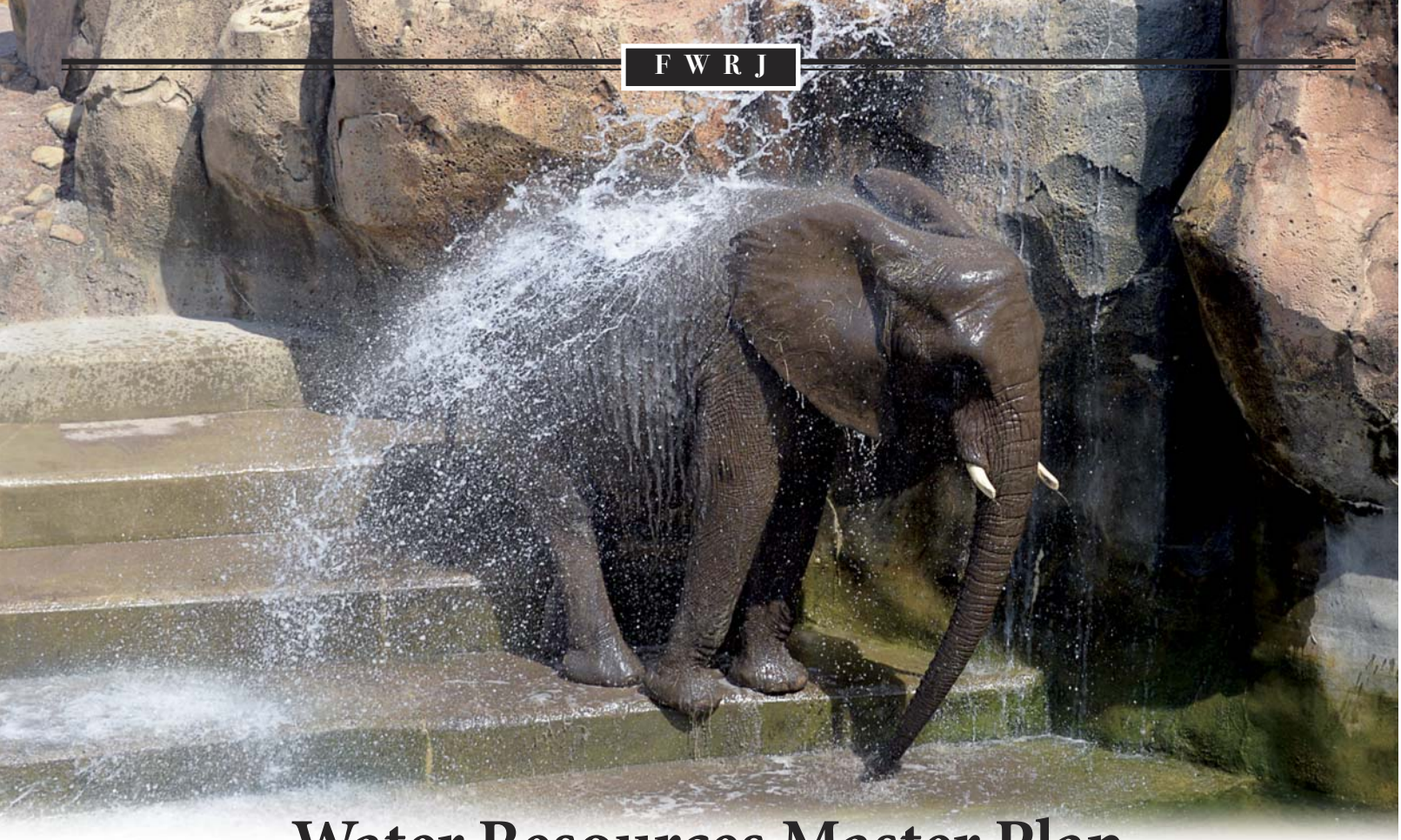

Water Resources Master Plan for Lowry Park Zoo

Tonya Simmons and Heather Maggio

History of the Zoo

Tampa's Lowry Park Zoo originated in the 1930s as a City of Tampa (City) municipal department with a small collection of Florida native species located near downtown Tampa on the grounds of the University of Tampa. During the mid-1950s, the Zoo was moved to a more spacious location on a city-owned parcel in the neighborhood of Seminole Heights, opening in 1957 as Lowry Park Zoo. In this new location, it grew gradually throughout the next three decades, but struggled to meet the professional standards of modern zoos. In 1982, community leaders created the Lowry Park Zoo Association to take over management of the Zoo for the City with the goal of creating a world-class facility through a public-private partnership. The Association then became the Lowry Park Zoological Society of Tampa Inc., as it remains today.

After years of fundraising, and through the help of the City, the original Lowry Park Zoo closed in the late 1980s for a $20-million reconstruction and reopened in 1998 as a modern 24-acre facility. Since that time, it has completed several additions and expansions that have brought the zoo to its current configuration. Construction phases included the following:

- The original footprint of the Zoo, referred to as "Old Zoo," was constructed in 1986.
- The stormwater basin, Wallaroo, was constructed in 2000 and 2001.
- The stormwater basin, Africa, was constructed in 2003.
- Safari Lodge was constructed in the Africa basin in 2008.
- The hospital and commissary were constructed in 2014 at the southwestern edge of the Africa basin.

Purpose of Zoo's Water Resources Master Plan

The Zoo holds water conservation and source water protection as two of its core values. As such, it wanted to develop and implement a holistic and progressive approach to reducing its water use and protecting the water quality of the Hillsborough River. The objective of the project was to improve water use efficiency within the Zoo and the quality of water discharged through the creation of a water resources master plan (WRMP). The WRMP was intended to evaluate viable water quality and reuse options that, when implemented, would reduce pollutants discharged by the Zoo to Hamilton Creek, a tributary to the Hillsborough River that discharges to Tampa Bay.

The Hillsborough River, the City's primary drinking water source, is an impaired waterbody (WBID 1443E) with an adopted fecal coliform total maximum daily load (TMDL) that has exceedance levels of 400 coliform fecal units (CFU)/100 mL as a monthly average, and 800

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CFU/100 mL as a maximum-day average. The Hillsborough River does not have a TMDL for nitrogen; however, it discharges into Tampa Bay, which has a TMDL for nitrogen that was approved by the U.S. Environmental Protection Agency in 1998. The allowable total nitrogen load for each major bay segment of Tampa Bay is as follows:

- Old Tampa Bay: 486 tons/year
- Hillsborough Bay: 1,451 tons/year
- Middle Tampa Bay: 799 tons/year
- Lower Tampa Bay: 349 tons/year

The Zoo property and Hamilton Creek are in the watershed of the impaired Hillsborough River. The Zoo property is located approximately 1,000 ft from the Hillsborough River, and Hamilton Creek, a tributary to the river, runs through the Zoo property before discharging into it (Figure 1).

Funding Sources and Engineer for the Water Resources Master Plan

The Zoo submitted a Cooperative Funding Initiative (CFI) proposal to the Southwest Florida Water Management District (SWFWMD). Through the CFI process, SWFWMD and project owners (also called cooperators) collaborated on a water management project with both entities typically paying 50 percent of the project cost. Acknowledging the importance of the project, the City provided the Zoo's matching funds for the CFI project and became the cooperator and project manager. In that role, the City retained Greenman-Pedersen Inc. (GPI) to develop the WRMP.

Existing Water Sources and Uses

The Zoo has two water sources: city-supplied potable water and self-supplied well water. The Zoo uses over 5 mil gal (MG) of well water per month for irrigation and to fill pools that are in its exhibits. The majority of this use is to fill exhibit pools. Potable water is used to meet all other needs, including the cleaning of exhibits. The Zoo purchases about 1.5 MG of potable water per month.

Existing Stormwater Management

The Zoo consists of three stormwater basins: Africa, Wallaroo, and Old Zoo. As shown in Figure 1, the Africa exhibit drains to a stormwater management pond (SWMP) that has an emergency overflow structure, which discharges directly to the Hillsborough River. Wallaroo drains to a separate SWMP, which has an emergency overflow structure that discharges into Hamilton Creek.

Stormwater management in Old Zoo is unique because the storm sewer in that part of the facility includes a mixture of relatively clean stormwater (runoff from roofs and sidewalks), which is referred to herein as "clean stormwater" and water with high levels of fecal matter (drained from exhibit pools during cleaning activities), which is referred to herein as "dirty stormwater." The Old Zoo storm sewer combines both clean and dirty stormwater and drains to Lake Sharon. Water is then pumped from Lake Sharon to the Zoo's Florida Department of Environmental Protection (FDEP)-permitted onsite industrial wastewater treatment system. The system includes sand filtration and ultraviolet (UV) disinfection.

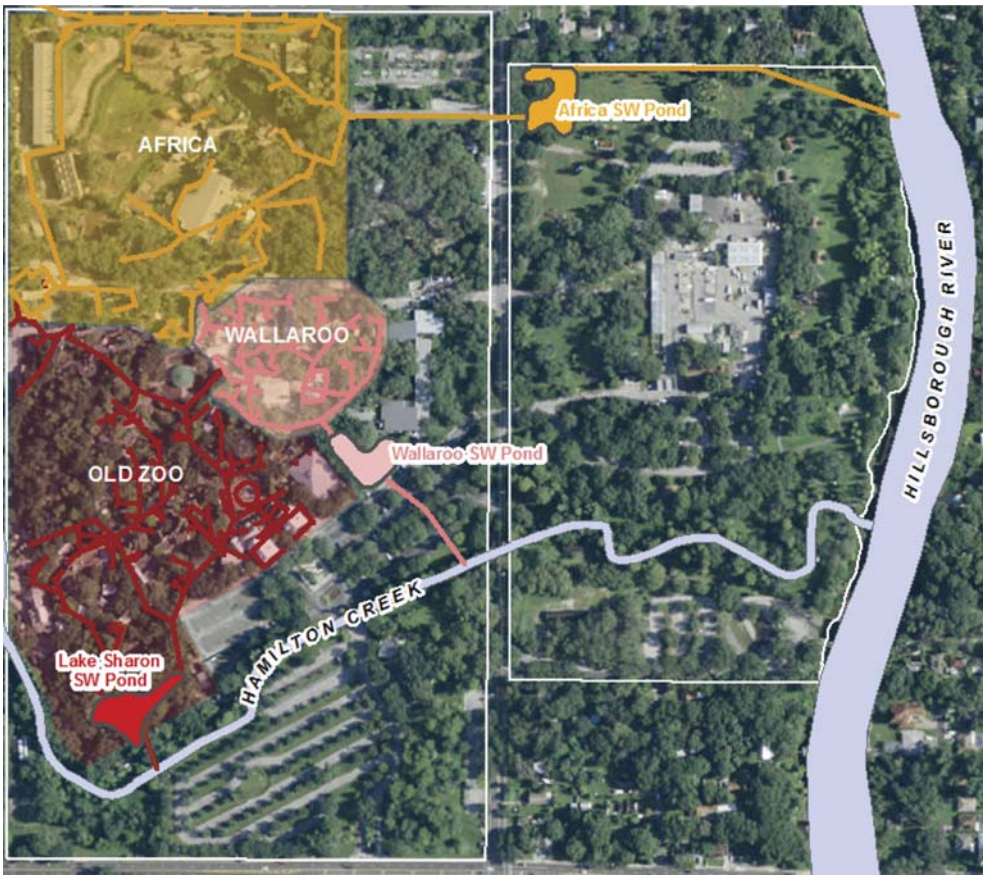

Figure 1. Zoo Property

More than 150,000 gal per day (gpd) of treated effluent from the system is discharged to Hamilton Creek through the Zoo's National Pollutant Discharge Elimination System (NPDES)-permitted outfall. The treated effluent outfall is co-located with an emergency overflow weir in Lake Sharon. Per the Zoo's operating protocol, in an effort to not discharge untreated Lake Sharon water over the weir, levels in Lake Sharon are closely monitored and exhibit pools are dropped and cleaned only when there is sufficient free board in the lake. The protocol also calls for discharging untreated Lake Sharon water to the City's sanitary sewer when the treatment system is taken off line for maintenance or repair, or if it cannot keep up with flow demands when the water level in the lake needs to be quickly dropped due to a storm event.

Nitrogen Levels in Treated Stormwater Effluent

As part of the 2009 Tampa Bay Reasonable Assurance Plan, Lowry Park Zoo was assigned a total nitrogen allocation, which was included in its industrial wastewater treatment permit for the Lake Sharon system. In the permit, the Zoo is allowed to discharge up to 1.5 tons/year of nitrogen as a total annual load, and up to 1 ton/year as a five-year rolling average.

The Zoo's effluent discharge data was reviewed by GPI from September 2012 through October 2015. In evaluating the NPDES data recording and reporting practices, GPI identified that Zoo maintenance staff would benefit from a custom calculator to record laboratory results and calculate loadings for monthly reporting to FDEP. A spreadsheet-based calculator was developed by GPI for the staff to use moving forward. The calculator also included a performance measurement so that the Zoo could track the performance of its nitrogen management efforts.

The performance metric calculated by the tool is nitrogen loading as a percent of the Zoo's permitted allocation. This allows the Zoo to track its nitrogen loadings as a percent of its annual and

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five-year allocations. Through GPI's review of historical effluent data for the Lake Sharon treatment system, it appeared that, since monitoring inception (September 2012), the Zoo had maintained nitrogen loadings in treated effluent from the Old Zoo that were well below permit limits. On average, the Zoo uses about 20 percent of its annual nitrogen loading allocation.

Fecal Coliform Levels in Treated Stormwater Effluent

As previously mentioned, the Hillsborough River fecal coliform TMDL includes exceedance levels of 400 CFU/100 mL as a monthly average, and 800 CFU/100 mL as a maximum-day average. The fecal coliform level on the Zoo's discharge monitoring reports (DMRs) was reviewed from September 2013 through August 2015. During this period, on average, the Zoo's fecal loading through the outfall has been 30 and 43 percent of its monthly average and maximum daily allowances, respectively. For the period of analysis, the Zoo had not exceeded the monthly average limit, but it did exceed the maximum day limit three times. The cause of the exceedances was: 1) untreated Lake Sharon water discharging over the weir during heavy rains; 2) the UV flow sensor malfunctioning; and 3) due to low precipitation, the concentration of fecal coliform was higher than the design values for the UV system.

Identifying and Scoring Potential Projects

After completing discovery and evaluation tasks, GPI determined that proposed project options should consider the following:

- The Zoo's greatest liabilities with respect to impacting water quality in the Hillsborough River included:
  - The potential of untreated Lake Sharon water topping over the weir and discharging into Hamilton Creek.
  - Failure of the UV system to disinfect Lake Sharon water prior to discharge to Hamilton Creek.
- Nitrogen in the Lake Sharon-treated effluent was well below the Zoo's permitted effluent limits.
- The UV system was capable of meeting fecal coliform effluent limits as long as the system was properly working and fecal coliform levels entering the UV system were within the design range.
- The Lake Sharon pumping and filtration systems were dated and inefficient.
- The pumping, filtering, and disinfection systems lacked backup power and instrumentation and controls, which could greatly improve system reliability and on-demand power, pumping, and treatment redundancy.
- Separation of clean rainwater from fecal-contaminated water in the Old Zoo storm sewer would be highly disruptive to animals because of the layout of the Old Zoo.
- Although the Zoo could decommission the Lake Sharon treatment system and dispose all untreated Lake Sharon water to the City's sanitary sewer through a metered connection, this option was highly undesirable at $4.71/100 cu ft.
- Reuse of treated Lake Sharon effluent provided an opportunity to offset water uses from wells and some uses of purchased potable water (exhibit washdown water, for example).
- The Zoo is committed to providing environmental education to its visitors and wanted project options to include at least one that Zoo visitors could themselves implement.

Based on these considerations, GPI developed a simple qualitative benefit–cost matrix to identify projects with fatal flaws and score project options.

Recommended Capital Projects

Based on the results of the benefit–cost matrix, the following three projects were identified.

Storage and Reuse of Treated Lake Sharon Wastewater

This recommended project includes storing treated water from Lake Sharon in an underground vault under the events lot. Except for the existing UV system, all other pumping and treatment systems would be upgraded and pumping, treatment, disposal, and outfall facilities relocated. Parameters used to conceptualize this project option are summarized and a conceptual layout is provided as Table 1. In Figure 2, existing storm sewer flowing to Lake Sharon is shown in red, Lake Sharon wastewater (WW) treatment components are shown in green, and treated effluent is in purple. The components of the proposed treatment and storage system are shown in pink.

Storage and Reuse of Diverted Clean Stormwater From Zoo Entrance Area

This option includes the capture/collection and pretreatment of clean stormwater from the Zoo's entrance area (see clean stormwater capture area in Figure 3). In the figure, clean stormwater is shown in orange and dirty stormwater in red. The proposed capture area is shown in pink.

This project option is considered an add-on to the Lake Sharon storage/reuse option. Clean stormwater would be conveyed to the vault via guttering and direct stormwater drainage pipes. It is assumed that some modification to the building guttering will be required to maximize rainwater collection potential. At least one hydrodynamic separation device (interceptor) would be required to remove debris and suspended solids from the stormwater runoff through gravitational settling and trapping.

Future basis-of-design efforts may identify that it is more cost-effective to capture, treat, and store these flows through the existing drainage system. This means that if this project option were not implemented, the potential to capture and reuse these flows would not be lost, as they would continue to flow to Lake Sharon, be treated by the new Lake Sharon treatment system, and then be stored in the vault.

Rain Gardens

Rain gardens were proposed throughout the Zoo and also in its parking lot. Candidate rain gar-

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Table 1. Conceptual Design Parameters for Treatment, Storage, and Reuse of Treated Lake Sharon Wastewater

Parameters	Conceptual Value	Basis of Conceptual Design
Storage Capacity (volume)	390,000 gallons	Maximize available footprint in Events Lot
Available Supply of Reuse Water	300,000 GPD	Average discharge via D-001 + Manatee backwash water
Total Potential Offset in Old Zoo	176,368 GPD	Replace 100% of Manatee and Otter well water and 50% of City-supplied potable water in Old Zoo (from meter # 31945071)
Storage Capacity (time)	2 days	Storage volume ÷ demand, where demand = potential offset
UV Disinfection Capacity	470 gpm	Capacity of existing UV system
Filtration Capacity	500 gpm	Selected to match capacity of existing UV-system capacity and to avoid the need to bypass filtration and UV and dump to sanitary sewer
Reuse Supply Finished Water Quality (WQ)	To be Determined	Recommended project can meet NPDES WQ requirements and should be acceptable for washing down exhibit pools after draining them to Lake Sharon. Recommended project may meet WQ needs of moats (water barriers) with little to no additional treatment. Further analyses are needed to identify other specific end uses such as toilet/urinal flushing, filling exhibit pools and/or backwashing Manatee filters. It is possible to meet or exceed existing WQ of well water with additional treatment (after storage and before delivery).
End Uses to be Supplied with Reuse Water		

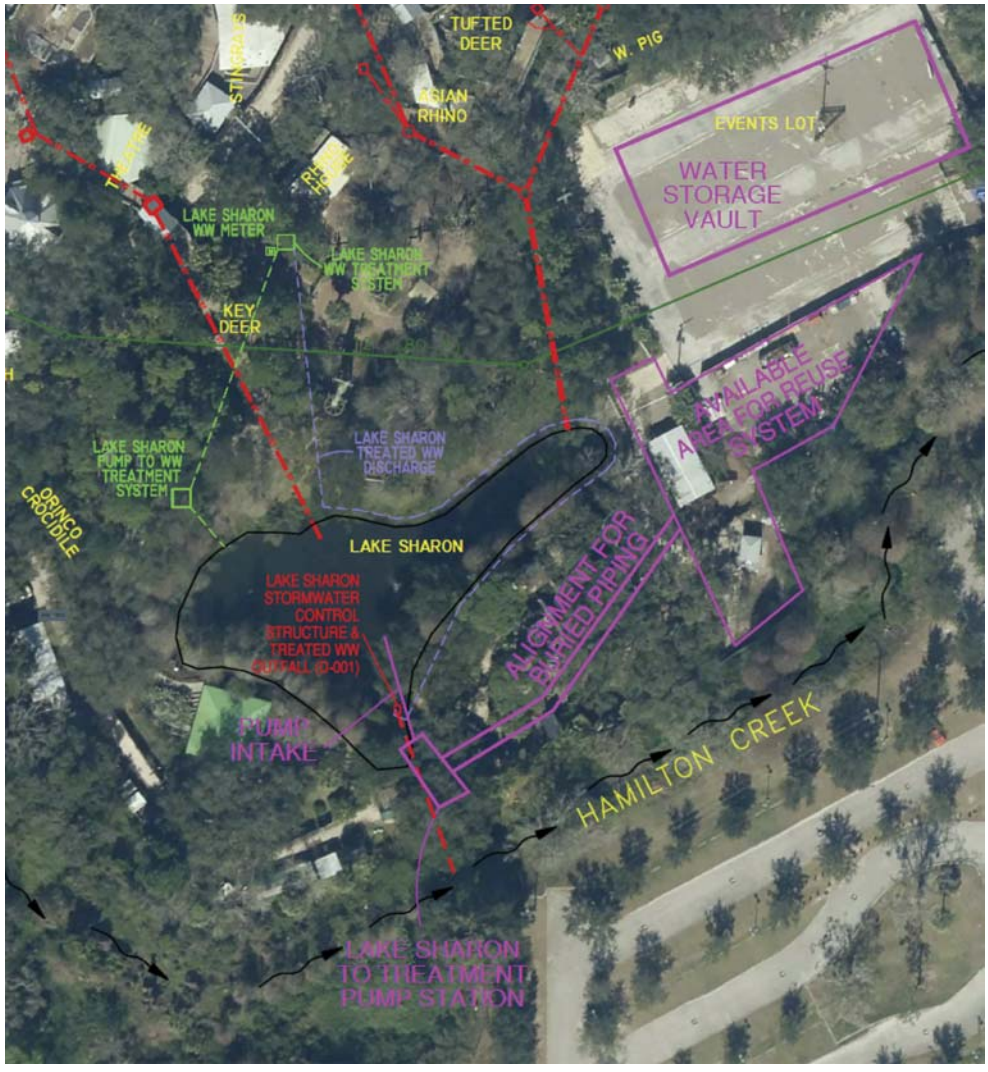

Figure 2. Treatment and Storage of Lake Sharon Wastewater

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den sites generally included areas that collect stormwater runoff from higher lying areas. Potential sites were located in public high-access areas to maximize exposure to visitors for their public education value. The rain garden project was conceptualized in coordination with the University of South Florida (USF). Candidate rain garden sites would be ranked by USF based upon the following factors: potential nitrogen sources within the contributing drainage area (30 percent), visibility (30 percent), accessibility (30 percent), and construction feasibility (10 percent). Then, the top four sites would be selected for implementation and would include two to three enhanced nitrogen removal (modified) rain gardens and one to two conventional rain gardens.

For traditional rain gardens, the International Stormwater Best Management Practices Database shows a total nitrogen (TN) removal efficiency of 21 percent and Version 3 of the Center for Watershed Protection's National Pollutant Removal Performance Database lists a median removal efficiency of 46 percent. The USF is currently monitoring both a conventional and a modified rain garden at a field site in Tampa. Results to date indicate 61 percent TN removal for the modified rain garden versus 34 percent TN removal for the conventional rain garden. Similar removal efficiencies are expected for conventional and modified rain gardens that may be implemented at the Zoo.

Next Steps and Other Recommendations

The following is a list of next steps for implementing the proposed capital projects:

- Submeter several end uses at the Zoo to better quantify appropriate storage volume, pumping requirements, and reuse piping.
- Identify acceptable water quality for each potential use of treated Lake Sharon wastewater.
- Conduct additional water quality testing of well water and treated Lake Sharon water to identify baseline water quality testing for parameters that relate to various uses (exhibit pools used by animals; exhibit pools used for animal containment, such as moats; and fouling of taps used for washdown water).
- Investigate the geotechnical aspects of the site of the proposed storage vault, the events lot.
- Most importantly, identify funding sources to implement the projects.

Figure 3. Clean Stormwater Capture Area in Old Zoo

Other recommendations that were not capital projects and/or were interim recommendations include the following:

- Install floating islands to improve water quality in Lake Sharon.
- The sand filters for the Lake Sharon wastewater treatment system are backwashed with untreated Lake Sharon water. Until the Zoo can upgrade the Lake Sharon treatment system, it was recommended to replumb the system to backwash filters with City potable water or treated Lake Sharon water.
- Installation of a prefilter to be installed upstream from the sand filters to remove shells and other debris entering the intake pipe. Also, it's recommended to raise the Lake Sharon pump inlet to reduce entrainment of shells and debris from the bottom of the lake.
- All hoses used for washing down exhibit pools after pool drops should be fitted with high-pressure nozzles with a shut-off feature.
- Approximately half of the aerators on handsink faucets are 2.2 gal per minutes (gpm), instead of 0.5 gpm. Replacing 2.2-gpm aerators with 0.5-gpm aerators reduces this end use by 30 percent. All toilets and urinals are currently 1.6 gal per flush (gpf) and 1 gpf, respectively. New or renovated bathroom facilities should use 1.28 gpf or dual-flush toilets to reduce this end use by 30 percent.
- Prerinse spray nozzles should be installed in food service areas with 1.6-gpm nozzles.

In an effort to conserve Florida's limited fresh water supplies and to protect the Hillsborough River and Tampa Bay from fecal coliform and nitrogen loads, SWFWMD, the City of Tampa, and Lowry Park Zoo teamed up to find a way to transform environmental liabilities into opportunities. When project funding becomes available, the Zoo will be able to improve the reliability of its industrial wastewater treatment system, replace up to 300,000 gpd of treated potable and well water with reclaimed water, and test nutrient removal efficiencies of traditional and engineered rain gardens.