Providing Minimum Flows to the Lower Hillsborough River and Sulphur Springs Run While Minimizing Impacts to Tampa's Potable Water Supply

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The Southwest Florida Water Management District (District or SWFWMD) is directed by Florida Statutes to establish minimum flows and levels (MFLs) for water resources within its service area boundaries. The minimum flow for a surface watercourse is defined as "the limit at which further withdrawals would be significantly harmful to water resources or ecology of an area." The District has established a minimum flow for two City of Tampa water bodies, including the Lower Hillsborough River and Sulphur Springs Run.

Established Minimum Flows

Lower Hillsborough River

The Lower Hillsborough River is tidally influenced and extends approximately 9.9 river mi from the Hillsborough River Dam to Tampa Bay. The Hillsborough River Dam separates the Lower Hillsborough River from the Hillsborough River Reservoir (Figure 1). Municipal water supply withdrawals from the Hillsborough River Reservoir result in near-zero freshwater flow to the Lower Hillsborough River for approximately half of each year (Figure 2).

Salinity values near the base of the Hillsborough River Dam can be as high as 10-13 practical salinity units (psu) during periods of no reservoir discharge. This negatively affects fish and wildlife that use tidal freshwater and low salinity habitats. As a result, the creation of a dry season <5 psu salinity zone downstream of the Hillsborough River Dam was chosen as the principal ecological criterion for establishing the Lower Hillsborough River minimum flows of 20 cubic ft per second (cfs), with an increase to 24 cfs during April through June.

Sulphur Springs Run

Sulphur Springs is an artesian spring that discharges to the Lower Hillsborough River via Sulphur Springs Run approximately 2.2 mi downstream of the Hillsborough River Dam (Figure 3). Sulphur Springs provides flows of low-salinity water that support downstream biological communities in Sulphur Springs Run and the Lower Hillsborough River. Sulphur Springs management goals were established (Figure 4) and resulted in a Sulphur Springs Run minimum flow between 10 and 18 cfs, depending on manatee thermal refuge temperatures, tidal water levels in the Lower Hillsborough River, and the extent of salinity incursions from the Lower Hillsborough River into Sulphur Springs Run.

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Figure 1. The Hillsborough River Dam impounds freshwater for the City of Tampa's water supply.

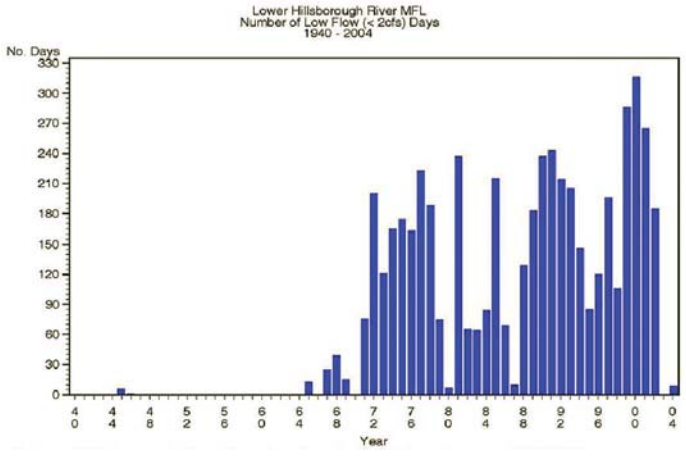

Figure 2. The City of Tampa's potable water supply needs have resulted in a significant reduction of freshwater flow into the Lower Hillsborough River.

Figure 3. Sulphur Springs Run connects Sulphur Springs with the Lower Hillsborough River. The spring water contributes to decreasing Lower Hillsborough River salinity.

Sulphur Springs Management Goals

- Minimize the incursion of brackish water from the Lower Hillsborough River into Sulphur Springs Run
- Maintain low salinity habitats in the Lower Hillsborough River
- Maintain a thermal refuge for manatees in the Lower Hillsborough River

Figure 4. Management goals provided the framework to establish a Sulphur Springs Run minimum flow.

Lower Hillsborough River Recovery Strategy

A recovery strategy has been adopted for the Lower Hillsborough River since its flow is periodically less than the established minimum flow. Rather than releasing reservoir water stored for potable water supply, the Lower Hillsborough River recovery strategy consists of diverting flows from Sulphur Springs, the Tampa Bypass Canal (TBC), Blue Sink, and Morris Bridge Sink to the base of the Hillsborough River Dam. The recovery strategy also includes a study to determine if the identified sources are sufficient to comply with the minimum flows. The City of Tampa implemented projects that are projected to cost $21.4 million, with 50 percent cooperative cost-sharing funded by the District (Table 1).

The recovery strategy establishes the order that the resources are to be utilized to comply with the minimum flow rules. The priority order (listed in decreasing priority) for the Lower Hillsborough River is as follows:

1. Sulphur Springs*
2. Blue Sink
3. Morris Bridge Sink**
4. Raw Water Transmission Pipeline/TBC Diversions**

* Provided 1) Sulphur Springs minimum flow compliance is first achieved and 2) No public health and safety concerns exist due to decreasing the potable water supply available from Sulphur Springs.

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Project	Flow (cfs)	Cost ($)	Cost/Flow ($/cfs)/1000	Lead Party	Status
Sulphur Springs Lower Wier	3	$395k	132	City of Tampa	Complete
Sulphur Springs Pumping Station	18	$5.3 M	294	City of Tampa	Complete
Blue Sink Diversion Project	3	$10.9 M	3,633	City of Tampa	In Design
TBC Raw Water Transmission Main & Pump Stations	11	$26 M	2,364 vs. 104,000	City of Tampa	Cancelled
TBC Diversions (Temporary)	11	-	-	SWFWMD	Complete
TBC Diversions (Permanent)	11	$4.8 M	436	City of Tampa & SWFWMD	In Design
Morris Bridge Sink Project	6	$1.6M	267	SWFWMD	In Design

Table 1. Multiple water sources are planned to be utilized for Lower Hillsborough River minimum flow purposes.

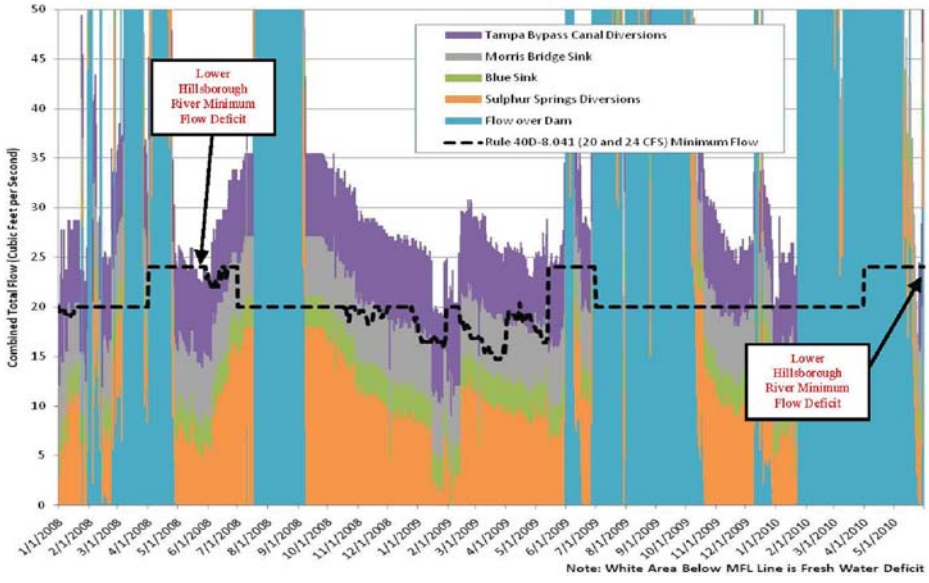

Figure 5. Water resource study results project the identified recovery strategy project will provide sufficient source capacity to comply with the Lower Hillsborough River and Sulphur Springs minimum flows.

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** Diversions from Morris Bridge Sink and the TBC are prioritized based on TBC water levels.

The cumulative flow from these resources and the minimum flow requirements were compared to determine if a deficit existed. It has been determined that the identified water sources are sufficient to meet the requirements nearly 100 percent of the time (Figure 5). The development of these sources has also been found to be conceptually feasible; however, the implementation of each project will be subject to an assessment of potential impacts and the approval of required permits.

Sulphur Springs

Sulphur Springs is a second-magnitude artesian spring that discharges to the Lower Hillsborough River approximately 2.2 mi downstream of the Hillsborough River Dam. This discharge occurs via a short spring run named "Sulphur Springs Run." The spring pool has been enclosed by a circular concrete wall since the early 1900s when the site was developed as a recreational swimming facility. The site remains within the boundaries of a municipally owned park; however, swimming in Sulphur Springs and Sulphur Springs Run is no longer permitted. The City of Tampa owns and operates this site and utilizes the resource to supplement the Hillsborough River Reservoir via a pump station and pipeline.

The pre-existing Sulphur Springs Pump Station utilized a single fixed speed pump. The station was constructed in the 1960s and was designed to supplement the City of Tampa's potable water supply by pumping Sulphur Springs flow to the Hillsborough River Reservoir.

Piping has since been modified to concurrently allow spring water discharge below the Hillsborough River Dam for Lower Hillsborough River minimum flow purposes.

Lower Hillsborough River and Sulphur Springs Run minimum flow requirements could not be achieved using the 1960s pump station. These requirements included concurrently providing a variable amount of water to Sulphur Springs Run, the Lower Hillsborough River at the base of the Hillsborough River Dam, and the Hillsborough River Reservoir. Historical data indicated Sulphur Springs flow was sufficient for minimum flow requirements at spring pool levels below the Sulphur Springs Pool overflow weir; however, continuously operating in this manner would eliminate the aeration associated with spring water overflowing the weir and dropping approximately 7 ft into Sulphur Springs Run. The following features were included in the pump station modifications to comply with minimum flow requirements:

- The existing building was repurposed into an electrical room for the new pumping station. The finished building was aesthetically enhanced by a commissioned native wildlife mural on the building exterior (Figure 6) minimizing visual impacts to the adjacent recreational facility.
- Two new 350-horsepower (HP) variable speed pumps were installed capable of meeting the highly variable flow and head requirements. The achievable pumping rate is 3 to 44 cfs from each pump; one pump is normally dedicated for pumping to the Lower Hillsborough River discharge location, and the other pump is normally dedicated for pumping to Sulphur Springs Run. The need for pumping redundancy required that each pump be sized for the combined flows to Sulphur Springs Run, the Lower Hillsborough River, and the Hillsborough River Reservoir.
- The pre-existing Sulphur Springs pump station pumped water to the Hillsborough River Reservoir via a 30-in. pipeline. A new pipeline segment, meter, and electric-motor-actuated throttling valves were installed to divide this flow between the Hillsborough River Reservoir and the Lower Hillsborough River.
- The need for highly variable flow rates required that each venturi meter be equipped with dual transmitters for accurate metering.
- Operating Sulphur Springs Pool at a decreased water level (to increase spring flow) required lowering the pump station intake. This was accomplished by installing new high-density polyethylene piping conforming to the funnel-shaped spring bathymetry and anchoring this piping onto precast concrete panels cabled to the spring pool wall.
- The spring run discharge was accomplished with a nozzle-equipped discharge header (Figure 7). This effort improved Sulphur Springs Run aeration and provides an aesthetic feature for the adjacent park.
- Sulphur Springs Run minimum flow requirements continuously change based on tide level, water temperatures, and water salinity. These data are obtained in real time via links to gages operated and maintained by the United States Geological Survey. This assures that compliance data are collected through an independent third party.

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Figure 6. Sulphur Springs Pump Station building aesthetics were an important consideration because the facility is located within a municipal park.

Figure 7. The new Sulphur Springs Run discharge header provides sufficient aeration to support downstream fauna.

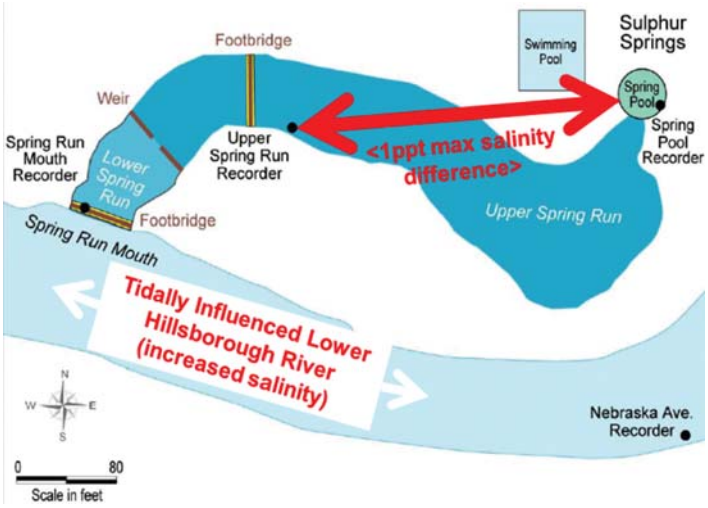

Figure 8. The Sulphur Springs Run minimum flow rule allows decreased spring run flow provided the salinity difference between the upper run and spring pool does not exceed 1 ppt for > 1 hour.

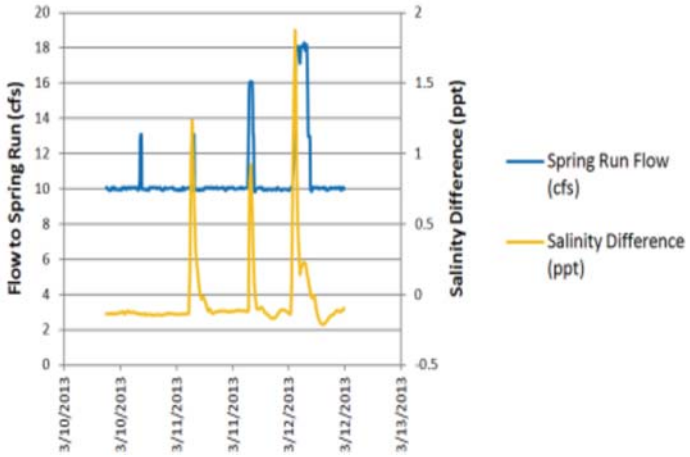

Figure 9. The new pump station automatically increases spring run flow when a salinity incursion is detected.

Figure 10. Sulphur Springs Run Lower Weir prior to rehabilitation (2009).

Figure 11. Rehabilitated Sulphur Springs Run Lower Weir (2011).

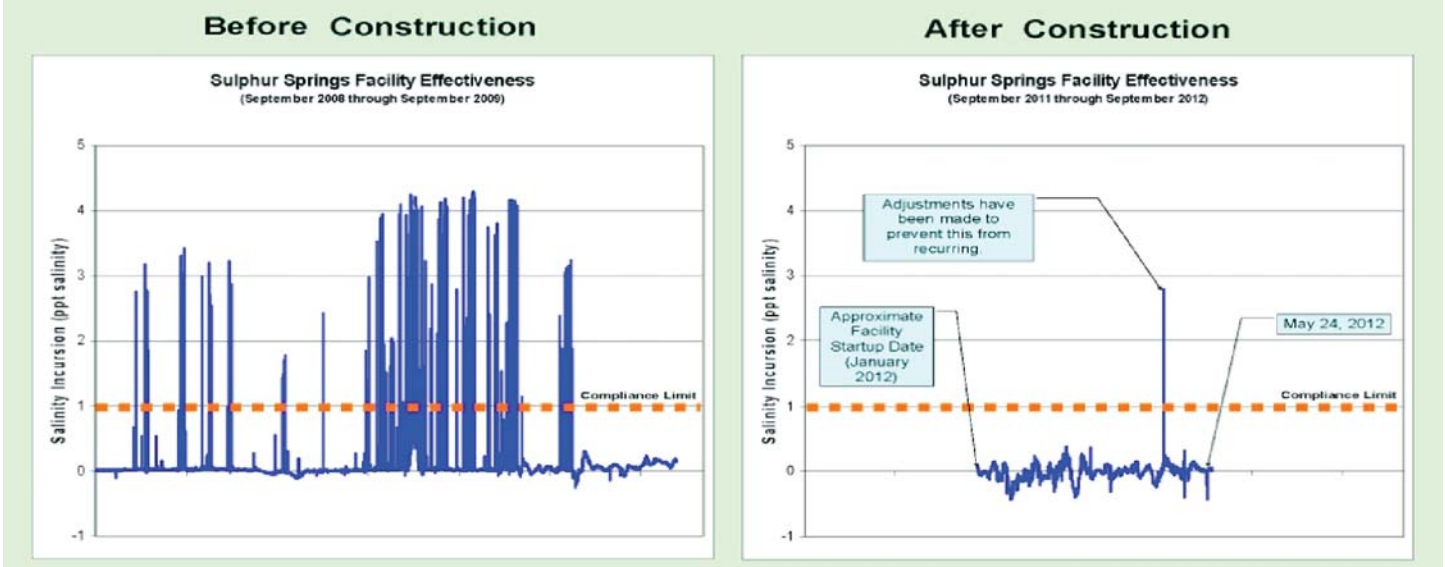

Figure 12. Preliminary performance results indicate significant success in meeting management goals for Sulphur Springs Run. Trend points (in blue) above the dashed red line indicate a time when the salinity management goals are not met.

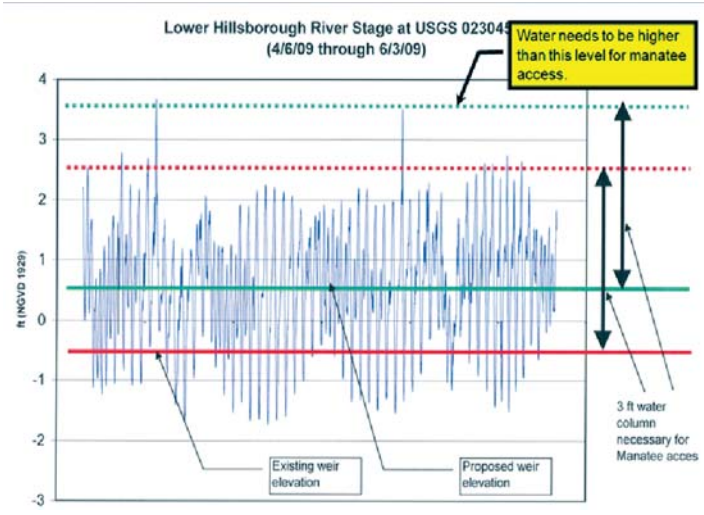

Figure 13. Lower Hillsborough River stage data suggest manatee access to the upper spring run is infrequent and for very limited durations.

Figure 14. The relatively shallow spring run has limited area accessible by manatees (red shaded area) at the median Lower Hillsborough River stage.

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- The new pump station was provided a bridge crane and monorail to an exterior loading dock, facilitating equipment maintenance.

Salinity Management Goal

One Sulphur Springs Run management goal is to minimize the incursion of brackish water from the Lower Hillsborough River into the upper spring run (Figure 8). This goal is considered to be achieved if the salinity difference between the spring pool conductivity gage and the upper spring run conductivity gage is >1parts per thousand (ppt) salinity for no more than 1 hour during each incursion. This goal has been achieved through a complex pump station automation scheme (Figure 9) and the rehabilitation of a weir dividing the lower spring run from the upper spring run.

The weir rehabilitation has been completed (Figures 10 and 11) and consists of stop log replacement, gantry hoist installation to aid in stop log operation, and an improved aluminum walkway with guardrails. Hydraulic modeling projects that the operation of this structure will allow a 3 cfs reduction to the Sulphur Springs Run minimum flow, while still meeting management goals. This flow is anticipated to be diverted to the Lower Hillsborough if ongoing performance tests continue to be successful (Figure 12).

Manatee Thermal Refuge Management Goal

Permitting the Sulphur Springs improvements involved efforts to ensure the endangered Florida manatee would not be impacted. Regulatory concerns concentrated on 1) not reducing the area accessible by manatees and 2) not reducing the thermal refuge area beneficial to manatees during cold weather periods. Figures 13 and 14 indicate that Sulphur Springs Run is relatively shallow and therefore does not permit manatee access at all Lower Hillsborough River tide levels, regardless if the weir structure is in place. In addition to the fact manatee access upstream of the structure is naturally limited, historical data indicate that a weir structure has been present in Sulphur Springs Run since 1906 or earlier (the structure is "grandfathered").

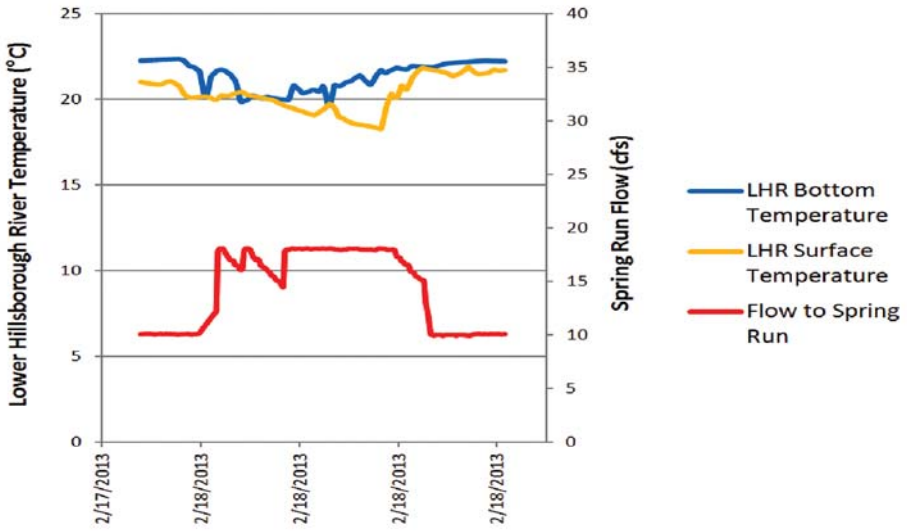

Figure 15. Pump station automation ensures an 18 cfs spring run flow when Lower Hillsborough River water temperatures are less than 20°C.

Thermal refuge concerns were investigated by modeling temperature changes in the Lower Hillsborough River immediately downstream of Sulphur Springs Run. Results indicate it is best to maintain a Sulphur Springs Run flow of 18 cfs when water temperatures in the manatee refuge zone are less than 20°C (Figure 15).

Minimizing Filamentous Algae Growth

Filamentous algae (Figure 16) grow in long visible chains, resulting in the formation of large mats. It is believed this growth occurs fastest in surface water bodies having low-flow velocities. This increased growth has been observed in Sulphur Springs Run when flow is reduced. The Sulphur Springs Pump

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Figure 16. Filamentous algae observed in Sulphur Springs Run.

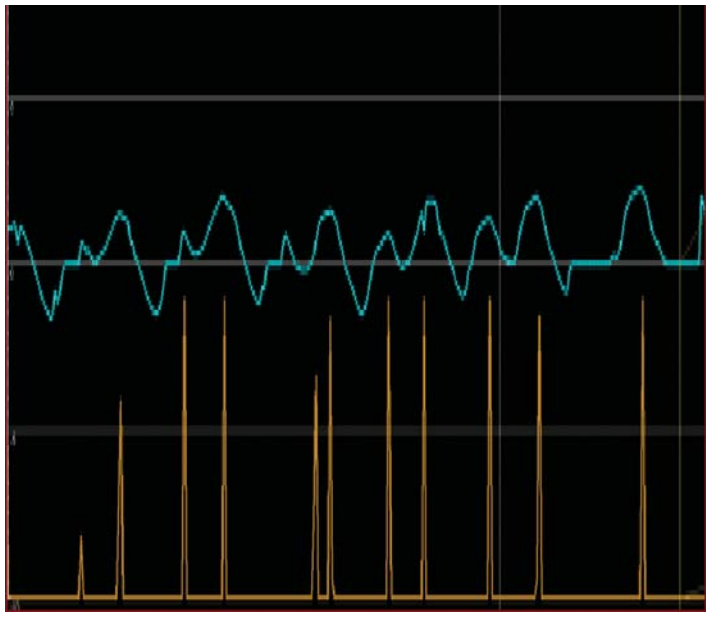

Figure 17. An algorithm was developed and shown to be accurate at predicting when high tide occurs. When a high tide is detected, spring run flow is increased to deter filamentous algae growth within Sulphur Springs Run.

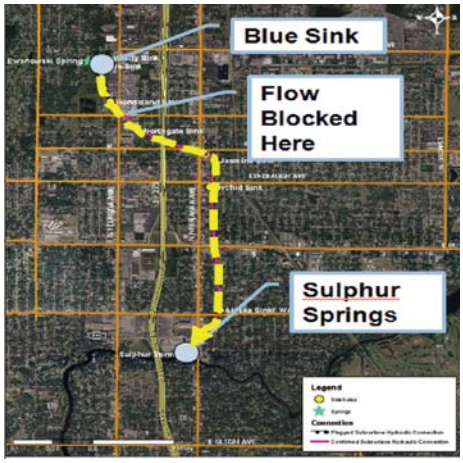

Figure 18. Historic flow path from Blue Sink to Lower Hillsborough River.

Figure 19. Proposed Blue Sink diversion facilities.

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Station therefore included automation to periodically increase Sulphur Springs Run flow velocity to deter filamentous algae growth. This is accomplished by increasing Sulphur Springs Run flow immediately after high tide, while the decreasing tide is concurrently drawing water out of the spring run (Figure 17).

Blue Sink

Blue Sink is a karst feature with standing water located approximately 2.8 mi from the Hillsborough River Dam. Pump tests, feasibility analyses, environmental permitting, a 90-percent pump station design, and a 100-percent transmission pipeline design have been completed to divert 3.1 cfs of water from Blue Sink for Lower Hillsborough River minimum flow purposes. Blue Sink Project construction is expected to begin in 2014.

Water in Blue Sink historically flowed below ground to the Lower Hillsborough River via discharge at Sulphur Springs. This flow path has since been blocked by a private construction project (Figure 18). Four alternatives, consisting of various combinations of pipeline, pump stations, and existing belowground flow channels were compared and ranked based on cost, regulatory requirements, wetland impacts, flood concerns, and reliability. The construction of a pump station adjacent to Blue Sink and a 16-in. pipeline to the Sulphur Springs Transmission Main was the highest ranking alternative (Figure 19). The recommended pump station alternative is a vacuum-primed horizontal centrifugal pump capable of diverting 3.1 cfs from Blue Sink to the Lower Hillsborough River.

The City of Tampa has been issued all environmental and water use permits for the Blue Sink project. During the permitting process, adjacent neighborhood associations expressed concerns, primarily related to lake-level and aquifer-level impacts due to Blue Sink diversions. Figure 20 and Figure 21 (Results of Blue Sink Pumping Test No. 2, Hillsborough County, Florida, SWFWMD, 2009) summarize impacts to lake levels and groundwater levels during the 30-day 3.1 cfs pump test. This data was used to calibrate a groundwater model that was utilized to simulate long-term impacts of Blue Sink Diversions. The results were used to support the City's water use permit application.

Raw Water Transmission Main and Tampa Bypass Canal Diversions

The Lower Hillsborough River Recovery Strategy plan includes an 11 cfs TBC diversion. This canal serves as flood relief to the northern Tampa Bay area and consists of an upper pool, middle pool, and a lower pool separated by control structures. The Hillsborough River Reservoir and the TBC middle pool are connected via the Harney Canal. Originally, this diversion was to be accomplished via a pump station and pipeline between the Harney Canal and the Lower Hillsborough River (Figure 22). An inde-

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Figure 20. Lake drawdown (in ft) during the Blue Sink Pump Test.

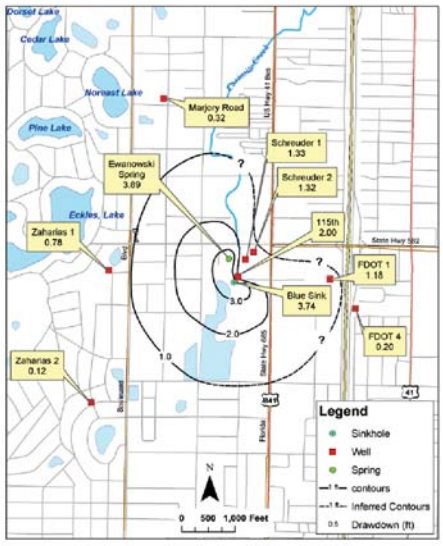

Figure 21. Upper Floridan aquifer drawdown during the Blue Sink Pump Test.

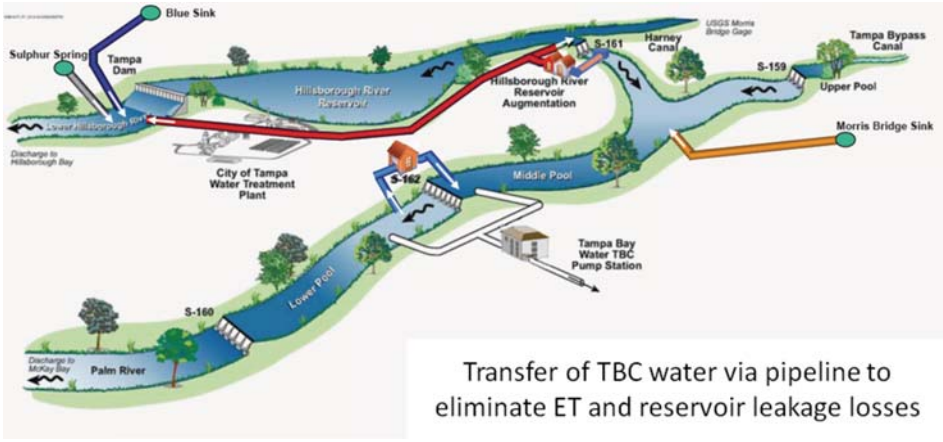

Figure 22. Tampa Bypass Canal diversions are being used to contribute 11 cfs to the Lower Hillsborough River minimum flow (graphic courtesy of SWFWMD).

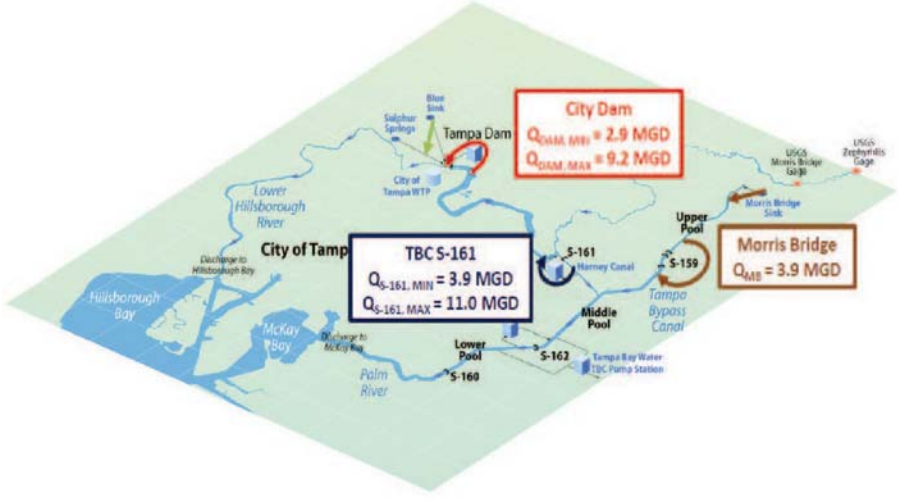

Figure 23. Planned infrastructure at TBC S-161 and the Hillsborough River Dam to implement Tampa Bypass Canal diversions.

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pendent peer review panel concluded this approach resulted in only minor improvements to evapotranspiration (ET) and leakage losses, resulting in unfavorable economics. Therefore, the Hillsborough River Reservoir is planned to be used as a flow path in lieu of a pipeline. This option requires diversion facilities at the Harney Canal (S-161) and Hillsborough River Dam (Figure 23).

Structure 162 Diversion Facility

The Structure 162 Diversion Facility supplements the TBC middle pool by pumping from the TBC lower pool (Figure 24). Water pumped from the TBC lower pool discharges to the Lower Hillsborough River via the Structure 161 Pump Station and the Hillsborough River Dam Diversion Facility (refer to Figure 23). Per rule, this facility is to be owned and operated by the District.

Harney Canal (Structure 161) Diversion Facility

As elucidated in Figure 23, the Lower Hillsborough River recovery strategy requires up to 17 cfs, or 11 mil gal per day (mgd), to be diverted from the TBC middle pool to the Hillsborough River Reservoir. The existing Harney Canal connects these water bodies, while Structure 161 (located within the Harney Canal) maintains the water elevation difference between the reservoir and the TBC middle pool.

Tampa Bay Water owns and operates the Harney Canal Pump Station located adjacent to Structure 161 (Figure 25). This pump station is permitted to augment the Hillsborough River Reservoir at a peak monthly rate of 40 mgd for the City of Tampa's potable water demand. The Harney Canal Pump Station design firm capacity matches the per-

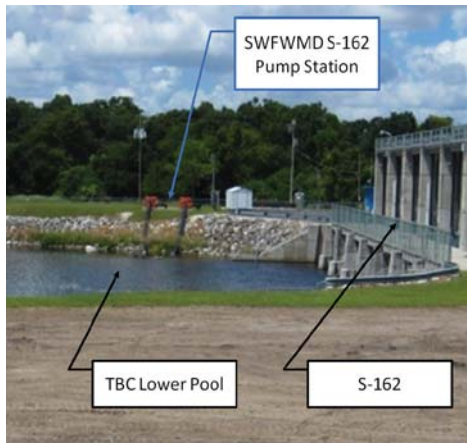

Figure 24. Southwest Florida Water Management District S-162 Pump Station.

mitted peak monthly rate; however, recent test results indicate the current firm capacity is approximately 36.6 mgd. Because the City of Tampa's potable water demand utilizes the entire firm capacity of the Harney Canal Pump Station, there was not sufficient existing capacity to concurrently meet potable water demand and minimum flow demands.

Per the recovery strategy implementation schedule, the District constructed additional pumping capacity to divert water "uphill" around Structure 161. This was to provide the City sufficient time to construct the then-planned permanent pumping facility and raw water transmission main. The District-constructed facility was therefore designed to be temporary in nature. Because the raw water transmission main was determined uneconomical, rule requires the City to assume the long-term diversion responsibilities at Structure 161. The City and the District are presently negotiating a cost sharing agreement for the City to construct a permanent Structure 161 diversion facility.

An alternatives analysis for the long-term 17 cfs diversion facility has evaluated several pump station configurations based on cost, regulatory considerations, schedule, operation and maintenance, reliability, and energy efficiency. Two main options were considered as follows:

1. Construction of a new pump station with a capacity matching minimum flow diversion requirements (17 cfs or 11 mgd firm capacity).
2. Modification of Tampa Bay Water's existing 36.6-mgd Harney Canal Pump Station to concurrently meet minimum flow requirements and potable water supply needs (79 cfs or 51 mgd firm capacity).

Several configurations were considered to achieve Option 1. These all involved two 65-HP pumps, variable speed pumping capacity, and a building with separate mechanical and electrical rooms. Improvement needs to achieve Option 2 included the replacement of two existing pumps with two larger 200-HP pumps, suction and discharge piping upsizing, two new variable frequency drives, intake structure modifications, and minor building modifications to provide conditioned space for the variable frequency drives. The alternatives analysis recommends Option 1 be pursued primarily due to an estimated $830,000 savings (20-year net present value) and a minimum four-month decrease in net implementation time. This project is in the preliminary design phase while the City and the District negotiate a cost sharing agreement.

Hillsborough River Dam Diversion Facility

As shown in Figure 23, providing minimum flows to the Lower Hillsborough River involves diverting water from the TBC and Morris Bridge Sink through or around the Hillsborough River Dam. Water in the TBC is lower in elevation than water in the Hillsborough River Reservoir (Figure 26). Because it is known that the Hillsborough River Reservoir leaks east towards the TBC, the recovery strategy indicates that 25 percent of the water pumped into the Hillsborough River Reservoir at Structure 161 is not required to be diverted to the Lower Hillsborough River. This results in the need for a Hillsborough River Dam Diversion Facility with a 12.8 cfs (9.2 mgd) capacity.

Similar to the temporary pump station at Structure 161, the District also installed a temporary pump station adjacent to the Hillsborough Dam (Figure 27). Rule requires

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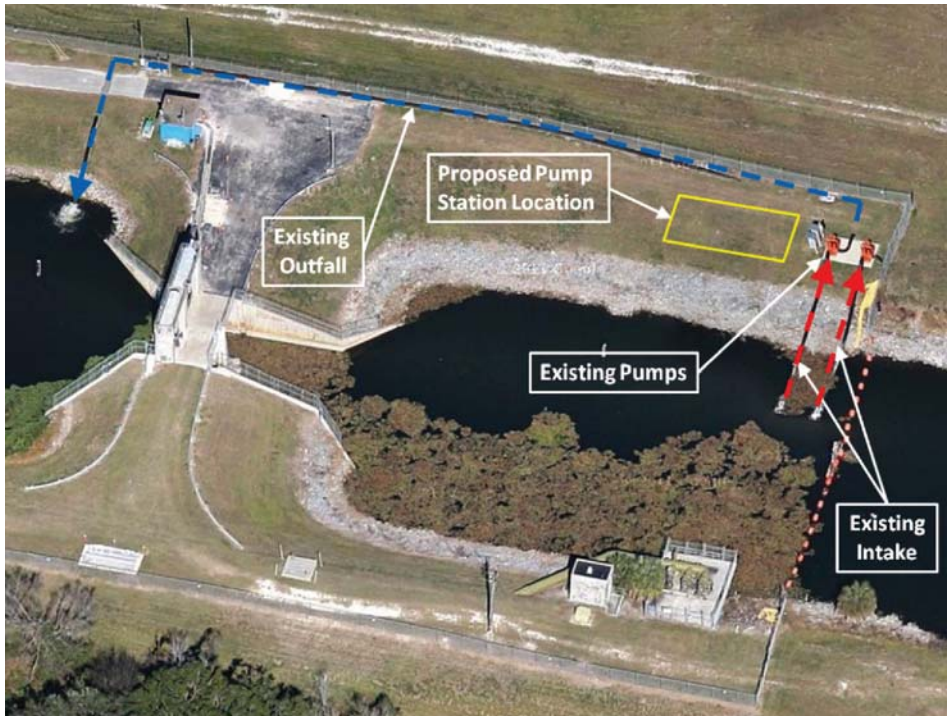

Figure 25. The Hillsborough River Reservoir (far left) is separated by the Tampa Bypass Canal middle pool (right) at Structure 161 (center left). Tampa Bay Water's Harney Canal Pump Station is pictured bottom right; the District's temporary minimum flows and levels diversion facility is pictured top right.

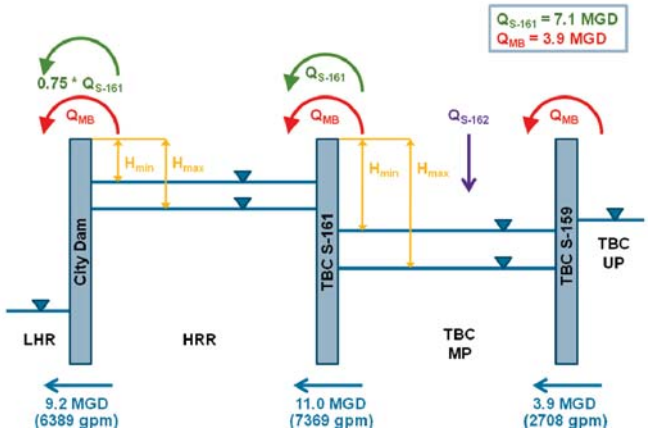

Figure 26. Lower Hillsborough River, Hillsborough River Reservoir, and Tampa Bypass Canal water surface elevations.

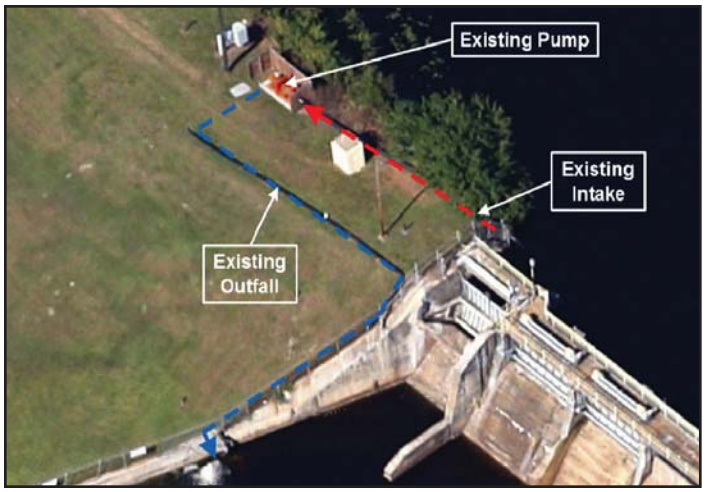

Figure 27. Temporary Southwest Florida Water Management District Pump Station at the Hillsborough River Dam.

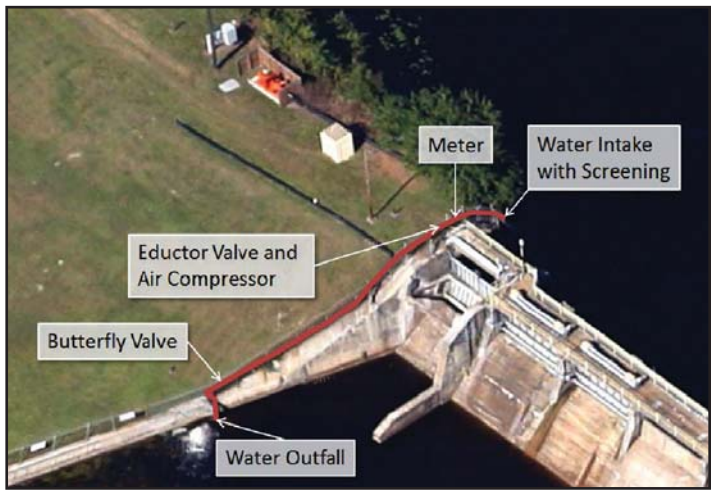

Figure 28. Proposed Hillsborough River Dam Siphon location.

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the City to assume the long-term diversion responsibilities at the Hillsborough River Dam because the raw water transmission pipeline was found to be uneconomical. The City and the District are therefore negotiating a cost sharing agreement to construct a permanent Hillsborough River Dam Diversion Facility.

An alternatives analysis for the permanent 12.8 cfs Hillsborough Dam Diversion Facility evaluated the following four alternatives:

1. Gravity flow pipeline
2. Siphon
3. Pump station
4. Gate modifications

Option 1 (gravity flow pipeline) was preferred due to the minimal energy requirements and simplicity; however, it was eliminated from consideration due to the risk associated with trenching through the Hillsborough River Dam embankment. Option 4 (gate modifications) was eliminated primarily for physical feasibility reasons; however, the low probability/high impact of a catastrophic gate or equipment failure was also considered. Option 2 (siphon) and Option 3 (pump station) were identified as feasible and studied further.

Twenty-year life cycle cost estimates were prepared for the pump station and siphon alternatives. An educator-primed siphon was recommended for implementation based on technical (less equipment and complexity) and economic analysis (estimated $290,000 savings, 20-year net present value). Figure 28 summarizes the preliminary siphon design that is intended to replace the temporary pump station.

Morris Bridge Sink

Morris Bridge Sink is a karst feature with standing water located near the upper reaches of the TBC. Use of this source involves sequentially pumping water from the sink to the TBC, then to the Hillsborough River Reservoir and eventually to the Lower Hillsborough River for minimum flows. A pump test has been completed and determined that the sink has the potential to deliver 6 cfs of flow on a sustainable basis. The pump station has been designed and is currently being permitted. Similar to the Structure 162 Diversion Facility, the Morris Bridge Sink facilities will be designed, permitted, constructed, owned, operated, and maintained by the District.

Conclusion

Although the recovery strategy has not yet been fully implemented, the completed projects show a high degree of effectiveness towards meeting the Sulphur Springs Run and Lower Hillsborough River management goals. The Sulphur Springs lower weir modifications and Sulphur Springs pump station modifications have proven to be effective at preventing salinity incursions into Sulphur Springs Run, while maintaining an effective manatee thermal refuge within the Lower Hillsborough River. Continuous salinity measurements made below the Hillsborough River Dam have shown a substantial reduction in salinity compared to previous years. Completion of the remaining projects is expected to fully meet the management goals, with anticipated improvements to fish and wildlife populations. The team effort between the City of Tampa and the District, along with the support and cooperation from multiple other regulatory agencies, has resulted in ongoing improvement to the Sulphur Springs Run and Lower Hillsborough River.