LOUISIANA METROPOLITAN WETLANDS

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LOUISIANA METROPOLITAN WETLANDS: A PLANNING PERSPECTIVE

A REPORT TO THE LOUISIANA STATE PLANNING OFFICE

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ABSTRACT

This study attempts to gather information from various sources concerning wetlands and their relationship to metropolitan areas and to present a decision-making framework in which this information could be used to make rational wetland development decisions. In chapter one, wetlands are defined and a general description of Louisiana's wetland Standard Metropolitan Statistical Areas (SMSA's)--Baton Rouge, Lafayette, Lake Charles, and New Orleans--are given. This description includes a delineation of the SMSA wetland areas and projections to 1995 of each SMSA's population, employment, and personal income. The second chapter examines wetland zoning and master land use plan projected wetland development for each SMSA. Chapter three focuses on the impacts of metropolitan development in wetlands in terms of pollution, reclamation, and channelization.

A per acre monetary evaluation of wetlands is given in chapter four both on the basis of non-competing wetland component functions (fishing, recreation, and tertiary sewage treatment) and on the basis of wetland energetics. Private and public construction and maintenance costs in wetland areas are considered in chapter five. A method useful in the projection of future metropolitan land space requirements and the location of activities--the planned requirements approach--is discussed in chapter six. In doing these projections, the planned requirements approach considers, among other things, employment and population projections, employment and residential densities, and standard land space requirements. In chapter seven, impacts discussed in the previous chapters are brought together in a framework for development decision-making which includes comprehensive costs and benefits, community goals, and distributional effects. Finally chapter eight synthesizes the preceding chapters into a comprehensive planning process leading to wetland development or nondevelopment and also points out areas for future research.

PREFACE

This study together with studies being performed at other universities and agencies in Louisiana will provide the research basis for the Louisiana coastal zone management plan. The plan is being formulated by the Louisiana State Planning Office under the Louisiana Coastal Resources Program and the U.S. Coastal Zone Management Act of 1972. The primary purpose of the Act is to assist states in formulating a plan for the balanced use of coastal resources accounting for ecological, cultural, historic, and aesthetic values of the area as well as the need for economic development and growth. Developing a practical process for state and local government to use in guiding the wise utilization of coastal resources is the purpose of the Coastal Resources Program.

Many persons aided us in the completion of this study. James Renner was our contact at the State Planning Office and provided valuable assistance at both technical and administrative levels. Doctors John Day, Daniel Earle, and Leonard Bahr, of Louisiana State University, Baton Rouge were particularly helpful regarding ecological, and construction and maintenance impacts of wetlands development. Many persons at various local, state, and federal agencies and private firms provided studies, maps, plans, projections, zoning ordinances, building codes, and other information. Particularly helpful were persons at the local and regional planning and development commissions in Baton Rouge, Lafayette, Lake Charles, and New Orleans; the Corps of Engineers; and the Soil Conservation Service. Some of them are referenced in the text. We express our appreciation to all who provided assistance.

AJM, Jr.
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TABLE OF CONTENTS

CHAPTER		PAGE
1.	INTRODUCTION	1
	WETLANDS	3
	METROPOLITAN WETLANDS	6
	BATON ROUGE	7
	LAFAYETTE	12
	LAKE CHARLES	16
	NEW ORLEANS	19
	APPENDIX 1-GENERALIZED DESCRIPTIONS OF EACH SOIL ASSOCIATION	25
2.	LAND USE IN METROPOLITAN WETLANDS: PRESENT AND PROJECTED	29
	INTRODUCTION	29
	BATON ROUGE SMSA	29
	LAFAYETTE SMSA	30
	LAKE CHARLES SMSA	31
	NEW ORLEANS SMSA	32
	NEW ORLEANS	32
	JEFFERSON PARISH	35
	ST. BERNARD PARISH	37
	ST. TAMMANY PARISH	37
	ST. CHARLES PARISH	37
	CONCLUSION	38
3.	THE IMPACTS OF URBAN DEVELOPMENT ON THE WETLANDS	41
	INTRODUCTION	41
	THE ECOLOGICAL WEB OF THE COASTAL WETLANDS	42
	A CIRCULAR TECHNOLOGY	42
	ZONES OF BIOLOGIC ACTIVITY	43
	URBAN WATER POLLUTION AND THE WETLANDS	47
	TYPES OF WATER POLLUTION	47
	URBAN STORM DRAINAGE	52
	URBAN LAND FILL OPERATIONS	57
	POLLUTION FROM THE MISSISSIPPI RIVER	58
	SUMMARY	60
	THE EFFECTS OF URBAN LAND RECLAMATION ON WETLANDS AREAS	62
	HISTORY OF URBANIZATION IN THE NEW ORLEANS AREA	62
	Primitive Cultures	62
	Modern Man	62
	EFFECTS OF RECLAMATION	64
	LAND LOSS TO THE WETLANDS DUE TO RECLAMATION IN THE NEW ORLEANS AREA	65
	Reclamation to the Present	65
	Current and Future Reclamation Projects	68
	EFFECTS OF RECLAMATION IN THE NEW ORLEANS AREA	70
	Subsidence	70
	Ecological Effects of Reclamation	76
	The Blue Crab	77

CHAPTER PAGE

LOSS OF PRODUCTIVE ACTIVITIES THAT BENEFIT THE COMMUNITY........ 80
Assimilative Capacity to Absorb Pollutants.................. 80
Accelerated Loss of Wetland to the Sea...................... 80
Loss of a Buffer Zone Against Tropical Storms............... 81
Conclusion.. 81
THE ECOLOGICAL EFFECTS OF CHANNELIZATION UPON WETLANDS AREAS....... 82
THE THREE TYPES OF CANALS....................................... 82
Drainage.. 82
Water Transportation.. 85
Oil and Gas Pipelines and Facilities........................ 85
WHAT CHANNELIZATION DOES TO THE WETLANDS........................ 86
Interferring with Sheetwater Flow Through the Marsh.......... 86
Allowing Rapid Salinity Changes with Resultant Death of Vegetation and Erosion of the Marsh.......................... 89
Allowing Marsh Destruction by Wave Action.................... 90
Straight vs. Sinuous Channels................................ 91
Destruction of Barrier Islands............................... 91
Conclusions.. 93

4. ECONOMIC VALUATION OF WETLANDS..................................... 96

INTRODUCTION.. 96
COMMERCIAL FISHERIES.. 101
NONCOMMERCIAL FISHERIES... 108
OTHER RECREATIONAL ACTIVITIES..................................... 109
DOMESTIC AND INDUSTRIAL WASTE ASSIMILATION........................ 117
WETLANDS ENERGETICS... 123
CONCLUSIONS... 130

5. CONSTRUCTION AND MAINTENANCE COSTS IN WETLANDS...................... 138

INTRODUCTION.. 138
A COMPARISON OF WETLAND AND DRYLAND CONSTRUCTION COSTS............ 138
WETLAND DEVELOPMENT: EDEN ISLES AND PONCHARTRAIN NEW TOWN.......... 139
EDEN ISLES.. 139
PONCHARTRAIN NEW TOWN... 140
WETLANDS HOMEOWNER MAINTENANCE COSTS............................... 148
WETLANDS PUBLIC MAINTENANCE COSTS.................................. 161
DEPARTMENT OF STREETS... 162
SEWERAGE AND WATER BOARD...................................... 163
APPENDIX 1-SOME IDENTIFIABLE COSTS OF DEVELOPMENT IN WETLANDS...... 164

6. FORECASTING FUTURE LAND USES IN WETLANDS............................ 170

INTRODUCTION.. 170
POPULATION PROJECTIONS.. 171
EMPLOYMENT PROJECTIONS.. 173

CHAPTER PAGE

LAND USE SPACE PROJECTIONS 178
COMMERCIAL LAND USE 180
MANUFACTURING 180
TRANSPORTATION, COMMUNICATIONS, AND UTILITIES 180
PUBLIC AND SEMI-PUBLIC 182
RESIDENTIAL 182
HIGHWAY, ROAD, AND STREET RIGHT-OF-WAY 183
RECREATION 183
TOTAL 1995 LAND USE PROJECTION 183
LAFAYETTE METROPOLITAN AREA 185
LAND USE LOCATION REQUIREMENTS 186
CONCLUSION 188

7. A DECISION FRAMEWORK FOR URBAN WETLANDS DEVELOPMENT DECISIONS 190

INTRODUCTION 190
EXISTING BENEFIT-COST MODELS 191
MARGLIN'S FRAMEWORK 191
LICHFIELD'S FRAMEWORK 194
HILL'S FRAMEWORK 197
DICKERT AND SORENSEN'S FRAMEWORK 201
A SYNTHESIS MODEL 201
INTRODUCTION 201
THE EQUITY CONSTRAINED BENEFIT-COST MODEL 210
TOWARD A MODEL FOR A GOALS SYSTEM 217
CONCLUSION 226

8. SYNTHESIS OF THE STUDY 229

LOUISIANA METROPOLITAN WETLANDS: A PLANNING PERSPECTIVE

CHAPTER 1

INTRODUCTION

The wetlands of Louisiana are an integral aspect of the state's physical, social, and economic landscapes. The metropolitan wetlands contiguous to Baton Rouge, Lafayette, Lake Charles, and New Orleans are all part of Louisiana's wetlands system. As such wetlands development decisions in these areas may affect the entire system which nature has maintained in a fragile balance. The presence of urban wetlands manifest themselves in a number of ways on their areas: through difficult construction and maintenance problems for homes, streets, and other structures; through threats of flood; as recreation and wildlife areas; through the fish and other seafood which they spawn; through the culture that has arisen by people utilizing wetlands and adapting to their presence; and in other ways. They are an integral part of life in South Louisiana and their destruction would mean a drastic change in the lifestyle of this area.

In this study, the wetlands are viewed from the perspective of the regional planner. They are viewed as an area about which developmental decisions will be made. The development alternatives, of course, should always include the no development alternative. Even though the planner elaborates alternatives, he or she is not the decision-maker in most cases. Decisions are normally made by politicians or political bodies. The planner indicates the impacts of each alternative, on whom they fall, and perhaps even attempts to discover and articulate the goals of the community (for use by the decision-makers), but he/she does not have the final say in development decisions. In doing his/her work, the planner attempts to be objective and not impart his/her own values as much as possible. This is the perspective from which this study is written. It discusses impacts, goals, the distribution of impacts and decision-making frameworks but it does not recommend decisions.

In the suceeding sections of this chapter, a general definition of wetland is given and Baton Rouge, Lafayette, Lake Charles, and New Orleans are located geographically with regard to the wetlands. Maps are included which delineate the wetlands and types of soils in the wetlands for each area. The soils are identified so that conditions which exist in one area can be projected to other areas with similar soils. Population and economic projections are also included for each metropolitan area. The second chapter describes for each area the existing zoning in wetlands and the projected wetlands use based on the area's master land use plan.

The impacts of development in the form of channelization, reclamation, and pollution on wetlands is described in chapter three. These impacts are important not only in expressing some of the monetary costs and benefits involved in wetlands development but also in accounting for some of the intangible and nonmonetary impacts. In economic (pecuniary) terms, chapter four evaluates the value of an acre of wetland based on non-competing activities such as commercial and sport fishing, recreation, and sewage treatment, and based on the energy content of the marsh. The extra costs, borne both privately and publically, of construction and maintenance in wetland areas is presented in chapter five. All of these monetary and nonmonetary costs and benefits are important in evaluating wetlands development decisions.

It is important for planners to be able to project the future land space requirements and location of activities. One method useful in doing this is the "planned requirements approach." By knowing this the planner can predict the pressures that will occur for the development of wetlands in the future. The planned requirements approach is presented in chapter six.

In chapter seven, impacts discussed in the previous chapters are brought together in a framework for developmental decision-making which includes all monetary, nonmonetary, and intangible costs and benefits; community goals; and distributional effects. Finally chapter eight attempts to point out areas for future research and study and to bring together all elements which have been previously presented into a comprehensive planning process leading to wetland development or non-development.

WETLANDS

According to A Land-Use Classification System for Use with Remote-Sensor Data (Anderson et al., 1972: 13-14), as modified by the Louisiana State Planning Office, the definition of wetland is as follows:

> Wetlands are of two varieties: forested and nonforested. Nonforested wetlands consist of seasonally flooded basins and flats, meadows, marshes, and bogs. Wetlands are usually relatively level areas. Uniform identification is difficult because the wetland areas change as the result of such factors as long-term drought, high rainfall, seasonal fluctuations in precipitation, and diurnal tides. The observations must be correlated with tide and weather information to obtain consistent results. Nonforested wetland may be either vegetated or bare. Vegetated nonforested wetland includes areas where the forest crown cover is less than 10 percent or the vegetation is nonwoody. Cattails, tules, and grasses such as Indian rice grass and saw grass occur in freshwater marshes and salt-tolerant grasses such as Spartina occur in the salt marshes. Bare nonforested wetland has tidal flats as its main component.
> Forested wetlands are the same as vegetated nonforested wetlands except that the forest crown cover is 10 percent or greater or recent clear cutting has occurred.

This is the definition used in this study. The State Planning Office's modification is to classify wetlands as "forested or nonforested" (Renner, 1975) while Anderson et al. (1972: 14) include forested wetland as "forest land." Areas which were formerly wetland but which are now developed for other use is classified by that new use.

Delineating of wetlands areas is performed using satellite and high altitude imagery (remote sensing techniques) along with topographic maps. A land-use classification system for use with remote sensing techniques should meet the below listed criteria (Anderson, et al., 1971: 3):

1. The minimum level of accuracy in the interpretation of the imagery should be about 90 percent.

2. The accuracy of interpretation for the several categories should be about equal.

3. Repeatable or repetitive results should be obtainable from one interpreter to another and from one time of sensing to another.

4. The classification system should be usable or adaptable for use over an extensive area.

5. The categorization should permit vegetation and other types of land cover to be used as surrogates for activity.

6. The classification system should be suitable for use with imagery taken at different times of the year.

7. Effective use of sub-categories that can be obtained from ground surveys or from the use of larger-scale or enhanced imagery should be possible.

8. Collapse of categories must be possible.

9. Comparison with land-use information compiled in the past or to be collected in the future should be possible.

10. Multiple-use aspects of land use should be recognized when possible.

Correspondence with a Louisiana soil scientist (Slusher, 1975) points out several problems with the above definition of wetland (Anderson et al., 1972: 13-14). Among them are: how long must the flooding continue -- an hour, a day, a week, a month; how often must the flooding occur -- once a year, or more frequently; when not flooded, are the soils saturated and if not saturated where is the water table; how long and how often must the soil be saturated?

Slusher (1975) points out that some wetland areas are easily discernible from dryland. However it is in the gradation between wetland and dryland that identification of wetland is difficult. These problems relate more to the field identification of wetlands than identification using remote sensing techniques.

Revision of A Land-Use Classification System for Use with Remote-Sensor Data is now underway and the following definition of wetland has been proposed but is subject to further revision (U.S. Geological Survey, 1975).

> Wetlands are those areas where the water table is at, near, or above the land surface for a significant part of most years. The hydrologic regime is such that aquatic or hydrophytic vegetation usually is established, although alluvial and tidal flats may be non-vegetated. Wetlands frequently are associated with topographic lows, even in mountainous regions. Examples of wetlands include marshes, mudflats, and swamps situated on the shallow margins of bays, lakes, ponds, streams, and man-made impoundments such as reservoirs. They include wet meadows or perched bogs in high mountain valleys and seasonally wet or flooded basins, playas, or potholes with no surface water outflow. Shallow water areas where aquatic vegetation is submerged are classed as open water and are not included in the Wetland category.
>
> Extensive parts of some river flood plains qualify as wetlands, as do regularly flooded irrigation overflow areas. These do not include agricultural land where seasonal wetness or short-term flooding may provide an important component of the total annual soil moisture necessary for crop production. Areas in which soil wetness or flooding is so short-lived that no typical wetland vegetation is developed, properly belong in other categories.
>
> Cultivated wetlands such as the flooded fields associated with rice production and developed cranberry bogs are classified as Agricultural Land. Uncultivated wetlands from which wild rice, cattails or wood products, etc., are harvested, or wetlands grazed by livestock, are retained in the Wetland category.
>
> Remote sensor data provide the primary source of land use and vegetative cover information for the more generalized levels of this classification system. Vegetation types and detectable surface water or soil moisture interpreted from such data provide the most appropriate means of identifying wetlands and wetland boundaries. Inasmuch as vegetation responds to changes in moisture conditions, remote sensor data acquired over a period of time will allow the detection of fluctuations in wetland conditions. Ground surveys of soil types or the duration of flooding may provide supplemental information to be employed at the more detailed levels of classification.

Wetland areas drained for any prupose belong to other land use and land cover categories such as Agricultural Land, Rangeland, Forest Land, or Urban or Built-up Land. When the drainage is discontinued and such use ceases, classification may revert to Wetland. Wetlands managed for wildlife purposes may show short-term changes in land use as different management practices are used, but are properly classified Wetland.

Two separate boundaries are important with respect to wetland discrimination: the upper wetland boundary above which practically any category of land use or land cover may exist, and the boundary between wetland and open water beyond which the appropriate Water category should be employed.

Forested Wetland and Nonforested Wetland are the Level II (sub-) categories of Wetland.

The following are examples of vegetation associated with Nonforested Wetland. Narrow-leaved emergents such as cordgrass (Spartina) and rush (Juncus) are dominant in coastal salt marshes. Both narrow-leaved emergents such as cattail (Typha), bulrush (Scirpus), sedges (Carex), sawgrass (Cladium) and other grasses (e.g., Panicum and Zizaniopsis miliacea), and broad-leaved emergents such as waterlily (Nuphar, Nymphaea), pickerelweed (Pontederia), arrow arum (Peltandra), arrowhead (Sagittaria), water hyacinth (Eichhornia crassipes), and alligatorweed (Alternanthera philoxeroides) are typical of brackish to freshwater locations. Mosses (Sphagnum), and sedges (Carex) grow in wet meadows and bogs.

This new definition responds to many of the criticisms of the old definition and should make identification of wetland areas less difficult. However, the old definition is used here.

METROPOLITAN WETLANDS

In the following section a general description of each metropolitan area included in this study is given. These include population projections, employment and personal income projections, and maps delineating wetland areas. The maps were compiled from land use maps supplied by the State Planning Office. The SPO maps were compiled using remote sensing techniques and the definition of wetland which was presented earlier.[1]

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[1]Since this study only concerns the wetlands in certain SMSA parishes, the wetland areas are shown as abruptly stopping at parish boundaries. Of course, this is not the case.

BATON ROUGE

The Baton Rouge Standard Metropolitan Statistical Area (SMSA) includes the parishes of Ascension, East Baton Rouge, Livingston, and West Baton Rouge. As seen on Map 1 in Attachment 1, the major Baton Rouge wetlands are in West Baton Rouge Parish near Choctaw Bayou, and in Ascension and Livingston Parishes near Lake Maurepas. The Soil Conservation Service designation for the soils in these areas is "swamp." A description of "swamp" appears in Appendix 1. Note that the major population parish of East Baton Rouge has very little designated wetland and this is located near the Mississippi River (SCS Soils designation--swamp and fresh water marsh, (Appendix 1)).[2] A "hole" in an area designated as wetland normally indicates that some type of extractive activity (e.g. oil well drilling) is taking place in that area which formerly was wetland. Apparently there is much room for the expansion of Baton Rouge into areas that are not presently wetland.

Table 1.1 presents population statistics for the Baton Rouge area. The population projections tend to vary depending on the source, projection method used, and assumptions made in the projections. It is probably safe to say, however, that there were in 1974 about 310,000 people in East Baton Rouge; by 1980, there will be about 345,000 persons; and population by 1990 will be about 410,000. In the SMSA, population estimates for 1974, 1980, and 1990 are approximately, 410,000, 460,000, and 565,000 respectively.

In Table 1.2 are shown employment data for Baton Rouge. Note that the Department of Commerce projections for East Baton Rouge for 1970 are smaller than Louisiana Department of Employment Security (LDES) estimates for 1969.

---

[2]Correspondence with the Director of the Baton Rouge-East Baton Rouge City-Parish Planning Commission (McEwen, 1975) indicates that he objects to the inclusion of East Baton Rouge in the Coastal Plain delineation.

TABLE 1.1

BATON ROUGE POPULATION

YEAR	BATON ROUGE SMSA	EAST BATON ROUGE PARISH
1970[1]	375,628	285,167
1971[2]		287,700
1971[3]		303,543
1973[1]	399,047	302,356
1974[1]	407,151	309,005
1974[3]		340,665
1980[2]		326,300
1980[4]	462,855	345,997
1990[2]		370,500
1990[4]	564,050	412,000
1985-90[3]		425,000

Sources:
1. Wrighton and Denton, 1975: 3.
2. Department of Commerce, 1971: 82.
3. Baton Rouge-East Baton Rouge City-Parish Planning Commission, no date.
4. Christou and Segal, 1973: 20.

TABLE 1.2

BATON ROUGE TOTAL EMPLOYMENT

YEAR	BATON ROUGE SMSA	EAST BATON ROUGE PARISH
1969[1]	137,850	118,325
1970[2]		103,297
1973[3]	182,450	155,575
1980[2]		131,000
1980[4]	208,285	176,459
1990[2]		150,100
1990[4]	253,823	210,120

Sources: 1. Bobo and Dudley, 1971: 174-76.

2. Department of Commerce, 1971: 82.

3. Bobo and Charlton, 1974: 197-200.

4. Computed by authors. See Text.

An even more ridiculous discrepency occurs for 1980 where Department of Commerce projections are smaller than LDES estimates for 1973 (Bobo and Charlton, 1974: 197-200). Thus the Department of Commerce projections are judged to be invalid. No estimates of total employment were available for the Baton Rouge SMSA. Using a very rough technique, the authors have projected the East Baton Rouge (EBR) and Baton Rouge SMSA (BRSMSA) employment for 1980 and 1990. Simply, the ratio of employment in EBR and BRSMSA in 1973 (155,575 and 182,450 respectively) to population in each area in 1973 (302,356 and 399,047 respectively) were computed. These ratios were 0.51 for EBR and 0.45 for BRSMSA. They were applied to 1980 and 1990 population projections by Christou and Segal (1973: 20) in each area. The resulting total employment figures are shown in Table 1.2.[3] It is probably safe to say that total employment estimates for EBR for 1973, 1980, and 1990 are 155,000, 175,000, and 210,000 respectively. The same estimates for the BRSMSA are 180,000, 210,000 and 255,000.

Personal income statistics for East Baton Rouge and the BRSMSA are presented in Table 1.3. Department of Commerce projections for total personal income (TPI) in EBR for 1980 and 1990 appear high. By simply assuming that EBR 1973 real (1958 dollars) per capita personal income (PCI) remains constant through 1990 and by multiplying 1973 PCI by Christou and Segal's (1973: 20) EBR population projections for 1980 and 1990, the authors are able to project a more realistic estimate of real personal income for 1980 and 1990 in EBR. Through a similar procedure, 1980 and 1990 real TPI in the BRSMSA was projected. The only difference is that PCI had to be computed first by dividing TPI by appropriate population data. In EBR, real TPI should be about 875,990, and

---

[3]This procedure assumes, of course, that unemployment and labor force participation rates among other things are constant over the projection period.

TABLE 1.3

BATON ROUGE PERSONAL INCOME

PRICE DEFLATOR[4]	YEAR	TOTAL PERSONAL INCOME (in millions of dollars)		PER CAPITA PERSONAL INCOME	
		Undeflated	Deflated to 1958 Dollars	Undeflated	Deflated to 1958 Dollars
			EAST BATON ROUGE		
1.3524	1970[1]	1053.1+	778.7	3684+	2724
1.5386	1973[1]	1343.9+	873.5	4405+	2863
1.11759	1980[2]	1468.9*	1314.3		
	1980[3]		990.6		
1.11759	1990[2]	2150.2*	1923.8		
	1990[3]		1179.6		
			BATON ROUGE SMSA INCOME		
1.3524	1970	1298.9+,1	960.4	3458+,3	2557
1.5386	1973	1668.2+,1	1084.2	4181+,3	2717
	1980[3]		1257.6		
	1990[3]		1532.5		

+In current dollars of that year. Deflated by authors.

*In 1967 dollars. Deflated by authors.

Sources: 1. Wilcox, 1975: 5.

2. Department of Commerce, 1971: 82.

3. Computed by authors. See text.

4. Economic Report to the President 1974: 252.

1180 millions of dollars for 1973, 1980, and 1990. The same figures for the BRSMSA should be about 1085, 1260, and 1535 millions of dollars.

LAFAYETTE

The SMSA of Lafayette is congruent with the parish of Lafayette. Map 1 (Attachment 1) shows the location of Lafayette's wetlands in the extreme eastern part of the parish along Bayou Vermillion and Bayou Tortue. Note that only a thin strip of wetland lies in Lafayette Parish with most of the wetlands near Lafayette lying in St. Martin Parish. The SCS soils designations in these wetlands are swamp and loamy soils (Appendix 1). Again, as in Baton Rouge, Lafayette's expansion does not appear to be constrained by wetland areas.

Table 1.4 presents population statistics for the Lafayette SMSA. In 1974, Lafayette had approximately 120,000 people. It is probably safe to say that by 1980 the population of Lafayette will reach 135,000 and by 1990, 170,000. Table 1.5 shows employment for Lafayette. Again the Department of Commerce projections seem exceedingly conservative. On the other hand, Diversified Economic and Planning Associates projections appear to be too large. Using the 1973 employment-population ratio (.40) and applying this to Christou and Segal's (1973: 20) projections of population for 1980 and 1990, as in the case of Baton Rouge, rough employment projections are derived. In 1973 total employment in Lafayette was 48,225. In 1980 and 1990, it will be near 55,000 and 65,000 persons respectively.

In Table 1.6 total personal income statistics for Lafayette are shown. By using the same procedure as for East Baton Rouge, TPI in 1980 and 1990 was computed. The various estimates are fairly close in this case. TPI in real terms should be approximately 310, 355, and 440 millions of dollars in 1973, 1980, and 1990.

TABLE 1.4

LAFAYETTE POPULATION

YEAR	LAFAYETTE SMSA
1970[1]	111,643
1971[2]	113,700
1973[1]	119,400
1974[1]	122,076
1980[2]	102,200
1980[3]	136,934
1980[4]	158,025
1990[2]	105,800
1990[3]	169,152
1990[4]	218,119
1990[5]	180,000

Sources:
1. Wrighton and Denton, 1975: 3.
2. Department of Commerce, 1971: 111.
3. Christou and Segal, 1973: 20.
4. Lafayette Chamber of Commerce.
5. Lafayette Regional Planning Commission 1974: 12.

TABLE 1.5

LAFAYETTE TOTAL EMPLOYMENT

YEAR	LAFAYETTE SMSA
1970[1]	46,075
1970[2]	37,893
1970[3]	46,275
1973[4]	48,225
1980[2]	38,100
1980[5]	54,774
1980[3]	63,500
1990[2]	39,900
1990[5]	67,661
1990[3]	80,000

Sources: 1. Bobo and Dudley, 1971: 174-176.

2. Department of Commerce, 1971: 111.

3. Diversified Economic and Planning Associates, Inc., 1974: 58.

4. Bobo and Charlton, 1974: 58.

5. Computed by authors. See text.

TABLE 1.6

LAFAYETTE PERSONAL INCOME

PRICE DEFLATOR[4]	YEAR	TOTAL PERSONAL INCOME (in millions of dollars)		PER CAPITA PERSONAL INCOME	
		Undeflated	Deflated to 1958 Dollars	Undeflated	Deflated to 1958 Dollars
1.3524	1970[1]	340.6+	251.8	3041+	2249
1.5386	1973[1]	476.4+	309.6	3992+	2595
1.11759	1980[2]	373.8*	334.5		
	1980[3]		355.3		
1.11759	1990[2]	506.3*	453.0		
	1990[3]		438.9		

+In current dollars of that year. Deflated by authors.

*In 1967 dollars. Deflated by authors.

Sources: 1. Wilcox, 1975: 5.

2. Department of Commerce, 1971: 111.

3. Computed by authors. See text.

4. Economic Report of the President, 1974: 252.

LAKE CHARLES

Calcasieu Parish comprises the Lake Charles SMSA. Map 2 in Attachment 1 delineates the wetlands in Lake Charles. The wetland areas which are rather distant from the City of Lake Charles are those that are near the Sabine River, (SCS soils designations (Appendix 1)--frequently flood bottomland soil, fresh water marsh, and swamp) and near the boundary of Calcasieu Parish with Cameron Parish (soils--fresh and salt water marshes). The wetlands near the city of Lake Charles are generally to the north and along the Calcasieu River (soils--bottomland and swamp). Expansion of Lake Charles to the south and east would not impact directly on the wetlands.

Population statistics for the Lake Charles SMSA are presented in Table 1.7. The two figures presented for 1975, 1980, and 1990 were derived by the Imperial Calcasieu Regional Planning and Development Commission (ICRP&DC) using two different methods. The lower figures are based on employment forecasts and the larger figures resulted from the "ratio technique" which assumes that changes in larger units (districts) will be reflected as proportional changes in the smaller unit (parishes) (ICRP&DC (no date): 131-132). In 1974, Lake Charles had 148,645 people. By 1980, it should have a population of about 165,000, and by 1990, about 180,000.

Employment statistics for Lake Charles are presented in Table 1.8. In this case, the Department of Commerce projections for 1980 and 1990 again appear to be conservative. The other estimates are relatively close. Once more using the 1973 employment-population ratio (.36) and applying this to Christou and Segal's (1973: 20) population projections for 1980 and 1990, rough employment projections are derived. Total employment in the Lake Charles SMSA in 1973 was 54,400. In 1980 and 1990, it will be approximately 60,000 and 65,000.

TABLE 1.7

LAKE CHARLES POPULATION

YEAR	LAKE CHARLES SMSA
1970[1]	145,415
1971[2]	145,600
1973[1]	149,794
1974[1]	148,645
1975[3]	170,758-178,929
1980[2]	144,100
1980[4]	163,382
1980[3]	179,061-198,750
1990[2]	153,700
1990[4]	181,647
1990[3]	200,960-239,960

Sources:

1. Wrighton and Denton, 1975: 3.
2. Department of Commerce, 1971: 112.
3. Imperial Calcasieu Regional Planning and Development Commission, no date: 289.
4. Christou and Segal, 1973: 20.

TABLE 1.8

LAKE CHARLES TOTAL EMPLOYMENT

YEAR	LAKE CHARLES SMSA
1970[1]	49,300
1970[2]	48,057
1970[3]	47,648
1973[4]	54,400
1975[3]	55,350
1980[2]	52,500
1980[3]	59,090
1980[5]	58,818
1990[2]	56,700
1990[3]	66,220
1990[5]	65,393

Sources: 1. Bobo and Dudley, 1971: 174-176.

2. Department of Commerce, 1971: 112.

3. ICRP&DC, no date: 135.

4. Bobo and Charlton, 1974: 197-200.

5. Computed by authors. See text.

Table 1.9 shows personal income statistics for Lake Charles. Again the Department of Commerce projections for total personal income in 1980 and 1990 appear too high. The East Baton Rouge procedure was used to yield real TPI in 1980 and 1990 of about 440 and 490 millions of dollars. For 1973, real TPI was 400 million dollars.

NEW ORLEANS

The New Orleans SMSA is comprised of Orleans, Jefferson, St. Bernard and St. Tammany Parishes. The wetlands in the New Orleans area are shown on Maps 1, 3, 4, and 5 (Attachment 1). Wetlands are located near Lake Ponchartrain in Orleans, St. Tammany, and St. Charles Parishes (SCS soils designations (Appendix 1)--swamp and fresh water marsh), Lake Borne in Orleans and St. Bernard Parishes (soils--salt water marsh), Lake Salvador and Lake Little in Jefferson Parish (soils--fresh water marsh, swamp, and salt water marsh) and along the Bogue Chitto and Pearl Rivers in St. Tammany Parish (soils--loamy and frequently flooded bottomland soils). Even though St. Charles Parish is not formally a part of the SMSA, it is included here because it may soon be a part and because the expansion of the New Orleans area is already exerting developmental pressures on it. It is obvious from the maps that the population center of New Orleans (Orleans and Jefferson Parishes) is surrounded by either water or wetland. Any expansion of New Orleans without further impact on the wetland areas would have to take place in St. Tammany Parish.

Table 1.10 presents population data for the New Orleans SMSA. In 1974, New Orleans had almost 1.1 million people. This should increase to about 1.2 million in 1980 and 1.4 million in 1990. Total employment in the New Orleans area was about 415,000 in 1973 as shown in Table 1.11. The 1973 employment population ratio for 1973 was 0.38 which when applied to Christou and Segal's

TABLE 1.9

LAKE CHARLES PERSONAL INCOME

PRICE DEFLATOR[4]	YEAR	TOTAL PERSONAL INCOME (in millions of dollars)		PER CAPITA PERSONAL INCOME	
		Undeflated	Deflated to 1958 Dollars	Undeflated	Deflated to 1958 Dollars
1.3524	1970[1]	481.8+	356.3	3305+	2444
1.5386	1973[1]	616.5+	400.7	4130+	2684
1.11759	1980[2]	579.1*	518.2		
	1980[3]		438.5		
1.11759	1990[2]	798.0*	714.0		
	1990[3]		487.5		

+In current dollars of that year. Deflated by authors.

*In 1967 dollars. Deflated by authors.

Sources: 1. Wilcox, 1975: 5.

2. Department of Commerce, 1971: 112.

3. Computed by authors. See text.

4. *Economic Report of the President*, 1974: 252.

TABLE 1.10

NEW ORLEANS POPULATION

YEAR	NEW ORLEANS SMSA
1970[1]	1,046,470
1971[2]	1,062,600
1973[1]	1,087,763
1974[1]	1,092,570
1980[2]	1,101,200
1980[3]	1,214,537
1990[2]	1,178,100
1990[3]	1,411,462

Sources: 1. Wrighton and Denton, 1975: 3.

2. Department of Commerce, 1971: 125.

3. Christou and Segal, 1973: 20.

TABLE 1.11

NEW ORLEANS TOTAL EMPLOYMENT

YEAR	NEW ORLEANS SMSA
1970[1]	412,000
1970[2]	372,963
1973[3]	415,900
1980[2]	435,600
1980[4]	461,524
1990[2]	470,900
1990[4]	536,356

Sources: 1. Bobo and Dudley, 1971: 174-176.

2. Department of Commerce, 1971: 125.

3. Bobo and Charlton, 1974: 197-200.

4. Computed by authors. See text.

(1973: 20) population projections for 1980 and 1990 yield rough employment projections for those years of about 460,000 and 535,000.

For New Orleans, total personal income statistics are shown in Table 1.12. Once again the Department of Commerce projections appear high. In this case the Baton Rouge SMSA procedure was used to project real TPI in 1980 and 1990 of 3615 and 4200 millions of dollars while real TPI was equal to 3200 million dollars in 1973.

This concludes the introduction and background for this study of Louisiana's urban wetlands from a planning perspective. It is clear that growth is projected for all of the wetland SMSA's. With the information presented so far, one should be able to pursue a more detailed look at considerations important in the development of wetlands. First, however, the next chapter presents a brief look at the plans that each urban area has for its wetlands.

TABLE 1.12

NEW ORLEANS PERSONAL INCOME

PRICE DEFLATOR[4]	YEAR	TOTAL PERSONAL INCOME (in millions of dollars)		PER CAPITA PERSONAL INCOME	
		Undeflated	Deflated to 1958 Dollars	Undeflated	Deflated to 1958 Dollars
1.3524	1970	3916.6[+,1]	2896.0	3743[+,3]	2767
1.5386	1973	4982.9[+,1]	3238.6	4581[+,3]	2977
1.11759	1980[2]	4906.7*	4390.4		
	1980[3]		3615.7		
1.11759	1990[2]	6774.2*	6062.3		
	1990[3]		4201.9		

+In current dollars of that year. Deflated by authors.

*In 1967 dollars. Deflated by authors.

Sources: 1. Wilcox, 1975: 5.

2. Department of Commerce, 1971: 125.

3. Computed by authors. See text.

4. <u>Economic Report of the President</u>, 1974: 252.

APPENDIX 1

GENERALIZED DESCRIPTIONS OF EACH SOIL ASSOCIATION*

Swamp

An area which is composed of mineral and organic elements near sea level and flooded most of the time by freshwater. It is mostly used for woodland (cypress and tupelo gum trees) and as a wildlife habitat.

Freshwater Marsh

An area that consists of black organic material two to eight feet thick over soft gray clays. In some places, the organic layers may separate from clayey layers and float. The area is too unstable for grazing and is mostly used for wildlife habitat.

Saltwater Marsh

An area which is composed of peat or muck underlain by slightly firm to semi-fluid gray clays, in addition to small parts which are underlain by fine sands. It is near sea level and the water table is at or above the surface most of the time. Included in this association are waters which are described as brackish, i.e., the salt content of the water ranges from saline to freshwater.

Floodplain

An area that consists of stratified grayish-brown silt loam, very fine sandy loam, grayish-brown silty clayloam, and gray clayey layers. This alkaline loam alluvial land is subject to flooding and in level areas it is used for pasture and recreation.

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*Consolidated descriptions from each parish's General Soil Map (Soil Conservation Service, various dates).

Loamy Soils

An area which is composed of fine sandy loam surface and a gray sandy clay subsoil and one that drains poorly.

Silty and Clayey Soils

An area which consists of a gray silt or clay loam surface with black silt loam or silty clay subsoil. It drains poorly.

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CHAPTER 2

LAND USE IN METROPOLITAN WETLANDS: PRESENT AND PROJECTED

INTRODUCTION

The purpose of this chapter is threefold: to examine the existence of wetlands in each SMSA and their zoning; to define projected growth and development in wetlands in each SMSA through their land use plans; and to state the regional and local policies that are used to encourage compliance with the plans.

BATON ROUGE SMSA

The Capital Region Planning Commission (CRPC) is the multi-parish (Ascension, East Baton Rouge, Livingston and West Baton Rouge) planning coordinating agency. In 1973, the agency published a land use plan for the entire region (Jordan, 1973) and the plan contains recommendations on development goals and objectives in addition to land use principles. The CRPC suggests that the local planning commissions consider, refine if they wish, and enforce a stated principle and development plan for their areas (Jordan, 1973). Both disadvantageous and advantageous uses of the wetlands which the regional commission discourages or encourages are presented in the report. The means of discouragement and encouragement take the following forms: (1) giving out information on the physical features (i.e. hazards, limitations, and advantages) of each zone; (2) making suggestions to each community on establishing ordinances and regulations in compliance with the land use plan (Jordan, 1973: 1-4); and (3) reviewing development proposals (Jordan, 1973: 13). Acceptable community uses of the wetlands established by the CRPC (Jordan, 1973: 22) are agricultural; recreational, not requiring structures; parks; scenic drives; nature areas; and drainage.

The Existing Land Use Map for East Baton Rouge (City-Parish Planning Commission (CPPC), 1975b) shows the areas along the Mississippi River in the northeast and along the boundary of the parish with West Baton Rouge Parish as wetlands. (See Map 1 in Attachment 1.) These areas are designated on the Zoning District Map to be industrial and agricultural (CPPC, 1975a). Wetlands, however, are marked as conservation areas on the Future Land Use Map, an obvious use conflict (CPPC, 1973). The Future Land Use Map designations were considered to be the most correct by a City-Parish Planning Commission staff member (Scheve, 1975). It is questionable, however, that the future land use designations will become reality if the zoning ordinances of the area allow the wetlands to be developed for both industrial and agricultural use.

In West Baton Rouge Parish, the wetlands run from southwest of Port Allen to West Baton Rouge-Iberville parish lines. The wetlands in Ascension and Livingston parishes continue northwesterly and southwesterly from Lake Maurepas. (See Map 1.) These parishes have no operational local planning commissions at this time. It may be, in these cases, that the acceptable future uses of the wetlands suggested by the Capital Regional Planning Commission will be adhered to.

LAFAYETTE SMSA

The wetlands in the Lafayette SMSA (Lafayette Parish) are on the eastern portion of the Parish line and go into St. Martin Parish (Map 1). The Lafayette Regional Planning Commission (LRPC) developed a Master Land Use Plan for the Lafayette Metropolitan area and for Lafayette Parish in 1973. In August, 1973, the Regional Planning Commission adopted planning principles which supported controlled growth which are: (1) no residential development should be allowed in floodways; (2) most recreational uses are incompatible with industrial uses; (3) prime natural areas should be provided for public use in perpetuity;

(4) no vacant land should be developed unless in conformity with the Master Land Use Plan; and (5) the adopted Master Land Use Plan for the Lafayette Metropolitan Area is to utilize drainage areas and attendant floodways as a structure of open space. Acceptable uses for these areas are: agriculture, recreation not requiring structures, parks, scenic drives, and nature areas (LRPC, 1973: 47-56). The future land use of the eastern wetland portion of Lafayette SMSA is a mixture of agricultural, "other" recreation and single family residential (LRPC, 1973: 97). The Commission's goals and plans appear to be in conflict.

Adjacent to the eastern portion of the Lafayette SMSA is St. Martin Parish. The wetlands are called marginal land in the St. Martin Parish Comprehensive Plan (Community Planners, 1969: 20). The principles and policies set up in this Plan suggest that the marginal land be used as public and semi-public space with an emphasis on outdoor recreation (Community Planners, 1969: 40). The Official Zoning Map of St. Martin Parish (Community Planners, 1969) designates the wetlands adjacent to Lafayette as F (inundation). This designation permits the uses allowed in controlled zone districts as long as the minimum floor level is one foot above highest flood level.

LAKE CHARLES SMSA

The wetlands in Lake Charles SMSA (Calcasieu Parish) are along the Sabine River, Calcasieu-Cameron Parish Line, and along the Calcasieu, Little, and Houston Rivers (Imperial Calcasieu Regional Planning & Development Commission, 1974). (See Map 2.) A Land Use Plan for the Lake Charles SMSA was submitted in 1973 to the Calcasieu Regional Planning Commission in an effort to control patterns of development for both urban and rural areas. The plan defines the projected use of wetland areas to be either agricultural or vacant.[1] The stated policy on the Land Use Map is to avoid development in areas subject to inundation of various degrees. Overall, the Land Use Plan projects growth in existing urban areas with little growth in rural areas. Therefore, the SMSA will continue to avoid development of the Parish wetlands for the next 20 years[2] (Diversified Economic and Planning Associates, 1973).

NEW ORLEANS SMSA

An Interim Land Use Plan was accepted by the Regional Planning Commission for Jefferson, Orleans, St. Bernard, and St. Tammany Parishes in 1973. It generally provides that for the future use of wetlands be for open and attractive types of development, e.g., passive recreation areas, general open space, or wildlife preserves. Also, the plan suggests that a determination be made at a later date and on much more information before reclamation of such areas occurs (N-Y Associates, 1973: 1-11). This proposal leaves future use of wetlands open to drastic changes.

NEW ORLEANS

According to the Interim Land Use Plan, portions of New Orleans' wetlands (Maps 1, 3, 4, 5) will be developed (see Figure 2.1). The Lake front Marsh Unit (1) is projected to have the following uses: agricultural, marsh, public

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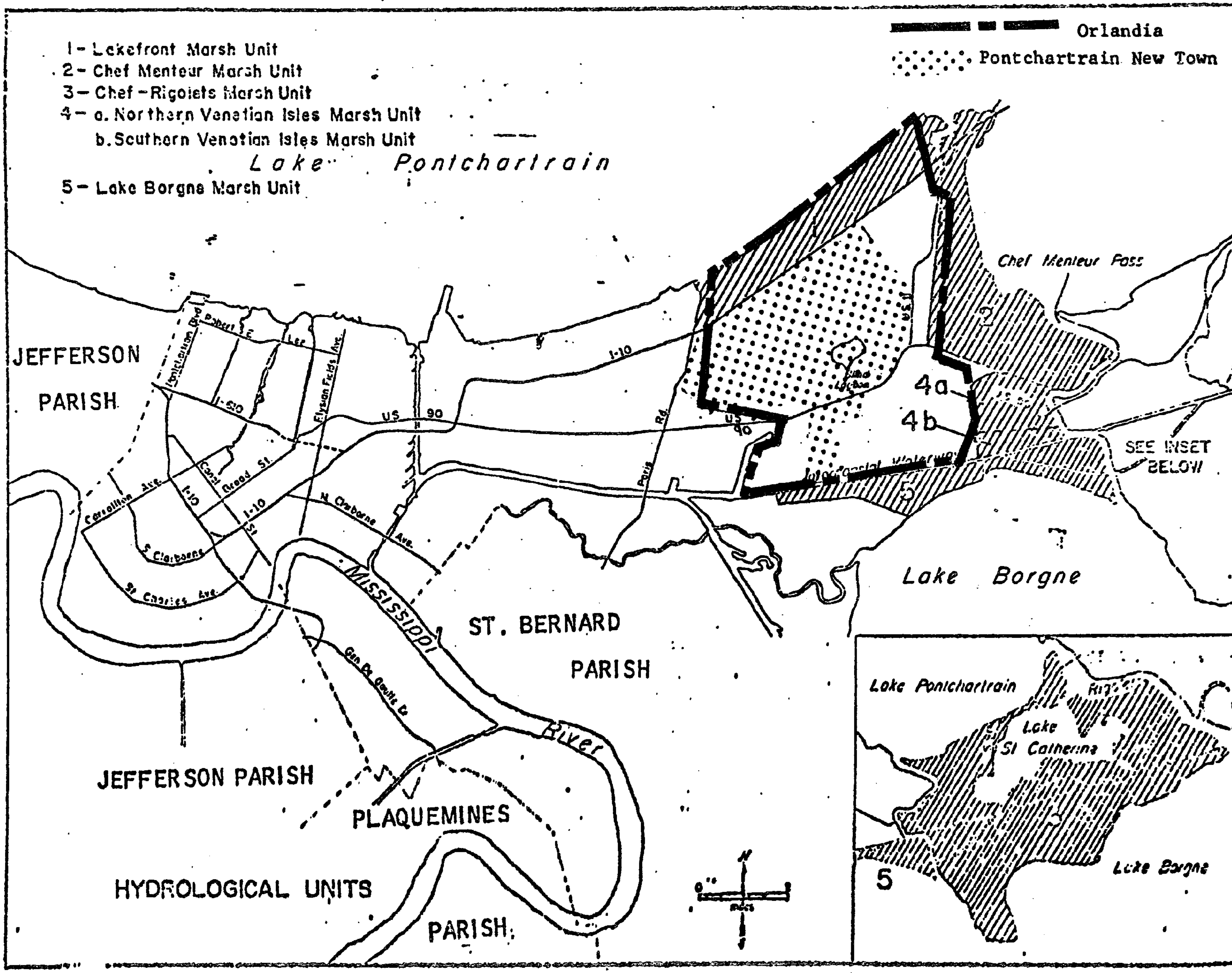
[1] Agricultural and vacant designations are the same in the study.

[2] The local planning agency, Calcasieu Regional Planning Commission, is in the process of revising the comprehensive zoning ordinance so that no comparison may be given with the regional plan (Ford, 1975).

FIGURE 2.1 Critical Wetlands in Orleans Parish



and semi-public, and medium density residential. The Chef Menteur Marsh Unit (2) is projected to contain commercial, agricultural, and marsh uses while the Venetian Isles Marsh Units (4a & b) are projected to contain low density residential and commercial uses (N-Y Associates, 1973: Projected Land Use Map).

Growth into these wetland units is permitted by the Comprehensive Zoning Ordinance for the City of New Orleans (New Orleans City Planning Commission (NOCPC), 1970a). The zoning in Lakefront Marsh Unit allows for low density residential and neighborhood business districts. In the Chef Menteur Marsh Unit the range of development potential is the following: low density residential to light industrial and non-urban uses.[3] Chef-Rigolets and the Lake Borgne Marsh Units are zoned non-urban, while the Ventian Isles unit is zoned for light and heavy industrial, residential and non-urban uses (NOCPC, 1970b).

The City Planning Commission has developed a Coastal Zone Management Plan for New Orleans (NOCPC, 1975). In New Orleans, the wetlands are essentially in the eastern portion of the Parish. The plan designates sections of wetlands that are still vital and should remain unaltered as part of the Maurepas-Pontchartrain-Borgne estuary--"critical wetlands". (See Figure 2.1 striped area.) It recommends that only impounded (already partially drained and leveed)

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[3]It is interesting to note that non-urban zoning allows single and two family residential, schools, churches, boat repair and ship yards, trailer parks, child care centers in addition to farms, recreational and conservation areas provided that the uses remain within the performance standards for smoke, dust, toxic or noxious waste materials, vibration, etc. (NOCPC, 1970a: Section 26, Article 5).

marsh should be developed (site of now defunct Pontchartrain New Town in Town). At present, the Coastal Zone Management Plan is under consideration by the City Planning Commission. No legal sanctions have been adopted, so the proposed urban development of Orlandia poses a threat to three of the wetland units in eastern New Orleans--Lakefront Marsh Unit, Chef Menteur Marsh Unit, Venitian Isles Marsh Unit (Figure 2.1). Recently a park has been proposed for the triangular section of wetland between U.S. Highways 90 and 11 and the shore of Lake Ponchartrain (Orleans Guide, 1975: 1-2). This is within the Chef Menteur Marsh Unit (2), an area designated to remain unaltered by the CPC. Any development in the park will, of course, alter the marsh.

JEFFERSON PARISH

The uses of the wetlands in Jefferson (Maps 1, 3, 5) are to be single family residential and industrial (N-Y Associates, 1973: Projected Land Use Map). A Comprehensive Zoning Ordinance was adopted by the Jefferson Parish Council in 1974 which will guide the urban growth of the parish, and is mainly in accordance with the regional Interim Land Use Plan (Jefferson Parish Council, 1974). Most of the existing wetlands are in the southern portion of the Parish on the west bank of the Mississippi River. This land has been zoned in two categories: residential S-1, or industrial U-1. S-1 zoning is primarily a low density residential district. Permitted uses in S-1 range from single and two family dwellings to farming and airports. U-1 zoning is for the manufacturing of products which give off offensive emissions of ordor, smoke, gas, excessive glare, light, or noise vibration. Undeveloped land along the river (see Figure 2.2) in the area south of Lapalco Boulevard from Algiers to Marrero is zoned S-1 and U-1. From Westwego to Bridge City, along the river north of the Westbank Expressway, the undeveloped land is also zoned for S-1 and U-1. South

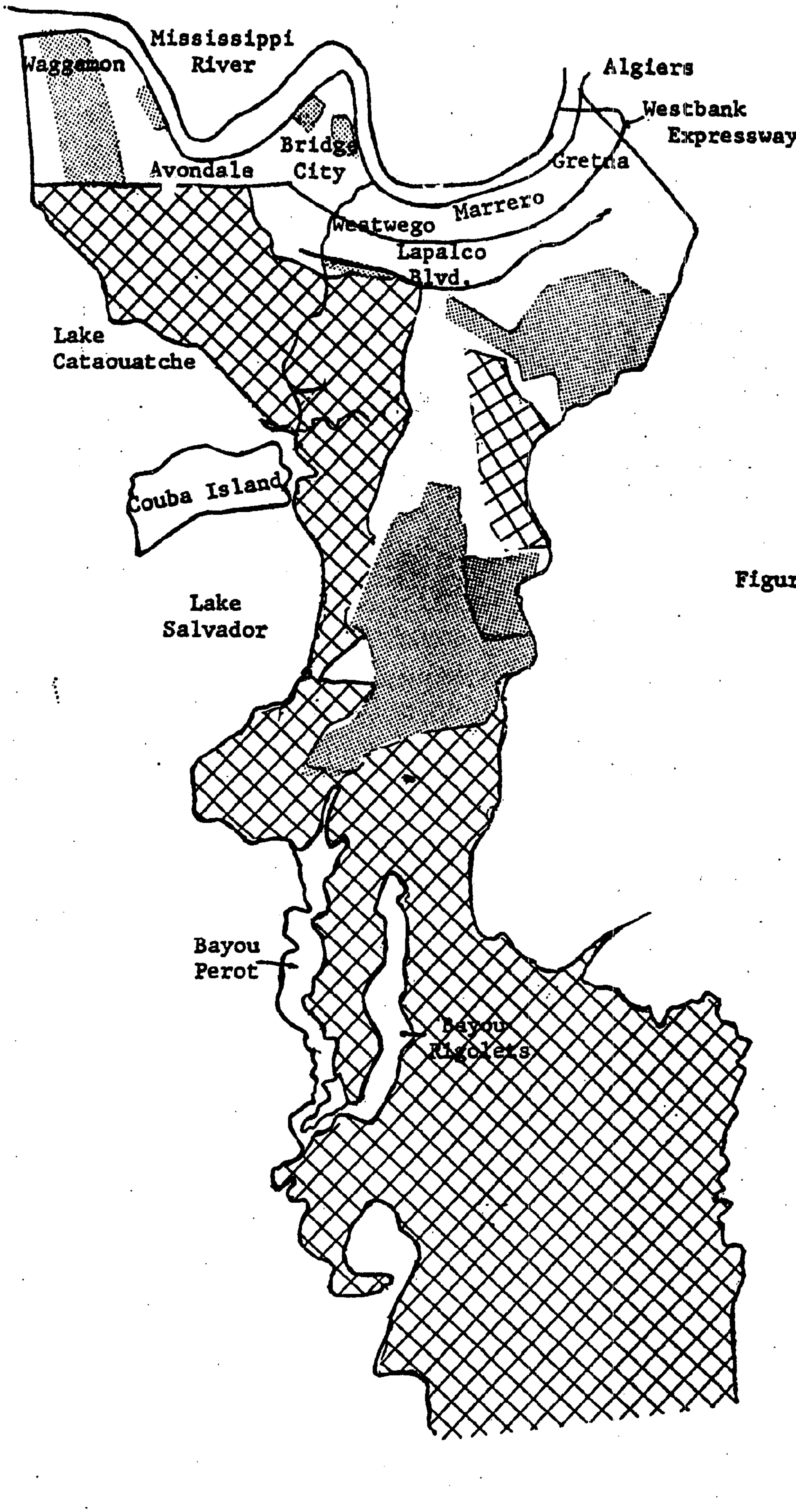

Figure 2.2 Parish of Jefferson

Southcentral Portion

Legend

U-1 Zoning

S-1 Zoning

of Lapalco Boulevard from Westwego to Waggamon the same zoning (S-1 and U-1) is applied. Generally vacant land near developed residential areas are zoned S-1. Outlying vacant lands are zoned U-1. Obviously, Jefferson Parish intends to develop its wetlands.

ST. BERNARD PARISH

St. Bernard Parish, like Jefferson, relies on its Comprehensive Zoning Ordinance which is in accordance with the regional Interim Land Use Plan to guide future land use. Most of St. Bernard Parish may be described as open marsh (Maps 4 and 5). The wetlands in the Parish are zoned A-1 rural. All uses permitted within residential, commercial, and industrial districts are allowed in A-1 zoning. The Parish Board of Adjustment may permit utilities, airports, and recreational development in the wetlands (St. Bernard Parish, 1971: 21).

ST. TAMMANY PARISH

Wetlands in St. Tammany Parish run along the Pearl River Flood Basin and Lake Pontchartrain (Maps 1 and 4). There are also small "islands" of wetlands within the center of the Parish. The regional Interim Land Use Plan projects that the "islands" of wetlands adjacent to cities will be urbanized. The major wetland areas are to remain undeveloped. There is no comprehensive zoning ordinance for St. Tammany Parish. Development of wetlands in the unincorporated areas may take any form.

ST. CHARLES PARISH

St. Charles Parish is not part of the New Orleans SMSA but it is adjacent to the SMSA and feels the pressures of urbanization. Therefore, a brief summary of existing and future land use for the parish is indicated. Two thirds of St. Charles Parish is wetlands (Maps 1 and 3). From Lake Pontchartrain to the roadbeds of the Illinois Central Railroad north of the Mississippi River, except for the strip development along Louisiana State Highway 18 and U.S. Highway 90 south of the Mississippi River, the parish remains marsh or swamp. The Existing and Future Land Use for St. Charles Parish was issued in June, 1974. It states that parish officials should strive for a better functional relationship between industrial, commerical, and residential land uses near existing thoroughfares. Wetland areas not currently proposed for development should be protected from pollution, fires and inappropriate uses (no examples given) by Parish and State agencies (N-Y Associates, 1974: 2-14). The study did not go into metropolitan growth in St. Charles such as extension of New Orleans Airport or I-410. Parish growth and retainment of the wetlands are divergent goals and unfortunately, the goals of the parish have not been made clear by the land use study.[4]

CONCLUSION

There is little harmony between zoning and land use plans in the state's metropolitan areas.

[4]The St. Charles Parish Planning Commission is currently revising the parish's zoning ordinance (St. Charles Police Jury, 1975).

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CHAPTER 3

THE IMPACTS OF URBAN DEVELOPMENT ON THE WETLANDS

INTRODUCTION

Man has inhabited much of the Louisiana coastal zone for thousands of years, doing little or no damage to the productive ecosystem of the wetlands. Since about 1700, however, modern man has greatly extended his range and influence in the coastal areas of Louisiana. Some of this influence has been to the detriment of the natural systems that pre-existed modern man in the area. Modern technology has accelerated the pace of urban expansion and the resulting destruction of valuable wetlands.

This chapter focuses on the three main activities of man that have detrimental effects on our coastal zone--pollution, reclamation, and channelization. These activities stress the biologic system that operates effectively to produce a plethora of living entities, many of which are extremely valuable to man. If our coastal areas are to continue to function at anywhere near their present levels of productivity, then these three activities of man must be wisely managed if the coastal zone is to be reclaimed for its greatest benefits.

Water pollution is an indirect contributor to estuarine loss. No actual wetlands are destroyed by pollution, but there exists, in polluted waters, massive interference by pollutants, with the essential cycle of life in the system. Reclamation is a direct destroyer of estuarine land. When land is drained and/or filled, it is lost to the system. Repercussions are felt in other parts of the estuary in many ways such as pollution, decreasing fish populations, reduced plant growth, etc. Canals and channelization destroy the broad interface between fresh and saltwater by shortening the distance water has to travel and allowing greater volumes of water to flow into and out of the wetlands due to increased capacity of the canals. Channelization also shortens the rich fringe marsh area. (A straight canal has less marsh contact than a sinuous natural channel.)

These three activities have combined to put tremendous pressure on the natural ecosystem of the wetlands but before these activities are considered individually, a brief description of the natural processes that form the ecological web of our coastal zone is given.[1]

THE ECOLOGICAL WEB OF THE COASTAL WETLANDS

A CIRCULAR TECHNOLOGY

Commoner (1971) has described the natural cycle of life as:

> The reciprocal interdependence of one life process on another; the natural interconnected development of the earth's life system and the nonliving constitutents of the environment; the repeated transformation of the materials of life in great cycles drawn by the energy of the sun. (Commoner: 1971: 17)

He stresses that the natural system is a circle, or perhaps, even better, a chain. Each link supports the next and they all return back again to repeat

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[1]Gagliano et al. (1973b) have listed primary causes of environmental deterioration in wetlands as:

(1) flood control and navigation improvement
(2) mineral extraction
(3) accelerated subsidence
(4) urban encroachment into wetlands
(5) water pollution

In the classification used in this study, deterioration factors 1, 3, 4, and 5 are put under the general category of reclamation. Factor 5 is the same as the pollution category. Factors 1 and 2 are covered in the category labeled canals and channelization. Obviously there are overlapping categories.

the process. In the real world, some links are larger than others, but once the chain is broken, drastic consequences occur.

Another analogy could be to compare the wetlands and the stress on them to a group of animals vs. two elephants involved in a tug of war. The two elephants represent natural and man-induced stresses on the environment pulling against the other side, the self-regenerating ecosystem of the wetlands. In my example, this ecosystem is represented by 5 oxen, 3 horses, and 2 men. If an ox is removed from the ecosystem side (side A), then the rest of the animals have to work harder to maintain a balance with side B (the stresses). There exists a point, however, beyond which removal of another animal collapses resistance and side A loses the tug-of-war. Conversely, if elephant 1 (man-induced stress) reduces his pull, then the system (side A) slacks until a new equilibrium is reached. Unfortunately, side B, especially elephant 1, is exerting so much stress on side A that the system is in danger of rapidly succumbing to the appetites of side B.

The question to be answered in this section is how is side A "set up?" How does this system work and later how is it in danger of being destroyed? Figure 3.1 illustrates in a general function diagram how the marsh estuary system is set up and how it functions. It is quite plain from this diagram that removal of any element or elements would cause rearrangement of the system to a new equilibrium. Nature has evolved the estuary to take advantage of natural conditions to produce the maximum possible life production in this environment. Tampering with this environment may lead to decline in productivity since the system operates at maximum efficiency.

ZONES OF BIOLOGIC ACTIVITY

There are three main zones of biologic activity that comprise the marsh-estuary system (Figure 3.1). These are: 1) Marsh, 2) sediment, and 3) water.

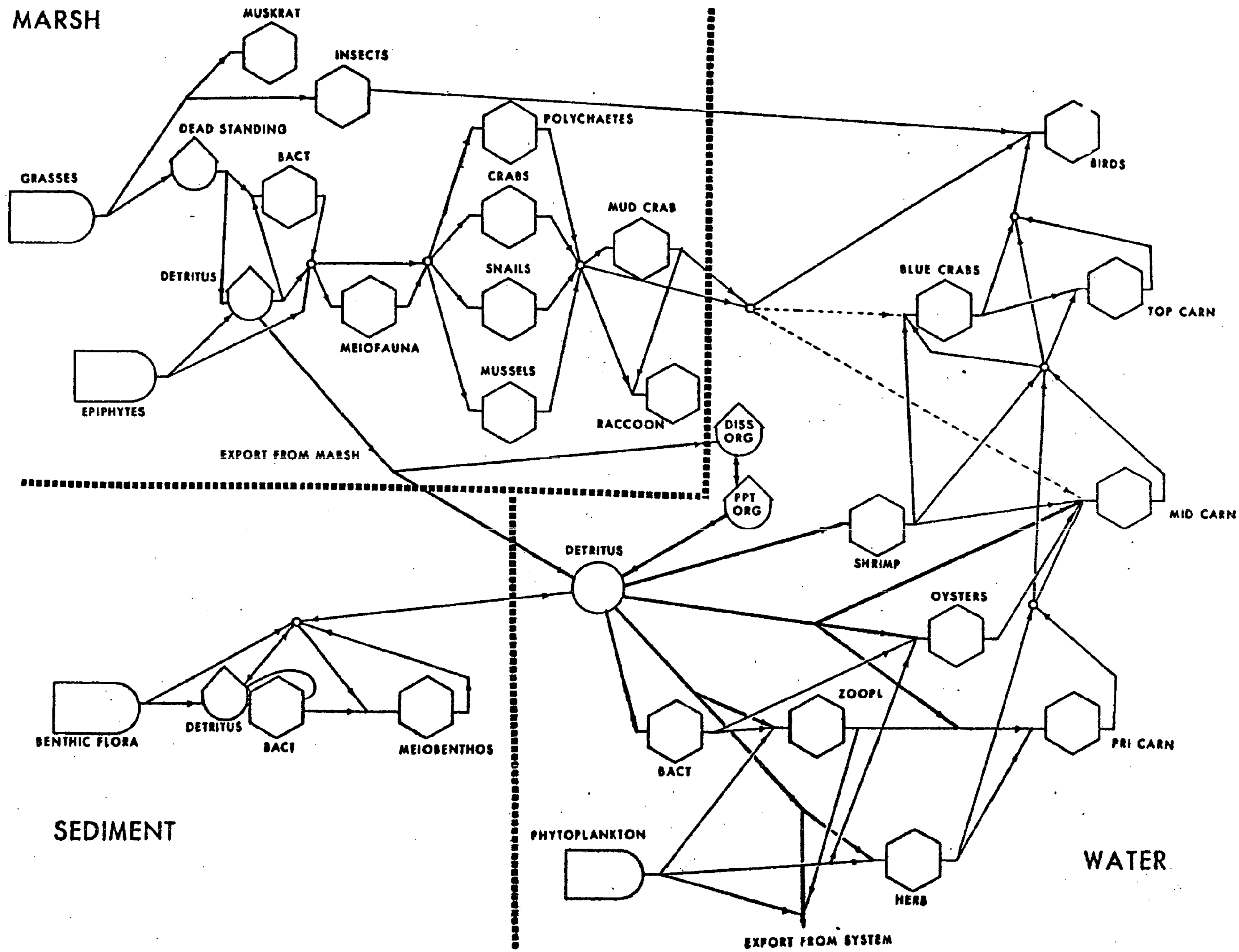

Figure 3.1. Biologic activity in the marsh-estuary system.
Source: Day et al., 1973: 63

Each is dependent on the other for continued productivity. Day (et al.) (1973) has devised a method of collecting the various living consumers in the wetlands into three categories: 1) packagers (primarily in sediment), 2) regulators (primarily in water) and 3) regenerators (in marsh and water).

Packagers organize organic material into forms available for convenient transfer to higher trophic levels (life requiring higher forms of nutrition). These packagers may be autotrophs (they make their own food) or heterotrophs (they consume primary plant matter). Cord grass (Spartina) and phytoplankton are examples of the former; snails and zooplankton are examples of the latter.

Regulators are organisms with generalized feeding habits. They regulate populations by feeding on the most abundant food sources. Regulators have longer life spans and larger individual sizes than packagers. They are also highly mobile. Regulators are subdivided into two classes: subsystem regulators and whole system regulators. Subsystem regulators feed on specific organisms, thus controlling specific populations. Catfish, blue crabs, shore birds, drum, croaker, etc. are considered subsystem regulators. This level (subsystem regulators) is analogous to mid-level carnivores. Whole system regulators feed on subsystem regulators as well as what the subsystem regulators feed on. Thus, they regulate the other regulators. This group includes animals such as trout, racoons, most birds, and man. There is little predation on these organisms (also called top carnovores), except by man who, of course, has assumed the role of the regulator of the entire system.

The Regenerators take waste from all sources and regenerate these wastes back into nutrients to start the whole cycle over again. Bacteria, yeasts, etc. are examples of this type of organism.

Table 3.1 illustrates some examples of each type of organism. It is by no means implied that these categories of life are rigid. There are organisms

TABLE 3.1

ECOLOGICAL ROLES OF SOME ESTUARINE SPECIES

PACKAGERS	REGULATORS	REGENERATORS
Spartina	Mature Fish	Bacteria
Benthic Algae	Poporsus	Yeasts
Periphyton	Pelicans	Molds
Phytoplankton	Herons	Meiofouna
Killifish	Egrets	Protozoa
Shrimp	Gulls	
Fiddler Crabs	Comb-jellies	
Juvenile Fish	Raccoon	
Marsh Snails	Man	
Modiolus		
Oysters		

Source: Day et al., 1973.

that function in more than one capacity. What these categories attempt to do is to point out the organism's primary function in the estuary. This enables the larger scheme of life to be assembled more simply to give the reader a more general, but fairly accurate, view of the circle of life.

The life cycle and the nonliving aspects of the environment can be diagnosed also. In Figure 3.2, the energy flows in the Barataria Bay section of the estuary known as the Barataria-Salvadore-Des Allemands system are shown. This diagram includes nonorganic inputs as well as removal, artifically, by man (e.g. pollution stress and fishing). Although this diagram includes man in the current system, it only includes him in the natural cycles as an extractor (fishing) and as a polluter of water. His activities, as later shown, enter the system at almost every point and, in fact, have greatly altered the entire system. On the diagram, even a small thing such as dredging has a profound effect on the whole range of activities in the marsh as we shall see later. An interesting aspect of this diagram is that Man, Pollution Stress and Dredging are grounds (symbolically). They effectively eliminate energy from the system and cause it to operate at a lower level than it would if it were not subject to stress.

In the next three sections, the problems created by these stresses are addressed and how they are hindering the cycles of the wetlands and, in fact, destroying the wetlands are shown.

URBAN WATER POLLUTION AND THE WETLANDS

TYPES OF WATER POLLUTION

There are two ways that the coastal waters can get polluted. These are by Man and by Nature. Nature is constantly shifting production from one area of an estuary to a new one. A good example of natural pollution would be the

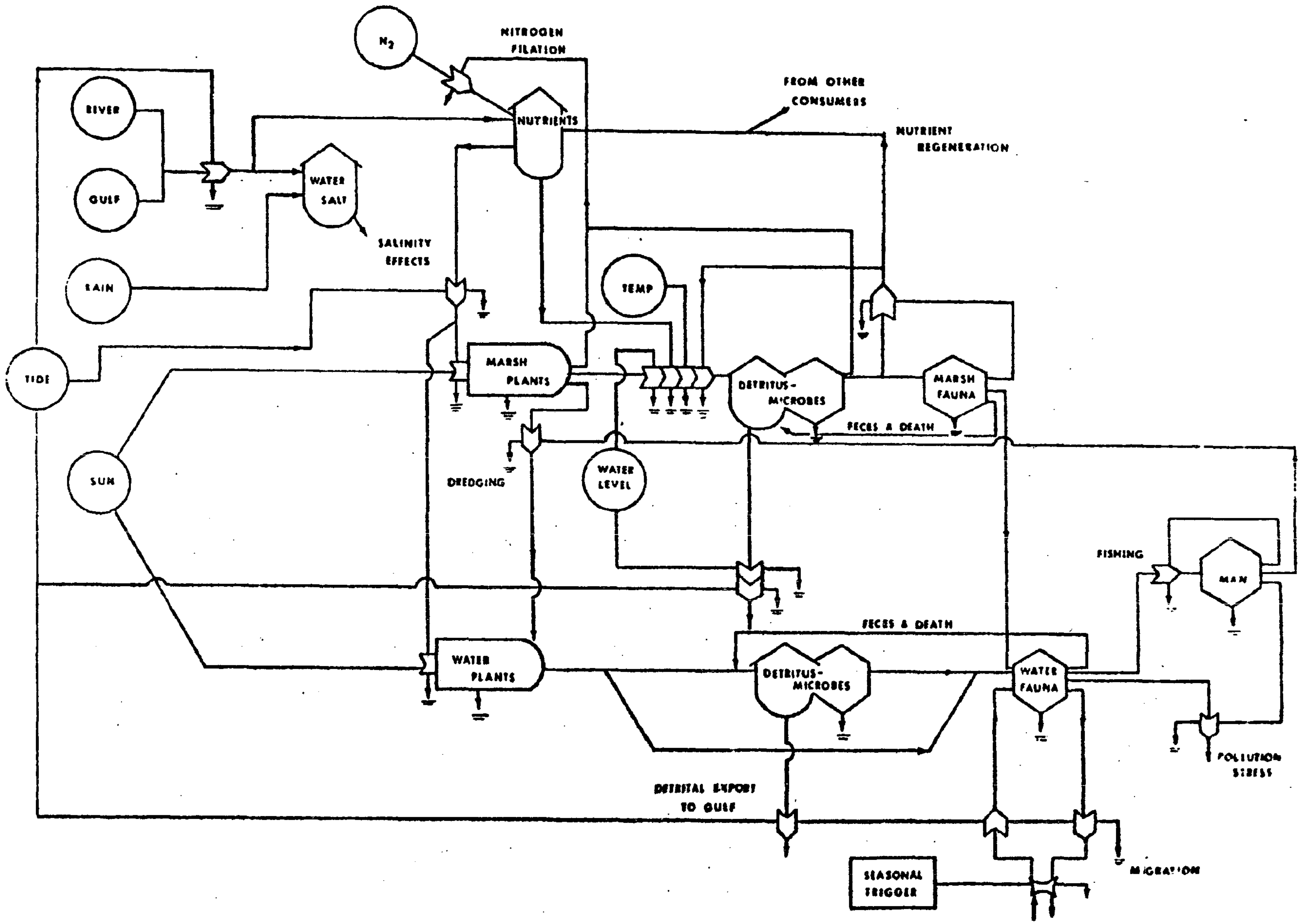

Figure 3.2. Energy flow diagram of the marsh-estuary system in Barataria Bay showing the most important processes and interactions. See text for discussion.

[redacted]ce: [redacted]y e[redacted]l., [redacted]3: [redacted] shifting of a distributory channel of the Mississippi River. The area that lost the freshwater input and sediment would begin a slow deterioration, but would increase its productivity temporarily. Day (1975) has concluded that an estuary reaches peak productivity shortly after being abandoned by its feeder distributory stream. After a delta complex is deprived of most of the previous sediment influx, seaward extension of the delta will give way to shoreline retreat caused by wave action and subsidence. The sea will encroach upon the delta resulting in partial drowning of the interdistributory basins producing a multitude of bays. The bays are confined to the skeletal framework of natural levee ridges in the beginning.

The result of this occurrence is a highly irregular shoreline resulting in a broader mixing zone along the fringe marshes. The length of interface together with the areal land-water ratio are major factors in determining biological productivity of the estuary. Eventually (especially if the shores are not well protected from wave erosion) the levee ridges subside and erode and whole estuaries merge and disintegrate back into a marine environment. Therefore, maximum productivity occurs after the river abandons the delta complex but before severe deterioration breaks up the wetlands and reclaiming it as open water (Gagliano et al; 1973b, 44-45). An estuary like the Pontchartrain-Maurepas-Borgne estuary in an advanced state of deterioration again drops in productivity as the environment slowly changes from an estuarine to a marine system.

The new area now being saturated with sediment by the relocated channel loses much of its flora and fauna due to drastic changes in salinity and turbidity of the water (pollution). At first, the highly turbid water blocks essential sunlight from the primary plants that are at the bottom of the chain of life. If that does not kill the plants, then salinity change does.

Organisms adapted to a certain range of salinity are replaced by others adapted to being near an active distributary system. This is a temporary thing and soon the estuary re-establishes a new equilibrium point with little change in overall productive capacity. Sediment contains nutrients both organic and inorganic that are basic to the chain of life in the wetlands. Once the newly flooded riverine area readjusts, it can regain productivity of a different type while the other estuary related to the former channel would assume the duties of the one recently flooded. The key to natural pollution not causing any lasting effect is that it <u>is</u> natural. Nature, by definition, can accommodate any natural phenomenon that occurs.

Long before man spilled oil, it leaked in many places into the environment. It is biodegradable, so no matter what it does initially, something can use it and degrade it into other useful products. Life as we know it developed to exist with most of the natural compounds that exist on earth. Man, however, has produced and refined chemicals and elements that nature has no way of returning to the system once they are produced. Some of these chemicals merely accumulate; others destroy life functions. Examples of some of the man-made nondegradable pollutants that might find their way into the drainage water pumped from New Orleans out to Lake Pontchartrain are included in Table 3.2. This is obviously only a partial list, but it points to the kind of linear technology that produces-uses-then discards things that cannot be recycled into the natural environment.

Mercury is a byproduct of the production of chlorine gas which is used for many industrial processes. When mercury, in its elemental state (unknown in the environment), is released into the water by effluent discharges, bacteria convert the metallic mercury into a soluble form, methyl mercury. The chemical processes that are life cannot use mercury; in fact, it inhibits these processes

TABLE 3.2

DANGEROUS EFFLUENTS IN URBAN DRAINAGE WATER

NONDEGRADABLES	DEGRADABLES
Glass	Petroleum
All Plastics	Natural Fibers
Mercury	Phosphates
Lead	Steel
Zinc	Nitrogen Oxides
Copper	Paper
Sulfuric Acid	Cellulose
Synthetic Insecticides	Nitrogen
Synthetic Detergents	Fertilizers
Synthetic Fibers	Carbon Monoxide
Some Drugs	$N.O._2$
Asbestos	
Aluminum	
all nonnatural organic compounds	

Source: Commoner, 1971 .

so the mercury not absorbed is stored. It is passed up the food chain until it reaches debilitating or lethal levels. Eventually, it may form compounds as it does in nature, but for all practical purposes, it is a permanent pollutant (Commoner, 1971).

Plastics (that are derived from petroleum) are examples of man-made compounds that cannot be degraded in the natural environment. They are not inherently poisonous but accumulate because of their persistence, causing a crowding-out of plants and other bottom dwellers in water that they are dumped into. For example when weathered into small pieces, styrofoam (a plastic) can cause gill impairment in fish. This particular plastic has been found in the middle of the Atlantic Ocean and in Antarctica indicating that accumulations of these man-made items is widespread (Commoner, 1971).

One way in which a city contributes to pollution in the wetlands is through storm drainage. The next section considers this with regard to New Orleans. When this happens in other cities, the results are similar.

URBAN STORM DRAINAGE

The City of New Orleans is built along the banks of the Mississippi, partly on the natural levee of the River and mostly on swamp and marsh (former wetlands) on the Pontchartrain-Maurepas-Borgne estuary system as well as the Barataria-Salvadore-Des Allemands estuary (west bank). Due to various factors that are discussed in detail later, much of the City is at or below sea level (by as much as -9 feet mean sea level in some areas). Some of the City annually recieves about 57" - 63" of rainfall. With an average runoff of about 24", there is need for a powerful and sophisticated pumping system to rid the City of water that falls within the levees that keep out the lakes and the river (Schambach: 1974 and Muller: 1974). New Orleans is like a bathtub surrounded by water with water running into it. Turn off the pumps and the

City may flood with each rain. The easiest place to put the water is in Lake Pontchartrain, which is at sea level. It would be too costly to pump into the river, which can have a surface elevation of up to +17 feet m.s.l.

The Sewerage and Water Board of New Orleans, that has the responsibility of keeping 57,455 acres of the New Orleans Metropolitan area (in Orleans Parish) dry, must pump approximately 5.01×10^9 cubic feet of water each year into Lake Pontchartrain to maintain the City (Sewerage and Water Board, 1973). (See Figure 3.3.) This water contains most of the elements listed in my Table 3.2 plus some raw sewage that seeps into the system. Besides removing about 250 square miles of feeder marsh from its basin, the City has dumped a heavy load of both biodegradable and nonbiodegradable effluents into the shallow and brackish lake.

The results could have been far worse than they have actually turned out to be for the Industrial Canal has helped keep the Lake cleaner than it would have been otherwise. This canal is connected to the Mississippi River Gulf Outlet (MRGO) and runs directly into the Gulf of Mexico. Due to tidal action, much salt water flows into the Lake each day during high tide.

> Since the Mississippi River Gulf Outlet opened in 1963, salinities have increased in Lake Pontchartrain and Lake Borgne, due to inflow of more saline waters from the Gulf. Mean annual chlorides from eastern Lake Pontchartrain for a 5 year period after the opening of the MR-GO are two to three times higher for a similar prior period before the opening of the outlet. (U.S. Army Corps of Engineers, 1974b: II-15)

The two natural passes (Rigolets and Chef Menteur) would not ordinarily provide the great flushing action that the water provides. Water pollution may be diffused and rendered less harmful due to man-made alteration. Of course, this alteration has definitely increased salinities in the Lake and changed the ecological character of much of the life there, but perhaps, at least, it

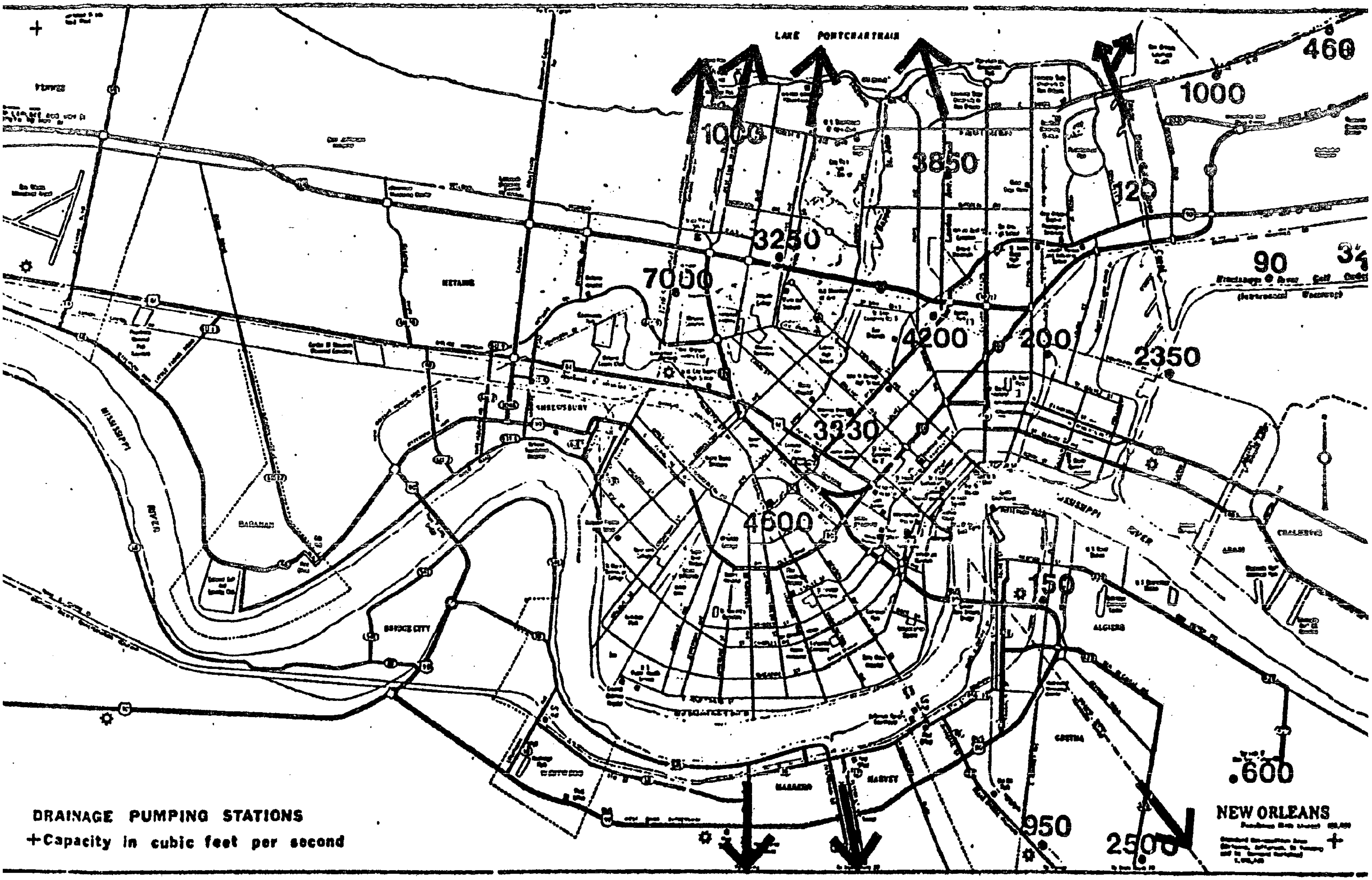

Figure 3.3. Drainage water pathways in New Orleans.*

*Arrows indicate pumping stations.

Source: City of New Orleans, Sewerage and Water Board: 1972.

forstalled serious pollution that may have occurred without it (U.S. Army Corps of Engineers, 1974b: II-18).

The artificial increase in salinities in Lake Pontchartrain caused by the MRGO is an example of a man-induced natural pollution (saltwater). The flora and fauna around the Lake have developed to tolerate brackish water. A sudden increase in salinities causes nonsalt-tolerant plant species (and the animals that feed on them) to die off. They eventually would be replaced by more salt-tolerant species until the system is in balance again. The detrimental aspect of this is that plant succession could take well over 100 years and in the meantime, a drop in productivity would be expected as the changeover is being accomplished. The key here, though, is that there is no unused accumulation of a foreign substance (such as plastics) that is an endproduct irreversible and unchangable. Nature accommodates drastic natural changes with its natural components that exist within it. The introduced man-made components are what cause much of the trouble and irreversible ecological damage such as extinction of animal species or permanent accumulation of nonbiodegradable and/or poisonous man-made substances.

Although saltwater may help cleanse the Lake, the sewage seepage can still cause problems. The sewerage and other nutrients may cause unnatural algal blooms that cannot maintain themselves when the nutrient supply is shut off (during dry weather, for example). This algal bloom dies and it's decomposition removes oxygen and adds amonia and nitrite compounds to the water. This either kills fish or drives them away. Another aspect of water with high nutrient content (in the form of sewerage) is the high rate of pathogenic organisms such as coliform and salmonella bacteria. Persons who swim in the Lake after the City has had a heavy rain run the risk of contracting hepatitis or serious infections from cuts or swallowed water. The Lake has been closed several times due to the threat of infection from this bacteria.

A minor problem, but still a nuisance, is the garbage that is directly dumped into the Lake by the good citizens that use the lakefront. Cans, bottles, food, etc. are thrown off the seawall daily. The food can be used in the environment, but the cans and bottles pose a hazard to anyone who ventures into the water.

On the west bank of the City, drainage water is pumped southward into the Barataria-Salvador-Des Allemands estuary system (Figure 3.3). Currently, urbanization has not yet posed an overload problem to this area, but if the new Mississippi River bridge and the I-410 expressway are constructed, development relating to these projects could cause population expansion with resulting extra pollution caused from runoff from the newly developed areas. If this new wetland area is developed, the resultant landscape will resemble that of New Orleans, with a high natural levee and very low reclaimed marsh that would have subsided as a result of becoming drained. This would entail a large pumping system that would seek to pump water to the easiest place available, i.e., the sea level marshes and swamps of the Barataria-Salvador-Des Allemands estuary, not the River with a natural levee crest of +14 feet and a river stage that varies from sea level to as much as +17 feet during flood stage. These waters would contain the same pollutants as New Orleans waters as they are pumped south. Lake Salvador and other smaller lakes would receive increased pollution and probably have greater problems than Lake Pontchartrain, due to the fact that this lake has a slow water exchange and could not flush out pollutants as fast as Lake Pontchartrain could. In any event, this water would work its way south along natural and man-made channels until it reached the lower estuary where all the productive fisheries are. It is not known at this time what the effects of this added pollution would do to the estuary in terms of productivity, but one can safely be assured that organisms would concentrate the heavy metals and the upper estuarine lakes would experience speeded up eutrophication. The local papers already have run articles about pelicans killed as a result of pesticide pollution from Mississippi River water (Brumfield: 1975). What added pollution stress will do is still debatable. Fish could be killed, lakes undergoing eutrophication would decline rapidly, etc. One could reasonably be sure only that the effect of this added pollution would be adverse.

URBAN LAND FILL OPERATIONS

The City of New Orleans has historically used the land-fill method for disposing of some of its garbage. The land fill provides a convenient storage area for the large amounts of waste that otherwise would be burned in incinerators, causing increased air pollution. The fill also provides cheap new drained land. It is far less expensive to use compressed refuse to fill a wetlands area than to haul in sand, silt, or other fill. According to Garland Colvin (1975) of the U.S. Soil Conservation Service, this burned compressed refuse may actually provide a firmer foundation than most of the marshy soils in the area.

Unfortunately, there are many adverse effects associated with land fill operations. One of these is severe water pollution. Decaying garbage breeds large quantities of coliform and salmonella bacteria. During heavy rains (which are quite common in the New Orleans area most of the year), this highly polluted, nutrient-rich water is washed into Bayou Bienvenu and then into Lake Borgne. Off and on for many years, the oyster beds in Lake Borgne have had to be closed to harvesting due to abnormally high bacterial counts, stemming from the runoff associated with the large land fills on Paris Road in St. Bernard and eastern Orleans Parish. This pollution killed some oyster beds and rendered some beds unusable due to the risk of infection or disease from the consumption of these shellfish. In 1969, in the Hopedale, Cocodrie, and Atchafalaya Bay area, there were 139,905 acres of land closed to shell-fishing. Of this, 884 acres were of oyster leases (Perret et al., 1971: 22).

POLLUTION FROM THE MISSISSIPPI RIVER

The Mississippi River is the largest river in the United States. It has the third largest drainage basin in the world, exceeded in size only by the watersheds of the Amazon and Congo. It drains 41% of the 48 contiguous states of the United States. The basin covers over 1,245,000 square miles and drains all or parts of 31 states and two Canadian provinces (Corps of Engineers, 1973a). The drainage basin resembles a funnel with the spout at the Gulf of Mexico. New Orleans is located in that spout. South of the confluence of the Red-Ouachita Rivers with the Mississippi, the River is virtually a canal with no drainage inputs all the way to the Gulf of Mexico.

The Mississippi River receives pollutants in every conceivable form. From steel mill wastes in Ohio to pesticide and fertilizer runoff on the Great Plains; from raw sewage contributed by most cities along the River to petrochemical plants that line its banks along the lower valley; the River serves as a sewerage line. The heavy metal content of the water (lead, mercury, iron, etc.) is very high and there are traces of many cancer-causing compounds such as pesticide residues to be found even after the water has been purified.

New Orleans adds to this pollution by dumping largely untreated sewage into the River. Many chemicals as well as large amounts of oil are inadvertently spilled into the River through the loading and unloading operations associated with the port of New Orleans, the third largest in the world. As an example, a story in the Times-Picayune reported that approximately 50 gallons of the potent pesticide Methyl-Parathion leaked into the River during loading operations (Ott, 1975). Several longshoremen were overcome by fumes and had to be hospitalized. Contact with the pesticide can be lethal because it can be absorbed through the skin. This type of incident is not unique and contributes more chemicals to a river already overburdened with them.[2]

If the currents off the Louisiana coast were more favorable to Louisiana, perhaps the river water would be diluted at sea and its damage minimized. Unfortunately, the predominant drift of water is east to west along the coast so the lower estuary is exposed to this polluted water constantly. After the river water is discharged from the mouth of the delta, the sediment and water begin a slow drift toward Texas. This is one of the reasons why the water off the Louisiana coastline is usually quite turbid. All types of organisms absorb the pollutants carried by the river water as it filters through the coastal bays and marshes of the Louisiana coastline (Day, 1975). If the water currents carried the river water further southward, at least the Gulf could dilute the pollutants before they infiltrated productive wetlands. If the water currents were west-to-east, then Mississippi, Alabama, and Florida would have Louisiana's problem. In this case, however, there are no larger estuaries to pollute in the eastern direction.

The recent mass deaths of brown pelicans off the Louisiana coast (Brumfield, 1975) at the southern end of the Barataria-Salvadore-Des Allemands estuary has been attributed to acute pesticide concentrations from Mississippi River water. Brown pelicans eat fish and the fish apparently had concentrated the pesticide residues in the River to such an extent that there was a dosage sufficient to kill the pelicans when they ate the fish. It is important to realize that New Orleans residents drink the water that contains these residues daily.

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[2]Two good examples of pesticide poisoning are DDT and Mirex. Juvenile blue crabs do not survive in waters containing more than 5 parts per <u>billion</u> DDT. Mirex, another pesticide is toxic to juvenile blue crabs either by contact, or by eating grass shrimp poisoned by it (Juworski: 1972, 94). DDT, although banned, is still loaded at the Port of New Orleans for other countries. Mirex is still used in Louisiana.

Table 3.3 presents an analysis of a water sample taken from the New Orleans water intake on April 5, 1972 and April 26, 1972. This is only a partial listing. Many more chemicals are found in trace amounts that vary considerably from time to time during the year in the River.

SUMMARY

To summarize, water pollution from the major urban area in the wetlands (New Orleans) come from these four sources:

(1) drainage water

(2) sewage

(3) refuse land fills

(4) dumping into rivers

Lafayette, and Lake Charles to a greater or lesser extent are involved with some of the above activities resulting in water pollution (U.S. Army Corps of Engineers, 1973). These pollutants either accumulate (plastics), poison (pesticides), or distort normal natural processes (algal blooms from sewage). The fragile web of the ecosystem can be distorted or broken by attack from many sides. Eliminate a predator fish and the former prey may explode in population and consume all the food, thus starving other life forms. Cause algal blooms and this causes lethal levels of amonia and nitrite compounds that kill many sessile organisms like clams and oysters and drive the mobile ones elsewhere. Pollution of water probably does not eliminate many organisms from the food chain, but distorts the system by adding too much nutrient or reducing the numbers of regulators (like fish) so that the system does not function properly. Water pollution together with reclamation (which will be discussed in the next section) upset the system with stresses that could, in the near future, cause a complete collapse of the wetlands as now known.

TABLE 3.3

ANALYSIS OF NEW ORLEANS INTAKE WATER SAMPLE

Dissolved Silica	(SiO_2)	(mg/1)*	5.8
Iron	(Fe)	(μg/1)**	90
Calcium	(Ca)	(mg/1)	44
Magnesium	(Mg)	(mg/1)	12
Dissolved Sodium	(NA)	(mg/1)	17
Dissolved Potassium	(K)	(mg/1)	3
Bicarbonate	(HCO_3)	(mg/1)	118
Dissolved Sulphate	(SO_4)	(mg/1)	70
Dissolved Chlorine	(Cl)	(mg/1)	21
Flouride	(F)	(mg/1)	.4
Nitrate	(N)	(mg/1)	1.6
Dissolved Solid Residue	---	(mg/1)	257
Ph	---	----	7.3
Dissolved Oxygen	(O_2)	(mg/1)	7.5
Chromium	(Cr)	(μg/1)	0
Nickel	(Ni)	(μg/1)	12
Copper	(cu)	(μg/1)	5
Lead	(Pb)	(μg/1)	10
Zinc	(Zn)	(μg/1)	10
Cobalt	(Co)	(μg/1)	6
Mercury	(Hg)	(μg/1)	.5
Manganese	(Mn)	(μg/1)	4
Strontium	(Sr)	(μg/1)	150
Lithium	(Li)	(μg/1)	10
Cadmium	(Cd)	(μg/1)	2
Aluminum	(Al)	(μg/1)	100

* mg/1 = milligram/liter
**μg/1 = microgram/liter

Source: U.S. Army Corps of Engineers, 1973b

THE EFFECTS OF URBAN LAND RECLAMATION ON WETLANDS AREAS

HISTORY OF URBANIZATION IN THE NEW ORLEANS AREA

Primitive Cultures

According to Dr. Richard Shenkel (1974), evidence gathered from archaeological research on Little Oak and Big Oak islands in eastern Orleans Parish[3] indicate human habitation in this area as early as 500 B.C. These peoples left only a few artifacts and shell middens as proof of their existence in the area. They lived with nature. It provided them with all the things they valued as necessities. They existed much as all the other organisms of the wetlands: within the framework of the ecosystem. In Figures 3.1 and 3.2, they could be classified as "top carnivores" or whole system regulators. Since they blended with the wetlands instead of attempting to fit the wetlands to their needs, there was no incompatability and the ecosystem was not altered.

Modern Man

When the French explorer Bienville decided that the new colony in America needed a city, he chose a spot of high ground about ninety miles upriver from the mouth of the Mississippi with good access to Lake Pontchartrain. The site he chose was +14 feet above sea level on the natural levee of the Mississippi. This site was to eventually become New Orleans.

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[3]Little Oak and Big Oak islands, according to Gagliano and van Beek (1970) are part of a fossil chain of barrier islands that once extended east-west through the Gulf of Mexico where New Orleans is now located. As the Mississippi built its St. Bernard Delta lobe, they became buried by sediment or, at least, surrounded by marsh as sedimentation converted open water into flood plain. Geological subsidence of the whole area has caused some of these islands to become completely buried. Two islands (in eastern New Orleans) that avoided this are Little Oak and Big Oak islands. After the River abandoned the St. Bernard Delta complex and subsidence and erosion began to reclaim the land, these two islands remained high and dry and provided a perfect campsite and base of operations for the primitive fishermen and hunters. There was shelter and dry land here, two items that were at a premium in a marsh environment.

As is the case of all natural levees, for most of the year they are indeed dry and suitable for the type of culture that the French brought with them (streets, permanent buildings, etc.). During peak floods, however, the River overflowed even here and deposited water and silt in many homes. This situation became even more critical as the fledgling city expanded away from the River. As is the case with all natural levees, elevations decrease fairly rapidly away from the River so that a little over a mile from the River the land is at sea level and would flood easily both from the River and the Lake. To protect the residences from these floods, Bienville had his engineer, Sieur de la Lour, construct a series of protective levees to keep the town dry during the spring floods. By 1735, the levee lines on both sides of the River extended from about 30 miles above New Orleans to about 12 miles below the City. By 1812, levees extended upriver to Baton Rouge on the east bank and 40 miles beyond Baton Rouge on the west bank (U.S. Army Corps of Engineers, 1970). It was this early system that initiated the pattern that still persists today of alteration of wetlands areas in order to sustain our type of culture in estuarine areas. As soon as the river water was stopped from overflowing, the basic building block of the delta (sediment) was removed, the nutrient base was lessened, and freshwater input was restricted to the estuarine areas behind the levees.

As New Orleans grew, it began to expand north away from the natural levees and into the backswamps that were always under water. To anyone who lived here, high tides from the Lake as well as floodwaters from the River were a constant threat. The settlers were forced to make only limited inroads into this area due to their inability to change this environment to suit their needs.

With the perfection of mechanical pumps in the late 1800's, these problems were solved. Now it was possible to build a levee and artificially drain an area and keep the water out by channeling it into leveed sea-level canals for transport to the Lake. Between 1879 and 1915, the city spent $27,500,000 constructing water, drainage, and sewerage facilities for the expanding city as well as reclaiming large tracts of swamp and marsh in the Gentilly area (Swerage and Water Board, 1973). By 1927, the east bank of Jefferson Parish had been drained also (Engineering News Record, 1927: 514). Now, not only were the wetlands being deprived of the River, but they were systematically being sectioned off and drained, destroying them completely. Since the natural levee was quite narrow and settled very early, the pattern of urbanization in New Orleans has been to reclaim wetlands first to the north to Lake Pontchartrain, then to the west in Jefferson Parish, and now to the east in Orlandia. The question is what does this removal of land from the estuarine ecosystem do to the system as a whole.

EFFECTS OF RECLAMATION

The following is a list of cause-effect relationships that can be attriuted to reclamation of wetlands in Louisiana:

(1) Irreversible loss of land to the estuary

- (a) Loss of habitat for birds, fish, reptiles, etc.
- (b) Loss of nursery area for birds and fish
- (c) Loss of detritus to the estuary
- (d) Loss of nutrient input into the estuary
- (e) Resultant loss in natural productivity
- (f) Loss of fresh water

(2) Loss of productive capacities that benefit man

- (a) Reduced assimilative capacity of water to absorb pollutants
- (b) Reduced commercial and sport fishing activities due to decreased total productivity
- (c) Loss of relatively cheap, effective municipal sewerage treatment by wetlands
- (d) Accelerated loss of wetland to the ocean
- (e) Loss of a buffer zone against tropical storms

The man-induced stress of reclamation has been the major cause of all the preceding negative effects on Louisiana's wetlands. The following is a discussion of these effects as to how they occur and why they are so destructive to Louisiana's estuarine system.

LAND LOSS TO THE WETLANDS DUE TO RECLAMATION IN THE NEW ORLEANS AREA

Reclamation to the Present

According to the U.S. Soil Conservation Service, the parishes that make up the SMSA for New Orleans contained large areas of wetlands in their natural state. (See Table 3.4) The three parishes of Orleans, Jefferson, and St. Bernard are totally the result of the Mississippi delta plain formation while St. Tammany is mainly pleistocene deposits of higher elevation that predate the Mississippi River's delta building in the area.

From the table one can see that the predominant natural zone is that of wetland. This wetland figure would be even higher if the measurements were taken in 1700, since there has been much deterioration and wetlands loss due to natural and artificial processes since that time.[4]

Table 3.5 is an estimate of wetlands that have been reclaimed in these areas as of the period 1970 - 1972 that the soil association maps were published. Thus, 110.3 miles of wetlands from two estuaries were reclaimed for urbanization from the 1274 square miles of SMSA wetlands as of 1971.

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[4]Current estimates put the rate of land loss of the Louisiana Coastline at 16.5 square miles per year (Gagliano and van Beek: 1970, 99). This rate has been determined to represent a rate of loss since the 1890's. Although the rate of 16.5 square miles could be applied to the period 1890-1970, prior land loss cannot be documented with any degree of reliability. All that can be said is that since the Mississippi River has changed course to its modern delta, the St. Bernard and Teche delta lobes have been deteriorating (a natural process) and that recent artificial activities have accelerated the demise of these fossil distributary systems.

TABLE 3.4

CLASSIFICATION OF LAND IN THE NEW ORLEANS SMSA

(PRE-URBANIZATION)

Parish	Pleistocene Uplands (in square miles)	Mississippi Natural Levee Deposits (in square miles)	Wetlands (Swamps and Marsh) (in square miles)	Total Parish Areas
Orleans	0	24	175	199 sq. mi.
Jefferson	0	54	355	409 sq. mi.
St. Bernard	0	39	471	510 sq. mi.
St. Tammany	636	0	273	909 sq. mi.
	636 sq. mi.	117 sq. mi.	1274 sq. mi.	2027 sq. mi.

Source: Soil Conservation Service Maps, 1970, 1971, 1972.

TABLE 3.5

RECLAIMED MARSH AND SWAMP IN NEW ORLEANS SMSA

Orleans[1]	63.0 square miles (1970)
Jefferson[1]	39.0 square miles (1971)
St. Bernard[1]	0.0 square miles (1970)
St. Tammany[2]	8.3 square miles (1972)
	110.3 square miles

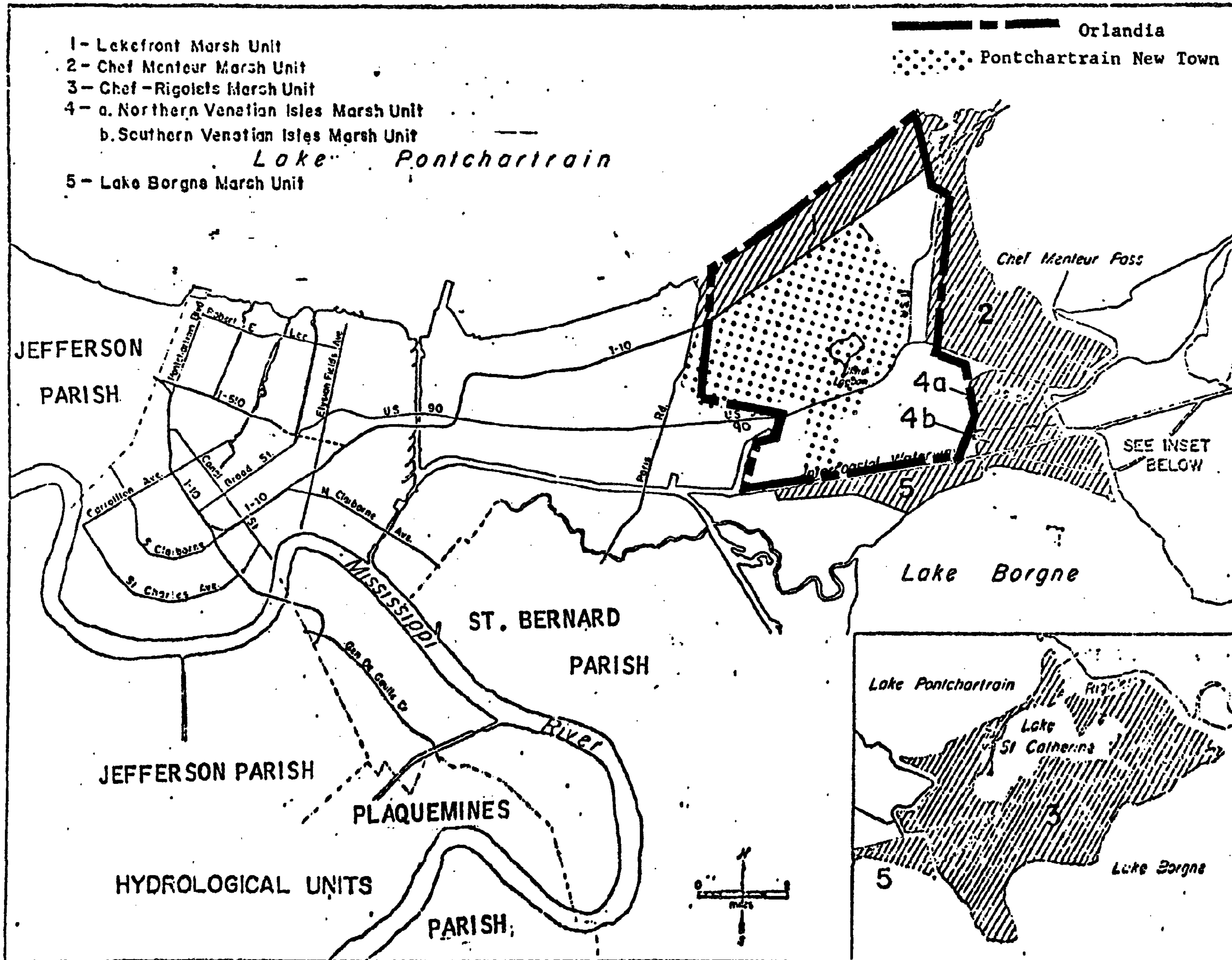
Sources: 1. Soil Conservation Service Maps, 1970, 1971, 1972.

2. Burk (1970).

Current and Future Reclamation Projects

Many more acres of marsh and swamps near New Orleans are being drained and there are plans to drain much more in the future. Orlandia is a proposed multi-stage 28,000 acre development that will take place totally in the partially altered wetlands of eastern New Orleans. The development of Orlandia is predicated on the implementation of a Corps of Engineers flood protection plan to protect the area from storms once the interior has been drained and urbanized. The levee-lock plan will entail a direct loss of 5,265 acres of wetlands due to actual construction (U.S. Army Corps of Engineers, 1974b: III-17). An additional 31,020 acres of marsh, swamp, and water in unaltered condition will be lost to the estuary behind the new levees. This is mainly in the Chalmette area. In eastern New Orleans, 14,904 acres of wetlands will be open to reclamation after being protected by the new levee-lock system. Some of this land is fresh water marsh, having been cut off from Lake Ponchartrain long ago, but some of this land north of the I-10 expressway (3,250 acres) has retained its viability and is in excellent condition (U.S. Army Corps of Engineers, 1974b: IV-2). Figure 3.4 is a map indicating the site of Orlandia. The striped areas represent areas of unaltered marshlands that will be taken from the Pontchartrain-Maurepas-Borgne estuary if the Lake Pontchartrain and Vicinity Hurricane Protection Plan is constructed.

Another area not in the SMSA, but nevertheless under pressure from expanding New Orleans is St. Charles Parish as discussed earlier. This same barrier plan will result in the destruction of 24,770 acres of estuarine marsh swamp, and water that feeds directly into Lake Pontchartrain (U.S. Army Corps of Engineers, 1974b: IV-2) in St. Charles Parish. Day (1975) has concluded that this wetland has taken on extreme importance as an estuarine area for Lake Pontchartrain. Hunting clubs have documented partially the productivity of the region for birds and fur-bearing animals. Day feels that since much of the


1 – Lakefront Marsh Unit
2 – Chef Menteur Marsh Unit
3 – Chef – Rigolets Marsh Unit
4 – a. Northern Venetian Isles Marsh Unit
b. Southern Venetian Isles Marsh Unit
5 – Lake Borgne Marsh Unit
Orlandia
Pontchartrain New Town
Lake Pontchartrain
Lake Borgne
Chef Menteur Pass
SEE INSET BELOW
JEFFERSON PARISH
ST. BERNARD PARISH
JEFFERSON PARISH
PLAQUEMINES PARISH
HYDROLOGICAL UNITS
Mississippi River
Lake Pontchartrain
Lake St Catherine
Lake Borgne
1-10
US 90
I-510
Paris Rd
Elysian Fields Ave
N Claiborne Ave
S Claiborne
St Charles Ave
Carrollton Ave
Canal St
Broad St
Robert E Lee
Intracoastal Waterway
2
3
4a
4b
5

fringe wetlands on Lake Pontchartrain have been reclaimed, removal of this wetlands unit would have dire consequences for the Lake in terms of maintaining any semblance of productivity. Much of the organic detritus that the Lake needs in its food chain (see Figure 1.1) comes from this area. Lake Pontchartrain fringes on the pleistocene uplands, so the inflow of river water from the nutrient poor acid pinelands does little in the way of providing material for the food chain. This material must come from the South and West shore wetlands. The South Shore is leveed from Jefferson Parish to Lake Catherine and the Swamps to the west are not as extensive as those in the southwest corner of the Lake. Therefore, the Lake depends heavily on this open wetlands to keep it "alive" under all the stress it receives from New Orleans. Table 3.6 lists the three projects that will do the most damage to the two estuaries in the New Orleans area. These projects directly relate to urban expansion of the New Orleans Metropolitan Area.

EFFECTS OF RECLAMATION IN THE NEW ORLEANS AREA

Subsidence

There are two basic types of subsidence. These are geologic and man-induced. Geologic subsidence has been occurring for millions of years along and off the Louisiana coast. Using subsidence rates determined by radiocarbon dating of organic marsh clays and peats, and their degree of burial (all deposits are being formed at or very near Gulf level), a subsidence rate of 0.36 feet per century was determined to be the mean for coastal Louisiana. However, rates as high as 1.5 feet per century have been determined and rates of 0.7 feet per century are not uncommon. In general, high rates of subsidence have coincided with areas of greatest natural land loss. (See Figure 3.5.)

TABLE 3.6

ESTUARINE LOSS AS A RESULT OF LARGE RECLAMATION PROJECTS

PROPOSED OR UNDER CONSTRUCTION IN THE NEW ORLEANS AREA

PROJECT	LAND LOSS	STATUS	AFFECTED ESTUARY
1) I-410	46,000 acres* (72 square miles)	Proposed	Salvador-Barataria-Des Allemands
2) Lake Pontchartrain Barrier Plan	72,927 acres* (114 square miles)	Under Construction	Pontchartrain-Maurepas-Borgne
Orlandia	28,000 acres* (44 square miles-within 2)	Proposed	Pontchartrain-Maurepas-Borgne
TOTAL 1 & 2 =	118,927 acres* (186 square miles)		

*Project will not directly destroy this marsh land, but resultant urbanization stimulated by the project will. Orlandia, for example, will be the result of construction of the protective levees around it by means of the Lake Pontchartrain Barrier Plan.

Sources: U.S. Army Corps of Engineers, 1974b: IV-2.
Gagliano, 1973a: 20-48.
New Orleans East, Inc., 1975: no page.

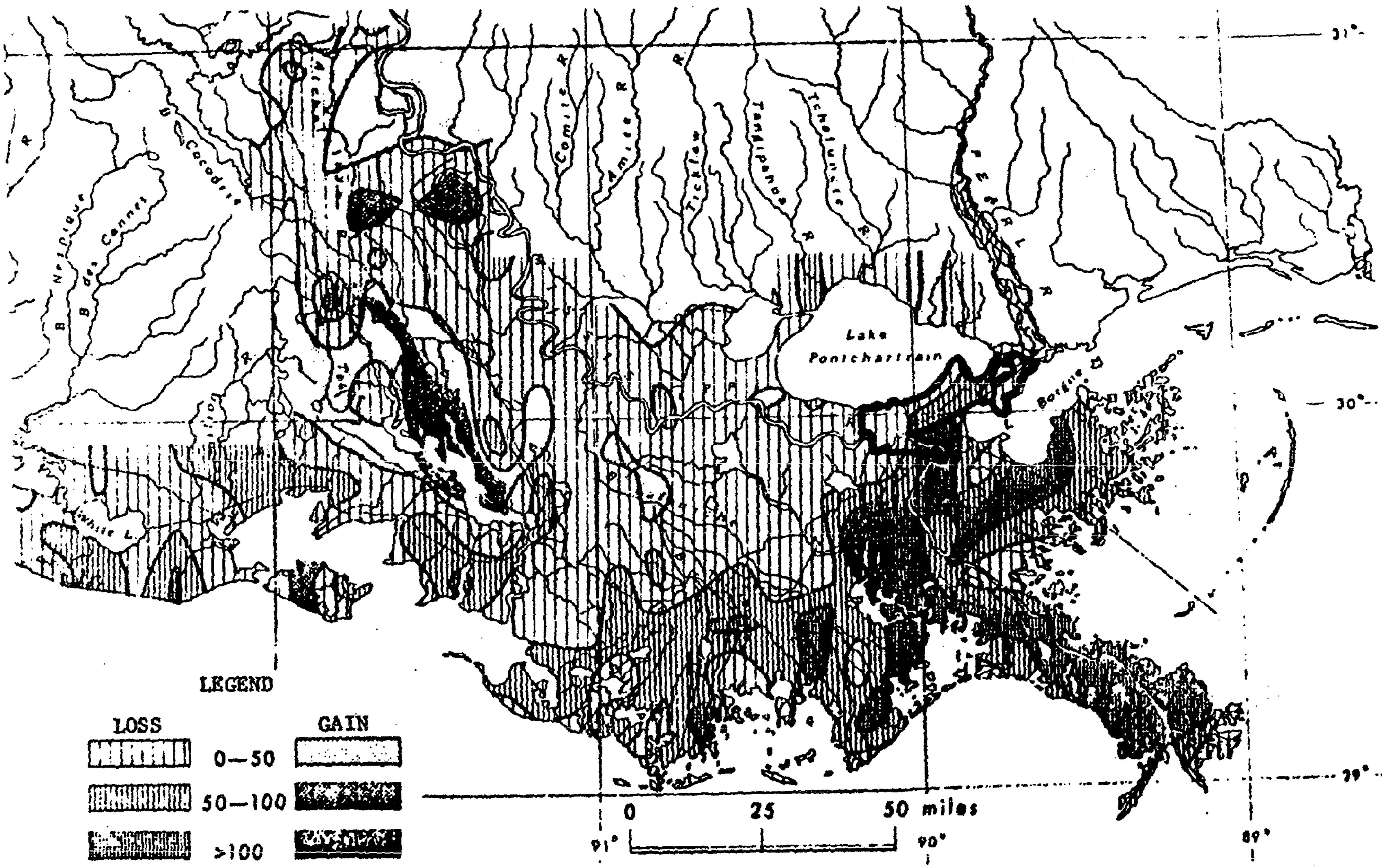


Figure 3.5. Land loss/gain in acres per year

Source: Gagliano and van Beek, 1970: 98.

In some places on the delta, the amount of land loss has been 300 acres per year (Gagliano and van Beek, 1970: 99). This is a pattern of fairly rapid deterioration of deltaic plains once the River shifts its course and land building sediment to another area. New Orleans exists on a part of an ancient delta called the St. Bernard complex. This delta was built intermittently from about 4800 years ago to about 700 years ago through various distributaries (Figure 3.6). The Bayou Sauvage distributary that formed Orleans Parish was formed in the period 1800-700 years ago. Since then, the River has deposited elsewhere (Gagliano and van Beek, 1970: 15-19). Figure 3.7 illustrates the progressive deterioration of the deltaic plain due to subsidence. Part C represents the highly urbanized section of New Orleans, whereas Part E approximates much of Eastern New Orleans. The phenomenon, if left undisturbed, would eventually cause Eastern New Orleans to be reinundated by the sea through gradual subsidence and marsh erosion.

Man-induced subsidence is a much more rapidly occurring phenomenon relating strictly to reclaiming and using the marsh and swamps for an urban growth area. Relating back to Figure 3.7, as the deltaic plain deteriorates marsh grass areas can keep pace with subsidence by the accumulation of partially oxidized dead detrital material called peat. The older the deltaic plain, the greater the peat deposits on the fringe tend to be. This situation can sustain an area long after subsidence has caused the original surface to sink below sea level. As long as the marsh grass thrives and is not destroyed by storms or drought or animal "eat outs", the area stays at sea level with an increasing peat accumulation. Natural processes can cause deterioration and land loss. Given enough time, they always do.

When man drains a swamp or marsh, the first order of business is to levee the area. This will change a salt or brackish marsh into a fresh one with

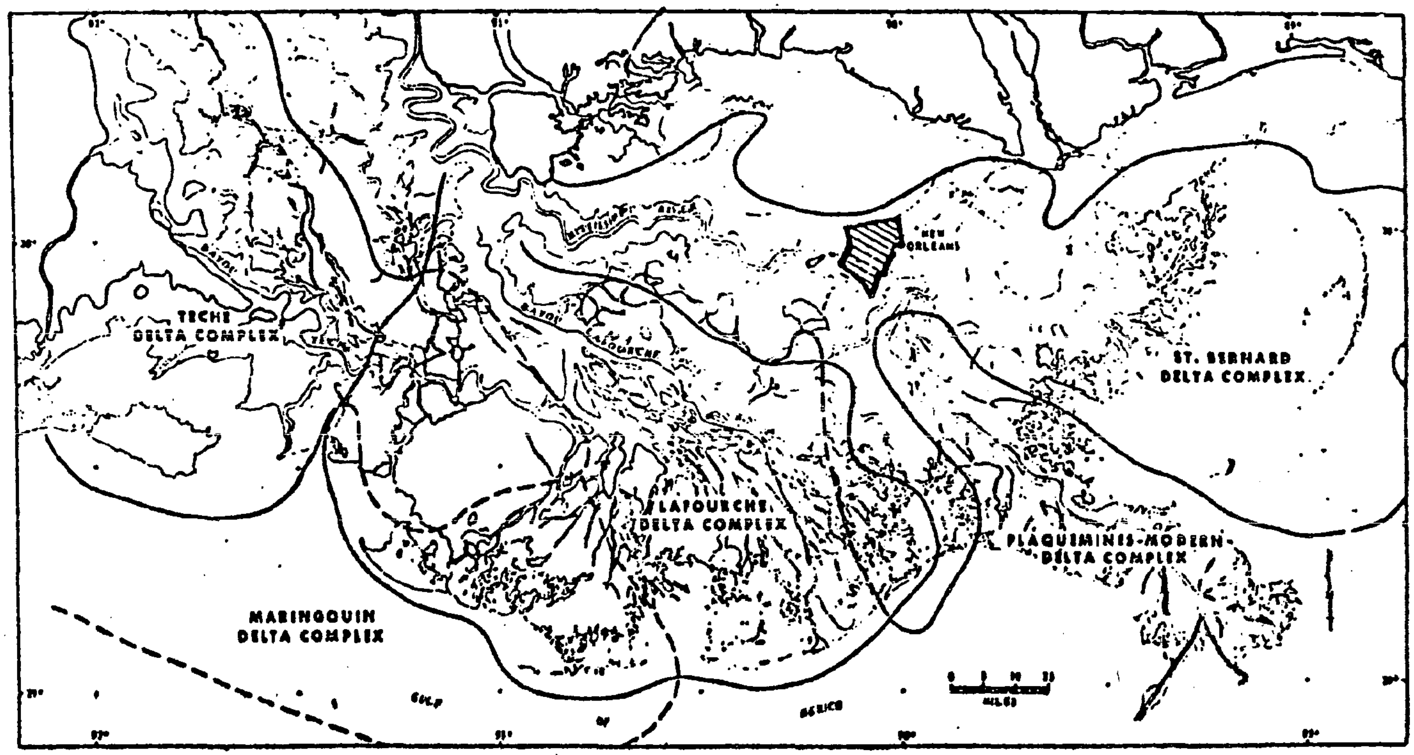


Figure 3.6. Principal delta lobe complexes. (After Frazier, 1967.)

Source: Gagliano and van Beek, 1970: 15.

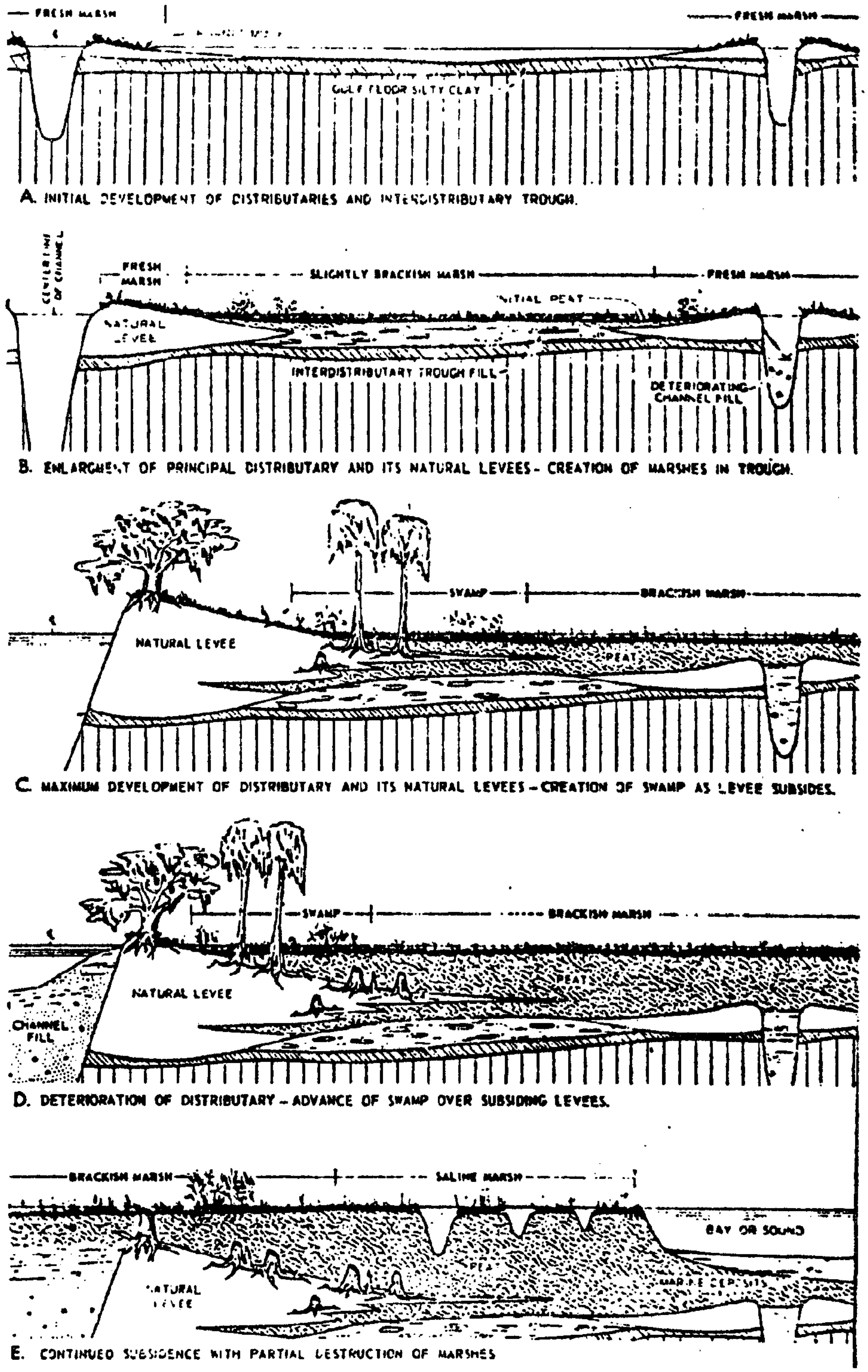


Figure 3.7. Subsidence in the deltaic plain.

Source: Gagliano and van Beek, 1970: 85.

resultant vegetation changes. Then canals are dug and pumping stations begin to drain the marsh. When this happens, the layers of peat that have accumulated lose their water and begin to oxidize. It has been estimated by Colvin (1975) that completely oxidized peat can lose 80% of its original volume. This means that the land "shrinks" downward. Areas of Lake Forest, an area in eastern New Orleans drained before the 1920's and formerly part of a marsh (see Chapter 5) have subsided to elevations of -6 feet. Some places in the new Orlandia project may experience subsidence to as much as -12 feet m.s.l. (Colvin, 1975). The initial subsidence is rapid followed by slow, prolonged sinking. The point is that after leveeing, draining, and filling, the marsh is nonexistent. If the levees fronting Lake Forest were to be taken down, the area would turn into an extension of Lake Pontchartrain, not a marsh. Even if all the levees in the New Orleans area were taken down, the River has changed course and no new sediment would exist to rebuild what was destroyed. Perhaps in a few thousand years, the River would swing back and build a new delta there. Even then, it would take several hundred years for conditions to approximate those that existed before reclamation. In our time frame at least, reclamation is a permanent alteration of wetland.

Ecological Effects of Reclamation

Immediately upon building a levee across a marsh that serves an estuary, one causes these effects:

(1) Loss of fresh water into the estuary

(2) Loss of detritus into estuary

(3) Loss of nursery area for marine organisms

The levee does not allow that broad band of mixing that makes the wetlands so productive. No fresh water can escape inside the levees. Obviously, detritus is trapped in the marsh or swamp also. The marine animals that use the area as a nursery for their young are blocked out; their numbers drop. The basic input of the estuary--detritus--is reduced; therefore, everything else drops accordingly in productivity much like a steam engine does when the amount of high pressure steam entering into it is reduced. (See Figure 3.1.)

The Blue Crab

The blue crab, in the trophic spectrum of the estuarine community, is an important predator and food item and is adversely affected by closure of a marsh. The blue crab is a detritivore, bottom predator, and common scavanger (Jaworski, 1972: 24). Table 3.7 lists some of the major food items of the blue crab. Notice that 20.2% of the food of the juvenile blue crab is directly associated with marsh vegetation. Notice also that clams make up 32.4% of the crabs' diet and clams are exclusively detrivores that depend on input from the marsh. Jaworski has also indicated that juvenile crabs frequent the marsh most of the time; whereas, large crabs tend to feed on water bottom in areas of strong current. It can be concluded that the marsh is an important habitat and food source for the blue crab. Since the crab is a Euryhaline species (15-45 p.p.t. salinity range), crabs would not live in a freshwater marsh (formed after levees cease the inflow of saltwater into the wetland), even if they could crawl over the levees.

Crabs form an important part of the diet of many fish. In Lake Pontchartrain, the fish that regularly consume them include (Darnell, RM 1958: 353-416):

(1) Alligator Gar
(2) Spotted Gar
(3) Sea Catfish
(4) Blue Catfish
(5) Yellow Bass
(6) Freshwater Drum
(7) Atlantic Croaker
(8) Blue Drum
(9) Red Drum
(10) Freshwater Eel

TABLE 3.7

FOOD ITEMS OF THE BLUE CRAB

30-74 mm (juvenile)

As a Detritivore		As a Predator	
Detritus (inorganic)	12.1%	Clams	32.4%
Organic Matter	7.7%	Crabs	2.7%
Vascular Plants	0.4%	Snails	1.9%
	20.2%		
		Other Crustaceans	31.7%
			68.7%

Total = 88.9% of Diet

Source: Jaworski, 1972: 24-25.

By eliminating a tract of marshland from the estuary, the effects spread not only to organisms that inhabit the marsh, but eventually to the whole system. The bay anchovy, a common resident of the lower estuarine waters and the prey of a multitude of fish, consumes plankton that live off of detritus and algae that depend on the marsh. In a Louisiana Wildlife and Fisheries sample catch taken from April 1968 - March 1969, the Bay anchovy made up 84.94% of the total noncommercial vertebrate catch (Perret et al., 1971: 43-44). They probably make up the greatest biomass of any fish in estuarine waters of the South Atlantic and Gulf of Mexico. They indirectly depend on marsh areas for food and many fish depend on them. Eliminate a marsh and total productivity has to drop.

To summarize, loss of a tract of wetland by means of reclamation causes loss of habitat for birds, fish, reptiles, plants, etc. They either leave or die. There is also a loss of nursery area for the animals that live there as well as many migratory marine organisms (such as the blue crab). Loss of detritus and nutrients from the decaying marsh grasses and other sources causes primary production of plants to drop in the wetlands and the amount of detritavores to decrease. Loss of fresh water that carries these nutrients into the coastal waters can cause increased salinities in the marsh and adjacent waters. Since the Mississippi is kept from flowing into these areas during spring flooding[5] rainfall becomes the only way for freshwater to get into a wetland. Levees stop drainage into the marsh. Once the land is

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[5]Approximately once every 2.8 years before the advent of the artificial flood protection levee, the river overtopped its natural levee bank (Gagliano and van Beek, 1970: 70), and flooded the backswamps and marshes behind the natural levee. This probably flushed out detritus and, of course, nutrients into the coastal waters when it happened.

urbanized, drainage water from pumps will help partially overcome the lack of freshwater in the existing marsh, but it, unfortunately, contains too many harmful elements.

The results of reclamation to the natural system appear to be a decrease in natural productivity due to loss of the above processes. A study of a particular marsh tract has never been done to find out exactly how much the productivity decreases, but it can be assumed from the indicated evidence that an adverse effect is felt by the estuarine environment when wetlands are reclaimed from the system.

LOSS OF PRODUCTIVE ACTIVITIES THAT BENEFIT THE COMMUNITY

Besides the losses suffered to the natural system, several productive functions of the wetlands are lost to the community when wetlands are drained. These include the capacity of the wetlands to treat sewage and spawn both commercial and sport fish which are discussed in detail in the next chapter.

Assimilative Capacity to Absorb Pollutants

The wetlands can assimilate much more than they are currently handling in the form of nutrients. Studies have shown, for example, that water hyacinths, considered a severe plant pest, can concentrate heavy metals (such as mercury) and remove them from the water (Day, 1975). Because of the marsh's high capacity for assimilation, pollutants dumped into the coastal waters can be filtered substantially before they enter the lower estuarine waters. By removing marsh by reclamation, this capacity is reduced.

Accelerated Loss of Wetland to the Sea

Indirectly, reclamation has contributed to the apparent accelerated land loss that is being experienced on the Louisiana coastline. One can only guess what the balance of depositional and erosional forces was prior to interference by man. It is known that the coast is currently losing 16.5 square miles per year to the sea. (See footnote 4.) The wetlands that are drained by man after undergoing subsidence are no longer capable of being called land because, as mentioned previously, if the levees were to be taken down, the reclaimed areas would return to open water, not marsh.

Loss of a Buffer Zone Against Tropical Storms

Day and Barr (1975) have suggested that another function of wetland, especially for New Orleans, is to act as a buffer against storms. When a hurricane crosses a marsh, friction slows down the waves and winds to some extent, so that the protective levees take less of a pounding from the elements. As the City of New Orleans expands further and further to the east, this buffer becomes smaller and smaller and the levee is subject to more stress from storm surges. With the land in some parts of the City far below sea level, it would be prudent to consider the consequences of a levee break during a major storm totally flooding parts of New Orleans. The so-called "project hurricane"[6] which the Corps of Engineers use as a basis for flood protection would pose a grave threat to New Orleans.

Conclusion

Reclamation, which is normally irreversible, is harmful to the estuarine system. It reduces nutrient supply, freshwater, and detritus entering the open

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[6]A standard Project Hurricane has a central pressure of 27.6" and a maximum wind velocity of 100 mph (5 minute average) at a radius of 30 nautical miles from the storm center. Hurricane Betsy of 1965 approaches the SPH level. It produced a 12.6 ft. tide surge. The levee east of Highway 11 in New Orleans is only 14 feet high (Corps of Engineers, 1974b). If there were no buffer to slow the force of the water, the levee would be in serious danger of collapse.

water. These three things are prime ingredients that make the wetlands productive. In addition, there is loss of habitant for marine organisms as well as terrestrial and airborne creatures. The destruction of marsh may reduce the system's capacity to perform other functions.

THE ECOLOGICAL EFFECTS OF CHANNELIZATION UPON WETLANDS AREAS

Channelization, like reclamation and water pollution, poses a serious threat to the ecological balance of the Louisiana estuarine system. Table 3.8 illustrates the extent to which the wetlands of our coast have been channelized. Canals and other man-made channels are over 63% of the lenght of natural bayous and passes. They have resulted in the destruction of 42,104 acres of wetland directly and as will be shown later, indirectly have contributed to the demise of much larger tracts of estuarine lands.

A more detailed look at the Barataria-Terrebonne area is shown in Table 3.9 where 2% of the area is man-made canals.

THE THREE TYPES OF CANALS

In Louisiana, there are basically three reasons to dig a channel in the wetlands. They are for drainage, water transportation, and oil and gas pipelines and facilities.

Drainage

In the Reclamation section of this chapter, one of the problems mentioned was subsidence. This subsidence necessitated artificial drainage through pumps to sea level canals for transport to a dumping ground such as a lake or a marsh. Although only some of the land is already reclaimed, the canal can extend past the reclaimed area far out into the marsh. Drainage canals also can be constructed in the marsh to facilitate drying of known mosquite breeding areas. This is regularly done in parts of eastern New Orleans in the marsh.

TABLE 3.8

CHANNELIZATION IN COASTAL LOUISIANA

Area	Length of Bayous and Passes (Miles)	Acreage (Acres)	Length of Canals and Channels (Miles)	Acreage (Acres)
Lake Maurepas and Lake Pontchartrain	6.2	765	0	0
Pearl River to MRGO	745.1	15,638	70.5	1,015
MRGO to Mississippi River	762.0	6,369	663.7	8,403
Mississippi River Delta	711.9	60,459	306.2	1,483
Mississippi River to Bayou Lafourche	1,173.4	25,266	1,166.6	9,133
Bayou Lafourche to Houma Navigation Canal	752.7	6,448	565.7	3,786
Houma Navigation Canal to lower Atchafalaya River	1,282.2	19,176	442.3	4,780
Lower Atchafalaya River to Vermillion Bay	817.7	15,487	261.5	3,452
Vermillion Bay to Sabine Lake	976.2	13,846	1,096.1	10,052
TOTALS	7,227.4 miles	163,454 acres	4,572.6 miles	42,104 acres

Source: Barrett, 1970.

TABLE 3.9

CHANNELIZATION IN THE BARATARIA-TERREBONNE REGION

Canal Area per Category	Total m^2	% Canal Area	% Total Area
Mineral Extraction Industries: Access Canals and Rig Cuts	69.1	65.1	1.31
Drainage	20.8	19.6	0.40
Navigation	11.0	10.3	0.21
Lumbering	2.5	2.3	0.05
Borrow Pits	1.2	1.1	0.02
Other	1.8	1.6	0.03
TOTAL	106.6	100.0	2.02

Total Area of Barataria-Terrebonne area 5258.6 square miles

Source: Gagliano et al., 1973b: plate 16.

Water Transportation

To facilitate barge and ship transportation, many canals have been and are currently being excavated. An example of a water transportation canal is the Mississippi River Gulf Outlet Canal. This canal cuts the distance from New Orleans to the open Gulf waters to 75.4 miles--40 miles shorter than using the Mississippi River. From 1958-1967, the U.S. Army Corps of Engineers spent an estimated $195,000,000 to construct the MRGO. When completed, it had a channel depth of from 36-38 feet and a width of 500-600 feet. There is a turning basin of 1000' by 2000' at New Orleans and a lock at Mereaux, Louisiana to connect with another canal that goes to the Mississippi River at Violet. This project involved the direct destruction (channel only) of 22,672,672 square yards of marsh. The 2000 feet of spoil dredged and piled upon the marsh the canal lenght yields 88,473,756 square yards more of marsh that is altered. These total 111,146,428 square yards of altered marsh. A total of 288,000,000 cubic yards of material was excavated for spoil banks (U.S. Army Corps of Engineers, 1961).

Oil and Gas Pipelines and Facilities

An estimated 47 oil or gas pipelines pass through the wetlands in the parishes of Orleans, Jefferson, and St. Bernard (U.S. Army Corps of Engineers, 1973b). These pipelines each have canals attending them. In addition, many of the larger canals were constructed solely for the purpose of transporting materials and men for the oil industries to the work sites in the wetlands and in the Gulf of Mexico.

WHAT CHANNELIZATION DOES TO THE WETLANDS

The lace work of channels that now crisscross the wetlands have had these five effects upon the wetlands:

(1) Interferring with sheetwater flow through the marsh;

(2) Allowing rapid salinity changes with the resultant death of vegetation and erosion of the marsh;

(3) Allowing destruction of marsh by wave action;

(4) Decreasing productivity by the presence of straight vs. sinuous channels that accelerate removal of freshwater and also confine water movement;

(5) Destruction of Barrier Islands with resultant increased destruction of marsh.

The following is a discussion of each of these destructive effects.

Interferring with Sheetwater Flow Through the Marsh

One of the prime requirements for an estuarine basin is uninterrupted freshwater flow in a sheetlike manner rather than through precisely defined channels down the estuary. In Louisiana, the estuarine basins of the State are distinctively divided by the natural levee systems that formed during delta building stages in each system.

A good example of this is the Barataria Basin estuary (Salvador-Barataria-Des Allemands estuary (see Figure 3.8). This Basin is distinctly enclosed by the Bayou Lafourche fossil distributary levee system on the west and north and the Mississippi River modern delta natural levees on the north and east. From the top of the estuary (see point A, Figure 3.8) to Barataria Bay, the elevation change is only 2 feet (from +2 feet at point A to sea level in Barataria Bay). Rainfall runoff from the natural levees, what falls directly upon the basin, and drainage water from the urbanized west bank of Jefferson Parish (see point B, Figure 3.8) contribute freshwater to the Basin.

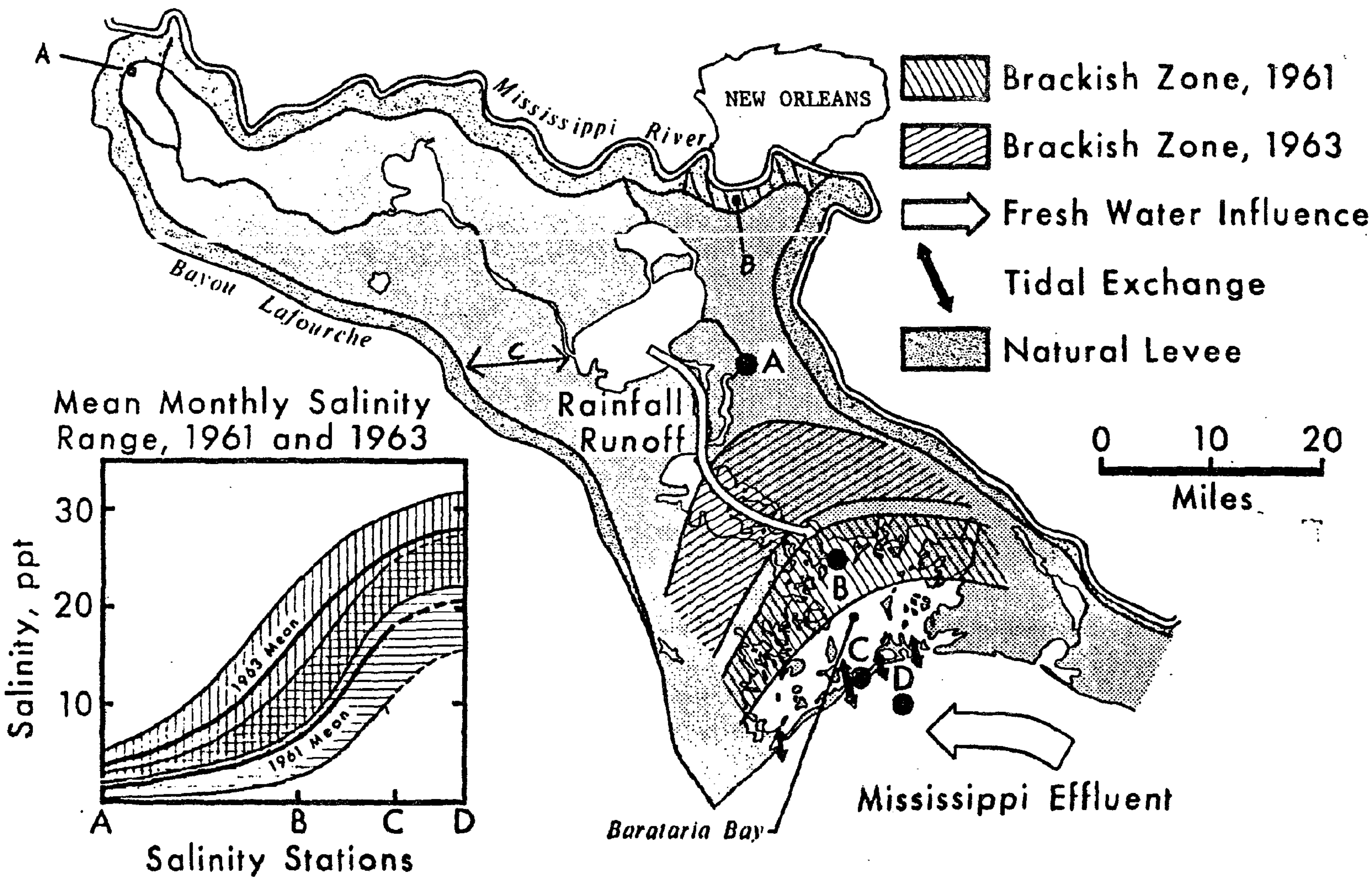

Figure 3.8. Fresh-salt water mixing zone in the Barataria-des Allemands estuary system. Primary fresh water input consists of locally derived runoff from catchment area bounded by crests of natural levee ridges along the Mississippi River and Bayou Lafourche. Tidal exchange is controlled by size of passes between barrier islands. The position of the brackish zone is contrasted between an exceptionally wet (1961) and an exceptionally dry (1963) year.

Source: Gagliano et al., 1973b: 58.

Despite the lack of nutrients from the Mississippi due to artificial levees blocking the floodwaters, the Barataria Bayou still receives nutrients from fertilizer runoff from sugar cane fields in the upper estuary and drainage water from the New Orleans Metropolitan Area. This apparently makes up for some of the loss of nutrients from the Mississippi River (Day, 1975). The rainfall for the whole area averages from 59.5" to 65.0" per year (Gagliano et al., 1973b: Plate 4), so there is still quite a lot of freshwater entering the estuary. The natural channels are sinuous and shallow, so the volume of water that they carry is less than one might expect. Therefore, quite a lot of water flows in a slow (due to the low gradient), sheet-like manner through the swamps and marshes, gradually dispensing nutrients and dispersing detritus downstream. When canals are dredged through this area, the sheet-like flow is lost.

Lateral Canals -- Lateral canals (illustrated by transect C on Figure 3.8) do major damage by cutting off sheetwater dispersal to the marshes and swamps to the south of them. The canal itself acts as a physical water shunt laterally, thus hindering the north-south movement of the water. Another hindering factor is the spoil bank. It is usually not economical to cart the dredged material away from the canal site so it is piled on one side of the canal. This practice not only destroys the marsh it covers, but produces a low levee that effectively stops water from flowing southward.

An example of a lateral canal now under consideration is the Bayou Barataria-Bayou Perot Canal in the Barataria Basin near Lake Salvador. The Corps of Engineers, affected by criticism of their channelization of the wetlands, has proposed to create a new marsh here by spreading spoil over an area of shallow ponds rather than on a spoil bank. They would dredge 1,300,000 cubic yards of material during the construction of this canal to be placed on about

215 acres and seeded in hopes of rebuilding marsh. However, the Canal (12 feet deep) will destroy 259 acres by converting it from marsh to water or terrestrial habitat (U.S. Army Corps of Engineers, 1974a: 60). The deep lateral canal will still shunt water laterally instead of north-south and will still pose a barrier to sheetwater flow, despite the attempt at constructive use of spoil (U.S. Army Corps of Engineers, 1974a).

Vertical Canals -- Canals running north-south do a great deal of damage also to this estuarine system. Gagliano and others (1973b) have suggested that these north-south channels that are quite deep tend to accelerate freshwater runoff down the Basin. The depth of the water, together with the spoil banks, tend to restrict freshwater flow to a few channels instead of the sheet flow that existed prior to intensive canal construction.

Allowing Rapid Salinity Changes with Resultant Death of Vegetation and Erosion of the Marsh

The framework of canals in the Barataria estuary (as well as others) has altered salinities drastically in the Basin. It has been demonstrated (Day, 1975) that tidal action in the Barataria system extends as far inland as Lake des Allemands. The same tides that allow freshwater to flow rapidly down restrictive canal channels also allow saltwater to intrude upstream at a rapid rate.

Limited depth of natural bays appears to be prohibitive to the development of a salt wedge and well-defined vertical stratification of a water column.[7] Mixing, as a result, occurs predominantly laterally. Combined with the gradual

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[7]Because of different densities, in deep water, saltwater tends not to mix with freshwater and this saltwater tends to maintain its salinities for long periods of time. In shallow systems and marshes, there is considerable mixing with resultant brackish water zones (Day, 1975).

dispersion of freshwater, this enhances development of a wide mixing zone characterized by low salinity gradients. Therefore, optimum biological habitats, in terms of salinity ranges, result and extend over wide areas (Gagliano et al., 1973b). In large canals, salt wedges can extend far inland (especially during storms). Vegetation exposed to high salinities in the formerly brackish or freshwater zone dies off.

Exposed organic muck is then easily eroded away and land loss to the sea is accelerated. Thus, the canal not only destroys marsh by its presence[8] (where marsh used to be), but contributes to the destruction of vegetation on its banks for quite a distance from it with resultant erosion and estuarine land destruction. Because of the reduced sheetwater flow, physical loss of marsh, and lack of large brackish water zone caused by channelization, there is a loss of detritus and habitat; therefore, there should be a drop in productivity.

Allowing Marsh Destruction by Wave Action

During storms, canals allow the high tides and waves to do greater damage to the marsh than would otherwise occur. A hurricane does a great deal of marsh damage and erosion without the added pressure of straight channels that carry high velocity water directly from the sea. Most vulnerable to high velocity water movement is the cane vegetation such as Spartina alterniflora and Spartina patens. They form a major obstruction to water flow since the density of these species is greatest during the late summer when storms are most likely to occur (Gagliano et al., 1973b).

After a hurricane leaves the area, spoil banks created by canals tend to act as levees, holding saline water in normally brackish areas, adding to plant death and eventual marsh erosion. Even swamp trees can be killed by exposure

[8]Measurements in the Barataria Basin indicate a total of 106 m_1^2 of canal area. This does not include modified wetland area resulting from deposition of dredge spoil on the canal banks (Gagliano et al., 1973b: 65).

to high salinities in canal water. An example of this is the cypress diebacks in the vicinity of the Houma Navigation Canal (a deepwater canal) near Dulac, Louisiana (Gagliano et al., 1973b).

Straight vs. Sinuous Channels

The natural drainage channels in the estuary are usually sinuous and shallow. Freshwater slowly moves downstream and laterally into the marsh through these channels. They are not deep enough for a saltwater wedge to form, so they allow gradual changes from fresh to saltwater. Often the most productive marsh areas are right along these channels. In contrast, a straight channel with a spoil bank provides a rapid freshwater and saltwater movement (if it is deep enough). Because of spoil banks and a deep channel, there is virtually no lateral movement of freshwater or nutrients into the marsh. Therefore, the productive marsh areas along the channels do not exist in this case and in fact may be totally obliterated by a spoil bank (Gagliano et al., 1973b).

Destruction of Barrier Islands

Gagliano and others (1973b) have concluded that shoreline retreat and the deterioration of the barrier islands that fringe the estuaries is among the most critical environmental problems in the area. These island chains act as an effective barrier to storm-generated tide surges that can do a great ecological damage to plant and animal life as well as cause severe erosion in the lower part of the estuary. These islands have a natural life span and eventually diminish and disappear if no new delta building occurs in the area. An example of a rapidly diminishing barrier island chain is the Chandeleur Island chain, the barrier islands that once fringed the old St. Bernard Delta. Deprived of sand, they are moving rapidly shoreward and diminishing in size (Day, 1975).

the catch to the fishermen and the value added in processing, and finally to impute a value to an acre of wetland.

The role of the coastal marshes in the development of commercial fish is only partially understood, and its value is difficult to determine. It has been suggested (Sewell and Hillman, 1971: B-17), for example, that the menhaden, which accounted for a total value of $19.9 million to commercial fishermen in Louisiana, is dependent upon the wetlands for food sources, primarily zooplankton and anabaena. The menhaden population appears to be determined by the number of its larvae entering the water after spawning in the wetlands. The role of the marsh in producing organic nutrients is not restricted to the immediate area of the marsh; it has been estimated that over half of the total production of organic matter in Gulf-coast estuaries originates from the surrounding marshes (Gosselink et al., 1974: 1-2). Thus, the real value of the marshes may accrue some distance from the marsh including out at sea.

Like menhaden, shrimp are dependent upon the marsh areas for nourishment (primarily polychaete worms, mollusk larvae, and small crustaceans), and for protection from predators. Further, the shrimp are the primary food source for the red drum, the spotted seatrout, and the gray snapper. Sewell and Hillman suggest (1971: B-13 & B-14) that none of the major commercial species of shrimp would continue to exist in commercial quantities if estuaries were unavailable for their development. Thus, the filling or diking of estuarine areas probably reduce commercial shrimp stocks in some direct relationship to the estuarine area removed.

As an organism, the oyster is thoroughly adapted to the estuarine system for food and spawning grounds. Although oyster production has remained relatively constant for the past 30 years, the acreage used for the production has increased from 19,767 in 1945 to 161,162 acres in 1973. This indicates a decline in oyster production from 500 to 50 pounds per acre, and is primarily the result of (1) change from intensive to extensive (requiring more area) cultivation; (2) competition for space with mineral extractive industries; (3) saltwater intrusion which brings predators, particularly the oyster drill; and (4) increasing urbanization with increased sewage and wastes. Because of this last factor, 41,710 acres, or 26% of water bottoms for oyster production, have been closed to harvesting for relatively brief periods. Saltwater intrusion, which has moved northward across Barataria Bay by approximately 4 miles since 1937, has resulted in a permanent loss of over 2 million acres of potential oyster producing waterbottoms (Louisiana Advisory Commission, 1973: 122-125, 142).

Obviously, wetlands are indispensable to the development of certain commercial species. Therefore the value of these fisheries shall be attributed to the wetlands on a per-acre basis. This approach, suggested by the Louisiana Advisory Commission on Coastal and Marine Resources (1973: 188), has a number of shortcomings which will be discussed later.

In 1973, the total landed value of commercial fisheries in Louisiana was $96,642,327, representing a total catch of 1,009 million pounds (National Marine Fisheries Service, 1974: 2). Table 4.2 provides information on Louisiana Landings for the years 1972 and 1973. Since the Department of Public Works (no date: 2-3) indicates that marsh and swampland constitute 5,393,564 acres in SMSA and non-SMSA coastal areas, this total dollar value represents $17.92 per SMSA and non-SMSA acre of dockside value, before the addition of value added in processing. The Louisiana Advisory Commission (1973: 187-188) recommends that the dockside values of commercial catches be multiplied by a factor of between 2.5 and 3.5 to obtain the total worth of production after value added in processing. Assuming a multiplier of 3.0, this results in a per-acre value of $53.76.

TABLE 4.2

LOUISIANA LANDINGS, 1972-1973

Species	1972		1973	
FISH	1,000 Pounds	Dollars	1,000 Pounds	Dollars
Bluefish	.3	17	.3	34
Bowfin	46.8	2,967	42.3	2,975
Buffalofish	2,502.6	328,268	1,380.0	193,258
Cabio	6.0	449	4.8	332
Carp	139.6	5,547	123.4	4,908
Catfish	4,998.7	1,399,623	4,943.1	1,491,747
Croaker	307.9	36,688	377.0	43,049
Drum (Black)	539.9	38,467	539.6	44,707
Drum (Red)	888.6	156,765	1,179.7	228,404
Flounder	507.2	89,637	269.0	53,311
Garfish	549.2	55,311	538.2	60,781
Grouper	5.0	437	8.1	687
Jewfish	---	---	5.5	285
King Whiting	437.6	37,085	283.1	24,604
Menhaden	928,252.1	15,279,288	894,930.3	37,220,673
Mullett	15.8	823	102.5	5,398
Paddlefish	13.2	894	14.2	1,172
Pompano	17.8	17,207	13.1	14,284
Sawfish	1.3	67	.1	42
Sea Catfish	72.3	7,229	69.9	7,646
Sea Trout (Gray)	---	---	1.2	163
Sea Trout (Spotted)	1,699.8	466,761	2,525.0	774,536
Sea Trout (White)	148.8	16,482	150.8	17,671
Shad	866.0	25,980	375.0	11,250
Shark	.3	15	.8	69
Sheephead (Fresh)	742.9	85,014	701.4	83,153
Sheephead (Salt)	171.7	15,884	168.5	11,468
Snapper	258.8	97,343	349.8	142,694
Spanish Mackrel	114.0	11,366	88.8	7,709
Spot	18.5	1,413	23.1	1,353
Tripletail	3.8	336	3.0	237
Unclassified Industrial	48.9	1,870	125.0	5,938
TOTAL FISH	943,375.4	18,159,233	909,336.6	40,454,538
SHELLFISH				
Crabs, Blue Hard	15,082.6	1,776,862	22,730.1	2,767,023
Crabs, Blue Soft & Peeler	101.9	109.130	119.4	131,552
Crawfish, Fresh	5,974.8	1,321,655	10,000.2	1,944,679
Shrimp, Fresh	6.6	3,423	---	---
Shrimp, Salt	82,987.7	42,020,975	58,641.2	45,773,389
Oysters, Meats	8,805.3	4,457,635	8,953.7	5,545,022
Squid	.4	42	---	---
Terrapin	.13	49	---	---
Turtle, Baby	.7	5,250	---	---
Turtle, Sea	2.6	671	15.0	4,200
Turtle, Snapper	81.4	21,268	13.0	3,663
Frogs	29.3	16,651	29.9	18,261
TOTAL SHELLFISH	113,072.8	54,733,611	100,502.5	56,187,789
GRAND TOTAL	1,056,448.2	72,892,844	1,009,839.1	96,642,327

Source: National Marine Fisheries Service, 1974: 2.

The catches of commerfial fish are not expected to remain constant, however. The National Marine Fisheries Service has estimated future prices and quantities of major fish species between the years 1970 and 2000 (Stone et al., 1973: 166-173), including shrimp, crabs, and oysters. Because of projected increases in quantities of catch and in real price, it has been estimated that the real value of shrimp would increase by an average annual rate of 4.5%, that of crab catches by 8.01%, and that of oysters by 1.32%.[2]

No projections were available for other species such as menhaden; for this reason, the quantities of catch of other species (not including shrimp, crab, oyster) are held constant. In 1973, these represented a total value of $43,435,341, and represented a value per acre of $7.87. Assuming a multiplier of 3 for value added in processing, the per acre value increases to $23.61.

To compute the present (discounted) value of an annual income stream, equation (4.1) is commonly used.

$$V = \sum_{t=1}^{n} \frac{a}{(1+r)^t} \qquad (4.1)$$

where V = present value of annual income stream

a = annual income (return)

r = interest rate

t = year t = (1,...,n)

For an annual income stream of infinite years (the potential life of the wetlands without development) equation (4.1) reduces to equation (4.2) (Barlowe,

$$V = \frac{a}{r} \qquad (4.2)$$

1972: 317-318). Substituting an annual return of $23.61, and assuming an interest rate of 6%, the value per acre would be $394 for all commercial fisheries except shrimp, crabs, and oysters. The 6% interest rate was midway at the Louisiana Advisary Commissions 5% to 7% range (1973: 187-188).

[2]Rates of increase calculated from Tables 61, 62, 63 of Stone, et al. 1973: 168-170.

Since the real value of catches of shrimp, crab, and oyster have been projected to increase, an adjusted present value equation should be used. It may be expressed as equation (4.3) (Barlowe, 1972: 317-318)

$$V = \frac{a}{r} \pm \frac{i}{r^2} \qquad (4.3)$$

where i represents the expected average increment (increase or decrease) in dollars to the annual return. Utilizing this adjusted equation, it is found that the value per acre of wetlands to the Shrimp, oyster, and crab industries is $436.83, $55.00, and $49.08 respectively (Table 4.3). Thus, the total value of an acre of wetlands to commercial fisheries in Louisiana is estimated to be $1261.36.

The above procedure for evaluating the contribution of an area of wetlands to commercial fisheries raises a number of questions. While it has been shown (see, for example, Stone et al., 1973: 101-109) that the life cycles of major commercial species are heavily dependent upon the estuaries, the state of the art does not permit a differentiation between the relative importance of the various types of wetlands for species survival. It appears that the brackish or saltwater marshes are considerably more important than freshwater swamps in this respect, but the available information does not permit the imputation of different values to such areas. The above estimate is, at best, an average value.

Secondly, since projected increases in the real value of catches were not available for certain major species such as menhaden, the above value of $1261.36 may be an underestimate. Furthermore, the future possible scarcity of seafood products may result in higher values than those estimated.

Finally, it has been pointed out (Gosselink et al., 1974: 3n) that this approach places the entire value of the commercial fishing industry upon the land area providing the nutrients and nursing space, without imputing any

TABLE 4.3

ESTIMATED VALUE OF COASTAL WETLANDS FOR COMMERCIAL FISHERIES

ACTIVITY	1973 LANDED VALUE[1] (1)	TOTAL ANNUAL PROCESSED RETURN[2] (1973) (2)	ANNUAL RETURN /ACRE[3] (3)	PROJECTED INCREASED RETURN/ACRE (4)	PRESENT VALUE[1] (PER ACRE) (5)
Shrimp	$ 45,773,389	$137,320,167	$25.46	4.5%	$ 742.58
Oyster	5,545,022	16,635,066	3.08	1.32%	62.62
Crabs	2,898,575	8,695,725	1.61	8.01%	62.66
All other Commercial fisheries	42,425,341	127,276,023	23.61	No estimate (Assumed to be zero)	393.50
TOTALS	$ 96,642,327	$289,926,981			$1,261.36

Sources: 1. Table 4.2.

2. Assumes processing increases dockside value by a factor of 3.

3. (2) ÷ (5,393,564) acres

4. See text.

5. Assumes an interest rate of 6% using equation (3).

value whatsoever to labor, capital, and management. Conversely, however, if the landed value of commercial fish species were only imputed to labor, capital, and management, then the scarcity values of fish or the estuaries' natural resources would be zero. This situation reflects the common property nature of fish in the seas; thus, while common property resources are free goods for individual users, they represent scarce goods for society (Stone et al., 1973: 110-113). Traditional economic analysis unfortunately cannot reflect the true value to society of a common property resource. For this reason the above approach which emphasizes the dependency of the fishing industry on the wetlands (for without them there would be no seafood industry) was used.

NONCOMMERCIAL FISHERIES

In addition to commercial fisheries, a substantial portion of the Gulf Coast landings are attributed to recreational activities. The National Marine Fisheries Service (1973: 23-24) reported that in 1970, 818,000 sport fishermen landed approximately 151,608,000 pounds of finfish in the western Gulf Coast area; that is, the area bounded by the Mississippi Delta and the Rio Grande. Of these, 341,000 engaged in ocean fishing, and 477,000 participated in sports fishing in sounds, rivers, and bays. During the same period, the Louisiana Wildlife and Fisheries Commission (1972: 28) reported that a total of 326,723 resident fishing licenses were sold in the State. Since the average catch per fisherman in the western Gulf area was approximately 185 pounds, it is possible to approximate a landing of 60,443,755 pounds for sports fishermen in Louisiana. While this figure may appear to be excessive, it represents only about 6% of the commercial fish catch during the same period. In Massachusetts, for example, it has been found that as much as 14% of total marine fishing was attributable to sports catches (Whitman, 1971: A-43).

While the product of sports fishing is recreation and not the fish themselves, the impact of sports fishing may have a real economic value, particularly where there is competition with commercial fisheries. For this reason, it has been suggested (Whitman, 1971: A-43) that each pound of sports catch be assumed to have an equal landed value by weight to a comparable commercial catch, with no inclusion of a factor for value added in processing. Nevertheless, it should be pointed out that considering average expenditures of about $95 per person (Louisiana Department of Public Works, no date: 77), these landed sports-fish represent a far greater impact than just their landed value.

Utilizing the same evaluation method as in the commercial fisheries, it is possible to impute an approximate value to the wetlands for their contribution to recreational fishing activities. Assuming an average price per pound of $0.18 (ranging from $0.016 for menhaden to $0.375 for red snapper--from Table 4.2), the total landed value of recreational fisheries in Louisiana would be $10,879,875. Since the majority of these fish are dependent upon the marshland in varying extent for both nutrition and breeding activities, the reduction of wetland acreage would result in a decline in recreational fishing activity. If the total landed value of sports fisheries were attributed to the coastal marsh area of 5,393,564 acres, this would result in a contribution per acre of $2.02. Using equation (4.2) with an interest rate of 6% described previously, the value per acre for sports fisheries would be $33.62.

OTHER RECREATIONAL ACTIVITIES

To assess the economic value of land and water recreational activities, several theoretical devices are available. The first of these, and the one most closely in keeping with traditional economic theory, is the estimation of user benefits. This method requires the derivation of a demand curve, relating price (or cost) of a recreational activity to the total quantity of activity demanded. The total user benefit, then, is the sum of the maximum prices which various users would be willing to pay for various units of output (Clawson and Knetch, 1966: 216-217). Nevertheless, the difficulties involved in estimating a demand function preclude the use of this method.

An alternative measure is the gross expenditure method which attempts to value recreation in terms of the total amount spent by the recreationist (Clawson, 1972: 5-6). For example, the 1960 Survey of Fishing and Hunting indicates that the average expenditure per person in 1960 was $80 for hunting, $95 for freshwater fishing, and $99 for saltwater fishing (Louisiana Department of Public Works, no date: 77). During the 1970-71 season, it was reported that 326,723 fishing licenses and 338,937 hunting licenses were sold in the State (Louisiana Wildlife and Fisheries Commission, 1972: 27-28). Table 4.4 provides a breakdown of the licenses sold in the coastal parishes. If it is assumed that each person who obtained a license spent an average of $80 for hunting, then hunting in the coastal zone accounts annually for $16,999,920 in equipment, food, lodging, and transportation. Similarly, average expenditures of $95 by fishermen would annually yield $20,455,685 in business in the coastal parishes.

Recent studies in New England (Whitman, 1973: A-36-A-38) have shown that recreation oriented activities have a general multiplier effect upon the economy in general, averaging between 2.76 and 3.07. Multipliers represent the total effect upon the economy in dollars, given a one dollar change in final demand for an economic sector. Assuming an average multiplier effect of 2.92, this would indicate that, should recreational hunting and fishing activities cease altogether, the coastal parishes would suffer a decline in economic activity of approximately $109,370,360. If the entire expenditures on fishing and 60% (as a conservative estimate) of those related to hunting were attributed

TABLE 4.4

LICENSES SOLD BY PARISH, LOUISIANA COASTAL ZONE, 1970-1971

FISHING SEASON

Parish	HUNTING Basic Resident ($2)	Non-Resident ($5)	Big Game ($2)	FISHING Basic Resident ($1)	Basic Resident ($2)	Non-Resident ($2)	Non-Resident ($3)
Acadia	4,919	82	453	1,351	1,013	1	10
Ascension	3,883	192	1,068	1,842	1,468	12	24
Assumption	1,764	---	355	776	386	1	3
Calcasieu	18,779	1,292	4,726	11,930	4,149	25	70
Cameron	1,674	820	123	2,866	9,295	120	184
E. Baton Rouge	22,381	212	8,662	13,501	10,621	128	336
Iberia	5,015	42	667	3,517	2,468	38	75
Iberville	3,419	4	1,518	2,416	1,731	12	14
Jefferson	15,198	54	1,868	10,418	7,084	28	77
Jeff. Davis	4,455	270	586	1,716	1,075	17	20
Lafayette	9,178	225	1,378	3,907	3,323	38	81
Lafourche	8,182	---	805	1,958	2,037	3	3
Livingston	5,745	9	2,764	1,939	1,119	20	21
Orleans	17,084	278	2,229	9,547	20,266	60	250
Plaquemines	2,175	---	211	965	3,446	1	264
St. Bernard	3,102	1	371	3,291	2,184	1	14
St. Charles	2,945	30	566	1,084	1,427	11	34
St. James	1,448	---	301	323	271	---	---
St. John	1,680	7	342	710	536	1	15
St. Martin	2,819	6	486	2,618	1,606	25	59
St. Mary	6,158	71	1,048	1,836	2,034	30	61
St. Tammany	6,318	116	2,001	5,294	3,243	222	325
Tangipohoa	7,257	41	1,793	2,806	1,993	50	90
Terrebonne	7,956	21	696	2,862	3,266	8	18
Vermillion	5,199	479	592	1,493	1,307	8	11
W. Baton Rouge	2,764	9	1,138	1,289	987	7	8
TOTALS	171,431	4,261	36,807	124,255	88,134	867	2,067

Source: Louisiana Wildlife and Fisheries Commission, 1972: 27-28.

to the wetlands, this would constitute a total dollar value of $89,514,459. Since the coastal parishes contain approximately 5,393,564 acres of wetlands (Louisiana Department of Public Works, no date: 2-7), this represents an average yearly value per acre of $16.60 for recreation expenditures for hunting and fishing. The present value at 6% would then be $276.60 (equation 4.2). Prices for recreation activities in 1971 are 1.37 times their 1960 levels (Department of Labor, 1974: 302-304 (Reading and Recreation Consumer Price Index)). To adjust recreation expenditures and this component of the present value of a wetland acre, $276.50 should be multiplied by 1.37 yielding a present value of $378.81 per acre. Total dollar value in 1971 was $122,634,808.

Additionally, the wetlands provide other recreational benefits to users. One method to evaluate these benefits is to assign a fixed value for a user-day of recreation activity, representative of the amount that users would be willing to pay for these activities. Table 4.5 provides a series of values for various recreation forms. It appears, however, that these rates are extremely undervalued; it has been suggested (Stone, 1973: 179) that a minimum value of $10 per user-day be employed. Information relating to the number of user-days is reproduced in Table 4.6. The activities selected represent those which take place primarily in wetlands areas, and the number of user-days is restricted to the coastal parishes of Louisiana.

Thus, with a minimum value of $10 per user-day, the benefits to recreationists in 1970 may be valued at $202,586,280. Since the coastal parishes contain 1,932,800 acres of water bodies in addition to wetlands (4,393,564 acres), the total area to be considered is 7,326,364 acres. The area of water bodies has been included because certain activities such as motor boating and water-skiing are not restricted to the wetlands, but may also take place over open bodies of water. This results in an average yearly per-acre benefit of $27.65.

TABLE 4.5

MEDIUM UNIT VALUES FOR RECREATION PARTICIPATION

ACTIVITY	DOLLARS PER PARTICIPATION DAY 1970	1980
Swimming	1.00	1.00
Sightseeing	1.00	1.00
Boating	1.50	1.50
Water Skiing	1.50	1.50
Hunting	4.50	4.50
Nature Walks	1.00	1.00
Striped Bass Angline	3.50	3.50
Miscellaneous Delta Angline	1.00	1.00

Source: Whitman, 1973: A-45.

TABLE 4.6

USER-DAYS FOR VARIOUS RECREATIONAL ACTIVITIES

LOUISIANA COASTAL PARISHES, 1970-1980 (PROJECTED)

	USER-DAYS			
ACTIVITY	1970	1975	1980	1985
Fishing	7,525,570	8,701,520	10,242,707	12,242,412
Motorboating	4,135,456	4,781,665	5,301,292	5,727,459
Hunting[1]	2,349,719	2,768,920	3,260,911	3,849,668
Crabbing	1,971,255	2,279,631	2,684,685	3,147,275
Waterskiing	1,442,601	1,668,022	1,964,404	2,346,787
Crawfishing	1,178,123	1,362,217	1,604,262	1,925,543
Birdwatching	1,610,904	1,862,625	2,193,584	2,620,579
TOTALS	20,258,628	23,424,600	27,311,845	32,905,723

[1]Represents 60% occurrence of hunting in wetlands areas.

Source: Louisiana State Parks and Recreation Commission, 1971: 192-195.

Nevertheless, it should be noted that the participation rate is not constant, but is projected to increase by 62% between 1970 and 1985, or by approximately 4.1% annually. For this reason, equation (4.3) should be used. Utilizing this formulation, the per acre present value for user benefits would be $775.73.

Nevertheless, it should be recognized that the evaluation of recreational activity is subject to a number of shortcomings. First, the methods used by necessity assign an equal value to all areas of wetland, regardless of the fact that some are more suitable for recreational activities than others, and that certain areas are totally or partially inaccessible for use. The method thus assigns an average value to each acre of wetlands. Secondly, the assignment of values per user-day of activity has been widely criticized by economists for its arbitrariness and insensitivity to recreation-demand analysis of the more traditional type (see, for example, Whitman, 1973: A-44 - A-45). However, as stated above, the difficulties in estimating a demand function for various recreational activities preclude the use of the more traditional marginalist analysis. Finally, and perhaps most importantly, the entire question must be raised of whether the nature of recreation is in reality a non-competing use of the wetlands. The development of recreational facilities may place increased pressure on coastal resources, and may further affect the wetlands' productivity.

If, however, commercial and non-commercial fisheries and other recreational activities may be regarded as non-competitive in nature and non-detrimental to the functioning of the wetlands, they represent considerable value to the coastal areas of Louisiana. These values are summarized in Table 4.7.[3] Note that the total present value for an acre of wetland ($2449.52) as derived here using Louisiana Advisory Commission (1973: 187-188) recommendation (3) (see above)

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[3]To these must be added the economic value of waste assimilation.

TABLE 4.7

ESTIMATED VALUE OF COASTAL WETLANDS FOR COMMERCIAL AND NONCOMMERCIAL FISHERIES AND RECREATIONAL ACTIVITIES

ACTIVITY	TOTAL ANNUAL RETURN	ANNUAL RETURN/ACRE[5]	PRESENT VALUE/ACRE
I. Commercial Fisheries a) total fisheries, including value added in processing[1]	$289,926,981	$ 53.76	$1,261.36
II. Noncommercial Fisheries[2]	10,879,875	2.02	33.62
III. Recreational Activities a. Economic impact of recreation expenditures[3]	122,634,808	22.74	378.81
b. Economic value of user benefits[4]	202,586,280	27.65	775.73
TOTALS	$626,027,944	$106.17	$2,449.52

Sources: 1. From Table 4.3.

2. See text.

3. See text.

4. See text.

5. Values shown do not include various expected increases overtime in the annual returns. See text.

is approximately equal to the value that is found using its recommendation (4)--multiplying annual returns by the life of a project (106.17 x 20) yields a total per acre value of $2123.40.

DOMESTIC AND INDUSTRIAL WASTE ASSIMILATION

In addition to the productivity of the wetlands in providing nutrients and breeding space for commercial fish species, the estuarine zone in Louisiana performs an important service in its ability to assimilate the wastes of urban complexes. Currently, approximately one-third of the U.S. population lives and works within estuarine zones. This phenomenon reflects to a large extent man's dependence upon the estuaries' natural assimilative capacity to absorb both the liquid and solid wastes of urban centers (Drobny, and Qasim, 1971: G-2). The purpose of this section is to define in monetary terms the contribution of the Louisiana wetlands in providing these assimilative services. The methodology employed will be to assign an economic value equal to the cost which would be incurred if these services were to be performed artificially in sewage treatment plants. It should be indicated at the outset, however, that in many cases the assimilative capacity of the estuarine systems has been exceeded by the dumping into them of untreated (raw) or partially treated sewage. This results in decreased desolved oxygen levels and accompanying pollution side effects. (See, for example, Drobny and Qasim, 1971: G-6 to G-10). For this reason, only the tertiary or final stage of waste treatment will be considered.

The organic pollution load is measured by biochemical oxygen demand (BOD), the amount of oxygen used in the process of aerobic decomposition of unstable organic material. BOD is generally measured in parts per million or in milligrams per liter, and it is an important indicator of the amount of organic matter present in sewage. The magnitude of BOD is directly proportional to the amount of organic material present while the rate at which the demand is satisfied depends upon the temperature (Steel, 1960: 453-454). The dissolved oxygen level of a stream depends upon the rate at which oxygen is withdrawn from the stream to oxidize the organic material. If the BOD completely depletes the stream of dissolved oxygen, the resulting anaerobic conditions retard decomposition, resulting in the production of offensive odors and the disappearance of many species (see chapter 3). Because the solubility of oxygen in water varies inversely with temperature, the danger of anaerobic conditions is greater in the summer than in the winter. Thermal pollution, primarily caused by the use of water for industrial cooling, acts to further decrease the level of dissolved oxygen (James and Lee, 1971: 374-375).

Other waste-water contaminants, including phosphorus and nitrogen, coliform bacteria, and toxic substances can be identified, but the response of an estuarine environment to these contaminants is not clearly predictable (Environmental Protection Agency (EPA), 1970: 7).

The processes used to treat waste water are roughly classified as primary, secondary, and tertiary treatment (EPA, 1970: 9-12). Primary treatment normally consists of removing particulate contaminants by means of sedimentation. The sludge formed is then reduced in volume by means of digestion by anaerobic bacteria, and dewatered by means of vacuum filtration, centrifugation, or sludge drying beds. Secondary treatment is generally some form of biological process which converts dissolved organic compounds to microorganisms which can then be settled out and removed in the final clarifier. The principal methods used are the activated sludge process and trickling filters. Tertiary treatment generally consists of processes used downstream from the secondary plant to remove an additional fraction of the contaminants. The status of sewage treatment in the U.S. in 1968 was such that 28.4% of the population served received primary treatment for their sewage, 65.4% received both primary and secondary treatment, and only 0.3% received the additional tertiary treatment.

Normal raw domestic sewage generally contains 200 milligrams per liter (mg/l) of both 5-day BOD[4] and volatile suspended solids. Primary treatment generally removes 35% of BOD, resulting in approximately 130 mg/l remaining for secondary treatment. If the activated sludge process is working at peak efficiency, 90% of the remaining 5-day BOD is removed. The secondary effluent from the activated sludge process will therefore measure approximately 13 mg/l of 5-day BOD (EPA, 1970: 12).

The cost of treatment in secondary facilities has been estimated to be about $0.04 per pound of BOD removed, a relatively small value when compared to the estimated cost of $2.00 per pound of BOD removed in tertiary treatment (Drobny and Qasim, 1971: G-21). Furthermore, the release of primary effluent by the New Orleans-Jefferson area may have exceeded the estuarine assimilative capacity, since a considerable area south of this urban zone has been closed to shell fishing because of bacterial pollution (see, for example, Louisiana Advisory Commission on Coastal and Marine Resources, 1973: 125-26, 165). For these reasons, only the contribution of the wetlands in providing tertiary treatment will be evaluated. This evaluation consists of assigning to the wetlands acreage the cost which would be incurred if the tertiary treatment, provided naturally by the estuarine system, were artificially duplicated.

Assuming a standard of 100 gallons per capita per day passes through a tertiary treatment facility (EPA, 1970: 34), and assuming an average of 13 mg/l

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[4]The level of dissolved oxygen depletion which occurs over a 5-day incubation period during which sewage is diluted with water containing a known amount of dissolved oxygen and the loss of oxygen over the 5-day period is noted (Steel, 1960: 453-454).

of 5-day BOD, a total of 4927 mg/capita/day or 1,798,355 mg/capita/year will be removed.[5] Since the population of the Louisiana coastal zone in 1970 was estimated to be 2,527,209 (Louisiana State Planning Office, 1974: 5), this represents a total of 4.545×10^{12} mg/year of BOD loadings, which converts to 1.002×10^{7} lbs/year. Actual domestic sewage discharge in the Louisiana coastal zone is considerably higher. Information provided by the Louisiana State Department of Health indicates that effluents from the New Orleans area have received only primary treatment (Louisiana Wildlife and Fisheries Commission, 1971: 20-22). Calculations show that the actual annual discharge of domestic sewage in the coastal zone is approximately 2.875×10^{7} lb/yr. of BOD or almost three times as great as that assumed in this analysis (Louisiana Wildlife and Fisheries Commission, 1971: 20-22).

In addition to the BOD loading contributed by domestic sewage, industrial wastes emptying into the estuarine areas in Louisiana are considerable, particularly in the vicinity of the Mississippi and Calcasieu Rivers. While the exact quantity of BOD discharged daily is not known, it has been indicated that the average discharge of industrial waste along the Louisiana coast is in excess of 1.44×10^{9} gallons per day (Louisiana Wildlife and Fisheries Commission 1971: 22-24). Again, if it is assumed that both primary and secondary treatment has been provided, the discharge will average 13 mg/l of BOD. This represents a total of 1.565×10^{5} lbs/day or 5.12×10^{7} lbs/year. It should be noted, however, that, as in the case of domestic BOD loadings, this assumption is at

[5]This analysis assumes that 100% of the BOD is removed from the secondary effluent during the tertiary process; in reality however, the most efficient tertiary process (lime clarification, ammonia stripping, and granular carbon absorption) will remove all but 1 mg/l of BOD (EPA, 1970: 15). It is assumed that the tertiary treatment provided by the wetlands will remove 100% of the 5-day BOD.

variance with actual conditions. Of the 120 sources of industrial discharge identified within the area encompassed by the Mermantau River Basin and the Chandeleur Sound, 47 provided less than secondary treatment, and many of these provided no treatment whatsoever (U.S. Army Corps of Engineers, 1973: 35-37).

The combined discharge of domestic and industrial secondary effluent measures approximately 6.714×10^7 lbs/year of BOD. If the total acreage of wetlands is estimated to be 5,393,564 (Louisiana Department of Public Works, no date: 4-6), this represents an average load of 12.45 lbs/acre/year of BOD.

This loading, however, is not expected to remain constant. Projections indicate that population in the five southermost Planning Districts in Louisiana is expected to increase by approximately 32% between 1970 and 1990 (Louisiana Office of State Planning, 1975: 5). Assuming that this projection is linear, this represents an average annual increase of 1.6%. For this reason, secondary effluent from both domestic and industrial sources is assumed to increase on the average by 1.07×10^6 lbs/year. Again, this projection may be an understatement, considering that value added in manufacturing has been increasing in Louisiana at an annual rate of approximately 6.7% (Office of State Planning, 1975: 39).

Drobny and Qasim (1971: G-39 to G-44) indicate that tertiary treatment costs in the U.S. vary considerably with plant size; however, since the majority of plants constructed range in capacity between 1 and 10 million gallons per day (mgd), they suggest the use of cost data corresponding to a plant size of 4 mgd. This establishes a cost of $2.00 per pound of BOD removed. On this basis, the annual work performed by an acre of wetlands in tertiary waste treatment may be valued at $24.90, and increasing at $0.40 or 1.6% annually. Utilizing equation (4.3), the value of an acre of wetland for these purposes may be estimated to be $526.11. If this is added to the present value per acre of wetlands shown in Table 4.7 ($2449.52), the total present value of non-competing functions of an acre of wetland is $2975.63, see Table 4.8 below.

It has been indicated that the actual work of waste assimilation performed by the wetlands is more than likely considerably greater because the quality of the effluent is less than that corresponding secondary to secondary treatment. Furthermore, it must be pointed out that the BOD loadings considered in this analysis relate only to the coastal zone of Louisiana, and does not include the effluent discharged north of the coastal zone, a large part of which is assimilated by the wetlands.

WETLANDS ENERGETICS

In the previous sections, the wetlands have been evaluated in terms of values imputed to the area for services provided "free" to society. In addition to these services, the wetlands play an important function in the ecological system by producing plants which constitute the first trophic level of the estuarine food system (Odum, 1954: 68).

Primary production in the Louisiana wetlands depends upon the various zones, including saline, intermediate, and brackish marshlands as well as freshwater marsh. Primary production in the marshwater interface zone (extending inland 150 feet from the open water) is dominated by oystergrass (*Spartina alterniflora*) and is the most highly productive, yielding as much as 2960 grams of dry weight per square meter per year (g dry wt/m^2/yr). The inland brackish waters are dominated by wiregrass (*Spartina patens*) and black rush (*Juncus roemerianus*), whose production has been estimated to be 1484 g dry wt/m^2/yr. Average primary net production (gross production less respirations (energy used by grass)) has been estimated to be 1518 g dry wt/m^2/yr in the Barataria Bay area (Day *et al*., 1973: 13) and 1785 g dry wt/m^2/yr in the total marsh area (Stone *et al*., 1973: 45-51). It has been suggested (de la Cruz, 1973: 149) that the marsh

TABLE 4.8

COMPONENT VALUES OF WETLAND FUNCTIONS

COMPONENT	TOTAL ANNUAL RETURN	ANNUAL RETURN/ACRE[3]	PRESENT VALUE/ACRE
I. Commercial Fisheries[1]	$289,926,891	$ 53.76	$1,261.36
II. Noncommercial Fisheries[1]	10,879,875	2.02	33.62
III. Recreational Activities[1]			
a) Economic impact of recreation expenditures	122,634,808	22.74	378.81
b) Economic value of user benefits	202,586,280	27.65	775.73
IV. Tertiary Waste Treatment[2]	134,280,000	24.90	526.11
TOTALS	$760,307,944	$131.07	$2,975.63

Sources: 1. From Table 4.7.

2. See text.

3. Values shown do not include various expected increases over time in the annual returns. See text.

areas are among the most productive in the world, the magnitude of the production being equal to, if not higher than, the net annual production of well-managed, highly subsidized croplands.

Only a small percentage (less than 10%) of the organic material produced in the wetlands is actually grazed by marsh herbivores; the bulk of the plant material dies and decomposes to organic detritus. The detritus is consumed by detritivores, which form the basis of the food chain for secondary and higher consumers, or is transported to estuarine and marine waters for consumption by higher species (de la Cruz, 1973: 147).[6]

The importance of the primary production in the coastal marshes should not be underestimated. In a study of the Lake Pontchartrain estuary, Darnell (1961: 565-567) finds that consumers within the lake depend in great measure upon primary production which takes place outside the lake. The fish and invertebrate species of the lake belong to either of two groups. The first includes those forms which feed largely upon organic detritus from the wetlands (rangia clam, stripped mullet, large scale menhaden, and white shrimp). The second group, including sea catfish, bay anchovy, and the blue crab, are omnivores and are characterized by a wide range of food tolerance at sea. It is noteworthy that the first group, including the commercially important menhaden and white shrimp, depend most conspicuously upon organic detritus with attendant bacteria. Darnell (1961: 567) concludes that detritus of vegetable origin is the most important single food material ingested by the fish and invertebrate consumers.

[6]It is interesting to note that particulate detritus contains a higher protein content and caloric value than live, standing dead, or partially decayed plants. This may be due to an increase in nutritive constituents or in microflora impregnating the organic detritus (de la Cruz and Gabriel, 1974: 883-884).

Table 4.9 provides a summary of energetics of a Georgia salt marsh ecosystem (Teal, 1962: 614-623). Following an input of 600,000 kilo-calories per square meter per year (kcal/m^2/yr), as much as 93.9% of solar energy is lost in photosynthesis. Of the remaining 6.1%, 77% is lost in plant respiration. The large amount of energy dissipation results from the second law of thermodynamics, which states that no transformation of energy will spontaneously occur without a degradation of energy from a more concentrated to a more dispersed form (odum, 1954: 65). It is interesting to note that Teal's finding of net primary production of 8,205 kcal/m^2/yr in the Georgia salt marsh is extremely close to the values of 8,088 kcal/m^2/yr in the Mississippi Gulf Coast estuaries (de la Cruz, 1974: 353-54), and 8,031 kcal/m^2/yr in coastal Louisiana (Stone, 1973: 51). Following respiration loss of 55% (4,534 kcal/m^2/yr) through bacterial and consumer (primary and secondary) respiration, a total of 3,671 kcal/m^2/yr are exported to the estuaries.[7] Again, this result is similar to that found by Day et al. (1973: 60-62) in the Barataria Bay estuary, where it was determined that the marsh exported 764 grams/m^2/yr. Using a conversion rate of 1 gram equivalent to 4.5 kilo-calories (Odum, 1967: 73), 764 g/m^2/yr equals an export of 3,438 kcal/m^2/yr.[8] Figure 4.2 indicates the importance of this export from the marsh to the water component. Table 4.10 shows the intake, respiration, and production of the four trophic levels of fish at the end of the water component.

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[7]The primary consumers in the Georgia saltmarsh were identified to belong to two groups. The first consists of herbivorous insects, including the saltmarsh grasshopper, which support the spiders, wrens, and nesting sparrows. The second group includes the detritus and algae feeders, of which crabs (Uca and Sesarna), annelids, nematodes, mussels, and snails predominate. This latter group functions as primary consumers, although the detritus also contains animal remains and numbers of bacteria that help decompose the Spartina. The carnivores (secondary consumers) preying on the algae and detritus eaters are principally mud crabs, raccoons, and rails (Teal, 1962: 616, 618-619).

[8]Day et al. (1973: 60-62) found a net primary product estimate of 1518 g/m^2/yr which converts to 6831 kcal/m^2/yr, somewhat lower than other net production values cited above.

TABLE 4.9

SUMMARY OF GEORGIA SALT MARSH ENERGETICS

TROPHIC LEVEL	RESPIRATION AND PRODUCTION ($kcal/m^2/yr$)
Input as sun light	600,000
Loss in photosynthesis	563,620 or 93.9% of sun light
Gross Primary production	36,380 or 6.1% of sun light
Producer respiration	28,175 or 77% of gross production
Net Production	8,205
Bacterial respiration	3,890 or 47% of net production
Primary consumer respiration	596 or 7% of net production
Secondary consumer respiration	48 or 0.6% of net production
Total energy dissipation by consumers	4,534 or 55% of net production
Export to estuaries	3,671 or 45% of net production

Source: Teal, 1962: 623.

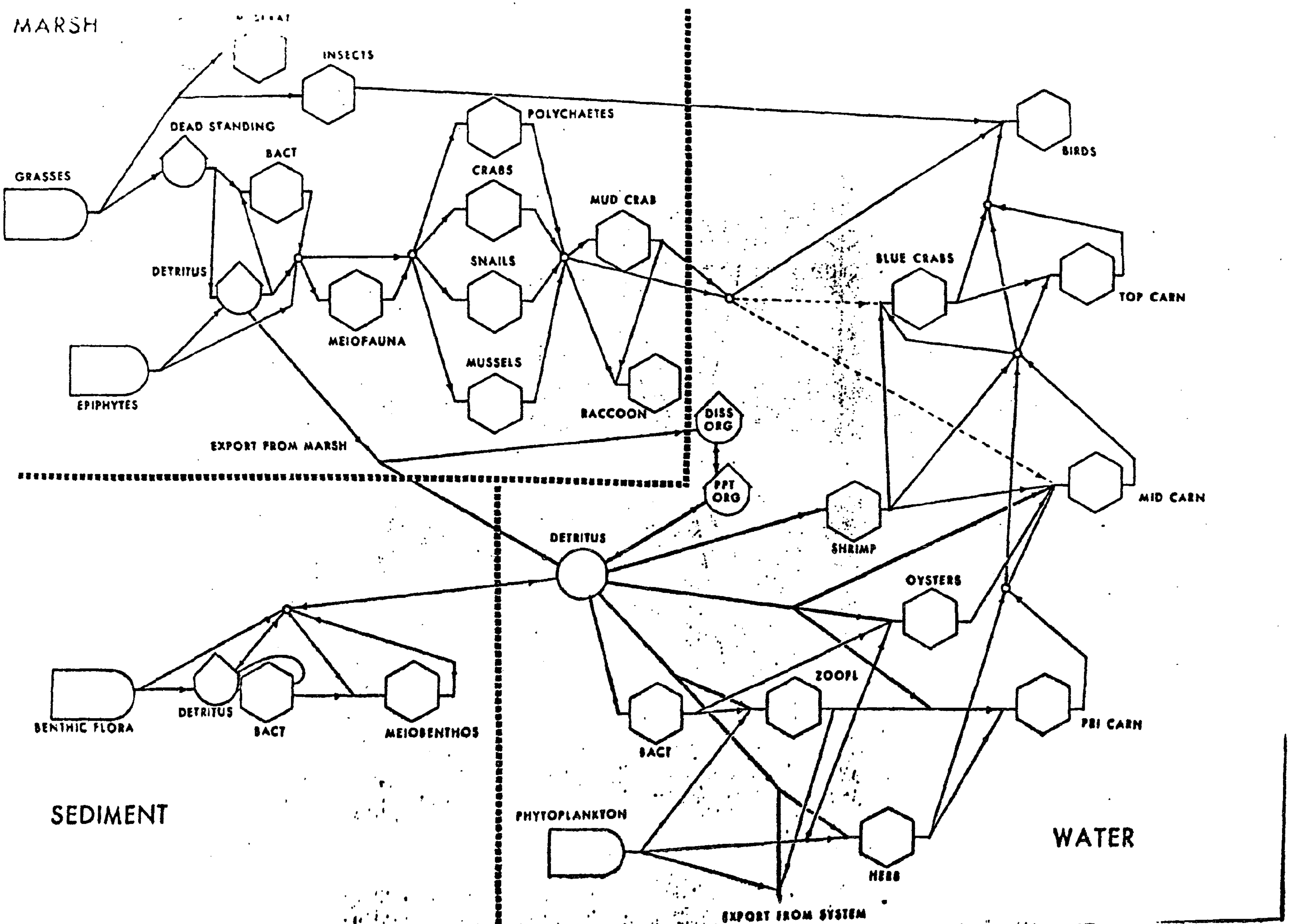

Figure 4.2. Diagram of marsh-energy system, by component. Heavy lines show the flow of detritus.

TABLE 4.10

ORGANIC BUDGETS FOR DIFFERENT TROPHIC LEVELS OF FISH, IN G DRY WT/M^2/YEAR

TROPHIC LEVEL	TOTAL INTAKE	RESPIRATION	FECES	PRODUCTION
Herbivores	3.00	0.72	1.25	1.03
Primary carnivores	2.23	0.54	0.93	0.76
Mid carnivores	31.00	7.48	17.93	10.95
Top carnivores	27.30	6.59	11.38	9.33
TOTALS	63.53	15.33	31.49	22.07

Source: Day *et al.*, 1973: 46.

An alternative method for the evaluation of the productivity of ecological systems was suggested by Odum (see, for example, 1971: 182-184 and 1967: 55), and was utilized in a similar study on the tidal marshes in Louisiana (Gosselink et at., 1974: 17-20). In this method, the total present value of an acre of wetland is evaluated on the basis of energetics rather than by summing non-competing productive components as discussed in preceding sections. The method suggests that energy is the common denominator for all processes. This realization permits the measurement of exchanges within an ecological system. The method requires the development of a ratio of energy consumption to Gross National Product, and thus gives an approximate value in monetary terms of the energy consumed per dollar of output. Odum (1971: 182) uses a ratio of 10,000 kcal/dollar. This may be an overvaluation, however; Gambel (1964: 2) states that the ratio in 1960 was approximately 90,000 kcal/dollar, down from 100,000 kcal/dollar in 1940. Assuming that the linear trend from 1940-1960 period holds for 1960-1971 period, the ratio in 1971 would be 84,500 kcal/dollar. Gilliland (1971: 1053) places the ratio in 1972 at 15,800 kcal/dollar. However, Day and Bahr (1975) expand this ratio by 20 due to the quality differences between natural and fossil energy. This yields a ratio of 316,000 kcal/dollar.

The evaluation of marsh energetics in monetary terms poses certain problems. First, as suggested above, there does not appear to be agreement upon the ratio of energy to Gross National Product; furthermore, a ratio of this type is subject to change, depending upon the efficiency of energy use. A second qualification, pointed out by Gosselink et al. (1974: 18) as well as Day and Bahr (1975)(see above), is that the energy generated in a natural system may be of different quality, and therefore not comparable to, the energy derived from fossil fuels. Nevertheless, as Gosselink et al. (1974: 18) state, the natural energy units are essential to life, and therefore the dollar value placed upcn them may be an understatement. Finally, there is the difficulty of determining at which stage of the ecological system the energetics should be evaluated. Presumably, it would be possible to evaluate solar energy as the original energy input; alternatively, one could evaluate the energy value of only top carnivores, since these are the species of most interest to man. Gosselink et al. (1974: 18) evaluate the primary net production (that is, gross production less respiration), as a measure of the energy flow of the natural community. Table 4.11 provides a summary of energy flows at various levels of the estuarine system of Louisiana; these are evaluated with four separate energy-GNP ratios.

CONCLUSIONS

Table 4.8 presents a summary of the component values of various non-competing functions of the wetlands considered in this chapter. It is interesting to compare the Table 4.8 values with the energy evaluation of the immediately preceding section (Table 4.11). For example, in Table 4.8 the present value per acre of the wetlands in Louisiana is estimated to be $2976 using summation of the values of component functions. This is about midway of the present values calculated at various production levels on the basis of wetland energetics using the 90,000 kcal/dollar or 84,500 kcal/dollar ratios (Table 4.11). The 316,000 kcal/dollar ratio leads to a value of $1714.17 per acre when computed at the net primary production stage. This is the value closest to $2976. The net primary production value is usually chosen to evaluate wetland energetics (Gosselink, et al., 1974: 17-21). Using the 10,000 kcal/dollar ratio, the wetland energetics method yields per acre values that appear exceedingly high--although not out of range with Gosselink et al. estimates (1974: 17-21).[9] The value of $2976 per acre is about 10 times the present value per acre of wetland

[9] If the 10,000 kcal/dollar ratio were multiplied by 20 to account for natural and fossil energy quality differences and the resulting ratio used to compute an annual return and a present value (at 6%) at the net primary production level, the per acre values would be $162.50 and $2708.33 respectively. (cont'd)

TABLE 4.11

ENERGY EVALUATION AT SEVERAL ECOLOGICAL LEVELS[1]

	ECOLOGICAL LEVEL			
	PRIMARY NET PRODUCTION	DETRITUS EXPORTED TO WATERS	FISH PRODUCTION	TOP CARNIVORE PRODUCTION
ANNUAL PRODUCTION				
g dry wt/m^2	1785[2]	764[3]	22.07[4]	9.33[4]
g dry wt/ acre	7,223,395.2	3,018,853.1	89,311.11	37,755.9
kcal/acre	32.5×10^6	13.6×10^6	401,900	169,901.5
EVALUATION AT 10,000 kcal/dollar				
Annual Return/Acre	$3250	$1360	$40.19	$17.00
Present Value/Acre[5] (eq. 4.2)	$54,166.67	$22,666.67	$699.83	$283.33
EVALUATION AT 90,000 kcal/dollar				
Annual Return/Acre	$361.11	$151.11	$4.47	$1.89
Present Value/Acre[5]	$6,018.33	$2518.50	$74.50	$31.50
EVALUATION AT 84,500 kcal/dollar				
Annual Return/Acre	$384.62	$160.95	$4.76	$2.01
Present Value/Acre[5]	$6410.33	$2682.50	$79.33	$33.50
EVALUATION AT 316,000 kcal/dollar				
Annual Return/Acre	$102.85	$43.04	$1.27	$ .54
Present Value/Acre[5]	$1714.17	$717.33	$21.17	$9.00

Sources: 1. Conversions from grams to kilo-calories are based upon 4.5 kcal/g dry wt.; conversions from square meters to acres are based upon 4046.72 m^2/acre. Income capitalization values are based upon 6% rate of interest.

2. Primary net production in kcal/acre is based upon an estimate by Stone *et al*. (1973: 51) of 1.3×10^{14} kcal in a marsh area of 4×10^6 acres, or 32.5×10^6 kcal/acre. This estimate would require that primary net production average 1785 g dry wt/m^2.

3. Day *et al*., 1973: 60.

4. Based upon information in Table 4.9.

5. Assumes interest rate of 6%.

presently used by the New Orleans District of the Corps of Engineers--annual return per acre of $17.07 at 6% yielding a present value of $284.50 (Gordon, 1975: 4). A recommendation has, however, been made to the New Orleans District that the annual return be increased to $133 per acre (Gordon, 1975: 5) which at 6% would yield a present value of $2216.67--much closer to the value derived here ($2976).

The values attributed to the Louisiana wetlands in this chapter have in all cases incorporated the most conservative estimates, and do not include other non-monetary and non-quantifiable properties (affect of wetlands on climate, on landscape aesthetics, etc.). Adjustments for increasing annual return (equation 4.3) have only been included where they have been previously estimated. However, annual returns for all components will probably increase. This emphasizes the conservative approach used here. For this reason, these values must be considered an underestimation; they do, however, provide at least a basis for the inclusion of otherwise neglected functions in the decision-making process, thus reflecting at least a portion of the true opportunity costs of developing these areas.

Furthermore, certain qualifications with regard to these values should be considered. First, they constitute short-run values only; if the productivity provided by such undeveloped areas remains fixed, there appear to be grounds to believe that the real benefits per acre of such productivity will increase over time. This is particularly true if increased population places increasing demand upon the environment, and food, recreation space, etc. becomes scarce.

Secondly, as suggested by Fisher, Krutilla, and Cicchetti (1972: 27), there is the possibility that the net benefits of a development project relative to alternative projects may actually decrease over time. The example

[9](cont'd) Although $2708.33 is close to $2976, there is no compelling reason why a ratio of 200,000 kcal/dollar should be used in preference to any of the other ratios without further research.

is given of a hydroelectric project during whose lifetime the cost of the best alternative sources of energy continuously decrease as plants embodying newer technologies come into being. Traditional benefit cost analysis generally calculates costs as of the construction date, thereby implying that the technology of alternative sources will remain fixed over the life of the project. This implicit assumption may result in the overvaluation of a development project relative to alternatives.

Third, as Gosselink _et al_. (1974: 22-23) observe, the process of development is largely irreversible: economic analysis may indicate that at some point the marginal opportunity costs of development (i.e., the benefits from preservation) have exceeded the marginal benefits of development. According to maximization theory, this would require that "undevelopment" should take place, up to a point where marginal benefits of development are equated to marginal costs. Apart from its impracticality, it is doubtful that any forseeable level of technology would be able to recreate a natural environment once development has occurred. On a preventative basis, however, Fisher, Krutilla, and Cicchetti (1972: 18-40) were able to find a solution to the problem of decreasing benefits of development relative to the increasing benefits from preservation. According to the analysis, a point is reached where the benefits of the best short-run development begin to fall; at this point, it will be optimal to refrain from development, although further development may be indicated by comparison of _current_ benefits and costs.

Many of the problems associated with decisions to develop natural areas are extra-economic in that they involve policy questions which are resolved outside of the economic framework. These include the decision to compensate private resource owners for keeping their land in a natural state, or to exact charges for the use of common property resources such as fisheries. The resolution of these problems would undoubtedly reflect the high value to society of such resources and prevent the less-than-optimal use of these areas. In any case the value of an acre of wetland in terms of recent price levels (1970-73) is probably between $2500 to $3000.

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CHAPTER 5

CONSTRUCTION AND MAINTENANCE COSTS IN WETLANDS

INTRODUCTION

Development costs, in terms of construction and maintenance, in areas which were formerly wetland are normally greater than in natural drylands. Developmental decisions, therefore, should take these added costs into account. In this chapter, actual cases are analyzed in order to divide costs into construction and maintenance costs, both in the public and private sectors. Although costs related are for New Orleans, they are felt to be applicable for the other urban areas after slight adjustment for cost of living differences.

A COMPARISON OF WETLAND AND DRYLAND CONSTRUCTION COSTS

The question posed in this section is: within the context of development costs, is there a marginal cost that can be attributed to the fact that the construction of a given project is to be in a wetland area?

In the area of construction costs, one of the largest information systems is the F. W. Dodge Division of McGraw-Hill Information Systems Company. This division of McGraw-Hill is primarily responsible for selectively issued microfilm copies of bidding documents detailing the plans for competitively bid construction jobs and as such provides a repository of plans for current construction projects of local interest. The F. W. Dodge Division also publishes Dodge Reports, Dodge Bulletins, four regional construction industry newspapers, and provides several construction statistics information services.

One informational publication of F. W. Dodge is a semi-annual publication entitled Costs and Trends of Current Building Projects. This publication contains cost analysis of current construction projects that have reached the "basic contract award" stage for a particular region of the country. Contained in the most recent issue of Costs and Trends (Year-End 1974) for Region F is a cost analysis for a dental clinic built in Metairie, Louisiana--a wetland area. There is also an analysis of a doctor's clinic built in Curtis, Nebraska--a natural dryland. Both structures are one story with no basement and involve approximately the same gross floor area. The cost per square foot of the Metairie building's foundation was $2.40 per square foot while the foundation cost of the Curtis building was $1.28 per square foot. Thus the Metairie building's foundation cost was almost twice (1.87) that of the Curtis building. This was due to the more complex piling foundation of the Metairie building which is required in wetlands. The increased cost of wetlands construction is obvious and dramatic.

WETLAND DEVELOPMENT: EDEN ISLES AND PONCHARTRAIN NEW TOWN

EDEN ISLES

Eden Isles is a development of approximately 5,300 acres located near the northeastern shore of Lake Pontchartrain. During the 1920's, area residents leveed off what is now Eden Isles and turned it into a agricultural community. The depression brought the end of the farmers and the growth of the fishing/seafood industries in the area, which led to the demise of the levee system. This caused the land to revert back to its wetland state. In the late fifties, developers bought up the land and built a new levee system and resold the land to Leisure, Inc. Since 1962, Leisure, Inc. has been selling lots on a retail basis for the community named by them as Eden Isles. Beginning in 1975, Leisure, Inc. ceased retailing parcels and shifted exclusively to wholesale transactions, by which they predict all property will be sold by September, 1976 (Burk, 1975).

Eden Isles' prime lot locations are waterfront parcels along man-made canals. Because of this unique construction, costs occur that are not seen in other developments. That is, bulkhead construction costs. The process used for land filling in this development is one called <u>backfilling</u>. Initial canals are dredged to a specified depth. Then bulkheads are constructed along the waterfront portion of each lot. The canals are then further dredged and this material is used to backfill the lot to the edge of the bulkhead. A current (1975) cost figure for bulkhead construction is approximately $50.00 per linear foot. The average size of a residential lot in Eden Isles comprises 60 feet of waterfront. Therefore, additional cost per single family residential lot due to bulkhead construction in Eden Isles is $3,000.00 (Burk, 1975).

In addition to bulkhead construction costs, the current (1975) cost of fill in Eden Isles is $0.75 per cubic yard. Lots are filled to a minimum of 6½ feet above mean sea level. This results in an additional cost per residential lot of $1,300.00.

These improvements to single family residential lots, improvements necessitated by the unique physical circumstances of the Eden Isles site, equal $4,300.00 per average waterfront lot not including the cost of the levee system, existing as built in the 1950's and included in the purchase price of $1,500 per acre paid by Leisure, Inc.

PONCHARTRAIN NEW TOWN

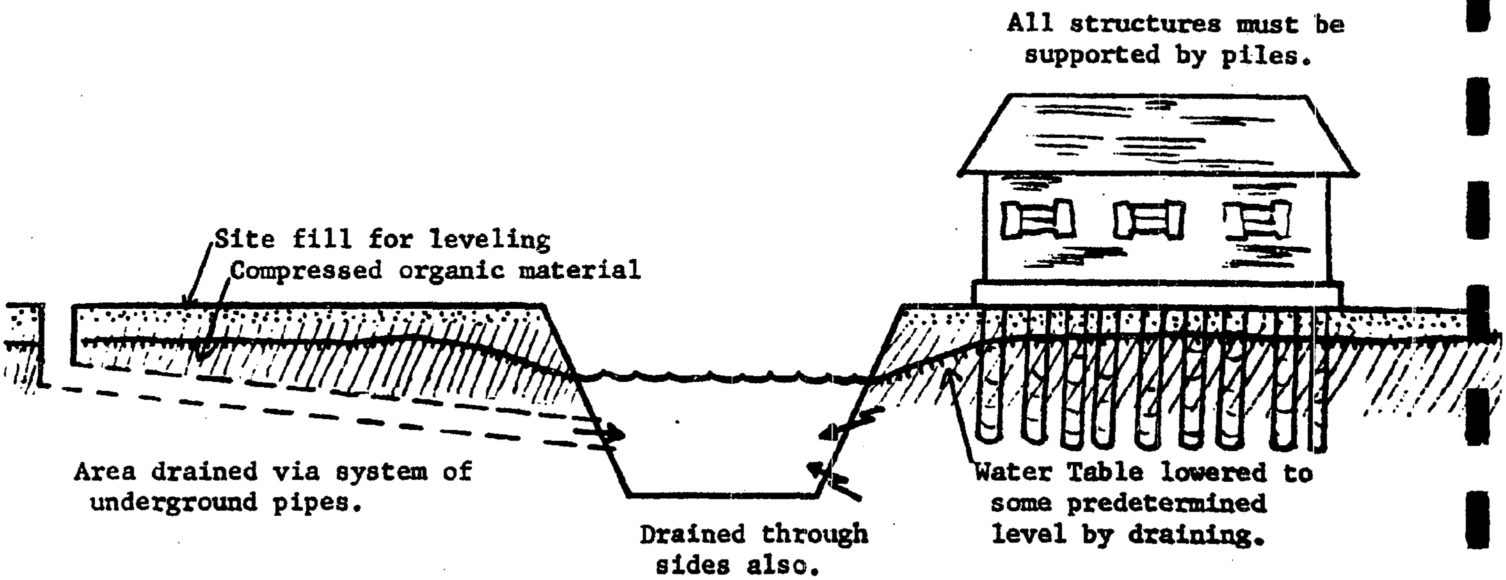
Pontchartrain New Town-In-Town was to be a planned community consisting of over 8,000 acres of developed land located within the city limits of New Orleans in an area known as New Orleans East--32,000 acres of land which is predominantly a natural wetland area (see Chapter 2). The idea was abandoned in 1975 in favor of the Orlandia project after federal loan guarantees under the U.S. Department of Housing and Urban Development New Communities Development Program were not granted.

Estimates of site development costs for Pontchartrain were prepared by three groups over a two and one-half year period. The first estimates were prepared by the firm of Tippetts-Abbett-McCarthy-Stratton (TAMS) in July, 1972. The second set of costs were drawn up jointly by Kaiser Engineers and Land Ventures, Inc. in February, 1974. The most recent cost estimates were prepared by the New Community Development Corporation of New Orleans in October, 1974. Cost data is based on two methods of land development which is used in wetland areas. One is known as the "wet" method or the "water drawdown" method. The other is known as the "dry" or "fill" method.

The water drawdown method is comprised of two major elements. One of these elements is an extensive system of canals and lakes, and the other is an extensive system of pumping stations. The canals and lakes serve as drains for the surrounding land. Water is then pumped out of the canals and lakes until a predetermined water table height is achieved (TAMS, 1972a: 24). (see Figure 5.1) One major requirement of the water drawdown method of land development is that it necessitates the use of pile supports for all structures built on the site.

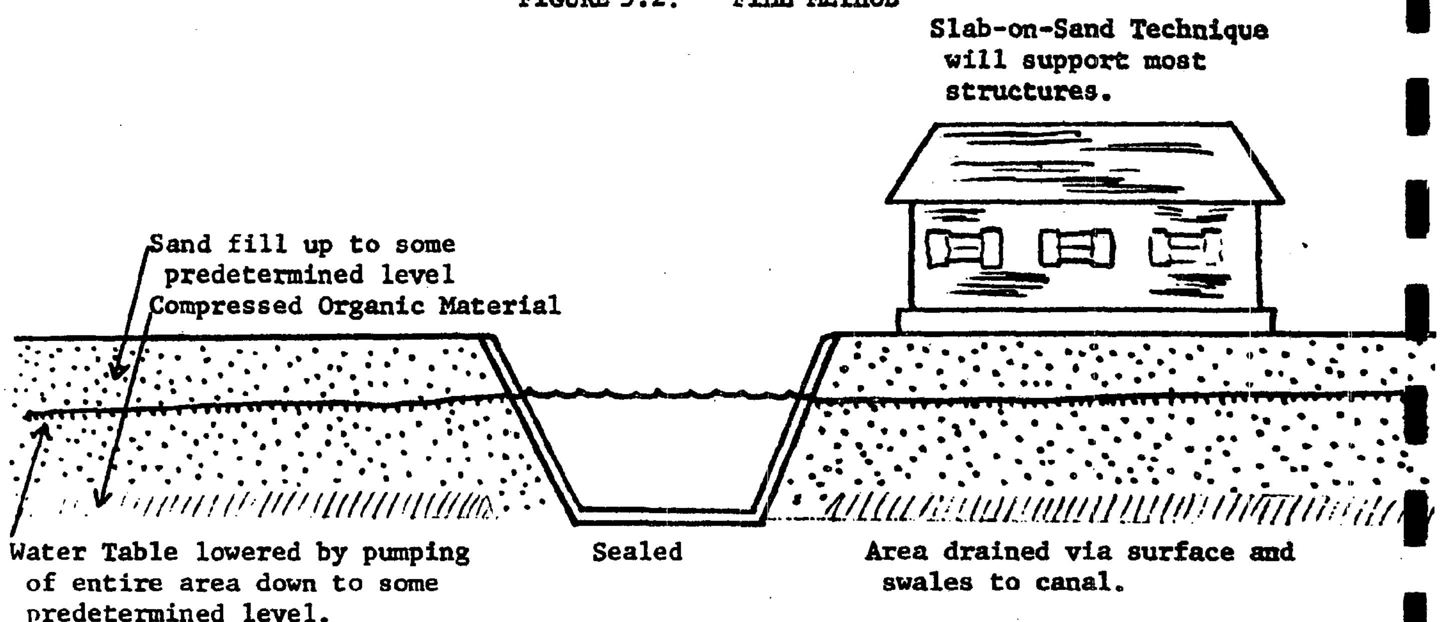
The other method of site development considered for use in Pontchartrain New Town-In-Town was the fill method. This is accomplished by raising the general site grade to a predetermined height above mean sea level (8.0 feet in this case) by means of large scale fill placement techniques (TAMS, 1972a: 25). The fill method is a three-step process. First, organic material (peat) must be removed from the site. Next, the site must be drained -- usually by means

FIGURE 5.1: WATER DRAWDOWN METHOD



Source: Burke, 1973.

FIGURE 5.2: FILL METHOD



Source: Burke, 1973.

of a system of excavated canals. And last, the site must be fulled with solid, nonorganic material, usually sand, to some predetermined height (Figure 5.2).

Pontchartrain New Town-In-Town had planned to use primarily the water drawdown method of land development. Table 5.1 shows an aggregate site development cost per residential acre ($28,000) computed from data prepared by the New Community Development Corporation of New Orleans, an arm of the City Planning Commission. It should be noted that a decision was made that the fill method was too expensive. Site fill costs on Table 5.1 refer to fill used in leveling the area after drainage.

Contained within the TAMS study is a breakdown as to foundation costs using both the dry and wet method of site development (TAMS, 1972b). Using the wet method, it is necessary to use pile foundations for all structures. Using the dry method, most structures (exceptions being high rise buildings which may require pile support) can be supported by means of the "slab on sand" technique. That is, the slab of the structure rests directly on the sand fill. Costs involved in the "slab on sand" technique are roughly equivalent to what foundation costs would be in natural drylands as no pilings are required. A comparison of costs of foundations using both methods is shown in Table 5.2. Note the similarity of foundation costs for small buildings as shown in Table 5.2 and as presented for the medical buildings in the last section. In the case of Ponchartrain New Town, any foundation savings resulting from the dry method of reclamation would probably be lost in increased land cost resulting from the more expensive dry reclamation process.

In addition to site preparation, there is another category of site development which was examined in the case of Pontchartrain: flood protection. The Kaiser study was done during a period when it was unsure as to when a levee system would be built or who would pay for it. Therefore in February, 1974 Kaiser included its costs in its analysis. First, Kaiser obtained from

TABLE 5.1

ESTIMATE OF SITE DEVELOPMENT COSTS PER RESIDENTIAL ACRE

PONTCHARTRAIN NEW TOWN-IN-TOWN
($1000's)

ITEM	DESCRIPTION		ESTIMATE OF 10/74[1]
1.	Clearing and Grubbing		No Estimate
2.	Peat Removal		No Estimate
3.	Lagoon Excavation		No Estimate
4.	Canal Excavation		.5003
5.	Site Fill		2.1012
6.	Site Grading		No Estimate
7.	Site Drainage		No Estimate
8.	Road Base		.9726
9.	Road Paving and Curb		5.0750
10.	Road Drainage		3.3420
11.	Bridges and Culverts		.7004
12.	Sanitary Sewers		5.4433
13.	Sewage Treatment		.6454[2]
14.	Water Supply		2.9618
15.	Lift Pumps		1.3208
16.	Electrical Power Distribution		.6604
17.	Street Lighting and Signs		.3002
18.	Industrial Area		No Estimate
19.	Sidewalks and Paths		.0110
20.	Blind Lagoon Levee		No Estimate
21.	Golf Course		.2542
22.	Reforestation (Allowance)		.0226
		SUBTOTAL	24.3111
	Contingency -- 15%		3.6467
		TOTAL	27.9578

Notes: [1]Costs in October 1974 Dollars

[2]75% of Cost of Sewage Treatment Subsidized by Federal Support (subsidy = 1.9362)

Source: New Community Development Corporation, 1974: II-3.

TABLE 5.2

ALTERNATIVE FOUNDATION COSTS IN PONCHARTRAIN NEW TOWN

(dollars per square foot)

	Pile	Slab on Sand
Single Family Residence Foundation	2.27	1.00
Duplex or Four-plex Foundation (2 or 3 story)	2.27	1.00
Townhouses and Garden Apartments Foundation	3.36	1.93

Source: TAMS, 1972b.

the U.S. Corps of Engineers a cost figure for the lakefront levee: $13,700,000. Kaiser than assessed Pontchartrain a 30% local share cost of $4,110,000. They then included the cost of construction of the north-south levee at $39/linear foot, which equaled $1,190,000 (Kaiser, 1974: A-9). (See Figure 5.3 for reference.) Thus, Kaiser had determined that flood protection would cost Pontchartrain developers directly over $5 million. By October, 1974 the levee system plan was finalized and subsidized entirely by the Corps of Engineers and the costs were eliminated completely from the New Community Development Corporation estimates.

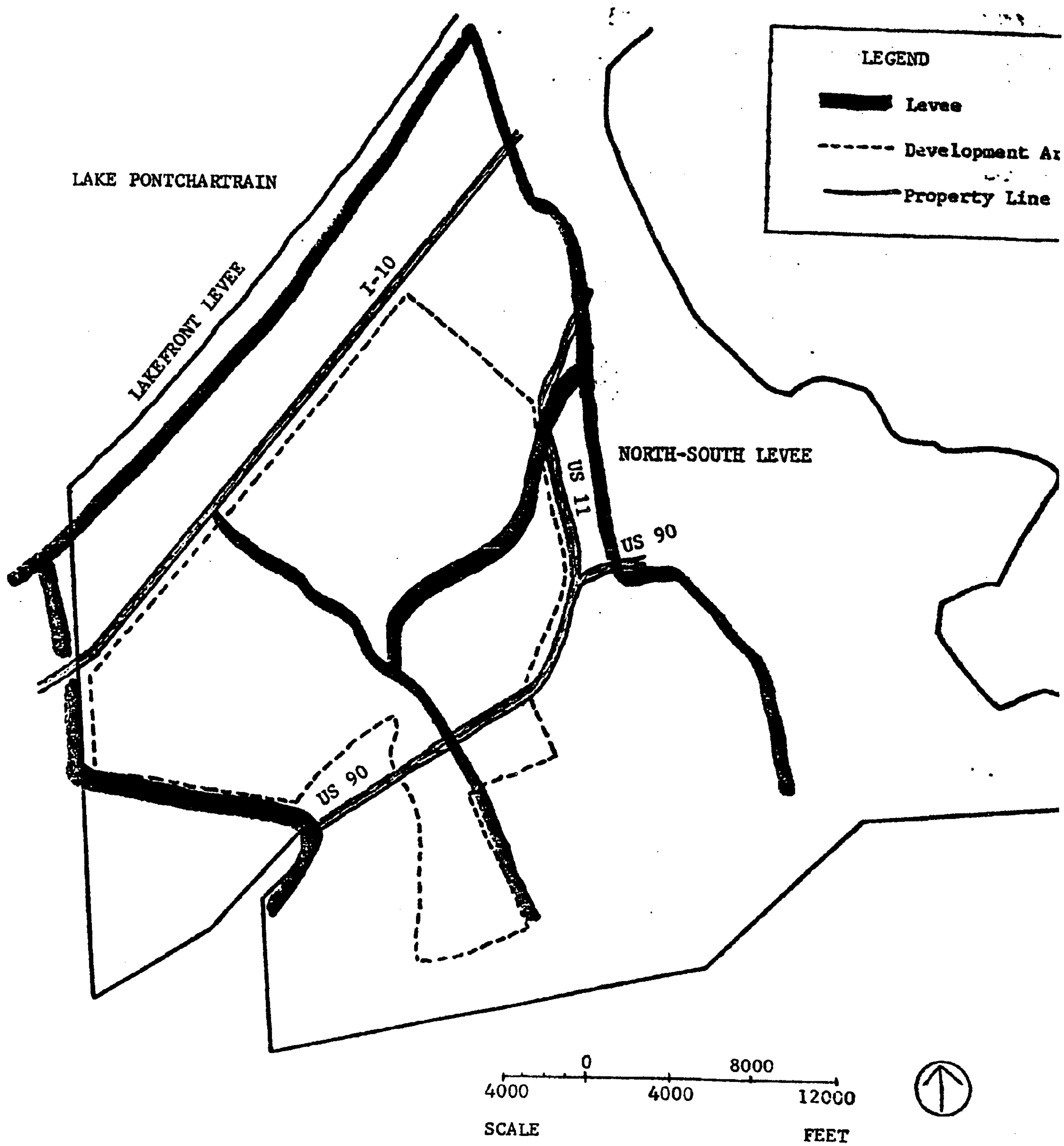
It is interesting to note the beginning of a pattern with respect to flood protection. Pontchartrain, like Eden Isles, has taken the issue for granted with respect to cost figures. The question of which comes first, development or flood protection, comes to mind at this point.

Diverting for a moment, the land reclamation projects in southern Louisiana of the early twentieth century were heralded to be the solution to the economic problems of the South (Harrison, 1947: 310). Additionally, the politicians and engineers who instigated and carried out these large scale federal projects were looked up to as "great men" of their day. An example of the public's regard for these men is seen in a quote from a New Orleans newspaper article of the time:

> No more noble undertaking than that of marshland reclamation could be imagined..., and the greatest credit is due to those who first exploited the idea of reclaiming the swamps. If monuments were erected to them in every town in the State, Louisiana would still owe them a debt; but they are modest people and are content to see, as monuments to their initiative and engineering skill, waving fields of crops, hundreds of carloads of agricultural products going to market, prosperous homes and farmers with swelling bank accounts, where formerly watery desert reigned supreme (Item, 1907).

FIGURE 5.3

Pontchartrain New Town-In-Town Levee System



Source: TAMS, 1972a: Figure 10.

WETLANDS HOMEOWNER MAINTENANCE COSTS

The next case of cost data which is examined with respect to development in a wetland environment deals with private maintenance costs associated with such development. The analysis is based upon an extensive study conducted by Earle and outlined in his dissertation entitled, Land Subsidence Problems and Maintenance Costs to Homeowners in East New Orleans, Louisiana (1975). In this study, Earle has delimited a study area located in eastern New Orleans and analyzed it extensively for present and potential subsidence conditions.

The study area as defined by Dan Earle's dissertation is broken down into six environmental units. These environmental units are based upon three sets of factors: (1) pre-reclamation physiography, (2) period of major modification by man, and (3) depth to barrier island sand (see Figure 5.4). Pre-reclamation physiography is used as an indicator of the combined conditions of base geology, soils, and vegetation. The original environments of the study area were determined to be natural levee, wetland, and lake rim.

Major modification periods are used as an indicator of the time and type of reclamation. It is assumed that the longer and more fully an area is reclaimed and drained before major development takes place, the better its foundation characteristics will become, other factors, such as soil types, being equal. Four modification periods are recognized as a basis for division. First, the pre-1700 period along the natural levee; second, the 1908-1916 federal reclamation project area; third, 1920-1960, scattered developments over the period; and last, since 1960, an area reclaimed and subdivided by a development company. The depth to barrier island sands was considered an important factor because of potentially good foundation conditions offered by this feature when near the surface.

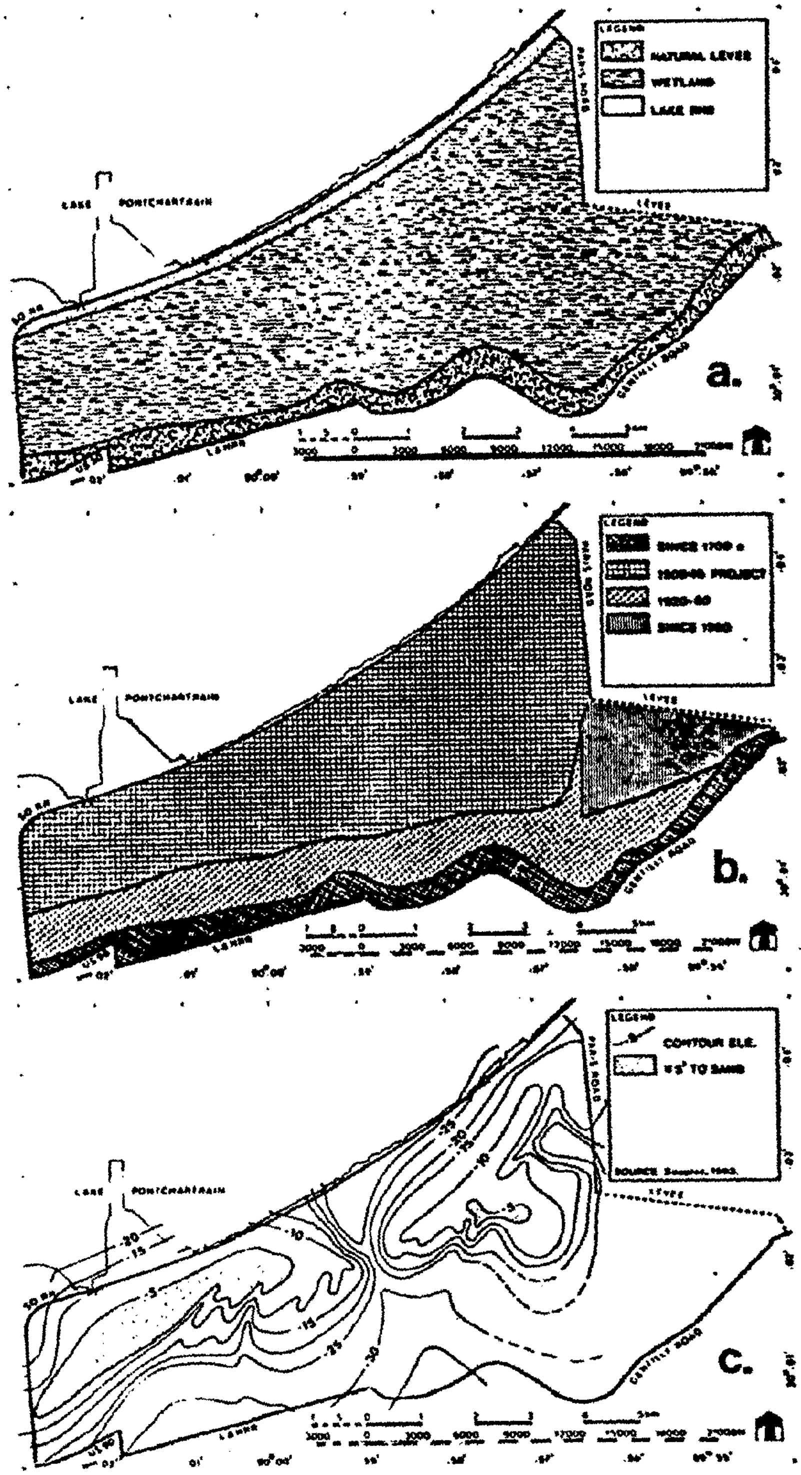


Figure 5.4: Factors Used to Determine Units in the Study Area
a) physiography b) reclamation period c) depth to barrier island

Source: Earle, 1975 (Figure 29).

The environmental units are (Figure 5.5):

N22-Natural levee, developed since 1700's, sand greater than 5 feet beneath the surface. This unit is referred to hereafter as the Natural Levee Unit.

W31-Wetland, reclaimed in 1908-1916 period, sand 5 feet or less beneath the surface. This unit is referred to hereafter as the Barrier Island Unit.

W32-Wetland, reclaimed 1908-1916 period, sand greater than 5 feet beneath the surface. This unit is referred to hereafter as the Reclaimed Wetland Unit.

W41-Wetland, developed in 1920-1960 period, sand 5 feet or less beneath the surface. This unit is referred to hereafter as the Island Fringe Unit.

W42-Wetland, developed in 1920-1960 period, sand greater than 5 feet beneath the surface. This unit is referred to hereafter as the Swamp Fringe Unit.

W52-Wetland, developed since 1960, sand greater than 5 feet beneath the surface. This unit is referred to hereafter as the Reclaimed Marsh Unit.

L32-Lake Rim, reclaimed in 1908-1916 period, sand greater than 5 feet beneath the surface. This unit is referred to hereafter as the Lake Rim Unit.

Based on U.S. Soil Conservation Service Soil Maps, all of Earle's units are classified as either Marsh or Swamp. The units known as Lake Rim, Barrier Island, and Natural Levee, which do not qualify, are also contained within the broad categories of Marsh and Swamp on the soil maps and comprise an unknown percentage of these areas. An extensive inventory and analysis as was done by

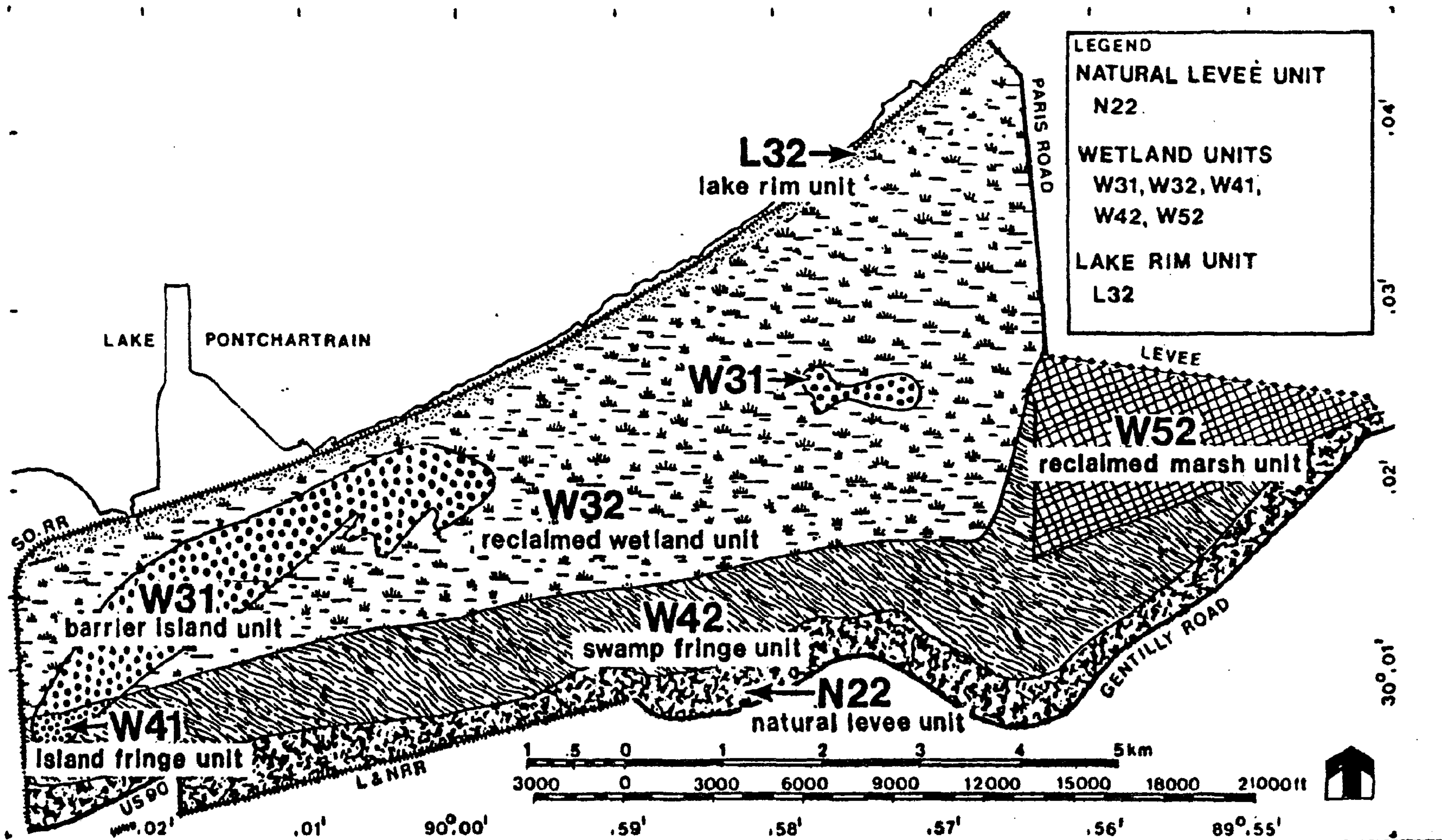


Figure 5.5: Environmental units of the study area. Based upon factors of physiography, reclamation period, and depth to barrier island sand.

Source: Earle, 1975 (Figure 30).

Earle is necessary for the over 2,000 square miles of marsh and swamp which is contained in or near the metropolitan areas of southern Louisiana in order to break down these areas further than the general categories.

For purposes of analysis and comparison, Earle's units termed Reclaimed Wetland, Reclaimed Marsh, and Swamp Fringe can be used to show general future expectations of maintenance costs and problems associated with development of areas categorized as Marsh or Swamp by the Soil Conservation Service. By Earle's definition, the major difference between the Reclaimed Wetland Unit and the Reclaimed Marsh Unit is the period in which the areas were reclaimed. The Reclaimed Wetland Unit was reclaimed during the 1908-1916 period; the Reclaimed Marsh Unit was reclaimed after 1960. Thus, the unit which demonstrates characteristics likely to be found if future reclamation and development occurs in a marsh environment is the Reclaimed Marsh Unit.

This Reclaimed Marsh Unit is comprised of 88.4% Lafitte soils (Earle, 1975: Table 7). Lafitte soils are normally made up of a thick organic layer (50" to 100") and are almost always flooded. (Soil Conservation Service, 1973). In all cases, the descriptions of the soil association labeled "Marsh" on the Soil Conservation Service Soil Maps contain such phrases as "consists of organic material...of various thicknesses (2' to 8')" and "the water table is at or above the soil surface most of the time". Based on the correlation between the definition of Lafitte soils and the terms used to describe marsh areas on the soil maps and based on the fact that the area of the Earle study termed Reclaimed Marsh is comprised of 88.4% Lafitte soils, it is assumed that future development in areas labeled "Marsh" in Table 5.3 will experience similar costs and problems in homeowner maintenance as was experienced by the environmental unit known as Reclaimed Marsh.

TABLE 5.3

RELATIONSHIP OF SOIL CONSERVATION SERVICE ASSOCIATION TO EARLE STUDY ENVIRONMENTAL UNITS

		MARSH[1]			SWAMP[1]			TOTAL WETLANDS	
		Reclaimed Marsh[2]			Swamp Fringe[2]			Marsh + Swamp	
SMSA	Parish	SCS Assn. #	Sq. Mi.	% of Parish	SCS Assn. #	Sq. Mi.	% of Parish	Sq. Mi.	% of Parish
New Orleans	Orleans	3, 4	130	65.0	5, 6	45	23.0	175	88.0
	Jefferson	3, 4, 5	288	70.0	7, 8	63	16.0	351	86.0
	St. Bernard	3	441	87.0	5	26	5.0	467	92.0
	St. Tammany	6	112	12.0	5	7	1.0	119	13.0
None[3]	St. Charles	1, 3	157	53.0	2	83	27.0	240	80.0
Baton Rouge	East Baton Rouge	NONE	---	----	3	27	6.0	27	6.0
	West Baton Rouge	NONE	---	----	3	14	7.0	14	7.0
	Ascension	NONE	---	----	8, 9	93	31.0	93	31.0
	Livingston	NONE	---	----	6	121	18.0	121	18.0
Lake Charles	Calcasieu	9, 10	86	7.8	8	32	3.2	118	11.0
Lafayette	Lafayette	NONE	---	----	4	24	9.0	24	9.0
None[4]	St. Martin	NONE	---	----	3	188	25.0	188	25.0

(1) As defined by Soil Conservation Service Soil Associations

(2) As defined by Earle Study

(3) Outside of, but adjacent to, New Orleans SMSA

(4) Outside of, but adjacent to, Lafayette SMSA

NOTE: Reclaimed Marsh includes Reclaimed Wetland in New Orleans. Areas whose soil maps indicate marsh areas, but which have been reclaimed for long periods can expect conditions similar to reclaimed wetland. Soil Conservation Service Soil Maps do not include length of reclamation period which is only difference between reclaimed marsh and reclaimed wetland.

Source: Soil Conservation Service General Soil Maps.

Additionally, it should be noted that the area termed Reclaimed Marsh is one of the most recently developed and the most recently reclaimed area in the City of New Orleans. Thus, reclamation immediately followed by development, as was the case in the Reclaimed Marsh area, is assumed to be the future pattern. Projections of costs and problems of maintenance in this area can be seen in Table 5.4.

The unit which demonstrates characteristics likely to be found if future reclamation and development occurs in a swamp environment is the Swamp Fringe Unit[1]. This Swamp Fringe Unit is comprised of 74.4% either Sharkey or Clayey soils (Earle, 1975: Table 7). In every description of soil associations labeled "Swamp" on the Soil Conservation Service soil maps, terms such as "Clayey soils" and/or "Sharkey soils" are used. Thus, it is assumed that future development in areas labeled "Swamp" in Table 5.3 will experience similar costs and problems in homeowner maintenance as shown in Table 5.4.

Recall here that period of reclamation is not given on the General Soil Maps and that the major difference between Earle's Reclaimed Marsh and Reclaimed Wetland is period of reclamation. Problems and costs associated with maintenance were not as great in the Reclaimed Wetland as in the Reclaimed Marsh. But Earle's future expectations for the Reclaimed Wetland is that problems and costs of subsidence will increase in this area (Earle, 1975: 287)[2]. His

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[1]This statement is based not only on the following analysis, but also on conclusions reached in an interview with Earle in August, 1975, in which he confirmed that the area termed Swamp Fringe correlates to areas designated as "Swamp" by the Soil Conservation Service.

[2]Summarizing Earle's evaluation of Reclaimed Wetland, he states the following: the yearly costs of subsidence in this unit are slightly below what would be expected in the study area. This unit holds an intermediate position in reports of landscape problems. The area is next to lowest in reports of building damages. The unit ranks in a moderate position in reports of utilities system damage. It is considered moderately stable with regard to land base conditions by comparison to other units in the study area. The future holds increased subsidence problems for this unit but will probably not be extensive (Earle, 1975: 286-288).

TABLE 5.4

COST AND PROBLEMS ASSOCIATED WITH MAINTENANCE OF HOMES IN EITHER A MARSH[1] OR SWAMP[1] ENVIRONMENT

	COSTS	LANDSCAPE CONDITIONS	BUILDING CONDITIONS	UTILITIES CONDITIONS	LAND BASE CONDITIONS	FUTURE EXPECTATIONS
MARSH[1] RECLAIMED MARSH[2]	mean yearly costs related to subsidence = $120 per household	ligh incidence of yard, walk, and driveway sinkage. Widespread problem of space under foundation where land has sunken away from piling supported slab (which settle relatively little).	floor and wall damage frequently reported conditions	All utilities systems except gas highly affected by subsidence.	The most serious subsidence conditions in the Earle study area. Composed of primarily 8 or more feet of organic soil (Lafitte) covered by a surface of sandy loam fill--brought in by the homeowner.	A subsidence process of 20 to 50 years will continue at a very gradually decreasing rate. Short-term relief not in sight for residents of the area.
SWAMP[1] SWAMP FRINGE[2]	mean yearly cost related to subsidence = $80 per household	high incidence of reports of a variety of problems: driveway warping, general land sinking; soil pot holes, and extensive street cracking. Problems of a more subtle nature, thus, may be missed by an untrained observer.	very high incidence of building tilt and associated floor and wall damage Extremely high reports of need for slab jacking and addition of piling supports.	All systems affected by subsidence.	Majority of soils made up of Sharkey Clay. Subsidence problems associated with mineral soils. Shrink/swell characteristics of clays thought to cause some observed damage; dewatering of saturated clays at depth is thought to be linked to the more serious damage.	Little can be done about the shrink/swell problems of clay other than reduction of soil moisture variability. Drainage of higher surrounding areas will affect ground water levels in the swamp area and may cause more subsidence problems.

(1) As defined by Soil Conservation Service Soil Association.
(2) As defined by Earle Study

Source: Earle, 1975; 281-286.

prediction has a solid basis in the fact that his study also covered three older sections of the City of New Orleans that were once swamp basins, a newer section built on recently reclaimed marsh, and an older section, built on a natural levee. In this extension of his study, it was found that subsidence is not an occurrence isolated to the primary study area (Figure 5.6) of eastern New Orleans and that these other areas may be more seriously affected by subsidence than the primary study area (Earle, 1975: 302).

The results of this analysis of other sections of New Orleans showed an extreme trend toward the higher end of the potential problem/cost scale tempered somewhat by the known area of little subsidence, the natural levee area. In summary, landscape problems due to subsidence in other areas (except natural levee) exceeded those in the study area. Degree of damage due to house tilt, floor damage, and wall damage because of subsidence exceeded the study area. In all cases, except damage to electrical systems, the other areas exceeded the study area in amount of reported damage (Earle, 1975: 302). Cost comparisons show the most obvious differences between the study area and other areas in problem/cost due to subsidence. To illustrate this point, refer to Earle's Cost Comparison Table (Table 5.5).

Thus, the Earle study clearly extrapolates trends of subsidence problems/costs in not only recently developed areas, i.e. Reclaimed Marsh, but also areas which have been developed and reclaimed for many years, i.e. Reclaimed Wetland. The extension of the study into other sections of New Orleans clearly demonstrates that problems and costs due to subsidence are not isolated occcurrences. It shows that reclaimed wetland environments cause significant homeowner problems and costs that must be weighed in a benefit-cost framework for reclamation projects. It shows that the problems are long-term and homeowners are paying hidden premiums beyond the normal costs of maintaining a home. And, last and most important, the Earle findings dictate that subsidence problems

FIGURE 5.6
General Soil Map of Orleans Parish, Louisiana (partial)

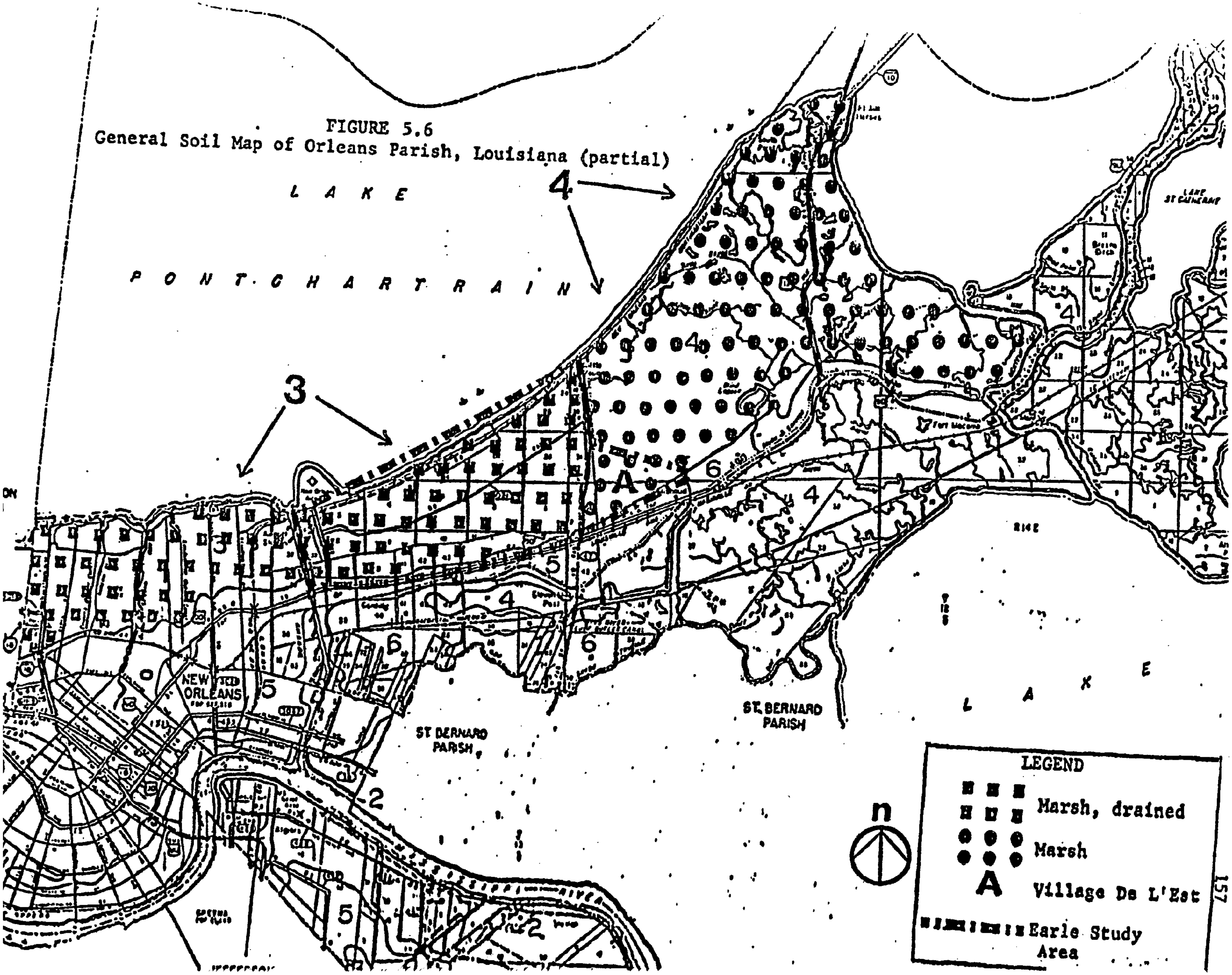

TABLE 5.5

COST COMPARISON OF STUDY AREA AND OTHER NEW ORLEANS AREAS

COST ITEM	STUDY AREA[1]	OTHER NEW ORLEANS AREAS
Average Yearly Cost Mean	$ 61	$ 92
Mean Single Biggest Expense	386	864
Mean Total Land Fill Cost	204	533
Mean Estimated Repair Costs	852	1978

(1) This is a mean computed for the entire study area--encompassing all environmental units.

Source: Earle, 1975: Table 72.

and costs are widespread enough that they should be of concern to governmental agencies which deal with the planning and future development of areas that are classified as either Marsh or Swamp by the Soil Conservation Service (Earle, 1975: 304).

The relationship of the Earle Environmental Units to the soil association classifications of the Soil Conservation Service is discussed next along with the SCS's descriptions of the limitations of such soils.

According to the U.S. Soil Conservation Service (SCS) General Soil Map for Orleans Parish, most of the study area of Earle's project is classified under the general description of soil association as "Marsh-Protected organic and mineral marshland" (labeled 3 on Figure 5.6). The description continues: "an area of protected brackish marshland adjacent to Lake Pontchartrain. Most of the acreage is in or being developed for urban or industrial use. The land occurs mostly at low elevations and is leveed and drained by pumps" (Soil Conservation Service, 1970).

The soil map gives a table expressing the "Degree of Limitations and Factors Affecting Use" of the various soil associations. It then breaks out such categories as Building Site, Low Cost Roads, Playgrounds, etc. Under "Marsh, Drained," that area within which Earle's project is contained, there is one statement which is used to describe all forms of development, except for wildlife management and agricultural use. The statement reads:

> Very severe limitations due to subsidence potential on areas having thick organic surface layers.

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[3]The soil map shows soil associations for a given area. A soil association is a landscape that has distinctive proportional patterns of soils (Soil Conservation Service, 1970). It normally consists of one or more major soils for which it is named, although several minor soils may be included.

> Severe limitations on areas having thin organic surface layers. Moderate limitations on made lands built up from loamy materials. (Soil Conservation Service, 1970)

Seventy percent of the area shown in the drained marsh area is comprised of organic material more than several feet thick (Soil Conservation Service, 1970). Approximately eighty-five percent of the Earle Project Area is comprised of organic material of substantial thickness (Earle, 1975: 93). The Soil Conservation Map further defines its terms thusly: "the words 'very severe' indicate a limitation so restrictive that the stated use is generally impractical". Uses listed are building sites; septic tanks - filter fields; sewage lagoons; low cost roads; landscaping and gardening; picnic areas, campsites, and golf fairways; and playgrounds.

A drained marsh area continues from Orleans Parish as shown on Figure 5.6 through Jefferson Parish north of Airline Highway (U.S. 61). Three home gas explosions have occurred in Jefferson Parish in this area since May, 1974. Although it has not been shown conclusively, there is some fear that ground subsidence has stressed the gas lines causing pipe failures, leaks, and subsequent explosions.[4] If subsidence has caused these explosions, then wetland construction may have tremendous costs and limitations associated with it as the explosions caused total destruction of the houses and injury to their residents (Frazer, 1975: A-2).

Also contained within the Earle Project Area is a section classified by the Soil Map as: "Marsh-mineral and organic marsh land" labeled 4 on Figure 5.6 including area A). The major difference between "3" and "4" according to the Soil Map is that the section labeled "3" is protected and that labeled "4" is not. The Soil Map is dated July, 1970. The Earle Project was conducted during

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[4]Movement of soil away from the pile supported slab (which settles relatively little) leaves the gas pipes unsupported ("hanging") and subject to stresses which exceed their capacity to withstand leading to cracks and gas leaks.

1974-75. Therefore, areas of urban development like Village De L'Est are not indicated on the Soil maps, but certainly do exist today within a levee system

Earle's Environmental Unit Evaluation for the area containing Village De L'Est (labeled "A" on Figure 5.6) - referred to by Earle as the "Reclaimed Marsh Unit" - should be recalled here (Table 5.4). In summary, the evaluation states: mean yearly costs related to subsidence in the Reclaimed Marsh Unit were found to be higher than any other area in the study. This unit ranks highest in extent of landscape element problems. All utilities systems except gas are highly affected by subsidence in this unit. The land base of this unit has the most serious subsidence conditions in the study area. And finally, it is expected that the area will continue to subside at a very gradually decreasing rate until all organic matter is oxidized or reduced, and the wet clays have consolidated. This process could take 20 to 50 years; short term relief is not in sight for residents of this area (Earle, 1975: 281-283).

The areas labeled "4" on the Soil Map is referred to under the general category of "Marsh" (as distinguished from "3" which is "Marsh, drained"). Degree of Limitations for area 4 reads: "Very severe limitations due to instability, permanently high water table, flood hazards and high subsidence potential <u>if drained</u>" (author's emphasis). This is the Ponchartrain New Town and Orlandia area. This area can expect problems similar to Village De L'Est once levees are built.

WETLANDS PUBLIC MAINTENANCE COSTS

Based on the knowledge that the City of New Orleans is located primarily in a reclaimed marsh or swamp environment, it is logical to assume that this fact will have some effect on maintenance costs with respect to public facilities, i.e., streets, sewers, and water lines. And although both the

Department of Streets and the Sewerage and Water Board admit that subsidence, flooding, and other problems caused by the fact of the wetland environment throughout the City, the degree of its effect on maintenance costs is unknown in both City departments.

DEPARTMENT OF STREETS

The City of New Orleans is divided into five districts for purposes of street maintenance. Each district has a supervisor which submits cost sheets at the end of each month itemizing all work on an actual cost of labor and material at time of entry basis. There are two reasons as to why maintenance costs due to wetland-related problems are unidentifiable with this system. First, no record, official or otherwise, is maintained as to the cause of the problems. All problems are categorized as simply "maintenance". Weed-control, street cracks due to subsidence, and chuck-hole repair are all the same with respect to recording of costs (Christina, 1975). Expert analysis of each situation is not what is called for--only an educated attempt at separating wetland from nonwetland related maintenance problems.

And second, total maintenance cost on a district basis is not computed. Significant differences may exist on a cost basis for each district. These differences may or may not be connected with the fact of the land either being wetland or nonwetland at one time. The Department of Streets has offered to provide the cost sheets for such analysis. It should be noted that there are an average of twenty cost sheets per district per month and costs are expressed in different units, i.e., per square yard and per linear foot. Thus, there are over twelve hundred cost sheets per year and all must be converted to a common denominator for comparison and analysis (Christina, 1975). Another study similar to Earle's is needed to analyze street maintenance costs in wetlands.

SEWERAGE AND WATER BOARD

When asked what portion of maintenance costs could be ascribed to the fact that sewerage and water lines were built in a wetland environment, the Sewerage and Water Board could not give a definitive answer. In a letter to Earle, dated March 7, 1975, from the SWB, it is stated that "The most common soil-related maintenance problem is open joints in pipe that are caused by a general subsidence of ground" (Busby, 1975a). But when asked what portion of funds labeled "Networks Operating and Maintenance", in the Sewerage and Water Board of New Orleans 1974 Annual Report, can be attributed to maintenance, specifically wetland-related maintenance, no answer is available (Busby, 1975b).

Therefore, it is obvious that maintenance costs do exist for streets, sewers, and water lines; and some of these costs are admittedly related to land base conditions. But under present accounting and recordkeeping systems, it is impossible to determine the extent to which these costs relate to these land base conditions whether they be wetland or nonwetland.

APPENDIX 1

Appendix 1 is a summary of itemized costs associated with wetland development which were discovered in the course of the preceding analysis.

APPENDIX 1

SOME IDENTIFIABLE COSTS DUE TO DEVELOPMENT TAKING PLACE IN A WETLAND ENVIRONMENT*

(dollars)

SITE PREPARATION COSTS	
Peat Removal (4)	.75/cy
Removal of Mud (3)	.56/cy
Excavation (2)	1 to 25/cy
Site Fill in Place (4)	1.50/cy
Riversand Backfill in Place (2)	4 to 16/cy
Shell Backfill in Place (2)	8 to 20/cy
Whitesand Fill in Place (2)	5 to 15/cy
Fill from Borrow Pit (3)	1.85/cy
Fill Material (1)	1.88/cy
Site Grading (4)	.15/cy
FLOOD PROTECTION AND DRAINAGE COSTS	
Levee System (4)	39.00/lf
Canal Excavation for Drainage (4)	60.20/lf
Swale Construction for Drainage (4)	2.50/lf
CONSTRUCTION COSTS	
Foundation of Metairie, Louisiana structure compared to Curtis, Nebraska structure (1975) (5)	2.26/sf - 1.22/sf
Foundation of New Orleans, La. structure compared to Baton Rouge, Louisiana structure (1972) (1)	.50/sf - .30/sf
Utilities - Sewerage Installation Costs in New Orleans compared to other nonwetland area (1972) (1)	15.00/rf - 7.00/rf

*cy = cubic yard; lf = linear foot; sf = square foot; rf = running foot. Numbers in parentheses refer to sources.

MAINTENANCE COSTS

Homeowner Costs Due to Subsidence (1)	See Table 5.4

COSTS NOTED BUT UNKNOWN -- BECAUSE OF NONEXISTENT ACCOUNTING SYSTEMS WITH RESPECT TO WETLANDS

Street Maintenance--subsidence

Maintenance of Public Services including parks and schools--subsidence

Maintenance of Other Public Services Including Drainage, Sewers, and Sidewalks

Fire Protection--Underground Combustion of Organic Soils

Property Value Depreciation--Neighborhood Deterioration Due to Subsidence

Increased Utility Rates Due to "Pass-on" Effect of Maintenance Costs (Costs are borne directly by company, Indirectly by consumer)

Gas Explosions--Explosions due to gas leaks in pipes stressed to failure (cracking) because of subsidence

Foundation Costs Using Pile Foundation Method:	
Concrete (4)	$78.00/cy
Piles (10 ton) (4)	$75.00 each
Piles (50 ton) (4)	$150.00 each

Foundation Costs Using Slab-On-Sand Method:	
Concrete (single story) (4)	$50.00/cy
Concrete (two or three story) (4)	$69.00/cy

COST TABLE SOURCE EXPLANATIONS

(1) From Earle Study.
(Earle, D. W., Jr. (1975) Land Subsidence and Maintenance Costs to Homeowners in East New Orleans, Louisiana. Unpublished Ph.D. dissertation, Louisiana State University, Baton Rouge.

(2) From New Orleans Sewerage and Water Board Contract Bids.
(Sewerage and Water Board of New Orleans Contract Numbers 2043, 2045, 3088, 3092, and 3094.)

(3) From Louisiana Highway Department Estimates.
(Pope, R. M., and Gosselink, J. G. (1973) "A Tool for Use in Making Land Management Decisions Involving Tidal Marshland," Coastal Zone Management Journal. Vol. I, No. 1. 65-74.)

(4) From Pontchartrain New Town In Town Studies (various).
(Kaiser Engineers and Land Ventures, Inc. (1974) Pontchartrain--Revised Financial Analysis: Supplemental Report. Kaiser: New Orleans, Louisiana.; New Community Development Corporation (NCDC) of New Orleans. (1974) Pontchartrain--Revised Financial Analysis, November 11, 1974. City Planning Commission: New Orleans, Louisiana.; Tippetts-Abbett-McCarthy-Stratton (TAMS). (1972a) Pontchartrain - Final Report Engineering Plan. TAMS: New York, New York.; ________________. (1972b) Pontchartrain--Engineering Appendix Cost Estimates. TAMS: New York, New York.)

(5) From F. W. Dodge Publication.
(Costs and Trends of Current Building Projects, Region F. Edition/Year End 1974, New York: McGraw-Hill.)

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____________ (1972b) Pontchartrain--Engineering Appendix Cost Estimates. TAMS: New York, New York.

CHAPTER 6

FORECASTING FUTURE LAND USES IN WETLANDS

INTRODUCTION

The pressure to develop the wetlands adjacent to urban areas stems from three forces. First, there has been a continuing shift in residential development from the high density inner city to the low density suburbs. As the urban boundary expands, residential areas bordering wetlands are expanded into the wetlands by residential developers. Second, certain land uses not compatible with residential use such as solid waste disposal plants, power generating facilities, and large industrial parks tend to locate on low cost, previously undeveloped land free of residential development; wetlands meet those criteria. Finally, as suburban areas mature, they desire such public amenities as large recreational areas. Nearby wetlands may be looked upon as relatively inexpensive land for such purposes.

In order to evaluate the strength of these forces of development, a forecast should be made of the future land use requirements of the urban population. A "planned requirements approach" (PRA) can be used to determine the amount, type, and location of land that will be needed by the future urban population (Chapin, 1965; Goodman and Freund, 1968: 106-136; and Krueckeberg and Silvers, 1974: 326-328). This chapter presents an example of such an analysis for the Lafayette SMSA. In order to implement PRA, a population projection for the area must be made. Following that employment projections and finally land use projects are made. This is the order of discussion in this chapter.

POPULATION PROJECTIONS

The Lafayette SMSA consists entirely of the parish of Lafayette which has an area of 176,269 acres. It is divided into three rural planning districts, having a combined area of 142,288 acres and the Lafayette metropolitan area having an area of 33,981 acres. Of the 21,421 non-agriculturally developed acres in the parish in 1972, approximately sixty-four percent or 13,743 acres fell within the Lafayette metropolitan area (Lafayette RPC, 1973a and b).

The growth potential of an urban area should be expressed in terms of the population it can be expected to sustain--the size of population, its composition and characteristics, and its spatial distribution. Population size supplies a basic yardstick for the estimation of space needs for various categories of land use. Population composition assists in estimating space requirements for various dwelling types, recreation areas, schools, and other community facilities for all segments of the population. Population distrubution provides clues as to how these various land uses and facilities should be located in the urban area (Chapin, 1965: 181).

Rough estimates of future population can be made by a simple extrapolation of historic population data. A combination of extrapolation and adjustments is used by the U. S. Department of Commerce (1971) in its Area Economic Projections 1990. This source predicts that the population of Lafayette Parish will decline from a 1970 population of 111,643 (Wrighton and Denton, 1975: 3) to a 1990 population of 105,800 while employment rises from 37,893 to 39,900 during that same period (Department of Commerce, 1971: 111) which as discussed in Chapter 1 seems unlikely.[1]

In appears that projections more strongly dependent on conditions existing within and immediately surrounding the SMSA would be preferable. One method that can be applied in this way to project population is the cohort survival method. This method utilizes fertility, mortality, and migration rates. While fertility and mortality rates as a function of age, race, and economic and social characteristics are well-established, migration is much more difficult to estimate. In general, migration is strongly dependent on the economic condition of the study area relative to the surrounding regions. If a region's economic condition is relatively strong, it will attract in-migration; if relatively weak economically, it will suffer out-migration. Thus, economic base and labor force considerations dominate the analysis of long-term migration (Goodman and Freund, 1968: 74) and consequently, population.

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[1]While it may not seem plausible for employment to rise as population decreases, some basic relationships between working age population, participation rate, and work force shows it to be at least possible. According to U. S. Census (1970) data, 62.5 percent of the population was of working age (16 years or older) and the participation rate in the City of Lafayette was 55.1 percent (Diversified Economic and Planning Associates-DEPA, 1974: 36). The product of population, working age factor, and participation rate yields the number of persons in the working force. For a 1970 population of 111,643, the above product yields a working force of 38,447 which is near the Department of Commerce projection (37,893) for employment. Working force does include the unemployed so the figures are not exactly comparable. If it is assumed that the fraction of the population of working age remains constant and if it is further assumed that the 1990 Lafayette participation rate has increased to the 1970 national participation rate of 60.3 percent (DEPA, 1974: 36), then the 1990 labor force becomes 39,873 for a 1990 population of 105,800. Again the Department of Commerce figure (39,900) does not include the unemployed. Even so, it is shown here that work force (and assumedly employment if unemployment remain constant) can increase as population drops. The method of projection used by the Department of Commerce is similar in that national totals of population, employment, GNP, personal income and earnings are projected and then a series of disaggregations and aggregations based upon historical trends are used to arrive at the employment and population of individual SMSA's.

Population projections for Lafayette Parish using the cohort survival method were carried out by Christou and Segal (1973: 21) and are presented in Table 6.1. As can be seen, three migration assumptions were used. The first assumed migration equal to the migration occuring in Lafayette Parish between 1960 and 1970. The second assumed a steady decline in migration over the next 20 years and the third assumed no migration. Although unforseen circumstances may cause a negative or out-migration, this seems unlikely; therefore, the no-migration assumption should yield a lower bound on the forecast population. The period from 1960 to 1970 was one of rapid growth in Lafayette due in part from increased oil production activity and from the associated service and wholesale industry which sprang up to serve the oil industry. It would seem that further increases in oil production will be minimal due to dwindling oil reserves. A continuation of the 1960 to 1970 migration rate should yield an upper bound for the population forecast. Since land use problems increase with population, it is important not to underestimate the future population. A second consideration is that although this projection is for 20 years, the projection will be no less relevent if it takes 30 or 40 years for the population forecast to be realized. With these points in mind, the upper bound projection of 177,548 is chosen as the 1990 parish population. In order to extend the parish projection an additional five years to 1995, mathematical extrapolation of census data and projected data was used as shown in Figure 6.1 and presented in Table 6.1. The 1995 parish population obtained was 200,000.

EMPLOYMENT PROJECTIONS

Economic activity in the form of employment data is also needed to determine space requirements. Diversified Economic and Planning Associates (DEPA) (1974: 55) has generated employment projections for Lafayette Parish for 1980 and 1990.

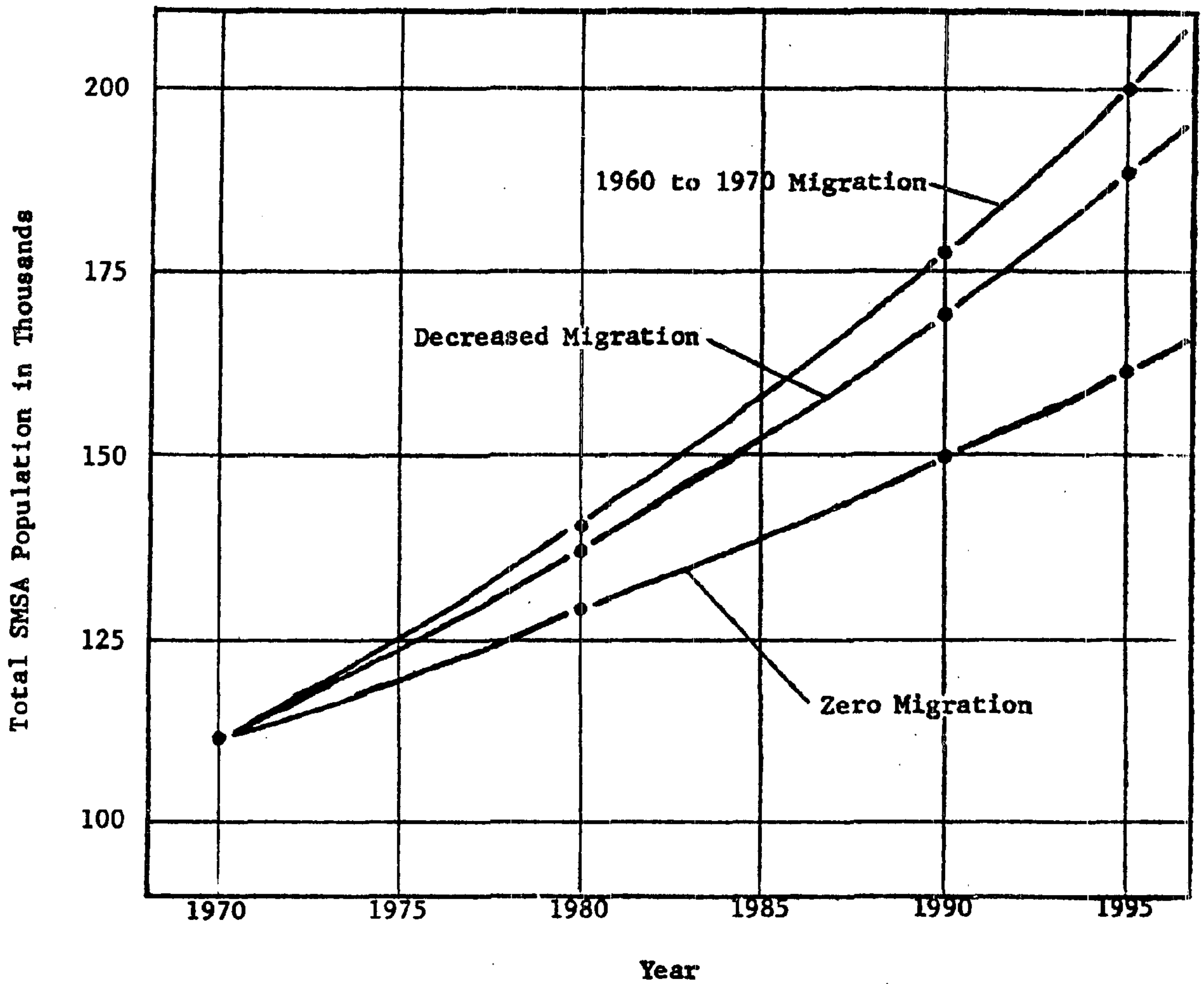

Figure 6.1 Extrapolation of Population Data to the Year 1995 for Lafayette SMSA (Parish)

Sources: 1970--Wrighton and Denton, 1975: 3.
1980 & 1990--Christou and Segal, 1973: 21.
1995--Computed by authors using simple mathematical projection of trend lines.

TABLE 6.1

LAFAYETTE SMSA POPULATION PROJECTIONS

Migration Assumptions	1980[1]	TOTAL POPULATION 1990[1]	1995[2]
1	140,001	177,548	200,000
2	136,934	169,152	188,000
3	128,850	149,584	162,000

Migration Assumptions

1 Constant 1960 to 1970 migration

2 Declining migration

3 Zero migration

Sources: 1. Christou and Segal, 1973: 21.

2. Computed by authors. See Figure 6.1.

These are presented in Table 6.2. Total employment estimates by DEPA were arrived at by two independent methods. In the first, linear extrapolation of historic total employment figures from the Bureau of Labor Statistics was used. This method when used alone seems without basis since numerous factors could conspire to blunt or even reverse an employment trend. The second method consisted of a linear extrapolation of the 1960 and 1970 participation rates to 1980 and 1990. The 1980 and 1990 participation rates were then applied to the populations projected for 1980 and 1990 to obtain total employment estimates (assumedly unemployment was accounted for, see footnote 1). An estimate of each employment sector's share as a percentage of total employment based on past and projected trends was used to determine employment in each sector. Each sector's share as a percentage of total employment and the resulting sector employment estimates are presented in Table 6.2.

In the data of Table 6.2, the commercial sector is the sum of the original data's mining, construction, wholesale trade, retail trade, finance, insurance, real estate, service industries, and "other nonagricultural" sectors. In addition, the sector "Public and Semi-Public" was DEPA's "government establishments" sector. These changes were made in order to use these data in conjunction with the acreage data which was available in the Lafayette Parish Master Land Use Plan (Lafayette RPC, 1973a: 4, 6, and 8) and the Lafayette Metropolitan Area Master Land Use Plan (Lafayette RPC, 1973b: 25).

The employment projections of Table 6.2 may be extended an additional five years to 1995 without introducing undue additional uncertainty to the estimates. The ratios of total employment to total parish population for 1970, 1980, and 1990 are 0.415, 0.454, and 0.451 respectively. By applying a total employment to total population ratio of 0.450 to the total 1995 population estimate (200,000), a total employment figure of 90,000 is obtained. This may then be

TABLE 6.2

EMPLOYMENT PROJECTIONS FOR LAFAYETTE PARISH

	1970		1980		1990	
	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER
TOTAL EMPLOYMENT	100.0	46,275	100.0	63,500	100.0	80,000
Commercial	62.8	29,075	66.3	42,101	65.7	52,560
Manufacturing	4.7	2,150	4.0	2,540	3.7	2,960
Transportation, Communications, Utilities	7.2	3,325	7.9	5,016	8.6	6,880
Public & Semi-Public	15.8	7,325	15.8	10,033	17.5	14,000
Agricultural	9.5	4,400	6.0	3,810	4.5	3,600

Source: DEPA, 1974: 55.

disaggregated into sector employment by further extension of past and predicted future employment share trends. In doing this it was assumed that agricultural employment would level off at 3600 and not be greatly influenced by the conversion of agricultural land to urban use. In 1990 agricultural employment would be 4.5 percent of total employment. In 1995 it (3600) would be four percent. The remaining 0.5 percent was distributed to the other sectors. These data are presented in Table 6.3.

LAND USE SPACE PROJECTIONS

The measures used to estimate space requirements by employment or other sector are frequently based on current space use per employee or per person, modified by anticipated impacts of new technology and legal requirements in zoning, subdivision, and housing codes. Allowances for auxiliary space needs for off-street parking, off-street loading, and landscaping standards are based on space requirements per person, household, worker, or shopper, among others. For these reasons, population forecasts and economic trend projections are fundamental in determining future space requirements. (Goodman and Freund, 1968: 123)

Using 1970 employment data and land use data contained in the Lafayette Master Land Use Plan (Lafayette RPC, 1973a: 4, 6, and 8) and the Lafayette Metropolitan Area Master Land Use Plan (Lafayette RPC, 1973b: 25) it is possible to obtain employment densities for commercial; manufacturing; transportation, communications, and utilities; and public and semi-public land use in the Lafayette SMSA (Parish). A community's future land use requirements cannot be projected with complete accuracy on a basis of current ratios because of future changes in technology, the law, etc. However, such densities are used in this report for the purpose of illustration.

TABLE 6.3

1995 EMPLOYMENT PROJECTIONS FOR LAFAYETTE SMSA

	Projected Shares	
	Percent	Employment
TOTAL EMPLOYMENT	100	90,000
Commercial	66.0	59,400
Manufacturing	3.8	3,420
Transportation Communications Utilities	8.6	7,740
Public & Semi-Public	17.6	15,840
Agricultural	4.0	3,600

Source: Computed by authors. See text.

COMMERCIAL LAND USE

Commercial uses are composed primarily of retail stores and office buildings. The amount of land required for such use can be based on several units of measure. Future population growth, future income estimates, and peak hour CBD population each can be used as a basis for land use requirements (Goodman and Freund, 1968: 123-124). Land area requirements in commercial areas that serve regions can be distinguished from those that serve neighborhoods. For most purposes employment rather than gross population is a more suitable indicator. In Table 6.4, 1970 commercial density (employees per acre) is used to project 1995 commercial acreage.

MANUFACTURING

Employment per net industrial acre tends to vary with the location of the plant, the nature of the manufacturing process, and the extent of automation. In-town plants by necessity economize on land. Out-lying plants tend to spread out as well as reserve additional land for future expansion (Goodman and Freund, 1968: 123). Table 6.4 presents 1995 manufacturing land use area.

TRANSPORTATION, COMMUNICATIONS, AND UTILITIES

Space needs for this group of linked uses can be related to population growth and its distribution, the status of present facilities, and expected technological advances (Goodman and Freund, 1968: 126). In this report no change in technology nor evaluation of the present state of adequacy or inadequacy of existing facilities is explicitly assumed; however, a general increase in services can be inferred from the increasing employment share of this sector from 1970 to 1995 as presented in Table 6.2 and Table 6.3. A 1970 density of 3.1 employees per acre is applied to the projected 1995 employment of this sector to obtain a 1995 land use requirement of 2,497 acres.

TABLE 6.4

1995 PROJECTED LAND USE REQUIREMENTS

FOR THE LAFAYETTE SMSA

	1970			1995	
	Acres[1] (1)	Employment[2] (2)	Emp. per Acre[3] (3)	Projected Emp.[4] (4)	Projected Acres[5] (5)
Commercial	1,550	29,075	18.8	59,400	3,160[5]
Manufacturing	220	2,150	9.8	3,420	349[5]
Transportation Communication Utilities	1,070	3,325	3.1	7,740	2,497[5]
Public & Semi-Public	1,138	7,325	6.4	15,840	2,475[5]
Residential	8,621				15,432[6]
Streets & Right-of-way	7,073				12,661[6]
Recreation	1,080				5,265[6]
					41,839

Sources: 1. Lafayette RPC, 1973a: 4, 6, and 8 and Lafayette RPC 1973b: 25.

2. DEPA, 1974: 55.

3. (2) ÷ (1)

4. Table 6.3

5. (4) ÷ (3)

6. Computed by authors. See text.

PUBLIC AND SEMI-PUBLIC

Space needs for governmental administrative and maintenance buildings and their related facilities along with other public and semi-public buildings are related most closely to population growth and the area's stage of urban development; however, other factors may be decisive. Legislators may procure federal or state governmental activities for the "home town", and on occasion, ambitious local leaders have dedicated their careers to monumental building programs. Because of these factors, some areas may be overbuilt with governmental offices while others may be sadly in need of new facilities (Goodman and Freund, 1968: 125). Present deficiencies or surpluses can be determined by survey and future land requirements estimated accordingly. It is assumed in this study that those factors that can be estimated are contained in this sector's employment projection; thus, the combination of employment density and future employment is used to determine this sector's space requirement in Table 6.4.

RESIDENTIAL

Residential use constitutes the greatest share of urban land use (Chapin, 1965: 422). The unit of measurement normally employed in residential area analysis is the family, but the household can be used as a crude substitute term (Chapin, 1965: 423). Thus population data (POP), being the original yardstick of growth, are translated into household data (number of households-HH), which in turn can be expressed in terms of dwelling units (DU), and through the medium of residential densities (acres per dwelling unit--A/DU), dwelling units are converted into residential acreage equivalents ($\frac{POP}{POP/HH} \times \frac{DU}{HH} \times \frac{A}{DU} \longrightarrow A$).

If it is assumed that the relationships among population, number of households, dwelling units, and dwelling unit density remain relatively constant from 1970 to 1995, then total residential acreage is proportional to total population. This method produces a residential use of 15,432 acres as presented in Table 6.4. The ratio of 1995 population to 1970 population is 1.79. Residential acreage in 1970 is 8,621 leading to 1995 residential acreage of 15,437.

HIGHWAY, ROAD, AND STREET RIGHT-OF-WAY

Highway, road, and street right-of-ways comprise a significant amount of land use. In this chapter it is assumed that this use is proportional to total population. This should result in an overestimate since about one-half of the 1970 acreage was contained in rural Lafayette and this portion of roads and right-of-way should not increase greatly as its use increases. The 1995 SMSA estimate appears in Table 6.4 as 12,661 acres computed similarly to residential acreage (1.79 x 7073 = 12,661).

RECREATION

Various standards exist for determining the size, location, and population served by recreational areas. Using minimum space standards which are related to population (see Table 6.5), a partial recreational space requirement of 1755 acres is computed for 1995. To include space for facilities not estimated on Table 6.5 a factor of three is arbitrarily used to increase the recreational acreage to 5265 acres (Table 6.4).

TOTAL 1995 LAND USE PROJECTION

The total land use requirement for Lafayette Parish (excluding agriculture) is 41,839 acres as determined here. This compares with a planned land use (excluding agriculture) of 111,483 acres out of a total of 176,269 acres in the Lafayette SMSA as determined in the Lafayette Master Land Use Plans (Lafayette RPC, 1973a: 26 and 1973b: 61). The difference between total Parish

TABLE 6.5

MINIMUM SPACE STANDARDS FOR RECREATIONAL FACILITIES

TYPE OF FACILITY	POPULATION STANDARD	MINIMUM SITE-SIZE STANDARD	ACREAGE REQUIREMENT PER 200,000 POP.
A. Region-Serving[1]			
1. Major natural parks	1 park/40,000 pop.	100 acres/park	500
2. Public golf course	1 hole/3,000[2] pop.	150 acres/18 holes	555
3. County fairgrounds	1/county seat	special[3]	---
4. Colosseums	1/metro. area	special[3]	---
5. Public Stadiums	1 stadium/ 100,000 pop.	special[3]	---
6. Botanical Gardens	1/metro. area	special[3]	---
7. Zoo	1/metro. area	special[3]	---
B. Local[4]			
1. Playground	1/acre/800 pop.	5-10 acres	250
2. Local parks	1 acre/1,000 pop.	2 or more acres	200
3. Recreation center	1 acre/800 pop.	15-20 acres	250
or playfield	1 acre/800 pop.	10-30 acres	---
TOTAL			1755

Sources:
1. Chapin, 1965: 420.
2. Sometimes the standard of 18 holes/30-50,000 is used.
3. Site size estimated according to size of facility appropriate for size of region served, facilities desired, and parking and service areas needed.
4. Chapin, 1965: 449.

area (176,269 acres) and the land use requirement (41,839 acres) would be available for agriculture.[2] Thus the Lafayette Master Land Use Plans would lead one to expect that by 1995, 63 percent of the parish land area would be developed rather than the 24 percent development projected in this chapter. While an overestimate of land use might lend a sense of urgency to various planning decisions which must eventually be made, there seems little else to gain from such a measure. Such an overestimate may be used as an excuse to develop land that is only marginally suited for development such as Lafayette's wetlands, which could become a residential area according to its Master Land Use Plan (see Chapter 2).

LAFAYETTE METROPOLITAN AREA

Having arrived at a projected 1995 land use requirement of 41,839 for the Lafayette SMSA, it is now necessary to estimate what portion of this will be contained in the Lafayette metropolitan area as opposed to the total Parish (SMSA). DEPA (1974: 33) predicts that 92 percent of the parish population will reside in the urbanized area of Lafayette by 1990. Using this same figure for 1995 with a total SMSA population of 200,000, one obtains an urban population of 184,000 and a rural population of only 16,000. This compares with a 1970 urban population of 79,010 and a rural population of 31,023. While a rural to urban shift is consistant with historic trends, it will be assumed here that rural land use requirements remain constant at the 1970 level except for recreational use which will increase to 3000 acres by 1995 from 236 in 1970

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[2] Agriculture is a declining land use and its projection using past relationships yields intuitively unappealing results. Therefore agriculture was not projected here and the above assumption that agriculture would conform to the available land was made. Since the Lafayette wetlands are in the Lafayette Metropolitan area, there is little danger of agricultural encroachment on wetlands because if the wetlands were developed they would probably be residential or recreational (see Chapter 2) areas.

in order to serve the urban population (which is similar to the Lafayette RPC's recreation total of 3,493 acres--Lafayette RPC, 1973a: 26). The difference between the total rural requirement (10,408 acres) and the total parish requirement (41,839 acres) yields an urban requirement of 31,431 acres excluding agriculture which is assumed to be nonexistent in the metropolitan area in 1995. Rural and urban acreages are presented in Table 6.6 for all uses.

LAND USE LOCATION REQUIREMENTS

The various space requirements presented in Table 6.6 must be balanced against the supply of available land. A vacant land study is necessary to identify the potential land uses for vacant and open land, taking into account the physiographic features and presence or absence of such man-made improvements to the land as streets and drainage facilities, accessibility to railroad and other transportation facilities, and the existence on or near the site of public water mains, a sewerage system, and other utilities (Chapin, 1964: 300). Then land use needs can be compared to vacant land attributes to determine specific land use locations.[3] In its simplest version, vacant land is classified using two basic categories: prime and marginal land. Lots, tracts, or areas judged suitable for building use are classed as prime for urban development. Lots, tracts, or areas judged unsuitable for building without extensive preparation or modification of the terrain are defined as marginal land. Generally marginal land is too low (that is, marshy or subject to flooding), or it is derelict land (for example, abandoned quaries). Prime land is all other land. Suitability for building is generally a matter for local determination, although the impact in wetlands can be over large regions.

In the case of the Lafayette Metropolitan planning area, about 640 acres bordered by state highways 94 and 353 and Bayou Vermilion are designated as swamp (estimated by authors). When the sum of this wetland and the other 500

[3]Using the equity constrained benefit-cost model as discussed in chapters 7 & 8.

TABLE 6.6

1995 PROJECTED LAND USE REQUIREMENTS

FOR THE LAFAYETTE SMSA, RURAL AND URBAN AREAS

	SMSA[1] (1)	RURAL[2] (2)	URBAN[3] (3)
Commercial	3,160	287	2,873
Manufacturing	349	34	315
Transportation Communication Utilities	2,497	373	2,124
Public & Semi-Public	2,475	113	2,362
Residential	15,432	2,870	12,562
Street Right-of-Way	12,661	3,731	8,930
Recreation	5,265	3,000	2,265
	41,839	10,408	31,431

Sources: 1. Table 6.4.

2. Lafayette RPC, 1973a: 4, 6, and 8.

3. (1) - (2).

acres of water (Lafayette RPC, 1973b: 61) areas is subtracted from the total Lafayette Metropolitan planning area of 33,981 acres (Lafayette RPC, 1973b: 25), a buildable area of 32,841 acres is obtained. Using these rough estimates, the Lafayette Metropolitan region could absorb the 31,431 acres of development projected for it in 1995 without encroaching upon the wetlands.

CONCLUSION

The purpose of this chapter is to outline a general method to forecast land use needs in the various urban areas rather than predict precise needs in Lafayette. If more prime land is available than needed in an urban area, obviously growth can occur without development of wetlands. Presented here have been various issues which should be confronted in formulating the forecast. Detailed forecasts for Lafayette and the other SMSA's have not been prepared because of both missing information and time constraints.[4]

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[4] When more disaggregated information on population (present and projected), land use (present), and employment (present and projected) are available, more detailed land use projections can be made.

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CHAPTER 7

A DECISION FRAMEWORK FOR URBAN WETLANDS DEVELOPMENT DECISIONS

INTRODUCTION

The decision to remove a wetland area from its naturally occurring state is a land use planning decision. Normally such decisions are reached using some form of benefit-cost analysis. Simple comparison of monetary costs and benefits, however, probably will not result in a decision which is implementable without considerable opposition and delay. Difficulties in implementation result because such simple procedures overlook the equity impacts of decisions. To determine the equity implications, the distribution of costs and benefits over groups should be considered along with all types of costs and benefits -- monetary, intangible, and nonmonetary but quantifiable. These costs and benefits include those that result both directly and indirectly from a decision. Without the specification of community or social goals, however, accounting for distributional effects is meaningless since the community has not specified its desired distribution. It is well recognized that no statement of goals may be severely criticized on the basis that this implies that all groups are equal. In the following sections, several benefit-cost models which consider to a greater or lesser extent (1) all types of costs and benefits, (2) their distribution, and (3) community goals are presented.

The importance of equity considerations in wetlands use decisions has been recognized in the literature. Dickert and Sorensen (1974: 142) point out that the few coastal planning studies that deal with socio-economic issues concentrate on factors such as demographic characteristics, employment, and per capita regional income and that questions of social equity are seldom raised. They trace the emphasis of most present coastal planning programs on environmental protection to the environmental degradation produced by past emphasis on economic development of coastal areas and resources. The question they now pose is to what extent will the present emphasis on environmental quality produce socially regressive effects and possibly generate a political backlash.

Besides the existing equity oriented benefit-cost models that are discussed in the following sections, a synthesis model related to wetlands decisions is presented in this chapter along with the problems involved in its implementation. Finally, proposed attributes that a system of goals should possess are recommended as an aid to policy-makers in setting goals.

EXISTING BENEFIT-COST MODELS

MARGLIN'S FRAMEWORK

Marglin (Maass et al., 1962: 18) views national welfare as having three attributes. One attribute is the size of the economic pie; another is the size of its slices; and a third is the method of slicing the pie. Maximizing the size of the pie is analogous to maximizing national income (or net benefits -- difference between total benefits and total costs) which is expressed as economic efficiency. Income redistribution and the method of achieving the distribution are analogous to the size of the slices (who gets what amount) and the method of slicing. He attaches importance to all three attributes. Therefore, decision-making using the efficiency net benefit maximization criterion, which emphasizes the first attribute and ignores the others, is not acceptable to Marglin.

Some policy-makers argue that income redistribution (equity) can be achieved by choosing the alternative plan or project which maximizes net benefits (the efficient alternative) and then, through taxation and subsidy (or some other means), by redistributing the net benefits from their original recipients to segments of society deemed more worthy by the policy-makers. This process, however, ties the policy-makers to specific means of income redistribution which the community may not accept (Maass et al., 1962: 18 and Maass, 1966: 215). A community may be in favor of some coastal resources utilization program which will allow the lower income segments of society to earn a better income but may be very much against welfare payments to those same persons. Thus, the method of slicing the pie is important and may rule out decisions made under such a framework.[1]

Marglin (Maass et al., 1962: 62-48 and Maass, 1966: 208-210) sets up three models which consider efficiency and equity and which do not specify how the income redistribution is to be effected. The models are concerned with the size of the total pie and its slices, but do not specify how a group attains one of the available slices. Thus, the models avoid the pitfall discussed above.

In the first formulation, Marglin specifies that the efficient (maximum net benefits) project be chosen subject to the constraint that a certain group receive specified net benefits per year (or some other time period). The

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[1]A related method of income redistribution is to choose the maximum net benefit alternative plan and then to "doctor" the alternative using the political process to account for "uneconomical objectives." However, it is counterlogical to choose an alternative based on one objective (such as economic efficiency) when this may not be the most important objective of the project. Furthermore, the political process is not well suited to make these modifications. The legislative process, rather than setting standards and objectives of programs, can then degenerate into project trading (Maass, 1966: 214).

constraint is the goal of the project in addition to efficiency.[2] In the second formulation, he specifies that net benefits received by a certain group be maximized subject to the constraint that a certain specified relationship between benefits and costs be met. In the third formulation a weighted sum of net benefits from economic efficiency and income redistribution in which one dollar of income to a certain group is valued at $(1 + X), of efficiency is maximized. Here X would be the shadow premium on redistribution benefits. These three formulations are "almost" equivalent as discussed by Marglin (Maass et al., 1962: 79-82 and Maass, 1966: 210). There is no apparent reason why the constraints, number of groups, and shadow premium cannot be expanded so that this model could consider more than one distributional goal in addition to efficiency.

In the third formulation, a major problem would be encountered in determining the value of X, and establishing that X is constant for all values of income redistributed. X would probably have to be subjectively determined. In the other formulations, the policy-makers must subjectively establish the net benefit which the group receives (first formulation) or the relationship between benefits and costs (second formulation). These subjective determinations may be difficult to establish and may vary among policy-makers (and others) resulting in controversy. However, it is probably better for the policy-makers (if they can agree) to be explicit concerning their values rather than to assume that a dollar of redistributed income to one group is no more or less socially desirable than a dollar of income to another group which is the implicit assumption that they make when the unconstrained efficient project is selected.

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[2]As used in this chapter, goals (objectives) may be distributional or other requirements of the project.

LICHFIELD'S FRAMEWORK

Lichfield, one of the early advocates of using benefit-cost analysis in planning, has developed planning balance sheet analysis (1960, 1964, 1971) which takes into account the distributional (equity) aspects of alternative plans for a public investment. The planning balance sheet is a set of social accounts for forecasting the implications of a plan for different interests in a community. The accounts distinguish between producers' and consumers' costs and benefits and include direct and indirect costs and benefits, both measurable (in money or other terms) and nonmeasurable (intangible). The measurable costs and benefits are presented in either capital (one time) or annual terms with real and transfer costs and benefits included.[3] Items are arranged in double entry with costs (transfer) to some accounts appearing as benefits (transfer) to others (Lichfield, 1960: 278).

Lichfield (1960: 276) defines costs as the value of goods and services used to produce and operate a project and benefits as the value of the services provided. He (1960: 274) defines direct costs and benefits as those which are taken into account by either private or public development agencies and indirect as those which are not. Direct and indirect costs and benefits include economic and non-economic costs and benefits (those which do and those which do not enter the production and comsumption process), and tangible (measurable) as well as intangible (nonmeasurable) costs and benefits (1960: 276).

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[3]Transfer costs and benefits are not included in traditional benefit-cost analysis since a benefit transferred to one group results in a cost for another and vice versa. Thus they have no effect of the grand summation of benefits and costs over groups (net benefits). However, because of his concern with the distributional (equity) aspects of a plan, Lichfield includes them. Real costs and benefits denote the efficiency of the investment whereas transfer costs and benefits denote the distributional characteristics of the plan (Lichfield, 1960: 277). See Prest and Turvey (1967: 160) for a discussion of technological and pecuniary spillovers, pecuniary spillovers being equivalent to transfer costs and benefits and technological spillovers equivalent to real costs and benefits.

A planning balance sheet might look as shown in Table 7.1 where $<u>a</u> denotes a benefit or cost in monetary units, <u>i</u> denotes an intangible benefit or cost, <u>M</u> denotes a benefit or cost in quantitative but non-monetary terms, and a dash (-) indicates no benefit or cost. The sector is the subgroup of producers or consumers who receive benefits or costs.

To interpret the planning balance sheet, capital and annual effects must be put on a comparable (present value) basis. Where there are no intangible items and all items are measured in monetary units (dollars) a numerical comparison of plans can be made by comparing the difference between total benefits and costs for each plan. The interpretation of the balance sheet becomes more difficult if some benefits and costs are measured in nonmonetary units such as mercury water pollution in micrograms per liter (<u>M</u> in Table 7.1). For the policy-maker to make rational decisions using the balance sheet, he/she must either be able to <u>subjectively</u> weight the items measured in nonmonetary units in monetary terms (usually dollars) which allows numerical comparisons or at least have some intuitive feeling as to the importance of the inconsistently measured items. Finally, if intangible items appear (<u>i</u> in Table 7.1) the interpretation of the balance sheet is most difficult and it is likely only useful because it includes <u>all</u> costs and benefits enumerated for the policy-maker. An intangible item would be, for instance, the aesthetic value of natural area. However, for the policy-maker to make a rational decision over alternatives using the balance sheet, he must have his own sense of weights for all items.

If the distribution of benefits and costs are of concern, the fact that the balance sheet allows the policy-maker to note the incidence of costs and benefits over subgroups is useful. However, some weighting system for the costs and benefits, depending on incidence, would be necessary to allow a comparison (numerical or otherwise) of plans.

TABLE 7.1

PLANNING BALANCE SHEET

	PLAN A				PLAN B			
	BENEFITS		COSTS		BENEFITS		COSTS	
Sector	Cap.	Ann.	Cap.	Ann.	Cap.	Ann.	Cap.	Ann.
				Producers				
X	\$a	\$b	-	\$d	-	-	\$b	\$c
Y	i_1	i_2	-	-	i_3	i_4	-	-
Z	M_1	-	M_2	-	M_3	-	M_4	-
				Consumers				
X^1	-	\$c	-	\$f	-	\$g	-	\$b
Y^1	i_5	i_6	-	-	i_7	i_8	-	-
Z^1	M_1	-	M_3	-	M_2	-	M_4	-

Source: Hill, 1968: 21

One problem in using the planning balance sheet is the difficulty in interpreting it, as outlined above (including potential problems involved with subjectively valuing nonmonetary costs and benefits). Hill (1968: 21) criticizes it on other grounds. He claims that the costs and benefits only have relevance when related to specific goals of the plan. Specific goals are not part of the balance sheet. Thus, there is no way of using it to determine the impact of the plan on the goals of the investment. Furthermore, comparison of different alternative plans' impacts on a certain set of goals cannot be made so that different plans for a public investment cannot be properly evaluated. Thus, by using the planning balance sheet, a policy-maker can become aware of the incidence of costs and benefits of the plan on groups but it does not help him to determine to what extent the goals of the plan will be accomplished. Hill's improvement which relates costs and benefits to specific goals for alternative plans is outlined next.

HILL'S FRAMEWORK

In Hill's "goals-achievement matrix" (1968: 21-28), the evaluation of alternative courses of action requires for each alternative the determination of whether or not the benefits outweigh the costs, measured in terms of the total array of goals. For each goal, a benefit-cost account is prepared which includes comprehensive costs and benefits of the tangible, intangible, monetary, and nonmonetary varieties. For each goal, under each alternative course of action (plan), costs and benefits are compared, aggregated where possible, and reported separately. The community's valuation of each of the various goals yields weights for them. Its valuation of the incidence on community groups of the plan's benefits and costs leads to a weighting of benefits and costs by groups. The weights applied to the incidence of goals can be interpreted as the community's desired distribution of net benefits, related to goals, and represents the community's conception of equity.

In the goals-achievement matrix, costs and benefits are always defined in terms of goals achievement. Benefits represent progress toward the desired objective and costs represent retrogression from it. If a goal is defined in terms of quantitative units, the costs and benefits are defined in the same units. Where no quantitative units are applicable, benefits and costs indicate progress towards or retrogression from the qualitative states that the objective describes. If a benefit of x units accrues, it can be nullified by a cost of x units provided that both costs and benefits apply to the same objective. This is different from the usual definition of costs and benefits (such as the one used by Lichfield) because costs and benefits only have significance in terms of goals achievement. In some cases, this may lead to an incomplete elaboration of costs and benefits since some costs and benefits may not be related to any specified goal.

Table 7.2 presents how a goals-achievement matrix for evaluating one of a set of alternative plans might look. In Table 7.2, I, II, III, ...are the descriptions of the various goals and each have a relative weight as shown. Affected groups are labeled a, b, c, ...and each group has a relative weight for each goal. A, B, C, ...are the costs and benefits in monetary, quantitative nonmonetary, or qualitative terms. A dash (-) in a cell implies that no cost or benefit accrues to that group under that goal for that particular plan. For a goal under which all costs and benefits can be expressed in the same quantitative units, Σ indicates their summation and a comparison of total costs and total benefits for that goal can be made. If, in the highly unlikely case, all costs and all benefits under all goals are expressed in the same quantitative units, it may be possible to arrive at a grand summation of costs

TABLE 7.2

GOALS-ACHIEVEMENT MATRIX

Goal Description	I			II			III			IV		
Relative Weight	2			3			5			4		
Incidence	Relative Weight	Costs	Benefits	Relative Weight	Costs	Benefits	Relative Weight	Costs	Benefits	Relative Weight	Costs	Benefits
Group a	1	A	D	5	E	-	1	-	N	1	Q	R
Group b	3	H	-	4	-	R	2	-	-	2	S	T
Group c	1	L	J	3	-	S	3	M	-	1	V	W
Group d	2	-	-	2	T	-	4	-	-	2	-	-
Group e	1	-	K	1	-	U	5	-	P	1	-	-
		Σ	Σ					Σ	Σ			

Source: Hill, 1968: 23

and benefits. But using this procedure to evaluate alternative plans suffers from the same criticism as Hill applied to Lichfield's work--costs and benefits are not related to specific goals. A, B, C, ...are not to be strictly interpreted as a specific value. To indicate uncertainty, a range of costs and benefits is preferable to the prediction of a unique outcome.

There are several difficulties with the goals-achievement matrix in its use to evaluate several alternative courses of public investment action. One difficulty may arise in determining what the goals of the investment are. There may be disagreement between the policy-makers, among community groups, and between policy-makers and groups. Resolution may be difficult or impossible with the top level policy-makers being left to subjectively establish the goals. Similarly weighing of goals and the incidence of costs and benefits over groups may be difficult. However, if these problems are solved, one major obstacle remains. That is interpreting the goals-achievement matrix.

It has already been pointed out that a grand summation is highly unlikely and perhaps undesirable. A high level policy-maker could simply be presented with the completed matrix for each alternative course of action and he could be left with his own resources to choose the best alternative. He must compare the weights ascribed to the goals and differential achievement of the goals, over all goals and weighted groups, by the various plans. That this requires a complex set of subjective comparisons to be made in the policy-maker's mind is obvious. Hill (1968: 25-26) goes through several methods of comparing plans but none handles the problem of making decisions over alternatives faced with large amounts of disaggregated data in a simple and satisfactory way. Thus interpreting the results after evaluation of alternatives is difficult.
Another criticism of the goals-achievement matrix is that it takes no account of the interaction and interdependence between objectives. Its shortcomings

notwithstanding, the goals-achievement matrix does consider all costs and benefits and does organize data for investment under alternative plans in a comprehensive way, taking into account all goals of an investment (not just economic efficiency), the relative importance of the goals, the groups which receive the benefits and costs from the investment, and the relative importance of the groups with regard to equity. If it is used, it is a step forward in eliminating poor decisions because of incomplete information.

DICKERT AND SORENSEN'S FRAMEWORK

Dickert and Sorensen (1974: 146-149) propose a process for the inclusion of social equity in the coastal planning program. The process which is similar to some of the benefit-cost models discussed earlier but generally less effective for decision-making includes: 1) identification of social impacts that may be occuring; 2) determine the extent and incidence on groups of the impacts; 3) compare the social impacts to environmental and economic factors in a way that will allow explication of tradeoffs between the factors; and 4) develop strategies to implement the mix of social, economic, and environmental values which have been determined. They list various socio-economic impacts which are shown in Table 7.3. This elaboration of impacts would be useful in implementing any of the benefit-cost models presented in preceding or succeeding sections.

A SYNTHESIS MODEL

INTRODUCTION

The equity constrained benefit-cost model is an evaluative framework and a decision model for choosing among alternative combinations of locations and designs for public projects. It includes community goals which are the

TABLE 7.3

SOCIO-ECONOMIC IMPACT CHECKLIST

Socio-economic considerations	Criteria/information which may be included in checklist for permit review or plan development
1. Will the project cause a change in the existing temporary or permanent employment base?	Mix of local industrial employment:
Effect on permanent employment for residents of coastal community (particularly for coastal communities with high annual or seasonal unemployment):	Percent of total employment for each industrial sector within the community.
Increase employment opportunities in service sector (commercial).	Percent resident local employment by industrial sector
Decrease seasonal fluctuation in employment.	Percent non-resident employment by industrial sector.
Decrease annual employment.	Seasonal fluctuation of employment by industrial sector (by quarter year).
Effect on diversity of employment opportunities in coastal community:	
Reduce dependence of community on single industry or economic sector.	
Increase dependence of community on single industry or economic sector.	
Effect on temporary (construction) employment for residents of coastal community (particularly communities with high annual unemployment):	
Decrease seasonal fluctuation in employment.	
Increase seasonal fluctuation in employment.	
Decrease annual employment.	
Effect of providing temporary employment (construction, seasonal help) for non-residents of coastal community (workers attracted or brought in from outside coastal community):	
Increase demand for housing (particularly rental, temporary mobile home).	Existing housing vacancy rate (by type):

TABLE 7.3 CONTINUED

Socio-economic considerations	Criteria/information which may be included in checklist for permit review or plan development
Increased use of public services (particularly schools, health, etc.).	Percent unused capacity of existing community service facilities and systems.
Integration of workers from outside community with community residents.	
2. Will the project cause a change in the existing tax base and thus the ability of jurisdiction to provide public services?	
Effect on assessed valuation of surrounding properties:	Estimated change in value (assessed values-rental rates) of properties surrounding site.
Displacement of low and middle income groups from coastal community. (Increased property taxes, increased property values, increased rents, increased cost of living.)	Mix of housing types and rental structure.
Limit or prevent acquisition of coastal properties by individuals with low and middle incomes. (Increased cost of property, increased taxes).	
Effect on net tax revenue to local community and/or to taxing jurisdictions:	Revenue expected to be provided to taxing jurisdiction from project.
Increase in net tax revenue.	
Decrease in net tax revenue.	
Effect on existing public services/ systems:	Public costs required to provide services for project:
Upgrade quality of health care services, particularly in communities with inadequate health care services.	
Increase educational quality and opportunities, particularly in communities with substandard educational systems.	
Increase quality of public safety services (police, fire, rescue), particularly in communities with substandard public safety services.	Percent unused capacity of existing service systems (water, fire, waste, sewer, police).

TABLE 7.3 CONTINUED

Socio-economic considerations	Criteria/information which may be included in checklist for permit review or plan development
Overburden capacity of existing public services (decrease quality and scope of services delivered) and/or require the expansion of public service systems (cost to residents of local community greater).	Estimated increase in public service required by the project.
3. Will the project cause a significant change in existing community social structure by excluding or encouraging immigration of income or population groups?	
Change in distribution of various income groups within coastal community (socio-economic mix):	
Increase income of lower income groups disproportionately more than upper and middle income groups.	
Increase income of upper and middle income groups disproportionately more than lower income groups.	Number of lower income groups which will be displaced or forced to move by the project.
Increase rental rates for housing or cost of tourist commercial services to level where low and middle groups could not afford rental housing or tourist commercial services in the coastal community.	Comparison of average rental rates or sales price for project and average rental rates or appraised market value for existing properties.
Decrease rental housing and tourist commercial rates to level low and middle income groups can afford to move into coastal community (integration with existing residents).	
4. Will the project produce a significant change in the identity of the local community?	
Loss of small town identity. Decrease in social interaction within the community. Change in well-being of the inhabitants.	Series of public hearings and meetings of community residents; photographic presentation describing visual character of the community; attitude survey concerning community goals and alternative futures.

TABLE 7.3 CONTINUED

Socio-economic considerations	Criteria/information which may be included in checklist for permit review or plan development
5. Will the project alter existing public access to the shoreline?	
Direct access to shore (or beaches by non-residents of coastal community or neighborhood).	Existing use (visitor days) of shoreline by local permanent residents and non-resident visitors (estimate increase or decrease in use from project).
Decrease use of shore by individuals or groups who are socially incompatible with local residents (displacement impacts).	
Increase use of shore by individuals or groups who are socially incompatible with local residents.	
Decrease use of shore (allow community or neighborhood residents more recreation per capita).	Existing per capita recreation space (persons/100 feet of shoreline); persons/square feet of beach. Estimate change in per capita recreation produced by the project.
Increase use of shore to levels of crowding and congestion (crowd out or discourage use by neighborhood or community residents).	
Invasion of privacy of local residents.	
Decrease convenience of private residents for use of community facilities (congestion).	
Transportational access to coast (automobile/transit):	Estimated number of vehicle trips produced by the project. Estimated increase in congestion.
Decrease use of shore by groups with limited mobility (those dependent on public transportation and/or those who cannot afford transportation costs).	
Same as effect on direct access (see above).	

TABLE 7.3 CONTINUED

Socio-economic considerations	Criteria/information which may be included in checklist for permit review or plan development
6. Will the choice of recreational use preempt or exclude other recreational users?	
Effect of providing recreational facilities or areas (by public funding).	Specify the socio-economic groups (organized, unorganized) that participate in each type of recreation activity. Inventory sites providing opportunity for activity preempted or not provided. Specify present unused capacity of these sites (percent) for recreational activity preempted or not provided.
Displace or preclude recreational activity participated in by one or more socio-economic groups (particularly low income groups with limited recreational opportunities).	

Source: Dickert and Sorenson, 1974: 148-49 distributional and other requirements of the project. The model considers comprehensive costs and benefits within its framework and also takes their distribution into account. Use of the algorithm results in the alternative which best meets the established goals becoming obvious. Thus its results are interpretable. Because it contains several attributes of the preceding models, it is termed a "synthesis" model and these attributes make it particularly advantageous for making wetlands use decisions.

If, for example, a highway between points a and b is being planned, several routes which are all technically feasible locations for the road are usually available. Some routes may go through wetland areas.[4] The alternative lineal routes between points a and b are each considered to be one location. Several routes may be concurrent except for slight variations at certain points. These are, nonetheless, considered to be different locations. By technically feasible is meant that the soil conditions, angles of terrain slope, etc. make it possible for a road of the same specified vehicular capacity and physical design to be built in any of these various locations. Unfortunately, every route which is technically feasible may not be included in the elaboration of routes by the planners because of human error.[5] This immediately presents the possibility that the optimal location-design alternative may not be selected since the optimal route might not be included in the set of technically feasible routes. Hopefully the engineers charged with presenting alternatives are technically capable and thorough in their deliberations so that the probability of this occuring is small.

[4]A highway is a rather simple wetland development if divorced from dependent related development. The equity model can be used in a similar manner for more complex wetland developments.

[5]It is assumed that the engineers are honest in their elaborations and do not omit certain technically feasible routes or present feasible routes as infeasible because of personal biases.

At every location, highways of several different designs may be technically feasible. Technically feasible here refers again to physical conditions which allow different designs of the same vehicular capacity to be constructed at a certain location. For instance, the highway may be constructed as different types: elevated, at grade, depressed, as a tunnel, etc. Each of these is termed a different design. Pope and Gosselink (1973) discuss some of the possible costs, ecologic and otherwise, of constructing various highway designs through wetlands. Furthermore the addition of various accoutrements such as noise buffers or landscaping to a highway of one type also results in a set of designs. Again all possible designs may not be considered by the planners. Assuming honesty among planners, only the designs elaborated by them are pertinent to decision making. In any case, it may be said that location-design alternative selection is first limited by technical constraints.

The set of all technically feasible designs considered by the planners at all locations is labeled as $\underline{N}$.

$$N = \{1,\ldots,j,\ldots,n\}$$

The set of all technically feasible locations elaborated by the planners is designated $\underline{M}$.

$$M = \{1,\ldots,i,\ldots,m\}$$

Since a location without a design is meaningless and vice versa, only combinations of locations and designs are pertinent here. These combinations are designated location-design alternatives. If a location and a design are incompatible because of technical reasons, this location-design is ignored in any subsequent deliberations. Each alternative can possibly affect several groups of citizens. The set of all groups which can possibly be affected (either negatively or positively) by any location-design alternative is designated as $\underline{G}$.

$$G = \{1,\ldots,r,s,t,\ldots,u,\ldots,g\}$$ [6]

The problem at hand is to select the location-design alternative which is according to some criterion optimal.[7] The criterion for selection could be economic efficiency (alternative with largest net monetary benefit) but this takes no account of the community's desired distributional aspects over certain groups or goals (equity aspects) of the project. However, if the project goals are achieved, then it is contended here that the conforming alternative with the largest net monetary benefit should be the one selected. The reason is simple. After the goals of the project are satisfied and equity achieved (as seen by the policy-makers and the community), the effect of the project on the total community should be considered. If the community is one homogeneous group of persons, then the efficient alternative is equitable. When the community diverges from homogeneity, then efficiency and equity may diverge. However, if the alternative has been selected so as to conform to the equity requirements as put forth by the policy-makers, then the total community with no other group presenting itself for special consideration should be considered. If the profit maximization instinct is valid at all, then the total community should get the greatest possible return on its investment. Thus the criterion for selecting the optimal alternative is to select the one with the largest

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[6]In order to avoid a meaningless level of disaggregation, one of the groups may be designated "rest of the world" or "rest of the community".

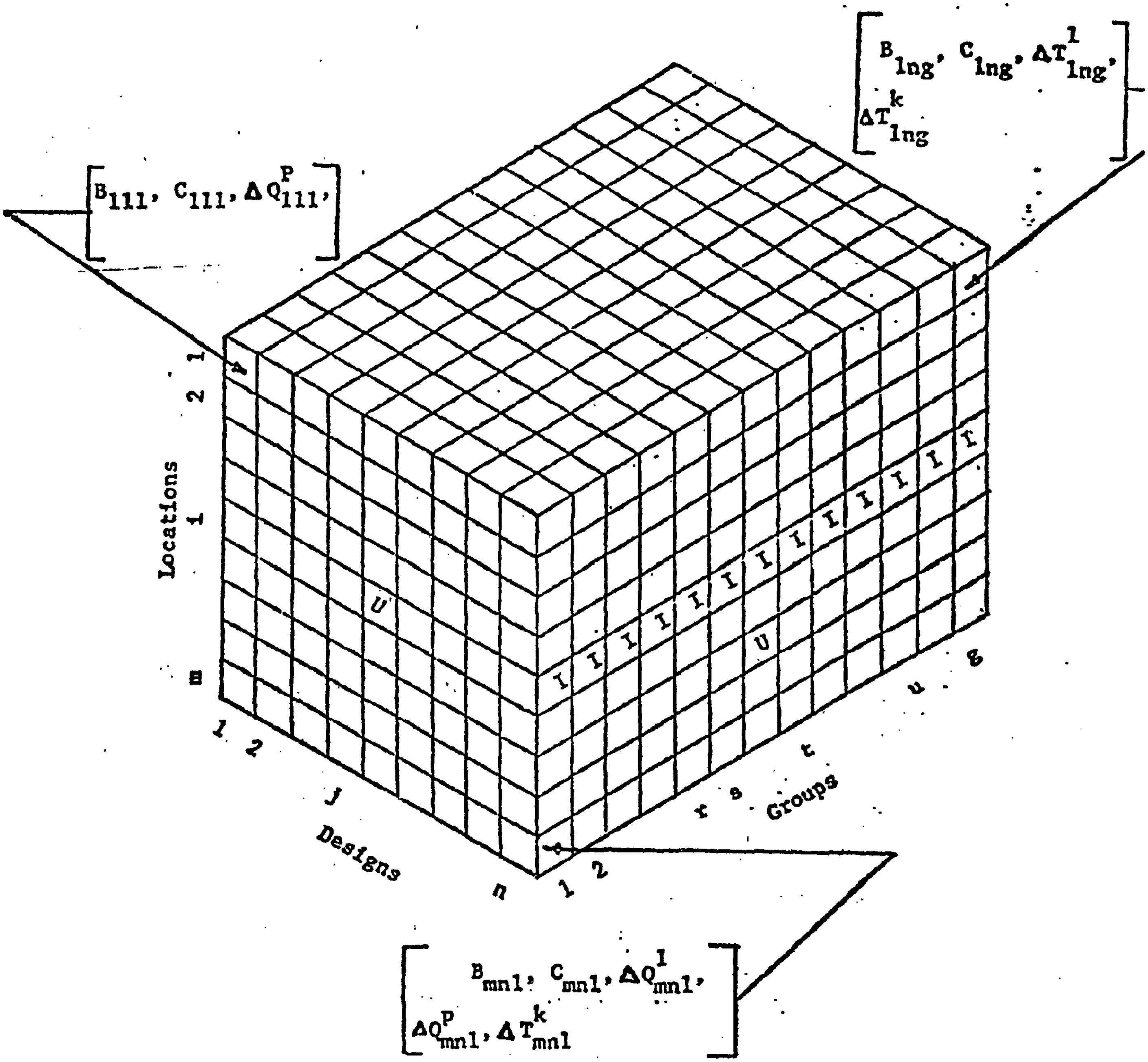
[7]The term "optimal" will continue to be used realizing that use of the equity constrained algorithm may result in the selection of a sub-optimal alternative because of alternative locations and designs not considered.

net monetary benefit (which might be considered the goal for the total community) subject to its achieving the goals established for the project (for special groups). The alternative may be termed the equity constrained efficient alternative.

THE EQUITY CONSTRAINED BENEFIT-COST MODEL

Figure 7.1 presents the evaluation matrix for the equity constrained benefit-cost model. In each cell is entered the impact of location-design alternative *ij* on group *r*. Similar to Hill (1968) and Lichfield (1960, 1964), all costs and benefits (for the project's life properly discounted) are entered into the matrix by group including those expressed in monetary terms, nonmonetary (but quantitative) terms, and intangible terms.[8] A cost is defined simply as a negative (detrimental) impact on a certain group (including taxes and tolls as related to the project) and a benefit is a positive (beneficial) impact both being measured in monetary, nonmonetary, or intangible terms. By monetary is meant dollars or some other pecuniary term. For instance, a monetary benefit might be the saved transportation cost that a new highway provides its users while a monetary cost might be the value of the lost fisheries production resulting from wetlands destruction. Nonmonetary costs and benefits could be quantitative measures such as the concentration of sulfur dioxide air pollution contaminant levels in parts per million. A cost would be an increase in contaminant levels and a benefit would be a decrease. If a wetland area's aesthetic value was destroyed by a project this would be an intangible cost. If it was enhanced, this is an intangible benefit. Intangibles

[8]Transfer costs and benefits are included because the distributional effects of the alternative is of interest in considering its equity.



"I" denotes that location $\underline{i}$ and design $\underline{j}$ are incompatible.
"U" denotes that group $\underline{r}$ is unaffected by design $\underline{j}$ at location $\underline{i}$.

Figure 7.1. Evaluation Matrix for the Equity Constrained Benefit-Cost Model. See text for explanation of the notation.

could be differentiated according to severity by descriptive adjectives such as "mild", "medium", or "severe". Not only are costs and benefits related directly to the highway included in the evaluation matrix but also costs and benefits related to spinoff development and other indirect effects of the highway.

The evaluation matrix, therefore, confronts two major problems of traditional benefit-cost analysis related to project implementation difficulties: 1) it takes into account all benefits and costs (including indirect ones or spillovers) and 2) it considers the distribution of benefits and costs over groups.

By looking at the matrix, one can determine the distributional effects of each alternative. However, unless the desired distribution of costs and benefits are specified in the goals of the project, the fact that the distribution of costs and benefits is known is meaningless. That is, unless the policy-makers with the community establish some desirable ("equitable") distribution of costs and benefits, no one distribution is superior to another. This is the subjective role of the policy-maker. Lichfield's (1960, 1964) planning balance sheet suffers from this fault since it indicates the distribution but does not specify (except perhaps in the policy-maker's mind) what is the desired distribution.

In the equity constrained benefit-cost model, the goals of the project are used to establish the distributional requirements of the project. For instance, suppose the policy-makers believe that groups r, t, and g should each receive net monetary benefits from the project of X dollars. This is one goal of the project. No alternative in which the monetary benefits to groups r, t, and g are less than X dollars would be acceptable. Only alternatives which satisfy this goal are considered by the policy-makers. Thus location-design selection is constrained by this requirement.

Similarly the policy-makers could constrain alternative selection by the requirement that air pollution levels be limited to a specified increase, or decreased by some amount, and so on for other impacts of the project not measured in monetary terms. For intangible items, the policy-makers could constrain alternative selection by specifying, for example, that no alternative which adversely affects the aesthetics of a wetland area would be acceptable. For some goals, such as these, society in general might be the special group.

Notationally, the equity constrained benefit-cost model could be written as follows (refer to Figure 7.1):

1. Enter total benefits expressed in monetary terms, $B_{\underline{ijr}}$, and total monetary costs, $C_{\underline{ijr}}$, into the evaluation matrix where $\underline{ij}$ is any location-design alternative and $\underline{r}$ is any group upon which this alternative impacts.
2. Enter the nonmonetary but quantifiable impact, $\underline{Q^e_{ijr}}$, into the matrix where $\underline{e}$ is an impact label in set $\underline{P} = \{1,\ldots,\underline{e},\ldots,\underline{p}\}$.
3. Enter the intangible impact, $\underline{\Delta T^h_{ijr}}$, into the matrix where $\underline{h}$ is an impact label in set $\underline{K} = \{1,\ldots,\underline{h},\ldots,\underline{k}\}$.
4. Compute $(B-C)_{ijr}$.
5. The objective of the algorithm is to select the alternative location-design, $\underline{ij}$, which maximizes the net benefit in monetary terms, $\max\limits_{ij} \sum\limits_{r=1}^{g} (B-C)_{ijr}$ (equity constrained efficient alternative).
6. Subject to:[9]

   1) $(B-C)_{ijr} \geq 0$ (No group $\underline{r}$ bears monetary costs which exceed monetary benefits.)

[9]These are sample constraints which may or may not be included in an actual case.

2) $(B\text{-}C)_{ijs} \geq \$L$ (Group s, specific group, receives a net monetary benefit of \$L. This could be specified to accrue from all aspects of the project in aggregate or from one or more project aspects such as better mass transportation, etc. net benefits due to increased jobs in certain sectors.)[10]

3) $\Delta Q^{e}_{ijr} \leq Z$ (The change in the status quo for any group r because of nonmonetary impact e is not greater than Z. For instance, no group r suffers an increase in a certain contaminant level greater than Z parts per million; e may be sulfur dioxide pollution.)

4) ΔT^{h}_{ijr} is none (Intangible impact h on any group r is negligible. For example, h may be the impact of an alternative wetland aesthetics.)

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[10]If this refers to one or only a subset of project aspects, the monetary benefits and costs would have to be entered into the evaluation matrix on a disaggregated basis -- $\underline{B^{a}_{ijr}}$ and $\underline{C^{a}_{ijr}}$ where a is an aspect label for the project in set $F = \{1,\ldots,a,b,\ldots,f\}$. Summations $\sum_{a=1}^{f} \underline{B^{a}_{ijr}}$ and $\sum_{a=1}^{f} \underline{C^{a}_{ijr}}$ equalling $\underline{B_{ijr}}$ and $\underline{C_{ijr}}$, respectively, would be necessary in steps 4, 5, 6.1 and 6.5. Summations over some aspects in step 6.2 might be necessary depending on the specification of the constraint -- $\sum_{a=b}^{f} (B\text{-}C)^{a}_{ijr} = (B\text{-}C)^{b,\ldots,f}_{ijr}$.

5) $\max_{ij} \sum_{r=1}^{g} (B-C)_{ijr} \geq 0$ (Net monetary benefits for the alternative chosen, ij, are positive).

6) etc.

Constraint 5 may be desirable if all costs and benefits are measured in monetary terms and if not met, the "no project" alternative would be selected. However, when nonmonetary and intangible benefits and costs exist, its usefulness is questionable because a combination of all three types of benefits may far exceed costs when monetary benefits do not exceed monetary costs and vice versa. Unfortunately there is no objective way to determine what is the actual case. Subjective determination could be made through the weighting of nonmonetary and intangible costs and benefits in monetary terms.

The model implies that a preset budget constraint is met for the funds to be expended on the project by the implementing (e.g., highway) agency. If the funds required to implement the project are increased by requiring the project to conform to equity considerations, obviously there will be less of the implementing agency's funds available for other projects. The effect of the preset budget constraint is to tell the implementing agency when the funds requirement of a project is too great because it is affecting the agency's ability to finance other projects.

Computationally, once all costs, benefits, and impacts are elaborated by location-design and group in the evaluation matrix, a decision-maker first eliminates all alternatives which do not meet the constraints and then selects the remaining alternative with the largest net benefit. This is the optimum alternative.

The equity constrained benefit-cost model, as already pointed out, has several attributes of the other models presented earlier. It has an objective function and constraints similar to Marglin's framework; and it considers distributional effects (Lichfield's planning balance sheet) and goals achievement (Hill's model). There is, however, a difference between the meaning of goals achievement as used here and as used by Hill (1968: 21-24) in the goals achievement matrix. In his work, there is no point defined as the point of goal achievement since benefits indicate progress toward a goal and costs indicate retrogression away from it, and these may accrue without limit. Alternative plans may be involved with more or less net benefits toward goal achievement without really achieving the goal. Here a goal is either achieved or not. It is a "yes" or "no" proposition. There is no possibility of a spread in goal achievement as in Hill's work. As long as the constraints are satisfied, the goals are achieved. The goals are set by the policy-makers who define their achievement. Finally, the results of the equity-constrained model are interpretable in that the alternative which best meets the model's optimization criterion is obvious as the one with the largest monetary net benefit subject to the constraints. As pointed out earlier, Hill's and Lichfield's models are very difficult to interpret as a basis for decision making over alternatives.

The equity constrained benefit-cost algorithm presents the best basis for decision making. The policy-makers and the community have established the goals of the project and the selected alternative achieves these goals. Thus, the policy-makers are not to be accused of and criticized for arbitrarily assuming that a dollar of net benefit to one group is the same as to another. From the information they possess, the policy-makers, in using the algorithm, have attempted to make an equitable decision.[11] If, in the rest of the

[11] In setting goals, policy-makers should not rely only on their own ideas of community needs but should also bring in the community ideas on what the goals should be. Of course controversy may result among groups and between groups and policy-makers. Setting goals is discussed in the following section.

community, no group appears worthy of special consideration, the policy-makers can hardly do otherwise than to assume that the rest of the community is a homogeneous group. For the rest of society, the policy-makers attempt to secure, in aggregate, the greatest return on their investment.[12]

TOWARD A MODEL FOR A GOALS SYSTEM

So far, several alternative models have been discussed which include goals in project evaluation and decision making over alternatives. Presented below are a set of attributes which it is proposed that a system of goals possess. This section is intended to assist goals-makers in formulating goals systems.

Pareto's criterion for an improvement is the following: any change which harms no one and which makes some people better off (in their own estimation) must be considered an improvement (Baumol, 1965: 376).[13] Table 7.4 presents the range of hypothetical situations that qualify as improvements.

Theoretically, all of the above situations qualify as social improvements. However, there is usually widespread opposition to overt programs producing the case 1 results. Many current programs, e.g., medicare, aid to dependent children, negative income tax, etc., are aimed primarily at the lower half of society, which suggest that society finds case 1 least desirable. However,

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[12]The preceding part of this paper is adapted from Chapter III of Mumphrey (1973).

[13]It is noted that other definitions of an improvement are possible such as "the difference between benefits and costs summed over all groups (total net benefits) is positive" and others. These are not considered because the recent history of projects such as highways which considered only total net benefits and not the distribution and magnitude of the net benefits over groups is filled with difficulties in implementation and controversy (Mumphrey and Wolpert, 1973). Besides, since <u>goals</u> programs are being discussed, a more ideal definition of "improvement" such as Pareto's is felt appropriate rather than a pragmatic definition such as positive total net benefits discussed above.

TABLE 7.4

POSSIBLE PARETO IMPROVEMENTS

	Net Change in Total Income[14]	
	Haves of society	Have nots
1	+	0
2	+	+
3	0	+

[14]Includes monetary, nonmonetary, tangible and intangible income.

it is not clear that no one is worse off as a consequence of these programs. Case 2 (horizontal equity) is more likely the only politically feasible one while case 3 (vertical equity) may also be desirable. Society may be also concerned with the relative magnitudes of the net changes in case 2 and may find some undesirable. Thus, although a goals system (set of goals) should attempt to create an improvement -- meet the Pareto criterion, it should be constrained so that case 1 does not occur.[15]

If a goals system is to insure an improvement of the case 2 or 3 variety, it should have certain attributes. They are: efficiency, equity, comprehensiveness, and implementability. As a consequence, the process, i.e., how, by, and for whom, through which the problems are identified and the goals are stated is critically related to the attainment of efficiency, equity, comprehensiveness, and implementability.

Traditionally, efficiency has referred to the maximization of net monetary benefits, since nonmonetary and intangible costs and benefits are difficult to measure. This is the meaning adopted here as in the objective function of the equity constrained benefit-cost model (step 5).[16] The objective function is here considered a goal as are the constraints. Efficiency considerations require that the total economic pie be maximized. Constraints (equity

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[15]It has been suggested that the Pareto criterion which considers only <u>marginal</u> changes in income is not appropriate for dealing with society's ongoing problems and that an <u>absolute</u> redistribution of income is necessary. Since this chapter assumes no great political upheavals (that would be necessary to bring about absolute redistribution in the United States), absolute redistribution is considered an impractical criterion for judging goals programs.

[16]If efficiency referred to the maximization of total net benefits including monetary, nonmonetary, tangible, and intangible costs and benefits, there would be no need to have equity constraints since equity would be attained in the maximization (Maass, 1966: 209-210). Equity refers, as above, to the distribution of all types of benefits and costs, including net monetary benefits.

considerations) are then required to assure that the pie will be divided properly as in cases 2 and 3 above. For goals systems, efficiency should be an important consideration, and is visible as the effect of the facility's goals achievement on an area's economy.

However, economic efficiency considerations should be tempered by including equity (distributional) requirements as part of the goals system. If distributional considerations are important in the goals system, they should constrain efficiency considerations as do the constraints in the equity constrained model (step 6). The absence of equity considerations may result in the occurrence of the socially undesirable case 1. Even if efficiency is of primary importance, attention should be given to the effect of the goals system on specific groups.

A goals system should be comprehensive, i.e., it should consider all segments of the community. Otherwise, certain segments may benefit at the expense of other segments and the Pareto criterion may not be realized. Therefore, the effects of one goal may need to be limited by other goals. For instance, if one goal of the system is an improved highway network, another goal (constraint) might necessarily be that the improved network not result in the destruction of any existing wetlands. Thus the distributional effects of the goals system should be accounted for by a comprehensive system. This, of course, is related to the equity attributes of the goals system.

Additionally, a goals system should be comprehensive so that the needs of certain segments are not ignored, including the poor, the near poor, and the affluent. Dickert and Sorensen (1974: 143-44) discuss this component of coastal planning programs. The needs of the bureaucratically unsophisticated, inarticulate, and powerless groups are often ignored unless they are included themselves in the goals making process. Sometimes members of the power structure are unable to articulate and sufficiently appreciate the problems of the "have nots"; and, since these groups are increasingly demanding direct participation, comprehensiveness may indeed mean the inclusion of all groups in the process by which goals are stated. Ignoring them in the short run probably results in their politicalization and opposition to the implementation of the goals system (Mumphrey, Seley, and Wolpert, 1971: 397-402).

Finally, the goals system should be implementable. There are two aspects of implementability. One deals with feasibility, e.g., it would not be rational for Denver to develop a shipbuilding industry. The other aspect of implementability deals with the goals themselves. Either the goals should contain a "by" statement, where appropriate, which discusses how they are to be implemented or the goals system should contain a separate subsystem on implementation.

Although implementation is the payoff, and it is not infrequently the sole criterion by which a goals system is deemed a success or failure, there are reasons for goals making other than implementation. One reason may be to establish communications about local problems among various local groups. This is a valid and a legitimate objective, because communication is an essential ingredient of community; however, it has to be classified as auxiliary because the basic motivation is achievement. In fact, Hill (1968: 22) defines a goal as "an end to which a planned course of action is directed". Even though the goals making process may serve to heighten awareness and perform the function of an encounter group, this does not lessen the necessity for goals achievement.

If the goals are not achieved, or a modicum of success realized, participants in the process usually become frustrated and disillusioned with the planning process in general. In fact, the failure of goals achievement may result in participants adopting particularistic group goals which, if implemented, would sometimes be at the expense of the general good (diverge from the Pareto criterion). A priority time-schedule for implementation may be desirable, so that certain groups realize that all goals cannot be accomplished at once and do not become frustrated because some goals are not accomplished as soon as they desire.

In summary, a goals system should possess the attributes of efficiency, equity, comprehensiveness, and implementability. More specifically, they ensure the realization of the Pareto criterion, and especially cases 2 and 3 noted above. Thus a preliminary and highly simplified model of a goals system is shown in Figure 7.2.

Figure 7.2 is concerned only with the goals system. However, the goals making program could be described as in Figure 7.3.

In this representation of the goals making program, it is contended that the goals system is conditioned both by the local problems and goals making process. For instance, if the process does not contain representatives or advocates for all groups, then, it is likely that the goals system will be biased and uncomprehensive, which may mean that a Pareto improvement will not occur. The inherent nature of local problems, e.g., racial tension, employment, problems of the enviornment, etc. mandates representativeness in the process so that the comprehensiveness attribute obtains.[17]

Citizens should participate in setting the goals and decision-making for wetland development, especially if the representativeness (comprehensiveness) attribute is to be attained. Shabman (1974: 198) lists the objectives of increased citizen participation as to 1) encourage a broader expression of viewpoints that are considered in public decision making and 2) redistribute the ability to influence public choices. However, he does point out that

[17]This section on a goals system model is adapted from part of Bobo, Mumphrey, and VanLandingham (1976).

Figure 7.2. The Goals System

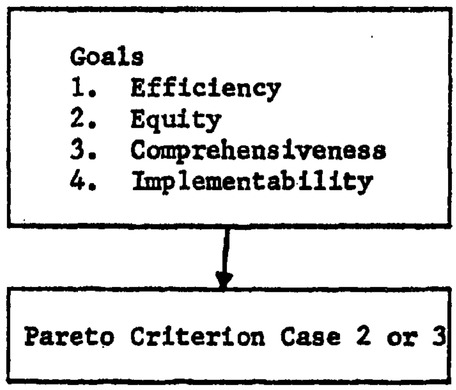
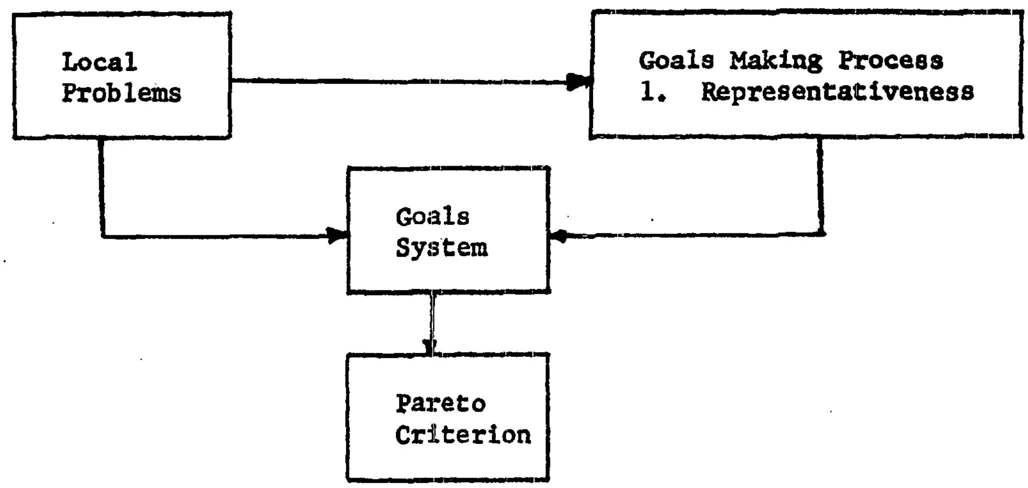


Figure 7.3. The Goals Program



it is not a panacea for solution of resource management problems and may simply reflect anti-intellectual "do nothing" thrusts.

According to Shabman (1974: 200-205), the type of group to which policy-makers are usually attentive are those which possess authority, legitimacy, unity and cohesion, data base and technical expertise, and staff and budget. Authority can be gained through some grant by the legislative process (normally). For instance, state and federal agencies are given authority by the Fish and Wildlife Coordination Act of 1958 to speak for fish and game interests with regard to major water development projects. An agency's recommendations, however, are not necessarily respected. A legitimate group is one for which the policy-makers have a basic trust or respect. Once environmental groups receive support of substantial numbers of congresspersons and senators, governmental agencies pay greater attention to them. Unity and cohesion in a group are often the result of good leadership which inspires activity by the group. Since many of the issues in which citizens are involved are highly technical, groups may endeavor to attain data base and technical expertise with the aid of expert outsiders such as biologists, economists, etc. Sophistication in the decision making process is another type of expertise normally required by a group. Without adequate staffing and budget generated either through private or public sources, groups will probably not be effective in their participation.

If decision-makers are to involve citizens from the beginning of the decision process, thereby avoiding their unexpected negative reactions at the project implementation point, the identification of and even help in the formation of groups with the above attributes should be accomplished by the policy-makers. Furthermore, groups with the above attributes are less subject to an irrational do-nothing proclivity. Groups, however, are not likely to participate unless the benefits involved with participation exceed the costs. In the past, groups with an economic stake in a Corps of Engineers or other project had good reason to participate in the decision making process whereas persons interested in ecological aspects of various projects saw the benefits as accuring to a large unorganized group. In the former case, benefits of participation to individuals exceeded the costs and in the latter case, they did not (Shabman, 1974: 203).

In bringing social equity questions into wetlands development decisions, Dickert and Sorensen (1974: 145-46) point out several problems. One problem, as pointed out earlier, is to define the composition and geographic distribution of interest and socio-economic groups within the coastal zone. These are the groups which both participate in goals-setting and decision-making, and are impacted by the proposed development. A second problem is motivating minority groups, especially unorganized ones, to participate. Of course they only participate if the benefits exceed the costs as above. Finally, the transactions costs of including public participation (and therefore social equity) in decision-making may be considerable. Transactions costs would be in terms of hearings; delays; alienation and frustration of various groups, etc.

CONCLUSION

The equity constrained benefit-cost model is a tool to be used in evaluation of and decision making over alternative locations and designs for public facilities. It takes into account the distributional effects of an alternative and the goals of the project in determining the (constrained) efficient alternative. It cannot be used to decide between projects in different sectors or even between competing projects in the same sector but only between technically feasible alternatives for the same project. Problems in its use lie in determining all of the groups affected by the project and measuring the effects in terms of monetary, nonmonetary, and intangible costs and benefits of the project on the groups. These, however, are problems with any benefit-cost model which considers distributional effects. As in other models, the establishment of the goals of the project may be a subject of controversy.

To mitigate the probability of controversy over the goals used in the equity constrained model, a goals system model was presented. It is an attempt to formalize a set of attributes which goals systems should possess in order to avoid the controversies that are likely to develop if a Pareto improvement involving horizontal or vertical equity does not result from facility implementation. It is felt that such attributes are applicable not only to goals in facility implementation but to all sets of goals be they national, regional, or local as long as improvement is desired.

The equity constrained benefit-cost model in which the goals possess the prescribed attributes is an attempt to provide a rational basis for decision making.

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CHAPTER 8

SYNTHESIS OF THE STUDY

In the preceding chapters, the impacts of development on wetlands areas have been discussed. It has also been pointed out that growth in population, employment, and income will occur over the next twenty years in Louisiana's wetland SMSA's. In no case, however, does land space needs require that the SMSA's growth occur in wetlands.[1] Other considerations, however, may make wetland development seem desirable. The equity constrained benefit-cost model is a decision framework which considers community goals, and comprehensive impacts of development, including those which make wetland development seem desirable, in reaching decisions on the overall desirability of wetland development (chapter seven).

In this section the equity constrained benefit-cost model and the other topics of this study will be synthesized into an SMSA wetlands development decision process. Refer to Figure 8.1. First an SMSA should be aware of which of its areas are wetland. The State Planning Office's land use classification system discussed in chapter one is used to delineate wetland areas. Following that, the Soil Conservation Service General Soil Maps for the various parishes are used to classify the soils within the wetland areas. This classification of soils is important since construction and maintenance problems and costs, discussed in chapter five, that have been experienced on similar soils in wetland areas

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[1]New Orleans is a special case, however. Although SMSA growth may occur in St. Tammany Parish, New Orleans is the only SMSA where growth near the existing population center without affecting the wetlands is extremely difficult.

previously developed may then reasonably be projected to occur in areas under consideration for development.

Early in the decision process, the goals of the community are established by the policy-makers and the community as discussed in chapter seven.

Concurrently, using the planned requirements approach (chapter six), projections of the amount of land space required, types of land uses, and the required attributes of locations and designs of future land uses (development) are made. If natural dryland is available for development (or existing developed dryland is available for redevelopment) along with wetland and the required location attributes are met, then alternative locations are technically feasible for a certain land use development. The equity constrained benefit-cost model, then, is used to determine where, if at all, the development should take place and the best design for it. If no dryland is available, the equity constrained benefit-cost model can be used to decide the location and design of the development in various wetlands, if at all.

The costs and benefits of the development are then elaborated by group for all location -designs and included in the equity model's evaluation matrix (chapter seven). The impacts described in chapters three, four, and five are useful in deriving monetary, quantitative non-monetary, and intangible costs of wetlands development. The benefits of development in terms of housing, jobs, tax base additions, etc.--that make wetland development seem desirable--were not discussed in this study but would also have to be included in the evaluation matrix.

Once impacts and goals are elaborated, the equity model can be used to determine whether or not the development should take place, its design, and where. The model's procedure is simple. First eliminate any location -designs which do not satisfy the community's goals (constraints). If no location-design satisfies all of the goals, then the proposed development is abandoned. If more than one location-design satisfies the goals, then the one of these with the largest net monetary benefit is selected as the optimal location-design.

Areas for further research concerning wetlands and planning are numerous. Ecologists have many years of work ahead determining the impact of pollution on natural systems and this is highly important to society in terms of its need for seafood. Similarly the effects of reclamation and channelization on natural systems are not fully understood. As for economic valuation of wetlands, more research is needed to discover the growth rate of the value of fish, the benefits associated with recreation and their growth, the energy to GNP ratio, and the ecological level at which wetland energetics should be evaluated.

Little is known about the additional construction and maintenance costs of public facilities in wetland areas and more research is needed concerning additional private construction and maintenance costs in many types of wetland areas. Furthermore research into some of the possible catastrophic dangers of wetlands development, such as gas explosions and hurricanes, is needed. Finally more detailed and disaggregated population, employment, and income projections are required to predict the course of development in the SMSA's.

In conclusion, this study has attempted to gather information from various sources concerning wetlands and their relationship to metropolitan areas and to present a decision-making framework in which this information could be used to make rational wetland development decisions.

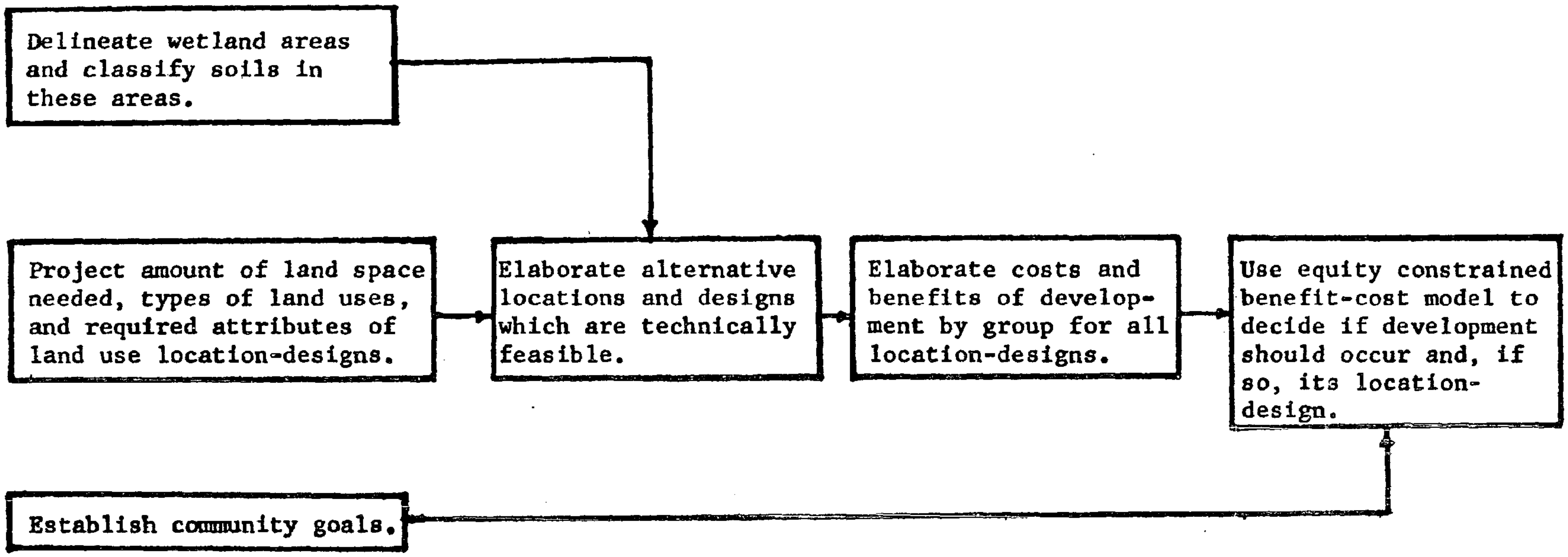

Figure 8.1. SMSA Wetlands Development Decision Process