louisiana, 24 km (15 mi) north of the epicenter. A second earthquake occurred on November 19, 1958, in Baton Rouge, Louisiana, 80 km (50 mi) north of the Prime Prospect Area. An intensity of V (MM scale) is estimated for this earthquake which shook houses and rattled windows. The Baton Rouge fault is active and has moved 6 cm (.20 ft) per year from 1959 to 1969 (Wintz et al., 1970).

2.1.5 Soils

Figure 2-8 shows the soils of the Lafourche Crossing Prime Prospect Area. The Prime Prospect Area is crossed by a series of distributary ridges of the Bayou Lafourche delta. The higher elevations of the natural levees are Commerce-Mhoon Association loamy soils. These soils are the best drained in the Prime Prospect Area and are easily cultivated. Cultivated fields of sugarcane and urbanized areas are the dominant use on this Association (Table 2-2).

Toward the toe of the natural levees and at lower elevations is the Sharkey-Tunica Association of clayey soils. These soils are poorly drained and subject to frequent flooding. Some parts of the Association are drained for cultivation but most of the soil is in mixed hardwood forest. In the center of the interdistributary basins is the Swamp Association of clay and organics. Low elevations have resulted in flooding most of the year. Most of the land is in cypress-tupelo gum



1 COMMERCE - MHOON ASSOCIATION
2 SHARKEY - TUNICA
3 SWAMP
4 FRESHWATER MARSH

Figure 2-8. Soils of the Lafourche Crossing Prime Prospect Area (After Soil Conservation Service 1960, 1969).

Table 2-2. Characterisitcs of Soils in the Lafourche Crossing Prime Prospect Area.

Soil Description	Type Land	Runoff	Flood Hazard	Permeability	pH	Dominant Use	Suitability for Pond Reservoir Area	Suitability for Buildings and Roads
Commerce-Mhoon loamy soils								
Commerce 50%	Prime	Medium	Slight	Moderate	Slightly acid to moderately alkaline	Sugarcane Settlement	Slight	Moderate
Mhoon 30%	Prime	Slow	Slight	Slow	Slightly acid to moderately alkaline	Sugarcane Cultivated fields	Slight	Severe
Convent & Sharkey 20%								
Convent	Prime	Medium to Slow	Moderate to very severe	Moderate	Medium acid to moderately alkaline	Cultivated field	Moderate to very severe	Moderate
Sharkey-Tunica Clayey soils								
Sharkey 70%	Prime	Slow to very slow	Severe	Very slow	Slightly acid to moderately alkaline	Drained for cultivation or mixed hardwood forests	Slight	Severe to very severe
Tunica 20%	Prime	Slow to very slow	Severe	Slow	Slightly acid to moderately alkaline	Mixed hardwood forest	Slight	Severe to very severe
Mhoon, Commerce Harris 10%								
Harris		Very slow	Severe	Very severe	Mildly alkaline	Wildlife	Severe	Severe-high shrink swell
Swamp Clay & Organics		Slow to very slow	Very severe	Very slow	Medium to slightly acid	Cypress-tupelo gum swamp; Wildlife	Very severe	Very severe
Marsh, Fresh water		Slow to very slow	Very severe	Very slow	Slightly to strongly acid	Wildlife	Very severe	Very severe

Slight - The limitation is not serious and is easily tolerated or overcome.
Moderate - The limitation needs to be recognized but it can be tolerated or overcome.
Severe - The limitation cannot be easily tolerated or is difficult to overcome. The stated use is questionable.
Very severe - The limitation is so restrictive that the stated use is generally impractical.

Source: SCS, 1960, 1969.

2.2 Hydrology and Water Use

2.2.1 Groundwater

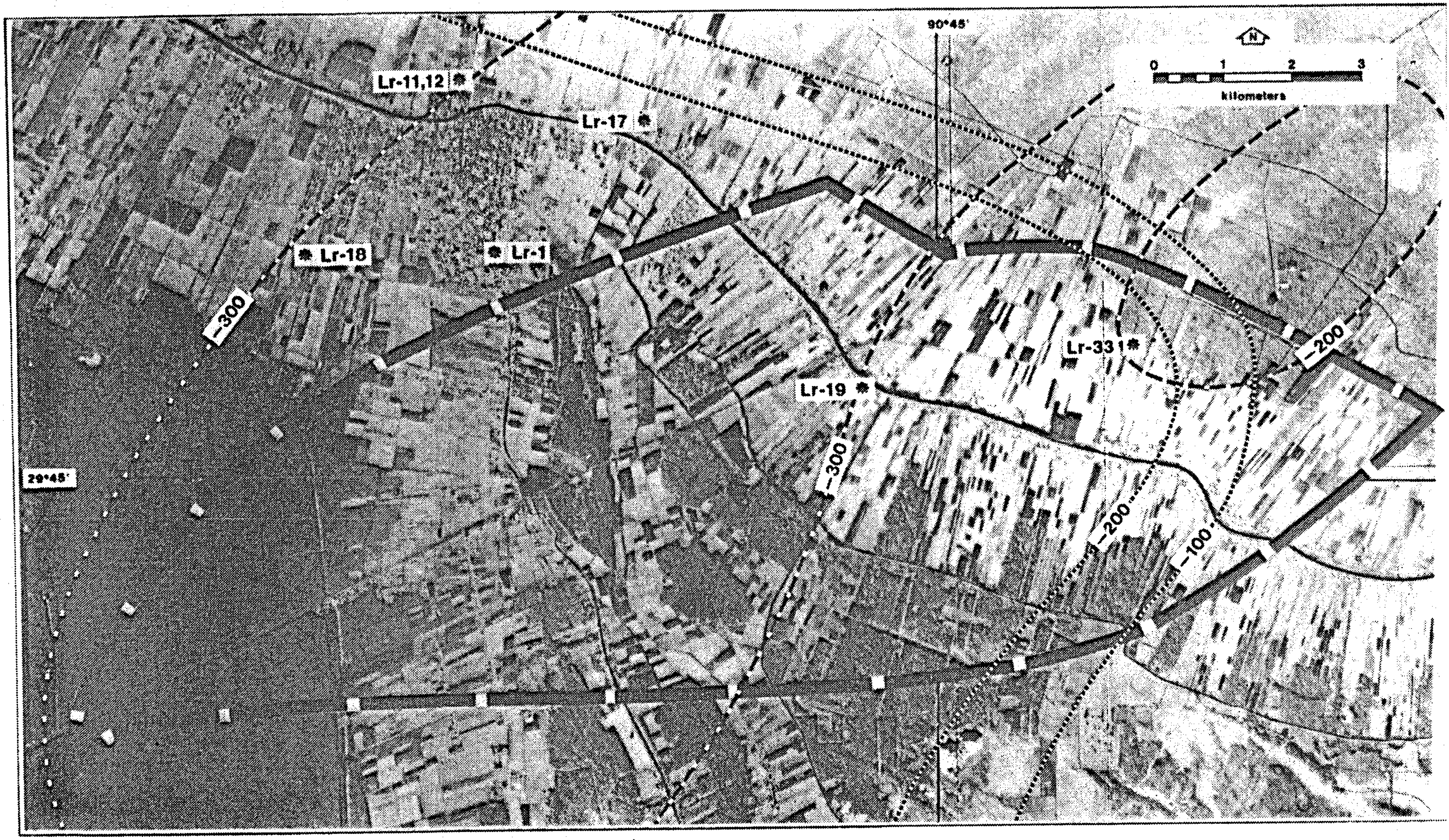
2.2.1.1 Occurrence

The Lafourche Crossing Prime Prospect Area can be characterized as an area of limited potable groundwater resources almost totally dependent upon surface water for consumptive use. Although abundant sands and gravel beds of the Mississippi alluvial valley are present, electric logs of exploratory oil and gas wells in the area indicate a lense of fresh groundwater, not more than 15 m (50 ft) thick, is present in some wells between about 46 and 76 m (150 and 250 ft) below the surface. The base of fresh groundwater in the area as mapped by Rollo (1960) is shown in Figure 2-9. However, chemical analyses of samples taken by the USGS from five water wells in the area showed that waters were all slightly saline (1000 to 3000 ppm total dissolved solids) to moderately saline (3000 to 10,000 ppm total dissolved solids), indicating the pausity of fresh groundwater locally (Table 2-4).

Table 2-4. Chemical Analyses of Water from Wells in the Lafourche Crossing Prime Prospect Area.

Well No.	Date	Screen Depth m	Screen Depth ft	Total Iron	Chloride	Total Dissolved Solids	Hardness as $CaCO_3$	pH
Lr-12	12-04-51	14	47.1	28	1260	3010	955	7.3
Lr-17	05-24-56	65	212.8	11	1950	3760	879	7.1
Lr-18	02-17-53	54	178	15	1480	3140	471	6.9
Lr-19	12-21-60	63	205.1	-	1500	2900	720	-
Lr-26	12-22-60	61	200	-	1540	2860	955	-

Source: USGS, 1978



* LR-19 WATER WELLS RECORDED BY USGS.

-200 ALTITUDE OF BASE OF FRESH GROUND WATER (250 PPM Cl^-). CONTOUR INTERVAL = 100'. (ROLLO, 1960).

-300 ALTITUDE OF BASE OF SLIGHTLY SALINE GROUND WATER (1000-3000 PPM DISSOLVED SOLIDS). CONTOUR INTERVALS = 100'. (WINSLOW, HILLIER AND TURCAN, 1968).

Figure 2-9. Groundwater of the Lafourche Crossing Prime Prospect Area (After Rollo, 1960; Winslow, Hillier, and Turcan, 1968).

Slightly saline water, which must be protected by surface casing, extends to between 92 and 122 m (300 and 400 ft) below the surface (Winslow, Hillier and Turcan, 1968).

The shallow stratigraphic sequence at Lafourche Crossing consists of Recent alluvial sediments of the Atchafalaya basin. Fine grained silts and clays of the "topstratum" (Fisk, 1952) extend to a depth of approximately 46 m (150 ft), and sands and gravels of the "substratum" extend from 92 to 122 m (300 to 400 ft) deep. The topstratum is dominated by backswamp silts and clays, but locally contains limited sand beds.

Due to the lack of sufficient groundwater resources, no studies of local geohydrology have been published for the Lafourche area. However, groundwater flow characteristics can be inferred from studies of aquifer systems along the Mississippi (Cardwell and Rollo, 1960; Hosman, 1972). Water level declines at the nearest centers of groundwater pumping, located eastward along the Mississippi River, do not extend into this area. Recharge of the aquifers below 200 feet deep occurs from 1) rainfall in the outcrop areas to the north and east, 2) direct hydraulic connection with the Mississippi River, and 3) vertical discharge of water from deeper aquifers. Recharge to the shallow sands in the topstratum is probably derived from 1) rainfall, and 2) inflow from underlying artesian aquifers.

2.2.1.2 Quality

Where fresh groundwater is available it is of the calcium and magnesium bicarbonate type, characterized by high concentrations of iron and hardness (Cardwell and Rollo, 1960). Chemical analyses available for wells in the area are listed in Table 2-4.

2.2.1.3 Quantity

Although the volume of fresh groundwater is limited, wells completed in sands and gravels of the substratum and the deeper Pleistocene sands and gravels can yield as much as 4000 gpm (gallons per minute) (Rollo, 1960). Yields of wells completed in the topstratum are expected to be much less, but data is not available.

2.2.1.4 Use

USGS files list ten wells in the Lafourche Crossing area which extend 78 m (255 ft) deep (Table 2-5). Three wells were originally listed for livestock use, the remainder are abandoned and unused. Water for public supply is taken from bayous and treated. The USGS maintains no water level observation wells in the area.

Table 2-5. Water Wells Recorded with the USGS in the Lafourche Crossing Prime Prospect Area.

Well No.	Depth m	Depth ft	Use	Date of Record
Lr-1	43	140	Abandoned	1912
Lr-11	78	255	Unused	1945
Lr-12	14	47	Unused	1957
Lr-17	67	220	Livestock	1951
Lr-18	54	178	Abandoned	1953
Lr-19	63	205	Livestock	1937
Lr-26	61	200	Livestock	1957
Lr-28	60	196	Unused	1957
Lr-29	45	146	Test boring	1951
Lr-33	76	250	Unused	1974

Source: USGS, 1978

2.2.2 Surface Hydrology

Since surface water is a residual component of precipitation, characteristics of surface flow such as quantity, quality, and drainage patterns are closely related to both physical and cultural features of the landscape. Climatic and geomorphic factors of an area determine the expected range and character of surface activity, establishing predictable hydrologic responses and drainage patterns in a natural setting. Cultural features such as canals, levees, weirs, pumps, storage, consumption, and other control factors interact with natural hydrologic events and regimes to produce a distinctive set of hydrologic processes and responses in a region. Water resource developments in the Prime Prospect Area are mainly related to water supply, agriculture, recreation, and transportation uses. Water quality problems identified in the Prime Prospect Area include chronic high bacteria counts and low dissolved oxygen content, mainly from municipal and residential discharges; seasonal seafood and sugarcane processing; natural contributions from swamp environments; and slow, sluggish water movement. This section describes the resulting surface water characteristics of stream regime, water quality, and water resources development as they pertain to the proposed action in the Lafourche Crossing Prime Prospect Area.

2.2.2.1 General Basin Hydrology

The Lafourche Crossing Prime Prospect Area is located on the deltaic plain of the Mississippi River, entirely within the wetlands environment of the Recent surface. The natural physiography is of alternating natural levee ridges and interdistributary basins.

Under natural conditions, precipitation and overbank flow would move from the crests of the natural levees down into the basin where it would collect in bayous and tidal streams and flow southward into marshes, bays, or the open Gulf. Surface slope in the wetlands is minimal, thus surface drainage is sluggish and subject to directional fluctuations from wind and tide influences.

Details of the surface drainage patterns around the Prime Prospect Area are shown in Figure 2-10. The natural hydrologic systems of the levees and interdistributary basins have been modified by man to a large extent. On the backslopes of levees, canals collect runoff before it can spread into a natural pattern. For example, Bayou Cutoff and St. Louis Bayou (Fig. 2-10) are former back slope depression bayous that have been dredged for drainage and water movement.

Between these collection canals, drainage in the interior of the basin is controlled by a network of drainage and irrigation canals to the extent that little natural surface flow remains. Drainage divides, such as the highway embankments, natural levees of the bayous, railroad embankments, and impoundment structures, confine and direct flow; but all these restricting features are breeched by one or more ditches, culverts, or canals. Local precipitation, pumping rates, and seasonal use dictates direction of flow in irrigation canals and drainage ditches as well as amounts of surface water stored in surface impoundments.

Surface water drainage in the marshes at the bottom of the basin is regulated by the combined effects of runoff from local rainfall, tidal oscillations, and weather events. Southerly

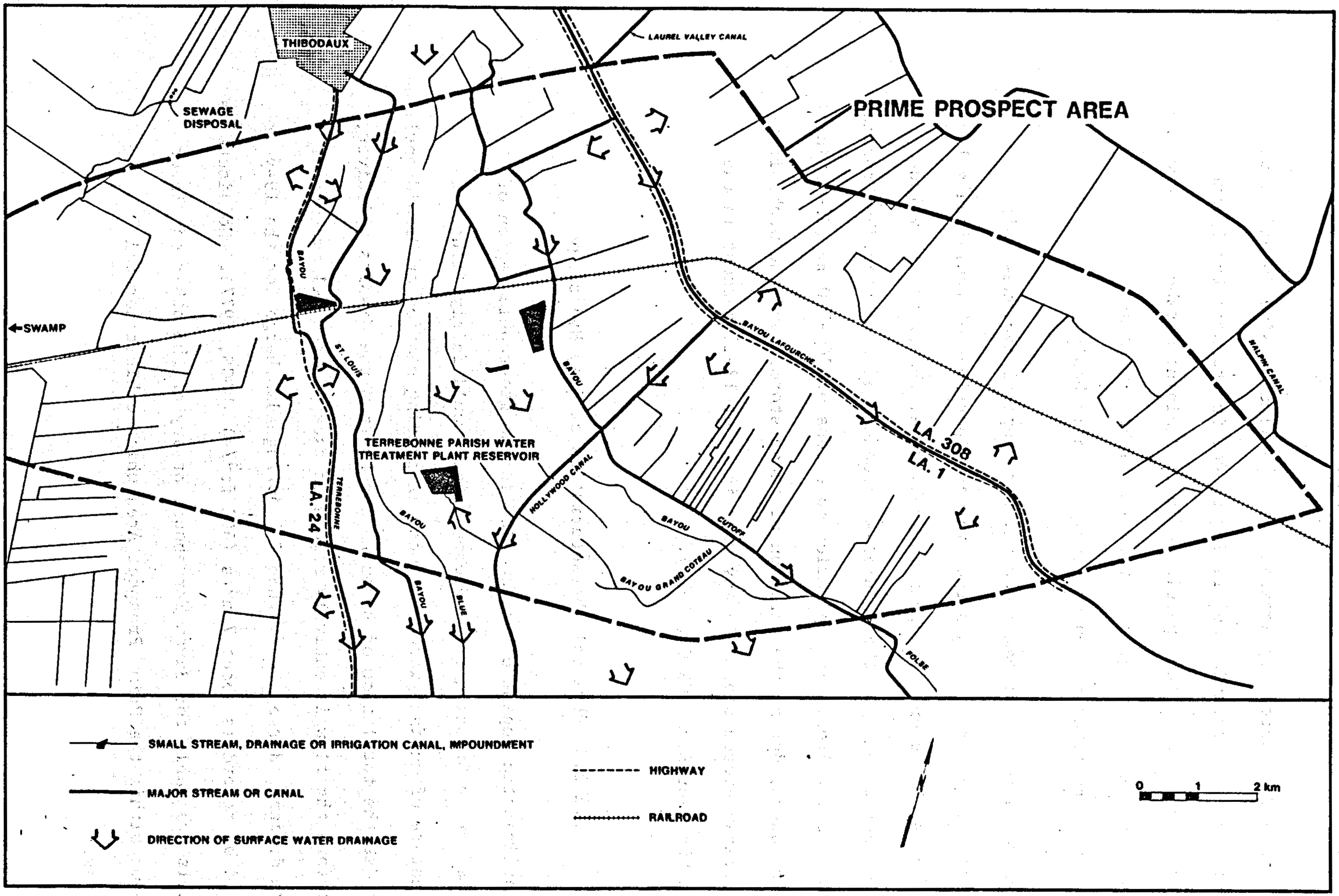


Figure 2-10. Surface drainage patterns of the Lafourche Crossing Prime Prospect Area.

winds pile Gulf waters up against the coastline causing inland flow, flooding of the wetlands, and rising stages in channels far inland. Northerly winds have the opposite effect, draining marshes and lowering channel stages. Drainage patterns and water levels are thus caused to fluctuate on an hourly or daily basis.

Excessive rainfall, stream flooding, and tropical cyclones which elevate Gulf waters (storm surge) inundate portions of Louisiana's low-lying coastal region. Though relatively rare, the tropical cyclone is a dangerous part of the natural environment of the Lafourche Crossing Prime Prospect Area. Precipitation in excess of 760-890 mm (30-35 in) is not unusual during the duration of these storms, and the probability of hurricane-force storms in any year is about 12-13 percent in the Prime Prospect Area (USACE, 1976).

2.2.2.2 Physical Characteristics of Area Hydrology

The anticipated regime of stream flow in the geographic region of the Lafourche Crossing Prime Prospect Area would fairly illustrate the nature of surface water regimes. A pumping station at Donaldsonville provides the total flow of Bayou Lafourche from the Mississippi River, therefore the flow is entirely regulated except for small amounts of storm drainage during heavy runoff. Average discharge for the 19-year period of record is about 7 m^3/s (600 ft^3/s) (USGS, 1977). No discharge data is available for Bayou Terrebonne or any of the other canals or streams within the Prime Prospect Area which exhibit natural regimes.

Fresh water input is derived primarily from local precipitation with some intermittant exchange through canals connected to the various natural watercourses. Annual precipitation averages about 1524 mm (60 in), and average annual runoff is estimated at 1.2 hm^3/km^2 (1014 $A\text{-}F/mi^2$) (Muller, 1975). Heavy rainfall causes rapid rises in streams and local flooding of low areas, whereas periods of drought cause extremely low flows in canals and streams with low water levels in swamps and marshes.

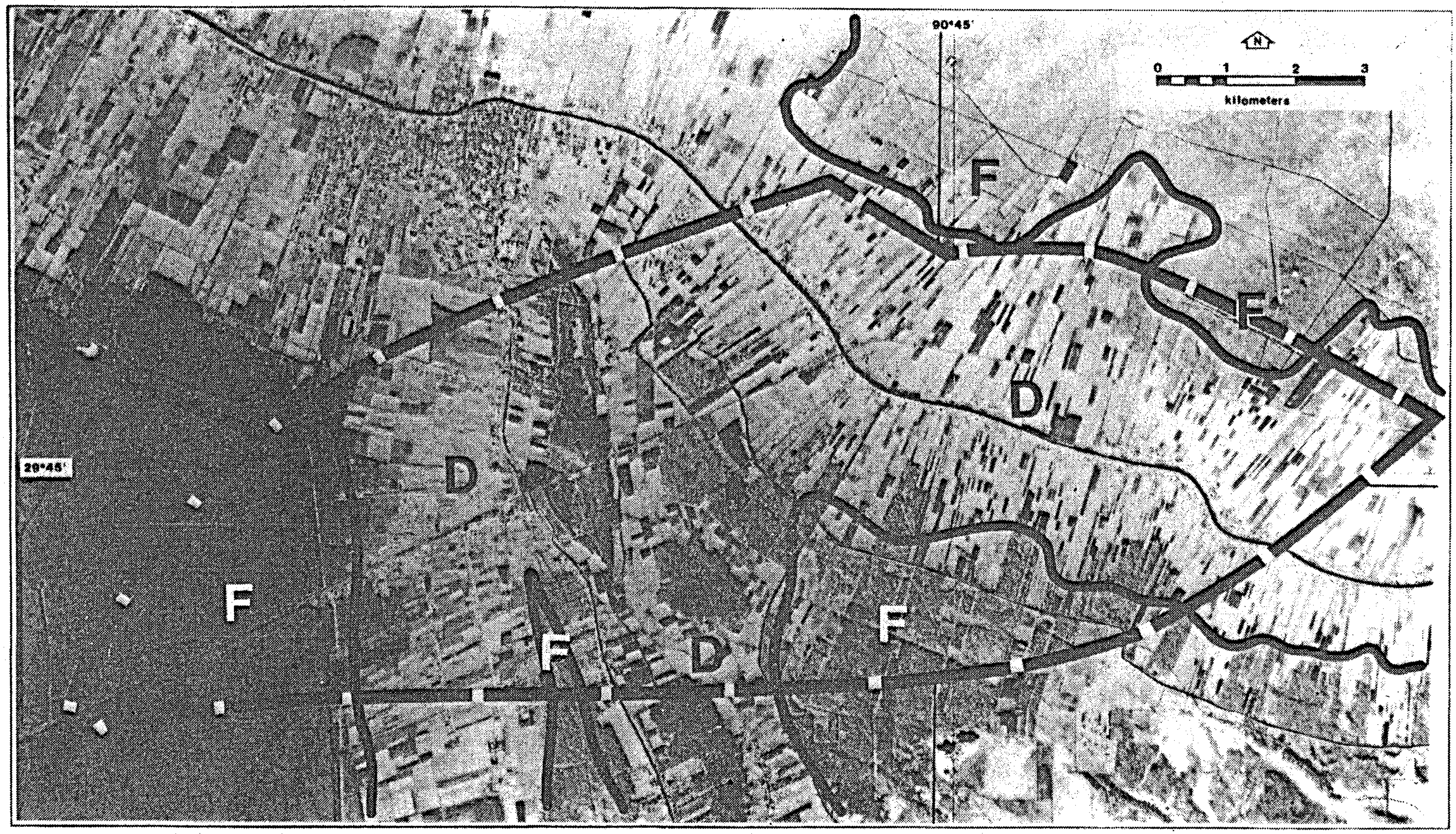
Runoff characteristics are governed by soil types, vegetation, and land-use within the basin. Table 2-6 lists the percent of precipitation expected as runoff from various surfaces. Reference to the soil type, vegetation, and land-use sections of this report points out the distribution and relative importance to surface runoff of these differences across the Prime Prospect Area.

Table 2-6. Runoff As a Percent of Precipitation on Various Surfaces.

Surface	% Runoff
Urban Residential	
single houses	30
garden apartments	50
Commercial and Industrial	90
Forested Areas (depending on soil type)	5-20
Parks, Farmland, Pasture	5-30
Asphalt or concrete pavement	85-100

Source: Linsley and Franzini, 1972

Expected flood hazard in the Prime Prospect Area is shown in Figure 2-11 where it is easily seen that the finger-like natural levees provide



D AREAS NOT INUNDATED BY 100 YR. FLOOD

F AREAS INUNDATED BY 100 YR. FLOOD

Figure 2-11. The floodplain of the Lafourche Crossing Prime Prospect Area (After Burk and Associates, in press).

preferred locations for development. Elevation of the Prime Prospect Area is below 1.5 m (5 ft) between the natural levee ridges, consequently the backswamps are below the level expected to be flooded by the 100-year flood and tidal inundation event. In general, the 100-year flood and tidal boundary lies between the 3 and 4 m (10 and 15 ft) elevation contours in areas inland from the marsh, and with the exception of the higher natural levee ridges, most of the Recent coastal area lies within the flood zone (McIntire et al., 1975).

2.2.2.3 Water Quality Characteristics

Surface water quality in the Lafourche Crossing Prime Prospect Area is generally good with only sporadic minor violations of water quality standards reported during the period 1975-1977 (La. Stream Control Commission, 1978). Most critical water quality problems occur in the marshes and estuaries south of Houma, La. In that area, untreated domestic waste from the cities and from the many camps in the area causes problems of chronic high bacterial concentrations. These problems are intensified by limited drainage from upper basin sources and by weather and tide influenced water level fluctuations. In addition, dissolved oxygen violations are common throughout the basin for two major reasons: 1) swamp water, which is naturally low in DO, combines with low flows and near stagnant conditions in the bayous, ditches, and canals; and 2) sugar mill effluent and seafood processing wastes, particularly along Bayou Terrebonne, create seasonal violations (Office of Water Planning and Standards, 1974).

Salinity conditions in surface waters are one of the most important environmental factors affecting water use and distribution of plants and animals. Vegetation, wildlife, and soils adjust to a range of water quality conditions produced by fluctuating salinities and water levels. Figure 2-12 shows the average distribution of surface salinities in the Louisiana coastal zone. On the average, salinity of surface water in the Prime Prospect Area is below 0.5 ppt (parts per thousand), indicating that the proposed action is in an area of freshwater swamps. However, saltwater intrusion has been observed in Bayou Lafourche, the Gulf Intracoastal Waterway, and the Houma Navigation Canal (La. Stream Control Comm., 1978), all south of the Prime Prospect Area.

Available information on water quality in the area is summarized in Table 2-7, and water quality criteria for stream segments in the vicinity of the Prime Prospect Area are shown in Table 2-8. Locations of the water quality sampling sites and the stream segments are shown in Figure 2-13. Comparison of these data shows that the most frequent violation of water quality standards is low dissolved oxygen (DO). Additionally, some violations of Cl, SO_4, and TDS are evident in the data, but on a more localized basis than the pervasive DO violations. Comparison of 1976 data with those for 1974 and 1975 indicates that no significant water quality changes occurred during that time in any stream segments in the vicinity of the Prime Prospect Area (La. Stream Control Comm., 1977a).

2.2.2.4 Water Resource Development

Municipal and domestic raw water supply is taken from surface water sources throughout the region, and most stream segments are

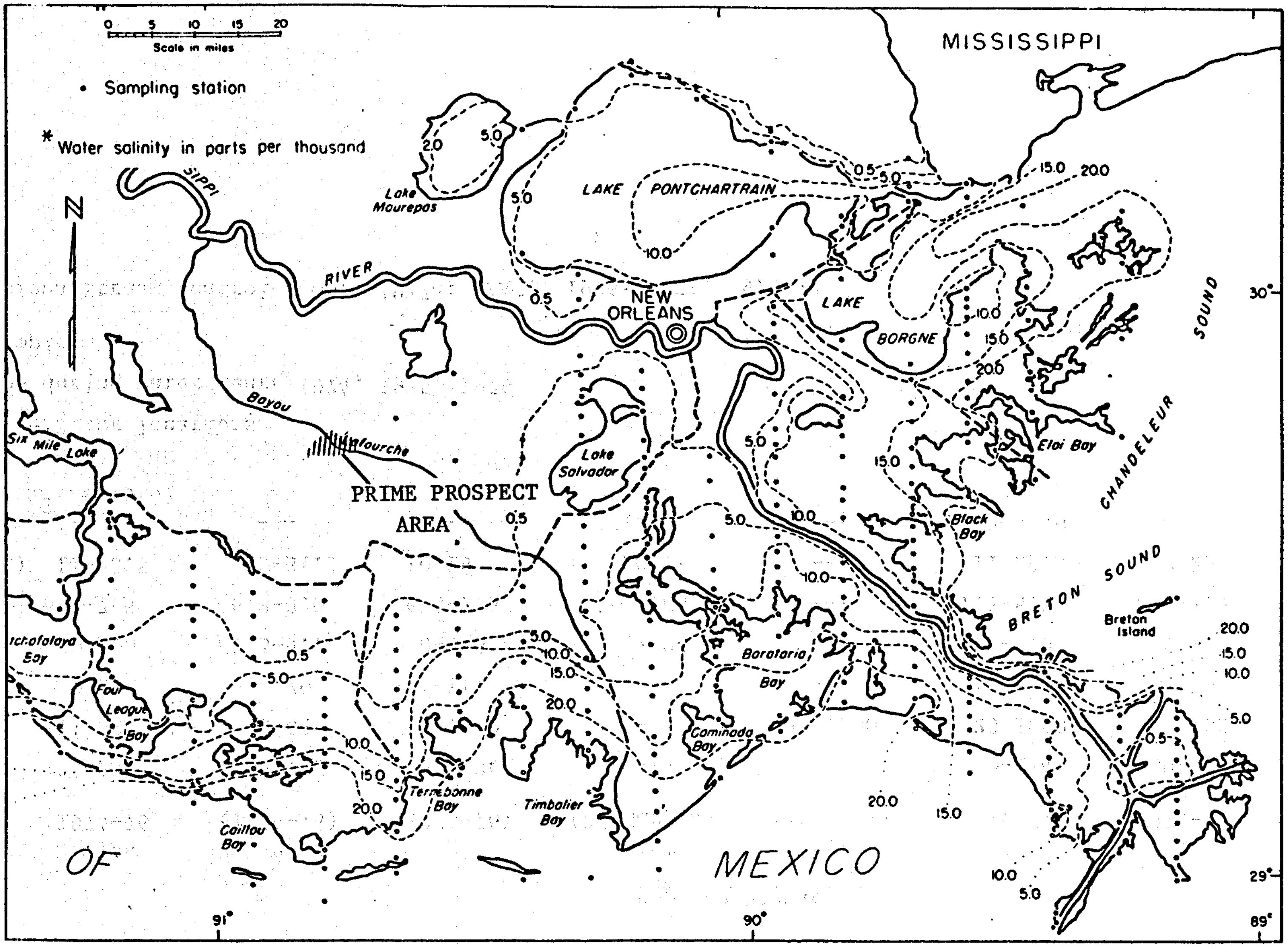


Figure 2-12. Isohaline map of the Louisiana Coast (After Chabreck, 1972).

Table 2-7. Water Quality Data (ranges of values in mg/l).

Parameter	Sampling Stations*							
	1** (1974-76)	2 (1974-76)	3 (1974-76)	4*** (27 Mar 75)	5 (1976-77)	6 (1976-77)	7 (1974-76)	8 (1976-77)
TDS	26-282	106-730	56-3784	---	---	9-184	30-1470	---
Cl	11-62	10-42	8-2050	---	30-7500	23-1600	10-1025	58-7500
SO_4	0-28	6-70	0-111	---	---	14-220	2-80	---
DO	0-8.0	2.5-9.1	0-3.8	7.95	---	5.3-8.9	1.5-9.0	---
pH (units)	6.3-7.5	6.8-8.0	6.4-7.5	7.65	---	7.5-8.2	6.9-7.9	---
Temperature (^oC)	11-28.5	10-31.5	10-29	20.1	---	11-29.5	10-29	---
Conductivity (micro-mhos/cm^2 at 25^oC)	----	---	---	318	---	363-4840	---	---

* See Figure 2-13 for locations

** Observations during water years 1974, 1975, 1976

*** One-time sample

Source: Louisiana Stream Control Comm., 1977a; USACE, 1976; USGS, 1976-77

Table 2-8. Water Quality Standards** (selected parameters) and Water Use Designations (selected stream segments).

SEGMENT	Water Uses* A	B	C	D	Cl (mg/l)	SO_4 (mg/l)	DO (mg/l)	pH (range)	TDS (mg/l)	Temp. (°C)
Bayou Lafourche (above Larose)	A	B	C	D	70	55	5	6.0-8.5	500	32
Bayou Lafourche (below Larose-TIDAL)	A	B	C		--	--	4	6.5-9.0	--	35
GIWW (Morgan City to Larose)	A	B	C	D	250	75	5	6.0-8.5	500	32
Bayou Black (GIWW to Houma)	A	B	C	D	82	39	5	6.0-8.5	291	32
Bayou Terrebonne (Thibodeaux to Bourg)	A	B	C		230	55	5	6.0-8.5	875	32
Bayou Terrebonne (below Bourg-TIDAL)	A	B	C		--	--	4	6.5-9.0	--	35
Bayou Petit Caillou (below Houma-TIDAL)	A	B	C		--	--	4	6.5-9.0	--	35
Bayou Blue (TIDAL)		B	C		--	--	4	6.5-9.0	--	35

* A = Primary Contact Recreation
B = Secondary Contact Recreation
C = Propagation of Fish & Wildlife
D = Domestic Raw Water Supply

** Chemical Parameters and Temperature = max. values
Dissolved Oxygen = min. values

Source: Louisiana Stream Control Comm., 1977b

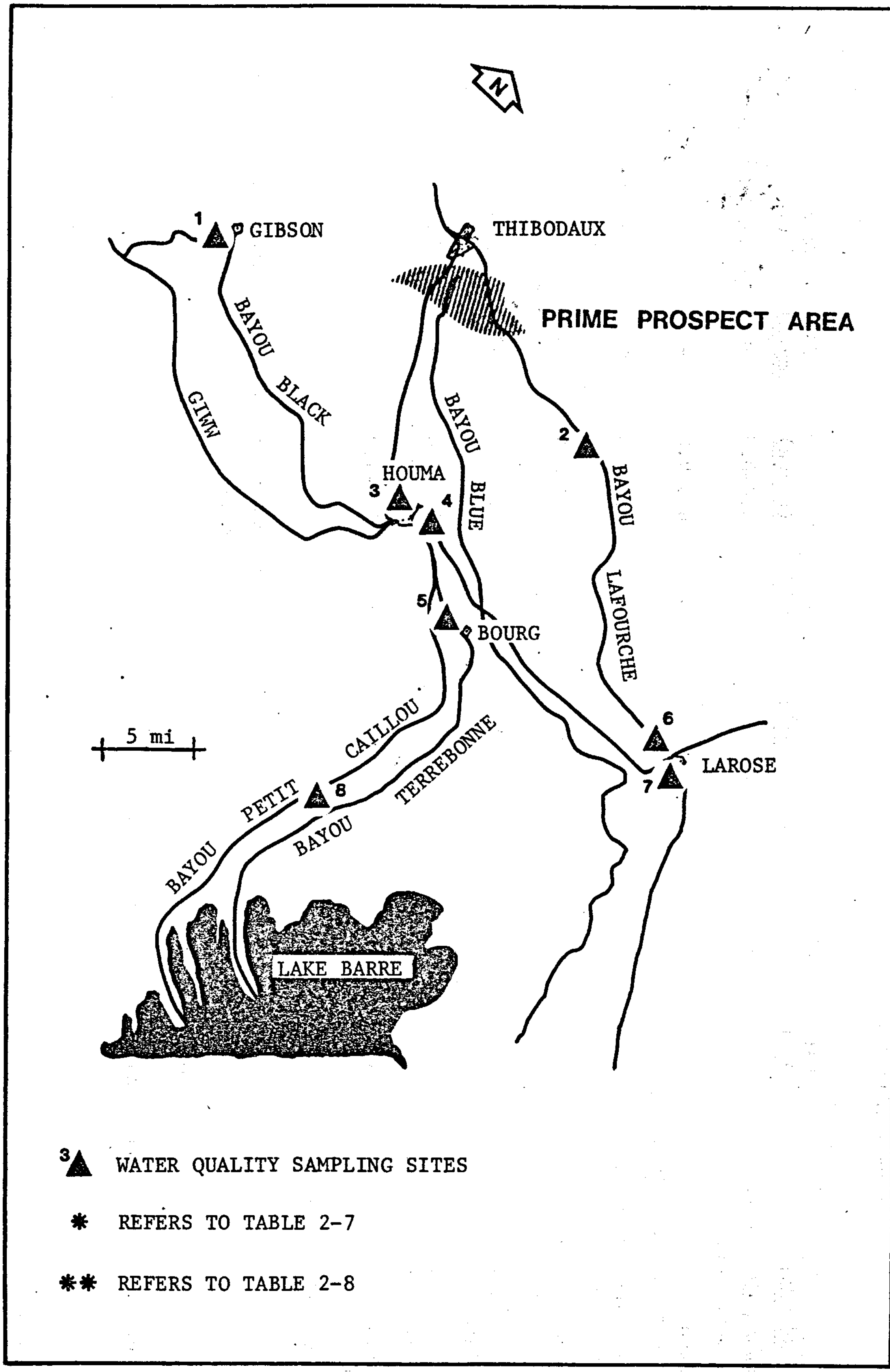


Figure 2-13. Locations of water quality sampling sites and stream segments (After Louisiana Stream Control Commission, 1977a).

classified as suitable for "primary" and "secondary contact recreation" as well as for "propagation of fish and wildlife" (Table 2-8). Extensive surface water management practices are conducted in the basin for crop irrigation, drainage, navigation, flood control, and in the lower part of the basin for saltwater intrusion problems.

Specific lists of municipal and industrial users, amounts of surface water used for irrigation, and point sources of municipal and industrial dischargers are available for the region around the Prime Prospect Area (USACE, 1973; USACE, 1974; Office of Water Planning and Standards, 1974). Table 2-9 lists representative types of major industrial dischargers located within or near the Prime Prospect Area. No wild, natural and scenic, or recreational waterways have been designated in or near the Prime Prospect Area (La. Wildlife and Fisheries Comm., 1976).

Table 2-9. Types of Major Industrial Discharges, Terrebonne Basin.

Oil and gas mining
Non-metallic mineral mining
Sugar and confectionary products
Seafood products
Paper and allied products
Water and sanitary services

Source: Office of Water Planning and Standards, 1974

2.3 Flora and Fauna of the Prime Prospect Area

The Prime Prospect Area is situated in southeastern Louisiana on the abandoned upper distributaties of the former Lafourche-Mississippi River Delta complex (Fig. 1-1). The present distribution of vegetation is controlled not only by the natural conditions, such as elevation above standing water and distance from salinity influences, but also by human activity such as farming, lumbering, and residental and industrial development. Vegetation observed in the Prime Prospect Area in July 1978 are listed in Appendix A.

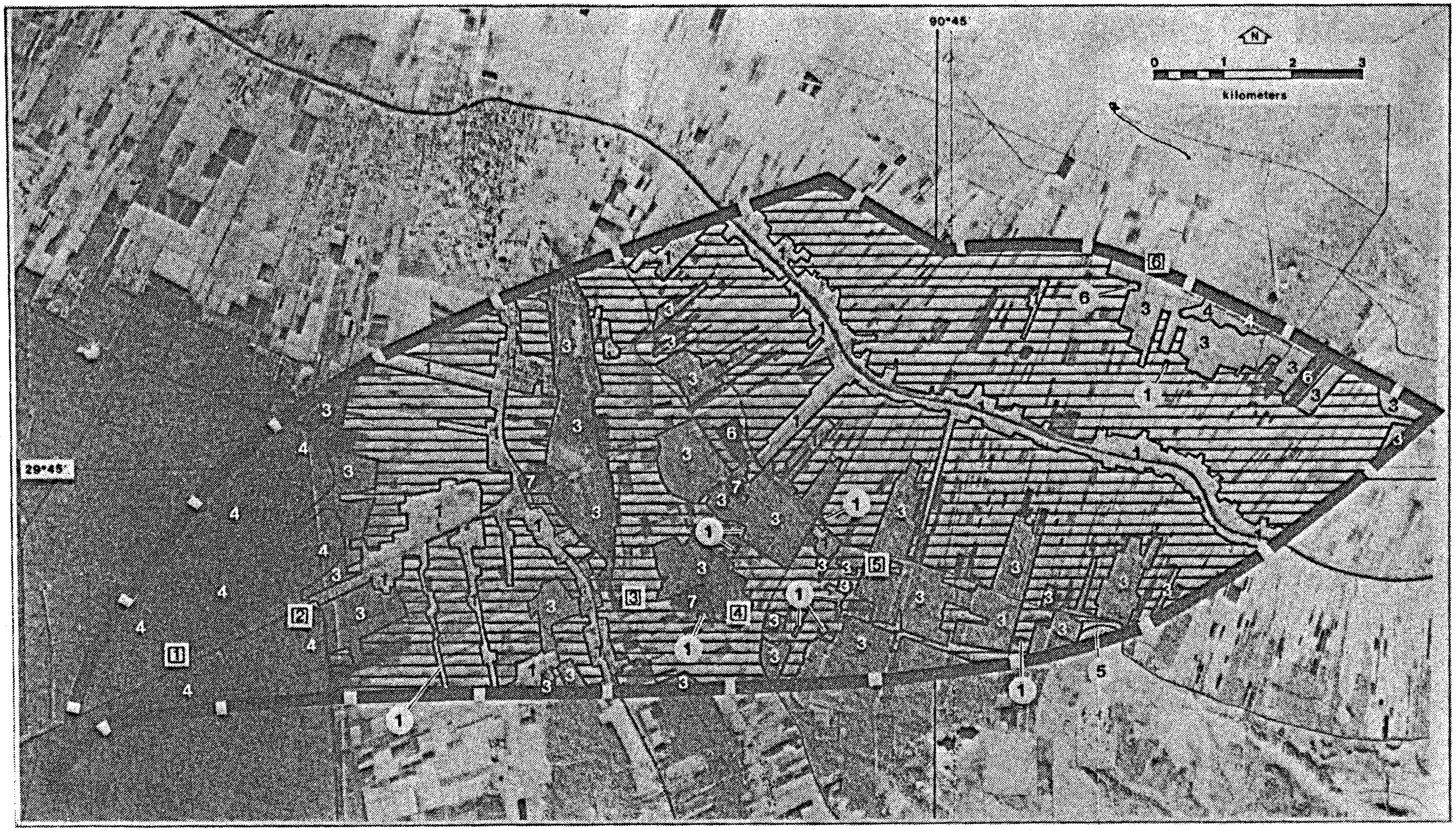
Within the Prime Prospect Area a number of terrestrial and aquatic habitat types can be broadly defined by land-use and/or soil moisture (Fig. 2-14). Terrestrial habitats include residential, agricultural, and bottomland hardwoods. Aquatic habitats include agricultural drainage canals, natural bayous, cypress-tupelo swamps and crayfish ponds. While many faunal species frequently occur in one or more of these types, they are discussed in conjunction with the areas in which they are most common or are of greatest recreational or commercial importance. Fish, amphibians, reptiles, birds, and mammals whose range includes the Prime Prospect Area listed in Appendix A.

2.3.1 Terrestrial Flora and Fauna

A discussion of specific types of terrestrial flora, areas of location, and utilization is given below.

Residential Areas- Virtually all of the Prime Prospect Area consists of terrestrial habitats greatly altered by man's landscaping activities. The higher, better drained natural levees that formerly supported dense stands of mixed levee hardwoods have been cleared of natural vegetation.

Human communities and industrial sites have been located on the crests of these natural levees adjacent to the bayous and the remainder of the area has been planted primarily in sugarcane.



1 DEVELOPED AREAS

[hatched box] AGRICULTURE

3 BOTTOMLAND HARDWOODS

4 BACKSWAMP

5 FRESH MARSH

6 CRAWFISH PONDS

7 WATER SYSTEMS BODIES

[6] VEGETATION OBSERVATION STOPS

Figure 2-14. Major vegetation systems of the Lafourche Crossing Prime Prospect Area.

A variety of vegetation has been planted around residential and industrial sites. Common tree species include live oak (Quercus virginica), pine (Pinus spp.), redbud (Cercis canadensis), mimosa (Albizzia julibrissin), fig (Ficus carica), and satsuma (Citrus reticulata). Many area residents also maintain small vegetable gardens where they grow tomatoes, okra, peppers, greens, and/or cabbage gardens for home consumption or sale on a limited basis.

Faunal species occurring in residential areas have become adapted to man's horticultural plants and maintenance of early successional stages of vegetation. Some species frequently occurring and commonly enjoyed in residential areas include green anoles (Anolis carolinensis), green treefrogs (Hyla cinerea), Northern Cardinals (Cardinalis cardinalis), Blue Jays (Cyanocitta cristata), Brown Thrashers (Toxostoma rufum), Northern Mockingbirds (Mimus polyglottos), House Sparrows (Passer domesticus), Carolina Wrens (Thryothus ludovicianus), fox squirrels (Sciurus niger), and southern flying squirrels (Glaucomys volans).

Agricultural Fields - Agricultural fields are the predominant habitat type within the Prime Prospect Area. Although some soybeans are grown, the principal agricultural crop is sugarcane. By reducing competition with other species, sugarcane growers can harvest an average of about 28 tons of cane per acre in this area (Bordelon, 1978; Landry, 1978).

Due largely to the lack of plant species diversity and year around cover, large areas of farm monoculture provide little wildlife habitat. Most of the wildlife occurring in these areas are restricted to naturally vegetated areas such as field borders, abandoned fields, ditchbanks and road shoulders.

Some hunting for Bobwhites, Mourning Doves, or rabbits may occur where the game birds are concentrated or where sufficient cover is available for rabbits.

Bottomland Hardwoods - The bottomland hardwoods flanking the natural levees in the north-south trending interdistributory basins are second growth communities (Connor and Day, 1976). These areas were cut over for timber and cleared for agriculture in the past. The drainage in these areas was accelerated through construction of numerous shallow drainage ditches. However, they still remain wetter than the higher, better drained natural levees and have, therefore, been abandoned for sugarcane production during the modern period of declining sugar prices. These bottomland hardwood communities occupy transition zones between the natural levee and swamp and contain species from both environments. These species are distributed according to their ability to withstand flooding, with those tolerant of the longer hydroperiod being at the base of the levee. Common bottomland hardwood species and vegetation characteristic of this habitat are listed in Appendix A.

Of the habitat types available for wildlife in the Prime Prospect Area, bottomland hardwoods provide the greatest amount of outdoor recreation, primarily hunting. Most of the game and non-game wildlife in the bottomland forests are species associated with the more advanced successional stages of vegetation. These areas provide important habitat for the numerous migratory bird species which winter in south Louisiana or pass through the area in route to more southerly climates. Squirrels (Sciurus spp.), rabbits, and deer (Odocoileus virginianus), all common in the bottomland hardwoods, provide many hours of hunter recreation.

2.3.2 Aquatic Flora and Fauna

Various locations of aquatic flora and fauna within the Prime Prospect Area, and specific species inhabiting these habitats are discussed below.

Agricultural Drainage Canals - Ditches and canals are dug to expedite the runoff of excess water from agricultural fields to natural drainage systems (Fig. 2-14). The field drainage ditches and channelized bayous generally do not have either rooted, submerged aquatics or floating aquatics due to the frequency of ditch cleaning operations and periodic flushing by heavy rainwater runoff. Furthermore, the water is usually shallow and heavily ladden with silt, conditions which tend to minimize aquatic flora and fauna. If the ditches have not been dredged for several years, a variety of emergent aquatic and wet site plants colonize the site. Common species include cattail (Typha spp.), horsetail (Equisetum hyemale), rushes, (Juncus sp. and Rhynchospora sp.), cyperus (Cyperus spp.) alligatorweed (Alternanthera philoxeriodes), and pennywort (Hydrocotyle sp.).

Faunal species able to survive in these frequently turbid, warm, and low-oxygenated waters include crayfish (locally referred to as crawfish) (Camburus spp.), several species of gar (Lepisosteus spp.), mosquitofish (Gambusia affinis), stinkpot (Sternotherus odoratus), several of the water snakes (Natrix spp.), and nutria (Myocastor coypus). These canals are the first aquatic recipient of agricultural pesticides.

Natural Drainage Systems - Most of the natural drainage systems within the Prime Prospect Area are bayous. These sluggish streams usually have a silt bottom and are turbid for quite a distance after receiving agricultural runoff. During late winter and spring when bottomland hardwoods and swamps are flooded with these nutrient-rich waters, colloidal clays are electrically attracted to leaves and detritus. Thus, nutrients are supplied to bottomland hardwood and swamp systems. The productivity of these systems is thereby enhanced. However, where the bayous remain muddy year round, these aquatic systems are less productive due to the restricted depth of light penetration. Light is necessary for photosynthesis, the most basic unit of aquatic production in such systems.

Species inhabiting these habitats are American alligator (Alligator mississippiensis), red-eared pond slider (Chrysemys scripta elegans), water snakes, and western cottonmouths (Agkistrodon piscivorus). Several additional species are sought by recreational and commercial interests for food. These species include alligator snapping turtles (Macroclemys temmincki), common snapping turtles (Chelydra serpentina), bullfrogs (Rana catesbeiana), garfish, buffalo (Ictiobus spp.), catfish (Ictalurus spp.) sunfish (Lepomis spp.), largemouth bass (Micropterus salmoides), and crappie (Pomoxis spp.).

Cypress-Tupelo Swamp - The swamp habitats lie on the eastern and western edges of the Prime Prospect Area. They are discussed with aquatic habitats because it is common for these flat, low lying areas (less than 1.5 meters above sea level) to have standing water for one or more months of the growing season.

The swamps flanking each side of the Prime Prospect Area are second growth communities. The commerical cypress stands were cut around the turn of the 20th century. However, regrowth in these particular areas seems to be good since the tree stands are healthy and rather dense. Bald cypress and water tupelo are the dominant species (Chabreck, 1970, 1972). Other common species include Drummond red maple, pumpkin ash, and buttonbush (Cephalanthus occidentalis) (Chabreck, 1970, 1972).

The standing water in swamp areas and sluggish bayous is often covered by dense mats of water hyacinths (Eichhornia crassipes), duckweed (Lemna spp. Wolfiella sp., and Spriodela spp.), water-meal (Wolffia spp.), and water lettuce (Pistia stratiotes).

The swamp and its associated vegetation provides habitat for crayfish, American alligators, and wading birds. Although wading bird rookeries are common in cypress-tupelo swamps, none were reported by Portnoy (1977) to be within the Prime Prospect Area. The swamp and bottomland forest habitats provide most of the wildlife associated sport and commercial activities in the Prime Prospect Area.

A very small portion of the southeastern part of the Prime Prospect Area consists of fresh marsh. Normally, the dominant vegetation consists of maidencane (Panicum hemitomon), cattail, bullrush (Scirpus californicus), saw grass (Cladium jamaicense), wapato (Sagittaria platyphylla), water hyacinth, and alligatorweed (O'Neil, 1949). However, this site appears to be undergoing changes due to grazing and alteration of drainage; therefore, the species composition is being disturbed.

Crayfish Ponds - The catching, cooking and eating of crayfish is deeply imbedded in the culture of south Louisiana. Historically (and today), crayfishing for home consumption has often been a family or multi-family affair. Most crayfishing takes place in ditches and canals, or in bottomland hardwood and cypress-tupelo forests during spring flooding. However, crayfish ponds have been developed for maximum crayfish production. Several such impoundments exist within the Prime Prospect Area. Water levels in these ponds are regulated for maximum crayfish production and elimination of competitor and preditor species. Most of the crayfish ponds in the Prime Prospect Area are fished for personal consumption rather than commercial sale.

Wildlife Related Activities - Area residents frequently participate in several wildlife oriented recreational or commercial activities. School kids limited by transportation fish in many of the accessible canals and bayous. Although the bottomland hardwoods and swamps are privately owned, most of them are hunted by friends and guests of the landowners.

The trapping of furbearers is a large commercial industry in Louisiana with much of the bottomland and swamp areas of the state being "leased" to trappers.

2.4 Endangered Species

No endangered or threatened plant species have been recorded in the vicinity of the Prime Prospect Area (U.S. Dept. of Energy, 1978).

One reptile and three bird species currently classified as endangered or threatened are either present or are potentially present in the Prime Prospect Area.

The American alligator, originally listed as endangered throughout its range, has made significant population gains in recent years and is currently listed as threatened in several south Louisiana parishes, including Terrebonne and Lafourche. Alligators could be present in any of the aquatic habitats of the project area but would more likely occur in the natural drainages or cypress-tupelo swamp.

Bachman's warbler (Vermivora bachmanii), being the most rarely observed North American warbler, is classified as endangered. The species inhabits heavily wooded swampy areas and is thought to nest in different areas of Louisiana each year (Lowery, 1974).

The Bald Eagle (Haliaeetus leucocephalus) is also classified as endangered. Sixteen nesting territories have been located in the state with the closest nests being about 19.2 km (12 mi) south-southeast, 22.4 km (14 mi) southeast, and 27.4 km (17 mi) east-northeast of the Prime Prospect Area (Aycock, 1978). Although immature and adult eagles may pass through the area, none would be expected to spend any length of time there (Lowery, 1974).

Peregrine Falcons (Falco peregrinus), another endangered species, migrate south in winter closely following concentrations of shorebirds and waterfowl, many of which winter along coastal Louisiana. Some falcons may pass through the area during migration or in search of food but would not be expected to spend an extended length of time within the Prime Prospect Area (Lowery, 1974).

2.5 Noise

2.5.1 Ambient Noise

Noise has been defined as any unwanted sound. Sound itself is a pressure level which fluctuates through any media such as air or water. Sound is quantified in terms of decibels, a logarithmic scale of pressure levels based on a reference pressure of $2x10^5$ newtons per square meter. The human ear does not hear the high and low frequencies of sound as well as the mid-range; therefore, a filter has been developed for use when analyzing sound for human response. This is called the "A" filter and the noise levels recorded through this filter are expressed as A-weighted decibels or dBA. Table 2-10 shows the common sound levels associated with selected activities which may occur in the Prime Prospect Area.

The ambient, or background, daytime noise level for the Prime Prospect Area varies between about 50 dBA in the undeveloped areas to about 65dBA or greater in Thibodaux (unpublished LOH data). Nighttime noise levels reach as low as 40-50 dBA depending upon the type of development and atmospheric conditions.

Table 2-10. Common Sound Levels

Sound source	dBA*	Response criteria	Intensity (W/m^2)
Carrier deck jet operation	150		10^9
	140	Painfully loud; limited amplified speech	10^8
	130		10^7
Jet takeoff (200 ft)		Maximum vocal effort	
Unmuffled geothermal well			
	120		10^6
Discotheque			
	110		10^5
Jet takeoff (2000 ft)			
Shout (0.5 ft)			
	100		10^4
Heavy truck (50 ft)		Very annoying, hearing damage (8 hr)	
	90		10^3
Pneumatic drill (50 ft)		Annoying	
	80		10^2
Freight train (50 ft)			
Freeway traffic (50 ft)		Telephone use difficult; intrusive	
	70		10^1
Air conditioning unit (20 ft)			
	60		1
Light auto traffic (50 ft)		Quiet	
	50		10^{-1}
Living room			
Bedroom			
	40		10^{-2}
Library			
Soft whisper (15 ft)		Very quiet	
	30		10^{-3}
	20		10^{-4}
Broadcasting studio		Just audible	
	10		10^{-5}
		Threshold of hearing	
	0		10^{-6}

*Typical A-weighted sound levels taken with a sound level meter and expressed as decibels on the scale. The "A" scale approximates the frequency response of the human ear.

Source: Council on Environmental Quality, 1970.

The healthy young adult ear can hear fluctuations of 1 dBA in sound levels under ideal conditions. However, the normal adult ear can only distinguish changes at 3 dBA or greater. Because of the logarithmic nature of the decibel scale, the doubling of the sound pressure level will produce an increase of only 3 dBA. Therefore, in order for noise from the well site to be perceived by the majority of the nearby residents, it must at least equal the ambient level. If the noise from the proposed action is less than the ambient level, it will be masked by the background noises. Thus, if during daytime hours the well produces less than 50-65 dBA at the nearest receptor, it will not be heard by the majority of the residents. The same is true for the 40-50 dBA nighttime noise level.

2.5.2 Regulations

In the absence of specific Louisiana state standards applicable to noise from geothermal activity, at least four different Federal regulations may apply to the proposed action. The first Geothermal Resources Operations Order No. 4 (USDI, 1975) sets a maximum allowable noise level of 65 dBA for all geothermal-related activity as measured at the lease boundary or 0.8 km (0.5 mi) from the source, whichever is greater. This level applies in the absence of any, more restrictive criteria and may be exceeded under emergency conditions or with the permission of all the residents within 0.8 km (0.5 mi) of the source.

Another Federal regulation applies to the personnel at the proposed action. The Occupational Safety and Health Act (OSHA) set forth guidelines (OSHA 1971) restricting the amount of noise in the work environment (Table 2-11).

Table 2-11. Permissible Noise Exposure.

Duration per day, hours	Sound level, dBA
8	90
6	92
4	95
3	97
2	100
1½	102
1	105
½	110
¼ or less	115

Source: OSHA, 1971

The United States Environmental Protection Agency (EPA) has established guidelines for general use, based on land use and type of activity. They are summarized in Table 2-12. Finally, the United States Department of the Interior (DOI) (1975) has published noise criteria for geothermal related activities (Table 2-13).

Table 2-13. Noise Levels Not to be Exceeded.

Land Use	Daytime (dBA)	Evening (dBA)	Night (dBA)
Industrial & Geothermal	70	65	60
Business & Commercial	65	60	50
Residential - Urban	60	55	45
Residential - Suburban	50	45	35
Residential - Rural	45	40	30
Agricultural	70	65	55
Recreational	45	40	30
Uninhabited or Range Lands	70	65	60

Source: U.S. Department of the Interior, 1975

The above criteria will be the most difficult to meet of the Federal regulations, particularly the night noise levels.

Table 2-12. Levels of Environmental Noise.

TO PREVENT	LEVEL	AREA
HEARING LOSS	Leq* (24) $\geq$ 70dBA	All areas
Outdoor Activity Interference and Annoyance	Ldn** $\geq$ 55dBA	Outdoor residential areas and farms and other outdoor areas where people spend widely varying amounts of time, and other places in which quiet is a basis for use.
	Leq (24) $\geq$ 55dBA	Outdoor areas where people spend limited amounts of time, such as school yards, playgrounds, etc.
Indoor activity interference and annoyance	Ldn $\geq$ 45dBA	Indoor residential areas
	Leq (24) $\geq$ 45dBA	Other indoor areas with human activities such as schools, etc.

*Leq - the equivalent noise level, is a summation of all the sound pressure levels over a given time period, which is then averaged out for that period of time to give a single sound level which is representative of all the various fluctuations. Leq (24) is a 24 hour equivalent level.

**Ldn - the day/night noise level, is an Leq(24) with a 10dBA penalty added to the nighttime hours.

Source: EPA, 1974

2.6 Atmospheric Conditions

2.6.1 Regional Climatology

Since there are no meteorological measurements at this Prime Prospect Area, and since it is located on similar terrain as Thibodaux and Houma, we may use long-term observations made at these two locations for the Prime Prospect Area as a first approximation. The meteorological data are given in Table 2-14. These data were obtained from the National Climatic Center in Asheville, N.C.

The general climatic classification for the Prime Prospect Area is humid sub-tropical with a strong maritime character. However, the Prime Prospect Area is also subject to infrequent but important polar influences during winter, as masses of cold air periodically move southward across the plains states and out over the Gulf of Mexico. These cold spells are usually of short duration and the winter months are normally mild. The normal temperature at Thibodaux from December through February is 13°C (56°F). The mean number of days with the temperature equal to or less than 0°C (32°F) as observed at Houma are approximately 5 days per year. The summer months are consistently quite warm. Although the normal temperature at Thibodaux from June through August is 27°C (81°F), the mean number of days with the temperature equal to and greater than 32°C (90°F) is nearly 20 days per month during this period at Houma.

Table 2-14. Meteorological Observations Near Lafourche Crossing Prime Prospect Area, Louisiana.

Month	J	F	M	A	M	J	J	A	S	O	N	D	Year
Temperature[a] °C	12.4	13.7	16.3	20.6	23.8	26.7	27.6	27.6	25.6	20.9	16.0	13.3	20.4
Precipitation[a] mm	116	134	140	120	143	150	215	156	194	77	104	142	1691
Wind Direction[b]	N	N	S	SSE	S	S	W	S	E	NNE	E	N	E
Wind Speed[b] m/s	2.9	3.3	3.1	2.7	2.3	1.7	1.4	1.3	2.0	2.0	2.4	2.8	2.3
Wind Direction[c]	N	E	SE	SE	SE	SE	SE	SE	E	NE	N	E	SE
Wind Speed[c] m/s	8.3	7.2	8.9	5.9	2.4	0.9	0.9	0.9	4.1	4.1	7.2	7.6	4.9
Thunderstorm Days[d]	2	3	5	5	6	10	17	15	6	2	4	3	78
Relative Humidity[d] percent	78	75	74	74	74	75	79	78	77	73	73	77	76
Mixing Height[e], m	390	680	830	1040	1040	1290	1320	1180	1140	960	680	500	921
Solar Radiation[f] Ly/day	200	315	400	435	520	565	475	465	430	390	297	193	390

a. Normal for 1941-1970 period at Thibodaux.
b. At New Orleans.
c. For Bayou Lafourche area with central position at $28^{\circ}49'$N and $90^{\circ}04'$W.
d. At Houma for mean number of days having thunderstorms.
e. From Holzworth (1964) for mean maximum mixing height.
f. For 1963-1973 period of Lake Charles, the closest site having solar radiation measurements.

Source: National Climatic Center, 1977.

From March through August the prevailing direction of the wind is from the southeast. The mean wind speed during this period is approximately 5 m/s (10 kts). From September through February most winds blow from the northeast quadrant with a stronger mean speed of 7 m/s (13 kts). Winds in excess of 77 m/s (150 kts) are estimated to have occurred during great hurricanes.

Rainfall is heavy with the normal annual total near 1669 mm (66 in) and 1691 mm (67 in) at Houma and Thibodaux, respectively. Amounts are substantial in all seasons, although there is an early autumn minimum in October (averaged between Houma and Thibodaux at about 81 mm (3.18 in). All other months produce an average of more than 102 mm (4 in), with July often more than 203 mm (8 in). Almost all rainfall is of the convective and air mass types, showery and brief, except occasionally during winter when nearly continuous frontal rains may sometimes persist for a few days.

2.6.2 Meteorology near the Prime Prospect Area

As described in the previous section (2.6.1), since the Prime Prospect Area has no meteorological observations and is located on the same general terrain as, and not very far from Thibodaux and Houma, the meteorology of the Prime Prospect Area may be approximated by the observations made at these two locations. However, since these cities do not have wind observations, New Orleans measurements and climatological summary are included. These data are summarized in Table 2-14. A description of meteorological and climatological conditions has already been given in 2.6.1. Since the Table is self-explanatory, it will not be discussed in detail. However, note that for air quality assessment, both solar radiation and mixing height are added in the table in addition to those basic parameters. Although they were not measured in the Prime Prospect Area, they may be used as a first approximation because both New Orleans and Lake Charles are located in the same Air Quality Control Region (i.e. 106) as the Prime Prospect Area (EPA, 1978).

Since the atmospheric stability class is very important in the diffusion calculation, Table 2-15 gives the pertinent information as a first approximation since there is no such measurement in the Prime Prospect Area. They will be used in the impact computation section on air quality due to the proposed action. Note that stability Class A represents extremely unstable conditions, B unstable, C slightly unstable, D neutral, E slightly stable, F moderately stable, and G extremely stable (Slade, 1968). It is evident from the Table that the combination of neutral and slightly stable conditions (D+E) occupied about 60 percent of the year.

2.6.3 Air Quality

The existing air quality data in the Prime Prospect Area as measured for a special study by the EPA Regional Office Group responsible for atmospheric surveillance are summarized in Table 2-16. Carbon monoxide and nonmethane hydrocarbons were measured by the Louisiana Department of Highways. For comparison purposes, measurements of carbon monoxide at Nederland and West Orange, Texas were also included in the Table since these two areas are located in the same Air Quality Control Region (i.e., 106) as the Prime Prospect Area (EPA, 1978). From Table 2-16 it is evident that, except for ozone and nonmethane hydrocarbons, other pollutants as listed and regulated by Federal and state agencies were within the National Standards.

Table 2-15. Percent Frequency and Wind Speed for Stability Classes Measured at Taft, Louisiana.

Stability Class	Percent Frequency	Average Wind Speed, m/s
A	10.33	3.7
B	1.72	3.8
C	2.37	4.2
D	29.43	3.7
E	29.61	2.8
F	14.48	1.6
G	12.06	1.0

Source: Louisiana Power and Light Company, 1974

Table 2-16. Summary of Air Quality Data Observed in Lafourche Parish as Compared to National Ambient Standards.

Pollutant	Average Time	Primary Standards[a]	Lafourche Parish
Particulate matter	Annual (Geometric mean)	75	41[c]
	24-hour[b]	260	103[c]
Sulfur oxides	Annual (Arithmetic mean)	80	3[c]
	24-hour[b]	365	13[c]
Carbon Monoxide	1-hour[b]	40	7.1[d], 8.4[e], 7.5[f]
Nitrogen Dioxide	Annual (Arithmetic mean)	100	7[c]
Photochemical Oxidants, O_3	1-hour[b]	160	321[c]
Hydrocarbons (nonmethane)	3-hour (6 to 9 a.m.)	160	327[g]

a. Units are in $\mu g/m^3$ except for CO which is in mg/m^3.

b. Not to be exceeded more than once per year.

c. For the year of 1976 (data source: EPA, 1978).

d. Highest reading as measured by the Louisiana Dept. of Hwy. at Gray, on LA 24 during March 1974.

e. Nederland, Texas, same as c., for comparison only.

f. West Orange, Texas, same as e.

g. Measured by the Louisiana Dept. of Hwy. at Raceland/U.S. 90 6 a.m. to 9 a.m. three hour reading on 28 March, 1974.

2.7 Unique Resources

2.7.1 Recreational Areas Existing and Proposed

Lafourche and Terrebonne Parishes offer ample outdoor and water oriented recreational opportunities. The East Timbalier Wildlife Refuge [137 ha (337 ac)] managed by the Bureau of Sport Fisheries and Wildlife, is located in Terrebonne Parish. The Isles Dernieres Preservation Area is also located within this Parish. Both areas are a haven for waterfowl, shore birds, and other wildlife species (Fig. 2-15).

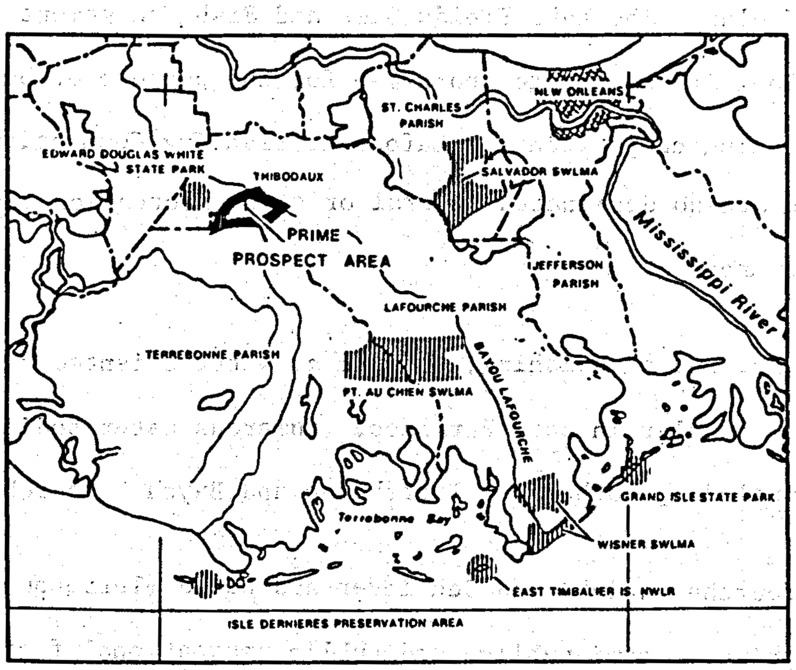


Figure 2-15. Federal and state conservation areas and parks.

Three state wildlife management areas are located within these parishes. The Pointe-au-Chien Wildlife Management Area 11,438.77 ha (28,243.88 ac) in Terrebonne Parish, the Lake Salvador Wildlife Management Area 8,756.58 ha (27,498.83 ac, part of it in St. Charles Parish) and the

Wisner Wildlife Management Area, 8,756.58 ha (21,621.20 ac) in Lafourche Parish. They allow public hunting, fishing, camping, birdwatching, and other forms of outdoor recreation.

The only area administered by the Louisiana State Park and Recreation Commission within the two parishes is the Edward Douglas White State Monument, 2.43 ha (6 ac) in Lafourche Parish. Southeast of Lafourche Parish in the neighboring Jefferson Parish, stands Grand Isle State Park, [56.7 ha (140 ac)], which is the closest state park to the Prime Prospect Area (Fig. 2-15). Directly south of the Prime Prospect Area is Lake Fields. The Lake Fields Game and Fish Management Commission leases lots along its shores to sportsmen for the purpose of building hunting and fishing camps (Central Lafourche Planning Commission, 1973). However, there are no designated Federal or state recreation areas in the Prime Prospect Area.

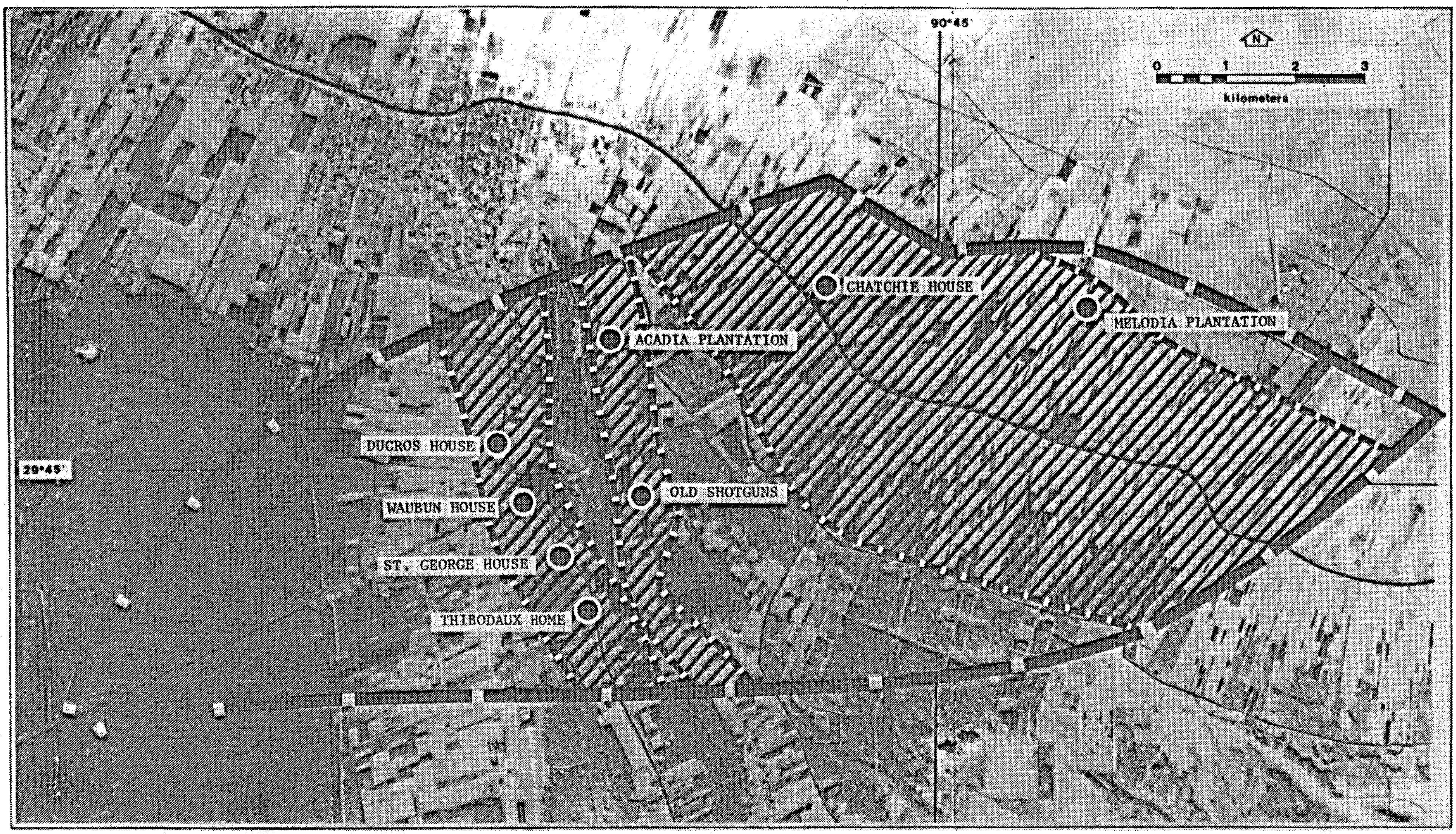
Hunting, fishing, and crawfishing, as well as water oriented recreational activities, are popular in both Parishes. Numerous water bodies satisfy these needs, including both Bayou Terrebonne and Bayou Lafourche.

Thibodaux (Lafourche Parish) and Schriever and Houma (Terrebonne Parish) have several private, semi-public, and public recreational facilities, such as swimming pools, golf courses, playfields, and school grounds, which are near or within the Prime Prospect Area (Section 6.2.3., Fig. 6-1). Several neighborhood parks and a regional park southwest of the Prime Prospect Area are planned for Terrebonne Parish.

2.7.2 Archaeological Sites

A Level I, Cultural Resources Survey was performed for the Prime Prospect Area. This level of survey is defined as a literature and map search to see if previously known sites are in the area and to determine high probability areas for site occurance (Department of Culture, Recreation, and Tourism, 1978). In addition, a one day driving survey was made through the area to observe the high probability areas.

No archaeological sites are located within the Prime Prospect Area. Two types of archaeological sites are expected within the areas, prehistoric and historic. The high probability areas for the two types of sites are approximately the same (Fig. 2-16). Sites are expected along the natural levees of the bayous from the crest of the levee to an area half way down the slope of the levee. Along Bayou Lafourche the high probability area differs from the usual pattern. The crest of the levee along Bayou Lafourche was first settled by small farmers in the 18th century. In the early 19th century Anglo-Americans came into the area to establish sugar plantations. Since the crests of the levees were already occupied, the Anglo-Americans settled half way down the levees. Sometimes a small farmer would sell his land fronting on the bayou to a plantation owner. The "big house" would then be built along the crest of the levee; but the quarters, sheds, and sugar house would be built half way down the levee (Rehter, 1971).



SIGNIFICANT HISTORIC SITES BUT NOT ENROLLED IN THE NATIONAL REGISTER

BOUNDARIES OF HIGH PROBABILITY AREAS FOR HISTORIC & PREHISTORIC SITES

Figure 2-16. Archaeological and historic sites and high probability areas in the Lafourche Crossing Prime Prospect Area.

After the well location is selected and before any site preparation or well construction begins, a Level II Cultural Resources Survey will be performed. A pedestrian survey will be made of the well site, access roads, and any other areas that will be directly impacted by the proposed action to determine if any archaeological sites are eligible for the National Register of Historic Places. Subsurface testing will also be conducted if necessary. A report of the survey will be submitted to the State Historic Preservation Officer and received prior to any site preparation or construction.

If an archaeological site eligible for the National Register is in the Prime Prospect Area, one of two alternatives must be chosen. One alternative is the avoidance of the archaeological site by either relocating the proposed action or by protecting the site (i.e. placing a fence around it to protect it from construction activities and construction workers). The second alternative is the excavation of the archaeological site. This alternative should be chosen only if there is no way to avoid the site. Excavation of an archaeological site is usually much more expensive than avoidance of the site. A report showing the location of the survey, the survey procedures, and the results of the survey must be submitted to the State Historic Preservation Officer (SHPO). The SHPO must review and clear the project prior to any work at the site.

2.7.3 Historical Sites

The Lafourche area was settled by small farmers in the 18th century. These farmers were of French and Creole origin and built on the crest of the natural levees. Beginning in the 1820s, Anglo-American planters arrived in the area to establish sugar plantations. Since the crest of the levee was already occupied, they settled half way down the levee (Rehter, 1971). Several old historical structures are located within the Prime Prospect Area; however, none are listed in the National Register of Historic Places. The Chatchie Plantation House is in the process of being nominated to the National Register, and several other structures are eligible for nomination but lack of time has delayed the process of nomination (Leslie, 1978).

Figure 2-16 shows the location of the plantation houses. Associated with these houses are tenant houses (often old slave quarters), sugar houses, barns, and sheds. These outbuildings are often away from the "big house", but they are also eligible for nomination to the National Register. These outbuildings are shown in Figure 2-16.

High probability areas for historic site occurance (Fig. 2-16) can be determined from the historic settlement patterns. These high probability areas are along the crest of the levees to half way down the levees. This hypothesis is modified around Bayou Lafourche due to the unusual settlement pattern found there. Along Bayou Lafourche the high probability area should extend from the crest of the levees to the toe of the levees.

A Level II Cultural Resources Survey will be performed after the well site is chosen to locate sites eligible for nomination to the

National Register of Historic Places. A report of this survey will be submitted to the State Historic Preservation Officer for review prior to any site preparation or construction.

There are three alternatives for mitigation procedures. One alternative is the total avoidance of the site. The second alternative is moving the structure to an aesthetically comparable area. The recording and measurement before disassembling the house is the last alternative.

2.8 Demographic and Socio-economic Setting

2.8.1 Demography

The Prime Prospect Area is located within Lafourche and Terrebonne Parishes. In 1975 Lafourche had a revised estimated population of 72,999 persons; Terrebonne Parish had a revised estimated population of 83,401 persons (Louisiana State Planning Office, 1977).

The most urbanized area of Lafourche Parish is represented by the City of Thibodaux (14,925 persons in 1970), the parish seat, which is adjacent to the Prime Prospect Area. The greatest concentration of development in this parish is found in a linear corridor along the natural levees of Bayou Lafourche following LA Highway 1. Part of this corridor lies within the Prime Prospect Area. Lafourche Parish had a population composition in 1970 of 89 percent white and 11 percent non-white.

Terrebonne Parish had a population of 76,049 persons in 1970. The Parish is classified as an urban parish since over 50 percent of its population lives in urban centers (U.S. Department of Commerce, 1972). As in Lafourche

Parish, development is greater along the natural levees of the bayous in a strip-clustered fashion.

The Prime Prospect Area contains part of the linear corridor along Bayou Terrebonne, leading south of Thibodaux in Lafourche Parish and north of Houma in Terrebonne Parish. Terrebonne Parish had a population composition of 81.9 percent white and 18.1 percent non-white in 1970. Although the majority of the Prime Prospect Area's population is white, there are a few concentrations of non-white groups, especially along the left descending bank of Bayou Terrebonne towards the town of Gray.

2.8.2 Ethnic Groups

Although Anglo-Americans settled along Bayou Lafourche and Bayou Terrebonne, the area is still considered Acadian (Bertrand, 1976). The French influence started before the Anglo-Americans arrived and continues into the present. There are no known Indian groups in the Prime Prospect Area.

2.8.3 Socio-Economic Characteristics

The principal economic activities in Lafourche Parish are mining, manufacturing, transportation, and trade; although most of the land in the Parish is used for agriculture (sugarcane fields) or is wetlands (marsh and swamp). Transportation is the major industry employer (21.9%), followed by manufacturing (21.8%), retail trade (19.6%), and mining (oil and gas extraction) (7.39%). Terrebonne Parish economic activities are also centered on mining, manufacturing, and retail trade. As in the case of Lafourche Parish, large tracts of land are in sugarcane fields or are marsh and swamp. The major industry employer is mining, followed by retail trade and manufacturing. Within the Prime Prospect Area are the following oil and gas fields: Southwest Lake Boeuf, Lafourche Crossing, Melodia, and Rousseau.

2.8.3.1 Agricultural Economy

Agricultural activities play a dominant role within the Prime Prospect Area. The principal crop within the Prime Prospect Area is sugarcane. Some small scale truck farming may be found in the Prime Prospect Area. Both parishes have experienced a steady decline in both the number of farms and the number of farmers in the last few years, although the average size of farms has increased (Landry, 1978).

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CHAPTER THREE - PROBABLE IMPACTS - DIRECT AND INDIRECT

3.1 Impacts Due to Drilling and Maintenance

3.1.1 Geology

Effects of hydraulic rotary drilling and well construction on the physical geology of the Prime Prospect Area can be divided into two classes: 1) effects related to well construction procedures, practices, or methods; and 2) well maintenance methods and procedures.

Most of the geologic effects of well construction such as mud invasion and acidizing are local, and can be measured in meters or tens of meters from the borehole. Only two procedures, hydraulic fracturing and squeeze (high pressure) cementing, may have effects observable at distances of hundreds or even thousands of meters from the borehole, in addition to having local impacts. Both of these downhole operations are highly specific with regard to depth and geologic setting; hydraulic fracturing is done to improve the permeability of a sandstone by filling (propping) pressure-induced fractures with sand grains larger than those of the fractured formation; and squeeze cementing is done to seal off a fluid-producing zone in a permeable formation. In some areas these procedures have been known to produce measurable uplift of the land surface, and even to result in observable fractures; but in the areas considered here, where hydraulic fracturing and pressure cementing in oil-test and production wells is a common practice, no such effects have ever been known to occur.

Well maintenance, in terms of procedures that might be employed to preserve or enhance the yield characteristics of geothermal production wells, might include acidizing or hydraulic fracturing, or both. Again, where properly employed, these procedures have not produced observable changes at the land surface.

3.1.2 Physiography

Drilling and maintenance of the proposed action will have no known significant adverse impacts on the physiography of the Lafourche Crossing Prime Prospect Area. The natural levees have a maximum slope of one to three percent and the backswamps are level; thus installation of the proposed action will not require reworking of large areas. There are no geologically unique features in the Prime Prospect Area.

3.1.3 Soils

Drilling and maintenance of the proposed action will not have significant adverse impacts on the soils of the Prime Prospect Area. Some soil erosion on the natural levees is expected from the installation of the drill pad and the access routes because of the low slopes and medium to very slow runoff characteristics. Overall, erosion should be less than that associated with sugarcane cultivation because the drill pad and access route will be covered by rock or gravel and the soil will not be exposed each year during cultivation. A plank road and drill pad surface will be used in the wetlands. The planks will retard runoff and erosion.

3.1.4 Groundwater

A groundwater well may be required to provide water during drilling operations. No measurable impacts are expected due to the limited duration of the activity and the limited volume of water required. Because groundwater needs are negligible, impacts such as surface subsidence and saltwater intrusion into the limited fresh groundwater zone are not expected to result from any of the drilling or maintenance operations.

It is likely that some brine, drilling muds, and possibly hydrocarbons (fuels and lubricants) will be lost to the surface at the well site either by inadvertant spills or leakage from storage pits. Surface spills will permeate arable soil, especially during dry periods, but only to some shallow depth due to the limited volumes likely to be spilled. Minor amounts of leakage are likely from the pits, even though they may be lined with an impermeable material. Whether the spill or leak is brine or fluid hydrocarbon, the effect will be long-lasting and difficult or impossible to remove. However, the impact will be small because the depth of contamination will be limited to near the surface and the area of the spill should be limited to the drill site. The limited fresh groundwater resources of the Prime Prospect Area, separated from the surface by more than 46 m (150 ft) of fine-grained deposits, should not be affected.

Subsurface impacts of drilling under normal operating conditions will be negligible because of the limited thickness of fresh groundwater and the surface casing program required by rules and regulations of the Louisiana Department of Conservation to seal off and protect the fresh water resources.

3.1.5 Surface Water

Potential impacts to surface water from drilling and maintenance are related to construction and development activities. Land clearing and leveling, road and drill pad construction, increased vehicular traffic, and other such activities associated with development and maintenance of the proposed action will cause increased runoff and erosion rates, increasing turbidity locally, and thereby degrading water use desirability or plant and animal habitat. This is an especially important concern in wetlands areas where rapid habitat changes result in pervasive environmental impact. Runoff from construction areas will contain oil and grease from vehicles and equipment, and chemicals from drilling muds. Existing drainage patterns may be further altered by road, storage pit, or levee construction, or by resulting channel sedimentation.

Flooding of the well site is a viable threat because of its potential location in a flood prone area. Site flooding could wash toxic materials and pollutants from the well site and storage pits into surrounding waterways where they could be quickly spread throughout the wetlands environment. The nature of surface water use for crop irrigation and domestic raw water supply in the Prime Prospect Area will make containment of such potential impacts especially important. Flood walls or impounding levees around the construction site may be necessary, depending upon the exact site selected within the Prime Prospect Area (Overlay).

3.1.6 Wildlife and Vegetation

Impacts associated with the drilling and maintenance of the proposed action may be of a direct or indirect nature and of permanent or temporary significance. Expected impacts are dependent upon such factors as:

1) standard procedures involved in well drilling and maintenance,
2) well siting, (whether in wetlands or better drained natural levees,
3) care taken in drilling and maintenance operations, and
4) mitigation measures incorporated into the drilling program.

The major impact expected from well drilling will be loss of habitat. Installation and maintenance of a geothermal well site within the Prime Prospect Area will require a commitment of up to 0.4 ha/km (1.7 ac/mi) for roads and 1000 m^2 (¼ ac) for drill pads. An additional 1.6 ha (4 ac) will be temporarily committed for the combined use of equipment storage, sumps, and laydown areas during installation (Overlay). Vegetation, and therefore existing wildlife habitat, will be lost in these areas. Wildlife presently existing on these proposed transportation corridors will be lost or displaced.

If roads are constructed such that natural drainage is impeded, water and nutrient flow from natural levees to cypress-tupelo swamps will be changed. This change may alter vegetation and productivity in the affected areas. Where water is impounded, woody vegetation may be killed and replaced by aquatic vegetation. Roads generally have the least impact in these areas if constructed parallel to drainage with culverts wherever necessary to provide unimpeded water flows.

Road construction and eventual road usage can also be expected to generate dust, especially under dry weather conditions. Dust coating the leaves of nearby vegetation can impair growth and reduce photosynthetic activity by reducing CO_2 exchange (Treshow, 1970). A slightly lower aquatic production in nearby water bodies may also result from increased surface water turbidity due to soil erosion during the installation phase.

Other changes in environmental quality may be associated with chronic and/or sudden release of gas, oil, bleed water, drill mud, or machine lubricants. Although there is little data available on the effects of such actions (St. Amant, 1972), certain potential impacts must be discussed.

Drilling mud, discharged at the surface and held in an impervious sump, will contain toxic chemicals and pollutants that should present only a localized impact at the storage area site. Some constituents used in drilling fluids and muds are included in Table 3-1. There is a remote possibility that some wildlife may use the sump area as a source of water or for other activities such as feeding, resting, or preening. Of even lesser possibility is the potential for an individual animal to pick up a sublethal dose of a toxic chemical and then be bagged and eaten by an unsuspecting hunter. If the sump area was allowed to dry, the contents could be blown over surrounding areas and become a problem to vegetation and wildlife.

Table 3-1. Some Constituents Used in Drilling Fluids and Muds and Selected Toxicities.

CONSTITUENT[1]	COMMENTS[2]	CONCENTRATION IN MUDS[2] (ppm)	96 hr. TLm[3] Fish	96 hr. TLm[3] Sea	TLV[4] (mg/m^3)
X Quebracho extract	Biodegradable	6,000-15,000	135	158	
x Lignosulfonates, calcium and chrome derivatives		12,000	7,800	12,000	10.0
Acrylonitrites (such as hydrolyzed polyacrylonitrite)					
Sodium salts of meta and pyrophosphoric acid					
Natural gums					
Tannins					
Molecularly dehydrated phosphates					
Subbituminous products					
Protocatechuic acid					
Barite					
Lignins (such as humic acids)					
Bentonite		15,000-105,000	14,500	100,000	<10.0
Sugarcane fibers					
Lime	irritating to skin and eyes	1,500-6,000			5.0
Granular material, such as ground nutshells		6,000-90,000			
Corn starch					
Saltwater					
Soluble caustic/lignin product					
Carboxy methyl cellulose					
X Crude oil					
X Sulfonated crude oil					
X Oil emulsions					
X Sodium chromate	must not be discharged to environment	750-6,000			0.5
Anionic and nonionic surfactants					
Organophylic clay		1,500-6,000	3,000	8,600	10.0
X Soaps of long-chain fatty acids		66,000-120,000	570	140	10.0
Phospholipids (e.g., lecithin)					
X Asbestos	very toxic	15,000-30,000			2 fibers/cc
Unisteam					

X = Greatest potential adverse impact on local vegetation and fauna

Source: 1) Collins, 1975, p. 463
2) O.P.G.E.E., 1977
3) 96 hr. TLm: the ppm required to kill 50% of the organisms in 96 hours
4) TLV: Level of pollutant below which a worker could be subject for 8 hours a day for 5 days a week.

Drilling muds and their associated chemicals are to be reinjected before the site is abandoned. However, if any toxic materials are left in the sump area, they may be taken up by vegetation and thereby incorporated into the local food web.

The hunting recreation currently provided in some of the Prime Prospect Area will probably be curtailed for some distance around the well site. The well construction and maintenance may also decrease hunter success and the quality of the recreational outing.

3.1.7 Land-use

Impacts on land-use from the proposed action would largely depend on the exact location of the well site. Urban and built-up areas, agricultural areas (sugarcane fields) including Prime Farmland areas, and wetland areas may be required by the proposed action.

About 0.69 ha (1.02 ac) for each kilometer (0.6 mi) of access route and about 1000 m^2 (0.25 ac) for each drilling pad will be altered as a result of the proposed action. During well drilling, another 1.6 ha (4 ac) (Overlay) per drill site will be altered adjacent to each well. After completion of each well, the affected areas are scheduled to be converted to their pre-project conditions by planting native species or appropriate crops. Land-use changes and environmental impacts will be minimized by laying pipelines going to the injection wells next to the access route.

3.1.8 Socio-economic

The labor force to be employed during the time of drilling and maintenance for the proposed action is expected to be commuter oriented from communities near the Prime Prospect Area.

Impacts on public services as a result of the proposed action will be non-existent or negligible since the working force is expected to come from nearby areas. Due to the small size of the operation and its short duration, economic impacts will not be significant.

3.1.9 Air Quality

Since there are only very limited studies (ERDA, 1977a) relating to the impacts on air quality due to geothermal exploration and production, the following discussions are given only as a first approximation.

Construction-related impacts on air quality will result from dust, exhaust emissions from construction machinery, and noncondensable gases released from geothermal fluids during preconstruction flow-testing. Since the land will be disturbed in connection with construction of additional drill pads, access routes, pipelines, and other related activities, dust will inevitably be generated. Because the concentration of total suspended particulate in the air is within ambient standards in the Prime Prospect Area as shown in Section 2.6.3, the added effect on air quality due to construction is minimum.

Exhaust emissions from drilling and construction machinery will include SO_2, NO_X, CO, hydrocarbons, and particulates. Diesel drives for the drilling rigs typically consume 2000 litres/day (550 gal/day) of fuel, resulting in emissions of approximately 23 Kg/day of CO, 9 Kg/day of particulates (ERDA, 1977b). The emissions associated with the operation of diesel-powered equipment for 5 days to prepare a well pad would be equivalent to those associated with a single day of drilling. A small amount of polluting emissions will also result from the operation of delivery trucks and private vehicles. These releases are expected to be minor, short-term, and should be readily dispersed because about sixty percent of the time the atmospheric stability classes are in D and E (Section 2.6.2). The accumulated level of impacts due to exhaust emissions from drilling and construction machinery is negligible.

Noncondensable geothermal gases will be released during drilling (ERDA, 1977b). Although the weight of the drilling mud should prevent a large release of gases to the surface during drilling, the mud will carry some gases to the surface. These gases will be released to the atmosphere from the water/steam separator at the well, from the drilling-mud cooling tower, and from the liquid sump. Maintenance of sufficient pressure within the well to protect against blowouts should result in acceptably low levels of gas emissions during drilling.

3.1.10 Recreation, Archaeological and Historical Sites

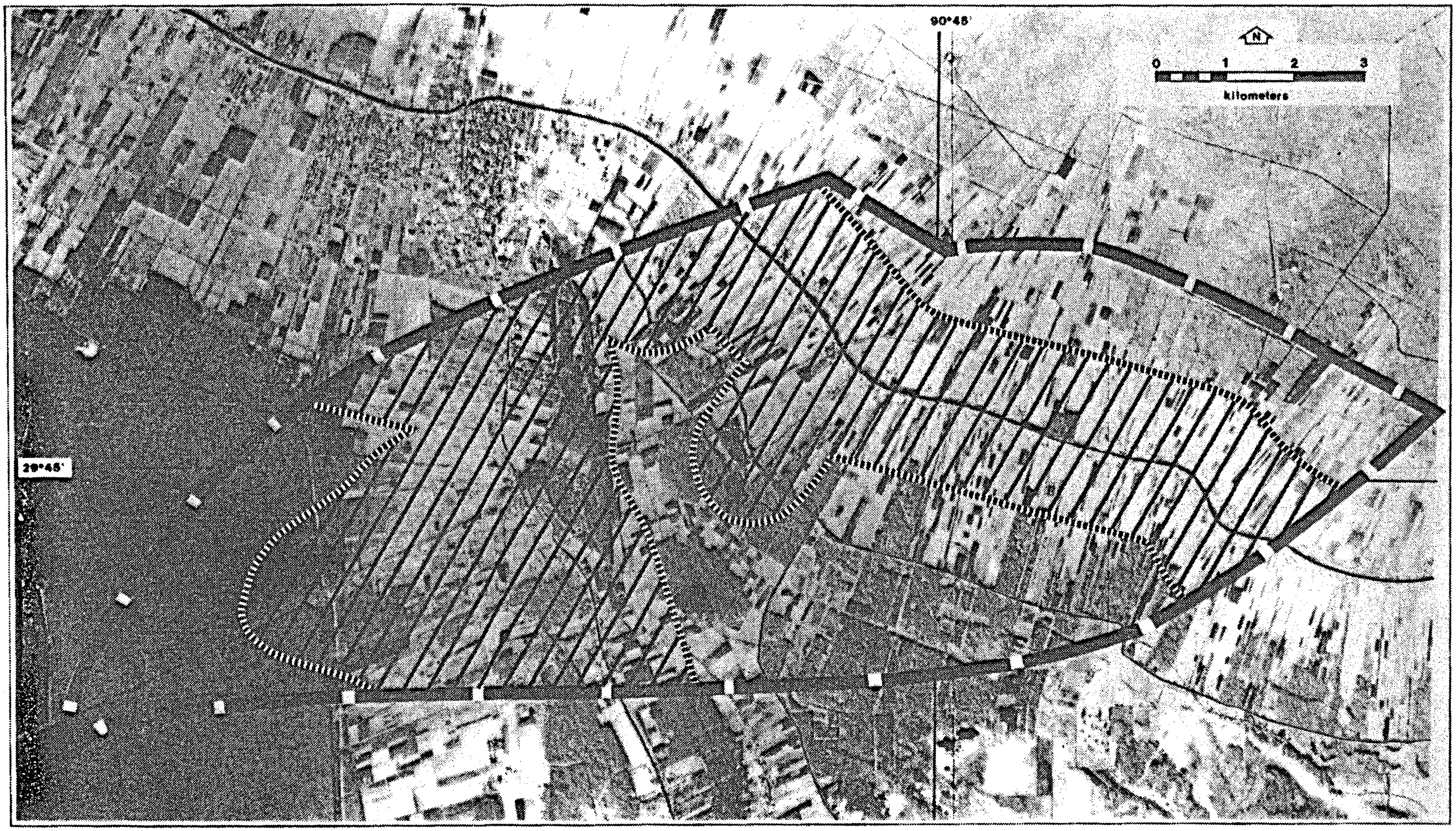
Depending on the exact location of the proposed action, the existing recreational areas could be impacted by drilling and maintenance. Archeological and historic sites could be destroyed by site preparation and drilling operations. If archaeological or historical sites eligible for the National Register of Historic Places will be damaged or destroyed structurally or aesthetically by the proposed action, mitigation procedures will be taken prior to the work.

3.1.11 Federal, State, Regional, and Local Land-use Programs

None of the Federal, state, and regional agencies contacted which responded foresee any conflicts with their projects resulting from the proposed action. Coordination with local governmental agencies plans and activities will be obtained prior to development of the proposed action.

3.1.12 Noise

Noise from the proposed action will vary in level and frequency depending on the particular operation occurring at any given time. During operation, an average drilling rig will produce a noise level of approximitely 90 dBA at 6 m (20 ft) from the engine room. An unmuffled, venting well will produce about 120 dBA at 31 m (100 ft) from the wellhead. The topography in the Prime Prospect Area is essentially level (less than three percent slope). Figure B-1, Appendix B, depicts the noise produced by normal operation of a drill rig as contour lines. Any rural residences within 2000 m (1.25 mi) (Overlay) of the drill rig will be in a noise level zone above the DOI minimum criteria for night noise. The suburban criteria for night noise is exceeded within 1500 m (5000 ft) of the well. Under normal operating conditions, anticipated noise levels will not exceed the criteria established in GRO Order #4. (Figure 3-1). These are generalizations because tree cover and structure type will affect noise attenuation. This is discussed in detail in Appendix B.



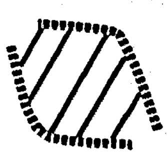

AREA WITHIN .8 KM (.5 MI) OF MAJOR CONCENTRATIONS OF RESIDENCES

Figure 3-1. The .8 km (.5 mi) noise zone around high population areas.

3.2 Impacts Caused by Flow-testing of the Proposed Action

3.2.1 Geology

The possible geologic impacts of flow-testing or operation of the proposed action are 1) land subsidence, and 2) contamination of or hydraulic effects upon the surface environment in the vicinity of the proposed action, or the subsurface environment, consisting of both fresh and saline aquifer systems. All such impacts are of a secondary nature, occurring as a consequence of fluid withdrawal, or fluid escape, from formations in the geopressure zone.

Effects of flow-testing on the physical geology of the Prime Prospect Area are those resulting from fluid pressure changes in the reservoirs tapped by the wells. Flow tests involve relatively small total volumes of produced fluids, by comparison with the volumes of fluid withdrawn during commercial operations. Detailed records for wells and well fields which have produced from geopressured reservoirs comparable to the ones to be flow tested at the Lafourche Crossing Prime Prospect Area indicate that no adverse environmental consequences should result from flow testing. Wallace (1962) describes the relation of production to reservoir pressure (Pz versus cumulative production, and cumulative water production) for numerous geopressured gas reservoirs in south Louisiana. Graphs of the relationships among these factors for four case history reservoirs are shown in Figures 3-2 and 3-3. No land subsidence was observed as a consequence of fluid withdrawals. A more detailed discussion of fluid withdrawals in the vicinity of the Prime Prospect Area is presented in Appendix C. Injection of brines will not result in fault activation. The brines will dissipate in the saltwater aquifers.

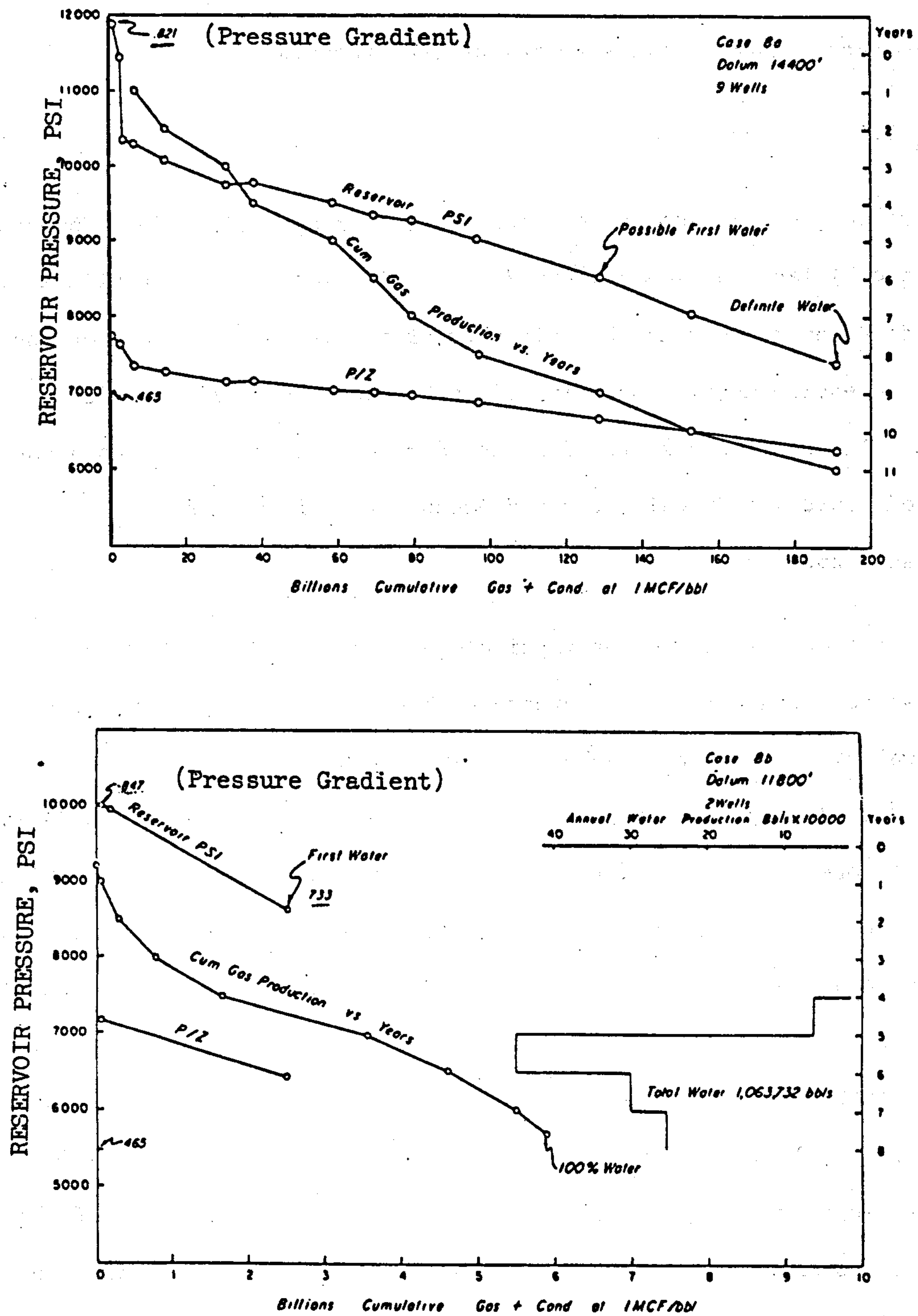


Figure 3-2. Relationship of production to reservoir pressure for geopressured gas reservoirs in south Louisiana (1) (After Wallace, 1962).

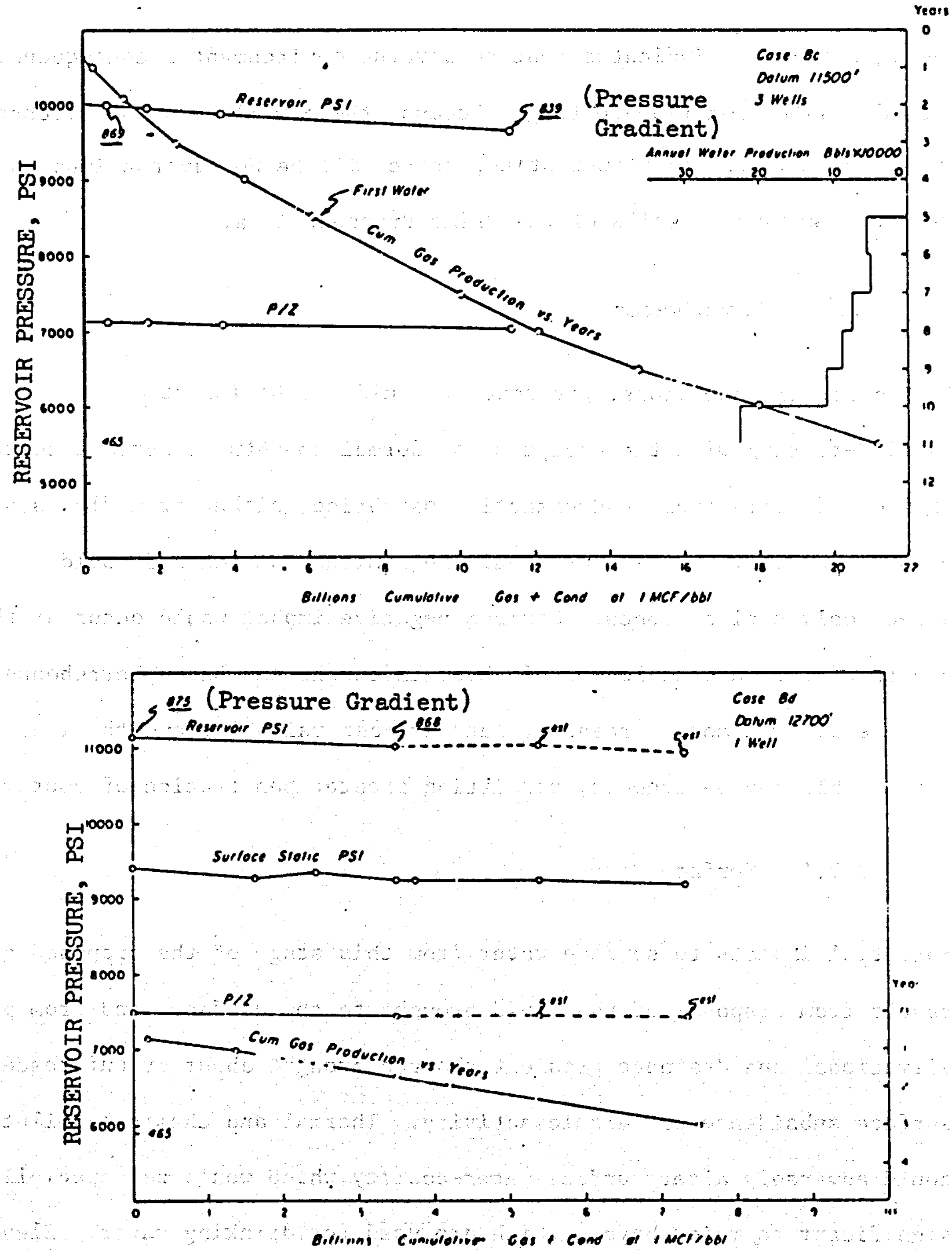


Figure 3-3. Relationship of production to reservoir pressure for geopressured gas reservoirs in south Louisiana (2) (After Wallace, 1962).

3.2.2 Physiography and Soils

Geologic analysis indicates that no adverse environmental consequences should result from flow-testing. Because there will be no subsidence of the surface due to flow-testing, there will be no adverse impacts on the physiography or soils of the Prime Prospect Area.

3.2.3 Groundwater

During normal conditions, groundwater would not be impacted by flow-testing with the exception of normal amounts of surface contamination of soils from inadvertantly lost brine, either from flow systems or storage pits. The impacts would be limited in area and would affect only shallow zones. Maximum negative impact would occur at the crests of the natural levees of Bayou Lafourche and Bayou Terrebonne where soils are most permeable, land is most valuable, and the local water table may be deepest, permitting greater penetration of contaminants.

3.2.4 Surface Water

Potential impacts to surface water from this stage of the proposed action result from disposal of the fluid brought to the surface, and from possible elevational and drainage gradient changes brought about by unforeseen land surface subsidence or seismic activity. Thermal and chemical pollution could adversely alter surface water quality which would be especially significant to major bayous which are used for drinking water. Elevation changes could alter surface flow patterns and present limits of swamp or marsh, disrupting irrigation and navigation uses or environmental systems dependent upon existing gradient flows and water regimes. Additionally, such elevation changes could increase saltwater encroachment in wetlands areas, impacting irrigation and domestic water supply uses.

3.2.5 Wildlife and Vegetation

Flow-testing and operation of the well may either directly or indirectly affect biota in the vicinity of the well site. Potential impacts directly generated from flow-testing and operation include liquid and gaseous effluents and noise. Potential impacts indirectly generated include dust, exhaust, and noise from increased automotive traffic to and from the well site.

Geothermal effluents are extremely hot brines and may contain concentrations of toxic elements in solid, liquid, or gaseous form. If released into the environment, any of these properties could cause adverse biological impacts. However, proper containment, insulation, and disposal (reinjection into saline aquifers) of geothermal products during normal operations should assure a minimal effect on the plant and animal life. It may, however, be necessary to flare uncondensable geothermal gases instead of reinjecting them. This may cause local increases in H_2S, SO_x, or CO_2 levels. If the H_2S is in high concentration, it may lead to acidification of water which may in turn solubilize the trace heavy metals (Schieler, 1976).

H_2S, a possible air pollutnat resulting from a blowout, can be highly toxic to terrestrial and aquatic flora and fauna. H_2S could be toxic within approximately 91 m (300 ft) of the blowout site. Beyond this distance H_2S will oxidize and the SO_x oxidation products could be toxic up to about 762 m

(2500 ft) (ERDA, 1976). If wind conditions are light and these substances remain in the atmosphere near the ground or are washed onto ground surfaces by rainfall, the soils and surface waters could become more acidic, and less conducive to plants and aquatic life. The impact will vary because plants and animals have differing tolerances to pH. The most severe impact would be to those areas used for agricultural production and/or acidic soils such as swamp or marsh. A change in soil pH would cause a change in nutrient availability and uptake by plants. Thus, plant growth and production would be altered and certain heavy metals may become more available to plants (and therefore the entire food chain). Agricultural crops may either be killed, have low production, or be unfit for human consumption. Soils already having a low pH may become intolerable for most biotic species if pH is lowered considerably.

Noise, another direct product of the proposed action, should cause only temporary movements of animals away from the well site.

During periods of flow-testing and operation, vehicular traffic to and from the well site is expected to increase. Automotive exhaust and dust may decrease vegetative productivity, especially for vegetation close to the roads, but should not cause permanent damage.

If the well is tested or operates during the hunting season, noise generated from the well operation and traffic moving to and from the well site may lessen the quality of the outdoor experience and decrease hunter success near the well site.

3.2.6 Land-use

No impacts are expected on land-use from the flow-testing and operating of the proposed action other than the commitment of land in the drilling of the proposed action.

3.2.7 Socio-economic

No socio-economic effects are expected in the Prime Prospect Area as a result of flow-testing and operation of the proposed action because of the commuter oriented work force and its small size.

3.2.8 Air Quality

Well-testing will result in the direct release of steam and a variety of other gases and particulates for approximately 70 days (ERDA, 1977a). The contaminant of greatest concern is hydrogen sulfide. Other gases that may be emitted are CO, NO_x, NH_3, CH_4, N_2, and H_2, based on typical noncondensable gas content for pressure fluids. Particulates released with the geothermal fluids or raised by equipment should not add significantly to the background level of particulates in the proposed well site area. The short duration of these emissions makes it unlikely that the air quality will be significantly affected outside of the immediate area of the well.

The impact of flaring the gases from a single plume is expected to be small, based on experiences from similar geothermal well tests (ERDA, 1977a). This particular project is miniscule when compared to the many flares which exist in major refineries, such as in the Lake Charles area, where the air quality is still within standards.

The impact of the cooling tower is expected to be negligible because of the small size required for the single well operation. A possible impact would be the increased occurrence of fog or the formation of steam fog during freezing temperatures in winter; but the frequency is small, since the mean number of days with the temperature equal or less than $0^{\circ}C$ ($32^{\circ}F$) as observed at Houma area is approximately 5 days per year.

3.2.9 Recreational, Archaeological, and Historical Sites

There will be no adverse impacts on known recreation or archaeological or historical sites as a result of flow-testing or operation of the proposed action.

3.2.10 Federal, State, Regional and Local Land-use Programs

None of the Federal, state and regional agencies contacted which responded foresee any conflicts as a result of the proposed action. Impacts or conflicts with the Lafourche waterway maintained by the U.S. Army Corps of Engineers will largely depend on the exact location of the proposed action. Coordination with local authorities will be sought before starting operations.

3.2.11 Noise

Noise from engines and venting may impact selected receptors. The degree to which this occurs will depend on the final location of the proposed action within the Prime Prospect Area (Overlay) (Section 3.1.12).

3.3 Unavoidable Direct and Indirect Impacts

3.3.1 Impacts from Drilling and Maintenance

The unavoidable impacts from drilling and maintenance may be summarized as follows:

1) Approximately 2 ha (5 ac) of wetlands will be destroyed for the well site if the proposed action is located in the interdistributary swamps.

2) Approximately 2 ha (5 ac) of Prime Farmland will be removed from productivity during the duration of the proposed action if the well is located on the natural distributary levees.

3) The natural levees are already modified by agricultural practices. Soil erosion is expected during the preparation of the road to the site and at the well site; but for the duration of the proposed action it will not exceed that already occurring in the agricultural fields.

4) Small amounts of brine, drilling muds, and hydrocarbons will be spilled during normal drilling and maintenance operations. However, the impacts will be limited in areal extent and depth and will not affect the artesian groundwater resources. Significant impacts such as land subsidence and saltwater intrusion, which accompany heavy groundwater use in some coastal areas, will not occur as a result of planned drilling and maintenance activities.

5) Access routes will alter existing drainage patterns. Runoff will increase turbidity in watercourses and degrade water use desirability and natural habitat during the installation phase.

6) The greatest impact due to drilling and maintnenance of a well will be the loss of habitat for drill pads and access routes. Biotic productivity in and near roads used for access to the well site may be reduced. Hunter success and the quality of the outdoor experience near the well site may be reduced.

7) Because the concentration of total suspended particulate in the air is within National Standards in the Prime Prospect Area (Section 2.6.3) the added impact on air quality due to construction is small. The accumulated level of impacts due to exhaust emission from drilling and construction machinery is also negligible. However, in order to prevent possible blowouts, maintenance of sufficient pressure within the well is very important. This should result in acceptably low levels of gas emissions during drilling.

8) There is a potential for noise impact from the proposed action in the Prime Prospect Area. The number of receptors affected and the degree of impact will depend on the final site location.

3.3.2 Impacts from Flow-testing and Operation

The unavoidable impacts from flow-testing and operation may be summarized as follows:

1) In all probability, some brine will be lost to the soil but the impact will be local and will not affect groundwater resources.

2) Gaseous releases, noise, and increased vehicular traffic, either directly or indirectly generated during testing and operation of a geothermal well, may cause adverse biological impacts.
3) Well-testing will result in the direct release of steam and a variety of other gases and particulates. The short duration of these emissions makes it unlikely that the air quality will be significantly affected outside of the immediate area of the well. However, due to the noxious odor of H_2S, inhabitants within a 3.2 km (2 mi) radius of the well should be informed.

The impact of flaring the gases from a single plume is expected to be small. The impact of the cooling tower is expected to be negligible due to its small size. (However, it may cause a "steam fog" during freezing temperatures in winter, but the frequency of freezing temperature is only five days per year in the Prime Prospect Area).

4) Some noise impact is expected from flow-testing and operation of the proposed action.

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CHAPTER FOUR - PROBABLE CUMULATIVE AND LONG-TERM ENVIRONMENTAL EFFECTS

4.1 Adverse

4.1.1 Geology

Unless the test well blows out and craters, or flows out of control for a long time (months or years), there will be no long-term environmental effects. Geopressured zone reservoirs commonly show rapid fluid pressure recovery to conditions very close to initial reservoir pressure following long periods of production at very large flow rates (Wallace, 1962). No adverse effects to the physical setting, in terms of geology, should be expected unless blowout occurs.

4.1.2 Physiography and soils

Interdistributary swamps will be destroyed by the installation of the proposed action (Overlay). During normal operations, cumulative and long-term adverse impacts will be limited to soil contamination by small amounts of drilling fluids, fuels, lubricants and brine. Soil contamination by such fluids could have long-term effects, but the volume of brine leakage should be small and the impact would be limited to the production well, pipelines, and disposal well sites. Normal system maintenance should insure that brine leaks are minimal and corrected when they are detected.

4.1.3 Groundwater

Local groundwater resources should not be adversely impacted.

4.1.4 Surface Water

Installation of the well will cause a change of water circulation patterns as a result of roadbeds, levees, impoundments, and other constructed impediments to wetlands hydrology. Water quality will be altered by chemical or thermal pollution, and from runoff containing lubricants and other toxins introduced into the environment by development of the well site.

4.1.5 Wildlife and Vegetation

The probable cumulative and long-term effects are similiar to those of most oil and gas well operations in Louisiana. The chronic low level discharges of oil, bleed water, machine lubricants and oil-emulsion drilling mud from prolonged drilling activities may have a long-term, cumulative effect on biological productivity in the vicinity of the well. Coating of vegetation and bottom sediments by oil emulsion drilling muds could lead to the imparting of an oily taste to animals that feed on these materials. Drilling muds may render ducks inedible.

Localized biological deserts are common sites around tank batteries, separators and similar facilities (St. Amant, 1972). If brine discharges are present on terrestrial sites, salt accumulation on fine-textured soils such as are present in the Prime Prospect Area would retard, if not totally prohibit, reestablishment of vegetation for many years (Coody, 1978; Landry, 1978).

Although vegetation and wildlife may recover from a short period of interrupted water and nutrient flow, roads which impede flow for a long period of time generally have a longer lasting impact on the affected species. These impacts can be minimized if roads are constructed parallel to drainage (where possible), and culverts, if used, are kept clean to allow unrestricted water movement.

4.1.6 Land-use

The cultural setting of the Prime Prospect Area is that of a rural community which is experiencing rapid growth. Industrial, commercial, and residential expansion of the cities of Thibodaux (Lafourche Parish) and Houma (Terrebonne Parish) influence development in the Prime Prospect Area. Settlements are predominantly in a strip cluster fashion, although more concentrated clusters running back from the natural levees are beginning to occur. Large tracts of land within the Prime Prospect Area are under sugarcane cultivation, the area's main agricultural crop.

Since the majority of the 30 to 50 workers which would be required during drilling and testing of the proposed action are expected to commute from nearby communities, no major cumulative and long-term adverse environmental effects are expected upon land-use.

4.1.7 Socio-economic

No adverse cumulative and long-term socio-economic effects are expected to occur in the Prime Prospect Area as a result of the proposed action. Since the drilling and testing time is of a short duration, and since no large influx of specialized workers into the area is expected, there would not be significant socio-economic impacts.

4.1.8 Air Quality

There are no known long-term or cumulative impacts on the air quality of the Prime Prospect Area.

4.1.9 Recreation, Archaeological and Historical Sites

No long-term effects are expected upon recreational areas resulting from the proposed action. One long-term effect on culture would be the damage to archaeological and historical sites that could be caused by greater accessability to those sites near the access routes. Vandalism is a major problem and is irreparable.

4.1.10 Federal, State, Regional, and Local Land-use Programs

The impact of the proposed action on Federal, state, regional, and local land-use plans in the Prime Prospect Area depends on the site location. There are navigable waterways, state lands and highways, and regional and local flood control projects and facilities which may be affected by the location of the proposed action. However, through coordination with all levels of government, adverse impacts will be minimized by avoiding sensitive land-uses.

4.1.11 Noise

The well site will be able to meet applicable Federal noise regulations if positioned properly and adequate mufflers are maintained. Since the majority of the noise produced by the operation will be during drilling, this effect will only be of short duration. Therefore, no negative long-term cummulative effects are anticipated from the proposed action.

4.2 Beneficial

4.2.1 Geology

Beneficial effects to the physical setting in terms of geology might include the creation of a relatively shallow reservoir of lowgrade heat as a result of waste-water disposal operation. This would be inconsequential if the volumes produced and disposed of are small.

4.2.2 Physiography and Soils

No known cumulative or long-term beneficial impacts will affect the physiography or soils of the Prime Prospect Area as a result of the proposed action.

4.2.3 Groundwater

Testing and producing a geothermal well at the Lafourche Crossing site is not expected to produce beneficial effects for the local groundwater resources.

4.2.4 Surface Water

If the consistency of the produced fluids allows, the produced waters could be used beneficially to supplement low stream flows and to dilute municipal and industrial waste effluent; or possibly they could supply a supplemental source of industrial processing or make-up water, leaving more of the surface water available for higher categories of use. Industrial requirements regarding dissolved solids content of raw waters are quite variable. Table 4-1 indicates maximum values accepted by various industries for process requirements.

Table 4-1. Total Dissolved Solids Concentration of Surface Waters That Have Been Used as Sources for Industrial Water Supplies

Industry/Use	Maximum Concentration (mg/l)
Textile	150
Pulp and Paper	1,080
Chemical	2,500
Petroleum	3,500
Primary Metals	1,500
Copper Mining	2,100
Boiler Make-up	35,000

Source: EPA, 1976

4.2.5 Wildlife and Vegetation

Whenever land-use changes occur, habitat for existing vegetation and wildlife is destroyed while habitat is created for other species. Land disturbances or changes in elevation, soil moisture, and soil or water chemistry will benefit species more tolerant of the newly created habitats.

4.2.6 Land-use

There are no expected beneficial impacts upon land-use as a result of the proposed action.

4.2.7 Socio-economic

Since the working force for the proposed action is expected to be commuting from nearby communities, economic benefits will be non-existent or minimal. Since no out-of-state workers are expected to move into the Prime Prospect

Area as a result of the proposed action, the cultural setting of the region is expected to remain unchanged.

4.2.8 Air Quality

There are no known beneficial impacts to the air quality of the Prime Prospect Area as a result of the proposed action.

4.2.9 Recreation, Archaeological and Historical Sites

There are no known beneficial impacts to recreation in the Prime Prospect Area as a result of the proposed action. New archaeological or historical sites may be located by the survey for the proposed action. Thus, they may be preserved or excavated before other uses destroy them.

4.2.10 Federal, State, Regional, and Local Land-use Programs

As local governments realize the area's potential for geothermal resources, they may develop and adopt regulations concerning these resources. No other beneficial cumulative and long-term environmental effects are expected as a result of the proposed action.

4.2.11 Noise

There are no known beneficial impacts from the noise of the proposed action on the Prime Prospect Area.

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CHAPTER FIVE - ACCIDENTS

As of the preparation of this document, there are no known detailed studies of well blowouts or other accidents associated with geothermal-geopressured wells in the Gulf Coast area. However, EPA conducted studies on two well blowouts in the wetlands of south Louisiana which indicate the possible areal extent of contamination from such accidents. These two well accident studies were on the Edna-Delcambre #4 well in Vermilion Parish, Louisiana (ERDA, 1976) and the McCormick Oil and Gas Well 1.6 km (1 mi) south of Intracoastal City, Louisiana (Castle, 1975). The Edna-Delcambre well blew fluid into the air approximately 30 m (100 ft). As a result of winds, brine fallout occurred at a maximum distance of 610 m (2000 ft) (Overlay) from the well site. At the McCormick Oil and Gas Well, maximum drift of fluid discharge was approximately 1828 m (6000 ft) (Overlay). Major contamination extended out 1525 m (5000 ft) and covered an area of 269 ha (665 ac) (Castle, 1975). The type of fluid and amount of discharge will depend on the character of individual wells. Some indication of what may be found in the Prime Prospect Area (Tables 5-1, 5-2, and 5-3) is available from other studies (Hankins et al., 1977; Wilson et al., 1977; Karkalits and Hankins, 1978). These estimates of components and concentrations were used to estimate the potential adverse impacts resulting from the proposed action.

OSHA guidelines protect worker health and welfare at the site of the proposed action. These programs are well defined and are the responsibility of the driller. The Department of Energy is directly concerned with reducing the potential of an accident which results in the uncontrolled release of heated brines and other fluids and gases into the environment. In other words, DOE wishes to avoid a blowout during the proposed action. In order to reduce the

Table 5-1. Summary of Water Analyses from an Edna Delcambre Well.

Component	Sand #3	Sand #1
	Concentration, mg/l	
Total Dissolved Solids	115,000	133,000
Total Hardness (as $CaCO_3$)	6,100	6,800
Chloride	67,000	80,000
Silicate (as SiO_2)	58	57
Bicarbonate (as $CaCO_3$)	1,100	1,100
Calcium	1,700	2,100
Magnesium	160	180
Iron	7	11
Zinc	<1	1
Strontium	290	400
Boron	60	63
Sodium	43,000	46,000
Potassium	290	290
pH	6.2	6.1

Source: Hankins *et al.*, in press

Table 5-2. Range of Concentrations Reported for Louisiana Geopressured Waters.

Component	Concentration, mg/l Minimum	Concentration, mg/l Maximum	Number of Analyses Reported
Total Dissolved Solids	200	345,000	64
Sodium	10	103,000	65
Potassium	50	1,100	45
Calcium	8	33,000	65
Magnesium	0	24,000	63
Chloride	10	201,000	66
Sulfate	0	407	61
Bicarbonate	0	2,500	65
Lithium	2	18	46
Strontium	3	265	10
Barium	4	1,000	34
Bromine	14	213	44
Iodine	5	74	45
Boron	18	67	38

Source: Wilson *et al.*, 1977

Table 5-3. Typical Gas Analysis from Delcambre Test Well

Component	Mole % Sand #3	Mole % Sand #1
CO_2	1.08	2.03
N_2	0.29	0.13
CH_4	92.78	95.36
C_2H_6	3.47	1.73
C_3H_8	1.12	0.37
i-C_4H_{10}	0.42	0.09
n-C_4H_{10}	0.32	0.09
i-C_5H_{12}	0.14	0.05
n-C_5H_{12}	0.09	0.04
C_6's	0.09	0.02
C_7 plus	0.20	0.09

Source: Karkalits and Hankins, in press

possibility of such an accident, blowout preventers will be installed, high pressure pipes and valves will be used, and casings will be cemented into place and overlapped. Annular space of each well will be cemented completely from the formation to the surface to provide greater stability to ensure sealing of aquifers. A spill prevention control and countermeasure plan will be devised. Weighted mud and high pressure mud pumps capable of injecting mud into the well to control pressures will be used during the proposed action.

5.1 Accidents During Site Preparation and Access Construction

5.1.1 Geology

Negligible effects on geologic conditions may be expected as a consequence of accidents during site preparation and access construction.

5.1.2 Physiography and Soils

There will be no adverse effects on the physiography of the Prime Prospect Area as a result of an accident during site preparation and access construction because there are no unique physiographic features. Soils may be contaminated if there is a spill of fuels or other toxic substances being transported to the site of the proposed action. The extent and degree of impact depends on the type and quantity of substance spilled.

5.1.3 Groundwater

Spillage of fuels or other foreign substances may contaminate shallow groundwater, but will not penetrate to deep groundwater resources.

However, the degree of impact will depend on the amount and type of spill and its location in the Prime Prospect Area.

5.1.4 Surface Water

Accidents during site preparation and access construction would be those common to any construction or industrial development requiring use of heavy machinery, vehicles, and petroleum or other toxic products. Leaking or overturned lubricant tanks would introduce pollutants into surface drainage networks. Fire and explosion would have the same effect. Toxins in drilling muds and other materials being brought to the site represent a potential impact if they are, by accident, leak, or collision, allowed to mix with surface waters and be distributed throughout the swamps and marshes.

In the Prime Prospect Area, construction accidents could close drainage ditches or breech levees and retaining structures. The effect would be to alter established surface flow patterns, allowing otherwise segregated water sources to mix.

5.1.5 Wildlife and Vegetation

Accidents having the greatest probability of occurrence during site preparation and access construction include spills and fire. Accidental spills of lubricants, fuels, drilling muds or chemicals directly on vegetation would probably kill exposed plants. When washed into aquatic systems, they could damage the habitat disrupting the food chain from plants up to higher aquatic forms. A list of some common constituents in drilling muds and their relative toxicities is given in Table 3-1.

The extent of damage due to accidents depends upon the clean-up procedures. Surfactants might prove more harmful to vegetation than the original spill (Cowell, 1969). Burning might remove a major portion of the hydrocarbons, and while it would destroy existing vegetation, reestablishments of perennials should not be retarded. Burning as a clean-up operation for major oil spills is currently practiced in the brackish to saline marshlands of coastal Louiaiana and has the support of the Louisiana Wildlife and Fisheries Commission (St. Amant, 1972; Castle, 1975). In other instances, plowing under in agricultural areas or pick-up from water bodies would be the most suitable clean-up procedures. Spills due to site and access preparation and construction would probably be localized and minor. Such spills should be contained and cleaned up when they occur but should not necessitate major clean-up operations.

Depending on moisture conditions at the time, accidental fires could spread through the area until extinguished or until reaching waterways or roads of sufficient size to stop them. In agricultural areas, fires should have little impact on natural vegetation because this vegetation is maintained in early successional stages, but they may have a large economic impact by destroying crops. Fires on levees and in bottomland hardwoods would have the greatest impacts by virtually destroying present vegetation. Vegetation in these areas would, however, recover in time. It is not likely that fires would spread in cypress-tupelo swamps due to the normally wet conditions on the swamp floor. Impacts would be localized in such areas.

5.1.6 Land-use

Impacts from accidents during site preparation and road construction will vary depending on the exact location of the well site. If the accident involves volatile or toxic cargoes and occurs near or within agricultural areas or Prime Farmland, these lands could be removed from production and existing crops could be damaged depending on the extent of the accident. Wetland areas could be ecologically damaged by such an accident. Trucks or vehicles with volatile fuel cargoes involved in accidents during site preparation or road construction could have devastating effects if the accident occurs near or within settled or recreational areas (Overlay).

5.1.7 Socio-economic

There may be an adverse impact to the individual should an accident occur; but there will not be any regional impact on the socio-economic structure of the Prime Prospect Area as a result of an accident during site preparation and access construction.

5.1.8 Air Quality

During site preparation and road construction, the impacts on air quality will result from dust, exhaust emissions from construction machinery, and noncondensable gases released from geothermal fluids during pre-construction flow-testing. These releases are expected to be minor, short-term, and should be readily dispersed because about 60 percent of the time the atmosphere stability classes are in D and E (Section 2.6.2).

However, accidents such as blowout may occur due to preconstruction flow-testing. For discussion of blowout with respect to air quality, see Section 5.2.8.

5.1.9 Recreation, Archaeological and Historical Sites

Accidents during site preparation and road construction would have little or no effect on recreation, archaeological or historical sites. The only problem would be the damage or destruction of the site if the plans given the survey archaeologist are not followed.

5.1.10 Federal, State, Regional, and Local Land-use Programs

There are no long-term impacts foreseen on land-use programs at any level of government. In case of an accident, disruption to a state highway or the Lafourche Waterway may occur depending on the proximity of the well site in relation to these facilities.

Should the accident occur in a developed residential or industrial zone, there is potential for disruption of these land-use activities until the accident is under control and cleaned up.

5.1.11 Noise

With the possible exception of explosions, the loudest accidental noise level from the well site would occur if the well were vented in an unmuffled condition. Anticipated noise levels produced by this occurrence are discussed in Appdndix B. Accidents of this nature may result in broken windows in buildings at the well site, and minor disturbance at nearby residences.

5.2 Accidents During Drilling and Operation

5.2.1 Geology

Accidents during drilling can permanently damage target reservoirs and all prospective overlying reservoirs by physical disruption as well as long-lasting hydrologic effects. The hydrologic and hydrodynamic effects could be widespread and long-lasting, especially if dissolved gas is released in vapor phase in overlying aquifers, as has occurred in many places in the Gulf Coast area.

Accidents that might have serious impacts on the geologic conditons and subsurface hydrology are blowout with cratering, or uncontrolled flow at very high rates. Whenever wells are drilled into the geopressure zone there is the danger of blowout (Stuart, 1970). When this occurs, the producing formation may be seriously damaged by erosion, collapse, and structural deformation in the vicinity of the well bore, with similar and even more widespread effects in overlying formations. With destruction of well casing by explosive upward movement of water and sand, cratering begins. Blowout craters more than 610 m (2,000 ft) (Overlay) in diameter, discharging steam, boiling hot water, and mud, have been formed in south Louisiana as a result of drilling accidents where wells penetrated the geopressure zone. Craters have boiled for months before the wells killed themselves, or were brought under control by relief wells drilled nearby.

5.2.2 Physiography and Soils

Soils will be contaminated as a result of a blowout during the drilling and operation of the proposed action. The extent and degree of contamination will depend on the duration and discharge of fluids during the uncontrolled flow.

5.2.3 Groundwater

Contamination of fresh and slightly saline groundwater resources could arise as a result of accidents which would cause deep formation brines to enter freshwater aquifers during drilling and operating the geothermal well and the associated brine disposal wells. Fresh groundwater could become permanently contaminated with brine high in NaCl and other constituents such as boron (Gustavson and Kreitler, 1976). Possible groundwater contamination mechanisms include:

- Surface brine spills from uncontrolled well blowouts
- Subsurface blowouts
- Lost circulation zones encountered during drilling
- Loss of brine due to hydraulic fracturing of the disposal aquifer or the casing cement
- Brine loss through leaky or inadequately plugged abandoned well casings
- High pressure hazards to future drilling into disposal formations

The former three mechanisms - surface blowouts, subsurface blowouts, and lost circulation - could occur with both production and brine disposal wells. However, because production wells will penetrate geopressured reservoirs and brine injection wells will be completed in normally pressured sands above 3050 m (10,000 ft), blowout hazards should be limited to production wells.

The latter three mechanisms - hydraulic fracturing, brine loss through abandoned wells, and pressure build-up in disposal sands - are potential problems limited to the brine disposal well operations.

Of all the hazards, the most immediate is a blowout of the deep production well. Problems associated with excessive pressures developed during brine disposal are unlikely in view of experience in brine disposal already operating in the Lafourche Crossing area. The Louisiana Department of Conservation (1976) reports a total of 20.52 million barrels of brine had been injected by 1975 into saline aquifers averaging about 458 m (1500 ft) deep from the following local oil and gas fields: Thibodaux, Lafourche Crossing, Rousseau, Melodia and S.W. Lake Boeuf. This is equivalent to the volume of brine produced over a period of 2.8 years by a geothermal well flowing at a rate of 20,000 bbl daily. The largest brine disposal rate attained in the area, based on a daily average computed from total annual disposal volumes, is 1900 bbl per day at surface pressures below 350 psi into a zone 7.6 m (25 ft) thick, at 397 m (1300 ft) below the surface. The rates and volumes of brine disposal required for a geothermal test well at Lafourche Crossing should be obtainable in the massive saline sands available below the base of slightly saline water.

In normal drilling operations the weight of the mud column in the hole is higher than the encountered formation fluid pressures. Hence, fluids do not flow from the formation into the well. If the weight of the mud column is less than formation pressure, an uncontrolled vertical flow of formation fluid can result in a blowout. Drilling into deep, geopressured reservoirs requires that all reasonable preventive measures be taken to maintain control of the well. Operational blowout preventers are required by the rules and regulations of the Department of Conservation. Drilling mud programs can take advantage of formation pressure data obtained from wells already drilled into the geopressured resource to assure that adequate mud weight is maintained.

If equipment malfunctions or other accidents result in a well blowout, drilling muds and formation fluids spilled on the surface would contaminate the soils and shallow sediments. The extent of contamination is dependent on the volume of fluid produced, the length of time the well is out of control, and the location of the spill. Limited volumes of fluid can be impounded at the well site to control the area of impact. High flow rates could result in contamination over a larger area. The greatest negative impact from brine infiltration into shallow soils would result if the blowout occurred near the crest of the natural levees when the soil is dry. Potential for infiltration diminishes in backswamp areas and as soil moisture increases. Groundwater resources are not likely to be affected by a well blowout at the surface.

Blowouts can occur totally below the surface if fluid from one formation (not necessarily geopressured) is lost to another formation of lower fluid pressure. In the worst case, a brine flow could be established from a deep saline aquifer into the fresh groundwater sands and gravels around the well bore. Such an occurrence should be prevented by the required surface casing and cementing program which is designed to seal off the fresh water resources. Should a subsurface blowout occur, a large volume of brine could be introduced into the shallow aquifer. The impact would be negligible due to the lack of groundwater use in the area. If necessary, the "slug" of contaminating brine could be partially removed from the aquifer, if it could be located, by a system of specially designed wells.

During drilling, fluids can enter aquifers in zones of "lost circulation" where the aquifer is highly permeable (gravel zones) and the pressure exerted by the column of drilling mud is greater than the fluid pressure in the aquifer. Lost circulation can usually be corrected by varying mud weight and viscosity or ultimately casing-off the problem zone. Aquifer contamination from this source is expected to be insignificant because the amount of fluid lost before circulation is reestablished will be small (a few barrels perhaps) and the fluid will likely be fresh water based mud.

Brine must be injected into saline sands which are under hydrostatic pressure (i.e., formation pressure is equal to the pressure produced by a column of water of height equal to the depth of the aquifer concerned). If injection pressure approaches or exceeds geostatic pressure [the weight of the overburden, about 2.2 Kg/.31 m (1 pound per foot of depth)], the area around the well bore and the formation can be fractured. Vertical flow paths could be created and brine could be forced into shallow fresh water aquifers or even to the surface.

Hydraulic fracturing is unlikely in normal brine injection operations because injection pressures are maintained well below fracture pressures. Aquifers of adequate volume for safe containment of the required volume of brine disposal are expected to exist at the well site.

Brine injection will undoubtedly increase the formation pressure in the receiving formation. Although the increase is expected to be localized around the well and to dissipate when injection is stopped, it is possible that abandoned wells cased through the same disposal reservoir have leaky, inadequately plugged casings which provide vertical flow paths for release of injection pressure build-up. Injected brine or native formation brine could be displaced through shallower casing leaks into saline sands, the thin fresh water zone, or even to the surface. Subsurface leaks are unlikely to be detected.

If brine disposal aquifers are of limited areal extent and are totally confined they will permanently retain the pressure increase produced during brine injection. It is possible the pressure could be higher than that anticipated in future drilling ventures in the area. Future operators must be aware of any unnatural formation pressures created in previously normally pressured formations so that back-flows and blowouts can be avoided.

Brine disposal experience in the Prime Prospect Area indicates the creation of permanently pressured disposal reservoirs is unlikely. Such a possibility can be avoided by monitoring the disposal well to assure the aquifer volume is sufficient to receive the brine without excessive pressure increase. Fault activation will not occur as a result of a well blowout. Fluid discharge will not be great enough for this to happen.

5.2.4 Surface Water

Accidental discharge of geothermal fluids to the surface poses the greatest potential impact to surface water. High temperature and pressures of the geothermal resource increase the possibility of accidents during drilling. Blowouts, thermal wellhead and casing cracks, scaling and clogging of injection wells, leaks, spills, and human errors could all result in venting of the produced fluids to the surface where they could be introduced into surface waters by drainage, seepage, or flooding.

Dorfman and Deller (1976) list these impacts from surface disposal, whether routine or accidental:

1) contamination of shallow aquifers and soils from leaks or flooding,
2) destruction of non-salt-tolerant vegetation adjacent to water-courses,
3) interruption of animal migration patterns,
4) disruption of food chains and ecological balance in estuarine waters, and
5) thermal pollution.

Produced geothermal fluids range in temperature from 150°C to 260°C (302°F to 500°F) (Dorfman, 1976). The highest recorded temperature in the Gulf Coast region is 273°C (523°F) at a depth of 5859 m (19,225 ft) (Dorfman, 1976). Chemical composition of the produced fluids varies from formation to formation. Sabadell and Axtmann (1975) report a high probability of environmental pollution by trace metals from geothermal sources.

Table 5-4 lists tolerance levels suggested by EPA (1976) for selected constituents. The range of relative hazard of constituents for which data are available can be evaluated by comparing the listed tolerance levels with levels of constituents found in Louisiana geothermal fluids (Table 5-2). The range of relative hazard is calculated by dividing the observed maximum and minimum concentrations by the appropriate limit (Schieler, 1976). This gives a number which indicates how much, if any, a given concentration exceeds maximum allowable concentrations (Table 5-5).

Table 5-5. Range of Relative Hazard of Known Geothermal Fluid Constituents.

Constituent	Range of Concentration (ppm)	Tolerance Level for Domestic Supply (ppm)	Range of Relative Hazard
TDS	200-345,000	500	0.4 -690
Chlorides	10-201,000	250	0.04-804
Sulfates	0-407	250	0 -1.6
Barium	4-1000	1	4 -1000
Boron	18-67	0.750	24 -89
Sodium	10-103,000	270	0.04-381

On the basis of these available data, barium, TDS, and chloride are the constituents which appear to present the greatest potential hazard. However, unknown hazards from toxic trace elements whose concentrations are unknown and for which no tolerance limits have been established may prove to be far more hazardous.

All species of fish and other aquatic life must tolerate a range of dissolved solid concentrations in order to survive. Estuarine and marsh species tolerate changes from fresh to brackish to sea water. Abrupt

Table 5-4. EPA Suggested Water Quality Criteria.

Constituent	Domestic	Aquatic
Alkalinity ($CaCO_3$)	20 mg/l	
Ammonia	0.02 mg/l	
As	50 μg/l	
Ba	1 mg/l	
Be	1100 μg/l	
B	750 μg/l	
Cd	10 μg/l	
Chlorides	250 mg/l	
Cr	50 μg/l	100 μg/l
Cu	1 mg/l	0.1 96-hr.LC_{50}*
Cn	5 μg/l	
total dissolved gasses	110% saturation value	
Fe	0.3 mg/l	1 mg/l
Pb	50 μg/l	100 μg/l
Ma	50 μg/l	100 μg/l
Hg	2 μg/l	0.1 μg/l
Ni	0.01 96-hr. LC_{50}	
N	10 mg/l	
Phenol	1 μg/l	
P	0.01 μg/l	
Se	10 μg/l	0.01 96-hr.LC_{50}
Ag	50 μg/l	0.01 96-hr.LC_{50}
Sulfates	250 mg/l	
TDS	500 mg/l	
Turbidity	limit 10% reduction in photosynthetic activity point	
H_2S	2 μg/l	
Temperature	a) increase in weekly average no greater than 1 C (1.8 F) b) daily cycle not altered in amplitude or frequency, summer maximum not exceeded	
Zn	5000 μg/l	0.01 96-hr.LC_{50}

*LC_{50} - the concentration of a toxicant which is lethal (fatal) to 50% of the organisms tested in a specified time.

Source: EPA, 1976

changes in these aspects of water quality resulting from accidental discharge of geothermal fluids into surface waters could eliminate desirable habitat and cause plasmolysis of leaves and stems in vegetation. The following limits in salinity variation have been recommended to protect wildlife habitats (EPA, 1976):

Natural Salinity (ppt)	Variation Permitted (ppt)
0- 3.5	1.0
3.5-13.5	2.0
13.5-35.0	4.0

Agricultural uses of water are also limited by dissolved solids concentrations. The following general classification of salinity hazards for irrigation water has been prepared (EPA, 1976):

Dissolved Solids Hazard for Irrigation Water (ppt)	
Water from which no detrimental effects will usually be noticed	0.5
Water which can have detrimental effects on sensitive crops	0.5-1.0
Water that may have adverse effects on many crops and requires careful management practices	1.0-2.0
Water that can be used for tolerant plants on permeable soils with careful management practices	2.0-5.0

Table 5-6 lists tolerance limits for agricultural water use of known constituents in geothermal fluids. The Table considers water uses for irrigation and livestock watering, pointing out known results of excessive concentrations of the constituents.

Table 5-6. Agricultural Use Criteria for Constituents in Geothermal Fluids.

Constituent	Criteria	Remarks
Ammonia		No criteria suggested.
Arsenic	0.1 mg/l	Toxicity to some crops at 0.5 mg/l; no livestock criteria suggested.
Barium		No criteria suggested.
Beryllium	.001 to .500 mg/l	Crop toxicity acidity dependent; no livestock criteria suggested.
Boron	0.75 mg/l	Toxic to sensitive plants, e.g. citrus at <1 mg/l; no livestock criteria suggested.
Cadmium		Reduced crop yields at 1 mg/l; crop accumulation related to zinc concentrations; no livestock criteria suggested.
Chromium		No criteria suggested.
Copper		Toxicity for plants begins at 0.1 mg/l; no livestock criteria suggested.
Iron		No criteria suggested.
Lead		Toxic to plants at <30 mg/l; no criteria suggested.
Manganese	0.2 mg/l suggested for acidiphilic crops	Toxicity to plants increases with decreasing pH; no livestock criteria suggested.
Mercury		Bio-accumulation but no criteria suggested.
Nitrates		No criteria suggested; nutrient for crops.
Phosphorus		No criteria suggested; nutrient for crops.
Selenium		No criteria suggested.
Silver		No criteria suggested.
H_2S		No criteria suggested.
Zinc		Toxic to some crops at 0.4 to 25 mg/l may cause iron deficiency in plants; no livestock criteria suggested.
Total Dissolved Solid (TDS)	5,000-15,000 mg/l suggested	Osmotic effects in plants; variable harm to both plants and animals.
Sodium		Toxic to certain plants; ratio to other cations important; no criteria given.

Source: EPA, 1978

Undetected or accidental venting of effluents through surface or subsurface faults could occur for several reasons. Faulty installation of casing, choice of hydraulically unsuitable disposal aquifers or reinjection well sites, and wells improperly plugged during abandonment could allow the fluids to escape undetected at some distance from the well site through faults or sand lenses with surface outcrops. Contamination of soils, reduction of water quality, and consequent threats to terrestrial and aquatic biota could result.

5.2.5 Wildlife and Vegetation

Accidents induced from blowouts, cracks in the wellhead or pipes, human error, or natural hazards (i.e. hurricanes, floods, subsidence, fault reactivation) could cause release of toxicants into the environment. The range and seriousness of the resulting impacts are dependent on the type, composition, quantity and length of exposure of the biologically degrading material released. Various environmental factors such as wind speed and direction, light, and atmospheric moisture also play an important part in determining range and seriousness of impacts resulting from accidents during drilling and operation.

Of these accidents, the blowout will probably have the most detrimental effect on the surrounding vegetation and fauna. The only quantitative data known to be available on range of impacts resulting from blowouts pertains to the Intracoastal City, Louisiana gas well blowout and oil spill. Oil was reported to be blown 1828 m (6000 ft) from the well site (Castle, 1975). The constituents of geothermal effluents and their concentration will determine their toxicity. Some of the expected constituents of geopressured brines are listed in Table 5-7. Comparison of concentrations in brine and acceptable standards are shown and those substances to be a hazard are marked with an X.

Table 5-7. Constituents in Geopressured Brines of Environmental Concern (ppm).

Hazard (X)	Component	Geopressured Waters of Louisiana[1] minimum	Geopressured Waters of Louisiana[1] maximum	Edna Delcambre No.1 Well[2] minimum	Edna Delcambre No.1 Well[2] maximum	Acceptable Standard[7]
X	Total dissolved solids	200	325,000	115,000	133,000	
	Total ($CaCO_3$) hardness			6,100	6,800	300[5]
X	Chloride	10	201,000	67,000	80,000	250[5]
	Silicates (SiO_2)			57	58	
	Bicarbonate	0	2,500	1,100	1,100	
	Calcium	8	33,000	1,700	2,100	
	Magnesium	0	24,000	160	180	
X	Iron			7	11	1.0
X	Zinc			<1	1	0.009-0.4[6]
X	Strontium	3	265	290	400	
X	Boron	18	67(75[10])	60	63	0.5-1.0
X	Sodium	10	103,000	43,000	46,000	270[5]
	Potassium	50	1,100	290	290	*[9]
	pH			6.2	6.1	
	Iodine	5	74			
X	Sulfate	0	407			250[5]
X	Lithuim	2	18			0.1[9]
X	Barium	4	1000			50.0
X	Bromine	14	213			
	CO_2			1.08[3]	2.03[3]	
	N_2			.29[3]	.13[3]	
X	H_2S	3.1[4]				0.3-3.0[8]
	CH_4	-		92.78[3]	95.36[3]	
	Other Hydrocarbon gases			0[3]	3.47[3]	

Sources:
1) Wilson et al., 1977.
2) Hankins et al., (in press).
3) Karkalits and Hankins, (in press).
4) CSGPC, 1970.
5) Tolerance level for domestic supply, using 7.
6) .01 of the 96-hour TL_{50} for fresh water fish fry or eggs
7) EPA, 1976.
8) Thompson and Kats, 1977.
9) Treshow, 1970. * indicates a toxic substance but no levels specified.
10) Gustavson and Kreitler, 1976.

Sodium, potassium, calcium and magnesium are all necessary nutrients for plants. An elevated sodium level resulting from a blowout would be high for domestic use but is expected to be diluted before it enters streams or aquifers.

Chloride ion is the single most prevalent ion in brine. It can be detected by animals at low levels. Any increase in chloride, hardness or TDS levels in an area must be compensated for by increased respiratory demand of the local fauna and flora. The salts may "sterilize" the soil for 10-25 years or more (Coody, 1978; Landry, 1978). The major effects would probably be within 300 m (984 ft) (Overlay) of the well.

The salt wedge reaching aquatic systems would probably sink to the bottom and cause disturbance of benthic fauna and rooted aquatics. Those soils in the Prime Prospect Area with a high clay content and high cation exchange capacity could extend the persistence of salinity problems. Levee soils would be the least affected, while the Sharkey clay loam, swamp and marsh soils would be most affected. However, Landry (1978) noted that sugarcane fields receiving a well blowout 15 years ago were still unusable, so the effects may be severe even in the better drained areas. Increased hardness (Mg, Ca) due to geothermal well effluents, while exceeding drinking water standards, may actually be beneficial since calcium and magnesium are necessary nutrients for plants. Increased water hardness raises the tolerance level of plants and animals to other toxic metals.

Heavy metals have been commonly found in geopressured waters and have been cited by many authors in the geothermal literature (Axtmann, 1975; Collins, 1975; Schieler, 1976; Balashov, 1975; Schmidt, 1973; Sabadell and Axtmann, 1975; and Koons et al., 1977). Similarly, Gulf Coast brines have been found to include significant levels of several heavy metals (Wilson et al., 1977; Hankins et al., 1977; Mayer and Ho, 1977), particularly zinc, boron, lithium, iron, strontium, barium, and bromide (Table 3-1).

Zinc may be a pollution problem in Gulf Coast brines (Table 3-1). It was found to be harmful to fresh water fish fry or eggs (EPA, 1976). The levels of zinc in soluble and exchangeable forms have been reported to increase with greater acidity and oxidation-reduction conditions (Gambrell et al., 1977). It would be most harmful on upland acidic soils under a dry conditions. A secondary effect of zinc contamination is to cause a shortage of manganese uptake, noted especially in soybeans, which lowers productivity and yield (Treshow, 1970).

Boron levels are very high in geothermal brines, sometimes over 75 times the maximum suggested by EPA (1976). Its effects are ameliorated on neutral to alkaline soils of high adsorption capacities (Biggar and Fireman, 1960). Vegetation of upland communities is most sensitive to boron where additions of over 0.5 ppm would cause inhibition of flowering, chlorosis and lowered plant production (Treshow, 1970). Lithium, similarly, causes chlorosis, burning, and impaired plant growth at the levels present in geothermal brines. Iron, strontium, barium, and bromine may be in excess of tolerable limits to fresh water fauna and terrestrial and aquatic flora. Their uptake will probably be greatest under reduced oxygen conditions, such as those present in the swamp, marsh, or other flooded soils.

In summary, the availability of heavy metals to plants and ultimately the rest of the food chain is dependent on Eh, pH, and other constituents of the soil. The alternating of reduced and oxidized conditions such as is present in the fresh marsh, swamp, or in recently dredged sediments makes these locations ideal for complexing and then solubilization of heavy metals. Thus, a spill during a flooded period would cause metals to be complexed under reduced conditions to form sulfide precipitates or to be surface adsorbed onto organic matter or clays. A dry period or dredging could oxidize and break these complexes allowing a pulse of heavy metals to be released. H_2S gas has been measured in the field near a geopressured site blowout at levels toxic or harmful to plants (Coastal States Gas Producing Co., 1970). This is probably a very localized phenomena.

In conclusion, there are many constituents in geopressured brines which can have detrimental impacts on flora and fauna. Toxicities are compounded by the high salt concentration of the brine and by high temperatures (Anderson, 1973), both of which may cause toxicity to occur at lower concentrations than under normal conditions. Fauna surviving the spray will avoid areas where vegetation has been destroyed. Fish kills can be anticipated in adjacent and downstream aquatic systems. Contamination of irrigation waters or agricultural fields may make hazardous the use of food produced there. It may be necessary to take those areas out of production. Measures should also be taken to discourage wildlife usage of the contaminated fields.

It is possible that a blowout may occur while drilling through an oil or gas formation. In such a case, oil or gas could fall on the surrounding areas and may cause local damage and fires. The seriousness of such a spill would be dependent on the type of hydrocarbon, the dosage received, the physiography of the area, weather conditions at the time of the spill, the type of local biota, the season of year, the previous exposure of the area to oil or other pollutants and the type of clean-up treatment implemented (Straughan, 1972).

Damage to flora would be most severe where the leaves are coated with oil. Vegetation with oiled leaves will probably be killed (Baker, 1971). Perennial plants with underground storage structures will be most likely to survive (Baker, 1971). However, annuals may not repopulate the contaminated area in the immediate future following a spill. Continued oilings may increase mortality of plants and even animals, especially in aquatic systems (Cowell, 1971). The time of year in which a blowout occurs has a direct bearing on survival of the biota (Cowell, 1969; Baker, 1971), with the greatest damage occurring during the reproductive seasons. The time of year least damaging to plants would be winter.

Hydrocarbons may migrate down into the soil (Dietz, 1973) and persist there for years (Blumer and Sass, 1972; Whelan et al., 1976) since the oxygen required for their microbial degradation (Zobell, 1973) may be limiting. An oil sheen on the sediment and leaf surfaces may reduce oxygen diffusion into the soil and lower vegetation productivity even though death does not ensue (Gebhart, 1973). Oxygen deprivation and toxicity may cause drastic reducitons in aquatic animal life. The effects of such a spill would be to eliminate oil sensitive species, thereby changing the community structure (Burk, 1976). The significance of this to the productivity and diversity of the biotic community will depend upon the importance of the adversely affected species within the community (Treshow, 1970).

A marsh community can be expected to recover from a spill within a relatively short period of time, either naturally or as a result of clean-up operations involving burning (Burk, 1976; Castle, 1975). The perennials would probably return within the next season after the burning, while the annuals would be slower to repopulate the area. Tree and shrub vegetation on the natural levees and spoil banks would also take longer to become reestablished after oiling and/or burning (Castle, 1975). It should also be noted that the impact from a blowout is likely to be confined to the immediate vicinity of the well (Castle, 1975). An oil slick resulting from a blowout could attract birds and would be most harmful during migrating periods when bird populations in south Louisiana are high (Erickson, 1963). Oil ingested during preening could line the alimentary tract and give lethal or sublethal doses of toxins to birds (Hartung and Hunt, 1966).

Aromatic compounds in oil are water soluble, thus increasing their biological accessibility. They are also more toxic than other oil fractions (Resource Tech. Corp., 1972). Their dispersal will depend on the area's physiography, air and water temperature, and weather conditons. Oils would be least likely to disperse rapidly in the winter and/or under calm wind and water conditions.

Clean-up operations might include burning, plowing, physical removal, surfactants, etc. The practices least likely to harm the Prime Prospect

Area would include controlled burning and plowing under in fields. Agricultural areas are already segmented and ditched for drainage making oil spills easily contained to minimize environmental impacts by restricting the amount of area affected. This would necessitate prompt action immediately following an accident. Mechanical removal of oil from the drainage ditches and burning of agricultural crops or plowing of contaminated fields would result in short-term productivity losses only.

Leaks, breaks, or washovers of the reserve ponds will introduce oils, drilling muds and metal shavings into the surrounding area. If the spills are small, they will probably not affect biota on a long-term basis (Marum, 1974; Fisk et al., 1974; Kritzler, 1974). A temporary lowering of productivity and diversity may result, and clean-up should be prompt to lessen damage. Subsidence, earthquakes or fault reactivation are considered very unlikely to occur in the Prime Prospect Area.

In summary, the most detrimental impacts upon vegetation and wildlife from an accident would result from release of brine, gas, or oil. Of these, brine would probably cause the greatest impact, lasting twenty years or more. Sugarcane fields may have to be abandoned and natural areas may suffer habitat degredation. A spill into Bayou Lafourche could contaminate local water supplies. Prompt containment and clean-up will mitigate these effects.

5.2.6 Land-use

The degree of impact from a well blowout on land-use depends on the site of the accident and the surrounding land-uses. If the accident is of the magnitude of the Tigre Lagoon or Intracoastal City accidents, large areas around the well may be covered by brines or hydrocarbons. Such an accident may require the evacuation of residences, public facilities, and businesses within 1830 m (6000 ft) or more of the Prime Prospect Area. Spilling of brines on agricultrual fields may leave the fields unproductive for up to 10 years (Coody, 1978). Roads, railroads, and navigable waterways may be closed until the blowout is controlled.

5.2.7 Socio-economic

The socio-economic impacts in case of an accident or well blowout would largely result in damages to agricultural areas, Prime Farmlands, and nearby buildings and structures. The amount of impact will be proportional to the extent of the accident, the adjacent land-uses, and the time needed to control it. Residential and built-up areas as well as recreational sites would have to be evacuated in case of a well blowout.

5.2.8 Air Quality

By standards of normal oil field operation, extraordinary precautions will be taken in the proposed project to prevent blowout of the test well. Yet the possibility of a blowout should be considered in view of the high pressures anticipated in the geopressured zone. Some documentation exists on blowout occurrences at various geothermal fields (ERDA, 1977).

Very little air quality impact data as a result of blowout is available in the literature. Some preliminary information may be inferred from the blowout of the Edna Delcambre #4 gas well in the Tigre Lagoon area in Louisiana (ERDA, 1976). The blowout took place on July 13, 1971, and resulted from negligence during workover as rams were changed on the blowout preventers. Depth of the producing interval at the time of blowout (July 13, 1971) was between 4078 m and 4275 m (13,380 ft and 13,880 ft), with three to four thousand pounds flowing pressure. The well caught fire ten hours after blowout and the fire lasted for ten days. Discharge of the highly saline ($\pm$ 150 ppt) formation fluid continued for approximately three months until the well was made inactive. The well was finally plugged and abandoned on November 4, 1971, by pumping cement through the relief well.

Since the emission rate of H_2S due to possible blowout from the proposed project is not known, one may calculate the impact on air quality as the result of the oxidation from H_2S to SO_2 from the experience gained by Edna Delcambre #4 well (ERDA, 1976). The computation of SO_2 is based on the following assumptions:

1) Emission height is assumed to be about 30 m (100 ft). This is based on data that during both the first and second blowout of Edna Delcambre #4 well, saline formation fluid was blown about 30 m (100 ft) vertically into the air. It is possible

that the gas may escape from the lower portions of the plume and increase the concentration of SO_2 at the level of the well; however, the amount should be negligible due to the high velocity of the plume.

2) Emission rate of H_2S is assumed to be about 6.8 Kg/hr. This is based on a Union Oil Co. well testing, which produced a total flow of 22,500 Kg/hr., of which 3 percent was noncondensable gases. Ninety-nine percent of this was CO_2. If the remaining percent is assumed to be entirely H_2S, the total emissions of H_2S would equal 6.8 Kg/hr.

3) Atmospheric stability is assumed to be F, the moderately stable condition commonly used as the air pollution computation for safety analysis.

4) Wind speed during stability F (which occurs about 14 percent of the year) in the Prime Prospect Area is 1.6 m/s. This is given in Section 2.6.2.

On the basis of the preceding information, the maximum concentration of SO_2 may be computed from standard EPA techniques to be about 192 $\mu g/m^3$, which is below national ambient air quality standards of maximum 24 hour concentration of 365/$\mu g/m^3$. The distance of this maximum concentration is expected to be about 1.6 km (1 mi) downwind from the blowout well. Although the concentration of SO_2 is below air quality standards, because of the unusual odor of H_2S, the area within a 3.2 km (2 mi) radius of the blowout well (such as campsites, if any, in the Prime Prospect Area) should be advised to evacuate.

In summary, the impacts of the proposed project on air quality are insignificant during construction and operation. However, should blowout occur, important pollutants will be SO_2 and H_2S. The maximum concentration of SO_2 is estimated to be below national ambient air quality standards. At present there is no national ambient standard for H_2S. However, because the "rotten egg" odor of H_2S can be detected at levels of 30 ppb, estimated H_2S concentrations of 80 ppb as a result of a blowout will be a nuisance. The distance of this maximum concentration is expected to be about 1.6 km (1 mi) downwind from the blowout well. No adverse effect on air quality is anticipated even under conservative estimates during stable atmospheric conditions. The effect of inversion layer is also small, because the minimum height of that layer is about 390 m (1280 ft) above ground (Section 2.6.2).

5.2.9 Recreation, Archaeological and Historical Sites

Accidents or blowouts may cause nearby recreational areas to be closed until the accident is under control. Accidents during drilling could release substances that are harmful to archaeological artifacts and historical structures. Deterioration of these sites could be the result of these accidents.

5.2.10 Federal, State, Regional, and Local Land-use Programs

In case of an accident or well blowout, state highways and/or the Lafourche Waterway may have to be closed depending on the proximity of the well site to these areas and the extent of the accident.

5.2.11 Noise

Unmuffled release of fluids and gases can produce a 120 dBA reading at 31 m (100 ft) from the wellhead. Such a level will adversely affect receptors near the proposed action which would not otherwise be impacted by normal operations.

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CHAPTER SIX - COORDINATION WITH FEDERAL, STATE, REGIONAL, AND LOCAL AGENCIES

6.1 Programs and Permits

Several government agencies at the Federal, state and local levels have rules and regulations, programs and permits concerning the testing, exploration, and development of geothermal resources (Harrel et al., 1978). A number of these agencies were contacted and asked to identify any regulations or permits which they may have regarding the proposed action in the Prime Prospect Area. A list enumerating the agencies contacted appears in Appendix D. An asterisk identifies those that responded.

6.1.1 Federal

Table 6-1 identifies Federal agencies having rules, permits and programs relating to geothermal activities. The Table also identifies executive orders which may affect the proposed action. Major Federal legislation concerning valuable resources is listed in Table 6-2.

6.1.2 State

Table 6-3 identifies agencies which have rules, permits or programs concerning or affecting activities related to exploration or development of geothermal resources in Louisiana. Drilling and production of geothermal resources in Louisiana is regulated by the Office of Conservation. Rules and regulations pertaining to these activities became effective on July 20, 1978. They are compiled under Statewide Order No. 29-P, and are available at the State of Louisiana Office of Conservation, Department of Natural Resources, Baton Rouge, Louisiana.

Table 6-1. Matrix of Federal Actions on Geopressure-Geothermal Well Testing Activities and Related Oil Activities.

FEDERAL AGENCIES	Coastal Const. Activities	Navigable Water	Mineral Leasing on Public Lands, O.C.S	Oil, Gas, Other Mining Leases, Permits & Other Act. Management Programs	Dredging and Filling Disposal of Dredge Material	Activities on Marine Sanctuary-Coastal Zones	Noise & Air Emissions	Effluent Disch. & Water Quality & Water Resources	Oil Pipelines (Interstate)	Fish & Wildlife Resources	EIS Review	Historic Sites Bldg. & Objects National Register	
Bureau of Land Management Dept. of the Interior			*	✓							X		43 USCA p. 1 et seq. OCS Land Set, 43 USCA pp 1331-1342
Bureau of Outdoor Recreation (Dept. of the Interior											X		16 USCA p. 460, 1; 16 USCA p. 460 1-4
U. S. Army Corps of Engineers	*✓	*✓			*✓				*✓		X		33 USCS sec. 408 (1960); 33 USCS sec. 404 (1960); FWPCC see 404-33 USCS: Sec. 1344 (Supp 1976).
Dept. of Commerce Coast & Geodetic Survey, NOAA	*✓					✓*					X		Coastal Zone Management Act (1972) P.L. NO. 92-583, 86 Stat. 1280, & U.S.C.pp. 1431 et seq.; 15 USCA pp. 311, 330a; 15USCA p.1501 et seq.
Environmental Protection Agency		*✓			*✓		✓*	✓* ✓			X		FWPCA Sec. 402 (1976) 42 USCA Sec. 1857. 1858, 3521 et seq. 4901 et seq.: 21 USCA p. 346a; 33 USCA pp. 1251 et seq; 14011 7
Federal Power Commission									*✓		X		USC p. 135 et seq. 16USCA pp. 791-825r:49 USCA pp 1671-1684: 15 USCA p. 717 et seq.
Geological Survey			*✓								X		43 USCA p. 1334, 1337: 43 USCA p. 31 et seq. : 30 USCA p. 351 et seq.
Interstate Commerce Commission									*✓				49 USCA p. 1 et seq. : 49 USCA p. 302 35 seq.: 49 USCA pl 901 et seq. 49 USCA p. 1001 et seq.
U. S. Coast Guard	*✓	*✓								✓	X		33 USCA p. 1221; 46 USCA p. 526; 33 USCA p. 14d; 33 USCA p. 1002; 14 USCA p. 81 et seq.: 14 USCA p. 1 et seq.
U. S. Fish & Wildlife Service (Dept. of the Interior)			✓		✓					*✓	X		16 USCA pp. 742a-742k; 16 USCA p. 1361 et seq.
Water Resources Council								✓			X		42 USCA p. 1962 et seq; Fed. Non-nuclear Energy Res. & Dev. Act, 1974 Sec. 13
Energy Research and Development Administration (ERDA)			*✓								X		42 USCA p. 5812 et seq.42 USCA p. 2011 et seq.: Fed. Non-Nuclear Energy Res. Dev. Act. 1974, Sec 3, 30 USCA pp. 661-668
Advisory Council on Historic Preservation											X	*✓	16 USCA 461-67 USCA 470-470m as ammended, 1973: 42 USCA 4321 et seq.1970
Executive Orders													
Floodplain Mgmt.													Executive Order 11988. May 24, 1977
Protection of Wetlands													Executive Order 11990. May 24, 1977

* Agencies Requiring Permits ✓ Agency Reviews EIS and EA or Reviews Applications x Agency has Rules and Regulations Applying to Action

Table 6-2. Major Federal Legislation Pertaining to Valuable Resources

Resources	Federal Legislation
Water.	Federal Water Pollution Control Act
Air.	Clean Air Act
Endangered Flora and Fauna	Endangered Species Act
Floodplains and Erosion Hazard Areas .	Flood Insurance Act
Barrier Island and Beaches	Coastal Zone Management Act
Historic and Cultural Resources. . . .	National Historic Preservation Act
Wildlife Refuges and Reserves.	Pitman-Robinson Act; Dingall-Johnson Land and Water Conservation Fund Act
Areas of Unique Cultural Significance.	National Historic Preservation Act
Minerals	Mineral Leasing Act
Prime Agricultural Lands	Homestead Act
Forests.	National Forest Management Act
Living Marine Resources.	Fisheries Conservation and Management Act; Marine Mammal Protection Act
Coastal Resources.	Federal Consistency Provisions of the Coastal Zone Management Act
Prime Farmlands.	Section 302 Rural Development Act

Note: For more extensive data concerning Federal programs, rules and regulations pertaining to geothermal and goepressured resources, see Department of Energy (DOE), 1978.

Source: Federal Register, 1978a, 1978b; SCS, 1978.

Table 6-3. Matrix of State Actions on Geopressure-Geothermal Well Testing Activities and Related Oil Activities.

State Agencies Louisiana	Drainage of Noxious or Poisonous Subst. into Nat. W.W. & Canals	Coastal Activities (CZMP)	Mineral Leasing State Public Lands	Geothermal Leasing Public State Lands	Public Lands Right-of Ways. Highway Access	Activities in Scenic River & Streams	Oil, gas and geotherm. regul. Geol. or geophysical exploration	Effluents discharge (oil & gas & geotherm). Water quality	Air emissions	Brine disposal	Fish & Wildlife Resources	Dredging & filling activities	Activities in or on archaeological landmarks. Cultural resources	Permit Reviews and/or EIS Review	Authorization
State Land Office			*x	*x	*x							*x			La. R.S. 41:1173-1174 Dec. 31, 1974: La. R.S. 41:1262-1268 Ammended by Acts 1970, No. 59: Acts 1974, No. 611: Title 30, p. 171-179.14
Louisiana Wildlife and Fisheries Commission			x			*x		*x						✓	Ch. 8 of Title 56, La. Rev. Stat. 1950, R.S. 56:1841-56:1849. Title 41, p. 12640
a) La. Stream Control commission								*x		x		x		✓	La. Rev. Stat. 56:1433; La. Rev. Stat. 56: 1431-56:1446 Div. of Wat. Pollution Contr. of L.W.&F. Comm.
b) Office of Coastal & Marine Resources	*x									*x				✓	La. R.S. 56:1453 <u>et seq.</u>, 1950: La. R.S. 56: 1461-63; La. R.S. 56:1464-1464.4
c) Office of Wildlife											x				Administers wildlife refuges, and programs of research on wildlife
La. Dept. of Transportation and Development															Senate Bill 930. Act 361. July 14, 1978. Submitted to the Secretary of Commerce for its approval.
a) Coastal Zone Mgt. Prog.		x													
b) Office of Highways					x										L.S.A. - 48; 344
La. Archaelogical Survey and Antiquities Commission													*x	✓	L.R.S. 41:1601-1603 as ammemded by Act 378 of 1974 La. standards for cultural resource surveying is in draft form.
La. Air Control Comm.									*x					✓	Title 40 Sec. 2204 of Title 40 of La. Rev. State, 1950. Title 40, Sec. 2201 <u>et seq</u>. Act 259 of 1964. Has given auth. to La. Dept. of Health to administer regul. applying to any source of air emissions.
a) La. Dept. of Health								*x	*x						R.S. 40:2204(A) Title 40 Sec. 2201 <u>et seq.</u>, Act 259 of 1964
State Mineral Board			*x	*x			*x								Title 30, Ch. 3 Sec. 211-216, La. Rev. Stat. of 1950 as ammen. by Act 175 of 1954. Title 30. p. 121-129, p. 151-159, p. 171-179.14
Dept. of Urban & Community Affairs														✓	Executive Order 60 A-95 Review
La. Dept. Office of Natural Resources (Office of Conservation)							*x			*x		x			Title 30, Order 29-F Act 134, Act 735: Order 25 B. La. Geothermal & Geopressured Energy Res. & Dev. Act, 1975. Title 30, Ch. 7 (Act 735: 1975): Ch. 8 (Act 784: 1975). Statewide order 29-P. July 20, 1978

* Agencies Requiring Permits ✓ Agency Reviews EIS and EA or Reviews Applications x Agency has Rules and Regulations Applying to Action

6.1.3 Regional

The South Central Planning and Development Commission, as the regional planning agency encompassing the Prime Prospect Area, does not have any specific rules, or require any permits regarding geothermal activities. This agency is in the process of helping Lafourche Parish develop a Coastal Zone Management (CZM) program. After the program is adopted, any activities proposed within the Parish would have to be coordinated with the CZM program objectives.

6.1.4 Local

Lafourche Parish and Terrebonne Parish participate in the National Flood Insurance Program. Thus, any action that is taken in a flood prone area must comply with all the necessary requirements of various related ordinances. The Department of Energy will coordinate all of its activities with the local government agencies.

6.2 Land-use Plans

Several Federal, state and local agencies were contacted by letter dated July 10, 1978 requesting identification of conflicts with any of their active or proposed plans that might result from the proposed action. A list of agencies contacted appears in Appendix D. Agencies which replied are identified by an asterisk.

A summary of the forms necessary for the drilling and production of geothermal resources in the State of Louisiana is shown in Table 6-4.

Table 6-4. Forms that Must be Submitted in the State of Louisiana for the Drilling and Production of Geothermal Resources.

Agency	Office	Form No.	Description
Dept. of Natural Resource	Conservation (District Office)	GR-10	Applications for permits to drill wells for geothermal development below the fresh water sands
"	"	GR-4	Applications for permits to repair or workovers
"	"	WH-GR	Well History & Work Resume Report
"	District Manager original to Office of Conservation Baton Rouge	GR-Operator's Monthly Rept.	Monthly Production
"	District Manager Office of Conservation	GR-4 and WH-GR	Directional drilling
"	District Manager Office of Conservation	GR-10-A (Application for Amended Permit to drill for Geothermal Resources)	Change of Operator
"	"	GR-5PD	Well off production or no longer in use as a service well
"	"	GR-4 Work Permit	Intention to plug any well or wells

6.2.1 Federal

U. S. Army Corps of Engineers, New Orleans District - This agency requested more detailed information regarding the nature of the work to be performed, a more precise location of the proposed action, and the duration of any testing before commenting on the action. An environmental assessment is now being prepared regarding the proposed action and will be supplied to the U.S. Army Corps of Engineers, New Orleans District for their review and comment. Bayou Lafourche, a waterway which runs through the Prime Prospect Area, is presently maintained by the U.S. Army Corps of Engineers.

Soil Conservation Service - This agency sees no conflicts with their plans and the geopressure resource well testing at the proposed area. They do identify parts of the Prime Prospect Area as Prime Farmland, namely, the natural levee corridors which feature Commerce, Mhoon, and Sharkey soils.

United States Department of Commerce. Maritime Administration - The only potential conflict identified by this agency regarding the proposed action would be if the exact location interferred with waterborne commerce on a navigable waterway.

United States Nuclear Regulatory Commission - This agency is not aware of any conflicts or potential conflicts between their activities and the proposed action.

United States Department of the Interior. Geological Survey - The Geological Survey is not aware of any conflict between their plans and the proposed action.

United States Water Resources Council - The U.S. Water Resources Council has no on-going programs which would be in conflict with the proposed action.

United States Department of the Interior. Heritage Conservation and Recreation Service. South Central Region - According to this agency, the proposed project appears to have no adverse impact on recreation.

6.2.2 State

A list of state agencies contacted regarding conflicts of their plans with the proposed action is included in Appendix D. None of the state agencies which responded foresee any conflicts between the proposed action and their plans.

The State Coastal Zone Management plan is not complete at this time, but it is expected to be in operation within a year. Since the Prime Prospect Area is adjacent to the defined Coastal Zone, care will be taken to assure that the testing is consistent with developing local and state Coastal Zone Management plans, and precautions will be taken to minimize impacts on wetlands. A large tract of public land, property of Nicholls State University, is located within the Prime Prospect Area in Lafourche Parish (Fig. 6-1).

6.2.3 Regional

The South Central Planning and Development Commission administers the South Central Planning District which comprises the south central

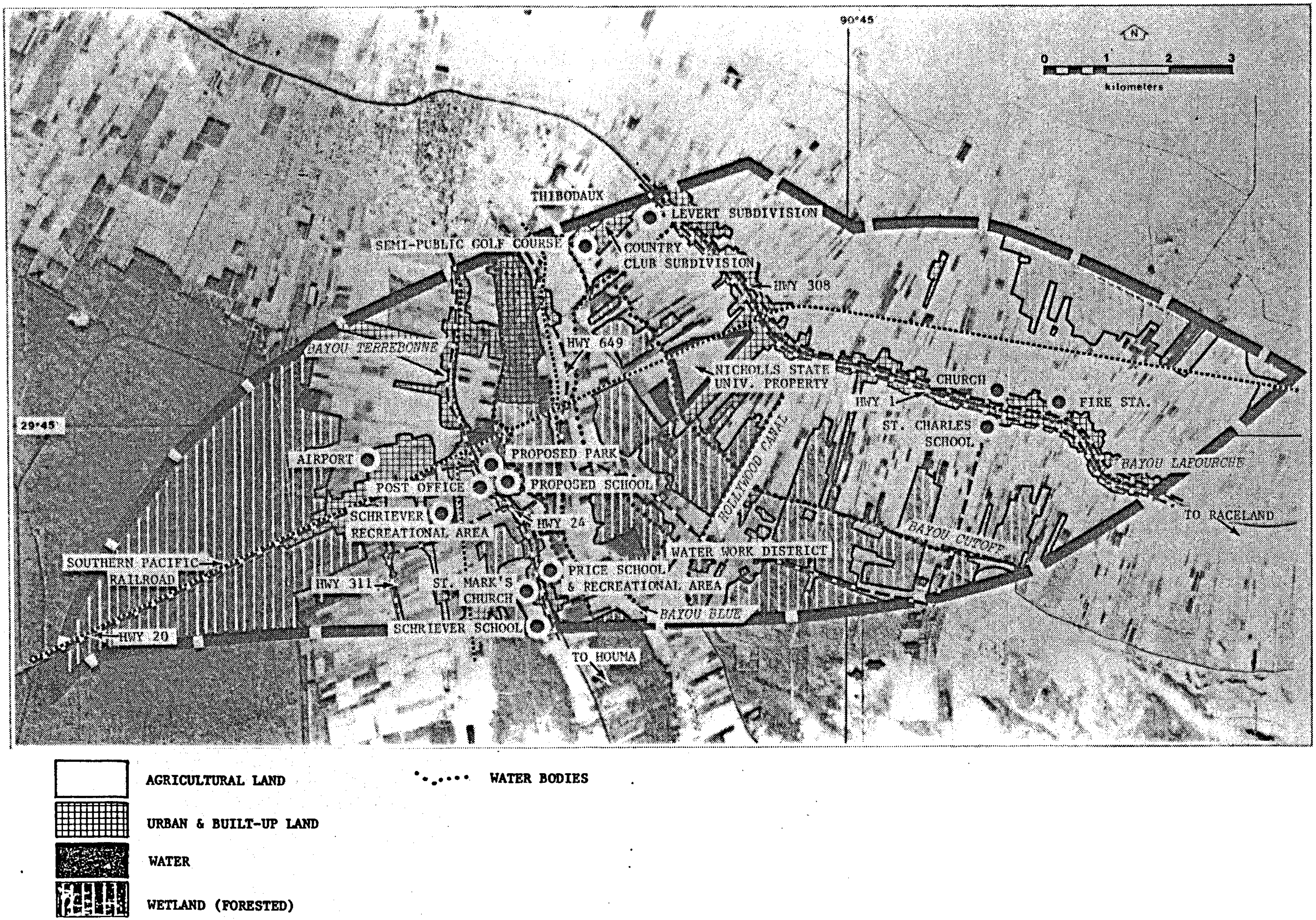

Figure 6-1. Land-use of the Lafourche Crossing Prime Prospect Area.

Louisiana parishes of Assumption, St. Charles, St. John the Baptist, Terrebonne, and Lafourche.

Both Lafourche and Terrebonne Parishes have extensive wetland areas which restrict urban development to higher grounds. Usually built-up areas are located along the natural levees of bayous where better foundation conditions are found. The most fertile soils are also commonly found on the natural levees and away from low-lying areas. Thus, development activities and agricultural endeavors sometimes compete for the best available land. Tables 6-5 and 6-6 show a land-use summary for Lafourche and Terrebonne Parishes.

Existing land-use plans developed by the South Central Planning & Development Commission (Fig. 6-2) for the Prime Prospect Area show built-up lands on the corridors following Bayous Lafourche, Terrebonne, and Bayou Blue. The heaviest concentration of developed land follows Bayou Lafourche from Thibodaux to Raceland and along Bayou Terrebonne towards Houma.

Within Lafourche Parish the natural levee areas along Bayou Blue are being developed for residential land-use. Some backswamp areas between the natural levee ridges are being reclaimed and developed along Hwy. 649.

Agricultural lands within the Prime Prospect Area are along the backslope of the natural levee ridges. The main crop is sugarcane, although some small truck farming operations can be found.

Table 6-5. Summary of Existing Land-use - Lafourche Parish

LAND USE CATEGORY	HECTARES	ACRES
Urban and Built-up Land		
11. Residential	1,200	2,964
12. Commercial and Services	200	494
13. Industrial	400	988
14. Extractive	37,313	92,131
15. Transportation, Communications and Utilities	100	247
16. Institutional	200	494
17. Strip and Clustered Settlement	3,701	9,139
18. Mixed	0	0
19. Open and Other	200	494
Agricultural Land		
21. Cropland and Pasture	48,917	120,783
22. Orchards, Groves, Bush Fruits, Vineyards and Horticultural Areas	0	0
23. Feeding Operations	0	0
24. Other	0	0
Rangeland - Not Applicable		
Forest Land		
41. Deciduous	1,400	3,458
42. Evergreen (coniferous and other)	0	0
43. Mixed	0	0
Water		
51. Streams and Waterways	700	1,729
52. Lakes	23,508	58,045
53. Reservoirs	2,300	5,681
54. Bays and Estuaries	42,514	104,975
55. Other	199,869	493,506
Wetland		
61. Forested	49,617	122,512
62. Nonforested	144,550	356,915
Barren Land		
71. Salt Flats	0	0
72. Beaches	0	0
73. Sand Other than Beaches	0	0
74. Bare Exposed Rock	0	0
75. Other	5,602	13,832
TOTAL ACREAGE	562,296	1388,387

Source: Louisiana State Planning Office, 1975.

Table 6-6. Summary of Existing Land-use - Terrebonne Parish

LAND USE CATEGORY	HECTARES	ACRES
Urban and Built-up Land		
11. Residential	2,200	5,434
12. Commercial and Services	600	1,482
13. Industrial	700	1,729
14. Extractive	38,713	95,589
15. Transportation, Communications and Utilities	300	741
16. Institutional	0	0
17. Strip and Clustered Settlement	3,201	7,904
18. Mixed	0	0
19. Open and Other	100	247
Agricultural Land		
21. Cropland and Pasture	22,407	55,328
22. Orchards, Groves, Bush Fruits, Vineyards and Horticultural Areas	0	0
23. Feeding Operations	0	0
24. Other	0	0
Rangeland - Not Applicable		
Forest Land		
41. Deciduous	8,603	21,242
42. Evergreen (coniferous and other)	0	0
43. Mixed	0	0
Water		
51. Streams and Waterways	31,351	7,410
52. Lakes	27,309	67,431
53. Reservoirs	100	247
54. Bays and Estuaries	97,133	239,837
55. Other	121,642	300,352
Wetland		
61. Forested	36,512	90,155
62. Nonforested	226,579	559,455
Barren Land		
71. Salt Flats	0	0
72. Beaches	300	741
73. Sand Other than Beaches	0	0
74. Bare Exposed Rock	0	0
75. Other	6,302	15,561
TOTAL ACREAGE	595,708	1,470,885

Source: Louisiana State Planning Office, 1975.

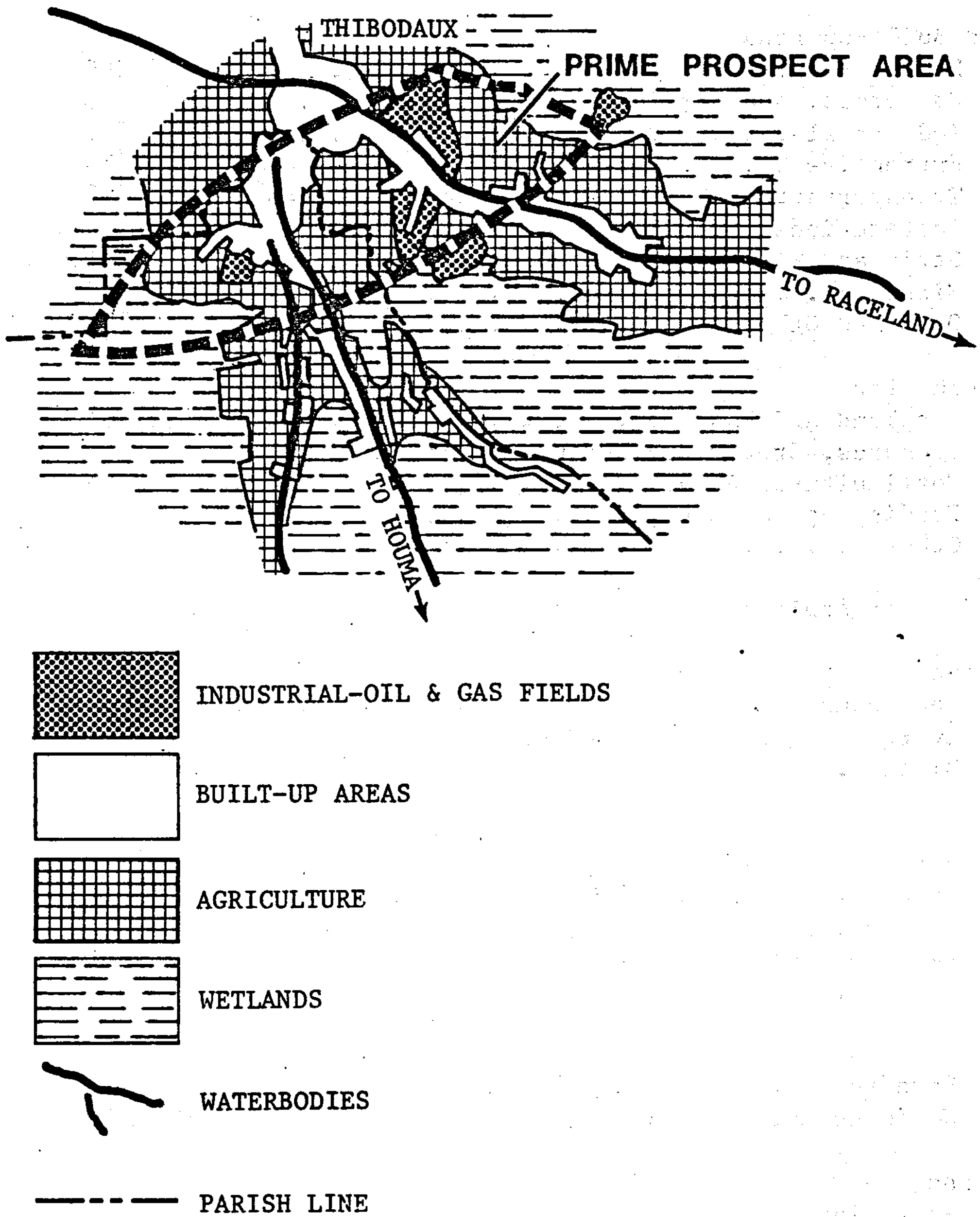

Figure 6-2. Proposed land-use for the Lafourche Crossing Prime Prospect Area (After South Central Regional Planning and Development Commission, 1974).

Present land-uses within the Prime Prospect Area are shown in Figure 6-1. This figure was developed from 1974 NASA aerial photos, 1974 USGS maps, and a 1978 field check. Expanding development is between Thibodaux and Raceland and Thibodaux and Houma where residential neighborhoods are sprouting. Other built-up areas are found in a strip development along secondary roads in both parishes. Major transportation routes, churches, schools, and other public and recreational facilities are also depicted in this figure.

6.2.4 Local

In Lafourche and Terrebonne Parishes the Parish Police Jury has executive and Legislative authority. Apart from the City of Thibodaux Planning Commission, the Central Lafourche Planning Commission and the Houma-Terrebonne Regional Planning Commission are the two local commissions with land-use plans and studies which cover the Prime Prospect Area. The Prime Prospect Area within Lafourche Parish is expected to continue to grow at a rapid rate as part of a parish which is rapidly growing. Table 6-7 shows projected land requirements for various uses within the Central Lafourche planning district comprising Wards 3, 4, 11, 7, 8, and 9 on both banks of Bayou Lafourche. The Central Lafourche Planning Commission's future land-use plan designates the area south of the Hollywood Canal, bounded by Bayou Cutoff on one side and Hwy. 645 on the other, and the area within the Prime Prospect Area limits as future industrial acreages.

Table 6-7. Projected Land Requirements for Various Uses - Central Lafourche Planning District.

	HECTARES (Acres)		
Land Uses	1970	1992*	Net Change
Residential	464 (1,145)	725 (1,790)	261 (645)
Recreational (Public & Semi-Public)	124 (306)	248 (613)	124 (307)
Commercial	134 (331)	237 (586)	103 (255)
Industrial	79 (195)	156 (385)	77 (190)
Streets & Highways	486 (1,199)	156 (385)	410 (1,013)
TOTAL	1,286 (3,176)	(3,063)	976 (2,410)

*Future acreage needed per projective 100 persons for each category.

Source: Central Lafourche Planning Commission, 1973

Within the Prime Prospect Area is the area of Terrebonne Parish which is experimenting the greatest growth, i.e., the area south of Thibodaux from Schriever to Houma where new residential areas are developing. (Houma-Terrebonne Regional Planning Commission, 1973). The Parish will require about 2174 ha (6,700 ac) to accomodate residential development by 1990 according to the Planning Commission studies. Forced drainage projects planned for the Parish would allow expansion of urban development. Table 6-8 shows projected land-use acreage for different land-use activities for Terrebonne Parish.

Table 6-8. Projected Land-use and Comparison, Houma-Terrebonne, LA, 1973.

Land Use Category	Existing Land Use 1970		Projected Land Use 1990		% Projected of Total Urban Area	Additional Land Required	
	ha	ac	ha	ac		ha	ac
Single Family Residential	3,918	9,675	6,116	15,100	42.5	2,197	5,425
Multi-Family Residential	85	209	608	1,500	4.2	523	1,291
CBD Commercial	15	36	81	200	0.6	66	164
General Commercial	547	1,351	3,321	8,200	23.1	2,764	6,824
Public & Quasi-Public	252	622	770	1,900	5.4	518	1,278
Recreation	17	43	446	1,100	3.1	428	1,057
Light Industrial	67	165	689	1,700	4.8	622	1,535
Heavy Industrial	65	160	1,053	2,600	7.3	988	2,440
Utilities	69	170	122	300	0.9	53	130
Transportation	668	1,649	1,175	2,900	8.1	507	1,251
Agricultural &	354,844	876,159	346,154	854,700	-	8,691	21,459
TOTAL URBAN	5,702	14,080					

Source: Houma-Terrebonne Regional Planning Commission, 1973

Both Lafourche and Terrebonne Parishes have land-use ordinances and control measures which comply with Federal guidelines for flood insurance because both are eligible for flood insurance under the National Flood Insurance Act of 1968, as ammended in 1971, and the Flood Disaster Protection Act of 1973, as ammended in 1975.

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CHAPTER SEVEN - ALTERNATIVES

7.1 Delay

This project is designed to drill a well into a geopressure reservoir to evaluate the reservoir potential over a sustained period of flow testing. A previous well test in Louisiana was in an abandoned oil well, and although it provided important data, it was not in the optimum location. The delay of this project will restrict the availability of geopressure reservoir data on geopressure exploration techniques and severely restrict the amount of information available on the geopressured resource.

7.2 No Build

The No Build alternative is not consistent with Congressional mandate as directed by the Geothermal Energy Research, Development and Demonstration Act of 1974 (U.S. Congress, 1975). This act directs the Federal Government to encourage and assist private industry in the development and demonstration of practicable means of producing energy from geothermal resources in an environmentally sound manner. This assistance is to include resource assessment and research and development projects.

7.3 Alternative Approaches

The DOE through the geopressure subprogram is evaluating alternative methods for obtaining the necessary chemical and physical data on the geopressure resource. One method is to conduct a literature search of published and unpublished reports or data. A second method is to redrill oil wells after they have been abandoned and the rigs are moved from the location. The literature search has not provided the necessary data in a form which is required to evaluate the resource. Schmidt (1973), Hankins (in press) Wilson et al. (1977), and Karkalits and Hankins (in press) provide some basic data but not in sufficient quantity or in the optimum location for future development of the resource. Redrilling of abandoned oil or gas wells is economical but the wells do not always occur in optimum resource areas. It becomes a decision, then, of whether to expend limited funds for projects which may never be developed because of physical, cultural, or economic constraint.

7.4 Location

A specific well site will be selected within the study area. Well site selection will be based on geologic, economic, and environmental consideration.

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APPENDIX A

VEGETATION AND WILDLIFE

VEGETATION AND WILDLIFE

Table A-1. Vegetation Noted at Selected Stops in Lafourche Crossing Prime Prospect Area (see Fig. 2-14 for location).

Stop I Backswamp adjacent to Louisiana Highway 20.

Common Name	Scientific Name
bald cypress	Taxodium distichum
bitter pecan	Carya aquatica
black willow	Salix nigra
button bush	Cephalanthus occidentalis
cyperus	Cyperus sp.
duckweed	Lemna sp.
ladies' ear drop	Brunnichia cirrhosa
red maple	Acer rubrum
rush	Juncus sp.
water-tupelo	Nyssa aquatica

Stop II Backswamp-levee ecotone adjacent to Louisiana Highway 20.

Common Name	Scientific Name
baldcypress	Taxodium distichum
cottonwood	Populus deltoides
hackberry	Celtis laevigata
nuttall oak	Quercus nuttallii
red maple	Acer rubrum
water oak	Quercus nigra

Table A-1 continued

Stop III Sugarcane field and drainage ditch.

Common Name	Scientific Name
Trees & Shrubs	
black willow	Salix nigra
button bush	Cephalanthus occidentalis
eastern baccharis	Baccharis halimifolia
hackberry	Celtis laevigata
red maple	Acer rubrum
swamp dogwood	Cornus drummondii
wax myrtle	Myrica cerifera
Vines	
morning glory	Ipomoea spp.
passion flower	Passiflora incarnata
trumper creeper	Campsis radicans
Herbs, Grasses, & Sedges	
barnyard grass	Echinochloa crusqalli
black-eyed susan	Rudbeckia sp.
brier	Smilax spp.
cattail	Typha sp.
chocolate weed	Melochia corchorifolia
coffeeweed	Sesbania exalta
curly dock	Rumex crispus
cyperus	Cyperus spp.
horsetail	Equisetum hyemale

Table A-1 continued.

Common Name	Scientific Name
Johnson grass	Sorghum halepense
pigweed	Chenopodium sp.
sensitive briar	Schrankia spp.
smell melon	Cucumis melo var dudain
spurge	Euphorbia sp.
sugarcane	Saccharum officinalus
verbena	Verbena spp.

Stop IV Second growth bottomland hardwoods.

Common Name	Scientific Name
Trees & Shrubs	
American elm	Ulmus americana
ash	Fraxinus sp.
black willow	Salix nigra
box elder	Acer negundo
cottonwood	Populus deltoides
red maple	Acer rubrum
swamp dogwood	Cornus drummondii
sweetgum	Liquidambar styraciflua
water oak	Quercus nigra
Vines	
blackberry	Rubus spp.
poison ivy	Rhus radicans
Virginia creeper	Parthenocissus quinquefolia
Herbs, Grasses, & Sedges	
coffeeweed	Sesbania exaltata

Table A-1 continued.

Common Name	Scientific Name
elderberry	Sambucus canadensis
elm	Ulmus sp.
hackberry	Celtis laevigata
red maple	Acer rubrum
swamp dogwood	Cornus drummondii
water oak	Quercus nigra
wax myrtle	Myrica cerifera
yaupon	Ilex vomitoria
Vines	
common green-brier	Smilax rotundifolia
grape	Vitus spp.
poison ivy	Rhus radicans
rattan vine	Berchemia scandens
Virginia creeper	Parthenocissus quinquefolia
Grasses, Herbs, Sedges	
bugle-weed	Lycopus spp.

East levee Bayou Lafourche Natural levee.

sugarcane	Saccharum officinalus
black willow	Salix nigra
Chinese tallow	Sapium sebiferum
hackberry	Celtis laevigata
live oak	Quercus virginiana
pine	Pinus spp.
sweet pecan	Carya illinoensis
water oak	Quercus nigra

Table A-1 continued.

Common Name	Scientific Name
giant ragweed	Ambrosia trifida
lesser ragweed	Ambrosia artemisiifolia
beakrush	Rhynchospora spp.

Stop V Second growth bottomland hardwoods.

Common Name	Scientific Name
Trees & Shrubs	
black willow	Salix nigra
bitter pecan	Carya aquatica
cottonwood	Populus deltoides
cypress	Taxodium distichum
elm	Ulmus sp.
red maple	Acer rubrum
water oak	Quercus nigra
wax myrtle	Myrica cerifera

Stop VI Backswamp-levee ecotone

Common Name	Scientific Name
American elm	Ulmus americana
bitter pecan	Carya aquatica
black willow	Salix nigra
box elder	Acer negundo
cottonwood	Populus deltoides

Table A-2. Fish Whose Range Includes the Lafourche Crossing Prime Prospect Area.

Common Name	Scientific Name
spotted gar	Lepisosteus oculatus
longnose gar	Lepisosteus osseus
bowfin	Amia calva
American eel	Anguilla rostrata
gizzard shad	Dorosoma cepedianum
threadfin shad	Dorosoma petenense
golden shiner	Notemigonus crysoleucus
river carpsucker	Carpiodes carpio
smallmouth buffalo	Ictiobus bubalus
largemouth buffalo	Ictiobus cyprinellus
spotted sucker	Minytrema melanops
blue catfish	Ictalurus furcatus
channel catfish	Ictalurus punctatus
flathead catfish	Pylodictis olivaris
golden topminnow	Fundulus chrysotus
mosquitofish	Gambusia affinis
sailfin molly	Poecilia latipinna
brook silverside	Labidesthes sicculus
sunfish	Lepomis spp.
largemouth bass	Microsterus salmoides
white crappie	Pomoxis annularis
black crappie	Pomoxis nigromaculatus

Source: Douglas, 1974

Table A-3 Reptiles and Amphibians Whose Range Includes the Lafourche Crossing Prime Prospect Area.

Common Name	Scientific Name
American alligator	Alligator mississippiensis
alligator snapping turtle	Macroclemys temmincki
common snapping turtle	Chelydra serpentina
stinkpot	Sternotherus odoratus
razor-backed musk turtle	Sternotherus carinatus
Mississippi mud turtle	Kinosternum subrubrum hippocrepis
Mississippi map turtle	Graptimys kohni
southern painted turtle	Chrysemys picta dorsalis
Mobil cooter	Chrysemys conicinna mobilensis
Missouri slider	Chrysemys floridana hoyi
red-eared pond slider	Chrysemys scripta elegans
three-toed box turtle	Terrapene carolina triunguis
Gulf Coast box turtle	Terrapene carolina major
western chicken turtle	Deirochelys reticularia miaria
midland smooth softshell	Trionyx muticus muticus
spiny softshell	Trionyx spiniferus
green anole	Anolis carolinensis
ground skink	Leiolopisma laterale
five-lined skink	Eumeces fasciatus
broad-headed skink	Eumeces laticeps
eastern glass lizard	Ophisaurus ventralis
western slender glass lizard	Ophisaurus attenuatus attenuatus
broad-banded water snake	Natrix fasciata confluens

Table A-3 Continued

Common Name	Scientific Name
yellow-bellied water snake	Natrix erythrogaster flavigaster
diamondback water snake	Natrix rhombifera
green water snake	Natrix cyclopion cyclopion
delta glossy water snake	Natrix rigida deltae
Graham's water snake	Natrix grahami
eastern garter snake	Thamnophis sirtalis sirtalis
brown snake	Storeria dekayi
eastern hognose snake	Heterodon platyrhinos
Mississippi ringneck snake	Diadophis punctatus strictogenys
rough green snake	Opheodrys aestivus
western mud snake	Farancia abacura reinwardti
black-masked racer	Coluber constrictor latrunculus
Texas rat snake	Elaphe obsoleta lindheimeri
Louisiana milk snake	Lampropeltis triangulum amaura
speckled king snake	Lampropeltis getulus holbrooki
western cottonmouth	Agkistrodon piscivorus leucostoma
southern copperhead	Agkistrodon contortrix contortrix
western pigmy rattlesnake	Sistrurus miliarus streckeri
canebreak rattlesnake	Crotalus horridus atricaudatus
western lesser siren	Siren intermedia nettingi
three- toed amphiuma	Amphuima tridactylum
central newt	Notophthalmus viridensens louisianensis

Table A-3 Continued

Common Name	Scientific Name
small-mouthed salamander	Ambystoma texanum
marbled salamander	Ambystoma opacum
southern dusky salamander	Desmognathus auriculatus
dwarf salamander	Eurycea quadridigitata
eastern narrow-mouthed toad	Gastrophryne carolinensis
Woodhouse's toad	Bufo woodhousei woodhousei
Fowler's toad	Bufo woodhousei fowleri
Gulf Coast toad	Bufo valliceps
northern spring peeper	Hyla crucifer crucifer
green treefrog	Hyla cinerea
squirrel treefrog	Hyla squirrella
upland chorus frog	Pseudoacris triseriata feriarum
northern cricket frog	Acris crepitans crepitans
gray treefrog	Hyla versicolor and H. chrysoscelis
bronze frog	Rana clamitans clamitans
pig frog	Rana grylio
bullfrog	Rana catesbeiana
southern leopard frog	Rana utricularia

Source: Conant, 1975

Table A-4. Density of Breeding Birds Registered on Study Plots in Habitats Similar to Those Found in Lafourche Crossing Prime Prospect Area, May and June, 1973.

Common Names	Scientific	TERRITORIAL MALES Males Per 100 Acres	TERRITORIAL MALES Acres Per Male
Bottomland Hardwoods			
Cardinal	Cardinalis cardinalis	57.5	1.7
White-eyes Vireo	Vireo griseus	45	2.2
Carolina Wren	Thryothorus ludovicianus	40	2.5
Yellow-billed Cuckoo	Coccyzus americanus	30	3.3
Red-bellied Woodpecker	Centurus carolinus	12.5	8.0
Yellowthroat	Geothlypis trichas	10	10.0
Yellow-breasted Chat	Icteria virens	7.5	13.3
Blue Jay	Cyanocitta cristata	5	20.0
Prothonotary Warbler	Protonotaria citrea	5	20.0
Indigo Bunting	Passerina cyanea	2.5	40.0
Carolina Chickadee	Parus carolinensis	2.5	40.0
Tufted Titmouse	Parus bicolor	2.5	40.0
Rufous-sided Towhee	Pipilo erythrophthalmus	2.5	40.0
Hooded Warbler	Wilsonia citrina	2.5	40.0
Sugarcane Field			
Red-winged Blackbird	Agelaius phoeniceus	40	2.5

Source: Adapted from Chabreck, 1973

Table A-5. Bird Species Present but not Established as Breeding Birds on Study Plots in Habitats Similar to Lafourche Crossing Prime Prospect Area, May and June, 1973.

Common Name	Scientific Name
Bottomland Hardwoods	
Mourning Dove	Zenaidura macroura
Painted Bunting	Passerina ciris
Ruby-throated Hummingbird	Archilochus colubris
Orchard Oriole	Icterus spurius
Red-winged Blackbird	Agelauis phoeniceus
Purple Grackle	Quiscalus quiscula
Brown Thrasher	Toxostoma rufum
Mockingbird	Mimus polyglottos
Wood Thrush	Hylocichla mustelina
Kentucky Warbler	Oporornis formosus
Paurla Warbler	Parula americana
Swainson Warbler	Limnothlypis swainsonii
Summer Tanager	Piranga rubra
Hairy Woodpecker	Dendrocopos villosus
Pileated Woodpecker	Dryocopus pileatus
Red-headed Woodpecker	Melanerpes erythrocephalus
Red-eyed Vireo	Vireo olivaceus
Sugarcane Field	
Common Crow	Corvus brachyrhynchos
Bobwhite	Colinus virginianus
Mourning Dove	Zenaidura Macroura
Hooded Warbler	Wilsonia citrina

Source: Adapted from Chabreck, 1973

Table A-6. Mammals Whose Range Includes Lafourche Crossing Prime Prospect Area.

Common Name	Scientific Name
Virginia opossum	Diadelphis virginiana
least shrew	Cryptotis parva
eastern pipistrelle	Pipistrellus subflavus
red bat	Lasiurus borealis
seminole bat	Lasiurus seminolus
northern yellow bat	Lasiurus intermedius
evening bat	Nycticeus humeralis
Rafinesque's big-eared bat	Plecotus rafinesquii
Brazilian free-tailed bat	Tadarida braziliensis
nine-banded armadillo	Dasypus novemcinctus
eastern cottontial[2]	Sylvilagus floridanus
swamp rabbit[2]	Sylvilagus aquaticus
gray squirrel[2]	Sciurus carolinensis
fox squirrel[2]	Sciurus niger
southern flying squirrel	Glaucomys volans
marsh rice rat	Oryzomys palustris
fulvous harvest mouse	Reithrodontomys fulvescens
white-footed mouse	Peromyscus leucopus
cotton mouse	Peromyscus gossypinus
hispid cotton rat	Sigmodon hispidus
eastern wood rat	Neotoma floridana
common muskrat[1]	Ondatra zibethicus
roof rat	Rattus rattus
norway rat	Rattus norvegicus

Table A-6 Continued

Common Name	Scientific Name
house mouse	Mus musculus
nutria[1]	Myocastor coypus
northern raccoon[1]	Procyon lotor
North American mink	Mustela vison
Neartic River otter[1]	Lutra canadensis
bobcat[1]	Lynx rufus
white-tailed deer[2]	Odocoileus virginianus

[1]Commonly trapped in Louisiana for its fur (O'Neil and Linscombe, 1977).

[2]Commonly sought after as a game species in Louisiana.

Source: Lowery, 1974

Table A-7. Common Bottomland Hardwood Species Ranked by Dominance.

COMMON NAME	SCIENTIFIC NAME
Drummond red maple	Acer rubrum var. drummondii
water tupelo	Nyssa aquatica
box elder	Acer negundo
cottonwood	Populus deltoides
bald cypress	Taxodium distichum
roughleaf dogwood	Cornus drummondii
black willow	Salix nigra
American elm	Ulmus americana
shagbark hickory	Carya ovata
pumpkin ash	Fraxinus tomentosa
water oak	Quercus nigra
persimmon	Diospyros virginiana
deciduous holly	Ilex decidua
bitternut hickory	Carya cordiformis
Shumard red oak	Quercus shumardii
sweetgum	Liquidambar styraciflua

Source: Chabreck, 1970

APPENDIX B

NOISE

NOISE

Noise from geothermal-related activities will vary in both level and frequency depending on the particular operation occurring at any given time. Therefore, for the purpose of this assessment, two of these possible noise levels will be analyzed; an operational or average, and a maximum anticipated. An average drilling rig in operation will output approximately 90 dBA at 6 m (20 ft) from the engine room. This level will be used as the operational level. An unmuffled, venting, geothermal well will produce about 120 dBA at 30 m (100 ft) from the well head. This noise level will be used as the maximum level that may possibly occur.

Noise reductions can be obtained by a variety of methods. The most dependable of these is the reduction due to increased distance from the source. The geometric spreading ratio of noise reduces a known level at a rate of three decibels for every doubling of a given distance from the source over hard surfaces. Over vegetated surfaces the drop-off rate increases to six decibels per doubling of distance. Other factors enter into the calculations to further increase the drop-off rate. Molecular absorbtion will attenuate 1 dBA per 305 m (1,000 ft) after the first 610 m (2000 ft). Atmospheric effects will also add 1 dBA per 305 m after the first 305 m to the drop-off rate. Figure B-1 depicts noise produced by normal operation of a drill rig as contour lines. As can be seen, to meet the DOI rural residential

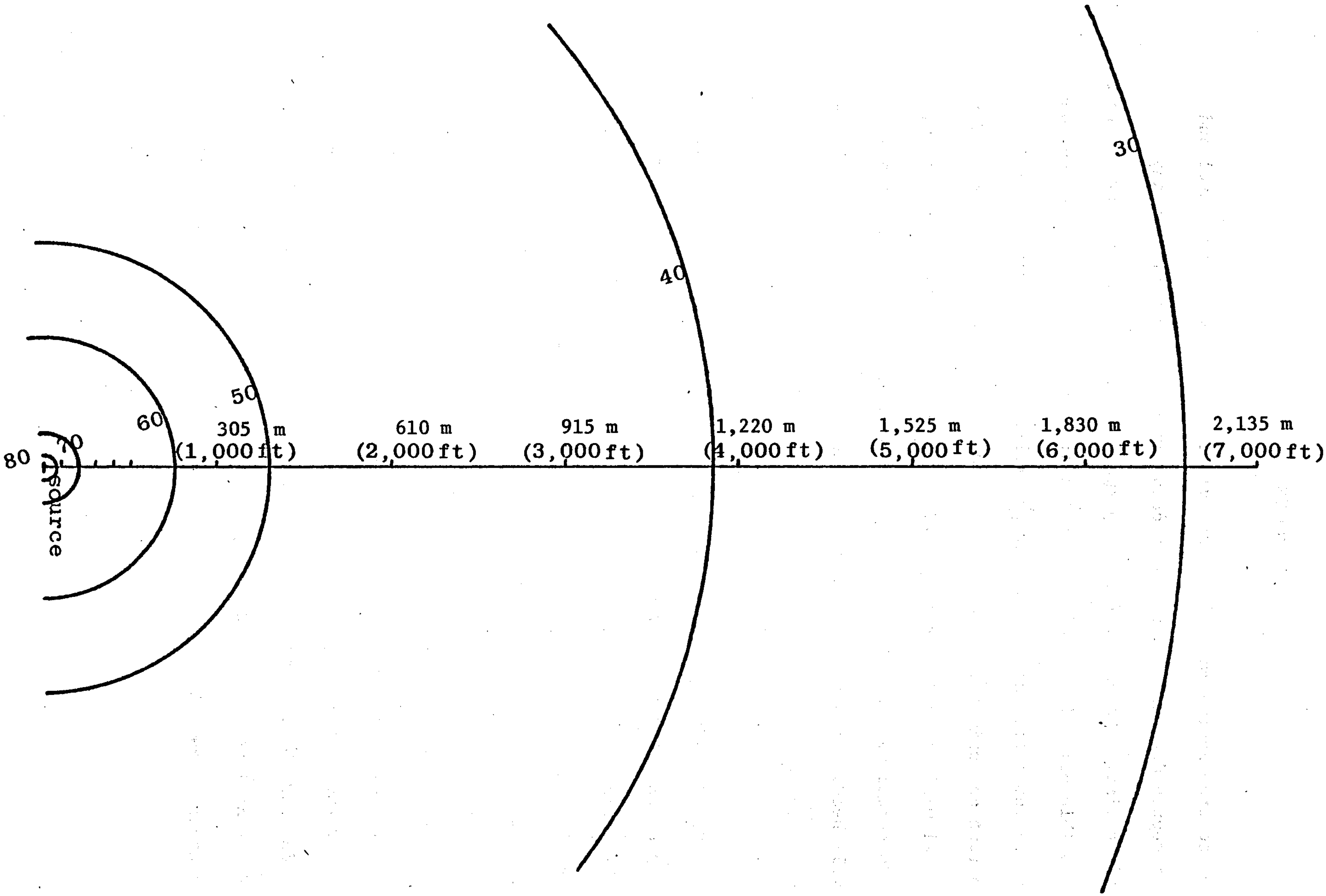

Figure B-1. Noise Contours from Well Site, Normal Operations (dBA) criteria at night, the drill rig would need to be placed a minimum of 2,000 m (1.25 mi) (Overlay) from the nearest residence. To meet the surburban criteria at night, the distance would be 1,500 m (5,000 ft). If the well were vented in an unmuffled condition, except during an emergency, the distances would be 7,050 m (4.5 mi) and 6,300 m (4 mi) respectively, as shown in Figure B-2. Under normal operating conditions, anticipated noise levels will not exceed the criteria established in Geothermal Resources Operations Order (GRO) No. 4 (Section 2.5).

The Lafourche Crossing Prime Prospect Area is generally devoid of landforms which might naturally aid in reducing noise levels. Trees abound in some areas and may be used to screen the well site not only from view but also from a noise standpoint. Experiments have shown (Cook et al., 1974) that rows of dense trees, about 31 m (100 ft) thick, will reduce a given noise level by four to six decibels in addition to the normal distance reduction. Landforms, such as berms, dikes or hills, will produce as much attenuation as 10-15 decibels depending upon their height. Greater reductions have been produced by a combination of trees and landforms, again depending upon height and relationship to the noise source. Generally, the higher the screen, and the closer the source, the greater the attenuation.

All the current noise regulations are based in some manner on the land-use of the receptor area. The land-uses or activities which are most likely to be affected by noise are called sensitive receptors. A sensitive receptor can be defined as a land-use whose primary function

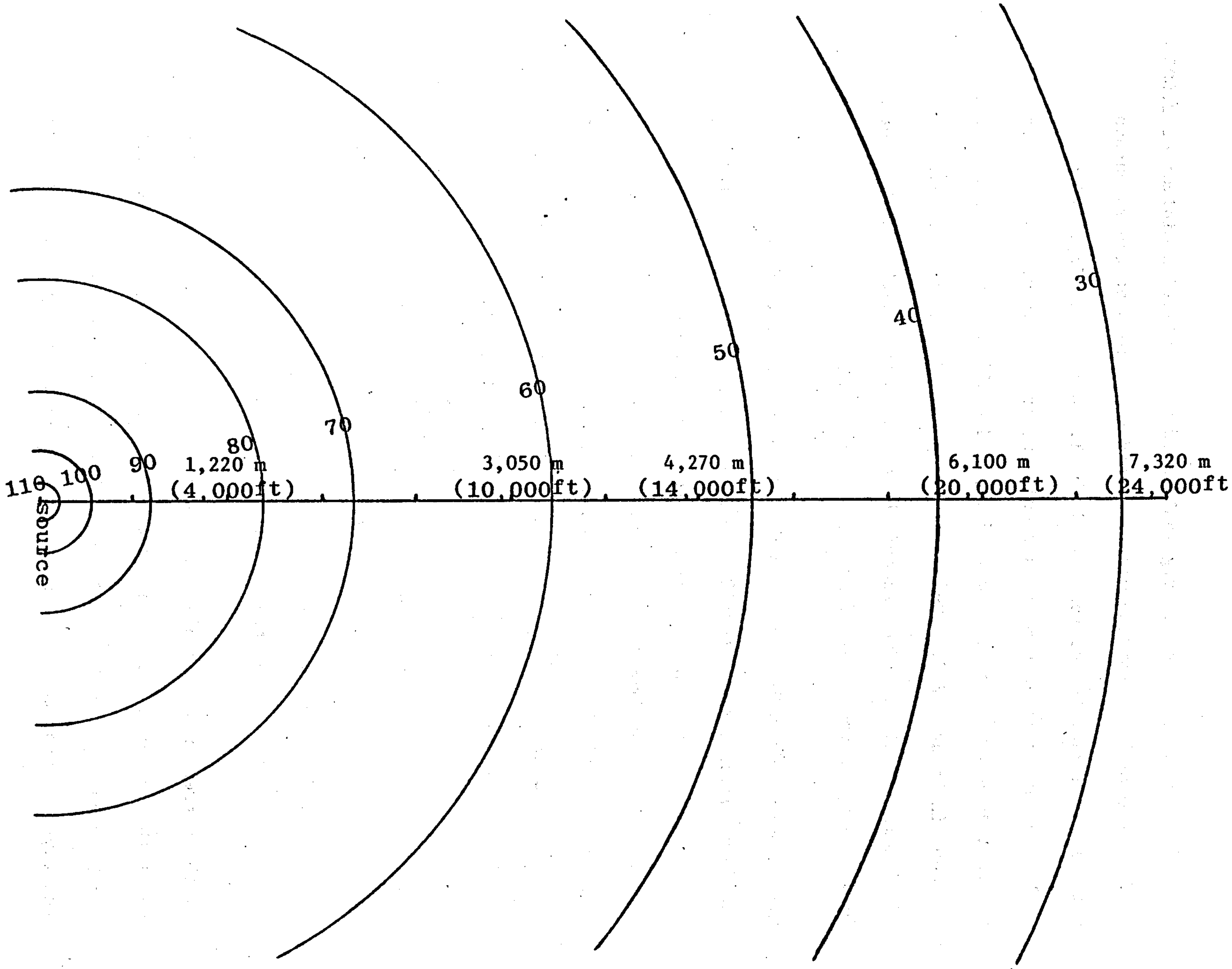

Figure B-2. Noise Contours from Well Site, Maximum Anticipated Level (dBA) is devoted to an activity where quietude is a critical factor of use [U.S. Federal Highway Administration (FHWA), 1978]. A list of sensitive receptors would include, but would not be limited to, churches, school, hospitals, cemeteries, rest homes, and certain parks.

Another major category of receptors, less critical than sensitive receptors, are residential receptors. Residential receptors present more of an analysis problem than do sensitive receptors because there is no general agreement between Federal agencies pertaining to a specific noise level which constitutes impaction. The U.S. Department of Housing and Urban Development (1971) gives the criteria level at a residence as exceeding 65 dBA for nine or more hours in any given 24 hour time span. The U.S. Federal Highway Administration (1978) suggests that 70 dBA during peak traffic hours should be the maximum desirable level from highways. The U.S. Department of the Interior(1973) gives 45 dBA as a maximum daytime level for rural residences.

To further compound this problem, some agencies allow for reductions due to the structure if there are no consistent outdoor activities. For instance, the EPA's criteria allow up to an L_{dn} of 55 dBA for the outside of residences or 45 dBA for the inside. Since any air-conditioned dwelling will attenuate more than 10 dBA, the level outside may, in certain cases, be greater than 55 dBA.

The effects of structures on noise will vary with the type of construction. Therefore, to adequately address this situation, some discussion of noise transmission is necessary. When noise from an outside source strikes a building, some of the noise is reflected and a part is transmitted through the structure.

The reduction of the noise level due to reflection and absorption by the walls, roof and windows is dependant upon the type of construction of the building and the living habits of the occupants. For example, a house with the windows open, at the same distance from a noise source as one with the windows closed, will experience a higher interior noise level.

The greatest influences on noise reduction for a structure are determined by the type of construction of the windows, walls, and roof. These all relate to the density of the structure itself. The more dense a structure, the greater the attenuation of transmitted noise. For noise reduction, solid concrete produces greater attenuation than brick veneer, which is better than wood frame. Similarly, the type of interior construction, such as paneling or sheet rock, and the thickness of the wall insulation will also affect the degree of attenuation.

Factors which influence sound transmission through the roof are primarily the type of shingles, type of ceiling construction and thickness of insulation. Windows also have a significant effect on a building's noise attenuation. The newer aluminum windows fit tighter than wood and therefore allow less noise through. Double-paned windows provide the greatest noise attenuation, while jalousie windows afford the least.

A graphic portrayal of the effect of construction on attenuation is shown in Figure B-3. Air-conditioned residences are generally considered to have the windows closed most of the time.

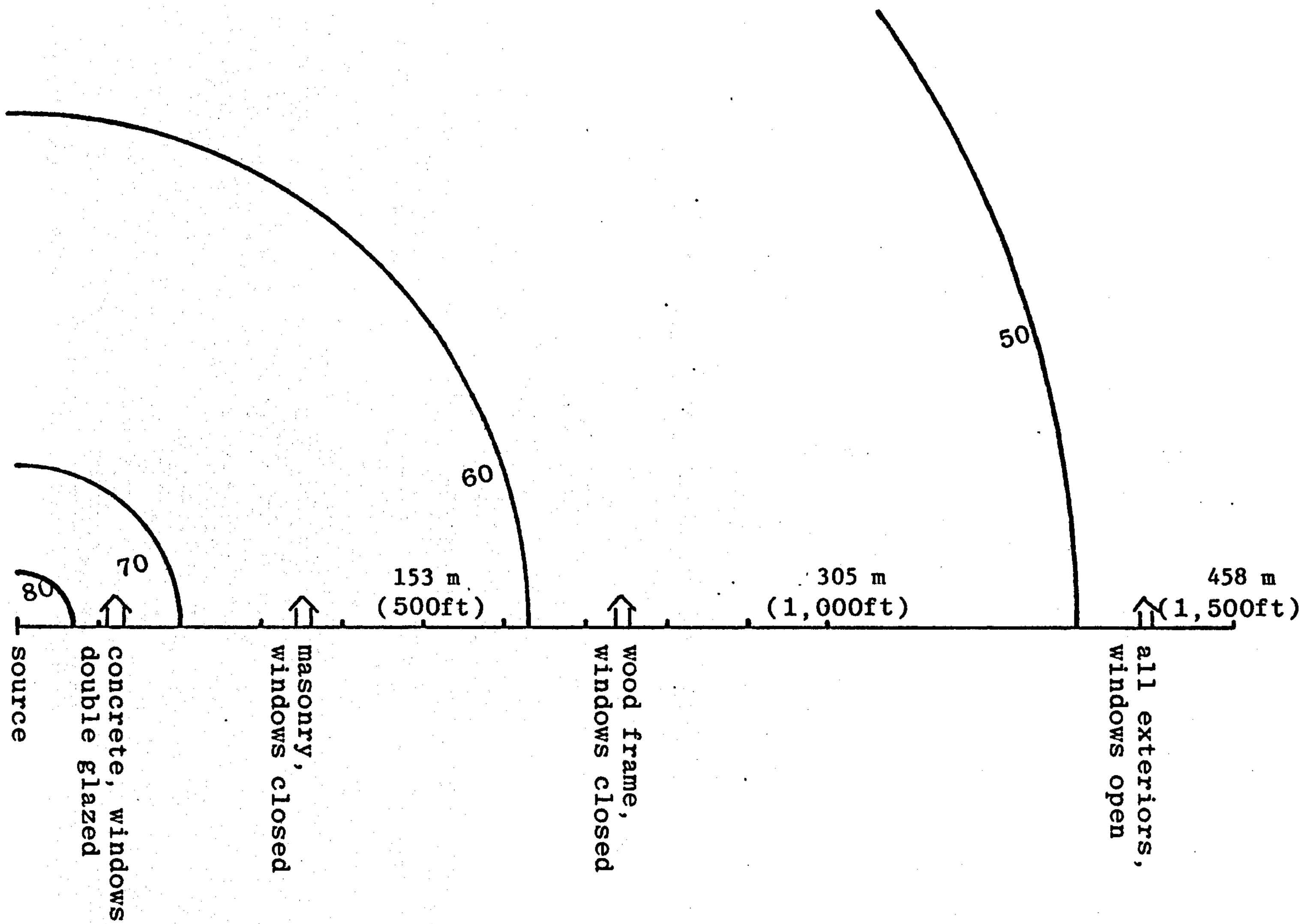

Figure B-3. The Effect of Structural Attenuation on Exterior Noise Levels to Produce an Interior L_{dn} of 45 dBA

APPENDIX C

GEOLOGY

GEOLOGY

The possible geologic impacts of flow-testing or operation of the proposed action are 1) land subsidence, and 2) contamination of or hydraulic effects upon the surface environment in the vicinity of the proposed action, or the subsurface environment, consisting of both fresh and saline aquifer systems. All such impacts are of a secondary nature, occurring as a consequence of fluid withdrawal, or fluid escape, from formations in the geopressure zone.

Land-surface subsidence as a result of fluid production from the subsurface is a complex hydrodynamic phenomenon related to the drainage function of fine-grained sediments, mainly swelling varieties of clay. This subsidence is closely controlled by the geometry of sediment facies distribution in the zone of hydraulic stress, the salinity and temperature of formation waters set in motion by the hydraulic stress, and the effects of structural deformation, mainly faults, as subsurface hydraulic barriers. Faults in the Louisiana Gulf Coastal Plain reflect natural hydrodynamic effects. Their location and the movement on them is mainly the consequence of differential compaction of sandy sediment facies and adjacent clayey sediment facies, in response to progressive compressive stress due to increasing overburden load, concurrent with continuing prograding deltaic deposition. Movement on such faults is likely to be renewed if the pressure of interstitial fluids in the fine-grained sediments is reduced, resulting in effective stress differentials greater than any the sediments have previously experienced.

Reactivation of movement on existing faults as a consequence of compressive stress induced by removal of fluids from the subsurface by wells is common in the Gulf Coastal Plain of Texas, and is evident in a few localities in Louisiana. All such movements are attributable to fluid pressure declines in reservoirs of the hydropressure zone only.

Susceptibility of any locality to land subsidence as a consequence of fluid withdrawal from reservoirs in the hydropressure zone is related to the hydrologic history of the locality and of the region in which it occurs. If the deposits in a coastal area have been preconsolidated by loading stress as a consequence of Pleistocene lowering of sea level, deep trenching and excavation of aquifers by rejuvenated coastal streams, and consequent drainage and widespread lowering of the water table several hundreds of meters below its present "static level" (the natural water level in aquifers before fluid withdrawals through wells); there will be no subsidence of the land surface until the head of water in these deposits is lowered by pumping below the level reached in the geologic past. The Holocene deposits, which overlie the Pleistocene deposits, have not been prestressed by natural drainage, and are highly susceptible to compaction as a result of fluid withdrawal and consequent head decline; land subsidence from fluid withdrawal is common where Holocene deposits are affected.

The major cycle of sea level decline that began with Late Wisconsin glaciation resulted in deep entrenchment of the Mississippi River system (Fig. C-1). Sediments were then transported to the outer edge

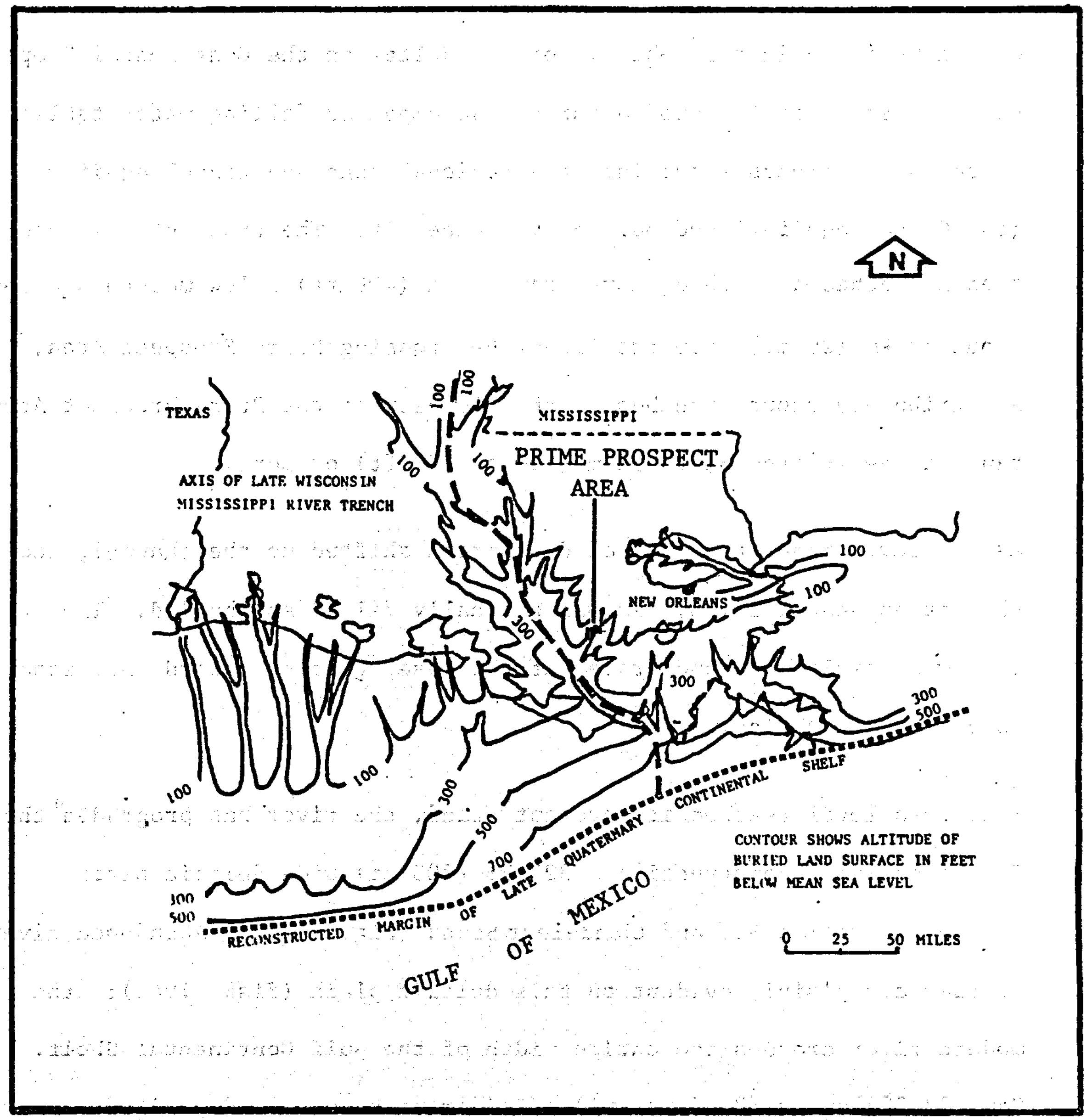

Figure C-1. Late Wisconsin entrenched valley system of the Mississippi River and postulated positions of minor stream trenches on the Continental Shelf (After Fisk and McFarlan, 1955).

of the Gulf Continental Shelf, forming deltas on the Continental Slope. Deep oxidation of the eroded surface accompanied falling water tables as the scour trenches cut into the regional sand and gravel aquifer (the Chicot aquifer) and partially drained it. The trunk stream scour trench reached a depth of more than 122 m (400 ft) below modern sea level, about 32 km (20 mi) from the Lafourche Crossing Prime Prospect Area, and tributary scour trenches in the vicinity of the Prime Prospect Area range in depth from 31 to 92 m (100 to 300 ft) or more.

As sea level rose, the site of deposition shifted up the channel, and the entrenched valley system was gradually filled and buried. The fill was mainly sand and gravel at the base, grading upward into sand, sandy silt, and clay.

Since sea level reached its present stand, the river has prograded the Gulf shoreline, constructing a 322 km (200 mi) wide deltaic plain between Vermilion Bay and Chandeleur Sound (Fig. C-2). Abandoned river courses are plainly evident on this deltaic plain (Fisk, 1944); the modern river crosses the entire width of the Gulf Continental Shelf. Some 33,324 cu km (8,000 cu mi) of sediment have been deposited in this latest cycle, and the underlying Prairie terrace has been downwarped as shown in Figure C-3 (Fisk and McFarlan, 1955). Subsidence of the Lafourche Crossing Prime Prospect Area as a result of this downwarp exceeds 31 m (100 ft), but Holocene deposition contemporaneous with subsidence more than offset the downwarp and produced the present land surface conditions.

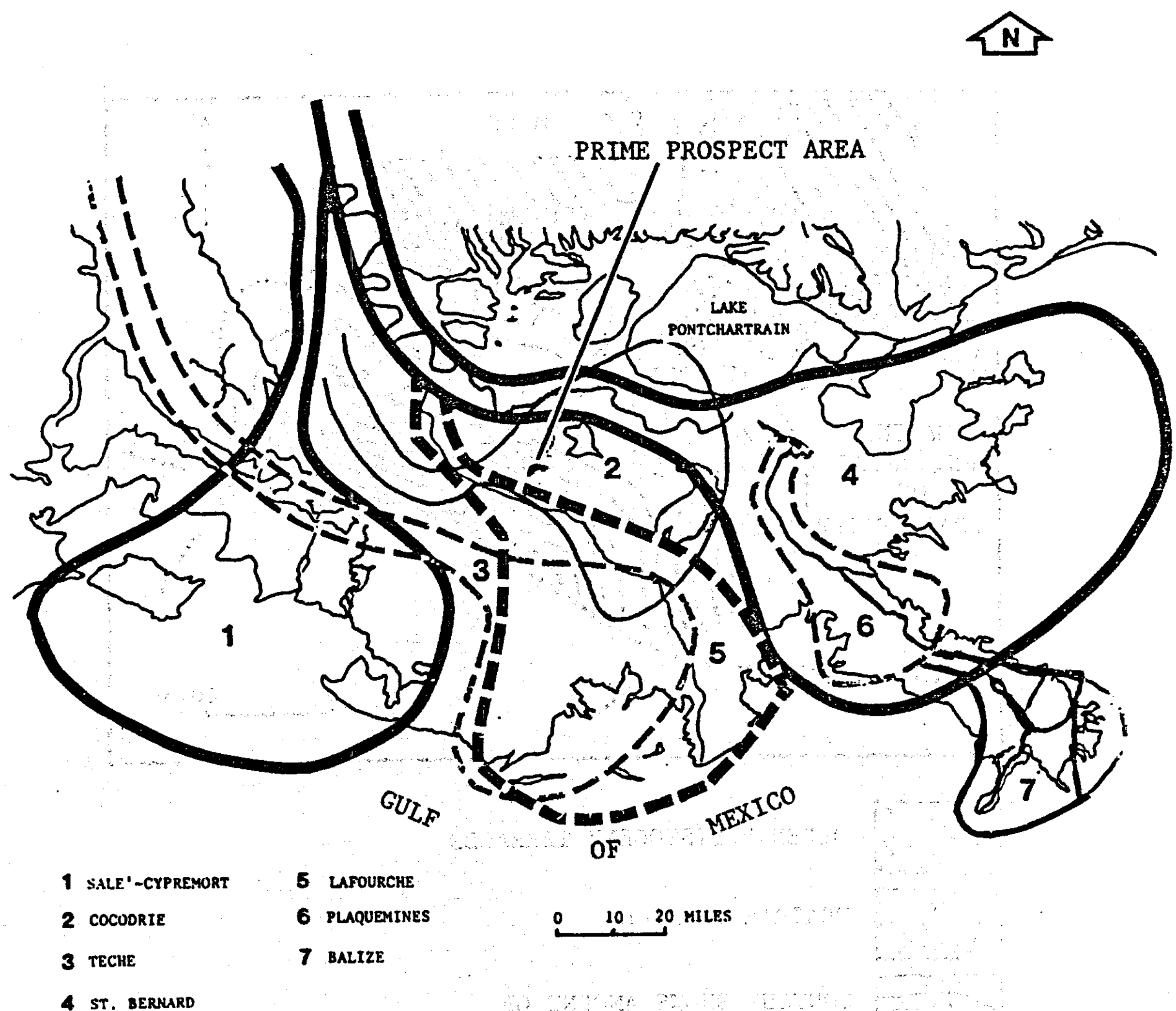

Figure C-2. Holocene Mississippi River deltas (After Kolb and Van Lopik, 1966).

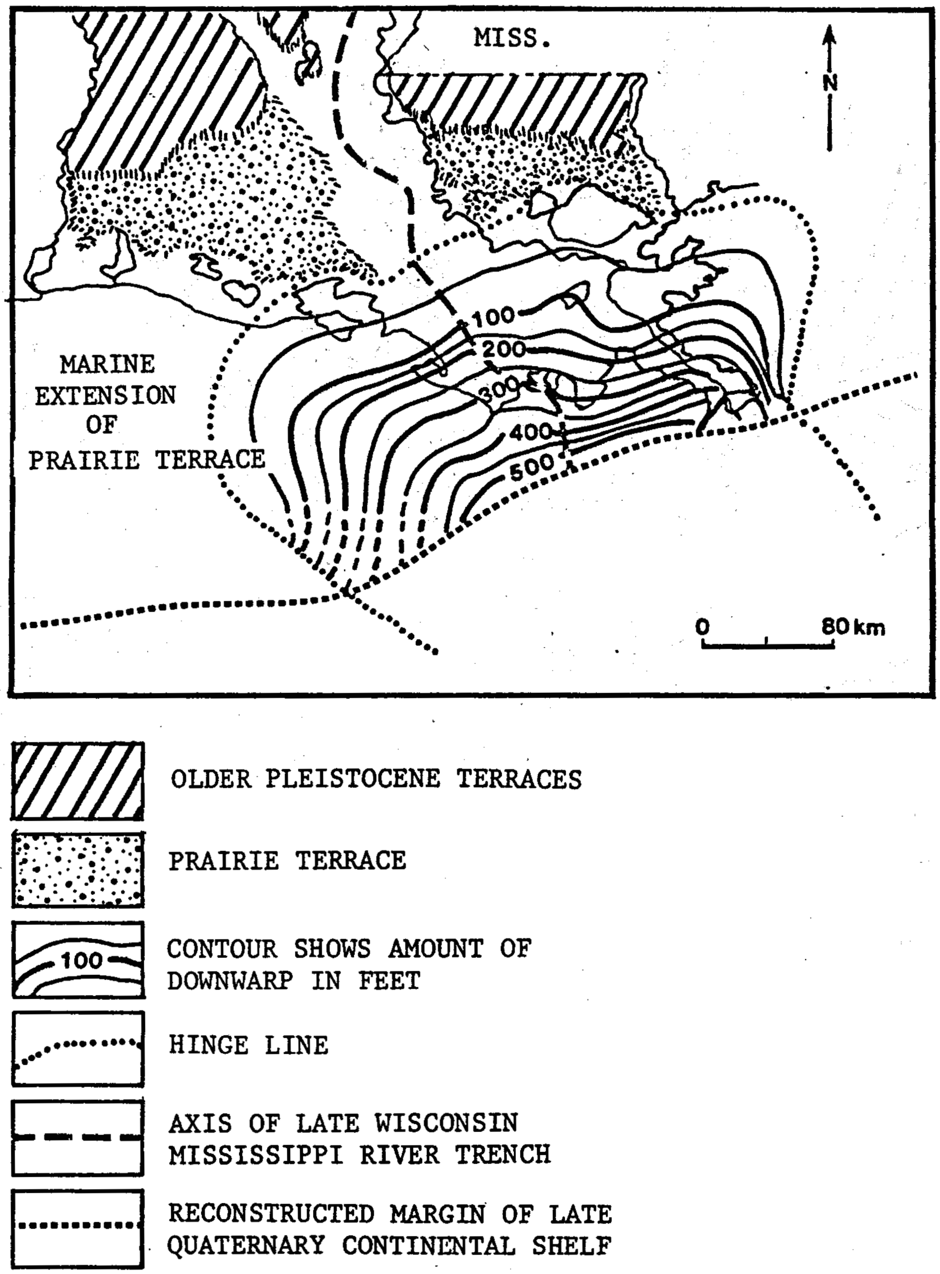

Figure C-3. Downwarp of the Prairie terrace in the area of Holocene deltaic deposition (After Fisk and McFarlan, 1955).

Bayou Lafourche, which passes through the Prime Prospect Area, marks the course of an abandoned channel of the Mississippi River. Holocene deposits, mainly alluvial channel sands, range in thickness from 31 to 153 m (100 to 500 ft) or more in short distances (a few km), because of the relief on the underlying pre-Holocene erosional surface. Pleistocene deposits, mainly of deltaic origin, occur to a depth of about 549 m (1,800 ft). These are underlain by deltaic and near-shore marine Pliocene sediments to a depth of about 1830 m (6,000 ft); the base of Upper Miocene deposits of similar origin is about 2440 m (8,000 ft) below sea level. Middle Miocene deposits, somewhat more calcareous than those above, occur to a depth of 4575 to 4880 m (15,000 to 16,000 ft) under the Prime Prospect Area. These include the principal oil and gas reservoirs.

Structural deformation of deposits that underlie the Prime Prospect Area, mainly growth faulting (sedimentary tectonics) and diapirism (salt tectonics), has a marked effect on conditions below a depth of about 2440 m (8,000 ft), as indicated on the structure map of the Lafourche Crossing field (Fig. C-4). This map, based upon the depth of occurrence of the Bigenerina Humblei sand (near the base of the Upper Miocene), conforms only in a general way with the maps of the Robulus "L" 43 marker and the underlying Operculinoides Plater marker, prepared by Louisiana State University under Department of Energy Contract No. EY-76-S005-4889. The fault complexity increases with depth, but the maps provided by the L.S.U. project do not indicate the displacement along fault boundaries of the site area. At the Bigenerina Humblei marker, however, the wedge-shaped fault block on which the Prime

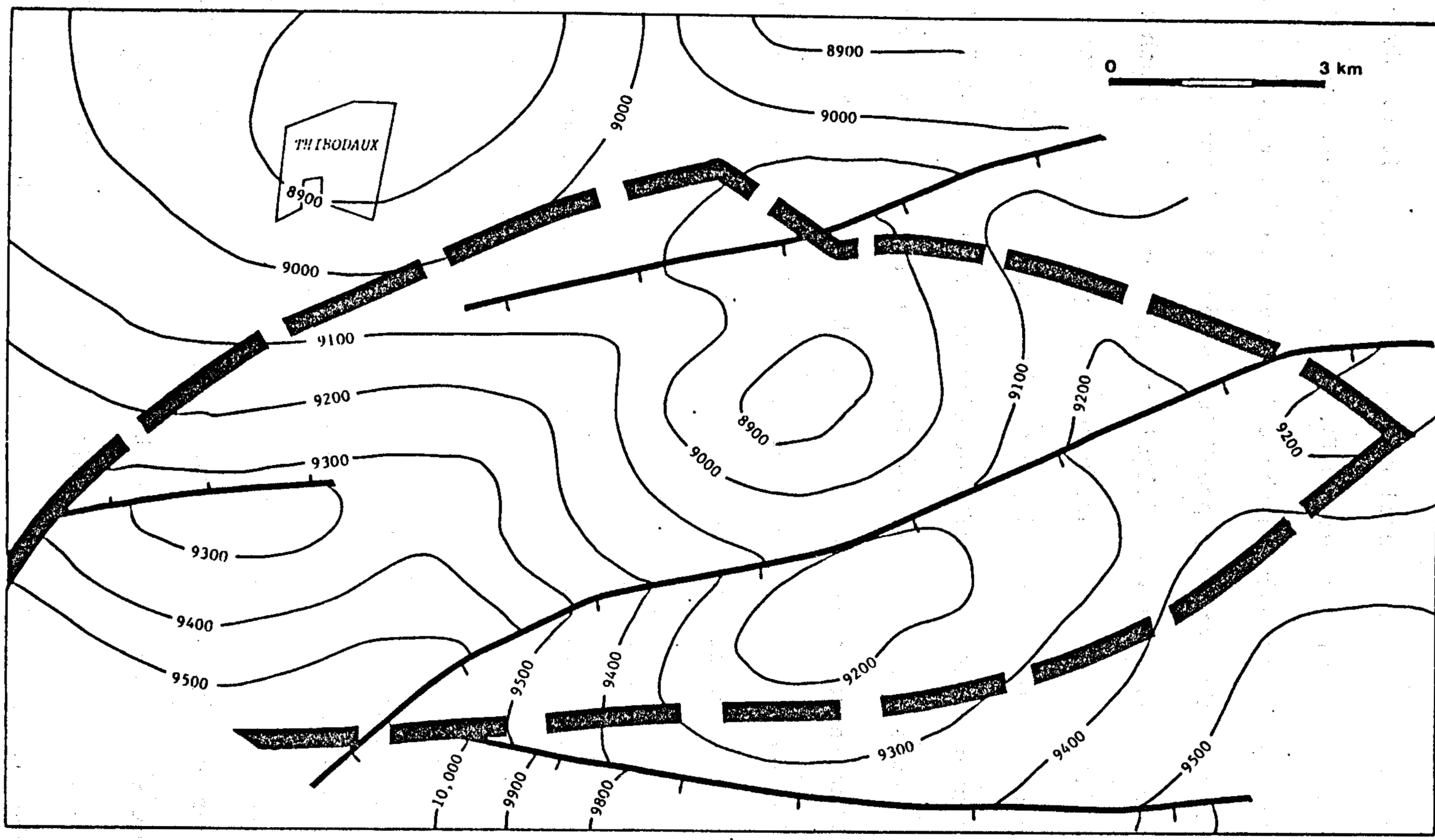

Figure C-4. Structure map of Lafourche Crossing field (After Jones, 1978).

Prospect Area occurs is less than 3.2 km (2 mi) wide from north to south; and the boundary faults converge westward at a point less than 3.2 km (2 mi) from the site. Both faults are downthrown to the south, the displacement on the northern fault being about 61 m (200 ft), and on the southern fault between 92 m and 122 m (300 and 400 ft). Other faults that cut this marker in the site area trend generally east-northeastward, are spaced 3.2 to 4.8 km (2 to 3 mi) apart, and are downthrown gulfward. All faults die out upward, and almost no displacement by faulting can be mapped at depths less than 1220 m (4,000 ft).

A broad, gentle uplift of the land surface is, however, associated with the Hollywood-Houma anticlinal structure which trends east-west and is located about 16 km (10 mi) south of the Prime Prospect Area. According to Meyerhoff (1968), deformation at depths below 2440 m (8,000 ft) is reflected at the land surface by .6 to 1.5 m (2 to 5 ft) of relief. This might escape notice elsewhere, but here it separates habitable land from the marsh. For this same reason, any land subsidence as a consequence of fluid withdrawal from oil and gas reservoirs would be highly conspicuous. As a matter of record, 19.9 billion m^3 (703 billion cu ft) of natural gas and 9.4 million barrels of condensate were produced between 1953 and 1965 from the Hollywood-Houma reservoirs, most of which are geopressured. No land subsidence attributable to these fluid withdrawals has been reported.

APPENDIX D

AGENCIES CONTACTED

APPENDIX D

Agencies Contacted During the Preparation of the Environmental Assessment

*U.S. DEPARTMENT OF THE INTERIOR
HERITAGE, CONSERVATION AND RECREATION SERVICE
18th and 5th Street C
Washington, D.C. 20240

*U.S. WATER RESOURCES COUNCIL
2120 L Street, Suite 800
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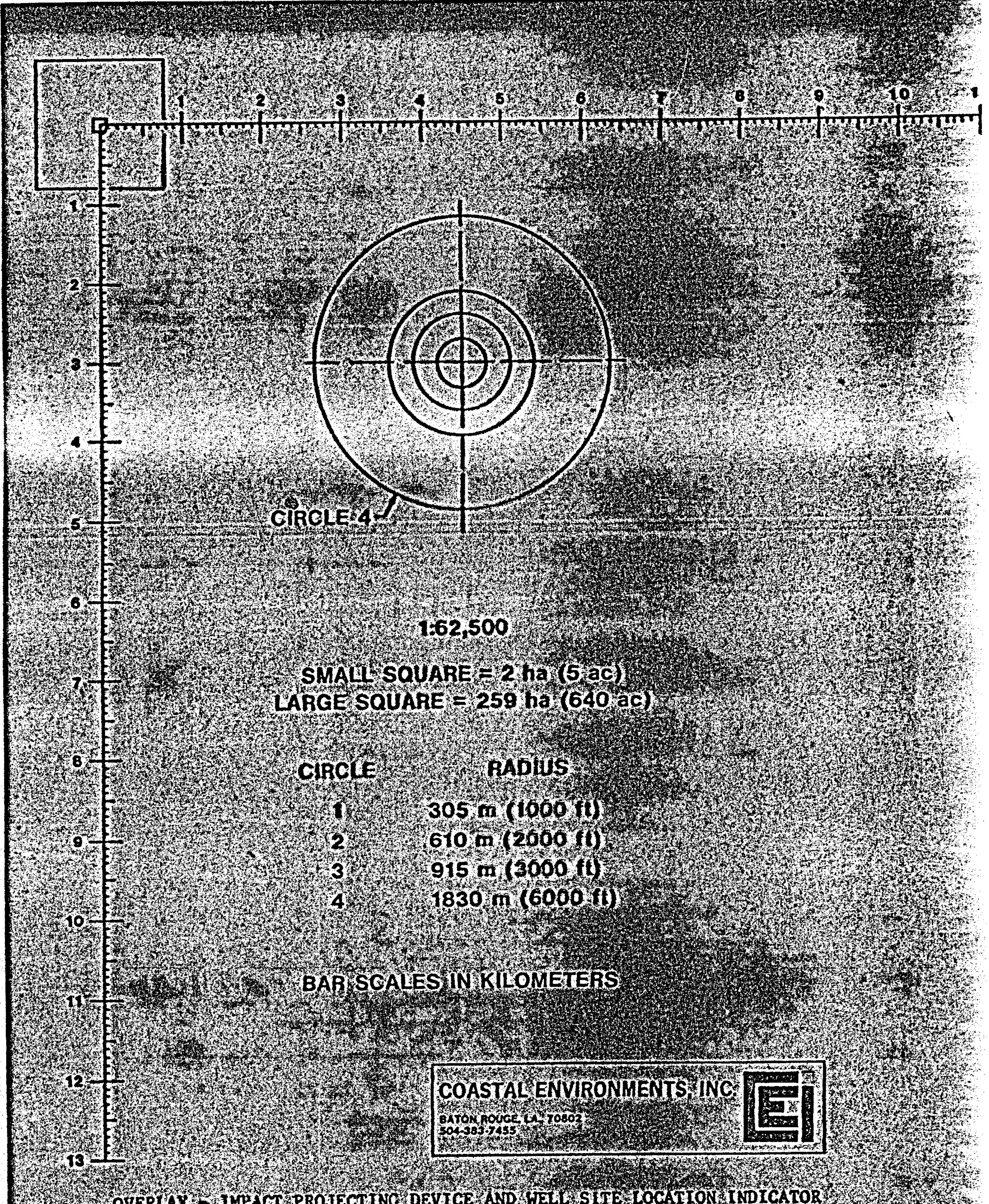

OVERLAY - IMPACT PROJECTING DEVICE AND WELL SITE LOCATION INDICATOR