QUANTIFYING WATER CONSERVATION IN THE FOUNDERS MEMORIAL GARDEN

by

SAMUEL VAHID KELLEHER

(Under the Direction of Ron Sawhill)

ABSTRACT

This thesis uses several tools to calculate stormwater runoff and water need for the Founders Memorial Garden on the campus of the University of Georgia. These data have never been documented and should allow garden administrators to make better-informed management decisions. The current condition of the Garden is first established, and is then compared to possible changes. The justification for undertaking this research stems from one of the values for which the Garden was created, namely that of education, to be "A place of education for future landscape architects" (Owens). The general movement within society for creating a more sustainable future and increasing environmental pressures, such as drought, means that the management of historic gardens will have to respond to these to remain viable. The tools provided herein should assist efforts to keep FMG intact while bringing it into the 21st century.

INDEX WORDS: Founders Memorial Garden, Landscape Architecture History, Stormwater, Runoff, EPA WaterSense, Landscape Water Requirement, Landscape Water Allowance, SCS Hydrologic Method, ArcGIS, Irrigation, Engineered Infiltration, Historic Preservation, Landscape Values

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SAMUEL VAHID KELLEHER

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SAMUEL VAHID KELLEHER

Major Professor: Ron Sawhill

Committee: Robert Vick
Maureen O'Brien
Marc van Iersel

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
June 2012

DEDICATION

To family and friends who have supported me throughout graduate school.

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I would like to acknowledge Ron Sawhill for his assistance during this process. Also the MLA class of 2012… to the "greatest MLA class of all time"

TABLE OF CONTENTS

Page

ACKNOWLEDGEMENTS v

LIST OF TABLES viii

LIST OF FIGURES ix

CHAPTER

1 Founders Memorial Garden and the College of Environment and Design 1

2 The Watershed 15

Concept 15

Practice 25

3 Case Studies of Similar Gardens 27

Reynolda Gardens (The Formal Gardens) 27

Kroon Hall, Yale School of Forestry and Environmental Studies 33

Thomas Jefferson University Lubert Plaza 37

Summary of Case Studies 41

4 Methodology 42

ArcGIS 42

SCS 42

WaterSense 47

Irrigation Management 51

Rainwater Harvesting 56

Amount of Change 57
5 Results 59
ArcGIS 59
FMG Watershed Baseline Evaluation 61
FMG Watershed Modification Alternative #1 64
FMG Watershed Modification Alternative #2 68
WaterSense 71
Irrigation Management 74
Rainfall Collection 76
6 Discussion 81
7 Conclusions 87
8 REFERENCES 92
9 APPENDICES: 95
A – SCS 95
B – WaterSense 98
C – Current Rainfall Collection 101
D – Raw Rainfall Data 106
E – Interview Notes 109

LIST OF TABLES

Page

Table 4.1: Tables from Georgia Stormwater Management Manual 43

Table 4.2: Athens rainfall data from Win TR-55.. 45

Table 4.3: Four hydrologic soil groups as defined by SCS. 46

Table 4.4: Matrix illustrating the amount of change rating. 58

Table 5.1: Baseline Win TR-55 calculations for FMG. 62

Table 5.2: Win TR-55 calculations adjusted for porous pavement. 65

Table 5.3: Win TR-55 calculations for combination of porous pavement and bamboo walk. 69

Table 5.4: (Above) Area totals, (Below) LWR calculations. 71

Table 5.5: Rainfall data for Athens Clarke County (2006-2011) 76

Table 5.6: Estimate of current collection versus potential collection. 77

Table 5.7: Estimate of potential impact of expanded rainfall collection to all roofs. 77

LIST OF FIGURES

Page

Figure 1.1: Basemap showing FMG location, buildings, and garden areas....................... 3

Figure 1.2: Basemap showing current parking in relation to FMG. 7

Figure 1.3: Section of 2008 Campus Master Plan. 8

Figure 1.4: Screenshot from recent U.S. Drought Monitor site illustrating the increasingly common state of drough in the State of Georgia..................................10

Figure 2.1: Map showing major watersheds in Georgia. 17

Figure 2.2: Map showing Upper Oconee watershed with relative location..................... 18

Figure 2.3: Map showing location of Tanyard Creek Watershed. 19

Figure 2.4: Map showing approximate comparison of pre-engineered watershed to current FMG watershed. 21

Figure 3.1: Aerial c.1920, shows a portion of the formal garden (bottom left). This photo, taken by Sears, documents the historic setting for the garden. 28

Figure 3.2: Basemap prepared by The Jaeger Company for the restoration plan of Reynolda Gardens. Plan courtesy of The Jaeger Company. 29

Figure 3.3: OLIN site plan for Kroon Hall. 34

Figure 3.4: Diagram illustrating stormwater capture, treatment, storage, and recycling.. 36

Figure 3.5: Andropogon Associates, Ltd. plan for Lubert Plaza 38

Figure 3.6: Andropogon Associates, Ltd. Diagram illustrating the water collection/circulation system. 40

Figure 5.1: Basemap illustrating FMG in relation to Tanyard Creek and the Oconee River.. 60

Figure 5.2: Basemap showing delineation of FMG watersheds. 61

Figure 5.3: Basemap illustrating the area proposed for porous concrete.......................... 64

Figure 5.4: Basemap illustrating the additional area proposed for the Bamboo Walk..... 68

Figure 5.5: Basemap showing garden areas with corresponding water use 73

Figure 5.6: Basemap showing irrigation details. 75

Figure 5.7: Basemap showing potential rainfall collection areas. 78

CHAPTER 1

Founders Memorial Garden and the College of Environment and Design

The University of Georgia (UGA) is one of the oldest institutions of higher education in the United States of America. It is renowned in various fields of study, one being landscape architecture under the College of Environment and Design (CED). Many parts of the campus are registered as historic, perhaps the most significant being the Founders Memorial Garden (FMG). The Landscape Architecture Department was originally established on the historical northwest corner of UGA's campus in Athens, Georgia (Figure 1.1), and has since developed into CED.

The landscape architecture program was established in 1928, originally housed in the Horticulture Division of the College of Agriculture (Owens and University of Georgia. Dept. of Landscape Architecture. 1983, 83), but moved into the Lumpkin House in 1939. The Lumpkin House is a Greek Revival building complex situated on what is now the roughly two and a half acre site constituting FMG (Hutchison 2011, 25). Consequently, this corresponds to the year that construction of the Garden was initiated, starting with the formal gardens adjacent to the south and east of the House (Adams 2004, 42). It had been a number of years in the works, but the Garden was a collaborative effort between the Garden Club of Georgia (GCG), the College, and the University. The GCG, later known as Garden Club of America, wished to commemorate the founders of the first garden club in the United States, while the College desired to have a living lab to benefit student learning. The University, on the other hand, received a Garden at no upfront cost with the understanding that they would permanently maintain it (Hutchison 2011; Adams 2004).

While the College grew in number and esteem, the Garden grew in its standing as a living memorial and as an example of the popular design of the times (Hutchison 2011, 32-34). The growth of the College necessitated a move to larger quarters, and in 1956 the newly renovated Denmark Hall became the home of the department, followed in 1958 by the GCG moving their headquarters to the Lumpkin House (Adams 2004, 42). This was followed in subsequent years by “expansion into Caldwell Hall in 1982, to Broad Street Studio in 1998, and Tanner Hall, on the east side of campus, in 2009” (Hutchison 2011, 64). By 2013, the College plans to have its undergraduate teaching facilities in the old Visual Arts building on Jackson street (College of Environment and Design: Strategic Plan DraftDesign 2009). Initially, the graduate programs will still be housed in Denmark Hall, but the goal as set by the College in the Strategic Plan is to have all instruction under one roof while converting Denmark Hall into a research center. The Lumpkin House and Garden will be restored for the use of seminars and heritage studies. The Garden will still be under the direction of CED, but physically it will be more disconnected from the student body of the College.

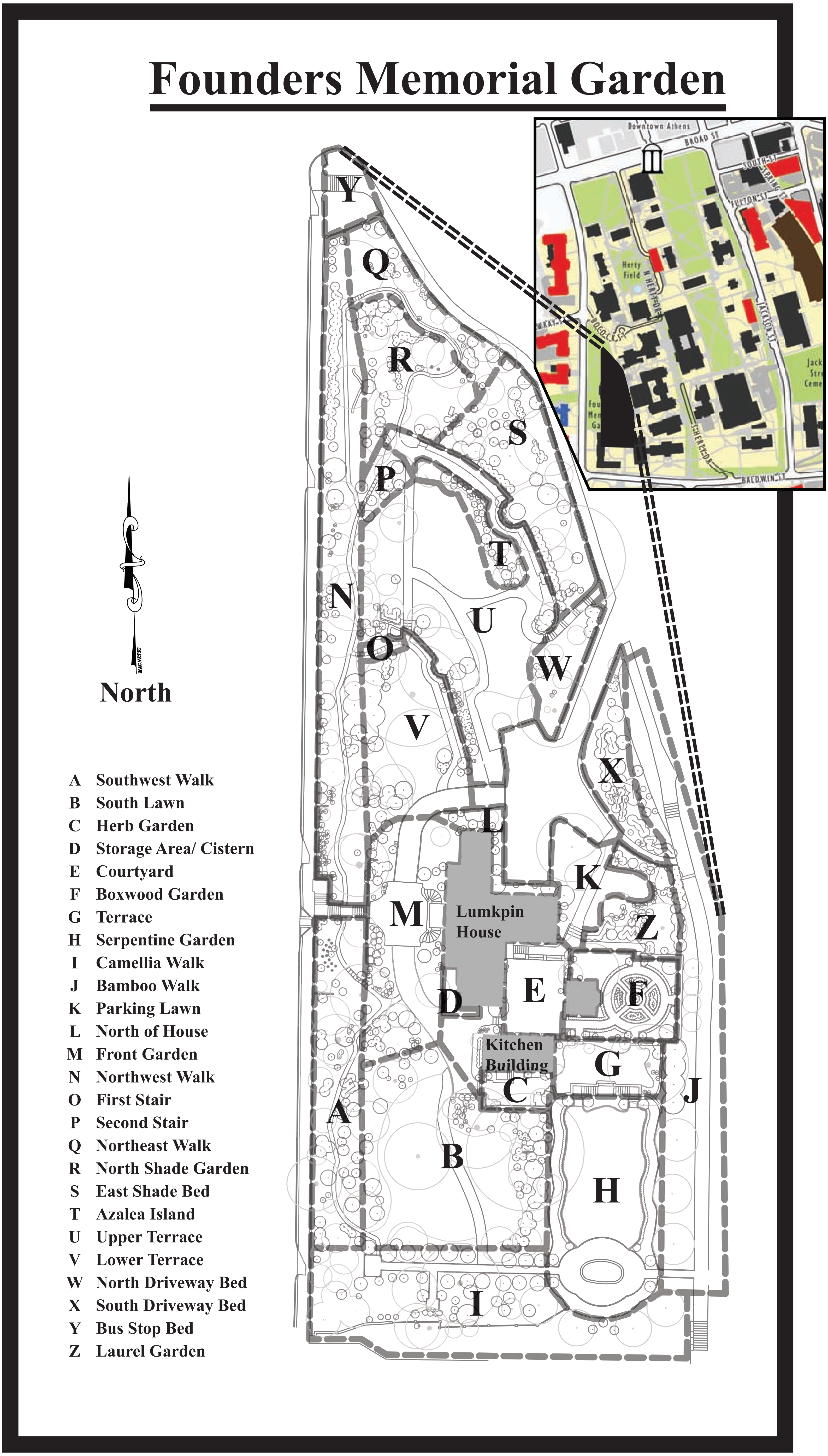


Figure 1.1: Basemap showing FMG location, buildings, and garden areas.
Map courtesy of Taylor Ladd.

The Garden exists today largely intact and healthy. Its management has been handed down through three generations of directors, Robert J. Hill, Allan Stovall, and David Nichols, with a board of directors that has changed every couple of years (Nichols 2012). Despite a relatively loose organization, lack of an endowment and lack of a clear mission since the retirement of Owens in 1973, the Garden has survived without many drastic changes. The stone paving skirt around one of the water features, added in 1988, is one of the bigger design modifications to happen, but it occurred for practical reasons due to an increase in foot traffic through the area and, in the opinion of the author, does not conflict with the Colonial Revival style or constitute a drastic change, especially when compared with the development of the rest of the campus in the last 40 years. A significant change that did not affect the look of the Garden but showed great improvement in water resource management was adding electricity for a recirculating pump on the boy-with-a-goose fountain. This was done in 2008. Both fountains are filled with local municipality water, and are cleaned yearly in the winter. Once filled, they only need water to make up for losses due to evaporation. Both fountains were resealed to protect them from leakage, and are shut off during times of severe water restriction. Other incremental changes have taken place, but most of these have been due to the typical maturation and decline that occurs in a living landscape. Plant substitutions and additions account for most of the changes (O'Brien 2012).

Even though the original agreement was that UGA would be the body responsible for maintaining the Garden, the onus has largely fallen to CED. "Today, the FMG is viewed as a departmental initiative that contributes to the larger UGA campus (Adams Personal Interview). While CED is fully responsible for the management of FMG, the

UGA Physical Plant provides budget assistance through the repair or replacement of "broken" components (Personal Interview)" (Hutchison 2011, 59).

In the current management structure, the Dean is the person with the final decision making obligation. While Owens likely had the most hands-on approach with the Garden, other deans seem to have kept abreast of developments in the Garden and participated when needed but mostly left the management to whatever committee was running it at the time. The committees have changed over the years, and have had varying degrees of function. Because of this management arrangement and due to environmental factors and influences of perception, the Garden quality has fluctuated throughout the years. In terms of perception, one could make the case that people remember the Garden on a perfect spring day when they were a student at UGA. When they come back 10, 20, 30 or 40 years later it may be another time of year and the Garden may not look as pleasing to them, but it could be that the Garden is just as healthy as the day they remember it.

The Garden has also been affected by changes in use over the years, namely a huge increase in the number of people using the Garden paths to go from parking lots to buildings on North Campus (Figure 1.2). Use of the Garden as a East-West connection is bound to change in the coming years with the, now opened, Special Collections Library and further development around the budding Northwest Precinct of campus. While the changes are not imminent, the master plan shows that roads and pedestrian circulation are going to change as well (Planning 2008). Part of the Plan is to transform the service drive between Denmark Hall and the Garden into a more pedestrian friendly zone similar to the promenade that connects North Campus to the Sanford Stadium area and South

Campus. This will change the North-South traffic coming through the Garden, which will open up opportunities for the expansion of FMG.

The primary justification for undertaking this research stems out of one of the values for which the Garden was created. Both Lindsay Hutchison and Dexter Adams dedicate sections of their theses to the educational component, that the Garden should be "A place of education for future landscape architects" (Owens). "FMG and the other historic campus landscapes surveyed for this report were intended to be direct sources of information for teaching purposes" (Adams 2004, 2). "As the primary value composing the Teaching historical pillar, it is disturbing that the Educational value is no longer as strongly held" (Hutchison 2011, 89).

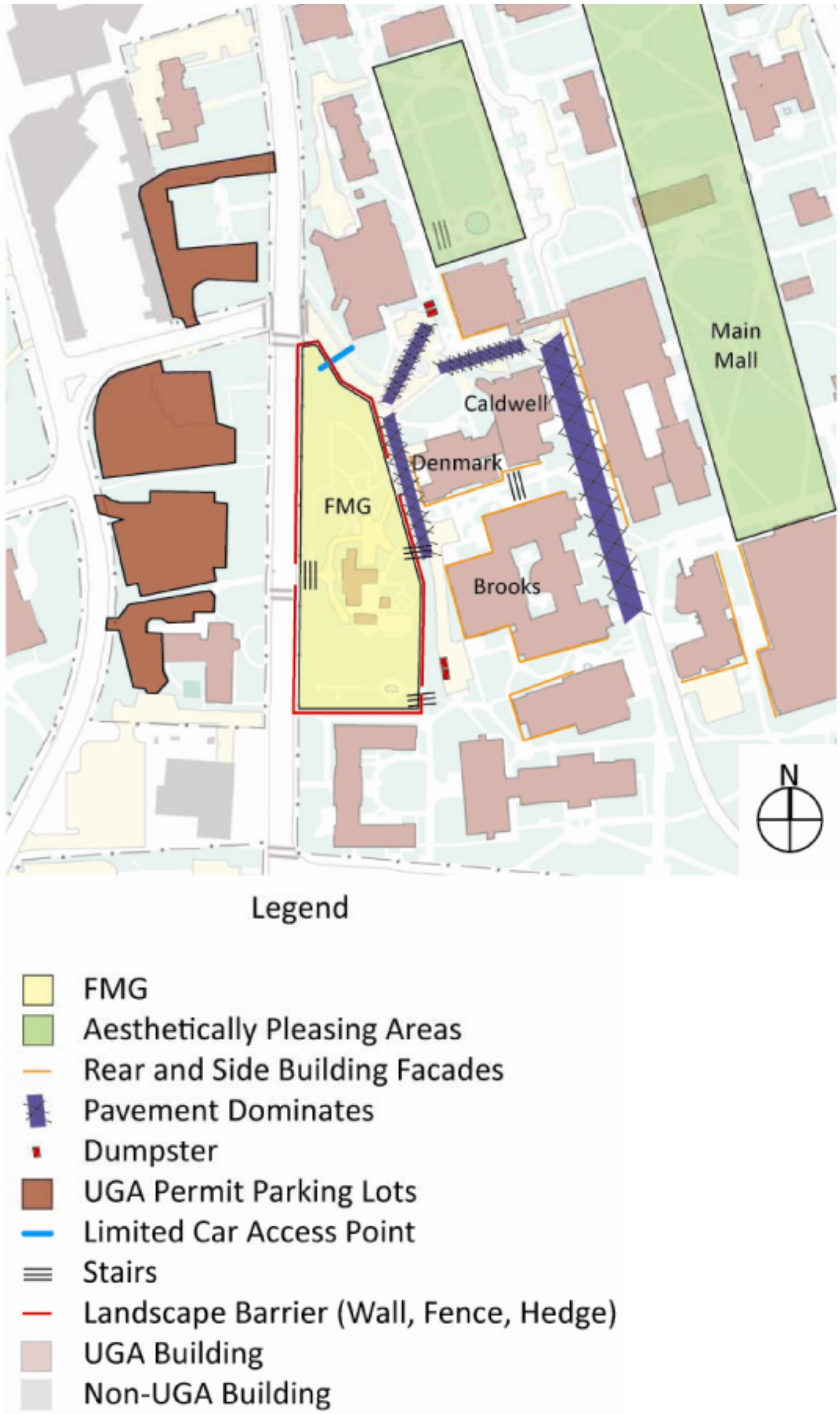


Figure 1.2: Basemap showing current parking in relation to FMG.
Basemap adapted from Hutchison 2011, Courtesy of UGA Office of University Architects.

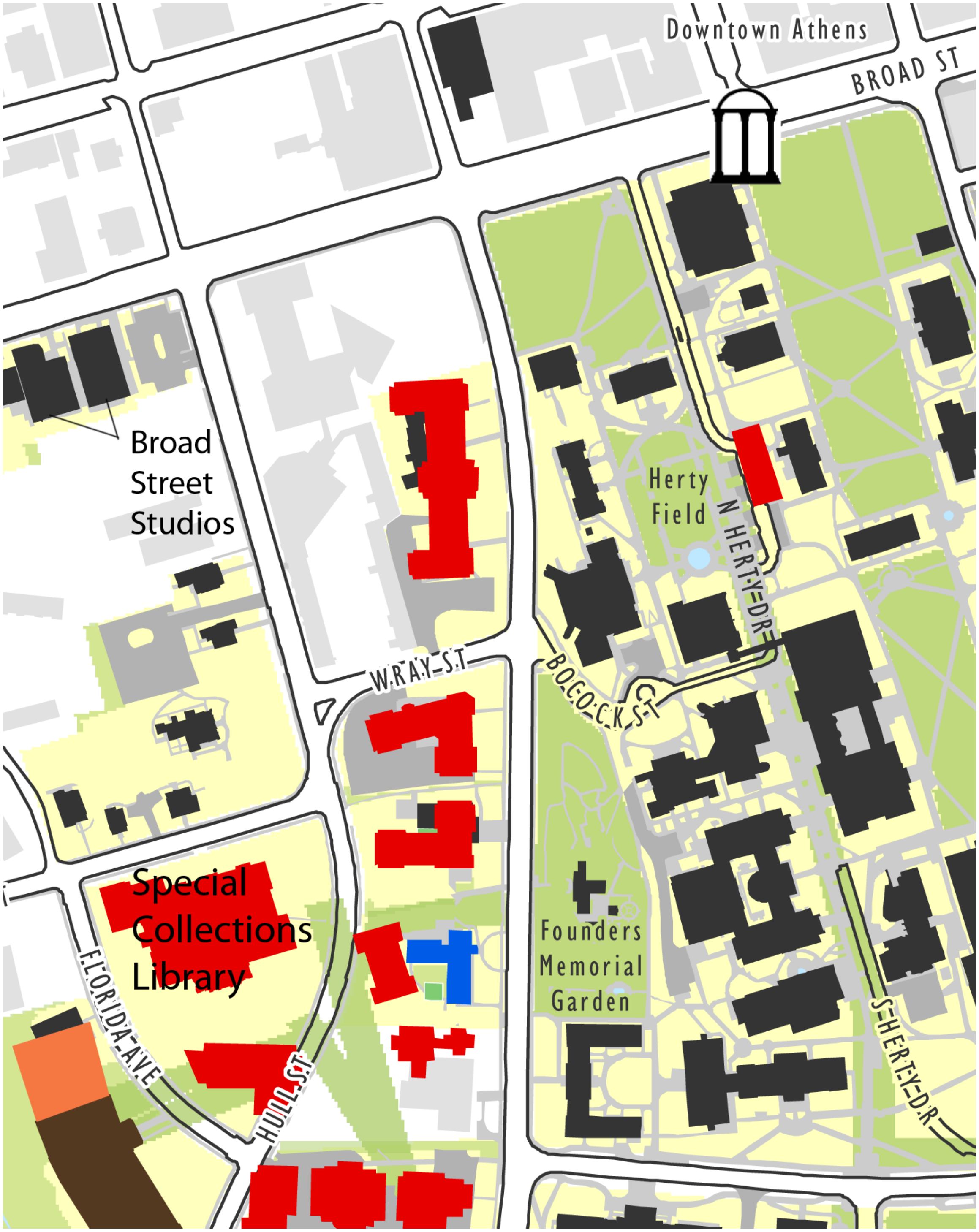
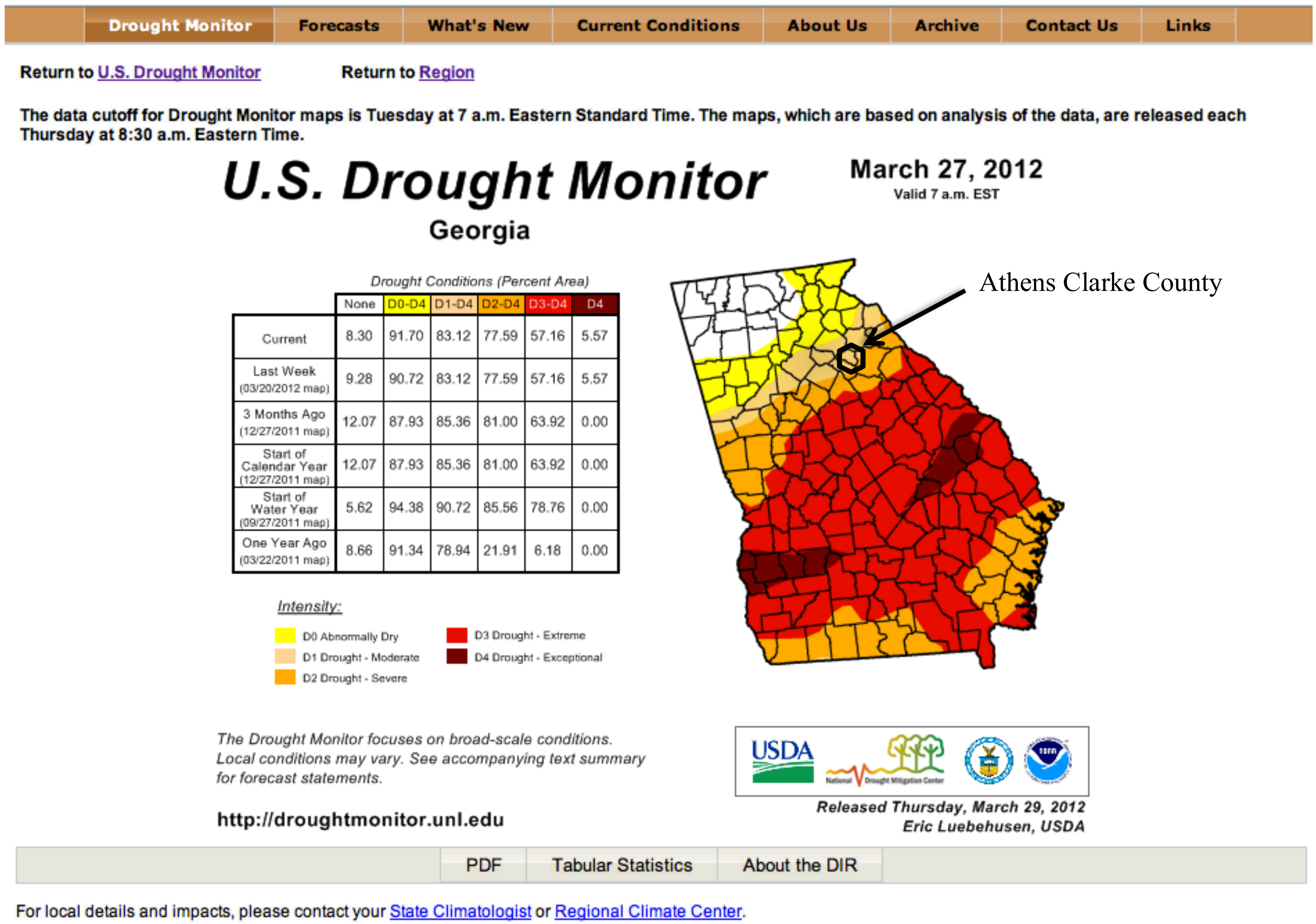


Figure 1.3: Section of 2008 Campus Master Plan.
Basemap courtesy of UGA Office of University Architects

During the formative years of the Garden, from looking at historical accounts, students participated heavily in the “design, construction, and modeling of FMG” (Wilkins 1950, 18). Currently, the primary educational role that the Garden plays is in plant identification. The graduate level Landscape Management class has undertaken to study the Garden and find ways to bring its management in line with current practices, but otherwise the Garden has taken on a more social and unstructured role for use by individuals to study and relax in the space (O'Brien 2012).

Since FMG was designed in a different era with different concerns means that water consumption was never really considered in the design of the Garden. When asked about this, Dexter Adams, who performed extensive historical research on FMG, said “No, never, in the Garden or in the region. Water was bountiful and cheap so it wasn’t considered necessary.” (Adams 2012) This attitude has changed in recent years due to droughts, and, even though it does not directly affect Athens, the long dispute over water usage between Alabama, Georgia, and Florida. Droughts have been periodic throughout the State’s history, but people have become especially aware of them in the past 30 or so years due to their severity and frequency (Yellin 2000).



	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	8.30	91.70	83.12	77.59	57.16	5.57
Last Week (03/20/2012 map)	9.28	90.72	83.12	77.59	57.16	5.57
3 Months Ago (12/27/2011 map)	12.07	87.93	85.36	81.00	63.92	0.00
Start of Calendar Year (12/27/2011 map)	12.07	87.93	85.36	81.00	63.92	0.00
Start of Water Year (09/27/2011 map)	5.62	94.38	90.72	85.56	78.76	0.00
One Year Ago (03/22/2011 map)	8.66	91.34	78.94	21.91	6.18	0.00

Figure 1.4: Screenshot from recent U.S. Drought Monitor site illustrating the increasingly common state of drought in the State of Georgia.

The dispute between Alabama, Florida and the State began in the 1990s over the decision of the Army Corp of Engineers and Georgia to allow Atlanta to use more water out of Lake Lanier, which is located approximately forty miles northeast of the city. The contention from Alabama and Florida is that this constituted a substantial change and needed approval from Congress. At first, the States tried to work out a water-sharing plan of their own, but when that failed the saga began working its way up through appeals to higher courts (Henry 2011; Hart 2003; Yellin 2000; "Three States Delay Water-Sharing Plan" 2002). The most recent chapter in this dispute resulted in the second highest Court of Appeals handing Atlanta a major victory by allowing them to continue using Lake Lanier as its primary water source, but Alabama and Florida have asked the Supreme Court to take up the issue (Williams 2012).

This local awareness and the general movement within society for creating a more sustainable future will mean that the management of historic gardens will have to change if they are to survive into the future. This will be especially true if even the most moderate of climate change models turns out to be accurate. With changes in average rainfall and temperature, Georgia is predicted to move from its current climate to one more similar to parts of Texas in the coming years. Currently, the average temperature is 63 degrees Fahrenheit and the average rainfall is 49 inches, but it is projected to be 66 degrees Fahrenheit and 35 inches of rain by 2099 (Porter 2012).

This, essentially, gives garden managers two choices: plan ahead for aesthetic and technological changes in the Garden or have a garden that periodically struggles to survive because of watering restrictions. The current cistern adjacent to the kitchen building helps but is not sufficient for long-term water supply (Adams 2012). It only provides for minimal watering to either the Boxwood Garden or the Serpentine Garden areas when used in drought conditions. If water restrictions go any longer than a week or two with no rain then the Garden will suffer due to lack of water.

This occurred in August of 2011 when students returned for the fall semester. Maureen O'Brien, the curator of the Garden, emptied the cistern to water the Boxwood Garden, and, fortunately, there was a small amount of rain the following weekend to allow her to water the Serpentine Garden. The restriction was only in place for two weeks, but had it gone any longer the health of the Garden would have been in danger.

This thesis is timely for several reasons. CED is developing an endowment fund so that the Garden will have a self-sustaining source of funding (Design 2009). This is being accompanied by a change in the governance structure. Student groups in the aforementioned landscape management class have researched a couple different management structures in the past few years. Dean Nadenicek, the current Dean, has used recommendations from the landscape management class to reconstitute the board of directors with clearer delineations of responsibilities and sub-committees to do work between bi-annual meetings (O'Brien 2012).

This thesis is intended to be looked at as a third leg that may serve to guide the decision making process in the management of the Garden. Dexter Adams' 2004 thesis focused on historic preservation and appropriate change in the Garden. Lindsay Hutchinson's 2011 thesis focused on defining the mission of the Garden and a value system by which decisions can be made. The following research explores the Garden from the point of view of water conservation and to provide tools by which garden health and water resource management decisions can be made.

This thesis intends to address three questions: What is currently happening to water in the Founders Memorial Garden, and how can the College better utilize evaluation methods in the management of the Garden? What tools are available and how can they be used to enhance the management of the Garden? How can the Garden minimize municipal water use and still fulfill its educational and historic mandates?

It stands to reason that looking at Adams' thesis and this thesis through the lens of Hutchison's thesis should be of great value for the College to meet the sustainability goals that the University has set whilst paying respect to the historic property. The latest Strategic Plan for the University is very illuminating when it says that "Sustainability is no longer an option; it is an imperative." Quantifying the benefits imparted by various changes will allow for a more objective evaluation of possible changes in the Garden. This is accomplished by establishing a baseline for the current state of the Garden in terms of water use and stormwater runoff. Adopting generally accepted methods and tools, several water-related calculations are performed to define and calculate this baseline. Secondarily, these same tools are used to quantify the benefit of various hypothetical changes that could be made in the Garden. There are a myriad other methods available that have not been chosen for this thesis, but from the research of the author and the latest material available at this time, the methods and tools chosen are widely accepted and in the very least, represent a starting point from which further research could be added.

The changes mentioned in this thesis are hypothetical and represent a few of hundreds of possibilities. Some of the changes evaluated are minimal while others are more extreme. Exploration of options is the goal, and there is no set target for water savings or stormwater remediation. Later paragraphs will explain how much of a change something is considered, but broadly, the changes are evaluated on how noticeable they are versus how much of an improvement they represent in terms of water conservation. It is the hope of the author that the data that has been collected and developed in this document will be used to evaluate changes being considered in the Garden, whether they are ones mentioned in this thesis or not. In the very least, even if this thesis is not used for future management decisions, it defines and documents the state of the Garden in 2012 and may be valuable in the historical record of CED.

Chapter 2

The Watershed

Concept

In order to apprehend the specific methods of calculation for FMG there is one overarching concept that must be understood. What a watershed is and how the hydrologic cycle works is ultimately a prerequisite to fully understanding any water conservation effort.

> "The central concept in the science of hydrology is the so-called hydrologic cycle- a convenient term to denote the circulation of water from the sea, through the atmosphere, to the land; and thence, with numerous delays, back to the sea by overland and subterranean routes, and in part, by way of the atmosphere… The science of hydrology is especially concerned with the… water in its course from the time it is precipitated upon the land until it is discharge into the sea or returned to the atmosphere. It involves the measurement of the quantities and rates of movement of water at all times and at every stage of its course." (USGS 2007)

Since water is in the earth, on the surface of the earth, or in the atmosphere, and because these are quantifiable values, to a certain degree, it is possible to calculate a water budget for a given area. "Water budgets are tools that water users and managers use to quantify the hydrologic cycle. A water budget is an accounting of the rates of water movement and the change in water storage in all parts of the atmosphere, land surface, and subsurface" (USGS 2007). There are numerous models and calculations to do this, such as, ground-water-flow, stream flow routing, general circulation, soil-veg-atmospheric transport, and even coupled models.

The Oxford English Dictionary defines watershed as “a narrow elevated tract of land separating two drainage basins” or “the thin line dividing the waters flowing into two different rivers.” The more common, modern understanding of the word interprets the watershed “as a drainage basin: an area of land within which all waters flow to a single river system” (Heathcote 2009, 4). Most watersheds are bound by ridges at its highest elevations and have at least one outlet at its lowest elevation. Just as the different definitions suggest, a watershed can be analyzed at different scales. The outlet of the regional watershed is usually a large river, lake, or the ocean. Typically a watershed is delineated on a contour map from the outlet, moving upward, perpendicular to the contour lines until the area is enclosed from both sides of the outlet. There are numerous methods to predict the amount of water that will flow through this outlet, and the next section will discuss those calculations.

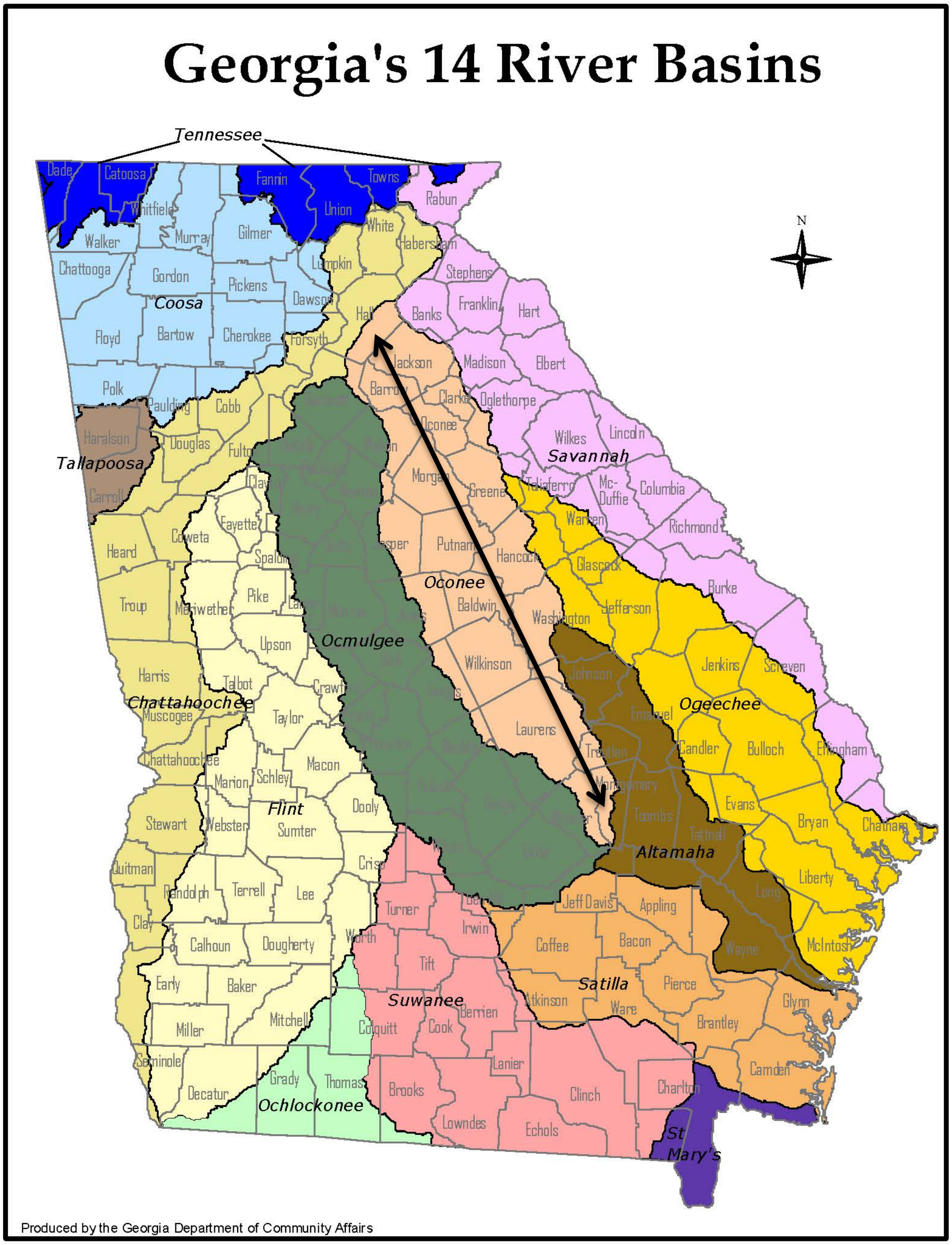


Figure 2.1: Map showing major watersheds in Georgia.
Map courtesy of Upper Oconee Watershed Network.

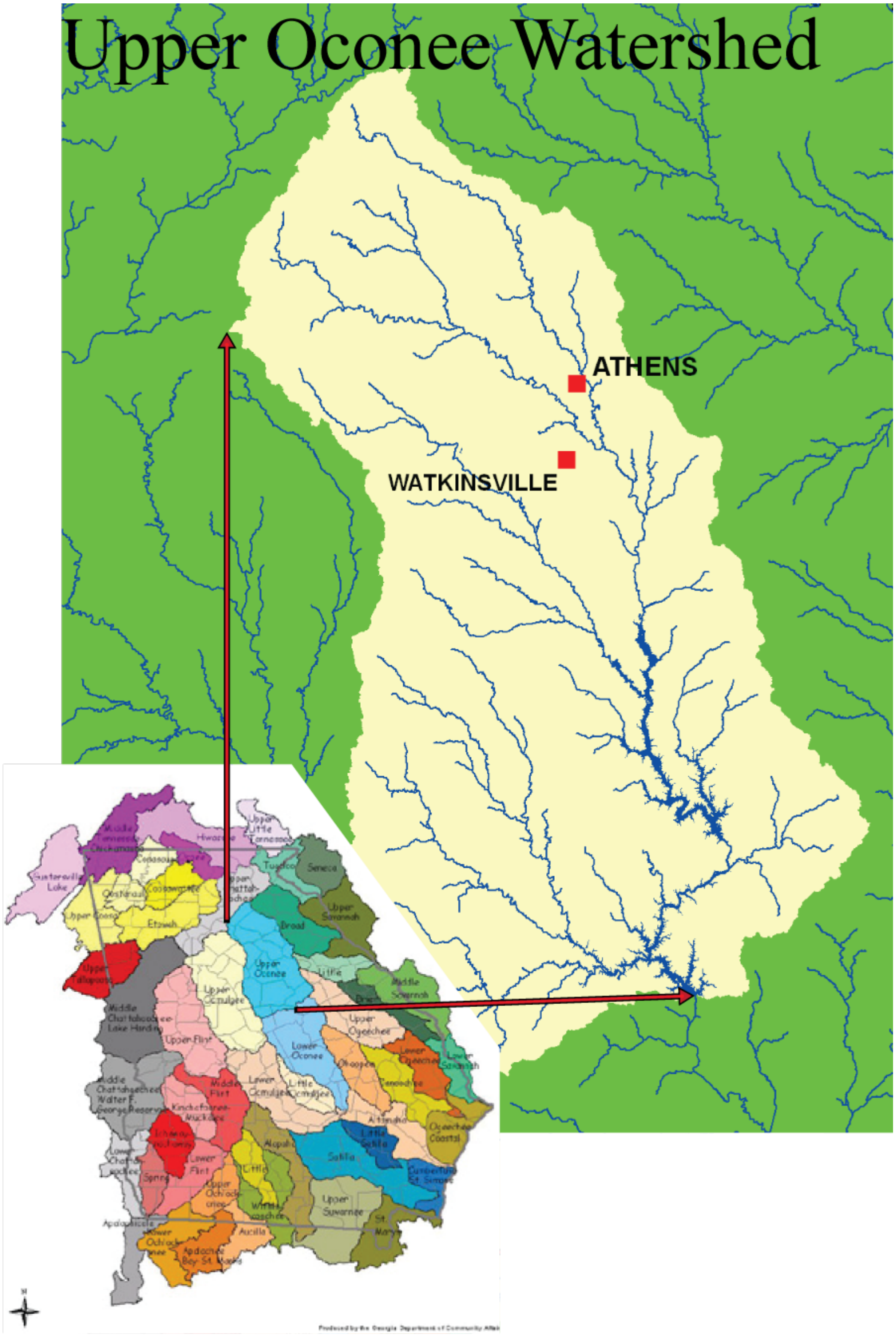


Figure 2.2: Map showing Upper Oconee watershed with relative location.
Adapted graphics courtesy of UGA College of Agricultural and Environmental Sciences and Upper Oconee Watershed Network.

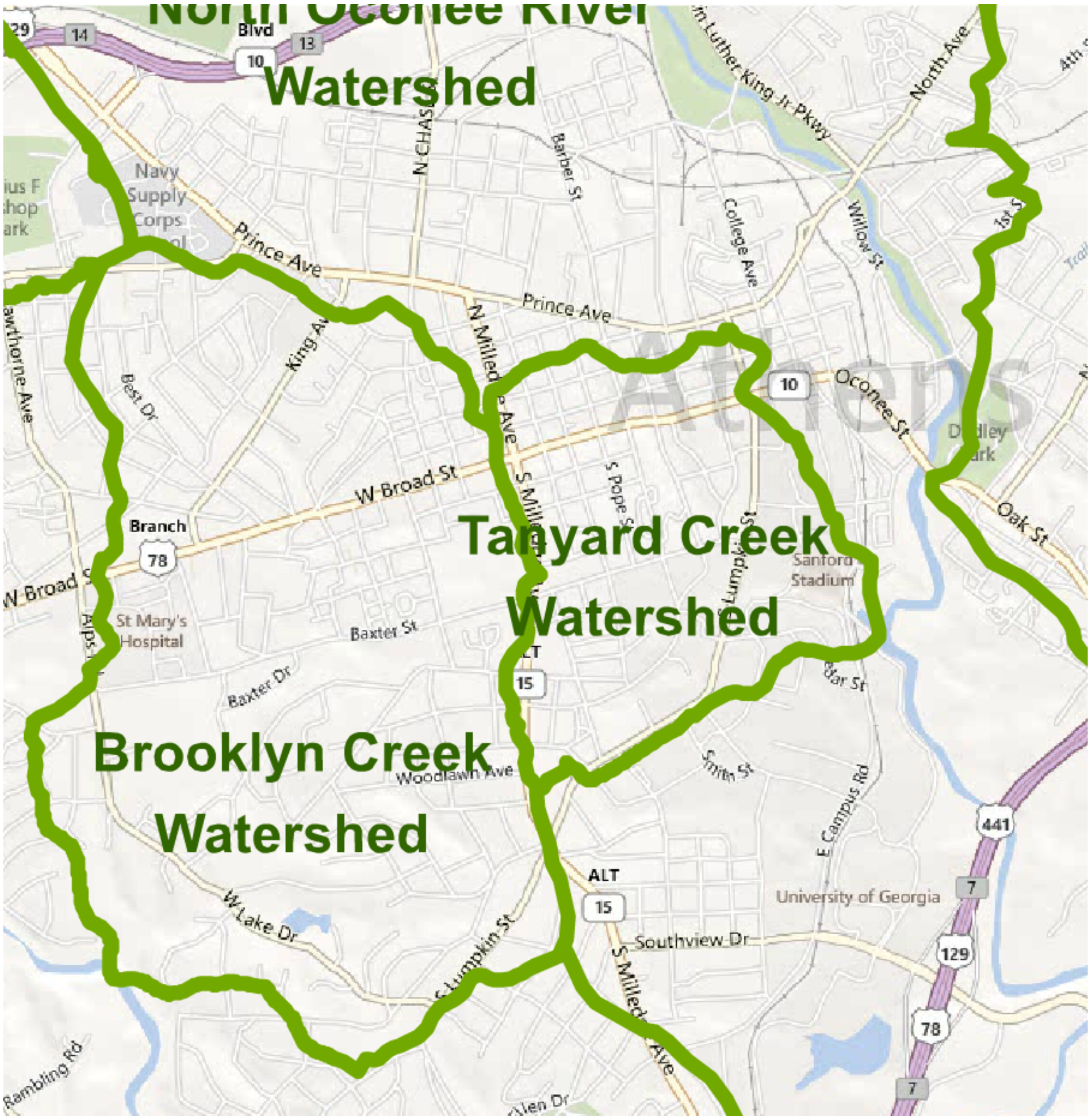


Figure 2.3: Map showing location of Tanyard Creek Watershed.
Map courtesy of Athens Clarke County.

FMG is part of the Tanyard Creek watershed (Figure 2.3), which is a minor watershed inside the larger Upper-Oconee watershed (Figure 2.2), which in turn contributes to the Oconee River Basin (Figure 2.1). It is helpful to analyze the local watershed for site-specific designs, but it is also important to know the watershed as a whole so that it is understood where the site is located within it. The water flowing in the greater watershed will affect the site, and site changes will also influence the larger watershed. The UGA campus is so engineered that all of the uphill area that would normally contribute to the overland flow across FMG is all piped underneath and connects to the city stormwater system. In this case, it makes the calculations for the Garden more direct and simple, but it required studying the data available for the larger area to make this determination. As an aside, it is interesting to compare what the watershed may have looked like before with what it is now for the area that constitutes FMG. It is not clear that this is exactly what it would have looked like due to grading and older construction that may have affected the site, but in general the graphic below illustrates an approximate comparison (Figure 2.4).

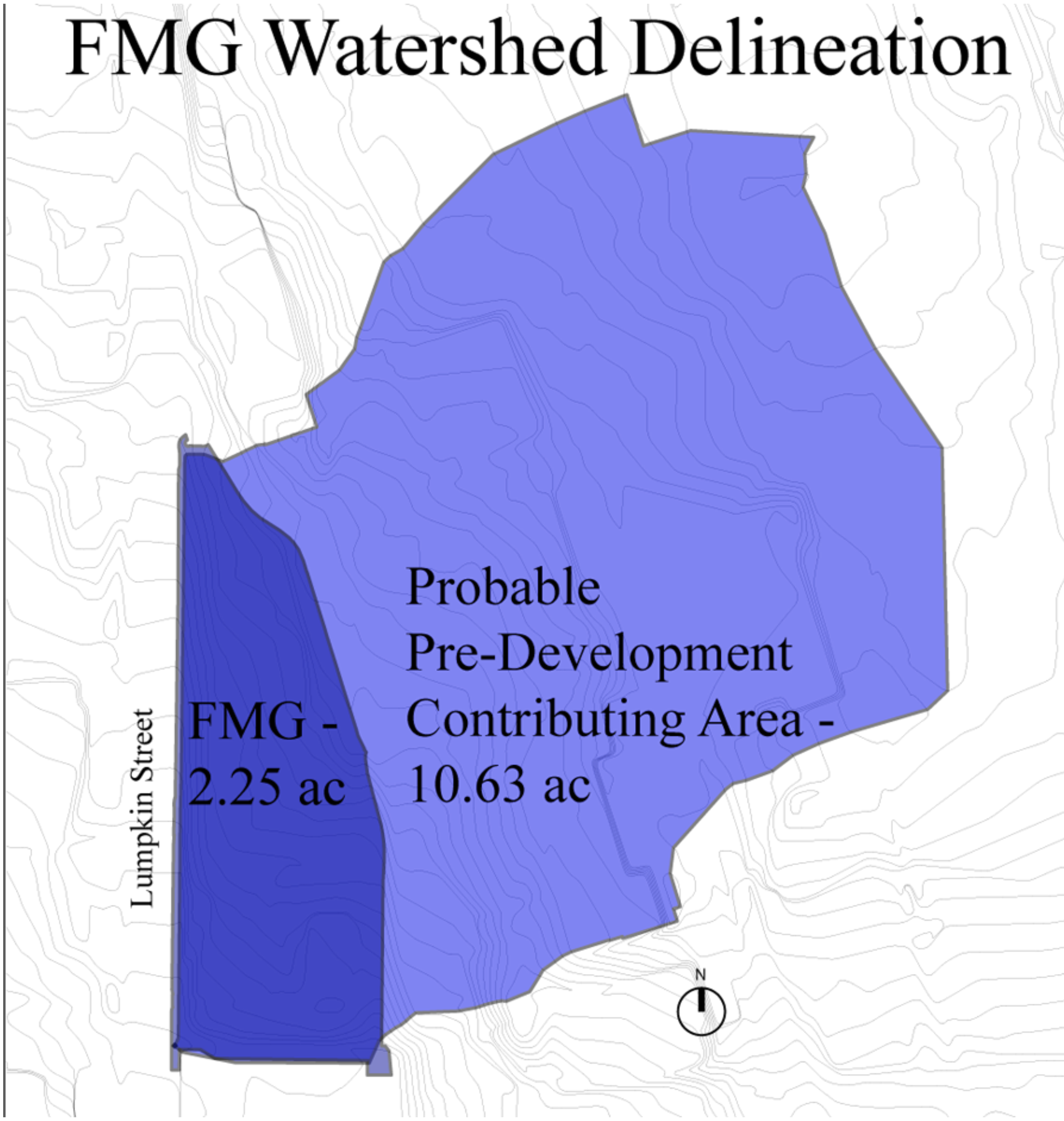


Figure 2.4: Map showing approximate comparison of pre-engineered watershed to current FMG watershed.

While the watershed accounts for water flowing over the surface of the earth, a complete water budget would also include large amounts of water flowing under the earth's surface and smaller amounts of water in the atmosphere. Generally, water under the earth's surface is typically referred to as groundwater. More specifically, aquifers refer to a particular component of the groundwater system. These aquifers are large, in some cases very large, bodies of water moving in the cavities in and between all the layers of soil, rock, and decomposed matter below the surface of the earth. Wells usually tap directly into these, but lakes and rivers affect them as well. In many cases a river or lake is the visible part of a body of water that can extend for miles under the ground. Therefore, even when water is taken from one of these sources it still results in a change to the aquifer. Related to this concept, the well known author Wendell Berry has said that we must learn "to see the city, not just as a built and paved municipality set apart by 'city limits' to live by trade and transportation from the world at large, but rather as a part of a community which includes also the city's rural neighbors, its surrounding landscape and its watershed, on which it might depend for at least some of its necessities, and for the health of which it might exercise a competent concern and responsibility." (Berry 2002).

The relationship between water runoff and underground water is that when water is allowed to move slowly across the ground more of it percolates into the soil, eventually making its way into the aquifer. Development typically results in the increase of impervious surfaces, and "more recent research… indicates that other land covers, such as disturbed soils and managed turf, also impact stormwater quality" (Law, Cappiella, and Novotney 2008; Battiata et al. 2010). "Our legacy infrastructure relies heavily on impervious surface. Stormwater runoff generated from this surface continues to cause myriad problems within our watersheds including flooding, erosion, lack of ground water and base flow recharge, and habitat destruction" (Walsh et al. 2005; Wang, Lyons, and Kanehl 2003; Davis, Traver, and Hunt 2010).

The difference between a predeveloped forest and an urban setting is that the forest has many more impediments to the movement of water. First, a drop of water hits the canopy and gets stuck on a leaf for a time. When more drops come behind it, the drop falls down onto more leaves in the understory, and eventually onto the ground where it hits a surface of mulching leaves and other organic matter. Only after soaking through that layer does it hit the ground and start the process of percolating through to the sub-surface. This process is very different for a drop hitting a roof, as another example. The drop that hits a roof will make its way into a gutter, maybe across a lawn or other vegetated surface, but it will be at a higher speed and more concentrated, thus not having the opportunity to soak in and possibly causing erosion along the way. In many places, especially urban areas, this drop will go from the roof, to the gutter, into a pipe and then into a water body. The drop will not be given a chance to permeate the soil, which not only would bolster the health of the land and river but also replenish the aquifer.

Much of the current research and practice in the field amounts to several methods of stormwater management. "Runoff can be reduced via canopy interception, soil infiltration, evaporation, transpiration, rainfall harvesting, engineered infiltration, or extended filtration" (Battiata et al. 2010). Another article refers to these methods as "Nature-based stormwater control measures" and include "bio-retention, vegetated swales and filter strips, green roofs, and permeable pavements" (Davis, Traver, and Hunt 2010). In general, these various methods attempt to replicate the natural processes that would occur if the site had never been developed.

Water in the atmosphere is the last facet to be explained. As most species that live on land see it, the water we interact with is on the surface of the earth. Given the right conditions, this visible layer of water evaporates and enters the atmosphere. The conditions that make a difference for evaporation are temperature, relative humidity, Vapor Pressure Deficit (VPD), and exposure to sun and wind. Water in the atmosphere is the primary method of water moving around the planet, even though, by percentage, it is a small amount of the water in the earth's system. Pressure systems and other forces in the atmosphere move this water vapor in the atmosphere around the earth, very often forming clouds and creating what we consider the main drivers of weather. When a large enough accumulation of water vapor forms in the atmosphere, precipitation occurs, and the water begins the hydrologic cycle again.

Another way that water can enter the atmosphere is through plant transpiration. Transpiration occurs when water is pulled up from the soil through the roots of the plant, which is used in the biological processes of the plant, and is then released, usually, through the leaves. Practically, it is very difficult to measure transpiration separate from evaporation so what is most often referred to is the combination of the two, called Evapotranspiration (ET), which is measurable. All species of plants have different ET rates based on how that particular plant uses water which can be compared to the base ET rate in order to estimate how much water a particular plant or set of plants may use. The rates are affected by light, temperature, and VPD. Light has the strongest effect on ET, typically meaning that the month with the highest light levels will have the highest ET rate, and therefore require the most amount of water during that time.

While "extensive research has been conducted on the water needs of various types of turfgrasses, very little data exists on the water needs of other vegetation, including groundcovers, shrubs, and trees. Additionally, the landscape coefficient varies depending on location, meaning that the available data cannot automatically be ascribed to the same species in different regions. However, vegetation can be described in broad categories as high-water-using, medium-water-using, or low-water-using" (EPA 2010). Also, unlike industrially farmed crops, there is not much money available to research evapotranspiration rates for common garden ornamentals.

Practice

The American Society of Landscape Architects has a variety of tenets associated with water use and stormwater management as they relate to larger watershed issues. The most relevant are:

> "Water resources should be equitably allocated, available water supplies should be efficiently used, all forms of water pollution should be eliminated, and land use should conserve and protect water resources and related ecosystems to sustain a high quality standard of living and the maintenance of the quality of ecosystems." (ASLA 2006)

> "The natural and cultural elements of waterways and their corridors should be protected through the systems of national, state, and local designation of rivers and greenways to ensure their integrity and use by this and future generations." (ASLA 2006)

> "The Millennium Ecosystem Assessment (MA) reports that coastal wetlands play a critical role in human health and well being through actions such as water purification and detoxifications of wastes; erosion control; buffering flooding consequences of storms and sea level changes; improved water supply; providing recreational, aesthetic, educational, tourism and water dependent commercial benefit; and habitat diversity." (ASLA 2007)

This represents a relative shift in attitude from traditional water management, especially stormwater management.

> "Traditional storm drainage systems, the conventional method of solving the problem of keeping the city's paved surfaces free of water, have until recently been unquestioned. As (in) the established vocabulary of engineering, water drains to the catchbasin. Yet the benefit of well-drained streets and civic spaces is paid for by the environmental costs of eroded streams, flooding and impairment of water quality in downstream watercourses, a condition that is akin to

> environmental degradation by design. Waste disposal systems are seen as engineering rather than biologically sustainable solutions to the ultimate larger problems of the eutrophication of water bodies. Yet cities produce vast quantities of nutrient energy that recycling programmes are only beginning to reuse for productive purposes." (Hough 2004)

The more current understanding of stormwater management is to work with natural systems, either allowing them to function as they would normally or mimicking them as best as possible. This is done through the aforementioned methods of canopy interception, soil infiltration, evaporation, transpiration, rainfall harvesting, engineered infiltration, or extended filtration, bio-retention, vegetated swales and filter strips, green roofs, and permeable pavements.

Not all of these methods would be considered appropriate for FMG, as some would violate the historic nature and require much more input such that there would probably not be a net benefit in the end. A good example of this is green roofs. If it were possible without major reinforcement of the building structures, it would be very noticeable and not in keeping with the historic fabric of the building complex. Rainfall harvesting, though, may be done with no change to the appearance of the building and is a way to further the water conservation and stormwater efforts. Aside from rainwater harvesting, the most practical of these solutions for FMG are porous pavements and engineered infiltration.

Chapter 3

Case Studies of Similar Gardens

In order to provide context for the research performed on FMG, several other gardens were analyzed. One historic garden was chosen for its similarities to FMG to provide direct comparison, and two modern garden designs were chosen to provide contrast to an historic garden. All three gardens in this section are related to a university and are all relatively small gardens roughly similar in size to FMG.

Reynolda Gardens (The Formal Gardens)

Reynolda Gardens (Figure 3.1), located in Winston-Salem, North Carolina, has many similarities to FMG. It is associated with a university, Wake Forest University, and is a property with both historic gardens and structures. FMG and Reynolda Gardens were designed by distinguished landscape architects of their time. The Formal Garden at Reynolda is approximately twice the size of FMG and differs in that it is not in the midst of the university campus, but rather about one mile from the University. They are both open to the public, although Reynolda Gardens has more limited hours. Also, being located in the Piedmont of North Carolina, the climate is similar to that of Athens, Georgia.

Figure 3.1: Aerial c.1920, shows a portion of the formal garden (bottom left). This photo, taken by Sears, documents the historic setting for the garden.

“The formal gardens were once part of the 1,607 acre estate of Mr. and Mrs. R. J. Reynolds. Designed by Harvard educated landscape architect Thomas W. Sears, the gardens were an expression of early twentieth century ideals of estate garden design and of Mrs. Reynolds’ love of plants and gardens.” (Reynolda Gardens of Wake Forest University: The Formal Gardens). Preston Stockton is the garden manager of the roughly 120 acres that make up Reynolda Gardens, part of which is the formal garden. Like FMG, there are areas that require high inputs of water, fertilizer, and pesticides. They have similar areas of boxwood and numerous other plants in common. The collection of roses is something unique to Reynolda Gardens, and those require a lot of water, especially in the summer. Preston Stockton estimates that each plant needs about 5 gallons of water per week in the summer, and there are between 800 and 900 plants.

“The formal gardens (Figure 3.2) are divided into two parts, which are separated by boxwood hedges, tea houses, and vine-covered pergolas” (Reynolda Gardens of Wake Forest University: The Formal Gardens). It is a very symmetrical design with one main longitudinal line dividing the site and several paths that bisect this line to create smaller parterres. Within this division there are 7 distinct gardens: the East Rose Garden, the West Rose Garden, the Blue and Yellow Garden, the Pink and White Garden, the annual Vegetables and Flowers, the Display Gardens and Children's Garden, and the All-American Rose Selection Garden.

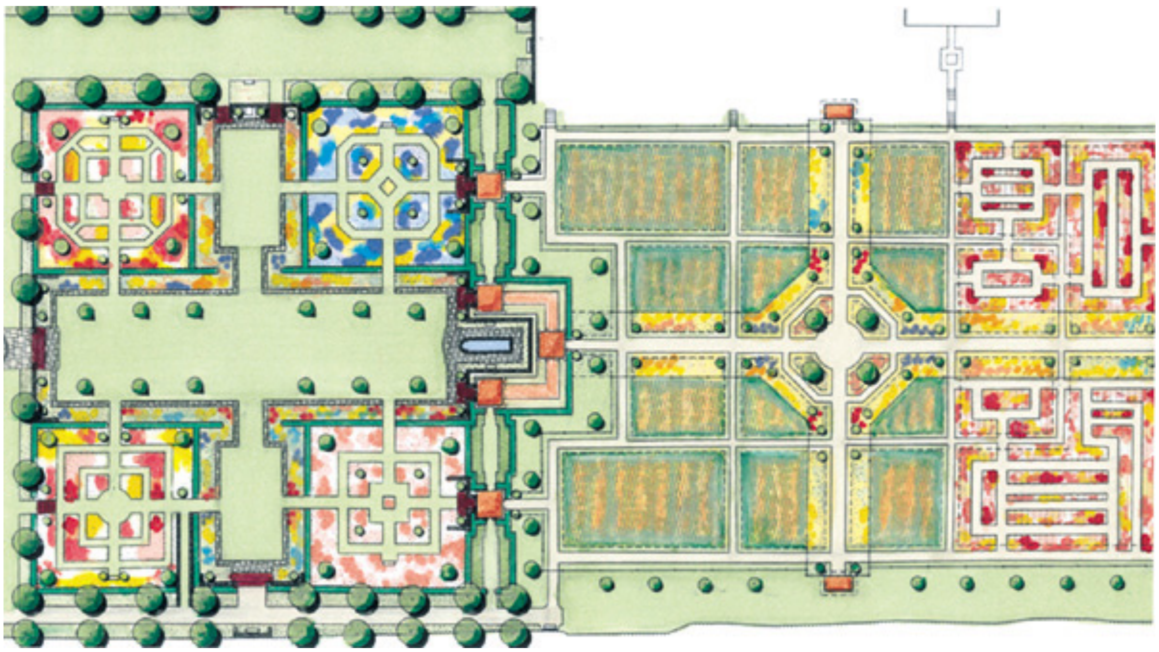


Figure 3.2: Basemap prepared by The Jaeger Company for the restoration plan of Reynolda Gardens. Plan courtesy of The Jaeger Company.

The water issues in this part of North Carolina are different than those in Georgia, but the garden managers are nonetheless aware of water use and do take steps to use water in the most responsible ways they can. They have looked into having underground cisterns installed, but have run into a problem of not having sufficient documentation to know the location of utilities and underground tunnels. They also have less space available due to the layout of the gardens and buildings. They could, therefore, take it on as a project, but the additional cost to survey everything has been limiting, even to determine where the cisterns could be placed. Similar to FMG, they are concerned about how and where they could place above ground cisterns, given that all of the garden structures, as well as the gardens, are historic. In FMG, there is a cistern attached to the southern wall of the Lumpkin House but it is screened off from view and not directly part of a main circulation route. Similar opportunities are not as available in Reynolda Gardens.

As far as irrigation is concerned, they operate very differently than FMG. In FMG, the irrigation is mostly low-volume drip irrigation, the benefits of which are a very even distribution and less water lost to evaporation. In Reynolda Gardens, the irrigation is nearly all pop-up sprayers. The garden staff only use the irrigation when they must, and they run it manually, checking around the garden as it is running, and shutting it off when the garden is sufficiently watered according to the garden manager. The garden's water source is the Yadkin River and is on a separate meter so that they are not charged for sewer utilities. A more in-depth comparative study would be interesting to determine which philosophy works better for water conservation.

Another difference is that the FMG system is much more automated, and can be changed, but otherwise is set so that the system will turn on at certain times even when no staff member is on site. This has the benefits of only running for the allotted time and not requiring the personnel to have any special knowledge of the Garden in particular to manage the system. Moreover, it can be set to run at more ideal times, such as early morning when regular staff members may not be working. The negatives to such a system are that oft times the system may come on even during a rain event when irrigation is not needed and also that, if there is a leak or rupture in any of the hoses, water can be wasted since the irrigation may be running at a time when no one is there to watch it. There are sensors and controllers that can prevent the irrigation from turning on in a rain event, but they still require maintenance, and the process will always need a certain amount of human input. At the very least, any irrigation system will need humans to check and maintain it to keep it in good working order.

In addition, there are certain areas of Reynolda's Formal Garden where plants are removed, and those beds lay fallow during the hottest, and driest, summer months. FMG is more limited in the amount of areas where it is possible to do this. In Reynolda, it is most common in the vegetable beds and certain other annual and perennial beds. In FMG, this is only done in a few very small areas where annuals are usually planted. Once it is determined that they won't survive garden staff remove them and cover the area with pine straw.

In the formal gardens there are not many problems with erosion, but on the property as a whole there are areas that are affected by it. The Village, which is a shopping area adjacent to the formal gardens, has larger amount of impervious surfaces, not all of which were planned with stormwater best management practices, causing periodic problems of erosion and minor flooding. An old man-made lake on the site, called Kimberly Lake, has become a wetland due to eutrophication but now has certain protections from the State due to its age and the species that have made it their habitat. In addition to the Reynolda properties, Wake Forest University owns a number of properties along the Silas Creek and the Yadkin River. In more recent master plans from the university, there is a focus on reducing the impervious surfaces that have been added over the years to prevent flooding and to increase the health of the water bodies.

In FMG, there are small areas that are affected by erosion, but not major problems. The few areas that exist are on steep slopes and are just below a sidewalk, thus receiving water from an impervious surface. UGA in the last three years has created an Office of Sustainability, which should ensure that erosion and runoff issues see continual improvement. Athens Clarke County has also recently been focusing on stormwater projects to reduce the amount of surface runoff and that increase infiltration. Lumpkin Street, which FMG drains into, is a good example of one of these projects to prevent flooding with infiltration trenches and other drainage improvements.

In summary, Reynolda Gardens shows that FMG is ahead of at least one of its peers in terms of water conservation and issues of sustainability. It stands to reason that FMG being associated with leading landscape architecture and historic preservation programs has served to push it to a higher standard. Wake Forest does not have either program, and the garden is not associated with any one school within the university. Proximity to the university, and college, may also play a role since Reynolda is some distance away from Wake Forest's campus. Collaboration between Maureen O'Brien and Preston Stockton would be helpful for both gardens since the gardens have so much in common, with the climates being comparable, and they hold the same position as the day-to-day managers of their respective gardens.

Kroon Hall, Yale School of Forestry and Environmental Studies

Kroon Hall (Figure 3.3) is the home of Yale's School of Forestry and Environmental Studies (F&ES). Yale University is located in New Haven, Connecticut. F&ES was founded in 1901 as the first school of forestry in the United States and has expanded into a leading institution on Environmental Studies (Yale 2012). It follows, similar to CED, that the school would place a high priority on sustainability and green infrastructure based on the mission of the School in which it is housed. The Kroon Hall site, while different from FMG in several areas, shares some significant similarities. It is comparable in size at 3.5 acres. It is located on a university campus and is associated with a department that shares some parallels to CED. In many ways the Kroon Hall site design, by OLIN, serves to illustrate the differences between a modern design and an historic one. Due to the change in times and the process by which these types of projects occur in the present, it cannot be said what the process would look like if FMG were being built today, but it is reasonable to surmise that many of the elements incorporated into Kroon Hall would be included into FMG. The climate is not similar to Athens, Georgia, so the plants and some other elements are not comparable, but the principles that guided this project and the stormwater practices illustrate a good lesson for FMG going forward.

The building was constructed with a consortium of architects, planners and landscape architects ensuring that the building and its surroundings were an "inspirational and instructional model of sustainable design" (Yale 2012). The Kroon Hall design was awarded LEED Platinum certification in 2010 by the United States Green Building Council (USGBC).

Figure 3.3: OLIN site plan for Kroon Hall.
Kroon Hall and courtyard outlined in black.

Some of the highlights from Kroon Hall are that it:

"Transformed the site of a decommissioned power plant, parking lot, and patchwork of service roads into a highly visible center for the study of environment on Yale's Science Hill campus. Graduation, happy hour, alumni events, and other school activities are commonly scheduled for the courtyard."

"Saves 634,000 gallons of potable water each year by eliminating the need to use potable water for irrigation and, in concert with water-conserving plumbing fixtures, reducing the building's potable water use by 81%."

"Treats and retains the first 1" of rainfall."

"Treats water to remove 80% of total suspended solids (TSS) for all water discharged to the municipal stormwater system." (Foundation 2009a)

Some of the lessons learned from Kroon Hall are that:

"Rainwater harvest systems may need to be supplemented to meet demand for greywater reuse. In this case, water discharged from building foundation pumps provides a make-up source."

"A 'first-flush' device is needed to remove trash, sediment, and other settleable solids from stormwater runoff."

"Mats of trailing plant roots in a pond can be more effective than soil for cleaning runoff water." (Foundation 2009a)

Figure 3.4 illustrates some of the finer details of this plan. One portion of stormwater first enters a manhole with an area built in that allows sediment to settle, called a sump, before going into the main water feature of the design. This water feature is sized to treat the first inch of rainfall from the corresponding area of roof. Time allows more sediment to settle and the floating plants in the water feature act as filters. In rain events greater than one inch the water overflows into the municipal stormwater system after passing through the water feature. The other portion of stormwater from the roof goes directly into tanks where it is treated with a product called Vortechnics on its way to the stormwater system. The Vortechnics system works by essentially forcing sediment to settle by creating a slight swirling of the water and water exits it in such a way that any floating pollutants are not allowed to leave. This is a highly engineered product and is able to do in a very small space what the other part does in a larger area. (Foundation 2009b)

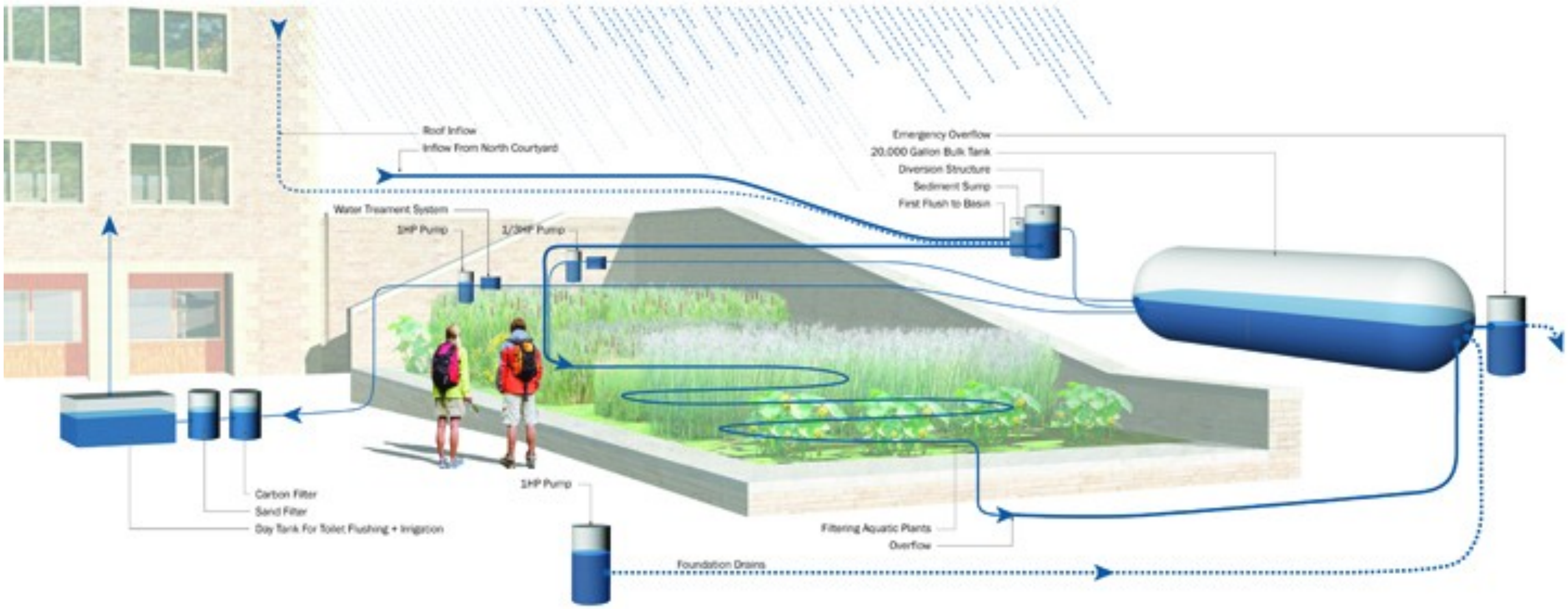


Figure 3.4: Diagram illustrating stormwater capture, treatment, storage, and recycling.

The Kroon Hall case study is helpful for comparison to FMG as an illustration of what has changed in landscape architecture and what a new project on a university campus and by a school that has sustainability as one of its core principles would look like. While not all the aspects of this project apply to FMG, it is helpful to consider some of the features incorporated and lessons learned in the continued development of the Garden, especially if new areas are added to the Garden. The lessons learned about rainwater collection can be applied immediately to FMG. In addition, the College should strive to treat and retain water with natural and engineered solutions to decrease the amount of stormwater runoff and the amount of suspended solids in the stormwater.

Thomas Jefferson University Lubert Plaza

Lubert Plaza is smaller than FMG, at 1.6 acres, but it is associated with a university and is another good example of landscape architecture in the twenty-first century. The Plaza is also in the midst of the university campus, like FMG, but different in that it is not linked to a college like CED. The Plaza replaced what were previously two above-ground parking decks with what is intended to be a new heart of the campus and a nexus of interaction with the city of Philadelphia, Pennsylvania. The design intention of the Plaza is to make the user feel like they are outside the city, and it seems from the case study that it accomplishes that. It also fulfills some key water collection and conservation goals at the same time.

Like Kroon Hall, Lubert Plaza is located in a very different climate, which eliminates some of the plant choices used in this project, but the same guiding principles and some of the solutions are possible for adoption in FMG. This case study illustrates the possibilities of reducing impervious surfaces as well as use of engineered rainwater collection and stormwater management. These lessons can be directly applied to FMG.

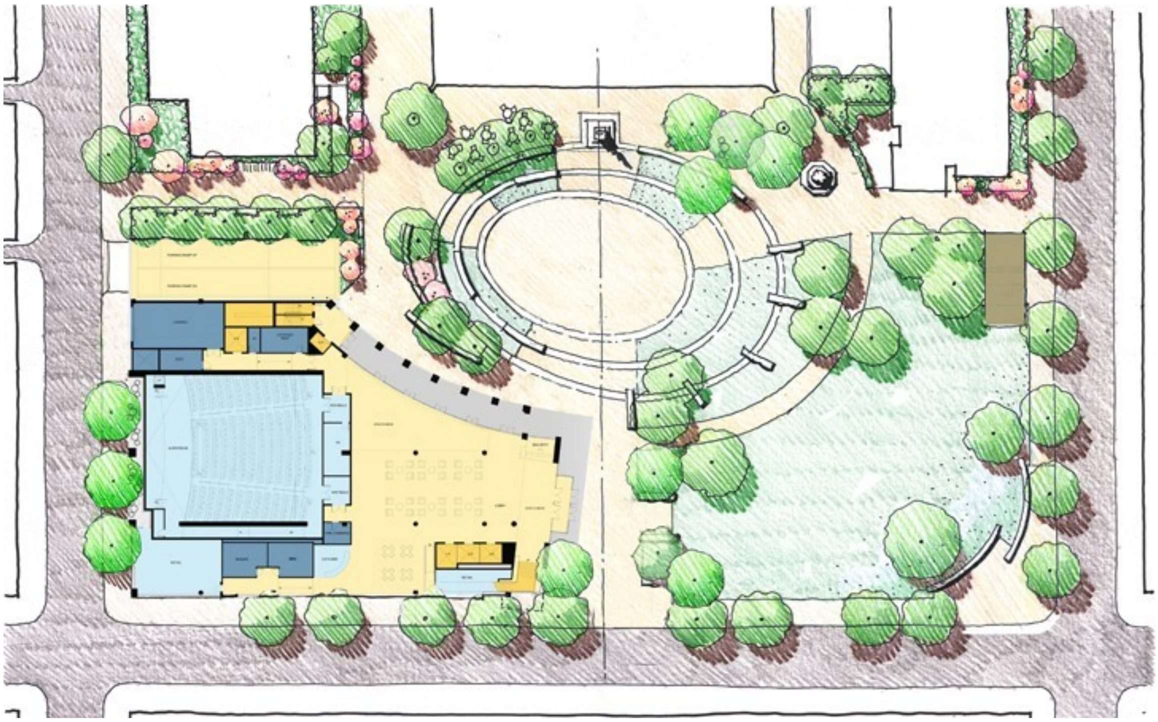


Figure 3.5: Andropogon Associates, Ltd. plan for Lubert Plaza

Some aspects from this project are:

"1.6 acres of new park space overlay an underground parking structure. The new space accommodates multiple activities from studying to eating to play, whereas the former space was primarily dedicated to parking."

"The new plaza and lawn area increase pervious surfaces from 7% of the total site area to 40%."

"Organic materials and light-weight aggregates augment the engineered soil of the green roof to increase water-holding capacity."

"A 17,000 gallon cistern adjacent to Locust Street provides irrigation for trees and lawn. The cistern is approximately 12 ft x 159 ft and runs parallel to the sidewalk avoiding utilities and trees, with several 'cut outs' to avoid root conflicts."

"53 new shade trees line the streets and embrace both the oval plaza at the center and the large event lawn."

"The new plaza adds valuable green space to this dense urban neighborhood and has become a social and environmental asset valued by both the University and the surrounding community." (Foundation 2006b)

Some of the lessons learned are:

"Post construction monitoring of plant performance and irrigation demands indicate that light weight soils require more water than most other soils."

"An organic management program was instituted post-occupancy to address plant health. Irrigation refinements continue. These are just two of the factors pointing toward the importance of involving the landscape architect post-occupancy for a project's health and sustainability."

"Survey respondents indicate that they would like more water in the plaza, and site furnishing, such as tables. Water and comfort are highly appreciated in the urban setting and landscape architects should be cognizant of this. As the plaza evolves it may be possible to include these elements."

"Most survey respondents were unaware of the site's benefit to the urban stormwater infrastructure. The performative function of landscape is of interest to the public and helps support the role of landscape architects in environmental design. Future design could make the stormwater performance aspect of the plaza more visible and readily grasped by the public." (Foundation 2006b)

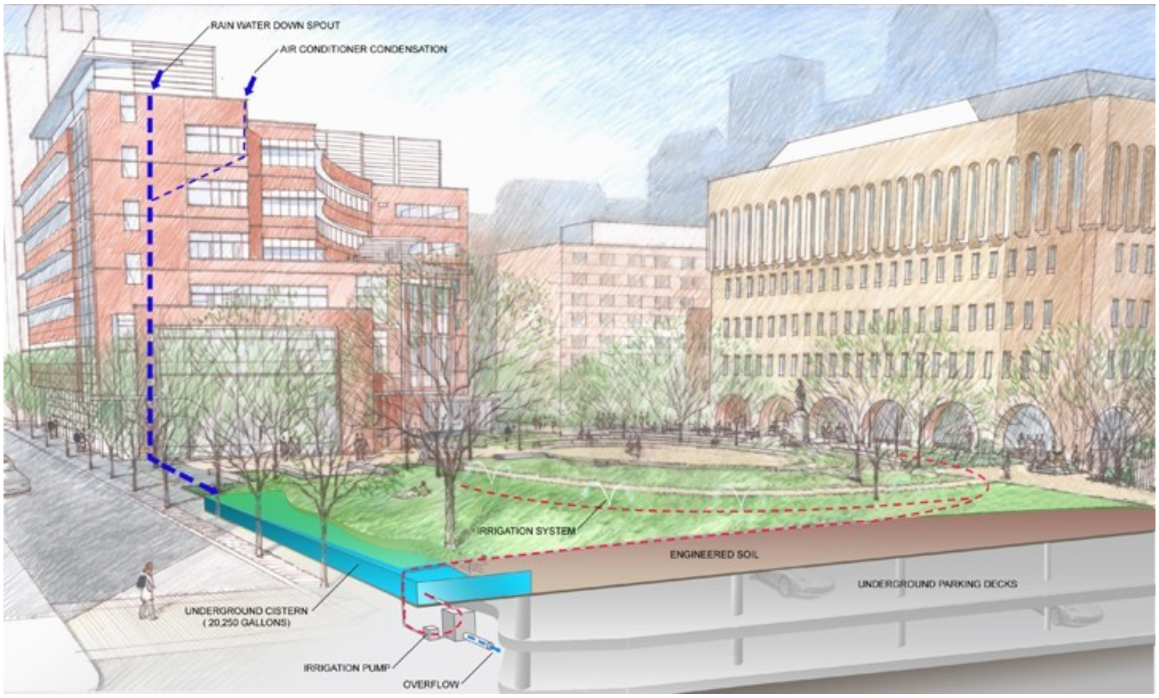


Figure 3.6: Andropogon Associates, Ltd. Diagram illustrating the water collection/circulation system.

Lubert Plaza offers some valuable lessons for post-occupancy evaluations and the importance of planning for water storage in a way that does not interfere with the landscape. Placing such a large cistern underground may be helpful for FMG. In this case

> "The cistern is comprised of plastic Atlantis Matrix Rain Tank modules with the perimeter wrapped in a non-woven geotextile and then a geomembrane. A weir assembly directs stormwater overflow to the City's combined sewer system." (Foundation 2006a)

This case study also highlights the benefits of reducing impervious surfaces. As with the previous case study, any new areas incorporated into the Garden should take into account these lessons and, in keeping with the goals of CED, ensure that the new area is in the forefront of landscape architectural design.

Summary of Case Studies

In summary, the case studies provide context and gives some direction for the rest of the research presented in this thesis. Reynolda Garden is valuable because of its direct correlation to FMG. Managers of both gardens would benefit by partnering, at least informally, with each other to share experience and knowledge. Kroon Hall provides an example of stormwater management that mixes a system that mimics nature and another system that is completely engineered. The products and methods used can be applied to FMG, as well as this principle of mixing two valid methods. The water feature in Kroon Hall also shows how eco-revelatory design can be incorporated. Lubert Plaza shows how creatively storage tanks can be placed underground, which FMG will have to incorporate if it is to achieve a large enough storage capacity to effectively supplement its water needs. This case study also highlights the benefits that can be achieved by reducing impervious surfaces in the landscape. Most importantly, the lessons from both Kroon Hall and Lubert Plaza show that having water conservation and sustainability as the guiding principles of a university garden project can result in award winning designs that are at the forefront of where the field of landscape architecture is going.

Chapter 4

Methodology

ArcGIS

ArcGIS (Geographical Information Systems) is used for the purpose of visualizing the larger watershed and, to a lesser extent, employing the hydrologic tools available in the program to analyze the watershed. Professionals, from landscape architects and architects to geologists and meteorologists, use the computer program to process data and create maps. It is utilized as a tool in this thesis because of its ubiquitousness in the industry, the knowledge base for the program at the university, and the data format available for the area of study.

Incorporated into the program is a toolset for hydrology within the spatial analyst extension. It is a powerful tool not only for creating maps, but it also allows the user to show what are, essentially, complex hydrologic models and their requisite formulas as images that can be visually interpreted. The tool will be applied to the local watershed, and, to a lesser extent, to a large portion of North Campus with small sections of both Tanyard Creek and the Oconee River to show context. For the purpose of this thesis, it is largely used to create graphics, which are further studied using the SCS method.

SCS

The primary evaluation method used in this thesis for stormwater runoff is the Soil Conservation Service (SCS) hydrologic method. This method was chosen based on recommendations in the Georgia Stormwater Management Manual for site acreage and the type of information desired (Table 4.1). It will be applied only to the FMG watershed to determine the baseline for the current state of the Garden and used for comparison with possible changes.

Table 4.1: Tables from Georgia Stormwater Management Manual

Table 2.1.1-1 Applications of the Recommended Hydrologic Methods

Method	Manual Section	Rational Method	SCS Method	USGS Equations	Water Quality Volume
Water Quality Volume (WQ_v)	1.3				✔
Channel Protection Volume (Cp_v)	1.3		✔		
Overbank Flood Protection (Q_{p25})	1.3		✔	✔	
Extreme Flood Protection (Q_f)	1.3		✔	✔	
Storage Facilities	2.2		✔	✔	
Outlet Structures	2.3		✔	✔	
Gutter Flow and Inlets	4.2	✔			
Storm Drain Pipes	4.2	✔	✔	✔	
Culverts	4.3	✔	✔	✔	
Small Ditches	4.4	✔	✔	✔	
Open Channels	4.4		✔	✔	
Energy Dissipation	4.5		✔	✔	

Table 2.1.1-2 Constraints on Using Recommended Hydrologic Methods

Method	Size Limitations[1]	Comments
Rational	0 – 25 acres	Method can be used for estimating peak flows and the design of small site or subdivision storm sewer systems. Not to be used for storage design.
SCS[2]	0 – 2000 acres*	Method can be used for estimating peak flows and hydrographs for all design applications.
USGS	25 acres to 25 mi^2	Method can be used for estimating peak flows for all design applications.
USGS	128 acres to 25 mi^2	Method can be used for estimating hydrographs for all design applications.
Water Quality	Limits set for each Structural Control	Method used for calculating the Water Quality Volume (WQ_v)

[1]Size limitation refers to the drainage basin for the stormwater management facility (e.g., culvert, inlet).
[2]There are many readily available programs (such as HEC-1) that utilize this methodology
* 2,000-acre upper size limit applies to single basin simplified peak flow only.

This method was developed by what is now called the Natural Resources Conservation Service (NRCS). The NRCS is one of the departments under the United States Department of Agriculture (USDA). The department started as the Soil Erosion Service in 1933 (NRCS) in response to worsening drought conditions affecting the Plains region of the US and Canada. Drought combined with new technologies and poor farming practices created a human crisis that resulted in people having to abandon the land they had previously farmed and great clouds of loose topsoil moving east and into the Atlantic ocean, even affecting eastern states. Due to these large clouds of dust, this event, which occurred for the rest of the 1930s, is commonly called the "Dust Bowl".

Since this era, the government has continued to study the best ways that land can be used without, in effect, worsening natural disasters. The department evolved from the Soil Erosion Service to the Soil Conservation Service in 1935 and remained that way until 1994 when the name was changed to the NRCS to reflect a broader mission (NCDC). The hydrologic calculations, known as SCS Method, have been studied and adjusted throughout the years and represent a great body of research. It also benefits from years of collected climatic data that allows for an accurate understanding of storms that occur in a given region.

Storms are analyzed in several ways. One unit, storm frequency, relates the chance of a storm occurring in a given year, which is usually translated into a 1, 2, 5, 10, 25, 50, or 100-year storm. This does not mean that every 100 years there will be a 100-year storm, but that there is a 1% chance that in a given year that storm may occur. Since rain events usually occur differently from region to region, there is a further breakdown of storms into type I, IA, II, and III. These units relate to intensity and the distribution of rainfall in a given storm event.

Table 4.2: Athens rainfall data from Win TR-55.

Athens, GA	Type II Rainfall Distribution
Rainfall Return Period (yr)	24-Hour Rainfall Amount (in.)
1	3.2
2	3.7
5	4.8
10	5.7
25	6.6
50	7.6
100	7.7

Other data collected by government agencies are utilized as well, such as soil surveys. The broad categories of soil ratings are A, B, C, and D (Figure 4.3). The categorization relates to the runoff potential and the rate of water transmission. Development and land use history can have an effect on runoff, but water transmission qualities come primarily from soil texture. The texture corresponds to the proportion of sand, silt, and clay in the soil. Loam is soil that has a fairly even distribution of the three components. Common soil texture names are sand, loamy sand, sandy loam, silt loam, loam, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, or clay. Each of these have their own drainage properties, but generally the greater percentage of sand the higher the rate of water transmission will be, while a greater percentage of clay will result in a lower the rate of water transmission (Brown 2003). Water transmission has a direct effect on runoff because if the rate of water added to the soil is greater than the transmission rate then the water will start to flow above the surface. There are other manners by which soils are categorized and named, but for the purpose of this thesis it is mainly important to understand the broad types and to know what type of soils are in the FMG watershed.

Table 4.3: Four hydrologic soil groups as defined by SCS.

Group A	A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sand or gravel and have a high rate of water transmission (greater than 0.30 in/hr). The textures of these soils are typically sand, loamy sand, or sandy loam.
Group B	B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr). The textures of these soils are typically silt loam or loam.
Group C	C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr). The texture of these soils is typically sandy clay loam.
Group D	D soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr). The textures of these soils are typically clay loam, silty clay loam, sandy clay, silty clay, or clay.

The computer program Win-TR-55 uses a graphic interface in which all the requisite data can be entered and then runs these calculations in the background to compute the related values. The inputs required are the watershed area, Curve Number (CN) for the site, time of concentration (Tc), hydraulic length, soil types in the given watershed, and storm type of the analysis area. CN is a factor that relates to the amount of stormwater runoff from a given surface, or the weighted average of all surfaces in the watershed. Tc is calculated based on the hydraulic length and ground surface cover. It is the time for runoff to travel the hydraulic length, which is the "hydraulically most distant point of the watershed to a point of interest within the watershed. Tc is computed by summing all the travel times for consecutive components of the drainage conveyance system" (Agriculture, Service, and Division 1986). The outputs are typically the runoff peak flow (Qp) and runoff volume (Qvol) but other data are available from the program as well. This data can be analyzed for the 1, 2, 5, 10, 25, 50 and 100-year storms. For this study all of the above storms have been calculated.

WaterSense

WaterSense is a program developed by the U.S. Environmental Protection Agency to help homeowners and landscape professionals create water-conserving landscapes. The program uses the best data available from weather stations and historical data, and creates a method by which an overall Landscape Water Requirement (LWR) as well as what is called Landscape Water Allowance (LWA) can be calculated, "For purposes of the specification, the LWA is 70 percent of the baseline amount of water that would be needed if the entire landscape was covered by a well-maintained expanse of average-height green grass" (EPA 2010). This program, similar to the Energy Star program, allows a homeowner or developer to label a property, or set of properties, as a WaterSense certified property. For purposes of this thesis, however, the certification and LWA are not of interest. The value to this thesis is in adapting the formulas to calculate baseline water requirements and potential water savings. There is a shortage of research into this topic and therefore limited methods or programs to do this type of evaluation. WaterSense, as adapted for this thesis, represents the best available program for estimating water need based on plant selection and environmental factors.

The required inputs for the formula are monthly average rainfall, average base ET rate for the area, and delineation of garden areas into low, medium, and high water use. The base ET rate is the amount of water a cool season grass uses if it has unlimited water available (van Iersel 2011).The ratings are based on general horticultural knowledge of plants, and while it is not the most scientific of determinations, it does allow for this type of estimation. Future research into standardized ET rates for common landscape plants would greatly increase the accuracy of this research. For the present, a matrix is devised to rate each area of the Garden based on numerous factors that affect water use of plants. With the assistance of Maureen O'Brien, who has many years of experience in the Garden and knows the areas that require the most water, each area of the Garden was evaluated for its level of water use.

The matrix rates each garden area on 9 factors with either a rating of zero, one, or two. Zero is given when the factor has little or no effect on the bed in question, one for a moderate effect, and two when the factor exercises a large influence on the bed. The factors include wind exposure, soil porosity, slope, sun exposure, plant need, competition/density, size of plants, newly installed, and a value adjustment to account for Maureen O'Brien's experience managing the Garden. If a value adjustment is applied then a note is also given as to why that area would require such an adjustment. The garden areas, as determined for this research, are based on what could be called "natural neighbors", meaning that if one area is shaded a large part of the day and an area just outside of that is not, then those would be counted as two separate areas. This implies that one bed, especially some of the larger beds, may be counted as two or more garden areas for this calculation. The plants in the beds are also taken into account, such that if one area has very well established plants that do not require much watering and another area has plants that require more water, these are generally counted as separate areas.

There is a level of subjectivity in this method that could be made more objective with further research. It is, however, very beneficial to have a garden manager with a wealth of experiential knowledge of the Garden. Dealing with a living landscape and all the factors mentioned above, it is necessary to have a person involved in the research with this type of knowledge. Moreover, while it might be possible in the future to determine exact evapotranspiration rates of plants and garden areas, it would take so much research and exact measurements of so many aspects of the environment that it would be cost and time prohibitive. It would also be very site and time specific. Because of this, it will always be helpful to have an individual on the ground with horticultural knowledge and experience managing the day-to-day operation of the Garden.

For the purpose of this thesis, data is taken from the closest weather station; UGA's meteorological lab located in nearby Watkinsville, for base ET rates and rainfall, and the formula is adapted to calculate the LWR for every month. Much like the SCS calculations, these monthly LWR numbers give a baseline to which changes can be calculated and can aid future management decisions.

This dataset can even be adapted to predict future changes in the Garden. There are at least 255 varieties of shrubs and trees in FMG, totaling over 1100 individual plants. The replacement of these plants will not happen at one time. Hence, it is important for the garden manager to be strategic in replacing plants so that over time FMG can be less water dependent. Historically, the plants, especially shrubs, have been selected because they were considered important to the profession. Therefore, with the College's focus on sustainability and for the continued educational value of the Garden, it is entirely in keeping with this precedent to transition over time the plants selected to require less water.

Further research, perhaps even an entire thesis, could be dedicated to identifying and scheduling replacement plants throughout FMG. The author suggests taking the current plant list and identifying replacement plants that would require less watering whilst fulfilling the role of the current plants. This would require working with the Garden managers to identify what is important about each plant, bed, and area. Is it texture, background color, or a seasonal color that the current plant provides? With this knowledge a more objective argument could be made for what plants to change and how the plants chosen still fit in with the aesthetic of the Garden. There will still be instances where the managers of FMG will need to decide what the balance is between historic preservation and water conservation, but this research could aid the decision making process greatly and have better results for FMG.

The criteria for selecting these plants should be based on recommendations as to the ideal conditions and the habitat of where it is being located in the garden. If it will go in a sunny and dry place then either drought tolerant plants or ones noted as having a low water requirement should be chosen. Whereas, if another plant is needed for a more moist area of the garden then a more water loving plant should be selected. The most important principle when choosing plants is to select plants that will survive with little added inputs, such as water, fertilizer, and pesticides, in their given location. Until more research is available, this subjective categorization of plant water need, based on the experience of people in the industry, will have to be relied on. It will always be necessary to properly site plants in the landscape and manage their establishment so that they will need fewer and fewer inputs – water, fertilizers and pesticides – as time goes by.

Irrigation Management

The express purpose of determining the water need of the landscaped areas of the Garden was not to be a guide for irrigation changes, but after evaluating each bed, and areas within the beds, it was clear that there are some built in inefficiencies with the current irrigation system. The matrix for rating each garden area is also a matrix for creating a better irrigation system. The Garden is outfitted with the foundation of an efficient state-of-the-art system. However, it is clear from the high, medium, and low-water use areas that the programming zones for the irrigation controller could be re-examined and adjusted to distribute water more efficiently. This section highlights some of the technologies available versus what FMG has installed, and also takes a look at irrigation controllers that could improve how and when water is distributed to the Garden.

The WaterSense program, and other sources, has an efficiency rating for the distribution of different types of irrigation. The rating is calculated by how much of the water used is directly applied to the plants and how much evaporation may be allowed by the application device. Hand watering is considered the least efficient because there is lots of overspray, and it is difficult to gauge the amount of water being applied. Above hand watering are overhead sprayers, followed by drip irrigation, which is generally considered the most efficient method.

“Micro Spray” and “Rotor” type overhead sprayers are found in garden applications, typically with turfgrasses. Both types of sprayers are given the same efficiency rating of 70 percent. In general, the determination of the type of sprayer to use depends on the geometry and area of the space to be irrigated. Other than that, the general difference between rotor and micro spray is that the former sends out a single, or multiple, stream of water and turns, while the latter sends water out all around at once. The rotor moves mechanically while the sprayer is fixed. Either of these can be purchased to cover certain angles, or it is also possible to purchase adjustable sprayers of both types. The typical standard designations are 45, 90, 180, and 360-degree sprayers. A well-designed system using overhead irrigation gives uniform coverage across the irrigated area while minimizing water loss due to wind, soil type, and overspray (Rainbird 2012a).

"Standard Drip" irrigation is rated at 70 percent efficient due to essentially being a tube with perforations with no compensation for changes in water pressure. "Pressure Compensated Drip" irrigation adds an element of control over perforated tube and is rated at 90 percent efficient, because it achieves more uniform distribution. The pressure compensated dripper ensures consistent flow from each inline emitter throughout the entire length of the tubing and throughout its operating range (Rainbird 1999). This allows for precise control over the amount of water released since it can be calculated by the emitter size, flow rate, and amount of time the water is running. Both types of drip irrigation are rated higher since they apply water close to the root zone and do not have overspray and mist that can evaporate or end up on other surfaces where it will then evaporate. The emitters for drip irrigation are either located inside of the tubing at fixed intervals, or they are a separate piece, usually called a barb, that can be manually inserted into the tubing at custom spacing. They both have similar efficiencies, and each has their own advantages.

One disadvantage of the tubing being on the ground surface is that wildlife, especially squirrels in FMG, discovers a new source for water and bite through the tubing. For this reason, the system has to be periodically checked and repaired to prevent the wasting of water, as well as damage to the Garden due to flooding or sensitive plants being harmed by water spray.

Irrigation control and planning opens up another range of options available to FMG to further support efforts to conserve water. This is an area of rapid development and one in which computer programming and remote sensing devices are becoming ever more important. This field will continue to expand so long as technology continues to become smaller, remote sensing becomes more accurate, and energy sources become more diversified. Longer life batteries and solar technologies are especially relevant in the arena of powering such devices. Of the myriad methods of irrigation control, this thesis focuses on the following types: manual ET-based, automated ET-based, and soil moisture based.

Manual ET-based irrigation management would be one step above how the Garden irrigation is currently managed. The information used to calculate the Landscape Water Requirement (LWR) can also be used to set a baseline for how long to run the irrigation system. Assuming the irrigation zones were changed to reflect the water requirements of each garden bed, the optimal time can be calculated for each month of the year based on the flow rates of each zone (Rainbird 2012b). This calculation will not be carried out in this thesis, but with the information included in the LWR calculations and information from industry leaders in irrigation, such as Toro and Rain Bird, this could be calculated if it was decided to pursue this method of irrigation management.

The garden manager would need to be aware of rain events in order to adjust the amount of water applied each week. This decision would be different at different times of the year, and this type of decision should be thought of ahead of time. It is possible, in good times, to maintain a constant level of moisture; however, in times of stress, garden managers need to decide garden priorities and minimal levels for garden areas. If there were sufficient rain to meet, or exceed, the calculated ET, or the calculated minimum water requirement, then the irrigation use could be suspended for those weeks. The garden manager should be aware of anomalies in the weekly weather and possibly run the irrigation for longer or shorter periods in the case of unseasonably warm or cool weather.

The automated ET-based irrigation control does as described above, but with real-time data and with an option of a rain gauge, it can optimize water use by automatically shutting itself off in the case of rain. This option requires more equipment, such as a server to download ET data from weather stations and a base station to transmit data to the controller. In the case of FMG, the company RainBird has a weather station in the area which could be used in the Garden if the corresponding RainBird Controller were installed. In the system less individual decision-making is needed, but it does require someone to maintain and double-check the system when it may not appear to be running correctly. This scheme, especially when incorporated with a rain gauge, will be much more efficient with matching water use to plant need.

Soil Moisture-based irrigation management almost literally examines water from the opposite side of an ET-based controlled system. Whereas ET is measured above the ground, soil moisture is measured underground in the root zone of the plants. The controller for this setup can also be outfitted with a rain gauge to maximize its effectiveness. Sensors are placed in each garden bed area, and they connect to the controller either directly or remotely. There are different types of programming for this system, which could be further explored with future research, but essentially limits can be set at different soil moisture percentages to turn the irrigation on and off. This is the same decision as above as to whether a constant soil moisture level is desired or whether the soil moisture can fluctuate within a minimal range aimed at keeping plants alive when water is less available.

Another task that had to be completed in order to truly analyze the irrigation system was to update the basemaps. For reasons unknown to the author, 'as-built' plans were never created in CAD and transferred to FMG staff, leaving them with hard copies of the irrigation plans as the only documentation. The process for digitizing was to scan the hard copies, scale them in GIS as close as possible to the real scale, mark each point in a blank irrigation file, and then check in the field on the accuracy of placement and type of equipment. The last step went through at least three iterations, all accompanied by Maureen O'Brien.

It can be said with a reasonable amount of certainty that one unfamiliar with the irrigation system could take the now digitized map and find what they are looking for in the Garden. It may not be survey quality, but it is legible and close enough that with little search one could locate any valve or spray head that needed to be found. It would be best, for future managers and staff, if the map were kept up to date, but one outcome of this thesis is the digitization of that file, which improves the continuity and transferability of that document.

Rainwater Harvesting

Rainwater harvesting is an ancient concept that is regaining popularity as people are becoming increasingly concerned about drought and climate change (MacCormack 2012; Dunlap 2012). Using a spreadsheet and method adapted by UGA Professor Alfie Vick, calculations have been made to estimate the amount of water that could be collected off of various surfaces. The inputs required for these calculations are local rainfall data, the surface area from which rainwater will be collected, and the storage tank capacity. The formulas used in this thesis were chosen because they are standard throughout the industry to estimate the amount of water collection possible. Other tools are available, but they delve into more detail than is necessary for the purpose of this thesis, and some use data formats that were not available for the Athens area. The roofs of the Lumpkin House and Kitchen Building will be considered along with the Courtyard and Serpentine Garden area.

Though the method of calculation is fairly straight forward, figuring out its impact on the stormwater runoff and supplemental plant water is difficult. Numerous variables exist that make it untenable to say with certainty that adding a tank with a certain storage capacity will save "X" many gallons per year for watering plants, or reduce the runoff volume by "Y". What is stated, however, is that with an empty tank the first one inch of rain can be collected, and that could reduce the runoff by a certain amount. Also, the estimate of water collected is given as the maximum amount that could be amassed and used for each month. It is given as a maximum because it assumes that the tank is emptied after each rain, which is a variable that cannot be guaranteed. Other variables include evaporation, clogged gutters and pipes, and the size and frequency of rain events themselves.

Amount of Change

Aesthetics will always carry a certain degree of subjectivity. What is objective are the tools and methods gathered in this thesis, and with these, potential changes to the Garden can be evaluated objectively. These changes, if implemented, could have a significant impact on the aesthetics of the Garden and therefore another tool is needed to relate the subjective and objective. This is necessary in order to fully understand the changes proposed in a holistic view of FMG. It is the author's hope that this will lessen the emotional response or backlash to change in the Garden.

If a particular modification will not be seen by people but will have a positive effect on reducing either the amount of water used or stormwater runoff, then implementation is a simple decision. Other alterations may constitute a minor to moderate change in the appearance of the Garden, but with the help of these calculations it should be easier to either justify or decline the change based on its water impact. Other changes may constitute a major change to the Garden, and therefore not realistic for this historic Garden, but illustrate how much of a difference could be made and should be considered in any future expansions of the Garden.

Table 4.4: Matrix illustrating the amount of change rating.

		Visibility of Change				
		Low		Medium		High
Garden Benefit	Major	1	2	3	4	4
		1	2	3	4	5
	Moderate	1	2	3	5	5
		1	2	4	5	5
	Minor	1	3	5	5	5

For the purpose of this thesis, the degree of change is considered on a scale of 1 to 5, 1 as minor, 3 as moderate, and 5 as major (Figure 4.6). A minor change is either something underground or hidden from sight that does not alter the experience of the user in the Garden. A moderate change would be an alteration that was still in keeping with the original style of the Garden, but may be noticeable. The limestone skirt around the pool is an example of this. A major change to the Garden would be something not in the original style which is also highly visible. These changes are not expected to be implemented, but are provided more as a comparison of old garden styles and their required inputs to a more modern understanding of sustainability. This does not mean that the original designers were wrong for designing a garden without these considerations, but it does illustrate how the profession of landscape architecture has changed over the years and how the body of knowledge related to issues of stormwater and water usage has grown.

Chapter 5

Results

ArcGIS

The use of GIS was the starting point for site analysis. The ability to both visit the site and see it in plan view made for a greater understanding of the site itself and the context surrounding it. Figure 5.1, created in GIS with spatial analyst, shows the location of FMG in relation to campus and downtown Athens. The gradation from light to dark illustrates the change in elevation from high to low, in this case the lowest elevations being bodies of water. One can notice the ridge that divides north campus with everything west of it draining into Tanyard Creek.

All other maps are presented with the relevant tool they were created for, but it should be noted that the raw data, such as areas and lengths, came out of GIS. The data was generally exported into AutoCAD or Adobe Illustrator for manipulation and representation. Microsoft Excel and Win TR-55 were the main engines to process the calculations, as the WaterSense and Rainfall tools are Excel based. To a lesser extent, Adobe Photoshop and InDesign were used in the creation of graphics.

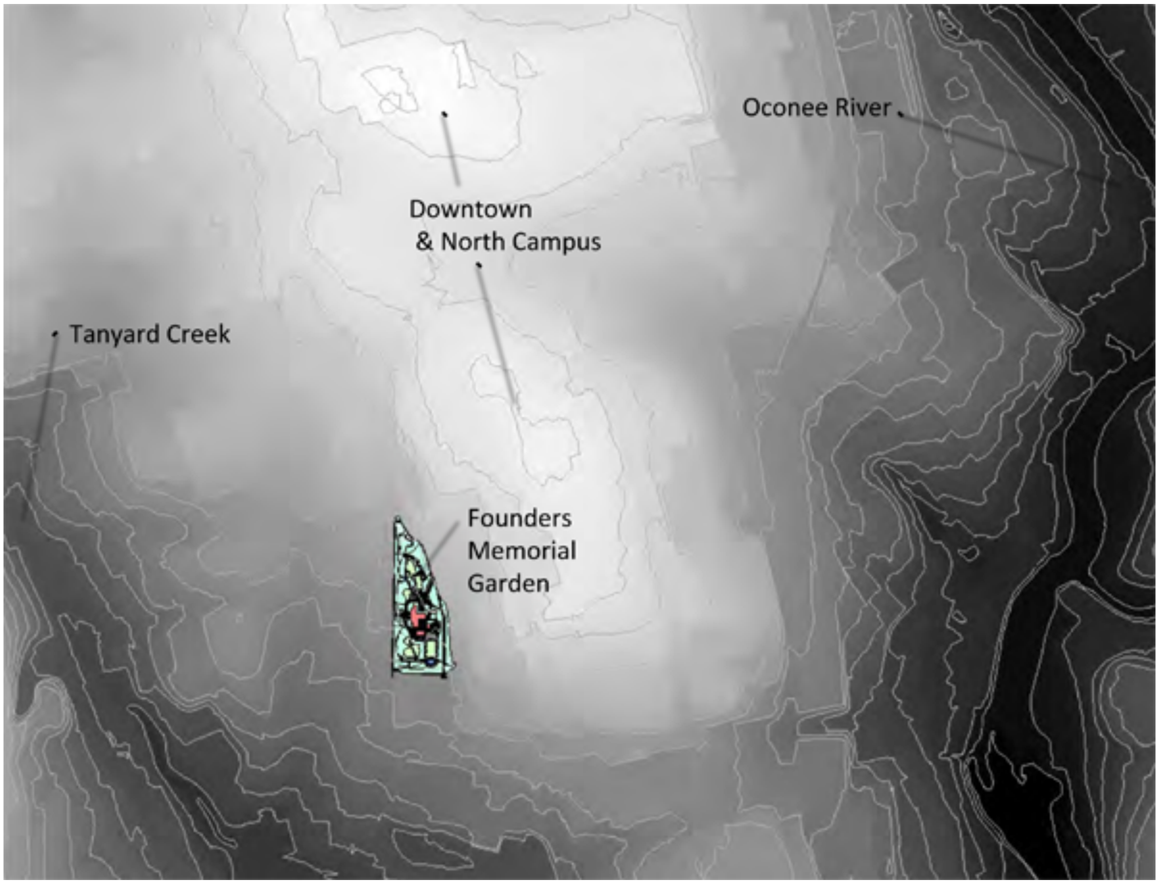


Figure 5.1: Basemap illustrating FMG in relation to Tanyard Creek and the Oconee River. (Not to Scale)

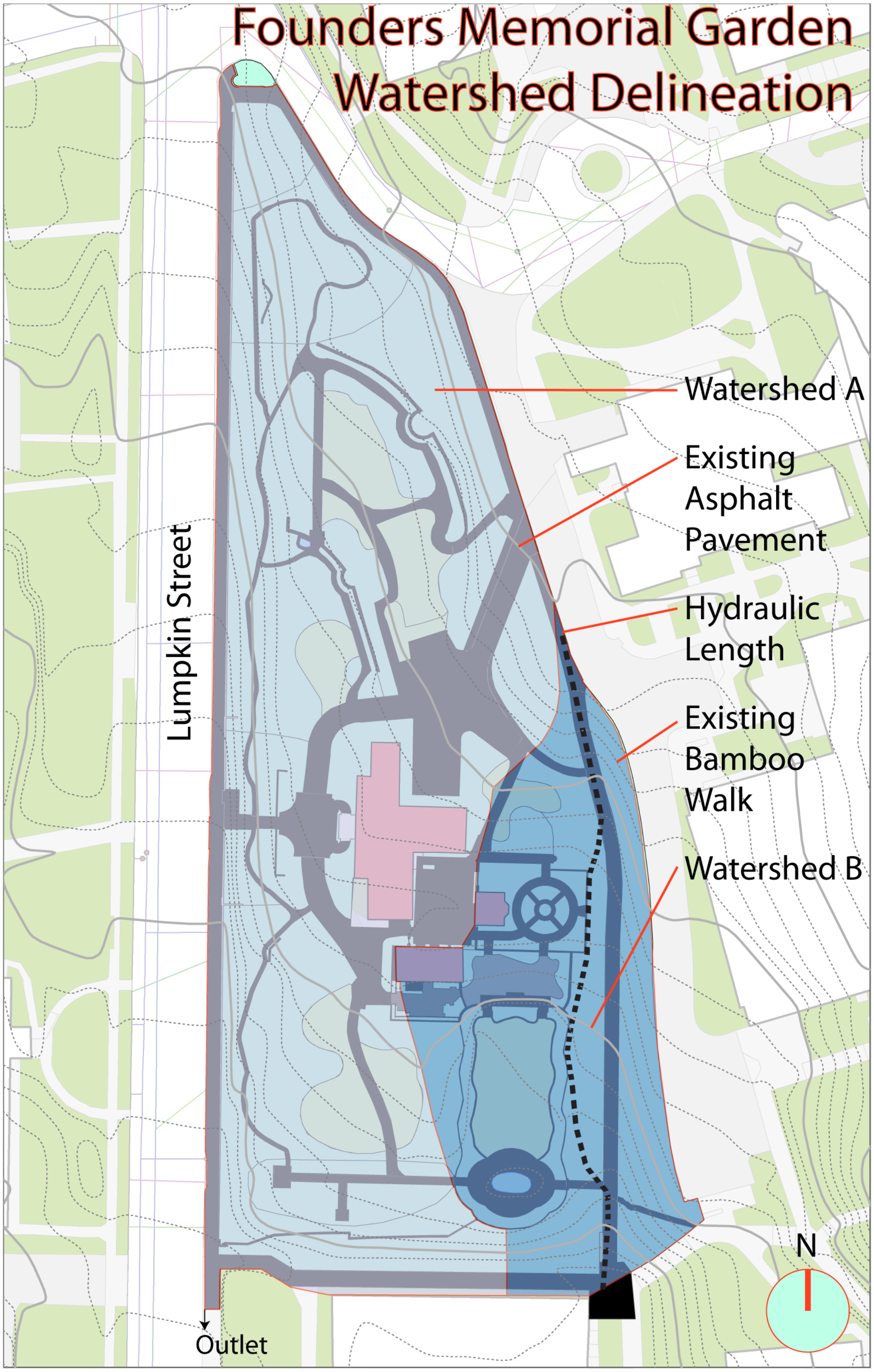


Figure 5.2: Basemap showing delineation of FMG watersheds.
Note that it is actually two smaller watersheds, but they have the same outlet at Lumpkin Street.

Table 5.1: Baseline Win TR-55 calculations for FMG.

Baseline

	Square Feet	Percent	Acres
Watershed Area	98,631	100.00%	2.26
Landscaped	57,931	58.73%	1.33
Buildings	3,321	3.37%	0.08
Hardscape	21,588	21.89%	0.50
Water	169	0.17%	0.00
Turf	9,877	10.01%	0.23
Gravel/Permeable	5,746	5.83%	0.13

% Impervious	CN Value used for SCS
0.25	70

	Sidewalk	Driveway	Herb Garden Area	Terrace	Other Impervious	Units = ft^2
Asphalt	10,388	5,132			3,806	Impervious
Cobble+Asphalt	941					Impervious
Flagstone w/ Mortar	188					Impervious
Sandstone	1,132					Impervious
Cobble	593					Pervious
Flagstone	3,568		350			Pervious
Pea Gravel	448			787		Pervious

Storm Frequency	**1**	**2**	**5**	**10**	**25**	**50**	**100**
Qp (cfs)	**2.65**	**3.76**	**6.49**	**8.91**	**11.45**	**14.35**	**14.65**
Qvol (cf)	**6,460**	**9,280**	**15,469**	**21,033**	**26,926**	**33,789**	**34,488**

The soil types present in the Garden are Cecil soils, CYB2 and CYC2, which are classified in the Hydrologic Soil Group as B soils (NCDENR 2009). This info along with the areas, hydraulic length, and types of surfaces were computed in WinTR-55. So long as there are no significant changes to the Garden these calculations should remain valid for many years. All of the impervious surfaces, buildings and hardscape in Table 5.1, equal about 25% of the site, which has the largest effect on the current runoff numbers. Otherwise, about 65% of the site is made up of landscaped and permeable surfaces, with the remaining 10% consisting of turf. The 1 year storm's peak flow for stormwater runoff, Qp, is 2.65 cubic feet per second, and a corresponding volume of runoff, Qvol, of 6,460 cubic feet (48,324 gallons). The 5 year storm's Qp is 6.49 cubic feet per second, and 15,469 cubic feet (115,716 gallons) for the Qvol. For a larger storm, the 25 year, the Qp is 11.45 cubic feet per second, and the Qvol equals 26,926 cubic feet (201,420 gallons). These same storms will be interpreted in the following two alternatives for comparison.

FMG Watershed Modification Alternative #1

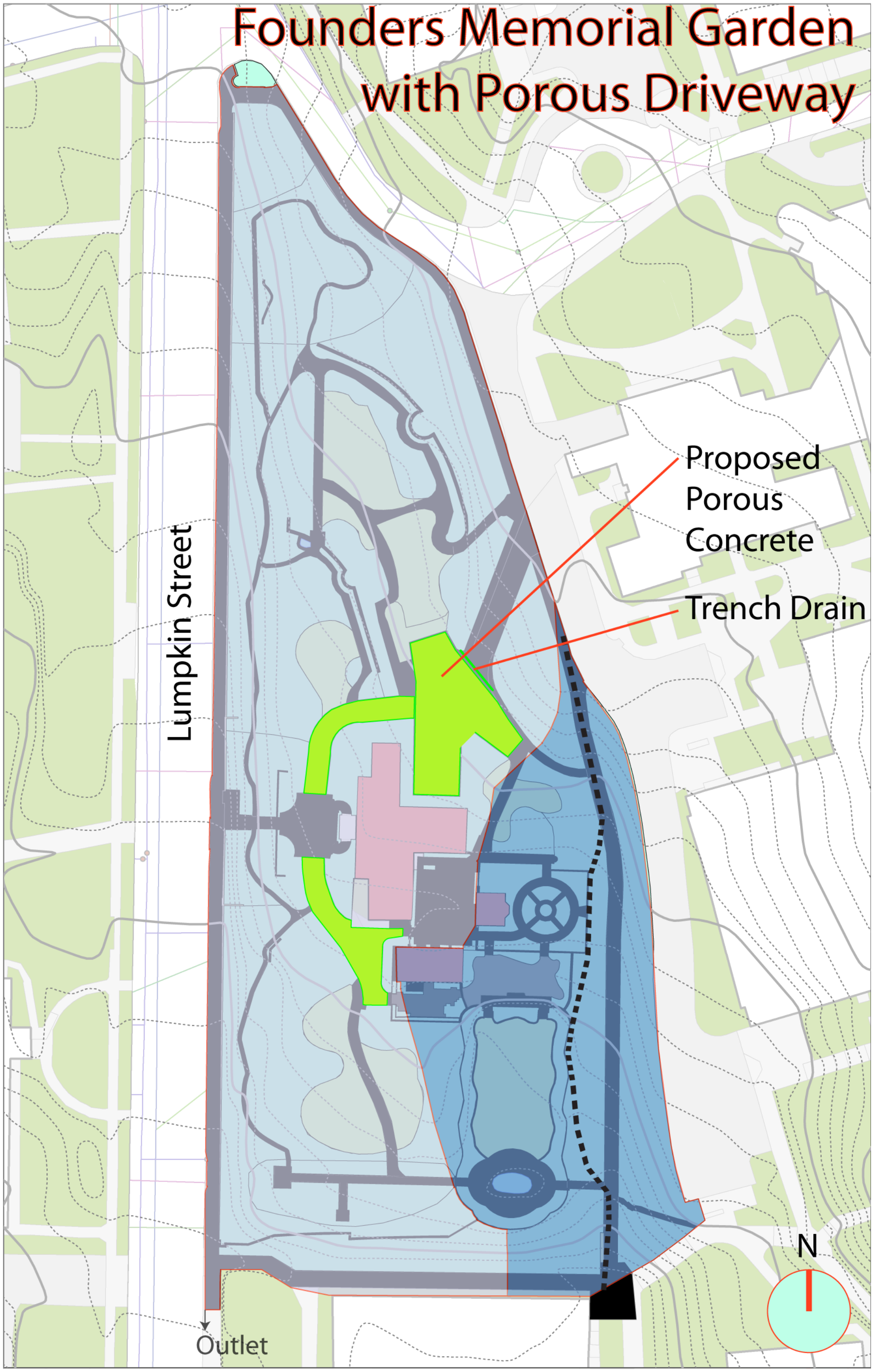


Figure 5.3: Basemap illustrating the area proposed for porous concrete.

Table 5.2: Win TR-55 calculations adjusted for porous pavement.

Porous Driveway

	Square Feet	Percent	Acres
Watershed Area	98,631	100.00%	2.26
Landscaped	57,931	58.73%	1.33
Buildings	3,321	3.37%	0.08
Hardscape	17,360	17.60%	0.40
Water	169	0.17%	0.00
Turf	9,877	10.01%	0.23
Gravel/Permeable	9,974	10.11%	0.23

Decreased Impervious	
Sqare Feet	Acres
-4,228	-0.10

% Impervious	CN Value used for SCS
0.21	68

	Sidewalk	Driveway	Herb Garden Area	Terrace	Other Impervious	Units = ft^2
Asphalt	10,388	904			3,806	Impervious
Cobble+Asphalt	941					
Flagstone w/ Mortar	188					
Sandstone	1,132					
Cobble	593					Pervious
Flagstone	3,568		350			
Pea Gravel	448			787		
Permeable Concrete		4,228				

Storm Frequency	**1**	**2**	**5**	**10**	**25**	**50**	**100**
Qp (cfs)	**2.27**	**3.31**	**5.92**	**8.26**	**10.74**	**13.59**	**13.88**
Qvol (cf)	**5,334**	**8,359**	**14,236**	**19,595**	**25,307**	**31,973**	**32,663**
Qp Reduction (%)	**14.34%**	**11.97%**	**8.78%**	**7.30%**	**6.20%**	**5.30%**	**5.26%**
Qvol Reduction (%)	**17.43%**	**9.92%**	**7.97%**	**6.84%**	**6.01%**	**5.38%**	**5.29%**

In this instance approximately 5% of the impervious surface was converted to a porous surface, but all other covers remained the same as the baseline. This reduced the CN value to 68, which in turn produced a reduction in the flow and volume of runoff. From only a 5% reduction in impervious surface the Qp is reduced by just above 14% for the 1 year storm, nearly 9% for the 5 year storm, and just above 6% for the 25 year storm. The runoff volume reductions for the same storms are nearly 17.5%, just under 8%, and just above 6%. This is a clear demonstration of the effect of reducing impervious surfaces in that the percent reduction in Qp and Qvol are greater for all storms than the percent reduction in such surface.

Porous asphalt does not perform as well as porous concrete in the state of Georgia (Sawhill 2012; "Georgia stormwater management manual" 2001), which would suggest that in order to achieve a comparable look and not change the appearance of the Garden it would be best to install porous concrete with black pigment to more closely match the asphalt. However, summer heat retention may be a reason to consider changing to a lighter color.

The locations of where to change to the porous material were chosen based on the existing slope conditions. The highest slope in the area suggested is no more than 1.5%, which is in keeping with the recommendations for porous concrete.

> "Porous concrete systems should not be used on slopes greater than 5% with slopes of no greater than 2% recommended. For slopes greater than 1% barriers perpendicular to the direction of drainage should be installed in sub-grade material to keep it from washing away, or filter fabric should be placed at the bottom and sides of the aggregate to keep soil from migrating into the aggregate and reducing porosity." ("Georgia stormwater management manual" 2001)

As noted at the bottom of the preceding paragraph, this system installation would require some extra bracing or filter fabric since the slope is generally equal to or greater than 1%. Placing the porous concrete system at the bottom of the slope also necessitates installing a drain at the top end in order to prevent water and sediment from overwhelming the porous area. Suggested in the map on page 60 is a trench drain that would divert water into the bed adjacent. Care would need to be taken so that the added runoff in that area does not cause erosion. It could even be another opportunity for engineered infiltration.

It should be noted that for these SCS calculations the CN had to be derived through a combination of experimentation and consultation of several sources. The reason is that “Research has not yet been done to measure curve-number values for porous pavement surfaces. Until it is done, values could be estimated by analogy with the measured runoff coefficients” (Ferguson, 126).

The CN value was derived by comparing the percentage of impervious surfaces of the before and after. The current condition of the Garden is roughly 25% impervious, and the CN value most closely related is “Residential 25% Impervious”, thus giving a CN value of 70. The additional permeable concrete would reduce impervious surfaces by about 5%. This corresponds closely with a CN value of 68 for “Residential 20% Impervious”. By analogy, this relates roughly to a value of 85 for porous concrete, if the entire site is broken down into its constituent parts of gravel, porous, impervious, turf and forest. It is acknowledged that there may be some built in inaccuracy in this method. The author suggests further research into CN values of porous pavements.

FMG Watershed Modification Alternative #2

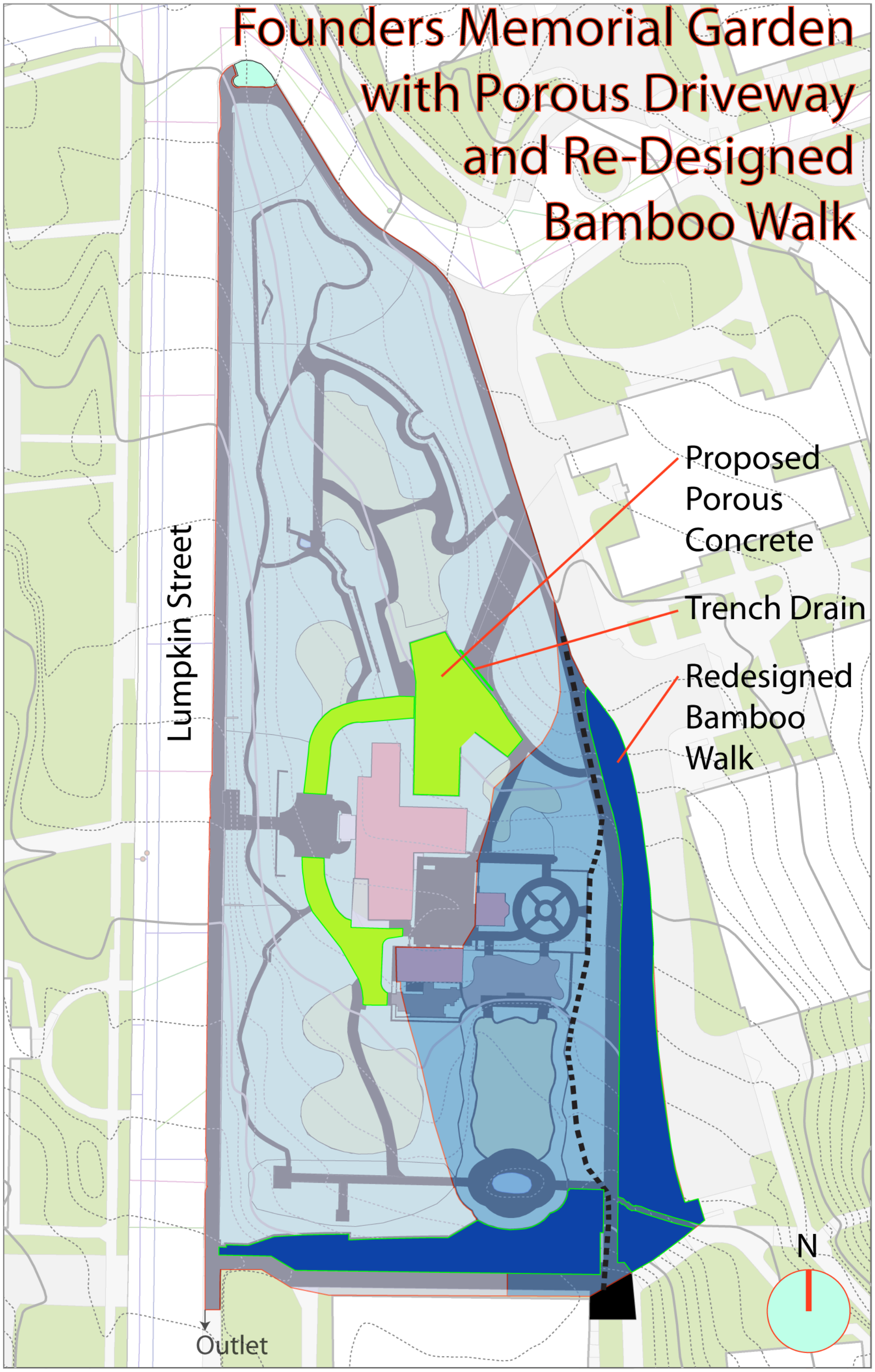


Figure 5.4: Basemap illustrating the additional area proposed for the Bamboo Walk.

Table 5.3: Win TR-55 calculations for combination of porous pavement and bamboo walk. This assumes The Bamboo Walk is redesigned, and engineered, to achieve a CN value of 30.

Porous Driveway + Engineered Bamboo Walk

	Square Feet	Percent	Acres
Watershed Area	98,631	100.00%	2.26
Landscaped	57,931	58.73%	1.33
Buildings	3,321	3.37%	0.08
Hardscape	17,360	17.60%	0.40
Water	169	0.17%	0.00
Turf	9,877	10.01%	0.23
Gravel/Permeable	9,974	10.11%	0.23

Decreased Impervious	
Sqare Feet	Acres
-4,228	-0.10

% Impervious	CN Value used for SCS
0.21	65

* = 0.219 Acres has been engineered to achieve a CN value of 30, closest to "Woods - Good" with A soil.

	Sidewalk	Driveway	Herb Garden Area	Terrace	Other Impervious	Units = ft^2
Asphalt	10,388	904			3,806	Impervious
Cobble+Asphalt	941					
Flagstone w/ Mortar	188					
Sandstone	1,132					
Cobble	593					Pervious
Flagstone	3,568		350			
Pea Gravel	448			787		
Permeable Concrete		4,228				

Storm Frequency	**1**	**2**	**5**	**10**	**25**	**50**	**100**
Qp (cfs)	**1.8**	**2.67**	**5.08**	**7.29**	**9.66**	**12.42**	**12.7**
Qvol (cf)	**4,200**	**7,044**	**12,477**	**17,499**	**22,923**	**29,285**	**29,943**

Percent Reduction over Permeable Driveway

Qp Reduction (%)	**20.70%**	**19.34%**	**14.19%**	**11.74%**	**10.06%**	**8.61%**	**8.50%**
Qvol Reduction (%)	**21.26%**	**15.73%**	**12.36%**	**10.70%**	**9.42%**	**8.41%**	**8.33%**

Percent Reduction over Baseline

Qp Reduction (%)	**32.08%**	**28.99%**	**21.73%**	**18.18%**	**15.63%**	**13.45%**	**13.31%**
Qvol Reduction (%)	**34.99%**	**24.09%**	**19.34%**	**16.80%**	**14.87%**	**13.33%**	**13.18%**

The Bamboo Walk was chosen for this redesign based on information that the area is slated for change as the latest Master Plan from the University is implemented. This example also includes the area south of the brick wall which closes off the Serpentine Garden and Joe Brown Hall. It is partially covered in the bamboo and could be included in the area adjacent to the Garden, but that was not part of the original garden, and is therefore not bound by the same limits of historic preservation. It represents just under 10% of the watershed resulting in a further 3 point reduction in CN, equaling an overall CN value of 65. Comparing Alternative #2 to Alternative #1 shows around a 20% reduction for both Qp and Qvol in the 1 year storm, 14% Qp and 12% Qvol in the 5 year storm, and around 10% for both measures with the 25 year storm. The greatest difference is to compare this alternative to the Baseline in terms of percent reduction in Qp and Qvol. The 1 year storm shows a 32% reduction in Qp and just over 34.5% reduction in Qvol, while the 5 year storm comes to 22% and around 19%, and the 25 year storm shows about 15% for both. This shows the difference between type A soils compared to B soils, with CN of 30 as opposed to 55. When all of the Bamboo is removed it will also require the removal of a lot of soil, possibly digging down 3 or more feet. This opens up the opportunity to amend the soils, and even bring in an engineered soil that is better for infiltration. The lessons learned from the case studies also highlight some of the engineered solutions possible in this area. It may be overambitious strive for such a drastically reduced amount of runoff, but it represents a large enough reduction that it makes a very compelling argument to set that lofty of a goal.

WaterSense

The results of the WaterSense calculations give a good estimate of the current water need of the Garden. The top part of Table 5.4 shows the total for each type of water use area, based on Figure 5.5 which is the basemap with ranked areas. The LWR values shown here are based on the adapted EPA formula (Appendix C). The Max Reduction is based on the total landscape having the lowest possible landscape water requirement, but this does not necessarily mean that all the plants installed are drought tolerant or absolutely low water using plants. It does imply that plants are well chosen for their location and are properly established so they are as healthy as possible. The turf areas in FMG are considered to be low water requiring turf due primarily to how well established it is throughout the Garden, and University practices that generally limit how much water is applied during summer months. The Zoysia turf areas could be treated in such a way as to change them to a higher category, but they managed to survive through the drier months and are watered more during the wetter months.

Table 5.4: (Above) Area totals, (Below) LWR calculations.

Totals for Garden Areas (sf)			
Low	Med	High	Turf-Low
22533.27	**16422.24**	**18245.33**	**9876.73**

	Average ET0 (in)	Average Rainfall (In)	Baseline (gal)	**Baseline LWR (gal)**	Min-LWR (gal)	**Max Reduction (gal)**
Jan	0.82	4.45	34407.38	n/a	n/a	n/a
Feb	1.52	4.31	63456.35	n/a	n/a	n/a
Mar	2.42	5.08	101333.14	n/a	n/a	n/a
Apr	3.91	3.68	163628.25	**45202.32**	7122.55	**38079.77**
May	4.73	3.88	197575.36	**61399.51**	15419.53	**45979.98**
Jun	5.65	4.02	236337.20	**80963.40**	25962.71	**55000.68**
Jul	5.14	4.64	215037.69	**61778.64**	11734.80	**50043.83**
Aug	4.70	3.57	196486.43	**64554.03**	18827.47	**45726.56**
Sep	3.49	3.69	145849.94	**35331.11**	1388.74	**33942.38**
Oct	2.24	3.18	93765.56	**12938.59**	n/a	**12938.59**
Nov	1.19	3.67	49808.99	n/a	n/a	n/a
Dec	0.42	3.92	17404.87	n/a	n/a	n/a
Year		48.09		**362167.60**	80455.80	**281711.80**

The major points of interest are Baseline LWR and the Max Reduction, in bold in the table above. It was not possible to calculate the total water actually used due to the presence of multiple meters that do not all go exclusively to the garden and unmeasured use of the supplemental rainwater. It would be suggested for further research to devise a way to get an accurate measurement to test this equation for FMG. The total estimated water need for the current state of the Garden is 362,168 gallons a year. The minimum LWR possible is 80,456 gallons, equaling a difference of 281,712 gallons. As mentioned in previous sections, this reduction represents the furthest reaches of what is possible if it were a single-minded focus of the garden to reduce the amount of water used in the garden. Trying to achieve this reduction while maintaining the Garden as an historic garden will continue to present the College with unique programming and design challenges as long as FMG exists.

WaterSense Worksheet & Corresponding Areas

Garden Area	Area Label	Area Rating	Wind Exposure	Soil Porosity	Slope	Sun Exposure	Plant Need	Competition/Density	Size of Plants	Newly Installed	Value Adjustment	Notes
Bus Stop Bed	A	↑ 13	2	1	2	2	2	1	1	2	0	
Northwest Walk	B	↑ 11	2	0	2	2	0	2	2	1	0	
Entry Bed	C	↑ 11	1	1	0	2	2	2	1	2	0	
Driveway Bed	D	↑ 11	1	1	2	2	2	1	1	1	0	
Courtyard	E	↑ 11	0	2	0	2	1	2	1	1	2	High Sun Exposure, surrounded by brick (Heat)
South Beds	F	↑ 10	0	1	1	1	2	2	2	1	0	
Northeast Bed	G	→ 9	0	1	2	1	1	2	2	0	0	
Azalea Island	H	→ 9	2	1	0	2	2	1	1	0	0	
Herb Garden	I	→ 9	0	2	0	1	2	1	1	2	0	
Northwest Perrinneal Bed	J	→ 8	0	2	0	2	2	1	0	1	0	
Ivy Bed	K	→ 8	1	0	2	2	0	1	2	0	0	High because of new plants
Laurel Garden	L	→ 8	1	0	1	1	1	1	1	2	0	
Boxwood Garden	M	→ 7	0	2	0	1	1	1	0	2	0	
Camellia Walk	N	→ 7	0	0	0	1	2	2	2	0	0	
Southwest Walk	O	→ 7	1	0	2	1	0	2	2	0	-1	Very well established, at the bottom of slope
Serpentine Perennial B	P	→ 7	0	1	0	2	2	0	0	2	0	
Shade Bed	Q	↓ 6	1	0	1	1	1	2	2	0	-2	Very well established, heavy tree canopy, water-loving plants at bottom of slope
Upper Lawn	R	↓ 6	2	0	1	2	2	1	0	0	-2	Watered less due to University Policies
Terrace	S	↓ 6	0	1	0	2	1	1	1	0	0	
Serpentine Perennial A	T	↓ 6	0	1	0	1	2	0	0	2	0	Irrigation could be separated
North End	U	↓ 5	1	0	0	1	1	1	1	0	0	
Northwest Lawn	V	↓ 5	1	0	1	2	2	1	0	0	-2	Watered less due to University Policies
South Lawn	W	↓ 5	0	1	2	2	2	0	0	0	-2	Watered less due to University Policies
Serpentine Turf	X	↓ 4	0	2	0	2	0	0	0	0	0	
Bamboo Walk	Y	↓ 3	0	0	0	0	0	1	2	0	0	

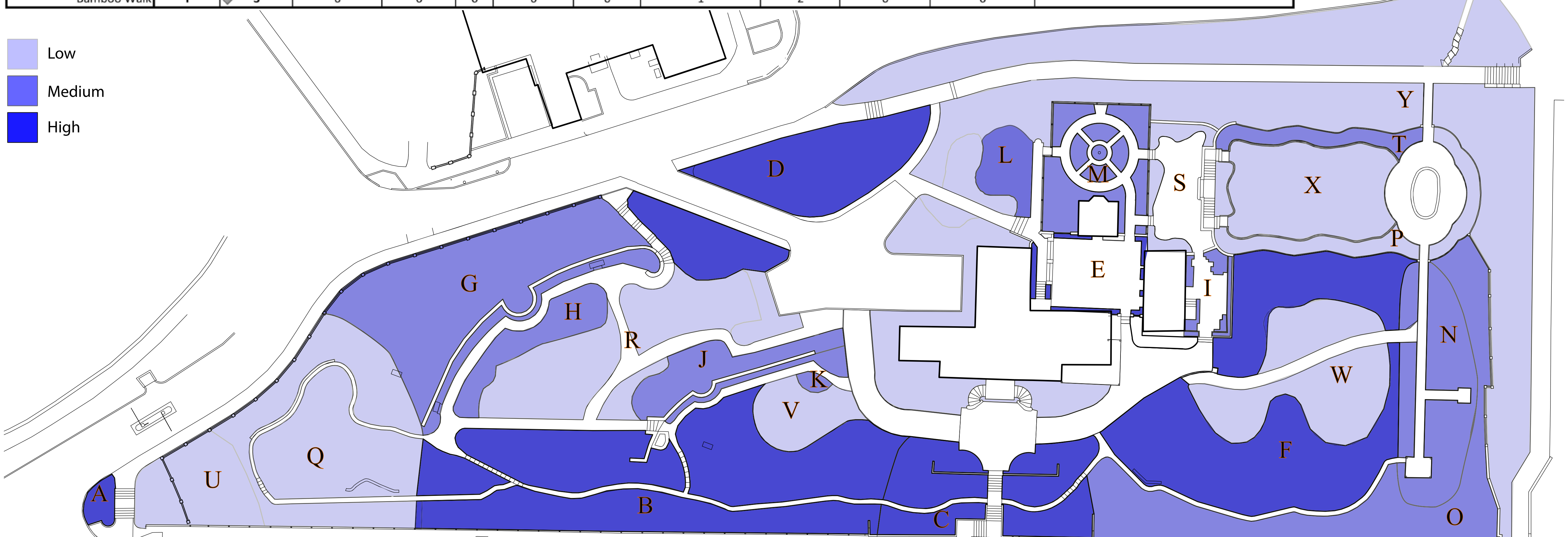


Figure 5.5: Basemap showing garden areas with corresponding water use.

Irrigation Management

In FMG, all areas but the turf are watered with pressure-compensated drip irrigation of the style with the emitters inside the tube. In some cases the barb type emitters have been added where needed. The turf is watered with micro-spray heads, which have an efficiency rating of 70 percent. In terms of efficiency, the equipment in the Garden cannot be drastically improved. Additional research and implementation of enhanced programming and control would also increase efficiency.

There is room for improvement in adjusting the irrigation zones to match water need according to Figure 5.5. Adjusting the irrigation zones to match the map zones for water usage would not constitute much of a change in the Garden, but would bolster the water conservation efforts of FMG. These zones could be programmed to run for different amounts of time so that lower use areas receive less water than higher use areas. Articulating the zones by prioritizing within each area, or at least having the most important areas on their own program, would allow watering in these areas in times when water was more limited. Furthermore, incorporating future rainwater collection systems into the supply for the irrigation system would strengthen water conservation efforts, especially if the previous step was incorporated. Figure 5.6 shows the irrigation zones and equipment.

Founders Memorial Garden

Irrigation Details

Figure 5.6: Basemap showing irrigation details.

LEGEND
Irrigation Features

- Backflow Preventer
- Defunct Control Box
- Defunct Spigot
- Drip Zone Kit
- Future Expansion
- Hose Inlet Adapter
- Spigot-Drop
- Spigot-Surface
- Spray Head
- Valve-Ball
- Valve-Bleed
- Valve-Electronically Controlled (Turf)
- Valve-Isolation
- Water Meter
- Water Lines
- Zone Boundary

Rainfall Collection

The basic formula for estimating the amount of monthly rainfall collection possible is:

Rainfall Collected = Catchment Area (sf) x Collection Efficiency x Monthly Median Rainfall x 0.62 (gal/sf/in of rain)

The monthly median rainfall is calculated from daily rainfall data over a five-year period, from 2006 to 2011 (Table 5.5). The catchment area was determined using the inquiry tool in GIS. The collection efficiency is assumed to be 85%, as this represents an average to good collection system that incorporates a first flush system. The final number is a conversion factor so that the result is in gallons.

Table 5.5: Rainfall data for Athens Clarke County (2006-2011)
Rainfall data courtesy of Georgia Automated Environmental Monitoring Network.

Month	Minimum (in)	First Quartile (in)	**Median (in)**	Third Quartile (in)	Mean (in)	Maximum (in)
January	0.64	2.65	**4.27**	5.42	4.45	9.47
February	0.75	2.68	**4.28**	6.53	4.31	9.24
March	1.05	2.72	**4.82**	4.6	5.08	10.9
April	0.69	1.86	**3.02**	4.77	3.68	10.92
May	0.41	2.08	**3.38**	4.94	3.88	11.34
June	0.87	1.97	**3.32**	6.03	4.02	13.25
July	0.93	2.38	**4.17**	5.02	4.64	10.53
August	0.09	2.03	**3.41**	5.37	3.57	7.62
September	0.17	1.69	**3.23**	4.86	3.69	11.84
October	0	1.37	**2.8**	4.82	3.18	9.14
November	0.33	2.14	**3.11**	4.82	3.67	14.98
December	0.81	2.44	**3.42**	5.28	3.92	8.87
Annual	28.61	26.01	**43.23**	62.46	48.09	71.39

Table 5.6: Estimate of current collection versus potential collection.

Collection Efficiency	Potential Gallons Collected			
85%	Current Roof	All Roofs*	Serpentine Area	Courtyard
January	2182.78	6928.64	5393.95	2250.29
February	2187.89	6944.87	5406.58	2255.56
March	2463.94	7821.09	6088.72	2540.14
April	1543.79	4900.35	3814.92	1591.54
May	1727.82	5484.50	4269.68	1781.26
June	1697.15	5387.14	4193.89	1749.64
July	2131.66	6766.38	5267.62	2197.59
August	1743.16	5533.18	4307.58	1797.07
September	1651.14	5241.10	4080.20	1702.21
October	1431.33	4543.37	3537.01	1475.60
November	1589.80	5046.39	3928.61	1638.97
December	1748.27	5549.40	4320.21	1802.34
Annual	22098.74	70146.42	54608.96	22782.21
Catchment Area	970	3079	2397	1000

* Does not include the storage building with slate roof.

Table 5.7: Estimate of potential impact of expanded rainfall collection to all roofs.

	All Roofs*	Baseline LWR	Current % Red.	Potential % Red.
January	6929.05	n/a	n/a	n/a
February	6945.28	n/a	n/a	n/a
March	7821.55	n/a	n/a	n/a
April	4900.64	45202.32	3.42%	10.84%
May	5484.82	61399.51	2.81%	8.93%
June	5387.46	80963.40	2.10%	6.65%
July	6766.78	61778.64	3.45%	10.95%
August	5533.50	64554.03	2.70%	8.57%
September	5241.41	35331.11	4.67%	14.84%
October	4543.64	12938.59	11.06%	35.12%
November	5046.69	n/a	n/a	n/a
December	5549.73	n/a	n/a	n/a
Annual	70150.55	362167.60	6.10%	19.37%

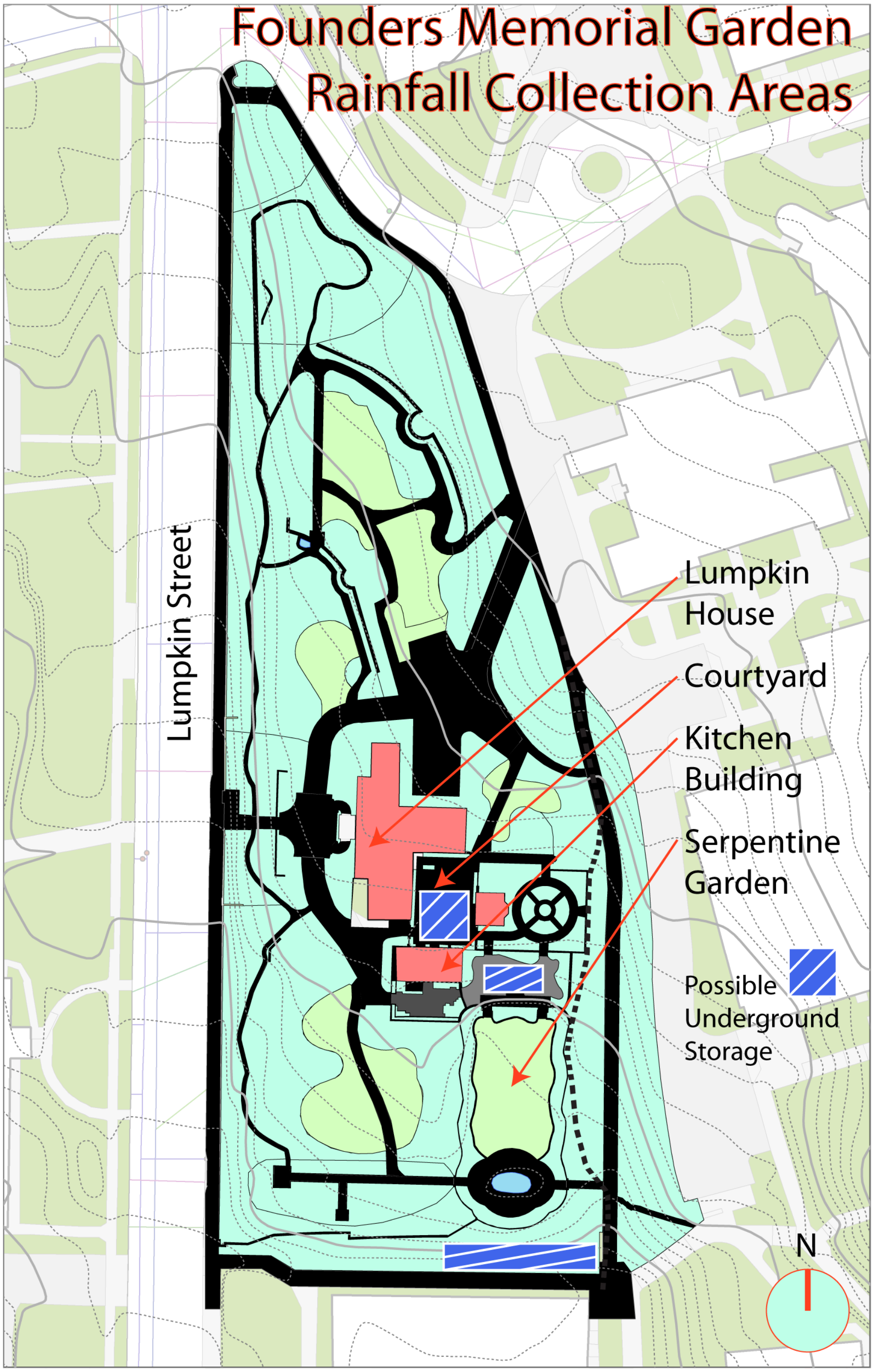


Figure 5.7: Basemap showing potential rainfall collection areas.

The four areas illustrated in Figure 5.7 were chosen because they are fairly clean and isolated from receiving additional stormwater runoff from other areas. The simplest and most likely additional collection is to add to the surface area collected off of roofs – for this reason only the roofs are considered in Table 5.7 for comparison. Currently, part of the Lumpkin House already has a collection system. Adding the remainder of Lumpkin House and the Kitchen Building more than doubles the amount of surface area collected. The Courtyard does not receive very much contributing water from outside, but there is the chance of food items or other minor pollutants getting into the collected water. The Serpentine Garden is the same, but will also contain any excess pesticides and fertilizers that are used on the lawn.

While these do represent more challenging scenarios they are possible with a few additions and controls in place. It is not as common to collect water off of such surfaces but it is done and there are collection systems designed for collecting from surfaces other than roofs. These systems will not be covered in depth, and should be studied further, but essentially they require more filtering before the water reaches the storage tank. Usually this is done with stages of larger aggregate down to finer aggregate for rough filtering and then fine filters that are either cleaned or replaced when they become clogged. So long as the water is stored in a clean tank, where light cannot reach to allow algae and other organisms to thrive, this water can be reused in the Garden. The water could be tested periodically to ensure nothing harmful is in the water, and procedures would need to be created to dispose of the water, but these two surfaces are very good candidates for attempting such a suggestion. Although it is the more difficult to implement, the increased collection off of these four surfaces combined would total in increase of 668%, meaning FMG could potentially be collecting more than 6.5 times more water than is currently being collected now.

The areas marked on the map for potential storage are provided as places to consider. The ideal storage tank capacity is estimated to be 81,000 gallons. This would allow the tank to hold enough water to cover the highest water use month. The least amount of water storage should be no less than 6,500 gallons. This amount of storage would allow the first inch of rainfall to be collected, which would at least cover the most frequent storm, improve the stormwater runoff values, and maximize the use after each rain event. The size, number, and placement of storage tanks would have to be discussed by the FMG managers. In some places these could be standard tanks, and in others they may have to be custom built similar to the one used in Lubert Plaza, but much more research into cost, need, and other factors is required in order to make a more concrete suggestion. This topic is discussed more in the following chapters, but essentially, the Garden managers will have to decide the balance between underground or above ground storage as well as what balance they want to strike between visibility or invisibility, and the various historic preservation and education benefits that can go with either.

These results demonstrate the benefits that rainfall collection could have in FMG. The water savings would ultimately result in less dependence on Athens Clarke County's drinking water. It should be noted that in the months of January, February, March, November, and December the collected water could possibly be used for other purposes such as cleaning and even supplemental water for the buildings.

Chapter 6

Discussion

With the results presented, it is important to dedicate a chapter to understanding what they mean for the management of the Garden. One difficulty with a thesis such as this one is that generally the garden manager may not be familiar with all of the tools used in it. Some of the tools are taught as part of the curriculum for both graduate and undergraduate landscape architecture students, while others are familiar to professors who work with Green Infrastructure and sustainability. Therefore, it is reasonable to assume that the knowledge of these tools is contained within the college. With that in mind, it is the hope of the author that these tools are used in the future management of the Garden and is not simply a snapshot of the spring of 2012.

GIS was the basis of most aspects of the thesis. The files will be made available to the garden manager, along with all the other data for this thesis. As changes happen to the Garden it is important to make sure those changes are reflected in the source files for GIS. In terms of future research, there are opportunities to go further with the spatial analyst tools, as well as when new tools are released. It may also be helpful to have multiple people, well versed in GIS, perform analysis on the site to create a greater bank of knowledge surrounding FMG.

When there is the opportunity to redesign the bamboo walk area, it would be worthwhile to explore a mix of design and engineering. The case studies provide some specific ways that this can be done, as well as many designers who specialize in this area of design. Further research into the work of OLIN studios and Andropogon Associates could give more ideas as to how this can be done. Another design firm which the author suggests is Atelier Dreiseitl. These examples highlight the technology available, as well as aesthetic range of possibilities. This thesis contains no design application, but it does offer an opportunity for CED to highlight the educational aspect of FMG by either giving students a chance to design the area or hiring a firm to complete it in a way that can be used as an education tool for students. The goal is to maximize the infiltration using a mix of engineered and natural solutions. For effect, the CN value for Woods, Good, with A soils was chosen to represent a maximum reduction of runoff for that area of the Garden.

Now that the framework is in place with all of the data available in this thesis (see Appendix B for raw SCS data), it will be possible for other design opportunities to be evaluated without having to regenerate everything. In addition, the SCS method was chosen for this thesis, but it is by no means the only method available for this type of research. It would be interesting for future research to analyze the site using other approaches and compare the results, even enlisting future landscape engineering classes to check these numbers or try other hypothetical situations. Changing to porous concrete and redesigning the bamboo walk area reduces the runoff for the 1-year storm by almost 30%, which shows the potential for change even while staying within a framework that respects historic preservation. Also, inquiries should be made with Athens Clarke County Unified Government to see what stormwater credits would be available for implementing such an improvement. They offer credits for various improvements which can reduce the fees that CED would have to pay for stormwater.

WaterSense is a fairly new tool and, as mentioned above, one that still needs further research to make it more accurate. Combined with the matrix that was created to evaluate each bed, though, it does represent a powerful tool for understanding, and presenting, water need in a garden. It is also helpful as a predictive tool to examine what will happen in the future, both planned changes and looking at natural succession.

One such example is studying the natural cycle of the older trees in the Garden. Some of those trees will likely need to be removed in the near future. Because it is such a highly managed landscape and not a forest, trees cannot just be allowed to fall as they would in a natural setting. For this reason, some of these older trees will be removed, probably in the next ten to fifteen years, thus morphing the nature of that garden area. Sun exposure will change, which will mean that the plants in the bed will have to be replaced, if they are not tolerant of sun exposure. This in turn will imply that the new plants will require more water until they are established. For a few years, a low use bed could change to a medium or high use bed. Other beds that currently have newly planted items will require less water in the future, especially areas that have younger trees that will create more and more shaded area, changing the suitable plant types and possibly reducing the water requirement. These examples serve to illustrate the need for this system to be re-evaluated every few years in order to remain a relevant tool in the Garden. That the system is in place and formulas are all set up should assist in the effort to keep the data current.

The link between knowing the water requirements for each landscaped area and the irrigation system is a very important one. The former gives the latter its structure, and if the first step is being taken it is a logical move to keep the irrigation adjusted so that water is being used in the most efficient way possible. The current system has been installed for almost three years, and it stands to reason that, if these adjustments are made now, it should be revisited in another 3 years.

Any irrigation system will require personnel who understand the system and make concerted effort to manage it. Manual ET-based control is more accurate than using the irrigation system purely based on intuition, but still requires a person to monitor the system and be proactive in conserving water with it. This may be possible at FMG because the manager is in charge of a relatively small area and understands how this type of irrigation management works. If the garden manager was less experienced, or more areas or duties were added to the manager's job, this system would become less accurate purely based on the amount of attention that could be paid to the week-to-week management. The flaws in manual control are that it is based on historical information and might not always apply if the weather is different than the historical average, and it does not automatically account for precipitation.

ET-based and Soil Moisture-based Controls represent an interesting opportunity in the Garden, both in terms of water conservation and education. Both systems require a manager who understands how they work and is responsible for maintaining it, but they also require fewer inputs on a day-to-day basis, which could increase the effectiveness of garden staff in others areas of the Garden. If an automated-ET system, or a soil moisture-based, were to be installed in FMG, it would be helpful to devise an experiment with a test bed and comparable control bed to test its effectiveness. It could even be explored with the two types of controllers in two beds and a control bed to have a full comparison of these two types of irrigation controls.

Research has not reached a point to where this data may be quantified, and there are so many variables that it would be difficult to calculate, but this experiment could be helpful to guide the decision making process for the board in charge of FMG. Dr. Marc van Iersel, from the Department of Horticulture, has also carried out much work in this area and such a partnership could further his research. Partnerships could be increased between CED and the Department of Horticulture, as well as opportunities to partner with industry. The Office of Sustainability offers grants for projects that aim to make UGA a more sustainable campus. There are also likely to be grant opportunities from many entities, such as, Rain Bird, Toro and other irrigation companies, as well as possibly the Extension Service or other state agencies interested in research related to water conservation. This is yet another example of an educational opportunity which FMG could provide to a new class of CED students.

The results of the rainfall collection calculations are presented as a cautious estimate of the maximum amount of water that could be collected off of the Lumpkin House and Kitchen Building. The historic Smokehouse Building has a slate roof and no gutters, so it has not been included in the calculations. Factors which would prevent the collection from reaching the estimated level relate to use of the cistern for garden watering and the frequency of rain. For example, if it rains two days in a row and the cistern is filled on the first day, then the second day of rain will not add to the amount of water collected. Also, if it rains during the summer and the cistern is already full, being saved for emergency use only due to the risk of drought, then that rainwater will not add to the amount collected.

One decision that the board of directors may want to consider is specifying the purpose for the existing cistern and any future storage devices. If the storage is for supplemental water use in the Garden then the management of them will be different than if they are for emergency use during water restrictions. Perhaps, they could consider some portion to be held in reserve during summer months in case of water restrictions, but the rest to be used to supplement water use. The policy should not be overly limiting, but an overall philosophy about what the storage capacity is for should clarify how it is used throughout the year.

Collaboration is mentioned in numerous places throughout this thesis. Partnerships, both inside and outside of the college will play an important role into if and how well the types of change discussed in this thesis are implemented. One area that has not been covered as well is the role of the Historic Preservation (HP) program. The HP program has had a large influence on how the garden has been managed into the present. There are, and will be, conflicts as to the best management practices for the Garden going forward, but it is important to have the HP voice at the table, since it is a part of CED. In these consultations a balance will have to be struck between honoring and preserving the past, while making responsible decisions that will insure that the Garden is able to exist, with integrity into the future.

Chapter 7

Conclusions

This thesis has two main purposes. The primary purpose is to define a baseline. The calculations for runoff and landscape water need have never been documented and should allow current and future garden managers to make better informed decisions regarding FMG. The secondary purpose is to provide tools and evaluate a few examples of how changes to the Garden compare to the baseline. The modifications explored in this thesis are the replacement of the asphalt parking area with porous concrete, the redesign of the Bamboo Walk area to reduce runoff and increase infiltration, gradual plant replacement to reduce water dependency, realignment of irrigation zones and better controls for more efficient water use, and expanding rainfall collection for supplemental water. The changes that are discussed but not quantified are the realignment of the irrigation zones and irrigation control options. The potential rainfall collection is calculated, but its effects on supplemental water and runoff are not fully quantified.

Replacing the asphalt parking with porous pavement would primarily be noticeable to people very familiar with the Garden, which in this case would be between moderate and minor giving it a value of 2, according to the scale created for this thesis. Considering how small of a change this would be to the Garden and how great of an effect it would have on reducing the stormwater runoff from the site, this change is more easily justified. Cost may be an issue, but over time the reduction in stormwater utility fees could offset the added cost of replacement. Also, this addition would bring with it an enhanced educational value to CED. Landscape engineering classes as well as construction classes could use it as an example of porous pavement. Currently, there are only a few examples that would be comparable to this possibility, and those are not as close, convenient, and relevant to CED.

Proposed changes already identified in the master plan will add area to the Garden, the area currently called the Bamboo Walk. It is the author's opinion that the design for those areas could highlight the treatment of stormwater and be an example of modern sustainable garden planning, as illustrated in the case studies. One opportunity with such a design would be to program it in such a way as to make it compatible with the historic Garden, but continue the educational mission of the Garden by making it relevant to what the school is inculcating in the current student body. There is not sufficient space for a more natural wetland, and, due to topography, it would have to be a more engineered design, but the area could be open and eco-revelatory in such a way that part of the beauty of the design is the engineering that makes it work.

The analysis related to the plant water need suggests that management over time could convert the Garden into a much lower water requirement. Reduction could be accomplished by replacing plants that are currently in high-water use areas with plants that would require less water in the same location over time. Another way this can be managed, which is already implemented to a certain degree, is to change areas in the Garden as the cover surrounding them changes. As trees shade out the plants below them, the area should adapt so that the plants will be the healthiest possible with the least amount of inputs possible. This will also apply when trees are removed and certain areas receive more sun than usual. The area should be replanted to plants that will be healthy with the amount of sun they will receive until they are once again shaded out by tree canopy. Ideally, most of the plants can be transplanted, but it will still require the purchase and disposal of plants as areas change. This process could be started with the highest water use areas identified in Figure 5.5.

The foundation of the Garden's irrigation system is efficient and functions well throughout the Garden, but the two areas of largest improvement are in the zoning/programming and the controllers. As a result of the LWR analysis, a new map was created, which can double as a suggested irrigation zone map. If the zones are changed to reflect this map, it will raise the efficiency of the whole system. The two types of controllers discussed would likely further assist the Garden with water conservation efforts of CED in FMG. It would be suggested to work with Dr. Marc van Iersel to set up an experiment with a test bed and control bed and then be able to compare the water savings. If the results of this test showed great reduction in water use, it could be expanded to the remainder of the Garden.

This would present a great learning opportunity for a studio, landscape engineering class, or landscape construction class. It would also be very informative to compare the historical data prior to the irrigation system being installed, with the current irrigation system, and then in the future with the advanced controls added to the system. Perhaps, having the numbers to compare could assist in reverse engineering better assessments of how much water can be saved with advanced irrigation controllers.

Rainfall harvesting may be done with little change to the Garden but can serve to reduce the volume of water leaving the site as well as the dependence on Athens' drinking water for the watering of plants. If the cisterns are located underground, then they would constitute a very minor change to the Garden, resulting in a value of 1 according to the Visibility of Change scale. The primary concern with placing them underground would be the storage capacity compared to where it could be located. The disturbance of soil, roots, and any other damage that could occur due to digging a large enough hole to install such a cistern would have to be carefully considered. For this site, the underground utilities are fairly well documented; however, the main concern would be the roots of larger trees and shrubs.

If some combination of underground and aboveground cisterns were required to achieve enough storage capacity then the visibility rating would increase. With some creative design and sourcing of materials, the collection devices could fit well with the style of both the Garden and House, which according to the defined scale would equal a 3, namely moderate change. If the cistern were similar to the one already in operation then the change would be a 4 or 5, depending on placement, because it does not fit at all with the aesthetic of the Garden – 4 if it were in a place similar to the current one with some fencing or screening around it to where it is not visible for most visitors and 5 if it were in a prominent place that required it to be in full view.

It would be suggested that one of the board's sub-committees assess the types of storage and potential locations and types. It is likely that the majority of storage could be below ground, but some other locations could be highlighted for educational purposes. Part of this could even be done in such a way as to show the inner workings of how the system works and allow for hands-on experiences for students and visitors.

It is the hope of the author that this research can further the mission of FMG and provide some needed tools to the board of directors and garden managers. Even if none of the suggested changes are made, it should serve as a tool for CED to possess such a study and assessment of the Garden for the historical record.

Lastly, these efforts should be focused on now so that FMG is prepared for the worst of what may come with climate change and the increased frequency of drought in the State. If the average rainfall drops and temperature rises, then the FMG managers will be prepared and the Garden should be able to maintain its integrity as an historic garden. If the climate change models turn out not to be accurate, these changes could still represent a valuable learning tool for future landscape architects while also, they eventually paying for themselves in reduced water expenditures.

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APPENDICES:

A – SCS

Baseline:

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
driveway	2.26	0.100	70	Outlet	

Total Area: 2.26 (ac)

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
driveway							
SHEET	35	0.0350	0.240				0.076
SHALLOW	109	0.1468	0.050				0.005
			Time of Concentration				0.1

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
driveway	Residential districts (1/2 acre)	B	2.26	70
	Total Area / Weighted Curve Number		2.26	70

Aternative #1:

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
driveway	2.26	0.100	68	Outlet	

Total Area: 2.26 (ac)

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
driveway							
SHEET	35	0.0350	0.240				0.076
SHALLOW	109	0.1468	0.050				0.005
				Time of Concentration			0.1

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
driveway	Residential districts (1 acre)	B	2.26	68
	Total Area / Weighted Curve Number		2.26	68

Alternative #2:

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
FMG	2.26	0.100	65	Outlet	

Total Area: 2.26 (ac)

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
FMG							
SHEET	35	0.0350	0.240				0.076
SHALLOW	109	0.1468	0.050				0.005
				Time of Concentration			0.1

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
	Open space; grass cover > 75% (good)	B	.227	61
	Paved parking lots, roofs, driveways	B	.479	98
	Gravel (w/ right-of-way)	B	.229	85
	Woods (good)	A	.219	30
	Woods (good)	B	1.111	55
	Total Area / Weighted Curve Number		2.26	65

B – WaterSense

WaterSense Single-Family New Home Specification: Water Budget Tool (V 1.01)

This water budget tool shall be used to determine if the designed landscape meets Criteria 4.1.1.1 of the specification.
Please refer to the WaterSense Water Budget Approach for additional information.

Your Name:	Sam Kelleher
Builder Name:	CED
Lot Number/Street Address:	Founders Memorial Garden
City, State, Zip Code:	Athens, GA 30602

EPA WaterSense

Peak Watering Month: June
Obtain from Water Budget Data Finder at www.epa.gov/watersense/nhspecs/wb_data_finder.html

Is an irrigation system being installed on this site? Yes

This worksheet determines the baseline and the landscape water allowance (LWA) for a site based on its peak watering month.

The baseline is the amount of water required by the site during the peak watering month if watered at 100 percent of reference evapotranspiration (ET_o). The following formula is used to calculate the baseline:

$$Baseline = ET_o \times A \times C_u$$

Where:
ET_o = Local reference evapotranspiration (inches/month)
A = Landscaped area (square feet)
C_u = Conversion factor (0.6233 for results in gallons/month)

The LWA is the water allotment for the site. The following formula is used to calculate the LWA:

$$LWA = 0.70 \times Baseline$$

Where:
LWA = Landscape water allowance (gallons/month)
Baseline = ET_o x landscaped area x 0.6233

To calculate the Baseline and LWA for a site, enter the designed landscaped area and average monthly reference evapotranspiration for the site's peak watering month. (Enter data in white cells only.)

STEP 1A - ENTER THE LANDSCAPED AREA (A)

67,078 **Area of the designed landscape (square feet)**

STEP 1B - ENTER THE AVERAGE MONTHLY REFERENCE EVAPOTRANSPIRATION (ET_o)

5.65 **Average monthly reference ET (inches/month) for the site's peak watering month**

Obtain from Water Budget Data Finder at www.epa.gov/watersense/nhspecs/wb_data_finder.html

OUTPUT - BASELINE FOR THE SITE

236,238 **Monthly baseline (gallons/month) based on the site's peak watering month**

OUTPUT - WATER ALLOWANCE FOR THE SITE

165,366 **Monthly landscape water allowance (gallons/month) based on the site's peak watering month**

Next Step: Click on the next tab labeled *Part 2 - LWR* to calculate the landscape water requirement.

WaterSense Single-Family New Home Specification: Water Budget Tool (V 1.01)

This water budget tool shall be used to determine if the designed landscape meets Criteria 4.1.1.1 of the specification.
Please refer to the WaterSense Water Budget Approach for additional information.

Your Name:	Sam Kelleher
Builder Name:	CED
Lot Number/Street Address:	Founders Memorial Garden
City, State, Zip Code:	Athens, GA 30602
Peak Watering Month:	June
Is an irrigation system being installed on this site?	Yes

This worksheet determines the monthly landscape water requirement (LWR) for a site based on its peak watering month.

The monthly LWR is the water requirement specific to the designed landscape. The sum of the LWRs for each hydrozone equals the site LWR.
The following formula is used to calculate the LWR for each hydrozone:

$$LWR_H = \frac{1}{DU_{LQ}} \times [(ET_o \times K_L) - R_a] \times A \times C_u$$

Where:
LWR_H = Landscape water requirement for the hydrozone (gallons/month)
DU_{LQ} = Lower quarter distribution uniformity
ET_o = Local reference evapotranspiration (inches/month)
K_L = Landscape coefficient for the type of plant in that hydrozone (dimensionless)
R_a =Allowable rainfall, designated by WaterSense as 25% of average peak monthly rainfall (R)
A = Area of the hydrozone (square feet)
C_u = Conversion factor (0.6233 for results in gallons/month)

To calculate the LWR for the site, enter the information requested below for the site's peak watering month. (Enter data in white cells only.)

STEP 2A - ENTER THE AVERAGE MONTHLY RAINFALL (R) AT THE SITE FOR THE PEAK WATERING MONTH IDENTIFIED IN PART 1

4.02 **Average monthly rainfall (inches/month) for the site's peak watering month**

Obtain from Water Budget Data Finder at www.epa.gov/watersense/nhspecs/wb_data_finder.html

STEP 2B - COMPLETE TABLE 1 BELOW (enter data in white cells only)

Enter the area of the hydrozone (square feet). The total area must equal the landscaped area entered in Step 1A.
Choose the plant type from the dropdown list (source data is displayed in Table 2).
Choose the irrigation type from the dropdown list (source data is displayed in Table 3; guidance is displayed in Table 4 and Table 5).

Table 1. Landscape Water Requirement

Zone	Hydrozone/Landscape Feature Area (sq. ft.)	Plant Type or Landscape Feature	Landscape Coefficient (K_L)	Irrigation Type	Distribution Uniformity (DU_{LQ})	LWR_H (gal/month)
1	22,533	Shrubs - Low water requirement	0.2	Drip - Press Comp	90%	1,951
2	16,422	Shrubs - Medium water requirement	0.5	Drip - Press Comp	90%	20,701
3	18,245	Shrubs - High water requirement	0.7	Drip - Press Comp	90%	37,278
4	9,877	Turfgrass - Low water requirement	0.6	Micro Spray	70%	20,976
5						-
6						-
7						-
8						-
9						-
10						-
11						-
12						-
13						-
14						-
15						-
Total Area =	67,078	Landscape Water Requirement for the Site (gal/month)				80,905

Table 2. Plant Type or Landscape Feature and Associated Landscape Coefficient

Plant Type or Landscape Feature	K_L Water Requirements: Low	Medium	High
Trees	0.2	0.5	0.9
Shrubs	0.2	0.5	0.7
Groundcover	0.2	0.5	0.7
Turfgrass	0.6	0.7	0.8
Pool, Spa, or Water Feature		0.8	
Permeable Hardscape		0	
Nonvegetated Softscape		0	

Source: Based on LEED for Homes Rating System 2008.

Table 3. Distribution Uniformity

Irrigation Type	$DU_{(LQ)}$ or EU*
Drip - Standard	70%
Drip - Press Comp	90%
Fixed Spray	65%
Micro Spray	70%
Rotor	70%
No Irrigation	NA

*Lower quarter distribution uniformity (DU_{LQ}) applies to sprinkler zones and emission uniformity (EU) applies to drip/microirrigation zones.
Source: (The Irrigation Association, October 2001) in Landscape Irrigation Scheduling and Water Management, IA 2005.

Table 4. Appropriate Irrigation Types - Landscaped Areas with Irrigation Systems

IF THE PLANT TYPE IS:	THEN THE IRRIGATION TYPE CAN BE: Drip - Standard	Drip - Press Comp	Fixed Spray	Micro Spray*
Trees	x	x		x
Shrubs	x	x		x
Groundcover	x	x		x
Turfgrass	x	x	x	x

* Micro spray may only be used on vegetation other than turfgrass if it meets the definition of microirrigation system, which according to the *2009 WaterSense Single-Family New Home Specification* is: "The frequent application of small quantities of water on or below the soil surface as drops, tiny streams or miniature spray through emitters or applicators placed along a water delivery line. Microirrigation encompasses a number of methods or concepts, such as bubbler, drip, trickle, mist or spray, and subsurface irrigation. For the purposes of this specification, microirrigation includes emission devices that have flow rates less than 30 gallons per hour."

Table 5. Appropriate Irrigation Types - Landscaped Areas without Irrigation Systems

IF THE PLANT TYPE OR LANDSCAPE FEATURE IS:	THEN THE IRRIGATION TYPE SHALL BE: Drip - Standard	Fixed Spray	No Irrigation
Trees, Shrubs, or Groundcover with Low Water Requirements (K_L = 0.2)	x		
Trees, Shrubs, or Groundcover with Medium or High Water Requirements (K_L > 0.2)		x	
Turfgrass with Low, Medium, or High Water Requirements (K_L > 0.2)		x	
Pool, Spa, or Water Feature		x	
Permeable Hardscape			x
Nonvegetated Softscape			x

*Please see additional information in the WaterSense Water Budget Approach for landscapes installed without irrigation systems.

OUTPUT - WATER REQUIREMENT FOR THE SITE

80,905 **Monthly landscape water requirement (gallons/month) based on the site's peak watering month**

Next Step: Click on the next tab labeled *Part 3 - Results* to view the results.

WaterSense Single-Family New Home Specification: Water Budget Tool (V 1.01)

This water budget tool shall be used to determine if the designed landscape meets Criteria 4.1.1.1 of the specification.
Please refer to the WaterSense Water Budget Approach for additional information.

Your Name:	Sam Kelleher
Builder Name:	CED
Lot Number/Street Address:	Founders Memorial Garden
City, State, Zip Code:	Athens, GA 30602
Peak Watering Month:	June
Is an irrigation system being installed on this site?	Yes

This worksheet determines if the designed landscape meets the water budget.

If the landscape water requirement is LESS than the landscape water allowance, then the water budget criterion is met.
If the landscape water requirement is GREATER than the landscape water allowance, then the landscape and/or irrigation system needs to be redesigned to use less water.

Your total landscape area in Step 2B is not equal to the total landscape area in Step 1A. Please complete Step 2B.

STEP 3A - REVIEW THE LWA AND LWR FROM PART 1 AND PART 2

LWA **165,366** (gallons/month) **LWR** **80,905** (gallons/month)

STEP 3B - REVIEW THE TOTAL AREA OF TURFGRASS* IN THE DESIGNED LANDSCAPE FROM STEP 2B

The designed landscape contains **9,877** **square feet of turfgrass.*** **This is** **15%** **of the landscaped area.**

*This includes the area of any pools, spas, and/or water features, designated by WaterSense to be counted as turfgrass.

OUTPUT - DOES THE DESIGNED LANDSCAPE MEET THE WATER BUDGET?

YES If YES, then the water budget criterion is met.
If NO, then the landscape and/or irrigation system needs to be redesigned to use less water.

The designed landscape water requirement is a 66% reduction in water use from the baseline calculated in Part 1.

C – Current Rainfall Collection

Rainfall Date	Rainfall Amount	H2O Vol. in Tank	Date Water Used	Est. Gallons Used	Notes
					Ready for use 17 June 08
23-Jun-08	0.80	1.00	25-Jun-08	310.00	
30-Jun-08	0.50	1.00	2-Jul-08	155.00	
7-Jul-08	1.50	1.00	8-Jul-08	155.00	Soaker Hose on Aspedistra
9-Jul-08	0.50	1.00			
10-Jul-08	1.50	1.00			
11-Jul-08	0.10	1.00			
			17-Jul-08	310.00	Soaker Hose on pots and boxgarden
			22-Jul-08	310.00	Empty
23-Jul-08	0.80	0.80			
			29-Jul-08	310.00	Serpentine garden
2-Aug-08	0.20	0.50			
6-Aug-08	0.15	0.50			
			7-Aug-08	310.00	Empty; boxwood garden
14-Aug-08	0.30	0.25	18-Aug-08	155.00	Empty
25-Aug-08	0.60	0.75			
29-Sep-08	0.75	1.00			
			2-Oct-08	412.92	
8-Oct-08	3.25	1.00	15-Oct-08	206.65	
17-Oct-08	1.25	1.00			
24-Oct-08	2.00	1.00	23-Oct-08	413.33	Fill into extra storage buckets
			10-Nov-08	310.00	Watered newly planted beds
14-Nov-08	0.75	1.00			
			19-Nov-08	206.67	
24-Nov-08	1.25	1.00			
2-Dec-08	0.75	1.00			
			12-Dec-08	206.67	
			16-Dec-08	206.67	Emptied to avoid freeze damage
18-20-Dec-08	3.00	1.00			
26-Dec-08	0.50	1.00			

Tan
k = 620

1" fills tank
1" piping leaving tank

29-Dec-08	0.30	1.00					
Total:	20.75		Total water used:	3977.90			
3-Jan-09	0.25	1.00				Jan	206.67
5-Jan-09	0.60	1.00	8-Jan-09	206.67	Used for planting beds	Feb	671.67
10-Jan-09	0.40	1.00				Mar	0.00
18-Jan-09	0.20	0.75	9-Feb-09	155.00		Apr	0.00
		0.50	11-Feb-09	310.00	Whole tank on Boxwoods	May	200.00
14-Feb-09	0.40	0.67	17-Feb-09	206.67	1/3 into storage	Jun	160.00
18-Feb-09	0.20	1.00				Jul	40.00
5-Mar-09	0.10	1.00				Aug	160.00
15-Mar-09	2.10	1.00				Sep	120.00
26-28-Mar-09	4.10	1.00				Oct	0.00
1-May-09	1.50	1.00				Nov	0.00
16-May-09	0.80	1.00		100.00		Dec	0.00
20-24-May-09	1.50	1.00	22-May-09	100.00			
4-Jun-09	1.20	1.00		80.00			
17-Jun-09	0.40	1.00		80.00		**1 YEAR ANNIVERSARY**	
12-Jul-09	0.65	1.00	7-Aug-12	40.00			
12-Aug-09	1.00	1.00					
			15-Aug-09	120.00			
20-Aug-09	0.30	0.60					
28-31-Aug-09	3.00	1.00					
3-Sep-09	**9.00**						
6-Sep-09	6.00		6-Sep-09	120.00			
12-Oct-09	4.50	1.00					
15-Oct-09	1.00						
22-Nov-09	1.25	1.00					
26-Dec-09	0.50						
29-Dec-09	0.30	1.00				Jan	120.00

						Feb	0.00
Total:	41.25		Total water used:	1518.33		Mar	0.00
						Apr	130.00
25-Jan-10	0.40					May	220.00
26-Jan-10	0.70			120.00		Jun	620.00
3-Feb-10	0.60					Jul	0.00
12-Feb-10	3.00				SNOW	Aug	0.00
22-Feb-10	0.50	1.00				Sep	240.00
				130.00		Oct	0.00
3-May-10	1.25	1.00	28-May-08	120.00		Nov	0.00
			30-May-10	100.00		Dec	0.00
1-Jun-10	0.50	1.00					
3-Jun-10	1.00	1.00					
17-Jun-10	0.75					**2 YEAR ANNIVERSARY**	
23-Jun-10	1.25						
			28-Jun-10	620.00	Emptied		
1-31-Jul-10	1.40	1.00					
1-31-Aug-10	7.50						
1-30-Sep-10	5.25			240.00			
1-31-Oct-10	1.40						
Nov	2.50						
Dec	1.50						
Total:	29.50		Total water used:	1330.00			
1-31-Jan-11	3.10					Jan	0
1-28-Feb-11	7.20				1" of snow	Feb	0
7-Mar-11	2.00					Mar	0
10-Mar-11	1.20					Apr	120
16-Mar-11	0.75					May	0
29-Mar-11	2.50					Jun	100

30-Mar-11	0.50				
8-Apr-11	1.20				
12-Apr-11	0.20				
18-Apr-11	1.25		19-Apr-11	120.00	
25-Apr-11	1.00	1.00			
29-Apr-11	0.20				
2-May-11	0.50				
4-May-11	0.25				
27-May-11	1.10				
28-May-11	0.75				
10-Jun-11	1.00				
17-Jun-11	1.20				
22-Jun-11	0.50		11-13-Jun-11	100.00	
23-Jun-11	1.25	1.00			
6-Jul-11	0.80				
9-Jul-11	0.20				
16-Jul-11	0.20				
1-Aug-11	0.15				
3-Aug-11	1.00				
20-Aug-11	2.25	1.00			
15-Sep-11	1.00	1.00	15-Sep-11	620.00	Emptied
11-Oct-11	1.25	1.00	7-Oct-11	620.00	Emptied
19-Oct-11	1.50	1.00			
28-Oct-11	0.75			50.00	
Nov	3.50				
Dec	5.00				
Total:	45.25		Total water used:	1510.00	
1-Jan-12	0.20				
10-Jan-12	0.25				
18-Jan-12	1.25	1.00	18-Jan-12	50.00	
22-Jan-12	0.75	1.00			
28-Jan-12	0.40				
15-Feb-12	0.20				
19-Feb-12	1.00				
27-Feb-12	0.30				

Jul	0
Aug	0
Sep	620
Oct	670
Nov	0
Dec	0

3 YEAR ANNIVERSARY

29-Feb-12	0.20				
1-Mar-12	0.30				
3-Mar-12	1.10				
5-Mar-12	3.25				
8-Mar-12	1.40				
			13-Mar-12	120.00	

D – Raw Rainfall Data

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Totals
1944	0	0	0	0	0	2.81	1.7	2.88	11.71	2.58	2.17	2.32	14.46
1945	2.38	7.57	2.77	8.3	2.09	0.95	5.69	4.36	6.49	1.86	2.77	8.45	44.02
1946	8.55	4.89	5.01	5.16	4.36	4.05	2.55	2.98	3.27	5.03	2.23	1.05	40.58
1947	9.05	2.1	5.85	4.32	4.77	6.21	0.93	3.85	1.31	4.86	8.1	4.46	55.81
1948	0	0	0	0	0	0	5.91	5.16	3.03	1.37	14.98	4.42	34.87
1949	4.33	7.14	2.55	6.79	4.32	3.32	3.97	4.47	2.66	2.83	1.46	3.01	46.85
1950	3.15	2.61	5.14	0.69	4.65	4.12	4.84	1.84	3.37	6.02	0.33	4.65	41.41
1951	2.65	2.16	4.82	3.3	0.55	7.87	8.01	0.09	4.73	1.37	1.88	6.42	43.85
1952	2.63	3.56	9.39	2.32	3.15	4.1	2.91	6.43	1.05	0.66	1.81	4.51	42.52
1953	6.77	5.66	3.61	2.63	6.04	4.65	5.08	1.4	6.5	0.2	0.75	8.04	51.33
1954	3.11	1.61	2.93	1.55	2.51	2.81	3.95	2.44	0.52	0.25	4.44	2.49	28.61
1955	5.32	4.55	2.61	2.27	4.34	2.36	5.7	2.8	1.17	1.64	2.99	1.18	36.93
1956	2.11	5.66	5.44	6.73	0.82	2.99	6.03	0.48	6.56	2.97	2.14	3.78	45.71
1957	5.05	3.1	3.95	3.94	5.94	1.32	1.36	1.6	6.53	6.13	9.16	3.42	51.5
1958	4.09	4.95	6.07	4.57	3.94	0.87	5.25	4.21	1.22	0.93	1.5	2.57	40.17
1959	3.84	4.76	5.96	2.4	11.34	1.97	10.39	1.24	5.54	5.58	2.34	3.08	58.44
1960	9.47	6.33	4.73	3.34	1.89	1.92	5.64	5.02	6.09	2.3	1.01	2.82	50.56
1961	2.25	9.24	6.98	6.4	3.38	4.94	6.95	7.43	1.75	0.2	2.73	7.65	59.9
1962	5.23	5.38	6.63	6.22	1.57	4.12	3.85	3.67	5.3	1.38	4.85	2.44	50.64
1963	5.91	3.76	5.98	7.9	5.83	12.22	4.74	0.87	4.64	0	5.44	5.79	63.08
1964	7.41	5.18	10.9	9.54	4.77	3.51	10.53	3.78	1.84	7.73	2.52	3.68	71.39
1965	1.83	4.92	7	4.66	0.93	6.02	4.41	1.44	5.27	2.9	1.5	1.03	41.91
1966	8.56	7.52	4.73	4.55	6.5	3.36	2.5	6.27	2.8	3.54	3.27	4.74	58.34
1967	4.27	4.14	2.27	4.87	5.69	13.21	7.98	5.91	1.28	3.6	6.36	6.58	66.16
1968	5.26	1.45	4.34	4.6	6.39	4.94	8.5	3.25	1.94	3.06	6.57	5.94	56.24

1969	4.95	3.38	4.86	5.69	4.61	1.49	2.28	5.92	5.19	1.98	2.02	3.88	46.25
1970	2.28	2.06	6.35	1.7	3.77	1.36	4.07	3.04	7.09	5.54	1.28	2.87	41.41
1971	4.06	5.62	7.91	4.17	3.05	4.4	3.27	4.56	2.75	2.95	4.02	2.81	49.57
1972	6.46	2.94	3.89	1.55	6.02	5.72	4.69	2.64	0.69	2.43	3.57	8.42	49.02
1973	4.28	2.68	9.86	3.58	8.02	3.18	2.15	3.09	4.09	0.66	1.78	6.97	50.34
1974	3.68	4.98	2.32	3.81	9.73	5.04	5.03	5.99	1.32	0.4	3.11	4.58	49.99
1975	5.55	6.43	10.12	2.8	7.21	3.18	6.55	3.66	6.09	3.83	3.86	2.76	62.04
1976	4.06	2.07	8.55	0.74	8.5	2.47	2.97	5.31	3.01	6.22	5.25	5.28	54.43
1977	4.14	1.79	5.99	1.86	0.88	1.76	5.58	6.33	3.35	7.41	4.86	2.19	46.14
1978	6.92	0.75	3.48	2.78	4.82	2.39	6.41	4.35	1.15	0.97	2.5	3.52	40.04
1979	6.54	6.21	2.72	8.1	3.68	2.51	5.94	3.45	2.44	2.56	3.5	1.38	49.03
1980	6.76	1.84	10	2.68	7.52	3.43	1.69	2.55	5.55	1.48	2.66	1.9	48.06
1981	0.64	6.73	2.45	2.1	3.67	1.5	2.32	1	1.04	2.06	1.81	7.57	32.89
1982	4.83	7.07	1.88	5.74	4.33	3.65	3.13	3.1	2.19	4.56	5.56	3.56	49.6
1983	3.19	5.42	6.1	5.17	2.3	3.17	1.99	2.06	5.62	3.64	6.9	8.22	53.78
1984	4.5	5.94	5.18	4.84	3.4	3.79	10.2	3.59	0.72	2.75	2.32	2.62	49.85
1985	4.11	4.62	1.15	1.73	3.81	2.08	6.36	2.39	0.62	5.15	4.99	1.39	38.4
1986	0.76	1.65	3.27	1.22	2.2	2.13	3.63	3.76	1.94	7.65	4.77	3.03	36.01
1987	6.29	5.17	4.29	0.89	2.3	3.34	4.83	0.98	2.39	0.36	2.61	2.39	35.84
1988	5.35	2.88	2.53	3.39	0.41	0.91	1.67	2.52	5.37	2.33	4.19	0.81	32.36
1989	2.1	3.21	3.96	4.2	3.99	6.21	6.2	1.97	10.3	5.85	3.51	5.29	56.79
1990	5.74	7.47	8.17	2.15	1.96	1.93	6.13	6.21	3.15	5.17	1.38	3.28	52.74
1991	6.32	3.32	6.07	4.52	5.78	10.94	6.17	5.19	2.22	0.12	1.58	3.19	55.42
1992	3.34	4.75	4.14	1.08	1.48	4.39	4.17	6.19	5.72	2.8	8.25	5.71	52.02
1993	4.4	5.01	7.35	2.73	3.24	1.36	1.54	2.03	3.23	3.85	3.43	2.83	41
1994	3.91	3.25	5.88	3.03	1.96	13.25	8.77	7.37	4.28	6.68	3.52	1.94	63.84
1995	4.88	6.39	2.61	3.02	4.33	6.54	2.28	7.22	3.41	7.29	5.03	2.52	55.52

1996	6.71	3.2	6.9	3.35	2.08	2.99	4.53	3.88	3.76	0.8	3.95	3.34	45.49
1997	5.23	7.72	1.66	3.99	2.79	5.01	4.88	1.55	6.79	7.75	3.52	5.91	56.8
1998	5.87	7.72	4.99	10.92	3.08	1.95	2.38	2.62	4.46	2.3	2.06	1.85	50.2
1999	5.45	2.74	2.75	2.51	1.16	6.95	3.49	4.09	3.29	3.78	2.7	2.54	41.45
2000	4.48	1.99	3.41	1.7	2.16	1.98	3.36	3.67	4.81	0.23	4.2	3.46	35.45
2001	2.75	3.03	8.58	1.83	3.03	5.14	10.38	0.85	1.57	0.42	0.65	1.49	39.72
2002	4.51	2.25	6.53	1.64	3.17	4.77	2.26	0.14	7.47	3.29	4.82	5.44	46.29
2003	1.74	4.54	5.67	2.5	7.98	5.98	8.27	3.41	1.69	2.07	3.94	2.29	50.08
2004	2.52	4.28	1.05	0.87	1.32	3.68	1.84	3.87	11.84	0.98	7.95	2.8	43
2005	2.59	4.89	6.85	5.87	2.67	10.25	9.35	5.47	0.17	2.97	2.78	4.56	58.42
2006	4.26	4.71	2.53	2.35	2.17	1.93	3.66	5.76	2.22	3.52	3.18	3.91	40.2
2007	3.48	2.92	3.89	1.64	1.56	2.17	3.48	1.72	0.53	2.35	2.35	5.42	31.51
2008	2.6	3.56	3.48	3	2.23	1.22	3.95	2.79	2.13	5.12	2.63	3.66	36.37
2009	2.7	3.67	7.05	4.47	3.58	1.66	1.33	2.7	9.86	9.14	5.17	8.87	60.2
2010	6.2	4.21	2.33	1.86	5.89	4.55	1.4	7.62	5.35	1.42	4.91	1.92	47.66
2011	3.32	4.72	6.65	2.6	0.82	2.44	1.46	2.44	1.55	4.35	3.08	3.68	37.11

Period of Record Statistics													
MEAN	4.45	4.31	5.08	3.69	3.88	4.02	4.64	3.57	3.69	3.18	3.67	3.92	48.03
S.D.	1.88	1.86	2.36	2.19	2.32	2.81	2.51	1.91	2.5	2.29	2.36	2.04	9.21
SKEW	0.4	0.33	0.47	1.09	0.88	1.72	0.67	0.29	0.95	0.62	2	0.77	0.12
MAX	9.47	9.24	10.9	10.92	11.34	13.25	10.53	7.62	11.84	9.14	14.98	8.87	71.39
MIN	0.64	0.75	1.05	0.69	0.41	0.87	0.93	0.09	0.17	0	0.33	0.81	28.61
NO YRS	65	65	66	66	65	67	68	68	67	68	68	68	64

E – Interview Notes
Personal Interview
Maureen O'Brien
30 Jan 2012

The ground manager is what used to be what is now called the Horticulturalist position. Before Maureen it was Doug Peterson (706.354.0625) and before him, Karen ___________.

There is a HORT lecture class that brings students by the garden to learn about home gardening and why certain aspects are relevant to them. Compost, Fertilizer and water harvesting are all touched on. Students learn, 168 from 2011, about how the water harvesting works. This is another way the garden fulfills its educational component.

The board of directors has been relatively low functioning, but with the structure that Dean Dan is putting in place it looks likely to "change and get structure back intact". It will meet 2x a year with sub-committees doing work in between meetings.

Part of the history with the board of directors is that shortly after the Garden Club moved their headquarters out to the Botanical Gardens the person who had the representative at the meetings changed and a replacement was never assigned. This correlated with less involvement of the Club and a put distance, literally, between the College and Garden Club. It also seems that the new, younger, members of the garden club are not as familiar with the garden and have less attachment. They are, in a sense, building up at the Botanical Gardens what the previous generation built up in FMG.

Plant additions, subtractions, and substitutions are common, but generally with a purpose in mind. Beds change due to loss of canopy when a tree is badly damaged or dies. The opposite occurs too. The Laurel Garden and the one of the beds around the large Pin Oak were added because the trees above them were shading out the grass and needed to be changed. Plants that were needlessly added in the more recent past have been removed, either upon the plant dying or when maintaining a bed during maintenance. Addition of species that are new to the industry is still happening (In keeping with one of the original mandates of the garden to be an area for teaching plants). Sometimes, it is a professor who requests a species be added so that they can teach their class that plant. This happens when there is not a certain plant on campus, or if there is one on another part of campus, but not anywhere else.

The Arbor was added in 1991. The sandstone skirt was added in 1988. The sundial, which was stolen in the 60s, has been returned and will be replaced in the garden. The Goose and Boy Fountain was damaged after its original installation and later an artist recreated the head and repaired the sculpture. In between another Goose fountain was used. The Fountain was changed to a recirculating fountain in 2010. The cistern was installed 18 June 2008 and has been in use since.

Overland flow has different requirements than rainwater collection. Rainwater is cleaner, chemically and with less sediment, and can be used without filtering at any risk of damaging plants. Rainwater collection is likely to be expanded onto the other building with a cistern underground (longer lasting, not visible so less visual change in the garden).

Next spring the roofs of the Lumpkin House buildings (not the slate roof) will be changed to standing seam metal roofs.

In bed behind office Armelaria (sp?) fungus has caused lots of damage. The bed was very dense with plants previously and it is a very moist area. Had Ivy cover most recently, but that was removed along with all the mulch to try to get rid of the fungus. This area would be good for dry loving plants.

Will order a soil probe in order to take core samples from different beds to see how deep the red clay is. This will give a clearer understanding of water absorbency and runoff potentials.

With the move to the visual arts building it seems that the use of the Garden by CED will be reduced. It will likely continue to have people use it for lunch and classes (by students from nearby buildings). Currently, about 1 class per week uses the garden from CED (plant ID, sketching, design, etc.). HPs and CLL people may have more interaction as Denmark develops into the CLL and a testing lab for HPs. The Garden is also trying to pull in more Garden Club oriented events and will do more to bring in outside visitors.

The Garden priorities in time of drought are as follows:
Boxwood Garden and Serpentine
Entrance at Lumpkin Street
Courtyard planters

Possible changes to increase sustainability of garden:
Increased water capture; adding some additional irrigation lines so irrigation can run less time (apply water directly where it is needed); more defined Master Plan so that upcoming changes can be anticipated; Look at adding, or taking away, mulch for increased, or decreased, water absorbency (bed specific); Find ways to reduce pine straw and bark… Use more of the leaves that naturally fall. May require some education, maybe even signs showing what is happening and why.

Changes that are coming to the Garden area in near future:

- Handicap ramps into boxwood garden and lower level Serpentine area.
- Remove bamboo between FMG and Joe Brown (possibly with steps)
- Bamboo walk removed and could be an area for new plantings
- Change cobblestone to flagstone in front of Lumpkin House
- Trying to determine area to feature native plants; possibly in northern section of the Garden – This will result in a change in tree cover and at least for a time

increased runoff due to disturbed site and plants in the process of establishing themselves. Also, higher water use to establish plants.

Neill Weatherly
Tuesday 7 February 2012
Informal Interview:

There have always been the two pools. The upper pool was not recirculating for a long time, and used to have a trickle down towards Lumpkin. It didn't run all the time but they would turn it on from time to time to help keep it clean. The groundcovers around were more suited for where the water ran over.

They may have old sprayers that could be put on a spike in the ground, but not sure. They didn't have anything fancy up until recently. Before plastic pipe irrigation was a lot more expensive and difficult to manage.

The droughts in the last 5 years seem worse than what has happened before, and it has taken a toll on campus trees. Even in the garden a lot of canopy has been lost which has changed the structure and look of the garden. Sun/Shade patterns have changed and a lot of places where grass used to grow it no longer can or a lot of shade plants have struggled with more sun exposure.

A lot of original plant material was more common further north. The people who worked with Owens were from Virginia and Pennsylvania and brought a lot of plants down that worked ok at the time. With the rise in temperatures of late and drier seasons there are now a lot of plants from the coastal plain and places that the plants couldn't grow here before (i.e. Southern Indian Azaleas, G.G. Gerbing and George Tabor).

David Nichols
Monday 6 Feb 2012
Interview Questions:

- What is the succession of directors in FMG?

Answer: Bob Hill, Allan Stovall, and David Nichols

- With the move to the Visual Arts Building, how do you think it will affect the use of the Garden?

Answer: Realistically, probably not much change in the management. May be that it gets used less for events and receptions, like the ones in the Owens Library, or when there is a talk in the MLC. It makes sense now because people have to walk up the hill anyway, but when they are on the other side it probably won't happen.

- With the development of the Northwest Precinct, how do you think it will affect the use of the garden?

Answer: Actually, there was concern for a few years that there would be less people coming to the garden. It used to be parking lots over where the Special Collections Library is so when they put that in it actually decreased the number of people in the garden.

- When, if at all, would expect work to be done changing the 'bamboo walk' area to make that path more internal to the Garden and the road above a pedestrian mall?

Answer: The car access will never completely be abandoned because of fire truck and handicap access, also any physical plant access. The bamboo walk may change, but will still have to be accessible.

- What are ways you feel the water management could be improved?

Answer: More capture of stormwater. Only backside of the house is currently being captured. Larger cistern, or underground cisterns could be added.

- I have heard that the board of directors is coming along, and that more participation is being sought from the Garden Club. Do you see this happening and that it will be a positive direction for the Garden?

Answer: With the 75th anniversary coming up and the drive to raise funds for the endowment along with Marianne Cramer's Landscape Management class and James Cothran's Historic Landscapes class the Garden has been getting more attention lately. The drawing contest is also helpful. More people are taking interest in the Garden. In the past, the goal was more to keep the garden going and not really improve or even actively manage it. The past curator could not do too much before Maureen took over due to physical limitations and the main focus was on keeping things from deteriorating.

- As to your knowledge and involvement, what was done in past drought?

Answer: In the more distant past the regulations may not have been followed completely. With so many eyes looking at the garden, and so many landscape architects around, it is difficult to let it go completely. Don't really see much changing of groundcovers and turf grasses. Summer annuals will still probably continue to be used for summer color.

Notes:

- There has been talk, but it's not likely, to replace the driveway with porous material. There are even porous asphalts, but they don't tend to do so well in the south.
- There has been talk about replacing the boxwoods in the garden with dwarf yaupon holly, which use less water and are more suited to the soils and climate.

Interview Questions

Dexter Adams

- How do you feel the FMG does with water usage? How does it compare with other similar areas on campus? Are there measures being taken to improve this, or how could it be improved (especially considering budget concerns)?

Answer: For such an intensively planted area the garden uses more water than other places on campus, but it uses it very efficiently with the irrigation system. Since most of it is drip irrigation instead of overhead watering. It is especially more efficient than before the system was installed and it was all done with hoses.

- What is the history of irrigation systems, or other water management systems in the garden that you know of?

Answer: One proposal, that didn't get installed, was to add a well in the garden. It is a low-yield water supply that can fill a cistern and that be used to water the garden. Not a fan of these systems.

- With the move over to old visual arts building how do you think that will affect the use of the Garden? With the development of Northwest Precinct?

Answer: From the Grounds perspective it won't change much, the preservation lab will still be next door and the Lumpkin House still occupied by CED. It may get less use from landscape architecture students, but the Garden will stay the same.

- How does the management change in times of drought? Is there a plan for droughts or some sort of list of priorities?

Answer: The University is a customer of Athens-Clarke County water utility so we comply with the graduated drought guidelines provided by the local utility. Personally, I think the Garden could apply for an exemption from those restrictions. The Armitage trial gardens on south campus have an exception because it is a site where research is being conducted.

- Do you recall any notes, or remember people mentioning, about water conservation, or water use being considered in design of the Garden?

Answer: No, never, in the Garden or in the region. Water was bountiful and cheap so it wasn't considered necessary.

- Are there any new technologies you see on the horizon that could help reduce dependence on outside water on campus, and especially in FMG? Any that the school is looking to incorporate into campus maintenance/planning (i.e. the more automated irrigation system on the recreational fields)?

Answer: The club sports fields have an advanced irrigation system with well, stormwater, and city water access. The well is one of the low-yield 'frac'-type wells. Grounds has been talking with Rain Bird and Calsense about master control systems.

- How does the cost of making changes/improvements factor into the decision making process? Is it common that it is often cheaper, and therefore hard to get approval, for better technologies that could save water and be more sustainable?

Answer: There is a payback on that [the master control system] with better control and sensing. And instead of having to tell 7 crew leaders what settings to use and how to adjust the irrigation just one person can manage it [with precision].

- In your personal opinion what sort of changes do you see as appropriate to make the garden more sustainable and a better source of current education curriculum while still maintaining appropriate respect for the historic nature of the garden? (Examples – Rainwater collection off of all buildings, substituting most water intensive plants with less water intensive plants, Underground cistern under the limestone skirt or with engineered turf)

Answer: Restricted since it is a traditional garden. A lot can be done, and has, we completely renovated the irrigation system. The cistern helps, but isn't sufficient.

When it comes to the limestone skirt, money is the main problem. Who is going to pay to remove it, and a goat path can still form from pedestrian traffic with the engineered turf.

Overland collection can work fine. It requires better filtering than rainwater but is done in several places around campus.