

Part 3. The St. Andrew Bay Estuarine System

The largest surface water body in the ecosystem is the St. Andrew Bay estuarine system. This system is linked to the entire ecosystem through the surface runoff from the land directly to the system and from the creeks that enter the bayous of the bay system. The St. Andrew Bay estuarine system, therefore, is the depository for all runoff in the ecosystem both natural and human altered. As such, the following overview of the St. Andrew Bay estuarine system is included below. This is not to single out the St. Andrew Bay portion of the ecosystem as more important than the other components of the ecosystem but because it receives the surface water from the remainder of the ecosystem. The majority of the point source discharges and the stormwater runoff from the most highly developed segment of the ecosystem enter St. Andrew Bay.

General Description. The St. Andrew Bay estuarine system is located in the Gulf Coastal Lowlands physiographic region. It consists of four named bays, West Bay, North Bay, St. Andrew Bay, and East Bay (Fig. 4 from SWIM plan). The system extends for approximately 31 miles along an axis parallel to the Gulf of Mexico and 13.5 miles inland to Econfinia Creek. The estimates of the area of the entire St. Andrew Bay estuarine system proper vary from approximately 94 square miles (Saloman et al., 1982) to 108 square miles (Pristas & Trent, 1978) or approximately 8.5% to 9.8% of the entire ecosystem. The average depth of the system is reported to be from 17- 27 feet depending on the source of the information. 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 is maintained as a navigation channel by the federal government while East Pass is not so maintained and is affected by the natural processes of the Gulf of Mexico. Currently, East Pass is completely closed as a result of natural processes and possible effects of the federally maintained West Pass. Plans to reopen East Pass have been developed, and the work is scheduled for completion in the near future. The Gulf Intracoastal Waterway traverses the system from west to east entering on the west at West Bay Creek near the Highway 79 bridge and exiting on the east at the easternmost extension of East Bay (Wetappo Creek).

The restricted amount of freshwater entering the system allows the influence of Gulf of Mexico water to dominate the bay. The basin itself is rather deep, with an average depth of 27 feet and a maximum depth of 65 feet. As a result of the low freshwater inflow, deep basin, and the influence of Gulf of Mexico water, St. Andrew Bay is characterized as a relatively deep, clear water, high salinity system.

Habitats. Beck et al. (2000) provided the number of hectares of a variety of habitats associated with the St. Andrew Bay estuary. There are 2.471 acres per hectare. The figures when converted to acres are 9832 acres of seagrass, 9273 acres of saltmarsh, and 877 acres of tidal flat. Other marine/estuarine biotic communities found in the St. Andrew Bay estuary are provided in Appendix 1.

Figure 4 St. Andrew Bay Area Geographic Features



Hydrology. St. Andrew Bay is unique to Florida embayments in that no major river flows into the system. Tides are diurnal, of small amplitude (about 1.5 ft), and can be modified by the wind direction and velocity. The spring-neap tide cycle is apparent and occurs about every two weeks. The system receives an average of 1,460 cubic feet per second (cfs) of freshwater excluding the freshwater discharged to the system from wastewater treatment plants. About 60 % of this inflow comes from Econfina Creek and Bear Creek both of which enter Deer Point Reservoir. The Deer Point dam then discharges about 950 cfs to North Bay.

The area of North Bay immediately below the Deer Point dam has been identified as the only major, truly estuarine part of the ecosystem (Ogren and Brusher, 1977). The quantity, quality, and timing of the discharge from the dam to this area of North Bay is critical to maintaining the estuarine conditions found here. Increasing population will require additional withdrawals of water from the reservoir that may alter the quantity and timing of the downstream discharge. Downstream flow should be evaluated in the near future to assess the effect of increased withdrawal from the reservoir. As stated previously, this work is scheduled for funding by the NFWFMD in the years 2001-2003.

The remaining 40% of the freshwater inflow enters the bay system through major tributaries to West Bay [Crooked Creek (35 cfs) and Burnt Mill Creek (35 cfs)] and East Bay [Sandy Creek (105 cfs)]. The amount of discharge of fresh water from Wetappo Creek to East Bay was not located. St. Andrew Bay proper has no major stream or creek entering it. Freshwater enters St. Andrew Bay through the bayous and stormwater runoff.

Major permitted point source discharges include the Military Point discharge of treated wastewater to East Bay (35 cfs), the Panama City Beach discharge of treated wastewater to West Bay (10 cfs), and the discharge of treated wastewater to St. Andrew Bay from the Panama City Wastewater Treatment Plant (7.75 cfs). The amount of treated wastewater to the system totals 52.75 cfs or 3.6% of the total natural freshwater inflow. Stormwater runoff is also a major component of freshwater inflow to the system. The volume of stormwater entering the system is not known. Details of the hydrology of the system can be obtained from Rodriguez and Wu (1990) and Hydroqual et al. (1993).

Two hydrological models of the bay system have been produced. However, both models were developed before East Pass closed. The closure of East Pass presents a problem in attempting to use the models under present circumstances. However, East Pass is scheduled for reopening in the fall of 2001, and the models should be adjusted to accept the dimensions and flow of the restored pass.

The first was a rather limited model accomplished by Rodriguez and Wu (1990). The second was a more comprehensive model produced for the Bay County Board of County Commissioners by Hydroqual Incorporated (Hydroqual et al., 1993). The hydrological model produced by Hydroqual was used to predict the movement and mixing of effluent from Bay County's Military Point Lagoon outfall. Water currents were predicted as a function of time and position throughout the St. Andrew Bay system, incorporating almost 100 square miles. The model also predicted the spatial and temporal variations of water levels, salinity, and water temperature. A water quality model to predict the affect of the effluent on water quality constituents such as dissolved oxygen and biological oxygen demand (BOD) used this information. The development of the hydrodynamic model encompassed three phases: (1) collection of data to guide the selection of a proper modeling framework and to provide information for initial and boundary conditions needed to run the model, (2) adjustment of the model parameters to improve the accuracy of the predictions, and (3) use of the calibrated model to predict long-term circulation in the estuary and effluent dispersal patterns. Each phase is summarized below.

Hydrodynamic data collection consisted of water surface elevations and current measurements during 1991 and 1992. Water levels were measured at six locations, four of which were at the estuary boundaries near West Pass, East Pass, and the Gulf Intracoastal Waterway (GIWW) entrances at West Bay and East Bay (Wetappo Creek). Water levels at two interior locations near Lynn Haven and Parker were used for model calibration and validation. Current meter data were collected at three sites in St. Andrew Bay. At each site, current speed and direction were measured at two locations in the water column: near-surface and near-bottom. In addition, temperature and conductivity sensors were attached to the current meters. The data showed that the flow patterns in the estuary were quite complex due to the bay's irregular geometry, tidally-driven currents, and mixing of salt and fresh water. As a result, a three-dimensional model was selected to accurately determine the time-dependent currents.

The hydrodynamic model was calibrated using data collected over a 100-day period during September to December 1991. The purpose of the calibration was to adjust empirically-driven model parameters to improve the accuracy of the predictions. The accuracy of the model was estimated by comparing predicted water levels and currents collected at the interior stations in the bay system against the model predictions. In general, the results showed good model performance for reproducing tidal amplitudes and times of high and low water. Amplitudes and fluctuations of the tidal currents were also well produced by the model. Measured and predicted salinity and temperatures were compared at several locations around the bay system. Accurate prediction of the vertical salinity profile is very important for water quality issues, and the comparisons showed that the vertical stratification was predicted rather well. Temperature profiles were also in good agreement, with the exception of a period of rapid cooling caused by the passage of a front. The drop in water temperature caused by atmospheric cooling of the water surface occurred more gradually in the model than was observed in the data.

The model was used to predict the bay's long-term circulation patterns, which determine the transport and fate of water quality constituents. The long-term mean flow should not be confused with the highly time variable flow occurring over a single tidal cycle. During the calibration period, the surface and bottom mean currents depicted a two-layer circulation pattern in most of the bay. This circulatory flow was primarily generated by longitudinal density gradients and modified by the mixing of fresh and salt water. The two-layer structure was evident at the diffuser for the Military Point discharge site in the bay.

Net flow rates were calculated at Wetappo Creek entrance of the GIWW, West Bay entrance of the GIWW, and the Gulf of Mexico during the calibration period. Daily flow rates at Wetappo Creek were relatively low, generally less than 14,130 cfs compared to the more variable flows at West Bay, where magnitudes greater than 35,320 cfs occurred regularly. Daily Gulf flows were less than 35,320 cfs but were usually directed into the bay. Overall flow balance for the 100 day period showed inflow occurring from the Gulf of Mexico and Deer Point Reservoir with mean flow rates of 10,140 cfs and 945 cfs respectively. These inflows were balanced by the net outflows at West Bay with 9113 cfs and Wetappo Creek with 2049 cfs. It is important to note that this net flow pattern applies only to the calibration period. Other time periods, with different forcing functions, may produce a significantly different flow structure.

Using the hydrodynamic predictions, the water quality model calculated effluent dilution during the calibration period. At a location east of the Dupont Bridge in East Bay, the model predicted considerably less dilution than was estimated by the 1988 U.S. EPA dye study. This may be related to different circulation patterns during the two studies. The effluent dilution was reduced during the calibration period by stratification and two-layer circulation occurring in the vicinity of the Military Point diffuser.

Water Quality. The existing data reveal that the water quality in the system is, in general, good. Bay County Utility Services Department maintains an extensive sampling program for the Deer Point Lake Reservoir watershed involving 13 sampling stations. Bay County is working with the NFWMD to establish six stream flow stations and three rain gauge locations. Bay County Wastewater Division performs quarterly sampling at 12 stations in St. Andrew Bay from the Hathaway Bridge to West Pass to the Dupont Bridge. Bay County also performs an analysis every four hours of the Deer Point Reservoir water being withdrawn for use by the public. The St. Andrew Bay Resource Management Association (RMA) has a continuing program of volunteer water quality sampling. This data is not used for regulatory purposes but provides for a valuable analysis of trends for those parameters measured. The RMA (1991-2000) has published a number of annual reports summarizing the data for the 60 + stations monitored.

The surface waters within the state of Florida are classified in accordance with their use, not by the actual quality of the water. For example, a water body may be classified as Class III, but have actual water quality that meets the standards for Class II. This water body is classified as Class III because it does not have a harvestable population of shellfish. Each class is defined by a set of parameters including the chemical, physical, and biological characteristics of the water and its intended use. The surface waters of the St. Andrew Bay ecosystem are classified as follows.

Water bodies designated as Class I are Potable Water Supplies. This means that the water is used as a supply of drinking water, and the standards for this classification are the most stringent. Class I water bodies in the St. Andrew Bay ecosystem include Deer Point Reservoir and its major tributaries: Bayou George Creek, Bear Creek, Big Cedar Creek, and Econfina Creek.

A water body designated as Class II is a Shellfish Propagation or Harvest area. This means that oysters and other shellfish can be harvested in these waters. The standards for Class II water bodies pay particular attention to those components that effect the quality of the shellfish harvested in the area to protect consumers from possible diseases associated with the consumption of raw or cooked shellfish. Fecal coliform standards are of particular concern, and the state monitors these waters carefully. The Class II waters in the St. Andrew Bay ecosystem include East Bay and tributaries east of Highway U.S. 98, but excluding Wetappo Creek; North Bay and tributaries north of U.S. Highway 98 to Deer Point Dam excluding Alligator Bayou and Fanning Bayou.

A water body designated as Class III provides for Recreation and Propagation of Healthy, Well-balanced Populations of Fish and Wildlife. Standards for Class III waters are not as stringent for some parameters as for the above discussed classes and are directed at maintaining biodiversity and water quality sufficient for human contact such as swimming and diving. All surface waters in the St. Andrew Bay ecosystem not listed as Class I or II or are designated as an Aquatic Preserve are designated as Class III water bodies.

Class IV and V water bodies are used as Agricultural Water Supplies (IV) or as Navigation, Utility and Industrial Use (V). There are no Class IV or V water bodies in the St. Andrew Bay ecosystem.

Aquatic Preserves are described in the SWIM plan as waters designated by the Florida Legislature for the purpose of preserving their biological resources and maintaining these resources in an essentially natural condition. The DEP, Office of Coastal Aquatic Managed Areas is responsible for managing Aquatic Preserves in accordance with the applicable statutes. According to the SWIM plan, the St. Andrew State Recreation Area Aquatic Preserve contains about 25,000 acres located below the mean high water line. The preserve boundary on the north is a line from Redfish Point westward to Courtney Point and south from Courtney Point into the Gulf of Mexico waters off of the St. Andrew State Recreation Area. The east boundary extends south from Redfish Point then eastward to East Pass, then into the waters of the Gulf of Mexico off shore of Shell Island. Essentially, the Aquatic Preserve is the water adjacent to St. Andrew State Recreation Area.

The DEP has determined that the best water quality is found in Econfina Creek and Sandy Creek. However, health advisories regarding mercury content have been issued for the consumption of largemouth bass in Deer Point Reservoir. The source or sources of the mercury have not been determined. Water quality adjacent to the urban areas of the bay is lower than the undeveloped areas of the system. This is probably due to the effects of stormwater runoff from the urbanized areas. The heads of some bayous have been affected by stormwater runoff, and Grand Lagoon has suffered a problem with siltation from runoff from the unpaved roads along the Lagoon.

The Florida Department of Health has been taking biweekly water samples from the St. Andrew Bay estuarine system and the Gulf of Mexico at 13 stations for determination of fecal coliform and *Enterococcus* levels in the water. Both groups of bacteria indicate contamination from animal intestinal tracts. The results of their sampling efforts are available on their web site www.myflorida.com under the section entitled environment. The results of each sampling event are rated as good, moderate, or poor for each group of bacteria. A rating of poor, requires re-sampling before issuing a health advisory. Health Advisories indicate that contact with the water at the site may pose an increased risk of infectious disease, particularly for susceptible individuals. Data from August 2000 through April 3, 2001 shows that all sites were rated good or moderate with the exception of the station at Carl Gray Park that was ranked poor for *Enterococcus* and moderate for fecal coliforms on March 20, 2001. As a result, a Health Advisory was issued.

The concentrations of both groups of bacteria in water appear to be linked to the amount of rainfall in a given period of time and to the stormwater runoff that results from the rainfall. The Florida Department of Agriculture and Consumer Affairs, Shellfish Environmental Assessment Section has developed a procedure to calculate the fecal coliform pollution of a water body based on the amount of rainfall in a given amount of time. They obtain field data and calculate conditions under which shellfish harvesting areas are opened and closed in relation to amount and duration of rainfall. Areas with large expanses of impermeable surfaces cause stormwater to runoff rapidly to the drainage system that ultimately discharges to a surface water.

Salinity in the St. Andrew Bay system varies with the distance from the passes to the Gulf of Mexico. Salinity is consistently highest in St. Andrew Bay proper where bottom and midwinter salinity typically exceeds 30 parts per thousand (ppt) on an annual basis. In the upper areas of the system, salinity can fall to about 10 ppt after heavy rainfall. In water of sufficient depth, stratification occurs with colder more saline, dense water occurring from mid-depth to the bottom.

Nitrogen and phosphorus levels remain, in general, in the lower range considered healthy for estuaries. Dissolved oxygen is generally good throughout the water column and at the water-sediment interface. However, some deeper areas of the system can exhibit depressed dissolved oxygen concentrations that approach the lower standard set for estuarine areas.

A problem area appears to be Watson Bayou that has experienced fish kills on an irregular basis over the years. The 1991 fish kill in the bayou was thought to be a result of leaking sewage lines and a sewage discharge to the bayou from the Millville Wastewater Treatment Plant located on a peninsula in the bayou. Sediment contaminants in the bayou are addressed in the sediment section of this report.

In February 1998, the DEP released a draft 303(d) list of the waters of the state that do not meet applicable water quality standards. Table 5 is a list of those waters in the St. Andrew Bay system that did not meet applicable standards in 1998, the cause of such designation, and the priority for correction of the deviation from the standards. The source of the problems for the waters listed in Table 5 appears to be predominantly stormwater runoff.

Currently, the FDEP is in the process of attempting to comply with the EPA conditions and guidelines regarding the definition and listing of impaired waters of the state. The final list of impaired waters for the St. Andrew Bay ecosystem must await the completion of that task.

Table 5. Segments of the St. Andrew Bay System on the 303(d) List, 1998

Name	Segment	Parameter of Concern	Priority
St. Andrews	Parker Bayou	0 DO, nutrients	Low
St. Andrews	Pitts Bayou	0 DO, nutrients	Low
St. Andrews	Pretty Bayou	0 DO, nutrients	Low
St. Andrews	Robinson Bayou	0 DO, nutrients	Low
St. Andrews	Warren Bayou	0 DO, nutrients	Low
St. Andrews	Direct runoff	7 nutrients	High
St. Andrews	Massalina Bayou	9 DO, nutrients	Low
St. Andrews	Watson Bayou	12 DO, nutrients	Low
St. Andrews	Johnson Bayou	13 DO, nutrients	Low
St. Andrews	Calloway Bayou	14 DO, nutrients	Low
St. Andrews	Beatty Bayou	16 DO, nutrients	Low
St. Andrews	Deer Point Lk	20 Mercury*	High

* based on fish consumption advisory

Sediment Quality. The U.S. Fish and Wildlife Service, Panama City Field Office conducted an extensive study of the quality of the sediments in the St. Andrew Bay estuarine system (Brim, 1998). This survey emphasized the deeper sediments of the Bay and associated bayous. The following was taken from the original document as submitted by Michael Brim of the U.S. Fish and Wildlife Service. These sediments are mostly comprised of silts and clays with small amounts of sand, and normally contain about 4% organic carbon. Unlike the shallow water areas where the sediments are primarily quartz sand with little organic carbon, the deeper sediments of the bay and bayous are particularly prone to become contaminated with chemicals because of the quantities of fine grain materials and carbon. If released into the bay, harmful chemicals will readily associate with these types of sediment substrates. Bayous in the urbanized areas of the system receive runoff from the surrounding developed areas and demonstrate varying degrees of siltation and possible sediment contamination.

The Fish and Wildlife Service evaluated over 100 sediment stations. The stations were located both in the open bay and in about 37% of the associated bayous. The evaluation included collecting composite samples of sediment at each station and submitting the samples to laboratories for a number of chemical analyses. Routinely, sediments were evaluated to establish the amounts (concentrations) of individual chemicals present including; organochlorine pesticides, polychlorinated biphenyls (PCBs), 21 metals (including cadmium, lead, and mercury), polycyclic aromatic hydrocarbons (PAHs), aliphatic hydrocarbons (AHs), and occasionally dioxin and furan compounds. Sediment grain size (per cent sand, silt, and clay) and the per cent of total organic carbon (TOC) were also determined for most samples. Most of the work was accomplished during the late 1980's with some additional samples collected during the early 1990's.

During the study period, the sampling revealed that sediments in the open bay were mostly free of chemical contaminants. However, the evaluation also revealed that several of the bayous were either significantly contaminated or were becoming so. The most contaminated sites included Watson Bayou, Massalina Bayou, Martin Lake, and Fred Bayou. Sediment stations were ranked and scored for the presence and amounts of individual contaminants using sediment quality guidelines. However, it is important to understand that sediment quality guidelines have only been developed for a limited number of chemicals. Of the twenty-two bayous evaluated, six (27%) were free of "guideline" chemicals in amounts that could cause adverse biological impacts. On the other hand, eight bayous (36%) had numerous chemicals present in amounts above or well above "guideline" values, and it is probable that adverse biological effects could occur in these areas. The remainder of the bayous fell somewhere in between these conditions.

Contamination observed at particular sites within St. Andrew Bay is probably the result of both historic and contemporary anthropogenic activities. Sources of chemicals included or include municipal and industrial point source discharges, urban stormwater runoff, boat and ship building and repair facilities, ports and marinas, vessel discharges, and air pollution (with associated atmospheric deposition of chemicals directly on the water or from land runoff). Conclusions from the sediment evaluations are that the many bayous of the St. Andrew Bay estuary are particularly susceptible to chemical contamination. In addition, the great majority (over 50,000 acres) of St. Andrew Bay is deep (more than ten feet) and contains sediments rich in silts, clays and organic compounds. This vast estuarine/marine area provides economically valuable habitat for marine life, including commercial shrimps, crabs, seatrout, flounder and mullet. These same deep-water sediments are of the type that are particularly susceptible to chemical contamination, and therefore these large habitat areas should be protected as much as possible from sources and releases of harmful chemicals.

Dredging for Navigation Projects. The natural depths of the bay system are adequate to meet the needs of the Gulf Intracoastal Waterway (GIWW). Maintenance dredging of the GIWW is not necessary within the bay system from about the Highway 79 Buchanan Bridge on the west to the entrance to the land cut on the east. The federally maintained channel from West Pass into the bay system requires periodic maintenance dredging of the entrance channel in the Gulf of Mexico and the pass between the jetties to the fork in the channel into Grand Lagoon. Material removed at each maintenance cycle is deposited on the beach on the west side of the west jetty in St. Andrews State Recreation Area. The material is beach quality sand. The environmental impacts of the maintenance dredging of West Pass have been minimal with the possible exception of the role played in the closing of East Pass. East Pass is the historic, natural inlet to the bay system. East Pass is currently completely closed due to Hurricane Opal and the possible interruption of littoral drift by the jetties at West Pass.

The Port of Panama City facility has not required maintenance dredging as such but has accomplished some new work. The dredged material from these projects has been placed in an upland, diked disposal area. Current plans for deepening the facility involves the placement of suitable material on Audubon Island in the bay to raise the elevation to a sufficient level to protect the colony of nesting brown pelicans and other water birds from wave action and storm surges. Dredged material disposal resulting from dredging at the Port does not appear to have been a problem in the past.

The ship channel that traverses St. Andrew Bay to Port Panama City and Stone Container has been proposed for deepening in the past. Deepening of the channel requires a place to dispose of the dredged material. To a degree, the type of material to be dredged determines the possible effects of the disposal method on the environment. The U.S. Army Corps of Engineers (COE) usually evaluates alternative disposal methods for channel deepening projects under the National Environmental Policy Act. It is during the review process that one addresses the environmental impacts. Usually there are three methods to be evaluated, disposal on bay bottom, disposal in the Gulf of Mexico, and disposal on land. It appears that the COE is in the process of addressing the proposed deepening again with disposal of the dredged material in the open water of the bay (Barkuloo, pers. comm., 2001).

Hazardous Substance and Material Transportation. The GIWW and the federal ship channels in the St. Andrew Bay estuarine system provide a means of transporting large volumes of material at a reasonable cost. The barges that traverse the St. Andrew Bay portion of the GIWW carry a variety of materials such as coal, petroleum products, and other commodities. The vessels that use the navigation channel to the Port of Panama City also carry a variety of materials to and from the Port. Therefore, the opportunity for accidental spills of hazardous materials exists for the bay. Within the St. Andrew Bay system, The U.S. Coast Guard has a station on the bay adjacent to the Naval Coastal Systems Station and maintains an oil spill response group. The Coast Guard has developed a Geographically Specific Tactical Response Plan to supplement the Area Contingency Plan that is in place. The DEP also has an oil spill and hazardous waste spill interest and works closely with the Coast Guard in the response planning process and onsite decisions should a spill occur. The counties also maintain a hazardous waste containment program to handle spills outside the jurisdiction of and in conjunction with the state and federal agencies. Rail and truck transportation present similar problems and have similar solutions. The local and state governments have developed the plans to address the possibility of accidents involving hazardous materials from these sources.

Part 4. Threats to the St. Andrew Bay Ecosystem

The activities that may lead to the alteration of the physical, chemical, and biological characteristics of the ecosystem are all related to human activities. Habitat alteration and destruction resulting from development and infrastructure needs, agriculture, and silviculture reduce natural areas and fragment the ecosystem. Chemical contamination from point and non-point source discharges and air emissions can alter the quality of the air, soil, water, and sediments and therefore, alter the biotic portion of the ecosystem. It is sufficient to say that the St. Andrew Bay ecosystem is experiencing a rapid increase in the growth of the human population with attendant alteration of the ecosystem to meet its actual and/or perceived needs. One could make a list of all the individual activities of humans that can adversely alter the ecosystem, but this list would be quite long. The Action Plans developed for this ecosystem management plan address the major human activities that have or will have an effect on the functioning of the ecosystem. Therefore, very general categories of actions that can affect the future condition of the ecosystem are provided here.

Human Population Growth. BEST and BEST, Inc. understand that the ecosystem can be unbalanced or severely altered when a single population of a species begins to dominate the system. This is particularly true if the species in question is greatly influential on the entire ecosystem. Humans are the only species that is not subject to the natural factors that regulate the density of a natural population in the ecosystem. The human population has succeeded in protecting itself from the effects of climate, predators, most epidemic diseases, and other natural density dependent and independent population control factors. Therefore, only the resources of the ecosystem essentially limit the density of the human population as that ecosystem is converted to human use. Conversion to human use is usually at the expense of the chemical, physical, and biological characteristics of the ecosystem. The growth figures cited earlier for Bay County (17% overall with 33% of that in rural areas) is a cause for concern from the point of view of maintaining and restoring ecosystem functions. Development in rural areas fragments the ecosystem into ever-smaller units that are separated from one another, and their functional relationships can be lost or severely limited.

Humans can minimize their cumulative affects on such aspects of the ecosystem as surface and ground water quality, air quality, and sediment quality by using pollution control measures and the existing regulatory programs. However, the control of the density of the human population is another matter. As density increases so does the loss or degradation of the habitats and ecological niches of an ecosystem. This results in the alteration or destruction of the functions and characteristics of that ecosystem.

Fragmentation of the Ecosystem. Dr. Eugene Odum (in an abstract from the 13th Annual Conference on Applications of Landscape Ecology in Natural Resource Management, 1998) stated the problem with which we are faced. He said, “Humans tend to chop up the environment into patches and strips with sharp boundaries thereby doing away with natural gradients and ecotones (i.e. buffers) and creating a mosaic of numerous patches of many kinds of ecosystems. Accordingly, land-use research and practical management must move up to the level of the region, so we can focus on interactions and exchanges between ecosystem patches and how best to arrange the patches on the landscape.” With this in mind, the St. Andrew Bay ecosystem should be the region of concern as the citizens struggle with human density limits and the pressure to increase the human density in the ecosystem.

Fragmentation of the St. Andrew Bay ecosystem to accommodate the needs of an increasing human population must be addressed to prevent the elimination of the ecosystem as it presently functions. The land use planning process must understand and respond to the cumulative adverse effects of the fragmentation of the remaining portions of the St. Andrew Bay ecosystem in addition to the direct loss of sections of the ecosystem by development.

The natural condition of the St. Andrew Bay ecosystem was a mosaic of the communities listed in Appendix 1. All the communities were interrelated and interconnected by **ecotones** (transition areas where one community type grades into another type, and components of both communities are intermixed). Ecotones are usually as diverse or more diverse than the adjoining communities. Human activities (agriculture, silviculture, development, roads, etc.) alter the natural communities and alter the connectivity between the remaining natural communities. The remaining natural communities are fragments of the former system and no longer function in relation to one another. The size of fragments is important in maintaining ecosystem functions. The ecological literature contains references to studies performed on the size of fragments of natural communities and their species diversity and use by certain groups of animals. The larger the size, the greater the diversity and the greater the use by mobile animals such as birds.

Establishing corridors of natural communities between the remaining fragments can restore some of the natural relationships including ecotones. Corridors also increase the size of the fragments by uniting them, provide for the dissemination of the flora and migration of the fauna between communities, and establish the natural functions of the fragments as a connected system. Roads, particularly those with medians, are very effective in fragmenting the ecosystem. The establishment of connecting corridors between communities should involve the consideration of placement of wildlife crossings under the roads within the connecting corridors.

Existing Regulatory Framework and Ecosystem Management. The rapidly expanding population of humans in the St. Andrew Bay ecosystem poses a significant threat to the integrity of the ecosystem. What can ecosystem management do to maintain or restore the functioning and biodiversity of an ecosystem that is continuously and progressively under the control of a single species (humans) within that system? It appears that the mechanisms are in place at the federal, state, and local levels to reduce the adverse impacts of the human population on the integrity of the ecosystem. The mechanisms are embodied in the federal and state environmental laws and regulations and in the local Comprehensive Growth Management Plans required of the counties and municipalities. Absolute compliance with these mechanisms is of great importance to overall ecosystem management. Deviations or variances from these mechanisms will adversely affect ecosystem functions. This is particularly true if deviations or variances become the rule rather than the exception.

The overall purpose of the regulatory agencies and their programs appear to be the minimization of the adverse effects of human actions on the environment. However, there are instances where responsibilities conflict and other instances where differences in procedures or responsibilities are confusing. Most of these agencies are subdivided into units tasked with the permitting of specific human activities such as point source pollution, air pollution, alteration of wetlands, etc. Assessment of the cumulative impacts of the actions permitted, and the application of the results of such analyses is difficult to incorporate into a system designed to evaluate impacts on a case by case basis. In addition, there is difficulty in relating the activities of one permit program with the activities of another program, and the rules have a tendency to change as political parties come and go from power at all levels of government. This results in an absence of consistency and reliability of the programs over the long term. As a result, the St. Andrew Bay ecosystem continues to be negatively affected by the alteration of the ecosystem for human uses.

The laws, rules, regulations, and procedures do exist, and they provide a means for public comment and recommendations in the process. It is not the purpose here to describe in detail the regulatory programs that are in place and functioning because it has been adequately addressed in the previous edition of this document and in the SWIM plan. The purpose of this document is to add to, refine, make recommendations, and seek information that will enhance the existing state of the ecosystem and gain a better understanding of what must be accomplished to maintain and restore, where necessary, the St. Andrew Bay ecosystem. Therefore, this plan does not flow from current laws, rules and regulations (although they are an integral part of management) but from the ecosystem itself as a functioning unit dependent upon the interrelationships of all its components.

The ecosystem management concept is a means of providing facts about the ecosystem to the regulators, uniting the various regulatory programs that are in place, and a means to oversee those programs. It is easy to locate statements such as, “water quality is the key to ecosystem management” or “sediment quality is the key to ecosystem management.” These statements are false. Any single characteristic of the ecosystem is no more or less important than any other characteristic of the ecosystem. To focus on one aspect is not ecosystem management and is not the “holistic” view. It is not difficult to imagine a St. Andrew Bay watershed stripped of its natural habitats and indigenous species, replaced with ornamental species, pavement, etc., while surface and ground water quality meet the regulatory classification standards of those waters. This could occur provided that the technology and means to sufficiently treat the volumes of domestic wastewater, industrial wastewater, drinking water, and stormwater generated under such conditions is sufficient to maintain the standards. However, the ecosystem with its attendant biodiversity, sediment characteristics, soil characteristics, etc. would be completely destroyed because the focus was directed at only one aspect of the natural ecosystem.

All of the human activities that degrade the ecosystem are the subject of one or more federal, state, and/or local governmental agency. Yet the St. Andrew Bay ecosystem remains in jeopardy.

Land Use Planning. As stated above, about two thirds of the St. Andrew Bay ecosystem is under the influence of the citizens of Bay County. The SWIM plan for the St. Andrew Bay ecosystem provides human population estimates for the various counties in the ecosystem. Bay County is, by far, the most populated county in the ecosystem and has a moderate to high rate of growth. The land use planning process of the all of the counties will determine the state of the St. Andrew Bay ecosystem in the future. Whether one prefers to discuss land use planning as Growth Management or something else, it is this ongoing process and the final results of that process that will determine the condition of the St. Andrew Bay ecosystem in the future. Will adequate preservation and conservation areas be incorporated into the evolving land use plans as valid land uses? If so, will these preservation and conservation areas be protected from variances or alterations of their designation? Will preservation and conservation areas be designated based on the value of the ecosystem functions of the land and water incorporated into these areas or on some other criterion? How will the most important functional areas of the ecosystem be determined? Will the process provide for the continued existence of species that are rare, endemic, and/or protected? Will serious consideration be given to providing corridors of undeveloped land and water that will connect the existing and future public lands and reduce the fragmentation of the ecosystem?

The citizens of the counties that are a part of the St. Andrew Bay ecosystem must answer these questions and thus, determine the fate of the ecosystem as they review and modify their growth management plans. The growth management plan developed and modified by the citizens of Bay County will have major effects on the ecosystem as a whole, the St. Andrew Bay estuarine system, and the endemic species of the ecosystem. This ecosystem management plan, by completion of its Action Plans, can provide information to the citizens as to the areas that would benefit the maintenance of ecosystem functions through preservation or conservation of these areas. The Action Plans that form the substance of this plan are directed at summarizing and providing the information necessary to make informed decisions regarding the maintenance of the St. Andrew Bay ecosystem.

Goals and Priorities for Ecosystem Maintenance and Improvement. Based upon the existing information, the St. Andrew Bay ecosystem is in fairly good condition at present. The ecosystem, as a whole, is not heavily urbanized and is, therefore, amenable to management techniques that will assure the quality of the ecosystem and the quality of human existence in the system well into the 21st century. Management of the growth in human population in the system is a primary concern. Random, unmanaged growth associated with an increasing population can result in the degradation of the ecosystem by altering the basic components of the ecosystem. Included among the possible alterations is fragmentation of habitats, conversion of habitat to infrastructure and housing, increased point source discharges and non-point source discharges of pollution, increased nutrification and contamination of waters, and other problems attendant with a growing human population. As stated above, growth management must play a major role in minimizing the adverse affects of population growth and distribution of population density.

Actions have been accomplished to ensure the maintenance of some of the characteristics of this ecosystem. The potable water supply of Deer Point Reservoir and the quality of the waters entering it have been conserved and preserved through the actions of the NFWFMD and Bay County. In doing so, the NFWFMD has also preserved large tracts of important habitat types that will, if properly managed, restored, and connected to other public land, assure the environmental quality of that subdrainage basin and enhance its biodiversity. The NFWFMD has begun aggressive restoration activities on their land that is in silviculture to establish natural biotic communities. The public lands in the ecosystem and their management to maintain the natural characteristics of the ecosystem are essential parts of maintaining the ecosystem as a functional entity. This is particularly true when these areas are interconnected.

Domestic wastewater treatment has improved. Conversion to AWT standards is improving the effluent of all the systems discharging to surface waters of the St. Andrew Bay estuarine system. A major discharge of treated wastewater from the Panama City Beach Wastewater Treatment Plant to West Bay is proposed for removal from the bay and converted to a wetland treatment area in the ecosystem. Stormwater runoff remains a problem but progress may be occurring regarding the treatment of runoff. Problems remain in that wetlands are being lost and habitats fragmented as the population increases at a rapid rate. The quality of certain types of sediments within the St. Andrew Bay estuarine system appears to indicate that past practices have degraded some areas of the bay that possess sediments that are disposed to the binding and retention of pollutants. Watson Bayou is of particular concern regarding sediment quality.

The overall goal of the ecosystem management process for the St. Andrew Bay ecosystem is to maintain and where necessary restore the ecological integrity of the system. Priority items to be addressed should include:

1. Maintenance of existing water quality with emphasis on the treatment of stormwater runoff. The NFWFMD is addressing this concern to a degree through the SWIM plan.
2. Reduction in the loss of habitat to development activities for residential, commercial, and infrastructure needs.
3. Reduction in the fragmentation of the ecosystem by providing connecting corridors between preservation and conservation lands in the ecosystem and adjacent ecosystems.
4. Reduction of wetland losses to development and conversion to other uses.
5. Protection of the surface water quality and conservation of water quantity. The NFWFMD is addressing these concerns through the SWIM plan.
6. Restoration of seagrass beds and other habitats.
7. Maintenance of biotic communities and species diversity by preserving tracts of interconnected land and water, preferably large tracts but not to exclude small tracts.
8. Preservation and conservation lands to be managed to retain natural or restored biotic communities by recognizing the importance of fire and flooding to these communities.
9. Restoration of those water bodies or segments of water bodies that do not meet the criteria of their classification as Class I, II, or III or become listed as impaired water bodies by the DEP.

Conservationists have traditionally relied upon the concept that public ownership of land and water is the best method to ensure the survival of ecosystems. The land acquisition programs that Florida has financed over the years are proof of the general acceptance that this is true for effective ecosystem management. Preservation 2000 and other programs have placed significant amounts of land in the public trust and preserved segments of the various ecosystems in Florida. The continuation of these programs such as the current Florida Forever program is the foundation of ecosystem management and restoration. However, it costs money to manage, restore, connect, and protect these lands. Concepts are being developed that are directed at involving land owners, through incentive programs, to be more directly involved in the maintenance of ecosystems in Florida. Experimental and new methods should be explored and given a chance to succeed with the realization that they also involve monetary costs to the public. However, until these new ideas are proven, land acquisition and the connection of these fragments must remain the cornerstones to obtaining the goals of ecosystem management.

In the final analysis, the success of the ecosystem management process in the St. Andrew Bay ecosystem will rest on:

1. The amount of the ecosystem that is in the ownership of the public or in the trust of private conservation organizations such as the Bay County Conservancy, Inc. and The Nature Conservancy.
2. The reduction of fragmentation by the establishment of corridors of natural communities between the segments of the ecosystem in public ownership and private ownership.
3. The restoration and quality of the management of the public's lands including upland, wetland, submerged lands, and their ecotones.
4. The desire of the citizens to maintain the quality of the natural environment of which they are a part.
5. The success of the ecosystem management programs for private lands developed by state and federal agencies.
6. The success of the land use planning process at the local level will be crucial to the success of ecosystem management in the St. Andrew Bay ecosystem.