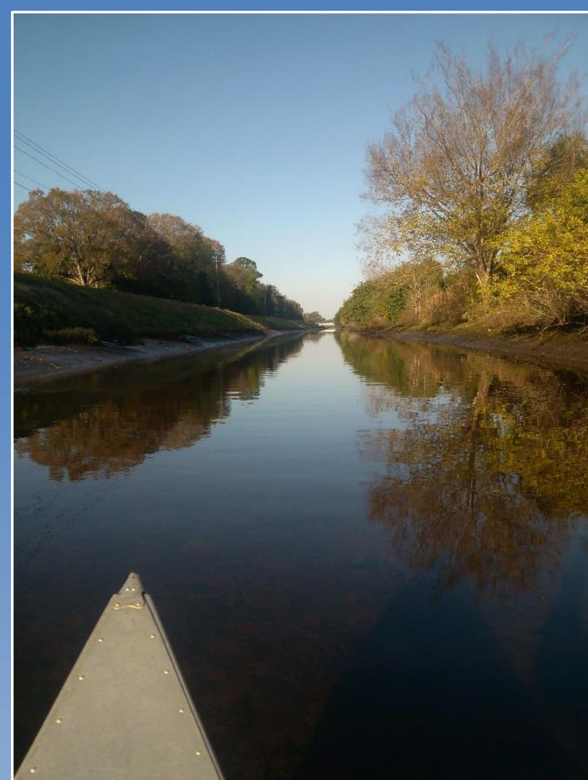
Channels A, G, and Rocky Creek Pilot Monitoring Project Report



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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's a freshwater and tidal tributary system bisected by two salinity control barriers owned and operated by the District.

The lower Rocky Creek system suffers 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 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.

Public Outreach

Public outreach occurred throughout the course of the project. Prior to the gates being opened, a public meeting was held on January 22, 2014 at Town 'N Country Regional Library, 7606 Paula Dr., Tampa, FL 33616. It was an open-house style meeting to provide information about the pilot study, how it will affect the operations of the water control structures, answer questions, and take public comment. There were

19 attendees participating in the meeting, including 12 members of the public and seven staff members from the District, Tampa Bay Estuary Program and GPI.

The meeting notification was mailed to 1,890 residents along Channels A & G and within the project area. Web-based meeting notification occurred on the District calendar webpage. The meeting was also noticed in the Florida Administrative Weekly.

The District also notified homeowners with registered groundwater monitoring wells by mail on January 8, 2014 and contacted residents with water access or using surface waters for landscape irrigation on April 10, 2014. Prior to modifying the gate operation, approximately 900 residents were contacted by certified letter June 3, 2014.

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 1.0 m mean sea level (MSL) and 1.2 m MSL, 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.

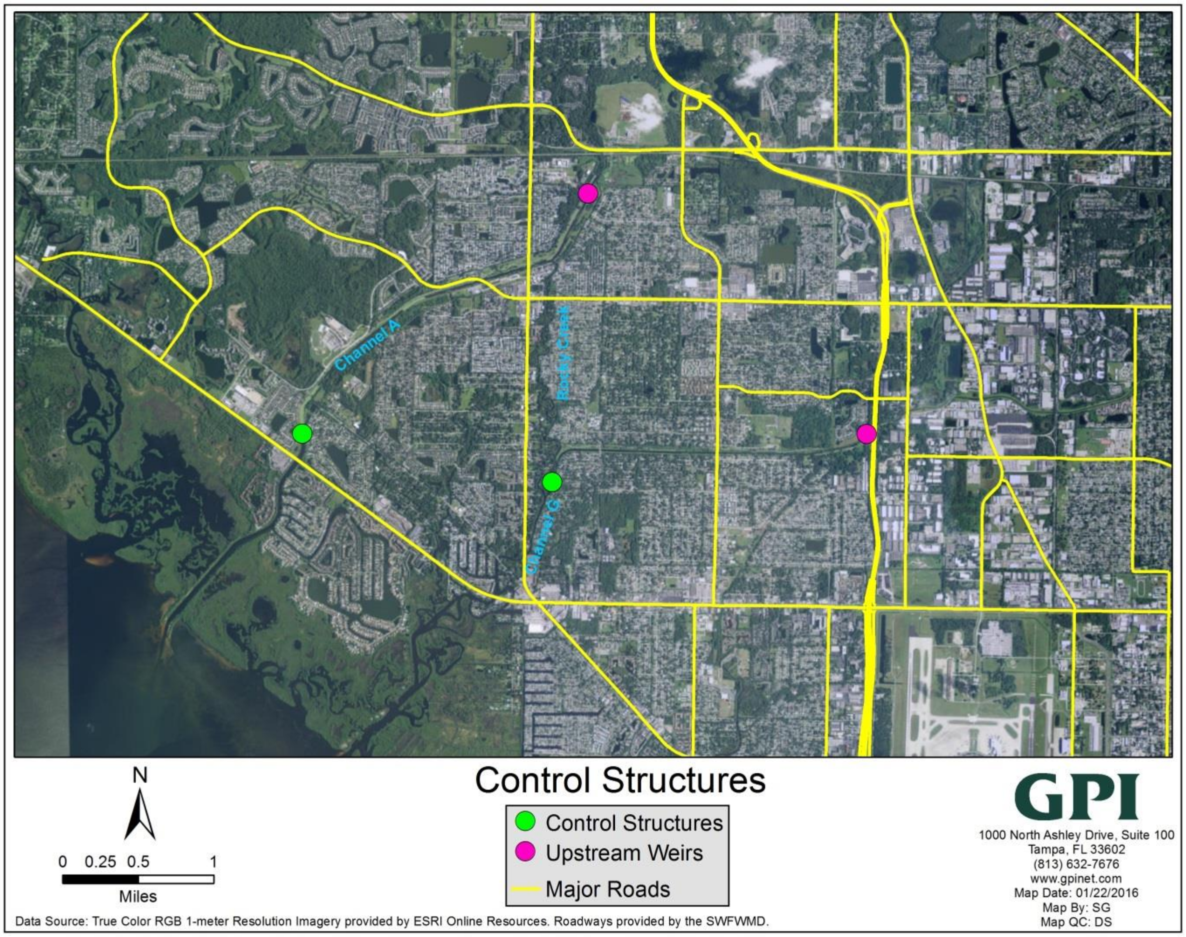

Figure 1 - Location of Channel A and G control structures

The salinity barriers commenced operation in late April 1978 at which time an upstream water level of 1.0 m 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 0.9 m. 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 did confirm 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.	**-** 1.5 m MSL **-** Note: manual sluice gate elevation is – 2.3 m MSL
Crest Elev.	2.6 m 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.	- 1.5 m MSL **-** Note: manual sluice gate elevation is – 1.5 m MSL
Crest Elev.	2.5 m 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 opening for this study, water levels in Channel A were maintained between 0.7 and 0.9 m 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 maintained between 0.6 and 0.9 m 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. Appendix A contains the structure operation schedules from January 2011- February 2012. The values indicate the height of the gate opening above the crest of the weir (e.g., a reading of 0.55 is an opening of 0.55 meters).

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 (January 2016). 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 canoe trip up Rocky Creek in February of 2015.

Water Level data from upstream and downstream gauges on Channels A and G (Table 1) reflect fluctuations in water levels pre- and post-modification. Due to some variability in the period of data collection in the earlier datasets, a two-year period prior to the structure opening was used to compare water levels in the channels following the structure openings.

On Channel G upstream, near the fixed weir, overall water levels dropped an average of 0.56 m compared to baseline conditions. Median, maximum, and minimum levels were also lower post-modification when compared to the baseline period. On Channel A upstream, near the fixed weir, water levels dropped a similar amount, averaging 0.56 m overall compared to baseline conditions.

Neither Channel G nor Channel A downstream gauges, located near the control structures, reflected as significant a change, due to the tidal nature of these sections of the channel.

Time Period	Start (2012) – 6/20/14					6/21/14 - 11/15/15				
Parameter	Average	Standard deviation	Median	Max	Min	Average	Standard deviation	Median	Max	Min
Channel G Upstream	0.79	0.12	0.76	1.71	0.38	0.23	0.25	0.24	1.19	-0.40
Channel G Downstream	0.20	0.26	0.20	1.44	-0.47	0.24	0.26	0.25	1.08	-0.42
Channel A Upstream	0.76	0.09	0.75	1.75	0.41	0.20	0.27	0.22	1.12	-0.49
Channel A Downstream	0.23	0.25	0.23	1.61	-0.34	0.19	0.28	0.20	0.81	-0.51

Table 1 - Water level (m) data summary from staff gauges on Channels A and G above and below structures

Bathymetry

In July 2011, field staff from GPI and Scheda Ecological Associates went out on Channels A & G complex to acquire bathymetric data using a depth pole and handheld Trimble® (Appendix A). Stations were set at random increments throughout both systems, to their respective termini in Old Tampa Bay. Due to large vegetation mats, the crew was unable to access the far upper portion of Channel G, near the upstream fixed weir (G-1).

Channel A has a narrow to non-existent littoral shelf and the general bathymetry of the main channel was a steep slope with a flat bottom. The contours of the above-water banks were also steep with little vegetation. The width of Channel A is approximately 50 meters with little variation throughout the system. The depth of the channel, at water level 0.83m, averaged 3 meters with a flat bottom.

The general bathymetry of Channel G is similar to Channel A in that it has a flat bottom, but it is a shallower water body, with an average depth of 1.5 meters, at water level 0.83m. The width of Channel G is approximately 20 meters with little variation throughout the system. There was evidence of local sediment deposition throughout both channels, though there was no evidence of a build-up north (upstream) of the control structures. Most of the deposits ranged between <1 - 1.5 m in some sections and were looser materials easily distinguished from the harder natural bottom.

Rocky Creek, unlike Channel A or G, is a natural meandering stream system. The banks are low relief and heavily vegetated. Some homes and businesses back up along the creek. Depths, at water level 0.83, ranged from 1.5 to 3m. Like Channel A and G, there was some evidence of sediment deposition in the Creek, between <1 – 1.5m.

One of the initial concerns of the project was the potential for a sediment plug to be dislodged and move downstream, causing adverse ecological effects, as well as silting in navigable canals in the neighborhoods downstream of the Channel A structure. The bathymetry did not indicate any significant build-up of sediment upstream of the Channel A control structure.

Post modification there was observable movement of organic and loose materials out of Channel G, exposing more sand bottom throughout the system north of the control structure. No observable change was noted in the bathymetry of Rocky Creek during other sampling trips, nor in Channel A. There were no reports from residents of sediment build-up in the downstream canals on Channels A and G, post-modification.

Due to budgetary constraints, there was no post-modification bathymetry. A future post-modification bathymetric survey of the system is recommended to accurately measure observed changes.

River Oaks Wastewater Treatment Plant

At the confluence of Rocky Creek with Channel A is the River Oaks Advanced Wastewater Treatment Plant, operated by Hillsborough County. Since 2003, the County has taken water quality readings at four locations near the plant as required by its National Pollutant Discharge Elimination System (NPDES) permit (FL0027821). Samples are taken for a variety of parameters including nutrients, DO, and conductivity. Though salinity readings were looked at as part of the baseline, they weren't retrieved for the post-modification portion of the study due to existing Environmental Protection Commission of Hillsborough County (EPHC) data and increased salinity monitoring as part of this study.

The facility is nearing the end of its useful life. As part of the Northwest Hillsborough Wastewater Consolidation Project, River Oaks will be retired in 2017. A new pump station and 36-inch transmission mains will be constructed to divert the flow to the Northwest Water Reclamation Facility, scheduled for expansion.

Benthic Sampling

Invertebrate samples from three stations in Tampa Bay were collected by EPCHC. The benthic invertebrate and sediment composition monitoring was conducted as part of special study sites for their annual Tampa Bay Benthic Monitoring Program. The samples were taken from Channel A, Channel G and Rocky Creek over a four year period during August 2011, September 2012 and August 2014 (Figure 2). The collected benthic faunal samples were identified to the species level.

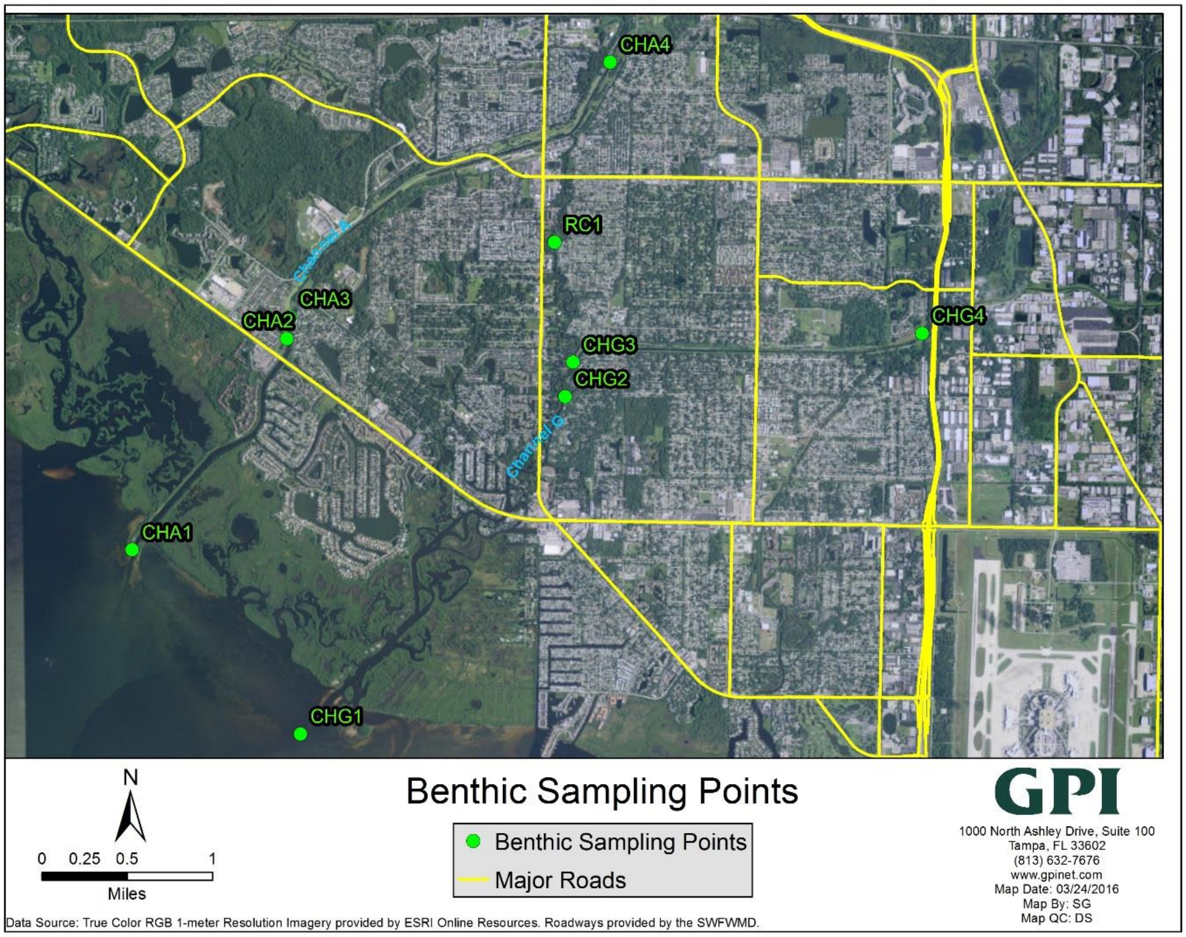

Figure 2 - EPC Benthic Sampling Sites

The species composition at each station were reviewed and assessed by location and year. Using the species composition, we attempted to determine what type of benthic community existed at the three stations over the four years. The species ecology and their habitat type, whether marine/estuarine or freshwater, determined the species types. All species were checked in the known scientific literature and their habitat type determined as such (Table 2). For example, the mud crab, *Eurypanopeus depressus* is considered marine, and therefore counted as a marine/estuarine species. Conversely, *Helobdella stagnalis* is considered a freshwater annelid or oligochaete, and therefore a freshwater species. Taxa that could occur in both freshwater and marine habitats were not counted for either habitat.

NAME	TAXA	HABITAT
Aricidea philbinae	Annelida	Marine
Cerithium muscarum	Mollusca	Marine
Nassarius vibex	Mollusca	Marine
Parastarte triquetra	Mollusca	Marine
COROPHIIDAE	Arthropoda	Marine
Ampelisca abdita	Arthropoda	Marine
Edotia triloba	Arthropoda	Marine
Americorophium ellisi	Arthropoda	Marine
Amakusanthura magnifica	Arthropoda	Marine
Cyclaspis varians	Arthropoda	Marine
Clymenella mucosa	Annelida	Marine
Eteone heteropoda	Annelida	Marine
Prionospio heterobranchia	Annelida	Marine
Capitella capitata complex	Annelida	Marine
Dubiraphia sp.	Insecta	Freshwater
Melanoides tuberculatus	Mollusca	Marine
Corbicula fluminea	Mollusca	Freshwater
Musculium sp.	Mollusca	Freshwater
Hobsonia florida	Annelida	Marine
Laeonereis culveri	Annelida	Marine
Glycera americana	Annelida	Marine
Polypedilum scalaenum group	Insecta	Freshwater
Oxyurostylis smithi	Arthropoda	Marine
Erichsonella attenuata	Arthropoda	Marine
Leptochelia/Hargeria sp.	Arthropoda	Marine
Bittiolum varium	Mollusca	Marine
Polypedilum halterale grp.	Insecta	Freshwater
Cryptochironomus sp.	Insecta	Freshwater
Tanytarsus sp. G of Epler, 2001	Insecta	Freshwater
Helobdella stagnalis	Annelida	Freshwater
Cryptochironomus sp.	Insecta	Freshwater
Cryptotendipes sp.	Insecta	Freshwater
Paracladopelma sp.	Insecta	Freshwater
Gloiobdella elongata	Annelida	Freshwater
Elliptio jayensis	Mollusca	Freshwater
Corbicula fluminea	Mollusca	Freshwater
Helobdella stagnalis	Annelida	Freshwater
Aulodrilus pigueti	Annelida	Freshwater
Pristina sp.	Annelida	Freshwater
Eupera cubensis	Mollusca	Freshwater
Cryptotendipes sp.	Insecta	Freshwater
Oecetis inconspicua complex	Insecta	Freshwater
ODONATA	Insecta	Freshwater
Procladius (Holotanypus) sp.	Insecta	Freshwater
Polypedilum halterale grp.	Insecta	Freshwater
Chironomus sp.	Insecta	Freshwater
Polypedilum sp.	Insecta	Freshwater
Corbicula fluminea	Mollusca	Freshwater
Melanoides tuberculatus	Mollusca	Freshwater
Pyrgophorus platyrachis	Mollusca	Freshwater
Hyalella cf. azteca	Arthropoda	Marine
Dubiraphia sp.	Insecta	Freshwater

Table 2 - Taxa and Habitats

Channel A Results

Channel A had the greatest number of marine and estuarine species over the four year sampling period. Overall, marine species increased substantially during the three sampling events at Channel A, more so than the other two sampling locations. The 2012 sampling year showed a spike in the freshwater fauna, as there was a 11 percent increase in freshwater species from 2011 (40% in 2011 to 51% in 2012). However, by 2014, marine and estuarine species composed 82 percent of the total benthic fauna (Figure 3)

Channel G Results

Freshwater fauna decreased annually over the sampling period at Channel G, with 2014 samples having only 40% freshwater fauna of the total species collected (Figure 3). Overall species composition consisted of both community types, but marine species increased steadily as a percentage of total community type, from 32% in 2011 (baseline) to 60% in 2014 (post-modification).

Rocky Creek Results

Rocky Creek consistently had the highest percentage of freshwater fauna over the three sampling years, although there was a modest decrease in freshwater species over that time (Figure 3). Insects were the primary taxa collected during all three years with oligochaetes and freshwater mollusks being the only other freshwater taxa found at this station (freshwater species: 2011 – 96%; 2012 -94%; and 2014 – 86%).

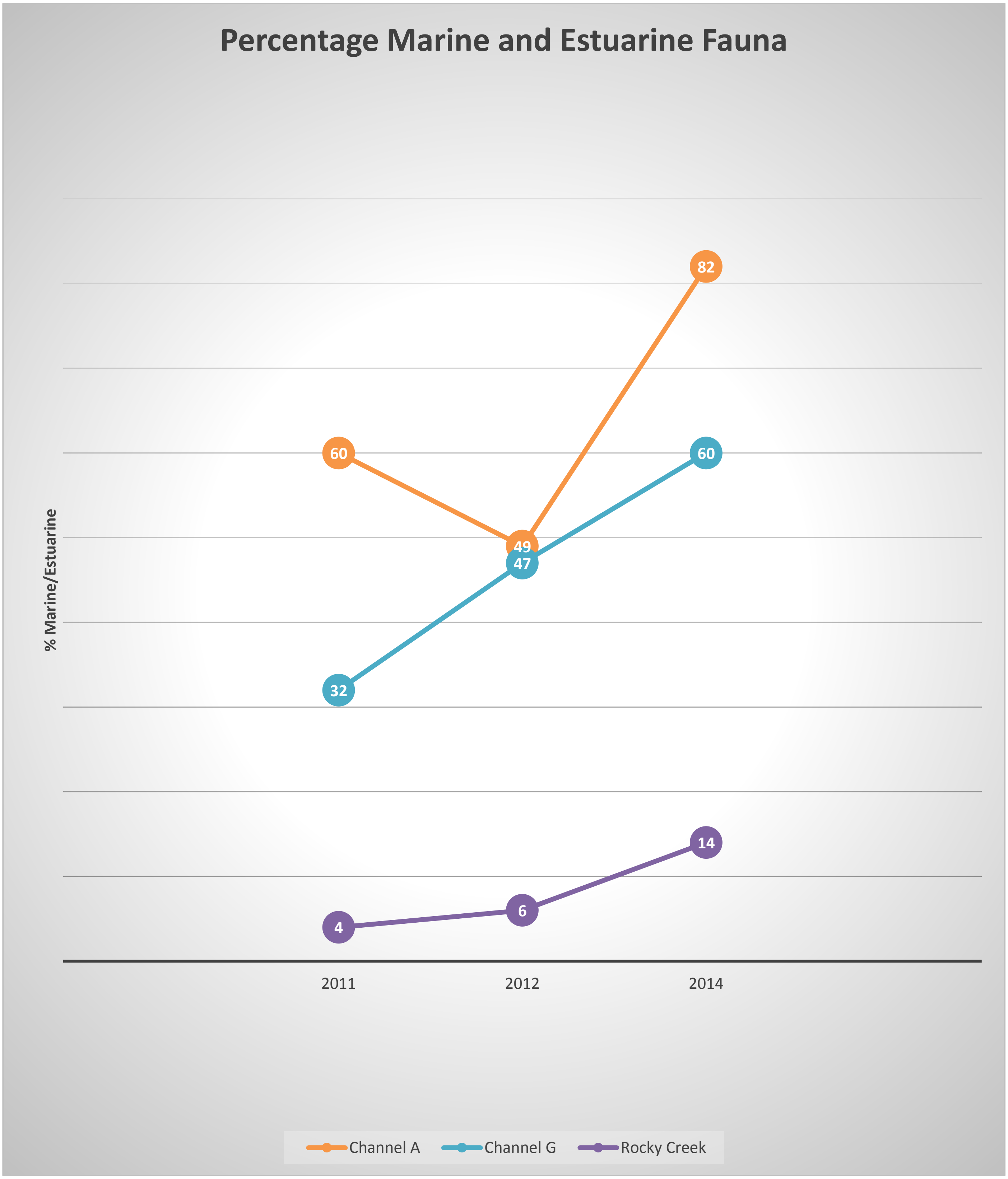

Figure 3 - Change in Percent of Marine/Estuarine Benthic Invertebrates

Sediment Chemistry

In addition to benthic invertebrate assessments, EPHC also sampled sediment chemistry at the same sites. Though, sampling effort during the pre-monitoring period was double that of the post-monitoring period. Below is a summary of any total effects level (TEL) and probable effects level (PEL) exceedances for common contaminants in the sediment samples, following the State of Florida numerical sediment quality assessment guidelines (FDEP, 1994). The average TEL and PEL exceedance per sample is also presented for comparison between the pre- and post-monitoring period in an attempt to adjust for differences in sampling effort. The guidelines are used for screening level analyses only and indicate when there might be or probably may be impacts to sediment-dwelling benthos due to specific contaminant concentration levels. Additional monitoring (acute and chronic sediment toxicity tests and biota tissue samples) would be needed to ascertain if sediment contaminant were truly impairing the ecology of the systems, as is typically performed under TBEP Sediment Quality Action Plan development.

Based on the very limited data it appears the potential for PEL exceedances went down after opening the barriers (i.e. very high contaminant concentrations decreased). Average TEL exceedances were similar during the pre- and post-modification in both Channels A (Table 3) and Channel G (Table 4) In Rocky Creek, there were fewer average TEL exceedances per sample in the post-modification period (Table 5).

Channel A	Pre-Modification (N = 8)		Post-Modification (N = 4)	
Parameter	TEL Exceedance	PEL Exceedance	TEL Exceedance	PEL Exceedance
Total PCBs	1			
Low MW PAHs	2			
High MW PAHs		2	2	
Total PAHs	2		1	
Total DDT	1		1	
Acenaphthene	7			
Acenaphthylene	8		4	
Anthracene	1			
Benzo(a)anthracene		2	2	
Benzo(a)pyrene		2	1	1
Chromium			2	
Chrysene		2	1	1
Copper	1		2	
DDD	1			
DDE	1			
DDT		1	1	
Dibenzo(a,h)anthracene	6	2	3	1
Dieldrin		1		
Fluoranthene		2	2	
Fluorene	2			
G BHC		1		1

Lead	1		1	
Nickel			1	
Phenanthrene	2		1	
Pyrene		2	2	
Zinc	1			1
TOTALS	**37**	**17**	**27**	**5**
MEAN Exceedance	**4.625**	**2.125**	**6.75**	**1.25**

Table 3 - Channel A Sediment Quality Guideline Exceedances

Channel G	**Pre-Modification (N = 8)**		**Post-Modification (N = 4)**	
Parameter	**TEL Exceedance**	**PEL Exceedance**	**TEL Exceedance**	**PEL Exceedance**
Low MW PAHs	3			
High MW PAHs	4	2	4	
Total PAHs	3	1	2	
Acenaphthene	7			
Acenaphthylene	8		4	
Anthracene	2			
Benzo(a)anthracene	3	2	4	
Benzo(a)pyrene	4	2	3	1
Cadmium			2	
Chrysene	3	2	2	1
Copper	1			
DDE	1			
DDT	1			
Dibenzo(a,h)anthracene	5	3	2	2
Dieldrin	1			
Fluoranthene	4	2	4	
Fluorene	3		1	
G BHC		1	1	
Lead	1		1	
Phenanthrene	3	1	3	
Pyrene	2	2	3	
Silver			2	
Zinc		1		
TOTALS	**59**	**19**	**38**	**4**
Mean Exceedance	**7.375**	**2.375**	**9.5**	**1**

Table 4 - Channel G Sediment Quality Guideline Exceedances

Rocky Creek	Pre-Modification (N = 2)		Post-Modification (N = 1)	
Parameter	**TEL Exceedance**	**PEL Exceedance**	**TEL Exceedance**	**PEL Exceedance**
Low MW PAHs	1			
High MW PAHs	2			
Total PAHs	2		1	
Total DDT	1			
Acenaphthene	2			
Acenaphthylene	2			
Anthracene	1			
Benzo(a)anthracene	2		1	
Benzo(a)pyrene	2		1	
Cadmium	1			
Chrysene	1	1	1	
Copper	1		1	
DDT	2			
Dibenzo(a,h)anthracene		2	1	
Fluoranthene	2		1	
Fluorene	2			
G BHC	1			
Lead	1		1	
Phenanthrene	2		1	
Pyrene	2		1	
Zinc		1		
TOTALS	**30**	**4**	**10**	**0**
Mean Exceedance	**15**	**2**	**10**	**0**

Table 5 - Rocky Creek Sediment Quality Guideline Exceedances

Benthic microalgae concentrations (BMAC)

In previous tidal tributary work in Tampa Bay (TBTTRT, 2008) benthic microalgae were determined to be an important driver in primary productivity in tidal tributary systems, and as such, are an essential component of a healthy, functional tidal tributary system. Benthic microalgae contribute to higher trophic levels through intermediate macroinvertebrate and then through juvenile fish pathways. In areas where the tidal tributary system exhibits 'flashy' freshwater/stormwater in-flow conditions, benthic microalgae can be adversely affected as heavy current and strong water pulses scour the bottom and disrupt production.

As part of the pilot monitoring project, baseline benthic microalgae chlorophyll (BMAC) samples were collected and analyzed to determine their presence, reflected as a measurement of milligrams of chlorophyll-a per cubic meter (mg CHLa/m^3). During the benthic macroinvertebrate sampling events in August 2011, BMAC samples were obtained from sediment cores taken at the same sampling sites as depicted in Figure 2. Results were analyzed by the EPCHC.

The results from the August 2011 samples (Table 6) are consistent with samples from the various tidal creeks sampled as part of the TBEP tidal tributary project, as well as results from August 2011 sampling in Bishop and Mullet Creeks -- two tidal tributary systems in Pinellas County. There was an outlier reading of 12,355 mg/m^3 at site 11CHA01, located at the mouth of Channel A, which was notably higher than other BMAC samples collected in the Tampa Bay region. Of note, one sample taken in Rocky Creek, near the middle of the Creek between Channels A and G, had BMAC levels less than the minimum detection level (MDL). Overall, the results indicate a system with moderately-enriched, benthic primary productivity.

Sites	mgCHLa/m3
11 CHG 03	260.11
11 CHA 04	953.76
11 1RC 01	Below MDL
11 CHA 03	520.23
11 CHA 02	1343.94
11 CHG 01	5072.30
11 CHA 01	12355.62
11 CHG 02	8107.02
11 CHG 04	390.17

Table 6 - BMAC samples, August 2011

Post-Modification

BMAC samples were not part of the EPC special studies for 2014, so no post-modification samples were collected.

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 7).

Water Year	Discharge, Cubic Feet per second
2005	22.7
2006	21.0
2007	9.13
2008	13.2
2009	10.7
2010	19.5
2011	19.6
2012	6.9
2013	29.2
2014	26.6
2015 (through 10/14/15)	57.8

Table 7 - Mean daily flow at the Channel G fixed weir structure.

Land-Based Fixed Site Sampling

Salinity sampling was conducted from a variety of bridges and shore spots during baseline and 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 post-modification to streamline the process and remove duplicative sites (Figure 4). Five samples were taken at each station for the baseline monitoring, seven for the post-modification, across a variety of tidal conditions (Table 8).

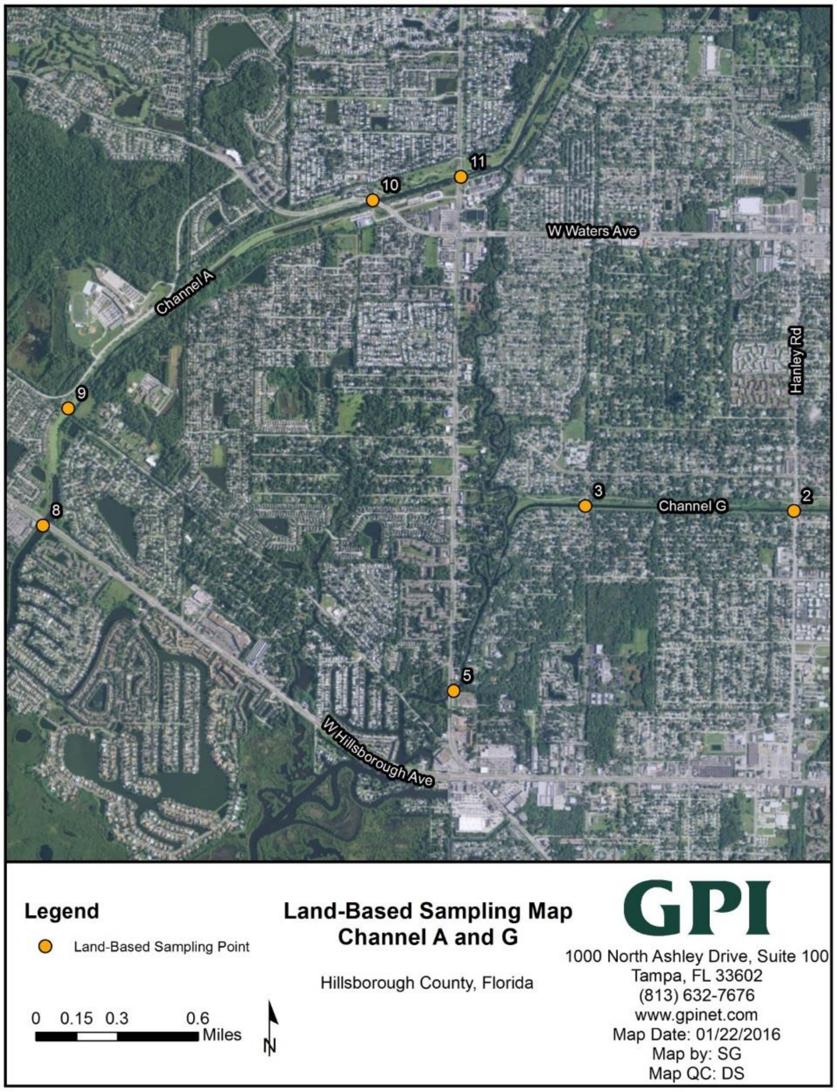

Figure 4 - Land-Based Sampling Sites

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

Table 8 - Tidal breakdown of land-based sampling data

Overall data shows an increase in salinity and tidal influence at most sites (Table 9). Sampling sites above the barriers (2, 3, 9, 10, 11) were indicative of a freshwater system with little to no evidence of tidal influence in the baseline data. However in post-modification sampling, the data for sites 9 and 10 show increased 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 evidence of tidal influence, as well as impacts from the flow of water through the open control gates, in the baseline data. An example of the impact of the open gates was recorded on 9/22/11, where the salinity reading at this site was 0.15 ppt. Gates 1 and 3 at Channel G were open for that sampling date. Post-modification data at this site showed overall increased salinity averages.

Site 8 was located on the Hillsborough Avenue Bridge across from Channel A. The data collected here reflect high salinity readings that are consistent with the expected estuarine conditions of the site.

Channel	Site	Water Depth (m)	Baseline Avg	Post-Modification Avg	Baseline Max	Post-Mod Max	St. Dev.
G - above	2	0.61	0.18	0.14	0.22	0.21	0.05
G - above	3	0.61	0.32	0.3	0.43	0.59	0.16
G - below	5	0.61	2.09	4.37	5.08	10.41	3.07
A - below	8	0.61	18.86	13.12	21.23	20.79	2.82
A - above	9	0.61	0.46	5.04	0.68	15.01	6.84
A - above	10	0.48	0.33	3.42	0.49	15.34	5.9
A - above	11	0.61	0.26	1.17	0.36	8.07	2.79

Table 9 - Land based salinity sampling (ppt)

Sonde Data

Sondes were deployed at various locations in the system to gather continuous 24-hr water quality data (Figure 5). The devices were Hydrolab DS5X sondesand were protected in a large PVC tube that was attached to a weighted stand so the sonde would be suspended in the water column, just off the bottom. Data was collected at 15-min intervals.

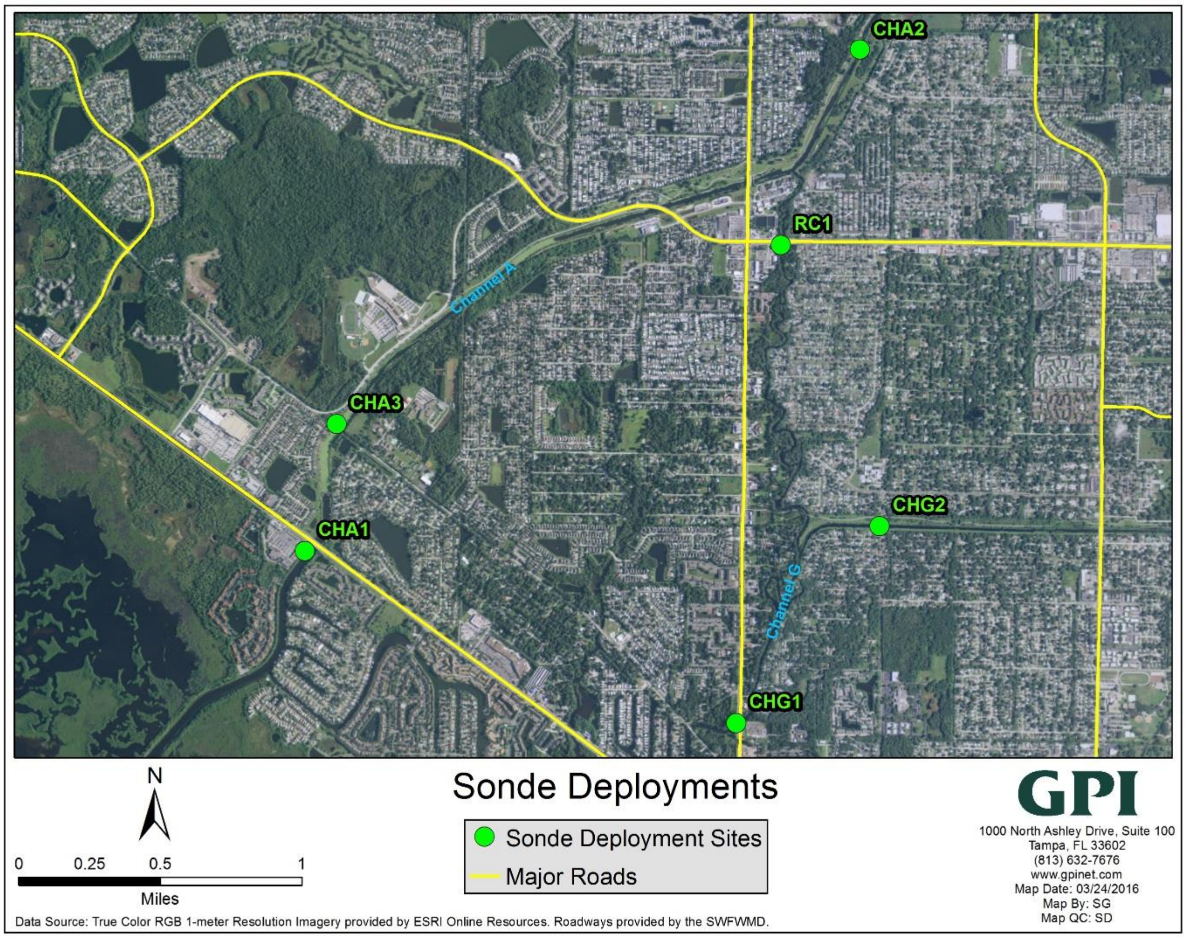

Figure 5 – Sonde deployment sites

Comparisons of baseline and post-modification data at site CHA1 shows more variability in salinity post-modification than during the baseline period (Table 10). Site CHG1 had higher average salinity post-modification, but similar minimums.

Post-modification water levels in the upper reaches of the system exposed the probe at CHA2 resulting in negative and artificially low readings in 2015. Therefore the data shown for CHA2 post-modification are from one three-day sampling event in 2014. The results of salinity measurements at site RC1 show more variability than baseline data. There was a range from a minimum reading of 0.11 ppt to a maximum of 5.04 ppt, suggesting strong tidal influence in the upper reaches of the system compared to baseline conditions.

Site CHA3 was only sampled during the baseline period due to access. It was difficult getting down the sides of the banks to deploy the sondes and the channel itself had little littoral shelf here, leaving the sonde prone to tipping over (as it had done during one baseline sampling event. It was determined that the proximity of CHA1 and the fact that there was another upstream site, CHA2, led to the decision to change sites.

A second site on Channel G (CHG2), upstream of the barrier, was added to replace CHA3, so there was at least one site above the control structure for both Channels A and G. Salinity at CHG2 showed wide variation indicating tidal effects in upper reaches of Channel G.

Site		Salinity (base)	Salinity (post)	DO (base)	DO (post)
CHA1	Average	3.31	7.47	4.47	3.54
	Maximum	7.53	19.64	6.82	4.81
	Minimum	0.03	0.12	3.06	1.45
	Standard dev.	2.08	5.66	0.71	0.99
CHA2	Average	0.11	0.14	7.19	1.60
	Maximum	0.14	0.16	7.69	1.78
	Minimum	0.1	0.13	6.33	1.45
	Standard dev.	0.01	0.01	0.39	0.04
CHA3	Average	0.5	*	7.19	*
	Maximum	0.61	*	9.30	*
	Minimum	0.34	*	5.49	*
	Standard dev.	0.77	*	0.83	*
CHG1	Average	1.25	6.64	6.15	4.89
	Maximum	12.75	16.03	6.48	8.36
	Minimum	0.11	0.46	5.82	2.91
	Standard dev.	2.49	2.78	0.35	1.38
CHG2	Average	*	3.17	*	2.16
	Maximum	*	20.30	*	7.31
	Minimum	*	0.15	*	0.90
	Standard dev.	*	3.95	*	1.34
RC1	Average	0.09	0.77	6.18	1.32
	Maximum	0.09	5.04	7.52	5.24
	Minimum	0.08	0.11	5.91	0.49
	Standard dev.	0.00	1.10	0.20	0.78

Table 10 - Sonde salinity data (ppt)

* Sites were not sampled during this period

Citizen Water Quality Sampling

During the public meeting in January 2014, a comment card was submitted with a concern about change in salinity in Rocky Creek's water as residents use creek water to irrigate the landscape. This was followed by discussion with two citizens who live on Rocky Creek and utilize the creek water for irrigation. They live just above the confluence of Channel G and Rocky Creek. They agreed to monitor surface salinity conditions over the course of the post-modification portion of the study. They were supplied with a salinity meter and took regular salinity readings at the surface of the creek behind their property. In addition to salinity, they recorded dates, times, temperature, and notes on weather and tide conditions. Their data showed an average salinity of 1.02 ppt, a median salinity of 0.65 ppt, a maximum salinity of 4.60 ppt, a minimum salinity of 0.02 ppt and a standard deviation of 0.99. There was larger variation in salinity than the land-based sites on Channel G, above the structure. This may be due to tidal conditions during the land-based sampling. A majority of the land-based samples taken by GPI were taken on outgoing or low tide conditions.

Environmental Protection Commission of Hillsborough County Sampling

EPCHC regularly conducts water sampling at fixed stations throughout the Rocky Creek watershed, which includes sites on Channels A and G, downstream of the salinity control structures. The Channel A site (Site 102) is located on the Hillsborough Avenue bridge, where it crosses Channel A, south of the control structure. The Channel G site (Site 103 on Rocky Creek) is also located on Hillsborough Avenue, south of the Channel G control structure. Data exist for DO, nutrients, bacteria, and water clarity.

Water quality data for many of the parameters goes back to 1974, offering a large dataset of historical conditions in the systems. The dataset for Channel A baseline is 1207 samples, post-modification is 64 samples. The dataset for Channel G baseline is 838 samples, post-modification is 39 samples.

Salinity

Monthly salinity sampling results from January 1974 through March 2012, and from July of 2014 through October of 2015 for both Channel A and G were compared (Table 11). From the EPCHC data, it appears that the area downstream of the control structure on Channel A has become closer to an oligohaline system with the constant addition of fresh water, while the area downstream of the control structure on Channel G has become fresh. Of note is the maximum value for Channel A, 48.07 ppt. This reading, from December 2, 2008, is significantly higher than the average salinity of seawater. This may be an erroneous reading.

SALINITY				
Salinity (ppt)	CHANNEL A 1974-6/2014	CHANNEL A 7/2014-3/2016	CHANNEL G 1974-6/2014	CHANNEL G 7/2014-3/2016
average	20.27	10.52	9.04	8.64
median	21.46	11.17	8.4	8.89
maximum	48.07	30.13	30.8	17.25
minimum	0.1	0.06	0.1	0.09
standard deviation	6.41	7.93	7.34	6.32

Table 11 - EPC Salinity values

Dissolved Oxygen

The data below (Table 12) represents monthly dissolved oxygen (DO) sampling results from January 1974 through March 2016. Both sites exhibited similar dissolved oxygen concentrations during the baseline time period. Post-modification dissolved oxygen levels improved at Channel G, while generally lower at Channel A. The range of DO readings remained fairly constant through both periods.

DISSOLVED OXYGEN				
DO(mg/L)	CHANNEL A 1974-6/2014	CHANNEL A 7/2014 - 3/2016	CHANNEL G 1974-6/2014	CHANNEL G 7/2014-3/2016
average	3.77	2.63	3.96	4.5
median	3.78	2.51	3.8	5.04
maximum	10.9	6.02	9.7	6.84
minimum	0	0	0.01	1.22
standard deviation	2.23	1.9	1.72	1.77

Table 12 - EPC DO (mg/L) data

Groundwater Modeling

In 2013, GPI, TBEP, and the District tasked INTERA, Inc. with evaluating the impacts of modification of the Channel A and G salinity barriers on Surficial Aquifer System (SAS) and Upper Floridan aquifer (UFA) heads. Modification of the salinity barriers was expected to lower the stages in the channels upstream of the salinity barriers, so INTERA was tasked with performing groundwater modeling to assess the vulnerability of currently permitted irrigation and domestic self-supply wells in the vicinity of Channels A and G to saltwater intrusion. INTERA used the District Wide Regulation Model (DWRMv2.1) with the FTMR (Focus Telescopic Mesh Refinement) module to develop the Channel A and G FTMR groundwater model. The FTMR module was added to create a local scale MODFLOW model with a finer specified grid (100 by 100-foot), which was a significant refinement from the coarser grid of 5,000 by 5,000-foot of the regional scale FWRMv2.1 model.

Daily water level data from groundwater observation wells were provided by SWFWMD for the 2008 calendar year in order to calibrate the model. The baseline simulation of the model adequately replicated the heads and fluxes present in the SAS and UFA over the model domain with the existing salinity barriers. An additional simulation was developed in order to investigate the impacts of the modification of the salinity barriers on the heads in the SAS and UFA. A maximum 2 foot-drawdown in the SAS was observed as a result of the alternate simulation near Channels A, G, and Rocky Creek where river stages were lowered in the barrier modification simulation (Figure 6). The decreases in head in the SAS could potentially cause an increase in saltwater intrusion in irrigation and domestic use wells that lie within the area of increased vulnerability. Minimal (< 0.27 ft.) head changes to the UFA due to salinity barrier modification were observed (Figure 7). Head changes in the UFA were a result of the direct connection between Channel G and the UFA that was created during construction of the channel, due to extensive penetration of the underlying limestone.

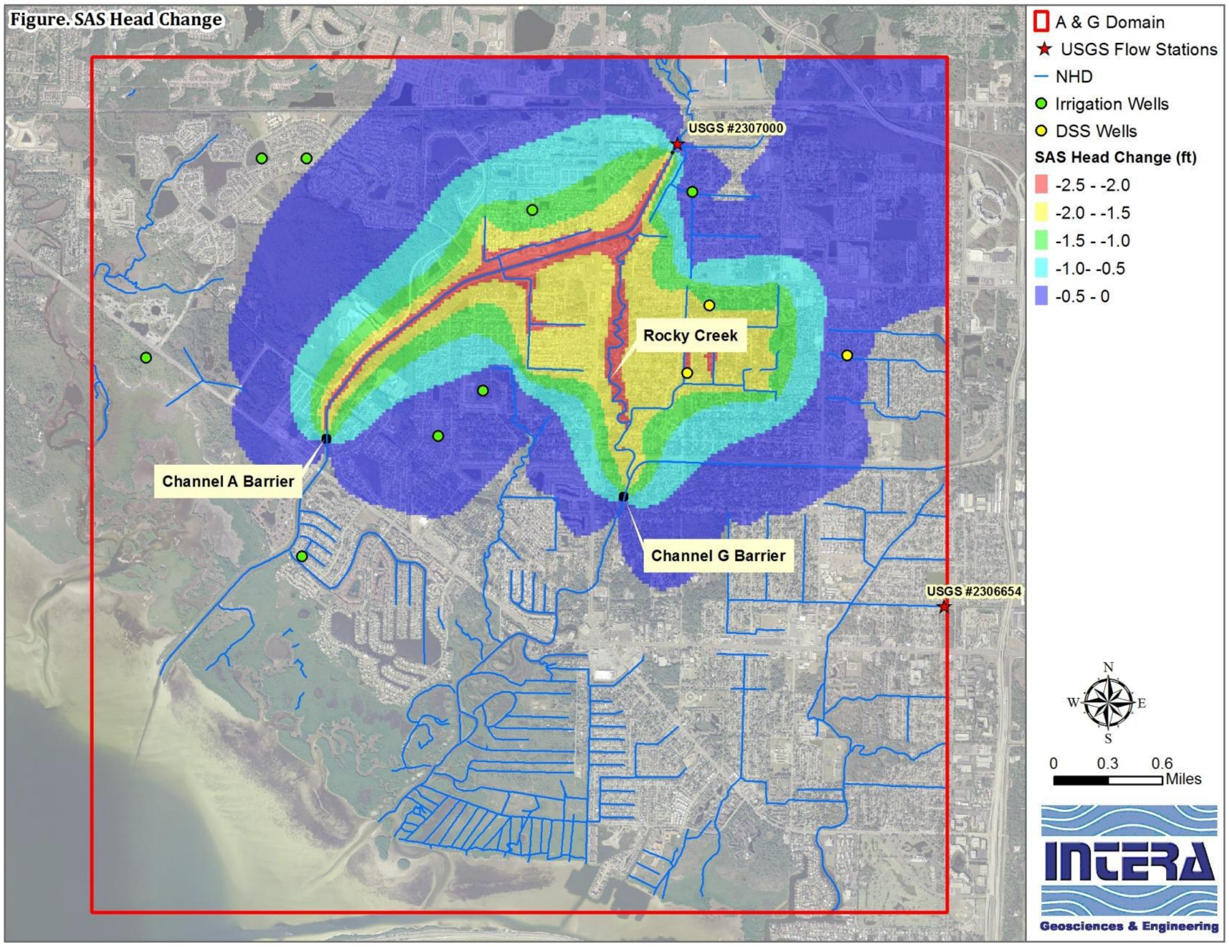

Figure 6 - Head change in Surficial Aquifer

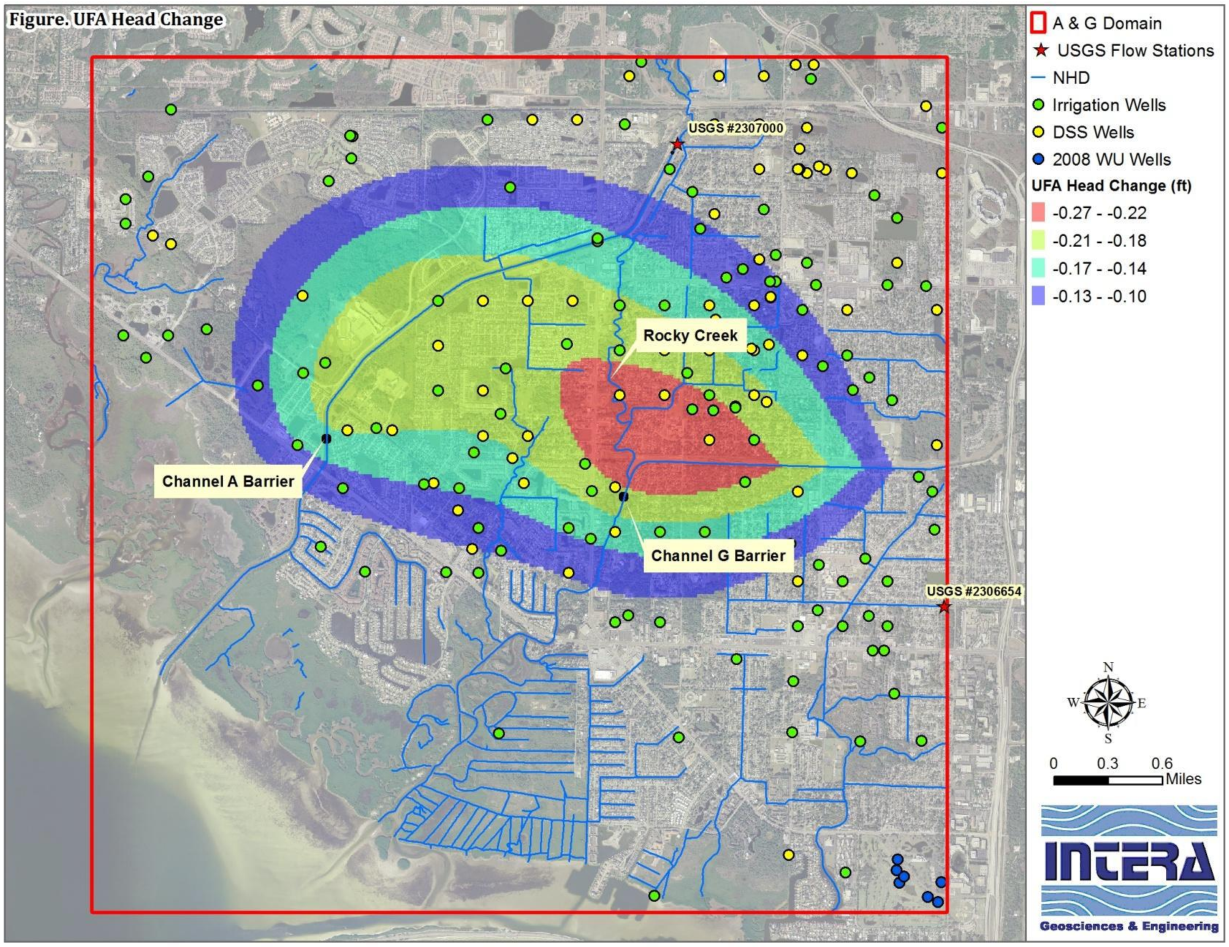

Figure 7 - Head change in Upper Florida Aquifer

Groundwater Production Wells

Groundwater production wells in the vicinity of the salinity barriers in Channel A and Channel G were identified during the baseline portion of the study (Figure 8). Locations of Water Use Permit (WUP) withdrawals were obtained from SWFWMD. Five owners were found for the 19 WUP groundwater withdrawal sites within the boundary:

1. Tampa Bay Water
2. Tampa Bay Sports Authority (City of Tampa)
3. Lindell Independence Land, LLC & Lindell Independence Office, LLC
4. Countryway Golf Club, Inc
5. Bayport Colony Apartments, LLC

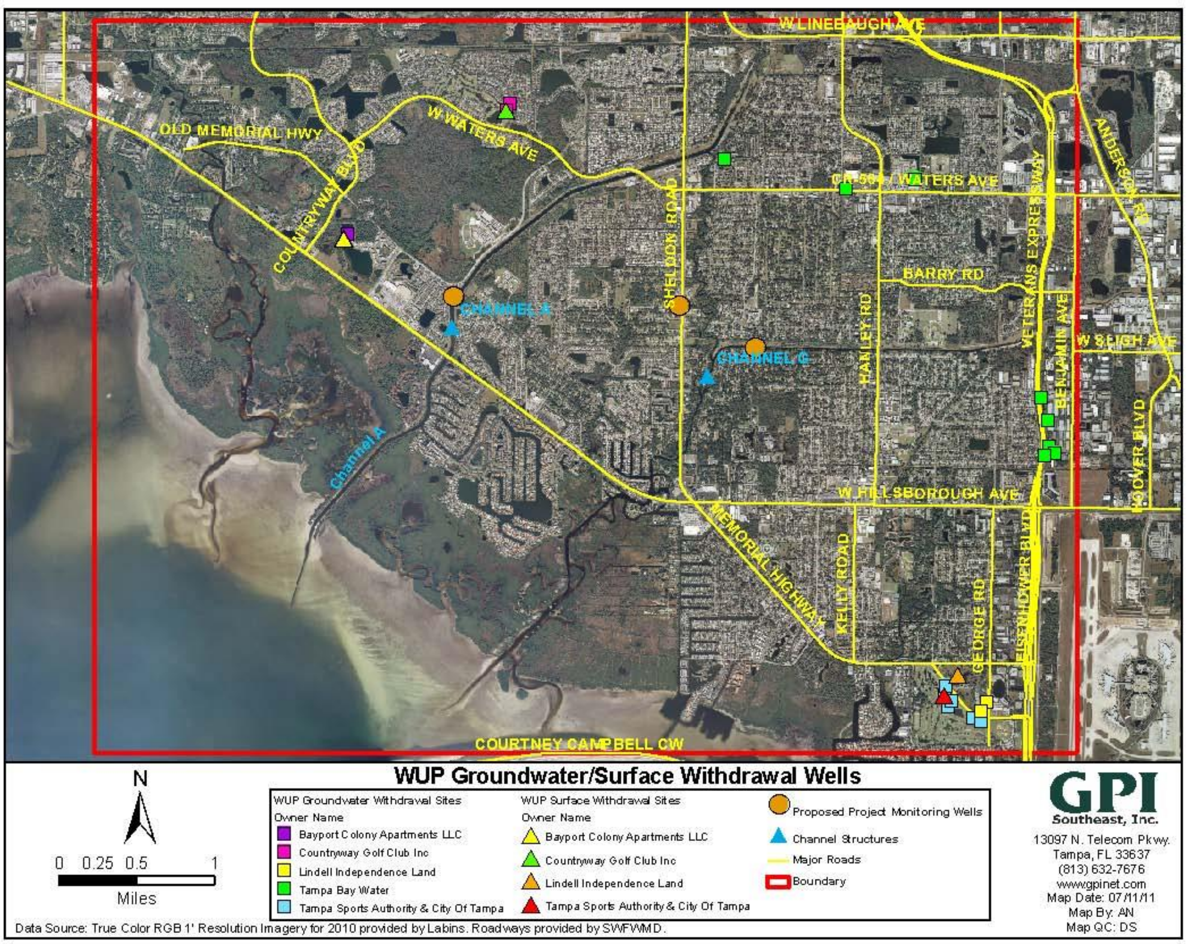

Figure 8 - Permitted Groundwater Withdrawal Wells in the Study Area

Tampa Bay Water owned the most groundwater withdrawal sites (8). However, the groundwater withdrawal wells owned by Tampa Bay Water are currently capped or plugged. The remaining groundwater withdrawal wells are considered “existing” in use with the Tampa Bay Sports Authority (City of Tampa) owning the majority (6) of the sites. The nearest permitted groundwater withdrawal wells to the proposed study monitoring wells are owned by Bayport Colony Apartments, LLC (less than one mile) and Countryway Golf Club, Inc (1.25 miles). However, the well at Bayport Colony Apartments was identified as being "proposed" and was not in use during the study period. During the baseline portion of the study, attempts were made to contact the Countryway Golf Course to try and get baseline salinity readings from their irrigation systems, but these efforts proved unsuccessful. The remaining wells, owned by Lindell Independence Land and the Tampa Sports Authority, are located southeast of Channel A (approximately 4 miles), and are beyond the geographic scope of this project.

Groundwater Sampling

Baseline and post-modification groundwater sampling was performed at three District monitoring wells in the watershed (Figure 9). During the course of the baseline study District staff attempted to locate the historic Channel A well but were unsuccessful, so a new monitoring well at Channel A was drilled on September 9, 2011. The well information is listed in Table 13. In addition to the new Channel A well, the existing Channel G and Sheldon Road wells were purged and checked by District staff. The three monitoring wells located near Channel A, Channel G and Sheldon Road (Figure 8) were then sampled using a YSI® 600XLM sonde.

For the Channel A well, there were two sampling events during the baseline monitoring, and three for post-modification monitoring. For the Channel G well, there were two sampling events during the baseline monitoring, and four for post-modification monitoring. For the Channel G well, there were two sampling events during the baseline monitoring, and three for post-modification monitoring. The sonde was generally left in place for three to four days with samples recorded every 15 minutes at each location.

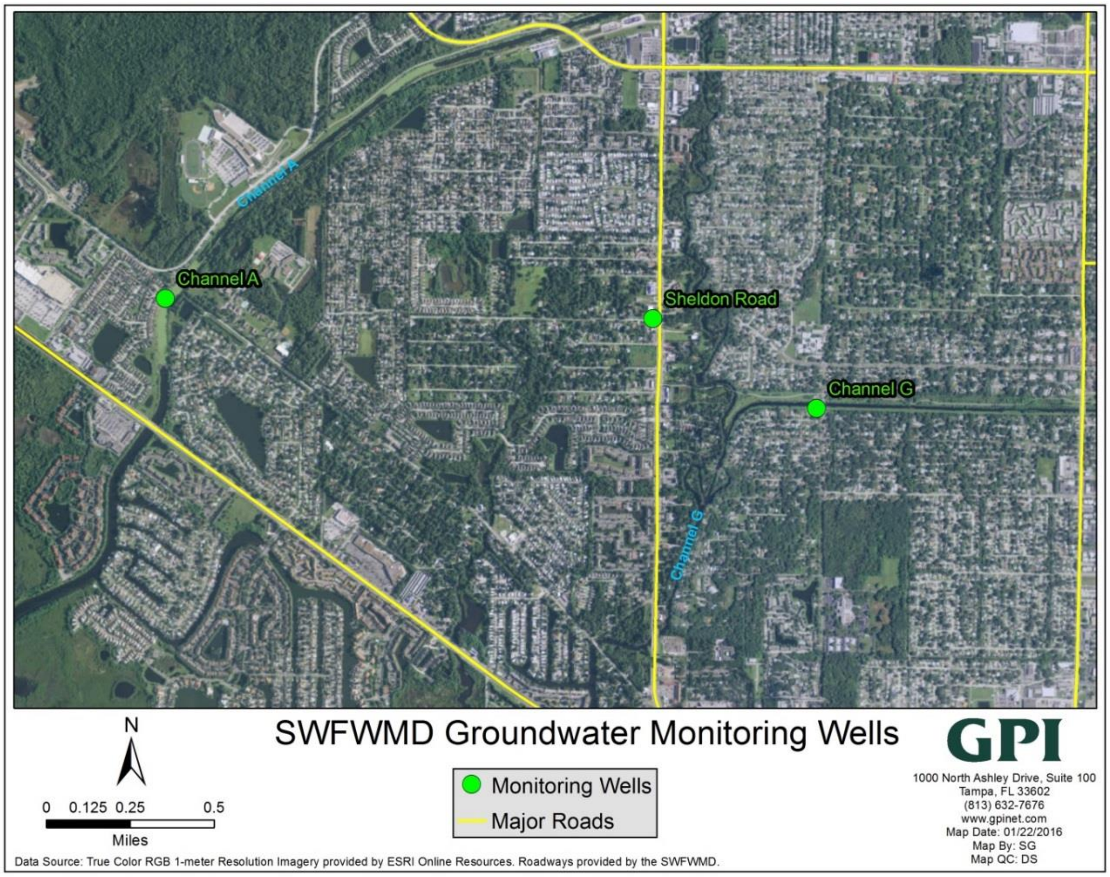

Figure 9 - Groundwater Monitoring Well Locations

	CHANNEL A well	CHANNEL G well	SHELDON ROAD well
Total depth (ft)	87.5	120	88
Casing depth (ft)	63	115	36
location	28°01’00.3”N 82°36’24.1”W	28°00’40.25”N 82°34’31.37”W	28°00’54.28”N 82°35’00.30”W
Diameter (in)	4	4	6
Construction date	9/9/11	1974	-

Table 13 - Groundwater Monitoring Well Information

Groundwater Results

Tables 14 and 15 represent groundwater pH and salinity data statistics. Comparisons of baseline and post-modification groundwater data show little variation in salinity or pH. However, slight increases in maximum pH and salinity measurements were observed. It is recommended that continuing groundwater monitoring be conducted to determine if increasing trends for these parameters occur in the future, if the barriers remain open into the foreseeable future.

Dissolved oxygen was collected for the baseline and post-modification period, but there were many anomalies with the data in both time periods, so the parameter was not included in the report. Water level data was not collected as part of this study.

The Channel A well is part of the District's Coastal Groundwater Network and is monitored once a year. Based on collected data from 2012 to 2015, the average salinity is around 0.79 ppt, comparable to data collected for this study. The District samples the Channel G well monthly, but only for groundwater levels so no water quality data is available.

pH	Ch A Baseline	Ch A Post	Ch G Baseline	Ch G Post	Sheldon Base	Sheldon Post
average	7.23	7.45	7.34	7.05	7.43	7.36
median	7.23	7.46	7.34	7.05	7.4	7.41
maximum	7.24	8.87	7.52	8.05	7.52	7.5
minimum	7.23	6.62	7.32	6.85	7.38	6.9
standard dev	0.07	0.07	0.08	0.08	0.15	0.15

Table 14 - pH Baseline v Post-Modification

Salinity (ppt)	Ch A Baseline	Ch A Post	Ch G Baseline	Ch G Post	Sheldon Base	Sheldon Post
average	0.74	0.72	3.43	3.52	0.6	0.61
median	0.74	0.72	3.43	3.52	0.6	0.62
maximum	0.75	0.81	3.46	3.95	0.6	0.63
minimum	0.74	0.71	3.38	3.37	0.59	0.58
standard dev	0.02	0.06	0.06	0.50	0.02	0.20

Table 15 - Salinity (ppt) Baseline v Post-Modification

Surface Water Modeling

It was anticipated that, as part of the pilot study, a model would be used to predict the hydrologic (water surface elevations) and salinity regimes in Channel A, Lower Rocky Creek, and Channel G resulting from modification of the structure operation. A salinity model, CE-QUAL-W2, a two-dimensional laterally averaged hydrodynamic model with process-based and mass balance based water quality, was chosen for the effort. However, it was discovered that insufficient data and the limited scope and budget of the study did not allow for full model calibration and validation.

Springs and Sand Boils

Starting in the fall 2014, some residents reported seeing sand boils and springs in parts of Channel G and one particular area in Rocky Creek. GPI staff toured the springs with resident Bill Hadley in February 2015. These springs (Figure 10) were recorded by a Trimble GPS unit as part of the post-modification vegetation survey in April 2015.

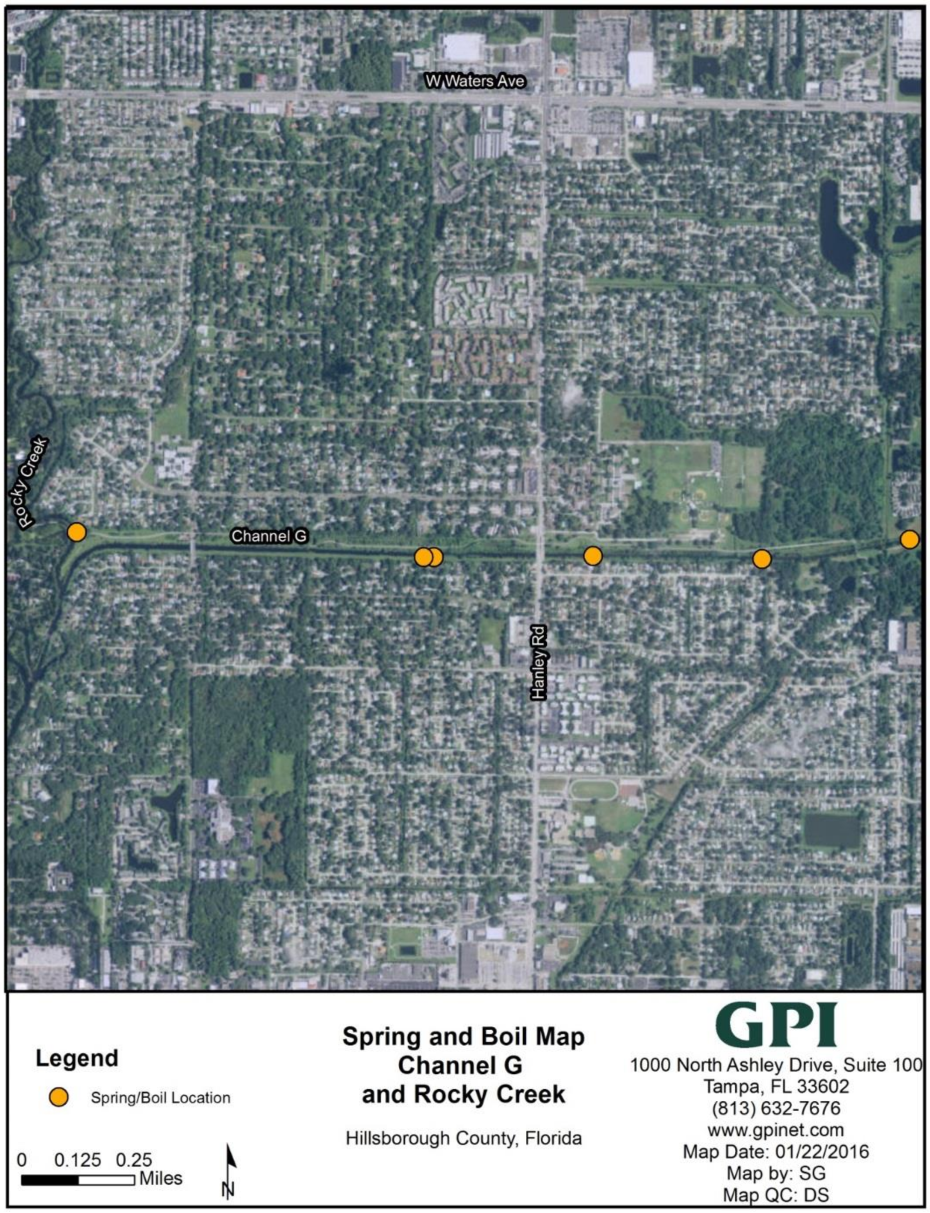

Figure 10 - Springs and sand boil locations

Vegetation Survey

Baseline

A vegetation survey of the Channel A, G, and Rocky Creek system was conducted between August of 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 segmented into sections (Figure 11) and percent abundance of all vegetation was recorded.

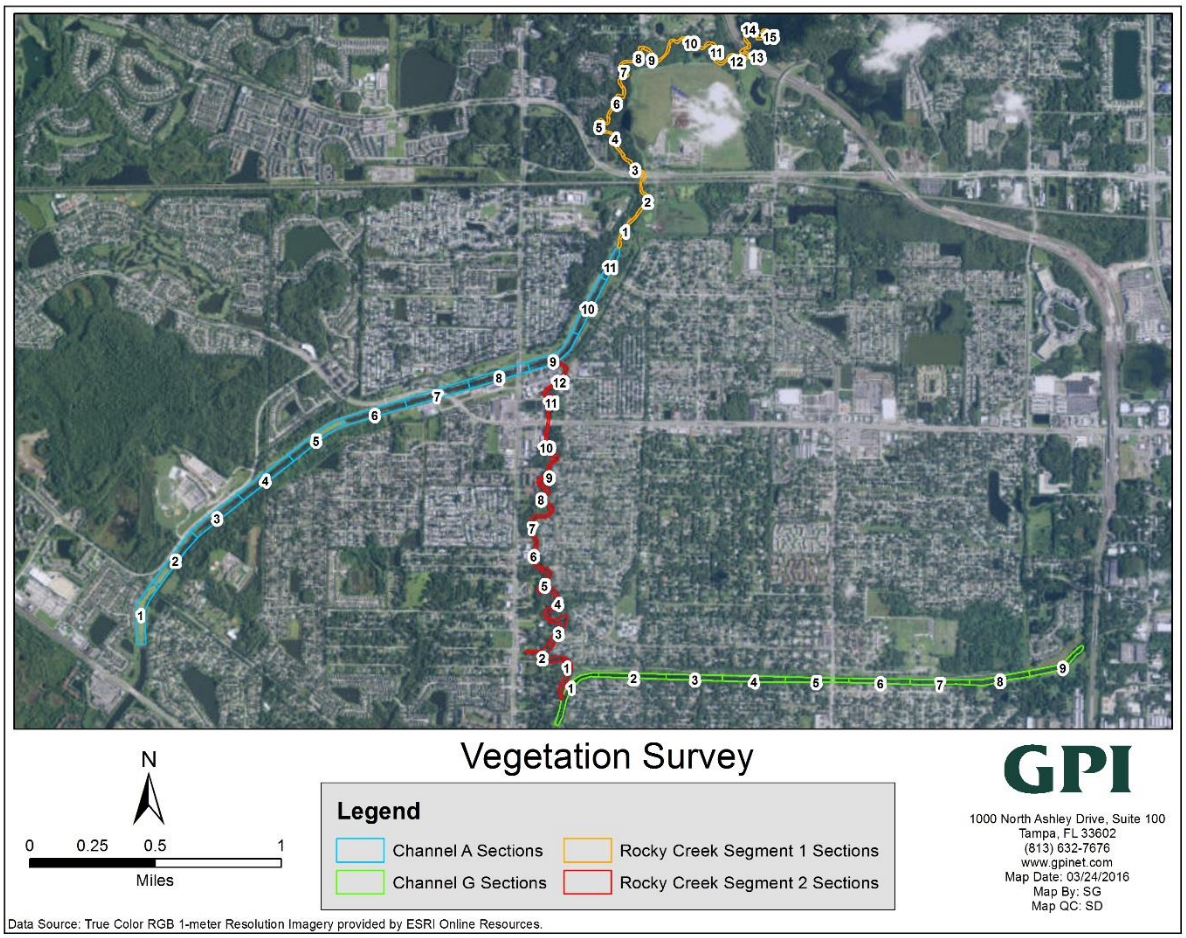

Figure 11 - Vegetation survey sections

The freshwater systems (Channel A and G above the fixed weirs) have a high prevalence of non-native, nuisance plant species, and many are listed by the Exotic Pest Plant Council as being invasive. 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, with water spangles (*Salvinia minima*) and water lettuce (*Pistia stratiotes*) forming floating mats in the channel and hydrilla (*Hydrilla verticillata*) as the most prevalent submerged pest plant species. In all, eight nuisance plant species were found in Channel A and 14 in Channel G.

At the time of the vegetation survey assessment, Channel G was experiencing a period of low flow and discharges over the upstream weir (G-1) were minimal. The nutrient-rich, stagnant water conditions during this period caused many parts of Channel G to be completely covered with floating aquatic vegetation. Pre-modification, both Channels A and G had a high prevalence of algal mats, indicating poor water quality and possible imbalance of flora, and there were many native plant species 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). However, the majority of the native species are considered opportunistic and are commonly prevalent in disturbed sites. There were a few 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 with the exceptions of seaside goldenrod (*Solidago sempervirens*), sand cordgrass (*Spartina bakeri*) and swamp flatsedge (*Cyperus ligularis*) – all of which can tolerate both salt and freshwater.

Lower Rocky Creek is a brackish system, and the plant species composition is very different from that observed upstream of the water control structures. Most of the plants observed in the brackish reach of the creek are tolerant of oligohaline-polyhaline conditions. Most notable were red mangrove (*Rhizophora mangle*) and leather fern (*Acrostichum danaeifolium*), found in 62% of the sections, and black mangrove (*Avicennia germinans*), found in 29% of the sections. Non-salt tolerant species were observed growing higher on the banks away from the influences of saltwater. The majority of plant species were native (42 species, 69% of the total number of species found in Lower Rocky Creek). Brazilian pepper was the only pest plant, but that species was prevalent along the banks in 76% of the sections. Upland native trees were also found above the high water lines on each bank.

Post- Modification

A post-modification survey was completed in the spring 2015, using the same sampling sections as the Hillsborough County baseline survey. In comparing the pre-modification vegetation survey conducted by Hillsborough County and our GPI 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 fixed weirs have 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 during both periods were alligator weed (*Alternanthera philoxeroides*), wild taro (*Colocasia esculenta*) and torpedograss (*Panicum repens*) along the banks. Torpedograss had the highest coverage. Below the fixed weirs, alligatorweed appeared stressed from fluctuating water levels and herbivory by manatees, which were observed feeding on it during the post-modification period. Prior to the barrier opening, water spangles (*Salvinia minima*) and water lettuce (*Pistia stratiotes*) had formed floating mats and hydrilla (*Hydrilla verticillata*) had been the most prevalent submerged pest plant species in the channels upstream of the gates. After the opening of the barriers, water spangles and hydrilla all but disappeared from Channels A and G, and water lettuce was only found in small amounts in half of the segments of Channel G and Rocky Creek. The most prevalent submerged pest plant species became Indian swampweed (*Hygrophila polysperma*), which formed a carpet along the bottom of the shallower sections of Channel G (following post-modification). In all, 13 pest plant species were found in Channel A, 17 in Channel G, and 19 in Rocky Creek during the post-modification period.

Channels A and G had relatively little algae in the post-modification period following the barrier opening, in contrast to the pre-modification baseline study in 2012, when there was a high prevalence of algal mats. The algae have likely been reduced by improved water quality and/or exposure to saltwater from tidal flushing. Following barrier opening, many native plant species were present upstream of the gates (51 species, 75% of the total number of species found in Channel A; 80 species, 65% of the species found in Channel G ; and 76 species, 66% of the species found in Rocky Creek). However, the majority of the native species are considered opportunistic and are commonly prevalent in disturbed sites. There were a few species present in Channels A and G and Rocky Creek that are indicative of healthy freshwater systems, most notably spatterdock (*Nuphar lutea* var. *advena*), which appeared to have greatly increased in cover in the deeper portions of the channels. Three other native freshwater species became more prevalent (following barrier opening): swamp dock (*Rumex verticillata*), smartweed (*Polygonum* sp.), and marshpennywort (*Hydrocotyle* sp.). All but a few of the plant species found in Channels A and G and Rocky Creek above the opened structures preferred freshwater. After barrier removal, there appeared to be an increase in the prevalence of more salt-tolerant species, especially string-lily (*Crinum americanum*) and seaside goldenrod (*Solidago sempervirens*) in all three systems, and giant leather fern (*Acrostichum danaeifolium*) in Rocky Creek. A few red mangrove (*Rhizophora mangle*) seedlings were observed in Section 3 of Channel A and Sections 1, 3 and 4 of Channel G.

Fish Survey

Fish sampling was performed at sites along Channel A, Channel G, and Rocky Creek. An initial two-day fish survey was conducted in August 2011 to formulate a baseline description of the existing fisheries community in the system. The survey methodology followed the tidal tributary sampling methods developed by the Fish and Wildlife Research Institute (FWC-FWRI) and utilized a 9.1-m 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 boat 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 1.5m, which were outside the Standard Operating Procedure (SOP) of the sampling methodology (FWC-FWRI, 2010b). 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 conducive to sampling utilizing the 9.1-m seine technique.

Fish surveys were again conducted on February 17, 2015 and June 16, 2015 to assess the changes in fish community structure in Channels A and G. Raising the gates removed obstacles not only to tidal flow, but to movement of salt-tolerant and common tidal fish species upstream into the systems. As indicated by the data below, salt-tolerant species were found dispersed throughout the channels, where previously they were only present below the control structures.

Channel A

The Channel A sampling site was located off Hillsborough Avenue, south of the control structure (Figure 12). This site was sampled in 2011 and 2015.

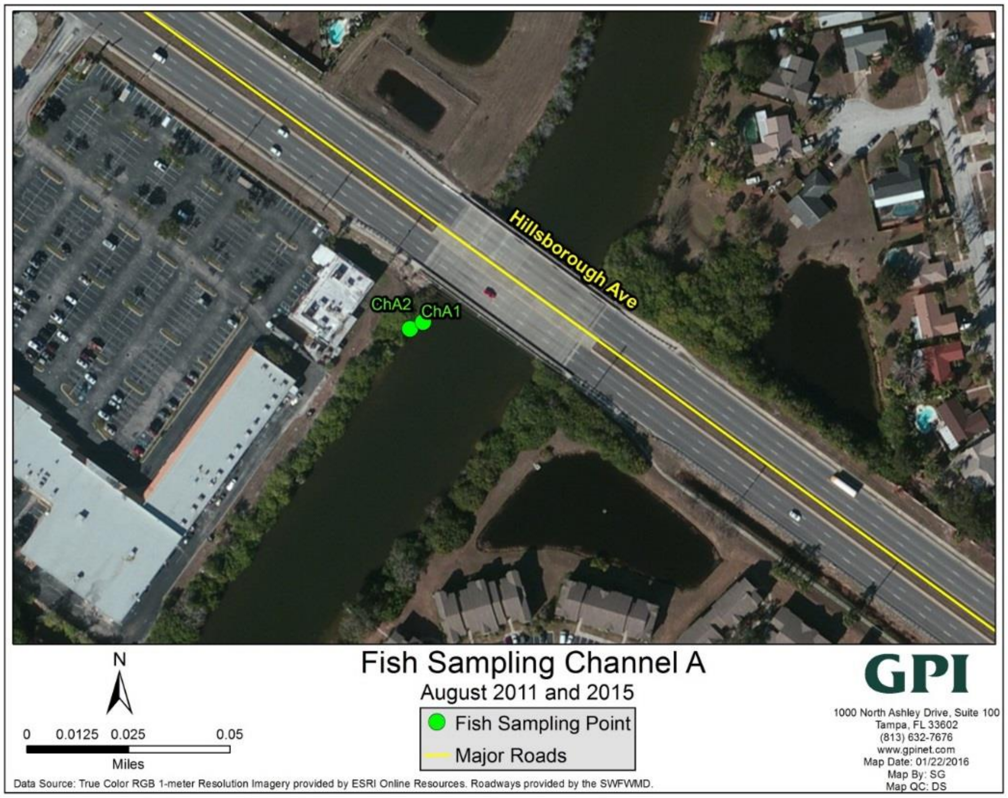

Figure 12 - Channel A fish sampling sites

Results of the Channel A sampling (Table 16, Figures 13-15) revealed a larger variety of fish species following barrier opening in comparison to the baseline. The most abundant species in the February 2015 sampling event was not a fish, but rather the 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.

ChA Below - August 2011			ChA Below - Feb 2015			ChA Below -June 2015		
Menidia spp.	63.6%	21	Eucinostomus harengulus	65.4%	17	Eucinostomus harengulus	56.5%	39
Leiostomus xanthurus	18.2%	6	Centropomus undecimalis	7.7%	2	Menidia spp.	24.6%	17
Cynoscion nebulosus	12.1%	4	Lucania parva	7.7%	2	Anchoa mitchilli	8.7%	6
Micropterus salmoides	3.0%	1	Poecilia latipinna	7.7%	2	Gambusia holbrooki	2.9%	2
Archosargus probatocephalus	3.0%	1	Callinectes sapidus	3.8%	1	Gobiosoma robustum	1.4%	1
	Total Fish	**33**	Leiostomus xanthurus	3.8%	1	Microgobius gulosus	1.4%	1
			Menidia spp.	3.8%	1	Oligoplites saurus	1.4%	1
				Total Fish	**26**	Trinectes maculatus	1.4%	1
			Palaemonetes spp.	100%	558	Lepisosteus sp.	1.4%	1
				Total Macroinverts	**558**		**Total Fish**	**69**
						Palaemonetes spp.	100%	1
							Total Macroinverts	**1**

Table 16 - Channel A below structure fish sampling results

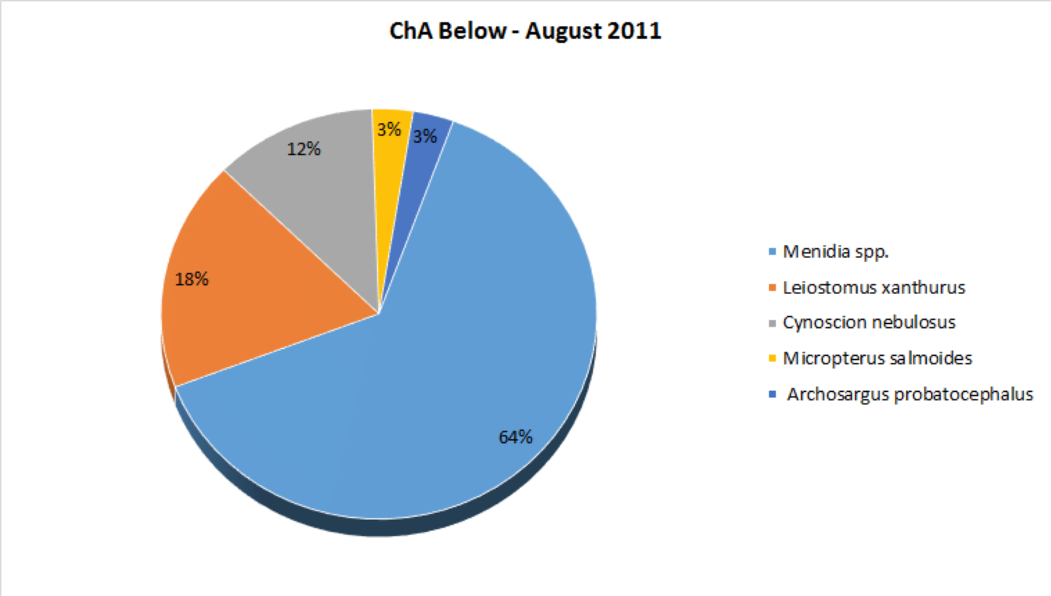

Figure 13- Species percentage Channel A baseline

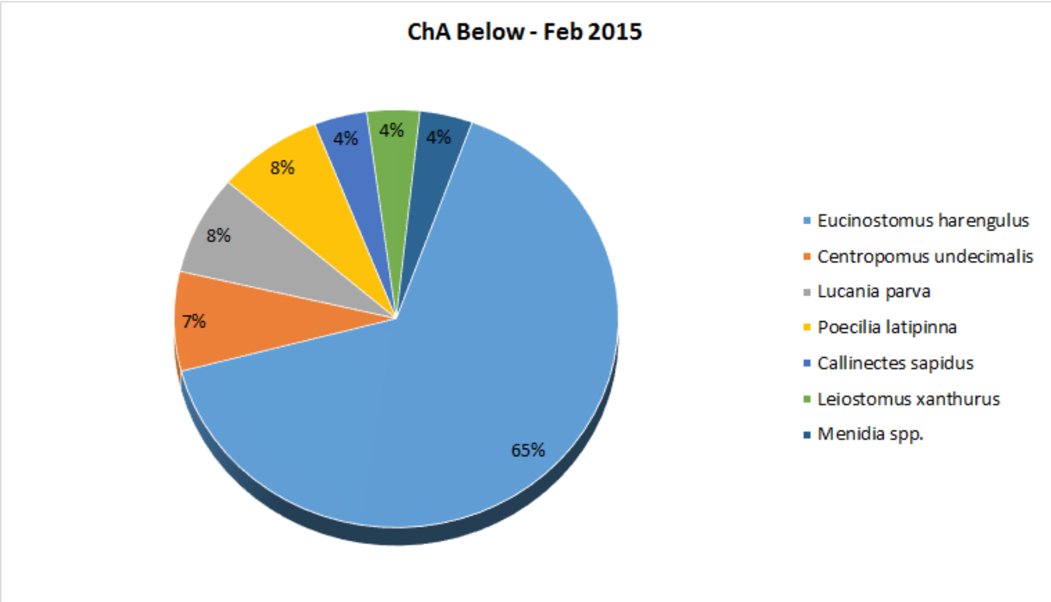

Figure 14 - Species percentage Channel A post-modification, Feb 2015

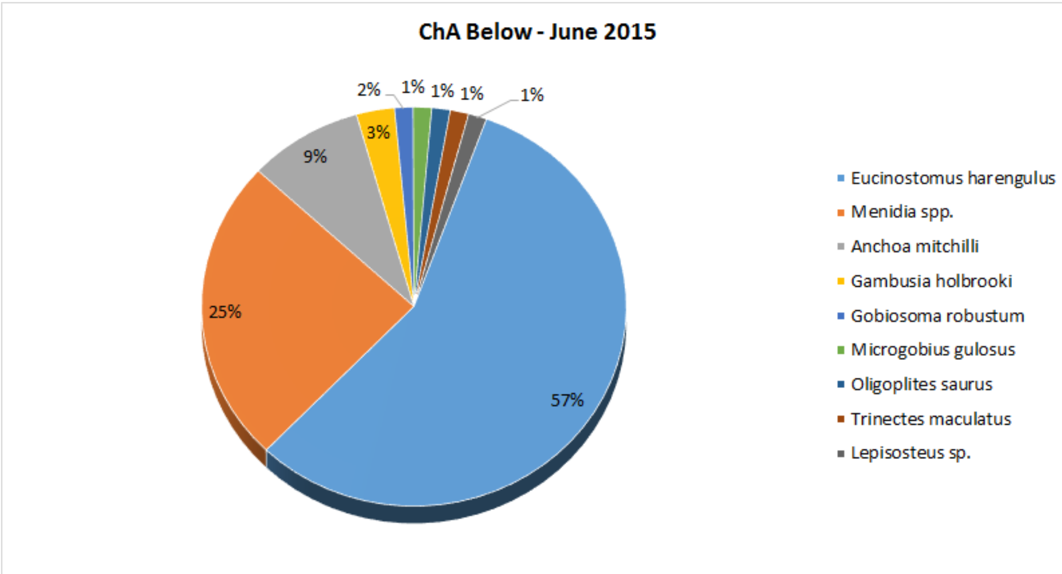

Figure 15 - Species percentage Channel A post-modification, June 2015

Channel G/Rocky Creek

Rocky Creek sampling sites were 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 post-modification (Figure 17).

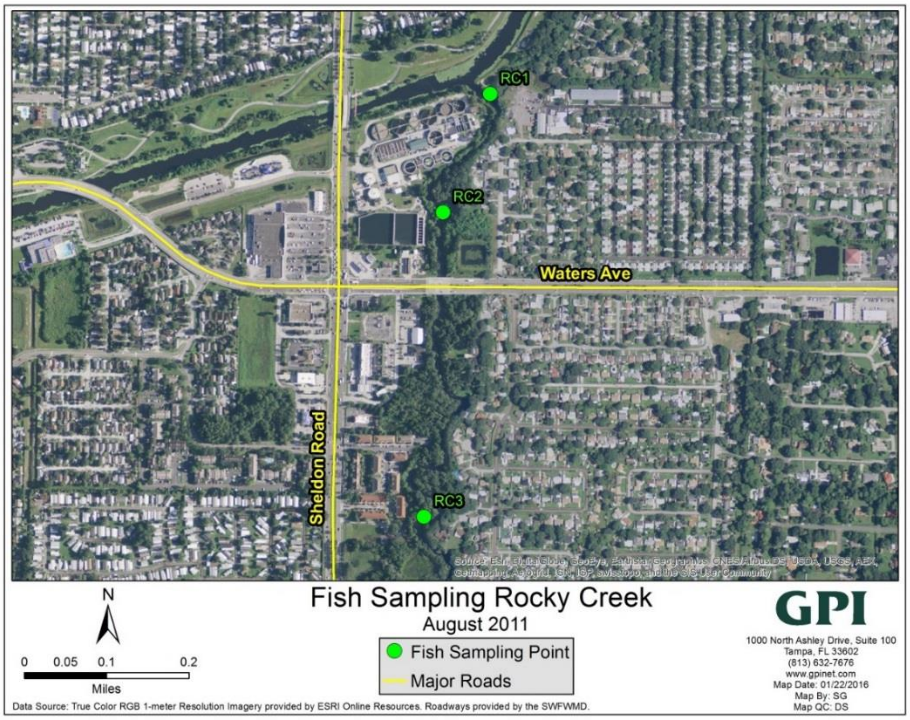

Figure 16 - Rocky Creek fish sampling sites (baseline only)

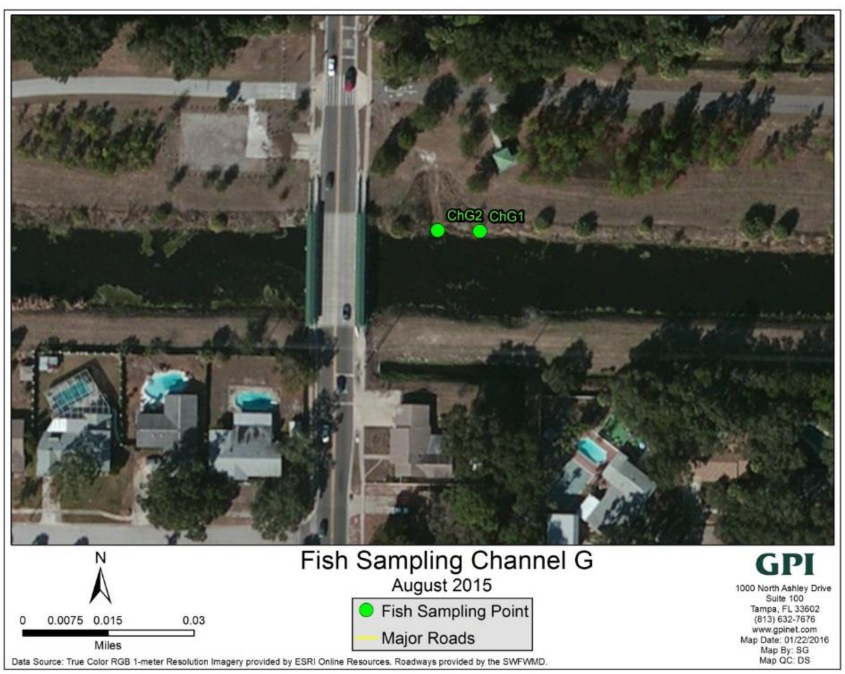

Figure 17 - Channel G fish sampling site above structure (post-modification only)

Results of Channel G sampling above the structures (Table 17, Figure 18-20) also show a larger variety of fish species 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 (*Palaemonetes* spp.). 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 were silversides (*Menidia* spp.). A few silversides were found in the baseline sampling, but below the control structure. In the post-modification sampling, silversides were found well above the control structure.

ChG/Rocky Creek Above- August 2011				ChG Above - Feb 2015				ChG Above - June 2015		
Gambusia holbrooki	32.1%	17		Gambusia holbrooki	65.0%	65		Menidia spp.	65.3%	96
Lepomis spp.	26.4%	14		Poecilia latipinna	20.0%	20		Gambusia affinis	9.5%	14
Microgobius gulosus	17.0%	9		Mugilidae spp.	7.0%	7		Gambusia holbrooki	8.8%	13
Menidia spp.	9.4%	5		Menidia spp.	5.0%	5		Poecilia latipinna	6.8%	10
Lepomis microlophus	5.7%	3		Gambusia affinis	3.0%	3		Fundulus similis	3.4%	5
Lucania parva	3.8%	2			Total Fish	100		Micropterus salmoides	2.7%	4
Micropterus salmoides	3.8%	2		Palaemonetes spp.	99.7%	330		Trinectes maculatus	1.4%	2
Lepomis gulosus	1.9%	1		Callinectes sapidus (female)	0.3%	1		Fundulus grandis	1.4%	2
	Total Fish	53			Total Macroinverts	331		Adinia xenica	0.7%	1
									Total Fish	147

Table 17- Channel G above structure fish sampling results

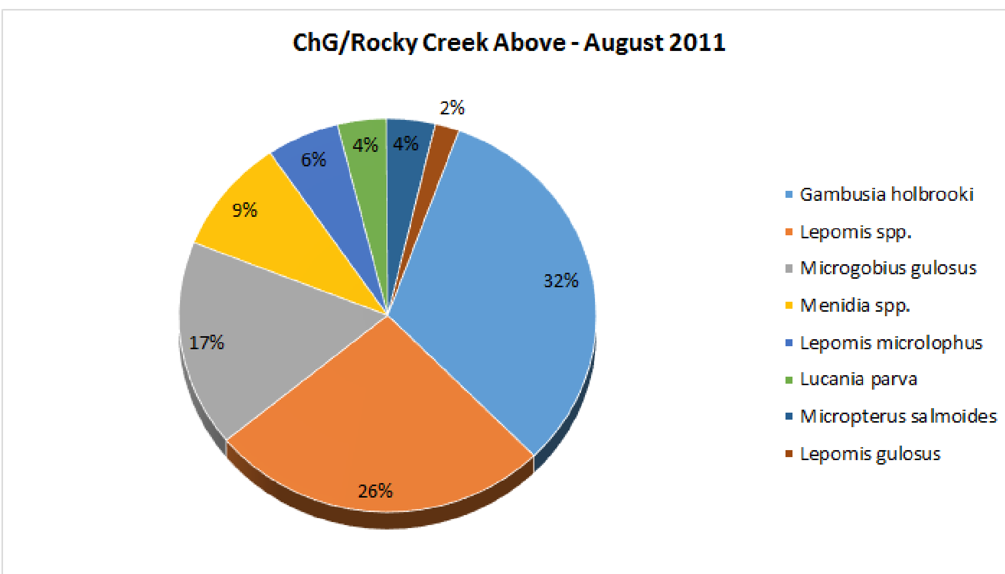

Figure 18 - Species percentage Rocky Creek baseline

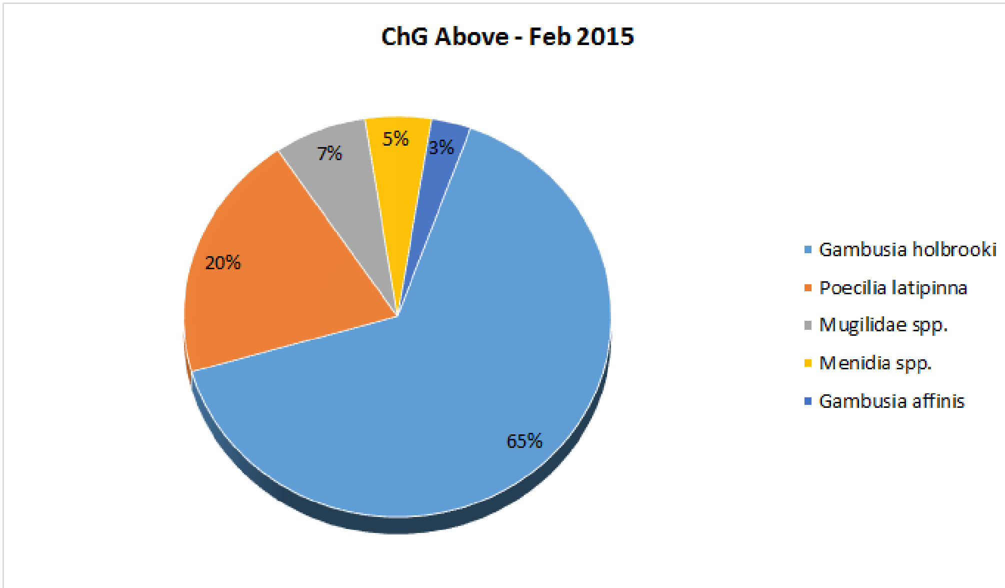

Figure 19- Species percentage Channel G above post-modification, Feb 2015

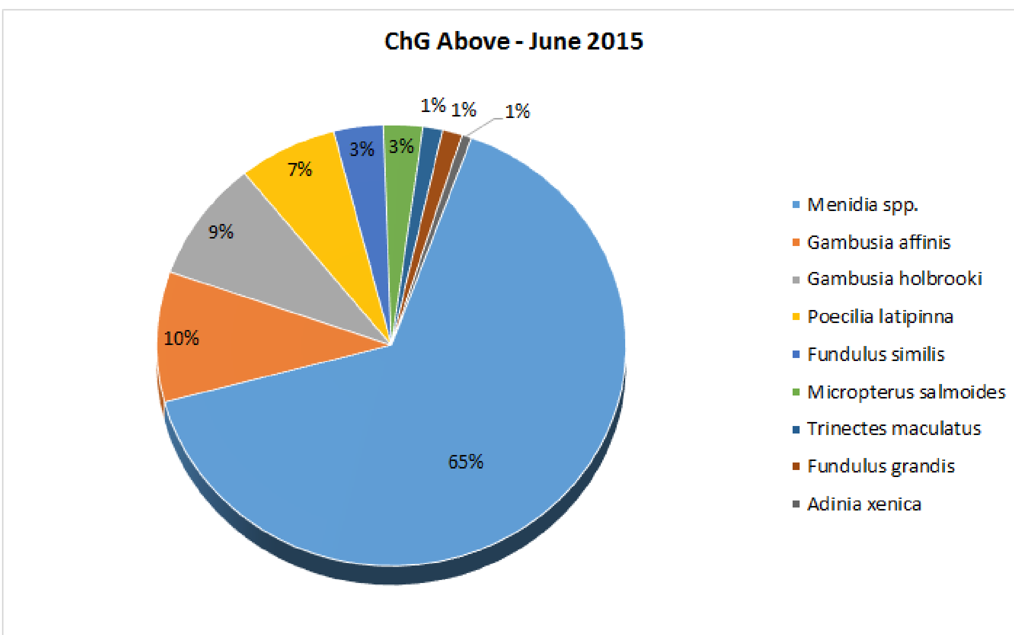

Figure 20 - Species percentage Channel G above, post-modification, June 2015

Channel G Below

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

Figure 21 - Channel G fish sampling sites

Results of Channel G sampling below the structures (Table 18, Figures 22-24) showed that the baseline samples had a larger variety of fish species and total number of fish compared to the post-modification samples. This is mainly due to the absence of sunfish (*Lepomis microlophus* and *Lepomis sp.)* during the post- modification sampling period (likely due to absence in upper reaches of the system). Sunfish accounted for 39% of the taxa represented in the baseline sample. The most abundant fish species in the baseline sampling (*Gambusia holbrooki*), was barely present in the February sampling event and not present in June. As in Channel A, the most abundant species in the Channel G, February 2015 sampling event was the grass shrimp (*Palaemonetes* sp.). The most abundant fish genus in the June event were silversides (*Menidia* spp.). A few silversides were found in the baseline sampling as well.

ChG Below - August 2011		
Gambusia holbrooki	44.4%	59
Microgobius gulosus	21.1%	28
Lepomis microlophus	18.8%	25
Lepomis spp.	7.5%	10
Poecilla latipinna	3.0%	4
Menidia spp.	2.3%	3
Micropterus salmoides	1.5%	2
Gobiosoma spp.	0.8%	1
Heterandria formosa	0.8%	1
	Total Fish	**133**

ChG Below - Feb 2015		
Poecilia latipinna	30.8%	4
Gobiosoma spp.	23.1%	3
Gambusia holbrooki	7.7%	1
Oreochromis aureus	7.7%	1
Palaemonetes paludosus	7.7%	1
Trinectes maculatus	7.7%	1
Lucania parva	7.7%	1
Menidia spp.	7.7%	1
	Total Fish	**13**
Palaemonetes spp	98.4%	299
Callinectes sapidus (Male)	1.6%	5
	Total Macroinverts	**304**

ChG Below - June 2015		
Menidia spp.	73.3%	22
Anchoa mitchilli	16.7%	5
Microgobius gulosus	3.3%	1
Eucinostomus harengulus	3.3%	1
Strongylura strongylura	3.3%	1
	Total Fish	**30**

Table 17 - Channel G below structure fish sampling results

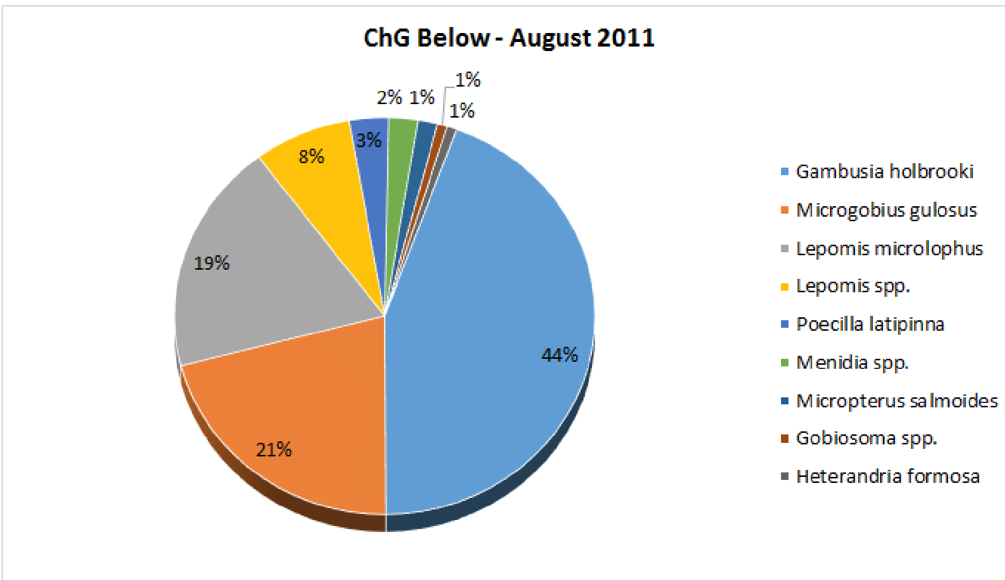

Figure 22 - Species percentage Channel G below, baseline

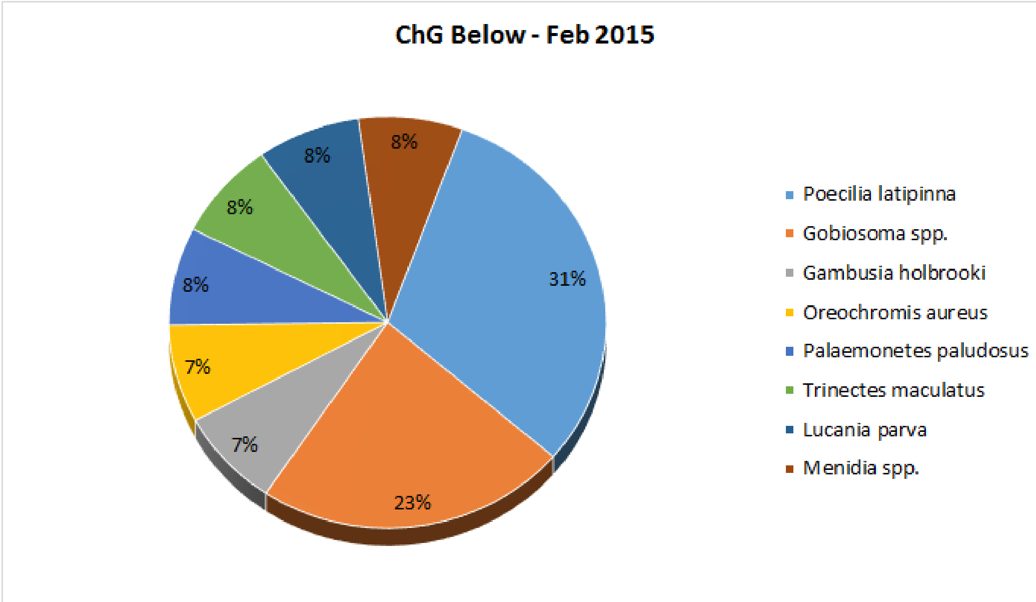

Figure 23 - Species percentage Channel G below, post-modification, Feb 2015

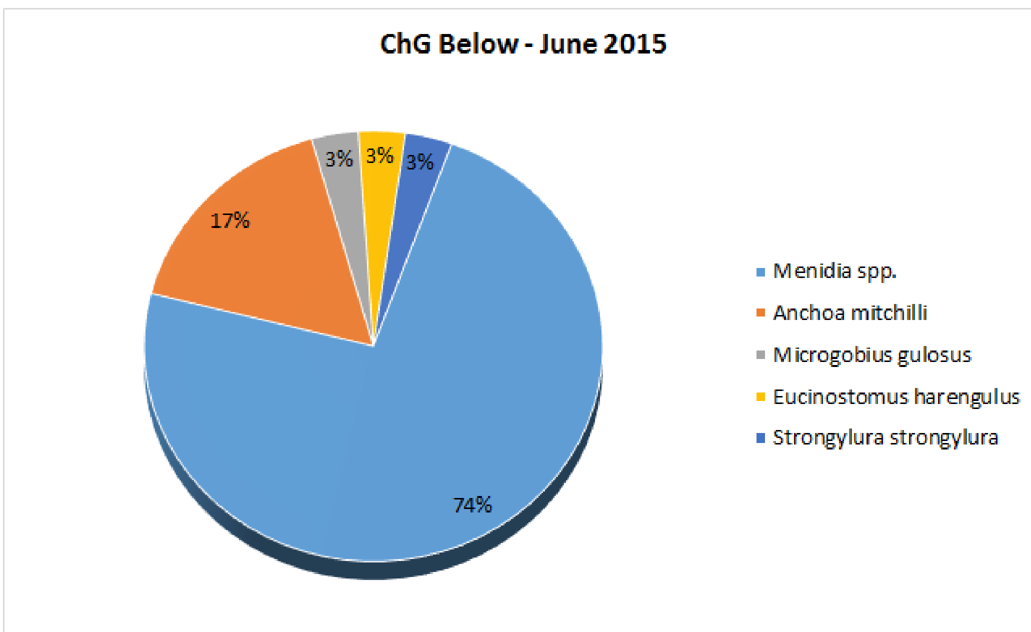

Figure 24 - Species percentage Channel G below, post-modification, June 2015

Other Observations

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

GPI participated in a 2013 study of Bishop and Mullet Creeks, two tidal creek in Pinellas County. Resident estuarine species found in the natural tidal system were also present in the post-modification fish data upstream of the salinity barriers. These species include *Poecilia latipinna* and *Adinia xenica.*

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 the known salinity tolerances of each species found during the sampling efforts (Table 18). Each species was then assigned a salinity tolerance (Table 19).

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

Table 18 - Salinity tolerance values

Archosargus probatocephalus	3
Adinia xenica	2
Anchoa mitchilli	2
Centropomus undecimalis	2
Cynoscion nebulosus	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
Poecilla latipinna	2
Strongylura strongylura	2
Trinectes maculatus	2

Table 19 - Salinity tolerance classification

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

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

Then, these values were plotted for each sampling area to show the trends before and after the salinity barriers were removed (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 June 2015 sampling below the salinity barrier in Channel G, as well.

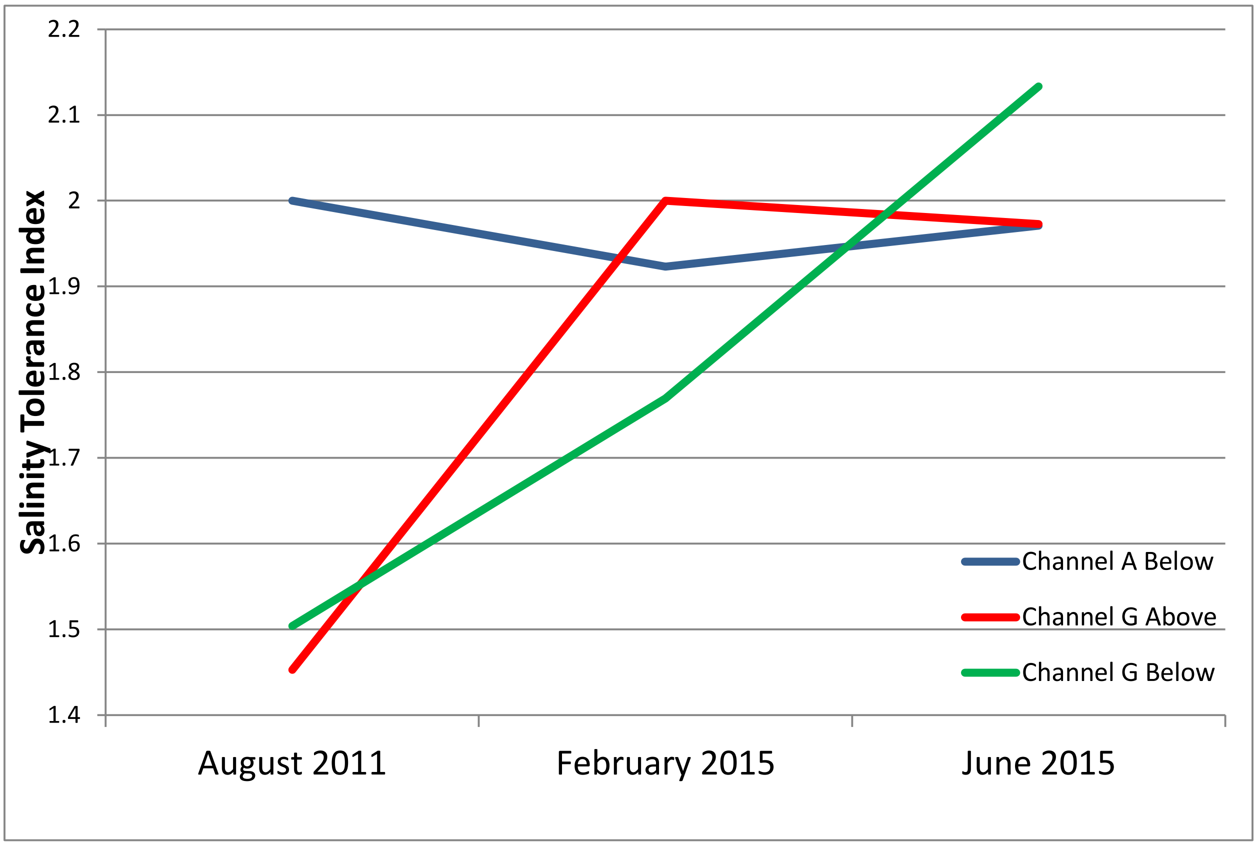

Figure 25 - Salinity Tolerance Index

The increase in salinity tolerant species post-modification indicates the system could be functioning 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

From the initial opening of the control structures on Channels A and G, manatees have been observed throughout the system by residents, the District, TBEP, and GPI staff (Table 20). Sightings ranged from individual animals to mixed pods (adults and calves) of up to six animals. The most recent sighting of manatees was on April 22, 2015, when GPI filmed two manatees grazing on alligator weed in Channel G.

DATE	LOCATION	COMMENTS
Tuesday, May 19, 2015	CHANNEL G	ADULT
Saturday, July 05, 2014	ROCKY CREEK	
Saturday, June 21, 2014	ROCKY CREEK	
Tuesday, July 01, 2014	ROCKY CREEK	WATERS AND SHELDON
Wednesday, July 02, 2014	ROCKY CREEK	
Saturday, August 02, 2014	ROCKY CREEK	FAMILY OF 5-6
Sunday, August 03, 2014	ROCKY CREEK	FAMILY OF 5-6
August, 2014	ROCKY CREEK	GENERAL SIGHTINGS THROUGHOUT THE MONTH
Sunday, August 17, 2014	CHANNEL G	BABY MANATEE, ADULT FEEDING
Saturday, July 04, 2015	ROCKY CREEK	FAMILY, ADULT
Sunday, July 05, 2015	ROCKY CREEK	FAMILY, ADULT
Monday, July 06, 2015	ROCKY CREEK	FAMILY, ADULT
Saturday, July 04, 2015	ROCKY CREEK	FAMILY, ADULT

Table 20 - Manatee Sightings Post-modification

Conclusion

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 and tidal flushing), as well as potential expansion of oligohaline fisheries habitat.

Groundwater sampling near Channel A and Rocky Creek do not show any significant indication of saltwater intrusion in both the baseline and post-modification sampling. The Channel G monitoring well site shows potential salinity intrusion issues during both the pre- and post-modification period. This occurrence was first observed in the 1970s during channel construction and is verified by data collected during the baseline and post-modification study period. In addition, Channel G well water level data indicated a downward trend from 2011 to the present. It's unclear whether this is a result of increases in groundwater discharge into the canals or some other cause.

In examining the changes in habitat types and biotic assemblages, there have been some notable changes in each. In comparing the pre-modification vegetation survey conducted by Hillsborough County and our GPI post-modification survey, it appears that vegetation cover likely increased on the canal banks and along littoral zones. Algal mats disappeared from the system, indicating greater tidal flushing. Salt-tolerant plants have begun to move up into areas upstream of the control structures. With respect to the biotic assemblages (fish), based on the available data, it appears that the Channel A and G systems post-modification, are functioning more similar to a natural tidal creek system then in their pre-modification state.

For benthic species, the three sampling events at each station show an increase in marine and estuarine species over the four year period**.** Channel A and G show a marked decline in freshwater species, while at Rock Creek the decrease was more modest. Continued sampling at the three locations is recommended to determine if a potential community and species composition shift was indeed occurring.

Surface water quality sampling results show that salinity has become more highly variable in the system, increasing in areas above the structures. Tidal influence has been shown in each of the reported salinity monitoring datasets collected dependently and independently of this study, that the system, above the structures, is becoming more tidal in nature. Dissolved oxygen levels have improved in some sampling sets (EPC sampling), while fluctuating in others (sonde data). Fluctuations in dissolved oxygen levels are typical of many tidal creek systems. Water levels have also become more variable without the control structure gates operating to keep constant water levels 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.

In summary, the raising of the control structure gates in June 2014 has resulted in a system that appears to be behaving more similar to SW Florida tidal creeks, as evidenced by changes in salinity, biotic assemblages, and habitat types. It is recommended that further monitoring be performed to assess the continued evolution of the system, as it relates to potential saltwater intrusion into the groundwater systems surrounding the immediate channels.

Recommendations

- Perform post-modification bathymetric survey of Channel A, Channel G, and Rocky Creek to inform operation and management decisions and provide additional information on vegetation and fish recruitment
- Increase frequency of water quality monitoring at Channel A surface well to at least three times per year to monitor for potential trends in saltwater intrusion

- Begin water quality monitoring at the Channel G groundwater monitoring well, three times a year
- Consider an additional year of sonde monitoring of both Channel G and Channel A for water quality
- Establish water level monitoring in Rocky Creek to better assess changes in that portion of the system
- Perform additional vegetation surveys at periodic intervals in the future to determine 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
- Frequent surface water quality sampling in partnership with Tampa Bay Estuary Program tidal tributary efforts
- Engage citizens in future management decisions in the system

References

Environmental Protection Agency. 2004. Draft Total Maximum Daily Load (TMDL) for Nutrients and Dissolved Oxygen & Nutrients in Rocky Creek. EPA Region 4. Atlanta, Georgia.

Environmental Protection Agency. 2013. Final Total Maximum Daily Loads for Dissolved Oxygen & Nutrients in Brushy Creek (WBID 1498), Rocky Creek (1507), Rocky Creek (Channel A) (1507A), Double Branch (Freshwater) (1513E), Double Branch (Estuarine) (1513F), Sweetwater Creek (1516), and Rocky Creek (Lower Segment) (1563). EPA Region 4. Atlanta, Georgia.

Florida Department of Environmental Protection. 1994. Application of the Sediment Quality Assessment Guidelines. Tallahassee, Florida.

FWC-FWRI. 2010a. Fisheries Independent Monitoring Program Procedure Manual. Florida Fish and Wildlife Research Institute. St. Petersburg, Florida.

FWC-FWRI. 2010b. 9.1m Backwater Seine Technique. Florida Fish and Wildlife Research Institute. St. Petersburg, Florida.

Southwest Florida Water Management District. 1979. Re-Evaluation of Operational Water Levels for Rocky Creek & Channels A&G, Upper Tampa Bay Watershed.

Southwest Florida Water Management District. 2003. Structure Profile: Channel A Salinity Barrier.

Southwest Florida Water Management District. 2003. Structure Profile: Channel G Salinity Barrier.

Tampa Bay Tidal Tributary Research Team (TBTTRT), E.T. Sherwood, editor. 2008. Tampa Bay Tidal Tributary Habitat Initiative Project: Final Report and Management Recommendations. Tampa Bay Estuary Program Technical Report #02-08. Report to the Pinellas County Environmental Fund. St. Petersburg, Florida.