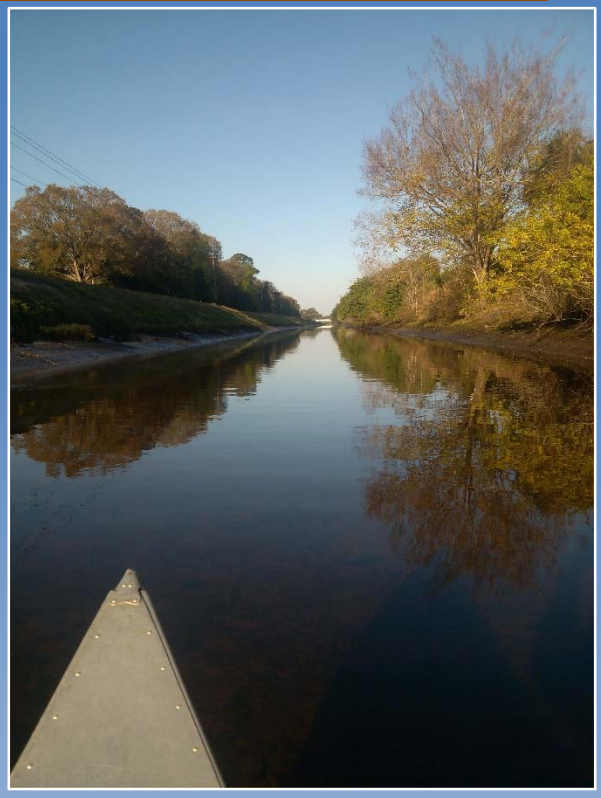
Channels A, G, and Rocky Creek Second Post-Modification Monitoring Project Report



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ACKNOWLEDGEMENTS

The Channels A & G Second Post-Modification Monitoring Project Draft Report for the Tampa Bay Estuary Program and Southwest Florida Water Management District was prepared by Scott M. Deitche, Blake M. Meinecke, and Alex Hipolito (GPI). Shannon Phillipus of GPI provided GIS assistance.

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Introduction

Tidal tributaries are important to the ecological health of Tampa Bay. The Tampa Bay Estuary Program (TBEP) estimates that there are over 300 named and unnamed tidal creeks and tributaries that enter Tampa Bay. These tidal systems serve as a nexus between freshwater inputs and tidally influenced salinity regimes. As such, they serve as major areas of productivity and habitat for the diversity of the greater estuary. Tidal creeks also serve as nursery habitat for many of the estuary's fish species.

Many of the tidal creeks have evidence of anthropogenic impacts, including barriers which restrict tidal movement, resulting in "flashiness" in the system whereby nutrient-rich pulses of freshwater enter the tidal creeks, overriding the system's ability to naturally assimilate the nutrients, as well as preventing a consistent oligohaline zone. To address these issues in Tampa Bay, the Southwest Florida Water Management District (SWFWMD or District), and TBEP contracted with Greenman-Pedersen, Inc (GPI) to conduct a study of salinity barriers in Tampa Bay, to not only inventory the anthropogenic barriers, but also look at candidates for modification to restore the natural hydrologic connectivity.

Two tributaries that fit the criteria for possible modification are Channels A and G. Channel A, Channel G, and lower Rocky Creek (collectively referred to as the Channel A & G complex for this study), which connects the two channels, are part of the greater Rocky/Brushy Creek and Upper Sweetwater Creek Watersheds. The Channel A & G complex is located in western Hillsborough County near the terminus of the Rocky-Brushy watershed. It is a freshwater and tidal tributary system bisected by two salinity control barriers owned and operated by the District.

The lower Rocky Creek system historically suffered from excessive, nuisance submerged aquatic vegetation (e.g. Hydrilla) growth and low dissolved oxygen (DO). The lower reach of the tributary (WBID 1507A) has a federal Total Maximum Daily Load (TMDL) for low DO and nutrients. The draft Environmental Protection Agency (EPA) TMDL report (EPA, 2004) states that "inadequate flushing in the lower, [tidally-influenced] reaches of Channel A due to small tidal amplitude, combined with the salinity gate operation schedule" is responsible for the low DO environment and impaired water quality. The TMDL for Rocky Creek was finalized in 2013 (EPA, 2013).

As part of the feasibility of removing salinity barriers in the Tampa Bay project, GPI was tasked with undertaking a pilot monitoring project on Channels A and G to determine baseline data in anticipation of a pilot modification project. This report compares the baseline and post-modification data for a variety of parameters, including water quality, shoreline vegetation, and fish communities.

Following the modifications of the salinity barriers in 2014, as part of the Tampa Bay Estuary Project, GPI was tasked with undertaking a second post-modification pilot monitoring project for Channels A and G in 2016-2017. The results and findings of the first pilot study were provided to TBEP and the District in the Channels A, G, and Rocky Creek Pilot Monitoring Project Report (GPI, 2015). This report presents the data collected during the second post-modification monitoring activities at the Channel A and G sites, and compares the results to the previous studies using a variety of parameters including water quality, shoreline vegetation, and fish communities.

Background

The Channel A and Channel G Salinity Barriers (Figure 1) were designed and constructed with the intent of preventing saltwater encroachment inland through the existing channels, and in the underlying aquifer (SWFWMD, 1979). The barriers were put into operation in April 1978. To prevent continued inland movement of saltwater via Channels A & G, the salinity barriers were located to approximate the saltwater/freshwater interface in surface waters that existed prior to channel construction. In the case of the Channel G Salinity Barrier, its location also took into consideration the potential for flushing two existing oxbows adjacent to Rocky Creek. To curtail the inland advancement of the saltwater/freshwater interface in the Floridan aquifer, the salinity barriers were designed to maintain an upstream pool elevation between 3.28 ft mean sea level (MSL) and 3.94 ftMSL, thereby creating an increased freshwater head. The increased upstream head was expected to contribute to the reduction of the upward leakage of saltwater in the underlying aquifer into the channels.

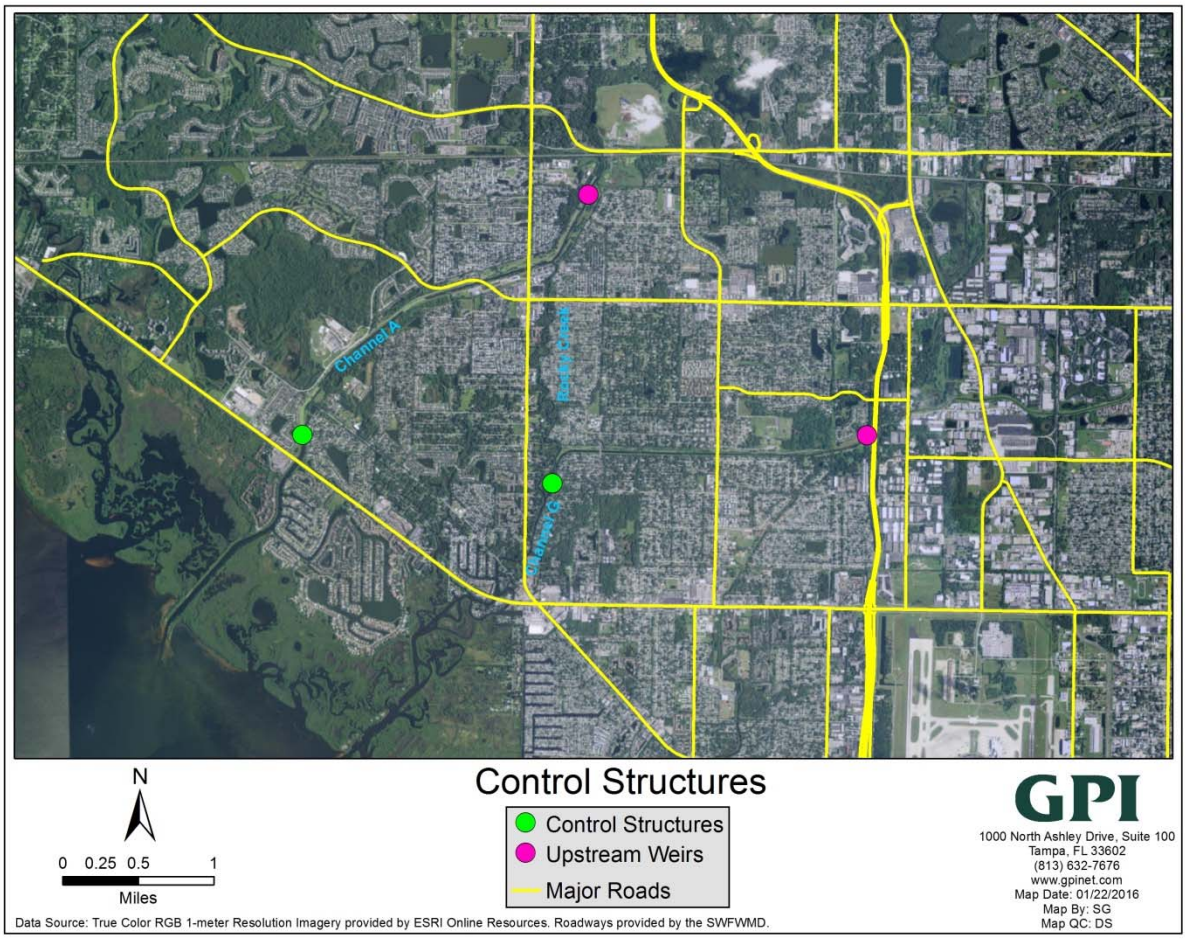

Figure 1 - Location of Channel A and G control structures

The salinity barriers commenced operation in late April 1978 at which time an upstream water level of 3.28 ft MSL was maintained above the structures. Prior to that time, the mean tide elevation was 0.1 m MSL, with the average daily range of fluctuation being approximately 2.85 ft. As a result of the higher water levels, the District received complaints and inquiries from residents living adjacent to Rocky Creek. Initially, these complaints were related to property damage landowners believed to be a direct consequence of the higher-water levels being maintained. Subsequent to the initial flooding complaints, local residents voiced concerns over the water quality in the creek, aquatic weed growth, dying trees, erosion and mosquito breeding -- all resident concerns were believed to be related to the District's operation of the salinity barriers. Consequently, District Staff made several site visits to investigate the reported problems. Observations made during these visits confirmed the heavy growth of water hyacinths in areas of Rocky Creek and Channel G. In some reaches of Rocky Creek, hyacinths formed a solid mat between creek banks. Other aquatic plants including hydrilla, alligator weed, and panic grasses were also observed. In addition to aquatic weed problems, the water was observed to be cloudy and slow moving. Dead trees adjacent to the creek were also noted. Pursuant to the requests made by Rocky Creek residents, and as a result of the conditions observed by the District Staff during their site visits, a re-evaluation of operational water levels and operational procedures was undertaken for Rocky Creek and Channels A and G.

The re-evaluation report (SWFWMD, 1979) concluded that:

- Water quality in Rocky Creek was strongly affected by stormwater runoff and by municipal/industrial discharges that were occurring at that time;
- The salinity barrier and its operation very likely contributed to nutrient accumulation and aquatic weed growth in the Creek;
- The salinity barrier operation contributed to tree mortality upstream of the structure in Rocky Creek due to higher water levels; and
- The maintenance of higher water levels upstream of the Channels A and G salinity barriers had a positive effect in reducing chloride concentrations in Upper Floridan aquifer groundwater monitoring wells located adjacent to Channel G. Higher water levels did not appear to have an effect on chloride concentrations in Channel A groundwater monitoring wells.

The re-evaluation report, completed in 1979, considered three alternatives for the operations of the salinity barriers:

1. Resuming pre-barrier flow conditions;
2. Maintaining a single continuous water level upstream of the barriers; and
3. Establishing an operational scheme that allows for fluctuating water levels.

Of the three alternatives, Alternative 3 was recommended and an operations schedule was proposed in the report. Recommendations to implement Alternative 3 included:

- Making Channel G the primary flow way for the Channel A & G complex in order to maximize water movement through Rocky Creek. This recommendation would require that the salinity barrier on Channel A remain closed except for periodic flushing.
- Implementing a channel-snagging project in Rocky Creek to eliminate dead trees in the channel resulting from the maintenance of higher water levels upstream of the salinity barriers.
- Constructing a navigable water hyacinth barrier at the confluence of Channel A and Rocky Creek.
- Operating the salinity barriers to flush water hyacinths downstream in an effort to reduce chemical treatment of nuisance aquatic weeds.
- Continuing the monitoring of chloride concentrations in groundwater monitoring wells adjacent to Channel A and Rocky Creek.
- Working with Hillsborough County for a proposed diversion of Channel G flows down Sweetwater Creek in order to reduce nutrient inflows to the Bay at the outfall of Rocky Creek.

Structure Information

Channel A

Invert Elev.	**-** 4.92 ft MSL **-** Note: manual sluice gate elevation is – 7.55 ft MSL
Crest Elev.	8.53 ft MSL
Location	Section 28, Township 28 S, Range 17 E
Lat / Long	28° 01’ 29” N and 82° 60’73”W

Channel G

Invert Elev.	- 4.92 ft MSL **-** Note: manual sluice gate elevation is – 4.92 ft MSL
Crest Elev.	8.20 ft MSL
Location	Section 35, Township 28 S, Range 17 E
Lat / Long	28° 00’ 31 “N and 82° 34’51”W

Structure Operations

Contact with staff in the Structure Operations section of the District (personal communication, 2011) indicated that there had been no change in the physical characteristics of the two salinity barriers and associated facilities since construction. The structures can be operated both automatically and manually while adhering to the adopted operations schedule.

When the gates were in operation, prior to the gates being opened in 2014, water levels in Channel A were maintained between 2.3 and 2.95 ft MSL. The system is controlled by a Programmable Logic Controller (PLC). There is both a High Water Override (HWOR) and Low Water Override (LWOR) sensor. They are used as overrides if the PLC is not working. There is also a Salt Water Override (SWOR) sensor that will close all gates if the downstream (salt) water level exceeds the upstream (fresh) water elevation.

The water levels in Channel G were historically maintained between 6.56 and 2.95 ft MSL, prior to the gates opening for this study. The structure on Channel G also has a HWOR and LWOR, as well as a SWOR that would close all gates if the downstream (salt) water level exceeds the upstream (fresh) water elevation.

Prior to 2005, the operational information for the two gate systems was recorded by hand on note paper. Since 2005, and the installation of a SCADA system, the operational logs are recorded digitally.

Post-Modification Water Levels

The gates at the control structures on Channels A and G were opened at 3pm on June 20, 2014 and remain open as of the writing of this report (September 2017). Following the modification to the gate operations, residents reported that large amounts of sediment and organic material were flushed out of the system, and in areas on Channels A and G, exposed a sandy canal bottom. In the eastern reaches of Channel G, limestone was also exposed.

Rocky Creek water levels dropped and left areas in the middle of the creek impassable to boats and kayaks during low tides for part of 2014 (after opening of the gate) and 2015. This information was obtained by correspondence with residents and observed by project staff on a Rocky Creek canoe trip in February of 2015. This condition continues to exist, however continuous tidal variations have begun to shift sediments within Rocky Creek creating some small channels.

Bathymetry

As part of the second post-modification monitoring study, a limited survey of the 2.06 mile portion of Rocky Creek, lying between Channel A and Channel G was undertaken to document sediment deposition patterns along the thread of the creek and determine the drainage divide location. To accomplish this, three benchmarks were set along the creek, and the top of sediment and bottom of sediment elevations were recorded via manual probings every 328 feet. A survey of the results was produced to within +/-1.0 foot horizontal and +/-0.1 foot vertical accuracy. Copies of the signed/sealed survey were submitted upon completion.

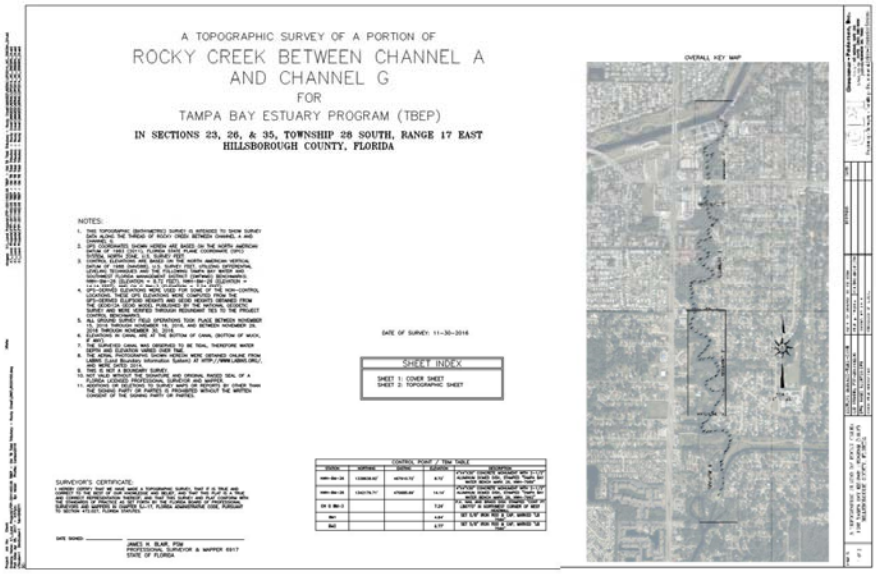

Figure 2 – Rocky Creek bathymetric survey

River Oaks Wastewater Treatment Plant

The River Oaks Advanced Wastewater Treatment Plant, operated by Hillsborough County, is situated at the confluence of Rocky Creek and Channel A. As part of the Northwest Hillsborough Wastewater Consolidation Project, River Oaks is slated to be retired. According to the most recent schedule information posted on Hillsborough County's web site, the River Oaks Diversion project is scheduled to be completed in December 2019. As part of this project, a new pump station and 36-inch transmission main will be constructed to divert flow to the Northwest Water Reclamation Facility, which is scheduled for expansion. In November of 2016, a broken sewage pipe near Rocky Creek in Town 'N Country resulted in the discharge of approximately 200,000 gallons of raw sewage. During this time, Hillsborough County officials urged residents to not fish, swim, wade, or contact water in the area. As a result, land based samples were not able to be collected from Site 5 during the December, 2016 sampling event.

Surface Water Quality

Flow

Limited daily flow information is available for the sites. The USGS monitors flow stations throughout Rocky Creek, though mainly in the freshwater reaches. There is one flow gauge on the upstream side of the fixed weir structure on Channel G (USGS 02306647 Sweetwater Creek). Below are estimates of the amount of freshwater that flows into Channel G (Table 1).

Water Year	Discharge, Cubic Feet per second
2005	21.5
2006	21.8
2007	7.95
2008	13.3
2009	12.4
2010	16.9
2011	21.3
2012	31.4
2013	29.7
2014	27.1
2015	43.3
2016	23.7
2017 (through 6/4/17)	2.57

Table 1 – USGS Mean daily flow (Calendar Year) at the Channel G fixed weir structure.

Land-Based Fixed Site Sampling and Bacteriological Data

Salinity sampling was conducted at 7 shoreline locations during the second year post-modification sampling using a YSI 556 multiprobe unit. For the baseline period, 12 sampling stations were originally monitored, but that number was reduced to seven for the first post-modification and second year post-modification sampling events to streamline the process and remove duplicative sites (Figure 2). Five samples were taken at each station for the baseline monitoring period, seven for the first post-modification period, and eight samples for second post modification period. Each sampling period consisted of a variety of tidal conditions (Table 2). In addition to tidal variation, the second post modification land based sampling events were distributed evenly between wet season (4) and dry season (4). As previously mentioned, Site 5 was not sampled in December 2016 due to a nearby sewage spill.

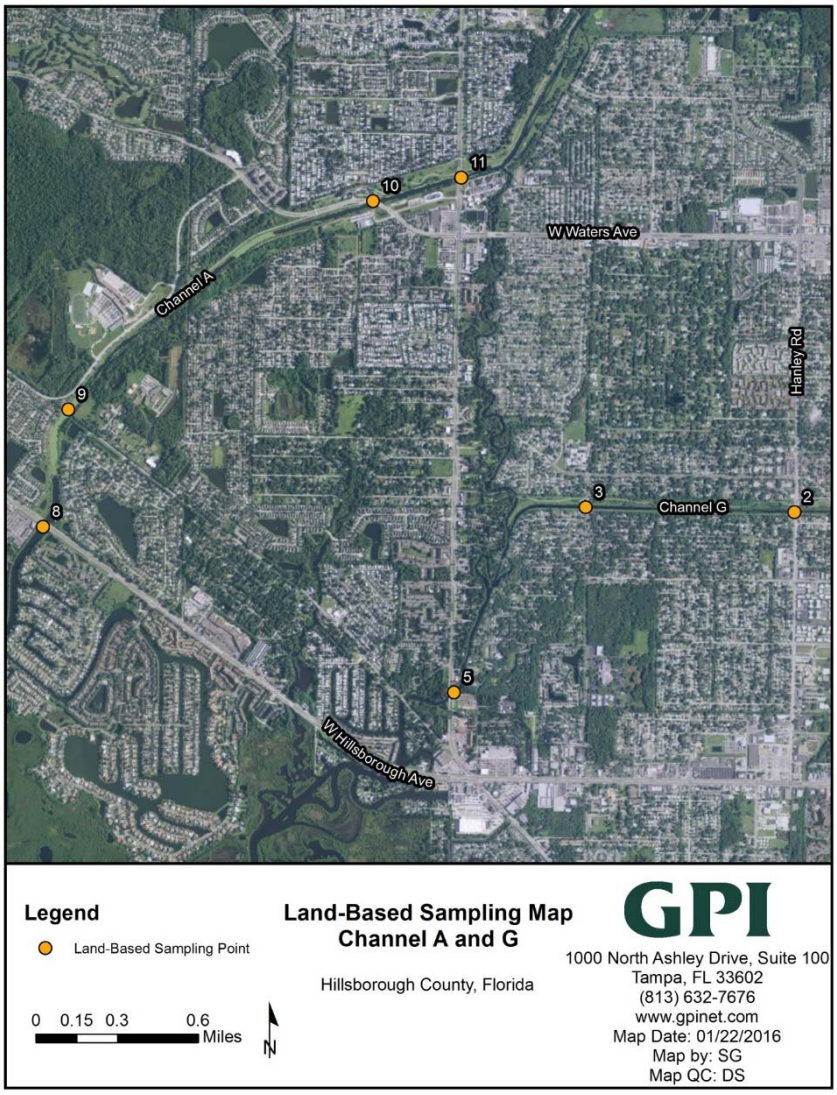

Figure 2 - Land-Based Sampling Sites

Channel	Site	Total Number of Baseline Samples	Baseline Samples Outgoing /Low Tide	Baseline Samples Incoming /High Tide	Total First Post-Mod Samples	First Post-Mod Samples Outgoing/ Low Tide	First Post-Mod Samples Incoming/ High Tide	Total Second Post-Mod Samples	Second Post-Mod Samples Outgoing/ Low Tide	Second Post-Mod Samples Incoming/ High Tide
G - above	2	5	2	3	7	4	3	8	4	4
G - above	3	5	2	3	7	4	3	8	4	4
G - below	5	5	2	3	7	4	3	7	3	4
A - below	8	5	2	3	7	4	3	8	4	4
A - above	9	5	2	3	7	4	3	8	4	4
A - above	10	5	2	3	7	4	3	8	4	4
A - above	11	5	2	3	7	4	3	8	4	4

Table 2 - Tidal breakdown of land-based sampling data

Overall data show an increasing salinity trend corresponding to additional tidal influence at most sites (Table 3). Because sampling events were divided equally between wet and dry seasons in the second post modification monitoring period, salinity measurements can also be compared during high flow (wet season) and low flow (dry season) periods (Table 4). Sampling sites above the barriers (2, 3, 9, 10, 11) were indicative of a freshwater system during the wet season in both the baseline and 2nd post modification monitoring periods due, in part, to higher base flow conditions during the latter period, and very little salinity difference is apparent in the systems over baseline period conditions. However, during the dry season in the second post-modification sampling period, the data for sites 2, 3, 9, 10, and 11 all show substantial increases in average and maximum salinity. Site 11 average salinity increased slightly and had a maximum salinity of over 8 ppt.

Sampling site 5, located below the barrier on Channel G showed significant evidence of tidal influence during the dry season compared to baseline data. The wet season average and maximum salinity measurements did not vary substantially from baseline. The second year post-modification data at this site showed overall increased salinity averages.

Site 8 is located on the Hillsborough Avenue Bridge across from Channel A. The data collected here reflect higher salinity readings that are consistent with the expected estuarine conditions of the site. However during the wet season a noticeable reduction in average salinity was observed at this site, likely due to increases in freshwater flows. Both wet and dry season max salinities at site 8 were slightly below baseline maximum conditions.

Channel	Site	Water Depth (ft)	Baseline Avg	First Post-Mod Avg	Second Post-Mod Avg	Baseline Max	First Post-Mod Max	Second Post-Mod Max	St. Dev.
G - above	2	2	0.18	0.14	1.21	0.22	0.21	7.13	1.73
G - above	3	2	0.32	0.3	2.82	0.43	0.59	9.81	3.65
G - below	5	2	2.09	4.37	4.81	5.08	10.41	15.61	5.87
A - below	8	2	18.86	13.12	10.26	21.23	20.79	17.86	6.28
A - above	9	2	0.46	5.04	6.42	0.68	15.01	16.78	6.4
A - above	10	1.6	0.33	3.42	3.86	0.49	15.34	12.35	4.46
A - above	11	2	0.26	1.17	3.45	0.36	8.07	10.22	4.03

Table 3 - Land based salinity sampling (ppt)

Channel	Site	Water Depth (ft)	Baseline Avg	Second Post-Mod Avg Dry	Second Post-Mod Avg Wet	Baseline Max	Second Post-Mod Max Dry	Second Post-Mod Max Wet	St. Dev. Dry	St. Dev. Wet
G - above	2	2	0.18	2.31	0.11	0.22	7.13	0.12	1.91	0.01
G - above	3	2	0.32	5.5	0.15	0.43	9.81	0.19	3.51	0.02
G - below	5	2	2.09	9.28	1.09	5.08	15.66	2.82	6.2	1.04
A - below	8	2	18.86	14.65	5.88	21.23	17.86	16.55	3.77	5.13
A - above	9	2	0.46	12.05	0.79	0.68	16.78	3.15	3.97	0.88
A - above	10	1.6	0.33	7.55	0.16	0.49	12.35	0.37	3.44	0.08
A - above	11	2	0.26	6.74	0.17	0.36	10.22	0.2	3.25	0.03

Table 4 - Land based salinity sampling wet vs. dry Season (ppt)

In addition to salinity, bacteriological data within Channel A downstream of the salinity barrier (Station 102, near fixed land based station #8 at Hillsborough Ave Bridge) was also evaluated from January 2013 until present (Figure 3). Channel G could not be evaluated, as bacteriological data collection was discontinued in 2006.

For more than a year prior to opening of the salinity barrier, during 2013 and the first half of 2014, fecal coliform levels (cfu/100ml) remained low. Following the opening of the Channel A structure, elevated fecal coliform levels (cfu/100ml) were recorded beginning in July 2014 until approximately August of 2015. Fecal coliform levels then fell and remained low from September 2015 until the beginning of the wet season in 2016. One distinct spike in fecal coliform levels appeared in December 2016, which likely corresponds with the documented sewage spill at the River Oaks plant discussed previously.

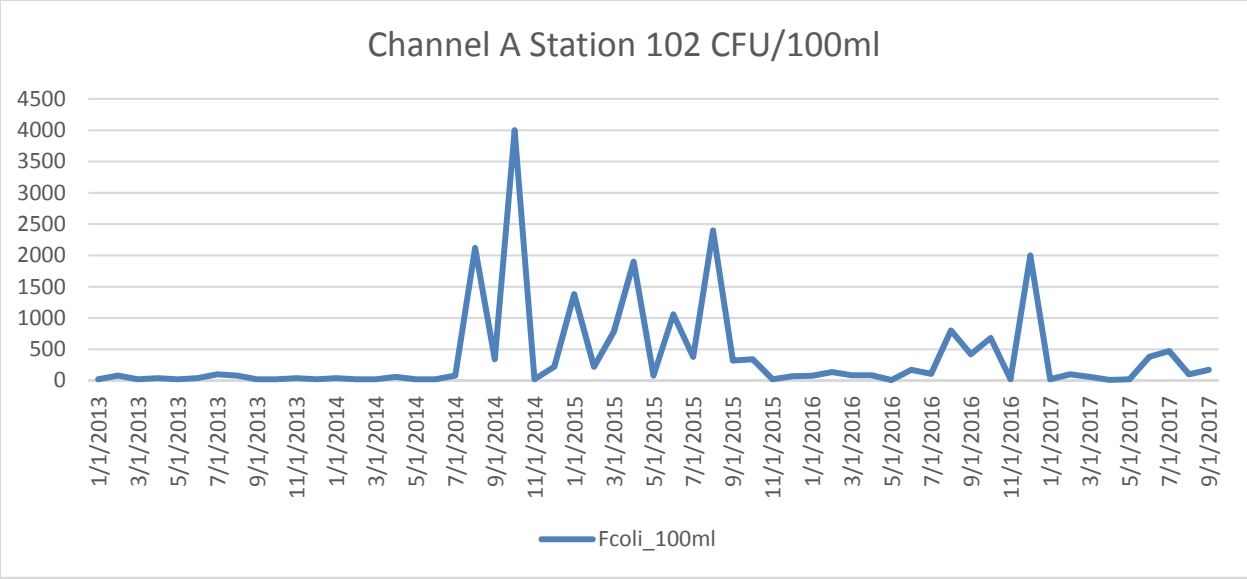

Figure 3 – Channel A Fecal Coliform

Groundwater Sampling

Groundwater parameters in the Channel G well were evaluated during the second post-modification monitoring period. Two prior sampling events were completed at this site during the baseline monitoring period, and four during post-modification monitoring period.

There were a total of six (three dry season, three wet season) groundwater sampling events at the Channel G well during the second post-modification monitoring period. The Channel G monitoring well information is included in Figure 4 and Table 5 for reference. A YSI® 600XLM sonde was deployed in the well to collect groundwater data during the six sampling events. The sonde was left in place for three to four days and water quality parameter measurements were recorded by the device every 15 minutes.

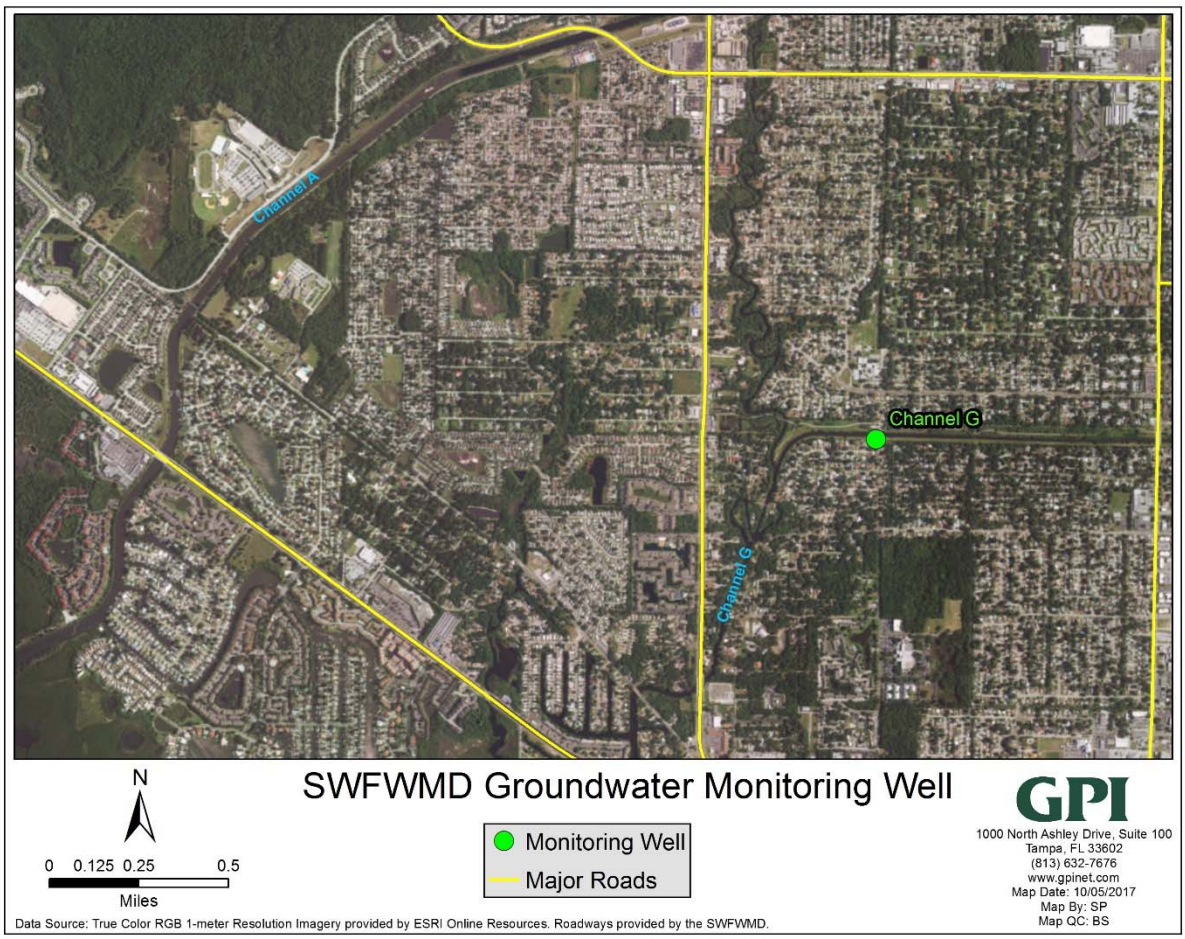

Figure 4 - Groundwater Monitoring Well Location

	CHANNEL G well
Total depth (ft)	120
Casing depth (ft)	115
Location	28°00'40.25"N 82°34'31.37"W
Diameter (in)	4
Construction date	1974

Table 5 - Groundwater Monitoring Well Information

Groundwater Results

Tables 6 and 7 represent groundwater pH and salinity data statistics. Comparisons of baseline and post-modification groundwater data show little variation in salinity or pH. Average, median, and minimum salinities measured during the 2nd post-modification period were lower than both the baseline and first post-modification monitoring periods. However, the maximum salinity observed during the 2nd post modification monitoring period was slightly higher than the first post-modification periods. It should be noted that these maximum values were only recorded during the first sampling event in December 2016. It is believed that the sonde used for this event may have been faulty, however company which supplied the sonde for this sampling event did not follow up with any post-calibration checks. In order to eliminate this potential error in the remainder of the sampling events, a groundwater sonde was sourced from a different environmental equipment company. The salinity readings recorded by the sonde during this deployment started at and slowly rose over the course of the 3 day monitoring period. No further anomalous salinity data were recorded during the 2nd post-modification monitoring period. Furthermore, no discernable difference in salinity or pH was observed between the wet season and dry season monitoring events. These results of the Channel G well monitoring are comparable to annual salinity measurements recorded by Southwest Florida Water Management District at the Channel A New Upper Floridan well (SID 782822) since 2012.

pH	Ch G Baseline	Ch G First Post-Mod	Ch G Second Post-Mod
average	7.34	7.05	7.28
median	7.34	7.05	7.23
maximum	7.52	8.05	8.04
minimum	7.32	6.85	7.07
standard dev	0.08	0.08	0.16

Table 6 - pH Baseline v Post-Modification

Salinity (ppt)	Ch G Baseline	Ch G First Post-Mod	Ch G Second Post-Mod
average	3.43	3.52	3.33
median	3.43	3.52	3.31
maximum	3.46	3.95	4.7
minimum	3.38	3.37	3.01
standard dev	0.06	0.5	0.34

Table 7 - Salinity (ppt) Baseline v Post-Modification

Vegetation Survey

Baseline

A baseline vegetation survey of the Channel A, G, and Rocky Creek system was conducted between August 2011 and February 2012 as part of the Hillsborough County Lake Assessment Program. Staff from the University of South Florida's Center for Community Design and Research and the Hillsborough County Stormwater Management Section completed this work. The system was divided into sections (Figure 5) and percent abundance of all vegetation was recorded. The first post-modification vegetation survey was conducted in April 2015.

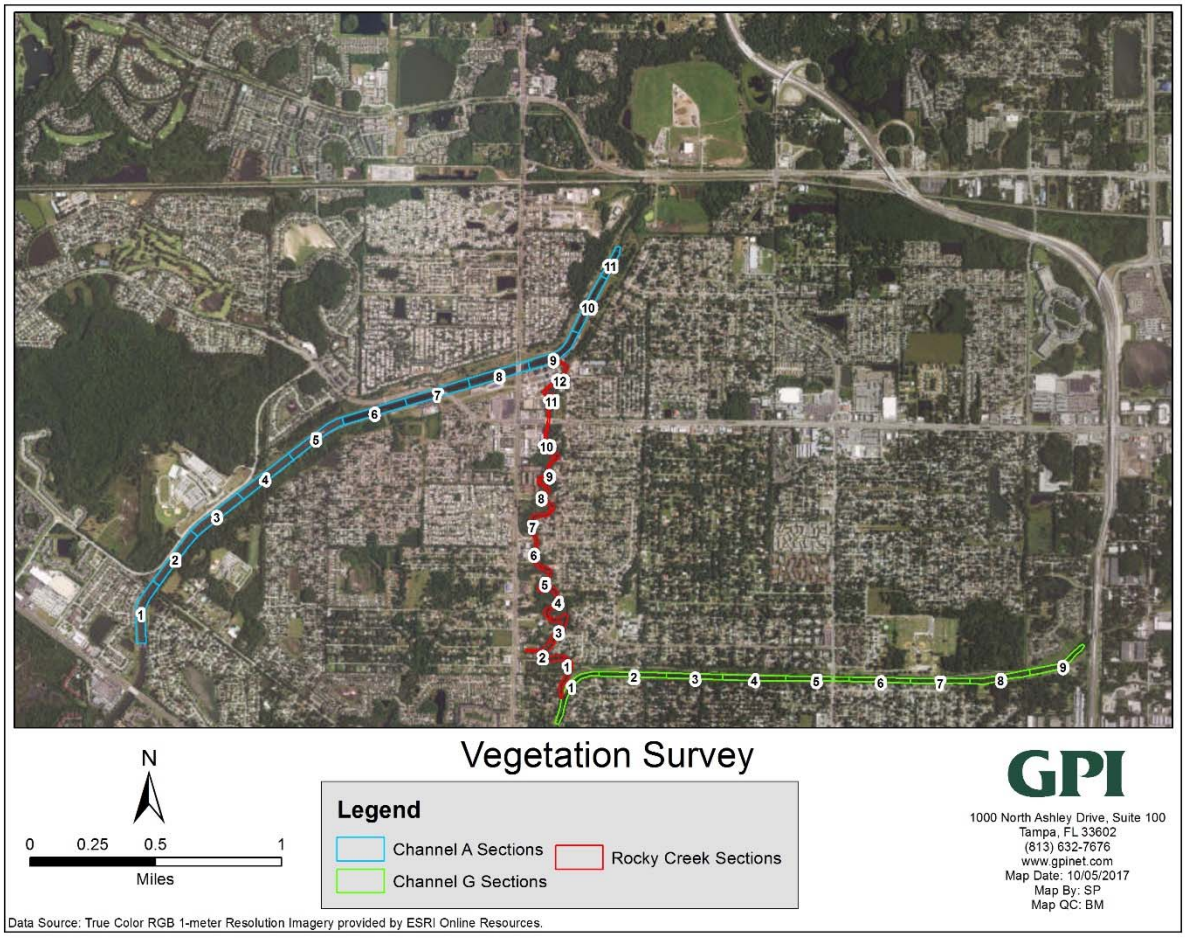

Figure 5 - Vegetation survey sections

During the baseline survey freshwater systems (Channel A and G above the water control structures) had a high prevalence of non-native, nuisance plant species, many of which are listed by the Exotic Pest Plant Council as being invasive pest plants. The most prevalent pest plant species are alligator weed (*Alternanthera philoxeroides*), wild taro (*Colocasia esculenta*), Brazilian pepper (*Schinus terebinthifolia*) and torpedograss (*Panicum repens*) along the banks, water spangles (*Salvinia minima*) and water lettuce

(*Pistia stratiotes*) formed extensive floating mats in the channel. Hydrilla (*Hydrilla verticillata*) was the most prevalent submerged pest plant species found during the baseline survey. In all, eight nuisance plant species were found in Channel A and 14 in Channel G during the baseline vegetation survey.

At the time of the baseline vegetation survey assessment, Channel G was experiencing low flow conditions with minimal discharges over the water control structure. The nutrient-rich, stagnant water conditions during this period caused many parts of Channel G to be completely covered with floating aquatic vegetation. Prior to modification, both Channels A and G had a high prevalence of algal mats, indicating poor water quality and possible imbalance of flora. While many native plant species were present (63 species, 89% of the total number of species found in Channel A and 70 species, 83% of the species found in Channel G), the majority of the native species were considered opportunistic and commonly prevalent at disturbed sites. There were a few native species present in Channels A and G that are indicative of healthy freshwater systems, most notably cinnamon fern (*Osmunda cinnamomea*) and spatterdock (*Nuphar lutea* var. *advena*). All but a few of the plant species found in Channels A and G upstream of the weirs preferred freshwater systems. The exceptions were seaside goldenrod (*Solidago sempervirens*), sand cordgrass (*Spartina bakeri*) and swamp flatsedge (*Cyperus ligularis*) – all of which can tolerate both salt and freshwater.

Second Post- Modification Monitoring

The second post-modification period survey was completed in the August 2017, using the same sampling sections upstream of the water control structures as the Hillsborough County baseline survey (and the first post-modification survey). Like prior sampling efforts, the scope of this second post modification sampling effort included assessment of percent abundance by recording species presence within each of the sampling segments. Considering Florida's subtropical climate, slight differences in year-to-year sample timing will not substantially effect vegetative presence/absence. In comparing the pre-modification vegetation survey conducted by Hillsborough County and our GPI second post-modification survey (following the Hillsborough County methodology), it appears that vegetation likely increased on the canal banks and along littoral zones upstream of the gates on Channels A, G, and Rocky Creek.

Channel A and G and Rocky Creek upstream of the water control structures had a high prevalence of non-native, nuisance plant species in both the pre- and post-modification time periods. Many are listed by the Exotic Pest Plant Council as being invasive. The most prevalent nuisance plant species found during the second post-modification monitoring period remained alligator weed (*Alternanthera philoxeroides*), wild taro (*Colocasia esculenta*) and torpedograss (*Panicum repens*). Torpedograss had the highest coverage. The alligatorweed appeared stressed from fluctuating water levels and possibly higher salinity. During the second post-modification monitoring period, no hydrilla was found in any of the systems. Water spangles and hydrilla all but disappeared from Channels A and G, and water lettuce was only found in small amounts in 72% of the Channel A segments and 16% of the Rocky Creek segments, indicating a significant shift in instream flora composition. No other submerged vegetation was observed during the second post-modification monitoring period. In all, 10 pest plant species were found in Channel A, 19 in Channel G,

and 16 in Rocky Creek during the post-modification period. Two additional pest species were found in Channel G in comparison to the prior monitoring period, however there was a reduction in the total number of pest species in both Channel A and Rocky Creek.

During the second post-modification monitoring period, many native plant species were present upstream of the water control structures (51 species, 75% of the total number of species found in Channel A; 62 species, 65% of the species found in Channel G ; and 34 species, 60% of the species found in Rocky Creek). The majority of the native species are considered opportunistic and are commonly prevalent in disturbed sites. Coverage of the freshwater species spatterdock (*Nuphar lutea* var. *advena*), which was prevalent during the first post-modification monitoring period, appeared to be reduced. Spatterdock was not found in Rocky Creek, and was only present in small amounts in 45% of Channel A sites, and 33% of Channel G sites. Other native freshwater species prevalent during the first post-modification monitoring period (e.g., swamp dock (*Rumex verticillata*), smartweed (*Polygonum* sp.), and marshpennywort (*Hydrocotyle* sp.)) were found in smaller numbers than previous monitoring periods. During the second post modification monitoring period, there appears to be an increase in the prevalence of more salt-tolerant species, including string-lily (*Crinum americanum*). This species was found in 100% of the sample sites in Channel A, 88% of the sample sites in Channel G, and 83% of the sites in Rocky Creek. Another salt tolerant species, giant leather fern (*Acrostichum danaeifolium*) was found in 100% of the sample sites in Rocky Creek, 90% of the sites in Channel A, and 77% of the sites in Channel G. Mangrove seedlings appeared in all three systems during the second post-modification monitoring period. Red mangroves (*Rhizophora mangle*) were observed in more than half (54%) and black mangroves (*Avicennia germinans*) were observed in 63% of the Channel A sample segments. Mangroves were observed in throughout Channel A with the exception of segments 9 and 11. Red mangroves were found in 33% and black mangroves 16% of the Rocky Creek sample segments. In the Rocky Creek assessment area, mangroves were observed at both ends, segments 1-3, 10 and 11. Red mangrove and white mangrove (*Laguncularia racemosa*) were both found in 11% of Channel G sample segments. Mangroves were only observed in Channel G in segments 1, 3, and 4 which are closer to the confluence with Tampa Bay.

Fish Survey

Fish sampling was performed at sites along Channel A, Channel G, and Rocky Creek. The first two-day fish survey was conducted in August 2011 to formulate a baseline description of the existing fisheries community in the system prior to gate opening. The survey methodology followed the tidal tributary sampling methods developed by the Fish and Wildlife Research Institute (FWC-FWRI) and utilized a 29.86 ft bag seine that was deployed with a boogie board (FWC-FWRI, 2010a).

The sampling conducted in August 2011 for this study took place along the shore at locations downstream from the control structures and from s boat at locations upstream of the control structures. Sampling was limited in the main channels upstream of the control structures due to the steep banks and depths of the channels, greater than 4.92 ft, which were outside the Standard Operating Procedure (SOP) of the sampling methodology. Samplers were unable to deploy the seine net properly on the lower reaches of Channels A and G (due to deep depths), so sample sites on those systems were restricted to areas just downstream of the control structure. Rocky Creek, due to its more natural shoreline, was most conducive to sampling utilizing the 29.86 ft seine technique.

Fish surveys were conducted during the first post-modification monitoring period on February 17, 2015 and June 16, 2015 to assess the changes in fish community structure in Channels A and G after the initial gate opening. Raising the gates removed not only to barriers to tidal flow, but also to movement of salt-tolerant and common tidal fish species upstream into the systems. As shown in the first post-modification monitoring period data, salt-tolerant species were found dispersed throughout the channels, where previously they were only present below the control structures.

As part of the second post-modification monitoring period effort, fish surveys were conducted on October 11, 2016 and May 24, 2017 to continue evaluation of the changes in fish community structure in Channels A and G. As indicated by the data below, salt-tolerant species were found to be increasingly dispersed throughout the system complex.

Channel A

The Channel A sampling site was located off of Hillsborough Avenue, south of the control structure (Figure 6). This site was sampled in 2011, 2015, and 2017.

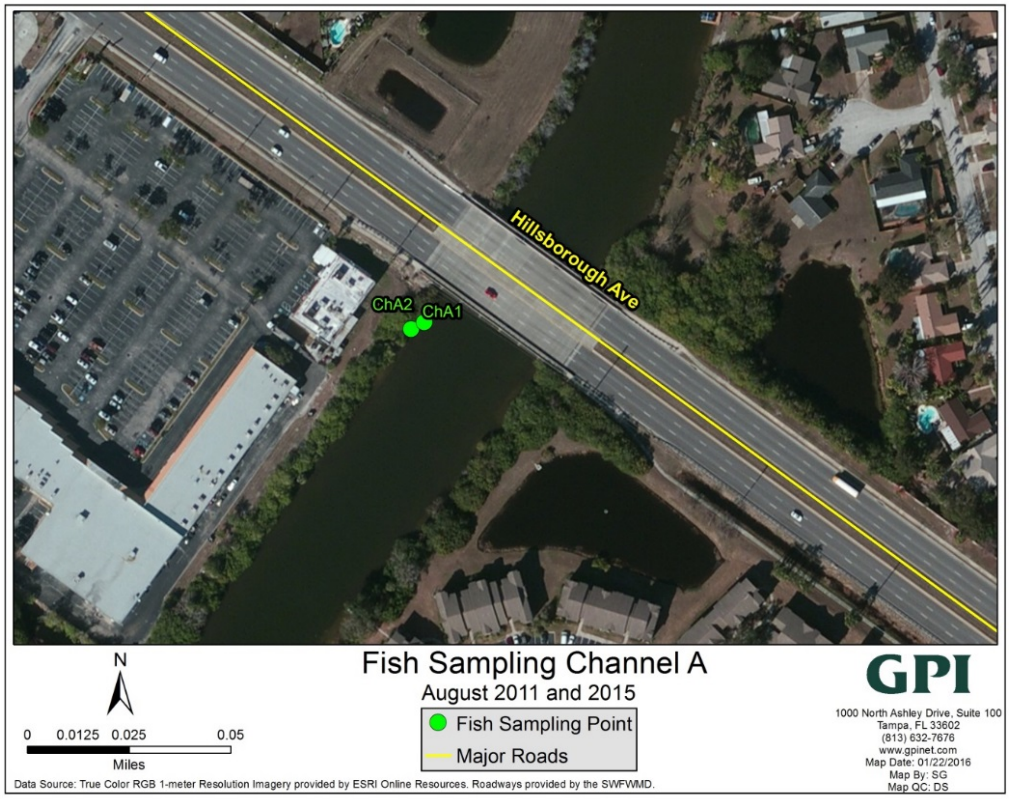

Figure 6 - Channel A fish sampling sites

Results of the Channel A sampling (Table 8, Figures 7-11) revealed a larger variety of fish species following barrier opening in comparison to the baseline period. The most abundant species in the February 2015 sampling event was not a fish, but rather grass shrimp (*Palaemonetes* sp.), one of the most common macroinvertebrates in tidal systems. The most abundant fish species for the February and June sampling events was the tidewater mojarra (*Eucinostomus harengulus*), commonly found in tidal creeks throughout Tampa Bay. Neither of these species were caught during the baseline sampling period. During the second post modification sampling event, less species diversity was observed. Atlantic silverside (*Menidia menidia*) were most abundant in the October 2016 sampling event, while only one individual was found in May 2017. Tidewater mojarra were most abundant in May 2017, and common in both events.

Sample Location	Ch.A Below		Ch.A Below		Ch.A Below		Ch.A Below		Ch.A Below	
Sample Date	Aug-11	Aug-11	Feb-15	Feb-15	Jun-15	Jun-15	Oct-16	Oct-16	May-17	May-17
Fish Identification	% Fish in Sample	Number INDIV	% Fish in Sample	Number INDIV	% Fish in Sample	Number INDIV	% Fish in Sample	Number INDIV	% Fish in Sample	Number INDIV
Atlantic Silverside *(Menidia menidia)*							57.69%	30	4.55%	1
Bay Anchovy *(Anchoa mitchilli)*					8.70%	6				
Blue Crab *(Callinectes sapidus)*			3.80%	1						
Clown Goby *(Microgoblus gulosus)*					1.40%	1				
Code Goby *(Gabiosoma robustum)*					1.40%	1				
Eastern Mosquitofish *(Gambusia holbrooki)*					2.90%	2				
Gar *(Lepisosteus sp.)*					1.40%	1				
Goby *(Gobiosoma sp.)*									4.55%	1
Hogchoker *(Trinectes maculatus)*					1.40%	1				
Largemouth Bass *(Micropterus salmoides)*	3.00%	1								
Leatherjacket *(Oligoplites saurus)*					1.40%	1				
Norfolk Spot *(Leiostomus xanthurus)*	18.20%	6	3.80%	1						
Rainwater Killifish *(Lucania parva)*			7.70%	2						
Sailfin Molly *(Poecilia latpinna)*			7.70%	2						
Sheepshead *(Archosargus probatocephalus)*	3.00%	1								
Silversides *(Menidia sp.)*	63.60%	21	3.80%	1	24.60%	17				
Snook *(Centropomus undecimalis)*			7.70%	2						
Spotted Seatrout *(Cynoscion nebulosus)*	12.10%	4								
Striped Mojarra *(Diapterus plumieri)*							1.92%	1		
Tidewater Mojarra *(Eucinostomus harengulus)*			65.40%	17	55.50%	39	40.38%	21	90.91%	20
Total Number of Individuals		**33**		**26**		**69**		**52**		**22**
Caridean Shrimp *(Palaemonetes sp.)*			100.00%	558	100.00%	1				
Total Macroinverts				**558**		**1**				

Table 8 - Channel A below structure fish sampling results

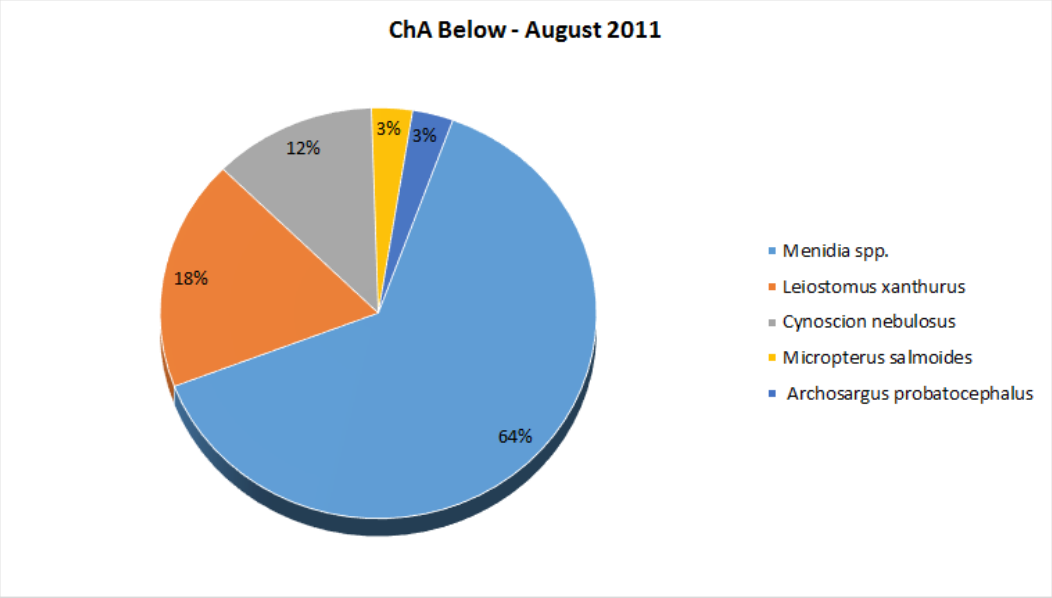

Figure 7 - Species percentage Channel A baseline

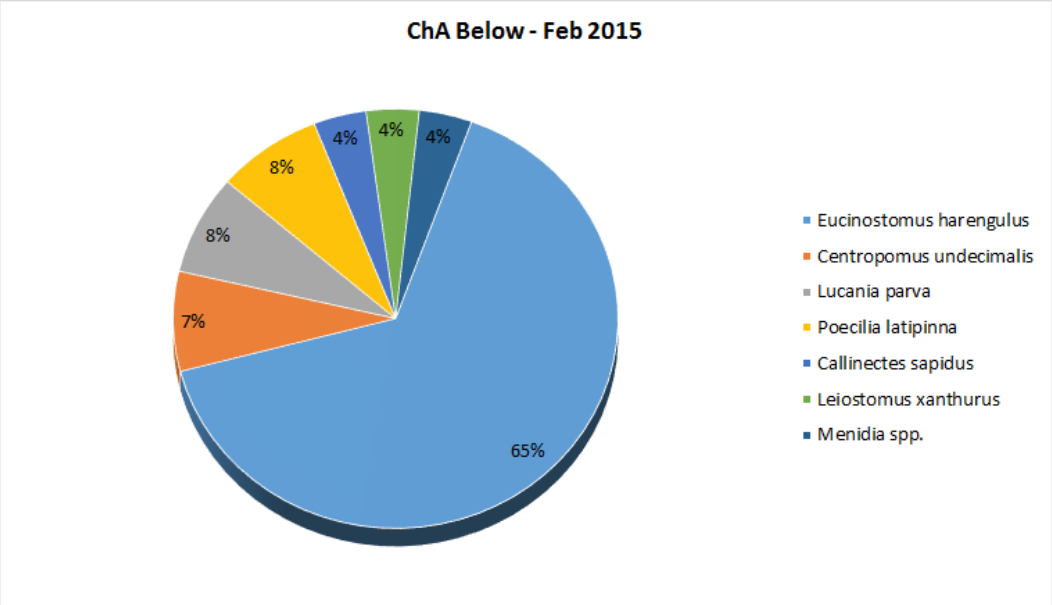

Figure 8 - Species percentage Channel A below, post-modification, Feb 2015

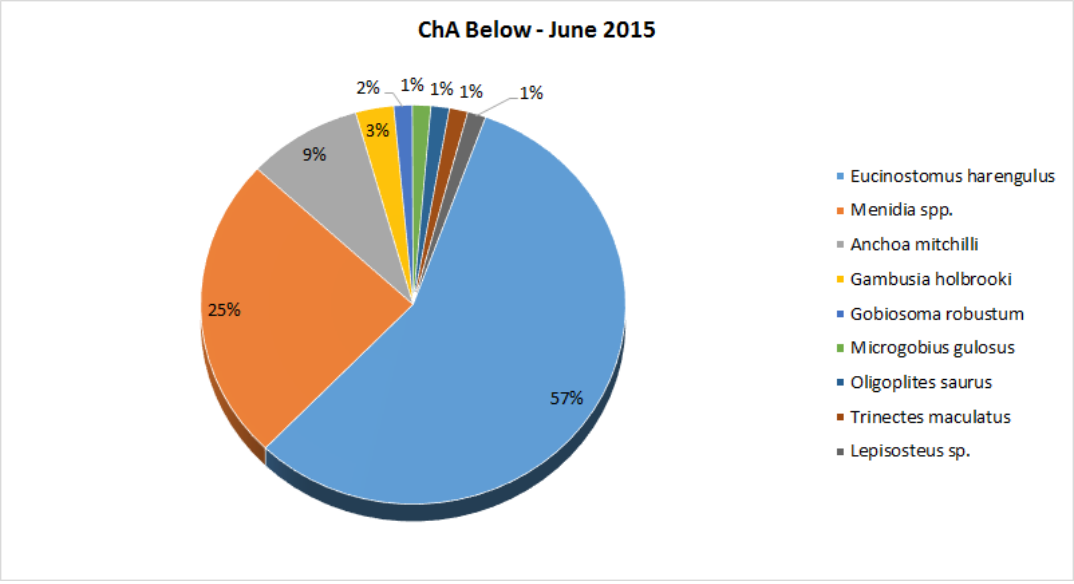

Figure 9 - Species percentage Channel A below, post-modification, June 2015

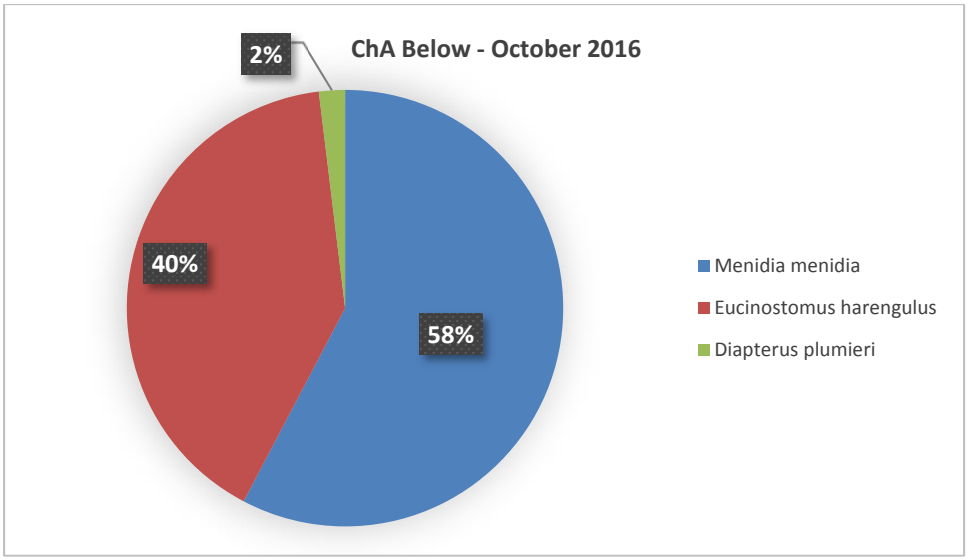

Figure 10 – Species percentage present in Channel A below, second post-modification October 2016

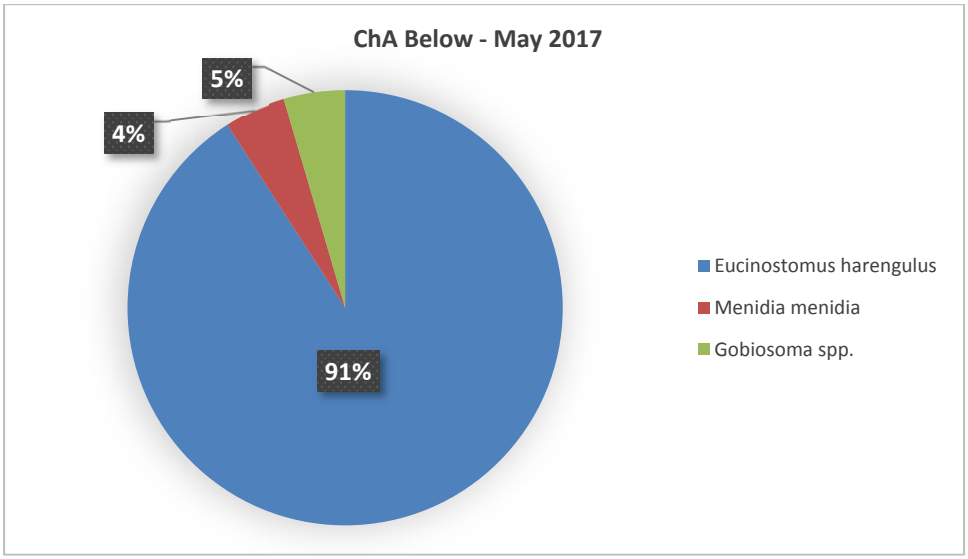

Figure 11 – Species percentage present in Channel A below, second post-modification May 2017

Channel G

Rocky Creek sampling sites were originally located throughout the system for baseline conditions (Figure 16). However, due to extremely low water conditions and inaccessibility of the previously sampled site in Rocky Creek in February and June 2015, sampling was not conducted in the formerly freshwater section of that system. A new site on Channel G upstream of the structure was added in 2015 to better assess the fish community during the post-modification period (Figure 12).

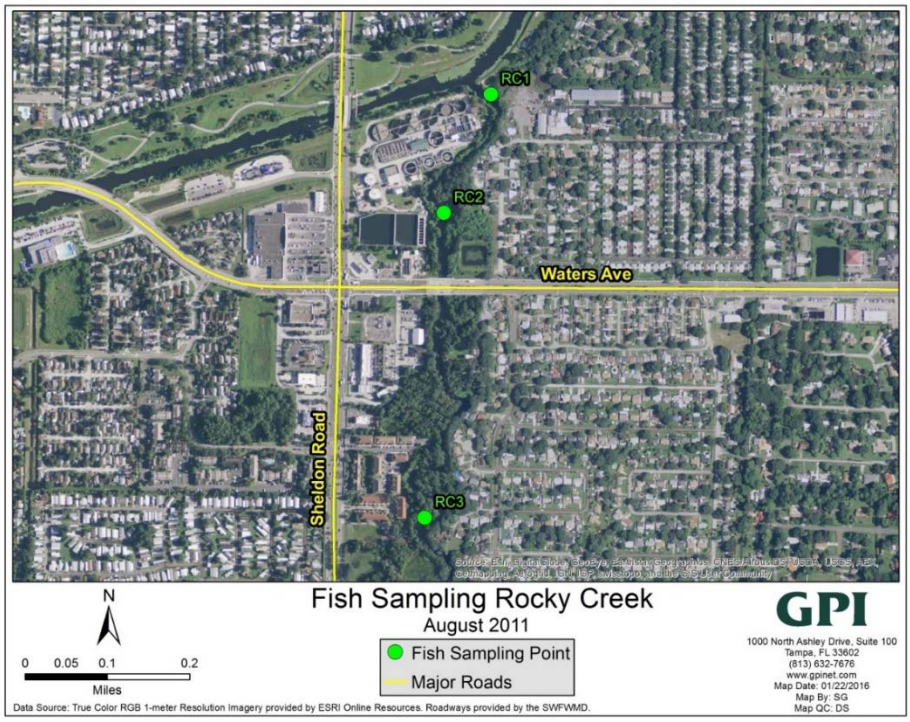

Figure 12 - Rocky Creek fish sampling sites (baseline only)

Figure 13 - Channel G fish sampling site above structure (post-modification only)

Results of Channel G sampling above the structures (Table 9, Figures 15-19) also show a larger variety of fish species immediately following post-modification in comparison to the baseline period. As in Channel A, the most abundant species in Channel G during the February 2015 sampling event was the grass shrimp. The most abundant fish species for the February event was the mosquitofish (*Gambusia holbrooki*), which was also the most abundant during the baseline period. Though classified as a freshwater fish, mosquitofish have a high salinity tolerance and are common throughout tidal creek systems in the Southeast. The most abundant fish genus in the June event was Atlantic silversides. A few silversides were found in the baseline sampling, but below the control structure. In the first post-modification sampling, silversides were found well above the control structure. Overall a smaller variety of species were found during the second post-modification sampling period. However, common snook (*Centropomus undecimalis*) were found during both the October 2016 and May 2017 sampling events, indicating that the system is being utilized by salt-tolerant species in the early stages of their life cycle. Visual observations of striped mullet (Mugil cephalus), typically a salt tolerant species, occurred at both the October 2016 and May 2017 sampling events. Tidewater mojarra were dominant during the October 2016 event, and snook were the most dominant species during the May 2017 event.

Figure 14 – Juvenile snook captured in net in Channel G, May 2017

Sample Location	Ch.G/Rocky Ck.Above		Ch.G Above		Ch.G Above		Ch.G Above		Ch.G Above	
Sample Date	**Aug-11**		**Feb-15**		**Jun-15**		**Oct-16**		**May-17**	
Fish Identification	**% Fish in Sample**	**Number INDIV**	**% Fish in Sample**	**Number INDIV**	**% Fish in Sample**	**Number INDIV**	**% Fish in Sample**	**Number INDIV**	**% Fish in Sample**	**Number INDIV**
Atlantic Silverside *(Menidia menidia)*									19.05%	4
Clown Goby *(Microgoblus gulosus)*	17.00%	9								
Diamond Killifish *(Adinia xenica)*					0.70%	1				
Eastern Mosquitofish *(Gambusia holbrooki)*	32.10%	17	65.00%	65	8.80%	13	15.79%	3	4.76%	1
Gulf Killifish *(Fundulus grandis)*					1.40%	2				
Hogchoker *(Trinectes maculatus)*					1.40%	2				
Largemouth Bass *(Micropterus salmoides)*	3.80%	2			2.70%	4				
Longnose Killifish *(Fundulus similis)*					3.40%	5				
Mullet *(Mugilidae sp.)*			7.00%	7						
Rainwater Killifish *(Lucania parva)*	3.80%	2								
Redear Sunfish *(Lepomis microlophus)*	5.70%	3								
Sailfin Molly *(Poecilia latpinna)*			20.00%	20	6.80%	10				
Silversides *(Menidia sp.)*	9.40%	5	5.00%	5	65.30%	96				
Snook *(Centropomus undecimalis)*							10.53%	2	76.19%	16
Sunfish *(Lepomis sp.)*	26.40%	14								
Tidewater Mojarra *(Eucinostomus harengulus)*							73.68%	14		
Warmouth Bass *(Lepomis gulosus)*	1.90%	1								
Western Mosquitofish *(Gambusia affinis)*			3.00%	3	9.50%	14				
Total Number of Individuals		**53**		**100**		**147**		**19**		**21**
Palaemonetes sp.			99.70%	330						
Clallinectes sapidus (female)			0.30%	1						
Total Macroinverts				**331**						

Table 9 - Channel G above structure fish sampling results

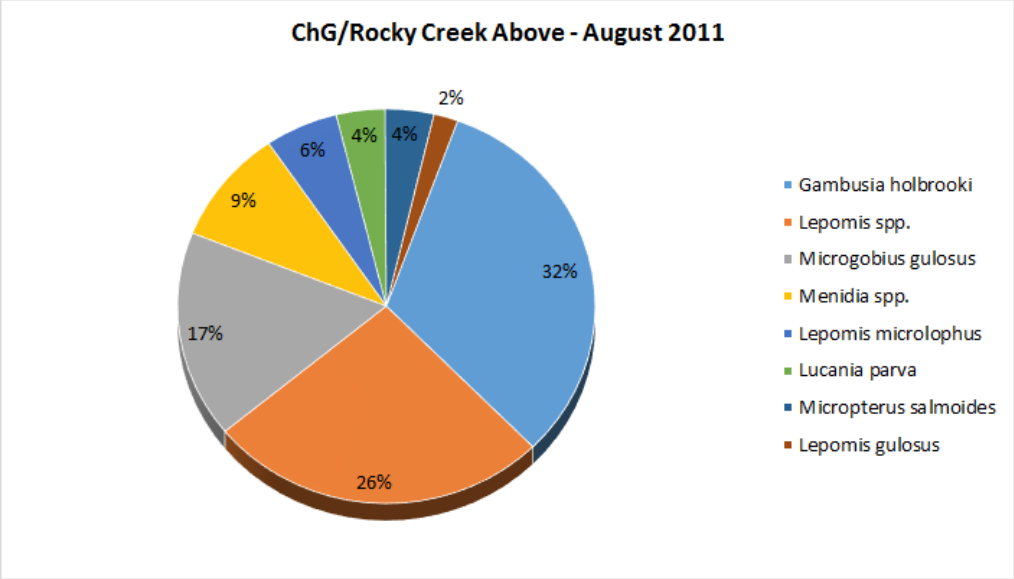

Figure 15 - Species percentage Rocky Creek/Channel G baseline

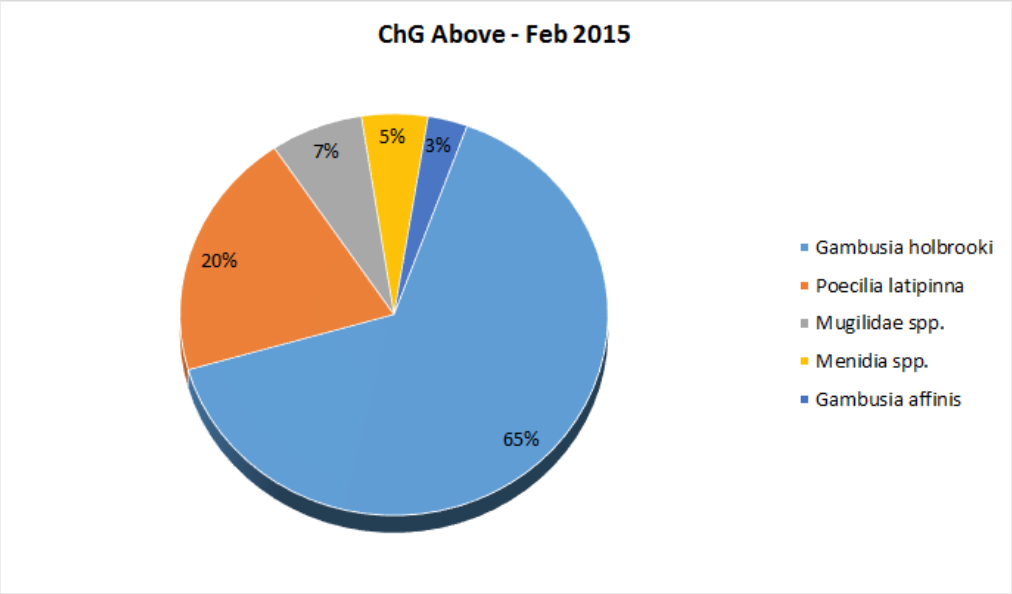

Figure 16- Species percentage Channel G above post-modification, Feb 2015

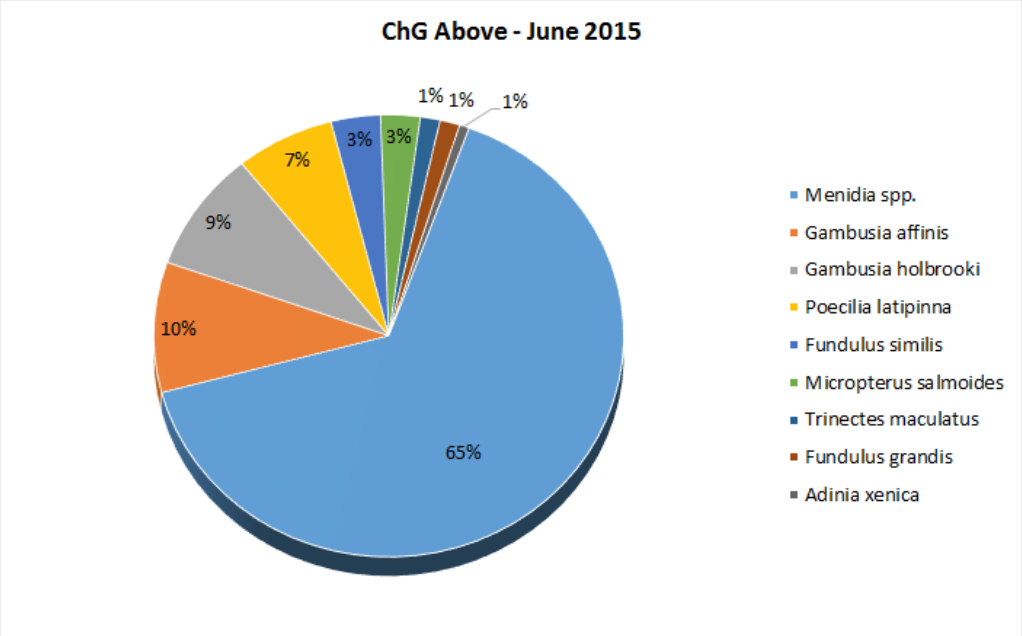

Figure 17 - Species percentage Channel G above, post-modification, June 2015

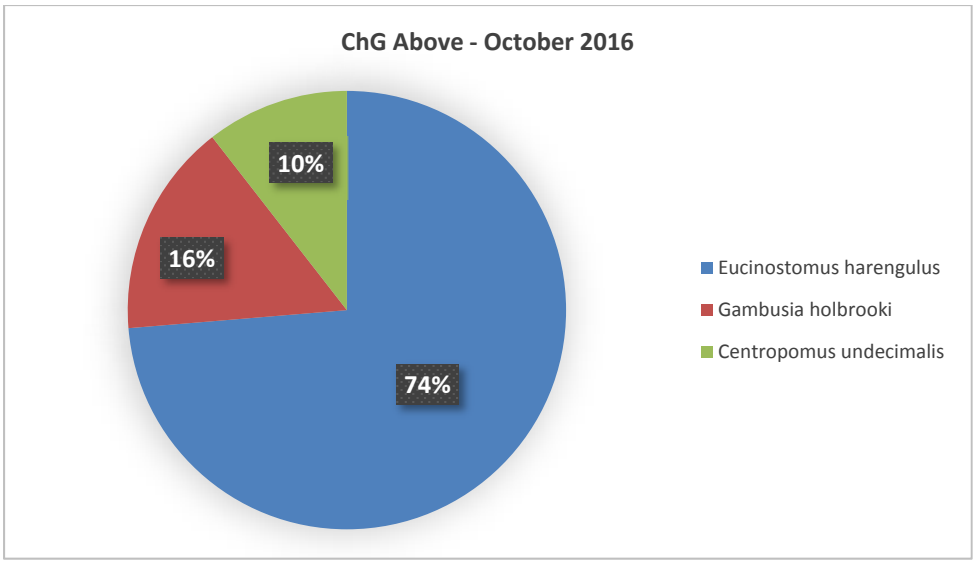

Figure 18 – Species percentage present in Channel G above, second post-modification, October 2016

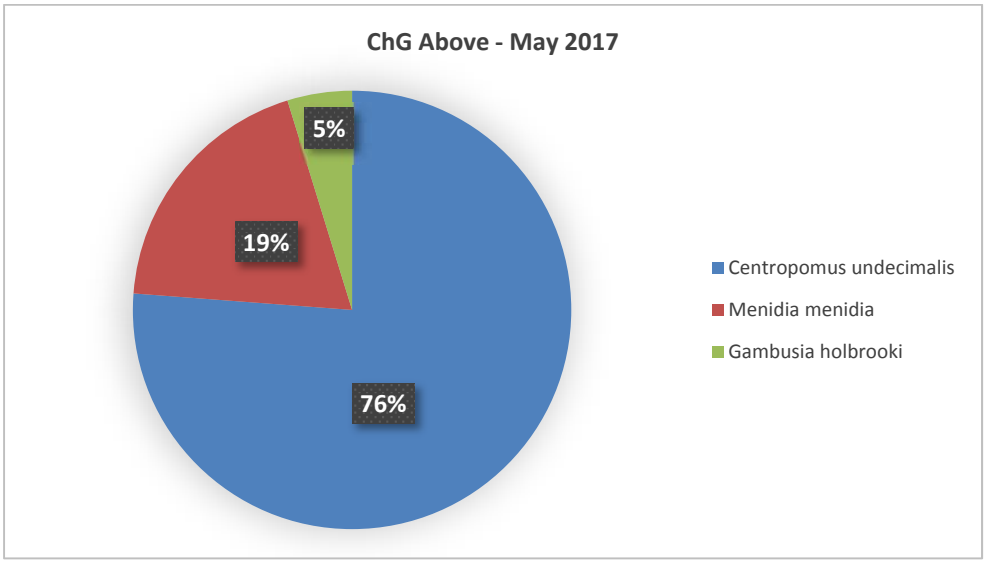

Figure 19 – Species percentage present in Channel G above, second post-modification, May 2017

Channel G Below

The Channel G sampling sites were located below the structure, just off Hillsborough Avenue (Figure 21).

Figure 20 - Channel G fish sampling sites

Results of Channel G sampling below the structures (Table 10, Figures 20-24) showed that the baseline samples had a larger variety of fish species and total number of fish compared to the first post-modification sampling events. This is mainly due to the absence of sunfish (*Lepomis microlophus* and *Lepomis sp.)* likely caused by higher salinities present after the opening of the control structure. Sunfish accounted for 39% of the taxa represented in the baseline period. The most abundant fish species in the baseline period, mosquitofish (*Gambusia holbrooki*), was barely present in the February 2015 sampling event and not present in June 2015. Only 3 mosquitofish were found in the second post-modification monitoring period. As in Channel A, the most abundant species in Channel G in the February 2015 sampling event was the grass shrimp (*Palaemonetes* sp.). The most abundant fish genus in June 2015 were silversides (*Menidia* spp.). A few silversides were found in the baseline sampling period as well. Samples collected at Channel G, below the gates, in 2016 were dominated by more salt-tolerant fish as well as a juvenile snook. The 2017 sampling event netted a wide variety of species including one largemouth bass, the only time this species has been found during monitoring since gate modification. Silversides were most abundant in the October 2017 event, and bay anchovy (*Anchoa mitchilli*) were dominant during the May 2017 event.

Sample Location	Ch.G Below		Ch.G Below		Ch.G Below		Ch.G Below		Ch.G Below	
Sample Date	Aug-11	Aug-11	Feb-15	Feb-15	Jun-15	Jun-15	Oct-16	Oct-16	May-17	May-17
Fish Identification	% Fish in Sample	Number INDIV	% Fish in Sample	Number INDIV	% Fish in Sample	Number INDIV	% Fish in Sample	Number INDIV	% Fish in Sample	Number INDIV
Atlantic Silverside (*Menidia menidia*)							86.49%	32	3.97%	10
Bay Anchovy (*Anchoa mitchilli*)					16.70%	5			82.14%	207
Blue Tilapia (*Oreochromis aureus*)			7.70%	1						
Clown Goby (*Microgoblus gulosus*)	21.10%	28			3.30%	1			3.17%	8
Code Goby (*Gabiosoma robustum*)									0.40%	1
Eastern Grass Shrimp (*Palaemonetes paludosus*)			7.70%	1						
Eastern Mosquitofish (*Gambusia holbrooki*)	44.40%	59	7.70%	1					1.19%	3
Goby (*Gobiosoma sp.*)	0.80%	1	23.10%	3					1.19%	3
Grass Shrimp (*Palemontes sp*)									1.19%	3
Hogchoker (*Trinectes maculatus*)			7.70%	1					0.40%	1
Largemouth Bass (*Micropterus salmoides*)	1.50%	2							0.40%	1
Least Killifish (*Heterandria formosa*)	0.80%	1								
Rainwater Killifish (*Lucania parva*)			7.70%	1					0.40%	1
Redear Sunfish (*Lepomis microlophus*)	18.80%	25								
Sailfin Molly (*Poecilia latpinna*)	3.00%	4	30.80%	4						
Silversides (*Menidia sp.*)	2.30%	3	7.70%	1	73.30%	22				
Snook (*Centropomus undecimalis*)							10.81%	1		
Spottail Needlefish (*Strongylura strongylura*)					3.30%	1				
Sunfish (*Lepomis spp*)	*7.5*	*10*								
Tidewater Mojarra (*Eucinostomus harengulus*)					3.30%	1	10.81%	4	5.56%	14
Total Number of Individuals		**133**		**13**		**30**		**37**		**252**
Caridean Shrimp (*Palaemonetes sp.*)			98.40%	299						
Blue Crab (*Callinectes sapidus*) (Male)			1.60%	5						
Total Macroinverts				**304**						

Table 10 - Channel G below structure fish sampling results

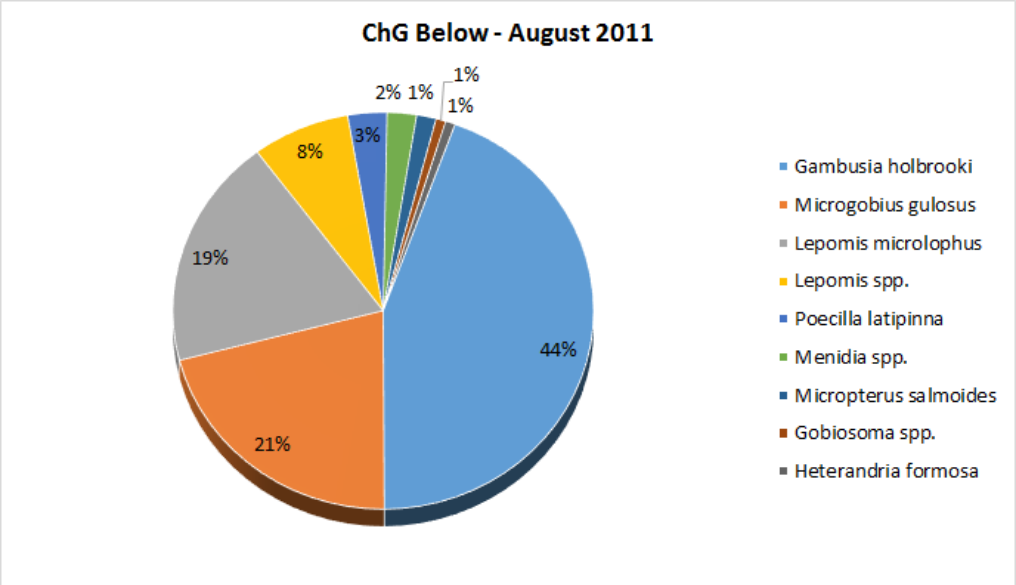

Figure 21 - Species percentage Channel G below, baseline

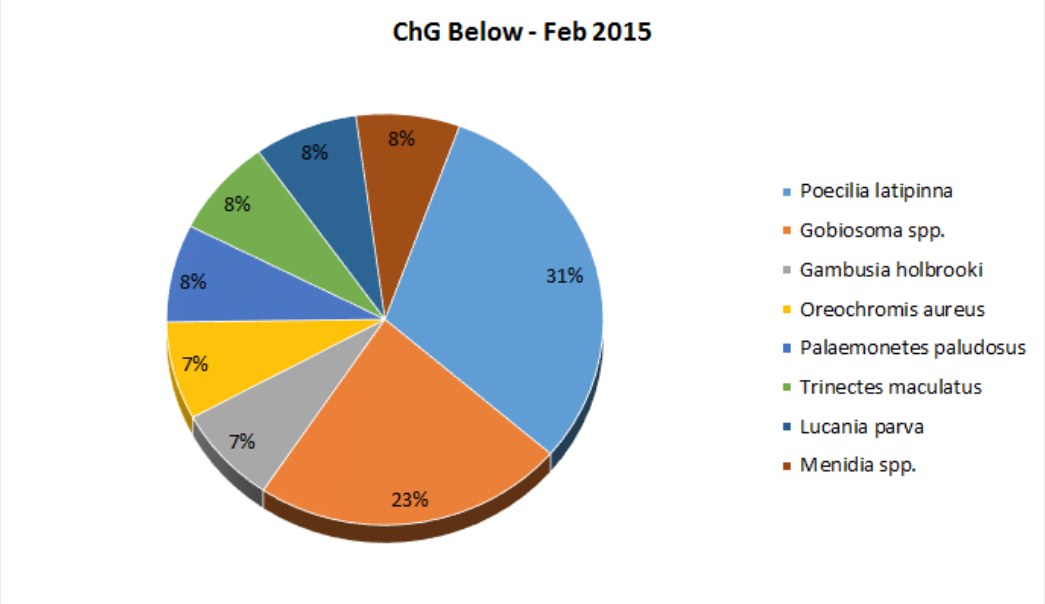

Figure 22 - Species percentage Channel G below, post-modification, Feb 2015

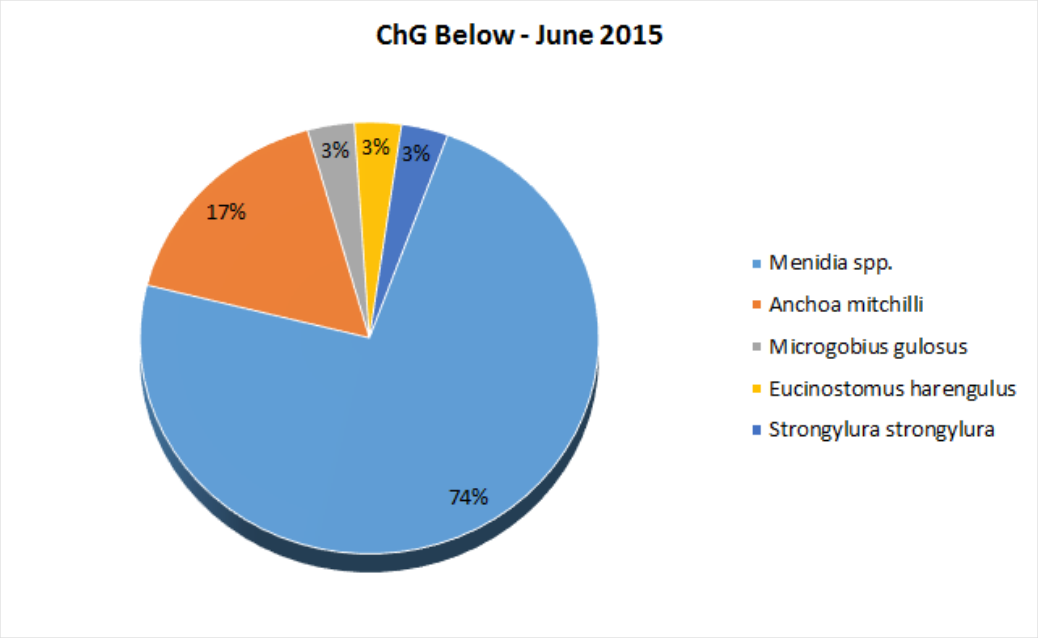

Figure 23 - Species percentage Channel G below, post-modification, June 2015

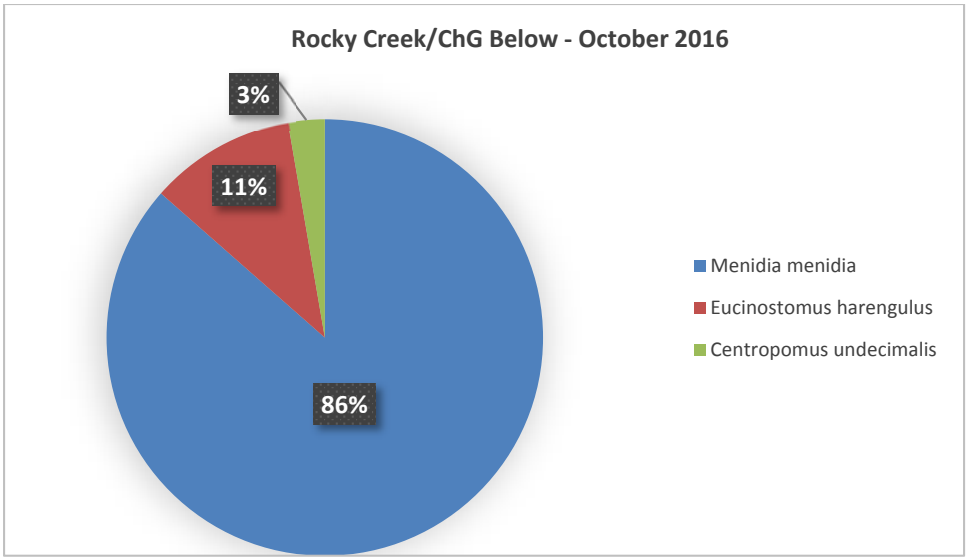

Figure 24 - Species percentage Channel G below, second post-modification, October 2016

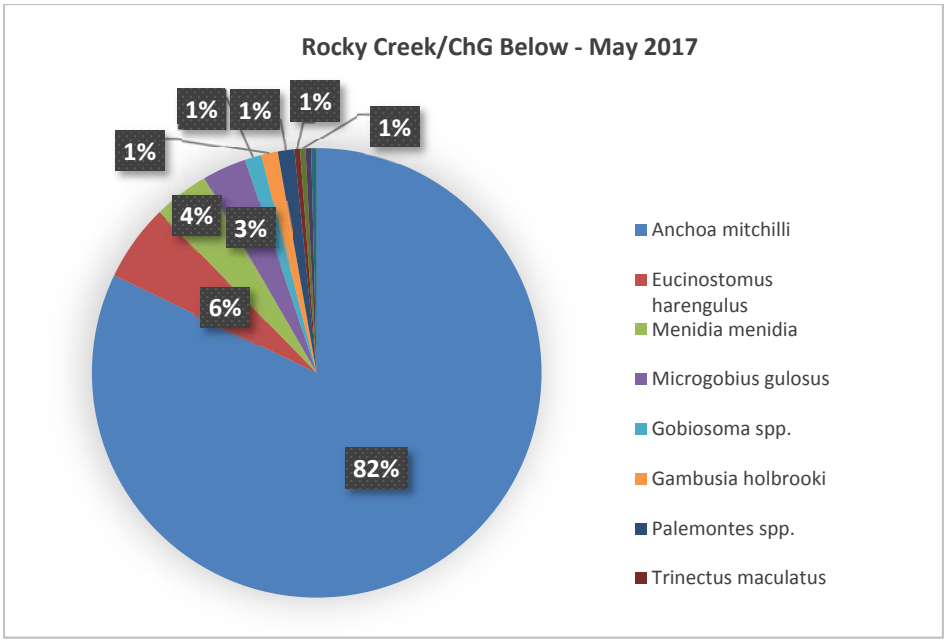

Figure 25 - Species percentage Channel G below, second post-modification, May 2017

Other Observations

Additional anecdotal observations from local fisherman and field observations of GPI staff continue to suggest larger numbers of salt-tolerant adult fish occurring above the control structures in Channels A and G post-modification, including common snook, jack crevalle *(Caranx hippos),* sheephead *(Archosargus probatocephalus*) and striped mullet *(Mugil cephalus).* There continues to be a decrease in previously-observed freshwater fish including sunfish (family Centrarchidae), largemouth bass (*Micropterus salmoides*), and armored catfish (*Hypostomus plecostomus*).

Salinity Tolerance Index and Analysis

To assess the change in salinity tolerance of the fish community at Channels A, G, and Rocky Creek, a salinity tolerance index was developed based on previously established estuarine salinity ranges (Tampa Bay Water, 2003) in conjunction with known salinity tolerances of each species found during all sampling events (Table 11). Each species was assigned a salinity tolerance classification score as depicted in Table 12.

Predominant habitat	Salinity Tolerance
Fresh (<.5 ppt)	1
Estuarine (.5 - 30ppt)	2
Saltwater (<30 ppt)	3

Table 11 - Salinity tolerance values

Salinity Tolerance Classification	
Species	**Salinity Tolerance Score**
Archosargus probatocephalus	3
Adinia xenica	2
Anchoa mitchilli	2
Centropomus undecimalis	2
Cynoscion nebulosus	2
Diapterus plumieri	2
Eucinostomus harengulus	2
Fundulus grandis	2
Fundulus similis	2
Gambusia affinis	2
Gambusia holbrooki	2
Gobiosoma robustum	2
Gobiosoma spp.	2
Heterandria formosa	1
Leiostomus xanthurus	2
Lepisosteus sp.	1
Lepomis gulosus	1
Lepomis microlophus	1
Lepomis spp.	1
Lucania parva	2
Menidia spp.	2
Microgobius gulosus	1
Micropterus salmoides	1
Mugilidae spp.	2
Oligoplites saurus	2
Oreochromis aureus	1
Palemontes spp.	2
Poecilla latipinna	2
Strongylura strongylura	2
Trinectes maculatus	2

Table 12 - Salinity tolerance classification scores

After each species was assigned a salinity tolerance score, the following formula was used to calculate the weighted average salinity tolerance for each sample period:

$$Salinity\ Tolerance\ Index = \sum(Relative\ Species\ Abundance * Salinity\ Tolerance)$$

These values were plotted for each sampling area to show trends before and after the gates were modified (Figure 25). Based on the patterns visible in the graph, the fish community salinity tolerance in Channel A below the salinity barrier does not appear to be affected by the removal of the barrier as the salinity tolerance of the sampled fish community does not change substantially. Above the salinity barrier in Channel G, an increased salinity tolerance is observed after the removal of the salinity barrier. That trend remains stable during both post-modification sampling periods. An increase in fish community salinity tolerance occurred during the second post-modification sampling period below the salinity barrier in Channel G, as well.

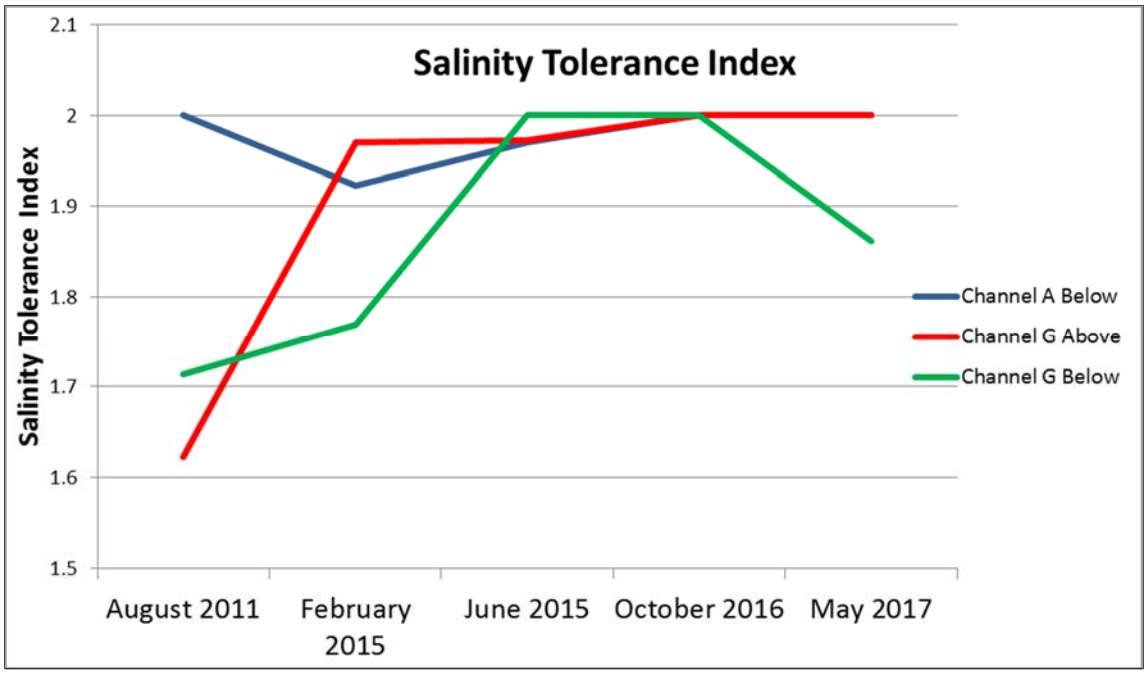

Figure 26 – Overall salinity tolerance index at all sites

The increase in salinity tolerant species post-modification indicates the system may be functioning more similarly to a natural tidal creek system. However, the short time frame of this study and sample sizes are not sufficient to make any definitive conclusions at this point.

Manatees

During the second post-modification period assessment, manatees were observed by residents and GPI staff during field activities. Two manatees were observed in Channel A behind Cody's Roadhouse restaurant (Land-Based Sampling Location 8) while collecting land based data. During the vegetation survey, conducted by GPI on August 15, 2017, manatees were seen swimming in Channel G by a local resident and GPI personnel.

Conclusions

The Channel A, G and Rocky Creek complex is a dynamic system including both tidal and freshwater reaches. Reduced tidal exchange due to historic operation of the two salinity barriers may have resulted in a "flashy" system. Seasonal releases of freshwater from the control structures interspersed between prolonged periods of no freshwater inflow, other than general runoff from adjacent lands along the channels, were perceived to cause "flashy" conditions in the estuarine portions of these systems below the salinity barriers. Further, saltwater has historically been prevented from moving up into Rocky Creek through operation of the salinity barriers. It was theorized that by modifying operation of the salinity barriers and allowing a more natural tidal exchange above the structures, the resultant ecosystem benefits might include reduction of algal mats and vegetation above the structure (due to reduced resident times, tidal flushing, and increased salinities), as well as potential expansion of oligohaline fisheries habitat.

The Channel G monitoring well site data did not strongly indicate potential salinity intrusion during the second post-modification period. Salinity levels within the Channel G well appear to be consistent between the first and second post-modification monitoring period, though additional monitoring is recommended. Salinity occurrence in the groundwater wells adjacent to the channel was first observed in the 1970s during channel construction and is verified by data collected during the baseline and post-modification study period.

In examining the changes in habitat types and biotic assemblages, there have been some notable changes. In comparing the pre-modification vegetation survey conducted by Hillsborough County and our second post-modification survey, it appears that vegetation cover likely increased on the canal banks and along littoral zones. Algal mats and submerged freshwater vegetation disappeared from all three systems, indicating greater tidal flushing and increased salinity conditions. Salt-tolerant plants have continued to encroach further upstream of the control structures. With respect to the biotic assemblages (fish), it appears that the Channel A and G systems are functioning more like a natural tidal creek system than in their pre-modification state. The Southwest Florida Water Management District has also reported a significant reduction in their vegetative management costs associated with these systems following the control structure modifications.

Surface water quality sampling results show that salinity has become more highly variable in the system, increasing in areas above the structures. Each of the reported salinity monitoring datasets evaluated during this study show that the upstream system is becoming more tidal in nature. Both channel systems above the structures are becoming more tidal in nature. Water levels are more variable in the upper portions of Channels A and G. This was most notable in the middle sections of Rocky Creek, where water levels dropped in some areas, resulting in stretches of Rocky Creek becoming un-navigable by boat and exposed during portions of the tidal cycle. There is a large salinity variance between wet and dry seasons within these systems. Higher freshwater base flows during wet months lead to noticeably decreased salinities both upstream and downstream of the water control structures. These conditions also appear to be more similar to other tidal creek systems prevalent in Tampa Bay.

In summary, the raising of the control structure gates in June 2014 has resulted in a system that appears to be continuing to trend towards a natural Southwest Florida tidal creek, as evidenced by changes in salinity, biotic assemblages, and habitat types.

Recommendations

- Continue to monitor salinity at the Channel G groundwater monitoring well
- Perform additional vegetation surveys at periodic intervals in the future to continue evaluation of changes in vegetative composition in the system
- Continue and potentially expand upon fish sampling study to assess young of year recruitment in the upper reaches of the system and identify the use of the entire system by economically important gamefish
- Continue surface water quality sampling in partnership with Tampa Bay Estuary Program tidal tributary efforts
- Engage citizens in future management decisions in the system
- Continue to explore public education opportunities to convey the importance of increasing tidal creek habitat for water quality and fisheries habitat enhancement.

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