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Lessons From US Watershed Investment Programs

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Discussing WIFIA's Structure and Effects

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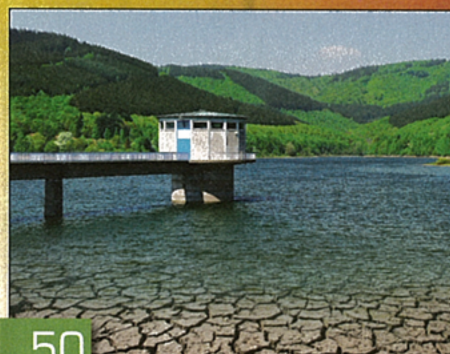

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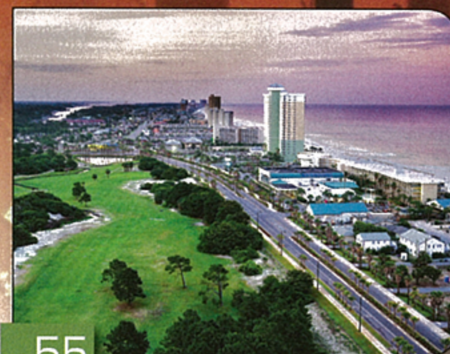

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Feature Articles

On the cover: With threats to drinking water supplies on the rise, providers are realizing the benefits of watershed investment programs. A recent study examined 13 such programs and focused on protecting source water through forest management.

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WILLIAM D. MUSSER AND MICHAEL B. BOMAR

Reclaiming Water to Rehydrate Wetlands: Panama City Beach's Conservation Park

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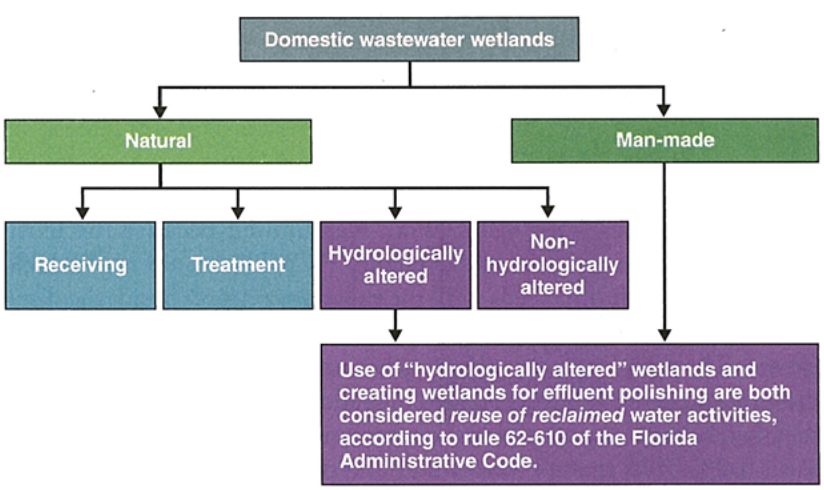
WHEN A GULF COAST CITY IN FLORIDA ADDRESSED ISSUES WITH ITS TREATED WASTEWATER DISPOSAL, IT ALSO RESTORED WETLANDS AND CREATED A PARK FOR PUBLIC ENJOYMENT.

As a consequence of a consent order, future development in Panama City Beach, Fla., was limited because the existing wastewater treatment facility (WWTF) would not be able to serve future needs until the growing concerns about the disposal of treated wastewater into sensitive estuarine waters was addressed. Through innovative approaches and progressive collaboration, a public–private partnership was formed that addressed the consent order, which ultimately resulted in a new regional conservation park. The city was then able to reuse 100% of its treated wastewater and provide future growth opportunities for the development community.

Panama City Beach is a city of more than 12,000 residents (United States Census Bureau 2010) in Florida's southern panhandle on the northern coast of the Gulf of Mexico. With an additional 5,000 tourists and winter residents, the city's wastewater flows and reuse requirements are highly variable. The city is served by one WWTF located between the West Bay of Saint Andrews Bay and the Gulf of Mexico (Figure 1). In 2000, the WWTF was treating approximately 7 mgd of wastewater on a maximum monthly average daily flow (MMADF). Approximately 50% of treated wastewater was reused through public-access irrigation of open space such as city parks, public rights of way, and golf courses. The remaining treated effluent was sent to an approximately 1-mi-long freshwater ditch near the WWTF that ultimately discharges into West Bay. The state of Florida classifies West Bay as Class II waters, which includes coastal waters where shellfish harvesting occurs. West Bay is also part of the diverse but fragile Saint Andrews Bay ecosystem, with more than 2,900 species of documented plants and animals (Keppner 2002).

FIGURE 1 Panama City Beach, conservation park project, and surrounding area

FIGURE 2 Florida Administrative Code categorization of wetlands for wastewater treatment and disposal



The WWTF is required to meet advanced treatment quality effluent limits of 5 mg/L carbonaceous biochemical oxygen demand; 5 mg/L suspended solids; 3 mg/L TN (total nitrogen); and 1 mg/L TP (total phosphorus). The city was allowed to continue discharge into West Bay as part of an agreed-upon consent order with a stipulation that surface water disposal cease by April 2011.

The consent order requiring the city to stop effluent disposal to West Bay was based on growing environmental concerns at both the local and state levels over the amount of nutrients discharged into the estuary and that ultimately flowed to the Gulf of Mexico. In addition, the US Fish and Wildlife Service and Florida Department of Agriculture closed a portion of West Bay to shellfish harvesting because of the surface water discharge from the WWTF.

REGULATING REUSE IN FLORIDA

The Florida Department of Environmental Regulation (FDEP) is the regulatory authority that administers permits for the treatment and disposal of domestic and industrial wastewater. Wetlands used to treat domestic wastewater are governed by the rules of the Florida Administrative Code (FAC) under rule number 62-610 (Florida Department of State 2010). When wetlands are used as part of the treatment or disposal of wastewater, the FDEP considers the wetlands as either natural or man-made (created). Projects using natural wetlands in the FAC are categorized as either receiving wetlands or treatment wetlands, and additionally as either hydrologically altered or nonhydrologically altered. The ultimate categorization affects the design criteria of the wetland system, threshold limitations, and opportunities or constraints for any beneficial uses. Figure 2 summarizes

Florida's categorization of wetlands for wastewater treatment.

In 2012, the FDEP indicated that Florida had 21 facilities with permitted man-made wastewater wetland treatment systems (4,000 acres) and 17 facilities using natural wetlands (6,200 acres); likewise, 10 natural wetlands were permitted (5,350 acres) compared with only two permitted man-made treatment wetlands (286 acres) (FDEP 2012).

From Figure 2, hydrologically altered wetlands were of particular interest to the city; these wetlands can be hydrated to restore or prevent potential loss of wetland acreage. Use of a hydrologically altered wetland or creating wetlands for effluent polishing are both considered reuse of reclaimed water activities according to FAC 62-610.

In addition to intensifying regulatory, community, and environmental pressures, a company with major local land ownership in Panama City Beach historically associated with the timber industry was shifting to a real estate development company with a focus to develop local timber lands. The city's WWTF did not have the capacity to handle the anticipated flows for this future development. With the agreed-upon consent order, discharge into West Bay was not an option. Public and private interests brought stakeholders together to identify a mutually beneficial solution to eliminating surface water effluent disposal, reusing wastewater effluent, providing wet-weather disposal, restoring hydrologically altered wetlands, and expanding the WWTF's treatment capacity for new development.

A UNIQUE OPPORTUNITY

Not all public entities are fortunate enough to have large, undeveloped areas within city limits that contain disturbed and/or altered wetland areas; thus, many of Florida's sites attempt permitting as treatment wetlands. Panama City Beach was fortunate to be offered a large area of disturbed wetlands, with a landowner who was willing to work with the city.

The timber company owned undeveloped property in the surrounding area and offered to sell a large tract of land to the city. The property was of little economic use for future development and contained many acres of disturbed jurisdictional wetlands that had been significantly altered. Historic uses in the area included native longleaf pine (*Pinus palustris*) logging, subsequent slash pine silviculture (i.e., forest cultivation), and turpentine farms. Man-made ditches were excavated in this area to lower the groundwater table and remove ponding to allow easier site access for equipment and facilitate more conducive growing conditions for slash pine.

In 2005, the city purchased 2,900 acres from the timber company, consisting of 2,072 acres of jurisdictional wetlands with significant impacts and 828 acres of associated uplands with various historic impacts. Figure 1 indicates the relationship between Panama City Beach, its WWTF, West Bay, and the receiving wetlands site. Baseline monitoring reports identified historic uses at the site and surface drainage practices to lower the water table, which would convert more hydric pine flatwoods to a mesic (dryer/moderately moist) condition. Species composition showed that the drying condition promoted loss of cypress trees in formerly deeper water habitats and loss of longleaf pine in formerly mesic flatwoods. The dominant vegetation at the time of the proposal had changed to black titi and slash pine. In addition, historic aerial photo documentation showed ditch dredging occurring in the 1960s on the site, and the FDEP confirmed that the area had more than 2,000 acres of hydrologically altered jurisdictional wetlands and thus would be applicable to that portion of the state code.

The available land for receiving wetlands was very large, creating an opportunity to spread out the treated effluent and manage the application rate in a very beneficial manner to help promote proper hydrologic restoration. In many receiving wetland projects, the volume of effluent delivered to the cells relative to the total storage volume available creates unnatural hydroperiods within the collection cells, which do not mimic unaltered wetland hydrology. Oversaturating a wetland does not promote self-sustaining systems because wetland habitats need dry periods to germinate and propagate seedlings and recruits. Increasing the saturation and inundation of the existing vegetation would lead to restoration of the palette of species to more hydric-tolerant (i.e., wetter) conditions. Thus, a plan was developed to take advantage of the available hydrologically altered wetland areas that rotated the effluent application schedule to simulate the wet and dry seasons in each polishing cell.

> The city's wastewater treatment facility did not have the capacity to handle the anticipated flows for future development.

To accomplish this, each wetland system was observed and the historic and existing hydroperiods analyzed to estimate their individual working application depth of water and evacuation time for purposes of creating resting periods for the systems. These had to be aligned to various input parameters in the water budget. The most critical factors were seasonal rainfall patterns, evapotranspiration, and effluent flows from the WWTF.

The project area also afforded the opportunity for other public beneficial uses beyond polishing reuse effluent and improving the water quality of West Bay. The city elected to take this vast, now publicly owned area

Clearly marked public trails through the conservation park include boardwalks that lead into areas that the public would otherwise be unlikely to see.

and provide opportunities for public outreach, education, and recreation. The infrastructure and facility design incorporated a multiuse approach to maximize the benefit of the land.

For example, the alignment of the 5 mi of force main to convey the reuse water to the site from the WWTF would also be used as a paved bike trail. The control building with reuse piping and valve manifold doubled as a public restroom and shelter. The treatment cell berms doubled as pathways with more than 25 mi of hiking and biking trails. New boardwalks through deep cypress domes offered the public seldom-seen perspectives of the natural environment (see the photographs on this page). Several kiosks provided information about habitat restoration through wetland rehydration, selective thinning, prescribed burning, longleaf pine and wiregrass (*Aristida stricta*) seedling plantings, and other important features of the park. They included descriptions of the historic use of the lands, ongoing restoration and rehydration activities, and future conservation of the property (see the photograph on page 59).

PERMITTING

Project permitting required hydrologic and ecologic monitoring to create a preconstruction baseline. Site water quality samples were taken from inside the headwaters of the wetland area within the centrally located drainage ditch and from the monitoring station at the point of discharge from the entire wetland system. Table 1 provides analysis of the water quality parameters most relevant to the necessary permits measured before project implementation and their upper limits after receiving reuse water.

TABLE 1 Water quality parameters measured before construction of Panama City Beach conservation park

Water Quality Parameter	Sampled (Preconstruction) *mg/L*	Reuse Maximum Allowed *mg/L*
Five-day CBOD	2–3	5
Total suspended solids	1.6–2	5
Total nitrogen (TN as N)	0.20	3
Total phosphorus (TP as P)	<0.20	0.8

CBOD—carbonaceous biochemical oxygen demand

The investigation also included the wetlands' species composition during the baseline monitoring period and afterward. Ongoing annual monitoring is required for woody vegetation, whereas herbaceous vegetation was required to be monitored only for the first three years but on a quarterly basis. The baseline monitoring occurred at four stations within the wetlands. Because of the previous site owner's surface water drainage practices, the wetland areas exhibited a juxtaposition of both wetland and upland species. In fact, before construction of the conservation park, the four most common woody species encountered throughout the baseline survey were an upland species, a facultative species, and two facultative wet species as classified by the US Army Corps of Engineers. Although obligate wetland species were also encountered as expected in onsite wetlands, they were far less common than historic aerials and records had indicated. Thus, the shift in wetlands composition to species tolerating drier conditions would provide opportunities in the treatment cells to rehydrate the wetlands with reuse water.

DESIGN AND CONSTRUCTION

To use the conservation park site, the treated reuse water had to be

At a newly created conservation park in Panama City Beach, Fla., informational kiosks are part of the public outreach center and control building.

collected, conveyed, and distributed on the basis of a complex rehydration schedule matched to three separate design phases of flows. Thus, design and construction was required at the existing WWTF, along an elevated power line corridor to the wetlands, at a central distribution point (control building), and in and around each polishing cell of the wetland tract.

The WWTF required modifications, including determining where to extract the reuse water from the plant. The WWTF was operating at 7 mgd (MMADF), but the buildout potential of the WWTF was based on three phases of development—phase 1 to increase capacity to 10 mgd, phase 2 to 14 mgd, and phase 3 to 18 mgd (ultimate buildout). The reuse transmission line was sized for the ultimate flow of 18 mgd and required construction of 5 mi of 36-in. ductile iron pipe to the receiving wetland site. Given the range of expected flows, it was thought that the lower velocities during early phases could potentially facilitate algae growth in the transmission main. Thus, the reuse water intended for the wetland was intercepted upstream of the existing WWTF dechlorination system to ensure a chlorine residual, but a dechlorination system was installed at the wetland site to remove any chlorine residual before discharge.

> Panama City Beach was fortunate to be offered a large area of disturbed wetlands, with a landowner who was willing to work with the city.

The WWTF's new pumping complex accommodated a 32-mgd hexplex of pumps with backup generators and a variable-flow-device control building. The parking area for this new facility doubled as an additional parking lot and trail head for the public use of the paved bike trail and connection to the city's trail system.

A 2003 evaluation of the existing wetlands established the composition, function, and value of each habitat. In addition, an evaluation of the surface drainage basins determined opportunities for isolating treatment cells. All of the basins were interconnected through various surface water interactions that ultimately drained to the northernmost basin, where an existing outfall ditch excavated by the logging industry carried away excess surface water from the entire system. This was a major contributor to the hydrologically altered state of the wetlands within the receiving areas.

Each hydrologic drainage basin and its corresponding wetland storage area was evaluated to determine the maximum volume it could contain and to estimate both the historic and existing hydroperiods of the main wetland habitat at the bottom of each cell basin. Although many of the wetlands historically had wet-season loading depths as deep as 18 to 24 in., existing ditches cut to drain the property for lumbering practices rendered many of the wetland systems unable to retain any appreciable standing water. In effect, much of the existing hydroperiod loading depths were 0 to <6 in. Even with the improved hydraulic loading of the cells from the reuse discharge and with proposed improvements to cells to make containment berms, some of the cells' proposed loading depths would still be less than their historic ranges. Still, the new loading rates were a significant increase in surface water addition, and significant hydrological restoration was expected in each cell.

Each wetland cell needed to control the applied reuse effluent to maximize storage capacity for the WWTF while attempting to restore the hydroperiods of the wetlands. In

Left: Some wetland cells in the conservation park needed raised containment berms with outfall control structures to control water flow. Right: Flow control boxes, along with gates and intake structures, were built to spread water into wetland cells without causing erosion.

most cases, the existing basins had topographic boundary lines that would contain the surface storage. Select areas needed raised control berms to control the flow of water within the cells (see the left-hand photograph on this page).

Modeling surface water storage routings of the rainfall hydrographs for various storm events ensured that the City of Panama City Beach understood the risks of overtopping a containment berm. Erosion protection at key emergency overflow discharge points was provided in these areas.

The containment berm modifications inadvertently caused some wetland loss, which had to be mitigated. Wetland creation to offset the losses was thus required, since the developer that made the lands available to the city preferred to retain all conservation rights that might be needed for future development impacts. The benefit of restoration and/or enhancement of more than 2,000 acres of hydrologically altered wetlands far exceeds the necessary loss of a few acres of wetlands to make the berms. After proper stabilization, the tops of the berms were used for public recreation by expanding bike trails and hiking paths around the perimeters of the receiving cells, allowing the conservation park to provide wildlife viewing. The transmission line connects to the headworks of the wetland receiving system at the control building and water distribution center. The front of the facility is an aesthetically pleasing public building, with a trail for recreational use and public restrooms by the public parking lot. The back half of the building contains the controls and piping for the reuse water distribution system and the space needed for operations and maintenance, including the dechlorination system and generator.

The control center's automated pumps convey water to one of four polishing cells. To spread water into the cells without causing erosion, a combination of flow control boxes with gates and intake structures was constructed, including the necessary means of dissipating the outflow water velocity into the spreader swales at each cell location, as shown in the right-hand photograph on this page.

A plan was developed to take advantage of the available hydrologically altered wetland areas that rotated the effluent application schedule to simulate the wet and dry seasons in each polishing cell.

OPERATION AND MAINTENANCE

During the period that the lands were primarily used for silviculture, a significant amount of native longleaf pines were grown and harvested in the area. Fast-growing slash pines were densely planted in replacement of upland and wetland habitat. Several prudent ecological activities were incorporated into the project: tree harvesting, invasive plant thinning, native tree and wiregrass seedling planting, and prescribed burning.

The site's usable mesic uplands originally contained longleaf pines; after these were harvested, the partially drained wetlands were often replanted with fast-growing slash pines at densities that in some cases restricted or eliminated sunlight from reaching potential groundcover species. The densely packed pine trees also eliminated the natural habitat's diversity. Selective tree thinning performed in these areas promotes more natural community distribution and sunlight penetration, allowing the development of subcanopy species and herbaceous plants. In addition, slash pine areas within the park were harvested to generate revenue for Panama City Beach.

Along with tree thinning and harvesting, a prescribed burning regimen was introduced to remove excessive buildup of organic detritus that can lead to devastating fires. Restoring periodic fires to the plant community has promoted growth of native wiregrass and longleaf pine communities that depend on fire to stimulate germination, has provided additional sunlight through the canopy, and has opened serotinous pine cones for seed dispersal. With the modified uplands now thinned and/or burned, the city planted wiregrass and longleaf pine in the upland buffer areas to facilitate long-term restoration of the areas that rim many of the receiving wetland cells.

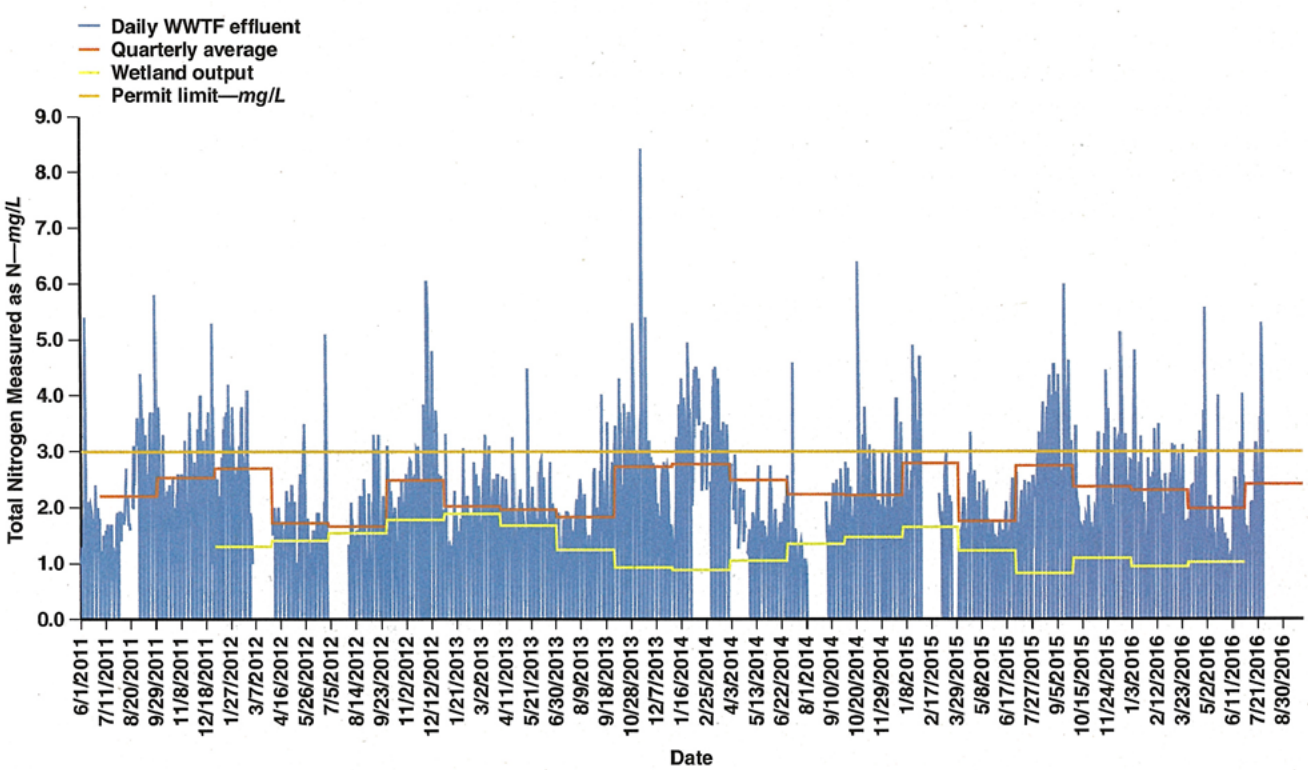
> With the conservation park fully implemented, Panama City Beach's wastewater treatment facility no longer discharges wastewater effluent into the West Bay of Saint Andrews Bay.

RESULTS

With the conservation park fully implemented, Panama City Beach's WWTF no longer discharges wastewater effluent into the West Bay of Saint Andrews Bay. The city now reuses 100% of its treated effluent and can accommodate future growth. Nutrient concentrations have been tracked in the effluent leaving the WWTF and at the discharge point from the conservation park outfall for more than five years; these concentrations show that nutrient levels following the polishing within the receiving wetlands are 25 to 50% below those observed in the WWTF effluent.

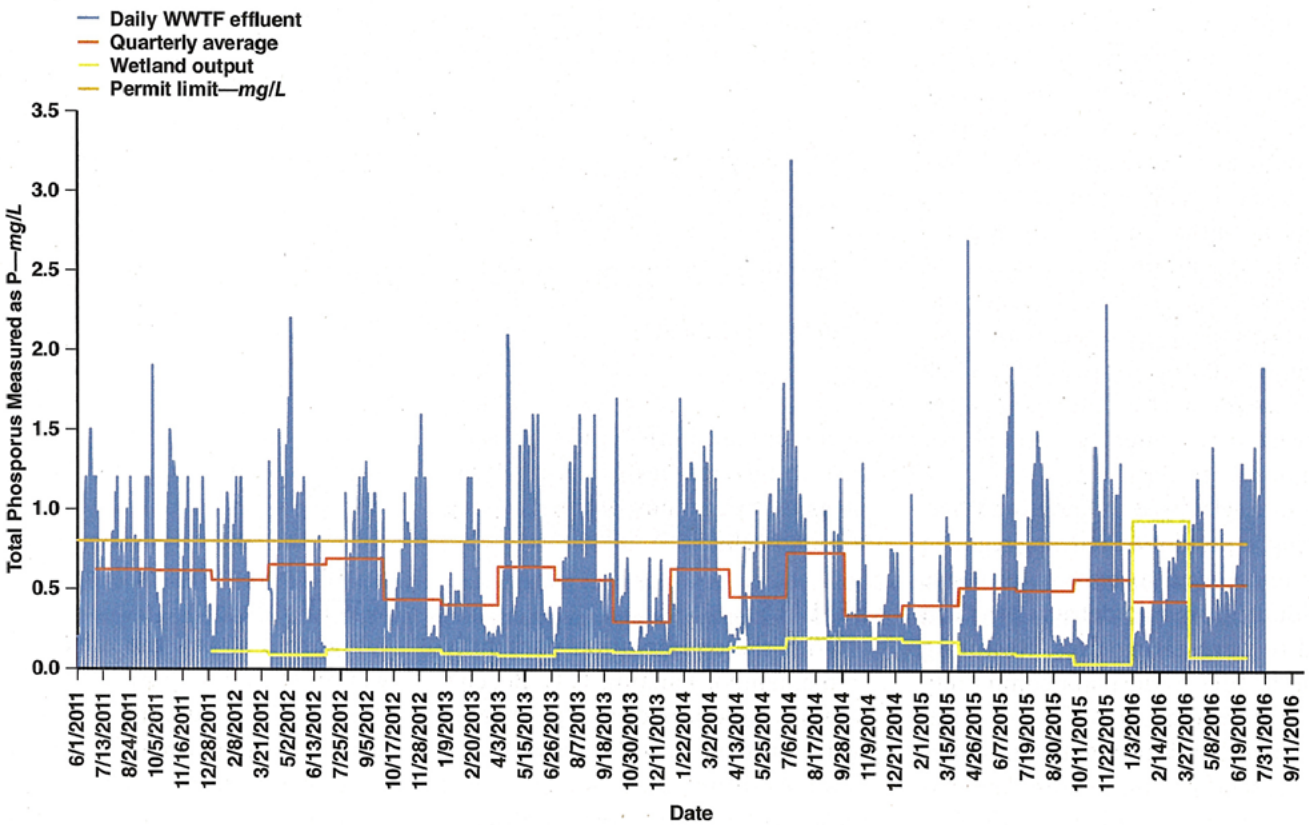
Figure 3 shows the effect of the wetlands by comparing the TN in the WWTF effluent with the TN leaving the final polishing cell in the conservation park, where the maximum permitted TN from the WWTF

FIGURE 3 Comparison of total nitrogen leaving the WWTF and total nitrogen leaving the conservation park



WWTF—wastewater treatment facility

FIGURE 4 Comparison of total phosphorus leaving the WWTF and total phosphorus leaving the conservation park



WWTF—wastewater treatment facility

is 3.0 mg/L. Likewise, Figure 4 compares the TP discharged from the WWTF and leaving the conservation park, where the permitted limit on TP is 0.8 mg/L. Although any particular day may have exceeded the WWTF discharge limit, the average TN leaving the plant on a monthly and quarterly basis was always within permitted limits; only once has the TP exceeded the limit on a quarterly basis.

Mitigation of the incidental impacts on wetlands to create berms included ongoing monitoring using the uniform mitigation assessment method (UMAM) to verify that the mitigation is providing the required ecological lift. Monitoring as part of the operational period resulted in improved UMAM scores in the required areas.

During this project's 10 years of planning and design, over 20 briefings were provided to the city council at public meetings, and more than 10 public meetings and presentations were given to conservation groups and regulatory agencies. During construction, since the opening of the park, the city has documented the site's historic use as a turpentine farm and celebrated the site's impact as a regional conservation area. As a result of the creation of Panama City Beach's conservation park, the city has created over 25 mi of multi-purpose bike and hiking trails, including two publically accessible trails. The conservation park has been a great success and has become a destination for bird watchers and outdoor enthusiasts.

As a result of the creation of Panama City Beach's conservation park, the city has created over 25 mi of multi-purpose bike and hiking trails, including two publically accessible trails.

ABOUT THE AUTHORS

*Since 1992, **William D. Musser** has been a vice-president with Tetra Tech, 201 E. Pine St., Ste. 1000, Orlando, FL 32801 USA; william.musser@tetratech.com. He is a professional engineer, professional hydrologist, and professional wetland scientist. He has been*