ADEM

TECHNICAL REPORT

A SURVEY OF THE LITTLE LAGOON WATERSHED

A CHARACTERIZATION OF THE WATERSHED
AND
SURVEY OF WATER AND SEDIMENT QUALITY

COASTAL PROGRAM
APRIL 2000

ALABAMA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
MOBILE BRANCH
2204 PERIMETER ROAD, MOBILE, AL 36615

This report was funded in part by the Alabama Department of Economic and Community Affairs, Office of the Governor, State of Alabama,

ADECA

Planning And Economic Development Division

and in part by a grant from the Office of Ocean and Coastal Research Management, National Atmospheric and Oceanic Administration, United States Department of Commerce.

DISCLAIMER

The mention of trade names or brand names in this document is for illustrative purposes only and does not constitute an endorsement by the Alabama Department of Environmental Management, the Alabama Department of Economic and Community Affairs or the National Oceanic and Atmospheric Administration.

A SURVEY OF THE LITTLE LAGOON WATERSHED

A CHARACTERIZATION OF THE WATERSHED
AND
SURVEY OF WATER AND SEDIMENT QUALITY

COASTAL PROGRAM
APRIL 2000

Prepared by:
Jeffrey Davies
ALABAMA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
MOBILE BRANCH
2204 PERIMETER ROAD, MOBILE, AL 36615

The appropriate citation for this document is:

Alabama Department of Environmental Management. 2000. *A Survey of the Little Lagoon Watershed. A Characterization of the Watershed and Survey of Water and Sediment Quality.* J.D. Davies, ed. ADEM Coastal Program, Mobile Alabama. 36 pp. w/ appendices.

Table of Contents

List of Tables and Figures

Tables

Figures

Characteristics of the Little Lagoon Watershed

General Description

The Little Lagoon Watershed (LLW) is located in extreme south Baldwin County, Alabama and is actually a portion of the much larger Wolf Creek hydrologic unit, as described by the US Geological Survey. The LLW encompasses approximately 20 square miles and is roughly bordered on its east end by State Highway 161. It extends west in a narrow band approximately 17 miles along the Fort Morgan Peninsula. On its north and south it is bordered roughly by State Highways 180 and 182 respectively. Its surface waterbodies consist of Little Lagoon and four small fresh/brackish water lakes, which drain into Little Lagoon. Little Lagoon is approximately 2,480 surface acres in area. The four lakes are Lake Shelby (678 acres), Middle Lake (250 acres), Little Lake (45 acres), and Gator Lake (45 acres). Gator Lake is located at the western tip of Little Lagoon. The other three lakes are all located in series within the Gulf State Park to the east of Little Lagoon (see figure 1). Average water depths in these waterbodies range from 4 to 6 feet. All of these waterbodies are connected by a network of canals and marshes. Water levels in the three lakes to the east are maintained via a weir located just west of Lake Shelby at State Highway 135. Little Lagoon itself is connected to the Gulf of Mexico by an inlet that is currently maintained by a dredging program conducted by the Alabama Department of Transportation.

Typically, a watershed boundary is defined by topography and resulting directional surface water flows. Because of the flat terrain and permeable nature of the soils in the area, the LLW boundary is not so easily defined. The watershed boundary as depicted in Figure 1 is only an approximation based on topographic interpretation. The surface water dynamics of the Little Lagoon system are governed more by ground water levels and the tidal influence of the Gulf of Mexico. Over ground surface flow (tributaries and storm runoff) makes up a very small portion of the total surface water inflow.

Geography

The LLW lies completely within the Coastal Lowlands subdivision of the East Gulf Coastal Plain. The entire Fort Morgan Peninsula and Perdido Key area is part of the western Florida barrier island and spit system. This area is characterized by broad well-developed gulf beaches backed by lines of discontinuous dunes that average 10 to 20 feet in height. Wetlands are a significant feature in the LLW and are made up of tidal marshes, swamp forests, and depressional wetlands mostly located within areas having ridge and swale topography (Alabama Coastal Area Board 1980).

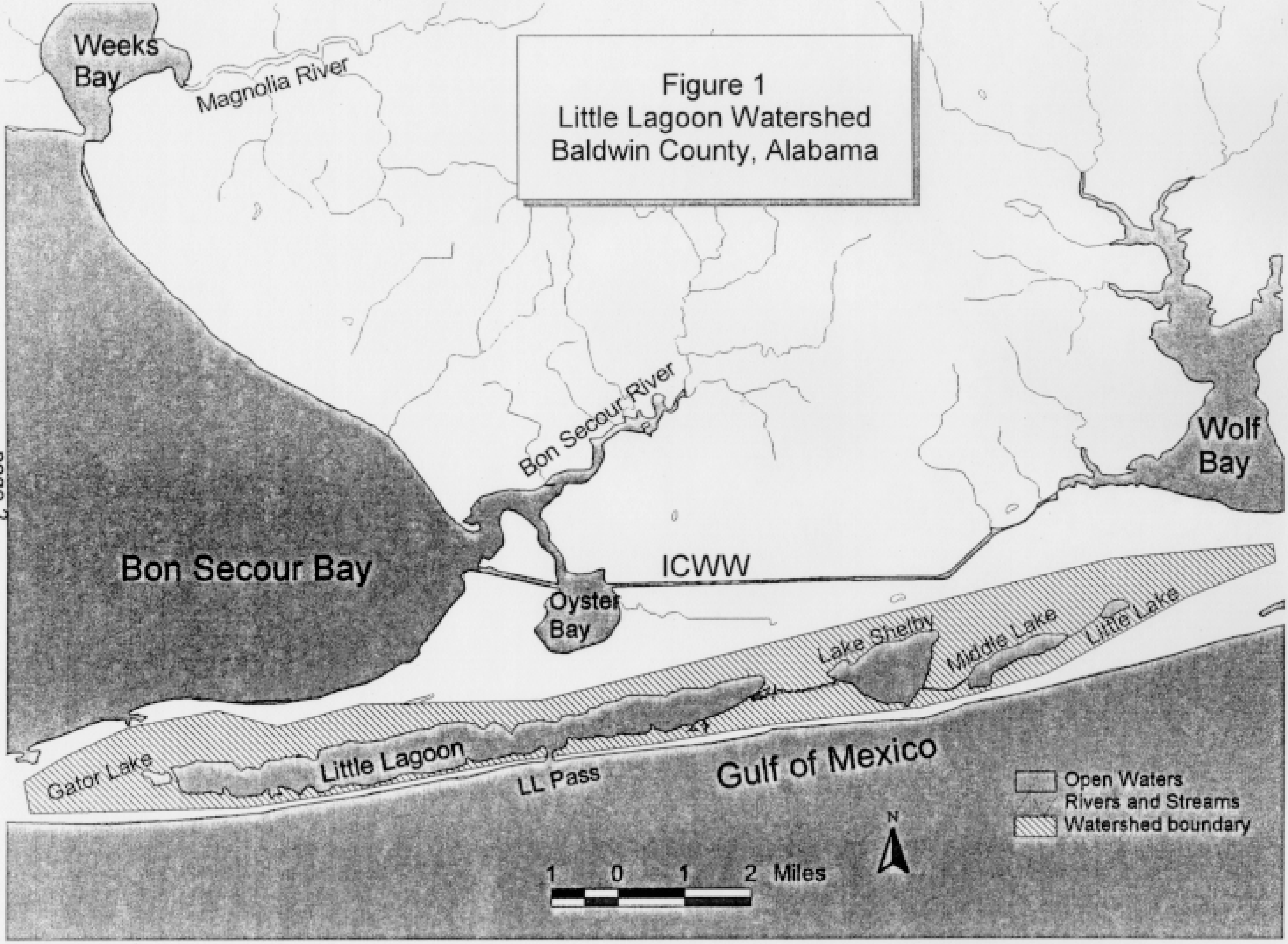


Figure 1
Little Lagoon Watershed
Baldwin County, Alabama

Soil Associations

Primarily two major soil associations make up the LLW. The Tidal Marsh Association makes up the areas of freshwater and saltwater tidal marsh. These soils are gray heavy or silty clays that have streaks and mottles of yellow and brown. These soils are poorly drained and support few trees, but there are a few willows and a dense cover of marsh cane, grasses and rushes. Most of the watershed is made up of soils of the Lakewood-St. Lucie-Leon Association. The majority of soils in this association have a high sand content and are very permeable. This accounts for the lack of over-ground surface flow and conversely, the high volume of ground-water exchange. These soils historically have very little agricultural value and vegetation consists primarily of sand pine, oak, palmetto, cactus, and seaoats. The wetter areas support slash pine, loblolly pine, gallberry, myrtle, and titi (U.S. Department of Agriculture 1964).

Climate

The climate of the LLW is essentially subtropical with long humid summers and short mild winters. The area is strongly influenced by the Gulf of Mexico, which tends to moderate temperatures throughout the year. The summer months are especially affected by the Bermuda High, a seasonal high pressure system that spreads over much of the eastern gulf and south Atlantic coast from May through September. The prevailing southerly winds produced by the Bermuda High are high in moisture content, which keeps summer temperatures along the coast lower than those inland. The average afternoon high in July, the hottest month, is 90° F which is in contrast to inland areas where highs often approach 100°F. Winters are typically short and mild with temperatures ranging from average daily lows of 43 °F to average daily highs of 60 °F in January, the coldest month (O'Neil and Mettee 1982).

Normal rainfall for the LLW averages 55 inches per year. Rates are fairly even throughout the year with a peak during the thunderstorm season in July (5.85 inches). The driest month is typically October or November (3.17 inches) (*ibid*).

Tropical storms and hurricanes are a major part of coastal Alabama's climate and pose an annual threat from June through October with the greatest threat in September. Since 1900, Alabama, Mississippi, and Northwest Florida have been hit by a total of 44 hurricanes. Twenty of those storms were a category 3 or stronger on the Saffir/Simpson scale system. Of that total, Alabama has sustained 11 direct hits with 5 of them being a category 3 or stronger (National Climatic Center 2000).

Land Use and Demography

The LLW is bracketed by the Alabama Gulf State Park at its eastern end and the Bon Secour National Wildlife Refuge at its west end. Together, these public lands make up approx. 50% of the total watershed area. The other 50% is mostly within the corporate limits of the cities of Gulf Shores and Orange Beach, AL. The land within the state park and the wildlife refuge is predominantly forested. The state park has various recreational facilities and public use areas including a 140 acre golf course and a 468 unit campground. The land outside the park and refuge is primarily urban. Because Gulf Shores and Orange Beach are resort towns, the land use is primarily retail business, light commercial, and single and multi-unit housing. Much of the waterfront property of Little Lagoon, outside the wildlife refuge, is developed in private resort homes, rental units, hotels, restaurants and convenience stores.

The population of Gulf Shores in 1970 was 910 permanent residents. In the fall of 1979, the Fort Morgan Peninsula and the towns of Gulf Shores and Orange Beach were devastated by Hurricane Frederick. After the storm, the combination of national publicity, low interest loan money and the availability of FEMA National Flood Insurance resulted in a dramatic economic boom for the entire area based on real estate development and tourism. Today, the permanent population of Gulf Shores is estimated at approx. 5,000 people (Steve Foote, p. c. 2000). Of course this number does not reflect the tourist population which fluctuates greatly, depending on the season. Based on rental unit occupancy rates, the total population (permanent residents plus lodged tourist), averaged through the year, can be estimated at 12,353 people. The Fort Morgan area would add at least another 1500 for a total of 13,853. On busy holiday weekends, like July 4th or the Gulf Shores Shrimp Festival, this number would likely approach 20,000 people (Alabama Gulf Coast Convention & Visitors Bureau 1998). Even this number does not reflect the daily influx of visitors from the surrounding counties. While the busiest tourist season occurs during the summer months, the mild winters allow for a yearly influx of winter tourists known locally as "snow birds". This group is made up primarily of retirement age tourist from northern states. "Snow bird season" typically runs from November through March and is of vital importance to the local economy.

Sanitary Sewer and Septic Systems

When development of the LLW began in the 1950s and 60s, it proceeded without the availability of a sanitary sewer system. Despite the fact that much of the area is completely unsuitable for below ground waste treatment, the conventional method for waste disposal was a septic tank system for each residence. Today, almost the entire LLW now has sewer service available through either Gulf Shores Utilities, City of Orange Beach, or South Alabama Utilities. Gulf Shores, Orange Beach, and the Fort Morgan area all have implemented a "septic tank ordinance" designed to phase out the use of septic tank systems. This ordinance requires all new commercial and private construction to hook up to the sewer system, where available, and prohibits expansion or renovation of failing systems in areas where sewer service is available. Gulf Shores Utilities confirmed that there are still many homes in its coverage area that utilize septic tank systems, however, they did not have specific data on locations or numbers (Clifford Johnson p.c. 2000). South Alabama Utilities estimated that at least 700 private residences in the Fort Morgan area are still utilizing septic tank systems (Phil Bass p. c. 2000).

Little Lagoon Pass

The State Route 182 Calloway Bridge was built in 1969 over a meandering inlet to Little Lagoon. The inlet had a history of migrating east and west over a 3 to 4 mile course and opened and closed based on tide cycles and meteorological events. It is reported that as more of the waterfront of Little Lagoon was developed, the unstable nature of the inlet became a problem causing septic systems to fail and back up into houses. As a result of outcry from local residents, The Governor directed the Alabama Department of Transportation (ALDOT) to maintain a clear opening to the Gulf. This procedure of periodically opening the inlet allowed for water exchange between Little Lagoon and the Gulf of Mexico. This maintained opening became known as Little Lagoon Pass.

The pass still opened and closed with storm events until 1980 when the governor directed the ALDOT to install sheet piling from the Little Lagoon Pass Bridge out into the gulf. The purpose of this was to stabilize the bridge abutment from damage caused by Hurricane Fredric and reduce the need for dredging. Again, given the right storm conditions, the pass would become blocked with sand. The governor then directed the ALDOT to install additional sheet piling to the north of the pass bridge. Additional piling was later extended further out into the gulf. This configuration provided adequate flow through the pass eliminating the need for continuous dredging but greatly reduced the westward flow of sand along the gulf beach. By 1989-1990 the beach area west of the jetties had noticeably receded. After complaints from west beach property owners, the ALDOT attempted to remove the jetties in November of 1991. The removal of 250 feet of jetties from the gulf side of the pass allowed the natural replenishment of sand to the beach west of the jetties, but necessitated the continued dredging of the pass. Now under court order, the ALDOT is required to dredge the Little Lagoon Pass to a specific cross-sectional area. This has proven to be a very costly procedure costing nearly 10 million dollars since 1991. In 1996, the ALDOT contracted an engineering firm to perform a hydrodynamic and sediment transport analysis of Little Lagoon Pass. After more than three years of study the ALDOT has proposed a plan to re-configure the Pass that will reportedly require much less maintenance and still meet the criteria specified in the court order.
(Historical information concerning Little Lagoon Pass was provided by the Alabama Department of Transportation.)

Wildlife and Fisheries

To the knowledge of this writer, there are no specific inventories of the wildlife and fish found in the LLW. In broader descriptions of Coastal Alabama, O'Neil (1982) and Mount (1975) have reported a total of 310 species of fish, 57 species of mammals, 40 species of amphibians, and 60 species of reptiles. The Bon Secour Wildlife Refuge reports an inventory of 373 species of both resident and migratory birds (Jane Griess, p. c. 2000).

The Marine Resources Division of the Alabama Department of Conservation and Natural Resources (ADCNR) has been conducting routine trawl surveys of Little Lagoon since the pass was permanently opened in 1992. In that time, MRD has collected 64 species of fish, 13 species of crabs, 7 species of shrimp, 11 species of mollusks, 1 species of starfish, and 2 species of jellyfish. Because the Little Lagoon system has no direct connections to larger coastal fresh water drainages, the freshwater fish species found there are probably not representative of coastal Alabama. Sampling conducted by the Wildlife and Freshwater Fisheries Division of ADCNR demonstrates a primarily freshwater fishery in the Gulf State Park Lakes (Shelby Lakes) including: largemouth bass (Micropterus salmoides), redear sunfish (Lepomis microlophus), bluegill sunfish (L. macrochirus), channel catfish (Ictalurus punctatus), blue catfish (Ictalurus furcatus), black crappie (Pomoxis nigromaculatus), and the hybrid striped bass (Morone chrysops x M. saxatilus) (William Tucker, p.c. 2000). This is by no means a complete list of the total freshwater species present in the Little Lagoon system.

Federally listed threatened (T) or endangered (E) wildlife species that occur, or may occur within the LLW would include:

E – Alabama beach mouse (Peromyscus polionotus ammobates)
E – Mississippi sandhill crane (Grus canadensis pulla)
T – Bald eagle (Haliaeetus leucocephalus)
E – American peregrine falcon (Falco peregrinus anatum)
T – Piping plover (Charadrius melodus)
E – Wood stork (Mycteria americana)
E – Red-cockaded woodpecker (Picoides borealis)
T – Eastern indigo snake (Drymarchon corais couperi)
T – Gogher tortoise (Gopherus polyphemus)
T – Loggerhead sea turtle (Caretta caretta)
T – Green sea turtle (Chelonia mydas)

Other species of interest include: the american alligator (Alligator mississipiensis), the jaguarundi (Felis yagouaroundi), the black bear (Ursus americanus), and the rainbow snake (Farancia erytrogramma erytrogramma).

The american alligator, previously listed as endangered, is now common in the State Park and the wildlife refuge and was sighted on several occasions during the course of this survey. Also during the course of this survey, this writer observed a large rainbow snake in Gulf State Park in the canal between Middle Lake and Lake Shelby. Rainbow snakes, while not a federally listed species, are considered somewhat rare and poorly known (Mount 1975). Mount (1986) reported a sighting of the poorly known jaguarundi (a medium-sized cat-like mammal native to Central and South America) in Gulf State Park in 1981 with another unconfirmed sighting on Fort Morgan. It is likely that the jaguarundi may account for some of the "mountain lion" and "black panther" sightings that are occasionally reported throughout the state. The few remaining black bears in Alabama occur mainly in north Mobile and Washington counties. However, in 1980 a black bear was struck and killed by an automobile on Canal Road near the north boundary of Gulf State Park. A black bear sighting was also reported in Bon Secour Wildlife Refuge in 1990. It is believed that these incidents were lone wandering males possibly seeking mates (Roger Clay, Jane Griess, J.C. Jarmon, p.c. 2000).

Water Use Classification System

All waters of the State are classified according to their best use. This is known as the water use classification system. There are a total of 8 water use classifications. Each has its own specific set of narrative and numeric criteria, which are used as evaluation tools to determine if the use is being supported. The surface waterbodies of the LLW fall under a number of use classifications. The three lakes within the State Park are classified as *Swimming and Other Whole Body Water-Contact Sports (swimming)*, and *Fish and Wildlife*. Little Lagoon is classified as *Fish and Wildlife, Swimming,* and *Shellfish Harvest*. The interconnecting marshes and canals as well as the man-made residential canal systems are not specifically classified and would fall under *Fish and Wildlife*. The LLW water use classifications and some of their numeric criteria appear in table 1.

Table 1. Water Use Classifications

Use Classification	**Criteria**					
	DO*** mg/l	Fecal Coliform (geo. mean) col/100ml	Fecal Coliform (one time) col/100ml	pH* s.u.	Temperature** Oct-May °F	June-Sept °F
Fish and Wildlife	5.0	1000	2000	6.5 - 8.5	+ 4.0	+ 1.5
Shellfish Harvest	5.0	14	43	6.0 - 8.5	+ 4.0	+ 1.5
Swimming and	5.0	100	NA	6.0 - 8.5	+ 4.0	+ 1.5

* pH also shall not deviate more than +/- 1.0 s.u. from ambient as result of waste discharge

** temperature criteria refer to rise above ambient temperature caused by addition of artificial heat

*** DO concentrations shall not be less than 5.0 mg/l except in dystrophic waters or where natural conditions cause the value to be depressed.

(ADEM Admin. Code R. 335-6-10-.09)

Water/Sediment Quality Survey

Materials and Methods

The Surface Water/Sediment Quality Survey was divided into two parts. The first part consisted of periodic site specific water sampling at fixed locations throughout the Little Lagoon system and was targeted at identifying areas and times of potentially impaired water quality. The second part of the survey consisted of an intensive; one time probabilistic sampling study designed to evaluate the water and sediment quality of the Little Lagoon system as a whole. It should be stressed that for most of the parameters analyzed in this survey, there are no applicable State or Federal criteria. The interpretation of these results is based on experience, references from previous studies and popular scientific literature.

Site Specific Sampling

Nine fixed sites were sampled on six occasions from April through September of 1999. The location of these sites ranged from Little Lake at the east end of the watershed to the west end of Little Lagoon. Site selection was designed to provide representative coverage of the Little Lagoon system and to target areas of potentially impaired water quality. Sampling was conducted on roughly a monthly basis. However, within those months, an effort was made to target times of greatest potential water quality impairment (see Table 2). A map and complete listing of these sites appears in Figure 2 and Table 3.

Table 2: Site Specific Sampling Dates and Special Conditions

Date	Conditions
4/1/99	Two days after heavy rain event
5/20/99	Drought
6/2/99	Two days after Memorial Day weekend, recent rain
7/7/99	Two days after July 4th weekend
8/24/99	Recent rain
9/21/99	Very high tides with tidal flooding

Water quality variables measured in this portion of the survey appear in Table 4. Temperature, dissolved oxygen, specific conductance, pH and salinity were measured *in-situ* utilizing a Hydrolab Scout® with H2O® probe. Depending on station depth, these measurements were taken either at mid depth or multiple depths in the water column. Water samples were collected at each site via a subsurface grab and returned to the ADEM Mobile Laboratory for analyses. All water quality monitoring, sampling and

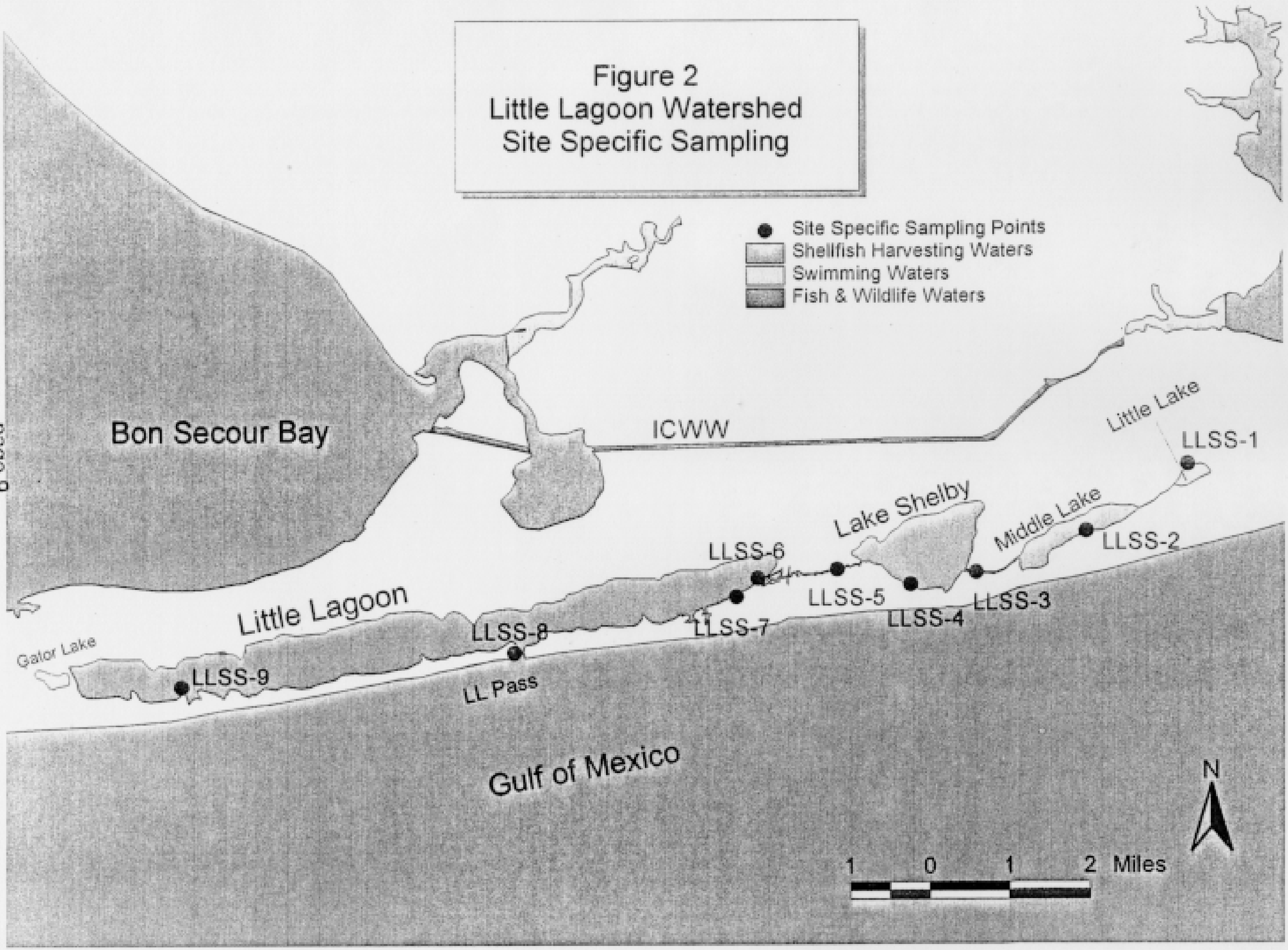


Figure 2
Little Lagoon Watershed
Site Specific Sampling

Table 3. **Little Lagoon Watershed Study**
Site Specific Sampling
Station ID Key

Station #	Water body	Description	Latitude			Longitude		
			deg	min	sec	deg	min	sec
LLSS-1	Little Lake	Eastern most lake in the Gulf State Park. Samples were taken on the north shore at the canoe landing.	30	16	31	-87	36	57
LLSS-2	Middle Lake	The middle lake in the Gulf State Park. Samples were taken at the camp ground pavilion boat docks.	30	15	47	-87	38	3
LLSS-3	Shelby/Middle L. Canal	The canal connecting Middle Lake and Lake Shelby. Samples were taken at the GSP Rd #2 Bridge.	30	15	21	-87	39	14
LLSS-4	Lake Shelby	Western most lake in the Gulf State Park. Samples were taken on the south shore at the boat ramp.	30	15	13	-87	39	57
LLSS-5	Lake Shelby/Little Lagoon Bayou	The bayou connecting L. Shelby and Little Lagoon. Samples taken at HW 135 Bridge on the west side of weir.	30	15	23	-87	40	45
LLSS-6	Lake Shelby/Little Lagoon Bayou	The bayou connecting L. Shelby and Little Lagoon. Samples taken at the bayou mouth near Little Lagoon.	30	15	17	-87	41	37
LLSS-7	Windmill Ridge Canal	Residential canal system at the southeast end of Little Lagoon. Samples taken at Windmill Rdg Rd Bridge.	30	15	5	-87	41	51
LLSS-8	Little Lagoon Pass	The pass connecting Little Lagoon and the Gulf of Mexico. Samples taken at the HW 182 Bridge.	30	14	29	-87	44	16
LLSS-9	Little Lagoon	Little Lagoon, west end. Samples taken at the Laguna Key Subdivsion Pier.	30	14	7	-87	47	53

Table 4. **Little Lagoon Watershed Study**
List of Site Specific Sampling Parameters

Parameter	Method Detection Limit
Water Physical	
Depth	-----
Temperature	-----
Specific Conductivity	-----
Salinity	-----
Total Suspended Solids	5.0 mg/l
Total Disssolved Solids	5.0 mg/l
Turbidity	1.0 NTU
Water Chemical	
Dissolved Oxygen	-----
pH	-----
Ammonia	0.01 mg/l
Nitrate+Nitrite	0.005 mg/l
Total Phosphorus	0.005 mg/l
Total Kjeldahl Nitrogen	0.1 mg/l
Water Biological	
Fecal Coliform	1 col/100ml

analyses were conducted in accordance with applicable ADEM standard operating procedures.

Probabilistic Sampling

The probabilistic sampling approach used in the second part of the water and sediment survey of the LLW was designed by the U.S. Environmental Protection Agency and is similar to that used in the Alabama Monitoring and Assessment Program (ALAMAP). This approach uses a systematic hexagonal grid. This grid is placed over a map of the area to be sampled. Sites are then randomly selected within this grid matrix. Each hexagon of the grid represents approximately 105 acres. This design, while having a random component ensures a more representative distribution of sample sites throughout the area of interest. This sample design also ensures strict adherence to requirements for probabilistic sampling and allows the proportion of the area that is affected by a certain condition to be estimated within given confidence limits. This affected area can then be graphically depicted and mapped for analysis allowing the scientist to make statements as to the overall ecological health of the study area. (Carlton et al 1997).

The probabilistic survey included both water and sediment sampling. Thirty sites ranging from Middle Lake to west Little Lagoon were sampled between July 20th and 22nd 1999. A map and complete listing of these sites appears in Figure 3 and Table 5.

Water and sediment quality variables measured in this portion of the survey appear in Table 6. Temperature, dissolved oxygen, specific conductance, pH, and salinity were measured *in-situ* utilizing a Hydrolab Scout® with H2O® probe. Depending on station depth, these measurements were taken either at mid depth or multiple depths in the water column. At each site a standard 20 cm diameter black and white Secchi disk was used to measure visibility. Water samples were collected from mid depth in the water column using a Kemmerer bottle. Fecal coliform samples were collected using a sub-surface grab. Sediment was collected using an Eckman dredge with only the top two centimeters saved for analysis. Sediments were analyzed for metals and organo-chlorine pesticides. All water and sediment quality monitoring, sampling and analyses were conducted in accordance with applicable ADEM standard operating procedures. Laboratory analyses were conducted by the ADEM Mobile Branch Laboratory and the ADEM Central Laboratory in Montgomery.

Little Lagoon Watershed
Probabilistic sampling
July 1999

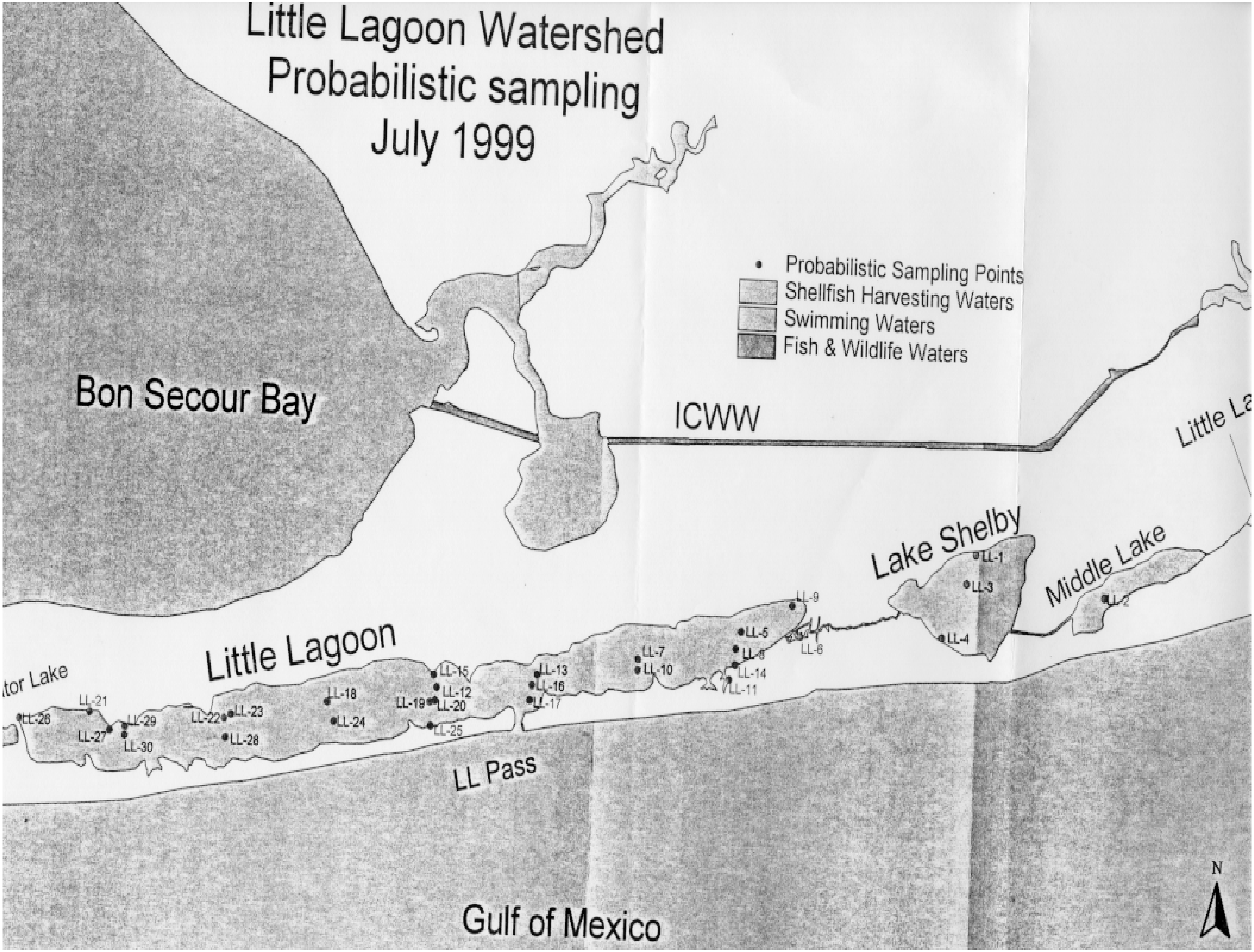


Table 5. **Little Lagoon Watershed Study**
Probabilistic Sampling
Station ID Key

Station #	Water body	Latitude deg	Latitude min	Latitude sec	Longitude deg	Longitude min	Longitude sec
LL-01	Shelby Lake	30	15	57	-87	39	44
LL-02	Middle Lake	30	15	39	-87	38	28
LL-03	Shelby Lake	30	15	43	-87	39	50
LL-04	Shelby Lake	30	15	17	-87	40	4
LL-05	Little Lagoon	30	15	16	-87	42	2
LL-06	LL/Shelby Bayou	30	15	15	-87	41	27
LL-07	Little Lagoon	30	15	1	-87	43	2
LL-08	Little Lagoon	30	15	8	-87	42	5
LL-09	Little Lagoon	30	15	29	-87	41	33
LL-10	Little Lagoon	30	14	56	-87	43	2
LL-11	Little Lagoon	30	14	54	-87	42	8
LL-12	Little Lagoon	30	14	44	-87	45	1
LL-13	Little Lagoon	30	14	52	-87	44	2
LL-14	Little Lagoon	30	15	0	-87	42	5
LL-15	Little Lagoon	30	14	50	-87	45	3
LL-16	Little Lagoon	30	14	47	-87	44	5
LL-17	Little Lagoon	30	14	40	-87	44	6
LL-18	Little Lagoon	30	14	35	-87	46	5
LL-19	Little Lagoon	30	14	37	-87	45	5
LL-20	Little Lagoon	30	14	38	-87	45	2
LL-21	Little Lagoon	30	14	25	-87	48	24
LL-22	Little Lagoon	30	14	25	-87	47	5
LL-23	Little Lagoon	30	14	27	-87	47	1
LL-24	Little Lagoon	30	14	26	-87	46	1
LL-25	Little Lagoon	30	14	26	-87	45	4
LL-26	Little Lagoon	30	14	21	-87	49	5
LL-27	Little Lagoon	30	14	17	-87	48	12
LL-28	Little Lagoon	30	14	16	-87	47	4
LL-29	Little Lagoon	30	14	19	-87	48	3
LL-30	Little Lagoon	30	14	15	-87	48	3

Table 6. Little Lagoon Watershed Study
List of Probabilistic Sampling Parameters

Parameter	Method Detection Limit
Water Physical	
Water Clarity (secchi)	----
Depth	----
Temperature	----
Specific Conductivity	----
Salinity	----
Total Suspended Solids	5.0 mg/l
Total Disssolved Solids	5.0 mg/l
Turbidity	1.0 NTU
Hardness	2.0 mg/l
Alkalinity	1.0 mg/l
Water Chemical	
Dissolved Oxygen	----
pH	----
Ammonia	0.01 mg/l
Nitrate+Nitrite	0.005 mg/l
Total Phosphorus	0.005 mg/l
Total Kjeldahl Nitrogen	0.1 mg/l
Biochemical Oxygen Demand (5day)	1.0 mg/l
Water Biological	
Fecal Coliform	1 col/100ml
Chlorophyll - *a*	0.1 mg/M^3
Sediment Organo-Chlorine Pesticides	
Chlordane	0.0015 ug/g
4,4'-DDD	0.05 ug/g
4,4'-DDE	0.0025 ug/g
4,4'-DDT	0.08 ug/g
Aldrin	0.0022 ug/g
alpha-BHC	0.034 ug/g
beta-BHC	0.0033 ug/g
delta-BHC	0.0011 ug/g
gamma-BHC (Lindane)	0.025 ug/g
Dieldrin	0.044 ug/g
Endosulfan-I	0.03 ug/g
Endosulfan-II	0.0024 ug/g
Endosulfan Sulfate	0.0036 ug/g
Endrin	0.039 ug/g
Endrin Aldehyde	0.0016 ug/g
Endrin Keytone	0.001 ug/g
Heptachlor	0.04 ug/g
Heptachlor Epoxide	0.0021 ug/g
Methoxychlor	0.86 ug/g
Toxaphene in solids	0.05 ug/g
Sediment Metals	
Aluminum	310 ug/g
Arsenic	0.90 ug/g
Cadmium	0.03 ug/g
Chromium	3.0 ug/g
Copper	7.0 ug/g
Lead	1.00 ug/g
Mercury	0.06 ug/g
Nickel	9.0 ug/g
Silver	0.1 ug/g
Tin	0.6 ug/g
Zinc	12 ug/g
Barium	60 ug/g
Iron	600 ug/g

Probabilistic Sampling
Results and Discussion

Numeric results of all probabilistic sediment and water quality sampling and monitoring appear in Appendix A.

Based on the Probabilistic Sampling portion of the survey, and EPA guidelines for data assessment, all of the surface waters of the LLW are meeting or exceeding the prescribed State water quality standards and these waters are fully supporting their water use classifications.

In-Situ Water Quality

In-Situ water quality refers to those parameters that can be measured in place or under actual conditions. These parameters are some of the most frequently used to evaluate water quality because of their speed and relative low cost. Thanks to technological advances in field instrumentation, more parameters can be measured *In-Situ* than ever before.

Dissolved Oxygen (DO) is probably the most important *In-situ* parameter because it is a fundamental requirement for all aquatic life. For all water use classifications applicable to waterbodies of the LLW, state regulations specify that DO concentrations shall not be less than 5mg/l except in dystrophic waters or where natural conditions cause the value to be depressed. In waters less than 10 feet total depth, this standard is applied at mid depth in the water column. In waters greater than 10 feet total depth, the standard is applied at the 5 ft. depth in the water column. Generally, a DO of 2mg/l or less is considered to be extremely stressful to most aquatic organisms. This condition is known as hypoxia (low DO) or anoxia (no DO). For a variety of reasons, hypoxia/anoxia does occur naturally, as is the case in the Mobile Bay jubilee phenomena where fish and invertebrates are literally driven onto the shore to escape low DO water. However, when these conditions become prevalent for long periods of time it can have a severe detrimental impact on an estuarine ecosystem.

In the LLW 97% of the waters had mid-depth DO concentrations of 5 mg/l or better; 2% were between 4 and 5 mg/l; while only 1% were less than 4 mg/l. The lowest DO recorded was 3.74mg/l. The area of lowest mid depth DO concentrations was located at the extreme west end of Little Lagoon (see figure 4). Generally, bottom DO concentrations are naturally lower than surface or mid-depth concentrations and hypoxic bottom conditions are not uncommon in coastal waters. However, persistent hypoxic or anoxic bottom conditions can be very detrimental to the benthic (bottom dwelling) community. In this survey only 2% of the waters had bottom DO concentrations less than 2 mg/l (see figure 5).

All other *in-situ* water quality measurements collected for this part of the survey were within the normal ranges for coastal waters and within state standards.

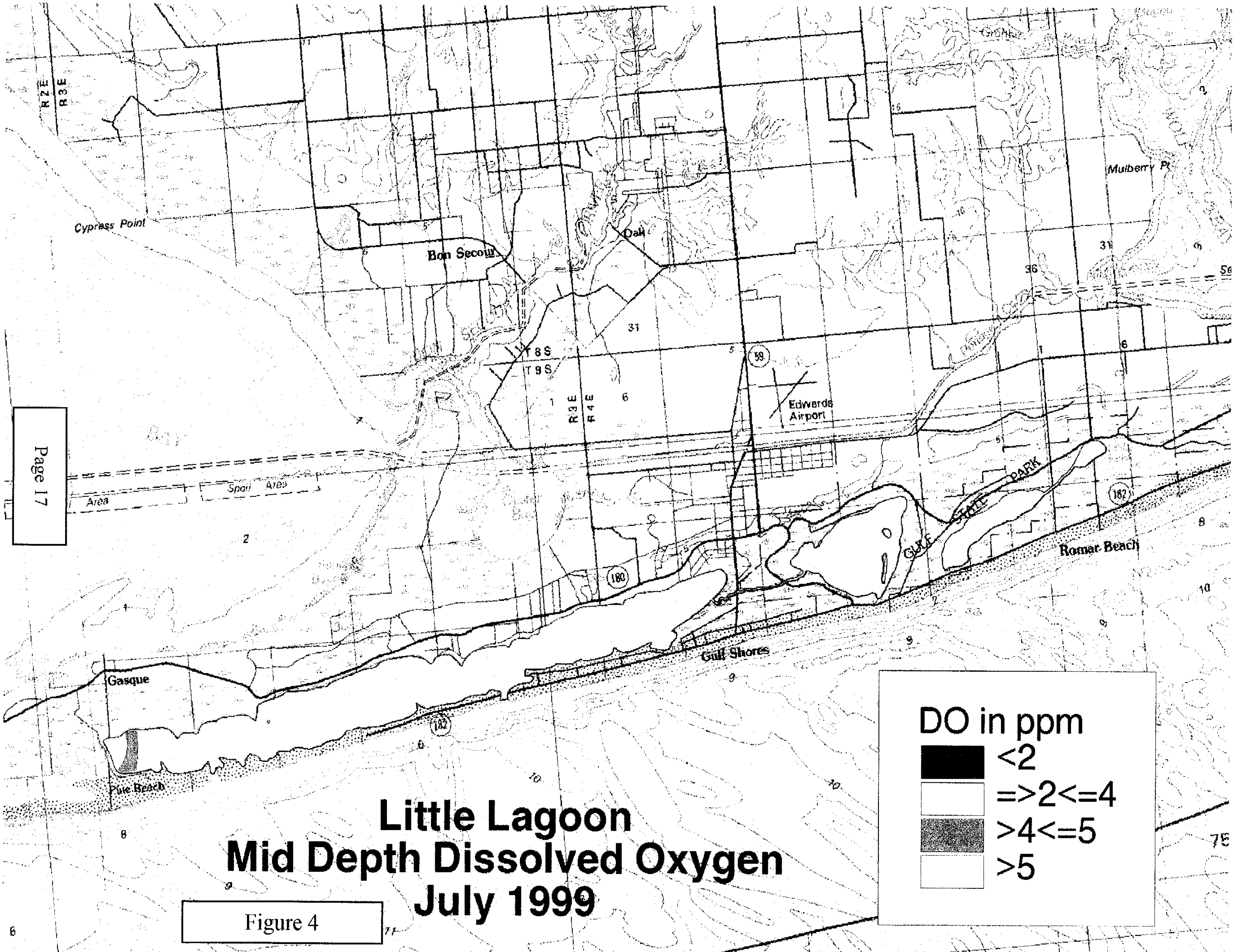
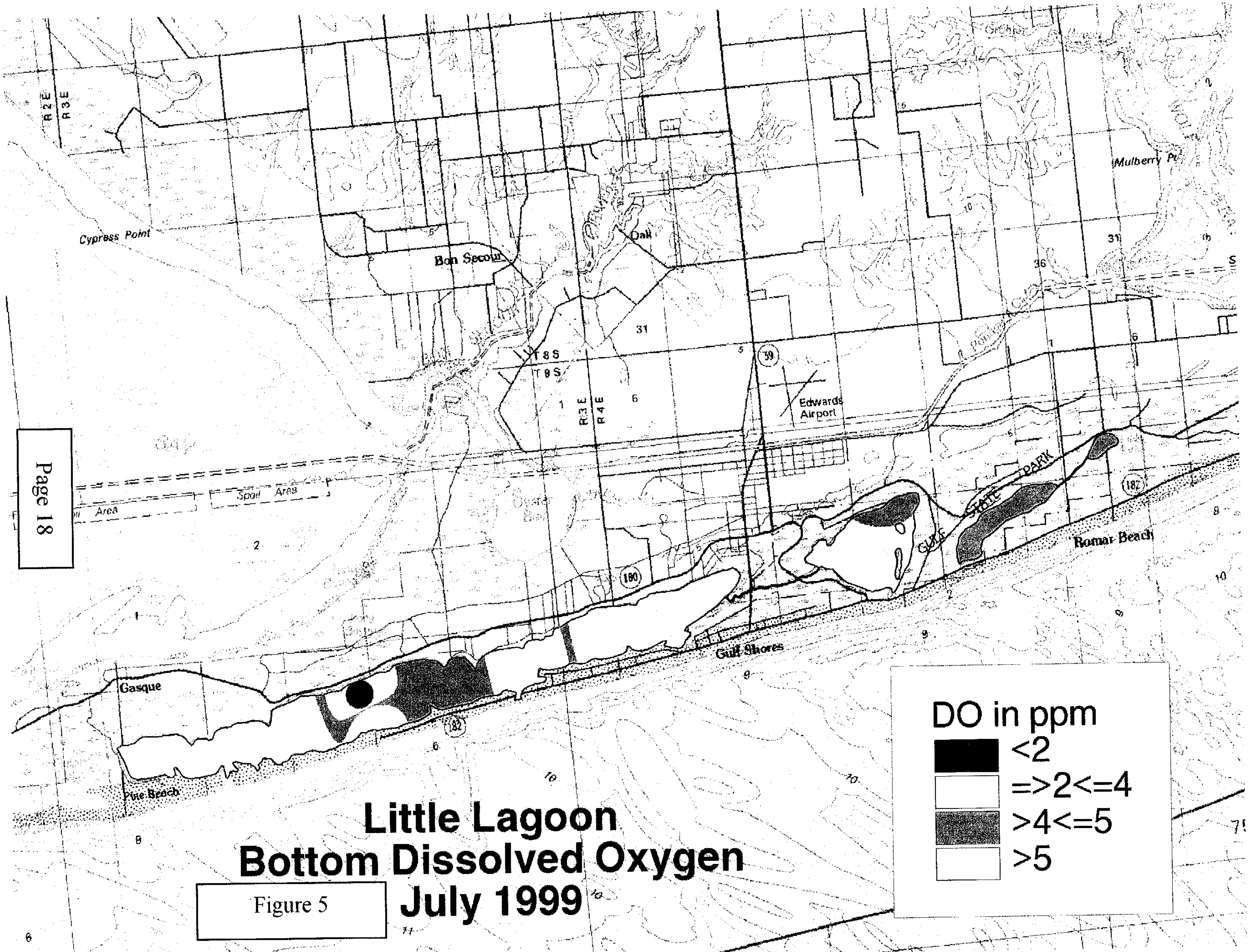

Little Lagoon
Mid Depth Dissolved Oxygen
July 1999
DO in ppm
<2
=>2<=4
>4<=5
>5
Cypress Point
Bon Secour
Dale
Mulberry Pt
Edwards Airport
Gasque
Pine Beach
Gulf Shores
Romar Beach
Gulf State Park
Spoil Area
R2E
R3E
R4E
T8S
T9S

Figure 4



Little Lagoon Bottom Dissolved Oxygen July 1999

Figure 5

Fecal Coliform Bacteria

Fecal coliform bacteria (FCB) are used by the ADEM as indicator species to indicate the possible presence of sewage or animal waste. FCB occur naturally in the environment, but consistently elevated numbers can indicate a continuous source of contamination. Potential sources for this contamination include failing septic systems, leaking or overflowing sewage collection lines, and runoff from residential or natural areas with large domestic or wild animal populations.

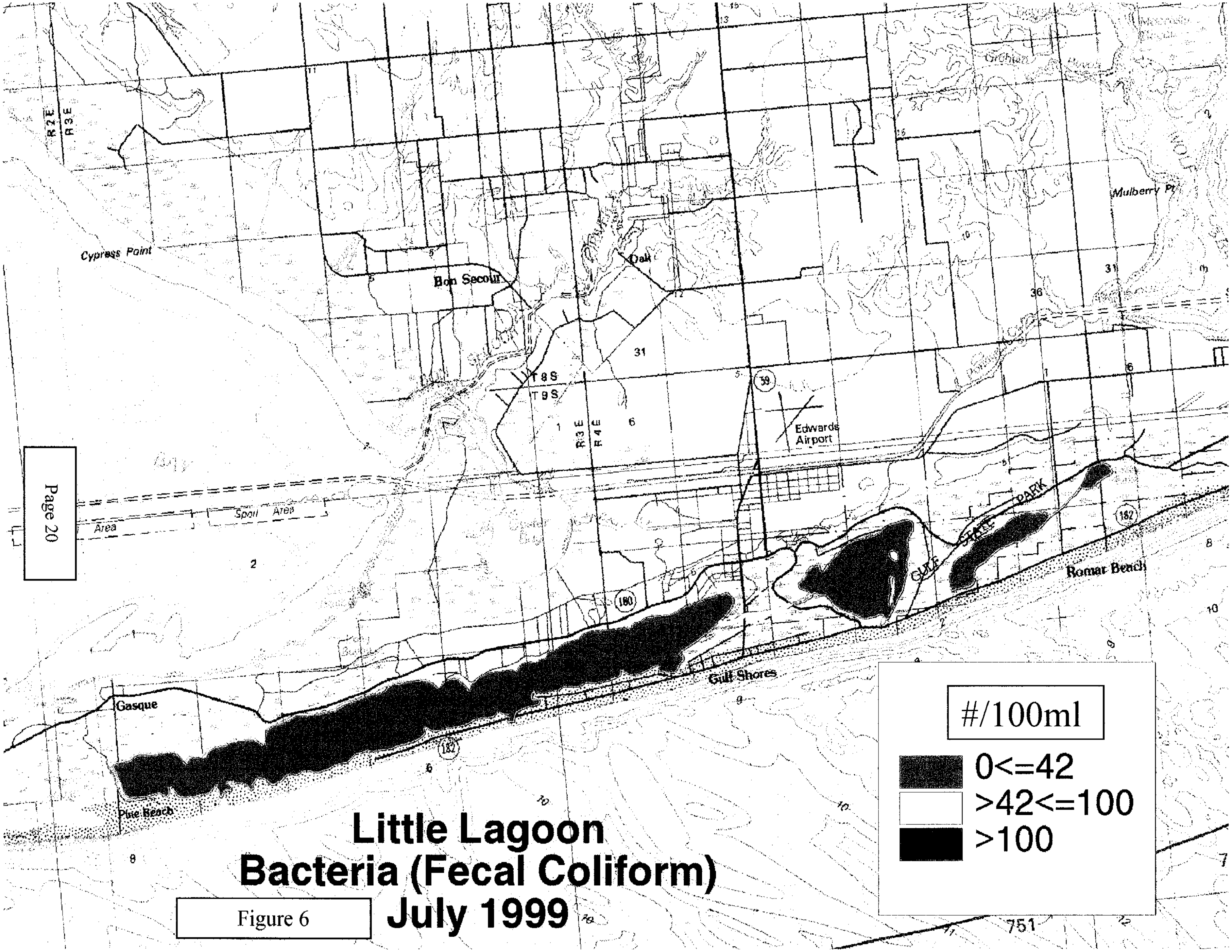
The FCB standards applicable to the waters of the LLW vary depending on the water use classification. Little Lagoon, with its Shellfish Harvesting classification, has the most stringent FCB standard requiring a geometric mean less than 14 colonies/100ml of water with a single sample maximum of less than 43 col/100ml. In the case of this study, the sampling regime was not sufficient to calculate geometric means, therefore, the one sample maximum of 43 col/100ml was the standard for evaluation. The three lakes within the State Park are classified for Swimming and require a geometric mean of less than 100col/100ml. There is no one-time sample maximum standard for this classification. The interconnecting marshes, canals and residential canals fall under the Fish and Wildlife classification and have a standard of 1000col/100ml (geo. mean) or 2000col/100ml in any one sample.

None of the probabilistic sampling sites revealed concentrations of FCB in excess of applicable use classification standards. The highest FCB concentration (46col/100ml) was found at LL-6, which is located in the canal between Little Lagoon and Lake Shelby. Overall, the fecal coliform data for the probabilistic portion of the survey indicate low to background levels of FCB contamination (see figure 6).

Nutrients

Increased nutrient input to a waterbody from point and nonpoint sources along with the internal recycling of nutrients can result in a condition known as eutrophication. This condition is most often expressed in an excessive phytoplankton bloom with reduced water clarity and an increased potential for dissolved oxygen depletion. This study measured concentrations of chlorophyll and four common nutrients as indicators of possible nutrient enrichment. In the absence of State or Federal criteria, this data was assessed based on criteria used in the Coastal ALAMAP, which states that nutrient enrichment is indicated if at least one of the following is true: 1.)chlorophyll-a exceeds 20 mg/m3, 2.) concentrations of ammonia (NH3) are greater than 0.2 mg/l, 3.) concentrations of nitrate/nitrite (NO3+NO2) exceed 0.5 mg/l, 4.) total Kjeldahl nitrogen (TKN) exceeds 1 mg/l or, 5.) phosphate (PO4) exceeds 0.1 mg/l.

94% of the waters in the LLW showed no signs of nutrient enrichment. The chlorophyll-a concentration at station LL-2 in Middle Lake was 20.0 mg/m3. This was relatively high compared to the rest of the sites sampled, but nutrient levels for the site were normal. Two sites in the west end of Little Lagoon did reveal elevated concentrations of TKN and NH3, but this enrichment was not expressed in the phytoplankton bloom as indicated by the low chlorophyll-a levels at these sites. Overall, this survey indicates that while there may be small areas of nutrient enrichment, it does



Little Lagoon
Bacteria (Fecal Coliform)
July 1999

Figure 6

not appear to be a major threat to the water quality of the Little Lagoon system (see figure 7).

Sediment Metals and Pesticides

The benthic flora and fauna is an integral part of the estuarine ecosystem and is dependent on good sediment quality as well as good water quality. Sediment samples from the 30 probabilistic sites were analyzed for 13 metals and 20 organo-chlorine pesticides. In the absence of State and Federal criteria for sediment quality, the observed concentrations were compared to "Ecological Response" levels developed by Long et al. (1995). These response levels establish three ranges in a given contaminant's concentration where detrimental effects are rare, occasional, and frequent. These three ranges are defined by two threshold concentrations known as Effects Range-Low (ER-L) and Effects Range-Moderate (ER-M). Values below ER-L rarely result in detrimental effects. Values over ER-L, but under ER-M result in occasional effects and finally, values over ER-M are likely to result in detrimental effects. Ecological Response guidelines are based on literature reviews of sediment toxicity studies.

Metals occur naturally in the environment and concentrations found in sediment can vary greatly depending on the geology and water chemistry of a given area. For the purposes of this survey, metal enrichment was gauged by the number of metals over ER-L. The degree of enrichment was divided into three categories: 1) none or slight enrichment (0-1 metals over ER-L), 2)moderate enrichment (2-3 metals over ER-L), and 3) heavily enriched (>3 metals over ER-L). 79% of the LLW sediments showed no metal enrichment or slight enrichment. 21% showed moderate enrichment, while no sediments showed heavy enrichment. In the area that demonstrated moderate metals enrichment (see figure 8), seven of the sites sampled had arsenic (As) levels over the ER-L value. Of those seven, three were also over the ER-L for nickel (Ni), three for chromium (Cr) and three for mercury (Hg). In the current and historical absence of heavy industry or agriculture in the watershed, there are no obvious sources of these metals. Two of the metals in question, chromium and arsenic, are used as preservatives in treated lumber, which is commonly used in construction, especially in piers and boathouses. While this survey did reveal concentrations of certain metals slightly over ER-L, these levels are not uncommon in coastal Alabama sediments (Carlton et al 1997) and none were over the ER-M threshold.

Organo-chlorine pesticide analyses indicate no contamination in any of the bottom sediments of the LLW. Laboratory results for all 30 sediment samples came back as "less than method detection limit". The soil associations described previously for the LLW are likely the main reason that sediments of the Little Lagoon system show little or no organo-chlorine pesticide contamination. Agriculture, one of the common sources of some of the more persistent and harmful pesticides in the environment, has never been a feasible land use anywhere in the watershed. Also, the abundant wetlands located in and around these waterbodies contain significant amounts of organic matter, silt and clay, which provide adsorption surfaces for toxic materials making these contaminants less available for bioaccumulation into the food chain (Brantley, 1999).

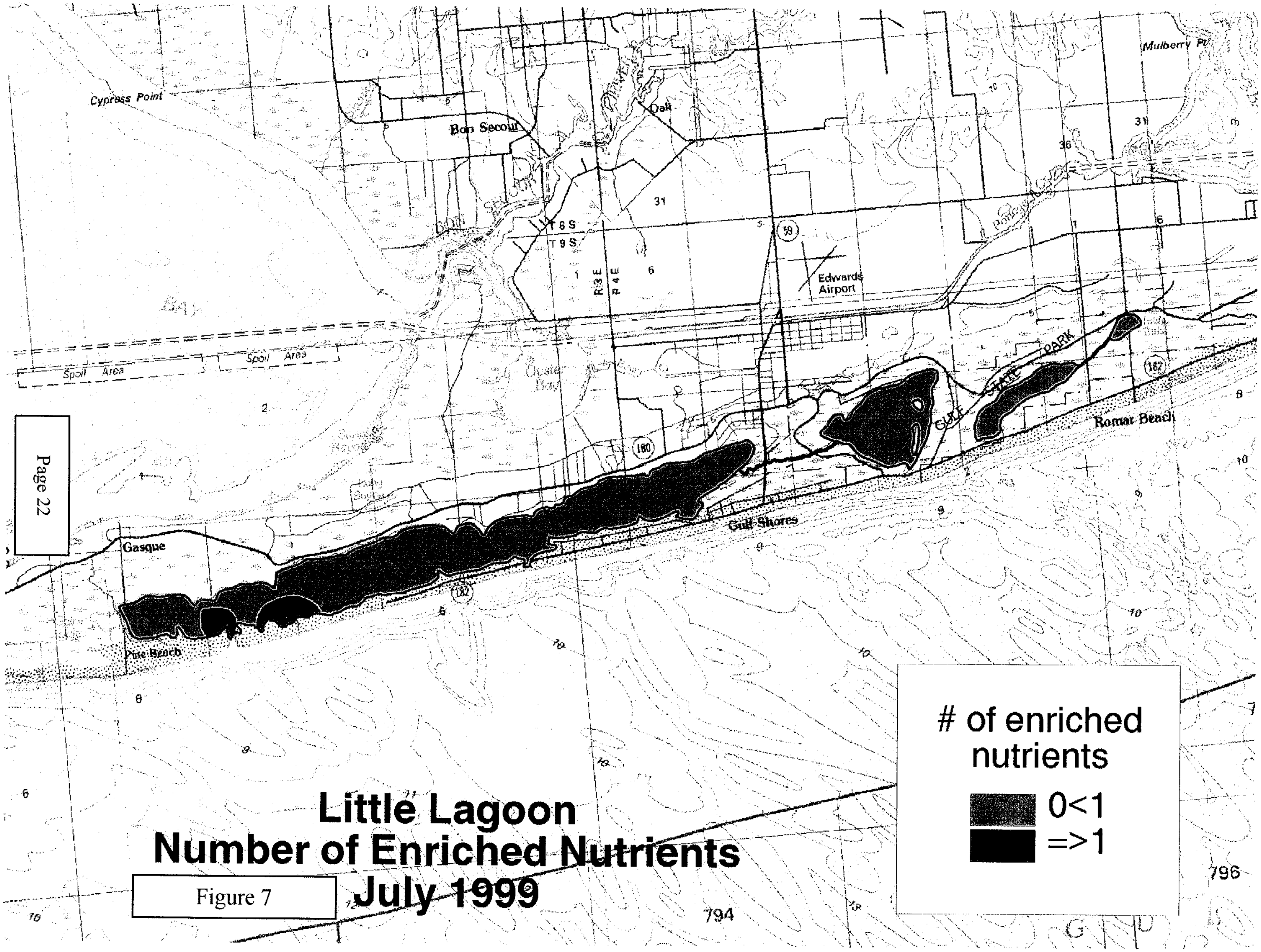
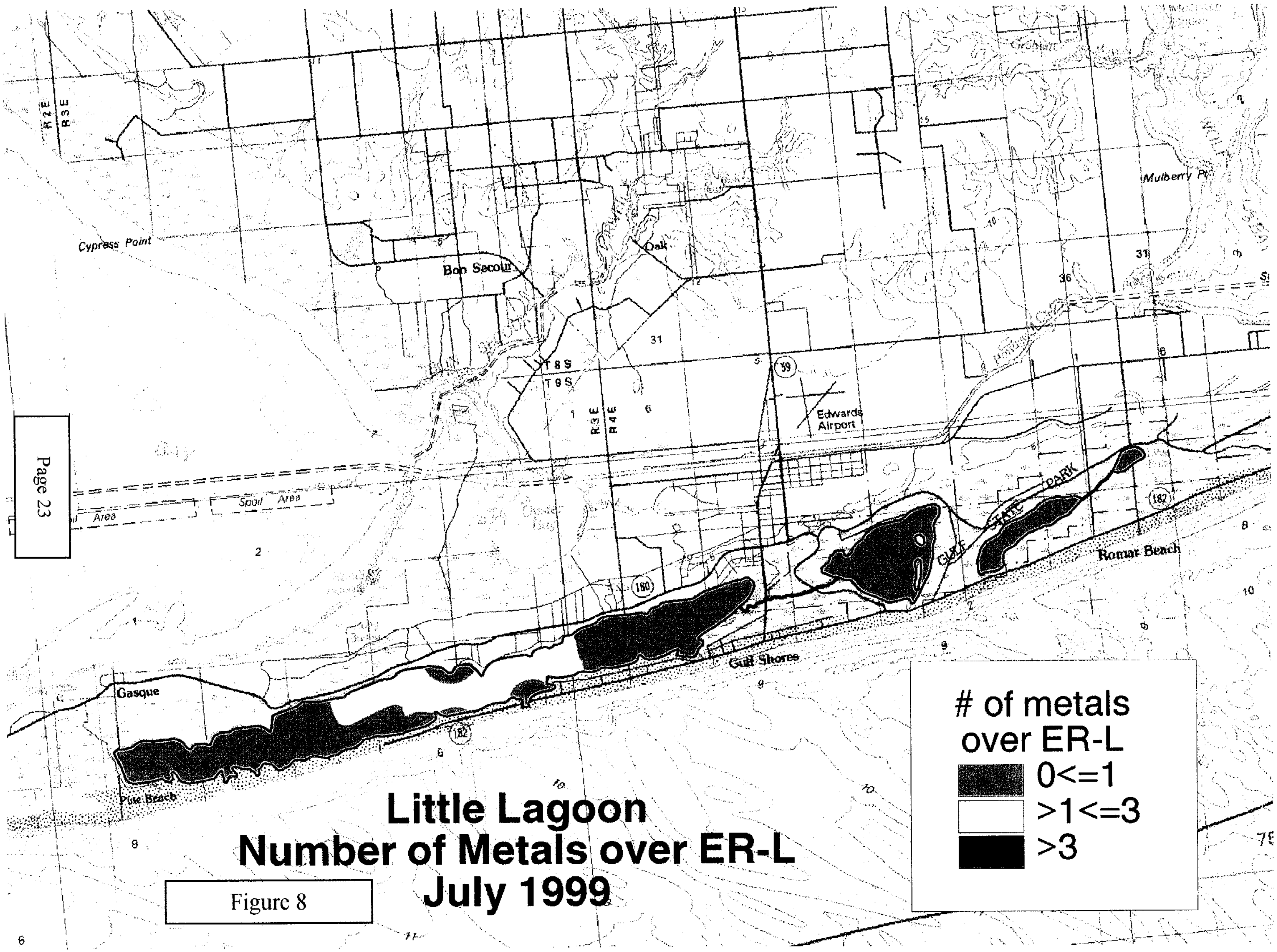


Figure 7

Little Lagoon
Number of Enriched Nutrients
July 1999



Little Lagoon
Number of Metals over ER-L
July 1999

Figure 8

Site Specific Sampling
Results and Discussion

Numeric results of all Site Specific water quality sampling and monitoring appear in Appendix B. Much of the data is graphically depicted in figures 9 through 15.

As mentioned previously, the location and timing of sampling used in this portion of the survey was designed to target areas and times of greatest potential water quality impairment and to provide representative coverage of the Little Lagoon system. Two general areas of impaired water quality were identified. Both of these areas demonstrated low DO and slightly elevated FCB concentrations.

Station LLSS-7 at Windmill Ridge Road was located near the entrance to a large network of man-made, residential canals. This is the largest of three such canal systems located on Little Lagoon. Poor flushing in dead-end canal systems such as this can lead to the buildup of pollutants associated with storm water runoff from residential/urban areas. This problem can impair water quality during the summer months when these systems are most stressed. Normal tidal fluctuations, in essence, just move the same slug of water back and forth within the canal system. It is not uncommon for such canal systems to go for long periods of time without a complete flushing. The most common water quality problem encountered in these circumstances is low dissolved oxygen (DO) concentrations. Another water quality problem sometimes encountered in dead-end canal systems is higher than normal concentrations of fecal coliform bacteria (FCB).

Station LLSS-7 (see figure 2) demonstrated typical water quality problems associated with a dead-end residential canal system. DO concentrations were below 5 mg/l (at mid depth) on three of the five months in which DO measurements were taken. The average mid-depth DO concentration for that period (most readings collected near mid day) was 4.6 ppm. This station also demonstrated slightly elevated fecal coliform counts (>100 col/100ml) on four of the six sampling events.

ADEM has addressed the issue of dead-end residential canals. Coastal regulations now contain language prohibiting the construction of new canals or the expansion of existing canals for the purpose or effect of creating new waterfront property (ADEM Admin. Code R. 335-8-2-.07).

The other area of impaired water quality identified in the Site Specific portion of the survey was within the marsh and canal system between Lake Shelby and Little Lagoon. Stations LLSS-5 and 6 (see figure 2) demonstrated hypoxic conditions with slightly elevated fecal coliform counts on at least half of the sampling events. Like the man-made residential canal system, this area also demonstrated inadequate flushing. The weir located at HW 135 on the west side of Lake Shelby, which was designed to maintain water levels and control salinity in the Gulf State Park lakes, impedes the natural flow of water through the area.

Station LLSS-5, located adjacent to this weir on its west side, demonstrated the least favorable water quality of all the nine stations sampled. The average mid-depth DO concentration at this site for the sampling period was 2.18 ppm. Because of their shallow depth, and organic loading, it is not unusual for estuarine marshes to experience hypoxic conditions during the hot summer months. This site also displayed the highest average temperature of all the sites sampled (30.3 ℃ or 86.5 ℉). High water temperatures, organic decomposition, and phytoplankton respiration will naturally depress DO concentrations. Similarly, station LLSS-6, located about one mile west of LLSS-5, also exhibited slightly elevated FCB levels and mild hypoxic conditions. While the depressed DO in this area may be attributed to natural causes, it is likely that this problem, as well as the FCB problem, is exacerbated by the lack of regular flow through the area. Salinity readings demonstrate the weir's influence on the water chemistry in this system (see figure 15). The average mid-depth salinity for LLSS-5 was 21.6 ppt, while the average salinity at LLSS-4 (the next site east of the weir) was 6.3 ppt.

While the FCB concentrations encountered at LLSS-5, 6, and 7 (see figure 10) were frequently greater than those observed at other stations in the study, they did not exceed the *Fish and Wildlife* water use classification standard of 2000col/100ml. As mentioned previously, FCB occur naturally in the environment, but consistently elevated numbers can indicate a continuous source of contamination. Potential sources for this contamination include failing septic systems, leaking or overflowing sewage collection lines, and runoff from residential or natural areas with large domestic or wild animal populations. Throughout the course of this study, no obvious sources were observed. Officials with Gulf Shores Utilities, which provides sewer service to the area in question, knew of no leaks or breaks in the collection system. Other reported potential sources were investigated, but proved unsubstantiated.

The Little Lake sampling site (LLSS-1; see figure 2) was one of the sites selected to provide representative coverage of the Little Lagoon system. Because of the remote nature of this waterbody and the almost complete lack of any potential anthropogenic impacts in the localized watershed, it is likely that the hypoxic conditions observed in Little Lake during July and August were of natural origin. As mentioned previously, these conditions are not uncommon in coastal inland waters. All three State Park lakes have darkly stained waters caused by naturally high levels of tannin (the same substance that gives tea its characteristic color). This dark coloration limits the depth of light penetration in the water column thereby producing a shading effect and limiting the oxygen production of photosynthetic algae. This dark water also absorbs more heat further reducing oxygen solubility. These factors, especially when combined with heavy loads of organic decomposition, could readily result in hypoxic conditions (Dr. David Bayne, p.c. 2000). Also, the main source of water to Little Lake is from groundwater inflow, which is generally very low in DO. Hypoxic conditions were not observed in Middle Lake or Lake Shelby.

The site specific nutrient data was evaluated based on the same parameters used in analyzing the probabilistic nutrient data. With the exception of some periodic slight TKN enrichment, the nutrient levels appear normal at all nine sites (see figures 11 - 14).

All other site specific sampling and monitoring indicates good overall water quality throughout the LLW.

Review and Conclusion

The most important features that contribute to the overall high water and sediment quality found in the waterbodies of the LLW are: approximately 50% of the watershed is maintained in either State Park or National Wildlife Refuge with minimal impact land use; there is currently no, nor historically has there been, any heavy industrial or agricultural operations located anywhere within the watershed; the shallow depth and limited access to Little Lagoon limits commercial development (i.e. marinas); the permanent opening and maintained dredging of the Little Lagoon Pass by the ALDOT provides a continuous exchange of water with the Gulf of Mexico; and perhaps most importantly, the pervious sandy soils, flat terrain and abundant wetlands act to filter out much of the pollutants generated within the watershed. It is this last feature that is probably most at risk.

At this time, there do not appear to be any significant, pervasive water quality problems within the LLW. However, as more and more of the watershed becomes covered by impervious surfaces (i.e. asphalt streets and parking lots, concrete driveways, sidewalks and rooftops), direct runoff to the surface waters becomes a greater potential source of pollution. Impervious surfaces collect and accumulate pollutants from the atmosphere, leaked from vehicles and all the many other sources associated with urban development. During storm events, these pollutants are quickly washed off and rapidly delivered to aquatic systems. There are many things municipalities, businesses, and residents can do to minimize the source of these pollutants and their discharge to surface water. Direct drainage of storm water runoff to surface waterbodies should be avoided whenever possible in favor of percolation disposal where runoff is allowed to soak into the soil. Property developers and city planners should consider the use of dedicated greenways where a portion of the land developed is set aside or even engineered to naturally treat storm water runoff and act as a buffer to protect nearby surface waters. Parking lots, driveways, and sidewalks could be constructed out of pervious materials such as shell and gravel instead of concrete and asphalt. Bulkheading of waterfront property should be avoided whenever possible in favor of natural buffer zones or riprap. All lawn and garden fertilizers, herbicides and pesticides should be used sparingly and responsibly and on-site septic systems and sewage collection lines should be routinely inspected and evaluated.

Figure 9
LLWS Mid Depth Dissolved Oxygen
Site Specific Sampling
1999

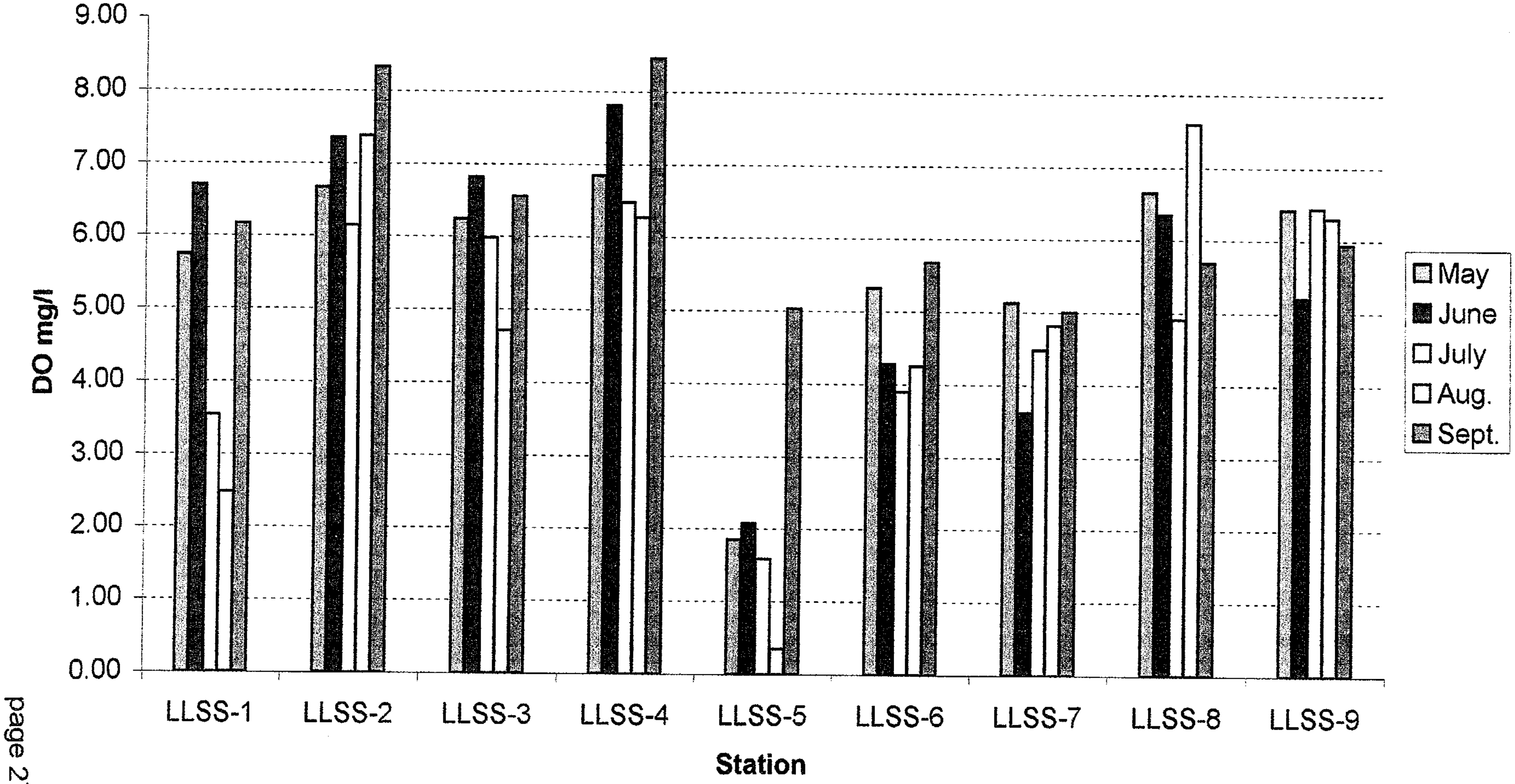
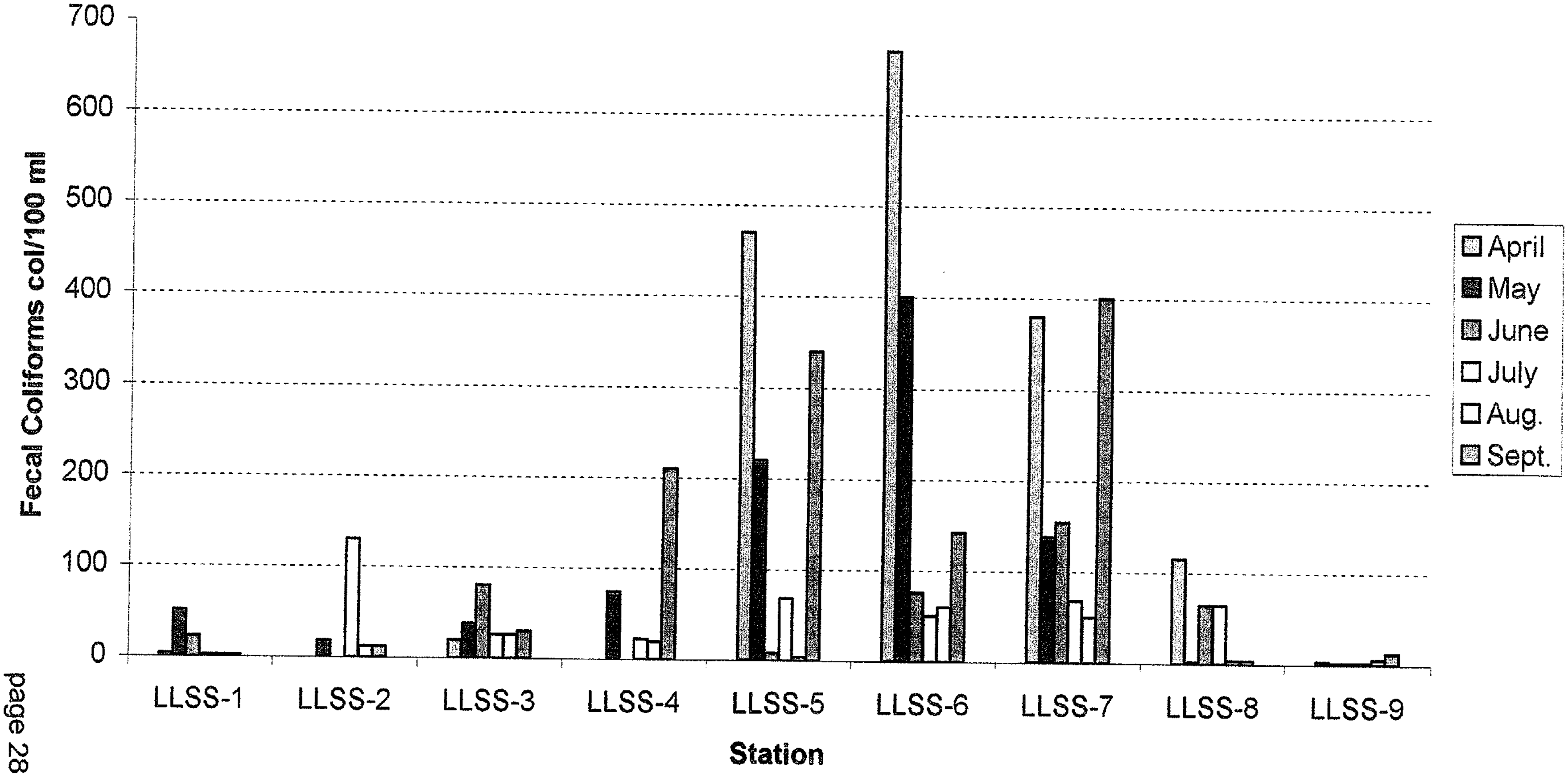
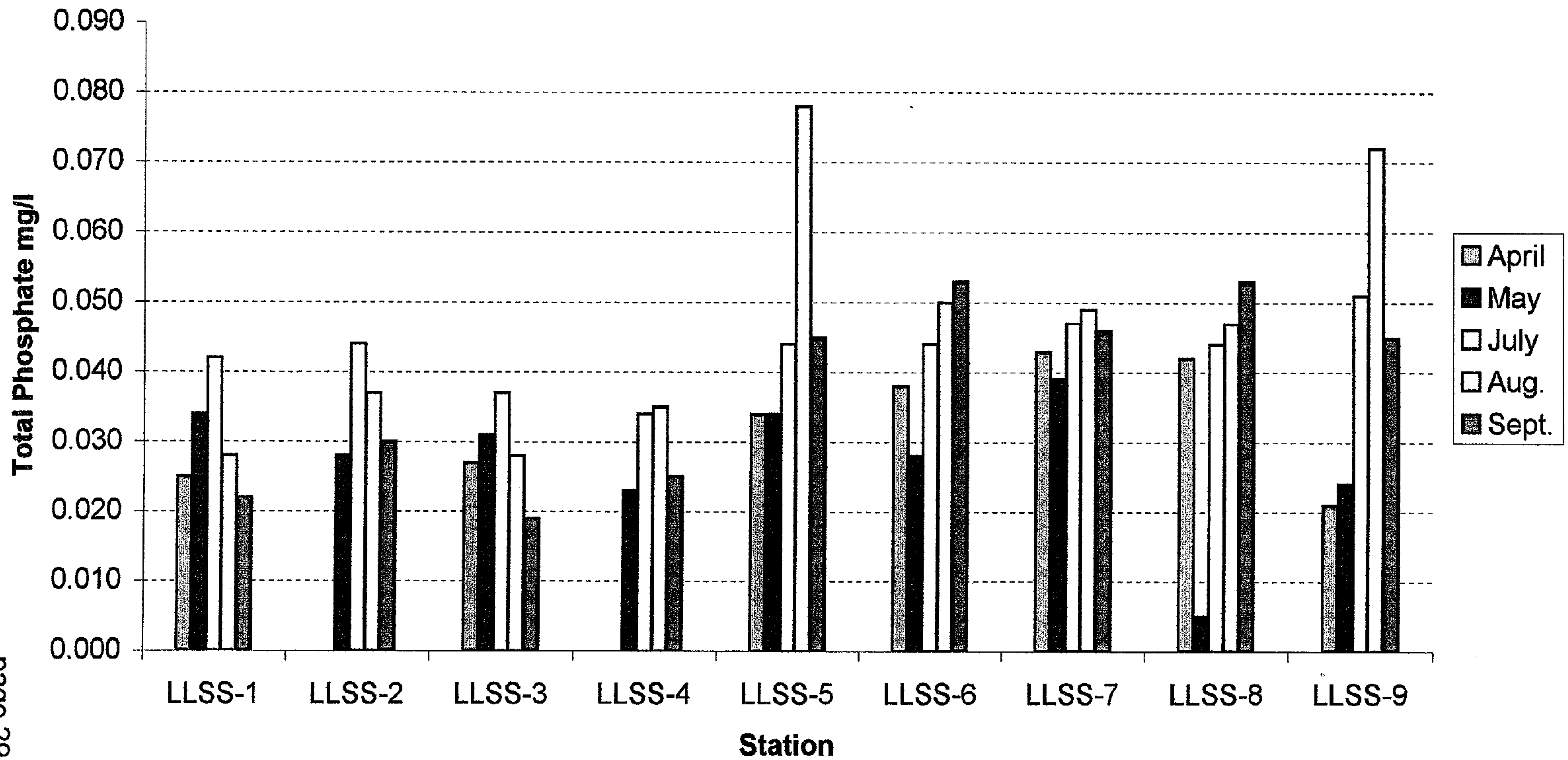


Figure 10
LLWS Fecal Coliforms
Site Specific Sampling
1999
(MDL=1 col./100ml)*



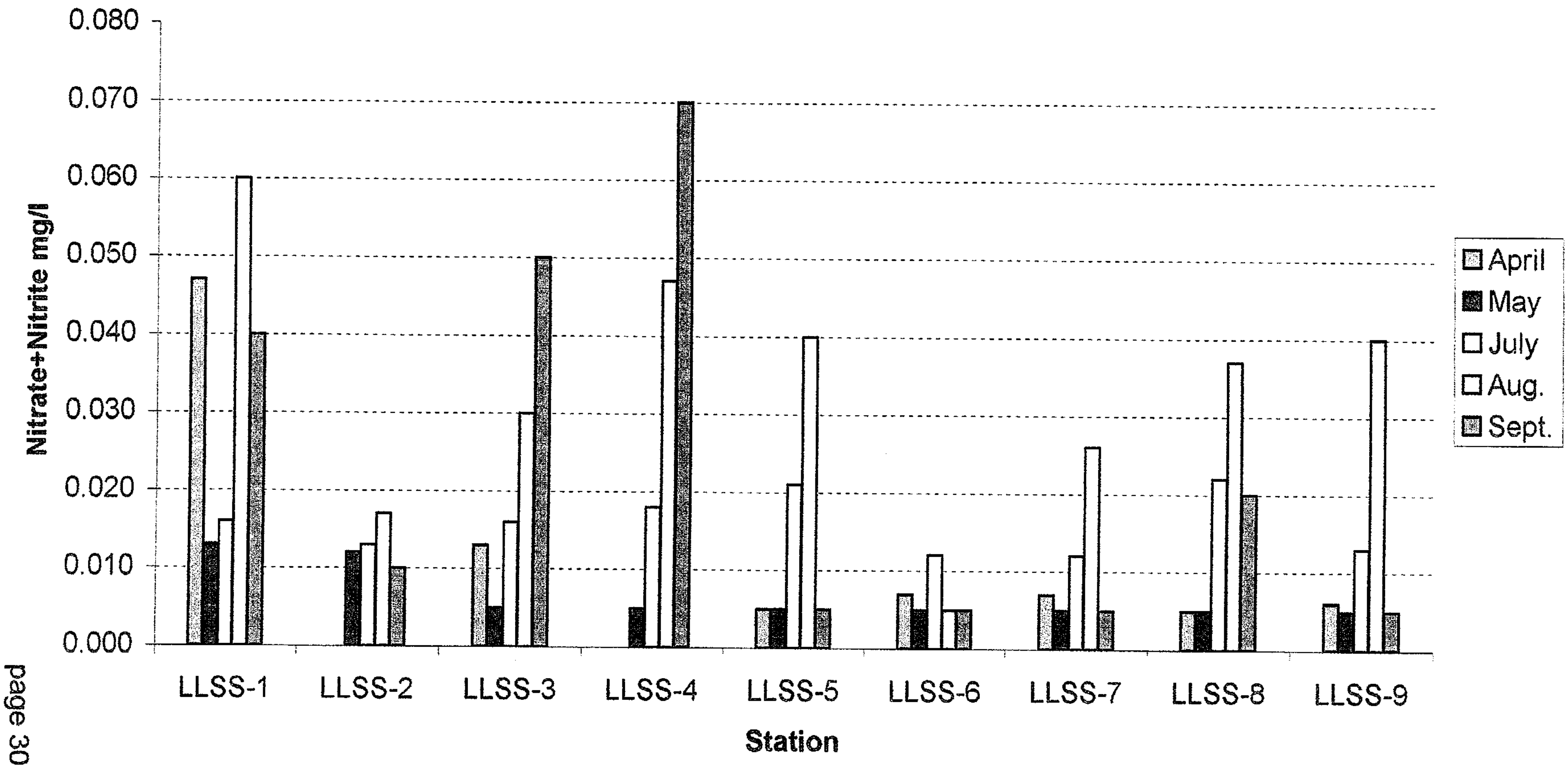
*MDL: method detection limit

Figure 11
LLWS Total Phosphate
Site Specific Sampling
1999
(MDL=0.005 mg/l)*



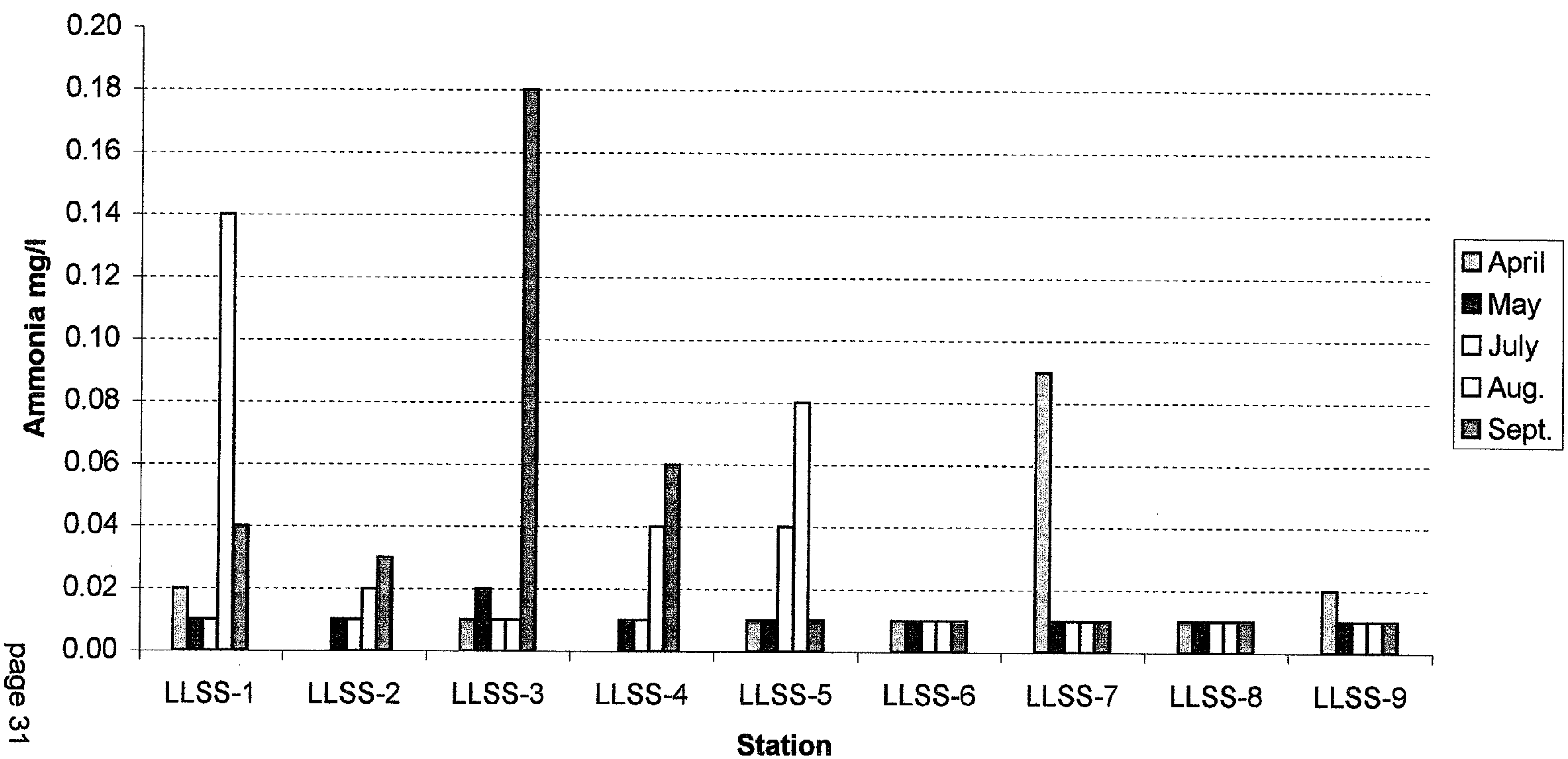
*MDL: method detection limit

Figure 12
LLWS Nitrate+Nitrite
Site Specific Sampling
1999
(MDL=0.005 mg/l)*



*MDL: method detection limit

Figure 13
LLWS Ammonia
Site Specific Sampling
1999
(MDL=0.01 mg/l)*



*MDL: method detection limit

Figure 14
LLWS TKN
Site Specific Sampling
1999
(MDL=0.1mg/l)

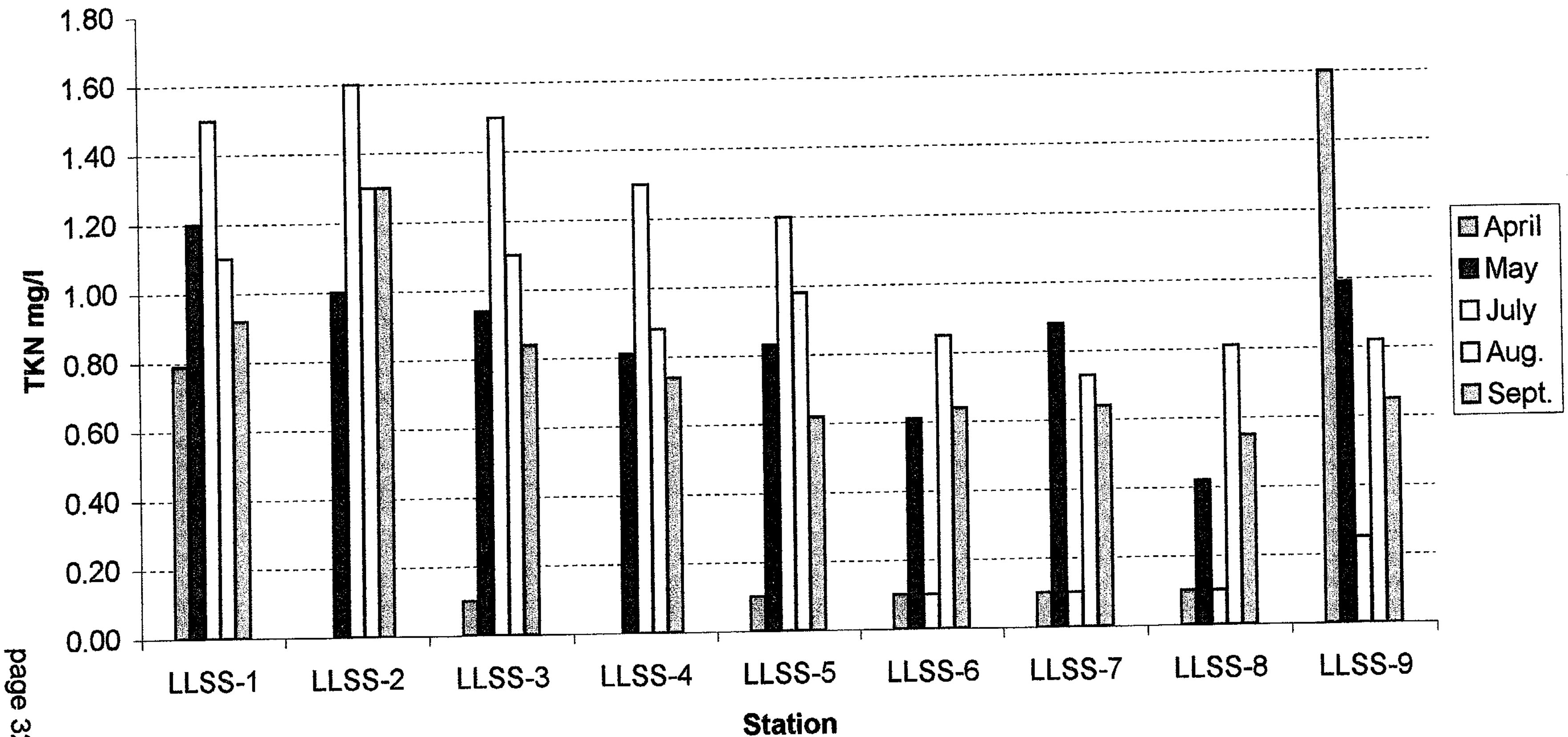
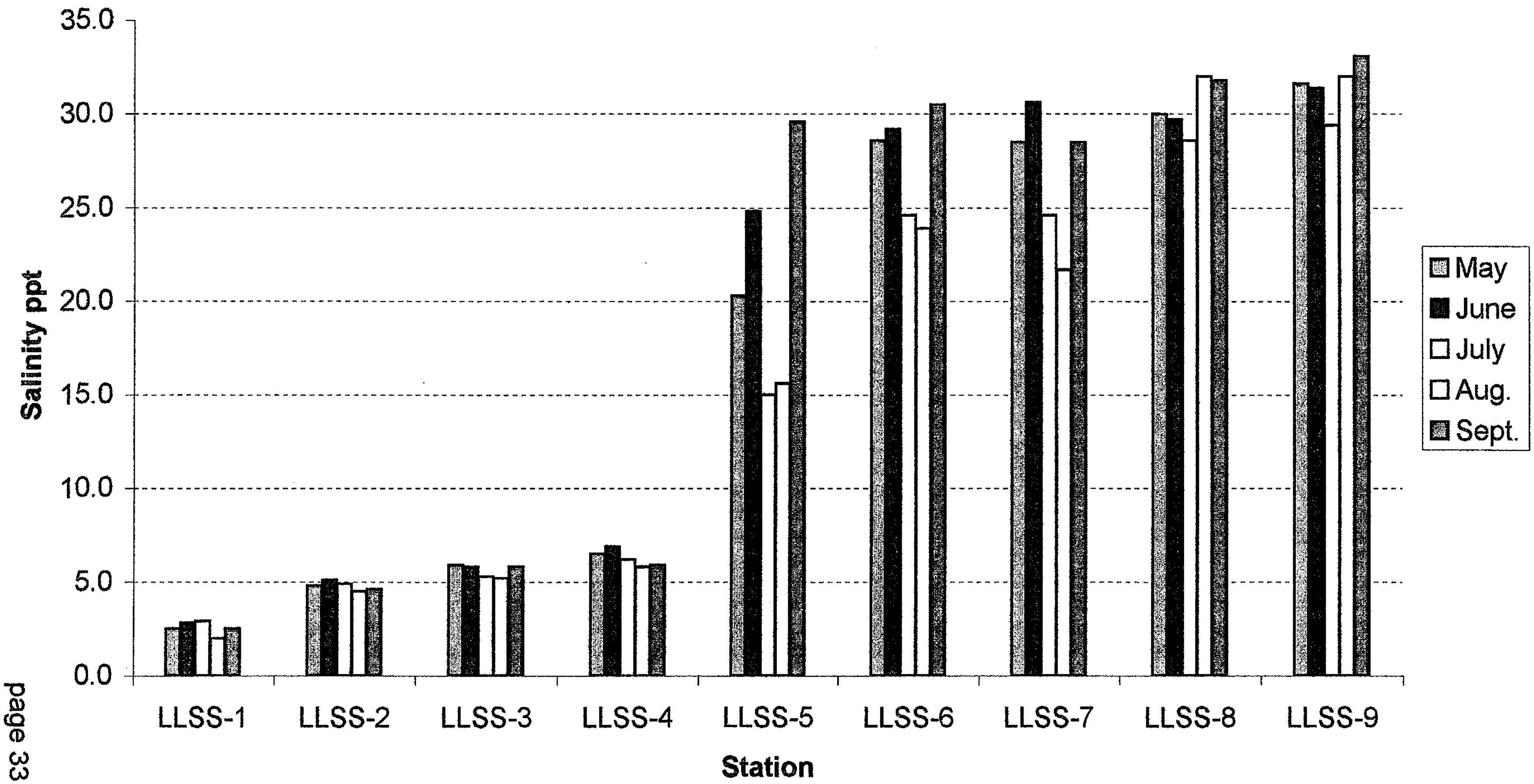


Figure 15
LLWS Mid Depth Salinity
Site Specific Sampling
1999



Literature Cited

Alabama Coastal Area Board. 1980. Inventory of Alabama's Coastal Resources and Uses. Alabama Coastal Area Board, Daphne, AL. 169pp.

Alabama Department of Environmental Management (ADEM). Revised 1999. ADEM Administrative Code: Water Quality Criteria (Chapter 335-6-10-.09)

Alabama Department of Environmental Management (ADEM). Revised 1995. ADEM Administrative Code: Coastal Area Management Program (Chapter 335-8-2-.07)

Alabama Gulf Coast Convention & Visitors Bureau. 1998. Economic Update. Alabama Gulf Coast Convention & Visitors Bureau, Gulf Shores, AL. 7pp.

Baldwin County Commission. 1999. Baldwin County Wetland Advanced Identification (ADID) Draft Technical Summary Document. William H. Brantley, Jr. ed. Baldwin County Commission, Baldwin County, AL. 130 pp.

Carlton, J.; J. S. Brown, J. K. Summers, V. D. Engle, P. E. Bourgeois. 1997. A Report on the Condition of the Estuaries of Alabama in 1993-1995: A Program in Progress. Alabama department of Environmental Management, Mobile, AL.

Long, E. R., D. D. Macdonald, S. L. Smith, F. D. Calder. 1995. Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. National Oceanic and Atmospheric Administration. Seattle Washington. 97pp.

Mount, R. H. 1975. The Reptiles and Amphibians of Alabama. Auburn Agricultural Experiment Station, Auburn, AL. 347 pp.

Mount R. H. 1986. Vertebrate Animals of Alabama in Need of Special Attention. Auburn Agricultural Experiment Station, Auburn, AL. 124 pp.

National Climatic Center web-site www.ncdc.noaa.gov. 2000. World Data Center for Meteorology, Asheville, NC.

O'Neil, P. E. and M. F. Mettee. 1982. Alabama Coastal Region Ecological Characterization. Volume 2, A Synthesis of Environmental Data. U. S. Fish and Wildlife Service, Office of Biological Services, Washington, D. C. FWS/OBS-82/42. 346 pp.

U.S. Department of Agriculture. 1964. Soil Survey of Baldwin County Alabama. (Series 1960, No. 12. Soil Conservation Service. 110 pp.

Personal Communications:

Phil Bass, South Alabama Utilities, Fort Morgan, AL.

Dr. David Bayne, Auburn University, Department of Fisheries and Allied Aquaculture, Auburn, AL.

Roger Clay, Alabama Department of Conservation and Natural Resources, Wildlife and Freshwater Fisheries, Spanish Fort, AL.

Steve Foote, City of Gulf Shores, City Planning Commission, Gulf Shores, AL.

Jane Griess, U.S. Fish and Wildlife Service, Bon Secour National Wildlife Refuge.

J.C. Jarmon, Alabama Department of Conservation and Natural Resources, Alabama Gulf State Park.

Clifford Johnson, Gulf Shores Utilities, Gulf Shores, AL

William Tucker, Alabama Department of Conservation and Natural Resources, Wildlife and Freshwater Fisheries, Spanish Fort, AL.

Appendices

Appendix A: Little Lagoon Watershed Probabilistic Sampling *In-situ* Water Quality and Laboratory Results

Appendix B: Little Lagoon Watershed Site Specific Sampling *In-situ* Water Quality and Laboratory Results

Appendix A

Little Lagoon Watershed
Probabilistic Sampling

In-situ Water Quality
And
Results of Laboratory Analyses

Key to Abbreviations

Temp. = Temperature (°C)
DO = Dissolved Oxygen (mg/l)
Cond. = Specific Conductivity (umhos/cm)
Salin. = Salinity (ppt = parts per thousand)
NH_3 = Ammonia (mg/l)
NO_3 + NO_2 = Nitrate + Nitrite (mg/l)
PO_4 = Total Phosphorous (mg/l)
TKN = Total Kjeldahl Nitrogen (mg/l)
TSS = Total Suspended Solids (mg/l)
TDS = Total Dissolved Solids (mg/l)
Turbidity (NTU = nephelometric turbidity units)
F. Coliform = Fecal Coliform (colonies/100ml)
Chlor-a = Chlorophyll a (ug/l)
BOD = Biochemical Oxygen Demand (mg/l)

Little Lagoon Watershed Probabilistic Samples
In-situ Water Quality

Station	Date	Time hrs	Secchi M	Depth M	Temp. °C	DO mg/l	pH su	Cond. µmhos/cm	Salin. ppt
LL-1	7/20/99	1150	0.7	Surf.	29.82	6.27	7.21	10430	5.9
				Mid.	29.69	6.06	7.14	10440	5.9
				Btm. 2.1	29.33	4.60	6.95	10480	6.0
LL-2	7/20/99	1010	0.6	Surf.	29.97	6.43	7.03	8230	4.6
				Mid.	29.65	5.86	7.01	8420	5.0
				Btm. 1.8	29.63	4.30	6.84	8750	5.0
LL-3	7/20/99	1210	0.8	Surf.	29.75	6.60	7.33	10460	5.9
				Mid.	29.73	6.59	7.30	10430	5.9
				Btm. 2.8	29.25	5.86	7.15	10370	5.9
LL-4	7/20/99	1230	0.8	Surf.	29.47	6.67	7.36	10440	5.9
				Mid.	29.47	6.65	7.35	10460	5.9
				Btm. 1.0	29.45	6.21	7.36	10410	5.9
LL-5	7/22/99	1210	0.8	Surf.	31.41	5.83	7.58	39330	25.0
				Mid.	31.29	5.82	7.58	39160	25.0
				Btm. 1.5	30.39	5.24	7.57	39660	25.6
LL-6	7/22/99	1235	btm. 0.6	Surf.					
				Mid.	32.98	4.79	7.31	30730	17.9
				Btm. 0.6					
LL-7	7/22/99	1120	btm. 0.7	Surf.	30.73	6.03	7.69	40400	26.0
				Mid.	30.73	6.03	7.69	40400	25.8
				Btm. 0.7	30.61	6.04	7.70	40780	26.2
LL-8	7/22/99	1140	0.8	Surf.	30.98	5.88	7.59	39320	25.1
				Mid.	30.90	5.88	7.59	39570	25.1
				Btm. 1.3	30.63	5.49	7.59	39260	25.2
LL-9	7/22/99	1245	0.7	Surf.	31.95	5.02	7.44	38420	24.6
				Mid.	30.71	5.55	7.51	38550	24.6
				Btm. 1.1	30.49	5.30	7.52	39440	25.2
LL-10	7/22/99	1126	0.7	Surf.	30.67	6.04	7.73	41070	26.3
				Mid.	30.67	6.02	7.73	40800	26.4
				Btm. 1.0	30.41	5.84	7.73	41370	26.5
LL-11	7/22/99	1200	btm. 0.4	Surf.					
				Mid.	31.53	5.43	7.52	38960	25.0
				Btm. 0.4					
LL-12	7/22/99	1025	0.8	Surf.	30.39	5.92	7.95	43400	28.0
				Mid.	30.30	5.85	7.95	43650	28.0
				Btm. 2.8	29.77	4.87	7.89	43490	28.2
LL-13	7/22/99	1050	1.1	Surf.	30.17	5.93	7.87	43330	28.0
				Mid.	29.60	5.47	7.90	45150	29.2
				Btm. 2.2	28.97	2.79	7.77	47000	30.4
LL-14	7/22/99	1145	btm 0.4	Surf.					
				Mid.	31.47	5.35	7.51	39010	24.9
				Btm. 0.4					
LL-15	7/22/99	1005	btm. 0.5	Surf.					
				Mid.	30.29	5.61	7.91	43780	28.3
				Btm. 0.5					

Little Lagoon Watershed Probabilistic Samples
In-situ Water Quality

Station	Date	Time hrs	Secchi M	Depth M	Temp. °C	DO mg/l	pH su	Cond. µmhos/cm	Salin. ppt
LL-16	7/22/99	1045	0.9	Surf.	30.15	5.98	7.88	43330	28.1
				Mid.	29.55	5.64	7.91	44800	29.0
				Btm. 2.4	28.91	2.93	7.75	46770	30.6
LL-17	7/22/99	1100	btm. 0.7	Surf.					
				Mid.	30.31	6.39	7.90	43370	28.0
				Btm. 0.7					
LL-18	7/21/99	1215	1.0	0.1	30.35	6.19	7.97	43840	28.1
				1.0	30.29	6.29	7.98	43870	28.2
				1.5	30.07	6.43	7.99	43860	28.3
				2.0	29.55	5.94	7.96	43400	28.2
				3.0	29.41	2.93	7.78	43880	28.3
				Btm. 3.3	29.39	1.39	7.63	44080	28.2
LL-19	7/22/99	940	0.8	Surf.	30.17	5.91	7.94	43600	28.2
				Mid.	30.09	5.86	7.94	43440	28.2
				Btm. 2.6	29.75	4.44	7.86	43950	28.5
LL-20	7/22/99	1015	0.8	Surf.	30.31	6.02	7.96	43440	28.0
				Mid.	30.29	6.00	7.96	43230	28.0
				Btm. 2.6	30.07	4.96	7.91	43680	28.1
LL-21	7/21/99	1030	0.5	Surf.					
				Mid.	31.04	5.11	7.63	42730	27.5
				Btm. 0.6					
LL-22	7/21/99	1135	0.6	Surf.	30.45	5.51	7.91	43920	28.3
				Mid.	29.75	4.99	7.88	43760	28.3
				Btm. 1.9	29.57	5.81	7.94	43670	28.6
LL-23	7/21/99	1200	0.7	Surf.	30.19	6.61	7.98	43790	28.2
				Mid.	29.85	6.40	7.98	43670	28.6
				Btm. 2.6	29.43	5.46	7.93	44080	28.4
LL-24	7/21/99	1230	1.1	Surf.	30.39	6.49	7.99	43520	28.2
				Mid.	30.35	6.51	7.99	43640	28.1
				Btm. 2.4	30.19	6.58	8.00	43500	28.1
LL-25	7/22/99	950	btm. 0.3	Surf.					
				Mid.	30.47	6.52	7.97	43760	28.3
				Btm. 0.3					
LL-26	7/21/99	1000	btm. 0.4	Surf.					
				Mid.	30.35	3.74	7.62	41670	27.4
				Btm. 0.4					
LL-27	7/21/99	1100	btm. 0.5	Surf.					
				Mid.	30.71	6.04	7.80	43230	27.9
				Btm. 0.5					
LL-28	7/21/99	1150	0.7	Surf.	31.12	6.75	7.98	43760	28.3
				Mid.	30.63	6.60	7.98	43780	28.3
				Btm. 1.6	29.79	5.49	7.94	43820	28.4
LL-29	7/21/99	1045	0.8	Surf.	30.37	6.58	7.90	43370	28.0
				Mid.	30.27	6.59	7.90	43450	28.0
				Btm. 2.0	29.57	5.60	7.87	43850	28.4
LL-30	7/21/99	1120	0.8	Surf.	30.37	6.70	7.91	43230	27.9
				Mid.	30.19	6.64	7.90	43220	28.1
				Btm. 2.0	29.69	6.00	7.85	43160	27.9

Little Lagoon Watershed Probabilistic Samples
Chemical / Physical / Biological Water Quality Analyses

Station	Date	Time hrs	Hardness mg/l	Alkalinity mg/l	Turbidity NTU	Chlor-a µg/l	<>	NH_3 mg/l	BOD(5) mg/l	<>	NO_3+NO_2 mg/l	PO_4 mg/l	<>	TKN mg/l	TSS mg/l	TDS mg/l	<>	F.Coliform col/100ml
LL-1	7/20/99	1150	1130	36	6.4	12.0	<	0.01	1.7		0.019	0.038		0.70	9	6560		4
LL-2	7/20/99	1010	866	31	6.5	20.0	<	0.01	2.4		0.012	0.041		0.70	9	4860		6
LL-3	7/20/99	1210	1110	36	4.6	13.0	<	0.01	1.8		0.010	0.034		0.60	12	6340		8
LL-4	7/20/99	1230	2230	36	4.9	14.0	<	0.01	2.9		0.011	0.038		0.72	14	6440		4
LL-5	7/22/99	1210	4880	98	6.2	7.2	<	0.01	2.6		0.007	0.040		0.72	29	26800	<	2
LL-6	7/22/99	1235	3690	84	7.0	10.0	<	0.01	3.1		0.012	0.045		0.44	15	18400		46
LL-7	7/22/99	1120	5010	98	6.9	1.0	<	0.01	3.0	<	0.005	0.046		0.48	19	28600	<	2
LL-8	7/22/99	1140	4860	96	5.6	6.5	<	0.01	3.1		0.005	0.040		0.49	22	25700	<	2
LL-9	7/22/99	1245	5050	96	9.3	10.0	<	0.01	2.8	<	0.005	0.054		0.52	27	25600		10
LL-10	7/22/99	1126	5330	100	8.1	7.8	<	0.01	3.2	<	0.005	0.046		0.51	32	26000	<	2
LL-11	7/22/99	1200	4730	100	9.3	12.0	<	0.01	3.1		0.006	0.059		0.56	28	2600		4
LL-12	7/22/99	1025	5720	107	5.7	10.0	<	0.01	3.9	<	0.005	0.045		0.44	29	29000		10
LL-13	7/22/99	1050	5990	109	4.4	10.0	<	0.01	4.3		0.008	0.045		0.54	30	29700	<	2
LL-14	7/22/99	1145	5010	96	6.5	8.1	<	0.01	2.7		0.006	0.051		0.56	25	27400		8
LL-15	7/22/99	1005	5620	108	5.8	9.2	<	0.01	4.8		0.006	0.053		0.45	25	29900		4
LL-16	7/22/99	1045	5500	107	4.5	10.0	<	0.01	4.7		0.005	0.042		0.55	23	28600		16
LL-17	7/22/99	1100	5270	107	6.0	9.2	<	0.01	4.3		0.005	0.045		0.50	26	28400		30
LL-18	7/21/99	1215	5820	107	3.8	7.0	<	0.01	2.8		0.006	0.029		0.49	22	30500	<	2
LL-19	7/22/99	940	5690	107	5.3	9.6	<	0.01	3.0		0.005	0.045		0.54	20	29300		2
LL-20	7/22/99	1015	5750	107	5.9	9.1	<	0.01	4.0		0.005	0.042		0.51	66	29300		6
LL-21	7/21/99	1030	5600	104	11.1	9.5	<	0.01	3.2		0.005	0.055		0.26	36	30600	<	2
LL-22	7/21/99	1135	5520	106	7.3	8.8	<	0.01	3.7		0.007	0.050	<	0.10	28	31200	<	2
LL-23	7/21/99	1200	5640	107	4.8	7.2	<	0.01	3.6	<	0.005	0.041		0.38	18	31600	<	2
LL-24	7/21/99	1230	5740	106	3.5	6.3	<	0.01	3.2		0.005	0.035		0.24	14	30900	<	2
LL-25	7/22/99	950	5750	106	6.5	7.4	<	0.01	4.0		0.005	0.048		0.61	29	31000		2
LL-26	7/21/99	1000	5340	106	18.7	14.0	<	0.01	3.7		0.007	0.077		0.56	38	30900	<	2
LL-27	7/21/99	1100	5280	105	11.3	10.0	<	0.01	3.5		0.005	0.065		0.63	29	30700	<	2
LL-28	7/21/99	1150	5350	107	6.0	3.6		0.25	3.7		0.028	0.046		0.56	25	31300	<	2
LL-29	7/21/99	1045	5420	106	5.4	8.4	<	0.01	4.5		0.006	0.042		0.54	26	30800	<	2
LL-30	7/21/99	1120	5330	107	5.5	7.0	<	0.01	3.2		0.005	0.044		1.12	26	31200	<	2

Little Lagoon Watershed Probabilistic Samples
Sediment Metals Analyses

Station	Date mm/dd/yy	Time hrs	Al <> ppm	As <> ppm	Cd <> ppm	Cr <> ppm	Cu <> ppm	Pb <> ppm	Hg <> ppm	Ni <> ppm	Ag <> ppm	Sn <> ppm	Zn <> ppm	Ba <> ppm	Fe <> ppm
LL-1	7/20/99	1150	< 300	< 0.90	< 0.03	5.0	< 7.0	< 1.00	< 0.06	< 9.0	< 0.1	< 0.6	< 12	<	500
LL-2	7/20/99	1010	< 300	< 0.90	< 0.03	4.0	< 7.0	< 1.00	< 0.06	< 9.0	< 0.1	< 0.6	< 12	72	160
LL-3	7/20/99	1210	12600	12.90	0.44	54.0	8.1	27.00	0.20	16.0	< 0.1	< 0.6	37	< 60	36800
LL-4	7/20/99	1230	< 300	< 0.90	< 0.03	< 3.0	< 7.0	< 1.00	< 0.06	< 9.0	< 0.1	< 0.6	< 12	< 60	210
LL-5	7/22/99	1210	3000	4.93	< 0.03	11.0	< 7.0	5.61	0.09	< 9.0	< 0.1	< 0.6	< 12	< 60	4730
LL-6	7/22/99	1235	6150	4.98	< 0.03	21.0	< 7.0	7.35	0.12	< 9.0	< 0.1	< 0.6	< 12	< 60	6790
LL-7	7/22/99	1120	310	< 0.90	< 0.03	< 3.0	< 7.0	1.62	< 0.06	< 9.0	< 0.1	< 0.6	< 12	< 60	< 600
LL-8	7/22/99	1140	1720	2.68	< 0.03	7.9	< 7.0	3.96	< 0.06	< 9.0	< 0.1	< 0.6	< 12	< 60	2820
LL-9	7/22/99	1245	3180	4.30	< 0.03	21.0	9.0	5.49	< 0.06	10.0	< 0.1	< 0.6	< 12	< 60	5950
LL-10	7/22/99	1126	2320	2.67	< 0.03	11.0	< 7.0	5.13	< 0.06	< 9.0	< 0.1	< 0.6	< 12	< 60	3550
LL-11	7/22/99	1200	404	< 0.90	< 0.03	< 3.0	< 7.0	1.20	< 0.06	< 9.0	< 0.1	< 0.6	< 12	< 60	< 600
LL-12	7/22/99	1025	13200	18.30	< 0.03	77.0	12.0	20.40	0.12	19.0	< 0.1	< 0.6	42	< 60	25100
LL-13	7/22/99	1050	12600	18.50	< 0.03	69.0	14.0	19.40	0.21	20.0	< 0.1	< 0.6	31	72	21200
LL-14	7/22/99	1145	622	1.42	< 0.03	5.6	< 7.0	2.92	< 0.06	< 9.0	< 0.1	< 0.6	< 12	< 60	900
LL-15	7/22/99	1005	365	< 0.90	< 0.03	3.7	< 7.0	1.06	< 0.06	< 9.0	< 0.1	< 0.6	< 12	< 60	< 600
LL-16	7/22/99	1045	13400	13.90	< 0.03	62.0	18.0	19.30	0.20	24.0	< 0.1	< 0.6	51	< 60	23000
LL-17	7/22/99	1100	425	< 1.90	< 0.03	4.1	< 7.0	2.79	< 0.06	< 9.0	< 0.1	< 0.6	< 12	< 60	640
LL-18	7/21/99	1215	12500	12.80	< 0.03	81.0	10.0	14.30	0.16	17.0	< 0.1	< 0.6	42	< 60	19100
LL-19	7/22/99	940	14000	19.10	< 0.03	93.0	15.0	22.60	nd	24.0	< 0.1	< 0.6	48	< 60	30800
LL-20	7/22/99	1015	14300	21.90	< 0.03	98.0	15.0	19.70	0.14	24.0	< 0.1	< 0.6	37	< 60	30900
LL-21	7/21/99	1030	453	< 0.90	< 0.03	3.0	< 7.0	< 1.00	< 0.06	< 9.0	< 0.1	< 0.6	< 12	< 60	610
LL-22	7/21/99	1135	405	< 0.90	< 0.03	3.0	< 7.0	< 1.00	< 0.06	< 9.0	< 0.1	< 0.6	< 12	< 60	650
LL-23	7/21/99	1200	5950	5.01	< 0.03	34.0	< 7.0	5.61	< 0.06	< 9.0	< 0.1	< 0.6	17	< 60	6870
LL-24	7/21/99	1230	766	< 0.90	< 0.03	7.8	< 7.0	4.61	< 0.06	< 9.0	< 0.1	< 0.6	< 12	< 60	1130
LL-25	7/22/99	950	257	< 0.90	< 0.03	< 3.0	< 7.0	< 1.00	< 0.06	< 9.0	< 0.1	< 0.6	< 12	< 60	< 600
LL-26	7/21/99	1000	368	< 0.90	< 0.03	< 3.0	< 7.0	1.86	< 0.06	< 9.0	< 0.1	< 0.6	< 12	< 60	< 600
LL-27	7/21/99	1100	435	< 0.90	< 0.03	< 3.0	< 7.0	1.51	< 0.06	< 9.0	< 0.1	< 0.6	< 12	< 60	< 600
LL-28	7/21/99	1150	700	< 0.90	< 0.03	3.4	< 7.0	2.39	< 0.06	< 9.0	< 0.1	< 0.6	< 12	< 60	800
LL-29	7/21/99	1045	880	< 0.90	< 0.03	6.3	< 7.0	3.89	< 0.06	< 9.0	< 0.1	< 0.6	< 12	< 60	1260
LL-30	7/21/99	1120	4620	3.99	< 0.03	20.0	< 7.0	8.51	< 0.06	< 9.0	< 0.1	< 0.6	14	< 60	5640

Little Lagoon Watershed Probabilistic Samples
Sediment Pesticides Analyses

Station	Date mm/dd/yy	Chlordane ppm	4,4'-DDD ppm	4,4'-DDE ppm	4,4'-DDT ppm	Aldrin ppm	alpha-BHC ppm	beta-BHC ppm	delta-BHC ppm	gamma-BHC (Lindane) ppm	Dieldrin ppm	Endosulfan-I ppm	Endosulfan-II ppm	Endosulfan Sulfate ppm	Endrin ppm	Endrin Aldehyde ppm	Endrin Keytone ppm	Heptachlor ppm	Heptachlor L, oxide ppm	Methoxychlor ppm	Toxaphene ppm
LL-1	7/20/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-2	7/20/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-3	7/20/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-4	7/20/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-5	7/22/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-6	7/22/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-7	7/22/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-8	7/22/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-9	7/22/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-10	7/22/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-11	7/22/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-12	7/22/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-13	7/22/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-14	7/22/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-15	7/22/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-16	7/22/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-17	7/22/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-18	7/21/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-19	7/22/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-20	7/22/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-21	7/21/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-22	7/21/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-23	7/21/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-24	7/21/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-25	7/22/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-26	7/21/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-27	7/21/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-28	7/21/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-29	7/21/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05
LL-30	7/21/99	<0.0015	<0.05	<0.0025	<0.08	<0.0022	<0.034	<0.0033	<0.0011	<0.025	<0.044	<0.03	<0.0024	<0.0036	<0.039	<0.0016	<0.001	<0.04	<0.0021	<0.86	<0.05

Appendix B

Little Lagoon Watershed
Site Specific Sampling

In-situ Water Quality
And
Results of Laboratory Analyses

Little Lagoon Watershed Site Specific Samples
LLSS - 1 Little Lake

Date	Time hrs	Observed Flow Direction	Depth M	Temp. °C	DO mg/l	pH su	Cond. µmhos/cm	Salin. ppt	<>	NH_3 mg/l	<>	NO_3+NO_2 mg/l	<>	PO_4 mg/l	<>	TKN mg/l	<>	TSS mg/l	<>	TDS mg/l	Turbidity NTU	<>	F.Coliform col/100ml
4/1/99	1100	none	surf. 0.1	nd	nd	nd	nd	nd		0.02		0.047		0.025		0.79		nd		nd			3
5/20/99	915	none	surf. 0.1	27.50	6.58	6.82	4530	2.5		0.01		0.013		0.034		1.20		12		2520	4.1		51
			mid. 0.4	27.25	5.74	6.82	4520	2.5															
			btm. 0.8	27.06	6.07	6.78	4500	2.5															
6/2/99	927	none	mid. 0.4	29.09	6.70	7.08	5060	2.8		nd		nd		nd		nd		nd		nd	nd		22
7/7/99	830	none	surf. 0.1	30.80	3.57	6.71	5350	3.0		0.01		0.016		0.042		1.50		8		3180	4.4	<	2
			mid. 0.4	30.80	3.54	6.70	5350	2.9															
			btm. 0.8	30.57	3.42	6.68	5330	3.0															
8/24/99	1100	none	surf. 0.1	31.58	2.84	6.69	3600	2.0		0.14		0.060		0.028		1.10	<	5		2060	3.0	<	2
			mid. 0.4	31.49	2.48	6.67	3600	2.0															
			btm. 0.8	31.31	2.09	6.65	3600	2.0															
9/21/99	1300	none	surf. 0.1	27.47	6.26	7.18	4490	2.5		0.04		0.040		0.022		0.92		6		2500	2.6		2
			mid. 0.4	26.75	6.16	7.20	4500	2.5															
			btm. 0.8	26.45	5.58	7.10	4500	2.5															

Little Lagoon Watershed Site Specific Samples
LLSS - 2 Middle Lake

Date	Time hrs	Observed Flow Direction	Depth M	Temp. °C	DO mg/l	pH su	Cond. µmhos/cm	Salin. ppt	NH_3 <> mg/l	<> NO_3+NO_2 mg/l	<> PO_4 mg/l	<> TKN mg/l	<> TSS mg/l	<> TDS mg/l	Turbidity NTU	<> F.Coliform col/100ml
4/1/99	nd	none	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
5/20/99	935	none	mid. 0.4	27.13	6.67	7.34	8450	4.8	0.01	0.012	0.028	1.00	12	4720	4.5	18
6/2/99	945	none	mid. 0.4	29.03	7.35	7.63	9130	5.1	nd	nd	nd	nd	nd	nd	nd	nd
7/7/99	900	none	surf. 0.1	30.59	6.22	7.25	8800	5.0	< 0.01	0.013	0.044	1.60	12	5390	7.1	130
			mid. 0.55	30.55	6.15	7.23	8800	4.9								
			btm. 1.1	30.43	6.17	7.24	8820	5.0								
8/24/99	1120	none	surf. 0.1	31.89	7.90	8.09	8120	4.5	0.02	0.017	0.037	1.30	16	4750	9.7	12
			mid. 0.4	31.83	7.38	7.76	8130	4.5								
			btm. 0.8	31.56	6.71	7.54	8080	4.5								
9/21/99	1320	none	surf. 0.1	27.57	8.44	8.17	8280	4.6	0.03	0.010	0.030	1.30	9	4860	9.0	12
			mid. 0.4	27.02	8.33	8.17	8300	4.6								
			btm. 0.8	26.69	7.43	7.97	8300	4.7								

Little Lagoon Watershed Site Specific Samples
LLSS - 3 Gulf State Park Rd 2 Bridge

Date	Time hrs	Observed Flow Direction	Depth M	Temp. °C	DO mg/l	pH su	Cond. µmhos/cm	Salin. ppt	NH_3 mg/l	NO_3+NO_2 mg/l	PO_4 mg/l	TKN mg/l	TSS mg/l	TDS mg/l	Turbidity NTU	F.Coliform col/100ml
4/1/99	1110	none	surf. 0.1	nd	nd	nd	nd	nd	< 0.01	0.013	0.027	< 0.10	nd	nd	nd	20
5/20/99	950	none	surf. 0.1	26.71	6.55	7.18	8730	4.9	0.02	< 0.005	0.031	0.94	10	5010	5.0	38
			mid. 0.65	26.52	6.24	7.15	10420	5.9								
			btm. 1.3	26.18	6.09	7.14	11020	6.3								
6/2/99	1000	out	surf. 0.1	28.25	6.95	7.43	9990	5.7	nd	nd	nd	nd	nd	nd	nd	80
			mid. 0.7	28.15	6.81	7.37	10130	5.8								
			btm. 1.4	27.17	5.35	7.13	12100	6.9								
7/7/99	920	none	surf. 0.1	30.21	6.15	7.13	9220	5.2	< 0.01	0.016	0.037	1.50	13	5660	5.3	26
			mid. 0.65	30.03	5.98	7.10	9490	5.3								
			btm. 1.3	29.73	5.41	7.01	10550	6.0								
8/24/99	1135	out	surf. 0.1	31.43	5.60	7.10	8720	4.9	< 0.01	0.030	0.028	1.10	9	5000	4.9	26
			mid. 0.65	31.28	4.71	7.04	8950	5.2								
			btm. 1.3	30.98	3.91	6.95	10060	5.6								
9/21/99	1230	in	surf. 0.1	28.04	6.38	7.23	10200	5.8	0.18	0.050	0.019	0.84	< 5	5880	1.4	30
			mid. 0.85	25.98	6.55	7.26	10270	5.8								
			btm. 1.7	25.75	5.91	7.19	10300	5.9								

Little Lagoon Watershed Site Specific Samples
LLSS - 4 Lake Shelby Boat Ramp

Date	Time hrs	Observed Flow Direction	Depth M	Temp. °C	DO mg/l	pH su	Cond. μmhos/cm	Salin. ppt	NH_3 <> mg/l <>	NO_3+NO_2 mg/l	PO_4 <> mg/l	TKN <> mg/l	TSS <> mg/l	TDS <> mg/l	Turbidity NTU	F.Coliform <> col/100ml
4/1/99	nd	none	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
5/20/99	1010	none	mid. 0.2	27.25	6.84	7.48	11410	6.5	< 0.01	0.005	0.023	0.81	6	6640	4.4	74
6/2/99	1015	none	mid. 0.2	28.76	7.81	7.64	12090	6.9	nd	nd	nd	nd	nd	nd	nd	nd
7/7/99	955	none	mid. 0.2	30.40	6.48	7.25	10840	6.2	< 0.01	0.018	0.034	1.30	10	6690	5.1	22
8/24/99	1155	none	mid. 0.2	32.08	6.27	7.38	10210	5.8	0.04	0.047	0.035	0.88	12	6020	5.4	20
9/21/99	1215	none	mid. 0.2	27.53	8.46	7.86	10370	5.9	0.06	0.070	0.025	0.74	7	5920	3.1	210

Little Lagoon Watershed Site Specific Samples
LLSS - 5 State HW 135 Bridge (west side of weir)

Date	Time hrs	Observed Flow Direction	Depth M	Temp. °C	DO mg/l	pH su	Cond. µmhos/cm	Salin. ppt	<>	NH_3 mg/l	<>	NO_3+NO_2 mg/l	<>	PO_4 mg/l	<>	TKN mg/l	<>	TSS mg/l	<>	TDS mg/l	Turbidity NTU	<>	F.Coliform col/100ml
4/1/99	1130	in	surf. 0.1	nd	nd	nd	nd	nd	<	0.01		0.005		0.034	<	0.10							470
5/20/99	1025	out	surf. 0.1	27.65	4.30	6.88	18330	10.8		0.01	<	0.005		0.034		0.83	<	5		7500	4.9		220
			mid. 0.65	30.03	1.85	6.74	32720	20.3															
			btm. 1.3	29.27	0.08	6.76	35700	22.8															
6/2/99	1030	none	surf. 0.1	29.93	3.30	7.01	36260	23.0		nd		nd		nd		nd		nd		nd	nd		8
			mid. 0.75	30.00	2.07	6.93	38730	24.8															
			btm. 1.5	29.93	2.24	6.94	39070	24.9															
7/7/99	1005	out	surf. 0.1	30.82	2.44	6.86	17500	10.2		0.04		0.021		0.044		1.20		7		11100	4.4		68
			mid. 0.5	31.93	1.58	6.84	24900	15.0															
			btm. 1.0	32.35	0.66	6.83	29700	18.5															
8/24/99	1210	out	surf. 0.1	32.47	2.16	6.85	17680	10.3		0.08		0.040		0.078		0.98		10		10500	8.5		4
			mid. 0.7	33.07	0.35	6.78	25790	15.6															
			btm. 1.4	33.05	0.50	6.80	25720	16.0															
9/21/99	1155	in	surf. 0.1	26.35	4.40	7.06	44750	28.5	<	0.01	<	0.005		0.045		0.62		22		31500	7.0		340
			mid. 0.7	26.60	5.03	7.35	45580	29.6															
			btm. 1.4	26.69	5.17	7.48	46000	29.8															

Little Lagoon Watershed Site Specific Samples
LLSS - 6 Bayou Village Canal Mouth

Date	Time hrs	Observed Flow Direction	Depth M	Temp. °C	DO mg/l	pH su	Cond. µmhos/cm	Salin. ppt	<>	NH_3 mg/l	<>	NO_3+NO_2 mg/l	<>	PO_4 mg/l	<>	TKN mg/l	<>	TSS mg/l	<>	TDS mg/l	Turbidity NTU	<>	F.Coliform col/100ml
4/1/99	1200	out	surf. 0.1	nd	nd	nd	nd	nd	<	0.01		0.007		0.038	<	0.10							670
5/20/99	1050	out	mid. 0.4	27.82	5.32	7.59	44500	28.6	<	0.01	<	0.005		0.028		0.61		11		19800	4.8	>	400
6/2/99	1050	none	surf. 0.1	29.17	4.25	7.36	44600	28.7		nd		nd		nd		nd		nd		nd	nd		76
			mid. 0.35	28.99	4.28	7.39	44340	29.2															
			btm. 0.7	28.64	4.43	7.54	46200	30.3															
7/7/99	1040	out	surf. 0.1	30.29	4.11	7.23	32880	20.7	<	0.01		0.012		0.044	<	0.10		12		25300	6.7		50
			mid. 0.3	30.43	3.90	7.42	39220	24.6															
			btm. 0.6	30.41	4.02	7.43	40690	26.1															
8/24/99	1230	out	surf. 0.1	33.54	4.92	7.37	28730	18.0	<	0.01	<	0.005		0.050		0.85		27		19600	7.4		60
			mid. 0.4	32.52	4.25	7.55	77000	23.9															
			btm. 0.8	32.39	3.35	7.53	38450	24.4															
9/21/99	1120	none	surf. 0.1	26.60	5.69	7.81	46850	30.5		0.01	<	0.005		0.053		0.64		27		31700	10.3		142
			mid. 0.4	26.60	5.67	7.81	46910	30.5															
			btm. 0.8	26.58	5.70	7.81	47000	30.5															

Little Lagoon Watershed Site Specific Samples
LLSS - 7 Windmill Ridge Rd Bridge

Date	Time hrs	Observed Flow Direction	Depth M	Temp. °C	DO mg/l	pH su	Cond. µmhos/cm	Salin. ppt	<>	NH_3 mg/l	<>	NO_3+NO_2 mg/l	<>	PO_4 mg/l	<>	TKN mg/l	<>	TSS mg/l	<>	TDS mg/l	Turbidity NTU	<>	F.Coliform col/100ml
4/1/99	1210	out	surf. 0.1	nd	nd	nd	nd	nd		0.09		0.007		0.043	<	0.10		nd		nd	nd		380
5/20/99	1115	out	mid. 0.3	27.98	5.13	7.58	44200	28.5	<	0.01	<	0.005		0.039		0.88		43		28500	7.0		138
6/2/99	1110	out	mid. 0.3	28.91	3.62	7.50	46970	30.6		nd		nd		nd		nd		nd		nd	nd		154
7/7/99	1110	out	mid. 0.2	30.82	4.48	7.53	38650	24.6	<	0.01		0.012		0.047		0.10		8		27400	6.6		68
8/24/99	1250	out	mid. 0.2	33.02	4.82	7.66	34230	21.7	<	0.01		0.026		0.049		0.73		24		19100	7.3		50
9/21/99	1100	none	mid. 0.35	26.49	5.00	7.63	44340	28.5	<	0.01	<	0.005		0.046		0.64		12		29000	5.7	>	400

Little Lagoon Watershed Site Specific Samples
LLSS - 8 Little Lagoon Pass

Date	Time hrs	Observed Flow Direction	Depth M	Temp. °C	DO mg/l	pH su	Cond. µmhos/cm	Salin. ppt	<>	NH_3 mg/l	<>	NO_3+NO_2 mg/l	<>	PO_4 mg/l	<>	TKN mg/l	<>	TSS mg/l	<>	TDS mg/l	Turbidity NTU	<>	F.Coliform col/100ml
4/1/99	1225	out	surf. 0.1	nd	nd	nd	nd	nd	<	0.01	<	0.005		0.042	<	0.10		nd		nd	nd		115
5/20/99	1125	in	mid. 0.25	26.35	6.65	8.08	46090	30.0	<	0.01	<	0.005	<	0.005		0.42		18		30300	1.0	<	2
6/2/99	1130	in	mid. 0.25	27.55	6.35	8.07	45680	29.7		nd		nd		nd		nd		nd		nd	nd		64
7/7/99	1140	out	mid. 0.25	29.91	4.91	7.86	44210	28.6	<	0.01		0.022		0.044	<	0.10		29		31800	7.0		64
8/24/99	1310	out	mid. 0.25	31.80	7.59	8.08	49370	32.0	<	0.01		0.037		0.047		0.81		51		32800	8.4		4
9/21/99	1040	none	mid. 0.25	26.77	5.69	7.90	48710	31.8		0.01		0.020		0.053		0.55		38		32800	15.2		4

Little Lagoon Watershed Site Specific Samples
LLSS - 9 Little Lagoon West End

Date	Time hrs	Observed Flow Direction	Depth M	Temp. °C	DO mg/l	pH su	Cond. µmhos/cm	Salin. ppt	<>	NH_3 mg/l	<>	NO_3+NO_2 mg/l	<>	PO_4 mg/l	<>	TKN mg/l	<>	TSS mg/l	<>	TDS mg/l	Turbidity NTU	<>	F.Coliform col/100ml
4/1/99	1240	none	surf. 0.1	nd	nd	nd	nd	nd		0.02		0.006		0.021		1.60		nd		nd	nd	<	3
5/20/99	1150	none	mid. 0.4	28.70	6.42	7.98	48430	31.6	<	0.01		0.005		0.024		0.99		22		32200	6.4	<	2
6/2/99	1155	none	mid. 0.4	27.75	5.21	7.95	47860	31.4		nd		nd		nd		nd		nd		nd	nd	<	2
7/7/99	1200	none	mid. 0.4	30.47	6.44	8.01	45230	29.4	<	0.01		0.013		0.051		0.25		25		32600	9.0		2
8/24/99	1330	none	surf. 0.1	32.35	6.28	8.01	47390	30.9	<	0.01		0.040		0.072		0.82		46		32400	17.3		6
			mid. 0.35	32.26	6.30	8.02	48000	32.0															
			btm. 0.7	31.91	6.08	8.03	47110	31.1															
9/21/99	1010	none	surf. 0.1	26.20	5.90	7.92	50390	33.1	<	0.01	<	0.005		0.045		0.65		26		34400	9.3		12
			mid. 0.55	26.17	5.94	7.92	50390	33.1															
			btm. 1.1	26.09	5.97	7.92	50360	33.1															