Assessment of Freshwater Inflows to North Bay from the Deer Point Watershed of the St. Andrew Bay System

Water Resources Assessment 08-01

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INTRODUCTION

The St. Andrews Bay Watershed covers about 750,000 acres in Bay, Calhoun, Gulf, Jackson, Walton and Washington counties with about 61 percent of the watershed located in Bay County (SWIM 2000). The watershed includes the Deer Point Lake Reservoir; St. Andrews, West, North and St. Joseph bays. The primary source of water into the St. Andrew Bay system is from the Deer Point Lake Reservoir. The Deer Point Lake Reservoir is also the major water source in Bay County, protection and preservation of this vital resource is a high priority for NWFWMD and Bay County.

The population in Bay County more than doubled between 1940 and 1950 from 20,686 to 42,689. The increased demand from this influx of new residents put a strain on local groundwater resources which provided most of the water used in the county. Rapid declines in groundwater levels and salt water intrusion created the need for an alternate water supply resource. To alleviate the salt contamination of wells and provide a reliable fresh water source, a surface water reservoir was proposed. In addition to providing ample drinking water, a reservoir was also desired for its recreation potential. A Special Act of the Legislature in 1957 gave the County permission to build and operate the reservoir.

A sheet pile dam was constructed across a narrow portion of North Bay at Deer Point, about three miles northeast of Lynn Haven. Deer Point Lake, which is impounded by the dam, covers from 4,500 to 5,500 acres, depending on the source cited, and has a storage volume of about 32,000 acre-feet. Impoundment of fresh water in Deer Point Lake began with the closing of the dam on November 17, 1961, and water began flowing over the spillway on November 29, 1961 (Toler et al. 1964).

Currently, about 600 million gallons per day enter the Deer Point Lake reservoir and about 50 million gallons per day are withdrawn from the Deer Point Lake reservoir for industrial and potable use (Bay County Utility Department). The reservoir supplies over 80 percent of the potable water to the population in Bay County. After water use withdrawals from the reservoir, about 550 million gallons of water flows over the dam into North Bay and the St. Andrews Bay system. The population in Bay County has grown to about 161,500 and is projected to grow to about 196,600 by the year 2025. The water use demands are projected to be about 79.5 million gallons per day by 2025.

As of 2006, over 41,149 acres along Econfina Creek and in the Econfina Recharge Area (ERA) have been purchased by the NWFWMD for protecting the future use and quality of the reservoir and the natural systems. The District purchased about 31,400 acres in the Sand Hill Lakes area that provides vital water recharge protection for the Deer Point Water Lake Reservoir. The Sand Hill Lakes area has an average recharge rate of approximately 30 inches a year which is one of the highest recharge areas in the District. This also means this area is highly susceptible to potential contamination if not properly protected.

This report assesses the current and long term fresh water inflows into the Deer Point Lake Reservoir and potential impacts of additional withdrawals from the reservoir on North Bay. The report includes three components: a biological characterization of North Bay, a watershed hydrologic model assessment of the Deer Point Lake watershed and a hydrodynamic model analysis of North Bay. The additional future withdrawals from the Deer Point Lake reservoir are examined to determine potential impacts on the biological communities and natural systems in North Bay.

1.0. NORTH BAY RESOURCE CHARACTERIZATION

1.1 General Description

The St. Andrew Bay estuarine system is located approximately midway in the panhandle of Florida in the Gulf Coastal Lowlands physiographic region. The system consists of four, interconnecting waterbodies, West, North, St. Andrew, and East Bays (Figure 1.1), with a combined surface area of about 59,600 acres (SWIM 2000). The bays extend approximately 31 miles (roughly northwest to southeast) along an axis parallel to the Gulf of Mexico and 13.5 miles inland (Keppner and Keppner 2001). Average depth has been reported to be from 17-27 feet, depending on the source (Keppner and Keppner 2001), with a maximum depth of 65 feet.

Historically, St. Andrew Bay had two passes into the Gulf of Mexico, a man-made pass located at the west end of Shell Island (West Pass) and one natural pass located at the east end of Shell Island (East Pass). West Pass was artificially cut in 1934 and is maintained to provide the primary navigation channel to the Gulf. East Pass is affected by natural processes in the nearshore Gulf and as such has been subject to frequent shoaling and closure. The pass is closed presently, although attempts are underway for its reopening. Historically, the majority of water exchange between the Bay and the Gulf occurred through East Pass. The Gulf Intracoastal Waterway (GIWW) traverses the system from west to east, entering on the western side of West Bay at West Bay Creek and exiting to the east through Wetappo Creek at the easternmost extension of East Bay. Some water is exchanged with Choctawhatchee Bay to the west and Lake Wimico and Apalachicola Bay to the east via the GIWW (Blumberg and Kim 2000).

St. Andrew Bay system differs significantly from other panhandle Florida estuaries in that there are no major freshwater inflows. The system naturally receives an average of 1,266 cubic feet per second (cfs) of freshwater of which about 60% enters from Econfina and Bear Creeks through Deer Point Lake. Discharge in Econfina Creek is continually supplied by groundwater springs from the Floridian Aquifer (Musgrove et al. 1964). The remaining 40% of the freshwater inflow enters through several tributaries to West Bay (Crooked Creek with about 24 cfs and Burnt Mill Creek with about 36 cfs) and East Bay (Wetappo Creek with about 124 cfs and Sandy Creek with about 108 cfs). Other tributaries contribute minor amounts to the estuary's water budget (see Blumberg and Kim 2000 for the most recent estimates of water budget). As a result of the low freshwater inflow, deep basin, and strong influence of Gulf of Mexico water, the St. Andrew Bay system is characterized as a relatively deep, clear-water, high salinity system (Keppner and Keppner 2001).

Deer Point Reservoir is located in the upper reach of North Bay approximately eight miles north of Panama City. The reservoir has a surface area of about 4,572 acres which drains a watershed of about 282,880 acres (SWIM 2000). The reservoir was created in 1961 through construction of a low dam across the head of North Bay. When the dam was constructed, saltwater which naturally occurred in the upper reaches of North Bay was flushed from out of the system forming the water supply reservoir and Deer Point Lake. The reservoir impounds flow from Econfina, Bear, Bayou George, and Cedar Creeks and now serves as the primary source of drinking water for most of the municipalities in Bay County (SWIM 2000). On average, Deer Point Dam discharges approximately 800 cfs (517 million gallons per day), to North Bay.

Figure 1.1. The St. Andrew Bay estuary.

The area of North Bay immediately below the Deer Point dam was identified as the only major, truly estuarine part of the St. Andrew system (Ogren and Brusher 1977). As such, it is one of the most productive areas of the system.

1.2 History of Deer Point Lake

Bay County officials began the planning for Deer Point Reservoir as early as the late 1940s due to rapid increases in the tourist trade and the industrial sector, primarily the paper industry which required millions of gallons per day for operations. As growth in the County increased, local ground water supplies proved inadequate resulting in a declining water table. In 1955, intrusion of salt water was noted (Taylor 1979). To alleviate the salt contamination of wells and provide a reliable fresh water source, a surface water reservoir was planned. In addition to providing ample drinking water, a reservoir was also desired for its recreation potential. A Special Act of the Legislature in 1957 gave the County permission to build and operate such a storage facility.

A sheet pile dam was constructed across a narrow portion of North Bay at Deer Point, about three miles northeast of Lynn Haven. The crest of the dam was set at 4.5 feet above mean sea level and extended 1400 feet as a fixed spillway (Toler et al. 1964). Deer Point Lake, which is impounded by the dam, covers 4,572 acres and has a storage volume of about 32,000 acre-feet. Impoundment of fresh water in Deer Point Lake began with the closing of the dam on November 17, 1961, and water began flowing over the spillway on November 29, 1961 (Toler et al. 1964).

A study was conducted by the U. S. Geological Survey and the Florida Geological Survey (Toler et al. 1964) to investigate the freshening of the lake. Shortly after the dam was closed (with the reservoir about half full, i.e., about 16,000 acre-feet), average chloride concentration was estimated at 7,400 ppm. Average seawater chloride concentration is about 19,000 ppm. At the time of spillway overflow, when the lake storage was about 32,000 acre-feet, chloride concentration was reduced to about 3,700 ppm. Chloride dropped steadily during the two months following dam closure, stabilizing at below 100 ppm by May 1962. Given the fresh water inflows recorded during the first year of operation, an average fill time of 21 days was estimated (Toler et al. 1964).

Prior to impoundment, the upper portion of North Bay had a mud bottom and averaged from four to five feet in depth. Four tributary streams flowed into this area of the bay: Cedar Creek coming in from the northwest and originating in the vicinity of Court Martial Lake; Econfina Creek coming in from the north, originating in Jackson County and flowing south through southeastern Washington County and northern Bay County where its flow is greatly increased by numerous limestone springs; Bear Creek from the northeast; and Bayou George originating in the Gaskin Wildlife Management Area on the eastern edge of Bay County. The mouths of Cedar Creek and Bayou George were fringed with saltmarsh, primarily black needlerush, and were overlooked by bluffs vegetated with live oaks, magnolia and cabbage palms (Taylor 1979).

Although the primary purpose of the reservoir was to provide water for domestic and industrial use throughout the County, the recreation and sport fishing opportunities were not overlooked. To this end, the Florida Game and Fresh Water Fish Commission initiated a study prior to dam construction to assist them in developing fishery management plans (Crittenden et al. 1957).

These collections provide some of the only pre-dam information for fishes in this portion of North Bay and are discussed in detail in the Biological Community section of this report. The study included sites in North Bay, the mouths of Cedar Creek and Bayou George and several locations in the upper reaches of the various tributaries. As expected, brackish water stations yielded primarily marine species with a few fresh water species present; fresh water stations were inhabited predominantly by fresh water fishes yet were invaded by several euryhaline marine species.

Interestingly, this study addressed two of the only environmental questions raised related to the proposed impoundment: (1) Is there a large enough source pool of freshwater fish in the tributaries to populate the new lake? (2) Will there be any significant survival of marine species in the lake after impoundment to compete with the expanding freshwater fish populations? The study concluded that there were ample freshwater populations in the tributaries to expand into the reservoir and that survival of marine species was highly unlikely. There apparently was little concern over the conversion of estuarine wetlands, grass beds and/or submerged estuarine soft bottom habitat to that of freshwater.

Shortly after dam construction and reservoir filling, the impoundment began to experience excessive growth of submerged aquatic vegetation, in particular, Eurasian watermilfoil (*Myriophyllum spicatum*). In an attempt to control this overabundance of plant growth, grass carp from the Amur River of Mongolia were introduced into the lake beginning in 1975, with several subsequent introductions. These fish have had only limited success in controlling the exotic vegetation. To assist with vegetation control, lake drawdowns were begun in the late 1970s; these too have met with limited success. Recently, another aquatic weed, lemon bacopa (*Bacopa caroliniana*), has become problematic in the lake. The annual aquatic plant survey conducted by the Department of Environmental Protection in September 1999 indicated that approximately 60% of the lake was covered with aquatic vegetation; of this, nearly 40% was lemon bacopa. Lake drawdowns are generally scheduled during winter months in an effort to expose submerged vegetation to subfreezing temperatures. A combination of air exposure and low temperatures can significantly enhance mortality of the rooted plants. The most recent drawdown was scheduled for January 2006.

The uniqueness and value of the reservoir was recognized as early as 1967 with the passage of a State law defining the watershed and prohibiting certain activities such as sewage and waste disposal and septic tank setbacks within it. This law defined the Deer Point Lake Watershed as primarily an area immediately around the reservoir and the lower reaches of the major tributaries, but did not define the actual hydrologic watershed.

To further conserve the natural resources of the lake, several designations have been conferred on the area, each of which provides a layer of resource protection. The lake and its major tributaries were designated as Class 1 (Potable Water Supplies) surface water bodies under Florida law to protect the primary drinking water supply for the County. In 1988, the lake was placed on the Surface Water Improvement and Management (SWIM) priority water body list by the Northwest Florida Water Management District (NWFWMD). The SWIM Act of 1987 directed each water management district to prioritize the surface waters within its jurisdiction and develop and implement plans for preservation and restoration of the priority water bodies.

A SWIM plan for the Deer Point Reservoir was developed in 1988 and revised in 1991. The major focus of the Deer Point Lake SWIM program was to document existing conditions of the lake and watershed such that strategies could be developed to ensure the preservation of water quality and natural resources. As a part of this program the NWFWMD undertook a series of projects related to land use description (Rains and Wiley 1990; Rains and Macmillan 1991), non-point source pollution assessment (Rains and Wiley 1990; Latham and Cairns 1994), water quality (FDER and NWFWMD 1992) and identification of sensitive areas (O'Rourke et al. 1993) within the watershed. These efforts culminated with a number of recommendations (Cairns et al. 1994), primarily directed towards local land use planning and land development regulations. Additional work examined the contribution of ground-water to the surface waters resources of Econfina Creek and Deer Point Lake (Richards 1997). This included development of a groundwater model to delineate the area of recharge that contributes to the flow of Econfina Creek.

Following the initial SWIM studies in the early 1990s and Richards work, the NWFWMD shifted the focus of their activities to water quality protection through land acquisition. Using Preservation 2000 and Save Our Rivers funding, the NWFWMD began purchasing property along Econfina Creek and within the recharge area of the watershed. As of 2006, over 41,149 acres along Econfina Creek and in the Econfina Recharge Area (ERA) have been purchased by the NWFWMD for protecting the future use and quality of the reservoir.

To prevent potential water quality degradation in the lake, Bay County enacted the Deer Point Lake Protection Zone Ordinance in 1994. The Protection Zone encompassed an area larger than the Deer Point Watershed described by the 1967 Florida law, but does not include the entire hydrologic watershed. The primary features of the ordinance include a requirement for low density development, a 75-ft natural vegetation setback, stringent storm water runoff requirements, and the prohibition of certain incompatible land uses within the Protection Zone.

1.3 General Features of North Bay

North Bay is a relatively small shallow estuarine embayment located in the northern portion of the St. Andrew Bay system (Figure 1.2). North Bay has a mean depth of 5.9 feet and a surface area of approximately 6,700 acres (McNulty et al. 1972). The bay consists of a relatively shallow shelf peripheral to a deeper mid-bay channel (Figure 1.3). Surface hydrology is influenced primarily by the interaction of freshwater inflow from Deer Point Dam, Mill Bayou, Fanning Bayou, Beatty Bayou, and numerous small creeks and tidal exchange with the Gulf; tides and winds have minor and secondary influences.

1.3.1 Watershed/Drainage Basins North Bay is bordered by numerous small watersheds (Figure 1.4) which drain approximately 317,125 acres. The largest of these is the Deer Point Lake watershed which is subdivided into several smaller sub-basins (i.e., Econfina Creek, Bayou George Creek, Bear Creek, and Cedar Creek). Land use and land cover (Figure 1.5) in the vicinity of North Bay is predominantly residential with scattered commercial to the south and upland forest, wetlands, and limited residential to the north. Freshwater inflows to North Bay are dominated by discharge from the Deer Point Reservoir which, in turn, is primarily influenced by flow from Econfina Creek.

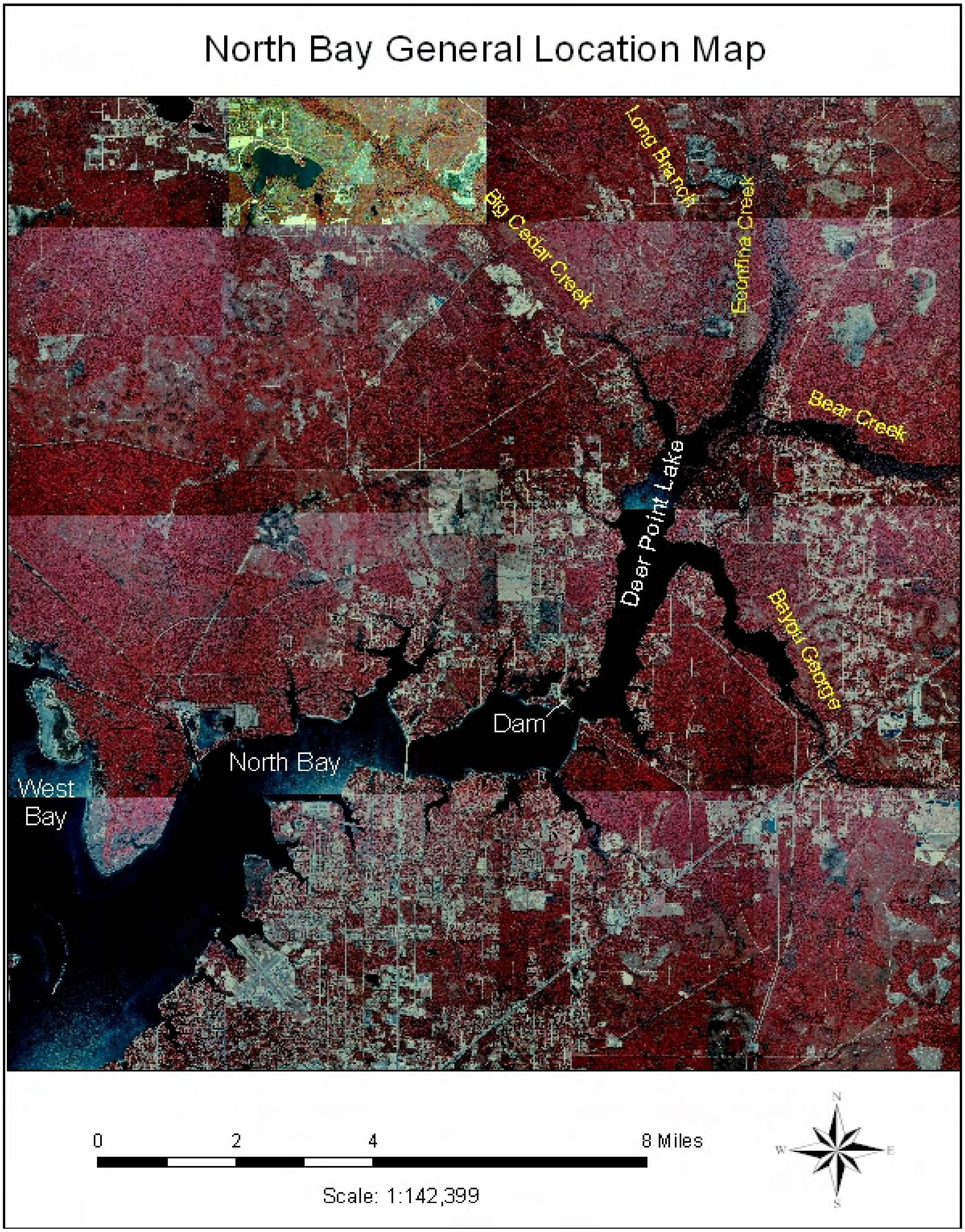

Figure 1.2. North Bay, including Deer Point Lake and its major tributaries. Base map is the 1999 Digital Orthophoto.

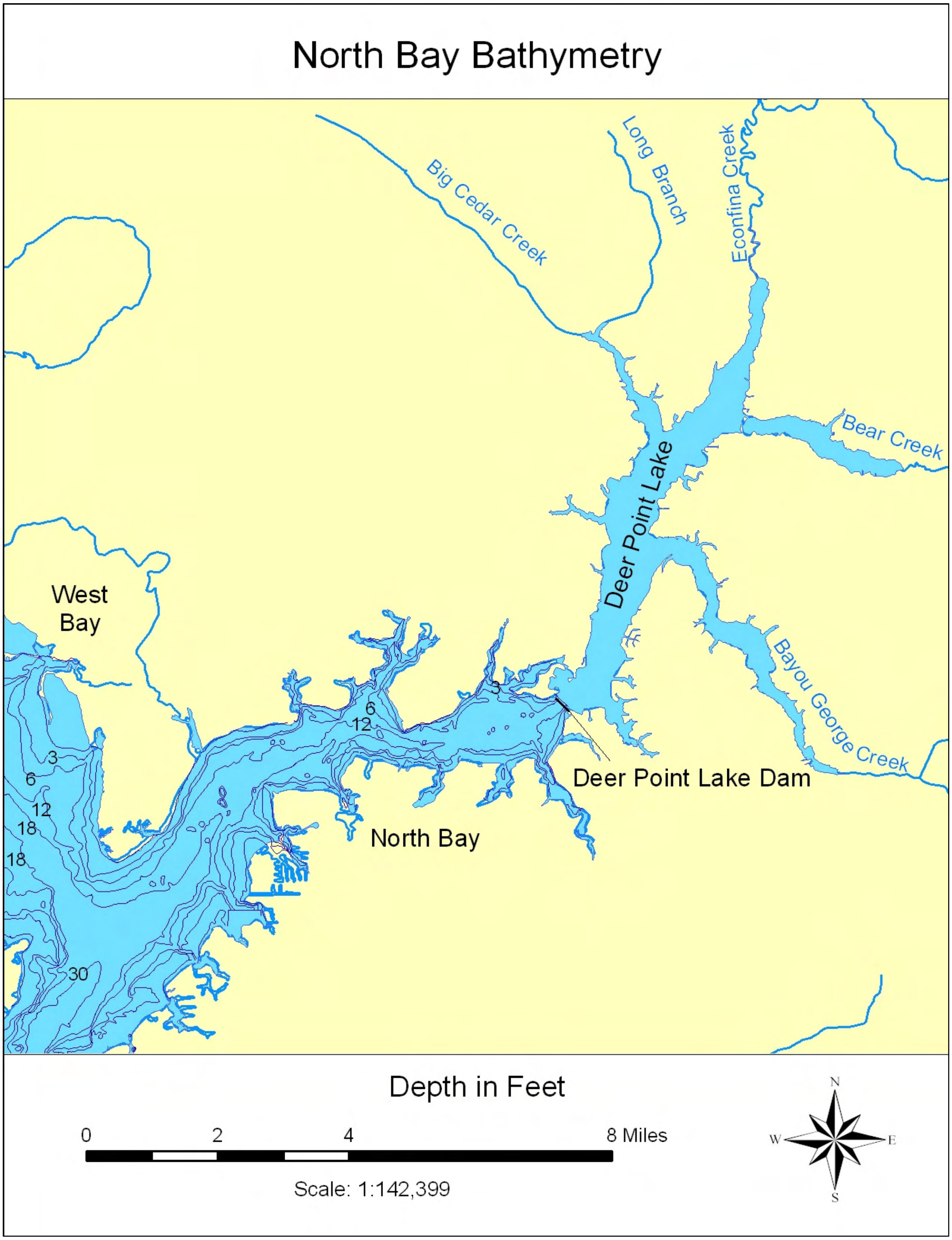

Figure 1.3. Bathymetry of North Bay. Depth contours are shown in feet.

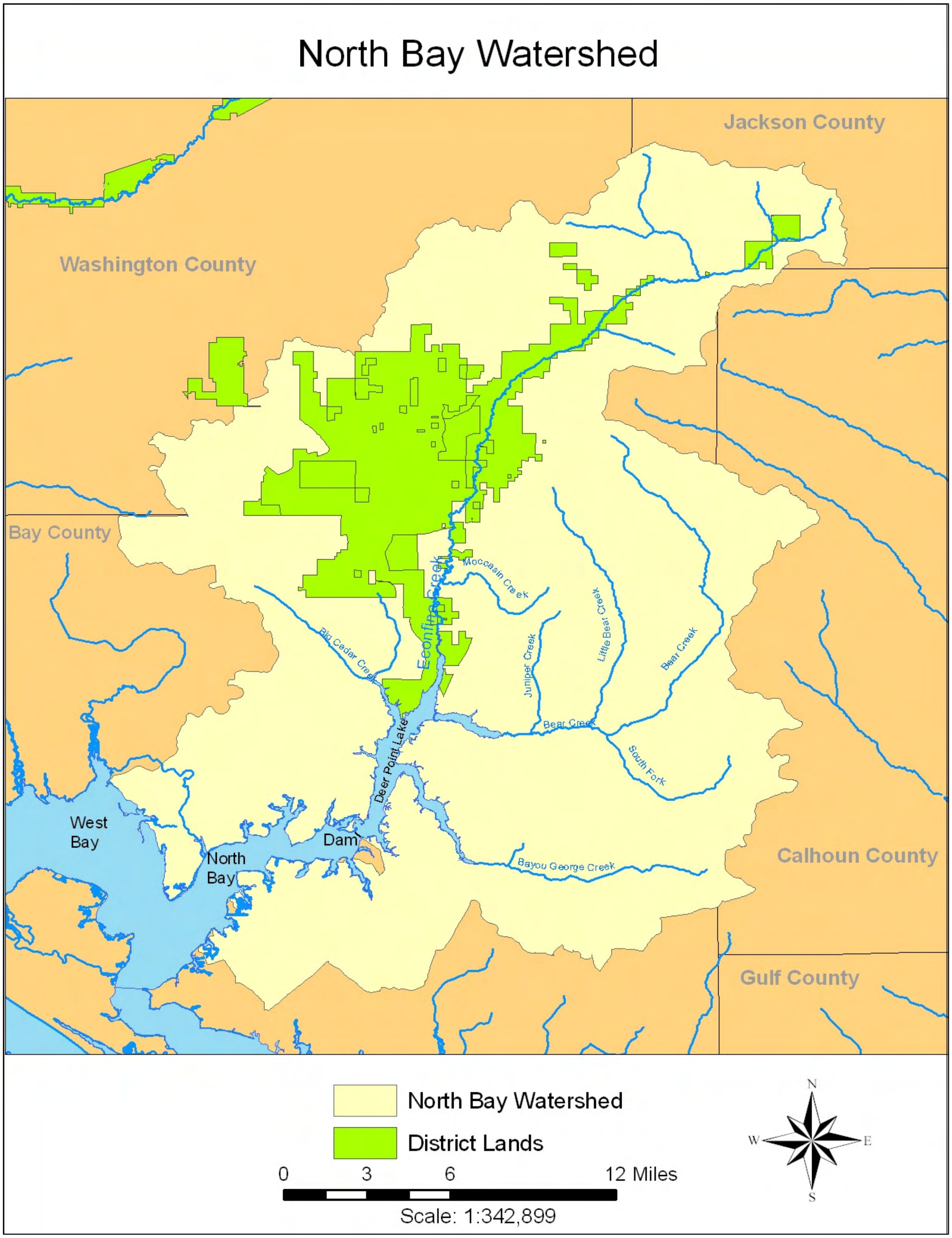

Figure 1.4. North Bay watershed including the location of lands owned by the Northwest Florida Water Management District.

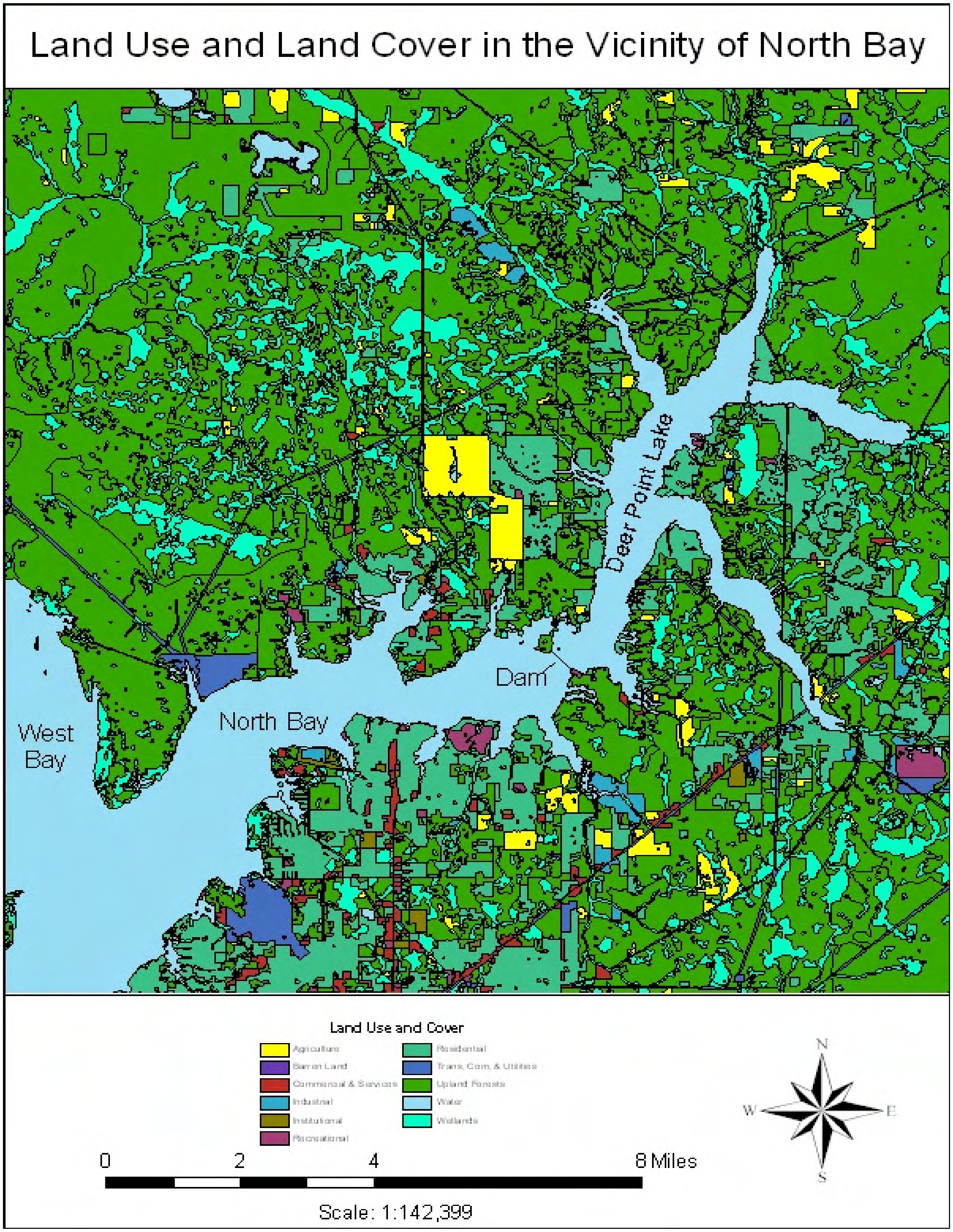

Figure 1.5. Land use and land cover in the vicinity of North Bay.

1.3.2 Water Quality Classifications Surface waters within the St. Andrew Bay are classified as Class I, II or III. These classifications are based on use, not by the actual quality of the water. Water bodies designated as Class I are Potable Water Supplies. These waters are used to supply drinking water and have the most stringent water quality standards. Class I waters include Deer Point Reservoir and its major tributaries: Bayou George Creek, Bear Creek, Cedar Creek, and Econfina Creek.

Class II waters are designated as Shellfish Propagation or Harvest areas. These areas have water quality standards focusing on particular components that affect the quality of the shellfish harvested to protect consumers from possible diseases associated with their consumption. All North Bay waters and tributaries north of U.S. Highway 98 to the Deer Point Dam are classified as Class II excluding Alligator and Fanning Bayous. North Bay is further delineated into the Eastern and Western conditionally approved areas (Figure 1.6). The Eastern Section is temporarily closed to harvesting when cumulative six-day rainfall, measured at the Vicksburg Forestry Tower, exceeds 1.96 inches or Econfina Creek stage, measured at Bennett FL, exceeds 6.51 feet. The Western Section is temporarily closed when cumulative six-day rainfall exceeds 1.91 inches or Econfina Creek stage exceeds 6.60 feet. Currently, commercial harvesting is prohibited in all bayous surrounding North Bay and conditionally approved in the main open water section of the bay (Figure 1.6). In addition, commercial harvesting was prohibited from a small area on the southern shore of North Bay including the Lynn Haven Boat Basin and the mouth of Anderson Bayou, effective at sunset on November 30, 2000.

Class III waters are designated to provide Recreation and Propagation of Healthy, Well-balanced Populations of Fish and Wildlife. Standards for these waters are not as stringent for most parameters as for the above discussed classes and are directed to maintaining biodiversity and water quality sufficient for human contact such as swimming (hence the name Fishable/Swimmable waters). All surface waters in North Bay not specifically listed as Class I or II are designated as Class III.

1.3.3 Water Quality Characteristics The existing water quality data set for St. Andrew Bay generally, and specifically for North Bay, suggests that the system is healthy. While poor quality is found in some bayous and tributaries, overall water quality throughout the main open-water areas of the system is good. The St. Andrew Bay Resource Management Association (RMA) has a continuing program of volunteer water quality sampling with data collected from 60+ locations from 1990 to present. The following water quality analysis is taken from the four open-water stations in North Bay (Figure 1.7). Analysis of environmental conditions in the various bayous and tributaries surrounding North Bay was excluded from this discussion because water quality in these areas is more influenced by their localized watersheds than by possible changes in freshwater discharge from Deer Point Lake. Water quality in North Bay proper is summarized in Table 1.1. Graphs of the water quality data are provided in Appendix A. Salinity in North Bay varies spatially and temporally, ranging from 0 to 37 ppt. Salinity generally increases with distance from the dam for both surface and bottom measurements. Mean surface salinity increased from 15.4 to 22.8 ppt while bottom salinity increased from 24.7 to 29.6 ppt between Station 1 and Station 4, respectively. Significant vertical stratification was noted at all sites, with overall surface and bottom salinities averaging 18.9 and 27.3 ppt, respectively. Dramatic swings in salinity values were observed over relatively short time intervals during the 12 years of

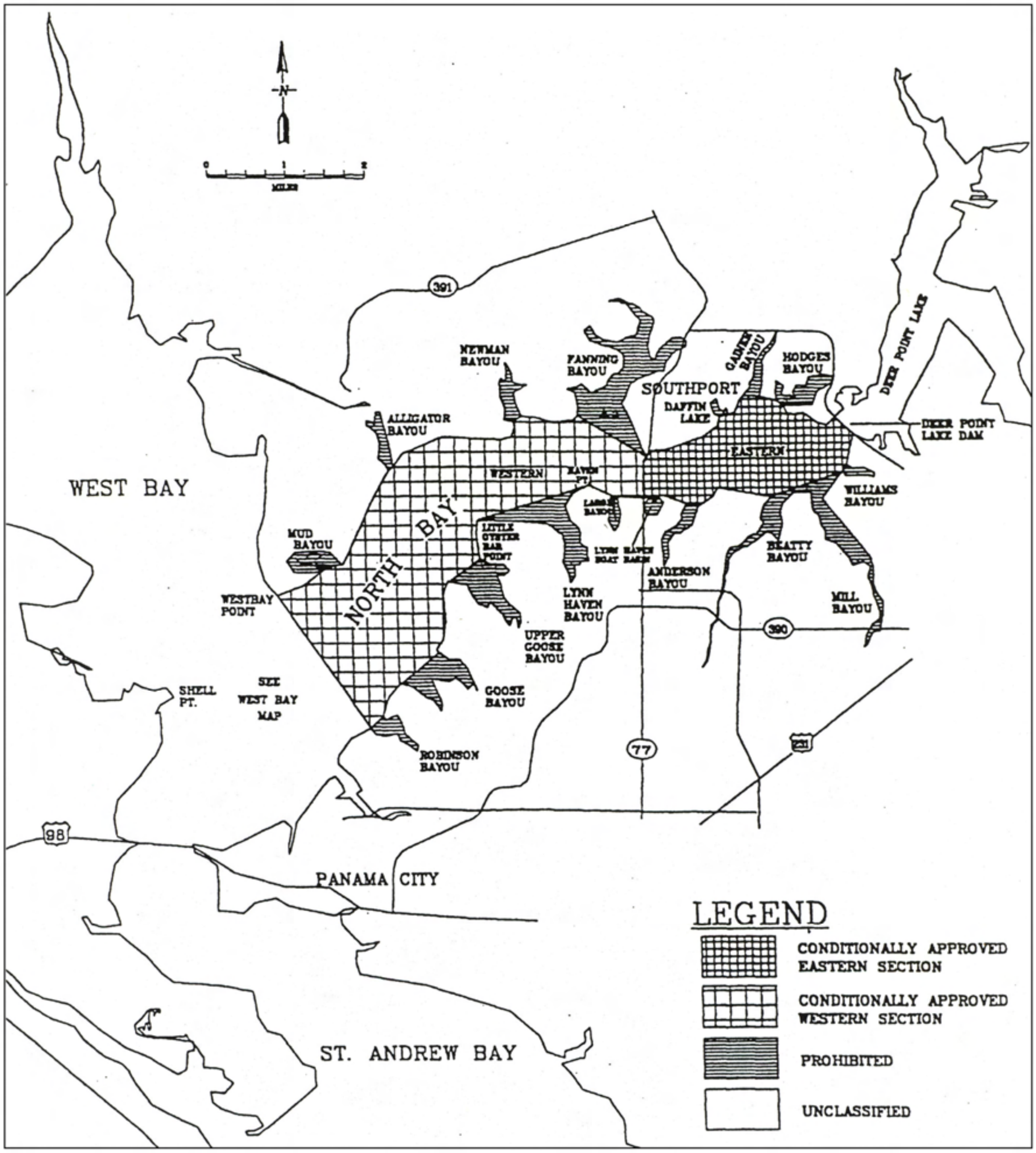

Figure 1.6. Classification of surface waters in North Bay (DEP 1999).

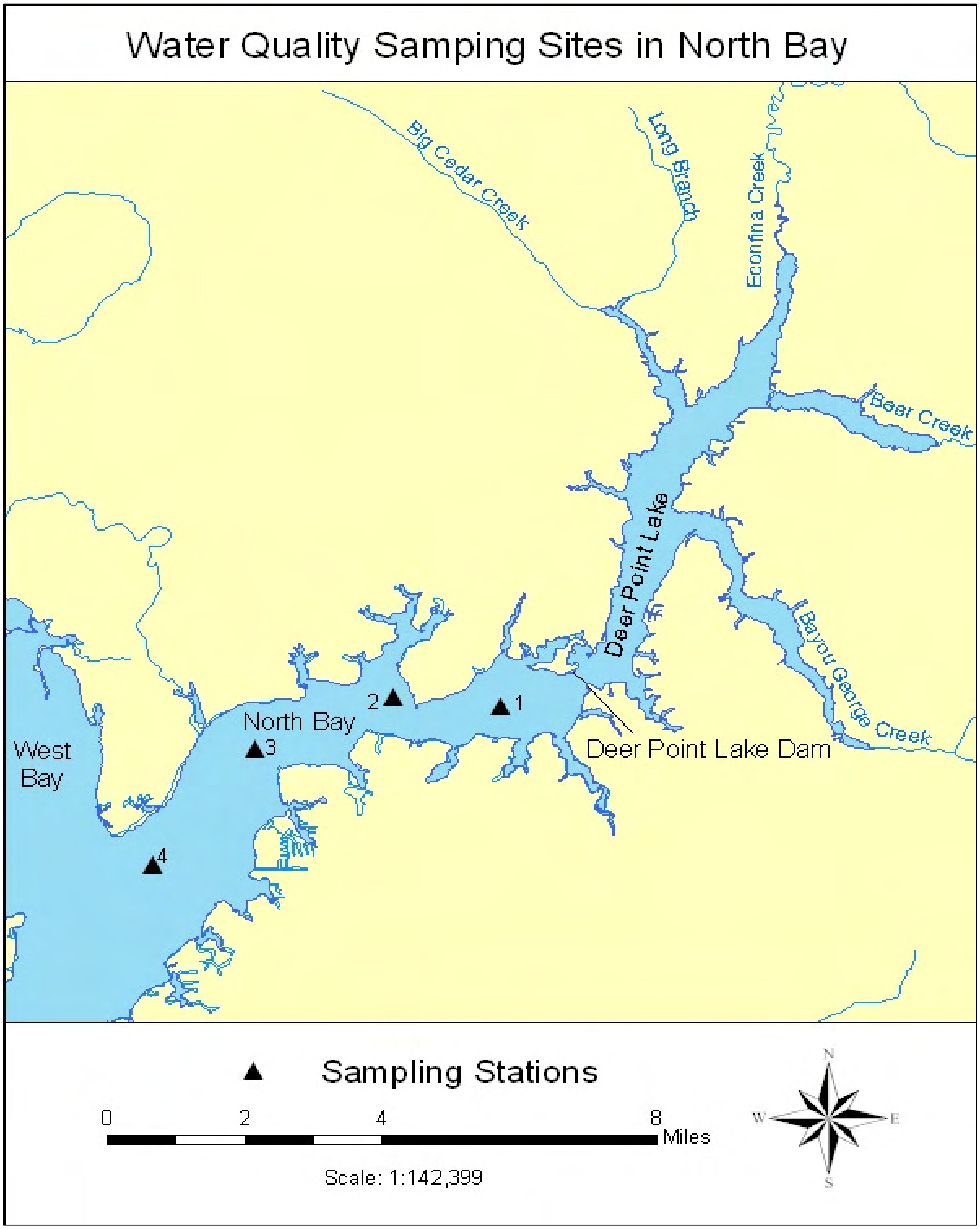

Figure 1.7. Open-water water quality sampling sites in North Bay. Sites are sampled by Baywatch, St. Andrew Bay RMA.

Table 1.1 Summary of water quality characteristics for North Bay locations (1990-2002). Units in table: depth (m), salinity (ppt), temperature (^{o}C), secchi (m), turbidity (NTU), dissolved oxygen (g/l), pH (standard units), total nitrogen (µg/l), total phosphorus (µg/l), chlorophyll-a (µg/l), and fecal coliforms (MPN). Data source: Baywatch, St. Andrew Bay RMA.

	Site	Depth	Salinity (surface)	Salinity (bottom)	Temp (surface)	Temp (bottom)	Secchi	Turbidity (surface)	Turbidity (bottom)
mean	NB-1	2.4	15.4	24.7	23.5	23.8	1.8	2	3.6
min			0	1	11	11	0.5	0	0.2
max			32.4	33.7	33	33	3	6.5	33
mean	NB-2	3.5	17.4	26.9	23	23.3	2	1.8	3.4
min			0	10	10	12	0.5	0.1	0.4
max			37	34.1	32	32	3.4	6.1	23.8
mean	NB-3	4.6	19.8	27.8	23	23.1	2.3	1.6	3.7
min			0	8	11	12	0.9	0.2	0.2
max			33	34.3	32	31	4.4	5.8	24.8
mean	NB-4	5.1	22.8	29.6	22.8	22.7	2.7	1.5	2.7
min			4	16.1	10.5	12	0.8	0.2	0
max			32	35	31	30.1	4.9	5.1	18.8
OVERALL									
mean		3.9	18.9	27.3	23.1	23.2	2.2	1.7	3.3
min			0	1	10	11	0.5	0	0
max			37	35	33	33	4.9	6.5	33

	Site		DO (surface)	DO (bottom)	pH (surface)	pH (bottom)	TN	TP	Chl-a	Fecal
mean	NB-1	2.4	7	5.5	7.9	7.9	271	12.6	2.6	181
min			3.4	1.2	5.7	6	110	3	0	0
max			12	12.1	8.7	8.6	630	27	10	995
mean	NB-2	3.5	7	5.6	7.9	7.9	267	12.3	2.9	64
min			3.3	1	6.5	6.1	90	5	1	0
max			11.3	10.8	8.8	8.7	980	21	15	540
mean	NB-3	4.6	7.1	5.5	8	7.9	260	12.7	2.9	77
min			3.1	1	6.4	6.3	70	5	0	0
max			11.5	14.8	8.8	8.6	550	32	11	920
mean	NB-4	5.1	7.1	5.8	8	8	239	11.4	2.6	6
min			2.9	1.6	6.4	6.7	70	4	1	0
max			9.8	10	8.8	8.8	440	19	6	49
OVERALL										
mean		3.9	7	5.6	7.9	7.9	259	12.2	2.7	83
min			2.9	1	5.7	6	70	3	0	0
max			12	14.8	8.8	8.8	980	32	15	995

observations; this appeared more conspicuous in surface rather than bottom salinity. Frequently surface salinities varied by as much as 20 ppt between monthly measurements; bottom salinity was noticeable more stable. Higher and less variable salinities were noted during the latter three years (1999-2002), coincident with drought conditions in the southeastern United States.

Salinity is related to freshwater discharge from Deer Point Lake as represented by flows from Econfina Creek. Both surface and bottom salinity at RMA Station 1, located in the upper reach of North Bay, were negatively correlated with Econfina Creek discharge over the last 11 years. These correlations, while significant, were weak with discharge explaining only 32 and 26% of the variation in surface and bottom salinities, respectively.

Temperature varied seasonally, ranging over the 12-year period from 10 to 33°C. Winter lows tended to vary more than summer highs. Temperature differed little between locations or depths. Water clarity was high at all locations in North Bay. Secchi depths averaged from 1.8 (Station 1) to 2.7 m (Station 4) with an overall mean of 2.2 m. In concordance, surface turbidity values were low ranging from 2.0 (Station 1) to 1.5 NTUs (Station 4). Bottom values were slightly higher and varied more at all sites than surface observations; high values were observed occasionally from bottom samples.

Dissolved oxygen was relatively high with surface values nearly always greater than bottom. Surface values averaged 7.0 mg/l across all locations and dropped below 4 mg/l only during the summer of 1996. On the other hand, bottom measurements were significantly lower than surface, averaging 5.6 mg/l, and frequently declined below 4 mg/l. Values below 2 mg/l were noted occasionally from bottom waters.

Nutrient concentrations were generally low throughout North Bay. Total nitrogen (TN) and total phosphorus (TP) averaged 259 µg/l and 12.2 µg/l, respectively. Both TN and TP generally decreased with distance from the dam. No seasonal trends were apparent for either nutrient.

Chlorophyll values were also low throughout the collection period, reflecting these low water column nutrient levels. Chlorophyll concentrations appeared relatively uniform among stations, averaging 2.7 µg/l overall. No trends were apparent either spatially or seasonally.

1.3.4 Sediment Characteristics Relatively little information exists on the physical nature of the sediments in North Bay. In general for St. Andrew Bay, grain size is related to depth with fine to medium grain quartz sands noted along the shallow shelf grading to fine silty clays and soft mud in the deeper areas. North Bay was characterized in this report as predominantly clayey silt – silty clay; however, none of the stations sampled were located near shore and 12 of the 15 stations were taken in bayous. North Bay sediments appear to have on the order of 3-4% TOC.

Two recent studies (Long et al. 1997; Brim 1998) focused on sediment contamination throughout St. Andrew Bay, with some sites in North Bay. Neither study provided detailed information on physical characteristics of the sediments sampled; grain size and TOC were discussed but not reported. Five of 31 locations (Long et al. 1997) and 15 of 105 sites (Brim 1998) were sampled in North Bay. Sediment quality from open water stations was good with low concentrations of metals, pesticides, PCBs, and PAHs. In addition, sediment toxicity tests indicated relatively low mortalities at these sites. Concentrations and toxicities were higher in samples collected from the surrounding bayous.

1.3.5 Habitats Associated with North Bay The North Bay watershed supports a variety of biotic communities and maintains a high level of biodiversity. Those habitats directly associated with surface waters of North Bay proper include: brackish wetlands, tidal salt marshes, seagrasses/submerged aquatic vegetation, soft and hard bottom.

Brackish wetlands. The brackish vegetation habitat includes both emergent and submergent plant forms. This habitat is primarily limited to salinities in the range of 0 to 15 ppt and is generally located along river mouths subject to tidal influence. Often the emergent portions of brackish marshes are dominated by sawgrass (*Cladium jamaicense*), but may contain large interspersed patches of black needlerush (*Juncus roemerianus*). In the underwater areas, various species of submerged aquatic vegetation (see below) often proliferate. No data are currently available to differentiate brackish wetlands from tidal salt marsh (see below). However, the presence of true brackish wetlands in North Bay is likely restricted to the immediate downstream vicinity of the dam and the heads of some of the tributary bayous which have sizeable freshwater inflows.

Tidal salt marsh. Salt marshes are similar to brackish marshes in that they serve as a transition between terrestrial and marine systems. Generally, salt marshes are intertidal and develop along relatively low energy shorelines. Unlike brackish marshes, they may be found under significantly more saline conditions. Salt marshes in the panhandle are usually characterized by large, fairly homogeneous expanses of dense black needlerush (*Juncus roemerianus*). Often they are accompanied on the waterward side by smooth cordgrass (*Spartina alterniflora*). The *Juncus* and *Spartina* zones are very distinctive and can be separated easily by elevation, with *Spartina* inhabiting the lower, regularly flooded zone, and *Juncus* found in higher, less flooded area. Frequently, additional species of cordgrass (*Spartina* spp.), salt grass (*Distichlis spicata*), various sedges (*Scirpus* spp.) and the common cane (*Phragmites australis*) occur.

Generally, tidal marshes can be divided into four ecological zones governing by elevation and extent of inundation: *Spartina alterniflora* zone, *Juncus* marsh, salt flats, and barrens (Wolfe et al. 1988). The *Spartina alterniflora* zone typically fringes tidal creeks and channels. A small landward increase in elevation permits development of lush *Juncus* stands that are by far the most extensive and conspicuous feature of the tidal marsh. *Juncus* plants may grow to 6-7 feet in height throughout the majority of the marsh declining to about one-half this height at the landward edge of the marsh near the flatwoods where they merge with the salt flats. Stunted plants of several genera typify the flats, especially *Salicornia*, *Batis*, *Borrichia* and *Aster*. The barrens are landward of the flats and consist of bare ground flooded by high tides for only brief periods. This infrequent tidal inundation coupled with long exposure to sunlight results in such high salt content of the soil that most plants are excluded.

Early estimates of tidal marsh habitat in the North Bay area (McNulty et al. 1972) indicated about 1664 acres (673 hectares) occurred. The largest contiguous tidal marsh area was located south of Little Oyster Point between Goose and Upper Goose Bayous. Smaller areas were located throughout most of the tributary bayous. More recent information, available from the

National Wetlands Inventory (NWI), indicated about 1060 acres of tidal marsh habitat adjacent to North Bay (Figure 1.8). It is unclear if the difference in these two estimates depicts recent habitat loss or differences in mapping methodologies between the two studies.

Seagrass/SAV. Seagrasses represent one of the most important habitats in the estuarine and nearshore environment. Seagrass beds support highly diverse and abundant floral and faunal communities and provide spawning, feeding, nursery and protective refugia for a wide array of aquatic organisms including many of recreational and commercial value. Seagrass beds in St. Andrew Bay are dominated by turtle grass (*Thalassia testudinum*) and shoal grass (*Halodule wrightii*). Other species include manatee grass (*Syringodium filiforme*), star grass (*Halophila engelmannii*) and widgeon grass (*Ruppia maritima*).

Vertical zonation of seagrasses generally correlates with tidal level in most shallow estuarine waters (Zieman 1987). *Halodule wrightii* and *Ruppia maritima* are abundant intertidally, with *Ruppia* preferring a somewhat lower level than *Halodule*; *Thalassia*, *Syringodium* and *Halophila* are found only below low water levels. Low or unusually high salinity may restrict or eliminate *Thalassia* and *Syringodium*. *Thalassia* and *Syringodium* are usually associated with stable, near-marine salinities (20-36 ppt), open coastal water, and subtropical to tropical temperatures. *Halodule* is generally found in more estuarine conditions (10-25 ppt), but also forms dense stands in open coastal, high-salinity regions, in areas of high water movement or in tidal flats where it is subject to exposure. *Ruppia* is most common in very brackish water (1-5 ppt), with meadows extending into the mouths of rivers (Dawes 1987).

Submerged aquatic vegetation (SAV) is the fresh/brackish water equivalent to seagrasses and includes such species as tapegrass (*Vallisneria americana*), pondweed (*Potamogeton* spp.) and widgeon grass (*Ruppia maritima*). SAV beds provide many of the same functions as seagrass beds, only in the fresh to oligohaline portions of the estuary.

Generally these species can tolerate only minor intrusion of salt for short periods of time and as such are limited to relatively narrow regions at the head of estuaries.

Submerged vegetation in the North Bay area was estimated to occupy about 1030 acres (417 hectares) in the early 1970s (McNulty et al. 1972). Although discussed as seagrass acreages, no data were presented to differentiate seagrass from SAV in these estimates. Submerged vegetation appeared to border most of the shoreline throughout North Bay, with widest expanse along the northwestern shore. More recent mapping by the U.S. Geological Survey from the early 1990s (Figure 1.9) indicated approximately 1283 acres of seagrass around North Bay. It is unclear if the difference in these two estimates depicts recent habitat increase or differences in mapping methodologies between the two studies. A new seagrass survey was completed in 2003 and will be incorporated in this analysis to assess potential trends in habitat acreage change.

Soft-bottom habitat. Unvegetated sand and mud bottoms make up the bulk of the bay bottom in St. Andrew Bay and its subareas, including North Bay. These bottoms, although devoid of most structure, are none-the-less quite productive in terms of infaunal organisms and the communities

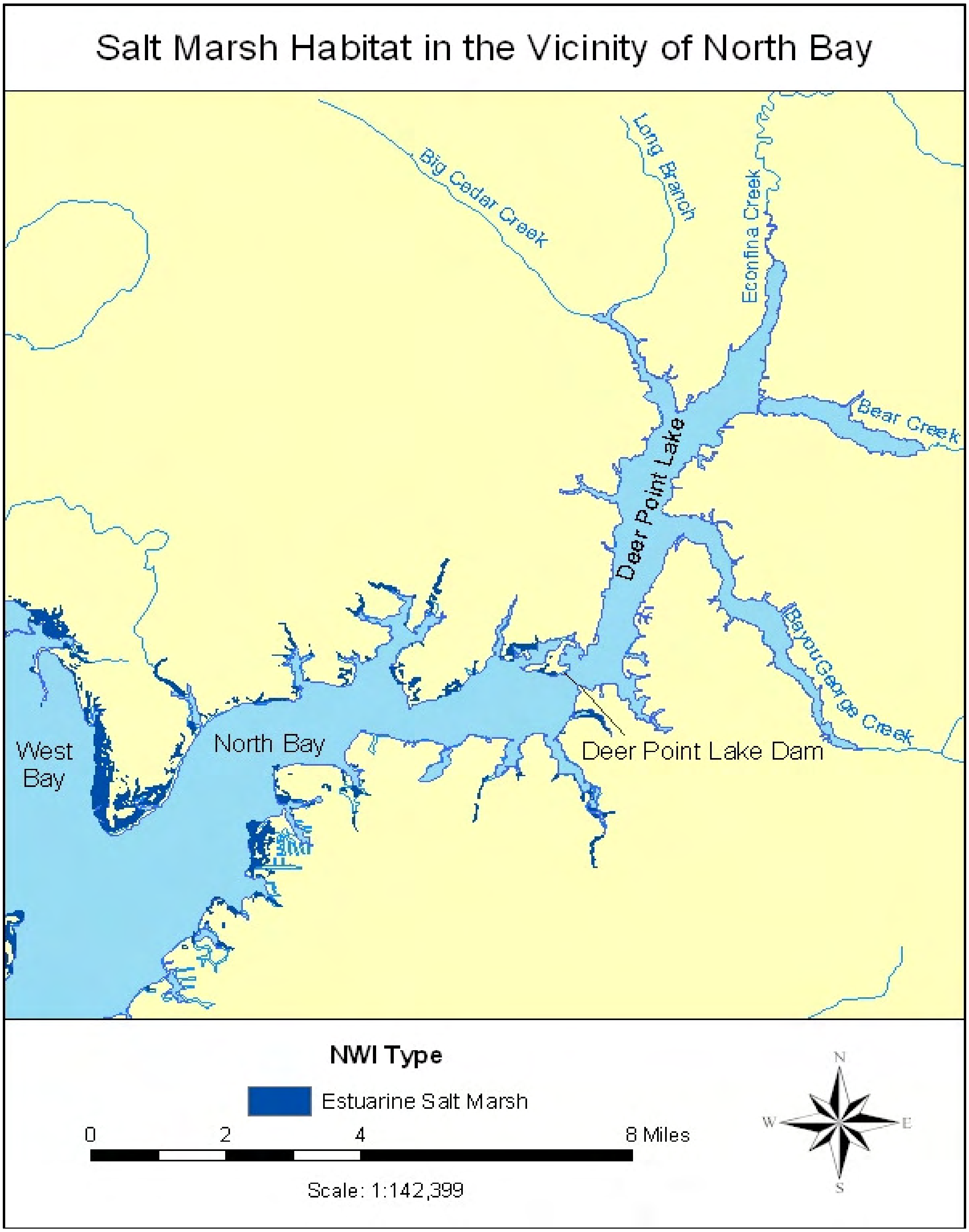

Figure 1.8. Estuarine salt marsh habitat in the vicinity of North Bay. Marsh coverage is based on National Wetlands Inventory (NWFWMD 1995).

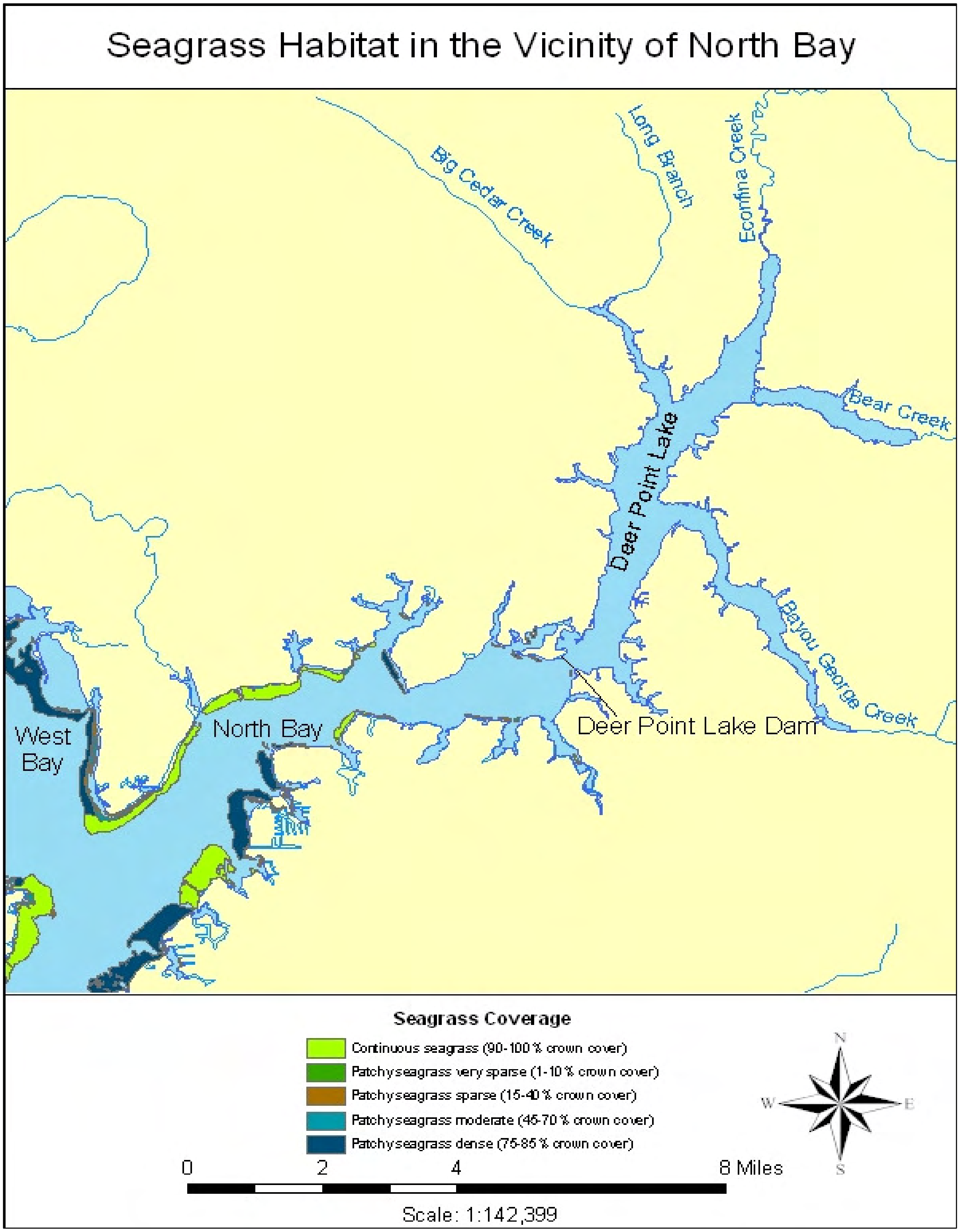

Figure 1.9. Seagrass habitat in the vicinity of North Bay. Seagrass coverage is based on U.S. Geological Survey mapping in the early 1990s.

they support. These areas serve as significant feeding habitat for a variety of fin and shellfish of recreational and commercial value.

Hard-bottom habitat. Most of the hard substrate habitat in panhandle estuaries is artificial, comprised of structures such as jetties, bridges, and pier pilings. Of the naturally occurring hard substrate habitats in this area, oyster reefs are the most abundant as well as ecologically and economically important.

The biology of the oyster has been extensively studied because of its economic interests (Galtsoff 1964; Kennedy et al. 1996). Oysters are typically reef building organisms, growing on the shell substrate accumulated from generations of oysters. They may occur in both intertidal and subtidal environments. The primary reef-building commercial oyster in the panhandle is the Eastern or American oyster (*Crassostrea virginica*). This species grows in a wide salinity range (10-30 ppt) with optimal growth occurring at water temperature of about 25^{o}C. Frequently reefs also contain large numbers of other bivalve mollusks such as horse oysters (*Ostrea equestris*) and hooked mussels (*Ischadium recurvum*).

The location and distribution of oyster reefs depend on many interacting factors which include complex combinations of geological, physical, chemical and biological processes. Reef oysters, although tolerant of broad ranges of important habitat variables such as temperature and salinity, are susceptible to various forms of physical disturbance and adversely affect or destroy reef structures. Success of the eastern oyster depends of factors that influence spawning, planktonic larval development, metamorphosis of the spat stage, and longevity of the sexually mature adult. Commercial harvesting, predation, disease and physical processes such as sedimentation (burial) are major causes of mortality in the developing oyster reefs. Water circulation is important for larval transport, settlement, delivery of food (phytoplankton), and removal of waste. Salinity is a key factor in the incidence of predation and disease, with both increasing with increasing salinity.

Estimates of the coverage of oyster habitat in North Bay appear to differ significantly. Early estimates indicated only limited available oyster habitat with approximately 15 acres (6 hectares) of reefs in North Bay (McNulty et al. 1972). This included four natural and 11 planted areas. Reports compiled by the Shellfish Environmental Assessment Section of the Department of Environmental Protection during the 1990s (DEP 1999) indicate at least eight bars (Figure 1.10) where commercial harvesting occurred; no acreages were provided. A recent survey provided by P. Couch, Florida Department of Agriculture and Consumer Service (personal communication) indicates more numerous reefs than previously thought. These areas include 13 natural reefs as well as 11 planted sites (Figure 1.11). Amounts and types of cultch material along with dates of when cultch was added are given for each of the planted sites (Appendix B, Table B-1).

<u>1.3.6 Biological Communities</u> Pre-dam study of the biological community in North Bay is limited to data collected by the Florida Game and Fresh Water Fish Commission between December 1956 and February 1957. This pre-impoundment survey was initiated to provide information on which to base future fisheries management plans for Deer Point Lake and included fish population sampling (Crittenden et al. 1957) and water quality analysis (Moody

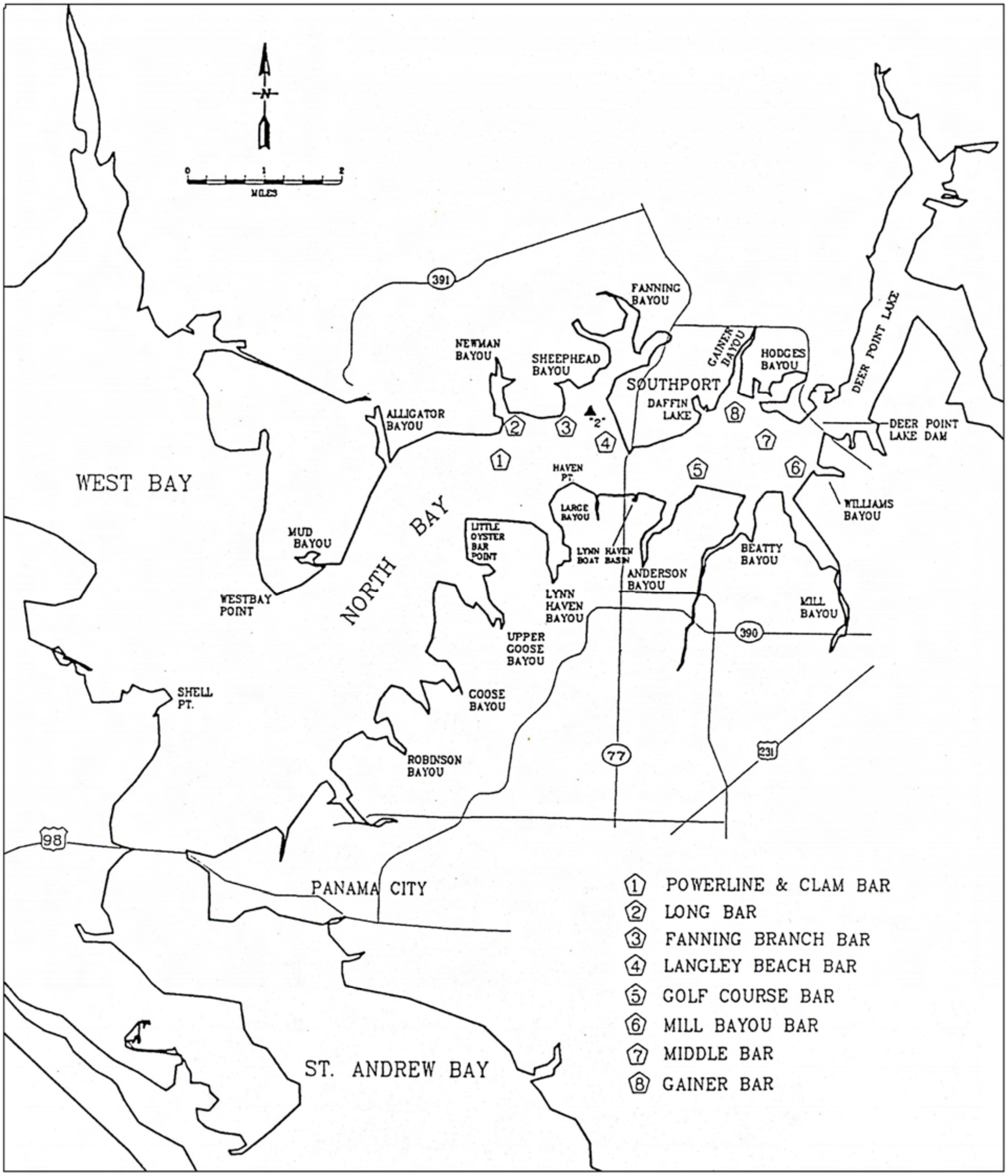

Figure 1.10. North Bay oyster bars (DEP 1999).

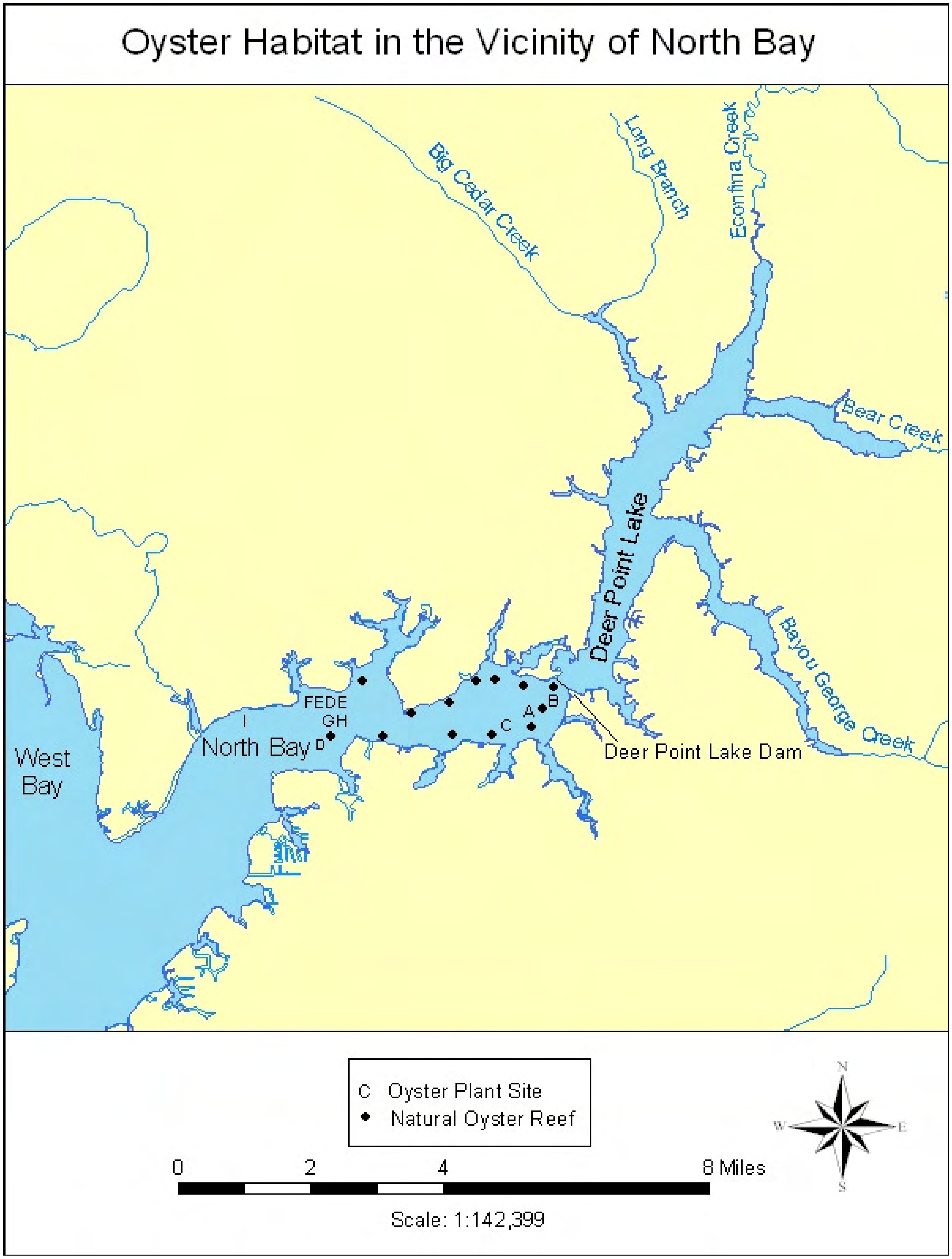

Figure 1.11. Oyster habitat in the vicinity of North Bay (FDACS 2003).

1956). Ten locations were sampled during the winter of 1956-1957 including one site in North Bay proper, five sites in brackish reaches of the major tributaries and four sites in the upper fresh water portions of the tributaries.

A summary of fishes collected from brackish water locations is given in Appendix B, Table B-2. These sites were dominated by a variety of oligohaline species commonly found in low salinity marsh habitats. Abundance and number of species were noticeable greater at the open-water site in North Bay (St. 2) and the lower Bayou George site (St. 4) compared to the other sites. The open-water site was dominated by striped mullet, pinfish, anchovies, and tidewater silversides; while pinfish, anchovies, and tidewater silversides predominated at the lower Bayou George station. These two stations tended to have higher salinities relative to the other brackish tributary sites. Collections at other sites ranged from two individuals comprised of two species in upper Bayou George (St. 7) to 69 individuals representing seven species in upper Cedar Creek (St. 21). Interesting, longnose gar were relatively abundant in the catch, making up over 15% of the total fish collected. Generally, gar are found only in the freshest portions of estuaries and are indicative of low-salinity brackish conditions.

Recent information (i.e., post-dam construction) on macroinvertebrate and fish communities in North Bay appears limited to a single study conducted in the early 1970s by the National Marine Fisheries Service. This study examined the distribution and abundance of penaeid shrimps (Brusher and Ogren 1976) and fishes (Ogren and Brusher 1977) at 12 sites throughout the St. Andrew Bay system and included a sampling location in North Bay (Station 12). Biweekly trawl collections were taken between September 1972 and August 1973. Data presented below were extracted from the above cited references and are used to characterize the fauna of the soft-bottom, open-water habitat in North Bay. [Note: Station 12 was located off Haven Point at $30^{o}15.4'$N and $85^{o}40.0'$W in 1.5 to 3.1 m of water.]

The fish fauna collected at North Bay Station 12 is characterized as estuarine with relatively high dominance of a few species (Appendix B, Table B-3). Nearly 25% of the total catch of fishes collected throughout the bay came from the North Bay site. The majority of this abundance was comprised of a six species: Gulf menhaden (*Brevoortia patronus*), bay anchovy (*Anchoa mitchelli*), pinfish (*Lagodon rhomboides*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*) and Atlantic threadfin (*Polydactylus octonemus*). While threadfin and pinfish may be found at high salinities, menhaden, bay anchovy, spot and croaker are generally observed in areas with relatively low and variable salinities; these species are dominant fish in Apalachicola Bay which receives large volumes of freshwater inflow. The high numbers of pinfish collected at the North Bay site suggest the presence of nearby seagrass beds which is their preferred habitat. Over 93% of the menhaden, 62% of the pinfish, 56% of the spot, and 43% of the croaker collected throughout St. Andrew Bay came from the North Bay location which is indicative of the estuarine nature of this area.

Typical of estuarine areas, North Bay supported only 56 species of fishes (of 128 collected throughout St. Andrew Bay) of which 22 species were represented by five or fewer individuals. Of these 56 species, the six species discussed above comprised 95.3% of the catch in North Bay.

Contrasting with fish abundance, shrimp were relatively underrepresented in North Bay (Appendix B, Table B-4); less than 5% of the shrimp collected throughout St. Andrew Bay came from the North Bay site. Pink shrimp (*Farfantepenaeus duorarum*) was the most abundant species in North Bay collections, making up nearly 85% of the total numbers of shrimp caught.

Pink shrimp are generally found in relatively high salinity areas in contrast to their congener (*F. aztecus*) and white shrimp (*Litopenaeus setiferus*) which prefer moderate to low salinities. Neither brown nor white shrimp were collected in high numbers at any site in the St. Andrew Bay system probably because of the relatively high salinity of the bay overall.

<u>1.3.7 Commercial Landings</u> Commercial harvests of several estuarine species have been reported for the St. Andrew Bay system, with a portion of the landings derived from North Bay. While overall county landings are dominated by such offshore finfish as grouper, some commercial species are caught entirely or in part in the estuary. Blue crabs and oysters fall into the former group, having been harvested entirely within the bay; shrimp are harvested primarily from the nearshore Gulf with a portion from the estuary. Of these three species, shrimp and blue crabs dominate the county harvest (Appendix B, Table B-5); a small and apparently declining oyster catch is reported. No data are available to segregate catches in the West, North and East Bay regions, the three areas where most of the estuarine landings are taken.

<u>1.3.8 Threatened and Endangered Species</u> The St. Andrew Bay ecosystem supports about 130 species of plants and 60 species of animals designated by the State of Florida, the federal government and/or tracked by the Florida Natural Areas Inventory (Keppner and Keppner 2001). Of these, only a limited number of species have been sighted or have the potential for inhabiting the submerged portions of North Bay; these include: Gulf sturgeon (*Acipenser oxyrhynchus desotoi*), Kemp's Ridley sea turtle (*Lepidochelys kempii*), and West Indian manatee (*Trichechus manatus*).

The occurrence of Gulf sturgeon in St. Andrew Bay was summarized by Brim (2000). He recounts a newspaper article from 1895 reporting sturgeon frequently caught at the head of North Bay. Commercial landings data from 1960 to 1984 report over 100,000 pounds of Gulf sturgeon were landed in the five panhandle counties with about 9% of the landings from Bay County. No records, however, are available as to location in the County where catches were made. Incidental capture by the Florida Game and Fresh Water Fish Commission of four fish in Bear Creek occurred in 1961, prior to dam construction. No captures have been reported since. St. Andrew Bay, because of its depth and marine-like conditions, may provide winter feeding habitat of moderate value to sturgeon (Brim 2000). It is unlikely that any critical summer habitat exists (or existed prior to dam construction) due to the lack of riverine habitat in the system. Research efforts in nearby systems (i.e., Apalachicola and Choctawhatchee Rivers) clearly show the importance of large river influence as primary habitat.

Beck et al. (2000), as cited in Keppner and Keppner (2001), listed three records of occurrence of manatee, 23 occurrences of Kemp's Ridley sea turtles and two occurrences of the fringed pipefish (*Anarchopterus criniger*, considered imperiled by The Nature Conservancy but not state or federally listed) in St. Andrew Bay. None of these sightings were noted from North Bay. However, occasional occurrence of manatees in the region may be likely near the outfall of the

Lansing-Smith Electrical Generating Plant where hyperthermal cooling water is discharged through a series of canals into Warren Bayou, a tributary of West Bay. Sightings of any of these species, however, are thought to be incidental and do not represent resident populations. Modifications of fresh water delivery to North Bay are not expected to have any measurable effects on these organisms.

1.4 Importance of Freshwater Inputs to Estuaries

The role of freshwater input in determining the productivity of river-dominated estuaries has been extensively discussed (Snedaker et al. 1977; Schroeder 1978; Cross and Williams 1981; Longley 1994; Livingston 1997; Estuarine Research Federation 2002). Under natural river inflow conditions, the combination of generally high levels of primary production together with reduced predator activities by stenohaline marine organisms have established conditions favoring rapid growth and enhanced productivity of euryhaline populations that are adapted to rapidly changing environmental conditions (Livingston 1984, 1991). This is particularly noticeable in systems with moderate to large riverine input and near the head of estuaries with relatively small freshwater inflow.

The effects of freshwater inflows to estuaries include, but are not limited to (Longley 1994): dilution of seawater to brackish conditions; dilution and transport of harmful materials and contaminants; creation and maintenance of low salinity nursery habitats; moderation of estuarine water temperatures; reduction of metabolic stresses and energy required for osmoregulation; transport of sediments and nutrients; modification of concentration-dependent chemical reactions; creation of resource partitioning mechanism for estuarine organisms; distribution and vertical movement of organisms in the water column; creation of cutting and filling mechanisms that affect estuarine erosion and deposition; creation of salt wedge and mixing zone; transport of allochthonous nutritive materials into the estuary; provision of stimuli for migration and orientation of certain estuarine organisms; and, stimulation of some organisms that may be considered nuisance.

A key component of the estuarine environment is its dynamic nature, which in part is a function of an ever-changing, non-uniform freshwater input. This freshwater input is modified by basin morphology, winds and tides to produce highly variable conditions both spatially and temporally. The seasonal timing and magnitude of inflows are highly important, particularly during the critical periods of reproduction and growth. Relatively few organisms have evolved the physiological and behavioral adaptations to tolerate these widely fluctuating conditions; yet, those that have may be found in high numbers. These organisms have evolved life history strategies to maximize the benefits provided by the estuary.

Freshwater flow appears to be one of the most important factors influencing physical and biological components of estuarine systems. Despite the seasonal and interannual variation, inflows to panhandle estuaries display a recurrent pattern of winter peaks and summer-fall lows. This pattern is reflected in the seasonality of individual estuarine organisms that display species-specific phase-lagged relationships to flow.

1.4.1 Species and habitats with freshwater dependence. Several species and habitats identified in this resource characterization appear dependent on freshwater flow to varying extents. While little long-term quantitative data exists on the abundance of estuarine species and habitats in North Bay relative to river discharge, inferences can be made based on studies in nearby water bodies and the comparative amounts of freshwater entering the system. Based on the similarity of species composition between North Bay fauna and that collected in these neighboring estuaries, it seems reasonable to assume similar general relationships exist here with environmental characteristics.

Studies carried out recently in Apalachicola Bay (summarized in Lewis et al. 1997) indicated that the abundance and distribution of dominant estuarine organisms were associated with various environmental factors such as river flow, rainfall, salinity and temperature. These associations, however, were highly variable and differed for each species (or taxonomic group) and for each bay region. While some consistency across bay regions was noted for some species (or taxonomic group characteristics), no single large-scale pattern was observed across the range of organisms examined. Flow and salinity were significant contributors to the infaunal variance explained while salinity (and occasionally flow) was influential for some shrimp catch. Temperature was the most frequently noted characteristic influencing the dominant fishes. North Bay shares many of the same dominant species with Apalachicola Bay; presumably similar relationships with environmental variables exist.

When annual fisheries data were examined, significant correlations were found between catch and Apalachicola River flow (Wilber 1992, 1994). As with fisheries-independent data, commercial harvests of blue crabs and oysters were related to flow in different ways. Annual blue crab landings from both Franklin and Wakulla counties (Wilber 1994) were positively related to river flows during the previous year's growout period (September to May). Annual commercial oyster landings were related positively to flows two years before (Wilber 1992). Both relationships suggest mechanisms related to the physical conditions in the bay during the early life history stages of the organisms which may be coupled to either increased food or decreased predation (both of which are provided by increased river flows). Increased oyster mortality (from both predation and disease) was associated with increased salinity in Apalachicola Bay (Livingston et al. 1999, 2000). Blue crabs, and to a lesser degree oysters, make up a significant fraction of the commercial landings in the Bay County area and may be affected by changes in freshwater discharges.

Overall ecological system function in estuaries may also depend on freshwater inflows. Primary productivity is intimately linked to riverine input of dissolved inorganic nutrients. This relationship, however, is mediated by the residence time of freshwater in the estuary, which is clearly a function of freshwater inflow (primarily) and winds and tides (secondarily). In Apalachicola Bay about 75% of the estuarine phytoplankton production occurs during the warm, low-flow months of May to November (Mortazavi et al. 2000). Phytoplankton standing stock during this time, as estimated by chlorophyll concentrations, is relatively low and a function of phytoplankton growth rate, zooplankton grazing, nutrient limitation (primarily nitrogen), sedimentation, and export from the bay. The latter three factors are significantly affected by freshwater discharge.

Recent studies (Chanton and Lewis 1999, 2002) provide evidence that the bulk of the secondary production in large alluvial river estuaries (e.g., Apalachicola Bay) is fueled from *in situ* phytoplankton productivity, not terrestrial detritus as previously thought. Zooplankton grazing can clearly result in substantial reductions in plankton biomass and provide a primary trophic transfer for phytoplankton primary production to upper level consumers in the estuary (Putland and Iverson 2007a, b). In addition, phytoplankton production can enter the food web through deposition to bottom sediments and subsequent incorporation into higher trophic levels through deposit-feeding infauna and epifauna. Organisms inhabiting areas closest to the mouth of the river and its distributaries appear more reliant on river-borne detritus than those living in areas more distant. However, even for these organisms, phytoplankton productivity plays a major role in faunal diets, making up at least half of the carbon transferred on average. Mid- and outer-bay organisms rely heavily on plankton production for subsistence (Chanton and Lewis 2002).

The North Bay estuary differs significantly from Apalachicola Bay in several important ways that influence primary production: lower freshwater inflows, increased residence time, and low nutrient inputs resulting in lower overall phytoplankton productivity. Without more information on nutrient loading and primary productivity in this system, it is difficult to predict production dynamics. It is likely, however, that phytoplankton productivity provides the base of the food web in the North Bay system and it is reasonable to expect similar trophic organization and transfers given a similar suite of organisms present.

<u>1.4.2 Flow dependence and salinity tolerance.</u> Habitats potentially vulnerable to changes in freshwater inflow in North Bay include tidal marshes, submerged aquatic vegetation and seagrass beds, and oyster reefs. Species living in these habitats have varying abilities to tolerate salt and could be impacted adversely by long-term declines in freshwater inputs. To assess this potential vulnerability, salinity ranges were compiled from the literature for the dominant organisms observed in estuarine portions of North Bay (Table C-1, Appendix C). Ranges are provided for different life history stages, where available. In general, estuarine species have wide salinity tolerances to cope with the dynamic, highly variable environment; food is often the limiting factor. Freshwater species, on the other hand, are less tolerant (often intolerant) of saline conditions and the amount of inundation is more influential in determining habitat and species distributions.

Brackish and tidal wetlands. Mapping efforts to date have not distinguished among marsh types around North Bay, but because there is relatively little freshwater input, other from Deer Point Lake, fresh and oligohaline marshes are likely not present or are highly limited in distribution. Wetlands around the perimeter of the bay are generally restricted to salt marshes whose inhabitants are capable of tolerating variable salinities that are moderate to high in concentration. These marshes are dominated by black needlerush (*Juncus roemerianus*) and smooth cordgrass (*Spartina alterniflora*), both displaying wide tolerance to salt (Table C-1, Appendix C). Needlerush has been observed growing in salinities up to 60 ppt (Eleuterius 1984). Growth was noted to be inversely related to salinity with greatest production in freshwater. Similarly cordgrass is found in environments with salinities ranging from near fresh to almost full sea water (Mendelssohn and Marcellus 1976; Pulich 1990); greatest production was noted at salinities less than 19 ppt (Mendelssohn and Marcellus 1976). Neddlerush and cordgrass, because of their salt tolerance, are able to compete favorably and dominate in areas where less salt tolerant vegetation can not survive.

Tidal marshes and their response to external variables were examined in the nearby Suwannee River delta (Clewell et al. 1999). They found no relationships between individual marsh species abundance from shoreline transect sites and any of the environmental variables measured, particularly salinity or salinity maximum. There was a strong negative relationship, however, between the *Cladium-Juncus* (i.e., sawgrass-needlerush) abundance ratio and several variables, particularly mean salinity (R^2=0.85) and salinity maximum (R^2=0.91). *Cladium* is more prominent in freshwater areas while *Juncus* is more salt tolerant. Clewell et al. (1999) suggested that long-term low flows may be accompanied by several changes in the tidal marshes. It is likely that no change will occur in the hydroperiod because of the proximity to the Gulf and the influence of tides; however, marsh inundation is likely to be more saline. Higher salinity may cause no harm to salt tolerant species such as *Juncus* (needlerush), *Phragmites* (giant cane), *Spartina* (cordgrass), *Scirpus* (bulrush) and *Typha* (cattail) but less tolerant species will likely not persist. Since the occurrence of fresh and oligohaline marshes is highly restricted in North Bay, little disturbance is expected in their distribution. No effects are anticipated in the more broadly distributed salt marshes with their high tolerance for moderate to high salinities.

SAV and seagrass beds. Similar to fresh and oligohaline marshes, submerged aquatic vegetation (SAV) is likely highly restricted in the vicinity of North Bay. SAV beds, if present, may be located in close proximity to freshwater inputs, near the heads of bayous and tributaries where salinity levels remain low; seagrasses are likely the dominant plant form. Vegetation mapping efforts to date have not distinguished the species present, either between SAV and seagrass generally or among the species of seagrass. Given the salinity ranges observed at open water sites in North Bay (0-37 ppt; see water quality section), widgeon grass (*Ruppia maritima*) and shoal grass (*Halodule wrightii*) are most likely to be encountered throughout most of the area; turtlegrass (*Thalassia testudinum*), if present, is likely found only in the lower portions of the bay.

Widgeon and shoal grass have broad salinity tolerances ranging from near fresh to hypersaline conditions while turtlegrass is most abundant at intermediate to high salinities (Table C-1, Appendix C). Based on a series of stress indicators such as shoot decline, growth rate and photosynthetic efficiency, all three species were able to tolerate salinities up to 55 ppt, with turtlegrass (60 ppt) and shoal grass (65 ppt) having slightly higher thresholds than widgeon grass (55 ppt) when salinities were gradually increased (Koch et al. 2007). Stress threshold levels dropped noticeably for turtlegrass (45 ppt) when salinity was pulsed without a slow osmotic adjustment period; no pulsed tests were run for the other species. In addition, turtlegrass seedlings were observed to survive 50 ppt when exposed to slow increases in salinity, yet all died at this level in pulsed experiments (Kahn and Durako 2006). It is interesting to note that while widgeon grass is highly tolerant of high salinity (up to 390 ppt in review by Kantrud 1991) and is able to produce reproductive shoots across a wide salinity range, it is often found dominating the low salinity freshwater-marine interface community (Koch et al. 2007). At the other end of the salinity range, widgeon grass is the only species capable of surviving extended periods in freshwater water (McMillan 1974). Shoal grass does not survive salinity less than about 3.5 ppt for six weeks (McMahan 1968) and turtlegrass dies between 5 and 10 ppt (McMillan 1974).

Interestingly, while widgeon grass survives well in low salinity waters, maximum photosynthetic efficiency has been observed between 10 and 20 ppt (Murphy et al. 2003). Because of the wide salinity tolerances of widgeon and shoal grass, and the preference of turtlegrass for moderate to high salinity, little change in seagrass bed distribution and dynamics is likely with small declines in freshwater inflows.

Oyster reefs. Oyster reefs occur primarily in the middle and upper portions of North Bay where salinities are noticeably affected by freshwater inflow. Despite their relatively limited spatial coverage, these reefs allow a moderate commercial fishery during most years (Table B-5, Appendix B). A larger reef expanse is probably restricted by limited freshwater inflow and relatively high salinity; bottom salinities seldom drop below about 20 ppt for more than a few weeks (see Figure A-1, Appendix A).

The eastern oyster (*Crassostrea virginica*) is an estuarine resident and as such tolerates the dynamic conditions found there; salinity tolerances for various life history stages are shown in Table C-1 (Appendix C). Adult oysters can survive in salinities from freshwater to 45 ppt with optimal conditions for growth between 10 and 30 ppt (Longley 1994; Pattillo et al. 1997). While capable of surviving at low salinities for short periods of time, oysters generally shut down and do not feed below about 3 ppt (Loosanoff 1953). Eggs and larvae prefer moderate salinities (10-29 ppt) with optimal growth of spat occurring from 13 to 30 ppt (Pattillo et al. 1997). Predation and disease, as contributors to mortality, affect oyster population dynamics and are directly related to salinity; both are higher in high salinity waters. A variety of predators feed on oysters including gastropod mollusks (*Thais haemastoma* and *Melongena corona*), crabs (*Callinectes sapidus* and *Mennippe mercenaria*) and fishes (*Pogonias cromis* and *Archosargus probatocephalus*). The southern oyster drill (*T. haemastoma*) is thought to be one of the major predators along the Gulf coast and is limited by average salinity below 15 ppt (Butler 1953). Crown conch (*M. corona*), while preferring salinities between 20 and 29 ppt, have been found in waters as low as 8.5 ppt (Hathaway and Woodburn 1961). High levels of mortality on some reefs have been attributed to the sporozoan parasite *Perkinsus marinus*, also called "Dermo". Incidence of *Perkinsus* infection is correlated with temperature and salinity (Soniat 1996) with mortality suppressed at low salinity. Infection intensity increases as salinity increases with 9 to 12 ppt as a minimum threshold (Ragone and Burreson 1993). Little is known concerning the occurrence of predators and disease on the North Bay reefs yet both are likely to be relatively high given the salinity ranges observed in the system (see salinity figures in Appendix). Declining freshwater inflows may increase the incidence of both.

Epibenthic invertebrates and fishes. Information on the epibenthic invertebrate and fish assemblages in North Bay is limited to a single trawling station located off Haven Point (Brusher and Ogren 1976; Ogren and Brusher (1977). Nearly 25% of the total fish catch (12 stations) came from this single site in North Bay. The fish community was dominated by six species that made up over 95% of the individuals collected: bay anchovy (*Anchoa mitchelli*), Gulf menhaden (*Brevoortia patronus*), pinfish (*Lagodon rhomboides*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*) and Atlantic threadfin (*Polydactylus octonemus*). Pink shrimp (Farfantepenaeus duorarum) was the most abundant shrimp making up nearly 85% of the shrimp catch. These species dominant many of the Gulf coast estuaries and display wide tolerances for environmental conditions, including salinity. Salinity ranges for these organisms (except Atlantic threadfin) are shown in Table C-1 (Appendix C).

In general, these species are typical estuarine inhabitants with broad tolerances. Most spawn in nearshore Gulf waters (shrimp offshore) such that their eggs and larvae are found predominantly in high salinity. Larvae move into estuaries where they reside as juveniles and grow before emigration again to the Gulf. As adults most have been recorded in salinities from near freshwater to >35 ppt; some are frequent inhabitants of hypersaline lagoons with salinities >45 ppt. Despite their high tolerance, greatest abundance is often found in mesohaline conditions (5-18 ppt); pink shrimp have generally higher abundance in waters >18 ppt. Because of these wide salinity tolerances, little change in distribution and population dynamics of these species is likely with small declines in freshwater inflows.

2.0. DEER POINT WATERSHED HYDROLOGIC DATA & MODEL ANALYSIS

2.1 Introduction Deer Point Lake is the major fresh water supply for Bay County, Florida. Currently Deer Point Lake supplies approximately eighty percent of all the fresh water used in the county. Bay County will continue to experience an increased demand on this water supply due to expected development and population growth. Proactive management of the increasing demand is critical now and for the future. The hydrologic analysis of the watershed evaluated the surface and groundwater freshwater flows in the Deer Point watershed. This analysis was a key component of the study to quantify fresh water inflows to the Deer Point reservoir for water supply. The hydrologic analysis also provided input data for the hydrodynamic model that evaluated effects of various freshwater withdrawal scenarios on salinity distributions in the North Bay.

2.1.1 Description of the Study Area The Deer Point Lake watershed is located north of Panama City, Florida. The watershed occupies portions of the following northwest Florida counties: Bay, Calhoun, Jackson and Washington (Figure 2.1). The watershed consists of two major physiographic regions and three distinctive physiographic sub-regions: *physiographic regions*: Coastal Lowlands and Western Highlands; *physiographic subregions*: sand hills, sand hill lakes and flatwood forests (NWFWMD 1990). Located in the northern section of the watershed, the sand hills are comprised of bits and pieces of higher marine terraces. The sand hill lakes are found in the northwestern section of the watershed and were formed by the dissolution of underlying limestone that collapsed and formed sinks and lakes. In the southern section of the watershed, flatwood forests and wetlands dominate the landscape

2.1.2 Freshwater Discharge The drainage basin of Deer Point Lake covers approximately 438 square miles. Deer Point Lake Dam impounds the flow of four major freshwater streams: Econfina Creek, Bear Creek/Little Bear Creek, Bayou George and Cedar Creek. Econfina Creek, the major tributary to Deer Point Lake, contributes an average flow of 534* cubic feet per second (cfs) to the lake *(*USGS Discharge 1935-2005)*. This creek flows approximately 28 miles from its headwaters to the lake and has a drainage basin area covering 181 square miles. For the most part, the Econfina Creek drainage basin lies within an area of excessively well-drained deep sandy soils (Richards 1997). These sandy soils allow for a higher than normal base-flow rate into the creek. Due to sandy soils and a constant spring discharge, Econfina Creek can sustain a flow of 250 to 300 cfs to the lake during periods of drought. Deer Point Lake receives about 60 to 80 percent of its total flow from Econfina Creek. Bear Creek/Little Bear Creek is the second largest tributary to Deer Point Lake and contributes an average flow of approximately 160 cubic feet per second (cfs) to the lake. Bear Creek flows 18 miles from its headwaters to the lake and drains the far east/northeast portion of the watershed. Little Bear Creek drains the northeast portion of the watershed and flows 11 miles from headwaters to its confluence with Bear Creek. This drainage basin covers 132 square miles with a good portion being poorly drained wetlands. The Bear Creek Watershed contributes about 20 percent of the total flow to Deer Point Lake. The Bayou George Creek Watershed is an area of abundant wetlands in the southeastern portion of the drainage basin. It covers 60 square miles and contributes an average flow of 15 cubic feet per second to Deer Point Lake. The creek flows 8 miles from its headwaters to Bayou George. Cedar Creek is located west of Econfina Creek in the southern sand hill lakes region. This creek originates from Court Martial Lake and flows 9 miles to Deer Point Lake. The Cedar Creek

Watershed covers 47 square miles and contributes an average of 12 cubic feet per second to the Lake. All basin area values were calculated using ArcGIS and all discharge values were calculated using the NWFWMD gages shown in Table 2.1, except Econfina Creek near Bennett.

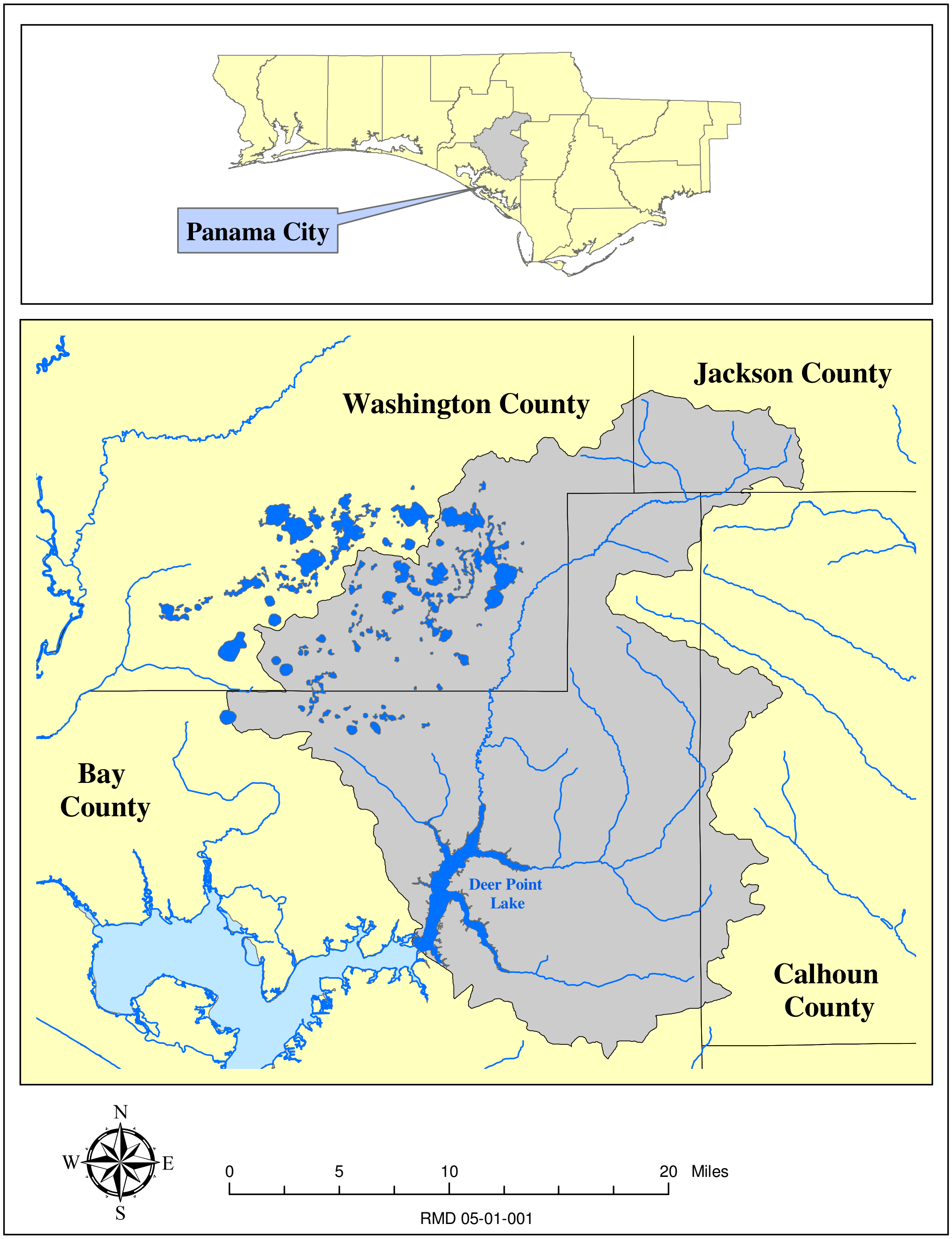

Figure 2.1 Counties of the Deer Point Lake Watershed

2.1.3 Groundwater Baseflow Discharge In an area of karst topography around Highway 20, Econfina Creek receives discharge from numerous Floridan aquifer springs. The springs are as follows: *1st Magnitude (>100 cfs)*: Gainer Springs; *2nd Magnitude (10 -100 cfs)*: Blue Spring and Williford Spring. During low flow periods this groundwater discharge accounts for the majority of the flow in the watershed. In order to determine baseflow discharge in the Econfina Creek watershed, initial baseflow separation was done using USGS HYSEP techniques (Figure 2.2). The USGS HYSEP technique separates stream flow hydrographs into baseflow and surface runoff components to estimate the ground water contribution to streamflow. The HYSEP results were used in continuous hydrologic models with a daily time-step. Based on a visual examination of the hydrographs, the HYSEP method was the chosen technique when compared to a baseflow separation model prepared with MODFLOW.

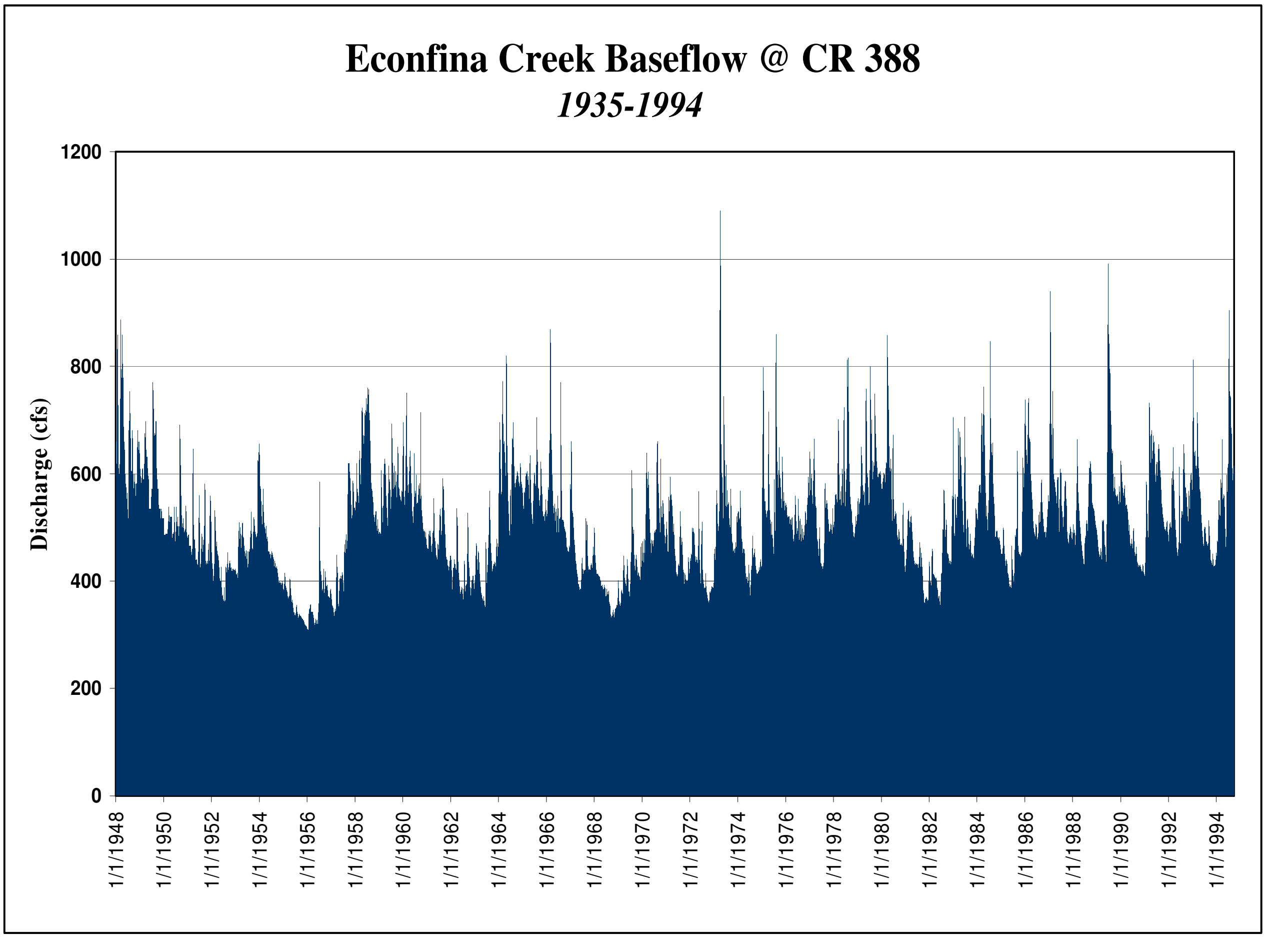

Figure 2.2 Econfina Creek – USGS HYSEP Baseflow Separation

2.1.4 Climate The climate of the Deer Point Lake watershed is moderate subtropical. The summers are long, warm and humid and the winters are mild to cool (USDA 1984). The average annual rainfall is approximately 64.75 inches with an annual average temperature of 68°F. Bay County receives almost half of its yearly rainfall from December through April. During the summer, thunderstorms occur one to three days a week. These summer storms only last about one to two hours and can produce up to two or three inches of rain. Winter and spring rains are usually not as intense as the summer thunderstorms (USDA 1984). “Summer temperatures are moderated by the Gulf breeze and by cumulus clouds, which frequently shade the land without completely obscuring the sun” (USDA 1984). The mean annual temperature from June through September is approximately 80°F. Generally the frost season is from November 29th through March 3rd. In Bay County the annual mean wind speed is approximately 7.5 mph with prevailing winds usually coming from the south/southwest in February through October and from the northwest in November through January.

2.1.5 Soils Soils data were obtained from the USDA soil surveys of Bay County, Calhoun County, Jackson County and Washington County. The soils data for these counties were digitized into a Geographical Information System (GIS) as a watershed overlay (Figure 2.3). The Deer Point Lake Watershed contains the following general soils: (1) soils of the sand ridges: sandy, excessively drained to somewhat poorly drained; (2) soils of the low uplands and flatwoods: sandy (0-40 inches), loamy (>40 inches), somewhat poorly drained and moderately well drained to very poorly drained; (3) soils of the wet depressions, flood plains, and swamps and marshes: organic surface layer (20-50 inches), very poorly drained.

2.1.6 Slopes/Geomorphology Gradients of the land surface in the Deer Point Lake watershed are flat to moderate (0 to 5 percent slopes). Due to low slopes and high permeability, the watershed has slow rates of runoff and low erosion potential (NWFWMD 1995). This contributes to the large amount of base flow occurring in Econfina Creek and its tributaries. The Deer Point Lake watershed is predominately in Bay County, which lies within the marine terraced Gulf Coastal Lowlands geomorphic province. This geomorphic province is divided into eight marine terraces based on elevation above sea level (USDA 1984) which are shown in the elevation model of the watershed in Figure 2.4. The Deer Point Lake watershed contains the following marine terraces: (1) Hazlehurst Terrace: Located in the NE portion of the watershed with an elevation of 215 - 300 feet (2) Coharie Terrace: Located in the NE portion of the watershed with an elevation of 120 - 215 feet; (3) Sunderland Terrace: Located in the northern portion of the watershed with an elevation of 100 - 170 feet; (4) Wicomico Terrace: Located in the northern portion of the watershed with an elevation of 70 - 100 feet (5) Penholoway Terrace: Located in the north-central portion of the watershed with an elevation of 42 - 70 feet; (6) Talbot Terrace: Located in the central portion of the watershed with an elevation of 25 - 42 feet (7) Pamlico Terrace: Located in the southern portion of the watershed with an elevation of 8 - 25 feet (8) Silver Bluff Terrace: Located in the extreme southern portion of the watershed, elevation of 0 - 10 feet.

2.1.7 Land Use The current land use in the watershed is predominately upland forest and wetlands (Figures 2.5 & 2.6). Currently, most of the watershed is non-urban with most of the residential land use in the watershed occurring around Deer Point Lake as shown in the aerial photo in Figure 2.7. Since the soils within the watershed are generally sand, agriculture is limited to an area east/northeast of Fountain, Florida. Percent coverage of land use type was used to estimate the impervious percentage of the drainage basin (Appendix D) for the modeling.

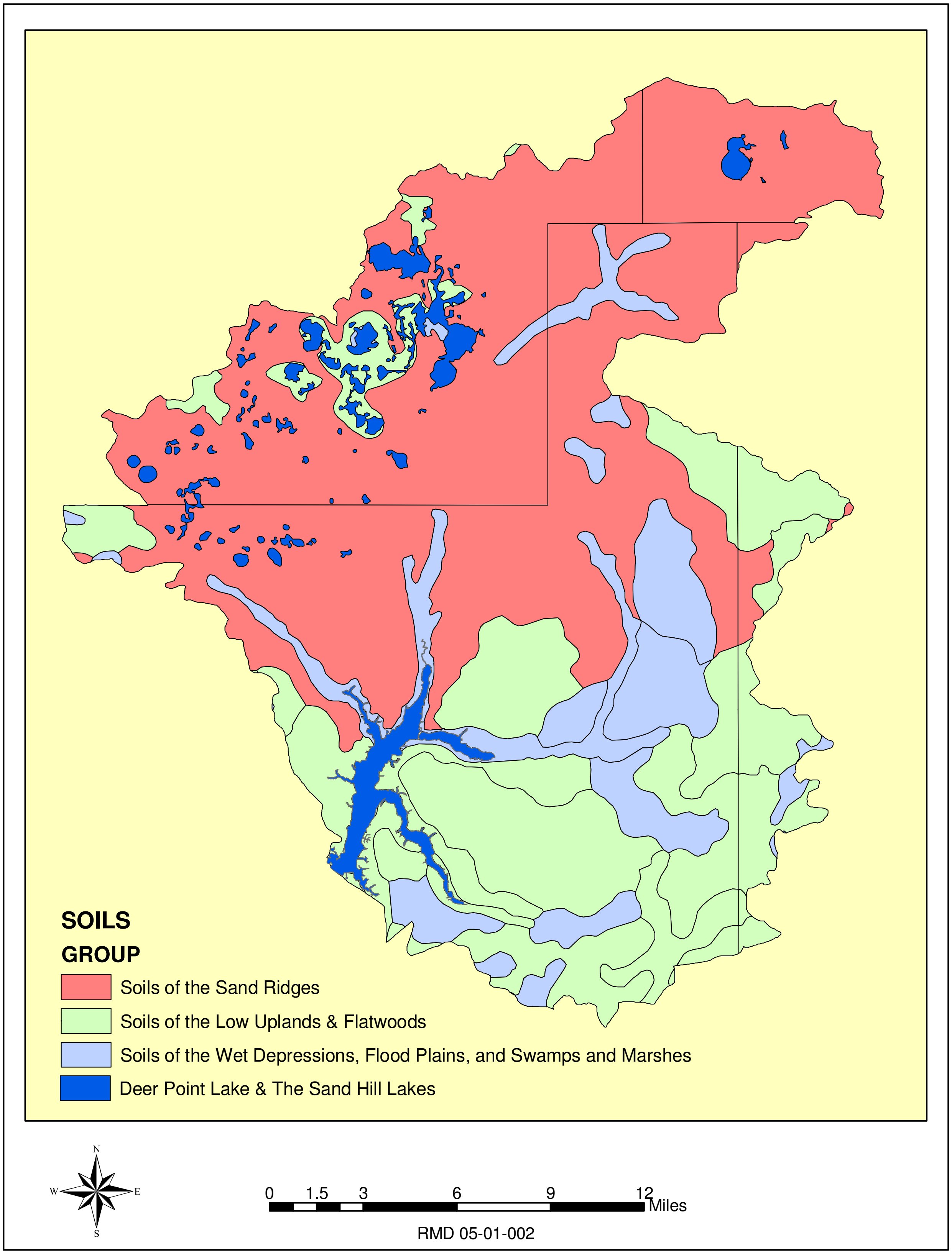

Figure 2.3 General Soils of the Deer Point Lake Watershed

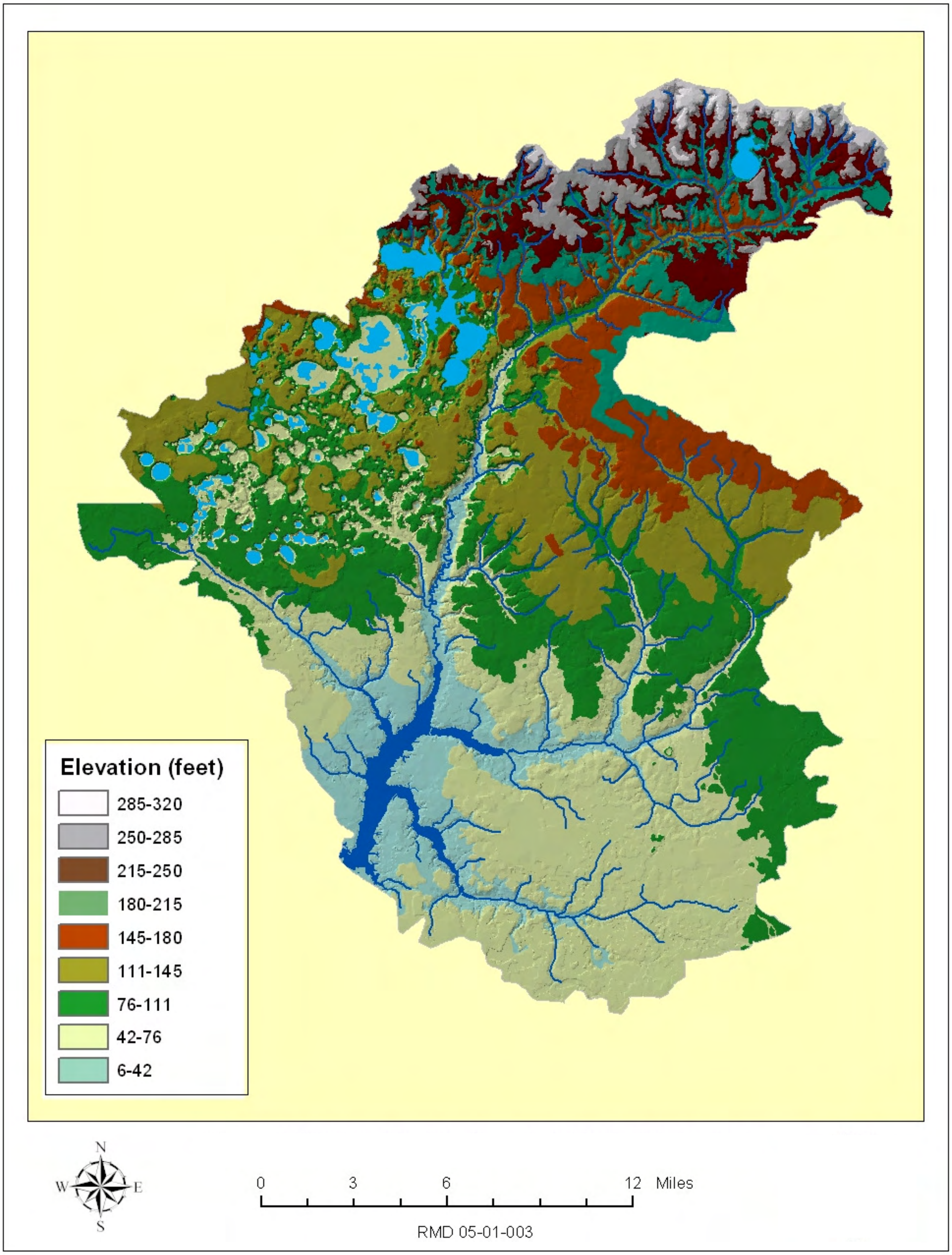

Figure 2.4 Elevation Model of the Deer Point Lake Watershed

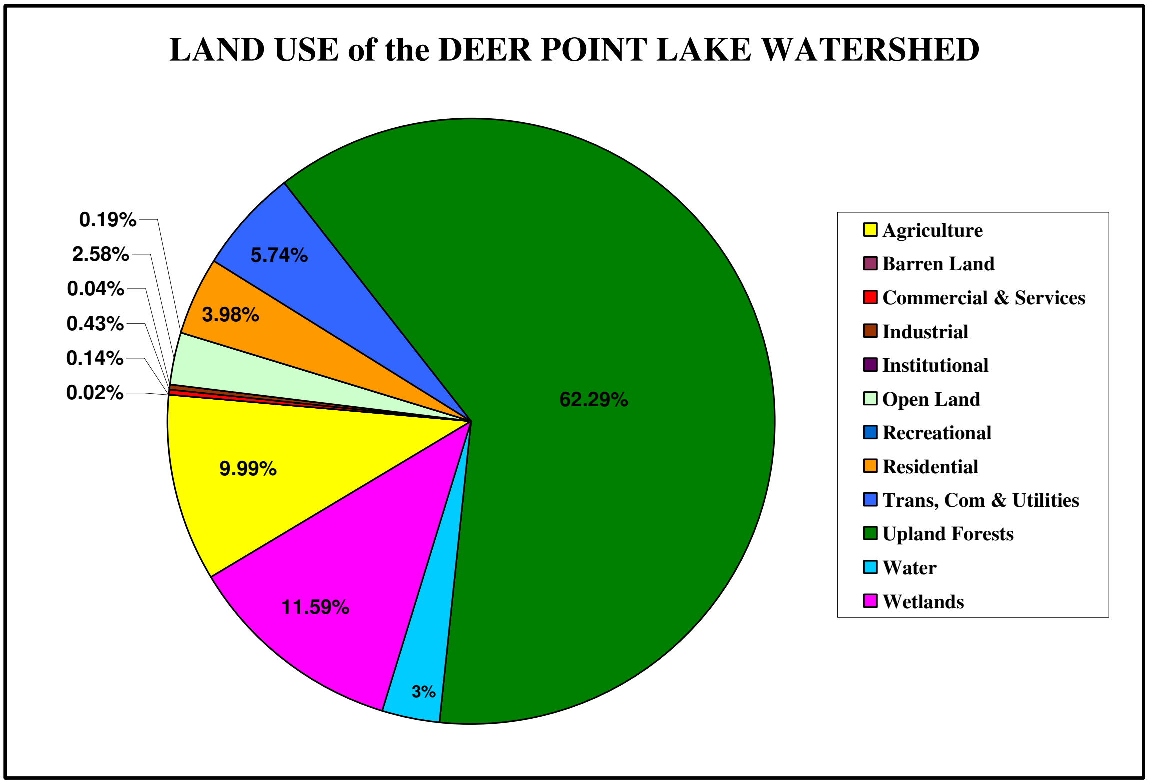

Figure 2.5 Land Use Percentage of the Deer Point Lake Watershed

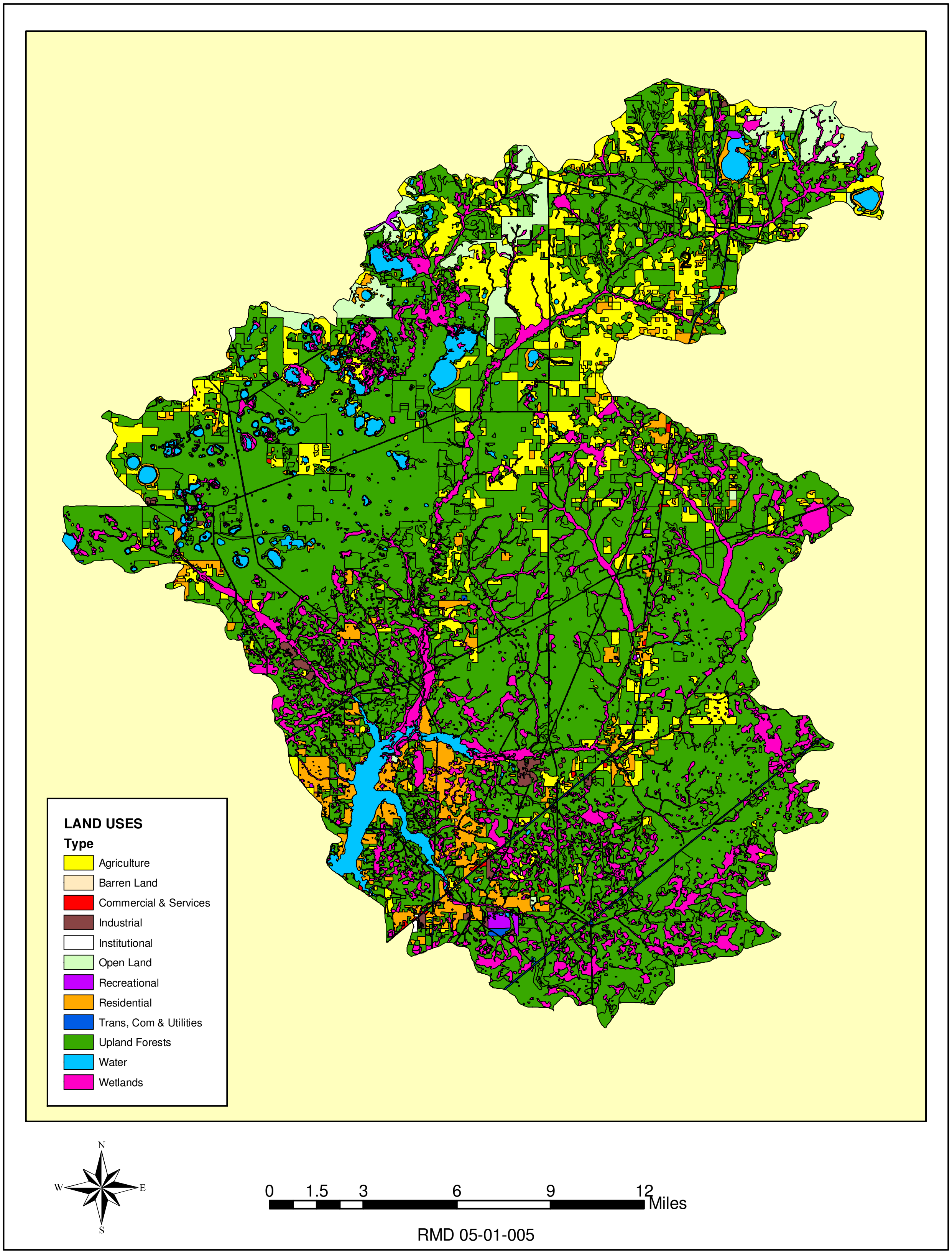

Figure 2.6 Land Use of the Deer Point Lake Watershed

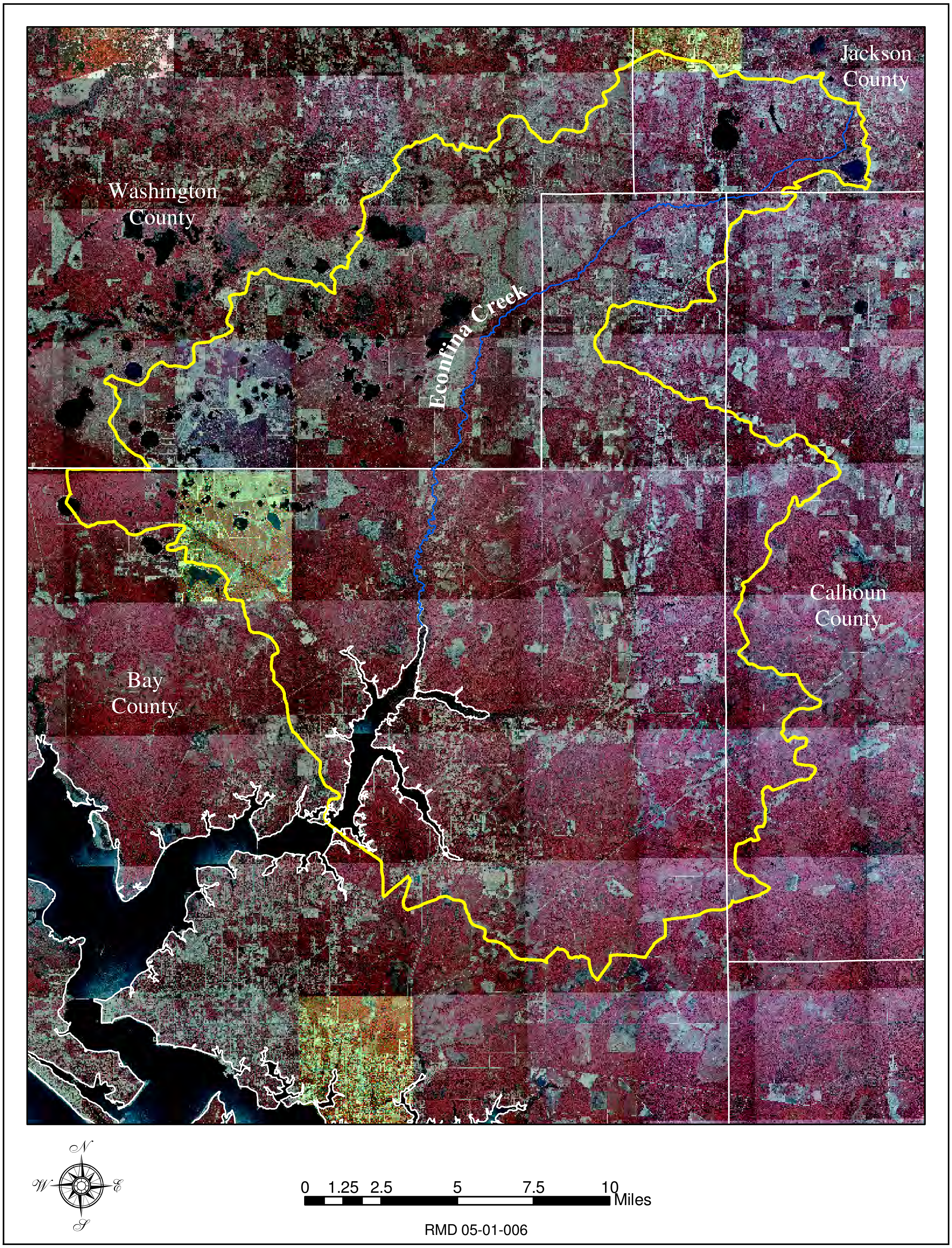

Figure 2.7 1999 Digital Ortho Photo of the Deer Point Lake Watershed

2.2 Deer Point Lake Hydrologic Model Analyses.

2.2.1 Purpose and Scope An XP-SWMM model of the Deer Point Lake watershed was developed and calibrated to aid in the prediction of fresh water discharge into North Bay. These model outputs were used as the fresh water inputs for a Hydrodynamic Model Analysis of North Bay. To support a tidal-influenced brackish ecosystem, North Bay depends on fresh water input from Deer Point Lake. Without the inflow of fresh water, the biological communities of the North Bay estuary ecosystem would be significantly altered from its current state. In order to protect this ecosystem, an agreement was established between NWFWMD and the Board of County Commissioners of Bay County to set the average and maximum withdrawals of fresh water from the Deer Point Reservoir. The agreement specifies the daily average withdrawal is not to exceed 69.5 MGD and a daily maximum of 82 MGD through 2010. In an extension to 2040, the daily average withdrawal is not to exceed 98 MGD and a maximum of 107 MGD.

2.2.2 Hydrologic Model Description Due to its ability to perform continuous simulations, the principal analytical tool used for this study was the XP Software Storm Water Management Model 2000 Version 8.5 (XP-SWMM2000). XP-SWMM 2000 is software designed for storm and waste water management modeling. The XP-SWMM 2000 software is based on EPA SWMM and is a comprehensive mathematical model that simulates runoff quantity in rural and urban systems. It can be used for floodplain analysis and detention basin design and retro-fit. There are three interface modes in XP-SWMM 2000: (1) runoff layer, (2) sanitary layer and (3) hydraulics (Extran) layer. Due to the natural setting of the Deer Point Lake hydrologic model, the runoff mode (surface runoff) and hydraulics mode (routing) were used in the simulation of the watershed.

2.2.2a Runoff mode Equipped with a choice of twelve different runoff methods, the runoff layer models the hydrologic cycle. The rainfall data in the model can be a single or continuous event. The runoff layer is based on Manning's equation:

$$\mathbf{Q = (1.486/\mathit{n})*W*(d\text{-}d_s)^{5/3}*S^{1/2}}$$

Where:
Q = Discharge, cfs
n = Pervious Value
W = Subcatchment Width, ft.
$\mathbf{d/d_s}$ = Depression Storage/Maximum Depression Storage
S = Slope, ft./ft.

"Infiltration and soil-water movement are the most important hydrologic processes, since they determine the rates and amounts of water available for surface and subsurface runoff, the amounts of water available for evapotranspiration, and the rates and amounts of recharge to ground water" (Dingman, 1994). XP-SWMM offers a number of infiltration methods such as: Horton, Green-and-Ampt, and Initial, Proportional and Continuing losses. Because the Green-and-Ampt infiltration equation is more physically based than the others, it was used in the Deer Point Lake model. Application of the Green-and-Ampt model requires estimates of the hydraulic conductivity, the porosity and the average capillary suction (Chow, Maidment and Mays 1988).

The Green-and-Ampt infiltration parameters in the model were obtained using the soil classification of the watershed. The Green-and-Ampt infiltration equation from the XP Software, Inc. workshop manual is as follows (XP Software, 2002):

Before Saturation: $\mathbf{F < F_s}$: $\mathbf{f = i}$ and $\mathbf{F_s = S_u IMD/(i/K_s - 1)}$ for $\mathbf{i > K_s}$ and no calculation of $\mathbf{F_s}$ for $\mathbf{i < K_s}$

After Saturation: $\mathbf{F > F_s}$: $\mathbf{f = f_p}$ and $\mathbf{f_p = K_s(1+S_u IMD/F)}$

Where:
f = infiltration rate (ft/sec)
$\mathbf{f_p}$ **=** infiltration capacity (ft/sec)
i = rainfall intensity (ft/sec)
F = cumulative infiltration volume, this event (ft)
$\mathbf{F_s}$ **=** cumulative infiltration volume to cause surface saturation (ft)
$\mathbf{S_u}$ **=** average capillary suction at the wetting front (ft)
IMD = initial moisture deficit for this event (ft/ft)
$\mathbf{K_s}$ **=** saturated hydraulic conductivity of soil (ft/sec)

2.2.2b Hydraulics (Extran) Mode The hydraulics layer uses the Saint-Venant Flow Equations (Dynamic Wave Routing). These equations allow the flow rate and water level to be calculated as functions of space and time, rather than of time alone (Chow, Maidment and Mays, 1988). The hydraulics mode has a variable time step and can handle multiple boundary conditions, conduits, pumps, weirs and orifices. The XP-SWMM 2000 hydraulics mode is more stable and competent than EPA-SWMM. The Saint-Venant equations from the XP Software, Inc. workshop manual are as follows (XP Software, 2002):

Continuity Equation: (Conserves Mass)

$$(\partial Q/\partial x) + (\partial A/\partial t) = 0$$

Momentum Equation: (Conserves Energy)

$$(\partial Q/\partial t) + ((\partial(Q^2/A))/\partial x) + (gA(\partial y/\partial x) + gA(S_e + S_c + S_f - S_o) = 0$$

Where:

$\partial Q/\partial t$ =	Local Inertia
$\{(\partial(Q^2/A))/\partial x\}$ =	Convective Inertia
$\partial y/\partial x$ =	Pressure Slope
S_e =	Eddy loss Slope
S_c =	Entrance/Exit Losses
S_f =	Friction Slope
S_o =	Bed Slope

2.2.3 Deer Point Lake Watershed Model Calibration The Deer Point Lake drainage basin was delineated using USGS quadrangles and GIS technology. Within this watershed there are twelve sub-basins (Figure 2.8). The hydrologic model contains the following nodes: *Econfina Creek*: 543(Sub-basin 1), 544(Sub-basin 2), 545(Sub-basin 3), 124(Sub-basin 6) and 321(Sub-basin 7 & 8); *Bear Creek*: 118(Sub-basin 4); *Little Bear Creek*: 547(Sub-basin 5); *Bear/Little Bear Confluence*: BC; *Cedar Creek*: 120(Sub-basin 10); *Deer Point* Lake: DPL(Sub-basin 9, 11 & 12 and Lake); *Deer Point Lake Dam*: Dam(Outfall); *Stone Container*: STC(Withdrawal) and *Panama City*: PC(Withdrawal) (Figure 2.8). Between each node, there is a conduit that routes the flow from the nodes to Deer Point Lake. Once the flow reaches Deer Point Lake, it becomes either lake storage, outflow over the dam or withdrawal for municipal/industrial use. Daily average withdrawal rates for these hydrologic models are between 69 – 78 cfs (Appendix E). These withdrawal rates were calculated from Bay County Water Utilities data from 1999-2002. Due to the complexity of modeling the watershed ground water flow in XP SWMM, constant inflows were used to simulate baseflow. In order to show an accurate baseflow condition, baseflow separation techniques were used to establish a constant inflow for the hydrologic model. Since there are time-step limitations with the USGS Hydrograph Separation (HYSEP) software, other techniques were utilized for baseflow prediction input into the hydrologic models with a fifteen minute or less time-step (Figure 2.9). Below are the baseflow calculations used in the calibration of the XP SWMM model:

Baseflow Calculations for the XP SWMM model included calculating the slope and initial discharge conditions for simulating baseflow. The terms include:

***Slope (m)*: m = (Qf - Qo) / (Tf - To)**

Where:
m = Slope
Qf = Discharge Final
Qo = Discharge Initial
Tf = Time Final
To = Time Initial

***Baseflow (cfs)*: y = m(T - To) + Qo**

Where:
y = Baseflow rate (cfs)
m = Slope
T = Time
To = Time Initial
Qo = Discharge Initial

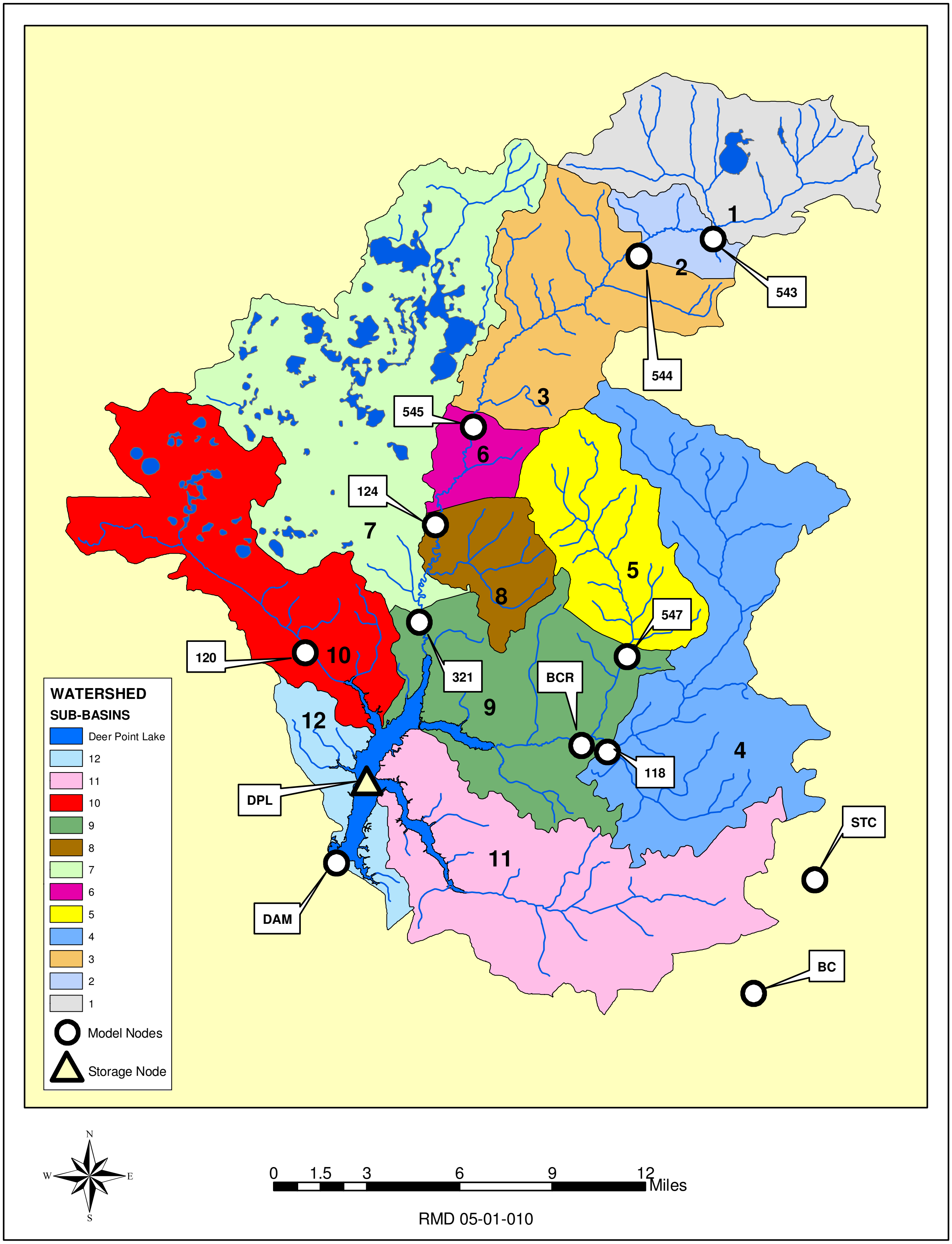

Figure 2.8 Sub-basin and Model Nodes of the Deer Point Lake Hydrologic Model

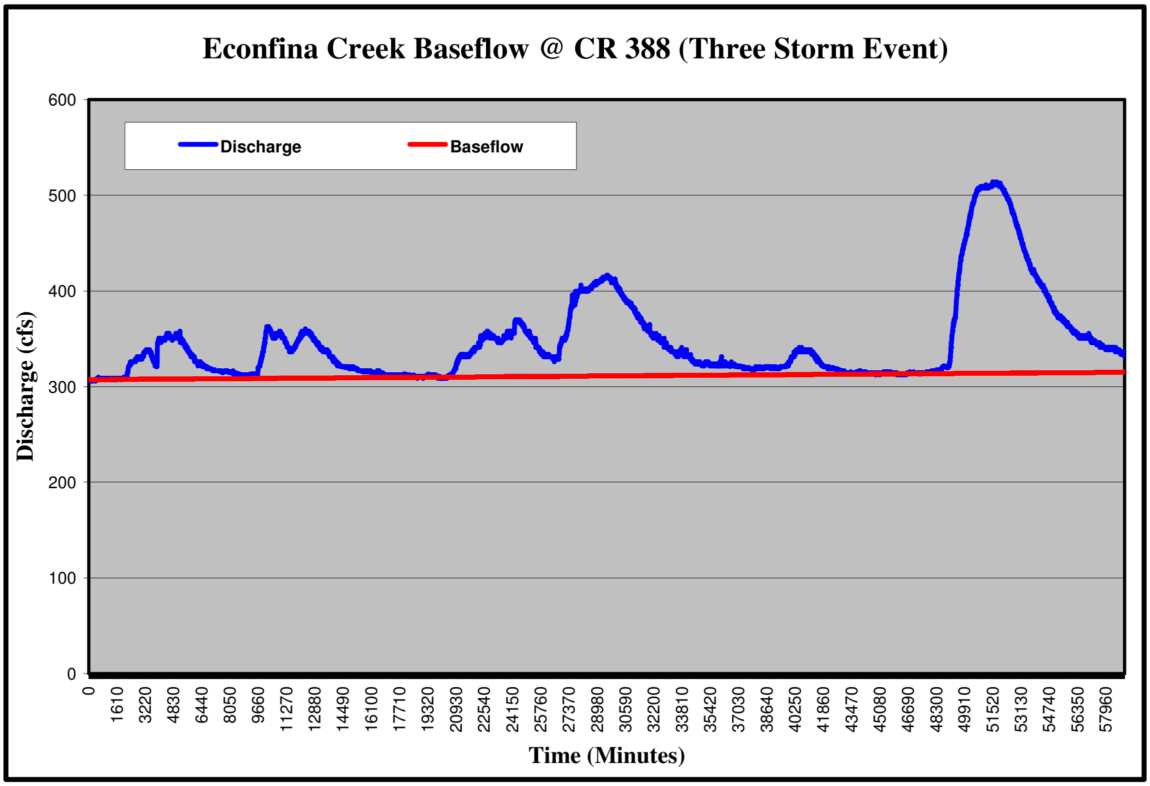

Figure 2.9 Baseflow Calibration Hydrograph for the Deer Point Lake Hydrologic Model

2.2.4 Three Storm Event Simulation Three average storm events were used to calibrate the Deer Point Lake Hydrologic Model. These three storms delivered half an inch to two inches of rainfall, which is normal for this watershed (Appendix F). The time period for these event was from August 19th, 2000 thru September 28th, 2000. Stage and Rainfall data for this model were obtained from the District's (NWFWMD) surface water database. The gages used for this particular model of the Deer Point Lake watershed are as follows: *Stage*: (1) Station 118, Bear Creek @ 231, (2) Station 124, Econfina Creek @ SR 20, (3) Station 321, Econfina Creek @ CR 388, (4) Station 545, Econfina Creek @ Walsingham Bridge, (5) Station 547, Little Bear Creek @ CR 388; *Rainfall*: (1) Station 118, Bear Creek @ US 231, (2) Station 543, Econfina Creek @ US 231 and (3) Station 639, NWFWMD Econfina Field Office (Figure 2.11). For this time period of forty days, the total rainfall equaled between eight to ten inches. Calibration was determined based solely on the closeness of the observed and simulated hydrograph at the farthest downstream station on Econfina Creek (Figure 2.10). Once the calibration was complete, the SWMM model was used to develop long term continuous simulations. These continuous simulations were used as the freshwater inputs in the Hydrodynamic model.

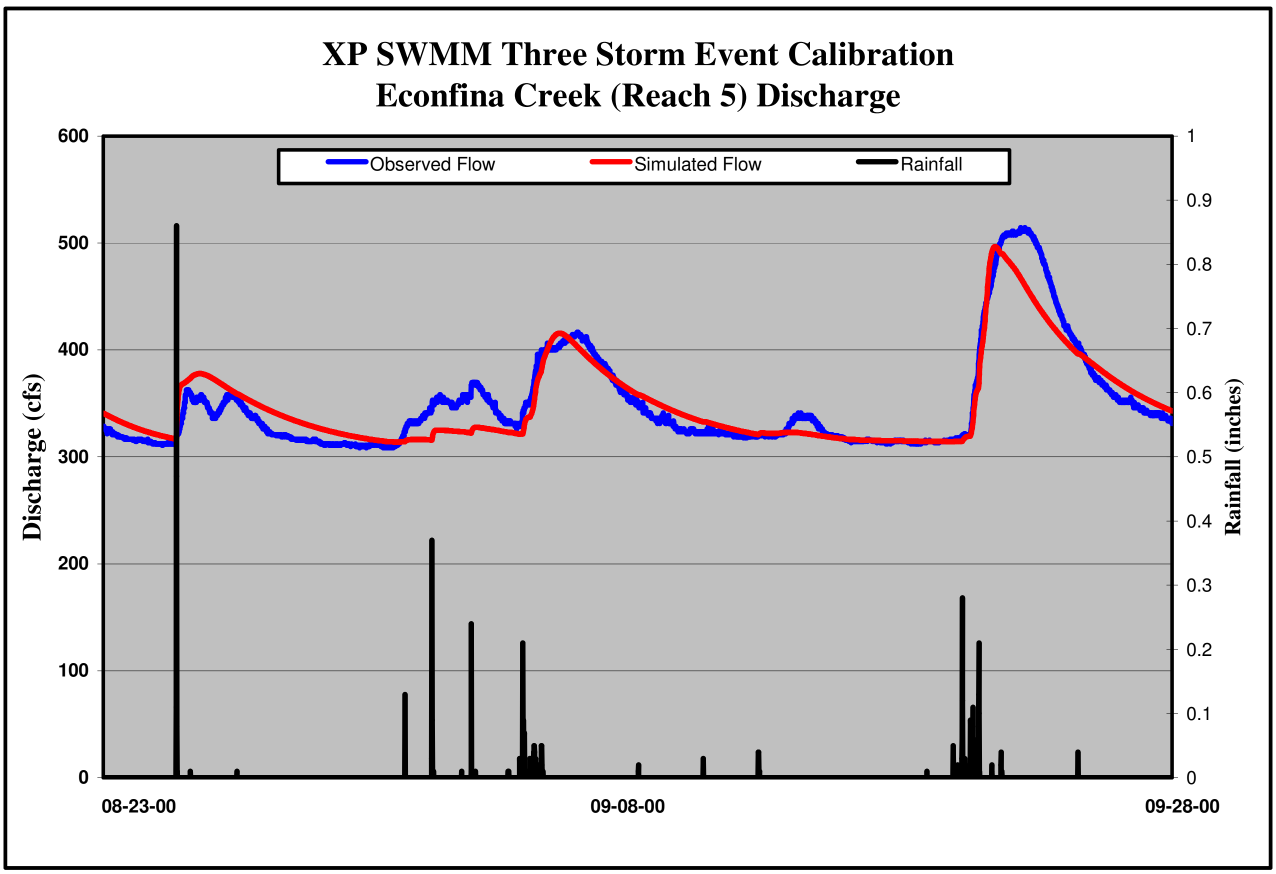

Figure 2.10 Calibration Hydrograph of the Deer Point Lake Hydrologic Model

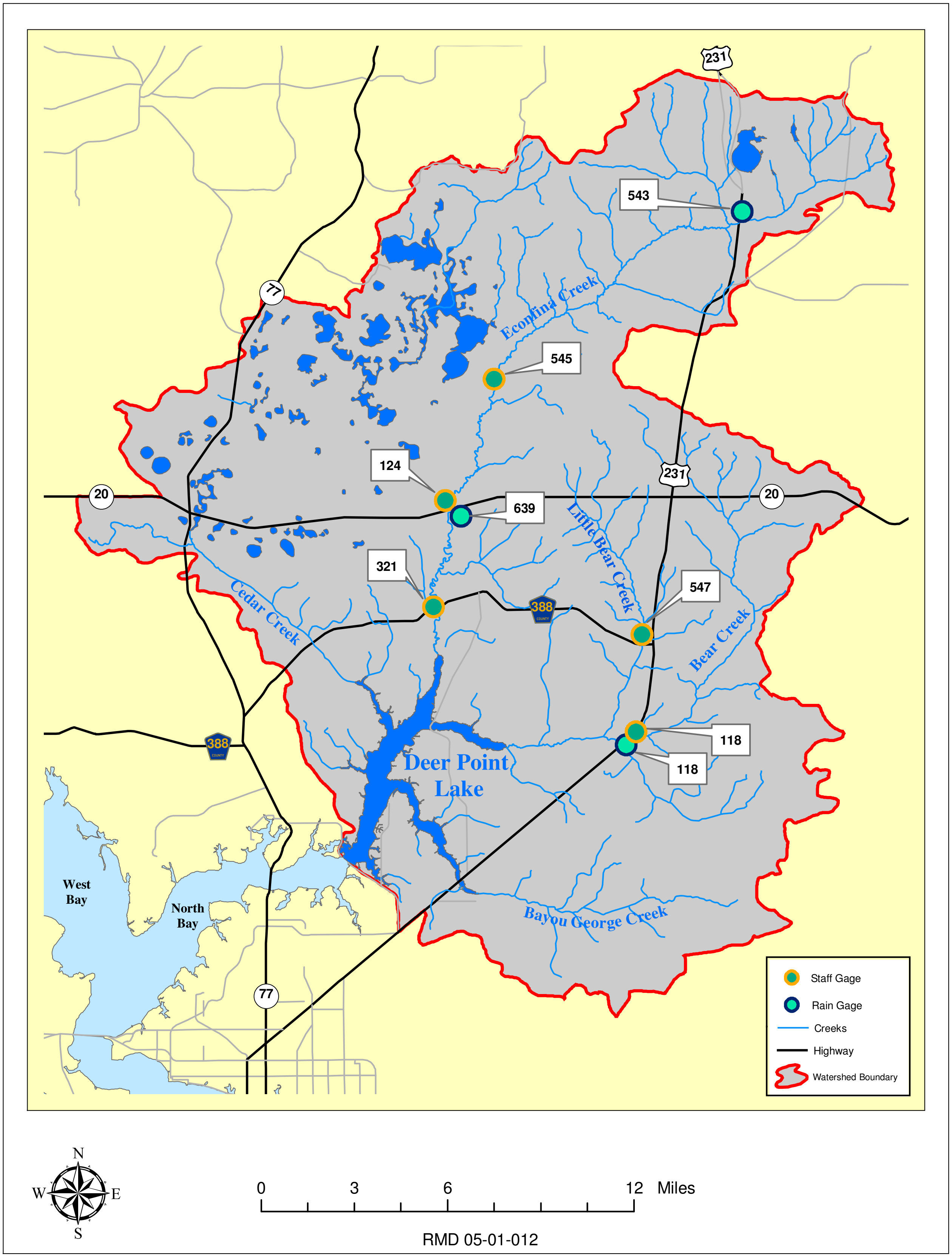

Figure 2.11 Deer Point Lake Watershed Monitoring Stations

2.3 Deer Point Lake Water Budget

Since the District has such an extensive surface water monitoring program within the Deer Point Lake basin, a water budget (Appendix G) was produced using discharge and rainfall data from the Northwest Florida Water Management District Surface Water Database (Figure 2.11/Table 2.1). In addition to input data (discharge and rainfall), output data such as withdrawal and evaporation were included in the water budget. The withdrawal data is based on monthly average withdrawal rates from the Bay County Water Utilities Department (Appendix E). The evaporation rates are based on data collected from Lake Seminole, which is a larger reservoir located approximately 60 miles northeast of Deer Point Lake. Due to the importance of this gaged data, the water budget total discharge was used as the primary input into the three dimensional hydrodynamic model for North Bay (Figure 2.15). The period of record for the water budget was January 1st, 1999 to December 31st, 2004. Since the monitoring network was established in the latter part of 1998, the XP-SWMM model was used primarily to extend the water budget to a continuous 10-year dataset. To accurately mimic the lakes discharge into the bay, a volume model and stage-storage relationship were developed and included in the water budget.

Table 2.1 Deer Point Lake Watershed Gage Information

DEER POINT LAKE WATERSHED - GAGE INFORMATION						
STATION	**Gage Type**	**Waterbody**	**Organization**	**Description**	**Latitude / Longitude**	**Period of Record**
118	Stage/Discharge & Rainfall	Bear Creek	NWFWMD	Bear Creek @ US 231	301913 852718	Stage: 08/08/1990 - Current Discharge: 08/08/1990 - Current Rainfall: 09/16/1998 - Current
120	Stage/Discharge	Cedar Creek	NWFWMD	Cedar Creek @ CR 388	302211 852733	Stage: 08/09/1990 - 10/24/1991
124	Stage/Discharge	Econfina Creek	NWFWMD	Econfina Creek @ SR20	302554 853246	Stage: 11/05/1992 - Current Discharge: 08/01/1998 - Current
321	Stage/Discharge	Econfina Creek	NWFWMD	Econfina Creek @ CR388	302304 853325	Stage: 04/08/1996 - Current Discharge: 04/08/1996 - Current
543	Rainfall	Econfina Creek	NWFWMD	Econfina Creek @ US231	303352 852327	Rainfall: 09/16/1998 - Current
545	Stage/Discharge	Econfina Creek	NWFWMD	Econfina Creek @ Walsingham Bridge	302855 853130	Stage: 08/27/1998 - Current Discharge: 08/01/1998 - Current
547	Stage/Discharge	Little Bear Creek	NWFWMD	Little Bear Creek @ CR 388	302206 852641	Stage: 08/25/1998 - Current Discharge: 08/01/1998 - Current
639	Rainfall	Econfina Creek	NWFWMD	NWFWMD Econfina Creek Field Office	302543 853241	Rainfall: 09/17/1998 - Current
86842	Rainfall	North Bay	NOAA	Panama City 5N Lynn Haven	3015 8540	Rainfall: 12/01/1971 - Current

2.3.1 Volume Surfer is a contouring and 3D surface mapping program that was used for extrapolating volumes for Deer Point Lake. Then a model for volume was created to extrapolate positive depths above the surface (Figure 2.12).

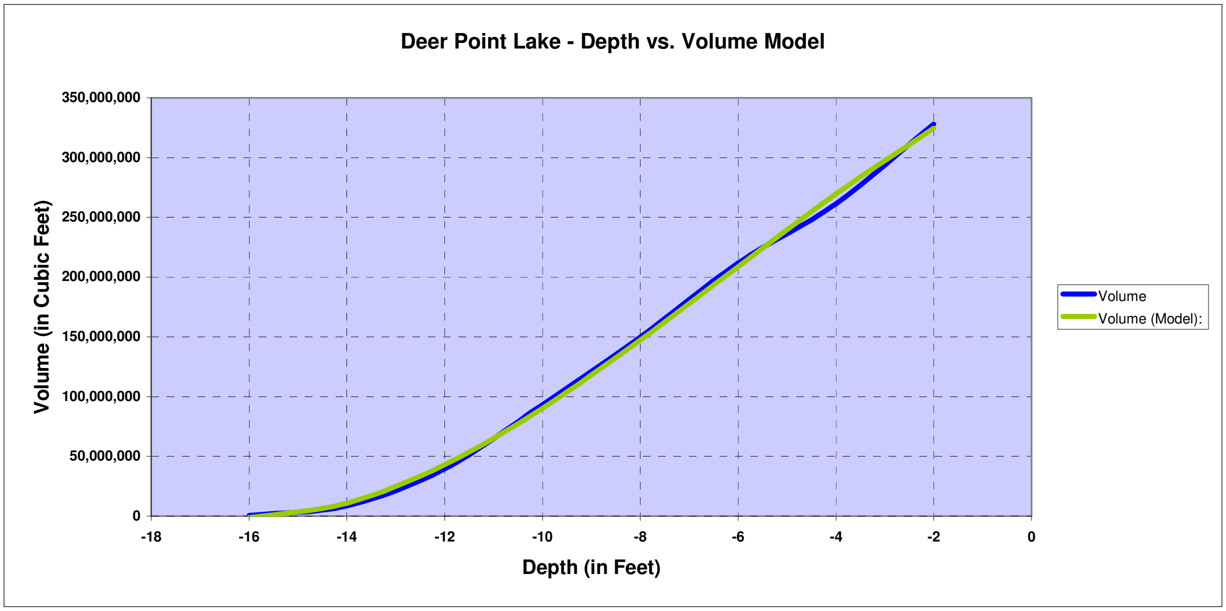

Figure 2.12 Depth vs. Volume Model for Deer Point Lake

2.3.2 Stage/Storage Relationship A stage/storage relationship for Deer Point Lake was established using the volume values calculated in Surfer (Figure 2.14). Bay County Utilities maintains a managed lake level using drawdown gates located west of the spillway (Figure 2.13). The county also draws the lake level down two to three feet in the winter as an effort to control aquatic weed growth. During the winter drawdown, freshwater is released from the lake into North Bay by opening all of the drawdown gates (Figure 2.13). This is a large freshwater input into North Bay at one time. Once the lake has been drawn down to its target elevation, the gates are closed and the lake is refilled to its lake management elevation. While the drawdown gates are closed for the refill, there is a time when no freshwater discharge enters the bay from the lake. These drawdown periods are reflected in the water budget because of their importance in the hydrodynamic models salinity results. In figure 2.15, the time periods with no discharge to the bay are after the drawdown during the lake refill. Due to the difficulty of predicting the freshwater discharge through the drawdown gates, the stage/storage equations were developed and the results are used in the water budget to aid in discharge prediction. Since water is only discharged over the spillway at or above an elevation of 4.5 feet above sea level, an adjusted

Figure 2.13 Deer Point Lake Drawdown Gates

change in storage equation was developed. This adjusted change in storage equation is used to help predict how much water is going over the spillway and through the drawdown gates. The stage storage computations include:

Stage-Storage Equations:

Storage = ***-3254.69 (D4)^4 + 53461.57 (D4)^3 + 7561146.91(D4)^2 + 110506752.22(D4) + 441729551.36***

- Where: D4 = Stage(feet)

Adjusted Change in Storage = ***IF(D3>=4.5,IF(D4>=4.5,-ABS(F4-F3),F4-F3),IF(D4>=4.5,((1093230000-F4)+(1093230000-F3)),F4-F3))***

- Where: D3 = Stage(Day Before)

  D4 = Stage(Day of)

  F3 = Storage (Day Before)

  F4 = Storage (Day of)

  Height of Spillway = 4.5 feet

The following assumptions were followed in determining the discharge to North Bay:

1) Inflow to the lake +/- Change in storage of the lake = Discharge to North Bay.
2) All storage/volume above 4.5 feet (spillway elevation) is discharged to North Bay.
3) Any net loss in lake storage was accounted for by increasing the discharge to North Bay by the net loss amount.
4) Any net gain in lake storage was accounted for by decreasing the discharge to North Bay by the net gain amount.

Based on the above assumptions, the following case scenarios exist for the Adjusted Change in Storage equation:

Scenario 1: Both Stage (Day Before) and Stage (Day of) are at or above 4.5 feet. Since both Stage (Day Before) and Stage (Day of) are above 4.5 feet, the change in storage (positive or negative) is assumed to flow over the spillway and discharged to North Bay.
Scenario 2: Stage (Day Before) is at or above 4.5 feet and Stage (Day of) is less than 4.5 feet. The net loss in storage is assumed to have been discharged to North Bay.
Scenario 3: Stage (Day Before) is below 4.5 feet and Stage (Day of) is at or above 4.5 feet. This scenario consists of two parts: The storage from the top of the spillway (4.5 feet) to the Stage (Day of) and the storage from the Stage (Day Before) to the top of the spillway. The net loss or gain in storage is determined to be the amount of storage above the spillway (4.5 feet) minus the amount of storage between Stage (Day Before) and 4.5 feet.
Scenario 4: Both Stage (Day Before) and Stage (Day of) are below 4.5 feet. Since both Stage (Day Before) and Stage (Day of) are below 4.5 feet, the change in storage (positive or negative) is assumed to have been discharged to North Bay.

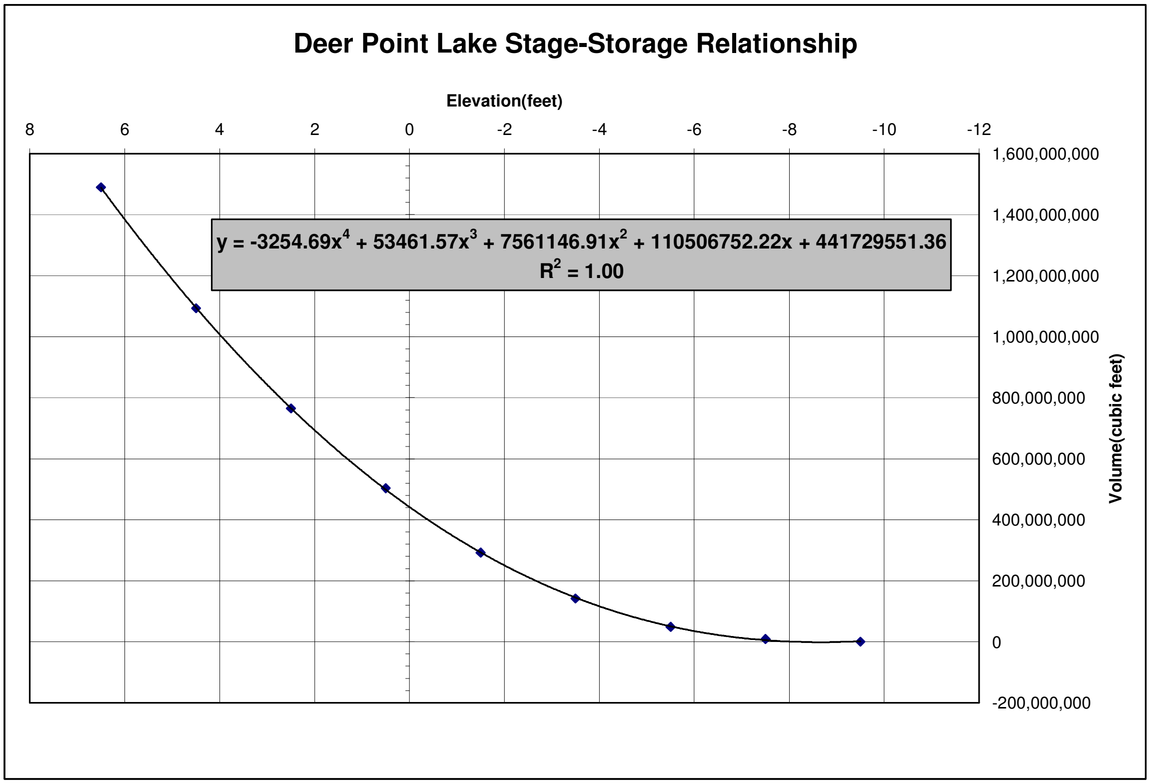

Figure 2.14 Stage-Storage Relationship for Deer Point Lake

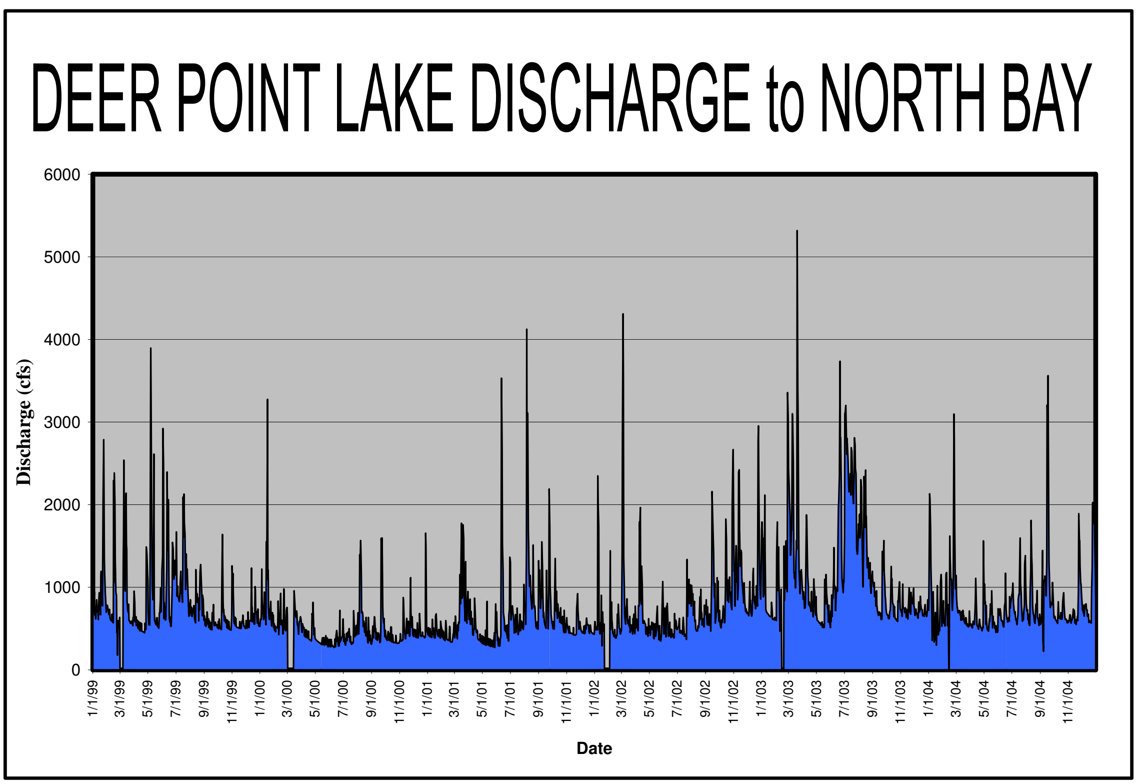

Figure 2.15 Deer Point Lake Discharge to North Bay

3.0. HYDRODYNAMIC MODELING ANALYSIS

3.1 Hydrodynamic Modeling Analysis of North Bay of St. Andrew Estuary

3.1.1 Purpose and Scope The primary objective of this analysis is to develop and apply a hydrodynamic model for North Bay to examine the effects of various freshwater withdrawal scenarios on salinity distributions in the bay. Since salinity is an important factor for the estuarine aquatic ecosystem, assessment of the effect of freshwater inflow on estuarine salinity will provide important technical support for water resource managers and biologists to develop best management scenarios to meet the increasing demand of water withdrawal, while preserving the estuarine ecosystem. The following sections describe field data collection and development, calibration and verification of the hydrodynamic model. Then, based on the freshwater discharges provided by NWFWMD, comparisons of salinity changes in North Bay for projected water withdrawal scenarios are provided though hydrodynamic model simulations.

3.1.2 Description of Hydrodynamic Model In order to investigate the impacts on North Bay due to increased freshwater withdrawals from Deer Point Lake, a three dimensional hydrodynamic model was applied to the North Bay watershed of the St. Andrew Bay System. A three dimensional model was selected because 1) salinity data indicated vertical stratification during collection of field data and review of historical data, 2) the geometry of North Bay consists of a wide entrance channel and the weir over which freshwater enters the bay is wide, 3) calibration of the model to field data collected at specific points in the x,y,z space would have otherwise been difficult, and 4) stratified water column as shown in initial field data sampling and later model simulations indicates that it is necessary to employ a 3D hydrodynamic model for the bay. While a 1D or 2D planar modeling approach could have been used to distribute the freshwater over the weir it would not have depicted the vertical salinity stratification observed. Similarly a vertical 2D model would have led to an incorrect assumption of the freshwater distribution entering and leaving the bay. It was therefore decided to use a 3D modeling approach so that known circulation within the system would have been well represented and the simulated distribution of freshwater would be based on the known geometry of the bay. Salinity profile measurements were completed at six locations in the St. Andrews Bay system in December 2002. A map of the locations and a graph of the profile data are provided in Appendix H. The measurements started at the outside of the jetties at the mouth of St. Andrews Bay and ended at the Highway 77 Bridge at Lynn Haven. Salinity was measured in one meter increments from the surface to the bottom and the results illustrate the increase in salinity with depth and increased stratification at stations farther from the mouth of the bay.

A nested grid cartesian coordinate system was adopted for the bay so that higher grid resolutions could be used in the North Bay. A limited field data monitoring program was conducted by NWFWMD to provide model calibration and verification data. Field observations of wind, tides, freshwater input, and salinity were used in the calibrations of the hydrodynamic model. The Princeton Ocean Model (POM, Blumberg and Mellor 1987) was applied to Northern St. Andrew Bay. It is semi-implicit, finite-difference model that can be used to determine the temporal and spatial changes of surface elevation, salinity, temperature, and velocity in response to wind, tide, buoyancy, and Coriolis forces. The model solves a coupled system of differential, prognostic equations describing conservation of mass, momentum, heat and salinity at each horizontal and

vertical location determined by the computational grid. This model incorporates a second-order turbulence closure sub-model that provides eddy viscosity and diffusivity for the vertical mixing (Mellor and Yamada, 1982). This model has a history of successful applications in other estuaries; for example, Oey et al., (1985a,b,c) for the Hudson-Raritan estuary, Blumberg, and Goodrich, (1990) for Chesapeake Bay, Galperin and Mellor, (1990a,b) for Delaware Bay, River and adjacent continental shelf, and Blumberg and Galperin, (1990) for New York Bight. In all of these studies, the model performance was assessed via comparisons with data and a confidence has been established that the model realistically reproduces the predominant physics. The model is capable of simulating time-dependent wind and multiple river inputs, and a variety of other forcing conditions. Details of model descriptions were discussed by Blumberg and Mellor (1987), and the enhanced version of the curvilinear coordinate formulation is given by Blumberg and Galperin (1990). Major governing equations used in the model are given below.
Continuity equation.

$$\frac{\partial}{\partial \zeta_1}(h_2 \mathrm{U}_1) + \frac{\partial}{\partial \zeta_2}(h_1 \mathrm{U}_2) + h_1 h_2 \frac{\partial \mathrm{W}}{\partial \mathrm{z}} = 0, \qquad (1)$$

Momentum equation (U1 direction)

$$\frac{\partial}{\partial \mathrm{t}}(h_2 \mathrm{U}_1) + \frac{1}{h_1}\frac{\partial}{\partial \zeta_1}[(h_2 \mathrm{U}_1)\mathrm{U}_1] + \frac{1}{h_2}\frac{\partial}{\partial \zeta_2}[(h_2 \mathrm{U}_1)\mathrm{U}_2] + \frac{\partial}{\partial \mathrm{z}}[(h_2 \mathrm{U}_1)\mathrm{W}]$$

$$+ \mathrm{U}_2\left(\frac{2\mathrm{U}_1}{h_1}\frac{\partial h_1}{\partial \zeta_2} - \frac{\mathrm{U}_1}{h_2}\frac{\partial h_2}{\partial \zeta_2} - \frac{\mathrm{U}_2}{h_1}\frac{\partial h_2}{\partial \zeta_1}\right) - \mathrm{U}_2 f h_2$$

$$= -\frac{1}{\rho_0}\frac{h_2}{h_1}\frac{\partial P}{\partial \zeta_1} + \frac{\partial}{\partial z}\left[\overline{-(h_2 \mathrm{u}_1)\mathrm{w}}\right] + \mathrm{F}_1 h_2 \qquad (2)$$

U1 and U2 are the horizontal velocities and W is the vertical velocity calculated from continuity. ζ1 and ζ2 are horizontal curvilinear orthogonal coordinates, z is the vertical coordinate, h1 and h2 are metric coefficients, P is the atmospheric pressure, and f is the Coriolis parameter. The terms F1 is related to the horizontal mixing processes and is parameterized as horizontal diffusion terms. The Reynolds stresses $\overline{\mathrm{u}_1'\mathrm{w}'}$ and $\overline{\mathrm{u}_2'\mathrm{w}'}$ are evaluated using the level 2½ turbulence closure model of Mellor and Yamada (1982) modified by Galperin et al. (1988)

The salinity and temperature equations:

$$\frac{\partial(S,T)}{\partial t} + \frac{\partial \mathrm{U}_1(S,T)}{\partial \zeta_1} + \frac{\partial \mathrm{U}_2(S,T)}{\partial \zeta_2} + \frac{\partial \mathrm{W}(S,T)}{\partial \mathrm{z}}$$

$$= \mathrm{A}_H\left[\frac{\partial^2(S,T)}{\partial \zeta_1^2} + \frac{\partial^2(S,T)}{\partial \zeta_2^2}\right] + \frac{\partial}{\partial z}\left[\mathrm{K}_v \frac{\partial(S,T)}{\partial z}\right] \qquad (3)$$

where S is the salinity and T is the temperature. Kv is the eddy diffusivity for salt and temperature, which is calculated from a second order turbulent model (Mellor and Yamada 1982). Density is a function of temperature and salinity calculated from the equation of state. The horizontal viscosity and diffusivity coefficients AH are calculated according to the Smagorinsky (1963) formulation where the coefficient c is set to 0.05 for both parameters (Equation 4).

$$A_m, A_H = c\Delta x\Delta y\left[\left(\frac{\partial U_1}{\partial \zeta_1}\right)^2 + \left(\frac{\partial U_2}{\partial \zeta_2}\right)^2 + \frac{1}{2}\left(\frac{\partial U_1}{\partial \zeta_1} + \frac{\partial U_2}{\partial \zeta_2}\right)^2\right]^{\frac{1}{2}} \qquad (4)$$

<u>3.1.3 Data Sets for Model Calibration and Verification</u> Two complete data sets are required for model calibration and verification. The data sets should consist of all external boundary conditions for model simulations, and observations at selected stations in the bay for model calibration and verification for the same model simulation period. To support model calibration and verification, a field data collection program was conducted by Northwest Florida Water Management District. Data collections included wind speed and directions, water levels, and salinity in several stations in North Bay. Location of the field station is shown in Figure 3.1. The observed data were divided into two data sets. One data set for the October 9- November 19 period was used in model calibration, while another data set for the period during November 19 December 19 was used in the model verification shown in Figure 3.2.

As shown in Figure 3.1, S593 is a wind monitoring station located on Deer Point Dam Causeway at County Road 2321. S594 is a tide station in eastern section of North Bay between the State Road 77 bridge and County Road 2321 bridge. Stations S595, S596, S598 were continuous salinity monitoring sites. All salinity measurement instruments were installed near the bottom to avoid damage by boats. Due to the small tidal amplitude and weak current near bottom, tidal variations of salinity in all three stations are not significant (Figure 3.3). In Station S595 near the dam in upper North Bay, almost no tidal variation of salinity can be observed.

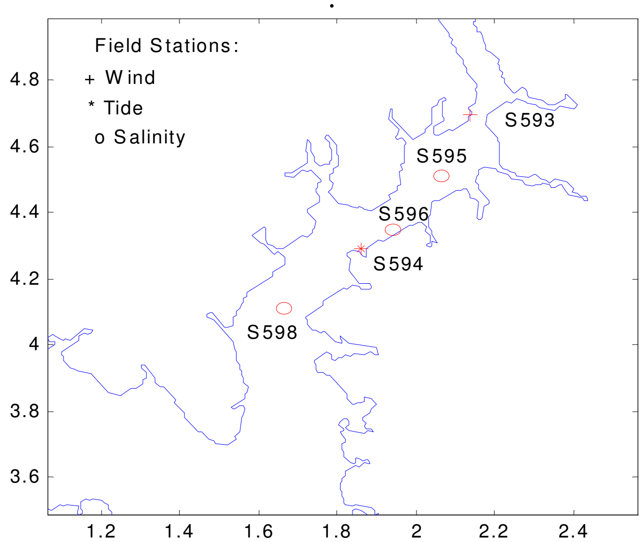

Figure 3.1 Locations of Field Data Collection Stations

The freshwater discharge to the bay is approximated from the hydrological model simulations of rainfall runoff from the upstream watershed and water budget in the Deer Lake Reservoir (Figure 3.2a), which was conducted by a hydrologist at NWFWMD to support the hydrodynamic modeling study. Observed water levels and the ocean boundary at Panama City Beach are given in Figure 3.2b, and observed wind is presented in Figure 3.2c.

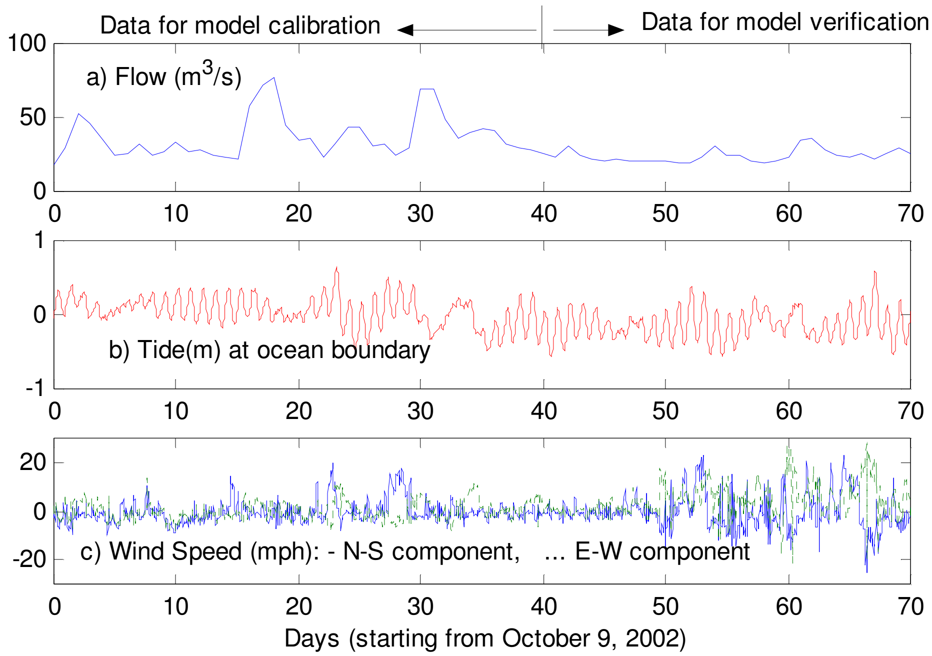

Figure 3.2 Time Series Data Used in Model Calibration and Verification.

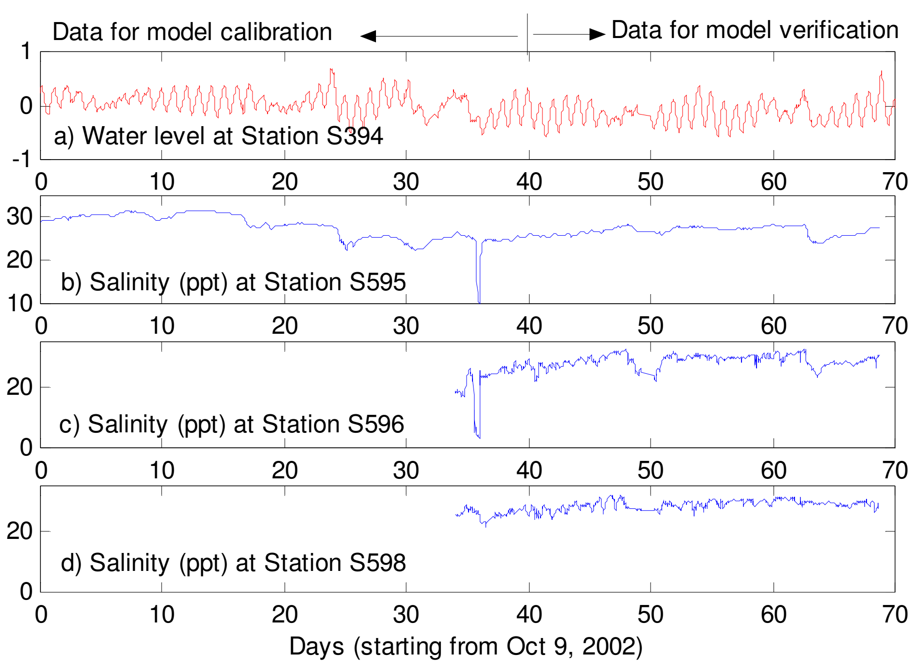

Figure 3.3 North Bay Data Used for Model Calibration and Verification.

3.1.4 Model Calibration and Verification Model calibration was conducted using field data collected from stations given above. Model calibration indicates an excellent agreement between model predicted and observed water levels. Model predicted salinity reasonably follows the general trend of the observed salinity. However, at times some differences in salinity variations are observed between model simulations and observed values.

3.1.4a Model Grid System A nested grid system of three difference grid sizes was developed for North Bay. The largest grids are used in the West Bay area (400mx200m), middle-size grids (200mx200m) are used in the lower part of the bay (Figure 3.4). For the North Bay area which is the focus of this study, high resolutions of the smallest grids (200mx100m) are used for better accuracy in salinity predictions. The employment of the mixed grid system allows efficient computations for long-term flow scenarios, while maintaining high resolution in the North Bay area.

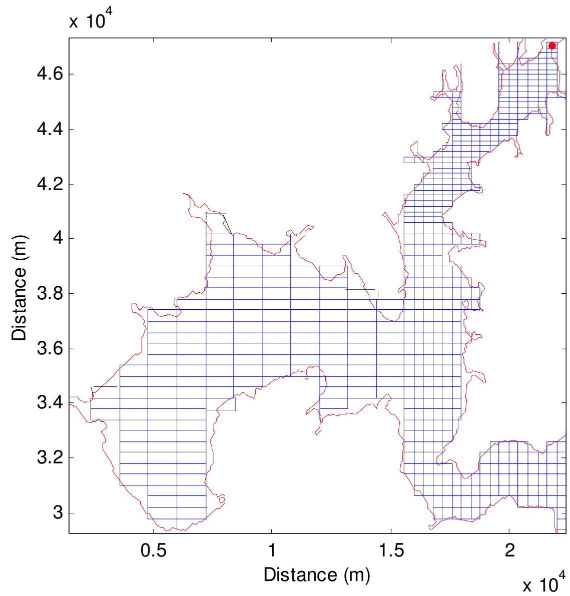

Figure 3.4 The Model Grid System for North Bay

3.1.4b Model Calibrations and Verifications The hydrodynamic model was calibrated and verified using field observations of water levels. The first data set for the period from October 9 - November 19 was used for model calibrations. A bottom friction coefficient of 0.0025 was selected, this provides the best agreement between model predictions and observations of water levels. For the model verification period from November 19 - December 19, the model coefficients determined from model calibration are kept unchanged. Excellent agreement between model predictions of water levels and observations during the verification period indicates that the model is capable of predicting water levels for other periods too. During the model simulation period, water levels consist of both tidal and non-tidal signals. As shown in Figure 3.5, the model satisfactorily predicts both tidal variations and those non-tidal sea level changes.

The model was also calibrated with salinity observations. Due the budget limitations, only three salinity observation stations were calibrated. The longest record of salinity was obtained at Station S595. At Station S596 and S598, observations were available only for a short period in November. In general, model predictions of salinity match well with the general trend of salinity observations (Figure 3.6 for all three stations. However, there is a short pulse of salinity drop at about 36 days at Station S595 and S596, the model was unable to reproduce such an event. An examination of the freshwater input from the SWMM hydrological model simulation and the water budget by NWFWMD hydrologists shows that there is no sudden freshwater increase during that period. Therefore, the sudden drop in salinity observation show in Figure 3.7 may be caused by the sudden release of fresh water in the Deer Point Lake Dam, which was not recorded in the observational data used in the SWMM hydrological model.

Verification of salinity (Figure 3.7) was conducted using another independent data set for the period 11/19 - 12/19. Keeping the model coefficients determined in model calibration phase, model predictions of salinity were compared to observations. As shown in Figure 3.7, model predictions of salinity reasonably match the general trend of salinity at all three stations. In other words, the mixing between fresh and saline water can be reasonably predicted by the calibrated and verified hydrodynamic model.

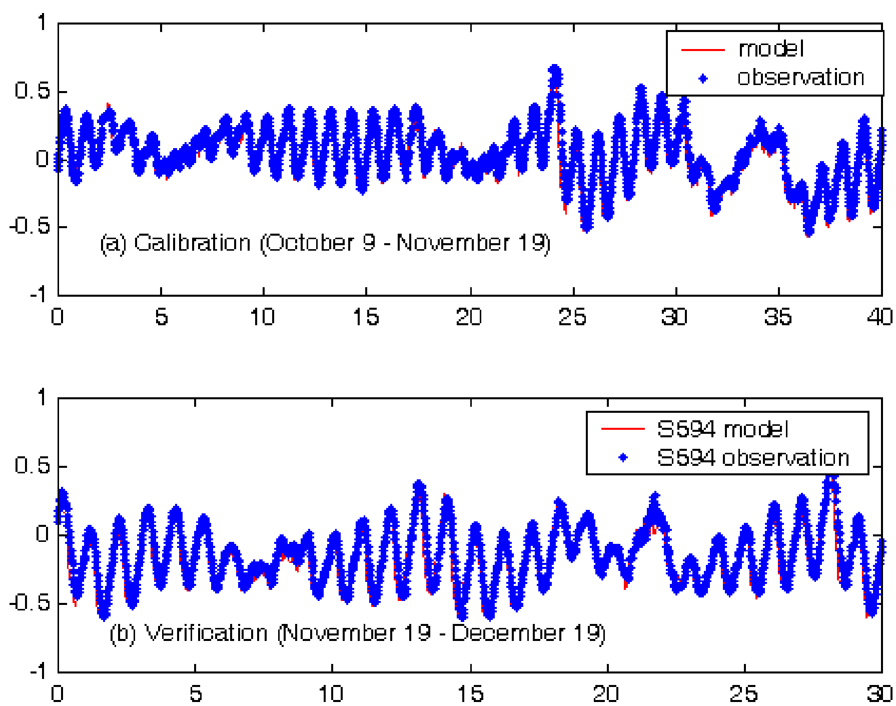

Figure 3.5 Comparison of Model Predicted Water Levels (m) with Observations at Station S594: 3.5a Model Calibration (Oct9-Nov19); 3.5b Model Verification (Nov19-Dec19).

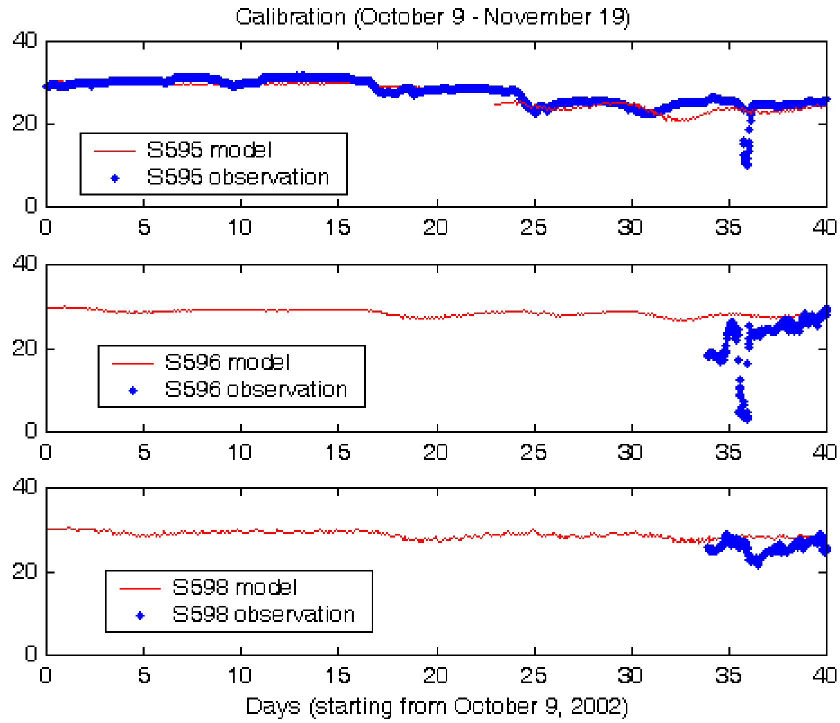

Figure 3.6 Comparison of Salinity (ppt) between Model Predictions and Observations for the Model Calibration Period (Oct 9 - Nov 19).

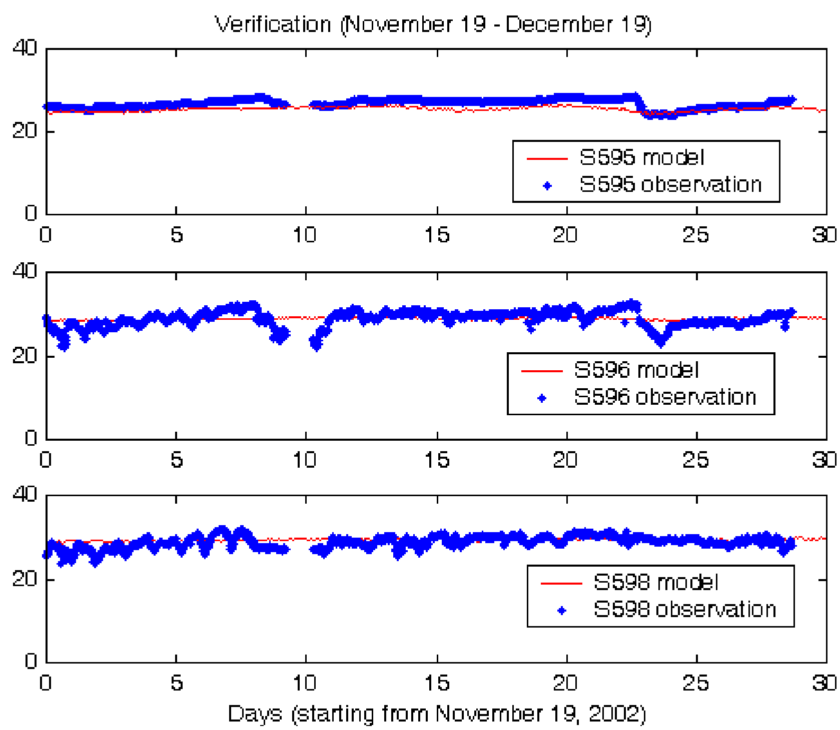

Figure 3.7 Comparison of Salinity (ppt) between Model Predictions and Observations for the Model Verification Period (Nov 19-Dec 19).

3.1.4c Circulation and Salinity Patterns

The calibrated and verified model was used to describe circulation patterns and salinity fields in the bay. As shown in Figure 3.8, stronger ebb currents mainly move from upper North Bay to the Gulf ocean boundary. In the West Bay area, currents are relatively weaker than those in the North Bay area. At flood tide, saline water moves into the bay and spreads into the North Bay and the West Bay.

The salinity field resulting from the hydrodynamic model simulations (Figure 3.9) indicates the result of fresh and saline water mixing through estuarine advection and dispersion. Due to the low fresh water discharge in the North Bay, salinity in the North Bay is high, ranging from 30 parts per thousand (ppt) to 33 ppt in the flood tide, and about 28 ppt to 31 ppt in the ebb tide. Salinity variation between low and high tide is not significant because the small tidal amplitude in the study area.

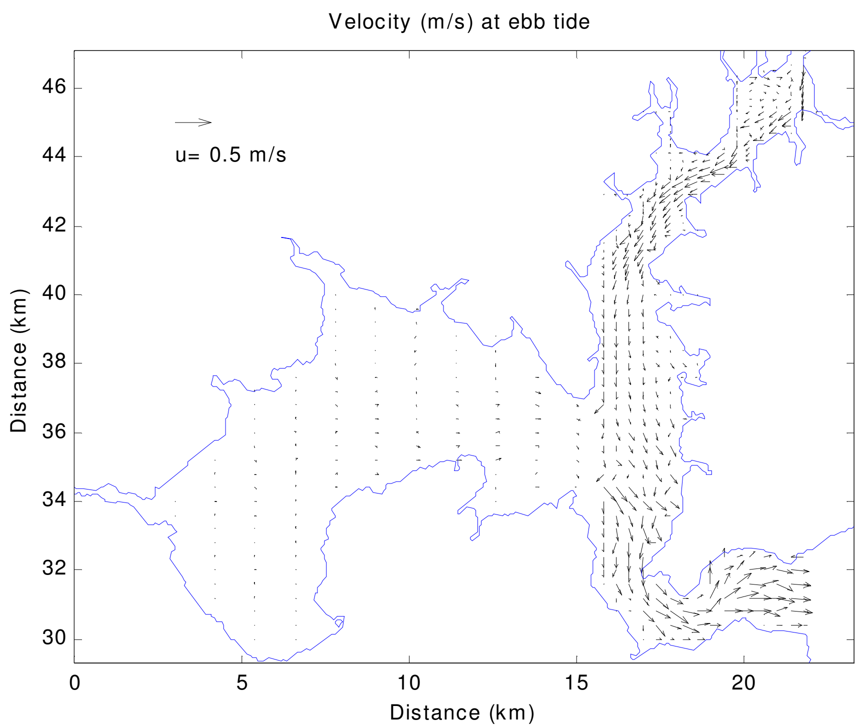

Figure 3.8 Model Simulated Currents at North Bay

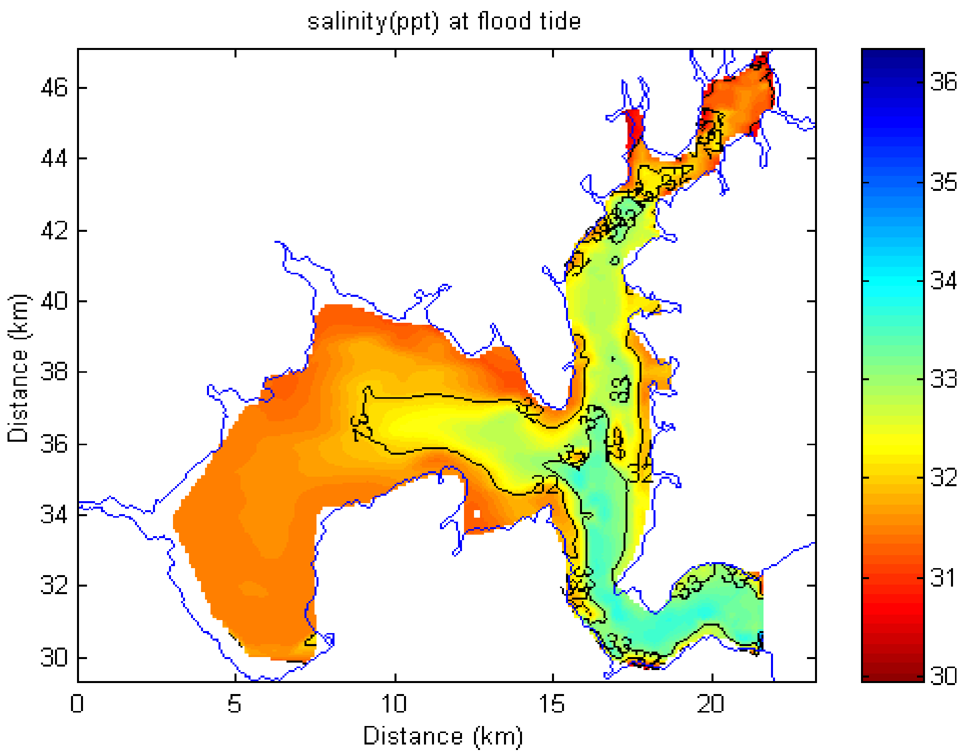

Figure 3.9 Model Simulated Salinity at North Bay

<u>3.1.5 Simulations of Salinity Changes</u> After the model had been reasonably calibrated and verified using available data in 2002 in North Bay, the model was applied to assess the changes of salinity resulted from the modifications of freshwater input in North Bay.

<u>3.1.5a Freshwater Inputs</u> Two 10-year flow scenarios were provided by the NWFWMD based on the assumptions given below:

<u>3.1.5b Base Line Flow Condition</u> The data used for day 1 through 1461 were simulated from a 1980 thru 1983 XP-SWMM run. During day 1 thru 1461 assume the following: no lake winter draw downs (winter draw downs were established as a method to control invasive aquatic weeds) and an average withdrawal rate of 45 MGD. The data used for day 1462 through 3653 are from the Deer Point Lake 1999-2004 Water Budget developed by NWFWMD, using real-time rainfall/flow data and a lake stage-storage relationship (Figure 3.10). During day 1462 thru 3653 assume the following: lake winter drawdowns and an average withdrawal rate of 45 MGD.

<u>3.1.5c 98 MGD Future Flow Scenario</u> Assume future scenario withdrawal rate of 98 MGD or 152 cfs. This future withdrawal that extends through 2040 was determined in an agreement between the District and Bay County that authorizes the county to withdraw an annual daily average not to exceed ninety-eight million gallons per day (Appendix I). The data used for day 1 thru 1461 were simulated from a 1980 thru 1983 XP-SWMM run. During day 1 thru 1461

assume the following: No lake winter draw downs and lake withdrawals are 98 MGD. The data used for day 1462 through 3653 are from the Deer Point Lake 1999-2004 Water Budget developed by NWFWMD, using real-time rainfall/flow data and a Lake stage-storage relationship (Figure 3.11). During day 1462 thru 3653 assume the following: lake winter drawdowns and lake withdrawals of 98 MGD.

The data generated from the Deer Point Lake watershed hydrological model (SWMM), developed by NWFWMD, was used for outputs of freshwater discharges for the base-line flow and the 98-MGD flow scenario. These data were directly used in setting up the freshwater input boundary for the 3D hydrodynamic model for the St. Andrew Bay. Time series of the base-line flow and the 98MGD flow scenarios are presented in Figures 3.10, 3.11 and 3.12.

The flow scenarios given above have been used in setting up river boundary conditions for model simulations. In addition, a harmonic tidal boundary condition has been set up using NOAA observations. According to NOAA data, the amplitude of major diurnal tidal component is 0.408 meters (1.24 ft). Hourly time series of surface and bottom salinity at four stations along North Bay (Figure 3.13) were obtained from model simulations for investigating salinity variation in response to the change in freshwater input.

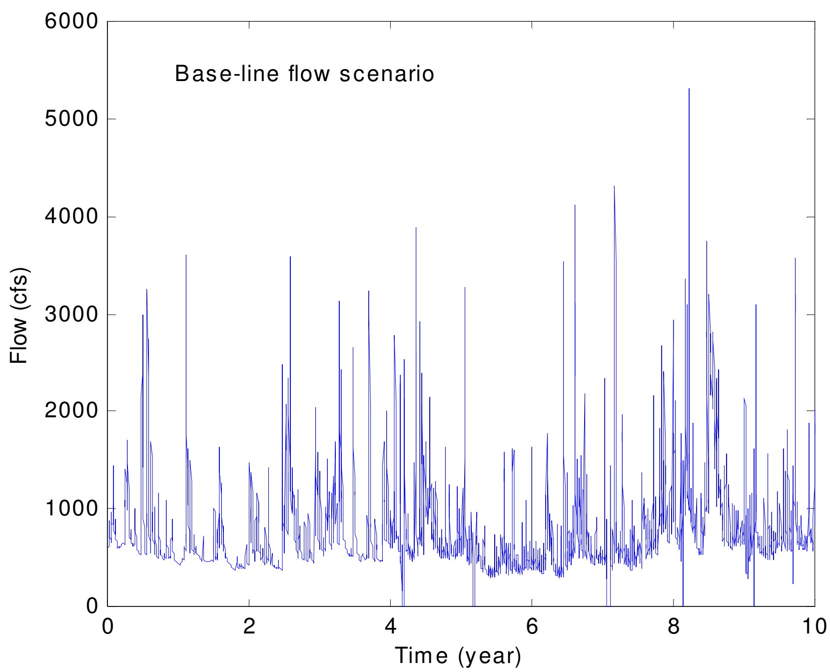

Fig 3.10 Base-line Flow

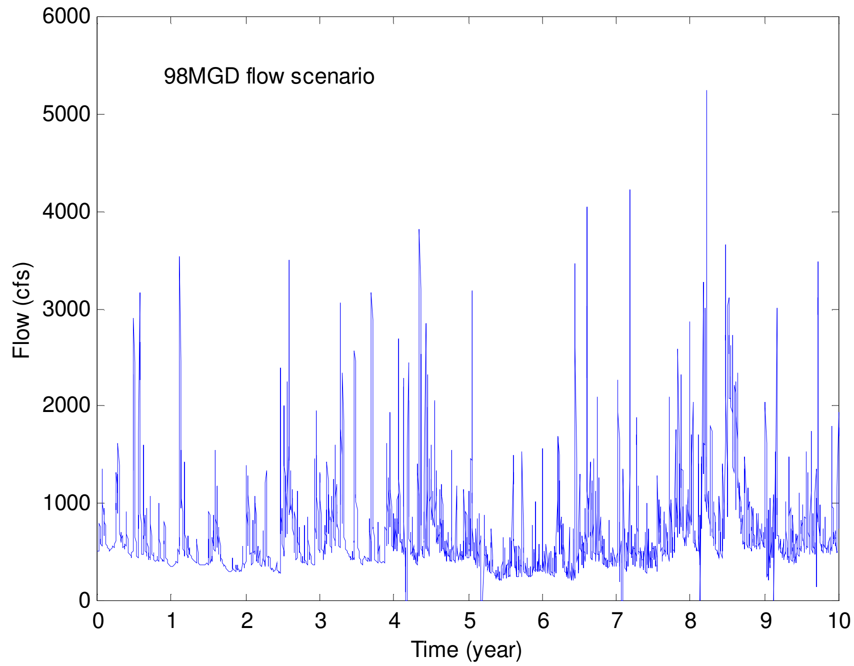

Fig 3.11 98MGD Flow

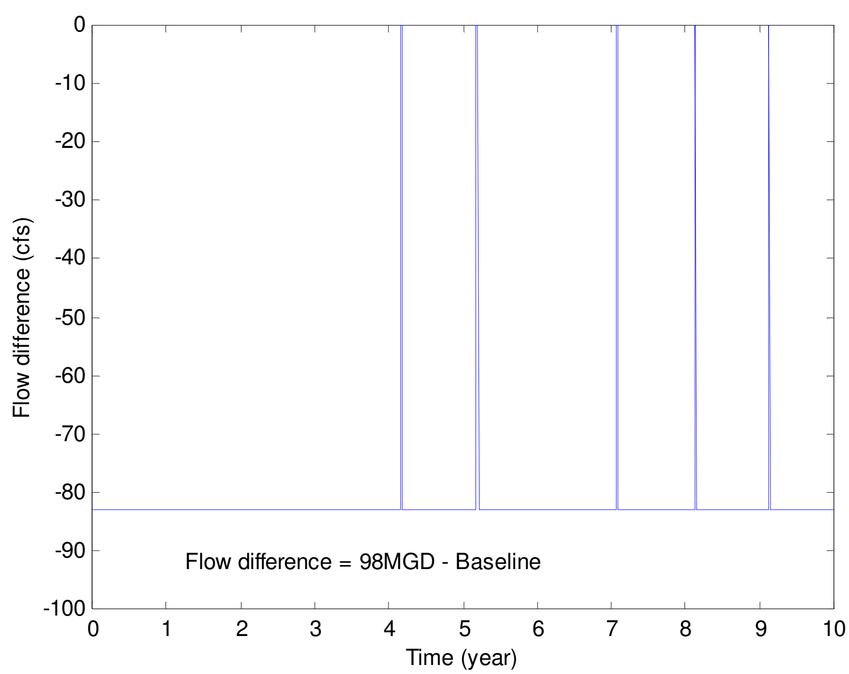

Fig 3.12 Flow Difference - 98MGD Flow and the Base-line Flow

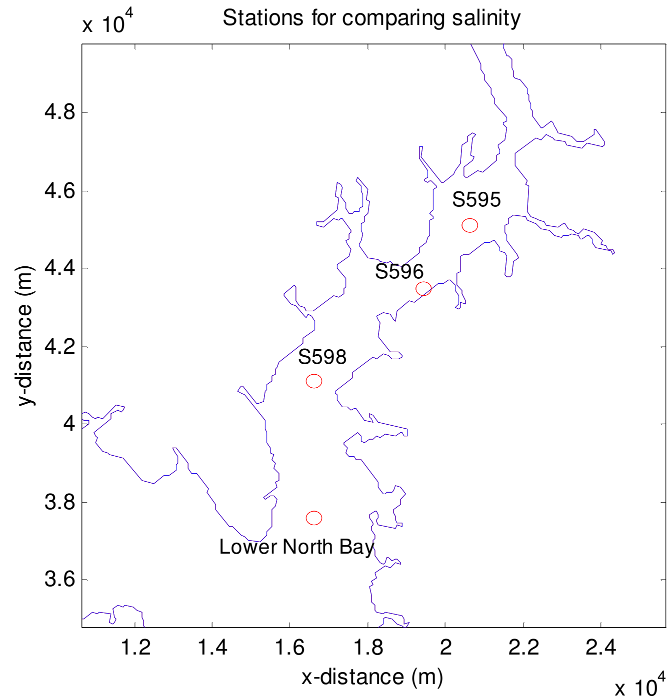

Figure 3.13 Station Locations for Time Series Hourly Salinity Output

3.1.5d Salinity Resulting from Base-Line Flow Condition. For the base-line flow scenario, hourly surface and bottom salinity from model predictions are shown in Figure 3.14 for the 0-5 year period and in Figure 3.15 the 5-10 year period. In general, salinity decreases from the lower North Bay to the Deer Point Lake Dam where freshwater is discharged into the bay. Average surface salinity is about 26.8, 28.8, 30.5, and 31.5 ppt in Station S595, S596, S598, and Lower North Bay, respectively. Average bottom salinity is 27.8, 29.9, 31.6, and 31.7 ppt in Station S595, S596, S598, and Lower North Bay, respectively. Vertical salinity stratification is stronger at S595 station near the dam. Near the lower North Bay, surface and bottom salinity is almost the same, which indicates a well mixed condition.

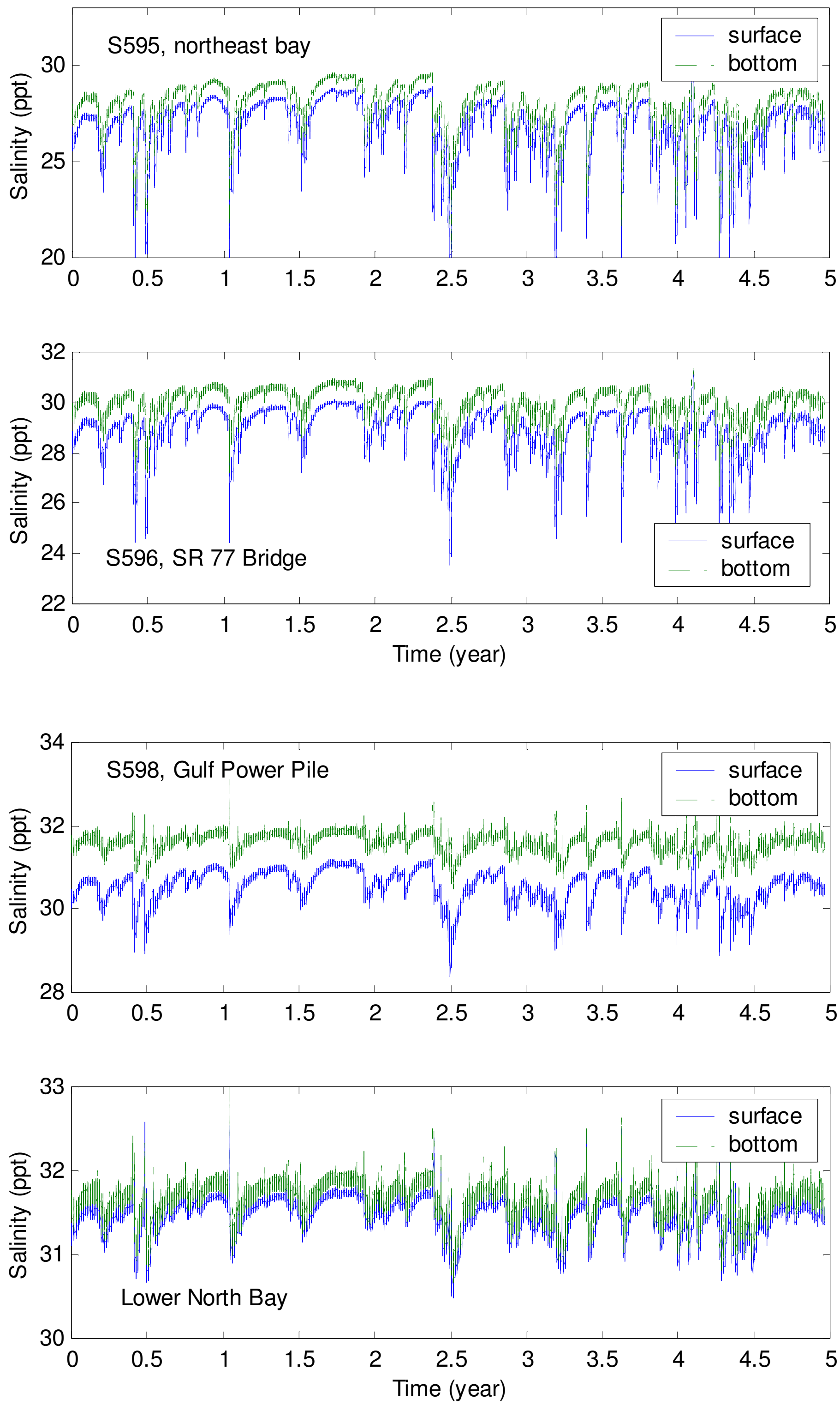

Figure 3.14 North Bay Salinity under Base-line Flow Scenario (Year 1-5)

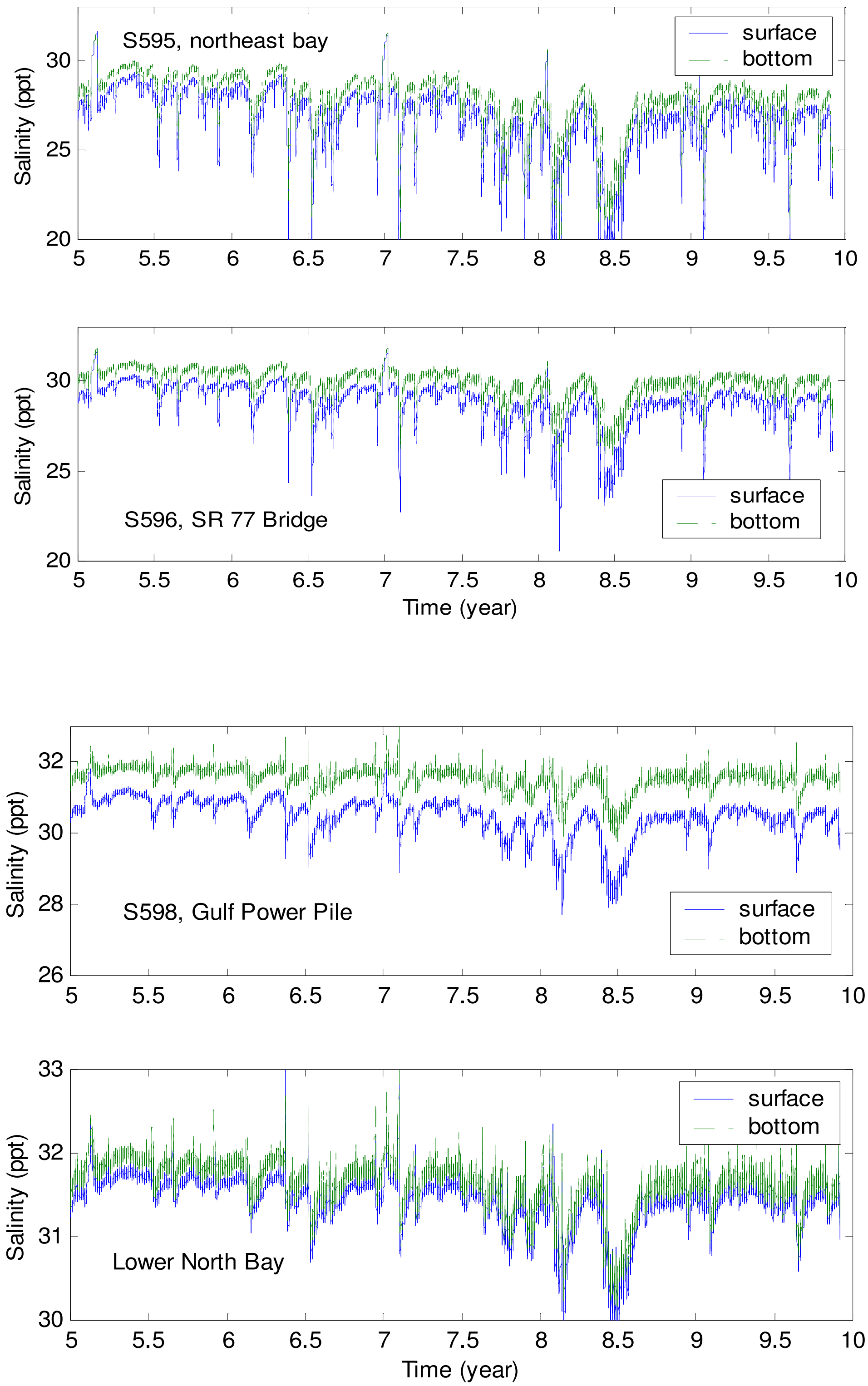

Figure 3.15 North Bay Salinity Under Base-line Flow Scenario (Year 5-10)

3.1.5e Salinity resulting from 98 MGD Flow Scenario Model predictions of salinity under 98MGD flow scenario are given in Figure 3.16 and Figure 3.17 at Station S595, S596, S598, and Lower North Bay, the average surface salinity is 27.2, 28.1, 30.6, and 31.5 ppt, respectively; and the average bottom salinity is 28.2, 30.1, 31.6, and 31.7 ppt, respectively.

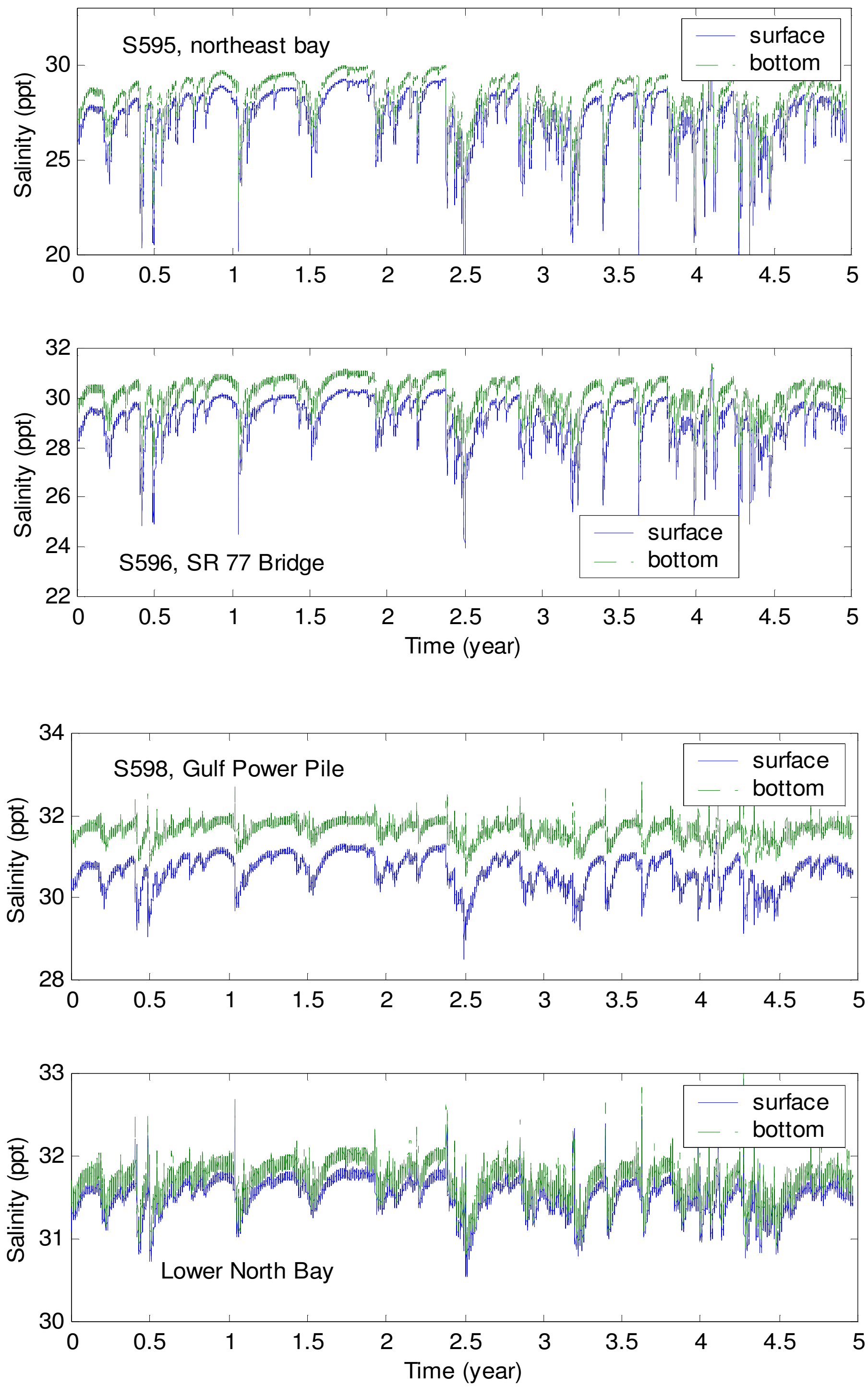

Figure 3.16 North Bay Salinity - 98MGD Flow Scenario (Year 1-5)

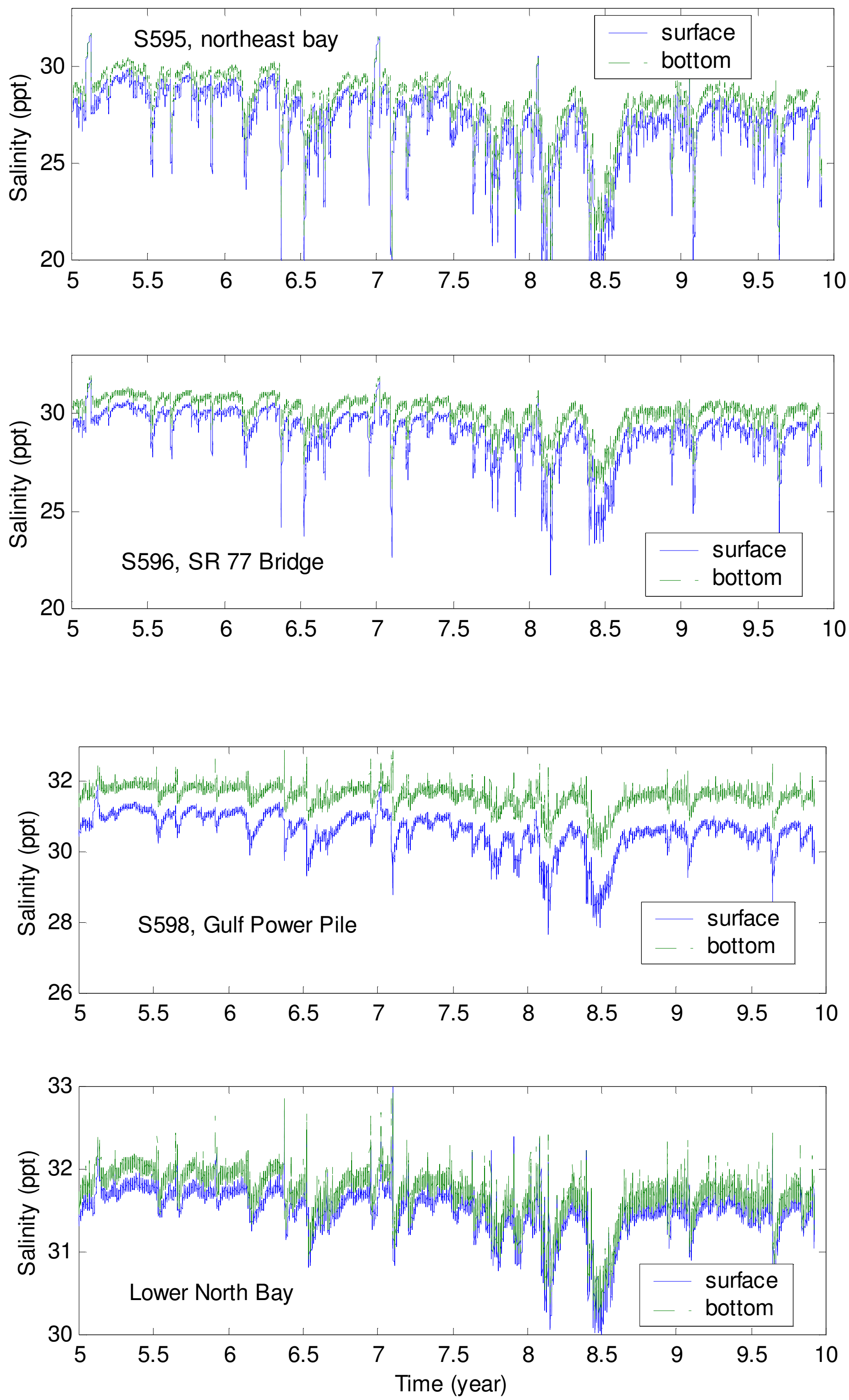

Figure 3.17 North Bay Salinity - 98MGD Flow Scenario (Year 5-10)

3.1.5f Comparison of Salinity Variations from Changing Freshwater Discharges Comparison of surface and bottom salinity differences between the base flow scenario and 98MGD scenario are shown for Station 595 in Fig 3.18 and Fig 3.19, Station 596 salinities are shown in Figure 3.20 and Fig 3.21, Station 598 salinities are shown in Fig 3.22 and Fig 3.23 and lower North Bay salinities in Fig 3.24 and Fig 3.25. As shown in Figure 3.18 & 3.19 salinity differences range approximately 1-3 ppt. Maximum surface salinity difference is 2.44 ppt at station S595, which is the closest station to the Deer Point Lake Dam. At the lower North Bay, salinity differences are 1.14 ppt and 0.70 ppt for the surface and bottom locations, respectively. A summary of the statistical analysis of salinity changes under different freshwater discharge scenarios is given in Table 3.1.

Table 3.1 Salinity Change Statistics - 98MGD Scenario and Base Scenario

Station	Baseline Scenario Mean (ppt)	98MGD Scenario Mean (ppt)	98MGD–Baseline Mean Difference (ppt)	Max difference (ppt)
S595 surface	26.72	27.16	0.44	2.44
S595 bottom	27.78	28.15	0.38	1.76
S596 surface	28.8	29.06	0.27	1.93
S596 bottom	29.92	30.11	0.19	1.60
S598 surface	30.48	30.61	0.13	1.61
S598 bottom	31.57	31.63	0.06	1.09
Lower North Bay - Surface	31.43	31.49	0.07	1.14
Lower North Bay - Bottom	31.64	31.72	0.08	0.70

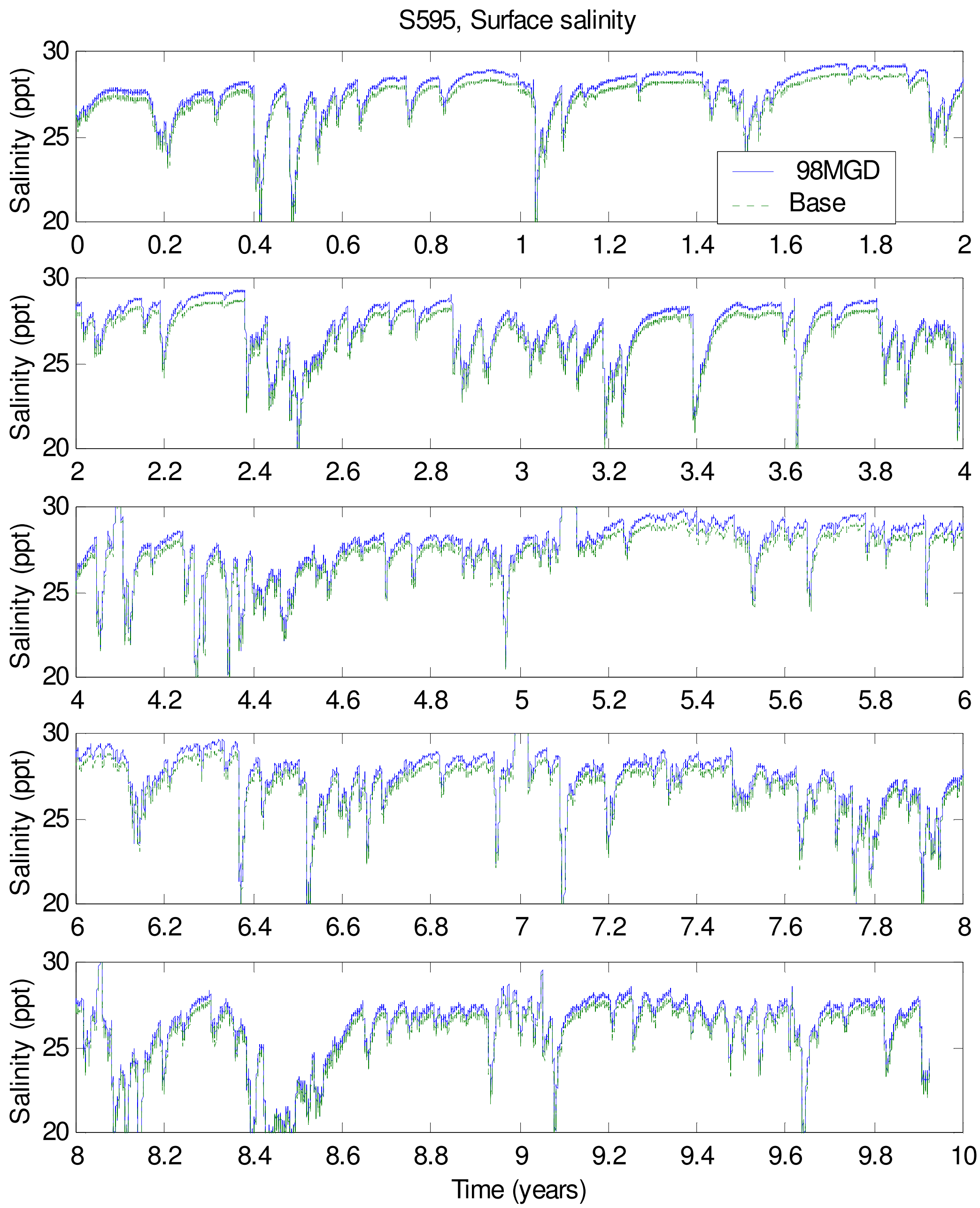

Figure 3.18 Surface Salinity - 98MGD Scenario and Base-line Flow, Station S595

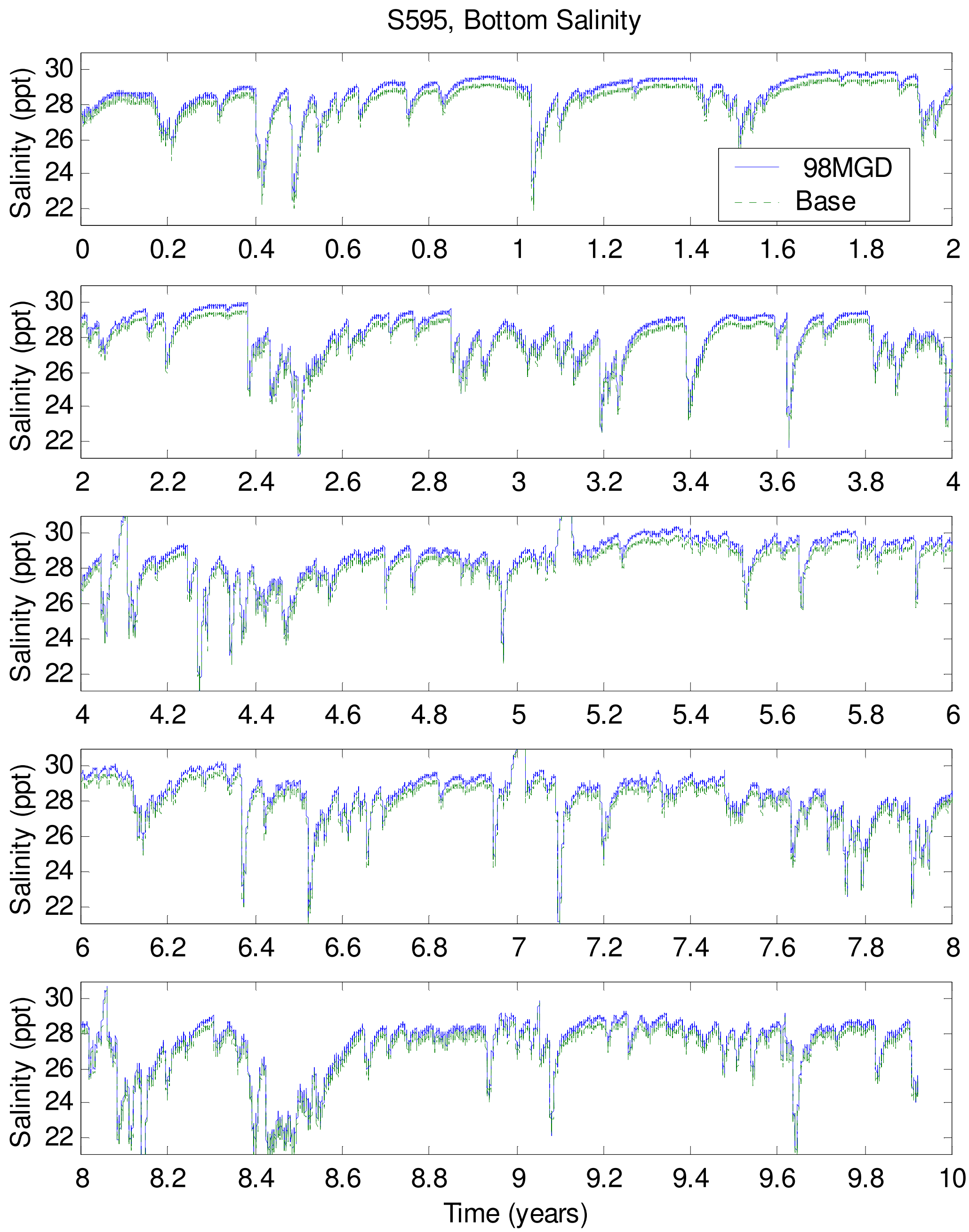

Figure 3.19 Bottom Salinity - 98MGD and Base-line Flow, Station S595

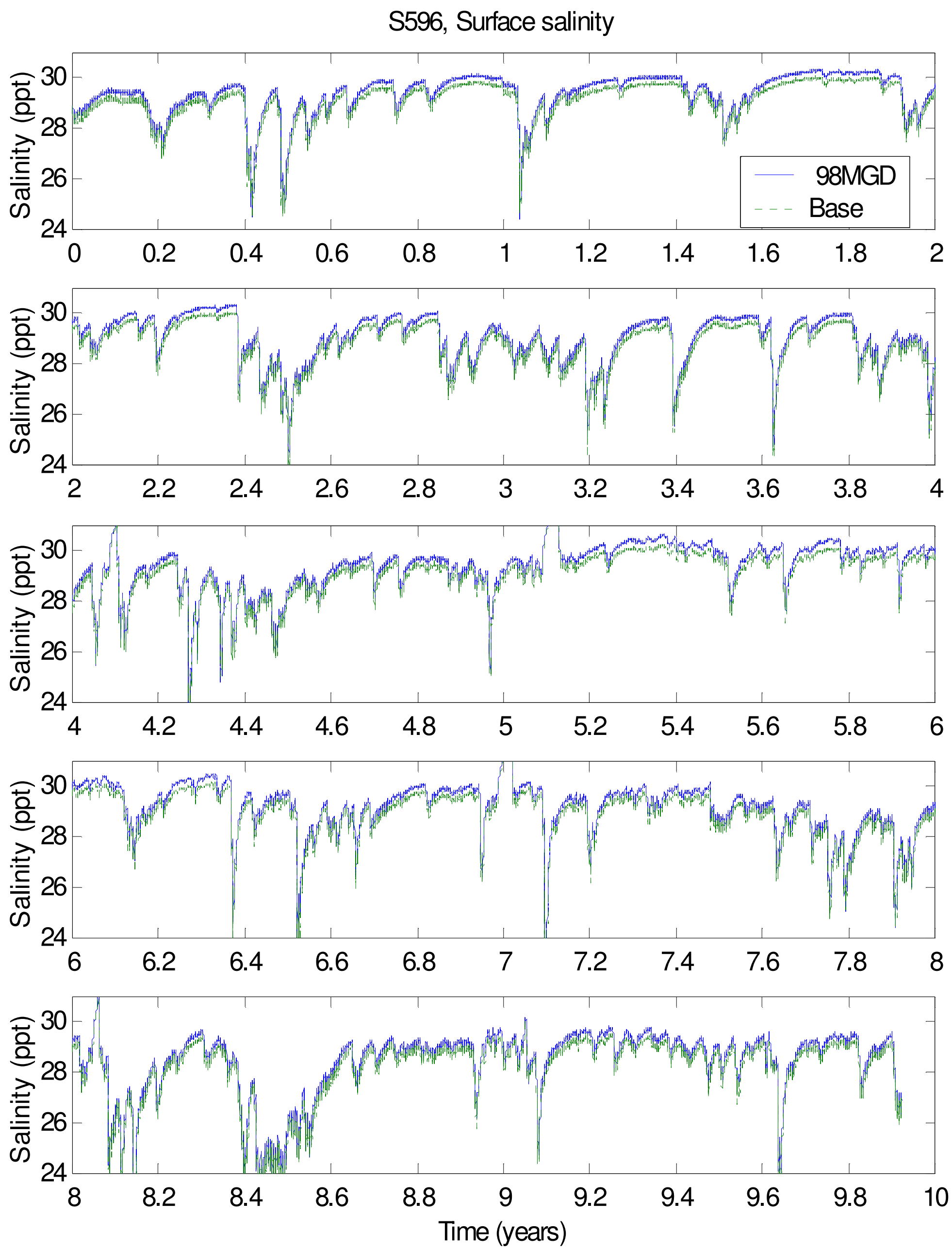

Figure 3.20 Surface Salinity - 98MGD Scenario and Base-line Flow, Station S596

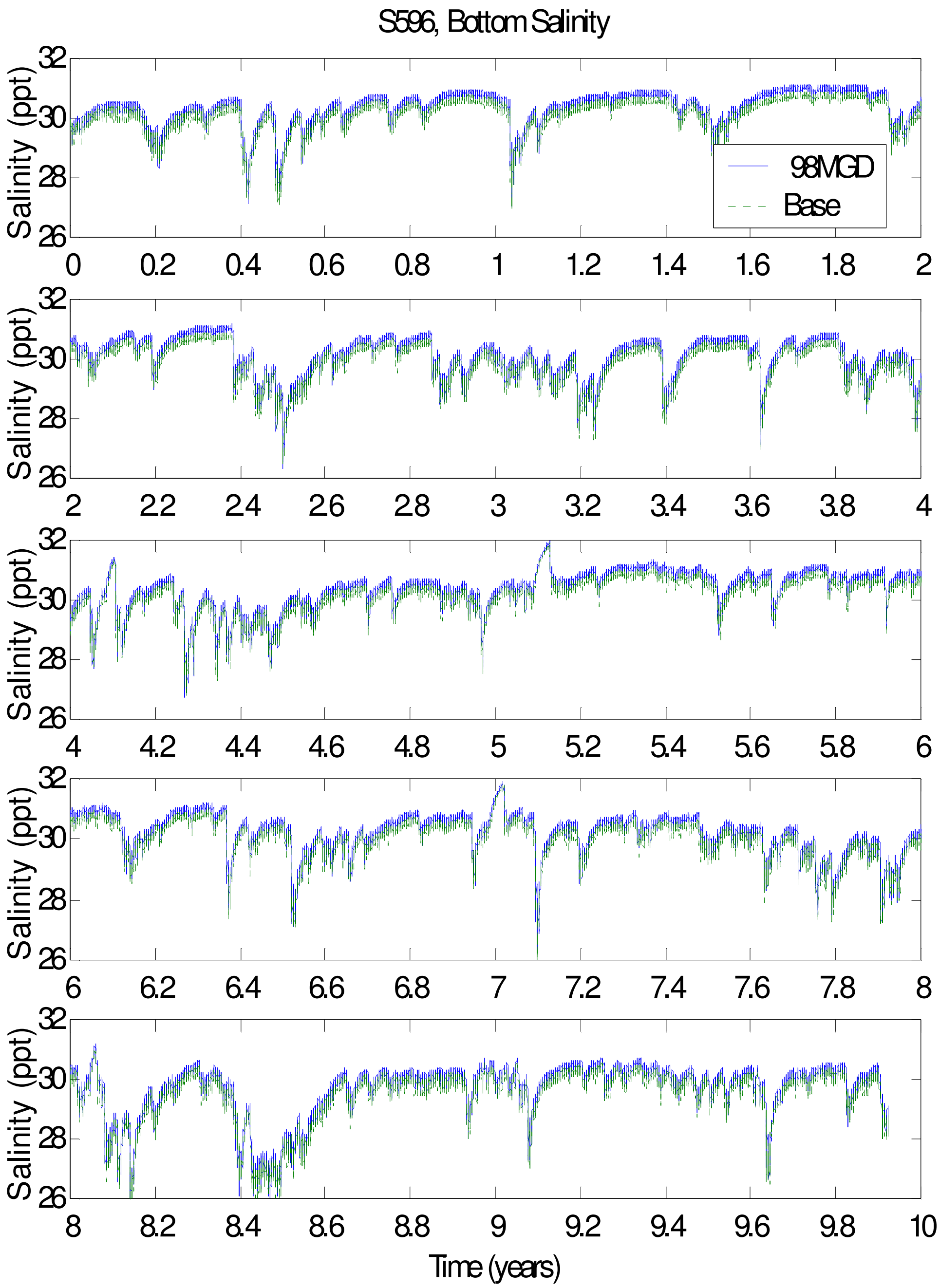

Figure 3.21 Bottom Salinity - 98MGD Scenario and Base-line Flow, Station S596

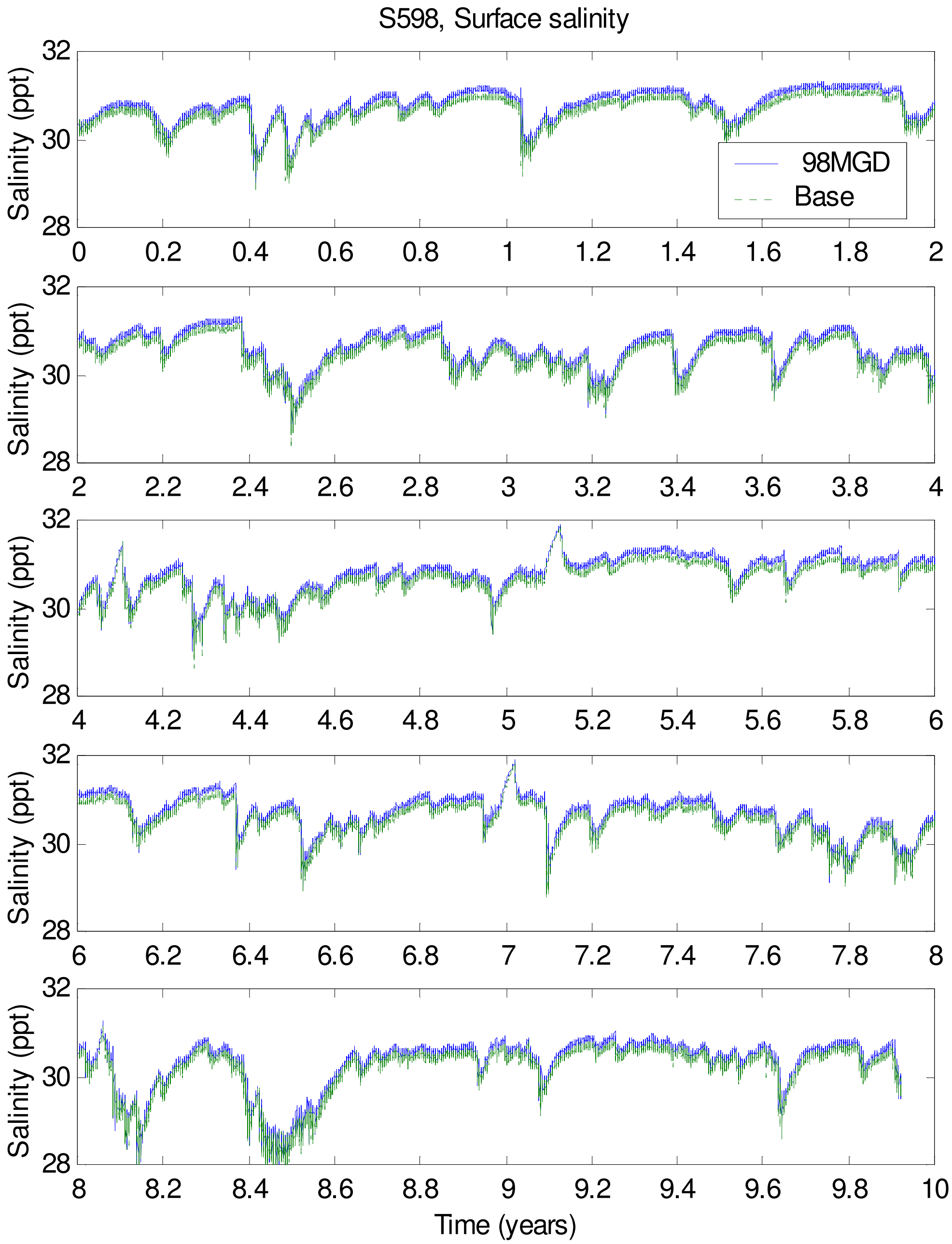

Figure 3.22 Surface Salinity - 98MGD Scenario and Base-line Flow, Station S598

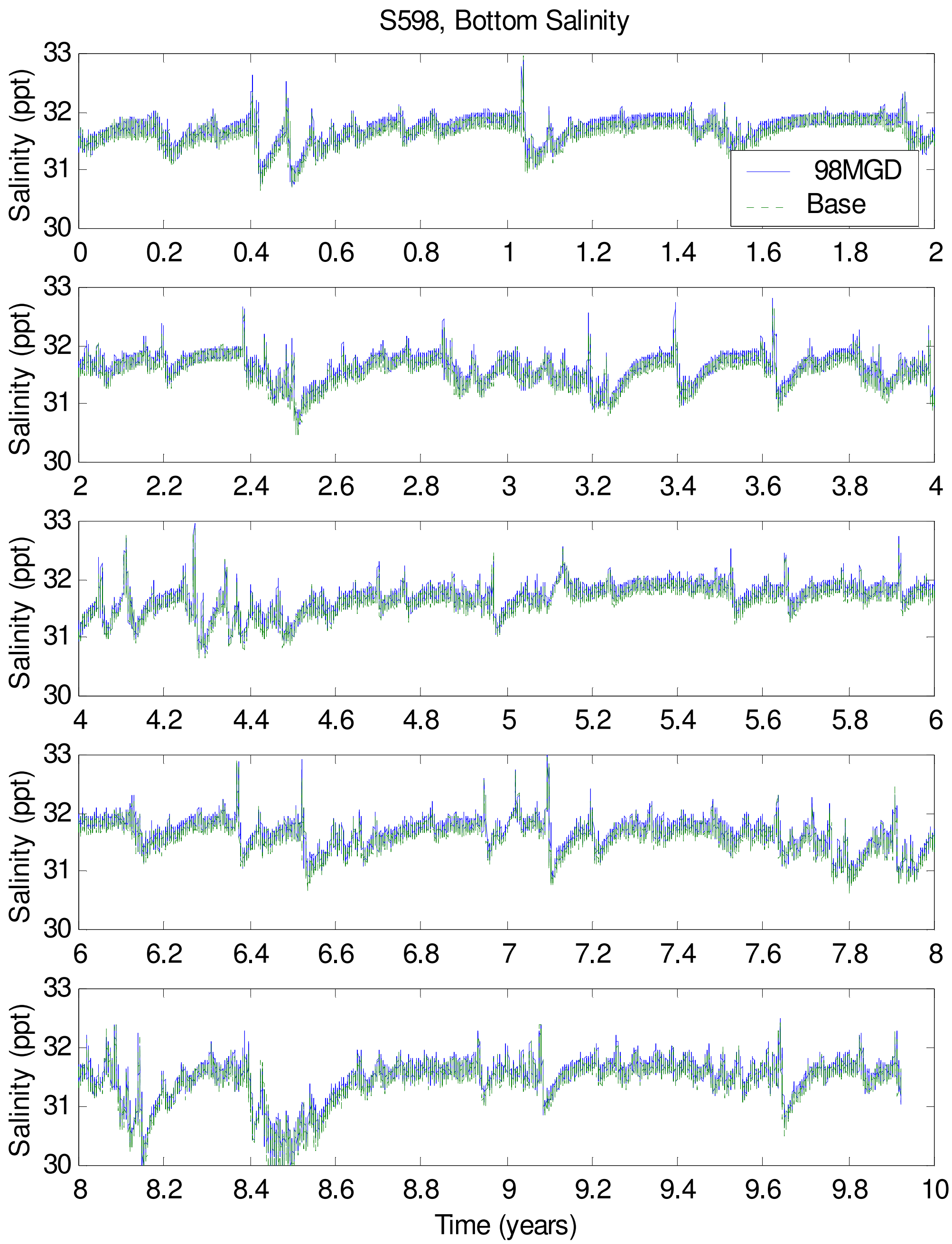

Figure 3.23 Bottom Salinity - 98MGD Scenario and Base-line Flow, Station S598

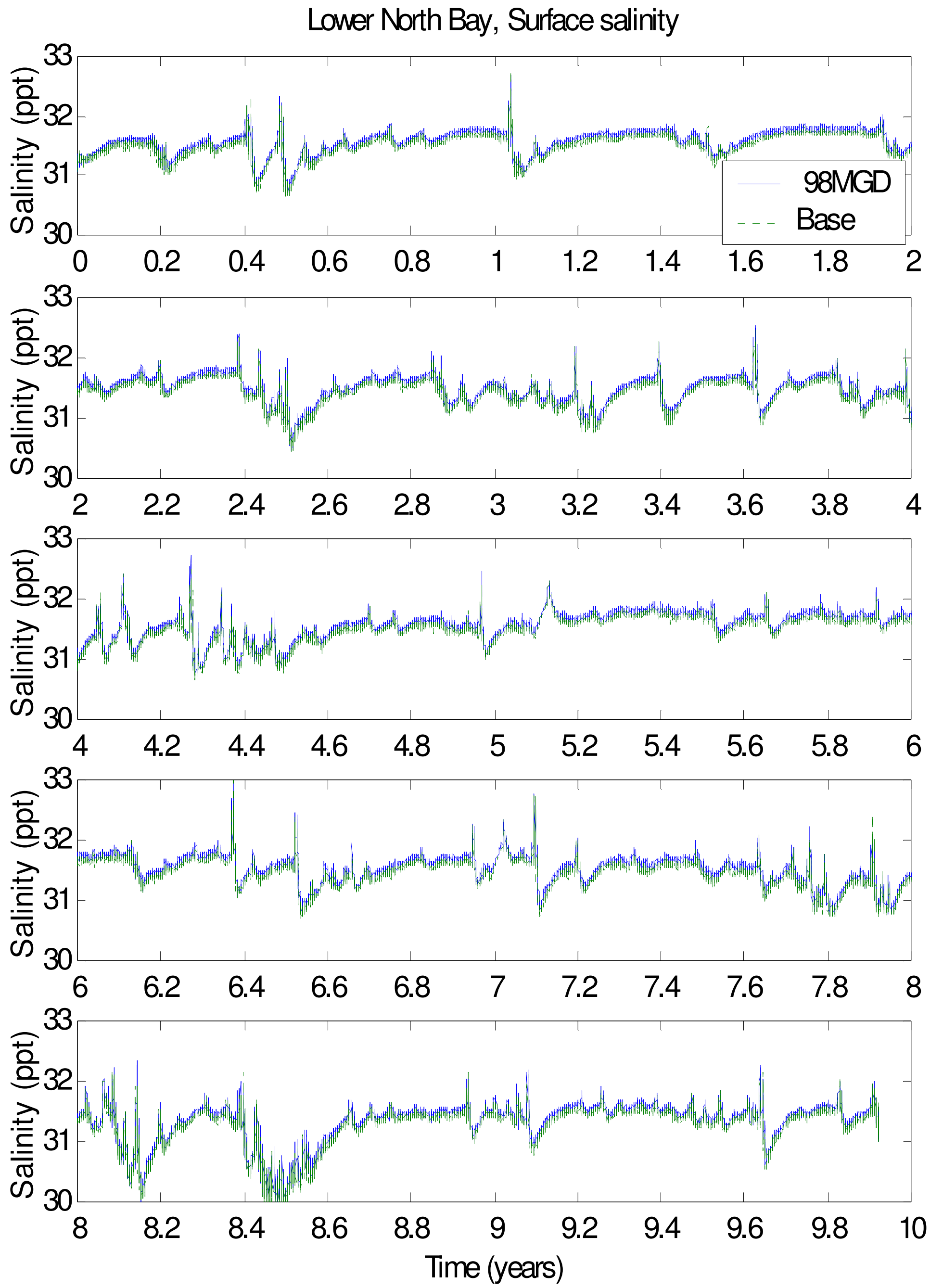

Figure 3.24 Surface Salinity - 98MGD Scenario and Base-line Flow, Lower North Bay

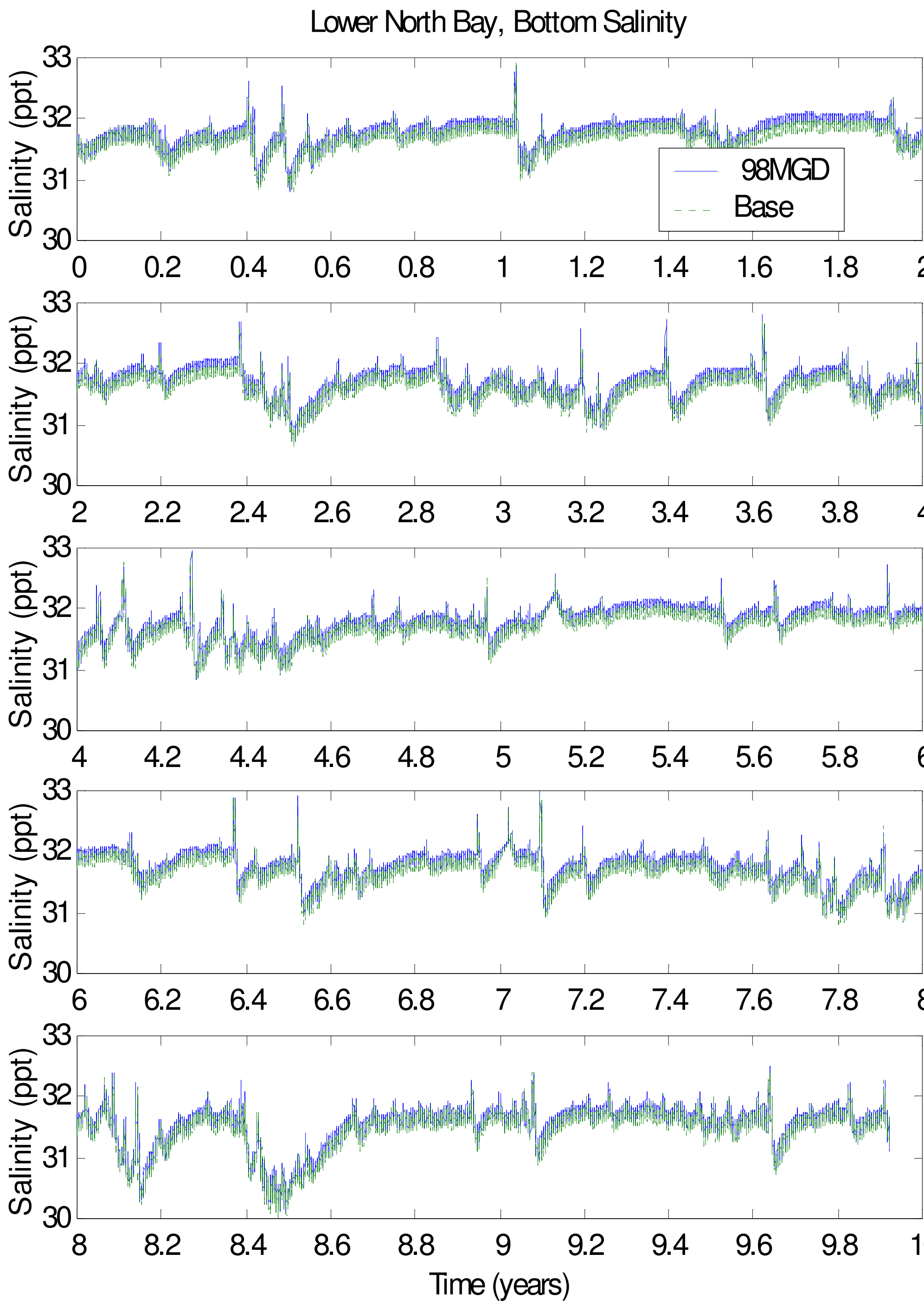

Figure 3.25 Bottom Salinity - 98MGD and Base-line Flow, Lower North Bay

4.0 CONCLUSION

The area of North Bay immediately below the Deer Point dam was identified as the only major, truly estuarine part of the St. Andrew Bay system (Ogren and Brusher 1977). As such, it is one of the more productive areas of this system. The quantity, quality and timing of freshwater discharge from the dam to this area of North Bay is critical to maintaining the estuarine conditions found here.

Freshwater inflows to North Bay are dominated by discharge from the Deer Point Reservoir which in turn is primarily influenced by flow from Econfina Creek. While Bayou George, Big Cedar and Bear Creeks provide inflow to the reservoir, Econfina Creek is estimated to contribute about 57 to 79% of the input to the lake. Roughly two-thirds of this flow is received from numerous natural springs connected to the Floridan Aquifer (Musgrove et al. 1965). Because of the high percentage of spring inflow, discharge from Econfina Creek, and from the lake to North Bay, is relatively stable over the year (i.e., limited seasonality).

Projected increases in future water supply withdrawals from the Deer Point lake reservoir through the year 2040 are not expected to have a significant affect on the biological communities and natural ecosystem in the North Bay portion of the St Andrew Bay system. The model results show an average increase in salinity of 0.4 parts per thousand (ppt) in North Bay as a result of reducing fresh water flow by the expected demand in the year 2040. This increase in average salinity is far less than natural variation in North Bay which can range from zero parts per thousand to over 30 parts per thousand as measured by the St. Andrew Resource Management Association from 1990 to 2002 (Appendix A).

A calibrated hydrodynamic model was applied to examine the changes of salinity in North Bay in response to the reductions of the freshwater inputs from Deer Point Lake Reservoir. A watershed hydrological model (SWMM) and water budget was utilized by NWFWMD to provide two long-term freshwater discharge scenarios over a 10-year period. Because of numerous surface water monitoring stations in the Deer Point Lake watershed, constructing a water budget was the preferred method to predict freshwater inputs into North Bay. Since the monitoring network was established in the latter part of 1998, the XP-SWMM model was used primarily to extend the water budget to a continuous 10-year dataset. Due to yearly winter drawdowns on the lake, the water budget stage-storage relationship calculations proved to be an important parameter for predicting accurate freshwater inputs into the bay. The drawdown gates were installed in 1979 and replaced in 1999.

In November 2002, the Bay County adopted a lake management plan to provide guidelines to anticipate rain events and maintain a lake level elevation of five feet. Since 1999, Bay County Water Utilities has performed winter drawdowns as a tactic to control and eliminate aquatic weed growth. Typically the drawdowns last for four to six weeks, but it varies depending on weather. During the drawdown, the bay receives an influx of freshwater until it has been lowered by approximately 3.5 feet. Once the lake has been lowered to its target elevation, the drawdown gates are closed and North Bay does not receive freshwater inputs until the lake reaches its required lake management plan elevation. The periods of no freshwater inputs are documented based on the drawdown gate record and stage values. If the gates are closed and the stage is below the spillway crest, then North Bay does not receive inputs from the lake. These periods of no flow from Deer Point Lake to North Bay are included in the flow scenarios used in the hydrodynamic model. One of the flow scenarios represents the base-line flow condition, while the other represents a scenario of reduced freshwater inflows due to increased diversions for future water supply demands. The reduced flows are based on the authorized withdrawal rate, not to exceed 98 million gallons per day (MGD), referenced in the Bay County Consumptive Water Use Permit (Appendix I).

The hydrodynamic model predicted salinity changes in the bay and the results indicate that, under the given flow scenarios, salinity changes in North Bay are small. The maximum change is 2.4 parts per thousand (ppt), while the average variation is 0.4 parts per thousand (ppt) over the 10-year period. Mode simulations also indicate that the average salinity in North Bay generally range from 27 parts per thousand near the Deer Point Lake Dam to 32 parts per thousand near the lower portion of the North Bay. Due to such a small change in salinity, the additional future withdrawals from the Deer Point Lake reservoir should not have a significant impact on the biological communities and natural systems in North Bay.

Management and protection of the Deer Point Lake Watershed will also be an important factor in the future health and biological diversity of North Bay and the St. Andrew Bay system. The importance of the Deer Point Reservoir as a natural resource and public water supply was recognized as early as 1967 with the passage of a State law defining the watershed and prohibiting certain activities such as sewage and waste disposal and septic tank setbacks within it. This law defined the Deer Point Lake Watershed as primarily an area immediately around the reservoir and the lower reaches of the major tributaries, but did not define the actual hydrologic watershed.

Additional protections have been added to protect this valuable resource. The lake and its major tributaries were designated as Class 1 (Potable Water Supplies) surface water bodies under Florida law to protect the primary drinking water supply for the County. In 1988, the lake was placed on the Surface Water Improvement and Management (SWIM) priority water body list by the Northwest Florida Water Management District (NWFWMD). The SWIM Act of 1987 directed each water management district to prioritize the surface waters within its jurisdiction and develop and implement plans for preservation and restoration of the priority water bodies. The NWFWMD, along with other government agencies, have purchased sensitive recharge areas within the watershed for preservation (Figure 4.1). As of 2006, over 41,149 acres along the Econfina Recharge Area (ERA) have been purchased by the NWFWMD.

The dynamics of the natural estuarine system North Bay were significantly altered when the dam was constructed across the upper portion of the bay forming the Deer Point Lake Reservoir. The freshwater lake formed by the impoundment and estuarine system below the dam have adapted to these altered conditions over the last 46 years. Studies and surveys of the North Bay suggest that the biological communities and ecosystem continue to function as a diverse, productive habitat. The results of this report indicate that the North Bay estuarine system should continue to function as a healthy ecosystem into the foreseeable future if properly managed and protected.

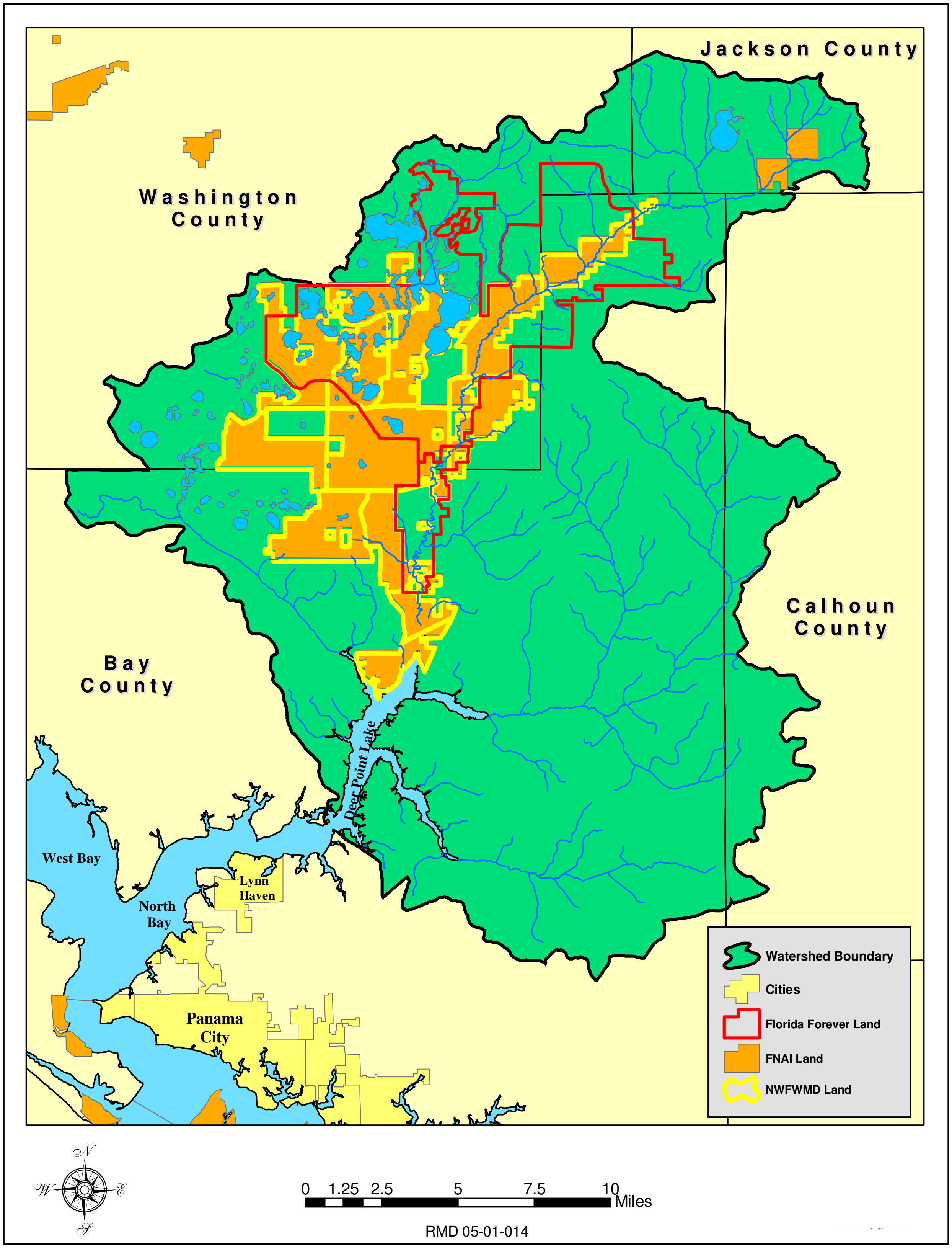

Figure 4.1 NWFWMD Land/Public Land in the Deer Point Lake Watershed

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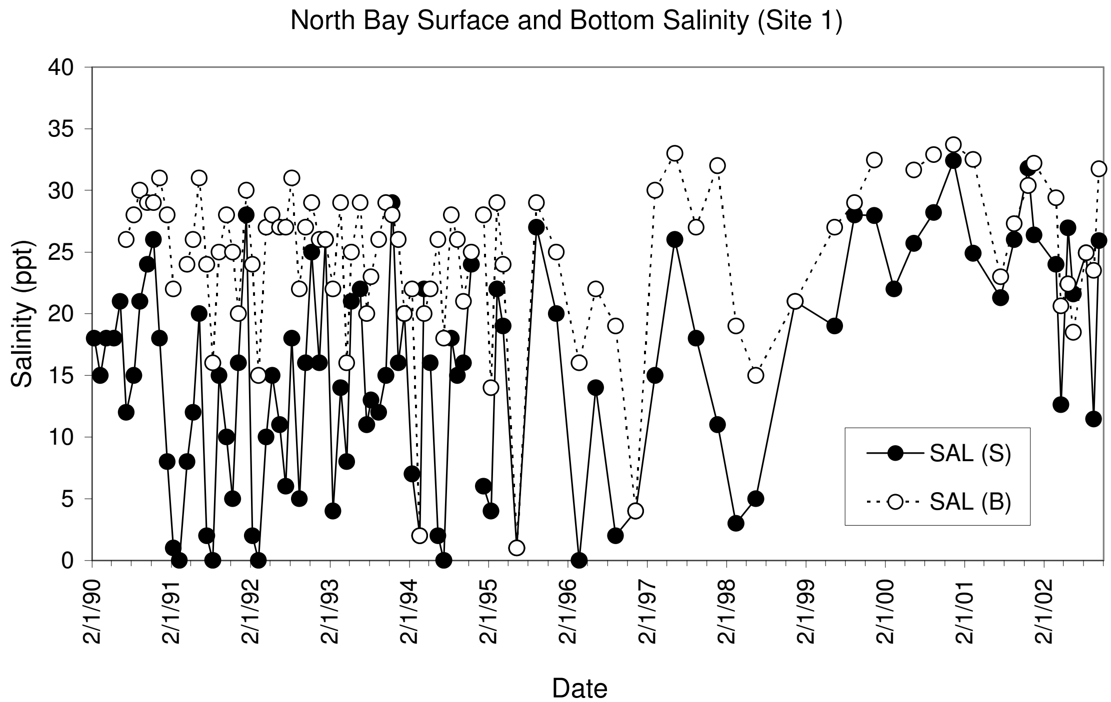
Appendix A - Historic North Bay Water Quality Data



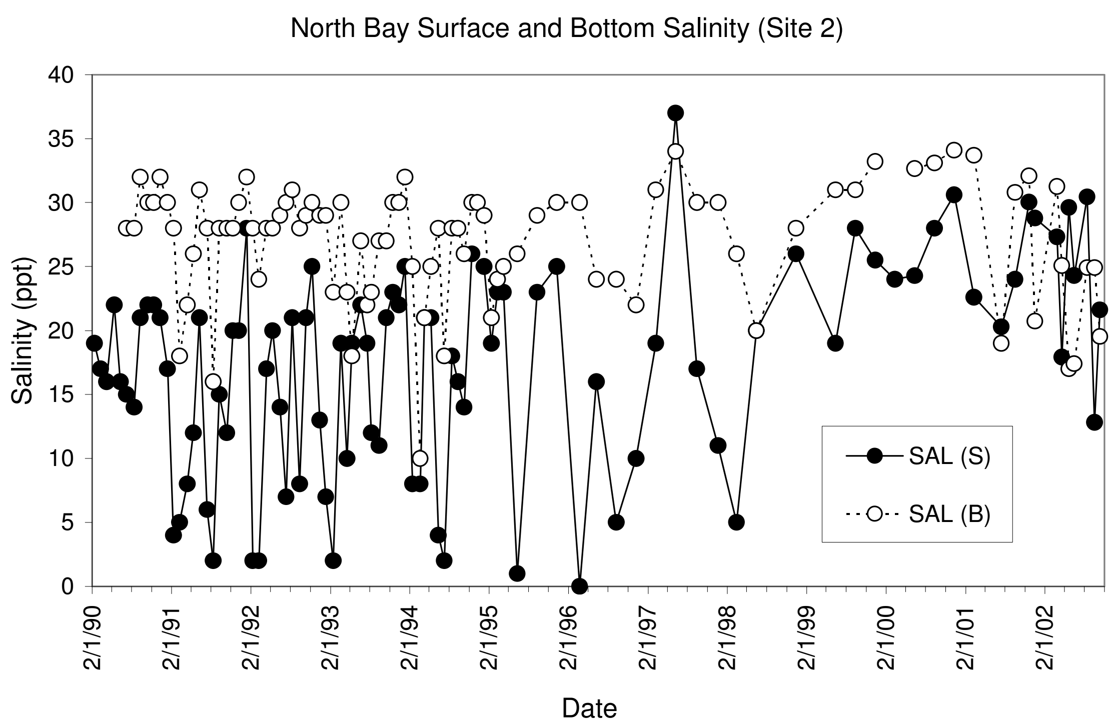
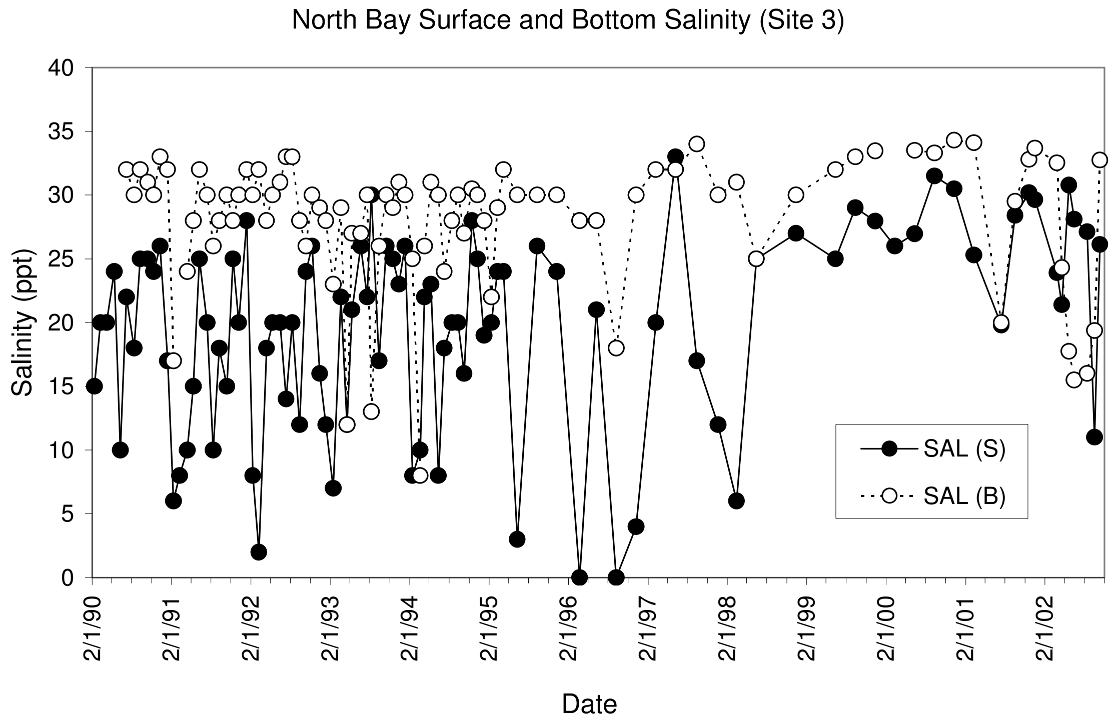


Figure A-1. Surface and bottom salinity at North Bay Stations 1 (upper panel) and 2 (lower panel) taken between 1990 and 2002 by the St. Andrew Bay RMA.



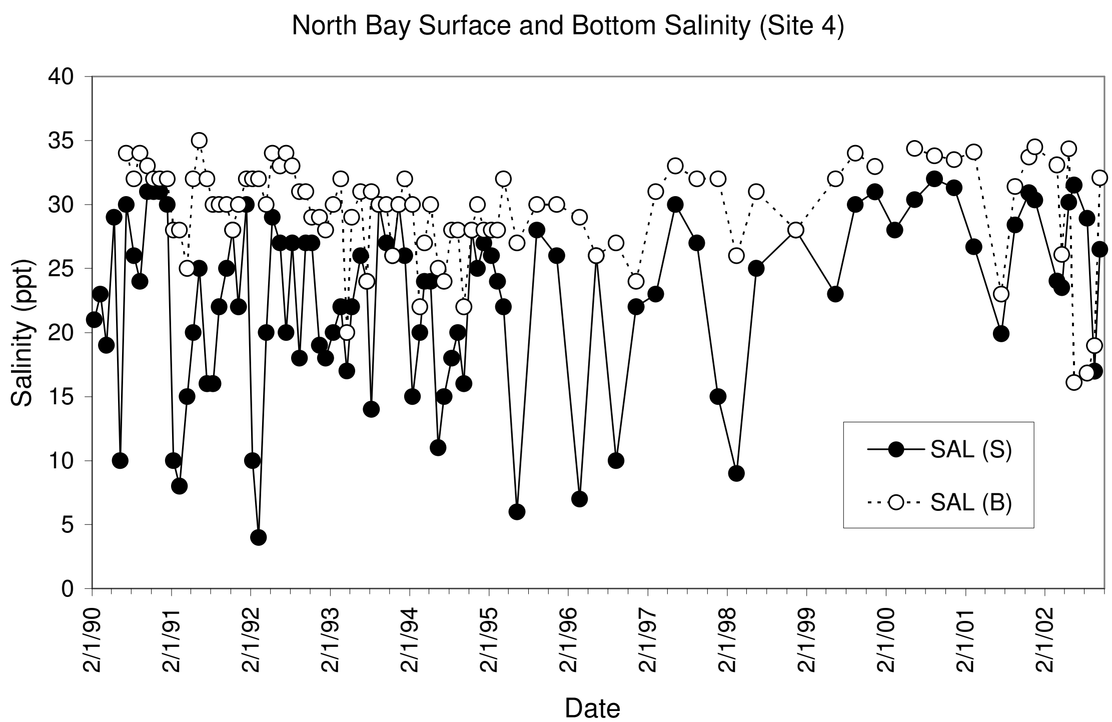
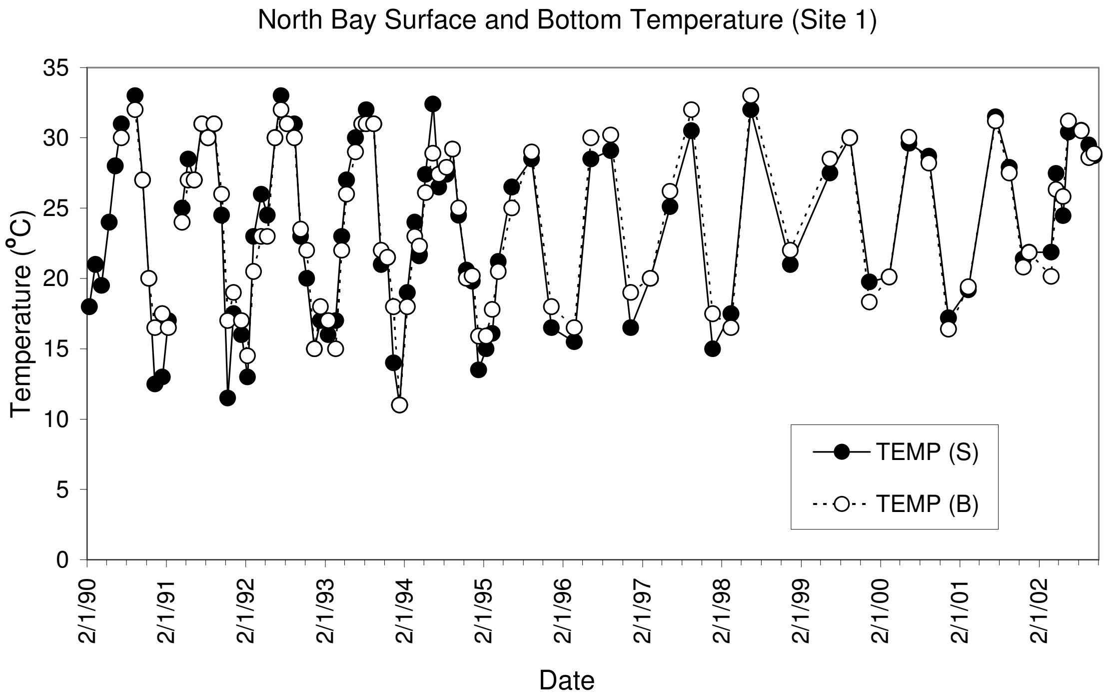


Figure A-1 (continued). Surface and bottom salinity at North Bay Stations 3 (upper panel) and 4 (lower panel) taken between 1990 and 2002 by the St. Andrew Bay RMA



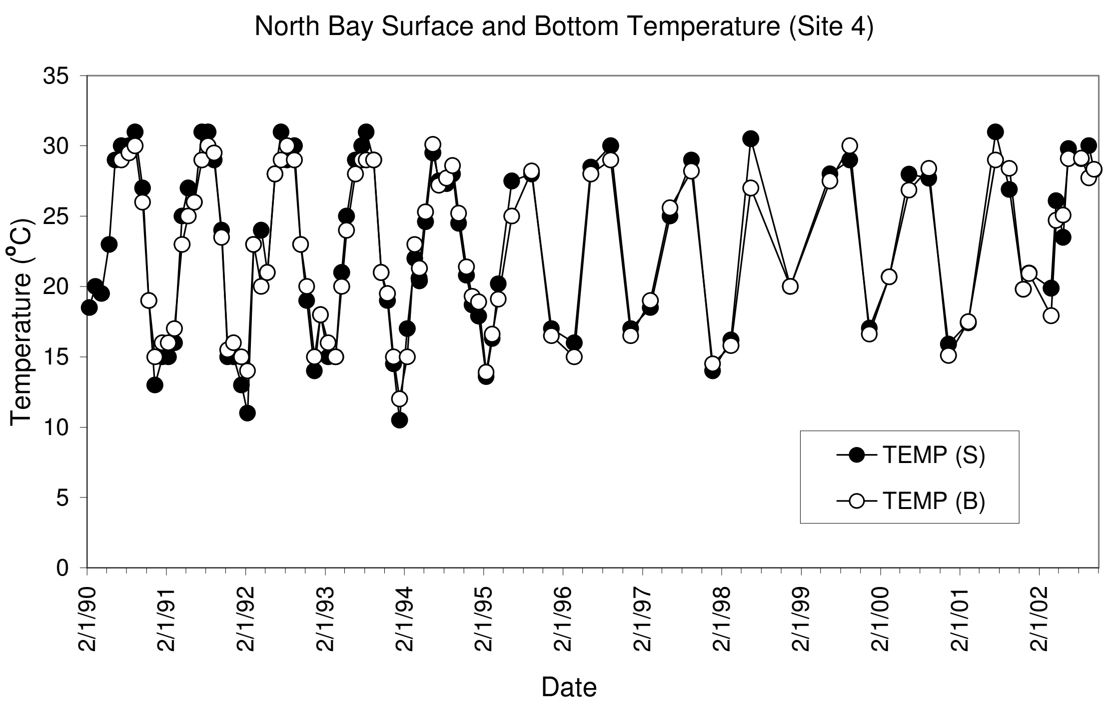
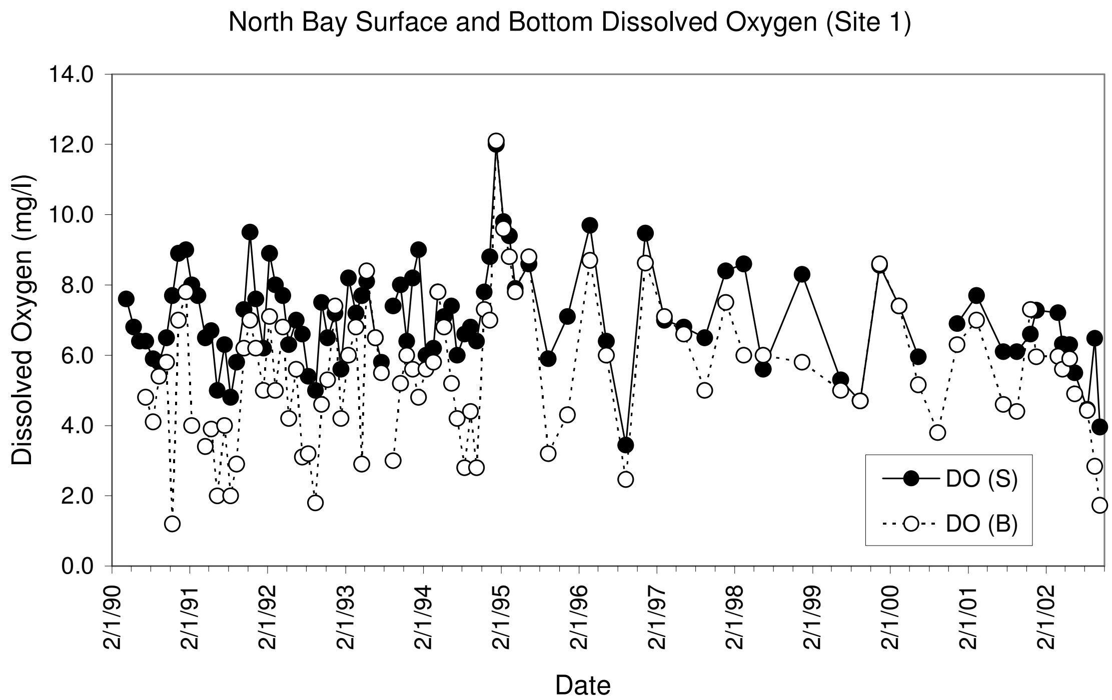


Figure A-2. Surface and bottom temperature at North Bay Stations 1 (upper panel) and 4 (lower panel) taken between 1990 and 2002 by the St. Andrew Bay RMA.



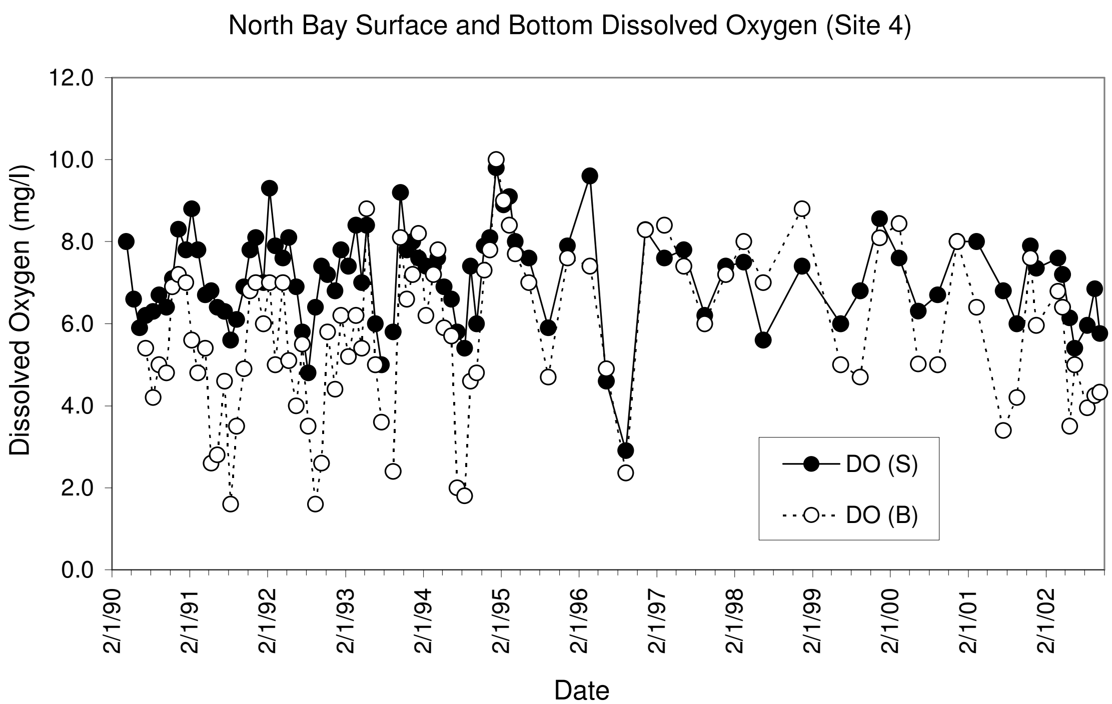
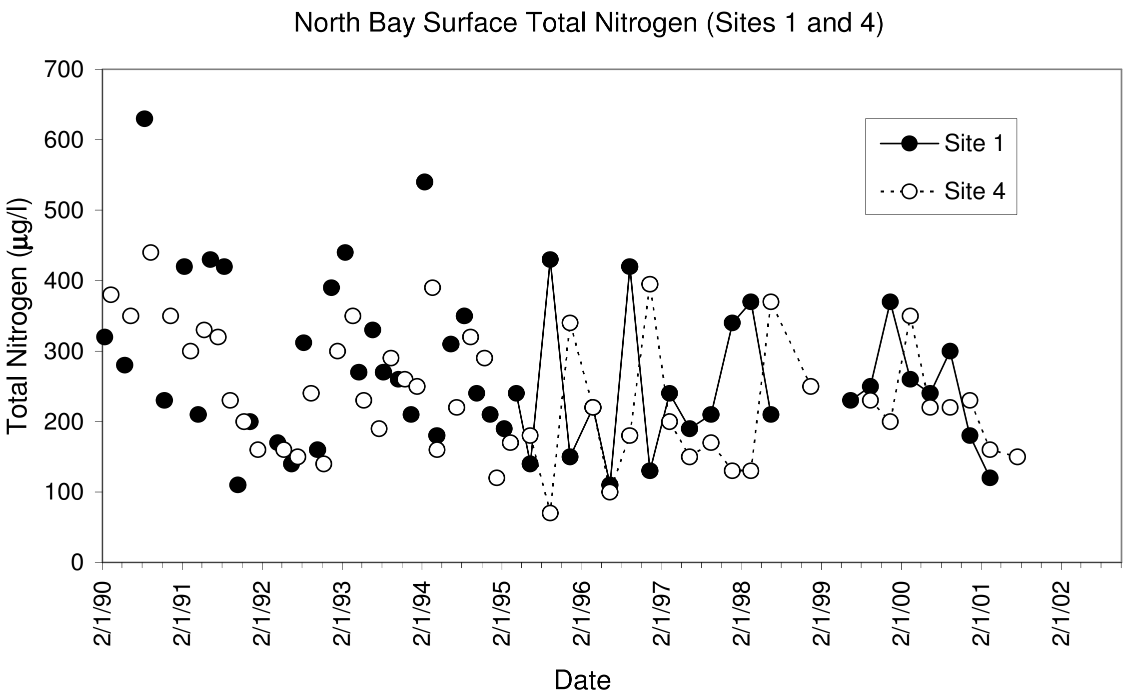


Figure A-3. Surface and bottom dissolved oxygen at North Bay Stations 1 (upper panel) and 4 (lower panel) taken between 1990 and 2002 by the St. Andrew Bay RMA.



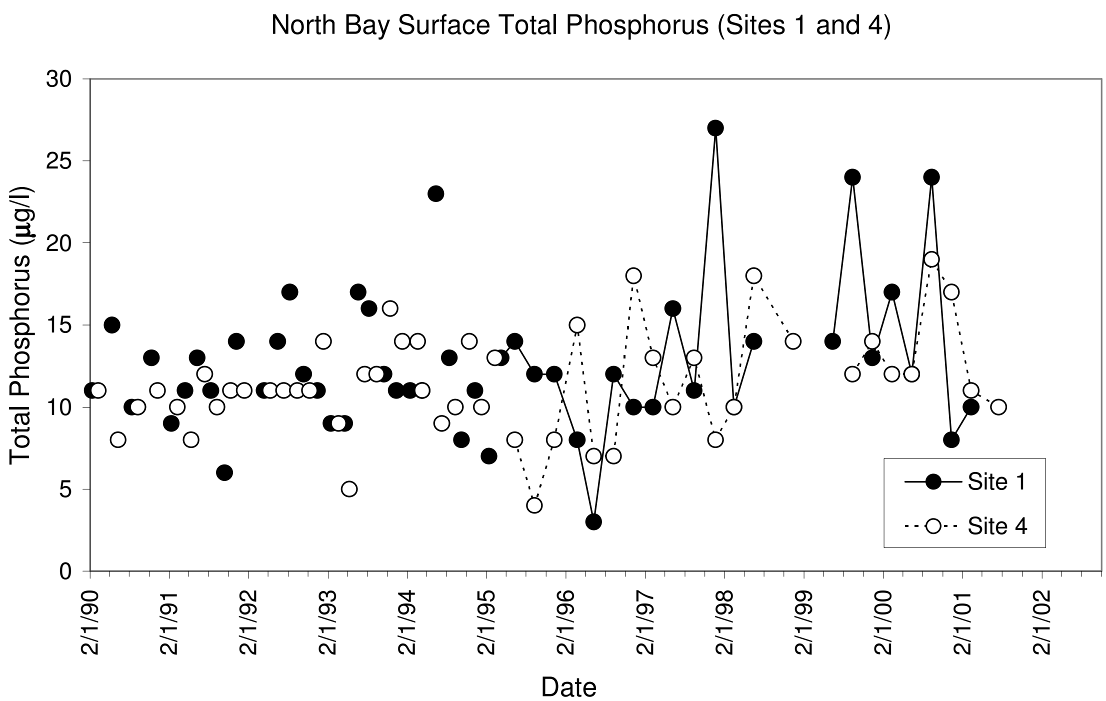


Figure A-4. Surface total nitrogen (upper panel) and total phosphorus (lower panel) concentrations at North Bay Stations 1 and 4 taken between 1990 and 2002 by the St. Andrew Bay RMA.

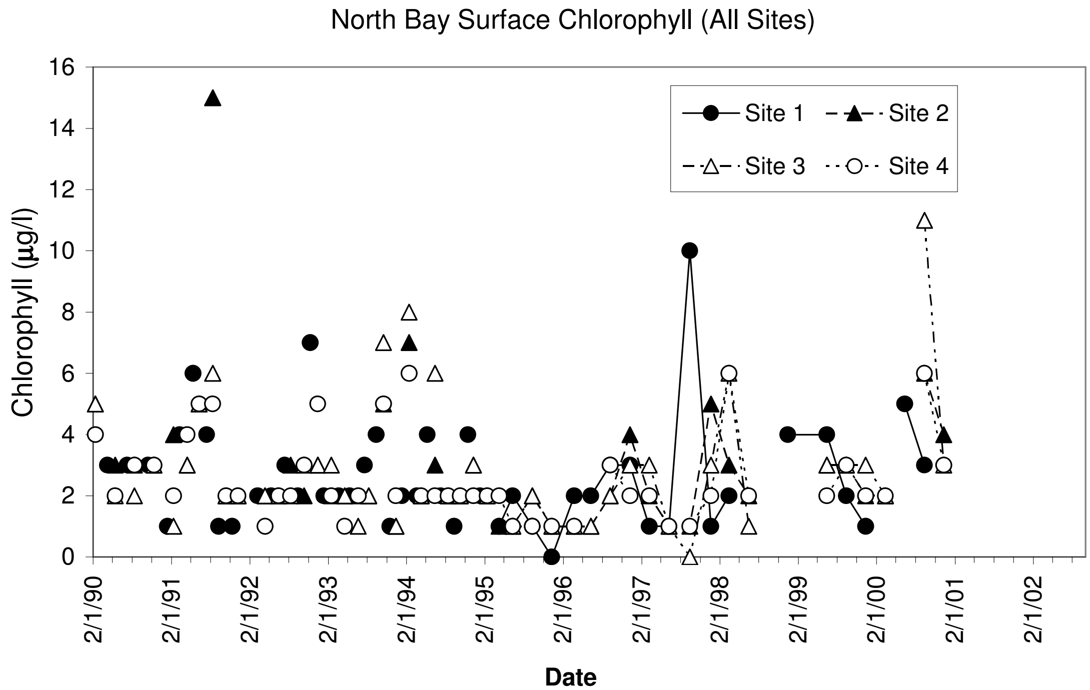


Figure A-5. Surface chlorophyll concentrations at the four North Bay stations taken between 1990 and 2002 by the St. Andrew Bay RMA.

Appendix B - Oyster Cultch and Marine Species Surveys

Table B-1. Amount and type of cultch material transferred to planted oyster reefs in North Bay. Data source: P. Couch (FDACS 2003).

Location[1]	Year of Transfer	Amount (yds^3)	Type of Cultch
A	1956	10,495	oyster shell
B	1957	190	oyster shell
C	1960	730	concrete rock
D	1964	1,654	clam shell
E	1969	15,623	oyster shell
F	1984	35,640	live oysters
G	1985	24,991	live oysters
H	1986	18,725	live oysters
I	1989	850	clam shell

[1] Locations are shown in Figure 18

Table B-2. Summary of fishes collected in the upper reaches of North Bay and its major tributaries prior to construction of the Deer Point Dam. Collections were made from 10 stations in brackish and fresh waters during 1956-57 by Chittenden et al. (1957). Only those fish collected at brackish water sites are included in the table below. Percent of catch is calculated only on these brackish collections.

Species	North Bay	Bayou	George	Bear Creek	Cedar	Creek	Total	Percent of Catch
	St. 2	St. 4	St. 7	St. 9	St. 10	St. 21		
Longnose gar (*Lepisosteus osseus*)	16	6	1	17	37	1	78	**15.5%**
Striped mullet (*Mugil cephalus*)	49	2	1			27	79	**15.7%**
Yellowfin menhaden (*Brevortia smithi*)	4	4			4		12	2.4%
Sea catfish (*Arius felis*)	7	5		13			25	**5.0%**
Speckled trout (*Cynoscion nebulosus*)	5	6			1	4	16	3.2%
Pinfish (*Lagodon rhomboides*)	35	13					48	**9.6%**
Anchovy (*Anchoa* sp.)	27	69					96	**19.1%**
Hogchoker (*Trinectes maculatus*)	1			1			2	0.4%
American eel (*Anguilla rostrata*)	4						4	0.8%
Longnose killifish (*Fundulus similis*)	19						19	3.8%
Gulf killifish (*Fundulus grandis*)	3	1					4	0.8%
Marsh killifish (Fundulus confluentes)		1					1	0.2%
Diamond killifish (*Adenia xenica*)	1	1					2	0.4%
Tidewater silverside (*Menidia beryllina*)	36	11					47	**9.4%**
Clown goby (*Microgobius gulosus*)	3	3					6	1.2%
Glut Herring (*Alosa aestivalis*)	1						1	0.2%
Black-cheek tonguefish (*Symphurus plagiusa*)	2						2	0.4%
Redfish (*Sciaenops ocellatus*)		2					2	0.4%
Silver perch (*Bairdella chrysoura*)		8		5		2	15	3.0%
Crevalle jack (*Caranx hippos*)		1					1	0.2%
Gulf pipefish (*Syngnathus scovelli*)		1					1	0.2%
Atlantic needlefish (*Strongylura marina*)		1					1	0.2%
Gizzard shad (*Dorosoma cepedianum*)				1			1	0.2%
Searobin (*Prionotus* sp.)				1			1	0.2%
Redear sunfish (*Lepomis microlophus*)					2		2	0.4%
Black drum (*Pogonias cromis*)					1		1	0.2%
White catfish (*Ictalurus catus*)						1	1	0.2%
Spotfin mojarra (*Eucinostomus argenteus*)						33	33	**6.6%**
Gray snapper *(Lutjanus griseus*)						1	1	0.2%
Totals	213	135	2	38	45	69	502	

Table B-3. Summary of fishes collected in North Bay relative to total catch in St. Andrew Bay. Collections were made from 12 stations throughout the bay system during 1972-73 by Ogren and Brusher (1977). Only those fish collected in North Bay are included in the table below.

Species	North Bay Catch	Total Catch	Percent of Total Catch
Dasyatidae (stingrays)			
Dasyatis sabina	20	56	35.7%
Dasyatis sayi	1	18	5.6%
Gymnura micrura	1	11	9.1%
Lepisosteidae (gars)			
Lepisosteus osseus	7	8	87.5%
Ophichthidae (snake eels)			
Ophichthus gomesi	3	148	2.0%
Clupeidae (herrings)			
Brevoortia patronus	2061	2204	93.5%
Dorosoma petenense	8	18	44.4%
Harengula jaguana	127	4211	3.0%
Opisthonema oglinum	172	956	18.0%
Sardinella anchovia	12	319	3.8%
Engraulidae (anchovies)			
Anchoa hepsetus	163	3869	4.2%
Anchoa mitchelli	1180	4682	25.2%
Anchoa nasuta	3	283	1.1%
Synodontidae (lizardfishes)			
Synodus foetens	29	1210	2.4%
Ariidae (sea catfishes)			
Arius felis	288	900	32.0%
Bagre marinus	260	740	35.1%
Batrachoididae (toadfishes)			
Opsanus beta	4	25	16.0%
Porichthys porossissimus	27	803	3.4%
Gadidae (codfishes)			
Urophycis floridanus	12	2570	0.5%
Atherinidae (silversides)			
Membras martinica	1	1	100.0%

Table B-3. *Continued*

Species	North Bay Catch	Total Catch	Percent of Total Catch
Serranidae (sea basses)			
Diplectrum bivittatum	3	2190	0.1%
Diplectrum formosum	9	865	1.0%
Pomatomidae (bluefishes)			
Pomatomus saltatrix	1	4	25.0%
Carangidae (jacks)			
Caranx hippos	10	17	58.8%
Chloroscombrus chrysurus	253	542	46.7%
Lutjanidae (snappers)			
Lutjanus griseus	1	2	50.0%
Gerreidae (mojarras)			
Eucinostomus argenteus	29	3085	0.9%
Eucinostomus gula	1	259	0.4%
Pomadasyidae (grunts)			
Orthopristis chrysopterus	80	4285	1.9%
Sparidae (porgies)			
Lagodon rhomboides	3990	6436	62.0%
Sciaenidae (drums)			
Bairdiella chrysoura	231	1818	12.7%
Cynoscion arenarius	118	882	13.4%
Cynoscion nebulosus	141	472	29.9%
Leiostomus xanthurus	11223	19778	56.7%
Menticirrhus americanus	18	157	11.5%
Micropogonias undulatus	13632	31210	43.7%
Ephippidae (spadefishes)			
Chaetodipterus faber	5	29	17.2%
Sphyraenidae (barracudas)			
Sphyraena guachancho	1	1	100.0%
Polynemidae (threadfins)			
Polydactylus octonemus	17236	95689	18.0%
Gobiidae (gobies)			
Bathygobius soporator	1	1	100.0%
Gobionellus hastatus	2	96	2.1%
Stromateidae (butterfishes)			
Peprilus alepidotus	2	61	3.3%
Peprilus burti	82	551	14.9%

Table B-3. *Continued*

Species	North Bay Catch	Total Catch	Percent of Total Catch
Triglidae (searobins)			
Prionotus rubio	1	17	5.9%
Prionotus scitulus	4	1232	0.3%
Prionotus tribulus	101	491	20.6%
Bothidae (lefteye flounders)			
Ancylopsetta quadrocellata	1	176	0.6%
Citharichthys spilopterus	3	37	8.1%
Etropus crossotus	13	521	2.5%
Soleidae (soles)			
Achirus lineatus	2	38	5.3%
Trinectes maculatus	1	81	1.2%
Cynoglossidae (tonguefishes)			
Symphurus plagiusa	119	6920	1.7%
Balistidae (filefishes)			
Monacanthus hispidus	9	41	22.0%
Ostraciidae (boxfishes)			
Lactophrys quadricornis	25	152	16.4%
Tetraodontidae (puffers)			
Spheroides nephelus	5	167	3.0%
Diodontidae (porcupinefishes)			
Chilomycterus schoepfi	7	114	6.1%
72 additional species		5998	
Totals	51739	207447	24.9%

Table B-4. Summary of shrimp collected in North Bay relative to total catch in St. Andrew Bay. Collections were made at 12 stations throughout the bay system during 1972-73 by Brusher and Ogren (1976). Only those species collected in North Bay are included in the table below.

Species	North Bay Catch	Total Catch	Percent of Total Catch
Farfantepenaeus duorarum (pink shrimp)	2737	37580	7.3%
Farfantepenaeus aztecus (brown shrimp)	279	1889	14.8%
Litopenaeus setiferus (white shrimp)	71	424	16.7%
Trachypenaeus constrictus (broken-neck shrimp)	122	3064	4.0%
Trachypenaeus similis (broken-neck shrimp)	3	10599	0.03%
Sicyonia brevirostris (rock shrimp)	9	9234	0.1%
2 additional species		6412	
Total	3221	69202	4.65%

Table B-5. Commercial landings of estuarine species in Bay County. Only those species that are caught partially or predominantly in St. Andrew Bay are included. Landing are given in pounds with the number of trips in parentheses. Landings reported here are those sold to wholesale seafood establishments within the county and do not reflect the actual location of capture. Data source: Florida Fish and Wildlife Research Institute (2007).

Year	Blue crab	Shrimp	Oyster
2006	65,337 (750)	479,649 (403)	11,004 (131)
2005	77,003 (642)	598,507 (419)	3,102 (36)
2004	87,052 (757)	427,639 (582)	45,187 (512)
2003	141,804 (928)	173,841 (432)	112,345 (1322)
2002	215,433 (866)	142,754 (497)	0 (0)
2001	213,459 (797)	267,349 (885)	164 (6)
2000	292,223 (919)	241,386 (1199)	182 (7)
1999	167,063 (1073)	238,761 (812)	28 (2)
1998	272,019 (1000)	292,558 (995)	12,871 (164)
1997	229,495 (790)	313,351 (1013)	307,145 (3122)
1996	282,439 (899)	378,752 (1058)	308,557 (3004)

Appendix C **Representative Salinity Tolerances for Dominant Species in North Bay**

Table C-1. Representative salinity ranges for the dominant organisms (emergent marsh, seagrasses, invertebrates and fishes) found in the estuarine portions of North Bay, Florida. Salinity ranges are given for different life history stages, where available, along with the source of information. Table entries are salinity values given in parts per thousand; ma = most abundant in stated range.

Species	Eggs and Larvae	Juveniles	Adults	References
Emergent Marsh				
Smooth cordgrass (*Spartina alterniflora*)			0.6-33.0 (<19 higher production) 6-34 (20±8 mean) 2-28 (12±7 mean) 15.2±7.8 mean (LA statewide) 83-115 lethal limits	Mendelssohn and Marcellus (1976) Pulich (1990) cited in Longley (1994) Chabreck (1972) cited in Longley (1994) Hester et al. (1998)
Black needlerush (*Juncus roemerianus*)			0-20 0-60 growth decreasing with salinity (max in freshwater) 13.9±8.3 mean (LA statewide) 0->40	Clewell (1981) Eleuterius (1984) Chabreck (1972) cited in Longley (1994) Touchette (2006)
Seagrasses				
Widgeon grass (*Ruppia maritima*)			<28 to set seed 0-33.2 (<25 ma) <74 lab survival (>46 no growth) 16-24 in field 0->60 (up to 390)- lit review 0-40 (10-20 optimal) 0-30 (growth lower in pulsed salinity)	Bourn (1935) cited in Longley (1994) Phillips (1960) McMillan and Moseley (1967) Zimmerman and Livingston (1976) Kantrud (1991) Murphy et al. (2003) La Peyre and Rowe (2003)

			36-70 (>55 stress threshold)	Koch et al. (2007)
Shoal grass (*Halodule wrightii*)			1-60 (dwarfing at high salinity); 25-34 abundant <74 lab growth 3.5-52.5 lab survival 23-37 lab survival 17(6 min)-36 in field 5-55 5-45 blade growth (10-35 max) 35-62 in field 36-70 (>65 stress threshold)	Phillips (1960) McMillan and Moseley (1967) McMahan (1968) McMillan (1974) Zimmerman and Livingston (1976) Dunton (1996) Lirman and Cropper (2003) Cotner et al. (2004) Koch et al. (2007)
Turtlegrass (*Thalassia testudinum*)			10-48 (25-38.5 optimal) <74 lab survival (>60 no growth) 10-50 lab survival 15-40 in field (24-35 optimal) 17(6 min)-36 in field 6-35 lab survival (growth least at 6) 22-36 field optimal 5-45 blade growth (15- 40 max) 10-50 (30-40 optimal for photosynthetic efficiency) 36-70 (>60 stress threshold)	Phillips (1960) McMillan and Moseley (1967) McMillan (1974) Zieman (1975) Zimmerman and Livingston (1976) Doering and Chamberlain (2000) Lirman and Cropper (2003) Kahn and Durako (2006) Koch et al. (2007)

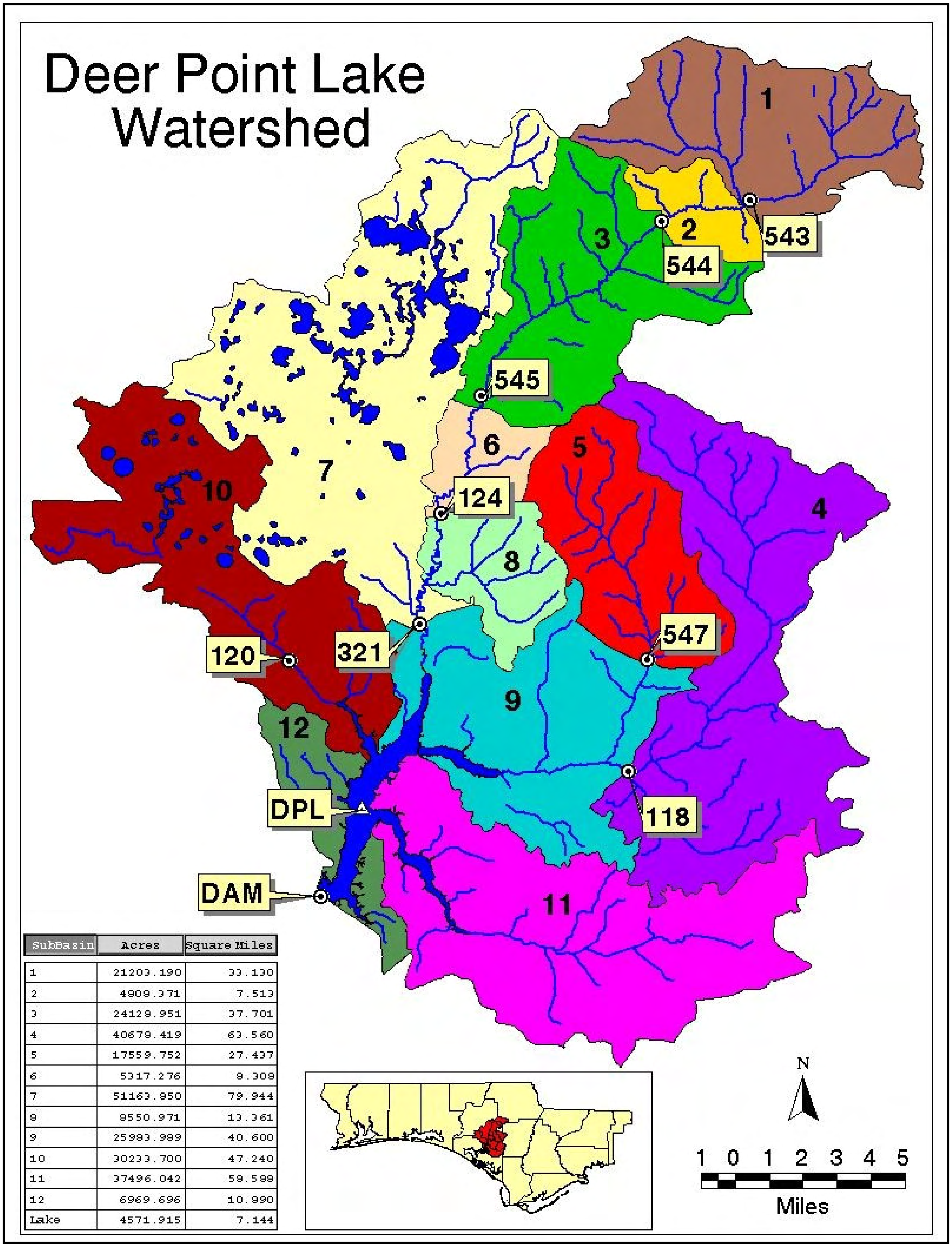
Appendix C **Representative Salinity Tolerances for Dominant Species in North Bay**

Invertebrates				
Eastern oyster (*Crassostrea virginica*)		3-44	<3 no feeding 5-30	Loosanoff (1953) Galtsoff (1964) Copeland and Hoese (1966)
	16-22 setting abundant			Chatry et al. (1983)
	17-24 optimal for spat		0-45 (10-30 best survival; 10-24 ma)	after Longley (1994)
	7.5-34 (10-22 optimal)-eggs 5-39 (25-29 optimal)-larvae	5.6-35 (13-30 optimal for growth-spat	2-43.5 (14-30 optimal for growth)	after Pattillo et al. (1997)
			2-35 11-29 (means per site; 4-24 mean lows)	Livingston et al. (2000) Bergquist et al. (2006)
Pink shrimp (*Farfantepenaeus duorarum*)	12-43	>20 5-47 >18 ma	25-45 15.5-37.7 ma	Hildebrand (1955) Tabb et al. (1962) Gunter et al. (1964) Stokes (1974)
		8-36 (20-35 optimal)	0.6-65 (lit review)	Copeland & Bechtel (1974)
	12-43 postlarvae	<1-47 (>20 preferred)	1-69 (25-45 ma)	after Pattillo et al. (1997)
Fishes				
Bay anchovy (*Anchoa mitchelli*)			2.3-36.9 (<5 ma) 5-35 0-30 0-34 (20-30 ma)	Gunter (1945) Springer and Woodburn (1960) Tabb and Manning (1961) Swingle (1971)
	0.5-1, 20-25	0-40	1-32	after Pattillo et al. (1997)
	0-30 (10-20 ma):means	0-30 (<15 ma): means	0-30 (<15 ma): means	Peebles et al. (2007)

Appendix C **Representative Salinity Tolerances for Dominant Species in North Bay**

Gulf menhaden (*Brevoortia patronus*)	6.6-33.2 larvae >29 eggs & early larvae 5-30 Postlarvae	0.1-31.6 (10-15 & >30 ma) 0-26 (<12 optimal) 0-40+ (<12 ma)	2-33.7 6.6-34.2 0.0-54.3 (lit review) 0-67 (20-25 ma)	Gunter (1945) Springer and Woodburn (1960) Swingle (1971) Copeland & Bechtel (1974) Longley (1994) after Pattillo et al. (1997)
Pinfish (*Lagodon rhomboides*)		2-30+ (>20 ma)	2.1-37.2 3.7-35.1 8-37 0-43.8	Gunter (1945) Springer and Woodburn (1960) Tabb and Manning (1961) Swingle (1971) Pattillo et al. (1997)
Atlantic croaker (*Micropogonias undulatus*)	25-35 (optimal)-eggs 15-35 (optimal)-larvae 15-36 larvae	0-30+ (5-15 ma) 0-37 (6-15 optimal) 0-36.7 (10-20 ma)	2-36.7 (<15 ma) 5-29.8 19-32 0->60 0-70 (15-20 ma)	Gunter (1945) Springer and Woodburn (1960) Tabb and Manning (1961) Swingle (1971) after Longley (1994) after Pattillo et al. (1997)
Spot (*Leiostomus xanthurus*)	30-35 eggs 6-36 larvae	0.1-30+ (5-20 & >30 ma) 0-36.2 (>10 ma)	2-36.7 (>15 ma) 5-34.2 9-48 0-60 (15-30 ma)	Gunter (1945) Springer and Woodburn (1960) Tabb and Manning (1961) Swingle (1971) after Pattillo et al. (1997)

Appendix D Deer Point Lake Impervious Percentages



SubBasin	Acres	Square Miles
1	21203.190	33.130
2	4808.371	7.513
3	24128.951	37.701
4	40679.419	63.560
5	17559.752	27.437
6	5317.276	8.308
7	51163.950	79.944
8	8550.971	13.361
9	25983.989	40.600
10	30233.700	47.240
11	37496.042	58.588
12	6969.696	10.890
Lake	4571.915	7.144

Appendix D Deer Point Lake Impervious Percentages

Deer Point Lake Impervious Percentage Calculations

Watershed 1	Acres	*Weighted Coefficient*	Total
Agriculture	3514	0.15	527.1
Commercial & Services	6.5	0.5	3.3
Industrial	89	0.5	44.5
Open Land	2478	0.15	371.7
Recreational	80	0.15	12
Residential	529	0.35	185.2
Trans, Com & Utilities	210	0.5	105
Upland Forests	11236	0.1	1123.6
Water	932	1	932
Wetlands	2129	0.5	1064.5
	21203.5		**4368.8**
Percent Impervious		**20.6**	

Watershed 2	Acres	*Weighted Coefficient*	Total
Agriculture	996	0.15	149.4
Commercial & Services	0.04	0.5	0.02
Industrial	4.4	0.5	2.2
Recreational	1.8	0.15	0.3
Residential	123	0.35	43.1
Trans, Com & Utilities	63	0.5	31.5
Upland Forests	3436	0.1	343.6
Water	12.6	1	12.6
Wetlands	171	0.5	85.5
	4807.84		**668.1**
Percent Impervious		**13.9**	

Watershed 3	Acres	*Weighted Coefficient*	Total
Agriculture	8638	0.15	1295.7
Commercial & Services	36	0.5	18
Industrial	25	0.5	12.5
Open Land	1075	0.15	161.3
Residential	818	0.35	286.3
Trans, Com & Utilities	252	0.5	126
Upland Forests	11658	0.1	1165.8
Water	164	1	164
Wetlands	1461	0.5	730.5
	24127		**3960.1**
Percent Impervious		**16.4**	

Watershed 4	Acres	*Weighted Coefficient*	Total
Agriculture	2650	0.15	397.5
Commercial & Services	77	0.5	38.5
Industrial	45	0.5	22.5
Institutional	0.5	0.45	0.23
Open Land	47	0.15	7.1
Residential	980	0.35	343
Trans, Com & Utilities	340	0.5	170
Upland Forests	30772	0.1	3077.2
Water	33	1	33
Wetlands	5734	0.5	2867
	40678.5		**6956**
Percent Impervious		**17.1**	

Appendix D Deer Point Lake Impervious Percentages

Watershed 5	Acres	*Weighted Coefficient*	Total
Agriculture	1628	0.15	244.2
Commercial & Services	40	0.5	20
Institutional	3.7	0.5	1.9
Open Land	19	0.15	2.9
Residential	298	0.35	104.3
Trans, Com & Utilities	203	0.5	101.5
Upland Forests	13296	0.1	1329.6
Water	29	1	29
Wetlands	2043	0.5	1021.5
	17559.7		**2854.8**
Percent Impervious		**16.3**	

Watershed 6	Acres	*Weighted Coefficient*	Total
Agriculture	920	0.15	138
Industrial	20	0.5	10
Residential	32	0.35	11.2
Trans, Com & Utilities	3.7	0.5	1.9
Upland Forests	3903	0.1	390.3
Water	31	1	31
Wetlands	408	0.5	204
	5317.7		**786.35**
Percent Impervious		**14.8**	

Watershed 7	Acres	*Weighted Coefficient*	Total
Agriculture	5305	0.15	795.8
Barren Land	12	0.1	1.2
Commercial & Services	23	0.5	11.5
Industrial	19.5	0.5	9.8
Institutional	46	0.45	20.7
Open Land	3129	0.15	469.4
Recreational	118	0.15	17.7
Residential	581	0.35	203.4
Trans, Com & Utilities	217	0.5	108.5
Upland Forests	33546	0.1	3354.6
Water	3596	1	3596
Wetlands	4572	0.5	2286
	51164.5		**10874.4**
Percent Impervious		**21.3**	

Watershed 8	Acres	*Weighted Coefficient*	Total
Agriculture	418	0.15	62.7
Commercial & Services	2	0.5	1
Industrial	11.6	0.5	5.8
Residential	143	0.35	50.1
Trans, Com & Utilities	53	0.5	26.5
Upland Forests	7115	0.1	711.5
Water	49	1	49
Wetlands	760	0.5	380
	8551.6		**1286.6**
Percent Impervious		**15.0**	

Appendix D Deer Point Lake Impervious Percentages

Watershed 9	Acres	*Weighted Coefficient*	Total
Agriculture	1059	0.15	158.9
Barren Land	3	0.1	0.3
Commercial & Services	38	0.5	19
Industrial	373	0.5	186.5
Institutional	1.9	0.45	0.9
Recreational	12	0.15	1.8
Residential	1185	0.35	414.8
Trans, Com & Utilities	385	0.5	192.5
Upland Forests	19068	0.1	1906.8
Water	92	1	92
Wetlands	3766	0.5	1883
	25982.9		**4856.4**
Percent Impervious		**18.7**	

Watershed 10	Acres	*Weighted Coefficient*	Total
Agriculture	1629	0.15	244.4
Barren Land	37	0.1	3.7
Commercial & Services	31	0.5	15.5
Industrial	304	0.5	152
Residential	1068	0.35	373.8
Trans, Com & Utilities	271	0.5	135.5
Upland Forests	22057	0.1	2205.7
Water	1049	1	1049
Wetlands	3787	0.5	1893.5
	30233		**6073.1**
Percent Impervious		**20.1**	

Watershed 11	Acres	*Weighted Coefficient*	Total
Agriculture	352	0.15	52.8
Barren Land	6	0.1	0.6
Commercial & Services	93	0.5	46.5
Industrial	287	0.5	143.5
Institutional	47	0.45	21.2
Open Land	57	0.15	8.6
Recreational	293	0.15	44
Residential	3655	0.35	1279.3
Trans, Com & Utilities	580	0.5	290
Upland Forests	24192	0.1	2419.2
Water	167	1	167
Wetlands	7768	0.5	3884
	37497		**8356.5**
Percent Impervious		**22.3**	

Watershed 12	Acres	*Weighted Coefficient*	Total
Agriculture	267	0.15	40.1
Barren Land	4	0.1	
Commercial & Services	45	0.5	22.5
Institutional	5.6	0.45	
Recreational	13	0.15	2
Residential	1581	0.35	553.4
Trans, Com & Utilities	52	0.5	26
Upland Forests	3719	0.1	371.9
Water	55	1	55
Wetlands	1221	0.5	610.5
	6962.6		**1681.3**
Percent Impervious		**24.2**	

BAY COUNTY WATER UTILITIES DEER POINT LAKE RESERVOIR WITHDRAWALS 1999-2002

DATE	MGD	CFS
Jan-99	30.3	47.0
Feb-99	29.8	46.2
Mar-99	34.5	53.5
Apr-99	46.3	71.8
May-99	46.4	71.9
Jun-99	45.0	69.7
Jul-99	47.3	73.3
Aug-99	45.6	70.7
Sep-99	47.5	73.6
Oct-99	41.2	63.8
Nov-99	39.0	60.5
Dec-99	34.1	52.9
1999 AVERAGE		**62.9**

DATE	MGD	CFS
Jan-00	32.8	50.8
Feb-00	36.7	56.8
Mar-00	42.9	66.5
Apr-00	44.5	69.0
May-00	56.5	87.6
Jun-00	56.9	88.2
Jul-00	58.3	90.4
Aug-00	53.1	82.2
Sep-00	47.0	72.8
Oct-00	47.5	73.6
Nov-00	38.9	60.2
Dec-00	34.0	52.6
2000 AVERAGE		**70.9**

DATE	MGD	CFS
Jan-01	31.3	48.5
Feb-01	32.6	50.5
Mar-01	36.5	56.6
Apr-01	42.2	65.4
May-01	55.1	85.4
Jun-01	55.7	86.4
Jul-01	51.4	79.6
Aug-01	44.9	69.7
Sep-01	44.5	69.0
Oct-01	43.1	66.8
Nov-01	38.9	60.2
Dec-01	34.0	52.6
2001 AVERAGE		**65.9**

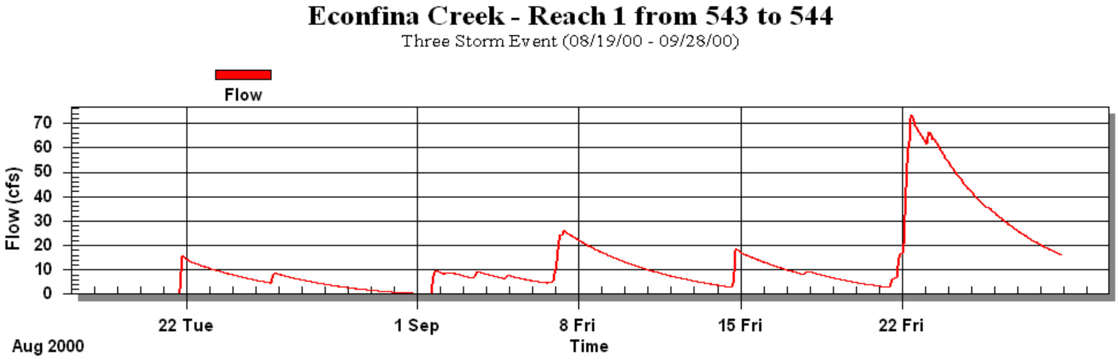
DATE	MGD	CFS
Jan-02	41.4	64.2
Feb-02	42.7	66.1
Mar-02	46.0	71.2
Apr-02	48.8	75.6
May-02	56.5	87.6
Jun-02	57.7	89.5
Jul-02	59.0	91.4
Aug-02	57.3	88.8
Sep-02	55.2	85.5
Oct-02	52.4	81.2
Nov-02	39.1	60.6
Dec-02	44.1	68.3
2002 AVERAGE		**77.5**

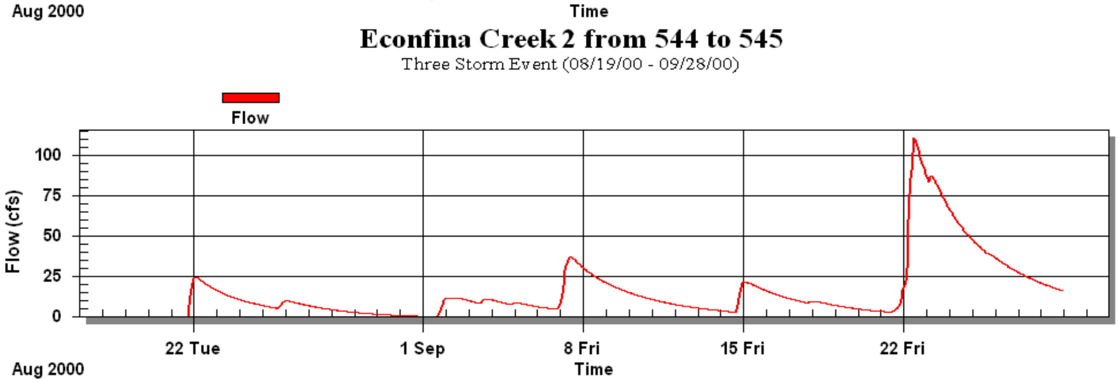
Three Storm Event (08/19/00 - 09/28/00)	
DATE	**CFS**
Aug-00	**82.2**
Sep-00	**72.8**
AVERAGE	**77.5**
***INDUSTRIAL (*Stone Container/Arizona Chemical*)**	**39**
MUNICIPAL USE	**39**

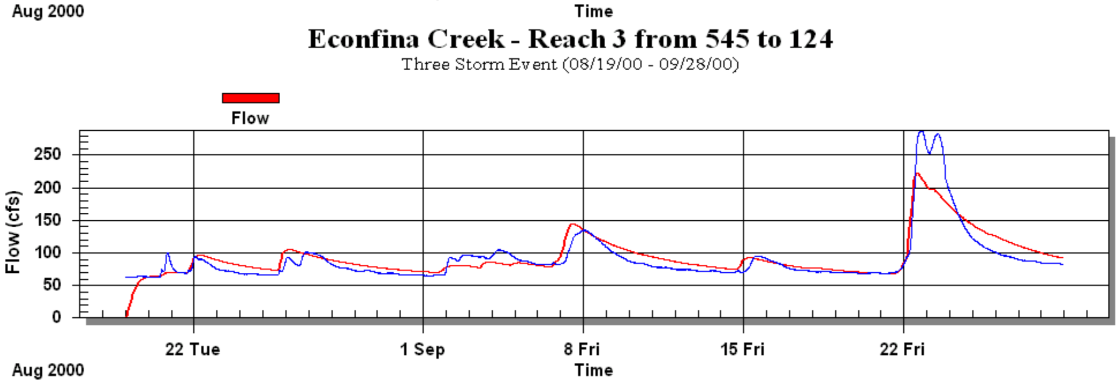
DEER POINT LAKE WATERSHED HYDROLOGIC MODEL

Three Storm Event					IMPERVIOUS			PERVIOUS			
NODE	Area (acres)	Percent Impervious (%)	Width (ft)	Slope (ft/ft)	Manning's Roughness (n)	Depression Storage (inch)	Zero Detention (%)	Manning's Roughness (n)	Zero Detention (%)	Ground Elevation (ft)	Invert Elevation (ft)
118	40,679	17	500	0.005	0.014	0.5	25	0.03	25	18	12
120	20,527	20	200	0.005	0.014	0.5	25	0.03	25	24	18
124	5,317	10	1	0.005	0.014	0.5	25	0.03	25	18	10
321	51,164	21	75	0.005	0.014	0.5	25	0.03	25	12	4
543	21,203	21	100	0.005	0.014	0.5	25	0.03	25	200	194
544	4,909	14	100	0.005	0.014	0.5	25	0.03	25	140	134
545	24,130	16	100	0.005	0.014	0.5	25	0.03	25	40	32
547	17,560	16	200	0.004	0.014	0.5	25	0.03	25	40	34
Deer Point # 1	4,572	100	200	0.003	0.014	0.5	25	0.03	25	7	1
Deer Point # 2	25,984	18	200	0.001	0.014	0.5	25	0.03	25	7	1
Deer Point # 3	6,970	24	200	0.001	0.014	0.5	25	0.03	25	7	1
Deer Point # 4	37,496	22	200	0.001	0.014	0.5	25	0.03	25	7	1

CONDUIT	Waterbody (Creek)	Upstream Node	Area (ft2)	Length (ft)	Manning's Coefficient (ft)	Max Width (ft)	Depth (ft)	Side Slope (ft)	Side Slope (ft)	Upstream Elevation (ft)	Downstream Elevation (ft)
Econfina 1	Econfina	543	150	17,364	0.014	19	6	1	1	194	134
Econfina 2	Econfina	544	396	45,359	0.014	60	6	1	1	134	32
Econfina 3	Econfina	545	544	27,668	0.014	60	8	1	1	32	10
Econfina 4	Econfina	124	584	29,969	0.014	65	8	1	1	10	4
Econfina 5	Econfina	321	696	10,421	0.014	110	6	1	1	6	1
LBearCr	Little Bear	547	300	21,378	0.014	44	6	1	1	34	6
Bcreek	Bear	118	306	4,127	0.014	45	6	1	1	12	6
Bear Creek	Bear	547/118	336	17,256	0.014	50	6	1	1	6	1
Cedar Crk.	Cedar	120	108	9,550	0.014	12	6	1	1	18	1

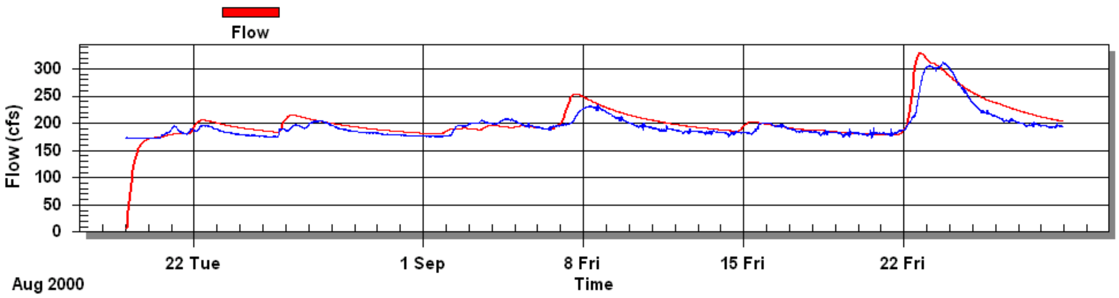

Econfina Creek - Reach 1 from 543 to 544
Three Storm Event (08/19/00 - 09/28/00)
Flow
Flow (cfs)
0
10
20
30
40
50
60
70
22 Tue
1 Sep
8 Fri
15 Fri
22 Fri
Aug 2000
Time


Econfina Creek 2 from 544 to 545
Three Storm Event (08/19/00 - 09/28/00)
Flow
Flow (cfs)
0
25
50
75
100
22 Tue
1 Sep
8 Fri
15 Fri
22 Fri
Aug 2000
Time


Econfina Creek - Reach 3 from 545 to 124
Three Storm Event (08/19/00 - 09/28/00)
Flow
Flow (cfs)
0
50
100
150
200
250
22 Tue
1 Sep
8 Fri
15 Fri
22 Fri
Aug 2000
Time

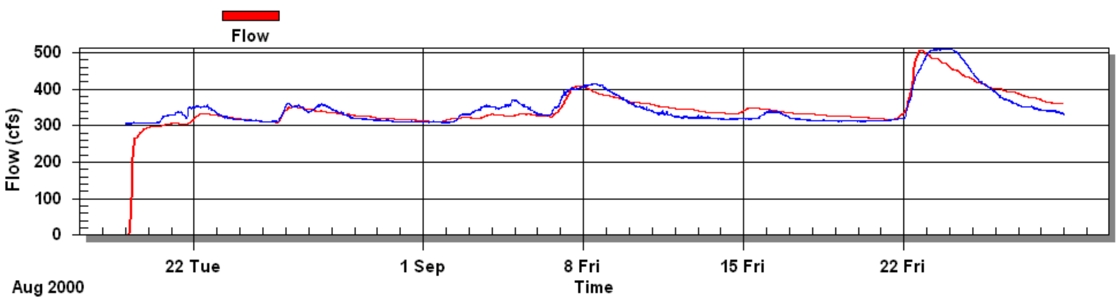
Econfina Creek - Reach 4 from 124 to 321

Three Storm Event (08/19/00 - 09/28/00)



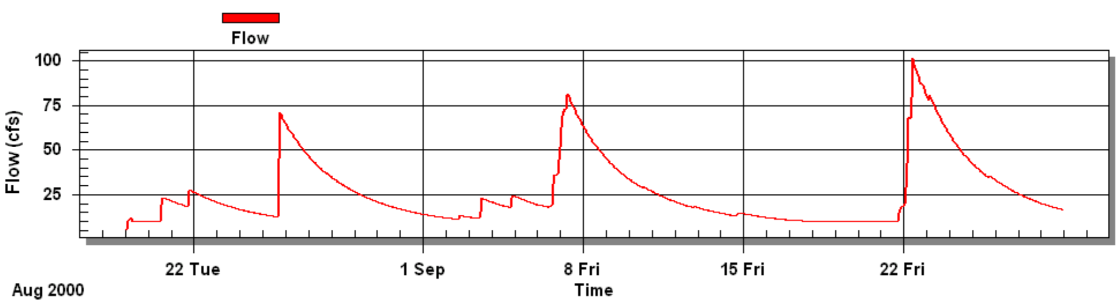
Econfina Creek - Reach 5 from 321 to DeerPoint

Three Storm Event (08/19/00 - 09/28/00)



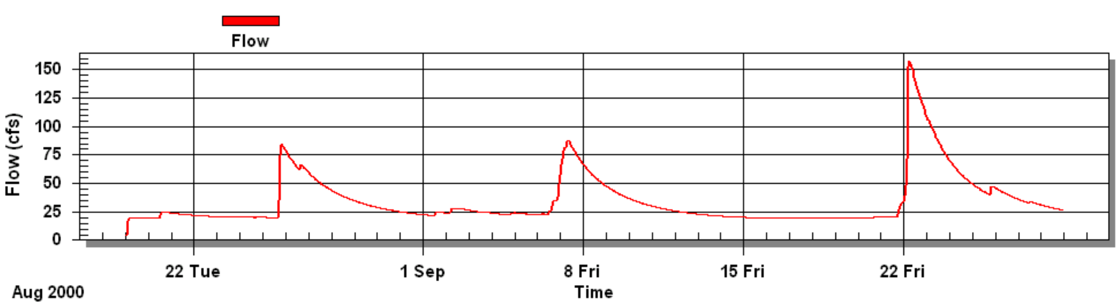
Cedar Creek from 120 to DeerPoint

Three Storm Event (08/19/00 - 09/28/00)



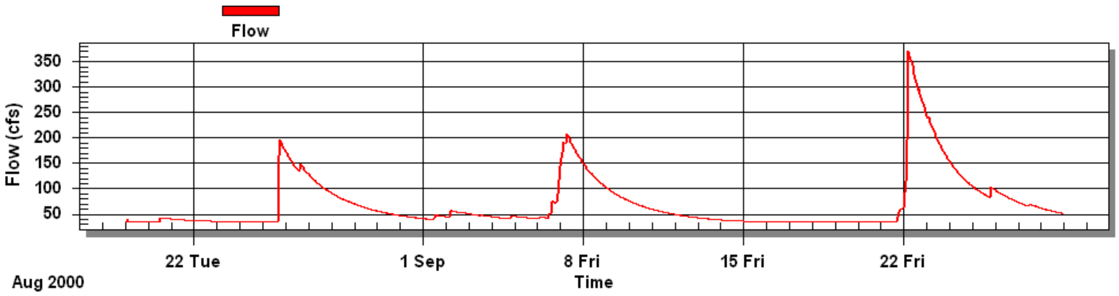
Little Bear Creek from 547 to BC

Three Storm Event (08/19/00 - 09/28/00)



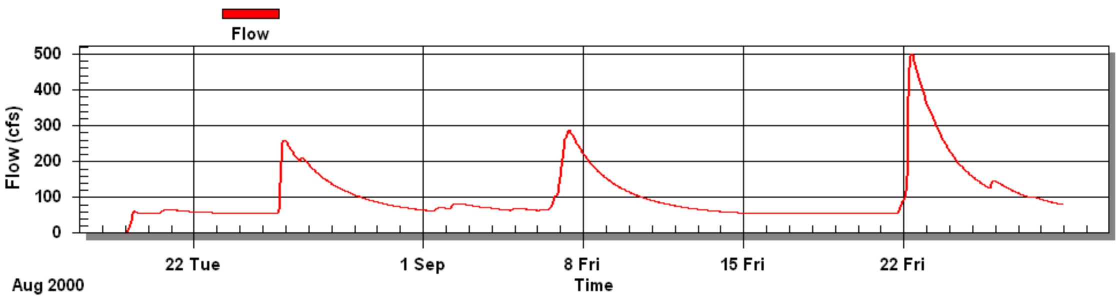
Bear Creek from 118 to BC

Three Storm Event (08/19/00 - 09/28/00)



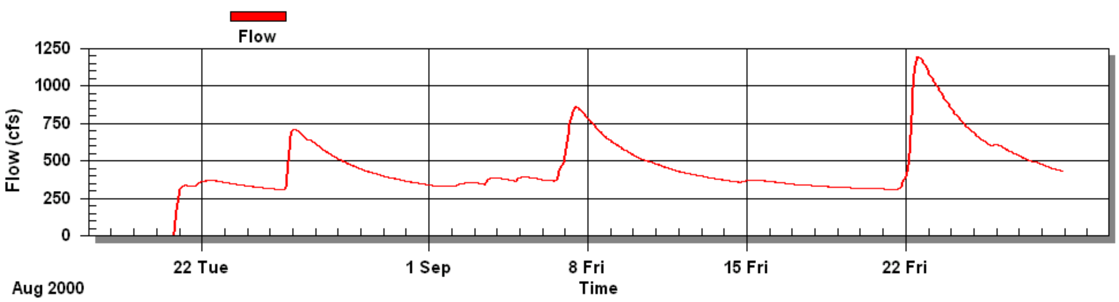
Bear Creek from BC to DeerPoint

Three Storm Event (08/19/00 - 09/28/00)



Deer Point Lake from DeerPoint to NorthBay

Three Storm Event (08/19/00 - 09/28/00)



XP SWMM 2000 Deer Point Lake Watershed Model
Three Storm Calibration (08/19/00 thru 09/28/00)

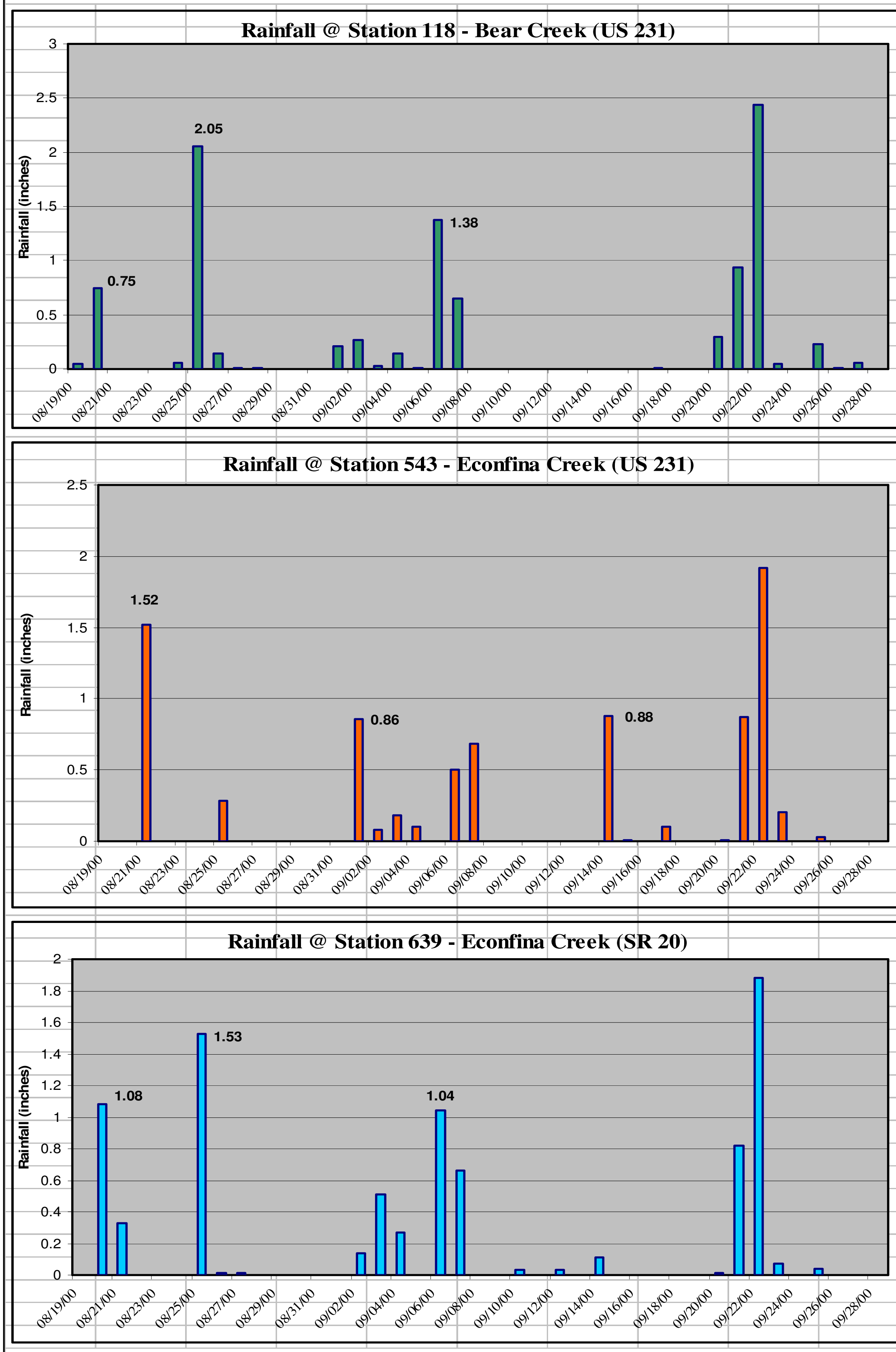


Figure R2 Rainfall during August 19, 2000 thru September 28, 2000 for Stations 118, 543 & 639

Appendix G Deer Point Lake Water Budget Example

Date	321 Econfina Creek (cfs)	118 Bear Creek (cfs)	547 Little Bear Creek (cfs)	Bayou George (cfs)	Cedar Creek (cfs)	Deer Point Lake Shoreline (cfs)	TOTAL TO LAKE (cfs)	Total W/Drawal the Lake (cfs)	Lake EVAP. Loss (cfs)	Direct Rainfall on the Lake (cfs)	Net Lake EVAP. (cfs)	TOTAL TO NORTH BAY (cfs)	Change in Storage (Adjusted)	Total Discharge with Stage/Storage
NA	Daily Average values from the NWFWMD Surface Water Database (Station 321)	Daily Average values from the NWFWMD Surface Water Database (Station 118)	Daily Average values from the NWFWMD Surface Water Database (Station 547)	Based on the median of the data from 08/08/90 to 10/23/91 (Station 119) Source: NWFWMD Surface Water Datatbase	Based on the median of the data from 08/09/90 to 10/24/91 (Station 120) Source: NWFWMD Surface Water Datatbase	((Runoff of Bear Creek Drainage Basin + Little Bear Creek Drainage Basin)/2) X Area of Shoreline	(SUM of all creeks & shoreline)	Net Withdrawal is based on monthly Withdrawal Rates (1999-2001) from Bay County Water Utilities Department	Evaporation Rates are from Lake Seminole	Based on a District Rainfall gage close to the Lake	Difference between Evaporation & Direct Rainfall	TOTAL TO NORTH BAY (cfs)	Based on Lake Stage & Drawdown Gates	Total Discharge with Stage/Storage
1/1/99	490	70	30	15	12	58	675	47.01	11.53	0.00	-11.53	616	0	616
1/2/99	496	74	40	15	12	68	704	47.01	11.53	169	157.51	815	-90	905
1/3/99	544	119	74	15	12	120	884	47.01	11.53	2	-9.60	827	0	827
1/4/99	554	114	46	15	12	91	832	47.01	11.53	0	-11.53	773	-181	954
1/5/99	516	91	34	15	12	70	738	47.01	11.53	0	-11.53	679	0	679
1/6/99	502	80	31	15	12	63	702	63.23	11.53	0	-11.53	628	-91	718
1/7/99	495	74	31	15	12	60	687	60.97	11.53	0	-11.53	615	0	615
1/8/99	491	69	31	15	12	58	675	60.03	11.53	0	-11.53	604	-90	694
1/9/99	500	81	35	15	12	67	710	57.88	11.53	111	99.89	752	-94	846
1/10/99	522	97	43	15	12	81	770	58.18	11.53	0	-11.53	700	-4	704
1/11/99	514	88	33	15	12	67	730	58.92	11.53	0	-11.53	659	-90	750
1/12/99	497	79	31	15	12	62	696	57.55	11.53	0	-11.53	627	-90	717
1/13/99	490	73	30	15	12	59	679	58.70	11.53	0	-11.53	609	0	609
1/14/99	497	76	34	15	12	63	698	57.53	11.53	234	222.82	863	0	863
1/15/99	543	125	61	15	12	109	866	57.02	11.53	0	-11.53	797	-136	933

Appendix G Deer Point Lake Water Budget Example

Stage-Storage Equations:

Storage = ***-3254.69 (D4)^4 + 53461.57 (D4)^3 + 7561146.91(D4)^2 + 110506752.22(D4) + 441729551.36***

- Where: D4 = Stage(feet)

Adjusted Change in Storage = ***IF(D3>=4.5,IF(D4>=4.5,-ABS(F4-F3),F4-F3),IF(D4>=4.5,((1093230000-F4)+(1093230000-F3)),F4-F3))***

- Where: D3 = Stage(Day Before)

  D4 = Stage(Day of)

  F3 = Storage (Day Before)

  F4 = Storage (Day of)

  Height of Spillway = 4.5 feet

The following assumptions were followed in determining the discharge to North Bay:

1). Inflow to the lake +/- Change in storage of the lake = Discharge to North Bay.
2). All storage/volume above 4.5 feet (spillway elevation) is discharged to North Bay.
3). Any net loss in lake storage was accounted for by increasing the discharge to North Bay by the net loss amount.
4). Any net gain in lake storage was accounted for by decreasing the discharge to North Bay by the net gain amount.

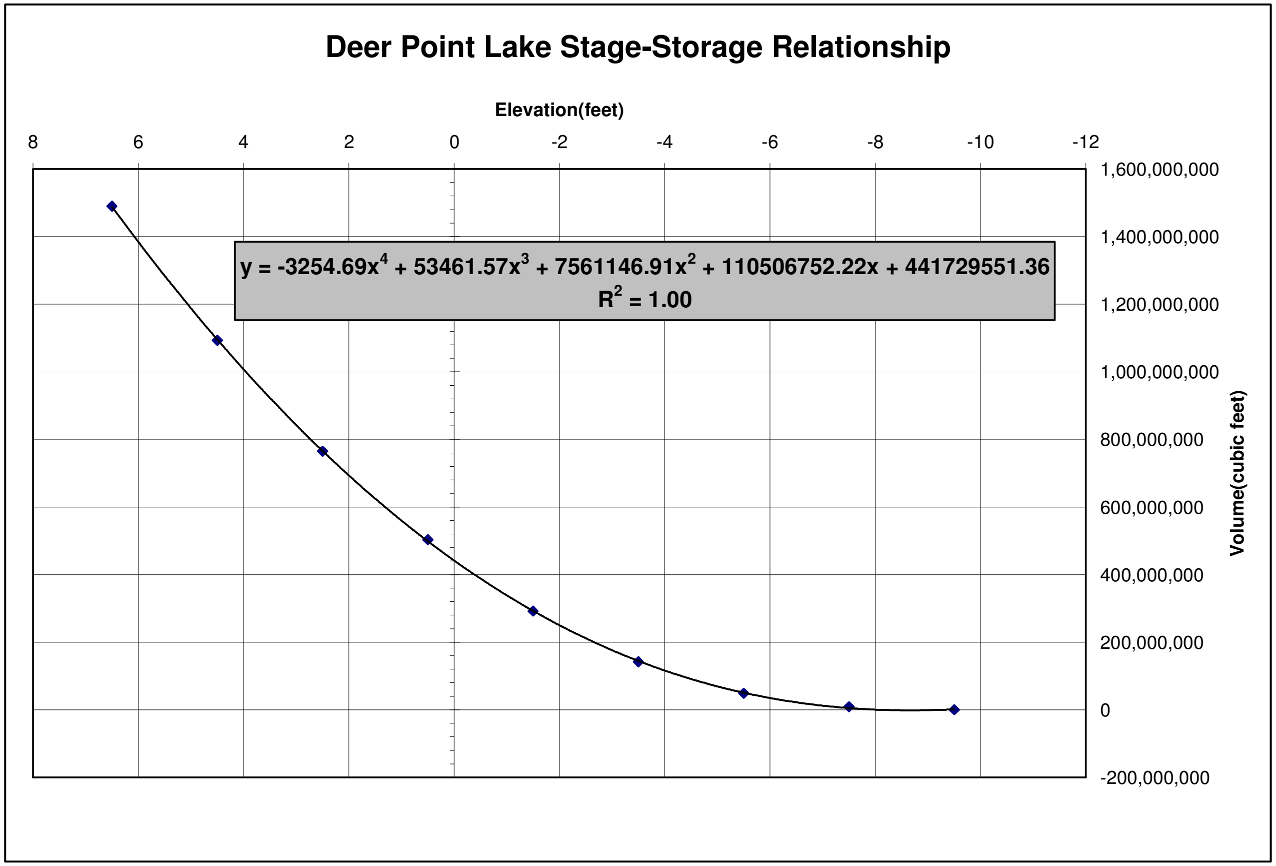
Based on the above assumptions, the following case scenarios exist for the Adjusted Change in Storage equation:

Scenario 1: Both Stage (Day Before) and Stage (Day of) are at or above 4.5 feet. Since both Stage (Day Before) and Stage (Day of) are above 4.5 feet, the change in storage (positive or negative) is assumed to flow over the spillway and discharged to North Bay.

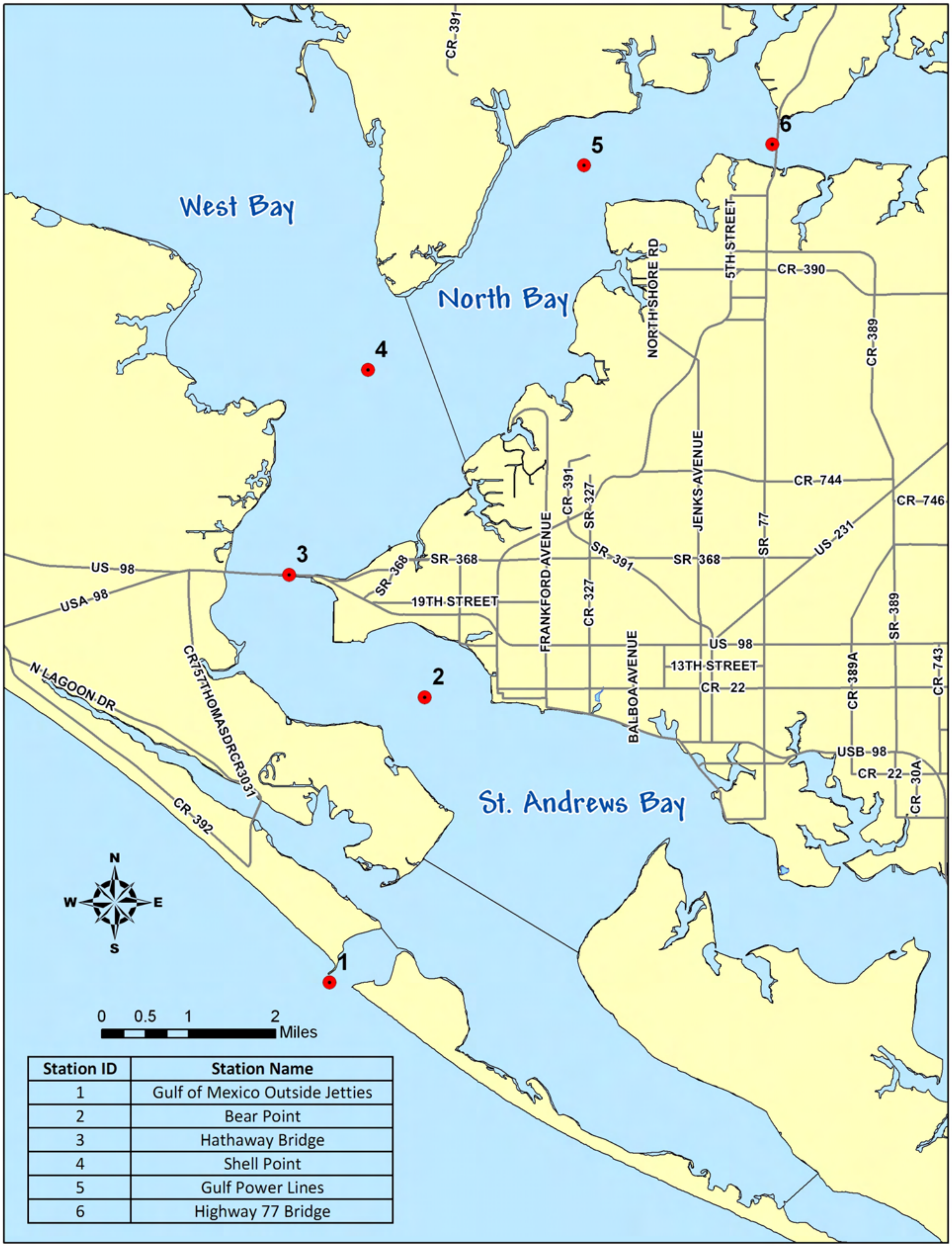
Scenario 2: Stage (Day Before) is at or above 4.5 feet and Stage (Day of) is less than 4.5 feet. The net loss in storage is assumed to have been discharged to North Bay.

Scenario 3: Stage (Day Before) is below 4.5 feet and Stage (Day of) is at or above 4.5 feet. This scenario consists of two parts: The storage from the top of the spillway (4.5 feet) to the Stage (Day of) and the storage from the Stage (Day Before) to the top of the spillway. The net loss or gain in storage is determined to be the amount of storage above the spillway (4.5 feet) minus the amount of storage between Stage (Day Before) and 4.5 feet.

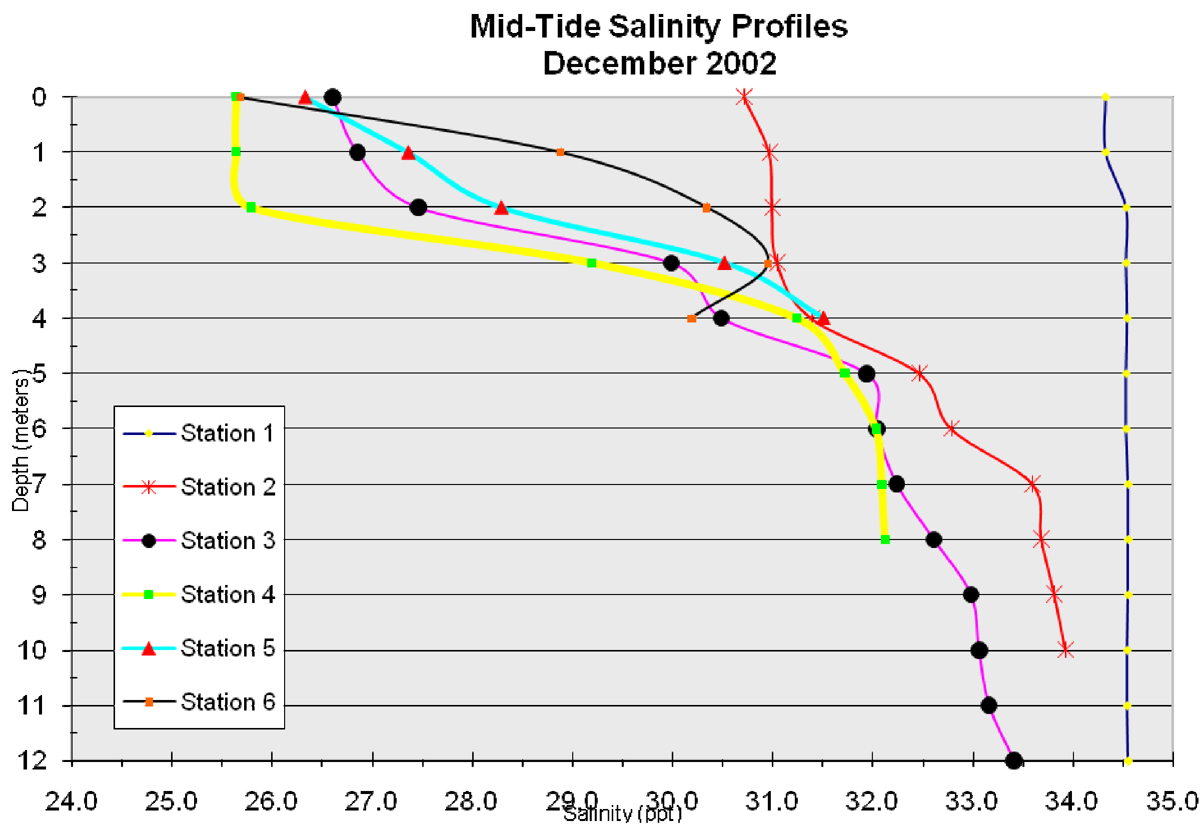
Scenario 4: Both Stage (Day Before) and Stage (Day of) are below 4.5 feet. Since both Stage (Day Before) and Stage (Day of) are below 4.5 feet, the change in storage (positive or negative) is assumed to have been discharged to North Bay.

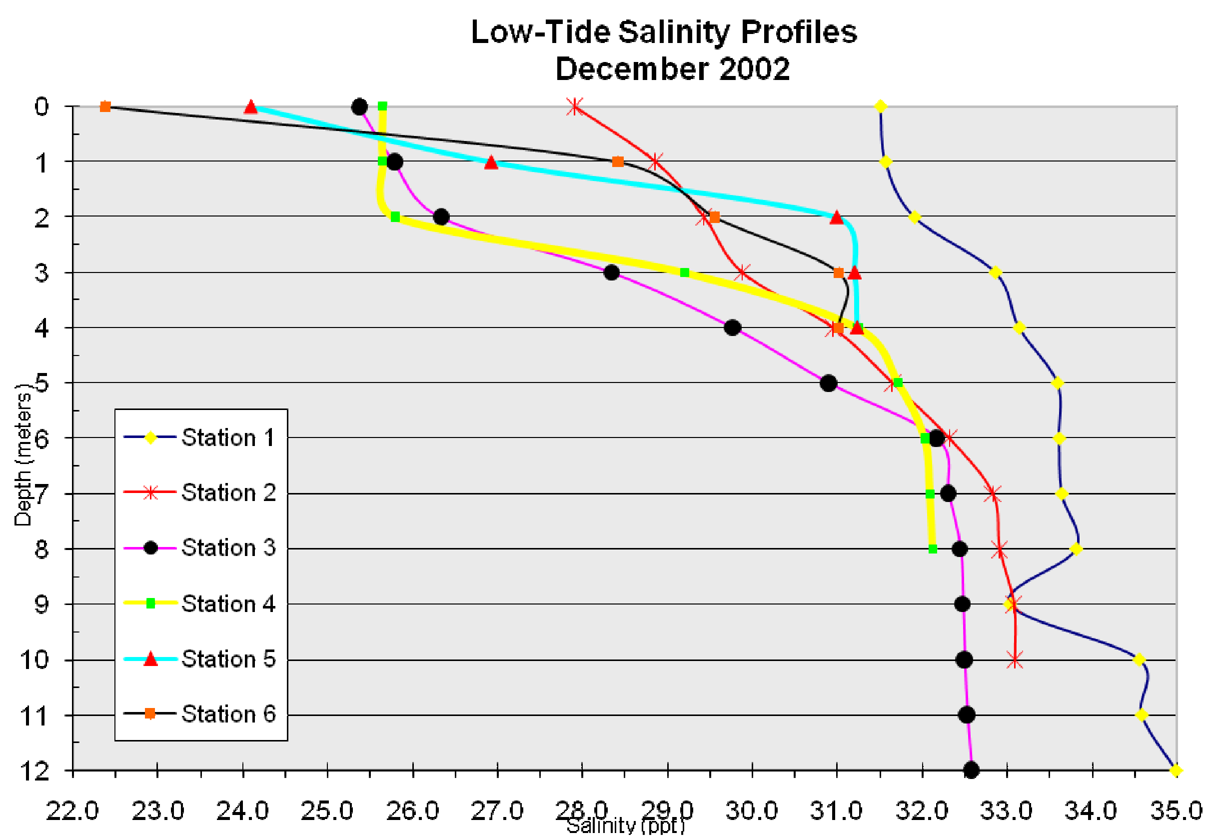


Appendix H   North Bay/St. Andrew Bay Salinity Profiles



Station ID	Station Name
1	Gulf of Mexico Outside Jetties
2	Bear Point
3	Hathaway Bridge
4	Shell Point
5	Gulf Power Lines
6	Highway 77 Bridge


Mid-Tide Salinity Profiles
December 2002
Depth (meters)
Salinity (ppt)
0
1
2
3
4
5
6
7
8
9
10
11
12
24.0
25.0
26.0
27.0
28.0
29.0
30.0
31.0
32.0
33.0
34.0
35.0
Station 1
Station 2
Station 3
Station 4
Station 5
Station 6


Low-Tide Salinity Profiles
December 2002
Depth (meters)
Salinity (ppt)
0
1
2
3
4
5
6
7
8
9
10
11
12
22.0
23.0
24.0
25.0
26.0
27.0
28.0
29.0
30.0
31.0
32.0
33.0
34.0
35.0
Station 1
Station 2
Station 3
Station 4
Station 5
Station 6

NORTHWEST FLORIDA WATER MANAGEMENT DISTRICT

MEMORANDUM

TO: File, Consumptive Water Use Permit S910142

FROM: Guy Gowens, Chief, Bureau of Ground Water Regulation

DATE: April 10, 1997

SUBJECT: Bay County Board of County Commissioners
Consumptive Water Use Permit S910142
Deerpoint Lake

The attached document identified as the "Agreement between the Northwest Florida Water Management District and the Board of County Commissioners of Bay County, Florida" represents Consumptive Water Use Permit S910142 issued to Bay County for the withdrawal of water from Deerpoint Lake.

As a reference:

Paragraphs 8-11 identifies withdrawal amounts and permit durations.
Paragraph 12 addresses the submittal of pumping reports by Bay County.
Attachment I identifies Terms and Standard Conditions.

Other reference numbers: DOAH Case No. 91-1414
NWFWMD Case No. 90-023

Northwest Florida
Water Management District

Route 1, Box 3100, Havana, Florida 32333-9700
(On U.S. Highway 90, 10 miles west of Tallahassee)

Walter D. Dover
Executive Director

(904) 539-5999

September 4, 1991

Mr. Pete A. Mallory, Esq.
Burke & Blue, P.A.
Post Office Box 70
Panama City, Florida 32402

Dear Mr. Mallory:

Please find enclosed one of the two original copies of the Bay County/Northwest Florida Water Management District Agreement, Authorization No. S910142, which was filed with the District's Agency Clerk on September 4, 1991. The District did not receive a request for an administrative hearing pertaining to the Agreement as of 5:00, p.m., on Friday, August 30, 1991.

Per your request, I have reviewed all consumptive use permit applications pending with the District. As of today's date there are no surface water consumptive use permit applications located within the entire Deerpoint Lake Drainage Basin (including other counties) pending with the District. As provided in the Agreement, the District will notify Bay County of any future surface water consumptive use permit applications submitted for withdrawal within the Deerpoint Lake Drainage Basin. Also, as a reminder, the first quarterly submittal of the County's pumping activity (per paragraph 12 of the Agreement) is due October 1, 1991.

It was a pleasure working with you and the other members of the Bay County staff. If I can every be of assistance, please let me know.

Sincerely,

W. G. Gowens, Chief
Bureau of Ground Water Regulation
Division of Resource Regulation

BEFORE THE NORTHWEST FLORIDA WATER MANAGEMENT DISTRICT
Route 1, Box 3100
Havana, Florida 32333

NORTHWEST FLORIDA WATER
MANAGEMENT DISTRICT,

Petitioner,

vs.

NWFWMD CASE NO. 90-023
DOAH CASE NO. 91-1414

BAY COUNTY BOARD OF
COUNTY COMMISSIONERS,

Respondent.

AGREEMENT

This Agreement is made and entered into between the Northwest Florida Water Management District (hereinafter the "District") and the Board of County Commissioners of Bay County, Florida (hereinafter the "Board").

The District and the Board admit the following:

1. The District is a public agency authorized by, and operating pursuant to, Chapter 373, F.S., and Chapter 40A-2, F.A.C., with its headquarters located in Gadsden County, Florida.

2. The Board owns and operates a public water supply withdrawal facility located in Section 6, Township 3 South, Range 13 West of Bay County, Florida.

3. The Board's public water supply withdrawal facility obtains its water supplies from Deerpoint Lake Reservoir, which was formed by the Board constructing a saltwater barrier across North Bay at Deerpoint Lake.

4. The Florida Legislature has adopted three (3) Special Acts concerning Deerpoint Lake and the Board's water system, said Acts being Chapter 67-1101, Laws of Florida; Chapter 27397,

Laws of Florida, 1951; and Chapter 30567, Laws of Florida, 1955. These Acts authorize the Board to:

(a) Construct a saltwater barrier, at the expense of Bay County taxpayers, to convert a portion of North Bay and surrounding lands into a fresh water reservoir;

(b) Construct or acquire, own, maintain and operate a water system for supplying water to the citizens of Bay County and to establish, fix and collect fees, rentals or other charges for providing said water;

(c) Enter into contracts and agreements for the supply and distribution of water for domestic and commercial use; and,

(d) Use any right-of-way, easement, lands under water or similar property rights owned or held by the State of Florida that are necessary, convenient or desirable in the construction, acquisition, improvement, operation or maintenance of the water system of the County.

5. The policy of the state, relative to the waters in the state, is set forth in Chapter 373, F.S., and generally provides that the waters in the state are among its basic resources, and such waters must be conserved or fully controlled to realize their full beneficial use. It is further declared to be the policy of the legislature:

(a) To provide for the management of water and related land resources;

(b) To promote the conservation, development, and proper utilization of surface and ground water;

(c) To develop and regulate dams, impoundments, reservoirs, and other works and to provide water storage for beneficial purposes;

(d) To prevent damage from floods, soil erosion and excessive drainage;

(e) To minimize degradation of water resources caused by the discharge of stormwater;

(f) To preserve natural resources, fish and wildlife;

(g) To promote the public policy set forth in s. 403.021, F.S.;

(h) To promote recreational development, protect public lands, and assist in maintaining the navigability of rivers and harbors; and,

(i) Otherwise to promote the health, safety and general welfare of the people of the State.

6. The Legislature has vested the Department of Environmental Regulation and the District the power and responsibility to accomplish the conservation, protection, management and control of the waters of the State.

7. The District and the Board recognize that special factors exist which make the Deerpoint Lake Watershed (as defined by Chapter 67-1101, Laws of Florida), the Deerpoint Lake Drainage Basin (as defined as the Deerpoint Lake Drainage Basin as identified on Attachment II that lies within Bay County) and North Bay unique in providing for the conservation, protection, management and control of the waters in the State.

Therefore, to provide for a coordinated and comprehensive approach to the conservation, protection, management and control of the water resources of the Deerpoint Lake Watershed (as defined by Chapter 67-1101, Laws of Florida), the Deerpoint Lake Drainage Basin and North Bay, the District and the Board mutually agree to the following:

8. The District acknowledges and recognizes the rights granted to the Board by the Acts identified in Paragraph 4 and authorizes the Board to withdraw water from the Deerpoint Lake Drainage Basin, at the location identified in Paragraph 2 of this agreement, for a daily average not to exceed sixty-nine million five hundred thousand (69,500,000) gallons per day and a maximum, on any given day, that does not exceed eighty-two million (82,000,000) gallons through the year two-thousand and ten (2010).

9. The District agrees to extend the duration of this authorization, as provided by Section 373.236, F.S., for a period ending on the date that any capital improvement bonds mature or are paid off, when such bonds are issued for water or sewer purposes and secured by the reserves therefrom; and which are issued pursuant to the Capital Improvement Element of the adopted Bay County Comprehensive Plan. However, in no event shall such authorization extend beyond the year two-thousand forty (2040). This extension will also authorize the Board to withdraw an annual daily average not to exceed ninety-eight million (98,000,000) gallons per day and a maximum withdrawal, on any given day, that does not exceed one-hundred and seven million (107,000,000) gallons.

10. The water use authorization granted in Paragraph eight (8) and nine (9) shall be managed by the Board and used for public water supply purposes, industrial uses, water resources enhancement and any other legal uses.

11. The District reserves to the Board an additional amount of water equal to the seven-day/ten-year (7Q10) low flow entering Deerpoint Lake for resource enhancement purposes which, when combined with the amounts allocated in Paragraphs eight (8) and nine (9) above, totals two-hundred and eight-five million (285,000,000) gallons per day. This amount (285,000,000 gallons) is identified by United States Geological Survey Map Series No. 38, 1970.

12. The authorizations provided herein are subject to the terms and standard conditions as provided in Attachment I. Also, the Board agrees to submit to the District on a quarterly basis, starting October 1, 1991, a water use report that provides the following information:

    a. Total daily withdrawals in gallons per day;

    b. Total monthly withdrawals in gallons per month; and,

    c. Identification of peak-day withdrawals for each month during the reporting quarter.

13. The Board also agrees to abide by the provisions of the Water Conservation Act of 1982, Section 553.14, F.S., and to develop, adopt and implement water conservation and water reuse strategies to encourage and promote the efficient use of the area water resources.

14. Any modifications to the authorized uses set forth herein shall be accomplished pursuant to Section 373.239, F.S.

15. The District will notify the Board of any Surface Water Consumptive Use Permit Application, requesting authorization to withdraw water from the Deerpoint Lake Drainage Basin, by forwarding to the County a copy of the application within ten (10) working days of application submittal. The District also agrees to forward to the Board a copy of any Notice of Proposed Agency Action relating to any Surface Water Consumptive Use Permit Application within the Deerpoint Lake Drainage Basin.

16. The District may allocate a portion of the seven-day/ten-year low flows (as identified by United States Geological Survey Map Series No. 38, 1970), referenced in Paragraph 11, whenever an applicant meets the provisions of Chapter 373, F.S., and Chapter 40A-2, F.A.C., and after consideration of any concerns or objections filed by the Board. The District will condition any Surface Water Consumptive Use Permit issued, within the Deerpoint Lake Drainage Basin lying within the County boundaries, to require an applicant to comply, prior to the construction of any withdrawal facility and the use of permitted water withdrawals, with all applicable Acts and applicable Ordinances adopted by the Board.

17. To meet the public notice requirements of this Agreement, the Board agrees to publish, within seven (7) days of the signing of this Agreement, the Notice of Agency Action set forth below. This notice shall be published in the legal ad section of a newspaper of general circulation in Bay County, Florida.

NOTICE OF AGENCY ACTION

The Northwest Florida Water Management District (the "District") gives notice of its intent to enter into an Agreement with the Bay County Board of County Commissioners.

The Agreement recognizes the rights of Bay County as delineated in Chapter 67-1101, Chapter 27397, and Chapter 30567, Laws of Florida, and the special factors which make the Deerpoint Lake Watershed, the Deerpoint Lake Drainage Basin and North Bay unique. The Agreement authorizes withdrawals from the Deerpoint Lake Watershed as defined by Chapter 67-1101, Laws of Florida. It also provides for a coordinated and comprehensive approach to the conservation, protection, management and control of the waters in the Deerpoint Lake Drainage Basin.

A copy of the Agreement can be obtained weekdays at the District's headquarters located on U.S. Highway 90 approximately three (3) miles northwest of the intersection of Highway 90 West and Interstate 10 (I-10). A copy also may be obtained by writing the District's Agency Clerk at Route 1, Box 3100, Havana, Florida 32333. Any person who is or may be substantially affected by the provisions of the Agreement has the right to an administrative hearing in accordance with Section 120.57, Florida Statutes, and Part V, Chapter 40A-1, Florida Administrative Code. A person requesting a hearing on this matter must file a petition with the District within fourteen (14) days of publication of this notice. A petition for an administrative hearing related to this Agreement is deemed filed with the District on the date of receipt by the Agency Clerk of the District. Failure to file a request for an administrative hearing within this time period constitutes a waiver of the right to an administrative hearing pursuant to Section 120.57, Florida Statutes.

18. Upon approval by the District's Governing Board, this Agreement, and the Consumptive Use Authorizations incorporated by reference, shall take effect upon the date of its filing by the Agency Clerk of the District and shall constitute final agency action by the District pursuant to Section 120.69, F.S., Rule 40A-1.208, F.A.C., and Chapter 40A-2, F.A.C.

BAY COUNTY BOARD OF
COUNTY COMMISSIONERS

Date 8/9/91 by Mike Nelson, Chairman

DONE AND ORDERED this 22 day of August, 1991 in Gadsden County, Florida.

NORTHWEST FLORIDA WATER
MANAGEMENT DISTRICT

by Vice Chairman
Ralph A. Peterson, Chairman

Attest: for
Phyllis J. Reppen, Secretary

Filed this 4th day of September, 1991

Ann Baggett
Agency Clerk

FILED
NWFWMD-AGENCY CLERK
Ann Baggett
SEP 4 1991
AM PM
7,8,9,10,11,12,1,2,3,4,5,6

ATTACHMENT I

NORTHWEST FLORIDA WATER MANAGEMENT DISTRICT
AUTHORIZATION NO. S910142
BAY COUNTY BOARD OF COUNTY COMMISSIONERS

TERMS AND STANDARD CONDITIONS

1. That all statements in the application and in supporting data are true and accurate and based upon the best information available, and that all conditions set forth herein will be complied with. If any of the statements in the application and in the supporting data are found to be untrue and inaccurate, or if Permittee fails to comply with all of the conditions set forth herein, then this Permit shall be revoked as provided by Chapter 373.243, Florida Statutes.

2. This Permit is predicated upon the assertion by the Permittee that the use of water applied for and granted is and continues to be a reasonable and beneficial use as defined in Section 373.019(4), Florida Statutes, is and continues to be consistent with the public interest and will not interfere with any legal use of water existing on the date this Permit is granted.

3. This Permit is conditioned on the Permittee having obtained or obtaining all other necessary permit(s) to construct, operate and certify withdrawal facilities and the operation of the water system.

4. This Permit is issued to the Permittee contingent upon continued ownership, lease or other present control of property rights in underlying, overlying or adjacent lands. This permit may be assigned to a subsequent owner, as provided by Chapter 40A-2.351, Florida Administrative Code, and the acceptance by the assignee of all terms and conditions of the Permit.

5. The use of the permitted water withdrawal is restricted to the use classifications set forth by the Permit. Any change in the uses of said water shall require a modification of this Permit.

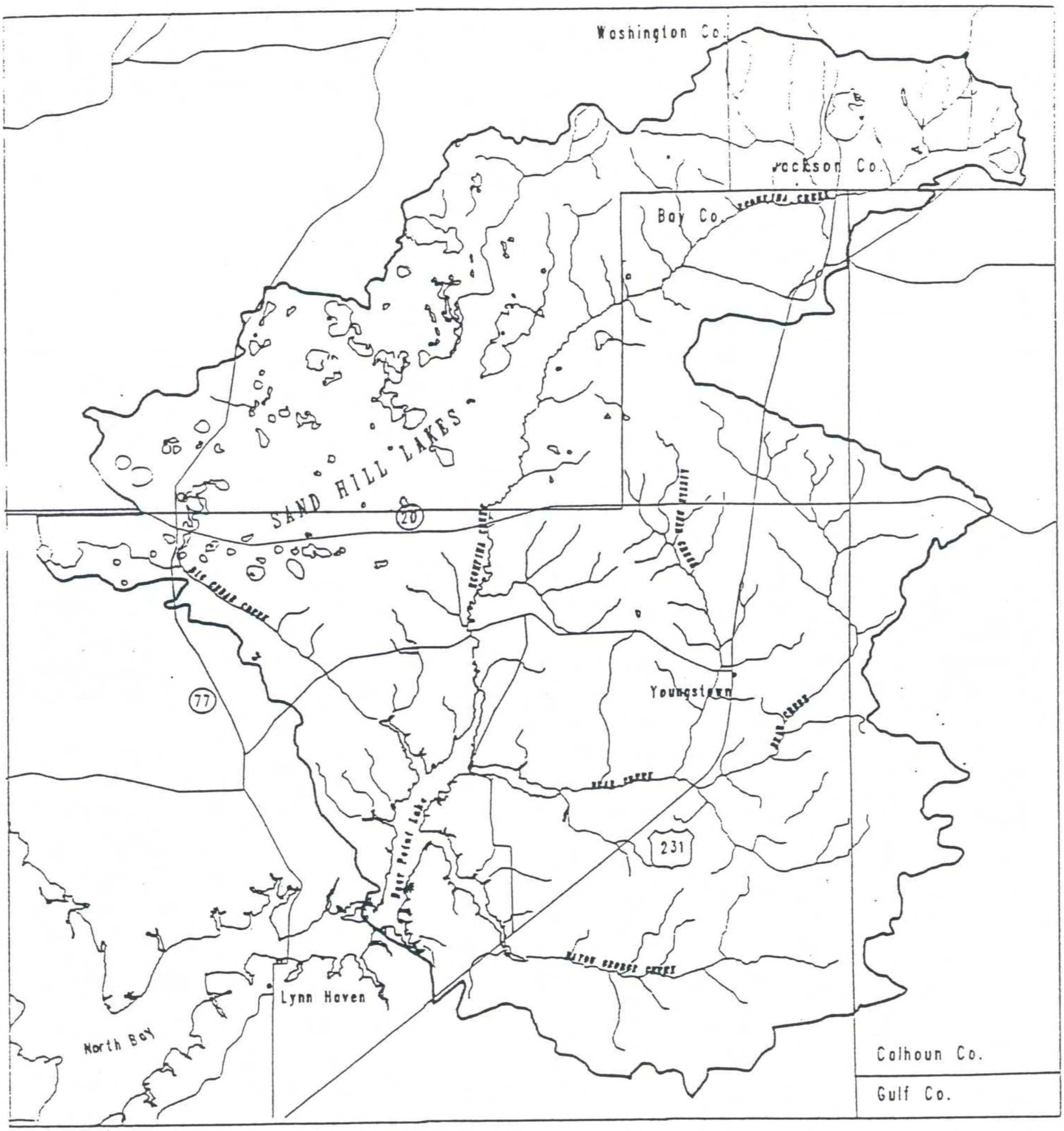
6. The District's staff, upon proper identification, will have permission to enter, inspect and observe permitted and related facilities in order to determine compliance with the approved plans, specifications and conditions of this Permit.

7. The District's staff, from time to time upon providing prior notice and proper identification, may request permission to collect water samples for analysis, measure water levels and collect any other information deemed necessary to protect the water resources of the area.

8. The District, pursuant to Section 373.042, Florida Statutes, at a future date may establish minimum and/or management water levels for the surface water hydrologically associated with the permitted withdrawals.

ATTACHMENT II

DEER POINT LAKE DRAINAGE BASIN



DEER POINT LAKE DRAINAGE BASIN