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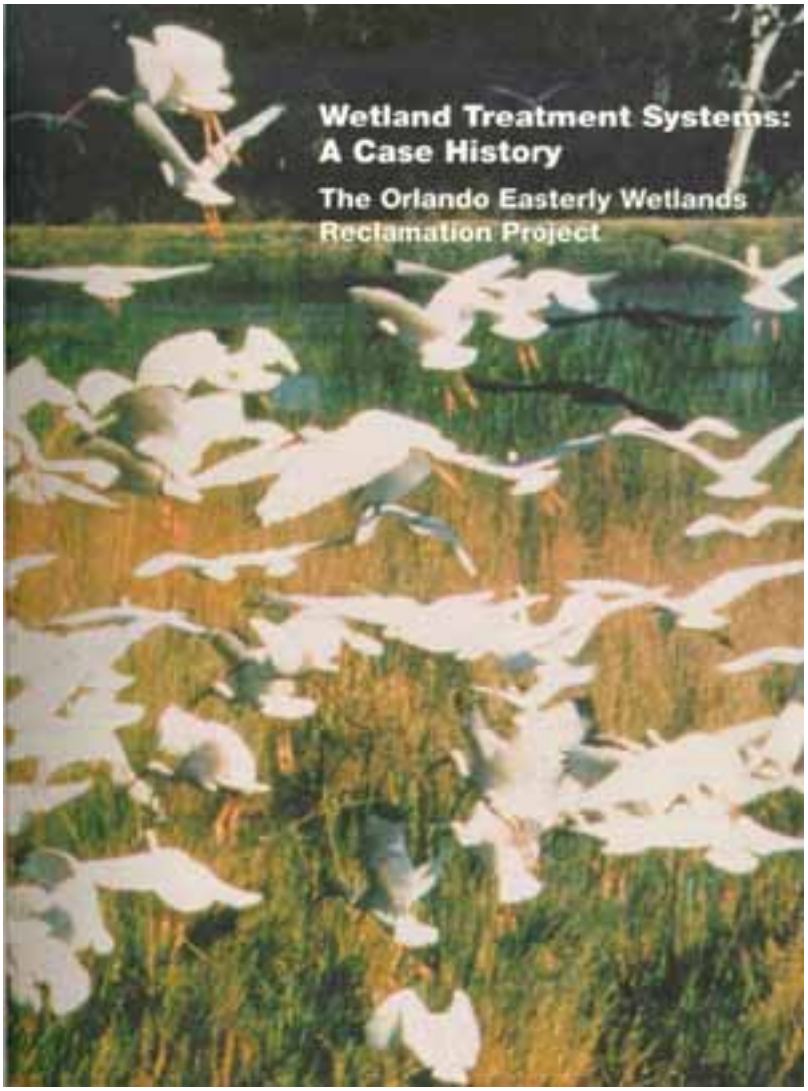
Orlando, FL - Wetland Treatment Systems: A Case History - The Orlando Easterly Wetlands Reclamation Project



A Case History: Orlando Easterly Wetlands Reclamation Project

Introduction

Wetlands have been the victim of progress in America. Research indicates that less than half of the 215 million acres of wetlands originally present in the United States prior to settlement remained by the mid 1970s. Much of this loss is due to the conversion of wetland areas into farmland.

Project Location.

Today, wetlands are recognized as a valuable natural resource. They help maintain the quality of our environment; provide habitat for a variety of plants and animals, including rare and endangered species; and offer a number of socio-economic benefits, ranging from flood protection to recreation opportunities.

In operation since 1987, the Orlando Easterly Wetlands Reclamation Project has demonstrated its successs as a treatment facilility, reuse project, and wildlife habitat.

The critical role which wetlands can play in reclaiming valuable freshwater resources is also recognized. Unlike the technology of the late 1960s and 1970s, which focused on the disposal of wastewater effluents as quickly and efficiently as possible (usually through discharge into streams, lakes, or oceans), wetlands treatment technology involves passing wastewater effluent or stormwater runoff through a wetland system. By acting as a natural filter for the pollutants that remain even in advanced treated wastewater effluent, wetland systems can polish the effluent so that it can be safely returned to fresh water sources.

One of the largest constructed wetland treatment systems built to date is the Orlando Easterly Wetlands Reclamation Project. Post, Buckley, Schuh & Jernigan, Inc. (PBS&J) served as design engineers for the City of Orlando, Florida. Background issues, special considerations, and performance results from this award-winning facility are discussed next.

Project Background

The Little Econlockhatchee (Little Econ) is a primary tributary to the Econlockhatchee River (Econ), which in turn is a primary tributary to the St. Johns River (SJR). The SJR system drains portions of the middle and upper east coast of Florida to the Atlantic Ocean. Over the years, much of the floodplain around both the SJR and the Econ system has been altered by drainage systems and subsequently converted to grazing lands for cattle. By 1980, 16 wastewater treatment plants (WWTPs) in the eastern Orange County area, discharged either primary or secondary effluent to the Little Econ.

The Orlando Easterly Wetlands was constructed on pasture land in an area which had been a natural wetland prior to human settlement and cattle grazing

The effects of these WWTP discharges on the Little Econ included decreased dissolved oxygen levels and the occurrence of Eichhornia crassipes (water hyacinth), Hydrilla verticillata, Najas guadalupensis, the duckweeds, and Panicum spp. which at times completely covered sections of the channel in the Econ system, and also contributed to frequent algae blooms in Lake Harney, a node within the SJR. (Located about one mile downstream of the confluence with the Econ, Lake Harney serves as a key indicator of water quality conditions in the Econ watershed.)

As part of a commitment to improve water quality conditions in the Little Econ, the City of Orlando began construction of an advanced wastewater treatment (AWT) plant which would replace a number of the existing package plants. By 1980, Phase I of the Iron Bridge Regional Water Pollution Control Facility (WPCF) was underway.

Iron Bridge WPCF Original Permit Conditions

BOD5	5 mg/L	(1001 lb/d)
TSS	5 mg/L	(1001 lb/d)
TN	3 mg/L	(600 lb/d)
TP	1 mg/L	(200 lb/d)

Permit regulations imposed on the Iron Bridge WPCF by the U.S. Environmental Protection Agency (USEPA) and the Florida Department of Environmental Protection (FDEP) were very stringent. Limitations for both effluent concentrations and loadings were based on the Phase I flow rate of 24 MGD. This meant that the capacity of future expansions to the treatment plant would be severely limited by the allowable effluent loading criteria in the USEPA National Pollutant Discharge Elimination System (NPDES) and FDEP permits, or the City would have to find an alternative discharge point.

Faced with a growing population and the need for additional wastewater treatment capacity, the City sought alternative effluent disposal options. An analysis of potential options was completed in 1984. The overall scope of the study included an investigation of such disposal options as deep well and aquifer injection, spray irrigation, moving the discharge point to another sub-basin of

the SJR system, water hyacinth treatment, and both natural and constructed wetlands treatment.

The conclusions of this study ranked the construction of a wetland for effluent disposal adjacent to the floodplain of the SJR as the number one alternative. Selection criteria included economics, restoration of previously lost wetlands, and creation of a wild-life habitat.

Siting Considerations

Critical to the successful design of the City's wetland system was the selection of an appropriate location. The site selected was about 1,640 acres in size and located about two miles west of the main channel of the SJR. Review of historical data, including surveys conducted in the late 1850s, indicated that much of the site was previously part of the wetland system adjacent to the SJR. An elaborate series of ditches had been used to drain the site when it was converted to pastureland shortly after the turn of the century . Since this conversion, it had been operated as a cattle ranch. Using this site meant that more than 1,200 acres of land would be restored to its natural wetland state.

Soil characteristics were another important consideration in site location. The surficial soils at the City's wetland system are generally fine sands underlain by clayey soils. The depth of the clayey soils range from the surface to several feet below the soil surface, and tend to restrict water movement downward to the groundwater.

A hydraulic gradient that exists across the site directs groundwater flows toward the east, away from residential wells located west of the site.

At the time the City acquired the site, most of the on-site surface waters were routed to a main canal that drained to a backwater area of the SJR. The course of the main canal bisected a natural wetland owned by the St. Johns River Water Management District (SJRWMD) known as Seminole Ranch. This canal formed part of a stormwater management system on the SJRWMD land that altered the natural wetland such that transitional and upland vegetation were invading the site.

Berms divide the 1,220-acre wetland system into treatment cells which provide additional nutrient removal to treated effluent passing through the site.

By using the discharge waters from the City's wetland treatment system, wetland hydrology on about 600 acres of the Seminole Ranch is being restored. Today, the water discharged from the City's wetland moves by sheet flow through Seminole Ranch prior to discharge into the SJR.

Existing topography was also a key consideration in selecting the project site. With a topographic gradient of about 15 feet across the site, the land slopes downward from the west to the east. The wetland

design used this gradient to divide the site into seventeen cells such that the average drop in elevation across each cell was limited to approximately three feet. This allows each treatment cell within the wetland system to be operated at dry season and wet season water depths that could range from sheet flow to a maximum depth of three to five feet.

Permitting Considerations

Fluctuating water levels are critical for the maintenance of desired plant communities within wetland treatment systems. The primary objective in designing the City's system was to use macrophytic communities to facilitate additional nutrient removal for up to 20 mgd of treated effluent from the Iron Bridge WPCF. The original permit issued by FDEP limited flow to 8 mgd, due in part to the untested nature of the system. Flow increases of about 3 to 5 mgd to a maximum of 20 mgd are being permitted by FDEP as the system demonstrates its ability to operate successfully at each increase. The current system is operating at a flow rate of 13 mgd, and the City has received approval from FDEP to increase flow to 16 mgd.

Anhingas and other bird species find the Orlando Easterly Wetlands to be a safe haven for raising their young.

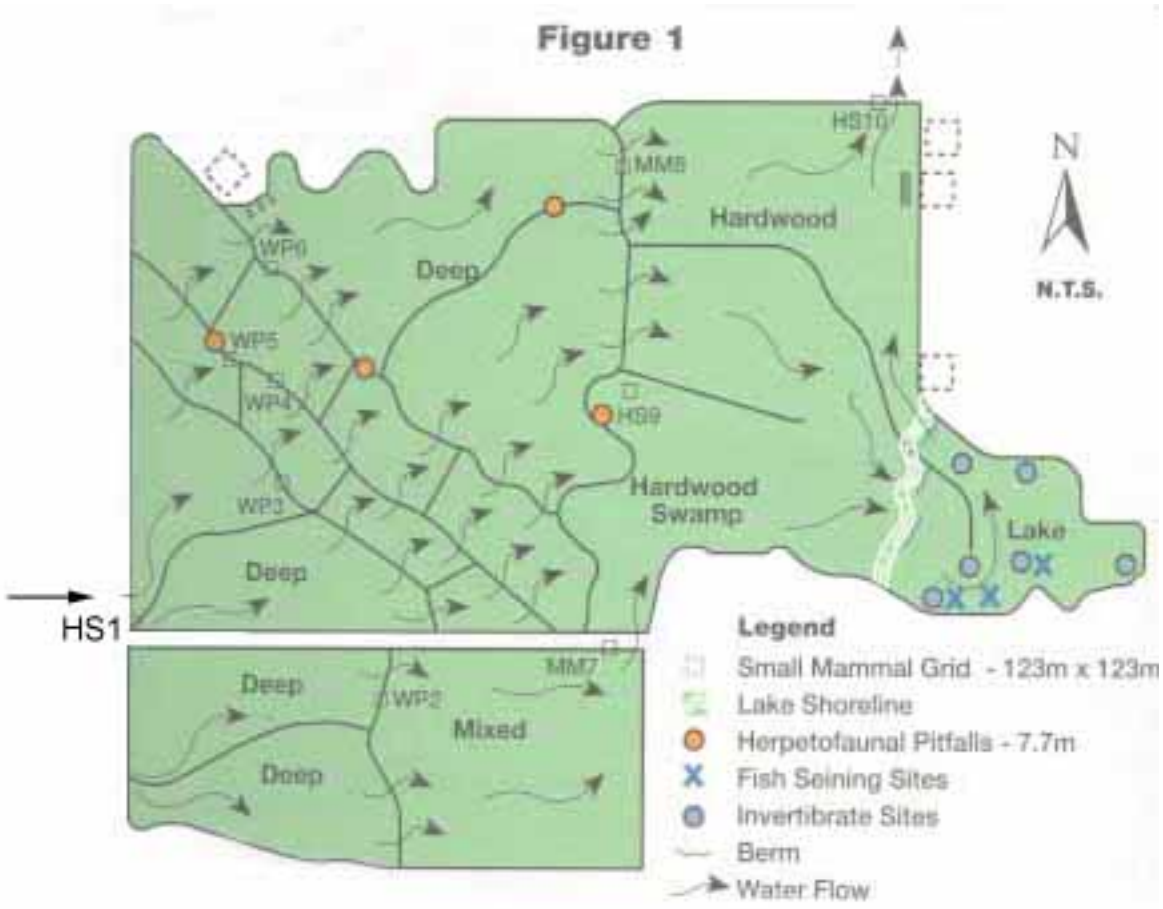
FDEP and USEPA did not allow the City to use existing permit conditions or wasteload allocations as the basis for nutrient limitations of the wetland discharge. This situation was largely due to the continued degradation of water quality conditions in Lake Harney. The USEPA NPDES and FDEP permits require that the wetlands' discharge meets existing background water quality conditions in nearby natural wetlands as well as complies with the loadings established under the wasteload allocation for discharges to the Little Econ.

The City conducted a 2.5-year water quality study in conjunction with the SJRWMD and FDEP to estimate the nitrogen and phosphorus limits for the wetland's operating permits. The nitrogen and phosphorus permit limits generated by this study are 2.31 mg/L and 0.2 mg/L, respectively.

Wildlife Considerations

A secondary objective of the Orlando Easterly Wetlands project was the creation of a wildlife habitat. During the conceptual design phase, the wildlife management area was thought of as a function of the wetland treatment process rather than as a specific plan for specific wildlife species. However, as permitting and design proceeded, wildlife issues shifted from simple descriptions of potential species occurrences in the general area of the wetland to the design of specific habitat types. This inclusion of areas designed as a wildlife habitat within the City's wetland system allows the project to serve as a valuable wildlife refuge and opens up the site for other uses in addition to wastewater treatment and disposal.

Developing the Wetlands



Approximately 1,220 acres of the project site were developed into the Orlando Easterly Wetlands project. The system is divided into seventeen cells oriented across the site so that the first twelve cells comprise about one-third of the total project area. The mixed marsh includes three cells that also comprise about one-third of the total area. The remaining two cells form the hardwood swamp. The cells were defined by constructing a series of earthen berms and were planted using about 2.1 million aquatic wetland plants. Vegetation originally planted in the wetland are shown in Figure 2.

All fill material used to construct the berms was excavated from a borrow pit (shown as the lake in Figure 1) located in the eastern part of the site. The habitat potential of the lake is enhanced by the use of an irregular shoreline, the varied slope of the littoral zone, the varied water depths (e.g., the rim ditch used to de-water the site was left in place and now averages up to 45 feet deep), and the placement of construction debris within the lake for fisheries habitat.

The system began operation in September 1987. AWT effluent is pumped about 7 miles from the Iron Bridge WPCF to a three-way splitter box at the wetland system, after which the water flows by gravity to the outfall structure. Rectangular weir structures are used to control the flow internally; two-inch flash boards are removed or inserted as needed. The berm design includes a three-foot freeboard capacity for

storage of stormwater inputs. This design allows the operators to control the flows into and out of any given cell without influencing the operation of the remaining areas of the wetland treatment system. The average travel time through the Orlando Easterly Wetlands varies from about 21 days during the dry season to about 65 days during the rainy season.

Wetland Components

Water enters the Orlando Easterly Wetlands system through the 12 cells that form the deep marsh. The deep marsh cells generally have an average depth of 3 to 3.5 feet and were planted with cattails (Typha spp.) and bulrush (Scirpus spp.). These areas were planned as cattail communities at the conceptual design stage, because the scientific literature at the time provided more information about using this species than any other species for wastewater treatment.

Bulrush and Cattail communities remove and store most of the nutrients from effluent entering the wetland system.

Because cattails are potentially capable of competitively eliminating other native plant species and consequently reducing the diversity of the emergent plant communities in the SJR basin, the SJRWMD voiced concern about the formation of such a large cattail community so near to the SJR. In response, PBS&J designed a large-scale in-situ experiment for the City to test the treatment capabilities and competitive effects of cattail versus bulrush communities. As a result, the first 12 cells of the City's system are planted with either cattails, bulrush, or a combination of the two.

To date, the results indicate there are subtle differences between the two plant species relative to water quality improvement. The bulrush cells appear to have a slightly

Figure 2
Orlando Easterly Wetlands Reclamation Project Species Planted

Red Maple (Acer rubrum)

Water hyssop (Bacopa caroliniana)

Canna (Canna flaccida)

Sawgrass (Cladium jamaicense)

Spikerush (Eleocharis cellulosa)

Pop ash (Fraxinus caroliniana)

Dahoon Holly (Ilex cassine)

Blue flag (Iris hexagona)

Soft rush (Juncu s effusus)

Sweet gum (Liquidambar styraciflua)

Sweet bay (Magnolia virginica)

Stone wort (Nitella sp.)

Cow lily (Nuphar luteum)

Water lily (Nymphaea odorata)

Black gum (Nyssa sylvatica)

Maidencane (Panicum hemitomon)

Knot grass (Paspalum distichum)

Smartweed (Polygonum punctatum)

Pickerelweek (Pontederia cordata)

Pondweed (Potamogeton illinoensis)

Swamp laurel oak (Quercus laurifolia)

Arrowhead (Sagittaria graminae)

Arrowhead (Sagittaria lancifolia)

greater nutrient uptake capacity than the cattail cells. The bulrush also have proven to be more tolerant of water level fluctuations than the cattails. The deep marsh cells are designed to take advantage of the microbial communities associated with the littoral zones within the cattail and bulrush communities to remove and store most of the nutrients entering the wetland system.

The deep marsh cells are followed by three mixed marsh cells. The mixed marsh is designed as a transition point between the water treatment aspects of the wetland treatment system and those associated more closely with wildlife habitat. Approximately 30 plant species were planted in the mixed marsh cells, and approximately 100 other species have become self established from the seed bank or off-site wetlands since system start-up.

Three-square bulrush (Scripus americanus)

Giant bulrush (S. Californicus)

Soft stem bulrush (S. Validus)

Pond cypress (Taxodium ascendens)

Thalia (Thanlis geniculata)

Cattail (Typha domingensis)

Cattail (T. latifolia)

Tapegrass (Vallisneria americana)

More than 200 animals species use the Orlando Easterly Wetland as habitat today.

Overall, the vegetative communities within the mixed marsh cells provide a very diverse habitat structure. The mixed marsh cells act as a nutrient polishing step to the deep marsh cells and maintain nitrogen and phosphorus concentrations at lower levels than those found in the deep marsh. An apparent difference in the nutrient removal processes in the deep marsh and mixed marsh cells is that the former relies more on bacterial uptake while algae are more dominant in the latter.

The final component of the Orlando Easterly Wetlands system is the hardwood swamp. This area is specifically designed as a wildlife habitat area. About 160,000 trees were planted throughout the cells, intermixed with an understory similar to that typical of the mixed marsh. In addition, an existing cypress (Taxodium spp.) head was preserved, and the lake, developed from the borrow pit, was located within these cells. Although the hardwood swamp cells were not expected to play a significant role in the nutrient uptake before system start-up, they have since proven to produce a net release of phosphorus back into the water column. This release of phosphorus can be partially attributed to the number of rookeries located within these cells. The nesting bird species typically found in the rookeries include several heron and egret species.

Measuring Success

In 1984, at the conclusion of the initial study which examined disposal alternatives, the City established the goal of creating a wetland treatment system that would provide both effluent polishing and a wildlife management area. Since system start-up, the performance of the Orlando Easterly Wetlands relative to nitrogen and phosphorus uptake and storage has been better than originally predicted by the design (see Table 1).

Wetland system designers included an operational plan for maintaining target communities and refuges for forage species.

The data in Table 1 show that the Orlando Easterly Wetlands project has consistently discharged a water quality that is better than the permit requirements. The discharge has, in fact, been statistically equal (æ < 0.05) to the water quality conditions in the SJR, both upstream and downstream of the discharge point (see Table 2). These data indicate that the system has acted to recover a resource-- fresh water--that now is being used to hydrologically restore the SJRWMD wetland site.

The annual performance of the system is shown by the data in Tables 3 and 4, with reference to Figure 1 for the station locations. These data indicate the system has performed very well for the first four years of operation. This can be partially attributed to the level of commitment by the City of Orlando to operate the system as a treatment process and as a wildlife habitat area. Operational procedures, such as varying water depths, employed by the project have attempted to minimize nutrient releases while maximizing the ability of the wetland treatment system to remove and store nutrients. The data in Table 4 also show that phosphorus concentrations are reduced to about 0.05 mg/L at the discharge point from the mixed marsh.

Water quality data are only one indication of the success of the Orlando Easterly system. Another measure of success is the diversity of the system and the array of wildlife species attracted by this diversity.

Table 1

TN and TP Discharge Concentrations*

	Flow (mgd)	TN (mg/L)	TP (mg/L)
FDEP	13.00	2.31	0.200
1988	10.00	0.84	0.095
1989	13.33	0.92	0.076
1990	13.28	0.93	0.090
1991	12.90	0.80	0.087

* This table compares the first four years of compliance data for the Orlando Easterly Wetlands project with the current FDEP permit criteria for TN and TP discharges. Flows shown represent influent discharges to the wetland system.

Figure 4

Orlando Easterly Wetlands Reclamation Project Observed State and Federally Listed Animal Species

Roseate spoonbill
Limpkin
Gree-backed heron
Little blue heron
Snowy egret
Tricolored heron
Peregrine falcon
Florida sandhill crane
Woodstork
Everglades snail kite
American alligator
Eastern indigo snake

The system has demonstrated that if properly managed, a constructed wetland can be used for water treatment, water quality improvement, and diverse wildlife habitat. In fact, data collected to date indicate that the system may attract more species than surrounding natural wetlands and generally may support a higher resident population than similar natural habitat areas (see Figure 3). The latter can be directly attributed to the higher productivity rates within the system.

The design of the Orlando Easterly Wetlands includes the preservation of upland areas around the site. Maintenance of the upland/wetland ecotone has increased the value of the potential habitat for wetland-dependent species.

The design also included an operational plan, i.e. managing water depths for maintaining the hydroperiod (optimal water depths and duration) for targeted vegetative communities in the system. This plan addresses procedures for maintaining the refuges for the forage species, which ultimately will lead to stabilizing the habitat of higher wildlife species such as birds, alligators, and otters.

Another measure of the Orlando wetlands success is the number of listed species which use the site (shown in Figure 4). To date, 145 bird species have been observed on site and 10 of these species are state or federally listed and are currently utilizing the system as part of their habitat. The sandhill crane and Everglades kite have successfully nested in the wetlands and fledged young during the third and fourth years of operation. This usage pattern of the wildlife habitat also serves as an on-going natural bioassay of the system, showing that the water quality goals have been met in full.

Table 2

Comparison of TN and TP Discharge Concentrations with the Annual Averages of Receiving Waters

(First Four Years)

	TN (mg/L)				TP (mg/L)			
	1988	**1989**	**1990**	**1991**	**1988**	**1989**	**1990**	**1991**
HS10	0.84	0.92	0.93	0.80	0.095	0.076	0.090	0.087
SJR1	0.87	0.88	1.08	1.05	0.137	0.074	0.098	0.053
SJR5	0.87	0.89	0.89	1.09	0.149	0.071	0.084	0.116
SR	0.95	1.00	1.09	1.06	0.117	0.070	0.080	0.067

HS10 = Orlando Easterly Wetlands Reclamation Project Discharge

SJR1 = Station in the St. Johns River Upstream of HS10

SJR5 = Station in the St. Johns River Downstream of HS10

SR = Average Annual Concentration for Seminole Ranch Monitoring Stations

Table 3

Comparison of TN Annual Averages Through the Orlando Easterly Wetlands Reclamation Project

(First Four Years)

	Nitrogen (mg/L)				
Station (1)	**1988**	**1989**	**1990**	**1991**	**Area (2)**
WP1	4.18	5.52	2.83	2.44	0
WP3	1.53	1.92	0.98	2.20	11
WP4,5	1.51	1.74	1.00	1.02	16
WP6	1.27	1.59	1.09	1.11	32
MM8	0.96	1.22	1.19	1.25	67
HS10	0.84	0.92	0.93	0.90	100

(1) These stations include influent and effluent samples in addition to four internal strat.

(2) Area equals the percent of wetland area upstream of the listed sample station.

Table 4

(First Four Years)

Station (1)	Phosphorus (mg/L) 1988	1989	1990	1991	Area (2)
WP1	0.572	0.720	0.41	0.23	0
WP3	0.103	0.080	0.16	0.37	11
WP4,5	0.102	0.065	0.14	0.12	16
WP6	0.106	0.070	0.11	0.11	32
MM8	0.091	0.050	0.05	0.06	67
HS10	0.095	0.076	0.09	0.087	100

(1) These stations include influent and effluent samples in addition to four internal strat.
(2) Area equals the percent of wetland area upstream of the listed sample station.

Community Acceptance

Orlando Easterly Wetlands Reclamation Project Awards	
1987	PBS&J Project Excellence Award
1988	Florida Institue of Consulting Engineers Excellence Award ACEC Excellence in Engineering Award
1990	FDEP Secretary's Award, Florida Department of Environmental Regulation
1990	State of Florida Governor's Environmental Award
1992	Water Environment Federation Outstanding Achievement Award (included with other City achievements) over the past 10 years

Orlando Easterly Wetlands Reclamation Project Costs

Land Acquisition.....$4,411,000
Wetlands Development
Structural.....4,232,000
Vegetation.....750,000

Force Main.....8,491,000
Effluent Pump Station....1,982,000
Engineering.....1,659,000

Total.....$21,525,000

The success of the Orlando Easterly Wetlands Reclamation Project is attributed not only to its success as a wastewater treatment facility and reuse project, but also to the benefits it offers surrounding communities. For visitors who wish to enjoy the beauty of Florida wildlife in a natural habitat, a portion of the project functions as a wilderness park with nature trails and seasonal camping facilities which are open from mid-January through September.

For area schools with environmental educations programs, it serves as a natural laboratory and research facility. The result is a project which exemplifies the current trend toward socially responsible environmental management.

Figure 3
Comparison of Wildlife Diversity

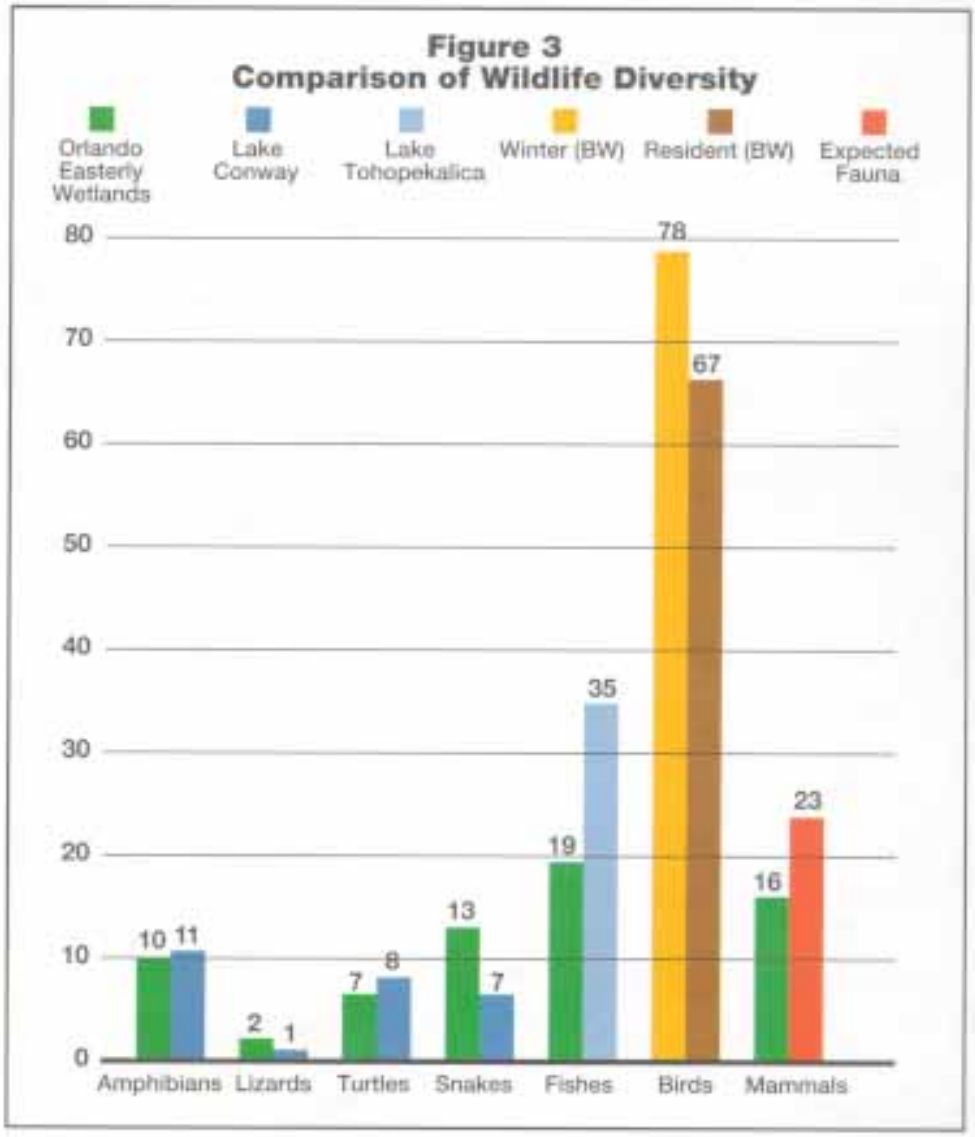


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Photo courtesy of Seth Blitch

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