Strategic Petroleum Reserve

PB 261 984

Final Environmental Impact Statement for

Bayou Choctaw

Salt Dome

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15. Supplementary Notes
This final EIS follows the draft EIS, PB 257 506.

16. Abstracts
The Federal Energy Administration proposes to implement the Strategic Petroleum Reserve (SPR), Title I, Part B of the Energy Policy and Conservation Act of 1975 (P.L. 94-163) through the development of a 99 million barrel crude oil storage facility at the Bayou Choctaw salt dome. The purpose of the SPR is to mitigate the economic impacts of any future interruptions of the petroleum imports. The Bayou Choctaw site, a salt dome with existing cavities located in Iberville Parish, Louisiana, has been identified as a candidate site for the ESR because it offers the advantage of large storage capacity, easy access to the distribution network, and a relatively short preparation period. This site-specific EIS analyzes the environmental impacts caused by site preparation and operation.

17. Key Words and Document Analysis. 17a. Descriptors

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Strategic Petroleum Reserve
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17c. COSATI Field/Group

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SUMMARY

STATEMENT TYPE: ( ) Draft (x) Final Environmental Statement

PREPARED BY: The Strategic Petroleum Reserve Office, Federal Energy Administration, Washington, D.C. 20461

1. Type of Action: ( ) Legislative (X) Administrative

2. Brief Description of the Proposed Action:

The Federal Energy Administration proposes to implement the Strategic Petroleum Reserve (SPR), Title I, Part B of the Energy Policy and Conservation Act of 1975 (P.L. 94-163) through the development of a 99 million barrel crude oil storage facility at the Bayou Choctaw salt dome. The purpose of the SPR is to mitigate the economic impacts of any future interruptions of the petroleum imports. Under the initial phase of the SPR, referred to as the Early Storage Reserve (ESR), one hundred fifty million barrels of oil will be stored by 1978. Of the different types of storage facilities, existing solution-mined salt dome cavities are among the most attractive for petroleum storage because of the relative low cost of bulk storage and the extreme geological stability of rock salt masses. The Bayou Choctaw site, a salt dome with existing cavities located in Iberville Parish, Louisiana, has been identified as a candidate site for the ESR because it offers the advantage of large storage capacity, easy access to the distribution network, and a relatively short preparation period.

3. Summary of Environmental Impacts and Adverse Environmental Effects:

This site-specific EIS analyzes the environmental impacts caused by site preparation and operation. Construction and preparation of the storage cavities, dock facilities and pipelines would degrade water quality by increasing the amound of suspended particulates, toxic sulfides, heavy metals, arsenic, pesticides and other toxic hydrocarbons. Marine operations (loading, unloading and transporting crude oil) create the risk of oil spills which have the potential to disrupt fish and shellfish production, destroy non-mobile aquatic organisms and birds, and damage marsh vegetation. Loading and unloading operations would also cause evaporative hydrocarbon emissions which would temporarily exceed the Federal standards.

Brine disposal into subsurface aquifers and surface water bodies would increase the salinity of the water. The use of ground water for displacement of crude oil during drawdown operations could cause some surface subsidence over water storage areas, slow salt water encroachment and movement of near-surface geologic faults. Beneficial impacts include the economic gains associated with additional employment and income in the Gulf region, as well as protection from economic losses that result from petroleum supply interruptions.

4. Alternatives Considered:

Alternative Storage Sites

Bryan Mound Salt Dome
Cote Blanche Island Mine
Weeks Island Mine
West Hackberry Salt Dome

Alternative Facility Components

Alternative Distribution Facilities

Alternative Distribution Terminal
Alternative Pipeline Distribution

Alternative Brine Disposal Facilities

Alternative Displacement Water Supplies

No Action

Comments on the Draft Statement have been received from the following:

Department of the Army, Corps of Engineers
Department of Transportation
Department of the Treasury
Advisory Council on Historic Preservation
Environmental Protection Agency
Federal Power Commission
Nuclear Regulatory Commission
Tennessee Valley Authority
Louisiana and Texas State Clearinghouse
Louisiana Air Control Commission
Louisiana Geological Survey
Louisiana State Soil and Water Conservation Committee
Capital Area Groundwater Conservation Commission
LOOP, Inc.

6. **Date made available to CEQ and the Public:**

Draft statement was made available to the Council on Environmental Quality and the public in September, 1976. This final statement was made available to the Council on Environmental Quality and the public on December 17, 1976.

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1. DESCRIPTION OF PROJECT

1.1 BACKGROUND

This document is a final site specific Environmental Impact Statement (EIS) for the proposed storage of crude oil at the The draft EIS was published on September 10, 1976. This project is part of the Strategic Petroleum Reserve (SPR) program currently being planned by the Federal Energy Administration (FEA). Creation of the SPR was mandated by Congress in Title I, Part B of the Energy Policy and Conservation Act of 1975, P.L. 94-163 (the Act) for the purpose of providing the United States with sufficient petroleum reserves to minimize the effects of any future oil supply interruption. The Act requires that within seven years the SPR contain a reserve equal to the volume of crude oil imports during the three consecutive highest import months in the 24 months preceding December 22, 1975 (approximately 500 million barrels). The Act further requires the creation within three years of an Early Storage Reserve (ESR) of 150 million barrels as the initial phase of the SPR to provide early protection from near-term disruptions in the supply of petroleum products.

A draft programmatic EIS (DES 76-2) addressing the effects of the SPR program as a whole was filed with the Council on Environmental Quality and made available to the public on June 25, 1976. The Final programmatic EIS was filed on December 17, 1976. That statement considers several different types of storage facilities, including the use of existing solution-mined cavities in salt formations and conventional mines, the construction of new solution-mined cavities and conventional mines, the use of existing and the construction of new conventional surface tankage, and the use of surplus tanker ships. The draft programmatic EIS should be consulted for a description of each of these storage methods and the potential impacts which might result from its use. The programmatic EIS also assesses the cumulative impacts which could be expected from use of various combinations of the different facility types.

Because of the severe time constraints placed upon the ESR completion schedule by the Act, FEA will use sites which have existing capacity that may be converted to oil storage for this initial phase of the SPR (see Early Storage Reserve Plan, FEA, April 1976). Potential ESR sites include existing solution-mined cavities in salt domes, and existing conventional mines which can be converted into storage facilities in a realtively short time. A total of eight candidate ESR sites have been selected by means of a screening process involving the application of a series of six criteria.* Of these eight candidate sites, only five are alternatives to one another for the purpose of selecting ESR storage sites to supply oil to refineries on the Gulf Coast, on the East Coast, and in the Caribbean. The other three candidate sites can only supply the inland refineries.

In addition to the Bayou Choctaw salt dome, the four other alternative candidate sites able to supply the Gulf Coast, East Coast and Caribbean market areas, include the West Hackberry salt dome (Cameron Parish, Louisiana), the Bryan Mound salt dome (Brazoria County, Texas), the Cote Blanche salt mine (St. Mary Parish, Louisiana), and the Weeks Island salt mine (Iberia Parish, Louisiana). Section 7.1 includes a more detailed discussion of the rationale supporting the selection of the five alternative sites and a brief summary of the impacts associated with each of the other four sites besides the Bayou Choctaw salt dome. Draft Environmental Impact Statements on all five alternative candidate sites (DES 76-4 through DES 76-8, September 1976) were filed with the Council on Environmental Quality and made available to the public on the same day so that the environmental impacts associated with the possible use of these sites compared with one another. EISs are also in preparation for the other three sites and will be made available prior to any subsequent site selection, as described in Section 7.1.

*These criteria are capacity, distribution accessibility, technical feasibility, potential environmental concerns, ease of acquisition and cost. Section II.E.1 of the programmatic EIS describes in detail how the criteria were applied to approximately 300 salt domes and approximately 300 existing mines to select 32 candidate SPR sites, including the eight candidate ESR sites.

1.2 PROPOSED FACILITIES

1.2.1 Concept for Storage in Salt Domes

The use of salt domes for petroleum storage is attractive because of both the relative low cost of such bulk storage and the extreme geological stability of rock salt masses. In addition, being deep underground provides security from most natural catastrophes or sabotage. In the Gulf Coast region, over 50 salt domes, both onshore and offshore, appear feasible for development (see Figure 1.1).

Salt domes are a major source of brine feedstock for chemical and salt industries in the gulf region. Cavities are formed by dissolving the salt with circulating water and pumping out the resulting brine (see Figure 1.2). The process requires a large volume of leach water (about 7 barrels fresh water or about 8 barrels seawater for every barrel of space created). Some of these cavities are currently used to store a number of petroleum products. In the U. S., the products stored are primarily LPG products such as propane, ethylene, etc., as well as some fuel oil. Although crude oil storage in solution cavities does not present difficult technical problems, it has been done principally in other countries. The one exception in the United States is the Venice Dome in Louisiana.

Both existing salt dome cavities and new cavities to be developed are being considered for the SPR. Salt domes with existing cavities have been identified as candidates for the ESR because they require less time to prepare for oil storage. Approximately 900 cavities with a total capacity of 300 million barrels are known to exist in salt domes and bedded salt formations. In some cases it is feasible to enlarge existing cavities or to leach additional cavities at selected sites.

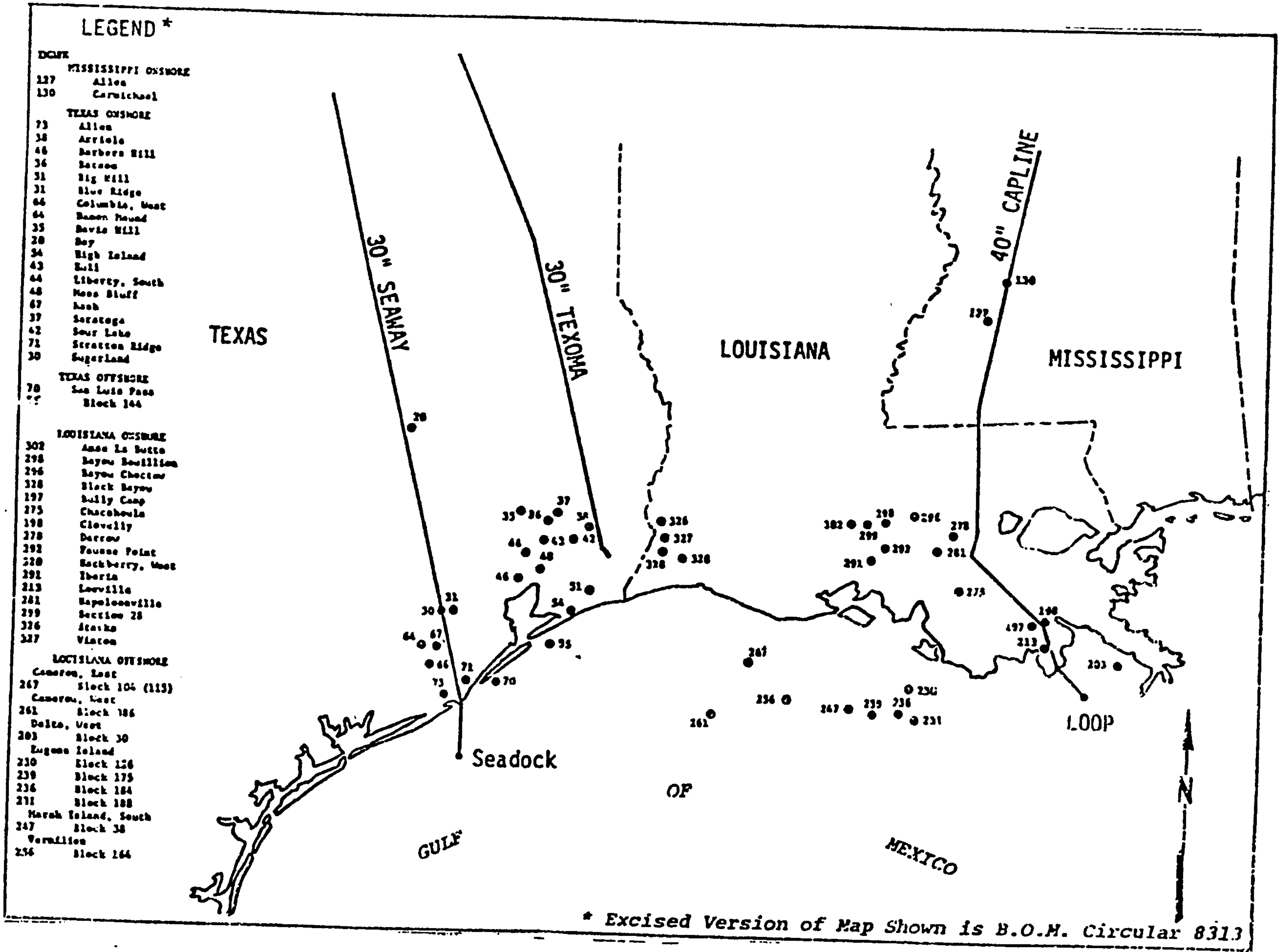

Figure 1.1. Gulf Coast Region Salt Domes

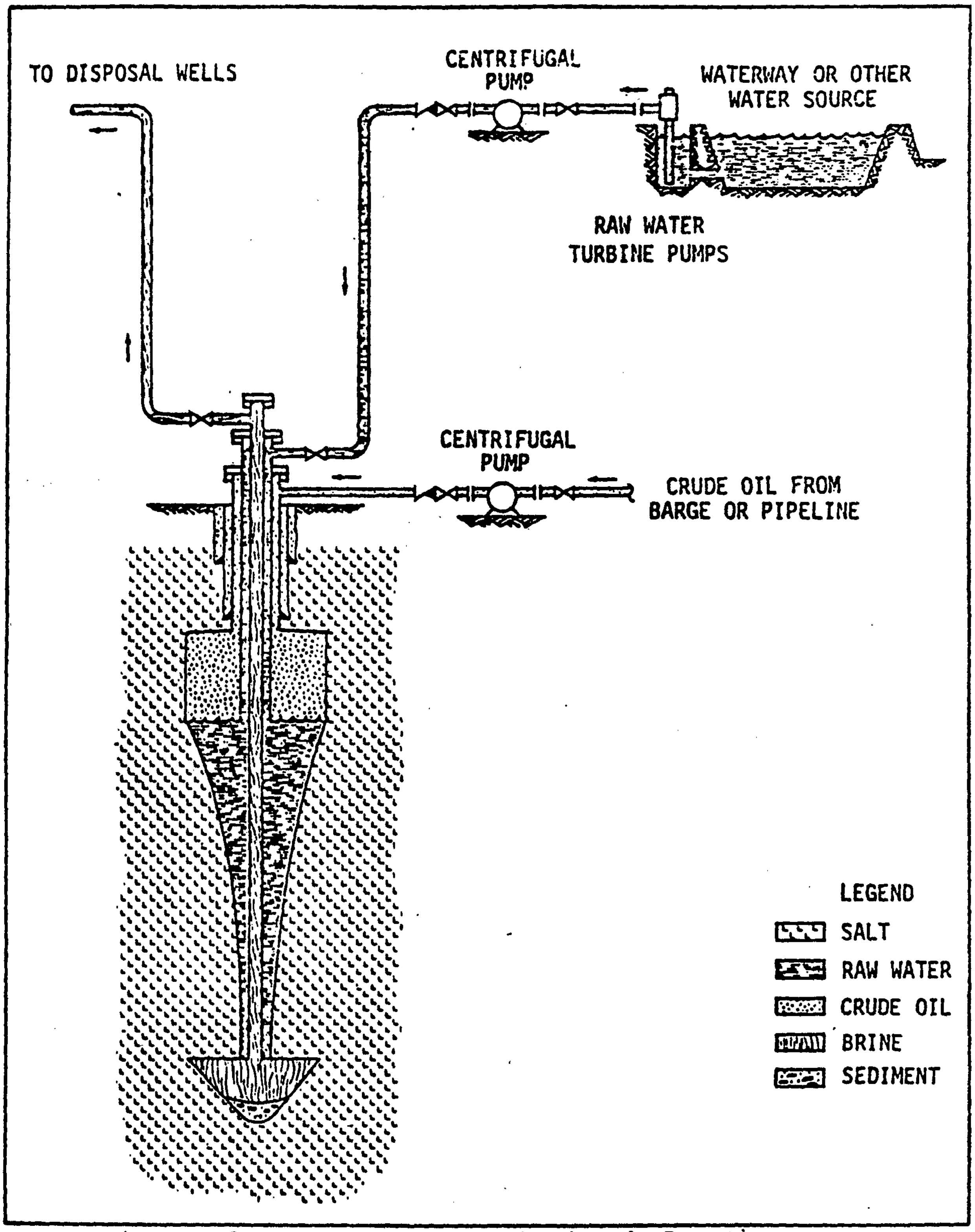

Figure 1.2. Typical Solution Cavity in Salt Formations

1.2.2 Proposed Storage Site

The Bayou Choctaw Strategic Petroleum Reserve (SPR) Facility located in south central Louisiana is currently designed to provide up to 99 million barrels (MMB) of the SPR requirements in the Baton Rouge/Capline storage region (see Figure 1.3). Eleven existing brine caverns in various states of repair and current usages would be adopted to provide the required storage area. These cavities are suitable for adaptation to petroleum storage, and the space could be made available to FEA under lease arrangements.

The dome is presently leased by Allied Chemical Corporation, Houston, Texas. They have leased the site since 1934 for the production of brine feedstock and presently sublease six of their developed caverns for hydrocarbon product storage. Bayou Choctaw dome is comparatively small with 1.3 cubic miles of salt above the depth of -10,560 feet. It is a shallow dome, however, with an average depth to caprock and salt being only -496 and -798 feet respectively. No sulfur mining has taken place in the caprock.

The stringent requirements of the Early Storage Reserve for 150 million barrels of storage to be completed within three years will necessitate careful timing in the development of the Bayou Choctaw site. Initially crude oil supplies delivered by barge transport must be used for early filling operations while the permanent facilities are being constructed. The full distribution system and many of the facilities needed for crude oil withdrawal operations may not be completed until near the end of the three year period, by which time the 99 million barrels of storage capacity at Bayou Choctaw would be accomplished.

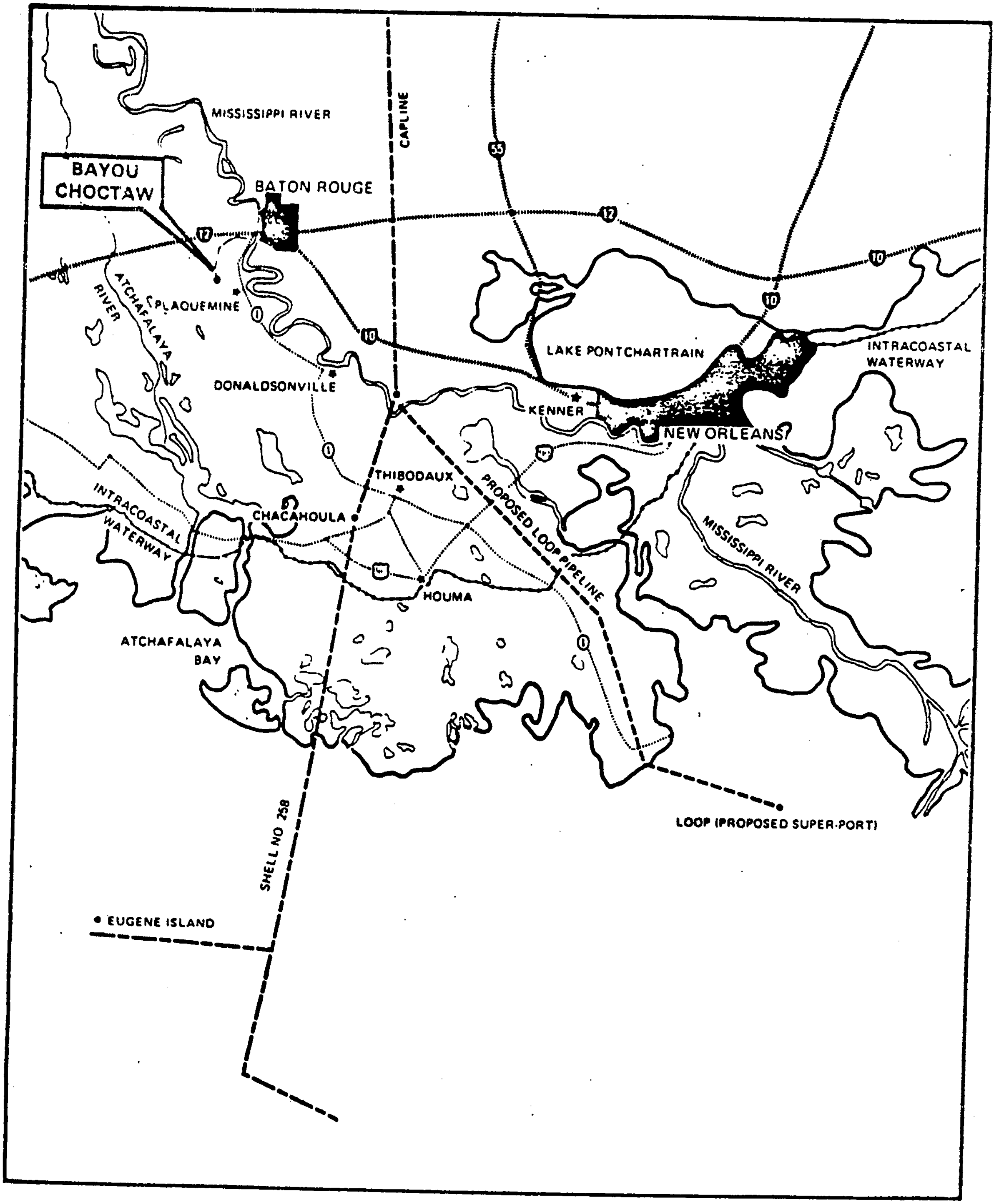

Figure 1.3 Baton Rouge/Capline Storage Region

1.2.3 Location

The Bayou Choctaw salt dome is located in the east central portion of Iberville Parish and extends slightly into West Baton Rouge Parish, Louisiana. The site is about 12 miles southwest of Baton Rouge, 3.4 miles south west of the town Addis (population about 730), and 4 miles northwest of Plaquemine (population about 7,800). The Mississippi River is located about 4 miles east of the dome. The Port Allen Canal, an extension of the Intracoastal Waterway, is a quarter mile to the west of the dome (see Figure 1.4).

A 4-mile paved parish road provides access to the northern edge of the dome from Louisiana State Highway No. 1. A network of improved gravel lease roads service the existing brine production and surrounding oil production wells. The general area surrounding the site is swampy with an elevation ranging from less than 5 feet to more than 10 feet above sea level, with no clearly positive topographic expression of the Bayou Choctaw salt mass. Major surface subsidence has occurred, however, due to the collapse of a solution cavity in 1955, resulting in the formation of a 12-acre lake (see Figure 1.5). This occurrence is discussed in Section 2.1.2.

Area Facilities

The Bayou Plaquemine and Port Allen Canal portions of the Intracoastal Waterway provide a waterway over 100 feet wide and 9 feet deep to within 2,000 feet of the western edge of the salt dome. The Intracoastal Waterway, Bull Bay and an unnamed canal could provide barge access to the central, north, and eastern portions of the dome. Bayou Choctaw is favorably located with respect to ship terminals along the Mississippi River. Union Texas Petroleum, an Allied subsidiary, has an LPG terminal 3.5 miles away. Port Allen near Baton Rouge is 12 miles distant. For the SPR facility, a new ship terminal for crude oil would be provided within 5 miles on the Mississippi River. A barge terminal is located adjacent to the site and would also be used for filling operations.

The site is well located with respect to existing pipelines. Exxon operates two 16-inch crude oil pipelines within 1 mile of the dome, transporting crude oil from St. James and southern Louisiana to their refinery at

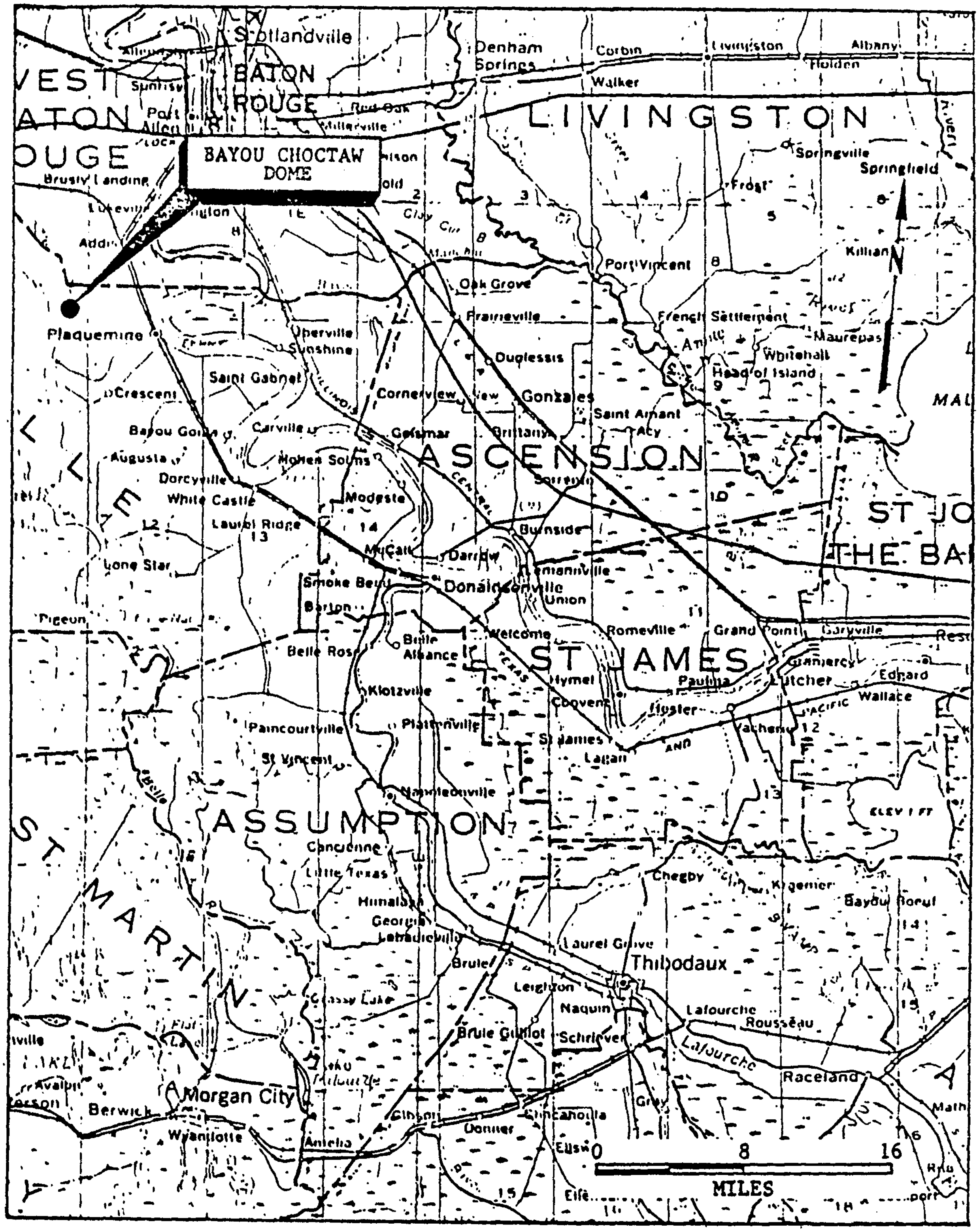

Figure 1.4 Location Map - Bayou Choctaw

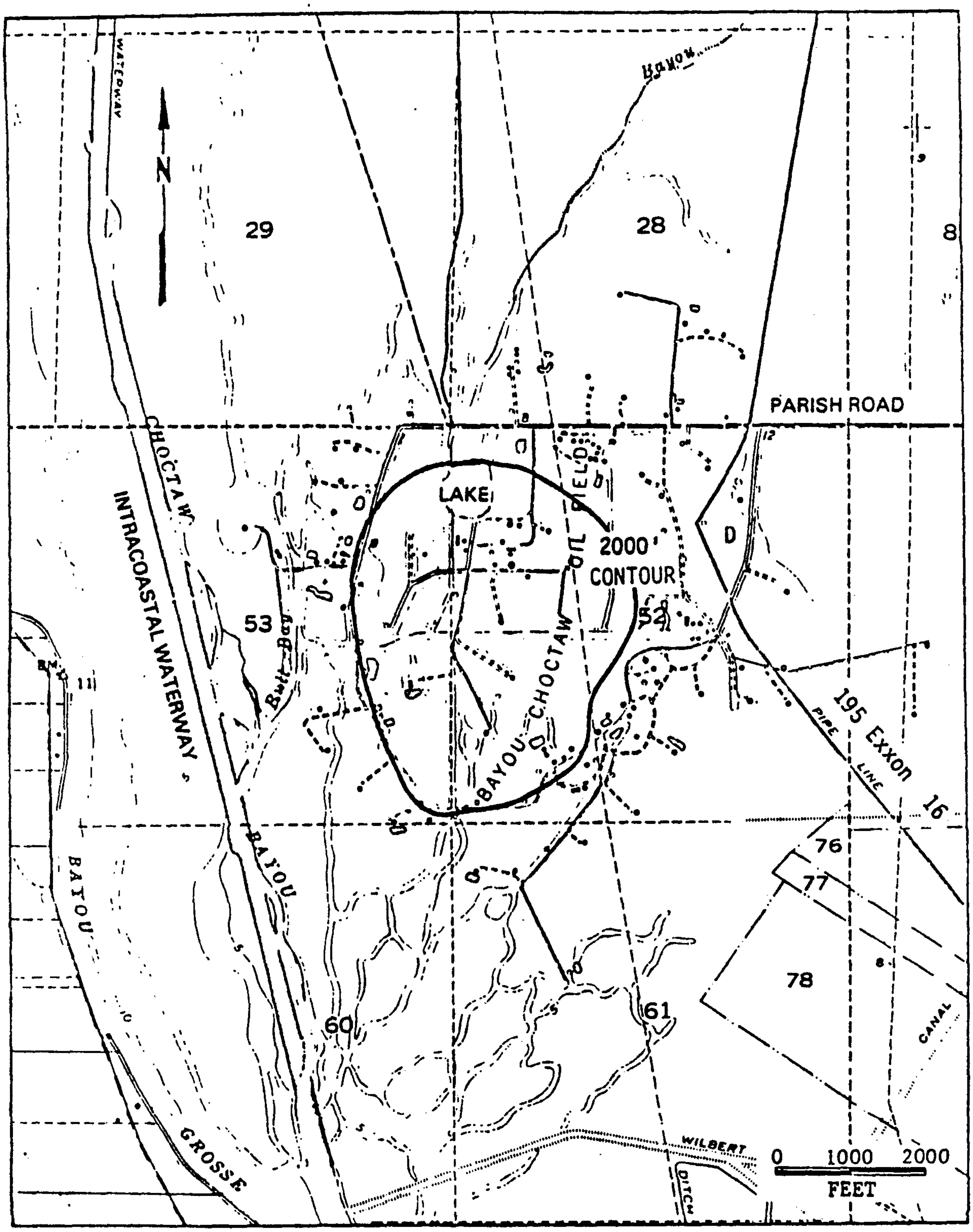

Figure 1.5 Site Map - Existing Facility

Baton Rouge (see Figure 1.5). Capline, a 40 inch pipeline operated by Shell, lies 25 miles east of the dome and transports crude oil from southern Louisiana to upper midwest refineries (see Figure 1.3). Capline throughput presently consists of 275,000 barrels per day domestic oil and 600,000 barrels per day foreign crude oil. Planned expansion will increase the throughput in 1976 to 1 million barrels per day. The proposed LOOP super tanker facilities will connect to Capline at their St. James terminal (see Figure 1.3).

Access to numerous refineries is available via Capline, and the distant refineries at New Orleans could be served by tankers. In addition, the 7 local refineries listed in Table 1.1 are accessible.

1.2.4 Capacity

The total developed capacity of the existing available caverns in the Bayou Choctaw dome is about 99.5 million barrels as reflected in Table H.1 (Appendix H). Of this amount, approximately 94 million barrels of usable storage space is planned for the SPR storage facility. In addition to the 94 million barrels of existing space, 5 million barrels would be made available in a new cavern (#21) which Allied has planned to develop to assure themselves of an adequate supply of brine feedstock. In this new cavern, crude could be stored concurrently with cavern development. Thus the current total design capacity for the facility is 99 million barrels.

The Bayou Choctaw dome could potentially be developed to larger capacities. Although the surface area is small compared to other Gulf Coast domes (330 acres within the -2,000 feet contour and 360 acres within the -3,000 feet contour) sufficient area remains to construct ten 10 million barrel caverns in the -1,000 feet to -2,000 feet interval or fifteen 10 million barrel caverns in the -3,000 feet to -4,000 feet range. In addition, 7 of the 11 candidate caverns have volumes less than 10 million barrels. Increasing these caverns to the 10 million barrel size would increase the gross total volume of present caverns to 120 million barrels. Thus, the combination of these two expansions would create a 270 million barrel complex.

Table 1.1 Baton Rouge/New Orleans Refineries

Company and Location	Capacity (BPD)	Distance (Miles)
Exxon - Baton Rouge	445,000	15
Texaco - Convent	140,000	35
Gulf - Belle Alliance	180,400	23
Shell - Norco	240,000	60
Taro - Port Allen	36,000	13
Good Hope Refineries - Good Hope	29,450	60
Murphy - Meraux	92,500	80
Total	1,163,350	

1.2.5 General System Description*

The presently planned SPR facility at Bayou Choctaw involves the conversion of existing brine cavities, including several cavities now storing refined products, to bulk crude storage. Crude oil supplies for filling the cavities are planned from two sources. Initially, an existing dock would be expanded on an existing canal, Bull Bay, adjacent to the storage site (see Fig. 1.6) and would be used in filling two of the cavities while the permanent facilities were being constructed. Then a new permanent tanker dock is planned on the Mississippi River, some 4 miles northeast of the storage site (see Fig. 1.6). Medium sized tankers (up to 65,000 DWT) could then supply the storage facility via a new pipeline connection.

The crude oil supplies would be injected into the salt caverns through the well tubings by pumps located at a central pump building on the storage site. The existing brine in the salt cavity is thus displaced, and the resulting brine (except that portion which can be marketed as feedstock to chemical industries) must be disposed of. The present plan for brine disposal is to drill twenty-eight deep subsurface injection wells to be located off the southern flanks of the dome as shown in Fig. 1.6 and to pump the waste brine into deep saline aquifers.

For withdrawal of the stored oil, displacement water from adjacent canals and bayous through the onsite lake (see Fig. 1.6) would be injected into the storage cavity through the well tubing, at sufficient pressure to push the crude oil out and through the pipeline to the distribution terminal on the Mississippi River. Distribution of the stored oil is planned via tankers from the permanent distribution terminal. The oil would be shipped to local and regional refineries as well as to markets on the east coast (see

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*Derived from preliminary engineering designs. Although details may change as designs are finalized, the maximum facility requirements are assumed as a worst case condition.

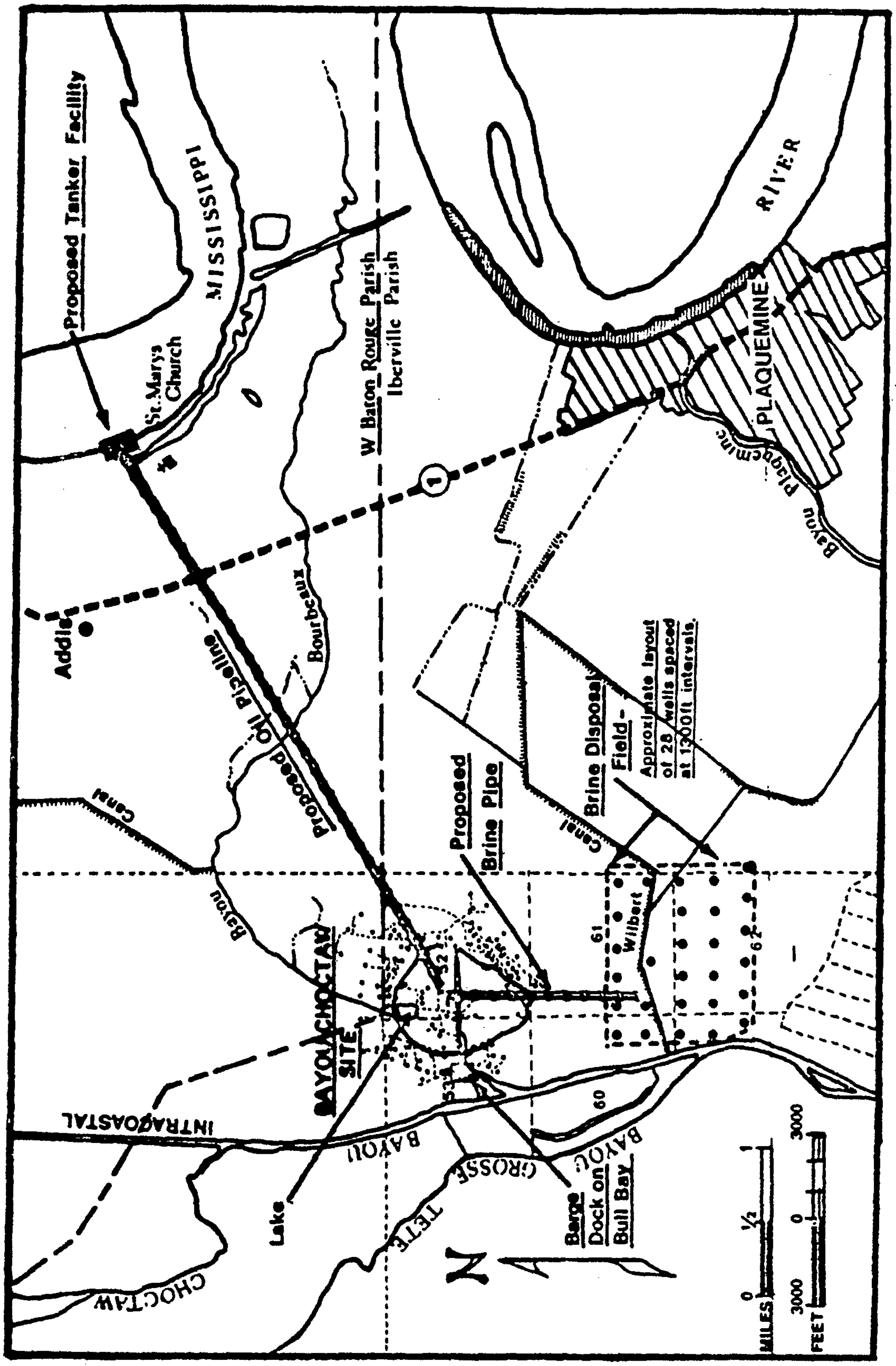

Figure 1.6 General Facilities (proposed)

Table 1.1). As currently planned, the existing dock would be expanded and used for part of the permanent distribution system.

1.3 SITE DEVELOPMENT AND CONSTRUCTION

1.3.1 Physical Facilities

The proposed facility at Bayou Choctaw would involve the conversion of eleven existing brine cavities owned by Allied Chemical Corporation. Conversion of the site to a crude oil storage facility, as presently planned, entails the following developments.

1.3.1.1 Storage Site Layout

Temporary facilities: Initial crude oil fill operations are planned via an existing barge dock adjacent to the site and connected to Port Allen Canal, a portion of the Intracoastal Waterway (ICWW). It is estimated that 75,000 barrels per day can be barged to the existing facility; which requires only one storage cavern to begin fill operations.

An existing custody transfer unit and an existing 10-inch pipeline would deliver the supplies to temporary injection pumps at the designated cavern. The displaced brine would flow into Allied's brine tanks, and the amount of brine in excess of Allied's current requirements of about 34,000 barrels per day would be pumped to one or two disposal wells located off the southern flank of the dome. The resulting disposal rates anticipated would be 41,000 barrels per day (1200 gpm). Facilities for crude withdrawal are not planned for use during the initial fill period.

Permanent facilities: For the permanent storage facilities, three separations of crude oil grades are planned. Caverns Nos. 1, 8A and the gallery of Caverns Nos. 3, 11, and 13 are planned for storing crude oil grade A. Caverns Nos. 15, 17, and 20 are assigned for crude oil grade B. Caverns Nos. 16, 18, 19, and 21 are planned for storing crude oil grade C. The existing wells into these caverns and the planned re-entry wells required for providing sufficient flow or for intersecting chimneys which have developed in some caverns are shown in Figures 1.7 and 1.8. See Appendix H for a discussion of existing cavern conditions and proposed cavern conversion procedures. At this particular site, it is planned to construct containment dikes to enclose all of the designated storage wells as shown in Fig. 1.7. Details of the various grading requirements are discussed in Section 1.3.3.

Present planning provides an oil supply system of 2 separate but simultaneous sources: (1) the local barge dock located on Bull Bay would be expanded to provide a maximum of 10,000 barrels per hour (7,000 gpm), and (2) the new tanker terminal to be located on the Mississippi River would provide a maximum of 30,000 barrels per hour (21,000 gpm).

A proposed 500,000 barrel brine pit (600 feet by 600 feet) on the storage site (see Figure 1.7) is designed as a brine holding pond for the displaced brine during oil fill operations, and as a surge pond for displacement water during oil withdrawal operations. The presently planned location for the brine disposal field of 28 injection wells is in a swamp area approximately 1 mile south of the storage site (see Figure 1.6). Roadways elevated on several feet of fill would be required for service to this area.

The lake at the northwest corner of the storage area (see Figure 1.7) which is planned as the source of displacement water was formed in 1955 when a previous solution cavern No. 7 collapsed, causing surface subsidence. The approximately 12-acre lake is about 85 feet deep and is connected by several canals to local waterways.

1.3.1.2 Central Buildings

According to preliminary designs, all oil injection pumps will be located in a central pump building (approximately 50 feet by 100 feet) situated at the southern edge of the lake (see Figure 1.7). The raw water lift pumps would also be located adjacent to the lake. Another pump building,

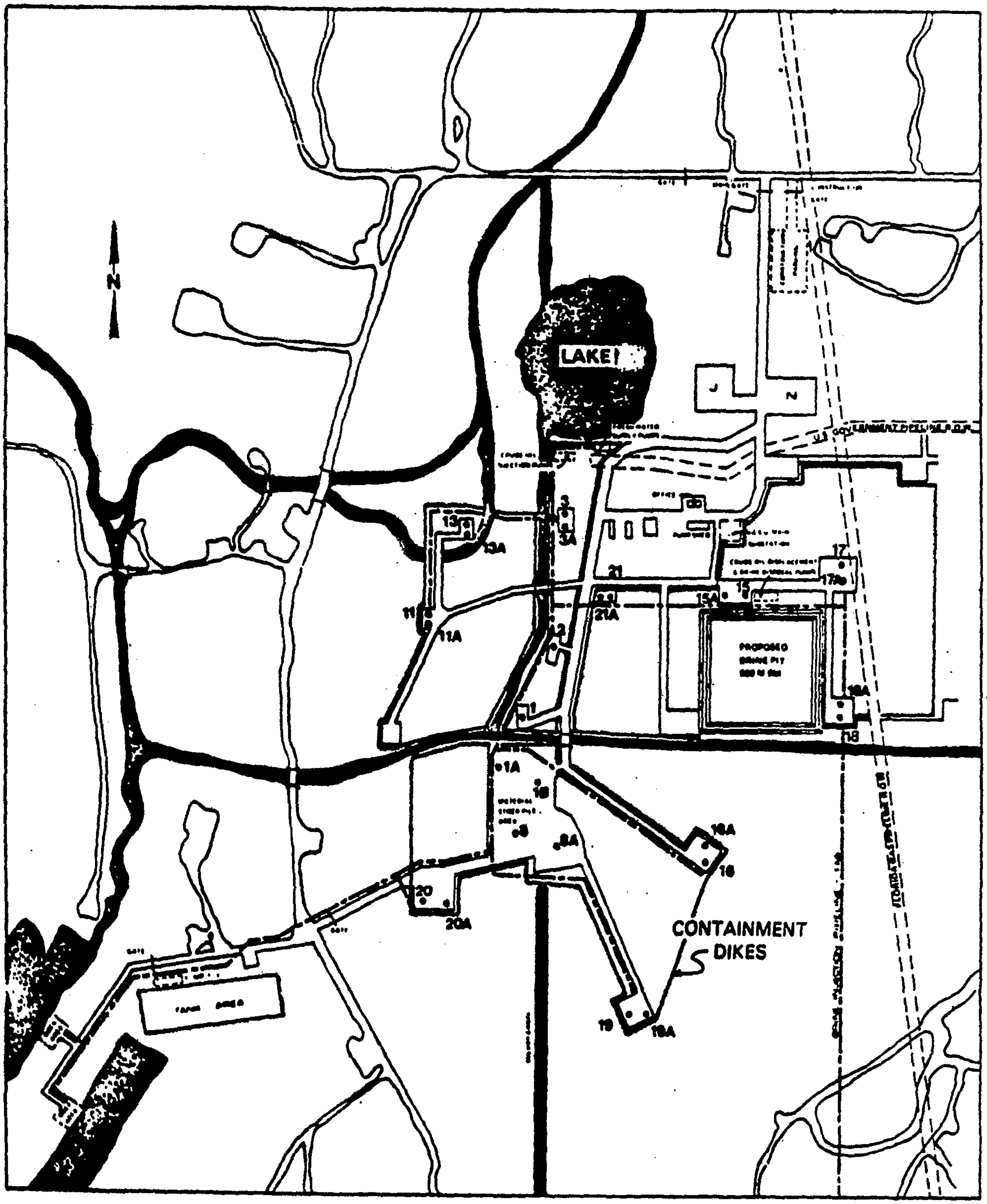

Figure 1.7 Proposed Storage Facility

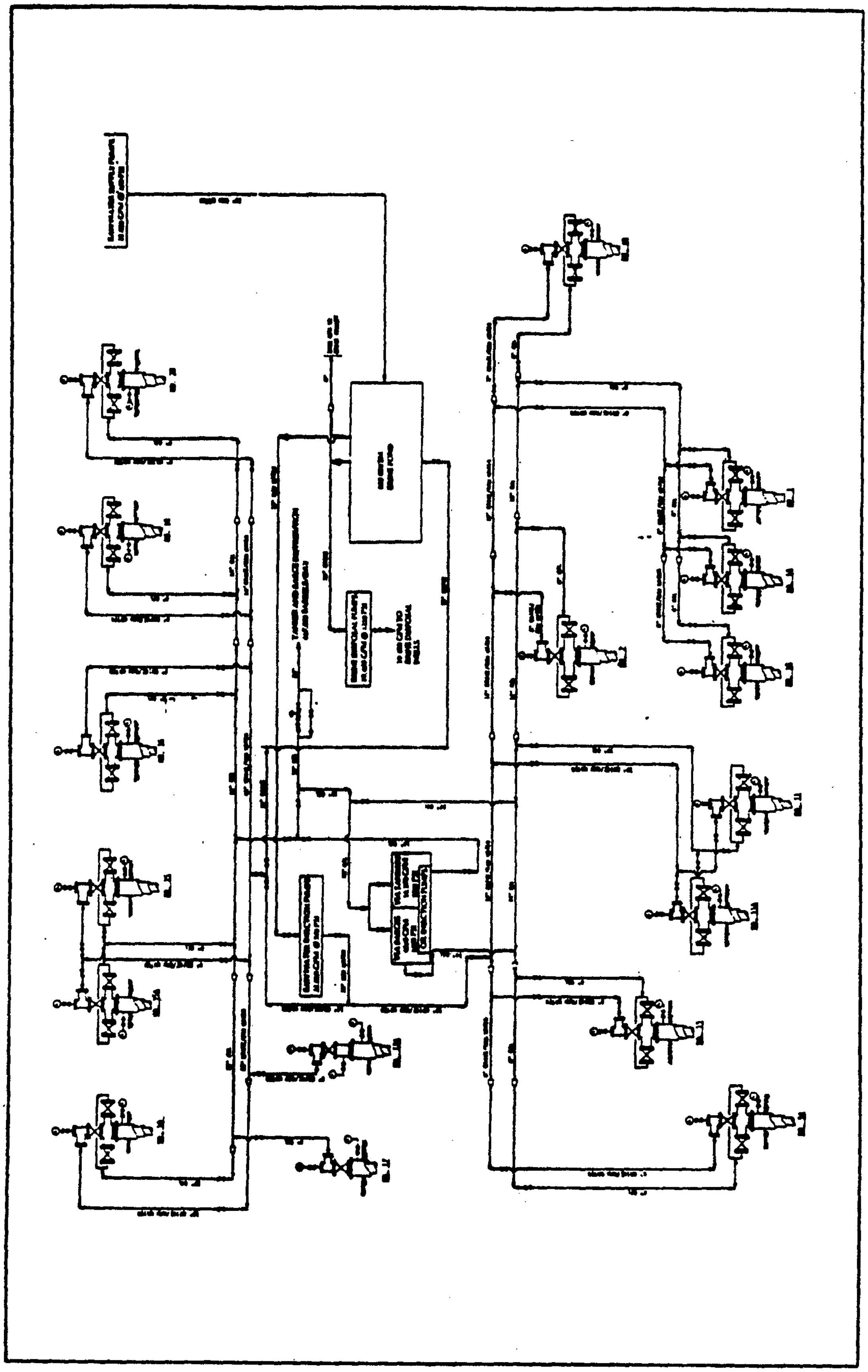

Figure 1.8 Flow Diagram - Bayou Choctaw

located just north of the brine pond, would house the displacement pumps and brine injection pumps. A list of the various pump requirements is found in Table 1.2. The main office building would contain all control equipment, a repair shop, and a chemical laboratory.

The office building is an existing one. The pump buildings would be constructed as part of the SPR facility. They would be of standard industrial construction built upon concrete slabs. In cases of insufficient soil bearing strength, concrete piles would support beams upon which the floor would be laid.

1.3.1.3 Brine Disposal

The proposed method of disposal for the saturated brine (about 265 ppt) which is displaced during crude oil fill operations would be to (1) partially utilize it as brine feedstock during initial fill operations and (2) inject it into subsurface saline reservoirs off the southern flank of the salt dome. The brine disposal system has been designed for disposing of a maximum of 40,000 barrels per hour (28,000 gpm) of waste brine. During rapid refill (for completed fill within 150 days) an average of 27,800 barrels per hour (19,450 gpm) would be produced.

The brine ejected from the various storage wells during fill operations would be collected in a brine surge pond. The pond (about 600 feet by 600 feet) is sized to hold 500,000 barrels, or the amount of brine which would be displaced by filling from two tanker loads of oil. This would provide temporary brine storage in event of a temporary brine injection system breakdown. In addition, the pond would act to settle out any insoluables which could damage pumps or clog the disposal wells.

The disposal system, as currently planned, would require a 28-well brine injection system. A 6,500 feet by 30-inch pipeline would be constructed from the pumping facilities at the central plant to the disposal area. The wells

	QUANTITY	H.P.	R.P.M.	P.S.I.	Total MPBH Avg. Design Rate	Total MPBH Max. Design Rate	TYPE
OIL INJECTION FROM BARGES	2	1200	1750	1000	7,000	10,000	Turbine Drive
OIL INJECTION FROM TANKERS	4	3500	1750	1000	21,000	30,000	"
DISPLACEMENT	4	1500	3600	500	32,000	46,000	"
BRINE DISPOSAL	4	3500	3600	1250	28,000	40,000	"
WATER SUPPLY	3	1200	3600	100	32,000	46,000	"
BARGE LOADING	2	300	1750	1000	7,000	10,000	"
TANKER LOADING	4	800	1750	1000	21,000	30,000	Diesel Engine Drive
PIPELINE TRANSFER	4	3500	1750	1000	21,000	30,000	Turbine Drive

Table 1.2 Preliminary Pump Requirements

would be spaced at 1,300 feet intervals in a roughly rectangular field of about 1,150 acres located in the lower half of Section 61 and the upper half of Section 62, south of the dome site (see Figure 1.6). A right-of-way would be cleared and a roadway built the length of the system. A total of approximately 6.5 miles of new access roadway would be required. The disposal area is located in a backwater swamp forest, and the majority of roadways would have to be elevated on several feet of fill. A pad of fill (about 200 feet by 200 feet) would also be required at each wellhead where sufficient dry ground is not available for the drilling and servicing of the disposal wells.

As in the storage cavity wells, the brine injection wells would be drilled by standard oil rigs. Injection wells, however, would be approximately 5000 to 7000 feet deep, and would normally require approximately 30 days for drilling, plus downhole completion work.

1.3.1.4 Displacement Water Supply

The preferred option for raw water supplies for the Bayou Choctaw SPR facility is to extract the water from an intake point on the south side of the lake which was formed due to the collapse of cavern No. 7 (see Figure 1.7). The lake has a surface area of approximately 12 acres and a maximum depth of around 85 feet. It is connected by canal to Bayou Bourbeaux and the Intracoastal Waterway (see Figure 1.6).

Approximately 46,000 barrels of displacement water per hour (32,000 gpm) is required for crude oil withdrawal operations.

Due to the increased capacity created from additional leaching caused by the fresh water introduced into the cavity, it takes about 15 percent greater raw water injection rates than the 40,000 barrels per hour of brine to be displaced.

Any leaching of newly developed caverns for replacement brine feedstock or non-program storage uses would not take place concurrently with crude withdrawal operations. Thus, the raw water supply system would be designed for meeting the 46,000 barrels per hour withdrawal system demand.

1.3.1.5 Crude Oil Supply and Distribution

The Bayou Choctaw dome presents several options for crude oil delivery to the site and for distribution from storage to regional markets. Because of the stringent timetable for the Early Storage Reserve, both fill and withdrawal of the oil is designed for a 150 day turnover. The planned storage capacity of 100 million barrels at Bayou Choctaw would require an average delivery rate of 667 thousand barrels per day (19,450 gpm). The system is designed for a peak rate of 960 thousand barrels per day (28,000 gpm) to allow for supply surges.

Barge facilities: According to present plans for initial filling of the first cavern (probably No. 15), the existing barge dock on Bull Bay adjacent to the site would be utilized. This dock presently handles 50,000 barrel barge tows and single barges of up to 25,000 barrels. The present facility handles approximately 3,500 barrels per hour. There is one 5,000 barrel strip tank at the dock that collects pump fluids as well as rain run-off from the dock areas. There are two 450 HP pumps, and a 10-inch pipeline to transport the crude oil to the storage site. Initially, only an auxiliary 150 HP electric pump would be required to supplement existing equipment for the initial fill operations.

The existing barge facility would be expanded for use in the permanent SPR storage facility. A new barge mooring slip (12 ft by 110 ft by 1200 ft) would be excavated parallel to the existing dock, and a new dock would be constructed at this new slip. Both docks would be adapted to accommodate 75,000 barrel barge tows. Three 150,000 barrel oil surge tanks, one for each oil grade, and one 10,000 barrel fuel oil tank would be required. These tanks would be enclosed in a diked area of approximately 400 ft by 700 ft (6.5 acres) as a standard method of compliance with SPCC regulations.*

The construction of the new barge slip would utilize typical dry land draglines to create the space before flooding and standard dredge techniques to complete the work. The spoil would be deposited on dry land on the

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*Spill Prevention Control and Countermeasure Plan as called for in 40 CFR 112.7.

banks of the new barge slip. In addition, the existing barge slip would be enlarged in the same way. A total of approximately 86,000 cubic yards of earth would be moved in the building of these barge facilities.

Part of the barge terminal design involves the isolation of the existing barge slip from the adjacent bayou for oil spill containment purposes. The plan is to dam off the secondary connections from the mooring area to the ICWW so that in case of a spill during loading or off-loading, floating booms would be placed above and below the dock area to contain the spill. A canal is planned, bypassing the dock area, to provide access for other traffic to Bayou Bourbeaux.

The docks would be similar to the existing dock. A platform would be provided for the loading equipment. Mooring dolphins (or groups of piles) would consist of 18-inch diameter, concrete filled piles driven to an approximate depth of 60 ft.

<u>Tanker facilities</u>: In addition to expansions at the existing barge dock, a new tanker facility would be constructed on the Mississippi River, just southeast of Addis, some 5 miles to the east of Bayou Choctaw (see Fig. 1.9). The dock would provide mooring for two tankers. An estimated 1.5 million cubic yards of material would be dredged and the spoil would be deposited in the river channel.

The terminal would be situated on a 250 acre tract of land, Sections 30, 31 and 32, that Allied has acquired in simple fee ownership. The onshore facilities would be located on the landward side of the Mississippi flood protection levee, and only approximately 30-40 acres of the property would be utilized by the facility. Six 200,000 barrel oil surge tanks, one 100,000 barrel ballast water surge tank, and one 25,000 barrel fuel oil tank (for pump fuel) are planned at the location. The tanks, of standard plate steel floating roof type, would be enclosed with adequate containment dikes as a standard method of compliance with SPCC regulations.

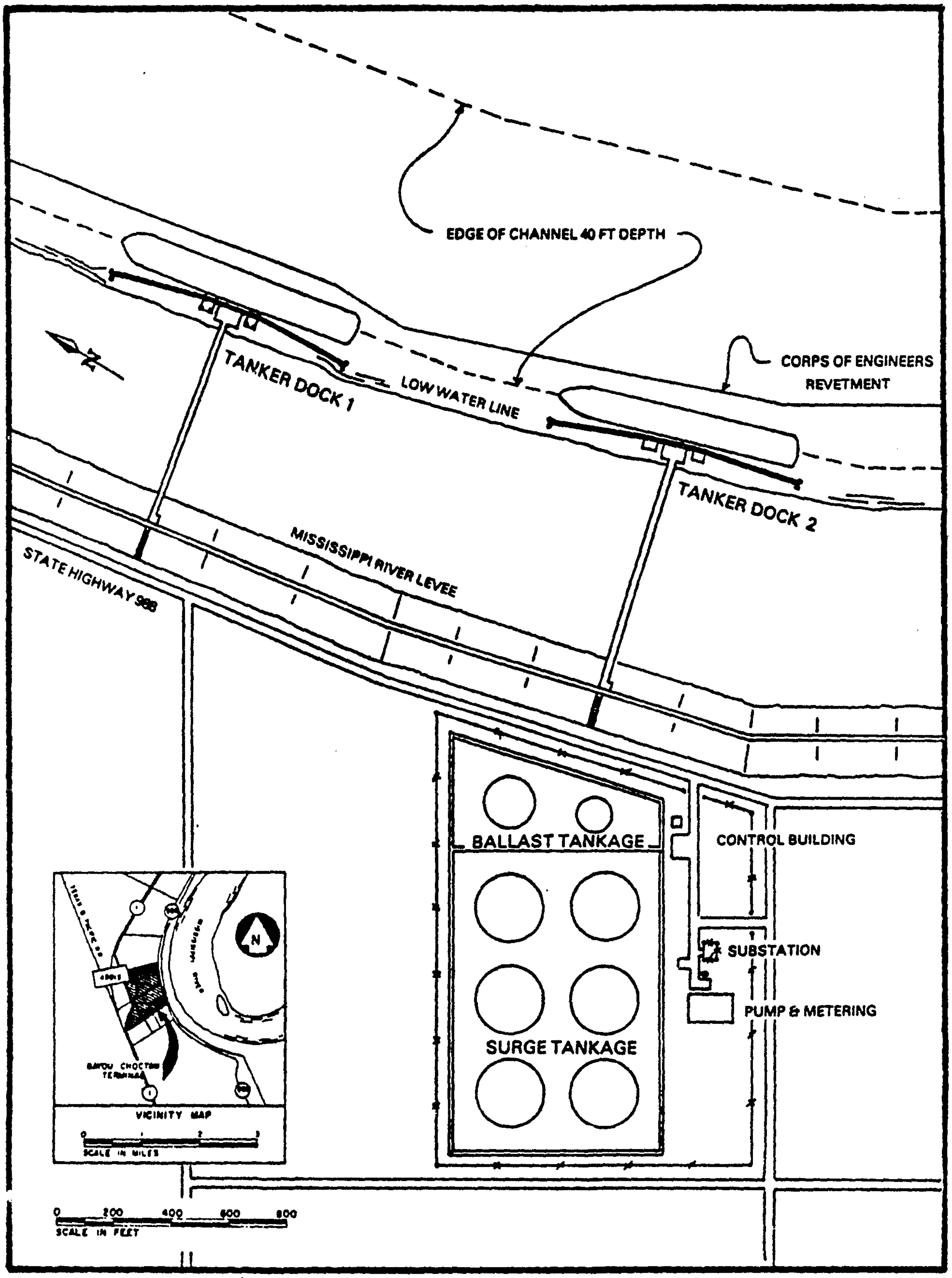


Figure 1.9 Proposed Tanker Terminal

For this particular terminal site, it is planned that ballast water would be pumped back to the storage site through a separate pipeline, and would then be disposed of through the brine injection system. Most of the oily waste would be skimmed off the surge pond before injecting the waste water. Since ballast disposal is a problem only during distribution from storage, and brine disposal is a problem only during filling operations, both functions of disposal can be handled by the same injection well system.

The twin 30-inch pipeline, connecting the terminal site to the storage site would cross about 2.5 miles of agricultural land (sugar cane) and about 2.5 miles of backwater swamp area. Only about 0.5 miles of this latter is through undisturbed swamp forests, however; the remainder would parallel an existing pipeline right-of-way to the storage site. The required 75 foot right-of-way to the new pipelines would involve approximately 45 acres in total. Installation of the pipelines must meet all applicable Department of Transportation standards.

1.3.2 Land Requirements

Allied Chemical Corporation, Houston, Texas, occupies the entire Bayou Choctaw salt dome under a lease, plus much of the surrounding land. They have leased a 2,150 acre tract since 1934. Approximately 40 million tons of salt have been produced from the dome and brine production continues at a rate which develops approximately 3.5 million barrels of additional space per year.

The main storage site, including storage wells, central pumping facilities, and brine holding pond, would require approximately 120 acres of land over the salt dome. Of this area, 8 acres would be used for the central pump buildings, office buildings, and other control and safety facilities. The brine holding pond would require an 8.3 acre plot. The oil storage wells, as shown in Figure 1.7, would be enclosed in earthen containment dikes encircling an area of roughly 104 acres.

The barge dock area on Bull Bay is located on a 6 acre plot. In addition, however, a second barge mooring slip would be excavated requiring approximately 3 acres.

The 5 mile distribution pipeline to the Mississippi terminal would require a 75 ft. right-of-way, or approximately 45 acres. Allied owns the terminal location property, sections 30, 31, and 32, some 250 acres in simple fee.

The present design for a brine disposal field would require a 1 mile by 50 ft. right-of-way(6 acres) from the storage site to the disposal area. The wells would be spaced evenly in a rectangular field of approximately 1,150 acres. The total disturbed land for the injection well system would be approximately 65 acres.

In total, approximately 1,570 acres are needed for the project as planned.

1.3.3 Road Construction and Other Grading

Most of the roads needed to the various storage wells already exist. The major requirements for new road construction would be the access roads for drilling and servicing the brine disposal wells, requiring about 6.5 miles of new construction. These access roadways would require from 1 to 2 feet of fill, 40 to 50 feet in width because of the swamp area in which the disposal system would be constructed. In addition, each disposal well site would require an area approximately 200 ft. by 200 ft. for the construction and maintenance of the wells. A part (50 ft by 50 ft) of this area would be used as a drilling mud pit during drilling operations, but would be reclaimed after the well is completed. The individual well sites would be elevated on fill because of the swamp environment. A total of 160,000 cubic yards of fill would be required in the construction of the disposal system if the entire area were located in swamp. This represents a total of 65 acres disturbed area.

A levee system is planned to enclose the entire storage area as a precaution against oil spills from a ruptured wellhead which may contaminate the local environment. The storage wells would be divided into three or four major subsections (see Fig. 1.7). Each subsection would be graded and containment dikes constructed on their perimeters. The dikes would be approximately four to five feet in height. Also the oil tankage areas at the distribution facilities would be contained in containment dikes to prevent oil contamination of the local waterways as required in the Spill Prevention Control and Countermeasure Plan (SPCC). Dike enclosures are a standard engineering practice for compliance with this regulation. The containment dikes would require an estimated total of 83,000 cubic yards of earth moved for their construction.

1.3.4 Pipeline Construction Techniques

Three basic methods of construction may be used during construction of the off-site pipelines: (1) flotation canal method, (2) push ditch method, and (3) conventional dry land method.

Flotation Canals: The flotation canal method of construction is required in the marsh portions of the pipeline route where the ground cannot support heavy construction equipment. Therefore, the work must be done on construction barges operating in a canal.

In the flotation canal method, a canal is dug along the route to accommodate construction barges. The canal is dredged to provide a water depth of approximately 7 feet and a channel width of 40 to 50 ft. at the bottom and up to 75 ft. at the top of the canal. The marine equipment needed for construction are a dredge, a pipe lay barge, materials barges, personnel boats, and special equipment barges required for tie-ins and work at pipeline crossings. A 100 to 150 ft. right-of-way is required.

One or two pipe ditches are dug in each flotation canal, as required, to accommodate the proposed pipelines(s). The spoil removed in dredging the flotation canal and pipe ditches is stored along both sides of the flotation canal until after the pipelines have been installed.

The pipe lay barge, approximately 40 to 50 ft. wide and 400 to 450 ft. long, travels along the flotation canal while the joints of pipe are being welded together. The completed pipeline is then lowered off the stern of the barge into the pipe ditch(s). When backfilling, a barge mounted dipper dredge travels along the flotation canal filling the canal behind it.

For the pipeline routes presently planned, flotation canals would not be required since marsh areas would not be crossed. If the alternate brine disposal pipeline to the Gulf of Mexico were chosen, as discussed in Section 7.4, marshlands to the south near the Gulf would be crossed. Perhaps 20 to 30 miles of the route could require barge lay techniques, although the majority would be done using push ditch and conventional methods, parallel to existing pipeline rights of way.

Push Ditches: The push ditch method of construction would be used in the swampish portions of the pipeline route where the ground can support marsh buggy mounted excavating and backfilling equipment, but cannot support conventional dry land pipeline construction equipment. This method would most probably be used in constructing the pipeline to the proposed tanker terminal, about 2.5 miles of which crosses backwater swamp areas. In addition, portions of the proposed brine disposal system which would involve about 6.5 miles of pipeline through swamp areas, would be constructed using this technique. As an alternative to burial of the brine line, however, the entire disposal field may be fenced off and the pipelines could be supported above surface on piles beside the service roads.

In the push ditch method, a right-of-way approximately 100 feet is cleared. When the ditches are excavated, they naturally fill with water from the surrounding swamp. Four or five push sites are selected at convenient locations along the proposed route. These sites are used to assemble the pipe joints into a completed pipeline and to float it to its final location. The fabrication and assembly of the pipeline consists of welding together joints of pipe, each approximately 40 feet long, on the push site. The assembled pipeline is pushed forward into the push ditch by the length of another joint of pipe, and the assembly procedure is repeated. A marsh buggy, or similar equipment, travels along the ditch with the front end of the pipeline to guide and to aid in starting and stopping the pipeline as the assembly continues.

After a portion of pipeline is assembled and in its desired location, it is filled with water, causing the pipe to sink to its final position. Draglines, mounted on marsh buggies, travel along the right of way filling the ditch with the spoil which was stored along the sides.

The push-ditch method of pipeline installation is normally preferred in marsh areas of coastal Louisiana. Experience has shown that this method greatly reduces potential environmental damage and has proven feasible for lines in excess of 40 inches in diameter.

Conventional pipeline laying: Conventional construction would be used through the dry portions of a pipeline route where heavy construction equipment could be supported.

With the conventional dry land method, a right-of-way width of approximately 125 feet is cleared. Excavation equipment digs the pipe ditches. The pipe joints are then strung along the pipe ditches, welded together, the required corrosion protection applied, and the pipe is lowered into the ditch and backfilled in accordance with 49 CFR Part 195.

1.3.5 Development Timetable

According to present plans, the first 6 months of site preparation and facility conversion would involve the emptying of Cavern No. 15 of its stored fuel oil into another cavern developed for that purpose; and would require that at least one brine disposal well be drilled. Early fill via the existing barge facility would take place over the next 18 months while the permanent facility components are being built. The fill rates start at 2,000 barrels per hour for the first 3 months, then increase to 5,000 barrels per hour from the expanded first dock. After 6 months, the rate would double to 10,000 barrels per hour as the second barge dock is put into operation (see Table 1.3). During the early fill period, the brine disposal wells and additional cavern entry wells would be drilled; all pipelines would be constructed and tested; all pumps, metering, buildings, and security systems would be installed; and the tanker terminal would be constructed to allow fill from that location. Part of the initial fill requirements may come from the first tanker dock as soon as it is completed. All of the facilities required for the emergency distribution of the stored oil are scheduled for completion by the time the 100 million barrels are obtained.

Table 1.3

Preliminary Timetable for Conversion and Fill

Month Period	Fill Rate Capacity (MBPH)*	No. of Months	Cum. Storage (MMB)**	Phase of Development
0-6	0	6	0	Facility approvals
6-12	0	6	0	Site preparation
12-15	2.0	3	2.96	Early fill: via existing barge dock
15-21	5.0	6	18.08	Via expanded barge dock
21-30	10.0	9	63.44	Via additional barge dock
30-33	40.0	3	100.00	Completed fill: via new tanker terminal and barge facilities

*MBPH denotes thousand barrels per hour.

**MMB denotes million barrels.

1.4 OPERATION AND MAINTENANCE

1.4.1 Operating Procedures

1.4.1.1 Storage Phase

The goals of the Early Storage Reserve Program (ESR) is to complete the first 150 million barrels of oil in storage, ready for emergency withdrawal within three years from December, 1975 while the facilities for the remainder of the Strategic Petroleum Reserve are under construction. To provide for early withdrawal capability before storage is completed, the storage system would be equipped with oil return bypass valves to allow intermittent recovery of stored oil.

The ESR facility at Bayou Choctaw is planned for completion 33 months into the program (see Table 1.3). It is expected that there would be an interim period from the time of facility completion until a need arises for emergency distribution of the stored oil. During this interim period, the only activities at the site would be security and maintenance activities.

Security measures: Security measures planned for the SPR facility are standard for petroleum storage facilities. The main storage site would be fenced and properly lighted. All wellheads would have pneumatic gate valves on brine and crude lines to allow for remote control. These controls plus all electrical equipment are housed in a security building. All pipelines would be monitored with pressure switches at each end of the line for early detection of leaks. The facility would maintain standard fire prevention systems and warning devices.

Equipment testing and maintenance: During the storage period, all equipment would be serviced and tested on a regular basis to ensure proper working order. Pumps, pressure valves, and safety equipment would be lubricated and operated at least once a month. Maintenance crews would be on duty on a 24-hour basis.

1.4.1.2 Extraction Phase

The SPR Program plans for an emergency delivery of stored oil over a 5-month period. The plan would require delivery rates for this 99 million barrel facility of

667 thousand barrels per day. The facility's systems are designed to yield a maximum of 960 thousand barrels per day to allow for lag periods in onloading.

Recovery process: Crude oil stored in each salt cavity would be recovered by pumping raw water into the bottom of the cavity, thus displacing the oil through the concentric tubing at the top of the cavity. The oil would leave each wellhead at 500 psi, a pressure capable of transporting the oil via pipeline to the distribution facility.

Distribution: The new tanker terminal planned on the Mississippi River would be the distribution point for the Bayou Choctaw facility. During emergency distribution, a combination of barges and tankers would transport the supplies to local refineries in Baton Rouge and New Orleans; the Capline terminal at St. James; and possibly to the East Coast and Carribean markets as well.

1.4.1.3 Refill Phase

After an oil supply crisis has ended and provided that supplies are stabilized and new imports are sufficient for additional storage reserves, refill of the SPR storage facility is planned. The rate of fill would depend on the availability of surplus imports.

Refill process: The refill process is the reverse of the recovery process. The crude oil would be injected into the top of the storage cavity, thus displacing the brine which would go to the disposal wells. The brine disposal systems and cavity injection system are sized to handle a fill rate equal to the initial fill rate, i.e., 667 thousand barrels per day (19,450 gpm) over a five month period.

Refill capacity: Five fill and withdrawal cycles are planned for the SPR system. Although the cavern capacity enlarges during each cycle, only the original design capacity for each cavity is planned for refill. The fact that a smaller percentage of fresh displacement water would be introduced into the cavern during successive displacement cycles reduces the continued leaching process from about 90 percent enlargement to about 62 percent. Furthermore, due to casing limitations, total usage of the enlarged capacity would not allow total displacement in 150 days during subsequent withdrawals.

1.4.2 Safety Procedures

The following is a list of normal safety and engineering practices for oil storage and oil handling facilities which would be employed at the Bayou Choctaw facility.

1.4.2.1 Protective Control Devices

All storage cavity wellheads would be equipped with (1) hydrocarbon detection devices to protect against overfill, (2) pneumatic gate valves on crude and brine wellhead openings with high-low pressure switches for remote control of safety valves, and (3) valve limit switches, signal devices, and alarms.

Pump control and protective devices would be installed on all major pumping equipment to monitor critical operating variables and to automatically shut down the affected equipment in the event that an unsafe operating condition develops.

Pump station emergency shutdown systems would be installed at all stations to allow the shutdown and isolation of the pumping station in the event of an emergency. Pipelines would have meter bases and pressure switches monitored and would be visually inspected as a precaution against leaks. Pressure relief valves would be installed on piping, equipment, and pressure vessels as needed to prevent these systems from exceeding safe limits.

1.4.2.2 Fire Protection

Pump stations and meter stations would be provided with portable fire extinguishers to be selected, installed, classified, and rated in accordance with applicable standards of the National Fire Protection Association. Surface oil holding tanks at the distribution terminal would be equipped with standard fire prevention systems.

1.4.2.3 Corrosion Protection

All buried portions of the pipelines would be externally coated with a cathodic protective coating and protected by impressed electrical currents. Sealed casings are required at highway or railway crossings, with insulators and spacers to electrically isolate the pipelines from the casing.

1.4.2.4 Protection from External Damage

All electrical equipment and control systems would be housed in buildings and elevated on fill where required for protection against flooding.

Protection of the pipelines from external damage would be provided by burying them and by marking their location. Additional weight and mechanical protection for those portions of the pipeline in areas of swamp or marsh, and at waterway crossings, would be provided by the external coating of wire-mesh reinforced concrete.

1.4.2.5 Protection of Local Surface Environment

Oil which normally leaks from pumps and valves in and around pumping stations, where oil may be drained from the system during normal or emergency operations or maintenance, would be collected and be piped into a central waste oil sump. Waste oil collected in this manner would be returned periodically to the storage system or sold to local "slop oil" marketers.

All surface tanks are required to be enclosed in adequate retention dikes to protect the area environment from leakage of oil. This is consistent with the Spill Prevention Control and Countermeasures Plan Requirement of 40 CFR 112-7.

1.4.2.6 Security

Main storage site access roadways would be equipped with security gates to prevent any interference with the facility by unauthorized persons. Since the facility would operate on a 24-hour basis, personnel would be on duty at all times. Pump stations would be fénced and/or housed in pump buildings. All fenced facilities would have warning signs posted conspicuously to warn the public of the nature of the facility.

1.5 TERMINATION AND ABANDONMENT

It is anticipated that the facility will be used for the foreseeable future as a storage site. When it is apparent that this use will cease, a termination plan will be developed which utilizes the most efficient means available (at that time) to minimize the impact on the environment.

It is logical to expect that essentially all crude oil (except for the protective blanket) will be removed from the caverns prior to termination of use of the facility. Thus, the caverns would all ultimately contain water which would in time become saturated brine. At this point no further changes in cavern size or shape would occur due to leaching. There remains the question of cavern collapse, but if the cavern is properly selected initially and if the protective blanket of oil is maintained to protect the cavern salt roof, such an event is unlikely.

There is the possibility that brine from an inactive cavern could, at some time in the future, come in contact with aquifers in the depth interval corresponding to cavern depth. For this to occur, however, would necessitate dissolution of a sizeable portion of the salt dome by the aquifer involved. Based on available information, such a dissolution process is extremely slow with the highest rates of dissolution amounting to only 1 foot per 125 years. Because the thinnest cavern wall adjacent to the side of the salt dome is estimated to be 180 feet thick after five cycles of use, it would appear that the caverns would provide secure containment for at least 22,500 years.

2. DESCRIPTION OF THE ENVIRONMENT

The environment which would be affected by the development of a Strategic Petroleum Reserves Facility at the Bayou Choctaw salt dome site includes the areas of the storage site, the displacement water and brine disposal locations, and the rights-of-way for all pipelines. In addition, the development of docking facilities on the Mississippi River will constitute a geographic area of potential environmental impact. This section will highlight those factors of the environment which may be affected by the project.

2.1 LAND FEATURES AND USES

2.1.1 Evolution of Salt Domes

A brief description of the evolution of salt domes is helpful in understanding the relationships between the salt, caprock and faulting that is found associated with salt domes.

The Bayou Choctaw salt dome is one of nearly 450 salt domes in the Gulf Coast region of the United States and Mexico. The salt in these domes was originally deposited in a broad shallow sea during Jurassic time (130 to 200 million years ago). Since then the salt basin was buried to depths of 15,000 to 35,000 feet by pelagic sediments of the Cenozoic age. In general the salt was deposited in horizontal beds, but due to alternating periods of deposition and erosion the surface of the salt had topographically high areas. Since the mechanism of initiating salt dome growth is one of isostatic adjustment, it was some of these topographic highs that began to rise first and eventually formed the nucleus of present day salt domes.[1] The salt begins to rise because the overlying sediment has an average density that is greater than the density of the salt (2.164 gm/cm^3). The sediment overlying the topographic high has a lower density than the sediments overlying the salt on all sides of the high; consequently the salt flows laterally and up toward the areas of least resistance, namely the topographic high. Approximately 4000 feet of overburden is needed to exceed the density of the salt, and a sediment depth greater than that will cause upward movement of salt[2] (see Fig. 2.1).

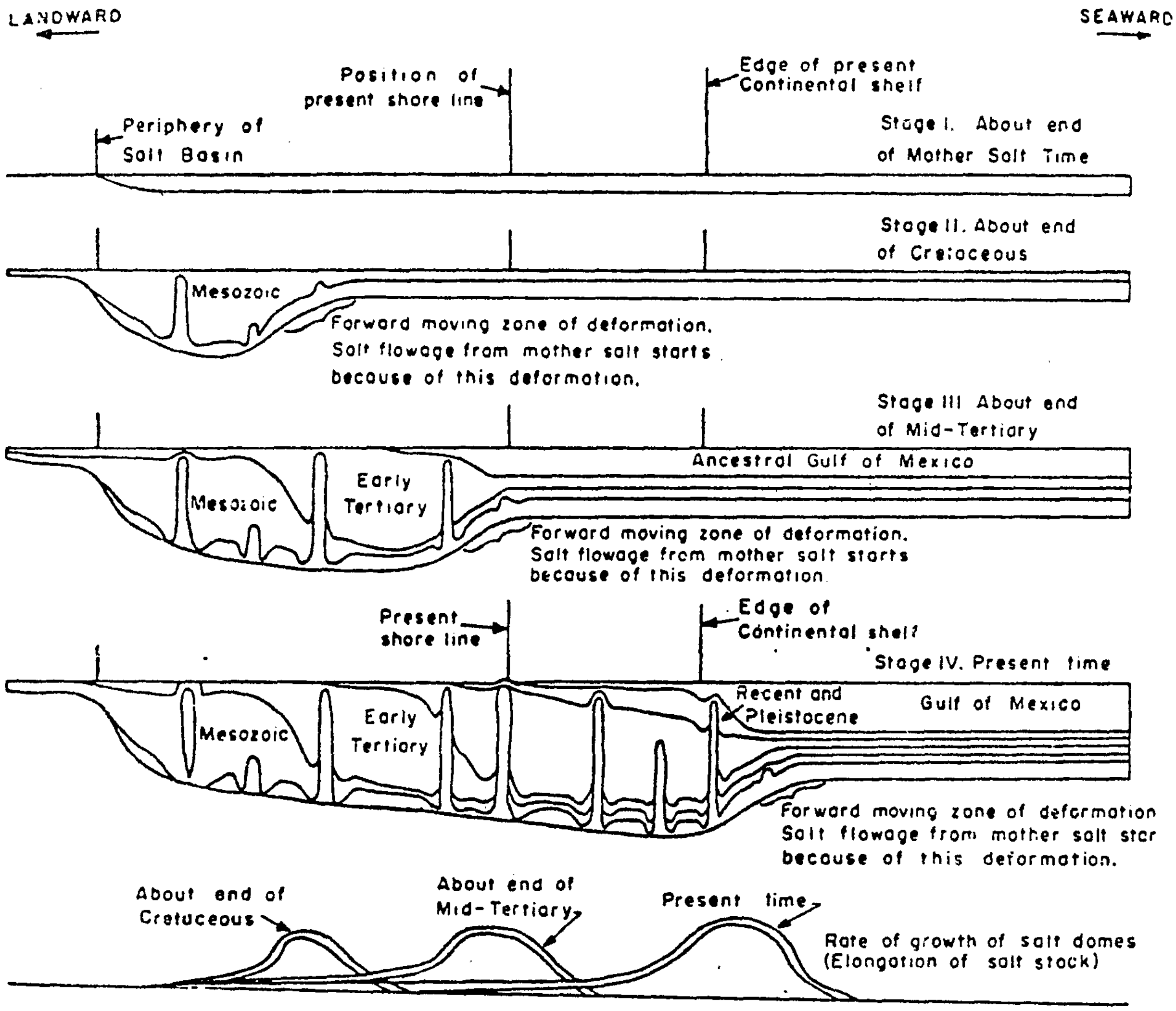


Figure 2.1 Idealized Sections Showing Development of the Gulf Coast Geosyncline and Growth of the Salt Domes.

It was the size and shape of the original surface irregularities of the salt that controlled the early rates of vertical movement. This in part explains the differences in the present day size of salt domes.

As the salt rises, sediment stretching and normal block faulting occurs in the overlying sediments. The increasing permeability along the fault planes allows the relatively easy descent of meteoric water. This water combined with existing ground water leaches the upper leading edge of the salt dome leaving various insoluble residues such as anhydrite, and minor amounts of dolomite, calcite, barite, pyrite, quartz, and sulfur.[3] The continuing rise of the salt further fractures the caprock allowing deeper water percolation and additional salt leaching, and hydration of the upper anhydrite layers. The result is a thickening of the caprock and the formation of gypsum. These residues are the prime constituents of the salt dome caprock.

2.1.2 Physiography and Man-Made Land Forms

There is no natural topographic expression of the Choctaw Salt Dome. The surface area is swampy with an elevation of approximately six to seven feet above sea level (see aerial photograph, Figure 2.2). The dome is located completely within the backwater swamp, on the eastern margin of the Atchafalaya Basin, to the west of the natural levee of the Mississippi River. To the east of the dome is the right natural levee of the Mississippi River, approximately three and one-half miles wide. As defined by agricultural development only the western margin of the natural levee is seen in the aerial photograph of Figure 2.2. To the south, west, and north, the backwater swamp stretches for at least ten miles without interruption. To the south the fresh water swamp forest continues for fifty miles and eventually grades into brackish and salt water marsh which ends at the Gulf Coast some eighty-one miles to the south of the dome.

A number of man-made or man-induced landforms and canals are present on and around the site. Two-thirds of a mile to the west of the dome is the Intracoastal Waterway that leaves the Mississippi River by lock about 1.5 miles south of Port Allen and extends southward to connect with the rest of the Intracoastal Waterway system

Figure 2.2 Aerial Photograph of Bayou Choctaw Site.

further south. Oil companies active in the area and Allied Chemical have constructed numerous artifical levees for road beds. In the process of developing the peripheral oil field, forest clearing and dredging of canals provided access to wells and pipeline connections. To the north and west of the central facilities of Allied Chemical is a small lake about 660 feet in diameter. The lake formed when the sediment and caprock overlying cavity No. 7 collapsed. The cause of the failure was the leaching of salt above the cavity around the casing and subsequent erosion of the caprock material. This collapse could have been avoided if a sufficient oil blanket had been maintained to prevent upward salt leaching and caprock erosion.

2.1.3 Regional Geology

The Bayou Choctaw salt dome lies within the eastwest trending Gulf Coast Geosyncline, which is characterized by more than 40,000 feet of sediment. Near the dome there are more than 9,000 feet of unconsolidated to poorly consolidated Miocene and younger sediments composed principally of sands and shales.

The dome is located 45 miles north of the early Miocene, westerly trending geosynclinal axis and near the north central perimeter of the Texas-Louisiana Coastal Basin, shown by the introductory maps. The monoclinal strata of the geosyncline through which the salt is rising dip in a southeasterly direction. The Miocene sediments are faulted by normal dip slip faults that strike northeast and are downthrown on the south side. The faults occur around the salt but do not cut the salt. Even if faulting was reactivated along existing fault planes it is unlikely that the salt would be affected because at the existing temperatures and pressure the salt is not subject to brittle failure.

Seismic activity in the Gulf Coast region is very low. The National Oceanic and Atmospheric Administration (NOAA) has classified the United States into four zones with differing degrees of expected seismic risk. These subdivisions are based on the recorded history of past seismic activity. Zone 0 covers areas having no reasonable expectancy of surface earthquake damage; Zone 1, expected minor damage; Zone 2, expected moderate damage; and Zone 3, possible major destructive earthquakes.

The Bayou Choctaw dome project area lies within the boundary of seismic risk Zone 1. In order to acquire more specific information, an earthquake data search was requested from the NOAA seismic information service. This NOAA office has catalogued the records of all known tremors occurring since the mid 1800's. The data search was requested to cover the rectangle from 28°55' north to 30°19' north, and from 90°10' west to 95°45' west. The results of the search indicated that only one earthquake was reported in this area. It occurred on October 19, 1930 at an epicenter approximately 4 miles southeast of Donaldsonville. A Richter magnitude was not recorded, but on the modified Mercalli scale the intensity was recorded as VI at Donaldsonville.* See Appendix G, page 12, for a discussion of the possibility of triggering an earthquake by brine injection.

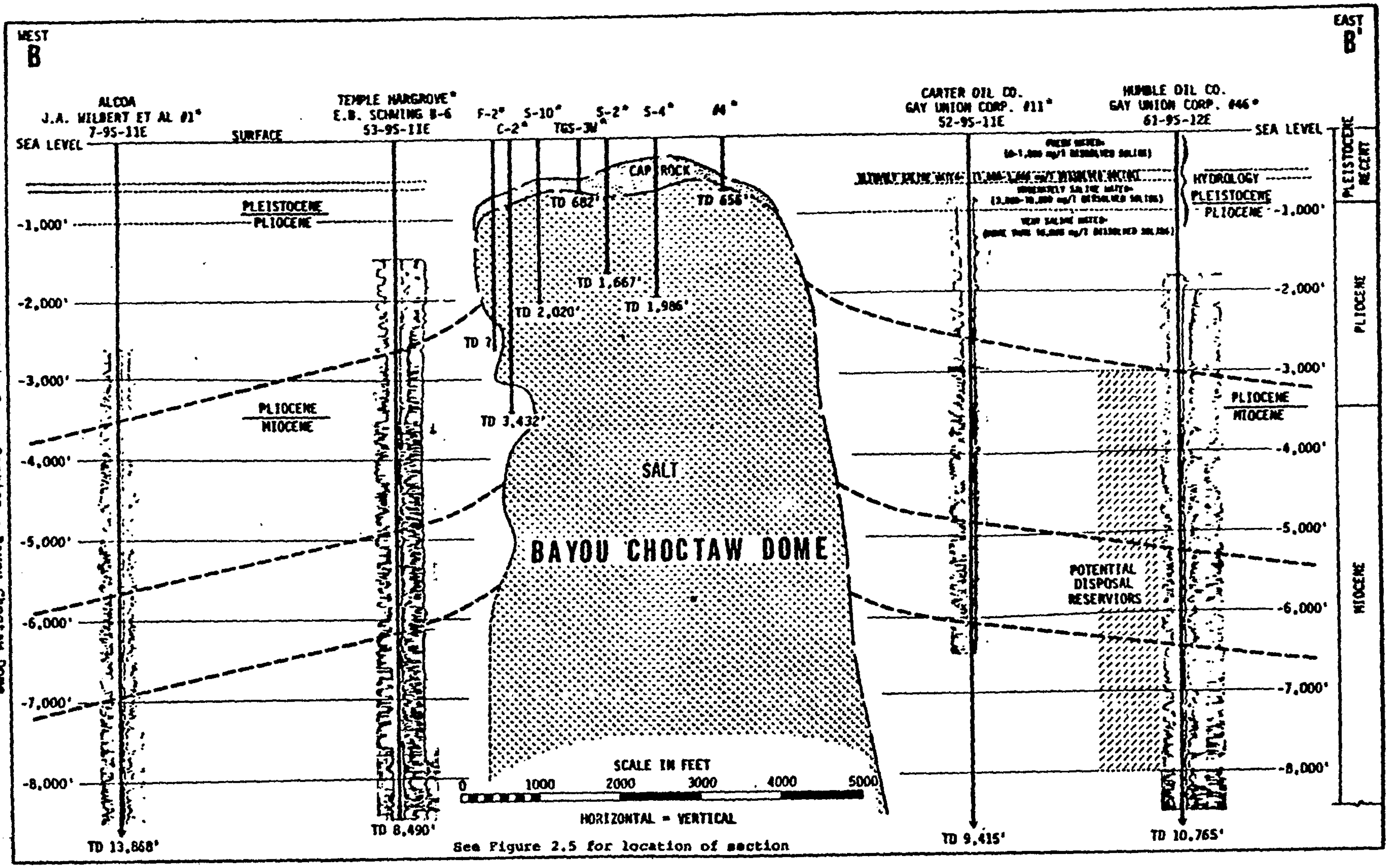
2.1.4 Local Geology

The Bayou Choctaw salt dome is nearly circular in plan view, a shallow, somewhat undulating, steep sided, overhanging, piercement type salt dome lying within the Texas-Louisiana Coastal Salt Dome Belt. Pleistocene and Recent age unconsolidated and partially consolidated sediments overlie the dome caprock with as little as 237 feet to as much as 839 feet of sands and muds.

Geological cross-sections, Figures 2.3 and 2.4, were constructed, using electric logs where available, to show in part the local sedimentary sequences and their relationship to the piercement salt mass. In areas where electric logs were available, predominantly over the more shallow portions of the dome, "stick plots" were utilized to show those wells having subsurface data on the caprock and/or salt tops.

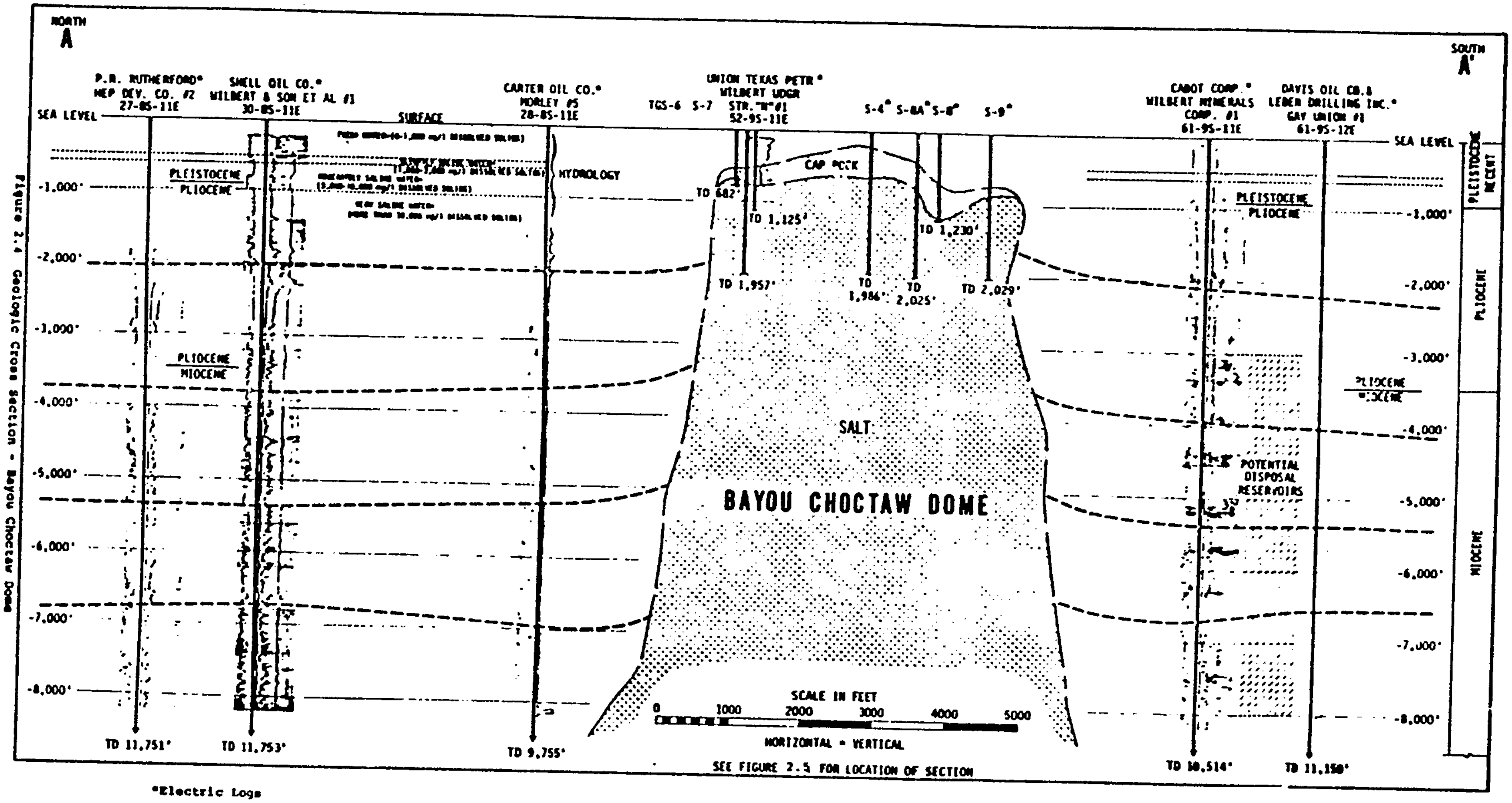
Unconsolidated and partially consolidated sands and shales of Pliocene and Miocene age underlie the Pleistocene and extend downward to about -9,000 feet. The thickness of the Miocene age formations in the Bayou Choctaw area is estimated to be about 6,000 ft., with the base of the Miocene probably at about -9,000 feet elevation. In the immediate vicinity of the dome these sediments have been forced upward by the salt piercement structure as shown on the cross-sections.

*At VI on the Mercalli scale, windows and glassware may be broken, knicknacks may fall off shelves, and furniture is moved or overturned.



*Electric Log

Figure 2.3 Geologic Cross Section - Bayou Choctaw Dome



*Electric Logs

Figure 2.4 Geologic Cross Section - Bayou Choctaw Dome

Faulting around the dome, within the Miocene and overlying Pliocene formation, is thought to be extensive and complex. Studies of numerous domes in the Gulf Coast area generally show a series of regional eastwest trending, south dipping faults downthrown on the south. Also, in the immediate area of the dome it is expected that where sufficient drilling has been done a characteristic fault pattern will be exposed exhibiting primary, normal, radial faulting with subsidiary, arcuate, concentric, normal faults between the radial faults. The greatest displacement is generally at depth and becomes progressively smaller upward. It is believed that faulting generally dies out short of the shallow, less saline aquifers. Based on seismic records these faults appear to be inactive today. Since the faults described do not enter the less saline aquifers there is little chance of communication with the deeper more saline aquifers.

2.1.5 Salt Dome Characteristics

Caprock: The caprock overlying the Bayou Choctaw salt dome is made up of insoluble residues of the salt and their alteration products. Studies of other domes suggest that a topmost zone of calcite several tens of feet thick can be present and that below the calcite a zone of gypsum generally somewhat thicker than the calcite may be found. Below the gypsum a zone of anhydrite varying in thickness but possibly several times as thick as the upper zones is usually present.

An analysis of records of drill holes penetrating caprock and salt indicate a highly irregular caprock surface and thickness. Geologic cross-section A-A' (Fig. 2.3) shows a caprock thickness of some 470 feet in an isolated area. General caprock thickness seems to vary from 200 feet to 400 feet. It appears that the caprock completely overlies the central salt stock but is not draped over the sides. Voids or sedimentary rock inclusions are reported to have been encountered during some of the caprock drilling. Geological cross-sections A-A' and B-B' (Fig. 2.3 and 2.4) show the lateral extent of the caprock as interpreted from available subsurface data.

Caprock is commonly intensely fractured, faulted and brecciated due to the upward pressures exerted by the rising salt stock. During periods when the salt is not rising as fast as the dissolution of the salt is occurring, the caprock may be partially unsupported and fall along new or pre-existing fault planes, thus creating brecciation commonly encountered by drilling.[3] This process is very slow, however, and probably would not have significant effects on the proposed project.

The faulting and fracturing which occurs in the caprock many times results in the formation of vuggy to cavernous porosity and associated high permeabilities. As a result, severe drilling fluid loss is often encountered while drilling the caprock interval, but the danger of subsidence is minimal.

Salt: A geologic structure map contoured on top of the salt and caprock (Fig. 2.5) and the accompanying geologic cross-sections A-A' and B-B', (Fig. 2.3 and 2.4) show the shape of the top of the salt mass as interpreted from the data yielded from some 30 drill holes reported to have penetrated the salt.[4]

Salt geometry shows a sharp piercement structure, almost circular in plan, having a broad irregular top at a depth below sea level of from -500 to -1,200 feet. The sides of the dome show steeply dipping contours, with the east side dipping at about 79° and gradually increasing to vertical. Overhang is demonstrated on the west side of the dome with at least ten holes penetrating the salt interval in this area. The shape of this salt overhang significantly decreases the area available for solution mined storage cavern construction. The lateral extent of the undercut of the salt on the west side is not known and a program of investigation would be required prior to any construction of the west perimeter of the dome. Only one of the existing cavities, however, and none of the cavities proposed for utilization in the SPR are located near the western boundary of the salt dome (see Appendix H).

The shallowest known salt occurrence is at -645 feet near the center of the dome while the deepest salt top intersection is at -9,327 feet on the extreme east flank. The surface area within the -2,000 foot salt contour is 330 acres while the area enclosed by the -3,000 foot contour is some 360 acres. The east-west axis of the dome at the -2,000 foot level is nearly 3,200 feet while the north-south axis is about 3,600 feet.

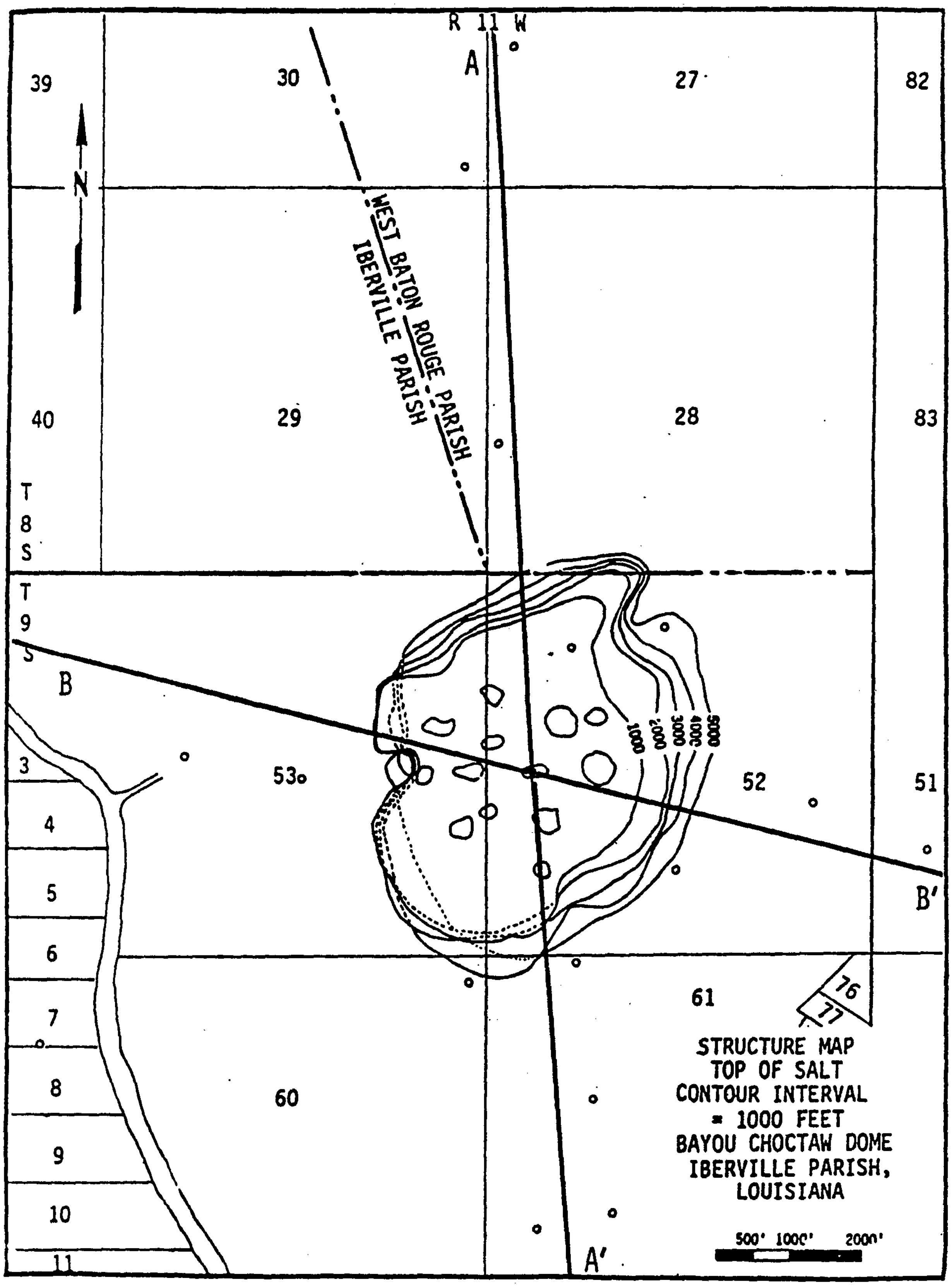


Figure 2.5 Salt Structure Contour Map of Bayou Choctaw Dome.

Faulting is commonly associated with a piercement type salt dome in the caprock immediately overlying the salt, and in adjacent formations whose bed boundaries were penetrated by the dome's rise. These faults have no effect on the storage characteristics of the dome since salt does not exhibit brittle failure under pressure.

The composition of the salt varies throughout the dome. In general, however, finely bedded and disseminated anhydrite will be present in amounts of perhaps three to seven percent and other insoluble minerals will comprise less than one percent of the volume of the dome. Blocks of sandstone and shale through which the piercement structure has passed will be found incorporated in the outer portions of the salt.

2.1.6 Soil Characteristics

Soil series on, and adjacent to the Choctaw Salt Dome in the parishes of Baton Rouge and Iberville include soils similar to the Commerce, Mhoon, and Sharkey soil series. The Barbary and Fausse series which are very similar to the Sharkey series may also exist in the vicinity. The Choctaw Salt Dome area is well within the backwater swamp area, and on the site itself the dominant soil series expected to be found will be the Barbary and Sharkey soils or soils closely related to them.

The following soil descriptions, developed by Lytle (1971), are samples of the range of typical soils to be found in and around the Choctaw site and possible areas of impact.[4] Detailed profile descriptions are not provided for Fausse or the Barbary soil series, but it should be kept in mind that they are very similar to the Sharkey series in development and represent what might be reasonably considered the extremes of a soil catena in which Fausse represents the better drained member and Barbary the wet member.[4]

The moderately well drained Commerce soils have a dark grayish brown loamy surface soil and brown mottled, silt loam or silty clay loam subsoil which is underlain at 24 to 30 inches by gray mottled brown silt loam or silty clay loam. The somewhat poorly drained Mhoon soils have a grayish brown silt loam, silty clay loam, or silty clay surface layer that is underlain at about 12 to 16 inches by gray mottled, stratified layers of silt loam, silty clay loam, and silty clay.

The poorly drained Sharkey soils have a dark gray or very dark gray plastic clay surface layer over a gray plastic clay subsoil and substratum. The Commerce, Mhoon, and Sharkey soils range respectively from slightly acid to moderately alkaline in reaction.

The principal use of the Commerce and Mhoon soils series is the farming of sugar cane and some mixed agriculture. The Fausse and Sharkey soils series are somewhat marginal for farming, particularly because of years of extreme flooding or where there is poor drainage. The poorly drained Sharkey and Barbary soil series are of little value agriculturally and are either left as backswamp or, in some areas, as pasture.[5] Therefore since the proposed project site is in the backswamp area there is little likelihood that a significant impact would be made to agricultural activities in the area.

2.1.7 <u>Regional Land Uses</u>

<u>Mineral and Fossil Fuel Extraction</u>: Since its discovery in 1931 by Standard Oil of Louisiana, the Choctaw Salt Dome oil and gas fields have been in continuous production. As noted earlier, associated with these wells are a number of access roads and dredged canals as shown in the aerial photograph of Figure 2.2. The pipeline rights-of-way associated with these and other fields are shown on a portion of the Oil and Gas Map of Louisiana, Figure 2.6.

The Allied Chemical Corporation is the principal user of the Bayou Choctaw dome and has occupied the site since 1934 for brine production. Space at the dome is also used for hydrocarbon product storage by Shell Oil Company and others under lease arrangements with Allied. Figure H.1 shows the present configuration (from a plan view) of caverns and their present degree of commitment for hydrocarbon storage.

<u>Agriculture:</u> The Choctaw Salt Dome is entirely located within the fresh backwater swamp to the west of the natural levee of the Mississippi River. No farming activity exists on the site of the proposed project, however, one mile to the west, agricultural development of the natural levees has been continuous for at least one hundred years. The primary crop on these natural levees is sugar cane, though in some areas cotton, soybeans, and truck crops are planted. Where the proposed pipeline would cross the natural levee, the agricultural development is about two to three miles wide. Some

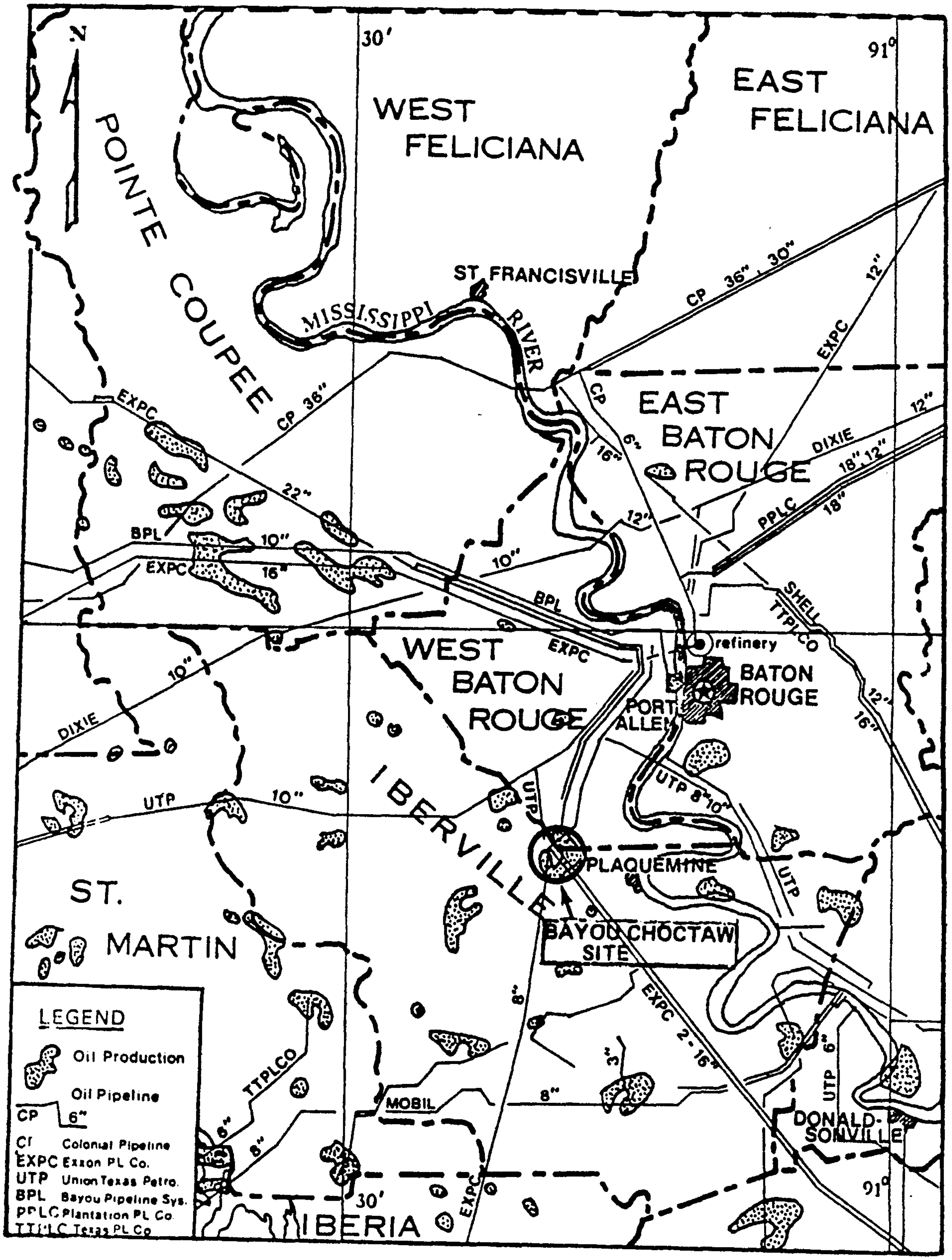


Figure 2.6 Pipelines in the Vicinity of Bayou Choctaw Site.

logging may periodically occur where mature stands exist, but accurate information on this use is not readily available. Through careful observations of the aerial photograph of Figure 2.2, it appears that logging of the area has not occurred recently.

Residential/Commercial Development: Except for the industrial development of Allied Chemical, no other operative developments were identified at the Choctaw Salt Dome. Residential development associated with the farms on the natural levees is present one or two miles to the east. Most residences are confined to the natural levees and none of them would be along the pipeline right-of-way. The residential communities near the Choctaw Salt Dome are Plaquemine and Morrisonville, on the Mississippi River (see Figure 2.7).

Recreation and Wildlife Resources: The recreation and wildlife resources of the area are both numerous and vast. However, most of the area of land involved in developing the Choctaw Salt Dome has already been disturbed. Only a few designated historical or recreational areas exist in the vicinity of Choctaw salt dome and they would not be affected by the project. Figure 2.7 taken from the Inventory of Basic Environmental Data, South Louisiana (1973) shows many of these resources identified by the Army Corps of Engineers and their relative proximity to Choctaw Salt Dome.[6]

The only designated recreational and wildlife areas that might be impacted are downstream along Bayou Choctaw and they would be affected only in the case of accidental oil spill in the Bayou.

2.1.8 Potential Development of the Site and Adjacent Areas

The potential development of the immediate vicinity in and around the Choctaw Salt Dome is restricted to activities involving mineral or fuel extraction and/or storage, inasmuch as the physical environment places severe constraints on the types of land use that are feasible for backwater swamp and coastal marshes. Recent studies have clearly delineated the impacts of swamp and marsh development and have shown that in the long run these so-called "land reclamation projects" are for the most part long term failures.[7] The history of the delta of Louisiana abounds with records of land reclamation failures. The reasons for these failures and the low potential of development results from the undesirable engineering properties of flood basin deposits.

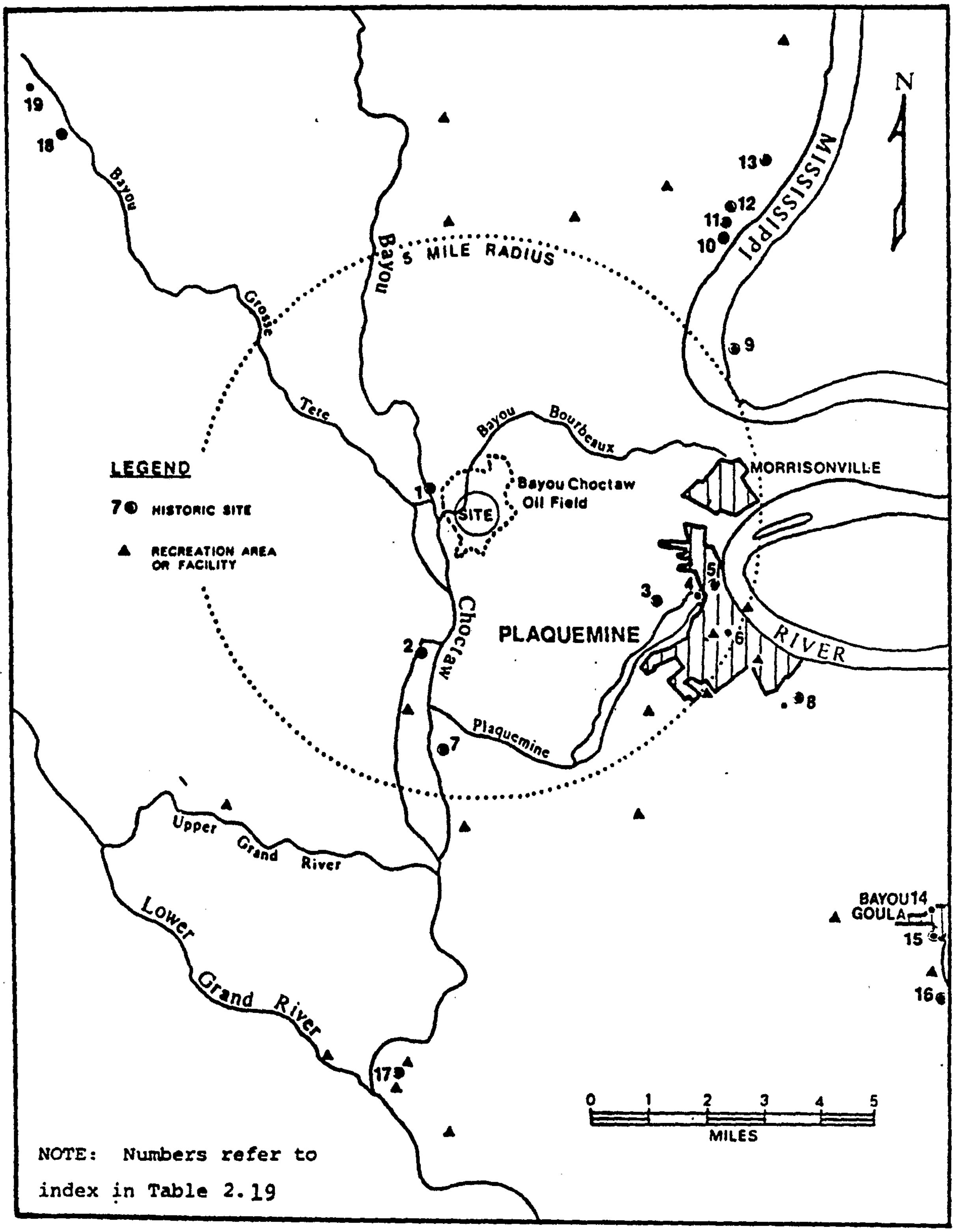


Figure 2.7 Recreational Areas and Historic Sites in the Vicinity of Bayou Choctaw Site.

The soil in this area provides an unstable foundation which makes the types of structures that can be built and maintained costly. The land surface often subsides below the surrounding water table, making it difficult to maintain drainage. With the reduction of the natural vegetation, erosion is increased and, as a result, canals become clogged. Side wall slumping into the canal also increases the cost of maintenance.

It is therefore unlikely that the land would be developed for purposes other than those relating to oil, gas, salt extraction and/or storage of petroleum products.

The agricultural areas to the west would not be disturbed by the proposed project and would probably remain as they are for the foreseeable future.

2.2 WATER ENVIRONMENT

The Bayou Choctaw Dome is located in the Terrebonne-Verret Drainage Area which is situated between the Atchafalaya and Mississippi River basins.[6] The northern half of the area is predominantly dry land while the southern half of the area is marshland. Surface water in the area is fresh with a salinity of less than .25 parts per thousand (ppt). Annual precipitation is on the order of 56-60 inches.[8] As shown in Figure D.1-1 of Appendix D.1, the region generally experiences a winter-spring precipitation surplus* of approximately 17 inches, while as shown in Figure D.1-2 of the same appendix, the summer-autumn precipitation surplus is approximately 2-3 inches.[9] In spite of the apparent abundance of rainfall during certain months of the growing season, which extends from February through November, evaporation and use by plants exceeds precipitation. This precipitation deficit** as indicated in Figure D.1-3 amounts to an average of 5-6 inches per season.[11]

2.2.1 Surface Water System

The surface water system is comprised of a network of rivers, bayous, canals and waterways, with several small lakes. The surface water system of interest to this study is shown in Figures 2.8 and 2.9. The surface waters affected by the proposed action include a section (reach) of the Mississippi River (Mile Point 228.4 to Mile Point 208.8), a portion of the Intracoastal Waterway including the Port Allen Canal and Choctaw Bayou, Bull Bay, Bayou Bourbeaux, and several smaller canals and bayous. The pond created by the collapse of Cavern No. 7 (linked to Bayou Bourbeaux and

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*Precipitation surplus represents the "extra" precipitation which is not utilized for evapotranspiration of soil moisture recharge; the surplus, therefore, represents water available for ground water recharge or subsurface runoff.[11]

**The deficit is defined as the difference between actual and potential evapotranspiration; it represents an index of moisture supply for vegetation.[10]

Bull Bay) is a significant water supply for the proposed project.

2.2.1.1 Hydrology

The Mississippi River is the major surface water body. The reach of interest for this project is bounded by two U. S. Army Corps of Engineers gaging stations, one located at Baton Rouge (Gage 01160 at Mile Point 228.4), and the other at Donaldsonville (Gage 01120 at Mile Point 175.4). There are no other gaging stations within this reach. Relevant hydrologic data are summarized in Table 2.1. Generally, stream flow is relatively constant over this 53 mile reach. The stream cross section is approximately 130,000 square feet (average river width of 2,600 feet with an average depth of 50 feet).[12] River velocities vary from 1.3 feet per second to 8.3 feet per second[13] primarily as a function of changes in stream flow. Monthly variations in flow rate are presented in Appendix D.2. The largest flow rate observed over the 98 years of record was 1,473,000 cfs; the minimum observed flow was 73,700 cfs.[8] Monthly data for the period of October 1973 through September 1974 indicate a high flow rate of 1,160,000 cfs and a low flow rate of 398,000 cfs. The average flow for the 1973-1974 time period was 925,000 cfs. In a typical year, high flow conditions occur during January, and low flow conditions occur in September through October. The Intracoastal Waterway intersects the Mississippi River at Mile Point 228.5 (0.1 mile from the gage 01160), and extends approximately 60 miles south to Morgan City. The waterway connects a series of bayous and drainage canals as shown in Figures 2.8 and 2.9.

The Port Allen Canal, which is synonymous with the portion of the Intracoastal Waterway under consideration, is connected to the Mississippi River by the Port Allen Locks located at Mississippi River Mile Point 228.5 at Baton Rouge. The locks are located approximately 14 waterway miles north of the Bayou Choctaw salt dome. The section of the canal extending from the locks to the dome area is trapezoidal in cross section, with a bottom width of 120 feet and a top width of 200 feet. Water depth is controlled at approximately 12 feet;

Table 2.1

Mississippi Water Quality Parameters Exceeding Proposed or Recommended EPA Standards

Location*	Parameter
Port Allen Lock Forebay	suspended solids, phenols, diazinon
Baton Rouge	dissolved cadmium
Baton Rouge harbor	suspended solids, phenols, diazinon
Mile 224	suspended solids, cyanide, phenols
Mile 212	suspended solids, phenols, DDD
Plaquemine	suspended solids, cyanide, mercury

*Location of all stations are indicated in Figure 2.9

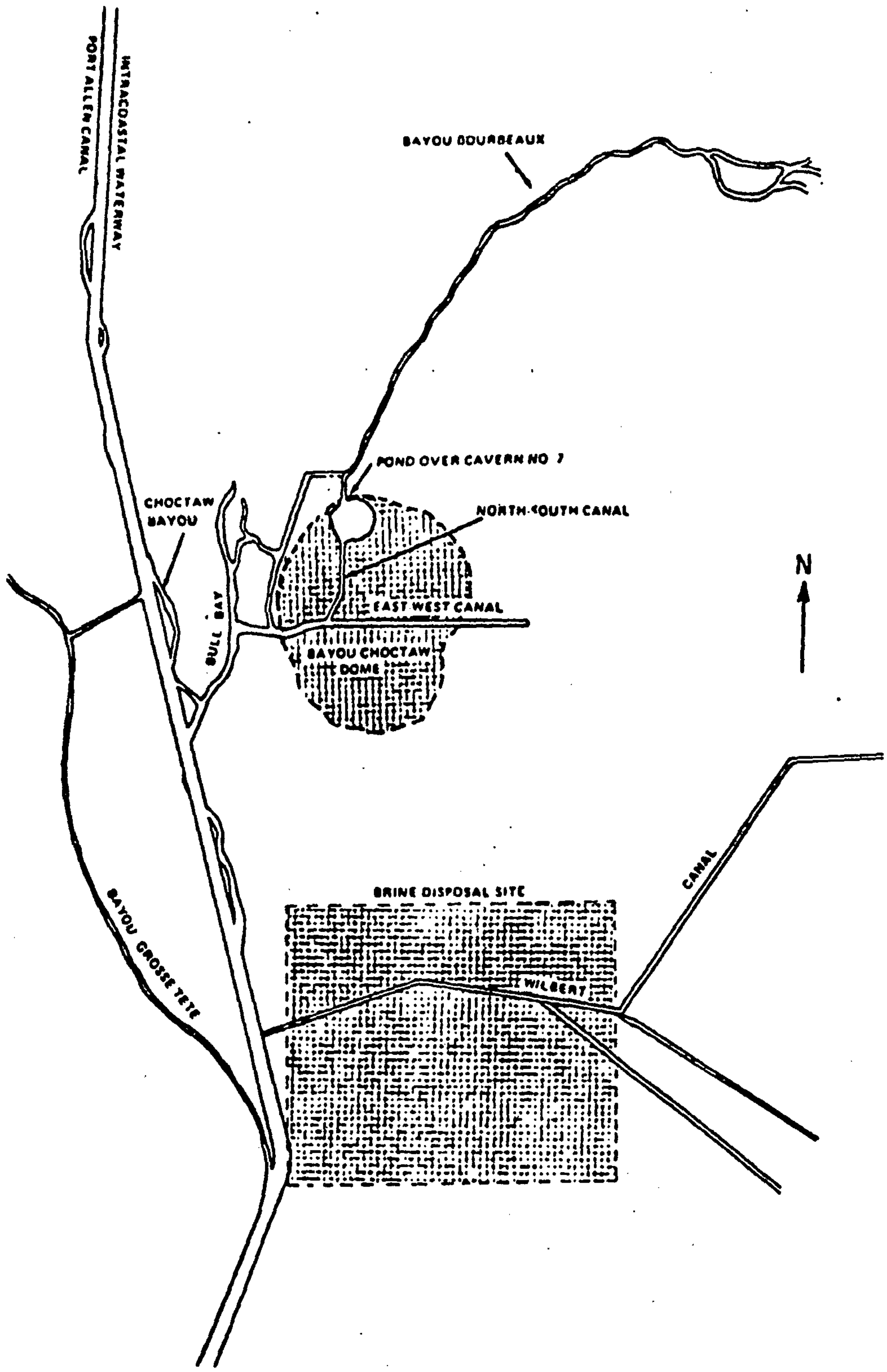

Figure 2.8 General Arrangement of Surface Water System in the Vicinity of the Bayou Choctaw Site (Small Scale Map)

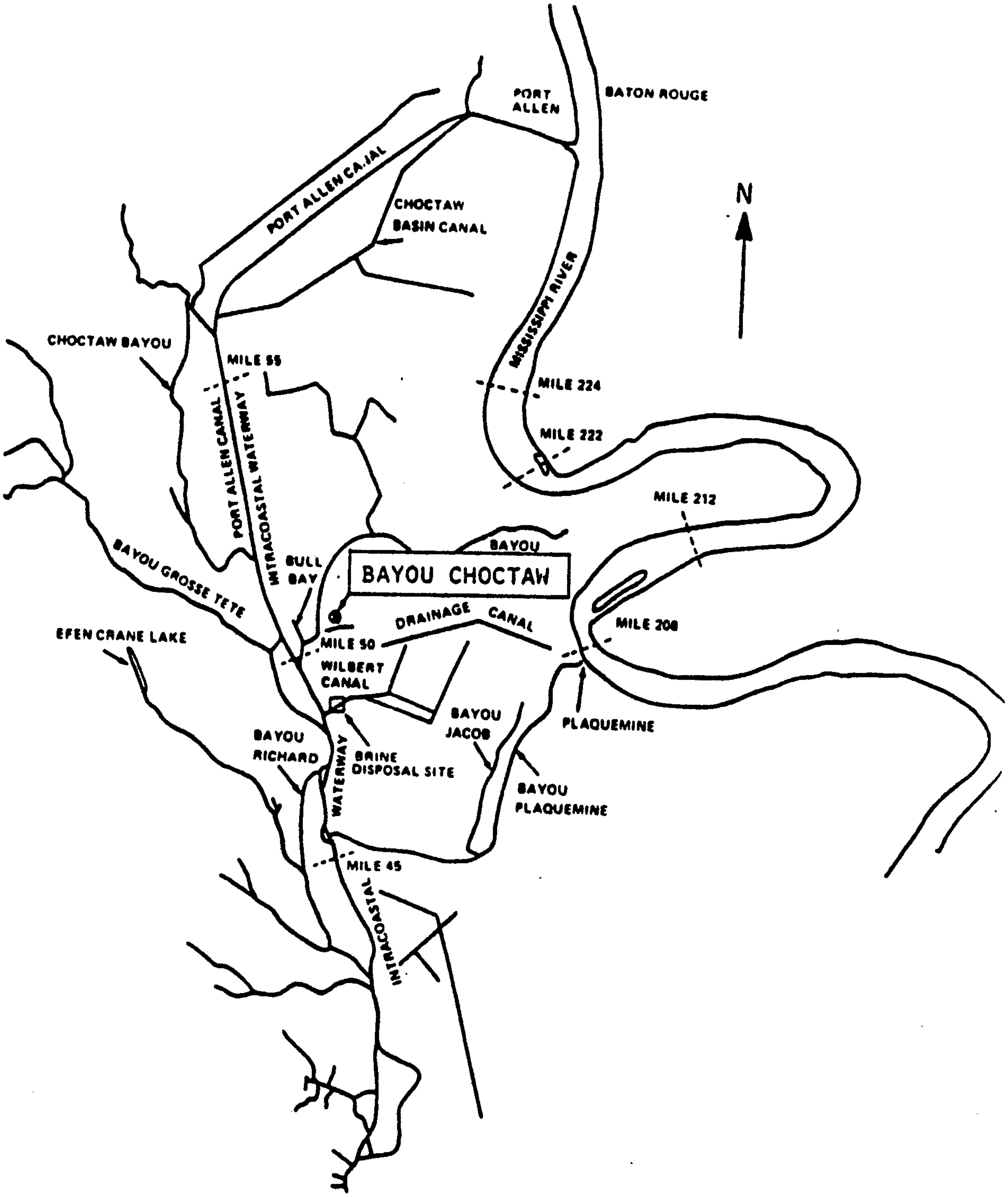

Figure 2.9 General Arrangement of Surface Water System in the Vicinity of Bayou Choctaw Site (Intermediate Scale Map)

however, fluctuations in depth do occur. The maximum design discharge of the locks is 3,500 cfs. The resulting velocity of water at a 12-foot depth in a trapezoidal channel of the above dimensions is 1.82 feet per second.

Tributaries to the Port Allen Canal in the vicinity of the Bayou Choctaw* salt dome include the Choctaw Bayou,* Bull Bay, Bayou Bourbeaux, the North-South Canal, and the East-West Canal. Both the North-South and the East-West Canals intersect the dome area and serve as recharge areas to the pond created by the collapse of Cavern No. 7. No volumetric flow data are available for these waterways. Water flow is typically sluggish (low velocity) and intermittent. Factors controlling water quantity include seasonal variations in precipitation, seasonal variations in flow of the Mississippi and Atchafalaya Rivers, and the regulated flow in the Port Allen Canal. For example, water depth in the North-South and the East-West Canals has been observed to vary between 4 feet and 14 feet.[14] Data for these waterways are presented in in Table 2.2.

Drainage from the land area encompassing the bayous and canals is toward the Port Allen Canal (westerly direction). However, due to minor variations in the slope of the land and the dominance of the volumetric flow rates in the Mississippi and the Atchafalaya Rivers, and the Port Allen Canal, flow direction is variable. These bodies of water determine the direction of flow in smaller connecting portions of the Intracoastal Waterway, including the bayous and canals. Therefore, under certain conditions backflow into the bayous and canals in the vicinity of the dome occurs. These waters are also affected by the tidal action of the Gulf of Mexico.[15] Navigation and flood control have been the impetus for the development of this portion of the Intracoastal Waterway.

*The dome is referred to as "Bayou Choctaw Dome" but the associated bayou is called "Choctaw Bayou"

Water Body	Location: Distance (miles) and Bearing from Storage Site	Direction of Flow	Major Connections
Bayou Bourbeaux	0.1 W	N-S	Bull Bay
Bayou Grosse Tete	1.2 W	NW-SE	Choctaw Bayou
Bayou Jacob	3.8 SE	NE-SW	Bayou Plaquemine
Bayou Plaquemine	4.2 S	E-W	Bayou Chactaw, Bayou Jacob
Bayou Richard	1.8 SW	N-S	Bayou Grosse Tete
Bull Bay	0.5 W	N-S	Choctaw Bayou, Bayou Bourbeaux
East-West Canal	0.1 S	E-W	Bull Bay, North-South Canal
North-South Canal	1.9 NNE	N-S	Bayou Bourbeaux
Choctaw Bayou	0.7 W	N-S	Bayou Grosse Tete, Bayou Plaquemine, Bull Bay, Wilbert Canal, Port Allen Canal
Efen Crane Lake	3.2 W	N-S	Bayou Richard (via unnamed canal and bayou)
Intracoastal Waterway	(see Port Allen Canal)		
Mississippi River	4.0 E	N-S	Gulf of Mexico, Port Allen Canal
Port Allen Canal	1.9 NW	N-S	Mississippi River, Choctaw Bayou, Bull Bay Bayou Grosse Tete, Bayou Plaquemine
Wilbert Canal	1.4 S	E-W	Choctaw Bayou

Table 2.2 Surface Water Bodies in the Vicinity of Bayou Choctaw Dome

A pond was created when Cavern No. 7 collapsed. The pond is connected to the Bayou Bourbeaux and the East-West Canal via the North-South Canal. The surface area of the pond is approximately 12 acres; its depth is 85 feet. Assuming a conical shape, the volume of the lake is approximately 110 million gallons.

The Wilbert Canal intersects the Port Allen Canal one mile south of the confluence of the canal with Bull Bay. The Wilbert Canal crosses the proposed brine disposal site. No data are available for this waterway, although it is probably similar to the East-West Canal both in geometry and flow. The Wilbert Canal, however, probably has a larger volumetric flow rate than the East-West Canal during periods of intense precipitation, due to the relatively larger area drained by this canal system.

Other waterways within the vicinity of the Bayou Choctaw salt dome include the Bayou Grosse Tete, Bayou Plaquemine, and numerous smaller bayous.

2.2.1.2 Water and Sediment Quality

The State of Louisiana has promulgated water use designations for the waterways of interest to this study. Numerical limits for selected parameters (i.e., physical, chemical, and biological characteristics) have been established. (See Tables D.4-1 through D.4-4 of Appendix D.4.) The Mississippi River is the only surface water body in the vicinity of the Bayou Choctaw salt dome that is designated for use as a raw domestic water supply. The Mississippi River, the Choctaw Bayou, the Bayou Grosse Tete, the Bayou Plaquemine, and the Intracoastal Waterway are all designated as suitable for secondary contact recreation, (e.g., swimming, boating) and for the propagation of fish and wildlife.

Tables 2.3 and 2.4 present available water and sediment quality data for the Mississippi River, Bayou Plaquemine, and the Intracoastal Waterway. The locations at which these data were collected are shown in Figure 2.9. Four sites along the Mississippi River (Mile Points 228.5, 224, 212, and 208), one on Bayou Plaquemine, and four on the Intracoastal Waterway (mile points 55, 50, 45 and

	MISSISSIPPI RIVER			BAYOU PLAQUEMINE		INTRACOASTAL WATERWAY	
	**MP 228.5		MP 208.8				
	State Criteria	Measured (July)	Measured (July) (Oct)	State Criteria	Measured (March)	State Criteria	Measured (March)
Chloride (mg/l)*	<75	17	28/28	<250	--	<250	--
Sulfate (mg/l)	120	50	57/56	75	--	75	--
Dissolved Oxygen (mg/l)	>5.0	6.8	6.8/8.4	>5.0	10.4	>5.0	8.1
pH	6.5-9.0	7.7	7.3/7.8	6.0-8.5	7.5	6.0-8.5	7.5
Coliform (colonies/100 ml)	2000+	--	6.20/2800	1000	--	1000	--
Maximum (°C)	32	29.5	29.0/18.5	32	11.3	32	15.5
Total Dissolved Solids (mg/l)	400	231	279/--	500	--	500	--

* mg/l = milligram/liter
** MP = mile point

+Total Coliform

Table 2.3 Comparison of Selected Surface Water Quality Parameters with Promulgated State Criteria

Table 2.4 COMPARISON OF SELECTED SURFACE WATER AND SEDIMENT QUALITY PARAMETERS WITH EXISTING CRITERIA, MISSISSIPPI RIVER, MP 228.5

PARAMETER	PROPOSED EPA CRITERIA Public Water Supply (μg/l)	Aquatic Life (μg/l)	RECOMMENDED LIMIT FOR SEDIMENT (mg/kg)	MP 228.5 Water (μg/l)	MAX APRIL '75 Sediment (mg/kg)
Arsenic	50	-	-	1	5
Cadmium	10	30+	-	1	2
Chromium	50	50	-	0	9
Copper	1000	1/10 LC50	-	4	10
Lead	50	30	<50	0	30
Mercury	2	0.2	<1	.1	.1
Nickel	-	1/50 LC50	-	0	10
Zinc	5000	5/1000 LC50	<50	10	44
COD	-	-	<50000	25000	22000
TKN	-	-	<1000	460	730
Oil & Grease	-	-	<1500	3000	<1000
Sulfide	-	2.0	<1700	-	-
Suspended Solids	-	80000	-	168000	-
Phenols	1.0	100	-	17	-
Cyanides	200	5	-	0	0
PCB	-	0.002	-	0	.011
Aldrin	1	0.01	-	<.01	0
DDT	50	0.002	-	0	0.0024
DDD	-	-	-	0	0
DDE	-	-	-	0	0
Dieldrin	1.0	0.005	-	0	.0018
Chlordane	3.0	0.04	-	0	.008
Endrin	0.2	0.002	-	0	.0005
Heptachlor	0.1	0.01	-	0	0
Lindane	4.0	0.02	-	0	0
Toxaphene	5.0	0.01	-	0	0
Diazinon	-	0.009	-	<.01	-
Malathion	-	0.008	-	0	-
Parathion	-	0.001	-	0	-

+4 μg/l when hardness <100 mg/l; 30 mg/l when hardness >100 mg/l

Table 2.4 (cont'd) COMPARISON OF SELECTED SURFACE WATER AND SEDIMENT QUALITY PARAMETERS WITH EXISTING CRITERIA MISSISSIPPI RIVER MP 224

PARAMETER	PROPOSED EPA CRITERIA Public Water Supply (µg/l)	PROPOSED EPA CRITERIA Aquatic Life (µg/l)	RECOMMENDED LIMIT FOR SEDIMENT (mg/kg)	MP 224 Water (µg/l)	MAX MARCH/APRIL '75 Sediment (mg/kg)
Arsenic	50	-	-	4	6
Cadmium	10	30+	-	0	1
Chromium	50	50	-	10	11
Copper	1000	1/10 LC50	-	8	1
Lead	50	30	<50	4	<10
Mercury	2	0.2	<1	.1	0
Nickel	-	1/50 LC50	-	2	7
Zinc	5000	5/1000 LC50	<50	20	11
COD	-	-	<50000	19000	1000
TKN	-	-	<1000	750	84
Oil & Grease	-	-	<1500	10000	1000
Sulfide	-	2.0	<1700	-	-
Suspended Solids	-	80000	-	26600	-
Phenols	1.0	100	-	30	-
Cyanides	200	5	-	10	0
PCB	-	0.002	H	0	0
Aldrin	1	0.01	-	0	0
DDT	50	0.002	-	0	.0003
DDD	-	-	-	0	.0003
DDE	-	-	-	0	0
Dieldrin	1.0	0.005	-	0	0
Chlordane	3.0	0.04	-	0	0
Endrin	0.2	0.002	-	0	0
Heptachlor	0.1	0.01	-	0	0
Lindane	4.0	0.02	-	0	0
Toxaphene	5.0	0.01	-	0	0
Diazinon	-	0.009	-	0	-
Malathion	-	0.008	-	0	-
Parathion	-	0.001	-	0	-

+4 µg/l when hardness <100 mg/l; 30 mg/l when hardness >100 mg/l

Table 2.4 (cont'd) COMPARISON OF SELECTED SURFACE WATER AND SEDIMENT QUALITY PARAMETERS WITH EXISTING CRITERIA MISSISSIPPI RIVER MP 212

PARAMETER	PROPOSED EPA CRITERIA Public Water Supply (μg/l)	PROPOSED EPA CRITERIA Aquatic Life (μg/l)	RECOMMENDED LIMIT FOR SEDIMENT (mg/kg)	MP 212 Water (μg/l	MAX MARCH/APRIL '75 Sediment (mg/kg)
Arsenic	50	-	-	0	3
Cadmium	10	30+	-	0	1
Chromium	50	50	-	20	15
Copper	1000	1/10 LC50	-	110	2
Lead	50	30	<50	9	<10
Mercury	2	0.2	<1	0	0
Nickel	-	1/50 LC50	-	3	10
Zinc	5000	5/1000 LC50	<50	160	14
COD	-	-	<50000	15000	3100
TKN	-	-	<1000	960	370
Oil & Grease	-	-	<1500	3000	1000
Sulfide	-	2.0	<1700	-	-
Suspended Solids	-	80000	-	250000	-
Phenols	1.0	100	-	16	-
Cyanides	200	5	-	0	0
PCB	-	0.002	H	0	0
Aldrin	1	0.01	-	0	0
DDT	50	0.002	-	0	0
DDD	-	-	-	.01	0
DDE	-	-	-	0	0
Dieldrin	1.0	0.005	-	0	0
Chlordane	3.0	0.04	-	0	0
Endrin	0.2	0.002	-	0	0
Heptachlor	0.1	0.01	-	0	0
Lindane	4.0	0.02	-	0	0
Toxaphene	5.0	0.01	-	0	0
Diazinon	-	0.009	-	0	-
Malathion	-	0.008	-	0	-
Parathion	-	0.001	-	0	-

+4 μg/l when hardness <100 mg/l; 30 mg/l when hardness >100 mg/l

Table 2.4 COMPARISON OF SELECTED SURFACE WATER AND SEDIMENT QUALITY PARAMETERS WITH
(cont'd) EXISTING CRITERIA BAYOU PLAQUEMINE

	PROPOSED EPA CRITERIA		RECOMMENDED LIMIT FOR SEDIMENT	(MARCH '75)	
	Public Water Supply	Aquatic Life		Water	Sediment
PARAMETER	(µg/l)	(µg/l)	(mg/kg)	(µg/l)	(mg/kg)
Arsenic		-	-	58	9.4
Cadmium		30+	-	0.5	<2
Chromium		50	-	<0.5	44
Copper		1/10 LC50	-	5	50
Lead		30	<50	<1.0	122
Mercury	NOT	0.2	<1	6.8	80
Nickel		1/50 LC50	-	14	31
Zinc	APPLICABLE	5/1000 LC50	<50	8.8	153
COD		-	<50000	16500	2000
TKN	FOR	-	<1000	680	1000
Oil & Grease		-	<1500	7500	9100
Sulfide	BAYOU	2.0	<1700	-	-
Suspended Solids		80000	-	127000	-
Phenols	PLAQUEMINE	100	-	-	-
Cyanides		5	-	-	-
PCB		0.002	H	-	-
Aldrin		0.01	-	<0.001	<0.0001
DDT		0.002	-	<0.006	<0.006
DDD		-	-	<0.005	<0.0014
DDE		-	-	<0.003	<0.0063
Dieldrin		0.005	-	<0.002	0.0053
Chlordane		0.04	-	0.015	0.023
Endrin		0.002	-	<0.003	0.0011
Heptachlor		0.01	-	<0.001	<0.0001
Lindane		0.02	-	<0.001	0.00085
Toxaphene		0.01	-	<0.05	<0.005
Diazinon		0.009	-	-	-
Malathion		0.008	-	-	-
Parathion		0.001	-	-	-

+4 µg/l when hardness <100 mg/l; 30 mg/l when hardness >100 mg/l

Table 2.4 (cont'd) COMPARISON OF SELECTED SURFACE WATER AND SEDIMENT QUALITY PARAMETERS WITH EXISTING CRITERIA INTRACOASTAL WATERWAY (ten miles south of Bayou Plaquemine)

	PROPOSED EPA CRITERIA		RECOMMENDED LIMIT FOR SEDIMENT	(MARCH '75)	
	Public Water Supply	Aquatic Life		Water	Sediment
PARAMETER		(µg/l)	(mg/kg)	(µg/l)	(mg/kg)
Arsenic		-	-	48	10.6
Cadmium		30+	-	0.5	<2
Chromium		50	-	<0.5	11
Copper	NOT	1/10 LC50	-	9.0	8
Lead		30	<50	<1.0	4.6
Mercury	APPLICABLE	0.2	<1	10	4.6
Nickel		1/50 LC50	-	14	16
Zinc	FOR	5/1000 LC50	<50	2.0	34
COD		-	<50000	13700	1300
TKN	INTRACOASTAL	-	<1000	270	1300
Oil & Grease		-	<1500	12000	1000
Sulfide	WATERWAY	2.0	<1700	-	-
Suspended Solids		80000	-	96000	-
Phenols		100	-	-	-
Cyanides		5	-	-	-
PCB		0.002	H	-	-
Aldrin		0.01	-	< 0.001	0.0006
DDT		0.002	-	<0.006	<0.006
DDD		-	-	<0.005	<0.00037
DDE		-	-	<0.003	<0.00053
Dieldrin		0.005	-	0.012	0.00068
Chlordane		0.04	-	0.095	0.0017
Endrin		0.002	-	0.003	<0.003
Heptachlor		0.01	-	0.026	<0.0001
Lindane		0.02	-	0.049	<0.0005
Toxaphene		0.01	-	<0.050	<0.005
Diazinon		0.009	-	-	-
Malathion		0.008	-	-	-
Parathion		0.001	-	-	-

+4 µg/l when hardness <100 mg/l; 30 mg/l when hardness >100 mg/l

one located approximately 10 miles south of the confluence with the Bayou Plaquemine), were selected as representative of the study area. These data were compared with applicable standards and/or EPA recommended criteria levels. Detailed water quality data are presented in Appendix D. Since no detailed water quality or sediment data are available for the low flow period (September through October), a "worst case" analysis corresponding to low flow conditions was not possible.

The Mississippi River, Bayou Plaquemine, and the Intracoastal Waterway conform to those state water quality standards for which numerical criteria have been set for these bodies of water with the exception of coliform count(see Table 2.3). In addition to State of Louisiana numerical standards, the EPA has established guidelines for various water uses (e.g. domestic raw water supply, propagation of aquatic life, sediment quality). These criteria are of general applicability regardless of the particular body of water in question. Guidelines or recommended criteria differ from standards in that they do not have legal standing. In some cases, water use guidelines are more stringent than geographical (states) standards for the same pollutant. Also guidelines or criteria recommend different levels of the same pollutants for different use designations. Thus, it is possible for a guideline to be exceeded without violating a standard.

Water quality and sediment data for the surface water system of interest, proposed EPA numerical criteria for the propagation of freshwater aquatic life,[16] and suggested numerical concentration parameters for sediment,[17] are presented in Table 2.4. More detailed tables of both water and sediment quality data and EPA recommended criteria are presented in Appendix D.

Data for the three points along the Mississippi River are presented in Table 2.4. The Port Allen Locks are located at Mile Point 228.5 which is immediately downstream of the Baton Rouge Harbor. Mile Points 224 and 212 define the reach that will be affected by dredging operations associated with the proposed action. Comparison of the data for these three points reveals no distinctive differences in water quality among these points. Heavy metals and pesticide chemical concentrations decrease slightly in the downstream direction. A comparison of available water quality data with recommended criteria shows excessive concentrations of suspended solids. Concentrations of phenols, diazinon, cyanide and DDD exceed criteria for water supply but are within criteria for aquatic life.

Sediment composition data for three locations along the Mississippi River (Mile Points 228.4, 208.8, and 175.4) are presented in Appendix D. Generally the sediment is comprised of fine sand (100 to 250 micrometers). Sediment samples for total Kjeldahl nitrogen, chemical oxygen demand, and oil and grease, approach the upper limit of established EPA guidelines. These high concentrations result from heavy use of the navigable waterways, and the agricultural and industrial development of the drainage area.

Available data for Bayou Plaquemine show high sediment levels of heavy metals. Concentrations of lead, mercury, and zinc are above recommended levels. Concentrations of copper, nickel, and chromium are just within recommended levels. Water concentrations of mercury and suspended solids exceed recommended levels. Sediment concentrations of total Kjeldahl nitrogen and oil and grease approach the upper limit of EPA recommended criteria. Concentrations of several pesticide chemicals (dieldrin, endrin, and toxaphene) in the water are near or exceed recommended levels.

Bayou Plaquemine was permanently sealed from the Mississippi River concurrent with the opening of the Port Allen Locks in 1961.[18] Since then, the Bayou has been subjected to vacillating flow conditions, primarily due to the relative levels of the Atchafalaya River, the Mississippi River, and the controlled depth along the Port Allen Canal.

Water and sediment quality data for one point along the Intracoastal Waterway, located approximately 15 miles downstream of the junction of the Bayou Plaquemine and the Port Allen Canal, are presented in Table 2.4. Additional data are presented in Appendix D. The water quality at this point is indicative of the water quality of the canals and bayous upstream of this point for a southerly flow direction of these waters. The available data were recorded during a time period when the flow was in the northerly direction. During northerly flow, observed water concentrations of pesticide chemicals (dieldrin, chlordane, endrin, heptachlor, lindane, and toxaphene) significantly exceeded recommended levels.

Similar data at three stations upstream of this point (presented in Appendix D) indicate these substances are within recommended levels except for concentrations of zinc, phenols, diazinon, suspended solids and cyanide which exceed the upper limit of recommended criteria. The flow condition during which these data were recorded is unknown; however, it would appear to be in the southerly direction. These data indicate that the waters in the Intracoastal Waterway vary in degree of pollution depending on the direction of flow. Sediment concentrations of zinc shows appreciable buildup (i.e. concentration factors in the sediment greater than in the water column).

Available water quality data for the pond over Cavern No. 7 are presented in Appendix D. These data are within recommended guidelines for bodies of water as noted in Appendix D. No water quality (nor sediment quality) data are available for Choctaw Bayou, Bull Bay, Bayou Bourbeaux, the North-South Canal, the East-West Canal, or the Wilbert Canal. These waterways are connected to the waters of the Mississippi River and the Intracoastal Waterway (ICW), and are directly influenced by the motion of the river and the ICW. Thus, the data presented in Table 2.4 for the Mississippi River at Mile Point 228.5, the ICW, and Bayou Plaquemine are believed to be indicative of the water quality for the above waterways.

2.2.1.3 Elutriate Tests

No specific elutriate tests have been performed to date for the dredging sites associated with the SPR program at the Bayou Choctaw site.* However, elutriate tests have been performed on samples from the Mississippi River[19] and from the Intracoastal Waterway (and its tributaries).[15] The results of tests for one site on the Bayou Plaquemine and one site on the Intracoastal Waterway (both sites are identified on Figure 2.9) are presented in Table 2.5. EPA recommended criteria are included in the table. Generally the results of the tests indicate a pollution potential from heavy metals, organic material, and pesticide chemicals if bottom sediments are disturbed by dredging. The Bayou Plaquemine results indicate a lower potential for resuspension of heavy metals and pesticide chemicals than do the results for the Intracoastal Waterway.

The data from the Intracoastal Waterway may not be representative of expected conditions because the flow direction in the waterway was toward the north rather than to the expected south direction at the time the samples were obtained. The data recorded for Bayou Plaquemine are probably typical of conditions in the vicinity of Bull Bay.

Standard elutriate tests were performed on the sediment in the Mississippi River at Mile Point 224.[19] The results of these tests on two samples are presented in Table 2.6. Comparison of the results with recommended water quality criteria shows that no appreciable quantities of oxygen demanding materials, nutrients or heavy metals were observed.

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*The elutriate test is designed to predict the release of sediment pollutants into the water. The test consists of vigorously shaking one part bottom sediment with four parts water, on a volume basis, for 30 minutes, followed by a one-hour settling time and appropriate centrifugation and 0.45 μm filtration. Both sediment and water samples must be from the same location. The elutriate test yields the concentration of various components suspended and dissolved in the water at the completion of the test.

Resulting concentrations are compared with applicable water and to determine quality criteria.

Table 2.5 Elutriate Test Data for Bayou Plaquemine and Intracoastal Waterway

PARAMETER	EPA Recommended Quality Criteria for Aquatic Life (μg/ *)	Test Results Bayou Plaquemine (μg/l)	Test Results Intracoastal Waterway (μg/l)
Cadium	4/30+	1.1	1.8
Chromium	50.0	0.5	0.5
Copper	1/10LC50	15.0	16.0
Lead	30.0	1.0	1.0
Mercury	0.2	3.0	0.2
Nickel	1/50LC50	21.0	21.0
Zinc	5/1000LC50	6.5	11.0
COD	-	221,000.0	658,000.0
TKN	-	2,480.0	1,240.0
Oil and Grease	-	-	-
Sulfide	-	-	-
Suspended Solids	80000	-	-
Phenols	100	-	-
Cyanides	5	-	-
PCB	0.002	-	-
Aldrin	0.01	.001	.001
DDT	0.002	.003	.012
DDD	0.006	.0015	.0015
DDE	-	.012	.003
Dieldrin	0.005	.010	.002
Chlordane	0.04	.010	.01
Endrin	0.002	.003	.003
Heptachlor	0.01	.001	.001
Lindane	0.02	.027	.001
Taxaphene	0.01	.05	.05
Diazinon	0.009	-	-
Malathion	0.008	-	-
Parathion	0.001	-	-
Arsenic	-	-	-

* ug/l - micrograms per liter

+ 4μg/l when hardness <100mg/l; 30mg/l when hardness >100mg/l.

Table 2.6 Elutriate Test Data for Mississippi River (Mile 224)

PARAMETER	EPA Recommended Quality Criteria: PUBLIC WATER SUPPLY (μg/l*)	EPA Recommended Quality Criteria: AQUATIC LIFE (μg/l)	TEST RESULTS: MISSISSIPPI RIVER MILE 224 (μg/l)
Cadmium	10	4/30+	-
Chromium	50	50	0
Copper	1000	1/10LC50	9
Lead	50	30	1
Mercury	2	0.2	0
Nickle	-	1/50LC50	1.5
Zinc	5000	5/1000LC50	15
COD	-	-	180,000
TKN	-	-	820
Oil & Grease	-	-	-
Sulfide	-	-	-
Suspended Solids	-	80000	-
Phenols	1.0	100	14
Cyanides	20.0	5	-
PCB	-	0.002	-
Aldrin	1	0.01	-
DDT	50	0.002	-
DDD	-	0.006	-
DDE	-	-	-
Dieldrin	1.0	0.005	-
Chlordane	3.0	0.04	-
Endrin	0.2	0.002	-
Heptachlor	0.1	0.01	-
Lindane	4.0	0.02	-
Taxaphene	5.0	0.01	-
Diazinon	-	0.009	-
Malathion	-	-.008	-
Parathion	-	-.001	2
Arsenic	5	-	-

+ 4 μg/l when hardness <100 mg/l; 30 mg/l when hardness >100 mg/l.

* ug/l - micrograms per liter

2.2.1.4 Water Usage

The surface waters of the Mississippi River serve as a water supply for industrial and agricultural activities. Most municipal and rural water supplies are groundwater. In 1970, in the Baton Rouge area extending to Donaldsonville, industrial water usage averaged approximately 440 million gallons a day; municipal usage averaged 39 million gallons per day, and rural domestic water use averaged 0.3 million gallons per day.[20] A recent study analyzed present and future water requirements for industrial, municipal, rural, and steam electric power production in the East Baton Rouge area and concluded that freshwater in the area was plentiful. Appendix D identifies industrial and municipal users of water in the study area.

2.2.2 Subsurface Water Systems

Both shallow (up to 1,000 feet deep) and deep (greater than 1,000 feet deep) aquifers are present in the study area. Both currently serve as a water supply for predominately municipal activities with some groundwater being used for industrial operations.

2.2.2.1 Shallow Aquifers

The Plaquemine aquifer, the major shallow subsurface aquifer in the Bayou Choctaw salt dome region is comprised of deltaic and alluvial deposits of sand and gravel topped by a clay and silt surface layer approximately 100 feet thick. Figure 2.10 shows the maximum depth of fresh ground water in the Plaquemine-White Castle area, which includes the Bayou Choctaw oil field.[11] In this figure fresh water is that which has a chloride content of less than 250 mg/liter.

The structure of the Plaquemine aquifer is fairly well known. East-West sections (A-A' and B-B') are shown in Figure 2.11. The base of the aquifer slopes down in the southeastward direction. The fresh-salt water interface generally slopes down in a northward direction. In section A-A' of Figure 2.11, Stations 1 and 2 are within the Bayou Choctaw oil field. Station 3 is less than one mile east of the oil field. North-south sections (C-C', and D-D') are shown in Figure 2.12. Station 24 of Section C-C' is approximately 2.3 miles to the southeast of the center of the proposed brine

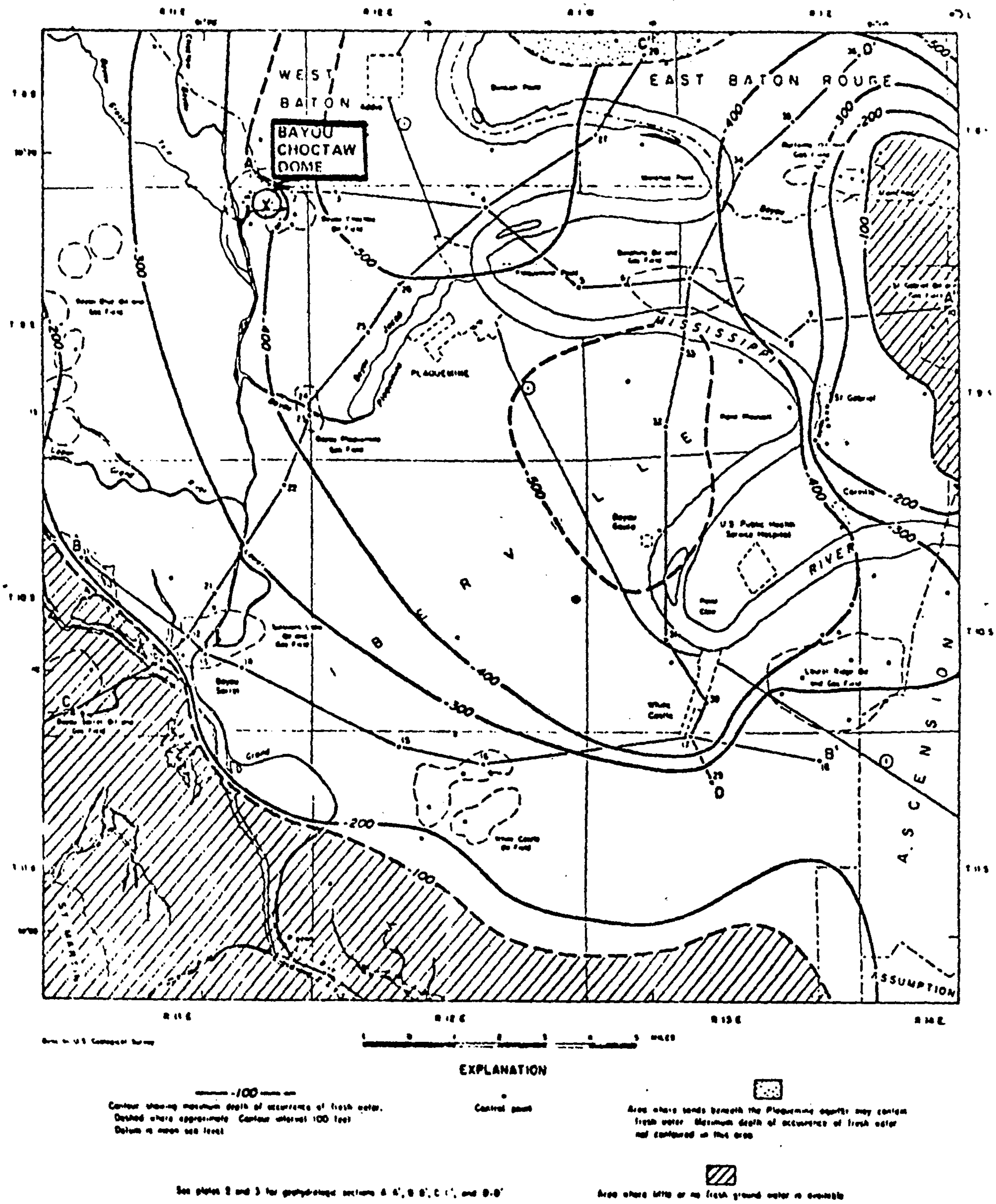
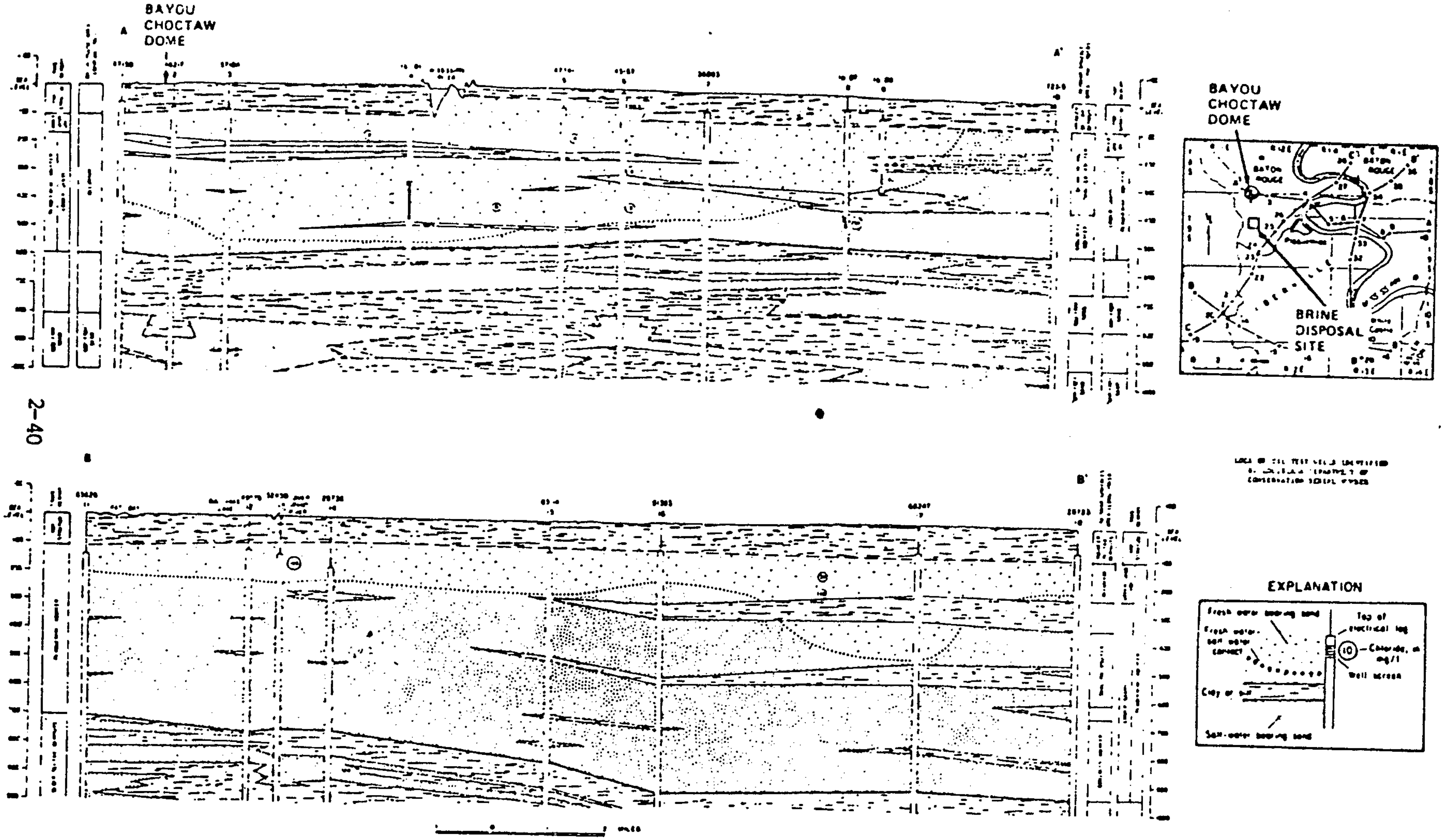


Figure 2.10 The maximum depth of occurrence of fresh ground water in the Plaquemine-White Castle Area, Louisiana*

*In this figure water with a chloride content of less than 250 mg/l is defined as fresh water.



~~PLATE 2~~ EAST-WEST GEOHYDROLOGIC SECTIONS SHOWING THE PRINCIPAL AQUIFER AND THE VERTICAL DISTRIBUTION OF FRESH AND SALTY WATER IN THE PLAQUEMINE-WHITE CASTLE AREA, LOUISIANA.

Figure 2.11

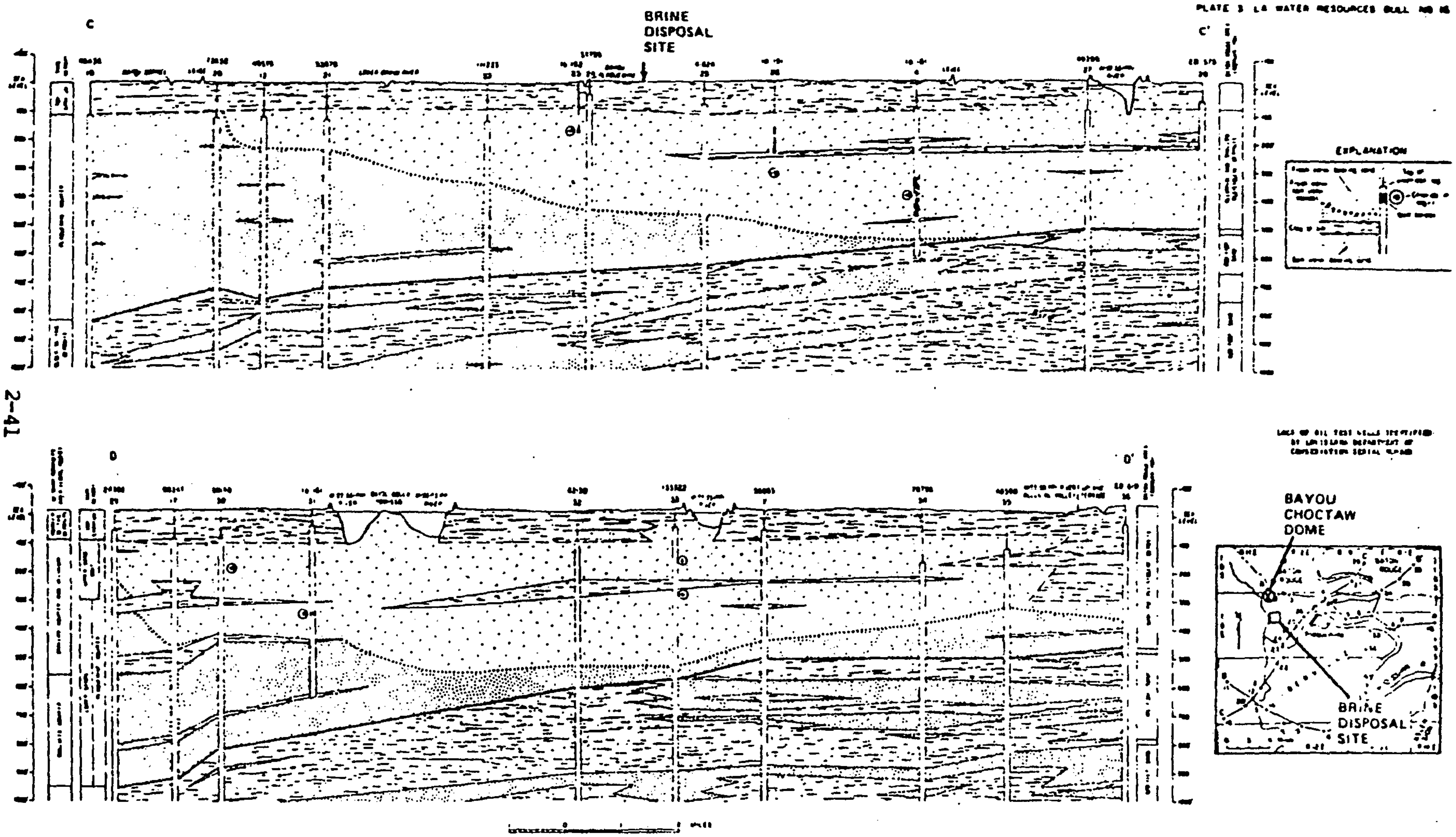


PLATE 3 NORTH-SOUTH GEOHYDROLOGIC SECTIONS SHOWING THE PRINCIPAL AQUIFER AND THE VERTICAL DISTRIBUTION OF FRESH AND SALTY WATER IN THE PLAQUEMINE-WHITE CASTLE AREA, LOUISIANA

Figure 2.12

disposal zone. Both sections A-A' and C-C' indicate that below the 100 foot surface aquitard*lie massive sand beds with only a few thin aquitards down to 600 feet. Approximately 250 feet of the top sands contain fresh water; the next 200 feet contain saline water. In all four sections, the salt water - fresh water interface occurs in most places in a sand.

The Bayou Choctaw dome is mostly within the Mississippi Alluvial Plain section of the Coastal Plain physiographic province.[21] The alluvial valley is approximately 50 miles wide in the vicinity of the dome. The dominant feature in the valley is the Mississippi River. The River directly influences the quantity and quality of water in the Plaquemine aquifer. The thalweg** of the channel ranges from 50 to 130 feet below mean sea level. It intersects the Plaquemine aquifer (100 feet deep), and is believed to be hydraulically connected.

The significance of the hydraulic connection is in terms of pressure transmitted to the aquifer by the river. Figure 2.13 shows the piezometric surface is 17 feet above mean sea level near Bayou Choctaw (during April 10 to 14, 1961), when the river stage at Donaldsonville, 30 miles southeast, was 25 feet. Figure 2.14 shows the piezometric surface to be about 5 feet near Bayou Choctaw (during October 17 and 18, 1960) when the river stage at Donaldsonville was 3 feet. The arrows attached to the contour lines in both Figures show that shallow ground water is moving from the river to the aquifer at high river stage and from the aquifer toward the river at low river stage. The physical movement of the water is slow (about one foot per day). Therefore, approximately one percent of the water in the aquifer is affected by this exchange and the aquifer is not depleted during periods of low river levels.[11]

*An aquitard is a geologic formation that impedes the course water between aquifers.

**A thalweg is a line joining the deepest points in a channel.

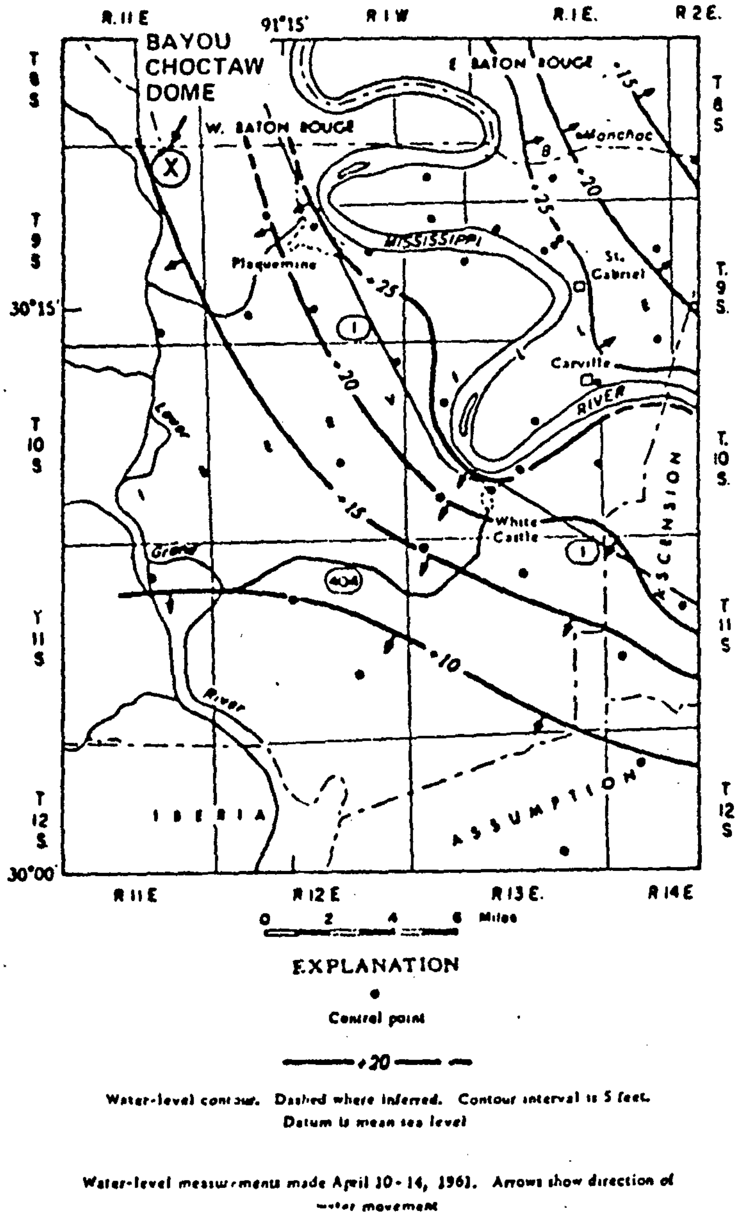
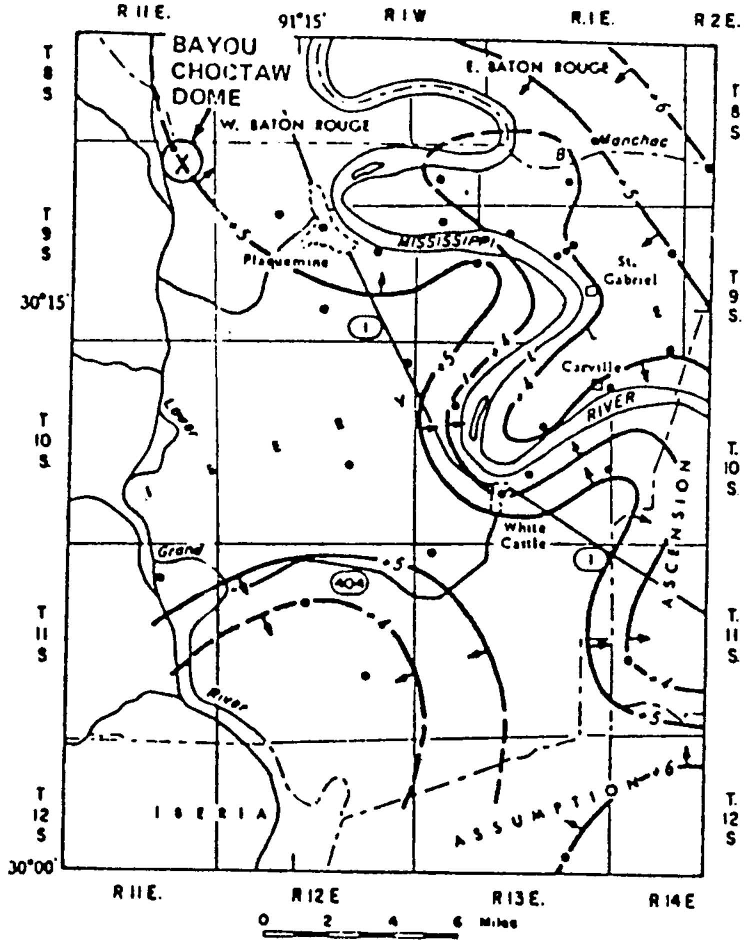


Figure 2.13 Motion of Water in the Plaquemine Aquifer Away from the Mississippi River at High River Stage



EXPLANATION

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Control point

———— •4 ———— ——

Water-level contour. Dashed where inferred. Contour interval is 1 foot. Datum is mean sea level

Water-level measurements made October 17-18, 1960. Arrows show direction of water movement

Figure 2.14 Motion of Water in the Plaquemine Aquifer Away from Mississippi River and toward a discharge area southwest of White Castle at low river stage

Tests of wells in the Plaquemine aquifer have demonstrated a significant capacity. Thirty 10-inch wells pumped 40 million gallons per day for a short time period with a lowering of ground water levels in the immediate vicinity of the wells from 25 to 40 feet. In 22 months of operation, 40 wells in the aquifer (Port Allen Locks area) pumped 28 million gallons per day with a drawdown 10 feet below water levels for the particular stage of the Mississippi River.

The Plaquemine aquifer is a source of fresh water for several municipalities in both Iberville and West Baton Rouge parishes. Pertinent data are provided in Appendix D. These data indicate at least 2.2 million gallons per day are drawn from the aquifer in Iberville Parish and at least 0.725 million gallons per day in West Baton Rouge Parish. The water wells serving the municipalities of Plaquemine (1.65 million gallons per day) and Addis (0.1 million gallons per day) are specially significant because these wells are located within 5 miles of the Bayou Choctaw site.

Water quality data for these subsurface waters are presented in Appendix D.

2.2.2.2 Deep Aquifers

The brine disposal site currently under consideration overlays the deep subsurface aquifers southwest of the Bayou Choctaw salt dome. Both fresh and salt water occur in the top 1,000 feet in sand, gravel, silt, and clay of Pleistocene and Holocene age already discussed. Sands and shales of Pliocene and Miocene age are found at deeper levels. The Miocene age deposits are probably between 3,000 and 9,000 feet under the surface. It is proposed that the brine will be disposed of in the Miocene age sands at depths of 5,000 to 8,000 feet.

Data presented in Appendix D for several locations south and west of the salt dome were used to determine the general features of the deep aquifers in the area. Twenty sand beds with thicknesses greater than 70 feet are present in the 3,000 to 9,000 foot interval. These thick sands and other thin sands are separated by thin shale and silt beds. There are two zones containing thick sand beds suitable for brine disposal. One 800 foot zone between -5,000 and -5,800 feet contains 345 feet of sand occurring in layers greater than 30 ft. thick. Most of these sand beds are probably interconnected. The second zone, between 7,000 and 7,700 feet, contains 430 feet of sand in beds greater than 50 feet thick. Thick sand beds comprise 45 to 60 percent of each zone; thin sand beds comprise 10 to 25 percent; and thin shale and silt beds comprise about 30 percent. A number of thin shale beds lie between the two zones. Below approximately 9,000 feet, alternate layers of shale and sand occur. The shale layers are usually less than 40 feet thick.

Available data indicate that the 3,000 to 9,000 feet sands contain salt water and have no characteristics indicating the presence of oil or gas.

The presence of faults can impede the flow of water in the deep aquifers. As shown in Figure 2.15, the major Baton Rouge fault lies 7 miles to the north of the proposed site. A second fault extends south from the salt dome approximately 5 miles. A third regional faulting zone connects the Bayou Choctaw salt dome with the Bayou Bleu salt dome.[22] The Baton Rouge fault forms a barrier to water flow at certain levels.[22]

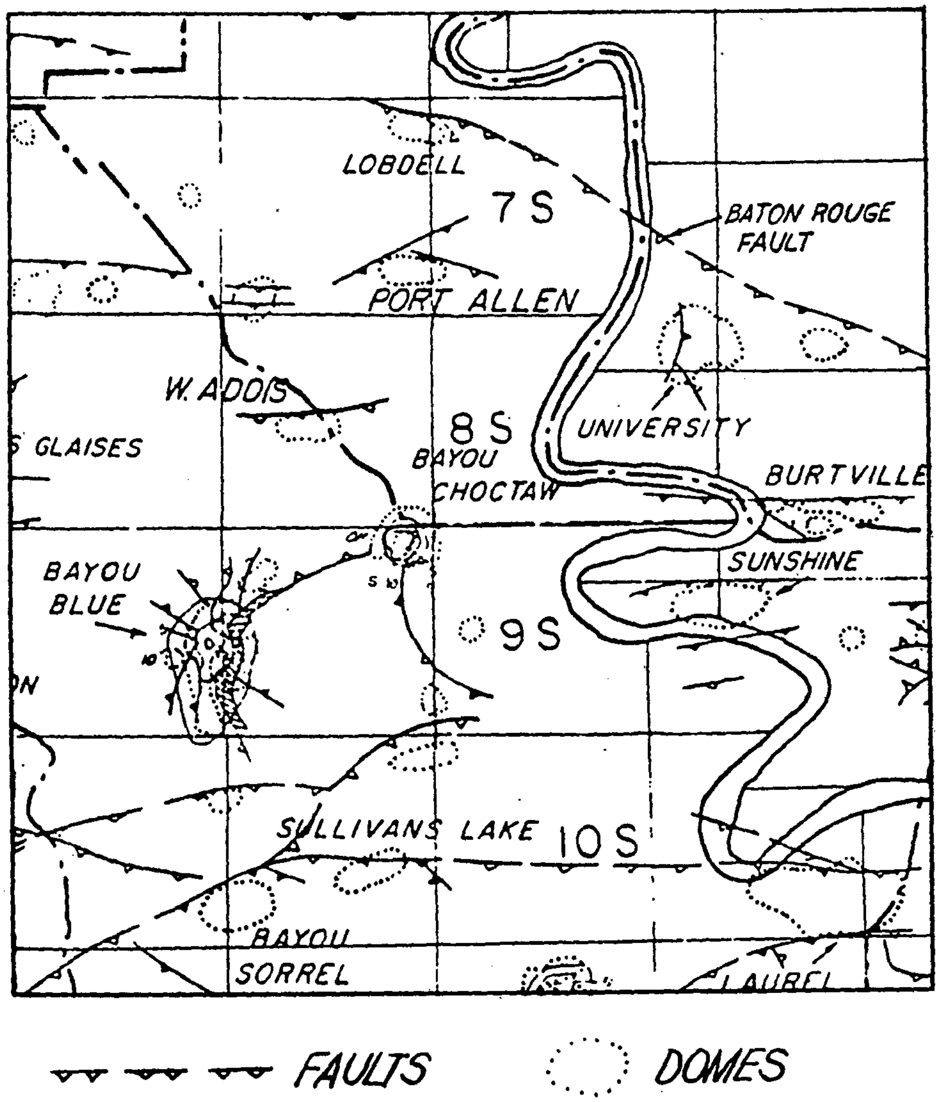

Figure 2.15 Geological Faults and Salt Domes in the Vicinity of Bayou Choctaw.

Source: Wallace, W. E., "Fault and Salt Map of Southern Louisiana", Gulf Coast Association of Geological Societies Transactions, Vol. 16, 1966, p. 373

2.3 METEOROLOGICAL CONDITIONS

2.3.1 Climatic Conditions*

The climate of the Bayou Choctaw area is classified as humid-subtropical with strong marine influences. Seasonal fluctuations are moderate. In winter the days vary from cool and clear to overcast. In summer the days are generally warm and humid, broken by afternoon showers, with little variety day to day.

The average freezing season at Baton Rouge (approximately 15 miles NW of the site), is between December 8 and February 15, with typically 16 or 20 days having temperatures at or below 32°F.[23] In New Orleans 75 miles east southeast of the site, December and January are the foggiest months, with six to seven days per month of heavy fog restricting visibility to less than a quarter mile.[24] December through April is usually the windiest at Baton Rouge with mean wind speeds of 8-10 mph.[25] The percent of winds less than 1 mph at Baton Rouge, plotted per month, is shown in Figure 2.16 and the monthly mean wind speeds are shown in Figure 2.17. The November through March period is typically the coldest with temperatures in the 50's, while the driest period (with 2½ - 3 inches of rain), is September through November. The normal rainfall on a monthly basis at Baton Rouge is plotted in Figure 2.18. June, July, and August are usually the warmest and most humid months, with temperatures in the low 80's (see Figure 2.19. Thunderstorm frequency in the area is greatest in July and August, (16 and 13 respectively), with an approximate mean annual number of days with thunderstorms being 70-75 days.

The monthly distribution of tornadoes, funnel clouds and waterspouts for the southeastern part of Louisiana, including New Orleans and Baton Rouge, is shown in Figure 2.20.[26]

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* The data presented in the following section are not site specific in that the nearest weather monitoring stations are 15-20 miles away. Data presented are from the nearest station to Bayou Choctaw, usually Baton Rouge.

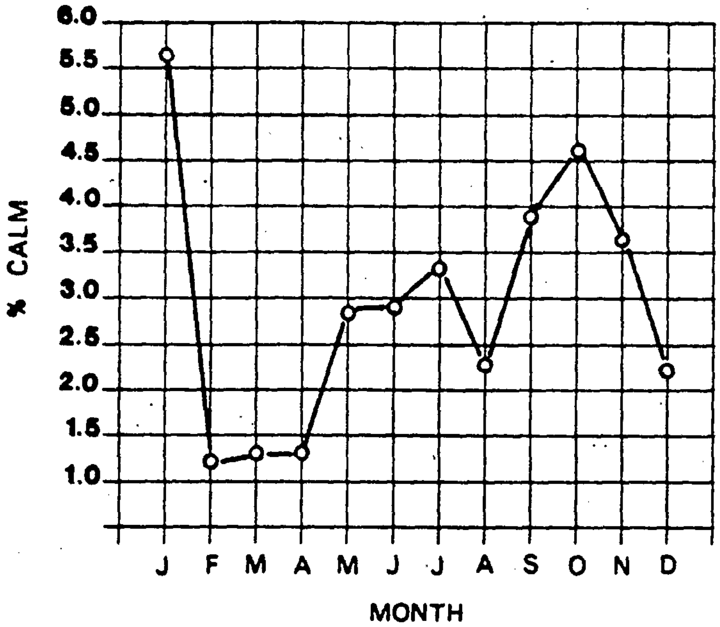


Figure 2.16 Monthly Percentage Calm at Baton Rouge (Wind speeds ≤ 1 mph.)

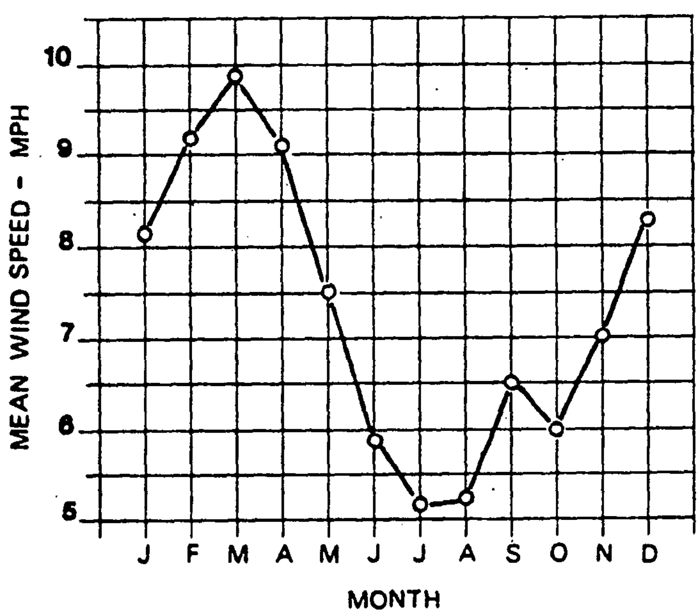


Figure 2.17 Mean Monthly Wind Speed at Baton Rouge

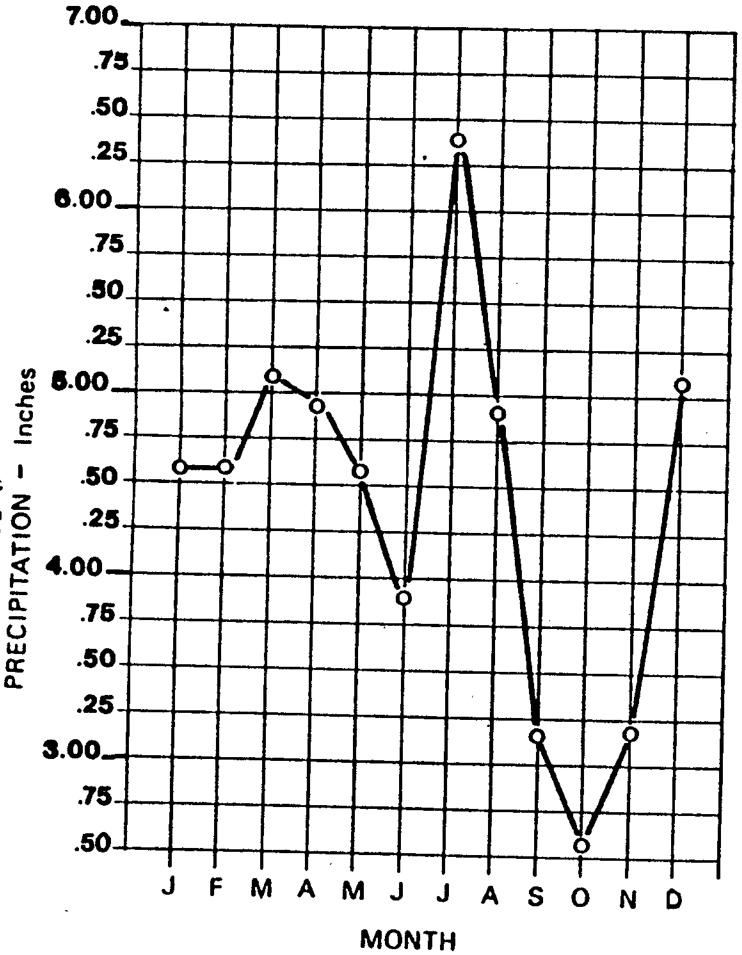


Figure 2.18 Monthly Normal Precipitation at Baton Rouge

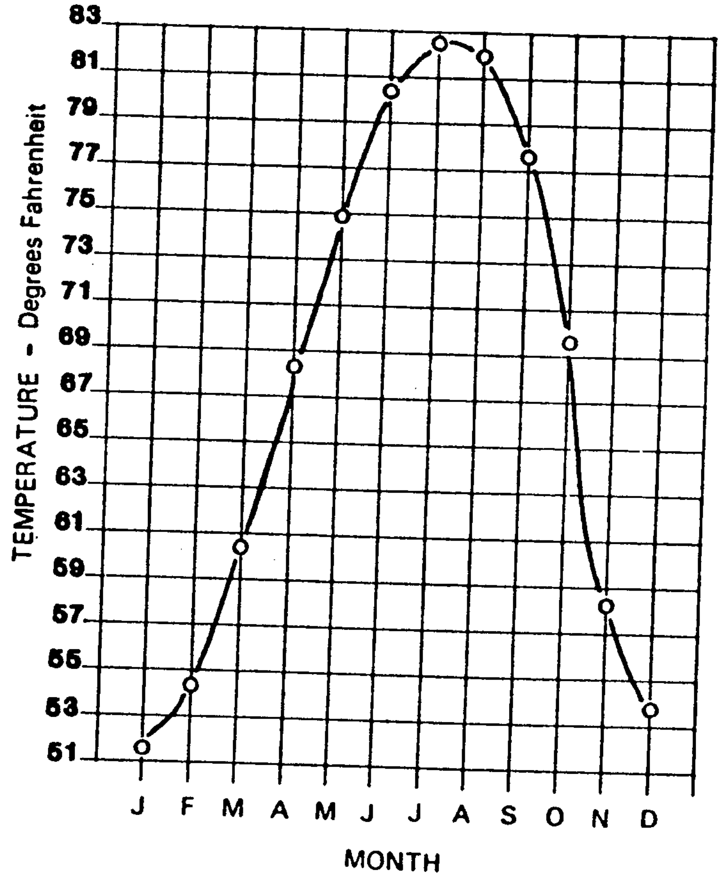


Figure 2.19 Monthly Normal Temperature at Baton Rouge

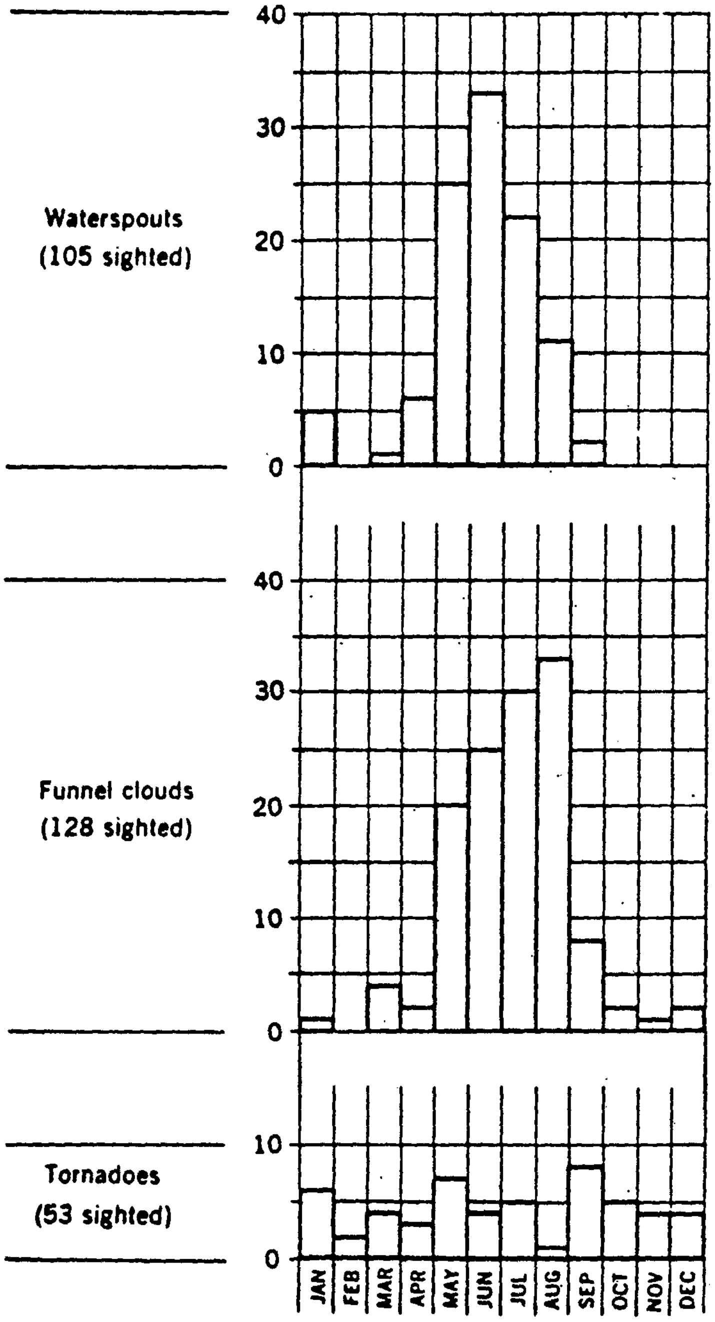


Fig. 2.20 Monthly Distribution of Tornadoes, Funnel Clouds and Waterspouts Based on Storm Data, NOAA, 1961 through 1973.

The annual rainfall in the area is approximately 53 inches at Baton Rouge and the annual lake evaporation losses are roughly 48 inches.[27]

The nearest wind rose data are from Baton Rouge. Figure 2.21 shows this pattern for the Baton Rouge area and Figure 2.22 gives a general profile of the wind rose patterns for the Gulf Coast. The annual percent frequency of wind, by speed groups, for New Orleans and Baton Rouge shows very similar characteristics:[27]

Wind Speed Groups	Baton Rouge	New Orleans
0- 3 mph	17%	16%
4- 7 mph	29%	27%
8-12 mph	35%	32%
13-18 mph	17%	19%
19-24 mph	3%	5%
25-31 mph	--	1%
Mean Speed	8.3 mph	9.0 mph

Eighty percent of the winds in Baton Rouge are less than 11 knots (12.6 mph.)[26] Extreme winds at 30 feet above ground with a 50 year recurrence interval are around 95 mph and with a 100 year recurrence interval, around 100 mph.[28]

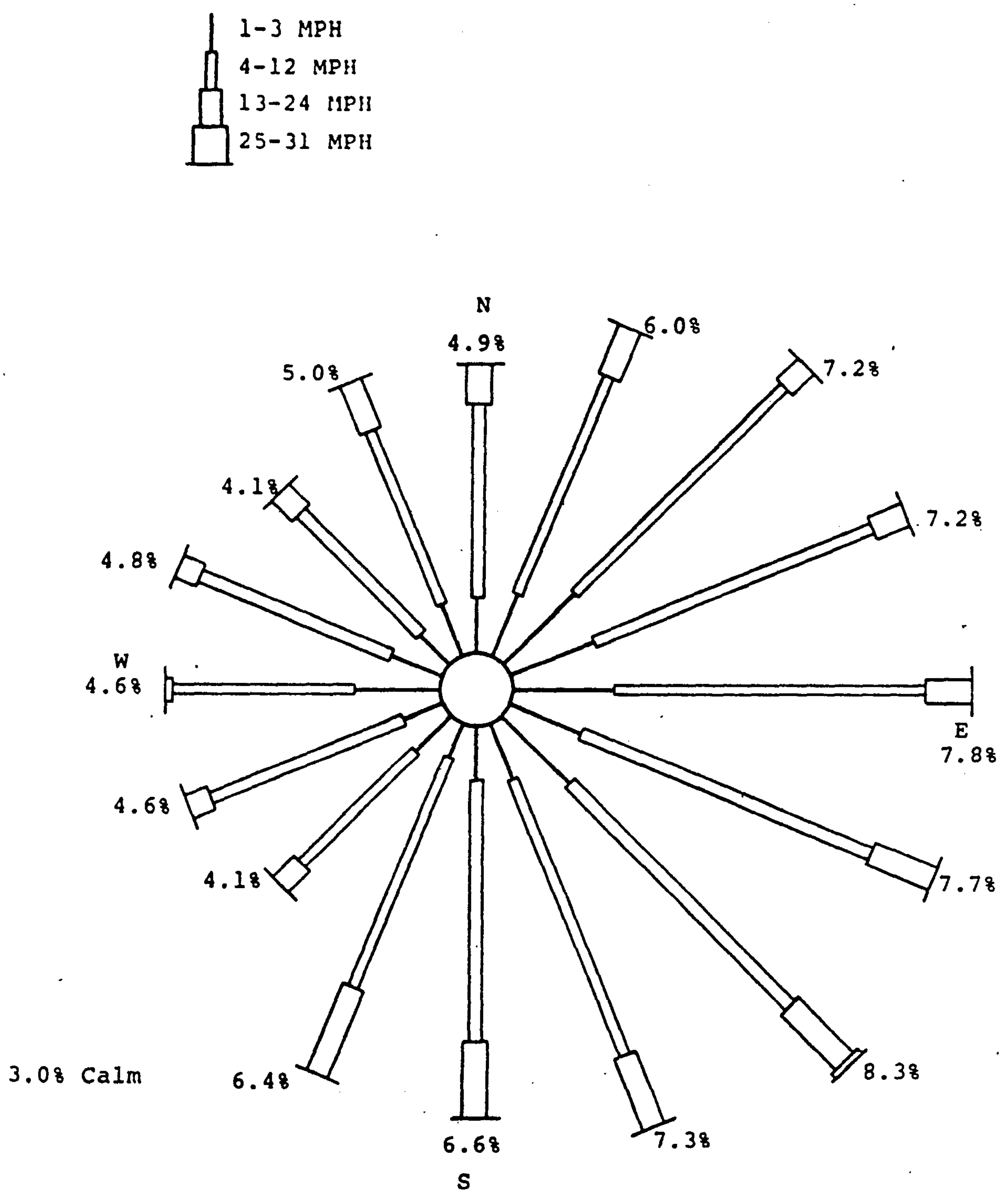


Figure 2.21 Annual Wind Rose, Baton Rouge, Louisiana
(Jan. 1942 thru Feb. 1945).

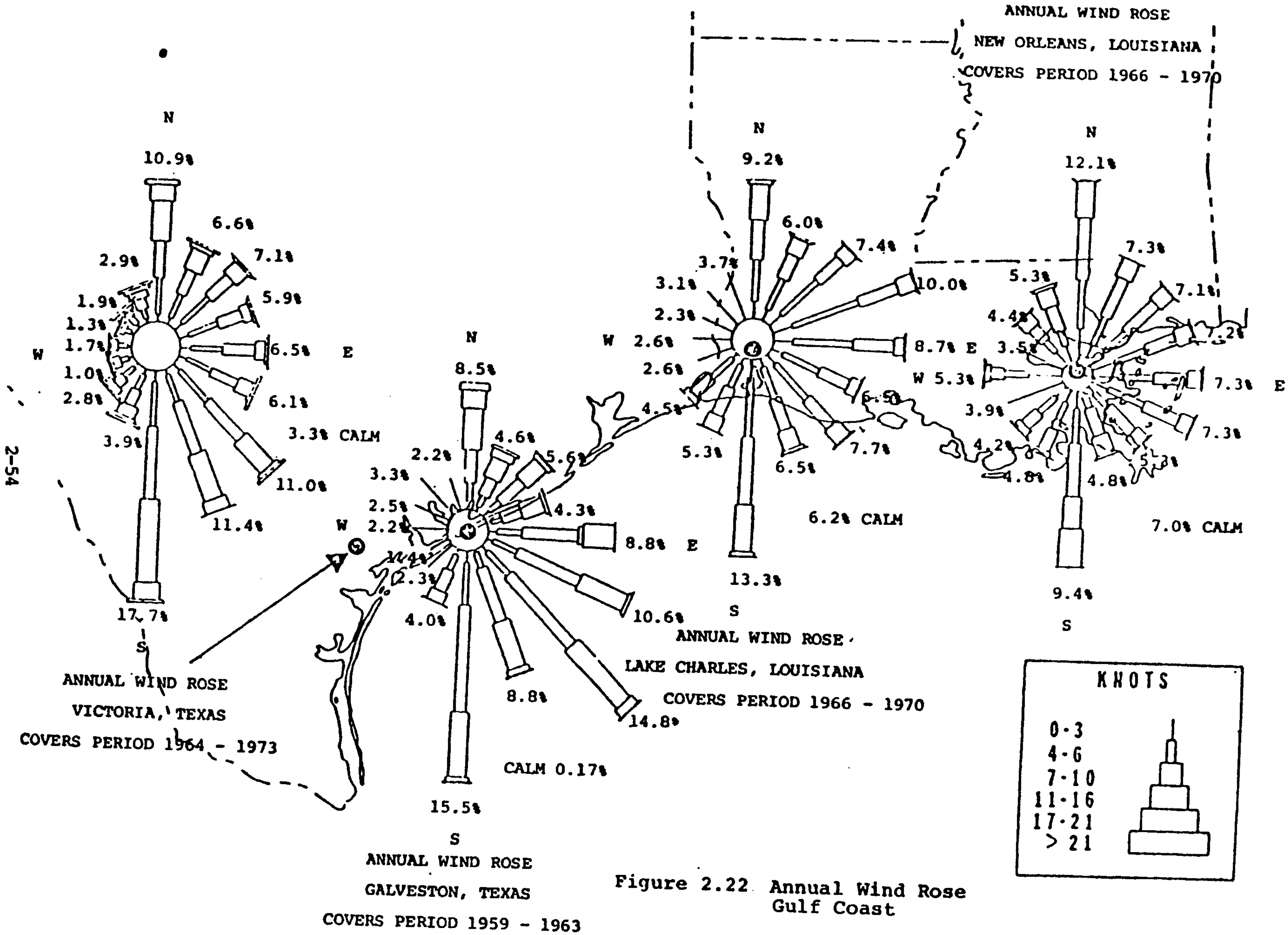


Figure 2.22 Annual Wind Rose Gulf Coast

Severe storm statistics on the two 50 nautical mile strips (57.6 statute mile strips) of coastline in Louisiana surrounding Bayou Choctaw reveal these details:[29]

Number of Tropical Cyclones Reaching the Mainland 1886-1970*

	West	East
All Tropical Cyclones	11	15
All Hurricanes	5	8
Great Hurricanes	-	-

Number of Years Between Tropical Cyclone Occurrences

(Average for Period 1886-1970)

	West	East
All Tropical Cyclone	7	5
All Hurricanes	7	10
Great Hurricanes	-	-

Risk of Tropical Cyclones**

	West	East
All Tropical Cyclones	13%	18%
All Hurricanes	6%	9%
Great Hurricanes	-	-

*Dual numbers represent statistics for the Western 50 miles and the Eastern 50 miles in sequence, which surround Bayou Choctaw on the West and East, respectively.

Definitions:

Tropical Cyclone	39-73 mph
Hurricane	74-124 mph
Great Hurricane	125 mph

**Risk equals the probability that a tropical storm, hurricane or great hurricane will occur in any one year in a 50 nautical mile segment of coastline.

The storms passing through the area with winds 100 mph or greater occurred in 1964, 1965, and 1971. These were Hurricane Hilda (2-6 October 1964), which passed west of Morgan City and north of Baton Rouge with winds between 100-120 mph; Hurricane Betsy (9-10 September 1968), which passed just east of Morgan City, inducing peak gusts of 92 mph recorded in Baton Rouge; and Hurricane Fern (3-13 September 1971), which passed through New Orleans.[26,30]

Atmospheric stagnation periods are minimal due to the Gulf Coast winds. The total number of forecast days of high meteorological potential for air pollution in a 5-year period is approximately 10 days.[31]

The seasonal inversion* frequency as percent of total hours is reported to be approximately 35 percent for winter, 25 percent for spring, 30 percent for summer, 35 percent for fall, with the annual inversion frequency of 30 percent.[32]

2.3.2 Existing Air Quality

In compliance with the Federal Clean Air Act, the State of Louisiana has adopted an Implementation Plan which provides for the implementation, maintenance, and enforcement of the Federal Air Quality Standards promulgated by the Environmental Protection Agency (EPA) on 30 April 1971 (36 FR 8186). The Louisiana Air Control Law requires any person intending to initiate new construction or modify an existing facility which may increase air contaminants to file the appropriate applications and reports with the Louisiana Air Control Commission (LACC) stating plans, specifications, anticipated emissions and quantities, and plans for the abatement of emissions for the proposed construction or modification. Exemptions apply to volatile organics of these categories:

- saturated halogenated hydrocarbons
- perchloroethylene
- benzene
- acetone
- C_1-C_5-n-paraffins
- isobutane
- methanol
- crude oil and condensates

*A reversal in the normal atmospheric temperature gradient such that temperature increases with altitude (within 300 to 600 feet), results in an atmospheric inversion. The hotter air on top acts as a ceiling to any material diffusing vertically.

Exemptions on the basis of low photochemical reactivity can be made if economic hardship induced by their control can be shown for other volatile organics. Tables 2.7 and 2.8 show the Federal Ambient Air Quality Standards and the Louisiana Ambient Air Quality Standards. Louisiana's primary emphasis has been directed to monitoring air quality and controlling emissions in highly industrialized areas of the State. The nearest monitoring stations to the site are along the Mississippi River industrial corridor between Baton Rouge and New Orleans. These stations have had many equipment problems and the resulting data are good for suspended particulates only, except in Baton Rouge and New Orleans, where ozone concentration data have also been compiled.

The air quality monitoring stations nearest to Bayou Choctaw are at Addis, 2 1/2 miles northeast of the site, Baton Rouge, 15 miles northeast of the site, and Carville, 19 miles southeast of the site. Figures 2.23 and 2.24 show the 1975 suspended particulate measurements for the two stations at Baton Rouge. The data received from the LACC for the monitoring stations within 50 miles of Bayou Choctaw are included in Appendix B. These stations, their distances and directions from the site, and the types of pollutant data collected are given below:

Addis	2½ miles, NE	Suspended Particulates
Baton Rouge	15 miles, NE	Suspended Particulates
Carville	19 miles, SE	Suspended Particulates
Geismar	20 miles, SE	Suspended Particulates
Garyville	48 miles, SE	Suspended Particulates

A review of data shows that the late fall and winter are the periods when the highest levels of suspended particulates are encountered. Figure 2.25 shows a scatter plot of these data for Garyville, Geismar, Carville, and Addis. The bi-modal appearance can be attributed to the tornado season and the more frequent occurrences of stagnant air during the late fall and winter.

Along the Baton Rouge-New Orleans industrial corridor, pollutant concentrations can be expected to be considerably higher than those of areas like Bayou Choctaw. In order to represent the Bayou Choctaw salt dome area more appropriately, the best profile comes from the LACC

Table 2.7 Federal Ambient Air Quality Standards

Pollutant	Standard	
Particulates:		
Annual Geometric Mean	75 $\mu g/m^3$	
24-hour Maximum	260 $\mu g/m^3$	
Sulfur Oxides:		
Annual Arithmetic Mean	80 $\mu g/m^3$	(0.03 ppm)
24-hour Maximum	365 $\mu g/m^3$	(0.14 ppm)
3-hour Maximum	-	
Carbon Monoxide:		
8-hour Maximum	10 mg/m^3	9 ppm
1-hour Maximum	40 mg/m^3	35 ppm
Photochemical Oxidants:		
1-hour Maximum	160 $\mu g/m^3$	(0.08 ppm)
4-hour Maximum	98 $\mu g/m^3$	(0.05 ppm)
Hydrocarbons (Non-methane):		
3-hour Maximum	160 $\mu g/m^3$	(0.24 ppm)
Nitrogen Dioxide (NO_2):		
Annual Arithmetic Mean	100 $\mu g/m^3$	(0.05 ppm)

$\mu g/m^3$ = Micrograms per Cubic Meter

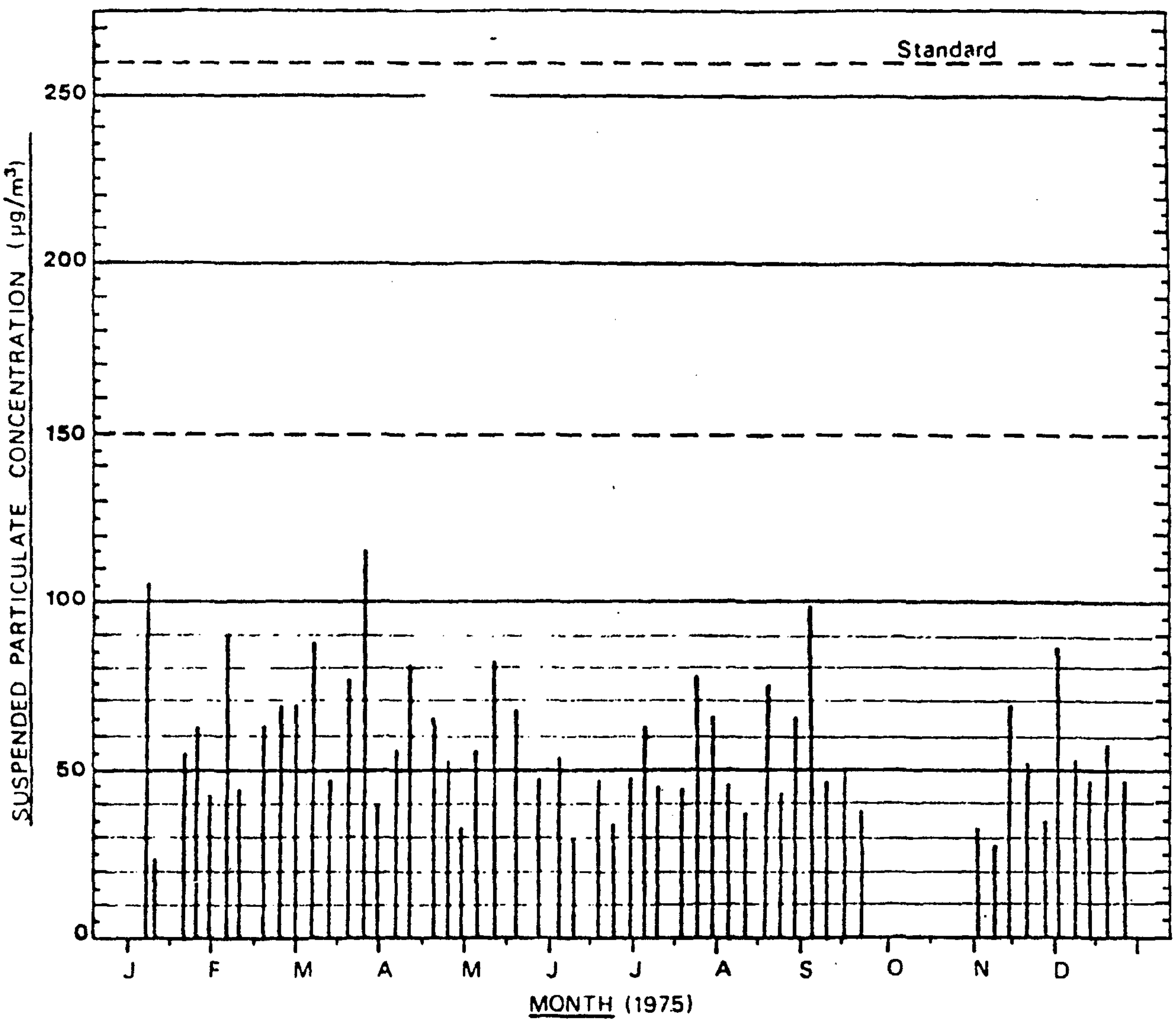
mg/m^3 = Milligrams per Cubic Meter

Table 2.8 Louisiana Ambient Air Quality Standards

Pollutant	Standard (maximum permissible concentrations)	
Suspended Particulates:		
Annual Geometric Mean	75 $\mu g/m^3$	
Maximum 24-hour Mean	260 $\mu g/m^3$	
Dust Fall	20 $tons/mi^2/month$	
Coefficient of Haze:		
Annual Geometric Mean	0.06 COH/1000 lin.ft.	
Annual Arithmetic Mean	0.75 COH/1000 lin.ft.	
Maximum 24-hr. Mean	1.50 COH/1000 lin.ft.	
Sulfur Dioxide (SO_2)		
Annual Mean	80 $\mu g/m^3$	
Maximum 24-hour Mean	365 $\mu g/m^3$	
Maximum 3-hour Mean		
Sulfur Acid Mist: (Sulfur Trioxide or any Combination Thereof)		
Maximum Annual Mean	4 $\mu g/m^3$	
24-hour Mean	12 $\mu g/m^3$	not to be exceeded more than 1% of the time
1-hour Mean	30 $\mu g/m^3$	
Carbon Monoxide (CO):		
8-hour Maximum	10 mg/m^3	
1-hour Maximum	40 mg/m^3	
Hydrocarbons (Non-Methane):		
3-hour Maximum between 6:00 and 9:00 a.m.	160 $\mu g/m^3$	
Total Oxidants:		
Annual Arithmetic Mean	58.8 $\mu g/m^3$	
4-hour Maximum	98.0 $\mu g/m^3$	
1-hour Maximum	160 $\mu g/m$	
Nitrogen Dioxide (NO_2):		
Annual Arithmetic Mean	100 $\mu g/m^3$	

Note: Hourly Means are not to be exceeded more than once per year.

$\mu g/m^3$: Micrograms per Cubic Meter

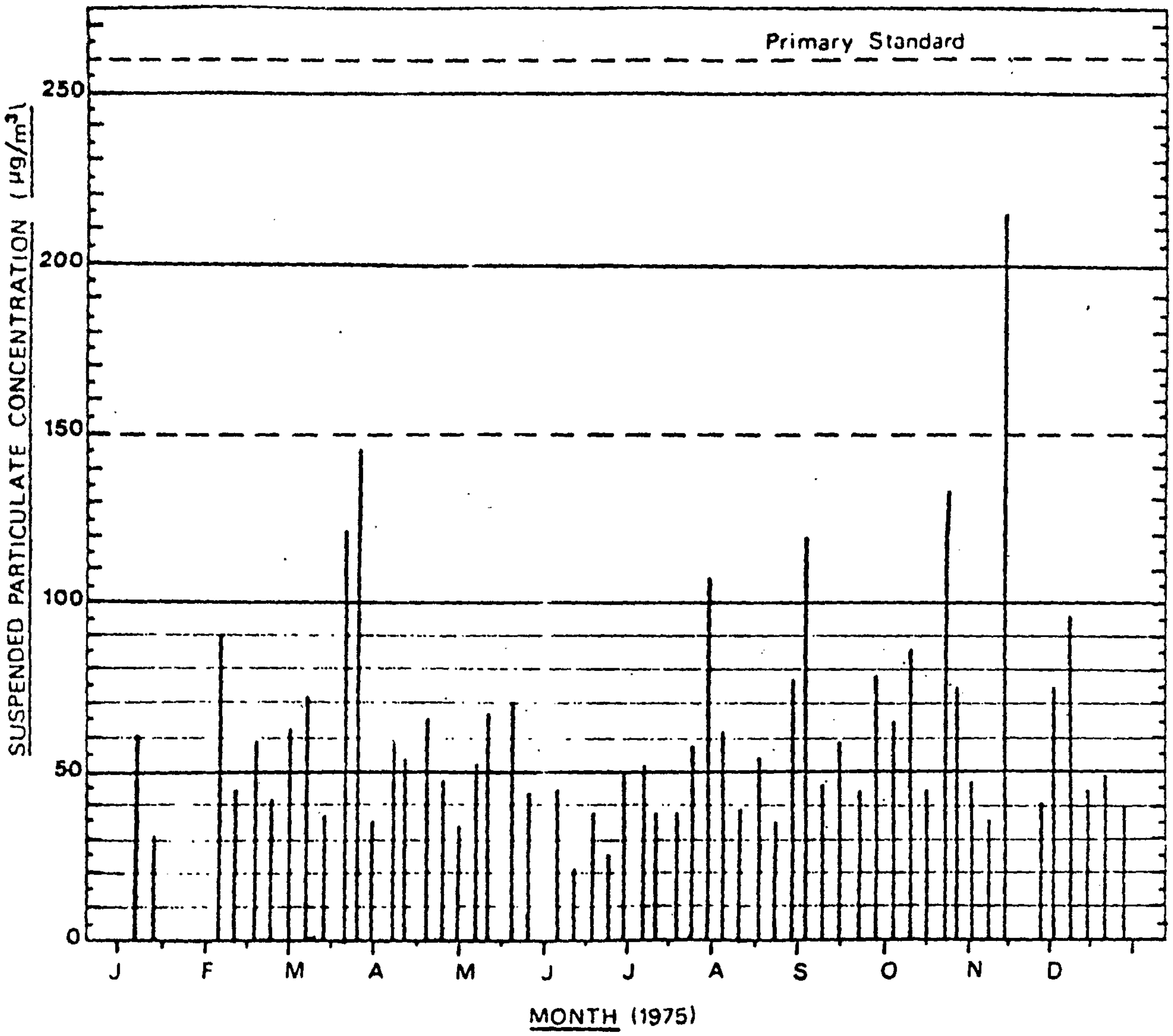


Louisiana Air Control Commission Suspended Particulate Sampling Data

City: Baton Rouge — Number of Samples: 53

Site: 3142 Evangeline St. — Geometric Mean: 54

Figure 2.23



Louisiana Air Control Commission Suspended Particulate Sampling Data

City: Baton Rouge

Site: LSU

Number of Samples: 55

Geometric Mean: 56

Figure 2.24

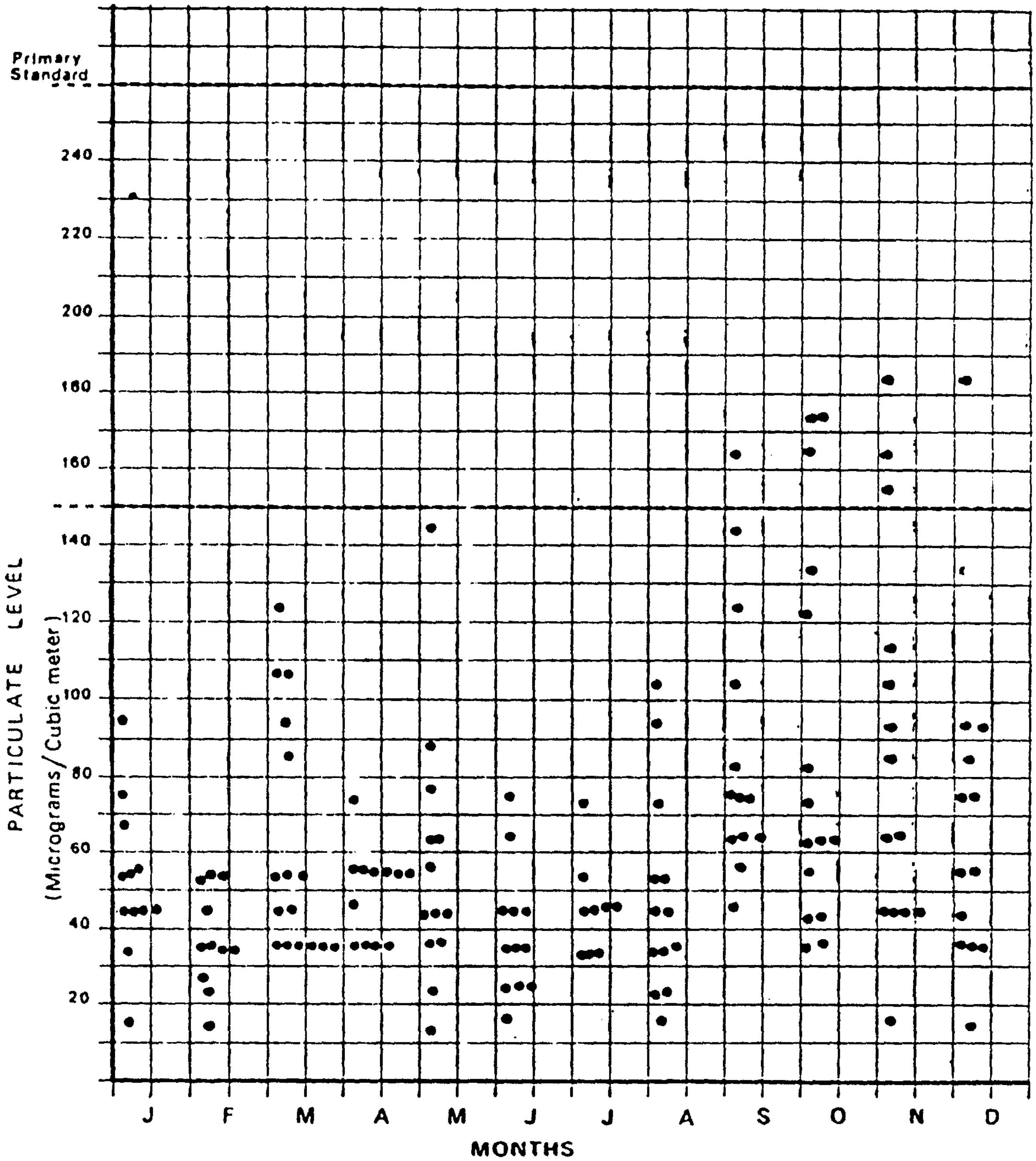


Figure 2.25 Suspended Particulate Data-Scatterplot for Carville, Garyville, Geismar, and Addis. 1975

and their compilation of annual emissions of particulates, hydrocarbons, and sulfur oxides by parish.

The measure of tons/year of emissions is not a fair comparison of parishes. Thus, these numbers were reduced to a roughly common form of pounds per square mile per hour. Table 2.9 shows these adjusted emissions for the parishes surrounding Bayou Choctaw. Included is the predominant industry of each parish, based on census statistics of the total work force and the distribution among the various industry and commerce operators in each parish. Table 2.10 shows the percent contribution by industry to the net parish emissions as compiled by the LACC. These parishes are all typical of the industrial corridor from Baton Rouge to New Orleans, and none of them fully represents the ambient air quality of the Bayou Choctaw site. Since the salt dome is 15 miles away from the nearest major industrial center (Baton Rouge), it is expected that the air quality at Bayou Choctaw will be less polluted than air in industrial areas during most of the year. However, when strong southwesterly winds occur, the ambient conditions on site could be considerably higher than would otherwise be characteristic of the rural, undeveloped area. The existing oil and gas production on the flanks of the dome as well as the LPG storage in cavities certainly contribute to elevated hydrocarbon levels. The general region of southern Louisiana is considered to have a significant need to reduce SO_2 and hydrocarbon emissions in the near future.

Table 2.9 Emissions and Industry Profiles for Parishes Surrounding Iberville Parish (1970)

						Predominant (% of Total Work Force) Industry			
							Industry as % of Manufacturing Work Force		
Parish	Area Sq. Mi.	Pop. Density	SO_x lb/mi^2-hr.	Hydrocarbons lb/mi^2-hr	Particulates lb/mi^2-hr	Construction	Mining	Manufacturing	Chemical
Iberville	627	49	1.2	20.8	1.0	13.0%	4.5%	17%	51%
W. Baton Rouge	203	83.1	6.7	3.9	3.0	6 %	-	-	-
Ascension	301	123.2	9.4	10.0	405	10 %	-	41%	73%
E. Baton Rouge	459	621.3	17.5	58.9	18.9	51 %	1 %	19%	37%

Source: 1) "County Business Patterns-Louisiana, 1973" Bureau of Census.

2) Public Affairs Research Council of Louisiana, Inc., "Parish Profiles," Baton Rouge, Louisiana, 1973.

3) Emissions from LACC Implementation Plan.

Table 2.10 Percent Contribution by Industry to Net Parish SO_x, Hydrocarbon and Particulate Emissions 38

Parish	Chemical Industrial Processing, Point Sources	Solid Waste Disposal, Point Sources	Transportation, Area Sources	Photochemical & Petroleum Refining Point Sources
Iberville:				
SO_x	4 %	5%	90 %	--
HC	92 %		3.3%	--
Particulates	6 %	41%	16 %	--
W. Baton Rouge:				
SO_x	41 %	3%	56 %	--
HC	--	3%	41%	--
Particulates	--	31%	13%	--
E. Baton Rouge				
SO_x	4 %	--	12 %	76%
HC	23 %	--	13 %	62%
Particulates	66 %	3%	3 %	12%
Ascension				
SO_x	76 %	--	22 %	--
HC	56 %	--	17 %	--
Particulates	99.5%	--	--	--

Source: LACC Implementation Plan

2.3.3 Noise

Ambient sound levels at the site and in the near vicinity of Bayou Choctaw are typical of a secluded, essentially flat, moderately forested area. In the winter and spring, the contributing sound sources are wind in the trees, periodic bird calls and the rustle of the grasses and brush. The day-night weighted levels are about 48 dBA on reasonably calm days (winds less than 10 mph).[33] In the summer, the marshland sound is dominated by the buzz of mosquitoes and other insects, frogs, crickets, bird calls, and the sound of the foliage on the trees and brush, as winds blow through. On a normal summer evening, the sound levels can be as much as 10 to 15 dBA higher than winter levels due to the activities of native creatures and insects.

The Bayou Choctaw site is characterized by remote area ambient sound patterns, and local activity on roads nearby barely penetrates to the site due to the sound attenuation of moderate forests.

In preparation of the environmental impact report for the proposed off-shore superport, Seadock, Inc. performed a brief ambient sound survey in the area of Jones Creek where their on-shore facilities will be located.[33] While this study is not site specific for Bayou Choctaw, the area is similar and the ambient levels and spectra can be assumed to be representative of sound sensitive areas around the site. Figures 2.26 and 2.27 show the daytime, evening, and night-time octave band spectral for two sites chosen by Seadock, Inc. on the basis of their sensitivity to interruption by sound. The first is approximately 2,000 feet from a running creek, the second is at a small community roadside. These spectra were taken in early March when deciduous trees are still barren and the insect population is relatively low. Figure 2.28 is the ambient spectrum taken from a Department of Transportation sound survey of the Florida Everglades.[34] Those spectra are a little "quieter" than the Jones Creek area daytime spectra which can be attributed to the lack of human activity (road traffic in particular) in the everglades.

The A-weighted* levels range from a low of 40 dBA (night time) to a high of 48 dBA (daytime). In the summer, these ambient levels may be as high as 50 dBA in the evening.

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*The A-weighting is a method of adjusting the sound pressure level (dB re: 0.0002 bar) at each center octave band frequency in much the same way that the human ear does in attenuating incident sounds. Essentially, a young, normal human ear is much more sensitive to sounds between 500Hz and 8,000Hz than it is to low and high frequency sounds. This apparent "attentuation" is very closely matched by the A-weighted scale used in sound measurements.

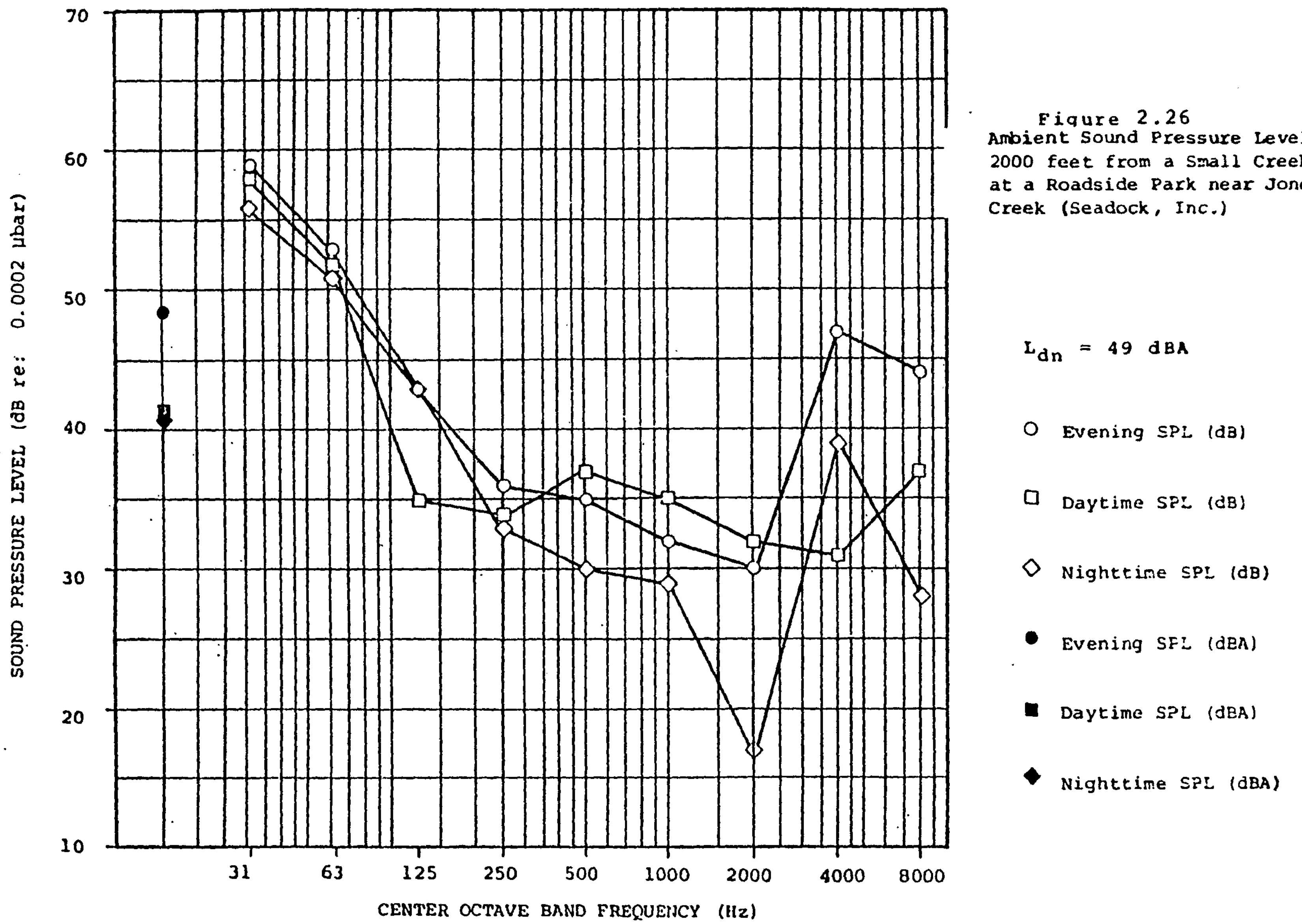

Figure 2.26
Ambient Sound Pressure Levels, 2000 feet from a Small Creek at a Roadside Park near Jones Creek (Seadock, Inc.)

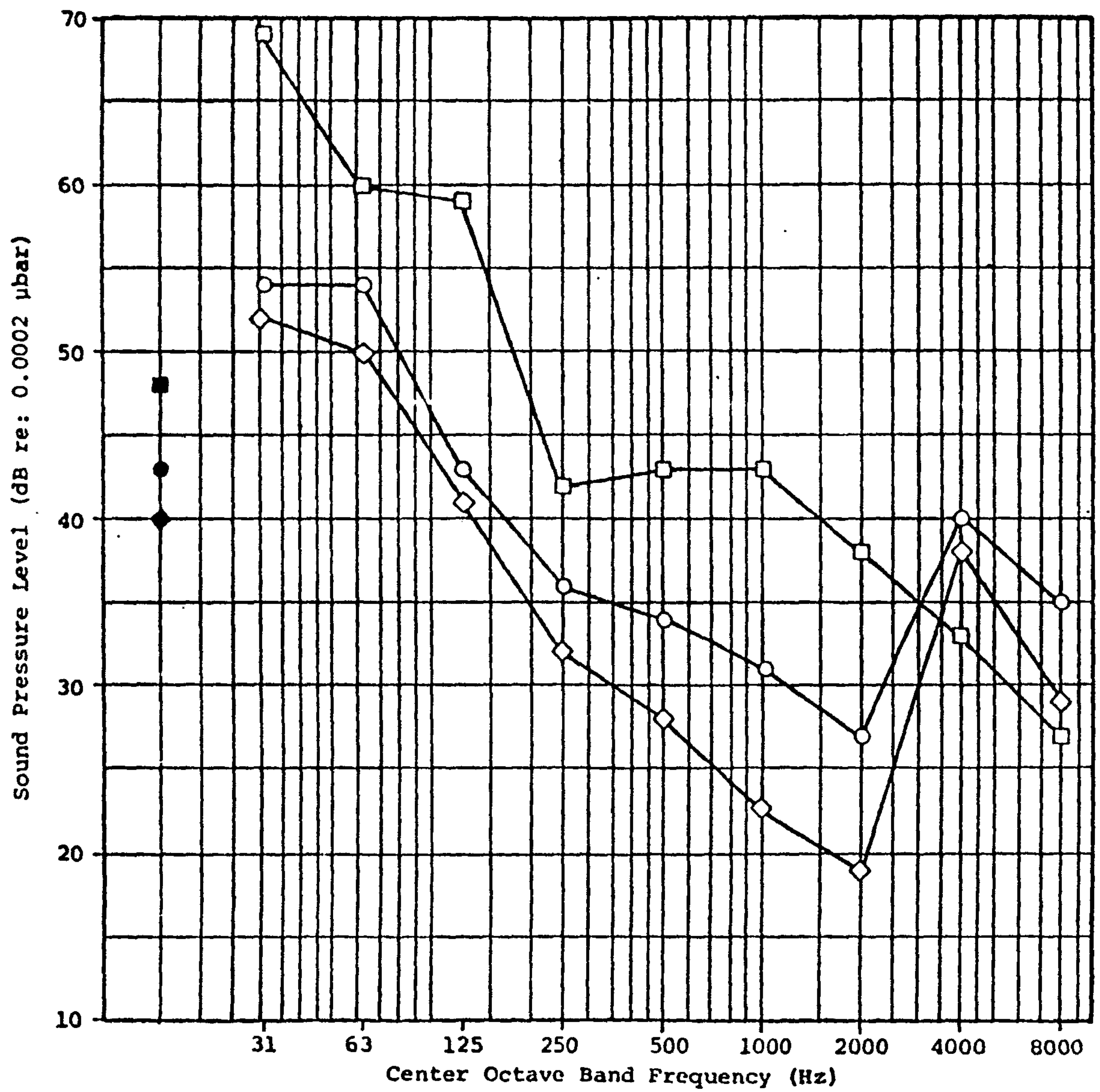

Figure 2.27

Ambient Sound Pressure Levels, in Small Community Roadside near Jones Creek (Seadock, Inc.)

L_{dn} = 48 dBA

○ Evening SPL (dB)

□ Daytime SPL (dB)

◇ Nighttime SPL (dB)

● Evening SPL (dBA)

■ Daytime SPL (dBA)

◆ Nighttime SPL (dBA)

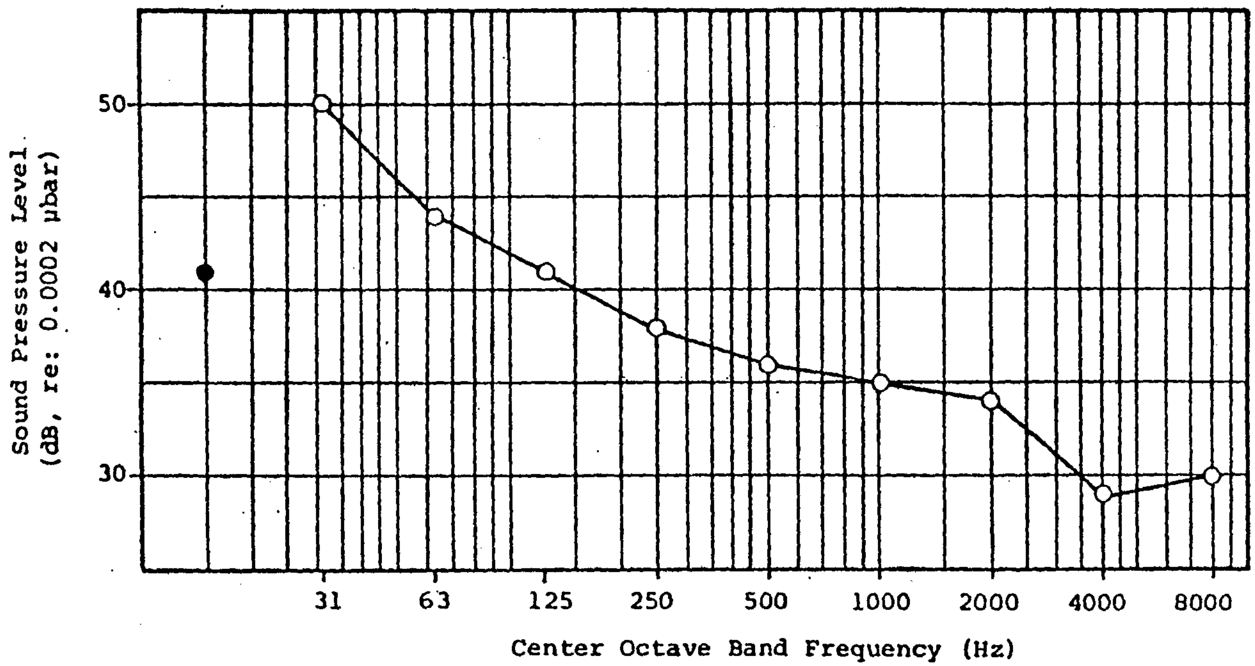

Figure 2.28

Ambient Sound Pressure Levels, Florida Ever-glades, Early March, Daytime

2.4 SPECIES AND ECOSYSTEMS

2.4.1 Natural Environments of the Area

The environmental setting of the project encompasses West Baton Rouge and Iberville Parishes in southcentral Louisiana. The total area of these parishes is approximately 595,000 acres. Surface water is mainly in swamp forest and small bodies of open water.[35] The dome lies approximately 60 miles north of the Gulf of Mexico, 4 miles west of the Mississippi River and 2,000 feet east of the Port Allen Canal (part of the Intracoastal Waterway). It is near the 2 parish boundaries and within the confines of the Terrebonne-Verret Drainage area.

Natural vegetation within the region is influenced by heavy rainfall and humid conditions which are prevalent throughout the year. Average annual rainfall is 56 to 60 inches.[5] Where feasible, much of the land that is not inundated by water is used for agriculture, primarily for sugar cane production.

Section 2.4.1.1 describes typical ecosystems, possible rare and endangered species and important commercial species of the study area (West Baton Rouge and Iberville Parishes). Subsequent sections describe the specific environmental setting of the construction sites.

2.4.1.1 Ecosystems

Three ecosystems were identified which correspond to units utilized in the Inventory of Basic Environmental Data - South Louisiana:[35] cleared lands, woodlands, and fresh waters.

Characteristic flora and fauna of these environments as well as their vegetation types are summarized in Table 2.11. Figure 2.29 shows the distribution of vegetation types in these ecosystems.

Cleared Lands

Cleared lands include the two man-determined vegetation types of crop and pastureland, and urban and suburban areas. There are 197,102 acres of cleared lands in the 2 parish study area, of which 177,000 acres are cropland

Table 2.11 Characteristic Flora and Fauna of the Bayour Choctaw Environmental Setting

Ecosystem	Cleared Lands		Woodlands	Inland Waters (fresh)
Vegetation Type	croplands and pasture lands	urban and suburban areas	deciduous swamp and bottomland forest	Freshwater wetlands
Typical herbs and grasses	signal grass, goatweed	St. Augustine carpet grass	sedges, spiderwort, panic grass	N/A
Typical shrubs	N/A	ornamentals	palmetto, elderberry, youpon, pawpaw	N/A
Typical trees	N/A	ornamentals	cypress, water tupelo, water oak	N/A
Typical mollusks and crustaceans	N/A	N/A	snails	snails, crayfish, clams
Typical amphibians and reptiles	ornate box turtle	toads	southern copperhead, ornate box turtle, skins, tree frogs	leapord frog, water snakes, cottonmouth, bull frogs
Typical fish	N/A	N/A	N/A	gar, sunfish, carp, drum, crappie, shad, buffalo
Typical birds	ducks, bobwhite, mourning dove, eastern meadowlarks, red-winged blackbirds, sparrows, horned lark	starling, house sparrow, grackles, cardinal	woodpeckers, wood duck, warblers, woodcock, red-shouldered hawk, barred owl	ducks, shorebirds, herons, egrets
Typical mammals	striped skunk, cotton rat, rice rat	house mouse, Norway rat	squirrel, swamp rabbit, raccoon, bobcat, gray fox	nutria, otter

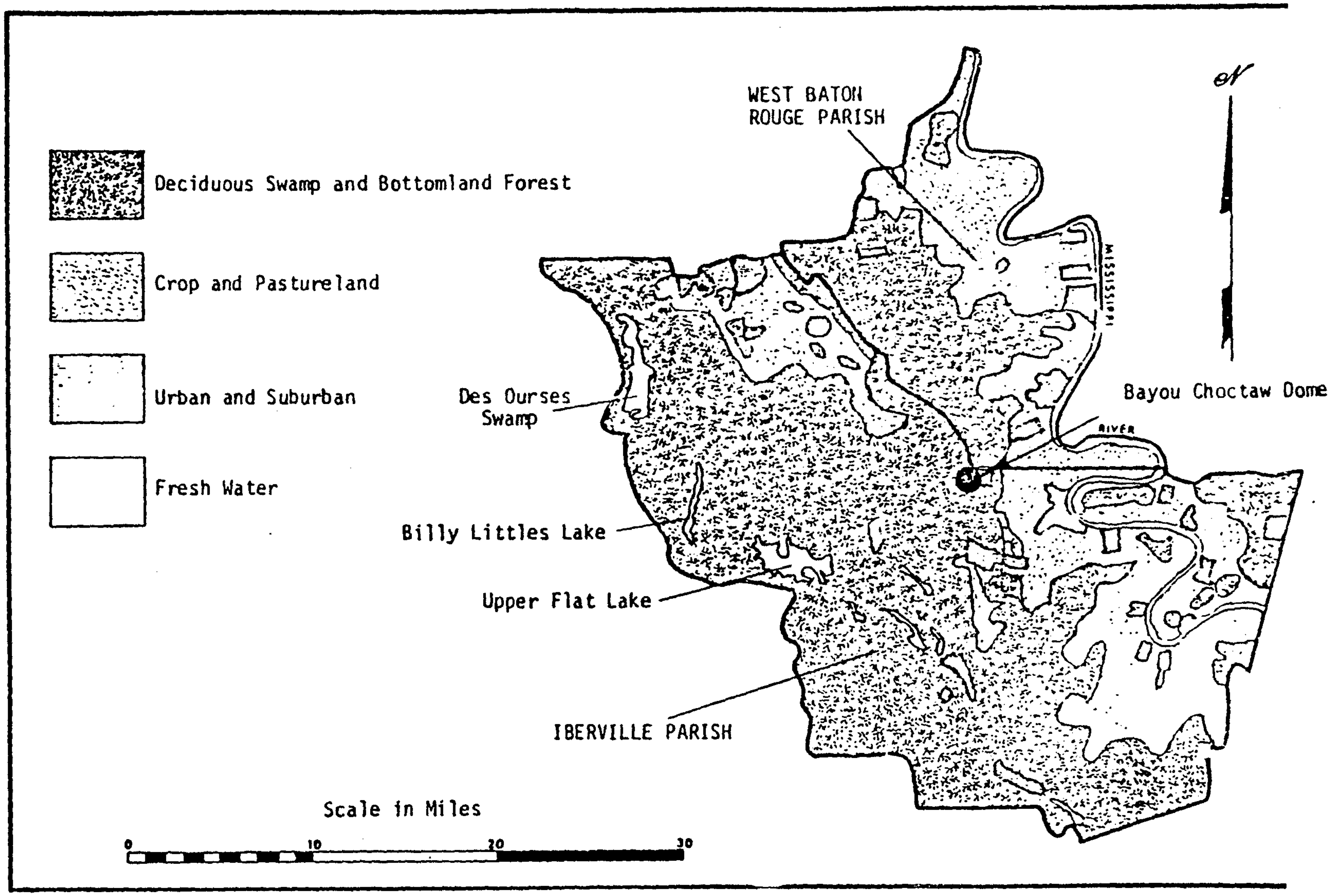

Figure 2.29 Distribution of Vegetation Types in Two Parish Study Areas of the Bayou Choctaw Salt Dome

along the Mississippi River. Cleared lands do not support as diverse a fauna as are prevalent in other vegetation types. Blackbirds, sparrows, fieldbirds, skunks, rats, and mice are typical wildlife. Sugar cane and soybeans are predominant crops. Signal grass (Brachiaria platyphylla) and goatweed (Croton capitatus) are the dominant pasture species.

Woodlands

Some 341,300 of the 595,000 acres in Iberville and West Baton Rouge Parishes are forestland,[36] composed primarily of the deciduous swamp and bottom land forest vegetation types (260,500 acres oak-gum-cypress and 80,800 acres elm-ash-cottonwood).[36] Soils are predominatly fine grained or organic soils that are poorly drained. Often, wooded swamps occur in association with scrub swamps that appear in small areas along streams and at the head of embayments or impoundments. A layer of water approximately one foot deep may cover the surface area of these swamps. Water tolerant trees, such as bald cypress and tupelo gum, occupy perpetually swampy low lying areas. Slightly drier sites on elevated ground within swamps may support bald cypress, sweetgum, eastern cottonwood, overcup oak, water oak, nuttall oak, black willow, sycamore, ash, red maple, box elder, cherry bark oak, hackberry, bitter pecan, and swamp tupelo.

The bottomland forest provides excellent habitat for a variety of terrestrial, avian, and aquatic wildlife, including leopard and tree frogs, cottonmouth snakes, deer, bobcats and small furbearing mammals such as nutria, raccoons, and opossums. A variety of wading birds, such as snowy egret, great egret, Louisiana heron and anhinga, and woodland birds such as the pileated woodpecker, redheaded woodpecker, chickadee, and titmouse, are found in the bottomland forests.

Fresh Waters

Total open water surface area in the two parishes was 8,798 acres in 1967[35] Predominant bodies of open water within the region are the Mississippi River, Bayou Grosse Tete, Bayou Choctaw, the Atchafalaya River, (a minor portion of which borders Iberville Parish on the west). In addition there are numerous minor canals and bayous which traverse the area.

The heavy vegetation and low topography of the region contribute to excellent habitat for a wide variety of aquatic organisms.

Macrophytes* are the dominant aquatic vegetation within the region. In places, water surfaces are covered with a blanket of duckweed (Lemna). Macrophytes serve as a primary food source for many insects, mammals, and birds of the region.

Benthic (bottom dwelling) and suspended algae are abundant in the swamp waters of the region. Many of the macrophytes contain growths of periphyton on their submerged portions. Besides being utilized as food by herbivorous fish, grazing zooplankton, snails, and insect larvae, benthic algae provide a considerable amount of detritus to the system upon their death and decay.

Zooplankton groups which are likely to occur in the swamps are copepods, cladocerans, rotifers, ostracods, amphipods, and protozoans. As primary and secondary consumers, zooplankters are an important intermediate link between primary producers and detritus and other consumers.

Benthic invertebrates in swamps and wetlands of Louisiana similar to those of the study area are dominated by dipterans, oligochaetes, and amphipods.[35] Other benthic invertebrates occurring in the fresh waters include crayfish, isopods, trichopteran larvae, mollusks, protozoans, and nematodes. Benthic invertebrates perform an important function in the ecosystem by feeding on detritus, phytoplankton, and bacteria and by providing food for larger invertebrates and fish. These organisms are relatively immobile as a group, rendering them especially vulnerable to environmental stress.

The most common fish in the region are catfish (Ictalurus spp.), freshwater drum, largemouth bass (Micropterus spp.) other sunfish (Lepomis spp. and Pomoxis spp.), buffalo

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*Higher plants; as used here, aquatic plants with complex structures; i.e., leaves, roots, stems, etc.

(Ictiobus spp.), gar (Lepisosteus spp.), mosquitofish (Gambusia affinis), and several species of minnows.

Several authors have reported that stocked and fertilized fish ponds and highly productive marsh waters can produce 200 to 500 pounds of fish per acre per year.[37,38] Lantz[38] reported fish biomass varying from 56 to slightly over 504 pounds per acre for four shallow lakes in south-central Louisiana. The average biomass during 1969 and 1970 was approximately 250 pounds per acre. Sunfish, catfish, suckers, and gizzard shad often constituted over 80 percent of the total biomass reported, which is probably representative of the annual fish productivity of the bayou-swamp-canal complex overlying and surrounding the Bayou Choctaw salt dome.

2.4.1.2 Rare or Endangered Species of the Study Area

Rare or endangered species of wildlife and vegetation are listed by the U. S. Department of Interior Fish and Wildlife Service.[39] Lists of rare or endangered species have been extracted from a U. S. Corps of Engineers report.[35]

Wildlife species or subspecies in the region that are considered endangered include the Southern Bald Eagle, Arctic Peregrine Falcon, and American alligator. Due to unsuccessful reproduction, Southern Bald Eagle and Arctic Peregrine Falcon populations in the United States are generally declining. Nesting sites of the eagle are scattered along the coast of Louisiana in tall trees in close proximity to large bodies of water. The Arctic Peregrine Falcon is found during migration and winter months along the Gulf of Mexico shore but will probably not be found within the study area since it is not on the coast. The American alligator is found in marshes and lakes throughout southern Louisiana including the two parish study area.

None of the aquatic organisms considered to be rare or endangered by the U. S. Department of Interior, Fish and Wildlife Service, are found within the study area. The U. S. Army Corps of Engineers, New Orleans District, considers the pallid sturgeon (Scaphirhynchus albus) as rare within the state of Louisiana. This species is a potential inhabitat of the area.[35]

2.4.1.3 Important Commercial Species of the Study Area

Important commercial vegetation includes several species of trees and crops grown on area farms. The timber industry of the two parish study region is important. Annually, approximately 7-9 million board feet (Doyle scale) of saw timber comprised primarily of cottonwood, willow, oak, ash, and gum trees are harvested (see Table 2.12.[40]

About 80,421 acres of land in the two parish area were classified as pasture cropland in 1967. Soybeans (with 352,738 bushels) and field corn (with 157,201 bushels) were the leading crops in the two parish area[41] (Table 2.13.) Sugarcane is an important crop in the two-parish area but not a leading plant product. It is listed under "other crops" in Table 2.13. The most important species of commercially valuable wildlife are the aquatic furbearers. Louisiana bayou country is not normally associated with trapping, but this state leads the United States in wild fur production, averaging about 40 percent of the total catch each year.[42] The furbearing species likely to be found in the salt dome area are the racoon and opossum, which prefer bottomland hardwood stands. Gray and red foxes, bobcats, mink and nutria may also be present.[43]

The overflow lakes, bayous, and back swamp areas support large populations of crayfish, frogs, and a number of commercially valuable fish. Twenty-four species of crayfish inhabit the wetlands of Louisiana, 6 of which are found in the study area.[44] The dome area is part of the most productive area for crayfish in Louisiana, the leading state in harvest of crayfish for food,[45] but there is a negligible harvest in the two-parish area of main consideration.

Table 2.12 Forest Resources Production, Louisiana, 1971

Timber Severed by Species (Board Feet-Doyle Scale)	Iberville	W. Baton Rouge	Total Severance For Study Area Figures include timber conservation contracts	Total Severance For the State Figures include timber conservation contracts
Cypress	333,775	16,567	350,342	5,115,245
Oak	1,142,899	250,005	1,392,904	94,270,675
Ash	979,689	174,381	1,154,070	8,017,229
Pine	39,974	47,666	87,640	894,909,756
Gum	772,797	273,674	1,046,471	42,379,132
Other Products	--	--	--	5,934,468
Cottonwood & Willow	1,181,630	22,331	1,203,961	15,859,333
Other Hardwoods	1,338,791	1,286,298	2,625,089	54,667,013
Total Sawtimber	5,789,555	2,070,922	7,860,477	1,121,152,851
Pulpwood Pine (Cords*)	35.68	20.75	56.43	2,341,604.76
Pulpwood Hardwood (Cords*)	3,008.58	1,550.17	4,558.75	813,716.19
Total Pulpwood (Cords*)	3,044.26	1,570.92	4,615.18	3,155,320.95
Special Timber Products **	3,164	699	3,863	
Total Tax Receipts	3,705.54	1,279.22	4,984.76	1,732,216.24

*Standard cords = 128 cubic feet

**Special Timber Products: Veneer logs, in thousand board feet.

Source: "1971 Timber and Pulpwood Production in Louisiana," a report released by the Louisiana Forestry Commission, Baton Rouge, April 1972.

Table 2.13 Agricultural Production in the Bayou Choctaw Study Area (1969)

		PARISH	
CROP HARVESTS		Iberville	W. Baton Rouge
Field Corn	Acres	2,833	511
	Bushels	140,683	16,518
Sorghum	Acres	851	1,137
	Bushels	38,859	55,564
Wheat	Acres	565	1,022
	Bushels	3,575	22,924
Other Grain	Acres	-	-
Soybeans	Acres	8,864	3,925
	Bushels	231,511	121,227
Hay	Acres	5,091	1,875
	Tons	8,096	4,618
Cotton	Acres	42	345
	Bales	29	127
Potatoes	Acres	18	2
Vegetables, Corn, Melons	Acres	28	114
Orchards	Acres	418	100
Other Crops	Acres	19,256	10,155
LIVESTOCK AND POULTRY SALES			
Cattle & Calves	No.	16,285	3,202
Hogs & Pigs	No.	201	106
Sheep & Lamb	No.	-	1
Horses & Ponies	No.	34	13
Chickens 3 mos.+	No.	2,63[illegible]	400

Source: "1969 Census of Agriculture"
U.S. Department of Commerce, Bureau of the Census

A number of fishes are harvested commercially and for sport in freshwaters of Louisiana. Major sport species found in the area include the blue and channel catfish (Ictalurus furcatus and I. punctatus), largemouth bass (Micropterus salmoides), sunfish (Lepomis spp. and Pomoxis spp.), and buffalo (Ictiobus spp.). Commercial take of carp (Cryprinus carpio), catfish, bullheads, and gar (Lepisosteus spp.) totaled over 6.5 million pounds in 1970.[35]

2.4.2 Environmental Setting of the Bayou Choctaw Site

The Bayou Choctaw salt dome is located in the east central portion of Iberville Parish, Louisiana. A portion of the dome extends slightly into West Baton Rouge Parish. The land elevation ranges from 0 to 10 feet above mean sea level. The northern half of the dome is relatively dry (raised about 5 to 10 feet) while the southern half is swampland. The entire site is overlain by a complex of canals, bayous, and swamps directly connected to the Intracoastal Waterway via Bayou Plaquemine and Port Allen Canal. Large volumes of surface water are available through this complex and the system permits immediate water interchange. The concentration of dissolved solids in the surface waters ranges from 120 to 180 parts per million.

At present the site is dominated by industrially developed lands recovered from natural swamp and forest. The site has been previously cleared and filled for utilization as a salt leaching and hydrocarbon storage facility. A network of improved gravel roads service the developed areas.

The Bayou Choctaw site is part of the deciduous swamp and bottomland forest ecosystem (described in Section 2.4.1.1) interspersed with cleared areas for wells. The dominant vegetation at the site consists of bald cypress and water tupelo (tupelo gum) trees, although sedges and panic grasses are also common. Within the deciduous swamp forest, major species of wildlife are deer, swamp rabbit, gray squirrel, wading birds, woodpeckers, ducks, frogs, raccoon, mink, and alligator. This ecosystem affords feeding, resting, and nesting habitat for characteristic species. The general area of the site is a potential nesting habitat for the endangered Southern Bald Eagle. The deciduous swamp forest is sensitive to moisture changes and any significant decrease in water levels would adversely affect the forest community.

In addition to the fauna characteristic of cleared, industrialized areas, animals from the surrounding swamp forest will occasionally utilize the area for feeding. Various pioneer plant species of a disturbed area such as willow, perennial, and annual herbs and grasses are on the site.

The aquatic environment at the Bayou Choctaw dome consists of a vast swamp area which is part of the Terrebonne-Verret Basin. The swamp area is interconnected by a canal-bayou-lake complex that is directly connected to the Intracoastal Waterway by Bayou Plaquemine and Port Allen Canal. A large volume of low salinity (about 0.2 parts per thousand) surface water is available.

The most apparent constituent of the swamp complex at the Bayou Choctaw dome is the aquatic macrophyte community. Plants which often dominate the freshwater marshes in southern Louisiana include bulltongue, maidencane and spikerushes (accounting for 66 percent of marsh vegetation),[46] Giant cutgrass, elephant's ear, various pondweeds, and black willow also dominate the marsh-canal interface along the Intracoastal Waterway. A blanket of duckweed (family: Lemnaceae) covers much of the water surface on the site during warm parts of the year. The freshwater marsh is the most diverse habitat.[46]

Marshes are among the most productive natural ecosystem in the world, with mean net productivity of organic materials as high as 2,000 grams dry weight per square meters per year.[47] Since the Bayou Choctaw dome is in a temperate, nutrient enriched area, this level of production should be indicative of specific production in the vicinity of the proposed facility.

Emergent marsh vegetation serves as the most important producer of the organic detritus cycle. More plant biomass is produced than is consumed by the herbivores, and as this material dies and decomposes, it furnishes food for a wide variety of detritus-feeding organisms. In fresh marshes, this organic matter is incorporated into the soil, and peat soil develops, consisting of approximately 80 percent organic matter.

Several groups of organisms feed directly on the aquatic macrophytes or on the detritus which macrophytes produce upon decay. The diet of nutria consists almost entirely of macrophytes and these animals are common in the swamp-bayou complex around the Bayou Choctaw dome. Crayfish and some other aquatic invertebrates also feed heavily on detritus.

The majority of phytoplankton found in the standing waters at the site consists of green algae, blue-green algae, and diatoms.[46] Maximum phytoplankton density usually occurs during the spring. Phytoplankton provides a major food source to herbivores and zooplankton as well as small filter feeding fish such as shad.

Benthic algae (periphyton) are also abundant in the swamp water of the Bayou Choctaw dome site. Besides being utilized as food by herbivorous fish and grazing zooplankton, snails and insect larvae and benthic algae provide detritus to the system upon their death and decay. Net annual primary production for phytoplankton plus benthic algae in more southern Louisiana marshes is 906 grams dry weight per square meter per year of organic material, and this level of production is believed representative of the swamp at the Bayou Choctaw site.[48]

The U. S. Army Corps of Engineers, New Orleans District, reports that the most common freshwater zooplankter in areas similar to the Bayou Choctaw site is the copepod <u>Eucyclops agilis.</u> Other abundant groups are cladocerans, rotifers, ostracods, amphipods, and protozoans.[15] Zooplankters are an important intermediate link between both primary producers and detritus and other consumers. The zooplankton community in Louisiana coastal marshes produces an average of 25 grams of organic materials per square meter per year.[48] The Bayou Choctaw swamp areas are believed to have comparable levels of production.

Although there is no specific benthic invertebrate data for the bayou-swamp-canal complex overlying and surrounding the Bayou Choctaw dome, a study of 4 shallow freshwater lakes in southwestern and southcentral Louisiana provides data which are assumed to be similar to that for organisms which may be found at Bayou Choctaw.[38] Of the data available, these most closely approximate the characteristics of the construction site. The average depth of these lakes ranged from 4 to 9 feet, as compared to an average depth of 2 to 3 feet at the site. They contain submerged and emergent aquatic vegetation and some are partially surrounded by bald cypress and tupelo trees.

The numbers and biomass of aquatic invertebrates vary seasonally because many species overwinter as juveniles and increased biovolume is evident as summer progresses. During spring months, the average number of aquatic invertebrates is estimated as 680 per square meter; biovolume is 7.1 cubic centimeters per square meter.

Some of the more common fish occurring in the swamp-lake-bayou complex of the site are blue catfish (*Ictalurus furcatus*), channel catfish (*Ictalurus punctatus*), fresh water drum (*Aplodinotus grunniens*), largemouth bass (*Micropterus salmoides*), and other sunfish (*Lepomis* spp.), buffalo (*Ictiobus* spp.), and gar (*Lepisosteus* spp.), mosquitofish (*Zambusia*), and minnows. The major sport fishes sought in the area are largemouth bass, crappie, catfish and sunfish. There is commercial fishing in the area for catfish, bullheads, buffalo, gar, and carp.

2.4.3 Environmental Setting of the Displacement Water Source

During withdrawal of stored crude oil from the 11 Bayou Choctaw dome storage caverns, raw water would be pumped from the onsite lake on the dome to displace the stored crude. This lake was formed as a result of cavern collapse and surface subsidence. It covers a surface area of approximately 12 acres on the north central portion of the dome and is approximately 85 feet deep.

Site preparation and construction would require a pumping station at the lake, an intake structure and pipeline connections to the 11 storage cavities. The source water lake presently contains aquatic macrophytes and probably maintains a diverse community of invertebrates. Although no specific data exist for fish populations in the lake, it is almost certain to contain sunfish and crappie, as well as some "rough"nongame fish such as gar, carp, and buffalo.

2.4.4 Environmental Setting of the Brine Disposal Area

The 28 proposed disposal wells would be drilled to a depth of -7,000 feet on a surface grid pattern covering approximately 1,150 acres of swampland. It is anticipated that only 1 to 2 acres per well would be disturbed by clearing and drilling. Approximately 68 acres of swamp would be directly used by filling for well pads and road beds.

The vegetation in the deciduous swamp and bottomland forest is characterized by bald cypress, water tupelo, sedges, and panic grasses. Only a small portion of this land (1 or 2 acres per wellhead) would actually be cleared and filled. About 40 acres of swamp forest land would be cleared for roadway rights of way.

Resident wildlife consists of wading birds, other waterfowl, small furbearers, rabbits, deer, and squirrels. Other types of birds feed in the area.

Waters within this swamp community south of the dome contain plankton, benthic invertebrates, fish, and aquatic reptiles and amphibians, as well as a variety of aquatic macrophytes and other vegetation. The productivity of the plankton and types of fish found in these waters will be almost identical to the characteristic swamp-bayou-canal complex which was described for the dome itself: phytoplankton equals 906 grams dry weight per square meter per year, zooplankton equals 25 grams dry weight per square meter per year. Fish production is estimated to be approximately 256 pounds per acre per year.[38]

2.4.5 Environmental Setting of the Pipelines

A pipeline network in addition to that of the brine disposal system would be required for connections to the 11 storage wells and for delivery to and from the distribution terminals at Bull Bay and at the Mississippi River site.

Land requirements for all pipeline systems that utilize 75 foot right of way would be approximately 22.5 acres of crop and pastureland, 11 acres of previously industrialized land, and 22.5 acres of deciduous swamp and bottomland forest (see Table 2.14).

The deciduous swamp and bottomland forest is a community dominated primarily by bald cypress, water tupelo, reptiles, small mammals, and birds. The cleared agricultural land consists of crops, pastures, and fallow fields on the natural levee bordering the Mississippi River. Common crops include sugar cane, cotton, soybeans, and truck crops and the dominant pasture species are signal grass (Brachiaria platyphylla) and goatweed (Croton capitatus). Cropland, because of the uniformity in vegetation and resulting lack of plant species does not normally support as diverse a fauna as do other ecosystems. Nonetheless, grain fields and leafy crops provide food for migrating birds in the fall and spring, as well as for deer, cottontail rabbit, bobwhite, and other small animals year round.

The interconnected swamp-bayou complex is the only aquatic environment crossed by proposed pipelines. It contains fish, benthic invertebrates, plankton, periphyton, and aquatic macrophytes; and is described in detail in Section 2.4.2 above.

2.4.6 Environmental Setting of the Dock and Terminal Facilities

2.4.6.1 Barge Dock on Bull Bay

The environmental setting of the barge dock has been described in Section 2.4.2 above.

2.4.6.2 Addis Docking Facility

The Mississippi River dock and terminal facilities at Addis would utilize about 30 of the 250 acres of previously disturbed bottomland and cropland. The disturbed areas are characterized by various pioneer plant species such as willow, perennial and annual herbs and grasses.The

Table 2.14 Acreages Affected in Various Community Types for Components of the Proposed Bayou Choctaw Dome Strategic Petroleum Reserve Facility

Community Type	Cleared Lands		Woodlands	Inland Waters
	Croplands, Pasturelands	Previously Industrialized	Deciduous Swamp & Bottomland Forest	Freshwater Wetlands
Component				
Dome Site	0	100	0	0
Displacement Water Source	0	0	0	12
Brine Disposal Area	0	8.3	68	0
Pipelines	22.5	11	22.5	0
Dock and Terminal Facility	0	30	10	0
TOTAL	22.5	149.3	100.5	12

aquatic biological community of the lower Mississippi River including the study area consists mostly of organisms associated with large, sluggish streams. The river near St. Mary's Church is wide and deep with steep shorelines and fluctuating water levels, preventing establishment of large, permanent aquatic macrophyte beds. The turbidity and currents also deny benthic algae an opportunity to grow. The phytoplankton of the Mississippi River are mostly the same as those found in adjacent lakes and backwaters, such as diatoms of the genera *Asterionella*, *Melosira*, and *Navicula*.[8,49]

Fishes dominate the fauna of the lower Mississippi River in the study area. Common species are mostly "rough" or nongame fish such as paddlefish (*Polyodon spathula*), gizzaard shad (*Dorosoma cepedianum*), buffalo (*Ictiobus* spp.), drum (*Aplodinotus grunniens*), gar (*Lepisosteus* spp.), and carp (*Cyprinus carpio*).[50] Other species found in the area include the skipjack (*Alosa chrysochloris*), shovelnose sturgeon (*Scaphirhyncus platyrhyncus*), several catfish (*Ictalurus* spp.) and sunfish (*Micropterus* sp., *Lepomis* spp. and *Pomoxis* spp.).[51]

It is doubtful that a true zooplankton community exists in large streams.[49] Samples collected in the middle Mississippi River indicated that zooplankters were never abundant, and contained only species of zooplankton found in adjacent bodies of water.[50] Rotifers are often the most abundant group in these situations although some cladocerans, nematodes, and copepods are found.

Benthic invertebrates commonly found in slow moving turbid streams with silt or mud bottoms are usually dominated by bloodworms (Chironomidae) and oligochaetes (Tubificidae) which can withstand silt and low dissolved oxygen concentrations. May fly larvae (especially the genus (*Hexagenia*), may be found in mud bottoms of lakelike areas. In areas of siltation, mollusks and many aquatic insect larvae are uncommon or completely absent.

2.5 SOCIOECONOMIC CHARACTERISTICS

2.5.1 Population

2.5.1.1 Population Density

The project site is located in Iberville Parish near its border with West Baton Rouge Parish. The impact of project operations would be felt in these two parishes and in East Baton Rouge Parish and Ascension Parish. Table 2.15 shows the population density of these four parishes, and the extent of urban and rural development. Towns having a population of less than 2000 are not considered as urban areas. The area immediately surrounding the site is definitely rural, with a number of people living along highways connecting towns and major intersections. The majority of these people do not farm the surrounding land, but commute to jobs in town.

2.5.1.2 Towns and Urban Areas

There are 15 to 20 villages within a ten mile radius of the site which have populations of less than 1,000. Towns of the area include: Plaquemine, pop. 7,739*; Port Allen, pop. 5,728; and Donaldsonville, pop. 7,367. Most commercial and retail businesses servicing the area are located in Baton Rouge, pop. 165,963. Figure 2.30 shows the location of these centers of population relative to the site.

Baton Rouge: This is the capitol of Louisiana, a major industrial center and port city, and the home of Louisiana State University. The population of Baton Rouge grew 8.9% in the years between 1960 and 1970, and it is the third largest city in the State.

Plaquemine: This town was built at the locks which enabled goods traveling from the waterways of the Atchafalaya Basin and west to enter the Mississippi River and vice versa. These locks were built in 1895 and at one

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*This is the population within the corporate limits, an additional 1,224 people live in unincorporated Plaquemine Southwest. All population figures given in this section are from the 1970 census.

TABLE 2.15

POPULATION DENSITY OF SURROUNDING PARISHES

	IBERVILLE	WEST BATON ROUGE	EAST BATON ROUGE	ASCENSION
Population				
Total	30,746	16,864	285,167	37,086
Per square mile	49.0	83.1	621.3	123.2
Rural population*				
Farm	1,535	479	2,960	1,087
Non-farm	18,824	9,685	34,649	24,00'
Urban population				
% Rural	66.7	61.1	13.1	68.0
% Urban	33.3	38.9	86.9	32.0

*Non-farm and farm totals based on sampling only; may not add to total rural population.

Source: 1970 Census Data

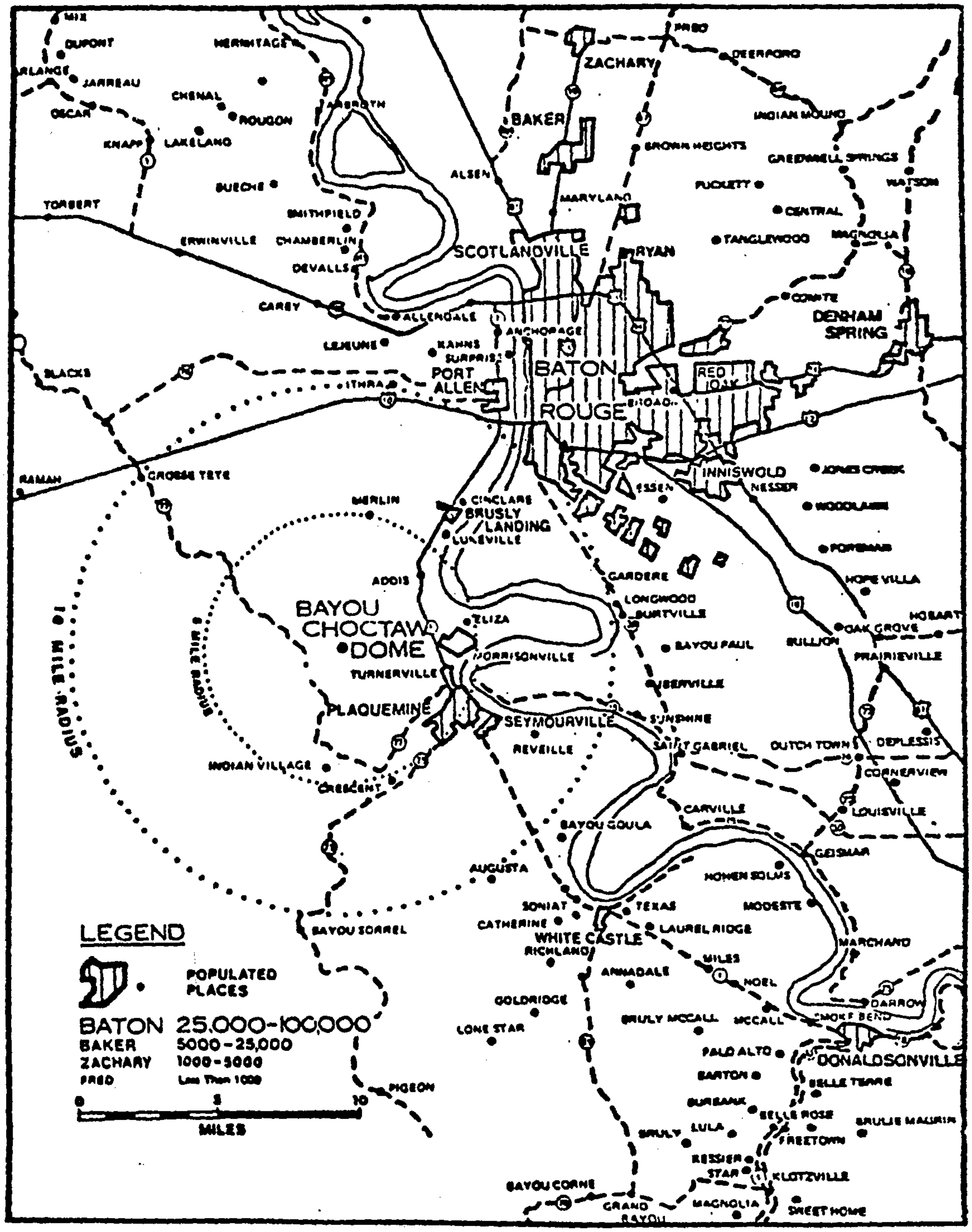

Figure 2.30 Population Centers Surrounding Bayou Choctaw

time provided the highest freshwater lift capable of elevating a barge up to 55 feet. It is the parish seat of Iberville Parish. The influx of industry to the area during the past decade has encouraged young people to stay rather than move to the larger cities. Plaquemine's population, however, grew by only .7 percent between 1960 and 1970.

2.5.1.3 Historical Growth and Trends

The site lies within an area that until 20 years ago was quite economically underdeveloped with a population tending to migrate into the cities. In 1956 Dow Chemical built a plant near Plaquemine. The plant employs over 1,000 people. This development was followed by Hercules, Georgia Pacific, the Nadler Foundary, and other smaller industries. This recent industrialization has brought a substantial increase in tax revenues available to communities and a stimulation of employment opportunities, but not a marked increase in the population of Iberville Parish. Many of the workers employed by these industries live in the neighboring West and East Baton Rouge Parishes and Ascension Parish, and commute to their jobs.[52]

The area southeast of Baton Rouge experienced substantial growth during the decade 1960-1970. Rates of population expansion for each of the four parishes during that time are:

Iberville	2.7%
West Baton Rouge	14.0%
East Baton Rouge	24.0%
Ascension	32.8%

2.5.2 Cultural Patterns

The small communities near the project site are unique compared to towns of the same size in other regions of the country. Early French influence can be seen in the layout of property boundaries in long, narrow plots of land stretching out from waterways, according to the French distribution of arpents. The French-speaking community is the largest ethnic language group, and the area is distinguished by the predominance of French place names and family names. A basically conservative influence is exerted in these small communities by families that have been established here for generations and by an active awareness of the historical significance of local landmarks.

Within this area of study, the region west of the Mississippi River has a more equal racial balance than the east side. All four parishes except Iberville have had an influx of white population and all four parishes have experienced an out-migration of non-whites.

2.5.3 Community Services

2.5.3.1 Housing

The availability of housing for sale or rent is severely limited in the area west of the Mississippi River near the site. Table 2.16 shows the number of housing units in the four parishes under study and indicates a greater availability in the communities east of the Mississippi.

2.5.3.2 Education and Schools

The Louisiana State guidelines for pupil-teacher ratios assign one teacher to each 27 pupils (or major fraction of that unit) at the elementary level, and one teacher per 25 pupils at the secondary level. Additionally, high schools (grades 9 through 12) are entitled to a minimum of two enrichment teachers, and an additional two more for every additional 300 pupils. These "enrichment" teachers specialize in music, art, vocational education, counselling, and library science.

The number of regular and special education teachers allotted to the public schools of parishes which may be affected by the proposed project are as follows:

Parish	Pupil Enrollment*	Teachers**
Iberville	7,907	407.6
West Baton Rouge	3,893	201
East Baton Rouge	65,970	3,205.6
Ascension	10,941	488.3

*Pupil enrollment for the school year 1973-74.

**Teacher allotment in state education budget for school year 1975-76

TABLE 2.16

HOUSING UNITS AND OCCUPANCY BY PARISH

	IBERVILLE	WEST BATON ROUGE	EAST BATON ROUGE	ASCENSION
Year-Round Housing Units	9,096	4,803	88,936	11,214
Occupancy & Tenure				
Occupied dwelling units	8,144	4,403	81,460	10,030
Owner-occupied	5,202	2,906	54,049	7,394
Renter-occupied	2,942	1,497	27,411	2,636
Vacant Year-Round Units for Sale or Rent	328	133	5,537	730
Vacancy rate	3.6%	2.8%	6.8%	7.3%
Median Value (Owner-occupied)	$10,300	$12,400	$17,800	$12,600

Source: U. S. Bureau of Census, 1970

2.5.3.3 Police and Fire Protection

Police protection for the proposed site would be provided by the Iverville Parish Sheriff's office operating from Plaquemine, the parish seat. Plaquemine itself has a police force of 24 officers including radio operators. Fire protection would be available from Plaquemine's municipal fire department which has three stations and a total of six fire engines. These are manned by a staff of 16 paid firemen supervised by a fire chief and assistant fire chief, and a number of volunteer firemen in the area.

Addis, which is north of the site in West Baton Rouge Parish, has a volunteer fire department with one engine.

Baton Rouge has a police force of 444 officers in uniform (513 personnel in the police department), and a fire department with a total of 379 paid firefighters.*

2.5.3.4 Hospitals

The hospital closest to the site is the Rhodes J. Spedale General Hospital in Plaquemine, which has 60 beds and nearly 100 personnel. There are three hospitals in Baton Rouge offering general medical and surgical services: Baton Rouge General Hospital with 387 beds, the Earl K. Long Memorial Hospital with 238 beds, and Our Lady of the Lake Hospital with 400 beds.**

2.5.3.5 Outdoor Recreational Facilities

Hunting and fishing are major forms of recreation in the region. More licenses for fishing are issued here than for hunting and trapping. Over 14,000 resident fishing licenses were granted in Iberville Parish during the 1973-74 season, and over 22,000 in East Baton Rouge.

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* International Management Assoc., The Municipal Yearbook 1975, Vol. 42, 1975.

** American Hospital Association Guide to the Health Care Field, published by the American Hospital Assoc., 1975 Edition

This latter parish ranked sixth in the state in the number of fishing licenses sold. Over 16,000 resident hunting licenses were sold in the entire four-parish area, and over 8,000 additional licenses for big game.[53]

2.5.4 Economic Characteristics

2.5.4.1 Basic Economy of the Area

Manufacturing: There are over 125 manufacturing plants in Baton Rouge and its suburbs. The manufacturing industry provides the greatest number of jobs to the four parishes. The distribution of employment among various categories of industries is shown in Appendix I. About 22,800 persons are employed in manufacturing alone. Chemical plants dominate the manufacturing field and employ the greatest number of workers. Second in number of plants is the manufacture of goods relating to construction. The construction industry itself is the second largest employer in the area.

This area is particularly well suited for manufacturing due to: (1) an abundance of fresh water provided by the Mississippi River; (2) convenient shipping facilities via the port at Baton Rouge and the confluence of four railroad systems; (3) close proximity to mineral resources that provide raw materials for the production of organic and inorganic chemical compounds.

Shipping: The volume of cargo handled at the Port of Baton Rouge has steadily increased. In 1974 the port handled an estimated 53.5 million tons. About 800 vessels used the public port facilities that year.

A large proportion of cargo is grain that is transferred by barge traffic from regions of the country bordering the Mississippi and its tributaries. The port offers a grain elevator with 7.5 million bushel capacity and a 340 foot grain wharf. This port is the second largest grain exporter in Louisiana.

An 11 million gallon tank terminal is provided for the transfer of liquid products. A large bulk handling terminal provides for the shipping of ores and concentrates. The port's Public Commodity Warehouse offers 75,000 square feet of covered storage area, and an additional 200 acres are available for open storage.

Mineral Production: A number of minerals are commercially extracted in the area. This includes salt, sand and gravel, lime, cement, and natural clays, but the most important are petroleum, natural gas, and natural gas liquids. This industry is particularly important to Iberville Parish where the value of its mineral production in 1971 exceeded $67,000,000 (See Appendix I).

Agriculture and Forestry: The arable land in this region is used as pasture for grazing cattle and raising a limited variety of cash crops. The major crop in terms of acreage harvested is sugar cane, followed by soybeans and corn.

Lumbering is an important industry in Iberville Parish where there are about 279,300 acres of commercial forest. Several lumber companies and wood product industries are located here.

2.5.4.2 Employment Distribution

The employment status of men and women in the four parishes is shown in Table 2.17. The relative high rate of unemployment in Iberville Parish may be accounted for by the effects of an unsteady job market in some of the plants and a lack of skills among a sizable proportion of the labor force. (This situation may improve somewhat in the future because of a vocational school being built in Plaquemine.)

Although East Baton Rouge Parish has a low unemployment rate, the pool of available workers is larger there.

The occupational distribution of men and women is given in Table 2.18. The largest number of workers are in the categories listed as (1) craftsmen, foremen and kindred; (2) equipment and vehicle operators and kindred; and (3) laborers.

The number and proportion of workers who commute out of their home parishes to their jobs is high (see Appendix I). It generally indicates a widespread pattern of commuting reflecting the concentration of jobs in Baton Rouge and the growth of manufacturing plants along the Mississippi north and south of that city, developing areas in Iberville and Ascension Parishes.

TABLE 2.17

EMPLOYMENT STATUS, BY PARISH

	IBERVILLE		WEST BATON ROUGE		EAST BATON ROUGE		ASCENSION	
	Male	Female	Male	Female	Male	Female	Male	Female
In Labor Force*	5,936	2,927	3,437	1,545	66,938	40,484	8,147	3,273
Employed	5,341	2,677	3,197	1,386	64,252	38,325	7,705	3,100
Unemployed	595	250	240	159	2,686	2,159	442	173
% Unemployed	10.0%	8.5%	7.0%	10.3%	4.0%	5.3%	5.4%	5.3%

* Excludes military personnel

Source: U. S. Bureau of Census 1970.

Table 2.18 EMPLOYMENT IN MAJOR OCCUPATIONAL GROUPS BY PARISH

Occupational Groups	IBERVILLE		WEST BATON ROUGE		EAST BATON ROUGE		ASCENSION	
	Employees	Percent	Employees	Percent	Employees	Percent	Employees	Percent
Total Reported	5,979	100.0%	1,719	100.0%	88,653	100.0%	6,551	100.0%
Agriculture, Forestry, Fisheries	(D)	(D)	(D)	(D)	410	0.5%	(D)	(D)
Mining	262	4.4%	(D)	(D)	637	0.7%	(D)	(D)
Contract Construction	1,252	20.9%	108	6.3%	15,217	17.2%	642	9.8%
Manufacturing	2,131	35.6%	(D)	(D)	16,902	19.1%	2,697	41.2%
Transportation and Public Utilities	282	4.7%	566	32.9%	5,733	6.5%	525	8.0%
Wholesale Trade	112	1.9%	53	3.1%	7,113	8.0%	314	4.8%
Retail Trade	938	15.7%	329	19.1%	17,840	20.1%	1,531	23.4%
Finance, Insurance, Real Estate	175	2.9%	72	4.2%	7,344	8.2%	254	3.9%
Personal, Medical, Legal & Educational Services	674	11.3%	108	6.3%	16,865	19.0%	492	7.5%
Unclassified	(D)	(D)	42	2.4%	592	0.7%	(D)	(D)

"D" denotes figures withheld to avoid disclosure of operations by individual reporting units

Source: County Business Patterns 1973, compiled by the U. S. Bureau of Census.

2.5.4.3 Income Distribution Patterns

The number of households with an income less than the national poverty level is relatively high in Iberville Parish (37.9%). Median income of families is $6251, and of individuals, $1367. This reflects a situation in which a large part of the indigenous population of the parish derives its income from social security benefits and public assistance, while many higher-paying positions in industries that have come into the parish have been taken by people living outside of it who have more skills. Furthermore, the slow rate of housing development in Iberville Parish has inhibited the migration of workers and their families there.

A similar but less pronounced situation exists in West Baton Rouge Parish. Ascension Parish is similar to Iberville Parish in having a high proportion of low income residents (30.6% below national poverty level), but its median income level is in the range of $10,000. The existance of a proportionately large working force in east Baton Rouge Parish is reflected in its low rate of poverty level households (18.6%) and its median income ($7070) which is approximately the wage level of craftsman and equipment operators (See Appendix I).

2.6 UNIQUE FEATURES

2.6.1 Archaeological and Historical Sites

As is true for most every major deltaic complex in the mid-latitudes, the Mississippi delta was an attractive habitat for prehistoric man due to its abundance and variety of resources available to sustain primitive economics. Archaeological sites are numerous all over the delta. They are present to the south, east, and northwest of the Choctaw Salt Dome. However, few of these sites are near the salt dome and none on it, as is evident in Figure 2.31, and therefore none would be affected by the project.

2.6.2 Parks, Wildlife Refuges, and Scenic Areas

No state parks, national parks, or recreational areas are expected to be in the area of potential impact (see Figure 2.32.

2.6.3 Biologically Sensitive Areas

Within the region the primary physiographic features are natural levees, formed from alluvial deposits of the Mississippi River and its distributaries, with associated inter-levee basins. Three ecosystems: cleared lands, woodlands, and freshwater, have been identified in the two parish study area.

Cleared lands comprise a relatively small portion of the study area and are not considered ecologically sensitive. Within the two parish area the woodlands ecosystem is composed entirely of the deciduous swamp and bottomland forest vegetation type. Wooded swamps along rivers and streams comprise the bulk of this habitat type. This ecosystem is particularly sensitive to changes in ground and surface water levels and salinity.

Predominant bodies of water comprising the fresh water ecosystem are the Mississippi River, Bayou Grosse Tete, Bayou Choctaw, the Atchafalaya River (a minor portion of which borders Iberville Parish on the west), and numerous minor canals and bayous which traverse the area. This ecosystem is also very sensitive to changes in salinity and water levels.

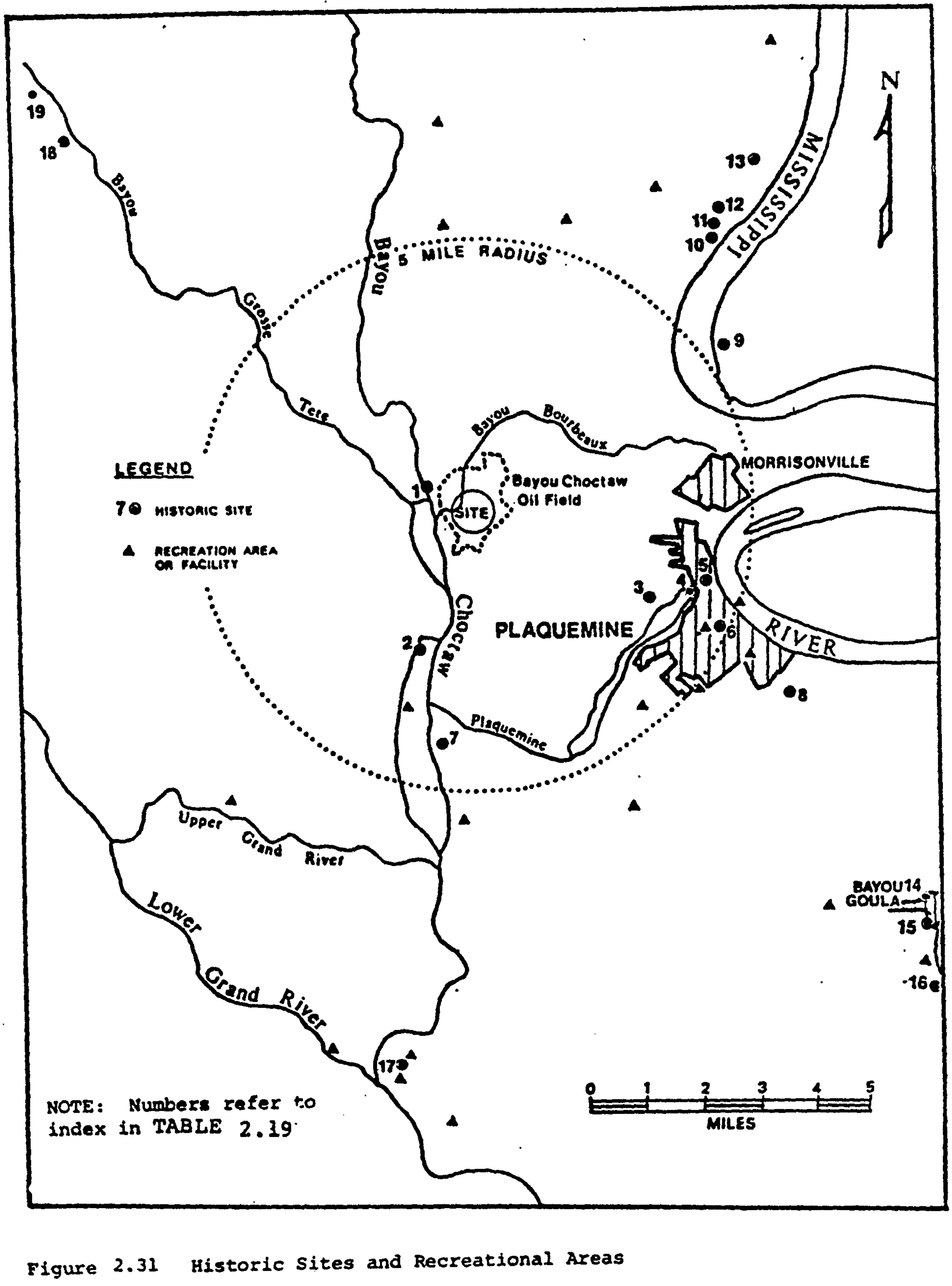

Figure 2.31 Historic Sites and Recreational Areas

Table 2.19

ARCHEOLOGICAL AND HISTORICAL SITES FROM LOUISIANA STATE PLAN
(NOT LISTED IN NATIONAL REGISTER)

Map Ref. No.	Parish	Name	Location
1	Iberville	Bayou, Choctaw, or Bayou Go-To-Hell	Beside Louisiana Highway 75 N. of Indian Village.
2	Iberville	Bay Farm Plantation	S. of Grosse Tete on Louisiana Highway 77
3	Iberville	Hunter's Lodge	On Louisiana Highway 77, 2.2 mi. W. of La. 1 out of Plaquemine
4	Iberville	Bayou Plaquemine	Flows out of Mississippi River at Plaquemine
5	Iberville	Bayou Plaquemine Lock*	U.S. Gov't. Reservation (14 acres) confluence of Bayou Plaquemine with Mississippi River in Plaquemine
6	Iberville	a) Plaquemine b) Middleton Home	Town on La. Highway 1. Eden and Plaquemine Streets, Plaquemine.
7	Iberville	Indian Village or Village Point	At confluence of Bayous Plaquemine and Gross Tete
8	Iberville	St. Louis Plantation or Home Plantation	On La. 405, 1.6 mi. S. of Plaquemine.
9	E. Baton Rouge	Cottage Site	River Rd., 6½ mi. S. of Baton Rouge Bridge on Duncan Point.

*National Register of Historic Places

Table 2.19 (continued)

Map Ref. No.	Parish	Name	Location
10	W. Baton Rouge	Lousteau House	River Road near Brusly.
11	W. Baton Rouge	a) Brusly b) Cazenave	Town on La. 1. Off River Road (La. 1), at Brusly.
12	W. Baton Rouge	Sandbar House	River Road (La. 1), N. of Brusly.
13	W. Baton Rouge	Antonio	On River Road (La. 1), just N. of Brusly.
14	Iberville	a) Bayou Goula b) Bayou Goula Site	Town on La. Highway 75, N. of Indian Village. West Bank of Mississippi River, 5 mi. S. of Plaquemine.
15	Iberville	Tallyho	On River Road (La. 405), ½ mi. S. of Plaquemine.
16	Iberville	Nottaway Plantation House	On River Road (La. 405), 1½ mi. N. of White Castle.
17	Iberville	Schwing Place Mound	East of Lower Grand River near town of Bayou Souvel.
18	Iberville	Grosse Tete	Town on Louisiana Highway 77, N.W. of Plaquemine
19	Iberville	Hotard	1 mi. N. of Grosse Tete on Louisiana Highway 77.

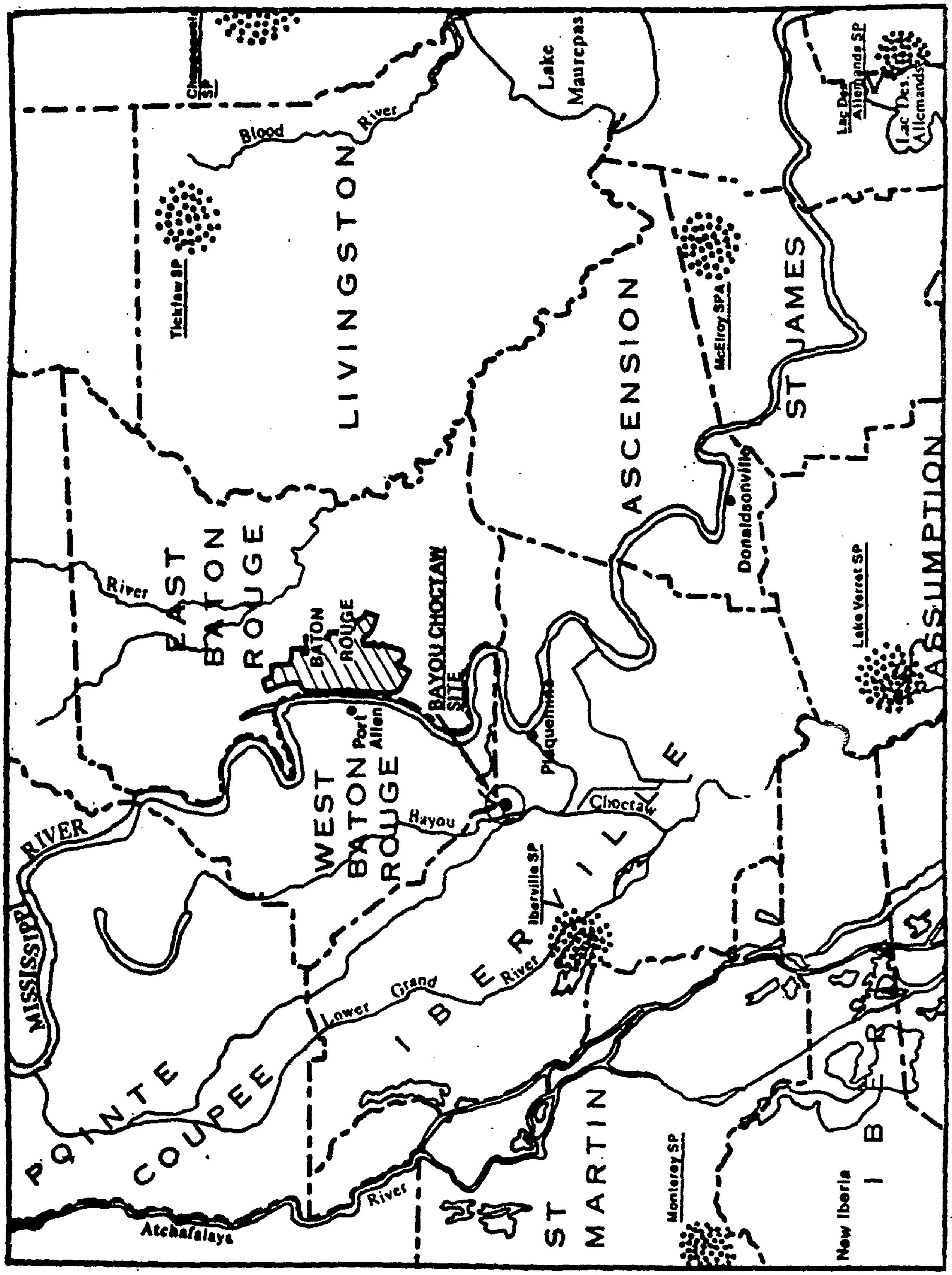

Figure 2.32 Proposed Parks in the Vicinity of Bayou Choctaw Site

Wildlife species or subspecies considered "endangered" in the region include the Southern Bald Eagle, Arctic Peregrine Falcon, and American Alligator.[39] Due to unsuccessful reproduction, Southern Bald Eagle and Artic Peregrine Falcon populations are generally declining in this country. Nesting sites of the eagle are scattered along the coast of Louisiana in tall trees within close proximity to large bodies of water. The Arctic Peregrine Falcon is found during migration and winter months along the Gulf of Mexico shore and will probably not be found within the study area. The American Alligator occurs in the marshes and lakes throughout southern Louisiana and is present in the swamp of the project area.

None of the aquatic organisms considered to be rare or endangered by the U. S. Department of Interior, Fish and Wildlife Service, occur within the study area. The U. S. Army Engineers, New Orleans District, considers the pallid sturgeon (Scaphirhynchus albus)as rare within the state of Louisiana. This species is a potential inhabitant of the area.[35]

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3. ENVIRONMENTAL IMPACT OF THE PROPOSED ACTION

3.1 IMPACT OF SITE PREPARATION AND CONSTRUCTION

3.1.1 Land Features and Uses

Impacts of the proposed project on land features and uses would occur almost exclusively during site preparation and the construction of facilities. They would result primarily from building the docks, laying the pipelines, and creating the required levees around the storage site and tank areas. Minor soil erosion would occur due to the exposure of the soil during these construction activities and the tendency of the soil to break loose during heavy rainfall in the area.

Erosion would be a temporary adverse effect, however, and permanent changes to land features are not decidedly detrimental. These changes include: additional roadways, enlargement of Bull Bay dock and part of the Mississippi River Channel, providing access to the permanent dock, and constructing levees around the oil storage wells and tanks.

It is anticipated that access roads to the various storage wells would be built on elevated fill of at least four feet to remain above flood state levels. The roadways, in conjunction with other levees would provide a dike against flood waters as well as containment for spilled oil. Local soil having a high clay content would be used to minimize potential seepage of brine or oil into the surrounding land. The dikes would be revegetated to prevent erosion and to help preserve the aesthetics of the site.

3.1.1.1 Geologic Impacts

Construction: The major geologic impact that would occur during construction is the suspension of sediment during dredging.

Dredging would be required to expand the existing barge terminal on Bull Bay, and spoil would be used for fill or deposited on site in designated fill areas and revegetated to minimize erosion. Further dredging in the Mississippi River during construction of the permanent dock facilities would remove approximately 1.5 million cubic yards of spoil which would be deposited in the river channel, a common practice in Mississippi navigation control.

In any dredging operation a certain amount of turbidity would result. Since the proposed dredging would be done hydraulically and the spoil would be deposited on the bank, or used for fill, the amount of material put into suspension would not constitute a significant geologic impact.

Deepening and widening of Bull Bay would initially cause some turbidity during construction and early operation. However, after the larger suspended sediment particles have settled and the extremely fine clay and silt particles have lodged between larger particles, the amount of erosion or turbidity that subsequently results would be low.[1] Tidal currents would not be a factor in the resuspension of sediments because these currents are nearly imperceptible. Another factor that would limit the amount of stream bed erosion is colloidal cementation of sediment in the channel. The sediments in this area are sand, silt and clay with high organic content. Clay minerals commonly form colloidal suspensions which are capable of forming bonds between sediment particles regardless of size. The high organic content of these sediments would generate humic acid which in some cases would also form bonds between particles, thereby increasing the sediment coherence.[2]

Operation: The three potential impacts of geologic significance resulting from the operation of the petroleum storage facility are: channel erosion due to increased barge traffic in Bull Bay, possible land surface subsidence due to storage cavity collapse, and fracture of the aquiclude* above and below the disposal aquifer by high pressure injection of brine.

An impact of increased barge traffic along Bull Bay is erosion on the channel bottom and shore caused by the movement of the barges. The barges may generate wakes capable of transporting some material from the sides of the channel, but natural development of vegetation would eventually act as a wave baffle and dissipate wave energy.

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*An aquiclude is a geologic formation so impervious that for all practical purposes it completely obstructs the flow of ground water (although it may be saturated with water itself), and completely confines other strata with which it alternates in deposition.

Turbulence along the bottom caused by the passage of a barge may initiate some sediment motion but the slow speed (2-3 knots)[3] of the barges and the 1.5 foot clearance should preclude any significant turbidity or bottom erosion.

Therefore, the general conclusion regarding bottom scour and channel bank erosion in Bull Bay is that impacts would be minimal for the duration of the proposed activities.

The potential geologic impact of operation is cavity collapse. Surface subsidence occurred at the Bayou Choctaw Dome over the number 7 well in 1954.[4] The operator indicated that salt was "washed out" up to the caprock and the subsidence was a result of partial collapse of the caprock and overlying sediments. If a proper oil blanket has been maintained, upward leaching of the salt could have been avoided. It should be noted that this well was an active brining operation at the time of collapse. Water from near-by canals and bayous filled the subsided area forming a roughly circular lake with a diameter of about 200 yards. Sonar probing in 1975 showed the maximum depth to be 85 feet. Appendix K contains a detailed discussion of subsidence.

The third potential impact is the fracture of the aquiclude above and below the injection aquifer. The volume and porosity of the sandstone aquifers in the area designated for brine disposal indicate that injection at a rate of 19,450 gallons per minute would not fracture the overlying rock or cause contamination of overlying fresh water aquifers (see Section 3.2).

Effects on Geohydrology: Potential impacts on the geohydrology of the area depend primarily on the source of leaching water or displacement water and the destination of the brine discharge. These matters are discussed in Section 3.2.

Effects on Soils: Routine operating conditions such as equipment testing, maintenance, and oil extraction or cavity refill are not expected to affect soil conditions significantly. Small amounts of fill dirt and shells would migrate to immediately adjacent areas. During floods, larger quantities of fill dirt might migrate to surrounding areas. The amounts and types of fill dirt should not significantly change the character of nearby soils.

3.1.1.2 Land Use Impacts

Construction: During construction land usage patterns would be affected at the storage facility site, along pipeline routes, and at the dock sites. About 104 acres surrounding the eleven cavities proposed for the project would be enclosed by containment dikes as discussed in Section 3.2.2.2. The land is presently developed with elevated areas for the buildings, roadways, etc. serving the existing brine production and storage facilities. The pipeline right-of-way from the storage site to the brine disposal field will be 50 feet wide and about 6,000 feet long. Additional rights-of-way connecting the individual wells in the disposal area would require a total area 50 feet wide and 30,000 feet long. Total right-of-way area for brine disposal would amount to about 42 acres. This land is currently a deciduous swamp forest. Only the right-of-way for the pipeline corridor would be cleared. Construction of the buried pipeline to the storage site would cause temporary disturbance due to the excavation, and the cleared corridor would be maintained during the life of the project. Elevated roadways would service the disposal wells. Culverts would be installed to minimize interruption of the natural drainage patterns.

The dual pipeline right-of-way leading to permanent dock facilities on the Mississippi River would be approximately 5 miles long and would cross Louisiana Highway No. 1 and the Texas-Pacific Railroad. About half of the route passes through backwater swamps and half through sugar cane fields. The proposed pipeline would disturb about 30 acres of sugar cane. It is assumed that no existing structures would need to be removed to accommodate this right-of-way.

During construction of the pipeline on dry land, a temporary right-of-way 125 feet wide would be required. At the completion of backfill operations on each segment of the pipeline, this right-of-way would be reduced to a width of 75 feet and could be restored to previous use. The permanent right-of-way to be maintained during the project would amount to about 45.5 acres, based on a 75-foot width, extending the five miles from the storage site to the dock.

The land impacted by the project is summarized in Table 3.1. Land adjacent to the Mississippi River would be required for the construction of a permanent dock, to be located on a 250 acre tract.

Operation: Operation of the SPR project at the Bayou Choctaw dome would permanently require land at the site itself, pipeline rights-of-way, and a tanker terminal. The impact of this land use upon other land use is discussed in this section.

Use of the Site and Adjacent Areas: During the life of the proposed project the site would be restricted from other commercial or residential uses. The mining of sulfur or other minerals from the caprock under the site would not be feasible during facility operation. The majority of the acreage would remain in its present condition. If the project is terminated, the wells would be plugged. Surface structures may be removed to partially restore the site to the original condition. The elevated areas would be left in place.

All required wells would be located within 3 miles of the site. These areas would be restricted from other uses during the life of the project.

Land Use Along Pipeline Rights-of-Way: Pipeline connections to 11 caverns would be required for oil and fresh water/brine. Most of the routes are through developed areas on the site. During the operational period, these pipelines would cause little land use impact.

A pipeline would be required from the raw water intake on the pond to a raw water distribution point. The intake would probably be placed adjacent to the present one since a greater raw water capacity is required. The intake pipeline would parallel present ones and would cause little land use impact.

A pipeline would be required from a central distribution point to the brine pond and disposal wells. This line would proceed in a southwestward direction through swamp. The right-of-way would be kept clear over the life of the project. No industrial or agricultural use of this land is foreseen at present.

Table 3.1 Land Impacted by Pipeline Systems During Construction and Operation of the Storage Facility.

	Pipeline Distance	Construction Phase: Width of Right-of-way	Construction Phase: Acreage Affected	Operation Phase: Width of Right-of-Way	Operation Phase: Acreage Affected
Storage Site to Brine Disposal Field	6,000 ft.	125 ft.	17.2	50 ft.	6.9
Brine Disposal Field Connections to Individual Wells	30,000 ft.	125 ft.	86.2	50 ft.	34.5
Oil Distribution System	26,400 ft.	125 ft.	75.8	75 ft.	45.5

A pipeline would be required from the site to a tanker terminal on the Mississippi River 5 miles away. This pipeline would cross marsh, pastureland, cropland, and possibly industrial sites. The marsh portion would be cleared over the life of the project. Agricultural land would be restored to its former use. Structures would not be permitted over the pipeline right-of-way.

An alternate plan requires a pipeline to fresh water wells rather than to the surface water intake. No major impact is foreseen should this additional pipeline be laid.

3.2 WATER QUALITY

Site preparation and construction activities would involve a significant amount of dredging, first in the construction of barge docks on Bull Bay and later in the construction of the permanent dock on the Mississippi River. These dredging operations, would have a significant impact on the water environment (discussed in subsection 3.2.1). In addition, a considerable amount of earth-moving would occur during site preparation and construction. Such activity would also have an impact on the water environment and this is described in subsection 3.2.2. Chemical and biological pollutants would be generated during site preparation and construction. Their impact on the water environment is described in subsection 3.2.3.

No leaching is currently planned in the process of site preparation and construction, and thus the problem of obtaining an adequate leaching water supply should not occur. Likewise, the problem of brine disposal (due to leaching) should not occur during site preparation and construction. The possibility exists that the current operator of the existing caverns, Allied Chemical Corporation, may require fresh water to replace brine removed for feedstock. Such an operation is currently a standard procedure, as already described, and such operations are not considered part of the site preparation and construction activity.

The operation of the facility would affect water quality in the vicinity of the dome. Such effects can be divided into three major categories. The first effect, which is discussed in subsection 3.2.4 deals with the withdrawal of water from the environment in order to displace oil from the caverns. The second effect results from the disposal of brine displaced from the caverns by oil during each filling cycle, as discussed in subsection 3.2.5. The third effect is concerned with the effect of maintenance dredging operations. This effect is discussed at the end of subsection 3.2.1.

3.2.1 Impact of Dredging

The dredging operations during site preparation and construction would occur primarily in two areas:

(1) The junction of the Port Allen Canal and Bull Bay and (2) the Mississippi River near Mile 222. In each case the impact on water quality can be divided into two parts: (1) the impact of dredging on water quality at the dredging site and (2) the impact on water quality at the disposal location for the dredged material. The location of dredging areas subsequently discussed are indicated in Figure 3.1.

Quantitative prediction of the impact of dredging operations and the disposal of dredged material on the water environment is currently not feasible because of the absence of tested and accepted methods for such prediction. Various research programs currently underway as part of the Dredged Material Research Program, U.S. Army Corps of Engineers Waterways Experiment Station, Environment Effects Laboratory, may ultimately produce the necessary prediction techniques. At the present time only a qualitative description of such impact, based on past observations under similar conditions, is possible.

The proposed disposal and transportation for disposal of dredged material would be performed in accordance with all applicable Federal and state laws and regulations. Federal regulations regarding the disposal of dredged material have undergone numerous revisions in the past several years, as discussed in Appendix D.4. At the present time the actual quality of the sediment is not the deciding factor in determining the necessary disposal procedures. Instead, the quality of the standard elutriate, produced by a mixture of sediment and water from the same site, is the governing factor. The quality of the elutriate is compared with the appropriate proposed EPA numerical criteria (tabulated in Appendix D.4) for water at the disposal site, and the decision regarding disposal procedures is based on the results of the comparison. Generally, if the elutriate exceeds the EPA criteria for water at the disposal site an alternate site must be selected.

The procedure discussed in the preceding paragraph applies to the disposal of dredged material only. In the actual dredging operation, no regulation requires comparing the quality of the elutriate to the ambient water quality. Such a comparison is useful however, for predicting the impact of the dredging operations on the ambient water quality at the dredging site. In the paragraphs which follow, the quality of the elutriate is frequently used in assessing the impacts of both the dredging operation and the disposal of the dredged material.

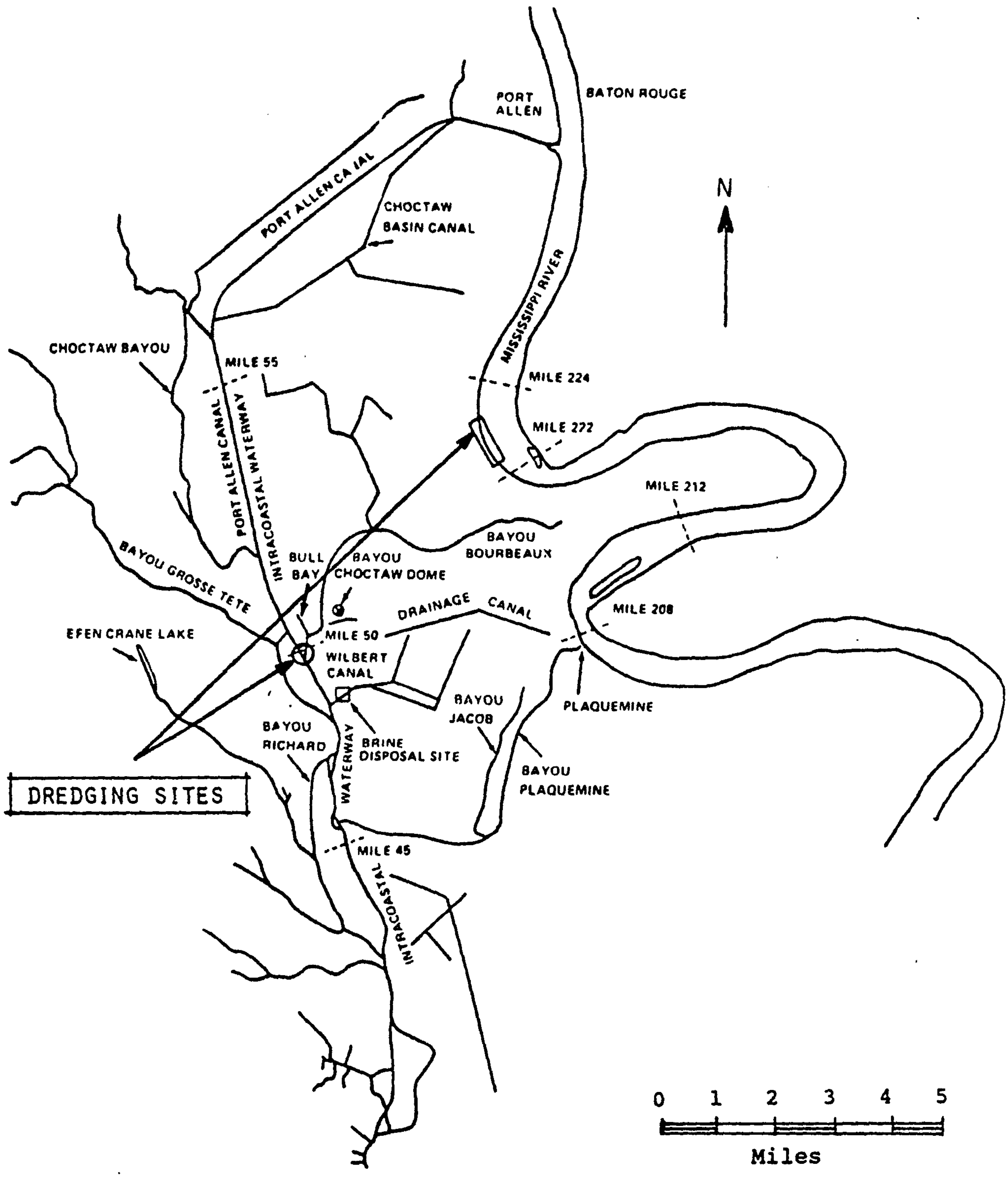

Figure 3.1 Dredging Sites for Bayou Choctaw

Dredging Operation at the Junction of Port Allen Canal and Bull Bay

As noted in Section 1, the dredging operations in the vicinity of the mouth of Bull Bay associated with enlarging the existing barge dock and dredging for an additional dock would involve removal of 86,000 cubic yards of earth from the area. Up to 60,000 cubic yards of this would be removed by dry excavation procedures in the construction of the new barge slip. The excavated and dredged material would be discharged on the eastern bank of the canal and bay.

Because of the geometry of Bull Bay and the Port Allen Canal, and the apparent absence of strong persisting currents, dredging in this body of water should not have any appreciable impact on water quality in any other body of water. Within the canal-bay area itself, degradation of water quality may result from (1) an increase in turbidity* of the water, (2) the release of toxic substances trapped within or adsorbed on the bottom sediments, such as sulfides, arsenic and other heavy metals, pesticides and other toxic hydrocarbons, and ammonia.**

At the site of the dredging activity, there would be an inevitable increase in turbidity as a result of the turbulence created by the dredge. Since the bottom sediments are polluted, and the release of a fraction of these pollutants during dredging cannot be avoided, the probable severity of the impact must be established. Most researchers have concluded that the dredging operation, using modern techniques, has little long-term effect on the water overlying the sediments.[5,6,7,8,9]

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*Turbidity is a measure of the amount of light that will pass through a liquid and describes the degree of opaqueness produced by suspended particulate material. In contrast to turbidity, suspended solids is a direct measurement quantifying the actual amount of particulate material in the water.

**Ammonia is the reduced nutrient in the inorganic nitrogen cycle and becomes toxic at sufficiently high concentrations. Such toxic concentrations have been observed in the effluent discharged from diked dredge material near Charleston, S.C.[7]

This appears to be the case even when the sediments are highly polluted. These investigations report that some dredging activities increase water turbidity and pollutants to a very minor degree up to a mile from the dredge site under certain conditions. A significant increase in any pollutant has been reported only within 200 feet of the dredge.

The sediment sampled near the Port Allen Canal at Bayou Plaquemine was approximately half sand*. Sediments comprised predominantly of sand would create little turbidity problem at the dredging site because their settling rate is rapid in comparison with silt or clay particles. The amount of silt and clay appears significant in this case and thus turbidity would be more severe. Generally, suspended solids increases are localized near the dredging and exert little apparent stress on surrounding aquatic organisms.

Hydraulic dredges, which would be used in the proposed dredging operation, use revolving cutterheads and cause some localized turbidity. However, a large percentage of the sediment-laden water near the operating cutter head is sucked into the dredge and discharged with the dredge material into the disposal area. Clam shell and bucket dredges, which are used in cast and stack methods, allow little water-sediment contact while being removed, and disruption of the sediments near the dredge is minimal.

Although the effect of dredging should be localized within the canal-bay junction area, some consideration must be given to the possible pollutants which might be released from the bottom sediments. The sulfide content of bottom sediment samples taken from the Gulf Intracoastal Waterway did not exceed standards[10] as discussed in Section 2.2 and Appendix D.6. No significant impact is anticipated as a result of the release of hydrogen sulfide during dredging. The results of the elutriate test on the bottom sediments (Table D.6-10 of Appendix D.6) indicates there would be no significant release of heavy metals from the sediments into overlying waters. In fact, the

*In the absence of other data it is assumed that the sediment at the mouth of Bull Bay is the same as that at the junction of the Port Allen Canal and Bayou Plaquemine.

sediments show a tendency to absorb metals from the water. A certain amount of arsenic would be released from some of the sediments. A concentration of 68 μg/l was obtained in the elutriate test (Table D.6-10 of Appendix D.6). This is only slightly higher than the concentration in the water (58 μg/l) (as given in Table D.6-6). Neither level exceeds EPA-water quality criteria and thus the release of arsenic would not cause significant impacts.

Pesticides have been used heavily in the Louisiana wetlands and were found in the bottom sediments of the Port Allen Canal as previously noted. The release of pesticides and other toxic hydrocarbons during dredging can result in water quality degradation and a severe impact on aquatic life. An analysis of pesticides in the water, the sediment, and sediment elutriate was presented in subsection 2.2. This analysis indicates that the levels of pesticides in the sediment were generally much higher than the corresponding levels in the water, and the levels in the elutriate exceeded the EPA criteria for toxaphene, dieldrin, endrin and DDT. As previously noted, the elutriate contained higher levels than the water sample for lindane, heptochlor, epoxide, dieldrin, endrin, DDT, and DDE. Thus the release of pesticides from bottom sediment to the water during the dredging operation would change the local levels of pesticides in the water by an appreciable amount, especially in the case of dieldrin, endrin, and DDT.

Windom[7] concludes from studies along the southeastern coast that toxic amounts of ammonia are released from polluted sediments when they are dredged. This may also be the case with sediments from the Port Allen Canal. Analyses were not conducted for ammonia in the sediment but appreciable amounts of ammonia were present in the water samples presented in Table D.6-6. The presence of ammonia in the water suggests that ammonia is also present in the sediment.

In summary, the impact of dredging at the site near the canal-bay junction should be confined primarily to the junction area. Within that region all available data indicates that the most significant environmental impacts would be localized increases in the levels of dieldrin, endrin, and DDT, coupled with localized increase in turbidity. These increases should be temporary and should dissipate upon completion of the dredging operation.* Heavy metals and pesticide increases would pose little threat of food chain contamination. Increased turbidity would force visual hunting fish temporarily from the area. All benthic organisms within a 2 to 3 acre area would be destroyed at the Bull Bay Dock facility due to dredging activities. These effects are discussed in greater detail in Section 3.4.5.

<u>Disposal of Dredged Material Near the Junction of Port Allen Canal and Bull Bay</u>

The impact of the disposal of dredged material (spoil) from the canal-bay junction represents a problem separate but related to the impact of the dredging operation itself. As noted previously, the dredged material would be deposited on the eastern bank of the Port Allen Canal. From this point the spoil would tend to pass into the nearby swamp. Of major concern in the disposal area are the possibilities for (1) an increase in turbidity of the water in the disposal area; (2) a significant release of aquatic nutrients; (3) the depression of dissolved oxygen levels; (4) the release of toxic sulfides; (5) the release of toxic heavy metals or arsenic; (6) the release of pesticides or other toxic hydrocarbons mixed in the bottom sediments.

The greatest impact from increased turbidity and suspended solids on the aquatic resources would be realized in the disposal of the dredged material. The relative impact of the suspended solids on the aquatic system is in part determined by the method of disposal, whether it be (1) open water disposal, (2) hydraulic dredging onto adjacent unconfined areas, (3) hydraulic dredging into adjacent confined areas, or (4) mechanical dredging by casting and stacking. Current design for the Port Allen Canal-Bull Bay operation calls for hydraulic dredging but whether the disposal area would be confined or unconfined has not been established. Although the material dredged from the waterways would be a mixture of sands, clays, silt and organic debris, some portion

*These conclusions are based on the assumption that the characteristic of the sediment at the canal-bay junction are similar to those at the junction of the canal and Bayou Plaquemine. The assumption is based on the fact that although the dredge site and the elutriate data site as discussed in section 2.2.1.1 are less than 5 miles distant, they are both part of the same Intracoastal Waterway system and drain areas of similar terrain.

(-48%) of the material would be fine silt, which in still water requires many hours to settle. Wind action and drainage flow tend to keep this material in suspension. As noted previously half of the sediment material should be sand, which tends to settle out within a few seconds.

The potential for release of pollutants degrading to the water quality during disposal of the dredged material has been assessed by reviewing the sediment elutriate test results. These data are reported in Appendix D.6 and have been discussed in subsection 2.2. The soluble orthophosphorus concentration measured during the elutriate test on bottom sediments was 0.07 mg/l which was approximately twice the concentration in the water. In general, phosphorus is released from the sediments to the water only in very small quantities. The concentration of phosphorus in the elutriate is, however, just adequate to support a large aquatic biomass, typical of eutrophic conditions,* if the waters were confined without dilution. Total Kjeldahl nitrogen (TKN) in the elutriate is roughly equal to that in the corresponding water. TKN is comprised of organic nitrogen plus ammonia. Based on a comparison of the organic nitrogen release to the relatively small release of dissolved organic carbon from the sediments, it appears that most of the TKN released is in the form of particulate detrital material and ammonia. The TKN values measured in the sediments strongly suggest the presence of a considerable amount of detrital plant matter.

The release of nutrients, particularly nitrogen, in either confined or unconfined disposal areas is a matter of concern. Within a confined disposal area, these nutrients may encourage the growth of excessive populations of algae and the consequent degradation of water quality. In an unconfined disposal area, or a confined area with insufficient retention capability, the rapid release of water transporting enriching sediment materials may be viewed as undesirable in certain areas. On the other hand, the Louisiana Advisory Commission on Coastal and Marine Resources[11] believes the enrichment

*eutrophic conditions- in a body of water such that the increase of mineral and organic nutrients has reduced the dissolved oxygen content, producing an environment which favors vegetation over animal life forms.

of coastal and marsh waters is beneficial. In either case, it is likely that released nutrients would be rapidly assimilated into the swamp system because of extensive interconnections and additional mixing due to canal traffic.

The elutriate test (Table D.6-10) indicates that the sediments have significant potential for the release of oxygen demanding substances. Chemical oxygen demand (COD) of the elutriate is greatly increased over that of the water while TKN and dissolved organic carbon levels, (which are measures of the organic material), are not increased to the same extent. It is concluded from these data that much of the COD released from the sediments is in the form of reduced iron, manganese, and possibly other reduced metals.

If dredged materials were to be disposed of in unconfined disposal areas, precautions would be necessary to avoid a harmful depression of dissolved oxygen (DO) levels in adjoining waters. The disposal of dredged materials into a confined area with an adequate transport water retention time may be used to advantage to overcome this potential problem. If the oxygen demanding sediments are dispersed adequately into a shallow retention area where the overlying water may undergo atmospheric re-oxygenation, the net effect would be to satisfy the oxygen demand without risking a water quality problem. The growth of algae in the confined area, stimulated by the release of nutrients from the sediments, would further aid in satisfying oxygen demand since algae produce oxygen during photosynthesis. Windom[7] observed a significant increase in DO in confined disposal areas. If care is taken in design of the confinement area, the sediment transport water could be returned to the waterway after sufficient time for suspended solids to be deposited and nutrients to be removed by algae, but before the algae population becomes senescent and dies. Then the returning transport water would be of good quality with high oxygen and low nutrient content. Under these circumstances, the confined disposal area would serve much like an oxidation pond similar to those used for many years to treat municipal and industrial organic wastes.

As noted previously, in the discussion of the impact of dredging at the dredging site, the level of sulfide in the bottom sediments did not exceed standards. Thus the release of hydrogen sulfide during the disposal process should not represent a significant effect.

The release of toxic heavy metals has been discussed previously and it was noted that no significant decline in water quality should be encountered. The observation was made that the sediments show a tendency to absorb the metals from the water, even if the sediments have high concentrations of toxic heavy metals. This tendency appears most evident for the case of zinc. Zinc concentration was high in the sediments analyzed; (153 mg/kg). The concentration of dissolved zinc in elutriate water, however, was 6.5 μg/l. This is less than the concentration in the water before the elutriate test (8.8 μg/l). Mercury is a similar case. Mercury contamination amounts to 80.0 mg/kg of the sediment. The level in the elutriate waters however was 3.0 μg/l and was less than the level in the water sample (6.8 μg/l).* Absorption of mercury in this manner from the water is commonly observed.[10] Windom[7] has also reported this uptake of metals from the water rather than release from the sediments. He ascribes this phenomenon to oxidation of ferrous iron sulfides to ferric oxides which trap the other metals. Ferric oxides are insoluble and retain the occluded metals as long as the oxides are not reduced again to sulfides.

The release of arsenic from the dredged material to the water system in the disposal area should not cause any significant degradation because as discussed earlier, the level of arsenic in the elutriate sample was only slightly higher than that in the corresponding water sample and neither level exceeds any known standard.

The question of pesticide release was discussed earlier in connection with the impact of dredging on the dredging site. As noted in that discussion, the levels of pesticides in the elutriate were greater than the levels in the corresponding water sample for lindane, heptachlor, epoxide, dieldrin, endrin, DDT and DDE. As discussed in subsection 2.2, the current levels of pesticides in the water already exceed EPA standards in some cases, and thus the disposal of dredged sediments may appreciably increase the current levels in the marsh, especially with respect to dieldrin, endrin and DDT.**

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*Although the level of mercury in the elutriate is less than that in the corresponding water sample, both exceed the proposed EPA numerical criteria given in Appendix D.4.

**This statement is based on the assumption that the level of pesticide in the marsh is similar to that in the Port Allen Canal.

The geographic features of the disposal area must also be considered. Large, continuous disposal areas running perpendicular to the general flow of surface waters may halt, impede, or redirect the flow of such waters. This may in turn produce alterations in period of inundation and sediment deposition. If possible, the location of the disposal area would be arranged so that general surface drainage is not disrupted.

If a contained disposal area is used, most of the containment structure would hold turbid water and an aqueous mixture of dredged solids from the dredging site. The excess water, in most cases representing 80 to 95 percent of the total volume of materials pumped into the containment structure, would be discharged from the disposal areas. The impact of this excess water on the receiving water body would vary according to (1) the length of time of containment, (2) the quality and volume of the receiving water, and (3) the quality and quantity of the dike effluent. In general, the impact should be similar to that related to dredging, but the severity of the impact should be less if proper containment procedures have been followed.

In summary, the impact of the dredged material on the disposal site would consist of an increase in turbidity, TKN (in the form of detrital matter and ammonia), COD, and certain pesticides (dieldrin, endrin and DDT) combined with a possible decrease in DO. The flow of surface water in the swamp may also be affected. The impact of the dredging disposal operation can be localized and minimized by employing the most recent technology in disposal.[12,13,14,15] Table 4.1 (Section 4) lists several mitigating measures which may be applied.

The brief time that pesticides and heavy metals are mobilized in the water suggests that food chain magnification is unlikely. Increased turbidity would force visual hunting fish from the area temporarily. Detailed analysis of biological impacts are presented in Section 3.4.5.

Dredging Operation at the Mississippi River

As discussed in Section 1, the construction of the dock facility on the Mississippi River would involve dredging approximately 1.5 million cubic yards of material during the period of dock construction. Hydraulic dredging would be used and the dredging operation would be confined to a region located at Mile 223 and extending 3000 ft. farther to the south. The disposal site for the dredged material would be the channel of the river in the vicinity of the dredging operation shown in Figure 3.1.

As with the docks at the canal-bay junction, it is appropriate to divide the impact analysis into two parts: (1) the impact at the site of the dredging and (2) the impact of the dredged material at the disposal site. In the case of the canal-bay junction, these two regions were fairly well separated, but in the case of the river, the distinction between the two sites is not as clear. However, the discussion which follows will treat the two separately. Clearly under certain conditions the dredging and disposal operations may be close enough together to cause a combined impact on certain regions. Such combined impacts can be identified only when a more complete plan for the dredging operations in the Mississippi River is developed.

The impact on water quality at the dredging site in the channel would be generally similar to that experienced in the canal-bay junction, except that the effects may be distributed over a larger area due to the larger size of the body of water involved. With such distribution over a larger area, there should be some dilution of the levels of the various contaminants. In this respect, past experience involving maintenance dredging is worthy of note:

"A comparison of the large volume of natural sediment transported by the river (178 million cubic yards per year) and the annual dredging of the Mississippi River from Baton Rouge to New Orleans (4,833,700 average cubic yards per year for July 1960-June 1974) indicates that dredging is a minor contribution to the suspension and dissolving of chemical constituents from sediment sources in the crossings."[16]

Because of the comparatively small amount of material to be dredged (1.5 million cubic yards over a period of ~1 year) for the tanker facility, the dredging operation would not cause a major impact on the overall environment of the river. At the same time, disturbing the bottom sediments would produce some changes in the water quality in the immediate vicinity. The major concern is a degradation of water quality resulting from (1) an increase in turbidity, (2) the release of toxic substances contained within the bottom sediments, such as sulfides, arsenic and other heavy metals, pesticides, other toxic hydrocardons, and ammonia.

A number of specific considerations regarding these four problem areas have already been stated for the case of the canal-bay junction, and many of these comments are equally applicable to the case of the ship channel. For the sake of brevity these comments will not be repeated. Only significant differences will be discussed in the paragraphs which follow.

In considering the possibility of increased turbidity, the description given for Port Allen Canal-Bull Bay is generally applicable except for the fact that the bottom sediment in the river contains a greater fraction of sand and thus should settle faster. Because of the very likely presence of stronger currents and wave action in the river however, the turbidity plume may extend over a larger region. The size and duration of this plume would depend upon the number and size of the dredges operating in the area and the length of the time period during which dredging occurs. Past experience with dredging in the Mississippi River between Baton Rouge and the Gulf indicate that:

"The dredging process and the disposal of dredged material effect an increase in turbidity in the river immediately downstream from the work area. Because of the large volume of flow, the high natural turbidity of Mississippi River water and the settling characteristics of the solids dredged, turbidity increases caused by dredging are not distinguishable 100 to 200 feet downstream"[17]

The available elutriate data taken at Red Eye Crossing (Mile 224), provided in Table D.3-4 of Appendix D.3, does not include sulfides. The level of sulfides are not available in any of the Mississippi River sediment quality data. Thus no assessment can be made of the possible release of toxic sulfides due to dredging.

Based on the available data, the release of heavy metals would not appear to cause any significant degradation. As noted in a recent dredging study for this portion of the Mississippi River, "The materials dredged from the crossings are primarily inorganic sands and silts deposited since the previous dredging. As a result of this makeup, the quality of the sediment in these crossings is fairly good and should result in minimal re-dissolving of metals into the river."[17] Elutriate data at Red Eye Crossing for arsenic indicates the same level of arsenic in the elutriate as in the river water. It is unlikely that the release of arsenic in the Mississippi River would be significant.

With respect to the release of pesticides, no elutriate data is available. The level of DDT in the sediment taken in the river at the Port Allen lock forebay, and Mile 208 are significantly higher than the level of DDT in the sediment at any station in the canal-bay area. The level of DDT in the sediment at Miles 222 and 224 (which bracket the dredging site) and at Red Eye Crossing were roughly equal to those observed in the canal-bay area. Because an increased level in DDT was expected to result from the dredging operation in the canal-bay area, it would appear likely that a similar (and possibly more severe) increase in DDT levels in the Mississippi River would be produced.

The level of phenols (10 μg/l) in one elutriate sample at Red Eye Crossing exceeded the level (4μg/l) in the corresponding water sample. In a second elutriate sample, the level of phenols (18 μg/l) was less than the level (30 μg/l) in the corresponding water sample. From this data alone it is not possible to predict whether dredging would cause an increase in the ambient level of phenols in this portion of the Mississippi River. In 26 out of 39 samples taken at 20 other sites along the river between Baton Rouge and the Gulf of Mexico, however, the level of phenols in the elutriate sample exceeded the level in the corresponding water sample. In all samples at all sites the level of phenols in both the elutriate and the water exceeded the proposed EPA numerical criteria for public water supply intake. Thus the trend indicates that dredging is more likely to increase than decrease the level of phenols in the water.

In summary, the dredging operation in the Mississippi River would be characterized by a turbidity plume larger than that experienced in the canal-bay area; but the plume would dissipate more rapidly because of the larger fraction of sand present in the sediment. It appears likely that an increase in the level of DDT and phenols would be produced in the vicinity of the dredging site within the same region in which increased turbidity would be encountered. Increased DDT, phenols and turbidity levels are not expected to exert any significant influence on the biota. The Mississippi River is already quite turbid and organisms living there are adapted to high turbidity levels. The benthic invertebrates in the dredge site would be eliminated but populations should re-establish within two years. A detailed discussion of biological impacts is presented in Section 3.4.5.

Disposal of Dredged Material in the Mississippi River

The impact of the disposal of the dredged material on water quality in the Mississippi River would differ in many respects from that encountered in the swamp near the junction of the Port Allen Canal and Bull Bay. Clearly there is a basic difference in that the disposal area for the Mississippi River would be the river channel. The basic concerns, however, remain the same: (1) an increase in turbidity of the water, (2) a significant release of aquatic nutrients and the depression of disolved oxygen levels, or (3) the release of toxic substances contained within the bottom sediments, such as sulfides, arsenic and other heavy metals, pesticides, other toxic hydrocarbons, and ammonia.

Probably the most significant difference in the impact observed would be the turbidity plume generated by the sediment discharged into the river channel. Previous studies of canal dredging in Louisiana have indicated that silt can be carried as far as 1300 feet from a dredge discharge. However, at distances greater than a few hundred feet, turbidities did not exceed those often attained under natural conditions.[18] The amount of material drifting away from the dredge discharges was estimated to be only one percent of the total dredged material, and evidence of fine material in suspension was lost in the natural turbidities over distances of 1000 feet. Turbidities and suspended solids levels can often reach very high levels, as indicated by hydraulic maintenance dredging studies in Alabama, where suspended solids along the bottom of the disposal area often exceeded 10,000 mg/l within 400 feet of the dredge discharge.[8] The turbidity plume from the disposal operation extended 400 to 1200 feet, depending on wind and current conditions during dredging. However, the Alabama studies indicate that suspended solids concentrations were less than 100 mg/l at distances greater than 400 feet from the source. Average suspended solids values in the Mississippi River range from 44 to 245 mg/l as shown in Appendix D.3. Thus the turbidity plume would be visible for less than 400 feet downstream of the discharge point.

Based on the available elutriate data for Red Eye Crossing, the discharge of dredged material would not have any significant impact on the level of TKN in the river. Thus the release of aquatic nutrients would not cause significant impacts. The depression of the dissolved oxygen level in the river due to the discharge of oxygen demanding substances would not cause significant impacts. The extent of the release of toxic sulfides, toxic heavy metals, arsenic, and pesticides has already been described in the discussion of the dredging operation on the river. As noted in that discussion, an increase in the level of DDT and phenols would apparently be the primary impacts.

In summary, the impact of the discharge of the dredged material on the water quality of the disposal area would consist primarily of increased levels of turbidity, DDT, and phenols over a region extending downstream from the disposal site. Because the dredged sediments are largely sand, the turbidity would dissipate fairly rapidly due to settling. Due to the fact that the dredging operation may occur over a period of several months, however, turbidity plumes would be present in the region for a similar period of time. Because of the large volumetric flow rate of rivers, the DDT and phenols levels should be rapidly diluted with distance downstream. The undesirable effects of the disposal process can be minimized by conforming to the latest dredge disposal techniques.[12,13,14,15] Table 4.1 (Section 4) lists several mitigating measures which may be applied.

Rapid dissipation of spoil associated contaminants suggests that biological impacts would be minor and short term. Some fish may avoid the deposition sites and some benthic organisms may be killed by sand deposition. See section 3.4.5. for a detailed discussion of biological impacts.

Maintenance Dredging

Maintenance dredging at the barge docks on Bull Bay may be needed to keep the mooring slip deep enough to permit the necessary barge traffic. It is highly probable that such dredging would be required to maintain the necessary depth near the tanker dock on the Mississippi River.

The impact of maintenance dredging on both the canal-bay area and the Mississippi River would be quite similar to that incurred during the original dredging for site preparation and construction. The impact would include (1) increased turbidity and suspended solids; (2) increased oxygen demand due to the decomposition of disturbed organic sediments; (3) the release of hydrogen sulfide into the waters from anaerobic sediments; and (4) the release of nutrients, heavy metals, oil and grease, and pesticides. The amount of material to be dredged during maintenance, however, would be significantly less than the amount initially dredged and thus at both sites the impact on the water system, due to the dredging and due to the disposal of dredged material, would be reduced. At the same time, notice should be taken that maintenance dredging operations are inherently cyclic in nature. At the junction of the Port Allen Canal and Bull Bay it would be unlikely that more than one maintenance dredging operation would be needed in a 12 month period,but at the permanent dock on the Mississippi River, a number of dredging cycles would very likely be involved during the life of the facility.

At the site of the dredging operations, in one respect, maintenance dredging may have a cumulative favorable impact on the water system. The removal by dredging and proper disposal of polluted bottom sediments may improve the overlying water quality. A fraction of the bottom sediments are suspended into the water column each time a deep-draft vessel passes. This mixing permits the release of pollutants from the bottom sediments into the water column and the subsequent degradation of water quality. Since efforts are underway to reduce the discharge of polluting substances to surface waters, it may be expected that sediments, which are subsequently deposited in place of those that have been removed, will be less likely to contain pollutants that would adversely affect water quality. The net effect, then, would be the removal of a source of water pollution from the channel. Mercury, for example, is concentrated in most of the bottom sediments sampled along the region. Concentrations in the water are also of concern. Removal of the sediments polluted with mercury may permit both the establishment of a more healthy aquatic life and improved water quality. Continued maintenance of the channel depths would minimize the suspension of bottom sediments by the passage of ships and, hence, minimize the adverse effects of increased turbidity and the release of pollutants trapped in the bottom sediments.

3.2.2 Impact of Earth Excavation and Fill Operations

Sediment represents the major non-point source of water pollution on most construction sites, especially on those which required extensive grading. Sediment includes solids and organic materials detached from the ground surface by erosion and carried into the drainage system principally by runoff. The introduction of sediment into various natural bodies of water and the associated turbidity and solids deposition results in numerous adverse physical, chemical, and biological effects. Suspended sediment ultimately reduces the storage capacity of waterways, thereby, increasing flooding hazards; fouls and destroys aquatic habitats; impedes navigation, increases water treatment costs, diminishes recreational and property values; and enhances the transport of other harmful pollutants such as human and animal sanitary wastes, pesticides, and petrochemicals.

The site preparation and construction activity would involve a significant amount of earth movement as discussed in Section 1.3.3. Approximately 263,000 cubic yards of earth would be displaced during this process, excluding the dredging operations already discussed in subsection 3.2.1. Associated with this movement of earth, approximately 90 acres of land would be disturbed. Based on the analysis presented in Appendix F, approximately 7,000 cubic yards of sediment would be washed into the surface water system as a result of erosion of this disturbed land by rainfall. As shown in the same appendix this discharge of sediment could conservatively produce an increase in the ambient suspended solids level of approximately 7 percent in the immediate vicinity. Fill activities would destroy all benthic organisms and most forms with limited mobility in the path of the earthen dikes. Turbidity changes would have negligible effects on the aquatic fauna and flora. A detailed discussion of these effects is presented in Section 3.4.1.

3.2.3 Chemical and Biological Pollutants

Numerous solid and liquid products, both organic and inorganic, used in construction are a source of water pollution. The major sources of construction-related chemical pollution can be broadly grouped under the following headings:

- Petroleum products
- Herbicides and pesticides
- Fertilizers
- Metals
- Soil additives
- Construction chemicals
- Miscellaneous wastes

Of these, petroleum products, herbicides and pesticides, and fertilizers appear to be the best known and the best documented sources of chemical pollution:

(a) Pollution from petroleum products generally occurs from improper disposal of waste materials such as crankcase oil and various cleaning solvents, leakage of fuels and oil from storage facilities and damaged or improperly maintained vehicles, fuel spills during equipment refueling operations, and the use of oils for dust control on roadways.

(b) Herbicides and pesticides are used on some construction sites to control undesirable vegetation, insects, and rodents. Pollution from these chemicals is due to their improper use, handling, and disposal.

(c) Fertilizers are extensively utilized in the revegetation of areas affected by grading operations. Like herbicides and pesticides, pollution is caused by their improper use, i.e., applying too much fertilizer or improper preparation of the ground surface prior to application.

The biological pollutants which generally enter receiving streams and other water bodies as a result of construction activities are bacteria, fungi, worms, viruses, and other less prevalent organisms. Biological pollution is primarily a result of poor sanitary conditions at a construction site - generally improper disposal of human wastes, garbage, and other organic material. The disturbance, exposure, and subsequent erosion of surface soils that contain bacteria and other organisms are also contributing factors. Regardless of their origin, biological pollutants generally have an adverse effect on water quality. The degree depends on the use of the water and the nature of the biological organisms. The pollutants of major concern are the pathogenic organisms associated with human wastes. The biological effects of pollution are discussed in Section 3.7.

3.2.4 Withdrawal of Surface Water

Current design calls for continuously withdrawing the oil at an average rate of 19,450 gpm for a period of 150 days. All displacement water is to be drawn from the pond over cavern No. 7, a relatively small body of water described in sub-section 2.2.1.1. If the pond were completely isolated, a withdrawal rate of 19,450 gpm (43.3 cfs) would initially lower the water level of the lake at a rate of 8.28×10^{-5} ft/sec, which is relatively fast. Because the pond is connected with the Port Allen Canal/Choctaw Bayou via Bull Bay, the East-West Canal, and the North-South Canal, such removal of water will induce a flow into the pond from these neighboring water bodies.

As described in Appendix G.1, under steady-state conditions* the calculated velocity in the North-South Canal would be .18 ft/sec; in the East-West Canal, .18 ft/sec; in Bull Bay, .09 ft/sec; and in the Port Allen Canal/Choctaw Bayou, .023 ft/sec. These velocities are all relatively small when compared with the velocities which the canal system is designed to handle (1.82 ft/sec), or the velocity of the Mississippi River, which ranges from ~1.3 to ~8.3 ft/sec.[19]

As shown in the same appendix, the height differentials** necessary to maintain such velocities under steady-state conditions are also small. Table 3.2 provides a

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* Steady-state conditions occur when all flow velocities, discharge rates, intake rates, and water surface heights are constant.

**The height differential is the difference in surface heights of two bodies of water relative to some common reference plane (sea level).

Table 3.2

SUMMARY OF EFFECTS OF WITHDRAWAL OF WATER FROM POND OVER CAVERN NO. 7

Body of Water	Depth (ft.)	Width (ft.)	Induced Velocity (ft/sec)	Slope (ft/mile)	Distance (Miles)	Height Differential (ft.)
North-South Canal	4	60	.18	8.96×10^{-3}	0.3	2.69×10^{-3}
East-West Canal	4	60	.18	8.96×10^{-3}	0.3	2.69×10^{-3}
Bull Bay	8	60	.09	1.03×10^{-3}	0.4	4.12×10^{-4}
Port Allen Canal	12	120 (bottom)	.023	3.95×10^{-5}	14.0	5.53×10^{-4}
		200 (top)		TOTAL	15.0	6.35×10^{-3}

tabulation of these height differentials. As noted in the table, the final total height differential between the pond and the Port Allen Canal at the Port Allen Lock is only 6.35 x 10^{-3} feet under steady-state conditions. This height difference would be achieved in a relatively short time (less than 1 hour) due to the rapid rate at which the water level in the pond initially would be dropping.

Notice should be taken, however, that the preceding computations are based on the assumption of steady-state conditions in all of the bodies of water from the Mississippi River to the on-site pond. In reality, steady-state is not maintained due to wind, rain, and other weather effects, plus the effects of industrial and municipal discharges and withdrawals. At the same time, the small height differentials and corresponding small induced velocities suggest that the current surface water system is capable of supplying the necessary displacement water without any significant impact on the environment.

The water quality within the pond over cavern No. 7 is clearly dependent upon the quality of the water entering from the replenishment source. As noted in Section 2.2, the water in the pond is brackish with a salinity of 1 ppt[20] while the water in the Port Allen Canal is fresh with a salinity of .18 ppt.[21] Thus the withdrawal process will cause lower salinity water to enter the pond, thereby lowering its salinity. The change in salinity predicted during the 150-day displacement process is less than one part per thousand as shown in Figure 3.2. As indicated in the figure, the salinity of the pond rapidly decreases during the displacement process. After 25 days, the salinity would be the same as that of the replenishment source. Some phytoplankton and zooplankton would be entrained (drawn into the intake) with each fill cycle and a locally important food source for fish and other consumers would be reduced. Benthic organisms in the lake would not be disturbed. See Section 3.4.2 for a detailed discussion of biological impacts.

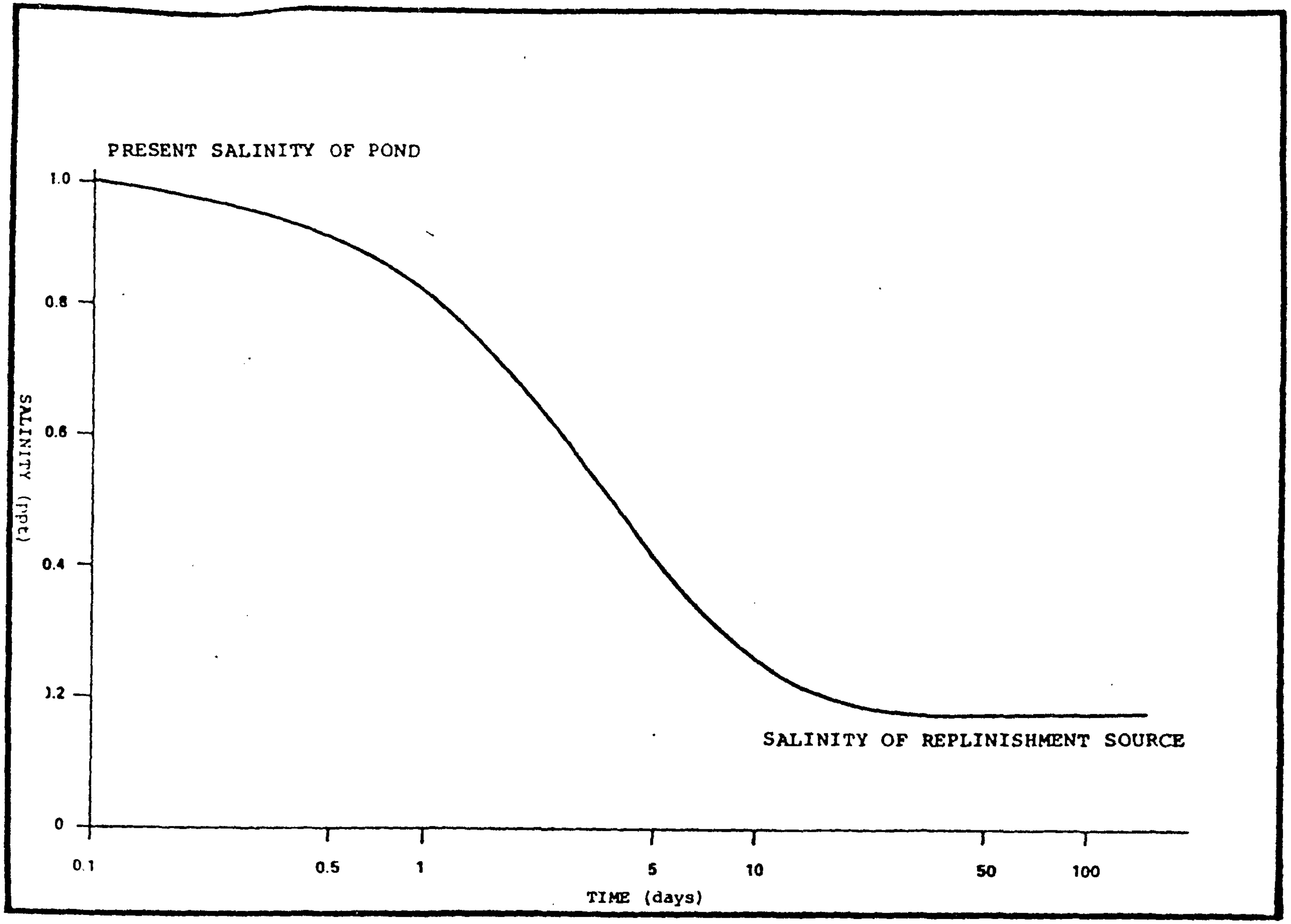

Figure 3.2 Variation with Time of Salinity in the Pond Over Cavern No. 7 due to Raw Water Withdrawal at 19,450 gpm.

3.2.5 Brine Disposal

During crude filling of the storage cavities at the Bayou Choctaw site, 267 ppt brine would be displaced at the rate of 19,450 gpm for a period of 150 days. Current design calls for the disposal of the brine by means of 28 brine-injection wells spaced 1300 feet apart in a roughly rectangular pattern with each well capable of a maximum injection rate of $\sim$ 1000 gpm. Injection depths would range from -5000 to -7000 feet. The location of the brine disposal field is indicated in Figure 3.3

The potential environmental problems associated with subsurface brine disposal are:

- earthquakes,
- the danger of aquifer fracture interference with oil and gas wells,
- the contamination of fresh ground water,
- the contamination of surface water.

Earthquakes may be induced by faults being lubricated by fluid injection. There is documented evidence of earthquakes being triggered as a result of subsurface injection of fluid accompanied by an increase in injection reservoir pressure. The two known cases of this phenomena have occurred in Colorado in an area of high natural rock stress. One occurred near Denver and was associated with a disposal well that injected liquid waste from the Rocky Mountain Arsenal. The other occurred near Rangly, Colorado and was associated with a water flood in the Rangly oil field. The mechanism causing the earthquake is not well understood. However, all those who have studied the problem agree that the existence of high natural earth stress as in Colorado, Wyoming, and California is a prerequisite. In the Texas-Louisiana Gulf Coast the natural earth stress is low. This region is a tectonically relaxed area characterized almost exclusively by normal faulting (no reverse or overthrust faults). Numerous water flood and liquid waste injection sites have been in operation along the Louisiana-Texas Gulf Coast for many years without reported occurrences of earthquakes. Therefore, it would appear that earthquake occurrence in the vicinity of Bayou Choctaw, as a result of the injection of brine, is highly unlikely.

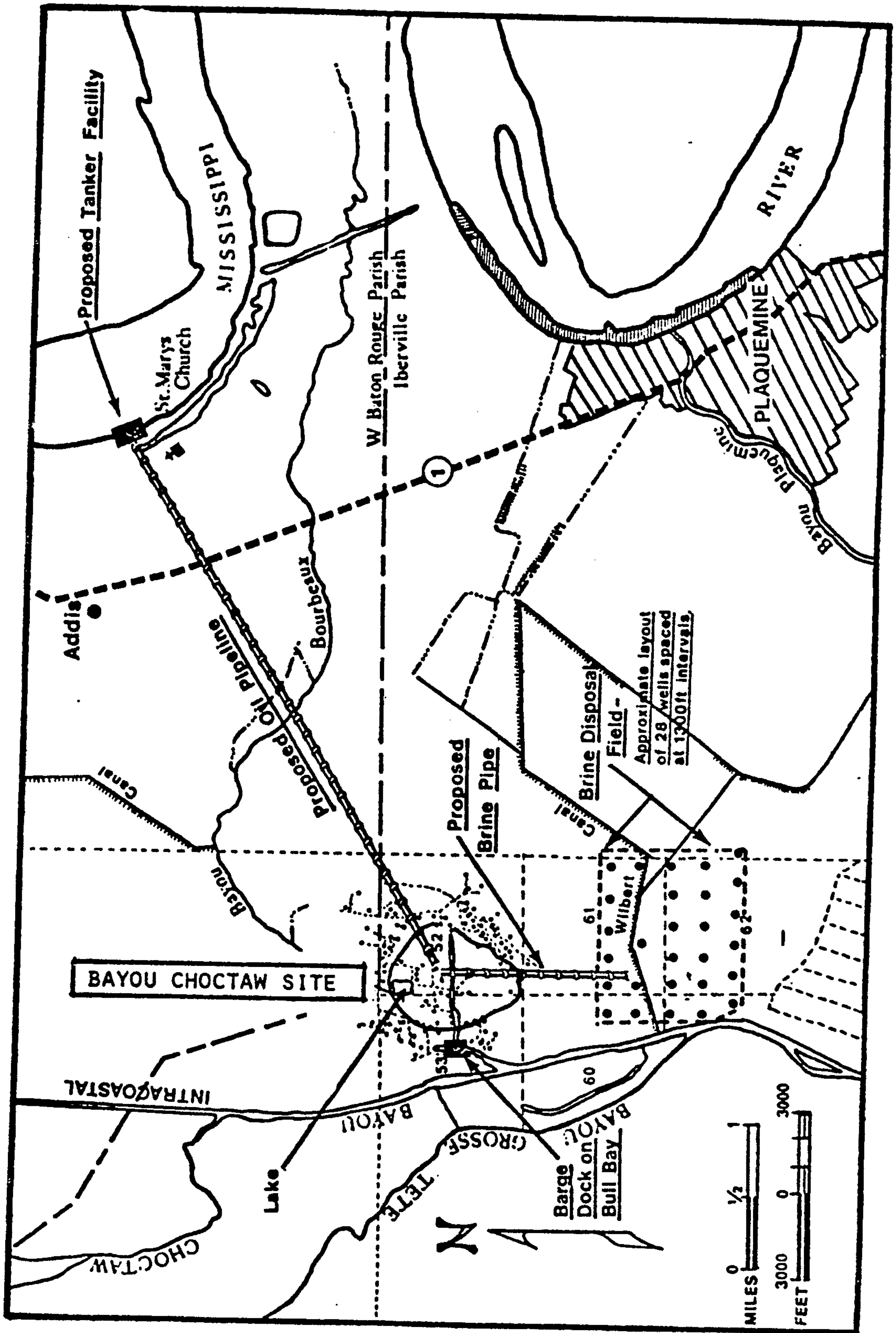

Figure 3.3 General Facilities (proposed)

A reservoir satisfactory for subsurface waste disposal must possess adequate volume and have impermeable strata such as shale aquicludes* above and below the storage layer. Excessive pressure buildup could lead to aquiclude fracture and loss of containment. Pressure buildup depends upon:

- the aquifer size,
- the pumping rate,
- the quantity of waste fluid,
- the aquifer porosity;
- the aquifer permeability, and
- clogging agents in the waste such as colloids or materials which support bacterial growth.

In some areas, lateral interconnections between aquifers provide very large reservoir capacities. Such interconnections may often be demonstrated by electric well logs** in separated wells. Negative indications by electric log data (such as those encountered at the current site) do not prove that reservoir capacity is small but strongly suggest caution in estimating capacity.

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*An aquiclude is a geologic formation so impervious that for all practical purposes it completely obstructs the flow of ground water (although it may be saturated with water itself), and completely confines other strata with which it alternates in deposition.

**Electric logs are strip charts plotting electrical resistivity of the earth versus depth, thus identifying types of geological strata. One log is normally generated for each well drilled.

The disposal of the brine from the displacement process at the Bayou Choctaw site would involve 23,815 bbl/day (695 gpm) per well. This injection rate is approximately four times the reinjection rates for the East Texas oil fields.[22]

Although, as discussed in subsection 2.2.2, the comparison of well logs could not verify the continuity of sand layers in the area, two zones containing thick sand beds suitable for brine disposal were determined.* The top zone from -5000 to -5800 ft and the second zone from -7000 to -7700 ft consist of sands greater than 50 ft thick, most of which are probably interconnected. Thus the thickness and lateral extent of these beds are not precisely known at this time. In order to carry out any analysis of the effect of brine injection on the deeper aquifers, conservative assumptions were made, as discussed in Appendix G.2, such that resulting impacts would not be underestimated.

Based on reservior size extrapolated from well log data, the capacity and pressure buildup of the reservoir were calculated in accordance with the basic equations governing the flow of slightly compressible fluids through porous media.[23]

The estimated characteristics of the individual reservoirs are summarized in Table 3.3. The estimated total dimensions of the entire disposal site are presented in Table 3.4 along with the resulting computed brine disposal capacity. This capacity, 1.11 x 10^9 barrels, is approximately eleven times the volume of brine to be injected during an individual filling cycle (94 x 10^6 barrels). Thus, in terms of total capacity, the aquifer appears capable of holding the total volume of brine discharged during the 5 filling cycles for which the facility is designed. As described in Appendix G.2 the average pressure increase in the aquifer for one cycle of the displacement process would be 121 psi. For the full five cycles, if no leakage occurs from the aquifer, the average pressure increase would thus be 605 psi. It is important to note; however, that the thickness of the sands would vary from well to well, ranging from 50 to 200 feet. If each well injects

*The correlation of sand beds consists of studying the electric logs from a number of wells in a given area and determining whether or not within some specific interval of depth the same sand bed is present at several different well sites. The average thickness and horizontal dimensions of the sand bed can be approximately established in this manner.

Table 3.3 Characteristics of Pliocene-Miocene Aquifers in the Vicinity of Bayou Choctaw

Total Thickness of Disposal Sands	1250 feet
Individual Reservoir Characteristics	
Diameter	31,680 feet
Depth	6,000 feet
Thickness	50, 100, 200 feet
Initial Pressure	3,000 psig
Normal Pressure Gradient	.5 psi/ft
Fracture Pressure Gradient	.75 psi/ft
Temperature	54° C (130° F)
Porosity	33%
Permeability	1.00 darcies
Well Conditions	
Diameter	10 inches
Surface Flow Rate	23,815 BPD
Fluid Properties	
Viscosity	.550 centipoises
Compressibility (effective)*	10^{-5}/psi
Density	10.5 ppg

*includes water and rock

Table 3.4 Brine Storage Capacity at Bayou Choctaw

Length of Disposal Site	6 miles
Width of Disposal Site	6 miles
Area of Disposal Site	36 $miles^2$
Thickness of Disposal Sands	1250 feet
Gross Volume of Disposal Sands	1.26×10^{12} ft^3
Net Volume of Disposal Sands	74.1×10^9 bbls
Average Pressure Increase	1500 psi
Brine Disposal Capacity	1.11×10^9 bbls

the same total volume of brine, the average pressure buildup in each reservoir would be inversely proportional to the sand thickness. In a reservoir with 50-foot sand thickness, the average pressure increase in the reservoir after one cycle would be 308 psi, and in the absence of leakage after five cycles the total average pressure increase would be 1540 psi. This pressure increase exceeds 1500 psi, the pressure at which the aquiclude would fracture. Clearly the pressure buildup in the thinner sand layers is the most crucial in the brine injection process.

In addition to the average pressure increase in each reservoir after the completion of a single injection cycle, consideration must also be given to the transient pressure buildup during the injection process itself. Based on the calculations described in Appendix G.2, the variation of surface pressure and bottom hole pressure with respect to time is presented in Table 3.5 for a reservior with 50-foot sand thickness. As shown in this table, after 5 months of injection, the bottom hole pressure would increase from 3000 to 3547 psig, (guage pressure), which is well below the fracture pressure of 4500 psig. When the injection process stops at the end of the filling cycle, the pressure throughout the aquifer would begin to equalize, causing a drop in the bottom hole pressure. After 2 days, the pressure would be essentially uniform throughout the reservoir with a value of 3,308 psig. Because the reservoir is very likely not totally isolated from other aquifers in the area, as time progresses the pressure would tend to return to the initial value, 3,000 psig. In the worst case, the pressure would remain at 3,308 psig and this would represent the starting pressure for the second injection cycle. The pressure variation with respect to time during the second injection cycle would be essentially identical to the first cycle except for the overall 308 psi increase, as shown in Table 3.5. As before, at the end of the injection process, the pressure throughout the reservoir would begin to equalize and after 2 days would be essentially uniform at 3,616 psig. This sequence of pressure variation would be repeated for cycles # 3 and 4, as shown in Table 3.5. At the end of the first month of the fifth cycle, the bottom hole pressure would reach value of 4,621 psig, thereby exceeding the fracture pressure of 4,500 psig. The injection process into the 50-foot sand layers thus could not complete the first month of the fifth cycle without the risk of fracturing the aquiclude.

Table 3.5 **Reservoir Pressure Build-Up History at Bayou Choctaw in a 50 Foot Sand Layer**

	Month	Surface Pressure (psig)	Bottom Hole Pressure (psig)
a. Cycle #1	0	0	3000
	1	279	3389
	3	374	3484
	4	405	3515
	5	436	3547
	5 (+ 2 days)	308	3308
b. Cycle #2			
	0	308	3308
	1	587	3697
	3	682	3792
	4	713	3823
	5	744	3855
	5 (+ 2 days)	616	3616
c. Cycle #3			
	0	616	3616
	1	895	4005
	3	990	4100
	4	1021	4131
	5	1052	4163
	5 (+ 2 days)	924	3924
d. Cycle #4			
	0	924	3924
	1	1203	4313
	3	1298	4408
	4	1329	4439
	5	1360	4471
	5 (+ 2 days)	1232	4232
e. Cycle #5			
	0	1232	4232
	1	1511	4621

If the fracture pressure is exceeded, the aquiclude above and/or the aquiclude below the aquifer may rupture, causing the injected brine to be released into other subsurface water systems. Because the pressure in the aquifer is greatest in the vicinity of the injection well casing, the most probable point of rupture is in the vicinity of the well casing. In this case, the injected brine might find a passage upward around the well casing. Prediction of the ultimate height above the injection depth which the brine might reach is not practical. Brine might under some conditions however, reach the surface. In this situation both shallow subsurface fresh water aquifers and surface fresh water systems could be contaminated with the brine. Obviously the longer the injection process continues after the rupture the more serious the contamination problem.

For injection into reservoirs consisting of 100-foot sand thickness, the buildup of pressure during the injection process is shown in Table 3.6. For this case the pattern is similar to that observed for the 50-foot sands except that the pressure buildup is not so great as to fracture the aquiclude prior to completion of the entire five cycles.

The assumptions on which these calculations are based are noted in Appendix G. The water within the aquifer would have to be subjected to chemical and biological analyses before its compatibility with the brine to be injected could be determined. Such analyses are necessary because of three potential problem areas:[24,25,26,27,28,29]

(1) Incompatibility of waters

(2) Water-sensitive formations

(3) Water quality considerations (see Table 3.7 for a typical water quality rating system)

Table 3.6 Reservoir Pressure Build-Up History at Bayou Choctaw in a 100 Foot Sand Layer

		Month	Surface Pressure (psig)	Bottom Hole Pressure (psig)
a.	Cycle #1	0	0	3000
		1	84	3195
		3	132	3242
		4	147	3258
		5	163	3273
		5 (+ 2 days)	154	3154
b.	Cycle #2			
		0	154	3154
		1	238	3349
		3	286	3396
		4	301	3412
		5	317	3427
		5 (+ 2 days)	308	3308
c.	Cycle #3			
		0	308	3308
		1	392	3503
		3	440	3550
		4	455	3566
		5	471	3581
		5 (+ 2 days)	462	3462
d.	Cycle #4			
		0	462	3462
		1	546	3657
		3	594	3704
		4	609	3720
		5	625	3735
		5 (+ 2 days)	616	3616
e	Cycle #5			
		0	616	3616
		1	700	3811
		3	748	3858
		4	763	3874
		5	779	3889
		5 (+ 2 days)	770	3770

Table 3.7

WATER QUALITY RATING CHART

	Rating 1	2	3	5	10	20
Membrane filter test (0.45 μ filter) slope	0-0.09 excellent	0.10-0.29 very good	0.30-0.49 good	0.50-0.99 acceptable	1.00-1.79 fair	1.80+ excessive
Filtered solids mg/liter	0.-0.04 negligible	0.5-0.9 very low	1.0-2.4 low	2.5-4.9 moderate	5.0-9.9 large	10.0+ excessive
Tot. sulfide increases lb/day/1,000 sq ft	0 none	0.001 very low	0.002-4 low	0.005-9 moderate	0.01-0.019 large	0.02+ excessive
Iron count increases lb/day/1,000 sq ft	0 none	0.001-0.011 very low	0.012-0.11 low	0.12-0.59 moderate	0.60-1.1 large	1.2+ excessive
Sulfate-reducing bacteria colonies/ml	0 none	1-5 very low	6-9 low	10-20 moderate	30-90 large	100+ excessive
Total bacteria count colonies/ml	0 none	1-99 very low	100-999 low	1,000-9,999 moderate	10,000-99,999 large	100,000+ excessive
Corrosion rate (30 days) (insulated coupon) mils/year	0 none	0.01-0.09 very low	0.10-0.99 low	1.00-4.9 moderate	5.0-9.9 high	10.0+ excessive
Pit depth (30 days) (insulated coupon) mils	0 none	1 shallow	2-3 minor	4-5 moderate	6-10 deep	10+ excessive
Pit frequency (30 days) (insulated coupon) pits/sq in	0 none	1 very low	2 low	3 moderate	4 high	5+ excessive

Source: Wright, C.C., "Rating Water Quality and Corrosion Control in Water Floods", Oil Gas Journal Vol. 61, No. 20 (1963), p. 154.

Additional discussion of the potential problems resulting from chemical and biological reactions occurring during injection is provided in Appendix G.2.

The injection process would increase the salinity of the aquifers involved to a small degree. Salinity in these aquifers is estimated to range from 35 - 45 ppt.[30] The injection of 500 x 10^6 bbls of brine with a salinity of 267 ppt* would cause an increase of approximately 1.8 ppt over the present level based on the assumption of complete mixing. This increase appears insignificant.

Fresh ground water may be contaminated by leakage through unknown aquifer connections or faults, aquiclude fracture, poorly plugged abandoned wells, and well blowout. Surface water is most likely to be contaminated through poorly plugged abandoned wells or well blowout. The danger of blowout may be minimized by using dense mud as a plugging agent if the hazard is known.

As noted in Appendix G.2, the possibility exists that brine injection could cause pollution of shallow fresh ground water zones if abandoned wells at Bayou Choctaw permit flow to shallow aquifers (such as the Plaquemine aquifer) from the brine injection zone. This could occur if the old well casings are corroded and are therefore open in both the fresh water aquifers and brine injection zones.

Oil and gas maps of the Louisiana Department of Conservation show that approximately 78 wells (19 abandoned) exist within one mile of the brine disposal site. As shown in Table 3.8 these wells lie within or to the north of the disposal site.

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*The brine after several months storage in the salt caverns would be saturated, with a salinity of 267 ppt.

TABLE 3.8

Distribution of Wells with respect to the Brine Disposal Site

Distance Interval (ft)*	Number of Abandoned Wells	Number of Operating Wells
0 - 2500**	2	0
2500 - 3500	0	0
3500 - 4500	1	0
4500 - 5500	1	4
5500 - 6500	6	34
6500 - 7500	9	21
	19	59

*Measured from the center of the disposal site northward.

**Lies within brine disposal site

The Louisiana Department of Conservation requires that at least two and sometimes 3 cement plugs be placed in a well at abandonment. One of the plugs must be placed at the base of the fresh water and is specifically designed to protect the fresh water from any contamination due to leakage of fluids from below. In addition, the well bore below this cement plug must be left full of a fluid that is of sufficient density to resist the pressure gradient of the formations below the plug and thus prevent flow into the old well bore. Many times, this fluid remaining in the well is a gel mud which tends to thicken and harden, and become impermeable with time. This further reduces the possibility of leakage.

If an abandoned well is left completely unplugged, in the worst case it could act as an open pipe connecting the Plaquemine aquifer and the brine disposal reservoirs thus contaminating fresh water. The flow rate was calculated according to the Theis non-equibilibrium equation (discussed in Appendix G.2) for such an unplugged well located 3000 feet north of the northern boundary of the brine disposal field. Table 3.9 provides a tabulation of the resulting flow rates for both 50-foot and 100-foot sands. The flow rates were calculated for three different times. The first corresponds to one day after the end of the first fill cycle. The second corresponds to 100 days after the end of the cycle and the the third to 1000 days after the end of the cycle and the third to 1000 days after. As indicated in the table, the flow rates from the 50-foot sands are greater than those from the 100-foot sands. This is a result of the greater pressure buildup in the 50-foot sands. The flow rates are small compared with the injection rates, but over a long period of time (20 years), such a well could leak 630 million gallons or 15 million barrels of saline water,* or approximately 3 percent of the total volume of brine injection. When compared with the total volume of the Plaquemine aquifer, 15 million barrels of water is small, since 29 times that volume was drawn from the aquifer during a 22-month period, without significantly affecting the overall water level.

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* The salinity of the water flowing through an unplugged well depends upon the location of the well relative to the point of brine injection. The further away from the injection point the lower the salinity of the water. The maximum salinity would be the same as that of the injected brine, while the minimum would be equal to the original salinities of water in the aquifer.

Table 3.9 Flow Rate Through Unplugged Well*

Number of Days after end of Fill Cycle	Sand Thickness	
	50 feet	100 feet
1	60 gpm	19 gpm
100	47 gpm	14 gpm
1000	43 gpm	13 gpm

*Well bore diameter assumed to be 12".

To avoid such leakage the records of the two wells that lie within the injection pattern would be carefully checked to insure the wells were properly plugged, and if not, the wells would be replugged. The records of the abandoned wells to the north would be checked to insure they were adequately plugged. If a substantial number of the wells to the north appear to need replugging, use of an injection site further to the south would be considered.

Brine disposal at Bayou Choctaw is not expected to adversely affect existing oil and gas production. More than fifty wells produce oil and gas from depth intervals of -2,000 to -10,000 ft. in the Bayou Choctaw field. These depths bracket the proposed depths for brine injection -5000 to -7000 ft. All of the oil and gas wells are located in an area from 1 to 1½ miles north of the injection site. It is possible that pressure build-up in the disposal sands would be accompanied by slight pressure increases in oil and gas strata. This could benefit hydrocarbon production by reducing the effect of pressure loss due to oil and gas depletion.

Louisiana rules and regulations prevent brine injection into oil and gas reservoirs except when prescribed procedures are followed. In such cases the brine serves as a water drive for the reservoir. In general, disposal wells must be designed to avoid inadvertent injection into oil and gas sands unless prior clearance is obtained. Further discussion is provided in Appendix G.2

Based on available data, combined with the assumptions noted in the preceding paragraphs, the Pliocene-Miocene aquifers appear capable of containing the brine discharged during the lifetime of the facility without risk of fracture, with the possible exception of the 50-foot thick sand layers. If aquifer fracture is avoided, no significant change in the current environment in the aquifers would be produced.

In the absence of aquifer fracture, the injection process would not change the purity or availability of surface or subsurface fresh water systems in the region. No impact on flora and fauna is envisioned.

3.3 AIR QUALITY

3.3.1 Storage Site Construction and Operation

Construction

During the construction of the facilities on the dome, the first 6 months would involve the construction of roads and drilling pads. The following 16 months would principally be dedicated to drilling and construction of the wellheads for the storage cavities, with the concurrent onsite construction activities taking place during the last 12 months of this period. The construction equipment used would be the major source of air pollutants.

In order to estimate the magnitude of the impact on air quality from construction and other equipment, conservative assumptions which tend to overestimate impacts were used for the number of vehicles, hours of usage, and emission rates, all based on normal construction requirements. The onsite vehicle sources, such as bulldozers, trucks, etc., are assumed to be 10 heavy duty diesel vehicles plus 10 heavy duty gasoline vehicles, assuming a usage of 2,000 hours per year and an average speed of 10 miles per hour.[31] Drill rig equipment includes 2 Caterpillar D-352-TA diesel engines rated at 750 continuous horsepower each, 2 GMC 6-71 twin engines rated at 750 continuous horsepower each, and less than 10 smaller engines. These smaller engines, for purposes of analysis, are considered to total 3000 horsepower and to be heavy duty diesels of miscellaneous construction type. A drill rig is assumed to operate continuously for 20 hours per day at 75 percent load (i.e., at 2,250 horsepower) for about 8 months at the dome and an additional 23 months at the brine injection field. The Environmental Protection Agency has compiled emission factors for gasoline and diesel industrial equipment, including drill rigs, in grams per horsepower per hour, and for heavy duty diesel and gasoline powered vehicles in units of grams per mile traveled. These emission factors are shown in Table 3.10, along with an example of how the emission rate for the assumed operating conditions were calculated.

The only true stationary pollutant sources would be the drill rig, for 20 to 25 days at each location. A review of Table 3.10 indicates that one drill rig emits significantly more pollutants than diesel powered

Table 3.10 Emission Factors and Emission Rates
Vehicles and Drill Rig Equipment

Heavy Duty Vehicles

	Emmission Factors		Emission Rates/Truck	
Pollutant	Heavy Duty Gasoline (g/mi)	Heavy Duty Diesel (g/mi)	Heavy Duty Gasoline (g/sec)	Heavy Duty Diesel (g/sec)
Carbon Monoxide	188	28.7	0.21	.033
Hydrocarbons	13.8	4.6	.016	.0053
Nitrogen Dioxide	12.6	20.9	.014	.024
Particulates	1.3	1.3	.0015	.0015
Sulfur Dioxide	0.36	2.8	.0004	.003

Note: These emission factors are for average speeds of 18 mph, 20% idle. Conversion to emission rates in grams per second per truck is demonstrated in the following example for carbon monoxide:

$$0.21 \text{ g/sec} = (188 \text{ g/mi})\ (10 \text{ mi/hr})\ \left(\frac{18}{10}\right)\ (2{,}000 \text{ hr/yr})\ \left(\frac{1 \text{ yr}}{3.15 \times 10^{7} \text{ sec}}\right)$$

Source: Compilation of Air Pollutant Emission Factors. Second Edition, Supplement No. 5, U.S. Environmental Protection Agency, December 1975.

Diesel Industrial Equipment; Drill Rigs

Pollutant	Emission Factors (g/hp-hr)	Emission Rates (g/sec)
Carbon Monoxide	3.03	1.58
Hydrocarbons	1.12	0.583
Nitrogen Dioxide	14	7.31
Particulates	1.0	0.521
Sulfur Dioxide	0.931	0.485

Note: Calculation of emission rates for the specified operating conditions is demonstrated in the following example for carbon monoxide:

$$1.58/\text{sec} = (3.03 \text{ g/hp-hr})\ (2{,}250 \text{ hp})\ \left(\frac{20 \text{ hr}}{24 \text{ hr}}\right)\ \left(\frac{1 \text{ hr}}{3{,}600 \text{ sec}}\right)$$

Source: Compilation of Air Pollutant Emission Factors Second Edition, U.S. Environmental Protection Agency March 1975.

Table 3.11 Downwind Pollutant Concentrations from Drill Rigs

Pollutant:	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides (NO_2)	Sulfur Dioxide (SO_2)	Particulates
Sampling Time:	1 hour	3 hours	Annual Mean	24 hours	24 hours
Federal Standard:	40,000 $\mu g/m^3$	160 $\mu g/m^3$ (non-methane)	100 $\mu g/m^3$	365 $\mu g/m^3$	260 $\mu g/m^3$
Distance Downwind x (km)	Groundlevel, Centerline Concentrations ($\mu g/m^3$) at x Kilometers Downwind				
.5	127	39	17	23	24
1	39	12	5	7	7
2	15	5	2	3	3
5	3	1	-	-	-
10	1	-	-	-	-

vehicles. Calculations of the downwind, ground level concentrations of the various pollutants from a drill rig are shown in Table 3.11. These calculations are based on the Gaussian dispersion model presented in Appendix A. The meteorological conditions assumed represent the most frequent occurrence of atmospheric conditions: D stability class (or neutral), which assumes overcast conditions for day and night, and a wind speed representing the mean of the wind speed group most likely to occur at this location. These assumptions represent atmospheric conditions at Baton Rouge which occur 7.4 percent of the time.* For greater than 90 percent of the time, dispersion characteristics would be more favorable than the conditions assumed for the analysis. Therefore, the true impact on air quality would be less than predicted. Using a more stable class such as E or F (the most stable conditions) would result in less confidence in the numbers calculated and represents a much more unlikely condition (less than 1 percent of the time) considering that construction activities would continue for more than a year. Comparison of the resulting emission concentrations, measured in of the resulting emission concentrations, measured in micrograms per cubic meter ($\mu g/m^3$), with the Federal Standards indicates that all pollutant levels would be within the Federal Standards at 500 meters downwind from the drill rig site.

The downwind concentrations shown in Table 3.11 do not include ambient levels at the site. These levels are not known. However the worst case assumption of the magnitude of the degradation to the local air quality at this site is to assume ambient concentrations are zero.** In this case, the estimated contribution from drill rigs in the local area would cause an increase of $39 \mu g/m^2$ in local hydrocarbon levels at a distance 500 meters (1640 feet) downwind of the drilling operations. These concentrations given in Table 3.11 do not present a health hazard within site boundaries and diminish to levels well below Federal

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* All dispersion calculations in this report assume these same conditions for consistency.

** There are two concerns which control the acceptability of emissions. One is meeting Primary Air Quality Standards, and the second is determining if there is a "Significant degradation" of ambient air quality. Since drill rig emissions do not exceed air quality standards, assuming an ambient concentration of zero allows estimation of a worst case for air quality degradation.

Standards at offsite locations. There might be some slight onsite odor, but an individual would have to be extremely close to the emission source to encounter concentrations exceeding an olfactory threshold. Ambient air quality measurements taken at industrial centers in the New Orleans-Baton Rouge industrial corridor along the Mississippi River indicate suspended particulate levels as high as 145 $\mu g/m^3$ at Baton Rouge, 15 miles north of the site. Even assuming these ambient levels are present, the contribution from drill rigs would not result in the Federal Standards being exceeded.

Spray painting of the various crude and ballast surge tanks is another short duration source of pollutants during construction. For the purpose of this analysis, the worst case of an organic based paint with the maximum allowable concentration of photochemically reactive materials is assumed.

The quantity of paint required depends on several variables. It is assumed that one gallon would cover 100 square feet (the average of 2 estimates) if 2 coats of paint were applied, one gallon would weigh 15 pounds (the range is 10 to 15 pounds per gallon), half the weight would be solvent (50 to 55 percent is normal), and 20 percent of the solvent would be photochemically reactive. For 8-hour working days and a coverage rate of approximately 525 square feet per hour (for 2 coats), the result would be an emission rate of 39.45 pounds per hour (4.97 grams per second) of solvent hydrocarbons. The maximum rate of emissions for photochemically reactive species of hydrocarbons from painting would then be 20 percent of this rate or 7.89 pounds per hour (1μg/sec). Painting at the barge dock is assumed to last for 30 days, and at the tanker dock for 82 days. Table 3.12 shows the ground level, downwind centerline concentrations for total hydrocarbons and the reactive species. It assumes painting operations behave like a point source of emissions. The photochemically reactive (non-methane) hydrocarbon levels are below the 3-hour Federal Regulation of 160 micrograms per cubic meter (ug/m^3), but might be noticed by an observer within one kilometer (3,280 feet). Concentrations are likely to be noticed by an observer as an odor rather than seen as smog. These hydrocarbon levels should go unnoticed to a casual observer.

Table 3.12 Hydrocarbon Emissions from Tank Painting

Groundlevel Centerline Concentration at x Kilometers Downwind

Distance Downwind x (km)	Total Hydrocarbons 3 hr sample ($\mu g/m^3$)	Photochemically Reactive Hydrocarbons 3 hr sample ($\mu g/m^3$)
.5	290	58
1	100	20
2	40	8
5	10	2
10	5	1

Tons of Total Hydrocarbons from Painting Operations

Barge Dock	Tanker Dock	Net
4.7 tons in 30 days	12.9 tons in 82 days	17.6 tons
or	or	
0.4 tons/year	2.9 tons/year	

Comparisons with Federal Standards, which designate maximum concentrations considered acceptable in protecting the public health and welfare and preserving the quality of the air environment, provide one means of assessing construction impacts on air quality. Table 3.13 lists the estimated total tonnage of major air pollutants from drill rig operations, from diesel and gasoline construction vehicles, and onsite painting, based on their respective emission factors and the approximate operating conditions. A look at the mass of pollutants generated from onsite construction activities indicates that the total tons of particulates for Iberville Parish may be increased by 0.7 percent from these activities. Assuming the pollutants from construction activities at Bayou Choctaw settle within a 5 mile square (25 square miles), then there would be a net increase in the tonnage per square mile per year for hydrocarbons, particulates and sulfur dioxide of 1.1 tons per square mile per year, 0.8 tons per square mile per year, and 0.7 tons per square mile per year, respectively. The actual extent to which this increase in air pollutants would be felt is not possible to assess. Air quality problems may or may not exist in the area at present, but the low absolute levels of contaminants generated from onsite activities suggest that no appreciable air pollution would result from this source.

Operation

During storage and withdrawal phases of the Strategic Petroleum Reserve program at Bayou Choctaw, no significant degradation of the ambient air quality is expected. There would be a slight increase of traffic to and from the site during withdrawal. Oil leakage from valves, seals, and gauges on site during fill and withdrawal operations is expected to be slightly greater than during storage. Oil leaked from pumps would be collected in sumps and disposed of. These activities are not expected to cause any notable change in air pollutant levels on the site.

3.3.2 Construction and Operation at the Tanker and Barge Dock Facilities

Barge dock facilities to accommodate the Strategic Petroleum Reserve program's requirements would involve expansion of the existing barge dock on Bull Bay to twice its present size and the concurrent construction of three 150,000 barrel floating roof oil surge tanks and ballast storage

Table 3.13 Total Tonnage of Pollutants from Major Pollutant Sources for Duration of Onsite Construction

Drill Rigs (operating 20 hr/day, 16 months)

	Total for 16 months (tons)	Tons/year
Carbon Monoxide	72.4	54
Hydrocarbons	27	20
Nitrogen Oxides as NO_2	334	251
Sulfur Dioxide	22	17
Particulates	23.8	18

Construction Equipment (10 heavy duty diesel, 10 heavy duty gasoline) (2,000 hr/year, 18 months)

	Total for 18 months (tons)	Tons/year
Carbon Monoxide	125	83
Hydrocarbons	11	7.5
Nitrogen Oxides as NO_2	19	13
Sulfur Dioxide	1.8	1.2
Particulates	1.6	1.1

Total Tonnage from Onsite Construction

	Tons/year	Tons/year; Iberville Parish (1970)*	% Increase in Parish Total
Hydrocarbons	27.9**	57,254	0.05
Particulates	19.1	2,694	0.71
Sulfur Dioxide	18.2	4,659	0.40

*Source: Louisiana Air Control Commission, Implementation Plan, 1972.
**This value includes total painting hydrocarbon mass as shown in Table 3.12, for barge dock construction.

tanks at the dock site. The tanker docks and facilities would be built concurrently at a site on the Mississippi River approximately four miles away. Six 200,000 barrel floating roof surge tanks and various auxiliary facilities would be constructed at this location over a 10 month period. The construction equipment which would be used at both sites is assumed to be 10 heavy duty diesel and 10 heavy duty gasoline vehicles. Operating conditions and the expected emissions are similar to those discussed in Section 3.3.1 for construction at the dome. The emissions from heavy duty gasoline and diesel vehicles are shown in Table 3.10 and the total tonnage of pollutants from construction at the tanker dock are estimated in Table 3.14. This equipment would be the principal source and the tables present reasonable estimates of the net additions to Iberville Parish annual tonnages. The total mass of three major pollutants: hydrocarbons, particulates, and sulfur dioxide from both dock and tank farm construction for this project (Tables 3.13 and 3.14) are estimated to be 38.4 tons per year, 20.2 tons per year, and 19.4 tons per year, respectively. These represent increases in the 1970 Iberville Parish estimated totals of 0.07 percent, 0.75 percent and 0.42 percent respectively. All the increases are less than one percent of the parishwide values[32] and would have little significance with respect to change in air quality in Iberville Parish. The air pollution levels in this Parish are dominated by the petrochemical industry, so construction equipment activities at the tanker dock and barge dock are not likely to noticeably change existing levels, and would be of short duration.

Operation

There are two operational phases of the barge and tanker dock facilities. The first phase involves those operations occurring during fill or drawdown cycles. At all other times, the facility is in a standing storage mode in which no crude oil is transferred. During fill operations, tanker and barge unloading or loading would result in highly elevated hydrocarbon concentrations significant distances downwind from the respective docks. Also, the standing storage hydrocarbon losses from the floating roof crude oil storage tanks would contribute a small increment locally. These same losses would also occur during the storage phase of the program, since the tanks would be kept full or partially filled in order to maintain their structural integrity.

Table 3.14 Pollutants from Construction at the Tanker Dock

Construction Equipment

Total Tonnage of Pollutants (12 months)

	Tons/year	Tons/Year Iberville Parish (1970)*	% Increase in Parish Total Tonnage from Terminal Construction
Carbon Monoxide	83		
Hydrocarbons **	10.5	57,254	0.02
Nitrogen Dioxide	1.3		
Sulfur Dioxide	1.2	4,659	0.03
Particulates	1.1	2,694	0.04

*Source: Louisiana Air Control Commission, Implementation Plan, 1972.

** These values include total painting hydrocarbon mass as shown in Table 3.12 for tanker dock construction.

Standing storage vapor losses from floating roof crude oil storage tanks are estimated using an equation fitted to empirical data developed by the American Petroleum Institute for annual volume losses.[33] In the worst case, the tanks were assumed to be riveted tanks with a pan roof and single seal and painted light grey or aluminum. The losses calculated in this case are approximately 32 percent greater than those for a welded tank with the same specifications. Based on preliminary specifications of the crude oil, a true vapor pressure of 1.8 pounds per square inch absolute (psia) was assumed at an annual average temperature of 70°F. The resulting vapor loss rate is then 6.11 grams per second for each of the six 200,000 barrel tanks at the tanker dock, and 2.39 grams per second for each of the three 150,000 barrel tanks at the barge dock.*

Tables 3.15 and 3.16 show the ground level, centerline concentrations estimated at several distances downwind from the tanks at each tank farm location. The configuration of the tanks and the estimated wind direction at their respective sites are shown schematically in these tables. The distances downwind are measured from the center of the tank or midpoint of the line connecting two tanks. Since these tanks are very large (156 to 180 feet in diameter), a correction for the area source due to vapor losses around the seal of the floating roof has been made before using the point source Gaussian dispersion model as recommended in the Workbook of Atmospheric Dispersion Estimates.[34] The analysis for the treatment of an area source as a point source is discussed in Appendix A. Tanks at the loading/unloading facilities would cause a local increase in hydrocarbon levels as shown in Table 3.15 and 3.16. However, even with the wind direction used to estimate the worst case, concentrations fall off sharply at distances of 5 to 10 kilometers downwind.

During initial fill operations, the existing barge dock would be used until expansion is complete and the tanker dock facilities are operable. Barge delivery capacity would be 50,000 barrels per day at this stage. The sources of hydrocarbon emission from vessel loading and

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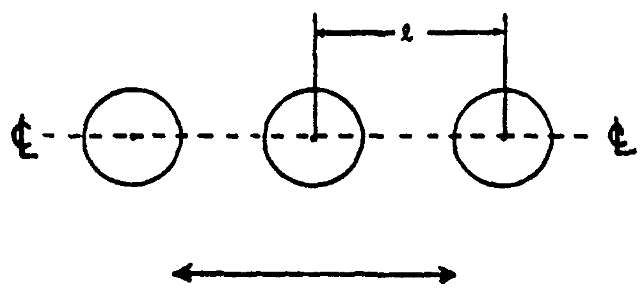
*It should be noted that this crude oil has a very low vapor pressure. Should crudes with higher vapor pressures be involved, the loss rates would be higher.

Table 3.15 Ground Level Downwind Concentrations of Hydrocarbons Resulting from Evaporation at the Bayou Choctaw Barge Dock Oil Surge Tanks

Configuration:

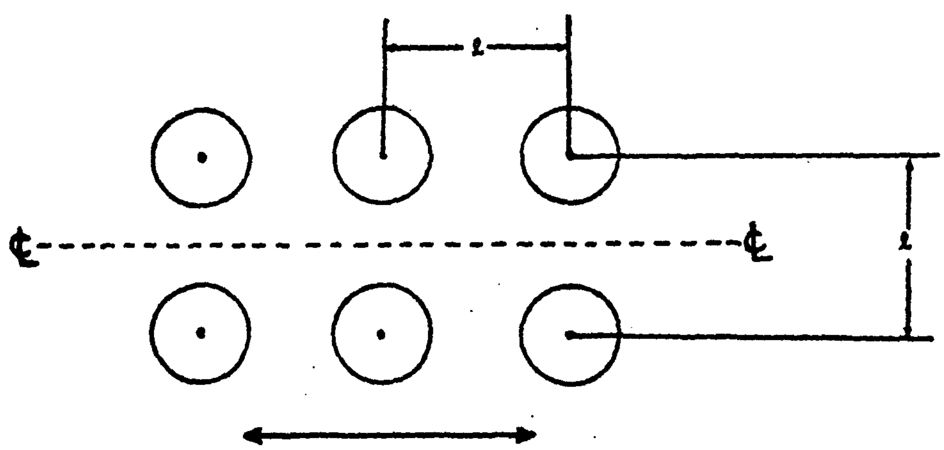


Tank volume = 150,000 barrels/tank
ℓ = 71.5 meters

Downwind Distance x(km)	Hydrocarbon Concentration 3-hour Sample $\chi(\mu g/m^3)$
.5	255
1	105
2	43
5	11
10	2

Table 3.16 Ground Level Downwind Concentrations of Hydrocarbons Resulting from Evaporation at the Bayou Choctaw Tanker Dock Oil Surge Tanks

Configuration:



ASSUMED WIND DIRECTION

Tank volume = 200,000 barrels/tank
ℓ = 100 meters

Downwind Distance x(km)	Hydrocarbon Concentration 3-hour Sample χ(μg/m³)
.5	7,500
1	4,330
2	1,970
5	567
10	214

unloading would be vent stacks which release vapors which would fill the continually increasing or decreasing space unoccupied by oil in the oil tanks.[35] The barge docks on Bull Bay Canal would be able to handle a 2 barge tow and a single barge tow of 75,000 barrel total capacity. The tanker docks would handle approximately two 350,000 barrel tankers. It is assumed that all vessels would unload/load their full cargo in 24 hours, resulting in the following emission rates:*

Barge (25,000 barrel): 6 grams per second (loading and unloading)

Two tow barge (50,000 barrel): 11 grams per second (loading and unloading)

Tanker (350,000 barrel): 79 grams per second(loading)
69 grams per second(unloading)

During the drawdown operations, it is estimated that 150,000 barrels per day would be transported by barge and 517,000 barrels per day would be transported by tankers. This means less than 2 tankers of 350,000 barrel capacity and about 2 barge tows of 75,000 barrel capacity would be required to be loaded each day for the 150 day drawdown period.

The concentrations downwind from these tankers or barges simultaneously loading or unloading has been calculated using a Gaussian dispersion model for the dispersion of the hydrocarbon vapor plume. The vent stacks are assumed to be 500 meters apart at each dock site during oil transfer operations. Table 3.17 shows the estimated hydrocarbon concentrations at the centerline of the plume from transfer operations at each dock. The calculations treat the emissions from each vessel as a separate dispersion problem. The net downwind centerline concentration is then the sum of the concentrations at the specified distances downwind from the respective vessels. These concentrations within a strip 200 meters (656 feet) in width and a length of 2.5 kilometers (1.2 miles) downwind from the most distant vessel are high when compared to the Federal Standard of 160 $\mu g/m^3$ for photochemically reactive hydrocarbons. However, probably not more than one percent of

*As determined using the Environmental Protection Agency's estimation of vessel transfer losses[36] and a true vapor pressure of 1.8 psia at 70° F.

Table 3.17 Vessel Crude Oil Transfer Groundlevel, Centerline Hydrocarbon Concentrations

Total Hydrocarbons 3-hour Sample ($\mu g/m^3$)	Distance Downwind x Kilometers .5	1	2	5	10
Tanker Loading[a]	6,125	2,368	988	247	90
Tanker Unloading[a]	5,350	2,068	861	216	79
Barge Loading and Unloading[b]	755	277	113	28	10

(a) for two tankers, berthed .5 kilometers apart, loading/unloading concurrently with the wind passing in line with the tanker vents

(b) for one barge and a two-barge tow, berthed .5 kilometers apart, loading/unloading concurrently, with wind passing in line with the barge vents these vapors are even slightly reactive photochemically. Thus, these concentrations of hydrocarbons would not contribute to smog formations. Some observers within this area may notice elevated hydrocarbon odors.

These concentrations of hydrocarbons are estimated for the worst case, and may be reduced by the installation of vapor recovery systems for tanker loading and unloading. Loading and unloading operations would result in an estimated total hydrocarbon emissions of about 2,000 tons from initial fill operations occurring over about 2.8 years, and about 2,000 tons from each 150 day drawdown or fill operation. The net hydrocarbon tonnage released to the local air environment from the Strategic Petroleum Reserve operations at Bayou Choctaw would be roughly 4 percent of the total emissions for the entire parish in 1970.

The overall ambient hydrocarbon levels in the near vicinity of the tanker and barge docks would be noticeably increased for the duration of tanker loading or unloading. Standing storage losses from tanks would also contribute. These estimated hydrocarbon concentrations, while far greater than the total contribution from vehicles and drill rigs, are substantially different in character from other air pollutants. Some elements of the vapor may elicit an unpleasant olfactory response, depending on the sulfur content of the oil, but the vapor would not be toxic to humans or local biota. The impacts on air quality of elevated concentrations of inert hydrocarbons such as are released from crude oil transfer operations have not been reported in the literature.* A search of the literature revealed no assessments of the impacts of these hydrocarbons in concentrations typical of the levels expected from this project.

Presently, the only guideline which relates to hydrocarbon emissions is the Federal standard for the photochemically reactive hydrocarbons. This standard is intended for the comparison of hydrocarbon emissions from internal combustion equipment because most often these emissions are

*At this time there are no Federal or State standards which establish guidelines for acceptable levels of photochemically inert hydrocarbons.

the precursors to traffic induced smog, but is inappropriate as a device to estimate the relative magnitude of the impact on air quality due to elevated levels of hydrocarbons which have chemical properties different from those for which the regulation was developed. To date, emissions concentrations (at any level) from crude oil transfer and storage operations are exempt from Federal and state regulations. Whether this situation would continue over the lifetime of the Strategic Petroleum Reserve program is speculative. Vapor recovery system technology does exist for transfer systems used elsewhere in the petroleum industry where refined petroleum products often require controls to minimize reactive emissions.

The USEPA has required the State of Louisiana to revise the State Implementation Plan (SIP) for photochemical oxidant for the Louisiana portion of the Southern Louisiana-Southeastern Texas AQCR.* The revision must include a plan for the compliance with the national standard for photochemical oxidant by July 1977 in this AQCR. Construction and operation of the SPR facility probably will have begun prior to July 1977 and will continue after that data, and therefore may be affected by the revision of the SIP. However, as indicated in the preceding paragraphs, the SPR program is not presently felt to constitute a significant source of reactive hydrocarbons and would not be an important contributor to regional photochemical oxidant generation.

Another requirement for state implementation plans to meet the NAAQS is new source review. The most recent ruling from EPA regarding new source review has established the trade-off system**. Under this provision, new sources are required to show that emissions from the new source plus SIP-required reductions from existing sources equal a net decrease in emissions. That is, the new source should not delay progress toward achieving the NAAQS in non-attainment AQCRs. The effects, if any, of this ruling on the SPR program remain uncertain at this time.

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*41 Federal Register, No. 138, July 16, 1976.
**Environmental Reporter, October 28, 1976, pp. 1091-94.

3.3.3 Noise Impacts

Construction activity associated with the conversion of the existing space at Bayou Choctaw and ancillary facilities may cause some noise impacts for residential, recreational, farming, and other land uses in the general vicinity. The construction is planned to take place over a period of approximately 30 months and would occur at the following locations.

Storage Site Area

Contributing noise sources at the storage site area during site preparation would be air compressors, trucks, diesel engines, pumps, drilling rigs, impact equipment, concrete mixers, and general construction related equipment. Noise levels typical of this equipment are given in Table 3.18. Diesel engines would provide the most consistent source of noise. Impact and drilling equipment would create the peak sound levels. The areas adjacent to the storage site are predominately industrial and marshlands. The nearest agricultural land is at least 1 mile away and the nearest residential area is at least two miles distant. No noise sensitive activities are known to occur adjacent to the storage site area.

During operations at the storage facility, the primary noise generation would be from pumps associated with fill and discharge operations. Early fill operation (75,000 barrels per day) would commence during the construction period and would continue for 23 months. During this period, a temporary injection system would pump oil into cavern No. 15. Barges would be in operation at the temporary barge dock on the Intracoastal Waterway. The diesel engines and pumps associated with this initial fill operation would be a primary noise source at the barge site. Since the injection rates involved during initial fill are less than 10 percent of those expected for the permanent facility, impacts due to permanent facility operation would be the worst case condition and are discussed in the following paragraphs.

After completion of the docking facilities on the Mississippi River near Addis, fill operations would require the operation of oil injection pumps with approximately 13,750 total horsepower motors and brine disposal pumps with 18,000 total horsepower. These pumps, together with other lower horsepower pumps which would be used for oil

Table 3.18 Construction Equipment Noise Levels

Equipment	A-weighted sound level at 50 feet (dBA)
Air Compressor	81
Backhoe	85
Concrete Mixer	85
Crane Mobile	83
Dozer	87
Generator	78
Grader	85
Pile Driver	101
Pump	76
Rock drill	98
Truck	88

SOURCE: "Noise Emission Standards for Construction Equipment Background Document for Portable Air Compressors," U.S. Environmental Protection Agency, EPA 550/9 - 76 - 004.

discharge operations, would be sheltered in a pumphouse at the storage facility. Although noise levels within the pump house are expected to exceed 90 dBA, typical pump house construction should reduce exterior noise from this source to less than 70 dBA at 50 feet from the structure. As noted in Appendix C, federal guidelines for safe noise levels (average sound energy over a 24 hr period with an adequate margin of safety) are 55dB for outdoor activities and 45 dB for indoor activities.

Additional noise at and near the storage facility would be caused by the increased vehicle traffic due to maintenance and operating personnel. Present plans provide for the utilization of 34 personnel during fill and withdrawal operations and 12 personnel during standby operation. It is estimated that noise from all sources associated with fill/withdrawal operations would increase the noise levels by 3 dB at the site perimeter. Because of the area industrial land use and the remoteness of the site from residential and other noise sensitive use areas, it is not anticipated that this increased level of noise from storage facility operations would interfere with either outdoor or indoor activities near the storage area.

Pipeline Corridors

Two pipeline systems would be built for the operation of the facility; one 2 miles long extending directly south from the storage site to the brine disposal area, and the other extending east approximately 4 miles to the distribution terminal. The pipeline construction consists of (1) excavation, (2) laying of pipe, (3) welding, and (4) finishing operations. The proposed pipeline route passes within a quarter mile of several residences on the southern end of the town Addis. Due to the short duration (1 to 2 weeks) of construction at this location, the temporarily increased noise would not impose significant stress on local residents. With the possible exception of these residences, all noise sensitive areas are well beyond the noise impact boundary from pipeline construction which is estimated to be L_{eq}* = 55 dB at 500 feet from the pipeline construction. (See Appendix C).

*Equivalent Sound Level (L_{eq}) is a steady noise level containing the same noise energy as a varying level measured over the same period of time.

Terminal and Dock

Major noise sources from the terminal and dock construction are expected to be pile driving for the dock construction and diesel engine noise in the terminal area construction. Trucks, concrete mixers, compressors, and general construction equipment would all contribute to increased ambient levels. For construction activity at the dock and terminal site the daytime L_{eq} during the period of construction is estimated to be 70 dB at the center of the site. It is probable the residents in Sections 31 and 33 would experience an increase in ambient noise levels during the period of construction activity. Night time construction activity is not anticipated in the terminal area.

When tanker unloading and loading occur, the major noise associated with the operations would be from tanker pumps discharging crude oil, tanker loading pumps, and pipe transfer pumps.

The pumps for both tanker loading and pipeline transfer to the storage area would be electrically powered and would be housed in a pump house on the terminal site. Noise from the diesel engines powering the tankers and tanker discharge pumps would contribute negligibly to daytime ambient levels. It is estimated that night time levels would be increased by approximately 4 dB along the perimeter of the terminal area. Noise from the terminal operation would not affect land use beyond 2,000 feet from the terminal site. Residents of the St. Mary's Church in Section 33, 0.5 miles to the South of the dock area, would not be affected.

Brine Disposal Area

There would be noise generated from drilling operations at the storage facility and at the brine injection wells about 2 miles south of the storage facility. Conventional oil drill-rig equipment would be used for work over and drilling of wells at the storage site and at the 28 brine disposal wells in Sections 60, 60 and 62. Noise from conventional oil drilling equipment reaches levels of 95 to 100 dBA at 50 feet from the drill rig. The noise impact zone (L_{eq} = 55 dB), within which Federal guidelines are exceeded for normal outdoor activities, is estimated to extend approximately 1,800 feet from the drilling sites; however, all drilling sites are in remote areas at least a mile from any residences, and noise from these sites should have little effect on existing land use.

Summary of Noise Impacts

Noise impacts from the Bayou Choctaw construction and site preparation are summarized in Table 3.19. Federal guidelines for safe levels of excessive noise, as outlined in Appendix C, would not be exceeded beyond 2000 ft from any of the site construction or beyond 500 ft. from pipeline construction. The nearest residential area is at least 1 mile from any of the construction sites or 0.25 miles from a proposed pipeline construction area.

During fill and/or discharge operations, there would be noise generated from the 24 hour operation of pumps at both the storage and terminal facilities. Since the storage and terminal facility pumps would be enclosed in pumphouses, there would be negligible noise impacts to residential areas, the closest of which are one mile from the terminal and at least two miles from the storage facilities. The Federal guidelines listed in Appendic C would not be exceeded except perhaps for very near the pump buildings on the facility property.

Table 3.19 Summary of Sound Level Contribution (dB) from Construction Activities

Construction Site	L_{eq}	L_{dn}	Distance from Center of Site
Storage Site Area	55	55	2,000'
Pipeline Corridors*	55	55	500'
Terminal and Dock area*	64	55	2,000'
Brine Disposal Area	55	55	1,800'

*No night time activity planned.

3.4 SPECIES AND ECOSYSTEMS

3.4.1 Impacts on Bayou Choctaw Area

The Bayou Choctaw dome area consists of a developed tract around the salt cavity wells, an adjacent dock area on the Port Allen Canal and Choctaw Bayou, an oil field, and a proposed brine disposal field. The salt cavity and dock areas are industrialized locations from which the main vegetation has been cleared, and the oil field area is greatly modified by a network of roads in addition to oil well facilities. The total area involved is approximately 2,250 acres. During construction approximately 110 acres would be redisturbed, (10 acres at the dock; 100 in the storage area). Approximately 20 additional acres would be cleared in the storage area. The construction of the brine disposal facilities (pipelines, fill and mud pits at the disposal wells, and roads) would alter approximately 68 acres of wetlands. Total land which would be disturbed by construction is approximately 198 acres. Most of the dome is surrounded by a Deciduous Swamp and Bottomland Forest community. This type of community extends from the southern part of the dome area into the oil field. Construction of earthen retention dikes at the storage site and dock would result in increased turbidity for a short time in a local bayou-canal complex. This increased turbidity would result from loose soils on and near the retention dike washing into the bayous and canals. This effect would be most evident if heavy rainfall occurred or shortly after dike construction. This area would be highly susceptible to erosion until revegetated. If the construction of dikes occurs relatively early in the growing season, it is expected the banks would begin to be colonized by plants during the same season. The reestablishment of a plant community would act to retard erosion and provide a feeding area for birds and other wildlife.[37]

Fill operations would destroy all immobile benthic organisms and most forms of limited mobility in the path of the earthen dike. Benthic invertebrates, including midge, mosquito, and gnat larvae, mayflay and dragonfly nymphs, and worms, are particularly vulnerable to physical and chemical environmental changes due to their low mobility. Numbers of individual organisms potentially covered by filling range from 2.97×10^6 during early spring months to 2.49×10^7 in summer in the total area of 9 acres. These values were established for several shallow freshwater lakes in South-central Louisiana which are biologically similar to the site area.[38] Corresponding losses of biovolume are 1.14×10^5cc in spring and 2.6×10^5cc in summer. This would be a permanent loss of organisms important in food webs as fish food and as organic material consumers (detritivores). The impact is only of minor local significance in view of the total acreage of swamp forest in the area. Waters surrounding the dikes would receive a sediment load which also is detrimental to some benthic invertebrates due to clogging or abrasion of gills.

The fish in waters on the dome can be expected to emigrate from areas of activity associated with dike construction and inhabit nearby undisturbed areas. If all fish emigrate from the southwestern sector of dike construction (20 acres), a loss of up to 5,000 lbs/year (250 lbs/acre/year) production can be expected.[38,39] Approximately 70 percent of this potential production (3,500 lbs) would be "rough" fish such as gar, suckers, and shad.[40] Fish production would be permanently lost in this area of the dike but is not a major impact.

Phytoplankton productivity would be greatly reduced as lower light levels occur due to turbidity increases, other factors remaining constant. Turbidity increases would be less inhibiting in areas not immediately adjacent to construction activity. Plankton production has been recorded for southern Louisiana wetlands at 906 g net dry wt of organic matter/m^2/year for phytoplankton and 25 g net dry wt of organic matter/m^2/yr for zooplankton.[41] Maximum impact on plankton production would occur if site preparation occurred in spring because of seasonal plankton blooms. The effect on area phytoplankton would be negligible no matter what the duration, since construction on the dome involves a limited expanse of swampland and only one canal (approximately 98 acres). If there is an inhibition of phytoplankton growth, this would occur for a maximum of several months during and after construction.[8] Considering the large fresh water area and the flushing characteristics of the interconnected bayous, change in plankton production resulting from turbidity would be relatively minor. Algal population increases could be stimulated by increased mineral nutrient wash-in.[8]

The productivity of emergent aquatic macrophytes along the bayou-canal-swamp complex of the dome would not be appreciably affected by increased turbidity since their leaves and photosynthetic stems predominately occur above the water level. Approximately 20 acres of aquatic macrophytes would be removed in the southwestern sector of the storage area for construction of a dike and materials stockpile area. Plant production of approximately 2,000 g dry wt/m2/yr[42] would be sacrificed, about 10 acres of which would be permanently lost due to land filling. The remaining 10 acres would not be as productive as previously since this area would be enclosed by dikes.

The vegetation on the site has been cleared of trees and no additional clearing should be needed. Upon completion of construction, colonizing species of grasses, shrubs, and possibly willow would revegetate the area within a year. Loss of soil from the site would be reduced due to the flat topography of the area, and erosion should not restrict the natural revegetation of the site.

Noise and human activities during facility construction would disrupt the site as a feeding or nesting area for wildlife, but when construction is terminated wildlife would gradually return. A limited variety of wildlife would be on or near the highly industrialized dome. Cottontail and swamp rabbits and grey and fox squirrels are present. Rabbit densities of 0.1 to 0.5 per acre and squirrel densities of 0.5 per acres are common in the site area.[43] Wildlife in this area probably is accustomed to disturbance because of the hydrocarbon storage activity which has been occurring on the site for some time. Recovery from construction and other human activities in the area, provided times of construction do not coincide with breeding and nesting, would probably occur within 2 or 3 weeks after completion of construction. A negligible permanent loss of habitat would occur for these animals due to construction of buildings, tanks and related facilities.

It is extremely unlikely that any rare or endangered birds or mammals would be affected during site preparation and construction because these organisms do not utilize the disturbed habitat found at the site. Rare or endangered plants are not present. The American alligator (Alligator mississippienis), although officially considered endangered throughout most of its range, has become more plentiful in recent years and is reported near the vicinity, although it avoids areas of greater human activity.[44] The pallid sturgeon (Platyrhyncus albus), considered rare in the Southern Louisiana area by the New Orleans Corps of Engineers, is a potential inhabitant of the bayou-canal complex on Bayou Choctaw dome but would be relatively unaffected by even a considerable increase of turbidity in the water, because it is highly tolerant of turbid waters.[43]

Normal facility operations would cause significantly less impact on the local environment than those from construction activities. Out-migration of wildlife due to noise and human activity would occur during pumping operations but to a lesser degree than during pipeline and facility installation. The primary threat to biological organisms would occur in the event of an accidental oil or brine spill or wellhead blowout, but retention dikes will serve to minimize the effects of such accidents. A more detailed discussion of accidental spills is found in Section 3.7.

In summation, the primary construction (diking and filling) and operation impacts at the Bayou Choctaw site would disturb some species, especially benthic invertebrates. Temporary removal of vegetation in already disturbed areas, and minor short term turbidity and water quality changes with negligible effects on the aquatic fauna and flora would also occur. The significance of these impacts is evaluated in the summary Section 3.4.6.

3.4.2 Impacts on Displacement Water Source

During facility operation, displacement water required for crude oil withdrawal would be taken from a 12 acre on-site lake formed when a salt cavern (#7) on the north central portion of the dome collapsed. The lake has a maximum depth of 85 ft and a capacity of 8.6 million barrels. Because of its interconnection by canal with Bayou Bourbeaux and the Intracoastal Waterway, it would be able to supply sufficient water to meet the 115 million barrel/150 day cycle requirement, as well as the maximum flow requirement of 46,000 barrels/hour.

The intake system would include the pumping station and an intake structure. A one-half inch mesh screen would cover the intake structure. A maximum current of 0.5 ft/sec. would be induced at the screen. All phytoplankton and zooplankton in the displacement water would be entrained (drawn in). As a worst case, this represents an estimated productivity loss over 5 months of approximately 210,000 kg of organic material.[37] An impingement (entrapment against the intake screen) problem would not develop because most aquatic animals large enough to become trapped (fish and crayfish) on the one-half inch screen would also possess sufficient mobility to escape the 0.5 ft/sec maximum current.

Some mobile animals may temporarily emigrate from the site during construction and during operations. This emigration would be a response to increased noise and human activity; however, no permanent habitat alteration would occur and animals would again use the site after activities cease.

The interconnected hydrological system including the displacement lake, the Intracoastal Waterway, and Bayou Bourbeaux would prevent any significant drawdown in the lake due to displacement water removal. Therefore, no impacts to benthic invertebrates or aquatic plants would occur.

In summation, a locally significant loss of plankton production would occur with each 5-month fill-withdrawal cycle (210,000 kg). Benthic organisms, however, would be relatively undisturbed and wildlife emigrations in response to human activities would be minor and of short duration.

3.4.3 Impacts of the Brine Disposal System

The brine pond, pump and some of the pipelines would be constructed on the dry northern portion of the dome. The impact on this cleared, industrialized land is described in Section 3.4.1.

The brine disposal area would be a roughly rectangular field covering approximately 1,150 acres of swampland, with 28 wells spaced at 1,300-foot intervals. Roadways and well pads would have to be constructed for drilling and servicing the brine disposal wells. This would require 6.5 miles of new roadbed construction. Approximately one acre of fill or dry land would be sufficient for operations at each well. A total of approximately 68 acres of Deciduous Swamp and Bottomland Forest south of the dome would be directly affected by clearing and landfill for the brine disposal system. The dominant species of trees in this vegetation type (tupelo gum and bald cypress) would be the species lost in greatest numbers and timber volume. Wildlife habitat would be altered in the cleared area. This would displace an estimated 12 to 60 rabbits and about 130 squirrels. Noise impact from construction activities would force emigration of some wildlife from areas of construction and would put others, particularly deer, under stress.

Earth moving activities for pad construction would be needed before construction of brine disposal wells, and these activities would increase turbidity and add nutrients to swamp water of the dome. Increases in turbidity from construction would affect most of the 1,150 acres of swampland by decreasing light penetration and possibly reducing plankton production. However, as stated for the dome bayou-canal complex, an influx of nutrients from the sediments and fill could increase phytoplankton, periphyton and macrophyte production in areas not buried by fill, thus ameliorating the effects of reduced light levels on plant productivity. Community composition also could be affected since different species have different physiological tolerances and ecological dependencies.

Benthic invertebrates covered by fill would be eliminated while those in the surrounding turbid waters would be affected to different degrees. Mollusks (e.g., snails and bivalves) covered by siltation from rain runoff from the fill areas could suffocate or suffer gill abrasion. This could also occur with fish and crayfish. Crayfish can survive in water made turbid by its high content of detrital matter and presumably could tolerate high turbidity produced by other sources. Crayfish may temporarily decline in the areas affected by high turbidity at the dome because of a decline in food supply. They are omnivores which feed mainly on organic matter which has been greatly decomposed.[43] Recolonization of the area after turbidity levels return to normal should be rapid. An estimated 68 acres containing invertebrates would be eliminated by fill and assuming an average of 680 benthic invertebrates/m^2,[38] a total of about 3.5×10^8 organisms would perish. These invertebrates are an integral part of the aquatic food web.[39] Siltation caused by construction activities might eliminate a small portion of benthic invertebrates in the rest of the brine disposal area or affect their feeding, respiration or reproduction. This reduction of invertebrates numbers in the aquatic system and food web would be of only local significance and, for the most part, would be only temporary. Many species of sunfish and other freshwater fish which feed mainly by sight would be forced to emigrate from the area in order to find food. This invasion of surrounding, undisturbed areas could result in stressing adjacent fish populations. The large volume of the system of interconnected waters would result in lower stress levels than if there were not such an expanse of contiguous water. Fish should move back within a short time (~2 months) after turbidity settles and disturbances cease, if construction of brine disposal components takes place in summer months.

In summation, construction of the brine disposal system at Bayou Choctaw would cause very localized severe biological impacts. Approximately 68 acres of swampland would be cleared or filled, thereby causing a reduction in primary and secondary production. Loss or alteration of habitat for birds, furbearers and other wildlife would occur during construction. Additionally, the entire brine disposal field would be affected during the construction period due to noise and/or water quality changes. Recovery after construction would result in a change in species composition and operational activities would disturb wildlife during the operation phase. Maintenance and normal human activity and noise would cause some displacement or stress. The greatest potential for adverse environmental effects during brine disposal operations would result if an accidental spill occurs at a wellhead or from a pipeline. The extent of the impacts would depend on the size of the spill and the localized setting. Accidental spills are discussed in Section 3.7.

3.4.4 Impact from Pipelines

Pipelines needed for the proposed crude oil storage development at Bayou Choctaw dome include: (1) connections to the 11-cavern storage site layout from the Bull Bay dock site and from the Mississippi River dock site,

(2) the displacement water line from the 12-acre on-site lake to the storage cavities, (3) connections from the storage cavities to the 8.3 acre brine pond, (4) the brine disposal line from the central pumping facility to the disposal field with smaller pipeline connections to the individual injection wells, and (5) a 5-mile distribution line from the storage site to the Mississippi River terminal facility.

Pipelines from the 11-cavern storage layout to the brine settling pond and to the displacement water source would cross cleared, industrialized areas. Pipelines from the Bull Bay Dock facility to wellheads on the southwestern portion of the dome would be installed adjacent to an existing pipeline along the access roadway. Impacts on the water quality of the bayou-canal complex would result from a slight turbidity increase during construction activities. Due to the small acreage involved, pipeline installation impacts to the aquatic biota would be relatively short term and almost negligible in terms of loss of plankton, benthos, aquatic vegetation or fish emigration, when the vast amount of bayou-canal-swamp habitat in the area is considered.

Very little dry land, except highly disturbed grass covered areas and some cropland would be affected by burial of the pipelines. Pipeline rights of way would revegetate within several months to a year, depending on the season of construction. Dry land crossing would only affect, during one growing season, the previously disturbed industrialized areas and adverse impacts would be slight. Removal of vegetation in swampland crossings would disturb biological communities as discussed in Section 3.4.3, and would force emigration of mobile animals from the area. Most of the impacts on mobile wildlife and aquatic communities would be felt for a short period of time and recovery, with an altered species composition, would occur within one year. Birds, waterfowl, nutria, muskrats, deer, and small mammals, as well as alligators, turtles and snakes, would permanently or temporarily lose the habitat in the pipeline route or the habitat would be degraded for them.

The oil distribution system would require the construction of a 5-mile pipeline to the Mississippi River terminal utilizing a 75 to 100 foot right-of-way, part of which would follow an existing pipeline route. This would require 45 acres of swamp forest and agricultural land. Adverse ecological impacts to agricultural or previously industrialized lands would be minimal. Once pipelines are buried, agricultural activities in the right of way can resume within one growing season. Impacts on the swamp forest communities would be similar to those described above for brine lines crossing swampland. Only 2 to 4 acres of previously undisturbed swamp would be affected, however, since existing routes would be used for the right of way.

In general, pipeline installation creates short-term and very localized impacts on biological systems except long-lived components such as trees. These impacts usually are not as severe and are short term compared to impacts resulting from filling and other construction activities which involve installation of permanent above-ground components.

Pipelines would cause minor environmental impacts under normal conditions after construction. Maintenance of rights of way by mowers would drive mobile organisms from the vicinity temporarily. These organisms would return when maintenance operations cease. The greatest potential for severe localized environmental impacts would occur due to spillage of a large quantity of crude oil or brine. The probability and effects of such spills are discussed in Section 3.7. In summation, pipeline impacts are very localized and relatively minor.

3.4.5 Impacts from Dock Facilities Construction

Initial crude oil fill operations would be conducted from an existing barge dock (Bayou Choctaw Barge Terminal) adjacent to the site. There would be no impacts until site preparation and construction for the new dock facilities begin.

During site preparation and construction, heavy metals and pesticides would be released from sediments by dredging activities. These would not persist at increased levels after dredging but would be dispersed and in part re-absorbed on sediments. The potential for toxic effects or physiological effects (which might affect such functions as reproduction or behavior) is slight. The potential for biological magnification (increase in concentrations of materials in animals which consume contaminated food organisms) is also slight due to the short time these materials are in suspension. Dredging activities on Bull Bay would increase suspended matter, causing light attenuation and an accompanying reduction in phytoplankton productivity. Because of the currents and water movement in the vicinity of this dock, an area much larger than the 6 acres of dock and wetlands could be influenced. Turbidity caused by dredging is apparent for less than 1,300 ft. from the source in most cases.

Benthic invertebrates such as insect larvae, mollusks, crayfish and worms would be killed directly by being covered with heavy loads of sediment from dredging and spoil disposal in the 6 acres of wetlands used for dock facilities. Benthic organisms in surrounding waters could also be covered with sediment. Some forms may suffer up to 90 percent mortality (mollusks are the most susceptible) from gill abrasion and clogging.[46] The densities of species and types present vary seasonally and with conditions of water quality, available food and other factors. Lantz[38] found 81 organisms/m^2 in spring months and 680 organisms/m^2 in summer months in a similar habitat of southcentral Louisiana. That portion of the 6 acres which is not permanently covered by fill would produce aquatic invertebrates at pre-construction densities in about one year.[8] The net loss to the benthic invertebrate community in the six acres of the Bull Bay Dock facility is estimated at less than 18.5×10^6 organisms for a period of one to two years.[38] Fish in the dredging area would emigrate, especially those species such as bass, other sunfish, pickerel, and others which feed mostly by sight. Effects on sight feeders would be limited to a 1,300 ft radius of the dredging. Other species which feed by other senses and thrive on detrital matter probably would remain in the area. Fish forced to leave the area and take up residence in surrounding areas, would cause increased competition with adjacent fish populations for such things as food, cover and possibly breeding areas. There would be increased stress to both the existing and displaced populations. Fish numbers would normalize within one year after construction is complete because fish food sources will have recovered. Construction activities may force mobile wildlife such as birds, furbearers, and amphibians and reptiles into surrounding wetlands with no major stress on the surrounding populations. Recovery and immigration of organisms of these species would occur within a year after construction, except on the 6 acres which are permanently altered.

The 6 acres of disturbed wetlands vegetation would be permanently lost. This habitat includes swamp vegetation such as sedges, rushes, aquatic macrophytes and possibly some trees (water tupelo and bald cypress). Total loss of wetland production would be approximately 9,100 kg. of dry wt of organic material per year.[42]

A tanker dock would be constructed near St. Mary's Church on the Mississippi River 4 miles east of Bayou Choctaw. Approximately 1.5 million cubic yards would be dredged from the shore and deposited into the Mississippi channel. The resulting increased turbidity would be evident for several miles downstream. Adverse impact would be local and relatively low. Plankton populations are generally low in large, turbid rivers entering only from upstream backwater and as displaced periphyton.[45] Fish would temporarily emigrate from extremely turbid areas in the main channel, but the large riverine forms there are well adapted to high turbidity and fish production would not be reduced over the long term. Aquatic macrophytes do not form an established bank community on the Mississippi River because of fluctuating water levels; therefore, few or no impacts would affect aquatic macrophytes in the area. Pesticides and heavy metals in dredge materials would be widely dispersed and in large measure re-adsorbed on sediments elsewhere. Background levels are high in the lower Mississippi in any case and construction of the dock would result in a redeposition rather than an increase in such pollutants.

The dock facility on the Mississippi River would be constructed on approximately 30 acres in previously developed area. The terrestial fauna and flora found are those which can tolerate disturbed community conditions. Once construction is complete, displaced birds and small mammals would move back into the area for occasional feeding. However, waterfowl and some furbearers would permanently avoid the area since human activities and disturbances would continue during ensuing project operations.

In summation, heavy metals and pesticides would be stirred up when dock areas are dredged but would quickly resettle and pose relatively little threat of food chain contamination. An estimated 18.5 x 10^6 benthic organisms would be destroyed at the Bull Bay Dock facility but populations would re-establish in one to two years. Increased turbidity produced by dredging would force visual hunting fish temporarily from the area and construction noise could force wildlife to temporarily avoid the site. A small amount of primary production (9,100 kg dry wt) organic material per year would also be lost.

Further biological impacts would result from the operation of the terminal facility, involving primarily water quality impacts due to oil spills from tanker transfer and transport operations. An analysis of the risk of spills and the associated impacts to the aquatic environment are discussed in Section 3.7.

3.4.6 Summary of Species and Ecosystems

Construction of all components of the Bayou Choctaw SPR project would impact 1,350 acres. Only 166 acres would be previously undisturbed land (68 of 1,150 acres in the brine field, 4 of 45 acres along the pipeline and an additional 94 acres from all other facilities).

Fill operations at the dome site would destroy between 2.97×10^6 and 2.49×10^7 benthic invertebrates (midge, mosquito, and gnat larvae, mayfly, and dragonfly nymphs and worms). This represents a biovolume loss of 1.14×10^5 to 2.6×10^5 cc. A permanent loss of 1.6×10^5 kg (352,000 lbs) of phytoplankton and macrophyte production would be incurred per year. Fish losses total 5,000 lbs/yr; of which 70 percent are rough fish. These impacts are biologically severe but very localized (20 acres of aquatic habitat filled or otherwise significantly modified). Construction noise and human activity would disturb wildlife and some emigration can be expected to occur. A negligible amount of wildlife habitat would be lost.

The most significant biological effect of obtaining displacement water from the 12-acre lake would be the loss of 210,000 kg (462,000 lbs) of organic matter per 5 month cycle (worse case estimate). This represents a local loss of food for fish, crayfish and other consumer organisms and they may emigrate from the area in response to the food shortage. There would be no appreciable effects on benthic organisms.

The brine water disposal system would permanently change 68 acres of swamp forest to dry land and as many as 3.5×10^8 benthic organisms could be destroyed by filling operations. This represents a significant, but localized impact. Loss of these organisms would reduce fish food supplies at a time when fish are forced to emigrate. This would place some stress on adjacent populations. Fish might also experience gill abrasion due to excess suspended solids. Construction operations would increase turbidity over as much as 1,150 acres of swamp forest and short term productivity losses would occur. Plankton community composition could be temporarily altered.

Noise and human activities associated with construction, operation and maintenance of this system would be relatively short term. An estimated 12 to 60 rabbits and 130 squirrels would be forced from the 68 acres and emigration of wildlife may stress adjacent populations.

Pipeline rights-of-way would clear 22.5 acres of agriculatural land and 225 acres of swamp forest wildlife habitat. Successional species and organisms which prefer open, ecotonal habitat may increase in number.

Dredging and spoil deposition activities would destroy 18.5 x 10^6 benthic organisms (insect larvae, mollusks, crayfish and worms) at the Bull Bay Dock facility. Populations should recover in one to two years, however. Visual hunting fish such as bass, other sunfish and pickerel would emigrate temporarily due to increased turbidity levels. A small amount of primary production, 9,100 kg dry wt organic matter/yr, would be lost. Pesticide and heavy metal mobilization would be a transient phenomenon with little, if any, food chain magnification expected.

It is very unlikely that any rare or endangered species of birds or mammals would be affected during site preparation and construction. Rare and endangered plants are not known to inhabit the site locality.

3.5 Waste Disposal

During the site preparation and construction phase, generated wastes include surplus lumber and metal goods, paper, waste concrete, sewage, and, possibly, formation water from the drilling process.

Construction wastes are usually handled by the construction contractor, who is required to leave the site clear of wastes. Surplus lumber and scrap metal are normally sold to local dealers who handle such materials. Disposal of waste paper, concrete, and other non-marketable goods is usually at a local land fill site. Probably no more than a few thousand cubic yards of each of these types of materials would be generated during the entire project. Within a 20-mile radius of the Bayou Choctaw Dome there are 9 sanitary land fills west of the Mississippi River capable of handling project wastes; the newest one being the Iberville Parish sanitary land fill which is about 2.5 miles from the site.

Earth bulldozed for tank site preparation and construction of brine pits would be used for containment dikes. Dredged material from the expansion of the existing barge dock facilities on Bull Bay would be deposited around the new barge slip and used to supply landfill for nearby uses. The 1.5 million cubic yards of material dredged in the construction of the tanker terminal on the Mississippi River would be deposited in the channel.

Sewage treatment and disposal would be through the planned septic tank system that is to be constructed in compliance with the state regulations.

Formation water produced during the well-drilling process would probably be reinjected into the well hole with the drilling mud, or collected by drilling support tank trucks supplied by the drilling contractor to handle such wastes. Once the drilling is complete, the drilling contractor hauls off all the drilling mud to be processed and re-used on another project. The mud pit where drilling mud is prepared and stored would be cleaned and covered with topsoil.

The major waste product during operation is ballast water received from the tankers during oil on-loading. During withdrawal of the stored oil, tankers up to 65,000 DWT are expected at the Mississippi River tanker terminal. Up to 50,000 barrels of ballast water would be generated by each 65,000 DWT tanker loaded, of which as much as 5 percent or 2,500 barrels per tanker may be recoverable oil. To recover this oil, the ballast water would be pumped back to the storage site where oil would be skimmed off before the water is pumped to the brine disposal wells. The recovered oil would be injected into the main oil storage cavities, or sold to "slop oil" marketers.

Waste oil from the facilities such as minor leaks from pumps and valves, would also be collected and injected into the storage cavities.

3.6 SOCIOECONOMIC EFFECTS

3.6.1 Manpower Requirements

On-Site Construction and Drilling: An estimate of the total manpower requirements of the project is shown on Figure 3.4. The level of manpower needed for work on the storage site itself is shown by the dotted line. Construction of the required buildings, brine pool, fencing and similar installations would require about 10 skilled craftsmen and laborers for an initial 4 month period, and 4 skilled workers for the ensuing 7 months. An additional 12 skilled workers and laborers would be employed for 6 months in the construction of pipelines for (1) the disposal of brine presently occupying the caverns, and (2) the displacement of oil with raw water during oil recovery procedures. These construction operations would proceed concurrently with the drilling of wells for brine disposal, water supply, and additional access to the cavities. Current plans call for the use of 2 conventional drill rigs and one or two workover rigs. The drill rigs would be operated by about 32 men working in shifts, and the workover rig, by 6 to 12 men.

The number of men working on site during the day shift is not expected to exceed 50 during the 11 months of construction and drilling. Six to 12 men would be on site during each of 2 evening shifts to continue drilling. After the initial construction on site, the work force would be reduced to about 8 personnel employed to monitor the filling of the cavities and maintain equipment. Unloading of materials during construction and of oil from barges at Bull Bay would require 5 workers throughout the 25 month construction period.

Construction of Permanent Dock and Pipelines: The preparation of the site and construction of the dock on the Mississippi River is expected to take 14 months. Construction here would begin at the same time that work begins on the storage site and would employ about 25 men during the initial 4 months. The number of workers at the dock would rise to about 50 during the ensuing 6 month peak period, then drop again to 25.

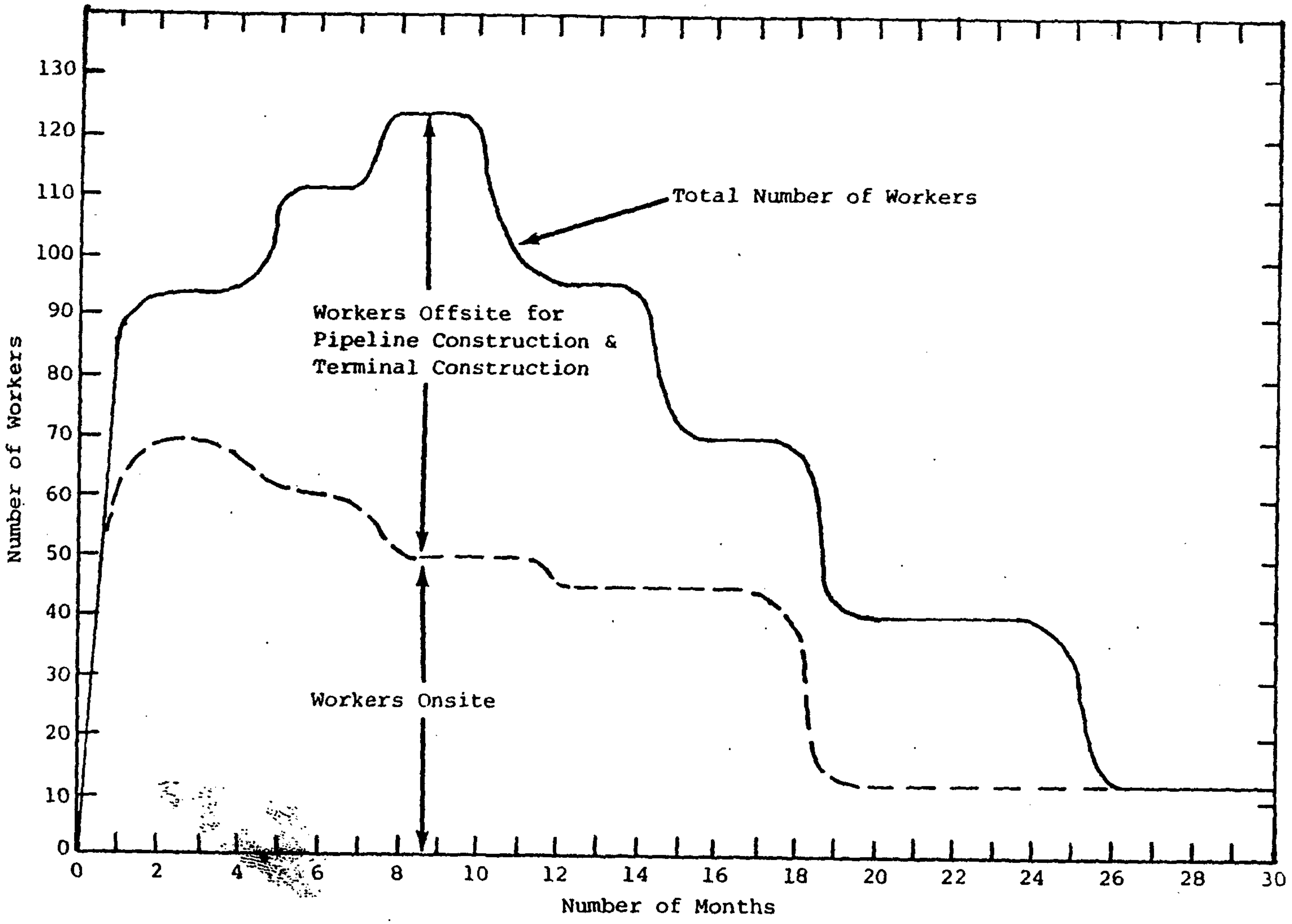

Figure 3.4 Manpower Requirements for Bayou Choctaw

One pipeline would be laid between this dock and the storage site, a distance of about 6 miles. Construction of this pipeline would be delayed until 7 months of work on the dock have been completed. Laying of the pipeline and related tasks would employ about 25 men for a period of 18 months.

Approximately 10 personnel would be required to maintain the proposed facilities and for monitoring operations at the storage site, at the permanent dock, in the brine disposal field, and along the pipeline rights of way. It is anticipated that 6 skilled workers and technicians would be needed, 3 general laborers, and one person for clerical work. Efforts would be made to fill these positions with qualified persons from Iberville and West Baton Rouge Parishes.

During oil recovery procedures, a work force of 20 to 30 skilled laborers would be required for a period of 5 months. This estimate includes personnel to operate and monitor pumps and valves, and dock workers to load tankers with oil from the storage site. A similar level of manpower would be necessary when the cavities are refilled at the end of the petroleum shortage period. These workers would be drawn from the greater Baton Rouge area (which includes Port Allen, Plaquemine and towns in the intermediate area), and from Ascension Parish residents across the Mississippi River.

Workers who had been employed by the project during the construction phase, a maximum of 155 persons, would probably seek replacement work in the Baton Rouge area. This number is insignificant compared to a total civilian labor force in the Baton Rouge area, which is projected to be in the range of 180,000 persons at the time of completion of the project.

Summary: Construction of facilities at Bayou Choctaw, dock construction on the Mississippi River, pipelaying operations and unloading of barges would involve about 155 workers. Due to the short duration of on-site construction, and the delayed starting date of the major pipelaying work, peak manpower requirements are not expected to exceed 125 persons. This employment peak is anticipated to occur about 8 months after construction starts, and last for about 4 months. During operation, 10 workers would be required with the number increasing to 23-30 during recovery operations.

3.6.2 Sources of Labor and Supplies

Construction is a major industry in the Baton Rouge area, and it is anticipated that experienced contractors would be available.* Work similar to that required for the proposed project has been performed by local firms involved in the development of oil fields and the construction of facilities for large petrochemical plants.

The work requires primarily skilled craftsmen and operators who would be permanent employees of the contractors, and would be living in the Baton Rouge area. They would commute to their jobs at the Bayou Choctaw site and at the dock site on the Mississippi River.

Many of the supplies can be purchased from local firms in Baton Rouge. Specialized equipment, pipe, and wellheads may be brought in from regional suppliers in New Orleans, Morgan City, and Lafayette.

3.6.3 Effects on Community Services

No significant migration of workers to the area is anticipated to result from the project. The major impact would be increased traffic on Highway 1 leading from Baton Rouge to Morrisonville, and on parish roads leading to the storage site and the dock.

The operation of the storage facility would, by itself, contribute only a small part to the overall growth of the predominatly rural area of Iberville Parish. If the dock facilities built on the Mississippi River are permitted to be used by private industry when they are not needed by the federal government, this could encourage incidental growth at Addis.

Operation of the project would not produce a need for additional housing in the region if local residents are employed, as is expected. Rental units are available in Baton Rouge to accommodate the 10 to 15 workers and worker's families that might be drawn from outside the region during project construction.

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*In East Baton Rouge Parish alone there are about 700 consturction constractors, employing over 15,000 workers (County Business Patterns, 1973).

Almost all workers would be hired from Baton Rouge and surrounding towns, and would commute to their jobs. The additional activity in the area and installation of equipment can be expected to contribute to the demand for expansion of police and fire protection services. Continued use of the site would require expenditures to be made by the parishes to upgrade access roads to the area.

School systems are not expected to be affected by the project since it would not draw significant numbers of new families with school-age children to the area.

Security guards would be stationed at the storage facility site and at the dock to prevent theft of equipment and materials. They would cooperate in their activities with the sheriff's department of Iberville Parish, which has jurisdiction over these areas. Fire-fighting equipment would be on hand at the site and the dock. Auxiliary aid in containing fires is available from the Plaquemine fire department.

Medical facilities in Plaquemine and Baton Rouge would be used to provide emergency care to workers at the site and at the dock. Since workers and their families would primarily be established residents of the Baton Rouge metropolitan area, no additional stress on health services is expected to result from the project.

3.6.4 Economic Impact

Employment and Payroll; The major local benefits of the project would be the direct employment and payroll. It is anticipated that a number of local contractors would be hired for various phases of construction. The payroll during site preparation and construction would be approximately as follows.*

1st through 4th month:	$158,000 per month
5th through 7th month:	193,000 per month
8th through 11th month:	219,000 per month
12th through 15th month:	114,000 per month
16th through 25th month:	70,000 per month

*Based on an average wage rate of $1750 per month.

This amounts to a total of $3,243,000 in payroll alone during the period of construction. Payroll for the staff of 10 persons required for maintenance of the site would amount to about $18,000 per month for the life of the project. During periods of oil withdrawal and refill of the cavities, the payroll would rise to $43,750 per month. Income received by workers would tend to circulate in the Baton Rouge area.

Local and Business and Industry: The construction phase of the project would benefit the following local businesses: building contractors, construction material suppliers, pump and pipe manufacturers and distributors, metal fabricators and suppliers, and drilling companies. There are also a number of firms in the area that specialize in the repair of the kinds of equipment that would be used.

To avoid adverse social and economic effects on the area, it is expected that these local contractors would be used as much as possible. The business generated by the project would not create a significant number of permanent new jobs, but would be an important source of income for these industries.

Tax Benefits; Sources of tax revenue for Louisiana and the parishes are: (1) severance taxes (and royalties) from the extraction of oil and gas, (2) property taxes, and (3) sales tax (3% State tax plus 3% city and parish tax on general goods and services). Severance tax would not apply to this operation. If the site, rights of way, materials and equipment are federally owned, then these items would be exempt from property and sales taxes.

In the event that the oil is withdrawn from the salt cavities, the companies that purchase the oil would be exempt from State sales tax if they are registered wholesalers (most oil companies are registered). Tax benefit from the project would accrue indirectly from the income and purchasing power of the workers.

Community Costs; Costs to the community would be primarily those paid for public services: trash collection, police and fire protection, and the added costs of road maintenance in the vicinity of the site.

The present and projected growth rate of general construction, heavy industry and the oil and gas industry in the area indicates that replacement jobs at the end of the project's construction period would probably be available.

3.7 EFFECTS OF ACCIDENTS AND NATURAL DISASTERS

The potentiality of accidents and natural disasters is discussed in this section with particular emphasis on the possibility of crude oil or brine spills. The discussion is based on probabilities of occurrence contained in appropriate literature and applied to the specific facilities proposed for the Strategic Petroleum Reserve (SPR) in the Bayou Choctaw Dome.

3.7.1 Pipeline Accidents

Liquid pipeline accident or failure data gathered by the Department of Transportation covering the years 1968 through 1973 show fairly consistent statistics.[48] Analyses of these data indicate that an accident rate of 0.00136 incidents occurred per mile/year.[49] However, taking into account the improvements in pipeline materials, manufacturing processes, construction, and testing procedures, reasonable accident/failure frequency is projected to be 5×10^{-4} per mile/year.[49] These probabilities include spills caused by external forces including natural disasters, corrosion, operational reliability, and a 10 percent contingency category.[49]

Using this accident or failure frequency, the expected frequency of an incident per year for the various types of pipelines in this SPR project is given in Table 3.20. Also presented in this table are the lengths of each of the pipeline systems and the number of operational years associated with a program of 5 fill/withdraw cycles. The number of operational years is computed by adding the time of each period of active operation for each pipeline system. For example, the crude pipeline configuration would be operational from the barge dock for up to 23 months at limited capacity, and another year at full capacity during the initial fill, the five 5-month withdrawal periods, and the four 10-month refill periods. Note that although the system is presently designed for 5-month refill periods, a 10-month period was assumed in the above calculation under the worst case possibility of lower crude availability during refill. These longer periods give conservative results which tend to overestimate the magnitude of the impacts from the operation.

Table 3.20 Expected Accident or Failure Frequency

Type of Pipelines	Approximate Length (mi)	Expected Accident or Failure Frequency (Events/Year)	Approximate Number of Operational Years[1]
Crude Oil			
Barge Dock	< 1.0	.001	8.3
Tanker Terminal	~ 6.0	.003	5.5
On-Site Lines	1.6	.0008	8.3
Brine			
Disposal	3.0	.0015	6.25
On Site	1.6	.0008	6.25
Raw Water			
Source	< 1.0	.0005	5.0
On Site	1.6	.0008	5.0

1. Assumes the maximum 23-month limited barge dock operation plus another 1-year full barge dock operation during the initial fill, only tne projected 1-month tanker terminal operation during the initial fill, but full facility operation for the 5 five-month withdrawals, and 4 ten-month refill periods.

Employing the data from Table 3.20, the probabilities of a given number of spills from each of the types of pipelines during the life of the project have been computed. These probabilities are presented in Table 3.21. Note that in each case by far the most probable number of pipeline spills is zero. In fact, the largest probability of a crude pipeline spill is projected to be 1.6 percent from the tanker terminal crude line. There is less than 1 percent probability of a spill from any other line. These probabilities of spill are higher than the actual risks involved because the base data deal with higher pressure (1000 psi) oil lines. The operating pressures for most of the crude pipelines at this SPR site are relatively low (less than 500 psi). The same data base that was used to compute an accident frequency rate projects the mean spill size to be about 1,000 barrels.

Brine spills due to pipeline accidents have about the same probability as oil spills. The magnitude of the mean brine spill size is expected to be about 1,000 barrels, as it is with oil spills. The maximum credible brine spill is 3,000 barrels.

Should an oil or brine spill occur within a diked area, the spill would be contained until it could be removed. Should a spill occur above ground in an undiked area, it would tend to flow to a lower level until trapped by the terrain, or until it flowed into a body of water. Some of the spill would soak into the ground. A spill from a buried pipeline would soak into the ground; part of the spill might surface where it would behave as runoff material. The material remaining in the ground would contaminate the upper layer of ground water which is slightly brackish, but would not move down into the freshwater aquifers because of the pressure of an aquitard discussed in Section 2.2.

3.7.2 Risk of Oil Spills During Marine Transportation

3.7.2.1 Introduction and Summary

This section presents estimates of both the probability and the size of oil spills arising from accidents during marine operations and transport. Marine operations considered include the voyage of the tankship up the Mississippi River to Port Allen or the permanent dock at Addis, barge tow along the Intracoastal Waterway between

Table 3.21 Probabilities of Pipeline Failure During Project *

Pipeline	Number of Spills		
	None	One	More than one
Barge Dock Crude Line	99.2	0.8	Nil
Tanker Terminal Crude Line	98.4	1.6	Nil
On-Site Crude Lines	99.3	0.7	Nil
Brine Disposal Lines	99.1	0.9	Nil
On-Site Brine Lines	99.5	0.5	Nil
Raw Water Line	99.75	0.25	Nil
On-Site Water Lines	99.6	0.4	Nil

* Probabilities are given in percent and calculations assume that pipeline integrity is checked prior to each withdrawal/refill cycle.

Port Allen and Bull Bay, and loading and offloading operations at a terminal. Accidents include vessel casualties, such as collisions and groundings, and mishaps at the marine terminal, such as failure of hose connectors, overfilling of tanks, opening the wrong valves, etc.

A detailed description of the estimated risk of oil spills from accidents is presented in the following two subsections. A summary is provided in the following paragraphs.

The estimates of oil spill risks from accidents are based primarily on statistical analyses. The number of vessel casualties, which would result in the spill of oil, were derived from the Coast Guard's listing of Commercial Vessel Casualties for fiscal years 1969 through 1974. The count of ship traffic was obtained from "Waterborne Commerce of the United States," U. S. Army Corps of Engineers. Combined, these data yielded the expected frequency of spills per transit of a tankship or tankbarge from the Gulf to the terminal. Similarly, the frequency of spills for loading and offloading oil at the terminal was obtained from incidents reported by the Coast Guard's Pollution Incident Reporting System and Corps of Engineers' traffic data, both covering the entire United States. The distribution of the quantity of oil spilled, with the number of spills, was developed from the Coast Guard Commercial Vessel Casualty data for losses from tank barges in Western Rivers* and the inland Gulf region. The quantities spilled are distributed log normally versus number fraction of spills. This relationship was modified for application to tankship casualties and accidental spills during loading and offloading at the marine terminal.

The above methodology is based on the assumptions that the planned crude oil transport operation is essentially the same as that for which the accident experience has accrued and that the added ship traffic along the Mississippi or Intracoastal Waterway does not in itself increase the likelihood of accidents. These assumptions seem justifiable. For the first assumption, the facilities, tankships and barges to be used are nearly the same as those now used in the area. For the second assumption, it may be noted that only 235 tank ship trips are required to

*Primarily the Mississippi River System.

fill or disburse 94 x 10^6 bbls of oil. This is small compared with the annual one-way vessel traffic in the Mississippi of 15,000 ships and 19,000 barge tows.

Estimates of the risk of oil spills were based on two filling and distribution alternatives: (1) transport by tank ship only via the Mississippi River to the permanent dock to be built near Addis, Louisiana; and (2) by both tank barges and tankships (the presently proposed system). For the latter it was assumed that the barges would make the maximum number of trips consistent with the Bull Bay terminal pumping capacity of 75,000 bbls/day. Thus over a 1000day period, approximately 3 years, 75 x 10^6 bbls could be moved by barge. Therefore, for this option it is assumed that 75 x 10^6 bbls would be supplied by 188 tankship (400,000 bbls each) trips up the Mississippi to Port Allen where they would offload into an unspecified shore facility. This oil, in turn, would be loaded onto tank barges (approximately 20,000 bbls capacity each) for shipment along the Intracoastal Waterway to Bull Bay. A total of 3,571 barge trips would be required. The remainder of the oil, 19 x 10^6 bbls, would be transported by tankship via the Mississippi to the permanent terminal near Addis.

The estimates of risk of accidental oil spills is summarized in Table 3.22. The expectation quantity of crude oil spilled per trip from vessel accidents, such as groundings, rammings (striking fixed objects, submerged or on or above the water surface), structural failure, fires and explosions, etc., is 0.19 barrels per trip for the barges (21,000 barrels capacity), and 1.35 barrels per trip for the tankships (400,000 barrels capacity). Accidents at the marine terminal, such as overfilling a tank, opening the wrong valve, etc., have an expectation quantity of oil spilled of 0.93 barrels per trip for tankships and 1.86 barrels per trip for barges.

The total expected quantity of oil spilled during the transport of 94 x 10^6 bbls of oil via tankships alone is 536 bbls. The quantity expected to be spilled during filling via tankships and tankbarges is 7,321 + 536 = 7,857 bbls. The large difference between the two fill systems arises solely from barge transport. The risk from the tankship phase of the operation is the same for both systems, since the number of trips required is the same.

Table 3.22 Risk of Spills of Crude Oil from Marine Transport Accidents at the Choctaw Site

	Tankbarges	Tankships
Frequency of Oil Spills From Vessel casualties[c], spills/trip	6.9×10^{-5}	5.0×10^{-5}
Median quantity of oil spilled from vessel casualties[c], bbls/spill	1100	8300
Expectation quantity of oil spilled from vessel casualties[c], bbls/trip	0.19	1.35
Frequency of oil spills from accidents at the marine terminal, spills/trip	1.7×10^{-2}[d]	8.4×10^{-3}
Median quantity of oil spilled from accidents at the marine terminal, bbls/spill	18	18
Expectation quantity of oil spilled from accidents at the marine terminal bbls/trip	1.86[d]	0.93
Total expectation quantity of oil spilled for transport of 94×10^6 bbls, bbls, Permanent System	-	536[b]
Total expectation quantity of oil spilled for transport of 94×10^6 bbls, bbls, Temporary System	7321[a]	536[b]

a 3571 barge trips
b 235 tankship trips
c Collisions, groundings, rammings, structural failure of vessel, etc.
d Two loading-offloading operations per barge trip

Figures 3.5 and 3.6 show the frequency distribution of spill sizes for tankship and barge transportation accidents on a per trip basis.

Oil spilled onto water produces a very extensive slick. The following relationship between spill quantity and slick area or radius, assumes unhindered (no wind, currents, or surface obstacles) spreading and a circular-shaped slick:

$$A = \pi r^2 = 2.52 \times 10^4 \quad (V)^{3/4}$$

where A is square meters, r is the radius of the slick in meters, and V the volume spilled in barrels.

These dimensions are achieved 24 to 48 hours after the spill. For the median spill quantities listed in Table 3.22 the ultimate slick dimensions were computed:

Quantity Spilled (barrels)	18	1,100	8,300
Slick area (m^2)	0.22×10^6	4.81×10^6	21.9×10^6
Slick radius (m)	469	1,237	2,640

With respect to the barge transport portion of the proposed fill system, spills at the very southern end of the Intracoastal Waterway and at the Bull Bay terminal are expected to remain at the site, and in the absence of booms or other containment measures, the slicks would tend to spread into the surrounding marsh and swamps rather evenly. There are no known major water currents in this area and the vegetation above the water surface would limit the effect of wind on the movement of the slicks. Spills in the remainder of the Intracoastal Waterway would be confined by the natural banks. The slicks would tend to spread in either direction, depending on the wind direction, and to occupy an approximate area as indicated above. Since the winds in the area are predominately from the south and east, spills in the southern end usually would drift northward whereas spills near the Port Allen end of the canal would drift westward.

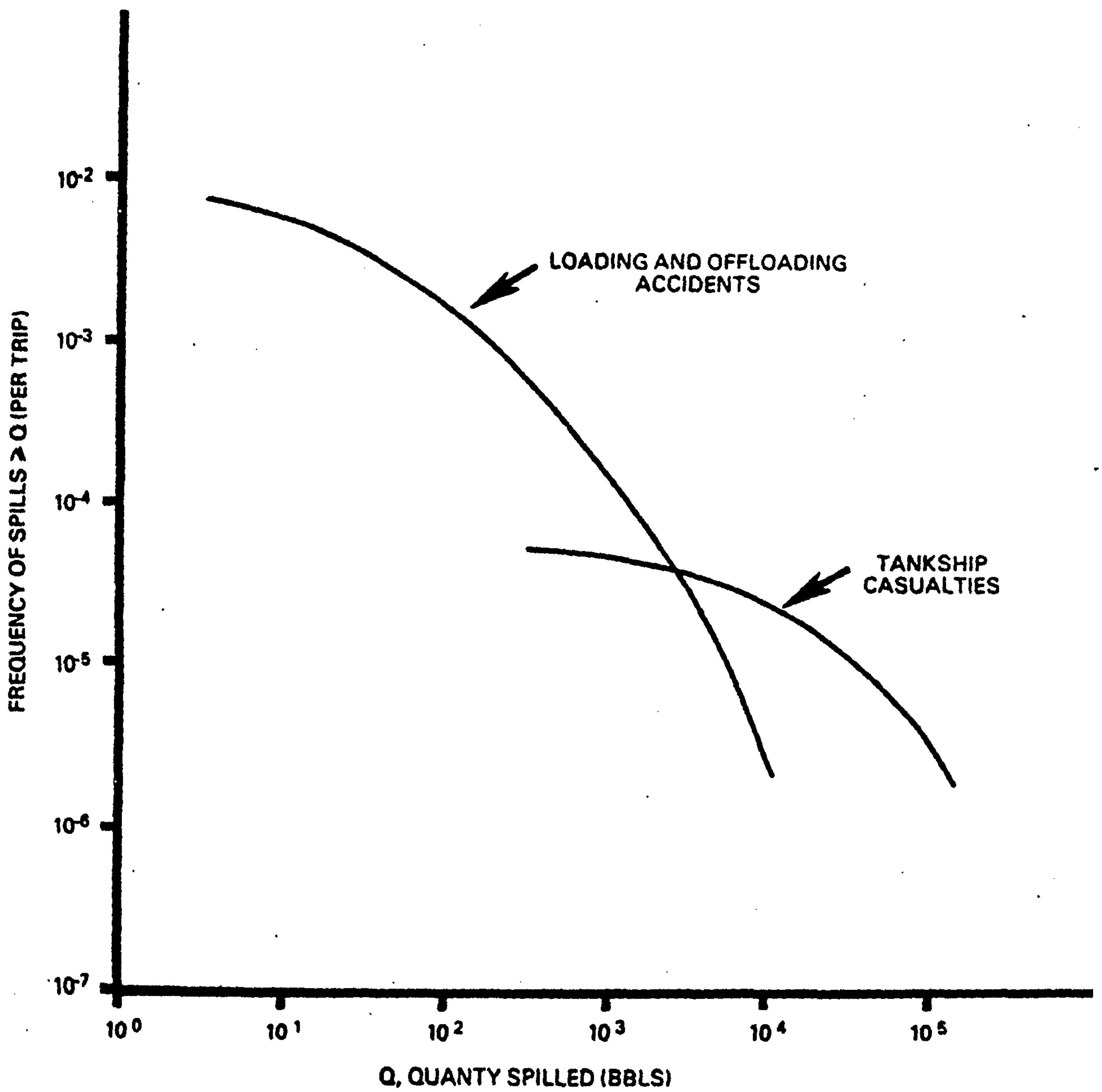

FIGURE 3.5

ESTIMATED FREQUENCY PER TRIP OF CRUDE OIL SPILLED FROM ACCIDENTS DURING TRANSPORT BY TANKSHIPS

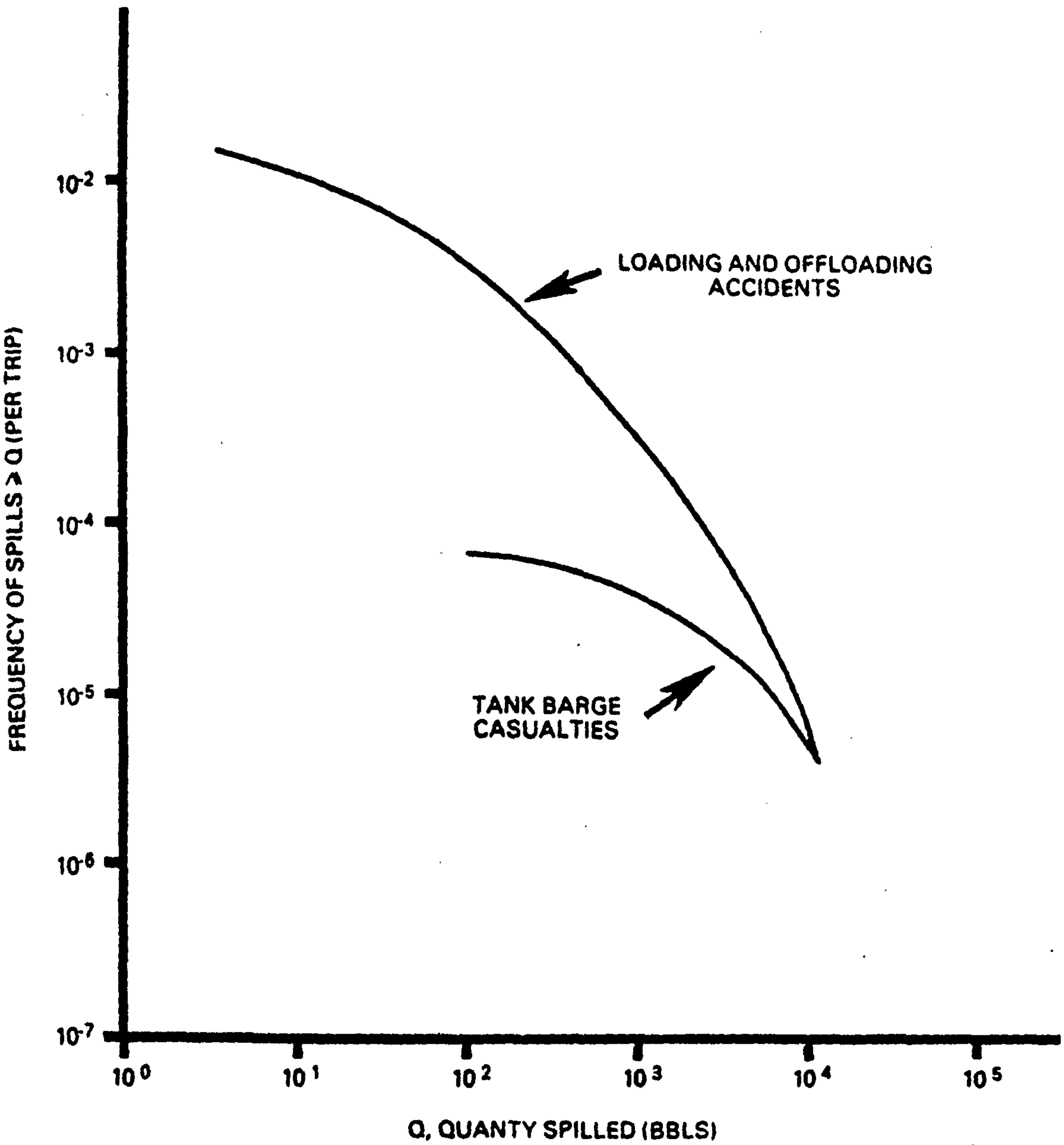

FIGURE 3.6

ESTIMATED FREQUENCY PER TRIP OF CRUDE OIL SPILLED FROM ACCIDENTS DURING TRANSPORT BY TANK BARGE

Movement of spills in the Mississippi generally would be controlled by the river's current, especially at the higher stages of the river. At high stage in the vicinity of New Orleans, the cross-sectional velocity is 5 knots.[57] At low stages, the velocity is less than 1 knot.[51] By contrast, wind drift generally is only about 2 to 3 percent of the wind speed, which is less than 18 mph 95 percent of the time.[50] The river above Head of Passes is about 600 meters wide.[51] Hence spills exceeding a few tens of barrels to a few hundred barrels may span the width of the river, depending on the rate of the spill and the current.

3.7.2.2 Risk of Spills from Vessel Casualties

The estimation of the frequency of shipping accidents and spills of oil was based on the number of reported accidents to tankships and tankbarges compared with the number of trips these vessels made into U. S. ports along the Gulf Coast (Brownsville, Texas to Key West, Florida) and along the GIWW (Gulf Intracoastal Waterway). The accident data was obtained from the U. S. Coast Guard Commercial Vessel Casualty Reporting System in which pertinent items of information have been recorded on magnetic tape. The data for the entire Gulf Coast area are summarized in Tables 3.23 and 3.24 for tank ships and tank barges respectively. Tankbarge casualties with cargo loss in the GIWW only, are listed in Table 3.25. Only casualties which resulted in loss of cargo, i.e., rupture of at least one of the cargo tanks, were counted for the estimate of spill frequency. From the tables only 1.4 percent of the reported tank ship casualties and 3.9 percent of the reported tank barge casualties were sufficiently severe to result in a spill of the cargo.

This data base is believed to be accurate and complete. The reporting system has been in effect for over 10 years, and by law, all vessel casualties with more than $1,500 total damages must be reported. Casualties sufficiently severe to cause the loss of cargo invariably involve total damages much greater than $1,500.

For all U. S. ports along the Gulf Coast, there were a total of 9,830 inbound tank ship trips and 76,856 inbound barge trips during calendar year 1974.[52] For a 6 year period corresponding to fiscal year 1969 through

Table 3.23 Tankship Accidents In Inland Gulf Waters During Fiscal Years 1969-1974

Cause	Number of Vessel Casualties	Number of Vessel Casualties with Cargo Loss
Collisions (with other vessels)	81	1
Rammings (collisions with fixed, floating and submerged objects)	75	1
Groundings	14	1
Fires and Explosions	3	0
Structural Failures	24	0
Other (flounderings, capsizing, flooding, undetermined)	11	0
Total	208	3

Table 3.24 Tank Barge Accidents in Inland Gulf Waters During Fiscal Years 1969-1974

Cause	Number of Vessel Casualties	Number of Vessel Casualties with Cargo Loss
Collisions (with other vessels)	712	25
Rammings (collisions with fixed, floating and submerged objects)	383	9
Groundings	122	8
Fires and Explosions	19	0
Structural Failures	25	4
Other (flounderings, capsizing, flooding, undetermined	35	4
Total	1,296	50

Table 3.25 Tankbarge Casualties with Cargo Loss in the Western Portion of the Gulf Intracoastal Waterway[a] During Fiscal Years 1969 - 1974

Cause	Number of Vessel Casualties with Cargo Loss
Collisions (with other vessels)	13
Rammings (collisions with fixed, floating and submerged objects)	8
Groundings	6
Structural Failures	1
Other (flounderings, capsizing, flooding, undetermined)	0
Total	28

a Brownsville, Texas to Harvey Lock on the Mississippi fiscal year 1974, it was estimated that there were 60,000 tank ship trips into Gulf Coast harbors during which liquid cargo was carried.

These estimates are believed to be correct to within at least a factor of 2. The reason for this is that the count of outbound ships and barges very nearly equals the inbound count and it is likely that many, if not most, carry a liquid cargo.

This count of tankship traffic was combined with the count of casualties with cargo loss, Table 3.23 to obtain an estimate of spill frequency:

$$\frac{3\text{(losses in 6 years)}}{60{,}000\text{ (transits in 6 years)}} = 5.0\times10^{-5}\text{ spills/transit}$$

In using this estimate, it must be kept in mind that it represents an average for the entire Gulf Coast area. To the extent that vessel traffic conditions and channel configuration of the Mississippi River differ from the other Gulf Coast port areas, the actual loss frequency to be expected would be somewhat different. In particular, the tank ship docks planned at Addis could contribute to a higher loss frequency. Tankships, while loading or offloading at these docks, are at the outside edge of the deepwater channel, where they appear to be especially vulnerable to being struck by passing vessels and barge tows.

From Table 3.25, there have been 28 tank barge casualties which resulted in a loss of cargo during the 6 year period in the western 685.4 mile portion of the GIWW (Brownville, Texas to Harvey Lock). From U. S. Army Corp of Engineers data there were 33,887 eastbound tank barge trips along the GIWW during 1974.[51] Assuming an equal number of westbound trips, and that the annual number of tank barge trips along the GIWW has been relatively constant, it is estimated that there were 408,000 tank barge trips along the western portion of the GIWW during the 6 year period, fiscal year 1969 - fiscal year 1974. Accordingly, the frequency of casualties with cargo loss on the GIWW for tank barges is:

$$\frac{28\text{ (losses in 6 years)}}{408{,}000\text{ (transits in 6 years)}} = 6.9\times10^{-5}\text{ spills/transit}$$

Although this frequency applies generally to the GIWW, it is taken as an estimate of the loss frequency for the segment of the Intracoastal Waterway from Port Allen Lock to Bull Bay. As such, this estimate is conservative (loss frequency higher than actual) since the distance between Port Allen and Bull Bay is only 13.5 miles whereas most barge trips in the GIWW (685.4 miles from Brownville, Texas, to Harvey Lock) are much longer.

The Coast Guard Vessel Casualty data shows the dollar value of the cargo loss. These data for tank barge casualties in both the Gulf Coast region and on Western Rivers (mainly the Mississippi-Ohio River system) have been plotted on probability coordinates in Figure 3.7. The cost of the material spilled in each incident is distributed log normally with the number of spills. The cumulative distribution curve in Figure 3.7 should be interpreted for any given percent of all spills as having cargo value equal to or less than the indicated value.

Most of the spilled cargos consisted of crude oil and petroleum fuels, and at the time most of the spills occurred, it is assumed that the average value of these materials was $3.00 per barrel. Using this value, the data in Figure 3.7 were converted to a frequency distribution of quantity spilled (barrels) as shown in Figure 3.8. The curve in Figure 3.8 begins to bend over at spill quantities of 8,000 to 10,000 barrels and this reflects the fact that the capacity of many barges is between 10,000 to 20,000 barrels.

The median quantity spilled is approximately 1,100 barrels. From Table 3.26 the most common tank barge sizes are 1,500, 2,750, and 3,000 tons. The two larger sizes are those planned for use in the initial phase to fill the Bayou Choctaw salt dome cavities. These barges would hold 15,000 to 21,000 barrels of oil in 6 tanks of 2,500 to 3,500 barrel capacity each. Hence the median spill represents approximately 1/3 the capacity of a typical barge cargo tank. The reasons only a fraction of the contents of a cargo tank is spilled are that the damage in a casualty is such that all the cargo cannot leak out, and that the outflows often are sufficiently slow to permit taking measures, such as transfer of the cargo to another vessel or tank, to limit the amount lost.

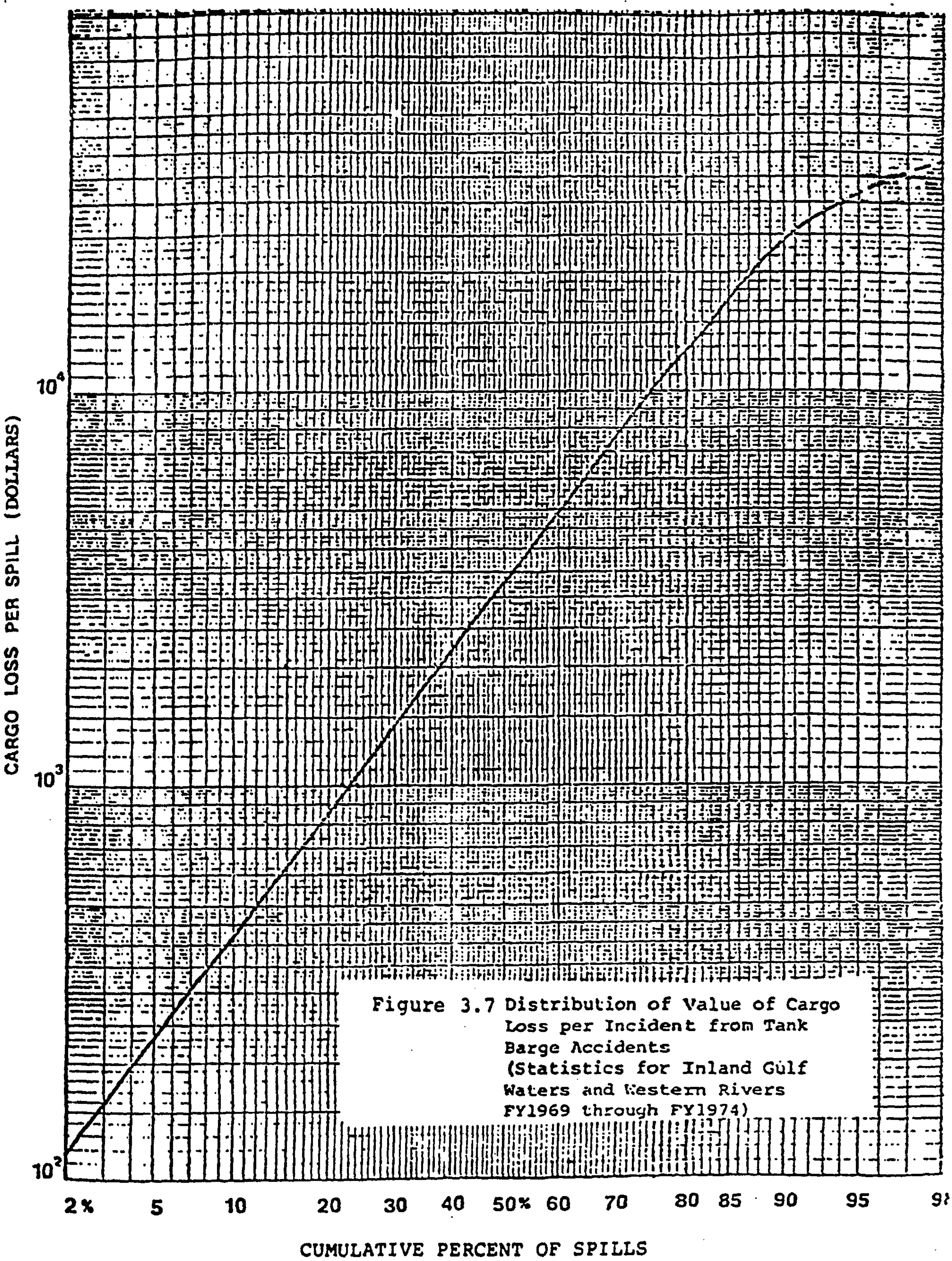

Figure 3.7 Distribution of Value of Cargo Loss per Incident from Tank Barge Accidents (Statistics for Inland Gulf Waters and Western Rivers FY1969 through FY1974)

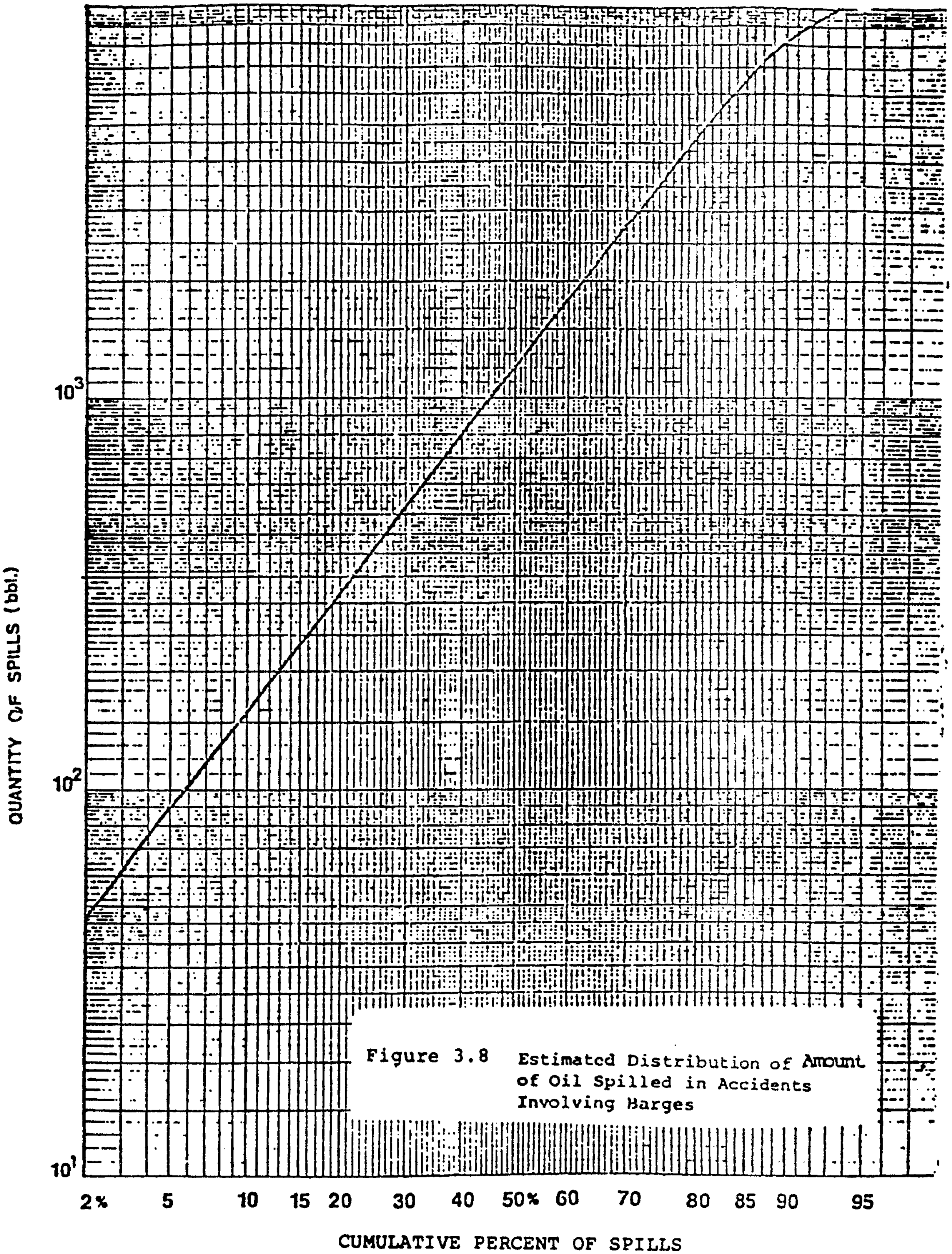

Figure 3.8 Estimated Distribution of Amount of Oil Spilled in Accidents Involving Barges

Table 3.26 Barge Size Distribution, Tank

Representative Barge Size (Dimensions in ft)	Draft Empty (ft)	Draft Loaded (ft)	Nominal Tons/Barge	Number of Barges
508 x 90	4.0	34.0	32425	1
340 x 54	2.5	11.0	4680	13
290 x 53	1.5	11.0	3000	520
240 x 50	2.0	9.0	2750	427
185 x 54	1.5	9.6	2100	154
220 x 40	1.5	9.0	2000	65
148 x 54	1.5	9.0	2000	99
195 x 35	1.5	9.0	1500	662
180 x 35	1.5	9.0	1300	105
135 x 40	1.5	6.0	1000	276
215 x 25	1.5	9.0	1200	3
175 x 26	2.0	9.0	1000	38
140 x 26	1.0	6.0	626	91
110 x 30	1.5	6.0	345	191

(Source: U.S. Army Corps of Engineers Waterborne Commerce Statistics Center, Transportation Lines on the Mississippi River System and the Gulf Intracoastal Waterway 1974 (Transportation Series 4)).

The barge spill distribution curve was modified to estimate the spill size distribution for tankship casualties. For the reasons suggested above, it was assumed that the median spill from a tankship casualty also would be the amount equivalent to onethird the volume of a cargo tank. In addition, the slope of the tankship spill distribution (i.e. the variance) was assumed to be the same as for tankbarges. Table 3.27 shows the characteristics of a tankship with a cargo capacity slightly more than 400,000 bbls. Although larger tankships may be used (up to 85,000 DWT), these would be light loaded. Regardless the size of the tankship used, it is assumed that they would carry approximately 400,000 bbls of oil with approximately 25,000 bbls in each wing tank. Accordingly, loss of one third the contents of one of these tanks is 8,300 bbls which is assumed to be the median spill. The spill size distribution for tankships is shown in Figure 3.9. Figure 3.9 also indicates the reasonableness of this estimated distribution. The distribution of spill sizes from all tank ship casualties in U. S. inland coastal waters during fiscal years 1969 through 1974 is shown by the points plotted. These lie below the estimated curve for a 55,000 DWT tank ship as expected since the casualties include a large number of smaller tank ships. The available data indicate that the prediction gives a conservative estimate (tends to overestimate the consequences).

Estimates of the expected spill size frequency from tank ship and barge casualties are presented in Tables 3.28 and 3.29 respectively. The per trip frequencies are simply the product of the spill frequency and the fraction of spills in the given size range from Figures 3.8 and 3.9. These data were used to help derive the estimates presented in Table 3.22 and Figures 3.5 and 3.6 discussed above. The expectation quantity of crude oil spilled is the sum of the products of frequency and quantity spilled (average of the ranges in Tables 3.28 and 3.29) for all spill sizes.

3.7.2.3 Spills at the Marine Terminal

Spill frequency and size during operations at the barge and tank ship terminals were estimated in a manner similar to that used for vessel casualties. A count was made of the total number of spills and quantity spilled at marine terminals during a single year, 1974. Next, an estimate was made for the total number of barges and

Table 3.27

Characteristics of a 60,000 DWT Tankship

Length Overall	731 feet
Beam	105 feet
Draft	43 feet
Gross Tonage	32,000
Net Tonage	23,000
Number of Wing Tanks	8
Approximate Capacity of the Wing Tanks	27,500 bbls
Number of Center Tanks	5
Approximate Capacity of the Center Tanks	46,000 bbls
Total Capacity	440,000 bbls

Source: "Offshore Petroleum Transfer Systems for Washington State," Oceanographic Institute of Washington, December 16, 1974, p. III-54.

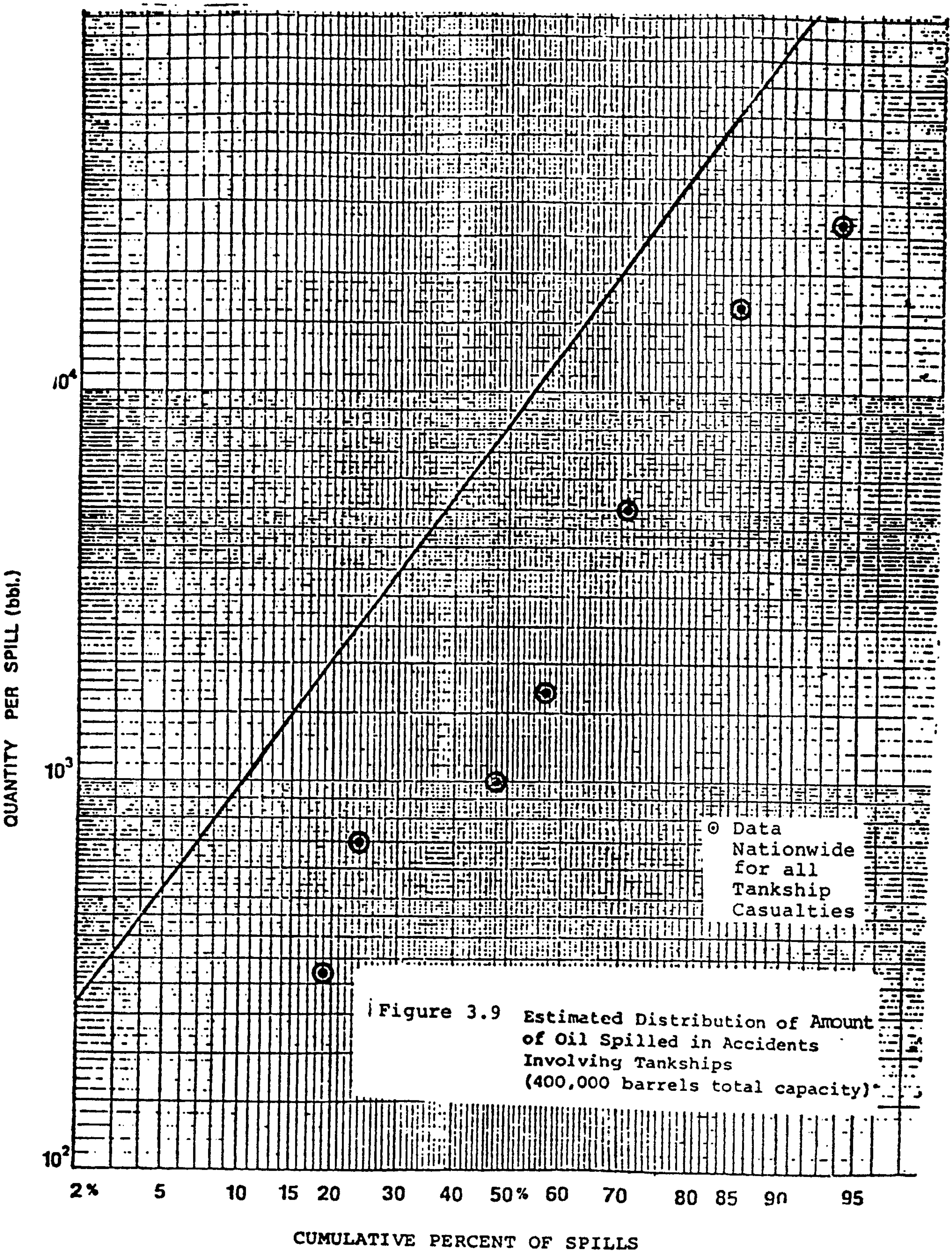

Figure 3.9 Estimated Distribution of Amount of Oil Spilled in Accidents Involving Tankships (400,000 barrels total capacity)

Table 3.28 Estimated Spill Size Frequency From Tankship Accidents (Permanent Fill and Distribution System)

Spill Size (BBLS)	Frequency (Per Tankship Trip)	Frequency Per Transport of 94×10^6 bbls[a]
300	1.2×10^{-6}	2.8×10^{-4}
300-1000	4.0×10^{-6}	9.4×10^{-4}
1000-3000	8.5×10^{-6}	2.0×10^{-3}
3000-10,000	1.4×10^{-5}	3.3×10^{-3}
10,000-30,000	1.2×10^{-5}	2.8×10^{-3}
30,000-100,000	7.2×10^{-6}	1.7×10^{-3}
100,000[b]	3.3×10^{-6}	7.8×10^{-4}

a 235 Trips

b Maximum quantity spilled is 400,000 bbls, the maximum amount transported by the tankship.

Table 3.29 Estimated Spill Size Frequency From Barge Accidents (Intermediate Fill System)

Spill Size (BBLS)	Frequency (Per Barge Trip)	Frequency Per Transport of $75x10^6$ BBLS[a]
100	$4.9x10^{-6}$	0.017
100-300	$9.7x10^{-6}$	0.034
300-1000	$1.8x10^{-5}$	0.064
1000-3000	$1.7x10^{-5}$	0.061
3000-10,000	$1.5x10^{-5}$	0.054
10,000[b]	$4.6x10^{-6}$	0.016

a 3571 Barge Trips in 1000 days maximum time of continuous operation.

b The maximum quantity spilled is 21,000 bbls, the capacity of the barge.

tankships loaded or unloaded at these terminals. Spill frequency was obtained simply from the quotient of number of incidents and the number of loading and offloading operations. A spill size distribution was estimated by adjusting the distribution in Figure 3.8 so that the median equalled the size of the average spill. Data on the individual incidents were not examined and the actual size distribution could not be developed.

The data base for the number of spill incidents was the U. S. Coast Guard's Pollution Incident Reporting System (PIRS).[53] Data for the year 1974 are reported in summary form by the Coast Guard.[59] The number of spills and the total amount spilled in the entire United States at marine terminals from the shore facility and from tankship and tank barges at the terminal have been accumulated and broken down by type of cause. These are reproduced in Table 3.30. It is not clear from this source if all these spills were associated with loading and unloading operations. However, from the nature of the causes listed, they could have been. The assumption made here is that they were. This is conservative in the sense that the number of spill incidents associated with loading and offloading may be overestimated. The law requires that all spills of polluting substances must be reported.[53] U. S. Coast Guard personnel feel that all of the larger spills eventually are reported, and therefore, the data base is adequate.

The manner in which the number of loading and offloading operations were counted also tends to overestimate the frequency of spills. During recent years, there were approximately 33,000 tank ship trips into all U. S. ports annually.[55] A major fraction of tank barge traffic into U. S. ports occurs in Gulf Coast ports, approximately 80,000 trips inbound annually.[52] During 1974, there were 34,000 east bound tank barge trips along the Intracoastal Waterway.[52] It is assumed that for each inbound trip into a port, a tank ship or tank barge makes at least one stop to load or offload a bulk liquid cargo. For traffic on the Intracoastal Waterway, the assumption is made that the number of trips in one direction only corresponds to at least 2 loading/offloading operations, one at the origin and one at the destination. This adds to a total of 181,000 loading and offloading operations. Not included in this count is an appreciable tank barge traffic along

Table 3.30

Spills Loading and Offloading Bulk Cargo

At a Marine Terminal

Cause	Shore Facility		Tankships and Tank Barges	
	Number of Incidents	Total Barrels Spilled	Number of Incidents	Total Barrels Spilled
Tank Ruptures, Leaks	7	477	-	-
Pipe and Hose Ruptures and Leaks	82	921	117	296
Valve Failure	21	191	120	722
Pump Failures	9	1,742	18	19
Other Leaks and Equipment Failure	81	250	182	957
Tank Overflow	30	24,179	366	2,916
Personnel Errors	85	2,340	278	1,994
Intentional Discharges Including Bilge Pumping	6	73	112	1,016
Natural or Chronic Phenomenon	22	420	4	0
Unknown	21	28	116	7,647
Total	364	30,621	1,313	15,567
Average Spill	84 bbls/spill		12 bbls/spill	

the Mississippi River system and tank barge trips into US ports other than those along the Gulf Coast. Therefore, a total of 2×10^5 loadings and unloadings of bulk liquid cargo are assumed to occur annually at marine terminals in the United States. Because of the count of operations left out, it is believed that the value 2×10^5 may be low by a factor of 2. Combining this value with the number of spill incidents listed in Table 3.27, the following spill frequencies are obtained:

$$\frac{364}{2 \times 10^5} = 1.8 \times 10^{-3} \text{ spills/trip}$$

from docked tankships and tankbarges at the terminal, and

$$\frac{1313}{2 \times 10^5} = 6.6 \times 10^{-3} \text{ spills/trip}$$

from the dock facilities during loadings and offloadings.

The estimated log normal distributions of the quantity of oil spilled are shown in Figure 3.10. As before, these were derived from the distribution in Figure 3.7 using the average spill sizes listed in Table 3.30 as the median values.* Finally, the frequency of spills in a given size range was calculated as the product of the spill frequency and the percent of spills in the size range. These are listed in Table 3.31 and were used to help construct Figures 3.5 and 3.6 discussed above. The probability of spills for the tank barge shipments in Table 3.31 reflects that fact that they are loaded at Port Allen and offloaded at Bull Bay, two operations. The data listed in Table 3.28 also were used to calculate the median spill size and expected spill quantities listed in Table 3.31 above.

3.7.2.4 Ecological Impact of Oil Spills

Oil releases resulting from oil storage in the Bayou Choctaw salt dome could result from spillage from barges, tankers or terminal facilities, or from pipeline ruptures.

*This tends to overestimate the size of the spills in the distribution, since the median in a log normal distribution is always less than the average.

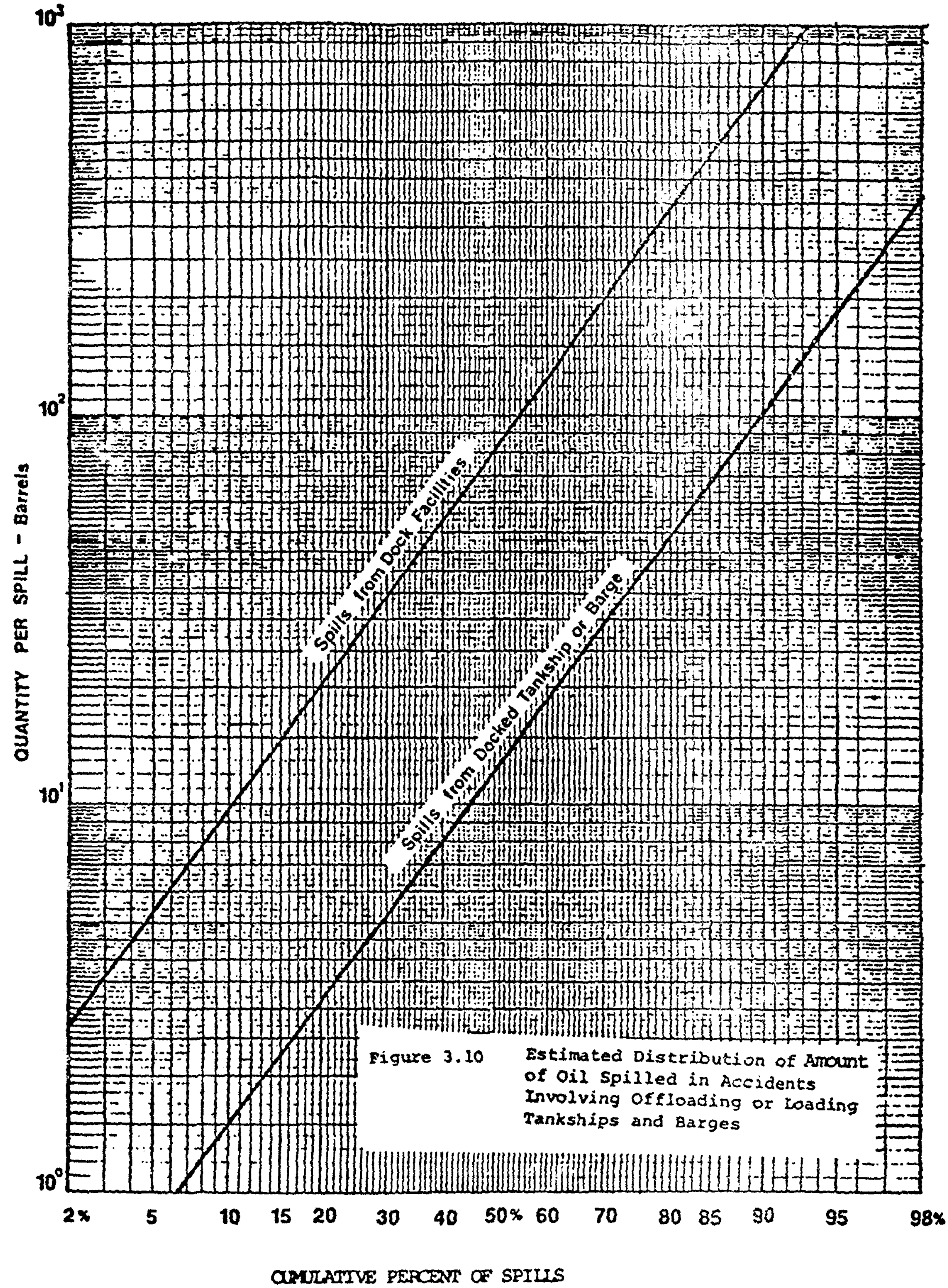

Figure 3.10 Estimated Distribution of Amount of Oil Spilled in Accidents Involving Offloading or Loading Tankships and Barges

Table 3.31 Estimated Spill Size Frequency From Accidents During Loading or Offloading at the Dock

SPILL SIZE (BBLS)	FREQUENCY (PER OPERATION)	FREQUENCY DURING BARGE SHIPMENTS $75x10^6$BBLS	FREQUENCY DURING TANK SHIP SHIPMENTS $94x10^6$BBLS
3	$1.4x10^{-3}$	10.0	.33
3-10	$1.8x10^{-3}$	12.9	.42
10-30	$2.0x10^{-3}$	14.3	.47
30-100	$1.8x10^{-3}$	12.9	.42
100-300	$9.0x10^{-4}$	6.4	.21
300-1,000	$4.2x10^{-4}$	3.0	.10
1,000	$1.5x10^{-4}$	1.1	.04

a 3571 barge trips and two operations per trip.

b 235 tankship trips.

These releases represent a hazard to biological communities in open water (the bayou-canal complex and the Mississippi River), on dry land (disturbed area on the dome and land crossed by pipelines from the dome to the Mississippi), and in the deciduous swamp and bottomland forest ecosystems.

The impact of releases into water is primarily dependent on: (1) the amount and type of oil released, (2) the time of year, (3) how long the oil "weathers", (4) the number and frequency of spillages, and (5) the type and efficiency of cleanup operations. These concerns also apply to spills on land, except that consideration of spill "weathering" is inappropriate. There is always the potential for introduction of this oil into water from land. Oil at the land surface is subject to transport by runoff. The oil may infiltrate into the level of ground water, and from there may seep into surface bodies of water. Oil may also move to land from water and may be deposited on shores or beaches.

Background levels of pollutants, including petroleum, in surface waters in the dome vicinity are relatively low. (These levels are discussed in Subsection 2.2.1 and presented in appendices to it.) The low level means that there is no reason to believe that the organisms present are particularly tolerant of pollutants.

Aquatic Impacts; The waterways near the dome are relatively narrow so that spilled oil would spread rapidly along them if not confined or rapidly cleaned up and would come into almost immediate contact with aquatic communities. The oil would be affected after release and/or during transport by separating processes of evaporation, dissolution, emulsification, sedimentation, and chemical oxidation, as well as biological degradation. There would be differential effects of surface tension forces on different components. The higher, more toxic oil components are lost by evaporation, creating a surface residue which may become heavy enough to sink. Particles in suspension (silt, clay, organic material) may combine with the oil so that sedimentation is increased. Conditions of increased turbidity, such as during periods of high surface water runoff or water turbulance, would increase this effect. Bacterial masses in the slick can increase sedimentation also. Emulsification aided by human addition of surface active agents may result in suspended globules which disperse. However, emulsification of water in the oil rather than oil in water can occur in nature and tends to hold the oil mass together.

If not cleaned up, spills of median size calculated for the operations connected with oil storage could affect appreciable areas. Under idealized conditions of no wind, currents, or surface obstacles, the median quantity of oil spilled from a barge, 1,100 barrels, would cover approximately 1,189 acres of water surface in 24 to 48 hours after the spill. The median spill from a tanker, 8,300 barrels, would spread to cover approximately 5,411 acres. A large spill of 10,000 barrels, about barge capacity, would form a slick of about 5 to 10 miles on the Mississippi. Oil spilled during high water periods might even reach the Gulf Coast. With a large spill on the Intracoastal Waterway, the slick would spread along the Waterway into cross passages and perhaps into surrounding wetlands. Based on a typical wetlands holding capacity of 25 barrels per acre for 75 percent of the oil spilled, a maximum of 300 acres could be contaminated in this manner.

Main groups of organisms which would be affected by oil spillage into water include plankters, nekton, benthos, macrophytes, periphyton, microbes, and aquatic birds and mammals. These groups, except for microbes, are described in Section 2.4.

Plankton, because of their lack of mobility, would be unable to avoid spill areas. Many zooplankters exhibit daily vertical migrations. Whether they would be deterred in this by oil at some level, most probably at the surface or bottom, is not known. Planktonic organisms generally have a high level of reproduction with lifespans of short duration. They are able to rapidly replace losses. If they were not subjected to a continuing stress, there would be only short term effects, if any. Field data do not conclusively demonstrate an effect. Oil may be ingested by some zooplankton and constituents of oil may be transferred to higher levels in food chains. There is little evidence of concentrations of the oil constituents at these higher levels. Dissolved oil levels likely to occur near a heavy spill or an area of chronic pollution have physiological effects on phytoplankton. Photosynthesis has been known to be accelerated at lower concentrations

(10 to 30 ppb) and decreased at higher concentrations (60 to 200 ppb).[56] Organisms associated with the water surface, the neuston, would presumably be subject to toxic or mechanical effects from contact with fresh oil slicks. Under laboratory conditions involving oil suspensions, droplets of oil have been noted to adhere to spines of marine phyto- and zooplankton, especially after contact with the surface film.[58]

Fish and alligators (nekton) should be able to avoid spills. There is evidence suggesting avoidance behavior.[56] Fish kills have generally occurred only in restricted bodies of water, and probably are attributable to direct toxic effects, lowered oxygen by restriction of diffusion from the atmosphere, or increased biochemical oxygen demand, or a combination of these.[57] Oil products have been known to be quite toxic in the laboratory. Fishes may be more resistant to oil toxicity than many organisms because the mucus with which their exterior body surfaces are coated is oil repellant.[56] Microscopic studies on gills of fish collected after exposure to oil spilled off the Louisiana coast showed effects of the exposure, including loss of cells, "sloughing", and swollen branchial filaments. These responses were attributed to direct toxicity of hydrocarbon fractions within the water column.[59] Toxic effects of aged crude may be greater than for fresh crude.[60]

Fish may be contaminated by intake of petroleum hydrocarbons in food, which results in tainting of flesh which may persist for several months. Lack of sufficient cleanup after a release near the dome would result in a loss of fish as a food source due to the persistance of hydrocarbons in fish flesh. Physiologic effects of oil uptake which may affect fish production have not been demonstrated but are thought to exist.[56]

Benthic organisms would be affected principally by covering over from oil sedimentation and/or reduced oxygen levels. Bottom organisms would be susceptible to smothering and would be affected by physical alteration of substrate characteristics such as the texture necessary for attachment, irregularities providing cover, and the distribution of food. Contaminated bottom sediments act as sources of occasional or continuing recontamination of the water above. Effects depend on the area covered, thickness and composition of sedimented oil, and how long the oil is present. In cases of large-scale marine-spill oil settling, kills have been extremely large, with almost complete elimination of animal life.[56] Effects have been noted to persist for many years under these circumstances. Organisms are not equally successful at recolonizing polluted areas and several years may be required to reattain pre-impact levels of diversity and community structure.[56] Bottom marine organisms can accumulate petroleum hydrocarbons in their tissues after ingestion.[56] These effects on marine benthos would probably be paralleled in fresh water. Degradation of settled oil would result in a change in its composition. The compounds most resistant to microbial breakdown persist the longest. These are relatively toxic to the majority of decomposing organisms.

Deciduous swamp and bottomland forest in the dome area would present the main potential for oil spill impact to aquatic macrophytes. Oils can penetrate into plants either through stomates or directly through the epidermis. Oil can interfere with transpiration and translocation of materials, by traveling within intercellular spaces, blocking them and stomates.[56] Oil may also travel in the vascular system.[6] Rates of cellular respiration may be increased or decreased.[56] Photosynthesis can be inhibited.[61] Cell membranes may be substantially damaged by contact with oil hydrocarbons, resulting in leakage of cell sap into intercellular spaces and admitting oil components into the cell.[6]

Studies have not been directed specifically toward effects of oil on the deciduous swamp and bottomland forest ecosystems. However, certain generalities are known from studies of macrophytes of other wetlands. One time coatings by small to intermediate quantities are not exceedingly harmful, but repeated oil coating is lethal to macrophytes. One-time exposures to oil have resulted in death of heavily coated shoots with regrowth from living roots. Very heavy oil contamination may smother the entire plant.[56] This probably would not affect the dominant trees in the swamp forest area at Bayou Choctaw Salt Dome because oxygen exchange for their lower parts occurs above the water line. Mangrove trees have been killed by oil spills.[56] Damage varies with the season. Active growth processes are adversely affected. Among plants with shorter lives than trees, annuals tend to be more affected than perennials if coated during active growth periods since perennials may regenerate from their roots. Oil may also influence such growth functions as flowering, seed development, and vegetative reproduction by underground roots. Growth stimulation under certain conditions following oil contamination has been reported by several investigators. It has been hypothesized that this might be a consequence of an increased level of nutrients, a "fertilizing effect."[56]

Periphyton communities, like benthic communities, are very substrate dependent. Since organisms of such communities tend to be small, an oil coating would probably have a very great impact, obliterating most of the community where present. Many of the periphytic organisms are related to plankton in that they share with them great potential for increasing numbers in a short period, and probably have similar sensitivities to dissolved oil fractions. After the oil is broken down or otherwise removed, they should recolonize suitable surfaces relatively rapidly.

Effects of oil on microorganisms (bacteria, some fungi and yeasts) are not well known;[62] however, they are generally conceded to contribute to oil degradation.[56,62,63] The question has been raised whether significant microbial growth on oil might require minimal levels of nitrogen and/or phosphorus availability in the general aquatic medium.[62] In a system with a high detrital component in a warm climate, such as the swamp forest ecosystem, it appears that conditions would be good for biological degradation of the spilled oil.

Birds and mammals are subject to loss of insulating capacity if they come into direct contact with oil. In the case of water birds, buoyancy is also lost. An affected bird may drown, or may rapidly lose body heat and starve because of the increased metabolic rate required to sustain heat production, or succumb to pneumonia, or be poisoned by ingesting oil during excessive preening. Birds which have come into contact with oil may be diverted from feeding by the excessive preening behavior. If poisoning does not result from ingesting the oil, other physiological disturbances may occur. Oil-exposed birds might not lay eggs which would have been produced or eggs that they do lay might not hatch. Survival in adults and young after oil gets on the feathers is very low. Even with birds treated to remove the oil, the survival rate generally has not exceeded 20 percent.[56]

Mammals frequenting water, such as muskrats, minks and others, are dependent on fat deposits for insulation in addition to fur. Fouling of their fur would not be nearly as threatening to survival as fouling of birds' feathers. Loss of food and habitat would be detrimental as with birds. Only small numbers of mammals and birds would be likely to be affected by an oil spill at the Bayou Choctaw Salt Dome because they are not abundant in the water areas which could be affected.

Terrestrial Impacts: Oil impacts on land would mainly result from pipeline spills. Levels of impact would depend on the amounts of oil released, biological richness and physical characteristics of the affected area, and times of year when the releases occurred.

Effects on plants and soil animals (springtails, mites, nematodes, earthworms, etc.) could be severe but limited to the immediate area of the leakages. If roots of larger plants are cut off from air, the plants would soon die. Other organisms in soil--bacteria, fungi, algae--probably would not be uniformly affected. Under conditions of good aeration and nitrogen and phosphate availability, there probably would be proliferation of soil bacteria which would degrade the oil. Indeed, a current method for disposal of oily wastes is spreading them out and plowing them under so that bacterial degradation is facilitated.[63]

With a near median spill size of 1,000 bbls and an initial infiltration into the ground to a depth of 0.1 meter (3.9 inches), about 1,600 m^2 or approximately 0.4 acres would be immediately affected. The exact coverage depends on soil types, viscosity of oil, pipeline pressure, soil moisture, and other factors. In a spill of this size, oil would probably reach the water table. Slow discharge into nearby bodies of water via water table transport would probably eventually occur. The spill could be a source of low level contamination for an indefinite period which might exceed several years. Releases into navigable bodies of water can be prevented by a trench dug near the point of entry into such a water body. When oil collects in the trench (generally after rains), it can be pumped off.

Effects of Cleanup Operations; Containment and cleanup operations of oil spills from barges, tankers and at dock facilities into the Mississippi River or the Port Allen Canal and spills from oil pipeline ruptures are the responsibility of the polluter, and if the responsible party does not clean up the spill, the Coast Guard is obliged to.

The Coast Guard must be notified whenever a spill occurs and an On-scene Coordinator oversees cleanup operations and takes whatever steps are necessary to assure appropriate cleanup procedures are implemented. Biological effects of cleanup operations are minimal. Emulsifiers and other chemical agents have been virtually discontinued and the use of such agents must be approved by the Coast Guard on the scene.[64] Mechanical removal procedures (booming, skimming and pumping) can be expected to ameliorate some of the potentially harmful effects of an oil spill.

Cleanup operations in marshes and on beaches could involve removal of damaged vegetation and dead animals. Burial can contaminate or have other impacts on the specific site used to dispose of such material.

3.7.3 Fires and Explosion

An analysis of the available fire and explosion data associated with petroleum production, storage and transportation (for example, U. S. Geological Survey data) indicates that almost all major fires and explosions are linked with equipment failure or blowouts.[65] Only during the core hole drilling phase does the possibility exist in the Strategic Petroleum Reserve program, and during this phase it is only a remote possibility. The more probable occurrence is for minor fires caused during repairs or maintenance, or by overheated engines or leaks onto hot surfaces.

The only significant impact on the environment due to fires would generally be temporary release of smoke to the atmosphere. It is unlikely that any crude or brine spill would occur because of the protective measures such as levees and automatic valves. Even in conjunction with outer continental shelf (OCS) oil and gas production, where the risk of environmental release is greater, from 1968 to 1975 only two fires or explosions resulted in oil spills. Although it is rare for crude spills to catch fire, if a 100-barrel spill did occur, the following emissions would occur:[66] CO-34,000 to 34,700 lbs; SO_2-62 to 3,400 lbs (SO_2 emissions vary depending on emitted H_2S concentrations); and NO_x-66 to 1,000 lbs. Since combustion is incomplete, certain quantities of petroleum would vaporize, and carbon particulates, carbon monoxide, nitrous oxide, and sulfur monoxide would be formed. The weather conditions at the time of the accident would influence the exact amounts. This would degrade the air quality for a short time.

3.7.4 Accidental Injury

In incidents recorded by U.S.G.S. from 1968 through 1975 a total of fifteen people were killed (nine in a single explosion) and 42 injured in some twenty injury or fatility-causing OCS (Outer Continental Shelf) accidents that did not stem from high pressure or blowouts, 65 however ship specific incidents are not included. Offshore operations are more dangerous because of the compact work area on a platform.

3.7.5 Natural Disasters

Natural disasters that may affect the dome include seismic events, hurricanes, tornadoes, high winds, lightning, and floods. These phenomona are not expected to pose a severe threat to the project, nor to cause the project to serious-sly degrade the environment. The effect of natural disasters on pipelines and tankers has already been factored into the statistics of Section 3.7.1 and 3.7.2. Other potential effects of disasters are examined in this section.

Seismic Events: The National Oceanic and Atmospheric Administration (NOAA) has classified the United States into four zones of expected seismic risk based on the recorded history of past seismic activity. Zone 0 covers areas having no reasonable expectancy of surface earthquake damage; Zone 1, expected minor damage; Zone 2, expected moderate damage; and Zone 3, possible major destructive earthquakes.

The area of Bayou Choctaw Salt Dome lies within the boundary of seismic risk Zone 1 as defined above.[67] A search conducted by NOAA shows two earthquakes have been recorded with epicenters within 100 miles of Bayou Choctaw. The largest occurred in 1930 about 30 miles southeast of the site. The other took place in 1958 about 15 miles east-southeast of the site. The largest of the two was felt in White Castle, Donaldsonville, and Napoleonville. Some chimney and window damage resulted at Napoleonville.

Based on the historical record, the probability of an earthquake in this area is moderate, perhaps 50 percent over the 25 year life of the project. Should an earthquake occur, the past record and the types of faults present (no reverse or overthrust faults) indicate that ground movement would be small. Surface structures would not be appreciably damaged. Wellheads and the wells down to the storage cavities would not be affected. If they are broken, a few barrels of water and/or oil would escape within a diked area. The storage integrity of the caverns would not be affected, although new wells might be required to gain access to the stored oil.

Hurricanes, High Winds, Tornadoes, and Floods: A major hurricane passes through this area about every four years.[68] Winds at the site exceeded 100 mph during hurricanes in 1964 and 1965. Heavy rainfall, local and regional[69] flooding, and tornadoes often accompany hurricanes. The storage integrity of the facility would not be threatened by a hurricane. Sufficient hurricane warning is available so that oil transfer would be stopped and surge tanks emptied. Oil pipelines are buried and therefore would not be affected. The largest potential oil spill would be caused by a wellhead rupture that could release approximately 100 barrels which would be widely dispersed by the high winds and rain.

The 500,000 barrel brine storage pit may be left partially filled despite hurricane warnings due to the difficulty in draining it completely. The high winds could pick up the brine and disperse it widely. Assuming that the winds pick up 100,000 barrels of brine (an event that is unlikely) and disperse it over a 10 square mile area, the salinity in the 10 square mile area would be increased by 1.1 parts per thousand for a few days. The impact of this salinity increase would be negligible compared to other storm effects.

Tornadoes not associated with hurricanes could be more hazardous because of the lack of warning. It is possible that a tornado could strike one of the large oil surge tanks near the dock and cause a major oil loss. Tornado frequency in this area is about 3 tornadoes per 3600 square miles per year.[70,71]

Thom has computed a mean ground track area of 2.8 mi^2 per tornado period. Howe[72] has recomputed ground track area by state and region, arriving at an estimate of 0.61 square miles per tornado in Louisiana. The probability, P, of a site in Louisiana being struck by a tornado in one year is:

$$P = 3 \text{ tornadoes/yr} \cdot 0.61 \text{ mi}^2\text{/tornado/}10{,}000 \text{ mi}^2$$

or

$$P = .183 \times 10^{-4} \text{ per year}$$

Over an assumed 25 year facility life, the probability of exposure to a tornado is 0.0046.

The oil surge tanks are designed to withstand very strong winds and should remain intact for most tornadoes. Should a break occur, the oil would be trapped within the diked area.

<u>Lightning</u>: Lightning may interrupt operations and cause fires if certain system components are hit. There is a low probability that fires would occur, but in the event that they did occur, they would cause only slight environmental degradation in the form of air pollution (see Section 3.7.3). There is no risk of explosion from such fires.

3.7.6 Cavity Collapse

The inherent characteristics of solution mined caverns make them one of the safest possible means for crude oil storage. The plastic nature of salt at the temperatures and pressures present permit the caverns to withstand shock forces far in excess of any earthquake known to have occurred in the Gulf Coast region. Although cavity collapses have occurred in this region, these collapses seem to have occurred as a result of factors such as uncontrolled leaching adjacent to the caprock, with subsequent subsidence of the unsupported overburden.[73]

A number of factors affect the stability of cavities in salt domes including: cavity depth, diameter, and temperature; dissolution; and proximity of the salt dome boundary or other cavities. These factors were considered in selecting the cavities proposed for development in the SPR Program.

For existing cavities, the major factor is changes in proximity to salt dome boundaries or multiple cavities. Since cavities used for oil storage grow approximately 15 percent during each cycle of fill and withdrawal due to dissolution of salt, it may be necessary to control growth of the cavity in some cases. Upward growth may be controlled by maintaining a blanket of oil near the ceiling and may be controlled in all directions by using saturated brine rather than fresh water as the displacement fluid.

The proposed storage caverns use a blanket of crude oil to control growth in the upward directions (see Figure 3.11). The location of the oil-brine interface would be monitored by any one of several available instruments such as sonic interface detection, nuclear logging, and oil column pressure gauging. Thus, the level of the oil-brine interface would be controlled to preclude upward leaching. However, as may be noted from Figure 3.11, the physical arrangement of the well casings prohibits withdrawal of the oil above the location of the annulus through which the oil is withdrawn. Thus, an oil blanket would always be present in any leached space above the location of the annulus. This provides a fail-safe design not subject to operator error. Casing cement failures at upper levels (for example the 16" @ 2,500' in Figure 3.11) would be easily detected and repaired using standard techniques.

The analysis of the parameters of the cavities proposed for use at Bayou Choctaw is presented in Appendix K.

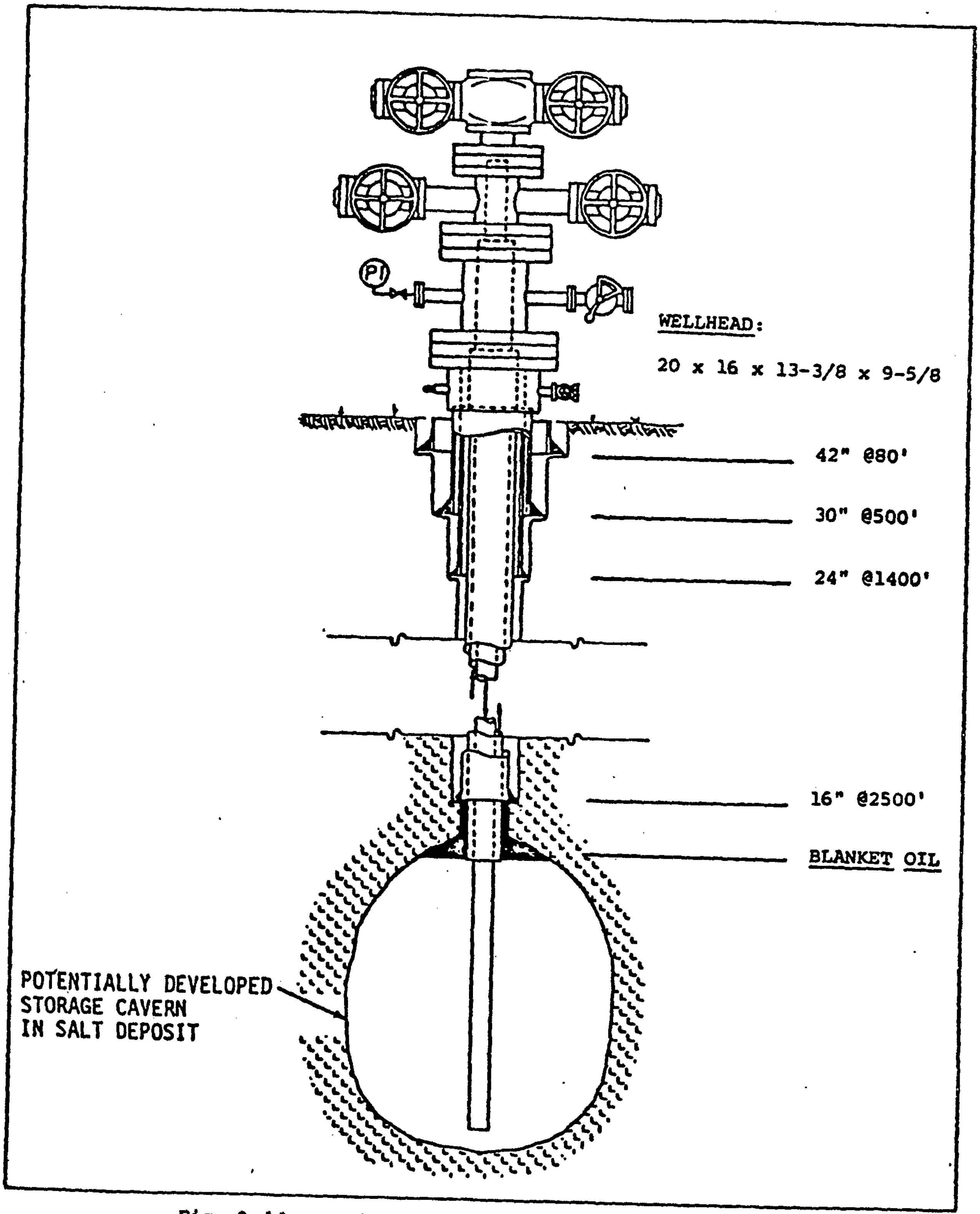

Fig. 3.11 Typical Storage Well

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4. PROBABLE ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED

4.1 SUMMARY

The anticipated environmental impacts of the construction and operation of the proposed Strategic Petroleum Reserve storage program at the Bayou Choctaw salt dome are abstracted in this section. In addition, mitigating measures and unavoidable impacts are summarized in tabular form in Table 4.1 at the end of this Section.

Construction operations would be the most disruptive, causing unavoidable soil erosion, increased turbidity and sediment resuspension in Bull Bay and the Mississippi River near the dock sites. The construction of new roads, pipelines and further development of the storage site itself would involve the temporary disturbance of existing industrial, agricultural and swamp land, and would force resident wildlife in the swamp forest to emigrate to more tranquil settings until human disruption ceases. Because most of the land required for the project is already used for industrial purposes, the total area removed from non-industrial uses would amount to 166 acres.

The surrounding surface water system would experience very localized, unavoidable temporary increases in turbidity, resuspension of sediments and/or biocides from dredging operations and erosion. The resultant impacts on the aquatic community would primarily involve the elimination of minor amounts of benthic organisms and reduced plankton production in the dredged area. During drawdown operations, the use of on-site lake-canal system for the water supply would result in a minor water level drop of the lake. While some loss of organisms is expected from entrainment, the impact is not considered significant (see Section 3.4).

The handling of crude oil results in unavoidable temporary, localized increases in hydrocarbon emissions around unloading and loading sites. Levels would not be generally noticeable beyond one kilometer from dock facilities, and should a vapor recovery system be employed during delivery operations, emissions of hydrocarbons would be reduced significantly. During the construction phase of the SPR program, air pollutant levels in the vicinity of the salt dome and the docks would be unaboidably raised, principally due to heavy duty diesel construction equipment. The major pollutors are expected to be the drill rigs with emission rates of 0.3 gm/sec to 1 gm/sec for hydrocarbons, sulfur dioxide, carbon monoxides and particulates. Nitrogen dioxide emission rates could be as high as 5 gm/sec at the site. None of the ambient air quality standards would be exceeded half a kilometer from the site (see Table 3.13). The painting of the tanks at the dock facilities would temporarily (less than 3 months) raise the hydrocarbon levels above the ambient standards in an area within 1 kilometer of the site. The surge tank working loss from the loading operations at Bull Bay are expected in a (worst case) to raise ambient hydrocarbon levels above the primary standard to a distance of 100 meters from the dock. While these hydrocarbon emissions would elevate local levels, they are primarily non-photochemically reactive species (lighter, saturated hydrocarbons) and should not contribute significantly to oxidant concentrations in the area. These estimates are based on the worst case assumption of very stable wind conditions (<5 mph), which are not characteristic of the Gulf Coast region in general. The predicted oxidant concentrations are, therefore, more severe than would actually be expected.

The injection of brine into deep saline aquifers off the flanks of the salt dome would unavoidably increase the downhole pressure of the aquifer temporarily. The magnitude of these deep aquifers tend to allow rapid pressure equalization provided the injected brine does not clog the aquifer and seal the local injection area off from lateral communication with the rest of the aquifer. A brine settling pond is to be employed to assure this does not happen. Additional treatment of the brine may be required if it is determined that it is chemically and biologically incompatible with the saline water in the aquifer.

Pipeline Accidents

Crude oil spills along the buried pipeline routes, of a median volume of 1000 barrels would result in an initial unavoidable infiltration of ten centimeters into the surrounding soil. This infiltration would result in approximately 0.4 acres of land area being affected. Over a period of years the oil contamination of this area would decrease due to degradation of the crude and dissolution due to the heavy annual rainfall in the area. Because the water table in the Bayou Choctaw area is so near the surface (-2 to 3 feet), some quantity of any oil spilled from a pipeline failure would reach the water table and consequently seep with the natural water migration, resulting in a low level contamination of nearby water bodies for several years. Should a spill occur, the magnitude of this contamination could be minimized by digging trenches at the point of entry into the nearby waterbody (Bull Bay and the Mississippi River). The oil then would be collected from these trenches as it migrates towards the water body. Oil migration is aided by heavy rainfalls and thus the location of the point of entry into either Bull Bay or the Mississippi River would have to be determined fairly rapidly after spills of a significant size.

The unavoidable effects of an underground pipeline spill on soil organisms in the immediate vicinity (a distance of one meter or less) could be severe. If such a spill occurred organisms such as mites, collembola, nematodes, earthworms, etc., would be killed. It is not anticipated that the soil organisms in the path of the oil migration in the water table would be as severely affected, since the concentration are increasingly diluted with time, rainfall and distance from the spill site. This migration would result in an unavoidable loss of soil organisms and some vegetation.

The only above ground pipelines would be at the storage site and at the terminal facility on the Mississippi River. Should a spill occur above ground, it is readily detectible by inspection. The magnitude of such a spill is expected to be 1000 barrels or less. These spills are readily contained and cleaned up, causing negligible unavoidable environmental damage such as destruction of soil organisms and localized vegetation.

Tankships and Barge Oil Spills

The probability of tankship spills, ranging from less than 300 barrels to greater than 10,000 barrels (for 235 trips to transport 94 x 10^6 barrels), is estimated to be from 2.8 x 10^{-4} to 7.8 x 10^{-4}, respectively. The total expectation quantity of crude spilled is 536 barrels for the fill of the cavity to 94 x 10^6 barrels, with 235 tankships trips. During the initial barge fill operating involving approximately 3571 barge trips up to Bull Bay, the probability of barge spills ranging from less than 100 barrels to greater than 10,000 barrels is estimated to range from 1.7 x 10^{-2} to 1.6 x 10^{-2} respectively. The total expectation quantity of crude spilled is 7321 barrels for these 3571 trips. This number is extremely conservative (overestimating the impact) and is based on using barges for 1000 days which is considered longer than planned. This spill probability is higher than that expected from tankship deliveries required to completely fill the storage capacity, partly due to the greater number of trips the barges would make during the initial fill phase of the program. Over the life of the facility, assuming five fill and drawdawn cycles, the total expected quantity of oil spilled is 5360 barrels. The total spill volume expected over the lifetime of the project reflects the low probability of such spills, but does not reflect the anticipated median quantity of such a spill should it occur (eg. 1100 barrels/spill for barges, and 8300 barrels/spill for tankships).

Should a spill of median expected volume occur on open water, an oil slick, uncontained, could range (in 24-49 hours) from 1200 acres to 5400 acres (1100 barrels to 8300 barrels). Depending on the weather conditions and the rapidity of containment and clean-up operations, oil slicks could cover a significant portion of Bull Bay. Spills at the dock facility at Bull Bay would primarily be contained by the planned spill control equipment and the banks of the ditch. Spills in the Mississippi between the terminal and the mouth of the river would be expected to be swept downstream by the currents. While most fish are able to escape the effects of an oil spill, there would be some unavoidable "tainting" of the flesh which would make them undesirable as food. Depending on the size of the spill, it is unavoidable that some fish and birds would be killed and that some wildlife habitat would be destroyed.

A general increase in the background level of oil contamination in the bottom sediments would result in an unavoidable disruption of the benthic community structure.

Most types of vegetation appear to be able to withstand light to moderate oil contamination. Short term unavoidable effects are generally the death of oiled roots, reduced germination of contaminated seeds and consequently the reduction in annual species reproduction. Recovery is relatively rapid, taking less than two years. If more than four oil spills (1000 barrels) occur within a two to three year period, substantial unavoidable vegetation mortality would be sustained and recovery would be retarded. The occurance of spills of this magnitude and frequency is unlikely because of the low probability of spills and the expected fill and refill frequency of the SPR program.

TABLE 4.1

SUMMARY OF PRIMARY ENVIRONMENTAL IMPACTS
MITIGATION PROCEDURES AND UNAVOIDABLE ENVIRONMENTAL EFFECTS

ACTION	PRIMARY IMPACT	MITIGATION	UNAVOIDABLE IMPACT
Dredging			
Bull Bay	9-10 acres of swamp disturbed during construction of the dock and barge slip.	none	same as primary impact
	-mobile animals (especially birds) leave the area; they may return within 2-3 months of completion	none	same as primary impact
	-temporary, localized increase in turbidity	-follow most recent advances in dredging technology to minimize turbidity dispersion	turbidity localized to within 200 feet
Disposal of Spoil Dredged from Bull Bay	-slight temporary localized increase in turbidity, TKN (detrital matter and ammonia, COD, pesticides	-follow most recent dredge disposal technology	less than primary impact
	-possible slight decrease in total dissolved oxygen	none	same as primary impact
	-temporarily eliminate benthic forms in areas dredged	none	same as primary impact
	-temporarily reduce plankton productivity due to increased turbidity	none	same as primary impact

ACTION	PRIMARY IMPACT	MITIGATION	UNAVOIDABLE IMPACT
Disposal of Spoil Dredged from Bull Bay (continued)	-dredge spoil smothering soil organisms and vegetation where disposed on site 3-6 acres.	use spoil containment dikes to reduce the area covered by spoil	smothering of soil organisms and vegetation; less than primary impact
Mississippi River	-moderate increase in turbidity	-follow most recent advances in dredging technology to minimize turbidity.	less than primary impact
	-crayfish, fish, and other mobile forms emigrate from turbid areas.	none	same as primary impact
	-release of sediment-bound nutrients	none	same as primary impact
	-induced increase in primary production of algae (phytoplankton and peri-plankton) from release of bound nitrogen, phosphorous and carbon compounds plus detritus	none	same as primary impact
	-increased secondary production by zooplankton benthic organisms and filter feeding fish	none	same as primary impact
	-potential inhibition or stoppage of primary production in localized areas where unusual quantities of pesticides and their degradation products are re-suspended	none	same as primary impact
Disposal of Spoil Dredged from Mississippi River	-moderate increase in turbidity, TKN, COD	none	same as primary impact

ACTION	PRIMARY IMPACT	MITIGATION	UNAVOIDABLE IMPACT
Disposal of Spoil Dredged from Mississippi River (continued)	-sediment settling suffocate mollusks and shell-fish and/or cause gill abrasion	disposal in contained land spoil area.	elimination of some terrestial habitat.
	-benthic invertebrates buried and/or killed.	disposal in contained land spoil area.	elimination of some terrestial habitat.
Withdrawal of Displacment Water from onsite Lake	-surface level on lake drop less than 0.006 feet	none	same as primary impact
	-change in salinity depending on the source of replenishment water	none	same as primary impact
	-potential decrease in salinity is estimated to be <1 ppt.	none	same as primary impact
	-entrainment in intake structures of about planktonic organisms	-clear screen to mini-mize higher velocities of water through screens	reduced number of planktonic organisms entrained
		-design intake structure to avoid creation of intake velocity greater than fish's ability to escape	reduced impingement of fish
Dissolution of Salt by Successive Draw-down-Refill Cycling	-potential leakage of oil and/or brine through flanks and caprock of salt dome, causing contami-nation of water and soil	-use of permanent oil blanket to avoid cavity leaking above safe depth and to avoid damage to the integrity of the well casing.	no impact
	-potential coalescence of cavities #15 and #17	-use of saturated brine for displacement water in cavities	no impact
		-reduce number of draw-down refill cycles	no impact

ACTION	PRIMARY IMPACT	MITIGATION	UNAVOIDABLE IMPACT
Brine Injection	-blowouts if wells are drilled through pressure zones and excessive pressure buildup occurs	-careful evaluation of aquifer capacity, extent and pressure gradients	less risk that maximum pressure level exceeded.
	-possible strata fracture and contamination of freshwater aquifers	-use conservative spacing of injection wells; $\sim$ 1000 ft.; discontinue injection	reduced risk
	-interference with existing oil production operations	-careful monitoring of injections	reduced risk
	-temporary increase in pressure equalized over short period at end of injection	-monitoring to detect loss of pressure indicating loss of pressure containment	reduced risk
	-increase in salinity ($\sim$1 ppt) in the aquifer	-none	same as primary impact
Enclosure of the Storage Site	- $\sim$104 acres altered surface drainage	none	same as primary impact
	- $\sim$120 acres of land disturbed	none	same as primary impact
	-possible destruction of a very small number of nests and individual animals	none	same as primary impact
	-some vegetation destroyed and regrowth not allowed.	none	same as primary impact
	-noise causing mobile wildlife to temporarily leave the site.	-reduce noise of construction equipment to reduce impact	reduced shift of organisms

ACTION	PRIMARY IMPACT	MITIGATION	UNAVOIDABLE IMPACT
Pipelines			
-pipeline connections to 11 storage cavities, to brine surge pond.	approximately 11 acres disturbed	none	same as primary impact
-oil distribution pipeline	22.5 acres permanently disturbed swamp forest during operation and construction	none	22.5 acres permanently disturbed land
	22.5 acres temporarily (3 yr.) disturbed sugar cane land	bury pipeline below conceivable cultivation	22.5 acres subject to short-term disturbance
-displacement water (brine) disposal system construction	68 acres of swamp forest permanently committed	none	68 acres committed
	-loss of swamp community productivity of ~ 2000 g dry wt/M^2/yr (equivalent to 51 tons/yr of dry vegetation	-install culverts to maintain natural drainage patterns through landfill areas	reduced productivity loss because natural drainage minimally disturbed
	increased soil erosion from fill areas	-plant grasses on banks of landfill area to prevent soil runoff into swamp forest	reduced soil erosion
Additional Barge and Tankship Traffic	-erosion from increased wave action on the banks of the ICWW	-seed and plant banks with native brush and underbrush to waterline	less erosion from wave action
	-bottom scour from increased turbulence	none	same as primary impact
	-increased chance of oil spill at docks or in transit	-construction of spill retention device at docks	decreased chance of oil spill; minimize extent of spill

ACTION	PRIMARY IMPACT	MITIGATION	UNAVOIDABLE IMPACT
Additional Barge Traffic			
Intracoastal Waterway and Bull Bay	-emissions of hydrocarbons, sulfur oxides, carbon monoxide nitrogen oxide and particulates resulting in a slight increase in ambient levels	none	same as primary impact
	-increased noise levels from vessel operations and from pumping of crude oil	-enclose pumps in acoustically insulated pump houses	reduced increase in noise levels close to dock facilities; levels below 55 db at nearest residence
Oil Spilled from Vessel in Transit	-potential oil spill of 1100 to 8,300 barrels covering 1,200 to 5,400 acres	-rapid containment with booms, absorbents to minimize spread of slick with the tides and winds	-reduce area covered by slick depending on volume contained in 48 hours
	-temporary contamination of sediment	rapid cleanup	reduced exposure to oil
	-oil may affect taste of fish and decrease larval development	none	same as primary impact
	-moderate oil contamination of vegetation causing death of roots, reduced germination of contaminated seeds and a reduction in annual species (recovery relatively rapid in 2 yrs.)	rapid clean-up	reduced impact on vegetation
Above Ground Oil Pipeline Spill	-minor contamination of soil and vegetation in small area near spill	clean up promptly	reduced surface soil and vegetation contamination
Underground Oil Pipeline Spill	-minor contamination of soil to 10 cm depth from spill (~1000 bbl) covering ~0.4 acres	none	same as primary impact
	-migration of oil via water table into water bodies	-dig trenches at point of entrance into water body and collect and dispose of oil	minimal contamination of water bodies from oil not collected

ACTION	PRIMARY IMPACT	MITIGATION	UNAVOIDABLE IMPACT
Road Construction, Building Foundations, Wellhead Pads	- 90 acres disturbed	none	90 acres disturbed
	-erosion	-plant or seed with native vegetation	reduced erosion
	-7000 cu.yd./yr. sediment washed into water from erosion due to rainfall on 90 disturbed acres	-avoid landfill work during rainy season	reduced loss due to erosion, less than 7000 cu. yds.
Emissions Drill Rig Operations	-at .5 km, centerline concentrations of emissions CO (8 hr): 75 ug/m^3 HC (3 hr): 7 ug/m^3 NO_2 (an Mean): <1 ug/m^3 SO_2 (24 hr): 1 ug/m^3 Particulates (24 hr): 1 ug/m^3	none	same as primary impact
	-noise levels less than 55 dB at nearest residence	none	same as primary impact
Vessel Loading and Unloading	-maximum of 383 g/sec hydrocarbon emissions during unloading at at rate of 400 MB/day	-use of a vapor recovery system at dock	reduced hydrocarbon emissions
Bull Bay	-surge tank working loss hydro-carbon emissions of 1.3 g/sec.	-use of a vapor recovery system on tank	reduced hydrocarbon emissions
	-at 2 km, centerline concentrations of emissions HC (3 hr): 374 ug/m^3 hydrocarbon levels using a point source assumption	-use of a vapor recovery system	reduced hydrocarbon emissions

ACTION	PRIMARY IMPACT	MITIGATION	UNAVOIDABLE IMPACT
Mississippi Terminal	-floating roof storage tanks standing storage loss of 5.2 g/sec.	-use of welded tanks as opposed to riveted tanks	reduced hydrocarbon emissions by 32%
	-at 2 km, the 3 hr maximum centerline hydrocarbons concentration of 374 g/m^3, and 99 g/m^3 at 5 km	-use of a vapor recovery system	reduced hydrocarbon emissions by 87%
Project Work Force	-increase in local traffic load	none	same as primary impact
	-increased demand for local maintenance operations	none	same as primary impact
Operation of Facility	-increased responsibility to assure security and respond to fire hazards	-SPR employment of dedicated security and fire fighting capabilities	minimal demand on local police and fire fighting capabilities

4.2 CONSIDERATIONS OFFSETTING ADVERSE ENVIRONMENTAL EFFECTS OF THE PROPOSED ACTIVITY

The United States possesses abundant natural resources and yet is dependent upon the importation of large quantities of fuels. It has become increasingly dependent upon petroleum imports, which now constitute approximately 35 to 45 percent of the nation's oil consumption and account for 20 percent of the total domestic energy usage. In 1974 the annual cost of these imports was over $25 billion.

In the past twenty-five years, the United States has experienced four sudden denials of oil imports for various reasons by oil-exporting countries. Not, however, until the oil embargo of 1973-74 did the nation find itself without the capacity and resources to offset the interruption of oil imports. This embargo reduced the quantities of petroleum exported to the United States by approximately 2 million barrels per day for 19 weeks and caused world prices for crude oil to escalate.

Although the economic impacts of these events on the United States economy are still under study and debate, most of the macroeconomic study estimates of the repercussions of supply denial and simultaneous price increases tend to indicate a Gross National Product (GNP) loss of approximately $35-45 billion.[1,2] Although not all of this GNP loss can be ascribed to the embargo, the interruption contributed significantly to increases in the consumer and wholesale price indices. In addition, the GNP loss was reflected in higher unemployment and stagnation in several sectors, including automobile sales and housing starts, which exacerbated the economic downturn believed to have started in late 1973. During this period, the embargo prevented real growth that probably would have stabilized unemployment and provided a stronger base for eventual economic recovery.

The United States is now more vulnerable to a petroleum supply interruption than it was in the fall of 1973. In responding to that interruption, many relatively easy steps to conserve energy were taken, and significant improvements in energy efficiency have been achieved. Higher energy prices, natural gas shortfalls, and continued uncertainty about the availability and prices of alternative forms of energy have induced many energy users to restrict their energy consumption and emphasize more effective energy management practices. However, additional improvements will require substantial investment, longer lead times, and even more intensive energy management. Moreover, the program to convert oil- and gas-fired utilities and industrial plants to coal will have converted many plants to coal, which will largely preclude further conversion to coal during a future supply interruption. Some estimates have shown that a future supply interruption of the magnitude of the one in 1973-74 could cause a reduction in GNP that, in terms of employment impact, would be equivalent to the loss of jobs for 2 million workers. Economic effects would not be limited to some geographical areas or industries but would affect the entire nation.

Standby supplies of petroleum have been proposed repeatedly as a way to buffer the impact of future supply interruptions. The National Petroleum Council (NPC)[3], Ford Foundation,[4] and the Energy Laboratory at the Massachusetts Institute of Technology MIT)[5] have all recommended this action. In addition, the International Energy Program (IEP) agreement, which the United States has entered into with 17 other energy importing countries, provides for the establishment of this type of reserve. Although the western European countries and Japan have developed stockpiles, the only appreciable stocks in the United States are working inventories.

The concern voiced by these organizations as well as the public, in addition to the nation's formal commitments to the IEP, provided strong impetus for passage of the Energy Policy and Conservation Act of 1975 (P.L. 94-163), which provides for the creation of the Strategic Petroleum Reserve. The Bayou Choctaw ESR storage facility provides 99 million barrels of the SPR requirement.

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3. Petroleum Storage for National Security; National Petroleum Council; Aug. 1975.

4. Time To Choose America's Energy Future; Ford Foundation; 1974.

5. Energy Self-Sufficiency: An Economic Evaluation; Massachusetts Institute of Technology, Energy Laboratory Study Group; 1974.

5. RELATIONSHIP BETWEEN SHORT TERM USES OF THE ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG TERM PRODUCTIVITY

The short term use of the land and minerals for this project would have little effect on the long term productivity of this land.

The short term use of part of the dome for the SPR program would dedicate some underground space for use as a storage facility for the life of the project. The use of the salt dome for brine extraction is not prevented by the use of the dome for petroleum storage. The subsurface disposal of brine would render some salt irretrievable; however, this quantity is small in relation to the net amount available, thus the long term consequences from this loss of salt are insignificant.

The disposal of up to 500 million barrels of brine in the saline aquifers would increase their salinity slightly. Because the brine would be injected at depths of approximately -5000 to -7000 feet, the depths overlap the oil and gas producing interval. Therefore, care would be exercised to assure that brine is not inadvertently injected into oil and gas sands in a manner which would reduce oil and gas production. It is possible that the injection would offset losses in pressure in the geological formation due to oil and gas depletion, thereby possibly enhancing oil and gas recovery.

There would be short term adverse effects on the vegetation and wildlife on the site and along the pipeline rights of way (described in detail in Section 3.4). Wildlife would reestablish in these areas with some alterations in species balance resulting from clearing vegetation to maintain the site and rights of way. Hunting and fishing resources would be reduced temporarily but would suffer no long term impairment. While there would be some impact on the natural ecosystems during the construction of the facilities and intermittently throughout the life of the project due to maintenance procedures, some long term advantage would be derived from the ability of pipeline corridors to support more varied vegetation.

The availability of crude oil from this project would mitigate the effects of an interruption in supply of foreign oil, serving to enhance productivity that would otherwise be reduced by lack of supply of oil energy sources and petrochemicals.

6. IRREVERSIBLE OR IRRETRIEVABLE COMMITMENTS OF RESOURCES

Of the resources committed to the development and operational phase of Strategic Petroleum Reserve facilities at Bayou Choctaw salt dome, only a few of these commitments are irreversible or irretrievable. They are:

Salt: The deep well injection of the brine from solution mining of the salt dome irreversibly commits a solid salt resource. However, because salt domes, beds, and deposits are present throughout many parts of the United States, and since the Bayou Choctaw site cavities have been created during mineral extraction, this is not a new commitment of resources.

Energy: This energy consumption analysis includes the energy required to supply materials, prepare and operate the site, as well as transport the crude during fill and withdrawal operations.

Materials utilized in the construction of the Bayou Choctaw facility include estimated maximum amounts of 26,000 tons of steel and 115,000 tons of concrete. Assuming 40 million BTU are required to supply a ton of steel and 6 million BTU per ton of concrete, the energy required to supply materials is about 1,730,000 million BTU.

Equipment operations for site preparation and operations will consume approximately 130,000 million BTU. In addition, the energy required for crude transportation for each fill/withdrawal cycle amounts to about 450,000 million BTU for pipeline transport and about 2,830,000 million BTU for barge and tanker transport. In the above it has been assumed that short haul barge and tanker transport consumes about 350 and 750 BTU per ton-mile, respectively.

In terms of crude oil equivalence content (5.5 million BTU/barrel), the potential oil resource utilization for the proposed 5 cycle SPR program at Bayou Choctaw is about 3.32 million barrels. Since during a 5 cycle program 500 million barrels of crude can be handled by this site the energy resource utilization amounts to less than 0.7% of the potential energy storage capacity.

Land Area, Vegetation, and Wildlife: A resource that is committed for the life of the project and must be in fact be considered irretrievable is the natural vegetation and wildlife that is lost along the pipeline routes. A maximum 85 acres of land would be continuously cleared of obstructive vegetation, altering the associated habitats for the duration of the project.

During construction, there would be a temporary loss of vegetation productivity in the area adjacent to the pipeline, which is considered insignificant when the total productivity of the area is evaluated (see Section 3.4).

During withdrawal operations, some organisms would be entrained with the displacement water. These organisms would be lost from the population, but because the number entrained is a small percentage of the normal population, this loss is insignificant.

Water Resources: Assuming that five fill and withdrawal cycles are involved during the life of the project, approximately 2.1 x 10^{10} gallons (64,450 acre ft) of water would be taken from the surface water system of the Lake-Bayou-Canal System and ultimately injected into the deep saline aquifers. This water would be irretrievable in its original form (low salinity) since the salt in the dome would dissolve to saturate the brine during periods when water is in the cavity. When the amount of surface water available in the area (from runoff) is considered, the loss of this volume over the life of the project is insignificant.

Construction Materials: Most of the concrete, steel and other materials used in construction must be considered as an irretrievable commitment of resources since no valid estimate of salvage can be made at this point. Approximately 8150 tons of steel would be required for pipe, wells, and other components.

Labor; To construct and operate the facility for twenty years, approximately 440 man years of effort are required. This involves approximately 140 man years of construction effort and approximately 300 man years of operational effort.

Investment: The cost of construction for the project at this site is estimated to be approximately 83.6 million dollars. Operating costs would range from one million dollars per year to three million dollars per year. These costs do not include the value of the stored oil.

Oil: Some of the stored oil may not be recoverable due to loss on the cavern walls and from solution in the brine. Assuming that loss is approximately one percent (see page 9-21), a total of 100,000 barrels might not be recoverable from the caverns.

7. ALTERNATIVES TO THE PROPOSED ACTION

Several alternatives to the proposed action have been examined. These include alternative storage sites, alternative facility components and no action.

7.1 ALTERNATIVE STORAGE SITES

During any future oil import interruption, SPR crude oil will have to be distributed to refineries in each of three major markets: East Coast and Caribbean via tanker ship; inland via the Seaway, Texoma and Capline pipelines; and the Gulf Coast refinery complexes (Freeport, Port Neches and St. James). The Bayou Choctaw salt dome storage site is one of a group of five sites within the eight candidate ESR sites which can service all three markets, including each of the three pipelines (see Figure 7.1). Of the eight sites there are only five candidate sites which can supply both the Gulf Coast, and the Caribbean and East Coast markets. Based on current demand, these two markets combined would, in the event of a supply interruption, require approximately 75 percent of the 150 million barrels in the ESR, or about 110 million barrels. Together the five sites have an existing capacity of approximately 330 million barrels--well above the 110 million barrels needed for the two markets.

Site selection, therefore, will involve a two-step decision-making process. The first decision in the site selection process will be to choose two or three of the five sites for the purpose of satisfying the ESR needs of the Gulf Coast, the East Coast and the Caribbean. These five candidate sites are thus alternatives for accomplishing this purpose. Site specific EISs have been prepared for all five alternative candidate sites. The impacts which would result from development of each of the other four candidate sites are described briefly in Sections 7.1.1 - 7.1.4. The individual statements should be consulted for a detailed assessment of these impacts.

The second step of the site selection process will involve choosing sites to satisfy the ESR requirement for the inland refineries. The remaining three of the eight candidate ESR sites are unique in that oil from them could be distributed only to the inland market area because they are "downstream" on major crude oil transmission pipelines. One would connect with the Seaway pipeline market area, while the other two would service the same part of the inland market area served by the Capline pipeline. Because of their ability to supply this inland market, those of the five candidate sites which are considered in the first step of site selection, but are not selected in that process, would be considered again as alternatives to the three inland market sites during the second step in the site selection process. EISs are now in preparation for the additional three inland sites which will be considered.

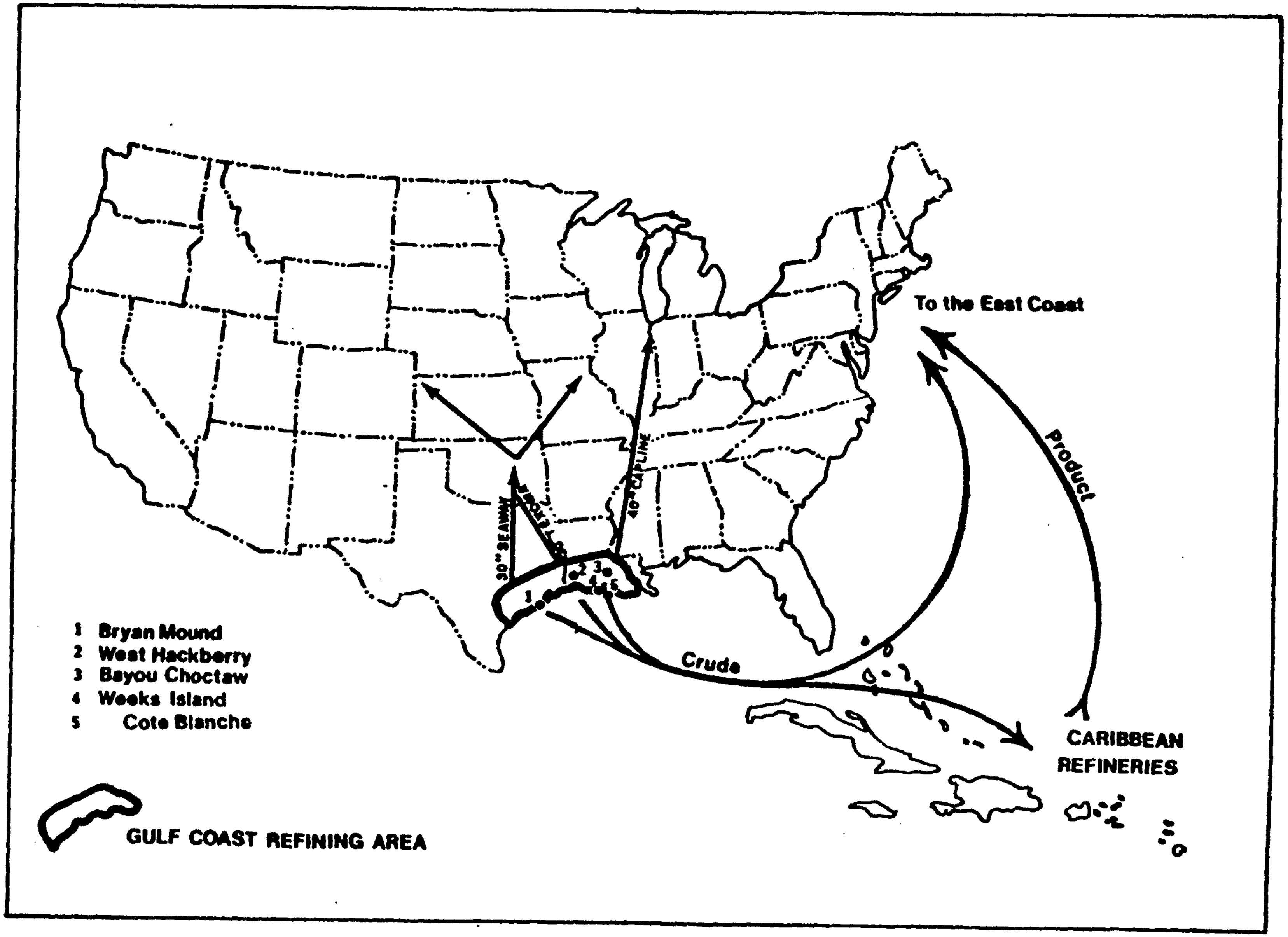

Fig.7.1 SPR Distribution Network

The future site selection for the longer-range portion of the SPR program will be very similar to the process described above for the ESR. Candidate sites will be grouped geographically according to market and distribution requirements. Each group will comprise a set of alternative sites, and EISs will be prepared which compare the impacts of developing each site. Those among the first eight which are not selected for the ESR will be considered as alternative storage sites for the longer-term phase of the SPR if they were rejected as ESR sites for reasons other than unsuitability for oil storage; e.g., if they were found to be unavailable for the ESR within the required time frame.

7.1.1 West Hackberry

Converting existing solution-mined cavities in the West Hackberry salt dome to a 60-million barrel oil storage facility would require drilling three new wells for oil injection and 11 brine disposal wells, and constructing a temporary barge dock on Alkali Ditch as well as a new tanker terminal on the Calcasieu River with connecting oil pipelines to the site. Displacement water for oil withdrawal would be pumped from Black Lake Bayou. The construction and operation of these facilities would cause several unavoidable disturbances, but no long term environmental effects. The most significant of these are displayed in Table 7.1. and discussed below for storage site construction, brine disposal, dock facilities and pipelines, oil displacement, marine operations, and facility operations.

7.1.1.1 Storage Site Construction

The storage site itself would require three new wells, two 10,000 barrel brine surge tanks, pump and office buildings, and access roadways. Since the land is now used for industrial purposes, no major land use changes are anticipated. However, the construction activity would temporarily disrupt soils around the storage site and cause an increase in erosion and runoff which would diminish local water quality. Over the course of construction, the level of suspended solids are expected to increase just over 2 percent.

Construction equipment would temporarily reduce on-site air quality with increased concentrations of carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxides (NO_x), hydrocarbons (HC), and 0.3 tons of particulates per month. Only the HC might exceed primary air quality and standards.

Since the land is classified as already highly disturbed, the water, air, and noise impacts are not expected to affect vegetation, wildlife, or aquatic biota significantly.

Construction of the storage site facilities and brine disposal wells together would generate 700 man-months of labor in the Lake Charles area, which would result in approximately $1.2 million in wages. Although local traffic would increase somewhat during the construction period, no significant adverse impacts on community facilities or local housing are anticipated.

7.1.1.2 Brine Disposal

To dispose of the brine now in the West Hackberry dome cavities would require drilling 11 brine disposal wells and installing two 10,000-barrel surge tanks as well as a 10,000-foot pipeline between the storage site and disposal area. The brine disposal area would include 25 acres of pasture and 10 acres of marsh; filling the marsh would reduce fish and shellfish production by as much as 1,650 pounds annually.

Brine injection would increase salinity in the disposal aquifer by one part per thousand (ppt). Fracture of the overlying rock is not likely at standard brine injection rates, but brine could seep into the Chicot Sands fresh water storage area if old wells around the disposal area were not adequately plugged.

An alternative to injection wells for brine disposal would involve a brine pipeline running 20 miles to the Gulf of Mexico and would protect the geology and water quality near the site but would increase salinity in the Gulf to a maximum of 3.5 ppt 16 feet downstream of the diffuser and 0.1 ppt over a 250-acre area. Construction would temporarily disturb soils and lower water quality along the pipeline route, crossing the Sabine National Wildlife Refuge.

7.1.1.3 Dock Facilities and Pipelines

The proposal for storage at West Hackberry calls for the construction of a temporary barge dock on Alkali Ditch and construction of a new tanker terminal on the Calcasieu River, connected to the storage site by a four-mile pipeline. The temporary facilities at Alkali Ditch would include two 1,000-barrel surge tanks (one for oil and one for brine), while the facilities at the tanker terminal would include a total of six tanks - two 100,000-barrel oil surge tanks, two 100,000-barrel ballast holding tanks, and two 15,000-barrel tanks for emulsion treatment. Construction would require dredging 35,000 yards of material from Alkali Ditch and 1 million yards from the Calcasieu River Channel. This could increase levels of turbidity, toxic sulfides, heavy metals and arsenic, as well as pesticides and other toxic hydrocarbons in bottom material. Disposal of the dredge spoil would destroy 90 acres of marshland. Maintenance dredging would also be required at both sites.

Construction of the proposed dock and pipeline facilities would require about 700 man-months of labor over approximately one year. The payroll for this aspect of the project would be about $1.2 million.

Paint solvent emissions from the preparation of the facilities would exceed standards at 2 kilometers from the site.

As an alternative to the construction of the proposed dock and pipeline facilities, the existing Lone Star Terminal could be expanded with a 12-mile pipeline to the storage site as an alternative to construction of a new tanker terminal on the Calcasieu River. Less dredging would be required, 660,000 cubic yards. The dredge spoil could be disposed of in a less sensitive area, an already disturbed abandoned industrial property. However, the longer pipeline would disrupt 180 acres of marsh and farm land, as opposed to 55 acres of farm land, would slightly decrease water quality in the marsh, and would eliminate an additional 312 tons of productive marsh materials.

Two additional oil distribution alternatives that involve existing pipelines may be possible with minimal new construction. Connection to these pipelines would disrupt 70 acres of brackish marsh and 50 to 80 acres of rice farming, at an annual income loss of nearly $33,000 in the latter. A third alternative, a new pipeline to the Texoma Terminal, would disturb more marsh and dry land than any other alternative. Associated dredging in the Sabine-Neches Waterway would temporarily eliminate bottom organisms and lower water quality in the vicinity.

7.1.1.4 Displacement

Water to displace the stored oil would be taken from Black Lake Bayou at the rate of 10,650 gallons per minute for 150 days, which would increase salinity slightly and temporarily lower the surface of the lake. Intake structures would trap some small organisms, but water quality and ecology in the lake would be restored shortly after displacement was completed.

An alternative environmentally less desirable and more expensive than the use of Black Lake Bayou would involve groundwater from drilled wells. Drilling the wells would eliminate the use of coastal plain grasslands for one year, and pumping would depress the local water table and possibly contaminate groundwater temporarily with salt water.

7.1.1.5 Marine Operations

Over the life of the project, the risk of oil spillage from accidents is the same for the proposed facility at West Hackberry as for the alternative of expanding the Lone Star Terminal, estimated at approximately 273 barrels for the tankship option and 3,087 barrels with the temporary barge system. Oil spills would destroy non-mobile species in their path, and leave a residual oily taste in fish caught in the vicinity. Vegetation contaminated by an oil spill would die but the contaminated area would revegetate itself within a couple of years.

Tanker and barge unloading during fill and tanker loading during withdrawal would result in the release of substantial amounts of hydrocarbons. During fill, barges and tankers would release 781 pounds per day and 8,286 pounds per day respectively. During withdrawal, tankers would release 20,953 pounds per day. This would cause the Federal standard of 160 ugm/m^3 to be exceeded as far as 6 miles downwind for the barge operations, and for the tankers 30 miles during fill and 45 miles during withdrawal. Emissions from crude oil transfers are not regulated in the State of Louisiana.

7.1.1.6 Facility Operations

The major impacts associated with facility operation would occur during fill and withdrawal. During these operations the oil storage tank at the barge dock and those at the tanker terminal would release hydrocarbons at rates of 588 and 500 pounds per day respectively. This would cause the Federal standards of 160 ugm/m^3 to be exceeded as far as 3 kilometers downwind for the barge dock, and greater than 2 kilometers downwind for the tanker terminal. The storage phase of the program would cause no additional significant impacts.

Only ten people would be needed to operate the facility during the storage phase. During oil recovery operations, 20 to 30 people would be required.

West Hackberry

Table 7.1 ENVIRONMENTAL IMPACT SUMMARY

ACTIVITY	IMPACTS DUE TO ACTIVITIES						
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7.1.2 Bryan Mound

Converting existing solution-mined cavities in the Bryan Mound salt dome into a 58-million barrel oil storage facility would require on-site construction; construction of pipelines between the site and the Seaway dock, the Seaway tank farm (both under construction), and the displacement water source (Brazoria and Harris Reservoirs). Although the oil storage facility at the Bryan Mound salt dome would not likely cause long term adverse impacts, it would alter the local environment in several significant ways. The most significant effects are discussed below and displayed in Table 7.1.2 for storage site construction, brine disposal, storage tanks, dock facilities, pipelines, displacement, marine operations, and facility operations.

7.1.2.1 Storage Site Construction

Construction of dikes, roadways, well-heads, and buildings at the storage site would affect some already disturbed land within the existing site. Turbidity and suspended solids would be increased, but since little resident wildlife is on the site, impact would be minimal.

Construction equipment would temporarily degrade on-site air quality with hydrocarbons, SO_2, CO and NO_2; approximately 0.5 tons per acre of dust per month would be generated from construction activity. Since the area surrounding Bryan Mound is industrially developed, air quality is often degraded and pollutant levels may exceed Primary Air Quality Standards by factors of 3-15.

7.1.2.2 Brine Disposal

The Dow Chemical Company would process the brine displaced during fill through two close-by chemical plants. If Dow could not take the brine, a 4-mile pipeline would carry it to the Gulf for disposal. The two miles of pipeline along a 100-ft. wide corridor would affect 24 acres of coastal prairie, beach, marsh and developed land. The installation of two miles of pipeline in the Gulf would destroy 24 acres of benthic habitat temporarily. Although the increased salinity from brine disposal in the Gulf would destroy bottom organisms in the diffusion area, they would repopulate shortly after disposal stopped.

A second alternative brine disposal method, deep well injection, would require ten wells spaced at 1000-foot intervals one mile outside the perimeter of the site and would require 20 acres of additional land. The adverse effects of this alternative include drilling noise for a 12-month period, a one percent chance of brine spill from pipeline or well-head failure, and the possibility that overpressurization would contaminate the freshwater aquifers.

7.1.2.3 Dock Facilities, Storage Tanks, and Pipelines

Oil supply and distribution would involve on-site storage tanks, a pipeline system, and dock facilities (including a 20,000 barrel surge tank). Thirty acres of land would be cleared. During construction, runoff would carry some petroleum, herbicides, pesticides, and sediment into adjacent waters. The painting of the four 400,000-barrel floating-roof storage tanks would cause a vapor plume one kilometer long and 200 meters wide on several days during a 90-day period, depending on winds.

The proposed method of crude oil supply and distribution is designed to utilize, under a common carrier contract, the Seaway dock facilities now being constructed east of Bryan Mound, and the Seaway tank farm facilities west of Bryan Mound. Initially, the facility would consist of three tanker docks, to moor tankers from 35,000 to 85,000 dead weight tons (DWT), and a 15,000,000-barrel tank farm, located 7 miles west-northwest of the harbor. Ultimately, the dock facility could be expanded to four docks and the tank farm to a 27,000,000-barrel capacity with pipelines for inland distribution to northwestern and mid-western United States markets. Constructing the 100,000-barrel ballast treatment facility at the dock would require the clearing of three acres of already disturbed land. The painting of the tanks would release solvent emissions downwind. Treated ballast water released to Freeport harbor would contain 7 ppm of oil (maximum monthly average). Oil recovered from the ballast treatment process would be injected into the cavities at Bryan Mound.

Construction of new barge docks in the ICW approximately one mile southeast of the storage site is an alternative to the proposed facilities. The most significant impacts would be those associated with dredging. Dredged materials would be deposited in a 184-acre disposal area 3 miles east of the dredging site.

Oil distribution would require two 30-inch pipelines, both along 100-foot rights-of-way. A 3.7-mile pipeline connecting the site with the Seaway dock at Freeport would be routed along the protected side of an existing levee and would cause minimal damage to the already disturbed land involved. A 4.5-mile pipeline would link the site to the Seaway Storage Tank Facility to the west. This pipeline would affect 18 acres of marsh and 26 acres of coastal prairie as well as 9 acres of disturbed land. In addition, the pipeline would cross the Brazos River and the necessary dredging would increase turbidity up to one mile downstream and increase levels of toxic heavy metals, hydrocarbons, and pesticides. One-half acre of benthic habitat would be eliminated, but repopulation would occur after one to two months following completion of construction.

The pipeline spill expectation for the entire project is 106 barrels. Spills associated with pipelines would be discovered quickly as a result of constant monitoring. On land areas contamination of soil would occur to a 10-centimeter depth and cover 0.4 acres for a 1,000-barrel spill. If rupture occurred at the Brazos River crossing, that section of the pipeline could be quickly isolated by valves on both sides.

7.1.2.4 Oil Displacement

Water to displace the stored oil would be taken from Brazoria and Harris Reservoirs via Dow Plant B at a maximum rate of 14,000 gallons per minute. No significant impact on the reservoirs or the Brazos River replenishment sources is expected since the reservoir volume is ten times the projected volume of displacement water required for one cycle.

A 24-inch concrete pipeline, requiring 15 acres for a 25 foot right-of-way, would be constructed for carrying water to the site from the Dow Chemical plant located five miles away. Construction would have little effect on the use of nine acres of previously developed land. Six acres of coastal prairie, although destroyed temporarily, should return to its previous condition during the next growing season.

Water from an alternative source of supply for displacement, the Gulf of Mexico, would be transported by a two-mile pipeline. Construction of a pumping station would affect one to two acres permanently and would temporarily affect up to 14 acres of coastal prairie and marsh. Unattached organisms of low mobility would be entrained at the intake during the five-month withdrawal phase, although intake velocities are relatively low.

A second alternative source for displacement water is the Brazos River, adjacent to the site. Less than one mile of disturbed industrial land would be involved, and dredging for the intake would destroy a small area of benthic habitat. Entraining and entrapping organisms of low mobility at the intake would be a minor problem.

7.1.2.5 Marine Operations

One of the most significant impacts from the operation of tankers and barges is the risk of accidental spillage in and approaching Freeport Harbor. Tanker traffic would reach a maximum during an emergency withdrawal of stored oil, with a worst case condition of 1.5 tankers per day (32,000 DWT) unloading 58 million barrels in 150 days. The total spillage expected during the lifetime of the program is 1,655 barrels, including terminal spills and vessel accidents. Should a maximum credible vessel accident occur in a given cycle, a median spill size of 5,300 barrels is estimated, which could involve about 3,850 acres of water surface in 48 hours if the spill is uncontained by the harbor and entrance channel.

If the alternative of constructing barge docks on the ICW is implemented, a total spillage of 14,500 barrels (versus 1,655 for tankers) could be expected for the fill or withdrawal project cycles because the number of barge trips is higher than that for tankers.

During the life of the project, offshore spills would affect a more diverse and productive habitat than spills in the harbor and would cause destruction of immobile species and residual oily taste in fish.

Vessel loading and unloading at the Seaway dock would result in significant hydrocarbon emissions. It is estimated that vapor losses would occur at rates of 46,100 pounds per day during unloading and 70,500 pounds per day during loading at the respective proposed fill and withdrawal rates of 254,000 and 385,000 barrels per day. Under worst case atmospheric conditions, these operations would cause hydrocarbon concentrations to greatly exceed the 3-hour Federal standard of 160 $\mu gm/m^3$ for a considerable distance (greater than 10 kilometers) downwind. The maximum concentration at .5 kilometers is estimated at 57,700 $\mu g/m^3$ (total hydrocarbons). The State of Louisiana currently exempts from regulation emissions from crude oil transfers.

7.1.2.6 Facility Operations

During fill and withdrawal, hydrocarbon vapors would be emitted from the surge tank and the four storage tanks at rates of 12.2 and 986 pounds per day respectively. Under worst case atmospheric conditions, the vapors from the storage tanks would cause concentration to slightly exceed the 3-hour Federal standard of 160 $\mu gm/m^3$ for approximately .5 kilometer downwind.

The weight of the filled tanks may cause some minor subsidence due to compaction of aquifers, unconsolidated material, and caprock.

The crew of ten, present at the site during the storage phase primarily for security and monitoring purposes, would expand to 46 during the loading and withdrawal phases.

Bryan Mound

Table 7.2

ENVIRONMENTAL IMPACT SUMMARY

ACTIVITY	IMPACTS DUE TO ACTIVITIES						
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7.1.3 Cote Blanche

Converting the Cote Blanche salt mine into a 27-million barrel oil storage facility would require relocation of existing mining operations, construction of a new pump shaft at the existing mine, enlargement of a barge slip, and construction of four barge loading platforms and associated pipelines to the site. Although they are not likely to cause long term adverse impacts, construction and operation of this facility would alter the local environment in several significant ways. These effects are shown in Table 7.1.3 and discussed below for storage site acquisition and construction, dock facilities and pipelines, marine operations, and facility operations.

7.1.3.1 Storage Site Acquisition and Construction

The major construction activity at the storage site itself, sinking a new 12-foot pump shaft and pump station, would require minimum surface grading over 1 acre and therefore create only small, localized increases in dust, and of vehicle exhaust from construction equipment. Ecological effects would be limited to minor accumulations of dust on foliage in the immediate vicinity of the construction. Proposed freezing of the area surrounding the pump shaft would prevent any construction disturbance to the groundwater.

Development of a replacement mine would require considerably more construction activity. Approximately 20 acres of land now in pasture and forest would be needed for new mine development. Grading at the new mine site would increase soil erosion and runoff and lower surface water quality in the local area. The use of drilling mud around the walls of the hole to prevent water inflow would protect groundwater.

Although government acquisition of the mine site would eliminate the annual property tax of $26,000, construction of the storage facilities, including docks and pipelines, would provide 20,000 man-weeks of labor for 83 weeks and total annual earnings of $6.3 million for two years. Economic gain resulting from an interruption in mining to accelerate the storage schedule would be offset by unemployment or underemployment of 120 mine workers and a loss of $1.7 million in earnings. If Domtar decided not to construct a new mine, the 120 jobs permanently lost would eliminate annual earnings of $1.2 million. The multiplier effect of this decision would entail the loss of another 200 service jobs and associated incomes within the region.

7.1.3.2 Dock Facilities and Pipelines

Enlargement of the barge slip and construction of four barge loading platforms would require excavation and disposal of 250,000 cubic yards of soil materials to create 9 acres of open water from marshland and involve another 20 acres of marsh and forest. Construction of four half-mile pipelines between the docks and the storage site would also disturb soils on the island.

Surface water quality would decrease in the access canal near the excavation and disposal sites with increases in biological oxygen demand (BOD) and nutrients and decreases in dissolved oxygen (DO) and pH. Since the existing barge slip is now dredged bi-annually, the additional excavation associated with enlargement of the dock facility would be less significant than in an otherwise undisturbed area.

The dock construction would not affect any rare species but would remove a small quantity of vegetation (e.g., oyster grass), and bottom organisms (e.g., blue crab).

As an alternative to enlarging the dock, the construction of a pipeline from Cote Blanche to St. James, following a route along either Bayou Teche (80 miles) or the Atchafalaya River (60 miles), is more likely if both Cote Blanche and Weeks Island are developed for storage. The Bayou Teche route would affect a larger number of acres (1,201 as opposed to 923), of which a greater percentage is now undisturbed. Both routes would degrade the quality of surface water by lowering pH and DO and increasing nutrient concentrations and BOD from deposits of excavated soils. However, by supplanting the barges, the pipeline would cause less impact from oil spills. The pipeline would be more expensive to construct but less expensive to operate than the barge facilities.

7.1.3.3 Marine Operations

The use of barges for transporting oil to and from the storage facility would increase erosion along the banks of the Intracoastal Waterway (ICW) and would in turn increase turbidity. Over the lifetime of the project, it is expected that about 2,700 barrels of oil would be spilled and that the maximum credible spill (Gulf shore) would be 60,000 barrels from a 45,000 DWT tanker. Although slow water currents and minimal wave action would inhibit the oil from spreading, the oil reaching shore would destroy many sensitive marsh species, which would regenerate after two years.

Transporting the oil to and from the dock at the storage site would result in significant hydrocarbon emissions, both during transit and at the transfer points in the Mississippi River and in the Gulf of Mexico. System leakage ("breathing") losses from tankers and barges would occur at a maximum annual atmospheric loading rate of 244 tons/year during fill and withdrawal. These emissions would be dispersed along the Mississippi River - Intracoastal Waterway route from the Gulf to the storage site. VLCC-tanker transfers in the Gulf and tanker-barge transfers in the Mississippi River would cause emissions at maximum annual rates of 1,220 tons/year and 1,300 tons/year respectively. Under worst case atmospheric conditions, transfers at the Mississippi River transfer point would cause hydrocarbon concentration in excess of the three-hour Federal standard of 160 $\mu gm/m^3$ as far as 6.8 miles downwind. The State of Louisiana currently exempts from regulation emissions from crude oil transfers.

An an alternative to small barges, large, seagoing barges might be used to transport part of the oil directly between the tankers in the Gulf and the site. This system would require larger dock facilities and a pipeline across the island creating a greater impact on the ecology of the island. However, their use could result in a 42 percent reduction in spilled oil and a 37 percent reduction in hydrocarbon emissions.

7.1.3.4 Facility Operations

Transferring the oil from the storage cavern to the barges at the dock would result in significant hydrocarbon emissions as the barge tanks are filled with oil and the vapors contained therein are vented to the atmosphere. These venting losses would occur at a maximum annual atmospheric loading rate of 731 tons/year. Under worst case atmospheric conditions, this operation would cause hydrocarbon concentrations in excess of the three-hour

Federal standard of 160 $\mu gm/m^3$ as far as 4 miles downwind. Because of unavoidable system leaks, minor amounts of hydrocarbons and hydrogen sulfide would be emitted during filling of the storage cavern as a result of flaring of the vapors that would be vented during that operation.

Fifteen employees would be needed during the 150-day withdrawal and the 300-day refill periods. Only two to three permanent employees would be needed to maintain security on the site during the storage phase of the program.

Cote Blanche

Table 7.3 ENVIRONMENTAL IMPACT SUMMARY

ACTIVITY	IMPACTS DUE TO ACTIVITIES						
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7.1.4 Weeks Island

Conversion of an existing salt mine to an 89-million barrel oil storage facility at Weeks Island would involve the construction of a new replacement salt mine, enlargement of an existing barge slip, and construction of abutment barge docks and six and one-half mile pipelines between the barge slip and storage facility. Although the oil storage reserve at Weeks Island is not likely to cause long term adverse impacts, construction and operation of this facility would alter the local environment in several significant ways. These effects are discussed below and in Table 7.1.4 for the construction of the storage site as well as for a new replacement mine, dock facilities, pipelines, marine operations, and facility operations.

7.1.4.1 Storage Site Construction and Acquisition

Conversion of an existing salt mine to an 89 million-barrel oil storage site would entail only temporary, local increases in the levels of hydrocarbons, NO_x and SO_2, as well as dust, which results from the grading needed for the above-ground pump station and small electric substation.

Construction of a new salt mine to replace that converted for oil storage would involve about 20 acres of land used currently as a landfill site. The socioeconomic impact of such construction would depend on whether (1) salt production was interrupted and (2) Cote Blanche followed a construction schedule similar to Weeks Island.

Development of the new mine at Weeks Island with no interruption in salt production would require 18,500 man-weeks of labor over 93 weeks and provide an estimated $6 million in salaries. If mining operations continue uninterrupted at Weeks Island as well as at Cote Blanche, production at both sites would yield a total of $13.9 million.

With a 64-week cessation in salt production at Weeks Island, designed to expedite the completion of the storage facility, 16,800 man-weeks over 73 weeks could be required, and the resulting loss in salt production would decrease state revenue, through severance taxes, by $92,000 and local revenues by $50,000. If construction interrupted salt production at both Weeks Island and Cote Blanche, $11.7 million in salaries would be lost, of which $7 million would be lost by local residents. The resulting 3.5 million-ton decrease in salt production would proportionately reduce state revenues, through severance tax, by $210,000 and local revenues by $150,000.

A construction schedule for Weeks Island that does not require an interruption in salt mining would cause a shortage of laborers for the time that both mine relocation and storage conversion peak. One possible solution to this problem would entail a different coordination of activities between the two sites. If the Cote Blanche mine were closed during conversion at Weeks Island, the unoccupied work force could assist in mining operations at Weeks Island to expedite construction without drawing heavily from the outside labor market.

7.1.4.2 Dock Facilities and Pipelines

The proposed method of crude oil supply and distribution is designed for barge transport coordinated with a pipeline system. Six abutment docks would be constructed to accommodate 25,000-barrel barges,and the southern portion of an existing barge slip would be enlarged by 80 percent. An estimated 250,000 cubic yards, involving about 9 acres of marsh and spoil banks, would be excavated for the slip and transported to an approved Corps of Engineers site. Ancillary equipment (manifold, pumps, meters) would require ten acres adjacent to the slip. The excavation would temporarily displace local aquatic life, including benthic organisms like blue crabs. Increased runoff from the grading of the adjacent ten acres would cause temporary turbidity, BOD, DO and nutrient problems.

Barge transport would require the construction of six 0.5-mile pipelines between the barge slip and the storage facility. Although excavation and backfilling would, in displacing several thousand cubic yards of soil, temporarily cause sediment to run off into the barge slips and Waterway, overall impact would be small.

Despite the probability that a pipeline rupture would cause oil spill is low, a maximum spill of 500 barrels would most likely affect only three acres.

With both Weeks Island and Cote Blanche as storage facilities, the proximity of the two sites increases the possibility that a large diameter pipeline could replace the barge system as the means of supply and distribution for the sites. Two alternative pipeline routes to St. James are available, one running 80 miles along Beyou Teche and the other 60 miles along Atchafalaya. The first would more adversely affect virgin wetland forest. The pipeline would involve a lower operating expense and probability of oil spill than those of barge transport.

7.1.4.3 Marine Operations

Barge operations would involve a total distance of 225 miles. Oil would be offloaded from very large crude carriers (VLCCs) to 45,000 DWT tankers in the Gulf of Mexico, transported up the Mississippi River to Venice, Louisiana, and transferred to 25,000-barrel barges for further transport up the Mississippi through Algiers Lock to the ICW and ultimately Weeks Island barge slip.

Daily barge traffic should increase 11 percent for the 28-month fill period and 36 percent for the shorter 9-month withdrawal period.

The maximum credible oil spill for the Gulf, possibly 60,000 barrels, could render 840 to 1,680 acres of marsh (1.5 percent of total marsh in the area) nonproductive for two years. Of the expected average spill of 1,827 barrels, 312 barrels may occur at the barge slip and 1,515 barrels anywhere in the ICW, Mississippi River, or the Gulf. The maximum credible spill from barges into the ICW, estimated at 20,000 barrels, could affect 10 miles of the channel. Transporting the oil from the dock at the storage site would result in significant hydrocarbon emissions, both during transit and at the transfer points in the Mississippi River and in the Gulf of Mexico. "Breathing" losses from tankers and barges would occur at a maximum annual atmospheric loading rate of 800 tons/year during fill and withdrawal. These emissions would be dispersed along the Mississippi River-Intracoastal Waterway route from the Gulf to the storage site. VLCC-tanker transfers in the Gulf and tanker-barge transfers in the Mississippi River would cause emissions at maximum annual rates of 4015 tons/year and 2140 tons/year respectively. Under worst case atmospheric conditions, transfers at the Mississippi River transfer point would cause hydrocarbon concentrations in excess of the three-hour Federal standard of 160 $\mu gm/m^3$ as far as 7.5 miles downwind. The State of Louisiana currently exempts from regulation emissions from crude oil transfers.

As an alternative to small barges, large seagoing barges might be used to transport part of the oil directly between the tankers in the Gulf and the site. This system would require larger dock facilities and a pipeline across the island creating a greater impact on the ecology of the island. However, their use could result in a 42 percent reduction in spilled oil and a 46 percent reduction in hydrocarbon emissions.

7.1.4.4 Facility Operations

Transferring the oil from the storage cavern to the barges at the dock would result in significant hydrocarbon emissions as the barge tanks are filled with oil and the vapors contained therein are vented to the atmosphere. These venting losses would occur at a maximum annual atmospheric loading rate of 2,410 tons/year. Under worst case atmospheric conditions, this operation would cause hydrocarbon concentrations in excess of the 3-hour Federal standard of 160 $\mu gm/m^3$ as far as 5.7 miles downwind. Because of unavoidable system leaks, minor amounts of hydrocarbons and hydrogen sulfide would be emitted during pumping. Minor amounts of sulphur dioxide would be emitted during filling of the storage cavern as a result of flaring of the vapors that would be vented during that operation.

Fifteen workers would be required for transfer operations during fill or withdrawal periods. A crew of five or less would be required during the storage phase of the program, primarily for security purposes.

Weeks Island

Table 7.4 ENVIRONMENTAL IMPACT SUMMARY

ACTIVITY	IMPACTS DUE TO ACTIVITIES						
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]							
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]							
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]							
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]							
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]							
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

7.2 ALTERNATIVE FACILITY COMPONENTS

The Bayou Choctaw SPR facility has been designed for utilizing the most feasible alternatives for distribution, brine disposal, and raw water supply system components. These alternatives, however, may be subject to the following shortcomings:

The proposed tanker terminal on the Mississippi River may prove to be too costly, or may not be completed in time to be utilized for ESR fill requirements.

Subsurface brine injection may be rejected as a feasible disposal method after detailed subsurface surveys are completed.

A raw water source other than, or in addition to surface waters from the onsite lake may be required.

Possible alternatives and the environmental impacts for each of these components are summarized in Table 7.5 are discussed in detail in the following subsections.

7.2.1 Alternative Distribution Facilities

The present plans for distribution facilities at Bayou Choctaw call for initial fill operations from an existing barge dock adjacent to the Intracoastal Waterway (ICWW) on Bull Bay. The proposed expansion of the barge dock would provide barge access for both fill and withdrawal operations. The expansion would require the construction of a second barge dock and would involve the excavation and/or dredging of nearly 60,000 cubic yards of earth from about 3 acres of dry land on the bank of the ICWW for a new barge mooring slip. As discussed in Section 3.4, the environmental impacts associated with the facility construction would primarily be disturbance to some wildlife, temporary destruction of vegetation in an already disturbed area, and minor short term turbidity and water quality changes having negligible adverse effects on the aquatic biota.

If the proposed barge dock facilities on Bull Bay are not constructed, supply and distribution requirements would have to be totally satisfied by the proposed tanker facility now planned for construction on the Mississippi River

Table 7.5

Summary of Alternatives to Proposed Facilities and Major Environmental Impacts of Alternatives

DISTRIBUTION	CONSTRUCTION	OPERATION
1. Expansion of existing barge dock (proposed)	Barge mooring slip excavation 86×10^3 cu. yds. affects from 5 to 8 acres of dry land. Temporarily increases turbidity due to excavation, dredging, and soil erosion.	Imposes short detour around Bull Bay dock area. Increases barge traffic (12 barges or 3 barge tows per day; duration 5 to 10 mo.) Expectation quantity of oil spilled in transport accidents is 0.19 bbls per barge trip. Potential oil spill at dock easily contained by boom in isolated barge slip. Expectation quantity of oil spilled in terminal accidents is 1.86 bbls per barge trip. Total loss of 7321 bbls per fill or withdrawal cycle.
2. Tanker Terminal at Addis (proposed)	Dredging tanker berths 1.5×10^6 cu. yds. River banks already developed industrial area. On site grading and tank construction on 30 acres of shore property, previously agricultural. Pipe-line crosses 22 acres sugar cane production, precludes $7,500 3-year crop; 0.5 miles new swamp forest; 2 miles along esisting pipeline ROW (right-of-way).	Increases tanker traffic (max. 2 tankers per day, 720 MBPD, 5 to 10 mo. duration). Increases transport time (220.5 river mi.) Expectation quantity of oil spilled in transport accidents is 1.35 bbls per tanker trip. Potential oil spill at terminal may be difficult to contain at high currents. Expectation quantity of spill at terminal is 0.93 bbls per tanker trip. Total loss of 536 bbls per fill or with drawal cycle.

DISTRIBUTION	CONSTRUCTION	OPERATION
3. Tanker-Terminal-Capline at St. James (alternative)	Dredging tanker berths 1.0×10^6 cu. yds. Site is existing tank farm. Uses about 30 acres of 550 acre terminal site. Pipeline parallels existing pipeline ROW. May preclude 127 acres sugar cane production ($43,500, 3 yr. crop)	Increases tanker traffic (max. 2 tankers per day. 720 MBPD, 5 to 10 mo. duration) Existing traffic is 2 to 3 tankers per day and 1 to 2 barge tows per day; 75 percent utilization. Transport distance 160 river miles. Risk of accidental oil spill (same as proposed site). Access to shared containment and cleanup facilities.
BRINE DISPOSAL		
1. Subsurface Injection (proposed)	System construction permanently alters 65 acres swamp forest with elevated access roads. Drilling duration 12 mo. Mud pits to be reclaimed.	Probability of brine spill due to pipeline or wellhead failure <1.0%. Major spill could destroy swamp habitat. Well clogging may require flushing, possibly resulting in oil fill delay (2 day surge capability absorbed by brine pond).
2. Gulf Disposal (alternative)	Pipeline parallels existing pipeline ROW 96 mi. to Gulf + 20 mi. to sufficient water depth. Crosses extensive swamp and fresh to saline marsh areas. Total 350 acres wetlands. Could contribute to salinity intrusion.	Probability of brine spill <1.0%. Major spill could destroy swamp and marsh habitat. Detectable salinity increases (0.1 ppt) in Gulf waters would occur in about 450 acres. Increases of 2.5 ppt extend over only <1 acre under normal current conditions (duration 10 mo.) Benthos in diffuser area would be adversely affected but would repopulate within 2 mo. after cessation of discharges.

DISTRIBUTION	CONSTRUCTION	OPERATION
RAW WATER SUPPLIES		
1. Black Lake (proposed)	Little or no impact. Existing lift pump on site.	Induced velocity, max .18 ft/sec in adjacent bayou, .023 ft/sec in ICWW. Entrainment of low mobility organisms near intake (Max Vel. 0.5 ft/sec).
2. Mississippi River (alternative)	Little or no impact. Ballast water pipeline between Mississippi terminal and storage site would be used.	At mean low water, Mississippi discharge is 200,000 cfs. Facility requirement is 3.6×10^{-6} of total discharge.
3. Shallow Subsurface Wells (alternative)	Minimum road and pipeline construction (<2 miles new road construction). Drilling duration about 3 mo.	Brackish water taken. Saline/freshwater interface not adversely affected. Duration 5 mo. Extremely small probability of surface subsidence.

some 4 miles east of the site, requiring an increased initial fill rate and correspondingly enlarged systems components if the current fill and withdrawal criteria are to be met. An enlarged physical plant at the distribution terminal would present substantially greater costs and would entail a greater risk of accidents due to increased traffic and docking congestion at the proposed tanker facility.

Alternative Distribution Terminal: An alternative to the construction of the proposed tanker facility on the Mississippi River near Addis is to install a longer pipeline to the Capline terminal at St. James, 35 miles south on the Mississippi River. Capline is a major inland distribution pipeline operated by Shell Oil Company. The 40-inch line begins at St. James and terminates at Patoka, Illinois. Its design capacity is 1,250,000 barrels per day and present throughput is 875,000 barrels per day, comprised of 275,000 barrels per day from domestic markets and 600,000 barrels per day from imports. If the Louisiana Offshore Oil Port (LOOP) supertanker terminal is built, it would be connected to Capline at St. James. The St. James terminal has 3 tanker docks, 1 barge dock, and 1 tanker/barge dock. The associated tank farm, occupying approximately 550 acres, has an existing 6.4 million barrel capacity. There is space for construction of additional storage capacity at the tank farm.

If the alternative distribution terminal were constructed, the same facilities as described in Section 1.3.1.5 for the proposed terminal near Addis would be constructed as expansions to the existing terminal at St. James. Two new tanker/barge docks would be constructed, requiring an estimated 1 million cu. yds. of dredge. Surge tankage requirements would be six 200,000 barrel tanks to be located west of the existing tank farm on approximately 30 acres of the terminal property. Unlike the Addis site, however, where ballast water would be piped back to the Bayou Choctaw site for disposal, the St. James location necessitates that a ballast water treatment system be installed. Four 125,000 barrel tanks would receive the ballast and allow gravity separation of the oily mixture. Emulsions would be treated in separate 35,000 barrel tanks. Mechanical oil/water separators would be included. The treated ballast water, with an allowable maximum contamination level of <30 ppm of oil by weight, would be deposited into the river channel. The recovered oils would be collected in another 35,000 barrel "slop tank" from which they could be returned to the storage system or sold to local waste oil marketers.

As planned for the proposed terminal site at Addis, the 1 million cu. yds. of spoil from the required dredging at St. James would be dumped into the river channel which would subsequently deposit the material on sand bars downstream. This is standard practice in dredging and channel maintenance on the Mississippi River. Turbidity resulting from the dredging would extend considerable distances downstream. Although sedimentology data are not available for the St. James site, it is assumed that the river contains much the same sediment composition throughout the lower delta region. For this reason, the extent and impacts of trans-location of sediments at this site would be similar to that of the proposed dock facility at Addis. (See Section 3.2.)

The potential for routine small oil spills during terminal transfer operations would be essentially the same at both locations. Generally small spills occurring during normal operations do not have long range damaging effects on the environment. Successive accidental spills of greater magnitude (from 30 to 100 barrels) can have pronounced effects. The potentially higher ambient pollution levels near the St. James terminal, which are due to the existing oil transfer operations, could add to the damage of possible repetitive spills. Because of the river's current (about 5 ft per second at low water stage), containment of a sizeable spill could not be easily managed, nor would the oil have time to weather before reaching shore. The expectation quantity of a terminal oil spill is calculated at 0.93 barrels per tanker trip. Should a spill occur, a median quantity of 18 barrels is expected. The probability of a sizeable spill (30-100 barrels) is 1.8×10^{-3} per trip, and 0.42 over an entire fill or withdrawal cycle. Section 3.7.2 deals with marine accidents during transport and terminal operations in detail.

Due to decreased transport distances, the potential for vessel accidents is slightly less for the St. James location, which is about three-fourths the distance up the river of the proposed terminal at Addis. On the other hand, increased congestion due to the existing St. James terminal operation could increase the likelihood of an accident. As discussed in Section 3.7.2, however, the expectation quantity of an oil spill resulting from collision, grounding, or other transport accident is 1.35 barrels per tanker trip, or a total of 536 barrels lost due to all causes during the course of one entire fill or withdrawal cycle. This total amounts to .0005 percent of the 100 million barrel storage capacity handled.

Terminal Pipeline Connections: Whereas the pipeline route to the presently proposed terminal near Addis is approximately 5 miles long, crossing some 22.5 acres of dry agricultural land (mostly in sugar cane production) and 22.5 acres of backwater swamp forest, the alternate route to the St. James terminal site would be approximately 41 miles long, involving about 250 acres of primarily agricultural and wetlands areas (see Table 7.6).

For the most part, the alternate pipeline route would parallel the existing Exxon No. 195 pipeline right-of-way which passes within 1 mile of the Bayou Choctaw site and about 5 miles from the St. James terminal (see Figure 7.2). The use of the existing Exxon right-of-way would not adversely affect large portions of the natural setting of the region. Although a 50-foot corridor of land would be disturbed for pipeline construction, the disruption of these lands would not create as great an impact as would construction on previously undisturbed forest or swamp. Pipeline rights-of-way are generally kept clear of trees and are not as highly productive of wildlife.

Lands crossed by the alternate distribution pipeline from St. James to Choctaw would be 21 miles of agricultural land predominantly planted in sugar cane, 7 miles of forest, and 13 miles of swamp forest. Based upon a 50-foot right-of-way, acreages needed for construction are 127, 42, and 79 respectively. The loss of 127 acres of sugar cane production for 3 years during and immediately after construction would result in a maximum loss of 2,667 tons of sugar cane production or currently valued at $43,579.[1] Because the pipeline would follow the existing Exxon pipeline right-of-way, it is doubtful that any trees would have to be removed. For this reason, the 42 acres of forest and 79 acres of swamp forest right-of-way would require only the removal of brush and grasses. It is likely that during construction of the pipeline, numerous birds, small mammals, alligators, other reptiles, and amphibians would be disturbed in the area adjacent to the pipeline corridor.

The only developed areas near the pipeline route are South of White Castle (population 2200), and southwest of Donaldsville (population 7400). Major transportation arteries crossed are Bayou Plaquemine, formerly a portion

Table 7.6

Pipeline Alternatives and Affected Areas

		AGRICULTURE (sugar cane)	FOREST	BACKWATER SWAMP FOREST	MARSH FRESH	MARSH INT.	MARSH BRA.	MARSH SAL	TOTAL
PLANNED DISTRIBUTION CHOCTAW - ADDIS (75 ft ROW)	MILES	2.5		2.5					5
	ACRES	22.5		22.5					45
ALTERNATE DISTR. CHOCTAW - ST. JAMES (50 ft ROW)	MILES	21	7	13					41
	ACRES	127	42	79					248
ALTERNATE BRINE DISP. CHOCTAW-GULF* (50 ft ROW)	MILES	30	7	28	12	4	9	6	96
	ACRES	182	42	170	72	24	54	36	580

* INCLUDES 38 MILES OF ROUTE FROM CHOCTAW TO ST. JAMES.
DOES NOT INCLUDE ADDITIONAL 20 MILES FROM SHORE TO OCEAN DEPTH OF 20 FEET.

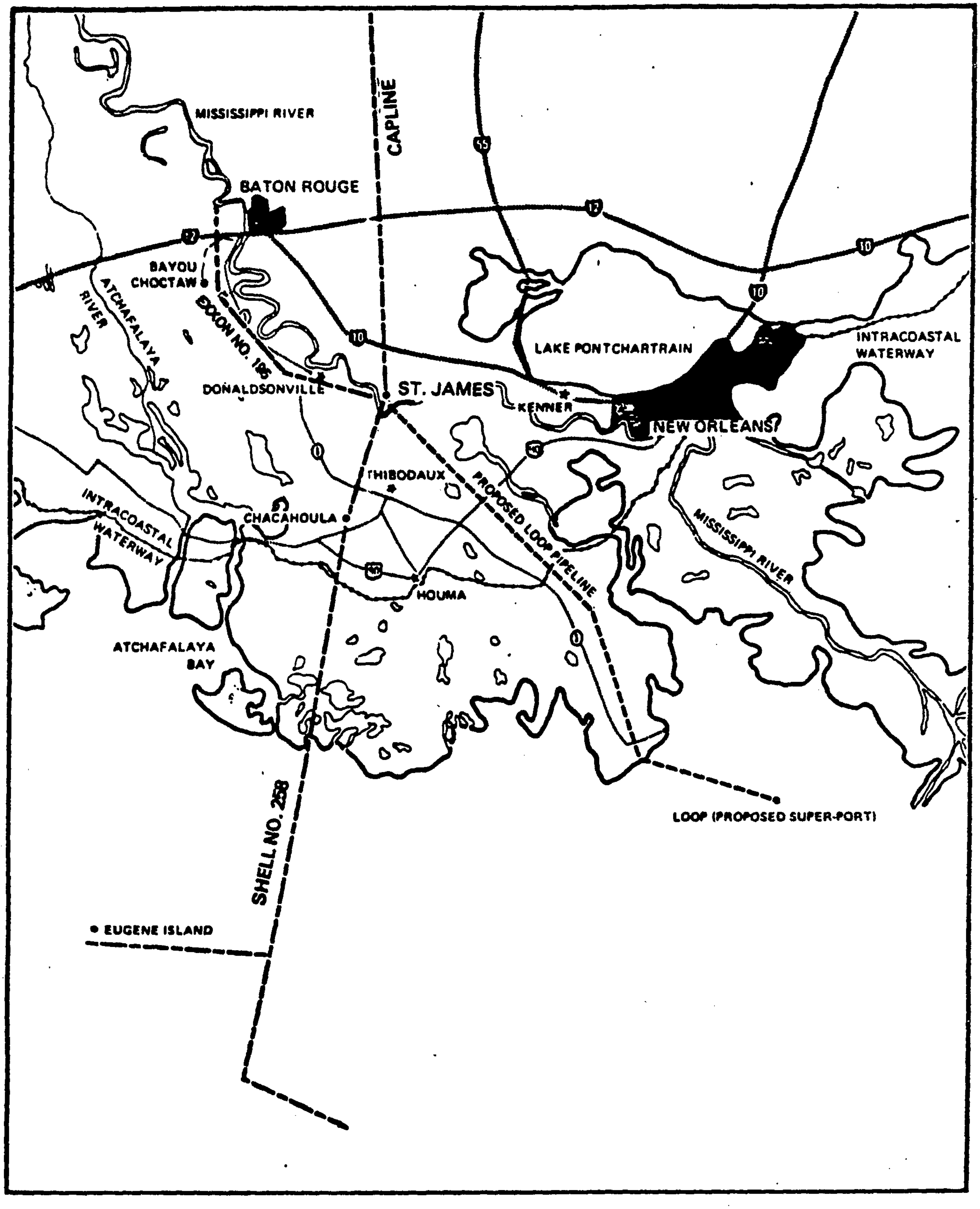

Figure 7.2 Existing Pipeline Routes for Alternatives

of the Intracoastal Waterway); State Highway No. 1; and Bayou Lafourche. Two other highways and five other canals would be crossed.

Construction of the pipeline across Bayou Plaquemine would cause little if any interruption to potential barge traffic. The pipeline dredge barge would be a temporary obstacle but could usually be bypassed without delay. The pipeline itself would be assembled on shore and pulled across the canal when completed.

Dominant vegetation within the area of the waterways crossed by the pipeline is duckweed (Lemna), Eleocharis, Sagittaria and Panicum. Various species of algae, zooplankton and benthic invertebrates as well as birds, fish and alligators are also present.

Based on productivity data for other wetland vegetation of southern Louisiana of 2000 g dry wt/m^2/yr. and a 50 foot impacted corridor over a 100 foot expanse of water, 929 kilograms dry weight of biomass would be lost during construction of the pipeline. In addition, several thousand benthic organisms near the dredging site would be affected by increased turbidity. Although fish and other mobile organisms within the area would be able to avoid the site during dredging, some of these organisms may, to a limited extent, be adversely impacted by abrasion to the gills resulting from the intake of suspended sediment.

Because the impacts at the site would be of relatively short duration and because the natural habitat would return to normal productivity levels within a reasonably short time (less than 2 years), the overall impacts to major and minor waterways would be negligible.

7.2.2 Alternative Brine Disposal Facilities

Deep Well Injection

The proposed brine disposal system calls for injection into deep saline aquifers off the flank of the salt dome. (See discussion in Section 1.3.1.3, page 1-20.)

Disposal in the Gulf

An alternative to deep-well brine injection is the construction of a pipeline for direct disposal into the Gulf of Mexico. The required pipeline would be 116 miles long, including the 20 mile extension into the Gulf required to reach a sufficient depth of 20 feet (see Table 7.6). The first 38 miles of the route would parallel the Exxon No. 195 pipeline right-of-way which would coincide with the alternate distribution pipeline between Bayou Choctaw and St. James as discussed in Section 7.4.1. The remaining 58 miles from St. James to the Gulf would follow the Shell No. 258 pipeline route (see Fig. 7.2). The use of existing pipeline routes is a common practice in pipeline engineering and would help to minimize disturbance to the natural areas which would be crossed.

Based on Agricultural Stabilization and Conservation Service (ASCS) data,[1] construction of a pipeline on a 50 ft. right-of-way over a total of 30 miles of sugar cane cropland would result in the temporary loss of approximately 182 acres of production or 3822 tons of cane. The monetary value of the ensuing loss of harvest would be nearly $62,500.

Impacts of freshwater swamp forest would be minimal because the proposed alternative routes follow existing rights-of-way. Because these rights-of-way are continuously cleared and maintained they cannot be considered a true forest. Approximately 35 miles of forest would be traversed by the pipeline. During construction activities and routine maintenance, the forest environment in proximity to the corridor would be disturbed. As a result, many species of birds, mammals, amphibians and reptiles within the rights-of-way would be displaced. Depending upon the season when construction takes place, use of the rights-of-way by birds for nesting and feeding could be interfered with.

The most productive natural vegetation within the region is in the marsh environment. A total of 31 miles of various types of marshland would be disrupted for pipeline construction. A 50 ft. right-of-way located along the No. 258 Shell pipeline corridor would disturb 186 acres of marshland. According to Day et al. (1973)[2] net primary marsh productivity* is 1518 g dry wt/m^2/yr. Using this as a representative value, a total of 1.14 x 10^9 g dry wt/yr (or 1258 tons) of primary productivity would be lost. The productivity of these lands is expected to return within one year.

In some areas of the marsh environment, the terrain may require barge-lay construction techniques (see Section 1.3.4). A path of brackish marsh vegetation (*Spartina* spp. and other marsh grasses) up to 150 feet wide would be eliminated over barge-lay sections of the line. This vegetation would return within one year except for access roads which would require filling. Increased turbidity would result from filling and pipelaying within the marsh, possibly as far as 1/4 mile from the pipeline depending on currents, wind action and the type of sediment present. The increased turbidity would not affect the surrounding marsh grasses but may temporarily interrupt habitation of the areas by fish, shellfish, benthic organisms, and wildlife.

Constructing the pipeline through the marsh would affect wildlife populations, especially waterfowl and small mammals. During November through March overwintering ducks, geese and other waterfowl would be displaced along with birds which are present the entire year. Waterfowl would avoid the construction route for feeding and nesting, but would return after construction. Numerous resident waterfowl and other birds would be displaced by construction at other times than winter. Mammals such as nutria, mink, otter, muskrat and raccoon would emigrate from areas near construction, but would produce little stress on the surrounding ecosystem under normal conditions since a relatively small area is involved and the ecosystem is productive. Trapping is permitted in the area and several trapline areas may be interrupted for one season. Small mammals should repopulate the construction area within a year or two.

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*Net primary productivity is the amount of new organic matter produced by photosynthesis in green plants in a given time interval minus the organic matter degraded to inorganic constituents in powering plant metabolism in the same interval.

There is a measurable hazard (about one percent probability) that rupture of the pipeline would occur. Planned monitoring systems would detect small pressure changes, allowing a rapid shutdown of pumping. The saturated brine released by a pipeline rupture would have severe effects on local biota. Temporary recovery or replacement of affected nonmobile organisms would occur at different rates, depending on ease of establishment, life span, and other factors.

The alternative brine disposal line to the Gulf would extend into the Gulf approximately 20 miles to water at least 20 ft. deep. Burial of this segment of the line would temporarily disturb approximately 100 acres of benthic habitat and would temporarily drive fish populations from the immediate vicinity of the line. Once the line is installed, fish would return to the area and benthic invertebrate populations should return to normal within 6 months.

A simple brine diffuser design would provide about seventy 9-inch ports oriented upward at about 5 ft. off the ocean floor and spaced 10 ft. apart. As calculated in assessment of Gulf brine disposal for similar facilities, the 250 ppt. brine* is rapidly diluted in 35 ppt sea water under current conditions assumed to be .8 knots or 1.35 feet/sec. The overall increase in salinity is reduced to 3.4 ppt at a distance of 16 feet down current and 2.0 ppt at a distance of 50 feet. The far field traces of 1.0 ppt and 0.1 ppt excess isohalines, however, extend 1300 feet and 18,000 feet, respectively. The total ocean area affected by increased salinities of 0.1 ppt or greater is approximately 250 acres under normal current conditions.

Impacts of Brine Disposal

In general, except for points in the immediate vicinity of the diffuser ports, the salinity increases are relatively moderate, with no portion of the ocean floor in the disposal area experiencing increases greater than 3.5 ppt.

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*These calculations were based on a brine concentration of 250 parts by weight of salt in one thousand parts of water.

The mortality to low mobility organisms close to the diffuser, such as phoronids, pelecypods, and polychaetes, would be irreversible. Recolonization, however, should occur relatively quickly once the brine discharges have ceased. There is reason to believe that mobile organisms susceptible to higher salinities would avoid the discharge area. Some stimulation of primary and secondary production throughout the marine communities may occur at the edges of the area of appreciable mixing since nutrient availability for primary producers and consumers may be increased by the mixing.[3]

7.2.3 Alternative Displacement Water Supplies

Mississippi River: The first alternative to the use of the on-site lake as the total source of displacement water is to pipe a supplement from the proposed distribution terminal on the Mississippi River. The same pipeline planned for transporting ballast water from the terminal to the storage site would be adapted for raw water supply during displacement operations. During loading operations, water piped from the Mississippi River would be used to displace the stored oil and the oily ballast from the onloading tankers would be stored in ballast water tanks at the terminal site. During subsequent tanker down-times, the ballast water would be pumped to the storage site for disposal.

The discharge of the Mississippi River at mean low water stages is about 200,000 cubic feet per second (89.8 x 10^6 gallons per minute). The maximum requirement for displacement water at the proposed Bayou Choctaw facility would be 71.3 cubic feet per second (32,000 gallons per minute). Thus, less than .035 percent of the river's flow would be utilized with no measurable effects on water availability.

Shallow Subsurface Aquifers: A second alternative for a source of displacement water is to drill ground water wells. The tentative location for the required wells is over the -7000 ft. depth to salt contour directly south of the storage site. The pipeline connections to the well area would follow the same route as that proposed for the brine disposal line; thus, no new terrain would be disturbed by this additional pipeline construction. The number of wells required would depend on the actual water yields obtainable, as discussed in Section 2.2.1.2. An average of 19,450 gallons per minute supply is required. Assuming 6 wells and a spacing of 1000 ft., at least a 5000 ft. by 50 ft. (5.7 acre) surface area would be required for the well system. The wells at this location would be situated in the northern edge of the swamp south of the site. This construction would eliminate swamp production of 4.2 tons dry weight per year. Once construction is completed, vegetation would recover within one year and wildlife would return after human activity ceases.

Based on available data (see Section 2.2), fresh water is available in the Plaquemine aquifer at depths between 100 and 450 feet. Saline water occurs at greater depths. In the vicinity of the site an aquitard occurs at depths between 600 and 800 feet.

Slightly saline water (1 - 3 parts per thousand) occurs at a depth of 500 feet. The yield of a single 12-inch diameter well is estimated to be in the range of 500-2000 gallons per minute (gpm) with 100 feet of drawdown after one day of pumping from an aquifer.[4] Thus to achieve the required average flow rate of 19,450 gpm, the minimum number of wells of such size would be 10 and the maximum would be 40.

Moderately saline water (3-10 parts per thousand) occurs at a depth of 1000 feet. The yield of a well of the same diameter (12 inches) would be 2000-5000 gpm for an aquifer thickness of 150 feet.[4] Thus for the required flow rate, the minimum number of wells would be 4 and the maximum would be 10.

The required flow rate of 19,450 gpm represents 28 x 10^6 gallons per day, which is the rate at which water has been withdrawn from 40 10-inch wells near Port Allen for a period of 22 months, as described in subsection 2.2,[5] resulting in a 10 foot reduction in wtaer level at a distance of .5 miles from the pumping site. Examination of water table contours representing high and low river stages reveals that a 10-foot drop due to pumping would correspond closely to the change in the water table level at Bayou Choctaw due to the fluctuation of the Mississippi River.

The preceding analysis suggests that the Plaquemine Aquifer is capable of supplying the required displacement water. The reduction of water level in the aquifer should be similar to that previously experienced near Port Allen. If such is the case, the impact would primarily be limited to a region roughly 1 mile in diameter centered at the pumping site. Within such a region the impact would generally be greater than that produced by changes in the stage of the Mississippi River. The use of this alternative could affect any existing water well in the area, which currently experiences reduced output during low river stage. Further analysis of the shallow subsurface aquifer is provided in Appendix D-8.

7.3 NO-ACTION ALTERNATIVE

A description of the no-action alternative and its impacts, as it applies to the entire program, is provided in the Programmatic EIS (DES-76-2). Within the SPR, a decision not to develop the Bayou Choctaw facilities would result in the development of one of the other candidate sites to take its place. In that case, the impacts described in Section 3.0 would not occur and the existing environment of Bayou Choctaw (as described in Section 2.0) would be maintained. However, a decision not to develop Bayou Choctaw would result in other impacts: those associated with the alternate facility. Since many of the candidate sites are also located in the Gulf Coast Region, it is likely that many of the impact resulting from the development of the replacement site would be substantially the same as those for Bayou Choctaw. However, the detailed impacts of any particular facility are very site-specific and are discussed in the EIS for that site.

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8. RELATIONSHIP OF THE PROPOSED ACTION TO LAND USE PLANS

The Louisiana State Planning Office has designated this general area of West Baton Rouge and Iberville Parishes as wetlands consisting of deciduous swamp and bottomland forests. The area which includes the proposed storage site is not planned for any urban or suburban build-up. Of the two parishes, only West Baton Rouge is vested with authority to enforce parish-wide zoning ordinances, and the Bayou Choctaw storage site lies almost entirely in Iberville Parish. The proposed distribution terminal on the Mississippi River, however, is located in West Baton Rouge Parish. Land along the Mississippi is heavily industrialized and the development of the proposed terminal is compatible with present land use patterns. Land use plans and zoning restrictions have been proposed for both Iberville and West Baton Rouge Parishes, but none have been adopted yet.

The population of the two parishes is expected to rise as follows:

	1970	1980	1990
Iberville Parish	30,746	32,600	35,200
West Baton Rouge Parish	16,864	17,900	19,300

Given the moderate increase in population projected for these parishes, land usage patterns will probably not change substantially. A generalized projection of land use for a large section of Louisiana including this area shows that the storage site would be in an area designated as "open space."[1] The proposed pipelines would cross through agricultural land, and the dock site would be in an industrial area. This study further indicates that in the land corridor affected by this project, some agricultural land may be converted to industrial usage, but the project would not infringe upon areas designated for non-industrial urban usage.[2]

REFERENCES

1. Based on Obers Projections, Series E, 1972; prepared for the U.S. Water Resources Council.

2. Inventory of Basic Environmental Data: New Orleans-Baton Rouge, U.S. Army Corps. of Engineers, March 1975,

9. CONSULTATION, RELATED PERMITS, AND DISCUSSION OF COMMENTS

Various local and regional agencies contributed information and assistance for the preparation of this Environmental Impact Statement. A list of these agencies is given in Section 9.1. Further advice and coordination will be sought from agencies having regulatory jurisdiction over those segments of the environment which will or could potentially be affected by the proposed project. Procedures are currently underway to prepare applications for those permits and licenses which would be required to proceed with the implementation of the project. Those Federal and state agencies whose concerns interface with the proposed actions are listed in Section 9.2.

The Draft Environmental Impact Statement was released for public review and comment in September 1976. A list of those agencies and organizations from which comments were requested is given in Section 9.3. The Draft Statement was sent to the Louisiana State Clearinghouse so that all state agencies of Louisiana having an interest in the proposed project could review the document and respond to statements and conclusions relating to their concerns. Those comments which were received within the time allotted, are included in Section 9.4. Minor changes to the text of the statement have been made in response to these comments. The comments from various agencies are included in their entirety in Appendix L.

9.1 AGENCIES AND GROUPS CONSULTED

In preparation of the Draft Environmental Impact Report numerous agencies, governmental units, and other groups were consulted for information and technical expertise pertaining to the proposed project. These groups are listed below:

<u>Federal Agencies</u>

Bureau of Land Management, New Orleans, Louisiana
Department of the Interior
Environmental Protection Agency, Dallas, Texas
Federal Insurance Administration
Housing and Urban Development Administration, New Orleans, Louisiana
National Marine Fisheries Commission
National Oceanic and Atmospheric Administration, New Orleans, Louisiana
Occupational Safety and Health Administration (OSHA), New Orleans, Louisiana
United States Army Corps of Engineers, New Orleans, Louisiana
United States Bureau of Indian Affairs
United States Geological Survey

<u>State Agencies</u>

Louisiana Agricultural, Stabilization and Conservation Service, Alexandria, Louisiana
Louisiana Air Control Commission, New Orleans, Louisiana
Louisiana Commission on Stream Control, Baton Rouge, Louisiana
Louisiana Department of Conservation
Louisiana Economic Development Administration, Baton Rouge, Louisiana
Louisiana Governor's Council on Environmental Quality
Louisiana Soil Conservation Service
Louisiana State Department of Education, Baton Rouge, Louisiana
Louisiana State Department of Employment Security, Baton Rouge, Louisiana
Louisiana State Planning Office, Baton Rouge, Louisiana
Louisiana Wildlife and Fisheries Commission, Baton Rouge and New Orleans, Louisiana

Local Agencies

Secretary of Police Jury, Iberville Parish,
Plaquemine, Louisiana

Other

Allied Chemical Corporation, Houston, Texas
Butler Associates, Inc., Tulsa, Oklahoma
Fenix and Scisson, Inc., Tulsa, Oklahoma
Gulf Coast Towing Association, Golden Meadows, Louisiana
Gulf Oil Corporation, Houston, Texas
LOOP, Inc. (Louisiana Offshore Oil Port),
New Orleans, Louisiana
Louisiana Power and Light
Louisiana State University, Center for Wetland Resources,
Baton Rouge, Louisiana
Louisiana State University, Institute for Environmental
Studies, Baton Rouge, Louisiana
Nicholls State University, Thibodaux, Louisiana
Texas A & M University, College Station, Texas
Texas Eco, Bryan, Texas

9.2 ENVIRONMENTALLY ORIENTED PERMITS AND LICENSES

Regulatory Bodies and Their Jurisdictional Concerns:

A number of Federal regulations which must be complied with during project development are listed in Table 9.1. Also included in the list are state regulations which are relevant to the program. FEA will consult with the state agencies in charge of implementing these regulations pursuant to the Intergovernmental Coordination Act of 1968.

Table 9.1 Regulatory Bodies

AGENCY	REGULATORY JURISDICTIONAL CONCERNS	REFERENCE	REMARKS
1. U.S. Army Corps of Engineers, New Orleans, District Engineer	"Regulations on Navigable Waters"	33 CRF 209	
	A. "Permits for Activities in Navigable Waters or Ocean Waters"	33 CFR 209.120	
	1. Prohibits the unauthorized obstruction or alteration of any navigable waters.	33 CFR 209.120b(2)	
	2. Discharge of dredged materials into navigable waters.	33 CFR 209.120,(b)(3), (b)(7),(g)(5)(ii)	
	3. Structures or activities affecting the navigability of navigable waters; includes structures under a navigable waterway.	33 CFR 209.120,(b)(3) (e)(i),(g)(5)(ii)	
	4. Discharge of refuse into navigable waters.	33 CFR 209.120(b)(4)	
	5. Temporary occupation with use of any sea-wall, bulkhead, etc.	33 CFR 209.120(b)(5)	
	6. Declares a national policy to encourage a productive and enjoyable harmony between man and his environment.	33 CFR 209.120 (c)(4)	
	7. Preservation of the quality of the aquatic environment as it affects the conservation, improvement and enjoyment of fish and resources.	33 CFR 209.120(c)(5)	
	8. License needed which will reflect upon properties listed in the National Register of Historic Places.	33 CFR 209.120(c)(7)	
	B. "Piers, Dredging, etc. in Waterways."	33 CFR 209.130	
	1. Structures or activities affecting the navigability of navigable waters; includes structures under a navigable waterway.	33 CFR 209.130(b)(14)	
	2. Work connecting canals to navigable waters.	33 CFR 209.130(b)(16)	
	3. Fixed structures on the outer continental shelf.	33 CFR 209.130(q)	

Table 9.1 Regulatory Bodies (continued)

AGENCY	REGULATORY JURISDICTIONAL CONCERNS	REFERENCE	REMARKS
	4. Piers or bulkheads at the coastline.	33 CFR 209.130(b)(13), (b)(12)	
	C. "Permits for Discharges or Deposits into Navigable Waters."	33 CFR 209.131	
2. U.S. Coast Guard, District Commander of 8th Coast Guard District (New Orleans)	<u>Coast Guard Regulations on Oil Spills</u>	33 CFR 154	Letters of intent must be submitted and approved 60 days prior to date the operation is intended to begin.
	A. Letter of intent to operate oil transfer facility.	33 CFR 154.110	
3. U.S. Environmental Protection Agency, Region VI	<u>Regulations on Policies and Procedures for the National Pollutant Discharge Elimination System (NPDES)</u>	40 CFR 125	
	1. These Regulations proscribe the policy and procedures to be followed by the Administrator of the U.S.E.P.A. pursuant to Sections 402 and 403 of the Federal Water Pollution Control Act.	33 USC 1251 nt	
	2. Requires permits . . . for any industrial discharges into navigable waters including the "contiguous zone" territorial sea. Such a permit would probably be necessary for discharge of effluents from the offshore and onshore terminal waste treatment facilities. In addition, should the NPDES permit system requirements not apply to a particular operation, certification is still required from the EPA administrator (or from appropriate designated State or Interstate agencies) whenever a Federal license or permit is being sought for activities which may result in discharge into the navigable waters.		The State of Louisiana does not yet have an approved program for issuing NPDES permits. However, the State has to certify that it has seen and approved the permit application before EPA will act on it.

Table 9.1 Regulatory Bodies (continued)

AGENCY	REGULATORY JURISDICTIONAL CONCERNS	REFERENCE	REMARKS
	Regulations on Oil Pollution Prevention	40 CFR 112	
	A Spill Prevention, Control, and Countermeasures Plan (SPCC) must be prepared for each oil handling facility, within six months of the commencement of facility operations.	40 CFR 112.3	
	Regulations on Transportation for Dumping, and Dumping of Materials into Ocean Waters	40 CFR 220	
	Permit for ocean dumping required for brine disposal.	40 CFR 220.1(b)(2)	
4. Louisiana Stream Control Commission (enforcement agency is the Louisiana Division of Water Pollution Control) (Baton Rouge)	(a) Certificate of Approval required for permission to discharge wastes into the public water. (b) State reviews applications for NPDES permits before submission to U.S. Environmental Protection Agency. (c) Permit for waste disposal.	Louisiana Regulation Requiring Submission of Reports for the Discharge of Industrial Waste. . . 40 CFR 123 Subpart A, Section 123.3.	Certificate of Approval required 3 to 12 weeks before beginning discharges. 3.
5. Louisiana Air Control Commission (enforcement agency is the Louisiana Division of Air Control and Occupational Health)	(a) Certificate of Approval for construction of sources of air pollution emissions. Applies to onshore turbines, barge loading and unloading facilities, surge tanks, pumps, and related facilities.	Louisiana Air Control Commission Regulations Section 6.1.	At present, no permit is required if only crude oil is handled, but this will be changed by early 1977.
	(b) Approval for open burning of land clearing debris is not specifically required at present so long as the guidelines stipulated in the air control regulations are met. However, it is advisable to notify the Division prior to such burning to determine that predicted ambient air quality and atmospheric conditions at the time of burning will be suitable and to alert the Division that burning is planned and will be properly conducted.	Louisiana Air Control Commission Regulations, Section 11.0.	

Table 9.1 Regulatory Bodies (continued)

AGENCY	REGULATORY JURISDICTIONAL CONCERNS	REFERENCE	REMARKS
6. Louisiana State Division of Health Bureau of Environmental Services	(a) Permit for installation of sewage treatment facilities and for disposal of solid and oily water wastes. (b) Plans and specifications must be approved before construction of a water supply system is commenced.	Chapter 10. Sanitary Codes, Sections 10.50 and 10.56.4, State of Louisiana	
7. Louisiana State Department of Conservation	(a) Well drilling for brine production. (b) Injection wells for salt water or waste disposal. (c) Permit required for storage of hydrocarbons.		
8. Louisiana State Department of Highways.	Right-of-way for pipelines and power lines passing under or over highways.		
9. Louisiana State Land Office	(a) Right-of-way for pipeline crossing state-owned lands and navigable waterways. (b) Surface lease for storage and transportation of oil and gas.		
10. State of Louisiana Department of Public Works	(a) Levee Leakage - for pipeline crossing, construction of ramps for access to the pipeline; construction of a dock. (b) Permit to lay pipelines under or across navigable waterways or across stream. (c) Letters of objection or no objection concerning construction of barge facilities and tanker facilities.		
11. Louisiana State Fire Marshal	(a) Approval of plans and specifications for all barge facilities, tanker facilities, and pipeline construction.		
12. Not Established	Compliance with Coastal Zone Management Plan, when adopted.*		

*Note: The State of Louisiana is in the process of developing a Coastal Zone Management Plan, but a final program has not yet been adopted. None of the adjacent coastal states have Federally approved management programs.

Table 9.1 Regulatory Bodies (continued)

AGENCY	REGULATORY JURISDICTIONAL CONCERNS	REFERENCE	REMARKS
13. Atchafalaya Basin Levee Board	(a) Permit required for any activity affecting Mississippi River flood protection levee; issued only after board receives letters of no objection from Corps and Department of Public Works. Board will submit letter of objection or no objection to Corps for activities in Mississippi River.		(a) Concerns construction of tanker facility on the Mississippi River near Addis.
	(b) Permit required for any activity involving levees within the district. Board will submit letter of objection or no objection to Corps for activities involving waterbodies.		(b) Concerns construction of pipeline to Addis tanker terminal.
14. Lafourche Basin Levee Board	Permit required for any activities involving levees within district, which includes that part of Ascension and St. James Parishes west of the Mississippi and part of Assumption Parish. Board will submit letter of no objection to Corps.		Concerns construction of alternative tanker facility near St. James and construction of pipeline to that facility.
15. West Baton Rouge Police Jury	(a) Permits required for construction of docks and buildings at tanker facility on Mississippi.		
	(b) Approval required for crossing roads, ditches, canals, waterways during pipeline construction.		
16. Ascension Parish	Approval required for all crossings of Parish roads, ditches, or canals.		For construction of pipeline to St. James tanker facility alternative.
17. Assumption Parish	Approval required for all crossings of Parish roads, ditches, or canals.		
18. Iberville Parish	Approval required for all crossings of Parish roads, ditches, or canals.		
19. St. James Parish	Approval required for all crossings of Parish roads, ditches, or canals.		

9.3 PARTIES FROM WHICH COMMENTS WERE REQUESTED

As a part of the review process for the Draft Environmental Impact Statement, comments have been requested from the departments, agencies, and organizations listed below:

Federal Agencies

Appalachian Regional Commission
Council on Environmental Quality
Department of Agriculture
Department of the Army, U. S. Corps of Engineers
Department of Commerce
Department of Defense
Department of Health, Education, and Welfare
Department of Housing and Urban Development
Department of Interior
Department of Labor
Department of State
Department of Transportation
Department of Treasury
Energy Research and Development Administration
Environmental Protection Agency
Federal Power Commission
Interstate Commerce Commission
Nuclear Regulatory Commission
Tennessee Valley Authority
Water Resources Council

State Agencies

Texas and Louisiana State Clearinghouses
New York State, Office of Environmental Analysis

Regional and Local Agencies

Gulf States Marine Fisheries Commission
Iberville Parish Police Jury
Louisiana Offshore Terminal Authority

Other Organizations

Allied Chemical Corporation
American Fisheries Society
American Littoral Society
American Petroleum Institute

Center for Law and Social Policy
Ecology Center of Louisiana, Inc.
Electric Power Research Institute
Environmental Defense Fund, Inc.
Environmental Policy Center
Friends of the Earth
Funds for Animals, Inc.
Institute of Gas Technology
Interstate Natural Gas Association
Izaak Walton League of America
LOOP, Inc.
National Association of Counties
National Audubon Society
National League of Cities
National Parks and Conservation Association
National Resource Defense Council, Inc.
National Science Foundation
National Wildlife Federation
Seadock, Inc.
Sierra Club
Sierra Club-Gulf Coastal Regional Conservation Committee
Sierra Club-Southern Plains Regional Conservation Committee
U. S. Conference of Mayors

9.4 PARTIES FROM WHICH COMMENTS WERE RECEIVED

9.4.1 Federal Agencies

9.4.1.1 Advisory Council on Historic Preservation

Comment

"We would suggest . . . that the final environmental statement for the project contain evidence of the Louisiana State Historical Preservation Officer's concurrence in FEA's determination of no effect."

Response

The Louisiana State Historical Preservation Officer was contacted by letter dated November 29, 1976 regarding existing or potential sites of historical interest which might be affected by the project. No response has been received.

9.4.1.2 Department of the Army, New Orleans District, Corps of Engineers

Comment a

"The statement excludes the push-ditch method of pipeline installation which is preferred for installation of pipelines in marsh areas of Coastal Louisiana. Experience has shown that this method greatly reduces potential environmental damage, and it has been proven feasible for lines in excess of 40 inches in diameter."

Response

This method is described on page 1-30 of the DES. We have noted that this is a preferred method for this type of pipe line.

Comment b

"Page 2-4, Figure 2-2. The area labeled 'marsh' should be changed to 'swamp' to conform to the description on page 2-3, paragraph 3, which is correct."

Response

The change has been made on the figure.

Comment c

"Page 2-15, paragraph 1, sentence 2. We disagree with this statement. The first sentence on page 1-23 indicates that about 1,150 acres of wooded swamp would be utilized for the brine disposal system. The wildlife resources of 1,150 acres of wooded swamp are not considered insignificant."

Response

A field large enough to accommodate 28 disposal wells spaced at 1,300 foot intervals, would cover 1,150 acres, but the total land disturbed for construction of wellpads and roadways would amount to only about 65 acres, as noted on page 1-28.

Comment d

"Page 2-73, paragraph 1. The loblolly pine is generally absent from the Mississippi River flood plain and should be deleted from this paragraph."

Response

The change has been made in the text.

Comment e

"Page 2-76, paragraph 2. The American alligator is not a commercially valuable wildlife species in the project area and should therefore be deleted from this Section."

Response

Discussion of the American alligator has been deleted from this paragraph.

Comment f

"Page 2-104, paragraph 1. The American alligator also occurs in the swamp of the project area."

Response

The change has been made in the text.

Comment g

"Page 3-5, paragraph 7. Change 'marshlands' to 'swamp.'"

Response

The change has been made in the text.

Comment h

"Page 7-44, paragraphs 2 and 3. Reasons should be given as to why the proposed source of displacement water is a better source than the alternative of Mississippi River withdrawal."

Response

Current design calls for obtaining all displacement water from the pond over cavern number 7. This pond is connected with the Port Allen Canal via Bull Bay, the East-West Canal, and the North-South Canal as shown in Figure 2-8. The Port Allen Canal is in turn connected with the Mississippi River via the Port Allen Locks at Mile Point 228.4 of the river approximately 14 miles from the dome site. The ultimate source of the displacement water in this surface water system is in fact the Mississippi River. Because the proposed displacement water supply system utilizes existing surface water channels without any significant adverse impact, it appears to be the best choice.

Comment i

"Applications for permits should be made as soon as practicable and well in advance of any need to perform the proposed work."

Response

Applications for permits are being filed well in advance of the proposed work.

Comment j

"Two factors of considerable concern are critical to continuing use of disposal areas; they are: encroachment of water courses that provide natural circulation of surface waters and creation of vector problems. Scheduling of work may create difficult and costly disposal problems."

Response

Dredge spoil is to be confined in the disposal area so that it will not encroach upon watercourses that provide natural circulation of surface waters. Disposal of solid waste materials in a sanitary land fill maintained by the Parish government should present no vector problems.

Comment k

"[The statement does not consider] the impacts of surface preparation for painting during construction and operation phases. The adverse impacts on inhabitants, structures, equipment, and terrain can be significant."

Response

It is anticipated that no surface preparation for painting will be required during construction, since the tanks will have been primed prior to shipment. Surface preparation activities during maintenance operations will probably include abrasives blasting prior to the application of paint. Emissions associated with the use of abrasive materials vary as a function of the material used as well as the type of surface. Typical abrasive materials include sand, slag, garnet, and steel grit. The amount of particulate matter entrained into the atmosphere due to the use of the substances would be a maximum for sand blasting. Emission factors developed by the San Diego County APCD* indicate that for operations using sand as the abrasive material, approximately one percent of the applied material would be emitted as fugitive dust. The impact of these emissions at the site boundary during sand blasting operations are expected to be minor assuming worst-case meteorological conditions and a violation of the applicable standards for particulate matter is not anticipated.

*Private Communication with Andy Segal, San Diego County APCD, December 1976.

On the basis of the above, it is concluded that the impact of surface preparation activities for painting during the construction and operational phases on ambient air quality is acceptable.

Comment 1

"It is noted that (in connection with the taking of excavated material from a barge slip to a suitable disposal site in accordance with a permit) mention of two important documents have been omitted from each EIS. They are the Federal Water Pollution Control Act (FWPCA), Title 33 U.S.C. 1323 and 1344, and the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA), Title 33 U.S.C. 1413(e). Section 404 of FWPCA provides for control of dredged material disposals in navigable waters and MPRSA provides for control of dredged material disposal and transportation of dredged material for disposal in ocean waters. Federal projects involving disposal in navigable or ocean waters or transportation for disposal in navigable or ocean waters are evaluated for permit and other regulatory actions by the Corps of Engineers and the Environmental Protection Agency under guidelines and criteria promulgated pursuant to the requirements of the FWPCA and MPRSA. The regulatory guidelines and criteria for Corps of Engineers evaluations of proposed projects are contained in Title 33 C.F.R., Part 209 which has also not been mentioned. Other laws enacted before 1972 are also directly related to the procedures for processing permit applications. These include the River and Harbor Act of 1899, the Fish and Wildlife Coordination Act of 1958, the National Environmental Policy Act of 1969, and the Coastal Zone Management Act of 1972, all of which are referenced in Title 33 C.F.R., Part 209. A statement to the effect that, 'the proposed disposals and transportation for disposal of dredged materials will be performed in accordance with all applicable Federal and state acts and regulations,' should be included in each EIS or Statement of Findings for each project."

Response

Permits required pursuant to the Federal Water Pollution Control Act and the Marine Protection, Research and Sanctuaries Act of 1972 are issued by the Department of the Army, Corps of Engineers. The permit procedures and the Acts upon which they are based are outlined in the Army Corps of Engineers Regulations on Navigable Waters, 33 CFR 209. Compliance with 33 CFR 209 was indicated in Table 9.2 on page 9-4, of the Draft Statement. These regulations also appear in Section 9.2 of the Final Environmental Impact Statement. The assurance that the proposed disposals will be carried out in accordance with all applicable Acts and Regulations was added to the Draft Statement, Section 3.2.1.

Comment m

"Including consideration of admittedly excessive emissions and conservation and economic factors, it would seem that application of vapor recovery technology should be given equal consideration for all SPR sites."

Response

Emission control technology for marine terminals require three systems: (1) a ship-side vapor collection system, (2) a shore-side collection system, and (3) a vapor control unit. The vapor control unit represents the key consideration in emission control technologies, and there are several units which are currently used in the petroleum industry. Incineration and refrigeration are the most appropriate methods for the Bayou Choctaw Marine terminal.

The shipboard vapor collection system conveys the hydrocarbon vapors to the shore-side system, with both systems having collection efficiencies between 90 and 95 percent. These vapors are then incinerated via an elevated, smokeless flare. Smokeless flares convert the hydrocarbons to carbon dioxide and water with better than 99% efficiency. Flaring these gases can create sulfur dioxide and nitrogen oxides if sufficient sulfur and nitrogen are present in the vapors. These combustion by-products can be removed with at least 90 percent recovery by scrubbing the gas with water. The overall efficiency of a collection-incineration emission control system is greater than 95 percent.

Refrigeration of the collected hydrocarbon vapors results in the liquefaction of the vapors which can then be reinjected into the crude oil at the marine terminal. This recovery has been shown to be greater than 90 percent efficient. Should reinjection not be feasible, the recovered vapors can be used for fuel or sold to petrochemical industries. The overall efficiency of such a vapor recovery system is about 86 percent.

With vapor controls having overall efficiencies between 86 percent and 95 percent, the total hydrocarbon emissions for initial fill and the 150-day drawdown would range from 100 to 280 tons.

9.4.1.3 Department of Transportation, Federal Highway Administration, Baton Rouge, Louisiana

Comment a

For states where the proposed sites are located, a circulation of the Draft Environmental Statement directly to the state agency would be appropriate.

Response

FEA policy regarding distribution of environmental statements indicates that distribution is to be made through the State Clearinghouse. It is believed that the Clearinghouse can better identify those state agencies which should comment on the draft environmental statement.

Comment b

Where proposed pipelines would cross or utilize highway rights-of-way and when overweight construction traffic is anticipated during construction activities, coordination with the Louisiana Department of Highways is recommended.

Response

FEA, as it develops construction plans, will consult with state agencies and will coordinate its activities with the Louisiana Department of Highways as is appropriate.

9.4.1.4 Department of the Treasury, Washington, D. C.

Comment a

"We find the statements to be objectively directed to their stated purpose, and it appears that the salt dome and mine storage facilities . . . are superior to above ground storage from both the economic and environmental viewpoints."

No response

Comment b

" . . . such facilities and the petroleum stored therein should be owned by the Government and . . . the costs should be borne directly by the beneficiaries--the U. S. energy consumers."

Response

It is intended that the proposed storage facility and petroleum stored therein would be owned by the Government. Funds for the project have been appropriated by Congress out of general tax revenues; however, energy consumers would share the burden more directly through FEA's entitlements program, as discussed in the programmatic EIS.

Comment C

The statement implies that among the benefits and costs of the project are the employment effects. Conventional cost-benefit analysis deals with a national perspective and assumes a full employment economy. Social costs of lay-offs, such as unemployment compensation can be expected to be miniscule and probably need not be considered in the analysis.

Response

It is recognized that the work force required at each individual site is insignificant compared to national employment levels. However, the sites are located in rural areas where a small scale economy could potentially be disrupted. A local perspective of employment effects was chosen in order to ascertain whether there would be any impact on the surrounding towns and parishes, and if so, to assess the magnitude of such impacts.

9.4.1.5 Environmental Protection Agency Region, Dallas, Texas

Comment a

"Oxidant air quality data recorded in 1975 in the Southern Louisiana-Southeast Texas Air Quality Control Region (AQCR) recorded second-high oxidant levels for the Baton Rouge area at 0.170 parts per million (ppm), New Orleans at 0.094 ppm, and Lake Charles at 0.174 ppm. The Louisiana State Implementation Plan (SIP) required revision for photochemical oxidants for the Louisiana portion of the Southern Louisiana-Southeast Texas AQCR (41 Federal Register, No. 138, July 16, 1976). The state is required to submit a revision of the SIP to achieve the attainment of the national standard for photochemical oxidants by July 1977. Inclusion of the above information would strengthen the final statement."

Response

Data collected in the southern third of the state indicates that the hydrocarbon and oxidant standards were violated during the period 1974-1975. A study performed by Kem-Tech Laboratories, Inc.* indicated that the three-hour hydrocarbon standard was consistently violated during 1974 in Lafourche Parish. This is not uncommon, however, as the subject standard is fairly consistently exceeded in most parts of the United States. The key issue in a discussion of hydrocarbon emissions is the reactive fraction, the type of gaseous hydrocarbons felt to contribute to smog formation. The fraction of reactive species was not quantified in the Kem-Tech monitoring program; however, elevated oxidant levels as observed in the area by the LACC during 1975 attest to the presence of reactive hydrocarbons and oxides of nitrogen. During 1975 in the Louisiana portion of the Southern Louisiana-Southeast Texas AQCR, second-highest hourly oxidant readings in excess of the national standard were recorded at Baton Rouge (340 g/m^3), New Orleans (188 g/m^3), and Lake Charles (348 g/m^3). These data indicate that sufficient amounts of reactive species are present in the atmosphere to result in significant photochemical activity. However, the primary sources of the reactive species are difficult to discern as regional transport mechanisms are involved.

*Kem-Tech Laboratories, Inc., Supplemental Report, Air Pollution Study of Lower Lafourche Parish, Louisiana, prepared for LOOP, Inc., February 28, 1975.

A synopsis of the available air quality data from local and regional sources indicates that existing pollutant levels at Bayou Choctaw are below the applicable State and Federal air quality standards with the exception of hydrocarbons and photochemical oxidants. The latter contaminant will violate the applicable standards on occasion while hydrocarbon levels will often be in excess of the three-hour national standard. However, the local average fraction of reactive hydrocarbons has not been established.

Comment b

"When the oil is removed from the storage cavities, some of the oil will remain on the walls of the cavities and therefore in the brine. When oil is reintroduced to the caverns, the brine will carry the entrained oil with it. The statement should provide assurances that the concentration of entrained oil in this brine will be such that no adverse impacts to the disposal aquifer will occur. The statement should discuss the possibility of the need for treatment of the brine for removal of the oil as well as the ultimate disposal of any recovered oil. A quantitative discussion of evaporative hydrocarbon emissions originating from the proposed brine storage reservoir should also be included in the statement."

Response

All of the caverns under consideration for petroleum storage are currently filled with brine. The walls of such caverns will thus be water-wetted when the brine is displaced by crude oil during the first storage cycle. Although experimental data is currently not available involving water, oil, and salt, past experience involving water, oil, and other material* such as sand or rock suggest that water as opposed to oil will preferentially wet the salt wall. Thus, even when the cavern is filled with oil, there is reason to believe that the walls will remain water-wetted. In this case, when the oil is displaced by water, no oil film will be present on the walls. If, however, the walls are oil-wetted, a thin film of oil might initially occur along the walls when the oil is being displaced by water. Near the bottom of the cavern, however, the walls would remain water-wetted because this portion of the cavern

*V. L. Streeter, Handbook of Fluid Dynamics, New York, 1961.

always contains brine. Thus, as the oil is displaced by fresh or brackish water, the salt walls at the bottom will commence being dissolved by incoming water. Thus, any oil film will tend to be "rolled up" as the salt wall to which the film is attached is essentially dissolved out from under it. For these reasons the presence of an oil film on the walls for any long period of time is unlikely when the cavern is filled with either water or brine.

Although the film may not be present, the horizontal interface between the oil (above) and the water (below) will always be present whether the cavern is filled with oil or water. This interface will allow some of the more soluble constituents of the oil to pass into solution in the water which will with time grow increasingly saline. The solubility of crude oil in brine is unknown, but in sea water such solubility ranges from 12.3 to 17.4 ppm for representative crude oils.* With increasing salinity, the solubility of the oil should decrease and thus the maximum level of oil dissolved in the brine should not exceed the range for sea water.

In addition to dissolved oil, some of the oil will form an emulsion in the water. Such an emulsion can be divided into two parts. The first part consists of the larger globules which may initially be present, but which with time will tend to rise to the oil-water interface. At the interface, these globules may coalesce with the main body of oil or they may cluster together, possibly forming a separate layer along the interface. The second part of the emulsion consists of the smaller globules or micelles which are sufficiently small to remain permanently in emulsion. The micelles may be distributed throughout the brine in the emulsion layer, but logically would be present in greatest concentration near the interface already noted. The amount of oil in either type of emulsion is generally dependent upon the type and degree of agitation occurring at the oil-water interface during both the filling and withdrawal operations and cannot be predicted. To minimize producing such an emulsion, the filling and withdrawal operations would be accomplished with minimum agitation of the interface in general.

*I. Lysyl and E. C. Russell, Water Research, Volume 8, p. 863, 1974.

Because of the factors already described during the process of filling the cavern with oil, a certain amount of oil in solution will be transported with the displaced brine. The maximum amount in solution would appear to be less than 18 ppm. For a ten million barrel cavern this would be approximately 180 barrels of oil. Care will be taken to provide a sufficient distance between the emulsion layer and the withdrawal point so that the emulsion is not transported with the displaced brine.

With respect to the disposal of the brine by subsurface injection, the presence of oil in solution in the quantities noted previously would pose no apparent problem, but the presence of oil in emulsion could possibly cause clogging of the sands of the receiving formation in or near the well bore. Such clogging would reduce permeability, and would thus produce larger pressure increases than originally anticipated. This is clearly undesirable. Thus, the level of emulsion of oil in water must be minimized for safe and efficient subsurface disposal.

Based on the available information, sound engineering practices would dictate monitoring the displaced brine for the level of oil in solution or emulsion prior to subsurface disposal. By use of proper operating procedures, however, these levels can be minimized and an oil-water separation system does not appear necessary at this time. Such a system will be incorporated into the design, however, if studies which are currently underway provide any indication that unacceptable levels of oil in emulsion will be encountered. A quantitative assessment of vapor releases from the surface of the brine pond would be very conjectural since the primary source of such releases would be from oil globules in the emulsion, and efforts will be made to prevent the emulsion from being pumped out of the cavern.

Comment c

The buried pipelines will be coated with cathodic protection. The Final EIS should address the effects of any potential leaching of cathodic material on the groundwater."

Response

Pipelines are usually coated with a relatively inert asphalt-like material which provides oxidation protection and insulation properties. In addition cathodic protection is achieved by having a small DC current on the pipeline or by having a sacrificial metal such as a magnesium alloy (e.g., 6 percent aluminum, 3 percent zinc, and 91 percent magnesium) as the anode and the pipeline as the cathode. The technique of utilizing a small DC current to inhibit electrochemical reactions introduces no foreign materials into the environment. The sacrificial anode scheme utilizes the oxidation of the magnesium anode to provide the current flow to inhibit oxidation of the pipeline and consequently forms ionic materials over the lifetime of the anode. It is generally assumed that for a large pipeline of 30 inches in diameter or more, a 17 to 32 pound anode rod will be utilized with a coating of plaster which is composed of gypsum, clay, and sodium sulfate to provide protection for a section of pipe several hundred feet long (e.g. 500 feet) for aproximately 12 to 14 years. The plaster will also deteriorate as the anode is oxidized. One could expect to obtain sulfates, silicates, oxides, and carbonates of the aluminum, magnesium, zinc, and calcium materials from the anode and its coating.

The pipeline in the region of Bayou Choctaw is buried in a swampy soil which is composed of silts, clays, and probably some organic matter. This soil represents the upper layer of an aquitard approximately 100 feet thick as shown in Figure 2.11 (page 2-40). Because the water table is near the surface and the soil is usually water saturated, the carbonates formed from reactions between the groundwater and the chemicals used for the cathodic system will contribute to the hardness of the water. Sulfates present in the coating will dissolve slowly and contribute to the levels in the groundwater. The fact that this groundwater moves very slowly (less than 50 feet per year), coupled with the slow dissolution rate of these chemicals, indicates that there will be little change in the groundwater quality. The insoluble materials are expected to aggregate on clay particles present in the soil.

Comment d

"The facility is planned to be used for five fill and displacement cycles. However, the EIS does not address termination of the facility. The actions proposed as part of the termination plan could affect future use of the dome, subsidence, and groundwater, and therefore, should be presented in the final statement."

Response

FEA is developing a facility to be used for an indefinite period of time. It is anticipated that this facility will be dedicated to storage of petroleum or other products, and as such, the development of the termination plan at this time is believed to be inappropriate. At such time as termination of the use of the facility is being considered, such a plan will be developed utilizing the most current information available to insure protection of the environment.

A Section referring to termination of the facility has been added to the text of Chapter 1.

9.4.1.6 Federal Power Commission, Washington, D. C.

Comment a

". . .there does not appear to be any conflict between the development of the SPR and the continued production, transportation, and sale of natural gas from domestic sources. It therefore does not appear that the proposed project presents any conflict with FPC jurisdictional interests."

No Response

9.4.1.7 Nuclear Regulatory Commission, Washington, D. C.

Comment a

"We have determined that the proposed actions, per se, have neither radiological, health, and safety aspects, nor will they adversely affect any activities subject to regulation by the Nuclear Regulatory Commission."

No Response

9.4.1.8 Tennessee Valley Authority, Chattanooga, Tennessee

Comment a

"We have determined that we have no significant comments on any of the five sites or statements involved in the Strategic Petroleum Reserve."

No Response

9.4.2 State Agencies

9.4.2.1 Louisiana Geological Survey, Baton Rouge, Louisiana

Comment a

"It is our opinion that the geological presentations are well done and adequate for the purposes intended."

No Response

9.4.2.2 Louisiana State Soil and Water Conservation Committee, Baton Rouge, Louisiana

No Comments

9.4.3 Local Agencies

9.4.3.1 Capitol-Area Groundwater Conservation Commission, Baton Rouge, Louisiana

Comment a

"State Act 641 (1976), relative to the underground storage of hydrocarbons, gave to the Commissioner of Conservation the power and duty to regulate such activities and to hold public hearings to assure 'that the use of the salt dome cavity for the storage of liquid and/or gaseous hydrocarbons will not contaminate other formations containing fresh water.' Hopefully, presentations to be made by your agency, at these hearings, will discuss and offer solutions to any potential long-term and short-term problems that could adversely affect our groundwater resources."

Response

Should public hearings be held under the Act, FEA will attend and be prepared to discuss any potential long-term and short-term problems that could adversely affect the groundwater resources of the area.

Comment b

"Although the principal aquifers of our district contain saline water near the Choctaw dome, the deepest fresh water zone--the 2,8000-foot sand of the Baton Rouge area--whose base is at a depth of about 4,000 feet in the Bayou Choctaw field area, should be protected from encroachment that may be caused by injection operations. Before final plans are approved, a study should be made to map the base of the 2,800-foot sand in order to assure that all the aquifers of our district are protected. Casing in the injection wells should be set and cemented to below the base of the 2,800-foot sand and the injection zone(s) should be separated from the bottom of the 2,800-foot sand by an areally extensive clay or shale with a thickness of about 100 feet. The plan discussed in the EIS (pages 3-34 and G-18) for using injection zones below a depth of 6,000 feet should satisfy the latter requirement. Although it is recognized that the normal rate of groundwater movement is generally very slow (less than a foot per day), and that faults in the area affect to some extent the northward movement of salt water, it is also recognized that assurance is needed to prevent the movement, especially on a long-term basis, of salt water toward and into the heavily pumped groundwater areas in West Baton Rouge, Pointe Coupee, and East Baton Rouge Parishes."

Response

Before committing to disposal by injection, FEA will conduct the appropriate studies to map the base of the 2,800-foot sand. Casings in the injection wells will be set and cemented to below the base of this aquifer. The existence of an areally extensive clay or shale with a thickness of approximately 100 feet will be confirmed.

Based on currently available information, the disposal zone appears sufficiently separated from the heavily pumped aquifers in West Baton Rouge, Pointe Coupee, and East Baton Rouge Parishes to preclude any appreciable movement of the salt water interface toward and into those parishes. The worst case envisioned would involve 23.5 million barrels of brine (25% of the total injected) leaking into the 2,800-foot sand. As a result of this worst case condition, the salt water interface, which is roughly 14 miles north of the site already, would move only 94 feet to the north. This worst case, however, represents an extremely pessimistic view because it neglects: (1) the fact that the brine will be injected over a depth interval of 2,000 feet which is separated from the 2,800-foot sands by approximately 1,000 feet of sands and clays; (2) the compressibility of the water in the aquifers; (3) the elasticity of the aquifer; (4) the presence of intervening faults; and (5) the probable presence of discontinuities in the aquifer (pinch-outs).

Comment c

"Section 1.3.1.3. A brine surge pond that will hold approximately 500,000 barrels is discussed. No mention is made of what action will be taken to protect the underlying alluvial aquifer from salt water seepage through the confining layer. The confining layer will slow, but not stop the vertical movement. In addition to depending upon the lower permeability of the confining layer to retard the vertical movement of salt water, consideration should be given by planners to using an artificial impermeable commercial sealer and/or liner in the pond to prevent the movement of salt water through the confining layer into the shallow aquifer that is a local source of water."

Response

The brine surge pond will be constructed with a membrane liner.

Comment d

"Page 2-39. The maximum depth of fresh water on the illustration on this page, as well as the cross sections in the EIS, is based on the chloride content of 250 mg/l (milligrams per liter), and not dissolved solids which is the constituent now used in the Underground Injection Control Program implementing Public Law 95-523. The U.S.

Geological Survey Hydrologic Atlas 310 shows the altitude of the top of 3,000 mg/l dissolved solids to be about 600 feet, and the altitude of the 10,000 mg/l dissolved solids surface to be about 2,000 feet below mean sea level. It should be clearly stated in the discussion of the maximum depth of fresh water in the EIS that the maximum depth of occurrence of fresh water is based on the chloride content of the water and not dissolved solids. The EIS fails to mention the fact that the salt water-fresh water interface occurs in most places in a sand."

Response

Changes have been made to the text on pages 2-38 and to Figure 2-10 to clarify the definitions of freshwater as presented in the Figure. FEA will insure that Public Law 93-523, with the appropriate definition of freshwater (less than 1,000 mg/liter total dissolved solids) is complied with. FEA has access to and has made considerable use of U.S.G.S. Hydrologic Atlas 310 in evaluating the nature of the subsurface water system in general. The EIS has been modified to make note of the fact that the salt water-fresh water interface occurs in most places in sand.

Comment e

"Beginning on page G-9, the geohydrology at the Choctaw dome area is discussed. This section should include recommendations for the locating of the 10 supply wells, whose yield will be about 2,000 gallons per minute each, and also include the location of other water wells, if any, in order to predetermine the impact on existing wells. The effects of this pumping from the alluvial aquifer could not only cause local excessive water level declines, but more importantly, could also cause salt water coning and encroachment into nearby wells. The EIS should consider these potential problems and offer alternatives, such as the use of water from the Mississippi River, and solutions that will minimize any adverse effects resulting from this pumping."

Response

The use of wells as a source of displacement water represents an alternative to the use of the surface water system, which is the proposed source. In the event that surface water systems should prove impractical or if wells are adopted as the primary source to replace the surface water systems, any necessary additional studies will be performed.

9.4.4 Individuals and Organizations

9.4.4.1 LOOP, Inc. (Louisiana Offshore Oil Port), New Orleans, Louisiana

Comment a

"There is no indication that specific, competent geomechanic analyses will be made to assure stability of multicavity configurations after five fill/withdrawal cycles. Such analyses should be required for each of the candidate salt domes (DES 76-4, -5, -6) actually selected.

"The analyses would establish allowable roof distance below the caprock, center to center spacing versus diameter (s/d ratio), vertical separation, and plastic zone proximity to the dome flank. These criteria should be related to calculated creep, stress, and subsidence for the actual or safe strength levels of the specific salt and surrounding rock. The arbitrary criteria enumerated in the programmatic draft EIS's are no substitute for geomechanic analyses."

Response

Additional studies of salt dome and storage cavern properties will be conducted as appropriate. A special analysis of cavern stability parameters at Bayou Choctaw conducted by FEA is included as Appendix J. These parameters include roof and wall thickness and cavern dimensions.

APPENDIX A

ATMOSPHERIC DISPERSION MODEL

Emission concentrations for a 10 minute sampling time downwind from a gaseous release are based on a Gaussian dispersion model.

$$\chi\ (x,0,0;H) = \left(\frac{Q}{\pi \sigma_y \sigma_z \mu}\right) \exp\left[-\tfrac{1}{2}\left\{\frac{H}{\sigma_z}\right\}^2\right]$$

where

χ = Concentration in $\mu g/m^3$ at x^m downwind

Q = Emissions rate in μg/sec of pollutants

σ_y = Sutton factors

σ_z = Sutton factors

u = Average wind velocity, meter/sec

H = Effective stack height in meters

The values for σ_y and σ_z are taken from graphs from the Workbook of Atmospheric Dispersion Estimates.[1] H is taken to be zero for ground release. Stability condition F is assumed. These assumptions lead to conservative, "worst case" estimates.

The downwind concentrations at various ranges for a unit source are given in Table A-1.

Table A-1 Downwind concentrations* from a continuous 1 gm/sec release (stable F-type atmosphere, wind speed km/sec)

x(km)	χ ($\mu gm/m^3$)
0.5	1040.0
1.0	334.0
2.0	118.0
5.0	31.2
10.0	6.22

*10-Minute sample time.

The results given above are for unvarying wind conditions over a 10 minute sampling period. The concentration can be corrected for wind meander up to 24 hour sample times by $\chi(t) \propto t^{-.17}$ power law. Table A-2 gives concentration correction ratios for 1, 3, 8, and 24 hour averages assuming (worst case) no change in wind conditions. A wind speed of 2 m/sec is assumed.

Table A-2 Variation of calculated concentration

Sample time t	$\chi(t) / \chi(10 \text{ min}) = \left(\frac{t}{10 \text{ min}}\right)^{-.17}$
10 min	1.00
1 hour	.74
3 hour	.61
8 hour	.52
24 hour	.44

The tabular correction data cannot be extended to one year to obtain annual average concentration. Instead, the "worst case" wind direction (SE) is chosen from the annual wind rose of Section 2.3. A typical wind speed is chosen to represent each speed group. The neutral stability class, D, is assumed. The annual average concentration is[1]

$$\bar{\chi} = \sum_i \frac{2.03\ Q}{\sigma \mu_i x} f_i \times 10^6$$

where

$\bar{\chi}$ = annual average concentration ($\mu gm/m^3$)

Q = source (gm/sec)

σ_z = vertical dispersion coefficient (m)

μ_i = wind speed for i^{th} group (m/sec)

x = downwind distance (m)

f_i = fraction of the time the wind is blowing in the chosen direction in the i^{th} wind speed group.

The wind speed for a group is taken to be the midvalue. The parameter, σ_z, is taken from graphs.[1]

Typical values are:

x(m)	500	1000	2000	5000	10,000
σ_z(m)	18	31	50	89	135

The values of f_i and u_i from the wind rose are:

u_i(m/sec)	f_i
.894	.014
3.576	.055
8.270	.013
12.517	.001

The values of these parameters are combined as indicated above for a source strength of 1 gm/sec from a point, ground level source. The annual average concentrations (converted to $\mu gm/m^3$) for the unit source are listed in Table A-3 at several distances.

Table A-3: Annual Sector - averaged concentrations for a gm/sec source (southeasterly winds)

Downwind Distance x (km)	Concentration ($\mu gm/m^3$)
0.5	7.37
1.0	2.14
2.0	0.664
5.0	0.149
10.0	0.0492

REFERENCES

1. U. S. Environmental Protection Agency, "Workbook of Atmospheric Dispersion Estimates," Office of Air Programs, Publication No. AP-26, Revised 1970.

APPENDIX B

AIR POLLUTION MONITORING DATA

The following data were provided by the Louisiana Air Control Commission. These data represent the most thorough and consistent monitoring results the Commission has compiled to date. The Suspended Particulate data monitoring capabilities are the most refined in the state. A few key locations are operable for oxidant monitoring; one of them is at Baton Rouge. The table is representative only of the maximum oxidant concentrations measured during the stations on-time, as well as the number of violations of the standards recorded.

Table B-1 Monthly Suspended Particulate Sampling Data

CITY: Garyville

SITE: Azalea and South Apricot St.

YEAR: 1975

SAROAD CODE: 192580002

1° Standard 24-hr. max. = 260 μg/m^3

SAMPLING TYPE: Pop. Oriented

2° Standard 24-hr. max. = 150 μg/m^3, Annual geom. mean = 60 μg/m^3

NO. OF SAMPLES: 56

ANNUAL GEOMETRIC MEAN: 51

MONTH	DAY	24 HR. MEASURE μg/m^3
Jan.	6	56
	30	34
Feb.	5	50
	11	33
	17	39
	23	35
Mar.	1	55
	7	37
	13	60
	19	44
	24	123
	31	44
Apr.	6	57
	12	38
	18	59
	24	52
	30	33
May	6	42
	12	61
	18	60
	24	46
	30	21
Jun.	5	45
	11	24
	17	35
	29	36

MONTH	DAY	24 HR. MEASURE μg/m^3
Jul.	5	57
	11	30
	17	30
	23	45
	29	31
Aug.	4	20
	10	36
	16	36
	22	49
	28	73
Sep.	3	108
	9	51
	15	71
	21	49
	27	75
Oct	3	55
	9	73
	15	80
	21	63
	27	124
Nov.	2	113
	8	66
	14	88
	20	43
	26	93
Dec.	2	76
	8	56
	14	75
	20	92
	26	56

Source: Louisiana Air Control Commission, New Orleans, La.

Table B-2 Monthly Suspended Particulate Sampling Data

CITY: Geismar

YEAR: 1975

1^{o} Standard 24-hr. max. = 260 μg/m³

2^{o} Standard 24-hr. max. = 150 μg/m³, Annual geom. mean = 60 μg/m³

NO. OF SAMPLES: 56

ANNUAL GEOMETRIC MEAN: 71

SITE: Wintz Meat Market

SAROAD CODE: 191280004

SAMPLING TYPE: Source Oriented

MONTH	DAY	24 HR. MEASURE μg/m³
Jan	6	69
	30	41
Feb.	5	43
	11	53
	17	57
	23	21
Mar.	1	96
	7	54
	13	33
	19	36
	25	109
	31	106
Apr.	6	57
	12	72
	18	43
	24	52
	30	58
May	6	146
	12	89
	18	72
	24	51
	30	31
Jun.	5	42
	11	25
	17	44
	23	64
	29	75

MONTH	DAY	24 HR. MEASURE μg/m³
Jul.	5	45
	11	71
	23	42
	29	49
Aug.	4	39
	10	50
	16	38
	22	109
	28	97
Sep.	3	170
	9	126
	15	145
	21	68
	27	75
Oct.	3	44
	9	138
	15	172
	21	177
	27	163
Nov.	2	166
	8	151
	14	180
	20	69
	26	107
Dec.	2	181
	8	96
	14	139
	20	89
	26	38

Source: Louisiana Air Control Commission, New Orleans, La.

Table B-3 Monthly Suspended Particulate Sampling Data

CITY: Carville

SITE: Public Health Service Hospital

YEAR: 1975

SAROAD CODE: 191280002

1° Standard 24-hr. max. = 260 μg/m³

SAMPLING TYPE: Pop. Oriented

2° Standard 24-hr. max. = 150 μg/m³, Annual geom. mean = 60 μg/m³

NO. OF SAMPLES: 37

ANNUAL GEOMETRIC MEAN: 36

MONTH	DAY	24 HR. MEASURE μg/m³
Jan.	12	20
	18	42
Feb.	5	29
	17	36
	23	15
Mar.	1	35
	7	39
	25	81
	31	34
Apr.	18	37
	24	35
May	18	45
	24	35
	30	13
Jun.	5	24
	17	27
	23	20
	29	34

MONTH	DAY	24 HR. MEASURE μg/m³
Aug.	10	21
	22	58
	28	46
Sep.	3	81
	9	61
	15	69
Oct.	3	39
	9	34
	15	42
	21	64
	27	63
Nov.	2	45
	8	41
	14	42
	20	19
Dec.	8	40
	14	38
	20	33
	26	15

Source: Louisiana Air Control Commission, New Orleans, La.

Table B-4 Monthly Suspended Particulate Sampling Data

CITY: Addis

SITE: West River Subdivision

YEAR: 1975

SAROAD CODE: None

1° Standard 24-hr. max. = 260 μg/m^3

SAMPLING TYPE: Source Oriented

2° Standard 24-hr. max. = 150 μg/m^3, Annual geom. mean = 60 μg/m^3

NO. OF SAMPLES: 6

ANNUAL GEOMETRIC MEAN: 62

MONTH	DAY	24 HR. MEASURE μg/m^3	MONTH	DAY	24 HR. MEASURE μg/m^3
Jan.	1	50			
	7	45			
	13	58			
	19	79			
	25	96			
	31	60			

Source: Louisiana Air Control Commission, New Orleans, La.

Table B-5 Monthly Suspended Particulate Sampling Data

CITY: Baton Rouge SITE: LSU

YEAR: 1975 SAROAD CODE: 190280003

1° Standard 24-hr. max. = 260 μg/m³ SAMPLING TYPE: Pop. Oriented

2° Standard 24-hr. max. = 150 μg/m³, Annual geom. mean = 60 μg/m³

NO. OF SAMPLES: 55

ANNUAL GEOMETRIC MEAN: 56

MONTH	DAY	24 HR. MEASURE μg/m³	MONTH	DAY	24 HR. MEASURE μg/m³
Jan.	6	60	Jul.	5	51
	12	31		11	38
				17	38
Feb.	5	90		23	58
	11	44		29	108
	17	59			
	23	41	Aug.	4	62
				10	39
Mar.	1	62		16	53
	7	71		22	35
	13	37		28	77
	19	120			
	25	145	Sep.	3	124
	31	35		9	46
				15	59
Apr.	6	59		21	43
	12	53		27	78
	18	66			
	24	48	Oct.	3	64
	30	33		9	86
				15	44
May	6	52		21	137
	12	67		27	74
	18	70			
	24	43	Nov.	2	47
				8	35
Jun.	5	45		14	216
	11	21		26	41
	17	38			
	23	26	Dec.	2	75
	29	50		8	96
				14	43
				20	49
				26	40

Source: Louisiana Air Control Commission, New Orleans, La.

Table B-6 Monthly Suspended Particulate Sampling Data

CITY: Baton Rouge

YEAR: 1975

1^{o} Standard 24-hr. max. = 260 μ g/m^3

2^{o} Standard 24-hr. max. = 150 μg/m^3, Annual geom. mean = 60 μg/m^3

NO. OF SAMPLES: 53

ANNUAL GEOMETRIC MEAN: 54

SITE: 3142 Evangeline St.

SAROAD CODE: 190280002

SAMPLING TYPE: Pop. Oriented

MONTH	DAY	24 HR. MEASURE μ g/m^3
Jan.	6	105
	12	23
	18	55
	24	62
	30	42
Feb	5	90
	11	44
	17	62
	23	69
Mar.	1	69
	7	88
	13	47
	19	77
	25	119
	31	40
Apr.	6	56
	12	51
	18	65
	24	52
	30	32
May	6	56
	12	81
	18	68
	24	48
Jun.	6	53
	11	30
	17	47
	23	33
	29	48

MONTH	DAY	24 HR. MEASURE μ g/m^3
July	5	62
	11	45
	17	45
	23	77
	29	65
Aug.	4	46
	10	37
	16	74
	22	42
	28	63
Sep.	3	99
	9	47
	15	50
	21	39
Nov.	2	39
	8	28
	14	69
	20	51
	26	35
Dec.	2	87
	8	52
	14	47
	20	58
	26	47

Source: Louisiana Air Control Commission, New Orleans, La.

Table B-7 Continuous Oxidant (O_3) Sampling Monthly Report

CITY: Baton Rouge SAROAD CODE: 190280003

YEAR: 1975

1° and 2° Standard: 1 hour max. = 0.08 ppm

MONTH	HIGHEST	2nd HIGHEST	# VIOLATION	% TIME OBSERVED
January	0.061 1/25/75	0.0500 1/15/75	0	97
February	0.0550 2/13/75	0.0470 2/14/75	0	69
March	0.0580 3/25/75	0.0550 3/18/75	0	79
April	0.0740 4/22/75	0.0580 4/16/75	0	95
May	0.1470 5/18/75	0.1220 5/12/75	24	97
June	0.1470 6/26/75	0.1120 6/27/75	11	65
July	0.1420 7/12/75	0.1270 7/13/75	19	98
August	0.0790 8/5/75	0.0760 8/8/75	0	86
September	0.1020 9/1/75	0.0810 9/18/75	4	98
October	0.1700 10/11/75	0.1150 10/9/75	12	97
November	0.0570 11/25/75	0.0400 11/17/75	0	98
December	0.0450 12/27/75	0.0420 12/4/75	0	95

Source: Louisiana Air Control Commission, New Orleans, La.

APPENDIX C

NOISE ANALYSIS

Definitions and Terminology

A-Weight - A frequency weighting network which is used in sound analysis to simulate the response of the human ear. (A-weighted sound levels are expressed in units of dBA).

Environmental Noise - By section 3 (11) of the Noise Control Act of 1972, the term "environmental noise" means the intensity, duration, and character of sounds from all sources.

Equivalent Sound Level - The level of a constant sound which, in a given situation and time period, has the same sound energy as does a time varying sound. Technically, equivalent sound level is the level of the time weighted, mean square, A-weighted sound pressure. The time interval over which the measurement is taken should always be specified.

Sound Level - The quantity in decibels measured by a sound level meter satisfying the requirements of American National Standards Specification for Sound Level Meters S1.4-1971. Sound level is the frequency-weighted sound pressure level obtained with the standardized dynamic characteristic "fast" or "slow" and weighting A, B, or C; unless indicated otherwise, the A-weighting is understood. The unit of any sound level is the decibel, having the unit symbol dB.

Sound Pressure Level - In decibels, 20 times the logarithm to the base ten of the ratio of a sound pressure to the reference sound pressure of 20 micropascals (20 micronewtons per square meter). In the absence of any modifier, the level is understood to be that of a mean-square pressure.

Federal Guidelines

The Federal Environmental Protection Agency has established guidelines for limits of L_{dn} requisite for the protection of public health and welfare.*

Table C-1 Summary of Noise Levels Identified As Requisite to Protect Public Health And Welfare with an Adequate Margin of Safety

Effect	Level	Area
Hearing Loss	$L_{eq}(24) \leq 70dB$	All areas.
Outdoor Activity interference and annoyance.	$L_{dn} \leq 55dB$	Outdoors in residential areas and farms and other outdoor areas where people spend widely varying amounts of time and other places in which quiet is a basis for use.
	$L_{eq}(24) \leq 55dB$	Outdoor areas where people spend limited amounts of time, such as school yards, playgrounds, etc.
Indoor Activity interference and annoyance.	$L_{dn} \leq 45dB$	Indoor residential areas.
	$L_{eq}(24) \leq 45dB$	Other indoor areas with human activities such as school, hospitals, etc.

$L_{eq(24)}$ represents the sound energy averaged over a 24-hour period.

L_{dn} represents the L_{eq} with a 10 dB nighttime weighting.

*Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, "USEPA, 550/9-74-004, March 1974.

Symbols

L_{eq} Equivalent A-weighted sound level over a given time interval.

L_d Daytime equivalent A-weighted sound level between the hours of 0700 and 2200.

L_n Nighttime equivalent A-weighted sound level between the hours of 2200 and 0700.

L_{dn} Day-night average sound level - the 24 hour A-weighted equivalent sound level, with a 10 decibel penalty applied to nighttime levels.

i.e.,

$$L_{dn} = 10 \log \left[\frac{15}{24} \times 10^{\frac{L_d}{10}} + \frac{9}{24} \times 10^{\frac{L_n+10}{10}}\right].$$

Analysis of Construction Operations Noise

The calculation of L_{eq} and L_{dn} requires the estimations of the noise level for each type of machine, the number of machines for each machine type, and the usage factor at each construction site. From these factors a noise impact area about each construction site is calculated. The impact area is then examined for type of land use, i.e., residential, limited outdoor use, schools, playgrounds, etc. Where people are exposed to levels of L_{dn} >55dB or $L_{eq}(24)$>55dB, a noise impact is indicated.

Noise Measures

The descriptors L_{eq} and L_{dn} quantify those aspects of sound which have been found to correlate well cumulative community exposure to noise and community annoyance. Accordingly, the Environmental Protection Agency has selected Equivalent Sound Level (L_{eq}) for the purpose of identifying levels of environmental noise.

Equivalent Sound Level is formulated in terms of the equivalent steady noise level which in a stated period of time would contain the same noise energy as the time-varying noise during the same time period.

The mathematical definition of L_{eq} for an interval defined as occupying the period between two points in time t_1 and t_2 is:

$$L_{eq} = 10 \log \left[\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} \frac{p^2(t)}{p_o^2} \, dt \right]$$

where p(t) is the time varying sound pressure and p_o is a reference pressure taken as 20 micropascals.

APPENDIX D

WATER QUALITY ANALYSIS AND CONCLUSIONS

APPENDIX D.1

PRECIPITATION DATA IN THE VICINITY OF THE BAYOU CHOCTAW DOME

This appendix contains three figures concerning precipitation in the vicinity of the Bayou Choctaw Dome. Figure D.1-1 presents the distribution of average winter-spring precipitation surplus in southern Louisiana based on monthly water balances for the 24-year period from 1945 to 1968. The corresponding summer-autumn precipitation surplus is given in Figure D.1-2. The average seasonal precipitation deficits for the same area are provided in Figure D.1-3.

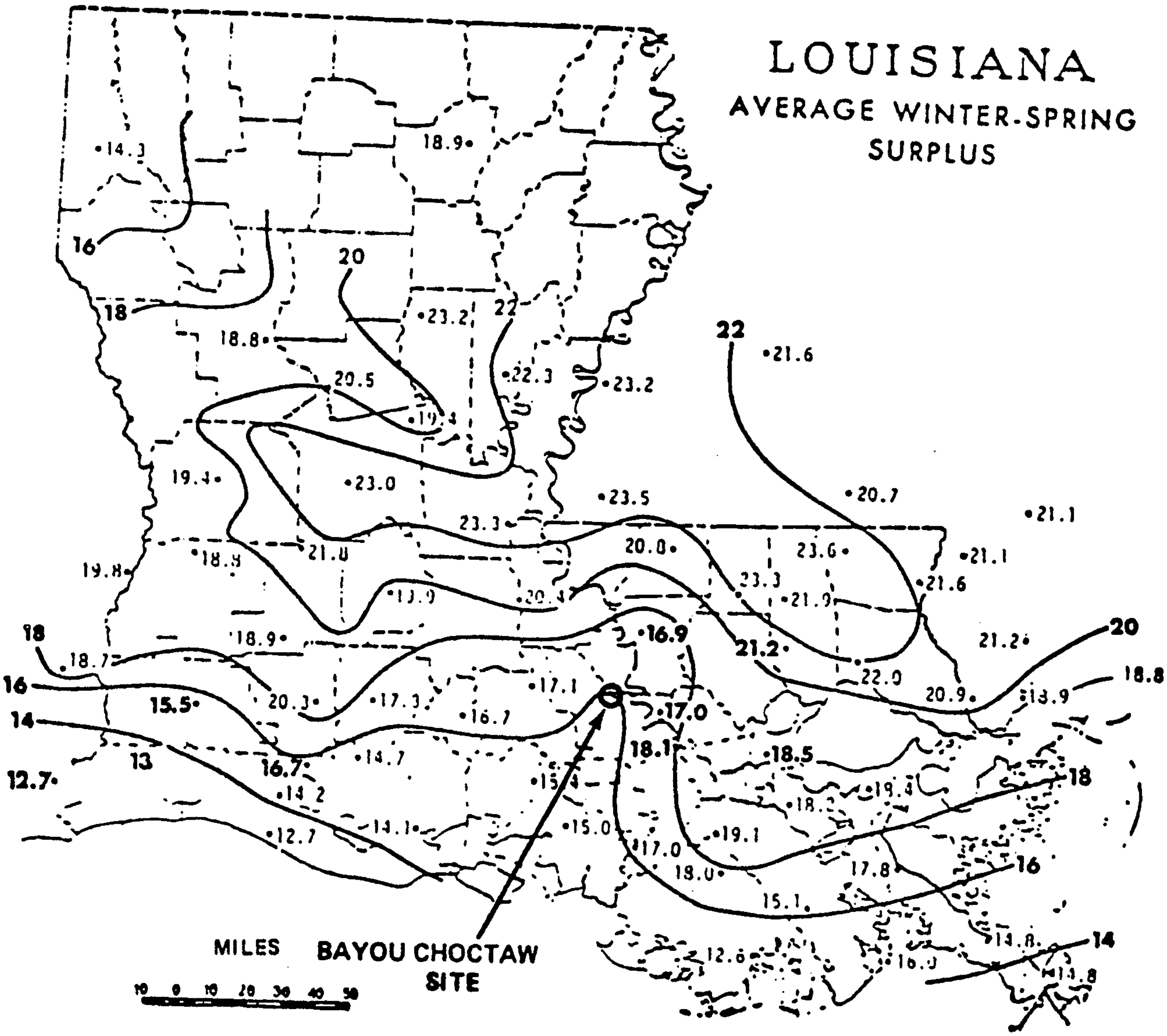

Figure D.1-1

Distribution of average winter-spring precipitation surplus in southern Louisiana. Station averages were determined from monthly water balances for the 24-year period between 1945 and 1968. Surplus values are given in inches.

Source: "Water Balance in Louisiana Estuaries," Report No. 3, Center for Wetlands Resources, Louisiana State University, Baton Rouge, La., June 1973.

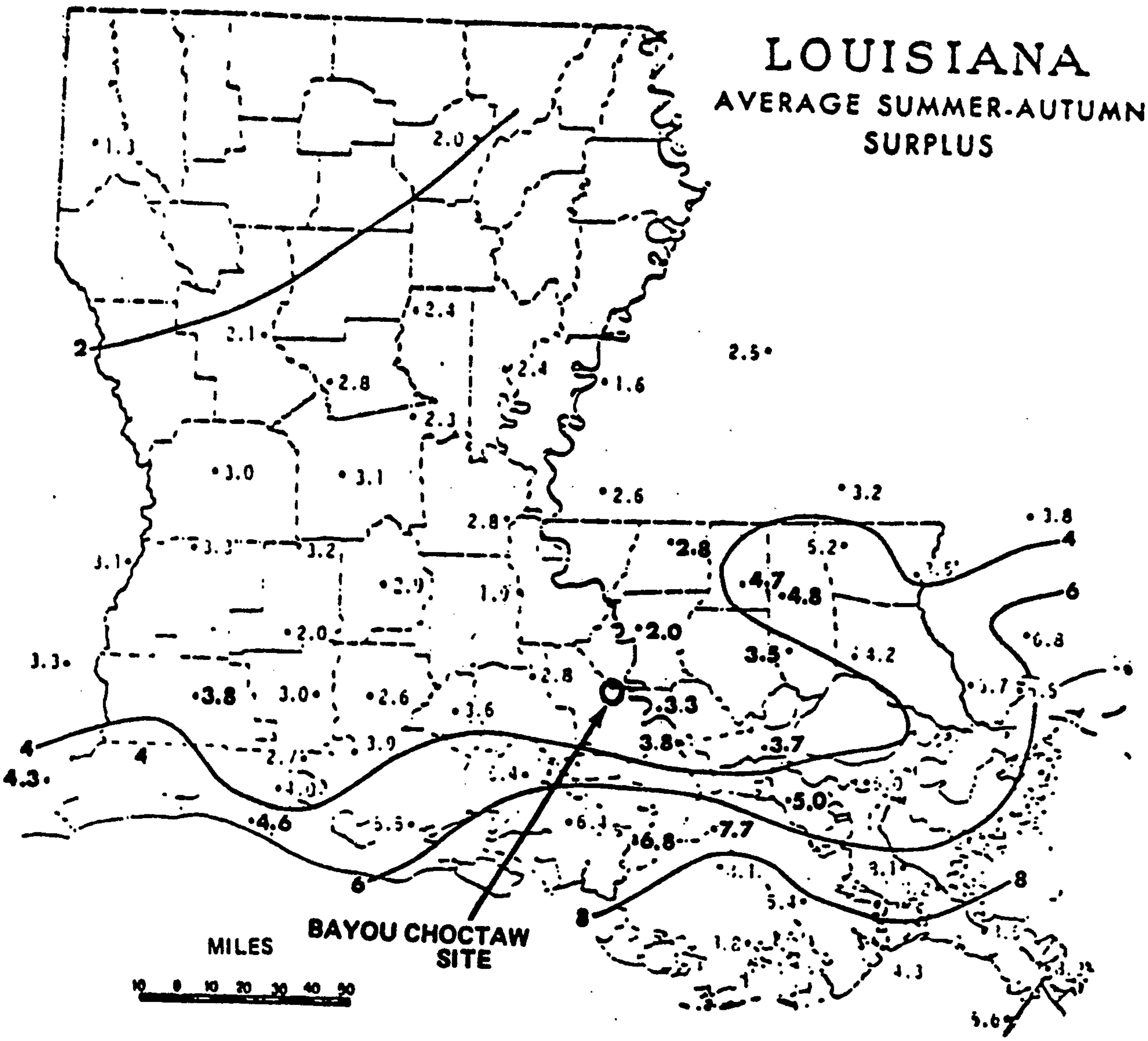

Figure D.1-2

Distribution of average summer-autumn precipitation surplus in south and central Louisiana. Station averages were determined from monthly water balances for the 24-year period between 1945 and 1968. Surplus values are given in inches.

Source: "Water Balance in Louisiana Estuaries," Report No. 3, Center for Wetlands Resources, Louisiana State University, Baton Rouge, La., June 1973.

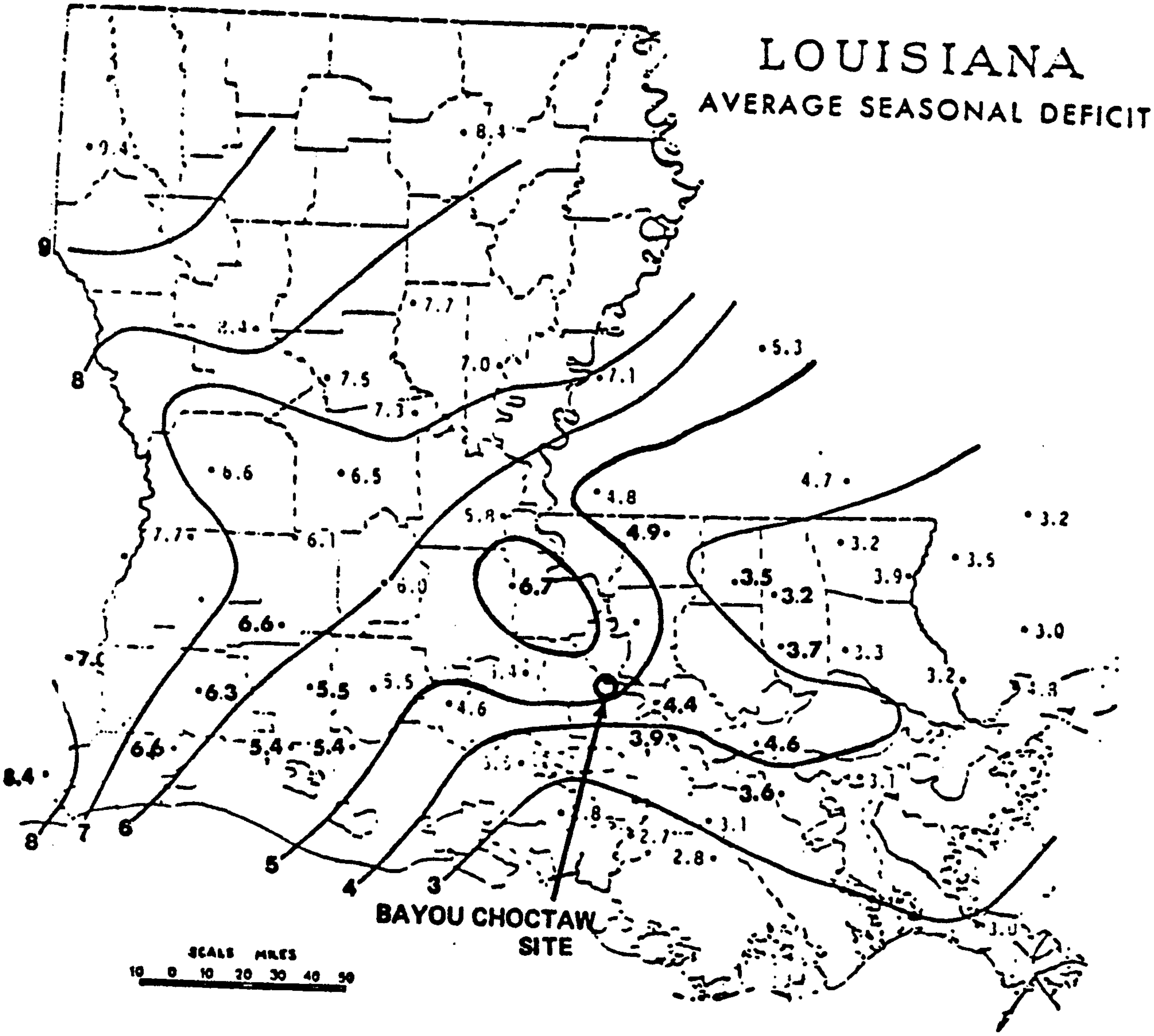

Figure D.1-3

Average seasonal precipitation deficits in south and central Louisiana. Station averages were determined from monthly water balances for the 24-hour period between 1945 and 1968. Deficit values are given in inches.

Source: "Water Balance in Louisiana Estuaries," Report No. 3, Center for Wetlands Resources, Louisiana State University, Baton Rouge, Louisiana, June 1973.

APPENDIX D.2

VOLUMETRIC FLOW DATA FOR THE

MISSISSIPPI RIVER

This appendix consists of one table containing data for the volumetric flow of the Mississippi River. Table D.2-1 presents data for the average discharge rate for the river at Baton Rouge during the period from December 1973 to September 1974.

Table D.2-1. Mississippi River Flow Data

Stream	Tributary To	Location	Drainage Area (sq.mi.)	Measured Previously (water years)	Measurements Date	Measurements Discharge*
Mississippi River	Gulf of Mexico	Lat 30°30'25", long 91°11'55", East Baton Rouge - West Baton Rouge Parish line, at bridge on U.S. Highway 190, at Baton Rouge, La., MP 228.4	f1,243,500	1941-58b, 1973	12-13-73	926,000
					12-20-73	951,000
					12-27-73	771,000
					1- 3-74	781,000
					1- 8-74	880,000
					1-10-74	921,000
					1-11-74	940,000
					1-17-74	1,060,000
					1-17-74	1,030,000
					1-24-74	1,070,000
					1-24-74	1,040,000
					1-31-74	1,090,000
					1-31-74	1,070,000
					2- 7-74	1,160,000
					2-14-74	1,160,000
					2-22-74	1,110,000
					2-28-74	1,020,000
					3- 7-74	893,000
					3- 7-74	868,000
					3-14-74	872,000
					3-21-74	858,000
					3-21-74	828,000
					3-28-74	894,000
					3-28-74	901,000
					4- 4-74	930,000
					4-11-74	818,000
					4-18-74	814,000
					4-26-74	792,000
					9-17-74	398,000

*In cubic feet per second

Source: "Water Resources Data for Louisiana", U.S. Department of the Interior, Geological Survey, 1974.

APPENDIX D.3

WATER QUALITY AND BOTTOM SEDIMENT DATA

FOR THE MISSISSIPPI RIVER

This appendix consists of 10 tables relating to water quality and bottom sediment data in the Mississippi River. The locations of all stations are indicated in Figure 2.9. Table D.3-1 provides water quality data at Baton Rouge. Tables D.3-2 through D.3-5 provide water quality and bottom sediment data (including pesticides) for Baton Rouge harbor, Port Allen lock forebay, Mile 224 and Mile 212, respectively. Tables D.3-6 through D.3-8 provide pesticide analysis data for Mile 222 (west bank), Mile 222 (center) and Mile 208 (west bank) respectively. Table D.3-9 contains water quality data at Plaquemine while Table D.3-10 provides sediment composition data for Baton Rouge, Plaquemine and Donaldsonville.

Table D.3-1. Analyses of Samples Collected from Mississippi River at Baton Rouge, Louisiana

WATER QUALITY DATA, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

DATE	TIME	DIS-SOLVED SILICA (SIO2) (MG/L)	DIS-SOLVED CAL-CIUM (CA) (MG/L)	DIS-SOLVED MAG-NE-SIUM (MG) (MG/L)	DIS-SOLVED SODIUM (NA) (MG/L)	DIS-SOLVED PO-TAS-SIUM (K) (MG/L)	BICAR-BONATE (HCO3) (MG/L)	CAR-BONATE (CO3) (MG/L)	ALKA-LINITY AS CACO3 (MG/L)	DIS-SOLVED SULFATE (SO4) (MG/L)
JULY 24...	2300	8.8	43	13	17	3.4	146	0	120	50

DATE	DIS-SOLVED CHLO-RIDE (CL) (MG/L)	DIS-SOLVED FLUO-RIDE (F) (MG/L)	AMMONIA NITRO-GEN (N) (MG/L)	TOTAL ORGANIC NITRO-GEN (N) (MG/L)	TOTAL NITRO-GEN (N) (MG/L)	TOTAL PHOS-PHORUS (P) (MG/L)	TOTAL ORTHO PHOS-PHORUS (P) (MG/L)	DIS-SOLVED SOLIDS (RESI-DUE AT 180 C) (MG/L)	DIS-SOLVED SOLIDS (SUM OF CONSTI-TUENTS) (MG/L)	HARD-NESS (CA,MG) MG/L)
JULY 24...	17	.3	.01	.70	2.4	.25	.09	231	224	160

DATE	NON-CAR-BONATE HARD-NESS (MG/L)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS)	PH (UNITS)	TEMPER-ATURE (DEG C)	COLOR (PLAT-INUM-COBALT UNITS)	TUR-BID-ITY (JTU)	DIS-SOLVED OXYGEN (MG/L)	PER-CENT SATUR-ATION	CARBON DIOXIDE (CO2) (MG/L)
JULY 24...	40	403	7.7	29.5	10	70	6.8	88	4.7

Source: "Water Resources Data for Louisiana," U.S. Department of the Interior, Geological Survey, 1975.

Table D.3-2. Analyses of Samples Collected from Mississippi River at Baton Rouge Harbor

WATER QUALITY DATA, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

DATE	TIME	DISSOLVED KJEL. NITROGEN (N) (MG/L)	TOTAL KJEL. NITROGEN IN BOTTOM DEP. (MG/KG)	TOTAL NONFILTRABLE RESIDUE (MG/L)	SUSPENDED SOLIDS (MG/L)	VOL. NONFILTRABLE RESIDUE (MG/L)	LOSS ON IGNITION IN BOTTOM DEPOSITS (MG/KG)	CHEMICAL OXYGEN DEMAND (HIGH LEVEL) (MG/L)	COD IN BOTTOM DEPOSITS (MG/KG)	CYANIDE (CN) (MG/L)
APR.										
04...	1200	.44	1300	34	84	20	48300	18	32000	.03
04...	1330	.53	1300	30	88	28	43700	23	33000	.00

DATE	TOTAL CYANIDE IN BOTTOM DEPOSITS (UG/G)	PHENOLS (UG/L)	OIL AND GREASE (MG/L)	OIL AND GREASE IN BOTTOM DEPOSITS (MG/G)	DISSOLVED ARSENIC (AS) (UG/L)	TOTAL ARSENIC IN BOTTOM DEPOSITS (UG/G)	DISSOLVED CADMIUM (CD) (UG/L)	TOTAL CADMIUM IN BOTTOM DEPOSITS (UG/G)	DISSOLVED CHROMIUM (CR) (UG/L)	TOTAL CHROMIUM IN BOTTOM DEPOSITS (UG/G)
APR.										
04...	0	25	3	<1.0	0	7	0	2	0	14
04...	0	18	2	<1.0	1	9	0	3	0	12

DATE	DISSOLVED COPPER (CU) (UG/L)	TOTAL COPPER IN BOTTOM DEPOSITS (UG/G)	DISSOLVED LEAD (PB) (UG/L)	TOTAL LEAD IN BOTTOM DEPOSITS (UG/G)	DISSOLVED NICKEL (NI) (UG/L)	TOTAL NICKEL IN BOTTOM DEPOSITS (UG/G)	DISSOLVED MERCURY (HG) (UG/L)	TOTAL MERCURY IN BOTTOM DEPOSITS (UG/G)	DISSOLVED ZINC (ZN) (UG/L)	TOTAL ZINC IN BOTTOM DEPOSITS (UG/G)
APR.										
04...	3	16	0	30	0	15	.1	.1	6	74
04...	4	17	1	30	0	15	.1	.1	10	70

DATE	ALDRIN (UG/L)	ALDRIN IN BOTTOM DEPOSITS (UG/KG)	CHLORDANE (UG/L)	CHLORDANE IN BOTTOM DEPOSITS (UG/KG)	DDD (UG/L)	DDD IN BOTTOM DEPOSITS (UG/KG)	DDE (UG/L)	DDE IN BOTTOM DEPOSITS (UG/KG)	DDT (UG/L)	DDT IN BOTTOM DEPOSITS (UG/KG)	DIAZINON (UG/L)	DIELDRIN (UG/L)
APR.												
04...	.00	.0	.0	14	.00	5.8	.00	.0	.00	3.4	.00	.00
04...	.00	.0	.0	11	.00	3.4	.00	.0	.00	4.2	.01	.00

DATE	DIELDRIN IN BOTTOM DEPOSITS (UG/KG)	ENDRIN (UG/L)	ENDRIN IN BOTTOM DEPOSITS (UG/KG)	ETHION (UG/L)	HEPTACHLOR (UG/L)	HEPTACHLOR IN BOTTOM DEPOSITS (UG/KG)	HEPTACHLOR EPOXIDE (UG/L)	HEPTACHLOR EPOXIDE IN BOTTOM DEPOSITS (UG/KG)	LINDANE (UG/L)	LINDANE IN BOTTOM DEPOSITS (UG/KG)	MALATHION (UG/L)
APR.											
04...	3.2	.00	.0	.00	.00	.0	.00	.0	.00	.0	.00
04...	2.1	.00	.0	.00	.00	.0	.00	.0	.00	.0	.00

DATE	METHYL PARATHION (UG/L)	METHYL TRITHION (UG/L)	PARATHION (UG/L)	PCB (UG/L)	PCB IN BOTTOM DEPOSITS (UG/KG)	TOXAPHENE (UG/L)	TOXAPHENE IN BOTTOM DEPOSITS (UG/KG)	TRITHION (UG/L)	2,4-D (UG/L)	2,4,5-T (UG/L)	SILVEX (UG/L)
APR.											
04...	.00	.00	.00	.0	26	0	0	.00	.04	.01	.01
04...	.00	.00	.00	.0	3	0	0	.00	.04	.01	.01

Source: "Water Resources Data for Louisiana," U.S. Department of Interior, Geological Survey, 1975.

Table D.3-3. Analyses of Samples Collected from Mississippi River at Port Allen Lock Forebay

WATER QUALITY DATA, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

DATE	TIME	DISSOLVED KJEL. NITROGEN (N) (MG/L)	TOTAL KJEL. NITROGEN IN BOTTOM DEP. (MG/KG)	TOTAL NON-FILTRABLE RESIDUE (MG/L)	SUSPENDED SOLIDS (MG/L)	VOL. NON-FILTRABLE RESIDUE (MG/L)	LOSS ON IGNITION IN BOTTOM DEPOSITS (MG/KG)	CHEMICAL OXYGEN DEMAND (HIGH LEVEL) (MG/L)	COD IN BOTTOM DEPOSITS (MG/KG)	CYANIDE (CN) (MG/L)
APR.										
04...	1530	.45	730	202	108	29	37200	21	22000	.00
04...	1615	.46	690	76	144	22	27000	25	21000	.00

DATE	TOTAL CYANIDE IN BOTTOM DEPOSITS (UG/G)	PHENOLS (UG/L)	OIL AND GREASE (MG/L)	OIL AND GREASE IN BOTTOM DEPOSITS (MG/G)	DISSOLVED ARSENIC (AS) (UG/L)	TOTAL ARSENIC IN BOTTOM DEPOSITS (UG/G)	DISSOLVED CADMIUM (CD) (UG/L)	TOTAL CADMIUM IN BOTTOM DEPOSITS (UG/G)	DISSOLVED CHROMIUM (CR) (UG/L)	TOTAL CHROMIUM IN BOTTOM DEPOSITS (UG/G)
APR.										
04...	0	17	3	1.0	0	5	1	2.	0	7
04...	0	17	1	<1.0	1	4	0	2	0	9

DATE	DISSOLVED COPPER (CU) (UG/L)	TOTAL COPPER IN BOTTOM DEPOSITS (UG/G)	DISSOLVED LEAD (PB) (UG/L)	TOTAL LEAD IN BOTTOM DEPOSITS (UG/G)	DISSOLVED NICKEL (NI) (UG/L)	TOTAL NICKEL IN BOTTOM DEPOSITS (UG/G)	DISSOLVED MERCURY (HG) (UG/L)	TOTAL MERCURY IN BOTTOM DEPOSITS (UG/G)	DISSOLVED ZINC (ZN) (UG/L)	TOTAL ZINC IN BOTTOM DEPOSITS (UG/G)
APR.										
04...	4	10	0	20	0	10	.1	.1	10	44
04...	3	10	0	30	0	10	.0	.1	[illegible]	40

DATE	ALDRIN (UG/L)	ALDRIN IN BOTTOM DEPOSITS (UG/KG)	CHLORDANE (UG/L)	CHLORDANE IN BOTTOM DEPOSITS (UG/KG)	DDD (UG/L)	DDD IN BOTTOM DEPOSITS (UG/KG)	DDE (UG/L)	DDE IN BOTTOM DEPOSITS (UG/KG)	DDT (UG/L)	DDT IN BOTTOM DEPOSITS (UG/KG)	DI-AZINON (UG/L)	DI-ELDRIN (UG/L)
APR.												
04...	<.01	.0	.0	0	.00	5.6	.00	.0	.00	2.4	.10	.00
04...	.00	.0	.0	[illegible]	.00	3.7	.00	.0	.00	2.2	<.01	.00

DATE	DI-ELDRIN IN BOTTOM DEPOSITS (UG/KG)	ENDRIN (UG/L)	ENDRIN IN BOTTOM DEPOSITS (UG/KG)	ETHION (UG/L)	HEPTA-CHLOR (UG/L)	HEPTA-CHLOR IN BOTTOM DEPOSITS (UG/KG)	HEPTA-CHLOR EPOXIDE (UG/L)	HEPTA-CHLOR EPOXIDE IN BOTTOM DEPOSITS (UG/KG)	LINDANE (UG/L)	LINDANE IN BOTTOM DEPOSITS (UG/KG)	MALA-THION (UG/L)
APR.											
04...	1.8	.00	.5	.00	.00	.0	.00	<.1	.00	.0	.00
04...	1.2	.00	.5	.00	.00	.0	.00	<.1	.00	.0	.00

DATE	METHYL PARA-THION (UG/L)	METHYL TRI-THION (UG/L)	PARA-THION (UG/L)	PCB (UG/L)	PCB IN BOTTOM DEPOSITS (UG/KG)	TOX-APHENE (UG/L)	TOX-APHENE IN BOTTOM DEPOSITS (UG/KG)	TRI-THION (UG/L)	2,4-D (UG/L)	2,4,5-T (UG/L)	SILVEX (UG/L)
APR.											
04...	.00	.00	.00	.0	11	0	0	.00	.03	.01	.01
04...	.00	.00	.00	.0	9	0	0	.00	.02	.01	.01

Source: "Water Resources Data for Louisiana," U.S. Department of Interior, Geological Survey, 1975.

Table D.3-4. Analyses of Samples Collected from Mississippi River at Mile 224

WATER QUALITY DATA, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

DATE	TIME	DIS-SOLVED KJEL. NITRO-GEN (N) (MG/L)	TOTAL KJEL. NITRO-GEN IN BOTTOM MAT. (MG/KG)	TOTAL NON-FILT-RABLE RESIDUE (MG/L)	SUS-PENDED SOLIDS (MG/L)	VOL. NON-FILT-RABLE RESIDUE (MG/L)	LOSS ON IGNI-TION IN BOTTOM MA-TERIAL (MG/KG)	CHEM-ICAL OXYGEN DEMAND (HIGH LEVEL) (MG/L)	COD IN BOTTOM MA-TERIAL (MG/KG)	TOTAL ORGANIC CARBON (C) (MG/L)	CYANIDE (CN) (MG/L)
MAR.											
11...	1230	.75	84	--	206	30	4020	19	1000	7.0	.01
23...	1530	.75	50	114	126	60	7240	10	500	5.7	.00

DATE	TOTAL CYANIDE IN BOTTOM MA-TERIAL (UG/G)	PHENOLS (UG/L)	OIL AND GREASE (MG/L)	OIL AND GREASE IN BOT-TOM MA-TERIAL (MG/G)	DIS-SOLVED ARSENIC (AS) (UG/L)	TOTAL ARSENIC IN BOTTOM MA-TERIAL (UG/G)	DIS-SOLVED CAD-MIUM (CD) (UG/L)	TOTAL CADMIUM IN BOTTOM MA-TERIAL (UG/G)	DIS-SOLVED CHRO-MIUM (CR) (UG/L)	TOTAL CHRO-MIUM IN BOTTOM MA-TERIAL (UG/G)
MAR.										
11...	0	14	10	.0	0	2	0	0	0	11
23...	0	30	2	1.0	4	6	0	1	10	5

DATE	DIS-SOLVED COPPER (CU) (UG/L)	TOTAL COPPER IN BOTTOM MA-TERIAL (UG/G)	DIS-SOLVED LEAD (PB) (UG/L)	TOTAL LEAD IN BOTTOM MA-TERIAL (UG/G)	DIS-SOLVED NICKEL (NI) (UG/L)	TOTAL NICKEL IN BOTTOM MA-TERIAL (UG/G)	DIS-SOLVED MERCURY (HG) (UG/L)	TOTAL MERCURY IN BOTTOM MA-TERIAL (UG/G)	DIS-SOLVED ZINC (ZN) (UG/L)	TOTAL ZINC IN BOTTOM MA-TERIAL (UG/G)
MAR.										
11...	0	1	4	<10	2	5	.0	.0	10	11
23...	7	1	0	<10	0	7	.1	.0	20	6

DATE	TOTAL ALDRIN (UG/L)	ALDRIN IN BOTTOM MA-TERIAL (UG/KG)	TOTAL CHLOR-DANE (UG/L)	CHLOR-DANE IN BOTTOM MA-TERIAL (UG/KG)	TOTAL DDD (UG/L)	DDD IN BOTTOM MA-TERIAL (UG/KG)	TOTAL DDE (UG/L)	DDE IN BOTTOM MA-TERIAL (UG/KG)	TOTAL DDT (UG/L)	DDT IN BOTTOM MA-TERIAL (UG/KG)	TOTAL DI-AZINON (UG/L)	TOTAL DI-ELDRIN (UG/L)
MAR.												
23...	--	.0	--	0	--	.3	--	.0	--	.3	--	--
APR.												
06...	.00	--	.0	--	.00	--	.00	--	.00	--	.00	.00

DATE	DI-ELDRIN IN BOTTOM MA-TERIAL (UG/KG)	TOTAL ENDRIN (UG/L)	ENDRIN IN BOTTOM MA-TERIAL (UG/KG)	TOTAL ETHION (UG/L)	TOTAL HEPTA-CHLOR (UG/L)	HEPTA-CHLOR IN BOTTOM MA-TERIAL (UG/KG)	TOTAL HEPTA-CHLOR EPOXIDE (UG/L)	HEPTA-CHLOR EPOXIDE IN BOT-TOM MA-TERIAL (UG/KG)	TOTAL LINDANE (UG/L)	LINDANE IN BOTTOM MA-TERIAL (UG/KG)	TOTAL MALA-THION (UG/L)
MAR.											
23...	.0	--	.0	--	--	.0	--	.0	--	.0	--
APR.											
06...	--	.00	--	.00	.00	--	.00	--	.00	--	.00

DATE	TOTAL METHYL PARA-THION (UG/L)	TOTAL METHYL TRI-THION (UG/L)	TOTAL PARA-THION (UG/L)	TOTAL PCB (UG/L)	PCB IN BOTTOM MA-TERIAL (UG/KG)	TOTAL TOX-APHENE (UG/L)	TOX-APHENE IN BOTTOM MA-TERIAL (UG/KG)	TOTAL TRI-THION (UG/L)	TOTAL 2,4-D (UG/L)	TOTAL 2,4,5-T (UG/L)	TOTAL SILVEX (UG/L)
MAR.											
23...	--	--	--	--	0	--	0	--	--	--	--
APR.											
06...	.00	.00	.00	.0	--	0	--	.00	.02	.00	.00

Source: "Water Resources Data for Louisiana," U.S. Department of Interior, Geological Survey, 1975.

Table D.3-5 Analyses of Samples Collected at Mississippi River Mile 212

WATER QUALITY DATA, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

DATE	TIME	DIS-SOLVED KJEL. NITRO-GEN (N) (MG/L)	TOTAL KJEL. NITRO-GEN IN BOTTOM MAT. (MG/KG)	TOTAL NON-FILT-RABLE RESIDUE (MG/L)	SUS-PENDED SOLIDS (MG/L)	VOL. NON-FILT-RABLE RESIDUE (MG/L)	LOSS ON IGNI-TION IN BOTTOM MA-TERIAL (MG/KG)	CHEM-ICAL OXYGEN DEMAND (HIGH LEVEL) (MG/L)	COD IN BOTTOM MA-TERIAL (MG/KG)	TOTAL ORGANIC CARBON (C) (MG/L)	CYANIDE (CN) (MG/L)
MAR.											
12...	1200	.75	370	--	250	38	9240	15	3100	8.5	.00
23...	1430	.96	75	110	149	52	6710	10	800	8.4	.00

DATE	TOTAL CYANIDE IN BOTTOM MA-TERIAL (UG/G)	PHENOLS (UG/L)	OIL AND GREASE (MG/L)	OIL AND GREASE IN BOT-TOM MA-TERIAL (MG/G)	DIS-SOLVED ARSENIC (AS) (UG/L)	TOTAL ARSENIC IN BOTTOM MA-TERIAL (UG/G)	DIS-SOLVED CAD-MIUM (CD) (UG/L)	TOTAL CADMIUM IN BOTTOM MA-TERIAL (UG/G)	DIS-SOLVED CHRO-MIUM (CR) (UG/L)	TOTAL CHRO-MIUM IN BOTTOM MA-TERIAL (UG/G)
MAR.										
12...	0	9	3	1.0	0	3	0	0	0	15
23...	0	16	1	1.0	0	2	0	1	20	2

DATE	DIS-SOLVED COPPER (CU) (UG/L)	TOTAL COPPER IN BOTTOM MA-TERIAL (UG/G)	DIS-SOLVED LEAD (PB) (UG/L)	TOTAL LEAD IN BOTTOM MA-TERIAL (UG/G)	DIS-SOLVED NICKEL (NI) (UG/L)	TOTAL NICKEL IN BOTTOM MA-TERIAL (UG/G)	DIS-SOLVED MERCURY (HG) (UG/L)	TOTAL MERCURY IN BOTTOM MA-TERIAL (UG/G)	DIS-SOLVED ZINC (ZN) (UG/L)	TOTAL ZINC IN BOTTOM MA-TERIAL (UG/G)
MAR.										
12...	110	2	9	<10	3	10	.0	.0	160	14
23...	4	1	1	<10	1	7	.0	.0	10	8

DATE	TOTAL ALDRIN (UG/L)	ALDRIN IN BOTTOM MA-TERIAL (UG/KG)	TOTAL CHLOR-DANE (UG/L)	CHLOR-DANE IN BOTTOM MA-TERIAL (UG/KG)	TOTAL DDD (UG/L)	DDD IN BOTTOM MA-TERIAL (UG/KG)	TOTAL DDE (UG/L)	DDE IN BOTTOM MA-TERIAL (UG/KG)	TOTAL DDT (UG/L)	DDT IN BOTTOM MA-TERIAL (UG/KG)	TOTAL DI-AZINON (UG/L)	TOTAL DI-ELDRIN (UG/L)
MAR.												
23...	--	.0	--	0	--	.0	--	.0	--	.0	--	--
APR.												
06...	.00	--	.0	--	.01	--	.00	--	.00	--	.00	.00

DATE	DI-ELDRIN IN BOTTOM MA-TERIAL (UG/KG)	TOTAL ENDRIN (UG/L)	ENDRIN IN BOTTOM MA-TERIAL (UG/KG)	TOTAL ETHION (UG/L)	TOTAL HEPTA-CHLOR (UG/L)	HEPTA-CHLOR IN BOTTOM MA-TERIAL (UG/KG)	TOTAL HEPTA-CHLOR EPOXIDE (UG/L)	HEPTA-CHLOR EPOXIDE IN BOT-TOM MA-TERIAL (UG/KG)	TOTAL LINDANE (UG/L)	LINDANE IN BOTTOM MA-TERIAL (UG/KG)	TOTAL MALA-THION (UG/L)
MAR.											
23...	.0	--	.0	--	--	.0	--	.0	--	.0	--
APR.											
06...	--	.00	--	.00	.00	--	.00	--	.00	--	.00

DATE	TOTAL METHYL PARA-THION (UG/L)	TOTAL METHYL TRI-THION (UG/L)	TOTAL PARA-THION (UG/L)	TOTAL PCB (UG/L)	PCB IN BOTTOM MA-TERIAL (UG/KG)	TOTAL TOX-APHENE (UG/L)	TOX-APHENE IN BOTTOM MA-TERIAL (UG/KG)	TOTAL TRI-THION (UG/L)	TOTAL 2,4-D (UG/L)	TOTAL 2,4,5-T (UG/L)	TOTAL SILVEX (UG/L)
MAR.											
23...	--	--	--	--	0	--	0	--	--	--	--
APR.											
06...	.00	.00	.00	.0	--	0	--	.00	.02	.01	.01

Source: "Water Resources Data for Louisiana," U.S. Department of Interior, Geological Survey, 1975.

Table D.3-6. Pesticide Analyses of Samples Collected at Mississippi River Mile 222.0 (near bank)

WATER QUALITY DATA, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

DATE	TIME	ALDRIN IN BOTTOM DE-POSITS (UG/KG)	CHLOR-DANE IN BOTTOM DE-POSITS (UG/KG)	DDD IN BOTTOM DE-POSITS (UG/KG)	DDE IN BOTTOM DE-POSITS (UG/KG)	DDT IN BOTTOM DE-POSITS (UG/KG)	DI-AZINON IN BOTTOM DE-POSITS (UG/KG)	DI-ELDRIN IN BOTTOM DE-POSITS (UG/KG)	ENDRIN IN BOTTOM DE-POSITS (UG/KG)	ETHION IN BOTTOM DE-POSITS (UG/KG)
JUNE										
18...	0800	.0	0	.2	.0	.0	.0	.0	.0	.0
19...	1545	.0	0	.0	.0	.0	.0	.1	.0	.0

DATE	HEPTA-CHLOR IN BOTTOM DE-POSITS (UG/KG)	HEPTA-CHLOR EPOXIDE IN BOT-TOM DE-POSITS (UG/KG)	LINDANE IN BOTTOM DE-POSITS (UG/KG)	MALA-THION IN BOTTOM DE-POSITS (UG/KG)	METHYL PARA-THION IN BOT-TOM DE-POSITS (UG/KG)	METHYL TRI-THION IN BOT-TOM DE-POSITS (UG/KG)	PARA-THION IN BOTTOM DE-POSITS (UG/KG)	PCB IN BOTTOM DE-POSITS (UG/KG)	TOX-APHENE IN BOTTOM DE-POSITS (UG/KG)	TRI-THION IN BOTTOM DE-POSITS (UG/KG)
JUNE										
18...	.0	.0	.0	.0	.0	.0	.0	<1	0	.0
19...	.0	.0	.0	.0	.0	.0	.0	1	0	.0

Source: "Water Resources Data for Louisiana," U.S. Department of Interior, Geological Survey, 1975.

Table D.3-7. Pesticide Analyses of Samples Collected at Mississippi River Mile 222.0 (center)

WATER QUALITY DATA, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

DATE	TIME	ALDRIN IN BOTTOM DE-POSITS (UG/KG)	CHLOR-DANE IN BOTTOM DE-POSITS (UG/KG)	DDD IN BOTTOM DE-POSITS (UG/KG)	DDE IN BOTTOM DE-POSITS (UG/KG)	DDT IN BOTTOM DE-POSITS (UG/KG)	DI-AZINON IN BOTTOM DE-POSITS (UG/KG)	DI-ELDRIN IN BOTTOM DE-POSITS (UG/KG)	ENDRIN IN BOTTOM DE-POSITS (UG/KG)	ETHION IN BOTTOM DE-POSITS (UG/KG)
JUNE										
18...	0810	.0	0	.1	.0	.3	.0	.0	.0	.0
19...	1550	.0	0	.4	.0	.7	.0	.0	.0	.0

DATE	HEPTA-CHLOR IN BOTTOM DE-POSITS (UG/KG)	HEPTA-CHLOR EPOXIDE IN BOT-TOM DE-POSITS (UG/KG)	LINDANE IN BOTTOM DE-POSITS (UG/KG)	MALA-THION IN BOTTOM DE-POSITS (UG/KG)	METHYL PARA-THION IN BOT-TOM DE-POSITS (UG/KG)	METHYL TRI-THION IN BOT-TOM DE-POSITS (UG/KG)	PARA-THION IN BOTTOM DE-POSITS (UG/KG)	PCB IN BOTTOM DE-POSITS (UG/KG)	TOX-APHENE IN BOTTOM DE-POSITS (UG/KG)	TRI-THION IN BOTTOM DE-POSITS (UG/KG)
JUNE										
18...	.0	.0	.0	.0	.0	.0	.0	0	0	.0
19...	.0	.0	.0	.0	.0	.0	.0	0	0	.0

Source: "Water Resources Data for Louisiana," U.S. Department of Interior, Geological Survey, 1975.

Table D.3-8. Pesticide Analyses of Samples Collected at Mississippi River at Mile 208.8 (near bank)

WATER QUALITY DATA, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

DATE	TIME	ALDRIN IN BOTTOM DEPOSITS (UG/KG)	CHLORDANE IN BOTTOM DEPOSITS (UG/KG)	DDD IN BOTTOM DEPOSITS (UG/KG)	DDE IN BOTTOM DEPOSITS (UG/KG)	DDT IN BOTTOM DEPOSITS (UG/KG)	DIAZINON IN BOTTOM DEPOSITS (UG/KG)	DIELDRIN IN BOTTOM DEPOSITS (UG/KG)	ENDRIN IN BOTTOM DEPOSITS (UG/KG)	ETHION IN BOTTOM DEPOSITS (UG/KG)
JUNE										
10...	0845	.0	5	2.6	.0	3.9	.0	.9	.0	.0
19...	1455	.0	0	.5	.0	1.3	.0	.1	.0	.0

DATE	HEPTACHLOR IN BOTTOM DEPOSITS (UG/KG)	HEPTACHLOR EPOXIDE IN BOTTOM DEPOSITS (UG/KG)	LINDANE IN BOTTOM DEPOSITS (UG/KG)	MALATHION IN BOTTOM DEPOSITS (UG/KG)	METHYL PARATHION IN BOTTOM DEPOSITS (UG/KG)	METHYL TRITHION IN BOTTOM DEPOSITS (UG/KG)	PARATHION IN BOTTOM DEPOSITS (UG/KG)	PCB IN BOTTOM DEPOSITS (UG/KG)	TOXAPHENE IN BOTTOM DEPOSITS (UG/KG)	TRITHION IN BOTTOM DEPOSITS (UG/KG)
JUNE										
10...	.0	.0	.0	.0	.0	.0	.0	--	0	.0
19...	.0	.0	.0	.0	.0	.0	.0	0	0	.0

Source: "Water Resources Data for Louisiana," U.S. Department of Interior, Geological Survey, 1975.

Table D.3-9. **Analyses of Samples Collected at Lower Mississippi River River Basin - Mississippi River Main Stem at Plaquemine, Louisiana**

LOCATION.--Lat 30°17'00", long 91°13'21", T.9 S., R.12 E., St. Helena meridian, Iberville Parish, at west bank ferry landing at Plaquemine.

DRAINAGE AREA.--Indeterminate.

PERIOD OF RECORD.--Chemical analyses: January 1973 to current year.

WATER QUALITY DATA, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

DATE	TIME	DIS-SOLVED SILICA (SIO2) (MG/L)	DIS-SOLVED IRON (FE) (UG/L)	DIS-SOLVED CAL-CIUM (CA) (MG/L)	DIS-SOLVED MAG-NE-SIUM (MG) (MG/L)	DIS-SOLVED SODIUM (NA) (MG/L)	DIS-SOLVED PO-TAS-SIUM (K) (MG/L)	BICAR-BONATE (HCO3) (MG/L)	CAR-BONATE (CO3) (MG/L)	ALKA-LINITY AS CACO3 (MG/L)	DIS-SOLVED SULFATE (SO4) (MG/L)	DIS-SOLVED CHLO-RIDE (CL) (MG/L)
OCT. 16...	0820	4.9	30	44	12	--	3.3	148	0	121	56	28
NOV. 13...	1030	4.8	10	39	11	45	3.4	134	0	110	53	68
DEC. 04...	1300	6.0	0	36	9.4	21	3.8	116	0	95	44	24
JAN. 07...	1400	6.3	10	36	9.0	18	2.7	112	0	92	42	22
FEB. 12...	0815	6.8	30	34	9.8	17	2.3	105	0	86	41	21
MAR. 05...	1515	6.4	40	34	9.3	17	2.2	102	0	84	38	22
APR. 22...	0850	5.8	90	29	7.6	11	2.2	91	0	75	30	13
MAY 21...	1530	6.5	0	35	9.4	12	2.6	105	0	86	38	14
JUNE 10...	0820	6.4	10	41	12	23	2.7	121	0	99	45	33
JULY 11...	1200	7.4	10	47	13	24	3.2	141	0	115	57	28
AUG. 08...	1200	6.1	10	40	12	23	3.1	131	0	107	50	24
SEP. 10...	1300	--	10	43	15	36	3.5	150	0	123	81	29

DATE	DIS-SOLVED FLUO-RIDE (F) (MG/L)	TOTAL NITRATE (N) (MG/L)	TOTAL NITRITE (N) (MG/L)	TOTAL NITRITE PLUS NITRATE (N) (MG/L)	TOTAL PHOS-PHORUS (P) (MG/L)	DIS-SOLVED SOLIDS (RESI-DUE AT 180 C) (MG/L)	DIS-SOLVED SOLIDS (SUM OF CONSTI-TUENTS) (MG/L)	SUS-PENDED SOLIDS (MG/L)	HARD-NESS (CA+MG) (MG/L)	NON-CAR-BONATE HARD-NESS (MG/L)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS)	PH (UNITS)
OCT. 16...	.3	.68	.00	.65	.11	284	--	44	160	38	434	7.8
NOV. 13...	.2	.62	.01	.63	.16	316	282	165	140	33	512	7.8
DEC. 04...	.2	.78	.01	.79	.22	202	201	213	130	33	375	7.8
JAN. 07...	.2	1.1	.01	1.1	.17	200	191	81	130	35	359	7.7
FEB. 12...	.3	1.2	.01	1.2	.26	--	184	245	130	39	335	7.7
MAR. 05...	.2	1.0	.02	1.1	.27	182	179	261	120	36	325	7.5
APR. 22...	.1	1.0	.01	1.1	.15	146	144	114	100	25	262	7.3
MAY 21...	.2	1.4	.00	1.4	.13	179	169	162	130	40	306	7.8
JUNE 10...	.2	1.3	.01	1.3	.11	231	223	208	150	53	403	7.5
JULY 11...	.5	2.1	.01	2.1	.22	279	243	142	170	55	435	7.3
AUG. 08...	.4	.99	.01	1.0	.17	243	223	--	150	42	407	7.7
SEP. 10...	.4	.25	.00	.25	.13	293	--	56	170	46	496	8.2

Table D.3-9. (Concluded)

WATER QUALITY DATA, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

DATE	TEMPER-ATURE (DEG C)	COLOR (PLAT-INUM-COBALT UNITS)	TUR-BID-ITY (JTU)	DIS-SOLVED OXYGEN (MG/L)	BIO-CHEM-ICAL OXYGEN DEMAND 5 DAY (MG/L)	IMME-DIATE COLI-FORM (COL. PER 100 ML)	FECAL COLI-FORM (COL. PER 100 ML)	TOTAL ORGANIC CARBON (C) (MG/L)	CYANIDE (CN) (MG/L)	PHENOLS (UG/L)	OIL AND GREASE (MG/L)	TOTAL ARSENIC (AS) (UG/L)
OCT. 16...	10.5	80	10	8.4	3.5	2800	--	4.5	.00	0	0	--
NOV. 13...	16.5	--	85	7.0	2.5	3500	750	6.6	.00	0	2	--
DEC. 04...	10.5	40	75	9.0	1.4	7900	720	4.4	.00	0	0	3
JAN. 07...	8.5	30	50	10.5	3.4	810	150	3.0	.00	3	1	2
FEB. 12...	7.0	30	40	10.2	3.2	4400	700	5.3	.00	1	0	3
MAR. 05...	8.5	40	70	10.6	3.1	3500	300	9.2	.01	0	0	4
APR. 22...	14.5	5	45	8.7	1.0	1800	340	4.3	.00	1	0	1
MAY 21...	22.0	30	55	6.0	--	770	120	6.4	.00	3	0	7
JUNE 10...	25.0	33	70	6.4	1.4	2800	--	3.2	.00	2	0	3
JULY 11...	29.0	5	55	6.5	.8	5700	420	5.2	.01	0	0	3
AUG. 08...	20.0	5	40	6.5	1.4	4200	220	5.0	.00	0	5	4
SEP. 11...	29.0	5	2	7.0	3.0	3900	210	8.4	.00	1	2	4

DATE	DIS-SOLVED ARSENIC (AS) (UG/L)	TOTAL CAD-MIUM (CD) (UG/L)	DIS-SOLVED CAD-MIUM (CD) (UG/L)	TOTAL CHRO-MIUM (CR) (UG/L)	HEXA-VALENT CHRO-MIUM (CR6) (UG/L)	TOTAL LEAD (PB) (UG/L)	DIS-SOLVED LEAD (PB) (UG/L)	TOTAL MERCURY (HG) (UG/L)	DIS-SOLVED MERCURY (HG) (UG/L)	TOTAL ZINC (ZN) (UG/L)	DIS-SOLVED ZINC (ZN) (UG/L)
OCT. 16...	2	--	0	--	0	--	--	.2	--	--	--
NOV. 13...	1	--	0	--	0	--	1	.1	--	--	0
DEC. 04...	2	2	2	15	0	9	3	.1	.2	30	0
JAN. 07...	1	3	1	<10	1	20	0	.0	.0	30	0
FEB. 12...	1	1	0	<10	1	13	1	.0	.0	60	20
MAR. 05...	0	1	0	<10	0	67	0	.2	.2	50	6
APR. 22...	1	1	1	<10	0	1	0	.1	.1	10	7
MAY 21...	3	1	0	<10	0	64	1	.1	.1	40	20
JUNE 10...	1	1	0	<10	0	0	1	.1	.0	30	5
JULY 11...	1	0	0	<10	0	6	1	.1	.1	20	0
AUG. 08...	1	0	0	<10	0	10	0	.5	.2	30	0
SEP. 10...	1	0	0	<10	0	7	2	.1	.0	30	10

Source: "Water Resources Data for Louisiana," U.S. Department of Interior, Geological Survey, 1975.

Table D.3-10 Mississippi River Sediment Composition

Location	Composition *(%)					
	Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand
Baton Rouge	8%	3%		60%	27%	2%
Plaquemine			1%	88%	10%	1%
Donaldsonville		5%		70%	24%	1%

*Sediment classifications are based on particle size as follows:

Clay	-	1 to 5 µm
Silt	-	5 to 50 µm
Very Fine Sand	-	50 to 100 µm
Fine Sand	-	100 to 250 µm
Medium Sand	-	250 to 500 µm
Coarse Sand	-	500 to 1000 µm

Source: Kolb, C.R.,"Review of Petrographic Studies of Bed Material, Mississippi River, Its Tributaries, and Off-Shore Areas of Deposition," Technical Report #3-436, U.S. Army Waterways Experiment Stations, Vicksburg, Miss., June 1956.

APPENDIX D.4

WATER QUALITY STANDARDS

All specific State of Louisiana water quality criteria pertinent to the bodies of water in the vicinity of the Bayou Choctaw site are provided in Table D.4-1. These criteria specify how the water of a bayou, canal, or river may be used, and also specify upper and/or lower limits for certain water quality parameters.

In addition to the specific water criteria set forth by the state, there exist certain numerical criteria proposed by EPA in 1973 for water quality in general. Table D.4-2 provides such criteria for domestic raw water supply while Table D.4-3 provides the criteria for freshwater aquatic life. The uses specified in the state criteria for a given water body determine which EPA criteria are applicable.

The situation regarding sediment quality criteria has undergone considerable revision in recent years. On 26 June 1973 the Environmental Protection Agency (EPA), Region VI, issued proposed regional bottom sediment criteria to be used in evaluating the suitability of disposal of dredged or fill materials. On 15 October 1973 the EPA published in the Federal Register "Environmental Protection Agency Criteria for Evaluation of Permit Applications for Ocean Dumping" (40 CFR 227, 38 FR 28618). This criteria was to be used in evaluating the suitability of discharge of dredged or fill material in the ocean, and, until guidelines were promulgated, in inland waters also. Dredged or fill material was considered to be unacceptable if the ratio of the constituent concentration in the standard elutriate to the constituent concentration in the receiving water was greater than 1.5. The standard elutriate results from a mixture of 4 parts unfiltered receiving water to 1 part dredged material.

On 6 May 1975 the EPA in conjunction with the Corps of Engineers published the inland water criteria for dredged or fill material entitled: "Navigable Waters Procedure and Guidelines for Disposal of Dredged or Fill Material" (40 CFR 230, 40 FR 19794). As previously stated, the Ocean

Dumping Criteria's elutriate test required that after the material to be dredged had been vigorously mixed for 30 minutes with four parts of the water to which it is to be discharged and the supernatent from the mixture has been filtered through a 0.45 micron filter, the concentration of the constituents should be equal to or less that 1.5 times the concentration of those same constituents in the water before mixing. The new proposed (6 May 1975) Navigable Water Criteria allowed for application of a 10:1 dilution of the standard elutriate. Mathematical expressions of the above relationships are as follows:

$$\frac{C_e}{C_w} \leq 1.5$$ (based on 40 CFR 227, 38 FR 28618)

$$\frac{(0.1\ C_e + 0.9\ C_w)}{C_w} \leq 1.5$$ (based on 40 CFR 230, 40 FR 19794)

where C_e = Concentration from the standard elutriate test (dissolved)

C_w = Concentration in the receiving water (dissolved)

The newer proposed guidelines (40 CFR 230, 6 May 1975) were revised on 5 September 1975 (40 CFR 230, 40 FR 41292). These new interim final guidelines, entitled "Environmental Protection Agency - Navigable Waters - Discharge of Dredged or Fill Material," have eliminated both the 1.5 elutriate criteria as well as the 10:1 elutriate dilution of the May 6 guidelines. As a substitute, the new guidelines recommend (1) comparing the elutriate to applicable narrative and numerical guidance contained in such water quality standards as are applicable by law, (Tables D.4-1, D.4-2, and D.4-3) and, (2) possibly performing a total sediment chemical analysis. In addition, the guidelines note that EPA and the Corps of Engineers in the coming months will prepare and publish a procedures manual that will cover summary and description of tests, definitions, sample collection and preservation, procedures, calculations, and references.

Based on the proposed procedures described in the three preceding paragraphs, no official sediment quality criteria currently are in effect. At the same time, in situations where sediment quality data is available but not elutriate data, the need arises for comparing the sediment quality data with some standard. Table D.4-4 provides certain recommended limits for various sediment quality parameters and can be used for such a comparison. The data in Table D.4-4 are not official and thus serve only as guidelines.

Table D.4-1. Specific Water Quality Criteria
State of Louisiana

Segment		Water Uses				Criteria						
Agency I.D. Number	Description	Primary Contact Recreation	Secondary Contact Recreation	Propagation of Fish and Wildlife	Domestic Raw Water Supply	Chloride (mg/1) Not to exceed	Sulphate (mg/1) Not to exceed	Dissolved Oxygen (mg/1) Not less than	pH Range	Coliform:	Temperature °C	Total Dissolved Solids (mg/1) Not to exceed)
050020	Mississippi River: From Old River Control Structure to Huey P. Long Bridge above New Orleans		X	X	X	75	120	5.0	6.5 to 9.0	T.C. 2000	32	400
110100	Bayou Choctaw - Headwaters to Intracoastal Waterway		X	X		250	75	5.0	6.0 to 8.5	1000	32	500
110110	Bayou Grosse Tete - Headwaters to Intracoastal Waterway		X	X		25	25	5.0	6.0 to 8.5	1000	32	200
110120	Bayou Plaquenine - Headwaters to Intracoastal Waterway		X	X		250	75	5.0	6.0 to 8.5	1000	32	500
110140	Intracoastal Waterway (North-South) - Port Allen to Bayou Sorrel		X	X		250	75	5.0	6.0 to 8.5	1000	32	500

Source: "Inventory of Basic Environmental Data, South Louisiana Mermentau River Basin to Chandeleur Sound with Special Emphasis on the Atchafalaya Basin," U.S. Army Corps of Engineers, New Orleans District, September, 1973.

Table D.4-2. Proposed EPA Numerical Criteria for Water Quality (freshwater aquatic life).

Parameter	µg/l
Cadmium	30 (hardness > 100 mg/l) 4 (" < 100 mg/l)
Chromium	50
Copper	1/10 LC50
Lead	30
Mercury	0.2
Nickel	1/50 LC50
Zinc	5/1000 LC50
pH	6-9
Ammonia	1/20 LC50 (20 µg/l)
Sulfides	2
Suspended & settleable solids	80 mg/l
Turbidity and light penetration	10% change in compensation pt.
Color	10% change in compensation pt.
Oils	1. None visible on surface 2. 1000 mg/kg Hexane extractable substances in sediments 3. 1/20 LC50
Phenols	1/20 LC50 (0.1 mg/l)
Cyanides	1/20 LC50 (.005 mg/l)
PCB	0.002
Aldrin	0.01
DDT	0.002
Dieldrin	0.005
Chlordane	0.04
Endrin	0.002
Heptachlor	0.01
Lindane	0.02
Toxaphene	0.01
Diazinon	0.009
Malathion	0.008
Parathion	0.001
DO	4.0 mg/l (>31°C)

Source: "Proposed Criteria for Water Quality," Vol. I, U.S. Environmental Protection Agency, Washington, D.C., 1973.

TABLE D.4-3

PROPOSED EPA NUMERICAL WATER QUALITY CRITERIA
FOR
PUBLIC WATER SUPPLY INTAKE

Parameter	ug/l
Arsenic	50
Cadmium	10
Chromium	50
Copper	1,000
Lead	50
Mercury	2
Zinc	5,000
Phenols	1.0
Cyanides	200
Aldrin	1
Chlordane	3
DDT	50
Dieldrin	1
Endrin	0.2
Heptachlor Epoxide	0.1
Heptachlor	0.1
Lindane	4
Toxaphene	5

Source: Interim Primary Drinking Water Standards, 50 CFR 141, March 14, 1975.

Table D.4-4. Recommended Concentration Limits of Selected Sediment Parameters

Parameter	Units (dry weight basis)	Non-Polluted mean	Non-Polluted range	Polluted mean	Polluted range
COD[a]	mg/kg	21,000	2,000-48,000	177,000	39,000-395,000
COD[b]	mg/kg			50,000	
TKN[a]	mg/kg	550	10-1,310	2,640	580-6,800
TKN[b]	mg/kg			1,000	
grease - oil[a]	mg/kg	560	110-1,310	7,150	1,380-32,100
grease - oil[b]	mg/kg			1,500	
sulfide[a]	mg/kg	140	30-150	1,700	100-3,700
mercury[b]	mg/kg			1	
lead[b]	mg/kg			50	
zinc[b]	mg/kg			50	

Source:

a) A. Oneil and Scova, "The Effect of Dieldrin on Water Quality," World Dedges and Main Control, 7(14), p. 24-31. 1971.

b) Slotta, L.S. and (1974) "Estuarine Impacts Related to Dredge Spoiling," In: Proceedings of the Sixth Dredging Semina, Texas A & M University, January 25, 1974, Center for Dredging Studies Report No. eds-176:20-37.

APPENDIX D.5

INDUSTRIAL AND MUNICIPAL DISCHARGE AND INTAKE DATA INVOLVING SURFACE WATER BODIES IN THE VICINITY OF BAYOU CHOCTAW

This appendix consists of five tables. Industrial discharges into the Mississippi River are tabulated in Table D.5-1 while similar municipal discharge data are provided in Table D.5-2. A summary of water systems drawing water from the Mississippi is provided in Table D.5-3. Industrial discharges into the Port Allen Canal are tabulated in Table D.5-4, while municipal discharges into the Port Allen Canal and Bayou Plaquemine are summarized in Table D.5-5.

Table D.5-1. Industrial Discharges Into the Mississippi River in the Vicinity of Bayou Choctaw Salt Dome

Industrial Installation No.	Name of Industry	Location	Receiving Stream	Vol. of Discharge (MGD)	Present Industrial Wastewater Treatment Facilities	Expected Degree of Treatment
5-3	Dow Chemical USA (LA Div.)	Between Addis, LA & Plaquemine, LA	Miss. River (mile 209 AHP)	570.0	Confidential treatment system. Some inplant control measures.	Unknown
5-14	CIBA-Geigy Corp.	St. Gabriel, LA	Miss. River (mile 199.6 AHP)	5.5	Inplant control measures, separators, filtration, neutralization, chlorination.	Primary
5-18	William T. Burton Industries, Inc. (Cedar Grove Factory)	White Castle, LA	Miss. River	8.6	Recirculation & impoundment.	None
5-19	Cora-Texas Mfg. Co.	White Castle, LA	Miss. River (mile 192.6 AHP)	0.7	Impoundment, recirculation.	None
5-2	Cos-Mar Co.	Geismar, LA	Miss. River (mile 187.8 AHP)	0.837	Inplant control measures, API separators, chemical treatment.	Primary
5-19a	Myrtle Grove Sugar Factory	Plaquemine, LA	None	18.80	Partial impoundment and recirculation.	None
5-1	J. Supple & Sons Planting Co. Ltd. (Catherine Refinery)	Dorcyville, LA	Miss. River (mile 194.0 AHP)	6.48	Muds impoundment. Cane wash partial recirculation condensor water to river.	None

Table D.5-1. (Continued)

Industrial Installation No.	Name of Industry	Location	Receiving Stream	Vol. of Discharge (MGD)	Present Industrial Wastewater Treatment Facilities	Expected Degree of Treatment
5-5	Goodyear Tire & Rubber Co.	Plaquemine, LA	Miss. River (mile 210 AHP)	7.27	Inplant control measures.	None
5-4	Georgia Pacific Corp. (Chemical Div.)	Plaquemine, LA	Miss. River (mile 205 AHP)		Inplant control, API separator, neutralization, aeration, and settling ponds.	Secondary
5-8	Hercules, Inc.	Plaquemine, LA	Miss. River (mile 204.8 AHP) & Bayou La Butte	Discharge #1: 0.75 Discharge #2: 0.10	Discharge #001: skimmers and oil separators, and neutralization. Some inplant control measures.	Primary
5-19b	Gulf States Utilities		Miss. River (mile 201.7 AHP)	1390.0	Neutralization.	Less than primary
5-19	Stauffer Chemical Co.	St. Gabriel, LA	Miss. River (mile 199.7 AHP)	0.93	An average of 600 gallons per minute of waste water is discharged from the production of liquid chlorine and 50% liquid caustic soda. Waste effluents are segregated from drainage by separate drainage systems. Heavy metal bearing streams are segregated into a holding basin from the other effluents, allowed to settle, and then treated with chemicals to precipitate the elemental mercury in a continuous process, with enough storage provided to handle emergency situations. After the precipitate has been allowed to settle in the holding pond, it is finally treated by activated carbon filtration. Where possible, water from all effluent systems is recycled for in-plant use. All effluents are monitored daily to provide operational control and are also automated to give controlled discharge.	Primary and Tertiary

Table D.5-1. (Concluded)

Industrial Installation No.	Name of Industry	Location	Receiving Stream	Vol. of Discharge (MGD)	Present Industrial Wastewater Treatment Facilities	Expected Degree of Treatment
19-7	Smithfield Sugar Co-op	Port Allen, LA	Miss. River (mile 241.2 AHP)	5.04	Inplant control measures, impoundment	Approaching secondary
19-10	Polar Grove Plating & Refining Co.	Near Sunrise, LA	Miss. River (mile 232.6 AHP)	10.9	Sedimentation, neutralization, stabilization basins.	Secondary
19-9a	Cargo Carriers Inc.	Port Allen, LA	Miss. River (mile 227.9 AHP)	7.92	None.	None
19-4	Harry L. Laws & Co. (Cinclare Central Factory Division)	Brusley, LA	Miss. River	11.08	Filter coke impoundment with some inplant control measures.	None
19-1	Copolymer Rubber & Chemical Corp.	Near Port Allen, LA	Miss. River (mile 227.2 AHP)	1.12	Effluent from coagulation and drying operations is passed through a floatation basin to remove rubber solids and is discharged into an effluent basin. Effluent from the polymerization, recovery and raw materials operations is passed through an API skimmer to remove oil, hydrocarbons and precipitated catalyst residue, and is then discharged into the effluent canal. Effluent from a stream generating plant is also discharged into the effluent canal. The canal provides a holding time of about 24 hours to allow final sedimentation and floatation of residual materials, and conducts the total effluent to a pumping station discharge point at the Mississippi River.	Primary

Source: "Inventory of Basic Environmental Data, New Orleans - Baton Rouge Metropolitan Area," prepared for U.S. Army Corps of Engineers, New Orleans District, by Engineer Agency for Resources Inventories, U.S. Army Engineer Topographic Laboratories, Washington, D.C., March 1975.

Table D.5-2. Municipal Discharges Into the Mississippi River in the Vicinity of Bayou Choctaw Salt Dome

Ref. No.	City	Major Receiving Stream	Primary Discharge Location	Existing Treatment	Present Population Served	Design Population	Present Equiv. Pop. Served	Existing Flow (MGD)		[illegible]
								Avg.	Max.	
5-4	Plaquemine (North S.T.P.)	Mississippi River	Mississippi River	Primary Treatment (not categorized)	1,000 to 4,999	2,000	NA	0.1 to 0.49	0.1 to 0.49	0.2
5-5	U. S. Public Health Service Hospital Carville	Mississippi River	Mississippi River	Biological Filters with Clarifiers	475	650	475	0.1 to 0.49	0.1 to 0.49	0.2 avg 0.432 max

Ref. No.	Present Influent Loadings (MG/L)		Removal Efficiency of Facility		Present Effluent (MG/L)		Year Facility Constructed	Capital Cost of Facility	Yearly O & M Costs of Facility	Type of Sludge Treatment
	BOD_5	S.S.	BOD_5	S.S.	BOD_5	S.S.				
5-4	NA	NA	30 to 64.9	NA	NA	NA	NA	NA	NA	NA
5-5	96	NA	85 to 94.9	NA	NA	NA	Circa 1958	NA	NA	Sludge Beds

Source: "Inventory of Basic Environmental Data, New Orleans - Baton Rouge Metropolitan Area," prepared for U.S. Army Corps of Engineers, New Orleans District, by Engineer Agency for Resources Inventories, U.S. Army Engineer Topographic Laboratories, Washington, D.C., March 1975.

Table D.5-3. Water Systems Drawing from the Mississippi River

Map No.	System (and/or name of Responsible Agency)	Community(s) Served	Water Source	Approx. no. Customers
	Iberville Parish			
5-1	U.S. Public Health Hosp.	Carville	191.8 AHP	950
5-6	Dow Chemical	Plaquemine	210.2 AHP	475

Source: "Inventory of Basic Environmental Data, New Orleans - Baton Rouge Metropolitan Area," prepared for U.S. Army Corps of Engineers, New Orleans District, by Engineer Agency for Resources Inventories, U.S. Army Engineer Topographic Laboratories, Washington, D.C., March 1975.

Table D.5-4. Industrial Discharge Data for the Port Allen Canal

Industrial Instal-lation No.	Name of Industry	Location	Stream	(MGD)	Present Industrial Wastewater Treatment Facilities	Expected Degree of Treatment
19-12a	Exxon (Port Allen)	Port Allen, LA	GIWW Morgan City to Port Allen	0.003	None	None

Source: "Inventory of Basic Environmental Data, New Orleans - Baton Rouge Metropolitan Area," prepared for U.S. Army Corps of Engineers, New Orleans District, by Engineer Agency for Resources Inventories, U.S. Army Engineer Topographic Laboratories, Washington, D.C., March 1975.

Table D.5-5. Municipal Discharge Data into Bayou Plaquemine and the Port Allen Canal

Map Ref. No.	City	Major Receiving Stream	Primary Discharge Location	Existing Treatment	Present Population Served	Design Population	Present Equiv. Pop. Served	Existing Flows (MGD) Avg.	Existing Flows (MGD) Max.	Designed Hydraulic Capacity (MGD)
5-1	Plaquemine (S.T.P.)	Bayou Plaquemine	Bayou Plaquemine	Secondary Treatment (not categorized)	5,000 to 9,999	1,500	NA	0.1 to 0.49	0.1 to 0.49	.264 avg .324 max
19-1	Port Allen (S.T.P.)	Three Canals	Three Canals	Secondary Treatment (not categorized)	5,000 to 9,999	10,000	NA	0.5 to 0.99	1.0 to 4.9	1.0

Map Ref. No.	Present Influent Loadings (MG/L) BOD_5	Present Influent Loadings (MG/L) S.S.	Removal Efficiency of Facility BOD_5	Removal Efficiency of Facility S.S	Present Effluent (MG/L) BOD_5	Present Effluent (MG/L) S.S	Year Facility Constructed	Capital Cost of Facility	Yearly O & M Costs of Facility	Type of Sludge Treatment
5-1	330	27	85 to 94.9	NA	NA	NA	NA	NA	NA	Sludge Digestor
19-1	NA	NA	85 to 94.9	NA	NA	NA	Circa 1960	NA	NA	Aerobic Digestor

Source: "Inventory of Basic Environmental Data, New Orleans - Baton Rouge Metropolitan Area," prepared for U.S. Army Corps of Engineers, New Orleans District, by Engineer Agency for Resources Inventories, U.S. Army Engineer Topographic Laboratories, Washington, D.C., March 1975.

APPENDIX D.6

WATER QUALITY, SEDIMENT, AND ELUTRIATE DATA FOR THE CANAL-BAYOU NETWORK IN THE VICINITY OF BAYOU CHOCTAW

Eleven tables comprise this appendix. The locations of all stations listed in the tables are provided in Figure 2.9. Tables D.6-1 through D.6-3 provide water quality and bottom sediment data for Miles 55, 50, and 45, respectively along the Port Allen Canal. The only available water quality data for the pond over Cavern No. 7 at Bayou Choctaw dome is presented in Table D.6-4. In situ water quality parameters, measured at the junction of the Port Allen Canal and Bayou Plaquemine and on Bayou Grosse Tete, are provided in Table D.6-5. Table D.6-6 presents analysis of water samples obtained at the same two points previously noted while Table D.6-7 presents pesticide analysis data for the same two sites. Analysis of sediment samples for the first of the two points previously noted is provided in Table D.6-8, while the corresponding pesticide analysis of the sediment is presented in Table D.6-9. Water quality analysis of standard elutriate* from the same site is provided in Table D.6-10 while the pesticide analysis of the same elutriate is presented in Table D.6-11.

*Standard elutriate is the supernatant resulting from the vigorous 30-minute shaking of one part of bottom sediment with four parts water (on a volumetric basis) collected from the same sample site, followed by a one-hour settling time and appropriate 0.45 μm filtration.

Table D.6-1. Analyses of Samples at Intracoastal Waterway (Port Allen to Morgan City), at Mile 55

WATER QUALITY DATA, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

DATE	TIME	DISSOLVED KJEL. NITROGEN (N) (MG/L)	TOTAL KJELD. NITROGEN IN BOTTOM DEP. (MG/KG)	TOTAL NONFILTRABLE RESIDUE (MG/L)	SUSPENDED SOLIDS (MG/L)	VOL. NONFILTRABLE RESIDUE (MG/L)	LOSS ON IGNITION IN BOTTOM DEPOSITS (MG/KG)	CHEMICAL OXYGEN DEMAND (HIGH LEVEL) (MG/L)	COD IN BOTTOM DEPOSITS (MG/KG)	CYANIDE (CN) (MG/L)
APR.										
20...	1050	.00	900	604	112	0	53000	11	22000	.00
20...	1455	.04	1300	100	112	0	63500	15	32000	.01

DATE	TOTAL CYANIDE IN BOTTOM DEPOSITS (UG/G)	PHENOLS (UG/L)	OIL AND GREASE (MG/L)	OIL AND GREASE IN BOTTOM DEPOSITS (MG/G)	DISSOLVED ARSENIC (AS) (UG/L)	TOTAL ARSENIC IN BOTTOM DEPOSITS (UG/G)	DISSOLVED CADMIUM (CD) (UG/L)	TOTAL CADMIUM IN BOTTOM DEPOSITS (UG/G)	DISSOLVED CHROMIUM (CR) (UG/L)	TOTAL CHROMIUM IN BOTTOM DEPOSITS (UG/G)
APR.										
20...	0	11	0	<1.0	2	15	0	1	10	12
20...	0	7	2	<1.0	2	3	0	1	0	12

DATE	DISSOLVED COPPER (CU) (UG/L)	TOTAL COPPER IN BOTTOM DEPOSITS (UG/G)	DISSOLVED LEAD (PB) (UG/L)	TOTAL LEAD IN BOTTOM DEPOSITS (UG/G)	DISSOLVED NICKEL (NI) (UG/L)	TOTAL NICKEL IN BOTTOM DEPOSITS (UG/G)	DISSOLVED MERCURY (HG) (UG/L)	TOTAL MERCURY IN BOTTOM DEPOSITS (UG/G)	DISSOLVED ZINC (ZN) (UG/L)	TOTAL ZINC IN BOTTOM DEPOSITS (UG/G)
APR.										
20...	2	23	0	30	2	25	.0	.1	6	77
20...	7	23	0	20	2	35	.0	.1	0	92

DATE	ALDRIN (UG/L)	ALDRIN IN BOTTOM DEPOSITS (UG/KG)	CHLORDANE (UG/L)	CHLORDANE IN BOTTOM DEPOSITS (UG/KG)	DDD (UG/L)	DDD IN BOTTOM DEPOSITS (UG/KG)	DDE (UG/L)	DDE IN BOTTOM DEPOSITS (UG/KG)	DDT (UG/L)	DDT IN BOTTOM DEPOSITS (UG/KG)	DIAZINON (UG/L)	DIELDRIN (UG/L)
APR.												
20...	.00	.0	.0	7	.00	2.0	.00	.2	.00	.4	.01	.00
20...	.00	.0	.0	6	.00	.0	.00	.7	.00	.5	.01	.00

DATE	DIELDRIN IN BOTTOM DEPOSITS (UG/KG)	ENDRIN (UG/L)	ENDRIN IN BOTTOM DEPOSITS (UG/KG)	ETHION (UG/L)	HEPTACHLOR (UG/L)	HEPTACHLOR IN BOTTOM DEPOSITS (UG/KG)	HEPTACHLOR EPOXIDE (UG/L)	HEPTACHLOR EPOXIDE IN BOTTOM DEPOSITS (UG/KG)	LINDANE (UG/L)	LINDANE IN BOTTOM DEPOSITS (UG/KG)	MALATHION (UG/L)
APR.											
20...	.6	.00	.0	.00	.00	.0	.00	<.1	.00	.0	.00
20...	.7	.00	.1	.00	.00	.0	.00	.1	.00	.0	.00

DATE	METHYL PARATHION (UG/L)	METHYL TRITHION (UG/L)	PARATHION (UG/L)	PCB (UG/L)	PCB IN BOTTOM DEPOSITS (UG/KG)	TOXAPHENE (UG/L)	TOXAPHENE IN BOTTOM DEPOSITS (UG/KG)	TRITHION (UG/L)	2,4-D (UG/L)	2,4,5-T (UG/L)	SILVEX (UG/L)
APR.											
20...	.00	.00	.00	.0	50	0	0	.00	.00	.00	.00
20...	.00	.00	.00	.0	62	0	0	.00	.02	.00	.07

Source: "Water Resources Data for Louisiana," U.S. Department of Interior, Geological Survey, 1975.

Table D.6-2. Analyses of Samples Collected at Intracoastal Waterway (Port Allen to Morgan City), at Mile 50

WATER QUALITY DATA, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

DATE	TIME	DISSOLVED KJEL. NITROGEN (N) (MG/L)	TOTAL KJELD. NITROGEN IN BOTTOM DEP. (MG/KG)	TOTAL NON-FILTRABLE RESIDUE (MG/L)	SUSPENDED SOLIDS (MG/L)	VOL. NON-FILTRABLE RESIDUE (MG/L)	LOSS ON IGNITION IN BOTTOM DEPOSITS (MG/KG)	CHEMICAL OXYGEN DEMAND (HIGH LEVEL) (MG/L)	COD IN BOTTOM DEPOSITS (MG/KG)	CYANIDE (CN) (MG/L)
APR.										
20...	1115	.28	1300	100	116	14	53700	4	34000	.00
20...	1430	.39	1000	0	32	0	56000	12	40000	.00

DATE	TOTAL CYANIDE IN BOTTOM DEPOSITS (UG/G)	PHENOLS (UG/L)	OIL AND GREASE (MG/L)	OIL AND GREASE IN BOTTOM DEPOSITS (MG/G)	DISSOLVED ARSENIC (AS) (UG/L)	TOTAL ARSENIC IN BOTTOM DEPOSITS (UG/G)	DISSOLVED CADMIUM (CD) (UG/L)	TOTAL CADMIUM IN BOTTOM DEPOSITS (UG/G)	DISSOLVED CHROMIUM (CR) (UG/L)	TOTAL CHROMIUM IN BOTTOM DEPOSITS (UG/G)
APR.										
20...	0	17	0	1.0	1	4	0	<1	0	0
20...	0	9	0	1.0	1	6	0	<1	0	11

DATE	DISSOLVED COPPER (CU) (UG/L)	TOTAL COPPER IN BOTTOM DEPOSITS (UG/G)	DISSOLVED LEAD (PB) (UG/L)	TOTAL LEAD IN BOTTOM DEPOSITS (UG/G)	DISSOLVED NICKEL (NI) (UG/L)	TOTAL NICKEL IN BOTTOM DEPOSITS (UG/G)	DISSOLVED MERCURY (HG) (UG/L)	TOTAL MERCURY IN BOTTOM DEPOSITS (UG/G)	DISSOLVED ZINC (ZN) (UG/L)	TOTAL ZINC IN BOTTOM DEPOSITS (UG/G)
APR.										
20...	5	17	0	20	0	20	.0	.1	0	55
20...	4	27	1	20	1	20	.0	.1	0	71

DATE	ALDRIN (UG/L)	ALDRIN IN BOTTOM DEPOSITS (UG/KG)	CHLORDANE (UG/L)	CHLORDANE IN BOTTOM DEPOSITS (UG/KG)	DDD (UG/L)	DDD IN BOTTOM DEPOSITS (UG/KG)	DDE (UG/L)	DDE IN BOTTOM DEPOSITS (UG/KG)	DDT (UG/L)	DDT IN BOTTOM DEPOSITS (UG/KG)	DIAZINON (UG/L)	DIELDRIN (UG/L)
APR.												
20...	.00	.0	.0	9	.00	2.8	.00	.5	.00	.0	.01	.00
20...	.00	.0	.0	6	.00	1.6	.00	.4	.00	.0	.00	.00

DATE	DIELDRIN IN BOTTOM DEPOSITS (UG/KG)	ENDRIN (UG/L)	ENDRIN IN BOTTOM DEPOSITS (UG/KG)	ETHION (UG/L)	HEPTACHLOR (UG/L)	HEPTACHLOR IN BOTTOM DEPOSITS (UG/KG)	HEPTACHLOR EPOXIDE (UG/L)	HEPTACHLOR EPOXIDE IN BOTTOM DEPOSITS (UG/KG)	LINDANE (UG/L)	LINDANE IN BOTTOM DEPOSITS (UG/KG)	MALATHION (UG/L)
APR.											
20...	.2	.00	.0	.00	.00	.0	.00	.0	.00	.0	.00
20...	.6	.00	.0	.00	.00	.0	.00	.0	.00	.0	.00

DATE	METHYL PARATHION (UG/L)	METHYL TRITHION (UG/L)	PARATHION (UG/L)	PCB (UG/L)	PCB IN BOTTOM DEPOSITS (UG/KG)	TOXAPHENE (UG/L)	TOXAPHENE IN BOTTOM DEPOSITS (UG/KG)	TRITHION (UG/L)	2,4-D (UG/L)	2,4,5-T (UG/L)	SILVEX (UG/L)
APR.											
20...	.00	.00	.00	.0	74	0	0	.00	.05	.00	.12
20...	.00	.00	.00	.0	25	0	0	.00	.03	.00	.15

Source: "Water Resources Data for Louisiana," U.S. Department of Interior, Geological Survey, 1975.

Table D.6-3. Analyses of Samples Collected at Intracoastal Waterway (Port Allen to Morgan City), Mile 45.

WATER QUALITY DATA, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

DATE	TIME	DIS-SOLVED KJEL. NITRO-GEN (N) (MG/L)	TOTAL KJEL. NITRO-GEN IN BOTTOM DEP. (MG/KG)	TOTAL NON-FILT-RABLE RESIDUE (MG/L)	SUS-PENDED SOLIDS (MG/L)	VOL. NON-FILT-RABLE RESIDUE (MG/L)	LOSS ON IGNI-TION IN BOTTOM DE-POSITS (MG/KG)	CHEM-ICAL OXYGEN DEMAND (HIGH LEVEL) (MG/L)	COD IN BOTTOM DE-POSITS (MG/KG)	CYANIDE (CN) (MG/L)
APR.										
20...	1140	.41	1200	19	44	6	54800	16	38000	.08
20...	1355	.37	1100	22	48	10	49300	17	34000	.00

DATE	TOTAL CYANIDE IN BOTTOM DE-POSITS (UG/G)	PHENOLS (UG/L)	OIL AND GREASE (MG/L)	OIL AND GREASE IN BOT-TOM DE-POSITS (MG/G)	DIS-SOLVED ARSENIC (AS) (UG/L)	TOTAL ARSENIC IN BOTTOM DE-POSITS (UG/G)	DIS-SOLVED CAD-MIUM (CD) (UG/L)	TOTAL CADMIUM IN BOTTOM DE-POSITS (UG/G)	DIS-SOLVED CHRO-MIUM (CR) (UG/L)	TOTAL CHRO-MIUM IN BOTTOM DE-POSITS (UG/G)
APR.										
20...	0	8	0	1.0	3	4	0	<1	0	9
20...	0	15	1	<1.0	1	3	0	<1	0	7

DATE	DIS-SOLVED COPPER (CU) (UG/L)	TOTAL COPPER IN BOTTOM DE-POSITS (UG/G)	DIS-SOLVED LEAD (PB) (UG/L)	TOTAL LEAD IN BOTTOM DE-POSITS (UG/G)	DIS-SOLVED NICKEL (NI) (UG/L)	TOTAL NICKEL IN BOTTOM DE-POSITS (UG/G)	DIS-SOLVED MERCURY (HG) (UG/L)	TOTAL MERCURY IN BOTTOM DE-POSITS (UG/G)	DIS-SOLVED ZINC (ZN) (UG/L)	TOTAL ZINC IN BOTTOM DE-POSITS (UG/G)
APR.										
20...	6	18	0	20	1	15	.0	.1	0	67
20...	5	21	1	30	1	15	.0	.1	0	64

DATE	ALDRIN (UG/L)	ALDRIN IN BOTTOM DE-POSITS (UG/KG)	CHLOR-DANE (UG/L)	CHLOR-DANE IN BOTTOM DE-POSITS (UG/KG)	DDD (UG/L)	DDD IN BOTTOM DE-POSITS (UG/KG)	DDE (UG/L)	DDE IN BOTTOM DE-POSITS (UG/KG)	DDT (UG/L)	DDT IN BOTTOM DE-POSITS (UG/KG)	DI-AZINON (UG/L)	DI-ELDRIN (UG/L)
APR.												
20...	.00	.0	.0	12	.00	4.5	.00	.4	.00	.0	.00	.00
20...	.00	.0	.0	11	.00	1.4	.00	.3	.00	.0	.01	.00

DATE	DI-ELDRIN IN BOTTOM DE-POSITS (UG/KG)	ENDRIN (UG/L)	ENDRIN IN BOTTOM DE-POSITS (UG/KG)	ETHION (UG/L)	HEPTA-CHLOR (UG/L)	HEPTA-CHLOR IN BOTTOM DE-POSITS (UG/KG)	HEPTA-CHLOR EPOXIDE (UG/L)	HEPTA-CHLOR EPOXIDE IN BOT-TOM DE-POSITS (UG/KG)	LINDANE (UG/L)	LINDANE IN BOTTOM DE-POSITS (UG/KG)	MALA-THION (UG/L)
APR.											
20...	.5	.00	.0	.00	.00	.0	.00	<.1	.00	.0	.00
20...	.2	.00	.0	.00	.00	.0	.00	.0	.00	.0	.00

DATE	METHYL PARA-THION (UG/L)	METHYL TRI-THION (UG/L)	PARA-THION (UG/L)	PCB (UG/L)	PCB IN BOTTOM DE-POSITS (UG/KG)	TOX-APHENE (UG/L)	TOX-APHENE IN BOTTOM DE-POSITS (UG/KG)	TRI-THION (UG/L)	2,4-D (UG/L)	2,4,5-T (UG/L)	SILVEX (UG/L)
APR.											
20...	.00	.00	.00	.0	25	0	0	.00	.06	.00	.23
20...	.00	.00	.00	.0	46	0	0	.00	.05	.00	.21

Source: "Water Resources Data for Louisiana," U.S. Department of Interior, Geological Survey, 1975.

Table D.6-4. Water Quality Data for Small Pond Over Cavern No. 7 (Taken during the summer of 1973)

Chemical Characteristic	Amount
Na_2SO_4	30 ppm
Ca	32.1 ppm
Mg	24.9 ppm
Fe	0.6 ppm
NaCl	1000.0 ppm
ph	6.8 ppm

Source: Webb, C.B., private communication, Allied Chemical Corporation, Bayou Choctaw, Louisiana, March 26, 1976.

Table D.6-5. In Situ Parameters Measured During the Period 23-28 March 1975 on the Port Allen Canal and Bayou Plaquemine

	Station 16+	Station 14+
Time/Date	0830/26MAR	0215/26 Mar
Depth (m)	4.8	5.0
Temp (°C)	11.3	15.5
DO (mg/l)	10.40	8.1
pH	7.45	7.75
Cond. (μmho/cm)	270	265
ORP** (mv)	+305	+330
Sed. pH	7.35	7.80
Direction of Flow	N	N

\+ Station 16 is located on the Bayou Plaquemine near its junction with Port Allen Canal.

Station 14 is located on the Port Allen Canal 9 miles South of Bayou Plaquemine.

** Oxidation-reduction potential

I=indeterminate.

Source: "Gulf Intracoastal Waterway, Petit Anse, Tigre and Carlin Bayous; and Bayou Grosse Tete, Louisiana," Draft Environmental Statement, U.S. Army Corps of Engineers, New Orleans District, November 1975.

Table D.6-6 Analysis of Water Samples Taken During the Period 23-28 March 1975 on the Port Allen Canal and Bayou Grosse Tete

	Sample Station 16	Sample Station 14
Total COD (ug/l)	18.1	22.9
Dissolved COD (mg/l)	16.5	13.7
Total TKN (mgN/l)	1.03	0.98
Dissolved TKN (mgN/l)	0.68	0.27
NO_3 (mgN/l)	0.97	0.55
NH_3 (mgN/l)	0.25	0.14
Solluble Ortho P (mgP/l)	0.03	<0.01
Total P (mgP/l)	0.75	0.75
Dissolved Organic Carbon (mg/l)	15.5	10.7
Grease & Oil (mg/l)	7.5	12.0
Total Susp. Solids (mg/l)	127	96
Volatile Susp. Solids (mg/l)	118	84
Total Zn (μg/l)	36	63
Sol. Zn (μg/l)	8.8	2.0
Total Cd (μg/l)	0.7	0.5
Sol. Cd (μg/l)	0.5	0.5
Total Cu (μg/l)	5	19
Sol. Cu (μg/l)	5	9
Total Cr (μg/l)	14	10
Sol. Cr (μg/l)	<0.5	<0.5
Total Ni (μg/l)	54	83
Sol. Ni (μg/l)	14	14
Total Pb (μg/l)	6.5	5.2
Sol. Pb (μg/l)	<1	<1
Total As (μg/l)	58	48
Sol. As (μg/l)	58	48
Total Hg (μg/l)	6.8	12.8
Sol. Hg (μg/l)	6.8	10.0

*Station 16 is located on the Bayou Plaquemine near its junction with Port Allen Canal.
Station 14 is located on the Port Allen Canal 9 miles south of Bayou Plaquemine.

Source: "Gulf Intracoastal Waterway, Petit Anse, Tigre and Carlin Bayous; and Bayou Grosse Tete, Louisiana," Draft Environmental Statement, U.S. Army Corps of Engineers, New Orleans District, November 1975.

Table D.6-7 Pesticide Analysis of Water Samples Taken During the Period 23-29 March 1975 on the Port Allen Canal and Bayou Plaquemine (All concentrations expresses as ng/l)

	Station 16**	Station 14**
Toxaphene	<50	<50
Lindane	<1.0	49
Heptachlor	<1.0	26
Heptachlor Epoxide	<1.0	4.9
Aldrin	<1.0	1.0
Chlordane	<15	95
Dieldrin	<2.0	12
Ethion	ND	ND
Methoxychlor	<1.0	1.7
Endrin	<3.0	<3.0
O,P'-DDT	<3.0	<3.0
P,P'-DDT	<3.0	<3.0
O,P'-DDE	<1.0	<1.0
P,P'-DDE	<2.0	<2.0
O,P'-DDD	<2.0	<2.0
P,P'-DDD	<3.0	<3.0

**Station 16 is located on the Bayou Plaquemine near its junction with Port Allen Canal.

Station 14 is located on the Port Allen Canal 9 miles south of Bayou Plaquemine.

Source: "Gulf Intracoastal Waterway, Petit Anse, Tigre and Carlin Bayous; and Bayou Grosse Tete, Louisiana," Draft Environmental Statement, U.S. Army Corps of Engineers, New Orleans District, November 1975.

Table D.6-8 Analysis of sediment samples* taken from Station #16** and 14 on the Gulf Intracoastal Waterway during the period 23-29 March 1975

Station #	#16	#14
% Water	21	14
% Coarser Than Sand	9	0
% Sand	42	98
% Finer Than Sand	48	2
COD (mg/kg)	2,000	1300
TKN (mg/kg)	1,000	1300
Grease & Oil (mg/kg)	9,100	1000
H_2S (mg/kg)	3.49	<.69
Total Zn (mg/kg)	153	34
Total Cd (mg/kg)	<2	2
Total Cu (mg/kg)	50	8
Total Cr (mg/kg)	44	11
Total Ni (mg/kg)	31	16
Total Pb (mg/kg)	122	13
Total As (mg/kg)	9.4	10.6
Total Hq (mg/kg)	80.0	10.6

* All concentrations reported on dry weight basis.

** Station 16 is located on the Bayou Plaquemine near its junction with Port Allen Canal.

Station 14 is located on the Port Allen Canal 9 miles south of Bayou Plaquemine.

Source: "Gulf Intracoastal Waterway, Petit Anse, Tiqre and Carlin Bayous; and Bayou Grosse Tete, Louisiana," Draft Environmental Statement, U.S. Army Corps of Engineers, New Orleans District, November 1975.

Table D.6-9 Pesticide analysis of sediments samples+ taken from Station #16** and 14 on the Gulf Intracoastal Waterway during the period 23-29 March.

Station #	#16	#14
Toxaphene	<5.0	<5.0
Lindane	0.85	<0.5
Heptachlor	<0.10	<0.1
Heptachlor Epoxide	0.46	<.12
Aldrin	<0.10	<0.6
Chlordane	23	1.7
Dieldrin	5.3	0.68
Ethion	ND*	ND
Methoxychlor	0.13	0.2
Endrin	1.1	<0.3
O,P'-DDT	<0.30	<0.3
P,P'-DDT	<0.30	<0.3
O,P'-DDE	2.7	<0.2
P,P'-DDE	3.6	0.33
O,P'-DDT	1.2	0.17
P,P'-DDD	<0.20	<.20

+ All concentrations expressed as ng/g.

* Not detectable.

** Station 16 is located on the Bayou Plaquemine near its junction with Port Allen Canal.

Station 14 is located on the Port Allen Canal 9 miles south of Bayou Plaquemine.

Source: "Gulf Intracoastal Waterway, Petit Anse, Tigre and Carlin Bayous; and Bayou Grosse Tete, Louisiana," Draft Environmental Statement, U.S. Army Corps of Engineers, New Orleans District, November 1975.

Table D.6-10 Analysis of standard elutriate of sediment samples taken from Station # 16* and 14 on the Gulf Intracoastal Waterway during the period 23-28 March 1975.

Station #	#16	#14
COD (mg/l)	221	658
TKN (mg/l)	2.48	1.24
Soluble Ortho P (mgP/l)	0.07	0.04
Dissolved Organic Carbon (mg/l)	10.9	31.2
Sol. Zn. (μg/l)	6.5	11
Sol. Cd (μg/l)	1.1	1.8
Sol. Cu (μg/l)	15	16
Sol. Cr (μg/l)	< 0.5	< 0.5
Sol. Ni (μg/l)	71	71
Sol. Pb (μg/l)	< 1.0	< 1.0
Sol. As (μg/l)	68	124
Sol. Hg (μg/l)	3.0	< 0.2

*Station 16 is located on the Bayou Plaquemine near its junction with Port Allen Canal.

Station 14 is located on the Port Allen Canal 9 miles south of Bayou Plaquemine.

Source: "Gulf Intracoastal Waterway, Petit Anse, Tigre and Carlin Bayous; and Bayou Grosse Tete, Louisiana," Draft Environmental Statement, U. S. Army Corps of Engineers, New Orleans District, November 1975.

Table D.6-11 Pesticide analysis of standard elutriate of sediment samples+ taken from Station # 16** and 14 on the Gulf Intracoastal Waterway during the period 23-29 March 1975.

Station #	#16	#14
Toxaphene	<50	<50
Lindane	2.7	<1.0
Heptachlor	<1.0	<1.0
Heptachlor Epoxide	1.1	<1.0
Aldrin	<1.0	<1.0
Chlordane	<10	<10
Dieldrin	10	<2
Ethion	ND*	ND
Methoxychlor	<1.0	<1
Endirn	3.0	3
O,P'-DDT	3.0	<3
P,P'-DDT	3.0	12
O,P'-DDE	2.0	2
P,P-DDE	12	<3
O,P'-DDD	<1.0	<1
P,P'-DDD	<2.0	<2

+All concentrations expressed as ng/l.

*Not detectable.

**Station 16 is located on the Bayou Plaquemine near its junction with Port Allen Canal.

Station 14 is located on the Port Allen Canal 9 miles south of Bayou Plaquemine.

Source: "Gulf Intracoastal Waterway, Petit Anse, Tigre and Carlin Bayous; and Bayou Grosse Tete, Louisiana," Draft Environmental Statement, U.S. ARmy Corps of Engineers, New Orleans District, November 1975.

APPENDIX D.7

YIELD, WATER QUALITY AND UTILIZATION OF SHALLOW SUBSURFACE AQUIFERS NEAR THE BAYOU CHOCTAW SALT DOME

Four tables make up this appendix. Table D.7-1 provides records of the yield of selected water wells in parishes near the Bayou Choctaw site. Complete chemical analysis of water from some of these wells is presented in Table D.7-2 while partial chemical analysis for a number of other wells is provided in Table D.7-3. Table D.7-4 provides a summary of water utilization for the shallow subsurface aquifers.

Table D.7-1. Records of Selected Water Wells

Use of water: Ind, industrial; Irr, irrigation; P, public supply; S, stock; U, unused.
Yield: The yield shown is the measured or reported yield from pumping or acceptance tests and generally reflects the capacity of the pump installed rather than the well capacity. P, rated pump capacity; yield not measured.
Specific capacity: Not corrected for pipe friction or for varying pumping periods. Number in parentheses is pumping period, in hours. R, specific capacity calculated from reported yield and drawdown, pumping period not reported.

USGS well number	Owner and owner's well number	Driller	Year completed	Depth (feet)	Screened interval (feet below land surface)	Diameter of well (inches)	Use of water	Yield (gpm)	Specific capacity (gpm per foot of drawdown)
	EAST BATON ROUGE PARISH								
EB-375	Louisiana State University	D. K. Summers	1955	2,500	2,460-2,500	12-10- 6	Irr	[a]664	8
	IBERVILLE PARISH								
Ib-12	J. Supple's Sons Planting Co., Ltd., No. 3 (Catherine Mill).	W. M. Eberhart & Son	1944	268	188- 268	18-12	Ind	3,000	R 100
-28	Louisiana State University	Coastal Water Well Corp.	1949	197	154- 194	12- 6	S	750	R 50
-30	City of Plaquemine, No. 2	Stamm-Scheele, Inc.	1952	256	161- 251	16-12	P	1,400 2,580	R 40.0 R 32.2
-60	City of Plaquemine, No. 1	Stamm-Scheele, Inc.	1952	254	179- 250	16-12	P	1,400 2,710	R 42.4 R 34.7
-61	City of Plaquemine, No. 3	Stamm-Scheele, Inc.	1952	255	180- 251	16-12	P	1,400 2,640	R 43.8 R 35.2
-62	Cora-Texas Manufacturing Co.	Coastal Water Well Corp.	1955	276	194- 274	20-12	Ind	3,500	------------
-63	Cora-Texas Manufacturing Co.	Coastal Water Well Corp.	1937	190	----------	10	Ind	P 1,700	------------
-87	Gulf States Utilities Co., Willow Glen Plant, No. 2.	Coastal Water Well Corp.	1957	473	430- 470	12- 8	U	520	6.0 (92)
-98	Gulf States Utilities Co., Willow Glen Plant, No. 5.	Coastal Water Well Corp.	1958	190	147- 187	12- 8	Ind	500	39.2 (360)
-99	Gulf States Utilities Co., Willow Glen Plant, No. 6.	Coastal Water Well Corp.	1958	190	147- 187	12- 8	Ind	300	43.9 (24)
-101	Cora-Texas Manufacturing Co.	W. M. Eberhart & Son	1959	273	201- 271	18-10	Ind	P 2,000	------------
-129	Solvay Process Div., Allied Chemical Corp., No. 5.	Layne Louisiana Co.	1948	240	195- 236	18-12	Ind	1,000	------------
-131	Solvay Process Div., Allied Chemical Corp., No. 6A.	W. M. Eberhart & Son	1953	132	72- 132	12	Ind	1,200	R 30
-132	Solvay Process Div., Allied Chemical Corp., No. 7A.	W. M. Eberhart & Son	1952	148	88- 148	18-12	Ind	1,000	R 40
-133	Solvay Process Div., Allied Chemical Corp., No. 8A.	W. M. Eberhart & Son	1952	161	91- 161	18-12	Ind	1,100	R 20.8
-170	Gulf States Utilities Co., Willow Glen Plant, No. 7.	Coastal Water Well Corp.	1961	265	243- 263	8- 6	Ind	252 416	43.6 (1.8) 39.0 (0.4)
-178	Gulf States Utilities Co., Willow Glen Plant, No. 8.	Stamm-Scheele, Inc.	1962	190	147- 187	12- 8	Ind	500	13.9 (8)
-181	The Dow Chemical Co., La. Div., No. 1	Stamm-Scheele, Inc.	1964	482	346- 480	30-18	Ind	3,050 5,300	100 (2.5) 97 (2)
-182	The Dow Chemical Co., La. Div., No. 2	Stamm-Scheele, Inc.	1963	447	344- 445	30-18	Ind	5,740	137 (8)
-183	The Dow Chemical Co., La. Div., No. 3	Stamm-Scheele, Inc.	1963	422	317- 420	30-18	Ind	5,300	149 (8)
-191	A. Wilbert's Sons Lumber & Shingle Co., Myrtle Grove Mill.	W. M. Eberhart & Son	1962	262	170- 197 207- 260	16-12	Ind	3,000	R 30
-196	Town of White Castle	Layne Louisiana Co.	1966	250	182- 202 230- 250	14-10	P	600 1,500	112 (8) 94 (24)
-199C	Iberville Water District No. 2, No. 1	Stamm-Scheele, Inc.	1967	220	190- 220	10- 6	P	300	33.3
-205	Shell Oil Co., Bayou Goula Plant, No. 1	Stamm-Scheele, Inc.	1967	250	170- 250	12- 8	Ind	1,500	69.8
-206	Shell Oil Co., Bayou Goula Plant, No. 2	Stamm-Scheele, Inc.	1967	241	160- 241	12- 8	Ind	1,500	116.1
-208	Louisiana State University	Summers Brothers	1969	187	147- 187	12	Irr	1,845	47.3
-210	Gulf States Utilities Co., Willow Glen Plant, No. 9	Stamm-Scheele, Inc.	1968	220	140- 175 180- 215	16-10	Ind	521	78.1
-211	Gulf States Utilities Co., Willow Glen Plant, No. 10.	Stamm-Scheele, Inc.	1968	188	138- 188	16-10	Ind	521	100.8
-212	Geigy Chemical Corp., No. LA	Stamm-Scheele, Inc.	1968	216	135- 186 196- 216	16- 8	Ind	2,000	69.8
-213	Geigy Chemical Corp., No. LB	Stamm-Scheele, Inc.	1968	208	136- 208	16- 8	Ind	2,000	74.3
-214	Geigy Chemical Corp., No. LC	Stamm-Scheele, Inc.	1968	216	136- 216	16- 8	Ind	2,000	79.2
-215	Geigy Chemical Corp., No. LD	Stamm-Scheele, Inc.	1968	190	140- 190	16- 8	Ind	2,000	59.6
-216	Geigy Chemical Corp., No. LE	Stamm-Scheele, Inc.	1968	230	149- 230	16- 8	Ind	2,000	94.1
-217	Geigy Chemical Corp., No. C-7	Layne Louisiana, Inc.	1970	220	160- 220	26-18	Ind	P 2,500	------------
-218	Geigy Chemical Corp., No. E-5	Layne Louisiana, Inc.	1970	235	175- 235	26-18	Ind	P 2,500	------------
-219	Geigy Chemical Corp., No. C-5	Layne Louisiana, Inc.	1970	220	160- 220	26-18	Ind	P 2,500	------------
-220	Stauffer Chemical Co., No. 1	Stamm-Scheele, Inc.	1968	196	140- 196	16- 8	Ind	1,500	70.9
-221	Stauffer Chemical Co., No. 2	Stamm-Scheele, Inc.	1968	230	150- 230	16- 8	Ind	1,500	101.7
-222	Stauffer Chemical Co., No. 3	Stamm-Scheele, Inc.	1968	215	135- 215	16- 8	Ind	1,500	99.5
-223	Town of White Castle	L. B. Haney Plumbing & Well Drilling, Inc.	1969	227	187- 227	14-10	P	750	18.9
-224	Goodyear Tire & Rubber Co., No. 1	Stamm-Scheele, Inc.	1968	430	310- 350 370- 430	24-14	Ind	6,430	132.2
-225	Goodyear Tire & Rubber Co., No. 2	Stamm-Scheele, Inc.	1970	438	337- 438	24-14	Ind	-------	------------
-227	Georgia-Pacific Corp., No. 1	Stamm-Scheele, Inc.	1969	380	278- 380	16-10	Ind	2,030	93.7
-228	Georgia-Pacific Corp., No. 2	Stamm-Scheele, Inc.	1969	350	278- 350	16-10	Ind	2,050	95.2
-229D	Hercules, Inc., Allemania Plant	Layne Louisiana, Inc.	1967	525	425- 525	12- 8	Ind	500	20.0
	WEST BATON ROUGE PARISH								
WBR-119	Copolymer Rubber & Chemical Corp., No. 1	W. M. Eberhart & Son	1967	365	285- 365	16-10	Ind	P 1,200	------------
-120	Copolymer Rubber & Chemical Corp., No. 2	W. M. Eberhart & Son	1967	358	268- 358	16-10	Ind	P 1,200	------------

[a] Flowed 530 gpm, 1955.

Source: Whiteman, Jr., C.D., "Ground Water in the Plaquemine-White Castle Area, Iberville Parish, Louisiana," Water Resources Bulletin No. 16, Department of Conservation, Louisiana Geological Survey, and Louisiana Department of Public Works, Baton Rouge, La., 1972.

Table D.7-2. Complete Chemical Analyses of Water From Wells

(Analyses of U.S. Geological Survey)

Well No.	Depth (feet)	Date of collection	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Phosphate (PO_4)	Dissolved solids: Residue on evaporation at 180°C	Dissolved solids: Sum of determined constituents	Hardness as $CaCO_3$	pH	Specific conductance (micromhos at 25°C)	Color
				Milligrams per liter																				
ASCENSION PARISH																								
An-227	233	4-23-63	--	15	0.11	0.00	85	33	172	6.3	0	592	0.0	184	0.0	0.0	0.14	0.00	794	788	347	*7.8	1,430	15
EAST BATON ROUGE PARISH																								
EB-256	220	5- 5-45	69	22	1.3	----	37	12	18	2.6	0	200	0.5	12	0.0	2.8	----	----	208	207	142	7.3	334	--
-257	220	4-24-59	69	25	1.8	0.01	40	12	27	1.7	0	225	.4	15	.3	.1	0.13	0.5	235	233	147	*7.4	389	0
-575	2,500	6- 1-55	97	30	.07	.01	.6	.0	245	1.2	9	305	1.7	196	.6	.0	.37	1.0	634	635	2	8.5	1,110	20
IBERVILLE PARISH																								
Ib-17	225	5- 5-45	68	18	4.5	----	122	5.4	84	8.9	0	620	1.1	9.0	0.0	0.2	----	----	533	558	326	6.8	880	--
-18	185	5- 5-45	69	41	6.1	----	134	2.1	76	7.4	0	622	.6	5.0	.0	.2	----	----	533	579	343	6.9	876	--
-23	220	3- 8-57	65	22	.68	0.01	37	11	15	1.4	0	164	15	16	.3	.0	0.2	0.6	194	199	138	7.5	329	5
-28	197	3- 8-57	69	24	2.0	.05	40	14	122	2.0	0	280	.0	142	.3	.0	.08	.3	469	483	158	7.4	853	10
-31	200	5- 6-59	68	40	13	.04	110	27	26	4.7	0	518	1.4	17	.2	.2	.13	.4	484	482	387	*7.1	796	60
-60	254	3- 8-57	65	22	5.5	.01	92	22	12	2.1	0	410	.0	11	.1	.0	.00	.3	364	364	320	7.2	629	5
-65	190	4- 1-57	66	20	.77	.10	41	8.5	15	1.0	0	145	23	16	.1	2.5	.03	.8	200	199	137	7.5	328	0
-87	473	11-25-57	72	30	.17	.00	4.3	1.4	408	1.7	0	593	.0	308	1.0	.0	.34	2.1	1,020	1,050	16	8.2	1,780	40
		12- 6-57	72	38	.90	.00	32	11	1,030	3.6	0	529	11	1,350	.6	.0	.47	.8	-----	2,770	125	7.7	4,880	30
-88	190	1-21-58	70	22	2.3	.08	72	21	53	2.5	0	412	.6	34	.1	.0	.09	.1	393	408	266	7.6	676	5
-89	310	4-18-61	70	22	.86	.10	51	11	145	1.8	0	474	.6	80	.0	.1	.08	.0	587	545	174	*7.6	962	20
-118	166	8-23-61	68	17	-----	.06	102	29	46	2.8	0	527	.6	31	.0	.0	.40	.0	500	489	375	*7.6	574	30
-119	310	2-19-60	70	24	5.9	.01	56	15	248	2.7	0	556	.6	200	.4	.3	.20	.6	830	822	200	*7.8	1,410	50
-124	186	8-23-61	70	29	-----	.00	15	1.7	190	2.9	0	368	.4	111	.8	.0	.33	3.5	568	536	46	*7.4	911	100
-132	148	10- 4-61	69	14	1.4	.00	56	19	34	2.9	0	320	.8	18	.3	.8	.06	.00	307	303	218	*7.7	554	5
-154	300	3-15-61	70	29	.36	----	21	7.5	120	1.8	0	396	.0	16	.5	.1	----	----	402	391	83	7.4	629	30
-161	370	5-26-61	65	23	.40	.00	45	11	34	1.3	0	263	.6	10	.0	.1	.05	.00	264	255	156	*7.7	444	20
-162	348	6- 2-61	69	21	.33	.02	22	5.1	125	2.0	0	394	.0	23	.2	.3	.10	.3	420	394	76	*7.7	669	40
-163A	317	6- 7-61	69	21	7.6	.08	92	22	34	4.3	0	460	.8	16	.0	.0	.15	.2	478	418	320	*6.9	731	40
-163B	420	6-29-61	71	18	.15	.00	36	4.4	84	1.6	0	324	.6	19	.3	.1	.16	.2	359	324	108	7.2	558	10
-171	440	10-26-61	70	16	.17	.00	8.7	2.8	224	9.7	0	456	.0	115	1.2	.9	.38	1.4	650	602	33	*7.9	1,000	40
-182	447	6-28-66	69	35	1.6	----	45	48	20	2.9	0	408	.4	9.8	.0	5.3	----	----	391	367	310	*6.9	650	10
-190	200	6-25-66	70	26	.35	----	49	14	41	2.0	0	299	.0	18	.0	.1	----	----	300	297	182	*7.2	506	5
-205	250	11-19-70	--	32	1.6	.08	31	9.1	214	4.0	0	332	1.2	225	.5	.0	----	----	686	681	115	7.9	1,200	15
-223	227	11-20-70	68	27	.78	.07	33	10	20	1.9	0	193	.0	10	.1	.0	----	----	200	198	125	8.0	318	5
WEST BATON ROUGE PARISH																								
WBR-8	232	7-10-68	--	20	1.9	----	53	13	11	1.8	0	251	0.0	5.2	0.2	2.5	----	----	232	231	186	*7.4	394	5

*Field determination; other values determined in laboratory.

Source: Whiteman, Jr., C.D., "Ground Water In The Plaquemine-White Castle Area, Iberville Parish, Louisiana," Water Resources Bulletin No. 16, Department of Conservation, Louisiana Geological Survey, and Louisiana Department of Public Works, Baton Rouge, La., 1972.

Table D.7-3. Partial Chemical Analyses of Water From Selected Wells

(Analyses by U.S. Geological Survey unless otherwise indicated. Results of analyses by other laboratories have been adjusted to conform with U.S. Geological Survey reporting standards.)

Well No.	Depth (feet)	Date of collection	Temperature (°F)	Iron (Fe)	Sulfate (SO_4)	Chloride (Cl)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$	pH	Specific conductance (micromhos at 25°C)	Color	Remarks
				Milligrams per liter								
ASCENSION PARISH												
An-65	180	5-13-59	69	-----	----	10	------	551	----	1,030	---	
-145	175	2- 8-62	68	-----	----	230	------	218	----	1,120	---	
-213	326	10-23-61	70	5.6	----	13	------	269	----	846	---	
-247	373	10- 2-64	--	.7	0	895	[a]1,760	164	7.3	3,390	---	Analysis by Curtis Laboratories.
-250A	168	7-29-65	--	12	0	5.0	[a]416	289	7.2	649	---	Analysis by Curtis Laboratories.
-250B	300	8- 8-65	--	.25	0	236	[a]899	188	7.8	1,640	---	Analysis by Curtis Laboratories.
-250C	73	8-21-65	--	25	0	13	[a]925	695	7.4	1,620	---	Analysis by Curtis Laboratories.
EAST BATON ROUGE PARISH												
EB-202	250	7-10-40	--	-----	----	231	------	78	----	-----	---	Fluoride, 0.0 mg/l.
-266	270	4-24-59	69	-----	----	22	------	169	8.0	547	---	
-284	304	11-10-43	--	1.5	----	1,840	------	375	----	-----	---	Fluoride, 0.6 mg/l.
-420	354	11-25-56	--	.1	----	95	------	40	----	-----	---	
-625	420	2- 7-57	--	.1	----	78	------	20	----	-----	---	
-716	165	12-28-59	68	1.8	----	69	------	124	----	626	---	
-762	280	12-27-63	--	----	----	65	------	28	----	361	---	
IBERVILLE PARISH												
Ib-10	317	8-25-66	68	0.65	3	63	------	106	7.2	-----	---	
		12- 7-59	--	-----	----	19	------	102	----	357	---	
-20	361	10- 2-47	--	1.0	----	5.2	450	170	7.6	-----	25	Analysis by Louisiana State Board of Health.
		5-27-57	--	1.2	----	6.9	461	---	7.5	-----	5	Analysis by Louisiana State Board of Health.
-21	300	9- 5-61	--	-----	----	41	------	99	----	659	---	
-22A	200	2- -47	--	7.2	.8	9.7	750	400	8.0	-----	70	Analysis by Louisiana State Board of Health.
-22B	370	2- -47	--	3.0	.0	46	640	320	7.8	-----	40	Analysis by Louisiana State Board of Health.
-27	182	2- 4-66	--	-----	.4	226	------	98	----	1,370	60	
-32	180	3- -55	--	4	.4	640	------	230	7.9	-----	---	Analysis by Esso laboratory, Baton Rouge, La.
		2- 4-66	--	-----	.4	672	------	58	----	2,800	60	
-40	430	10- 5-61	--	4.7	----	9.0	------	341	----	780	---	
-41	156	12- 9-58	69	-----	----	21	------	192	[b]8.8	-----	---	
-43	180	5- 8-59	--	-----	----	6.2	------	671	----	845	---	
-45	190	5- 8-59	70	-----	----	4.1	------	316	[b]6.9	652	---	
		12- 8-59	70	3.8	----	3.1	------	184	----	700	---	
		5- 4-60	--	-----	----	5.4	------	410	----	758	---	
		11- 7-61	--	-----	----	7.2	------	214	----	442	---	
		3-30-62	--	-----	----	10	------	155	[b]7.3	796	---	
		5-13-64	--	-----	----	5.6	------	187	----	609	---	
		5- 4-65	70	-----	----	3.6	------	398	----	760	---	
-50	216	12- 9-58	70	-----	----	17	------	112	[b]6.8	-----	---	
-51	185	5- 4-60	--	-----	----	20	------	136	----	412	---	
-52	200	12- 9-59	--	-----	----	69	------	166	----	877	---	
-53	180	5- 4-60	68	-----	----	380	------	136	----	1,930	---	
-59	297	1- 9-50	--	.9	----	9.2	210	152	7.0	-----	10	Analysis by Louisiana State Board of Health.
-65	190	4-22-60	62	-----	----	17	------	177	----	386	---	Complete analysis in table 3.
		2- 7-66	--	-----	24	16	------	102	----	408	15	
-66	183	4-26-60	67	-----	----	16	------	501	----	1,020	---	
		5-27-66	68	-----	.0	15	------	248	----	580	---	
-67	200	12-24-58	67	6.3	----	25	------	328	----	922	---	
		5-27-66	67	-----	.2	21	------	280	----	686	---	
-72	300	10-11-60	--	-----	----	15	------	140	----	335	---	
-74	260	5-23-49	--	1.0	----	18	263	126	7.5	-----	15	Analysis by Louisiana State Board of Health.
-76	176	10-26-61	68	10	----	7.0	------	450	----	836	---	
-77	185	1-10-61	--	-----	----	12	------	172	----	617	---	
-78	185	1-10-61	--	-----	----	13	------	256	----	567	---	
-80	159	5- 8-59	71	-----	----	12	------	218	----	583	---	
-81	139	4-25-60	70	-----	----	19	------	225	----	525	---	
-83	329	2-15-56	--	.6	----	18	438	243	7.2	-----	15	Analysis by Louisiana State Board of Health.
		10-17-60	68	1.4	----	12	------	282	----	717	---	
-86	185	5- 6-59	69	-----	----	840	------	125	[b]7.7	3,180	---	
		11-18-60	--	-----	----	1,290	------	150	----	6,360	---	
-90	160	12- 9-58	70	-----	----	686	------	114	[b]7.0	2,730	---	
		5- 4-60	--	-----	----	623	------	112	----	2,630	---	
-92	200	4-25-60	70	1.4	----	150	------	58	----	1,100	---	

[a] Residue at 105°C.
[b] pH determined in field.

Table D.7-3. Partial Chemical Analyses of Water From Selected Wells (Continued)

Well No.	Depth (feet)	Date of collection	Temperature (°F)	Iron (Fe)	Sulfate (SO_4)	Chloride (Cl)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$	pH	Specific conductance (micromhos at 25°C)	Color	Remarks
				Milligrams per liter								
IBERVILLE PARISH—Continued												
Ib-95	210	4-22-60	68	1.8	----	18	------	135	[b]7.3	326	---	
		2- 8-66	--	-----	10	21	------	142	----	350	10	
-97	200	5-13-59	70	-----	----	7.5	------	261	----	556	---	
		12- 7-59	68	-----	----	5.6	------	318	----	732	---	
		4-22-60	68	-----	----	5.1	------	488	----	845	---	
		4-18-61	68	-----	----	4.6	------	275	----	530	---	
-98	190	4-18-61	68	.39	----	20	------	158	[b]7.6	659	---	
-100	304	7-17-59	--	.23	----	66	------	28	----	1,030	---	
		2- 7-66	--	-----	.0	65	------	28	----	1,010	40	
-102	207	4-25-60	69	-----	----	320	------	76	----	1,580	---	
		2- 4-66	--	-----	.8	257	------	62	----	1,360	200	
-107	196	4-22-60	68	2.6	----	14	------	112	[b]7.5	310	---	
-109	178	6- 9-61	68	-----	----	48	------	134	----	571	---	
		2- 4-66	--	-----	.0	43	------	120	----	525	15	
-110	175	4- 9-62	68	-----	----	292	------	196	----	1,790	---	
-111	186	10-23-59	--	3.1	----	160	------	296	----	1,260	---	
		3-30-62	--	-----	----	169	------	174	7.6	1,320	---	
-113	222	4-25-60	70	-----	----	274	------	---	----	1,300	---	
		4-10-61	--	-----	----	226	------	101	----	1,430	60	
-118	166	1-19-60	68	5.9	----	29	------	371	----	858	---	Complete analysis in table 3.
-120	295	2- 6-50	--	.6	----	75	735	90	7.5	-----	15	Analysis by Louisiana State Board of Health.
		2-24-60	--	1.2	----	61	------	143	----	1,090	---	
-123	179	10-18-60	--	-----	----	212	------	65	----	1,220	---	
		2- 4-66	--	-----	.4	402	------	110	----	1,860	60	
-134	180	7-30-57	--	2.4	----	18	425	203	7.3	-----	150	Analysis by Louisiana State Board of Health.
-135	444	9-12-60	--	1.9	----	236	------	170	----	1,670	---	
-136	115	11-16-60	--	-----	----	682	------	116	----	2,730	---	
-137A	137	5-11-48	--	1.4	----	498	1,300	62	7.6	-----	90	Drill-stem test. Analysis by Louisiana State Board of Health.
-137B	147	7- 2-48	--	.2	----	534	1,400	75	7.6	-----	45	Production well. Analysis by Louisiana State Board of Health.
-137C	162	5-11-48	--	.2	----	850	1,900	89	7.8	-----	10	Drill-stem test. Analysis by Louisiana State Board of Health.
-137D	187	5-11-48	--	1.2	----	358	800	83	7.9	-----	75	Drill-stem test. Analysis by Louisiana State Board of Health.
-140	178	6- 6-41	--	1.7	----	10	340	160	7.6	-----	15	Analysis by Louisiana State Board of Health.
		1-10-61	--	-----	----	16	------	206	----	517	---	
-143	190	2- 9-61	--	1.2	----	201	------	159	----	1,360	---	
		2- 8-66	--	-----	.0	193	------	158	----	1,290	150	
-145	174	10-15-41	--	4.4	----	127	830	160	7.8	-----	55	Analysis by Louisiana State Board of Health.
-146	190	2- 9-61	68	-----	----	220	------	190	----	1,420	---	
		3- 8-61	68	5.2	----	-----	------	---	----	-----	---	
		2- 8-66	--	-----	----	216	------	155	----	1,370	30	
-147	180	2- 9-61	--	.76	----	151	------	190	----	1,130	---	
		2- 8-66	--	-----	.0	149	------	188	----	1,090	40	
-148	180	2- 9-61	69	2.0	----	40	------	224	----	828	---	
		2- 8-66	--	-----	.2	39	------	136	----	688	40	
-149	200	2- 9-61	--	-----	----	26	------	260	----	706	---	
-150	200	2- 9-61	--	-----	----	20	------	220	----	600	---	
		2- 8-66	--	-----	1.2	19	------	216	----	562	15	
-155	157	3- 8-61	--	-----	----	658	------	210	----	2,780	---	
		2- 4-66	--	-----	.2	658	------	166	----	2,720	30	
-158	180	4- 3-61	68	-----	----	23	------	306	[b]7.5	739	---	
		2- 8-66	--	-----	.2	22	------	181	----	598	10	
-159	185	4- 3-61	--	-----	----	23	------	183	----	503	---	
		2- 7-66	--	-----	.2	22	------	174	----	496	15	
-160	336	4-21-61	--	1.6	----	240	------	165	----	1,560	---	
		3- 3-62	--	-----	----	225	------	106	7.7	1,550	---	
-169	430	10-17-61	69	6.5	----	7.0	------	301	[b]7.2	977	---	
-172	370	10-26-61	69	3.8	----	100	------	416	----	1,000	---	
		2- 7-66	--	-----	.2	92	------	350	----	1,050	15	
-176	180	4-16-62	68	16	----	5.0	------	319	----	713	---	
-179	401	4-23-63	--	-----	----	108	------	335	----	1,260	---	
		10-16-64	--	-----	----	116	------	235	----	1,150	---	
-180A	336	7-11-63	--	1.4	----	21	347	232	7.4	-----	30	Fluoride, 0.2 mg/l. Analysis by Louisiana State Board of Health.
-192	262	2- 4-66	--	-----	.0	40	------	127	----	496	15	
-193	155	2- 8-66	--	-----	.0	167	------	128	----	1,130	150	
-194	180	2- 7-66	--	-----	.0	169	------	146	----	1,170	70	
-195	180	2- 7-66	--	-----	.0	9.2	------	144	----	340	10	

[b] pH determined in field.

Table D.7-3. Partial Chemical Analyses of Water From Selected Wells (Concluded)

Well No.	Depth (feet)	Date of collection	Temperature (°F)	Iron (Fe)	Sulfate (SO_4)	Chloride (Cl)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$	pH	Specific conductance (micromhos at 25°C)	Color	Remarks
				Milligrams per liter								
IBERVILLE PARISH—Continued												
Ib-196	250	3- 2-66	68	-----	3.6	7.6	------	118	----	289	15	
-197	248	5-27-66	--	-----	2.6	1,100	------	150	----	4,020	---	
-201A	198	7-23-65	--	2.0	0	410	[a]967	185	7.4	1,890	---	Analysis by Curtis Laboratories.
-201B	135	8- 4-65	--	.6	0	150	[a]906	41	7.8	1,510	180	Analysis by Curtis Laboratories.
-202A	120	8-30-65	--	7.5	0	44	[a]677	265	7.6	1,090	---	Analysis by Curtis Laboratories.
-202B	240	9- 4-65	--	1.5	0	640	[a]1,580	248	7.8	3,050	---	Analysis by Curtis Laboratories.
-202C	320	9- 7-65	--	.35	0	360	[a]1,330	76	7.9	2,540	---	Analysis by Curtis Laboratories.
-203A	356	10-31-67	--	.2	5.0	313	------	116	7.6	1,650	---	Analysis by Rice & Co.
-203B	174	10-31-67	--	.7	16	36	------	156	7.6	480	---	Analysis by Rice & Co.
-204A	365	11-13-67	--	.5	42	385	------	80	7.8	1,850	---	Analysis by Rice & Co.
-204B	177	11-13-67	--	-----	34	131	------	210	7.6	1,040	---	Analysis by Rice & Co.
-205	250	10-23-67	--	.8	.6	36	[a]343	109	8.0	548	30	Fluoride, 0.2 mg/l. Analysis by Curtis Laboratories. Complete analysis in table 3.
-206	241	11-20-70	--	-----	----	102	------	86	----	782	---	
-216	216	6- 5-68	--	1.5	9.1	31	[a]284	140	7.5	452	35	Fluoride, 0.2 mg/l. Analysis by Curtis Laboratories.
-221	230	11-20-70	--	2.5	----	61	------	202	----	570	---	
-224	430	9-16-68	--	1.6	0	12	[a]519	455	6.9	816	---	Fluoride, 0.1 mg/l. Analysis by Curtis Laboratories.
-225	438	11-19-70	--	-----	----	28	------	345	----	828	---	
-227	380	7-20-69	--	3	0	21	[a]571	612	7.1	947	---	Fluoride, 0.0 mg/l. Analysis by Curtis Laboratories.
-228	350	7- 3-69	--	.6	0	18	[a]627	495	7.1	1,030	---	Fluoride, 0.0 mg/l. Analysis by Curtis Laboratories.
-229A	160	10- -67	67	9.0	0	9.0	[a]456	355	7.1	713	10	Fluoride, 0.1 mg/l. Analysis by Curtis Laboratories.
-229B	364	10- -67	68	1.5	.2	21	[a]619	377	7.4	1,000	10	Fluoride, 0.1 mg/l. Analysis by Curtis Laboratories.
-229C	527	10- -67	70	.8	0	80	[a]762	59	8.0	1,210	30	Fluoride, 0.4 mg/l. Analysis by Curtis Laboratories.
-230	262	11-20-70	66	-----	----	20	------	170	----	471	---	
WEST BATON ROUGE PARISH												
WBR-8	232	3- 2-42	--	-----	----	6	------	234	----	-----	---	Fluoride, 0.1 mg/l. Complete analysis in table 3.
		11-22-54	--	2.2	----	15	339	309	7.5	-----	5	Fluoride, 0.3 mg/l. Analysis by Louisiana State Board of Health.
-117	227	11-18-70	--	.16	----	7.6	------	212	----	416	---	
-118	358	11-18-70	--	-----	----	8.4	------	188	----	517	---	
-120	358	11-19-70	--	.78	----	11	------	331	----	688	---	

[a] Residue at 105°C.

Source: Whiteman, Jr., C.D., "Ground Water In The Plaquemine-White Castle Area, Iberville Parish, Louisiana", Water Resources Bulletin No. 16, Department of Conservation, Louisiana Geological Survey, and Louisiand Department of Public Works, Baton Rouge, La., 1972.

Table D.7-4. Utilization of Shallow Subsurface Aquifers

Map No.	System (and/or name of Responsible Agency)	Community(s) Served	Water Source	Quantity (10^6 gpd)	Storage Facilities (1,000 gallons)	Treatment Processes	Approx. Number of Customers
	Iberville Parish						
5-2	Grosse Tete	Grosse Tete	1 well	.040		Sand Screening	768
5-3	Maringouin	Maringouin	2 wells	.160	200.0 tank	Sand Screening	2,257
5-4	Prejean Water Supply	Maringouin					
5-5	Plaquemine	Plaquemine	3 wells	1.650	Two 500.0 Elev.	Alluv. Screening	14,000
			3 wells			Sand Screening	
5-7	Hercules, Inc.	Plaquemine					
5-8	Rosedale	Rosedale	1 well	.048		Sand Screening	600
5-9	Iberville-St. Gabriel #2	East Bank of Miss. River	2 wells	.087		Alluv. Screening	1,950
5-10	White Castle (1,2)	White Castle	2 wells	.180		Alluv. Screening	2,300
5-11	Bell Grove Waterworks	White Castle	G	.005			100
5-12*	Little Italy	White Castle	G	.008			140
5-13*	Random Oaks		G	.001			46
5-14*	Sexton & Sons		G	.023			420

G - groundwater; number of wells unknown

Table D.7-4. Utilization of Shallow Subsurface Aquifers (Concluded)

Map No.	System (and/or name of Responsible Agency)	Community(s) Served	Water Source	Quantity (10^6 gpd)	Storage Facilities (1,000 gallons)	Treatment Processes	Approx. Number of Customers
West Baton Rouge Parish							
19-1	Bueche Water System	Bueche	G	.006			118
19-2	Salter Water System	Erwinville	G	.003			50
19-3	Port Allen (1,2)	Port Allen	3 wells	.350	700.0 in two Elev.	Sand Screening	6,200
19-4	Erwinville Water Co.	Erwinville	G	.014			280
19-5	Felps Water Well	Port Allen	G	.007			130
19-6	4th Ward Water District	Port Allen	3 wells	.090		Sand Screening	1,218
19-7	Port of Greater Baton Rouge	Port Allen	G	.005			100
19-8*	R. D. Phillips	Port Allen					
19-9	West Baton Rouge District 1	Addis	2 wells	.100		Alluv. Screening	2,000
19-10	West Baton Rouge District 2	Brusly	1 well	.130		Sand Screening	2,019
19-11*	West Baton Rouge		1 well 1 well	.020		Sand Screening Alluv. Screening	301
19-12	North Fertile Acres	North Fertile Acres	2 wells				110
19-13	Grand Bayou Water Co.	N. of U.S 190	1 well		12.0 reservoir		150
19-14	Rougon Store Water System	Rougon Store	1 well				30
19-15	Suburban Water Co.	Lynndale Subd.	1 well		10.0 tank		250

Source: Inventory of Basic Environmental Data, New Orleans - Baton Rouge Metropolitan Area, prepared for U.S. Army Corps of Engineers, New Orleans District, by Engineer Agency for Resources Inventories, U.S. Army Engineer Topographic Laboratories, Washington, D.C., March 1975.

APPENDIX D.8

DEEP SUBSURFACE WATER QUALITY DATA

This appendix consists of a single table containing data relating to chemical analyses and physical measurements of water from deep subsurface aquifers.

Table D.8-1. Chemical Analyses and Related Physical Measurements of Waters from Deep Subsurface Aquifers (Analyses in milligrams per liter, except as indicated)

Parish	Location	Depth or producing interval (feet)	Date of Collection	Silica (SiO_2)	Total Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved Solids	Barium (Ba)	Strontium (Sr)	Iodine (I)
Iberville	T.9 S., R.10 E	1,739-1,791	10-23-36	-	-	640	165	11,480	-	348	-	20	19,100	-	-	-	31,753	-	-	-
Iberville	T.9 S., R.10 E	6,837	1-31-38	-	-	1,652	562	14,825	-	75	-	0	26,800	-	-	-	45,712	-	-	-

Parish	Location	Depth or producing interval (feet)	Date of Collection	Bromine (Br)	Manganese (Mn)	Phosphate (PO_4)	Hardness as $CaCo_3$: Calcium, Magnesium	Hardness as $CaCo_3$: Non-Carbonate	Specific Gravity	Specific conductance (micromhos at 25°C)	pH	Temperature (°C)	Remarks
Iberville	T.9 S., R.10 E	1,739-1,791	10-23-36	-	-	-	-	-	-	-	7.6	-	Humble Oil and Refining Co.
Iberville	T.9 S., R.10 E	6,837	1-31-38	-	-	-	-	-	-	-	7.8	-	Humble Oil and Refining Co.

Source: Winslow, A.G., Hillier, D.E., and Turcan, Jr., A.N. "Saline Ground Water in Louisiana", Hydrologic Investigations, Atlas HA-310, Department of the Interior, U.S. Geological Survey, 1968.

APPENDIX E

TERMINAL VULNERABILITY AND OIL SPILL RESPONSE

Spill Vulnerability

Data compiled by the U. S. Environmental Protection Agency[1], based upon a survey of oil gathering and distribution facilities involving 4423 oil spills, corroborates the Department of Transportation spill data used in Section 3, with respect to the ratio of pipeline leaks versus terminal equipment that contributed to the spills, but much of the pipe was very old (over 25 years) and corrosion accounted for over 54% of the reported leaks.

The corrosion protection systems to be employed in the Strategic Petroleum Storage Project will reduce significantly the incidence of corrosion related oil spills, but pipeline leaks clearly pose the greatest hazard. The following tables show the distribution of spills by subsystem, (Table E-1) and the relative severity of spills associated with each subsystem, (Table E-2).

Another study sponsored by the U. S. EPA[2] to develop data for a course in oil spill prevention and control, collected the judgments and experience of oil facility operators with respect to the principal causes of leaks and spills within each subsystem. These judgments, presented on Table E-3, are related in terms of the probability and severity of leaks or spills that are associated with components of these subsystems for which spill data are shown on Tables E-1 and E-2.

The probability symbols, H, M and L represent High, Medium and Low probability of that component's failing. The severity of a spill has been evaluated on the basis of cleanup requirements according to the following:

1 - Major cleanup required to restore environment

2 - Intermediate cleanup required to restore environment

3 - Minor cleanup required to restore environment

Oil Spill Clean-up Capacity in Vicinity of Bayou Choctaw Dome

Due to the extensive oil production and pipeline transmission activity in the Mississippi River Delta area, there are many other oil handling facilities and third party clean-up services, with modern equipment, chemicals and absorbent materials. A cross survey of Oil Spill control facilities, conducted for the American Petroleum Institute in 1970[3], reports the availability of cooperating oil handling facilities and clean-up contractors by ZIP code, within each state.

This survey shows that there are 48 oil handling facilities, each one with some clean-up capacity, and 2 third party clean-up services in the same ZIP Area as the Bayou Choctaw Dome Site. In the western contiguous ZIP Area there are 147 oil handling facilities and 34 third party clean-up services, and in the southern contiguous ZIP area (including the New Orleans area) there are 286 oil handling facilities and another 54 third party clean-up services.

Assuming that the Federal Energy Administration relies principally on third party clean-up contractors for assistance, there are approximately 90 such sources of personnel and equipment within a 100 mile radius of the petroleum storage site.

Table E-1 Gathering/Distribution System Spill Events by Subsystem and Equipment.

ELEMENT	NUMBER OF EVENTS	% SYSTEM EVENTS	% SUBSYSTEM EVENTS
Pipeline Subsystem	3225	73.03	100.00
Pipe	3117	70.44	96.64
Scraper Trap Equipment	23	0.53	0.37
Pipe Support Structure	0	—	--
Stream Crossing	7	0.16	0.22
Road Crossing	50	1.13	1.55
Equipment Not Identified	30	0.68	0.93
Storage Subsystem	133	3.12	100.00
Tanks	78	1.78	56.52
Tank Firewall	0	—	—
Tank Associated Equipment	57	1.29	41.30
Power Equipment	0	—	—
Equipment Not Identified	3	0.07	2.17
Pump Station Subsystem	165	3.66	100.00
Pumps	88	1.99	4.32
Centrifugal Pumps	1	0.02	0.62
Reciprocating Pumps	3	0.07	1.85
Manifold Equipment	6	0.14	3.70
Rotary Pumps	0	—	—
Steam Engine	0	—	—
Gas Turbine	0	—	—
Steam Turbine	0	—	—
Internal Combustion Engine	0	—	—
Electrical Motor	0	—	—
Pressure Controls	1	0.02	0.62
Metering Equipment	4	0.09	2.47
Valve	23	0.52	14.20
Valve Operating & Control Equipment	4	0.09	2.47
Electric Power & Control Equipment	2	0.05	1.23
Communications Equipment	0	—	—
Drainage System Equipment	3	0.07	1.85
Power Equipment	0	—	—
Equipment Not Identified	27	0.61	6.67
Safety Subsystem	3	0.05	100.00
Pressure Sensing Equipment	0	—	—
Pressure Switching Equipment	0	—	—
Flow & Gauge Equipment	1	0.02	50.00
Temperature Recorders	0	—	—
Power Equipment	0	—	—
Equipment Not Identified	1	0.02	50.00
Gathering Subsystem	870	19.66	100.00
Gravity	73	1.65	8.39
Suction	41	0.93	4.71
Pressure	8	0.18	0.92
Equipment Not Identified	748	16.90	85.98
Subsystem/Equipment Not Identified	21	0.47	N/A
Total G/D System Failures	4423	100.00	N/A

Table E-2 Spill Events for Onshore Gathering/ Distribution Systems by Subsystem and Spill Category

Subsystem		Number of Spill Events			
	Minor	Moderate	Major	Not Identified	Totals
Pipeline	36	2429	634	83	3182
Storage	1	96	38	1	136
Pump Station	1	111	38	10	160
Safety	0	1	1	0	2
Gathering	8	775	83	2	868
Not Identified	2	15	2	0	19
Totals	48	3427	796	96	4367

Table E-3 Areas of Potential Spills Probability/Severity

	Tank Farms	Terminals	Onshore Production
EQUIPMENT			
Tanks			
Gauges	H/3	M/3	M/3
Sampling facilities	H/3	H/3	
Shell and bottoms	L/1	L/1	L/1
Underground seepage	L/1	L/1	
Containment dikes	M/2	M/2	L/2
Dike drains	H/2		M/2
Pipe, Valves & Fittings			
Seal failure			L/1
Valve stem packing	M/3	M/3	M/2
Gaskets	M/2	H/3	M/2
Pipe rupture	L/1	L/1	L/1
Pump & Mechanical Equipment			
Seals	M/2	M/3	H/1
Lubricating systems			
Loading Stations			
Fill safeguards		L/1	H/2
Curbs and drains		M/2	M/2
OPERATIONS			
Tanks			
Filling/Overfilling	H/1	H/1	L/2
Sampling	H/2	M/3	L/3
Cleaning	H/1	L/2	L/2
Dike draining	H/2		
Pipe, Valves & Fittings			
Maintenance		H/2	H/2
Collision		H/1	
Pumps			
Maintenace	H/3	H/3	H/2
Loading Racks			
Overfills		H/2	
Loading drips		H/3	

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1. "Petroleum Systems Reliability Analysis"(2 Volumes), EPA Report No. EPA-R-2-73-280a, August 1973.

2. "Oil Spill Presentation Control and Countermeasure Plan Review" by Rue University and The School of Public Health, The University of Texas, Sponsored by U. S. EPA, February 1975.

3. "Oil Spill Control Survey for Onshore and Offshore Facilities" American Petroleum Institute, March 1970.

APPENDIX F

CALCULATION OF SEDIMENT TRANSPORT

The annual volumetric transport rate for sediment, Q_s, can be expressed as

$$Q_s = C_{ro} A_d \, PF$$

where

C_{ro} = runoff coefficient

A_d = disturbed area (ft^2)

P = annual precipitation (ft/year)

F = Fraction of a year ground is exposed

Values of the runoff coefficient are not precisely known. A conservative estimate would be

$$C_{ro} \sim .02$$

Now as noted in subsection 3.1.2.2, the disturbed area is

$$A_d = 90 \text{ acres}$$

$$= 3.92 \times 10^6 \text{ ft}^2$$

Also as noted in subsection 2.2,

$$P \sim 58 \text{ inches}$$

$$= 4.83 \text{ ft}$$

Thus, for an assumed 6 months exposure,

$$Q_s = .02 \times 3.92 \times 10^6 \times 4.83 \times 0.5$$

$$= 1.89 \times 10^5 \text{ft}^3\text{/year}$$

$$= 7.01 \times 10^3 \text{yd}^3\text{/year}$$

The increase in the turbidity of the surface water system will depend on the total volume of water present in the surface water system V_{sw} in the vicinity of the Bayou Choctaw site. This volume is difficult to calculate precisely. Based on the dimensions of the major bodies of water in the area

$$V_{sw} \sim 3.9\text{x}10^8 ft^3$$
$$= 1.45\text{x}10^7 yd^3$$

Now the mass of the sediment M_s transported annually would be

$$M_s = Q_s \rho$$

Where ρ = density of the sediment

$$M_s = Q_s \rho$$
$$= 7.01\text{x}10^3 yd^3/\text{year x}(100 lb/ft^3 \text{x} 27 ft^3/yd^3)$$
$$= 1.89\text{x}10^7 lb/\text{year}$$
$$M_s = 1.89\text{x}10^7 lb/\text{year x}454 gm/lb$$
$$= 8.58\text{x}10^9 gm/\text{year}.$$

The most conservative assumptions would be that none of the transported sediment settle out except for the sand and larger aggregate. Sand and larger aggregate typically exceeds 50% in this area. Thus, the annual increase in suspended sediment in the water would be a maximum of:

$$\frac{M_s}{V_{sw}} = \frac{8.58\text{x}10^9 gm/\text{year x}0.5}{1.45\text{x}10^7}$$
$$= 295.8 gm/yd^3$$
$$= \frac{295.8 gm/yd^3}{7.65\text{x}10^5 cm^3/yd^3}$$
$$= 3.86\text{x}10^{-4} gm/cm^3$$
$$= 3.86\text{x}10^{-1} gm/l$$
$$= 386 mg/l$$

Now the average level of suspended solids in Louisiana marshes is 200 mg/l. Thus the increase in the suspended solid would be

$$SS = \frac{386}{200}$$

$$SS = 190\%$$

Appendix G

Analysis of Water Supply and Brine Disposal

This appendix contains the analysis of impact of withdrawal of water for use as a displacement water supply and an analysis of water supply and brine disposal.

APPENDIX G.1

Calculations Relating to Effects of Withdrawing Displacement Water from the Pond Near Cavern No. 7

1. Induced Flow in the North-South Canal

The width of the canal is

$W = 60$ feet

The depth of the canal is

$H = 4$ feet

Under steady-state conditions, the induced flow in the canal Q_i must equal the withdrawal rate Q_o. The induced velocity for such a flow rate would be

$$
\begin{aligned}
U_i &= Q_i/(H \times W) \\
&= 2597/(4 \times 60) \\
&= 10.8 \text{ ft/min} \\
&= .18 \text{ ft/sec}
\end{aligned}
$$

2. Induced Flow in the East-West Canal

The width of the canal is

$W = 60$ feet

The depth of the canal is

$H = 4$ feet

As before, under steady-state conditions

$$Q_i = Q_o$$

and the induced velocity would be

$$\begin{aligned} U_i &= Q_i/(H \times W) \\ &= 2597/(4 \times 60) \\ &= 10.8 \text{ ft/min} \\ &= .18 \text{ ft/sec} \end{aligned}$$

3. Induced Flow in Bull Bay

The width of the bay is

$W \cong 60$ feet

The depth of the bay is

$H \cong 8$ feet

As before under steady-state conditions,

$$Q_i = Q_o$$

and the induced velocity would be

$$\begin{aligned} U_i &= Q_i/(H \times W) \\ &= 2597/(8 \times 60) \\ &= 5.4 \text{ ft/min} \\ &= .09 \text{ ft/sec} \end{aligned}$$

4. Induced Flow in Port Allen Canal/Choctaw Bayou

The width of the canal/bayou is

$W = 160$ feet

The depth of the canal/bayou is

$H = 12$ feet

As before under steady-state conditions

$Q_i = Q_o$

and the induced velocity would be

$$U_i = Q_i/(H \times W)$$
$$= 2597/(12 \times 160)$$
$$= 1.35 \text{ ft/min}$$
$$= .023 \text{ ft/sec}$$

5. <u>Height Differential for Induced Flow in the North-South Canal</u>

Based on Manning's relation [4/]

$$U_i = \frac{1.49}{n} R^{2/3} S^{1/2}$$

where

n = coefficient of roughness

R = hydraulic radius

S = surface slope

Now the coefficient of roughness for earth bottoms is [5/]

$$n = .025 \text{ ft}^{1/3}/\text{sec}$$

The hydraulic radius is defined as the cross-sectional area divided by the wetted perimeter. Thus

$$R = A/P$$
$$= (4 \times 60)/(4 + 60 + 4)$$
$$= 3.53 \text{ ft}$$

If Manning's relation is solved for the slope,

$$S = \left[\frac{U_i n}{1.49 R^{2/3}}\right]^2$$
$$= \left[\frac{(.18) \times (.025)}{(1.49) \times (3.53^{2/3})}\right]^2$$
$$= 1.70 \times 10^{-6} \text{ ft/ft}$$
$$= 8.96 \times 10^{-3} \text{ ft/mile}$$

Now the distance from the pond to the east-west canal measured along the north-south canal path is

L = 0.3 miles

Then the height differential would be

$\Delta H = S\ L$

$= 8.96 \times 10^{-3} \times .3$

$= 2.69 \times 10^{-3}$ ft

6. <u>Height Differential for Induced Flow in the East-West Canal</u>

Based on Manning's relation as before

$$U_i = \frac{1.49}{n} R^{2/3} S^{1/2}$$

As before for an earth bottom

$n = .025\ ft^{1/3}/sec$

The hydraulic radius is

$R = A/P$

$= (4 \times 60)/(4 + 60 + 4)$

$= 3.53$ ft

Solving for the slope,

$$S = \left[\frac{U_i n}{1.49 R^{2/3}}\right]^2$$

$$= \left[\frac{(.18^{-2}) \times (.025)}{1.49 \times (3.53)^{2/3}}\right]^2$$

$= 1.70 \times 10^{-6}$ ft/ft

$= 8.96 \times 10^{-3}$ ft/mile

The distance from the north-south canal to Bull Bay along the east-west canal

L = 0.3 miles

Then the height differential is

$\Delta H = S\ L$

$= 8.96 \times 10^{-3} \times 0.3$

$= 2.69 \times 10^{-3}$ ft

7. Height Differential for Induced Flow in Bull Bay

Based on Manning's relation as before

$$U_i = \frac{1.49}{n} R^{2/3} S^{1/2}$$

As before, for an earth bottom

$n = .025\ ft^{1/3}/sec$

The hydraulic radius is

$R = A/P$

$= 8 \times 60/(8 + 60 + 8)$

$= 6.3$ feet

Solving for the slope,

$$S = \left[\frac{U_i n}{1.49\ R^{2/3}}\right]^2$$

$$= \left[\frac{(.09) \times (.025)}{(1.49) \times (6.3)^{2/3}}\right]^2$$

$= 1.96 \times 10^{-7}$ ft/ft

$= 1.03 \times 10^{-3}$ ft/mile

The distance from the east-west canal to the Port Allen Canal/Choctaw Bayou is

$L = 0.4$ mile

Then the height differential is

$\Delta H = S\ L$

$= 1.03 \times 10^{-3} \times 0.4$

$= 4.12 \times 10^{-4}$ ft

8. <u>Height Differential for Induced Flow in Port Allen Canal/Choctaw Bayou</u>

Based on Manning's relation as before

$$U_i = \frac{1.49}{n} R^{2/3} S^{1/2}$$

As before for an earth bottom

$n - .025\ ft^{1/3}/sec$

The hydraulic radius

$R = A/P$

$= (12 \times 160)/(41.8 + 120 + 41.8)$

$= 9.43$ ft

Solving for the slope,

$$S = \left[\frac{U_i n}{1.49\ R^{2/3}}\right]^2$$

$$= \left[\frac{(.023) \times (.025)}{1.49\ (9.43)^{2/3}}\right]^2$$

$= 7.48 \times 10^{-9}$ ft/ft

$= 3.95 \times 10^{-5}$ ft/mile

The distance from Bull Bay to the Mississippi River via the Port Allen Lock along the Port Allen Canal is

L = 14 miles

Then the height differential is

$\Delta H = S\ L$

$= 3.95 \times 10^{-5} \times 14$

$= 5.53 \times 10^{-4}$ ft

APPENDIX G.2

BAYOU CHOCTAW WATER SUPPLY AND BRINE DISPOSAL ANALYSIS

This appendix contains analysis principally concerned with water supply and brine disposal questions in the Bayou Choctaw salt dome area. The sources of these were

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and

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Geohydrology at Bayou Choctaw Dome (by Charles G. Smith)

Quantity

Whiteman [2/] discusses the large ground-water yields available from the Plaquemine Aquifer (i.e. the alluvial sands between -100 and -600 feet) and the constant recharge available from the Mississippi River. To supply the 20,000 gpm required for displacement water at Bayou Choctaw dome ten wells pumping 2000 gpm might be required. Properly designed and spaced, these wells would supply the required volume of fresh water (some brackish water would be pumped from wells screened at the base of the aquifer) with minimum well-to-well interference and drawdowns at each well or probably not more than a few ten's of feet.

Quality

Salt water encroachment may result from development of a large ground water supply at Bayou Choctaw Dome. However, because brackish water can be used for displacement, wells screened deep in the aquifer would help to remove the unwanted saline water from the aquifer.

An additional problem of water quality must be considered. Locally high concentrations of iron in the ground-water can cause encrustation of well screens and reduce the expected efficiency and life of the well. Three water wells at Bayou Choctaw dome are now abandoned due in part to encrustation problems. Before a water supply well field is designed data regarding local water salinities and iron content should be obtained.

Subsidence

Subsidence will probably not be significant at Bayou Choctaw, although there is no method for accurately predicting it, because (1) pumping will be limited to 150 day periods, (2) water level declines will be small and recovery to original conditions will be rapid, and (3) the aquifer supplying the water contains only minor amounts of clay (in Houston subsidence is proportional to the decline in the potentiometric surface and the percentage of clay above the screened) (Gabrysch, R. K.)[1/]

References

1. Gabrysch, R. K., 1969, Lank-surface subsidence in the Houston-Galveston region, Texas: International symposium on land subsidence, Tokyo, Japan, 1969, Proc., p. 43-54.

2. Whiteman, C. D., Jr., 1972. Ground Water in the Plaquemine-White Castle Area Iberville Parish, Louisiana. Louisiana Department of Conservation Geological Survey and Dept. of Public Works, Water Resources Bulletin No. 16.

Potential Problems involved in Brine Injection at Bayou Choctaw (by Charles G. Smith)

A question has been raised regarding the possibility of chemical or biological reactions occurring during brine injection at Bayou Choctaw which would clog the well or reservoir sediments and reduce brine disposal efficiency. A complete answer can not be given in the absence of a chemical comparison of the injected brine and the native groundwater. Presently neither of these components have been analyzed.

Nevertheless, a partial list of possible problems and potential solutions is appropriate.

Reservoir permeability reduction by clay swelling. Donaldson (1972) and Hower and et al. (1972) outlines the problem of clay hydration and permeability reduction during subsurface injection operations. The concentration of brine anticipated for injection at Bayou Choctaw may be sufficiently high to prevent clay hydration. The use of zirconium chloride to pretreat the aquifer has successfully reduced the adverse effects of clay swelling (Donaldson, 1972).

Bacteria in injection stream. Clogging of injection well screens by organic matter, including algae, is a potential problem. Control procedures are outlined for various organisms by Ehrlich (1972) and Ostroff (1965). Chlorine, hypochlorite and formaldehyde are mentioned as commonly used disinfectants in water and waste injection systems.

Scale. Mineral precipitation in pipelines, well screens, and on the reservoir face may occur during brine injection operations (Donaldson, 1972; Barnes, 1972). Phosphates may be added to the system to control these scale deposits.

Insoluble Residue. Ostroff (1965) describes filtration systems necessary to remove insoluble minerals and sediment from solutions prior to injection. Sedimentation and filtration may be required at Bayou Choctaw, due to sediment in the source water (from the pond over Cavern No. 7) or because of insoluable minerals in the produced brine.

References

1. Barnes, Ivan, Water-Mineral Reactions Related to Potential Fluid-Injection Problems, in T. D. Cook, ed., Underground Waste Management and Environmental Implications: Am. Assoc. Petroleum Geologists Mem. 18, p. 294-297.

2. Donaldson, Erle C., 1972, Injection Wells and Operations Today, in T. D. Cook, ed., Underground Waste Management and Environmental Implications: Am. Assoc. Petroleum Geologists Mem. 18, P. 24-46.

3. Ehrlich, Garry G., Role of Biota in Underground Waste Injection and Storage, in T. D. Cook, ed., Underground Waste Management and Environmental Implications: Am. Assoc. Petroleum Geologists Mem. 18, p. 298-307.

4. Hower, W. F., R. M. Lasater, and R. G. Mihram, Compatibility of Injection Fluids with Reservoir Components, in T. D. Cook, ed., Underground Waste Management and Environmental Implications: Am. Assoc. Petroleum Geologists Mem. 18, p. 287-293.

5. Ostroff, A. G., 1965, Introduction to Oilfield Water Technology; Englewood Cliffs, N. J., Prentice-Hall, Inc., p 412.

The Possibility of Triggering an Earthquake (by Bill R. Hise)

There is documented evidence of earthquakes being triggered as a result of subsurface injection of fluid accompanied by an increase in injection reservoir pressure. The two known cases of this phenomena have occurred in Colorado in an area of high natural rock stress. One is near Denver in association with a disposal well that injected liquid waste from the Rocky Mountain Arsenal, and the other is near Rangly, Col. in association with a water flood in the Rangly oil field. The mechanism causing the earthquake is not well understood. However, all those who have studied the problem agree that the existence of high natural earth stress (e.g., Col., Wyoming, Cal.) is a prerequisite.

In the Texas-Louisiana Gulf Coast the natural earth stress is low - here we deal with a tectonically relaxed area which is characterized almost exclusively by normal faulting. (No reverse or overthrust faults.) Numerous water flood and liquid waste injection sites have been in operation along the Louisiana-Texas Gulf Coast for many years without reported occurrences of earthquakes. Therefore, it would appear that earthquake occurrence along the La.-Tex. Coast as a result of the injection of brine from the strategic oil storage project would not be a problem that can be foreseen at this time.

Oil and Gas Production (by Bill R. Hise)

Some fifty wells produce oil and gas from depths of 2,000 - 10,000 ft. in the Bayou Choctaw field. These depths bracket the proposed depths for brine injection. All of the oil and gas wells are located in an area from 1 mile to 1-1/2 miles north of the injection site.

Abandoned Wells (by Bill R. Hise)

Two abandoned oil and gas wells lie within the proposed injection site at Bayou Choctaw. Outside the site, to the east, west, and south, there are no abandoned wells for at least a distance of 1 mile. However, to the north, there are 13 existing wells within 1/2 mile of the north line of the square pattern of the injection wells. Some of these wells are still producing, while others are abandoned. Some 1-1/2 miles north of the injection site lies the center of the Bayou Choctaw oil field with many additional wells of both the active and abandoned type.

The Louisiana Department of Conservation requires that at least two and sometimes 3 cement plugs be placed in a well at abandonment. One of the plugs must be placed at the base of the fresh water and is specifically designed to protect the fresh water from any contamination due to leakage of fluids from below. In addition, the well bore below this cement plug must be left full of a fluid that is of sufficient density to exceed the pressure gradient of the formations below the plug and thus prevent flow into the old well bore. Many times, this fluid remaining in the well is a gel mud which tends to thicken and harden, and become impermeable with time. This further reduces the possibility of leakage.

It would appear that the records of the two wells that lie within the injection pattern should be carefully checked to insure the wells were properly plugged, and if not, the wells should be replugged. The records of the abandoned wells to the north should be checked to insure they are adequately plugged. If a substantial number of the wells to the north appear to need replugging, it may be advisable to make the injection site further to the south.

Reservoir Mechanics Analysis in Brine Disposal (by Bill R. Hise)

The analysis of the subsurface pressure involved in the injection of brine through wells into subsurface aquifers is needed to predict when that pressure may approach the fracture pressure. If brine injection is continued when the subsurface pressure approaches or exceeds the fracture pressure the brine may escape the disposal aquifer and contaminate nearby fresh water aquifers.

The analysis of the pressures involved in brine disposal involves two considerations. The first is the total brine storage capacity of the disposal aquifer neglecting any pressure build up around the disposal wells during injection. The calculation of the maximum amount of brine which can be stored in disposal aquifer(s) before reaching fracture pressure can be made using the following equation:

$$Q = \frac{l \times w \times h \times \phi \times C_e \times p}{5.61} \qquad (1)$$

where:

Q	=	Brine Disposal Capacity Bbls
l	=	Length of disposal aquifer(s) - feet
w	=	Width of disposal aquifer(s) - feet
h	=	Thickness of disposal aquifer(s) - feet
ϕ	=	Porosity
C_e	=	System compressibility vol/vol/psi
p	=	Allowable aquifer pressure increase psi
5.61	=	Conversion constant - ft^3 to Bbls.

Equation (1) yields the theoretical maximum brine storage capacity for a linear model of any dimensions. In order to investigate the problems associated with injecting brine through wells into a reservoir, it is more convenient to sub-divide the total linear volume of the disposal aquifer into individual cylindrical reservoirs and prorate the amount of brine to be injected into each one. The radius of the individual cylindrical reservoirs can be derived from the length and width of the linear system. The reservoir thickness for the cylindrical reservoirs can be adjusted to force the total volume of the cylindrical reservoirs to equal the total volume of the linear disposal system.

The problem posed by injection the disposal brine through wells is the pressure build up at the injection well due to radial flow from the well into the reservoir. This build up is in addition to the increase in average reservoir pressure which can be calculated from the cylindrical equivalent of equation (1). In practice, injection must cease when the well bore pressure reaches the fracture pressure even though the average pressure in the reservoir may still be below fracture pressure.

There are two phases in the analysis of the pressure build-up at the well bore during injection. First, when injection is started at a constant rate a transient pressure distribution is set up in the reservoir and the well bore pressure begins increasing. The character and magnitude of this increase can be calculated from the following equation:

$$p_w = p_i + \frac{qu}{7.08\ kh} \ln\left[\frac{14.22\ kt}{uC_e\ \phi\ r_w^2}\right] \qquad (2)$$

where:

p_w = Well bore pressure, psig

p_i = Reservoir pressure, psig

q = Flow rate, Bbls/Day

u = Brine viscosity, cps

k = Permeability, darcys

h = Thickness, feet

t = Time, days

C_e = System compressibility vol/vol/psi

ϕ = Porosity

r_w = Well bore radius, feet

The relationship shown as Equation (2) sets forth the behavior of the well bore pressure until the pressure affects are felt at the boundary of the reservoir. The time at which this occurs can be calculated from the so called "readjustment time". The equation for the readjustment time is:

$$t_R = .04 \frac{\mu C_e \phi r_e^2}{k} \qquad (3)$$

where:

t_R = Readjustment time, days.

μ = Viscosity, cps

C_e = System compressibility, vol/vol/psi

ϕ = Porosity, fraction

r_e = Reservoir radius, feet

k = Permeability, darcys

Equation (3) specifies the injection time during which Equation (2) is applicable. After this time, there is a period of pressure adjustment and then the reservoir pressure enters a phase known as "semi-steady state". In this latter phase the reservoir pressure is increasing at every point in the reservoir, but at the same rate of increase. The time for the transition from transient to semi-steady state requires an additional unit of time equal to the readjustment time. Therefore, it takes an injection time equal to $2t_R$ from the start of injection for the injection pressure pressure at the well bore to be described by the semi-steady equation:

$$P_w = P_i + \frac{5.615\ qt}{\pi r_e^2\ h\ \phi\ C_e} + \frac{q\ u}{7.08\ kh}\left[\ln\frac{r_e}{r_w} - \frac{3}{4}\right] \tag{4}$$

In this equation the first term (P_i) is the initial reservoir pressure, the second is a volumetric term that accounts for the increase in average pressure in the disposal aquifer, and the third term gives the frictional pressure difference between the well bore and the external boundary of the reservoir for any flow rate and flow geometry. If the injection time needed to dispose of a given amount of brine exceeds $2t_R$, then the analysis of the injection pressures can be made by the use of equation (4).

Equations (1) through (4) pertain to subsurface pressures. If it is desired to predict the surface pressure from the well bore pressure, terms must be included to account for the static pressure loss of the brine and friction loss of the flowing brine in the well between the surface and the reservoir. These two relationships are well known in the field of hydraulics. Therefore, the final relationship necessary to predict surface injection pressure during brine disposal at "semi-steady state" conditions is:

$$P_{ws} = P_i + \frac{5.615\ qt}{\pi r_e^2\ h\phi C_e} + \frac{q\ u}{7.08\ kh}\left[\ln\frac{r_e}{r_w} - \frac{3}{4}\right] - \Delta_p\ (\text{head loss}) + \Delta_p\ (\text{pipe friction}) \tag{5}$$

Equation (5) can be conveniently solved either by hand or on a computer and a schedule of surface and well bore pressure versus time can be obtained. This is the equation on which the results presented as Table 2 in the section on brine disposal was based.

Bayou Choctaw Reservoir Mechanics (by Bill R. Hise)

Geological correlations from electric logs of wells in the vicinity of the Bayou Choctaw Dome indicate that individual disposal aquifers can be traced over distances of at least 4 miles. If an additional 50% is added to this to allow for a reasonable extrapolation beyond the proved value, a single aquifer might be expected to be continuous for some 6 miles. Geological investigations revealed at least 14 potential disposal sands in the section of at least 50 feet in thickness or greater with a total thickness of 1250 feet. Other data and project requirements at Bayou Choctaw are:

1. Disposal wells: 28
2. Injection Rate: 695 gpm (23,815 BPD) per well
3. Total Brine Injection per Cycle: 90,000,000 Bbls
4. Injection Time: 150 days
5. No. of Cycles: 5
6. Total Thickness of Disposal Aquifers: 1250 ft.
7. Porosity: 33%
8. Average Depth: 6000 ft.
9. Initial Reservoir Pressure: 3000 psig
10. Average Permeability: 1000 mds (1 darcy)
11. System Compressibility: 10^{-5} vol/vol/psi
12. Fracture pressure: 4500 psig (.75 psi/ft)
13. Brine Viscosity: 0.55 cps
14. Reservoir Temperature: 130°F
15. Brine Density: 10 ppg

Table 1 shows the results of a calculation of the total brine disposal capacity available assuming injection to an average reservoir pressure equal to the fracture pressure. As shown, the total capacity is estimated at approximately 1 billion barrels (1.11×10^9 Bbls). Items 8 and 9 on Table 1 pertain to a single injection cycle. The 90 million barrels of brine to be disposed of in a single cycle would raise the average reservoir pressure in the brine disposal aquifers by 121 psi. A total of 5 cycles of injection would increase the average reservoir pressure by 5 x 121 psi or 605 psi. This would increase the average reservoir pressure from 3000 psig to 3605 psig, or to a gradient of 0.60 psi/ft. This is well within the estimated fracture pressure of 4500 psig.

In order to investigate the problems associated with injecting brine through wells into the total disposal volume, it is more convenient to subdivide the gross sand volume shown in Table 1 into individual cylindrical reservoirs, and prorate the amount of brine to be injected into each one. The model equivalent cylindrical reservoir for Bayou Choctaw had the following parameters:

1. Reservoir Diameter: 6 miles

2. Reservoir Thickness: 50 feet

All other parameters were as previously listed. The assumption was made that to complete a total of 28 disposal wells at least some of the wells would have to be completed in reservoirs as small as 50 feet in thickness. As this would be the worst case from the standpoint of fracture problems, it is the one analyzed from the standpoint of pressure buildup at the well bore during injection.

A calculation of the readjustment time for the cylindrical reservoir 50 feet thick indicates that the transient phase of the pressure distribution lasts for about 20 days after injection starts. This means that after 40 days or a little over 1 month the radial pressure distribution across the reservoir during injection will be controlled by the "semi-steady state" equations. (Refer to the appendix on reservoir mechanics for further discussion on transient and "semi-steady state" flow condition). As an injection cycle will last approximately 150 days, it appears that analysis of the pressure buildup across the reservoir during injection will be primarily specified by "semi-steady state" mechanics.

Table 2 is a computer printout of surface and bottom hole injection pressures as a function of time for "semi-steady state" flow for the injection rates and reservoir conditions expected at Bayou Choctaw for a 50 foot thick disposal sand. As shown, after 5 months or 150 days of injection (1 cycle), the reservoir pressure at the well bore has increased to 3547 psig or some 547 psi above the initial pressure. Based on a volumetric analysis similar to that shown in Table 1, some 154 psi of this increase is due to an increase in average pressure while the other 393 psi is attributable to a pressure increase at the well due to radial flow friction loss of the injected brine in the cylindrical reservoir.

An analysis of the reservoir pressure at the well bore at the end of injection for the fifth injection cycle, assuming injection into a 50' thick sand, can be made by combining the calculations presented in the previous paragraph. The total reservoir pressure increase after 5 injection cycles would be 5 x 154 or 770 psi. In view of the total of 28 wells injecting into the 14 sands available, it will be necessary to complete two injection wells in each disposal sand. Therefore, the total increase in average reservoir pressure after 5 injection cycles would be 2 x 770 or 1540 psi. The information in Table 2, based on the analysis in the preceeding paragraph, indicates the increased reservoir pressure due to injection only as 393 psi. The total of the two, or 1933 psi, is the approximate increase in reservoir pressure at the injection well at the end of pumping on the fifth cycle for the case of injection into a 50-foot thick sand. This neglects interference between the wells which is assumed to be small for the proposed injection pattern at Bayou Choctaw. This should be the worst condition from the standpoint of reservoir pressure increase and potential problems. The 1933 psi exceeds the allowable pressure of 1500 psi by 433 psi. Therefore, it would appear that the 50 foot thick aquifers at Bayou Choctaw could only be used for some four cycles of injection.

Table G.2-1

Brine Storage Capacity at Bayou Choctaw
(Assuming No Interconnection of Sands)

1. Length of Disposal Area = 6 miles
2. Width of Disposal Area = 6 miles
3. Area of Disposal Area = 36 miles^2
4. Thickness of Disposal Sands - 1250 feet
5. Gross Volume of Disposal Sands - 1.26×10^{12} ft^3
   (36 mi^2 x 5280 x 5280 x 1250)
6. Net Volume of Disposal Sands - 74.1×10^9 bbls
   (1.26×10^{12} x .33 porosity ÷ 5.61 ft^3/bbl
7. Brine Disposal Capacity - 1.11×10^9 bbls
   a. Compressibility - 10^{-5} vol/vol/psi
   b. Reservoir Pressure - .5 psi/ft
   c. Fracture Pressure - .75 psi/ft
   d. Depth - 6000 feet
   e. Average Pressure Increase - 1500 psi
8. Disposal Volume of Brine on Initial Cycle - 90×10^6 bbls
9. Average Pressure Increase for Initial Cycle - 121 psi

Table G.2-2

Bayou Choctaw

RESERVOIR PRESSURE BUILDUP HISTORY IN THE BAYOU CHOCTAW FIELD

RESERVOIR CONDITIONS ARE AS FOLLOWS:
- INITIAL RESERVOIR PRESSURE OF 3000. PSIG.
- RESERVOIR TEMPERATURE OF 130. DEGREES F.
- AVERAGE POROSITY OF 0.330.
- AVERAGE PERMEABILITY OF 1.00 DARCIES.
- AVERAGE THICKNESS OF 50. FEET.
- DEPTH OF 5000. FEET.
- RADIUS OF 15000. FEET.

WELL CONDITIONS ARE AS FOLLOWS:
- DIAMETER OF 10.000 INCHES.
- MAXIMUM SURFACE FLOWING PRESSURE OF 3000. PSIG.
- SURFACE FLOW RATE OF 25815. BPD.

FLUID PROPERTIES ARE AS FOLLOWS:
- VISCOSITY OF 0.550 CENTIPOISES.
- COMPRESSIBILITY OF 0.000010.
- DENSITY OF 10.00 PPG.

MONTH	SURFACE PRESSURE	BOTTOM HOLE PRESSURE
1.	279.	[illegible]
3.	374.	3484.
4.	405.	3515.
5.	436.	3547.
6.	468.	3578.
7.	499.	3609.
8.	530.	3640.
9.	561.	3672.
10.	593.	3703.
11.	624.	3734.
12.	655.	3765.
13.	686.	3797.
14.	718.	3828.
15.	749.	3859.
16.	780.	3891.
17.	812.	3922.
18.	843.	3953.
19.	874.	3984.
20.	905.	4016.
21.	937.	4047.
22.	968.	4078.
23.	999.	4109.
24.	1030.	4141.
25.	1062.	4172.
26.	1093.	4203.
27.	1124.	4235.

REFERENCES APPENDICES G

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2. Inventory of Basic Environmental Data, New Orleans-Baton Rouge Metropolitan Area, U. S. Army Corps of Engineers, New Orleans District, March, 1975.

3. Whiteman, Jr. C. D., "Ground Water in the Plaquemine-White Castle Area, Iberville Parish", Louisiana Water Resources Bulletin No. 16, Department of Conservation, Louisiana Geological Survey, and Louisiana Department of Public Works, Baton Rouge, La., 1972.

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APPENDIX H

SUMMARY OF INFORMATION ON EXISTING CAVITIES,

CAVITY CONVERSION PROCEDURES AND DRILLING PROCEDURES

1. Existing Caverns

Twenty-three caverns have been created at the Bayou Choctaw dome. There are 6 caverns which Allied leases to the Industry for product storage (three of which could be made available for the SPR program providing new space is created). There are 6 caverns which have been plugged and abandoned, and 2 caverns which were started but have not been developed, leaving 9 uncommitted caverns available for storage (see Figure H.1). The 9 caverns (1,2,3,8A,11, 13,18,19, and 20), plus the 3 committed but available caverns (15,16 and 17) have a gross volume of 99,595,000 bbls and a net storage capacity of about 94 million barrels (see Table H.1). A summary of the current cavern conditions follows:

Caverns Nos. 18, 19 and 20, with a combined gross volume of approximately 25 MMB, are presently used by Allied for brine production. Well #20 is only 500 ft. from well #8A but because of its much greater depth, no communication between the two is expected. The wells and casings are in good condition, and the cavities are well developed with no chimneys in the ceilings.

Caverns Nos. 3, 11, and 13, with a combined gross volume of approximately 19 MMB, have coalesced but the entire gallery was pressure tested to 100 psi. Surveys indicate that 140 ft. of salt still separates the three cavities, but they do not show the point of interconnection.Similar crudes could be stored in this gallery of three wells. Well #3 would be abandoned and a replacement would be drilled. An additional well would be required to penetrate a large chimney (500 MB) which has developed in Cavern #11. Nitrogen would be used to fill a small chimney area (15 MB) in Cavern #13 before storing crude.

Cavern No. 1 is presently idle with a large leak in its casing requiring repair. Two additional wells would be drilled to intersect chimneys that have developed in the

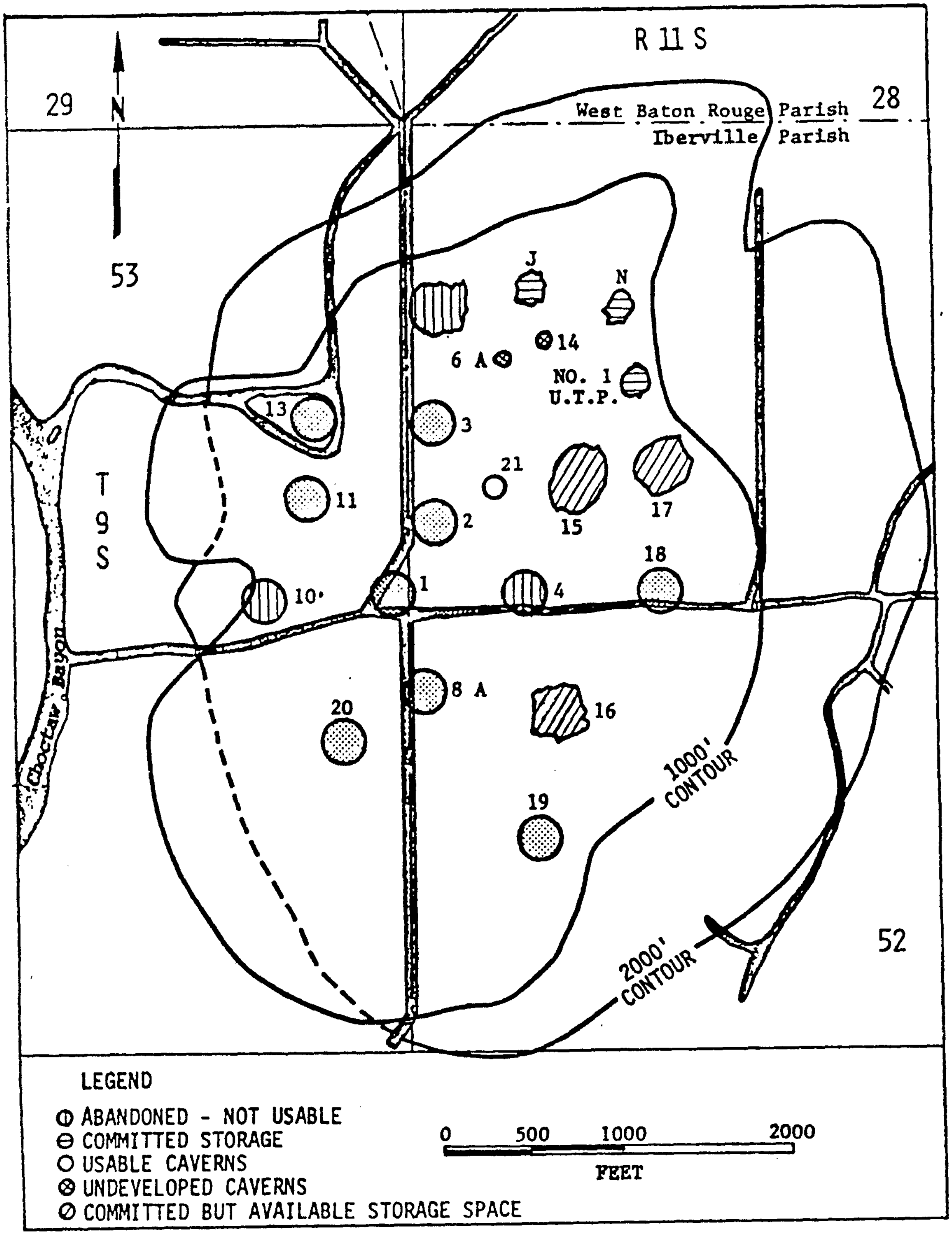

Figure H-1 Diagram of Existing Cavities

Table H-1 Cavern Data for Bayou Choctaw

CAVERN	DEPTH TO CAPROCK/SALT (feet)	TOP OF CAVERN (feet)	BOTTOM OF CAVERN (feet)	PRODUCTION CASING (inches)	MAXIMUM DIAMETER/HEIGHT	GROSS VOLUME$\times 10^3$ (barrels)	PLANNED STORAGE VOL.$\times 10^6$ (barrels)
1	415/653	988	1,816	10-3/4"	418/1007	8,102	8
2	376/639	741	1,608	13-3/8"	* /1121	6,000	**
3	506/660	876	1,830	10-3/4"	295/1130	4,236	5
8A	432/776	1,242	1,978	10-3/4"	235/765	3,155	5
11	N /704	1,067	1,812	13-3/8"	400/953	10,454	10
13	571/875	1,112	1,883	13-3/8"	300/918	5,055	5
15	477/637	2,597	3,297	13-3/8"	480/980	16,618	17
16	659/807	2,620	3,264	13-3/8"	* /644	8,800	9
17	454/825	2,598	4,043	13-3/8"	295/1543	12,175	10
18	430/850	3,500	4,285	16	480/883	10,000	10
19	550/850	2,980	4,312	20	415/1420	9,000	9
20	500/681	4,126	4,328	20	355/326	6,000	6
21	425/643	New Solution Well					5
						99,595	99

* No sonar caliper survey available.

** Not included in present storage designs.

cavern's ceiling. The approximate gross volume is 7.6 MMB.

Cavern No. 8A has an estimated gross volume of approximately 3.1 MMB. There is a small leak in the casing, which must be repaired, and a small chimney (15 MB) has developed which must be filled with nitrogen before storage of crude oil.

Caverns Nos. 15, 16 and 17, with a combined gross volume of approximately 37.5 MMB, are presently in use for hydrocarbon storage but Allied has indicatated that the space could be made available if replacement wells were provided. Cavern #15 contains fuel oil which could be transferred to Cavern #18 to make this space immediately available. Caverns #16 and #17 contain ethane. All the existing wells and casings are in good condition. An additional well would be drilled into each cavity, however, to meet required fill and withdrawal rates. Caverns Nos. 15 and 17 are separated by only 170 feet of salt; thus the caverns would coalesce after two or three fill cycles, requiring that similar types of crude be stored in these two caverns.

Caverns Nos. 6A and 14, with a combined volume of only 70 MB, are both idle and undeveloped because of a high magnesium content brine which is incompatible with Allied's chemical requirements. These wells are of interest to the SPR program because with proper disposal of the undesirable brine, they could be leached to sufficient size to be used by Allied for their committed storage, thus releasing caverns Nos. 15 and 17 for crude storage.

Cavern No. 2 is estimated to have a volume of 6 MMB, but the casing has collapsed and downhole conditions are not known. Re-entry into this cavern would be an economic risk because to repair the casing and then examine downhome conditions may prove to reveal the caverns as unacceptable for storage. This cavern is not being included in the present facility design.

Caverns Nos. 4 and 10, it is believed, have been leached into the caprock and are unacceptable for storage purposes.

A study of the 11 available caverns of Bayou Choctaw indicates that they are technically acceptable for conversion to crude oil storage based on presently available information. In only two of the caverns has the roof extended to or above the casing shoe of the cemented string.

Sufficient salt remains, however, between the roof and the caprock to preclude the possibility of loss of the stored product through the caprock into the upper strata.

2. Well and Wellhead Conversions

The Allied caverns at Bayou Choctaw exist in various conditions and states of repair. To accommodate the required flow rates for withdrawal in 150 days, an auxiliary entry well into each of these caverns would be constructed. The original wells would be adapted for crude oil injection and recovery. The new wells would be used for brine recovery and raw water injection.

The following would be the general procedures for preparing the caverns for crude storage:

(1) Empty any product which may be presently stored in the cavern.
(2) Remove existing pipes from hole.
(3) Run cement-bond and casing-corrosion logs, and sonar-survey the cavern to determine ceiling conditions.
(4) Pressure test casing.
(5a) If a leak is found, set a bridge plug in the casing to determine the point of leakage.
(5b) Perforate at the leak and squeeze full of cement until a 1500 psi shut-off is attained.
(5c) Drill out bridge plug.
(5d) Pressure test casing.
(6) Pressure test cavern (in caverns Nos. 3, 11, and 13, the entire gallery must be pressured tested.
(7) Drill auxiliary wells) to intersect any large chimney areas found. Pressure test casing and shoe before drilling into the cavern.
(8) Run displacement casings and install wellheads.
(9) Connect to distribution lines.
(10) Small chimney areas in caverns would be filled with nitrogen before crude storage commences.

3. Drilling Procedures

The Bayou Choctaw salt dome is reached at an average depth of 650 ft Caprock with a maximum thickness of 420 ft which covers most of the dome's crest. The ceilings of the storage cavities range from 741 to 4000 ft. below the surface. The new auxiliary wells would require 13-3/8 inch casing cemented from the surface to the ceiling, and 10-3/4 displacement tubing suspended to the top of the sump.

Conventional oil rigs would be used. The majority of oil rigs are of the diesel powered rotary type. Some are direct coupled and some are diesel-electric. Casing sizes to be used for the project will be somewhat larger than required for "oil field" wells of comparable depth. Consequently, drill rigs may have "oil field" depth ratings up to 10,000 feet. The required finished casing size for the auxiliary wells would be 13-3/8 inches, but because of the larger casings needed to cement the borehole at various intervals from the cavity to the surface, the various bore capabilities of the rig is critical.

A certain amount of difficulty in drilling through the caprock would be expected. This happens most often when cavernous zones resulting from natural leaching of the anhydrite and gypsum formations cause a loss of the drilling fluid necessary for lubricating the bit and transporting spoil to the surface. In most cases, circulation could be re-established, but if caprock conditions at one of the re-entry wells fails in circulation, the well could be completed at greater expense without full circulation. It is estimated that in 20% of boreholing through caprock some difficulty with lost circulation may be experienced.

Drilling fluid, commonly called "mud", could be of a variety of constitutions, depending on drilling conditions. "Highly inhibited muds" may be required in difficult shales, but non-exotic clays would be used when possible. Needless to say, the cheapest and least toxic mud that would do the job would be used, but the actual formulation would be determined by experience on the site. It may be possible, in some instances, to get by with non-toxic "native muds" until the "top hole" is cased off, and then to convert to saturated brine. The salt must be drilled with salt saturated mud or brine to prevent hole enlargement by leaching.

Disposal of used muds is also an important consideration. Normal procedure would be to transfer the mud with the rig, continually recycling a volume equal to twice the borehole size. There would be pits of saline mud which would have to be cleaned up and buried. In the Gulf Coast region, the humidity is too high to economically dry the waste. Therefore, mud would have to be hauled away when drilling operations are completed.

APPENDIX I

SUMMARY OF LOCAL MINERAL PRODUCTION, EMPLOYMENT, AND COMMUTING PATTERNS BY PARISH

The tables contained in this appendix summarize the value of mineral production, employment in major industries, commuting patterns of workers, and median earnings of selected occupational groups. The parishes covered in this summary are: Iberville, West Baton Rouge, East Baton Rouge, and Ascension.

TABLE I-1 VALUE OF MINERAL PRODUCTION, BY PARISH

Minerals listed in order of value	Iberville	West Baton Rouge	East Baton Rouge	Ascension
	Petroleum Salt Natural Gas Nat. gas. liq. Sand & Gravel	Petroleum Natural Gas Clays	Lime, Cement Petroleum Sand & Gravel Natural Gas	Nat. gas liquids Petroleum Salt Natural Gas
1969	$60,166,000	$4,382,000	$16,320,000	$11,178,000
1970	61,881,000	2,603,000	16,074,000	43,501,000
1971	67,260,000	withheld*	21,616,000	46,369,000

*Withheld to avoid disclosing individual company confidential data.

Source: U. S. Army Corps of Engineers, Inventory of Basic Environmental Data: New Orleans - Baton Rouge Metropolitan Area, March, 1975.

TABLE I-2

EMPLOYMENT IN MAJOR INDUSTRIES (PARISH)

	IBERVILLE		WEST BATON ROUGE		EAST BATON ROUGE		ASCENSION	
	No.	%	No.	%	No.	%	No.	%
Total	8,018	100	4,583	100	102,577	100	10,805	100
Agriculture, forestry & fisheries	548	6.9	309	6.7	1,133	1.1	459	4.2
Mining	363	4.5	68	1.4	981	0.9	209	1.9
Construction	1,088	13.6	617	13.4	10,116	9.8	1,450	13.4
Manufacturing	1,361	17.0	1,070	23.3	17,722	17.2	2.643	24.4
Furniture*	103	1.2	12	0.2	193	0.1	60	0.5
Primary & fabricated metal	62	0.7	71	1.5	1,060	1.0	142	1.3
Machinery	74	0.9	23	0.5	287	0.2	35	0.3
Elec. machinery	13	0.1	15	0.3	126	0.1	4	0.0
Transport equip.	48	0.5	54	1.1	171	0.1	96	0.8
Other durables	94	1.1	32	0.6	999	0.9	72	0.6
Food & kindred	97	1.2	105	2.2	1,101	1.0	240	2.2
Textile mill & apparel	--	--	--	--	65	0.0	108	0.9
Printing, publishing	17	0.2	12	0.2	902	0.8	37	0.3
Chemical	697	8.6	548	11.9	8,017	7.8	1,467	13.5
Other nondurable	156	1.9	198	4.3	4,801	4.6	382	3.5
Railroad	17	.2	59	1.2	403	0.3	25	0.2
Trucking service	77	1.0	26	0.5	753	0.7	107	0.9
Other transport.	210	2.6	204	4.4	1,143	1.1	345	3.1
Communications	51	0.6	14	0.3	1,310	1.2	192	1.7

*Includes lumber and wood products.

TABLE I-2

EMPLOYMENT IN MAJOR INDUSTRIES (PARISH) - cont'd

	IBERVILLE		WEST BATON ROUGE		EAST BATON ROUGE		ASCENSION	
	No.	%	No.	%	No.	%	No.	%
Utilities & sanitary	179	2.2	80	1.7	1,838	1.7	229	2.1
Wholesale trade	217	2.7	185	4.0	4,316	4.2	338	3.1
Food & dairy	270	3.4	87	1.8	2,213	2.1	282	2.6
Eating & drinking	202	2.5	126	2.7	2,500	2.4	359	3.3
General merchandise	81	1.0	88	1.9	2,654	2.5	234	2.1
Motor vehicle retailing & service stations	205	2.5	87	1.8	2,196	2.1	321	2.9
Other retail	322	4.0	201	4.3	5,705	5.5	463	4.2
Banking & credit	67	0.8	28	0.6	1,911	1.8	131	1.2
Insurance & real estate	169	2.1	107	2.3	3,633	3.5	142	1.3
Business & repair service	176	2.2	86	1.8	3,430	3.3	245	2.2
Private households	395	4.9	210	4.5	3,175	3.0	391	3.6
Other personal service	294	3.7	152	3.3	4,060	3.9	376	3.4
Entertainment	13	0.2	20	0.4	810	0.7	79	0.7
Hospitals	348	4.3	104	2.2	3,123	3.0	248	2.2
Health services	102	1.2	25	0.5	1,752	1.7	144	1.3

TABLE I-2

EMPLOYMENT IN MAJOR INDUSTRIES (PARISH) - cont'd

	IBERVILLE		WEST BATON ROUGE		EAST BATON ROUGE		ASCENSION	
	No.	%	No.	%	No.	%	No.	%
Education Elementary, Secondary, College (Gov't)	482	6.0	251	5.4	10,625	10.3	543	5.0
Education Elementary, Secondary, College (Private)	148	1.8	43	0.9	1,884	1.8	173	1.6
Education Other	75	0.9	11	0.2	930	0.9	37	0.3
Welfare, religion	148	1.8	71	1.5	1,815	1.7	110	1.0
Legal engineering	121	1.5	77	1.6	4,383	4.2	156	1.4
Public administration	289	3.5	177	3.8	6,063	5.9	394	3.6

TABLE I-3 Commuting Patterns, by Parish

	Iberville	West Baton Rouge	East Baton Rouge	Ascension
All workers	7,921	4,357	100,391	10,588
Work in parish of residence	4,845	1,794	79,683	6,695
percent of workers	61.2	41.2	79.4	63.2
Work outside parish of residence	2,049	1,957	9,591	2,785
Place of work not reported	1,027	606	11,117	1,108

Source: U. S. Army Corps of Engineers, Inventory of Basic Environmental Data: New Orleans - Baton Rouge Metropolitan Area, March 1975.

TABLE I-4 Median Earnings of Selected Occupation Groups*

	Iberville	West Baton Rouge	East Baton Rouge	Ascension
Male, total with earnings	$5,813	$6,459	$ 7,905	$7,377
Prof., mgrs., & kindred	9,138	8,154	11,112	8,443
Craftsmen, foremen & kindred	6,596	8,008	8,343	8,980
Operatives & kindred	6,260	6,237	6,888	7,924
Laborers, except farm	3,631	4,231	4,041	3,904
Female, total with earnings	2,217	2,593	3,350	2,357
Clerical & kindred	3,500	3,620	4,013	3,476
Operatives, including transport	1,767	2,400	2,563	3,485

APPENDIX J

CAVERN STABILITY ANALYSIS

This appendix evaluates cavern stability parameters at Bayou Choctaw salt dome. The parameters include the cavern dimensions and configuration, proximity to other caverns, the salt dome boundary, the caprock, and the thickness of the plastic and brittle salt which encircles the caverns.[1,2]

Twenty-three caverns have been created at the Bayou Choctaw dome. Twelve of those caverns are suitable for storing oil in this program. The cavern numbers are 1, 2, 3, 8A, 11, 13, 15, 16, 17, 18, 19, and 20. In caverns 2 and 3, the roof has extended to or above the casing shoe of the cemented string. However, sufficient salt remains between the roof and the caprock as in all the wells, to preclude the possibility of loss of the stored petroleum through the caprock into the upper strata. Table J.1 gives pertinent cavern data.

Figure J.1 illustrates the relative position of caverns proposed for oil storage at Bayou Choctaw. Several caverns are currently within 250 feet of each other. Caverns 11, 13, and 3 have reportedly coalesced, but the level of coalesce could not be determined (it is judged to be between 1,135 to 1,230 feet). Figure J.2 is a cross-section of the three caverns with the speculated connection between 11 and 13. Table J.2 presents the maximum and minimum diameters of the cone of influence* and acreage expected if collapse occurs at any of the Bayou Choctaw caverns. Figure J.3 is a site map with the areas of influence outlined.

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*A cone of influence is actually a truncated cone (frustrum), apex down, projected from the caprock to the ground surface. The angle of the frustrum is dependent on the shear angle of the overburden. It is the largest volume of material above a cavern that could be influenced during a collapse.

Table J.1 Cavern Data - for Bayou Choctaw

Cavern	Total Depth Original*	Total Depth Present*	Top of Caprock*	Top of Salt*	Top of Cavern*	Maximum Diameter*	Height of Cavern*
1	1,995	1,816	415	653	988	418	1,007
2	1,862	1,608	376	639	741	*	1,121
3	2,006	1,830	506	660	876	295	1,130
8A	2,007	1,978	432	776	1,242	235	765
11	2,020	1,812	None	704	1,067	400	953
13	2,030	1,883	571	875	1,112	300	918
15	3,577	3,297	477	637	2,597	480	980
16	3,481	3,264	659	807	2,620	360	644
17	4,141	4,043	454	825	2,598	295	1,543
18	4,383	4,285	430	850	3,500	480	883
19	4,400	4,312	550	850	2,980	415	1,420
20	4,452	4,328	500	681	4,126	355	326

* Dimensions expressed in feet

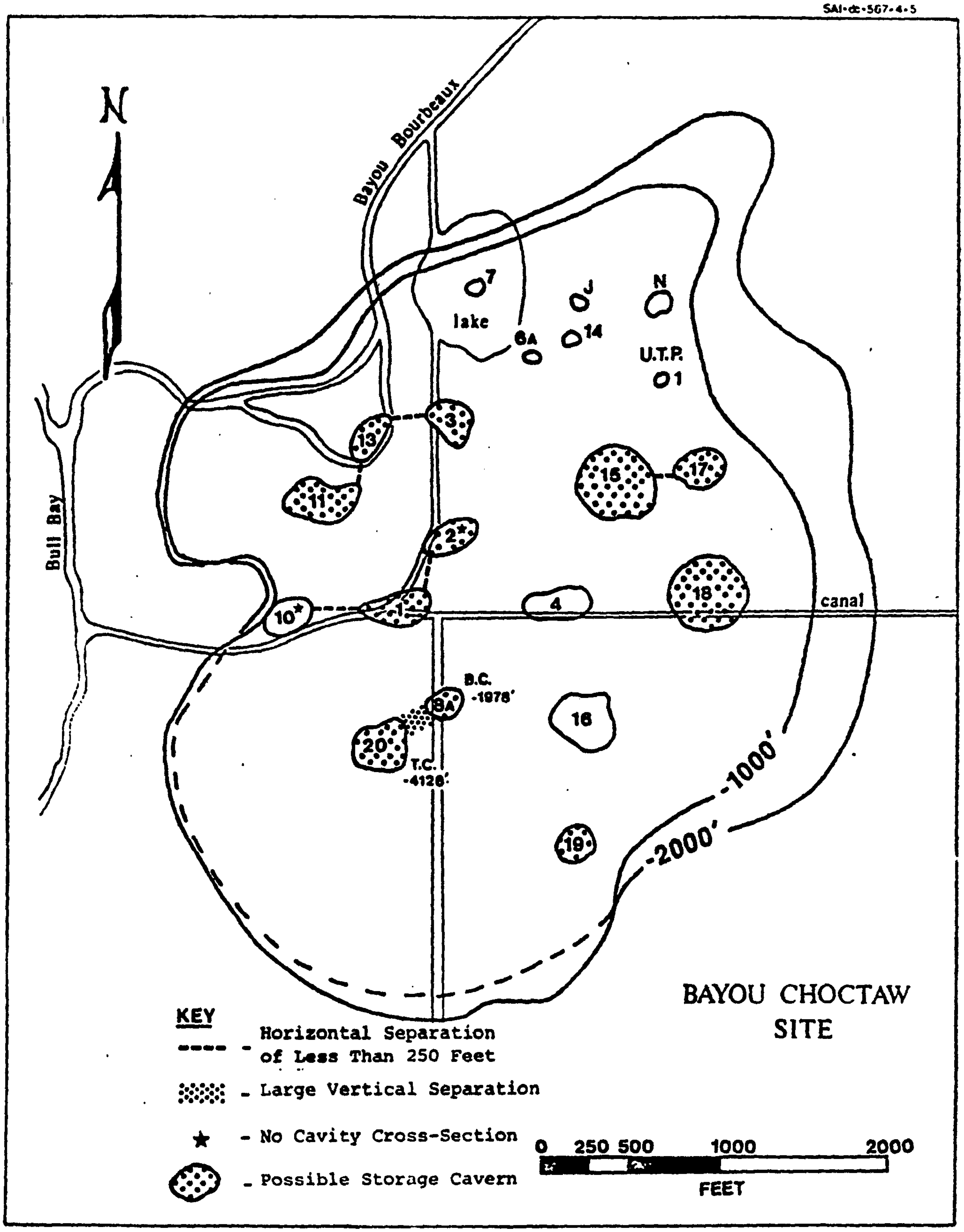

Figure J.1 Surface Projection of Cavern Diameter

Table J.2 Bayou Choctaw - Cones of Influence

Potentially Impacted Land	Cavern Number	Maximum Cavity Diameter (Feet)	Depth to Caprock (Feet)	Cone of Influence Angle (Degree)	Maximum-Minimum Cone Diameter (Feet)	Acres in the Cone of Influence
3	1	418	415	40 15	1,114 640	22 7
3	3	295	506	40 15	1,001 664	18 8
3	8A	235	432	40 15	960 466	17 4
3	13	300	571	40 15	1,258 606	29 7
1	15	480	477	40 15	1,280 736	30 10
3	16	360	659	40 15	1,466 713	39 9
3	17	295	454	40 15	1,056 538	20 5
3	18	480	430	40 15	1,202 710	26 9
3	19	415	550	40 15	1,338 710	32 9
3	20	355	500	40 15	1,194 623	26 7

1 - Dry Land
2 - Swamp/Marsh
3 - Flowing Water
4 - Contained Reservoirs
    and Brine Ponds

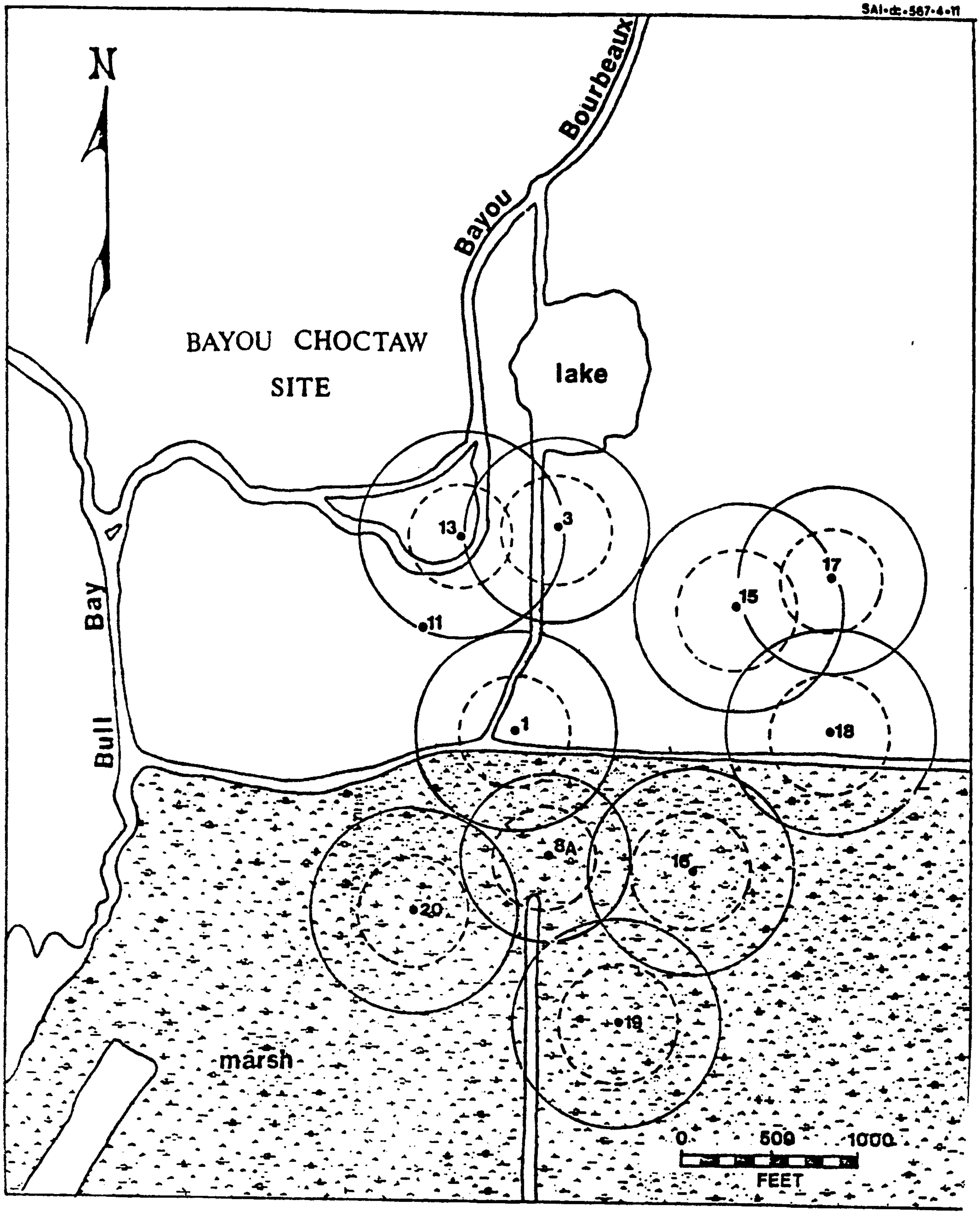

Figure J.3 Site Map of Bayou Choctaw Showing Areas of Expected cones of Influence in the Event of Cavern Collapse.

The growth of the caverns after various cycles cannot be precisely calculated. It is known that the caverns have the potential of increasing in volume by approximately 14 percent, but there are at least two major complicating factors: (1) some caverns have complicated shapes; (they differ significantly from cylinders, hence there is more surface area at which dissolution could occur, and consequently the diameter increase estimates based on a 14 percent volume increase of a cylinder would be too large); (2) the length of time that the volume of fresh displacement water would have to become saturated is not known. Nevertheless, to estimate the maximum possible cavern growth, diameters after each cycle were calculated for each cavern (Table J.3).* The assumptions were made that caverns were cylinders and that the displacement water became saturated.

The maximum and minimum thicknesses of the combined brittle and plastic zone for the roof and walls were calculated using formulas (1) and (2), and the maximum range of values for the octahedral yield point τ_o reported in the literature[1] (τ_o = 4,000 psi, τ_o = 700 psi).

$$\delta_w = \frac{a}{2}\left[e^{\left(\frac{\Delta p}{6\sqrt{\tau_o}} - \frac{1}{2}\right)} - 1 \right] \qquad (1)$$

where δ_w = thickness of plastic zone of the cavern wall

$\frac{a}{2}$ = radius of the cavern

Δp = pressure difference (between lithostatic pressure and minimum oil storage pressure)

τ_o = octahedral yield point**

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*It was assumed that the roof and floor were not leached because the roof is protected by an oil blanket and the floor is protected by insoluable residues that settle to the bottom during cavern formation.

**The octahedral yield point, is the magnitude of the shearing stress associated with the octahedral plane when yielding occurs. The octahedral plane is inclined so as to form an equal angle between the principal stress axis at a point in a stressed body.

Table J.3 Bayou Choctaw Cavern - Diameter After Each Cycle

Cavern Number	Cavity Diameter (feet)	Cavern Height (feet)	Diameter After Each Cycle* (feet)				
			1	2	3	4	5
1	418	1,007	446	477	510	545	583
2	Not Known	1,121					
3	295	1,008	315	336	359	383	409
8A	235	765	251	268	287	306	328
11	400	953	427	457	488	522	558
13	300	918	320	342	366	391	418
15	480	980	513	548	586	626	670
16	360	644	384	411	439	470	502
17	295	1,543	315	337	360	385	411
18	480	883	513	548	586	626	670
19	415	1,420	443	474	507	542	579
20	355	326	379	405	433	463	495

*In theory the dissolution at any wall is equal to half the difference between the diameter of the cavern after each cycle and the original cavern diameter.

$$\delta_r = \frac{a}{2}\left[e^{\left(\frac{\Delta p}{3\sqrt{2}\tau_o} - \frac{1}{3}\right)} - 1 \right] \qquad (2)$$

where δ_r = combined thickness of brittle zone and plastic zone at the roof of the cavern

a = diameter of the cavern

Δp = difference between the lithostatic pressure and the minimum oil storage pressure

τ_o = octahedral yield point

The pressure difference Δp can be calculated according to the relation

$$\Delta p = (\rho_r - \rho_o)(d_s + t)\, g \qquad (3)$$

ρ_r = average density of all solid material above the cavern

ρ_o = density of oil

d_s = depth to salt

t = thickness of salt roof

g = acceleration due to gravity

These formulas are based on plasticity theory and have been used successfully to size the critical dimensions of a system of storage cavities in salt.[1] The roof of salt over the cavity was designed so as not to be less than δ_w, and the horizontal distance between cavern centers was not to be less than $2\delta_r$.

Figure J.4 illustrates a cylindrical cavern in vertical cross-section with the thickness of the brittle and plastic rock salt. In many cases, the computed thickness is observed to be a negative number. This occurs when the upper range of the yield point is used for a particular

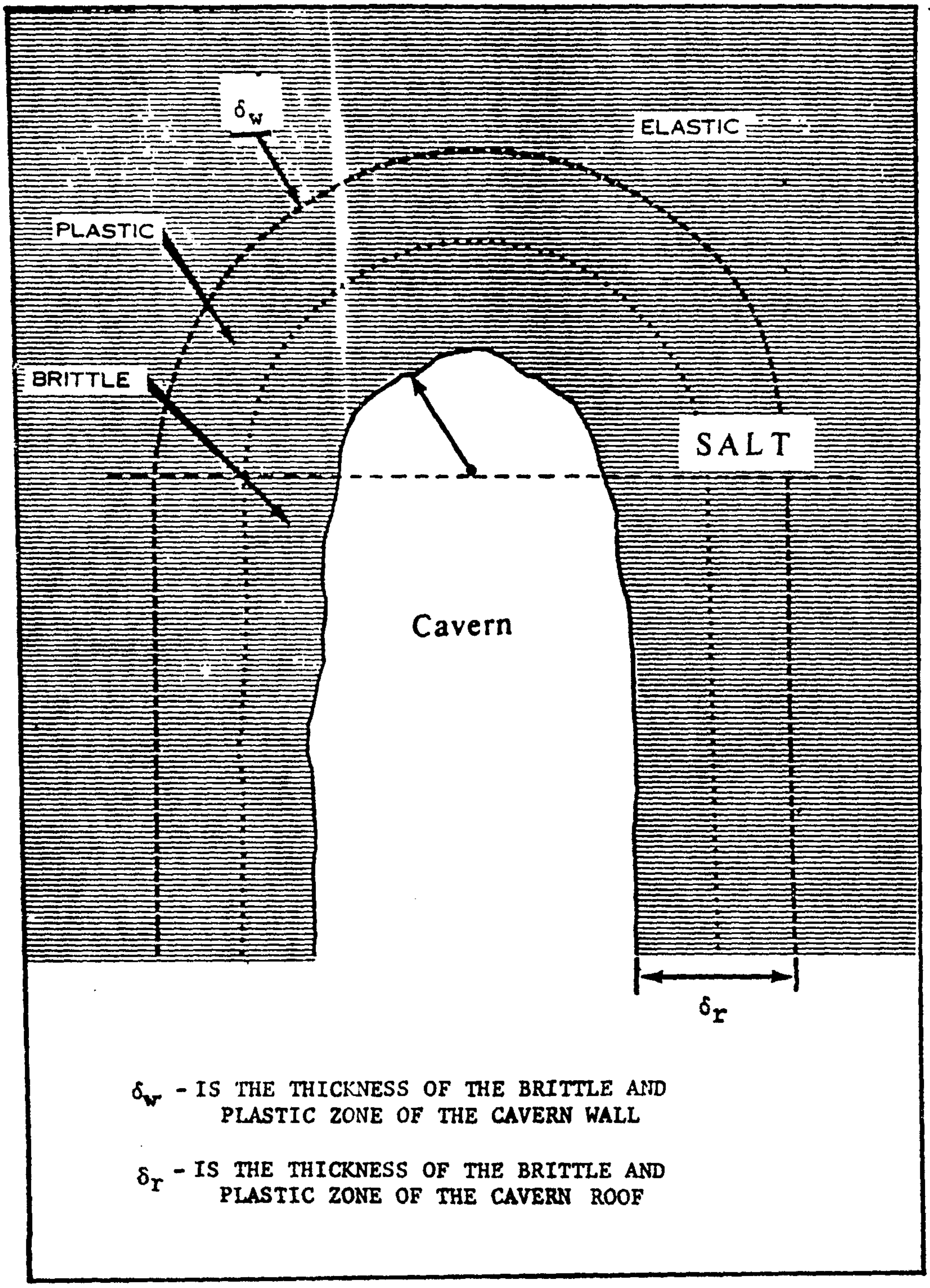

Figure J.4 Vertical Cross-Section of a Cylindrical Cavern With a Hemispherical Roof Illustrating the Thicknesses of the Brittle and Plastic Zones of the Walls and Roof cavern. Such a result indicates that for a high compressive strength there is no brittle or plastic zone; all of the salt surrounding the cavern is elastic. This, however, is unlikely and emphasizes the limitation of using ranges of data based on salt tests from other domes. The octahedral yield point of salt varies from dome to dome, and the actual value of this parameter is unknown at the caverns under consideration.

To obtain a closer approximation of the true value of τ_o for the roof and walls of each cavern, equations (1) and (2) were solved were solved for τ_o when the thickness of the combined brittle and plastic zone was assumed to be zero. The true value of τ_o then would be slightly greater than the result of this calculation.

Because of the form of equations (1) and (2), it is somewhat difficult to visualize the manner in which the computed thickness of the brittle and plastic zones varies with depth and with octahedral yield point. For the case of the cavern roof, based on equation (2), Figure J.5 provides a series of plots of the dimensionless ratio $2\delta_r/a$ (representing the computed thickness divided by the cavern radius) as a function of the roof depth, for values of τ_o varying from 100 psi to 4,000 psi. As indicated in Figure J.5, negative values of the roof thickness radius ratio are predicted for all the values of τ_o. With increasing depth, the ratio increases relatively slowly, but at some point becomes positive. The larger the value of τ_o, the greater the depth at which this crossover point occurs. For example, for a τ_o of 100 psi at the roof, the crossover point occurs at a depth of approximately 310 feet, while for a τ_o of 3,000 psi, the corresponding depth is roughly 8,900 feet. With increasing depth beyond the crossover point, the computed thickness continues to increase in an exponential fashion. Notice should be taken that the shapes of the curves presented in Figure J.5 (including the location of the crossover points) are independent of the cavern radius. The computed thickness itself is, however, directly proportional to the radius.

Similar plots of cavern wall thickness as a function of depth and octahedral yield point are provided in Figure J.6, based on equation (1). The general characteristics of the curves, as expected, closely resemble those given in Figure J.5. The computed thickness of the brittle and plastic zones for a cavern wall is, however, greater than the corresponding thickness for a cavern roof for the same depth and same value of τ_o.

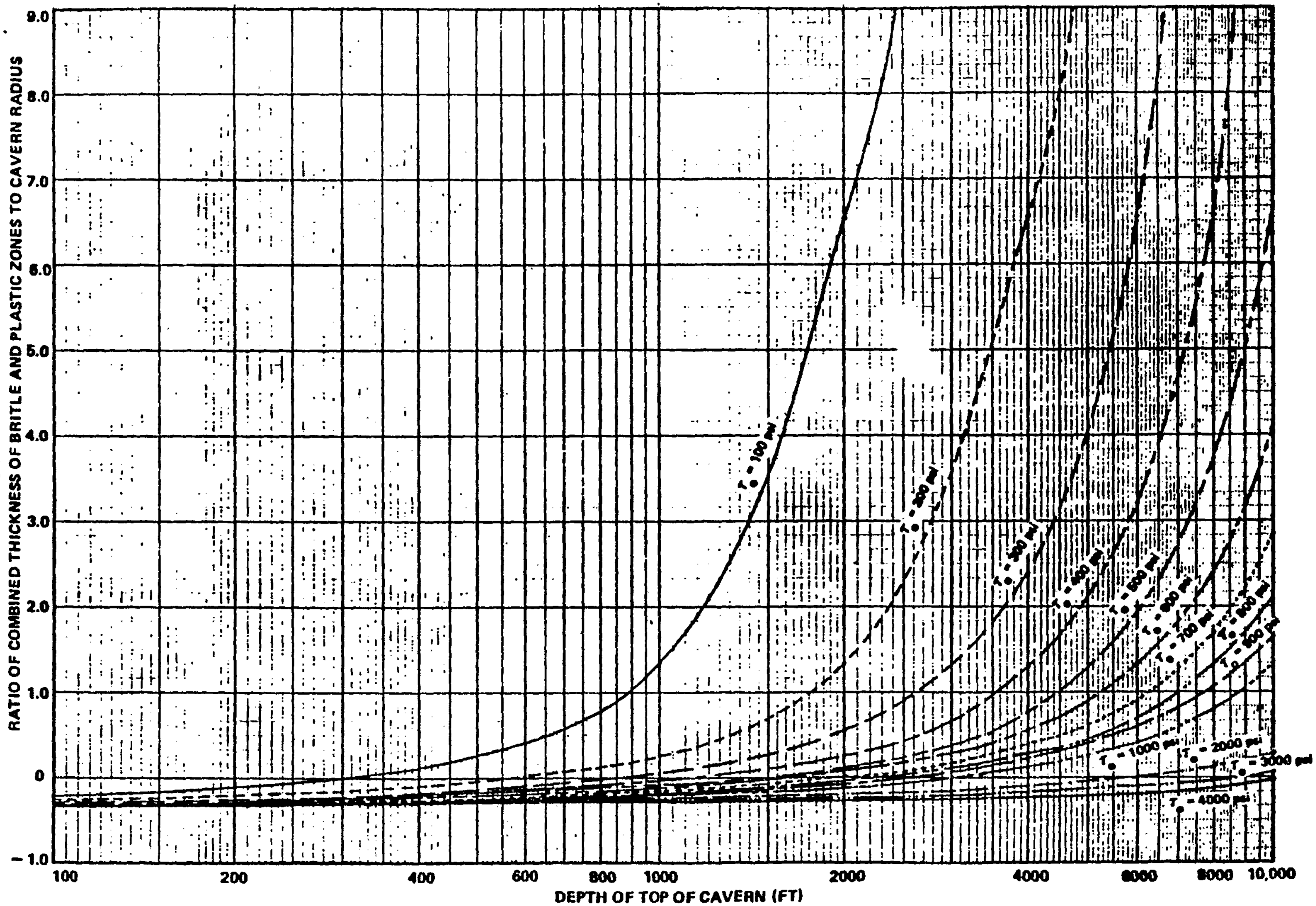

Figure J.5 VARIATION OF COMPUTED THICKNESS OF BRITTLE AND PLASTIC ZONES FOR CAVERN ROOF

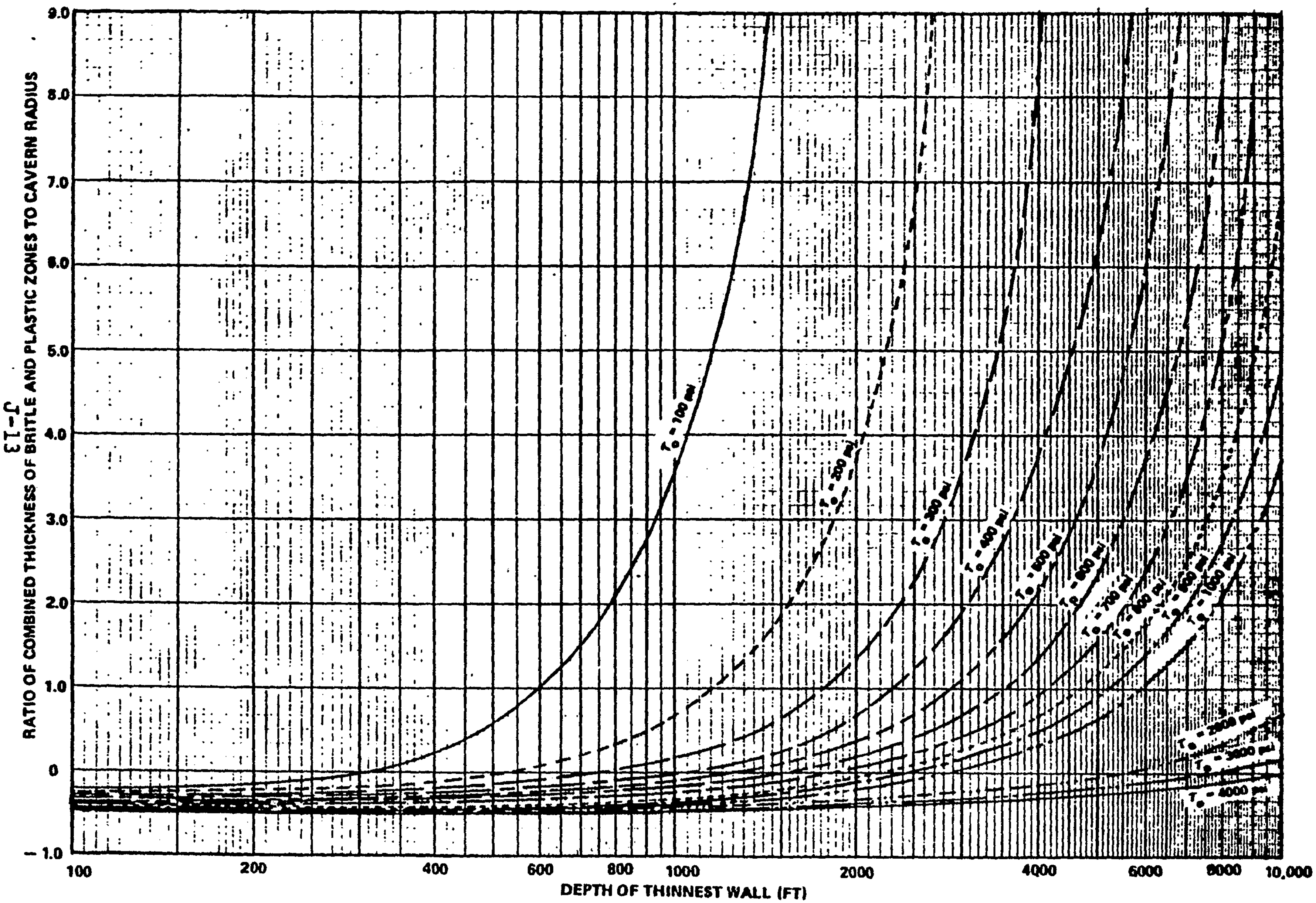

Figure J.6 VARIATION OF COMPUTED THICKNESS OF BRITTLE AND PLASTIC ZONES FOR CAVERN WALL

The thickness of the zone of plasticity has been calculated for the roofs of all 12 caverns at Bayou Choctaw (Table J.4). These thicknesses were calculated using formula (2). The thickness of the zone of plasticity has also been calculated for the walls separating caverns 15 and 17, 1 and 10, 11 and 13, and 13 and 3. The calculations for the cavern walls were made using formula (1) (Table J.5).

Two octahedral yield points for salt were used: τ_o = 700 psi and τ_o = 4,000 psi. The roof thicknesses listed on Table J.4 indicate that at τ_o 700 psi, 26 to 77 feet of salt above the roof are required to contain the plastic and brittle zones in the roof of these caverns. The negative values indicate that at, τ_o = 700 psi and at a given cavern depth and diameter, this value of the octahedral yield point of the salt exceeded the true value and therefore, a brittle and plastic zone does not exist. These negative numbers are unrealistic because they imply a negative thickness to the plastic and brittle zone.

Using τ_o = 700 psi, the thickness of the zone of plasticity of the wall of cavern 15 is 130 feet and for the wall of cavern 17 is 80 feet. Combined, the two zones exceed the 150 feet of salt between the caverns. This means that there is no elastic salt between the caverns now. After five cycles, the two caverns will have coalesced by dissolution of salt or sooner if slabbing occurs (Figure J.7).

Coalescence does not necessarily mean that a collapse or subsidence will occur, but the possibility is increased. For the remaining pairs of caverns, all thicknesses of the zones of plasticity have negative values which indicates that τ_o for the salt at these locations is less than 700 psi.

The calculated increase in diameter of cavern 1 after five cycles is 164 feet; each wall theoretically will expand by 82 feet and therefore will not be in danger of coalescing with cavern 10 (Figure J.8 . Caverns 11 and 13 will probably coalesce during the fifth cycle by dissolution or before by slabbing (Figure J.2). The simultaneous increase in the diameters of caverns 13 and 3 will, after five cycles, be just enough to dissolve the 200 foot wall between them (Figure J.2).

To reiterate, the calculations of diameter increase per cycle are based on the assumption that the displacement water will become saturated before being removed, and that the caverns are cylinders.

Table J.4 Bayou Choctaw - Combined Thickness of Plastic and Brittle Zone in the Cavern Roof

(Expressed in feet)

Cavern Number	Maximum Cavern Radius	Depth of Cavern Roof	Depth to Salt	Thickness of Roof Salt	Plastic Zone Thickness for Values of: τ_o = 700 psi	τ_o = 4000 psi	Values of τ_o With Zero Thickness of Plastic Zone
1	209	988	653	335	-32.1	-54.8	349 psi
2	111	741	639	102	-20.9	-29.7	261 psi
3	148	876	660	216	-25.2	-39.2	309 psi
8A	118	1,242	776	466	-13.8	-30.3	439 psi
11	200	1,067	704	363	-28.5	-52.1	377 psi
13	150	1,112	875	237	-20.4	-38.9	393 psi
15	240	2,597	637	1,960	26.3	-54.4	918 psi
16	180	2,620	807	1,813	20.5	-40.7	926 psi
17	148	2,598	825	1,773	16.4	-33.5	918 psi
18	240	3,500	850	2,650	70.0	-49.4	1,237 psi
19	208	2,980	850	2,130	38.1	-45.3	1,053 psi
20	178	4,126	681	3,445	77.5	-34.0	1,458 psi

Table J.5 Bayou Choctaw - Combined Thickness of Plastic and Brittle Zone in the Cavern Wall

(Expressed in feet)

Cavern Number	Maximum Cavern Radius	Depth of Thinnest Wall	Actual Thickness Between Caverns	Plastic Zone Thickness for Values of: τ_0 = 700 psi		τ_0 = 4000 psi		Values of τ_0 With Zero Thickness of Plastic Zone
15	240	3,200	150	130.1	210.3	-68.6	null	1,306 psi
17	148	3,200		80.2		-42.3		1,306 psi
1	209	1,500	250	-12.7	null	-72.2	null	612 psi
10	106	1,500		- 6.4		-36.6		612 psi
11	200	1,450	130	-14.9	null	-69.4	null	591 psi
13	150	1,450		-11.1		-52.0		591/694 psi *
13	150	1,700	200	- 0.6	null	-50.6	null	591/694 psi *
3	148	1,700		- 0.6		-50.1		694 psi

*For cavern 13 two values of τ_0 for the wall are given. These values correspond to the two depths (1,450 and 1,700 feet) at which the thinnest walls for cavern 13 occur.

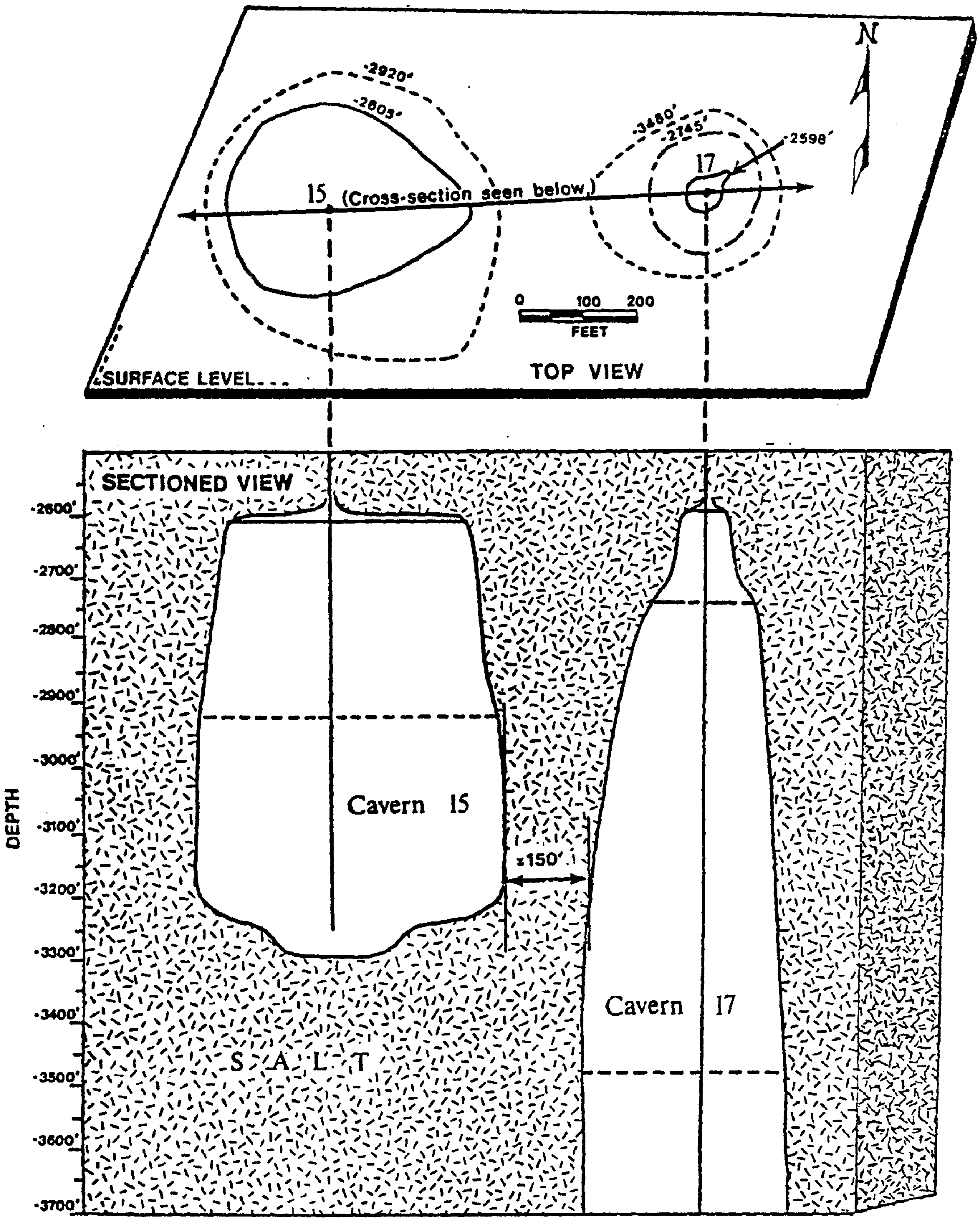

Figure J.7 Cross-Sectional Relationship of Caverns 15 and 17 at Bayou Choctaw.

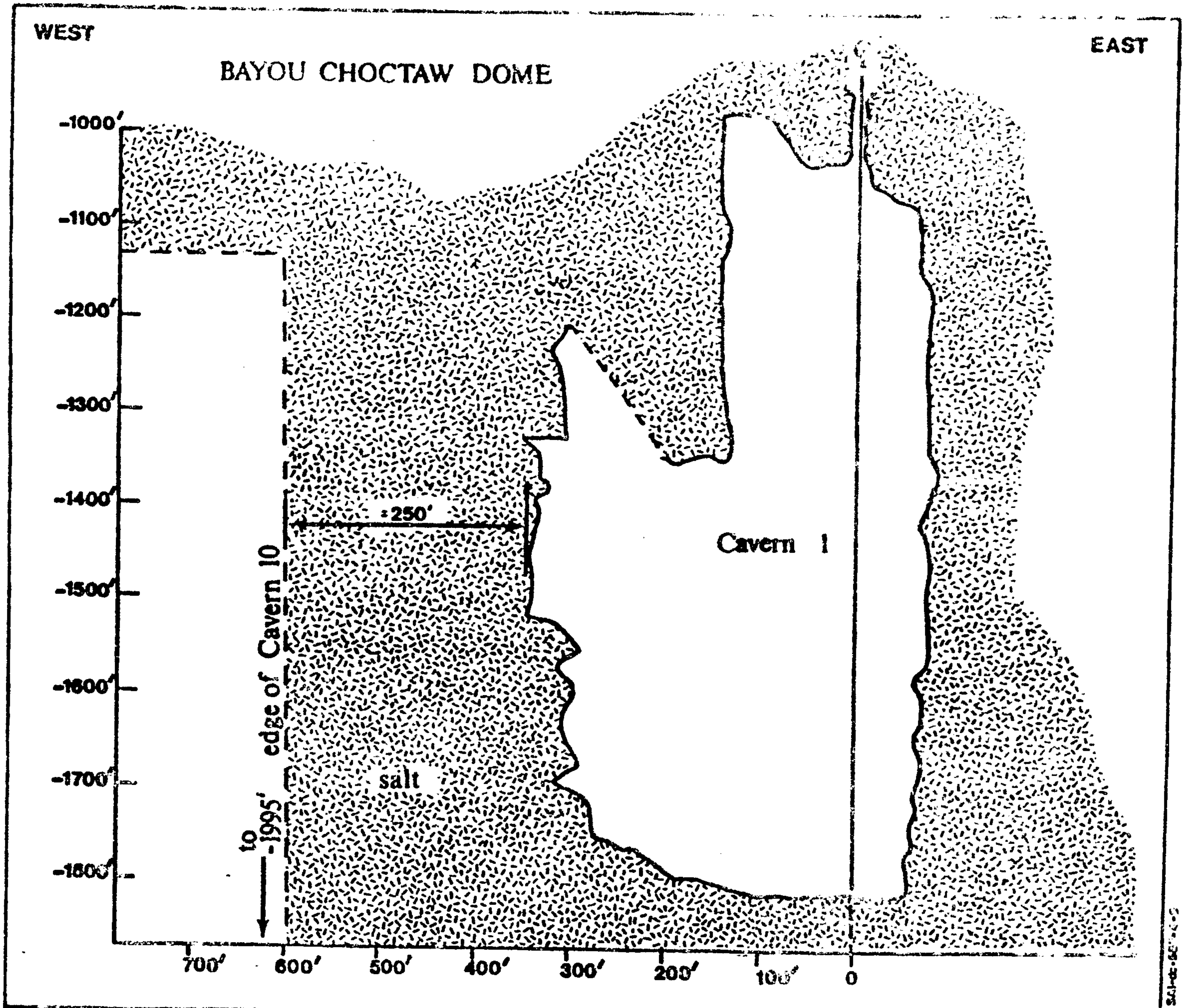

Figure J.8 Cross-Sectional Relationship of Caverns 1 and 10 at Bayou Choctaw

REFERENCES

APPENDIX J

[1] S. Serata and E. F. Gloyna, "Principles of Structural Stability of Underground Salt Cavities," Journal Geophysical Resources, 65, pp. 2979-2987, 1960.

[2] G. E. Korbin, "Simple Procedure for the Analysis of Deep Tunnels in Problematic Ground, 17th U.S. Symposium on Rock Mechanics," Snowbird, Utah, Utah Engineering Station, p. 1, A3-1, 7, 1976.

APPENDIX K

DISCUSSION OF SUBSIDENCE

The collapse of a storage cavern in salt is not analgous to debris falling into an empty hole and causing a "sinkhole" at the surface. These caverns are always full of a nearly incompressible fluid, brine, or oil which if a collapse occurs is displaced volume for volume by falling caprock and overlying sediments.

There appear to be three possible types of surface subsidence associated with caverns in salt or the collapse of such caverns. Subsidence due to surface emergence of oil, and subsidence due to absorption of oil into existing pore space. Only if the stored fluid reaches the surface or moves into voids or pores can there be surface subsidence during collapse.

Creep closure is the tendency of the salt surrounding a cavern to flow in toward the cavern causing a reduction in volume of the cavern. The caprock and sediments overlying a cavern with active closure will also tend to subside, but the rate of subsidence and ground surface manifestation will depend on the cavern depth and the elasticity of the salt and overlying sediments. The subsidence that might occur would probably be very broad (geographically) and shallow (nearly imperceptible without using surveying tehniques).

Subsidence with surface emergence of oil can be envisioned by the following analogy. (This analogy is used to illustrate a point and it is not suggested in this report to be a real possibility). If the entire column of sediment, above the cavern has a diameter equal to the diameter of a cylindrical cavern and a height equal to the depth of the cavern roof, and it is lowered into the cavern by a distance equal to height of the cavern in a manner analogous to a piston in a cylinder, and if the fluid in the cavern was completely displaced by percolating through the sediments of the "piston" rather than compressed, there would be a surface depression equal in volume to the original cavern filled but not overflowing with the displaced fluid. This is a simplified case which assumes that, the imperfect packing of falling particles, adsorption, absorption, dissolution, and trapping of the displaced fluid do not occur. In reality, these five mechanisms reduce the amount of oil that will continue to rise through the cone of influence and emerge on the surface. With these mechanisms, oil will probably reach the surface as small seeps, and as the sediment settles into the place formerly occupied by the oil, a small surface depression will form. Multiple depressions will appear as a wide area of shallow subsidence filled with oil.

The third type of subsidence occurs without surface emergence of oil. Using the piston and cylinder model again with the assumption that the oil percolates up through water saturated sediments that have zero empty pore space, there is a volume for volume displacement of oil and by the laws of conservation of mass, the combined volume of the oil and saturated sediments remains constant. Now envision an overlying layer of unsaturated sediment with unit volume and empty pore space. If the oil moves up from the saturated layer into the empty pores of the unsaturated layer, there would be a volume decrease in the saturated layer, but the volume of the unsaturated layer would remain constant as long as the oil only fills empty space. The result of "deflating" the saturated layer would be subsidence of the upper layer which now contains oil in the previously empty pore space. Oil would not emerge on the surface until all of the pore space near a potential seep was filled with oil.

The rate at which collapse and subsidence proceeds has not been quantified, but estimates range from 36 hours to 36 days (Section 4.4.2). Since the viscosity of oil is much greater than brine, the collapse will proceed slower when the cavity contains oil, a surface depression is less likely to form, and a depression caused by collapse of an oil-filled cavern probably will be smaller than a surface dispersion of a brine-filled cavern collapse. There are two reasons for this: (1) a smaller volume of oil will be injected into caprock voids and almost none into aquifers leaving less room for subsidence, and (2) less oil will reach the surface because oil will be trapped more easily than brine.

APPENDIX L - COMMENTS RECEIVED

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT. CORPS OF ENGINEERS
P. O. BOX 60267
NEW ORLEANS, LOUISIANA 70160

IN REPLY REFER TO
LMNPD-RE

10 November 1976

Mr. Steven E. Ferguson
Executive Communications
Room 3309
Federal Energy Administration
Washington, DC 20461

Dear Mr. Ferguson:

Your draft environmental impact statements (EIS) for the first five candidate sites selected for possible use as petroleum storage facilities for the initial phase of the Strategic Petroleum Reserve (SPR) were referred to this office from our Washington Office for comment.

We have reviewed the EIS's for the following candidate sites: West Hackberry salt dome, Bayou Choctaw salt dome, Cote Blanche Island mine, Weeks Island mine, and Bryan Mound salt dome. They have been reviewed in accordance with our areas of responsibility and expertise as outlined in the Council on Environmental Quality guidelines, Title 40 C.F.R., part 1500, published in the Federal Register dated 1 August 1973, and US Army Corps of Engineers administrative procedures for permit activities in navigable waters or ocean waters, Title 33, C.F.R., Part 209, published in the Federal Register dated 25 July 1975.

We offer the following comments regarding the five draft impact statements for your consideration:

a. Comments on West Hackberry site.

(1) General comments.

(a) The West Hackberry site has significant potential for adverse impacts upon the water quality of the adjacent area. The assumption that the naturally occurring sediments in the area of Black Lake

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are predominantly sand, may be in error. Available soil curves for the material removed during dredging activities in the Calcasieu River at this point indicate a high amount of silt. This could greatly increase the amount of heavy metals, nutrients, and pesticides released to the water column over that as assumed in the EIS. The establishment of soil characteristics (soil curves) and elutriate analyses should be made to quantify the impacts upon the water column. The effluent from any unconfined disposal or open water disposal of dredged material could have a significant impact upon Calcasieu Lake. The minimal release of mercury mentioned (.5 ug/l) is significantly above the criteria limit of 0.1 ug/l as established by the 1975 EPA, Proposed Criteria for Water Quality-Marine Water Constituents (Aquatic Life). This site is the least acceptable alternative as far as the impacts upon the water quality in the project area are concerned.

(b) Some areas lack site-specific information which is required to adequately assess the probable impacts. Emphasis is placed too heavily on data taken from areas removed from the project area.

(2) Specific comments.

(a) Page 1-6, paragraph 2. Sabine National Migratory Waterfowl Refuge should be Sabine National Wildlife Refuge.

(b) Page 1-26, paragraph 2. This statement excludes the push-ditch method of pipeline installation which is normally preferred for installation of pipelines in marsh areas of coastal Louisiana. Experience has shown that this method greatly reduces potential environmental damage and it has been proven feasible for lines in excess of 40 inches in diameter.

(c) Page 2-15. Aerial photograph is erroneously labeled. The area labeled "flooded marsh" has not been a marsh for many years; and, "road platform to oil wells" is not a road but is a walkway.

(d) Page 2-26, paragraph 1. Black Lake is part of a contributing productive marsh system and specific water quality and sediment data are required to fully assess and evaluate the impacts.

(e) Page 2-63, table 2.8. We recommend inclusion of Delphinids under "Typical Mammals" and "Inland and Estuarine Waters."

(f) Page 2-72, paragraph 1. Primary productivity, as well as salinity is certainly a controlling factor in the number of species present.

(g) Page 2-72, paragraph 2, line 13. Does this statement imply that the genus is present and/or dominant in the project area?

(h) Page 2-72, paragraph 2, line 17. Some of these genera are not "epiphytic" algae.

(i) Page 2-72, paragraph 4. Site-specific information is necessary. Black Lake cannot be accurately compared to Calcasieu Lake.

(j) Page 2-73, paragraph 1. Further explanation is needed concerning recent salinity increases in the project area, especially the impacts of the Intracoastal Waterway and Calcasieu River upon salinity alterations.

(k) Page 2-76, last paragraph. In 1975 and 1976, the American alligator was harvested for its hide in parts of Cameron, Calcasieu, and Vermilion Parishes.

(l) Page 2-80, paragraph 2. We suggest the word "Atlantic" be placed before "Croaker."

(m) Page 3-3, paragraphs 2 and 3. There will be significant turbidity and bottom erosion due to the turbulence. Reference 4 is not based on sound data from properly conducted studies.

(n) Page 3-10, paragraph 4. Figure 3.4 has been omitted. The location of dredged material disposal areas will be determined by the Corps permit application process. Note General Comment e(2) below, also.

(o) Page 3-19, paragraph 3. A description of the disposal operation is necessary before the impacts can be adequately assessed.

(p) Page 3-29, last paragraph. Water quality data for the Calcasieu River is available from the New Orleans District Office.

(q) Page 3-66, paragraph 4. Construction of roads in wetlands usually constitutes a permanent loss of wetlands and should not be considered a "short-term" impact.

(r) Page 3-68, paragraph 3. Further discussion is needed to explain phytoplankton productivity increases resulting from turbidity. We believe there will be decreases in productivity.

(s) Page 3-112, paragraph 2. Reduction of food supply and habitat description will definitely be of importance.

(t) Page 4-5, paragraph 2. Direct contact of the less mobile benthic organisms with oil is likely, and not unlikely as stated in the EIS.

(u) Page 4-9. Shared uses of disposal areas may not always be permissible. Note General Comment e(2) below, also.

(v) Page 6-1, paragraph 6. In wetlands, natural grasses are usually allowed to revegetate pipeline corridors; hence, installation would not represent a permanent loss of resources. The total of 350 acres of land appears to be excessive for pipeline right-of-way.

(w) Page 6-2, paragraph 2. The withdrawal of surface water may be very significant depending upon the volume of runoff and the time of the year the surface water is withdrawn.

(x) Page 9-3. State of Louisiana regulatory bodies were omitted from this table.

b. Comments on Bayou Choctaw site.

(1) General comment

As stated for the West Hackberry site, the comment on the push-ditch method of pipeline installation applies to this site also.

(2) Specific comments.

(a) Page 2-4, figure 2-2. The area labeled "marsh" should be changed to "swamp" to conform to the description on page 2-3, paragraph 3, which is correct.

(b) Page 2-15, paragraph 1, sentence 2. We disagree with this statement. The first sentence on page 1-23 indicates that about 1,150 acres of wooded swamp would be utilized for the brine disposal system. The wildlife resources of 1,150 acres of wooded swamp are not considered insignificant.

(c) Page 2-73, paragraph 1. The loblolly pine is generally absent from the Mississippi River flood plain and should be deleted from this paragraph.

(d) Page 2-76, paragraph 2. The American alligator is not a commercially valuable wildlife species in the project area and should therefore be deleted from this section.

(e) Page 2-104, paragraph 1. The American alligator also occurs in the swamp of the project area.

(f) Page 3-5, paragraph 7. Change "marshlands" to "swamp."

(g) Page 7-44, paragraphs 2 and 3. Reasons should be given as to why the proposed source of displacement water is a better source than the alternative of Mississippi River withdrawal.

c. Comments on Cote Blanche Island mine and Weeks Island mine sites.

(1) General Comments.

(a) The EIS's for both these sites are almost identical except for site description and page numbering. Comments here are applicable to both sites; however, for reference purposes, the page numbers used are those in the Cote Blanche mine EIS.

(b) Site-specific information on the flora and fauna on these two islands is lacking. Data cited in most cases are from studies which did not include sampling in the project area. Deletion of non-site-specific data and inclusion of data from on-site investigations would substantially improve the statements.

(c) Due to the limited area that would be affected, the Cote Blanche and the Weeks Island sites would be the most environmentally acceptable, as far as the impacts upon the water quality are concerned. The lack of pipeline canals and associated construction activities for these two alternatives appears to impact wetlands the least. The water quality data in EIS's for these two sites are deficient. Additional water quality data is required to more readily quantify the impacts in order to choose the most acceptable alternative site.

(d) Note General Comments d(4) and d(5) below.

(2) Specific comments.

(a) Page 3.1-1, paragraph 3, sentence 3. This sentence should be revised as follows: "The bays are generally shallow and are rimmed by brackish, intermediate, and fresh marshes to the north and by predominantly brackish marsh to the south."

(b) Page 3.1-1, paragraph 3, sentence 5. The only island which provides protection to the Atchafalaya Bay-Vermilion Bay complex is Marsh Island. Several oyster reefs between Marsh Island and Pointe Au Fer to the east could also provide similar protection. Gulf Coast Barrier Islands usually refer to such islands as the Timbalier Chain, Isles Dernieres, and Chandeleurs.

(c) Pages 3.4-15 through 3.4-26. Data presented in tables 3.4-1 through 3.4-12 were obtained from study areas which are located 50 and 90 miles from the project area. The utility of these data with regards to the project area is questionable. Site-specific data should be used.

(d) Page 3.4-31. Comment (c) above applies here also.

(e) Page 3.6-13, paragraph 1, sentence 1. The blue goose is the dark color phase of the lesser snow goose. This sentence should be revised as follows: "Snow geese are also...."

(f) Page 3.6-13, paragraph 1, sentence 5. The reddish egret is uncommon to rare in the project area.

(g) Page 3.6-19, paragraph 5. Change "blue goose" to "lesser snow goose."

(h) Page 3.6-20, paragraph 1, sentence 1. The American alligator was not listed as a game species in portions of Louisiana. The discussion of the American alligator should be removed from the Game Species section and moved to the Threatened and Endangered Species section.

(i) Page 3.6-21, paragraph 2, sentence 3. Change "Vermilion" to "Calcasieu."

(j) Page 3.6-22, paragraph 4. Two additional reptilian species that occur in the coastal region of Louisiana, and which are currently considered rare and endangered should be added to this section. These are the hawksbill and the leatherback turtles.

(k) Page 3.6-28, paragraph 1. The choice of studies conducted in Barataria Bay and in the Gulf of Mexico to help characterize the primary producers that could be expected to be found near these two islands is a poor one. Prevailing environmental conditions in the vicinity of the subject study areas are near marine as opposed to near freshwater conditions in Cote Blanche and Weeks Island areas.

(l) Page 3.6-28, paragraph 2, last sentence. None of the representative marsh species cited in this sentence occur in the project area.

(m) Page 3.6-40, paragraph 4. The Atlantic menhaden and the Gulf menhaden are separate species. The Gulf menhaden is the most important fish in terms of harvested weight.

(n) Page 3.6-43, sentences 1 and 2. The dollar/acre values cited are in gross error.

(o) Page 3.6-47, line 4. The American alligator is not a controlled game species.

(p) Page 3.6-58, table 3.6-6. This table should be revised to agree with Federal Register, Volume 41, No. 117, 16 June 1976, "Endangered and Threatened Species, Plants."

(q) Page 3.6-59, table 3.6-7. The hawksbill and the leatherback turtles should be added to this table, as they are known to occur in coastal Louisiana.

(r) Page 3.6-61, table 3.6-9. Data presented in this table are of no value in predicting the primary producers of the project area because the surrounding ecosystem is predominantly freshwater and the primary producers presented here are primarily marine.

(s) Page 3.6-71, table 3.6-14. Comments in (r) above apply for the same reason.

(t) Page 4.2-18, paragraph 2. The statement that the area to be excavated is similar to other Louisiana marsh systems (e.g.; Barataria Bay) is incorrect. The marshes surrounding Barataria Bay are predominantly saline as opposed to the predominantly freshwater marshes of the project area.

(u) Page 4.3-54, paragraph 2. High ambient turbidity restricts growth of submerged aquatic plants in the project area. This paragraph should be deleted.

(v) Page 8.2-28, paragraph 1. The loblolly pine is generally absent from the Mississippi River flood plain and should therefore be deleted from this paragraph.

(w) Page 8.2-28, paragraph 2. The turkey is not common in the wooded swamp traversed by the pipeline routes.

(x) Page 8.2-30, paragraph 6. Comment a(2)(b) above applies here also.

(y) Page 8.2-31, paragraph 2. Experience has shown that subsidence and oxidation limit the quantity of backfill material resulting in permanent loss of marsh habitat.

d. Comments on Bryan Mound salt dome site.

(1) General comments.

(a) Pipelines proposed under this project will cross the Brazos River Diversion Channel, Jones Creek and various wetland areas. Department of the Army permits will be required for this work.

(b) The pipelines proposed will intersect the Freeport and vicinity hurricane protection project in one or more locations and may require construction within the project right-of-way in other areas. Permits for this work should be obtained from the Velasco Drainage District.

(c) The FEA 30" pipeline from the Bryan Mound site to Seaway Hank Farm will cross the Brazos River Diversion Channel right-of-way and the West Brazos River Floodgate access road. Coordination of the pipeline crossing of these facilities with us will be required.

(2) Specific comment.

Page 1-12, figure 1.6. The word "Highway" should be changed to "Roadway on Hurricane Flood Protection Levee" and the note "To Intracoastal Waterway and Gulf of Mexico" should be changed to "Road to Intracoastal Waterway Floodgates."

e. General comments.

(1) Applications for permits should be made as soon as practicable and well in advance of any need to perform the proposed work.

(2) Two factors of considerable concern are critical to continuing use of disposal areas; they are: encroachment of watercourses that provide natural circulation of surface waters and creation of vector problems. Scheduling of work may create difficult and costly disposal problems.

LMNPD-RE
Mr. Steven E. Ferguson 10 November 1976

(3) None of the four EIS's for the proposed sites considers the impacts of surface preparation for painting during construction and operation phases. The adverse impacts on inhabitants, structures, equipment, and terrain can be significant.

(4) It is noted that (in connection with the taking of excavated material from a barge slip to a suitable disposal site in accordance with a permit) mention of two important documents has been omitted from each EIS. They are the Federal Water Pollution Control Act (FWPCA), Title 33 U.S.C. 1323 and 1344 and the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA), Title 33 U.S.C. 1413 (e). Section 404 of FWPCA provides for control of dredged material disposals in navigable waters and MPRSA provides for control of dredged material disposal and transportation of dredged material for disposal in ocean waters. Federal projects involving disposal in navigable or ocean waters or transportation for disposal in navigable or ocean waters are evaluated for permit and other regulatory actions by the Corps of Engineers and the Environmental Protection Agency under guidelines and criteria promulgated pursuant to the requirements of the FWPCA and MPRSA. The regulatory guidelines and criteria for Corps of Engineers evaluations of proposed projects are contained in Title 33 C.F.R., Part 209 which has also not been mentioned. Other laws enacted before 1972 are also directly related to the procedures for processing permit applications. These include the River and Harbor Act of 1899, the Fish and Wildlife Coordination Act of 1958, the National Environmental Policy Act of 1969, and the Coastal Zone Management Act of 1972, all of which are referenced in Title 33 C.F.R., Part 209. A statement to the effect that, "the proposed disposals and transportation for disposal of dredged materials will be performed in accordance with all applicable Federal and state acts and regulations", should be included in each EIS or Statement of Findings for each project.

(5) Notwithstanding the Louisiana State policy exempting crude oil transfer emissions from emission control regulations, prevailing high levels of hydrocarbon emissions merit greater consideration of vapor recovery rather than flaring or release. Flaring is proposed for the Cote Blanche and Weeks Island SPR with considerable attention given to an alternative of using vapor recovery technology. Release is viewed as reasonably acceptable for the Bayou Choctaw and West Hackberry SPR with bare mention made of available vapor recovery technology. Oxidation products of flaring or high levels of hydrocarbon emissions could be objectionable or hazardous to vessels and their crews moored or at work on navigable waters near transfer sites. Including consideration of admittedly excessive emissions and conservation and economic factors it would seem that application of vapor recovery technology should be given equal consideration for all SPR sites.

LMNPD-RE
Mr. Steven E. Ferguson

10 November 1976

Thank you for the opportunity to review and comment on these draft environmental impact statements.

Sincerely yours,

EARLY J. RUSH III
Colonel, CE
District Engineer

Copy furnished
Mr. Timothy Atkeson
Council on Environmental Quality

Form FHWA 121 (Rev. 5-73)

UNITED STATES GOVERNMENT

DEPARTMENT OF TRANSPORTATION

FEDERAL HIGHWAY ADMINISTRATION

Memorandum

SUBJECT: Other Agency Statements
Federal Energy Administration
Strategic Petroleum Reserve
Weeks Island and Cote Blanche Mines
West Hackberry and Bayou Choctaw Salt Domes

DATE: October 15, 1976

In reply refer to: 06-22.2

FROM: Division Administrator
Baton Rouge, Louisiana

TO: Mr. J. W. White, Regional Administrator
Fort Worth, Texas

06-00.8

Your September 27, 1976, memorandum requested our review and comments on the subject statements.

The following comments are offered for your consideration in responding to the Federal Energy Administration:

Circulation of the draft environmental impact statements to state agencies was handled through the state clearing houses. It would appear that for states where the proposed sites are located, direct circulation to affected state agencies would be appropriate.

For both the Bayou Choctaw and the West Hackberry Salt Dome facilities associated proposed pipeline alternatives will cross or utilize highway right-of-way. Coordination with the Louisiana Department of Highways is recommended, if not already done.

Table 9.2, page 9-5, in the West Hackberry statement, list Texas regulatory bodies instead of appropriate Louisiana regulatory bodies.

Consultation with the Louisiana Department of Highways is recommended if overweight construction traffic is anticipated during construction of the facility.

The proposed Strategic Petroleum Reserve sites should not have any adverse effect on the highway transportation facilities in the affected areas.

for M. C. Reinhardt

U.S. DEPARTMENT OF TRANSPORTATION

REGIONAL REPRESENTATIVE OF THE SECRETARY
9-C-18 FEDERAL CENTER
1100 COMMERCE STREET
DALLAS, TEXAS 75202

Adm.
D...
D... Comp.
Ex...
Cong...
SWFRC
Consumer Aff.
EEO
PIO
Legal
RARP
Prod/Proc
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Exc, Appeals
Mgmt.
Opns:
Consv.
Res. Dev.
Energy Study
Compliance
RARP
Prod/Proc
Wh/Ret
Area Mgrs.
Dist. A
Other

October 27, 1976

Mr. Delbert Fowler
Regional Administrator
Federal Energy Administration
P. O. Box 35228
Dallas, Texas 75235

Dear Del:

Enclosed are comments concerning Environmental Impact Statements covering Weeks Island and Cote Blanche Mines and West Hackberry and Bayou Choctaw Salt Domes. One additional copy has been provided for your Washington office.

Thank you for the opportunity to review the Statements.

Sincerely,

Ed Foreman

ljb
Enclosures

ASSISTANT SECRETARY

THE DEPARTMENT OF THE TREASURY
WASHINGTON, D.C. 20220

NOV 1 1976

Dear Mr. Davies:

This is in response to your letter of September 16 requesting that this Department review and comment on the draft environmental impact statements for the first five candidate sites selected for possible use as petroleum storage facilities for the Early Storage Reserve. We find the statements to be objectively directed to their stated purpose and it appears that the salt dome and mine storage facilities addressed in the statements are superior to above ground storage from both the economic and environmental viewpoints.

The Department supports the concept of a strategic petroleum stockpile and considers it to be an essential national need. However, we wish to reiterate that such facilities and the petroleum stored therein should be owned by the Government and that the costs should be borne directly by the beneficiaries -- the U.S. energy consumers.

One other comment applicable to the five statements concerns the implication that among the benefits or costs of each project is the employment effects, positive in the case of employing construction workers to build storage facilities and negative in the case of "laying-off" salt mine workers. Conventional cost-benefit analysis deals with a national rather than a regional perspective and assumes a full employment economy. Under such assumptions employment effects are considered neither costs nor benefits since one more job in any region implies one less job elsewhere.

Similarly the "cost" of laying-off salt mine workers is not a cost at all if alternative employment opportunities exist. Some social costs of lay-offs, such as unemployment compensation paid during the time workers are between jobs, might be expected, but these costs relative to the "normal" job turnover costs for the region involved can be expected to be miniscule and probably need not be considered in the analyses.

Thank you for the opportunity to review the statements and I trust that our comments will be of assistance in the preparation of the final environmental impact statements.

Sincerely,

Warren F. Brecht
Assistant Secretary (Administration)

Mr. Robert L. Davies
Deputy Assistant Administrator for
Strategic Petroleum Reserves
Federal Energy Administration
1726 M Street, N.W.
Washington, D.C. 20461

Advisory Council on
Historic Preservation
1522 K Street N.W
Washington, D.C. 20005

October 1, 1976

Mr. Robert L. Davies
Deputy Assistant Administrator
Strategic Petroleum Reserve
Federal Energy Administration
Washington, D. C. 20461

Dear Mr. Davies:

This is in response to your letter of September 10, 1976 for comments on the draft environmental statements for the proposed storage of crude oil at the Weeks Island salt mine located in Iberia Parish, Louisiana and at the Cote Blanche salt mine located in St. Mary Parish, Louisiana. The Advisory Council notes that cultural resource studies to date indicate no properties included in or known to be eligible for inclusion in the National Register of Historic Places will be affected by the proposed project, but that an archeologist will be on site to monitor construction activity. Accordingly, we wish to remind Federal Energy Administration that should previously unknown cultural resources be encountered during construction which are subsequently determined to be eligible for inclusion in the National Register, it is required to afford the Council an opportunity to comment in accordance with the "Procedures for the Protection of Historic and Cultural Properties" (36 C.F.R. Part 800) prior to taking any action with respect to the undertaking, including salvage of the cultural resource.

Should you have questions or require additional assistance in this matter, please contact Michael H. Bureman of the Council staff at P.O. Box 25085, Denver, Colorado 80225, telephone number (303) 234-4946.

Sincerely yours,

Louis S. Wall
Assistant Director, Office
of Review and Compliance

 Filed 11/2/76 Lm

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
FIRST INTERNATIONAL BUILDING
1201 ELM STREET
DALLAS, TEXAS 75270

November 1, 1976

Mr. Robert L. Davies
Deputy Assistant Administrator
Executive Communications - Room 3309
Federal Energy Administration
Washington, D. C. 20461

Dear Mr. Davies:

We have reviewed the Draft Environmental Impact Statement for the Strategic Petroleum Reserve to be located at Bayou Choctaw Salt Dome, Iberville Parish, Louisiana. The purpose of the Reserve is to mitigate the social and economic impacts of any future interruptions of petroleum imports to the United States of America. The Reserve will store 150 million barrels of oil by December of 1978 in the Early Storage Reserve (ESR), and 500 million barrels by 1982 under the entire program.

Petroleum will be stored in conventional mines, solution-mined salt cavities, or above-ground conventional tanks. The proposed action at the Bayou Choctaw salt dome is part of the ESR and is to store 99 million barrels of oil. The dome is presently leased by Allied Chemical Corporation, Houston, Texas.

The statement discusses many of the impacts which could be associated with the project; however, we offer the following comments for your consideration in developing the Final Environmental Impact Statement:

1. Oxidant air quality data recorded in 1975 in the Southern Louisiana-Southeast Texas Air Quality Control Region (AQCR) recorded second-high oxidant levels for the Baton Rouge area at 0.170 parts per million (ppm), New Orleans at 0.094 ppm, and Lake Charles at 0.174 ppm. The Louisiana State Implementation Plan (SIP) required revision for photochemical oxidants for the Louisiana portion of the Southern Louisiana-Southeast Texas AQCR (41 Federal Register, No. 138, July 16, 1976). The state is required to submit a revision of the SIP to achieve the attainment of the national standard for photochemical oxidants by July 1977. Inclusion of the above information would strengthen the final statement.

2. When the oil is removed from the storage cavities some of the oil will remain on the walls of the cavities and therefore in the brine. When oil is reintroduced to the caverns the brine will carry the

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entrained oil with it. The statement should provide assurances that the concentration of entrained oil in this brine will be such that no adverse impacts to the disposal aquifer will occur. The statement should discuss the possibility of the need for treatment of the brine for removal of the oil as well as the ultimate disposal of any recovered oil. A quantitative discussion of evaporative hydrocarbon emissions originating from the proposed brine storage reservoir should also be included in the statement.

3. The buried pipelines will be coated with cathodic protection. The Final EIS should address the effects of any potential leaching of cathodic material on the groundwater.

4. The facility is planned to be used for five fill and displacement cycles. However, the EIS does not address termination of the facility. The actions proposed as part of the termination plan could affect future use of the dome, subsidence, and groundwater and, therefore, should be presented in the final statement.

These comments classify your Draft Environmental Impact Statement as LO-2. Generally, we have no objections to the action as proposed. We are requesting some additional information in order to assess fully the possible impacts to the air and water resources of the area. The classification and the date of our comments will be published in the Federal Register in accordance with our responsibility to inform the public of our views on proposed Federal actions, under Section 309 of the Clean Air Act.

Definitions of the categories are provided on the attachment. Our procedure is to categorize our comments on both the environmental consequences of the proposed action and on the adequacy of the impact statement at the draft stage, whenever possible.

We appreciate the opportunity to review the Draft Environmental Impact Statement, and we would be happy to discuss our comments with you. Please send us two copies of the Final Environmental Impact Statement at the same time it is sent to the Council on Environmental Quality.

Sincerely yours,

John C. White

John C. White
Regional Administrator

Enclosure

ENVIRONMENTAL IMPACT OF THE ACTION

LO - Lack of Objections

EPA has no objections to the proposed action as described in the draft impact statement; or suggests only minor changes in the proposed action.

ER - Environmental Reservations

EPA has reservations concerning the environmental effects of certain aspects of the proposed action. EPA believes that further study of suggested alternatives or modifications is required and has asked the originating Federal agency to re-assess these aspects.

EU - Environmentally Unsatisfactory

EPA believes that the proposed action is unsatisfactory because of its potentially harmful effect on the environment. Furthermore, the Agency believes that the potential safeguards which might be utilized may not adequately protect the environment from hazards arising from this action. The Agency recommends that alternatives to the action be analyzed further (including the possibility of no action at all).

ADEQUACY OF THE IMPACT STATEMENT

Category 1 - Adequate

The draft impact statement adequately sets forth the environmental impact of the proposed project or action as well as alternatives reasonably available to the project or action.

Category 2 - Insufficient Information

EPA believes the draft impact statement does not contain sufficient information to assess fully the environmental impact of the proposed project or action. However, from the information submitted, the Agency is able to make a preliminary determination of the impact on the environment. EPA has requested that the originator provide the information that was not included in the draft statement.

Category 3 - Inadequate

EPA believes that the draft impact statement does not adequately assess the environmental impact of the proposed project or action, or that the statement inadequately analyzes reasonably available alternatives. The Agency has requested more information and analysis concerning the potential environmental hazards and has asked that substantial revision be made to the impact statement. If a draft statement is assigned a Category 3, no rating will be made of the project or action, since a basis does not generally exist on which to make such a determination.

FEDERAL POWER COMMISSION
WASHINGTON D C 20426

IN REPLY REFER TO

OCT 14 1976

Executive Communications
Room 3309
Federal Energy Administration
Washington, D.C. 20461

245001

Gentlemen:

We appreciate the opportunity to comment on the five site-specific Draft Environmental Impact Statements for the proposed Strategic Petroleum Reserve (SPR) mandated by Congress under the Energy Policy and Conservation Act of 1975 (P.L. 94-163). We note that this act requires that by 1983 the SPR contain a reserve of approximately 500 million barrels of crude oil to provide protection from potential disruptions to the national supply of petroleum products.

The Federal Power Commission, Bureau of Natural Gas staff has reviewed the SPR impact statements and offers the following comments:

> At the five site locations analyzed, there does not appear to be any conflict between the development of the SPR and the continued production, transportation, and sale of natural gas from domestic sources. It therefore does not appear that the proposed project presents any conflict with FPC jurisdictional interests.
>
> The staff believes that the development of an SPR would protect the supply of energy sources other than oil itself during an emergency. A drastic reduction in oil availability could, for example, be accompanied by increased demand for natural gas for use in electric generation. Such use is regarded as inferior and as having a low priority in view of the needs of industrial, commercial, and residential customers who are feeling the impact of a worsening natural gas shortage. The SPR would lessen the impact of a simultaneous shortage in oil and gas which together provide about three-quarters of the energy consumed in this country.

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Filed LAM 11/2/76

The Federal Power Commission is actively directing its attention and efforts toward regulatory actions to improve the current imbalance between natural gas supply and demand. After reviewing the SPR site-specific draft environmental impact statements, we believe that the proposed project would be in the national interest.

S. William Yost, Chief
Bureau of Natural Gas

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

NOV 4 1976

Executive Communications
Room 3309
Federal Energy Administration
Washington, D. C. 20461

00001

Dear Sirs:

This is in response to your letter of September 10, 1976, inviting our comments on the draft environmental statements concerning the following projects:

West Hackberry Salt Dome, DES 76-4
Bayou Choctaw Salt Dome, DES 76-5
Bryan Mound Salt Dome, DES 76-6
Cote Blanche Mine, DES 76-7
Weeks Island Mine, DES 76-8

We have reviewed the statements and have determined that the proposed actions, per se, have neither radiological health and safety aspects nor will they adversely affect any activities subject to regulation by the Nuclear Regulatory Commission. Accordingly, we have no comments to offer.

Thank you for providing us with the opportunity to review these draft environmental impact statements.

Sincerely,

Voss A. Moore, Assistant Director
for Environmental Projects
Division of Site Safety and
Environmental Analysis

TENNESSEE VALLEY AUTHORITY

CHATTANOOGA, TENNESSEE 37401

October 28, 1976

Mr. Robert L. Davies
Deputy Assistant Administrator
Federal Energy Administration
Room 3309, Executive Communications
Washington, D.C. 20461

Dear Mr. Davies:

We have determined that we have no significant substantive comments on any of the five sites or statements involved in the Strategic Petroleum Reserve.

Sincerely,

Peter A. Krenkel, Ph.D., P.E.
Director of Environmental Planning

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Louisiana Air Control Commission

State Office Building
Phone (504) 527-5115

P.O. Box 60630
New Orleans 70160

October 11, 1976

Mr. Robert L. Davies
Deputy Assistant Administrator
Executive Communications, Rm. 3309
Federal Energy Administration
Washington, D.C.

RE: Strategic Petroleum Reserve. Draft Environmental Impact Statements for: Weeks Island Mine, Cote Blanche Mine, West Hackberry Salt Dome, and Bayou Chactaw Salt Dome.

Dear Mr. Davies:

This agency has reviewed the above referenced impact statements. The review indicated the section of the reports dealing with the air quality impact was not supplied. Until such data is made available to this office we are unable to comment on the proposals impact on air quality.

Very truly yours,

Orey Tanner Jr

Orey Tanner, Jr., P.E.
Air Quality Section
Louisiana State Division of Health

OT/yw

cc: Mr. DeWitt H. Braud, Jr.
Environmental Coordinator
State of Louisiana
Commission on Intergovernmental Relations
P. O. Box 44455
Baton Rouge, Louisiana 70804

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STA.E OF LOUISIANA
COMMISSION ON INTERGOVERNMENTAL RELATIONS

EDWIN EDWARDS
GOVERNOR
SENATOR MICHAEL H O KEEFE
CHAIRMAN
LEON TARVER
EXECUTIVE DIRECTOR

P O BOX 44455
BATON ROUGE, LOUISIANA 70804
389-5664

October 13, 1976

Mr. Orey Tanner, Jr., P.E.
La. Air Control Commission
Air Quality Section
P. O. Box 60630
New Orleans, Louisiana 70160

RE: Strategic Petroleum Reserve, Draft Environmental Impact Statements for: Weeks Island Mine, Cote Blanche Mine, West Hackberry Salt Dome, and Bayou Choctaw Salt Dome.

Dear Mr. Tanner:

As indicated in our letter of transmittal of September 27, 1976, you were forwarded only excerpts from selected portions of each of the documents referenced above. As the number of available statements was limited, we hoped to provide you with enough information to make a determination of need for additional data, which we could provide.

Enclosed, please find excerpts from each document specifically pertaining to air quality impact.

If we can be of further assistance, please let us know.

Sincerely,

DeWitt H. Braud, Jr.
Environmental Coordinator

DHB:dn

Enclosures

cc: Mr. Robert L. Davies
Federal Energy Administration

STATE OF LOUISIANA
DEPARTMENT OF CONSERVATION

LOUISIANA GEOLOGICAL SURVEY

GEOLOGY BUILDING
BOX G
UNIVERSITY STATION
BATON ROUGE, LA. 70803

October 21, 1976

Mr. Robert L. Davies, Deputy Assistant Administrator
Executive Communications
Federal Energy Administration
Room 3309
Washington, D. C. 20461

Re: Stratigic Petroleum Reserve
Draft Environmental Impact Statement:
Weeks Island, Cote Blanche, West
Hackberry and Bayou Choctaw

Dear Mr. Davies:

Our staff has reviewed those sections of the (five) impact statements relative to the geological consideration involved in the Stratigic Petroleum Reserves plan.

It is our opinion that the geological presentations are well done and adequate for the purposes intended.

Thank you for the opportunity to comment.

Very truly yours,

LOUISIANA GEOLOGICAL SURVEY

Leo W. Hough, State Geologist

Harry L. Roland, Jr.

by: Harry L. Roland, Jr.
Assistant State Geologist

HLR:FMM

filed LM 11/2/76

LOUISIANA
STATE SOIL AND WATER CONSERVATION
COMMITTEE

LOUISIANA STATE UNIVERSITY
P. O. DRAWER CS
Telephone 389-5017
BATON ROUGE, LOUISIANA 70893

October 1, 1976

Mr. Robert L. Davies
Deputy Assistant Administrator
Executive Communications, Room 3309
Federal Energy Administration
Washington, D. C. 20461

Re: Strategic Petroleum Reserve,
Draft Environmental Impact
Statements for:
Weeks Island Mine - DES 76-8
Cote Blance Mine - DES 76-7
Bayou Choctaw Salt Dome - DES 76-5
West Hackberry Salt Dome DES 76-4

Dear Mr. Davies:

A copy of the above documents have been received.

We have no additional comments to make at this time on information furnished us.

If you require further information concerning these documents, please let us know.

Sincerely,

Charley S. Staples
Executive Director

CSS:ry
cc: DeWitt H. Braud, Jr.
Fred Huenefeld, Jr.

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SERVING West Feliciana, East Feliciana, Point Coupee, East Baton Rouge, W Baton Rouge

Capital-Area Groundwater Conservation Commission

P. O. Box 64526
Baton Rouge, Louisiana 70896
Telephone (504) 924-7420

October 21, 1976

Mr. D. M. Fowler, Regional Administrator
Federal Energy Administration, Region VI
P.O. Box 35228
Dallas, Texas 75235

REFERENCE: DES 76-2 - Choctaw Dome, September, 1976

Dear Mr. Fowler:

The referenced EIS mentions that one of the potential problems (page 3-31) is "the contamination of fresh ground water" and recommends (page G-10), in regards to brine injection activities, that a partial list of possible problems and potential solutions" be developed. With these thoughts in mind, the referenced EIS was reviewed with regard to the possible impact the described activities could have, on a long-term and short-term basis, on the local and regional ground-water resources. Although the Choctaw Dome is not in our District, the development and operations could affect ground-water resources in the neighboring parishes in our district, unless the potential problems are examined and the necessary precautions, if any, are exercised. The following comments are intended to stress that plans consider alternatives and solutions that will assure that our ground-water resources are not adversely affected.

State Act 641 (1976), relative to the underground storage of hydrocarbons, gave to the Commissioner of Conservation the power and duty to regulate such activities and to hold public hearings to assure "that the use of the salt dome cavity for the storage of liquid and/or gaseous hydrocarbons will not contaminate other formations containing fresh water". Hopefully, presentations to be made by your agency, at these hearings, will discuss and offer solutions to any potential long-term and short-term problems that could adversely affect our ground-water resources.

Although the principal aquifers of our district contain saline water near the Choctaw Dome, the deepest fresh water zone -- the "2,800-foot" sand of the Baton Rouge area -- whose base is at a depth of about 4,000 feet in the Bayou Choctaw field area, should be protected from encroachment that may be caused by injection operations. Before final plans are approved, a study should be made to map the base of the "2,800-foot" sand in order to assure that all the aquifers of our district are protected.

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Casing in the injection wells should be set and cemented to below the base of the "2,800-foot" sand and the injection zone(s) should be separated from the bottom of the "2,800-foot" sand by an areally extensive clay or shale with a thickness of about 100 feet. The plan discussed in the EIS (pages 3-34 and G-18) for using injection zones below a depth of 5,000 feet should satisfy the latter requirement. Although it is recognized that the normal rate of ground-water movement is generally very slow (less than a foot per day) and that faults in the area affect, to some extent, the northward movement of salt water, it is also recognized that assurance is needed to prevent the movement, especially on a long-term basis, of salt water toward and into the heavily pumped ground-water areas in West Baton Rouge, Pointe Coupee, and East Baton Rouge Parishes.

Section 1.3.1.3. A brine surge pond that will hold approximately 500,000 barrels is discussed. No mention is made of what action will be taken to protect the underlying alluvial aquifer from salt water seepage through the confining layer. The confining layer will slow, but not stop the vertical movement. In addition to depending upon the lower permeability of the confining layer to retard the vertical movement of salt water, consideration should be given by planners to using an artificial impermeable commercial sealer and/or liner in the pond to prevent the movement of salt water through the confining layer into the shallow aquifer that is a local source of water

Page 2-39. The maximum depth of fresh water on the illustration on this page, as well as on the cross sections in the EIS, is based on the chloride content of 250 mg/l (milligrams per liter), and not dissolved solids, which is the constituent now used in the Underground Injection Control Program implementing Public Law 95-523. By the way, U.S. Geological Survey Hydrologic Atlas 310 shows the altitude of the top of 3,000 mg/l dissolved solids to be about 600 feet, and the altitude of the 10,000 mg/l dissolved solids surface to be about 2,000 feet, below mean sea level. It should be clearly stated in the discussion of the maximum depth of fresh water in the EIS that tne maximum depth of occurence of fresh water is based on the chloride content of the water and not dissolved solids. The EIS fails to mention the fact that the saltwater-freshwater interface occurs in most places, in a sand.

Beginning on page G-9, the geohydrology at the Choctaw Dome area is discussed. This section should include recommendations for the locating of the 10 supply wells, whose yield will be about 2,000 gallons per minute each, and also include the location of other water wells, if any, in order to predetermine the impact on existing wells. The effects of this pumping from the alluvial aquifer could not only cause local excessive water level declines, but more importantly, could also cause salt-water coning and encroachment into nearby wells. The EIS should consider these potential problems and offer alternatives, such as the use of water from the Mississippi River, and solutions that will minimize any adverse effects resulting from this pumping.

Yours very truly,

A. N. Turcan, Jr.
Director

ANT/rer
cc: Austin F. Anthis
Leo V. Bankston
A. N. Cameron
U.S. Geological Survey
Salvador J. (Bay) Cardinal, President
Iberville Parish Police Jury
Arnold C. Chauviere
Louisiana Department of Conservation
J. Coerver
Bureau of Environmental Services
Charles M. David
J. Friloux
Federal Energy Administration
Baton Rouge, Louisiana
Ralph B. Holloway
J. E. Jumonville, President
Atchafalaya Levee Board
Raymond R. Loup
Bentley B. Mackay, Jr.
Governor's Council on Environmental Quality
A. Darrel Primeaux
William A. Romans
Lucius J. Treuil

( )

LOOP INC

350 BANK OF NEW ORLEANS BLDG.
1010 COMMON STREET
NEW ORLEANS, LA 70112
(504) 529-7241

November 3, 1976

File: 5.03

00002

Executive Communications
Room 3309
Federal Energy Administration
Washington, DC 20461

Dear Sir:

The site-specific draft EISs for five candidate ESR sites have been reviewed per your request of September 10, 1976.

We agree that underground storage of crude oil, utilizing existing technology, offers maximum protection against fire, storm and sabotage and is low cost with small environmental impact relative to other storage concepts.

There is no indication that specific, competent geomechanics analyses will be made to assure stability of multicavity configurations after five fill/withdrawal cycles. Such analysis should be required for each of the candidate salt domes (DES 76-4,5,6) actually selected.

The analysis would establish allowable roof distance below the caprock, center to center spacing vs. diameter (s/d ratio), vertical separation and plastic zone proximity to the dome flank. These criteria should be related to calculated creep, stress and subsidence for the actual or safe strength levels of the specific salt and surrounding rock. The arbitrary criteria enumerated in the programmatic draft EIS are no substitute for geomechanics analyses.

LOUISIANA OFFSHORE OIL PORT

For the West Hackberry salt dome (DES 76-4), the impact of the alternate brine disposal by pipeline to the Gulf of Mexico can be quantified while disposal by subsurface injection cannot, in particular, the effect on the freshwater acquifier. Why shouldn't pipeline disposal be preferable here as was the case for the Bryan Mound salt dome (DES 76-6)?

Yours very truly,

W. B. Read

W. B. Read
President

APPENDIX M

GLOSSARY OF TERMS

The following glossary of terms is provided for the reviewer when reading this report.

acre-foot	-a measure of water drainage or run-off volume equal to the quantity of water that would cover one acre of land to a depth of one foot (43,560 cu.ft.).
adsorption	-an adhesion in an extremely thin layer of molecules to the surfaces of solid bodies or liquids with which they are in contact.
aldehydes	-various highly reactive compounds typified by acetaldehyde and characterized by the group CHO.
alluvium deposits	-rock fragments that are transported by modern rivers and deposited in river beds, flood plains, lakes and estuaries and natural levees.
amphipod	-small, free-swimming crustaceans (includes beach fleas).
anaerobic	-refers to life or processes occurring in the absense of free oxygen; refers to conditions characterized by the absence of free oxygen.
anhydrite	-an evaporite mineral, $CaSO_4$, associated with gypsum and found in sedimentary rocks.

aquiclude — -a geologic formation so impervious that for all practical purposes it completely obstructs the flow of ground water (although it may be saturated itself), and completely confines other strata with which it alternates in deposition.

aquifer — -a water-bearing strata.

aquitard — -a geologic formation of a rather impervious and semi-confining nature which transmits water at a very slow rate compared to an aquifer. Over a large area of contact, however, it may permit passage of large amounts of water between adjacent aquifers.

artesian water — -ground water that is under sufficient pressure to rise above the level at which it is encountered by a well, but which does not necessarily rise to or above the surface of the ground.

artesian well — -a well which reaches artesian water.

bayou — -a stream or small river that is a tributary to another river - term local to southern states.

bbl — -barrel or barrels - one barrel of petroleum equals 42 U.S. gallons.

benthos — -organisms fixed to or growing on the bottom of water bodies.

biocide — -substance destructive to many different organisms.

blanket oil — -used during formation of solution cavity to prevent undesired leaching of cavity ceiling.

bottom scour	-bottom scour is the erosion of sediment by moving water from the bottom of the stream channel.
BPD	-barrels per day - an oil production or distribution rate.
MB/D	-thousand barrels per day.
MMB/D	-million barrels per day.
brackish	-slightly saline water between fresh water (<0.3 ppt) and sea water concentrations ($\sim$35 ppt).
breccia	-a rock consisting of sharp cornered bits cemented together by sand clay or lime. Collapse breccias are derived from material broken up during the collapse of a solution cavity roof, while fissure breccias are accumulations of fragments in a solution fissure.
brine	-concentrated or nearly concentrated salt water achieved by dissolving water with the salt inside a salt dome, thus creating a cavity. Brine produced in this way is commonly used as feedstock (raw material) by chemical industries or for refining into common salt.
^{o}C	-degrees Celsius (formerly called Centigrade) - conversion of Celsius to Fahrenheit is $9/5\,^{o}C + 32^{o} = {}^{o}F$.
calcareous	-composed of or characteristic of calcium or limestone, having a chalky nature.

calcite -calcium carbonate, $CaCO_3$, a mineral found in the form of limestone, chalk and marble.

caprock -a mantle of associated minerals across the top of most shallow, piercement salt domes. No well defined layers are evident due to complexity and irregularity; however, three fairly well-defined zones are distinguishable in developed caprock:
(1) anhydrite zone
(2) transition zone - contains sulfur, gypsum, and less important minerals
(3) calcite zone - top zone in developed caprock.

cast and stack dredging -type of dredging that deposits dredge spoil on the bank of the canal/river by means of pipeline or conveyor belt.

Centipose -unit for measuring viscosity, which is the tendency of a fluid to resist change of form.

cfs -cubic feet per second -a rate of water volume flow.

cheniers -long sinuous ridges of sand deposited on top of the swamp deposits of a delta. They represent stationary phases of a regressing shoreline. The type area for their development is the Mississippi Delta.

chlordane -a chlorinated, highly poisonous, volatile oil $C_{10}H_6Cl_8$, used as an insecticide.

cladocera — -small, aquatic crustaceans (includes water fleas).

CO — -carbon monoxide - a colorless, odorless, highly poisonous gas, produced by the incomplete combustion of any carbonaceous material i.e., gasoline.

COD — -chemical oxygen demand.

colloid — -a substance that, when apparently dissolved in water, diffuses not at all or very slowly through a membrane, and usually has little effect on freezing point, boiling point, or osmotic pressure of the solution.

consolidated rock — -incoherent and relatively hard, naturally formed mass of mineral matter.

Cretaceous — -a period of time from 136 million years to 65 million years ago.

crude oil — -unrefined oil as it comes from the ground.

darcy — -a measure of the permeability of rock. One darcy (D) equals a permeability such that one millilitre (ml) of fluid, having a viscosity of one centipoise, flows in one second under a pressure differential of one atmosphere through a porous material having a cross-sectional area of one square centimeter (cm^2) and a length of darcy (continued) — one centimeter. The working unit is the millidarcy (mD) one thousandth of a darcy. Darcy's Law relates to the flow of fluids, especially gas, oil, and water in underground rocks.

DDT — -dichloro-diphenyl-trichloroethane - a powerful insecticide effective on contact.

decibels: dB — -logarithmic unit method of expressing the relative intensity of sound pressure. The human ear is sensitive to changes in atmospheric pressure (sound vibrations) ranging from just barely audible at 0.0002 μbar to the threshold of pain at 2000 μbars. This range in sensitivity is so tremendous that a more workable expression of these ranges is to compress them on a logarithmic scale. In order to do this, the reference sound pressure is usually taken as the sound pressure detectable, that of 0.0002μbars. The intensity of sound is then measured in decibels by the following function:

$$\text{Intensity (in dB)} = 20 \log_{10} \left(\frac{\text{Pressure}}{0.0002\ \mu\text{bar}}\right)$$

Using this method, the range of human sensitivity is from) dB (pressure at 0.0002μbar) to approximately 140 dB (pressure at 2000 μbar).

Psychacoustic studies indicate that a 10 dB increase in sound intensity is perceived as a doubling of loudness.

decibels: dBA (continued)	-A-weighted level - a unit is similar to dB Sound Pressure Level (SPL) in that it represents sound intensity level. However, the A-weighted level includes attenuation at each frequency which is similar to the ear's attenuation of frequencies. Since the human ear is much less sensitive to low frequencies, it implies that a sound at 250 Hz of 65 dB (SPL) is perceived relative to a sound at 1000 Hz of 65 dB (SPL) as much less intense. The A-weighted scale has been developed to adjust by frequency the overall sound pressure level of noise to an approximation of how the ear would hear this noise.
detritus	-material produced by the disintegration and weathering of rock that has been moved from its site of origin. Also, fragments of detached or broken down material such as leaves and other plant parts.
diapir	-an intrusion of salt from the salt bed into overlying sediments, often in the form of a ridge or stalk-like piercement structure.
diazonium	-the grouping (organic chemistry), = N ≡ N, (triple bond of nitrogen).
dieldrin	-chlorinated organic chemical, $C_{12}H_8Cl_6O$, a white crystalline contact insecticide, obtained by oxidation of aldrin; used in mothproofing.
disseminated anhydrite	-particles of anhydrite ($CaSO_4$) dispersed through enclosing rock.
diurnal	-day active.
DO	-dissolved oxygen.
dwt or DWT	-deadweight capacity - naval architecture term for total carrying capacity of a ship expressed in long tons (2,240 lbs); displacement of a fully loaded vessel less the weight of the ship itself.

electric logs	-the log of a well or borehole obtained by lowering electrodes in the hole and measuring various electrical properties of the geologic formations traversed.
emulsification	-the process of dispersing one liquid in a second immiscible liquid (liquids that will not mix with one another).
endrin	-a poisonous white crystal, $C_{12}H_8OCl_6$, insoluble in water, used as a pesticide. A stereo-isomer of dieldrin.
entrainment	-capture of an object or organism by a flowing liquid or gas.
euryhaline	-organisms that can tolerate a wide range of salinities.
eurythermal	-organisms that can tolerate a wide range of temperature.
eutrophic	-rich in nutrients and organic materials, therefore, highly productive.
evaporite	-a sediment resulting from the evaporation of saline water. Most evaporites are derived from bodies of sea water. Evaporite minerals are formed in the reverse order of their solubilities, i.e., the least soluble form first.
fault	-a fracture in rock along which there has been an observed amount of displacement. Faults are rarely singular planar units; normally occur parallel sets of planes along which movement has taken place to greater or lesser extent. Such sets are called fault or fracture-zones.
flexure	-bending of sedimentary layers.

floating roof tank	-a vertical cylindrical tank with a roof designed to float on top of the stored liquid product (commonly oil) as the level in the tank rises and lowers.
fluvial	-formed or produced by the action of flowing water.
Frasch mining	-much mined sulfur (elemental sulfur) is produced from caprock of salt domes by the Frasch process utilizing super-heated steam to melt the sulfur in caprock. Drilling well design consists of a concentric arrangement of pipes of various diameters. Steam is injected into the sulfur bearing zone through one of the inner tubing strings. Compressed air is injected through the innermost tubing string which forces water and molten sulfur to rise in the large outer diameter pipes. The molten sulfur then flows through heated pipes to settling tanks. Frasch process sulfur is very pure, producing as much as 99.5 percent sulfur.
g dry wt/m^2/yr	-grams dry weight per square meter per year - a measure of the rate or organic production per area of yield.
geosyncline	-a large generally linear geologic trough which subsided deeply throughout a long period of time, in which a thick succession of stratified sediments accumulated (for example, the Gulf of Mexico depression).
geosynclinal axis	-a line which is parallel to the longest horizontal dimension of, and roughly bisects, a geosyncline.

GPD	-gallons per day - flow rate for liquids.
GPM	-gallons per minute - flow rate for liquids.
gypsum	-an evaporite mineral, $CaSO_4 2H_2O$. found in clays and limestones, sometimes associated with sulfur.
H_2S	-hydrogen sulfide; an inflammable, poisonous gas with the characteristic smell of rotten eggs.
halite	-an evaporite mineral, NaCl, common salt.
herpetofaunal	-reptiles and amphibians regarded collectively as a faunistic grouping.
Holocene	-the period of time from one million years ago to present.
horizons	-the various layers of soil each of which is a few inches to a foot or more thick.
HP or hp	-horsepower; equal to a rate of 33,000 foot-pounds per minute, the power required to raise 33,000 pounds a distance of one foot in a time of one minute.
humic acid	-a gelatinous material formed as a precipitate when organic matter is treated with a strong base, and the resulting solution is acidified.
hydraulic dredging	-this method includes a suction pipeline with either plain suction or cutting heads for digging hard material. The sediments dredged are conveyed by pipeline either to a barge or to a deposition area on shore.

impingement - entrapping of objects or organisms against a screen or filter by the force of a liquid or gas moving through or against the screen.

injection well - a well that brine will be forced into.

inversion - a reversal in the normal atmospheric temperature gradient such that temperature increases with altitude (within 300 to 600 ft) and results in an atmospheric inversion. The warmer air on top acts as a ceiling to any material normally diffusing vertically.

isopach - a line on a map joining points of equal thickness of a rock or sediment type.

isopleth - (1) a graph plotting the occurrence or frequency of a phenomenon in meteorology, etc., as a function of two variables, time and space.
(2) the line connecting points on a graph that have equal or corresponding values with regard to certain variables - synonym - isoline.

isostatic - subject to equal pressure from every side.

Kcal - kilocalorie.

Kcal/m^2/yr - kilocalorie per square meter per year - a measure of the rate of organic energy production per area of yield.

kg - kilogram.

leach - to remove soluble constituents from a substance by the action of a percolating liquid, in this case, water taking salt from a salt dome into solution.

littoral	-a shallow zone that extends from shore to the lakeward limit of rooted aquatic plants; the shoreward region of a water body; in marine environments the tidal zone.
log normal distribution	-a distribution in which the logarithm of a parameter is normally distributed.
long ton	-2,240 pounds, as opposed to 2,000 pounds in a short ton.
lotic	-pertaining to flowing waters such as streams and rivers.
LPG products	-Liquid Petroleum Gas, commercial petroleum derivatives such as propane, ethane, ethylene, etc.
macrophyte	-any plant that can be seen with the naked, unaided eye; e.g., aquatic mosses, ferns, liverworts, rooted plants.
Mercalli scale	-a 12-point scale for classifying the magnitude of an earthquake.
meteoric water	-water which occurs in or is derived from the atmosphere.
mg	-milligrams - 1/1000 of a gram.
mg/l	-milligrams per liter.
Miocene	-the time span from 12 to 26 million years ago characterized by the development of large mountain ranges (the fourth epoch of the Tertiary Period).

Moh scale -an empirical hardness scale related to standard minerals:

	MINERAL	COMMON EQUIVALENTS
10.	Diamond	
9.	Corundum	
8.	Topaz	Hard File
7.	Quartz	Penknife
6.	Orthoclase	Window glass
5.	Apatite	Teeth
4.	Fluorite	
3.	Calcite	
2.	Gypsum	Fingernail
1.	Talc	

The steps between various minerals are by no means equal, e.g., diamond is about ten times as hard as corundum, whereas corundum is only about 10% harder than topaz.

monocline -strata that dip for an indefinite or unknown length in one direction and which do not apparently form sides of hills or valleys.

-a step-like bend in otherwise horizontal or gently dipping beds.

MSL -Mean Sea Level.

N/A -not available or unknown.

NaCL -sodium chloride (salt).

Nekton -macroscopic swimming organisms able to navigate at will (fish, amphibians, large aquatic insects, etc.).

NO_x -Nitrogen Oxides - NO, NO_2, etc.

occluded	-prevents the passage of.
OCS	-Outer Continental Shelf.
OD	-Outer Diameter - in reference to pipe or tubing size.
Org/m^3	-organisms per cubic meter.
overburden	-material of any nature consolidated or unconsolidated that overlies a deposit of useful materials, minerals, coal or salt.
pelagic sediments	-sediments derived from open ocean settling from the shells of unicellular organisms known as foraminifera. The shells are composed of either silicon or calcium. In addition, red clays of land mass origin are also deposited.
permeability	-a rock is said to be permeable if water or other liquids in contact with its upper surface tend to pass through the rock more or less freely to the lower surface. Permeability may be achieved by the rock being either porous or pervious. The essential feature of a bed of permeable rock is that the liquid it contains may be extracted by pumping. Permeability is measured in darcies.
permeability of an aquifer	-the capacity of an aquifer to transmit water under pressure.
pervious	-a rock is said to be pervious if it is permeable by virtue of mechanical discontinuities such as joints, bedding planes, fissures, etc. (e.g., some limestones and some igneous rocks).

pH	-a measure of acidity of a liquid determined by the concentration of hydronium (H_3O^+) ions per mole of liquid. The pH value equals the negative logarithm of the hydronium concentration. A hydrogen ion concentration of 10^{-7} equals a pH of 7. The scale has a range from 1 to 14 with values below 7 indicating increasing acidity, and values above 7 indicating increasing alkalinity.
photosynthesis	-the metabolic process by which simple sugars are manufactured from carbon dioxide and water by plant cells using light as an energy source.
piercement dome	-a salt dome in which the salt core has broken through the overlying strata until it reaches or approaches the surface.
piezometric surface	-an imaginary surface that everywhere coincides with the static level of the water in the aquifer.
pimple-mounds	-small rounded circular elevations 15 to 30 feet in diameter and 2 to 6 feet in height.
Pleistocene	-a time span from 1 to 2 million years ago characterized by 4 ice ages in North America (the earlier of the 2 epochs comprised in the Quaternary Period).
Pliocene	-latest epoch of the Tertiary or the corresponding system of rocks.

porosity — A rock is said to be porous if it possesses cavities between the mineral grains making up the rock which can contain liquid. The term porosity ratio' or simply porosity is given to the percentage of void space that a rock contains. Porosities of sedimentary rocks range from less than 1% to more than 50%; sandstones from 5% to 15%; loose sand and gravel may reach 45%; while clays, which are exceedingly porous rocks, sometimes reach 50% porosity. (Porous rock is not necessarily permeable.)

ppm — parts per million.

ppt — parts per thousand.

product — refined petroleum products.

psi — pounds per square inch - pressure measurement.

psig — guage pressure in pounds per square inch and including pressure of atmosphere, as opposed to absolute pressure (psia) pressure measure with respect to zero pressure.

raw water — As used in this report, raw water is that water used for cavity leaching or oil displacement.

re-entrant — re-entering or directed inward as a re-entrant angle in a coastline or any indentation in a land form, usually more or less angular in character.

revetment — a facing made on a soil or rock embankment to prevent scour by weather or water.

rose (wind rose) -a graphic illustration of wind speed and direction related to percent frequency of occurrence.

rotifer -a phylum of minute, multicellular aquatic organisms which possess a wheel-like bank of cilia at the anterior (oral) end.

saline -water containing a significant quantity (>.3 ppt) of dissolved natural salts of sodium, magnesium, etc.

sedimentary -rocks formed from material derived from pre-existing rocks by processes of denudation (deposition of eroded material), together with material of organic origin.

senescent -the study of the biological changes related to aging.

sessile -pertaining to those organisms that are attached to substrate and not free to move about.

shale -a fissile rock composed of laminated layers of claylike, fine grained sediments.

SMSA -Standard Metropolitan Statistical Area.

soil catena -a soil series, a horizontal gradation of soils of a similar origin.

solution cavity -cavity formed in soluble rocks (or salt) primarily by solution action (natural or man-made).

sonar -a system that uses underwater sound, at sonic or ultrasonic frequencies, to detect and locate objects in water.

sonar caliper survey -a technique for measuring internal configurations of a cavity.

SPR	**-Strategic Petroleum Reserve.**
sour crude	**-crude oil with a high sulfur content.**
SO_x	**-Sulphur oxides - SO_2, etc.**
standard elutriate	-the supernatant resulting from the vigorous 30 minute shaking of one part of bottom sediment with 4 parts water (on a volumetric basis) collected from the same sample site, followed by a 1-hour settling time and appropriate 0.45 microns (μ) filtration.
stomata (plural of stoma)	-a small opening or pore in a surface.
strike	-The course or bearing of the outcrop of an inclined bed or structure on a level surface; the direction or bearing of a horizontal line in the plane of an inclined stratum, joint, fault cleavage plane or other structural plane. It is perpendicular to the direction of the dip.

substrata	-layer or stratum of earth or rock lying immediately under another.
surge tank	-a storage tank which serves to keep the pumping rate/pressure through a pipeline constant by storing excess or providing a surplus when the rate of pumping 'surges' up or down, respectively.
suspended particulate matter (particulates)	-Any finely divided solid and/or liquid matter which does not settle from the ambient air.
suspended solids	-a direct measurement quantifying the actual amount of particulate material in the water.
sweet crude	-crude oil with a low sulfur content.
tectonic	-of, pertaining to, or designating the rock structure and external forms resulting from the deformation of the earth's crust. As applied to earthquakes, it is used to describe shocks due to volcanic action or to collapse of caverns or land slide.
Tertiary	-the period of time extending from 65 million to 2 to 3 million years ago.
thalweg	-a line joining the deepest points in a channel.
throw	-the amount of vertical displacement as a result of faulting.
TKN	-total Kjeldahl nitrogen (sum of free ammonia and organic nitrogen compounds).
toxaphene	-organic compound, $C_{10}H_{10}Cl_8$, a toxic, waxy, amber solid, with mild chlorine-camphor smell, soluble in organic solvents, melts at 65-90°C. Used as insecticide (also known as technical chlorinated camphene).

transmissibility, coefficient of -the rate of flow of water in gallons per day through a vertical strip of the aquifer 1 foot wide extending through the vertical thickness of the aquifer at a hydraulic gradient of 1 foot per foot and at the prevailing temperature of the water. The transmissibility from a pumping test is reported for the part of the aquifer tapped by the well.

turbidity -a measure of the amount of light that will pass through a liquid. It describes the degree of opaqueness produced by suspended particulate material.

turbidity plume -a localized area of suspended sediments often associated with dredging operations that reduces the amount of light penetration through the water in that localized area.

Vol. -volume.

vuggy porosity -porosity due to vugs in calcareous rock.

vugs -cavities often with mineral linings different in composition from the surrounding rock.