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**A PRELIMINARY ENVIRONMENTAL ASSESSMENT
OF SELECTED GEOPRESSURED - GEOTHERMAL PROSPECT AREAS:
LOUISIANA GULF COAST REGION**

**Volume II
ENVIRONMENTAL BASELINE DATA**

**INSTITUTE FOR ENVIRONMENTAL STUDIES
LOUISIANA STATE UNIVERSITY
BATON ROUGE, LOUISIANA**

**Prepared for
U. S. DEPARTMENT OF ENERGY
DIVISION OF GEOTHERMAL ENERGY**

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VOLUME II
ENVIRONMENTAL BASELINE DATA

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D. P. Harrison, R. A. Muller, J. P. Newman, Jr., C. G. Smith, Jr.
J. I. Bailey, Jr., G. G. Kelly, K. C. Reibert

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AUTHORS BY SUBJECT MATTER AND DEPARTMENT

Unlike the case with the companion volume, the work of the individual authors in this volume was consolidated so as to present a composite picture of each of the six prospect areas. Thus, the following listing is presented in order to identify the work of the individual authors, as well as the department represented.

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CONTENTS

	Page
List of Figures	viii
List of Tables.	xi
INTRODUCTION TO VOLUME II	1
PROSPECT AREA NO. 1: SOUTH JOHNSON'S BAYOU	3
Geology and Geohydrology	5
Geologic Setting.	5
Economic Geology.	5
Ground-Water Resources and Quality.	5
Aquifer Availability for Brine Disposal	12
Soils	12
Air Quality.	16
Measured Ambient Air Quality.	16
Predicted Ambient Air Quality	16
Water Resources and Flood Hazards.	19
Hydrology	19
Water Usage and Quality	22
Flood Hazards	22
Ecological Systems	24
General Setting	24
Commercial Harvests	36
Unique Ecological Features.	36
Land Use	39
General Land Use.	39
Historical and Archeological Sites.	40
Wildlife Preserves and Management Areas	40
PROSPECT AREA NO. 2: SWEET LAKE	47
Geology and Geohydrology	49
Geologic Setting.	49
Economic Geology.	49
Ground-Water Resources and Quality.	49
Aquifer Availability for Brine Disposal	57
Soils	59

	Page
Air Quality.	63
Measured Ambient Air Quality.	63
Predicted Ambient Air Quality	65
Water Resources and Flood Hazards.	67
Hydrology	67
Water Usage and Quality	67
Flood Hazards	74
Ecological Systems	74
General Setting	74
Commercial Harvests	76
Unique Ecological Features.	83
Land Use	83
General Land Use.	83
Historical and Archeological Sites.	89
Wildlife Preserves and Management Areas	89
PROSPECT AREA NO. 3: ROCKEFELLER REFUGE	91
Geology and Geohydrology	93
Geologic Setting.	93
Economic Geology.	93
Ground-Water Resources and Quality.	93
Aquifer Availability for Brine Disposal	100
Soils	100
Air Quality.	100
Measured Ambient Air Quality.	100
Predicted Ambient Air Quality	105
Water Resources and Flood Hazards.	106
Hydrology	106
Water Usage and Quality	108
Flood Hazards	111
Ecological Systems	111
General Setting	111
Commercial Harvests	118
Unique Ecological Features.	120

	Page
Land Use	120
General Land Use.	120
Historical and Archeological Sites.	125
Wildlife Preserves and Management Areas	126
PROSPECT AREA NO. 4: SOUTHEAST PECAN ISLAND	131
Geology and Geohydrology	133
Geologic Setting.	133
Economic Geology.	133
Ground-Water Resources and Quality.	133
Aquifer Availability for Brine Disposal	139
Soils	141
Air Quality.	141
Measured Ambient Air Quality.	141
Predicted Ambient Air Quality	146
Water Resources and Flood Hazards.	146
Hydrology	146
Water Usage and Quality	149
Flood Hazards	150
Ecological Systems	154
General Setting	154
Commercial Harvests	161
Unique Ecological Features.	161
Land Use	161
General Land Use.	161
Historical and Archeological Sites.	169
Wildlife Preserves and Management Areas	169
PROSPECT AREA NO. 5: ATCHAFALAYA BAY.	171
Geology and Geohydrology	173
Geologic Setting.	173
Economic Geology.	173
Ground-Water Resources and Quality.	173
Aquifer Availability for Brine Disposal	179
Soils	180

	Page
Air Quality.	180
Measured Ambient Air Quality.	180
Predicted Ambient Air Quality	185
Water Resources and Flood Hazards.	185
Hydrology	185
Water Usage and Quality	188
Flood Hazards	191
Ecological Systems	192
General Setting	192
Commercial Harvests	195
Unique Ecological Features.	195
Land Use	200
General Land Use.	200
Historical and Archeological Sites.	209
Wildlife Preserves and Management Areas	209
PROSPECT AREA NO. 6: LAFOURCHE CROSSING	211
Geology and Geohydrology	213
Geologic Setting.	213
Economic Geology.	213
Ground-Water Resources and Quality.	213
Aquifer Availability for Brine Disposal	221
Soils	221
Air Quality.	222
Measured Ambient Air Quality.	222
Predicted Ambient Air Quality	226
Water Resources and Flood Hazards.	228
Hydrology	228
Water Usage and Quality	231
Flood Hazards	235
Ecological Systems	235
General Setting	235
Commercial Harvests	239
Unique Ecological Features.	239

	Page
Land Use	239
General Land Use.	239
Historical and Archeological Sites.	240
Wildlife Preserves and Management Areas	251
REFERENCES & MAP SOURCES	253

FIGURES

Page

SOUTH JOHNSON'S BAYOU PROSPECT AREA

Fig. 1-1	Location Map	7
Fig. 1-2	Ground-Water Occurrence, Oil and Gas Fields.	9
Fig. 1-3	General Soil Areas	13
Fig. 1-4	SO _x Emission Sources in Vicinity	18
Fig. 1-5	Series of Cheniers	20
Fig. 1-6	Lakes Formed Behind Cheniers	20
Fig. 1-7	Small Cheniers	21
Fig. 1-8	Open Marsh	22
Fig. 1-9	Flood Hazards.	25
Fig. 1-10	Flooding from Hurricane Audrey	27
Fig. 1-11	Vegetative Zones	31
Fig. 1-12	Access Roads to Wells.	33
Fig. 1-13	Complete Disturbance of Marsh.	33
Fig. 1-14	Moderate Disturbance of Marsh.	34
Fig. 1-15	Chenier-marsh Interface.	34
Fig. 1-16	Beach.	35
Fig. 1-17	Commercial Fisheries, Unique Ecological Features	37
Fig. 1-18	Land Use	41
Fig. 1-19	Archeological Sites.	43
Fig. 1-20	Wildlife Refuges	45

SWEET LAKE PROSPECT AREA

Fig. 2-1	Location Map	51
Fig. 2-2	Ground-Water Occurrence, Oil and Gas Fields.	53
Fig. 2-3	Ground-Water Areas	61
Fig. 2-4	Predicted SO _x Concentrations	66
Fig. 2-5	Irrigation Canals and Rice Fields.	68
Fig. 2-6	Hydrologic Features, Flood Hazards	69
Fig. 2-7	Pumping Station on North Canal	71
Fig. 2-8	Flooded Rice Fields.	71
Fig. 2-9	Pattern of Cultivated Fields	75

Fig. 2-10	Vegetative Zones	77
Fig. 2-11	Unique Ecological Features	79
Fig. 2-12	Land Use	81
Fig. 2-13	Sectional Roads.	84
Fig. 2-14	Archeological Sites.	85
Fig. 2-15	Wildlife Refuges	87

ROCKEFELLER REFUGE PROSPECT AREA

Fig. 3-1	Location Map	95
Fig. 3-2	Ground-Water Occurrence, Oil and Gas Fields	97
Fig. 3-3	General Soil Areas	101
Fig. 3-4	Low Relief Marsh	106
Fig. 3-5	Levees in Rockefeller Wildlife Refuge.	107
Fig. 3-6	Deep Lake.	107
Fig. 3-7	Joseph Harbor Bayou.	109
Fig. 3-8	Impoundments in Rockefeller Wildlife Refuge.	109
Fig. 3-9	Flood Hazards.	113
Fig. 3-10	Vegetative Zones	115
Fig. 3-11	Access Canals and Slips.	117
Fig. 3-12	Estuarine Ecosystems	119
Fig. 3-13	Estuarine and Marsh Ecosystems	119
Fig. 3-14	Commercial Fisheries and Unique Ecological Features.	121
Fig. 3-15	Land Use	123
Fig. 3-16	Archeological Sites.	127
Fig. 3-17	Rockefeller Refuge	129

SOUTHEAST PECAN ISLAND PROSPECT AREA

Fig. 4-1	Location Map	135
Fig. 4-2	Ground-Water Occurrence, Oil and Gas Fields.	137
Fig. 4-3	General Soil Areas	143
Fig. 4-4	Cheniers	147
Fig. 4-5	Cheniere au Tigre.	147
Fig. 4-6	Freshwater Canal	148
Fig. 4-7	Canal System	148
Fig. 4-8	Hydrologic Features, Flood Hazards	151

Fig. 4-9	Vegetative Zones	155
Fig. 4-10	Access Canals and Slips.	158
Fig. 4-11	Wildlife Refuges	159
Fig. 4-12	Commercial Fisheries, Unique Ecological Features	163
Fig. 4-13	Land Use	165
Fig. 4-14	Archeological Sites.	167

ATCHAFALAYA BAY PROSPECT AREA

Fig. 5-1	Location Map	175
Fig. 5-2	Ground-Water Occurrence, Oil and Gas Fields.	177
Fig. 5-3	General Soil Areas	181
Fig. 5-4	Land Accretion: Wax Lake Outlet	186
Fig. 5-5	Spoil Islands.	186
Fig. 5-6	Four League Bay.	187
Fig. 5-7	Access Canals and Slips.	187
Fig. 5-8	Hydrologic Features, Flood Hazards	193
Fig. 5-9	Vegetative Zones	197
Fig. 5-10	Access Canal	199
Fig. 5-11	Beach.	199
Fig. 5-12	Commercial Fisheries, Unique Ecological Features	201
Fig. 5-13	Land Use	203
Fig. 5-14	Archeological Sites.	205
Fig. 5-15	Wildlife Refuges	207

LAFOURCHE CROSSING PROSPECT AREA

Fig. 6-1	Location Map	215
Fig. 6-2	Ground-Water Occurrence, Oil and Gas Fields.	217
Fig. 6-3	General Soil Areas	223
Fig. 6-4	Predicted SO _x Concentrations	228
Fig. 6-5	Hydrologic Features, Flood Hazards	229
Fig. 6-6	Water Treatment Plant.	232
Fig. 6-7	Pattern of Levee Development and Backswamps.	236
Fig. 6-8	Vegetative Zones	237
Fig. 6-9	Unique Ecological Features	241
Fig. 6-10	Land Use	243

Fig. 6-11	Developed Levee: Bayou Lafourche.	245
Fig. 6-12	Developed Levee: Bayou Terrebonne	245
Fig. 6-13	Forested Backswamp	246
Fig. 6-14	Historical and Archeological Sites	247
Fig. 6-15	Wildlife Refuges	249

TABLES

Page

SOUTH JOHNSON'S BAYOU PROSPECT AREA

Table 1-1	Oil and Gas Field Data	6
Table 1-2	Chemical Analyses of Ground Water.	15
Table 1-3	Thickness of Saline Aquifers	15
Table 1-4	Air Quality Data: Lake Charles.	16
Table 1-5	Concentrations of Selected Air Pollutants: Vinton, La.	17
Table 1-6	Louisiana Air Quality Standards.	17
Table 1-7	Water Quality Assessment: Sabine River Basin, Segment 15.	23
Table 1-8	Louisiana Water Quality Criteria: Portions of Sabine River Basin, Segment 15	23
Table 1-9	Major Characteristics of Ecosystems.	29
Table 1-10	Characteristic Plant Species of Marsh Types.	30
Table 1-11	Soil and Water Salinity of Marsh Types	30
Table 1-12	Summary of Land Use.	40

SWEET LAKE PROSPECT AREA

Table 2-1	Oil and Gas Field Data	50
Table 2-2	Driller's Log of USGS Test Well.	56
Table 2-3	Chemical Analyses of Ground Water.	58
Table 2-4	Thickness of Saline Aquifers	59
Table 2-5	Air Quality Data: Lake Charles.	63
Table 2-6	Concentrations of Selected Air Pollutants: Lafayette, La.	64
Table 2-7	Louisiana Air Quality Standards.	64
Table 2-8	Point Sources of SO _x	65
Table 2-9	Water Quality Assessment: Calcasieu River Basin, Segment 25.	72
Table 2-10	Water Quality Assessment: Mermentau River Basin, Segment 7	73
Table 2-11	Louisiana Water Quality Criteria: Portions of Mermentau River Basin	73
Table 2-12	Major Characteristics of Ecosystems.	74
Table 2-13	Characteristic Plant Species of Fresh Marsh.	76
Table 2-14	Soil and Water Salinity of Fresh Marsh	76
Table 2-15	Summary of Land Use.	84

ROCKEFELLER REFUGE PROSPECT AREA

Table 3-1	Oil and Gas Field Data	94
Table 3-2	Chemical Analyses of Ground Water.	103
Table 3-3	Thickness of Saline Aquifers	103
Table 3-4	Air Quality Data: Lake Charles.	104
Table 3-5	Concentrations of Selected Air Pollutants: Lafayette, La. .	104
Table 3-6	Louisiana Air Quality Standards.	105
Table 3-7	Water Quality Assessment: Mermentau River Basin, Segment 11.	110
Table 3-8	Louisiana Water Quality Standards: Portions of Mermentau River Basin	110
Table 3-9	Major Characteristics of Ecosystems.	112
Table 3-10	Characteristic Plant Species of Marsh Types.	112
Table 3-11	Soil and Water Salinity of Marsh Types	117
Table 3-12	Summary of Land Use.	125

SOUTHEAST PECAN ISLAND PROSPECT AREA

Table 4-1	Oil and Gas Field Data	134
Table 4-2	Chemical Analyses of Ground Water.	140
Table 4-3	Thickness of Saline Aquifers	140
Table 4-4	Air Quality Data: Lake Charles, Baton Rouge, Garyville, La.. . . .	142
Table 4-5	Concentrations of Selected Pollutants: Morgan City, Lafayette, La.. . . .	142
Table 4-6	Louisiana Air Quality Standards.	145
Table 4-7	Water Quality Analyses	149
Table 4-8	Water Quality Assessment: Mermentau River Basin, Segment 11.	153
Table 4-9	Water Quality Assessment: Mermentau River Basin, Segment 21.	153
Table 4-10	Major Characteristics of Ecosystems.	154
Table 4-11	Characteristic Plant Species of Marsh Types.	157
Table 4-12	Soil and Water Salinity of Marsh Types	157
Table 4-13	Summary of Land Use.	162

ATCHAFALAYA BAY PROSPECT AREA

Table 5-1	Oil and Gas Field Data	174
Table 5-2	Thickness of Saline Aquifers	180
Table 5-3	Air Quality Data: Garyville, La.. . . .	183

Table 5-4	Concentrations of Selected Air Pollutants: Galliano, Morgan City, La.	184
Table 5-5	Louisiana Air Quality Standards.	184
Table 5-6	Water Quality Analyses	189
Table 5-7	Water Quality Assessment: Atchafalaya Basin, Segment 11.	190
Table 5-8	Water Quality Assessment: Terrebonne Basin, Segment 9	190
Table 5-9	Louisiana Water Quality Criteria: Atchafalaya Bay	191
Table 5-10	Major Characteristics of Ecosystems.	192
Table 5-11	Characteristic Plant Species and Soil and Water Salinities of Marsh Types: Hydrologic Unit VI	196
Table 5-12	Characteristic Plant Species of Marsh Types: Hydrologic Unit VI.	196
Table 5-13	Summary of Land Use.	209

LAFOURCHE CROSSING PROSPECT AREA

Table 6-1	Oil and Gas Field Data	214
Table 6-2	Chemical Analyses of Ground Water.	220
Table 6-3	Driller's Log of USGS Drillhole.	220
Table 6-4	Thickness of Saline Aquifers	221
Table 6-5	Air Quality Data: Garyville, La.	222
Table 6-6	Concentrations of Selected Air Pollutants: Galliano, Morgan City, Norco, La.	225
Table 6-7	Louisiana Air Quality Standards.	226
Table 6-8	Point Sources of SO _x	227
Table 6-9	Water Quality Analyses	232
Table 6-10	Water Quality Assessment: Terrebonne Basin, Segment 3	233
Table 6-11	Water Quality Assessment: Terrebonne Basin, Segment 7	233
Table 6-12	Louisiana Water Quality Criteria: Portions of Bayou Terrebonne.	234
Table 6-13	Louisiana Water Quality Criteria: Portions of Bayou Lafourche	234
Table 6-14	Major Characteristics of Ecosystems.	239
Table 6-15	Summary of Land Use.	246
Table 6-16	Historic Places.	251

INTRODUCTION TO VOLUME II

This is the second volume of a two volume report which presents a preliminary environmental assessment of selected geopressured-geothermal prospect areas in the Louisiana Gulf Coast region. This interdisciplinary study was sponsored by the Division of Geothermal Energy, U.S. Department of Energy, under Contract No. ET-78-S-05-5862, and was conducted by the Institute for Environmental Studies, with participation by representatives of other departments at Louisiana State University and consultants.

In the companion volume (Volume I), the six prospect areas under study are compared on the basis of potential impacts to the environment as a result of geopressure test well activities. In this volume, a separate section is presented for each of the six prospect areas studied. Each section includes a compilation and discussion of environmental baseline data derived from existing sources. In those instances where data specific to the prospect area were not available, regional data are reported.

The photographs included were taken by project investigators during aerial and ground reconnaissance of the prospect areas in the spring and summer of 1978.

PROSPECT AREA NO. 1: SOUTH JOHNSON'S BAYOU

GEOLOGY AND GEOHYDROLOGY

Geologic Setting

Economic Geology

Ground-Water Resources and Quality

Aquifer Availability for Brine Disposal

Soils

AIR QUALITY

Measured Ambient Air Quality

Predicted Ambient Air Quality

WATER RESOURCES AND FLOOD HAZARDS

Hydrology

Water Usage and Quality

Flood Hazards

ECOLOGICAL SYSTEMS

General Setting

Commercial Harvests

Unique Ecological Features

LAND USE

General Land Use

Historical and Archeological Sites

Wildlife Preserves and Management Areas

PROSPECT AREA NO. 1: SOUTH JOHNSON'S BAYOU

GEOLOGY AND GEOHYDROLOGY

Geologic Setting

South Johnson's Bayou prospect area is located along the western 16 km (10 mi) of the Cameron Parish coastline with approximately 64 per cent of the prospect on land and 36 per cent under the adjacent Gulf waters (Fig. 1-1). The irregularly shaped prospect is 19.3 km (12 mi) wide along the southwest-northeast axis and 9.7 km (6 mi) wide along the northwest-southeast axis. The prospect area is approximately 113.7 km² (43.9 mi²) in areal extent. The prospect area is bounded by major faults to the north and south which join to the east and west, and probably contains numerous, smaller faults within these boundaries.

Economic Geology

Within the prospect area boundaries, oil and gas are produced from Johnson's Bayou Field, oil is produced from part of the Deep Bayou field, and gas is produced off-shore from W. Cameron blocks 17 and 19 (Fig. 1-2). Production from these fields is from upper Miocene sands at depths ranging from 1,366 meters (4480 feet) at Johnson's Bayou to 3,639 meters (11,939 feet) at W. Cameron Block 19. Production data on these fields and two fields outside the prospect area boundaries are given in Table 1-1.

Ground-Water Resources and Quality

Figure 1-2 shows the depth of occurrence of three different qualities of ground water for the prospect area. The base of fresh ground water (less than 250 ppm chlorides) was mapped by Rollo (1960). Maps of the base of slightly saline water (1000 to 3000 mg/l dissolved solids) and moderately saline water (3000 to 10,000 mg/l dissolved solids) were prepared in a study of saline water resources in Louisiana by Winslow, et al., (1968). The definition of freshwater used by Rollo is based on chloride content, while the saline water resources are categorized on the basis of dissolved solids content in which freshwater would be less than 1000 mg/l dissolved solids. When comparing this map with the ground-water resource maps for the other prospect areas, it should be noted that Whitman (1965) found the relationship between dissolved solids content and chloride content in fresh and brackish ground water in southwestern Louisiana to be variable. He found the

Field	Producing Formation	Year of Discovery	Estimated Area Proved (Acres)		Number of Wells								Wells Producing At End of Year 1975		Producing Formation (s)					Deepest Zone Tested	Depth of Hole (Feet)
	Name Age and Depth (feet)				Cumulative To End of Year 1975	During Year 1975				Flowing	Artificial Lift	Oil Gravity (API)	Av. Porosity (Percent)	Producing Thickness (Av. Net Feet)		Structure	Name				
						Completed	Abandoned	Producing Thickness (Av. Net Feet)													
									Oil					Gas	Oil			Gas	Oil	Gas	
West Cameron Block 17 Block 19	Miocene U 10,658 Miocene U 11,939	1967 --	1962 1965	160 --	5140 720	2 --	31 6	0 --	1 0	0 --	1 0	0 --	21 3	0 --	47 --	P P	20 --	425 200	AF AF	Miocene L Miocene L	17,066 16,900
W. Johnson Bayou	Miocene U 8,946	--	1971	--	480	--	3	--	0	--	0	--	3	--	--	P	--	X	X	Miocene U	9,555
Deep Bayou	Miocene U 8,231	1960	1967	40	1500	1	3	0	0	0	0	0	0	0	X	P	5	43	AF	Miocene U	10,000
Johnson Bayou	Miocene U 4,480	1959	1946	1190	1720	47	24	0	0	0	1	13	12	6	40	P	100	355	AF	Miocene L	13,543
Cameron Meadows	Pliocene 1,269 Miocene U 3,089 Miocene L 8,306	1931 1931 1931	1931 1931 1931	1240	840	132	13	21	2	2	0	9	4	53	20 32 57	P P P	37 140 134	140 140 134	DS	Miocene L	15,073

Table 1-1. Oil and gas field data: South Johnson's Bayou prospect area. (From La. Dept. of Natural Resources, 1975).

FIG. I-1 PROSPECT AREA NO. I: SOUTH JOHNSON'S BAYOU

following relationship between chlorides and dissolved solids for the Chicot and the Chicot-Atchafalaya aquifer:

Aquifer	Prospect Area Included	Chlorides (ppm)	Dissolved Solids (ppm)
Chicot--Western Portion	1 & 2	250 450	620 1000
Chicot--Eastern Portion	3 & 4	250 425	700 1000
Chicot-Atchafalaya	5	250 360	810 1000

Hence, the maps of ground-water quality prepared for each prospect area are not precisely compatible. Furthermore, the maps are based on determinations of ground-water salinity made from resistivity measurements recorded on electrical logs, and this technique is not precise. However, because the transition between freshwater and slightly saline water is often abrupt, the maps are an adequate representation of the actual water quality distribution.

The coastal area of Cameron Parish was included in the comprehensive study of ground-water resources of southwestern Louisiana by Jones, et. al., (1954). This study was updated by Harder, et. al., (1967). Both studies show that the Chicot aquifer, an unconsolidated sand and gravel deposit, extends to a depth of 366 to 396 meters (1200 to 1300 feet) in the coastal region at Johnson's Bayou, and that this aquifer and all deeper sands contain only salty water. Slightly saline water occurs in the upper sands of the Chicot to a depth of more than 183 meters (600 feet) in the eastern portion of the prospect area. Moderately saline water extends to between 305 and 335 meters (1000 and 1100 feet) below the surface (Fig. 1-2).

In the South Johnson's Bayou prospect area, as in the other prospect areas along the coastal deltaic plain, the Chicot aquifer is overlain by Recent age, coastal marsh deposits which are characterized as fine grained clayey sediments to depths of 30 to 61 meters (100 to 200 feet). Such a sequence is recorded in driller's logs of the two water wells located closest to the prospect which showed clay extending as deep as 91 meters (300 feet).

Where fresh ground water is lacking, chemical analyses of ground water are also rare. A partial chemical analysis of water from only one well near the prospect is available and is presented in Table 1-2. With the exception of the U.S. Geological Survey observation well Cn-94, all water wells shown in Figure 1-2 are used by the oil and gas industry.

Aquifer Availability for Brine Disposal

Geophysical logs of two wells from the Johnson's Bayou field were examined to determine the total thickness of individual sands at least 9 meters (30 feet) thick below a depth of 457 meters (1500 feet). The data are summarized in Table 1-3.

Records of salt water disposal wells filed with the Louisiana Department of Natural Resources indicate disposal wells in Johnson's Bayou field are all rated less than 400 barrels per day. According to the Summary of Field Statistics and Drilling Operations in Louisiana for 1975 (La. Dept. of Natural Resources, 1975), two disposal wells were operating in Johnson's Bayou field with total volume injected for 1975 at 36,500 barrels. Total injected volume at the field for all years to 1975 was 707,000 barrels. One well operating in Cameron field injected brine at an average rate of 7,800 barrels per day during 1975.

The low disposal rates at fields in the Johnson's Bayou prospect area are not thought to be a function of inadequate disposal aquifers, but rather simply that the rates are adequate to handle the volume of brine disposal required at those fields. The aquifer volume at South Johnson's Bayou prospect area appears adequate to allow for disposal of brine produced during a three year test of geopressured resources at this site.

Soils

The soils of the prospect area are classed as coastal marsh (Lytle and Sturgis, 1962). These soils include peats, mucks and clays of the marsh and the Palm Beach Soils of the chenier ridges, both of which are high in organic matter and mineral plant nutrients. The soils are relatively impermeable. Figure 1-3 shows the general soil types in the prospect area and region.

Table 1-2. Chemical analyses from water well Cn-44: South Johnson's Bayou prospect area. (From USGS files, Baton Rouge, La.).

Well No.	Cn-44
Date	6-1-50
Screen Depth (feet)	382-423
Concentrations (mg/l)	
Total Iron	---
Calcium	70.4
Magnesium	33.4
Sodium	1232.0
Potassium	---
Bicarbonate	351.4
Sulfate	0
Chloride	1900
Dissolved Solids	3679.7
Hardness as CaCO_3	313

Table 1-3. Thickness of saline aquifers: Potential brine disposal reservoirs, South Johnson's Bayou prospect area. (From La. Geological Survey files, Baton Rouge, La.)

Depth Interval	Average Total Thickness of Sandstone Beds Greater than 30 feet Thick
1500-2000 ft	210 ft
2000-3000 ft	445 ft
3000-4000 ft	405 ft
4000-5000 ft	335 ft

AIR QUALITY

Measured Ambient Air Quality

The Louisiana Air Control Commission (LACC) sampling station nearest to the South Johnson's Bayou prospect area is located at Lake Charles, approximately 77 km (48 mi) northeast of the prospect area. 1976 annual average pollutant concentrations measured at the Lake Charles station are shown in Table 1-4.

Table 1-4. 1976 ambient air quality data: Lake Charles health unit station.
(From LACC, 1976).

	Sulfur Dioxide ($\mu\text{g}/\text{m}^3$)	Ozone ($\mu\text{g}/\text{m}^3$)	Nitrogen Dioxide ($\mu\text{g}/\text{m}^3$)	Particulates ($\mu\text{g}/\text{m}^3$)
Annual average*	1.5	-	43	55
24 hr. Maximum*	13	-	77	154
3 hr. Maximum**	181	282	--	--
1 hr. Maximum**	223	282	--	--

* Non-continuous monitor: 24 hour sample taken once per week.

** Continuous monitor: operated only approximately 10% of the time during 1976.

In addition to the Lake Charles-LACC station, limited air quality data resulting from a special study by Radian Corporation (1977) are available. This study covered a three month sampling period in 1976. The sampling station was located in Vinton, Louisiana approximately 50 km (31 mi) north-northeast of the prospect area. Average measured concentrations for six pollutants from this monitoring station, along with their dates of collection, are presented in Table 1-5.

Measured concentrations of all pollutants except ozone are well below ambient air quality standards (listed in Table 1-6). The entire south Louisiana region has been designated a non-attainment area with respect to ozone.

Predicted Ambient Air Quality

Due to the absence of sampling stations within the prospect area, the annual average air quality was predicted using the Climatological Dispersion Model--CDM (U.S. Environmental Protection Agency, 1973). Sulfur oxides were chosen as the pollutants for the modelling effort because emissions from a geopressure test well are more likely to contribute to SO_x levels than the other pollutants for which standards exist.

Table 1-5. Average concentrations of selected pollutants: Vinton station.
(From Radian Corporation, 1977).

Pollutant	Period of Data Collection	Average Concentration ($\mu\text{g}/\text{m}^3$)
Nitrogen Oxides	July 17 - Oct. 17, 1976	17.7
Nitric Oxide	July 17 - Oct. 17, 1976	5.1
Nitrogen Dioxide	July 17 - Oct. 17, 1976	12.6
Sulfur Dioxide	July 17 -31 & Sept. 1 - Oct. 17, 1976	0.966
Ozone	July 17-31 & Sept. 1 - Oct. 17, 1976	62.3
Particulates	July 17 - Oct. 17, 1978	43.6

Table 1-6. Ambient air quality standards: State of Louisiana. (From LACC, 1976).

Pollutant	Standards Primary	Secondary
Sulfur Dioxide		
Annual Arithmetic Mean	80 $\mu\text{g}/\text{m}^3$ **	60 $\mu\text{g}/\text{m}^3$
24-Hour Maximum	365 $\mu\text{g}/\text{m}^3$	260 $\mu\text{g}/\text{m}^3$
3-Hour Maximum	----	1300 $\mu\text{g}/\text{m}^3$
Carbon Monoxide		
8-Hour Maximum	10 mg/m^3 ***	10 mg/m^3
1-Hour Maximum	40 mg/m^3	40 mg/m^3
Ozone (Oxidant)		
Annual Arithmetic Mean	58.8 $\mu\text{g}/\text{m}^3$	58.8 $\mu\text{g}/\text{m}^3$
1-Hour Maximum	160 $\mu\text{g}/\text{m}^3$	160 $\mu\text{g}/\text{m}^3$
Nitrogen Dioxide		
Annual Arithmetic* Mean	100 $\mu\text{g}/\text{m}^3$	100 $\mu\text{g}/\text{m}^3$
Total Suspended Particulate*		
Annual Geometric Mean	75 $\mu\text{g}/\text{m}^3$	60 $\mu\text{g}/\text{m}^3$
24-Hour Maximum	260 $\mu\text{g}/\text{m}^3$	150 $\mu\text{g}/\text{m}^3$

*Non-continuous monitor.

** $\mu\text{g}/\text{m}^3$ = micrograms per cubic meter.

*** mg/m^3 = milligrams per cubic meter.

KEY

--- GEOPRESSURE PROSPECT BOUNDARIES

X CENTER OF PROSPECT AREA

⊙ SO_x EMISSION SOURCE

FIG. I-4 SO_x EMISSION SOURCES WITHIN 35Km OF SOUTH JOHNSON'S BAYOU PROSPECT AREA

The only significant (1 ton per yr) SO_x emission source in Louisiana within 35 km (22 mi) of the center of the prospect area is as follows:

<u>Source</u>	<u>Distance and Direction from Center of Prospect Area</u>	<u>SO_x (tons/yr)</u>
Mobil Oil Corporation	10 km - E (6 mi)	1.0

These data are for 1974 and were obtained from the National Emission Data System Point Source Listings maintained by the U. S. Environmental Protection Agency (U. S. EPA, 1974).

The Port Arthur, Texas region, 25 km (16 mi) northwest of the center of the prospect area, is heavily industrialized. However, emission data for this area were not readily available. On the basis of the predicted ambient air quality studies of Lafourche Crossing and Sweet Lake prospect areas, however, it is felt that the impact of any pollutants from the Port Arthur area would be small.

Using the CDM model and data on the Mobil Oil Corporation SO_x emissions, predicted annual average SO_x concentrations are zero everywhere within the prospect area. Figure 1-4 shows the location of the emission source relative to the prospect area.

WATER RESOURCES AND FLOOD HAZARDS

Hydrology

The South Johnson's Bayou prospect area includes the most complex series of cheniers--abandoned beaches located inland--found along Louisiana's coast (Fig. 1-5). Although most of the cheniers are relatively low, approximately 1.5 meters (5 feet) above mean sea level, their effect upon surface water drainage and quality is significant.

A system of long narrow lakes have formed behind many of the cheniers because surface water drains to the east and west, rather than directly over the cheniers to the Gulf (Fig. 1-6). Blue Buck Ridge is the most significant of the cheniers. Running east-west across the center of the entire prospect area, Blue Buck Ridge acts as a natural drainage divide preventing most of the surface water from draining southward. Below Blue Buck Ridge in the south-east section of the prospect area is a complicated series of shorter cheniers further influencing surface drainage (Fig. 1-7).

Fig. 1-5. Series of cheniers: South Johnson's Bayou prospect area.

Fig. 1-6. Lakes formed behind cheniers: South Johnson's Bayou prospect area.

Fig. 1-7. Small cheniers: South Johnson's Bayou prospect area.

While the cheniers have the most significant influence upon surface drainage in the prospect area, much of the western half of the prospect is open marsh with typical low elevation and gradients (Fig. 1-8). The marsh, as in other coastal wetlands, is influenced by a variety of factors not directly associated with the cheniers. Water circulation is dependent on runoff from adjacent uplands, excessive local rainfalls, astronomical tides and storm surges. The diurnal variation in water circulation in the marsh is dependent primarily on synoptic weather types. The open water of the Gulf of Mexico is also significantly affected by synoptic meteorological conditions and tides. Approximately 36 per cent of the prospect area is off-shore.

Noticeable within the prospect area is the relative lack of canals and ditches as well as the few natural drainage systems. The Sabine River and Pass just to the west of the prospect area have little effect on the hydrologic patterns within the prospect area.

Fig. 1-8. Open marsh: South Johnson's Bayou prospect area.

Water Usage and Quality

The agencies operating water quality sampling stations in Louisiana--the U.S. Army Corps of Engineers, the U.S. Geological Survey, and the Louisiana Stream Control Commission--maintain no stations within the prospect area. However, a preliminary assessment of water quality conditions has been made in the water quality management basin and basin segment of which the prospect area is a part. This work was done as part of the Louisiana 208 Water Quality Program which is funded under Section 208 of the Federal Water Pollution Control Act Amendments of 1972. Under the 208 Program, a plan is being developed to achieve state water quality standards.

The entire South Johnson's Bayou prospect area is within the Sabine River Water Quality Management Basin, Segment 15. The initial water quality problem assessment of that basin and segment is given in Table 1-7. The assessment was made by staff of the Louisiana Soil and Water Conservation Committee and the Louisiana Department of Agriculture (La. State Planning Office, 1977). State water quality criteria for the portions of the Sabine Basin, Segment 15, included within the drainage area of the prospect are given in Table 1-8.

Flood Hazards

A flood hazard analysis has been made of the Louisiana Gulf coast area by the U. S. Army Corps of Engineers for the Federal Insurance Administration (U.S. Army

Table 1-7. Initial water quality problem assessment: Sabine River Basin, Segment 15. (From La. State Planning Office, 1977).

Problem	Statewide Priority Ranking	Assessment
Municipal and Industrial Discharges	1	No significant pollution.
Specific and Localized Problems	2	No significant pollution.
Sediment and Nutrients	3	Agricultural producing sediment area: cotton, pasture.
Low Concentrations of Pollutants (herbicides, pesticides)	4	Herbicides used on cropland attached to sediments.

Table 1-8. Louisiana water quality criteria (numerical): Sabine River Basin, portions of Segment 15. (From La. Stream Control Commission, 1977).

Segment Description:	Sabine Pass (tidal)
Water Uses:	Primary contact Recreation Secondary Contact Recreation Propagation of Fish and Wildlife
Chlorides	not applicable
Sulfates	not applicable
Dissolved Oxygen	5.0 mg/l
pH Range	6.5 to 9.0
Bacteria standard	Monthly total coliform median most probable number $\leq$ 70/100 ml; not more than 10% of samples > 230/100 ml (shellfish propagation standard)
Temperature	35 ⁰ (max. value)
Total dissolved solids	not applicable

Corps of Engineers, 1970). That analysis includes projected area of flooding in two cases, as follows:

100-Year Flood: A flood which has an average frequency of occurrence of once in 100 years, but can occur during any year and even during successive years.

Standard Project Flood: The most severe flood which can be expected to occur within a geographic area under the most severe meteorological and hydrological conditions considered characteristic of that area (i.e., excluding extremely rare conditions).

In both these cases, the entire South Johnson's Bayou prospect area would be flooded, according to the Corps study.

Figure 1-9 shows the Surge Reference Line (SRL) as it traverses the prospect area. The SRL refers to the calculated synthetic coastline determined where the maximum storm surge height would occur during a 100-year flood situation with winds perpendicular to the coast. Along the line shown in Figure 1-9, storm surge would be expected to reach a maximum depth of approximately 3.4 meters (11.1 feet) during the most severe storm in a 100-year period (U.S. Army Corps of Engineers, 1970).

Southwestern Cameron Parish has had a history of severe damage from hurricane storm surge. This is, of course, a function of the fact that the area is relatively well populated for the coastal region, with communities and highways close to the coast. The most severe hurricane to strike the area in this century was Hurricane Audrey on June 25-28, 1957. Figure 1-10 shows the extent of flooding in coastal Louisiana from that storm. Four damaging hurricanes and 21 hurricanes or tropical storms with minor or unassessed damage have struck southwestern Louisiana in the period of 1886-1971 (U.S. Army Corps of Engineers, 1972).

ECOLOGICAL SYSTEMS

General Setting

The South Johnson's Bayou prospect area includes four ecosystem types according to the classification devised by Bryan and Newman (Newchurch, et.al., 1978): marine, estuarine, saline marsh, and ridge. Table 1-9 gives the major characteristics of these ecosystem types. (Section VIII, Vol. 1 of the Report includes a detail description).

Fig. 1-10. Flooding from storm during Hurricane Audrey. (From U.S. Army Corps of Engineers, 1972).

Table 1-9. Major characteristics of ecosystems in South Johnson's Bayou prospect area.

<u>Marine Ecosystem</u>	Coastal open water system with unobstructed access to the open Gulf. The water regimes and water chemistry of this ecosystem are determined primarily by the ebb and flow of oceanic tides. Salinity levels vary from 10,000 to 35,000 mg/l, depending on riverine discharge and distance offshore.
<u>Estuarine Ecosystem</u>	Coastal system, semi-enclosed by land, with open, partially obstructed, or sporadic access to the Gulf and with a measurable quantity of ocean-derived salt in the water. Salinities vary between 500 and 25,000 mg/l.
<u>Saline Marsh Ecosystem</u>	An emergent vegetated wetland system subject to tidal fluctuations of salt water greater than 500 mg/l salinity. This definition includes Chabreck's saline, brackish and intermediate marshes (Chabreck, 1972).
<u>Ridge Ecosystem</u>	Isolated systems of higher ground within fresh or saline marsh ecosystems. These areas include beaches, cheniers, natural and artificial levees, Pleistocene islands, salt domes, spoil banks and Indian mounds.

Vegetative zones within the prospect area and in the vicinity are shown in Figure 1-11. Chabreck's marsh type classification (1972) is used to delimit vegetation zones with saline, brackish, and intermediate marsh types present in the prospect area. Brackish marsh predominates among the marsh types, although significant areas of intermediate and saline marshes are present. Tables 1-10 and 1-11 give the plant species characteristic of these marsh types, and soil and water salinities, respectively. The data are specific to Hydrologic Unit IX which includes the coastal marshes from Sabine Pass to approximately 16 km (10 mi) east of Calcasieu Lake.

The marshes of the prospect area are variously modified as a result of oil and gas activity. The modifications are of several kinds. Canals are noticeably absent, but shell roads link the marsh drilling sites with Highway 82 on Blue Buck Ridge--the major chenier of the prospect area (Fig. 1-12). Figure 1-13 shows the most extreme form of modification within the prospect area--complete disturbance of the marsh environment as a result of oil and gas field facility siting. A more moderately disturbed situation is shown in Figure 1-14.

Table 1-10. Plant species characteristic of marsh types, Hydrologic Unit IX--South Johnson's Bayou prospect area. (From Chabreck, 1972).

Species	Marsh Type		
	Saline	Brackish (% Composition)	Intermediate
<u>Batis maritima</u>	20.24		
<u>Distichlis spicata</u> (saltgrass)	54.66	8.96	
<u>Paspalum virginatum</u>		7.22	13.29
<u>Scirpus californicus</u>			6.73
<u>Scirpus olneyi</u>		6.99	6.21
<u>Spartina alterniflora</u> (oystergrass)	24.29		
<u>Spartina patens</u> (wiregrass)		59.81	46.83

Table 1-11. Soil and water salinity of marsh types, Hydrologic Unit IX--South Johnson's Bayou prospect area. (From Chabreck, 1972).

Variable	Vegetative Type		
	Saline	Brackish (Mean Concentration, ppt)	Intermediate
Water salinity	--	6.41	2.43
Total soil salts	3.07	6.60	5.12

-- No samples taken.

- LEGEND**
--- GEOPRESSURE PROSPECT BOUNDARIES
✕ CHURCH
✕ SCHOOL
✕ AIRPORT
✕ QUARRY, MINE
✕ MARSH
--- CANAL, BAYOU
--- MAJOR WATERWAY
○ GAS AND OIL FIELD
--- UNIMPROVED ROADS
--- HARD SURFACE ROADS
--- 4 LANE HARD SURFACE ROADS
--- LEVEE
--- RAILROADS
- PLEISTOCENE DEPOSITS
- ALLUVIAL RIDGES
- FORESTED WETLANDS
(CYPRESS-TUPELO GUM SWAMP)
- NON-FORESTED WETLANDS:
- FRESH MARSH
- INTERMEDIATE MARSH
- BRACKISH MARSH
- SALINE MARSH
- MODIFIED WETLANDS

FIG. I-II VEGETATIVE ZONES: SOUTH JOHNSON'S BAYOU (PROSPECT 1)

Fig. 1-12. Access roads to well sites: South Johnson's Bayou prospect area.

Fig. 1-13. Complete disturbance of marsh environment: South Johnson's Bayou prospect area.

57

Fig. 1-14. Moderate disturbance of marsh environment: South Johnson's Bayou prospect area.

Fig. 1-15. Chenier-marsh interface: South Johnson's Bayou prospect area.

The prospect area includes the largest area of chenier, a ridge ecosystem, of all the prospect areas. Cheniers are abandoned beaches located inland and because they are higher than the surrounding marsh, they restrict water movement and thus reduce the use of the marshes of this prospect area as nurseries for fishes and shellfish. Figure 1-15 shows an example of chenier-marsh interface within the prospect area. The cheniers are important as refugia during storms and as landfalls for trans-Gulf migratory birds. Natural vegetation include live oak, hackberry, elm and other trees with numerous understory species. The cheniers of the prospect area are highly modified, however. The predominant land uses on the cheniers are residential and agriculture--primarily cattle grazing.

The second significant ridge ecosystem in the prospect area is the well-defined beach along the coast (Fig. 1-16). To the east of the prospect area boundaries, the coastal beach is developed as a resort area. The beaches within the prospect area are undeveloped. Approximately 36 per cent of the prospect area is open Gulf waters--a marine ecosystem.

Fig. 1-16. Beach: South Johnson's Bayou prospect area.

There are no published synecological studies on the biota of the prospect area.

Commercial Harvests

Trapping of muskrat and nutria occurs in the marshes of the prospect area. Controlled harvest of alligators also takes place within the prospect. As mentioned above, the marshes and estuarine waters of the prospect are not productive as nurseries for commercial fishes relative to coastal marshes within the other prospect areas. Important off-shore fisheries are reported to be outside the immediate prospect area (Fig. 1-17). These produce significant harvests of shrimps, menhaden, and anchovy (Burk and Associates, 1977b).

Unique Ecological Features

The prospect area is within the range of the endangered red wolf, Canis rufus (Burk and Assoc., 1977b). The red wolf is listed as an endangered species (U.S. Department of the Interior, 1977) because of habitat loss and interbreeding with coyotes and dogs. The American alligator, Alligator mississippiensis, is listed as threatened by the U.S. Department of the Interior (1977). In coastal Louisiana, however, alligators have been numerous enough for controlled harvests to be held annually since 1972. Alligators are present and are harvested from the prospect. It is probable that the threatened designation for alligators in coastal Louisiana will be dropped with harvests remaining controlled.

A wading bird rookery and duck and geese concentrations are located outside of the prospect area to the north and northeast, respectively (Fig. 1-17).

The northwest portion of the prospect area is relatively unmodified chenier plain marsh. It has been recommended by Burk and Associates (1977a) as a potential preservation area on the basis of its naturalness, representativeness, unique ecological value and other criteria.¹ The 946 hectare (2,338 acre) site is described by Burk and Associates (1977a) as prime muskrat marsh and as habitat for reddish egret, red wolf, and roseate spoonbill. Abundant waterfowl, blue wing teal, and alligator have been observed at the site.

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¹ Recommendations as to potential preservation and restoration areas in Louisiana coastal regions were made by Burk and Associates in the above referenced report to the Louisiana State Planning Office, Coastal Resources Program. Such a report was required under provisions of the federal Coastal Zone Management Act of 1972. There is no indication that the recommendations made in the report will be implemented. Of 50 potential areas, the site described above was given a priority ranking of 15 by Burk and Associates.

LAND USE

General Land Use

Land use within the South Johnson's Bayou prospect area and in the vicinity is depicted in Figure 1-18, and summarized in Table 1-12. Current land use patterns were mapped using 1:108,000 scale, false color infrared imagery flown by NASA in 1972. Land use was verified and corrected through aerial and field reconnaissance during the spring and summer of 1978. The land use classification scheme used is based on the system outlined in U.S. Geological Survey Professional Paper 964 (Anderson, et. al., 1976), with modifications to provide more suitable information for this project.

Current land use in the prospect area is dominated by residential and agricultural activity (primarily cattle grazing) located on the numerous east-west trending cheniers (former beach ridges) that roughly parallel the coast within the prospect area. The cheniers are approximately 1.5 meters (5 feet) above mean sea level which is relatively high ground in this coastal area.

In Figure 1-18, the community of Johnson's Bayou (population 704 (U.S. Dept. of Commerce, 1973)) is shown as being located just to the east of the prospect area boundary. However, the community's school, recreation center, cemetery, and many residences are located within the prospect area. While this part of Cameron Parish is distinctly rural in character, the prospect area is relatively densely populated compared to the other coastal prospect areas and compared to other areas within such a short distance from the coast.

Industrial activity within the prospect area is limited to the extraction of oil and gas. Processing and transmission activities are part of this land use (Fig. 1-13). Most of this activity takes place in the areas between the cheniers which are classified as non-forested wetlands (Fig. 1-18). There are several large oil and gas fields with a number of active well sites in these low-lying, poorly drained areas (Fig. 1-2), although the use of canals for access is not generally required. Shell roads commonly lead to drilling rigs and completed wells (Fig. 1-12).

Highway 82, a major State highway connecting southwest Cameron Parish with Highway 27 to Lake Charles, traverses the prospect area. Several minor roads provide communication among the populated cheniers.

Approximately 36 per cent of the total area of the prospect is open Gulf waters.

Table 1-12. Summary of land use: South Johnson's Bayou prospect area.

Land Use Category	Area Extent km ² (mi ²)	% of Total Area
11 Residential	ANS	
12 Commercial and Service	ANS	
21 Cropland and Pasture	34.7 (13.4)	30.5
51 Streams and canals	ANS	
52 Lakes	ANS	
62 Nonforested wetlands	36.5 (14.1)	32.0
72 Beaches	2.1 (0.8)	1.8
Gulf of Mexico	40.7 (15.7)	35.7

ANS: Area not significant.

The onshore portion of the prospect area is entirely within the coastal zone as defined by Act 361 of the 1978 Louisiana Legislative Session (La. Revised Statutes, 1978). As such, certain activities within the coastal zone, including extractive activities, will be subject to land use controls by the State of Louisiana under provisions of the Act and the Federal Coastal Zone Management Act of 1972.

Historical and Archeological Sites

There are no recorded historical sites within the prospect area or in the vicinity. Archeological sites, all outside the prospect area boundaries, are shown in Figure 1-19. Two are shell middens in unknown condition. The campsite, CM 49, is presently under cultivation and its condition is unknown (Deborah Woodiel, personal communication, 1978).

Wildlife Preserves and Management Areas

There are no wildlife preserves or management areas within the prospect area. The Sabine National Wildlife Refuge, a federally owned preserve of 57,757 hectares (142,717 acres), is located 8.7 km (5.4 miles) north of the prospect area boundaries (Fig. 1-20). The Refuge is noted for its migratory waterfowl populations. Restricted waterfowl hunting and trapping are the only public activities allowed within the Refuge (U.S. Army Corps of Engineers, 1976).

FIG.1-19 ARCHEOLOGICAL SITES:
SOUTH JOHNSON'S BAYOU (PROSPECT I)

PROSPECT AREA NO. 2: SWEET LAKE

GEOLOGY AND GEOHYDROLOGY

Geologic Setting

Economic Geology

Ground-Water Resources and Quality

Aquifer Availability for Brine Disposal

Soils

AIR QUALITY

Measured Ambient Air Quality

Predicted Ambient Air Quality

WATER RESOURCES AND FLOOD HAZARDS

Hydrology

Water Usage and Quality

Flood Hazards

ECOLOGICAL SYSTEMS

General Setting

Commercial Harvests

Unique Ecological Features

LAND USE

General Land Use

Historical and Archeological Sites

Wildlife Preserves and Management Areas

PROSPECT AREA NO. 2: SWEET LAKE PROSPECT

GEOLOGY AND GEOHYDROLOGY

Geologic Setting

The Sweet Lake prospect area is located on the Prairie Terrace (Pleistocene) of southeastern Calcasieu Parish and north-central Cameron Parish (Fig. 2-1). The Pleistocene surface is considered the "uplands" in Calcasieu Parish, in contrast to the low-relief Recent age deposits of the coastal marsh and stream valleys. The Pleistocene age Chicot aquifer is the source of fresh ground water locally. Pliocene sands of the Evangeline aquifer underlie the Chicot at a depth of approximately 427 meters (1400 feet). The geopressured Frio (Oligocene) sandstones and shales occur approximately 4,267 meters (14,000 feet) below the surface. The prospect area is approximately 31.8 km² (20.0 mi²) in areal extent. Major east-west trending faults bound the prospect area to the north and south. Subsurface geologic data are insufficient to reveal the east and west limits of the prospective resource.

Economic Geology

Grosse Savanne oil field and Sweet Lake oil and gas field are the only producing fields in the vicinity of the prospect area (Fig. 2-2). They are located southwest of the prospect beneath marsh deposits of Recent age and produce from Upper Miocene sandstones between depths of 1,362 and 2,946 meters (4,470 and 9,665 feet). Production data on these fields are given in Table 2-1.

Ground-Water Resources and Quality

Figure 2-2 shows the depths of occurrence of three different qualities of ground water for the prospect area. The base of fresh ground water (less than 250 ppm chlorides) was mapped by Rollo (1960). Maps of the base of slightly saline water (1000 to 3000 mg/l dissolved solids) and moderately saline water (3000 to 10,000 mg/l dissolved solids) were prepared in a study of saline water resources in Louisiana by Winslow, et.al. (1968). The definition of freshwater used by Rollo is based on chloride content, while the saline water resources are categorized on the basis of dissolved solids content in which freshwater would be less than 1000 mg/l dissolved solids. When comparing this map with the ground-water resource maps for the other prospect areas, it should be noted that Whitman (1965)

Field	Producing Formation		Year of Discovery	Estimated Area Proved (Acres)		Number of Wells						Wells Producing At End of Year 1975		Producing Formation (s)						Deepest Zone Tested	Depth of Hole (Feet)
	Name Age and Depth (feet)	Cumulative To End of Year 1975				During Year 1975				Flowing	Artificial Lift	Oil Gravity (API)	Av. Porosity (Percent)	Producing Thickness (Av. Net Feet)		Structure	Name				
						Completed	Abandoned	Oil	Gas					Oil	Gas			Oil	Gas		
Grosse Savanne	Miocene U 9,665	1956	--	40	--	1	--	0	--	0	--	0	--	0	38	P	4	--	X	Miocene U	10,070
Sweet Lake	Miocene U 4,470	1926	1926	680	160	86	3	0	0	2	0	1	0	26	30	34	360	80	DS	Miocene L	16,356

Table 2-1. Oil and gas field data: Vicinity of Sweet Lake prospect area. (From La. Dept. of Natural Resources, 1975).

found the relationship between dissolved solids content and chloride content in fresh and brackish ground water in southwestern Louisiana to be variable. He found the following relationship between chlorides and dissolved solids for the Chicot and the Chicot-Atchafalaya aquifer:

Aquifer	Prospect Area Included	Chlorides (ppm)	Dissolved Solids (ppm)
Chicot--Western Portion	1 & 2	250 450	620 1000
Chicot--Eastern Portion	3 & 4	250 425	700 1000
Chicot-Atchafalaya	5	250 360	810 1000

Hence, the maps of ground-water quality prepared for each prospect area are not precisely compatible. Furthermore, the maps are based on determinations of ground-water salinity made from resistivity measurements recorded on electrical logs, and this technique is not precise. However, because the transition between fresh-water and slightly saline water is often abrupt, the maps are an adequate representation of the actual water quality distribution.

Abundant fresh ground-water resources are contained in the Chicot aquifer (Pleistocene age) in the Sweet Lake prospect area. The Chicot aquifer is a gulfward thickening wedge of sand and gravel which outcrops and is recharged north of Calcasieu Parish. At Sweet Lake the aquifer is approximately 427 meters (1400 feet) thick. Table 2-2 illustrates the sequence of sands, gravels and shales in the Chicot aquifer, and the fine-grained topstratum overlying the aquifer from the surface down to approximately 357 meters (1170 feet). The Chicot aquifer is mappable as a continuous aquifer system westward along the Texas coast and eastward into the Atchafalaya Basin. In southwest Louisiana the aquifer is divided into three units: the "200 foot" (61 meter) or "upper sand unit", the "500 foot" (152 meter) sand, and the "700 foot" (213 meter) sand, named for the depth of the sands in the Lake Charles area. The Chicot aquifer is an important source of industrial water in Lake Charles and irrigation water throughout southwestern Louisiana.

Table 2-2. Driller's log of USGS test well Cn-88U: Sweet Lake prospect area.
(From USGS files, Baton Rouge, La.).

Type of Rock	Thickness (Feet)	Depth
Clay, brown	11	11
Clay, brown and red	6	17
Sand, fine and shale	39	56
Shale, red and blue	42	98
Sand, med. white	32	130
Shale, brown and green	46	176
Sand, fine blue	93	269
Sand, coarse and gravel, pea	56	325
Sand, fine and med.	67	392
Sand, coarse and gravel	30	422
Sand, coarse	72	710
Shale	3	713
Sand and big gravel	171	885
Sand, fine w/streaks of shale	121	1005
Sand, coarse and shale	22	1027
Shale, hard	10	1037
Sand and sandy shale	72	1109
Shale	61	1170

Pumpage of ground water in Lake Charles and for irrigation in surrounding parishes has lowered the potentiometric surface in the Chicot aquifer and thereby reversed the natural coastward flow of fresh ground water in the aquifer. As a result water in the Sweet Lake area is being drawn slowly northward and salt water is advancing at a rate estimated to be approximately 21 meters (70 feet) per year (Harder, et.al., 1967).

The greatest thickness of freshwater in the Chicot aquifer and other deeper sands (the Evangeline and Jasper aquifers) occurs north of Calcasieu Parish, where the natural southward movement of freshwater in the aquifers has flushed salt

water from the sands. South from this area the depth to the base of fresh ground water diminishes and salt water eventually fills the aquifers at some distance off-shore. At the Sweet Lake prospect area the freshwater section is approximately 274 meters (900 feet) thick. The maximum depth of slightly saline ground water is at 305 meters (1000 feet), and the maximum depth of moderately saline ground water is 366 meters (1200 feet) (Fig. 2-2).

Water wells recorded by the U.S. Geological Survey (USGS) in the vicinity of the Sweet Lake prospect area are shown in Figure 2-2. These wells are used for irrigation and to a lesser extent for domestic supply. Not all the wells shown on the map are still in use and probably numerous additional wells have been drilled in the area and are not yet recorded with the USGS. According to Harder (1960) most of the wells in the Calcasieu Parish area shown in Figure 2-2 are completed in the "200 foot" (61 meter) sand and are capable of producing more than 6.3 liters/sec (1000 gallons/min). Within the prospect area boundaries, no wells are used for irrigation which is supplied by surface canals. Domestic water supplies for houses within the prospect area are taken from shallow wells in the Chicot aquifer (USGS files, Baton Rouge, La.).

Chemical analyses from selected wells in the vicinity of the Sweet Lake prospect area are listed in Table 2-3. The freshwater section is characterized as "mostly calcium magnesium bicarbonate water" (Harder, et. al., 1967).

Although southwestern Louisiana is projected to experience continued growth and thereby increased ground-water usage, it is expected that the Chicot aquifer will continue to provide an adequate supply of freshwater (Harder, et. al., 1967). Salt water intrusion is a threat only to well users at or near the salt water - freshwater interface.

Aquifer Availability for Brine Disposal

Three well logs of oil and gas wells within the prospect area were examined to determine the total thickness of sandstones having individual thicknesses of at least 9 meters (30 feet) below a depth of 610 meters (2000 feet). The data are summarized in Table 2-4.

Well No.	Date	Screen Depth	Total Iron	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Sulfate	Chloride	Dissolved Solids	Hardness as CaCO ₃
Cameron Parish												
"500-foot" Sand												
Cn-88-L	2-10-64	794-804	.01	5.2	26	396	3.1	297	0	520	1130	120
	10- -71		---	---	--	---	---	---	--	540	----	---
Cn-88-U	10- 1-64	656-666	---	---	--	---	---	---	--	170	----	---
	3-19-74	" "	---	---	--	---	---	---	--	160	----	---
"700-foot" Sand												
Cn-88-A	2-11-64	953	1.4	3.4	35	865	7.0	301	0	1270	2400	154
Calcasieu Parish												
"200-foot" Sand												
Cu-165	6- 7-49	386	---	---	--	---	---	---	--	55	----	---
Cu-497	6-23-55	412	---	---	--	---	---	---	--	56	----	---
Cu-161	5-16-55	450	.23	25	6.9	124	1.9	254	.2	144	433	91
"500-foot" Sand												
Cu-549	5-16-55	750	---	---	--	---	---	---	--	34	----	---

Table 2-3. Selected chemical analyses (concentrations in mg/l) of ground water in the Sweet Lake prospect area.
(From USGS files, Baton Rouge, La.).

Table 2-4. Thickness of saline aquifers: Potential brine disposal reservoirs, Sweet Lake prospect area. (From La. Dept. of Natural Resources files, Baton Rouge, La.).

Depth Interval	Average Total Thickness of Sandstone Beds Greater than 30 Feet Thick
2000-3000 ft	400 ft
3000-4000 ft	565 ft
4000-5000 ft	410 ft

Records on file with the Louisiana Department of Natural Resources show three salt water disposal wells in Sweet Lake field are rated at 30,000 bbl per day. The highest average daily injection rate determined from total annual reported injection volume was 17,400 bbl per day in 1975 for one well (La. Dept. of Natural Resources, 1975). A geopressure test well producing 40,000 bbl per day for one year would produce 1.46×10^7 barrels of brine in one year. For comparison, 1.09×10^7 barrels of brine were disposed of by 4 wells in Sweet Lake field during 1975. The total volume of brine disposed of in Sweet Lake field by 1975 was 7.6×10^7 .

Soils

The soils of the prospect area are mainly of the Crowley, Midland and Lake Charles series. These soils contain moderate amounts of organic matter and low amounts of phosphorous. The major feature of the soils in this area is that underlying sediments are fairly impermeable clays which allow rice fields to remain flooded. Figure 2-3 shows the general soil types in the prospect area and region.

AIR QUALITY

Measured Ambient Air Quality

The Louisiana Air Control Commission (LACC) sampling station nearest to the Sweet Lake prospect area is located at Lake Charles, approximately 29 km (18 mi) north-northwest of the prospect area. 1976 annual average pollutant concentrations measured at the Lake Charles station are shown in Table 2-5, below.

Table 2-5. 1976 ambient air quality data: Lake Charles health unit station. (From LACC, 1976).

	Sulfur Dioxide ($\mu\text{g}/\text{m}^3$)	Ozone ₃ ($\mu\text{g}/\text{m}^3$)	Nitrogen Dioxide ($\mu\text{g}/\text{m}^3$)	Particulates ($\mu\text{g}/\text{m}^3$)
Annual average*	1.5	-	43	55
24 hr. Maximum*	13	-	77	154
3 hr. Maximum**	181	282	--	--
1 hr. Maximum**	223	282	--	--

* Non-continuous monitor: 24 hour sample taken once per week.

** Continuous monitor: operated only approximately 10% of the time during 1976.

In addition to the Lake Charles--LACC station, limited air quality data resulting from special studies by Radian Corporation (1977) and Ashland Chemical Company (Minott, personal communication, 1978) are available. The Radian study covered a three month sampling period in 1976. The Ashland study was carried out during 1975 and 1976. Two sampling stations were located in the general vicinity of the Sweet Lake prospect area. Their distance and direction from the center of the prospect area are as follows:

Lafayette (Radian) 106 km - NE (66 mi)
 New Iberia (Ashland) 125 km - E (78 mi)

Average measured concentrations for six pollutants from the Lafayette monitoring station, along with their dates of collection, are presented in Table 2-6.

The Ashland Chemical Company study reported only 24-hour average SO_2 values. The single highest value of $115 \mu\text{g}/\text{m}^3$ was approximately 32 per cent of the primary standard and 45 per cent of the secondary. The second highest value was $61 \mu\text{g}/\text{m}^3$ while most daily readings were below $20 \mu\text{g}/\text{m}^3$.

Table 2-6. Average concentrations of selected pollutants: Lafayette station.
(From Radian Corporation, 1977).

Pollutant	Period of Data Collection	Average Concentration ($\mu\text{g}/\text{m}^3$)
Nitrogen Oxides	July 17 - Sept. 30, 1976	10.1
Nitric Oxide	July 17 - Sept. 30, 1976	3.9
Nitrogen Dioxide	July 17 - Sept. 30, 1976	6.1
Sulfur Dioxide	July 17 - Sept. 30, 1976	1.0
Ozone	July 17 - Oct. 17, 1976	78.0
Particulates	July 17 - Oct. 17, 1976	52.3

Table 2-7. Ambient air quality standards: State of Louisiana
(From LACC, 1976).

Pollutant	Primary	Standards	Secondary
Sulfur Dioxide			
Annual Arithmetic Mean	80 $\mu\text{g}/\text{m}^3$ **		60 $\mu\text{g}/\text{m}^3$
24-Hour Maximum	365 $\mu\text{g}/\text{m}^3$		260 $\mu\text{g}/\text{m}^3$
3-Hour Maximum	----		1300 $\mu\text{g}/\text{m}^3$
Carbon Monoxide			
8-Hour Maximum	10 mg/m^3 ***		10 mg/m^3
1-Hour Maximum	40 mg/m^3		40 mg/m^3
Ozone (Oxidant)			
Annual Arithmetic Mean	58.8 $\mu\text{g}/\text{m}^3$		58.8 $\mu\text{g}/\text{m}^3$
1-Hour Maximum	160 $\mu\text{g}/\text{m}^3$		160 $\mu\text{g}/\text{m}^3$
Nitrogen Dioxide			
Annual Arithmetic Mean*	100 $\mu\text{g}/\text{m}^3$		100 $\mu\text{g}/\text{m}^3$
Total Suspended Particulate*			
Annual Geometric Mean	75 $\mu\text{g}/\text{m}^3$		60 $\mu\text{g}/\text{m}^3$
24-Hour Maximum	260 $\mu\text{g}/\text{m}^3$		150 $\mu\text{g}/\text{m}^3$

*Non-continuous monitor.

** $\mu\text{g}/\text{m}^3$ = micrograms per cubic meter.

*** mg/m^3 = milligrams per cubic meter.

Measured concentrations of all pollutants except ozone are well below ambient air quality standards (listed in Table 2-7). The entire south Louisiana region has been designated a non-attainment area with respect to ozone.

Predicted Ambient Air Quality

Due to the absence of sampling stations within the prospect area, the annual average air quality was predicted using the Climatological Dispersion Model--CDM (U.S. Environmental Protection Agency, 1973). Sulfur oxides were chosen as the pollutant for this modelling effort because emissions from a geopressure test well are more likely to contribute to SO_x levels than the other pollutants for which standards exist.

Significant (≥ 1 ton per yr) SO_x emission sources within 35 km (22 mi) of the center of the prospect area appear in Table 2-8, below. These data are for 1974 and were obtained from the National Emission Data System Point Source Listings maintained by the U.S. Environmental Protection Agency (U.S. EPA, 1974).

Table 2-8. Point sources of SO_x within 35 km of the center of the Sweet Lake prospect area (1974^x data).

Source	Distance and Direction from the Center of the Prospect Area		SO_x (tons/yr)
Continental Oil (Lake Charles)	29 km - NNW	(18 mi)	918
Continental Oil (Westlake)	29.5 km - NW	(18 mi)	4041
Olin Corporation	29 KM - NW	(18 mi)	1749
Continental Carbon	30 KM - NNW	(19 mi)	74
Consolidated Aluminum	24 km - NW	(15 mi)	35
Gulf States Utilities	34 KM - NNW	(21 mi)	87,802
Cities Service	30 km - NW	(19 mi)	30,855
Conoco Chemical	32 km - NNW	(20 mi)	3,408

Figure 2-4 shows the annual average predicted ambient air quality within the prospect area resulting from these emission sources. The map maximum SO_x concentration is $14 \mu\text{g}/\text{m}^3$. Near the center of the prospect area the SO_x concentration is $3 \mu\text{g}/\text{m}^3$. There is an accumulation of industry to the west of Lake Charles as indicated by the steep concentration gradient in the northwest quadrant of Figure 2-4. This concentration gradient dissipates to the southeast and the SO_x profile is flat within the prospect area.

KEY

--- GEOPRESSURE PROSPECT BOUNDARIES

X CENTER OF PROSPECT AREA

2/ PREDICTED ANNUAL AVERAGE
SO_x CONCENTRATIONS (μg/m³)

FIG. 2-4 PREDICTED ANNUAL AVERAGE
SO_x CONCENTRATIONS: SWEET LAKE (PROSPECT 2)

WATER RESOURCES AND FLOOD HAZARDS

Hydrology

The Sweet Lake prospect area is located within the southern margins of the Pleistocene Uplands with elevations ranging from 4.6 meters (15 feet) in the north-central portion of the prospect area to 1.5 meters (5 feet) in the southwestern portion. The prospect boundaries are not definitively set at this time (October 1978). If the southern boundary were to be extended to the southwest, it would include portions of coastal marsh.

The natural surface drainage in the prospect area is primarily toward the south, but present drainage patterns have been modified considerably by canal networks for rice irrigation and drainage of crops (Fig. 2-5). The topographic sheets suggest a sort of radial drainage pattern toward the southeast, south, and southwest from the highest elevations in the north-central section of the prospect area. Surface waters, therefore, drain by canal southward to the Gulf Intracoastal Waterway and Sweet Lake, 6 km (4 mi) from the prospect boundaries, and by "overland" flow into Willow Lake, Sweet Lake, and the wetland marshes immediately to the north of the Gulf Intracoastal Waterway.

The prominent surface water bodies within the prospect area are these canals, and include the major canal shown in Figure 2-6 through which irrigation water is pumped from Sweet Lake to the rice fields of the prospect area. Irrigation water is also pumped from the Gulf Intracoastal Waterway through North Canal to the fields east of the prospect area (Fig. 2-6 and 2-7).

Water Usage and Quality

Water usage within the prospect area is for domestic supply and agriculture. Domestic water is supplied by shallow wells in the Chicot aquifer. The houses are spaced so that generally one well supplies each house. Rice fields within the prospect area are supplied with irrigation water by surface canals from the major canal drawing water from Sweet Lake (Fig. 2-6). The pumps at Sweet Lake community, 1.6 km (1 mi) south of the prospect area boundaries, have a capacity of 2,839 liters/sec (45,000 gallons/min) each (Caddy, personal communication, 1978). The rice fields are irrigated four months out of the year (April-July), during which time they are impounded and flooded (Fig 2-8).

Fig. 2-5. Irrigation canals and rice fields: Sweet Lake prospect area.

Fig. 2-7. Sweet Lake pumping station on North Canal: Vicinity of Sweet Lake prospect area.

Fig. 2-8. Flooded rice fields: Sweet Lake prospect area.

The agencies operating water quality sampling stations in Louisiana--the U.S. Army Corps of Engineers, the U.S. Geological Survey, and the Louisiana Stream Control Commission--maintain no stations within the prospect area. However, a preliminary assessment of water quality conditions has been made in the water quality management basin and basin segment of which the prospect area is a part. This work was done as part of the Louisiana 208 Water Quality Program which is funded under Section 208 of the Federal Water Pollution Control Act Amendments of 1972. Under the 208 Program, a plan is being developed to achieve state water quality standards.

The Sweet Lake prospect area is in both Segment 25 of the Calcasieu River Water Quality Management Basin and Segment 7 of the Mermentau-Vermilion-Teche Water Quality Management Basin (Fig. 2-6). The initial water quality problem assessments of these segments are given in Tables 2-9 and 2-10. The assessments were made by staff of the Bureau of Environmental Services, Louisiana Department of Health and Human Resources; the Louisiana Soil and Water Conservation Committee; and the Louisiana Department of Agriculture (La. State Planning Office, 1977). State water quality criteria for the portion of the Gulf Intracoastal Waterway into which surface water from the prospect area drains, are given in Table 2-11.

Table 2-9. Initial water quality problem assessment: Calcasieu River Basin, Segment 25. (From La. Office of State Planning, 1977).

Problem Area	Statewide Priority Ranking	Assessment
Municipal and Industrial Discharges	1	Small unsewered communities.
Specific and Localized Problems	2	Frequent oil spills in Black Lake.
Sediment and Nutrients	3	Agricultural producing sediment area: cropland (rice, soybeans).
Low Concentrations of Pollutants (herbicides, pesticides)	4	Herbicides used on cropland attached to sediments.

Table 2-10. Initial water quality problem assessment: Mermentau-Vermilion-Teche Basin, Segment 7. (From La. Office of State Planning, 1977).

Problem Area	Statewide Priority Ranking	Assessment
Municipal and Industrial Discharges	1	Towns unsewered.
Specific and Localized Problems	2	No significant pollution.
Sediment and Nutrients	3	Agricultural producing sediment area: cropland (rice, soybeans).
Low Concentrations of Pollutants (herbicides, pesticides)	4	Herbicides used on cropland attached to sediments.

Table 2-11. Louisiana water quality criteria (numerical): Mermentau-Vermilion-Teche Basin, portions of Segment 7. (From La. Stream Control Commission, 1977).

Segment Description:	Intracoastal Waterway-- Calcasieu Lock to Vermilion Lock
Water Uses	Secondary Contact Recreation Propagation of Fish and Wildlife
Chlorides	250 ppm
SO ₄	75 ppm
Dissolved Oxygen	5.0 mg/l
pH Range	6.0 to 8.5
Bacteria Standard	In 5 samples in 30 days, fecal coliform $\leq$ log mean of 1,000/100 ml; 10% of total samples in 30 days < 2,000/ 100 ml (secondary contact recreation standard)
Temperature	32° C
Total Dissolved Solids	500 ppm

Flood Hazards

A flood hazard analysis has been made of the Louisiana Gulf coast area by the U.S. Army Corps of Engineers for the Federal Insurance Administration (U.S. Army Corps of Engineers, 1970). That analysis includes projected area of flooding in two cases; as follows:

100-year Flood: A flood which has an average frequency of occurrence of once in 100 years, but can occur during any year and even during successive years.

Standard Project Flood: The most severe flood which can be expected to occur within a geographic area under the most severe meteorological and hydrological conditions considered characteristic of that area (i.e. excluding extremely rare conditions).

Figure 2-6 shows the portions of the Sweet Lake prospect area that would be flooded in both of these cases. Four damaging hurricanes and 21 hurricanes or tropical storms with minor or unassessed damage have struck south-western Louisiana in the period of 1886- 1971. The area of damage extends north of the prospect area (U.S. Army Corps of Engineers, 1972).

ECOLOGICAL SYSTEMS

General Setting

The Sweet Lake prospect area includes two ecosystem types according to the classification devised by Bryan and Newman (Newchurch, et. al., 1978): Prairie ecosystem and freshwater ecosystem. The prospect boundaries (major growth faults) are not definitively set at this time (October 1978). If the southern boundary were to be extended to the southwest, it would include portions of the fresh marsh ecosystem type. Table 2-12 gives the major characteristics of these ecosystem types. (Section VIII, Vol. 1 of the Report includes a detailed description).

Table 2-12. Major characteristics of ecosystems in Sweet Lake prospect area and vicinity.

WETLAND AND AQUATIC ECOSYSTEMS:

Fresh Marsh Ecosystem.

A herbaceous emergent vegetated wetland system which is subject to flooding with freshwater all or part of the year.

Freshwater Ecosystem.

Freshwater ecosystems are divided into three subsystems: Palustrine, lacustrine, and riverine. These are all open freshwater areas where salinities are less than 500 mg/l.

TERRESTRIAL ECOSYSTEMS:

Prairie Ecosystem.

Terrestrial upland system which is naturally dominated by grasses.

The prospect area is located entirely on the Pleistocene terrace in what was once tall grass prairie. After the initial clearing and grazing, the system reverted to short grasses and weedy herbs. In this prospect area, the prairie vegetation is highly modified by agricultural activities. Rice and soybeans are the principal crops grown, with some pasture. The pattern of fields indicated in Figure 2-9, a false color, infrared photo of the prospect area (scale: 1:108,000), shows the highly modified character of the area.

Fig. 2-9. High altitude photograph of Sweet Lake prospect area showing pattern of cultivated fields.

Vegetative zones within the prospect area and in the vicinity are shown in Figure 2-10. Tables 2-13 and 2-14 give the characteristic plant species and soil and water salinities, respectively, of the fresh marsh ecosystem type. The data are specific to Hydrologic Units VIII and IX of which the prospect area is a part.

Eleven species of amphibians and many reptiles including turtles and snakes are common to the prairie ecosystem. Geese are the dominant game animal.

Freshwater ecosystems are confined to the numerous canals and ditches in the prospect area. The canals which are used for irrigating rice crops and for drainage, are entirely fresh and are variable in water level and subject to drought.

No published reports deal specifically with the biological and ecological features of this prospect.

Table 2-13. Plant species characteristic of fresh marsh, Hydrologic Units VIII and IX--vicinity of Sweet Lake prospect area. (From Chabreck, 1972).

Species	% Composition	
	Unit VIII	Unit IX
<u>Alternanthera philoxeroides</u>	9.46	25.87
<u>Eleocharis sp.</u>	5.60	8.46
<u>Panicum hemitomon</u>	21.50	<5
<u>Paspalum virginatum</u>	---	5.77
<u>Sagittaria falcata</u> (bulltongue)	28.00	22.88
<u>Spartina patens</u> (wiregrass)	8.09	7.96

Table 2-14. Soil and water salinity of fresh marsh vegetative type, Hydrologic Units VIII and IX--vicinity of Sweet Lake prospect area. (From Chabreck, 1972).

Variable	Mean Concentration, ppt	
	Unit VIII	Unit IX
Water salinity	.41	1.27
Total soil salts	1.03	1.60

Commercial Harvests

There are no large lakes or streams in this prospect area and thus little or no fishery resources. Game animals such as geese and ducks may be harvested. The major agricultural crop is rice and the prospect area is intensively cultivated for

this crop. Soybeans are also grown, and there is some acreage in pasture for beef cattle.

Unique Ecological Features

The prospect area is included within the range of the endangered red wolf (Fig. 2-11). However, because of the highly modified character of the area, it is unlikely that any red wolf are extant. No other endangered species are likely to occur within the prospect or in the vicinity. If redefined prospect boundaries were to include portions of the fresh marsh ecosystem to the southwest, it is likely that the alligator (threatened status) would be present.

LAND USE

General Land Use

Land use within the Sweet Lake prospect area and in the vicinity is depicted in Figure 2-12, and summarized in Table 2-15. Current land use patterns were mapped using 1:108,000 scale, false color infrared imagery flown by NASA in 1972. Land use was verified and corrected through aerial and field reconnaissance during the spring and summer of 1978. The land use classification scheme used is based on the system outlined in U.S. Geological Survey Professional Paper 964 (Anderson, et. al., 1976), with modifications to provide more suitable information for this project.

The predominant land use within the prospect area is agriculture. More than 95 per cent of the land in the prospect area is under cultivation. Rice is the major crop with some soybean acreage and pasture lands. The entire area is laid out in a standard township pattern with sectional roads and irrigation ditches dividing the rectilinear fields (Fig. 2-13).

A number of residential buildings are located along the section roads within the prospect area. There are also two churches and several stores. The unincorporated community of Sweet Lake is located 1.6 km (1 mi) south of the prospect area. No major Parish roads traverse the prospect area, and there is no industrial activity within the prospect boundaries or in the immediate vicinity. The Sweet Lake oil field is located 5.6 km (3.5 mi) to the south of the prospect area boundaries (Fig. 2-2).

Fig. 2-13. Sectional roads dividing fields: Sweet Lake prospect area.

Table 2-15. Summary of land use: Sweet Lake prospect area.

Land Use Category	Area ¹ Extent km ² (mi ²)	% of Total Area
11 Residential	ANS	
12 Commercial and Service	ANS	
21 Cropland and Pasture	51.8 (20.0)	~100
51 Streams and Canals	ANS	

ANS: Area not significant.

Historical and Archeological Sites

There are no historical or archeological sites within the prospect area. Two shell deposits have been identified from aerial photographs on the banks of Willow Lake, to the southwest of the prospect boundaries (Fig. 2-14). They have not been surveyed and it is therefore unknown if they have any archeological significance (Deborah Woodiel, personal communication, 1978).

Wildlife Preserves and Management Areas

There are no wildlife preserves or management areas within the prospect area. The Lacassine National Wildlife Refuge, a federally owned preserve of 12,596 hectares (31,125 acres), is located approximately 14.5 km (9 mi) to the east of the prospect area boundaries (Fig. 2-15). Approximately 16.9 km (10.5 mi) to the southwest of the prospect is the eastern portion of the Sabine National Wildlife Refuge: a federal refuge of 57,757 hectares (142,717 acres). Both Refuges are noted for their waterfowl populations. Restricted hunting, trapping, and fishing are the only public activities allowed on Refuge land (U.S. Army Corps of Engineers, 1976).

PROSPECT AREA NO. 3: ROCKEFELLER REFUGE

GEOLOGY AND GEOHYDROLOGY

Geologic Setting

Economic Geology

Ground-Water Resources and Quality

Aquifer Availability for Brine Disposal

Soils

AIR QUALITY

Measured Ambient Air Quality

Predicted Ambient Air Quality

WATER RESOURCES AND FLOOD HAZARDS

Hydrology

Water Usage and Quality

Flood Hazards

ECOLOGICAL SYSTEMS

General Setting

Commercial Harvests

Unique Ecological Features

LAND USE

General Land Use

Historical and Archeological Sites

Wildlife Preserves and Management Areas

PROSPECT AREA NO. 3: ROCKEFELLER REFUGE

GEOLOGY AND GEOHYDROLOGYGeologic Setting

The Rockefeller Refuge prospect area is located on the coastal plain in south-east Cameron Parish, beneath coastal marsh deposits (Fig. 3-1). The only relief locally is provided by Grand Cheniere Ridge, an ancient beach ridge standing as much as 3 meters (10 feet) above sea level. The prospect is bounded by arcuate, east-west trending faults that encircle an area having a maximum east-west dimension of 29 km (18 mi) and a maximum north-south dimension of 11 km (7mi). Approximately 80 per cent of the prospect area is on land, with 20 per cent under the adjacent Gulf waters. The areal extent of the prospect is approximately 207 km² (79 mi²).

The generalized geologic sequence at the Rockefeller Refuge prospect area is similar to that described for South Johnson's Bayou and Southeast Pecan Island prospect areas. The geopressed reservoirs occur in Upper Miocene sandstone beds as shallow as 3658 meters (12,000 feet).

Economic Geology

Gas is produced from Upper Miocene sandstones from five fields within and in the vicinity of the prospect area (Fig. 3-2). Table 3-1 gives production data on these fields.

Ground-Water Resources and Quality

Figure 3-2 shows the depth of occurrence of three different qualities of ground water for the prospect area. The base of fresh ground water (less than 250 ppm chlorides) was mapped by Rollo (1960). Maps of the base of slightly saline water (1000 to 3000 mg/l dissolved solids) and moderately saline water (3000 to 10,000 mg/l dissolved solids) were prepared in a study of saline water resources in Louisiana by Winslow, et al (1968). The definition of freshwater used by Rollo is based on chloride content, while the saline water resources are categorized on the basis of dissolved solids content in which fresh-water would be less than 1000 mg/l dissolved solids. When comparing this map with the ground-water resource maps for the other prospect areas, it should be noted that Whitman (1965) found the relationship between dissolved solids content and chloride content in fresh and brackish ground water in southwestern Louisiana to be variable. He found

Field	Producing Formation	Year of Discovery	Estimated Area Proved (Acres)	Number of Wells								Wells Producing At End of Year 1975		Producing Formation (s)						Deepest Zone Tested	Depth of Hole (Feet)
	Name Age and Depth (feet)			Cumulative To End of Year 1975	During Year 1975				Flowing	Artificial Lift	Oil Gravity (API)	Av. Porosity (Percent)	Producing Thickness (Av. Net Feet)		Structure	Name					
					Completed		Abandoned						Oil	Gas							
					Oil	Gas	Oil	Gas									Oil	Gas	Oil	Gas	
Little Pecan Lake	Miocene U 10,843	1954	1952	160	4220	8	36	0	0	0	1	2	7	0	37	P	25	367	DF	Miocene L	16,920
Deep Lake	Miocene U 6,925	--	1952	--	6040	--	84	--	1	--	1	--	18	--	--	26	--	518	AF	Miocene L	18,281
Constance Bayou	Miocene U 14,000	--	1953	--	1240	--	13	--	1	--	0	--	1	--	--	P	--	600	D	Miocene L	16,900
Crab Lake	Miocene U 9,652	1954	1954	80	1289	2	14	0	2	0	0	1	4	0	43	P	36	210	DF	Miocene L	17,900
Price Lake	Miocene U 13,217	1964	1963	40	640	1	7	0	0	0	0	0	3	0	42	P	13	107	DF	Miocene L	17,212

Table 3-1. Oil and gas field data: Rockefeller Refuge prospect area. (From La. Dept. of Natural Resources, 1975).

FIG. 3-1 PROSPECT AREA NO: 3: ROCKEFELLER REFUGE

the following relationship between chlorides and dissolved solids for the Chicot and the Chicot-Atchafalaya aquifer:

Aquifer	Prospect Area Included	Chlorides (ppm)	Dissolved Solids (ppm)
Chicot--Western Portion	1 & 2	250 450	620 1000
Chicot--Eastern Portion	3 & 4	250 425	700 1000
Chicot-Atchafalaya	5	250 360	810 1000

Hence, the maps of ground-water quality prepared for each prospect area are not precisely compatible. Furthermore, the maps are based on determinations of ground-water salinity made from resistivity measurements recorded on electrical logs, and this technique is not precise. However, because the transition between freshwater and slightly saline water is often abrupt, the maps are an adequate representation of the actual water quality distribution.

The geohydrologic framework of the Rockefeller Refuge prospect area is very similar to that of the South Johnson's Bay prospect area to the west and Southeast Pecan Island prospect area to the east. Freshwater occurs more than 183 meters (600 feet) deep in the western portion of the prospect, and the Chicot aquifer underlies the prospect to a depth of 396 meters (1300 feet). Although the prospect is approximately 80 km (50 mi) southeast of the industrial ground-water pumping center in Lake Charles, the effects are felt. The pressure in the aquifer has been lowered from its original level above sea level to a few feet below sea level, and the flow of ground water has been reversed from the natural southerly flow to a north-northwesterly direction toward the centers of pumping in Lake Charles and toward the area of heavy irrigation pumping from the Chicot aquifer in Jefferson Davis and Acadia Parishes.

According to a map by Rollo (1960) the base of freshwater varies from less than 30 meters (100 feet) below the surface in the eastern area of the prospect to more than 183 meters (600 feet) deep in the western area (Fig. 3-2). Freshwater is limited to the "upper sand unit" of the Chicot aquifer (Harder, et. al., 1967). The maximum depth of slightly saline ground water is 183 meters (600 feet); with the maximum depth of moderately saline ground water at 244 meters (800 feet).

As in the other geopressure prospect areas located in the coastal plain, the ground water contained in the Chicot aquifer is isolated from surface contaminants by a coast-wide blanket of clay and silt of Recent Age.

Ground-water wells exist only along Grand Cheniere Ridge, an ancient beach ridge now isolated by Recent deltaic plain clay deposits. The wells shown in Figure 3-2 are for domestic supplies and were drilled in 1955. Their average depth is about 76 meters (250 feet), completed in the "upper sand unit" of the Chicot aquifer. Typical driller's logs indicate 46 meters (150 feet) of clay above the aquifer. Chemical analyses are available for two of these wells and are listed in Table 3-2 (USGS files, Baton Rouge, La.).

Aquifer Availability for Brine Disposal

Geophysical logs of three wells in the Rockefeller Refuge prospect area were examined to determine the thickness of saline aquifers available from brine disposal. Table 3-3 lists the results, showing the average total sand thickness from the three wells of sands 9 meters (30 feet) thick or greater in each 305 meter (1000 foot) interval between 305 and 1524 meters (1000 and 5000 feet).

As of 1975, brine disposal wells were operating in Deep Lake field (1 well, 722 meters (2370 feet) deep, 1.556×10^6 bbls in 1975) and Little Pecan Lake (2 wells, 838 meters (2750 feet) average depth, 1.289×10^6 bbls in 1975) (La. Dept. of Natural Resources, 1975). For comparison, a geopressure test well producing 40,000 bbl per day for one year would produce 1.46×10^7 barrels of brine in one year. The total volumes of brine disposed of from Deep Lake field through 1975 was 1.672×10^7 bbls.

Soils

Soils within the prospect area are coastal types similar to the South Johnson's Bayou prospect area. These peats, mucks and clays are high in organic matter and relatively impermeable. Figure 3-3 shows the general soil types in the prospect area and region.

AIR QUALITY

Measured Ambient Air Quality

The Louisiana Air Control Commission (LACC) sampling station nearest to the Rockefeller Refuge prospect area is located at Lake Charles, approximately 77 km (48 mi) northwest of the prospect area. 1976 annual average pollutant concentrations measured at the Lake Charles station are shown in Table 3-4.

Table 3-2. Chemical analyses from USGS water wells near the Rockefeller Refuge prospect area. (From USGS files, Baton Rouge, La.).

Well No.	Cn 41	Cn 42
Date	2-2-55	2-2-55
Screen Depth (feet)	460	460
Concentrations (mg/l)		
Total Iron	1.2	1.2
Calcium	48	44
Magnesium	19	17
Sodium	408	317
Potassium	---	---
Bicarbonate	416	360
Sulfate	2.1	0.5
Chloride	547	416
Dissolved Solids	1230	1000
Hardness as CaCO ₃	198	181

Table 3-3. Thickness of saline aquifers: Potential brine disposal reservoirs, Rockefeller Refuge prospect area. (From La. Geological Survey files, Baton Rouge, La.).

Depth Interval	Average Total Thickness of Sandstone Beds Greater than 30 feet Thick
1000-2000 ft	415 ft
2000-3000 ft	375 ft
3000-4000 ft	370 ft
4000-5000 ft	480 ft

Table 3-4. 1976 ambient air quality data: Lake Charles health unit station. (From LACC, 1976).

	Sulfur Dioxide ($\mu\text{g}/\text{m}^3$)	Ozone ₃ ($\mu\text{g}/\text{m}^3$)	Nitrogen Dioxide ($\mu\text{g}/\text{m}^3$)	Particulates ($\mu\text{g}/\text{m}^3$)
Annual average*	1.5	-	43	55
24 hr. Maximum*	13	-	77	154
3 hr. Maximum**	181	282	--	--
1 hr. Maximum**	223	282	--	--

* Non-continuous monitor: 24 hour sample taken once per week.

** Continuous monitor: operated only approximately 10% of the time during 1976.

In addition to the Lake Charles-LACC station, limited air quality data resulting from special studies by Radian Corporation (1977) and Ashland Chemical Company are available (Minott, personal communication, 1978). The Radian study covered a three month sampling period in 1976. The Ashland study was carried out during 1975 and 1976. Two sampling stations were located in the general vicinity of the Rockefeller Refuge prospect area. Their distance and direction from the center of the prospect area are as follows:

Lafayette (Radian)	96 km -NNE (60 mi)
New Iberia (Ashland)	98 km -NE (61 mi)

Average measured concentrations for six pollutants from the Lafayette monitoring station, along with their dates of collection are presented in Table 3-5.

Table 3-5. Average concentrations of selected pollutants: Lafayette station. (From Radian Corporation, 1977).

Pollutant	Period of Data Collection	Average Concentration ($\mu\text{g}/\text{m}^3$)
Nitrogen Oxides	July 17 - Sept. 30, 1976	10.1
Nitric Oxide	July 17 - Sept. 30, 1976	3.9
Nitrogen Dioxide	July 17 - Sept. 30, 1976	6.1
Sulfur Dioxide	July 17 - Sept. 30, 1976	1.0
Ozone	July 17 - Oct. 17, 1976	78.0
Particulate	July 17 - Oct. 17, 1976	52.3

The Ashland Chemical Company study reported only 24-hour average SO_2 values. The single highest value of $115 \mu\text{g}/\text{m}^3$ was approximately 32 per cent of the primary standard and 45 per cent of the secondary. The second highest value was $61 \mu\text{g}/\text{m}^3$ while most daily readings were below $20 \mu\text{g}/\text{m}^3$.

Measured concentrations of all pollutants except ozone are well below ambient air quality standards (listed in Table 3-6, below). The entire south Louisiana region has been designated a non-attainment area with respect to ozone.

Table 3-6. Ambient air quality standards: State of Louisiana. (From LACC, 1976).

Pollutant	Standards	
	Primary	Secondary
Sulfur Dioxide		
Annual Arithmetic Mean	$80 \mu\text{g}/\text{m}^3$ **	$60 \mu\text{g}/\text{m}^3$
24-Hour Maximum	$365 \mu\text{g}/\text{m}^3$	$260 \mu\text{g}/\text{m}^3$
3-Hour Maximum	----	$1300 \mu\text{g}/\text{m}^3$
Carbon Monoxide		
8-Hour Maximum	$10 \text{ mg}/\text{m}^3$ ***	$10 \text{ mg}/\text{m}^3$
1-Hour Maximum	$40 \text{ mg}/\text{m}^3$	$40 \text{ mg}/\text{m}^3$
Ozone (Oxidant)		
Annual Arithmetic Mean	$58.8 \mu\text{g}/\text{m}^3$	$58.8 \mu\text{g}/\text{m}^3$
1-Hour Maximum	$160 \mu\text{g}/\text{m}^3$	$160 \mu\text{g}/\text{m}^3$
Nitrogen Dioxide		
Annual Arithmetic Mean	$100 \mu\text{g}/\text{m}^3$	$100 \mu\text{g}/\text{m}^3$
Total Suspended Particulate*		
Annual Geometric Mean	$75 \mu\text{g}/\text{m}^3$	$60 \mu\text{g}/\text{m}^3$
24-Hour Maximum	$260 \mu\text{g}/\text{m}^3$	$150 \mu\text{g}/\text{m}^3$

*Non-continuous monitor.

** $\mu\text{g}/\text{m}^3$ = micrograms per cubic meter.

*** mg/m^3 = milligrams per cubic meter.

Predicted Ambient Air Quality

Due to the absence of sampling stations within the prospect area, the annual average air quality was predicted using the Climatological Dispersion Model--CDM (U.S. Environmental Protection Agency, 1973). Sulfur oxides were selected as the pollutants for the modelling effort because emissions from a geopressure test well are more likely to contribute to SO_x levels than other pollutants for which standards exist. However, there are no SO_x emission point sources within 35 km (22 mi) of the

center of the prospect area that meet the criterion for significant SO_x emitters (≥ 1 ton per yr). As a result, the model predicts an SO_x concentration of zero everywhere within the prospect area.

WATER RESOURCES AND FLOOD HAZARDS

Hydrology

The Rockefeller Refuge prospect area is a typical coastal Louisiana lowland marsh characterized by a relative lack of distinctive relief (Fig. 3-4). A large part of the prospect lies at or only slightly above mean sea level except for the low natural levies adjacent to the natural drainage courses, and the spoil banks along the sides of canals and ditches. The only other break in topography is found along Grand Cheniere Ridge, a narrow abandoned beach ridge with a maximum height above mean sea level in the prospect area of less than 2 meters (7 feet). Because of its location in only a small part of the northern edge of the prospect area, Grand Cheniere Ridge does not significantly affect surface water movement within the prospect area as a whole. The lack of cheniers in most of the prospect area, in contrast to the South Johnson's Bayou prospect area, contributes to relatively unimpeded general water circulation. Access canals to oil and gas wells within the area, as well as the levees and ditches of Rockefeller Wildlife Refuge impoundments and other management projects have modified the natural drainage locally (Fig. 3-5).

Fig. 3-4. Areal photo showing low relief marsh: Rockefeller Refuge prospect area.

Fig. 3-5. Levees in Rockefeller Wildlife Refuge: Rockefeller Refuge prospect area.

Fig. 3-6. Deep Lake: Rockefeller Refuge prospect area.

Located within the prospect are many small shallow lakes, the largest of which are Deep Lake (Fig. 3-6) and Miller Lake. Due to the low gradients, the normal surface water circulation except for tidal flow is slight. Natural drainage systems are relatively few, the most noticeable being Joseph Harbor Bayou (Fig. 3-7) and Hog Bayou.

The impoundments, which are most extensive in the northern half of the prospect area, can be considered as open water systems (Fig. 3-8). Approximately 20 per cent of the prospect area is open Gulf waters.

The movement of water within the marsh of the prospect area varies according to season, and synoptic meteorological variables, tides, storm surges and run off. These natural variables as well as the built features complicate the prediction of the movement of water within the area. During certain periods and under certain conditions the movement of water may be towards the south, for example. At other times, under different conditions movement may be in another direction, or discernible movement may be completely lacking.

Water Usage and Quality

Because most of the prospect area is protected for wildlife, water usage is largely limited to wildlife management purposes. There is no fresh surface water available in the prospect area. Residents of Grand Cheniere Ridge obtain water from shallow wells.

The agencies operating water quality sampling stations in Louisiana--the U.S. Army Corps of Engineers, the U.S. Geological Survey, and the Louisiana Stream Control Commission--maintain no stations within the prospect area. However, a preliminary assessment of water quality conditions has been made in the water quality management basin and basin segment of which the prospect area is a part. This work was done as part of the Louisiana 208 Water Quality Program which is funded under Section 208 of the Federal Water Pollution Control Act Amendments of 1972. Under the 208 Program, a plan is being developed to achieve state water quality standards.

The Rockefeller Refuge prospect is in the Mermentau-Vermilion-Teche Water Quality Management Basin, Segment 11. The initial water quality problem assessment of this segment is given in Table 3-7. The assessment was made by the staffs of the Bureau of Environmental Services, Louisiana Department of Health and Human Resources; and the Louisiana Department of Agriculture (La. State Planning Office, 1977). State water quality criteria for Hog Bayou, part of which is within the prospect area, are given in Table 3-8.

Fig. 3-7. Joseph Harbor Bayou: Rockefeller Refuge prospect area.

Fig. 3-8. Impoundments in Rockefeller Wildlife Refuge: Rockefeller Refuge prospect area.

Table 3-7. Initial water quality problem assessment: Mermentau-Vermilion-Teche Basin, Segment 11. (From La. State Planning Office, 1977).

Problem	Statewide Priority Ranking	Assessment
Municipal and Industrial Discharges	1	Pecan Island unsewered.
Specific and Localized Problems	2	No significant pollution.
Sediment and Nutrients	3	Agricultural production: rice, sugar cane.
Low Concentrations of Pollutants (herbicides, pesticides)	4	No significant problem until sufficient monitoring data prove otherwise.

Table 3-8. Louisiana water quality criteria (numerical): Mermentau-Vermilion-Teche Basin, portions of Segment 11. (From La. Stream Control Commission, 1977).

Segment Description:	Hog Bayou
Water Uses:	Secondary Contact Recreation Propagation of Fish and Wildlife
Chlorides	250 ppm
Sulfates	75 ppm
Dissolved Oxygen	5.0 mg/l
pH Range	6.5 to 9.0
Bacteria Standard	Monthly total coliform median most probable number $\leq$ 70/100 ml; not more than 10% of samples > 230/100 ml (shellfish propagation standard)
Temperature	32° C
Total Dissolved Solids	350 ppm

Flood Hazards

A flood hazard analysis has been made of the Louisiana Gulf coast area by the U.S. Army Corps of Engineers for the Federal Insurance Administration (U.S. Army Corps of Engineers, 1970). That analysis includes projected area of flooding in two cases; as follows:

100-Year Flood: A flood which has an average frequency of occurrence of once in 100 years, but can occur during any year and even during successive years.

Standard Project Flood: The most severe flood which can be expected to occur within a geographic area under the most severe meteorological and hydrological conditions considered characteristic of that area (i.e. excluding extremely rare conditions).

In both these cases, the entire Rockefeller Refuge prospect area would be flooded, according to the Corps study.

Figure 3-9 shows the Surge Reference Line (SRL) as it traverses the northernmost portion of the prospect area. The SRL refers to the calculated synthetic coastline determined where the maximum storm surge height would occur during a 100-year flood situation with winds perpendicular to the coast. Along the line shown in Figure 3-9 storm surge would be expected to reach a maximum depth of approximately 3.8 meters (12.6 feet) within the prospect area during the most severe storm in a 100-year period (U.S. Army Corps of Engineers, 1970). Four damaging hurricanes and 21 hurricanes or tropical storms with minor or unassessed damage have struck southwestern Louisiana in the period of 1886-1971 (U.S. Army Corps of Engineers, 1972).

ECOLOGICAL SYSTEMS

General Setting

The Rockefeller Refuge prospect area includes four ecosystem types according to the classification devised by Bryan and Newman (Newchurch, et.al., 1978). The offshore portion of the prospect area is, of course, the marine type ecosystem. The onshore portion includes saline marsh type, estuarine, and ridge ecosystems. Table 3-9 gives the major characteristics of these ecosystem types. (Section VIII, Vol. 1 of the Report includes a detailed discussion).

Vegetative zones within the prospect area and in the vicinity are shown in Figure 3-10. Chabreck's marsh type classification (1972) is used to delimit vegetation zones with saline, brackish, and intermediate marsh types present in the prospect area. Brackish marsh predominates among the marsh types, although significant areas of intermediate and saline marshes are present. Tables 3-10 and 3-11 give the plant species characteristic of these marsh types, and soil and water salinities, respectively. The data is specific to Hydrologic Unit VIII within which the prospect area is located.

Table 3-9. Major characteristics of ecosystems in Rockefeller Refuge prospect area.

<u>Marine Ecosystem</u>	Coastal open water system with unobstructed access to the open Gulf. The water regimes and water chemistry of this ecosystem are determined primarily by the ebb and flow of oceanic tides. Salinity levels vary from 10,000 to 35,000 mg/l, depending on riverine discharge and distance offshore.
<u>Estuarine Ecosystem</u>	Coastal system, semi-enclosed by land, with open, partially obstructed, or sporadic access to the Gulf and with a measurable quantity of ocean-derived salt in the water. Salinities vary between 500 and 25,000 mg/l.
<u>Saline Marsh Ecosystem</u>	An emergent vegetated wetland system subject to tidal fluctuations of salt water greater than 500 mg/l salinity. This definition includes Chabreck's saline, brackish and intermediate marshes (Chabreck, 1972).
<u>Ridge Ecosystem</u>	Isolated systems of higher ground within fresh or saline marsh ecosystems. These areas include beaches, cheniers, natural and artificial levees, Pleistocene islands, salt domes, spoil banks and Indian mounds.

Table 3-10. Plant species characteristic of marsh types, Hydrologic Unit VIII--Rockefeller Refuge prospect area. (From Chabreck, 1972).

Species	Marsh Type		
	Saline	Brackish (% Composition)	Intermediate
<u>Alternanthera philoxeroides</u>			8.31
<u>Cyperus odoratus</u>			6.17
<u>Distichlis spicata</u> (saltgrass)	68.75	27.87	
<u>Paspalum virginatum</u>		<5	6.39
<u>Scirpus robustus</u>	6.25	<5	
<u>Spartina alterniflora</u>	10.94		
<u>Spartina patens</u> (wiregrass)	6.25	53.80	36.84

KEY

--- GEOPRESSURE PROSPECT BOUNDARIES

— SRL — SURGE REFERENCE LINE

(3.8) 100-YEAR MAXIMUM TIDAL FLOOD ELEVATION AT SRL (METERS MSL)

SCALE 1:62,500

FIG. 3-9 FLOOD HAZARDS: ROCKEFELLER REFUGE (PROSPECT 3)

Table 3-11. Soil and water salinity of marsh types, Hydrologic Unit VIII--Rockefeller Refuge prospect area. (From Chabreck, 1972).

Variable	Vegetative Type		
	Saline	Brackish	Intermediate
	(Mean Concentration, ppt)		
Water salinity	14.16	6.03	1.85
Total soil salts	9.55	6.67	2.39

The marsh ecosystem is somewhat modified as a result of both the wildlife management practices of the Refuge and oil and gas activity. There are several active gas fields within the prospect area (Fig. 3-2 and 3-11). Those within the Rockefeller Wildlife Refuge are specially permitted by the State, including some control over drilling and production practices to protect wildlife and the integrity of the marsh environment.

Fig. 3-11. Access canals and slips north of Deep Lake: Rockefeller Refuge prospect area.

Other activities within the Refuge include wildlife management and related scientific studies, and public fishing and nature study. (See the Land Use section below for a more detailed discussion of Refuge practices).

The ridge ecosystem in the prospect area is principally confined to a small section of Grand Cheniere Ridge in the northeastern portion of the prospect area. It is highly modified with residences and pasture lands predominating. The ridge ecosystem also includes beach, and the spoil banks of impoundments and canals within Rockefeller Wildlife Refuge. The estuarine ecosystem in the prospect area includes lakes, ponds, bayous and canals as the principle aquatic habitat types (Fig. 3-12 and 3-13).

This prospect area has more site specific data on biological and ecological subjects than any other prospect because of the presence of the Rockefeller Refuge. Most studies concern economically important species such as shrimps, Atlantic croaker, and catfishes. There has been a study on marsh inundation in Rockefeller Refuge (Graff, 1976) and a study on widgeon-grass (Joanen, 1964). Ecological studies of the area include Chamberlain (1957), Adams (1956) and Joanen (1968). Knudsen (1976) and Knudsen, et.al. (1977) have measured growth rates of brown shrimp in the marsh, while Jemison (1960) studied the food habits of waterfowl. Studies on alligators in Rockefeller Refuge include Joanen and Perry (1971), Joanen and McNease (1970), and Chabreck (1963, 1971, and 1973). Aspects of the life history and ecology of the Atlantic croaker have been discussed by Arnoldi, et.al. (1974); Arnoldi (1974); Clairain (1974); Knudsen and Herke (1978); Yakupzack (1976) and Yakupzack, et.al. (1977). Other fish population studies have been by Coole, et.al. (1976); Perry (1967, 1973); Perry and Avault (1968) and Perry and Carver (1972). General fish community studies have been reported by Perry (1976, 1978). Perrett, et.al. (1971) included this area in their survey of fish and major invertebrates.

Commercial Harvests

The lack of cheniers, which restrict the circulation of water, the export of detritus, and the migration of species, makes the marshes and estuaries in this prospect area productive nurseries for fisheries species. Also, the relatively unmodified character of the prospect area due to its protected status contributes to its productivity. Specifically, penaeid shrimps, Atlantic croaker, and menhaden spend the early stages of their life cycle in the onshore portions of the prospect area and are harvested in the Gulf (Fig. 3-14). No trapping of muskrat, nutria or alligator is allowed in the Refuge, although the area provides habitat for these species.

Fig. 3-12. Estuarine ecosystem: Rockefeller Refuge prospect area.

Fig. 3-13. Estuarine and marsh ecosystems: Rockefeller Refuge prospect area.

Unique Ecological Features

Large populations of alligators (threatened status) and wading birds are found within the prospect area (Fig. 3-14). The Refuge is protected for migratory waterfowl, which are very numerous. In general, the prospect area is of significant ecological and scientific value because of its protected status and because of the high biological productivity of its ecosystems.

LAND USE

General Land Use

Land use within the Rockefeller Refuge prospect area and in the vicinity is depicted in Figure 3-15 and summarized in Table 3-12. Current land use patterns were mapped using 1:108,000 scale false color infrared imagery flown by NASA in 1972. Land use was verified and corrected through aerial and field reconnaissance during the spring and summer of 1978. The land use classification scheme used is based on the system outlined in U.S. Geological Survey Professional Paper 964 (Anderson, et.al., 1976), with modifications to provide more suitable information for this project.

Approximately 82 per cent of the onshore portion of the prospect area is the State owned Rockefeller Wildlife Refuge and Game Preserve (see discussion below). The northern section of the prospect area includes a portion of a major chenier, Grand Cheniere Ridge, with elevations of up to 3 meters (10 feet) above mean sea level. This relatively high ground is intensively utilized with a number of private residences as well as facilities serving the Refuge. The communities of Grand Cheniere, population 1,166 (U.S. Dept. of Commerce, 1973), and Pecan Island (unincorporated) are effectively located all along Grand Cheniere, although their centers are indicated to the west and east of the prospect area, respectively. Agricultural activities on Grand Cheniere Ridge are limited to cattle grazing.

Industrial activity within the prospect area is entirely extractive. There are two large, active gas fields within the prospect boundaries, as well as several smaller fields (Fig. 3-2). The policy with respect to oil and gas activities of the Louisiana Department of Wildlife and Fisheries, administrative agency for the Refuge lands, has been to allow oil and gas extraction as long as that activity is consistent with the purposes of the Refuge (Joe Herring, personal communication, 1977). Extraction practices are regulated to some extent by the Department, and monitoring for impacts on wildlife is performed. Department of Wildlife and Fisheries staff have indicated that a reassessment of the appropriate level of extractive activity in the coastal

refuges and game preserves is underway. The direction is likely to be to limit oil and gas activity in these areas (Lyle St. Amant, personal communication, 1977).

Highway 82, a major State highway connecting southwestern Cameron and Vermilion Parishes with more populated areas, traverses the northern portion of the prospect area. Several shell roads provide access into the interior of the Refuge.

Approximately 19 percent of the prospect area lies beneath open Gulf waters. There are a number of natural lakes and impoundments within the prospect boundaries.

Table 3-12. Summary of land use: Rockefeller Refuge prospect area.

Land Use Category	Area Extent km ² (mi ²)	% of Total Area
11 Residential	ANS	
12 Commercial and Services	ANS	
21 Cropland and Pasture	2.6 (1)	1.3
52 Lakes	6.9 (2.7)	3.3
62 Nonforested Wetlands	157.2 (60.7)	76.1
Gulf of Mexico	39.9 (15.4)	19.3

ANS: Area not significant.

The onshore portion of the prospect area is entirely within the coastal zone as defined by Act 361 of the 1978 Legislative Session (La. Revised Statutes, 1978). As such it will be subject to land use controls by the State of Louisiana under provisions of the Act and the federal Coastal Zone Management Act of 1972.

Historical and Archeological Sites

There are no historical or archeological sites located within the prospect area. Three archeological sites have been identified just to the north of the prospect boundaries, however (Fig. 3-16). Two of these, CM 38 and CM 48, are village sites. Both are under cultivation and their condition at present is unknown. The most recent survey of these sites took place in the early 1950's. CM 39 on North Island chenier, is a partially destroyed shell midden (Deborah Woodiel, personal communication, 1978).

Wildlife Preserves and Management Areas

Rockefeller Wildlife Refuge and Game Preserve (Fig. 3-17) accounts for 82 per cent of the onshore portion of the prospect area. It is the premier wildlife preserve owned by the State. The Refuge was received by the State through a gift from the Rockefeller Foundation and operates under an annual budget of more than a million dollars.

Wildlife management and scientific research are the main activities of Louisiana Department of Wildlife and Fisheries resident staff. A number of structures, access roads, and canals are maintained to improve conditions for nature study for the staff and public. Over 250 km (155 mi) of levees alone, are located within the Refuge. Fishing is allowed in several areas, but only from the shore.

The Refuge is noted for its migratory water fowl populations, wading bird colonies, and one of the highest concentrations of alligators in North America (La. Department of Wildlife and Fisheries, 1972).

KEY

--- GEOPRESSURE PROSPECT BOUNDARIES

Cm 38 ○ STATE SURVEY NO. AND SITE
SITE DISCRIPTION: VILLAGE SITE
PRESENT CONDITION: UNKNOWN
(UNDER CULTIVATION, 1952)

Cm 39 ○ SITE DISCRIPTION: SHELL MIDDEN
PRESENT CONDITION: PARTIALLY
DESTROYED

Cm 48 ○ SITE DISCRIPTION: VILLAGE SITE
PRESENT CONDITION: FAIR (UNDER
CULTIVATION, 1953)

SOURCE: LA. DIV. OF ARCHEOLOGY & HISTORIC PRESERVATION

SCALE 1: 62,500

**FIG. 3-16 ARCHEOLOGICAL SITES:
ROCKEFELLER REFUGE (PROSPECT 3)**

FIG. 3-17 ROCKEFELLER WILDLIFE REFUGE AND GAME PRESERVE: PROSPECT AREA NO. 3

PROSPECT AREA NO. 4: SOUTHEAST PECAN ISLAND**GEOLOGY AND GEOHYDROLOGY**

Geologic Setting

Economic Geology

Ground-Water Resources and Quality

Aquifer Availability for Brine Disposal

Soils

AIR QUALITY

Measured Ambient Air Quality

Predicted Ambient Air Quality

WATER RESOURCES AND FLOOD HAZARDS

Hydrology

Water Usage and Quality

Flood Hazards

ECOLOGICAL SYSTEMS

General Setting

Commercial Harvests

Unique Ecological Features

LAND USE

General Land Use

Historical and Archeological Sites

Wildlife Preserves and Management Areas

PROSPECT AREA NO. 4: SOUTHEAST PECAN ISLAND

GEOLOGY AND GEOHYDROLOGYGeologic Setting

The Southeast Pecan Island prospect area is located in the coastal marsh of south-central Vermilion Parish (Fig. 4-1). The prospect area is bordered by down-to-the-coast faults along the north and south boundaries encompassing an area of approximately 199 km² (77 mi²). At its maximum dimensions, the prospect is approximately 27 km (17 mi) east to west and 9 km (5.5 mi) north to south. The top of the prospective geopressure reservoir in the Lower Miocene (Frio) is at a depth of 4267 meters (14,000 feet). Approximately 79 per cent of the prospect area is on land, with 21 percent under the adjacent Gulf waters.

Economic Geology

Pecan Island and Freshwater Bayou are two large gas fields within the prospect area boundaries producing from Upper Miocene sandstones from depths of approximately 2286 meters (7500 feet) and 3444 meters (11,300 feet), respectively. North Freshwater Bayou and Fire Island are two gas fields to the north of the prospect area (Fig. 4-2). Production data from these four fields are given in Table 4-1.

Ground-Water Resources and Quality

Figure 4-2 shows the depth of occurrence of three different qualities of ground water for the prospect area. The base of fresh ground water (less than 250 ppm chlorides) was mapped by Rollo (1960). Maps of the base of slightly saline water (1000 to 3000 mg/l dissolved solids) and moderately saline water (3000 to 10,000 mg/l dissolved solids) were prepared in a study of saline water resources in Louisiana by Winslow, et. al., (1968). The definition of freshwater used by Rollo is based on chloride content, while the saline water resources are categorized on the basis of dissolved solids content in which freshwater would be less than 1000 mg/l dissolved solids. When comparing this map with the ground-water resource maps for the other prospect areas, it should be noted that Whitman (1965) found the relationship between dissolved solids content and chloride content in fresh and brackish ground water in southwestern

Field	Producing Formation	Year of Discovery	Estimated Area Proved (Acres)	Number of Wells								Wells Producing At End of Year 1975		Producing Formation (s)						Deepest Zone Tested	Depth of Hole (Feet)
	Name Age and Depth (feet)			Cumulative To End of Year 1975	During Year 1975				Flowing	Artificial Lift	Oil Gravity (API)	Av. Porosity (Percent)	Producing Thickness (Av. Net Feet)		Structure	Name					
					Completed	Abandoned	Producing Thickness (Av. Net Feet)														
		Oil	Gas	Oil	Gas	Oil	Gas	Oil	Gas	Oil	Gas	Oil	Gas								
Fire Island	Miocene U 14,150	--	1964	--	960	--	3	--	0	--	1	--	0	0	X	P	--	16	A	Miocene U	17,893
N. Fresh Water Bayou	Miocene U 13,005	1958	1958	40	3340	1	24	0	0	0	0	0	14	0	42	P	25	239	AF	Miocene L	19,030
Pecan Island	Miocene U 7,500	--	1943	--	4740	--	47	--	2	--	2	--	35	0	48	P	--	175	D	Miocene U	19,012
Fresh Water Bayou	Miocene U 11,307	--	1952	--	2900	--	20	--	0	--	0	--	4	0	X	P	--	60	D	Miocene U	18,373

Table 4-1. Oil and gas field data: Southeast Pecan Island prospect area. (From La. Dept. of Natural Resources, 1975).

Louisiana to be variable. He found the following relationship between chlorides and dissolved solids for the Chicot and the Chicot-Atchafalaya aquifer:

Aquifer	Prospect Area Included	Chlorides (ppm)	Dissolved Solids (ppm)
Chicot--Western Portion	1 & 2	250 450	620 1000
Chicot--Eastern Portion	3 & 4	250 425	700 1000
Chicot-Atchafalaya	5	250 360	810 1000

Hence, the maps of ground-water quality prepared for each prospect area are not precisely compatible. Furthermore, the maps are based on determinations of ground-water salinity made from resistivity measurements recorded on electrical logs, and this technique is not precise. However, because the transition between freshwater and slightly saline water is often abrupt, the maps are an adequate representation of the actual water quality distribution.

Fresh ground water is available to depths in excess of 244 meters (800 feet) in the central and eastern portion of the prospect area in the "upper sand unit" of the Chicot aquifer (Fig. 4-2). However, no ground-water use is recorded in the prospect area. The nearest wells are northwest along State Highway 82 on Pecan Island, a chenier and topographically high area in the marsh. Of the four wells recorded by the U.S. Geological Survey (USGS), two are used for domestic consumption and livestock (Ve-557, Ve-596), one is an observation well maintained by the USGS (Ve-639), and data on the final well (Ve-656) are lacking (USGS files, Baton Rouge, La). Water analyses are available for two wells and are listed in Table 4-2.

The "upper sand unit" of the Chicot aquifer extends to approximately 335 meters (1100 feet) in the prospect area. Electrical logs, from which estimates of the depth and quality of ground water were made, indicate brackish water occupies massive sands shallower than the "upper sand unit" in the area. Moderately saline water (3000 to 10,000 mg/l dissolved solids) extends to between 305 and 335 meters (1000 and 1100 feet) less than 274 meters (900 feet) west of the prospect area boundaries.

Aquifer Availability for Brine Disposal

Electrical logs of two wells in the northwestern portion of the prospect area were examined to determine the thickness of saline aquifers available for brine disposal. Table 4-3 lists the results, showing the average total sand thickness from the two wells

Table 4-2. Chemical analyses from USGS water wells near Southeast Pecan Island prospect area. (From USGS files, Baton Rouge, La.).

Well No.	Ve-557	Ve-639
Date	4-30-58	1-12-65
Screen Depth (feet)	515	603-608
Concentrations (mg/l)		
Total Iron	---	0.43
Calcium	---	33
Magnesium	---	49
Sodium	---	200
Potassium	---	---
Bicarbonate	---	378
Sulfate	---	0.4
Chloride	156	308
Dissolved Solids	---	804
Hardness as CaCO ₃	---	284

Table 4-3. Thickness of saline aquifers: potential brine disposal reservoirs, Southeast Pecan Island prospect area. (La. Geological Survey files, Baton Rouge, La.).

Depth Interval	Average Total Thickness of Sands Greater than 30 feet Thick
1000-2000 ft	255 ft
2000-3000 ft	335 ft
3000-4000 ft	460 ft
4000-5000 ft	450 ft

for sandstone beds 9 meters (30 feet) thick or greater in each 305 meter (1000 foot) interval between 305 and 1524 meters (1000 and 5000 feet).

Only one salt water disposal well is recorded within the prospect. The well is rated at 1000 barrels per day but disposed of less than 100 barrels per day during 1976 into sandstone layers between 716 and 853 meters (2350 and 2800 feet) below the surface (La. Dept. of Natural Resources, 1976).

The low disposal rates at fields in the prospect area are not thought to be a function of inadequate disposal aquifers, but rather simply that the rates are adequate to handle the volume of brine disposal required. The aquifer volume at Southeast Pecan Island prospect area appears adequate to allow for disposal of brine produced during a three year test of geopressured resources at this site.

Soils

The soils of the prospect area are coastal marsh types: peats, mucks and clays. These are high in organic matter and relatively impermeable. Fig. 4-3 shows the general soil types in the prospect area and region.

AIR QUALITY

Measured Ambient Air Quality

The Louisiana Air Control Commission (LACC) sampling stations nearest to the Southeast Pecan Island prospect area are located at Lake Charles (110 km (68 mi) NW of the prospect area), Baton Rouge (153 km (93 mi) NE of the prospect area) and Garyville (170 km (106 mi) NE of the prospect area). 1976 annual average pollutant concentrations measured at these stations are shown in Table 4-4.

In addition to these three LACC stations, limited air quality data resulting from special studies by Ashland Chemical Company (Minott, personal communication, 1978), Cabot Corporation (Beck, personal communication, 1977), and Radian Corporation (1977) are available. The Ashland study was carried out during 1975 and 1976. The Cabot study extended from March 1976 to July 1977, while the Radian study covered a three month sampling period in 1976. Four sampling stations were located in the general vicinity of the Southeast Pecan Island prospect area. Their distance and direction from the center of the prospect area are as follows:

New Iberia (Ashland)	67 km - NE (42 mi)
Franklin (Cabot)	82 km - NE (51 mi)
Morgan City (Radian)	108 km - NE (67 mi)
Lafayette (Radian)	77 km - NNE (48 mi)

Average measured concentrations for six pollutants from the Morgan City and Lafayette monitoring stations, along with their dates of collection, are presented in Table 4-5.

Table 4-4. 1976 ambient air quality data: Lake Charles, Baton Rouge, and Garyville stations. (From LACC, 1976).

	Sulphur Dioxide ($\mu\text{g}/\text{m}^3$)	Ozone ($\mu\text{g}/\text{m}^3$)	Nitrogen Dioxide ($\mu\text{g}/\text{m}^3$)	Particulate ($\mu\text{g}/\text{m}^3$)
Lake Charles, Health Unit				
Annual Average*	1.5	---	43	55
24 hr. Maximum*	13	---	77	154
3 hr. Maximum**	181	282	---	---
1 hr. Maximum**	223	282	---	---
Baton Rouge				
Annual Average*	1.9	---	37.2	47.0
24 hr. Maximum*	20	---	74	155
3 hr. Maximum**	155	394	---	---
1 hr. Maximum**	162	394	---	---
Garyville				
Annual Average*	1.9	---	18.5	43.0
24 hr. Maximum*	16	---	73	100
3 hr. Maximum**	94.3	---	---	---
1 hr. Maximum**	105	---	---	---

* Noncontinuous monitor: 24 hour sample taken once per week.

** Continuous monitor: operated only approximately 10% of the time during 1976.

Table 4-5. Average concentrations of selected pollutants: Morgan City and Lafayette stations. (From Radian Corp., 1977).

Site	Pollutant	Period of Data Collection	Average Concentration ($\mu\text{g}/\text{m}^3$)
Morgan City	Nitrogen Oxides	July 17-Aug. 31, 1976	9.3
	Nitric Oxide	July 17-Aug. 31, 1976	4.8
	Nitrogen Dioxide	July 17-Aug. 31, 1976	4.6
	Sulfur Dioxide	July 17-Sept. 30, 1976	2.4
	Ozone	July 17-Oct. 17, 1976	80.6
	Particulate	Aug. 1-31, Oct. 1-17, 1976	77.8
Lafayette	Nitrogen Oxides	July 17-Sept. 30, 1976	10.1
	Nitric Oxide	July 17-Sept. 30, 1976	3.9
	Nitrogen Dioxide	July 17-Sept. 30, 1976	6.1
	Sulfur Dioxide	July 17-Sept. 30, 1976	1.0
	Ozone	July 17-Oct. 17, 1976	78.0
	Particulate	July 17-Oct. 17, 1976	52.3

The Ashland study reported only 24-hour average SO_2 values. The single highest value of $115 \mu\text{g}/\text{m}^3$ was approximately 32 per cent of the primary standard and 45 per cent of the secondary. The second highest value was $61 \mu\text{g}/\text{m}^3$, while most daily readings were below $20 \mu\text{g}/\text{m}^3$.

The Cabot study collected both 3-hour maximum and 24-hour SO_2 average concentrations. During normal conditions, the maximum concentrations noted were approximately 70 per cent of the secondary standards with the majority of the individual readings showing less than 20 per cent of the standard.

Measured concentrations of all pollutants except ozone are all well below ambient air quality standards (listed in Table 4-6, below). The entire south Louisiana area has been designated a non-attainment area with respect to ozone.

Table 4-6. Ambient air quality standards: State of Louisiana. (From LACC, 1976).

Pollutant	Standards	
	Primary	Secondary
Sulfur Dioxide		
Annual Arithmetic Mean	$80 \mu\text{g}/\text{m}^3$ **	$60 \mu\text{g}/\text{m}^3$
24-Hour Maximum	$365 \mu\text{g}/\text{m}^3$	$260 \mu\text{g}/\text{m}^3$
3-Hour Maximum	----	$1300 \mu\text{g}/\text{m}^3$
Carbon Monoxide		
8-Hour Maximum	$10 \text{ mg}/\text{m}^3$ ***	$10 \text{ mg}/\text{m}^3$
1-Hour Maximum	$40 \text{ mg}/\text{m}^3$	$40 \text{ mg}/\text{m}^3$
Ozone (Oxidant)		
Annual Arithmetic Mean	$58.8 \mu\text{g}/\text{m}^3$	$58.8 \mu\text{g}/\text{m}^3$
1-Hour Maximum	$160 \mu\text{g}/\text{m}^3$	$160 \mu\text{g}/\text{m}^3$
Nitrogen Dioxide		
Annual Arithmetic* Mean	$100 \mu\text{g}/\text{m}^3$	$100 \mu\text{g}/\text{m}^3$
Total Suspended Particulate*		
Annual Geometric Mean	$75 \mu\text{g}/\text{m}^3$	$60 \mu\text{g}/\text{m}^3$
24-Hour Maximum	$260 \mu\text{g}/\text{m}^3$	$150 \mu\text{g}/\text{m}^3$

*Non-continuous monitor.

** $\mu\text{g}/\text{m}^3$ = micrograms per cubic meter.

*** mg/m^3 = milligrams per cubic meter.

Predicted Ambient Air Quality

Due to the absence of sampling stations within the prospect area, a study was initiated to predict the annual average air quality using the Climatological Dispersion Model--CDM (U.S. Environmental Protection Agency, 1973). Sulfur oxides were selected as the pollutant for the modelling effort because emissions from a geopressure test well are more likely to contribute to SO_x levels than other pollutants for which standards exist. However, there are no SO_x emission point sources within 35 km (22 mi) of the center of the prospect area which meet the criterion for significant SO_x emitters (≥ 1 ton per yr). As a result, the model predicts an SO_x concentration of zero everywhere within the prospect area.

WATER RESOURCES AND FLOOD HAZARDS

Hydrology

The Southeast Pecan Island prospect area lies within the coastal marsh of southern Louisiana. The area is very poorly drained and could be considered an area of water rather than of land. Relief, as in the other areas of coastal marshes is lacking except along the few natural drainage courses and along the spoil banks on the sides of canals. Abandoned beach ridges or cheniers are also natural areas of high ground and are evident along the southern section of the prospect (Fig. 4-4).

The natural drainage within the prospect area is complicated by the cheniers which generally parallel the existing coastline. Highest of the cheniers is Cheniere au Tigre (Fig. 4-5) which has a maximum height above sea level of approximately 3.6 meters (12 feet). The other cheniers within the prospect area are generally lower than Cheniere au Tigre but, because of their longer lengths and their locations, affect the natural drainage to a greater extent. The cheniers tend to control the flow of water during normal conditions, but during times of high water the lower cheniers are easily breached and overtopped.

Many small shallow irregular shaped lakes are present behind the chenier ridges especially in the areas on either side of Freshwater Bayou as it enters the Gulf. Freshwater Bayou is the largest and most notable natural drainage system in the prospect. The bayou and adjacent canal (Fig. 4-6) are connected to a large system of canals and ditches constructed within the prospect area and adjacent marsh areas to the west and north (Fig. 4-7).

Fig. 4-4. Cheniers: Southeast Pecan Island prospect area.

Fig. 4-5. Cheniere au Tigre: Southeast Pecan Island prospect area.

Fig. 4-6. Freshwater Bayou Navigation Canal: Southeast Pecan Island prospect area.

Fig. 4-7. Canal system: Southeast Pecan Island prospect area.

The flow and direction of water around, and sometimes over, the cheniers is difficult to calculate. Generally, water movement, as in other areas of the coastal marsh, is dependent upon the existing meteorological and hydrological conditions. During normal conditions the cheniers are the most important factor in controlling the flow of water in the prospect area.

Water Usage and Quality

There is no fresh surface water within the prospect area, and no domestic or agricultural ground-water usage recorded (USGS files, Baton Rouge, La.).

The most recent water quality data for sampling stations within the prospect area (Fig. 4-8) are listed in Table 4-7, below.

Table 4-7. Water quality analyses: Southeast Pecan Island prospect area. (From U.S. Environmental Protection Agency files, Washington, D.C.; USGS files, Baton Rouge, La.).

Variable	Site #29300 1977	Site #87016 1972-1974 (low-high values for period indicated)	Site #76589 1972-1974	Site #2933 1977
Conductivity (micromhos at 25°C)	18700.0*	7.300.0-13.300.0	200.0-12,700.0	23349.9*
Temp (C°)	---	13.9-21.7	10.0-32.5	---
pH	8.2*	7.7-8.2	5.7-8.7	7.65*
Concentrations (mg/l)				
SO ₄	940.0*	---	---	1,100.0*
HCO ₃	106.0*	---	---	138.5*
Mn (µg/l)	10.0*	---	---	20.0*
Ca	160.0*	---	---	200.0*
Mg	450.0*	---	---	570.0*
NH ₃	.070*	---	.080-.150	.180*
K	170.0*	---	---	---
Na	3,400.0*	---	---	4,800.0*
Cl	---	2,394.0*	140.0-3,249.0	---

* One sample only.

A preliminary assessment of water quality conditions has been made in the water quality management basin and basin segments of which the prospect area is a part. This

work was done as part of the Louisiana 208 Water Quality Program which is funded under Section 208 of the Federal Water Pollution Control Act Amendments of 1972. Under the 208 Program, a plan is being developed to achieve state water quality standards.

The Southeast Pecan Island prospect area is in portions of the Mermentau-Vermilion-Teche Water Quality Management Basin, Segments 11 and 21 (Fig. 4-8). The initial water quality problem assessments for these segments are given in Tables 4-8 and 4-9. These assessments were made by the staffs of the Bureau of Environmental Services, Louisiana Department of Health and Human Resources; and the Louisiana Department of Agriculture (La. State Planning Office, 1977).

There are no water bodies within the prospect area for which numerical criteria have been set (La. Stream Control Commission, 1977).

Flood Hazards

A flood hazard analysis has been made of the Louisiana Gulf coast area by the U.S. Army Corps of Engineers for the Federal Insurance Administration (U.S. Army Corps of Engineers, 1970). That analysis includes projected area of flooding in two cases; as follows:

100-Year Flood: A flood which has an average frequency of occurrence of once in 100 years, but can occur during any year and even during successive years.

Standard Project Flood: The most severe flood which can be expected to occur within a geographic area under the most severe meteorological and hydrological conditions considered characteristic of that area (i.e. excluding extremely rare conditions).

In both these cases, the entire Southeast Pecan Island prospect area would be flooded, according to the Corps study.

Figure 4-8 shows the Surge Reference Line (SRL) as it traverses the marsh to the north of the prospect area. The SRL refers to the calculated synthetic coastline determined where the maximum storm surge height would occur during a 100-year flood situation with winds perpendicular to the coast. Along the line shown in Figure 4-8, storm surge would be expected to reach a maximum depth of approximately 4.2 meters (13.8 feet) during the most severe storm in a 100-year period (U.S. Army Corps of Engineers, 1970). Four damaging hurricanes and 21 hurricanes or tropical storms with minor or unassessed damage have struck southwestern Louisiana in the period of 1886-1971 (U.S. Army Corps of Engineers, 1972).

Table 4-8. Initial water quality problem assessment: Mermentau-Vermilion- Teche Basin, Segment 11. (From La. State Planning Office, 1977).

Problem Area	Statewide Priority Ranking	Assessment
Municipal and Industrial Discharges	1	Pecan Island unsewered.
Specific and Localized Problems	2	No significant pollution.
Sediment and Nutrients	3	Agricultural production: rice, sugar cane, soybeans.
Low Concentrations of Pollutants (herbicides, pesticides)	4	No significant problem until sufficient monitoring data prove otherwise.

Table 4-9. Initial water quality problem assessment: Mermentau-Vermilion-Teche Basin, Segment 21. (From La. State Planning Office, 1977).

Problem Area	Statewide Priority Ranking	Assessment
Municipal and Industrial Discharges	1	No significant pollution.
Specific and Localized Problems	2	No significant pollution.
Sediment and Nutrients	3	May be silting. Agricultural production: rice, soybeans sugar cane.
Low Concentrations of Pollutants (herbicides, pesticides)	4	Fish kills in Charenton Canal-Lake Fausse Point-Bayou Teche System.

ECOLOGICAL SYSTEMS

General Setting

The Southeast Pecan Island prospect area is very similar to the other two chenier plain coastal prospect areas: South Johnson's Bayou and Rockefeller Refuge. Four ecosystem types, according to Bryan and Newman's schema (Newchurch, et.al., 1978), are present: marine in the off-shore portion; saline marsh, estuarine, and ridge ecosystems in the onshore portion. Table 4-10 gives the major characteristics of these ecosystem types. (Section VIII, Vol. 1 includes a detailed discussion).

Table 4-10. Major characteristics of ecosystems in Southeast Pecan Island prospect area.

<u>Marine Ecosystem.</u>	Coastal open water system with unobstructed access to the open Gulf. The water regimes and water chemistry of this ecosystem are determined primarily by the ebb and flow of oceanic tides. Salinity levels vary from 10,000 to 35,000 mg/l, depending on riverine discharge and distance offshore.
<u>Estuarine Ecosystem.</u>	Coastal system, semi-enclosed by land, with open, partially obstructed, or sporadic access to the Gulf and with a measurable quantity of ocean-derived salt in the water. Salinities vary between 500 and 25,000 mg/l.
<u>Saline Marsh Ecosystem.</u>	An emergent vegetated wetland system subject to tidal fluctuations of salt water greater than 500 mg/l salinity. This definition includes Chabreck's saline, brackish and intermediate marshes (Chabreck, 1972).
<u>Ridge Ecosystem.</u>	Isolated systems of higher ground within fresh or saline marsh ecosystems. These areas include beaches, cheniers, natural and artificial levees, Pleistocene islands, salt domes, spoil banks and Indian mounds.

Vegetative zones within the prospect area and in the vicinity are shown in Figure 4-9. Chabreck's marsh type classification (1972) is used to delimit vegetation zones with saline, brackish, and intermediate marsh types present in the prospect area. Brackish marsh predominates among the marsh types, although significant areas of intermediate and saline marshes are present. Tables 4-11 and 4-12 give the plant species characteristic of these marsh types, and soil and water salinities, respectively. The data is specific to Hydrologic Unit VII within which the prospect area is located.

FIG. 4-9 VEGETATIVE ZONES: SOUTHEAST PECAN ISLAND (PROSPECT 4)

Table 4-11. Plant species characteristic of marsh types, Hydrologic Unit VII--Southeast Pecan Island prospect area. (From Chabreck, 1972).

Species	Marsh Type		
	Saline	Brackish (% Composition)	Intermediate
<u>Batis maritime</u>	18.18		
<u>Borrichia frutescens</u>	9.10		
<u>Juncus effusus</u>	27.27	14.59	
<u>Panicum virgatum</u>		<5	8.59
<u>Sagittaria falcata</u>			12.64
<u>Scirpus validus</u>		11.11	5.51
<u>Scirpus robustus</u>	18.18	<5	
<u>Spartina alterniflora</u>	27.27		
<u>Spartina patens</u> (wiregrass)		56.70	30.63
<u>Vigna repens</u>		<5	8.59

Table 4-12. Soil and water salinity of marsh types, Hydrologic Unit VII--Southeast Pecan Island prospect area. (From Chabreck, 1972).

Variable	Vegetative Type		
	Saline	Brackish	Intermediate
	(Mean Concentration, ppt)		
Water Salinity	10.63	4.48	2.07
Total Soil Salts	8.21	6.14	2.21

The marsh and estuarine ecosystem is considerably modified as a result of oil and gas activity (Fig. 4-2). Fig. 4-10 shows a network of access canals and slips in the southern portion of the prospect area.

Fig. 4-10. Access canals and slips: Southeast Pecan Island prospect area.

Cheniere au Tigre is the only modified naturally occurring ridge ecosystem in the prospect area. It is the site of an abandoned resort. Trappers and others use the cheniere to land planes and camp. The spoil banks of the numerous canals in the prospect area are also ridge ecosystems. There is a narrow beach--also a ridge ecosystem--on the coast.

A small portion of the Paul J. Rainey Wildlife Refuge and Game Preserve, a private preserve, is within the prospect area (Fig. 4-11). The Louisiana State Wildlife Refuge and Game Preserve boundary is less than 1.6 km (1 mile) to the northeast of the prospect area boundary. (See the Land Use section below for a more detailed discussion of these preserves).

Studies specific to the prospect area include an environmental impact statement on the dredging of Freshwater Bayou (U.S. Army Corps of Engineers, 1976) and an inventory of zooplankton, fishes and larger invertebrates by Juneau (1975). Studies on the fisheries of nearby Marsh Island include Tarbox (1970), Herke (1971), Holloway (1969), Weaver (1969) and Wengert (1972). Chabreck (1968) studied the effects of cattle grazing on Marsh Island plants and animals.

Commercial Harvests

The marshes and estuarine ecosystems of the prospect area are nurseries for penaeid shrimps, Atlantic croaker, and menhaden. Major commercial fisheries border the off-shore boundaries of the prospect (Fig. 4-12). Muskrat and nutria are trapped within the prospect. Blue crabs are also harvested within the prospect area.

Unique Ecological Features

Duck and wading bird colonies are found in the northern portion of the prospect area (Fig. 4-12). Alligator are also present and are harvested within the prospect. The harvests are controlled due to the threatened status of the alligator.

LAND USE

General Land Use

Land use within the Southeast Pecan Island prospect area and in the vicinity is depicted in Figure 4-13, and summarized in Table 4-13. Current land use patterns were mapped using 1:108,000 scale false color infrared imagery flown by NASA in 1972. Land use was verified and corrected through aerial reconnaissance during the spring and summer of 1978. The land use classification scheme used is based on the system outlined in U.S. Geological Survey Professional Paper 964 (Anderson, et.al., 1976) with modifications to provide more suitable information for this project.

The onshore portion of the prospect area consists primarily of undeveloped non-forested wetlands. There are a number of small cheniers in the prospect area of high enough elevation for cattle grazing or residences but are not used for these purposes. The most prominent of these is Cheniere au Tigre in the eastern portion of the prospect area. It was once a hunting and fishing resort area with several buildings which have since been abandoned. Local trappers use the high ground for temporary camps. Cheniere au Tigre, like the other cheniers in the prospect area, is isolated from approach by land.

An extensive chenier system is located approximately 3.7 km (2.3 mi) northwest of the prospect boundaries. Two cheniers: Front Ridge and Back Ridge are closest to the prospect area. Land use on these cheniers is predominantly residential and cattle grazing. The cheniers are relatively intensely settled. The residents of Pecan Island (unincorporated) have homes along Front and Back Ridges. Highway 82, a major

State highway connecting the coastal portions of Cameron and Vermilion Parishes with population centers further inland, passes through the town of Pecan Island.

There are several major gas fields within the prospect area (Fig. 4-2). A relatively extensive system of canals and ditches have been constructed within the prospect area to provide access to wells. A gas transmission station is located on Mulberry Island, a chenier in the south-central portion of the prospect area.

Freshwater Bayou Navigation Canal (Fig. 4-6) is a federally owned waterway that traverses the prospect area from north to south. The canal is under the jurisdiction of the U.S. Army Corps of Engineers, New Orleans District. It is a major transportation route between Intracoastal City and the Gulf of Mexico and is equipped with locks to facilitate waterborn traffic and to limit saltwater intrusion. The canal connects with the Intracoastal Waterway near Intracoastal City.

Approximately 21 per cent of the prospect area lies beneath Gulf waters. There are numerous small lakes among the cheniers.

Table 4-13. Summary of land use: Southeast Pecan Island prospect area.

Land Use Category	Area] Extent km ² (mi ²)	% of Total Area
14 Transportation	1.3 (0.5)	0.6
21 Cropland and Pasture	2.0 (0.8)	1.0
51 Streams and Canals	ANS	
52 Lakes	ANS	
62 Nonforested Wetlands	151.5 (58.5)	76.1
Gulf of Mexico	43.6 (16.8)	21.2

ANS: Area not significant.

The onshore portion of the prospect area is entirely within the coastal zone as defined by Act 361 of the 1978 Legislative Session of the Louisiana Legislature (La. Revised Statutes, 1978). As such it will be subject to land use controls by the State of Louisiana under provisions of the Act and the federal Coastal Zone Management Act of 1972.

**FIG.4-14 ARCHEOLOGICAL SITES:
SOUTHEAST PECAN ISLAND (PROSPECT 4)**

Historical and Archeological Sites

There are no historical sites within the prospect area or in the vicinity. One archeological site, VM 15, is located within the prospect boundaries (Fig. 4-14). The site is a camp site under cultivation. Pottery shards have been found at the site and placed in a collection at Louisiana State University. The site to the north of the prospect area boundaries, VM 32, is a shell midden in good condition (Deborah Woodiel, personal communication, 1978).

Wildlife Preserves and Management Areas

A portion of the Paul J. Rainey Wildlife Refuge and Game Preserve, a private preserve owned by the National Audubon Society, is located within the prospect area (Fig. 4-11). The Refuge is 10,587 hectares (26,161 acres) in areal extent. No hunting or trapping activities are allowed.

Bordering the Paul J. Rainey Refuge to the east of the prospect boundaries are the state-owned Louisiana State Wildlife Refuge and Game Preserve and Marsh Island Wildlife Refuge and Game Preserve (Fig. 4-11). Both are noted for their migratory waterfowl populations which are strictly protected. One of the highest concentrations of alligators in the State is found in the Marsh Island Impoundment Canal (La. Dept. of Wildlife and Fisheries, 1972).

Shell Keys National Wildlife Refuge is located in the Gulf off of Marsh Island (Fig. 4-11). It is a preserve for seabird populations.

PROSPECT AREA NO. 5: ATCHAFALAYA BAY

GEOLOGY AND GEOHYDROLOGY

Geologic Setting

Economic Geology

Ground-Water Resources and Quality

Aquifer Availability for Brine Disposal

Soils

AIR QUALITY

Measured Ambient Air Quality

Predicted Ambient Air Quality

WATER RESOURCES AND FLOOD HAZARDS

Hydrology

Water Usage and Quality

Flood Hazards

ECOLOGICAL SYSTEMS

General Setting

Commercial Harvests

Unique Ecological Features

LAND USE

General Land Use

Historical and Archeological Sites

Wildlife Preserves and Management Areas

PROSPECT AREA NO. 5: ATCHAFALAYA BAY

GEOLOGY AND GEOHYDROLOGYGeologic Setting

The Atchafalaya Bay prospect area is situated beneath the eastern end of Atchafalaya Bay and the adjacent marsh area of Point Au Fer Island, and the mainland and Four League Bay in southwestern Terrebonne Parish (Fig. 5-1). Approximately 59 per cent of the prospect area is beneath the waters of Atchafalaya and Four League Bays. The prospect area is in two sections, separated by a northeast-southwest trending fault. The limits of the two parts of the prospect are not clearly defined by faults.

The prospect area is approximately 267 km^2 (103 mi^2) in areal extent. A generalized stratigraphic sequence within the prospect area from the surface down includes approximately 30 meters (100 feet) of topstratum (Fisk, 1952) of highly organic silts and clays; Pleistocene sands and clays (the Chicot aquifer) to approximately 610 meters (2000 feet); Upper Miocene sandstones and shales as much as 61 meters (200 feet) thick to depths of 4267 meters (14,000 feet) or more. The geopressed resource extends downward from a depth of 3353 meters (11,000 feet).

Economic Geology

Ten oil and/or gas fields are produced from Upper Miocene sandstones either within the prospect area boundaries or in the vicinity (Fig. 5-2). Production data on these fields is given in Table 5-1.

Ground-Water Resources and Quality

Figure 5-2 shows the depth of occurrence of three different qualities of ground water for the prospect area. The base of fresh ground water (less than 250 ppm chlorides) was mapped by Rollo (1960). Maps of the base of slightly saline water (1000 to 3000 mg/l dissolved solids) and moderately saline water (3000 to 10,000 mg/l dissolved solids) were prepared in a study of saline water resources in Louisiana by Winslow, et. al. (1968). The definition of freshwater used by Rollo is based on chloride content, while the saline water resources are categorized on the basis of dissolved solids content in which freshwater would be less than 1000 mg/l dissolved solids. When comparing this map with the ground-water resource maps for the other prospect areas, it should be noted that Whitman (1965) found

Field	Producing Formation		Year of Discovery	Estimated Area Proved (Acres)	Number of Wells								Wells Producing At End of Year 1975		Producing Formation (s)						Deepest Zone Tested		Depth of Hole (Feet)
	Name Age and Depth (feet)					Cumulative To End of Year 1975		During Year 1975				Flowing	Artificial Lift	Oil Gravity (API)	Av. Porosity (Percent)	Producing Thickness (Av. Net Feet)		Structure	Name				
																Oil	Gas			Oil	Gas		
						Oil	Gas	Oil	Gas	Oil	Gas											Oil	
Point au Fer	Miocene U 5,208	1956	1941	520	3000	20	29	1	4	0	1	2	7	2	40	P	50	230	D	Miocene U	16,835		
Halter Island	Miocene U 7,540	1954	1953	720	1260	8	9	0	0	0	0	1	6	0	46	P	12	70	D	Miocene U	19,065		
Deer Island	Miocene U 7,930	1953	1942	400	2920	11	35	0	0	1	1	5	7	0	40	P	72	166	D	Miocene U	17,030		
Oyster Bayou	Miocene U 9,144	1967	--	160	--	2	--	0	--	2	--	0	--	0	39	P	X	--	A	Miocene U	14,003		
Mosquito Bay	Miocene U 10,266	1970	1955	80	480	1	3	0	0	0	0	0	0	0	53	P	X	40	A	Miocene U	16,020		
Rice Bayou	Miocene U 13,340	--	1975	--	160	--	2	--	0	--	0	--	0	--	--	P	--	30"	X	Miocene U	16,300		
Palmetto Bayou	Miocene U 11,984	1955	1956	120	480	3	3	0	0	0	0	0	0	0	35	P	30	35	A	Miocene U	19,000		
Bayou Penchant	Miocene U 6,874	1953	1944	240	1100	7	71	0	6	0	5	0	39	0	45	P	30	440	D	Miocene U	17,504		
Four League Bay	Miocene U 7,132	--	1952	--	320	--	2	--	0	--	0	--	0	--	--	P	--	8	A	Miocene U	16,275		
Wildcat Bayou	Miocene U 12,912	--	1957	--	320	--	2	--	0	--	1	--	1	--	--	P	--	10	A	Miocene U	15,556		

Table 5-1. Oil and gas field data: Atchafalaya Bay prospect area. (From La. Dept. of Natural Resources, 1975).

FIG. 5-1 PROSPECT AREA NO.5: ATCHAFALAYA BAY

the relationship between dissolved solids content and chloride content in fresh and brackish ground water in southwestern Louisiana to be variable. He found the following relationship between chlorides and dissolved solids for the Chicot and the Chicot-Atchafalaya aquifer:

Aquifer	Prospect Area Included	Chlorides (ppm)	Dissolved Solids (ppm)
Chicot--Western Portion	1 & 2	250	620
		450	1000
Chicot--Eastern Portion	3 & 4	250	700
		425	1000
Chicot-Atchafalaya	5	250	810
		360	1000

Hence, the maps of ground-water quality prepared for each prospect area are not precisely compatible. Furthermore, the maps are based on determinations of ground-water salinity made from resistivity measurements recorded on electrical logs, and this technique is not precise. However, because the transition between freshwater and slightly saline water is often abrupt, the maps are an adequate representation of the actual water quality distribution.

The Atchafalaya Bay prospect area contains fresh ground water only in a limited area centered north of Four League Bay to a depth of 914 meters (3000 feet). Moderately saline water is present to 2438 meters (8000 feet) at the coast of Point Au Fer Island (Fig. 5-2). No ground-water use is documented in the Atchafalaya Bay prospect area (USGS files, Baton Rouge, La.). Beyond the estimates of ground water quality made from electrical logs of oil and gas test wells, no ground-water analyses are available.

The Pleistocene water bearing sands of the area are artesian and isolated from surface recharge by the relatively impermeable topstratum. Additional protection is provided by the fact that the potentiometric surface of the aquifers is above sea level, i.e., any vertical ground-water movement would be from the aquifer upward instead of from the surface downward.

Aquifer Availability for Brine Disposal

Geophysical logs of four wells in the Atchafalaya Bay prospect area were examined to determine the total thickness of individual sands at least 9 meters

(30 feet) thick below a depth of 610 meters (2,000 feet). The data are summarized in Table 5-2.

Table 5-2. Thickness of saline aquifers: Potential brine disposal reservoirs, Atchafalaya Bay prospect area. (From La. Geological Survey files, Baton Rouge, La.).

Depth Interval	Average Total Thickness of Sandstone Beds Greater than 30 feet thick
2000 - 3000 ft	375
3000 - 4000 ft	285
4000 - 5000 ft	255
5000 - 6000 ft	335
6000 - 7000 ft	540

Only one salt water disposal well is reported in the Atchafalaya Bay prospect area (La. Dept. of Natural Resources, 1976). The well is located in Bayou Penchant field and disposed of 3.5×10^6 barrels of brine during 1976. The resulting average daily disposal rate is approximately 9,600 barrels.

For comparison, a geopressure test well could have as much as 40,000 barrels of brine to dispose of per day. The saline aquifer volume at Atchafalaya Bay appears adequate to allow for disposal of brine during a three year geopressure resource test. The low disposal rate at the Bayou Penchant well field is not thought to be a function of inadequate disposal aquifers, but rather simply that the rate is adequate to handle the volume of brine disposal required.

Soils

The soils within the prospect area are all coastal marsh types: peats, mucks, and clays. These are high in organic matter and relatively impermeable. Figure 5-3 shows the general soil types in the prospect area and region.

AIR QUALITY

Measured Ambient Air Quality

The Louisiana Air Control Commission (LACC) sampling station nearest to the Atchafalaya Bay prospect area is located at Garyville, approximately 98 km (61 mi) northeast of the prospect area. 1976 annual average pollutant concentrations

measured at the Garyville station are shown in Table 5-3.

Table 5-3. 1976 ambient air quality data: Garyville station. (From LACC, 1976).

	Sulfur Dioxide ($\mu\text{g}/\text{m}^3$)	Ozone ($\mu\text{g}/\text{m}^3$)	Nitrogen Dioxide ($\mu\text{g}/\text{m}^3$)	Particulates ($\mu\text{g}/\text{m}^3$)
Annual Average*	1.9	---	18.5	43.0
24 hr. Maximum*	16	---	73	100
3 hr. Maximum**	94.3	---	---	---
1 hr. Maximum**	105	---	---	---

* Noncontinuous monitor: 24 hour sample taken once per week.

** Continuous monitor: operated only approximately 10% of the time during 1976.

In addition to the Garyville-LACC station, limited air quality data resulting from special studies by Radian Corporation (1977) and Cabot Corporation (Beck, personal communication, 1977) are available. The Radian study covered a three month sampling period in 1976, while the study conducted by Cabot extended from March 1976 to July 1977. Three sampling stations were located in the general vicinity of the Atchafalaya Bay prospect area. Their distance and direction from the center of the prospect area are as follows:

Franklin (Cabot)	53 km - NNW (33 mi)
Morgan City (Radian)	38 km - N (24 mi)
Galliano (Radian)	91 km - W (57 mi)

Average measured concentrations for six pollutants from the Morgan City and Galliano monitoring stations, along with their dates of collection, are presented in Table 5-4.

The Cabot study collected both 3-hour maximum and 24-hour average SO_2 concentrations. During normal conditions, the maximum concentrations noted were approximately 70 per cent of the secondary standards with the majority of the individual readings showing less than 20 per cent of the standard.

Measured concentrations of all pollutants except ozone are well below ambient air quality standards (listed in Table 5-5). The entire south Louisiana area has been designated a non-attainment area with respect to ozone.

Table 5-4. Average concentrations of selected pollutants: Galliano and Morgan City stations. (From Radian Corporation, 1977).

Site	Pollutant	Period of Data Collection	Average Concentration ($\mu\text{g}/\text{m}^3$)
Galliano	Nitrogen Oxides	July 17 - Sept. 30, 1976	7.1
	Nitric Oxide	July 17 - Sept. 30, 1976	2.3
	Nitrogen Dioxide	July 17 - Sept. 30, 1976	4.8
	Sulfur Dioxide	July 17 - Sept. 30, 1976	1.2
	Ozone	Sept. 1 - Oct. 17, 1976	81.2
	Particulate	Aug. 1-31, Oct. 1-17, 1976	41.9
Morgan City	Nitrogen Oxides	July 17 - Aug. 31, 1976	9.3
	Nitric Oxide	July 17 - Aug. 31, 1976	4.8
	Nitrogen Dioxide	July 17 - Aug. 31, 1976	4.6
	Sulfur Dioxide	July 17 - Sept. 30, 1976	2.4
	Ozone	July 17 - Oct. 17, 1976	80.6
	Particulate	Aug. 1-31, Oct. 1-17, 1976	77.8

Table 5-5. Ambient air quality standards: State of Louisiana. (From LACC, 1976).

Pollutant	Standards	
	Primary	Secondary
Sulfur Dioxide	80 $\mu\text{g}/\text{m}^3$ **	60 $\mu\text{g}/\text{m}^3$
Annual Arithmetic Mean		
24-Hour Maximum	365 $\mu\text{g}/\text{m}^3$	260 $\mu\text{g}/\text{m}^3$
3-Hour Maximum	----	1300 $\mu\text{g}/\text{m}^3$
Carbon Monoxide		
8-Hour Maximum	10 mg/m^3 ***	10 mg/m^3
1-Hour Maximum	40 mg/m^3	40 mg/m^3
Ozone (Oxidant)		
Annual Arithmetic Mean	58.8 $\mu\text{g}/\text{m}^3$	58.8 $\mu\text{g}/\text{m}^3$
1-Hour Maximum	160 $\mu\text{g}/\text{m}^3$	160 $\mu\text{g}/\text{m}^3$
Nitrogen Dioxide		
Annual Arithmetic* Mean	100 $\mu\text{g}/\text{m}^3$	100 $\mu\text{g}/\text{m}^3$
Total Suspended Particulate*		
Annual Geometric Mean	75 $\mu\text{g}/\text{m}^3$	60 $\mu\text{g}/\text{m}^3$
24-Hour Maximum	260 $\mu\text{g}/\text{m}^3$	150 $\mu\text{g}/\text{m}^3$

*Non-continuous monitor.

** $\mu\text{g}/\text{m}^3$ = micrograms per cubic meter.*** mg/m^3 = milligrams per cubic meter

Predicted Ambient Air Quality

Due to the absence of sampling stations within the prospect area, a study was initiated to predict the annual average air quality using the Climatological Dispersion Model--CDM (U.S. Environmental Protection Agency, 1973). Sulfur oxides were chosen as the pollutants for the modelling effort because emissions from a geopressure test well are more likely to contribute to SO_x levels than the other pollutants for which standards exist. However, there are no SO_x emission point sources within 35 km (22 mi) of the center of the prospect area that meet the criterion for significant emitters (≥ 1 ton per yr). As a result, the model predicts an SO_x concentration of zero everywhere within the prospect area.

WATER RESOURCES AND FLOOD HAZARDS

Hydrology

The Atchafalaya Bay prospect area is located in the extreme southwestern margin of the Mississippi-Atchafalaya deltaic complex. The prospect area northern boundary lies immediately to the south of the mouth of the Atchafalaya, where the river discharges its load of freshwater and silt into Atchafalaya Bay, and where much of the newly emerging complex of mudflats and spoil islands is rapidly evolving as the Atchafalaya Delta (Fig. 5-4 and 5-5). Indeed, including the emerging deltaic areas, Atchafalaya Bay covers approximately 50 per cent of the prospect. Approximately 15 per cent of the prospect consists of other open water surfaces; Four League Bay (Fig. 5-6), Mosquito Bay, Lake Chapeau, Big Carrion Crow Bayou, and other bayous and a number of canals for gas and oil production and pipelines (Fig. 5-7). The remaining 35 per cent of the prospect consists of marshes ranging from brackish to intermediate.

Seasonal river discharge from the Atchafalaya is the overriding influence on the hydrology of the Bay. The river carries approximately 30 per cent of the total discharge of the Mississippi River at this time. The allocation of the Mississippi River discharge is maintained by the Old River Control Structure, about 80.5 km (50 mi) northwest of Baton Rouge. Earlier in this century the proportion of the total discharge carried by the Atchafalaya was much smaller; it has increased steadily since that period. The control structure was completed in 1963 to maintain a more constant diversion of 30 per cent into the Atchafalaya (Shlemon, R., 1972).

Because of the increasing flow of the Atchafalaya during the first half of this century, most of the environments within and in the immediate vicinity of

Fig. 5-4. Land accretion in Wax Lake outlet: West of Atchafalaya Bay prospect area.

Fig. 5-5. Spoil Islands in Atchafalaya Bay: Atchafalaya Bay prospect area.

Fig. 5-6. Four League Bay looking toward Atchafalaya Bay: Atchafalaya Bay prospect area.

Fig. 5-7. Access canals and slips: Atchafalaya Bay prospect area.

Atchafalaya Bay are in an almost constant state of flux. Most of the bay is less than 3 meters (10 feet) deep, and the increasing sediment load of the river has been deposited as huge splays of silt. Some of these deposits are now above sea level most of the time, and they are beginning to be colonized by willows and other water-tolerant shrubs and trees. The U.S. Army Corps of Engineers maintains a navigation channel through the Bay and rather large circular spoil islands, looking from the air somewhat like mud volcanoes, are conspicuous features of the emerging delta.

Atchafalaya Bay, therefore, consists of a complex mix of both freshwater from the river, and sea water from the Gulf. Circulation and salinity within the Bay depend upon the magnitude of the Atchafalaya River discharge, tides and storm surges, and on synoptic weather patterns along the Louisiana coast. In the latter case, brisk southerly winds drive sea water toward the coastline, raising water levels and salinity, but northerly winds drive sea water off-shore, decreasing water levels and salinity. Most of the Bay waters are fresh for at least eight months of most water years--the months of maximum discharge from the Atchafalaya River, and the topography of the Bay is subject to rapid change during high-water periods of the Atchafalaya River and also during tropical storms and hurricanes. In this dynamic environment, the prediction of water levels and circulation patterns would be difficult.

The marsh areas are extremely low with most elevations below 0.3 or 0.6 meters (1-2 feet). Elevations occasionally reach 1.5 meters (5 feet) or more on some of the spoil banks along the canals. Because of the low elevations and the gentle regional subsidence of the Mississippi-Atchafalaya delta complex, some of the marsh has broken up into patches of open water and lakes. For example, on Point Au Fer Island more than 50 per cent of the marsh is actually open water. The dredging of canals in Four League Bay and Mosquito Bay gas fields has undoubtedly increased exchanges of salt water into the marshes, and also resulted in somewhat larger amounts of open water. From the air, the effects of the river discharge and the oil and gas industry appear to be extensive.

Water Usage and Quality

No freshwater use for domestic or agricultural purposes is documented for the prospect area.

The most recent water quality data for sampling stations within the prospect area and in the vicinity are given in Table 5-6.

Table 5-6. Water quality analyses: Atchafalaya Bay prospect area. (From U.S. Environmental Protection Agency files, Washington, D.C.; USGS files, Baton Rouge, La).

	Site #88902 1973-1974	Site #2921400 1974-1975	Site #292325 1974-1975
	(low-high values for period indicated)		
Conductivity (micromhos-field)	200.0 - 19800.0	265.0 - 23000.0	286.0 - 20700.0
Temp. (C ⁰)	8.3 - 32.0	10.5 - 30.0	11.5 - - 28.5
pH Range	6.5 - 9.2	7.5 - 8.1	7.3 - - 8.5
Concentrations (mg/l)			
B	----	.000 - 1400.0	30.0 - 1200.0
SiO ₂	----	2.4 - 6.50	----
SO ₄	----	24.0 - 1100.0	21.0 - 1000.0
HCO ₃	----	85.0 - 142.0	86.0 - 139.0
Ca	----	23.0 - 200.0	24.0 - 180.0
M ₈	----	7.20 - 370.0	7.3 - 340.0
NH ₃	.080 - .190	.00 - .080	.000 - .080

A preliminary assessment of water quality conditions has been made in the water quality management basins and basin segments of which the prospect area is a part. This work was done as part of the Louisiana 208 Water Quality Program which is funded under Section 208 of the Federal Water Pollution Control Act Amendments of 1972. Under the 208 Program, a plan is being developed to achieve state water quality standards.

The Atchafalaya Bay prospect area is in portions of two water quality management basins: the Atchafalaya River Basin, Segment 11; and the Terrebonne Basin, Segment 9 (Fig. 5-8). The initial problem assessments for these segments are given in Tables 5-7 and 5-8. These assessments were made by the staffs of the Bureau of Environmental Services, Louisiana Department of Health and Human Resources; and the Louisiana Department of Agriculture (La. State Planning Office, 1977).

State water quality criteria for Atchafalaya Bay are given in Table 5-9.

Table 5-7. Initial water quality problem assessment: Atchafalaya River Basin, Segment 11. (From La. State Planning Office, 1977).

Problem	Statewide Priority Ranking	Assessment
Municipal and Industrial Discharge	1	No significant pollution.
Specific and Localized Problems	2	Silting is serious.
Sediment and Nutrients	3	No significant pollution.
Low Concentrations of Pollutants (herbicides, pesticides)	4	No significant pollution until sufficient monitoring data prove otherwise.

Table 5-8. Initial water quality problem assessment: Terrebonne Basin, Segment 9. (From La. State Planning Office, 1977).

Problem	Statewide Priority Ranking	Assessment
Municipal and Industrial Discharge	1	Unsewerd homes, sugar mill: Black Bayou.
Specific and Localized Problems	2	No significant pollution.
Sediment and Nutrients	3	Agricultural production: sugar cane.
Low Concentrations of Pollutants (herbicides, pesticides)	4	No significant pollution until sufficient monitoring data prove otherwise.

Table 5-9. Louisiana water quality criteria (numerical): Atchafalaya Bay.
(From La. Stream Control Commission, 1977).

Segment Description	Atchafalaya Bay (tidal)
Water Uses	Secondary Contact Recreation Propagation of Fish and Shellfish
Chlorides	not applicable
Sulfates	not applicable
Dissolved Oxygen	5.0 mg/l
pH Range	6.5 to 9.0
Bacteria Standard	Monthly total coliform median most probable number $\leq$ 70/100 ml; not more than 10% of samples $>$ 230/100 ml (shellfish propagation standard)
Temperature	35°C - maximum value
Total Dissolved Solids	not applicable

Flood Hazards

A flood hazard analysis has been made of the Louisiana Gulf coast area by the U.S. Army Corps of Engineers for the Federal Insurance Administration (U.S. Army Corps of Engineers, 1970). That analysis includes projection area of flooding in two cases; as follows:

100-Year Flood: A flood which has an average frequency of occurrence of once in 100 years, but can occur during any year and even during successive years.

Standard Project Flood: The most severe flood which can be expected to occur within a geographic area under the most severe meteorological and hydrological conditions considered characteristic of that area (i.e., excluding extremely rare conditions).

In both these cases, the entire Atchafalaya Bay prospect area would be flooded, according to the Corps study.

Figure 5-8 shows the Surge Reference Line (SRL) as it traverses the marsh to the east of the prospect area. The SRL refers to the calculated synthetic coastline determined where the maximum storm surge height would occur during a 100-year flood situation with winds perpendicular to the coast. Along the line shown in Figure 5-8, storm surge would be expected to reach a maximum depth of approximately 3.8 meters (12.5 feet) during the most severe storm in a 100-year period (U.S. Army Corps of Engineers, 1970). Eight damaging hurricanes and 16 hurricanes or tropical storms with minor or unassessed damage struck the Louisiana coast in this area during the period 1886 to 1971 (U.S. Army Corps of Engineers, 1972).

ECOLOGICAL SYSTEMS

General Setting

The Atchafalaya Bay prospect area is divided by major growth faults into two parts (Fig. 5-1). Aquatic ecosystems include, in the larger section, the eastern portion of Atchafalaya Bay as well as Gulf waters south of Shell Reef and Eugene Island. Atchafalaya Bay is classified as a freshwater ecosystem according to the Bryan and Newman schema (Newchurch, et al., 1978). Although the Bay is adjacent to the Gulf, the large volume of freshwater input from the Atchafalaya River makes most of the Bay waters fresh for at least eight months of most water years. Thus, the overriding influence on the hydrology of the Bay is seasonal river discharge, with tidal influences predominating during low water periods. Lunar tides are normally 0.5 meters (1.6 feet).

Aquatic ecosystems in the smaller section of the prospect area include Four League Bay (brackish) and the estuarine ecosystems of the open water bodies within the marshes. A total of 65 per cent of the entire prospect area consists of large open water systems.

Table 5-10 gives the major characteristics of the ecosystem types in the prospect area. (Section VIII, Vol. 1 of the Report includes a detailed discussion).

Table 5-10. Major characteristics of ecosystem types in Atchafalaya Bay prospect area.

<u>Estuarine Ecosystem</u>	Coastal system, semi-enclosed by land, with open, partially obstructed, or sporadic access to the Gulf and with a measurable quantity of ocean-derived salt in the water. Salinities vary between 500 and 25,000 mg/l.
<u>Freshwater Ecosystem</u>	Freshwater ecosystems are divided into three subsystems: Palustrine, lacustrine, and riverine. These are all open freshwater areas where salinities are less than 500 mg/l.
<u>Saline Marsh Ecosystem</u>	An emergent vegetated wetland system subject to tidal fluctuations of salt water greater than 500 mg/l salinity. This definition includes Chabreck's saline, brackish and intermediate marshes (Chabreck, 1972).
<u>Fresh Marsh Ecosystem</u>	A herbaceous emergent vegetated wetland system which is subject to flooding with freshwater all or part of the year.
<u>Ridge Ecosystem</u>	Isolated systems of higher ground within fresh or saline marsh ecosystems. These areas include beaches, cheniers, natural and artificial levees, Pleistocene islands, salt domes, spoil banks and Indian mounds.

Vegetative zones within the prospect area and in the vicinity are shown in Figure 5-9. Chabreck's marsh classification (1972) is used to delimit vegetation zones with brackish and intermediate marsh types present in the prospect area. Tables 5-11 and 5-12 give the plant species characteristic of these marsh types, and soil and water salinities for Hydrologic Units V and VI, respectively. The Atchafalaya Bay prospect is within portions of both of these (Fig. 5-8). Marsh within the prospect is modified as a result of oil and gas activity (Fig. 5-2). Access canals and levees disrupt the hydrological patterns within the prospect area and contribute particularly to salt water encroachment because of the north-south orientation of many of the canals (Fig. 5-10).

Ridge ecosystems within the prospect area include spoil banks and beaches (Fig. 5-11).

There are several published studies of the flora and fauna of the prospect area. Extensive studies of vegetation were reported by Montz (1976). Perret, et al. (1971) and Juneau (1975) included the area in their general survey of fish, larger invertebrates and zooplankton. Cuzon du Rest (1963) also studied zooplankton, as did Bryan, et al. (1975, 1976). The studies of Bryan, et al., also included macrobenthic invertebrates (see Dugas, 1977), phytoplankton, and fish. Hoese (1975) also reported on the sport and commercial fisheries of Atchafalaya Bay.

Commercial Harvests

The open water systems of the prospect area are productive fisheries for a number of species (Fig. 5-12). In Atchafalaya Bay (Hoese, 1975), blue catfish, freshwater drum, channel catfish and sunfishes are the primary species harvested during periods of low salinity (late winter through spring). Speckled trout, sand trout, black drum and redfish are harvested during periods of high salinity (summer and fall). Oysters are also harvested in the Bay near Shell Reef. Four League Bay contains major inshore shrimp and crab areas. The marshes of the prospect area are important nursery grounds for Atlantic croaker and penaeid shrimps.

The Shell Reefs are dredged for clam shell which is used commercially in the manufacture of cement, glass, lime, and other products and as fill material.

Unique Ecological Features

The prospect area includes wading bird colonies and a seabird colony just south of the prospect boundaries with gulls, terns, black skimmers and willets

Table 5-11. Plant species characteristics and salinities of marsh types, Hydrologic Unit V--portions of Atchafalaya Bay prospect area. (From Chabreck, 1972).

SPECIES	Marsh	
	Brackish	Intermediate
	(% Composition)	
<u>Distichlis spicata</u> (saltgrass)	13.09	< 5
<u>Leptochloa fascicularis</u>	----	9.23
<u>Scirpus olneyi</u>	6.57	7.07
<u>Spartina patens</u> (wiregrass)	63.39	34.23
<u>Vigna repens</u>	< 5	7.07
VARIABLE	(Mean concentration, ppt)	
Water Salinity	7.61	4.68
Total Soil Salts	5.95	4.88

Table 5-12. Plant species characteristics of marsh types, Hydrologic Unit VI--portions of Atchafalaya Bay prospect area. (From Chabreck, 1972).

SPECIES	Marsh Type	
	Brackish*	Intermediate
	(% Composition)	
<u>Spartina cynosuroides</u>		9.81
<u>Spartina patens</u> (wiregrass)		68.63
<u>Vigna repens</u>		11.76

*No data

Fig. 5-10. Access canal oriented north-south: Atchafalaya Bay prospect area.

Fig. 5-11. Beach: Atchafalaya Bay prospect area.

among the bird population (Fig. 5-12).

The new delta being formed in Atchafalaya Bay is a unique area of land accretion on the Louisiana coast where the dominant geological process is land loss due to subsidence, erosion and other factors. Silt carried by the Atchafalaya River is being deposited as mud flats at the mouth of the River, to the north of the prospect area boundaries. It has been estimated that the new delta in northern Atchafalaya Bay will extend out beyond Point au Fer Island by the year 2020 (Coleman, personal communication, 1978).

LAND USE

General Land Use

Land use within the Atchafalaya Bay prospect area and in the vicinity is depicted in Figure 5-13, and summarized in Table 5-13. Current land use patterns were mapped using 1:108,000 scale false color infrared imagery flown by NASA in 1972. Land use was verified and corrected through aerial reconnaissance during the spring and summer of 1978. The land use classification scheme used is based on the system outlined in U.S. Geological Survey Professional Paper 964 (Anderson, et. al., 1976), with modifications to provide more suitable information for this project.

Approximately 65 per cent of the prospect area is open water; the remaining 35 per cent is classified as nonforested wetlands. (See the discussions above on hydrology and ecological setting for a description of these systems). The prospect area is uninhabited and without roads.

Industrial activity is extractive. There are a number of active oil and gas fields within the prospect area and in the vicinity (Fig. 5-2). An aerial survey of the marsh portions of the prospect area revealed a considerable network of access canals for the industry. Spoil banks on the canals form the highest elevations in the prospect area.

The prospect area is entirely within the coastal zone as defined by Act 361 of the 1978 Louisiana Legislative Session (La. Revised Statutes, 1978). As such, certain activities within the coastal zone, including extractive activities, will be subject to land use controls by the State of Louisiana under provisions of the Act and the Federal Coastal Zone Management Act of 1972.

KEY

— GEOPRESSURE PROSPECT BOUNDARIES

TR 21 O STATE SURVEY NO. AND SITE
SITE DESCRIPTION: WAVE WASHED SHELL
PRESENT CONDITION: DESTROYED

TR 27
SITE DESCRIPTION: SHELL MIDDEN
PRESENT CONDITION: DESTROYED

TR 64
SITE DESCRIPTION: SHELL MIDDEN
PRESENT CONDITION: GOOD

TR 102
SITE DESCRIPTION: BEACH DEPOSIT OF RANGIA
PRESENT CONDITION: HIGHLY DISTURBED

TR 103
SITE DESCRIPTION: SHELL MIDDEN
PRESENT CONDITION: GOOD

SHELL KB 0 SHELL DEPOSITS, IDENTIFIED FROM AERIAL
PHOTOS ONLY

SOURCE: LA. DIV. OF ARCHEOLOGY & HISTORIC PRESERVATION

SCALE 1:82,985

FIG.5-14 ARCHEOLOGICAL SITES:
ATCHAFALAYA BAY (PROSPECT 5)

Table 5-13. Summary of land use: Atchafalaya Bay prospect area.

Land Use Category	Aerial Extent km ² (mi ²)	% of Total Area
54 Bays and Estuaries	172.0 (66.4)	64.6
62 Nonforested Wetlands	94.3 (36.4)	35.4

Historical and Archeological Sites

There are no historical sites within the prospect area or in the vicinity. The archeological sites designated with the TR prefix (Fig. 5-14) are shell middens, most of which have been destroyed by wave action. The shell midden with the most archeological significance is site TR 103 on Deer Island to the north of the prospect boundaries. Further investigation of this site has been recommended. The designated Shell KB sites shown in Figure 5-14 were identified as shell accumulations by aerial photography only. They have not been surveyed (Deborah Woodiel, personal communication, 1978).

Wildlife Preserves and Management Areas

There are no wildlife refuges or game preserves within the prospect area or in the near vicinity. Approximately 58 km (36 miles) to the east of the prospect boundaries is the state-owned Pointe au Chien Wildlife Management Area (Fig. 5-15). It is 11,130 hectares (27,504 acres) in extent and is managed for the hunting of deer, squirrel, rabbit, turkey, woodcock and waterfowl. Commercial trapping is also allowed (La. Dept. of Wildlife and Fisheries, 1972).

PROSPECT AREA NO. 6: LAFOURCHE CROSSING

GEOLOGY AND GEOHYDROLOGY

Geologic Setting

Economic Geology

Ground-Water Resources and Quality

Aquifer Availability for Brine Disposal

Soils

AIR QUALITY

Measured Ambient Air Quality

Predicted Ambient Air Quality

WATER RESOURCES AND FLOOD HAZARDS

Hydrology

Water Usage and Quality

Flood Hazards

ECOLOGICAL SYSTEMS

General Setting

Commercial Harvests

Unique Ecological Features

LAND USE

General Land Use

Historical and Archeological Sites

Wildlife Preserves and Management Areas

PROSPECT NO. 6: LAFOURCHE CROSSING

GEOLOGY AND GEOHYDROLOGYGeologic Setting

The Lafourche Crossing prospect area is located near the juncture of Bayou Lafourche and Bayou Terrebonne and their associated natural levees and "backswamp" deposits (Fig. 6-1). The prospect area is limited by two east-west trending, down-to-the-coast faults which join to the east and west and encircle the prospect area, which has an areal extent of approximately 91 km² (35 mi²). Numerous faults having less displacement occur within the prospect area.

The generalized geologic sequence in the prospect area begins with approximately 30 meters (100 feet) of fine grained silts and clays of the topstratum (Fisk, 1952), underlain by massive sands and clays of Pleistocene age to a depth of approximately 610 meters (2000 feet). Finally, alternating sandstones and shales of Upper and Middle Miocene age occur to an approximate depth of 4267 meters (14,000 feet), which includes the geopressed sands of the prospect area.

Economic Geology

The prospect area takes its name from Lafourche Crossing gas field, near the center of the prospect area. This field produces from Upper Miocene sandstones as shallow as 2481 meters (8140 feet). Other gas fields in or near the prospect are Thibodaux, Rosseau, Lowlands, Southwest Lake Boeuf and Melodia (Fig. 6-2), all producing from Upper Miocene sands at depths of 2918 to 3945 meters (9,572 to 12,943 feet). Table 6-1 gives additional production data on four of these fields.

Ground-Water Resources and Quality

Figure 6-2 shows the depth of occurrence of three different qualities of ground water for the prospect area. The base of fresh ground water (less than 250 ppm chlorides) was mapped by Rollo (1960). Maps of the base of slightly saline water (1000 to 3000 mg/l dissolved solids) and moderately saline water (3000 to 10,000 mg/l dissolved solids) were prepared in a study of saline water resources in Louisiana by Winslow, et.al. (1968). The definition of freshwater used by Rollo is based on chloride content, while the saline water resources are categorized on the basis of dissolved solids content in which freshwater would be less than 1000 mg/l dissolved solids. When comparing this map with the ground-water resource maps for the other prospect areas, it should

Field	Producing Formation	Year of Discovery	Estimated Area Proved (Acres)	Number of Wells								Wells Producing At End of Year 1975		Producing Formation (s)						Deepest Zone Tested	Depth of Hole (Feet)	
	Name Age and Depth (feet)			Cumulative To End of Year 1975	During Year 1975				Flowing	Artificial Lift	Oil Gravity (API)	Av. Porosity (Percent)	Producing Thickness (Av. Net Feet)		Structure	Name						
					Completed	Abandoned	Oil	Gas					Oil	Gas			Oil	Gas				
		Oil	Gas	Oil	Gas	Oil	Gas	Oil	Gas	Oil	Gas	Oil	Gas									
Rousseau	Miocene U 9,572	--	1952	--	3400	--	22	--	0	--	1	--	6	--	--	P	--	130	D	Miocene U	16,100	
Melodia	Miocene U 12,943	--	1958	--	840	--	8	--	0	--	1	--	4	--	--	P	--	52	AF	Miocene U	16,300	
LaFourche Crossing	Miocene U 8,140	1939	1941	240	1120	10	5	0	0	0	0	0	2	0	52	31	15	45	D	Miocene U	17,200	
Thibodaux	Miocene U 10,552	--	1954	--	6440	--	22	--	0	--	1	--	4	--	--	P	--	156	DF	Miocene U	15,800	

Table 6-1. Oil and gas field data: Lafourche Crossing prospect area. (From La. Dept. of Natural Resources, 1975).

be noted that Whitman (1965) found the relationship between dissolved solids content and chloride content in fresh and brackish ground water in southwestern Louisiana to be variable. He found the following relationship between chlorides and dissolved solids for the Chicot and the Chicot-Atchafalaya aquifer:

Aquifer	Prospect Area Included	Chlorides (ppm)	Dissolved Solids (ppm)
Chicot--Western Portion	1 & 2	250	620
		450	1000
Chicot--Eastern Portion	3 & 4	250	700
		425	1000
Chicot-Atchafalaya	5	250	810
		360	1000

Hence, the maps of ground-water quality prepared for each prospect area are not precisely compatible. Furthermore, the maps are based on determinations of ground-water salinity made from resistivity measurements recorded on electrical logs, and this technique is not precise. However, because the transition between freshwater and slightly saline water is often abrupt, the maps are an adequate representation of the actual water quality distribution.

Sands and gravels equivalent to the Chicot-Atchafalaya aquifer of southwestern Louisiana extend into the Lafourche Crossing prospect area. This aquifer system is a sequence of massive sand and gravel beds extending to a depth of approximately 610 meters (2000 feet) below the surface with occasional layers of clay. Only the upper 610 meters or less of the aquifer contains freshwater. The remainder of the aquifer and deeper sands contain water in excess of 10,000 mg/l dissolved solids.

Although freshwater is shown in Figure 6-2 to extend to 610 meters or more beneath the surface, water analyses from local wells (Table 6-2) indicate that saline water (Cl in excess of 250 ppm) is present near the surface and, in fact, no wells sampled by the U.S. Geological Survey yielded freshwater (USGS files, Baton Rouge, La.).

Water wells in the Lafourche Crossing prospect area were generally drilled to depths ranging from 30 to 60 meters (100 to 200 feet) deep. Current records in the USGS files show all wells are either used for watering livestock or are abandoned or unused (USGS files, Baton Rouge, La.). Due to the poor quality of the ground water locally, water for consumptive use in Thibodaux and other local communities is taken from Bayou Lafourche and treated.

Table 6-2. Selected chemical analyses of ground water in the Lafourche Crossing prospect area. (From USGS files, Baton Rouge, La.).

Well No.	Cl ⁻	Fe(total)	Hardness as CaCO ₃	Depth of Well
(Concentrations in mg/l)				
Lr 12	1,260	28	955	47.1 ft.*
Lr 15	527	0.9	779	220 ft.
Lr 17	1,950	11	879	212.8 ft.
Lr 18	1,480	15	471	178 ft.
Lr 19	1,500	--	720	205.1 ft.
Lr 25	2,810	--	1,420	190 ft.
Lr 26	1,540	--	995	200 ft.

* Originally completed to 210 ft.

Table 6-3 illustrates the sequence of sands and clays of the topstratum above the water-bearing sands of the Atchafalaya aquifer at Lafourche Crossing. The upper 22 meters (72 feet) of sediment is the natural levee and alluvial deposits of Bayou Lafourche. The underlying 28 meters (93 feet) of clay is an efficient seal separating the shallow sands at the surface from the underlying water bearing sands and gravels. The limited freshwater resources in the Atchafalaya aquifer are therefore protected from contamination originating at the surface by the thick clay layer.

Table 6-3. Driller's log of USGS drillhole Lr-2: Lafourche Crossing prospect area. (From USGS files, Baton Rouge, La.).

Type of rock	Thickness	Depth
Sandy loam	30 ft.	30 ft.
Sand, fine	42 ft.	72 ft.
Gumbo and shale*	93 ft.	165 ft.
Sandy shale	20 ft.	185 ft.
Sand, coarse	85 ft.	270 ft.
Sand, gravelly	140 ft.	410 ft.
Shale	110 ft.	520 ft.
Gumbo, hard	20 ft.	540 ft.
Sand	6 ft.	546 ft.
Mud and sand, soft	132 ft.	678 ft.

* Gumbo and shale indicate clay of varying consistancy.

Aquifer Availability for Brine Disposal

Three well logs of oil and gas wells were examined to determine the average total thickness of sandstone beds 9 meters (30 feet) or thicker in the depth interval 305 to 1524 meters (1000 and 5000 feet). The data are summarized in Table 6-4, below.

Table 6-4. Thickness of saline aquifers: Potential brine disposal reservoirs, Lafourche Crossing prospect area. (From La. Geological Survey files, Baton Rouge, La.).

Depth Interval	Average Total Thickness of Sandstone Beds Greater than 30 feet Thick
1000-2000 ft.	750 ft.
2000-3000 ft.	375 ft.
3000-4000 ft.	375 ft.
4000-5000 ft.	420 ft.

Salt water disposal wells in the Lafourche Crossing prospect area dispose of gas field brines at depths ranging between 259 and 1116 meters (850 and 3660 feet). However, most disposal wells are located between 305 and 610 meters (1000 and 2000 feet). The maximum injection rate reported is under 2000 barrels per day. The wells are located in oil and gas fields as follows:

	Number of operating wells
Thibodaux Field	5
Melodia Field	6
Lafourche Crossing	1
S.W. Lake Boeuf	8

The total amount of brine injected in all wells in the fields listed above for 1975 was 1.8×10^6 bbl (La. Dept. of Natural Resources, 1975). A geopressure well producing 40,000 bbl/day for 365 days produces 1.46×10^7 bbls--an amount 387,700 bbls less than the total volume disposed of in Rousseau and Thibodaux fields combined, at an average depth of 396 meters (1300 feet), with maximum injection pressure of 850 lb/sq. in. (La. Dept. of Natural Resources, 1975).

Soils

The soils of the prospect area include Commerce and Mhoon on the better drained levee tops. Sharkey and Fausee soils are found on the slope of the levees with coastal marsh soils in the backswamp portions of the prospect area. These soils have surface

infiltration rates (the upper 30 cm or 12 in) ranging from a high of 1.5 cm to 5 cm (0.6 to 2 in) per hour along the natural levee crests to less than 0.15 cm (0.6 in) per hour in the backswamp areas. Infiltration rates are not limited by the low permeabilities of these soils when they are dry and surface cracks exist. However, soon after saturation the cracks will heal and the permeability will control vertical water migration.

Although even the marsh soils have a small measurable infiltration rate when wet (0.015 cm (0.006 in) per hour), infiltration of fluids introduced at the surface is negligible when the soils are saturated and hydraulic conditions do not favor recharge. Some swamp and marsh areas may be discharge areas for ground water during periods of high water in local streams (Miller, personal communication, 1978).

Figure 6-3 shows the general soil types in the prospect area and region.

AIR QUALITY

Measured Ambient Air Quality

The Louisiana Air Control Commission (LACC) sampling station nearest to the Lafourche Crossing prospect area is located at Garyville, approximately 40 km (25 miles) north-northeast of the prospect area. 1976 annual average pollutant concentrations measured at Garyville are shown in Table 6-5.

Table 6-5. 1976 ambient air quality data: Garyville station. (From LACC, 1976).

	Sulfur Dioxide ($\mu\text{g}/\text{m}^3$)	Ozone ($\mu\text{g}/\text{m}^3$)	Nitrogen Dioxide ($\mu\text{g}/\text{m}^3$)	Particulates ($\mu\text{g}/\text{m}^3$)
Annual Average*	1.9	---	18.5	43.0
24 hr. Maximum*	16	---	73	100
3 hr. Maximum**	94.3	---	---	---
1 hr. Maximum**	105	---	---	---

* Noncontinuous monitor: 24 hour sample taken once per week.

** Continuous monitor: operated only approximately 10% of the time during 1976.

In addition to the Garyville-LACC station, limited air quality data resulting from a special study by Radian Corporation (1977) are available. This study covered a three month sampling period in 1976. Three sampling stations were located in the general vicinity of the Lafourche Crossing prospect area. Their distance and direction from the center of the prospect area are as follows:

Norco	45 km - NE (28 mi)
Galliano	58 km - SE (36 mi)
Morgan City	40 km - W (25 mi)

Average measured concentrations for six pollutants from these monitoring stations, along with their dates of collection, are presented in Table 6-6.

Measured concentrations of all pollutants except ozone are well below ambient air quality standards (listed in Table 6-7). The entire south Louisiana region has been designated a non-attainment area with respect to ozone.

Table 6-6. Average concentrations of selected pollutants: Galliano, Morgan City, and Norco stations. (From Radian Corp., 1977).

Site	Pollutant	Period of Data Collection	Average Concentration ($\mu\text{g}/\text{m}^3$)
Galliano	Nitrogen Oxides	July 17-Sept. 30, 1976	7.1
	Nitric Oxide	July 17-Sept. 30, 1976	2.3
	Nitrogen Dioxide	July 17-Sept. 30, 1976	4.8
	Sulfur Dioxide	July 17-Sept. 30, 1976	1.2
	Ozone	Sept. 1-Oct. 17, 1976	81.2
	Particulate	Aug. 1-31, Oct. 1-17, 1976	41.9
Morgan City	Nitrogen Oxides	July 17-Aug. 31, 1976	9.3
	Nitric Oxide	July 17-Aug. 31, 1976	4.8
	Nitrogen Dioxide	July 17-Aug. 31, 1976	4.6
	Sulfur Dioxide	July 17-Sept. 30, 1976	2.4
	Ozone	July 17-Oct. 17, 1976	80.6
	Particulate	Aug. 1-31, Oct. 1-17, 1976	77.8
Norco	Nitrogen Oxides	July 17-Oct. 17, 1976	28.6
	Nitric Oxide	July 17-Oct. 17, 1976	10.4
	Nitrogen Dioxide	July 17-Oct. 17, 1976	18.8
	Sulfur Dioxide	Aug. 1-Oct. 17, 1976	6.6
	Ozone	Aug. 1-Sept. 30, 1976	57.6
	Particulate	July 17-Oct. 17, 1976	68.0

Table 6-7. Ambient air quality standards: State of Louisiana. (From LACC, 1976).

Pollutant	Standards	
	Primary	Secondary
Sulfur Dioxide		
Annual Arithmetic Mean	80 $\mu\text{g}/\text{m}^3$ **	60 $\mu\text{g}/\text{m}^3$
24-Hour Maximum	365 $\mu\text{g}/\text{m}^3$	260 $\mu\text{g}/\text{m}^3$
3-Hour Maximum	-----	1300 $\mu\text{g}/\text{m}^3$
Carbon Monoxide		
8-Hour Maximum	10 mg/m^3 ***	10 mg/m^3
1-Hour Maximum	40 mg/m^3	40 mg/m^3
Ozone (Oxidant)		
Annual Arithmetic Mean	58.8 $\mu\text{g}/\text{m}^3$	58.8 $\mu\text{g}/\text{m}^3$
1-Hour Maximum	160 $\mu\text{g}/\text{m}^3$	160 $\mu\text{g}/\text{m}^3$
Nitrogen Dioxide		
Annual Arithmetic* Mean	100 $\mu\text{g}/\text{m}^3$	100 $\mu\text{g}/\text{m}^3$
Total Suspended Particulate*		
Annual Geometric Mean	75 $\mu\text{g}/\text{m}^3$	60 $\mu\text{g}/\text{m}^3$
24-Hour Maximum	260 $\mu\text{g}/\text{m}^3$	150 $\mu\text{g}/\text{m}^3$

*Non-continuous monitor.

** $\mu\text{g}/\text{m}^3$ = micrograms per cubic meter.

*** mg/m^3 = milligrams per cubic meter.

Predicted Ambient Air Quality

Due to the absence of sampling stations within the prospect area, a study was initiated to predict the annual average air quality using the Climatological Dispersion Model--CDM (U.S. Environmental Protection Agency, 1973). Sulfur oxides were chosen as the pollutants for the modelling effort because emissions from a geopressure test well are more likely to contribute to SO_x levels than the other pollutants for which standards exist.

SO_x emission sources within 35 km (22 mi) of the center of the prospect area that meet the criterion for significant emitters (≥ 1 ton per yr) appear in Table 6-8. These data were obtained from the National Emission Data System Point Source Listings (U.S. Environmental Protection Agency, 1974).

Table 6-8. Point sources of SO_x within 35 km of the center of the Lafourche Crossing prospect area. (From U.S. Environmental Protection Agency, 1974).

Source	Distance and Direction from Center of Prospect Area	SO_x (tons/yr)
Southdown Sugars (Houma)	17 km - SSE (10.5 mi)	6
South Coast Corp.	18 km - ESE (11 mi)	29
Freeport Chemical	33 km - NNW (20.5 mi)	22,400
Nalco	35 km - NNE (22 mi)	63

Figure 6-4 shows the predicted ambient air quality in the prospect area and vicinity resulting from these sources. The map maximum SO_x concentration is $6 \mu\text{g}/\text{m}^3$. Near the center of the prospect area the SO_x concentration is $2 \mu\text{g}/\text{m}^3$.

Industrial sources within 35 km to 50 km (22 to 31 mi) of the center of the prospect area have a total emission of 44,333 tons/yr. The inclusion of the emissions from these sources raises the map maximum SO_x concentration to $9 \mu\text{g}/\text{m}^3$ and the prospect area concentration to $4 \mu\text{g}/\text{m}^3$.

WATER RESOURCES AND FLOOD HAZARDS

Hydrology

The Lafourche Crossing prospect area is located astride Bayous Lafourche and Terrebonne (Fig. 6-5). Bayou Lafourche is an abandoned distributary of the Mississippi River. The water in Bayou Lafourche originates mostly as a controlled diversion of Mississippi River water upstream from north of the prospect at Donaldsonville. Rain-fall directly into the Bayou supplements the diversion flow. The Bayou acts more or less as a conduit across the prospect area and the delta. Bayou Terrebonne is a secondary distributary of the Mississippi. There is no diversion of Mississippi River water through Bayou Lafourche into Bayou Terrebonne. Bayou Terrebonne drains some of the inter-distributary basin between Bayou Lafourche and the Atchafalaya systems. Other open water bodies within the prospect area include small bayous and dredged canals.

Within the prospect area the highest elevations are along the natural levees of Bayou Lafourche. Elevations range from a maximum of 5.5 meters (18 feet) down to a minimum of about 0.3 meters (1 foot) above sea level in some of the backswamps.

KEY

--- GEOPRESSURE PROSPECT BOUNDARIES

X CENTER OF PROSPECT AREA

6 / PREDICTED ANNUAL AVERAGE
 SO_x CONCENTRATIONS ($\mu\text{g}/\text{m}^3$)

FIG. 6-4 PREDICTED ANNUAL AVERAGE SO_x
 CONCENTRATIONS: LAFOURCHE CROSSING (PROSPECT 6)

KEY

- GEOPRESSURE PROSPECT BOUNDARIES
- 100-YEAR FLOOD LIMIT
- STANDARD PROJECT FLOOD LIMIT
- WATER QUALITY BASIN BOUNDARIES
- 12-3 WATER QUALITY BASIN-SEGMENT NOS.
- 3202 WATER QUALITY STATION

SCALE 1:62,500

FIG. 6-5 HYDROLOGIC FEATURES, FLOOD HAZARDS:
LAFOURCHE CROSSING (PROSPECT 6)

Surface drainage on the natural levees is excellent, with drainage ditches and canals across the sugar cane fields toward the backswamps. East of Bayou Lafourche the drainage is into the Halpin Canal, the Rathborne Swamp, Lake Boeuf, and ultimately into the Barataria estuary. West of Bayou Lafourche, the drainage is into a number of canals, secondary distributaries such as Bayou Terrebonne, and an extensive backswamp west of Little Bayou Black. All of the drainage is ultimately southward to the Gulf Intracoastal Waterway and the coastal marshes of Terrebonne Parish.

Water Usage and Quality

Bayou Lafourche is the source of potable water for the city of Thibodaux which is upstream from the prospect area, and for the Lafourche and Terrebonne water districts-- within and downstream from the prospect area. There is a large water treatment facility within the prospect (Fig. 6-6). It has a capacity of treating 8 million gallons of water per day and a reservoir with a 90 million gallon capacity. The facility is part of the Terrebonne Water District serving all of Terrebonne Parish except the city of Houma (Sampey, personal communication, 1978).

Selected water quality analyses from Bayou Lafourche stations are given in Table 6-9.

A preliminary assessment of water quality conditions has been made in the water quality management basin and basin segments of which the prospect area is a part. This work was done as part of the Louisiana 208 Water Quality Program which is funded under Section 208 of the Federal Water Pollution Control Act Amendments of 1972. Under the 208 Program, a plan is being developed to achieve state water quality standards.

The Lafourche Crossing prospect area is primarily in Segments 3 and 7 of the Terrebonne Water Quality Management Basin (Fig. 6-5). The initial problem assessments for these segments are given in Tables 6-10 and 6-11. These assessments were made by the staffs of the Bureau of Environmental Services, Louisiana Department of Health and Human Resources; the Louisiana Soil and Water Conservation Commission; and the Louisiana Department of Agriculture (La. State Planning Office, 1977). Water quality criteria for the portions of Bayous Lafourche and Terrebonne within the prospect area are given in Tables 6-12 and 6-13.

Fig. 6-6. Water treatment plant: Lafourche Crossing prospect area.

Table 6-9. Water quality analyses: Lafourche Crossing prospect area. (From U.S. Environmental Protection Agency files, Washington, D.C.; USGS files, Baton Rouge, La.).

	Site #0738100 1969-1976 (low-high values for period indicated)	Site #3202 1972-1978
Conductivity (michromhos)	396*	140.0-1270.0
Temp. (C°)	---	7.5-32.0
pH	7.8*	6.8- 8.5
Concentrations (mg/l)		
SO ₄	46.0*	3.0-70.0
HCO ₃	126.0*	----
Mn (µg/l)	77.9-233.0	----
Ca	40.0*	----
Mg	9.7*	----
K	3.30*	----
Na	74.0*	7.0-235
TDS	225.0*	----
Cl	28.0*	----

*One sample only.

Table 6-10. Initial water quality problem assessment: Terrebonne Basin, Segment 3. (From La. State Planning Office, 1977).

Problem Area	Statewide Priority Ranking	Assessment
Municipal and Industrial Discharge	1	All towns unsewered except Thibodaux; low DO, high organic load.
Specific and Localized Problems	2	No significant pollution.
Sediment and Nutrients	3	Agricultural sediment producing area: Sugar cane.
Low Concentrations of Pollutants (herbicides, pesticides)	4	Herbicides used on cropland attached to sediment. No significant pollution until sufficient monitoring data prove otherwise.

Table 6-11. Initial water quality problem assessment: Terrebonne Basin, Segment 7. (From La. State Planning Office, 1977).

Problem Area	Statewide Priority Ranking	Assessment
Municipal and Industrial Discharge	1	Low dissolved oxygen.
Specific and Localized Problems	2	No significant pollution.
Sediment and Nutrients	3	Agricultural sediment producing area: sugar cane.
Low Concentrations of Pollutants (herbicides, pesticides)	4	Herbicides used on cropland attached to sediment. No significant pollution until sufficient monitoring data prove otherwise. Pesticide runoff from cane fields has allegedly caused fish kills.

Table 6-12. Louisiana water quality criteria (numerical): Portions of Bayou Terrebonne. (From La. Stream Control Commission, 1977).

Segment Description:	Bayou Terrebonne from Thibodaux to Bourg
Water Uses	Primary Contact Secondary Contact Recreation Public Water Supply
Chlorides	230 ppm
Sulfates	55 ppm
Dissolved Oxygen	5.0 ppm
pH Range	6.0 - 8.5
Bacteria Standard	Not < 5 samples in 30 days, fecal coliform $\leq$ log mean of 200/100 ml; 10% of total samples in 30 days $\leq$ 400/100 ml. (primary contact recreation standa
Temperature	32° C
Total Dissolved Solids	875 ppm

Table 6-13. Louisiana water quality criteria (numerical): Portions of Bayou Lafourche. (From La. Stream Control Commission, 1977).

Segment Description:	Bayou Lafourche from Donaldsonville to Larose
Water Uses:	Primary Contact Secondary Contact Recreation Public Water Supply Shellfish Propagation
Chlorides	70 ppm
Sulfates	55 ppm
Dissolved Oxygen	5.0 ppm
pH Range	6.0 - 8.5
Bacteria Standard	Not < 5 samples in 30 days, fecal coliform < log mean of 200/100 mg; 10% of total samples in 30 days $\leq$ 400/100 ml (primary contact recreation standa
Temperature	32° C
Total Dissolved Solids	Not applicable

Flood Hazards

A flood hazard analysis has been made of the Louisiana Gulf coast area by the U.S. Army Corps of Engineers for the Federal Insurance Administration (U.S. Army Corps of Engineers, 1970). That analysis includes the projected area of flooding in two cases, as follows:

100-Year Flood: A flood which has an average frequency of occurrence of once in 100 years, but can occur during any year and even during successive years.

Standard Project Flood: The most severe flood which can be expected to occur within a geographic area under the most severe meteorological and hydrological conditions considered characteristic of that area (i.e. excluding extremely rare conditions).

Figure 6-5 shows the portions of the prospect area that would be flooded in these two cases. Note that the broad levees of Bayous Lafourche and Terrebonne are not subject to flooding in these two worst cases.

ECOLOGICAL SYSTEMS

General Setting

The Lafourche Crossing prospect area is located primarily on the natural levees of Bayous Lafourche and Terrebonne with areas of backswamp between and to the west and east of the two levee systems. The levees are classed by Bryan and Newman (Newchurch, et.al., 1978) as ridge type ecosystems. They are highly modified for residential, commercial, and agricultural uses and have been largely cleared of their native vegetation--live oak and other hardwoods. Figure 6-7, a false color, infrared photo of the prospect area (scale: 1:108,000) shows the highly modified character of the two levee systems with the forested backswamps between the levees and to the east and west.

The backswamps include fresh marsh, bottomland forest and ridge (spoil banks) ecosystem types according to Bryan and Newman's schema. All of these ecosystem types are wetland types. Bryan and Newman, as well as others (e.g., McIntire, 1975) consider the prospect area to be part of the coastal wetlands system. However, the prospect area is not included in the coastal zone as delimited in Act 361 passed by the State in the 1978 Legislative Session (La. Revised Statutes, 1978). Thus, it will not be subject to land use controls as provided for under that legislation.

Fig. 6-7. High altitude photograph of Lafourche Crossing prospect area: Developed levees and backswamp.

Freshwater ecosystems in the prospect area include Bayous Lafourche and Terrebonne--the major open water bodies in the prospect area. There are also a number of smaller bayous and dredged canals. There has been considerable oil and gas development both on the natural levees and in the backswamp area. Several fields are active (Fig. 6-2).

Table 6-14 gives the major characteristics of the ecosystems of the prospect area. (Section VIII, Vol. 1 of the Report includes a detailed description).

Vegetative zones within the prospect area and in the vicinity, as defined by Chabreck (1972), are shown in Fig. 6-8.

There have been no published synecological studies on biological communities within the prospect area. However, Barataria Basin to the east of the prospect has been extensively studied, particularly the productivity and composition of the bottom-land swamp community (Conner, 1975; Conner and Day, 1976; Conner, et.al., 1975; Day, et.al., 1975). The results of these authors would probably be applicable to the backswamps of the Lafourche Crossing prospect area.

FIG. 6-8 VEGETATIVE ZONES: LACOMBE CROSSING (PROSPECT 6)

Table 6-14. Major characteristics of ecosystems in Lafourche Crossing prospect area.

<u>Bottomland Forest.</u>	Areas with woody vegetative cover flooded by freshwater all or part of the year. Two subsystems are recognized: cypress swamp forests and bottomland hardwood forests.
<u>Fresh Marsh Ecosystem.</u>	A herbaceous emergent vegetated wetland system which is subject to flooding with freshwater all or part of the year.
<u>Freshwater Ecosystem.</u>	Freshwater ecosystems are divided into three subsystems: Palustrine, lacustrine, and riverine. These are all open freshwater areas where salinities are less than 500 mg/l.
<u>Ridge Ecosystem.</u>	Isolated systems of higher ground within fresh or saline marsh ecosystems. These areas include beaches, cheniers, natural and artificial levees, Pleistocene islands, salt domes, spoil banks and Indian Mounds.

Commercial Harvests

Finfish are not harvested within the prospect. Crawfish harvests are taken from impoundments in the backswamp areas. Deer, raccoon and squirrel are also taken in the backswamp. Sugar cane is the principal agricultural harvest and the natural levees of the prospect area are intensively cultivated for that crop.

Unique Ecological Features

Unique ecological features in the vicinity of the prospect area include stands of swamp loosestrife, Decodon verticellatus, a rare shrub found to the south of the prospect area (Burk and Assoc., 1977b). Alligator concentrations and a wading bird rookery are found to the north of the prospect area (Fig. 6-9).

LAND USE

General Land Use

Land use within the Lafourche Crossing prospect area and in the vicinity is depicted in Figure 6-10, and summarized in Table 6-15. Current land use patterns were mapped using 1:108,000 scale false color infrared imagery flown by NASA in 1972. Land use was verified and corrected through aerial and field reconnaissance during the spring and summer of 1978. The land use classification scheme used is based on the system outlined in U.S. Geological Survey Professional Paper 964 (Anderson, et.al., 1976), with modifications to provide more suitable information for this project.

The natural levees of Bayous Lafourche and Terrebonne make up the major portion of the prospect area. These are intensively cultivated for sugar cane with continuous strip residential and commercial development on both sides of the Bayous (Fig. 6-11 and 6-12). Incorporated places entirely within the prospect boundaries are Lafourche, population 500; and Schriever, population 100 (La. Dept. of Public Works, 1976; U.S. Dept. of Interior, 1970). The southernmost portion of the city of Thibodaux, population 16,182, is located within the prospect boundaries. The city ranks 16th of incorporated places in Louisiana with the largest population gain in the 1970-1975 period (U.S. Dept. of Commerce, 1977a). It is an important center for the sugar cane industry in Lafourche Parish and is the home of Nicholls State University, enrollment 6,317.

Houma, population 30,588, is located approximately 19 km (12 mi) to the south of the prospect boundaries (U.S. Dept. of Commerce, 1977b). Its location on the Gulf Intracoastal Canal with a direct connection to the Gulf via the Houma Navigation Canal making it a major center for oil and gas activities to the south.

Agriculture is the dominant land use within the prospect area. The natural levees on both sides of Bayous Lafourche and Terrebonne are intensely cultivated for sugar cane. Areas of forested wetlands (backswamp) are present between the Bayous and on the western and eastern margins of the prospect area (Fig. 6-13). There is some commercial crawfish cultivation in these wetland areas.

Industrial activity within the prospect area is entirely extractive. There are two major gas fields and several smaller fields within the prospect boundaries (Fig. 6-2).

Highway 1, a major State highway linking the Baton Rouge area to the north with Lafourche Parish and the resort area at Grande Isle, traverses the prospect area. Highway 24 links Thibodaux and the area to the north with Houma, south of the prospect area. A section of the Southern Pacific railroad traverses the prospect area from west to east.

Bayous Lafourche and Terrebonne are the major streams within the prospect area. The smaller Bayous Cut Off, Grand, and Blue traverse the prospect area between the two major bayous.

Historical and Archeological Sites

The Bayou Lafourche area is rich in historical interest. Bayou Lafourche was once a distributary of the Mississippi River and an important transportation route for the French settlers who created large sugar plantations on its natural levees. There are no registered historical sites within the prospect area, although there are several

Fig. 6-11. Developed levee of Bayou Lafourche: Lafourche Crossing prospect area.

Fig. 6-12. Developed levee of Bayou Terrebonne: Lafourche Crossing prospect area.

Fig. 6-13. Forested backswamp area between Bayou Lafourche and Bayou Terrebonne: Lafourche Crossing prospect area.

Table 6-15. Summary of land use: Lafourche Crossing prospect area.

Land Use Category	Area ¹ Extent km ² (mi ²)	% of Total Area
11 Residential	8.8 (3.4)	9.7
12 Commercial and Service	1.0 (0.4)	1.1
14 Transportation	4.4 (1.7)	4.7
21 Cropland and Pasture	48.7 (18.8)	53.0
53 Reservoirs and Impoundments	0.3 (0.1)	0.3
61 Forested Wetlands	28.5 (11.0)	31.2

notable plantations north of the prospect area and several sites either on the National Register of Historic Places or with nominations pending for the Register (Fricker, personal communication, 1978) in the vicinity. The location of these with respect to the prospect area is depicted in Figure 6-14. Table 6-16 gives their period and status.

Table 6-16. Places of historical interest: Vicinity of Lafourche Crossing prospect area. (From Fricker; Leslie, personal communication, 1978).

Name	Period	Status
Dansereau Home	1870	Nomination pending slated for submission to State Preservation Office
Rienzi Plantation	1797	
St. John's Episcopal Church	1844	National Register of Historic Places
Laurel Valley Sugar Plantation	1831	National Register of Historic Places

The sites designated LF 92 and TR 93 in Figure 6-14 were identified and surveyed by the Archeological Office of the State Division of Archeology and Historic Preservation. LF 92, Bowie House, was once the residence of Jim Bowie. It is in excellent condition. TR 93, just to the south of the prospect boundaries, is an historic plantation with a house in good condition (Deborah Woodiel, personal communication, 1978).

Wildlife Preserves and Management Areas

There are no state or wildlife refuges or game preserves within the prospect area or in the near vicinity. The Louisiana Department of Wildlife and Fisheries administers three Wildlife Management Areas in or adjoining Lafourche Parish (Fig. 6-15). These are Pointe au Chien, 11,131 hectares (27,504 acres); Salvador, 11,521 hectares (28,469 acres), and Wisner, 12,141 hectares (30,000 acres) (La. Department of Wildlife and Fisheries, 1972). All three are noted for their waterfowl populations and are managed for hunting and trapping by the public.

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