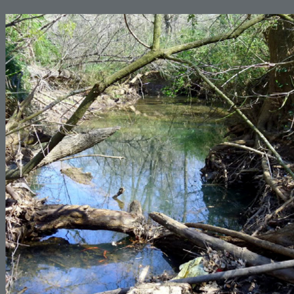
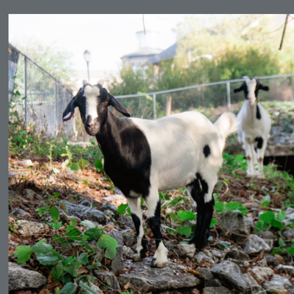
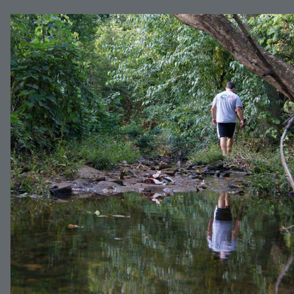
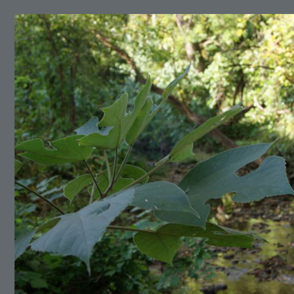
9 ELEMENT

WATERSHED MANAGEMENT PLAN

FALL UPDATE 2014

UGA CAMPUS STREAMS

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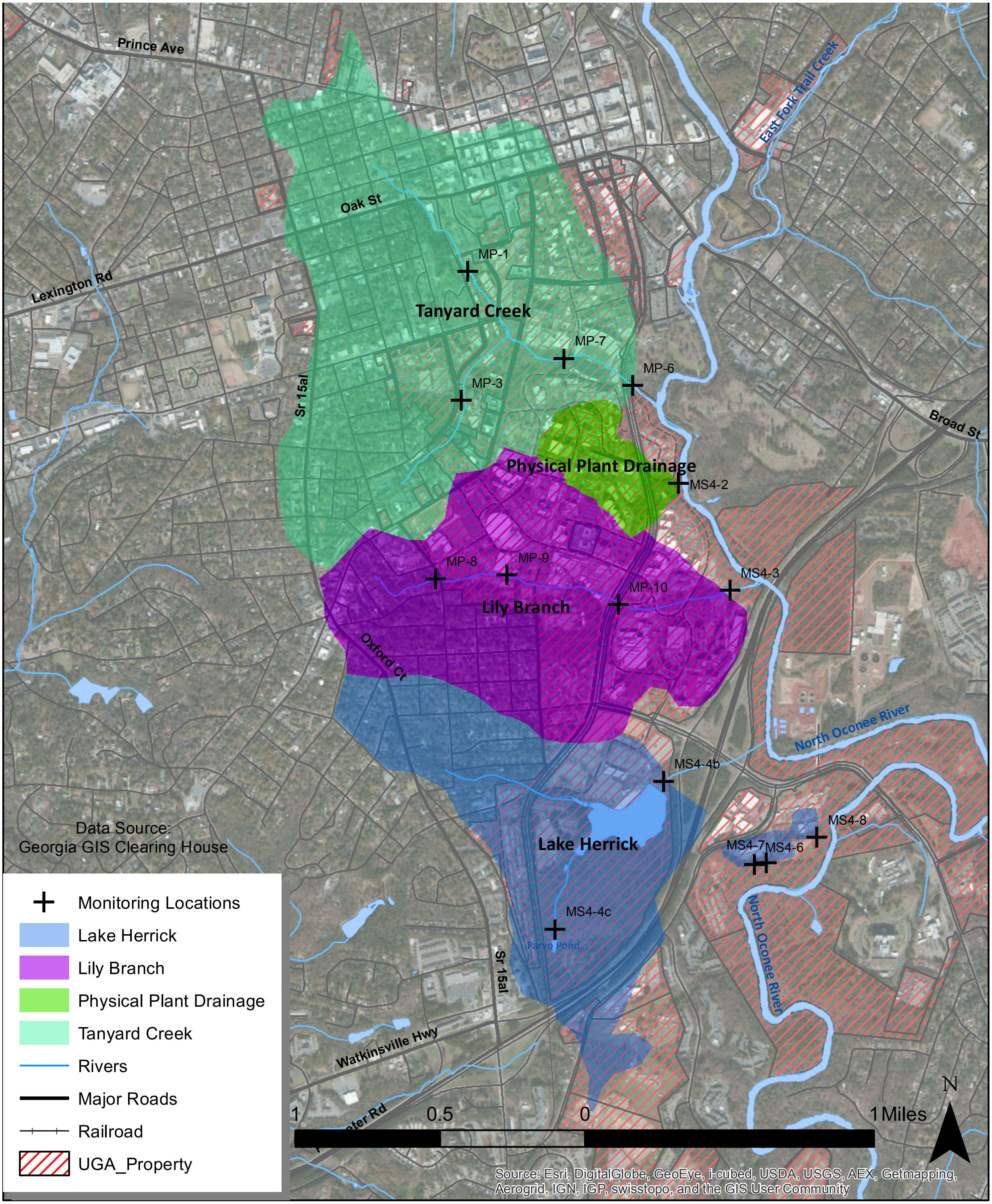


FIGURE 1. *This map shows an overview of the site.*

1 GOALS

ABOUT

The Lilly Branch Advisory Committee (Advisory Committee) was formed in December 2011 to oversee the development of this 9- Element Watershed Management Plan which originally included Lilly Branch, Tanyard Creek and Steam Plant watersheds and has now been extended to include Lake Herrick (collectively referred to as the Campus Watershed). The committee is made up of University of Georgia faculty from multiple departments with expertise in water quality or watershed planning; staff from the Office of University Architects, the Grounds Department, the Office of Sustainability, and the River Basin Center; staff from the Athens-Clarke County Stormwater Management Program; leaders of the community non-profit organizations Friends of Five Points and the Upper Oconee Watershed Network; graduate students; and student organization representatives. For a complete list of committee members, see Appendix A.

The Campus Watershed is highly developed and includes portions of the University of Georgia campus as well as residential and commercial neighborhoods in Athens-Clarke County. Major sections of these waterways flow under parking lots, roads and buildings where "out-of-sight, out- of-mind" has been the rule. The overarching goal of the Advisory Committee is to "daylight" the Campus Watershed in the minds of the University and Athens-Clarke County community, motivating improvements in water quality and ecosystem health through increased knowledge and public involvement and investment.

OBJECTIVES

The following objectives inform the direction of the Advisory Committee:

Protect public health and welfare by meeting water quality standards for pollutants that threaten or impair physical, chemical, or biological integrity of the watershed. This includes identifying and eliminating pollution sources and reducing stormwater runoff.

Engage the University of Georgia and Athens-Clarke County as well as residential and commercial occupants to implement Best Management Practices (BMPs) to enhance watershed health.

Create more defined public access to waterways in order to increase and deepen people's interactions with streams.

Increase public awareness and involvement in water quality issues through outreach to those who live, work, study, and recreate in the watershed.

Restore native buffers, flood plains, and habitat throughout the watershed.

2 WATERSHED MANAGEMENT

OVERVIEW

All three watersheds are heavily developed and urbanized, presenting unique challenges and opportunities for stream restoration.

Lilly Branch, Tanyard Creek, the Steam Plant Stream, and the waterways that make up the Lake Herrick watershed are all tributaries to the North Oconee River, which ultimately flows to the Atlantic Ocean via the Altamaha River. The headwaters of Lilly Branch, Tanyard Creek, and Lake Herrick all begin in Athens-Clarke County (ACC) to the west of the main University of Georgia (UGA) campus, while the Steam Plant watershed is entirely contained within campus.

Both Lilly Branch and Tanyard Creek are perennial streams and first-order tributaries to the North Oconee River. The North Oconee River is a part of the Upper Oconee River Watershed, which includes 618 impaired stream miles (including one impaired stream mile in Tanyard Creek). “Fishable” is the designated use assigned to both Lilly Branch and Tanyard Creek by the Georgia Environmental Protection Division (GA EPD)[1]. The North Oconee River is designated for Drinking Water. Three of the watersheds are heavily developed and urbanized, presenting unique challenges and opportunities for stream restoration while Lake Herrick includes recreation and natural areas in addition to urbanized headwaters.

FLOW PATH

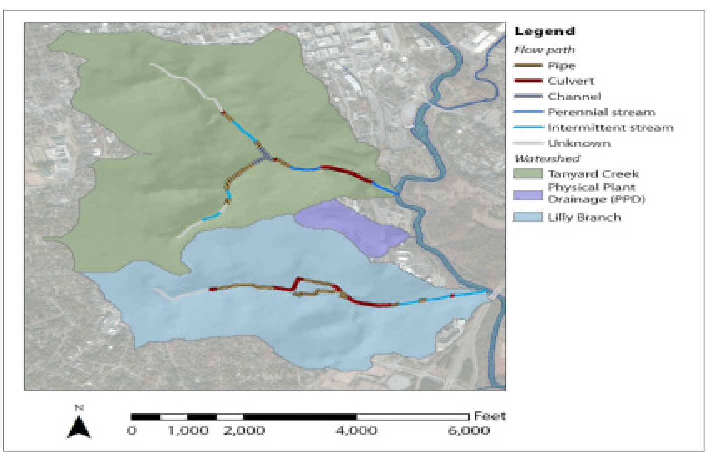


FIGURE 2. *This map shows the flow path of the Campus Watershed's water bodies, indicating which portions are piped or in culverts and which are daylighted.*

IMPERVIOUS SURFACES

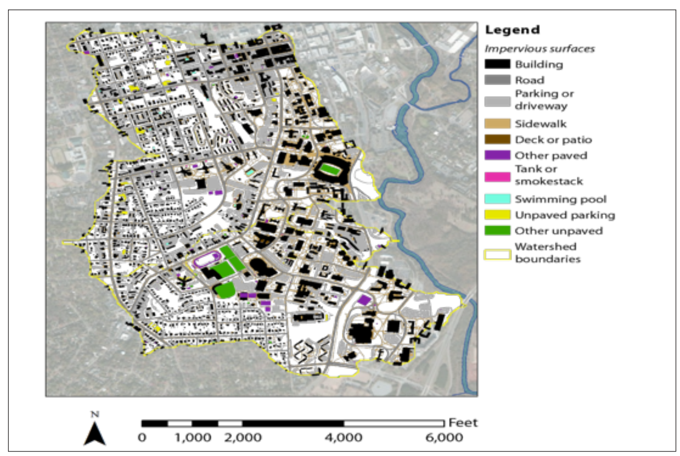


FIGURE 3. *Impervious surface cover.*

[1] Georgia EPD 305(b)/303(d) list.

PERCENT IMPERVIOUS SURFACE COVER, BY CATCHMENT

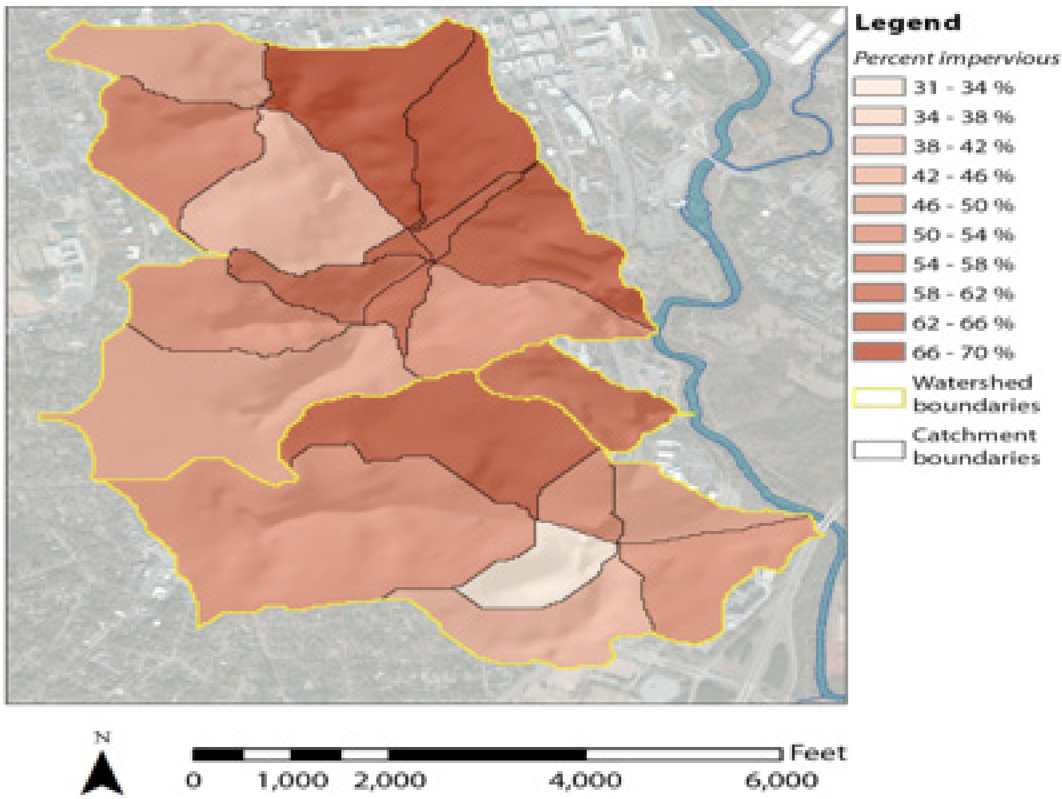


FIGURE 4. *Percent Impervious Surface Cover, by Catchment*

OWNERSHIP, BY PARCEL

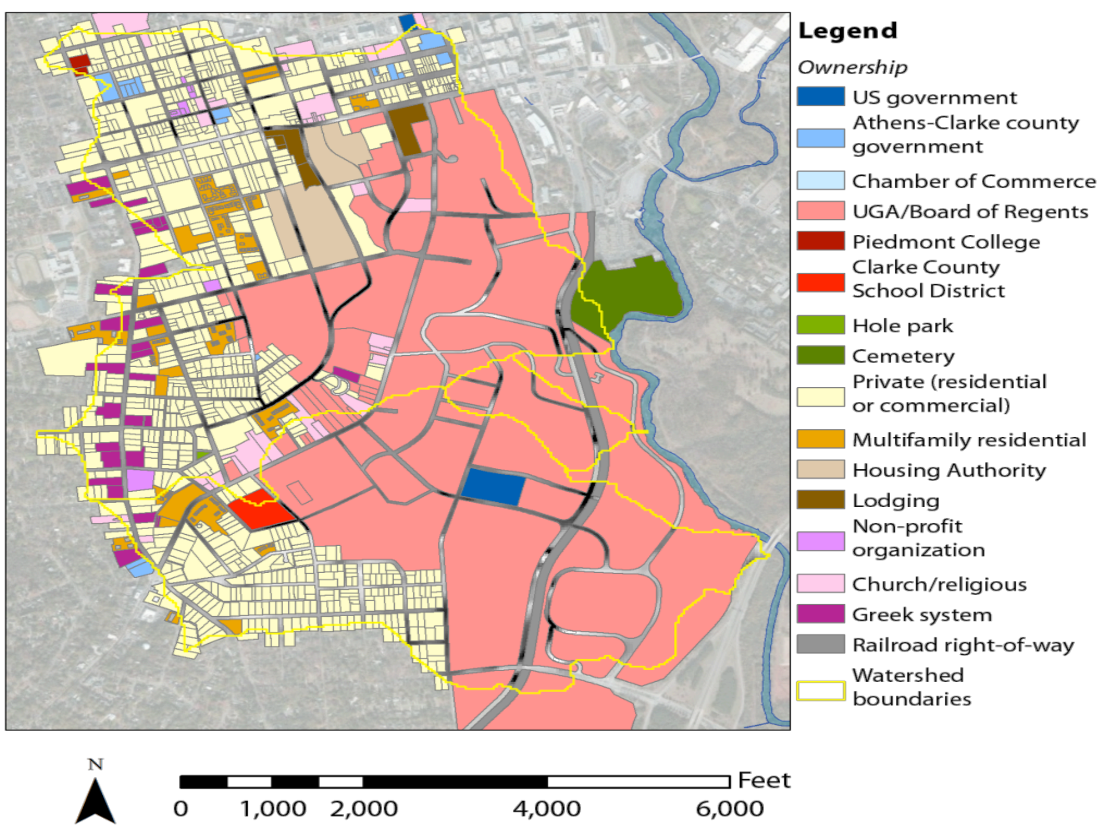


FIGURE 5. *Ownership, by parcel*

LILLY BRANCH WATERSHED

Lilly Branch totals 1.83 kilometers (1.14 miles) in length, beginning just south of South Lumpkin Street in the Five Points neighborhood. From its headwaters behind the Lumpkin Square Apartments, it is daylighted for less than a quarter of a mile before being piped under Foley Field (UGA's baseball stadium), the School of Veterinary Medicine, and East Campus Road. It daylights again near the Lamar Dodd School of Art before emptying into the North Oconee River. Approximately two-thirds of Lilly Branch is in culverts, with only two day-lit sections.

Lilly Branch has a shallow dry-weather depth in most areas. It finally deepens to over 5 feet (1.5 meters) towards its confluence with the North Oconee River.[2] The riparian buffers along the stream are narrow or nonexistent and are therefore not effective at slowing runoff and capturing pollutants from the impervious surfaces in the watershed. In both the day-lit and piped reaches, storm drains run directly into Lilly Branch. Because of the resulting extreme wet-weather increases in flow, bank erosion, bank instability, and sediment-loading plague the day-lit portions of Lilly Branch.

PHOTO 1: *Lilly Branch suffers from lack of riparian buffers.*

Biotic sampling in 2002, 2003, 2004, 2005, and 2010 all indicate poor water quality. These indicator organisms include diatoms (*Pinnularia* sp.), blue-green algae (*Oscillateria* sp.), desmids (*Euastrum* sp.), Spirogyra (*Ulothrix* sp.) and protists (*Euglena* sp.). No fish are found in the upper section but southern two-lined salamanders (*Eurycea cirrigera*) and spotted dusky salamanders (*Desmognathus conanti*) breed and nest in the stream. Macroinvertebrates include one crayfish (*Cambarus* sp.) and several aquatic worms. In the lower section, crayfish (*Cambarus sp.*) are found along with aquatic worms (*Olighochaetes*), midge larvae (*Chironmidae*), net-spinning caddisfly larvae (*Hydropsyche* sp.), cranefly larvae (*Tipula* sp.) water striders (*Gerridae*), and several species of fish including yellowfin shiners (*Notropis lutipinnis*), red-breasted sunfish (*Lepomis auritus*), creek chub (*Semotilus atromaculatus*), and Ocmulgee shiner (*Notropis callisema*)[3].

Historically, land within the Lilly Branch watershed was used for intensive cotton farming. In 1924, the Georgia 4-H Club established Camp Wilkins on the banks of Lilly Branch, where the School of Veterinary Medicine is today[4]. In the 1930s, the watershed began to be developed for other uses and is now heavily urbanized. Impervious surfaces now blanket approximately 40% of the Lilly Branch watershed. Runoff from nonpoint sources contains contaminants such as sediment, fecal bacteria, heavy metals, chemicals, and litter. The increase in impervious surfaces affects the stream's flow regime, increasing the frequency of bank-stressing events and causing high peaks with short durations and low overall base flow. In 2002, UGA professors demonstrated that rain events increase the volume of flow in Lilly Branch by a factor of 1,000[5]. Velocity and erosion have increased along with pollutant loads. In addition, the non-piped stream segments are heavily dominated by invasive species.

Much of the eastern portion of the watershed lies within the UGA campus. The headwaters of Lilly Branch, however, are in residential and commercial land. All of the wastewater in the watershed is believed to be treated in sewage systems, with no known septic systems in current use based on ACC files and map analysis.

[2] 2011 Spring Semester Environmental Practicum Report, Page 7.
[3] Ibid, Page 15.
[4] Georgia 4-H, www.georgia4h.org/public/more/4hcentennial/ga4hcentennial_1.ppt
[5] Carroll, G.; Palta, M.; Li, G.; and White, W. 2002. "An Assessment of Water Quality, Habitat, and Biota in Stinky Creek: A Small Urban Stream in Athens, Georgia."

TANYARD CREEK WATERSHED

Tanyard Creek totals 1.79 kilometers (1.11 miles) in length, with the Cloverhurst Branch tributary extending an additional 0.87 kilometers (0.54 miles), over a total watershed land area of 2.02 kilometers^2 (0.78 miles^2). The headwaters are located underneath a catch basin on Church Street, near the intersection of Milledge Avenue and Broad Street. It is then piped under Broad Street toward campus. It daylights and then meets with Cloverhurst Branch near the intersection of Baxter Street and Lumpkin Avenue just west of campus before entering a culvert underneath Sanford Stadium (the UGA football stadium). South of the Oconee Hill Cemetery, Tanyard Creek daylights again before reaching the North Oconee River.

Approximately 50% of Tanyard Creek runs through culverts and pipes. Additionally, the bed of Tanyard Creek has been greatly affected by urbanization. Anthropogenic influences and land use changes have modified the substrate material. Litter, riprap, stones, manmade gravel, asphalt, and sand from the roads and parking lots that border much of the day lit segments are present in the channel.[6] In February 2010, stream walks were conducted in the Tanyard Creek watershed by staff with the ACC Stormwater Management Program, who rated Tanyard Creek's overall stream condition as poor due to degradation of the bed, banks, and stream buffer.

PHOTO 2: *Around 50 percent of Tanyard runs through pipes.*

The development history of the Tanyard Creek watershed is similar to that of Lilly Branch. It was originally cleared for agriculture, but began urbanizing in the 1930s as a result of its proximity to downtown Athens and of the expansion of the University. In 1831, the first botanical garden in the state was created along Tanyard Creek. There were also several tanneries along the creek near present-day Lumpkin Street. Like Lilly Branch, Tanyard Creek is highly developed with 90% of its 2.02 kilometers^2 (0.78 mile^2) land area covered by surfaces of 40% imperviousness or greater with the same resulting impacts as described above. Most of the land in this drainage basin is in commercial or University use with some residential areas and transportation corridors.

STEAM PLANT STREAM

The Steam Plant Stream is 0.15 kilometers (0.09 miles) in length, originating near Boyd Hall and the Ecology Building and flowing past the UGA Steam Plant and Facilities Management staging area. Headwaters are culverted near the Facilities Management parking lot. The infrastructure actually failed in 2010, and the culverts had to be re-constructed at significant depth. Historic maps show a livestock pond in this area, which may explain the depth. The stream enters a culvert under East Campus Road and then daylights at River Road. This day-lit portion is heavily overgrown and infested with invasive plant species. The water here has a distinctive yellow hue that may result from iron-oxidizing bacteria. The stream then enters another culvert before emptying into the Oconee River.

The Steam Plant Stream watershed is much smaller than the Lilly Branch or Tanyard Creek watersheds. It sits entirely within UGA property. The easternmost corner of the watershed is a small wooded area where signs of raccoons and feral cats are evident, and the stream daylights at this sliver. Originally cleared for agricultural uses, the rest of the watershed is now covered by roads, parking lots, university buildings, and lawns.

[6] Tanyard Creek 2011 Athens-Clarke County Water Management Plan.

LAKE HERRICK WATERSHED

Lake Allyn M. Herrick is a 15-acre water body on the southern end of the University of Georgia's campus, located in the center of the Intramural Field and Oconee Forest Park complex. Its watershed encompasses 248 acres, including 66.4 acres which drain into the sub-watershed of a nearby pond.[7] Land uses within the watershed include the entirety of UGA's intramural fields and Oconee Forest Park, an apartment-style graduate student housing complex, a stretch of state highway, a campus transit facility (bus maintenance and storage), and a portion of a residential neighborhood.

The lake is contained within the Oconee Forest Park, a 117 acre tract of land which was established in 1982, the same year the lake was constructed for purposes of recreation, research, and teaching. It originally featured a beach with a swimming area, a boathouse with canoes and sailboats available for student use built in 1984, and a management plan that provided for fishing. It was also the site of an annual triathlon. However, swimming and boating were banned in 2002 following a period of declining water quality and various management problems. The lake managers also stopped stocking the water with fish. Since then, the lake itself has remained closed and persists in an underutilized state. However Lake Herrick and the Oconee Forest Park continue to be used by many classes for field studies in forestry, ecology, biology, and other biological sciences. The trails that run throughout the park are heavily used by walkers and runners.

Upstream of the lake is a tributary pond which drains a 66.4 acre subwatershed. The Oconee Forest Park Pond, has been nicknamed, "parvo pond" in reference to canine parvovirus, a highly contagious pathogen spread between dogs via fecal contact. Although both Lake Herrick and the Oconee Forest Park Pond have elevated levels of sediment, bacteria and nutrients, water quality conditions are consistently worse in the pond. Contaminant inputs are attributed to general nonpoint source pollution from domestic pets (given the presence of a popular dog park adjacent to the Oconee Forest Park Pond), urban stormwater runoff, erosion and sedimentation within the watershed and bacteria inputs from both wildlife (Canada geese).

PHOTO 3: *In 2002, swimming and boating were banned on Lake Herrick following a period of declining water quality and various management problems.*

[7] 2011 Spring Semester Environmental Practicum Report.

3 IMPAIRMENT SUMMARY

OVERVIEW

In addition to data collected by the Georgia Environmental Protection Division (GA EPD) and the United States Environmental Protection Agency (US EPA), water quality data has been collected for the Campus watersheds for many years by UGA researchers and students, non-profits, and consultants. The most consistent monitoring has been the UGA Grounds Department contract with Brown and Caldwell since 2004, which includes quarterly wet and dry sampling and the Upper Committee Watershed Network's (UOWN) annual sampling even beginning in 2001.

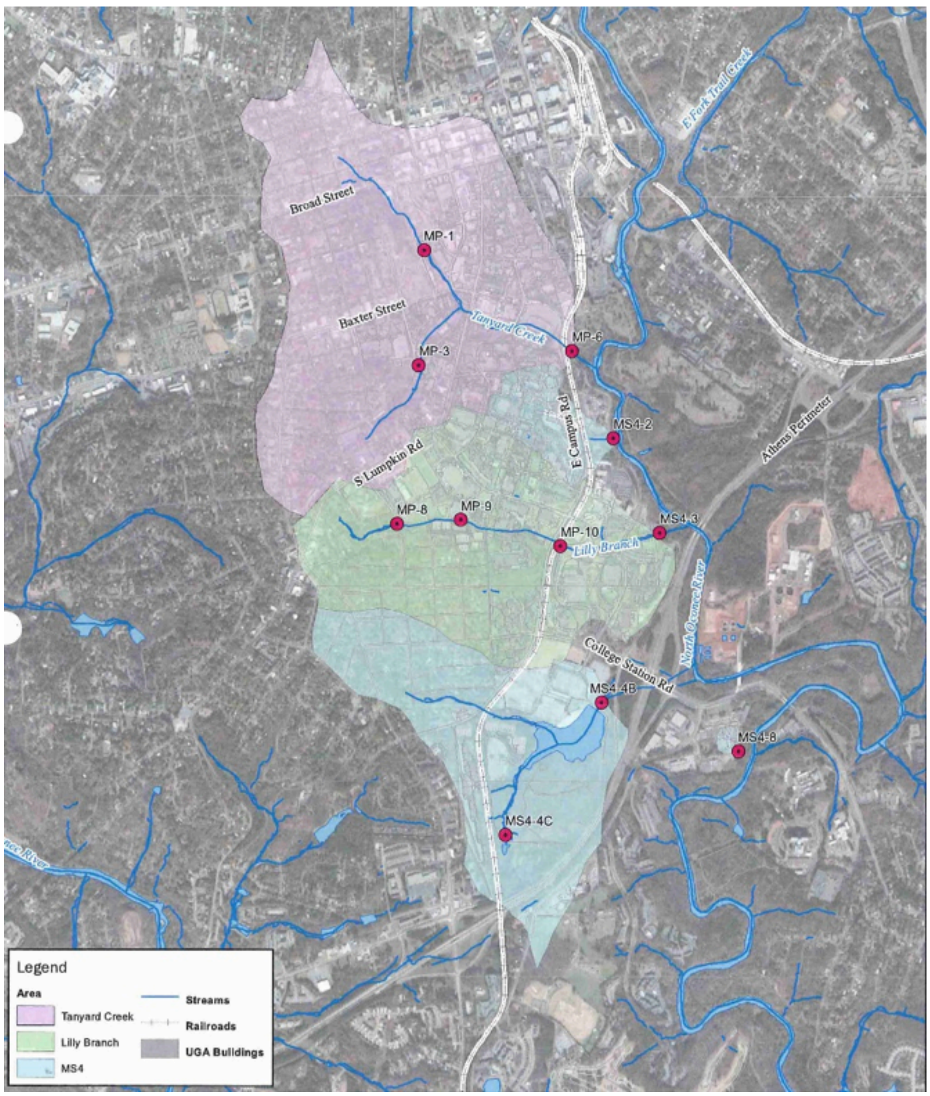


FIGURE 6: *Results from the Water Quality Monitoring Plan.*

The Advisory Committee examined and compiled this data along with the reports and classroom assignments performed by faculty and students. Researchers conducted targeted stream walks over several years and conducted additional sampling at the following locations to identify pollutant sources. For a full description of monitoring techniques, the Water Quality Monitoring Plan is attached as Appendix B.

MONITORING RESULTS

HIGH AT ALL SITES:

- Fecal Coliform Bacteria
- Total Phosphorus
- Total Nitrogen

HIGHER IN THE HEADWATERS THAN DOWNSTREAM:

- Acidic Conditions (Lake Herrick watershed has significantly lower pH upstream)
- Conductivity (Tanyard Creek watershed- but there is one large outlier sample)
- Turbidity (Lake Herrick watershed only)
- Total Suspended Solids (Lilly Branch wet sampling and Lake Herrick- for wet and dry- watersheds)
- Total Phosphorus (Tanyard Creek and Lake Herrick watersheds)
- Total Nitrogen (Tanyard Creek and Lake Herrick watersheds)
- Fecal Coliform (Tanyard Creek watershed-warm weather dry sampling; Lake Herrick watershed warm weather dry and cool weather wet; Lilly Branch watershed warm weather wet sampling)
- Zinc (Tanyard Creek and Lake Herrick watersheds)

HIGHER MOVING DOWNSTREAM:

- Conductivity (Lilly Branch watershed)
- Copper (Tanyard Creek and Lilly Brach watersheds)
- Lead (Lake Herrick and Lilly Branch watersheds)
- Zinc (Lake Herrick and Lilly Branch watersheds)
- Acidic Conditions (Lilly Branch watershed slightly lower pH downstream)
- Total Suspended Solids (Tanyard Creek watershed wet sampling)
- Total Phosphorus (Lilly Branch watershed only)
- Total Nitrogen (Lilly Branch watershed only)
- Fecal Coliform (Lilly Branch watershed cool weather wet sampling)

HIGHER IN THE TANYARD CREEK MAIN STEM THAN IN ITS TRIBUTARY, CLOVERHURST BRANCH:

- Zinc
- Copper
- Wet arsenic
- Wet lead
- Total Phosphorus
- Conductivity- but there is one outlier sample
- Total Nitrogen
- Fecal Coliform- warm weather dry sampling

HIGHER IN THE STEAM PLANT STREAM WATERSHED THAN ELSEWHERE:

- Wet Zinc
- Wet Copper
- Wet Arsenic
- Conductivity (especially during dry sampling)

OFFICIAL IMPAIRMENTS

Coliform bacteria are relatively harmless microorganisms that are present in large numbers in the digestive system and feces of humans and warm-blooded animals. Fecal coliform itself is not pathogenic but is considered an indicator species for other pathogenic organisms. Pathogens are typically present in such small amounts that it is impractical to monitor them directly. A common type of pathogenic organism associated with fecal coliform is E. coli, some types of which cause severe cramps and diarrhea in humans and can be very harmful and even deadly to young children and the elderly. While the presence of E. coli does not guarantee threats to human health, it is an indicator of the potential existence of such threats.

A Total Maximum Daily Load (TMDL) is a calculation of the maximum amount of a pollutant that a water body can receive and minimally achieve designated use. TMDLs are established for all state waters on the 305(b)/303(d) integrated List of Waters that do not meet criteria for their designated uses. Each TMDL limits the maximum amount of a pollutant by requiring a reduction (usually a percentage) in the current pollutant loading.

In 2002, US EPA Region 4 established fecal coliform TMDLs for streams with a designated use of fishing and drinking water in the Oconee River Basin. The TMDL for fecal coliform in regards to fishing is 100 colony-forming units (CFUs) per 100 milliliter (ml) in May through October, and 1000 CFUs per 100 ml in November through April. For Tanyard Creek, this required a 76% reduction in bacteria loadings. GA EPD increased that reduction to 94% in 2007.

FECAL COLIFORM BACTERIA, DRY SAMPLING

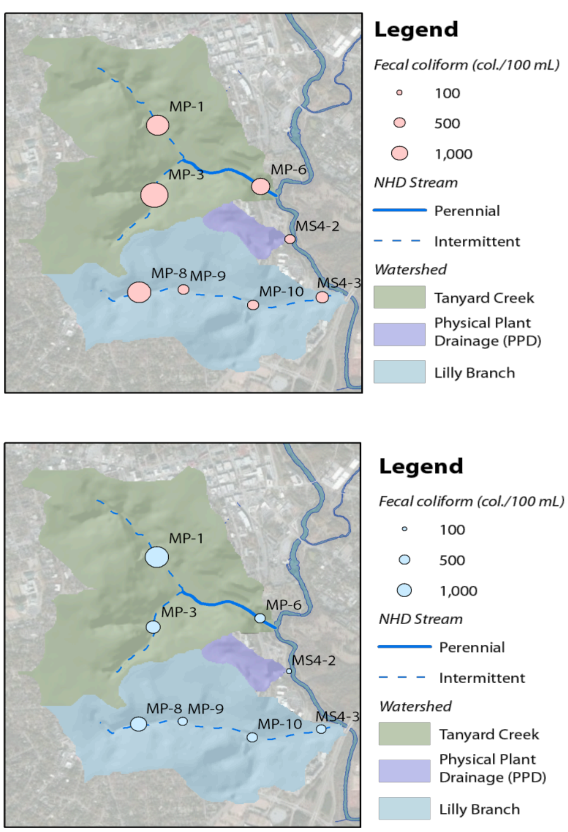


FIGURE 7. *Fecal Coliform Bacteria, Dry Sampling.*

The US EPA Region 4's 2002 TMDL also required a 72% reduction in fecal coliform loadings for eight miles of the North Oconee River (Trail Creek to Oconee River). GA EPD increased that reduction to 76% in 2007. The eight-mile segment includes the Tanyard Creek to Lilly Branch reach described in this Watershed Management Plan. There are additional smaller streams, including the Steam Plant Stream, Lilly Branch, and the outlet of Lake Herrick, that contribute to fecal coliform loadings.

Subsequent water quality sampling in Tanyard Creek and throughout the rest of the Campus Watershed continues to indicate levels of fecal coliform in excess of water quality standards. In Tanyard Creek, during dry weather events from September 2013 to May 2014, fecal coliform values ranged from 90 to 16,000 CFUs/ 100ml, down from 9 to 27,213 January – April 2012, and from 700 to 30,000 CFUs / 100ml during wet weather events. With a mean of 1851 CFUs / 100ml in dry weather and 11,214 CFUs /100ml in wet weather warm, Tanyard Creek greatly exceeds the state limit of a 1,000 CFUs / 100ml mean.

Especially high levels of fecal coliform have been found at MP-1u, the point where Tanyard daylights at Ben's Bikes and at MP-1, the point where the stream daylights just north of Baxter Street. Thus, much of the fecal contamination is occurring while the stream is still underground. The high concentrations that occur during dry weather conditions indicate that point sources of wastewater may be entering Tanyard Creek through leaking sewer lines near the stream. In fact, as described later in this report, the Advisory Committee discovered two leaking sewer pipes in this area pursuant to the development of this plan. High concentrations during wet weather events indicate the presence of bacteria typical in non-point source urban stormwater runoff. It may also indicate increased pressure on the sewer system during rain events due to infiltration and inflow.

Lilly Branch, the Steam Plant Stream and Lake Herrick also showed high levels of fecal coliform during the September 25, 2013-May 30, 2014 sampling season. Lilly Branch had fecal coliform ranging from 110 to 21,487 CFUs / 100ml in dry weather samples and 2200 to 23,000 CFUs / 100ml in wet samples. Its mean was 3,112 CFUs / 100ml in dry weather and 14,300 CFUs / 100ml in wet weather.

From Sept 25, 2013-May 30, 2014, the steam plant sampling location, MS4-2, had an average wet sample of 8,222 CFUs / 100ml. The average dry sample was 590 CFUs / 100ml. The average fecal coliform levels for Lake Herrick were 268 CFUs / 100ml dry in 2006 and an average of 630 CFUs / 100ml wet in 2007/2008. Recent tests show lower levels of fecal coliform. From Sept 25, 2013-May 30, 2014, the average wet sample was 19 CFUs / 100ml and an average dry sample of 46 CFUs / 100ml. The most recent Oconee Forest Park Pond tests showed high levels of fecal coliform. During the same time period, there was an average wet sample of 1,926 CFUs / 100ml and an average dry sample of 185 CFUs / 100ml. This is indicative of a noticiable trend from 2004-the present. All parameters, especially fecal, are much higher in Oconee Forest Park Pond than in Lake Herrick.

PATHOGENS

The Advisory Committee identified the contamination from fecal coliform and E. coli as a principal problem facing the watershed. Furthermore, they identified four candidate sources of the extremely high levels of fecal coliform present:

1. *One potential source is leakage from faulty sewage pipes. Sewage piping (constructed of terra cotta, polyvinyl chloride, or ferrous metal) develops clogs, cracks, and breaks due to age and poor installation or maintenance. This allows the release of raw, untreated sewage into the stormwater system and eventually into streams. Much of the sewage infrastructure in the Campus Watershed is aging.*

2. *Animal waste: Dog waste is often visible on the stream banks of Lilly Branch, and the upper portion of Lake Herrick is extensively used by dogs. Canada Geese are also likely a contributor in the Lake Herrick Watershed. Stormwater runoff then carries the waste into the streams—a process that is exacerbated by the Campus Watershed's high percentage of impervious surface.*

3. *Businesses, university facilities, and residential apartments dispose of waste in over 200 outdoor dumpsters in the Campus Watershed. These dumpsters are often inadequately covered or plugged, and they are susceptible to animal infestation and stormwater runoff.*

4. *Multiple food service businesses are located at the upper reaches of both Lilly Branch and Tanyard Creek. Near Lilly Branch's headwaters, witnesses have observed grease and other food waste being improperly disposed of. As a result, food waste directly infiltrates the stormwater system, drawing vermin and other animals to the streams.*

STORMWATER VOLUME

The second principal problem identified by the Advisory Committee is the volume of stormwater rushing into the streams during and immediately after rain events which undercuts stream banks. The volume is a result of the vast impervious cover across the watershed. The lack of healthy riparian buffers to intercept and filter the stormwater is a contributing factor to both principal problems.

LEAKING UNDERGROUND STORAGE TANK

In 1993, an oil sheen in Lilly Branch was first reported to GA EPD. Results of sampling both in the creek and in wells within the watershed indicated levels of methyl tert-butyl ether (MTBE, a gasoline additive) exceeding state standards. Based on both historical and recent groundwater data, the dissolved plume extends approximately 400 feet from the source, a tank pit area of a former gas station in the Five Points neighborhood. The plume covers the majority of the center and eastern portion of the property and has migrated in a general east-southeastern direction, where it intersects Lilly Branch, the receiving water body for this plume.

This contamination has led to a major remediation effort by the property owner, which began in the spring of 2012. The aim of the effort is to remove free product from the smear zone to the extent that measurable free product will not migrate to wells in low water table conditions nor accumulate to greater than one-eighth of an inch thickness. To ensure removal of free product trapped below the water table, dewatering is being used to expose the smear zone.[8] The remediation process is contracted to take 24 months from start to finish, beginning around April 1, 2013.[9]

PH

The pH measurements in aquatic systems generally vary between 6.0 and 9.0 Standard Units (s.u.) due to reactions with the atmosphere. Areas with large amounts of decaying vegetation can develop humic acid which decreases pH levels. Meanwhile, areas with limestone or karst geology add bicarbonate which results in an increase in alkalinity and an increase in pH.

The state of Georgia has issued regulations on the range of pH values allowed in waterways designated for fishing usage: 6.0 to 8.5 s.u. Dry weather values for pH in the Tanyard Creek watershed from September 25, 2013-May 30, 2014 ranged from 5.34 to 7.66 s.us. Wet weather values ranged from 5.79 to 6.86 s.u. Results from dry and wet weather monitoring indicated that all three Tanyard Creek sites did not meet the state's criteria of a pH between 6 to 8.5 s.u. (1) MP-3u (where Cloverhurst Branch daylights at Chadsworth Commons and South Church Street) had a dry weather pH value of 5.89 s.u., and (2) MP-6 downstream of where Tanyard Creek flows under Sanford Stadium) had a dry weather pH value of 5.34 s.u., a wet weather pH value of 5.96 s.u, and a second wet pH value of 5.79 s.u.

Values for pH in the Lilly Branch watershed ranged from 5.77 to 8.42 s.u. Dry weather results ranged from 5.85 to 8.42 s.u. Wet weather values ranged from 5.77 to 7.18 s.u. Results from dry and wet weather monitoring indicated that three sites did not meet the State's criteria of a pH between 6.0 to 8.5 s.u. (1) MP-8u – the headwaters of Lilly Branch – had a wet weather pH value of 5.77 s.u. (2) MP-10 (where Lilly Branch crosses under East Campus Road) had a dry weather pH value of 5.99 s.u. and (3) MS4-3 (slightly east of the Lamar Dodd School of Art parking lot) had a dry weather pH value of 5.85 s.u., a wet weather pH value of 5.84 s.u, and a second wet pH value of 5.90 s.u.

pH LEVELS

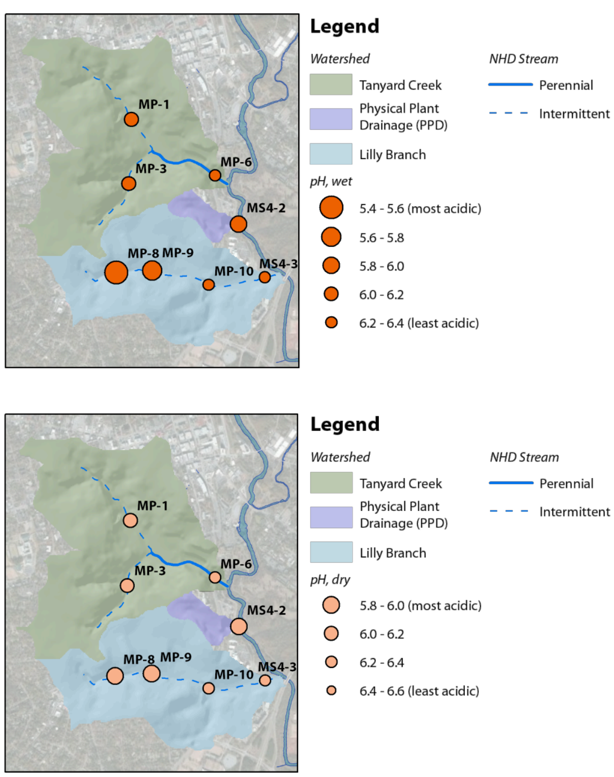


FIGURE 8: *pH levels.*

[8] Spring 2012 Environmental Practicum Report on Lilly Branch Leaking Underground Storage Tank.
[9] Phone interview with Michael Coughlan, EPD Underground Storage Tank Management Program Advanced Geologist, 03/18/2013.

Values for pH in the Steam Plant watershed ranged from 3.82 to 8.11 s.u. Dry weather results ranged from 5.85 to 8.11 s.u. Wet weather values ranged from 3.82 to 7.23 s.u. Results from dry and wet weather monitoring indicated that this one site, testing both in the field and lab, did not meet the State's criteria.

Values for pH in the Lake Herrick watershed ranged from 4.46 to 7.53 s.u. Dry weather results ranged from 4.75 to 7.53 s.u. Wet weather values ranged from 4.46 to 6.76 s.u. Results from dry and wet weather monitoring indicated that both sites did not meet the State's criteria. (1) MS4-4b – the effluent of Lake Herrick – had dry weather pH values of 5.24 and 5.71 s.u and (2) MS4-4c –the effluent of Oconee Forest Park Pond- had dry weather pH values of 5.79 and 4.75 s.u. and a wet weather pH value of 4.46 s.u.

The extremely low pH levels recorded at a few sites on a few occasions strike the Advisory Committee as abnormal and indicate unique conditions at these sites on these dates. The locations of the abnormal measurements suggest a source high in the watershed. Potential sources of low pH levels include acid rain, decomposition of organic matter, or runoff from coal burning or other polluting facilities. Since this is a residential area, fertilizer application or decomposition of organic matter (such as leaking sewer pipes, some of which indicated have been discovered and addressed) may be cause for the low levels. Aside from the infrequent low levels recorded on a few occasions, historical dry weather mean pH levels are low. This suggests a persistent stressor such as a long undiscovered leaking sewer line; continual use of fertilizers, bleach or other cleaning products; or some other source, possibly including the coal-fired boiler at the UGA Steam Plant which will be decommissioned in Fiscal Year 2016.

Dialogue with Brown and Caldwell, the consulting firm employed to collect quarterly data in the watershed, reveals confidence in the validity of the data. While equipment problems can distort measurements taken in the field and necessitate quality assurance, pH is usually not a parameter associated with such problems. Also, pH is calculated both in the field and in the lab, making a calculating or sampling error unlikely.

NUTRIENTS

In developed areas, high concentrations of phosphorous in stormwater runoff can increase stream productivity, resulting in an increase in algal blooms. As the blooms die off, decomposition triggers a reduction in oxygen, which can endanger aquatic life and its processes. Elevated concentrations of phosphorus are commonly found in lakebed sediments in the Georgia Piedmont region, likely having been transported from upstream tributaries.

There are no legal standards regarding phosphorus in Georgia's surface waters. However, in 2000, the US EPA published guidelines based on ecoregions to be used in the development of nutrient criteria.[10] These guidelines will be used by the state of Georgia in the coming years to develop phosphorus limits. Georgia is located in Ecoregion IX, known as the Southeastern Temperate Forested Plains and Hills. For this ecoregion, the US EPA recommends a total phosphorous (TP) limit of 0.03656 mg/L. According to GA EPD, studies are currently being performed on TP, and pre-

[10] US EPA, http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/ecoregions/index.cfm

liminary results indicate that the average value for the state is 0.13 mg/L. GA EPD also uses 0.5 mg/L as a general guidance to indicate an elevated level of TP.

Likewise, there are no state or federal standards for nitrogen levels in surface waters. However, the nutrient criteria guidelines developed by the US EPA described above include guidance for nitrogen concentrations. Again, the state of Georgia will likely use this guidance in the coming years to develop water quality standards for nitrogen concentrations. The recommended guideline from the US EPA for Ecoregion IX is 0.69 mg/L for total nitrogen (TN).

Total Phosphorous data collected in the Tanyard Creek watershed over the past year at MP-1, MP-3, and MP-6 indicated a wet weather data range of 0.900 to 3.500mg/L. The dry range was 0.6 to 3.5 mg/L. TP for these recent wet weather samples far exceed the previous years' which ranged from 0.115 to 0.224 mg/L indicated a new source for Tanyard Creek.

None of the sampling sites consistently met the EPA recommended limit. Although still exceeding the Total Nitrogen limit, the Lake Herrick watershed had the lowest values with over 40% of the samples meeting the EPA recommended limit.

For Lilly Branch, the testing sites included MP-8 and MS4-3 and the range for wet weather data was 0.900 to 2.900 mg/L while the dry weather data ranged from 0.600 to 2.00 mg/L. For the Steam Plant watershed, the wet weather data ranged from 0.800 to 1.400 mg/L and the dry weather data ranged from 0.800 to 2.300 mg/L. For the Lake Herrick watershed, the wet weather data ranged from 0.500 to 1.100 mg/L and the dry weather data ranged from 0.500 to 1.300 mg/L. The TP ranged for the all three of these watersheds also far exceeded the elevated TP limits for GA EPD and the US EPA. Possible sources of elevated TP levels include runoff of lawn fertilizer heavy in phosphorous.

The TN monitoring data collected in the Tanyard Creek watershed indicate a wet weather ranged from 0.9 to 3.5 mg/L and a dry weather data ranged from 0.6 to 3.5 mg/L. The Lilly Branch TN wet weather data ranged from 0.9 to 2.9 mg/L and the dry weather ranged from 0.6 to 2.0 mg/L. At the Steam Plant, wet weather TN levels ranged from 0.8 to 1.4 mg/L and the dry weather TN values ranged from 0.8 to 2.3 mg/L. The Lake Herrick watershed wet weather TN values ranged from <0.5 to 1.1 mg/L and the dry weather TN values ranged from <0.5 to 1.3 mg/L. The US EPA recommends a limit of 0.69 mg/L. None of the sampling sites consistently met the EPA recommended limit. Although still exceeding the TN limit, the Lake Herrick watershed had the lowest values with over 40% of the samples meeting the EPA recommended limit.

Monitoring results indicate a strong possibility of high TN levels in stormwater runoff, which could be a product of fertilizer used for landscaping and turf maintenance flowing into stream bodies, or of bacterial contamination in the watershed.

Stormwater runoff, again exacerbated by the watershed's high volume of impervious surfaces, can carry fertilizer into the streams. Many areas on campus and in residential areas are characterized by manicured turf that requires fertilizer and pesticide inputs. Another potential cause of high levels is illicit discharge from businesses, such as washing off cooking equipment into storm drains.

Many of the strategies that address fecal coliform contamination will also reduce the nutrient load. BMPs that address lawn runoff, dumpsters, and illicit discharge should lead to a reduction in nutrient inputs as will education campaigns aimed at homeowners and UGA employees.

CONDUCTIVITY

Conductivity is defined as the ability of water to conduct an electrical current. Conductivity increases with the amount of dissolved solids in the water and is thus greatly affected by the presence of minerals or other ions in the water column. It is used as a general ionic measurement for the purity of water. Conductivity itself is not a human or aquatic health concern, but it can indicate the presence of organic matter or other pollutants. While conductivity levels vary greatly among water bodies, a comparative look at conductivity levels throughout the same watershed can yield water quality insights particularly when looked at over time.

One conductivity sample in the 2013-2014 period at MP-1 in the Tanyard Creek watershed read 237 mS/cm on January 16th, 2014 on a dry weather sampling event. This event skewed both the MP-1 and Tanyard Creek watershed data. Aside from that one sample, the average conductivity level for MP-1 was 0.18 mS/cm. Conductivity at the sampling site in the Steam Plant stream was significantly higher than for the other three watersheds, aside from the MP-1 event.

COPPER

Levels of copper exceeded the water quality standard in wet weather conditions set by the Georgia Department of Natural Resources (GA DNR) during 2013-2014 at all sampled sites except for the headwaters of Lilly Branch and Cloverhurst Branch. While the standard for copper is 5 µg/L, the wet mean concentration MS4-2 at the Steam Plant reached 22.3 µg/L. Results from mean dry weather samples, however, remained below the state's limit at all sites within the watershed. This suggests significant non-point sources of copper contamination. Typical sources of copper contamination include runoff from building materials treated with preservatives, paint, and outdoor storage of scrap metal and automotive deposits that accumulate on pavement. [11]

LEAD

From 2013 to 2014, dry weather sample means exceeded both acute and chronic standards in the Steam Plant watershed. Both sampling sites in the Lake Herrick watershed, and the MP-3 site in the Tanyard Creek watershed exceeded GA DNR's water quality standards of 1.2 µg/L during wet weather conditions. Lead stormwater piping can be a potential source of lead pollution. Other sources include waste from industrial facilities, paint, runoff from automobiles, and batteries. [12]

TURBIDITY

Turbidity measures water's capacity to scatter light. Increased turbidity indicates higher levels of organic matter and suspended sediments. Georgia does not set standards for turbidity, since turbidity does not indicate specific pollution as an isolated variable. However, US EPA has documented and shared reference concentrations for each ecoregion. Under dry weather conditions, only one site met the mean reference condition of 5.7 NTU for turbidity in Ecoregion IX: MP-1 in Tanyard Creek. In wet weather conditions, all sites exceeded the reference condition, consistent with a watershed that has prevalent impervious surface cover and insufficient riparian buffers. For example, the 2013/2014 wet mean for MS4-4c at Oconee Forest Park Pond tested at 105.87 NTU. Increased turbidity indicates higher levels of organic matter and suspended sediments. The watershed's inadequate riparian buffers and prevalent impervious surface cover allow for more such particles to enter the streams in wet weather.

[11] http://www.oeconline.org/our- work/water/stormwater/stormwater%20report/impacts
[12] Ibid.

Suspended Solids

Used as one parameter to detect elevated levels of sediment in a stream system, suspended solids refers to mineral and organic material suspended in the water column. The state of Georgia does not regulate suspended solid levels, but some states use 50 mg/L as a limit for potential impairment12. In wet weather conditions, sites MS4-2 in the Steam Plant stream and MS4-3 in Lilly Branch exceeded the 50 mg/L guideline. [13]

None of the tested sites had a wet or dry sample mean exceeding this impairment limit from 2013-2014. Suspended solid levels could indicate erosion which is clearly evident in Lilly Branch. The loss of riparian buffers that protect stream banks and the high concentration of impervious surfaces that adds to the velocity of stormwater as it reaches the streams are contributing factors.

Invasive Species

Throughout the watershed, invasive species dominate the ecosystem, greatly altering the natural habitat. They outcompete indigenous species for nutrients, water and space. Often, predators that constrain aggressive exotic species in their native settings are not present in the new environment. This can lead to the alteration of the natural plant communities and displacement of dependent species.

Chinese privet, periwinkle, bush honeysuckle, Oregon grape, kudzu, Japanese honeysuckle, and Carolina geranium are the major invasive species identified by the Spring 2012 Environmental Practicum Class at UGA. That class's report on invasive species is attached as Appendix C. Chinese privet was singled out as an especially problematic invasive, as it grows abundantly on most of the Campus Watershed's stream banks.

PHOTO 4: *Invasives species alongside a fence at Tanyard Creek.*

[13] State of Oregon Department of Environmental Quality, 2001. "Restoring Soil Health to Urbanized Lands: The Critical Link Between Waste Prevention, Land Use, Construction, Stormwater Management, and Salmon Habitat Restoration".

4 CURRENT AND PROPOSED MANAGEMENT ACTIVITIES

WATERSHED MANAGEMENT STRATEGY:

THE ADVISORY COMMITTEE HAS DEVELOPED A FIVE-PRONGED WATERSHED MANAGEMENT STRATEGY:

- **a** Implement best management practices that reduce stormwater flow and eliminate the pollution sources identified through targeted sampling and stream walks;
- **b** Repair leaking sewer lines and stubs;
- **c** Restore targeted stream segments and effective riparian buffers;
- **d** Provide and facilitate ongoing education, outreach, and community engagement on watershed stewardship and best practices to an audience that includes the UGA community, businesses and residents within the watershed, and K-12 students;
- **e** Continue targeted water quality monitoring and stream walks to identify additional pollution sources and determine the effectiveness of management activities.

IMPLEMENT BEST MANAGEMENT PRACTICES

1. MANAGE STORMWATER

Stormwater control measures (SCMs) or Best Management Practices for Stormwater (BMPs) are structures or practices that control and manage stormwater by promoting infiltration and groundwater recharge, protecting or improving surface water quality, minimizing the use of potable water, and capturing runoff for reuse. Instead of focusing solely on maintaining a pre-development peak flow rate, sustainable stormwater development attempts to mimic the entire pre-development water cycle, including groundwater infiltration, evaporation, and total peak flow volume. To accomplish its goal, sustainable stormwater management uses small, distributed systems that retain runoff. These include rain gardens and bioretention areas, green roofs, vegetated sales, rain barrels and cisterns, pervious pavement, and impervious surface reduction and disconnection.[15]

On-site SCMs are now commonly implemented during new development to control the stormwater runoff generated on an individual project; however, adding onsite SCMs to previously developed areas is more challenging. In these areas, it can be especially beneficial to evaluate potential SCMs as an interconnected system, rather than as individual structures. Doing this requires the inclusion of regional SCMs that capture water from far beyond the property they are located on, as well as consideration of how SCMs can work together in series.[16] Sequencing structural

[14] Carter, T.; Fowler, L.; Vick, A.; Wenger, S., 2008. "Runoff Limits: An Ecologically Based Stormwater Management Program". Stormwater, the Journal for Surface Water Quality Professionals, March / April 2008.

[15] Alvi, K.; Cheng, M.; Riverson, J.; Shoemaker, L.; Zhen, J., 2006. "BMP Analysis System for Watershed-Based Stormwater Management". Journal of Environmental Science and Health, Vol. 41, No. 7, Page 1391-1403.

[16] Bengtsson, L.; Semadeni-Davies, A.; Villarreal, E.L., 2004. "Inner-city Stormwater Control Using a Combination of Best Management Practices". Ecological Engineering, Vol. 22, No. 4-5, Page 279-298.

SCMs to achieve optimal flow management and pollutant removal is sometimes referred to as creating a "treatment train".[17]

SCMs have different abilities to reduce runoff volume, to promote infiltration, and to remove certain kinds of pollutants.[18] The effectiveness of SCMs at removing a contaminant can be measured in either concentration or load. The effect of SCMs on contaminant concentration is determined by comparing the concentration of the water flowing into the SCM (influent) with the water that leaves it (effluent).

As a part of this Watershed Management Plan, a suitability analysis for future SCMs in the Lilly Branch, Tanyard Creek, and Steam Plant Stream watersheds was performed and is attached as Appendix D. The analysis identifies the regions where SCMs are most needed and most feasible and suggests the types of SCMs that are most appropriate within those regions. Since that time, an initial qualitative assessment of Lake Herrick was conducted in the spring of 2014. This assesment identified stormwater at a wetland pond, the Oconee Forest Park, as a potential BMP to improve the the lake water quality.

Recommendations are based on several weighted overlay analyses, using ArcGIS. Regions in need of stormwater control were determined by taking into account impervious surfaces, physical site conditions, and water pollution levels. Locations suggested as suitable for specific SCMs were determined by correlating site conditions with design criteria for each type of SCM. Land ownership was also taken into account regarding the feasibility of installing SCMs on a given property.

Information about SCM function, both in general and as it relates to specific water quality goals, is also included in the analysis to assist with future stormwater control decisions. The results will allow UGA to target SCMs in areas where they will be most effective and will assist the ACC Stormwater Management Program with SCM implementation and landowner education.

Choosing appropriate SCMs depends on understanding how each type of SCM fits a site's conditions and stormwater improvement goals as well as slope, soil infiltration rate, and water table depth. The following are the SCMs that will be pursued by the Advisory Committee in the Campus Watershed:

GREEN ROOFS consist of waterproofing and drainage mats, a lightweight growing media and plants suitable for the climate. They decrease runoff, encourage evapotranspiration, and reduce peak flows. They also prolong roof life, reduce energy costs within the building, and reduce urban heat island effects.

PHOTO 5. *UGA faculty and students examine an example of pervious parking in the watershed.*

DISCONNECT ROOF DRAINS from storm systems and instead direct them to vegetation, permeable soils, and SCMs. This reduces peak flows and encourages infiltration.

RAIN GARDENS and bioretention areas are shallow (6 to 8 inches deep) depressed areas that use vegetation and permeable soil to collect water and allow it to infiltrate which promotes groundwater recharge while reducing runoff volume and peak flow.

PERVIOUS PAVEMENT includes pores in the surface that allow water to collect in underlying storage areas, and then either infiltrate the soil directly or release slowly to an underdrain system. They are most appropriate for areas with low vehicular traffic volume, such as sidewalks, patios, residential park-

[17] Lloyd, S.D.; Porter, B.; Wong, T.H., 2002. "The Planning and Construction of an Urban Stormwater Management Scheme". Water Science and Technology: A Journal of the International Association on Water Pollution Research, Vol. 45, No. 7, Page 1-10.

[18] Lloyd, Porter, and Wong 2002.

ing pads, driveways, fire lanes, overflow parking areas, and some daily parking areas, such as those with infrequent turnover.

LEVEL SPREADERS are SCMs that can help protect receiving waters by converting concentrated runoff to slow, shallow sheet flow over the surface of the land. This enables infiltration and some evaporation. These are commonly used in conjunction with vegetative filter strips and riparian buffers.

RAIN BARRELS AND CISTERNS collect excess water on roofs and other hard surfaces for nonpotable reuse for irrigation, cooling, vehicle washing, and toilet flushing. Rain barrels are typically above ground, small (holding less than 100 gallons), and are frequently used to harvest water from the roofs of small buildings such as residences. Cisterns are larger and can be located above or below ground. Water harvesting can have a moderateimpact on runoff frequency and peak discharge, as well as a small impact on water quality.[19]

VEGETATIVE FILTER STRIPS are areas of closely planted vegetation, usually grass, onto which runoff is directed for filtration. They provide moderate infiltration and groundwater recharge, as well as some control of runoff volume and runoff frequency.

INFILTRATION BASINS AND TRENCHES are shallow cells without underdrains, typically filled with porous media (e.g. riprap), to enable infiltration. They encourage infiltration, groundwater recharge, runoff volume reduction, and protection of water and stream quality. They also offer moderate improvements to depression storage, peak discharge, and runoff frequency.

SWALES are used to convey runoff using an open drainage system, which alleviates flooding and reduces the need for conventional stormwater infrastructure. Vegetated swales are often planted with turf grass, though densely planted native plants with fibrous roots are preferred.[20] Bioswales incorporate engineered soil and underdrains like a bioretention area to promote infiltration.

STORM WATER WETLAND are used to divert storm water through a constructed wetland where pollutants are removed through settling and biological uptake. They have varying depths and vegetative plantings depending upon site characteristics.

As described in our suitability analysis, small, distributed SCMs will be encouraged and incentivized within the headwaters of Tanyard Creek and Lilly Branch, to treat runoff before it collects and poses a larger problem downstream. The analysis identified as highest priority for SCM installation (1) the North Campus/Downtown Zone of the Tanyard Creek main stem; (2) the area immediately south of Sanford Stadium; (3) the Steam Plant Stream (also called the Physical Plant Drainage [PPD]), (4) the western zone of Lilly Branch on the UGA campus; and (5) the Ramsey Center and a parking lot north of the East Village residential complex in the eastern zone of Lilly Branch. Environmental Practicum students developed plans for two SCMs in the North Campus/Downtown Zone of Tanyard. The first involves the installation of a bioretention basin at Cobbham Historic District Neighborhood Park. The estimated cost for a 9" and 1,381 square-foot basin at the site is $41,430. The second site is a vegetated roof installation at the top of Georgia Game Day Condominiums. For a vegetated area of 4,944 square feet, the group estimates a cost of $7,416. These plans are attached as Appendix E.

[19] Prince George's County, Maryland, 1999
[20] Carter, T.; Fowler, L.; Vick, A.; Wenger, S., 2008.

The proposed stormwater BMP projects discussed above were modeled for the Tanyard Creek watershed using the 2012 version of the Stormwater Assessment Tool (SWAT) for ArcGIS 10. The results of that model are attached as Appendix F.

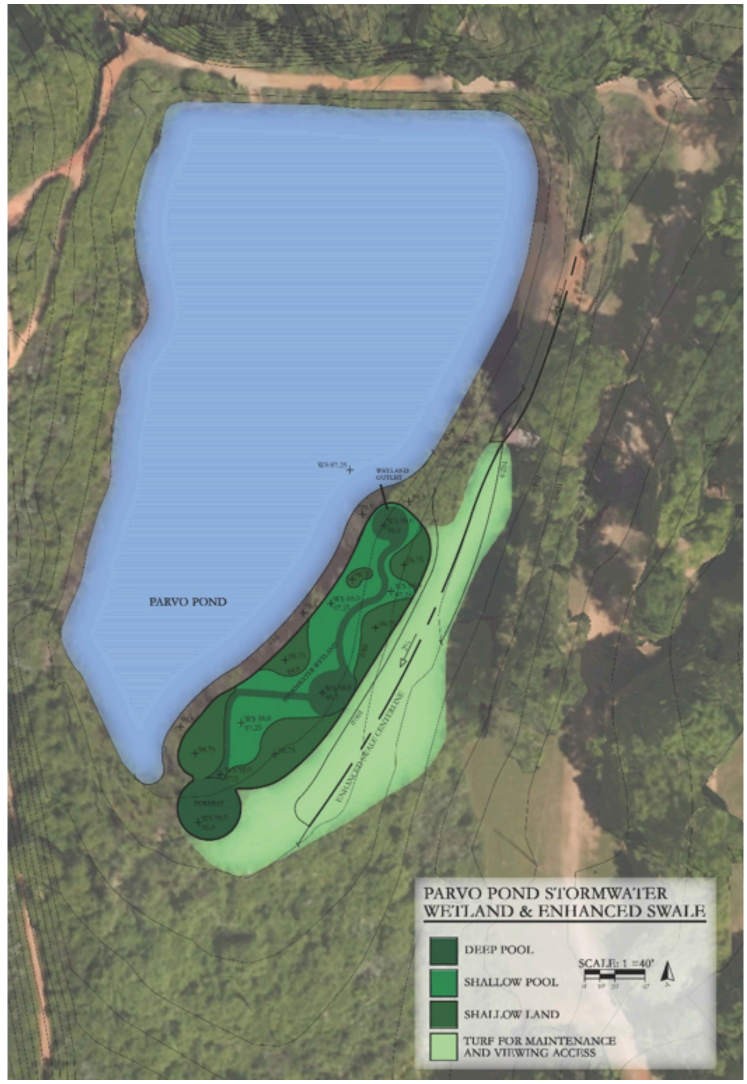


FIGURE 9

The proposed projects will complement UGA's past stormwater management activities. UGA has constructed 48 rain gardens within the target watersheds, ranging in size from less than 0.01 acres to 0.23 acres. These include the Lumpkin Street Drainage Improvements, including 15 rain gardens, enhanced swales, and a settling pond as well as native landscaping.[21] A green roof on the Lamar Dodd School of Art in the Lilly Branch watershed also manages stormwater. Seventeen cisterns have been sited within the watershed; these are capable of collecting and holding hundreds of thousands of gallons of rainwater.[22] Water quality protection measures such as these are included pursuant to all new construction and most renovations on campus with the goal of infiltrating and collecting stormwater onsite.

2. COLLECT DOG WASTE

A potential source of nutrients and fecal coliform is pet waste. Large amounts of dog waste were identified in several stream walks conducted over the course of the project through the upper, residential portions of the watershed. The Fall 2011 Environmental Practicum class undertook an extensive study of pet waste practices and preferences in the Lilly Branch headwaters. Their report is attached as Appendix G. The Spring 2013 Environmental Practicum Class, in conjunction with the ACC Stormwater Management Program, began implementing these recommendations. The Fall 2011 Practicum students conducted a focus group and two surveys and ultimately recommended the installation of waste bag receptacles with motivating signage as the most effective strategy for promoting waste pickup. They also recom-

[21] http://www.architects.uga.edu/planning/sustainable-design/lumpkin-street-drainage-improvements.
[22] http://www.architects.uga.edu/sites/default/files/pdf/UGAstormwater_November2009.pdf.

mended a targeted social outreach campaign to affect the behavior of dog owners through public service announcements, newspaper articles, and other methods. They analyzed the existing ACC ordinance relating to the collection of pet waste and found it generally adequate if enforced, though they suggested some specific improvements.

The Advisory Committee identified three areas for piloting the waste receptacles based on elevated fecal counts in water quality samples, high volumes of observed dog walkers, and high volumes of observed dog waste close to streams or stormwater systems:

1. The upper reaches of Lilly Branch is mostly in private ownership and the Advisory Committee has been unable to find a property owner willing to host such a receptacle at this point;
2. ACC owns a small parcel of property in the Upper Cloverhurst Branch. Students in the Spring 2013 Practicum Class assisted by staff from the ACC Stormwater Management Program developed an agreement with the ACC Solid Waste Department to erect and maintain pet waste receptacles on this property. This receptacle has been heavily used.
3. A large lawn on UGA's North Campus near the corner of Broad Street and Lumpkin Avenue at Herty Drive is frequently used as a dog run by downtown residents. Spring 2013 Practicum students worked with the UGA Grounds Department to assure the installation of a receptacle here after the field is restored following a construction project in Spring 2014.

Our next actions will include developing a media campaign to promote the use of these receptacles and exploring the potential for more active enforcement of the pet waste disposal ordinance by ACC.

3. MINIMIZE DUMPSTER RUNOFF

During Fall 2012, a River Basin Center employee surveyed the 226 dumpster sites in the Campus Watershed. He recorded the location of and property served by each dumpster, the ground cover directly below the dumpster (if any), the barrier surrounding the dumpster (if any), and the number of dumpsters at each site. Additionally, he recorded whether (1) refuse surrounded the dumpster, (2) the roof covered the dumpster, (d) the side doors were closed, (4) the dumpster was plugged, and (5) other leaks or extreme rust were present. For complete results, see the Watershed Dumpster Survey attached as Appendix H.

BMPs for dumpster runoff include placing the dumpster on an impervious platform to mitigate spills, covering the dumpster, posting signage regarding appropriate dumpster management practices, keeping the dumpsters plugged, keeping the roof and side doors closed, and keeping animals out of the garbage by enclosing the dumpster with walls and fences. [23]

Sixty-eight of the dumpsters surveyed were elevated on a platform, while the remaining 158 were at ground level. Around a quarter of the dumpsters were either completely uncovered or half-covered, and more than half had open side doors.

Only a few were surrounded on four sides by fences to prevent wildlife access. Over 30 of the dumpster sites had refuse outside of the dumpster. 38 dumpsters were badly rusted, leaking, or otherwise in disrepair. Finally, nearly half of the dumpsters were missing the plugs that prevent leachate from entering the watershed during rain events.

The UGA Services Department has been using this dumpster survey to target the dumpsters most in need of replacement and repair while furthering watershed protection goals. In 2013, five leaking dumpsters were replaced and 15 were plugged. In 2014 an additional 34 were replaced or refurbished. Among our next steps is the development of a similar education and replacement effort for the dumpsters located outside campus on private land.

PHOTO 6A. *ACC staff and UGA Environmental Practicum students and faculty.*

PHOTO 6B. *Flow in dry weather in a stormwater pipe suggests sewage leak.*

PHOTO 6C. *Looking into stormwater system for flow.*

PHOTO 6D. *Green dye is flushed down the toilet of a nearby business, helping hone exact location of leak.*

PHOTO 6E. *ACC Stormwater workers repair the leaks.*

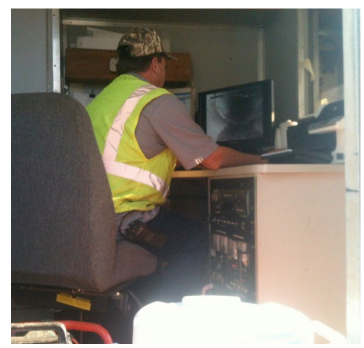


PHOTO 6F. *ACC Stormwater worker uses a camera to find the exact location and extent of the two damaged sewage pipes.*

4. ENFORCE ILLICIT DISCHARGE ORDINANCES

Several restaurants in the Campus Watershed are in visible violations of current ACC illicit discharge ordinances. These infractions can lead to high fecal coliform and other contaminant levels in the streams. The Fall 2012 Environmental Practicum Class developed and tested a "soft enforcement" campaign explaining the ordinances and the ramifications of their violation to owners and managers of a cluster of food businesses in the Five Points area, just upstream from the first daylighting of Lilly Branch. This audience was selected after reports of leaks from dumpsters and grease retention units at these businesses. The ACC Stormwater Management Program staff will determine whether future targeted outreach efforts are needed. Regardless, they maintain a stormwater hotline where residents can report illicit discharges and they conduct educational programs for all ages on problems caused by, and methods for controlling, stormwater runoff.

[23] State of Connecticut Department of Public Health "Best Management Practices for Location and Management of Dumpsters Relative to Public Water Supply Wells."

REPAIR LEAKING SEWER LINES

In an attempt to identify the source of the high levels of fecal coliform at the headwaters of Lilly Branch disclosed through targeted sampling, the Advisory Committee walked the stream in Fall 2012. They found a smelly, dry weather flow in one of the storm drains and alerted the ACC Public Utilities Department which investigated with dye and remote vehicles and identified two leaks. The department shut down Broad Street for several hours in order to repair a leaking sewer line underneath one of the buildings and another under Broad Street.

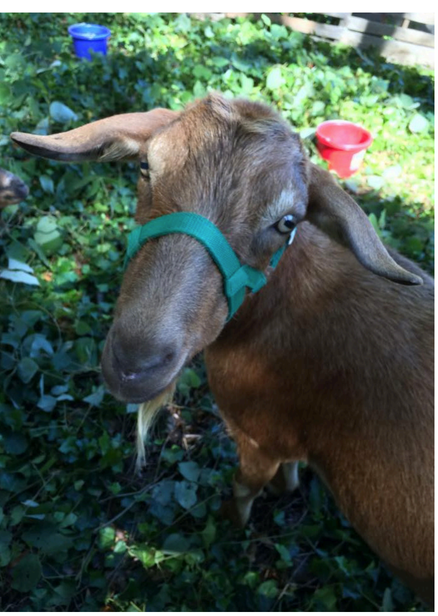
Due to the high levels of E. coli found at sampling locations where nonpoint sources are not implicated as well as the detection of leaking sewer pipes in the headwaters of Tanyard Branch pursuant to this project, the Advisory Committee believes that human waste from sewage is a major source of impairment. The Advisory Committee will continue to monitor for hotspots in order to help the ACC Public Utilities Department find and repair these sewage leaks. Given the extent of the aging sewer systems in these neighborhoods, the costs to the ACC government to repair the lines and to individual homeowners to repair or replace the stubs that connect their toilets and appliances to the sewer lines may be extensive. In Fall 2013, the Advisory Committee will consult with county staff and commissioners to develop strategies for determining the extent of the problem and for funding repairs.

RESTORE TARGETED STREAMS AND EFFECTED RIPARIAN BUFFERS

In-stream channel redesign can improve water quality and reduce runoff quantity and velocity. Several sections of Lilly Branch and Tanyard Creek and its Cloverhurst Branch are candidates for redesign as identified in Appendix I. The lower reaches of Cloverhurst near Baxter Street are daylighted but run through a cement channel highly susceptible to sediment and sediment-bound pollutants. Furthermore, this stretch is located on UGA property, which may allow restoration efforts to be coordinated amongst different schools and university groups. Tanyard Creek is piped under Broad Street, and as the housing projects undergo construction changes, the creek could be daylighted along this stretch of stream.

Riparian buffers are grass-covered or forested areas adjacent to a stream. They provide protection from stormwater impacts by intercepting sediment and sediment-bound pollutants, slowing and dispersing runoff flows, holding soil in place, and providing some infiltration.24 A riparian buffer of native vegetation that is at least 50 feet in width is recommended to protect water quality. However, the buffer in the vast majority of the Campus Watershed is far less than this. A next step for the Advisory Committee is to identify those areas where there is the potential to expand the vegetated buffer.

PHOTO 7. *A Chew Crew goat with some invasive species at Tanyard.*



In addition, in many places where there is a buffer, exotic invasive species have replaced native vegetation. Several creative methods have been identified for clearing these invasive species. This includes volunteer "pull" days and prescribed grazing with goats and sheep. The UGA Grounds Department currently uses sheep to remove invasive species in the Lilly Branch watershed. These sheep were first employed in 2011 and are brought in on a rotating basis. In addition to the flock of thirty sheep, two donkeys are stationed with the sheep to ward off coyotes and other predators.

Goats were first used as a part of a student sustainability grant in the Tanyard Creek Watershed in Spring 2012. For six weeks, the "UGA Chew Crew" munched their way through invasive plant species such as Chinese privet and English ivy. They were back on campus in Spring 2013 and 2014. With help from a Ford College Community Challenge Grant, the Chew Crew is expected to expand to the Driftmier Woods in Spring 2015. These prescribed grazing projects have attracted the attention of the community and engaged numerous UGA courses from multiple departments.

[24] McCoy, D.; and Sobecki, J, 2001. "Identifying Benefits and Barriers Associated with Reforesting Riparian Corridors".

EDUCATE AND REACH OUT

Education and outreach is key to changing individual and collective behavior and improving watersheds. The Advisory Committee targets its education efforts at residents living within the Campus Watershed including school children, homeowners, and University students, as well as the University community that works and studies in the Campus Watershed. Schoolchildren are seen as a particularly valuable audience due to the effect they have on the actions of their parents.

PHOTO 8. *Environmental Practicum students interact with Barrow Elementary students.*

1. CONTINUE AND EXPAND TEACHING PARTNERSHIP WITH ELEMENTARY SCHOOLS

Students in three recent UGA Environmental Practicum classes taught classes on watershed health at Barrow Elementary School which is located at the headwaters of Lilly Branch. These programs focused on pollution problems and solutions and the aquatic ecosystem. They were developed to meet Georgia Performance Standards for multiple grade levels. The program, designed in collaboration with Barrow School teachers, is intended as a model for elementary school students and will serve the greater community by educating our youth and encouraging them to take ownership over their interactions with the environment. The students will then spread that message to their families and friends. Students in the Spring 2013 Environmental Practicum developed a new lesson plan for watershed outreach as detailed in Appendix K and facilitated a partnership with EcoReach, an organization of graduate students at the Odum School of Ecology. Their goal is to share ecological lessons with K-12 students as well as Barrow School teachers to continue these watershed education efforts. In the Fall of 2014, students worked with educators at Barrow Elementary School to incorporate the Chew Crew into their enrichment program, using goats to teach students about watersheds. Educational efforts will be extended to Chase Street Elementary School and Clarke Middle School, which serves students in the Tanyard Creek watershed.

2. INVOLVE UGA CLASSES

Numerous classes have been involved in different aspects of this project. The most extensive work has been done by the graduate-level Environmental Practicum class which offers students the chance to apply their studies to real-world problems, including the development of this watershed plan. The Fall course is made up of law students who look at policy aspects of watershed restoration, while the Spring course includes students in law, environmental design, engineering, ecology, and other programs. Students in future Practicum classes will be involved in the implementation of this plan.

Numerous classes in the College of Environment and Design have completed projects in these watersheds. An undergraduate design studio has been using the stream site next to Ben's Bikes for several years. Initially, they focused on creating a community garden and cleaning out the stream area. The next studio class will focus more directly on restoration options for the channel and surrounding¬ flood plain.[25] In Fall 2013, a graduate studio chose to focus on restoration plans for the Cloverhurst Branch of Tanyard Creek near Bolton Dining Hall. Previous studios have created green infrastructure plans for campus, much of which would positively impact stream health and water quality. Future studio courses can help implement aspects of this plan.

[25] http://www.youtube.com/watch?v=GyWqRHSGDHY

Restoration also presents opportunities in independent study and internships. An undergraduate history intern investigated the history of the watersheds. See Appendix L for this history.

Finally, flow levels, IDEXX testing, and other fieldwork possibilities offer real-world experience for a field-monitoring class in the School of Forestry and Environmental Health Sciences.

In conclusion, the restoration of the watershed offers a real-life laboratory for stream restoration methods and policies for many disciplines.

3. ENGAGE THE COMMUNITY

PHOTO 9. *Part of the audience at the April 17, 2013 Community Meeting on the 9-Key Element Plan.*

Our community engagement strategy includes making watershed information and water quality data available to the public electronically and planning targeted educational meetings, activities and outreach campaigns.

Pursuant to this grant, the Advisory Committee has established a web presence for this information, hosted at the UGA. Office of Sustainability's website. The web presence catalogues projects and studies completed by UGA faculty and students from an array of schools and programs. It also includes the history of the watershed and historic uses of the water bodies.

The Advisory Committee hosted two community meetings – one in Spring 2012 and another in Spring 2013 – to elicit input for and to disseminate the results of this watershed plan. At the Spring 2013 meeting, around 20 attendees, including the Athens Clarke County Commissioner representing the district that contains the Campus Watersheds, heard presentations on the progress of the the grant and a range of watershed issues including the general history of the watershed, illicit discharge, dumpster runoff, pet waste, the underground storage tank remediation,, and BMP's for lawn care to reduce nutrient and pesticide pollution and to promote water efficiency.

MONITOR TO IDENTIFY SOURCES OF POLLUTION AND EFFECTIVENESS OF MANAGEMENT STRATEGIES

By monitoring water quality and by walking streams consistently over a period of months to identify "hot spots" for closer investigation, the Advisory Committee has eliminated several sources of pollution. These efforts must be ongoing in order to assure that new problems are quickly identified and addressed.

In Spring 2014, a new faculty member at the Odum School of Ecology who specializes in urban stream issues will join the Advisory Committee. At this point, the committee will re-evaluate the existing water quality monitoring plan and update it in order to more effectively identify hotspots and sources of pollution. The Advisory Committee will continue to use Brown and Caldwell's data for the eight sampling points throughout the Campus Watershed and will add new sampling sites as reflected in the updated water quality monitoring plan.

PHOTO 10. *UGA faculty member leads Environmental Practicum students on a walk of the watershed in Spring.*

The Advisory Committee will continue to work closely with the UGA Grounds Department, which has its own monitoring program in place. In previous years, their sampling had found elevated flows and bacteria downstream of Sanford Stadium during a home game. Upon entering the culvert to identify the source, they found a crossover flow caused by a crushed sanitary sewer line and a leaking line draining from an office in the bowels of the stadium that were both quickly repaired. Subsequent testing during the Fall 2012 football season showed bacteria and flow levels within accepted limits.

In addition to identifying pollution sources, water quality monitoring data will help evaluate the effectiveness of BMPs and SCMs over time, as measured against criteria established in the Plan Review (Section VI of this document).

5 THE NEXT STEPS

REVIEW PLAN ANNUALLY

Each year the Advisory Committee will review the Watershed Management plan and make updates. This is the first update of the original 2013 plan. The Advisory Committee will also prioritize implementation for the year.

AMEND MONITORING PLAN AND EXPLORE MODELING OPTIONS

With input from the River Basin Center (RBC) Director for Science, who assumed his position in January 2014, the Advisory Committee will reevaluate the water quality monitoring plan and investigate new modeling tools and partners to help us prioritize installation of SCMs.

DEVELOP MORE INFORMED FUNDING STRATEGY AND PROCURE FUNDING

To fund the BMPs and the educational component of the Plan, the Advisory Committee seeks to find initiatives that overlap with the goals of other entities, including the organizations represented by the Steering Committee. These include: at UGA, the Grounds Department, University Architects, the Office of Sustainability, and the River Basin Center; and at ACC, the Public Utilities Department, the Stormwater Management Program and the Water Conservation Office. We will continue to find ways to incorporate the watershed restoration activities proposed in this plan into both the routine work plans and the special projects of these organizations.

In addition, we will pursue grant opportunities. We expect to reapply for a Clean Water Act Section 319 grant to implement this plan in 2014. We will investigate the feasibility of a Five Star Restoration grant, which supports riparian restoration while also emphasizing local environmental stewardship and environmental education grants. The Tanyard Creek Chew Crew and the Society for Conservation Biology won a 2014 Ford College Community Challenge to expand the Chew Crew operations on campus. These funds are allocated towards developing Driftmier Woods as a prescribed grazing site, developing a "junior herders" program with Barrow Elementary School, and promoting interdisciplinary collaboration via a student design challenge.

We will continue to rely on UGA's great intellectual resources to undertake monitoring and restoration activities at no or at very low cost. Class projects and thesis work have and may continue to aid water quality monitoring, implementation, and outreach steps.

SCHEDULE AND MILESTONES

DOG WASTE BMPS

- Install 5 receptacles w/n watershed and begin waste removal
- Identify potential future sites for receptacles in the headwaters of LillyBranch
- Develop media campaign to promote the use of the receptacles
- Install additional receptacles in Lilly Branch
- Maintain the media campaign
- Evaluate need for active enforcement of pet waste disposal ordinance
- Install additional receptacles
- Continue waste removal

Milestones:

- **Year 2**: Install 3 receptacles
- **Year 3**: Develop communication campaign
- **Year 5**: Install 2 more receptacles

DUMPSTER BMPS

- Continue to replace and repair dumpsters
- Initiate dumpster education and repair/replacement campaign for dumpsters on privately owned land.
- Train University and ACC personnel regarding dumpster maintenance and management

Milestones:

- **Year 2**: Repair and/or replace 10 dumpsters
- **Year 3**: Repair and/or replace 10 dumpsters
- **Year 4**: Repair and/or replace 10 dumpsters
- **Year 5**: Review survey and evaluate needs

OUTREACH AND EDUCATION

- Continue to develop watershed website
- Update and maintain website and online database
- EcoReach takes over the Environmental Practicum's elementary education campaign at Barrow School
- Continue education and outreach to the community
- Continue illicit discharge hotline
- Continue extension program for home owners in areas of reduced fertilizer and pesticide use and water efficiency
- Develop and host workshops and/or educational materials for facilities staff to improve nursery management and materials storage to reduce pollutants
- Continue education and outreach to the community through Athens-Clarke County Stormwater Office

Milestones:

- **Year 1**: Transition from Environmental Practicum to EcoReach carrying out the education campaign at Barrow Elementary
- **Year 2**: Initiate education campaign at Chase Street Elementary School and Clarke Middle School (Tanyard)

WATER QUALITY MONITORING

- Update the current water quality monitoring plan to better identify hotspots, pollution sources and trends
- Continue current monitoring efforts
- Conduct additional monitoring to evaluate progress

- Identify hot spots and areas of concern and work with project partners to repair leaking infrastructure and fix problems

Milestones:

- **Years 1-10**: evaluate monitoring and identify hot spots. Fix leaks and address new non-point sources as they arise.

RIPARIAN BUFFER MANAGEMENT AND INVASIVE SPECIES REMOVAL

- Develop strategy for expanding existing riparian buffers
- Research prescribed grazing efforts to evaluate their effectiveness and impact
- Coordinate amongst groups which already have interest or tools to launch targeted invasive species removal activities, using Spring 2012 Environmental Practicum report as guide
- Began riparian buffer expansion efforts

Milestones:

- **Year 1**: Research prescribed grazing and develop strategy for increasing riparian buffers
- **Year 10**: Reduce the quantity of invasive species in the watershed and along stream banks and increase the width, extent and functionality of riparian buffers

STORMWATER CONTROL MEASURE

- Design and install stormwater wetland at Lake Herrick
- Include Storm Water Control measures on new construction including the Terry College of Business and the new Science Center
- Remove turf grass around the Ramsey Center and replace with native species and bioswales
- Evaluate Stormwater Control measures for the Steam Plant Stream parking lot
- Meet with Senior UGA administrators to discuss the importance of a concerted UGA strategy to manage stormwater in order to restore Campus Streams and protect water quality in the Oconee River with the goal being a stated commitment of intent and funding for restoration
- Meet with the ACC Commissioners whose districts comprise the watershed, and relevant ACC staff for the same purpose as outlined above
- Start dialogue with Georgia Game Day Condominiums about green roof possibilities
- Install bioretention basin at Cobbham Historic Neighborhood Park
- Conduct outreach on cisterns and on-campus water reuse
- Evaluate the effectiveness of campus cisterns and make future recommendations.
- Identify, evaluate, design, and install additional target SCM areas in the upper third of each watershed section, then install new SCMs
- Work with UGA Grounds department and University Architects to implement additional SCMs on campus.

- Coordinate with UGA classes in the College of Environment and Design on projects in the watershed
- Daylight area of Tanyard Creek under Hope Public Housing
- Identify additional projects for the downstream reaches of the watershed

Milestones:

- **Years 1-3**: identify, design and begin implementation of SCMs
- **Year 3**: lower levels of fecal coliform at up-stream sampling sites by 25%
- **Years 4-10**: move down into the rest of the watersheds. Lower levels of fecal coliform at all sampling sites to the state standard of 200 cfu/100 ml. Lower levels of TP, TN and Copper to State Standards or equivalent.