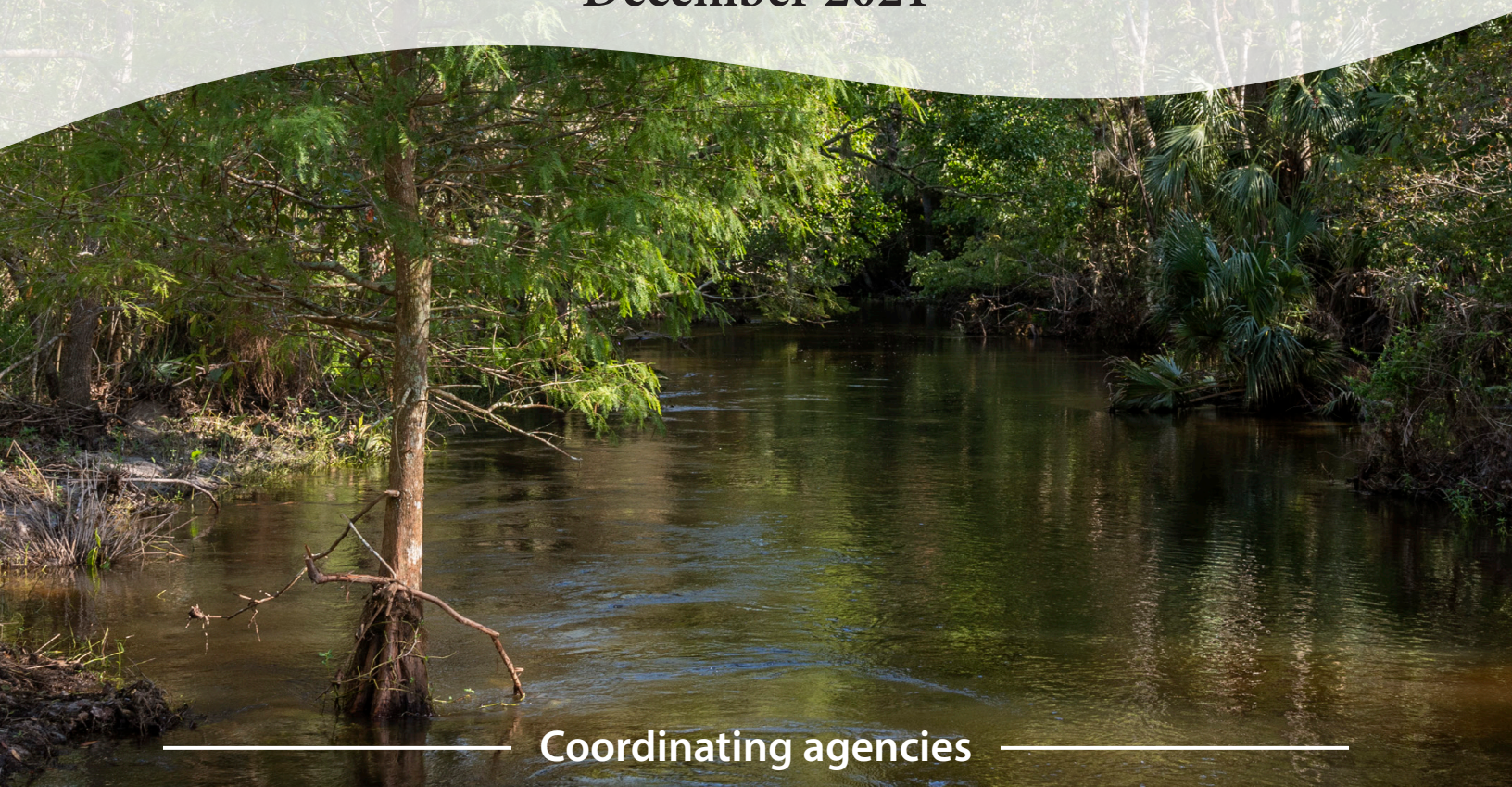
ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

Updates Regarding the Implementation of the Recommendations from the *2005 Little Wekiva Watershed Management Plan*

December 2021



Coordinating agencies

Florida Department of Environmental Protection ♦ St. Johns River Water Management District ♦ Seminole County ♦ Florida Fish and Wildlife Conservation Commission ♦ Florida Department of Transportation City of Altamonte Springs ♦ Orange County ♦ City of Orlando

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Executive Summary

The St. Johns River Water Management District (SJRWMD), in consultation with the Florida Department of Environmental Protection (FDEP), and various state and local government entities, provided updates regarding the implementation of recommendations from the Little Wekiva Watershed Management Plan (WMP) Final Report dated November 2005 and conducted a permit review within a specific area of the basin with the goal of identifying "significant contributors of sediment accumulation and any permits which the water management district has determined may have contributed to sediment buildup north of State Road (S.R.) 436 to assess whether the permittee is in violation of any permit conditions."

The 2005 WMP report of the Little Wekiva River Basin, conducted by the engineering firm CDM Smith, documents the extensive history of stormwater quantity and quality problems within the Little Wekiva River Basin including:

- An increase in rate of volume, flow and velocities due to the basin's urbanization;
- Minimal upstream storage and treatment due to much of the current development occurring before current stormwater regulations (pre-1983);
- Erosion and flooding, which has caused public safety concerns; and
- Adverse environmental and water quality impacts from the movement and deposition of sediments.

These conclusions are re-affirmed in this report. A thorough review of permits, permit violations, and analysis of major storm events and sedimentation in the river was completed. This analysis indicates scientific evidence is lacking to determine the contribution of sediment load from any individual source, current or historic. In short, general sediment accumulation and movement patterns strongly suggest that aggregate effects of basin urbanization, particularly prior to modern stormwater rules, are responsible for the majority of historic and current sediment issues.

The Summary and Recommendations section provides a list of projects and studies that will further benefit the river. Recommended projects focus on sediment removal from the river.

Introduction

Passed during the 2021 Regular Session of the Florida Legislature and later signed into law by Governor Ron DeSantis, Senate Bill 976 (SB 976) (CS/CS/SB 976 (*flsenate.gov*)), enacted as Chapter 2021-181, Laws of Florida (*http://laws.flrules.org/2021/181*), (the "Act"), directed the St. Johns River Water Management District (SJRWMD), in consultation with the Florida Department of Environmental Protection (FDEP), and various state and local government entities, to develop this report with updates regarding the implementation of recommendations from the Little Wekiva Watershed Management Plan Final Report dated November 2005. The Act also requires SJRWMD and FDEP to conduct a permit review within a specific area of the basin with the goal of identifying "significant contributors of sediment accumulation, any permits which the water management district has determined may have contributed to sediment buildup north of State Road (S.R.) 436 to assess whether the permittee is in violation of any permit conditions."

The agencies met and kicked off this effort in July, during which time the Act and history of sediment concerns in the watershed were discussed and the parameters for moving forward were established. As a result, the requirements of the Act were broken down into specific tasks and subsequent group meetings were held to work through each task and acquire the appropriate data. The Act specifically identified SJRWMD, FDEP, Florida Fish and Wildlife Conservation Commission, Florida Department of Transportation (FDOT) and Seminole County for this effort. Additionally, Orange County, the City of Orlando, and the City of Altamonte Springs actively participated in this assignment, given their participation in the 2005 Water Management Plan (WMP) study and report.

SB 976 was a direct result of concerns raised by residents of the Markham Woods community located in the western portion of Seminole County, north of S.R. 434, after these residents identified significant sediment accumulation within a portion of the Little Wekiva River that flows directly behind several residential homes in the area. This sediment accumulation, combined with growth of invasive plant species, has severely restricted the water flow through this channel adjacent to the main river stem.

The 2005 WMP report of the Little Wekiva River Basin, conducted by the engineering firm CDM Smith, was commissioned by SJRWMD in cooperation with Orange County, Seminole County, the City of Orlando and the City of Altamonte Springs. A copy of the 2005 report is attached to this document for reference. The 2005 WMP report documents the extensive history of stormwater quantity and quality problems within the Little Wekiva River Basin including:

- An increase in volume, rate of flow and velocities due to the basin's urbanization;
- Minimal upstream storage and treatment due to much of the current development occurring before current stormwater regulations (pre-1983);
- Erosion and flooding, which has caused public safety concerns; and
- Adverse environmental and water quality impacts from the movement and deposition of sediments.

Regarding the historic sediment movement and accumulation, the Executive Summary of the 2005 WMP report explains:

> *The basin has also experienced chronic occurrences of sedimentation, primarily along the Little Wekiva River. The problem of sedimentation along the river appears to be a direct result of urbanization of the river's watershed*

that has overtaxed the conveyance and sediment transport capacity of the river (DRMP, 1988). The river changes in elevation by approximately 58 feet from its headwaters in Orange County to S.R. 434 in Seminole County. Over time, the combined effect of channelization of segments of the river, urbanization, and the loss of the river's natural floodplain aggravated sedimentation problems along the Little Wekiva River.

The 2005 WMP report made 21 recommendations for improvements in specific "problem areas" throughout the system to address identified issues, including the issue of sediment movement and transport. In accordance with the legislative directives in SB 976, this current report revisits the project recommendations from the 2005 WMP report and provides updates in the following areas specifically listed in the Act:

A description of all projects or recommendations included in the report that have been implemented and their completion dates, an analysis of how the projects or recommendations achieved the results included in the report, an analysis of costs for ongoing operation and maintenance of the constructed projects completed, a list of permit violations which may have contributed to sediment buildup north of S.R. 436, an analysis of any new projects that may benefit the watershed, and recommendations and cost estimates for future studies or projects that may be necessary to identify new or potentially significant contributors of sediment accumulation in the Little Wekiva River.

This report also addresses findings related to the review of permits and associated violations.

Updates on recommendations from 2005 Report

The 2005 WMP Report summarized 21 Problem Areas but did not specifically call out the type of project or identify specific projects that should be implemented to address a Problem Area. The table following (Table 1) identifies the list of projects that have been designed, permitted, and constructed by the City of Altamonte Springs, Seminole County, Orange County, and the Florida Department of Transportation (FDOT) in the Little Wekiva Watershed, including the Problem Areas identified in the 2005 WMP Report. The details of a project design were developed as the local government addressed a specific Problem Area. Given the historic knowledge related to erosion and sediment movement issues prior to the 2005 report, this table also reflects permitted measures undertaken pre-2005.

The table includes the project description, completion date, and cost (when available). For each of these projects the responsible agency performs ongoing operation and maintenance activities that include inspections, mowing, aquatic vegetation control, sediment removal, and minor repairs to gabions, reno mattress wiring, etc. The costs associated with these activities are included in the overall operation and maintenance budget of each agency and are further described in the "Analysis of Operation and Maintenance" Section below.

To date, the agencies have not assessed, as a whole, the improvements made to the erosion and flooding problem in the Problem Areas. However, Seminole County has a comprehensive greater Wekiva basin study currently underway, which will include an update of the 2005 study, an analysis of the Little Wekiva River's current and future conditions, as well as recommendations for capital improvement projects for the river and surrounding basins.

Table 1. Little Wekiva River (LWR) Erosion and Sedimentation Control Permitting

Date of issuance	Permit #	Description	County location	Agency receiving permit	Project completion date	Project completion cost
4/7/1992	22306-1	Restoration for LWR, Restoration of River Bank and Removal of RR Ballast	Seminole	City of Altamonte Springs (COAS)	1992	$31,158
11/9/1993	20838-1	Riverside Acres Sedimentation Basin	Orange	Orange County (OC)	–	–
1/11/1994	20848-1	Wallington Drive Erosion Control	Orange	OC	–	–
9/27/1994	29072-1	Foot Bridge Raising at The Springs Community	Seminole	The Springs Community	1995	–
9/12/1995	22458-1	LWR Sediment Control Retrofit, Emergency Restoration of Channel	Seminole	Seminole County (SC)	1995	In-house
5/30/1996	27756-1	Kelvington Drive Erosion Protection	Orange	OC	–	–
1/1/1997	22430-1	Widening of S.R. 436 Pearl Lake Causeway to Douglas Ave	Seminole	Florida Department of Transportation (FDOT)	2001	$19,404,277
1/7/1997	22458-2	LWR Phase I, S.R. 434 to Springs Landing Blvd — Dredging of sediment	Seminole	SC	1997	In-house
2/14/1997	27756-2	Elba Way Erosion Protection	Orange	OC	–	–
7/8/1997	22522-1	LWR Erosion Management Plan, Area 1 and 2	Seminole	COAS	1997	$435,104
7/8/1997	22522-2	LWR Erosion Management Plan, Area 3	Seminole	COAS	1997	$184,539
6/3/1998	22430-2	Fairfield Suites	Seminole	Never Issued	–	–
7/1/1998	28104-1	Campo Bridge Replacement	Orange	OC	–	–
11/9/1998	27756-3	LWR RVR Erosion Protection — Riverside	Orange	OC	–	–
11/10/1998	22550-1	Seminole Wekiva Trail, Phase I	Seminole	FDOT	2001	$2,369,175

Table 1. Little Wekiva River (LWR) Erosion and Sedimentation Control Permitting — *Continued*

Date of issuance	Permit #	Description	County location	Agency receiving permit	Project completion date	Project completion cost
7/28/1999	56491-1	Little Wekiva Riverside Acres Culvert (emergency installation)	Orange	OC	–	–
9/13/1999	22522-3	LWR Erosion Management Plan, Modification of Areas 1 and 2	Seminole	SC	1999	–
10/21/1999	56459-1	LWR Master Erosion & Sedimentation — GCS 7 and 8, Weathersfield Ave Improvements, including GCS 4 and 5.	Orange, Seminole	COAS, OC, SC	2000	$432,435
11/8/2000	22550-2	Seminole Wekiva Trail, S.R. 434 to Sylvan Lake Park	Seminole	SC	2001	–
12/7/2000	66902-1	LWR Tributary Ditch	Seminole	FDOT	2002	$275,028
4/8/2002	56459-2	Northwestern Ave Bridge Area Stabilization Project	Seminole	SC	2003	$950,000
4/9/2002	22550-3	Seminole Wekiva Trail, From Markham Woods Road to GEOPark	Seminole	SC	2003	–
4/15/2002	82895-1	LWR Outfall @ Grove Court - Altamonte Spring Headwall Replacement	Seminole	COAS	2002	$155,025
11/12/2002	56459-3	Horse Lovers Lane/Spring Lake Outfall Area Erosion and Sediment Control	Seminole	SC	2003	$700,000
4/18/2003	56491-2	Riverside Acres S/D Arch Pipe Rehab	Orange	OC	3/8/2005	$3,356,762
5/8/2003	56459-4	Erosion Control Countermeasures at Riverbend Apts	Seminole	COAS	2003	$318,994.78
9/24/2003	56459-5	Sherry Drive Erosion Control — Section 1	Orange	OC	12/11/2006	$813,868.60

Table 1. Little Wekiva River (LWR) Erosion and Sedimentation Control Permitting — *Continued*

Date of issuance	Permit #	Description	County location	Agency receiving permit	Project completion date	Project completion cost
11/3/2003	56459-6	LWR — Gusty Lane Erosion Control Improvements	Orange	OC	3/22/2005	$145,261.60
8/13/2004	28104-2	Campo Bridge Replacement	Orange	OC	–	–
3/11/2005	56491-3	Riverside Acres S/D Arch Pipe Rehab	Orange	OC	12/13/2005	$619,000
3/11/2005	27756-4	LWR RVR Erosion Protection — Riverside	Orange	OC	9/8/2005	$290,171
7/13/2005	22430-4	LWR Embankment Repairs at S.R. 436 LTR Modification	Seminole	FDOT	2006	$596,000.00
9/29/2005	22550-4	Markham Park	Seminole	Reiche & Silliman, Inc.	–	–
12/29/2005	22550-5	Seminole Wekiva Trail, Jones Trailhead	Seminole	SC	–	–
2/17/2006	22430-3	LWR Embankment Repairs at S.R. 436	Seminole	FDOT – Never Issued	See 22430-4	–
5/8/2007	56459-7	Elba Way Grade and Dredge — Erosion Control Improvement	Orange	OC	7/27/2009	$821,289.20
2/10/2009	20838-2	Riverside Acres Sedimentation Basin Improvements	Orange	OC	–	–
4/17/2009	56459-8	LWR Slope Stabilization (Area 1)	Orange	OC	6/18/2009	$810,000
10/16/2009	28104-3	Campo Bridge Replacement LTR Modification	Orange	OC	11/7/2010	$396,842
2/24/2010	22430-5	S.R. 436 (Orange Ave) Intersection Improvements	Seminole	FDOT – Never Issued	See 22430-4	–
5/10/2010	121590-1	LWR Grade Control Structures, 9, 10 and 11	Seminole	SC	2015	$850,000

Table 1. Little Wekiva River (LWR) Erosion and Sedimentation Control Permitting — *Continued*

Date of issuance	Permit #	Description	County location	Agency receiving permit	Project completion date	Project completion cost
6/7/2010	22430-6	S.R. 436 (Orange Ave) Intersection Improvements LTR Modification	Seminole	FDOT	2011	$235,800.00
7/6/2010	56459-9	LWR Slope Stabilization (Area 2)	Orange	OC	9/25/2010	$656,757
6/11/2011	22550-6	Seminole Wekiva Trail, Stormwater Overflow System for Orange Boulevard	Seminole	SC	2012	–
11/1/2011	66902-2	S.R. 434 Outfall Ditch Modification	Seminole	FDOT	2012	$875,259
4/11/2012	20848-2	LWR at Wallington Drive Emergency Repair Project	Orange	OC	2012	$981,000
9/4/2012	131629-1	Wekiva River Erosion Repair, Stabilization for Sanlando Springs Run	Seminole	The Springs Community	–	–
5/8/2013	133762-1	Sherry Drive Bridge Replacement	Orange	OC	–	–
5/29/2013	134460-1	Calabria Drive Outfall pipe repair	Seminole	COAS	2013	$196,683
5/29/2013	22550-7	Seminole Wekiva Trail, Phase 4	Seminole	SC	2014	–
10/16/2014	133762-2	Sherry Drive Bridge Replacement	Orange	OC	–	–
1/30/2015	20848-3	LWR Erosion Control Project	Orange	OC — Never Issued	–	–
2/9/2015	20848-4	LWR Erosion Control Project North of Gusty Lane, North of Kathleen, Edgewater Dr.	Orange	OC	8/2/2016 1/10/2019	$438,323 $559,790
11/3/2016	133762-3	Sherry Drive Canal Bank Erosion Protection	Orange	OC	3/30/2019	$1,784,979
8/30/2017	56491-4	Riverside Acres Erosion Restoration/Stabilization Project	Orange	OC	7/3/2018	$220,210

Table 1. Little Wekiva River (LWR) Erosion and Sedimentation Control Permitting — *Continued*

Date of issuance	Permit #	Description	County location	Agency receiving permit	Project completion date	Project completion cost
7/25/2019	157229-1	LWR Erosion Control between S.R. 436 and S.R. 434, Projects 1–9	Seminole	COAS	2020	$5,934,899
11/2/2019	157229-2	LWR Erosion Control between S.R. 436 and S.R. 434, LTR of Consent Project #9	Seminole	COAS	2020	Included in 157229-1 above
3/10/2020	66902-3	S.R. 434 Box Culvert Clearing/Ditch Maintenance	Seminole	FDOT — Exemption Issued	2021	$254,016
12/30/2020	20848-5	LWR Erosion Control Project North of Gusty Lane, North of Kathleen, Edgewater Dr.	Orange	OC	Ongoing	$2,098,734
Pending	164850-1	Drainage Improvements, Willow Avenue — Alhambra Ave, North of Lake Harriet	Seminole	SC	–	–

Analysis of Operations and Maintenance

Seminole County:

The operation and maintenance of Seminole County's stormwater management system, which includes the series of culverts, structures, ponds and conveyance systems that safely convey and provide treatment to stormwater runoff, is managed under the county's National Pollutant Discharge Elimination System Permit (NPDES) FLS000038. Under this permit, the county maintains an inventory of its municipal separate storm sewer system (MS4) and operates it in a manner to reduce the discharge of pollutants to the maximum extent practicable. The NPDES permit also requires the county to conduct inspections and maintenance of this MS4 system. The MS4 inspection and maintenance program is conducted county-wide and in compliance with the inspection frequencies and maintenance requirements of the NPDES permit. Maintenance activities include litter collection, roadway repair, sediment removal from stormwater structures and culverts, pipe re-lining, street sweeping, and illicit discharge inspection and elimination. Seminole County also has a robust Adopt-A-Roadway and Adopt-A-River program and incorporates storm drain labeling into its education and volunteer programs.

The county's stormwater inspection and maintenance activities are tracked and recorded county-wide which includes annual inspections of the major outfall points to the Little Wekiva River. Per the NPDES permit, the county also must provide adequate funding sources to conduct the county-wide stormwater inspection and maintenance program. The average annual roads and stormwater maintenance budget attributed to compliance with the NPDES permit is $6,500,000.00. Although the tracking and funding is not specific to the best management practices or projects specifically along the Little Wekiva River, the county-wide NPDES program funding is sufficient to maintain the operation of the county-wide MS4 system and includes inspection and maintenance of the MS4 system within the Little Wekiva drainage basin.

City of Altamonte Springs:

The City of Altamonte Springs annual operation and maintenance costs related to the Little Wekiva River can vary significantly annually and would not be quantified separately from city-wide stormwater operation and maintenance costs unless a specific project could not be performed in house or requires SJRWMD permitting (see projects specifically listed in Table 1 above). Stormwater operation and maintenance annual expenditures and projected budgets are reported in the annual NPDES reports submitted by the city to FDEP and range in recent years from $2.2 to $6.7 million annually. Specific to activities within the river, the city performs an inspection of the river between S.R. 436 and S.R. 434 annually and after major storm events. Some minor repairs are performed while city staff are in the river, including but not limited to the following: minor repairs of gabion structures and reno mattress wiring; minor vegetative removal; and removal of obstructions. Site visits and inspections of privately-owned properties are performed in response to resident requests and concerns. In general, outside of damage from Hurricane Irma, the erosion control countermeasures along the river have held up well. The gabions under the bridge at the Seminole Wekiva Trailhead require the most frequent repair due to vandalism followed by the reno mattresses.

The city has a standing policy to remove the portion of fallen trees and/or tree debris from the river that are blocking or diverting flow, regardless of whether the tree has fallen from public or private properties. Some years that may be none, one or many with costs varying between $3,000 and $5,000 per tree. In 2017 and 2018, the years following Hurricanes Matthew and Irma respectively, there were trees or vegetative debris the entire length of the river within the city limits (S.R. 436 to S.R. 434) resulting in costs of $154,497 and $199,097.

In addition to in-river maintenance, in the late 1990's the city installed sedimentation boxes within the drainage basin to reduce sediment loading to the river at a cost of approximately $268,500. These boxes are serviced periodically by city employees with city vehicles (vactor trucks) along with other existing stormwater infrastructure within the city's MS4, however those costs are not quantified separately from city-wide operation and maintenance costs. Since 2001, the City has been performing city-wide street sweeping services on a regular basis. The city employs two full time drivers and has two street sweepers in its vehicular fleet. Taking into consideration the cost of street sweepers (approximately $300,000), life cycle, employee time and disposal of street sweepings, this program costs roughly $200,000 annually.

FDOT

District Five has an established robust and effective stormwater management program which includes the routine inspection and maintenance of the stormwater collection, conveyance, and treatment systems located within the FDOT right-of-way. Stormwater management activities include, but are not limited to: street sweeping, litter and debris collection, illicit discharge inspection and elimination, inlet and pipe desilting, roadway repair, and the inspection and maintenance of stormwater treatment facilities. These services are performed by a mix of consultants, asset management contractors, and FDOT maintenance personnel. Services provided under contractual agreement typically cover large regional areas such as roadway corridors or an entire county. Due to the nature of asset management contracts and the large area of coverage, the ability to develop a cost estimate for operation and maintenance activities for specific project areas is difficult. FDOT's annual operation and maintenance costs for Seminole County is estimated to be $1,099,500.00. This cost estimate is based on certain work activities completed within Seminole County during the 2019-2020 fiscal year and may not reflect all operation and maintenance costs.

FWC

FWC provided the following information regarding aquatic management in the Wekiva River area (Orange and Seminole counties) from July 2010 through April 2021. The program consisted of 425 events (58 since January 2018) with a total budget of slightly more than $726,000 to treat floating plants, trees blocking navigation, and specifically identified species.

Compliance Review

As the 2005 Report indicates, this area of the Little Wekiva River basin was largely developed prior to current stormwater regulations. The volume and rate of unabated runoff from this early development, including private property, continues to contribute to the erosion of the riverbed, banks, and the downstream transport of sediments. Since 2005, SJRWMD has issued permits to hundreds of projects within the study area of the 2005 Report. Each of these projects are required to implement and maintain proper erosion, sediment, and turbidity controls during construction activities to prevent the off-site discharge of sediment and turbid waters. In general, there have been occasions where erosion, sediment, and turbidity control measures are not properly maintained and the off-site discharge of sediment and turbid waters could have occurred. Additionally, rainfall events can occur in excess of the design capacity of these measures, resulting in the potential for off-site discharge of sediment and turbid waters.

SJRWMD and FDEP reviewed permits and compliance items in the Little Wekiva River and Little Wekiva River Tributaries Surface Water Basin boundaries as defined in the scope of the Act. Permits issued in 2013 or later identifying the Little Wekiva River as the receiving waterbody were reviewed as a potential source of erosion and sedimentation. Permit related compliance items were reviewed to select those items adjacent to the Little Wekiva River north of 436. That list of permit related compliance items was further reduced to those identifying erosion or sedimentation within the Little Wekiva River as a concern.

Table 2. Compliance review summary table

Permit ID	Site name	Date of discovery	Permittee
62355	I-4 Ultimate: I-4 Mainline from E. of Central Pkwy. to E.E. Williamson Rd.-Area 4D Pkg 51	3/11/2019 7/8/2020 11/13/2020	Florida Department of Transportation
157229	Little Wekiva River Erosion Control between S.R. 436 and S.R. 434, Projects 1-9	3/18/2020	City of Altamonte Springs
159939	Rooms To Go — Wekiva Trail	8/16/2021	G & J Management Company

Seminole County submitted a compliance list that coincided with the list in Table 2 above.

The City of Altamonte Springs also performed an analysis of sites developed within the city limits from 2014 to current, focusing on the areas west of I-4, north of S.R. 436, and south of S.R. 434. The following construction sites were documented to have had erosion issues. Only one site, Rooms to Go, was found to have directly discharged turbid waters to the Little Wekiva River. The I-4 Ultimate Project and City Furniture discharged turbid water to a city-owned stormwater pond.

- I-4 Ultimate Project (Permit ID 62355) — Erosion control issues confirmed multiple dates between 2016–2019
- Rooms to Go (Permit ID 159939) — Erosion control issues, two dates: July 8, 2021 and 19, 2021
- City Furniture — Erosion control issues confirmed multiple dates in July 2020 and August 2020

No non-permit related compliance items were identified as a potential source of erosion and sedimentation. However, it should be noted the majority of the riparian properties along the stretch of Little Wekiva River between S.R. 434 and S.R. 436 are private properties built prior to modern stormwater rules and permitting. Areas of erosion or activities contributing to sediment transport or turbidity may not have required permits and may not have been reported or inspected. Erosion and sediment transport could also have been gradual and undetected. Note, land use activities and corresponding erosion effects are not subject to regulatory purview in most cases. This review focused on the three permits identified in Table 2 above and a compliance issue reported to FDOT.

These three permits had a total of five associated compliance items that addressed possible turbidity and debris in the Little Wekiva River and flooding of offsite property. Each item identified was investigated by SJRWMD staff. Permittees implemented corrective actions and specific management control strategies to reduce the risk of future incidents.

For Permit ID 62355, District staff received a citizen complaint of turbid water and conducted an inspection of the outfall structure near Ginger Ale Springs. The Ginger Ale Springs outfall receives drainage from both Seminole County's and the FDOT's MS4. At this inspection, SJRWMD took a water quality sample and determined the site was in violation of water quality standards for turbidity for discharge into an Outstanding Florida Water (OFW). SJRWMD staff and the permittee's contractor investigated the area. Based on the investigation, an outfall structure in the FDOT stormwater pond that eventually flows into the Little Wekiva River adjacent to Ginger Ale Springs was not in compliance with best management practices. However, the pond in question had extra storage and was not discharging during the investigation. SJRWMD could not confirm the source of the turbidity at this time. However, SJRWMD staff determined sediment could have been introduced into the system which could have caused an overflow with turbid water into the outfall that discharges into the Little Wekiva River. As a result of SJRWMD findings, a Compliance Warning Letter was sent to the permittee.

As a recognition of the importance of the watershed and in partnership with the SJRWMD and the community, the permittee committed to enhance water quality protections by going above and beyond permit requirements for site compliance inspections (including every rain event), provide extra treatment of the stormwater leaving the site to remove turbidity, restore and stabilize all baffles and berms in the area, enhance contractor training for erosion and sediment control measures, desilt and video-inspect pipes that lead to the discharge, and coordinate with the local MS4 to investigate stormwater pipe system that directs water to the Little Wekiva River. All commitments of the permittee have been completed, documented and confirmed by SJRWMD. The investigation of the connectivity of the stormwater system is on-going.

In addition to incidents related to the three permits in Table 2, FDOT reported a citizen complaint they received related to a turbid discharge bubbling up from a drainage structure on the east side of Markham Woods Road in late September 2020. The FDOT contractor, SGL, determined the source of turbid water was from the I-4 Westbound Rest Area construction. Specifically, from an outfall pipe on the western side of the rest area adjacent to the Seventh Day Adventist Church on Markham Woods Road. This structure conveys storm water from the rest area ponds and connects to Seminole County's MS4 system near Markham Woods Road. From there the discharge flows north along Markham Woods Road into a wetland system which crosses under the road and eventually discharges into a large wetland system, which (via a canal) leads to another wetland system that is adjacent to the Little Wekiva River. The cause of the turbid water was determined to be damaged exfiltration system cleanout caps from a pond that contained turbid water. Upon discovery, new cleanout caps were installed to prevent further turbid discharges from the pond. Additionally, the rest area pond outfalls were plugged to prevent possible discharge of turbid water and additional BMPs were installed around the rest area and the rest area outfall pipe. Rain event site inspections were performed by FDOT and their consultant to ensure these corrective actions were functioning. FDOT provided SJRWMD a synopsis of the BMPs implemented to address the turbidity. No enforcement action was brought by either SJRWMD or FDEP. During a rain event inspection on Feb. 19, 2021, no turbid water was observed discharging from the rest area.

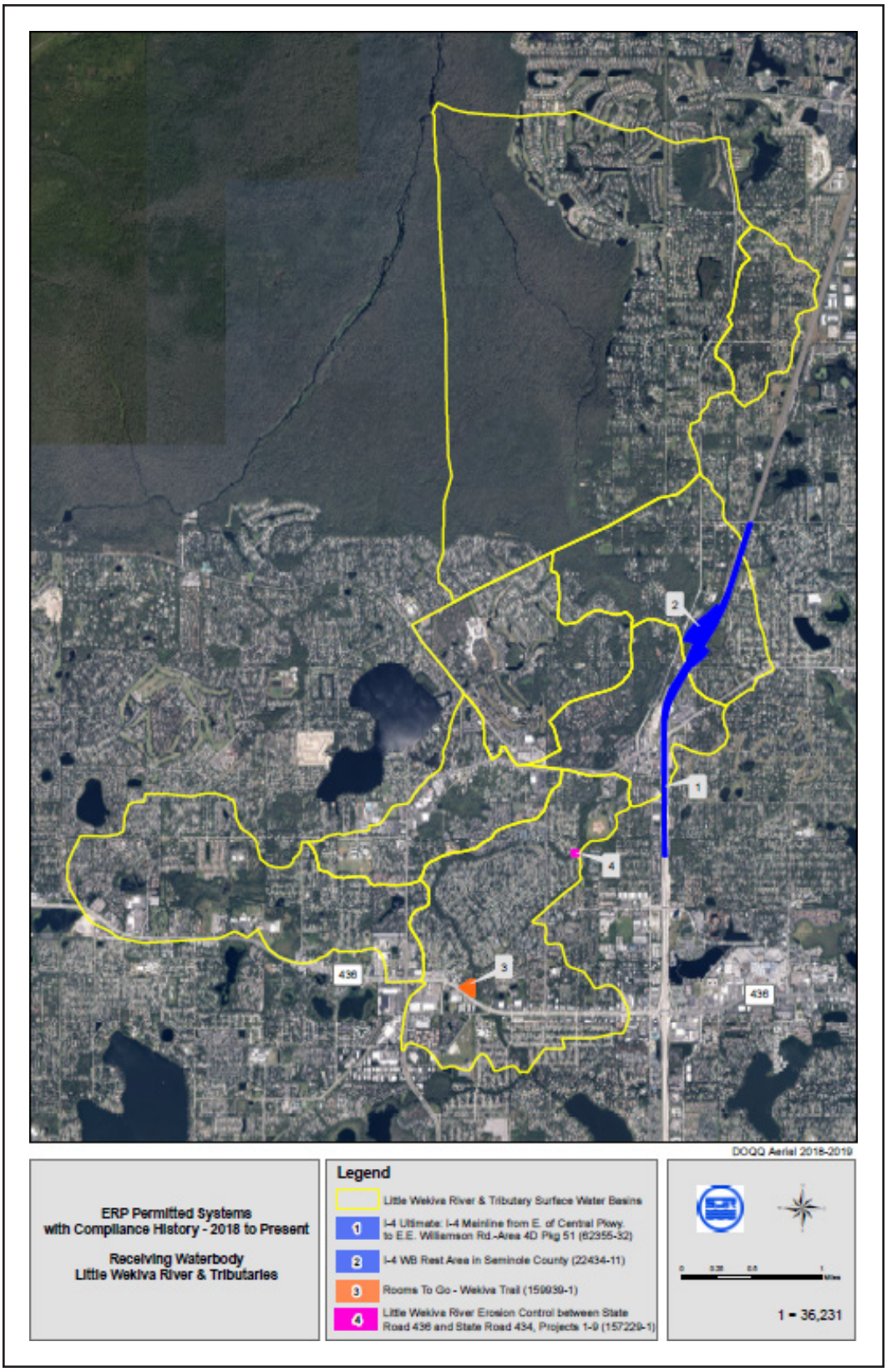

Figure 1. ERP Permitted Systems with Compliance History — 2018 to Present

Analysis of Significant Storm Events

There were several significant storm events affecting the majority of the Little Wekiva watershed during the 2005–2021 period. Seven named and one unnamed tropical storm passed over or near the basin (Figure 2). Available data show that five of these events resulted in discharge in the Little Wekiva greater than 207 CFS, or the 95th percentile (Figure 2). This discharge level was chosen because it represents conditions where significant sediment movement or accumulation may be expected to occur in the river based on observations and best professional judgements of the local governments monitoring conditions and complaints in the area.

There were also 61 precipitation events wherein total average rainfall exceeded 1.57 inches over the entire basin (Figure 2), which represents the 99th percentile. This rainfall threshold was chosen because it represents conditions where significant turbidity could be produced in individual stormwater systems, particularly poorly maintained, or failing systems. Many of these smaller, non-named storm events did not result in corresponding elevated discharge in the river. However, some precipitation events were associated with increased discharge, possibly because of antecedent wet weather. For example, both the summer/fall of 2005 and 2018 had periods of elevated river discharge in the absence of named tropical storms (Figure 2).

The City of Altamonte Springs provided detailed records of erosion complaints and maintenance records for the 2005–2021 period. These records were paired with the set of named storms and significant rainfall events to evaluate effects of regional rainfall on sediment delivery to the Little Wekiva River (Appendix A, Table A1). There was not a strong correspondence between significant rainfall events and reported erosion issues, as would be expected if local rainfall was a strong causative factor in river sediment accumulation. Many erosion reports in the Altamonte Springs records turned out to be highly localized homeowner drainage issues and/or lack of securing the banks of the private properties along the river upon inspection. Many of the remaining reports involved downed trees resulting in temporary flow blockages and localized erosion. Five erosion reports followed Hurricane Irma (September 2017) over the next few months following the storm so there is some evidence of erosive activity and possible sediment transport with that event. From the summer of 2018 to present, the City had at least ten reported erosion events. Some of those reports temporally coincided with rainfall events on 6/9/19, 12/17/19, 7/10/20, and 8/9/20.

Seminole County provided maintenance records for MS4 permitted structures (Appendix A, Table A2). One record indicated 6 cubic yards of sediment was removed from a baffle box adjacent to the Little Wekiva River for maintenance on 5/28/19, which was near a significant rainfall event (Figure 2). No other records indicate issues with erosion, sediment accrual or removal. Seminole County also conducts damage assessments to the Little Wekiva River after hurricane events as part of their emergency management plan. Photos of the Little Wekiva River after Hurricane Irma in 2017 are attached.

A review of SJRWMD permit compliance issues showed six events that may have contributed sediment to the Little Wekiva River north of S.R. 436 (Appendix A, Table A2). Only permit 62355, sequence number 32, was associated with a significant non-named rainfall event on 7/1/2017. The remaining permit issues did not appear to be related with any significant, individual rainfall events.

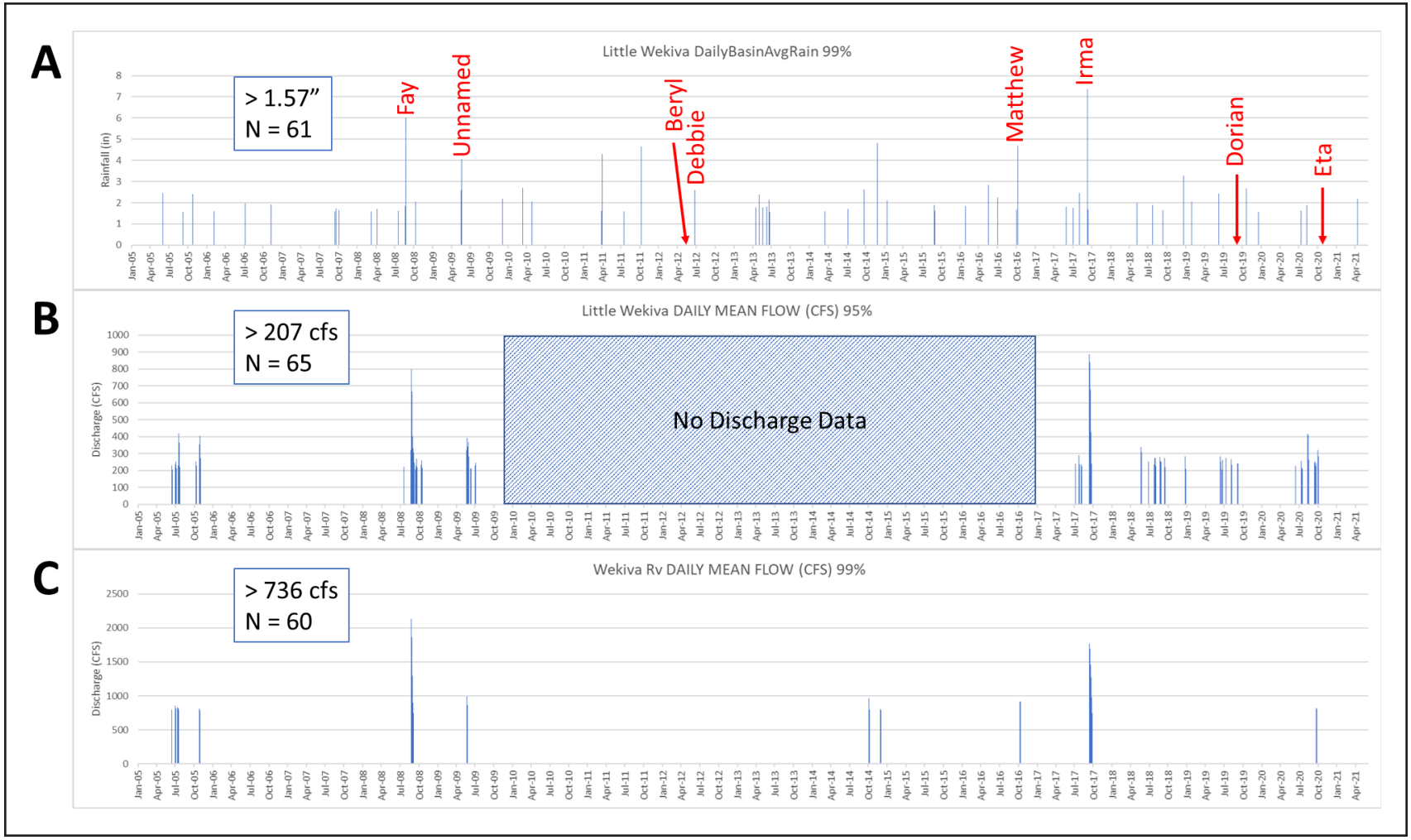

Figure 2. Hydrology data for the Little Wekiva and Wekiva River basins 2005–2021. A) Little Wekiva River total average basin rainfall. B) Little Wekiva River discharge. C) Wekiva River discharge.

Analysis of Stream Channel and Sediment Movement

FDOT contracted with the consulting firm Ayres, in summer/fall 2021, to perform a geomorphic evaluation of the Little Wekiva River north of S.R. 434 (report Appendix B) to help assess stream characteristics. Several types of data were analyzed and collected, including cross sections, relative elevations, flow velocities, channel slope, and current and historic imagery. Ayres concluded:

> **Erosion & Transport from Upstream and Deposition Downstream:** Stream dynamics and slope evaluations show that the lower reaches are mostly likely a depositional sink for natural upstream erosion exacerbated by urbanization and channel encroachment.
>
> **Persistent and Consistent Erosion and Sedimentation Issues System-wide:** Erosion and sedimentation issues have been a consistent problem in this watershed as documented in Watershed Management Plan from 2005 (CDM, 2005). Substantial investment has been made in the upper portions of the stream and watershed to mitigate these issues likely pushing the sedimentation problem further downstream into more rural and natural stream segments.
>
> **Plant Stabilizing Sediment Deposits:** Aquatic plant species tend to stabilize unwanted deposition in many parts of the county. Several plant species were observed during field reconnaissance in depositional areas within the lower reaches. These plant species exacerbate sedimentation issues by increasing channel roughness, lowering velocities, and therefore further increasing sedimentation.
>
> **Development Encroachment Limits Natural Stream Adjustments to Disturbances:** By encroaching on stream systems, we limit the natural ability of streams to adjust to watershed disturbances. The natural tendency of a stream with an urbanized watershed is to become more sinuous to lower the slope and limit the erosion that occurs because of increase runoff and peak flows from developed land covers. Without the ability to adjust to a new hydrologic regime the channel will continue eroding until mitigation is installed.

SJRWMD performed annual survey cross sections at seven sites in the Little Wekiva watershed (Figure 3). Data acquisition took place 2001–2017; although, some cross sections were not performed in some years because of access or workload issues. Table 3 shows the lowest depth recorded for each cross section. Cross sectional area was not calculated so lowest depth was used to infer stream channel morphology and conveyance.

Over the 17-year dataset, all sites had years with both sediment accrual and loss, suggesting that the extant bedload in the river is mobile and subject to movement during high discharge events (Table 3). The range of depth change among sites was relatively similar, ranging from 1.2–3.6 feet. The survey data did not demonstrate any consistent latitudinal movement of sediments downstream. In fact, downstream sites had cumulative sediment losses while upstream sites tended to have cumulative accrual.

Elevation range and cumulative change did not appear related. However, the Riverside Park North site had both the largest elevation change and greatest sediment accrual. Sediment accrual appeared to occur steadily at this site between 2003 and 2006, suggesting cumulative watershed effects rather than any specific event.

Six named stormed events occurred during this 17-year dataset (Figure 2). Only Fay appeared to have any substantial effect on sediment elevation. The Riverside Park Road South, Needles Road, and Lotus Park sites all had their greatest annual sediment elevation change between the 2008 and 2009 sample events, possibly due to

Hurricane Fay. It is difficult to connect other, smaller annual elevation changes with specific storm events. The two downstream sites (The Springs and Little Wekiva Road) remained relatively unchanged and did not appear to have any storm-related sediment accumulation.

SJRWMD minimum flows and levels (MFL) field work corroborates these findings. Two transect sites north of S.R. 434 demonstrate sediment accumulation over time (Appendix A, Figure A1-1). The northern Sabal Point transect showed significant sediment accrual between 2013 and 2021 (Appendix A, Figure A1-2), which appeared to displace the main channel to the west from its historical footprint. However, historical imagery suggests that this area has potentially captured sediments in the past and can have dynamic channel migration (Appendix A, Figures A1-3 and A1-4). The southern Springs Landing Blvd. site also appeared to have net sediment accruals of 0.5–1.0 feet from 2017–2021 (Appendix A, Figure A1-5).

Several past studies have been conducted regarding erosion and sedimentation in the Little Wekiva River and they are summarized in Appendix A, Exhibit A1.

Documentation of FDEP Biorecon of the river and a map of the sites visited in fall 2020 are shown in Appendix A, Figure A1-6 on pages 38–44.

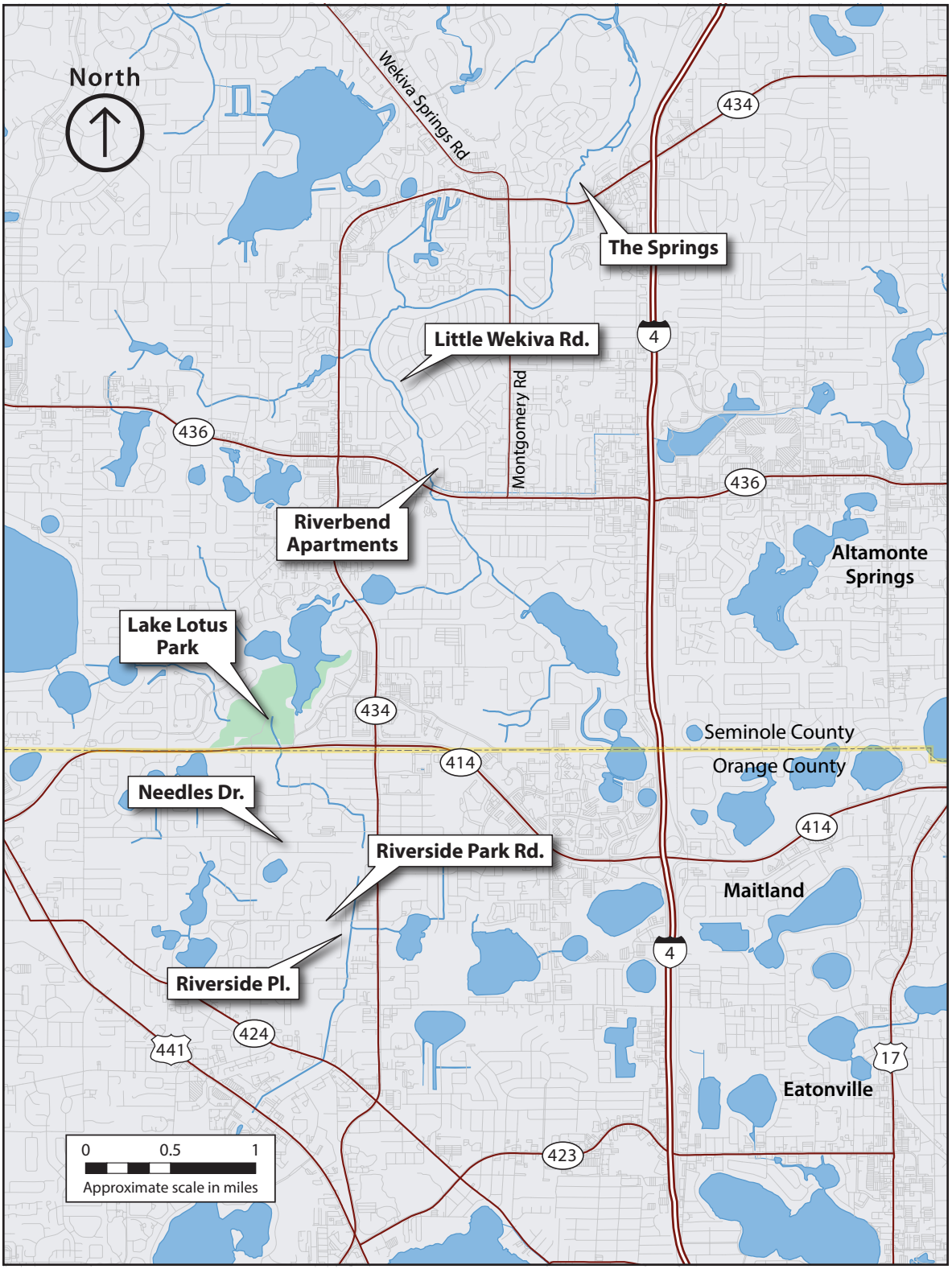

Figure 3. Approximate locations of the Little Wekiva River cross sections performed 2001–2017.

Table 3. Lowest recorded depth for each Little Wekiva cross section 2001–2017.
Elevation (feet, NGVD 29)

Year	The Springs	Little Wekiva Rd	Riverbend Apts	Lotus Park	Needles Rd	Riverside Park Rd N	Riverside Park Rd S
2001	22.4	–	40.2	53.4	64.7	67.2	67.8
2002	21.8	–	41.2	55.6	63.9	66.5	67.7
2003	21.6	32.0	39.6	54.5	63.2	66.3	67.3
2004	22.3	31.8	39.2	54.2	63.4	67.1	67.5
2005	–	–	–	–	–	–	–
2006	21.6	33.2	39.5	54.8	63.0	69.9	68.4
2007	20.8	32.9	39.3	54.5	62.9	69.7	68.3
2008	22.4	32.4	39.8	53.5	63.2	69.8	68.4
2009	22.0	32.3	38.7	54.4	62.0	69.8	67.2
2010	21.6	32.6	39.4	53.4	61.9	69.7	67.9
2011	21.8	33.0	39.0	53.4	63.0	69.8	67.7
2012	21.7	32.9	39.2	53.8	63.4	69.2	67.6
2013	21.7	–	–	53.8	–	–	–
2014	20.6	31.8	39.0	54.4	63.4	69.7	67.5
2015	–	–	–	–	–	–	–
2016	–	–	–	–	–	–	–
2017	21.5	–	38.8	54.4	63.4	69.8	67.4
Range	**1.8**	**1.4**	**2.5**	**2.2**	**2.8**	**3.6**	**1.2**
Cumulative	**-0.9**	**-0.2**	**-1.4**	**1.0**	**-1.3**	**2.6**	**-0.4**

Summary and Recommendations

The 2005 WMP report documents the extensive history of stormwater quantity and quality problems within the Little Wekiva River Basin and states that the combined effect of channelization, urbanization, and the loss of the river's natural floodplain aggravated sedimentation problems along the river. Historic aerial photos show sediment movement in the river dating back to the 1940s and 50s (see Appendix A, Figures A1-3 and A1-4).

There were several significant, named and unnamed tropical storm events affecting the majority of the Little Wekiva watershed during the 2005–2021 period that exhibited conditions where significant sediment movement, or accumulation, may have been expected in the river. Moreover, there were also 61 precipitation events wherein total average rainfall exceeded the 99th percentile of rainfall and represents conditions where significant turbidity and sedimentation could be produced in individual stormwater systems.

Changes in rainfall patterns and storm intensities, including more frequent and intense tropical storms, could have multiple impacts to the basin including an increase in the potential for flooding, stormwater runoff, and sediment movement within the river. To help minimize some of these potential impacts, SJRWMD is evaluating enhanced permit review and compliance for the Wekiva Basin.

Due to these factors and a lack of quantified data about the amount of historic sediment accrual and movement in the river, the scientific evidence is lacking to determine the contribution of sediment load from any individual source, current or historic. General sediment accumulation and movement patterns strongly suggest that aggregate effects of basin urbanization, particularly prior to modern stormwater rules, are responsible for the majority of historic and current sediment issues.

The consulting firm Ayres similarly concluded based on their site assessment and analysis that stream dynamics and slope evaluations show that the lower reaches are most likely a depositional sink for natural upstream erosion exacerbated by urbanization and channel encroachment; erosion and sedimentation issues have been a consistent problem in this watershed; observed plant species exacerbate sedimentation issues by increasing channel roughness (Note: local observations from area residents indicate plant growth in depositional areas occurred after the channel was filled in with sediment.), lowering velocities, and therefore further increasing sedimentation; and without the ability to adjust to a new hydrologic regime due to development along the river, the channel will continue eroding until mitigation is installed. These conclusions are consistent with the 2005 WMP and observations of environmental professionals with the cooperating local and state government agencies.

Following are a list of recommended studies and projects that will benefit the river and are based on the findings summarized above. In short, sediment removal projects, such as dredging and properly located and managed sediment traps, should be the focus of future projects to best improve sedimentation issues in the river. Furthermore, consistent and long-term in-stream maintenance activities (e.g., sediment removal, invasive plant control, etc.) are vital.

Recommended Studies

Baseline Survey of Little Wekiva Streambed Cross Sections

This project has commenced and is funded by Seminole County. Orange County completed a similar detailed survey of stream cross sections for the upper reach of the river. Seminole County has recently contracted to complete the next phase of that survey from the county line north to the preserve. This survey includes 133 stream cross sections and 110 lateral stormwater pipes. Collectively, the Orange and Seminole County surveys will provide an important baseline dataset that can be used to monitor and track potential changes in sediment accumulation.

Estimated cost: $176,835

Recurring Stream Survey Cross Sections

To understand and monitor the benefits of the projects proposed in the 2005 Watershed Management Plan, the working group determined that sediments in the river should be periodically monitored. Annual cross section surveys were performed from 2001 through 2017 at seven strategically picked sites in the Little Wekiva throughout Orange and Seminole counties. These survey data have been valuable in understanding how dynamic the sediments are in the river, how they respond to precipitation events, and how they respond to development in the basin. As development continues and stormwater retrofits are implemented, periodic surveys should be continued to both identify the benefits of erosion controls and identify emerging sedimentation issues.

Estimated cost: $16,500/yr

Environmental Monitoring

Sedimentation and stream channel changes affect the Little Wekiva River ecosystem. As surveys in the preserve have demonstrated, accumulated sediments can promote the invasion of exotic plant species. These plants can anchor sediments, serving as a physical barrier and increasing local sedimentation. These physical alterations to the river affect fish passage, wildlife movement, and avian use. To guard against invasive species and corresponding environmental effects, routine biological monitoring would ideally be paired with the recurring stream surveys. This would provide a more comprehensive assessment of the river's condition and provide early warning data of impending management issues.

Estimated cost: $23,000/yr

Site Specific Monitoring

Storm water systems are not designed to track sediments and it is very difficult to identify the source(s) of accumulated sediments. However, we know that the stormwater system as well as ongoing erosion of riverbanks are the ultimate source of new sediment entering the river. To understand the effects of individual projects on sedimentation, it will be necessary to perform site-specific monitoring. Storm event turbidity and sediment monitoring should be performed at:

- Stormwater outfalls with signs of sediment inputs
- Newly permitted stormwater inputs to the river
- Retrofits to existing stormwater conveyances
- Extensions or tie-ins to existing stormwater conveyances

Estimated cost: $2,500/site per year

Recommended Projects

Sediment Removal Project — Lake Lotus, City of Altamonte Springs

Lake Lotus is located in South Central Seminole County in the City of Altamonte Springs within the Little Wekiva River Basin and along the course of the Little Wekiva River. Main tributaries to the lake include the Little Wekiva River from the south, an unnamed tributary via a large floodplain wetland from the southeast (outfall from Lake Bosse) and an unnamed tributary from the northwest. The lake discharges northeast to Trout Lake, which discharges to the Little Wekiva River. Lake Lotus is approximately 110 acres and rather shallow, ranging in depths of 4 to 7 feet.

Urbanization in the lower reaches of the Little Wekiva River began in the 1950s and greatly accelerated in the 1970s. Overall, urbanization has reduced the habitat quality in the basin, particularly in this portion of the Little Wekiva River and in Lake Lotus. Chronic deposition of sediment at the confluence of the river and the lake has been documented by several agencies throughout the years. A list of reports and studies of the Little Wekiva River basin is attached for reference (Appendix A, Exhibit A1).

In 2003, the United States Army Corp of Engineers prepared a preliminary restoration plan for Lake Lotus for SJRWMD and the City of Altamonte Springs. The purpose of the project was to provide stream and riparian habitat restoration along the Little Wekiva River just upstream of Lake Lotus and floodplain and shoreline habitat restoration near the southern portion of the lake at the confluence of the river and the lake. At the time, it was estimated that a total of 18,057 cubic yards of sediment should be removed from the stream, floodplain and shoreline of the lake. The restoration plan included planting of native wetland vegetation and stream bank stabilization, for an estimated total cost of $1.15 million. Unfortunately, the project never moved forward beyond the proposal stage.

In 2007, SJRWMD authorized URS Corporation to start work on the Lake Lotus Restoration Plan. A draft conceptual plan was issued in September 2007, incorporating dredging of sediment deposits along the southern shoreline of the lake and the confluence of the Little Wekiva River and planting of native vegetation. To this date, no work commenced as a result of this conceptual plan.

In 2021, city staff performed a tabletop volumetric estimate of the sediment in Lake Lotus based on aerials and the bathymetric survey. The City estimated 24,019 cubic yards of sediment should be removed from the stream, floodplain and shoreline of the lake. The sediment deposition continues to reduce the quality of habitat adjacent to and in the southern portion of Lake Lotus, including wetlands and shoreline habitat that provide spawning areas for fish. The removal of the sediment at the confluence of the river and lake would provide optimal floodplain and habitat restoration.

In response to Senate Bill 976, the City of Altamonte Springs is recommending a future project to revisit the 2007 URS conceptual plan, updating the recommendations to reflect current conditions and providing a current cost analysis. The desired outcome would be that based on the updated conceptual plan, funding would also be received to move forward with sediment removal from Lake Lotus and habitat restoration along the southern shoreline.

Estimated cost: $1,150,000 in 2003 dollars

Sediment Removal Project — Little Wekiva River, Seminole County

Little Wekiva River downstream of the Springs development. Currently Seminole County is finalizing plans and supporting information for submittal of a permit application to remove sediment and nuisance vegetation for a segment of the Little Wekiva River downstream of the Springs and Springs Landing developments.

The proposed restoration area is approximately 4,000 LF in length and approximately 20 acres in total. This multi-agency, multi-jurisdictional project would provide much needed maintenance and restoration of the Little Wekiva River in this area. Proposed project activities include the harvesting of invasive plant islands, removal of deposited sediments within the river, re-contouring of historic meanders, and replanting with beneficial native plant species. The excess accumulated sediments and vegetation are causing the river to expand into the flood plain and potentially increase residential, commercial and municipal flooding.

Sediment Trap Project – Little Wekiva River, Seminole County

Seminole County is currently assessing the feasibility and location of a sedimentation pond upstream of the restoration project, as a part of its Wekiva Basin Study. Results of this assessment should be completed by summer 2022.

Appendix A

Table A1. Summary of erosion issues related to significant rainfall events reported by the City of Altamonte Springs.

Event Date	Rainfall amount (in)	Named event	Erosion issue reported
5/31/2005	2.45	–	
2005	–	–	707 Little Wekiva Road erosion — Property owner report erosion of private property
9/6/2005	1.57	–	–
10/24/2005	2.41	–	–
2/3/2006	1.60	–	–
7/6/2006	1.97	–	–
11/7/2006	1.92	–	–
9/13/2007	1.60	–	–
9/19/2007	1.72	–	–
10/2/2007	1.65	–	–
3/7/2008	1.58	–	–
4/5/2008	1.69	–	–
6/30/2008	–	–	River inspection conducted by City staff. Vandalism to gabions at San Sebastian trailhead noted by staff. Repairs completed, tree debris removed.
7/15/2008	1.62	–	–
8/20/2008	1.83	TS Fay	Flooding in streets in Spring Oaks neighborhood. No documented complaints regarding erosion.
8/21/2008	6.02	–	–
8/22/2008	2.73	–	–
10/9/2008	2.06	–	–
5/18/2009	2.60	Unnamed subtropical storm	–
5/19/2009	4.07	–	–
5/20/2009	2.66	–	–

Table A1. Summary of erosion issues related to significant rainfall events reported by the City of Altamonte Springs. — *Continued*

Event Date	Rainfall amount (in)	Named event	Erosion issue reported
12/4/2009	2.19	–	–
3/11/2010	2.71	–	–
4/25/2010	2.06	–	–
2/28/2011	–	–	–
3/28/2011	1.63	–	–
3/31/2011	4.30	–	Email from property owner at 515 Little Wekiva River regarding erosion of private property.
7/13/2011	–	–	River inspection conducted by staff. No major erosion issues noted.
7/15/2011	1.58	–	Inspection of river by city staff, reno mattresses required repair.
10/8/2011	4.65	–	–
3/29/2012	–	–	Email from 673 Little Wekiva Road, Spring Oaks, re: reno mattresses needing repair.
6/24/2012	2.61	TS Debbie	–
1/4/2013	–	–	Resident call about erosion at 625 Little Wekiva Road, site visit showed erosion was from private property downspouts.
4/14/2013	1.79	–	–
5/2/2013	2.39	–	–
5/20/2013	1.78	–	–
	–	–	Repairs to rip rap under Montgomery Road bridge. General maintenance of permitted rip rap, did not require SJRWMD permit.
6/6/2013	1.82	–	–
6/17/2013	2.13	–	–
6/21/2013	1.58	–	–
9/13/2013	–	–	Call from 407 San Sebastian Prado regarding erosion of private property.

Table A1. Summary of erosion issues related to significant rainfall events reported by the City of Altamonte Springs. — *Continued*

Event Date	Rainfall amount (in)	Named event	Erosion issue reported
12/5/2013	–	–	Permit for 455 Meander Drive — concrete wall/fence along LWR.
3/17/2014	1.58	–	–
	–	–	See SJRWMD permit #134460-1 Calabria Drive Outfall repair, required bank stabilization at 707 Little Wekiva Road to perform outfall repairs.
1/22/2014	–	–	Erosion at 459 N. Meander - site visit showed cause of erosion from downspouts of house (private property).
7/5/2014	1.69	–	–
8/28/2014	–	–	Erosion at Reserve at Wekiva Bend (private property).
9/23/2014	2.65	–	–
10/2014	–	–	River inspection by City staff. No repair items noted.
11/25/2014	4.82	–	–
1/12/2015	2.10	–	–
6/2/2015	–	–	Erosion issue at 449 N Meander Dr. Dispute between neighbors with underdrain behind wall and from roof drains on private property. Pipe was run to City property along river and was causing erosion from upland.
8/29/2015	1.89	–	–
8/31/2015	1.61	–	–
10/6/2015	–	–	443 N Meander Drive — erosion along side of private property. Site visit showed issue was with downspouts from home.
	–	–	701 Little Wekiva Road — trees down in river.
10/17/2015	–	–	Erosion along banks of Hidden Springs Condos, tree removal performed 03/2016.
11/18/2015	–	–	Erosion at 519 San Sebastian Prado. Site visit indicated erosion was from extended driveway on private property moving water towards river.

Table A1. Summary of erosion issues related to significant rainfall events reported by the City of Altamonte Springs. — *Continued*

Event Date	Rainfall amount (in)	Named event	Erosion issue reported
12/17/2015	–	–	Erosion issue at 411 San Sebastian Prado. Private property issue.
1/27/2016	1.83	–	–
5/17/2016	2.84	–	–
6/30/2016	2.26	–	–
10/1/2016	1.69	–	–
10/6/2016	4.68	Hurricane Mathew	–
	–	–	Email from Mary Brabham from Willie May Griffin regarding trees down in river, City already in proposal stage of removing trees between S.R. 436 and S.R. 434.
11/4/2016	–	–	Email from Victoria Nation SJRWMD erosion along 513 San Sebastian Prado, private property issue
5/30/2017	1.81	–	–
7/1/2017	1.75	–	–
7/31/2017	2.45	–	–
8/2/2017	–	–	Near Merrill Park, tree in river.
	–	–	EWP Tree Removal Project, from S.R. 436 to S.R. 434, completed August 2017.
9/10/2017	7.35	Hurricane Irma	See SJRWMD Permits 157229-1 and 157229-2
9/11/2017	1.68	–	–
	–	–	EWP Tree Removal Project, from S.R. 436 to S.R. 434 and Tributary through Merrill Park, completed November 2018.
9/22/2017	–	–	513 San Sebastian Prado, tree in river and erosion.
10/9/2017	–	–	Post hurricane erosion assessment.
1/8/2018	–	–	537 Little Wekiva Rd, erosion along private property.
5/6/2018	1.99	–	–
7/22/2018	1.89	–	–

Table A1. Summary of erosion issues related to significant rainfall events reported by the City of Altamonte Springs. — *Continued*

Event Date	Rainfall amount (in)	Named event	Erosion issue reported
8/22/2018	–	–	503 San Sebastian Prado, battling erosion issues of private property for several months.
9/9/2018	1.64	–	–
12/20/2018	3.28	–	–
1/27/2019	2.05	–	–
6/9/2019	2.43	–	–
7/15/2019	–	–	449 and 451 N Meander Dr. Erosion near river, erosion due to upland runoff (private property).
Circa 8/2019	–	–	Stone Creek at Wekiva; reclaimed water break blew out river bank, inspection also showed various deficiencies with permitted private stormwater system, including a stormwater pond bank that had blown out (private property).
10/19/2019	2.68	–	Info requested about City projects; residents at 419 San Sebastian Prado also experiencing erosion on private property.
12/17/2019	1.58	–	–
1/6/2020	–	–	Requested inspection for 613 Little Wekiva Rd, erosion and retaining wall failure (private property).
3/19/2020	–	–	451 N Meander Dr, City tract behind private property. Erosion addressed by City contractor.
4/4/2020	–	–	617 Little Wekiva Rd, call about tree in river
4/22/2020	–	–	677 Little Wekiva Rd, public records request about permits and LWR erosion control projects.
7/10/2020	1.63	–	–
7/16/2020	–	–	635 Little Wekiva Rd, called about recent flash flooding.
7/21/2020	–	–	891 Great Bend Rd, called about flash flood on July 15, downstream tree blockage and erosion on private property.

Table A1. Summary of erosion issues related to significant rainfall events reported by the City of Altamonte Springs. — *Continued*

Event Date	Rainfall amount (in)	Named event	Erosion issue reported
8/04/2020	–	–	607 Majorca Ave, called about the river flooding a couple weeks ago, stated that it's never been this fast/high before, not even during Irma, and that it's due the City's projects; also claiming 2-feet of private property loss.
8/9/2020	1.90	–	–
8/10/2020	–	–	643 Little Wekiva Rd, tree down and blocking flow.
8/17/2020	–	–	523 Little Wekiva Rd, called about erosion and debris (private property).
9/28/2020	–	–	Diane and Randall Mindrup at 725 Little Wekiva Circle (private property).
10/21/2020	–	–	Carlos Rivera and Yanira Feliciano, 623 and 625 Little Wekiva Rd. (private property).
4/11/2021	2.19	–	–
5/27/2021	–	–	Staff inspection of LWR, downed trees noted and City outfall requiring repair — currently working on RFP for removal of trees and scope for repairs to outfall.
4/12/2021	–	–	Mail from SJRWMD about 500 Yew Ct. (outside City)
7/8/2021	–	–	888 Little Bend Rd, tree removed from river.

Table A2. Maintenance records for Seminole County's MS4 permitted structures.

Asset #	Maintenance activity
S03835	No history of maintenance
S03791	No history of maintenance
S03841	No history of maintenance
S03794	No history of maintenance
S03839	No history of maintenance
S03779	No history of maintenance
S03832	No history of maintenance
S03697	6/5/19 — 1504 — Pipe repair minor — 1 repair
S03697	5/28/19 — 1571 — Filtration structure maintenance — cleaned pipe end — 6 cy
S03696	5/28/19 — 1571 — Filtration structure maintenance with above structure and included w/ wq
S03696	10/27/20 — 99613 — Pollution control inspection — 7 total
S20331	No history of maintenance
S20305	No history of maintenance
S20341	No history of maintenance
S02699	1200 — Manual ditch cleaning
S02699	4/2/13 — 1528 Mitered end repair minor — 1 repair
S02699	1/13/20 — Structure inspection — 1 each
S02699	3/3/14 — 99606 — Structure inspection — 1 each
S02050	4/11/13 —1528 — Mitered end minor — repair —1 each
S02050	7/7/20 — 99606 — Structure inspection
CNL252	7/9/14 — 1110 — Activity — 1 tree removal
CNL252	10/5/16 — 1573 — Activity — outfall maintenance — 1
CNL252	4/16/21 — 99615 — Activity — inspection
CNL469	No history of maintenance

Table A3. SJRWMD permit violations that may have contributed to sediment accrual north of S.R. 436.

Permit ID	Seq no.	Site name	Project acreage	Item	Item note	Date of discovery	Date resolved	Owner	Permittee
62355	32	I-4 Ultimate: I-4 Mainline from E. of Central Pkwy. to E.E. Williamson Rd.-Area 4D Pkg 51	0.089	1332664	Customer Inquiry regarding possible turbidity. SJRWMD regulatory scientist inspected construction site and determined site remediation was being conducted. Observed clear discharge.	7/18/2017	8/2/2017	Florida Department of Transportation	Florida Department of Transportation
–	–	–	–	1355632	Customer Inquiry from City of Altamonte Springs concerning flooding and turbidity from a construction site.	6/11/2018	9/27/2018	–	–
–	–	–	–	1368538	Customer Inquiry from FDEP concerning flooding into wetlands from a construction site.	3/11/2019	6/11/2019	–	–
157229	1	Little Wekiva River Erosion Control between S.R. 436 and S.R. 434, Projects 1-9	4.14	1389167	Customer Inquiry concerning possible flooding. SJRWMD engineer reviewed project and conducted a site inspection. Determined flooding was not a concern. Information shared with homeowner. Item resolved.	3/18/2020	3/20/2020	City of Altamonte Springs	Florida Department of Transportation
159939	1	Rooms To Go - Wekiva Trail	4.408	1426725	Customer Inquiry regarding debris (rocks and trees) in the river. SJRWMD regulatory scientist inspected the site along the river and did not observe any compliance issues. Item resolved.	8/16/2021	9/2/2021	Blue Ibis Atl Properties LLC	G & J Management Company

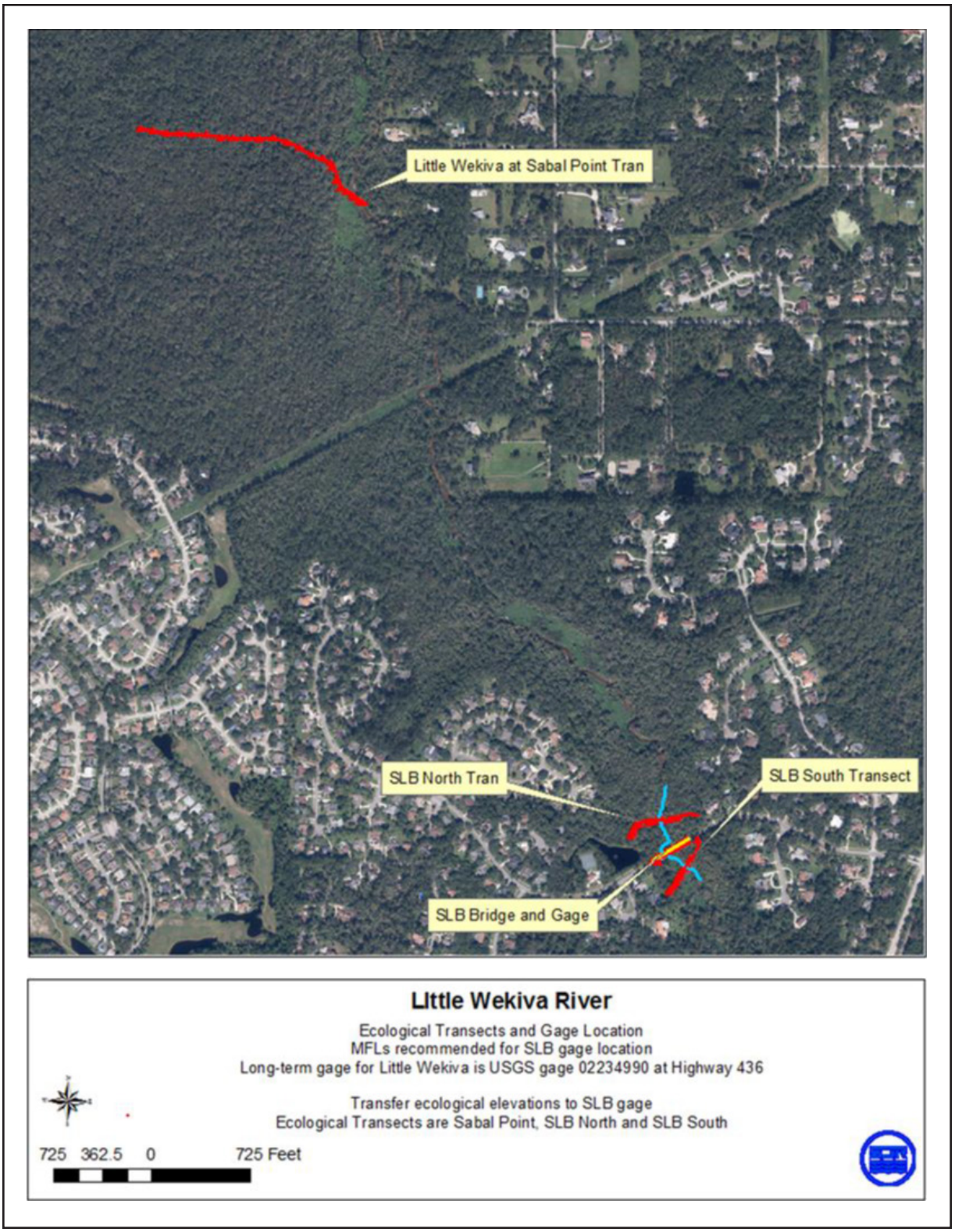

Figure A1-1. SJRWMD Little Wekiva River MFL transects north of S.R. 434.

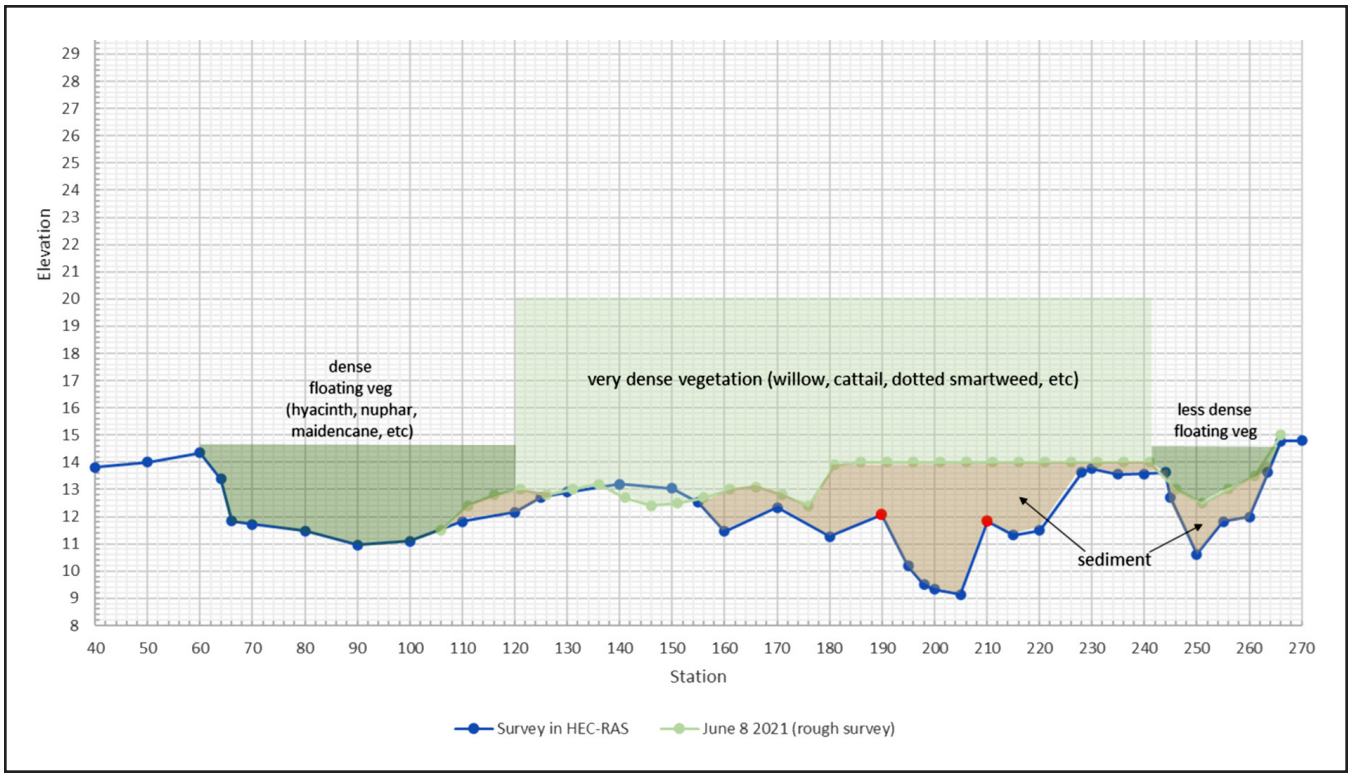

Figure A1-2. Sabal Point transect channel profile 2013 and 2021.

Figure A1-3. 1940 aerial imagery of the Sabal Point transect area.

Figure A1-4. 1957 aerial imagery of the Sabal Point transect area.

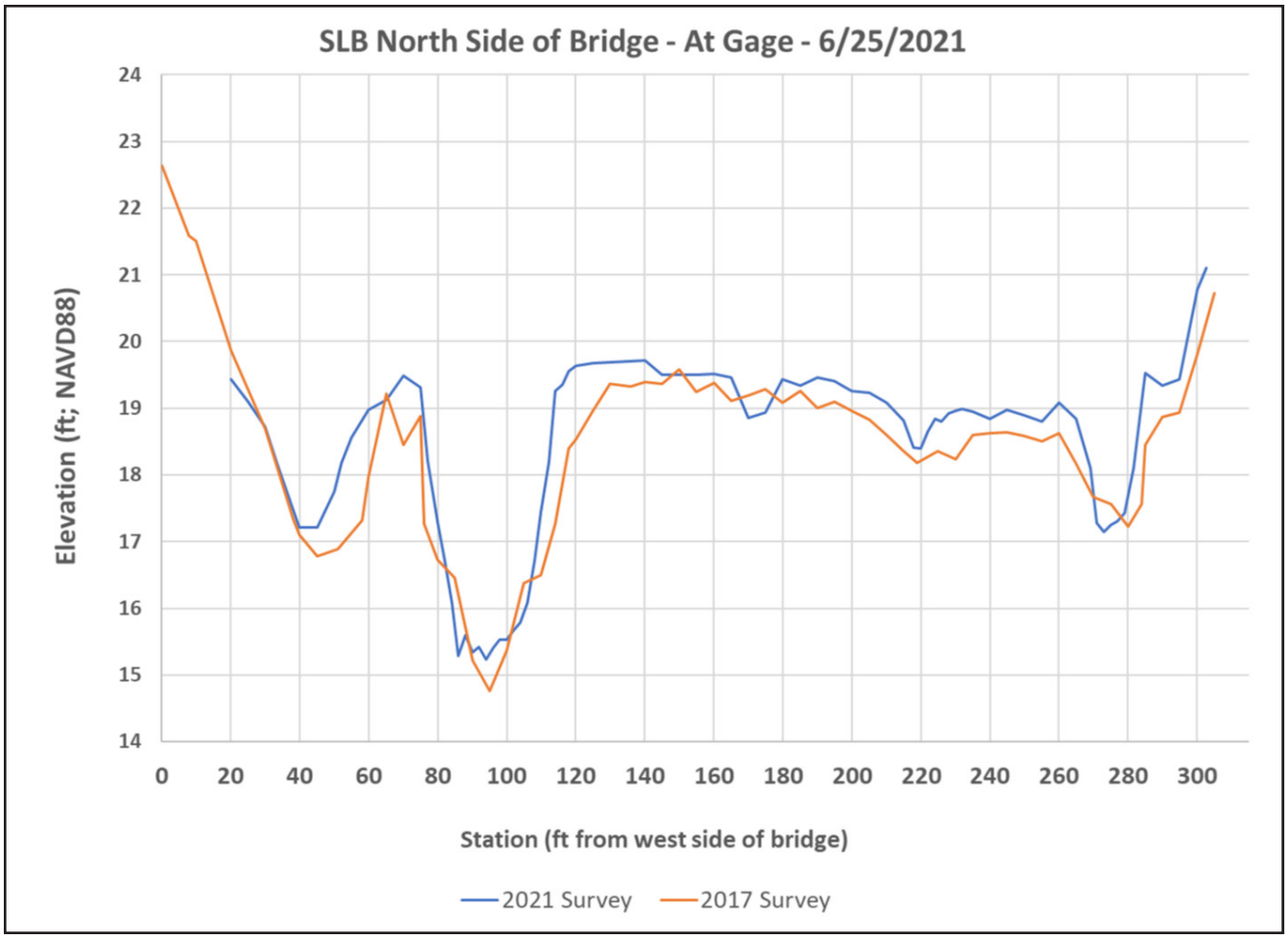

Figure A1-5. Springs Landing Blvd. north side MFL cross sections from 2017 and 2021.

Exhibit A1

Little Wekiva River and Lake Lotus

Review of Historic Erosion and Sedimentation Control Studies

The Little Wekiva River has a long documented history (back to 1960's) of erosion due to increased rates of volume, flow and velocities resulting from the urbanization of the watershed that has overtaxed the conveyance and sedimentation transport capacity of the river. In 1995 a Technical Working Group was formed to seek funding and make basin-wide decisions to solve erosion and flooding problems. The City participated in this group along with FDEP, Orange and Seminole Counties, FDOT, Florida Audubon Society, Friends of the Wekiva and local residents. The following is a summary of reports, studies and permits resulting from the collaborative efforts of the aforementioned agencies.

- 1995 — LWR Channel Stabilization Study - DRAFT Technical Memorandum, SJRWMD
- 1998 — Recommended Erosion and Sedimentation Countermeasures, Little Wekiva River Watershed Management Plan. This plan completed by SAI, Inc. in 1998 for SJRWMD, recommended various erosion and bank stabilization projects along river in both Orange and Seminole Counties. The following are a list of erosion and sedimentation control measures completed in Seminole County by the City and/or Seminole County in partnership with SJRWMD.
  - S.R. 436 at Riverbend Apartments (aka Reserve at Wekiva Bend (gabions);
  - Northwestern Avenue area (gabions);
  - Weathersfield bridge (gabions);
  - Horse Lover's Lane grade control structure #3,
  - San Sebastian and Spring Oaks Grade Control structures #6 and #8;
  - San Sebastian Area Grade Control Structures (Areas 1, 2 and 3);
  - Seminole County in partnership with SJRWMD completed grade control structures 9 (just east of Montgomery Road), 10 (just west of Sanlando Park) and 11 (at S.R. 434) in 2012.
- 1998 — Lake Lotus Park Sediment Removal Feasibility Study, BCI Engineers and Scientists for FDOT.
- 2001 — Little Wekiva River Reconnaissance and Priority Re-Evaluation, Orange and Seminole Counties, Florida, URS for SJRWMD.
- 2002 — Middle St. Johns River Basin Surface Water Improvement and Management (SWIM) Plan, SJRWMD
- 2003 — Lake Lotus Preliminary Restoration Plan, USACOE
- 2004 — Little Wekiva River Sediment and Geomorphic Re-Evaluation, CDM
- 2004 — Watershed Management Plan for the Little Wekiva River, CDM.
  - Comprehensive update to existing stormwater model;
  - Detailed pollutant load analysis;
  - Identification of conceptual projects for water quality projects.
- 2007 — Lake Lotus Restoration Plan, URS

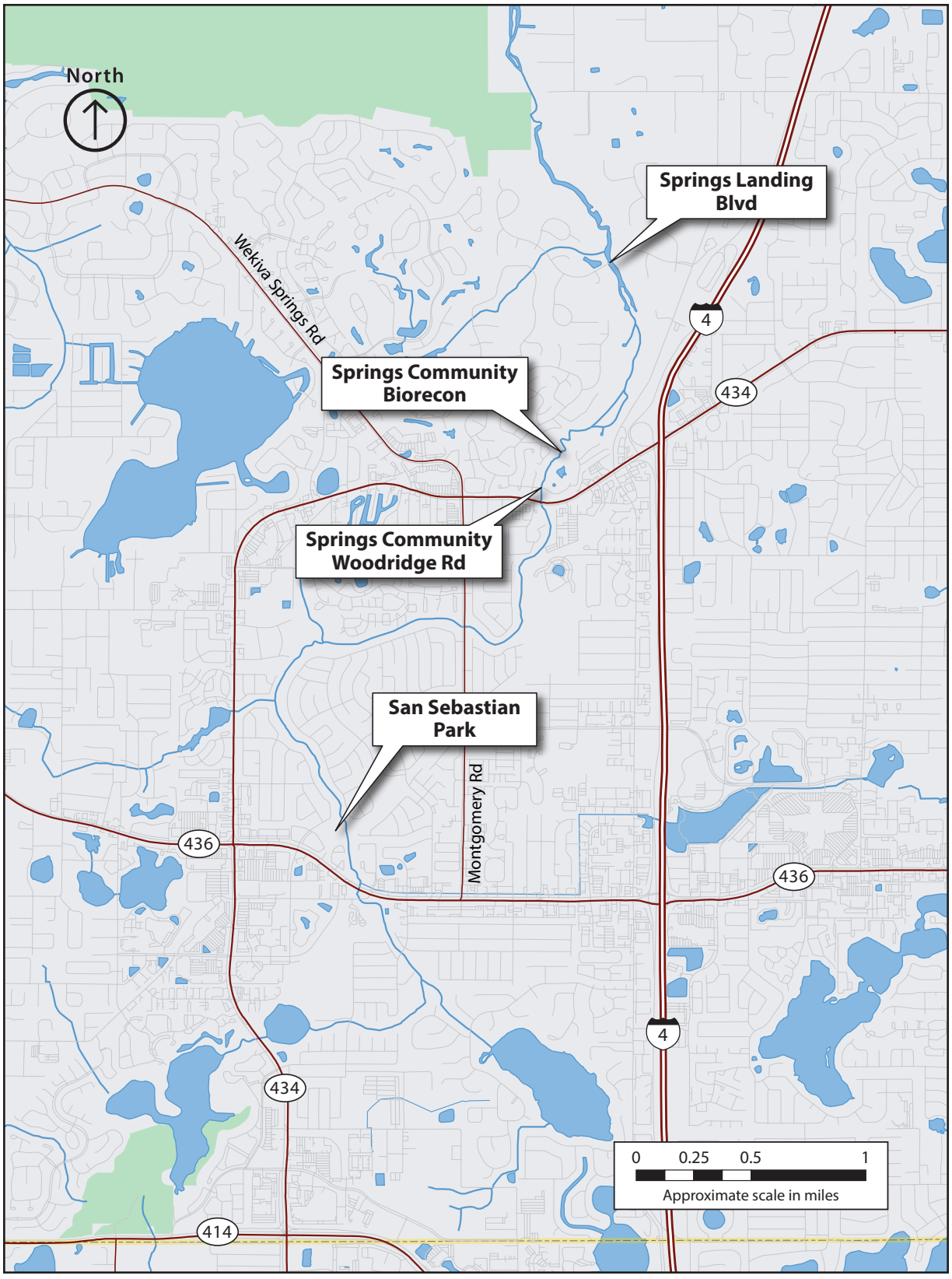

Figure A1-6. Documentation of FDEP Biorecon of the Little Wekiva

Springs community – Woodbridge Rd

Springs Community — Biorecon

Springs Community — Biorecon

Springs Community — Biorecon

Springs Community — Biorecon

Springs Community — Biorecon

San Sebastian Park

San Sebastian Park

Little Wekiva of off Springs Landing Blvd. (North side)

Little Wekiva of off Springs Landing Blvd. (South side)

Little Wekiva Project Area

Appendix B

Little Wekiva River

Geomorphic Observations and Sedimentation Analysis

Prepared for:

Little Wekiva Working Group

November 2021

Little Wekiva River

Geomorphic Observations and Sedimentation Analysis

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Ayres Project No. 36-4733.00

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Introduction

The Little Wekiva River near Wekiva Spring, Florida has been experiencing significant sedimentation issues downstream of ongoing I-4 construction projects. The root cause of the sedimentation has not been established, and some stakeholders have pointed to FDOT's construction activities on I-4 as a key contributor to the problem. Other stakeholders believe the issue is based upon natural river mechanics and quote a long historied past of known basin wide erosion and sedimentation issues.

Purpose and Objectives

FDOT engaged Ayres to qualitatively assess the sediment deposition problem and its underlying causes. To perform the assessment Ayres completed the following tasks:

- Reviewed past studies, reports, and articles related to the Little Wekiva River Basin sedimentation issues
- Performed a geomorphic field assessment
- Analyzed current and historical imagery and elevation data

All relevant findings from the efforts are documented and presented in this report. The report also provides geomorphic and hydraulic concepts to help the reader understand and interpret the results and concepts presented.

Project Location

The Little Wekiva River Basin is located in the north central portion of Orange County and the western portion of Seminole County, Florida. The segment currently in question is the approximately 5.5 mile stretch that extends from the crossing of W State Road 434 to the river's confluence with the Wekiva River. A map of the study reach, which is located approximately 12 miles north of Orlando, is shown below in Figure 1.

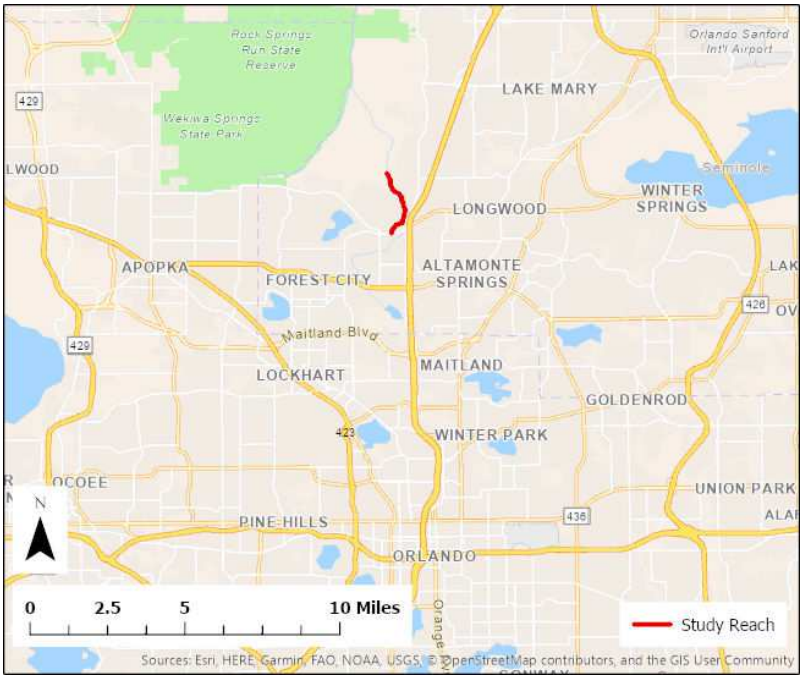

Figure 1: Study reach shown in relation to the area

Previous Studies

Numerous scientific studies have been published related to the erosion and sedimentation issues seen in the Little Wekiva River basin. The most recent and comprehensive study is the Little Wekiva River Watershed Management Plan dated 2005 (CDM, 2005). This report details a long history of erosion and sedimentation projects, studies, and issues. The report also presents a list of future stormwater and river functional improvement plans. In the report there are documented sedimentation issues that date back to the 1980s. The report states that the combined effect of channelization, urbanization, and the loss of the river's natural floodplain aggravated sedimentation problems along the river. The key takeaway from the literature review is that the sedimentation issues are not new to the system and that there are multiple projects underway and planned to combat ongoing issues seen throughout the system. Some of the more relevant studies and reports as listed in the Little Wekiva River Watershed Management Plan (CDM, 2005) are listed below.

- *Design Engineering Report, Little Wekiva River Basin Management Plan: Northwestern Avenue Bridge Area Erosion and Sediment Control Project, Final Report, Seminole County, Florida (SAI, 2002)*
- *Final Report, Little Wekiva River Reconnaissance and Priority Re-Evaluation, Orange and Seminole Counties Florida (URS, 2001)*
- *Individual Environmental Resource Permit Application and Erosion and Sediment Control Countermeasures in the Little Wekiva River Basin, SJRWMD (URS Greiner Woodward Clyde, 1999)*
- *Recommended Erosion and Sedimentation Countermeasures, Little Wekiva River Watershed Management Plan, SJRWMD (Singhofen & Associates Inc., Woodzvard-Clyde Consultants, 1998)*
- *Little Wekiva River Pilot Dredging Project, Contract No. 97W169A Reimbursement Requirements (Seminole County, 1997)*
- *Emergency Sediment Removal and Restoration, The Springs, Seminole County, Florida (Seminole County, 1996)*
- *SJRWMD Individual Environmental Resource Permit, Little Wekiva River, Sediment Removal and Restoration, Seminole County, Florida (Seminole County, 1996)*
- *Draft Little Wekiva River Channel Stabilization Study, Little Wekiva River Basin, Orange and Seminole Counties (SJRWMD, 1995)*
- *Little Wekiva River Restoration Project: Erosion and Sedimentation Mitigation, Orange County, Florida (Orange County Stormwater Management Department, 1994)*
- *Reestablish Streambank Vegetation, Streambank Stabilization, and Limited Dredging of the Little Wekiva River, Phase II, FDEP (University of Central Florida, 1993)*
- *Phase I Project Summary Report Little Wekiva River, Erosion and Sedimentation Study, Orange County, Florida (DRMP, Inc., 1988) An engineering study of the Little Wekiva*

Field Observations and Data Collection

Ayres performed a geomorphic field reconnaissance on November 19th, 2021. An Ayres team member was joined by two representatives from FDOT and one representative from E Sciences. The team focused the field efforts on the Little Wekiva River and traversed via kayak approximately 5 miles of the river corridor starting from the crossing of W State Rd 434 and traveling downstream. The river discharge during the visit was 45 cfs as approximated from USGS Gage Station 02234990 which is located at the upstream section of the study area. Key locations from the field effort are highlighted below in Figure 2. The following goals were accomplished as part of the effort:

- Visit the outfall from the I-4 construction projects
- Traverse the river both upstream and downstream of the outfall location
- Document any ongoing erosion and sedimentation
- Record any noticeable changes in river morphology
- Collect representative cross sections

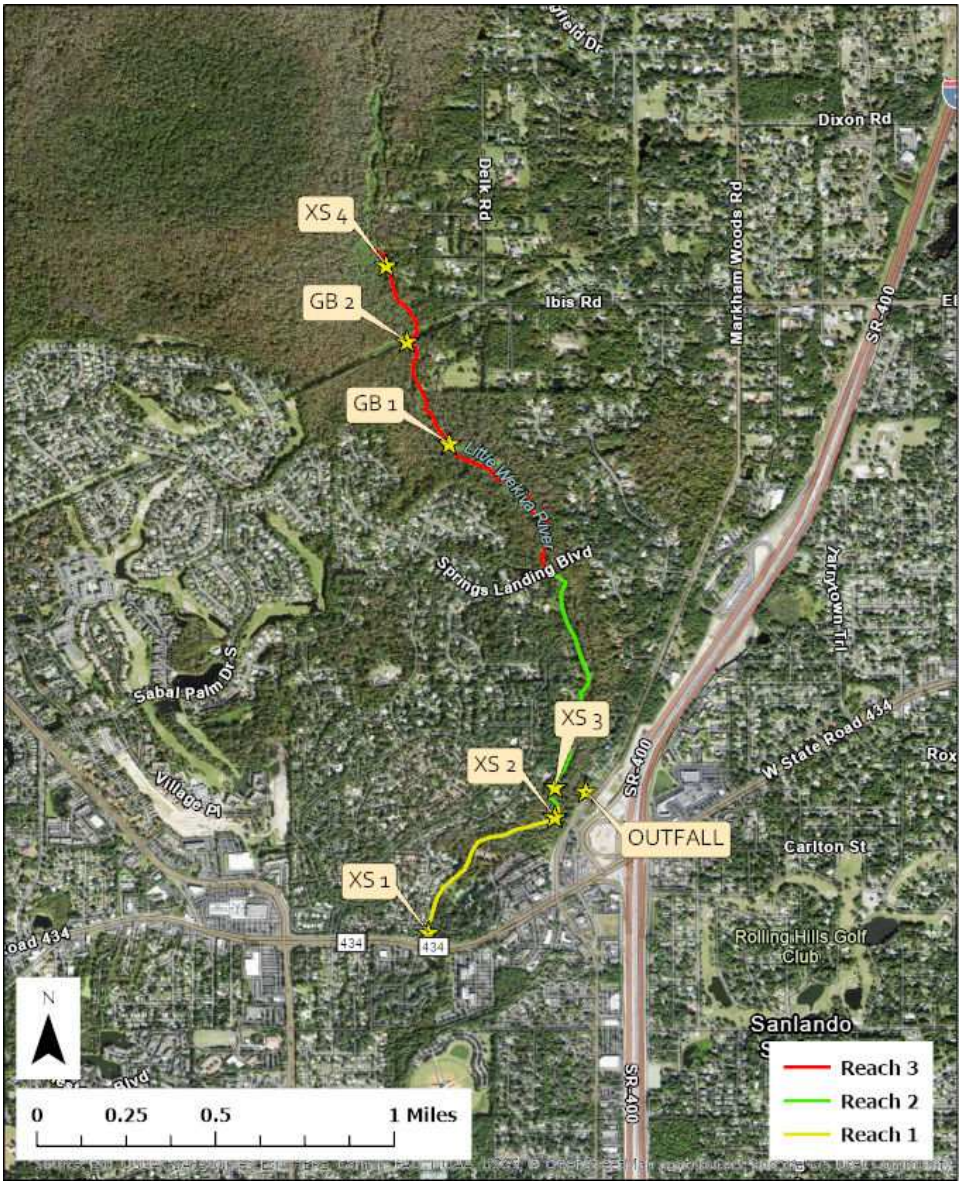

Figure 2: Study reaches shown with callouts for cross sections, grade breaks (GB), and outfall locations.

Field Observations

Outfall

The outfall location consisted of a concrete storm water pipe discharging into a large stilling basin and sediment retention structure with a rundown that flows into a small tributary stream which then flows into the Little Wekiva River. This outfall is combined storm water discharge from multiple sources including the I-4 construction project stockpile area. At the time of the field visit there was some sediment accumulation in the stilling basin as shown below in Figure 3. The stilling basin still had a lot of sediment capacity left at the time of the field visit though it was not known when the last time the basin was cleared out. Only clear water discharge from the structure was observed. No evidence of sedimentation was observed from the outfall of the sediment retention structure to its confluence with the Little Wekiva River.

Figure 3: Sediment accumulation in sedimentation basin located at the end of the outfall pipe from the I4 runoff.

Reach 1

Reach 1 is located between the intersection of W State Road 434 and the outfall location as shown in Figure 2. The river is a perennial sand bed channel approximately 30 ft wide. The channel width is consistent and homogenous throughout the reach. The floodplain is suburban development with little to moderate riparian buffer zone. The floodplain vegetation along the reach varies from forested to grass lawns in some locations. There was evidence of vertical incision as seen by steep bank slopes shown in Figure 4a. Additionally, there was evidence of lateral channel migration as shown by leaning trees (Figure 4b) Riprap was also seen placed along some of the homeowner banks, most likely as a countermeasure to prevent further lateral migration (Figure 4c). A representative sediment sample size was captured in Figure 4d. The sediment is medium to fine grained sand. Bedforms are generally limited to ripple formations (Figure 4e), indicating primarily bedload transport. While minor sedimentation throughout the reach was witnessed, it was mainly concentrated along the insides of bends and localized low velocity areas.

Figure 4: (a) Tall and steep bank slopes; (b) Sign of lateral instability shown by leaning trees into channel; (c) Riprap placed along banks of channel; (d) Representative sediment size shown; (e) Ripple bedforms shown.

Reach 2

Reach 2 is located between the outfall location and the crossing of Springs Landing Boulevard as shown in Figure 2. The river here is sinuous with more variable bankfull width throughout the reach. The floodplains consist of suburban developments with a moderate riparian buffer zone. The floodplain vegetation along the reach varies from forested to grass and heavy shrubs, transitioning into wetland species with in-channel plant growth along the lower portions of the reach (Figure 5 a&b). No strong evidence of vertical incision was noted. As a result, the reach has more floodplain connectivity than reach 1. Lateral instabilities were noted in the form of downed and leaning trees throughout the reach (Figure 5c). Sediment size remains consistent with Reach 1, medium to fine grained sands, and was confirmed through a visual inspection. Bedforms continue to be dominated by ripple features like Reach 1. While minor sedimentation throughout the reach was witnessed, it was mainly concentrated along the insides of bends and localized low velocity areas.

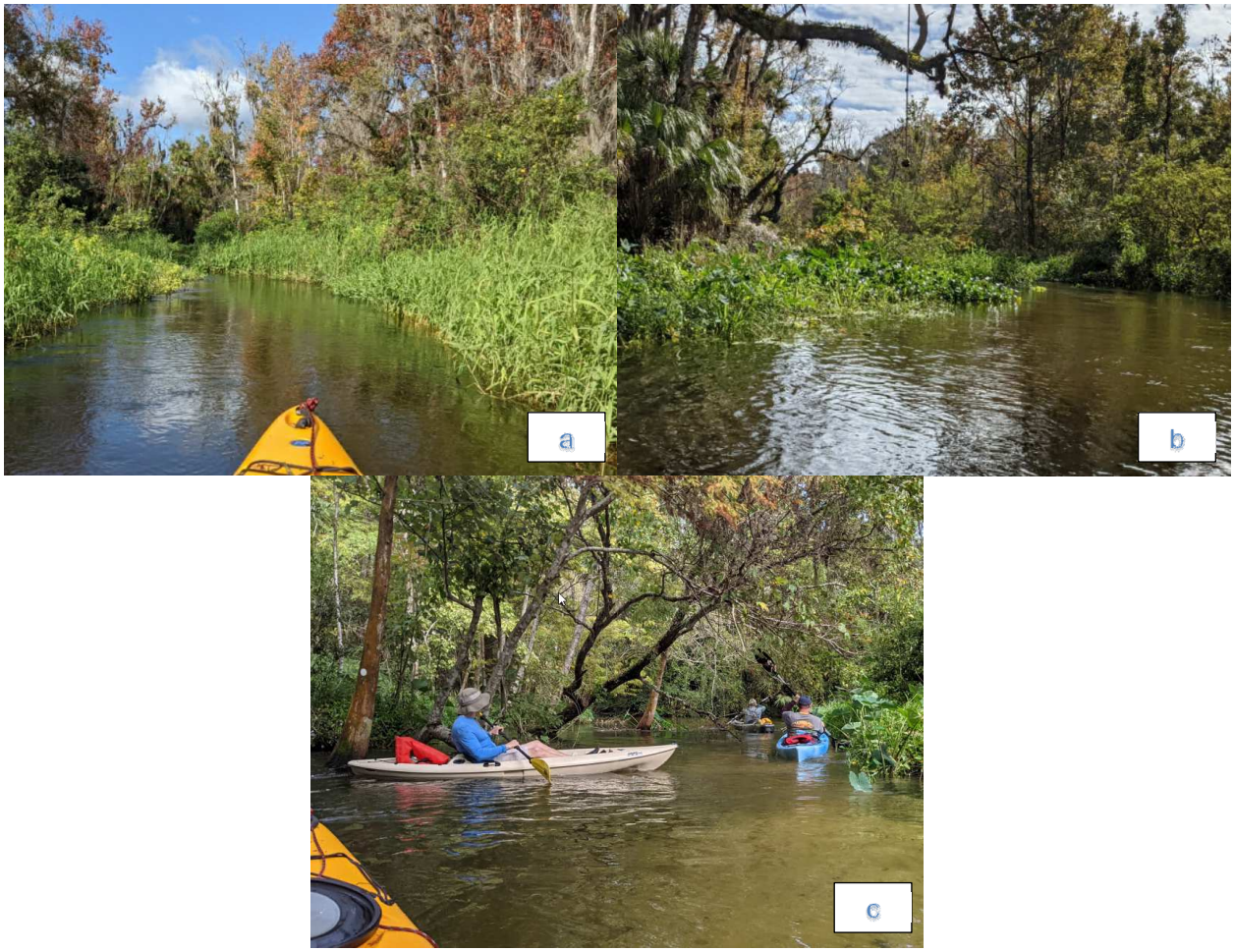

Figure 5: (a,b) Wetland vegetation seen toward downstream portion of reach; (c) Sign of lateral instability shown by leaning trees into channel

Reach 3

Reach 3 is located from the crossing of Springs Landing Boulevard to a point approximately 1 mile downstream as shown in Figure 2. The river here is sinuous with random variations in width. The floodplain land cover is a wide rural wetland with a large riparian buffer zone. There is little to no bankline visible through much of the reach either due to the presence of thick vegetation or very wide overland flow. The vegetation along the reach is forested with wetland type grasses and heavy shrubs. Numerous locations along the channel are completely blocked off due to aquatic vegetation (Figure 6a&b). These species consisted of mulitple varieties (FDOT): water hyacinth (*eichhornia crassipes*); water lettuce (p*istia stratiotes*); salvinia (*salvinia rotundifolia*); para grass (brachiaria mutica), red ludwigia (*Ludwigia repens*), Peruvian water primrose (ludwigia peruviana). Many of these species are known invasives to Florida There is no evidence of vertical incision throughout the reach. There was little evidence of lateral instabilities, though through a majority of reach it is believed that a large amount of flow is being conveyed through the wetlands adjacent to the channel. From a visual inspection, the sediment present was also consistent with the other reaches, medium to fine grained sand. In the lower portions of the reach the sand was topped with a layer of mud indicating a further reduction in sediment transport capacity. Ripple bedforms were present in the upper portion of the reach, however towards the lower, more vegetated sections, the bed was plane form indicating little to no transport capacity and flow velocity (Figure 6c). The lower portions of the reach have heavy sedimentation issues as evidence of the very shallow flow and sand choked channels.

Figure 6: (a,b) Thick in channel vegetation shown; (c) Shallow, slow flow shown with no bedforms present

Data Collection

To help identify stream characteristics several types of data were collected, including cross sections, relative elevations, flow velocities, and channel slope. Four river transects, or cross sections, were collected in the field, their locations are highlighted in Figure 2. It should be noted that the overbanks were not included in the transects due to private property access and safety concerns. Photos of the cross sections are presented in Figure 7. The cross sections are plotted below in Figure 8-Figure 11. Based on bankfull field indicators, flow was assumed to be at bankfull height at the time of the measurements. In addition to the cross-section measurements, surface water velocities, floodplain width, and channel slopes were estimated. Surface velocities were measured in the field using a timed float method. The floodplain widths were obtained from the 100-year water surface bounds obtained from the effective FEMA mapping. Channel slopes were calculated from 2005 LiDAR obtained from NOAA and are presented in Figure 12. Tabulated in stream characteristics are presented Table 1.

Figure 7: Photos of each cross section.

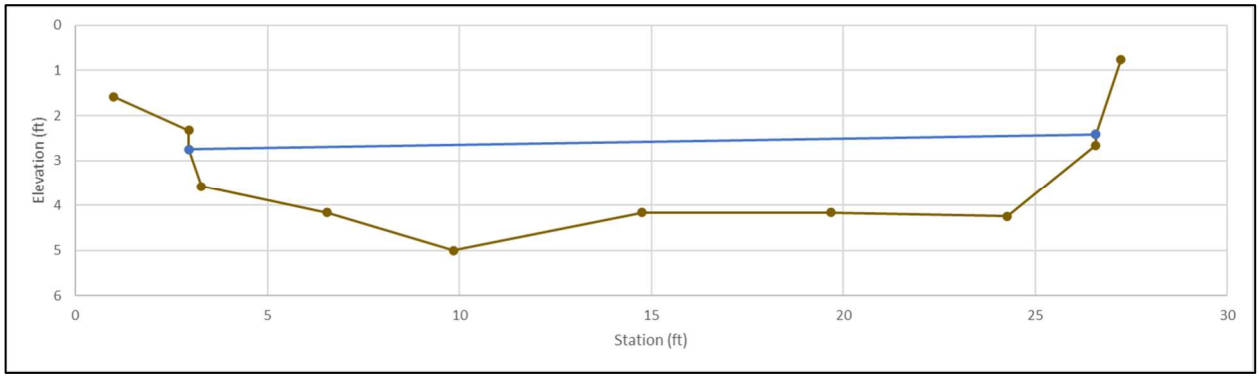

Figure 8: XS 1, the brown line represents ground points, the blue line represents the water surface.

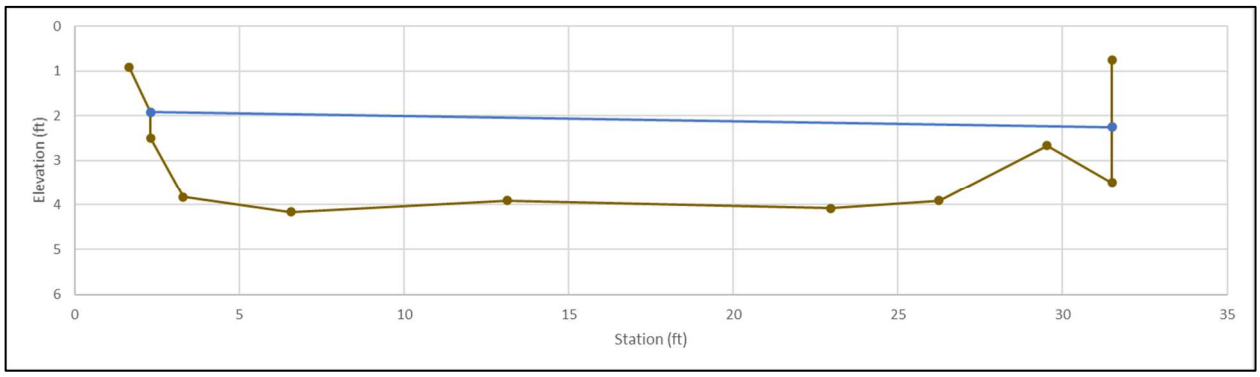

Figure 9: XS 2 plotted, the brown line represents ground points, the blue line represents the water surface.

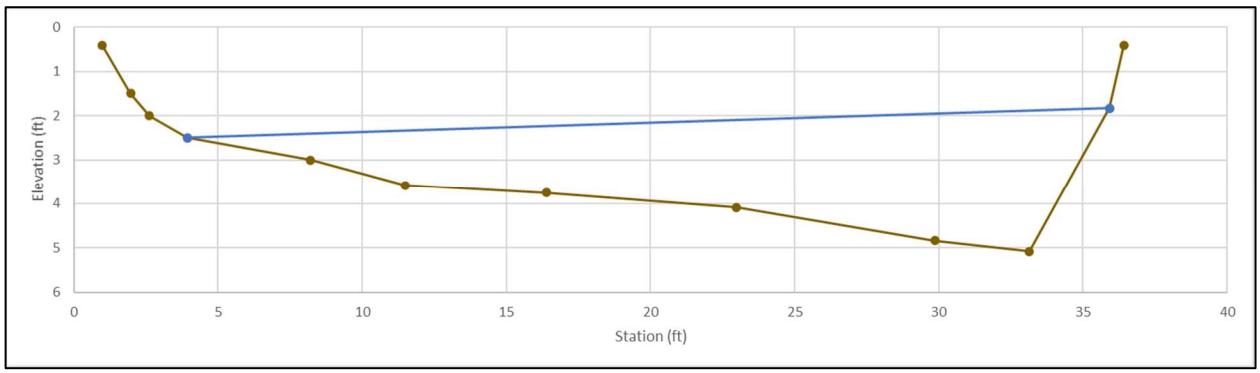

Figure 10: XS 3 plotted, the brown line represents ground points, the blue line represents the water surface.

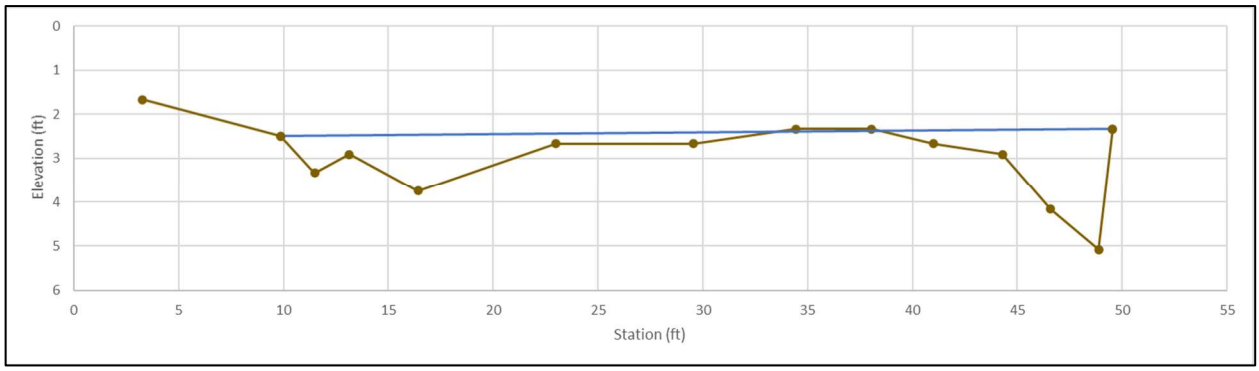

Figure 11: XS 4 plotted, the brown line represents ground points, the blue line represents the water surface.

Table 1: Tabulated stream characteristics

Transect	Bankfull Width	Av Depth	Floodplain Width	Width / Depth	Entrenchment Ratio (FW/BW)	Surface Velocity
	(ft)	(ft)	(ft)	(ft/ft)	(ft/ft)	(ft/s)
XS1	23.6	1.6	83	14.7	3.5	1.8
XS2	29.2	1.7	444	17.0	15.2	1.9
XS3	32.0	1.7	332	18.9	10.4	1.9
XS4	39.7	0.6	3035	69.8	76.5	0.3

Cross sections 1, 2, and 3 showed similar width to depth ratios and were all in the range of 12-20 which can all be classified as moderate (NEH, 2007). XS 4 width to depth ratio exceeded 60 which can be classified as very high. The entrenchment ratio, which is the measure of how vertically contained a river is (NEH, 2007), was the lowest at XS 1. XS 1, 2, and 3 entrenchment ratios can all be classified as slightly entrenched. XS 4 is not entrenched, and the entrenchment ratio value suggests a multiple thread channel. Surface velocities were virtually identical for XS 1, 2, and 3. The velocity at XS 4 was considerably slower at 0.3 ft/s.

Slope measurements were completed using 2005 LiDAR data obtained from NOAA and are shown below in Figure 12. Some changes in elevations may have occurred since then however, the locations of the grade breaks generally matched what was observed in the field. The overall slope was constant until the first noted grade break in reach 3 and was measured to be 0.06° or 0.0009 ft/ft. Between grade break 1 and 2 the slope was measured at 0.03° or 0.0005 ft/ft. Downstream of grade break 3 the slope was measured at 0.01° or 0.0002 ft/ft. The locations of the grade breaks are shown in Figure 2 and seem to coincide with the increase in floodplain width.

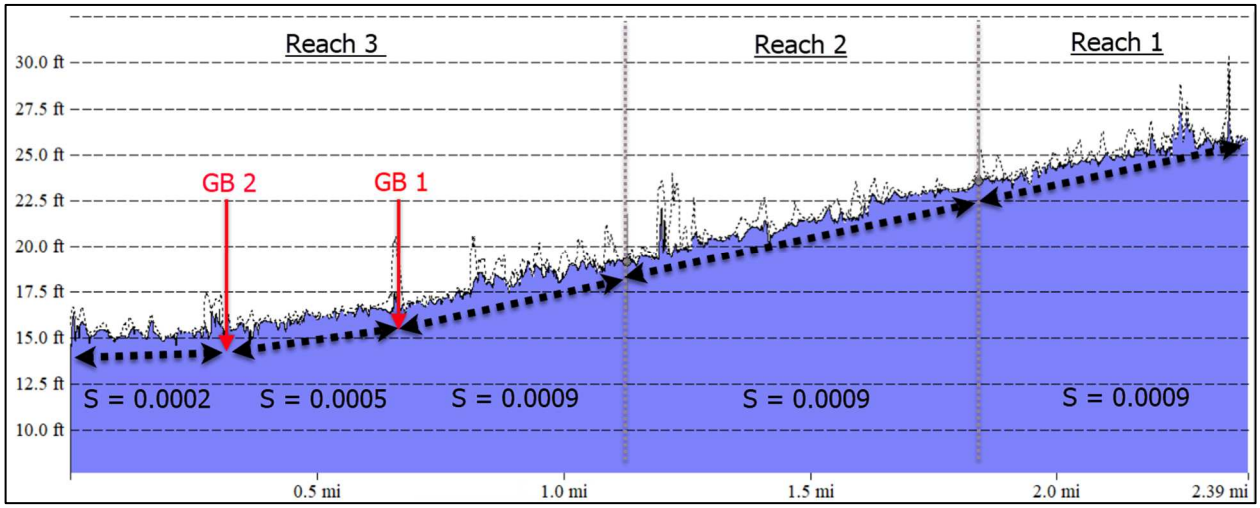

Figure 12: Slope calculations shown in relation to reach locations

Geomorphic Discussion

The driving factors controlling channel development and response are consistent with many other suburban-urban stream systems. By examining the conditions of the three reaches, a better understanding of the driving mechanisms and controls on the sedimentation issues exhibited throughout the study area, but most acute within Reach 3, can be developed.

Reach 1 & 2 are geomorphically similar evidenced by the similar width to depth ratios, flow depths, channel slopes, and flow velocities. The reaches are only subdivided to identify the location of the inflow from the I-4 construction site. These can be classified using the Rosgen Stream Classification System as "C" streams, which are typically characterized as semi-sinuous, low relief channels. While pool-riffle sequences were not evident during the field reconnaissance, it is possible that these features have been smoothed by increased sedimentation (NEH, 2007).

Reach 3 can be classified using the Rosgen Stream Classification System as "D" streams, which are characterized as multi-threaded channels dominated by aggradation, low bankfull depths, and large entrenchment ratios. Typically, these reaches have an abundant supply of sediment which can be vegetated or unvegetated depending on the hydrologic regimes (NEH, 2007).

Urbanized Hydrology & Stream Response

Development of watersheds has a pronounced effect on the hydrology of the overall system. The conversion of natural land cover to impervious surfaces results in a reduction in overall sediment and an increase in runoff (Lagasse, P., et. al. 2012). Paved surfaces and lawns tend to produce little sediment resulting in clear water conditions once storm runoff reaches a stream. That clear water can then entrain sediment from the first encountered source, typically a streambed or banks. Runoff increases are a result of a reduction in infiltration and overland flow travel times. In natural settings, runoff is forced to navigate rough variable landscapes with an abundant of depressions (Blazewicz et al, 2020). Development reduces the landscape roughness and stormwater systems efficiently deliver runoff to outfalls at streams resulting in larger-flashier peak flows.

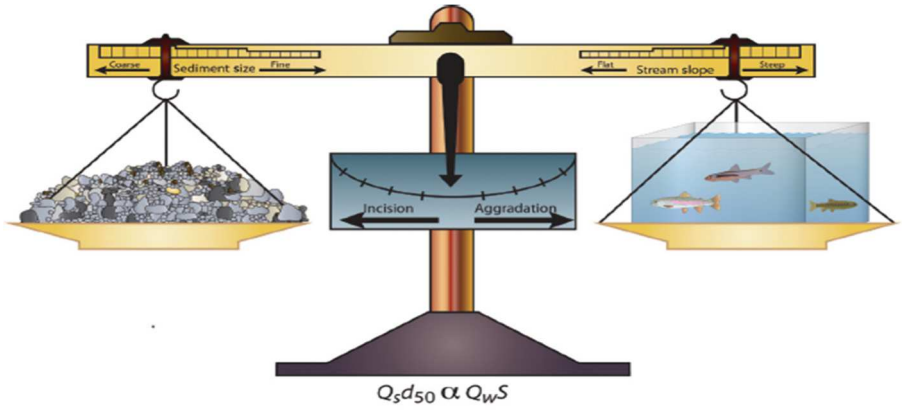

Figure 13: Lane's Balance showing the conceptual response to changes in slope, sediment input, discharge, and sediment size from Pollock, 2014.

Impacts to the Little Wekiva following the effects of urbanization can be understood using simple concepts and fundamentals of river processes. River processes work towards maintaining an equilibrium between discharge and sediment yield. Figure 13 shows Lane's balance, a simple conceptual model for understanding the feedbacks within a river system (Pollock, 2014). Generally, Lane's Balance states that there is a proportional balance between sediment load and sediment size on one side and discharge and slope on the other ($Qw*S \propto Q_s*d_{50}$). Using this relationship, forecasts can be made for the increased

discharge resulting from urbanization within the Little Wekiva watershed. Increasing discharge (▲Q_w) while decreasing the sediment load (▼Q_s) will cause the channel to flatten (▼S) and the sediment increase in size (▲d_{50}) as the system attempts to find a new equilibrium. Flattening the slope occurs by increasing the overall channel sinuosity and channel length (Wohl, 2014). Normally, this would balance out and the river would find a new equilibrium that mitigates instabilities and erosion. However, rivers require space to increase sinuosity through lateral migration and bank erosion. In urbanized settings, bank is often armored and hardened to protect infrastructure which limits this adjustment. If a river cannot adjust to mitigate erosion, it will continue unchecked until the sediment is too large to transport or there is no longer a source of sediment. The Little Wekiva Management Plans indicate a persistent problem with erosion in the upper portions of the river that have been mitigated through armoring and grade control. These symptoms are indicative of a long-term system-wide problem.

Sedimentation Processes

Stream systems can be divided into source, transport (or transfer), and accumulation reaches. The source zones are characterized by confined positions where lateral mitigation and widening is limited but stream power and slope are still high, resulting in incision and vertical erosion. Transfer reaches are characterized by lateral instability, meandering channels within channel erosion and deposits. Accumulation zones are defined by reduction of stream power and slope which results in the aggradation of sediment, shallow bankfull channels, and multi-threaded systems (Blazewicz et al, 2020).

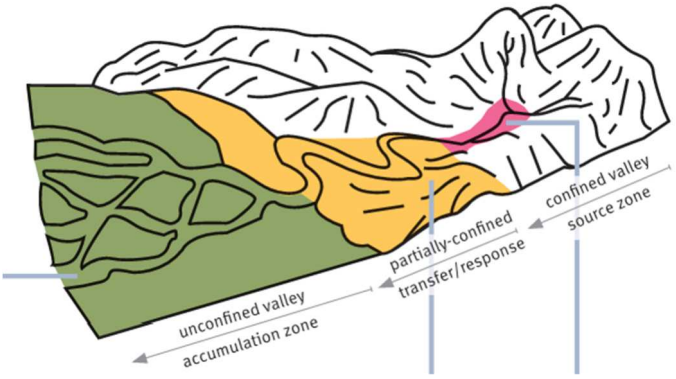

Figure 14: Conceptual model of sedimentation processes from source reaches to deposition reaches from Blazewicz et al, 2020.

Envisioning these systems in high-relief natural environments is easy, but this can also be triggered because of urbanization and encroachment. The portions of the Little Wekiva, upstream of Cross section 1 and Reach 1 have undergone extensive development and buildout within the watershed. The development of the watershed has a two major impacts on the stream system which both increase sedimentation and erosion. The first is urbanized hydrology, discussed in the previous section, and the second is confinement of the stream itself. Confinement of a stream through encroaching development, shown in Table 1 as the smaller Floodplain Width and Entrenchment Ratio, can cause a stream reach to transition and function as a source reach with localized pockets of deposition. The lack of space to adjust and move laterally, causes the stream to respond to urbanized hydrology by incising. Continuing downstream through Reach 2, the Little Wekiva transitions to a transport reach, evident by the lateral instability (Blazewicz et al, 2020). Finally, the stream transitions to an accumulation zone in Reach 3, characterized by multi-threaded systems, a lack of sediment conveyance, and wide-unconfined floodplains.

Conclusion

Based on the field reconnaissance and analysis of the Little Wekiva stream dynamics, it is our opinion that the sedimentation issues at within Reach 3 are an ongoing issue caused primarily by land use changes and development in the watershed. The reasons supporting this conclusion are described earlier in this report and are also summarized below.

- **Consistency of Sediment Size:** Sediment observations from upstream of the outfall are consistent with the sediment overserved downstream of the outfall indicating that the bulk of the sediment is likely sourced from upstream of the outfall.
- **Erosion & Transport from Upstream and Deposition Downstream:** Stream dynamics and slope evaluations show that the lower reaches are mostly likely a depositional sink for natural upstream erosion exacerbated by urbanization and channel encroachment.
- **Persistent and Consistent Erosion and Sedimentation Issues System-wide:** Erosion and sedimentation issues have been a consistent problem in this watershed as documented in Watershed Management Plan from 2005 (CDM, 2005). Substantial investment has been made in the upper portions of the stream and watershed to mitigate these issues likely pushing the sedimentation problem further downstream into more rural and natural stream segments.
- **Plant Stabilizing Sediment Deposits:** Aquatic plant species tend to stabilize unwanted deposition in many parts of the county. Several plant species were observed during field reconnaissance in depositional areas within the lower reaches. These plant species exacerbate sedimentation issues by increasing channel roughness, lowering velocities, and therefore further increasing sedimentation.
- **Development Encroachment Limits Natural Stream Adjustments to Disturbances:** By encroaching on stream systems, we limit the natural ability of streams to adjust to watershed disturbances. The natural tendency of a stream with an urbanized watershed is to become more sinuous to lower the slope and limit the erosion that occurs because of increase runoff and peak flows from developed land covers. Without the ability to adjust to a new hydrologic regime the channel will continue eroding until mitigation is installed.

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