Vernon River Watershed Management Plan
For the Reduction of Nonpoint Human Sources of Bacteria

December 2013

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Contents

Acronyms

BMP	Best Management Practice
FC	Fecal Coliform
FOG	Fats, Oils, and Grease
FSE	Food Service Establishments
GA EPD	Georgia Environmental Protection Division
NPS	Nonpoint Source
SSO	Sanitary Sewer Overflow
TMDL	Total Maximum Daily Load
US EPA	United States Environmental Protection Division
WMP	Watershed Management Plan

Introduction: History and Previous Work

There is a dispute as to whom the Vernon River was named after. Some believe it was James Vernon, one of the trustees of Georgia. James was instrumental in promoting indentured servitude to European groups and granting their passage to the colony named “Vernonburgh” by the German and Swiss settlers in 1742. However, others believe the river was named after Admiral Edward Vernon. Admiral Vernon commanded the West Indian fleet which provided military support for General James Oglethorpe and his newly establish colony, Savannah.

By the mid 1800’s, settlement of Vernonburg had transitioned from indentured servants to summer homes for nearby city dwellers from Savannah. Passing time “on the Salts” and being enveloped by the distinctive White Bluff breezes became a symbol of prominence.

In 1864 during the Civil War, the Confederate navy captured the USS Water Witch steamer which was stationed along White Bluff. The ship became the subject of much social excitement and is depicted in the town’s official seal.

Photo # NH 59309 "... Reconnoissance of Vernon River, Ossabaw Sound, Georgia ..." December 1861

GREAT SOUTHERN EXPEDITION—RECONNOISSANCE OF VERNON RIVER, OSSABAW SOUND, GEORGIA, DISCOVERY OF A REBEL BATTERY AND CAMP.—FROM A SKETCH BY OUR SPECIAL ARTIST. —SEE PAGE 148.

The Town of Vernonburg transitioned again to a permanent residential population. In the 1960's the town brought a lawsuit against the City of Savannah which led to the construction of the President Street Water Reclamation Facility, the largest water treatment plant operated by the city. Details of this story are documented in Ralph Nader's and James Fallows' book, The Water Lords, Chapter 3 "The Floating Crap Game".

Similar to the 1970's and 1980's growth trends across America, the Vernon River Watershed also saw rapid growth during this period. Population increases combined with the desire to abandon the city for "safe" suburbia created development pressure on this once rural watershed. The absence of tree and riparian buffer protection ordinances for residential zoned areas is reflected in the deforestation of much of the watershed. Without protection for wetlands and floodplains, homes and businesses were constructed in low areas on poorly drained soils. Many were built using individual septic systems which were only a few feet higher than sea level. There were also major roadways constructed at elevations lower than the water level in the river at high tide. In the 1990's, two rain events caused catastrophic flooding of 2,312 structures and overloaded city sanitary sewer plants.

Between 1998 and 2002 the City of Savannah constructed two stormwater pumping stations in the Casey Canal which flows to the Vernon River. Combined, the DeRenne and Montgomery Crossroads Pump Stations can pump 874,766 gallons per minute. In between the two pump stations is a city-owned golf course designed to serve as a detention basin for stormwater flowing from the DeRenne station to the Montgomery station. The Montgomery station acts as a regulator, releasing flow to Hayners Creek at a controlled rate during large storm events. The stations improved drainage for ten square miles of midtown residential and commercial properties, most located outside the Vernon River Watershed. Since 2007, the city has spent $170 million in drainage improvements, the vast majority designed to move the water quickly off the land into receiving water bodies.

In 2002 the Georgia Environmental Protection Division (EPD) completed stream assessments in the Ogeechee River Basin. One sample point located on the Montgomery Crossroad Bridge over Hayners Creek was selected to represent 3 reaches: Casey Canal North of DeRenne, Casey South of DeRenne, and Hayners Creek. While a total of sixteen samples were taken at this site, the total maximum daily load for fecal coliform was established from one single sample. This sample taken in March 5, 2002, resulted in a required 96% fecal coliform load reduction for the 3 reaches. This information can be found in the Georgia EPD Total Maximum Daily Load (TMDL) Report, 2005. Table 1 below is from Vernon River TMDL Implementation Plan. It describes the 3 reaches and lists the pollutants surpassing state regulated levels. The sample data used in the 2002 EPD stream assessment is shown in Table 5.1 (Section 5).

Table 1. Impaired Segments in the Vernon River Watershed

Impaired Segment	Location	Extent	Criterion Violated	Evaluation	Pollutant Addressed
Casey Area 1	Chatham County (North of DeRenne Avenue)	3 miles	Dissolved Oxygen, Fecal Coliform	NS	Fecal Coliform
Casey Area 2	Chatham County (DeRenne to Montgomery Cross Roads)	3 miles	Dissolved Oxygen, Fecal Coliform, Fish Consumption Guideline	NS	Fecal Coliform
Hayners Creek	Chatham County (Montgomery Cross Roads to Vernon River)	2 miles	Dissolved Oxygen, Fecal Coliform, Fish Consumption Guideline	NS	Fecal Coliform

Vernonburg residents have fought to protect the tranquility of their town and its water resources. They have many conservation easements protecting the maritime forest, a septic system maintenance ordinance, and have hired Dr. Joe Richardson, environmental biologist, to test water quality samples for the past 12 years.

In addition to water quality sampling by Vernonburg, the City of Savannah and Chatham County have also played a role in the protection of the Vernon River. Stormwater National Pollutant Discharge Elimination System (NPDES) permits require monitoring and inspection of stormwater infrastructure and the waterbodies to which the outfalls enter. The City's sanitary sewer system has been extended to all properties with the exception of 581 along the Vernon River, lower Hayners Creek reach. Sewer main maintenance and rehabilitation work is completed annually in the watershed. In addition the City has sponsored river clean ups in Hayners Creek and Harmon Creek reaches since 2003. The City pays for 50 kayak rentals, bags, refreshments for the volunteers, and disposal of the litter.

In 2004, the Town of Vernonburg threatened another lawsuit against the City of

Savannah claiming that the stormwater released from the Montgomery Crossroads pump station should be regulated by the state as a point source. The town believed the high levels of fecal coliform seen in Hayners Creek through Richardson’s sampling was caused by the increased flow from the pump station. The city believed the high levels were a result of failing septic systems on properties adjacent to the water. The contentious atmosphere was sequestered when the city agreed to complete a bacteria source tracking study in partnership with the Skidaway Institute of Oceanography. The Town of Vernonburg and Chatham County joined the group and completed the fecal coliform total maximum daily load (TMDL) implementation plan in 2010. Funds in the amount of $210,000 were received through the GA EPD Grants Unit under a federal Section 319(h) Nonpoint Source Implementation Program.

Section 1: Purpose and Goal

The purpose of this Watershed Management Plan (WMP) is to describe methods and a timeline to reduce the amount of human bacteria pollution in the Vernon River, with emphasis on the Hayners Creek and Casey Canal areas. This document is not regulatory in nature. The preparation process required stakeholders to acknowledge the pollution issues and provide feedback on how to improve water quality. Success of this process will be expressed through the reduction of the targeted bacteria pollutant, fecal coliform. Ultimately, a broader goal is to make businesses and landowners within the watershed more knowledgeable about watershed issues. Establishing a community that is aware of how human activities on land impact the surrounding waterways is key to the overall improvement of water quality.

The development of this WMP included nine elements (described below) to help ensure stakeholder involvement and achieve watershed protection goals. The nine elements recommended by the US Environmental Protection Agency (EPA) are as follows:

1. An identification of the sources or groups of similar sources contributing to nonpoint source (NPS) pollution to be controlled to implement load allocations or achieve water quality standards;

2. An estimate of the load reductions expected from management practices or controls;

3. A description of the NPS management practices that will need to be implemented to achieve the load reductions established in the TMDL or to achieve water quality standards;

4. An estimate of the technical assistance needed, and sources and amounts of funding needed;

5. An information/education component that will be used to enhance public understanding of and participation in implementing the plan;

6. A schedule for implementing the management practices that is measurable;

7. A description of interim, measurable milestones (e.g., amount of load reductions, improvement in biological or habitat parameters) for determining whether management measures or other control actions are being implemented;

8. A set of criteria that can be used to determine whether substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether the plan needs to be revised; and

9. A monitoring component to evaluate the effectiveness of the implementation efforts, measured against the criteria established under item (8) above.

This plan incorporated water quality data and recommendations from four sources:

1. The 2005 Georgia EPD's TMDL Report;

2. The bacteria source tracking study completed in conjunction with the 2010 Implementation Plan;

3. The bacteriophage tracer study initiated in conjunction with the 2010 TMDL Implementation Plan and completed in 2012; and

4. Water quality monitoring from the City of Savannah and the Town of Vernonburg.

In addition, a review of sanitary sewer spills and maintenance was completed and a study of stormwater infiltration and inflow was also completed. Zoning and land use patterns were considered as well.

The action items within this plan focus on local government operations, food service establishments, and residential septic systems. A reassessment of this plan is scheduled every five years. This will allow a chance for stakeholders to analyze project progress and adjust activities as new information is received.

Section 2. Stakeholders

During the drafting of the 2010 TMDL Implementation Plan, a stakeholder committee was formed. This committee was comprised of staff from the City of Savannah and Chatham County, residents from the Town of Vernonburg, and Vernonburg's water quality consultant. During the development of this watershed plan the committee was expanded to include two members residing in the watershed but outside of the Town of Vernonburg. Another new member is the director of the Ogeechee Riverkeeper Organization. These members add value by broadening the focus to a larger geographic area within the watershed. In addition with the participation of the Ogeechee Riverkeeper, promotion of watershed issues and outreach events will likely be more successful due to their large membership. The current stakeholders are shown in Table 2.1:

Table 2.1. TMDL Stakeholder Committee Members

Name	Organization	Email
Laura Walker	City of Savannah	lwalker@savannahga.gov
Suzanne Cooler	Chatham County	svcooler@chathamcounty.org
Andy Chisholm	Town of Vernonburg	Frank.a.chisholm@morganstanleysmithbarney.com
Dr. Joe Richardson	Coastal Environmental Analysis	joe@ceasurf.com
Jefferson Kirkland	Chatham County	jkirkla@chathamcounty.org
Emily Markesteyn	Ogeechee Riverkeeper	Emily@ogeecheeriverkeeper.org
Dr. Marc Frischer	Skidaway Institute of Oceanography	Marc.frischer@skio.uga.edu
Alan Boulton	Paradise Park Resident	Alan.phyllis@attnet
Margie Levy	Town of Vernonburg Resident	Margiel421@aol.com
Kris Carroll	River's End Resident	Divebuff2@aol.com

Section 3: Pollution Source Assessment

Coastal areas possess many desirable qualities for living and working. Consequently, they are the most heavily developed areas in the United States. Over half of the national populous resides in 17% of the nation's coastline. Coastal communities must balance economic development and the protection of natural resources. The increasing desire by coastal communities to preserve or restore function and quality of coastal creeks and rivers is changing the way neighborhoods and businesses are developed.

Since the mid-1980's, stormwater best management practices and green infrastructure have been applied in new developments to try and maintain watershed function to pre-developed conditions. Yet to date, no community has been successful in maintaining water quality to pre-developed conditions. Regardless of the efforts to build communities using engineered sustainable designs, water quality is consistently lost to some degree.

Rivers and tidal creeks are dominant features of coastal Georgia. The point at which fresh water meets saline waters is considered a transitional zone or mixing zone. These mixing zones form estuarine systems, a complex and dynamic environment. Estuaries are the nurseries to many finfish and crustacean species. Approximately 85% of commercially-harvested marine fish depend on estuarine habitats for at least part of their life cycle. Population growth and impervious surfaces in coastal regions has severe negative impacts on overall estuarine quality and function. Habitat and riparian zone encroachment by urban and suburban developments result in point and nonpoint sources of pollution reducing water quality and biodiversity.

This plan is one in many across the southeastern coast directed toward reducing one pollutant, fecal bacteria. Fecal bacteria loadings in a coastal water body are important as limits are set by Georgia EPD for shellfish harvesting and public swimming areas like beaches. Every year numerous beaches and shellfish beds are closed due to high levels of fecal coliform which often occur following a storm event. The Vernon River also experiences high fecal coliform (FC) levels after rain events. In order to pin point the sources of FC bacteria a bacteria source tracking study (BST) was completed in 2010 by the City of Savannah, Town of Vernonburg and the Skidaway Institute of Oceanography. Using the microbial antibiotic resistance method (MAR), samples from sources such as raccoon, deer, horse and bird scat were collected as well as samples from septic systems and sanitary sewer mains.

Overall, the results indicated wildlife as the predominant source of fecal bacteria with birds being the major wildlife generator in the watershed. Yet, human source loadings were the highest contributor in Casey Canal and Vernon River areas (see Table 3.1). Human sources were second highest in the Hayners Creek area. With respect to the two human sources, septic and sanitary sewer, there was an attempt to distinguish between the two. Table 3.2 shows a discriminant analysis classification among the various sources of contamination. The confidence level for the correct identification for sanitary sewer is quite low compared to the other sources and therefore distinction cannot be validated.

Table 3.1. Evaluation of Sources of Fecal Coliform Impairment

Waterbody	Source	Percent Contribution
Casey Canal (South of DeRenne)	Wildlife Human Domestic Pets	22% 74% 4%
Hayners Creek	Wildlife Human Domestic Pets	52% 41% 7%
Vernon River	Wildlife Human Domestic Pets	43% 52% 5%

Table 3.2. Discriminant Analysis Classification for the Various Contamination Sources within the Watershed

Actual Group	Bird	Other Animal	Septic	Sewer	% Correctly Classified
Bird	91	22	3	3	76.5
Other Animal	25	105	1	13	72.9
Septic	10	3	48	4	73.8
Sewer	7	14	4	23	47.9

Figure 3.1 shows a map of the areas covered by septic systems and those covered by the City's sanitary sewer system. Individual septic systems dominate the riparian edge of the Hayners Creek and Vernon River areas while the City's sanitary sewer system lies inland. The land surrounding the Casey Canal is covered by sanitary sewer.

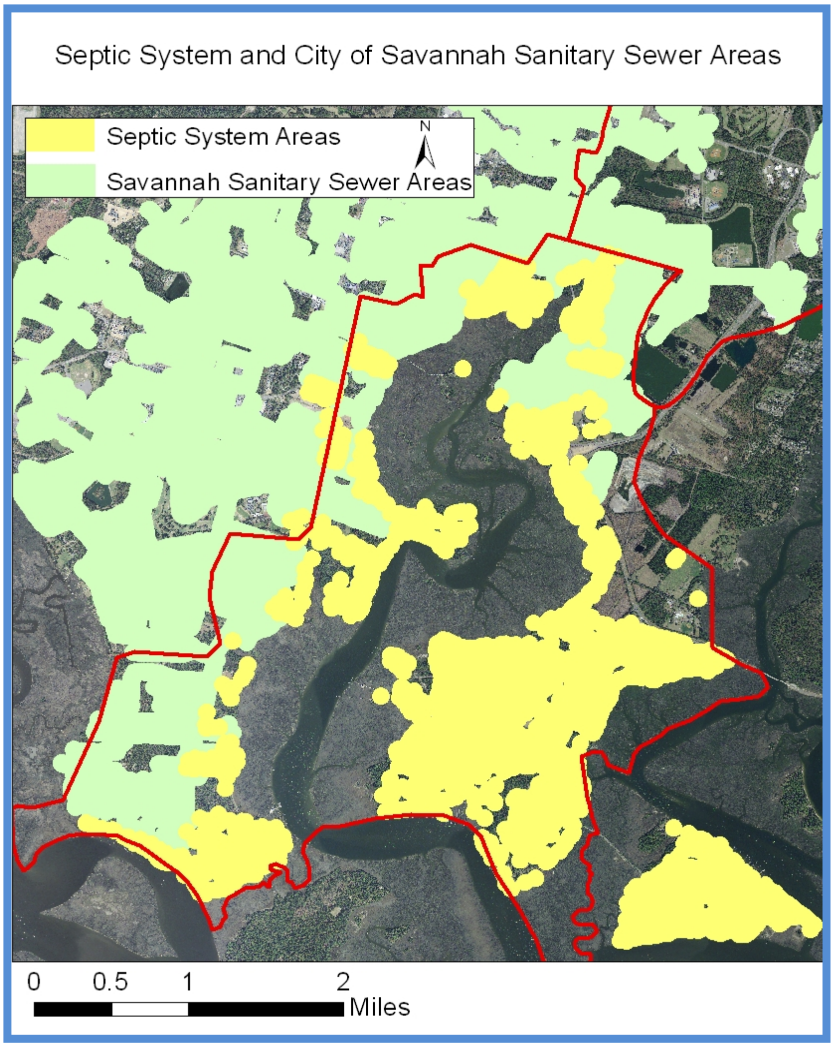

Figure 3.1 Areas serviced by Septic Systems and the City of Savannah's Sanitary Sewer System

There are approximately 1800 septic systems in the Vernon River Basin. Currently maintenance of individual septic systems is only voluntary with the exception of septic systems within the Town of Vernonburg. The Town adopted a septic system maintenance ordinance in December of 2006.

In 2009 the City of Savannah, the Skidaway Institute of Oceanography and Georgia Tech initiated a study to determine a better way to assess failing septic systems. Current methods of detection rely on the use of an inert dye. This study employed the use of a bacteriophage. Testing was conducted in both open waterways and coastal groundwater systems. The results demonstrated that the bacteriophage was detectable at greater distances and longer durations than the dye. The bacteriophage was also detected in groundwater revealing it moves quickly through soil. The ultimate advantage was the robustness of the bacteriophage and the improvement in detectability. But a disadvantage is the cost to deploy this method with routine monitoring.

The Vernon Basin has approximately 195 miles of gravity sanitary sewer main. In addition there are 9 privately owned and maintained sanitary sewer lift stations:

- Candler Hospital
- The Cedars at1029 Shawnee
- Chatham Villas at 10612 Middleground Road
- Goodwill on Sallie Mood Drive
- Mustard Seed (now Savannah Christian) at Old Montgomery Road
- Red Lobster Restaurant at Montgomery Crossroads
- St. Joseph's Hospital on Middleground Road
- Georgia Regional on Eisenhower
- Chatham County School Board at Hess Elementary on Whitfield Avenue
- Two private lift stations in the unincorporated Chatham County from Winterberry Lift Station on Ferguson Road

There are also 89 privately maintained sanitary sewer systems serving private developments (i.e. apartment complexes, plazas, hotels, businesses, etc.). In addition, Hunter Army Airfield operates and maintains a sanitary sewer collection system which includes approximately 30 miles of sanitary sewer collection system and 16 lift stations. Some of these are pumped directly to drain fields or septic systems.

The City of Savannah operates and maintains 44 sanitary sewer lift stations that are located in the Vernon River Basin. These are inspected daily to 2 times per week and have critical items such as SCADA (Supervisory Control and Data Acquisition System), generators, by-pass pumps, and failsafe auto-dialers. Stations that do not have by-pass pumps or generators have the capability to be tied into portable by-pump units or generators. These stations are maintained and operated by City Lift Station Maintenance Staff which includes Electronic Control Technicians, Maintenance Mechanics, and State certified operators. Along with the normal operation budget for the lift stations, the City also funds Lift Station Capital Improvements at costs approximately $2,000,000 per year. These include electrical, mechanical, and other station rehabs / upgrades. These projects do not include special projects which are needed at times.

Table 3.3 below shows the recorded sanitary sewer overflow (SSO) in the Vernon Basin since 2005. These do not account for any from Chatham County or any of the private systems.

Table 3.3. Records for Spills on the Vernon River Since 2005

DATE	LOCATION	GALLONS To Waters of the State
9/7/05	11607 Willis Drive to Casey Canal	225 gal
12/16/05	White Bluff / Travis to Harmon Canal	<10,000 gal
4/12/06	602L Plantation Drive to Vernon River	1,350 gal
2/6/07	Wilshire to Wilshire Canal	4,250 gal
8/3/07	Cranman Driver to Casey Canal	2,130 gal
12/28/07	1310 Grace Drive to Hayners Creek	265 gal
4/25/08	East 65th St / Truman Parkway to Casey Canal	1,395 gal
5/05/08	1415 Sherwood to Casey Canal	1,600 gal
4/08/09	15 Sherwood to Casey Canal	3,750 gal
4/21/09	7700 Waters Ave to Casey Canal	1,230 gal
5/2/09	Windsor / Largo to Wilshire Canal	3,600 gal
5/05/09	10611 Abercorn to Casey Canal	7,800 gal
5/06/09	Wilshire / Delmar to Casey Canal	220 gal
7/14/09	8601 Cresthill Place	700 gal
12/03/09	1132 Madrid Street to Casey Canal	80 gal
3/19/10	12328 Largo to Casey Canal	300 gal
4/25/10	100 Creekside Driver to Hayners Creek	600 gal
8/11/10	183 Wilshire to Wilshire Canal	600 gal
10/5/10	210 Wesley to Wilshire Canal	2,790 gal
11/29/10	East 57th St / Costa Rica to Casey Canal	6,800 gal
12/14/10	320 Kensington Drive to Harmon Canal	390 gal
2/9/11	1900 Wallin to Casey Canal	2,160 gal
3/18/11	13 Nina Ct to Harmon Canal	33 gal
5/31/11	1304 Grace Drive to Hayners Creek	370 gal
9/18/11	209 Wilshire to Wilshire Canal	595 gal
10/6/11	11607 Willis Drive to Wilshire Canal	1,440 gal
12/10/11	Lisa / Cranman to Casey Canal	850 gal
2/1/12	25 Ventura Blvd to Wilshire Canal	202 gal
2/14/12	511 Stuart Street to Casey Canal	330 gal
4/30/12	13010 Hermitage Circle to Vernon River	700 gal
6/1/12	1697 East 65th St to Casey Canal	235 gal
8/9/12	207 Montgomery Crossroads to Harmon	3,200 gal
10/25/12	7215 Sallie Mood to Casey Canal	9,500 gal
12/10/12	Travis / Cindy to Casey Canal	620 gal
1/7/13	East 65th / Abercorn to Casey Canal	876 gal
3/15/13	East 64th / Abercorn to Casey Canal	95 gal
3/18/13	East 46th / Harmon to Casey Canal	88 gal
3/31/13	Wilshire Blvd / Delmar to Casey Canal	235 gal
5/8/13	125 Tibet to Casey Canal	125 gal
10/25/13	East 67th / Fredrick to Casey Canal	235 gal
11/7/13	Victory Drive / Hibiscus to Casey Canal	600 gal
2/28/14	405 Montclair Blvd to Wilshire Canal	355 gal

Every sanitary sewer system will experience conditions that produce overflows. Overflows can cause a spill into waters of the state but more often they are contained on land. Past data show that SSOs are caused by FOG (fats, oils, and grease), roots, debris, and pipe conditions. These categories account for approximately 85% of all SSOs.

Spills into waters of the state also occur as shown in Table 3.3 above. Approximately 60% are related to FOG. FOG generated by food service establishments (FSE) and homes and their accumulation in the sanitary sewer system is an increasing problem. FOG will accumulate over time in a pipe and eventually lead to a full blockage. FSEs are required to install grease interceptors, but the current and most popular design which dates back to the late 1800's only provides an 80% removal rate. FSE's vary greatly in the amount and the type of oil they use, as do their opinions regarding the correct method for sizing a grease interceptor. Additionally, the standard method for testing grease interceptors (Method 1664 approved by the USEPA), has too great a variability for a high level of confidence in the results.

Private sewer laterals are another potential pollution source and area of concern. Recent studies show that the 60% of sanitary sewer pollution comes from leaking private laterals. In addition maintenance on private laterals is not currently required. Overtime roots, debris, and FOG can block a lateral causing a backup or overflow.

Analysis of Existing TMDL Fecal Loading Standard

Table 3.4 summarizes the 2002 fecal coliform load data used to establish the TMDL by the Georgia EPD in 2005 as part of their evaluation of stream segments in the Ogeechee River Basin. Note that a total of 16 samples were taken over a 11-month period. As per the state standard, their data collection includes four samples taken over a 30-day period for the geometric mean, with two periods occuring in the winter (November through April) and two periods in the summer (May through October). All of the samples were taken from the Casey Canal Southof DeRenne, just north of Montgomery Crossroad.

Table 3.4. Fecal Coliform Load and TMDL Data for Casey Canal South of DeRenne (GA EPD, 2005)

Date	Observed Fecal Coliform (counts/100 ml)	Estimated Instantaneous Flow On Sample Day (cfs)	Geometric Mean (counts/100 ml)	Mean Flow (cfs)	Geometric Mean Fecal Coliform Loading (counts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (counts/30 days)
26-Feb-02	1300	111.0				
5-Mar-02	**92000**	86.0				
12-Mar-02	330	61.0				
26-Mar-02	330	89.0	1900	86.8	1.21E+14	6.37E+13
14-May-02	330	39.0				
21-May-02	3300	40.0				
4-Jun-02	80	41.0				
11-Jun-02	17000	45.0	1103	41.3	3.34E+13	6.06E+12
9-Jul-02	490	44.0				
16-Jul-02	1100	44.0				
23-Jul-02	490	44.0				
1-Aug-02	460	46.0	590	44.5	1.93E+13	6.53E+12
20-Nov-02	790	57.0				
5-Dec-02	20	53.0				
10-Dec-02	20	70.0				
17-Dec-02	940	65.0	131	61.3	5.90E+12	4.50E+13

The geometric mean TMDL Fecal Coliform Loading (column 7) for the summer and winter periods were determined using the following equation:

$$TMDL = C_{standard} * Q_{mean} * 30 \text{ days} \qquad (1)$$

where:

TMDL: fecal coliform TMDL load (counts/ 100 mL)
$C_{standard}$: seasonal fecal coliform standard (as a 30-day geometric mean) in which summer has a standard of 200 counts/100 mL and winter has a standard of 1,000 counts/100 mL
Q_{mean}: stream flow as an arithmetic mean (cfs)

Equation (1) was also used in determining the actual Fecal Coliform Loading of a 30-day period (column 6) by replacing the $C_{standard}$ term with the observed geometric mean fecal coliform counts (column 4).

The critical loading of a stream is determined by analyzing the observed 30-day Fecal Coliform Loading that requires the largest percent to reduction in order for it to meet the TMDL. The critical loading, its associated TMDL, and required percent reduction are often the final values used by the Georgia EPD in their stream evaluation. However, the Georgia EPD also specifies that if during the winter period a single sample exceeds the maximum criterion of 4,000 counts/100 mL, then the following equation is used to establish the TMDL Fecal Coliform Loading:

$$TMDL = 4{,}000 \text{ counts (instantaneous) } /100 \text{ mL} * Q * 30 \text{ days} \qquad (2)$$

In order to obtain the actual Fecal Coliform Loading, the 4,000 count term in equation (2) is replaced with the single observed fecal coliform count that exceeded 4,000 counts.

Examining the Georgia EPD data taken from Casey Canal South of DeRenne in Table 3.4 indicates that the sample taken on March 5, 2002 (92,000 counts/100 mL) exceeded the 4,000 counts maximum criteria for winter months. As such, this single sample was used in establishing both the actual Fecal Coliform and TMDL Fecal Coliform loadings as follows:

$$\text{Actual Fecal Coliform} = \left(\frac{92000\ counts}{100\ ml}\right) * \left(\frac{86.0\ ft^3}{sec}\right) * \left(\frac{28{,}316.846\ ml}{ft^3}\right) * \left(\frac{86400\ sec}{day}\right) * (30\ days)$$

$$= 5.81E+15 \text{ counts/30 days}$$

TMDL Fecal Coliform

$$= \left(\frac{4000\ counts}{100\ ml}\right) * \left(\frac{86.0\ ft^3}{sec}\right) * \left(\frac{28{,}316.846\ ml}{ft^3}\right) * \left(\frac{86400\ sec}{day}\right) * (30\ days)$$

= 2.52E+14 counts/30 days

With an actual fecal coliform loading that exceeds the TMDL loading, the required percent reduction is:

$$\%\ Reduction = \frac{(5.81\ E{+}15 - 2.52E{+}14)}{5.81E{+}15} * 100\% = 96\%$$

Because this percent reduction is larger than any percent reductions obtained from the 30-day fecal coliform loadings shown in Table 3.4, the values associated with this single sample were used as the final representation of the critical loading for Casey Canal South of DeRenne in the Georgia EPD's 2005 TMDL Report (GA EPD, 2005).

Issues of Concern regarding the 2002 Georgia EPD TMDL Data

There are several issues of concern with the data and aforementioned conclusions of the 2005 GA EPD TMDL report.

1. The data shown in Table 3.4 was taken at a single location in the Casey Canal South of DeRenne at the Montgomery Crossroad (refer to Figure 3.2 below) and used to determine the actual fecal coliform loading and TMDL loading standard for Casey Canal South of DeRenne. However, rather than collecting fecal coliform and flow data from test points from Casey Canal North of DeRenne and Hayners Creek, the GA EPD used this single test point to represent all three water bodies. Subsequently, using the 2002 March 5th data point (92,000 counts/100 mL) caused the Casey Canal North of DeRenne and Hayners Creek water bodies to also be listed as not supporting their designated use.

2. While the GA EPD at Montgomery Crossroad sampling site is technically located at the southernmost point of Casey Canal (since its located north of Montgomery Cross Road), its location south of the City's stormwater pump station and tidal gate (see Figure 3.3) indicates that the samples are actually more representative of Hayners Creek than Casey Canal South of DeRenne. With the tidal gate serving as a barrier to tidal flow from the south and stormwater runoff from the south, the flow and coliform loading information on its south side (Hayners Creek) which is tidally influenced is quite different from that of the north side (Casey Canal South of DeRenne) which does not function as a natural waterway since the only inflow it receives comes from groundwater seepage and stormwater runoff.

3. As shown in Figures 3.3 and 3.4, there are two storm drain outlets that empty into Casey Canal South of DeRenne at this sampling site. These drains carry

water during storm events that would be representative of stormwater quality to the east and west, and not water quality of Casey Canal to the north.

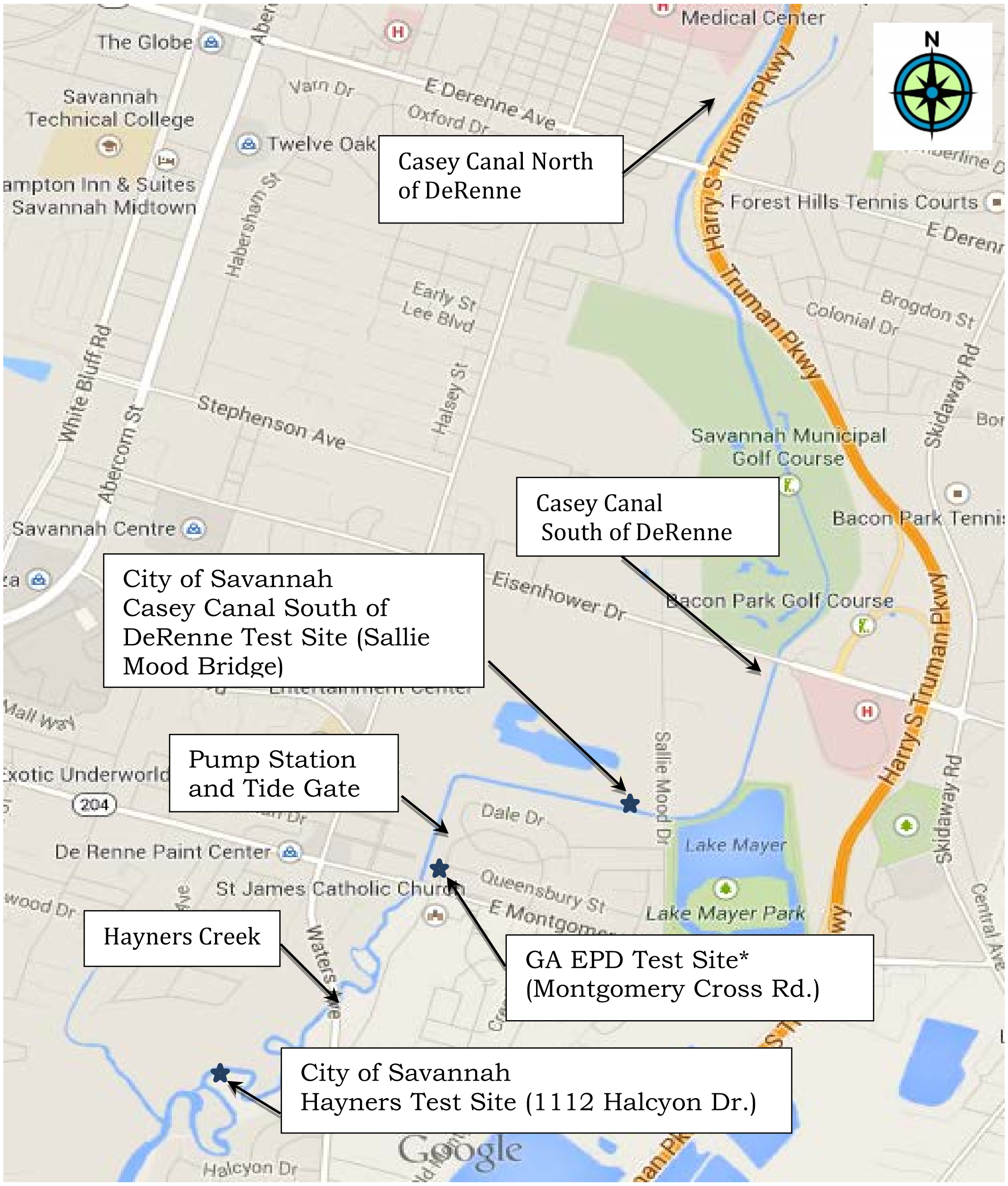

Figure 3.2. City of Savannah and Georgia EPD Test Site Information

*Note: boundary between Casey Canal South of DeRenne and Hayners Creek is Montgomery Cross Rd.

Figure 3.3. Location of the Georgia EPD Test Site Relative to Casey Canal South of DeRenne, Hayners Creek, and the City of Savannah's Stormwater Pump Station and Tide Gate

Figure 3.4. Storm Drain Outlet along Montgomery Cross Road at the Georgia EPD Test Site

Current Conditions at Casey Canal South of DeRenne and Hayners Creek

The data shown in Tables 3.5 ~ 3.10 were collected by the City of Savannah over a nine-month testing period (March through December) in 2011, 2012 and 2013. Whereas data for Casey Canal South of DeRenne were taken at Sallie Mood Bridge test site, data for Hayners Creek were taken at the test site located at 1112 Halcyon Drive (see Figure 3.2). Since no flow data were available for these two sites during these years, the flow data collected by the GA EPD in 2002 were used to determine approximated mean flow values shown in column 4 of the tables. Because the four 30-day sampling periods from 2002 do not correlate exactly with the 2011, 2012, and 2013 thirty day sampling periods, the approximated mean flow values were calculated by averaging the four closest (by date) 2002 mean flow values. For example, the approximated mean flow for May 2011 was obtained by averaging the four estimated instantaneous flow values (column 3, Table 3.4) from May 14, 2002 to June 11, 2002. The actual fecal coliform loadings, TMDLs, and percent reductions were obtained using the same methodology as outlined in the 2005 Georgia EPD TMDL report present in a prior section.

Table 3.5. 2011 Fecal Coliform Load and TMDL Data for Casey Canal South of DeRenne

Casey Canal South at Sallie Mood Bridge						
Date	Fecal Coliform (counts/100 ml)	Geometric Mean (counts/100 ml)	Approximated Mean Flow* (cfs)	Geometric Mean Fecal Coliform Loading (counts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (counts/30 days)	Required Percent Reduction
3/3/2011	270					
3/8/2011	18					
3/15/2011	78					
3/23/2011	330	105.76	86.75	6.7338E+12	6.3672E+13	None
5/4/2011	45					
5/10/2011	78					
5/17/2011	45					
5/24/2011	230	77.64	41.25	2.3505E+12	6.0553E+12	None
9/8/2011	78					
9/14/2011	78					
9/21/2011	160000					
9/29/2011	230	687.87	47.75	2.4108E+13	7.0094E+12	70.92
12/5/2011	45					
12/12/2011	790					
12/21/2011	20	89.25	62.67	4.1052E+12	4.5996E+13	None
*extracted from GAEPD 2002 flow data						

Table 3.6. 2012 Fecal Coliform Load and TMDL Data for Casey Canal South of DeRenne

Casey Canal South at Sallie Mood Bridge						
Date	Fecal Coliform (counts/100 ml)	Geometric Mean (counts/100 ml)	Approximated Mean Flow* (cfs)	Geometric Mean Fecal Coliform Loading (counts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (counts/30 days)	Required Percent Reduction
3/1/2012	78					
3/12/2012	45					
3/20/2012	45					
3/27/2012	790	105.69	86.75	6.7295E+12	6.3672E+13	None
6/4/2012	18					
6/11/2012	78					
6/18/2012	110					
6/25/2012	18	40.83	42.5	1.2737E+12	6.2388E+12	None
9/6/2012	78					
9/13/2012	110					
9/20/2012	230					
9/27/2012	170	135.34	47.75	4.7432E+12	7.0094E+12	None
12/3/2012	18					
12/13/2012	450					
12/20/2012	110					
12/27/2012	1348	186.16	61.25	8.3691E+12	4.4956E+13	None
*extracted from GAEPD 2002 flow data						

Table 3.7. 2013 Fecal Coliform Load and TMDL Data for Casey Canal South of DeRenne

Casey Canal South at Sallie Mood Bridge						
Date	Fecal Coliform (counts/100 ml)	Geometric Mean (counts/100 ml)	Approximated Mean Flow* (cfs)	Geometric Mean Fecal Coliform Loading	Geometric Mean TMDL Fecal Coliform Loading (counts/30 days)	Required Percent Reduction
3/7/2013	330					
3/21/2013	78					
3/27/2013	170	163.56	78.67	9.4440E+12	5.7739E+13	None
6/4/2013	7900					
6/11/2013	2400					
6/18/2013	45					
6/25/2013	140	587.89	42.5	1.8338E+13	6.2388E+12	65.98
9/3/2013	160000					
9/12/2013	45					
9/17/2013	330					
9/26/2013	17000	2521.01	47.75	8.8354E+13	7.0094E+12	92.07
12/5/2013	220					
12/12/2013	18					
12/17/2013	490					
12/23/2013	45	96.67	61.25	4.3457E+12	4.4956E+13	None
*extracted from GAEPD 2002 flow data						

Table 3.8. 2011 Fecal Coliform Load and TMDL Data for Hayners Creek

Hayners Creek at 1112 Halcyon Dr.						
Date	Fecal Coliform (counts/100 ml)	Geometric Mean (counts/100 ml)	Approximated Mean Flow* (cfs)	Geometric Mean Fecal Coliform Loading (counts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (counts/30 days)	Required Percent Reduction
3/3/2011	45					
3/8/2011	330					
3/15/2011	170					
3/23/2011	270	161.58	86.75	1.0288E+13	6.3672E+13	None
5/4/2011	790					
5/10/2011	630					
5/17/2011	230					
5/24/2011	4900	865.41	41.25	2.6201E+13	6.0553E+12	76.89
9/8/2011	490					
9/14/2011	78					
9/21/2011	160000					
9/29/2011	1100	1610.46	47.75	5.6442E+13	7.0094E+12	87.58
12/5/2011	490					
12/12/2011	230					
12/21/2011	230	295.95	62.67	1.3612E+13	4.5996E+13	None
*extracted from GAEPD 2002 flow data						

Table 3.9. 2012 Fecal Coliform Load and TMDL Data for Hayners Creek

Hayners Creek at 1112 Halcyon Dr.						
Date	Fecal Coliform (counts/100 ml)	Geometric Mean (counts/100 ml)	Approximated Mean Flow* (cfs)	Geometric Mean Fecal Coliform Loading (counts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (counts/30 days)	Required Percent Reduction
3/1/2012	1100					
3/12/2012	460					
3/20/2012	18					
3/27/2012	330	234.14	86.75	1.4908E+13	6.3672E+13	None
6/4/2012	130					
6/11/2012	490					
6/18/2012	130					
6/25/2012	1100	308.94	42.5	9.6369E+12	6.2388E+12	35.26
9/6/2012	78					
9/13/2012	490					
9/20/2012	140					
9/27/2012	330	204.99	47.75	7.1843E+12	7.0094E+12	2.43
12/3/2012	20					
12/13/2012	2300					
12/20/2012	700					
12/27/2012	330	321.06	61.25	1.4434E+13	4.4956E+13	None
*extracted from GAEPD 2002 flow data						

Table 3.10. 2013 Fecal Coliform Load and TMDL Data for Hayners Creek

Hayners Creek at 1112 Halcyon Dr.						
Date	Fecal Coliform (counts/100 ml)	Geometric Mean (counts/100 ml)	Approximated Mean Flow* (cfs)	Geometric Mean Fecal Coliform Loading	Geometric Mean TMDL Fecal Coliform Loading (counts/30 days)	Required Percent Reduction
3/7/2013	110					
3/21/2013	210					
3/27/2013	110	136.46	78.67	7.8790E+12	5.7739E+13	None
6/4/2013	490					
6/11/2013	2200					
6/18/2013	790					
6/25/2013	400	763.97	42.5	2.3831E+13	6.2388E+12	73.82
9/3/2013	160000					
9/12/2013	490					
9/17/2013	45					
9/26/2013	7000	2229.24	47.75	7.8128E+13	7.0094E+12	91.03
12/5/2013	45					
12/12/2013	490					
12/17/2013	45					
12/23/2013	130	106.57	61.25	4.7910E+12	4.4956E+13	None
*extracted from GAEPD 2002 flow data						

The actual fecal coliform loadings and TMDL limits shown in Tables 3.5 ~ 3.7 and Figure 3.5 for Casey Canal South of DeRenne shows three cases in which a reduction was required. Two of the three cases occurred in the month of September (2011, 2013) with the other point occurring in June 2013. In both September cases, the large geometric mean (column 3) values of 687.87 and 2,521.01 counts per 100 ml were due to 160,000 counts/100 ml samples collected taken on 9/21/2011 and 9/3/2013 respectively. Reviewing the other 2011, 2012, and 2013 load data, as well as the 2002 data used by the GA EPD for establish the TMDL, indicates that the 160,000 counts/100 ml samples are not indicative of the actual fecal coliform loading conditions of the water body. There is an external factor contributing to these readings that needs to be further investigated.

In the case of Hayners Creek, Tables 3.8 ~ 3.8 show required reductions ranging from 2.43% to 91.03% during the summer months of all three years with the highest fecal coliform loading reaching 7.81E+13 counts/30 days with a critical TMDL loading of 7.00E+12 counts/30 days. Figure 3.6 shows the relationship between the actual fecal coliform loadings and the TMDL limits for a three year period starting with year 2011. Note that for all three years, reductions are required for the summer periods (June and September samples). There are not any recent fecal coliform data for Casey Canal North of DeRenne since the City of Savannah does not have a regular sampling site within that water body.

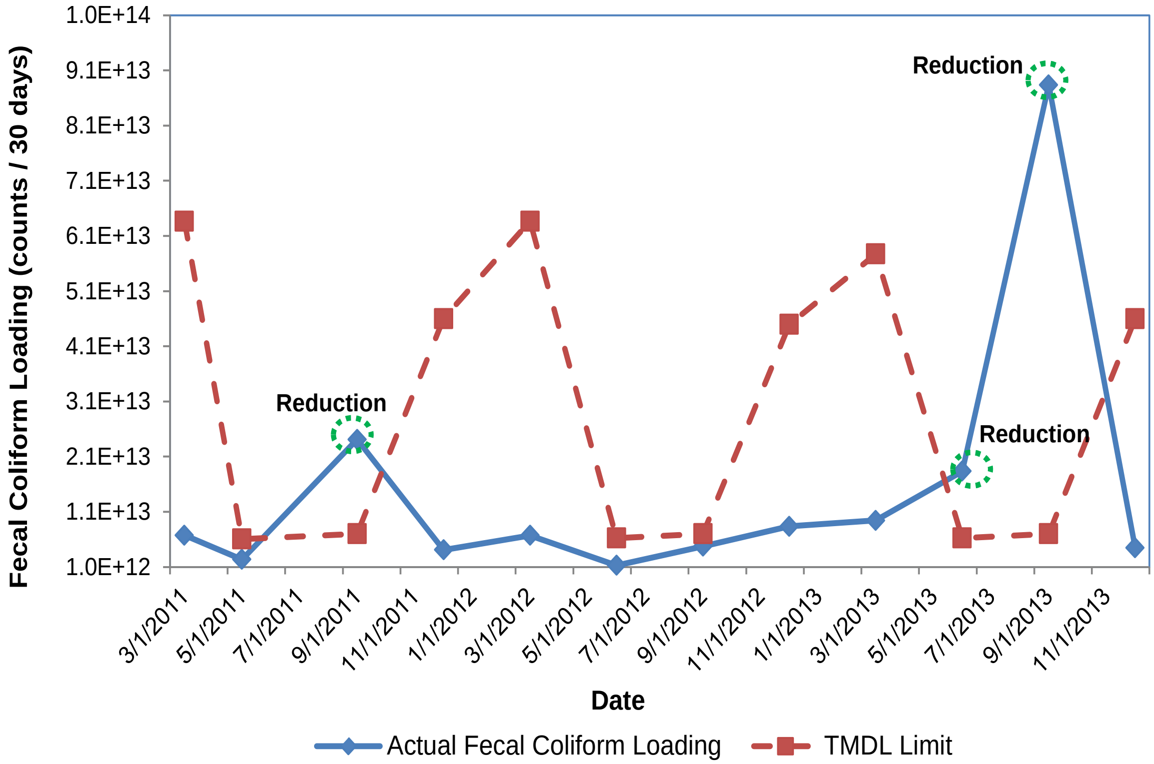

Figure 3.5. Comparison of Actual Fecal Coliform Loadings versus TMDL Limits for Casey Canal South of DeRenne for years 2011~2013

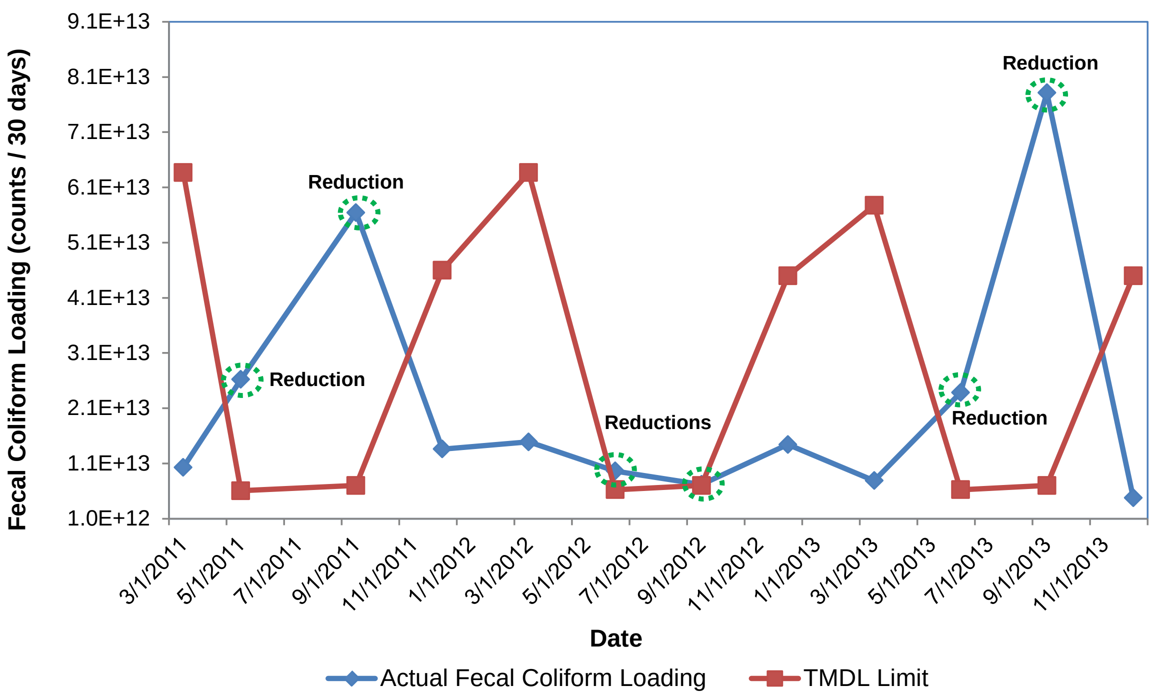

Figure 3.6. Comparison of Actual Fecal Coliform Loadings versus TMDL Limits for Casey Canal South of DeRenne for years 2011~2013

Proposed Changes by the City of Savannah

Change #1: While the city believes that sampling (fecal loading and flow) all three water bodies at three separate locations would provide a more accurate representation of their actual conditions, the city would like the Georgia EPD to consider removing the Casey Canal South of DeRenne from the 303(d) List for two reasons:

- Casey Canal South of DeRenne no longer functions as a natural waterway as a result of flood remediation projects in the 1980s which included the channelization of the banks and the construction of two pump stations with tidal gates that restrict the inflow tidal waters (see Figure 3.7). Whereas water south of the pump stations (Hayners Creek) is moving with tidal variation, water in Casey Canal (north of the pump stations) is stagnant with limited inflow from groundwater seepage and stormwater runoff.

- Records from the city's pumping stations (Table 3.11) indicate that the average flow entering Casey Canal South of DeRenne over the three-year period from 2011 thru 2013 was 7.96 cfs with a one year flow for 2013 of 11.09 cfs. These values are 14.5% (years 2011 thru 2013) and 20.0% (year 2013) the average flow of 54.8 cfs reported by the GA EPD at their test point on Montgomery Crossroad in 2002.

Table 3.11. Pumping Information from Montgomery Crossroad Pump Station (2011 ~ 2013)

Time Period	# Days	Pump Time (Hours)	Pump Rating (GPM)	Flow (cfs)
Jan 2011 ~ Dec 2013	1079	1,186.3	78,000	7.96
Jan 2013 ~ Dec 2013	365	559.2	78,000	11.09

Figure 3.7. View of the Pump Stormwater Pump Station and Tidal Gate at the Division of Casey Canal South of DeRenne and Hayners Creek

- As supported in Tables 3.5~3.7 and Figure 3.5, aside from the four single sample readings and three geometric means that exceed the state water quality standards for fecal coliform, the data appears to indicate a trend in which actual coliform loadings are below the TMDL limits.

Change #2: Based on the testing results shown in Tables 3.8~3.10, the city recommends the continued testing of Hayners Creek at the existing test site on Halcyon Drive. Unlike previous years, data collection will include both fecal coliform and flow measurements. Samples from this site provide an accurate representation of the water quality of the Hayners Creek since it includes several tributaries including the Harmon Canal.

Change #3: The City will establish a sampling site for the collection of fecal loading and flow data from Casey Canal North of DeRenne. Data collected at this site over several years will be used in assessing if Casey Canal North of DeRenne should be eventually delisted from the Georgia EPD's 303(d) list.

Section 4: Current Conditions

The Vernon River Watershed lies within the larger watershed of the Ogeechee River Basin and covers approximately 18,400 acres, including wetlands. Primary land uses in the watershed are classified as urban, residential and commercial. The developed area covers 85% of the total watershed. The remaining 15% includes water and wetlands. The water and wetland components include 19 miles of stormwater canals, 9 miles of natural streams, 500 acres of borrow pits, and 3200 acres of salt marsh.

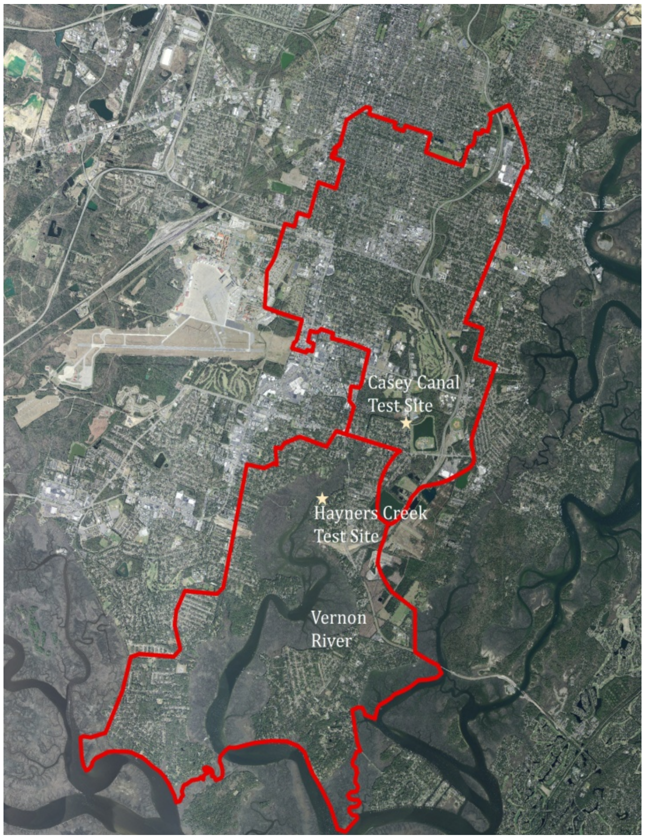

Figure 4.1 Casey and Vernon Drainage Basins

The focus of this plan is three distinct reaches within the Vernon River Watershed: The Casey Canal which terminates at the DeRenne Pump Station (Casey Canal North of DeRenne), the Casey Canal which terminates at the Montgomery Crossroads Station (Casey Canal North of DeRenne), and Hayners Creek. Figure 4.1 shows the location and proportion of the Casey sub basin with the Hayners and Vernon River basin. The Casey Canal no longer functions as a natural waterway. Flood remediation projects from the 1980's have channelized the banks and increased the canal's capacity to hold stormwater. The presence of two stormwater pump stations and associated tide gates restrict natural tidal movement resulting in a stagnant waterbody with the exception of natural groundwater infiltration. The land surrounding the Casey Canal is served by the City of Savannah sanitary sewer system. Land uses worthy of notation within the land adjacent to the Casey include a golf course, regional parks, and a community lake.

Downstream of Casey and separated by tidal gates lies Hayners Creek. It is a tidal waterbody that serves as the now “natural” headwaters to the Vernon River. Tidal creeks like Hayners are discrete habitats of shallow water. They are very dynamic places with extreme tidal shifts along narrow channels. There are natural stressors such as low dissolved oxygen from reduced flushing and long water retention times. Headwater tidal creeks are primary links between marine and terrestrial ecosystems and are predominantly intertidal habitats. The Hayners Creek sub-basin includes primarily residential lots served by individual septic systems. The east side of the basin is within the City of Savannah municipal limits and the west side of the basin is within Chatham County. The ecological quality of this headwater creek may provide an early warning of pollution effects to the greater system due to its direct association with the upland environment.

Hayners Creek flows into the main body of the Vernon River. Surrounding the Town of Vernonburg this stretch consistently exhibits low fecal coliform levels with the exception of samples taken after major rain events. A recent study on oxygen levels within the Vernon River conducted in July 2009 concluded the river has a high flushing rate within 24 hours. The strong tidal flow may attribute to the good water quality present within this Vernon River segment and beyond. In addition, development patterns in this reach are generally low in intensity with large residential lots and little commercial. Wide expanses of salt marsh buffer the river from the land. And the preservation of forested lands within the floodplain helps this reach maintain relatively overall good health. Table 4.1 summarizes the population and land area characteristics for both communities (Savannah and Vernonburg) and Chatham County.

Table 4.1 Area and Population Data for the Savannah, Vernonburg, and Chatham County

	Population and Land Area - U.S. Census Bureau			
Name	Land Area (square miles)	2010	2020	2030
Savannah	103.15	142,022	159,680	170,412
Vernonburg	0.4	125	168	174
Chatham County	426.44	276,434	88,259	97,242

Physical Characteristics

The Vernon River lies within the Ogeechee River Watershed. The Ogeechee River originates in the lower Georgia Piedmont and flows 245 miles to the Atlantic Ocean at Ossabaw Sound. The land in this region is composed of stream alluvium and terrace deposits of sand, silt, clay, and gravel, along with some organic muck and swamp deposits. Natural communities within the Ogeechee River Watershed include limestone shoals, sandbars, cypress-gum swamps, springs, bottomland hardwood forests and coastal salt marshes. Important habitats adjacent to the river floodplain include Carolina bays, springs, limesinks, sandhills and Altamaha Grit outcrops. Information regarding the watershed's land cover is provided in Figure 4.2.

The Vernon River watershed includes remnants ecosystems such as long-leaf slash pine, loblolly-shortleaf pine, oak-pine, oak-hickory; and oak-gum-cypress. These are depicted in Exhibit 3A along with intensities of development within the Casey South Canal, Hayners Creek and Vernon River reaches.

Within Chatham County there are US Fish and Wildlife endangered or threatened species that include bald eagle, eastern indigo snake, West Indian manatee, four species of moccasinshell, five species of turtle, wood stork, three species of whale, red-cockaded woodpecker, and shortnose sturgeon.

The waterways representing distinct reaches are divided by anthropogenic structures and natural conditions (Figure 4.3). The Casey Canal contains two stormwater pumping stations (Figure 4.4) and tidegates. The Montgomery Crossroads Pump Station divides the canal from the headwaters, Hayners Creek (Figure 4.5). The canal drains stormwater from land that is medium to intensely developed and served the City of Savannah sanitary sewer system.

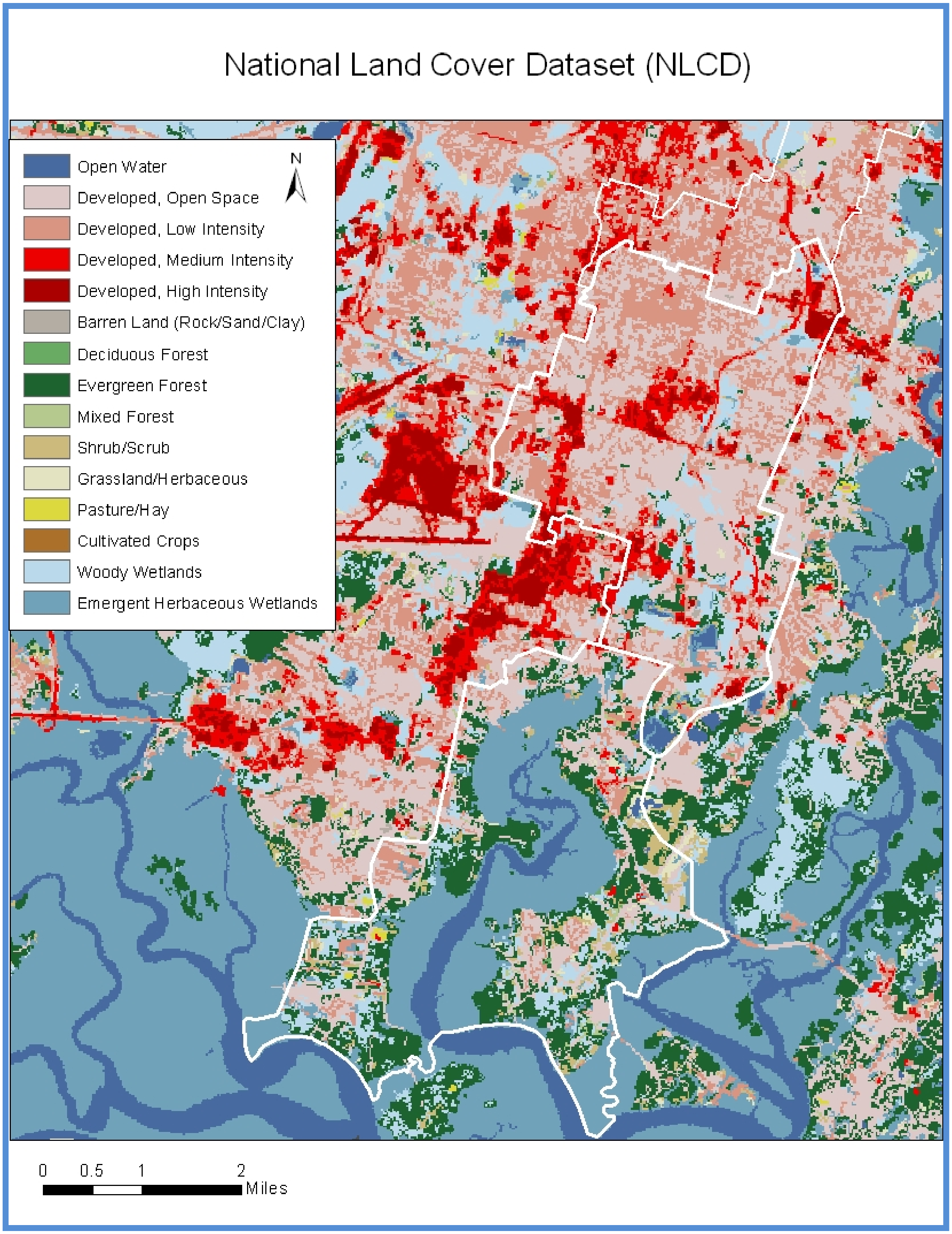

Figure 4.2 the Vernon River Watershed Land Cover Information

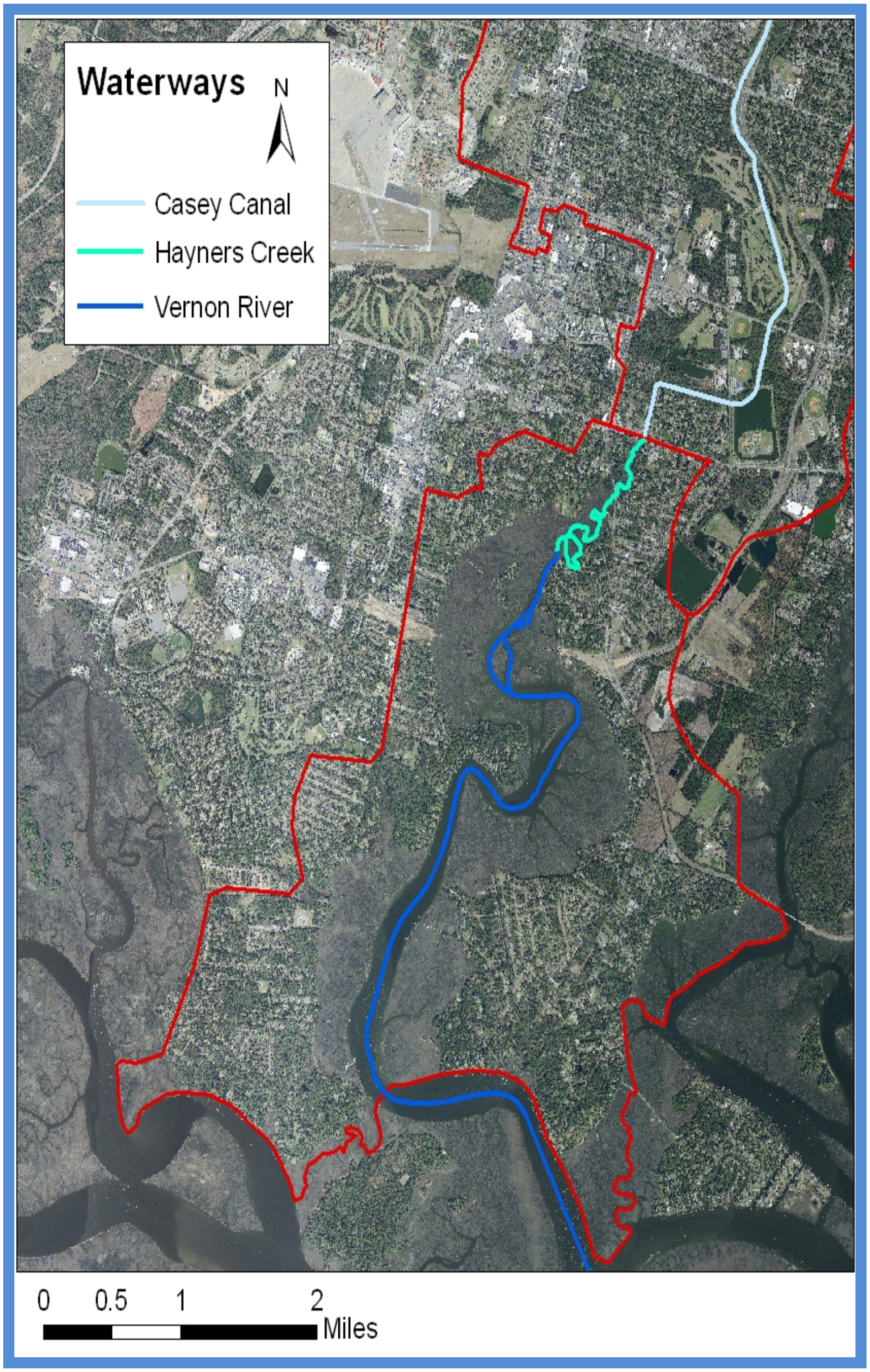

Figure 4.3 Waterways within the Vernon River

Figure 4.4 View of Casey Canal Looking North from Montgomery Crossroads

Figure 4.5 View of Hayners Creek Looking South from Montgomery Crossroads

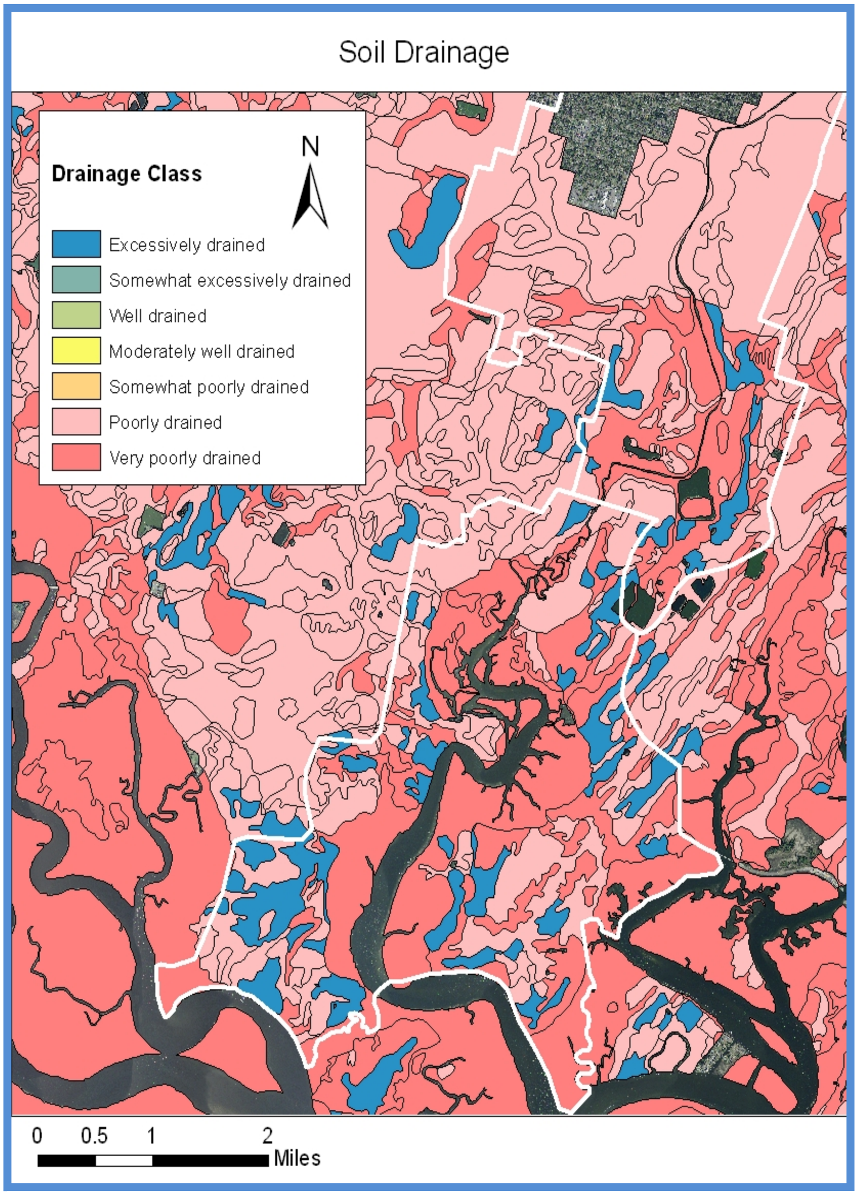

Figure 4.6 Soil Characteristics of the Vernon River Watershed

Vernon River Watershed soils (see Figure 4.6) can be characterized as sandy and clayey coastal sediment, which have a tendency to be strongly acidic. Abundant moisture and thick vegetative cover enhance the replenishment of any minerals that are lost to normal weathering. Soil wetness varies from well-drained to very poorly-drained. The best-drained soils are found on elevated sandy marine deposits. The most poorly drained soils are found near the coast where broad expanses of muddy marsh and floodplain deposits are barely above the water table.

In the early 1970's without protection for wetlands and floodplains, homes and businesses were constructed in low areas on poorly drained soils. Many were built using individual septic systems to treat and dispose of wastewater. Note that the poorly drained soil areas correspond with the locations where the majority of the septic systems are located in the Vernon River Watershed. The City of Savannah has extended the sanitary sewer infrastructure to as many homes and businesses as feasibly possible. Currently there are approximately 2500 septic systems within the Vernon River Basin, 80% of which are in unincorporated Chatham County.

Section 5. Public Involvement

Public outreach and education is the cornerstone of this watershed management plan. There will be a variety of venues used to disseminate information on water quality with the goal of achieving support for this plan and respective elements.

- Water Bill Inserts – One of the best ways to reach citizens is printing a short message on their water bill. This message could provide details on an upcoming event or a link to a website or resource where additional information can be acquired.
- Neighborhood Meetings – Savannah has registered Neighborhood Associations that hold monthly meetings. The meeting organizers are usually eager for presentations to fill the meeting time. Attendance can vary but is consistently good during the holidays. This is particularly an advantageous time to talk about the proper disposal of waste cooking oil.
- Professional Association Meetings – The Georgia Restaurant Association and the Public Works Association have quarterly meetings. Attendance at these will be critical when soliciting support for any new policies regulating FOG. The Rotary and Garden Clubs are also one of the best venues for water quality education. These groups are very active well educated and most importantly, they typically are a helpful positive voice for the cause.
- Website and Social Media – The partnership with the Ogeechee Riverkeeper organization will play a pivotal role in website and social media outreach. Currently, all activity focused on improving the water quality in the Vernon River Watershed is posted on the ORK website. Social media will be employed to advertise events as well as seeking feedback through "climate check" questions/surveys to measure the effectiveness of outreach efforts. Currently social media advertising is low cost and one of the best ways to target a certain

audience. Facebook and Google Ads have been used to promote previous events with success.

- ❖ Printed Media – The City of Savannah and Chatham County share costs annually for an 8-page insert in the Savannah Morning News. This insert is printed and distributed in January to advise citizens on flood hazard mitigation, insurance, and water quality. In addition the city distributes an activity book targeting elementary school age children to schools in Chatham County. Three pages of this booklet are dedicated to proper disposal of FOG and protection of local waters.
- ❖ Community Events – Staff organizes community events such as the Earth Day Festival and Rivers Alive to educate the public on area environmental issues. Water quality is always a big component of the outreach. Brochures, presentations, posters, and exhibits have been developed both specific to the Vernon River area and city-wide.

A good marketing strategy is needed when attempting to essentially change behavior in a population to protect water quality. Though Staff has learned a great deal about marketing in the past five years, hiring an expert to construct a marketing plan would be fantastic. The cost to accomplish this ranges from $15K to $35K. A marketing plan would include work developed exclusively for this Vernon River watershed effort. Things such as a mission statement, logo, tag, website, ads, etc. would be created. Also a timeline and budget for executing the plan over a five year period would be included. The power of a smart marketing plan cannot be underestimated, especially during these days when competition for seconds of attention is so aggressive.

Deploying a content marketing strategy would be ideally suited given this plan's goal. Through content marketing valuable information or content is provided to current and potential stakeholders for the purpose of building trust, branding, awareness, and positive sentiment. Types of content that typically form a content marketing strategy include: blog posts, email newsletters, power point presentations, podcasts, micro-videos, social media posts, live presentations, webinars, and white papers.

Table 5.1 Watershed Target Audiences

Source	Target Audiences	Specific Target Audiences	Priority (highest 1/lowest 4)
Failing Septic Systems	Homeowners	Riparian homeowners with septic systems	2
Leaking Private Laterals	Homeowners	Homeowners throughout watershed connected to municipal sanitary sewer	3
SSOs and Spills – FOG	FSEs, Homeowners, Haulers, Plumbers	Restaurants and homeowners in watershed and the businesses that provide installation and maintenance	1
Storm and Sanitary Sewer Connections	Haulers, Plumbers, Homeowners	Businesses and homeowners	4

Figure 5.1. Rivers Alive Hayners Creek 2011: (Peter Shonka, Assistant City Manager and Ray Pittman, Principal Engineer for Thomas and Hutton)

Section 6: Best Management Practices

A variety of best management practices (BMP) were considered during stakeholder meetings. Six were identified that focused on reducing human sources of bacteria. Each BMP is discussed in the sections shown below.

1. Septic and Private Lateral Maintenance Outreach Program

Two of the primary human sources of fecal coliform bacteria in the watershed include individual septic tanks used in areas not serviced by a sanitary sewer collection and treatment system, and faulty private lateral pipes connecting individual residences to public wastewater mains. The goal of the septic and private lateral maintenance program is twofold:

- Providing homeowners with resources to prevent septic system failure or costly sewer backups into homes and businesses.
- Making citizens aware of the sources of bacteria in the watershed and letting them know how they can play a part in protecting water quality.

2. Inflow and Infiltration Program

The purpose of the Inflow and Infiltration (I&I) program is to address water that is entering the city's sanitary sewer system either through inflow (stormwater entering the sanitary system through rain leaders, sump pumps, or foundation drains that are illegally connected to sanitary sewer pipes) and infiltration (groundwater infiltration into sewer pipes through cracks, joints, manholes, etc.).

Whereas infiltration reduction is best managed by the City of Savannah's existing infrastructure maintenance and renewal program, inflow reduction will be addressed through the creation of a team dedicated to identifying individual households and businesses with illicit storm and sewer connections. Having a designated team to address I&I issues will strengthen the city's existing efforts.

3. Additional Monitoring

The city's plan combines traditional BST methods with targeted fluorometry sampling which identifies human fecal contamination by detecting the presence of optical brighteners (OBs). Optical brighteners are a group of chemicals added to household products, primarily laundry detergents, in order to increase the brightness of items such as clothing due to the fluorescent nature of OBs. Since household plumbing systems mix human wastewater with greywater from washing machines, the detection of optical brighteners in a water body can be correlated to human sources of bacteria if bacteria impairment is present. The fluorometry testing involves the use of handheld fluorometers (which are already owned by the city) and a Geographical Information System (GIS) database which is used to track and manage the testing data.

4. FSE Grease Interceptor Study

Fats, oils, and grease comprise 60% of all sewer system blockages and 30% of sewer system spills into the environment. The city will be conducting a grease interceptor study to update the existing fats, oils, and grease ordinance. This study will include an extensive research on the latest interceptor technology, piloting of new testing procedures for interceptor effluent, and working with interceptor manufacturers to develop standards for varying food service establishment (FSE) types. A separate stakeholder committee will be developed and will include FSE owners/managers, plumbers, and representatives from the Georgia Restaurant Association, Chatham County Chapter.

First, the study will begin by researching a new method for testing grease trap interceptors. The EPA Method 1664 has high variability and experts agree a better way to test interceptor effluent is needed. The second step will be looking at structural modifications that can be applied to achieve the highest removal of FOG. Inlet and outlet configurations must be designed to distribute flow, and baffles should be included only with specific configurations. In addition, geometric changes can improve efficiency and residence times. Lastly, adopting a policy that addresses the five factors affecting grease interceptor performance could improve grease removal and lessen expenses for FSE owners. The five factors include retention time, temperature of influent, velocity of influent, design, and cleaning frequency.

5. 63rd Street Casey South Project

The proposed $25 million drainage project aimed at alleviating the routine flooding occurring along Abercorn and Habersham Streets near 63rd Street includes the replacement and enlargement of existing storm sewer pipe, new storm sewer pipe, and the installation of box culverts. While the project will increase the amount of stormwater entering the Casey, Hayners Creek, and Vernon River water bodies, the construction will improve the stormwater management of the basin by delineating existing tie-ins and removing illicit connections. In addition every manhole will be stamped into the metal with the phrase "Drains to River". This will hopefully curtail some illegal dumping into stormdrains and be a permanent reminder of the connection to the river.

6. Outreach and Education Campaign

The City of Savannah recognizes that outreach and education campaigns are critical in gaining public acceptance and participation in the Vernon River watershed management project. The city's plan is twofold: use volunteer activities such as Adopt-A-Stream monitoring, river cleanups, rain barrel and composter sales, and school assemblies to empower its citizens to build a sense of stewardship for protecting the Vernon River water quality. In addition, the city has advertising dollars that are used for seasonal public service announcements i.e. commercials, billboards, and utility billing inserts.

Section 7: Watershed Improvement Goals

The plan for reducing the actual fecal coliform loading in the Vernon River Basin is based on the findings from a detailed Bacteria Source Tracking (BST) study completed in 2010 and information collected from stakeholder meetings held bi-monthly from July 2009 thru December 2013.

The BST study provided detailed information regarding various bacteria sources including their percent contribution (Figure 7.1), and antibiotic resistance profiles. The primary findings and implications of the study are summarized in Table 7.1. Note that the average percent contribution for human sources of impairment for the three water bodies shown in Figure 7.1 is 56%. This high percentage, along with limitations associated with reducing the bacteria impairment caused by birds and wildlife within the watershed, form the basis of the plan which focuses on monitoring and reducing human sources of bacteria, including individual septic systems and community sanitary sewer systems.

Table 7.1. Findings and Implications of the 2006~2010 BST Study

Finding	Implication on Fecal Coliform Loading Reduction Plan
1. Birds and other wildlife appear to be the single largest source of fecal contamination.	1. Eliminating all human sources of bacteria will lessen the levels of contamination, but not eliminate the presence of fecal coliform.
2. Both sanitary sewer and septic systems contribute to fecal contamination.	2. Actions that address sanitary sewer and septic systems are worth pursuing.

Using the findings from the BST study, information gathered through a literature review of watershed management plans operating under similar conditions, and input from the stakeholders, the city developed the Best Management Practices (BMPs) shown in Table 7.2 for reducing the fecal coliform loadings within the basin.

Figure 7.1. Sources of Impairment for Casey Canal, Hayners Creek, and Vernon River

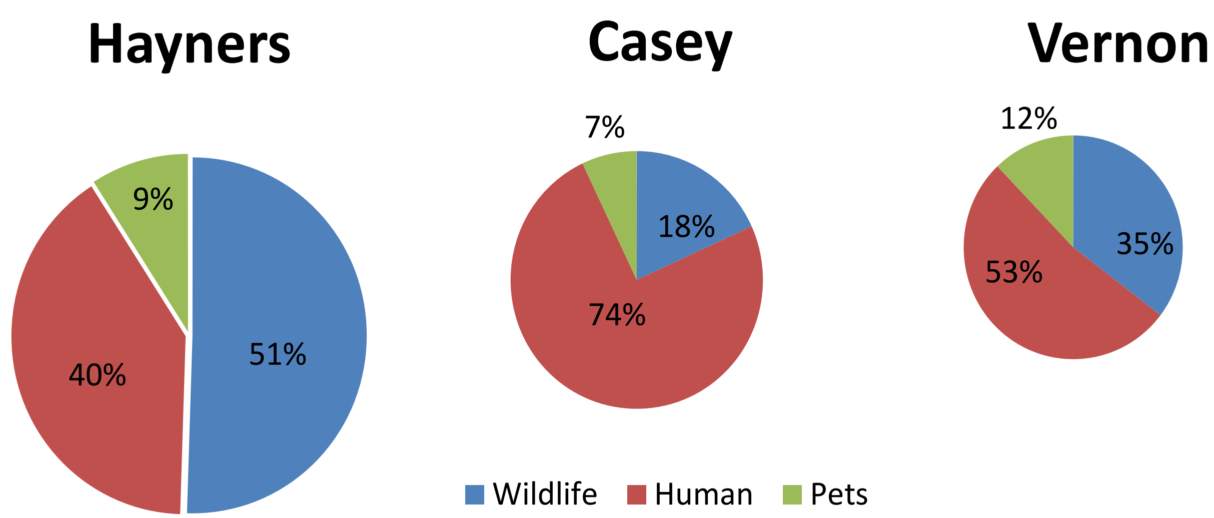

Table 7.2. BMPs for Reducing the Fecal Coliform Loading in the Vernon River Basin

BMP	Description	Water Body (ies)	Target Date
Septic and private lateral maintenance outreach program	Develop a campaign for routine and long term septic and private lateral maintenance.	Casey Canal Hayners Creek	2015
Inflow and Infiltration (I & I) Program	Team dedicated to accessing suspect areas of illicit storm and sewer connections.	Casey Canal Hayners Creek	2014
Additional Monitoring	Fluorometry-based water quality sampling	Casey Canal Hayners Creek Vernon River	2014
FSE Grease Interceptor Study	Study to measure the effectiveness of existing grease interceptors and pilot new models.	Casey Canal Hayners Creek	2015
Outreach, Education, Publications	Incorporate PSAs, commercials, and website development that promote water quality and stewardship	Casey Canal Hayners Creek Vernon River	2014
63rd Street Casey South Project	Replacement of existing storm sewer pipe. Project will delineate existing tie-ins and remove existing illegal ones	Casey Canal	2017

With implementation of the BMP's, overall watershed improvement goals may be achieved according to the following efficiency estimates:

1. Reduction of fecal coliform loads from septic systems and private laterals –
   a. BMP Extent: 3 (Medium, approximately 20%-50%)
   b. BMP Effectiveness: 3 (Medium to High, approximately 25%-75%)
2. Inflow and Infiltration Program –
   a. BMP Extent: 3 (Medium, approximately 20%-50%)
   b. BMP Effectiveness: UNK (Unknown)
3. Increased monitoring for optical brighteners throughout the entire watershed (not just the critical areas) to isolate human sources of fecal coliform –
   a. BMP Extent: UNK (Unknown)
   b. BMP Effectiveness: UNK (Unknown)
4. FSE Grease Interceptor Study and Resulting Policy Changes –
   a. BMP Extent: 3 (Medium, approximately 20%-50%)
   b. BMP Effectiveness: 3 (Medium to High, approximately 25%-75%)
5. 63rd Street Casey South Project aimed at alleviating the routine flooding occurring in the Casey South drainage basin –
   a. BMP Extent: 1 (Scattered or Low, approximately 5%-20%)
   b. BMP Effectiveness: 1 (Low to Medium, approximately 5%-25%)
6. Outreach and education campaign to improve the general comprehension of watershed functions and to promote stewardship of the Vernon River by the watershed residents –
   a. BMP Extent: UNK (Unknown)
   b. BMP Effectiveness: UNK (Unknown)

Table 7.3. provides guidance for rating the estimated management measure "extent" and "effectiveness" related to each identified potential source. Estimated BMP efficiency ratings have been provided either by local experts or derived from technical guidance information.

Table 7.3. BMP Efficiency Ratings

BMP Extent (Percentage of Sources to Which the BMP Has or Will Be Applied)	BMP Effectiveness (Percent Removal of Pollutant by the BMP)	Rating
None or negligible (approximately 0-5%)	None or negligible (approximately 0-5%)	.5
Scattered or low (approximately 5-20%)	Low to medium (approximately 5-25%)	1
Medium (approximately 20-50%)	Medium to High (approximately 25-75%)	3
Widespread or high (approximately 50% or more)	High (approximately 75% or more)	5
Unknown	Unknown	UNK

Section 8: Long-Term Monitoring

Fecal coliform (FC) and Enterococcus have been monitored in various locations throughout the Vernon River since 2005 (see Table 8.1). Both are fecal indicator bacteria that normally inhabitant the gastrointestinal tract of humans and many other warm-blooded animals. These fecal indicator bacteria are used to measure the sanitary quality of water for recreational, industrial, agricultural and water supply purposes. Monitoring will continue to serve as a tool to measure successful implementation of the recommended best management practices to reduce human bacteria pollution sources. Past, current, and future monitoring has complied with the Vernon River Quality Assurance Project Plan (QAPP) approved by EPD in November 2006 and supplemented in March 2013. The original QAPP outlines the project task description, personnel responsible for executing tasks and their corresponding certifications, methods and equipment and handling protocols. The supplement includes the same information for the fluorometry work.

During the creation of this watershed plan, monitoring of bacteria continued from April 2012 to December 2013 with the addition of a fluorometry study. The results are presented in Appendices A and B. Figure 8.1 shows the locations for bacteria sampling. Fluorometry testing occurred throughout the watershed as well. It took considerable time to develop procedures that optimize the fluorometry testing technology for use in our local waters. Appendix C summarizes the adjustments made to the state standard operating procedures for fluorometry testing.

In the future, monitoring FC and Enterococcus levels will continue at two sites and will expand to a third site. The additional site will be located at a point to capture the reach of the Casey Canal, north of DeRenne. Flow measurements will also be taken during fecal coliform sampling. Fecal coliform sampling will continue to follow GA EPD's standard of 4 samples within a 30-day period and taken at least 24 hours apart on a quarterly schedule. The geometric means will be calculated from the quarterly collective and presented in a graph format. The fluorometry work will continue at various sites within the watershed. This will be coordinated with the FC sampling.

Table 8.1. Summary of Existing and Future Fecal Coliform / Enterococcus Monitoring

Parameters to be monitored	Responsible Entity	Status	Time Frame	Purpose
Fecal Coliform in Casey Canal North of Montgomery	City of Savannah	Existing	2006-2019	Monitoring and support of WMP progress
Fecal Coliform in Casey Canal North of DeRenne	City of Savannah	New	2014-2016	Monitoring and support of WMP progress
Fecal Coliform in Hayners Creek	City of Savannah	Existing	2006-2019	Monitoring and support of WMP progress
Enterococcus at various sites in Vernon River	Town of Vernonburg	Existing	2006-2014	Monitoring and support of WMP progress
Fluorometry Various Sites	City of Savannah	Existing	2014-2019	Tracking human source pollution
Citizen survey on watershed topics	City of Savannah, Chatham County, Town of Vernonburg	New	2014	Measuring success of outreach and education program
Website interaction	City of Savannah, Ogeechee River Keeper	New	2014	Tracking visits to the website
Sanitary sewer spills	City of Savannah, Chatham County	Existing	2005-2019	Tracking human source pollution
Streamside Assessment	City of Savannah, Chatham County, Town of Vernonburg	New	2014-2019	Tracking physical changes to shoreline, identification of new discharges

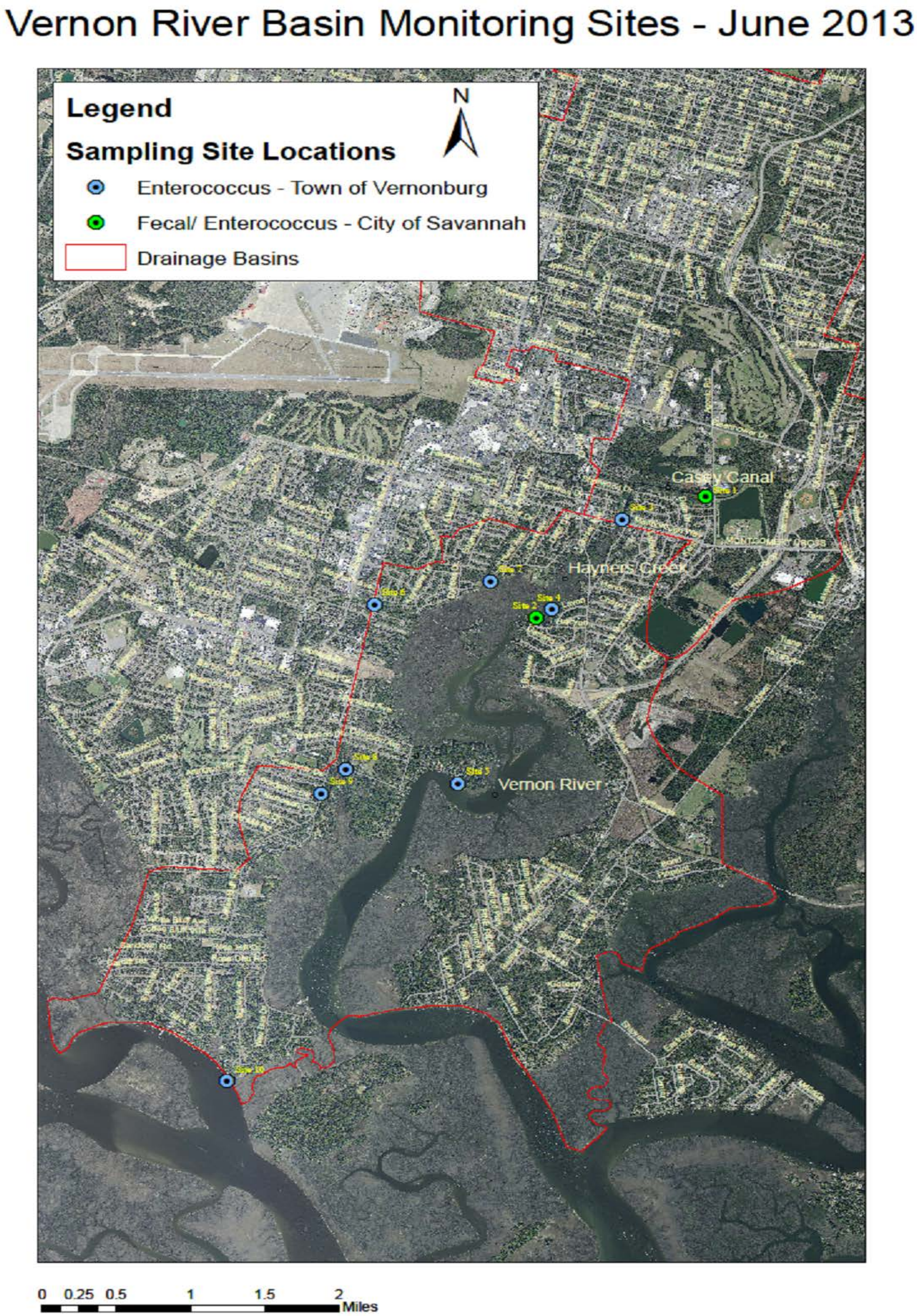

Figure 8.1 Map Showing the Fecal Coliform and Enterococcus Bacteria Sampling Locations

Sanitary sewer spills will continue to be assessed and recorded. For this plan's purpose, only spills resulting from FOG blockages will be included.

Lastly, streamside assessments will be completed. These assessments can be the most helpful way to monitor existing conditions and identify new pollution sources. This plan proposes two assessments annually to cover Hayners Creek, Casey Canal, and the Town of Vernonburg. One will be conducted in conjunction with the annual river clean up in the fall. The other will be conducted in the summer with the use of interns. A reporting document will be created for each section that includes a baseline map from the assessment completed in 2012. All results of the monitoring efforts will be posted on the website and a summary of any analysis will be presented in an annual report.

Section 9: Implementation, Evaluation and Revision

The Vernon River Water Quality Committee that served as the stakeholder group for the development of this WMP will continue to meet bimonthly at the President Street Water Reclamation Facility. Meetings will be announced on the Vernon River webpage which is hosted by the Ogeechee Riverkeeper. The monitoring of FC and Enterococcus will continue and play an important gauge with respect to the success of this plan's recommended best management practices.

Funding for some of the practices such as the voluntary septic system and private lateral maintenance programs will come from existing operating budgets in the City and County Environment, Conveyance, and Stormwater Departments. This funding will be at a minimum unless it can be enhanced with the match of local grant dollars. The grease interceptor study has potential benefits throughout the state and could be eligible for a Coastal Incentive Grant. The Skidaway Institute of Oceanography, Chatham County Health Department and the Georgia FOG Alliance are expected to lend support for this work. The 63rd Street Project will be monitored closely during construction and after completion to track any water quality changes in the Casey Canal.

Organization Roles and Responsibilities		
City of Savannah Water Resources Department	Local Government	Conduct monitoring and analysis. Report to stakeholder committee and execute public involvement and education initiatives.
Town of Vernonburg	Local Government	Conduct monitoring and report results. Attend stakeholder meetings and public education events.
Ogeechee Riverkeeper	Environmental Advocacy Organization	Attend stakeholder meetings. Assist with promotion of public education materials and events. Assist with organization and support of volunteer monitoring team.
Skidaway Institute of Oceanography	State Funded Institution	Provide technical expertise on water quality analysis. Continue to progress septic system monitoring project using bacteriophage.
Georgia Southern University	State Funded Institution	Provide technical expertise on fluorometry monitoring and analysis.
Chatham County	Local Government	Attend stakeholder meetings. Provide assistance in implementing applicable best management practices.

An annual report will be presented to the Vernon River Water Quality Committee and will include results from the bacteria monitoring and a progress report on the implementation of the best management practices. Revisions to this plan will occur every five years or as needed based on the accumulation of information that either establishes substantial improvement or further deterioration of the Vernon River water quality.

Appendix A
Fecal Coliform and Enterococcus Data

City of Savannah Sampling Results

Hayners Creek Qtr Samping

1112 Halcyon Dr.	Date	Fecal (MPN)	Entero (MPN)	FC Geomean	ENT Geomean
	6/4/2012	130	267		
	6/11/2012	490	196.8		
	6/18/2012	130	957		
	6/25/2012	1100	1259	308.9362478	501.6189617
	9/6/2012	78	1203		
	9/13/2012	490	1149		
	9/20/2012	140	584		
	9/27/2012	330	1741	204.9902309	1088.803024
	12/3/2012	20	570		
	12/13/2012	2300	1150		
	12/20/2012	700	456		
	12/27/2012	330	597	321.0646216	649.9470359
	3/7/2013	110	267		
	3/21/2013	210	1583		
	3/27/2013	110	91	136.4588023	338.0488457
	6/4/2013	490	499		
	6/11/2013	2200	1150		
	6/18/2013	790	957		
	6/25/2013	400	634	763.9702746	768.1568282
	9/3/2013	160000	2022		
	9/12/2013	490	237		
	9/17/2013	45	217		
	9/26/2013	7000	1828	2229.239112	660.3000887
	12/5/2013	45	275		
	12/12/2013	490	597		
	12/17/2013	45	137		
	12/23/2013	130	114	106.5715089	225.0262127

City of Savannah Sampling Results

Casey Canal Qtr Sampling

Sallie Mood Bridge	Date	Fecal (MPN)	Entero (MPN)	FC Geomean	ENT Geomean
	6/4/2012	18	90		
	6/11/2012	78	266.8		
	6/18/2012	110	168		
	6/25/2012	18	498	40.8326978	211.8148129
	9/6/2012	78	832		
	9/13/2012	110	498		
	9/20/2012	230	288		
	9/27/2012	170	143	135.3368336	361.363991
	12/3/2012	19	85		
	12/13/2012	450	832		
	12/20/2012	110	42		
	12/27/2012	1348	2300	188.6957736	287.4947012
	3/7/2013	330	227		
	3/21/2013	78	1827		
	3/27/2013	170	367	163.5632839	533.920779
	6/4/2013	7900	688		
	6/11/2013	2400	1583		
	6/18/2013	45	308		
	6/25/2013	140	256	587.8881694	541.3336307
	9/3/2013	160000	2022		
	9/12/2013	45	209		
	9/17/2013	330	297		
	9/26/2013	17000	1921	2521.005769	700.7333912
	12/5/2013	220	370		
	12/12/2013	18	160		
	12/17/2013	490	445		
	12/23/2013	45	10	96.66648899	127.4002938

2013 Enterococci bacteria Most Probable Number (MPN) per 100ml of water. Beaches advisories posted at 105.

Beginning in July 2012, samples from four sites were taken twice per month, allowing a running Geometric Mean *(GM)* to be calculated based on 3 samples within a month's time period.

Date	2-day rain	Casey *(GM)*	Hayners *(GM)*	Vernon *(GM)*	Wilshire *(GM)*	Harmon	VB ditch	White Bl ditch	Forest
Jan 4	0.2	650 *(661)*	85 *(125)*	10 *(10)*	1274 *(558)*				
Jan 16	0	272 *(482)*	226 *(172)*	41 *(16)*	605 *(626)*	52	0	na	0
Feb 8	0.97	3255 *(825)*	3873 *(420)*	161 *(40)*	2046 *(1166)*				
Feb 20	0.04	120 *(471)*	305 *(641)*	30 *(58)*	120 *(529)*	63	10	122	10
Mar 8	0	31 *(229)*	171 *(584)*	0 *(17)*	213 *(374)*				
Mar 20	0.49	218 *(93)*	31 *(117)*	10 *(7)*	332 *(204)*	20	74	20	0
Apr 10	0	75 *(80)*	52 *(65)*	20 *(6)*	171 *(229)*				
Apr 22	0	10 *(55)*	262 *(75)*	20 *(16)*	41 *(132)*	na	84	41	20
May 6	1.38	146 *(48)*	457 *(185)*	63 *(29)*	275 *(124)*				
May 30	0	121 *(56)*	262 *(316)*	0 *(11)*	226 *(136)*	173	10	479	20
June 12	0.47	249 *(163)*	86 *(217)*	0 *(4)*	450 *(302)*				
June 26	0.15	216 *(186)*	63 *(112)*	10 *(2)*	613 *(395)*	52	546	620	0
July 10	0	41 *(130)*	41 *(60)*	31 *(7)*	75 *(275)*				
July 26	0.55	2382 *(275)*	465 *(106)*	41 *(23)*	910 *(349)*	262	880	591	63
Aug 14	0.25	583 *(386)*	269 *(172)*	20 *(29)*	96 *(188)*	110	161	1223	10

Date	2-day rain	Casey *(GM)*	Hayners *(GM)*	Vernon *(GM)*	Wilshire *(GM)*	Harmon	VB ditch	White Bl ditch	Forest
Sept 11	0	160	31	20	496	246	75	19863	0
Oct 10	0.57	384	337	52	4352	52	30	703	41
Nov 19	0	395	295	74	379	1076	84	na	10
Dec 12	0.14	471	173	10	122	98	298	171	41

Appendix B
Fluorometry Data

City of Savannah Fluorometry Results

234 (Storm Sewer)

Yellow = positive for OB
Green = proceed to next step

Date	Time	Replicate	Fluoresc at 0 min. (RFU)	Step 1	Fluoresc at 5 min. (RFU)	% Reduction in Fluoresc at 5 min.	Step 2	Fluoresc at 10 min. (RFU)	% Reduction in Fluoresc at 10 min.	%Reduction@10 min./ %Reduction@5	Step 3	OB Result
8/12/2013	9:30 AM	1	72.65	UV	54.74	24.652	UV	48.22	33.627	1.364	Pos	Pos
		2	72.27	UV	60.32	16.535	UV	48.66	32.669	1.976	Neg	Neg
		3	71.08	UV	53.71	24.437	UV	49.65	30.149	1.234	Pos	Pos

City of Savannah Fluorometry Results

519 E Perry (Storm Sewer)

Yellow = positive for OB
Green = proceed to next step

Date	Time	Replicate	Fluoresc at 0 min. (RFU)	Step 1	Fluoresc at 5 min. (RFU)	% Reduction in Fluoresc at 5 min.	Step 2	Fluoresc at 10 min. (RFU)	% Reduction in Fluoresc at 10 min.	%Reduction@10 min./ %Reduction@5 min.	Step 3	OB Result
8/12/2013	9:45 AM	1	48.62	UV	48.25	0.761	Neg		n/a	n/a		Negative
		2	49.78	UV	48.16	3.254	Neg		n/a	n/a		Negative
		3	47.72	UV	47	1.509	Neg		n/a	n/a		Negative
9/19/2013	9:45 AM	1	46.21	UV	45.42	1.710	Neg		n/a	n/a		Negative
		2	46.69	UV	45.33	2.913	Neg		n/a	n/a		Negative
		3	47.32	UV	45.89	3.022	Neg		n/a	n/a		Negative

City of Savannah Fluorometry Results

Dock South of Bliss (Bougainvillea Bluff)

Yellow = positive for OB
Green = proceed to next step

Date	Time	Replicate	Fluoresc at 0 min. (RFU)	Step 1	Fluoresc at 5 min. (RFU)	% Reduction in Fluoresc at 5 min.	Step 2	Fluoresc at 10 min. (RFU)	% Reduction in Fluoresc at 10 min.	%Reduction@10 min./ %Reduction@5 min.	Step 3	OB Result
7/25/2013	9:15 AM	1	3.729	Neg		n/a			n/a	n/a		Neg
		2	3.788	Neg		n/a			n/a	n/a		Neg
		3	3.799	Neg		n/a			n/a	n/a		Neg
7/26/2013	9:35 AM	1	3.018	Neg		n/a			n/a	n/a		Neg
		2	2.997	Neg		n/a			n/a	n/a		Neg
		3	3.005	Neg		n/a			n/a	n/a		Neg
7/29/2013	10:28 AM	1	3.197	Neg		n/a			n/a	n/a		Neg
		2	3.192	Neg		n/a			n/a	n/a		Neg
		3	3.176	Neg		n/a			n/a	n/a		Neg
7/30/2013	9:40 AM	1	1.732	Neg		n/a			n/a	n/a		Neg
		2	1.779	Neg		n/a			n/a	n/a		Neg
		3	1.739	Neg		n/a			n/a	n/a		Neg
7/31/2013	10:58 AM	1	2.084	Neg		n/a			n/a	n/a		Neg
		2	2.132	Neg		n/a			n/a	n/a		Neg
		3	2.348	Neg		n/a			n/a	n/a		Neg
8/1/2013	11:48 AM	1	17.76	UV	16.8	5.41	Neg		n/a	n/a		Neg
		2	17.54	UV	16.79	4.28	Neg		n/a	n/a		Neg
		3	17.49	UV	17.1	2.23	Neg		n/a	n/a		Neg
8/5/2013	1:08 PM	1	30.66	UV	29.68	3.20	Neg		n/a	n/a		Neg
		2	30.54	UV	29.54	3.27	Neg		n/a	n/a		Neg
		3	30.97	UV	29.6	4.42	Neg		n/a	n/a		Neg
8/6/2013	2:13 PM	1	27.65	UV	27.05	2.17	Neg		n/a	n/a		Neg
		2	28	UV	26.93	3.82	Neg		n/a	n/a		Neg
		3	28.14	UV	27.47	2.38	Neg		n/a	n/a		Neg
8/7/2013	1:55 PM	1	29.88	UV	29.34	1.81	Neg		n/a	n/a		Neg
		2	30.8	UV	29.51	4.19	Neg		n/a	n/a		Neg
		3	30.57	UV	29.47	3.60	Neg		n/a	n/a		Neg

City of Savannah Fluorometry Results

Casey @ Montgomery Cross Rd.

Yellow = positive for OB
Green = proceed to next step

Date	Time	Replicate	Fluoresc at 0 min. (RFU)	Step 1	Fluoresc at 5 min. (RFU)	% Reduction in Fluoresc at 5 min.	Step 2	Fluoresc at 10 min. (RFU)	% Reduction in Fluoresc at 10 min.	%Reduction@10 min./ %Reduction@5 min.	Step 3	OB Result
		1	25.61	UV	25.06	2.15	Neg		n/a	n/a		Neg
8/8/2013	2:15 PM	2	25.36	UV	24.55	3.19	Neg		n/a	n/a		Neg
		3	25.42	UV	24.77	2.56	Neg		n/a	n/a		Neg
		1	26.52	UV	25.93	2.22	Neg		n/a	n/a		Neg
8/8/2013	2:15 PM	2	26.19	UV	25.49	2.67	Neg		n/a	n/a		Neg
		3	26.57	UV	25.84	2.75	Neg		n/a	n/a		Neg

City of Savannah Fluorometry Results

Harmon @ Edgewater

Yellow = positive for OB
Green = proceed to next step

Date	Time	Replicate	Fluoresc at 0 min. (RFU)	Step 1	Fluoresc at 5 min. (RFU)	% Reduction in Fluoresc at 5 min.	Step 2	Fluoresc at 10 min. (RFU)	% Reduction in Fluoresc at 10 min.	%Reduction@10 min./ %Reduction@5 min.	Step 3	OB Result
8/7/2013	2:05 PM	1	21.5	UV	21.81	-1.44	Neg		n/a	n/a		Neg
		2	21.67	UV	20.63	4.80	Neg		n/a	n/a		Neg
		3	21.58	UV	20.79	3.66	Neg		n/a	n/a		Neg
8/9/2013	8:55 AM	1	23.94	UV	22.38	6.52	Neg		n/a	n/a		Neg
		2	24.09	UV	22.71	5.73	Neg		n/a	n/a		Neg
		3	24.09	UV	22.39	7.06	Neg		n/a	n/a		Neg
8/12/2013	9:00 AM	1	56.49	UV	53.7	4.94	Neg		n/a	n/a		Neg
		2	54.42	UV	51.97	4.50	Neg		n/a	n/a		Neg
		3	55.84	UV	53.21	4.71	Neg		n/a	n/a		Neg

City of Savannah Fluorometry Results

Wilshire Canal @ Elk Lodge

Date	Time	Replicate	Fluoresc at 0 min. (RFU)	Step 1	Fluoresc at 5 min. (RFU)	% Reduction in Fluoresc at 5 min.	Step 2	Fluoresc at 10 min. (RFU)	% Reduction in Fluoresc at 10 min.	%Reduction@10 min./ %Reduction@5 min.	Step 3	OB Result
7/22/2013	2:55 PM	1	2.209	Neg		n/a			n/a	n/a		Neg
		2	2.204	Neg		n/a			n/a	n/a		Neg
		3	2.257	Neg		n/a			n/a	n/a		Neg
7/23/2013	3:10 PM	1	2.028	Neg		n/a			n/a	n/a		Neg
		2	2.184	Neg		n/a			n/a	n/a		Neg
		3	2.173	Neg		n/a			n/a	n/a		Neg
7/25/2013	8:56 AM	1	2.405	Neg		n/a			n/a	n/a		Neg
		2	2.482	Neg		n/a			n/a	n/a		Neg
		3	2.407	Neg		n/a			n/a	n/a		Neg
7/26/2013	9:22 AM	1	2.743	Neg		n/a			n/a	n/a		Neg
		2	2.42	Neg		n/a			n/a	n/a		Neg
		3	2.421	Neg		n/a			n/a	n/a		Neg
7/29/2013	10:15 AM	1	2.307	Neg		n/a			n/a	n/a		Neg
		2	2.188	Neg		n/a			n/a	n/a		Neg
		3	2.162	Neg		n/a			n/a	n/a		Neg

City of Savannah Fluorometry Results

Fell St./Augusta Ave. Storm Sewer

Yellow = positive for OB
Green = proceed to next step

Date	Time	Replicate	Fluoresc at 0 min. (RFU)	Step 1	Fluoresc at 5 min. (RFU)	% Reduction in Fluoresc at 5 min.	Step 2	Fluoresc at 10 min. (RFU)	% Reduction in Fluoresc at 10 min.	%Reduction@10 min./ %Reduction@5 min.	Step 3	OB Result
8/13/2013	9:44 AM	1	21.17	UV	19.83	6.330	Neg		n/a	n/a		Neg
		2	21.97	UV	20.51	6.645	Neg		n/a	n/a		Neg
		3	21.01	UV	19.56	6.901	Neg		n/a	n/a		Neg

City of Savannah Flourometry Results

Hayners @ Halcyon Bluff

Yellow = positive for OB
Green = proceed to next step

Date	Time	Replicate	Fluoresc at 0 min. (RFU)	Step 1	Fluoresc at 5 min. (RFU)	% Reduction in Fluoresc at 5 min.	Step 2	Fluoresc at 10 min. (RFU)	% Reduction in Fluoresc at 10 min.	%Reduction@ 10 min./ %Reduction@ 5 min.	Step 3	OB Result
		1	1.791	Neg		n/a			n/a	n/a		Neg
7/30/2013	10:28 AM	2	1.93	Neg		n/a			n/a	n/a		Neg
		3	1.93	Neg		n/a			n/a	n/a		Neg
		1	2.106	Neg		n/a			n/a	n/a		Neg
7/31/2013	10:30 AM	2	2.097	Neg		n/a			n/a	n/a		Neg
		3	2.071	Neg		n/a			n/a	n/a		Neg
		1	8.126	Neg		n/a			n/a	n/a		Neg
8/1/2013	11:30 AM	2	9.886	Neg		n/a			n/a	n/a		Neg
		3	8.928	Neg		n/a			n/a	n/a		Neg
		1	27.64	UV	26.75	3.22	Neg		n/a	n/a		Neg
8/5/2013	1:44 PM	2	27.53	UV	26.82	2.58	Neg		n/a	n/a		Neg
		3	27.71	UV	26.86	3.07	Neg		n/a	n/a		Neg
		1	25.46	UV	24.42	4.08	Neg		n/a	n/a		Neg
8/6/2013	2:45 PM	2	24.27	UV	24.03	0.99	Neg		n/a	n/a		Neg
		3	24.17	UV	23.85	1.32	Neg		n/a	n/a		Neg
		1	27.6	UV	27.09	1.85	Neg		n/a	n/a		Neg
8/7/2013	2:34 PM	2	27.79	UV	27.21	2.09	Neg		n/a	n/a		Neg
		3	27.78	UV	27.53	0.90	Neg		n/a	n/a		Neg
		1	30.85	UV	29.76	3.53	Neg		n/a	n/a		Neg
8/8/2013	2:00 PM	2	30.95	UV	29.31	5.30	Neg		n/a	n/a		Neg
		3	30.78	UV	29.97	2.63	Neg		n/a	n/a		Neg
		1	21.88	UV	19.62	10.33	UV	18.14	17.09	1.65		Neg
8/14/2013	9:45 AM	2	19.79	UV	18.54	6.32	Neg		n/a	n/a		Neg
		3	20.72	Uv	19.6	5.41	Neg		n/a	n/a		Neg

City of Savannah Fluorometry Results

Storm Sewer @ Hitch Dr.

Yellow = positive for OB
Green = proceed to next step

Date	Time	Replicate	Fluoresc at 0 min. (RFU)	Step 1	Fluoresc at 5 min. (RFU)	% Reduction in Fluoresc at 5 min.	Step 2	Fluoresc at 10 min. (RFU)	% Reduction in Fluoresc at 10 min.	%Reduction@10 min./ %Reduction@5 min.	Step 3	OB Result
7/31/2013	11:35 AM	1	2.904	Neg		n/a			n/a	n/a		Neg
		2	4.313	Neg		n/a			n/a	n/a		Neg
		3	2.943	Neg		n/a			n/a	n/a		Neg
8/1/2013	11:00 AM	1	44.5	UV	32.59	26.764	UV	29.95	32.697	1.222	Pos	Pos
		2	35.84	UV	31.12	13.170	UV	29.48	17.746	1.347	Pos	Pos
		3	71.88	UV	31.91	55.607	Pos		n/a	n/a		Pos
8/12/2013	9:25 AM	1	45.32	UV	39.95	11.85	UV	38.04	16.06	1.36	Pos	Pos
		2	46.6	UV	40.62	12.83	UV	38.42	17.55	1.37	Pos	Pos
		3	82.39	UV	40.32	51.06	Pos		n/a	n/a		Pos
8/13/2013	10:00 AM	1	31.76	UV	19.03	40.08	Pos		n/a	n/a		Pos
		2	26.83	UV	19.83	26.09	UV	19.56	27.097	1.039	Pos	Pos
		3	46.84	UV	20.2	56.87	Pos		n/a	n/a		Pos

City of Savannah Fluorometry Results

Wilshire Canal @ Largo

Date	Time	Replicate	Fluoresc at 0 min. (RFU)	Step 1	Fluoresc at 5 min. (RFU)	% Reduction in Fluoresc at 5 min.	Step 2	Fluoresc at 10 min. (RFU)	% Reduction in Fluoresc at 10 min.	%Reduction@10 min./ %Reduction@5 min.	Step 3	OB Result
7/22/2013	2:37 PM	1	2.352	Neg		n/a			n/a	n/a		Neg
		2	2.301	Neg		n/a			n/a	n/a		Neg
		3	2.367	Neg		n/a			n/a	n/a		Neg
7/23/2013	3:00 PM	1	2.263	Neg		n/a			n/a	n/a		Neg
		2	2.351	Neg		n/a			n/a	n/a		Neg
		3	2.314	Neg		n/a			n/a	n/a		Neg
7/25/2013	8:48 AM	1	2.213	Neg		n/a			n/a	n/a		Neg
		2	2.478	Neg		n/a			n/a	n/a		Neg
		3	2.442	Neg		n/a			n/a	n/a		Neg
7/26/2013	9:14 AM	1	2.233	Neg		n/a			n/a	n/a		Neg
		2	2.296	Neg		n/a			n/a	n/a		Neg
		3	2.272	Neg		n/a			n/a	n/a		Neg
7/29/2013	10:04 AM	1	2.379	Neg		n/a			n/a	n/a		Neg
		2	2.52	Neg		n/a			n/a	n/a		Neg
		3	2.402	Neg		n/a			n/a	n/a		Neg

City of Savannah Fluorometry Results

Hayners @ Montgomery Cross Rd.

Yellow = positive for OB
Green = proceed to next step

Date	Time	Replicate	Fluoresc at 0 min. (RFU)	Step 1	Fluoresc at 5 min. (RFU)	% Reduction in Fluoresc at 5 min.	Step 2	Fluoresc at 10 min. (RFU)	% Reduction in Fluoresc at 10 min.	%Reduction@10 min./ %Reduction@5 min.	Step 3	OB Result
8/2/2013	3:35 PM	1	24.3	UV	23.66	2.633744856	Neg		n/a	n/a		Neg
		2	24.23	UV	23.56	2.765167148	Neg		n/a	n/a		Neg
		3	24.59	UV	23.74	3.456689711	Neg		n/a	n/a		Neg
8/9/2013	9:05 AM	1	29.84	UV	27.97	6.266756032	Neg		n/a	n/a		Neg
		2	29.71	UV	27.84	6.294177045	Neg		n/a	n/a		Neg
		3	29.8	UV	28.08	5.771812081	Neg		n/a	n/a		Neg
10/24/2013	2:00 PM	1	28.32	UV	27.5	2.895480226	Neg		n/a	n/a		Neg
		2	28.4	UV	27.31	3.838028169	Neg		n/a	n/a		Neg
		3	28.78	UV	27.15	5.663655316	Neg		n/a	n/a		Neg

City of Savannah Fluorometry Results

Casey Canal @ Sallie Mood

Date	Time	Replicate	Fluoresc at 0 min. (RFU)	Step 1	Fluoresc at 5 min. (RFU)	% Reduction in Fluoresc at 5 min.	Step 2	Fluoresc at 10 min. (RFU)	% Reduction in Fluoresc at 10 min.	%Reduction@10 min./ %Reduction@5 min.	Step 3	OB Result
7/22/2013	3:20 PM	1	2.483	Neg		n/a			n/a	n/a		Neg
		2	2.516	Neg		n/a			n/a	n/a		Neg
		3	2.544	Neg		n/a			n/a	n/a		Neg
7/23/2013	3:25 PM	1	1.904	Neg		n/a			n/a	n/a		Neg
		2	1.904	Neg		n/a			n/a	n/a		Neg
		3	1.938	Neg		n/a			n/a	n/a		Neg
7/25/2013	9:34 AM	1	2.166	Neg		n/a			n/a	n/a		Neg
		2	2.165	Neg		n/a			n/a	n/a		Neg
		3	2.16	Neg		n/a			n/a	n/a		Neg
7/26/2013	9:47 AM	1	1.651	Neg		n/a			n/a	n/a		Neg
		2	1.612	Neg		n/a			n/a	n/a		Neg
		3	1.62	Neg		n/a			n/a	n/a		Neg
7/29/2013	10:40 AM	1	2.491	Neg		n/a			n/a	n/a		Neg
		2	2.447	Neg		n/a			n/a	n/a		Neg
		3	2.485	Neg		n/a			n/a	n/a		Neg

City of Savannah Fluorometry Results

Ditch @ Vernonburg

Yellow = positive for OB
Green = proceed to next step

Date	Time	Replicate	Fluoresc at 0 min. (RFU)	Step 1	Fluoresc at 5 min. (RFU)	% Reduction in Fluoresc at 5 min.	Step 2	Fluoresc at 10 min. (RFU)	% Reduction in Fluoresc at 10 min.	%Reduction@10 min./ %Reduction@5 min.	Step 3	OB Result
8/2/2013	3:10 PM	1	16.8	UV	16.92	-0.71	Neg		n/a	n/a		Neg
		2	16.89	UV	16.99	-0.59	Neg		n/a	n/a		Neg
		3	17.13	UV	16.81	1.87	Neg		n/a	n/a		Neg
8/6/2013	2:05 PM	1	9.284	UV	8.83	4.89	Neg		n/a	n/a		Neg
		2	9.111	UV	8.76	3.85	Neg		n/a	n/a		Neg
		3	9.085	UV	8.69	4.35	Neg		n/a	n/a		Neg
9/26/2013	10:15 AM	1	22.5	UV	21.8	3.11	Neg		n/a	n/a		Neg
		2	22.16	UV	21.63	2.39	Neg		n/a	n/a		Neg
		3	22.32	UV	21.7	2.78	Neg		n/a	n/a		Neg

City of Savannah Fluorometry Results

Ditch @ White Bluff

Yellow = positive for OB
Green = proceed to next step

Date	Time	Replicate	Fluoresc at 0 min. (RFU)	Step 1	Fluoresc at 5 min. (RFU)	% Reduction in Fluoresc at 5 min.	Step 2	Fluoresc at 10 min. (RFU)	% Reduction in Fluoresc at 10 min.	%Reduction@10 min./ %Reduction@5 min.	Step 3	OB Result
8/2/2013	3:00 PM	1	17.38	UV	16.48	5.18	Neg		n/a	n/a		Neg
		2	17.39	UV	16.48	5.23	Netg		n/a	n/a		Netg
		3	17.05	UV	16.29	4.46	Neg		n/a	n/a		Neg
8/6/2013	2:00 PM	1	16.26	UV	15.56	4.31	Neg		n/a	n/a		Neg
		2	16.41	UV	15.58	5.06	Neg		n/a	n/a		Neg
		3	16.48	UV	15.96	3.16	Neg		n/a	n/a		Neg
10/3/2013	10:00 AM	1	15.3	UV	15.1	1.31	Neg		n/a	n/a		Neg
		2	15.86	UV	15.24	3.91	Neg		n/a	n/a		Neg
		3	15.23	UV	14.63	3.94	Neg		n/a	n/a		Neg

City of Savannah Fluorometry Results

Wilshire Canal @ White Bluff

Yellow = positive for OB
Green = proceed to next step

Date	Time	Replicate	Fluoresc at 0 min. (RFU)	Step 1	Fluoresc at 5 min. (RFU)	% Reduction in Fluoresc at 5 min.	Step 2	Fluoresc at 10 min. (RFU)	% Reduction in Fluoresc at 10 min.	%Reduction@10 min./ %Reduction@5	Step 3	OB Result
		1	1.722	Neg		n/a			n/a	n/a		Neg
7/30/2013	9:56 AM	2	1.674	Neg		n/a			n/a	n/a		Neg
		3	1.725	Neg		n/a			n/a	n/a		Neg
		1	2.005	Neg		n/a			n/a	n/a		Neg
7/31/2013	11:05 AM	2	2.008	Neg		n/a			n/a	n/a		Neg
		3	2.011	Neg		n/a			n/a	n/a		Neg
		1	16.95	UV	15.82	6.67	Neg		n/a	n/a		Neg
8/1/2013	11:56 AM	2	16.43	UV	16.03	2.43	Neg		n/a	n/a		Neg
		3	16.37	UV	15.93	2.69	Neg		n/a	n/a		Neg
		1	18.51	UV	18.02	2.65	Neg		n/a	n/a		Neg
8/2/2013	3:25 PM	2	18.41	UV	18.35	0.33	Neg		n/a	n/a		Neg
		3	18.55	UV	18.16	2.10	Neg		n/a	n/a		Neg
		1	33.21	UV	26.31	20.78	UV	25.64	22.79	1.10	Pos	Neg
8/5/2013	1:17 PM	2	26.9	UV	25.82	4.01	Neg					Neg
		3	27.65	UV	26.41	4.48	Neg					Neg
		1	24.52	UV	23.22	5.30	Neg		n/a	n/a		Neg
8/9/2013	8:45 AM	2	24.48	UV	23.16	5.39	Neg		n/a	n/a		Neg
		3	24.68	UV	23.44	5.02	Neg		n/a	n/a		Neg
		1	64.92	UV	61.38	5.45	Neg		n/a	n/a		Neg
8/12/2013	8:50 AM	2	66.26	UV	62.18	6.16	Neg		n/a	n/a		Neg
		3	66.04	UV	62.12	5.94	Neg		n/a	n/a		Neg
		1	26.81	UV	25.44	5.11	Neg					Neg
8/13/2013	9:07 AM	2	28.03	UV	25.30	9.74	UV	24.15	13.84	1.42	Pos	Neg
		3	26.1	UV	25.34	2.91	Neg					Neg
		1	25.45	UV	24.09	5.34	Neg		n/a	n/a		Neg
8/14/2013	11:15 AM	2	25.29	UV	23.76	6.05	Neg		n/a	n/a		Neg
		3	25.43	UV	24.18	4.92	Neg		n/a	n/a		Neg

City of Savannah Fluorometry Results

Old Whitefiled @ Spanish Oaks (Creek)

Date	Time	Replicate	Fluoresc at 0 min. (RFU)	Step 1	Fluoresc at 5 min. (RFU)	% Reduction in Fluoresc at 5 min.	Step 2	Fluoresc at 10 min. (RFU)	% Reduction in Fluoresc at 10 min.	%Reduction@10 min./ %Reduction@5	Step 3	OB Result
7/30/2013	10:07 AM	1	2.5	Neg		n/a			n/a	n/a		Neg
		2	2.516	Neg		n/a			n/a	n/a		Neg
		3	2.411	Neg		n/a			n/a	n/a		Neg
8/14/2013	10:00 AM	1	22.33	UV	20.57	7.88	Neg		n/a	n/a	Neg	Neg
		2	22.5	UV	20.37	9.47	UV	19.27	14.36	1.52	Neg	Neg
		3	21.99	UV	20.11	8.55	UV	19.05	13.37	1.56	Neg	Neg

City of Savannah Fluorometry Results

Harmon @ Rivers End (Boat Ramp)

Yellow = positive for OB
Green = proceed to next step

Date	Time	Replicate	Fluoresc at 0 min. (RFU)	Step 1	Fluoresc at 5 min. (RFU)	% Reduction in Fluoresc at 5 min.	Step 2	Fluoresc at 10 min. (RFU)	% Reduction in Fluoresc at 10 min.	%Reduction@10 min./ %Reduction@5	Step 3	OB Result
8/5/2013	1:30 PM	1	24.93	UV	24.4	2.13	Neg		n/a	n/a		Neg
		2	25.26	UV	24.65	2.41	Neg		n/a	n/a		Neg
		3	25.25	UV	24.6	2.57	Neg		n/a	n/a		Neg
8/7/2013	2:15 PM	1	25.98	UV	25.93	0.19	Neg		n/a	n/a		Neg
		2	27.8	UV	25.65	7.73	Neg		n/a	n/a		Neg
		3	26.48	UV	25.95	2.00	Neg		n/a	n/a		Neg
8/8/2013	1:45 PM	1	29.36	UV	28.37	3.37	Neg		n/a	n/a		Neg
		2	29.24	UV	28.21	3.52	Neg		n/a	n/a		Neg
		3	29.21	UV	28.15	3.63	Neg		n/a	n/a		Neg
10/10/2013	8:15 AM	1	20.01	UV	19.6	2.05	Neg		n/a	n/a		Neg
		2	20.5	UV	19.8	3.41	Neg		n/a	n/a		Neg
		3	20.15	UV	19.85	1.49	Neg		n/a	n/a		Neg
10/11/2013	9:30 AM	1	21.23	UV	21	1.08	Neg		n/a	n/a		Neg
		2	21.1	UV	20.65	2.13	Neg		n/a	n/a		Neg
		3	21.2	UV	20.78	1.98	Neg		n/a	n/a		Neg
10/17/2013	1:30 AM	1	25.93	UV	25.5	1.66	Neg		n/a	n/a		Neg
		2	25.65	UV	25.4	0.97	Neg		n/a	n/a		Neg
		3	25.95	UV	25.6	1.35	Neg		n/a	n/a		Neg

City of Savannah Fluorometry Results

Storm Drain @ Levon (in Halcyon Bluff)

Date	Time	Replicate	Fluoresc at 0 min. (RFU)	Step 1	Fluoresc at 5 min. (RFU)	% Reduction in Fluoresc at 5 min.	Step 2	Fluoresc at 10 min. (RFU)	% Reduction in Fluoresc at 10 min.	%Reduction@10 min./ %Reduction@5 min.	Step 3	OB Result
7/30/2013	10:20 AM	1	2.023	Neg		n/a			n/a	n/a		Neg
		2	1.962	Neg		n/a			n/a	n/a		Neg
		3	1.971	Neg		n/a			n/a	n/a		Neg

Appendix C

Summary of Alterations to Fluorometry Procedures for the Vernon River

A fluorometry study was conducted for a period of approximately eight months in the Vernon River Watershed. During this time observations were noted on conditions and methods which optimized the identification of optical brighteners. These should be considered alterations to the standard procedures endorsed by the Georgia Department of Natural Resources. These alterations are specific to conditions of the Vernon River Watershed and for optical brightener detection using the *Aquafluor* handheld model:

- Sampling should be taken at the beginning of the outgoing tide;
- Conditions where the opportunity for photodecay to occur should be limited. Sampling should occur at or near sunrise and/or sunset. Also presence of optical brighteners was greatest when samples originated from relatively smaller waterways that were shaded by overstory trees.
- For the analysis a correction to the Georgia Department of Natural Resources Section *L. Optical-Brightener Verification by Photodegradation* was made as follows:

  The most significant error is found in steps 2a and 2b.

  These steps instruct as follows:
  a. If ratio < or = 1.5, conclude that the sample is negative for optical brighteners
  b. If ratio > 1.5, conclude the sample is positive for optical brighteners

  These two steps are incorrect and have reversed the correct inequality symbols. Step 2a should read > or = 1.5, and NOT < or =1.5; step 2b should read < 1.5, and NOT > 1.5. In other words, the correct procedure is that if the ratio is *greater than or equal* to 1.5, then the sample is negative for optical brighteners; if the ratio is *less than* 1.5, then the sample is positive for optical brighteners.
  The error can be explained by tracing the sources of this information. Section L of the GA SOP states that it adopted this method from the California State Water Resources Control Board's Standard Operating Procedure: "Measuring Optical Brighteners in Ambient Water Samples Using a Fluorometer" (Burres 2009).
- For the preparation of the calibration solution, California's Standard Operating Procedure "Measuring Optic Brighteners in Ambient Water Samples Using a Fluorometer" by Erick Burres was utilized. The California SOP contained an error in its instructions for preparing the standard calibration solution (following its directions results in a 500 ppm calibration solution instead of the intended 50 ppm solution). The following shows the correct method:

Preparation of the Standard Solution (50 ppm Optical Brightener solution)

1. Prepare 1 liter Erlenmeyer flask covered with aluminum foil to make it light-proof or a 1 liter amber bottle with 99.5 ml of DI (or distilled) water (a pipette can be used to remove 0.5 ml of water from an initial 100 ml).

2. Using a pipette, draw 0.5 ml (500.00 µl) of OB agent (Tide Original Scent is suggested). Wipe off excess OB agent that might have coated the pipette tip. Dispense the OB agent into the 1 liter vessel of DI water, cap and mix thoroughly. Allow foam to settle before next step. (This solution is 5000 ppm Tide and can be reserved as stock for further use.)
3. To then make the actual calibration solution (50.0 ppm Tide), add 0.5 ml (500.00 µl) of the 5000 ppm stock solution to 49.5 ml of DI water in a foil wrapped test tube or amber bottle. Cap the container and mix thoroughly. Allow foam to settle before use.

Calibration

For our Calibration Standard Value for the 50 ppm standard solution, we will use 100 relative fluorescence units (RFU). This means that 2 RFU will be relative to 1 ppm of standard solution.
Calibration should be performed before every sampling day.

1. Turn the *AquaFluor* on by pressing <ON/OFF>. Wait 5 seconds for the *AquaFluor* to warm up.
2. Assign a Calibration Standard Value.
    a. Press the <STD VAL> button.
    b. Use the ↑ and ↓ arrow buttons to set the standard value (100 RFU).
    c. When finished, Press the <ENT> or <ESC> button to accept the value and to return to the Home screen.
3. To perform the calibration, press the <CAL> button.
4. Press <ENT> to start the calibration.
5. Insert your blank sample (DI water) and press <ENT>. *AquaFluor* will average the reading for 10 seconds and set the blanking zero point.
6. Insert the standard solution sample and press <ENT>. The reading is averaged for 10 seconds and the Standard Calibration value is set.
7. Press <ENT> when the calibration is complete to accept the calibration. If <ENT> is not pressed within 10 seconds, you will be asked if you want to abort the calibration. Press the ↑ or ↓ arrow button to abort or accept the calibration respectively. If at any time during steps 1-4 you want to stop the calibration, press <ESC>. This will return you to the Home screen and will default the instrument to the previous calibration.
8. Press <DIAG> and wait for %FS-BLK and %FS-STD to be displayed. The ratio of the %FS-BLK:%FS-STD should be >5.

Sample Storage, Handling and Preparation

- The sample must be stored at room temperature and in a lightproof container. An amber bottle or a sample bottle covered with foil can be used. *Always protect the sample from light exposure. Optical brighteners photodecay.*
- Use a clean (new) cuvette for each sample. If it is not possible to use a new cuvette for each sample, after cleaning the cuvette fill it with a blank solution (DI water) and take a measurement to check for contamination. If the cuvette is contaminated do not use it again.
- Nitrile or latex gloves should be worn when transferring the sample from the sampler/bottle to the cuvette for analysis. Once the sample has been transferred to the

cuvette, the exterior sides of the cuvette should be dried and wiped clean using lens paper prior to insertion into the sample compartment of the instrument.

- Load 3 ml of sample into each cuvette (protect the sample from light as much as possible during loading). If 3 ml of sample is not available be sure that at least 2 ml of sample is used (1/2 of the cuvette is full).
- Do not take a measurement if there are air bubbles in the cuvette. Remove any bubbles present by lightly tapping on the outside of the cuvette wall with your finger, or slightly tilt the cuvette to dissipate the bubbles.

Sample Analysis

1. Turn the fluorometer on.
2. Insert the sample. The *AquaFluor* is designed with "ambient light rejection". The black sample compartment does NOT need to be closed when reading samples.
3. Press the <READ> button.
4. The reading result will appear on the top line of the Home screen.
5. Once the word "WAIT" disappears from the Home screen another reading can be made.

Analytical Procedure

1. Measure initial fluorescence using Aquafluor.
   a. If the sample measures <5 ppm (10 RFU) conclude that the sample is negative for optical brighteners.
   b. If the sample measures higher than >5 ppm (10 RFU), continue to step 2.

Note: Mark cuvettes at the top on one side with sharpie so that the cuvette can be placed into the sample compartment the same way each time.

2. Expose sample directly to UV light (by placing it in front of the UV lamp) for 5 minutes and then measure fluorescence again. Calculate the percentage of reduction in fluorescence after 5 min compared to before UV exposure.
   a. If % reduction < 8%, conclude the sample is negative for optical brighteners.
   b. If % reduction ≥30%, conclude the sample is positive for optical brighteners.
   c. If % reduction >8% and <30%, continue to Step 3.
3. Expose the sample under UV for another 5 min (i.e. accumulatively 10 min) and measure the fluorescence.
4. Calculate the ratio of % reduction in fluorescence after 10 min UV exposure over % reduction after 5 min UV exposure, or

$$\frac{\%\ \text{Reduction @10 min}}{\%\ \text{Reduction @5 min}}$$

   a. If the ratio is **≥ 1.5**, conclude that the sample is **negative** for optical brighteners.
   b. If the ratio is **< 1.5**, conclude that the sample is **positive** for optical brighteners.
5. Out of the 3 replicates

a. If all three are positive → conclude that the sample is positive for optical brighteners.
b. If two out of three positive → conclude that the presence of optical brighteners within the sample is undetermined.