Feasibility Analysis for Biological Water Reclamation Systems

Saving Water and Money Through Innovative Wastewater Treatment on UGA Campus

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I. Introduction

On average, UGA purchases 482 million gallons of water each year, at a cost in excess of $5 million. Approximately 4.5-4.8 million gallons are utilized for irrigation purposes and another 75-100 million gallons[1] are utilized for cooling tower makeup (to replace water lost through evaporation in the cooling towers). At the current rate structure, water used for cooling tower makeup costs the University at least $700,000, and may actually cost in excess of $1 million each year.

The U.S. Bureau of Labor Statistics' Consumer Price Index for 2012 estimated that, nationwide, municipal water rates increased by 2.1% from the previous year. Locally, Athens-Clarke County increased water rates two years ago by 10% with another rate increase expected this summer. Given this, the University can expect to see significant increases for potable water charges.

Currently the University is using potable water for cooling tower makeup. Non-potable water, generated according to the Georgia Department of Natural Resources' guidelines,[2] could be used for this purpose. By using potable water for cooling tower makeup, the University is incurring an unnecessary expense, contributing to heightened demand on increasingly scarce water resources, and missing a vital opportunity to further Sustainable UGA's mission. We propose a biological water reclamation system generating non-potable water for use for cooling tower makeup. This would create significant cost savings for the University while improving water security, furthering campus sustainability, and providing educational and research opportunities. If implemented, such a system would help further the goal of the University's *2020 Strategic Plan* to reduce potable water use by 40% by 2020.

This report is intended to provide relevant campus decision makers with more information about biological water reclamation systems to evaluate whether to invest money in a full-scale feasibility study. The report will first set forth a brief history of previous enquiries undertaken by the University regarding a biological water reclamation system. Next will follow a brief explanation of what biological water reclamation is. This section will include examples of some of the possible technologies and the partners we might engage with to bring one or more of these systems to campus. This will additionally be developed through case studies of extant systems and a description of efforts to bring this technology to Emory and Georgia Tech.

The bulk of the report will address the costs and benefits of a biological water reclamation system to the University. This section will provide more detailed information on water consumption for cooling tower use, the financial considerations the University faces in making a decision, and possible benefits of a biological water reclamation system. Included in this material will be an analysis of the various contractual methods for funding such a system as well as attempts to address the concerns articulated by members of the University's administration brought up in interviews conducted while researching this project. The report will conclude with a brief summary of some of the possible outcomes and a glossary of terms.

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1 This number may be low by as much as 30% per a conversation with Bob Salvatelli with Sustainable Water.

2 State of Georgia Department of Natural Resources Environmental Protection Division Water Protection Branch, *Guidelines for Water Reclamation and Urban Water Reuse* (Revised March 30, 2012), available at http://www.gaepd.org/Files_PDF/techguide/wpb/GAEPD_Guidelines_WaterReclamation_Reuse_Y2012.pdf

II. HISTORY

In 2010, while working on an outreach project for the University of Zamorano in Honduras, a team of UGA faculty and UGA's Office of University Architects began researching the viability of using constructed wetland treatment technologies for transforming sewage into useable water for crop irrigation. As the group learned about smaller footprint tidal flow wetland systems, they decided to incorporate the technology into the CED Jackson Street Building renovation. CED was receptive to the idea and the Office of University Architects (OUA) instructed the architect of record to hire Worrell Technologies, the patent holder for Living Machine Technology, to produce a feasibility study for incorporating a Living Machine into the future phase II expansion of the JSB. An initial meeting involving Worrell, OUA, Environmental Safety Division (ESD), and Facilities Management Division (FMD) was held to discuss the merits of the project and to gather feedback specifically from FMD and ESD. The initial project concept would treat wastewater from JSB, Bishop House, and a few other north campus buildings. Treated water would be incorporated into the cistern reuse system, constructed in phase I of the JSB renovation. It was understood that the value of this system would be pedagogical, as the amount of water treated would not produce significant enough savings to create a short-term life cycle payback. An initial concept and feasibility study were completed and remain for consideration if and when a Phase II expansion of the CED facility ever occurs.

In 2013, the Office of Real Estate and Space Management became aware of a project developing at Emory to reclaim campus wastewater for reuse in cooling towers and irrigation. Emory was working with Sustainable Water (SW), an investment company that specializes in constructing and operating water reclamation systems. Sustainable Water was teaming with Worrell Technologies to develop plans for a split hydroponic/tidal flow wetland system on the scale of 150-200,000 gallons per day. Sustainable Water would construct and operate the reclamation facility on Emory's campus and provide water back to Emory at a guaranteed lower rate than would be charged by the city of Atlanta. The water purchase agreement was projected to create significant savings for the university. It also presented faculty and students with a unique research facility and gave the university a substantial PR tool.

Shortly thereafter, Georgia Tech's Capital Planning and Space Management Office engaged with Sustainable Water to produce a feasibility study focused on Tech's planned EcoCommons development. Like Emory, Tech was interested in the savings it could generate by using reclaimed water for non-potable uses such as cooling tower make-up and irrigation. At this point, UGA's Real Estate and Space Management Office invited a representative from Sustainable Water and Worrell Technologies to speak to campus administrators about the two Atlanta projects. Representatives from OUA, FMD Energy Services, FMD Engineering, Office of Sustainability, and the Associate Vice President for UGA's Environmental Safety Division attended. In the meeting, water reclamation technologies were addressed as were the potential savings a system could create for the University. No immediate action resulted from the meeting, but a core group of attendees remained interested in the concept and wanted to investigate it further.

For about a year, this project stayed on the shelves, except as a conceptual study for CED or Engineering class projects, until Danny Sniff (Associate Vice President for Facilities Planning) asked that a tidal flow wetland be considered at the current Vet School to treat the bio-digester ef-

fluent. Bio-digesters are used to break down and sterilize animal carcasses and are seen as a more modern and efficient technology than incineration. Three biodigesters exist on campus: one at the VetMed complex, one at the Animal Health Research Center, and one at the Rhodes Animal Science Center. The problem with the VetMed digester (which is also indicative of problems at the other two digesters) is that Athens-Clarke County has opposed allowing the strong effluent produced by the digester into the sanitary sewer. In an interview with Joel Bacon, facilities manager at the Vet School, the school has not been able to use the digesters as intended. Currently, animal carcasses are incinerated at a different facility. A study was conducted in 2012 to look at the effluent's effect on BOD in wastewater; however no conclusion or decision has been made on the allowed use of the digesters.

This issue was discussed in an informal meeting held with Sustainable Water, FMD Engineering, the Office of Sustainability, and Real Estate and Space Management in the fall of 2013. Though no concrete plans or agreements were made after this meeting, Sustainable Water suggested that UGA look beyond just treating the digester effluent and towards treating large volumes of wastewater within the biodigester sewersheds, as the cost for a facility with a large treatment capacity would not be much greater than one with a small treatment capacity and the reclaimed water that a large system could produce would provide significantly larger savings to the University. In addition, Sustainable Water recommended that UGA complete a "water footprint assessment" that would aggregate water/sewer rates, estimate water use, and define the largest water users on campus. This could be a first step towards a more comprehensive feasibility study with Sustainable Water. The feasibility study is seen as a first step in planning for a reclamation system. Per the model proposed by Sustainable Water, the cost for the feasibility study is one of the only up-front costs the University would have to cover. If the feasibility study proved favorable, Sustainable Water would shoulder the costs of design, construction, and operation of the reclamation facility. UGA would pay Sustainable Water a set rate for water, which would be pegged below municipal water rates for a set amount of time (usually 10-20 years). At the end of the term, UGA could either take over the operation and maintenance of the system or re-enter into an O&M contract. Projected savings to the University, if similar to Tech and Emory, would be in the millions of dollars.

Both Tech and Emory have already worked with Sustainable Water to complete a feasibility study. It is the authors' understanding that costs for the study ranged from $30,000--$50,000. After completion of the study, Emory contracted with Sustainable Water to design, construct, and operate a facility on their campus. Currently that facility is under construction. Tech completed a feasibility study and is in the process of discussing with the Board of Regents the legalities of entering into a water purchase agreement with Sustainable Water. Per a conversation with Jason Gregory of Tech's Capital Planning and Space Management Office, Tech is ready to move forward with the project if given the green light by the Board of Regents.

Although the initial impetus for this research revolved around the possibility of implementing a biological waste water reclamation system to enable the use of the three bio-digesters on campus, our research quickly showed that it is likely more efficient and cost effective to emulate Emory and Tech and expand the scope of this concept to treat a larger volume of the campus' waste water and use this for cooling tower make-up.

The goal of this project is to provide enough information so that UGA's administrators can determine whether the projected benefits of such a wastewater reclamation system warrant the investment of a professional feasibility study. This paper does not seek to substitute a feasibility study produced by a professional consultant. However, it does emulate the studies completed for Tech and Emory and has compiled much of the same information that would be needed for a future feasibility study should one be conducted.

III. THE ART OF BIOLOGICAL WATER RECLAMATION

The concept of using biological systems to reclaim water from wastewater first began with John Todd's groundbreaking idea of living technologies that "bring people and nature together in fundamentally radical and transformative ways."[1] He defines living machines as devices made up of living organisms, usually housed in man-made casing or structure, that function together to perform some type of work.[2] Although living technologies could offer solutions for a variety of problems, the type Todd is most well-known for offers a means of filtering wastewater through a biological reclamation system. These systems are unique in that they do not require harmful chemicals, they use plants and animals in the treatment process, and they are aesthetically pleasing.[3] The main benefit of these ecologically-based water reclamation technologies "is a significant reduction in energy requirements."[4]

Types of Systems

As mentioned previously, biological water reclamation is being considered at other Georgia institutions of higher education. At both Emory and Tech, two main types of systems are being considered: Tidal-Flow Wetlands and Hydroponic Treatment Systems. The Tidal-Flow Wetlands (TFW) are the direct brainchild of Todd, popularized by the company Living Machine Systems. The TFW's primary method for treating wastewater is through mimicking the ocean's tidal flows to pass the wastewater through substrate that acts as a filter. TFW utilizes a series of anaerobic and aerobic tanks with a constructed wetland to filter the wastewater. These different tanks or wetlands repeatedly fill and drain, mimicking tidal events.[5] This design is extremely energy efficient, using two to four times less energy than aerated wetlands or conventional mechanical treatment plants, as well as robust and scalable[6]. Wastewater is kept below ground with plants on top, mitigating odors and making these systems easy to integrate with landscaping.[7]

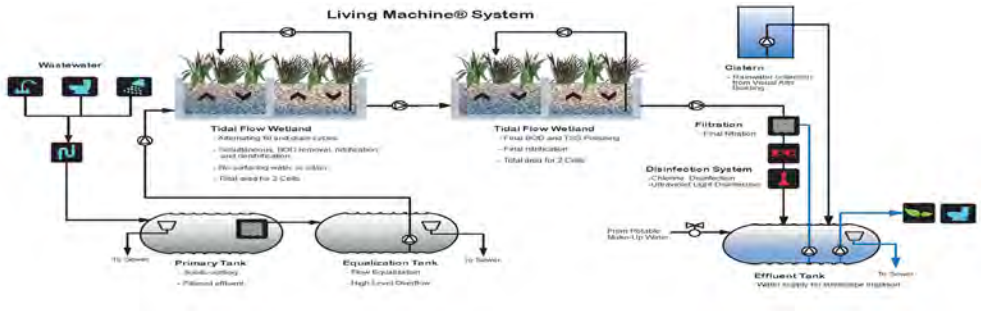

Figure 1. Tidal Flow Wetland Diagram

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1 Todd, John & Nancy Todd, *From Eco-Cities to Living Machines* (Berkeley: North Atlantic Books, 1993), 171.

2 *From Eco-Cities*, 167.

3 EPA, *Wastewater Technology Factsheet: the Living Machine*, EPA 832-R-01-004 (Washington: Office of Water, 2002), 1.

4 Sustainable Water, *Feasibility Study Black Water Reclamation and Reuse: Georgia Institute of Technology* (Richmond: Sustainable Water, 2013), 14.

5 Sustainable Water, 15.

6 Sustainable Water, 15.

7 Sustainable Water, 16.

The second type of system, Hydroponic Treatment, relies on complex adaptive ecosystems to break down organic waste in water, incorporating a series of interconnected, sequentially-operated biological reactors with lush vegetation housed in a greenhouse.[8] The plants' root systems "provide a natural habitat for microbial organisms" that break down waste.[9] This system uses increased diversity of microbe and bacteria species, providing as much root surface area as possible for these species to live on, in such a way that allows for significant reductions in physical footprint and sludge production compared to traditional biological treatment systems like the Living Machine.[10] Rather than relying on substrate to break down waste, the Hydroponic System utilizes the plants and microbes living on their roots to treat the wastewater. Hydroponic Treatment Systems are monitored by software that provides real-time data as to the influent/effluent quality and any potential threats to the system.[11]

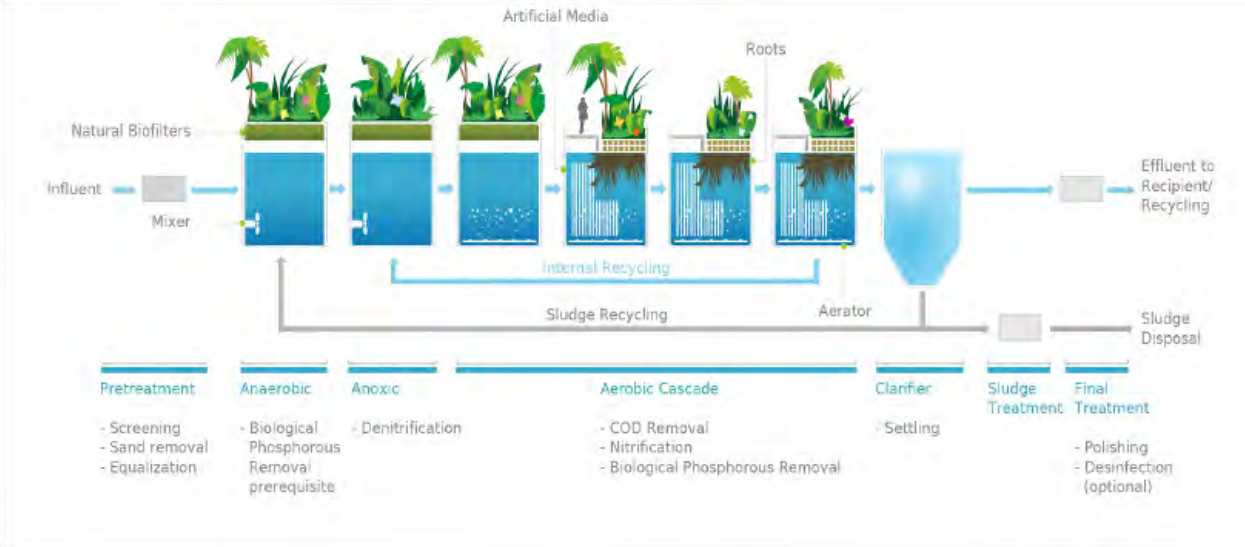

Figure 2. Hydroponic Treatment Diagram

Case Studies

Our research team visited two biological water reclamation systems to gain an idea of how these technologies function: an outdoors TFW system in Greensboro, NC and a TFW system contained in a greenhouse at Furman University. When planning a new middle and high school for Northern Guildford in Greensboro, the school board and taxpayers decided to invest in an onsite system rather than spend millions in construction costs to connect to the nearest municipal wastewater treatment plant.[12] This hybrid system is comprised of horizontal flow and tidal flow wetland cells that naturally filter all the wastewater from both schools, on average 12,000 gal/day.[13] We

8 Sustainable Water, 14.

9 Sustainable Water, 14.

10 Sustainable Water, 14.

11 Sustainable Water, 14.

12 "Guilford County Schools, Greensboro, NC," *Living Machines*, http://www.living-machines.com/Portfolio/Schools-Universities/Guilford-County-Schools,-Greensboro,-NC.aspx (accessed 27 April 2014).

13 Guilford County Schools.

spoke with the technician Dave Hicks about the benefits and costs of this system. He spoke of the water being reused to irrigate the two schools' soccer fields. This technology uses less energy than other water treatment systems, but requires a much larger footprint for the wetland's surface area. When the students are out in the summer, it is difficult to obtain enough "food" for the system to be healthy and provide enough water needed to irrigate the soccer fields. Dave said that he only has to spend two hours per day on maintenance for the system. The design of the Guildford TFW system may work for the purposes of these suburban schools; however it may be more difficult for a university to find enough land to accommodate the TFW's footprint requirements for treating the entire campus' wastewater.

The second system we visited, at Furman University in Greenville, SC, uses a tidal-flow wetland process housed inside a greenhouse. The technology cycles the wastewater between cells topped with lush vegetation, with a small enough footprint to fit under a greenhouse, and uses tidal flows for treatment. This system treats 5,000 gal/day and its design is significantly more compact than the one in Guildford due to advances in technology and a different design. This system, how-

Figure 3. Guilford TFW: Anaerobic Treatment Stage

Figure 4. Guilford TFW: Aerobic Treatment Stage

Figure 5. Furman TFW: Greenhouse

Figure 6. Furman TFW: Vegetated Cells

ever, costs more than the earlier model TFW design (seen at Guildford) and uses more energy. Dr. Brannon Andersen, Chair of the Department of Earth and Environmental Sciences, said that this system removes at least 50% of the Nitrogen in the wastewater and produces water that passes state regulations. One of the benefits of this system, is that it does not need to be fed during the summer months when there are fewer students on campus. It was designed so that water can be recirculated through the system so that it can survive the periods of lower nutrient levels. Jim Alderage, the technician operating this system, said that he only spends about four hours per week on maintenance. Although the wastewater processing cells were enclosed in the greenhouse, we did not smell any foul odors whatsoever. Indeed, Furman is so pleased with the smaller, trial TFW system that they are planning a much larger system that will treat wastewater campus-wide.

Systems in Georgia

Emory and Georgia Tech in Atlanta currently are exploring how to invest in these technologies with a company called Sustainable Water, and Emory has already broken ground on a system that will treat 150,000—200,000 gpd. Our research team discussed with both schools what types of systems they are planning on installing. For both, a combination of a large Hydroponic Treatment System and a smaller TFW system will be used to treat wastewater on campus. At Tech, the hydroponic component will treat the majority of the waste, since it handles large amounts with a smaller footprint. The TFW component will be incorporated into the landscape to treat the remaining wastewater. Tech's first phase, the TFW system, is estimated to cost about $7 million dollars and will treat 150,000 gpd. Phase II will include a Hydroponic Treatment system that will have an estimated footprint of 2,100 square feet and treat 250,000 gpd.[14] Cost estimates for phase II were not yet available. Reclaimed water will be used mainly for cooling tower make-up water. Both schools anticipate significant savings on water and sewer utilities.

In addition to the water and cost savings generated by these projects, the schools intend to use both systems to provide learning opportunities for students. Emory brought its faculty and staff together with Sustainable Water and held a charrette on how to incorporate the new technology into classroom learning. Tech held a similar charrette and will include testing cells in the Hydroponic Treatment system for students to use as a learning lab.

14 Sustainable Water, 7.

IV. WATER FOOTPRINT ANALYSIS

A Water Footprint Analysis seeks to compile any and all pertinent information concerning overall water and sewage use. This includes information on water consumption, prominent uses of domestic water, and rates paid for water and sewage. It also defines the sewershed within which a reclamation system could be sited and seeks to provide pertinent information, including plans for future development, within that area. As this will include many technical terms, please visit the Glossary for any profession-specific terms and definitions.

Basic Campus Facts

UGA's main campus consists of 455 buildings totaling 16,262,042 square feet[1] within a 759 acre campus. Main campus generally refers to the contiguous campus that is bound by Broad Street to the north; Newton, Finley, and Lumpkin Streets to the west; the Upper Oconee River to the east and the 5 Points neighborhood and South Milledge Avenue to the south. Enrollment was 34,536 students in 2013 and has averaged 34,687 students over the last 5 years. In 2013 there were 9,385 full time employees (faculty and staff) and 630 part-time employees at UGA.[2]

Campus is informally divided into precincts by the Office of University Architects for Facilities Planning. The digesters that serve the Veterinary School, the Animal Health Research Center, and the Rhodes Animal Science Center mentioned at the beginning of this study are located in what are referred to as the "South Campus" and "East Campus" precincts. South Campus generally refers to the parts of main campus south of Cedar Street. East Campus is defined as the part of main campus east of the rail line, north of College Station Road, and west of the Upper Oconee River and Loop 10.

Water Conveyance to and from Campus

The University is supplied potable water from the Athens-Clarke County Department of Public Utilities. The city's drinking water is drawn from three sources: the North Oconee River, the Middle Oconee River, and the Bear Creek Reservoir. Water is then treated at the J. G. Beacham Water Treatment Plant which has a capacity of 36 million gallons a day.[3] Campus water consumption is tracked by city-owned meters at each individual building. Separate meters (also owned by ACC) are dedicated to irrigation. In addition to the ACC meters, UGA has installed its own meters to track make-up water consumption for cooling towers.

It is estimated that UGA purchases approximately 480 million gallons of potable water each year. As would be expected of a major research university campus, water use peaks during the summer months because of the increased need for irrigation and air conditioning.[4]

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1 Moore, Mary T., ed., *UGA 2013* (The University of Georgia, 2013), 93.

2 Moore, 76.

3 "Your Drinking Water from Source to Tap," Athens-Clarke County Public Utilities Department, http://www.envirothon.org/files/2014/Water_Treatment_Brochure.pdf (accessed April 24, 2014).

4 David Spradley, interview by Liverman, Gann, Abrunzo, Energy Services Department, February 14, 2014.

Campus water consumption can be broken down into three major groups: domestic use (sinks, toilets, laboratories, food preparation), irrigation, and utility use (largely cooling towers but also UGA's steam plant).[5] Calculating campus water consumption is straightforward for domestic and irrigation uses, as these are metered separately by Athens-Clarke County. However, determining the amount of water used for campus utilities is more difficult. This water use is recorded by campus sub-meters "downstream" of ACC building meters, many of which provide inaccurate or unreliable readings. A discussion of how inaccurate data was handled for this report is included further along in this paper.

Wastewater collection and treatment is the responsibility of the Athens-Clarke County Department of Public Utilities which operates three facilities to serve the approximate 121,265 residents[6] Athens uses a separated storm water/sanitary sewer system. On main campus, sanitary sewers convey wastewater to the North Oconee Water Reclamation Plant, located off College Station Road across the Oconee River from East Campus. This wastewater treatment plant, completed in 2012, is designed to handle 14 million gallons per day.[7]

Water Rates

Water rates are set by the Athens Clarke County Public Utilities Department. Rates are based on a tiered structure that increases the price per gallon as overall consumption increases. Rates for potable water begin at $4.61 per 1,000 gallons and may increase to $11.52 per 1,000 gallons for consumption that is higher than 25% of the Winter Average. The total amount of sewage that a customer is charged for is inferred from and equal to the total amount of water consumed. Rates for sewage are set at a flat rate of $4.60 per 1,000 gallons. Unlike the water rate, the sewer rate does not increase as the total amount of water consumed goes up. Water consumption for irrigation, if metered separately, is billed at $11.53 per 1,000 gallons. However, no sewage costs are paid as it is assumed that irrigation water is either infiltrated into the soil or evapotranspired and does not enter the sanitary sewage system. Rates are subject to increases. A request to the Athens Clarke County Water Business office for a history of rate increases within the last five years has not been returned. However, David Spradley, Director of UGA's Energy Services Department, states that "two years ago or so the water/sewer rate(s) increased approximately 10%".[8] Mr. Spradley also states that from conversations with ACC he expects to see another rate increase but that the rate increase amount has not been calculated yet.[9]

Issues Pertaining to Data Collection of Cooling Towers Make-up Water Consumption

One of the single largest uses of water on campus is for cooling towers. A general rule of thumb for determining cooling tower consumption is that approximately 30% of overall water consumption is used for this purpose. Since most of the water supplied to cooling towers is evaporated, many institutions meter cooling tower water separately in order to receive a rebate on the

5 Ibid., February 14, 2014.

6 "State and County Quick Facts", U.S. Department of Commerce United States Census Bureau (accessed April 24, 2014).

7 "ACC Water Reclamation Facilities", Athens-Clarke County Unified Government (accessed April 24, 2014).

8 Spradley, David, email message to Benjamin Liverman, April 3, 2014.

9 Ibid., April 3, 2014.

inferred sewage costs. For large institutions like UGA this can result in significant savings. To date, UGA has separately metered its cooling towers. However, it is not currently requesting a rebate for sewage from Athens Clarke Count. This is due to a few factors.

First, the sub-meters UGA uses to meter cooling tower consumption have been unreliable. From a conversation with Johnathon Lanciani and Bob Salvatelli of Sustainable Water, this is not at all an uncommon issue facing larger institutions. *The Blackwater Reclamation & Reuse Feasibility Study* produced by Sustainable Water for Georgia Tech, states that "as meters begin to age they have a tendency to underreport usage". Over-reporting is also a possible occurrence. Johnathon Lanciani explains that a variety of reasons can cause meters to become inaccurate and that a meter may spin freely after an initial push, resulting in a higher, inaccurate reading.

Compounding this problem is the sheer number of cooling towers on campus that must be tracked with limited personnel and the added problem that many meters are very hard to access. Some are placed high up in mechanical rooms towards the ceiling, making them difficult to access and service.[10]

In addition, in the event there is a mechanical problem, cooling tower make-up may flow constantly until it is discovered during a routine inspection. If and when this occurs, make-up water would largely overflow into the sanitary sewer instead of evaporating through the cooling tower. In these instances, it would be difficult to determine how much water was evaporated and how much should be charged with the sewage rate.

These issues make it difficult for UGA to verify its cooling tower use and therefore build a case for claiming sewage charge exemptions from water used for cooling tower make-up. Energy Services is focusing on replacing or repairing broken meters and has work order requests in for about a dozen of them.[11] However, this may be an ongoing issue as campus has over 65 sub-metered cooling towers that must be monitored and maintained.

Obtaining accurate cooling tower consumption data for the purposes of this report has been difficult and confirms Mr. Spradley's information about inaccurate metering. This group has found several instances where meter readings for cooling tower use were well above the upstream meter (owned by ACC) for total building consumption. This information was shared with Mr. Spradley who confirmed that the readings were inaccurate. Mr. Spradley suggested that the group replace the inaccurate readings with an estimated usage amount of 300,000 gallons per meter per month. Mr. Spradley explains that this would be *just* an estimate, and would change depending on the time of year. However, for this study, meter readings that were determined to be inaccurate were replaced with a reading of 300,000 gallons per month regardless of the time of year. The first chart below shows cooling tower usage from 2011-2014 based off sub-meter readings. It is followed by a chart that shows cooling tower usage with identified inaccuracies replaced with the number Mr. Spradley suggested above. Months with noted inaccuracies are highlighted in yellow in the chart and represent an over-reporting of more than 100 million gallons. (See Figures 7 & 8)

10 Spradley, David, email message to Benjamin Liverman, March 28, 2014.

11 Ibid., March 28, 2014.

Cooling Towers: Combined Sewersheds 1, 1a, 2 (2011-2014)

	January	February	March	April	May	June	July	August	September	October	November	December
2011					2,410,430	5,131,012.00	0.00	2,391,940.00	8,317,640.00	1,878,320.00	1,099,230.00	87,682,980.00
2012	705,100.00	1,556,186.00	2,741,320.00	2,131,390.00	10,192,640.00	1,868,470.00	28,595,140.00	3,913,671.00	3,500,090.00	971,760.00	754,770.00	985,460.00
2013	813,190.00	567,690.00	543,768.00	996,532.00	1,078,940.00	5,646,320.00	2,067,040.00	3,302,828.00	2,618,370.00	1,389,510.00	577,410.00	962,270.00
2014	356,720.00	394,530.00										

Figure 7. Cooling Tower Consumption, May 2011-Feb 2014 (includes inaccurate readings)

Cooling Towers: Combined Sewersheds 1, 1a, 2 (2011-2014)

	January	February	March	April	May	June	July	August	September	October	November	December
2011					2,410,430	2,565,506.00	2,565,506.00	2,391,940.00	1,878,488.00	1,878,320.00	1,099,230.00	1,282,980.00
2012	705,100.00	1,556,186.00	2,741,320.00	2,131,390.00	1,358,340.00	1,868,470.00	4,092,170.00	3,913,671.00	3,500,090.00	971,760.00	754,770.00	985,460.00
2013	813,190.00	567,690.00	543,768.00	996,532.00	1,078,940.00	4,036,689.00	2,067,040.00	3,302,828.00	2,618,370.00	1,389,510.00	577,410.00	962,270.00
2014	356,720.00	394,530.00										

Figure 8. Cooling Tower Consumption, May 2011-Feb 2014 (replaces inaccurate meter readings with number suggest by Energy Services)

It must be noted however, that for the purposes of this paper a complete analysis of cooling tower consumption was not accomplished. Only "obvious" spikes in water consumption (where cooling tower sub-meter readings were greater than the building meter readings) were identified and altered. This analysis does not claim to have identified all over-reporting. Nor did it make an attempt to identify instances of under-reporting. This second point is of importance because, as the group learned from its conversation with Sustainable Water, underreporting of cooling tower use is a common problem as meters begin to age, and could possibly be a significant issue here at UGA.

Focus Area

Two of the digesters (the Vet Med digester and the AHRC digester) are located in South Campus both within the Vet School Complex. The third digester, the Rhodes Animal Science Center digester, is located in the southeastern edge of East Campus, close to Loop 10.
As the initial driver behind this study is based on treating the effluent from the digesters, the authors focused attention on the sewersheds within which the digesters are located.

A sewershed is a land area in which a sewer system drains to a single point, much like a watershed but dependent on the network and flow of sewage pipes rather than the topography of the land.[12] (See Figure 9)

The authors found it important to define the sewersheds that encompassed the digesters for two reasons. First it would let one know the type of facilities that contribute waste in the sewershed. This is valuable as, for example, a digester will produce a wholly different type of wastewater than a typical residential home. Knowing the potential contributors to the waste stream may be of value when making decisions about potential treatment methods. Second, it would reveal the quantity of facilities within the sewer shed. This allows one to estimate the sewage contribution from non-UGA buildings for which there was not access to water-use data.

The sewershed for the Vet Med and AHRC digesters (Sewershed 1) includes most of south campus. It extends as far north as East Green and Soule Streets to include the Ecology and dance building. To the west it extends almost to Lumpkin where it picks up most of the UGA Athletics facilities. To the south it includes much of the 5 Points neighborhood south to University Drive and Driftmier Woods, and is bound to the east by East Campus Road.

12 Zidar, Kate, *Citizens' Guide to The Sewershed* (Pratt Institute Graduate Center for Planning and the Environment, 2005), 8.

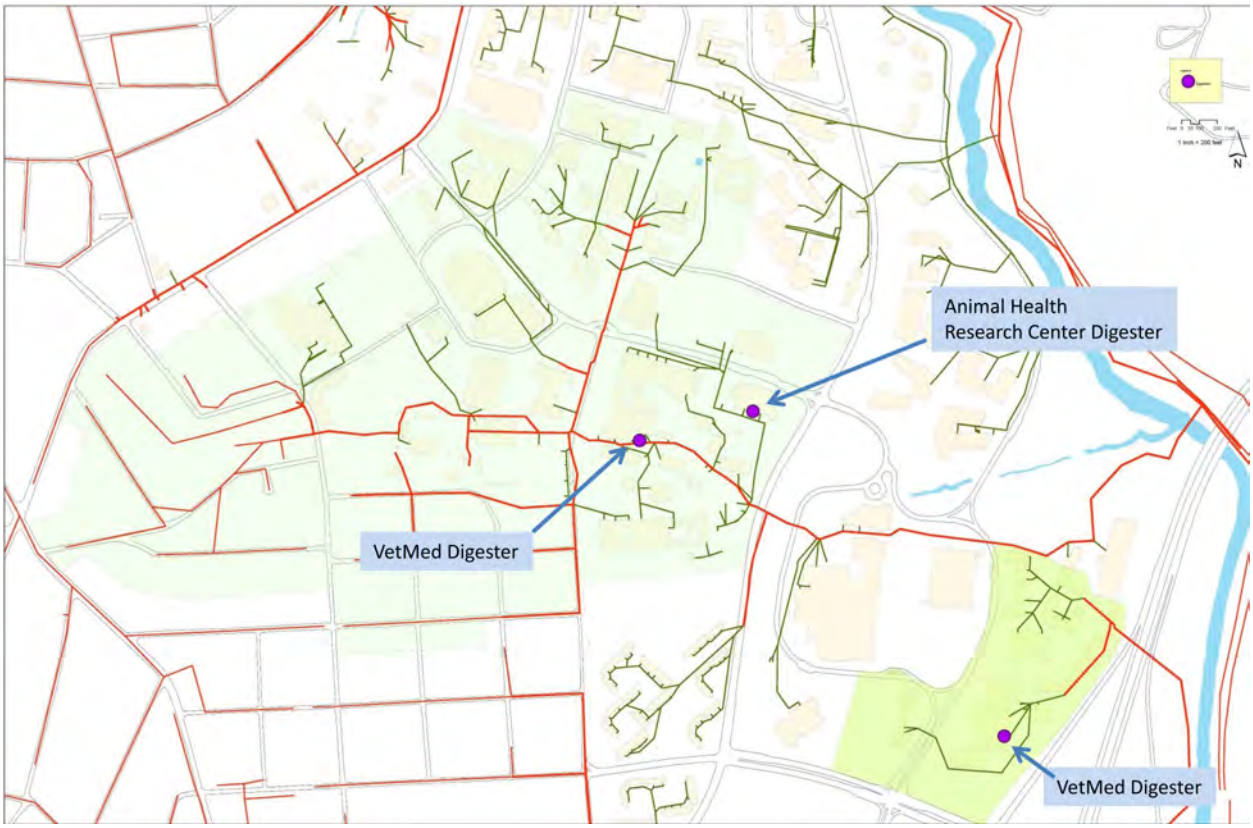

Figure 9. Map showing approximate location of digesters (purple), sewer lines (green and red), and delineated sewersheds

The second sewershed (Sewershed 2) which includes the Animal Science Center digester encompasses about one third of East Campus to include 5 dormitories, the UGA Visitors Center, the Rhodes Animal Science Center, and the Facilities Management East Shop. (See Figure 10)

Sewage Produced in Sewershed 1

- total daily sewage flow: 310,234.25 gpd to 405,004.46 gpd

In Sewershed 1, all sewage is conveyed to a point approximately 670 feet south of the intersection of Carlton Street with East Campus Drive (on the west side of East Campus Drive at the boundary of the current VetMed complex). Approximately 78 UGA buildings, as well as 215 non-campus structures are located within this sewershed. The majority of non-campus buildings are private residences but include Barrow Elementary School, a few businesses along Milledge Avenue, the U.S. Forest Service Building, and several multi-residence apartments.

Water meter data provided by Mr. Spradley shows that in 2012 and 2013 the sewage charges for all the buildings within Sewershed 1 were $392,747.00 and $411,420.00 respectively. Dividing these sums by the Athens-Clarke County per gallon sewage rate of $0.0046, one can estimate that these buildings produced 85,379,782 gallons in 2012 (or 233,917 gpd) and 89,439,130 gallons in 2013 (or 245,038 gpd). This, however, does not account for UGA's cooling tower water use (which typically does not return to the sanitary sewer), nor is this gallon per day estimate adjusted to reflect changes in use from month to month throughout the year.

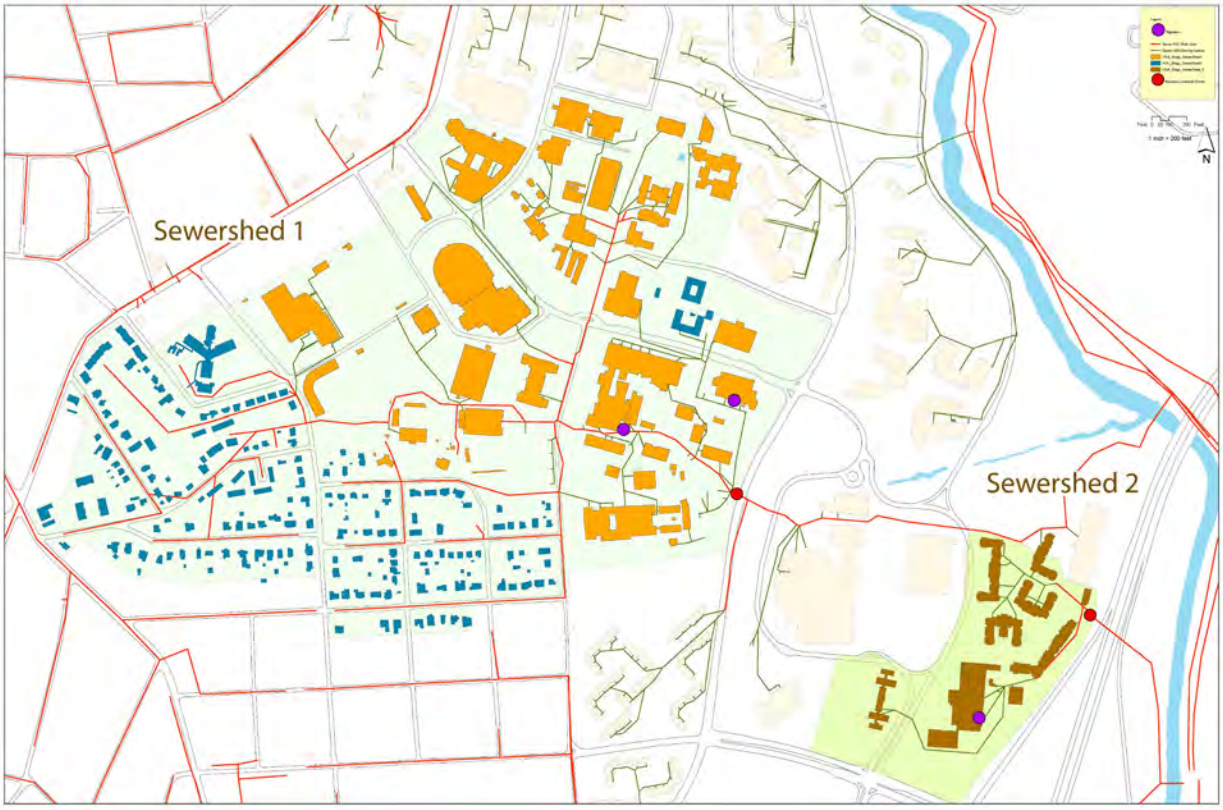

Figure 10. Map shows sewersheds 1 & 2. Sewershed 1 includes orange UGA buildings and blue ACC buildings. Sewershed 2 shows UGA buildings in brown. Digesters are shown with purple dots. The bottom of each sewershed is shown with a red dot.

To create a baseline estimate of sewage produced by the 215 non-campus structures the authors made a conservative assumption that all non-campus structures would be calculated as a typical residence. The Water Business Office of the Athens Clarke County Public Utilities Department was contacted to inquire about an estimate for per-household sewage. In an email response dated March 28th, 2014, Michelle Stroud writes that a household of three people produce 4,500 gallons of sewage per month (based on a 30 day average).[13] According to the U.S. Census data, the average household in Georgia has 2.7 people.[14] Therefore, the estimate provided by the ACC Water Business Office was applied as a per household, per month estimate with an estimated gallons per day usage of 150 gallons. The authors estimated conservatively that non-campus buildings add an approximate load of 967,500 gallons per month and 32,350 gallons per day. Added to the amount produced by UGA buildings, and not accounting for cooling tower use, this data insinuates that sewage flow at the bottom of Sewershed 1 would be approximately 266,267 to 277,388 gpd.

The above estimate appears to be conservative when compared to flow monitoring that was completed by Reeves Design in 2012 in a study commissioned by the UGA Physical Plant (now called Facilities Management). The study was requested to determine how much digester effluent

13 Stroud, Michelle, email message to Benjamin Liverman, March 28, 2014.

14 "State and County Quick Facts", U.S. Department of Commerce United States Census Bureau (accessed April 24, 2014).

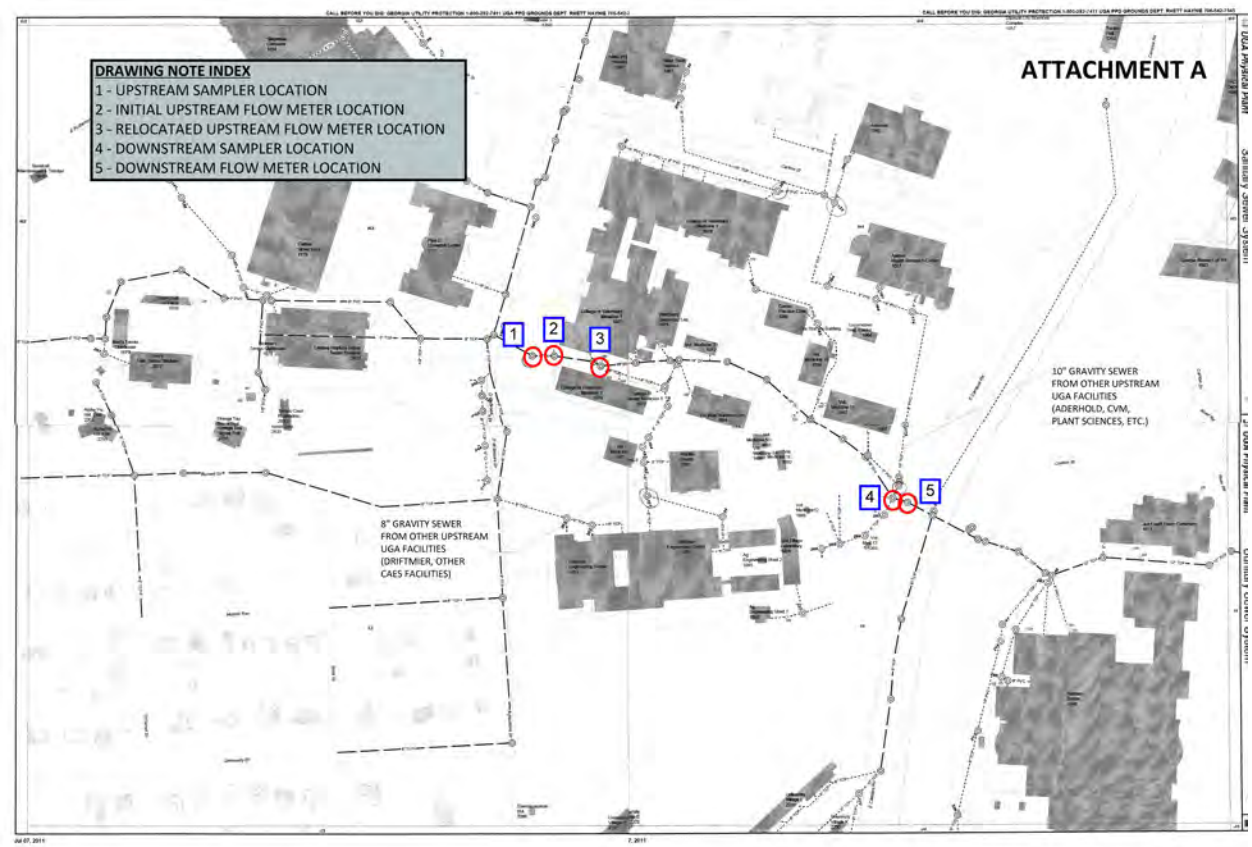

Figure 11. Map from CVM waste water analysis report showing locations of flow testing.

could be released daily into the sanitary sewage system while still maintaining effluent quality standards set by Athens-Clarke County. Flow metering occurred at two locations, one of which is at the bottom of Sewershed 1. (See Figure 11)

Monitoring from 2/21/12 to 3/15/12 showed results ranging from a high of 554,715 gpd on Thursday, 2/23/12 to a low of 250,151 gpd on Sunday 3/11/12. The average daily flow for the 24 day period was 405,004.46 gpd. This time period included a portion of UGA's Spring Break (Monday 3/12/12-Thursday 3/15/12). During this four day period the average daily flow was 310,234.25 gpd.[15] This lower daily average was likely a result of the majority of students and faculty being absent during the break. As these numbers represent the results of actual flow metering, the authors feel that these should be given greater weight than the earlier estimates mentioned in the preceding paragraph.

From a conversation with Brent Zern (an Emory University environmental engineer who has been working on that university's water reclamation project) when estimating the amount of sewage to withdraw from existing sanitary sewer systems for reclamation use, a rule of thumb is to only withdraw two thirds of the average flow. This is in order to maintain sufficient flow to carry solids through the pipes and prevent build-ups. Following the average daily flow measured by Reeves Design, one should expect an allowable average daily withdrawal of 271,353 gallons

15 Reeves Design Services, LLC, *CVM Waste Water Analysis Technical Memorandum*, June 25, 2012.

per day. During times when student population is greatly reduced (e.g. Spring Break) a daily withdrawal limit would be 207,857 gpd.

Sewage Produced in Sewershed 2

- total daily sewage flow estimated at: 67,232 gpd in July and 24,614 gpd in December

In Sewershed 2 all sewage is conveyed to a point just east of the 1516 Dormitory at the border of UGA property next to Loop 10. Approximately ten buildings contribute to this sewershed, about half of which are dorms. Based off meter data provided by Energy Services, in 2012 and 2013 UGA was charged $113,462.00 and $145,265.00 in sewage fees respectively. Dividing by the per gallon rate of $0.0046 shows that Sewershed 2 produced approximately 24,665,652 gallons in 2012 and 31,579,348 gallons in 2013. In this sewershed there are no non-campus contributors.

Average sewage costs taken over a three year period for July and December were $9,587.33 and $3,510.00. This would equate to a 2,084,202 gallon average in July and a 763,043 gallon average in December with a daily July usage (averaged on a 31 day period) of 67,232 gpd and a daily December usage of 24,614 gpd. As in the estimate provided for Sewershed 1, this estimate does not account for water lost through cooling tower evaporation.

Given that only 2/3^{rds} of the total flow can be "sewer-mined", this allows for a withdrawal of approximately 44,843 gpd in July and 16,418 gpd in December. (See Figure 12)

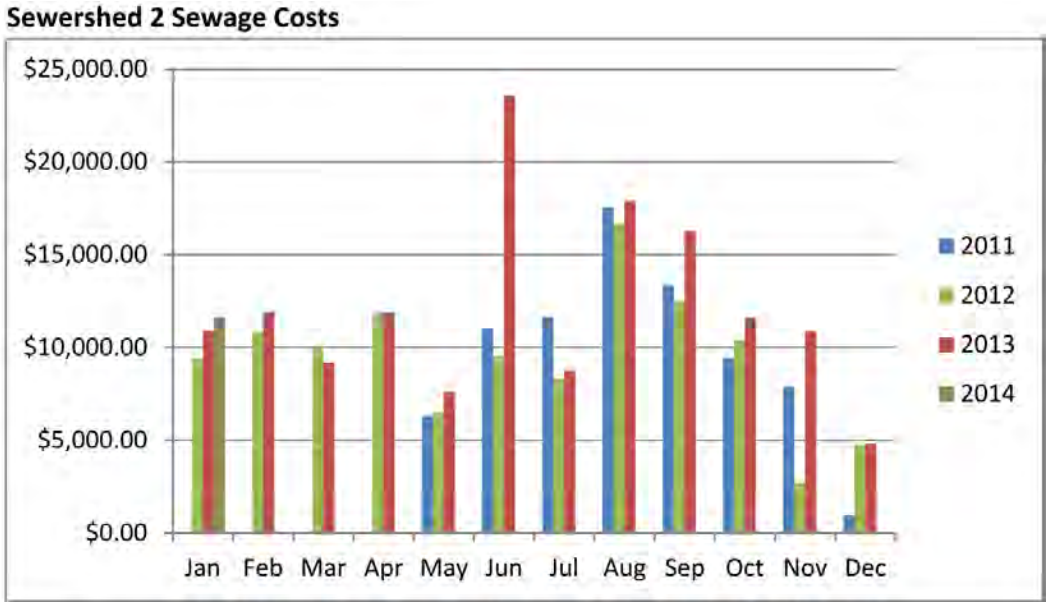

Figure 12. Graph showing waste water costs per month from May 2011 to January 2014 within Sewershed 2

Based off of interviews with Emory and Georgia Tech, a reclaimed water system starts to work economically once it can produce and use over 100,000 gpd. In order for this to occur there needs to be enough sewage feedstock to support a 100,000 gpd system. Therefore, the authors looked at an adjacent sewershed (Sewershed 1A) to see whether it could produce enough feedstock for a 100k gpd reclamation facility. This approach would depend largely on whether or not it would be feasible and *not* cost prohibitive to sewer mine at both the outfall of Sewershed 2 and Sewershed 1A.

Sewage Produced in Sewershed 1A

- total daily sewage flow estimated at:151,865 gpd in July; 55,346 gpd in December

Sewershed 1A is actually downstream recipient of all the sewage conveyed through Sewershed 1. On its own it covers about a third of east campus (everything west of Sewershed 2 and south of Lily Branch) and also includes about half of the Family and Graduate Housing apartments on the corner of Southview Drive and East Campus Road. (See Figure 13)

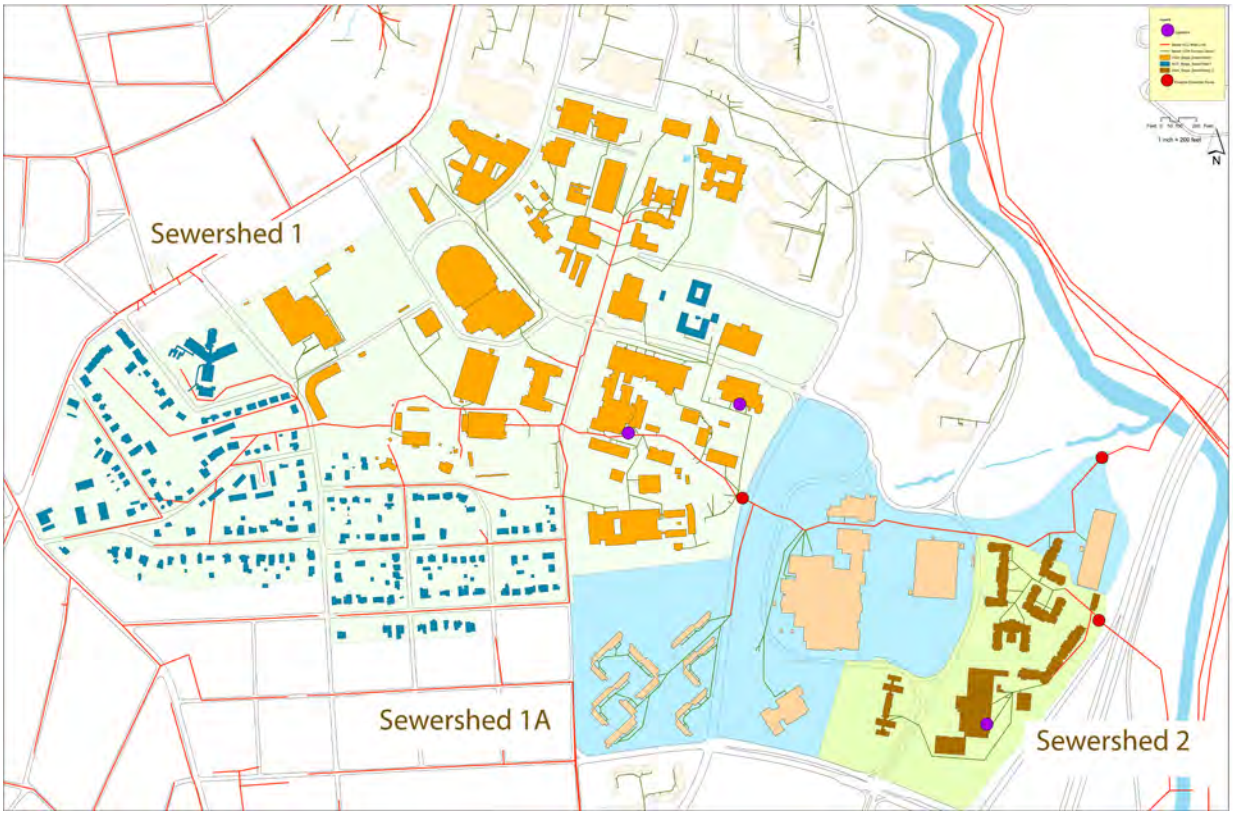

Figure 13. Map showing location of all three sewersheds. Sewershed 1A is actually a downstream part of Sewershed 1. Extraction points at the bottom of each sewershed are identified with red dots.

In addition to the sewage contributed by Sewershed 1, Sewershed 1A contributes roughly 151,865 gpd in July and 55,346 gpd in December. Sewage costs for the area identified as Sewershed 1A are shown in the chart below. As in the estimate provided for Sewersheds 1 and 2, this estimate does not account for water lost through cooling tower evaporation. (See Figure 14)

If extraction could occur at the bottom of Sewersheds 1A and 2, then all digester effluent would be captured and there would be more than sufficient sewage flow to run a large reclamation facility. However, costs or logistical concerns for creating two extraction points would have to figure in to any decisions concerning this option. (See Figure 15)

Reuse Opportunities

As the purpose of any treatment facility is to reclaim water for an intended use, this research team investigated water use trends within or adjacent to Sewershed 1, 2, and 1A for the purpose of locating the most appropriate sites for receiving reclaimed wastewater. In general,

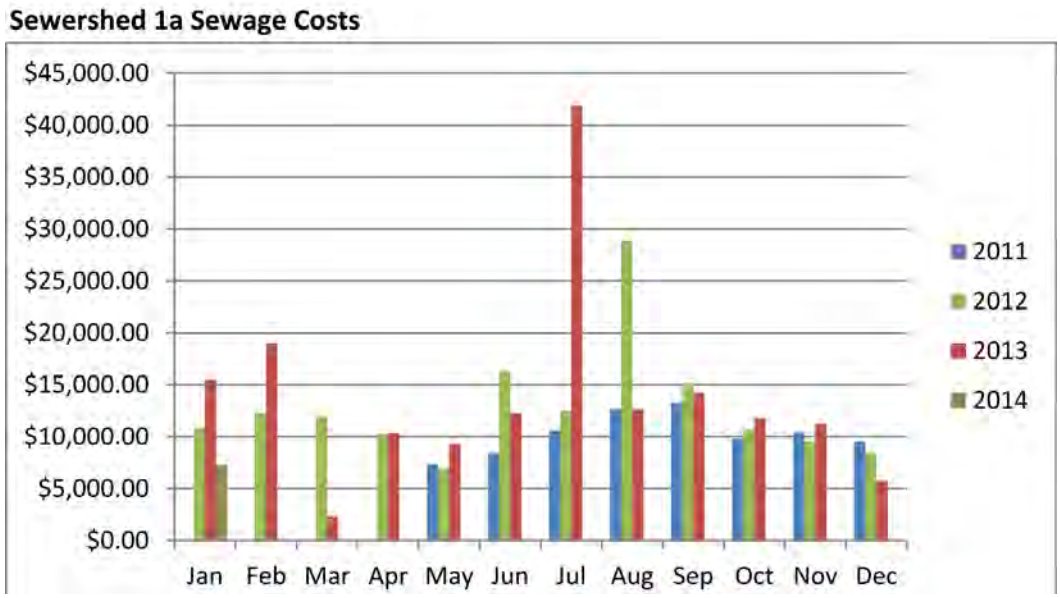

Figure 14. Graph showing waste water costs per month from May 2011 to January 2014 within Sewershed 1A

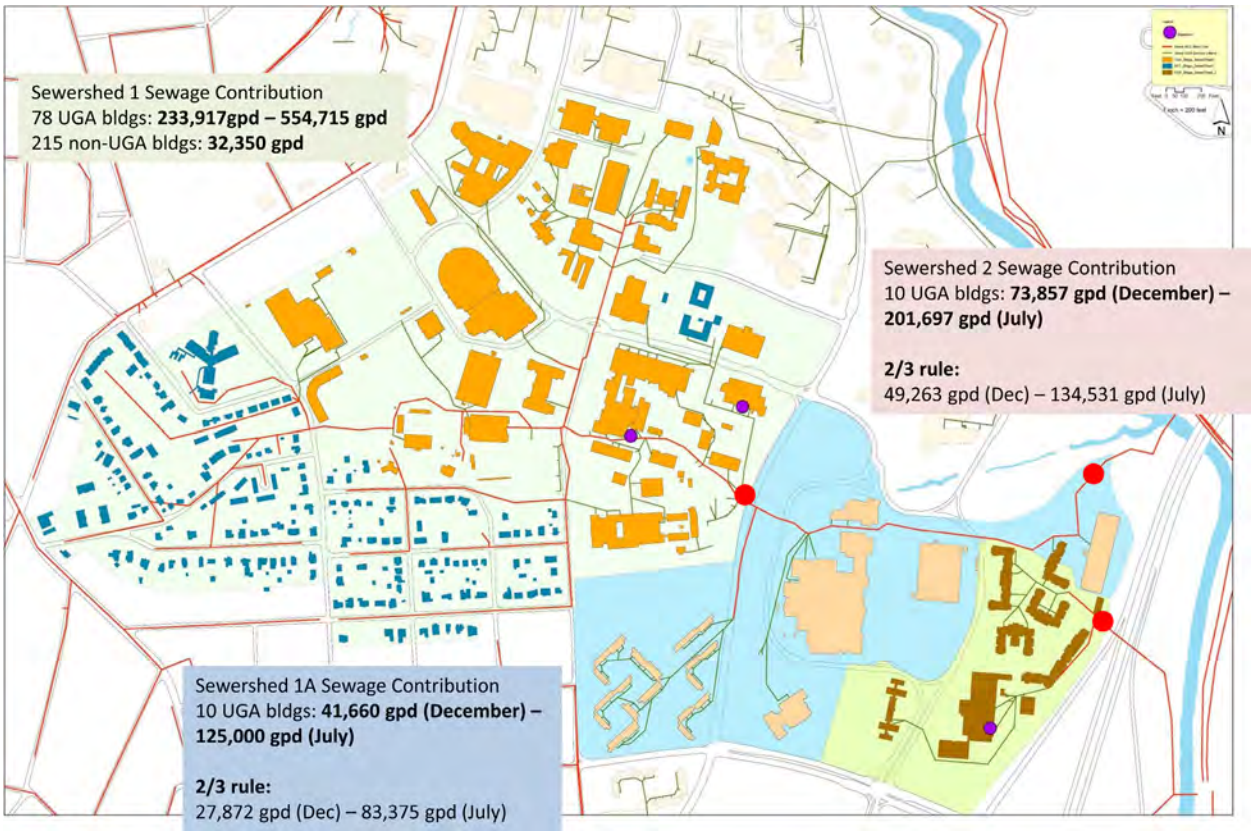

Figure 15. Map shows totals for sewage estimates within defined sewersheds.

reclaimed water may be used domestically (toilet flushing, animal cage washing), for irrigation, or for utilities (cooling tower make-up water). The Georgia Environmental Protection Department sets standards for water quality when reclaiming blackwater for each of the above uses. Though each of the above uses can and should be investigated further, from the interviews and research conducted through this project it appears that using reclaimed water for cooling tower make-up is more dependable and produces a much quicker return on investment than domestic or irrigation use. This is because cooling towers use much more water at a single deliverable point than irrigation or domestic systems. Connecting reclaimed water to cooling towers is likely less expensive than connecting to a building for domestic use, where one would likely have to retrofit a building's plumbing. Cooling towers also have a larger and more constant need than irrigation. Therefore, this paper will focus on opportunities for reusing water for cooling tower make-up. This is not to recommend against using reclaimed water for any of these other purposes—that should be done wherever and whenever it is feasible and makes economic or strategic sense. Rather, this paper recommends that cooling tower consumption should drive the calculations for sizing of a reclaimed water system, as well as the decisions relating to the delivery system of piping reclaimed water.

Sewershed 1 Cooling Tower Consumption

- Average yearly use: 12,940,634 gallons. Value of potential rebate: $59,527.00
- July use estimated at 66,523gpd; December use estimated at 21,955 gpd
- District Energy Plant 2 estimated use to grow to over 60,000 gpd by 2016

In Sewershed 1 there are 12 cooling tower sub-meters that were referenced for this project. Looking at data from these cooling towers (adjusted for some inaccuracies as explained in the preceding section) one can see that water consumption drops in the winter (a two year average of 680,615 gallons in December) and rises in the summer (a two year average of 2,062,234 gallons in July). This would come to a 31 day average winter use of 21,955 gpd and a summer use of 66,523 gpd. This also assumes that each cooling tower within the sewershed can be connected to the reclaimed water source.

Based off of interviews with Emory and Georgia Tech, a reclaimed water system starts to work economically once it can produce and use over 100,000 gpd. In order to achieve that metric, a system would have to provide reclaimed water for utilities outside of the sewershed. (See Figure 16)

Just to the north of Sewershed 1 is the UGA District Energy Plant 2 (also known as the South Campus Chiller Building). The plant currently has two 1,000 ton chillers and uses approximately 16,000,000 gallons of water a year. This plant is connected to a chill water loop that serves many of the buildings included within Sewershed 1. Currently UGA has plans to add another 1,000 ton chiller to the building within the next two years to accommodate the new Science Learning Center (which will begin construction in summer 2014). Net water usage after this expansion is estimated at around 22,000,000 gallons a year.[16]

16 Spradley, David, email message to Benjamin Liverman, March 28, 2014.

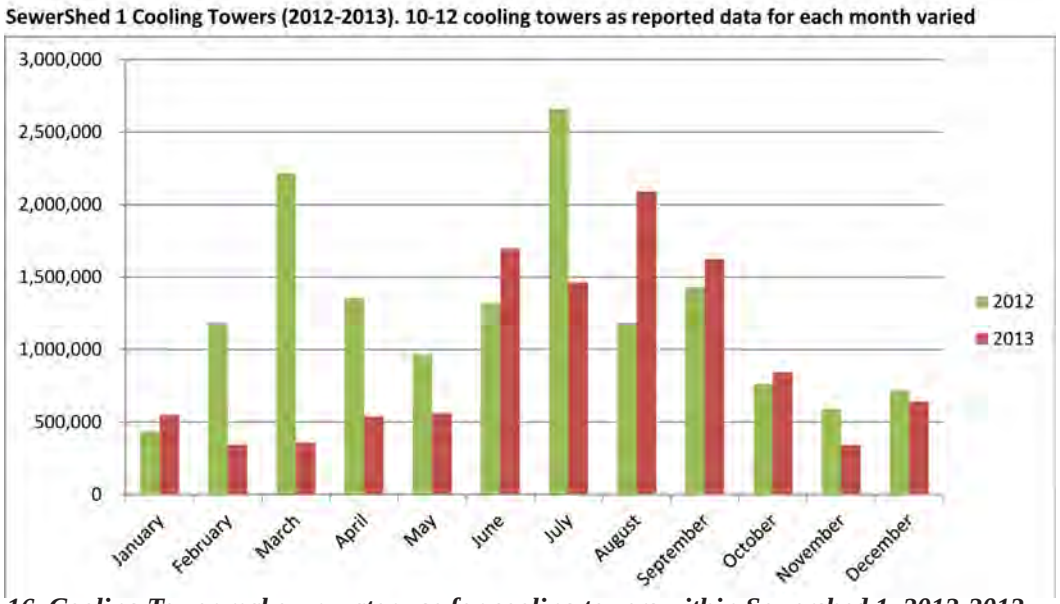

Figure 16. Cooling Tower make-up water use for cooling towers within Sewershed 1, 2012-2013

As stated, the District Energy Plant 2 (DEP2) serves a chill water loop that runs through a large portion of south campus. The plant is supplemented by many smaller chillers along this loop. Over the years, these chillers will be removed as they age and the DEP2 will be expanded accordingly. Within the next fifteen years, Energy Services hopes to remove many of the cooling towers in south campus and expand the DEP2 by an additional 7,000 tons. Ultimately this will result in a plant with a 10,000 ton capacity and an estimated yearly water use of 40 to 50 million gallons.

Not accounting for monthly fluctuations, the DEP2 currently uses approximately 43,835 gpd (based off an estimate of 16 million gallons a year divided by 365), will increase its use to 60,274 gpd after its initial expansion for the Science Learning Center, and will eventually need approximately 110,000 to 140,000 gpd once it is fully built out. For these reasons (large, dependable, and growing water consumption) it seems logical to recommend the DEP2 as a recipient of reclaimed water. Furthermore, the DEP2 is in close proximity to UGA's steam plant. Though data for the steam plant's water consumption is not included in this report, it seems likely that the steam plant would need more water in winter. This would help maintain a more constant end use for any reclaimed water produced. (See Figure 17)

Sewershed 2 & 1A Cooling Tower Consumption

- Average yearly use: 8,825,844 gallons. Value of potential sewage rebate: $40,599.00
- total CT use in Sewershed 2 & 1A: estimated at 32,830 in July and 9,460 gpd in December

There are only 2 cooling towers within Sewershed 2, one for the Rhodes Animal Science Center and one for East Campus Village (which serves 5 dorms with approximately 2,500 beds). As with the cooling towers identified in Sewershed 1, one can see that water consumption drops in the winter (a two year average of 148,650 gallons in December) and rises in the summer (a two year average of 721,700 gallons in July). This would come to a 31 day average winter use of 4,795 gpd and a summer use of 23,281 gpd. (See Figure 18)

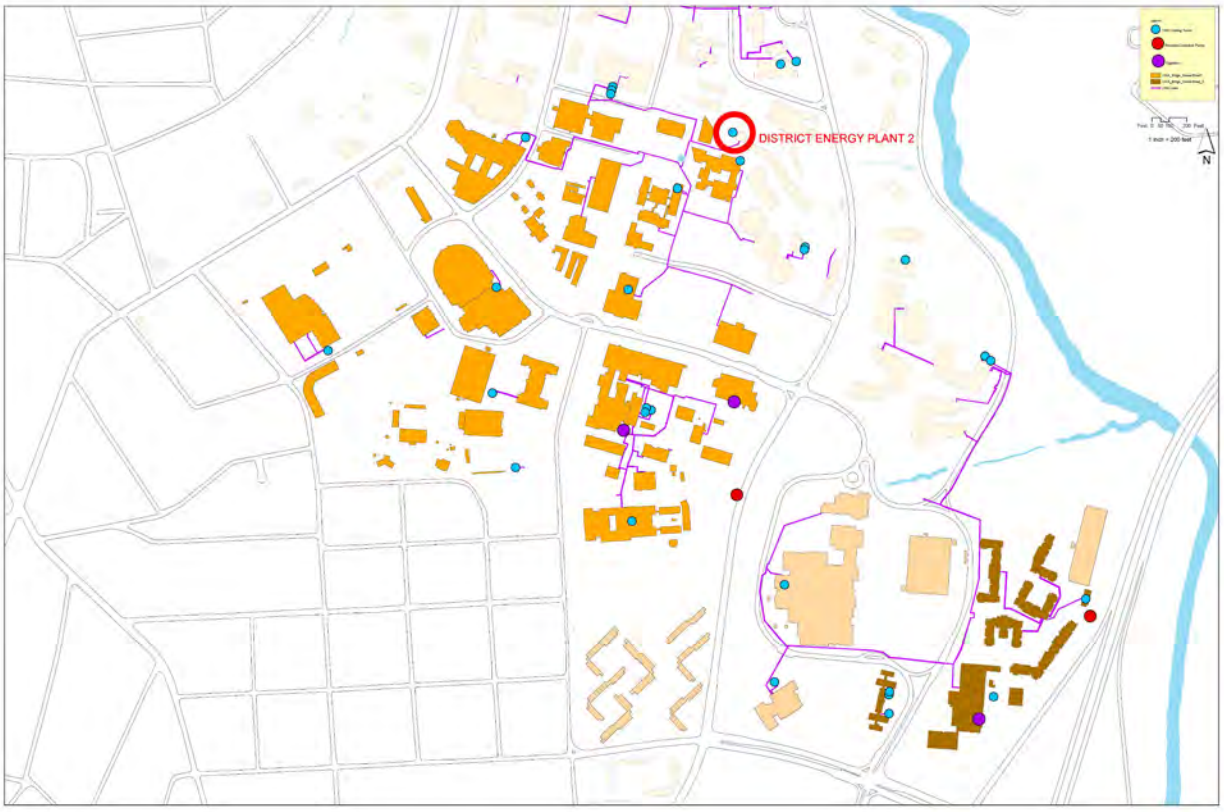

Figure 17. Map shows chill water loops within or adjacent to Sewersheds 1 & 2. District Energy Plant 2 is identified towards the top of the map, just north of the Ecology Building. Digesters are shown as purple dots, cooling towers shown as blue dots, chill water loops shown as purple lines, and the bottom of each sewershed represented by a red dot.

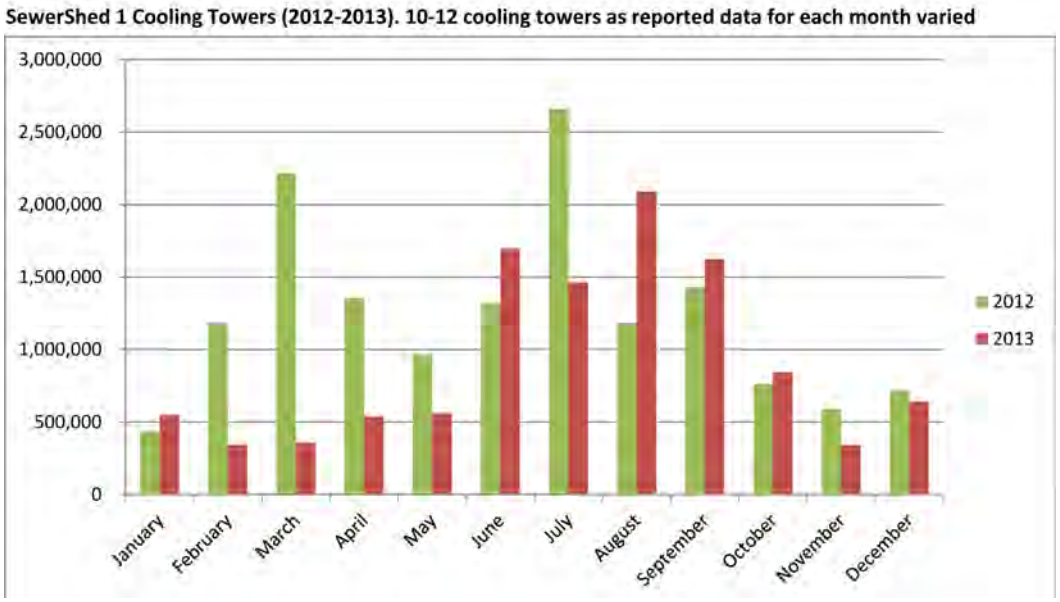

Figure 18. Cooling Tower make-up water use for cooling towers within Sewershed 2, 2012-2013

In Sewershed 1A there are three cooling towers, one at the Ramsey Student Center, one at East Campus Dining, and one at the University Health Services. There are additional cooling towers located within the Performing and Visual Arts campus, just north of Sewershed 1A. However data from these was not requested for this study. The map below shows these locations. (Note, cooling tower location per map is only approximate. In addition, the research team has made an effort to proof cooling tower location and has identified where discrepancies have been found. However, further ground-truthing is needed.) (See Figure 19)

Figure 19. Map shows locations of cooling towers in East Campus.

The three cooling towers for which data was retrieved contributed a two year December average of 144,600 gallons (or 4,665 gpd), and a two year July average of 296,010 gallons (or 9,549 gpd). Combined with the cooling towers identified in Sewershed 2, this only comes to 9,460 gpd in December and 32,830 gpd in July. This is well below the unofficial threshold of 100,000 gallons per day.

Without complete data for East Campus it is impossible to say for certain whether or not there may be enough utility water demand to support a reclamation facility of a scale that is generally considered to be profitable, though it appears unlikely. To support such a system, a reclaimed water distribution network would likely have to extend to main campus (and likely there to the District Energy Plant 2).

The following map summarizes cooling tower consumption per sewershed, including the consumption of the District Energy Plant 2. (See Figure 20)

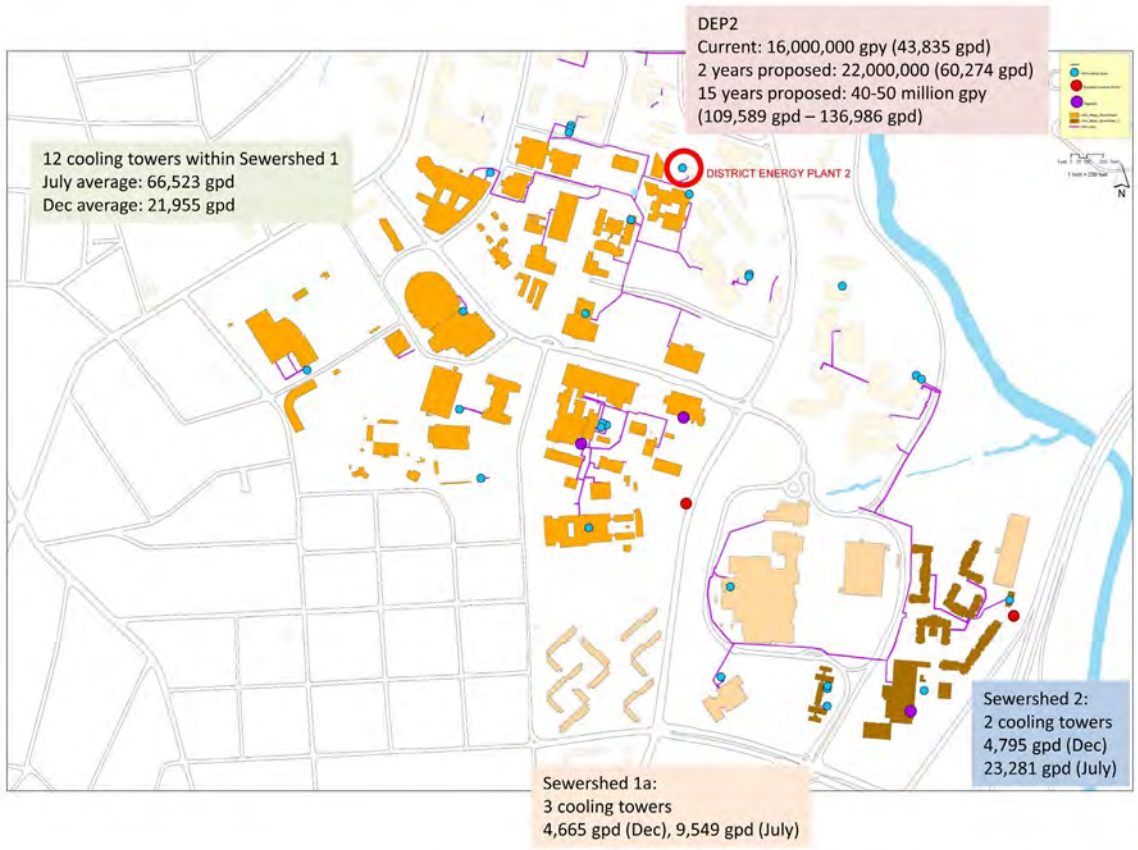

Figure 20. Map shows locations of cooling towers and chill water loops. Cooling tower consumption is totaled for each sewershed.

Proposals for further investigation

From the information presented in this paper the authors would like to propose further investigation of two scenarios. It should be noted that these are only conceptual ideas and that the diagrams and maps presented are only conceptual as well. For any actual planning to occur, cooling tower make-up use would have to be verified, sewage flow would have to be verified, and a detailed cost estimate would have to be created concerning the reclamation facility, and the cost of piping reclaimed water across campus.

Scenario 1:

The first scenario occurs largely in Sewershed 1 where there is an average daily sewage flow of roughly 300,000 to 400,000 gallons per day. In the first scenario, sewage is extracted at the outflow of Sewershed 1 and distributed to the DEP2. Where possible, distribution branches off to cooling towers along the main distribution route. Possible cooling towers close to this path include: Driftmier, VetMed (3 cooling towers here), Davidson Life Sciences (outside of Sewershed 1 calculations but in route to DEP2), and the Ecology Building. If feasible, distribution could be extended to the Coverdell Center and Miller Plant Sciences (both of which showed high, though often questionable cooling tower meter readings). Of course, without accurate data on cooling

tower consumption this proposal should only be viewed as an educated guess. Cooling tower use will have to be confirmed as a next step. As it stands now, data shows that the cooling towers in Sewershed 1 combined with the DEP2 should have more than enough demand for at least a 100,000 gpd system, but it remains questionable as to whether or not winter demand could sustain such a system. Of course, reclaimed water could be distributed outside of the study area (and if useful it is recommended that this be done) however, the cost of piping reclaimed water across campus where sidewalks, roads, buildings, and a tremendous network of utilities exist could be such that a distribution network is limited only to the most prolific consumers of utility water. See diagram below. (Figure 21)

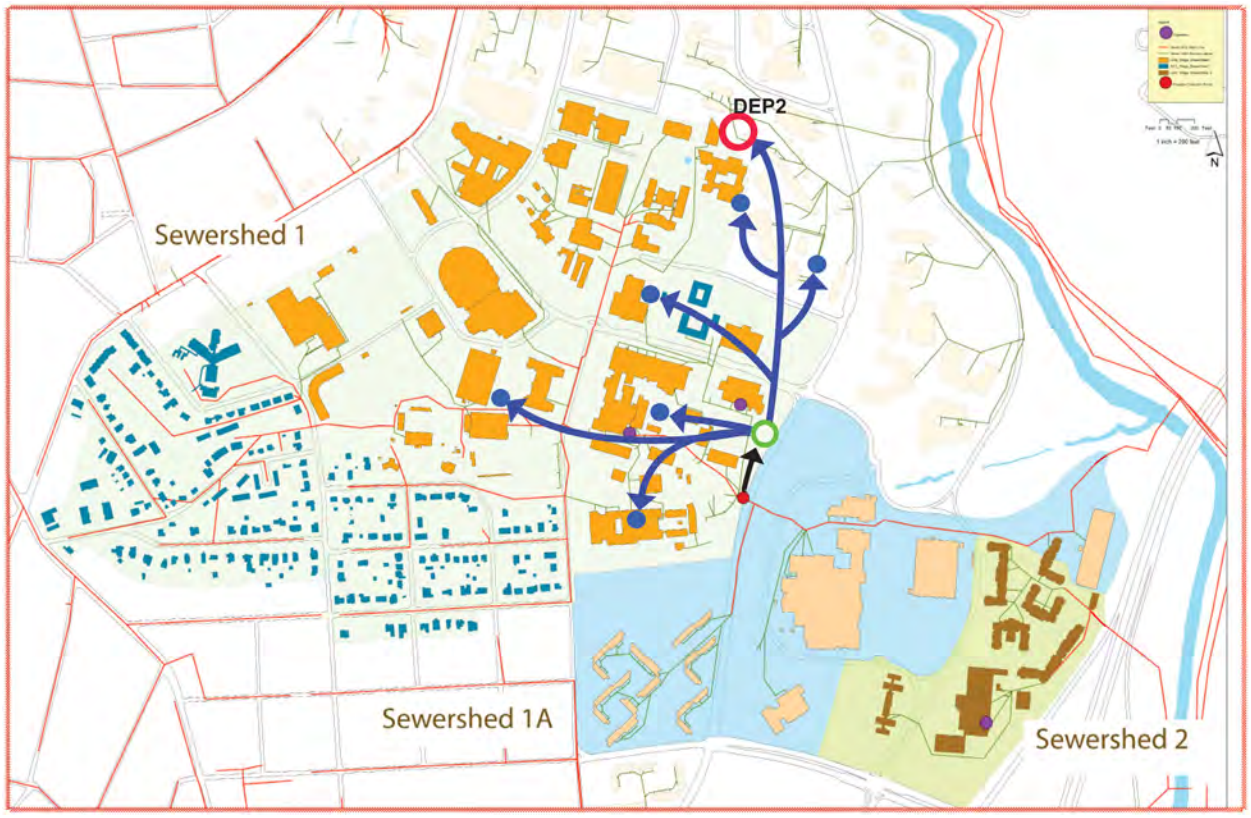

Figure 21. Proposal showing sewage being extracted at outflow of Sewershed 1, treated at a close by vicinity, and possibilities for distribution.

In this scenario, a reclamation facility could be located somewhere on the grounds of the current Veterinary Medicine complex. With the VetMed Hospital relocating next year to College Station Road, there is an opportunity to reuse some of the outdoor paddock areas by Building 1064. Even if the above site is not suitable, there are other open spaces in the area that could be explored for suitability. The map below shows a close up of the Vet Med campus and highlights a few of these areas along with their approximate size in square feet. (See Figure 22)

Pros: This scenario would allow use of the VetMed and AHRC digesters. There would be enough sewage feedstock for a 200,000 gpd system. It would also provide a visible reclamation

Figure 22. Current VetMed Campus with paddocks by bldg. 1064 highlighted to show possible sites for reclamation system.

facility on South Campus very close to many science and research facilities as well as the future Science Learning Center. A distribution network would not have to cross major roads or the railroad tracks to reach potential end users.

Cons: This scenario does not allow for use of the digester at the Rhodes Animal Science Center.

Unknowns: It is not known whether there is sufficient demand at a reasonable distance to the reclamation and extraction site to support a system in the range of 100-200,000 gallons per day. This, of course, is dependent on distribution costs and may or may not be a limiting factor.

Scenario 2:

In the second scenario, extraction and treatment occur in East Campus and reclaimed water is distributed back to the DEP2. Two separate extraction points would pump sewage from Sewershed 2 and from the combined Sewershed 1/1A. Sewage estimates here range from 500-600,000 gpd in July and 380-480,000 gpd in December. Cooling tower demand in the southern half of East Campus appears to range from only 9,000 – 30,000 gpd. In order to reach a threshold of treating 100-200,000 gpd, options for distributing reclaimed water to the performing arts corridor (northern half of East Campus) or across the railroad tracks to South and Central Campus should be explored. Likely the DEP2 would be a logical recipient of reclaimed water. As with the first scenario, the distribution system should branch off to cooling towers along the route to the DEP2 wherever possible. (See Figure 23)

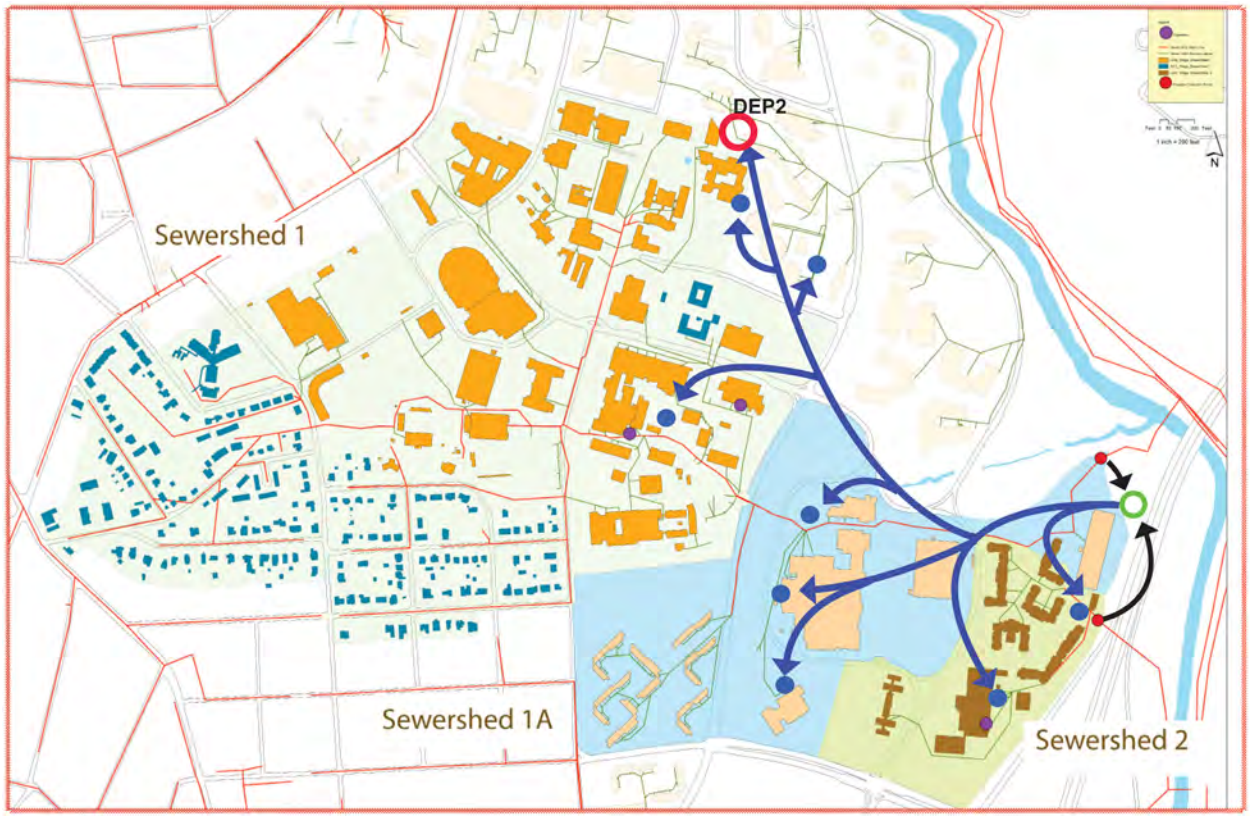

Figure 23. Proposal showing sewage being extracted at outflow of Sewershed 1/1A as well as Sewershed 2, treated at a close by vicinity, and possbilities for distribution.

In Scenario 2, extraction would occur at both the bottom of Sewershed 2 and the bottom of Sewershed 1/1A. Therefore two pumps and grinders would have to convey sewage to a reclamation facility. This facility could perhaps be sited either in lot E06 (which is largely an overflow lot) or as an abutment to East Village Parking Deck. An area roughly 13,000 sf in size could be removed from the parking lot while still allowing for circulation to the parking deck as well as game day circulation to Loop 10. There is also an area approximately 50' wide from the eastern edge of the deck to the UGA property line. This area along the eastern side of the deck could provide ample space for a hydroponic system similar to what is proposed at Georgia Tech. (See Figure 24)

Pros: This scenario would allow use of all three digesters. There would be ample sewage feedstock to support a 200,000 gpd or greater system. Though the reclamation facility would be a little less central than the one proposed in Scenario 1, it would still be in an active part of campus and close to a student resident population.

Cons: From the current data, it appears doubtful that there is enough cooling tower demand to support a 200,000 gpd system within East Campus. There would likely be greater up-front costs to create a distribution system that could reach significant users like the DEP2. Any distribution system would have to cross the railroad tracks and East Campus Road.

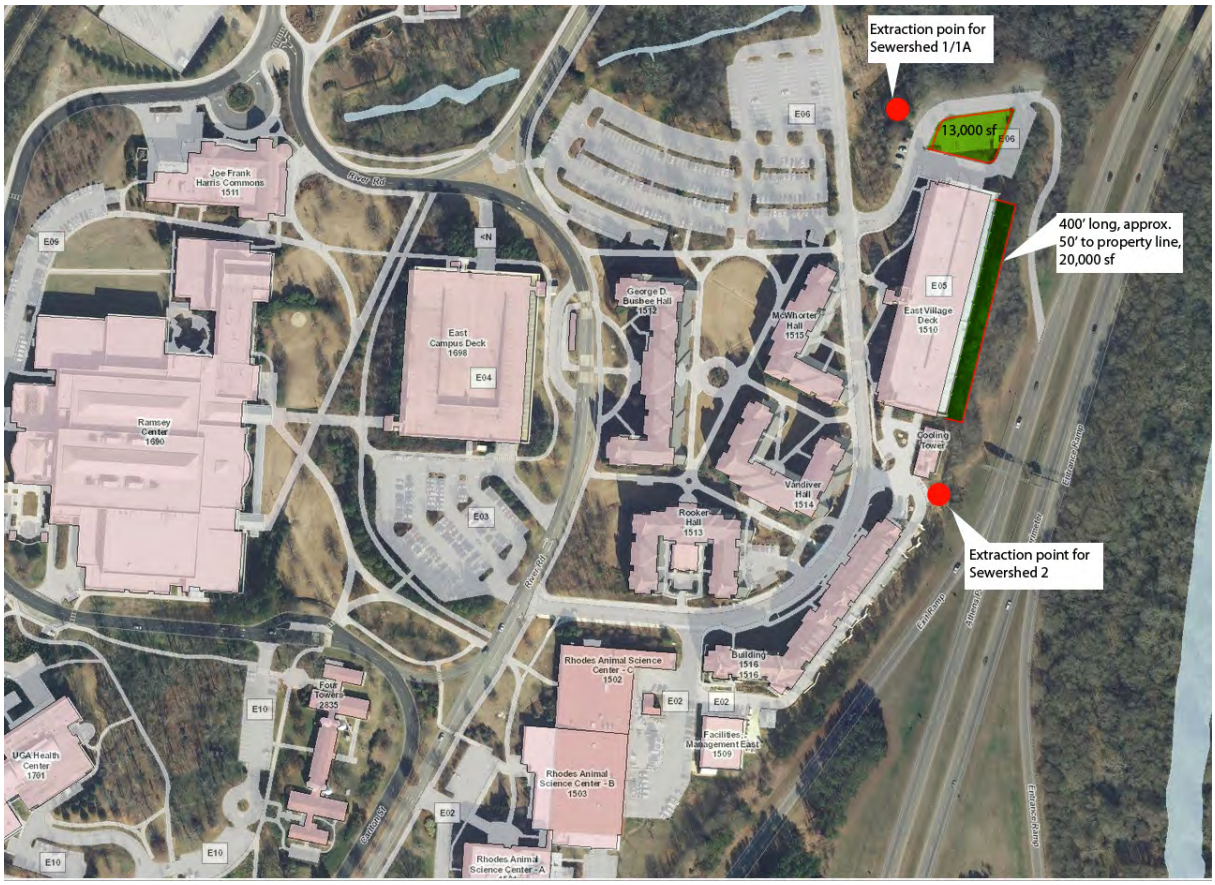

Figure 24. Two potential treatment sites highlighted in green within proximity of proposed sewage extraction points.

Unknowns: It is not known how significant distribution costs will be and whether they will be a limiting factor.

V. COSTS AND BENEFITS

A. Contractual Approaches

There are three general ways to fund and provide for the operation of a biological water reclamation system that the University might consider. The first is to directly fund the project, outlaying the initial capital investment and taking on full responsibility for the facility as an owner operator. The second is to enter into a water purchase agreement with an organization such as Sustainable Water. Under this scenario, the partner would build and operate the facility, and the University would purchase the non-potable water from the partner at a rate below that which the University is currently paying Athens-Clarke County. The third option would be to enter into a public-private partnership within which a private developer would build the facility on University grounds in return for the right to operate the facility for a given period of time.

The Owner Operator Approach

Under the owner operator system, the University would hire an organization such as Sustainable Water to build the biological water reclamation system on campus and would then internally operate and maintain the system. The main concern with this approach is the initial capital outlay. For example, stage one of Georgia Tech's system is expected to cost approximately $7 million to build and will produce 200 thousand gallons per day, about 73 million gallons per year. Based on current estimates, the University may be able to use that much water for cooling tower makeup, so we might expect a similar construction cost of about $7 million. However, given that the University has approximately 65 cooling towers in active use, additional funds will need to be allocated to piping from the biological water reclamation system to the individual towers.

If the University were to build a system of that capacity, the financial savings may make it worthwhile. The University pays approximately .461 cents per gallon for water and .46 cents per gallon for inferred sewage at the current tier one rates. The University may be able to receive a rebate from Athens-Clarke County on some portion of the .46 cents per gallon rate for the sewage mined to generate the non-potable water. Given these figures, (and assuming a full rebate from ACC on every gallon of sewage mined) the University could save approximately $1 million each year with a 200 thousand gallon per day system. If no rebate was negotiated, the University would see a savings of approximately $670,000.00 per year. At this point, it is difficult to assume how Athens-Clarke County will respond to such a proposition. However, Georgia Tech is exploring several price rebate scenarios ranging from a small portion to a complete rebate from the City of Atlanta, and according to Bob Salvatelli of Sustainable Water, his experience is that there is usually an agreement leading to some rebate for the volume of sewage extracted and treated. Savings discussed here would of course be reduced by the operational costs of the facility, particularly the cost of employing a Class I Biological Wastewater Operator to comply with the Georgia Department of Natural Resources guidelines.

This is one of the main drawbacks to being an owner operator: the University would essentially be entering into the wastewater treatment business. Anecdotal evidence from our site visits and case studies indicate this might not be as onerous of a concern as it would seem. The University might already have a qualified employee who could act as the operator. When Furman University built their demonstration system, they discovered that they were already employing

a former wastewater operator who was able to take on the necessary duties. The Furman system requires very little management and the remotely-accessible control panel allows the operator to receive warnings and make adjustments without physically being at the facility. Additionally, the University may consider entering into an agreement with Athens-Clarke County to co-fund one of their operators in such a role.

In addition to having a qualified operator, the University would be responsible for meeting all regulatory and municipal requirements. Amongst these would be the initial design approval and permitting; the organization that the University hires to build the system would be able to assist in this process. Beyond that, the University would have ongoing monitoring and compliance requirements for water quality and safety. Finally, there may be concerns that a biological water treatment facility would qualify as a public works project and that public procurement laws would apply. If this is the case, the University might need to open the project to competitive bid. It is likely that such a project would qualify for a best value project exemption which would allow the University to consider elements beyond the lowest bid standard in the selection of a contractor; such elements might include previous performance, experience level, and specialized knowledge of the type of project in question.

Water Purchase Agreement

Under a water purchase agreement, an organization such as Sustainable Water would design, construct, operate, and maintain the biological water treatment facility. The University may, under such a system, lease the land on which the facility sits to the organization. The organization would produce non-potable water and provide it to the University. The rate the University would pay would be less than what it is currently paying to the county. This would pay for the cost of the facility over the term of the contract, at the end of which the University would have the option of either assuming owner operator status, selling the facility to the organization, or leasing it to the organization.

One of the chief benefits of entering into such an agreement is the significantly reduced initial cost. Instead of outlaying the capital investment upfront, the organization with which we enter the water purchase agreement would bear the cost. The University would still be responsible for the feasibility study, which would likely cost about $20,000 to $50,000depending on the data already available and the sampling and testing that needs to be done. Under this model, the University would benefit from reduced and potentially more predictable rates for cooling tower makeup water. If the above-mentioned projected rate increases are correct, the University could save in excess of $5 million or more over the next twenty years. Additionally, the University might stand to benefit from rebates or reduced sewer payments for the sewage mined.

Under this model, the University would also avoid entering the sewage treatment business. The organization operating the facility would be responsible for complying with all of the Georgia Department of Natural Resources guidelines throughout the term of the contract including hiring the appropriately trained operator(s), and conducting all required monitoring and compliance requirements. Additionally they would bear the operational and maintenance costs. While this would lower the University's investment and logistical costs, the counter argument would be

lower long term cost savings over the term of the contract. It would additionally decrease the University's control over design specifications. Were the University to take over control at the end of the contract term, members of the University administration have expressed concerns in regards to operational transition and reliability.

Independent of which funding model is utilized, the University will need to concern itself with the design specifications, maintenance needs, and reliability of the system. One of the lessons learned from visiting Furman University is that value engineering[1] and other initial cost savings measures can have long term consequences that increase the day-to-day operational costs, in time and money, of the facility. Two areas specifically discussed were the size of holding tanks and the pumps and grinder used to extract the sewage. If the holding tanks are undersized, then overall performance is affected. Similarly, if the pumps and grinders utilized in extracting the sewage are undersized, they will be more prone to failure and need replacement, as well as causing the system to operate at less than peak capacity.

Public-Private Partnership

A public-private partnership blends the advantages and responsibilities of the two previously discussed models. Under such a structure, the University and a private partner would jointly invest the initial capital necessary to build the biological water treatment facility. The University would likely license the system design and technology from an organization such as Sustainable Water and then open the project to competitive bidding. In return for its investment, the private partner would have the right to operate the facility and be appropriately reimbursed for a period of years.

Compared to being an owner operator, this funding structure has a number of benefits. The University would have less upfront cost, would avoid entering directly into the sewage treatment business, and would not necessarily be responsible for the upkeep, maintenance, or regulatory compliance. This might come at the cost of overall long-term savings and lack of direct control or oversight. Compared to the water purchase agreement, the University would likely be able to negotiate better rates having expended some of the upfront cost to build the system.

This funding model does come with some potentially significant concerns. First, the University would likely need to enter into the aforementioned competitive bidding process. With this will come concerns about value engineering as well as a broader variety and quantity of contracts and contractual partners. There are not many public-private partnerships of this nature to draw on as examples in Georgia. While a potentially creative approach, the logistical complexity of this funding route may outweigh its usefulness. A full-scale feasibility study will better inform the decision-making process with more specific and accurate figures for the costs and benefits of the various approaches.

B. Economic Analysis

To provide some context on the owner operator and water purchase agreement models, this section will analyze the potential impact of a 200,000 gallon per day / 73 million gallon per year

1 Value engineering refers to the process by which less expensive and lower specification parts are substituted as a cost saving measure.

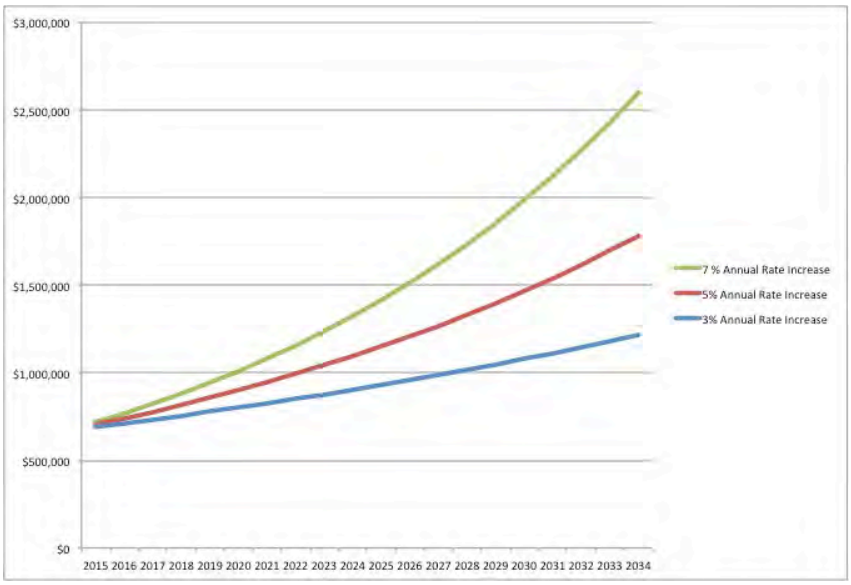

Figure 25. Annual Rate Increase (See Appendix B for data)

system. At the current tier one rates, the University pays Athens-Clarke County $672,330 for 73 millions gallons of water. The following chart shows how much the same amount of water will cost each year for the next twenty years at 3%, 5%, and 7% per year rate increases. (See Figure 25)

In 2024, 73 millions gallons of water will cost the University $903,555 at a 3% annual increase, $1,095,155 at a 5% annual increase, and $1,322,575 at a 7% annual increase. In 2034, the costs will be $1,214,303, $1,783,892, and $2,601,705 respectively. Based upon these figures, over the next twenty years the University will have spent between $18,607,732 and $29,491,874 on potable water that could instead be generated by a biological water reclamation system.

Under an owner operator approach, cost savings would occur in two ways. The University would save the cost of the water and inferred sewage instead of purchasing from the city, less the operating costs of the system, each year. The University would likely also be eligible for a rebate from Athens-Clarke County on the sewage it is mining and treating.

Appendix C contains data on how much 73 millions gallons of sewage will cost each year for the next twenty years with 3%, 5%, and 7% per year rate increases. The data also includes how much of that could be saved at 100%, 75%, and 50% rebates from Athens-Clarke County. Even at a 50% rebate, the University would be able to save between $4,646,882 and $7,364,963 additionally on the sewage mined alone.

Under a water purchase agreement, the University would see lesser but none-the-less considerable costs savings. The following chart shows the difference between what 73 million gallons of water currently costs the University and what it will cost each year for the next twenty years at 3%, 5%, and 7% per year rate increases. (See Figure 26)

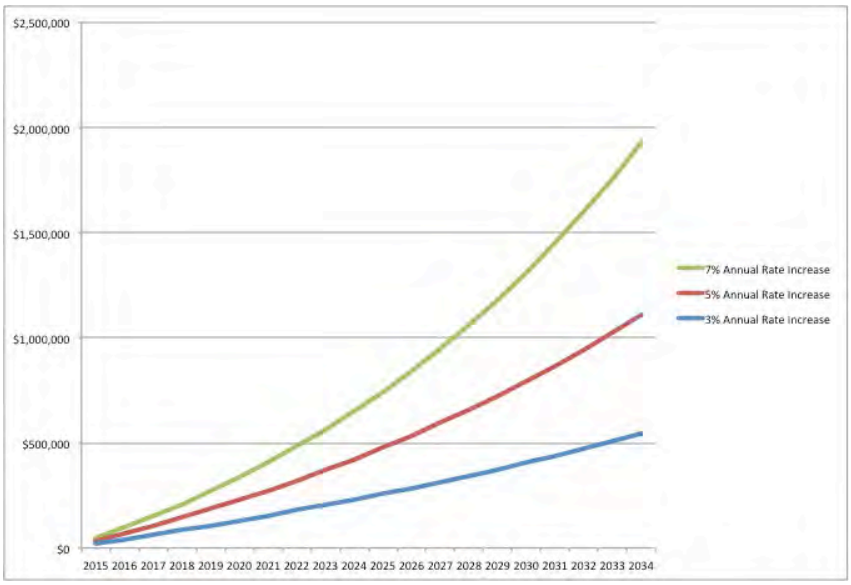

Figure 26. Annual Rate Differential (See Appendix D for data)

If the University were able to secure the rate it is currently paying over the next twenty years, it could cumulatively save between $5,161,132 and $16,045,274 over the cost of paying Athens-Clarke County. The University may also see the above set forth sewage savings under such a model.

VI. UGA ADMINISTRATIVE CONCERNS

In order to identify and address the concerns of UGA administration, our research team interviewed key staff members that would be most affected by the installation of a biological water reclamation system. The question considered to be the highest priority was in regards to actual dollar savings: how much money would this system save the university versus what it is paying now and how much would it cost to maintain it? Jason Gregory from Georgia Tech said that their TFW system would cost about $7 million, but that they expect significant cost savings as a return on their investment. However, it must be noted that water rates for the city of Atlanta may be significantly higher than rates in Athens. Further study will need to be conducted to determine potential savings here in Athens-Clarke County.

The second-most important question concerns the environmental benefit and the amount of water the technology would allow the university to conserve. Feasibility studies for both Tech and Emory show that they can expect significant reductions in potable water use by implementing biological water reclamation technologies. Furthermore, analysis completed in the paper suggests that UGA could reduce the need for potable water by at least 100,000 gpd and perhaps much higher.

Operation and maintenance concerns were also brought up. In general, our interviews revealed that O&M staff were often concerned about redundancies within the system. In every system examined for this paper, with the exception of Guildford Middle School, the wastewater system could be completely bypassed if needed, and potable water could be turned back on to supply utility or irrigation needs. In fact, having this redundancy was seen as beneficial to the acceptance of new technology but also as beneficial to the overall water security of the institution. At Georgia Tech, O&M is looking into including redundancies to the system's design (to plan for possible system failures) and increasing storage for reclaimed water to allow for seamless operation in the event of any system failure.

Staff members were also interested in how big the footprint would need to be, whether offensive odors could be avoided, and the contractual issues that might arise. From the projects examined for this paper, it appears as if the footprint necessary to operate a biological treatment system is relatively small—only a few thousand square feet are needed for a hydroponic system to treat 100,000 gpd. Regarding odor, ourresearch team asked everyone we interviewed about odor issues: all who had been around an implemented system said that there is no odor. We did not experience odor issues while visiting the TFW systems at Guildford and Furman. Further investigation is needed regarding concerns over contractual issues. Tech is in conversations with the Board of Regents over the implications and feasibility of a water purchase agreement. Updates to this conversation will be useful for UGA to follow if and when it decides to pursue a water reclamation facility.

With millions of taxpayers' dollars at risk, UGA staff understandably want to be sure that a biological water reclamation system will save money and water. Our research indicates that there is tremendous potential for saving both. For further details on our interviews with UGA staff and outside expertise, please see the Interview Notes in the Appendix.

VII. FUTURE RECOMMENDATIONS

Several outcomes and future considerations have been identified through the research conducted for this report. The following are the recommendations of the authors.

- First, we recommend engaging Sustainable Water to validate and further investigate the data and conclusions compiled in this report. Sustainable Water has offered, *at no cost to UGA*, to begin an initial investigation of the feasibility and cost savings of a proposed biological treatment plant. This would involve discussions with FMD's Energy Services and Operations and Maintenance Departments as well as the contractor(s) responsible for the chemical treatment of UGA's cooling towers. They would also need access to billing information and UGA GIS shapefiles for utilities and basic infrastructure. We suggest UGA engage with Sustainable Water to take them up on these free-of-charge services.

- Secondly, UGA should continue to support Energy Service's efforts to improve metering of campus cooling towers.

- Third, with more accurate information, the Department of Energy Services should pursue rebates for the inferred sewage cost of cooling tower make-up water. This could potentially save several hundred thousand dollars per year, even without the inclusion of a biological water reclamation system.

- Fourth, we encourage UGA's administration to officially engage with Georgia Tech's Facilities Planning Office and Legal Department to discuss the benefits, hurdles, and contractual obligations of investing in a biological water reclamation system. Although some of this information is already included in the report, it might benefit UGA administration to personally engage with Tech in understanding these details.

- Fifth, UGA should consider working with Sustainable Water to complete a full Feasibility Study. Although, a full feasibility study will require some initial investment by UGA, it would be necessary to go through such a thorough study to understand the full implications of a water treatment system on campus. It should also be noted that UGA's District Energy Plant 1 will also eventually expand to 10,000 ton capacity. This plant, located at the corner of Baxter and Newton Streets was not considered for this paper as it was assumed that the distance between the sewage extraction points and the DEP1 would result in high costs for creating a distribution system. However, the pros and cons of connecting a reuse system to the DEP1 should be further investigated in any future feasibility study.

- Lastly, if projections from an official feasibility study are favorable and if Tech clears the way with the Board of Regents, UGA could begin planning and designing a biological water reclamation system in conjunction with the District Energy Plant 2 expansion.

VIIi. ACKNOWLEDGEMENTS

Thank you to all of the professionals and experts who helped us in gathering the information for this report. We greatly appreciate our UGA staff, David Spradley and Fred Remen giving us time to discuss their concerns and providing us with data. Thank you to Bob Salvatelli and Jonathan Lanciani from Sustainable Water for helping us fully understand what they do and for providing us with so much expertise and input. Finally, thank you to Dr. Brannon Andersen and Dave Hicks for giving us tours of the TFW systems at their schools' campuses. An additional thank you to Jason Gregory for spending an afternoon discussing Tech's plans for designing, and possibly constructing, a biological water treatment plant on their campus.

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APPENDIX

APPENDIX A: GLOSSARY

Engineering Terms

- **Chiller**- a system that utilizes either a vapor-compression or absorption refrigerant cycle to cool a fluid for heat transfer within a system
    - liquid refrigerant changes phase to a gas in an **evaporator** which absorbs heat from the water to be cooled, gas is then compressed to a higher pressure (**compressor**/generator), converted back into a liquid by rejecting heat through a **condenser**, and then expanded (**expansion device)** into a low-pressure mixture of liquid and vapor that goes back into the evaporator

  http://www.industry.usa.siemens.com/automation/us/en/process-instrumentation-and-analytics/solutions-for-industry/hvacr/pages/how-does-a-chiller-system-work.aspx
- **Condenser-** device to dissipate excess energy in A/C systems
- **Cooling Tower**- large metal tower that allows heat energy absorbed by the chiller to be rejected out of the system into the atmosphere, cooling the water with fans and allowing it to evaporate outside (used to lower the water temperature in large chiller systems)
- **Energy Source**- on-site energy in the form in which it arrives as or occurs on a site
- **Evaporator-** refrigerant liquid is converted to gas, absorbing heat from the air in the compartment (opposite of a condenser)
  https://www.swtc.edu/ag_power/air_conditioning/lecture/evaporator.htm

Biological Water Reclamation Terms

- **Sewershed-** all the land area that is drained by a network of municipal separate storm sewer system conveyances to a single point of discharge into a water
  http://www.epa.gov/region10/pdf/permits/npdes/id/ids027561_ms4_fp_2012.pdf
- **Anaerobic (tank)-** without air; Untreated waste water enters the (buried) tank and begins the treatment process. Primary separation of solids and bacteria begin biological break-down of contaminants.
- **Anoxic (tank)-** without oxygen; the environment is referred to as anoxic in that oxygen is only present in the bound form of nitrate. Attached growth media is included to serve for 'floc-forming' microorganisms responsible for the conversion of nitrate to nitrogen gas, as well as the additional removal of BOD.
- **Aerobic (tank)-** requiring oxygen; The oxygen aids aerobic bacteria in converting ammonia, a major human waste component also toxic to many plants, into nitrates to be further processed.
- **Clarifier-** Provides a calm, non-aerated environment so that gravity can pull residuals down towards the funnel shaped bottom of the tank. From here, the diluted effluent flows to the next stage and the settled layer of residuals is recycled to the anaerobic bioreactor tank.

Water Quality Terms

- **Biological Oxygen Demand (BOD)—** Natural organic detritus and organic waste from waste water treatment plants, failing septic systems, and agricultural and urban runoff, acts as a food source for water-borne bacteria. Bacteria decompose these organic materi-

als using dissolved oxygen, thus reducing the DO present for fish. Biochemical oxygen demand (BOD) is a measure of the amount of oxygen that bacteria will consume while decomposing organic matter under aerobic conditions. Biochemical oxygen demand is determined by incubating a sealed sample of water for five days and measuring the loss of oxygen from the beginning to the end of the test.
http://www.gaepd.org/Files_PDF/techguide/wpb/devwtrplan_b.pdf

- **Chemical Oxygen Demand (COD)—**does not differentiate between biologically available and inert organic matter, and it is a measure of the total quantity of oxygen required to oxidize all organic material into carbon dioxide and water. COD values are always greater than BOD values, but COD measurements can be made in a few hours while BOD measurements take five days.
  http://www.gaepd.org/Files_PDF/techguide/wpb/devwtrplan_b.pdf

  The chemical oxygen demand test procedure is based on the chemical decomposition of organic and inorganic contaminants, dissolved or suspended in water. The result of a chemical oxygen demand test indicates the amount of water-dissolved oxygen (expressed as parts per million or milligrams per liter of water) consumed by the contaminants, during two hours of decomposition from a solution of boiling potassium dichromate. The higher the chemical oxygen demand, the higher the amount of pollution in the test sample.
  http://www.businessdictionary.com/definition/chemical-oxygen-demand-COD.html#ixzz2rjIQ9HtY
- **Why are COD and BOD important?**

  If effluent with high BOD levels is discharged into a stream or river, it will accelerate bacterial growth in the river and consume the oxygen levels in the river. The oxygen may diminish to levels that are lethal for most fish and many aquatic insects. As the river re-aerates due to atmospheric mixing and as algal photosynthesis adds oxygen to the water, the oxygen levels will slowly increase downstream. The drop and rise in DO levels downstream from a source of BOD is called the DO sag curve.

  The main focus of wastewater treatment plants is to reduce the BOD in the effluent discharged to natural waters. Wastewater treatment plants are designed to function as bacteria farms, where bacteria are fed oxygen and organic waste. The excess bacteria grown in the system are removed as sludge, and this “solid” waste is then disposed of on land.
  http://www.gaepd.org/Files_PDF/techguide/wpb/devwtrplan_b.pdf
- **pH—** The pH of water affects the solubility of many toxic and nutritive chemicals; therefore, the availability of these substances to aquatic organisms is affected. As acidity increases, most metals become more water soluble and more toxic. Toxicity of cyanides and sulfides also increases with a decrease in pH (increase in acidity). Ammonia, however, becomes more toxic with only a slight increase in pH.

  Most water’s pH is around 7 – 7.5. Most streams draining coniferous woodlands tend to be slightly acidic (6.8 to 6.5) due to organic acids produced by the decaying of organic matter. Natural waters in the Piedmont of Georgia also receive acidity from the soils. In waters with high algal concentrations, pH varies diurnally, reaching values as high as 10 during the day when algae are using carbon dioxide in photosynthesis. pH drops during the night when the algae respire and produce carbon dioxide.

Alkalinity is the capacity to neutralize acids, and the alkalinity of natural water is derived principally from the salts of weak acids. Hydroxide, carbonates, and bicarbonates are the dominant source of natural alkalinity. Reactions of carbon dioxide with calcium or magnesium carbonate in the soil creates considerable amounts of bicarbonates in the soil. Organic acids such as humic acid also form salts that increase alkalinity. Alkalinity itself has little public health significance, although highly alkaline waters are unpalatable and can cause gastrointestinal discomfort.

- **Turbidity—**an indicator of the amount of material suspended in water; it measures the amount of light that is scattered or absorbed. Suspended silt and clay, organic matter, and plankton can contribute to turbidity. Phtoelectric turbidimeteres measure turbidity in nephelometric turbidity units (NTUs). Turbidity units are supposed to correspond to TSS concentrations, but this correlation is only approximate.

  Turbidities of 10 NTU or less represent very clear waters; 50 NTU is cloudy; and 100-500 or greater is very cloudy to muddy. Some fish species may become stressed at prolonged exposures of 25 NTUs or greater. Furthermore, Barnes (1998) recommended that to maintain native fish populations in Georgia Piedmont Rivers and streams, that random monthly values should never exceed 100 NTU; that no more than 5 percent of the samples should exceed 50 NTU; and no more than 20% should exceed 25 NTU. http://www.gaepd.org/Files_PDF/techguide/wpb/devwtrplan_b.pdf
- **Total Suspended Solids (TSS)—**Sediment is usually measured as a concentration of total suspended solids (TSS), which is the dry weight after filtering a water sample, expressed in mg per liter. To determine a suspended sediment load (mass/time), the TSS concentration must be multiplied by the flow rate (volume/time).

  Similarly, average TSS concentrations in the range of 25-80 mg/L represent moderate water quality. An average concentration of 25 mg/L has been suggested as an indicator of unimpaired stream water quality (Holbeck-Pelham and Rasmussen, 1997). Some states use 50 mg/L as a screening level for potential impairment to waterbodies. http://www.gaepd.org/Files_PDF/techguide/wpb/devwtrplan_b.pdf
- **Why are Turbidity and TSS important?** Fine sediment deposited on the streambed can fill gravel spaces, eliminating spawning habitat for some fish species and also eliminating habitat for many invertebrate species. Turbidity and or TSS can reduce light penetration, decreasing algal growth, and low algal productivity can reduce the productivity of aquatic invertebrates, a food source of many fish. High turbidity levels affect fish feeding and growth; the ability of salmonids to find and capture food is impaired at turbidities from 25 to 70 NTU. Gill function in some fish may also be impaired after 5 to 10 days of exposure to a turbidity level of 25 NTU.

  Turbidities of less than 10 describe very clear waters. Waters with turbidity in excess of 50 are quite cloudy, and waters with turbidities exceeding 500 are downright muddy. Large bed loads can also reduce or eliminate pool habitat essential to low-flow and summer survival of fish. Essentially, channels with high bed loads tend to feature shallower water and a larger wetted perimeter. Channel bed topography as well as the size distribution of sediments on the bottom of the channel (referred to as substrate) are vital factors for the productivity of many fish species. Pools provide resting areas for fish, protection from terrestrial and avian predators, and sometimes provide cooler water,

which lowers metabolic needs. Areas of cool water in streams and lakes are called thermal refugia. http://www.gaepd.org/Files_PDF/techguide/wpb/devwtrplan_b.pdf

Sewage Conveyance Terms

- **Sewer Lateral—**Pipes conveying sewage from an individual building to a common gravity sewer line
- **Sewer Stub—**The junction at the municipal sewer system where the home's sewer line is connected. http://www.encyclo.co.uk/define/Sewer%20Stub
- **Sanitary Sewer –**underground carriage system specifically for transporting sewage from houses and commercial buildings to treatment or disposal. Sanitary sewers serving industrial areas also carry industrial wastewater. The 'system of sewers' is called sewerage.
- **Pump Station (Lift Station)—**a gravity sewer sump with a pump to lift accumulated sewage to a higher elevation. The pump may discharge to another gravity sewer at that location or may discharge through a pressurized force main to some distant location. Wastewater lift stations are facilities designed to move wastewater from lower to higher elevation, particularly where the elevation of the source is not sufficient for gravity flow and/or when the use of gravity conveyance will result in excessive excavation depths and high sewer construction costs.

  Key elements of lift stations include a wastewater receiving well (wet-well), often equipped with a screen or grinding to remove coarse materials; pumps and piping with associated valves; motors; a power supply system; an equipment control and alarm system; and an odor control system and ventilation system. Lift station equipment and systems are often installed in an enclosed structure. They can be constructed on-site (custom-designed) or prefabricated.

  Lift stations are used to reduce the capital cost of sewer system construction. When gravity sewers are installed in trenches deeper than three meters (10 feet), the cost of sewer line installation increases significantly because of the more complex and costly excavation equipment and trench shoring techniques required. The size of the gravity sewer lines is dependent on the minimum pipe slope and flow. Pumping wastewater can convey the same flow using smaller pipeline size at shallower depth, and thereby, reducing pipeline costs.

  United States Environmental Protection Agency Office of Water Washington, D.C. EPA 832-F-00-073 September 2000 Collection Systems Technology Fact Sheet Sewers, Lift Station http://liftstationservices.com/?page_id=48

gpd	200000	
gpy	73000000	
Water T1	0.00461	
Sewage T1	0.0046	
Rate Increase	3%	
Year	Cost	Difference
Current	$672,330	
2015	$692,500	$20,170
2016	$713,275	$40,945
2017	$734,673	$62,343
2018	$756,713	$84,383
2019	$779,415	$107,085
2020	$802,797	$130,467
2021	$826,881	$154,551
2022	$851,688	$179,358
2023	$877,238	$204,908
2024	$903,555	$231,225
2025	$930,662	$258,332
2026	$958,582	$286,252
2027	$987,339	$315,009
2028	$1,016,959	$344,629
2029	$1,047,468	$375,138
2030	$1,078,892	$406,562
2031	$1,111,259	$438,929
2032	$1,144,597	$472,267
2033	$1,178,935	$506,605
2034	$1,214,303	$541,973
Cumulative	$18,607,732	$5,161,132

gpd	200000	
gpy	73000000	
Water T1	0.00461	
Sewage T1	0.0046	
Rate Increase	5%	
Year	Cost	Difference
Current	$672,330	
2015	$705,947	$33,617
2016	$741,244	$68,914
2017	$778,306	$105,976
2018	$817,221	$144,891
2019	$858,082	$185,752
2020	$900,987	$228,657
2021	$946,036	$273,706
2022	$993,338	$321,008
2023	$1,043,004	$370,674
2024	$1,095,155	$422,825
2025	$1,149,912	$477,582
2026	$1,207,408	$535,078
2027	$1,267,778	$595,448
2028	$1,331,167	$658,837
2029	$1,397,726	$725,396
2030	$1,467,612	$795,282
2031	$1,540,993	$868,663
2032	$1,618,042	$945,712
2033	$1,698,944	$1,026,614
2034	$1,783,892	$1,111,562
Cumulative	$23,342,795	$9,896,195

gpd	200000	
gpy	73000000	
Water T1	0.00461	
Sewage T1	0.0046	
Rate Increase	7%	
Year	Cost	Difference
Current	$672,330	
2015	$719,393	$47,063
2016	$769,751	$97,421
2017	$823,633	$151,303
2018	$881,287	$208,957
2019	$942,978	$270,648
2020	$1,008,986	$336,656
2021	$1,079,615	$407,285
2022	$1,155,188	$482,858
2023	$1,236,051	$563,721
2024	$1,322,575	$650,245
2025	$1,415,155	$742,825
2026	$1,514,216	$841,886
2027	$1,620,211	$947,881
2028	$1,733,626	$1,061,296
2029	$1,854,980	$1,182,650
2030	$1,984,828	$1,312,498
2031	$2,123,766	$1,451,436
2032	$2,272,430	$1,600,100
2033	$2,431,500	$1,759,170
2034	$2,601,705	$1,929,375
Cumulative	$29,491,874	$16,045,274

APPENDIX C: PROSPECTIVE SEWAGE RATE INCREASE AND REBATE DATA

gpd	200000		
gpy	73000000		
Sewage T1 Rate	0.0046		
Increase	3%		
Current	$335,800		
Rebate	100%	75%	50%
2015	$345,874	$259,406	$172,937
2016	$356,250	$267,188	$178,125
2017	$366,938	$275,203	$183,469
2018	$377,946	$283,459	$188,973
2019	$389,284	$291,963	$194,642
2020	$400,963	$300,722	$200,481
2021	$412,992	$309,744	$206,496
2022	$425,381	$319,036	$212,691
2023	$438,143	$328,607	$219,071
2024	$451,287	$338,465	$225,644
2025	$464,826	$348,619	$232,413
2026	$478,771	$359,078	$239,385
2027	$493,134	$369,850	$246,567
2028	$507,928	$380,946	$253,964
2029	$523,165	$392,374	$261,583
2030	$538,860	$404,145	$269,430
2031	$555,026	$416,270	$277,513
2032	$571,677	$428,758	$285,839
2033	$588,827	$441,620	$294,414
2034	$606,492	$454,869	$303,246
Cumulative	$9,293,764	$6,970,323	$4,646,882

gpd	200000		
gpy	73000000		
Sewage T1 Rate	0.0046		
Increase	5%		
Current	$335,800		
Rebate	100%	75%	50%
2015	$352,590	$264,443	$176,295
2016	$370,220	$277,665	$185,110
2017	$388,730	$291,548	$194,365
2018	$408,167	$306,125	$204,083
2019	$428,575	$321,432	$214,288
2020	$450,004	$337,503	$225,002
2021	$472,504	$354,378	$236,252
2022	$496,130	$372,097	$248,065
2023	$520,936	$390,702	$260,468
2024	$546,983	$410,237	$273,491
2025	$574,332	$430,749	$287,166
2026	$603,049	$452,286	$301,524
2027	$633,201	$474,901	$316,600
2028	$664,861	$498,646	$332,431
2029	$698,104	$523,578	$349,052
2030	$733,009	$549,757	$366,505
2031	$769,660	$577,245	$384,830
2032	$808,143	$606,107	$404,071
2033	$848,550	$636,412	$424,275
2034	$890,977	$668,233	$445,489
Cumulative	$11,658,725	$8,744,044	$5,829,362

gpd	200000
gpy	73000000
Sewage T1 Rate	0.0046
Increase	7%
Current	$335,800

Rebate	100%	75%	50%
2015	$359,306	$269,480	$179,653
2016	$384,457	$288,343	$192,229
2017	$411,369	$308,527	$205,685
2018	$440,165	$330,124	$220,083
2019	$470,977	$353,233	$235,488
2020	$503,945	$377,959	$251,973
2021	$539,221	$404,416	$269,611
2022	$576,967	$432,725	$288,483
2023	$617,355	$463,016	$308,677
2024	$660,569	$495,427	$330,285
2025	$706,809	$530,107	$353,405
2026	$756,286	$567,214	$378,143
2027	$809,226	$606,919	$404,613
2028	$865,872	$649,404	$432,936
2029	$926,483	$694,862	$463,241
2030	$991,337	$743,502	$495,668
2031	$1,060,730	$795,548	$530,365
2032	$1,134,981	$851,236	$567,491
2033	$1,214,430	$910,822	$607,215
2034	$1,299,440	$974,580	$649,720
Cumulative	$14,729,926	$11,047,445	$7,364,963

APPENDIX D: INTERVIEW MEETING NOTES

MEETING WITH DAVID SPRADLEY (UGA) February 14, 2014
Director of UGA Dept. of Energy Services

How complete is metering of cooling tower make-up on campus? How / how often is the metering data collected?

- Meter reader reads these only once a month. Cooling towers don't always have to run in the winter. (another possible reason for wonky numbers)
- Sewage isn't metered, it is inferred from water use
- All buildings have individual meters that belong to ACC
- UGA is billed monthly
- There are about 65 cooling towers on campus
- There are 7 chill loops on campus

Why the large stretches of zero use reporting / how accurate is the reporting?

- Maintenance will work on the sewer lines and then the meter will get bypassed (reason for funky data readings)

How interconnected are the CT's? How are they topped up?

- Looping of chiller loops ended up costing much more when the cost was based on usage. Consolidated water accounts into zones. Lowest tier rate 1 cent/gal for sewer and water.
- Looped or not, towers get water from the buildings they serve.
- Cooling towers are normally "downstream" of the building meter and in most cases have a meter of their own which is owned by UGA

What lessons have been learned from existing cistern projects?

- Buildings with chillers and cooling towers take up more water use. Most chillers on campus in the next 5-10 years are going away and moving towards chilled-water plants.

What contracting guidelines, if any, exist?

- Can now do multi-year contracting for performance projects (used to be only 1year)

What would be your greatest concerns with UGA implementing a biological water reclamation project?

- Sniff test is a concern
- Concern: What is it going to cost versus what they are paying now? They want to see savings if they are going to use millions of taxpayers' money.
- Concerns: how many gallons of water reduction could we see?
- Prioritization of concerns: 1-Cost benefit, 2-environmental benefit, 3-contract issues
- Need a financial vehicle before doing all this work. UGA needs a guarantee.

What other departments would you advise us to talk to?

- Involve O&M for discussing quality of water going into cooling towers with Fred Reman
- Talk to Annette Evans in Procurement office for contract questions

UNANSWERED QUESTIONS

With existing water collection systems (cisterns) that feed Cooling Towers are there any changes to CT maintenance or rate of inspections?
Does UGA inspect cooling towers under its own forces or does it higher a third party?
Does UGA contract w/ outside ?vendors? currently for any energy services?
What makes up a CT inspection?
Is cooling tower make-up water treated at each CT site?
What redundancies are built-in to current CT water supply?
Would you see a water reclamation system as a benefit (added water security?)
How could such a project benefit Energy Services?
What general legal considerations or concerns do y'all have?

EXTRA INFORMATION

- State separates Resident Instruction vs. B units for funding. Auxilary buildings get funding from their sales (fields, dining halls, etc.). Find some mechanism to charge auxilary units for these services for LM?
- Housing is auxilary. Was more cost-effective for them to connect to the District Energy Plant. Will expand District Energy Plant at East Campus and Cedar because the Science Learning Center is expanding.
- 7 chill water loops now and want to connect these eventually with the plants to minimize cooling towers.
- There is a 4-tiered structure for water and sewage utility costs. You can google Athens Water County Business Office to see the rates (different for Residential and Commercial)
- UGA spends $450,000-480,000 for irrigation annually (metered separately)
- It is expensive to dig below ground because you can only dig 4ft before you hit granite. It would be good to have the BWR system in close proximity to major water users.
- Sewer stubs/laterals belong to UGA and mains belong to ACC
- No penalty for using less water from ACC, just saves money
- If water is not evaporated and goes into sewer (blowdown or overrun) then ACC is going to want to know the content of the water
- Loops allow 3 chillers to run more efficiently than 1 big chiller @ 20%.
- Billing year cycles are based on Fiscal year
- We must be aware of Resident Instruction versus now--Resident Instruction utility expenses
- Energy Services master plan is to get away from individual chillers
- Water Business Office ?
- Campus is divided into zones, the overall H2O use within each zone determines the tier rate
- Irrigation is separately metered
- UGA doesn't demand a sewage rebate for cooling tower make-up use
- Big use, spread out
- Individual chillers going away in 5-10yrs, replaced with a larger system
- One near Bolton 10,000 chill water tons; 2nd at Cedar St near Steam Plant
- 70 down to C5, hoping to continue decreasing
- Change in Athens policy, unfair perception
- Meet with ACC, zoned water accounts split residential and commercial
- Lowest tier 0.01gal

- Drought stopped irrigation, lowered other uses--> 450-480 million gal/yr and irrigation is 10% or less
- Cost prohibitive to run lines to individual buildings--4ft down granite
- Questions: Ask about cost-effective break down? Athens rates? What rate is Emory paying?

MEETING WITH FRED REMEN (UGA) March 4, 2014

Director of UGA Dept. of Operations & Maintenance

What is your experience with water reclamation and reuse?

- St. Pete and Naples have lots of reclaimed water in FL (85%)- have separate lines for grey and blackwater
- In Georgia we still use chlorine in water (in FL they use UV)
- Clarke County needs to commit to putting purple pipe in the ground at the most water-using sections
- In South FL when people started conserving water, the water companies cried out because they were losing so much money
- Stormwater Treatment Area (STA)- constructed wetlands- South Fl Water Management District has most experience with biological filtration in a large, industrial manor

Does UGA have specific standards for utility grade water (cooling tower make-up)?

*To your knowledge are these standards possible using reclaimed water?

- One option is only doing primary treatment. Cooling tower water standards don't need to be the same as drinking water. We can ask cooling tower manufacturer for operation standards (ask Casey ___)

If such a project were to ever develop how would it be most beneficial to have O&M involved?

- Concern with maintenance costs
- What is involved with taking care of the system? Some never actually work: lifecycle costs.

* Are there specific benchmarks where you think O&M would need to approve or provide input?

- O&M approval: type of equipment, type of plant, reliability, etc. There are standards for high efficiency motors.

What kind of additional safe guards would have to built into a reclamation system?

- If we were to enter into a partnership with a 3rd party and there is a handoff to O&M, then we have to make sure that it can still be sufficiently run (not just run into the ground)
- SGO's put in equipment with 10yr life span when they only have 10yr contracts
- Concerned with reliability, redundancy (back-up), life-span. If system fails and have to turn on city systems then you will pay out the nose and lose all your savings

- fiber optics are the way to go- these systems need sophisticated control systems, otherwise you won't realize the savings--> monitoring is a chief concern

* metering * sampling?

- Proof of product- accurately meter all of our usage

UNANSWERED QUESTIONS

Are there any benchmarks you'd like to have input on concerning our specific project?

How would a system affect warranty on equipment?

Do we have service contracts for Cooling Towers? How do these work?

How could this affect warranty on service contracts?

EXTRA INFORMATION

- Energy Savings Company (ESCo) can figure out where you can save money- working with Tech to get $3-4 mill to get this assessment done for both
- ACC has agreement if you can prove your cooling tower you get a sewage rebate, but we do not participate
- Quality of water going into cooling towers?
- Big picture is how much money we give to ACC for sewage.
- As water quantity in these systems increase, costs decrease.
- What technologies are available to get us to the reclaimed status
- Chemical controls for treatment are a lot more rigorous than filtering effluent: storing, accounting for them, etc. is a big process
- Need to find a conglomeration of buildings where a system like this makes sense
- Look up Canyon Ranch
- Economic savings is a large concern
- Recommends Annette Evans (UGA Procurement) as best person to contact for contractual questions
- Meters are manually read once a month
- There are plans to connect the AHRC building to the Vet school chill H2O loop
- Fred's concerns: 1) money savings 2) H2O use reduction 3) What are environmental savings? 4) Footprint 5) Odor
- No volume discount from ACC
- If water is excess and goes into sewer (from reclaimed) ACC would want to know
- Concerns: aesthetics, cost vs now, prior to balanced budget 1yr post-amendment "guaranteed energy savings performance contact," Environmental Safety Division, water reduction, environmental savings, footprint, financial vehicle

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MEETING WITH JASON GREGORY March 21, 2014

Senior Educational Facilities Planner for Georgia Institute of Technology

General Questions:

What stage are you in now on this project?

- Feasibility Study is complete
- Flow metering has been completed and verified feasibility study assumptions
- GA Tech legal is in process of reviewing
- Next, Tech will approach BOR to seek approval and get guidance on how to structure deal (meeting is in April)
    - What did the BOR requested them to prepare for this meeting?
- If BOR approves, Legal and Real Estate will work to structure contract
- Stages: 1) Feasibility Study 2) Flow-Monitoring (make sure study is accurate) 3) circulate through legal department and through sustainable water the plans (*where they are at now) 4) Present to Board of Regents 5) Legal and Real Estate to Structure Deal 6) Construction docs

Does Tech have prior experience with water reclamation and reuse?

- On campus cisterns (some very large).
- Has an on-campus dedicated person to maintaining cisterns. (on a side note, Jason tells us that Tech has found that Tech thinks it makes more sense to have larger systems that are connected so that water can be diverted where it needs to go)
- Tech completed a StormWater study and master plan that seeks to reduce run-off by 50%
- They figured out the runoff conditions historic vs. existing to determine how much they need to minimize runoff and by what amount.
- They had to analyze an entire basin just to size a detention pond. The pond is part of the overall Stormwater and Landscape Master Plan.

What prior research did Tech do before asking Sustainable Water to conducting the Feasibility Report?

- Tech held talks with Emory to discuss Emory's system
- Administration felt that $20k was a small enough investment for a potentially big payoff

How many gallons had to be reclaimed (or dollars had to be saved) before decision makers at Tech felt that this project was a worthwhile venture?

What difficulties have you encountered moving from plans toward implementation?

- Being a state institute have to work through the BOR. Can't just do like Emory and say "build here."

Design Questions:

In the Tech Feasibility Study, there is a recommendation to have a second extraction point. A reason given for this is to have a redundant source for feedstock. How necessary do you think this is? (ie. not likely that sewers shut down and limit feed stock)

- They are using two extraction points: one at 200,000-250,000gpd that will provide enough water to chiller plants. Future expansion would have to tap into a combined line.

Is our understanding correct that you can only mine 2/3 of total sewer flow?

- This seems to be correct. You don't collect solids at all so you must maintain about 1/3 of the water flow to keep pipes from getting backed up.
- Plan to take out 200,000gpd and leave 100,000gpd

Does GaTech have specific standards for utility grade water (cooling tower make-up)?

- Are these based on the GA EPD water reclamation guidelines?
- To your knowledge are these standards possible using reclaimed water?
- Can these standards be made available to our team?

- Yes (they are based on GAEPD reuse guidelines). Plus Tech)&M had additional standards and requests.
- We need to follow up with Jason to see if we can get a copy of the standards that O&M requested.

What kind of additional safe guards did your team discuss that would have to built into a reclamation system? Metering? Sampling?

- Tech wanted redundancy, both within the reclamation system and in addition to it. Once system is built out Tech will have redundancy within the system by having the Living Machine and the separate Blue House system. Given a failure in these systems, Tech will have ability to use city water and to supplement with well water.
- They are using two extraction points: one at 200,000-250,000gpd that will provide enough water to chiller plants. Future expansion would have to tap into a combined line.

Is Tech planning to make the system a "learning lab" as well as a utility?

- Yes. They have already had charrettes with professors on this and would like to have a 'test cell' in the Blue House for students to be able to conduct experiments on. They may look

for STEM grants to help fund this portion of the project.

- What premium do you expect to pay for this?
- Are there specific pedagogical items you're planning to add?

- Program to integrate models for stormwater into student classes: Info Swim. iTrees is software that shows the difference for stormwater runoff with vs. without trees.
- Phase II will be attached to parking deck and be a great learning center. Can have a separate line as a test cell for students to play with (they have already begun discussions with facilty).

$$ Questions:

Will the water savings created by this project lower Tech into a lower tier water/sewer rate?

- In the water purchase agreement outlined in the feasibility study, is my understanding correct that Tech doesn't pay SW for the reclaimed water the system will produce?
- No. If SW builds and runs system, Tech will pay SW for water at rate 15% below city rate.
- Is SW's funding coming solely out of city rebates?
- No. City rebates (yet to be negotiated) will go back to Tech.
- Will Tech pay less for sewer (since it's my understanding that sewer charges are based on water meter readings and now Tech will be using reclaimed water instead of potable water)?
- Yes. Tech will have a lower sewer bill (regardless of negotiations on rebate with city) simply because their sewer bill is calculated by how much potable water they buy from the city. If they buy reclaimed water from SW that amount will not be calculated on their sewer charges.

What will the system cost to build?

- Phase I will cost approximately $7 million to build.

What costs are GaTech expected to cover up front?

- GA Tech paid $20,000.00 up front for feasibility study.

Can you describe the agreement with SW and the city as far as who will pay what in detail?

- Worked with sustainable water because Emory's study was very good and only $20,000. It provided them with info for the stormwater master plan.
- Possible Contract scenarios:
  - Tech builds and operates system, or
  - Tech builds system and SW operates system, or
  - SW builds and operates system. In this scenario Tech would pay SW for reclaimed water at 15% below city rate.
- Tech is negotiating rebate with city but has run several models to look at payback based on different rebate percentages.
- Cheaper to use blackwater reuse because they get a rebate back on it, rather than using well water. Will possibly get 98% credit back from the city.

O&M concerns:

How was your Operations and Maintenance staff involved in this process?

- Were they brought in during the feasibility study?
- What were their concerns?
    - Quality of water
    - Redundancy (they wanted to maintain city and well hook ups for safety)
- Were their concerns resolved?
- Any tips for approaching/involving O&M?
    - Tech has a "Decision Support Group" that helps get ideas off the ground by bringing different groups together early on in the process to make sure all parties understand issue and can have input. In this case, the team brought in O&M and Legal early on.

What were the concerns O&M specifically had about using reclaimed water for cooling tower make-up?

- They wanted to make sure it was suitable for utilities
- They wanted redundancies
- Also wanted a sizeable storage tank (If I understand this correctly, they wanted this to add security for water quality and quantity as a tank would allow for extra storage of water before it entered the system and would give O&M opportunity to test and treat water to deal with quality fluctuations if they arose).
- Biggest issues for on-campus reuse: people concerned with making sure water quality will be suitable for use, needs redundancies and extra storage for overflow

Did your O&M see a water reclamation system as a benefit (added water security?)

- Yes.

Testing for Feasibility Study:

What company performed sampling and flow testing?
Does not recall name, were hired through SW.

- How many sampling/testing sites? 3 sites
- What was the cost? $15,000.00
- Did the testing validate Sustainable Water's predictions? Yes.
- Any lessons learned from this process?
- They tested Summer through Fall to determine how flow would fluctuate in regards to semester changes
    - Found that because of heavy summer programs, flow stayed consistent
- **Need to find out if there were quality tests performed and what they were**
- Lesson learned: separate "clean" water uses (condensate water, roof drain, etc.) for reuse in toilets and stormwater for irrigation use. If water looks dirty in the toilets, people will keep flushing and this defeats the whole purpose. They have a separate line for roof drain vs. stormwater runoff, goes to other tank for filtration.

UNANSWERED QUESTIONS

The study recommended water reclamation utilization of 70%. Why is the facility utilization sweet spot set at this level?

Are there disadvantages to using a tidal flow wetland system for polishing water that has already been treated in a hydroponic system? (possibility of exposing treated water to unseen variables or contamination?)

What water rates do you pay?

What sewer rates do you pay? (Were these in line with Sustainable Water's calculations?)

What other departments would you advise us to talk to outside of Energy Services and O&M?

Can Sustainable Water actually "own" the system that they build since it's on campus?

If Tech were to own the system, or even if they leased it to SW, would this open Tech up to liability?

EXTRA INFORMATION

- Majority of folks a Tech are on board. VP for Finance & Administration is planner by trade and got behind the idea.
- They chose SW because of Emory's experience and because price seemed reasonable.
- They believe that savings from reclaimed water could be used to provide funding for the build-out of the eco-commons.
- Interestingly enough, they found that it is cheaper to use blackwater than well water because with well water they are not getting any credit back from the city.
- The hydroponic system (blue house) is more compact than the living machine (roughly 200'x40').
- The Living Machine has a larger footprint but uses less energy and is more flexible (design-layout-wise?)
- GaTech hasn't explored harvesting biomass yet from either system. Ron Carroll suggests that energy harvested from biomass could be an added benefit.
- Tech Students have gotten involved with project and have aided it with the use of two GIS plug-ins: InfoSwim (GIS based model for playing with stormwater model) and I-trees (GIS based model that calculates stormwater benefit of trees).
- In stormwater masterplan Tech discovered that it was more efficient to use infiltration as a strategy at the top (higher elevation) of the watershed, and use collection at the bottom.
- They presented their ideas to the Planning Area and people on campus are on board
- Combined storm and sewer system in ATL with only one outfall. All is treated in ATL's system and overflow goes into the Chattahoochee (for which they are being fined daily). 2 basins involved for the stormwater projects on campus.
- EcoCommons is a green space on campus designed to minimize stormwater runoff leaving the campus.
- In Basin A, not a lot of water is coming from off-campus (fairly self-contained). Within this basin sanitary and stormwater IS separated.
- Sewer water is always available here because even when the students are gone the dorms get used for other things. Stormwater levels are less consistent.
- Stormwater runoff that ends up in Chattahoochee affects mussels in Apalachicola
- Irrigation not that significant a user, 47% of 425 M g/yr for Basin A. Of total campus water

use, irrigation is 7%, heating and cooling 37%.

- Used the blackwater system and savings to sell the ideas in the stormwater master plan.
- In ATL charged separately for water and sewer.
- Chamber with a stirrer at the collection point to keep the flow regular as it enters the system
- 2 system options: hydroponics system (goes through filter fabrics, very compact, within greenhouse)= Blue House; living machine (spread out, less energy, aesthetic)
- there are statewide levels for water reuse quality that they have to adhere to
- biggest water need/sink are the chiller plants
- Reasons why not to do a conventional water reuse treatment plant: aesthetic (it's very ugly and don't want that on campus), odors, safety, and cost
- Education idea: College of Agriculture and Forestry could use the system for crops to produce other outcomes than just reclaimed water
- Decision Support Group discusses issues regarding any project on campus for Tech
- Phase I. Turnkey capital expense $7 million
- most likely Tech will purchase and build the system and only have SW maintain it so that Tech isn't liable. Will pay SW for water at a rate that is approx 15% less than the city
- Recommends: Show Emory and Tech studies to UGA admin and what this can look like
- Meeting with Board of Regents early next month
- West and South flow towards North-East
- Pretty much one outflow
- combined sewer and stormwater in ATL- heavy rain events overflows into the Chattahoochee
- Sewer fairly consistent year-round, even with ebb and flow of students because other programs compensate
- 200-250k p/day
- worked directly with Sustainable Water- reasonable price $20,000 and they were already working with Emory, provided a lot of data
- Basin A-> 47% of 425 mill gal/yr = 547 k/day?
- How much credit are you getting back from city?
- Scaling and is the water suitable? Above and beyond EPD requirements, possible benefit of reclaim system
- Creates redundancy both within system and in complement to city
- Phase 1=100-150 k gpd; Phase 2=250-300k

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<u>MEETING WITH EXISTING SYSTEMS' EXPERTS</u> March 28, 2014

Dr. Brannon Andersen at Furman University

Chair of Dept. of Earth and Environmental Sciences

How was this system built? Built and maintained by institution? Built by institution, maintained by third party? (Who is third party?) Built and maintained by a third party through a water purchase agreement?

- Furman hired Sustainable Water as engineers for the design of the system. Furman has staff that maintains it.
- Furman had a physical plant employee, Jim Elridge, who used to manage the waste treatment system for the Coors Brewery in Colorado. He is a licensed sewage treatment operator.

Among his normal duties he also manages this system.
- Dr. Andersen personally wrote the grant
- financed this system through a challenge grant- actual greenhouse facility $1 mill, Water Treatment System alone $300,000 (more expensive for smaller systems)

Describe the design process. What were major design concerns?
- LM system currently holds 3,000 gpd with a capacity for 5,000 gpd
- Looking to expand to whole campus with Sustainable Water to a 200,000 gpd system to pay for chiller water (finance through 20 years of water savings)
- Want to put new system by the chiller plant possibly- the whole area is one loop/centralized plant
- Reclaimed water currently goes back into the sewer because they ran out of money to add facilities for water reuse
- David del Porto did one design version (that they didn't use) involving more Ecological Design, but more pumps, fishes, etc. and was more sensitive to fluxes
- It was designed by Worrell (however, i think the contract was with Sustainable Water). The Living Machine siphons off sewage from a pump station near the greenhouse. Current system was designed to treat water that could be used by the science building for toilet and cage flushing. However, they do not currently reuse the water, they just treat it and send it back to sanitary. They use it for research now, but are planning to reconnect it to the building as was intended.
- Water can come to within 3" of the surface, but overflow drains keep it from getting higher. System was built to be double the size (on one side of a wallkway there are cells filled with planting media and vegetation, on the other side, there are empty cells where students/faculty perform testing and research)/

What prior research was done prior to conducting the Feasibility Report?
- He went on a tour of Ohio systems, read Orr's Earth & Mind and decided that Furman needed one of these systems

What steps did you take to make the system a "learning lab" as well as a utility? What premium did you pay for this? Are there pedagogical items you'd add if you could do this again?
- Classes do sampling at the LM in cells added on for experiments- have column experiments going right now to remove nitrate but didn't work
- share the greenhouse with biology

What liability concerns were there? What general legal concerns were there?
- David del Porto handled legal and regulatory issues
- legal was comfortable with what Worrell gave them

Do you have any other outputs from the system other than water? (harvesting plants for biomass, compost…)
- students harvest plants 2xs p/yr and use for compost

When system is not running at capacity (ie, winter) what are the drawbacks? How must mainte-

nance respond?

- they don't notice big difference in performance of LM depending on the season.
- They say the biggest difference has to do with when students are on or off campus. However, they say that as long as the system is kept wet, it has shown to operate well, even when students (and waste load) was lower.

What kind of monitoring do you have within the system?

- Maintenance guy spends about 4 hours p/week to clean filters, etc. - electric dashboard can be accessed by his computer and will send an alarm to his phone if something is wrong

What kind of safeguards/redundancies do you have within the system?

- If the LM shuts down it will run to the sewer lines

What advice would you give to an institution that is planning on designing and constructing its own reclamation system?

- Advice: don't let them value engineer the system down. The range of tolerance is really small, they spec these things out so precisely, and you will regret it later.
  Biggest problems with system is that there was value engineering on the pump (that siphons sewage to the LM) and the grinder. Too many solids make it through the system which causes them to have to clean their filters more regularly and to remove solids from their primary tank more often than intended.
  Their biggest piece of advice was not to value engineer the system. They say that the system is designed with small tolerances and that the way to avoid problems is to build to specifications.

<u>UNANSWERED QUESTIONS</u>

Was a feasibility report created for this project? Who was responsible for creating report?

Were sampling and flow testing carried out before construction to determine sewage flow and quality? How many sampling/testing sites? What was the cost? Did the testing validate design predictions? Any lessons learned from this process?

What difficulties did you encounter moving from plans to breaking ground?

What do you use your reclaimed water for, and how are those uses divided up by level of importance?

How was your Operations and Maintenance staff involved in this process? Were they brought in during the feasibility study? What were their concerns? Were their concerns resolved? Any tips for approaching/involving O&M?

What water rates do you pay? What sewer rates do you pay?

How much of a difference have you seen in your utility costs with this system in place?

Will the water savings created by this project lower your institution into a lower tier water/sewer rate?

Has this system helped to increase awareness about water reclamation in the area?

Does your institution own the system and lease it to a third party operator?

What kind of liability concerns do you have after having operated the system for ___ years?

EXTRA INFORMATION

- use 1 chlorine tablet once a month just for state (?) regulations, but it gets UV first, so it

doesn't need it

- Removes about 50% Nitrogen, but Phosphorous passes through the LM (water clear, nothing living in it, but nutrient-rich) Per professor, that is true of conventional waste water treatment systems as well as hydroponic systems. A flocculent would have to be used to remove phosphorus as an end treatment.
- electricity savings: power with solar panels
- wetlands do the best job but requires a large footprint
- Wastewater treatment plants use lots of energy
- pump out solids from recirculation tank 1 and primary tank every once in awhile
- not putting it back in to de-nitrate (says that they should-what does this mean?)
- Stage 2 is cell 5&6 polishing- doing gravity flow-though now and goes into disinfection (UV/chlorine and filtration)
- biofilms in shale rock help filter as it raises from the bottom then gravity-drains out (overflow drain to make sure it never reaches the top
- bottom of cells is a layer of black crates with a filter over them
- have state-run effluent tests once p/month
- Construction in the South sucks (no unions to keep tradesmen doing the job correctly) so you have to make absolutely sure that the effluent is going in the right place
- This system doesn't need to be fed, it can just recirculate and stay wet (no intake in winter)
- Jim Alderage is the tech for the system
- only electricity used when pumps run to fill it and the pumps are small, so doesn't use much
- 200-250 groups have come through to tour their LM
- Jim's advice- make sure you have a good set of pumps with a good grinder--> the tanks were value-engineered down to smaller ones and the grinder they decided to buy was not good enough, so they are seeing the repercussions now
- 4 levels of certification in Wastewater (A highest, D lowest) and Jim has a B in SC
- value-engineering savings will be $1,000 initially but will cost 4-5 times this to fix later
- Would want more oxidation reduction probes, pH meters would be nice (right now grad students do it manually
- No odor was observed during the visit.
- Says that wetlands (including properly made constructed wetlands) are hands down the best for treating water and removing phosphorus. However, they need a lot of space.
- Furman is looking at utilizing solar panels to run the LM system.

<u>Dave Hicks at Northern Guilford Middle School</u>
Wastewater System Management

How was this system built? Built and maintained by institution? Built by institution, maintained by third party? (Who is third party?) Built and maintained by a third party through a water purchase agreement?

- a standard septic system could have probably been used, but there is a finite lifetime span on it, plus this has a smaller footprint and you don't have to worry about redoing the sewer drainage area in 10 years

Describe the design process. What were major design concerns?
total of 14 cycles p/day, 1ft depth in center with 1-2 in out outside rings

- serve 3,000 students- larger footprint but lower in energy use
- design capacity is 12,000
- System is one of the oldest in south west. Consists of a open "wetland" for first phase, then pumped up to different wetland cells for final phase treatments. Looks like a precursor to what was built at Furman or what is being designed at Emory and Tech.

What do you use your reclaimed water for, and how are those uses divided up by level of importance?

- used to have good reuse for irrigating the football field, but a hole got poked in the drip line so the turf started rising during a game one time--didn't have the ability to turn it off during games and player's parents didn't want their noses in "poo" water, so had to stop
- Most of problems came from bad installation of irrigation system or from improper maintenance of fields (essentially, irrigation lines were bust open a few times, water leaked out onto field and this caused folks concern). The problem had nothing to do with reclamation system, but the fact that it was reclaimed water got parents up in arms.
- still use water for both soccer fields (middle and high school)

Do you have any other outputs from the system other than water? (harvesting plants for biomass, compost…)

NO

When system is not running at capacity (ie, winter) what are the drawbacks? How must maintenance respond?

- not a year-round school, so have to adjust the system in the summer
- With no one in school in the summer, you're lucky if you have 500 gpd to work with in the system
- have to look at the confluidity of influent volume to make sure it is not stressing the organisms (20,000 ?gpd needed to keep water levels static in the summer)

What kind of monitoring do you have within the system?

- system will text him if there are alarming conditions
- key is knowing the flows and what's changing by level sensors-- using submersible pressure sensors-- mechanical float is more dependable
- Measured today 1.2 Nitrogen, 0 nitrite, and 0 nitrate

What advice would you give to an institution that is planning on designing and constructing its own reclamation system?

- lesson: never let a plug aerator on a sandy field
- advice: make sure to check needed water demands and that you have a back-up plan if it runs out (their plan B is make-up water)
  When asked for lessons learned, Dave says that he would love it if the system were smart enough to temporarily by-pass problem cells. He also recommends that from the onset you know what your water demand is so that you are designing to meet that demand. He also

recommends having a water redundancy plan (extra cells if some cells go down, a well, or connection to city water).

UNANSWERED QUESTIONS

Was a feasibility report created for this project? Who was responsible for creating report?
What prior research was done prior to conducting the Feasibility Report?
Were sampling and flow testing carried out before construction to determine sewage flow and quality? How many sampling/testing sites? What was the cost? Did the testing validate design predictions? Any lessons learned from this process?
How was your Operations and Maintenance staff involved in this process? Were they brought in during the feasibility study? What were their concerns? Were their concerns resolved? Any tips for approaching/involving O&M?
What steps did you take to make the system a "learning lab" as well as a utility? What premium did you pay for this? Are there pedagogical items you'd add if you could do this again?
What liability concerns were there? What general legal concerns were there?
What difficulties did you encounter moving from plans to breaking ground?
What kind of safeguards/redundancies do you have within the system?
What water rates do you pay? What sewer rates do you pay?
How much of a difference have you seen in your utility costs with this system in place?
Will the water savings created by this project lower your institution into a lower tier water/sewer rate?
Has this system helped to increase awareness about water reclamation in the area?
Does your institution own the system and lease it to a third party operator?
What kind of liability concerns do you have after having operated the system for ___ years?

EXTRA INFORMATION

- Chlorine levels they had to put in at even just 1 ppm affected the fields negatively
- roof here is connected to a central cistern (top of which is a basketball court) and is a LEED building
- spends onsite about 2 hrs/d
- he uses UV filtration and has had a good experience with this method
- Have to die reuse water blue because the pipes aren't colored, but the chemicals turn it yellow (for when people cut into pipes, to know what kind of water it is)
- puts 1/12 of average weekly flow into the system
- water goes over weir to split box, then to irrigation
- getting extra oxygen in makes it easier to maintain and a more resilient system
- tried to reroute stormwater so it doesn't get into the system
- if he could do it differently, he would run the entire system with 4 pumps (being able to move the dirt around just right = energy savings by lessening the number of pumps)