Paynes Prairie Sheetflow Restoration Project: Navigating Numeric Nutrient Criteria Without Getting Stranded Up the Creek

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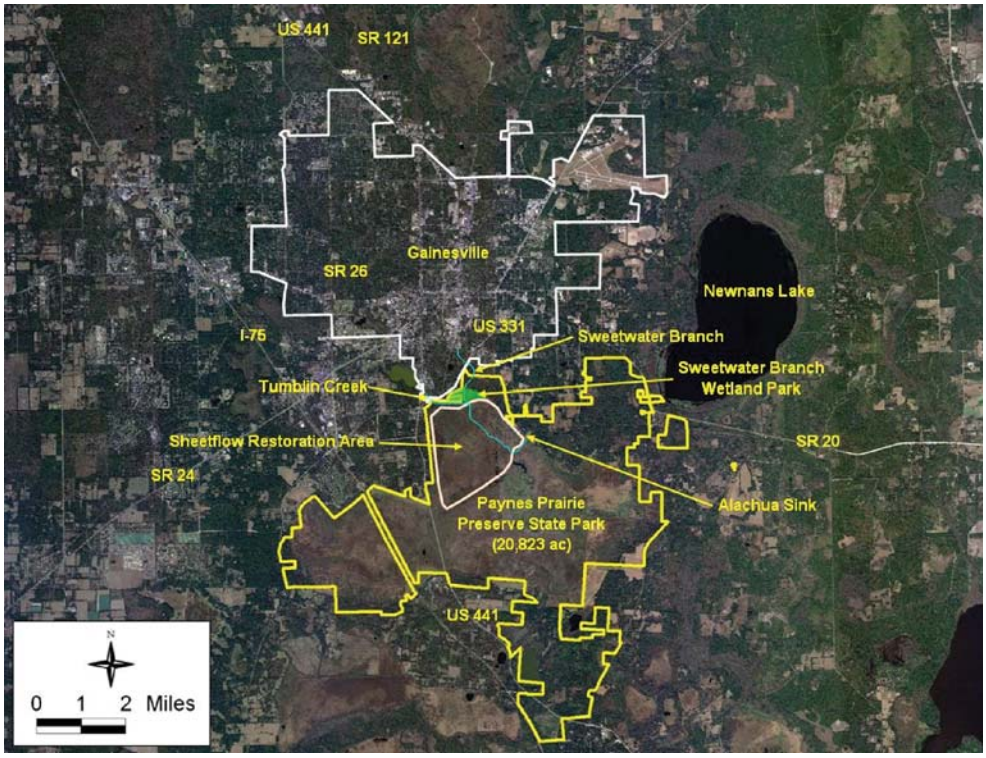

Figure 1. Project Location

The Paynes Prairie Sheetflow Restoration Project is located at the southern tip of Gainesville, adjacent to the Paynes Prairie Preserve State Park, which received an Outstanding Florida Water designation (Figure 1). The primary motivation for the project was to comply with nutrient reduction requirements established by a Total Maximum Daily Load (TMDL) for Alachua Sink, a 14-acre lake located within the state park. Alachua Sink was listed on Florida's verified list as being impaired for total nitrogen (TN) and Chlorophyll *a* under Florida's Impaired Waters Rule in 2002. A nutrient TMDL, designed to restore the designated use of the lake, was approved in 2006.

Figure 2 provides a closer view of the Alachua Sink watershed and the project area prior to construction of the project. Alachua Sink is drained by a sinkhole that connects to the Floridan aquifer. The watershed for Alachua Sink encompasses a broad area that includes Newnans Lake, wetlands within the state park, and Sweetwater Branch. In addition to the nutrient enrichment in Alachua Sink, there are several historical sources of human-induced stress to Sweetwater Branch and Paynes Prairie. Like many urban streams, Sweetwater Branch has been highly physically altered (channelized and incised). Additionally, the system receives significant stormwater flows originating from urban development constructed before modern stormwater regulations. The Gainesville Regional Utilities (GRU) Main Street Water Reclamation Facility (MSWRF) also discharges into Sweetwater Branch.

In its natural state, Sweetwater Branch flowed onto Paynes Prairie in a sheetflow pattern, which hydrated wetlands on the prairie. The natural sheetflow pattern onto the prairie had been disrupted by a manmade channel, constructed in the 1930s, which bypassed the natural wetlands and routed the flow directly to Alachua Sink (see Figure 2). Channelization resulted in dehydration of 1,300 acres of wetlands on the prairie and created a direct conduit for nutrients and other substances to be carried into Alachua Sink, which flows to the Floridan aquifer. Additionally, large amounts of trash and sediment carried by Sweetwater Branch were being deposited on the prairie.

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Total Maximum Daily Load Development

Sources of nitrogen to Alachua Sink identified through the TMDL process included the MSWRF discharge, urban stormwater runoff, septic tank discharges, and flow from Newnans Lake (Table 1). Newnans Lake is a hypereutrophic upstream waterbody that flows into wetlands in the state park, which ultimately flows into Alachua Sink.

The TMDL requires GRU to reduce nitrogen loads from the MSWRF by 55 percent and the municipal separate storm sewer system (MS4) to reduce nitrogen loads by 45 percent. The City of Gainesville, Florida Department of Transportation (FDOT) facilities, and Alachua County collectively own and maintain the MS4.

The Florida Department of Environmental

Protection (FDEP) assembled a basin management action plan (BMAP) working group to address the Alachua Sink TMDL, as well as other TMDLs in the Orange Creek Basin. Stakeholders included several municipalities, government agencies, agricultural representatives, environmental groups, and citizens.

After evaluating several different alternatives and having multiple discussions with the BMAP group, the restoration project was identified as the most cost-effective approach for meeting the TMDL requirements for both GRU and the city's stormwater utility. The primary project partners include GRU (owned by the City of Gainesville), Gainesville Public Works Department, St. Johns River Water Management District (SJRWMD), FDOT, FDEP Division of Recreation and Parks, FDEP Division of Water Resource Management, Alachua County, and Florida Fish and Wildlife Conservation Commission. Extensive discussions among the entire BMAP group resulted in unanimous support for the project. This partnership, combined with extensive public outreach, has resulted in broad support for the project in the community, as well as at the state and national levels, which is particularly important given the complexity of the project.

The project will meet TMDL requirements for Alachua Sink for the MSWRF and the MS4. However, in addition to improving water quality, the project provides a comprehensive approach for addressing several environmental problems resulting from previous anthropogenic activities in the watershed.

Project Description

The conceptual plan for the project is shown in Figures 3 and 4. The project includes multiple components to reduce nitrogen concentrations to background levels in order meet the TMDL. The primary project components are as follows:

1. *Main Street Water Reclamation Facility Enhancement*

   The MSWRF is rated at 7.5 mil gal per day (mgd) and includes activated sludge treatment, tertiary filtration, and disinfection. The plant was not specifically designed for nutrient removal; however, GRU has operated the plant to optimize nitrogen removal and will continue to do so as part of this project. The plant was also upgraded to achieve phosphorus removal via alum addition. Although the TMDL did not require reductions in phosphorus, it was necessary to reduce phosphorus concentrations in the MSWRF discharge to achieve the desired water quality for discharge onto Paynes Prairie. The plant achieves

Continued on page 24

Figure 2. Project Area Showing the Manmade Sweetwater Branch Canal

Table 1. Summary of Estimated Total Nitrogen (TN) Loads

Source	TN Reduction (percent)	TN Reduction (lb/year)
MSWRF	55 percent	48,000
Stormwater	45 percent	13,000
Other Sources	45 percent	145,000

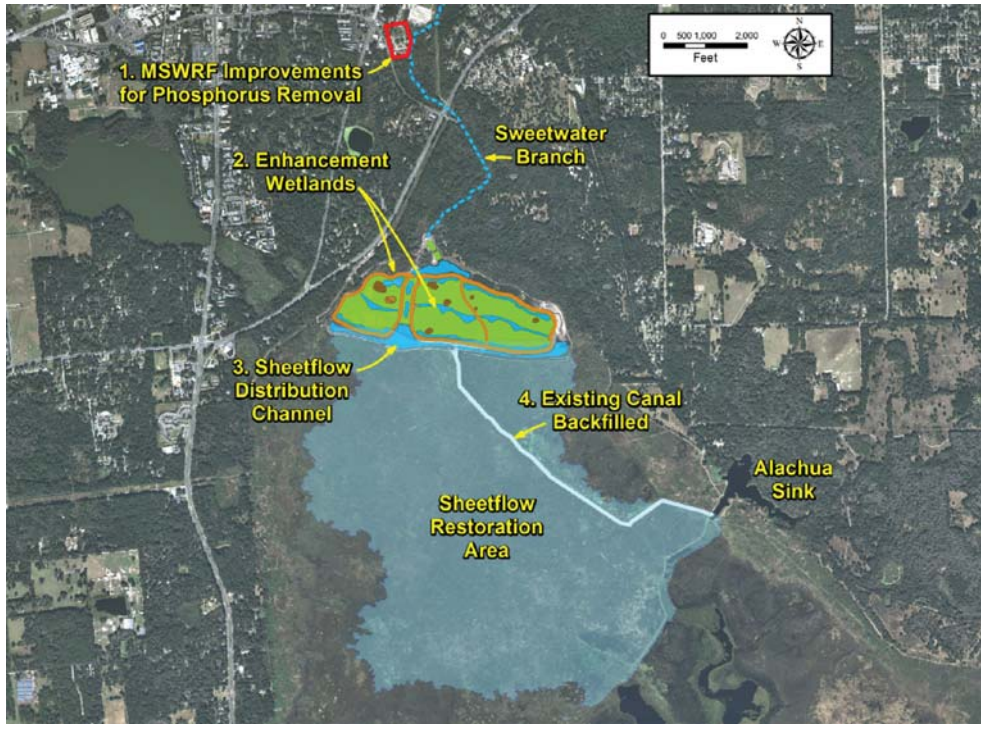

Figure 3. Paynes Prairie Sheetflow Restoration Project Conceptual Plan

Continued from page 23

average effluent TN of 8 mg/l or less and can achieve total phosphorus (TP) as low as 0.3 mg/l discharging into Sweetwater Branch.

2. Enhancement Wetland

All of the flow from Sweetwater Branch has been diverted to the inlet of a 125-acre enhancement wetland. Figure 4 shows the conceptual plan for the enhancement wetland in more detail. The inlet structure includes a sediment removal basin, trash rack, and forebay. Under nonstorm flow conditions, the flow is distributed into the wetland treatment cells, which flow into the distribution channel. To protect the wetland cells from damage during storm events, excess flow is diverted through bypass channels that flow directly into the sheetflow distribution channel. The wetland is designed to achieve average TN levels of 3 mg/l or less and TP levels of 0.3 mg/l or less.

3. Sheetflow Distribution Channel

The sheetflow distribution channel receives the flow from the wetland treatment cells. The distribution channel discharges onto the prairie via sheetflow, reestablishing the natural flow pattern in the Sheetflow Restoration Area (Figure 3). Nutrients in the water from the distribution channel are further reduced through the natural wetland processes in the prairie to reach background TN levels of approximately 1.4 mg/l, achieving the TMDL requirements before the water eventually reaches Alachua Sink.

5. Backfilling and Removal of the Existing 10,000-ft Channel

In conjunction with the construction of the sheetflow distribution channel, the existing manmade channel has been backfilled to reestablish the natural sheetflow pattern.

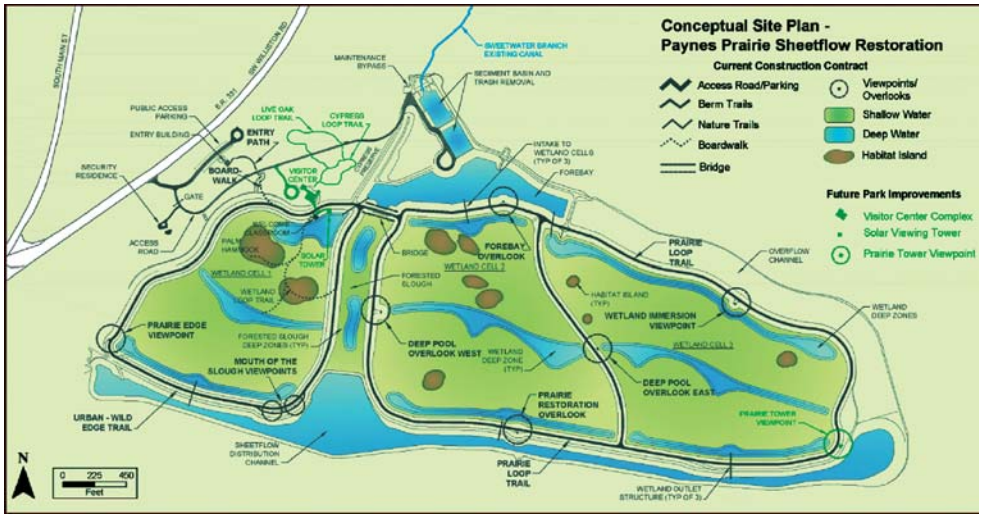

Figure 4. Enhancement Wetland Conceptual Design

Figure 5. Aerial Photo of Paynes Prairie Sheetflow Restoration Project: October 2015

Figure 5 is a photograph of the project, which was completed in September 2015 at a total project cost of $27.6 million. The project has the following benefits:

- Meets regulatory TMDL requirements for GRU, the City of Gainesville, and FDOT.
- Rehydrates over 1,300 acres of formerly impacted wetlands in Paynes Prairie.
- Intercepts and removes sediment, trash, and other pollutants that were previously carried onto the prairie by Sweetwater Branch, thereby protecting the prairie, Alachua Sink, and the Floridan aquifer.
- Creates high-quality wetland wildlife habitat and a public park.
- Restores part of the overall water balance to Paynes Prairie, which has been impacted by the channelization of Sweetwater Branch and diversion of water from the prairie at other locations.

As shown in Figure 4, the enhancement wetland provides a public park with approximately 3.5 mi of nature trails and boardwalks with numerous overlooks, and will ultimately provide a visitor center and other public facilities.

Numeric Nutrient Criteria Compliance Strategy

The project plan was developed prior to the enactment of the FDEP Numeric Nutrient Criteria (NNC) rule. Although it was known that NNC requirements would need to be addressed, the exact regulatory mechanism was not known. Therefore, GRU collected data to support site-specific criteria during the project design and construction period.

The Alachua Sink TMDL was adopted by FDEP and approved by the U.S. Environmental Protection Agency (EPA) as the NNC site-specific interpretation for Alachua Sink. Although the original TMDL did not specify a phosphorus limit, the site-specific interpretation set the phosphorus limit at the historical average so as to prevent an increase in phosphorus concentrations in the sink. As the project meets the TMDL, it will also meet the site-

specific NNC interpretation for Alachua Sink.

Meeting NNC requirements for Sweetwater Branch is more complex. As described, MSWRF will discharge an average TN of 8 mg/l. The MSWRF has the capability to produce effluent TP levels of 0.3 mg/l or less; however, in order to minimize chemical costs, the plant may be operated with effluent TP levels slightly higher than this with the downstream enhancement wetland providing additional polishing to produce TP levels of 0.3 mg/l discharging to the prairie. During nonstorm conditions, the MSWRF flow comprises about 80 percent of the flow in the 1.1-mi section of Sweetwater Branch between MSWRF and the enhancement wetland. Therefore, instream concentrations will be similar to those in the MSWRF effluent. The applicable instream threshold criteria for TN and TP for the north central Florida region are 1.87 mg/l and 0.3 mg/l, respectively. Therefore, the threshold interpretations will not be met for TN and TP, and site-specific criteria will be required.

Sweetwater Branch fails the Stream Condition Index (SCI), which is an invertebrate-based biological health assessment. A Stressor Identification Study, following EPA protocols, determined that habitat alteration, hydrologic modification, and sediment movement/smothering were the proximal causes for the failures. Sweetwater Branch does not suffer from excessive algae or periphyton growth and fully complies with the floral measures required by NNC. Therefore, it was concluded that nutrients were not a stressor associated with the degraded faunal community. Computer modeling, using QUAL2K, a one-dimensional water quality model, demonstrated that characteristics of Sweetwater Branch, including short water residence time and low light availability (from an extensive tree canopy), precluded the expression of nutrient enrichment within the 1.1-mi segment between the MSWRF and the enhancement wetlands. Because this portion of Sweetwater Branch is not expected to be affected by nutrients, it was appropriate to develop a site-specific interpretation of the narrative nutrient criterion for the segment.

Four alternatives were considered for complying with NNC for Sweetwater Branch:

- Construction of a pipeline to bypass Sweetwater Branch to meet threshold criteria.
- Exercising the water conveyance ("ditch") exception from stream NNC.
- Reclassification as a Class III Limited Waterbody.
- Level II Water Quality-Based Effluent Limitations (WQBEL).

Pipeline Construction

A pipeline could be constructed to divert the MSWRF discharge directly to the enhancement wetland, thus bypassing the 1.1-mi stretch of Sweetwater Branch. This would cost $8 million and would have no environmental benefit; thus, it represents the worst case if no regulatory relief could be obtained.

Exception from Stream Numeric Nutrient Criteria

Under the FDEP NNC rule (62-302.200), the threshold interpretations do not apply to ditches, canals, and other conveyances that are manmade or predominantly physically altered if they are (1) primarily used for water management purposes, and (2) have marginal or poor stream habitat or habitat components. The narrative criterion continues to apply to water conveyances and the section of Sweetwater Branch downstream of MSWRF if highly physically altered. The FDEP determines the habitat quality based on the FDEP habitat assessment method (FDEP SOP FT 3000). Although the instream habitat in Sweetwater Branch is very poor, the presence of a riparian forest buffer zone and tree

Continued on page 26

Continued from page 25

canopy were sufficient to elevate the habitat scores above the minimum required to meet the "ditch" exception. Therefore, the stream could not be excluded from the numeric threshold criteria based on the habitat assessment.

Reclassification

Reclassification of Sweetwater Branch to a Class III Limited Waterbody in conjunction with development of site-specific criteria for nutrients was considered. The Class III designation recognizes that physical alterations to a waterbody creates conditions that would not support all of the attributes of a Class III waterbody, and provides an alternate designated use target (support and maintenance of a limited biological community). This approach offers the advantage that the site-specific criteria would essentially be permanent, barring extensive physical restoration of the creek, which due to the extreme expense, would be unlikely.

The Class III designation would be reasonable for the stream since it is highly altered and it would not be feasible to return the 1.1-mi section of it to natural or near-natural conditions. The stream runs through highly urbanized areas of Gainesville, and consequently, Sweetwater Branch had been channelized for flood control purposes long before modern water quality or stormwater regulations. Full restoration of the creek would necessitate removal of large areas of urban development, cause flooding, and be prohibitively expensive. Despite this, based on discussions with members of the community, it was clear that there was a lack of local support for the reclassification approach, and the next alternative was considered.

Level II Water Quality-Based Effluent Limitations

Development of a Level II WQBEL was selected as the preferred approach for complying with the requirements of NNC. The Level II WQBEL may be re-evaluated with permit renewals and could be modified if appropriate. While this periodic re-evaluation places some potential monetary risk associated with the approach, it was more palatable to the community as it allows the opportunity for a physical restoration of the creek if funds become available in the future.

Level II Water Quality-Based Effluent Limitations Approach

The Level II WQBEL essentially requires two major demonstrations:

- Demonstration that the current and historic nutrient discharge is not the cause of the current impairment.
- Determination of limits that are appropriate to ensure that future discharges will not cause or contribute to impairment.

The cause of the impairment is demonstrated through a Stressor Identification Study (EPA, 2014) using historical and current data. The allowable nutrient limits are demonstrated through computer modeling. A study plan for the WQBEL was developed and approved by FDEP and is described.

Stressor Identification Study

To conduct a Stressor Identification Study, EPA developed a Causal Analysis/Diagnosis Decision Information System (CADDIS), which consists of a five-step process:

Step 1: Define the Case

Does biological health significantly differ when comparing data upstream and downstream from a discharge containing nutrients (e.g., in this case, the MSWRF), or are other physical factors influencing the system's biological response?

Step 2: List Candidate Causes

In Sweetwater Branch, targeted factors included water quality (especially nutrients and specific conductance), physical alteration (channelization and habitat), hydrologic modifications (impervious surfaces coupled with channelization), and landscape development factors.

Step 3: Evaluate Data from the Case.

These data were evaluated using the CADDIS guidelines.

Step 4: Evaluate Data from Elsewhere

Data from other systems were evaluated in conjunction with information from Sweetwater Branch.

Step 5: Identify Probable Causes

The Stressor Identification Study concluded that habitat alteration, hydrologic modifications, and sediment movement/smothering were the proximal causes for the SCI failures in Sweetwater Branch. Because floral communities were healthy, nutrients were not a stressor.

Modeling

The QUAL2K model, which is a public-domain, nonproprietary model, was used to assess instream water quality and floral impacts in Sweetwater Branch resulting from permitted flows and the design nutrient loadings from the MSWRF and other nutrient sources to the creek. By using the model to assess against a worst-case condition, GRU provided reasonable assurance that excess algae or periphyton would not occur and that water quality standards will be met in Sweetwater Branch.

Summary and Conclusions

The Paynes Prairie Sheetflow Restoration Project provides an integrated, collaborative, community-based approach to cost-effectively meet regulatory nutrient reduction requirements for multiple sources. The project integrates the construction of manmade treatment facilities with natural systems and includes multiple elements that act in concert to achieve the multiple goals of improving water quality, restoring natural systems, and protecting the Floridan aquifer.

An integral part of the project was the ability to obtain site-specific nutrient criteria for Sweetwater Branch that are protective of the creek and attainable with the project. Although the FDEP NNC rule became effective in October 2014, GRU collected biological and water quality data throughout the project conceptualization, design, and construction processes in anticipation of seeking site-specific nutrient criteria for Sweetwater Branch.

Several mechanisms were considered for seeking site-specific criteria before selecting the WQBEL approach. A study plan for obtaining the WQBEL was approved by FDEP, and the study is now nearly complete. The plan integrated the existing data and involved the collection of some additional data to demonstrate the appropriateness of the WQBEL. The approach included a Stressor Identification Study, which determined that nutrients are not causing adverse effects to the creek's flora or fauna. Computer modeling of future conditions were conducted to set appropriate nutrient criteria for Sweetwater Branch and discharge limits for the MSWRF.

References

- U.S. Environmental Protection Agency, 2014. Causal Analysis/Diagnosis Decision Information System (CADDIS) website http://www.epa.gov/caddis/index.html.
- Gao, X.; D. Gilbert; and W. Magley (2006). TMDL Report: Nutrient TMDL for Alachua Sink, WBID 2720A. Florida Department of Environmental Protection, Division of Water Resource Management, Bureau of Watershed Management. Tallahassee, Fla.
- White, L.D. (1975). Ecosystem Analysis of Paynes Prairie for Discerning Optimum Resource Use. University of Florida School of Forest Resources and Conservation Research Report No. 24. Gainesville, Fla.
- QUAL2K model: http://www.epa.gov/athens/wwqtsc/html/qual2k.html.