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1993

Coastal Zone '93

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EFFECTS OF SURFACE BRINE DISPOSAL ON THE MARSHES IN COASTAL LOUISIANA

Syed M. Haque[1]

ABSTRACT

Louisiana is a major oil and gas producing state. Salt water or brine is associated with oil and gas in the subsurface and is brought to the surface along with oil and gas. The amount of brine produced varies with types of wells, stratigraphy, construction techniques, and age of the well. The new fields generally produce less brine but with the gradual withdrawal of petroleum from the reservoir the volume of brine increases.

In 1986, more than 1 billion barrels of brine were disposed of in Coastal Louisiana. Disposal of brine into surface water body is economically practical but environmentally detrimental. Brine often contains small drops of oil. Chronic oil pollution as a result of low-level long term discharge of brine ultimately will kill vegetation and prevent recolonization. Continuous brine discharge alters coastal habitats and accelerates coastal land loss.

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Between 1964 and 1978, numerous new "ponds" were created in the Golden Meadow oil and gas field area, Lafourche Parish, Louisiana, where large amount of brine are being discharged. Surface brine discharge is a major contributor to the destruction of marshes and their conversion to "new ponds." This study points out the potential relationship between brine discharge and destruction of coastal marshes in Golden Meadow oil and gas field area in Lafourche Parish, Louisiana.

INTRODUCTION

Louisiana is a major oil and gas producing state (Figure 1). During 1987, the State produced 174, 517, 365 barrels of oil and 1,758, 791, 937 m.c.f. of gas (Louisiana Department of Natural Resources, 1987). Salt water or brine is associated with oil and gas in the subsurface and is brought to the surface along with the oil and gas. Usually, newly completed wells have a lower salt water to oil ratio than wells which have been pumping a number of years, because as the oil and gas is withdrawn through the wells, the salt water from below moves up in the sand to take the place of the displaced oil or gas.

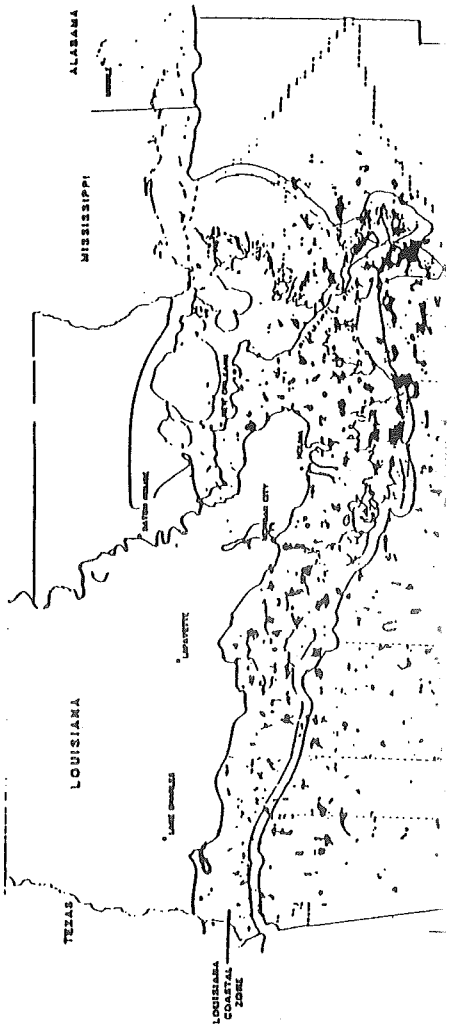
Under Louisiana Act 97 of 1983, it is not mandatory for oil and gas operators to provide yearly reports to the regulating authorities on the discharge of brine to surface water. For this reason, complete current surface brine disposal data are not available.

In May, 1986, however, Department of Environmental Quality (DEQ) requested all operators discharging salt water into streams, rivers, and non-potable water bodies to provide saltwater discharge data. In response, many operators reported the location, salinity, and daily volume of their discharges for 1986. Brine water discharge data for this study were collected from DEQ.

In 1986, about one billion barrels of brine were disposed in coastal Louisiana (Louisiana Department of Environmental Quality, 1986) but that number has decreased to 511 million barrels in 1992 (Hale, 1993, Personal Communications). This change may be attributed to higher environmental quality standards enacted by the Louisiana Department of Environmental Quality in 1991 or less oil and gas activities in Coastal Louisiana.

Nature of Brine

Brine is highly charged with minerals, especially sodium chloride. The major salts contributing to brine salinity are the sulfates (SO_4^{-2}), bicarbonate



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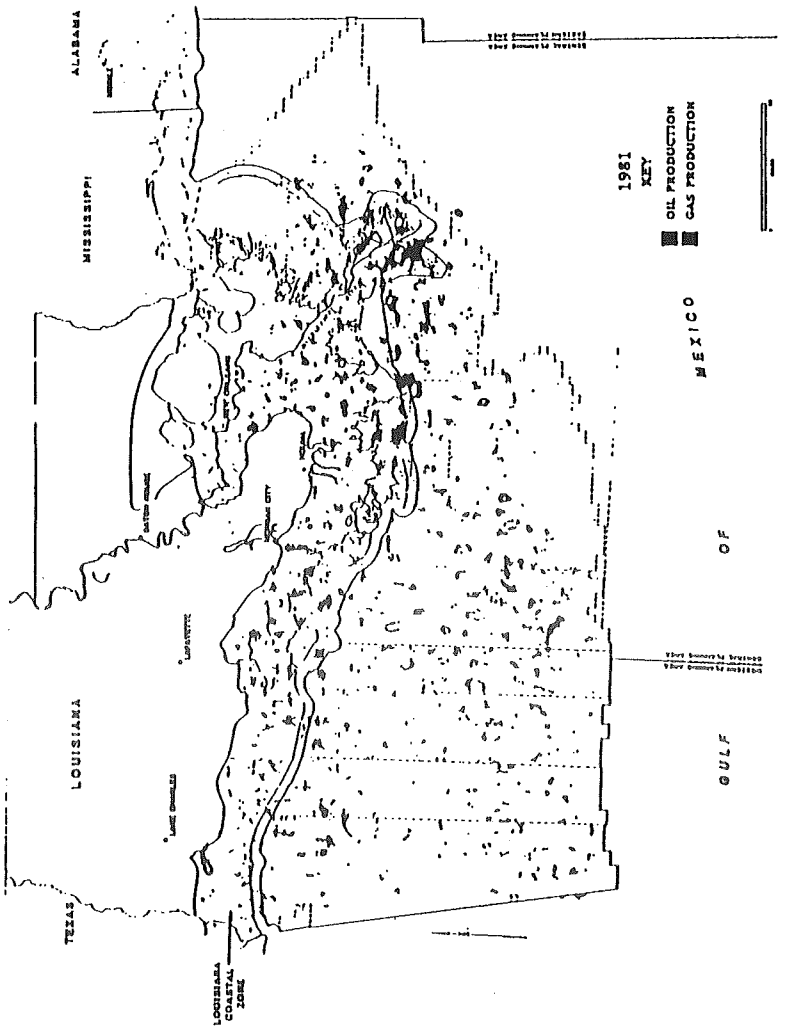

Figure 1. The location of the oil and gas fields in coastal Louisiana and offshore.

HCO_3^{-1}), and chloride (Cl^{-1}) of the cations sodium (NA^{+}), calcium (Ca^{+2}), and magnesium (Mg^{+2}). The composition of Gulf Coast brine and the concentrations of its various components are compared to those of sea water in the following data (Collins, 1967):

Table 1.

	Gulf Coast Brine (mg/1)	Normal Sea Water (mg/1)
Na	18,700 - 23,000	10,600
Ca	1,000 - 120,000	900
Mg	4,000 - 9,000	1,300
Cl	36,000 - 270,000	19,000
Br	118 - 3,200	65
SO_4	0 - 1,000	3,900
HCO_3	0 - 80	160

Sea water with its 19,000 mg/l of chloride is mild compared to some oil field brines in the Gulf Coast, which contain 14 times the above chloride concentration. A 1976 U. S. Environmental Protection Agency (EPA) report of brine discharges in Coastal Louisiana showed a chloride concentration of 10,000 - 115,000 mg/l with an average concentration of 61,000 mg/l (Table 2). Although oil field brines from Coastal Louisiana seem to be of marine origin, they differ from each other in composition because of their environments of deposition (Collins, 1970).

Table 2. Pollutants in produced water in Coastal Louisiana.

Pollutant Parameter	Range, mg/l	Average, mg/l
Oil and Grease	7 - 1,300	202
Cadmium	<0.005 - 0.675	<0.068

Table 2. (cont'd).

Pollutant Parameter	Ra
Cyanide	<(
Mercury	---
Total Organic Carbon	30
Total Suspended Solids	22
Total Dissolved Solids	32
Chlorides	10

Source: U.S. Environmental Protecti

Effects of Brines on Ecosystem

Brine pollution can have a environment. The coastal zone of L acres of marshes and estuaries. Louis fishery (menhaden) in the country, as crabs, oyster, and various fin fish (L provide food, shelter, and breeding lo organisms and form one of the most in north America (Chabreck, 1982).

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Table 2. (cont'd).

Pollutant Parameter	Range, mg/l	Average, mg/l
Cyanide	<0.01 - 0.01	<0.01
Mercury	----	<0.0005
Total Organic Carbon	30 - 1,580	413
Total Suspended Solids	22 - 390	73
Total Dissolved Solids	32,000 - 202,000	110,000
Chlorides	10,000 - 115,000	61,000

Source: U.S. Environmental Protection Agency (1976).

Effects of Brines on Ecosystem

Brine pollution can have a detrimental effect on the coastal environment. The coastal zone of Louisiana consists of over seven million acres of marshes and estuaries. Louisiana's coastal zone supports the largest fishery (menhaden) in the country, as well as other fisheries based on shrimp, crabs, oyster, and various fin fish (Lindstedt et. al 1991). Coastal marshes provide food, shelter, and breeding locations for marsh, estuarine, and marine organisms and form one of the most productive habitats for fish and wildlife in north America (Chabreck, 1982).

The predominant plant in the marshes is wire grass (*Spartina patens*). This grass thrives in the summer, flowers in early fall and dies shortly after blooming. Its normal life cycle provides decayed material and a complex root system to keep the marsh surface from subsiding. Discharged brine, with its high salt content, can kill the grass roots that bind the marsh soil together. Without the root structure, the marsh soil erodes easily, turning marsh into open water (U.S. Soil Conservation Service 1988 a). Between 1964 and 1978, many "new ponds" or open water areas have been created in the Golden Meadow oil and gas field area in Lafourche Parish (Figure 2). Conversion rates of land to open water in 1980 were about 50 mi^2 per year (130 km^2) in all of south Louisiana (Turner & Cahoon 1988).

The staff of the Louisiana Department of Environmental Quality (DEQ), Lafourche regional office, has documented numerous locations where such produced water has been discharged across land. In virtually every case, a total absence of vegetation is observed in the affected area (Anderson, 1987).

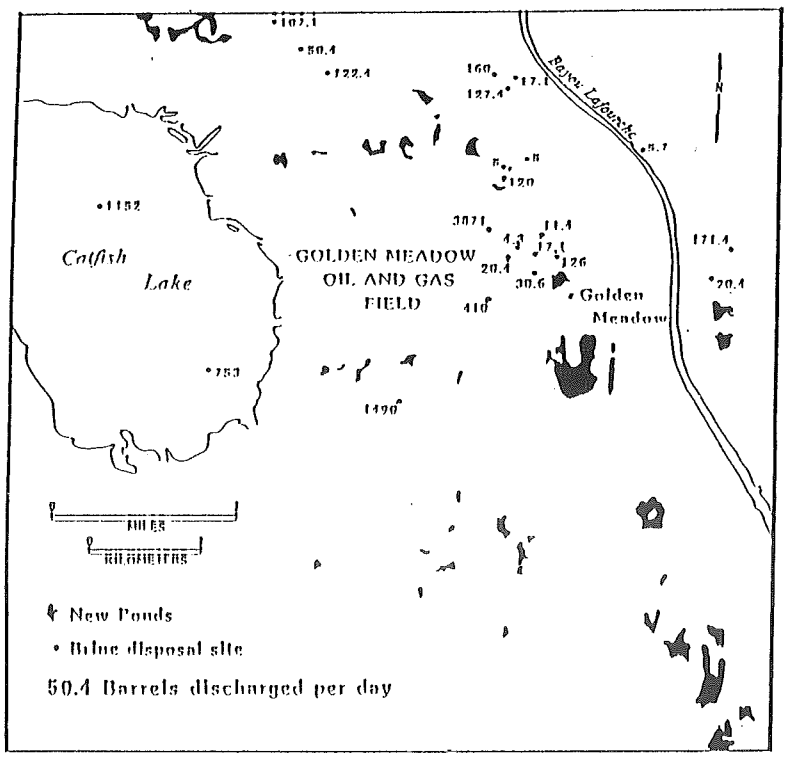

Figure 2. **"New ponds" In the Golden Meadow oil and gas field in Lafourche Parish, Louisiana, from 1964 to 1978.**

According to Biglane and L Louisiana coastal marshes introduce areas, destroying the vegetation a retainers. Oyster-producing areas w The high salinities damaged the nur Thus a change of salinity destroyed

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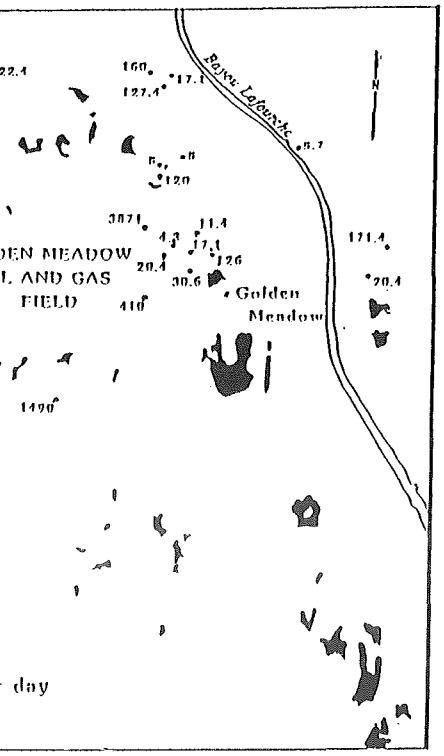
Effects of Brine Effluent on the Golde

In the Golden Meadow oil a operators discharge brine across ope discharge brine into shallow or slugg depends upon the amount of initia circulation within the coastal waters. channels are shallow, so the brine ef the water body. There is a high surrounding marshes after undergoi

For this study, surface brine d map (Figures 4 and 5). On the volume of oil and gas productio production, eight oil and gas fields eight fields, Golden Meadow field i study on the basis of large numbe surrounding marsh. All the existing in Golden Meadow field were plotte of daily brine disposal was record topographic map (1:24,000 scale) a compared to check the amount of observed that many acres of marsh water at brine disposal sites in the G



ıe Golden Meadow oil and gas field in Louisiana, from 1964 to 1978.

According to Biglane and Lafleur (1967), channels dug through the Louisiana coastal marshes introduced sea water into fresh and brackish marsh areas, destroying the vegetation and depriving the marshes of sediment retainers. Oyster-producing areas were covered with silt and dead grasses. The high salinities damaged the nurseries of both white and brown shrimp. Thus a change of salinity destroyed the original ecology of the region.

Brine is routinely discharged into Louisiana's coastal bayous, bays, and marshes with chloride concentrations ranging between 10 to 115 parts per thousand (ppt). The average chloride concentration of south Louisiana brine is about 61 ppt (U.S. Environmental Protection Agency, 1976). In coastal Louisiana, natural salinity is very low in fresh marshes, ranging from 0 to 5 ppt (Penfound and Hathaway, 1938). Brackish marsh salinity ranges between 5 and 18 ppt (Remane and Schlieper, 1971). Saltwater marsh systems are likely to be destroyed by salinities of 50 ppt or more (Conner et al., 1976).

Effects of Brine Effluent on the Golden Meadow Area

In the Golden Meadow oil and gas fields in Lafourche Parish, some operators discharge brine across open land and into marsh (Figure 3). Others discharge brine into shallow or sluggish waters. Distribution of brine effluent depends upon the amount of initial mixing, the tidal currents, and general circulation within the coastal waters. In the Golden Meadow area, canals and channels are shallow, so the brine effluent may build up to very high levels in the water body. There is a high probability that the brine moves to the surrounding marshes after undergoing varying degree of dilution.

For this study, surface brine disposal data were plotted on a small scale map (Figures 4 and 5). On the basis of concentration of disposal sites, volume of oil and gas production, and years of petroleum and brine production, eight oil and gas fields were selected for primary study. Of the eight fields, Golden Meadow field in Lafourche Parish was selected for final study on the basis of large numbers of surface brine disposal sites in the surrounding marsh. All the existing and reported surface brine disposal sites in Golden Meadow field were plotted on a 1:24,000 scale map and the volume of daily brine disposal was recorded. The 1964 Golden Meadow field topographic map (1:24,000 scale) and the photo revised map of 1979 were compared to check the amount of land loss during the said period. It was observed that many acres of marsh have been lost and converted to open water at brine disposal sites in the Golden Meadow area. All new open water

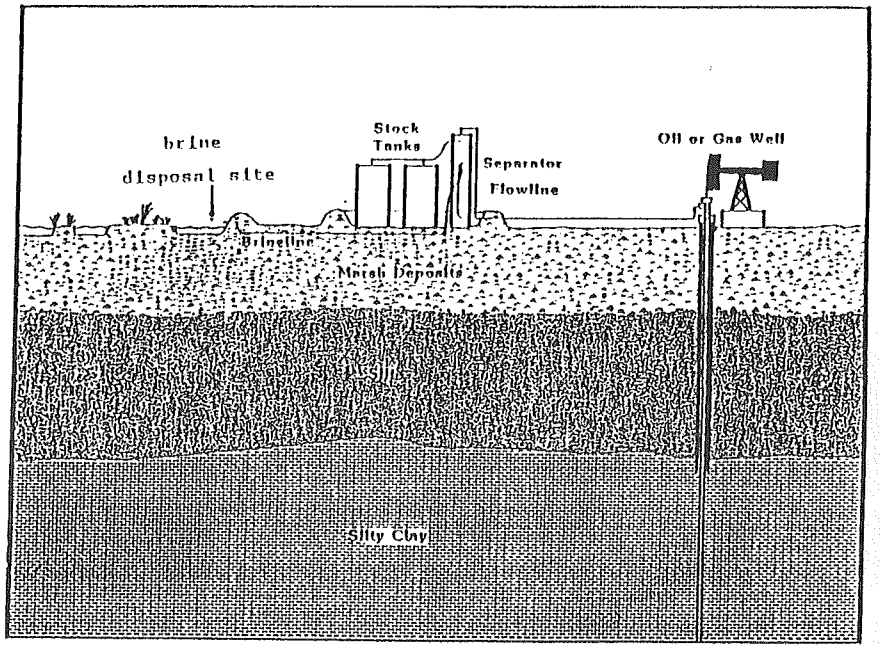
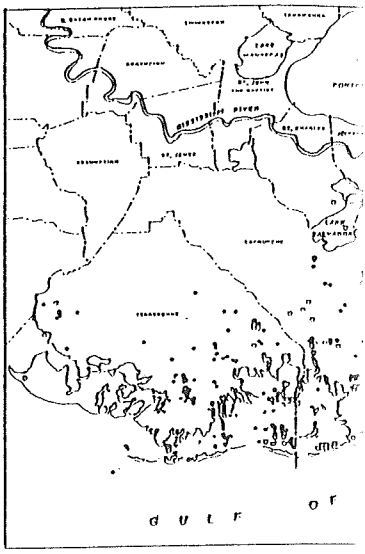


Figure 3. Generalized diagram of a typical brine disposal site in the Golden Meadow oil and gas field.



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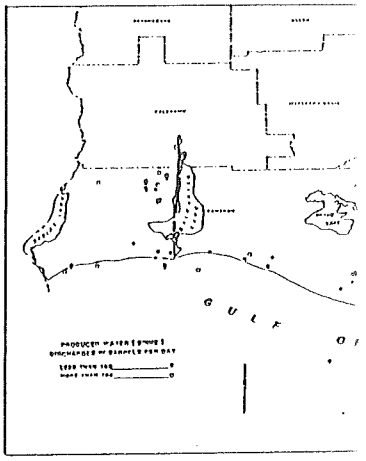

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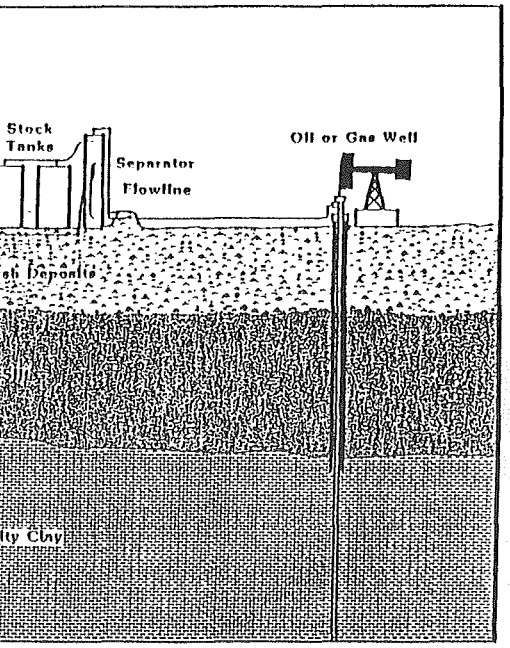

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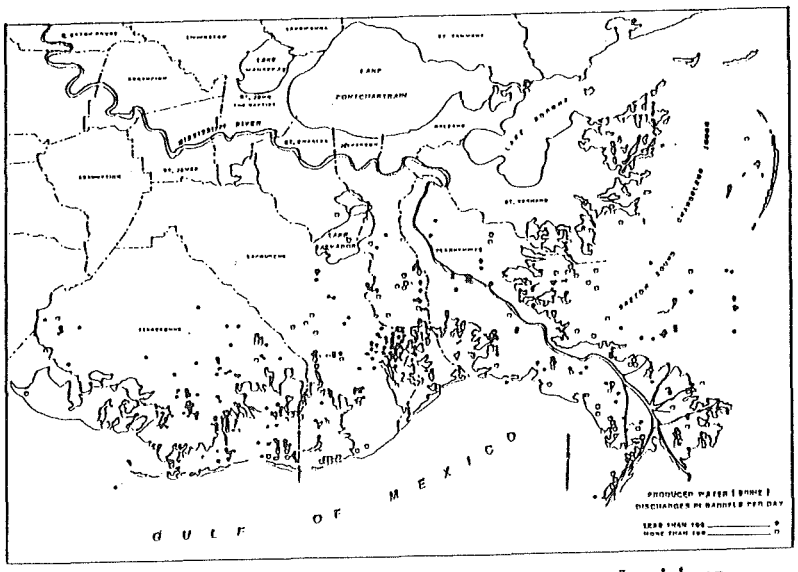

Figure 4. Brine disposal sites in southeast Louisiana.

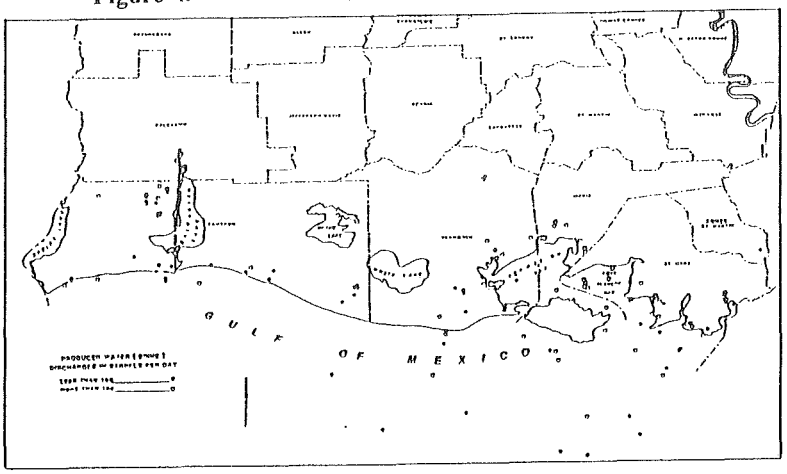

Figure 5. Brine disposal sites in southwest Louisiana.

areas were drawn on a map (Figure 2). Note that the map does not show changes in the shape or extent of old water bodies.

Large amounts of brine are being discharged into Louisiana's coastal bayous, bays, canals, and even directly into marshes. Localized marsh destruction has been reported at many places in the Golden Meadow and Lake Washington Field (Anderson, 1987) due to the effects of brine disposal. Significant wetland loss accompanied by "new ponds" has been observed in the Golden Meadow oil and gas field area, where large amounts of brine are being discharged to surface water. In many places, dredged canals have been used as convenient disposal sites for oil field brine. Brine discharged into canals moves to surrounding marshes and changes the ionic composition of the water body. Prolonged high chloride concentration of the water could lead to the extinction of most halophytes (Waisel, 1972), thus causing land loss. Direct and indirect impacts of canals and channelization in Louisiana caused 20% - 90% of land loss, depending on the location and period studied (Craig et al., 1979; Gaglicano, 1973; Scaife et al., 1983; Turner and Cahoon 1988). Because canals are often associated with surface brine disposal, it is assumed the two act in conjunction to further coastal land loss in Louisiana.

Hydrocarbon Pollution

Another problem with surface brine disposal is the release of hydrocarbons to surface water. The composition of brine and the concentration of its various components vary widely, depending on the source, the quality of the oil, the age of the well, etc. Brine, in general, contains petroleum hydrocarbons, organics, and heavy metals. Any of these materials can have a detrimental effect on the marine environment. For example, oil may interfere with the transfer of oxygen from the atmosphere into the water, coat birds and fish, impart an objectionable taste to fish, exert in direct toxic action on some organisms, or interfere with the organisms fish use for food in the natural food cycle.

Brine contains small drops of oil. Not all of this oil can be recovered during separation, and consequently, some is discharged to coastal waters. Continuous discharge of brine with small concentration of oil results in significant quantities of petroleum hydrocarbons entering coastal waters. Estimates of the oil content in discharged brine ranges from 1 to 4 tons of oil per one million barrels of oil produced (Kash et al., 1973), which is equivalent to 7 to 28 barrels of oil per million barrels of oil produced.

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Regulatory Interest

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2. Establishing guideline
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A 1988 LUMCON study showed evidence of contamination of bottom sediments in Grand Isle and Barataria Bay in the vicinity of surface brine discharges. The contamination was mainly from hydrocarbons. The obvious result was dark mud with a petroleum odor (Boesch, 1988). The net effects of hydrocarbon pollution in the above sites are unknown but in the Hudson Raritan estuary in New York, petroleum hydrocarbons are important pollutants often implicated in situations where biological damage has been reported (McGrath, 1974; Tanacredi, 1977; Stainken and Frank, 1979).

Regulatory Interest

Before 1983, surface brine disposal was controlled by the Louisiana Department of Conservation's statewide order No. 29-B, Section XV. Statewide order no. 29-B. Section XV, paragraph 2B stated that brine "may be disposed of in tidally affected waters, brackish water or any other water unsuitable for human consumption or agriculture purposes."

Act 93 of the 1983 legislature created the Louisiana Department of Environmental Quality (DEQ) by transferring the Environmental Control Commission from the Department of Natural Resources (DNR) to the new department. Three subagencies have been established to maintain and protect the state's natural resources: the Office of Air Quality, the Office of Solid and Hazardous Wastes, and the Office of Water Resources.

Act 97 of 1983 gave the Office of Water Resources most of the responsibilities and powers formerly assigned to the Department of Natural Resources, Office of Environmental Affairs. The Office of Water Resources is also given responsibilities for preventing water pollution under La. R.S. 1065 and 1094, including:

1. Investigating on its own, or on the basis of a complaint, any possibly illegal discharges of waste material or pollutants into the state waters.

2. Establishing guidelines and standards to control and abate water pollution.

3. Monitoring the volumes of water flowing in streams, including the high and low water marks of state water affected by waste disposal or pollution.

4. Developing regulations requiring waste treatment and rules prohibiting the unlawful discharge of untreated or improperly treated waste.

5. Developing permitting procedures and issuing permits, variances, licenses and compliance schedules for all waste water discharges or sources of water pollution.

Now operators are required to get permission from DEQ to discharge produced water into surface water bodies. They are required to submit a discharge permit application detailing the location of the facility, number of discharge points, name of receiving water, chloride concentration of produced and receiving water, and the volume of brine to be discharged.

In April 1989, Louisiana Water Quality Regulations, LAC 33:1X.708 was promulgated. The purpose of this regulation was to regulate radioactive and toxic materials associated with produced water that discharges to the surface waters of the State.

In March 20, 1991, Louisiana Water Quality Regulations, LAC 33:1X.708 was amended. This amendment includes effluent guidelines for the discharge of produced water, drill cuttings and drilling fluids, storm water run off, and reserve and production pit closures.

1991 Rules Related to Produced Water:

1. All produced water discharges must be specifically identified in a valid Louisiana Water Discharge Permit System (LWDPS) Permit.

2. The discharge of produced water directly on to any vegetable area, soil or intermittently exposed sediment surface is prohibited.

3. There shall be no discharge of produced water into lakes, rivers, streams, bayous, canals, or other surface waters or the state in areas regionally characterized as upland. There shall be no discharge of produced water to natural or man made water bodies located in intermediate, brackish or saline marsh area after January 1, 1995, unless the discharge or discharges have been authorized in an approved schedule for elimination or effluent limitation compliance.

State and Federal Marsh management policies are undergoing considerable change. This change is now being significantly influenced by

growing awareness of the seriousn

Louisiana currently is phasi
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ACKNOW

I would like to thank Dr. Ch
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manuscript, Edward Koch and Keit
are also due Pamela Allmond for

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Louisiana currently is phasing in restrictions on the discharge of brine to bayous, streams and other coastal waters. The regulations allow certain exceptions, including discharges into major river passes. In most cases, the state regulations will mean that companies have to reinject their produced waters.

ACKNOWLEDGEMENTS

I would like to thank Dr. Charles G. Groat and Virginia Van Sickle for initiating the study, Dr. Chacko J. John for his technical review of the manuscript, Edward Koch and Keith Graham for drafting the figures. Thanks are also due Pamela Allmond for typing the manuscript.

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