FEASIBILITY OF RAINWATER HARVESTING

IN NORTH GEORGIA'S HUMID CLIMATE

by

LINDA HENNEMAN

(Under the Direction of Bruce K. Ferguson)

ABSTRACT

With the growing implementation of active rainwater harvesting systems in large scale building projects in the southeast, the question of what value these systems provide in a humid climate is raised. A water budget model has been developed to provide an analysis of water supply and demand for a sample design site located in northern Georgia. Using historical precipitation and potential evapotranspiration data for two years (a wet year and a dry year), along with the catchment area, irrigation area and soil type of the design site, the value provided by an active rainwater harvesting system with cistern storage in the temperate southeast can be evaluated. The model generated, in the form of spreadsheets and charts, demonstrates the limits of the physical feasibility of such a system and can guide the design process toward practical choices.

INDEX WORDS: cistern, rainwater harvesting, storm runoff, potential evapotranspiration, landscape coefficient

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To Eliza and Margo

May you always enjoy singing and dancing in the rain

and to Mitch

May you always make'em laugh

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CHAPTER 1

INTRODUCTION

Purpose

Within the past ten years, there has been growing interest in the use of cisterns for storage of harvested rainwater for irrigation in the southeastern United States. This trend is particularly noticeable in recent construction projects on college campuses.

The use of cisterns--tanks for storing rainwater--has ancient precedents across the globe. Their use was once a traditional practice in the United States; for example, around 1900, homes were often built with integrated water harvesting systems, which included a cistern provided in the basement. (Thompson and Sorvig). More recently, rainwater harvesting--the collection of rainwater for reuse from roofs and the landscape--has proven its worth in arid regions of this country (eg. Arizona, Texas). However, its rise in popularity in the temperate Southeast, where rainfall can be plentiful, leaves questions for its application in humid climates. Environmental responsibility in water conservation is the apparent impetus for incorporating cisterns to supply landscape irrigation, however research based on regional weather data to support this practice in humid climates seems lacking.

This thesis attempts to make a contribution toward answering the question whether cisterns are, in fact, physically feasible in the humid climate of northern Georgia. Through the use of water budget modeling on a sample design site, rainwater storage in cisterns for use in landscape irrigation systems will be studied to determine the water conservation advantages. More specifically, this thesis attempts to answer the questions, to what degree can rainwater harvesting supply irrigation water in Georgia, and what design factors can be manipulated to make it optimally feasible on a specific site.

Timeliness

There appears to be a collective assumption that there are environmental benefits to be gained, not only in arid environments of the southwest, for example, but in the humid climate of the southeast, through the practice of harvesting and storing rainwater for future use. As academic institutions have proven to be fertile ground for the advancement of environmental responsibility in building construction, some southeastern university campuses are among those who have incorporated cisterns in recent construction projects. Examples can be found at the University of North Carolina - Chapel Hill, the University of Florida in Gainesville, the University of Georgia in Athens and Emory University in Atlanta, to name a few. In research for the current study, no sources of data collection being done to determine the benefits of the installed water harvesting systems were found at these institutions.

The current interest in cistern installation in the southeast may be the result of the following four factors:

1) Drought: Consecutive droughts in the years 1986-88, when maximum rainfall in Athens did not exceed 36” in any one year, created a severe enough water shortage to catch people’s attention. The Atlanta-Athens corridor has since become familiar with watering restrictions being imposed in summer months.

2) Government regulations to reduce storm runoff: The threat to the water supply from polluted and excessive runoff has been a great concern to local governments. As a result, new ordinances are now requiring management practices, which were formerly optional.

3) Growing interest in water conservation: Large institutions are looking to the future, seeing the costs associated with implementing what is required by ordinance and finding assets in conserving available natural resources, such as rainfall.

4) Growing environmental awareness: Concurrently, the concepts of 'sustainability' and 'green' construction are becoming mainstream ideas for environmentally responsible communities. In the construction industry, the U.S. Green Building Council's LEED (Leadership in Energy and Environmental Design) Building Rating System, launched in December 1998 (U.S. Green Building Council), has served as the spearhead, and now the benchmark, for environmentally responsible construction practices.

This thesis responds to these factors by exploring the degree to which rainwater harvesting can, in fact, contribute to water conservation and supply.

Thesis Approach

Examples of questions which can be raised regarding cistern use in the humid climate of the Southeast are: 1) Is rainfall plentiful enough that no additional irrigation is required? 2) When is it practical to make a water harvesting system 'active' by adding a cistern? How much storage is needed? 3) If irrigation is required only for plant establishment, does it make sense to install cisterns for the long term? 4) Must planting designs be adjusted to accommodate available quantities of harvested water? 5) Should cisterns serve the dual purpose of irrigation and stormwater detention? 6) For a given irrigated landscape planting area, what is the optimal catchment area to achieve valuable water conservation?

In an effort to shed light on these questions, Chapter 2, Water Harvesting Functions and Components, begins by briefly describing rainwater harvesting in the context of basic site hydrology. A general overview of the concepts and components of rainwater harvesting systems is presented, with an explanation of passive and active systems.

Chapter 3, Case Studies, presents three case studies of existing active rainwater harvesting systems in northern Georgia, all on university campuses. The Whitehead Biomedical Research Facility and the Math and Science Center are on the campus of Emory University in Atlanta, Georgia. The Paul G. Coverdell Center for Biomedical and Health Sciences is at the University of Georgia in Athens. All three have underground cisterns which supply irrigation systems with harvested roof runoff.

This thesis' question of physical feasibility will be approached through a water budget model which will be thoroughly described in Chapter 4, Method of Modeling Study. Two spreadsheets have been created for the model. The first determines an 'Irrigation Requirement' for a given planting area. The second spreadsheet models potential 'Irrigation Water Supply' from a given roof catchment area. The spreadsheets are applied using historical daily rainfall and evapotranspiration data for a dry year (2000) and a wet year (2003). Samples of the spreadsheets' applications are included in the Appendix (see Appendices A through D).

Chapter 5, Results, summarizes the information generated by this modeling study and illustrates it with the use of charts.   Types of information provided include total irrigation requirement for each year with varying landscape coefficients, total harvested water supplied for each year with varying catchment areas and cistern sizes.

Chapter 6, Conclusions, reviews ways these results might be used to inform future decisions regarding the implementation of active rainwater harvesting systems in the humid climate of northern Georgia.

CHAPTER 2

WATER HARVESTING FUNCTIONS AND COMPONENTS

Site Hydrology

Water harvesting operates in the context of, and modifies, site hydrology -- the flows and storages of water in the environment. The essential input of this hydrological process is precipitation, in the form of rain or melted snow. “Precipitation is the inflow that brings to life a landscape’s hydrologic resources” (Echols). Its quantity and intensity can vary widely from year to year. Varying toward extremes in either direction can bring dire hazards of flooding or drought. However, “the vast majority of [precipitation] events are small; over most time periods the small, numerous, frequent events support ecological resources and water supplies, and characterize the landscape’s water quality.”(Echols)

When precipitation occurs, depending on soil and ground cover characteristics, some of the water infiltrates the soil and some will runoff the surface. The infiltrated soil moisture provides necessary water for plant life. When the soil becomes saturated, excess moisture continues down to where it recharges ground water, which is then gradually discharged into streams. (Echols)

Stuart Echols, in his section on “Stormwater Hydrology” in Landscape Architecture Graphic Standards, aptly summarized the importance of these flows and storages in landscape hydrology:

> “Every step in landscape hydrology is a resource. Surface runoff can be harvested for on-site use. Evapotranspiration empowers the health and growth of trees, plants and ecosystems, and is a dominant component in a landscape’s energy balance. Varying soil-moisture governs irrigation water requirements and guides potential water conservation. Ground water recharge replenishes municipal water-supply wells. Base flow supplies the basic resource of aquatic ecosystems and downstream water supplies. Together rainfall,

runoff, infiltration and evapotranspiration define the natural character and maintain the ecological functions of a site." (Echols)

Water Budget

A water balance analysis is an inventory of the hydrology of a site, establishing volumes and rates of flow. It models the natural processes of water, in all its forms, in the environment over an extended period of time.

To use runoff as a water supply requires a studied integration of site layout, contouring, planting, and drainage (B. K. Ferguson). The results of hydrologic calculations can provide valuable parameters within which to design. Allowing design to be guided by a few quantitative criteria derived from mathematically modeling site information, can substantially increase the environmental benefits of the design, while not limiting diverse options in contouring, plantings and materials.

This thesis does not attempt the scope of a water balance study, but rather that of a water budget. A water budget can provide a supply and demand analysis for a given inflow and projected outflow requirement, showing whether there is a need for supplemental water. A water budget model will be used in this thesis to determine the advantage of an active rainwater harvesting system in northern Georgia.

Overview of Water Harvesting

Collection and beneficial use of rainwater is the primary goal of rainwater harvesting. Recent governmental ordinances requiring reduction of the volume of stormwater discharge from a site have provided additional incentives for the inclusion of rainwater harvesting systems in building projects. Captured rainwater can be put to a wide range of uses, depending upon the immediate need of the site. Agricultural irrigation and residential potable water are the most common uses (Kinkade-Levario Forgotten Rain: Rediscovering Rainwater Harvesting); other uses include landscape irrigation, washing cars, and flushing toilets. Some less obvious environmental benefits of rainwater harvesting are:

- It provides a self-sufficient water supply located close to the user.
- It reduces the need for and hence the cost of pumping groundwater.
- It recharges shallow groundwater supplies.
- It provides high-quality soft water that is low in mineral content.
- It mitigates urban flooding; thereby, reducing erosion caused by flooding.

(Kinkade-Levario et al.)

All rainwater harvesting systems provide the advantages of conserving water, reducing runoff, and, potentially, alleviating drought conditions.

The technical components of a rainwater harvesting system, no matter what the scale of the installation, can consist of up to six components:

1. Catchment: the surface area where rain falls
2. Conveyance: channels or pipes to collect and carry catchment runoff
3. Initial filtration: filtering out catchment debris and pollutants
4. Storage: cisterns that store collected rainwater for use
5. Distribution: system of delivery of rainwater to its use, either by gravity or pump
6. Purification: water treatment systems

(Kinkade-Levario "Rainwater Harvesting"; Winterbottom)

Roofs provide the most common and easiest catchment areas for harvesting rainwater (Kinkade-Levario Forgotten Rain: Rediscovering Rainwater Harvesting). Surface runoff from paved and unpaved areas can also be captured for reuse but "greater contamination by oils, salts, and particulates requires increased filtration"(Winterbottom). When designing a roof as a catchment area, the choice of roofing material in relation to intended water use is important.

Some issues to consider include: organic or porous roofing materials (wood, clay) which encourage mold and algae growth, rough textured materials (asphalt shingles) which hold dry pollutants (eg. bird feces), leachate potential of metal finishes or chemically treated materials (eg. lead flashing or solders should not be used if edible plants are to be irrigated). Winterbottom recommends stainless steel or galvanized steel with a baked-on enamel, lead-free finish as the best roofing materials for rainwater catchments where water quality is critical. For potable water harvesting, Kincade-Levario recommends a three-part roof coating product called "Raincoat 2000" which has been approved by the National Sanitation Foundation. (Kinkade-Levario Forgotten Rain: Rediscovering Rainwater Harvesting)

When considering a cistern in a rainwater harvesting system, three integral issues must be considered: size, cost and location. Size is a critical element because it determines the maximum potential amount of water that will be available for use through a dry spell. Cost most often limits size. Cisterns can be located underground, above ground, partially underground, or integrated into a building. Required size and location will influence material choices, which can include steel, concrete, plastic, polyethylene, fiberglass or masonry. Large, underground cisterns in commercial and institutional settings tend to be pre-cast concrete. Whether above ground or below, cisterns must have a light-tight cover to prevent evaporation, algae growth, mosquito breeding and animal intrusion.

Passive and Active Rainwater Harvesting

Rainwater harvesting systems fall into two categories: passive and active. In a passive system, stormwater is diverted, usually via site drainage and grading techniques, for immediate use in landscape irrigation. Passive rainwater harvesting involves contouring the site to divert stormwater runoff to areas requiring irrigation or areas specifically designed for infiltration.

Although passive systems, by definition, do not include storage devices (cisterns), the site's soil can serve as "a stormwater storage reservoir, where the water is available for the landscape's natural evapotranspiration" (Kinkade-Levario "Rainwater Harvesting") and ground water recharge.

In an active system, the diverted water is collected in a storage device for future use. When considering employing an active rainwater harvesting system, the site conditions, its climate and historical rainfall, as well as the intended water use, must be weighed in determining the type and size of system to design. In some cases, such as rural areas where supplemental water supply is unavailable, a harvesting system may be the primary source of water requiring a large catchment area and a large storage capacity. More often, as in the case studies referenced in this paper, it is expected that a harvesting system will provide an intermittent or occasional water supply to carry on irrigation through a dry spell, for example. However, before these decisions can be made, the likely quantity of water that may be available must be projected in relation to the quantity needed. This thesis provides a model for informing the design of an active rainwater harvesting system by estimating potential water supply and its use.

CHAPTER 3

CASE STUDIES

Case studies of recent water harvesting projects on Southeastern campuses illustrate the contemporary interest in water harvesting and the ways water harvesting is being integrated into building and site designs.

Whitehead Biomedical Research Facility, Emory University

Figure 3.1. Whitehead Biomedical Research Facility, Emory University, Atlanta, Georgia

For many in campus planning, the Whitehead Building at Emory University, completed in 2001 and awarded a ‘LEED Silver Rating’, provided a primer to ‘LEED certification’-inspired sustainable design.

This eight-story, 325,000 square foot, poured-in-place concrete structure was three stories out of the ground before the decision to attempt LEED certification was aired. Feeling that the time had come to pursue sustainability, Emory’s Director of Campus Planning, Jen Fabrick, and Director of Project Management and Construction, John Fields, took the proposal that Emory pursue LEED Certification for all future projects, including the Whitehead Building currently under construction, to Sr. Assoc. Vice President for Facilities Management, Robert Hascall; he, in turn, sought buy-in from Emory’s Board of Trustees. They approved the concept with the condition that the project remain within the current budget.

When the design team considered the possibility and studied the LEED requirements, they realized they were more than half way to acquiring certification. They had environmentally responsibly designed a building for an urban campus site. The building orientation and plan take advantage of natural daylighting. Energy is conserved with the use of heat recovery wheels and automated high-efficiency cage washers which recycle hot water, to name just a few of the building’s assets.

Figure 3.2. Plaza at Main Entry to Whitehead Building, Emory University

The project design already included a stormwater detention cistern: a custom, poured-in-place, box culvert-type tank which would lie below the paved plaza at the building's entry. This tank was designed to meet the requirements of DeKalb County to slow the release of storm water into Peavine Creek. It would collect roof water and surface runoff from the hardscaped plaza at the main entrance to the building. The underground tank had a unique shape due to the tight, urban building site constraints; adequate volume could not be achieved with a simple rectangular tank. In order to achieve the required detention volume, it was necessary to capture the area between the building's column footings to increase the tank size, thus the unique 'crenelated' plan of the tank (see Figure 3.3). The design team realized that by deepening the tank three feet, it could also be used to reclaim water for use as irrigation for site landscaping.

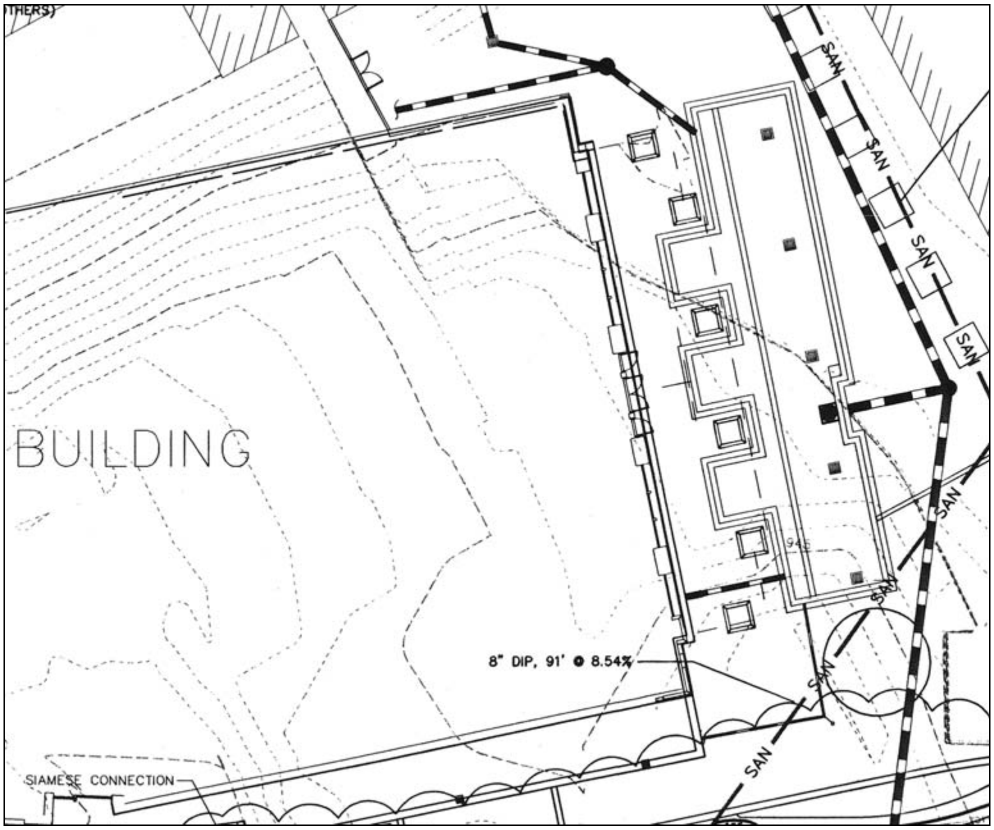

Figure 3.3. Drawing of 'crenelated' plan of cistern at Whitehead Building, Emory University (HOK Architects)

Convincing DeKalb County Public Works of the value and credibility of the idea to store and use stormwater was the next hurdle in the process. In the year 2000, this was a unique proposal that had not come up before on a county level and the public utility was concerned and skeptical, fearing water contamination could occur. The design team (which included both Emory University employees and their design consultants) argued that by adding retention storage area to the tank, less water would have to be sent into Peavine Creek. As previously mentioned, the tank was already receiving site and roof runoff.

Although resizing the cistern after building construction was well underway, the only additional cost to the project, since construction of the tank itself had not yet begun, was the cost of the reinforcement steel required. The re-bar for the smaller tank had already been purchased; the contractor then had to reorder longer steel to accommodate the new vertical dimension of the tank.

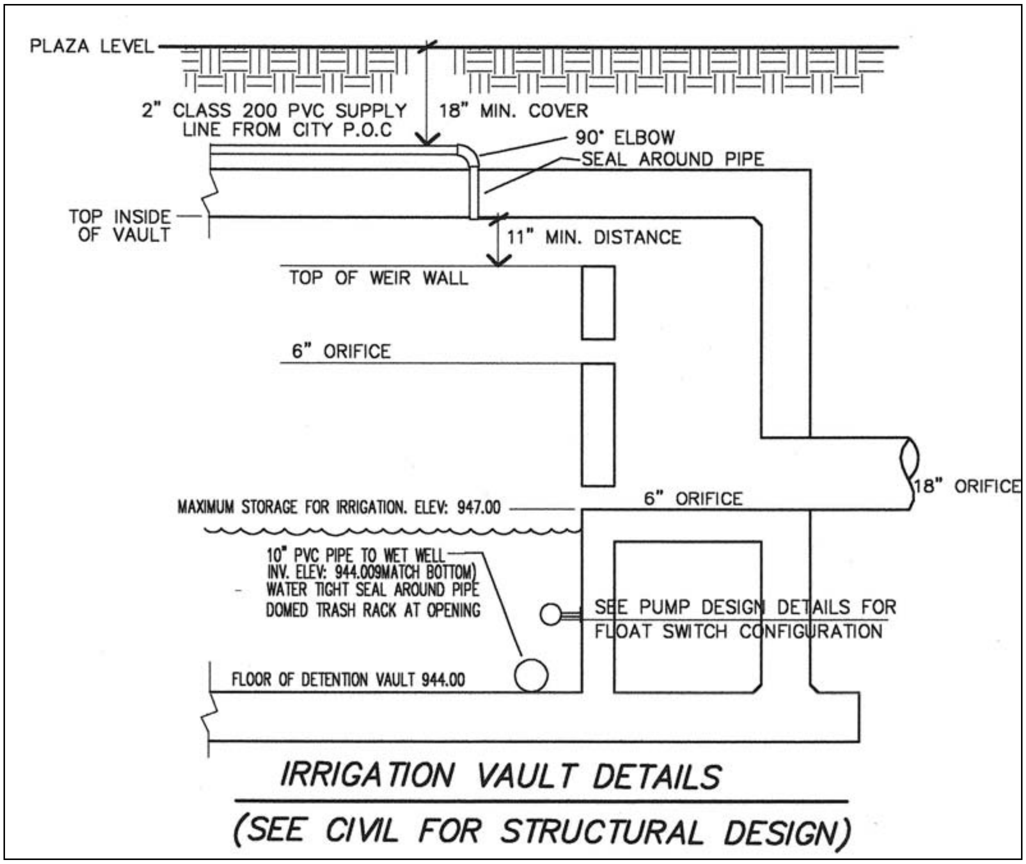

Figure 3.4. Partial Section through cistern at Whitehead Building, Emory University (HOK Architects)

Looking at the transverse section through the cistern (see Figure 3.4*)*, the retention basin at the lowest level of the tank sits below the invert elevation of the 18” diameter storm sewer outlet. Retained water is gravity fed through 10” PVC (domed ‘trash rack’ filter at opening) at the bottom of the retention basin to a wet well (8'x8' masonry enclosure for pump) where it is then pumped throughout the irrigation system.

All water in the tank above the level of the retention volume, flows through 6" orifices, slowing the flow, to the 18" storm sewer outlet, then to a main storm drainage line which empties into Peavine Creek. A 'weir' wall with an 11" minimum distance to top of tank prevents any chance of back flow contamination. Since this tank provides all irrigation water for the site, city water supply is piped directly into the tank, to be used when needed, as may be necessary during a drought.

The Whitehead Biomedical Research Facility was awarded the LEED Silver rating and initiated Emory University's sustainability efforts in all renovation and construction projects. Although the rainwater harvesting and irrigation systems are functioning, monitoring the system to collect data regarding amount of rainwater harvested or amount of make-up water required each year has not been done.

Math and Science Center, Emory University

Emory Math and Science Center, which houses the Departments of Mathematics, Physics and Environmental Studies, was in its programming phase in 1999 when Emory's Whitehead building was put on track towards LEED certification. The project was at that time called the "Science 2000" project. An excerpt from the Executive Summary of the Facilities Program document, completed in 1999, states the following:

The primary program objectives of the Science 2000 project are:

…To design the project with leadership in environmental responsibility using the US Green Building Council's LEED rating system.

This statement left the question of actual submission for LEED certification open-ended. Emory was moving toward making LEED certification mandatory for all new campus projects. It was during the Design Development phase of the Math and Science project that the architect, Cooper Carry, was directed to achieve LEED certification and was contracted for additional services to address the additional design requirements to meet Emory's environmental goals. The engineering firm of CH2MHill, was hired to manage the LEED application process.

Figure 3.5. Math and Science Center, Emory University, Atlanta, Georgia

As in the Whitehead project, Dekalb County's stormwater detention requirement had to be met. The Math and Science site was described by the civil engineer as being "short on land", so an underground detention tank-cistern was the obvious solution. Additional storage volume in the cistern for irrigation use was optional as far as DeKalb County was concerned, but not from the point of view of Emory's planners who were focused on making the home of their Environmental Studies Department an exemplary model of sustainable practices.

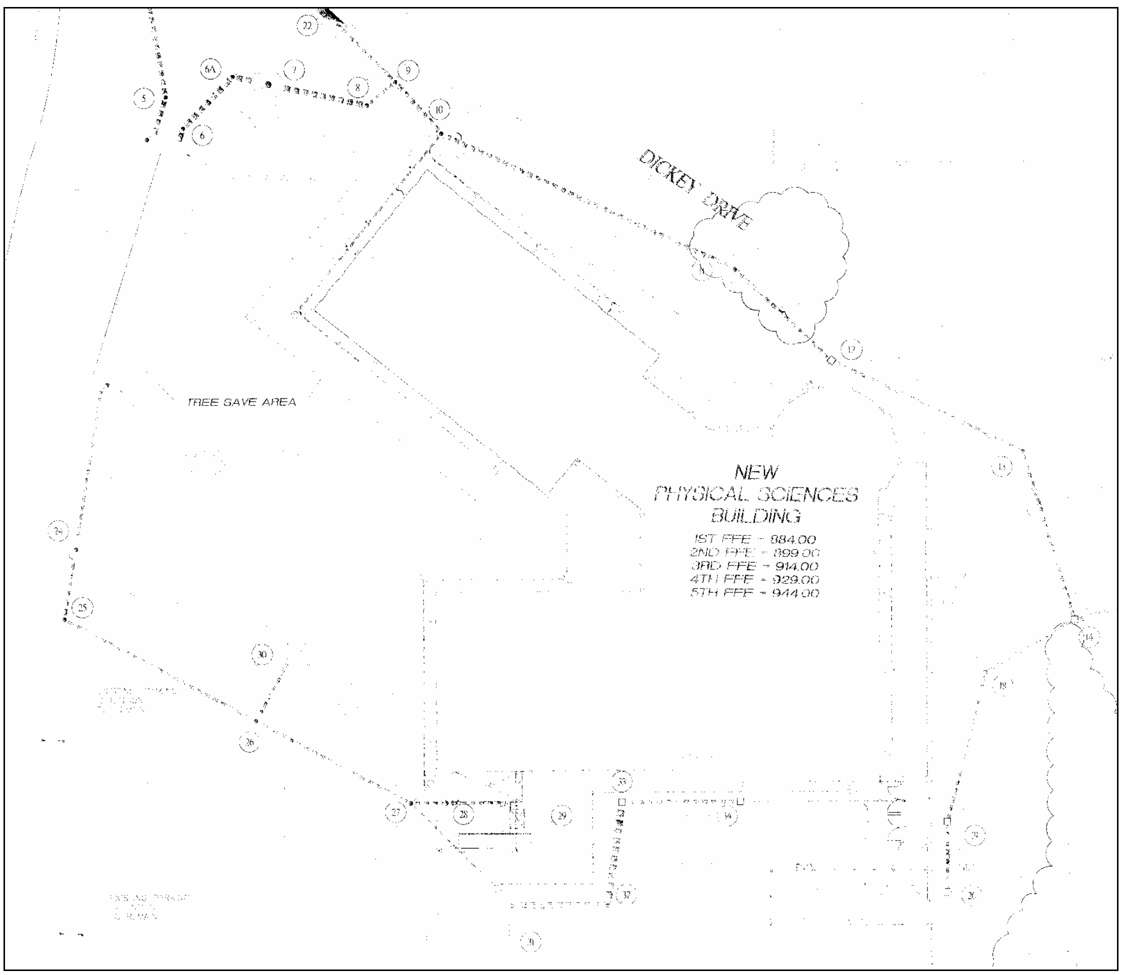

Figure 3.6. Plan showing cistern location, Math and Science Center, Emory University (Cooper Carry Architects)

As with the Whitehead project, it was assumed that harvested rainwater from both rooftop and surface runoff could be captured for use for on-site irrigation. With two distinct watersheds on the site, all site and roof drainage is being captured. The surface runoff is collected through curb inlets, catch basins and trench drains.

With specific LEED criteria in mind, the project's irrigation consultant, Fred Hall, who was then with Hydro-Environmental, Inc., calculated several scenarios to illustrate the concept of "Water Efficient Landscape Irrigation" to the users. This presentation, which is included here in Appendix E, illustrates one process used to determine the amount of irrigation water required for a particular site. Water use calculations were based on LEED Guidelines in collaboration with the U.S. Green Building Council; watershed calculations were based on the rational method which is considered standard practice. The goal was to establish minimum capacity required to not have an empty tank. Numerous scenarios of various types and quantities of plant materials which could be used on the site were projected by employing the landscape coefficient formula (University of California Cooperative Extension). Taking into account rainfall and evapotranspiration data, an estimation of the amount of irrigation required for the specific site was calculated. This quantity was then used in determining the size of the cistern, in combination with the required stormwater detention volume.

At the time the Math & Science Center was being designed, Dekalb County did not yet have water quality requirements for stormwater, however, reducing pollutants (average annual post development total phosphorous and total suspended solids) was encouraged by the LEED rating system. A manufactured product called "Stormceptor" (trademark) fit this requirement. The "Stormceptor" unit, a product of Hydro Conduit which is a division of Rinker Materials Corporation, is a pre-cast concrete device with a patented fiberglass insert for treatment of stormwater runoff. The "Stormceptor" slows down the flow so solids will settle on the bottom. It also skims oil off the top. "In-line 'Stormceptors'" (one at 14'-0" diameter and one at 7'-0" diameter) were installed at the base of the storm pipe system at each of the two watersheds on this site, to treat the water prior to reaching the cistern, for removal of pollutants and sediment.

Figure 3.7. Location of underground cistern at Math and Science Center, Emory University

The cistern is made of twin box culverts, side by side with holes in their adjacent sides so that they can share water volume and work as a unit. The bottom 4' is supposed to be the constant water level, except in drought. This cistern has no source of make-up water. Current employees at Emory's Facilites Management office believed the lack of make-up supply to have been the result of unfortunate value engineering but Cooper Carry's Bob Just, who was Project Architect, said that the institution chose to take the option that purported complete self-sufficiency. Two LEED points would be granted for the cistern if it handled only completely non-potable water; whereas only one point would have been granted if city water was piped to

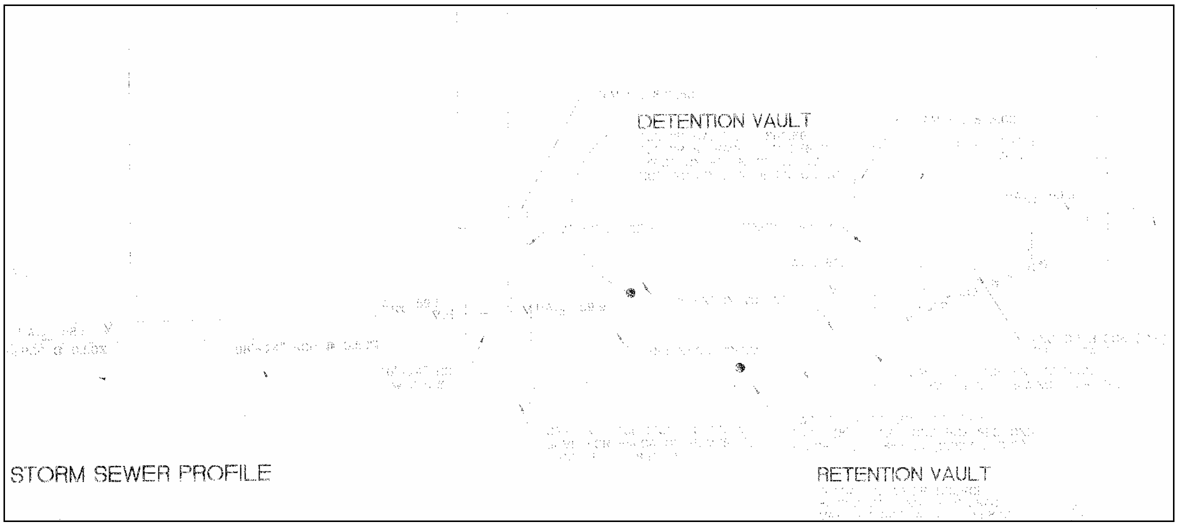

Figure 3.8. Storm Sewer Profile showing section through cistern at Math and Science Building (Cooper Carry Architects)

the cistern. Bob said it was also discussed to put a spigot in the general vicinity, so the vault could be recharged with a hose in an emergency, but the owner's representatives felt that is was not in the spirit of LEED to do so and it was not done. A representative from Emory's facilities planning office said there has been no problem with not having enough water in the cistern, though this has not been monitored mechanically.

Emory University's 153,000 square foot Math and Science Center is a LEED Certified facility.

Paul G. Coverdell Center for Biomedical and Health Sciences, The University of Georgia

On the main campus of the University of Georgia in Athens, the idea of including cisterns in new construction projects occurred during the construction of the Student Learning Center which was completed in 2003. When post-construction funds were available for adjacent site design, schematic plans for a cistern to harvest rainwater for landscape irrigation were seriously considered, but ultimately rejected due to impracticalities that would not have been an issue if the cistern had been considered in a pre-construction phase. The UGA Office of University Architects continued to look for opportunities to use rainwater harvesting technology.

Figure 3.9. Paul G. Coverdell Center for Biomedical and Health Sciences, The University of Georgia (Photo by Aaron Britton)

The Paul G. Coverdell Center for Biomedical and Health Sciences provided a valuable opportunity due to an existing on-site water source. The site chosen for the Coverdell Building had been a parking lot for many years. A stream, known as 'Stinky Creek', flowed in a large culvert beneath the parking lot and had long been forgotten by most. The new building would be built over the culverted stream, but the presence of the water on the site clearly needed to be managed and, at best, acknowledged as an asset.

The presence of the stream on the site with the associated ground water was the driving force behind the inclusion of a cistern in this new building project. The inexpensive solution for dealing with ground water on the building foundation would have been a pump in the basement to pump ground water into either the storm sewer or the sanitary sewer. However, since this was a situation where the University architects clearly could not daylight and restore the stream, they felt good environmental stewardship would be served by acknowledging the natural source of water and treating it as an asset rather than a problem. A cistern for water storage and use could serve the dual purpose of water conservation and controlling excess water on the building foundation. Due to budget constraints, there are a limited number of special options that can be kept in a project, however, the water harvesting system with cistern was held onto as an important aspect by the design team of HOK Architects and Whiting Turner Construction working closely with the UGA Office of University Architects.

As the building design developed with the restrooms stacked, it was clear that only a small amount of dedicated piping would be required to provide an alternate water source for toilet flushing. (If restrooms had been distributed in a variety of locations, this option would have been too costly.) With an onsite water source to be tapped, along with the necessity of keeping water from the foundations, a water collection system was designed to serve three distinct uses: 1) to provide make-up water for the cooling tower, 2) to provide water for toilets and urinals and 3) to provide water for landscape irrigation system The design team's thorough understanding of the cost of what was required to construct a system like the one being proposed proved crucial to ultimately keeping the active water harvesting system in the project.

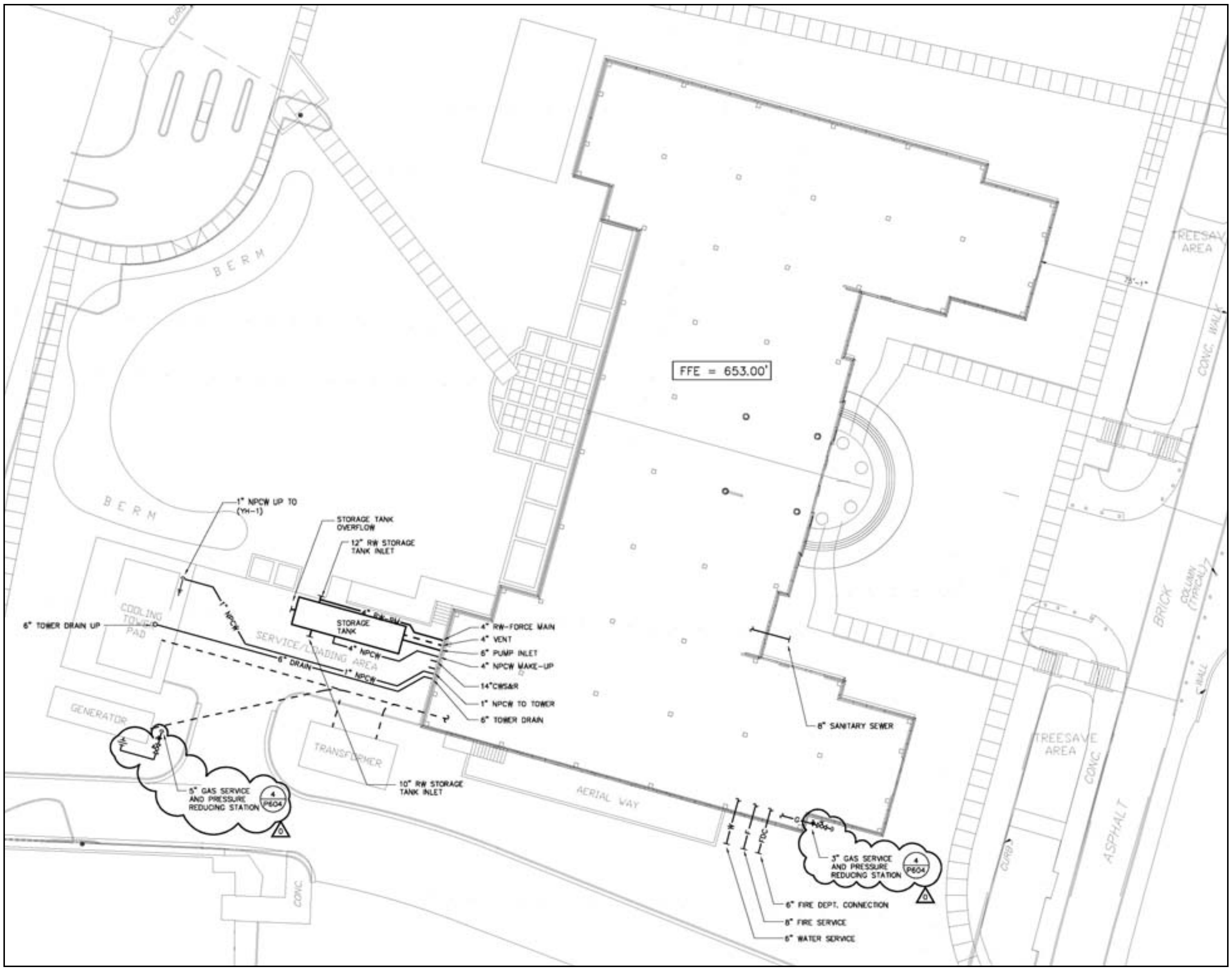

Figure 3.10. Site Plumbing Plan showing cistern location, Coverdell Center, University of Georgia (HOK Architects)

The Coverdell Building Water Collection System incorporates two methods of water collection:

1) Rainwater Collection System: All roof drainage is collected. The system includes all roof drains, gutters, downspouts and underground rainwater collection piping surrounding the perimeter of the building.

2) Groundwater Collection System: includes groundwater collection piping at the foundation level, below basement slab, and an interior lift station.

Figure 3.11. Pre-cast concrete cistern set in place, Coverdell Center, University of Georgia

All 'reclaimed' or harvested water goes to the 20,000 gallon pre-cast concrete "Reclaim Water Storage Tank", or cistern, located underground, beneath the driveway at the loading dock area of the Coverdell Building.

Of the three uses for reclaimed water in this building, the majority of reclaimed water is used by the cooling tower. The quantities currently used for irrigation and flushing of toilets is minimal. The University's facilities planners intend to monitor the water quantities used, but the mechanisms to do so are not yet in place.

CHAPTER 4

METHOD OF MODELING STUDY

The sample design site used for this study was the proposed addition to the Georgia Museum of Art on the campus of The University of Georgia in Athens, Georgia, along with an adjacent landscaped site (See Figures 4.1 – 4.3). The conceptual plan for the proposed addition was conceived by Gluckman Mayner Architects in collaboration with the Georgia Museum of Art and the UGA Office of University Architects. The proposed pitched roof area of the museum addition served as the catchment area for harvesting rainwater and the adjacent landscaped area to the south of the addition served as the irrigation area represented in this study. This chapter introduces the water budget model used to represent an active rainwater harvesting system in a project of this type.

The water budget model developed in this thesis differs from the Hydro-Environmental process (See Appendix E) in several respects, which are believed to be improvements. It uses daily data and calculations which yield more accurate results than monthly data. It uses both dry and wet sample years to reflect the characteristic variability of precipitation. Most significantly, it allows water budget calculation using alternative trial cistern size, catchment area, irrigated area and vegetation type.

Water Budget Model

To begin a water budget model for a rainwater harvesting system, a specific catchment area must be identified and irrigation requirements must be determined based on planting area, planting type and other environmental factors. Then, historical rainfall records are used to quantify potential harvested rainwater from the catchment and its use to fulfill the projected

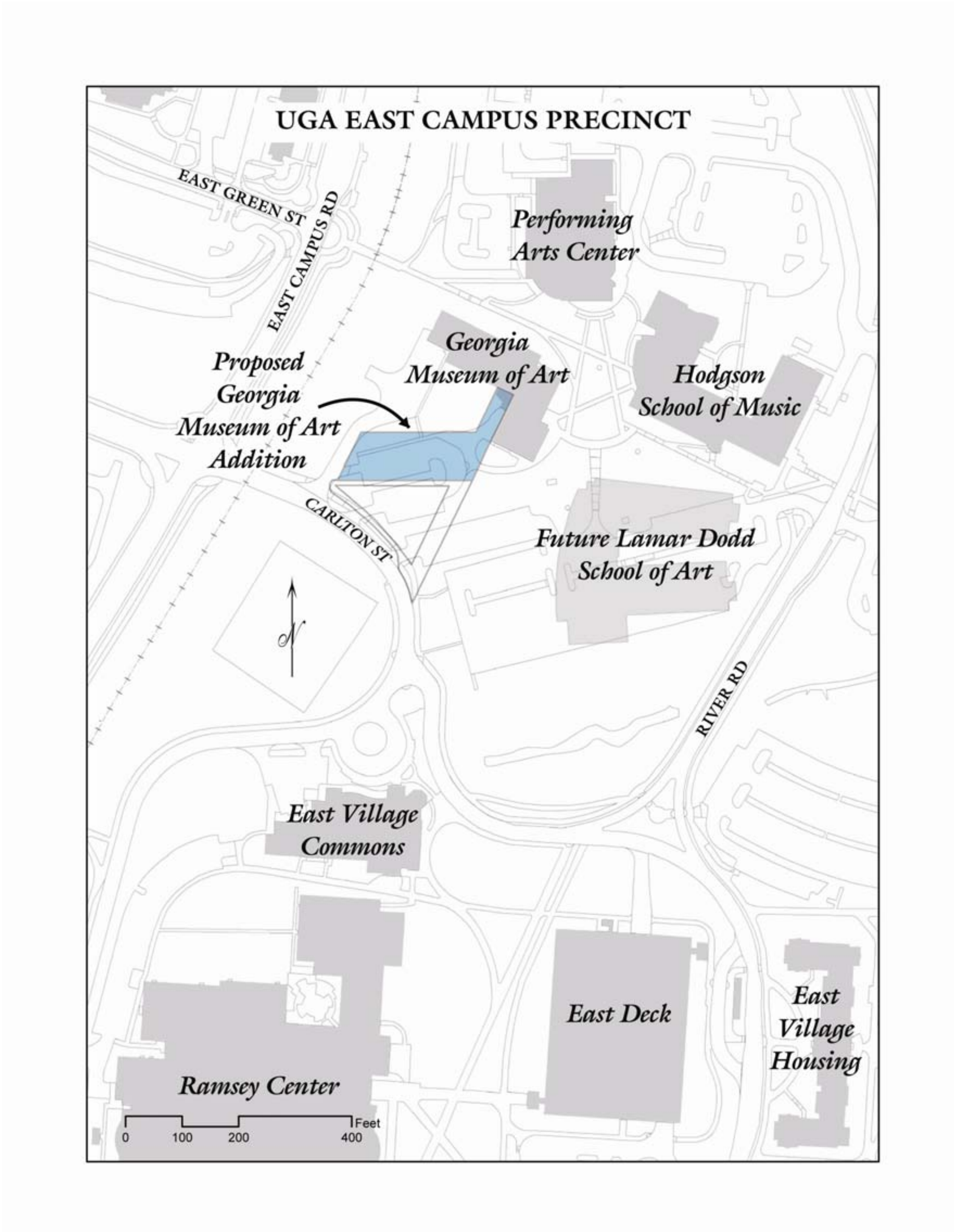

Figure 4.1. Partial Campus Plan showing Proposed Addition to Georgia Museum of Art designed by Gluckman Mayner Architects

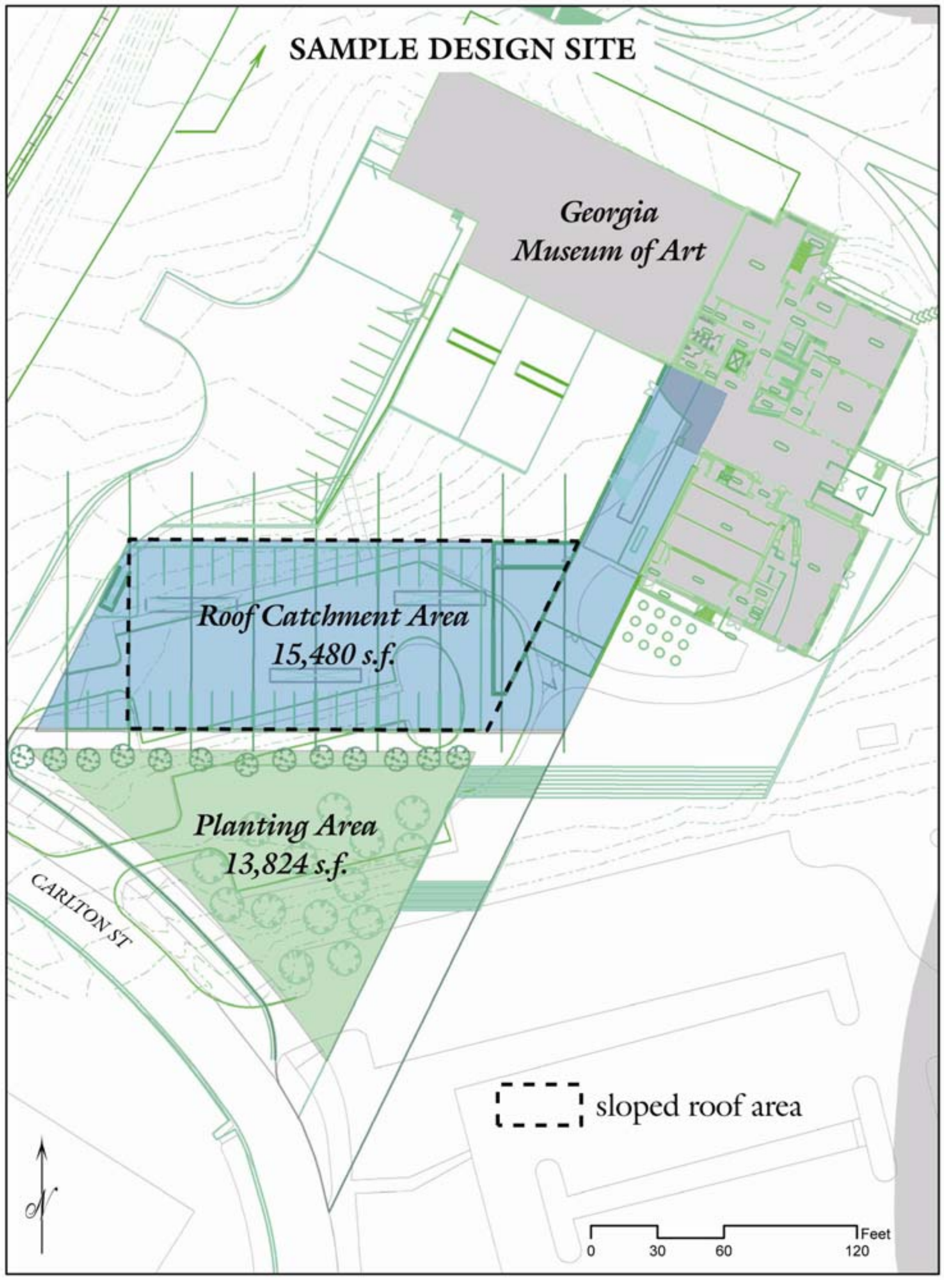

Figure 4.2. Sample Design Site Plan (Base drawing by Gluckman Mayner Architects)

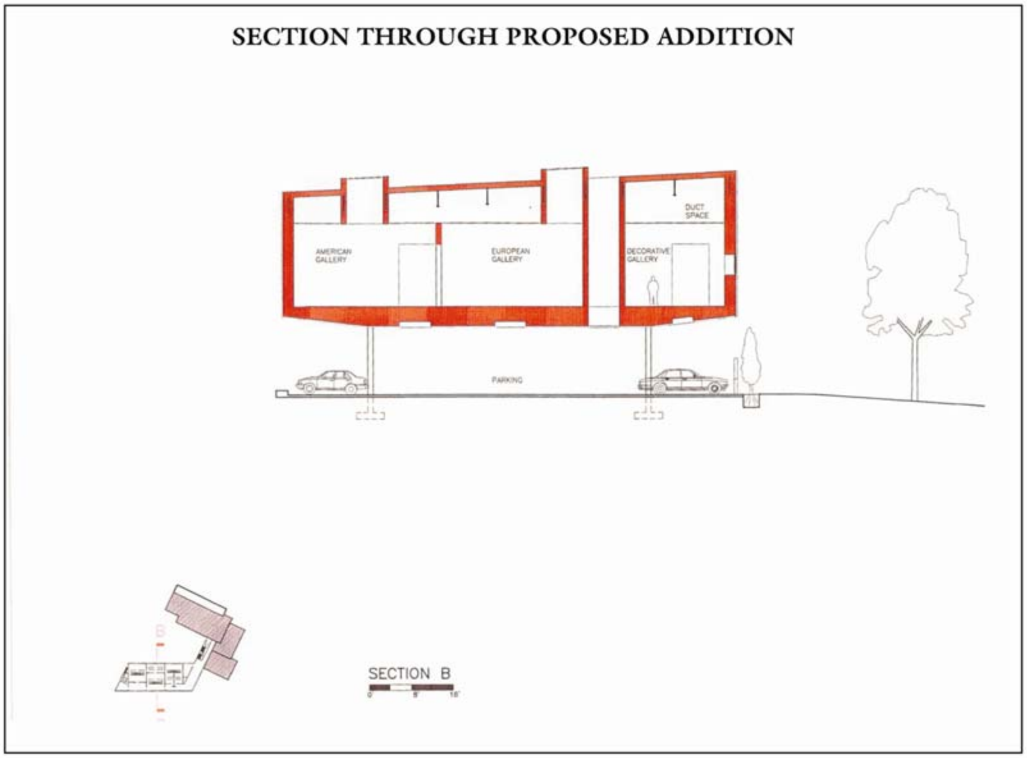

Figure 4.3. Section Through Proposed Addition, showing sloped roof. (Gluckman Mayner Architects)

irrigation requirement. The quantities resulting from the water budget analysis can be a basis for design proposals.

Given the catchment area, irrigation area and soil type of the design site, along with the daily precipitation and evapotranspiration data for two different years, one wet, one dry, a water budget model can illustrate the value provided by a rainwater harvesting system with cistern storage. To evaluate the feasibility of cistern use in the humid climate of northern Georgia, a water budget model has been developed to provide a daily supply and demand analysis based on a specific site.

In modeling on a daily time-step, it is assumed that an irrigation system is installed with very efficient irrigation scheduling, capable of applying the appropriate amount of water each day the water is needed. Such a system would probably include, for example, a soil-moisture sensor or evapotranspiration monitor to determine how much water is needed each day, and a controller determines when irrigation water is needed. (B. Ferguson notes)

Variables within the model can be altered in order to evaluate alternatives and arrive at the most efficient or desirable combination of factors. For example, it is possible to vary catchment area, irrigation area, cistern volume and planting design (by varying the landscape coefficient, K_L).

Daily rainfall data for two different years, one wet, one dry, were chosen for this modeling study. Whereas the average amount of precipitation in the Athens area per year is 49"(Hoogenboom et al.), the year 2000 had significantly lower than average rainfall at a total of 33.77" (dry year), and the year 2003 had higher than average precipitation at 60.9" (wet year). The daily precipitation amounts in these years are shown in Figures 4.4 and 4.5.

The Georgia Automated Environmental Monitoring Network (GAEMN) provided daily precipitation and evapotranspiration data for the years 2000 and 2003 (Hoogenboom et al.), as collected at the UGA Plant Sciences Farm GAEMN monitoring station in Watkinsville, Georgia, which is approximately 10 miles from the design site used in this study.

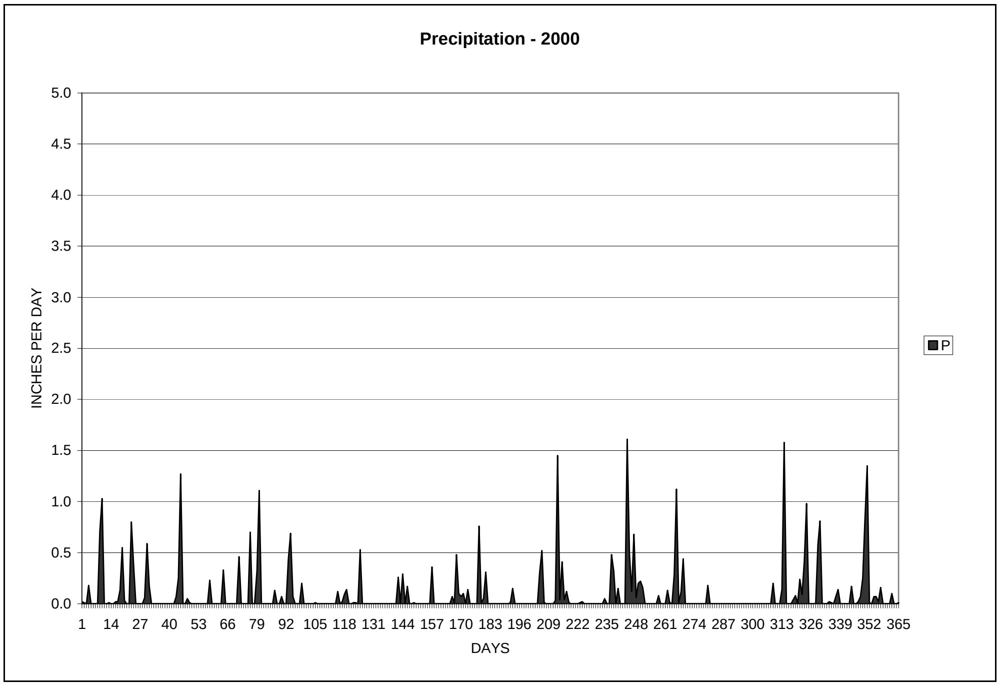

Figure 4.4. Chart of Daily Precipitation for the 'dry' year, 2000.

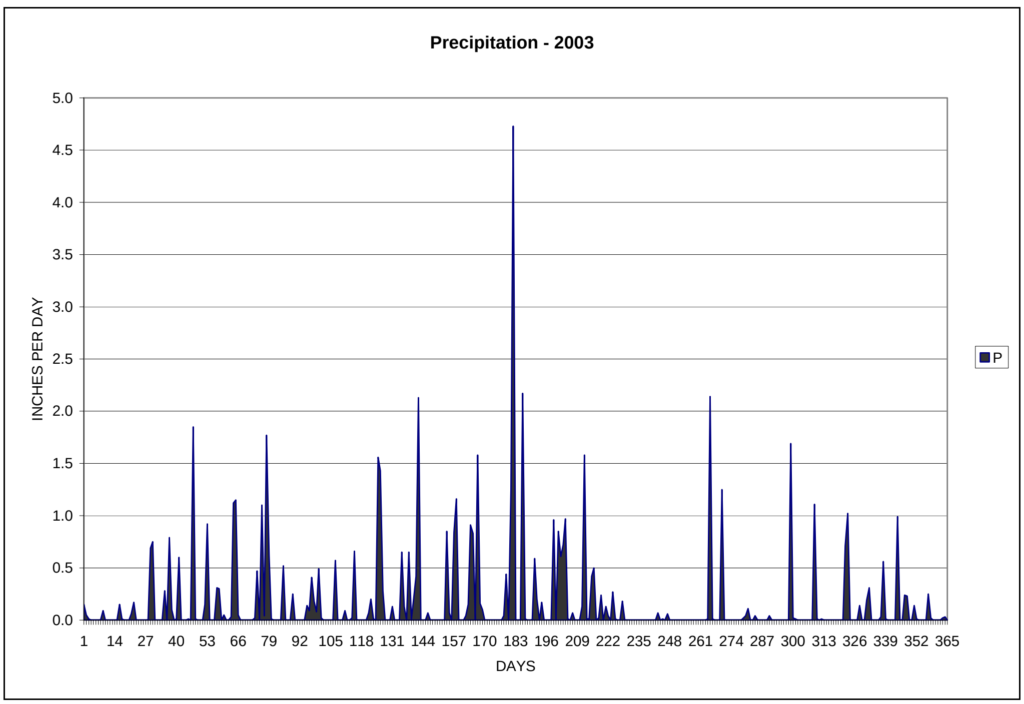

Figure 4.5. Chart of Daily Precipitation for the 'wet' year, 2003.

Two spreadsheet models were created: one to determine the irrigation requirement of the site, and another to track the irrigation supply provided by an active rainwater harvesting system. Table 1 defines the symbols used in the spreadsheets and in the following discussion of them.

Table 1. DEFINITIONS OF SYMBOLS

Symbol	**Unit**	**Definition**
A_P	sf	Planting area
Change in Storage	gal	Difference between current day's storage and prior day's storage
CN		SCS Curve Number in irrigated landscape area
Cum Net P	in	Cumulative net precipitation: Amount of natural rain water stored in landscape
Cum Q_{HARV}	in	Cumulative harvested roof runoff
E	in	Runoff coefficient for roofs
ET_L	in	Landscape evapotranspiration
Harvested water used for irgn.	gal	Daily total amount of harvested water used for irrigation
I_a	in	Initial abstraction as defined by SCS method
IE	in	Irrigation coefficient
Irgn. Req't.	in	Optimal irrigation requirement in Georgia
K_L		Landscape coefficient
Overflow	gal	Amount of water lost due to full tank
P	in	Precipitation
PEt	in	Potential evapotranspiration reported by GAEMN
P Consumptiion	in	Amount of natural rain water used by landscape plants
P Excess	in	Amount of natural rain water remaining in soil after plant use
Q	in	Surface runoff calculated by SCS method
Q_{HARV}	in	Harvested roof runoff
Roof Catchment	sf	Roof area from which rain water is harvested
S	in	Potential maximum retention after runoff begins, as defined for SCS Method
S_P	gal	Storage from Prior Day
Supplemental water	gal	Amount of water needed for irrigation from alternative source
TWA (gal)	gal	Total Water to Apply = TWA (in) x planting area, converted to gallons
TWA (in)	in	Total Water to Apply = Irgn. Req't. x Irrigation coefficient (IE)

Complete sample printouts of the spreadsheets are shown as Appendices A, B, C and D. The four printouts represent each of the two spreadsheet types (water supply and water use) implemented for each of the two sample years (2000 and 2003). The printouts show a particular case of catchment area, irrigation area, landscape coefficient and storage capacity. The values of these input variables were modified for other cases. The following sections describe the spreadsheets' mathematical content, in order from the top of the spreadsheet to the bottom, and from left to right. Generally, input variables are specified in the upper rows of each spreadsheet; subsequent rows perform daily water budget calculations using the input variables.

Spreadsheet I: Irrigation Requirement

The Irrigation Requirement spreadsheet contributes to determining the value of an active rainwater harvesting system by studying the characteristics of the soil and plantings on the sample site.

CN and S

In the upper left hand corner of the Irrigation Requirement spreadsheet, CN (Curve Number) and S, are two factors input as required for the SCS Curve Number runoff estimation method. These factors will be described below under "Runoff Depth".

Landscape Coefficient (K_L)

Next, to the right across the top of the page, the Landscape Coefficient (K_L) is given. This factor is one of the variables used in estimating vegetative water demand. "The landscape coefficient was derived specifically to estimate water loss from landscape plantings". (University of California Cooperative Extension) Different types and densities of vegetation have different values. This K_L factor is derived from three other variables: a species factor, a density factor and a microclimate factor, as follows:

$$K_L = \text{species factor } (k_s) \times \text{density factor } (k_d) \times \text{microclimate factor } (k_{mc})$$

A variety of species having different water needs can be used in landscape plantings and are often irrigated within a single irrigation zone. Variation in vegetation density can create differences in water loss as, for example, a dense planting with greater leaf area would lose a greater amount of water through evapotranspiration than a sparse planting. A range of microclimates can coexist in a single irrigation zone and can significantly affect plant water loss; for example, plantings in close proximity to hot pavement will have significantly greater water loss compared to those protected by tree canopy from wind and sun.

Each of K_L's three input factors has a potential numerical range. The details of the analysis for each can be found in "A Guide to Estimating Irrigation Water Needs of Landscape Plantings in California"(University of California Cooperative Extension). For the current study, various landscape coefficients (K_L) were used from a presentation (see appendix E) done by Fred Hall for the rainwater harvesting design presented to Emory University for their Math & Science Building. (Hall) The Emory site for which Hall's study was done is approximately 70 miles west of the design site referenced in this paper, therefore climate similarity exists between the two locations.

The K_L factor used in the spreadsheets shown in the Appendices A through D, K_L 0.55, represents "Mixed plantings – average conditions", as calculated by Hall. (see appendix E). (Hall) This factor represents possible projected conditions on the sample site.

Planting Area

Listed below Landscape Coefficient is the size of Planting Area, which comes from the site plan.

Irrigation Coefficient

Listed below Planting Area is the Irrigation Coefficient (IE), "defined as the beneficial use of applied water (by plants)" in the Guide to Estimating Irrigation Water Needs of Landscape Plantings in California (University of California Cooperative Extension). It is an unlikely occurrence that all applied water, meaning 100% efficiency, would be used by a planting. Since a standard method for calculating irrigation efficiency has not yet been established (University of California Cooperative Extension), this study will use a coefficient of 0.9 to represent efficiency losses when drip irrigation is in place, based on Hall's presentation in Appendix E.

Day

The first column (Day) of the spreadsheet lists 365 days of the year. Daily calculations have been made to arrive at yearly totals. Using daily information, instead of monthly data, provides a more accurate model.

Precipitation (P)

The second column (P) states the amount of Precipitation in inches per day. Daily rainfall data for the years 2000 and 2003 was obtained through the Georgia Automated Environmental Monitoring Network (Hoogenboom et al.).

Runoff Depth (Q)

The third column (Q) represents Runoff from the planted area, calculated using the SCS Method. This is a necessary step toward determining the amount of rainwater naturally in the soil and available to plants.

Given the daily rainfall data for each year, runoff is determined using the basic equation of the 'SCS Method'. The SCS Curve Number method, the basic equation of the SCS Method, is used to determine the depth of runoff. In contrast to the Rational Method, the SCS Method is more useful for applications that require an estimate of runoff volume. Ferguson suggests the SCS method for runoff calculation "because it takes into account zero or low amounts of runoff during small rainstorms, and increasing runoff with more intense rainfall".(B. Ferguson)

Technical Release 55 (TR-55) published by the U.S. Soil Conservation Service [currently known as The Natural Resource Conservation Service] (U.S. Soil Conservation Service) states the runoff equation as:

$$Q = (P-I_a)^2 / (P-I_a) + S$$

Where

Q = runoff (in.)

P = rainfall (in)

S = potential maximum retention after runoff begins (in)

Ia = initial abstraction (in)

The term "initial abstraction", in this case, refers to water losses prior to runoff ensuing. These losses include: infiltration, evaporation, water intercepted by vegetation, and water retained by surface topography.(U.S. Soil Conservation Service) TR-55 states "through studies of many small agricultural watersheds, I_a was found to be approximated by the following empirical equation":

$$I_a = 0.2S$$

Applying this empirical quantity to the SCS equation for calculating runoff provides the following equation:

$$Q = (P-0.2S)^2 / (P + 0.8S)$$

TR-55 describes S as "related to the soil and cover conditions of the watershed through the Curve Number (CN)", in the following equation:

$$S = (1000 / CN) – 10$$

The value of the Curve Number (CN), a unique feature of the SCS method, is indicated by land use in combination with the Hydrologic Soil Group (HSG) which employs four soil categories (A, B, C, D). "A soil's hydrologic soil group (HSG) describes its relative capability to infiltrate rain water or to divert it into runoff." (Echols) Theoretically, CN varies from 0 to 100; the value numerically increases as soil and cover conditions result in greater amounts of stormwater runoff.

In the case of the sample site for the current modeling study, borings (taken within 100 feet of the proposed building site) encountered varying thicknesses of fill soil which are described as "loose to medium dense silty sands and firm to stiff sandy silts with rock fragments" and has not been significantly compacted. Since the native soil classification as described in a county soil survey no longer exists on this highly disturbed construction site, the subsurface soils report's description was compared with the SCS description of Hydrological Soil Groups (HSG), indicating that the soil falls in Group B.

For each HSG, TR-55's Table 2-2a shows "Runoff curve numbers for urban areas" based on cover type and hydrologic condition for fully developed urban areas with established vegetation. It is assumed, for this study, that the sample site's irrigated landscape will fit the table's category of 'Open space' (such as lawns, parks, golf courses, cemeteries, etc.) in 'Good condition' with greater than 75% grass (or other) cover, containing no impervious area. Table 2-2a indicates a landscape in this classification in HSG 'B' as having CN of 61. CN 61 will be the primary curve number used in this study, resulting in a value of S equal to 6.39.

Precipitation minus Runoff (P-Q)

The fourth column (P-Q) indicates the amount of natural rainwater remaining for plant use. The estimated daily runoff depth (Q) is subtracted from the daily precipitation (P) amount; the difference equals the amount of rainwater that enters the soil for plant use.

Water entering soil for plant use $= P - Q$

Potential Evapotranspiration (PEt)

The fifth column (PEt) lists the daily Potential Evapotranspiration (PEt) [a.k.a. Reference Evapotranspiration (REt or ETr)]. Potential evapotranspiration (PEt) is, theoretically, the maximum amount of water that can leave a hydrologic system through the combined effects of evaporation (from soil and pond surfaces) and plant transpiration. PEt data used in the current modeling study was provided by the Georgia Automated Environmental Monitoring Network (Hoogenboom et al.) and is based on the Priestley-Taylor equation, a simplified version of the Penman equation. Ferguson states that PEt represents “a direct estimate of plant water use, if sufficient moisture is available in the soil to supply it”. (B. Ferguson)

Potential evapotranspiration (PEt) must be considered as a factor in determining the projected quantity of water available for plant use because “a large portion of the annual rainfall ends up leaving” a site this way (B. K. Ferguson). To distinguish between evapotranspiration and potential evapotranspiration, Ferguson states, “Evapotranspiration is produced by the interaction of a site’s climate and soil. The climate produces a potential evapotranspiration by supplying heat and solar energy. Given that potential, the soil limits evapotranspiration if the amount of water in the soil is limited. Evapotranspiration (Et) can never exceed potential evapotranspiration [PEt], but it can be less.”(B. K. Ferguson)

Figures 4.6 and 4.7 show daily PEt data for the two sample years. It can be noted that potential evapotranspiration (PEt) is similar between the two years, unlike precipitation in the same two years. Also, PEt is continuous from day to day at a rather low level, compared to

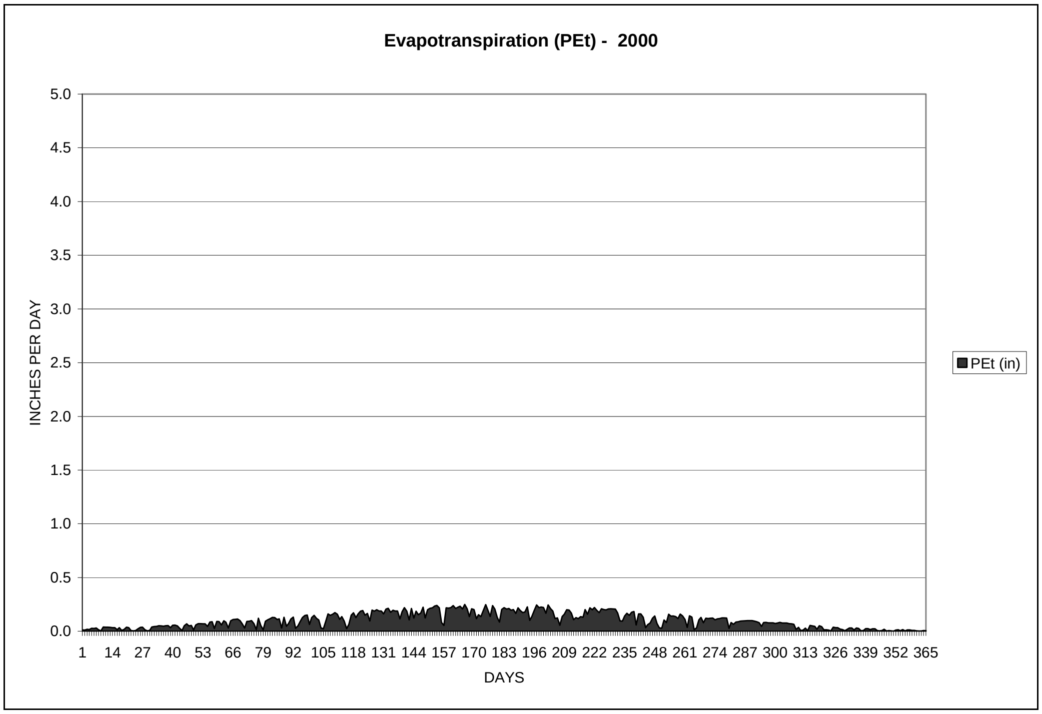

Figure 4.6. Chart of Daily Potential Evapotranspiration for the 'dry' year, 2000.

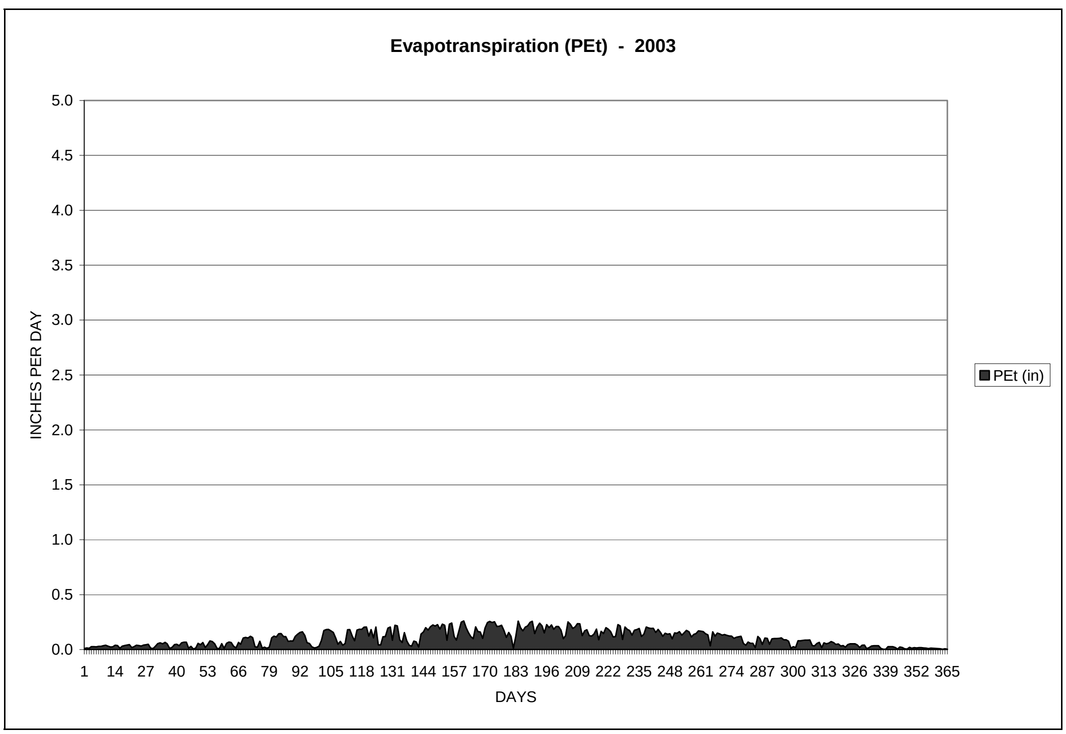

Figure 4.7. Chart of Daily Potential Evapotranspiration for the 'wet' year, 2003.

isolated rain events which concentrate precipitation into a relatively few intense days. It is the difference between daily precipitation and daily potential evapotranspiration that creates the need for storage of harvested water.

Cumulative Net Precipitation (Cum Net P)

Cumulative Net Precipitation (Cum Net P) is the cumulative amount of natural rain water stored in the landscape and available for plant use.

Cum Net P = (P-Q) + P Excess

If the amount of rainwater that enters the soil on a given day is not completely used up on that day, the amount of water in the soil continues to decline due to evaporation until it is effectively used up. Between PEt and Cum Net P, the lesser amount is consumed for daily landscape needs:

P Consumption = IF (PEt > Cum Net P, Cum Net P, PEt)

or

P Consumption = IF (PEt > Cum Net P, *then* Cum Net P, *otherwise* PEt)

If the Cumulative Net Precipitation in the soil is greater than the amount evapotranspired by the landscape, then there is an excess amount equivalent to Cum Net P minus P Consumption which is then added to the water stored in the soil (Cum Net P).

P Excess = IF(Cum Net P > P Consumption, Cum Net P – P Consumption, 0)

or

P Excess = IF(Cum Net P > P Consumption, *then* Cum Net P – P Consumption, *otherwise* 0)

Landscape Evapotranspiration

Water needs of landscape plantings are estimated using the California Guide's landscape evapotranspiration formula. The landscape evapotranspiration (ET_L) or minimum irrigation requirement is derived as follows: (University of California Cooperative Extension)

$ET_L = K_L \times PEt$

Irrigation Requirement

Column ten states the daily minimum Irrigation Requirement (which is to be distinguished from the 'design irrigation requirement' or Total Water to be Applied [TWA]). The irrigation requirement is arrived at by subtracting P Consumption from ET_L, if ET_L > P Consumption; if $ET_L \leq$ P Consumption, no irrigation is required on that day.

Irrigation requirement = IF (ET_L > P Consumption, ET_L – P Consumption, 0)

or

Irrigation requirement = IF (ET_L > P Consumption, *then* ET_L – P Consumption, *otherwise* 0)

Total Water Applied (inches)

The eleventh column (TWA in.) states the Total Water to be Applied, in inches. The California guide calculates the Total Water to Apply (TWA) by introducing an irrigation coefficient (IE) which takes into account the inefficiency of the irrigation system. (University of

California Cooperative Extension) Hall's presentation gives the IE for drip irrigation as 0.9 which will be used in the current model.

TWA(in) = Irrigation Requirement / IE

Total Water Applied (gallons)

The final column (TWA gal.) of this spreadsheet states the Total Water to be Applied, in gallons. To determine the total volume of water to be applied to the specific planted landscape, multiply the TWA(in) by the planting area, A_P (sf) of the landscape to be irrigated, then convert to gallons:

TWA(gals) = TWA(in) x A x 7.48/12

This final column will be entered into Spreadsheet II to calculate the Irrigation Water Supply.

<u>Spreadsheet II: Irrigation Water Supply</u>

The Irrigation Water Supply spreadsheet tracks the harvested rainwater from roof catchment to cistern through irrigation use and calculates quantities of overflow or supplemental water required.

Roof Catchment Area (sf)

In the upper left hand corner of the spreadsheet, the Roof Catchment Area is given in square feet. The Roof Catchment Area of the sample site used in this study, and as shown in

Appendices B & D, is 15,480 square feet. Other values of Roof Catchment Area can be entered (See Figures 5.5 – 5.7).

Runoff Coefficient (E)

The Rational formula is used to estimate roof runoff, because Rational runoff coefficients are available, specifically for long-term average runoff from impervious surfaces, during both small and large storms. Listed below Roof Catchment Area is the Runoff Coefficient which can vary depending on the characteristics of the roofing material used. A runoff coefficient with a value less than 1.0 must be applied to account for water loss resulting from, for instance, ponding in surface depressions or evaporation. Values for the Rational coefficient as related to surface type, show a range of 0.75-1.00 for roofs (American Society of Plumbing Engineers). Heather Kinkade-Levario states in her recent book Forgotten Rain that "a maximum of 90 percent of a rainfall can be effectively captured through rooftop rainwater harvesting". In her table estimating runoff efficiences for urban surfaces, she recommends a coefficient of 0.90 for smooth, impervious roof surfaces, including metal, tile, built-up roofing and asphalt shingles. (Kinkade-Levario Forgotten Rain: Rediscovering Rainwater Harvesting). For the current study, assuming either a built-up roof or asphalt shingles for the sample design site of the Georgia Museum of Art Addition, a constant coefficient of 0.90 was used based on Kinkade-Levario's recommendation.

Conversion factor (gals.)

To convert volumes of water given in units of square feet-inches into gallons it is necessary to use a conversion factor of 7.48/12 or the equivalent, 0.62.

Storage Capacity (gals.)

Moving across the top of the spreadsheet to the right, the proposed cistern Storage Capacity is given in gallons. The printouts in Appendices B and D model a 60,000 gallon capacity storage tank; alternative values can be entered. (The quantity of 60,000 gallons was chosen for the example spreadsheet based on the chart shown in Figure 5.1.)

Storage at End of Prior Year (gals.)

For the purposes of this study, each active rainwater harvesting system modeled began the year with an empty cistern, as if it were a new installation.

Day

The first column of Spreadsheet II: Irrigation Water Supply, indicates the days of the year, as daily information was used as a means to accurate results, similar to Spreadsheet I.

Precipitation (P)

The second column uses the same Precipitation data used in Spreadsheet I, obtained through the Georgia Automated Environmental Monitoring Network (Hoogenboom et al.). In Spreadsheet I, the rainfall was studied in relation to soil and plant needs. In Spreadsheet II, the same rainfall is collected from a Roof Catchment Area, and either immediately used or stored in a cistern for future use.

Harvested Roof Runoff (Q_{HARV})

Column 3 calculates the Harvested Roof Runoff of the pitched roof catchment area of the addition to the Georgia Museum of Art which has an area of 15,480sf. Employing the Rational Method, it is assumed that, "if rain were to fall on a totally impervious surface at a constant rate long enough, water would eventually run off the surface at the same rate as it was applied to the surface, and it assumes that the runoff coefficient would remain constant"(American Society of Plumbing Engineers). To determine the volume of water captured from this catchment area, the product of daily precipitation (in), roof area (sf), runoff coefficient (E) and conversion to gallons is used:

$$Q_{HARV} = P \times A \times E \times 7.48/12$$

Cum Q_{HARV}

In the interest of tracking the total amount of water harvested from the roof catchment area as the year progresses, Cumulative Harvested Roof Runoff (Cum Q_{HARV}) is included as column 4.

$$\text{Cum } Q_{HARV} = \text{Previous day's Cum } Q_{HARV} + \text{Current day's } Q_{HARV}$$

Total Water to be Applied (TWA gals.)

The results in the final column of Irrigation Requirement Spreadsheet I, stating daily data for Total Water to be Applied (gals), is input here in column 5 of Spreadsheet II. This column states values that will be used in calculations in columns 8 and 10 of Spreadsheet II.

Storage at end of previous day (Sp)

Given a pre-established storage tank capacity (gals.), the quantity of water stored in the tank was tracked on a daily basis through each year in column 6. Calculations were run with storage capacity on January 1 at 0, modeling a newly installed tank. The calculation to track the daily amount of water in the cistern is as follows:

Sp = Storage at end of previous day

CAP = Capacity of storage tank

$Sp = IF(Sp + Q_{HARV} - TWA>CAP, CAP, IF(Sp + Q_{HARV} - TWA< 0, 0, Sp + Q_{HARV} - TWA))$

or

Sp = IF(Sp + Q_{HARV} –TWA>CAP, *then* CAP, *otherwise* IF(Sp + Q_{HARV} –TWA< 0, *then* 0, *otherwise* Sp + Q_{HARV} – TWA))

Change in Storage (gals)

Simply by subtracting the storage quantity of the prior day from the current day's storage, in column 7, monitors the amount of change in storage from day to day:

Change in Storage (gals) = Current day's storage – yesterday's storage

Harvested Water Used for Irrigation (gals)

The final results of the Irrigation Requirement spreadsheet, daily values for Total Water to be Applied (TWA gals), now enter into the current calculation. The Total Water to be Applied (TWA) is the amount of irrigation water required for the plantings, however, that amount may not always be available for use purely from harvested roof runoff. Calculating the quantity of Harvested water used for irrigation is as follows:

Harvested water used for irrigation = IF (Q_{HARV} + Sp > TWA, TWA, Q_{HARV} + Sp)

or

Harvested water used for irrigation = IF(Q_{HARV} + Sp >TWA, *then* TWA, *otherwise* Q_{HARV} + Sp)

Overflow (gals)

Conversely, there will also be times when the storage tank is full and the tank overflows. For calculating the quantity of harvested water that overflows the storage tank provided, the following calculation is used:

Overflow =IF(Change in Storage < 0, 0, Q_{HARV} – Harv. water used for irgn.– Change in Storage)

or

Overflow =IF(Change in Storage < 0, *then* 0, *otherwise* Q_{HARV} – Harv. water used for irgn.– Change in Storage)

Supplemental Water Required (gals)

A calculation for the amount of Supplemental water required from another source when the storage tank cannot supply the necessary irrigation is:

Suppl. Water Req'd.=MAX (TWA-Q_{HARV} - Sp ,0)

Supplemental Water Required is equal to the maximum of either: [Total Water Applied (TWA) minus Harvested Roof Runoff (Q_{HARV}) minus Storage at end of previous day (Sp)] or [0].

Examples of this spreadsheet model for the years 2000 and 2003 can be found in the Appendix. As previously stated, variables within the model can be altered in order to evaluate alternatives and arrive at the most efficient or desirable combination of factors. In Appendices A, B, C and D, a singular scenario is presented across two years, one dry, one wet. The given catchment area and irrigation area of the sample design site was modeled using landscape coefficient K_L 0.55 and a cistern volume of 60,000 gallons.

CHAPTER 5

RESULTS

This chapter presents yearly totals derived from the water budget model and their comparative relationships as illustrated in bar charts.

Results derived from Spreadsheet I

Spreadsheet 1: Irrigation Requirement, produced useful results concerning the total amount of water required to be applied, given precipitation, potential evapotranspiration, soil conditions, planting area and vegetative type.

Irrigation Requirement

The difference in irrigation requirement between a wet and dry year was dramatically illustrated in the results of Spreadsheet I. All four of the landscape coefficients (K_L) given by Hall were run for both years. The four different Landscape coefficients (K_L) included K_L 0.22: mixed plantings – low conditions, K_L 0.55: mixed plantings – average conditions, K_L 0.7: turfgrass – average conditions and K_L 0.9: turfgrass – high conditions (see appendix E). The following table shows the resultant quantities of Total Water to be Applied (TWA) to the landsape plantings in gallons per year for each of the four landscape coefficients. TWA represents the total supplemental water needed by plantings from any source, whether city water or harvested rainwater.

Table 2. IRRIGATION REQUIREMENT RESULTS with varying K_L

		K_L 0.22	K_L 0.55	K_L 0.7	K_L 0.9
2000 (dry year)	**TWA** (gals)	**72,296**	**180,741**	**230,128**	**296,062**
2003 (wet year)	**TWA** (gals)	**560**	**1480**	**1939**	**2580**

The quantitites from 2003, the wet year, are minimal in all cases and would not indicate a need for an active rainwater harvesting system purely for the purpose of irrigation. In the case of mixed plantings (K_L 0.55), the annual TWA of 1,480 gallons amounts to only 0.17 inches on the Georgia Museum of Arts 13,824sf planted area. In the case of high maintenance turf grass (K_L 0.9) the annual TWA of 2,580 gallons amounts to 0.3 inches. However, the quantities from 2000, the dry year, particularly for landscape coefficients ranging from K_L 0.55 to 0.9, are more conducive to utilizing irrigation from some water source. On the Georgia Museum of Art's plantings, the TWA with K_L 0.55 in 2000 would require 21 inches of supplemental water during the year. The same planting area with TWA of K_L 0.9 would need 34 inches of irrigation from a water source.

<u>Results derived from Spreadsheet II</u>

Irrigation Water Supply

In the year 2000, the dry year, with precipitation of 33.77 inches, the Georgia Museum of Art roof catchment area of 15,480 square feet provided a total of 293,260 gallons of harvested runoff. In 2003, the wet year, with 60.93 inches of precipitation, 529,117 gallons were harvested from the same roof catchment area.

Cistern Capacity

To illustrate the results of the model, the landscape coefficients K_L 0.55 and K_L 0.9, representing differing vegetation conditions, are looked at across a range of potential cistern sizes.

First, using the landscape coefficient, K_L 0.55 (which represents mixed plantings under average conditions of density and microclimate), water supply and use for each of the years 2000 and 2003 was calculated varying the storage capacity of the cistern in increments of 10,000 gallons, in a range from 10,000 gallons to 150,000 gallons. Then, keeping all other variables unchanged, the same was done for K_L 0.9 (which represents high maintenance turf grass).

2000

In the dry year of 2000, a total of 293,260 gallons (Qharv) were harvested from the sample roof catchment area and the proposed mixed plantings (KL 0.55) required 180,741 gallons (TWA) of water to be applied. These two quantities for the year 2000:

Qharv = 293,260 gals.

TWA = 180,741 gals.

remain constant in Figure 5.1, below, which charts the Overflow and Supplemental Water Required as the size of the cistern increases by increments of 10,000 gallons from a 10,000 gallon storage tank to a 150,000 gallon storage tank.

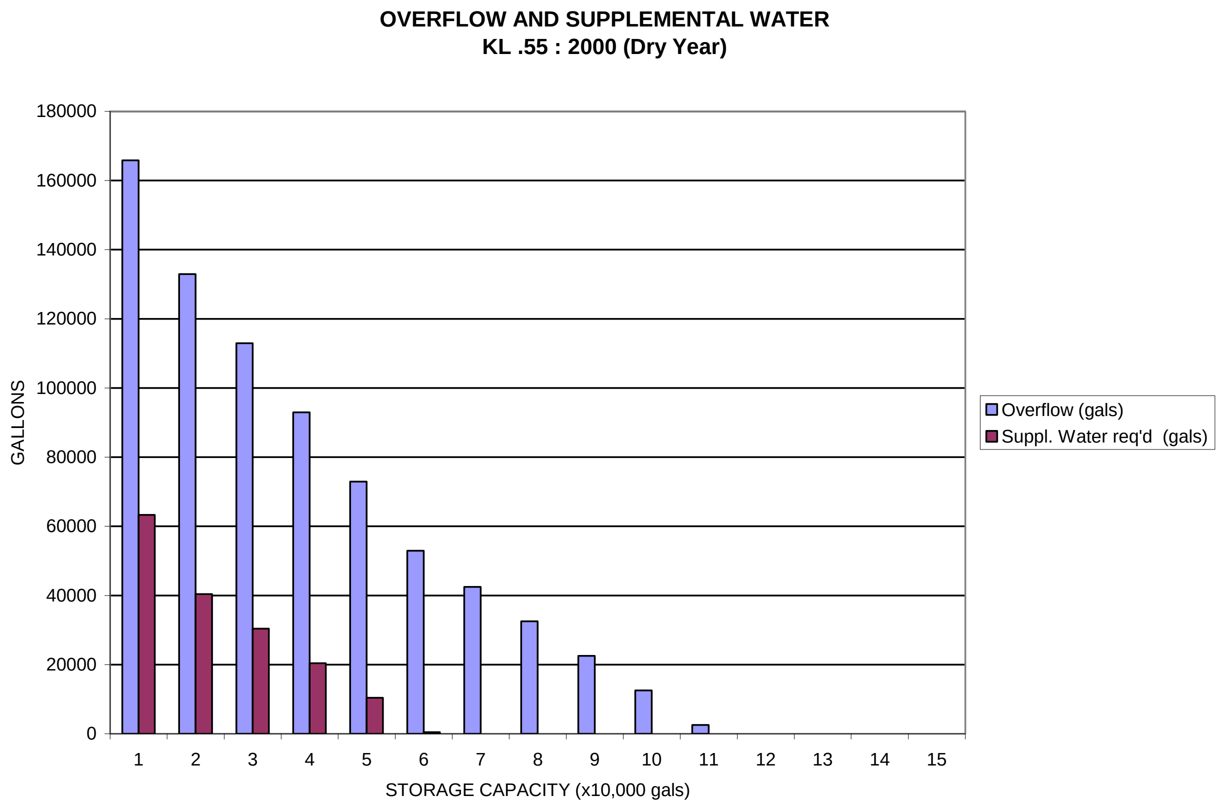

Figure 5.1. Overflow and Supplemental Water with K_L 0.55 in the 'dry' year, 2000.

The bar chart in Figure 5.1 provides a means of quickly determining the minimum cistern size needed to maximize use of harvested rainwater (Q_{HARV}) by eliminating both supplemental water required and loss of water to overflow. Figure 5.1 indicates that in the dry year of 2000, the minimum size would be 120,000 gallons.

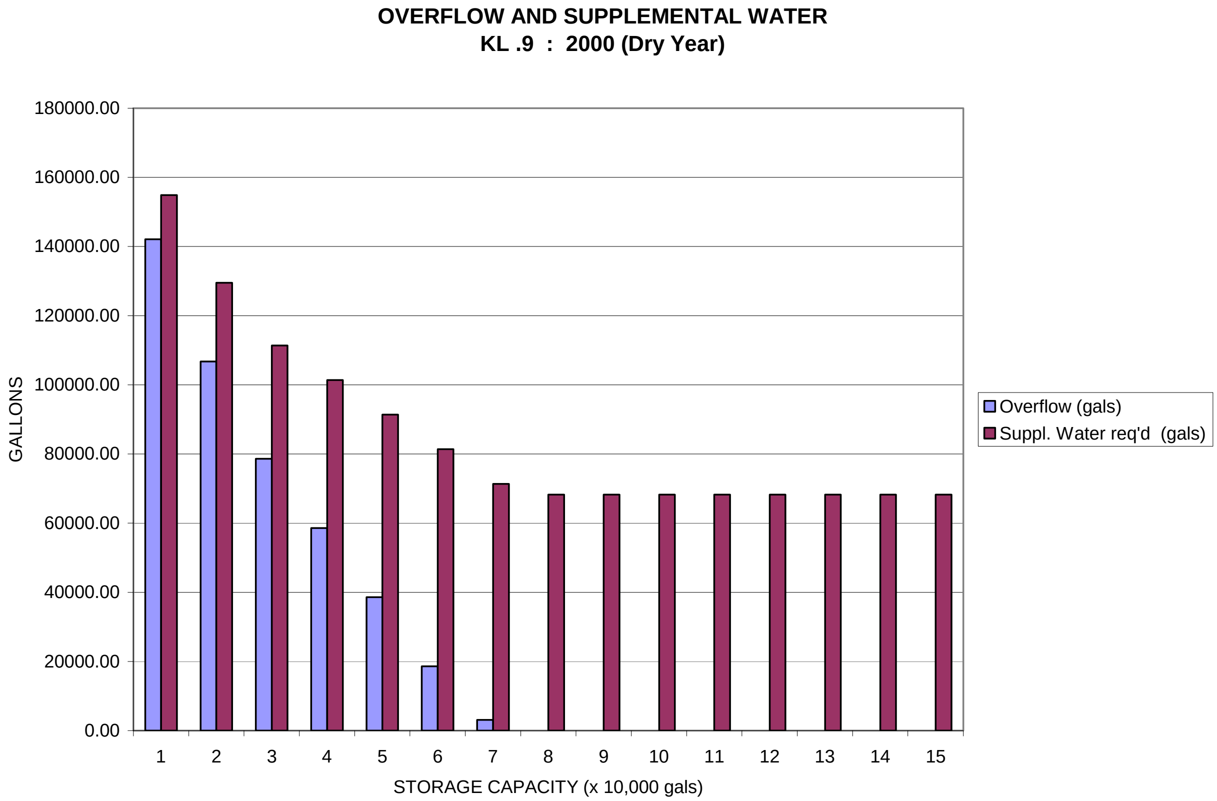

Figure 5.2. Overflow and Supplemental Water with K_L 0.9 in the 'dry' year, 2000.

In Figure 5.2, all data is the same as that of Figure 5.1 except the landscape coefficient K_L is raised from 0.55 to 0.9 representing high maintenance turf grass in average density and average microclimate (Hall). Almost twice as much water is required. Paradoxically, the most efficient cistern size is smaller, at 80,000 gallons. No larger cistern can supply the needed water; a great need remains unmet no matter how large the cistern.

2003

For the wet year of 2003, a total of 529,117 gallons (Qharv) were harvested from the sample roof catchment area of 15,480 square feet and the proposed mixed plantings (K_L 0.55) required a mere 1,480 gallons (TWA) of water to be applied. These two quantities for the year 2003:

Qharv = 529,117 gals.

TWA = 1,480 gals.

remain constant in Figure 5.3, below, which charts the Overflow and Supplemental Water Required as the size of the cistern increases from a 10,000 gallon storage tank to a 150,000 gallon storage tank. Note that the vertical scale is much greater than that in Figures 5.1 and 5.2, because of the great amount of water available in the wet year. Essentially, no storage capacity is beneficial for irrigation use in the wet year; all water demand is satisfied without cistern storage.

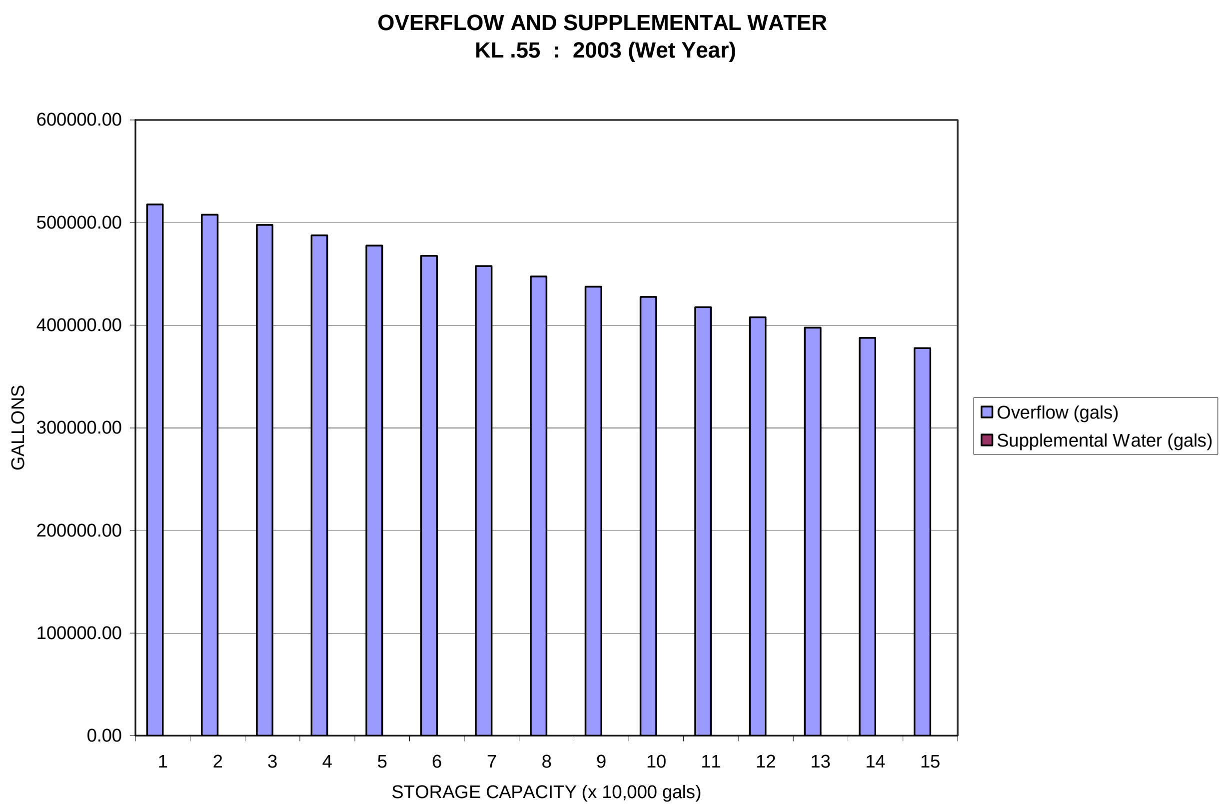

Figure 5.3. Overflow and Supplemental Water with K_L 0.55 in the wet year, 2003.

In the wet year of 2003, precipitation alone provided adequate water. Only 1,480 gallons of water would have been needed for irrigation of the design site with K_L 0.55 (See Table 2).

Passive rainwater harvesting methods would be sufficient to supply the irrigation requirement. An active rainwater harvesting system to be used for irrigation would not be called for in this situation. The decreasing amount of Overflow gallons shown in Figure 5.3 is directly proportional to the increasing tank size.

One might think that a more high maintenance planting area (K_L 0.9), such as a golf course for example, would have a much higher water demand than the prior example with K_L 0.55. However, as shown in Figure 5.4, the results are practically identical. The total water to be applied (TWA) when higher maintenance turf grass has been planted (K_L 0.9) is only 1100 gals greater than that required with K_L 0.55 (refer to Table 2).

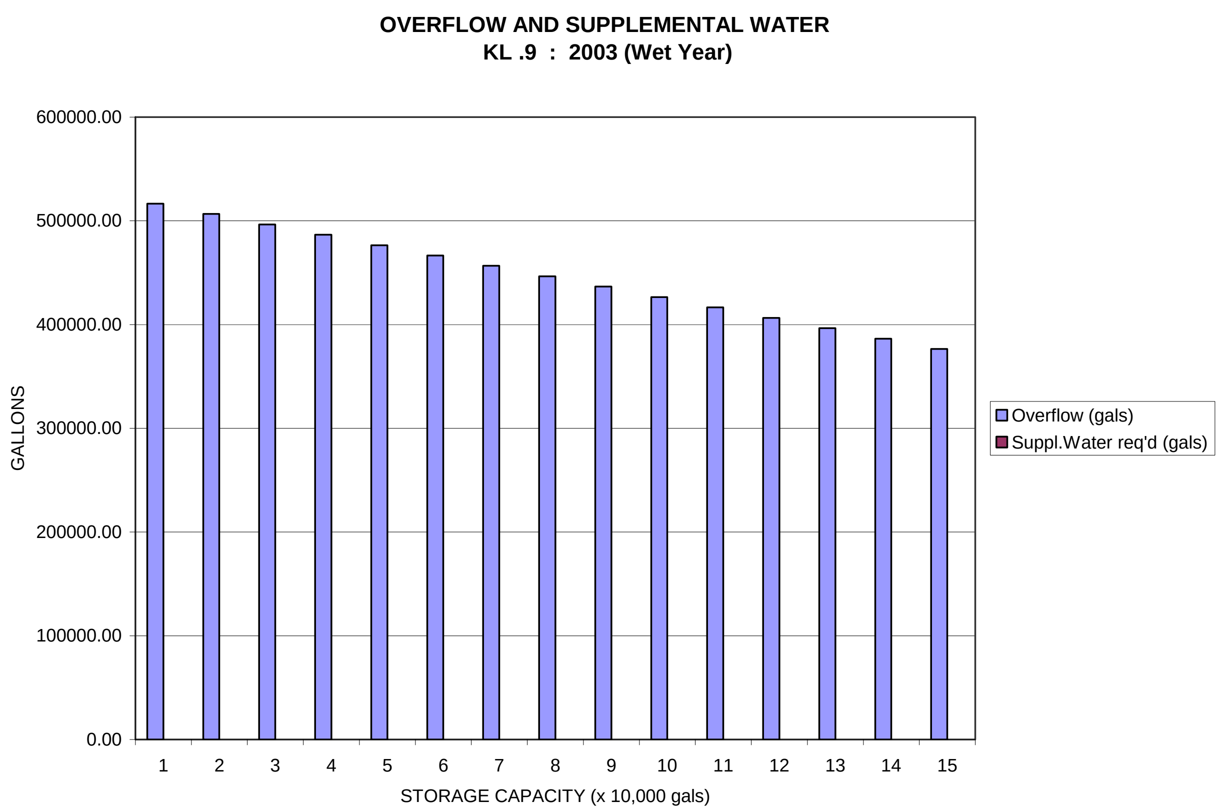

Figure 5.4. Overflow and Supplemental Water with K_L 0.9 in the wet year, 2003.

It is interesting to note that an active rainwater harvesting system used for irrigation in the wet year of 2003 is unnecessary even in the case of high maintenance turf grass. The decreasing amount of Overflow gallons shown in Figure 5.4 is directly proportional to the increasing tank size.

Catchment-Irrigation Area

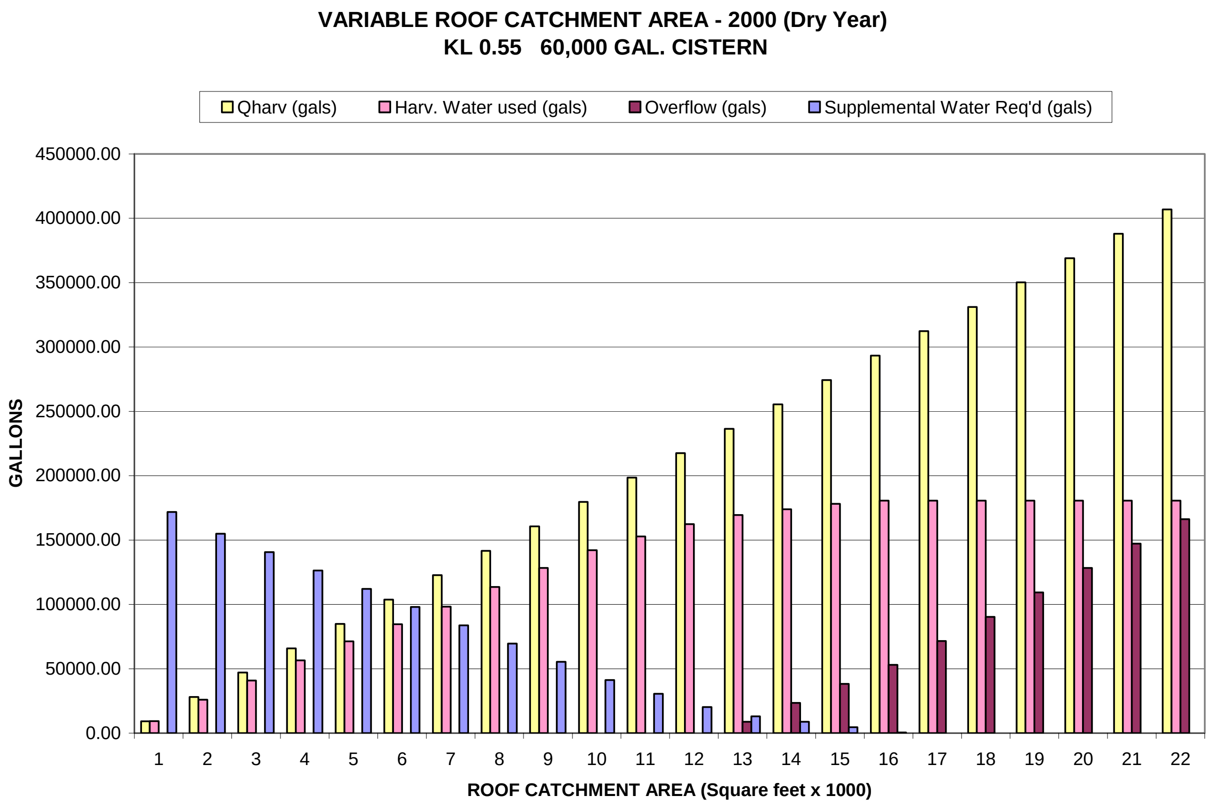

Figure 5.5. Variable Roof Catchment Area in the dry year, 2000.

Figure 5.5, Variable Roof Catchment Area in the dry year, 2000, charts a range of catchment sizes with the irrigation requirement constant using K_L 0.55, the planting area fixed as that of the sample site (13,824 sf) and a fixed cistern size of 60,000 gallons. Potential catchment area sizes are input, ranging from 500 square feet up to 21,500 square feet, increasing by increments of 1000 square feet.

At the left side of the chart in Figure 5.5, the catchment area is very small, only 500 sf. At that size, very little rainwater is harvested and irrigation needs must be met with supplemental water sources. Moving to the right along the x axis, as the roof catchment area increases, the amount of supplemental water required decreases. At approximately 12,500-13,000sf, the full irrigation need is close to being met and overflow appears for the first time. When the roof catchment area is at 15,500-16,000sf, the irrigation needs are completely met by this system with a 60,000 gallon cistern; supplemental water has disappeared entirely and there is approximately 50,000 gallons lost to overflow. Beyond 16,000sf, overflow continues to increase as no greater benefit can be gained by larger catchment area, unless the planting area or cistern capacity also increase.

For a given irrigated planting area, what is the optimal catchment area to achieve maximum water conservation? The two quantitites entering into this question are the Overflow and Supplemental Water Required. To answer the question fully would require calculations beyond the scope of the current study. Figure 5.5 illustrates the simplest model, in which the two quantities are weighted equally.

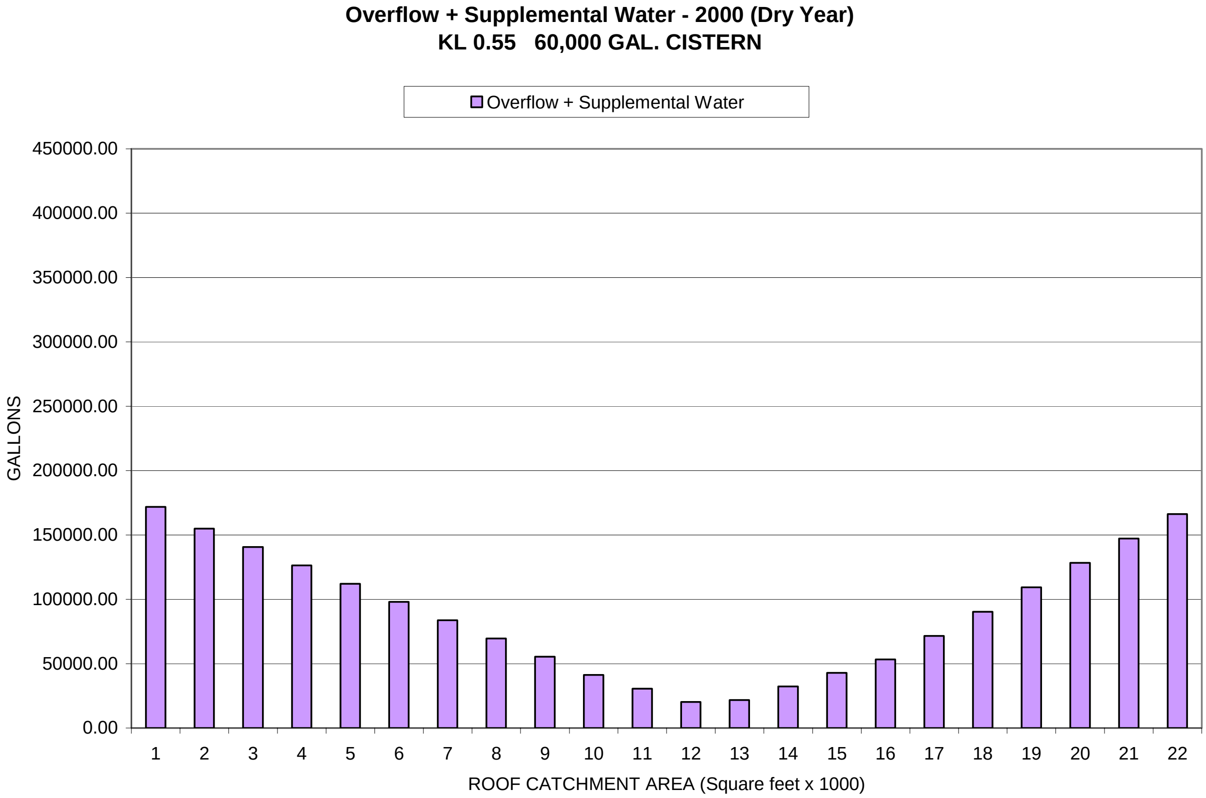

Figure 5.6. Overflow and Supplemental Water Required with Variable Roof Catchment Area in the dry year, 2000.

Figure 5.6 combines the quantities of Overflow and Supplemental water to determine which catchment area results in the most water conservation. This chart indicates that a catchment area of approximately 11,500-12,000sf, given a planting area of 13,800 with K_L 0.55 and a 60,000 gallon cistern, would optimally conserve water. However, this particular ratio of catchment area to irrigation area (11,500 / 13,800 = .83) cannot be construed as meaningful beyond this particular situation without further study.

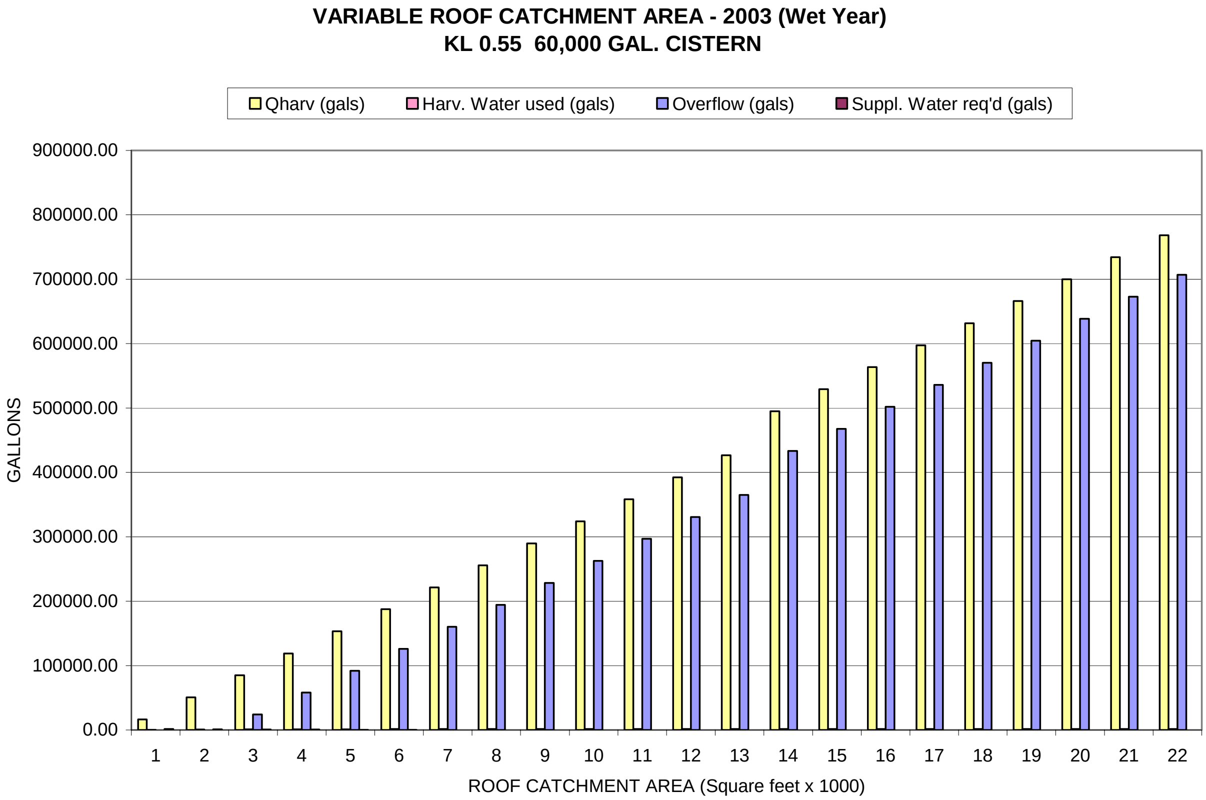

Figure 5.7. Variable Roof Catchment Area in the wet year, 2003.

The same type of chart showing variable roof catchment area was done for 2003, the wet year. The chart in Figure 5.7 keeps the irrigation requirement constant at KL 0.55, the planting area fixed at 13,824sf and uses the same fixed cistern size of 60,000 gallons as was done for the year 2000. The same range of potential roof catchment area sizes were input, ranging from 500 square feet up to 21,500 square feet, increasing by increments of 1000 square feet. In the wet year, there is no basis for selecting an optimal catchment area.

In Figure 5.7, the amounts of Harvested Water Used and Supplemental Water Required in 2003, the wet year, are so minimal they do not appear on the chart at all. The difference between the two quantities that are visible on the chart, the amount of water harvested (Q_{HARV}) and the amount of Overflow, equals the total of Harvested Water Used, 1,480 gallons, and the maximum storage capacity of the cistern, 60,000 gallons. This illustrates an active rainwater harvesting system in need of a use for the water being captured. Water needs other than irrigation must be considered if the objective is to conserve water by making use of water captured on site.

CHAPTER 6

CONCLUSIONS

This thesis has generated an evaluative model, in the form of spreadsheets, which can be used in design by iterative application of trial inputs. Although the model has been applied here only to one site in northern Georgia, it can probably be applied elsewhere using different input data. The spreadsheets and charts demonstrate the limits of the physical feasibility of a rainwater harvesting system and can guide the design process toward practical choices. This model should be applied using locally specific precipitation and potential evapotranspiration data for a specific design proposal.

The following conclusions are supported by the thesis results:

1) In the humid climate of northern Georgia, the question of whether a rainwater harvesting system is physically feasible does not have a fixed yes-or-no answer, rather the answer is specific to each project design. Design variables that could be manipulated in any one project to increase physical feasibility include catchment size, irrigation area, landscape planting composition (and thus landscape coefficient, K_L), and cistern size.

2) As roof catchment area increases, quantity of harvested water increases and the feasibility to support the landscape plantings increases up to the limit where all water that the landscape can take has been supplied.

3) As cistern size increases, feasibility increases up to a limit, which can be found by applying this model.

4) Various types and densities of vegetation, along with microclimate, can alter feasibility and can be modeled using these spreadsheets.

5) Size of planting area can be reduced or increased in this model to design for optimal water use efficiency.

As a result of what has been learned, the questions stated in the introduction are reviewed and reformulated.

1) 'Is rainfall plentiful enough that no additional irrigation is required?' This thesis demonstrates through the Irrigation Requirement Results displayed in Table 2, that in a dry year irrigation is clearly called for, while in a wet year there is no need for irrigation. This question is now reformulated as: since rainfall is not plentiful enough in a dry year, how will the required irrigation be provided? Rainwater harvesting could provide the solution.

2) 'When is it practical to make a water harvesting system 'active' by adding a cistern?' This question is now reformulated as: if an active rainwater harvesting system is put in place to accommodate irrigation needs in a dry year, how will the harvested water be put to use in a wet year? Should the cistern supply water for something in addition to irrigation? The Coverdell Center at The University of Georgia provides a perfect reference case in that the cistern provides water for the cooling tower, for toilet flushing, and for irrigation. An active rainwater harvesting system supplying multiple needs is desirable.

3) 'If irrigation is required only for plant establishment, does it make sense to install cisterns for the long term?' This thesis does not attempt to study plant establishment, however it does make a case for the feasibility of installing cisterns for the long term for irrigation during dry years.

4) 'Must planting designs be adjusted to accommodate available quantities of harvested water?' This thesis does determine that planting designs can be adjusted, as one of several

factors that can be varied, in determining a design. It is also possible that roof catchment areas can be increased to increase quantity of harvested water available.

5) 'Should cisterns serve the dual purpose of irrigation and stormwater detention?' It is not the intention of this thesis to examine stormwater management. However, it should be noted that the Whitehead Research facility at Emory is a case where this has been done.

6) 'For a given irrigated landscape planting area, what is the optimal catchment area to achieve valuable water conservation?' Although a simple example was looked at in the current model, to arrive at an optimal ratio of catchment area to irrigation area requires further study.

In conclusion, a spreadsheet model has been created that can be used to answer questions in future applications on specific sites. Using the model, factors can be manipulated in design to find the most feasible combination of catchment area, planting area, planting type (landscape coefficient, K_L), and cistern storage capacity.

Further refinements of this spreadsheet model in future studies would contribute valuable information. Among the possibilities for future studies are:

- Expanding the model to include multiple uses for harvested water
- Expanding the model to include stormwater management.
- A complementary study on the economic feasibility of rainwater harvesting systems in the southeast.
- A comparable study using this model on different sample sites.
- Tracking the process of employing the spreadsheet model as a tool to explore specific design options.

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APPENDIX A

IRRIGATION REQUIREMENT - 2000

IRRIGATION REQUIREMENT - 2000

SCS CN: 61
SCS Retention S 6.39

Landscape coefficient (K_L): 0.55
Planting area (sf): 13824
Irrigation Efficiency IE (drip): 0.9

Day	2000 c.e. P (in.)	Q (Runoff in.)	P-Q (in)	PEt (in)	Cum Net P(in)	P Consumption (in)	P Excess(in)	ET_L (in)	Irrigation Req't (in)	TWA (in)	TWA (gals)
1	0.020	0.000	0.020	0.012		0.000	0.000	0.006	0.006	0.007	62.20
2	0.010	0.000	0.010	0.011	0.010	0.010	0.000	0.006	0.000	0.000	0.00
3	0.000	0.000	0.000	0.019	0.000	0.000	0.000	0.010	0.010	0.011	97.44
4	0.180	0.000	0.180	0.015	0.180	0.015	0.165	0.008	0.000	0.000	0.00
5	0.000	0.000	0.000	0.027	0.165	0.027	0.138	0.015	0.000	0.000	0.00
6	0.000	0.000	0.000	0.026	0.138	0.026	0.112	0.014	0.000	0.000	0.00
7	0.000	0.000	0.000	0.030	0.112	0.030	0.082	0.017	0.000	0.000	0.00
8	0.000	0.000	0.000	0.013	0.082	0.013	0.069	0.007	0.000	0.000	0.00
9	0.710	0.000	0.710	0.003	0.778	0.003	0.775	0.002	0.000	0.000	0.00
10	1.030	0.000	1.030	0.039	1.805	0.039	1.766	0.021	0.000	0.000	0.00
11	0.000	0.000	0.000	0.038	1.766	0.038	1.728	0.021	0.000	0.000	0.00
12	0.000	0.000	0.000	0.038	1.728	0.038	1.691	0.021	0.000	0.000	0.00
13	0.010	0.000	0.010	0.035	1.701	0.035	1.665	0.019	0.000	0.000	0.00
14	0.000	0.000	0.000	0.033	1.665	0.033	1.632	0.018	0.000	0.000	0.00
15	0.000	0.000	0.000	0.033	1.632	0.033	1.599	0.018	0.000	0.000	0.00
16	0.020	0.000	0.020	0.014	1.619	0.014	1.605	0.008	0.000	0.000	0.00
17	0.020	0.000	0.020	0.034	1.625	0.034	1.591	0.019	0.000	0.000	0.00
18	0.130	0.000	0.130	0.009	1.721	0.009	1.712	0.005	0.000	0.000	0.00
19	0.550	0.000	0.550	0.017	2.262	0.017	2.245	0.010	0.000	0.000	0.00
20	0.030	0.000	0.030	0.037	2.245	0.037	2.208	0.020	0.000	0.000	0.00
21	0.000	0.000	0.000	0.033	2.208	0.033	2.175	0.018	0.000	0.000	0.00
22	0.000	0.000	0.000	0.007	2.175	0.007	2.168	0.004	0.000	0.000	0.00
23	0.800	0.000	0.800	0.004	2.168	0.004	2.164	0.002	0.000	0.000	0.00
24	0.380	0.000	0.380	0.006	2.164	0.006	2.158	0.003	0.000	0.000	0.00
25	0.000	0.000	0.000	0.022	2.158	0.022	2.136	0.012	0.000	0.000	0.00
26	0.000	0.000	0.000	0.035	2.136	0.035	2.101	0.019	0.000	0.000	0.00
27	0.000	0.000	0.000	0.038	2.101	0.038	2.063	0.021	0.000	0.000	0.00
28	0.000	0.000	0.000	0.013	2.063	0.013	2.050	0.007	0.000	0.000	0.00
29	0.060	0.000	0.060	0.003	2.050	0.003	2.047	0.002	0.000	0.000	0.00
30	0.590	0.000	0.590	0.009	2.047	0.009	2.038	0.005	0.000	0.000	0.00
31	0.170	0.000	0.170	0.038	2.038	0.038	2.000	0.021	0.000	0.000	0.00
32	0.000	0.000	0.000	0.043	2.000	0.043	1.957	0.024	0.000	0.000	0.00

Day	2000 c.e. P (in.)	Q (Runoff in.)	P-Q (in)	PEt (in)	Cum Net P(in)	P Consumption (in)	P Excess(in)	ET_L (in)	Irrigation Req't (in)	TWA (in)	TWA (gals)
33	0.000	0.000	0.000	0.045	1.957	0.045	1.912	0.025	0.000	0.000	0.00
34	0.000	0.000	0.000	0.050	1.912	0.050	1.862	0.027	0.000	0.000	0.00
35	0.000	0.000	0.000	0.048	1.862	0.048	1.814	0.026	0.000	0.000	0.00
36	0.000	0.000	0.000	0.048	1.814	0.048	1.766	0.026	0.000	0.000	0.00
37	0.000	0.000	0.000	0.051	1.766	0.051	1.715	0.028	0.000	0.000	0.00
38	0.000	0.000	0.000	0.053	1.715	0.053	1.662	0.029	0.000	0.000	0.00
39	0.000	0.000	0.000	0.034	1.662	0.034	1.628	0.019	0.000	0.000	0.00
40	0.000	0.000	0.000	0.056	1.628	0.056	1.572	0.031	0.000	0.000	0.00
41	0.000	0.000	0.000	0.058	1.572	0.058	1.514	0.032	0.000	0.000	0.00
42	0.000	0.000	0.000	0.050	1.514	0.050	1.465	0.027	0.000	0.000	0.00
43	0.070	0.000	0.070	0.026	1.465	0.026	1.439	0.014	0.000	0.000	0.00
44	0.250	0.000	0.250	0.006	1.439	0.006	1.433	0.003	0.000	0.000	0.00
45	1.270	0.000	1.270	0.050	1.433	0.050	1.382	0.028	0.000	0.000	0.00
46	0.000	0.000	0.000	0.070	1.382	0.070	1.313	0.038	0.000	0.000	0.00
47	0.000	0.000	0.000	0.049	1.313	0.049	1.264	0.027	0.000	0.000	0.00
48	0.050	0.000	0.050	0.054	1.264	0.054	1.210	0.030	0.000	0.000	0.00
49	0.010	0.000	0.010	0.013	1.210	0.013	1.197	0.007	0.000	0.000	0.00
50	0.000	0.000	0.000	0.059	1.197	0.059	1.139	0.032	0.000	0.000	0.00
51	0.000	0.000	0.000	0.070	1.139	0.070	1.068	0.039	0.000	0.000	0.00
52	0.000	0.000	0.000	0.070	1.068	0.070	0.998	0.039	0.000	0.000	0.00
53	0.000	0.000	0.000	0.069	0.998	0.069	0.929	0.038	0.000	0.000	0.00
54	0.000	0.000	0.000	0.069	0.929	0.069	0.860	0.038	0.000	0.000	0.00
55	0.000	0.000	0.000	0.046	0.860	0.046	0.814	0.025	0.000	0.000	0.00
56	0.000	0.000	0.000	0.086	0.814	0.086	0.728	0.047	0.000	0.000	0.00
57	0.000	0.000	0.000	0.088	0.728	0.088	0.640	0.049	0.000	0.000	0.00
58	0.230	0.000	0.230	0.024	0.640	0.024	0.616	0.013	0.000	0.000	0.00
59	0.000	0.000	0.000	0.091	0.616	0.091	0.524	0.050	0.000	0.000	0.00
60	0.000	0.000	0.000	0.089	0.524	0.089	0.435	0.049	0.000	0.000	0.00
61	0.000	0.000	0.000	0.059	0.435	0.059	0.376	0.032	0.000	0.000	0.00
62	0.000	0.000	0.000	0.098	0.376	0.098	0.279	0.054	0.000	0.000	0.00
63	0.000	0.000	0.000	0.084	0.279	0.084	0.194	0.046	0.000	0.000	0.00
64	0.330	0.000	0.330	0.030	0.194	0.030	0.164	0.016	0.000	0.000	0.00
65	0.000	0.000	0.000	0.097	0.164	0.097	0.067	0.053	0.000	0.000	0.00
66	0.000	0.000	0.000	0.110	0.067	0.067	0.000	0.060	0.000	0.000	0.00
67	0.000	0.000	0.000	0.110	0.000	0.000	0.000	0.061	0.061	0.067	580.49
68	0.000	0.000	0.000	0.113	0.000	0.000	0.000	0.062	0.062	0.069	592.93
69	0.000	0.000	0.000	0.098	0.000	0.000	0.000	0.054	0.054	0.060	518.30

Day	2000 c.e. P (in.)	Q (Runoff in.)	P-Q (in)	PEt (in)	Cum Net P(in)	P Consumption (in)	P Excess(in)	ET_L (in)	Irrigation Req't (in)	TWA (in)	TWA (gals)
70	0.000	0.000	0.000	0.070	0.000	0.000	0.000	0.038	0.038	0.043	366.96
71	0.460	0.000	0.460	0.030	0.000	0.000	0.000	0.016	0.016	0.018	157.56
72	0.000	0.000	0.000	0.090	0.000	0.000	0.000	0.050	0.050	0.055	474.76
73	0.000	0.000	0.000	0.093	0.000	0.000	0.000	0.051	0.051	0.057	489.27
74	0.000	0.000	0.000	0.100	0.000	0.000	0.000	0.055	0.055	0.061	524.52
75	0.000	0.000	0.000	0.071	0.000	0.000	0.000	0.039	0.039	0.043	373.17
76	0.700	0.000	0.700	0.016	0.000	0.000	0.000	0.009	0.009	0.010	82.93
77	0.000	0.000	0.000	0.122	0.000	0.000	0.000	0.067	0.067	0.074	640.62
78	0.000	0.000	0.000	0.052	0.000	0.000	0.000	0.028	0.028	0.032	271.59
79	0.320	0.000	0.320	0.013	0.000	0.000	0.000	0.007	0.007	0.008	68.42
80	1.110	0.000	1.110	0.093	0.000	0.000	0.000	0.051	0.051	0.057	489.27
81	0.000	0.000	0.000	0.105	0.000	0.000	0.000	0.058	0.058	0.064	553.54
82	0.000	0.000	0.000	0.116	0.000	0.000	0.000	0.064	0.064	0.071	609.52
83	0.000	0.000	0.000	0.127	0.000	0.000	0.000	0.070	0.070	0.078	669.64
84	0.000	0.000	0.000	0.127	0.000	0.000	0.000	0.070	0.070	0.077	667.57
85	0.000	0.000	0.000	0.109	0.000	0.000	0.000	0.060	0.060	0.067	574.27
86	0.000	0.000	0.000	0.114	0.000	0.000	0.000	0.063	0.063	0.070	599.15
87	0.130	0.000	0.130	0.031	0.000	0.000	0.000	0.017	0.017	0.019	163.78
88	0.000	0.000	0.000	0.130	0.000	0.000	0.000	0.071	0.071	0.079	684.15
89	0.000	0.000	0.000	0.046	0.000	0.000	0.000	0.026	0.026	0.028	244.64
90	0.070	0.000	0.070	0.070	0.000	0.000	0.000	0.039	0.039	0.043	369.03
91	0.000	0.000	0.000	0.112	0.000	0.000	0.000	0.062	0.062	0.069	590.86
92	0.000	0.000	0.000	0.131	0.000	0.000	0.000	0.072	0.072	0.080	690.37
93	0.430	0.000	0.430	0.026	0.000	0.000	0.000	0.015	0.015	0.016	138.90
94	0.690	0.000	0.690	0.049	0.000	0.000	0.000	0.027	0.027	0.030	259.15
95	0.070	0.000	0.070	0.089	0.000	0.000	0.000	0.049	0.049	0.054	466.47
96	0.000	0.000	0.000	0.127	0.000	0.000	0.000	0.070	0.070	0.077	667.57
97	0.000	0.000	0.000	0.147	0.000	0.000	0.000	0.081	0.081	0.090	773.30
98	0.000	0.000	0.000	0.152	0.000	0.000	0.000	0.083	0.083	0.093	798.18
99	0.200	0.000	0.200	0.063	0.000	0.000	0.000	0.035	0.035	0.038	331.71
100	0.000	0.000	0.000	0.127	0.000	0.000	0.000	0.070	0.070	0.077	667.57
101	0.000	0.000	0.000	0.148	0.000	0.000	0.000	0.081	0.081	0.090	779.52
102	0.000	0.000	0.000	0.119	0.000	0.000	0.000	0.065	0.065	0.073	626.10
103	0.000	0.000	0.000	0.104	0.000	0.000	0.000	0.057	0.057	0.064	549.40
104	0.000	0.000	0.000	0.031	0.000	0.000	0.000	0.017	0.017	0.019	163.78
105	0.010	0.000	0.010	0.022	0.000	0.000	0.000	0.012	0.012	0.013	116.10
106	0.000	0.000	0.000	0.088	0.000	0.000	0.000	0.049	0.049	0.054	464.40

	2000 c.e.								Irrigation		
Day	P (in.)	Q (Runoff in.)	P-Q (in)	PEt (in)	Cum Net P(in)	P Consumption (in)	P Excess(in)	ET_L (in)	Req't (in)	TWA (in)	TWA (gals)
107	0.000	0.000	0.000	0.161	0.000	0.000	0.000	0.089	0.089	0.098	847.94
108	0.000	0.000	0.000	0.147	0.000	0.000	0.000	0.081	0.081	0.090	775.37
109	0.000	0.000	0.000	0.158	0.000	0.000	0.000	0.087	0.087	0.097	833.42
110	0.000	0.000	0.000	0.174	0.000	0.000	0.000	0.095	0.095	0.106	914.28
111	0.000	0.000	0.000	0.159	0.000	0.000	0.000	0.087	0.087	0.097	835.50
112	0.000	0.000	0.000	0.111	0.000	0.000	0.000	0.061	0.061	0.068	582.57
113	0.000	0.000	0.000	0.136	0.000	0.000	0.000	0.075	0.075	0.083	715.25
114	0.000	0.000	0.000	0.094	0.000	0.000	0.000	0.052	0.052	0.057	493.42
115	0.120	0.000	0.120	0.023	0.000	0.000	0.000	0.013	0.013	0.014	122.32
116	0.000	0.000	0.000	0.063	0.000	0.000	0.000	0.034	0.034	0.038	329.64
117	0.020	0.000	0.020	0.150	0.000	0.000	0.000	0.082	0.082	0.091	787.81
118	0.090	0.000	0.090	0.171	0.000	0.000	0.000	0.094	0.094	0.105	901.84
119	0.140	0.000	0.140	0.126	0.000	0.000	0.000	0.069	0.069	0.077	661.35
120	0.000	0.000	0.000	0.161	0.000	0.000	0.000	0.089	0.089	0.098	847.94
121	0.000	0.000	0.000	0.186	0.000	0.000	0.000	0.102	0.102	0.114	980.62
122	0.010	0.000	0.010	0.191	0.000	0.000	0.000	0.105	0.105	0.117	1005.50
123	0.010	0.000	0.010	0.150	0.000	0.000	0.000	0.082	0.082	0.091	787.81
124	0.000	0.000	0.000	0.165	0.000	0.000	0.000	0.091	0.091	0.101	868.67
125	0.530	0.000	0.530	0.096	0.000	0.000	0.000	0.053	0.053	0.058	503.79
126	0.000	0.000	0.000	0.196	0.000	0.000	0.000	0.108	0.108	0.120	1032.45
127	0.000	0.000	0.000	0.187	0.000	0.000	0.000	0.103	0.103	0.115	986.84
128	0.000	0.000	0.000	0.200	0.000	0.000	0.000	0.110	0.110	0.122	1051.11
129	0.000	0.000	0.000	0.188	0.000	0.000	0.000	0.103	0.103	0.115	988.91
130	0.000	0.000	0.000	0.189	0.000	0.000	0.000	0.104	0.104	0.115	993.06
131	0.000	0.000	0.000	0.162	0.000	0.000	0.000	0.089	0.089	0.099	852.08
132	0.000	0.000	0.000	0.206	0.000	0.000	0.000	0.113	0.113	0.126	1082.21
133	0.000	0.000	0.000	0.214	0.000	0.000	0.000	0.118	0.118	0.131	1127.82
134	0.000	0.000	0.000	0.177	0.000	0.000	0.000	0.097	0.097	0.108	932.94
135	0.000	0.000	0.000	0.194	0.000	0.000	0.000	0.107	0.107	0.119	1024.16
136	0.000	0.000	0.000	0.188	0.000	0.000	0.000	0.104	0.104	0.115	990.99
137	0.000	0.000	0.000	0.188	0.000	0.000	0.000	0.104	0.104	0.115	990.99
138	0.000	0.000	0.000	0.114	0.000	0.000	0.000	0.063	0.063	0.070	601.23
139	0.000	0.000	0.000	0.181	0.000	0.000	0.000	0.100	0.100	0.111	953.67
140	0.000	0.000	0.000	0.218	0.000	0.000	0.000	0.120	0.120	0.133	1148.55
141	0.000	0.000	0.000	0.186	0.000	0.000	0.000	0.102	0.102	0.114	980.62
142	0.260	0.000	0.260	0.106	0.000	0.000	0.000	0.058	0.058	0.065	557.69
143	0.010	0.000	0.010	0.212	0.000	0.000	0.000	0.116	0.116	0.129	1115.38

	2000 c.e.								Irrigation		
Day	P (in.)	Q (Runoff in.)	P-Q (in)	PEt (in)	Cum Net P(in)	P Consumption (in)	P Excess(in)	ET_L (in)	Req't (in)	TWA (in)	TWA (gals)
144	0.290	0.000	0.290	0.123	0.000	0.000	0.000	0.068	0.068	0.075	648.91
145	0.000	0.000	0.000	0.187	0.000	0.000	0.000	0.103	0.103	0.114	984.77
146	0.170	0.000	0.170	0.153	0.000	0.000	0.000	0.084	0.084	0.094	806.47
147	0.000	0.000	0.000	0.169	0.000	0.000	0.000	0.093	0.093	0.103	889.40
148	0.000	0.000	0.000	0.223	0.000	0.000	0.000	0.123	0.123	0.136	1175.50
149	0.010	0.000	0.010	0.124	0.000	0.000	0.000	0.068	0.068	0.076	655.13
150	0.000	0.000	0.000	0.200	0.000	0.000	0.000	0.110	0.110	0.122	1053.18
151	0.000	0.000	0.000	0.213	0.000	0.000	0.000	0.117	0.117	0.130	1121.60
152	0.000	0.000	0.000	0.217	0.000	0.000	0.000	0.120	0.120	0.133	1144.40
153	0.000	0.000	0.000	0.233	0.000	0.000	0.000	0.128	0.128	0.143	1229.40
154	0.000	0.000	0.000	0.240	0.000	0.000	0.000	0.132	0.132	0.147	1262.57
155	0.000	0.000	0.000	0.218	0.000	0.000	0.000	0.120	0.120	0.133	1146.48
156	0.000	0.000	0.000	0.080	0.000	0.000	0.000	0.044	0.044	0.049	422.93
157	0.360	0.000	0.360	0.054	0.000	0.000	0.000	0.030	0.030	0.033	286.10
158	0.000	0.000	0.000	0.217	0.000	0.000	0.000	0.119	0.119	0.132	1140.26
159	0.000	0.000	0.000	0.215	0.000	0.000	0.000	0.118	0.118	0.132	1134.04
160	0.000	0.000	0.000	0.219	0.000	0.000	0.000	0.120	0.120	0.134	1152.70
161	0.000	0.000	0.000	0.238	0.000	0.000	0.000	0.131	0.131	0.146	1254.28
162	0.000	0.000	0.000	0.213	0.000	0.000	0.000	0.117	0.117	0.130	1119.52
163	0.000	0.000	0.000	0.222	0.000	0.000	0.000	0.122	0.122	0.136	1169.28
164	0.000	0.000	0.000	0.231	0.000	0.000	0.000	0.127	0.127	0.141	1219.04
165	0.000	0.000	0.000	0.207	0.000	0.000	0.000	0.114	0.114	0.127	1090.50
166	0.070	0.000	0.070	0.249	0.000	0.000	0.000	0.137	0.137	0.152	1310.26
167	0.010	0.000	0.010	0.208	0.000	0.000	0.000	0.114	0.114	0.127	1094.65
168	0.480	0.000	0.480	0.135	0.000	0.000	0.000	0.074	0.074	0.083	713.18
169	0.100	0.000	0.100	0.208	0.000	0.000	0.000	0.114	0.114	0.127	1094.65
170	0.070	0.000	0.070	0.202	0.000	0.000	0.000	0.111	0.111	0.124	1065.62
171	0.100	0.000	0.100	0.116	0.000	0.000	0.000	0.064	0.064	0.071	609.52
172	0.000	0.000	0.000	0.154	0.000	0.000	0.000	0.084	0.084	0.094	808.55
173	0.140	0.000	0.140	0.136	0.000	0.000	0.000	0.075	0.075	0.083	717.32
174	0.000	0.000	0.000	0.191	0.000	0.000	0.000	0.105	0.105	0.117	1007.57
175	0.000	0.000	0.000	0.247	0.000	0.000	0.000	0.136	0.136	0.151	1299.89
176	0.000	0.000	0.000	0.193	0.000	0.000	0.000	0.106	0.106	0.118	1015.86
177	0.000	0.000	0.000	0.139	0.000	0.000	0.000	0.076	0.076	0.085	729.76
178	0.760	0.000	0.760	0.239	0.000	0.000	0.000	0.131	0.131	0.146	1256.35
179	0.010	0.000	0.010	0.205	0.000	0.000	0.000	0.113	0.113	0.125	1078.06
180	0.050	0.000	0.050	0.128	0.000	0.000	0.000	0.071	0.071	0.078	675.86

Day	2000 c.e. P (in.)	Q (Runoff in.)	P-Q (in)	PEt (in)	Cum Net P(in)	P Consumption (in)	P Excess(in)	ET_L (in)	Irrigation Req't (in)	TWA (in)	TWA (gals)
181	0.310	0.000	0.310	0.086	0.000	0.000	0.000	0.047	0.047	0.052	451.96
182	0.000	0.000	0.000	0.204	0.000	0.000	0.000	0.112	0.112	0.125	1073.91
183	0.000	0.000	0.000	0.219	0.000	0.000	0.000	0.121	0.121	0.134	1154.77
184	0.000	0.000	0.000	0.206	0.000	0.000	0.000	0.113	0.113	0.126	1082.21
185	0.000	0.000	0.000	0.213	0.000	0.000	0.000	0.117	0.117	0.130	1119.52
186	0.000	0.000	0.000	0.196	0.000	0.000	0.000	0.108	0.108	0.120	1030.38
187	0.000	0.000	0.000	0.202	0.000	0.000	0.000	0.111	0.111	0.123	1061.47
188	0.000	0.000	0.000	0.165	0.000	0.000	0.000	0.091	0.091	0.101	868.67
189	0.000	0.000	0.000	0.217	0.000	0.000	0.000	0.119	0.119	0.133	1142.33
190	0.000	0.000	0.000	0.192	0.000	0.000	0.000	0.105	0.105	0.117	1009.64
191	0.000	0.000	0.000	0.173	0.000	0.000	0.000	0.095	0.095	0.106	912.20
192	0.010	0.000	0.010	0.178	0.000	0.000	0.000	0.098	0.098	0.109	935.01
193	0.150	0.000	0.150	0.226	0.000	0.000	0.000	0.125	0.125	0.138	1192.09
194	0.000	0.000	0.000	0.101	0.000	0.000	0.000	0.056	0.056	0.062	532.81
195	0.000	0.000	0.000	0.137	0.000	0.000	0.000	0.075	0.075	0.083	719.40
196	0.000	0.000	0.000	0.192	0.000	0.000	0.000	0.106	0.106	0.117	1011.72
197	0.000	0.000	0.000	0.244	0.000	0.000	0.000	0.134	0.134	0.149	1287.45
198	0.000	0.000	0.000	0.218	0.000	0.000	0.000	0.120	0.120	0.133	1148.55
199	0.000	0.000	0.000	0.225	0.000	0.000	0.000	0.124	0.124	0.138	1185.87
200	0.000	0.000	0.000	0.220	0.000	0.000	0.000	0.121	0.121	0.135	1160.99
201	0.000	0.000	0.000	0.166	0.000	0.000	0.000	0.091	0.091	0.101	872.81
202	0.000	0.000	0.000	0.243	0.000	0.000	0.000	0.134	0.134	0.149	1281.23
203	0.000	0.000	0.000	0.209	0.000	0.000	0.000	0.115	0.115	0.128	1102.94
204	0.000	0.000	0.000	0.189	0.000	0.000	0.000	0.104	0.104	0.115	995.13
205	0.310	0.000	0.310	0.118	0.000	0.000	0.000	0.065	0.065	0.072	619.88
206	0.520	0.000	0.520	0.124	0.000	0.000	0.000	0.068	0.068	0.076	655.13
207	0.010	0.000	0.010	0.056	0.000	0.000	0.000	0.031	0.031	0.034	296.47
208	0.000	0.000	0.000	0.138	0.000	0.000	0.000	0.076	0.076	0.084	725.62
209	0.000	0.000	0.000	0.159	0.000	0.000	0.000	0.087	0.087	0.097	835.50
210	0.000	0.000	0.000	0.200	0.000	0.000	0.000	0.110	0.110	0.122	1053.18
211	0.000	0.000	0.000	0.197	0.000	0.000	0.000	0.108	0.108	0.121	1038.67
212	0.030	0.000	0.030	0.168	0.000	0.000	0.000	0.092	0.092	0.103	885.25
213	1.450	0.000	1.450	0.107	0.000	0.000	0.000	0.059	0.059	0.065	563.91
214	0.040	0.000	0.040	0.126	0.000	0.000	0.000	0.070	0.070	0.077	665.49
215	0.410	0.000	0.410	0.115	0.000	0.000	0.000	0.063	0.063	0.070	607.45
216	0.040	0.000	0.040	0.137	0.000	0.000	0.000	0.075	0.075	0.084	721.47
217	0.120	0.000	0.120	0.129	0.000	0.000	0.000	0.071	0.071	0.079	677.93

Day	2000 c.e. P (in.)	Q (Runoff in.)	P-Q (in)	PEt (in)	Cum Net P(in)	P Consumption (in)	P Excess(in)	ET_L (in)	Irrigation Req't (in)	TWA (in)	TWA (gals)
218	0.010	0.000	0.010	0.202	0.000	0.000	0.000	0.111	0.111	0.124	1065.62
219	0.000	0.000	0.000	0.157	0.000	0.000	0.000	0.087	0.087	0.096	829.28
220	0.000	0.000	0.000	0.216	0.000	0.000	0.000	0.119	0.119	0.132	1138.18
221	0.000	0.000	0.000	0.200	0.000	0.000	0.000	0.110	0.110	0.122	1053.18
222	0.000	0.000	0.000	0.220	0.000	0.000	0.000	0.121	0.121	0.134	1158.91
223	0.010	0.000	0.010	0.193	0.000	0.000	0.000	0.106	0.106	0.118	1015.86
224	0.020	0.000	0.020	0.172	0.000	0.000	0.000	0.095	0.095	0.105	908.06
225	0.000	0.000	0.000	0.208	0.000	0.000	0.000	0.114	0.114	0.127	1094.65
226	0.000	0.000	0.000	0.202	0.000	0.000	0.000	0.111	0.111	0.124	1065.62
227	0.000	0.000	0.000	0.198	0.000	0.000	0.000	0.109	0.109	0.121	1040.74
228	0.000	0.000	0.000	0.207	0.000	0.000	0.000	0.114	0.114	0.127	1090.50
229	0.000	0.000	0.000	0.209	0.000	0.000	0.000	0.115	0.115	0.128	1100.87
230	0.000	0.000	0.000	0.207	0.000	0.000	0.000	0.114	0.114	0.126	1088.43
231	0.000	0.000	0.000	0.205	0.000	0.000	0.000	0.113	0.113	0.125	1080.13
232	0.000	0.000	0.000	0.169	0.000	0.000	0.000	0.093	0.093	0.103	891.47
233	0.000	0.000	0.000	0.095	0.000	0.000	0.000	0.052	0.052	0.058	501.71
234	0.050	0.000	0.050	0.094	0.000	0.000	0.000	0.052	0.052	0.058	495.49
235	0.000	0.000	0.000	0.141	0.000	0.000	0.000	0.078	0.078	0.086	744.28
236	0.000	0.000	0.000	0.166	0.000	0.000	0.000	0.091	0.091	0.101	872.81
237	0.480	0.000	0.480	0.148	0.000	0.000	0.000	0.081	0.081	0.090	779.52
238	0.320	0.000	0.320	0.177	0.000	0.000	0.000	0.097	0.097	0.108	932.94
239	0.000	0.000	0.000	0.183	0.000	0.000	0.000	0.101	0.101	0.112	964.03
240	0.150	0.000	0.150	0.059	0.000	0.000	0.000	0.032	0.032	0.036	310.98
241	0.000	0.000	0.000	0.162	0.000	0.000	0.000	0.089	0.089	0.099	852.08
242	0.000	0.000	0.000	0.161	0.000	0.000	0.000	0.089	0.089	0.099	850.01
243	0.000	0.000	0.000	0.129	0.000	0.000	0.000	0.071	0.071	0.079	677.93
244	1.610	0.000	1.610	0.034	0.000	0.000	0.000	0.019	0.019	0.021	180.37
245	0.490	0.000	0.490	0.060	0.000	0.000	0.000	0.033	0.033	0.037	315.13
246	0.120	0.000	0.120	0.075	0.000	0.000	0.000	0.041	0.041	0.046	395.98
247	0.680	0.000	0.680	0.122	0.000	0.000	0.000	0.067	0.067	0.074	640.62
248	0.060	0.000	0.060	0.141	0.000	0.000	0.000	0.077	0.077	0.086	740.13
249	0.200	0.000	0.200	0.073	0.000	0.000	0.000	0.040	0.040	0.045	383.54
250	0.220	0.000	0.220	0.030	0.000	0.000	0.000	0.017	0.017	0.019	159.64
251	0.160	0.000	0.160	0.028	0.000	0.000	0.000	0.015	0.015	0.017	147.20
252	0.000	0.000	0.000	0.105	0.000	0.000	0.000	0.058	0.058	0.064	551.47
253	0.000	0.000	0.000	0.080	0.000	0.000	0.000	0.044	0.044	0.049	420.86
254	0.000	0.000	0.000	0.158	0.000	0.000	0.000	0.087	0.087	0.097	833.42

	2000 c.e.								Irrigation		
Day	P (in.)	Q (Runoff in.)	P-Q (in)	PEt (in)	Cum Net P(in)	P Consumption (in)	P Excess(in)	ET_L (in)	Req't (in)	TWA (in)	TWA (gals)
255	0.000	0.000	0.000	0.140	0.000	0.000	0.000	0.077	0.077	0.086	738.06
256	0.000	0.000	0.000	0.141	0.000	0.000	0.000	0.078	0.078	0.086	742.20
257	0.000	0.000	0.000	0.136	0.000	0.000	0.000	0.075	0.075	0.083	715.25
258	0.080	0.000	0.080	0.118	0.000	0.000	0.000	0.065	0.065	0.072	621.96
259	0.000	0.000	0.000	0.160	0.000	0.000	0.000	0.088	0.088	0.098	843.79
260	0.000	0.000	0.000	0.141	0.000	0.000	0.000	0.078	0.078	0.086	742.20
261	0.000	0.000	0.000	0.109	0.000	0.000	0.000	0.060	0.060	0.067	576.35
262	0.130	0.000	0.130	0.035	0.000	0.000	0.000	0.019	0.019	0.021	182.44
263	0.010	0.000	0.010	0.143	0.000	0.000	0.000	0.079	0.079	0.088	754.64
264	0.000	0.000	0.000	0.131	0.000	0.000	0.000	0.072	0.072	0.080	690.37
265	0.290	0.000	0.290	0.015	0.000	0.000	0.000	0.008	0.008	0.009	78.78
266	1.120	0.000	1.120	0.030	0.000	0.000	0.000	0.016	0.016	0.018	155.49
267	0.010	0.000	0.010	0.106	0.000	0.000	0.000	0.058	0.058	0.065	559.76
268	0.120	0.000	0.120	0.128	0.000	0.000	0.000	0.070	0.070	0.078	673.79
269	0.440	0.000	0.440	0.080	0.000	0.000	0.000	0.044	0.044	0.049	418.78
270	0.000	0.000	0.000	0.121	0.000	0.000	0.000	0.067	0.067	0.074	638.54
271	0.000	0.000	0.000	0.117	0.000	0.000	0.000	0.065	0.065	0.072	617.81
272	0.000	0.000	0.000	0.120	0.000	0.000	0.000	0.066	0.066	0.074	634.40
273	0.000	0.000	0.000	0.122	0.000	0.000	0.000	0.067	0.067	0.075	642.69
274	0.000	0.000	0.000	0.105	0.000	0.000	0.000	0.058	0.058	0.064	553.54
275	0.000	0.000	0.000	0.115	0.000	0.000	0.000	0.063	0.063	0.070	603.30
276	0.000	0.000	0.000	0.117	0.000	0.000	0.000	0.065	0.065	0.072	617.81
277	0.000	0.000	0.000	0.125	0.000	0.000	0.000	0.069	0.069	0.076	657.20
278	0.000	0.000	0.000	0.124	0.000	0.000	0.000	0.068	0.068	0.076	650.98
279	0.000	0.000	0.000	0.122	0.000	0.000	0.000	0.067	0.067	0.075	644.76
280	0.180	0.000	0.180	0.028	0.000	0.000	0.000	0.015	0.015	0.017	145.12
281	0.000	0.000	0.000	0.081	0.000	0.000	0.000	0.045	0.045	0.050	429.15
282	0.000	0.000	0.000	0.063	0.000	0.000	0.000	0.035	0.035	0.039	333.78
283	0.000	0.000	0.000	0.085	0.000	0.000	0.000	0.047	0.047	0.052	447.81
284	0.000	0.000	0.000	0.088	0.000	0.000	0.000	0.048	0.048	0.054	462.32
285	0.000	0.000	0.000	0.094	0.000	0.000	0.000	0.052	0.052	0.058	495.49
286	0.000	0.000	0.000	0.095	0.000	0.000	0.000	0.052	0.052	0.058	501.71
287	0.000	0.000	0.000	0.098	0.000	0.000	0.000	0.054	0.054	0.060	516.22
288	0.000	0.000	0.000	0.098	0.000	0.000	0.000	0.054	0.054	0.060	518.30
289	0.000	0.000	0.000	0.098	0.000	0.000	0.000	0.054	0.054	0.060	518.30
290	0.000	0.000	0.000	0.098	0.000	0.000	0.000	0.054	0.054	0.060	518.30
291	0.000	0.000	0.000	0.095	0.000	0.000	0.000	0.052	0.052	0.058	499.64

Day	2000 c.e. P (in.)	Q (Runoff in.)	P-Q (in)	PEt (in)	Cum Net P(in)	P Consumption (in)	P Excess(in)	ET_L (in)	Irrigation Req't (in)	TWA (in)	TWA (gals)
292	0.000	0.000	0.000	0.087	0.000	0.000	0.000	0.048	0.048	0.053	460.25
293	0.000	0.000	0.000	0.080	0.000	0.000	0.000	0.044	0.044	0.049	418.78
294	0.000	0.000	0.000	0.046	0.000	0.000	0.000	0.025	0.025	0.028	240.49
295	0.000	0.000	0.000	0.081	0.000	0.000	0.000	0.045	0.045	0.050	429.15
296	0.000	0.000	0.000	0.082	0.000	0.000	0.000	0.045	0.045	0.050	431.22
297	0.000	0.000	0.000	0.078	0.000	0.000	0.000	0.043	0.043	0.048	410.49
298	0.000	0.000	0.000	0.078	0.000	0.000	0.000	0.043	0.043	0.048	410.49
299	0.000	0.000	0.000	0.078	0.000	0.000	0.000	0.043	0.043	0.047	408.42
300	0.000	0.000	0.000	0.072	0.000	0.000	0.000	0.040	0.040	0.044	379.39
301	0.000	0.000	0.000	0.076	0.000	0.000	0.000	0.042	0.042	0.047	402.20
302	0.000	0.000	0.000	0.082	0.000	0.000	0.000	0.045	0.045	0.050	433.30
303	0.000	0.000	0.000	0.075	0.000	0.000	0.000	0.041	0.041	0.046	395.98
304	0.000	0.000	0.000	0.076	0.000	0.000	0.000	0.042	0.042	0.047	402.20
305	0.000	0.000	0.000	0.075	0.000	0.000	0.000	0.041	0.041	0.046	395.98
306	0.000	0.000	0.000	0.071	0.000	0.000	0.000	0.039	0.039	0.043	373.17
307	0.000	0.000	0.000	0.069	0.000	0.000	0.000	0.038	0.038	0.042	364.88
308	0.000	0.000	0.000	0.064	0.000	0.000	0.000	0.035	0.035	0.039	337.93
309	0.200	0.000	0.200	0.016	0.000	0.000	0.000	0.009	0.009	0.010	85.00
310	0.000	0.000	0.000	0.036	0.000	0.000	0.000	0.020	0.020	0.022	188.66
311	0.000	0.000	0.000	0.006	0.000	0.000	0.000	0.003	0.003	0.004	33.17
312	0.000	0.000	0.000	0.011	0.000	0.000	0.000	0.006	0.006	0.006	55.98
313	0.140	0.000	0.140	0.029	0.000	0.000	0.000	0.016	0.016	0.018	153.42
314	1.580	0.000	1.580	0.006	0.000	0.000	0.000	0.003	0.003	0.003	29.02
315	0.000	0.000	0.000	0.054	0.000	0.000	0.000	0.029	0.029	0.033	281.95
316	0.000	0.000	0.000	0.049	0.000	0.000	0.000	0.027	0.027	0.030	257.08
317	0.000	0.000	0.000	0.045	0.000	0.000	0.000	0.025	0.025	0.028	238.42
318	0.040	0.000	0.040	0.019	0.000	0.000	0.000	0.010	0.010	0.012	99.51
319	0.080	0.000	0.080	0.050	0.000	0.000	0.000	0.027	0.027	0.031	263.30
320	0.000	0.000	0.000	0.041	0.000	0.000	0.000	0.023	0.023	0.025	217.69
321	0.240	0.000	0.240	0.011	0.000	0.000	0.000	0.006	0.006	0.007	60.12
322	0.090	0.000	0.090	0.014	0.000	0.000	0.000	0.008	0.008	0.009	74.63
323	0.420	0.000	0.420	0.009	0.000	0.000	0.000	0.005	0.005	0.006	49.76
324	0.980	0.000	0.980	0.004	0.000	0.000	0.000	0.002	0.002	0.002	18.66
325	0.000	0.000	0.000	0.036	0.000	0.000	0.000	0.020	0.020	0.022	190.73
326	0.000	0.000	0.000	0.033	0.000	0.000	0.000	0.018	0.018	0.020	176.22
327	0.000	0.000	0.000	0.033	0.000	0.000	0.000	0.018	0.018	0.020	174.15
328	0.000	0.000	0.000	0.020	0.000	0.000	0.000	0.011	0.011	0.012	103.66

	2000 c.e.								Irrigation		
Day	P (in.)	Q (Runoff in.)	P-Q (in)	PEt (in)	Cum Net P(in)	P Consumption (in)	P Excess(in)	ET_L (in)	Req't (in)	TWA (in)	TWA (gals)
329	0.580	0.000	0.580	0.015	0.000	0.000	0.000	0.008	0.008	0.009	80.85
330	0.810	0.000	0.810	0.005	0.000	0.000	0.000	0.003	0.003	0.003	24.88
331	0.000	0.000	0.000	0.017	0.000	0.000	0.000	0.009	0.009	0.010	89.15
332	0.000	0.000	0.000	0.030	0.000	0.000	0.000	0.016	0.016	0.018	155.49
333	0.000	0.000	0.000	0.031	0.000	0.000	0.000	0.017	0.017	0.019	163.78
334	0.020	0.000	0.020	0.011	0.000	0.000	0.000	0.006	0.006	0.007	60.12
335	0.010	0.000	0.010	0.030	0.000	0.000	0.000	0.017	0.017	0.019	159.64
336	0.000	0.000	0.000	0.026	0.000	0.000	0.000	0.014	0.014	0.016	136.83
337	0.070	0.000	0.070	0.005	0.000	0.000	0.000	0.003	0.003	0.003	24.88
338	0.140	0.000	0.140	0.007	0.000	0.000	0.000	0.004	0.004	0.004	37.32
339	0.000	0.000	0.000	0.024	0.000	0.000	0.000	0.013	0.013	0.014	124.39
340	0.000	0.000	0.000	0.024	0.000	0.000	0.000	0.013	0.013	0.014	124.39
341	0.000	0.000	0.000	0.015	0.000	0.000	0.000	0.008	0.008	0.009	80.85
342	0.000	0.000	0.000	0.022	0.000	0.000	0.000	0.012	0.012	0.013	116.10
343	0.000	0.000	0.000	0.022	0.000	0.000	0.000	0.012	0.012	0.014	118.17
344	0.170	0.000	0.170	0.006	0.000	0.000	0.000	0.003	0.003	0.004	31.10
345	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.002	0.002	0.002	20.73
346	0.000	0.000	0.000	0.007	0.000	0.000	0.000	0.004	0.004	0.005	39.39
347	0.020	0.000	0.020	0.019	0.000	0.000	0.000	0.010	0.010	0.012	99.51
348	0.070	0.000	0.070	0.002	0.000	0.000	0.000	0.001	0.001	0.001	12.44
349	0.250	0.000	0.250	0.006	0.000	0.000	0.000	0.003	0.003	0.004	31.10
350	0.790	0.000	0.790	0.003	0.000	0.000	0.000	0.002	0.002	0.002	16.59
351	1.350	0.000	1.350	0.001	0.000	0.000	0.000	0.000	0.000	0.000	4.15
352	0.010	0.000	0.010	0.010	0.000	0.000	0.000	0.006	0.006	0.006	53.90
353	0.000	0.000	0.000	0.014	0.000	0.000	0.000	0.008	0.008	0.009	74.63
354	0.070	0.000	0.070	0.005	0.000	0.000	0.000	0.003	0.003	0.003	24.88
355	0.070	0.000	0.070	0.015	0.000	0.000	0.000	0.008	0.008	0.009	76.71
356	0.020	0.000	0.020	0.003	0.000	0.000	0.000	0.002	0.002	0.002	14.51
357	0.160	0.000	0.160	0.012	0.000	0.000	0.000	0.007	0.007	0.007	64.27
358	0.000	0.000	0.000	0.012	0.000	0.000	0.000	0.007	0.007	0.007	64.27
359	0.000	0.000	0.000	0.008	0.000	0.000	0.000	0.004	0.004	0.005	41.46
360	0.000	0.000	0.000	0.009	0.000	0.000	0.000	0.005	0.005	0.005	45.61
361	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.002	0.002	0.002	18.66
362	0.100	0.000	0.100	0.001	0.000	0.000	0.000	0.001	0.001	0.001	6.22
363	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.001	0.001	6.22
364	0.000	0.000	0.000	0.006	0.000	0.000	0.000	0.003	0.003	0.004	33.17
365	0.010	0.000	0.010	0.006	0.000	0.000	0.000	0.003	0.003	0.003	29.02

Day	2000 c.e. P (in.)	Q (Runoff in.)	P-Q (in)	PEt (in)	Cum Net P(in)	P Consumption (in)	P Excess(in)	ET_L (in)	Irrigation Req't (in)	TWA (in)	TWA (gals)
Total	33.769							20.364	18.878	20.975	180740.94

APPENDIX B

IRRIGATION WATER SUPPLY - 2000

IRRIGATION WATER SUPPLY - 2000

Roof Catchment Area(sf):	15480
Runoff Coefficient (E):	0.9
Conversion factor (gals.)	7.48/12

Storage cap.(gals.):	60000.00
Stor. End of prior yr:	0.00

2000 c.e. Day	P	Q_{HARV} (gals)	Cum. Q_{HARV} (gals)	(KL = .55) TWA (gals)	Storage at end of prior day (gals)	Change in Storage (gals)	Harvested water used for irgn(gals)	Overflow (gals)	Suppl. Water req'd (gals)
1	0.02	173.69	173.69	62.20	0.00	111.49	62.20	0.00	0.00
2	0.01	86.84	260.53	0.00	111.49	111.49	0.00	0.00	0.00
3	0.00	0.00	260.53	97.44	198.33	86.84	97.44	0.00	0.00
4	0.18	1563.17	1823.70	0.00	100.89	-97.44	0.00	0.00	0.00
5	0.00	0.00	1823.70	0.00	1664.06	1563.17	0.00	0.00	0.00
6	0.00	0.00	1823.70	0.00	1664.06	0.00	0.00	0.00	0.00
7	0.00	0.00	1823.70	0.00	1664.06	0.00	0.00	0.00	0.00
8	0.00	0.00	1823.70	0.00	1664.06	0.00	0.00	0.00	0.00
9	0.71	6164.46	7988.15	0.00	1664.06	0.00	0.00	0.00	0.00
10	1.03	8944.11	16932.26	0.00	7828.52	6164.46	0.00	0.00	0.00
11	0.00	0.00	16932.26	0.00	16772.62	8944.11	0.00	0.00	0.00
12	0.00	0.00	16932.26	0.00	16772.62	0.00	0.00	0.00	0.00
13	0.01	86.84	17019.10	0.00	16772.62	0.00	0.00	0.00	0.00
14	0.00	0.00	17019.10	0.00	16859.47	86.84	0.00	0.00	0.00
15	0.00	0.00	17019.10	0.00	16859.47	0.00	0.00	0.00	0.00
16	0.02	173.69	17192.79	0.00	16859.47	0.00	0.00	0.00	0.00
17	0.02	173.69	17366.47	0.00	17033.15	173.69	0.00	0.00	0.00
18	0.13	1128.95	18495.43	0.00	17206.84	173.69	0.00	0.00	0.00
19	0.55	4776.34	23271.77	0.00	18335.79	1128.95	0.00	0.00	0.00
20	0.03	260.53	23532.30	0.00	23112.14	4776.34	0.00	0.00	0.00
21	0.00	0.00	23532.30	0.00	23372.66	260.53	0.00	0.00	0.00
22	0.00	0.00	23532.30	0.00	23372.66	0.00	0.00	0.00	0.00
23	0.80	6947.41	30479.71	0.00	23372.66	0.00	0.00	0.00	0.00
24	0.38	3299.34	33779.05	0.00	30320.07	6947.41	0.00	0.00	0.00
25	0.00	0.00	33779.05	0.00	33619.41	3299.34	0.00	0.00	0.00
26	0.00	0.00	33779.05	0.00	33619.41	0.00	0.00	0.00	0.00
27	0.00	0.00	33779.05	0.00	33619.41	0.00	0.00	0.00	0.00
28	0.00	0.00	33779.05	0.00	33619.41	0.00	0.00	0.00	0.00
29	0.06	521.06	34300.10	0.00	33619.41	0.00	0.00	0.00	0.00
30	0.59	5125.08	39425.18	0.00	34140.47	521.06	0.00	0.00	0.00
31	0.17	1476.32	40901.51	0.00	39265.55	5125.08	0.00	0.00	0.00
32	0.00	0.00	40901.51	0.00	40741.87	1476.32	0.00	0.00	0.00

2000 c.e. Day	P	Q_{HARV} (gals)	Cum. Q_{HARV} (gals)	(KL = .55) TWA (gals)	Storage at end of prior day (gals)	Change in Storage (gals)	Harvested water used for irgn(gals)	Overflow (gals)	Suppl. Water req'd (gals)
33	0.00	0.00	40901.51	0.00	40741.87	0.00	0.00	0.00	0.00
34	0.00	0.00	40901.51	0.00	40741.87	0.00	0.00	0.00	0.00
35	0.00	0.00	40901.51	0.00	40741.87	0.00	0.00	0.00	0.00
36	0.00	0.00	40901.51	0.00	40741.87	0.00	0.00	0.00	0.00
37	0.00	0.00	40901.51	0.00	40741.87	0.00	0.00	0.00	0.00
38	0.00	0.00	40901.51	0.00	40741.87	0.00	0.00	0.00	0.00
39	0.00	0.00	40901.51	0.00	40741.87	0.00	0.00	0.00	0.00
40	0.00	0.00	40901.51	0.00	40741.87	0.00	0.00	0.00	0.00
41	0.00	0.00	40901.51	0.00	40741.87	0.00	0.00	0.00	0.00
42	0.00	0.00	40901.51	0.00	40741.87	0.00	0.00	0.00	0.00
43	0.07	607.90	41509.41	0.00	40741.87	0.00	0.00	0.00	0.00
44	0.25	2171.07	43680.47	0.00	41349.77	607.90	0.00	0.00	0.00
45	1.27	11029.70	54710.17	0.00	43520.84	2171.07	0.00	0.00	0.00
46	0.00	0.00	54710.17	0.00	54550.53	11029.70	0.00	0.00	0.00
47	0.00	0.00	54710.17	0.00	54550.53	0.00	0.00	0.00	0.00
48	0.05	434.21	55144.38	0.00	54550.53	0.00	0.00	0.00	0.00
49	0.01	86.84	55231.23	0.00	54984.75	434.21	0.00	0.00	0.00
50	0.00	0.00	55231.23	0.00	55071.59	86.84	0.00	0.00	0.00
51	0.00	0.00	55231.23	0.00	55071.59	0.00	0.00	0.00	0.00
52	0.00	0.00	55231.23	0.00	55071.59	0.00	0.00	0.00	0.00
53	0.00	0.00	55231.23	0.00	55071.59	0.00	0.00	0.00	0.00
54	0.00	0.00	55231.23	0.00	55071.59	0.00	0.00	0.00	0.00
55	0.00	0.00	55231.23	0.00	55071.59	0.00	0.00	0.00	0.00
56	0.00	0.00	55231.23	0.00	55071.59	0.00	0.00	0.00	0.00
57	0.00	0.00	55231.23	0.00	55071.59	0.00	0.00	0.00	0.00
58	0.23	1997.38	57228.61	0.00	55071.59	0.00	0.00	0.00	0.00
59	0.00	0.00	57228.61	0.00	57068.97	1997.38	0.00	0.00	0.00
60	0.00	0.00	57228.61	0.00	57068.97	0.00	0.00	0.00	0.00
61	0.00	0.00	57228.61	0.00	57068.97	0.00	0.00	0.00	0.00
62	0.00	0.00	57228.61	0.00	57068.97	0.00	0.00	0.00	0.00
63	0.00	0.00	57228.61	0.00	57068.97	0.00	0.00	0.00	0.00
64	0.33	2865.12	60093.73	0.00	57068.97	0.00	0.00	0.00	0.00
65	0.00	0.00	60093.73	0.00	59934.09	2865.12	0.00	0.00	0.00
66	0.00	0.00	60093.73	0.00	59934.09	0.00	0.00	0.00	0.00
67	0.00	0.00	60093.73	580.49	59934.09	0.00	580.49	0.00	0.00
68	0.00	0.00	60093.73	592.93	59353.60	-580.49	592.93	0.00	0.00
69	0.00	0.00	60093.73	518.30	58760.67	-592.93	518.30	0.00	0.00

2000 c.e. Day	P	Q_{HARV} (gals)	Cum. Q_{HARV} (gals)	(KL = .55) TWA (gals)	Storage at end of prior day (gals)	Change in Storage (gals)	Harvested water used for irgn(gals)	Overflow (gals)	Suppl. Water req'd (gals)
70	0.00	0.00	60093.73	366.96	58242.37	-518.30	366.96	0.00	0.00
71	0.46	3993.39	64087.12	157.56	57875.41	-366.96	157.56	1711.24	0.00
72	0.00	0.00	64087.12	474.76	60000.00	2124.59	474.76	0.00	0.00
73	0.00	0.00	64087.12	489.27	59525.24	-474.76	489.27	0.00	0.00
74	0.00	0.00	64087.12	524.52	59035.97	-489.27	524.52	0.00	0.00
75	0.00	0.00	64087.12	373.17	58511.45	-524.52	373.17	0.00	0.00
76	0.70	6078.98	70166.11	82.93	58138.27	-373.17	82.93	4134.33	0.00
77	0.00	0.00	70166.11	640.62	60000.00	1861.73	640.62	0.00	0.00
78	0.00	0.00	70166.11	271.59	59359.38	-640.62	271.59	0.00	0.00
79	0.32	2779.65	72945.75	68.42	59087.80	-271.59	68.42	1799.03	0.00
80	1.11	9638.16	82583.92	489.27	60000.00	912.20	489.27	9148.89	0.00
81	0.00	0.00	82583.92	553.54	60000.00	0.00	553.54	0.00	0.00
82	0.00	0.00	82583.92	609.52	59446.46	-553.54	609.52	0.00	0.00
83	0.00	0.00	82583.92	669.64	58836.94	-609.52	669.64	0.00	0.00
84	0.00	0.00	82583.92	667.57	58167.30	-669.64	667.57	0.00	0.00
85	0.00	0.00	82583.92	574.27	57499.73	-667.57	574.27	0.00	0.00
86	0.00	0.00	82583.92	599.15	56925.46	-574.27	599.15	0.00	0.00
87	0.13	1128.95	83712.87	163.78	56326.30	-599.15	163.78	0.00	0.00
88	0.00	0.00	83712.87	684.15	57291.47	965.17	684.15	0.00	0.00
89	0.00	0.00	83712.87	244.64	56607.32	-684.15	244.64	0.00	0.00
90	0.07	607.90	84320.77	369.03	56362.68	-244.64	369.03	0.00	0.00
91	0.00	0.00	84320.77	590.86	56601.55	238.87	590.86	0.00	0.00
92	0.00	0.00	84320.77	690.37	56010.69	-590.86	690.37	0.00	0.00
93	0.43	3733.55	88054.32	138.90	55320.32	-690.37	138.90	0.00	0.00
94	0.69	5993.51	94047.83	259.15	58914.97	3594.65	259.15	4649.33	0.00
95	0.07	607.90	94655.73	466.47	60000.00	1085.03	466.47	141.43	0.00
96	0.00	0.00	94655.73	667.57	60000.00	0.00	667.57	0.00	0.00
97	0.00	0.00	94655.73	773.30	59332.43	-667.57	773.30	0.00	0.00
98	0.00	0.00	94655.73	798.18	58559.13	-773.30	798.18	0.00	0.00
99	0.20	1736.85	96392.58	331.71	57760.95	-798.18	331.71	0.00	0.00
100	0.00	0.00	96392.58	667.57	59166.09	1405.14	667.57	0.00	0.00
101	0.00	0.00	96392.58	779.52	58498.53	-667.57	779.52	0.00	0.00
102	0.00	0.00	96392.58	626.10	57719.01	-779.52	626.10	0.00	0.00
103	0.00	0.00	96392.58	549.40	57092.90	-626.10	549.40	0.00	0.00
104	0.00	0.00	96392.58	163.78	56543.50	-549.40	163.78	0.00	0.00
105	0.01	86.84	96479.42	116.10	56379.72	-163.78	116.10	0.00	0.00
106	0.00	0.00	96479.42	464.40	56350.47	-29.26	464.40	0.00	0.00

2000 c.e. Day	P	Q_{HARV} (gals)	Cum. Q_{HARV} (gals)	(KL = .55) TWA (gals)	Storage at end of prior day (gals)	Change in Storage (gals)	Harvested water used for irgn(gals)	Overflow (gals)	Suppl. Water req'd (gals)
107	0.00	0.00	96479.42	847.94	55886.07	-464.40	847.94	0.00	0.00
108	0.00	0.00	96479.42	775.37	55038.14	-847.94	775.37	0.00	0.00
109	0.00	0.00	96479.42	833.42	54262.76	-775.37	833.42	0.00	0.00
110	0.00	0.00	96479.42	914.28	53429.34	-833.42	914.28	0.00	0.00
111	0.00	0.00	96479.42	835.50	52515.06	-914.28	835.50	0.00	0.00
112	0.00	0.00	96479.42	582.57	51679.56	-835.50	582.57	0.00	0.00
113	0.00	0.00	96479.42	715.25	51097.00	-582.57	715.25	0.00	0.00
114	0.00	0.00	96479.42	493.42	50381.74	-715.25	493.42	0.00	0.00
115	0.12	1042.11	97521.53	122.32	49888.32	-493.42	122.32	0.00	0.00
116	0.00	0.00	97521.53	329.64	50808.12	919.79	329.64	0.00	0.00
117	0.02	173.69	97695.22	787.81	50478.48	-329.64	787.81	0.00	0.00
118	0.09	781.58	98476.80	901.84	49864.35	-614.13	901.84	0.00	0.00
119	0.14	1215.80	99692.60	661.35	49744.10	-120.26	661.35	0.00	0.00
120	0.00	0.00	99692.60	847.94	50298.55	554.45	847.94	0.00	0.00
121	0.00	0.00	99692.60	980.62	49450.61	-847.94	980.62	0.00	0.00
122	0.01	86.84	99779.44	1005.50	48469.99	-980.62	1005.50	0.00	0.00
123	0.01	86.84	99866.29	787.81	47551.33	-918.66	787.81	0.00	0.00
124	0.00	0.00	99866.29	868.67	46850.36	-700.97	868.67	0.00	0.00
125	0.53	4601.98	104468.26	503.79	45981.70	-868.67	503.79	0.00	0.00
126	0.00	0.00	104468.26	1032.45	50079.88	4098.19	1032.45	0.00	0.00
127	0.00	0.00	104468.26	986.84	49047.43	-1032.45	986.84	0.00	0.00
128	0.00	0.00	104468.26	1051.11	48060.60	-986.84	1051.11	0.00	0.00
129	0.00	0.00	104468.26	988.91	47009.49	-1051.11	988.91	0.00	0.00
130	0.00	0.00	104468.26	993.06	46020.57	-988.91	993.06	0.00	0.00
131	0.00	0.00	104468.26	852.08	45027.51	-993.06	852.08	0.00	0.00
132	0.00	0.00	104468.26	1082.21	44175.43	-852.08	1082.21	0.00	0.00
133	0.00	0.00	104468.26	1127.82	43093.23	-1082.21	1127.82	0.00	0.00
134	0.00	0.00	104468.26	932.94	41965.41	-1127.82	932.94	0.00	0.00
135	0.00	0.00	104468.26	1024.16	41032.47	-932.94	1024.16	0.00	0.00
136	0.00	0.00	104468.26	990.99	40008.31	-1024.16	990.99	0.00	0.00
137	0.00	0.00	104468.26	990.99	39017.33	-990.99	990.99	0.00	0.00
138	0.00	0.00	104468.26	601.23	38026.34	-990.99	601.23	0.00	0.00
139	0.00	0.00	104468.26	953.67	37425.12	-601.23	953.67	0.00	0.00
140	0.00	0.00	104468.26	1148.55	36471.45	-953.67	1148.55	0.00	0.00
141	0.00	0.00	104468.26	980.62	35322.90	-1148.55	980.62	0.00	0.00
142	0.26	2257.91	106726.17	557.69	34342.28	-980.62	557.69	0.00	0.00
143	0.01	86.84	106813.01	1115.38	36042.50	1700.22	1115.38	0.00	0.00

2000 c.e. Day	P	Q_{HARV} (gals)	Cum. Q_{HARV} (gals)	(KL = .55) TWA (gals)	Storage at end of prior day (gals)	Change in Storage (gals)	Harvested water used for irgn(gals)	Overflow (gals)	Suppl. Water req'd (gals)
144	0.29	2519.80	109332.82	648.91	35013.96	-1028.54	648.91	0.00	0.00
145	0.00	0.00	109332.82	984.77	36884.86	1870.89	984.77	0.00	0.00
146	0.17	1476.32	110809.14	806.47	35900.09	-984.77	806.47	0.00	0.00
147	0.00	0.00	110809.14	889.40	36569.94	669.85	889.40	0.00	0.00
148	0.00	0.00	110809.14	1175.50	35680.54	-889.40	1175.50	0.00	0.00
149	0.01	86.84	110895.98	655.13	34505.04	-1175.50	655.13	0.00	0.00
150	0.00	0.00	110895.98	1053.18	33936.76	-568.29	1053.18	0.00	0.00
151	0.00	0.00	110895.98	1121.60	32883.58	-1053.18	1121.60	0.00	0.00
152	0.00	0.00	110895.98	1144.40	31761.98	-1121.60	1144.40	0.00	0.00
153	0.00	0.00	110895.98	1229.40	30617.58	-1144.40	1229.40	0.00	0.00
154	0.00	0.00	110895.98	1262.57	29388.17	-1229.40	1262.57	0.00	0.00
155	0.00	0.00	110895.98	1146.48	28125.60	-1262.57	1146.48	0.00	0.00
156	0.00	0.00	110895.98	422.93	26979.12	-1146.48	422.93	0.00	0.00
157	0.36	3124.97	114020.95	286.10	26556.19	-422.93	286.10	0.00	0.00
158	0.00	0.00	114020.95	1140.26	29395.06	2838.87	1140.26	0.00	0.00
159	0.00	0.00	114020.95	1134.04	28254.80	-1140.26	1134.04	0.00	0.00
160	0.00	0.00	114020.95	1152.70	27120.77	-1134.04	1152.70	0.00	0.00
161	0.00	0.00	114020.95	1254.28	25968.07	-1152.70	1254.28	0.00	0.00
162	0.00	0.00	114020.95	1119.52	24713.79	-1254.28	1119.52	0.00	0.00
163	0.00	0.00	114020.95	1169.28	23594.26	-1119.52	1169.28	0.00	0.00
164	0.00	0.00	114020.95	1219.04	22424.98	-1169.28	1219.04	0.00	0.00
165	0.00	0.00	114020.95	1090.50	21205.95	-1219.04	1090.50	0.00	0.00
166	0.07	607.90	114628.85	1310.26	20115.45	-1090.50	1310.26	0.00	0.00
167	0.01	86.84	114715.69	1094.65	19413.09	-702.36	1094.65	0.00	0.00
168	0.48	4167.76	118883.45	713.18	18405.29	-1007.80	713.18	0.00	0.00
169	0.10	868.43	119751.88	1094.65	21859.87	3454.58	1094.65	0.00	0.00
170	0.07	607.90	120359.78	1065.62	21633.65	-226.22	1065.62	0.00	0.00
171	0.10	868.43	121228.20	609.52	21175.93	-457.72	609.52	0.00	0.00
172	0.00	0.00	121228.20	808.55	21434.83	258.91	808.55	0.00	0.00
173	0.14	1215.80	122444.00	717.32	20626.29	-808.55	717.32	0.00	0.00
174	0.00	0.00	122444.00	1007.57	21124.76	498.47	1007.57	0.00	0.00
175	0.00	0.00	122444.00	1299.89	20117.19	-1007.57	1299.89	0.00	0.00
176	0.00	0.00	122444.00	1015.86	18817.30	-1299.89	1015.86	0.00	0.00
177	0.00	0.00	122444.00	729.76	17801.43	-1015.86	729.76	0.00	0.00
178	0.76	6598.67	129042.67	1256.35	17071.67	-729.76	1256.35	0.00	0.00
179	0.01	86.84	129129.51	1078.06	22413.99	5342.32	1078.06	0.00	0.00
180	0.05	434.21	129563.73	675.86	21422.77	-991.22	675.86	0.00	0.00

2000 c.e. Day	P	Q_{HARV} (gals)	Cum. Q_{HARV} (gals)	(KL = .55) TWA (gals)	Storage at end of prior day (gals)	Change in Storage (gals)	Harvested water used for irgn(gals)	Overflow (gals)	Suppl. Water req'd (gals)
181	0.31	2690.75	132254.48	451.96	21181.12	-241.65	451.96	0.00	0.00
182	0.00	0.00	132254.48	1073.91	23419.92	2238.80	1073.91	0.00	0.00
183	0.00	0.00	132254.48	1154.77	22346.01	-1073.91	1154.77	0.00	0.00
184	0.00	0.00	132254.48	1082.21	21191.24	-1154.77	1082.21	0.00	0.00
185	0.00	0.00	132254.48	1119.52	20109.03	-1082.21	1119.52	0.00	0.00
186	0.00	0.00	132254.48	1030.38	18989.51	-1119.52	1030.38	0.00	0.00
187	0.00	0.00	132254.48	1061.47	17959.13	-1030.38	1061.47	0.00	0.00
188	0.00	0.00	132254.48	868.67	16897.66	-1061.47	868.67	0.00	0.00
189	0.00	0.00	132254.48	1142.33	16028.99	-868.67	1142.33	0.00	0.00
190	0.00	0.00	132254.48	1009.64	14886.66	-1142.33	1009.64	0.00	0.00
191	0.00	0.00	132254.48	912.20	13877.01	-1009.64	912.20	0.00	0.00
192	0.01	86.84	132341.32	935.01	12964.81	-912.20	935.01	0.00	0.00
193	0.15	1302.64	133643.96	1192.09	12116.64	-848.17	1192.09	0.00	0.00
194	0.00	0.00	133643.96	532.81	12227.19	110.55	532.81	0.00	0.00
195	0.00	0.00	133643.96	719.40	11694.38	-532.81	719.40	0.00	0.00
196	0.00	0.00	133643.96	1011.72	10974.99	-719.40	1011.72	0.00	0.00
197	0.00	0.00	133643.96	1287.45	9963.27	-1011.72	1287.45	0.00	0.00
198	0.00	0.00	133643.96	1148.55	8675.82	-1287.45	1148.55	0.00	0.00
199	0.00	0.00	133643.96	1185.87	7527.27	-1148.55	1185.87	0.00	0.00
200	0.00	0.00	133643.96	1160.99	6341.40	-1185.87	1160.99	0.00	0.00
201	0.00	0.00	133643.96	872.81	5180.41	-1160.99	872.81	0.00	0.00
202	0.00	0.00	133643.96	1281.23	4307.60	-872.81	1281.23	0.00	0.00
203	0.00	0.00	133643.96	1102.94	3026.37	-1281.23	1102.94	0.00	0.00
204	0.00	0.00	133643.96	995.13	1923.43	-1102.94	995.13	0.00	0.00
205	0.31	2690.75	136334.72	619.88	928.29	-995.13	619.88	0.00	0.00
206	0.52	4516.50	140851.22	655.13	2999.16	2070.87	655.13	0.00	0.00
207	0.01	86.84	140938.06	296.47	6860.54	3861.37	296.47	0.00	0.00
208	0.00	0.00	140938.06	725.62	6650.91	-209.62	725.62	0.00	0.00
209	0.00	0.00	140938.06	835.50	5925.29	-725.62	835.50	0.00	0.00
210	0.00	0.00	140938.06	1053.18	5089.80	-835.50	1053.18	0.00	0.00
211	0.00	0.00	140938.06	1038.67	4036.62	-1053.18	1038.67	0.00	0.00
212	0.03	260.53	141198.59	885.25	2997.95	-1038.67	885.25	0.00	0.00
213	1.45	12592.18	153790.77	563.91	2373.22	-624.73	563.91	0.00	0.00
214	0.04	347.37	154138.14	665.49	14401.49	12028.27	665.49	0.00	0.00
215	0.41	3559.18	157697.32	607.45	14083.37	-318.12	607.45	0.00	0.00
216	0.04	347.37	158044.69	721.47	17035.10	2951.73	721.47	0.00	0.00
217	0.12	1042.11	159086.80	677.93	16661.00	-374.10	677.93	0.00	0.00

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218	0.01	86.84	159173.64	1065.62	17025.18	364.18	1065.62	0.00	0.00
219	0.00	0.00	159173.64	829.28	16046.40	-978.78	829.28	0.00	0.00
220	0.00	0.00	159173.64	1138.18	15217.12	-829.28	1138.18	0.00	0.00
221	0.00	0.00	159173.64	1053.18	14078.94	-1138.18	1053.18	0.00	0.00
222	0.00	0.00	159173.64	1158.91	13025.76	-1053.18	1158.91	0.00	0.00
223	0.01	86.84	159260.49	1015.86	11866.85	-1158.91	1015.86	0.00	0.00
224	0.02	173.69	159434.17	908.06	10937.82	-929.02	908.06	0.00	0.00
225	0.00	0.00	159434.17	1094.65	10203.45	-734.37	1094.65	0.00	0.00
226	0.00	0.00	159434.17	1065.62	9108.80	-1094.65	1065.62	0.00	0.00
227	0.00	0.00	159434.17	1040.74	8043.18	-1065.62	1040.74	0.00	0.00
228	0.00	0.00	159434.17	1090.50	7002.44	-1040.74	1090.50	0.00	0.00
229	0.00	0.00	159434.17	1100.87	5911.94	-1090.50	1100.87	0.00	0.00
230	0.00	0.00	159434.17	1088.43	4811.08	-1100.87	1088.43	0.00	0.00
231	0.00	0.00	159434.17	1080.13	3722.65	-1088.43	1080.13	0.00	0.00
232	0.00	0.00	159434.17	891.47	2642.52	-1080.13	891.47	0.00	0.00
233	0.00	0.00	159434.17	501.71	1751.04	-891.47	501.71	0.00	0.00
234	0.05	434.21	159868.39	495.49	1249.33	-501.71	495.49	0.00	0.00
235	0.00	0.00	159868.39	744.28	1188.05	-61.28	744.28	0.00	0.00
236	0.00	0.00	159868.39	872.81	443.77	-744.28	872.81	0.00	429.04
237	0.48	4167.76	164036.15	779.52	0.00	-443.77	779.52	0.00	0.00
238	0.32	2779.65	166815.80	932.94	3388.24	3388.24	932.94	0.00	0.00
239	0.00	0.00	166815.80	964.03	5234.95	1846.71	964.03	0.00	0.00
240	0.15	1302.64	168118.44	310.98	4270.92	-964.03	310.98	0.00	0.00
241	0.00	0.00	168118.44	852.08	5262.58	991.66	852.08	0.00	0.00
242	0.00	0.00	168118.44	850.01	4410.50	-852.08	850.01	0.00	0.00
243	0.00	0.00	168118.44	677.93	3560.49	-850.01	677.93	0.00	0.00
244	1.61	13980.30	182098.73	180.37	2882.55	-677.93	180.37	0.00	0.00
245	0.49	4256.66	186355.39	315.13	16682.48	13799.93	315.13	0.00	0.00
246	0.12	1042.11	187397.50	395.98	20624.01	3941.53	395.98	0.00	0.00
247	0.68	5904.61	193302.11	640.62	21270.14	646.13	640.62	0.00	0.00
248	0.06	521.06	193823.17	740.13	26534.14	5264.00	740.13	0.00	0.00
249	0.20	1736.85	195560.02	383.54	26315.07	-219.07	383.54	0.00	0.00
250	0.22	1910.54	197470.56	159.64	27668.38	1353.31	159.64	0.00	0.00
251	0.16	1389.48	198860.04	147.20	29419.28	1750.90	147.20	0.00	0.00
252	0.00	0.00	198860.04	551.47	30661.57	1242.29	551.47	0.00	0.00
253	0.00	0.00	198860.04	420.86	30110.10	-551.47	420.86	0.00	0.00
254	0.00	0.00	198860.04	833.42	29689.24	-420.86	833.42	0.00	0.00

2000 c.e. Day	P	Q_{HARV} (gals)	Cum. Q_{HARV} (gals)	(KL = .55) TWA (gals)	Storage at end of prior day (gals)	Change in Storage (gals)	Harvested water used for irgn(gals)	Overflow (gals)	Suppl. Water req'd (gals)
255	0.00	0.00	198860.04	738.06	28855.82	-833.42	738.06	0.00	0.00
256	0.00	0.00	198860.04	742.20	28117.76	-738.06	742.20	0.00	0.00
257	0.00	0.00	198860.04	715.25	27375.56	-742.20	715.25	0.00	0.00
258	0.08	694.74	199554.78	621.96	26660.31	-715.25	621.96	0.00	0.00
259	0.00	0.00	199554.78	843.79	26733.09	72.78	843.79	0.00	0.00
260	0.00	0.00	199554.78	742.20	25889.30	-843.79	742.20	0.00	0.00
261	0.00	0.00	199554.78	576.35	25147.10	-742.20	576.35	0.00	0.00
262	0.13	1128.95	200683.74	182.44	24570.75	-576.35	182.44	0.00	0.00
263	0.01	86.84	200770.58	754.64	25517.26	946.51	754.64	0.00	0.00
264	0.00	0.00	200770.58	690.37	24849.46	-667.80	690.37	0.00	0.00
265	0.29	2519.80	203290.38	78.78	24159.09	-690.37	78.78	0.00	0.00
266	1.12	9727.06	213017.44	155.49	26600.11	2441.02	155.49	0.00	0.00
267	0.01	86.84	213104.28	559.76	36171.68	9571.57	559.76	0.00	0.00
268	0.12	1042.11	214146.39	673.79	35698.76	-472.92	673.79	0.00	0.00
269	0.44	3822.44	217968.84	418.78	36067.08	368.32	418.78	0.00	0.00
270	0.00	0.00	217968.84	638.54	39470.74	3403.66	638.54	0.00	0.00
271	0.00	0.00	217968.84	617.81	38832.20	-638.54	617.81	0.00	0.00
272	0.00	0.00	217968.84	634.40	38214.39	-617.81	634.40	0.00	0.00
273	0.00	0.00	217968.84	642.69	37579.99	-634.40	642.69	0.00	0.00
274	0.00	0.00	217968.84	553.54	36937.30	-642.69	553.54	0.00	0.00
275	0.00	0.00	217968.84	603.30	36383.76	-553.54	603.30	0.00	0.00
276	0.00	0.00	217968.84	617.81	35780.46	-603.30	617.81	0.00	0.00
277	0.00	0.00	217968.84	657.20	35162.65	-617.81	657.20	0.00	0.00
278	0.00	0.00	217968.84	650.98	34505.45	-657.20	650.98	0.00	0.00
279	0.00	0.00	217968.84	644.76	33854.46	-650.98	644.76	0.00	0.00
280	0.18	1563.17	219532.01	145.12	33209.70	-644.76	145.12	0.00	0.00
281	0.00	0.00	219532.01	429.15	34627.74	1418.04	429.15	0.00	0.00
282	0.00	0.00	219532.01	333.78	34198.59	-429.15	333.78	0.00	0.00
283	0.00	0.00	219532.01	447.81	33864.81	-333.78	447.81	0.00	0.00
284	0.00	0.00	219532.01	462.32	33417.00	-447.81	462.32	0.00	0.00
285	0.00	0.00	219532.01	495.49	32954.68	-462.32	495.49	0.00	0.00
286	0.00	0.00	219532.01	501.71	32459.18	-495.49	501.71	0.00	0.00
287	0.00	0.00	219532.01	516.22	31957.47	-501.71	516.22	0.00	0.00
288	0.00	0.00	219532.01	518.30	31441.25	-516.22	518.30	0.00	0.00
289	0.00	0.00	219532.01	518.30	30922.95	-518.30	518.30	0.00	0.00
290	0.00	0.00	219532.01	518.30	30404.65	-518.30	518.30	0.00	0.00
291	0.00	0.00	219532.01	499.64	29886.35	-518.30	499.64	0.00	0.00

2000 c.e. Day	P	Q_{HARV} (gals)	Cum. Q_{HARV} (gals)	(KL = .55) TWA (gals)	Storage at end of prior day (gals)	Change in Storage (gals)	Harvested water used for irgn(gals)	Overflow (gals)	Suppl. Water req'd (gals)
292	0.00	0.00	219532.01	460.25	29386.71	-499.64	460.25	0.00	0.00
293	0.00	0.00	219532.01	418.78	28926.46	-460.25	418.78	0.00	0.00
294	0.00	0.00	219532.01	240.49	28507.68	-418.78	240.49	0.00	0.00
295	0.00	0.00	219532.01	429.15	28267.19	-240.49	429.15	0.00	0.00
296	0.00	0.00	219532.01	431.22	27838.04	-429.15	431.22	0.00	0.00
297	0.00	0.00	219532.01	410.49	27406.81	-431.22	410.49	0.00	0.00
298	0.00	0.00	219532.01	410.49	26996.32	-410.49	410.49	0.00	0.00
299	0.00	0.00	219532.01	408.42	26585.83	-410.49	408.42	0.00	0.00
300	0.00	0.00	219532.01	379.39	26177.41	-408.42	379.39	0.00	0.00
301	0.00	0.00	219532.01	402.20	25798.02	-379.39	402.20	0.00	0.00
302	0.00	0.00	219532.01	433.30	25395.82	-402.20	433.30	0.00	0.00
303	0.00	0.00	219532.01	395.98	24962.52	-433.30	395.98	0.00	0.00
304	0.00	0.00	219532.01	402.20	24566.54	-395.98	402.20	0.00	0.00
305	0.00	0.00	219532.01	395.98	24164.34	-402.20	395.98	0.00	0.00
306	0.00	0.00	219532.01	373.17	23768.36	-395.98	373.17	0.00	0.00
307	0.00	0.00	219532.01	364.88	23395.19	-373.17	364.88	0.00	0.00
308	0.00	0.00	219532.01	337.93	23030.30	-364.88	337.93	0.00	0.00
309	0.20	1736.85	221268.86	85.00	22692.37	-337.93	85.00	0.00	0.00
310	0.00	0.00	221268.86	188.66	24344.23	1651.85	188.66	0.00	0.00
311	0.00	0.00	221268.86	33.17	24155.57	-188.66	33.17	0.00	0.00
312	0.00	0.00	221268.86	55.98	24122.39	-33.17	55.98	0.00	0.00
313	0.14	1215.80	222484.65	153.42	24066.42	-55.98	153.42	0.00	0.00
314	1.58	13720.45	236205.11	29.02	25128.80	1062.38	29.02	0.00	0.00
315	0.00	0.00	236205.11	281.95	38820.22	13691.43	281.95	0.00	0.00
316	0.00	0.00	236205.11	257.08	38538.27	-281.95	257.08	0.00	0.00
317	0.00	0.00	236205.11	238.42	38281.19	-257.08	238.42	0.00	0.00
318	0.04	347.37	236552.48	99.51	38042.78	-238.42	99.51	0.00	0.00
319	0.08	694.74	237247.22	263.30	38290.63	247.86	263.30	0.00	0.00
320	0.00	0.00	237247.22	217.69	38722.08	431.45	217.69	0.00	0.00
321	0.24	2084.22	239331.44	60.12	38504.40	-217.69	60.12	0.00	0.00
322	0.09	781.58	240113.02	74.63	40528.50	2024.10	74.63	0.00	0.00
323	0.42	3648.07	243761.10	49.76	41235.44	706.95	49.76	0.00	0.00
324	0.98	8509.89	252270.99	18.66	44833.76	3598.32	18.66	0.00	0.00
325	0.00	0.00	252270.99	190.73	53325.00	8491.23	190.73	0.00	0.00
326	0.00	0.00	252270.99	176.22	53134.26	-190.73	176.22	0.00	0.00
327	0.00	0.00	252270.99	174.15	52958.04	-176.22	174.15	0.00	0.00
328	0.00	0.00	252270.99	103.66	52783.89	-174.15	103.66	0.00	0.00

2000 c.e. Day	P	Q_{HARV} (gals)	Cum. Q_{HARV} (gals)	(KL = .55) TWA (gals)	Storage at end of prior day (gals)	Change in Storage (gals)	Harvested water used for irgn(gals)	Overflow (gals)	Suppl. Water req'd (gals)
329	0.58	5036.19	257307.18	80.85	52680.23	-103.66	80.85	0.00	0.00
330	0.81	7032.89	264340.07	24.88	57635.57	4955.33	24.88	4643.57	0.00
331	0.00	0.00	264340.07	89.15	60000.00	2364.43	89.15	0.00	0.00
332	0.00	0.00	264340.07	155.49	59910.85	-89.15	155.49	0.00	0.00
333	0.00	0.00	264340.07	163.78	59755.36	-155.49	163.78	0.00	0.00
334	0.02	173.69	264513.75	60.12	59591.58	-163.78	60.12	0.00	0.00
335	0.01	86.84	264600.59	159.64	59705.14	113.56	159.64	0.00	0.00
336	0.00	0.00	264600.59	136.83	59632.35	-72.79	136.83	0.00	0.00
337	0.07	607.90	265208.49	24.88	59495.52	-136.83	24.88	78.54	0.00
338	0.14	1215.80	266424.29	37.32	60000.00	504.48	37.32	1178.48	0.00
339	0.00	0.00	266424.29	124.39	60000.00	0.00	124.39	0.00	0.00
340	0.00	0.00	266424.29	124.39	59875.61	-124.39	124.39	0.00	0.00
341	0.00	0.00	266424.29	80.85	59751.22	-124.39	80.85	0.00	0.00
342	0.00	0.00	266424.29	116.10	59670.36	-80.85	116.10	0.00	0.00
343	0.00	0.00	266424.29	118.17	59554.26	-116.10	118.17	0.00	0.00
344	0.17	1476.32	267900.61	31.10	59436.09	-118.17	31.10	881.32	0.00
345	0.00	0.00	267900.61	20.73	60000.00	563.91	20.73	0.00	0.00
346	0.00	0.00	267900.61	39.39	59979.27	-20.73	39.39	0.00	0.00
347	0.02	173.69	268074.30	99.51	59939.88	-39.39	99.51	14.05	0.00
348	0.07	607.90	268682.20	12.44	60000.00	60.12	12.44	595.46	0.00
349	0.25	2171.07	270853.26	31.10	60000.00	0.00	31.10	2139.97	0.00
350	0.79	6861.94	277715.20	16.59	60000.00	0.00	16.59	6845.35	0.00
351	1.35	11723.75	289438.95	4.15	60000.00	0.00	4.15	11719.61	0.00
352	0.01	86.84	289525.79	53.90	60000.00	0.00	53.90	32.94	0.00
353	0.00	0.00	289525.79	74.63	60000.00	0.00	74.63	0.00	0.00
354	0.07	607.90	290133.69	24.88	59925.37	-74.63	24.88	508.39	0.00
355	0.07	607.90	290741.59	76.71	60000.00	74.63	76.71	531.19	0.00
356	0.02	173.69	290915.28	14.51	60000.00	0.00	14.51	159.17	0.00
357	0.16	1389.48	292304.76	64.27	60000.00	0.00	64.27	1325.21	0.00
358	0.00	0.00	292304.76	64.27	60000.00	0.00	64.27	0.00	0.00
359	0.00	0.00	292304.76	41.46	59935.73	-64.27	41.46	0.00	0.00
360	0.00	0.00	292304.76	45.61	59894.27	-41.46	45.61	0.00	0.00
361	0.00	0.00	292304.76	18.66	59848.66	-45.61	18.66	0.00	0.00
362	0.10	868.43	293173.18	6.22	59830.00	-18.66	6.22	692.20	0.00
363	0.00	0.00	293173.18	6.22	60000.00	170.00	6.22	0.00	0.00
364	0.00	0.00	293173.18	33.17	59993.78	-6.22	33.17	0.00	0.00
365	0.01	86.84	293260.03	29.02	59960.61	-33.17	29.02	18.43	0.00

2000 c.e. Day	P	Q_{HARV} (gals)	Cum. Q_{HARV} (gals)	(KL = .55) TWA (gals)	Storage at end of prior day (gals)	Change in Storage (gals)	Harvested water used for irgn(gals)	Overflow (gals)	Suppl. Water req'd (gals)
Total	33.77	293260.03		180740.94			180740.94	52948.13	429.04

APPENDIX C

IRRIGATION REQUIREMENT - 2003

IRRIGATION REQUIREMENT - 2003

SCS CN:	61
SCS Retention S:	6.39
Landscape coefficient K_L:	0.55
Planting Area (sf):	13824
Irrigation Efficiency IE (drip):	0.9

Day	2003 c.e. P (in.)	Q (Runoff in.)	P-Q (in.)	PEt (in.)	Cum Net P(in)	P Consumption (in)	P Excess (in)	ET_L (in)	Irrigation Req't (in)	TWA (in)	TWA (gals)
1	0.150	0.000	0.150	0.008		0.000	0.000	0.004	0.004	0.005	41.46
2	0.050	0.000	0.050	0.016	0.050	0.016	0.034	0.009	0.000	0.000	0.00
3	0.010	0.000	0.010	0.012	0.044	0.012	0.032	0.006	0.000	0.000	0.00
4	0.000	0.000	0.000	0.027	0.032	0.027	0.005	0.015	0.000	0.000	0.00
5	0.000	0.000	0.000	0.028	0.005	0.005	0.000	0.015	0.010	0.011	94.61
6	0.000	0.000	0.000	0.026	0.000	0.000	0.000	0.014	0.014	0.016	134.76
7	0.000	0.000	0.000	0.028	0.000	0.000	0.000	0.016	0.016	0.017	149.27
8	0.000	0.000	0.000	0.028	0.000	0.000	0.000	0.016	0.016	0.017	149.27
9	0.090	0.000	0.090	0.035	0.090	0.035	0.055	0.019	0.000	0.000	0.00
10	0.000	0.000	0.000	0.039	0.055	0.039	0.016	0.021	0.000	0.000	0.00
11	0.000	0.000	0.000	0.030	0.016	0.016	0.000	0.016	0.000	0.001	4.52
12	0.000	0.000	0.000	0.023	0.000	0.000	0.000	0.013	0.013	0.014	122.32
13	0.000	0.000	0.000	0.025	0.000	0.000	0.000	0.014	0.014	0.015	130.61
14	0.000	0.000	0.000	0.039	0.000	0.000	0.000	0.021	0.021	0.024	205.25
15	0.000	0.000	0.000	0.036	0.000	0.000	0.000	0.020	0.020	0.022	190.73
16	0.150	0.000	0.150	0.013	0.150	0.013	0.137	0.007	0.000	0.000	0.00
17	0.010	0.000	0.010	0.031	0.147	0.031	0.117	0.017	0.000	0.000	0.00
18	0.000	0.000	0.000	0.036	0.117	0.036	0.080	0.020	0.000	0.000	0.00
19	0.000	0.000	0.000	0.040	0.080	0.040	0.040	0.022	0.000	0.000	0.00
20	0.000	0.000	0.000	0.045	0.040	0.040	0.000	0.025	0.000	0.000	0.00
21	0.060	0.000	0.060	0.017	0.060	0.017	0.043	0.010	0.000	0.000	0.00
22	0.170	0.000	0.170	0.028	0.213	0.028	0.185	0.015	0.000	0.000	0.00
23	0.000	0.000	0.000	0.039	0.185	0.039	0.147	0.021	0.000	0.000	0.00
24	0.000	0.000	0.000	0.037	0.147	0.037	0.110	0.020	0.000	0.000	0.00
25	0.000	0.000	0.000	0.032	0.110	0.032	0.077	0.018	0.000	0.000	0.00
26	0.000	0.000	0.000	0.040	0.077	0.040	0.037	0.022	0.000	0.000	0.00
27	0.000	0.000	0.000	0.044	0.037	0.037	0.000	0.024	0.000	0.000	0.00
28	0.000	0.000	0.000	0.049	0.000	0.000	0.000	0.027	0.027	0.030	257.08
29	0.690	0.000	0.690	0.013	0.690	0.013	0.677	0.007	0.000	0.000	0.00
30	0.750	0.000	0.750	0.009	1.427	0.009	1.418	0.005	0.000	0.000	0.00
31	0.000	0.000	0.000	0.029	1.418	0.029	1.389	0.016	0.000	0.000	0.00
32	0.000	0.000	0.000	0.053	1.389	0.053	1.336	0.029	0.000	0.000	0.00

Day	2003 c.e. P (in.)	Q (Runoff in.)	P-Q (in.)	PEt (in.)	Cum Net P(in)	P Consumption (in)	P Excess (in)	ET_L (in)	Irrigation Req't (in)	TWA (in)	TWA (gals)
33	0.000	0.000	0.000	0.060	1.336	0.060	1.276	0.033	0.000	0.000	0.00
34	0.000	0.000	0.000	0.052	1.276	0.052	1.223	0.029	0.000	0.000	0.00
35	0.280	0.000	0.280	0.065	1.503	0.065	1.438	0.036	0.000	0.000	0.00
36	0.000	0.000	0.000	0.052	1.438	0.052	1.385	0.029	0.000	0.000	0.00
37	0.790	0.000	0.790	0.010	2.176	0.010	2.165	0.006	0.000	0.000	0.00
38	0.100	0.000	0.100	0.020	2.265	0.020	2.245	0.011	0.000	0.000	0.00
39	0.000	0.000	0.000	0.045	2.245	0.045	2.200	0.025	0.000	0.000	0.00
40	0.010	0.000	0.010	0.048	2.210	0.048	2.161	0.027	0.000	0.000	0.00
41	0.600	0.000	0.600	0.035	2.761	0.035	2.726	0.019	0.000	0.000	0.00
42	0.000	0.000	0.000	0.061	2.726	0.061	2.666	0.033	0.000	0.000	0.00
43	0.000	0.000	0.000	0.067	2.666	0.067	2.598	0.037	0.000	0.000	0.00
44	0.000	0.000	0.000	0.068	2.598	0.068	2.530	0.037	0.000	0.000	0.00
45	0.010	0.000	0.010	0.013	2.540	0.013	2.527	0.007	0.000	0.000	0.00
46	0.000	0.000	0.000	0.029	2.527	0.029	2.498	0.016	0.000	0.000	0.00
47	1.850	0.000	1.850	0.006	4.348	0.006	4.342	0.003	0.000	0.000	0.00
48	0.010	0.000	0.010	0.015	4.352	0.015	4.338	0.008	0.000	0.000	0.00
49	0.000	0.000	0.000	0.058	4.338	0.058	4.280	0.032	0.000	0.000	0.00
50	0.000	0.000	0.000	0.044	4.280	0.044	4.236	0.024	0.000	0.000	0.00
51	0.000	0.000	0.000	0.064	4.236	0.064	4.172	0.035	0.000	0.000	0.00
52	0.150	0.000	0.150	0.019	4.322	0.019	4.303	0.011	0.000	0.000	0.00
53	0.920	0.000	0.920	0.046	5.223	0.046	5.177	0.025	0.000	0.000	0.00
54	0.000	0.000	0.000	0.078	5.177	0.078	5.098	0.043	0.000	0.000	0.00
55	0.000	0.000	0.000	0.072	5.098	0.072	5.026	0.040	0.000	0.000	0.00
56	0.000	0.000	0.000	0.053	5.026	0.053	4.974	0.029	0.000	0.000	0.00
57	0.310	0.000	0.310	0.010	5.284	0.010	5.273	0.006	0.000	0.000	0.00
58	0.300	0.000	0.300	0.009	5.573	0.009	5.565	0.005	0.000	0.000	0.00
59	0.000	0.000	0.000	0.053	5.565	0.053	5.511	0.029	0.000	0.000	0.00
60	0.050	0.000	0.050	0.011	5.561	0.011	5.550	0.006	0.000	0.000	0.00
61	0.000	0.000	0.000	0.057	5.550	0.057	5.493	0.031	0.000	0.000	0.00
62	0.000	0.000	0.000	0.070	5.493	0.070	5.424	0.038	0.000	0.000	0.00
63	0.030	0.000	0.030	0.064	5.454	0.064	5.390	0.035	0.000	0.000	0.00
64	1.120	0.000	1.120	0.030	6.510	0.030	6.480	0.016	0.000	0.000	0.00
65	1.150	0.000	1.150	0.015	7.630	0.015	7.615	0.008	0.000	0.000	0.00
66	0.050	0.000	0.050	0.065	7.665	0.065	7.601	0.036	0.000	0.000	0.00
67	0.000	0.000	0.000	0.050	7.601	0.050	7.551	0.027	0.000	0.000	0.00
68	0.000	0.000	0.000	0.104	7.551	0.104	7.447	0.057	0.000	0.000	0.00
69	0.000	0.000	0.000	0.112	7.447	0.112	7.336	0.061	0.000	0.000	0.00

	2003 c.e.								Irrigation		
Day	P (in.)	Q (Runoff in.)	P-Q (in.)	PEt (in.)	Cum Net P(in)	P Consumption (in)	P Excess (in)	ET_L (in)	Req't (in)	TWA (in)	TWA (gals)
70	0.000	0.000	0.000	0.104	7.336	0.104	7.231	0.057	0.000	0.000	0.00
71	0.000	0.000	0.000	0.121	7.231	0.121	7.110	0.066	0.000	0.000	0.00
72	0.000	0.000	0.000	0.110	7.110	0.110	7.001	0.060	0.000	0.000	0.00
73	0.020	0.000	0.020	0.025	7.021	0.025	6.996	0.014	0.000	0.000	0.00
74	0.470	0.000	0.470	0.022	7.466	0.022	7.443	0.012	0.000	0.000	0.00
75	0.010	0.000	0.010	0.076	7.453	0.076	7.377	0.042	0.000	0.000	0.00
76	1.100	0.000	1.100	0.014	8.477	0.014	8.463	0.008	0.000	0.000	0.00
77	0.040	0.000	0.040	0.021	8.503	0.021	8.482	0.012	0.000	0.000	0.00
78	1.770	0.000	1.770	0.011	10.252	0.011	10.241	0.006	0.000	0.000	0.00
79	0.620	0.000	0.620	0.022	10.861	0.022	10.839	0.012	0.000	0.000	0.00
80	0.010	0.000	0.010	0.106	10.849	0.106	10.743	0.058	0.000	0.000	0.00
81	0.000	0.000	0.000	0.123	10.743	0.123	10.620	0.068	0.000	0.000	0.00
82	0.000	0.000	0.000	0.114	10.620	0.114	10.507	0.063	0.000	0.000	0.00
83	0.000	0.000	0.000	0.144	10.507	0.144	10.362	0.079	0.000	0.000	0.00
84	0.000	0.000	0.000	0.146	10.362	0.146	10.216	0.080	0.000	0.000	0.00
85	0.520	0.000	0.520	0.117	10.736	0.117	10.619	0.065	0.000	0.000	0.00
86	0.000	0.000	0.000	0.117	10.619	0.117	10.501	0.065	0.000	0.000	0.00
87	0.000	0.000	0.000	0.075	10.501	0.075	10.427	0.041	0.000	0.000	0.00
88	0.000	0.000	0.000	0.079	10.427	0.079	10.348	0.043	0.000	0.000	0.00
89	0.250	0.000	0.250	0.078	10.598	0.078	10.520	0.043	0.000	0.000	0.00
90	0.000	0.000	0.000	0.119	10.520	0.119	10.401	0.066	0.000	0.000	0.00
91	0.000	0.000	0.000	0.139	10.401	0.139	10.262	0.076	0.000	0.000	0.00
92	0.000	0.000	0.000	0.157	10.262	0.157	10.105	0.086	0.000	0.000	0.00
93	0.000	0.000	0.000	0.161	10.105	0.161	9.944	0.089	0.000	0.000	0.00
94	0.000	0.000	0.000	0.128	9.944	0.128	9.816	0.070	0.000	0.000	0.00
95	0.140	0.000	0.140	0.061	9.956	0.061	9.895	0.034	0.000	0.000	0.00
96	0.090	0.000	0.090	0.056	9.985	0.056	9.929	0.031	0.000	0.000	0.00
97	0.410	0.000	0.410	0.025	10.338	0.025	10.313	0.014	0.000	0.000	0.00
98	0.180	0.000	0.180	0.015	10.493	0.015	10.479	0.008	0.000	0.000	0.00
99	0.080	0.000	0.080	0.019	10.559	0.019	10.540	0.010	0.000	0.000	0.00
100	0.490	0.000	0.490	0.031	11.030	0.031	10.999	0.017	0.000	0.000	0.00
101	0.020	0.000	0.020	0.084	11.019	0.084	10.935	0.046	0.000	0.000	0.00
102	0.000	0.000	0.000	0.172	10.935	0.172	10.762	0.095	0.000	0.000	0.00
103	0.000	0.000	0.000	0.181	10.762	0.181	10.581	0.100	0.000	0.000	0.00
104	0.000	0.000	0.000	0.183	10.581	0.183	10.398	0.101	0.000	0.000	0.00
105	0.000	0.000	0.000	0.170	10.398	0.170	10.228	0.094	0.000	0.000	0.00
106	0.000	0.000	0.000	0.157	10.228	0.157	10.070	0.086	0.000	0.000	0.00

Day	2003 c.e. P (in.)	Q (Runoff in.)	P-Q (in.)	PEt (in.)	Cum Net P(in)	P Consumption (in)	P Excess (in)	ET_L (in)	Irrigation Req't (in)	TWA (in)	TWA (gals)
107	0.570	0.000	0.570	0.104	10.641	0.104	10.537	0.057	0.000	0.000	0.00
108	0.000	0.000	0.000	0.048	10.537	0.048	10.488	0.027	0.000	0.000	0.00
109	0.000	0.000	0.000	0.074	10.488	0.074	10.415	0.040	0.000	0.000	0.00
110	0.000	0.000	0.000	0.039	10.415	0.039	10.376	0.021	0.000	0.000	0.00
111	0.090	0.000	0.090	0.056	10.466	0.056	10.410	0.031	0.000	0.000	0.00
112	0.000	0.000	0.000	0.179	10.410	0.179	10.231	0.099	0.000	0.000	0.00
113	0.000	0.000	0.000	0.182	10.231	0.182	10.049	0.100	0.000	0.000	0.00
114	0.020	0.000	0.020	0.124	10.069	0.124	9.945	0.068	0.000	0.000	0.00
115	0.660	0.000	0.660	0.081	10.605	0.081	10.523	0.045	0.000	0.000	0.00
116	0.000	0.000	0.000	0.179	10.523	0.179	10.345	0.098	0.000	0.000	0.00
117	0.000	0.000	0.000	0.184	10.345	0.184	10.160	0.101	0.000	0.000	0.00
118	0.000	0.000	0.000	0.183	10.160	0.183	9.978	0.100	0.000	0.000	0.00
119	0.000	0.000	0.000	0.203	9.978	0.203	9.775	0.112	0.000	0.000	0.00
120	0.000	0.000	0.000	0.206	9.775	0.206	9.569	0.113	0.000	0.000	0.00
121	0.070	0.000	0.070	0.122	9.639	0.122	9.517	0.067	0.000	0.000	0.00
122	0.200	0.000	0.200	0.182	9.717	0.182	9.535	0.100	0.000	0.000	0.00
123	0.010	0.000	0.010	0.105	9.545	0.105	9.440	0.058	0.000	0.000	0.00
124	0.000	0.000	0.000	0.205	9.440	0.205	9.234	0.113	0.000	0.000	0.00
125	1.560	0.000	1.560	0.043	10.794	0.043	10.752	0.023	0.000	0.000	0.00
126	1.430	0.000	1.430	0.042	12.182	0.042	12.140	0.023	0.000	0.000	0.00
127	0.280	0.000	0.280	0.116	12.420	0.116	12.303	0.064	0.000	0.000	0.00
128	0.000	0.000	0.000	0.119	12.303	0.119	12.185	0.065	0.000	0.000	0.00
129	0.000	0.000	0.000	0.194	12.185	0.194	11.990	0.107	0.000	0.000	0.00
130	0.000	0.000	0.000	0.205	11.990	0.205	11.785	0.113	0.000	0.000	0.00
131	0.130	0.000	0.130	0.085	11.915	0.085	11.831	0.047	0.000	0.000	0.00
132	0.000	0.000	0.000	0.222	11.831	0.222	11.609	0.122	0.000	0.000	0.00
133	0.000	0.000	0.000	0.215	11.609	0.215	11.394	0.118	0.000	0.000	0.00
134	0.000	0.000	0.000	0.089	11.394	0.089	11.305	0.049	0.000	0.000	0.00
135	0.650	0.000	0.650	0.064	11.955	0.064	11.891	0.035	0.000	0.000	0.00
136	0.130	0.000	0.130	0.155	12.021	0.155	11.866	0.085	0.000	0.000	0.00
137	0.000	0.000	0.000	0.080	11.866	0.080	11.787	0.044	0.000	0.000	0.00
138	0.650	0.000	0.650	0.039	12.437	0.039	12.397	0.022	0.000	0.000	0.00
139	0.010	0.000	0.010	0.030	12.407	0.030	12.377	0.016	0.000	0.000	0.00
140	0.200	0.000	0.200	0.077	12.577	0.077	12.500	0.042	0.000	0.000	0.00
141	0.420	0.000	0.420	0.070	12.920	0.070	12.850	0.039	0.000	0.000	0.00
142	2.130	0.000	2.130	0.023	14.980	0.023	14.957	0.013	0.000	0.000	0.00
143	0.000	0.000	0.000	0.141	14.957	0.141	14.816	0.078	0.000	0.000	0.00

Day	2003 c.e. P (in.)	Q (Runoff in.)	P-Q (in.)	PEt (in.)	Cum Net P(in)	P Consumption (in)	P Excess (in)	ET_L (in)	Irrigation Req't (in)	TWA (in)	TWA (gals)
144	0.000	0.000	0.000	0.160	14.816	0.160	14.656	0.088	0.000	0.000	0.00
145	0.000	0.000	0.000	0.200	14.656	0.200	14.456	0.110	0.000	0.000	0.00
146	0.070	0.000	0.070	0.178	14.526	0.178	14.347	0.098	0.000	0.000	0.00
147	0.000	0.000	0.000	0.208	14.347	0.208	14.139	0.114	0.000	0.000	0.00
148	0.000	0.000	0.000	0.224	14.139	0.224	13.915	0.123	0.000	0.000	0.00
149	0.000	0.000	0.000	0.214	13.915	0.214	13.701	0.118	0.000	0.000	0.00
150	0.000	0.000	0.000	0.227	13.701	0.227	13.474	0.125	0.000	0.000	0.00
151	0.000	0.000	0.000	0.187	13.474	0.187	13.287	0.103	0.000	0.000	0.00
152	0.000	0.000	0.000	0.232	13.287	0.232	13.055	0.128	0.000	0.000	0.00
153	0.000	0.000	0.000	0.222	13.055	0.222	12.833	0.122	0.000	0.000	0.00
154	0.850	0.000	0.850	0.085	13.683	0.085	13.598	0.047	0.000	0.000	0.00
155	0.070	0.000	0.070	0.233	13.668	0.233	13.436	0.128	0.000	0.000	0.00
156	0.000	0.000	0.000	0.243	13.436	0.243	13.193	0.134	0.000	0.000	0.00
157	0.840	0.000	0.840	0.118	14.033	0.118	13.915	0.065	0.000	0.000	0.00
158	1.160	0.000	1.160	0.085	15.075	0.085	14.990	0.047	0.000	0.000	0.00
159	0.000	0.000	0.000	0.167	14.990	0.167	14.823	0.092	0.000	0.000	0.00
160	0.000	0.000	0.000	0.248	14.823	0.248	14.575	0.137	0.000	0.000	0.00
161	0.000	0.000	0.000	0.261	14.575	0.261	14.313	0.144	0.000	0.000	0.00
162	0.040	0.000	0.040	0.198	14.353	0.198	14.156	0.109	0.000	0.000	0.00
163	0.150	0.000	0.150	0.154	14.306	0.154	14.151	0.085	0.000	0.000	0.00
164	0.910	0.000	0.910	0.118	15.061	0.118	14.943	0.065	0.000	0.000	0.00
165	0.830	0.000	0.830	0.100	15.773	0.100	15.673	0.055	0.000	0.000	0.00
166	0.000	0.000	0.000	0.206	15.673	0.206	15.467	0.113	0.000	0.000	0.00
167	1.580	0.000	1.580	0.163	17.047	0.163	16.884	0.090	0.000	0.000	0.00
168	0.160	0.000	0.160	0.160	17.044	0.160	16.883	0.088	0.000	0.000	0.00
169	0.100	0.000	0.100	0.102	16.983	0.102	16.881	0.056	0.000	0.000	0.00
170	0.000	0.000	0.000	0.196	16.881	0.196	16.685	0.108	0.000	0.000	0.00
171	0.000	0.000	0.000	0.245	16.685	0.245	16.440	0.135	0.000	0.000	0.00
172	0.000	0.000	0.000	0.255	16.440	0.255	16.185	0.140	0.000	0.000	0.00
173	0.000	0.000	0.000	0.245	16.185	0.245	15.940	0.135	0.000	0.000	0.00
174	0.000	0.000	0.000	0.254	15.940	0.254	15.686	0.139	0.000	0.000	0.00
175	0.000	0.000	0.000	0.210	15.686	0.210	15.476	0.115	0.000	0.000	0.00
176	0.000	0.000	0.000	0.213	15.476	0.213	15.264	0.117	0.000	0.000	0.00
177	0.000	0.000	0.000	0.222	15.264	0.222	15.041	0.122	0.000	0.000	0.00
178	0.040	0.000	0.040	0.172	15.081	0.172	14.909	0.095	0.000	0.000	0.00
179	0.440	0.000	0.440	0.110	15.349	0.110	15.239	0.061	0.000	0.000	0.00
180	0.000	0.000	0.000	0.157	15.239	0.157	15.082	0.086	0.000	0.000	0.00

Day	2003 c.e. P (in.)	Q (Runoff in.)	P-Q (in.)	PEt (in.)	Cum Net P(in)	P Consumption (in)	P Excess (in)	ET_L (in)	Irrigation Req't (in)	TWA (in)	TWA (gals)
181	1.250	0.000	1.250	0.120	16.332	0.120	16.211	0.066	0.000	0.000	0.00
182	4.728	0.000	4.728	0.014	20.940	0.014	20.926	0.008	0.000	0.000	0.00
183	0.000	0.000	0.000	0.121	20.926	0.121	20.805	0.066	0.000	0.000	0.00
184	0.000	0.000	0.000	0.259	20.805	0.259	20.545	0.143	0.000	0.000	0.00
185	0.000	0.000	0.000	0.199	20.545	0.199	20.347	0.109	0.000	0.000	0.00
186	2.170	0.000	2.170	0.170	22.517	0.170	22.347	0.093	0.000	0.000	0.00
187	0.010	0.000	0.010	0.203	22.357	0.203	22.154	0.112	0.000	0.000	0.00
188	0.000	0.000	0.000	0.215	22.154	0.215	21.939	0.118	0.000	0.000	0.00
189	0.000	0.000	0.000	0.248	21.939	0.248	21.691	0.136	0.000	0.000	0.00
190	0.000	0.000	0.000	0.257	21.691	0.257	21.434	0.142	0.000	0.000	0.00
191	0.590	0.000	0.590	0.147	22.024	0.147	21.877	0.081	0.000	0.000	0.00
192	0.200	0.000	0.200	0.204	22.077	0.204	21.873	0.112	0.000	0.000	0.00
193	0.000	0.000	0.000	0.241	21.873	0.241	21.632	0.133	0.000	0.000	0.00
194	0.170	0.000	0.170	0.215	21.802	0.215	21.587	0.118	0.000	0.000	0.00
195	0.000	0.000	0.000	0.151	21.587	0.151	21.436	0.083	0.000	0.000	0.00
196	0.000	0.000	0.000	0.228	21.436	0.228	21.209	0.125	0.000	0.000	0.00
197	0.000	0.000	0.000	0.200	21.209	0.200	21.009	0.110	0.000	0.000	0.00
198	0.000	0.000	0.000	0.224	21.009	0.224	20.785	0.123	0.000	0.000	0.00
199	0.960	0.000	0.960	0.186	21.744	0.186	21.559	0.102	0.000	0.000	0.00
200	0.000	0.000	0.000	0.210	21.559	0.210	21.348	0.116	0.000	0.000	0.00
201	0.850	0.000	0.850	0.210	22.198	0.210	21.988	0.115	0.000	0.000	0.00
202	0.610	0.000	0.610	0.178	22.598	0.178	22.420	0.098	0.000	0.000	0.00
203	0.720	0.000	0.720	0.098	23.140	0.098	23.042	0.054	0.000	0.000	0.00
204	0.970	0.000	0.970	0.126	24.012	0.126	23.886	0.069	0.000	0.000	0.00
205	0.010	0.000	0.010	0.252	23.896	0.252	23.644	0.139	0.000	0.000	0.00
206	0.000	0.000	0.000	0.231	23.644	0.231	23.413	0.127	0.000	0.000	0.00
207	0.070	0.000	0.070	0.191	23.483	0.191	23.291	0.105	0.000	0.000	0.00
208	0.000	0.000	0.000	0.207	23.291	0.207	23.084	0.114	0.000	0.000	0.00
209	0.000	0.000	0.000	0.235	23.084	0.235	22.848	0.129	0.000	0.000	0.00
210	0.000	0.000	0.000	0.233	22.848	0.233	22.615	0.128	0.000	0.000	0.00
211	0.130	0.000	0.130	0.126	22.745	0.126	22.619	0.069	0.000	0.000	0.00
212	1.580	0.000	1.580	0.170	24.199	0.170	24.029	0.094	0.000	0.000	0.00
213	0.010	0.000	0.010	0.179	24.039	0.179	23.860	0.099	0.000	0.000	0.00
214	0.010	0.000	0.010	0.126	23.870	0.126	23.743	0.070	0.000	0.000	0.00
215	0.420	0.000	0.420	0.123	24.163	0.123	24.041	0.068	0.000	0.000	0.00
216	0.500	0.000	0.500	0.142	24.541	0.142	24.398	0.078	0.000	0.000	0.00
217	0.000	0.000	0.000	0.187	24.398	0.187	24.212	0.103	0.000	0.000	0.00

	2003 c.e.								Irrigation		
Day	P (in.)	Q (Runoff in.)	P-Q (in.)	PEt (in.)	Cum Net P(in)	P Consumption (in)	P Excess (in)	ET_L (in)	Req't (in)	TWA (in)	TWA (gals)
218	0.020	0.000	0.020	0.089	24.232	0.089	24.143	0.049	0.000	0.000	0.00
219	0.240	0.000	0.240	0.166	24.383	0.166	24.217	0.091	0.000	0.000	0.00
220	0.000	0.000	0.000	0.146	24.217	0.146	24.071	0.080	0.000	0.000	0.00
221	0.130	0.000	0.130	0.200	24.201	0.200	24.001	0.110	0.000	0.000	0.00
222	0.040	0.000	0.040	0.187	24.041	0.187	23.854	0.103	0.000	0.000	0.00
223	0.000	0.000	0.000	0.165	23.854	0.165	23.690	0.091	0.000	0.000	0.00
224	0.270	0.000	0.270	0.115	23.960	0.115	23.845	0.063	0.000	0.000	0.00
225	0.010	0.000	0.010	0.119	23.855	0.119	23.736	0.065	0.000	0.000	0.00
226	0.000	0.000	0.000	0.228	23.736	0.228	23.509	0.125	0.000	0.000	0.00
227	0.000	0.000	0.000	0.215	23.509	0.215	23.294	0.118	0.000	0.000	0.00
228	0.180	0.000	0.180	0.092	23.474	0.092	23.382	0.050	0.000	0.000	0.00
229	0.000	0.000	0.000	0.205	23.382	0.205	23.177	0.113	0.000	0.000	0.00
230	0.000	0.000	0.000	0.184	23.177	0.184	22.993	0.101	0.000	0.000	0.00
231	0.000	0.000	0.000	0.173	22.993	0.173	22.821	0.095	0.000	0.000	0.00
232	0.000	0.000	0.000	0.131	22.821	0.131	22.690	0.072	0.000	0.000	0.00
233	0.000	0.000	0.000	0.177	22.690	0.177	22.512	0.097	0.000	0.000	0.00
234	0.000	0.000	0.000	0.181	22.512	0.181	22.331	0.100	0.000	0.000	0.00
235	0.000	0.000	0.000	0.193	22.331	0.193	22.138	0.106	0.000	0.000	0.00
236	0.000	0.000	0.000	0.119	22.138	0.119	22.019	0.065	0.000	0.000	0.00
237	0.000	0.000	0.000	0.140	22.019	0.140	21.880	0.077	0.000	0.000	0.00
238	0.000	0.000	0.000	0.205	21.880	0.205	21.675	0.113	0.000	0.000	0.00
239	0.000	0.000	0.000	0.196	21.675	0.196	21.479	0.108	0.000	0.000	0.00
240	0.000	0.000	0.000	0.192	21.479	0.192	21.287	0.105	0.000	0.000	0.00
241	0.000	0.000	0.000	0.194	21.287	0.194	21.093	0.107	0.000	0.000	0.00
242	0.000	0.000	0.000	0.157	21.093	0.157	20.936	0.086	0.000	0.000	0.00
243	0.070	0.000	0.070	0.183	21.006	0.183	20.824	0.100	0.000	0.000	0.00
244	0.000	0.000	0.000	0.156	20.824	0.156	20.667	0.086	0.000	0.000	0.00
245	0.010	0.000	0.010	0.121	20.677	0.121	20.557	0.066	0.000	0.000	0.00
246	0.000	0.000	0.000	0.149	20.557	0.149	20.408	0.082	0.000	0.000	0.00
247	0.060	0.000	0.060	0.139	20.468	0.139	20.329	0.076	0.000	0.000	0.00
248	0.000	0.000	0.000	0.145	20.329	0.145	20.184	0.080	0.000	0.000	0.00
249	0.000	0.000	0.000	0.097	20.184	0.097	20.086	0.053	0.000	0.000	0.00
250	0.000	0.000	0.000	0.151	20.086	0.151	19.935	0.083	0.000	0.000	0.00
251	0.000	0.000	0.000	0.148	19.935	0.148	19.788	0.081	0.000	0.000	0.00
252	0.000	0.000	0.000	0.163	19.788	0.163	19.625	0.090	0.000	0.000	0.00
253	0.000	0.000	0.000	0.131	19.625	0.131	19.494	0.072	0.000	0.000	0.00
254	0.000	0.000	0.000	0.152	19.494	0.152	19.342	0.083	0.000	0.000	0.00

Day	2003 c.e. P (in.)	Q (Runoff in.)	P-Q (in.)	PEt (in.)	Cum Net P(in)	P Consumption (in)	P Excess (in)	ET_L (in)	Irrigation Req't (in)	TWA (in)	TWA (gals)
255	0.000	0.000	0.000	0.176	19.342	0.176	19.167	0.097	0.000	0.000	0.00
256	0.000	0.000	0.000	0.162	19.167	0.162	19.005	0.089	0.000	0.000	0.00
257	0.000	0.000	0.000	0.115	19.005	0.115	18.890	0.063	0.000	0.000	0.00
258	0.000	0.000	0.000	0.138	18.890	0.138	18.752	0.076	0.000	0.000	0.00
259	0.000	0.000	0.000	0.146	18.752	0.146	18.606	0.080	0.000	0.000	0.00
260	0.000	0.000	0.000	0.169	18.606	0.169	18.437	0.093	0.000	0.000	0.00
261	0.000	0.000	0.000	0.168	18.437	0.168	18.269	0.092	0.000	0.000	0.00
262	0.000	0.000	0.000	0.164	18.269	0.164	18.105	0.090	0.000	0.000	0.00
263	0.000	0.000	0.000	0.144	18.105	0.144	17.961	0.079	0.000	0.000	0.00
264	0.010	0.000	0.010	0.134	17.971	0.134	17.836	0.074	0.000	0.000	0.00
265	2.140	0.000	2.140	0.033	19.977	0.033	19.943	0.018	0.000	0.000	0.00
266	0.010	0.000	0.010	0.161	19.953	0.161	19.792	0.089	0.000	0.000	0.00
267	0.000	0.000	0.000	0.122	19.792	0.122	19.670	0.067	0.000	0.000	0.00
268	0.000	0.000	0.000	0.149	19.670	0.149	19.520	0.082	0.000	0.000	0.00
269	0.000	0.000	0.000	0.143	19.520	0.143	19.378	0.079	0.000	0.000	0.00
270	1.250	0.000	1.250	0.132	20.628	0.132	20.496	0.073	0.000	0.000	0.00
271	0.000	0.000	0.000	0.135	20.496	0.135	20.360	0.074	0.000	0.000	0.00
272	0.000	0.000	0.000	0.130	20.360	0.130	20.230	0.072	0.000	0.000	0.00
273	0.000	0.000	0.000	0.124	20.230	0.124	20.105	0.068	0.000	0.000	0.00
274	0.000	0.000	0.000	0.122	20.105	0.122	19.983	0.067	0.000	0.000	0.00
275	0.000	0.000	0.000	0.103	19.983	0.103	19.880	0.057	0.000	0.000	0.00
276	0.000	0.000	0.000	0.113	19.880	0.113	19.767	0.062	0.000	0.000	0.00
277	0.000	0.000	0.000	0.115	19.767	0.115	19.652	0.063	0.000	0.000	0.00
278	0.000	0.000	0.000	0.121	19.652	0.121	19.531	0.066	0.000	0.000	0.00
279	0.020	0.000	0.020	0.056	19.551	0.056	19.494	0.031	0.000	0.000	0.00
280	0.040	0.000	0.040	0.039	19.534	0.039	19.495	0.021	0.000	0.000	0.00
281	0.110	0.000	0.110	0.069	19.605	0.069	19.537	0.038	0.000	0.000	0.00
282	0.000	0.000	0.000	0.057	19.537	0.057	19.480	0.031	0.000	0.000	0.00
283	0.000	0.000	0.000	0.058	19.480	0.058	19.422	0.032	0.000	0.000	0.00
284	0.040	0.000	0.040	0.017	19.462	0.017	19.445	0.009	0.000	0.000	0.00
285	0.000	0.000	0.000	0.120	19.445	0.120	19.326	0.066	0.000	0.000	0.00
286	0.000	0.000	0.000	0.100	19.326	0.100	19.225	0.055	0.000	0.000	0.00
287	0.000	0.000	0.000	0.048	19.225	0.048	19.178	0.026	0.000	0.000	0.00
288	0.000	0.000	0.000	0.105	19.178	0.105	19.073	0.058	0.000	0.000	0.00
289	0.000	0.000	0.000	0.103	19.073	0.103	18.970	0.057	0.000	0.000	0.00
290	0.040	0.000	0.040	0.048	19.010	0.048	18.962	0.027	0.000	0.000	0.00
291	0.000	0.000	0.000	0.097	18.962	0.097	18.865	0.053	0.000	0.000	0.00

Day	2003 c.e. P (in.)	Q (Runoff in.)	P-Q (in.)	PEt (in.)	Cum Net P(in)	P Consumption (in)	P Excess (in)	ET_L (in)	Irrigation Req't (in)	TWA (in)	TWA (gals)
292	0.000	0.000	0.000	0.100	18.865	0.100	18.764	0.055	0.000	0.000	0.00
293	0.000	0.000	0.000	0.102	18.764	0.102	18.663	0.056	0.000	0.000	0.00
294	0.000	0.000	0.000	0.103	18.663	0.103	18.559	0.057	0.000	0.000	0.00
295	0.000	0.000	0.000	0.106	18.559	0.106	18.453	0.058	0.000	0.000	0.00
296	0.000	0.000	0.000	0.089	18.453	0.089	18.364	0.049	0.000	0.000	0.00
297	0.000	0.000	0.000	0.090	18.364	0.090	18.274	0.049	0.000	0.000	0.00
298	0.000	0.000	0.000	0.075	18.274	0.075	18.199	0.041	0.000	0.000	0.00
299	1.690	0.000	1.690	0.012	19.889	0.012	19.877	0.007	0.000	0.000	0.00
300	0.020	0.000	0.020	0.027	19.897	0.027	19.870	0.015	0.000	0.000	0.00
301	0.010	0.000	0.010	0.019	19.880	0.019	19.862	0.010	0.000	0.000	0.00
302	0.000	0.000	0.000	0.081	19.862	0.081	19.781	0.045	0.000	0.000	0.00
303	0.000	0.000	0.000	0.081	19.781	0.081	19.700	0.045	0.000	0.000	0.00
304	0.000	0.000	0.000	0.082	19.700	0.082	19.617	0.045	0.000	0.000	0.00
305	0.000	0.000	0.000	0.086	19.617	0.086	19.531	0.047	0.000	0.000	0.00
306	0.000	0.000	0.000	0.085	19.531	0.085	19.446	0.047	0.000	0.000	0.00
307	0.000	0.000	0.000	0.087	19.446	0.087	19.359	0.048	0.000	0.000	0.00
308	0.000	0.000	0.000	0.037	19.359	0.037	19.323	0.020	0.000	0.000	0.00
309	1.110	0.000	1.110	0.034	20.433	0.034	20.399	0.019	0.000	0.000	0.00
310	0.010	0.000	0.010	0.055	20.409	0.055	20.354	0.030	0.000	0.000	0.00
311	0.000	0.000	0.000	0.065	20.354	0.065	20.289	0.036	0.000	0.000	0.00
312	0.010	0.000	0.010	0.017	20.299	0.017	20.282	0.009	0.000	0.000	0.00
313	0.000	0.000	0.000	0.061	20.282	0.061	20.221	0.034	0.000	0.000	0.00
314	0.000	0.000	0.000	0.052	20.221	0.052	20.170	0.028	0.000	0.000	0.00
315	0.000	0.000	0.000	0.058	20.170	0.058	20.111	0.032	0.000	0.000	0.00
316	0.000	0.000	0.000	0.072	20.111	0.072	20.040	0.039	0.000	0.000	0.00
317	0.000	0.000	0.000	0.063	20.040	0.063	19.977	0.034	0.000	0.000	0.00
318	0.000	0.000	0.000	0.048	19.977	0.048	19.929	0.026	0.000	0.000	0.00
319	0.000	0.000	0.000	0.051	19.929	0.051	19.879	0.028	0.000	0.000	0.00
320	0.000	0.000	0.000	0.033	19.879	0.033	19.846	0.018	0.000	0.000	0.00
321	0.000	0.000	0.000	0.037	19.846	0.037	19.809	0.020	0.000	0.000	0.00
322	0.710	0.000	0.710	0.021	20.519	0.021	20.498	0.012	0.000	0.000	0.00
323	1.020	0.000	1.020	0.045	21.518	0.045	21.473	0.025	0.000	0.000	0.00
324	0.000	0.000	0.000	0.053	21.473	0.053	21.420	0.029	0.000	0.000	0.00
325	0.000	0.000	0.000	0.053	21.420	0.053	21.368	0.029	0.000	0.000	0.00
326	0.000	0.000	0.000	0.053	21.368	0.053	21.315	0.029	0.000	0.000	0.00
327	0.000	0.000	0.000	0.043	21.315	0.043	21.272	0.023	0.000	0.000	0.00
328	0.140	0.000	0.140	0.019	21.412	0.019	21.394	0.010	0.000	0.000	0.00

Day	2003 c.e. P (in.)	Q (Runoff in.)	P-Q (in.)	PEt (in.)	Cum Net P(in)	P Consumption (in)	P Excess (in)	ET_L (in)	Irrigation Req't (in)	TWA (in)	TWA (gals)
329	0.000	0.000	0.000	0.038	21.394	0.038	21.356	0.021	0.000	0.000	0.00
330	0.000	0.000	0.000	0.040	21.356	0.040	21.316	0.022	0.000	0.000	0.00
331	0.190	0.000	0.190	0.009	21.506	0.009	21.497	0.005	0.000	0.000	0.00
332	0.310	0.000	0.310	0.017	21.807	0.017	21.790	0.009	0.000	0.000	0.00
333	0.000	0.000	0.000	0.032	21.790	0.032	21.758	0.018	0.000	0.000	0.00
334	0.000	0.000	0.000	0.035	21.758	0.035	21.723	0.019	0.000	0.000	0.00
335	0.000	0.000	0.000	0.035	21.723	0.035	21.687	0.019	0.000	0.000	0.00
336	0.000	0.000	0.000	0.035	21.687	0.035	21.652	0.019	0.000	0.000	0.00
337	0.030	0.000	0.030	0.010	21.682	0.010	21.673	0.005	0.000	0.000	0.00
338	0.560	0.000	0.560	0.003	22.232	0.003	22.230	0.002	0.000	0.000	0.00
339	0.010	0.000	0.010	0.004	22.240	0.004	22.236	0.002	0.000	0.000	0.00
340	0.000	0.000	0.000	0.027	22.236	0.027	22.209	0.015	0.000	0.000	0.00
341	0.000	0.000	0.000	0.027	22.209	0.027	22.182	0.015	0.000	0.000	0.00
342	0.000	0.000	0.000	0.027	22.182	0.027	22.155	0.015	0.000	0.000	0.00
343	0.000	0.000	0.000	0.019	22.155	0.019	22.136	0.010	0.000	0.000	0.00
344	0.990	0.000	0.990	0.006	23.127	0.006	23.121	0.003	0.000	0.000	0.00
345	0.000	0.000	0.000	0.023	23.121	0.023	23.098	0.013	0.000	0.000	0.00
346	0.000	0.000	0.000	0.018	23.098	0.018	23.080	0.010	0.000	0.000	0.00
347	0.240	0.000	0.240	0.007	23.320	0.007	23.313	0.004	0.000	0.000	0.00
348	0.230	0.000	0.230	0.005	23.543	0.005	23.538	0.003	0.000	0.000	0.00
349	0.000	0.000	0.000	0.020	23.538	0.020	23.518	0.011	0.000	0.000	0.00
350	0.000	0.000	0.000	0.013	23.518	0.013	23.506	0.007	0.000	0.000	0.00
351	0.140	0.000	0.140	0.017	23.646	0.017	23.629	0.009	0.000	0.000	0.00
352	0.010	0.000	0.010	0.016	23.639	0.016	23.623	0.009	0.000	0.000	0.00
353	0.000	0.000	0.000	0.017	23.623	0.017	23.606	0.009	0.000	0.000	0.00
354	0.000	0.000	0.000	0.017	23.606	0.017	23.589	0.009	0.000	0.000	0.00
355	0.000	0.000	0.000	0.015	23.589	0.015	23.574	0.008	0.000	0.000	0.00
356	0.000	0.000	0.000	0.014	23.574	0.014	23.560	0.008	0.000	0.000	0.00
357	0.250	0.000	0.250	0.009	23.810	0.009	23.801	0.005	0.000	0.000	0.00
358	0.020	0.000	0.020	0.013	23.821	0.013	23.808	0.007	0.000	0.000	0.00
359	0.000	0.000	0.000	0.011	23.808	0.011	23.797	0.006	0.000	0.000	0.00
360	0.000	0.000	0.000	0.009	23.797	0.009	23.787	0.005	0.000	0.000	0.00
361	0.000	0.000	0.000	0.008	23.787	0.008	23.779	0.004	0.000	0.000	0.00
362	0.000	0.000	0.000	0.007	23.779	0.007	23.772	0.004	0.000	0.000	0.00
363	0.020	0.000	0.020	0.004	23.792	0.004	23.788	0.002	0.000	0.000	0.00
364	0.030	0.000	0.030	0.006	23.818	0.006	23.812	0.003	0.000	0.000	0.00
365	0.000	0.000	0.000	0.004	23.812	0.004	23.808	0.002	0.000	0.000	0.00

	2003 c.e.								Irrigation		
Day	P (in.)	Q (Runoff in.)	P-Q (in.)	PEt (in.)	Cum Net P(in)	P Consumption (in)	P Excess (in)	ET_L (in)	Req't (in)	TWA (in)	TWA (gals)
Total	60.928							20.504	0.155	0.172	1479.88

APPENDIX D

IRRIGATION WATER SUPPLY - 2003

IRRIGATION WATER SUPPLY-2003

Roof Catchment (sf):	15480
Runoff Coefficient (E):	0.9
Conversionfactor(gals)	7.48/12

Storage Cap. (gals):	60000.00
Stor. end of prior yr(gal):	0.00

2003 c.e. Day	P	Q_{HARV} (gals)	Cum. Q_{HARV} (gals)	(KL = .55) TWA (gals)	Storage at end of prior day (gals)	Change in Storage (gals)	Harvested water used for irgn(gals)	Overflow (gals)	Suppl.Water req'd (gals)
1	0.15	1302.64	1302.64	41.46	0.00	1261.18	41.46	0.00	0.00
2	0.05	434.21	1736.85	0.00	1261.18	1261.18	0.00	0.00	0.00
3	0.01	86.84	1823.70	0.00	1695.39	434.21	0.00	0.00	0.00
4	0.00	0.00	1823.70	0.00	1782.23	86.84	0.00	0.00	0.00
5	0.00	0.00	1823.70	94.61	1782.23	0.00	94.61	0.00	0.00
6	0.00	0.00	1823.70	134.76	1687.62	-94.61	134.76	0.00	0.00
7	0.00	0.00	1823.70	149.27	1552.86	-134.76	149.27	0.00	0.00
8	0.00	0.00	1823.70	149.27	1403.59	-149.27	149.27	0.00	0.00
9	0.09	781.58	2605.28	0.00	1254.32	-149.27	0.00	0.00	0.00
10	0.00	0.00	2605.28	0.00	2035.90	781.58	0.00	0.00	0.00
11	0.00	0.00	2605.28	4.52	2035.90	0.00	4.52	0.00	0.00
12	0.00	0.00	2605.28	122.32	2031.38	-4.52	122.32	0.00	0.00
13	0.00	0.00	2605.28	130.61	1909.06	-122.32	130.61	0.00	0.00
14	0.00	0.00	2605.28	205.25	1778.45	-130.61	205.25	0.00	0.00
15	0.00	0.00	2605.28	190.73	1573.21	-205.25	190.73	0.00	0.00
16	0.15	1302.64	3907.92	0.00	1382.47	-190.73	0.00	0.00	0.00
17	0.01	86.84	3994.76	0.00	2685.11	1302.64	0.00	0.00	0.00
18	0.00	0.00	3994.76	0.00	2771.95	86.84	0.00	0.00	0.00
19	0.00	0.00	3994.76	0.00	2771.95	0.00	0.00	0.00	0.00
20	0.00	0.00	3994.76	0.00	2771.95	0.00	0.00	0.00	0.00
21	0.06	521.06	4515.82	0.00	2771.95	0.00	0.00	0.00	0.00
22	0.17	1476.32	5992.14	0.00	3293.01	521.06	0.00	0.00	0.00
23	0.00	0.00	5992.14	0.00	4769.33	1476.32	0.00	0.00	0.00
24	0.00	0.00	5992.14	0.00	4769.33	0.00	0.00	0.00	0.00
25	0.00	0.00	5992.14	0.00	4769.33	0.00	0.00	0.00	0.00
26	0.00	0.00	5992.14	0.00	4769.33	0.00	0.00	0.00	0.00
27	0.00	0.00	5992.14	0.00	4769.33	0.00	0.00	0.00	0.00
28	0.00	0.00	5992.14	257.08	4769.33	0.00	257.08	0.00	0.00
29	0.69	5993.51	11985.65	0.00	4512.26	-257.08	0.00	0.00	0.00
30	0.75	6513.20	18498.85	0.00	10505.77	5993.51	0.00	0.00	0.00
31	0.00	0.00	18498.85	0.00	17018.96	6513.20	0.00	0.00	0.00
32	0.00	0.00	18498.85	0.00	17018.96	0.00	0.00	0.00	0.00

2003 c.e. Day	P	Q_{HARV} (gals)	Cum. Q_{HARV} (gals)	(KL = .55) TWA (gals)	Storage at end of prior day (gals)	Change in Storage (gals)	Harvested water used for irgn(gals)	Overflow (gals)	Suppl.Water req'd (gals)
33	0.00	0.00	18498.85	0.00	17018.96	0.00	0.00	0.00	0.00
34	0.00	0.00	18498.85	0.00	17018.96	0.00	0.00	0.00	0.00
35	0.28	2430.91	20929.76	0.00	17018.96	0.00	0.00	0.00	0.00
36	0.00	0.00	20929.76	0.00	19449.87	2430.91	0.00	0.00	0.00
37	0.79	6861.94	27791.69	0.00	19449.87	0.00	0.00	0.00	0.00
38	0.10	868.43	28660.12	0.00	26311.81	6861.94	0.00	0.00	0.00
39	0.00	0.00	28660.12	0.00	27180.24	868.43	0.00	0.00	0.00
40	0.01	86.84	28746.96	0.00	27180.24	0.00	0.00	0.00	0.00
41	0.60	5210.56	33957.52	0.00	27267.08	86.84	0.00	0.00	0.00
42	0.00	0.00	33957.52	0.00	32477.64	5210.56	0.00	0.00	0.00
43	0.00	0.00	33957.52	0.00	32477.64	0.00	0.00	0.00	0.00
44	0.00	0.00	33957.52	0.00	32477.64	0.00	0.00	0.00	0.00
45	0.01	86.84	34044.36	0.00	32477.64	0.00	0.00	0.00	0.00
46	0.00	0.00	34044.36	0.00	32564.48	86.84	0.00	0.00	0.00
47	1.85	16065.89	50110.25	0.00	32564.48	0.00	0.00	0.00	0.00
48	0.01	86.84	50197.09	0.00	48630.36	16065.89	0.00	0.00	0.00
49	0.00	0.00	50197.09	0.00	48717.21	86.84	0.00	0.00	0.00
50	0.00	0.00	50197.09	0.00	48717.21	0.00	0.00	0.00	0.00
51	0.00	0.00	50197.09	0.00	48717.21	0.00	0.00	0.00	0.00
52	0.15	1302.64	51499.73	0.00	48717.21	0.00	0.00	0.00	0.00
53	0.92	7990.21	59489.93	0.00	50019.85	1302.64	0.00	0.00	0.00
54	0.00	0.00	59489.93	0.00	58010.05	7990.21	0.00	0.00	0.00
55	0.00	0.00	59489.93	0.00	58010.05	0.00	0.00	0.00	0.00
56	0.00	0.00	59489.93	0.00	58010.05	0.00	0.00	0.00	0.00
57	0.31	2690.75	62180.69	0.00	58010.05	0.00	0.00	700.81	0.00
58	0.30	2605.28	64785.97	0.00	60000.00	1989.95	0.00	2605.28	0.00
59	0.00	0.00	64785.97	0.00	60000.00	0.00	0.00	0.00	0.00
60	0.05	434.21	65220.18	0.00	60000.00	0.00	0.00	434.21	0.00
61	0.00	0.00	65220.18	0.00	60000.00	0.00	0.00	0.00	0.00
62	0.00	0.00	65220.18	0.00	60000.00	0.00	0.00	0.00	0.00
63	0.03	260.53	65480.71	0.00	60000.00	0.00	0.00	260.53	0.00
64	1.12	9727.06	75207.77	0.00	60000.00	0.00	0.00	9727.06	0.00
65	1.15	9986.90	85194.67	0.00	60000.00	0.00	0.00	9986.90	0.00
66	0.05	434.21	85628.88	0.00	60000.00	0.00	0.00	434.21	0.00
67	0.00	0.00	85628.88	0.00	60000.00	0.00	0.00	0.00	0.00
68	0.00	0.00	85628.88	0.00	60000.00	0.00	0.00	0.00	0.00
69	0.00	0.00	85628.88	0.00	60000.00	0.00	0.00	0.00	0.00

2003 c.e.			Cum. Q_{HARV}	(KL = .55)	Storage at end	Change in	Harvested water	Overflow	Suppl.Water
Day	P	Q_{HARV} (gals)	(gals)	TWA (gals)	of prior day (gals)	Storage (gals)	used for irgn(gals)	(gals)	req'd (gals)
70	0.00	0.00	85628.88	0.00	60000.00	0.00	0.00	0.00	0.00
71	0.00	0.00	85628.88	0.00	60000.00	0.00	0.00	0.00	0.00
72	0.00	0.00	85628.88	0.00	60000.00	0.00	0.00	0.00	0.00
73	0.02	173.69	85802.57	0.00	60000.00	0.00	0.00	173.69	0.00
74	0.47	4082.29	89884.85	0.00	60000.00	0.00	0.00	4082.29	0.00
75	0.01	86.84	89971.70	0.00	60000.00	0.00	0.00	86.84	0.00
76	1.10	9552.69	99524.38	0.00	60000.00	0.00	0.00	9552.69	0.00
77	0.04	347.37	99871.76	0.00	60000.00	0.00	0.00	347.37	0.00
78	1.77	15371.83	115243.58	0.00	60000.00	0.00	0.00	15371.83	0.00
79	0.62	5384.93	120628.51	0.00	60000.00	0.00	0.00	5384.93	0.00
80	0.01	86.84	120715.35	0.00	60000.00	0.00	0.00	86.84	0.00
81	0.00	0.00	120715.35	0.00	60000.00	0.00	0.00	0.00	0.00
82	0.00	0.00	120715.35	0.00	60000.00	0.00	0.00	0.00	0.00
83	0.00	0.00	120715.35	0.00	60000.00	0.00	0.00	0.00	0.00
84	0.00	0.00	120715.35	0.00	60000.00	0.00	0.00	0.00	0.00
85	0.52	4516.50	125231.85	0.00	60000.00	0.00	0.00	4516.50	0.00
86	0.00	0.00	125231.85	0.00	60000.00	0.00	0.00	0.00	0.00
87	0.00	0.00	125231.85	0.00	60000.00	0.00	0.00	0.00	0.00
88	0.00	0.00	125231.85	0.00	60000.00	0.00	0.00	0.00	0.00
89	0.25	2171.07	127402.92	0.00	60000.00	0.00	0.00	2171.07	0.00
90	0.00	0.00	127402.92	0.00	60000.00	0.00	0.00	0.00	0.00
91	0.00	0.00	127402.92	0.00	60000.00	0.00	0.00	0.00	0.00
92	0.00	0.00	127402.92	0.00	60000.00	0.00	0.00	0.00	0.00
93	0.00	0.00	127402.92	0.00	60000.00	0.00	0.00	0.00	0.00
94	0.00	0.00	127402.92	0.00	60000.00	0.00	0.00	0.00	0.00
95	0.14	1215.80	128618.72	0.00	60000.00	0.00	0.00	1215.80	0.00
96	0.09	781.58	129400.30	0.00	60000.00	0.00	0.00	781.58	0.00
97	0.41	3559.18	132959.48	0.00	60000.00	0.00	0.00	3559.18	0.00
98	0.18	1563.17	134522.65	0.00	60000.00	0.00	0.00	1563.17	0.00
99	0.08	694.74	135217.39	0.00	60000.00	0.00	0.00	694.74	0.00
100	0.49	4256.66	139474.04	0.00	60000.00	0.00	0.00	4256.66	0.00
101	0.02	173.69	139647.73	0.00	60000.00	0.00	0.00	173.69	0.00
102	0.00	0.00	139647.73	0.00	60000.00	0.00	0.00	0.00	0.00
103	0.00	0.00	139647.73	0.00	60000.00	0.00	0.00	0.00	0.00
104	0.00	0.00	139647.73	0.00	60000.00	0.00	0.00	0.00	0.00
105	0.00	0.00	139647.73	0.00	60000.00	0.00	0.00	0.00	0.00
106	0.00	0.00	139647.73	0.00	60000.00	0.00	0.00	0.00	0.00

2003 c.e. Day	P	Q_{HARV} (gals)	Cum. Q_{HARV} (gals)	(KL = .55) TWA (gals)	Storage at end of prior day (gals)	Change in Storage (gals)	Harvested water used for irgn(gals)	Overflow (gals)	Suppl.Water req'd (gals)
107	0.57	4950.71	144598.44	0.00	60000.00	0.00	0.00	4950.71	0.00
108	0.00	0.00	144598.44	0.00	60000.00	0.00	0.00	0.00	0.00
109	0.00	0.00	144598.44	0.00	60000.00	0.00	0.00	0.00	0.00
110	0.00	0.00	144598.44	0.00	60000.00	0.00	0.00	0.00	0.00
111	0.09	781.58	145380.03	0.00	60000.00	0.00	0.00	781.58	0.00
112	0.00	0.00	145380.03	0.00	60000.00	0.00	0.00	0.00	0.00
113	0.00	0.00	145380.03	0.00	60000.00	0.00	0.00	0.00	0.00
114	0.02	173.69	145553.71	0.00	60000.00	0.00	0.00	173.69	0.00
115	0.66	5730.25	151283.96	0.00	60000.00	0.00	0.00	5730.25	0.00
116	0.00	0.00	151283.96	0.00	60000.00	0.00	0.00	0.00	0.00
117	0.00	0.00	151283.96	0.00	60000.00	0.00	0.00	0.00	0.00
118	0.00	0.00	151283.96	0.00	60000.00	0.00	0.00	0.00	0.00
119	0.00	0.00	151283.96	0.00	60000.00	0.00	0.00	0.00	0.00
120	0.00	0.00	151283.96	0.00	60000.00	0.00	0.00	0.00	0.00
121	0.07	607.90	151891.86	0.00	60000.00	0.00	0.00	607.90	0.00
122	0.20	1736.85	153628.71	0.00	60000.00	0.00	0.00	1736.85	0.00
123	0.01	86.84	153715.55	0.00	60000.00	0.00	0.00	86.84	0.00
124	0.00	0.00	153715.55	0.00	60000.00	0.00	0.00	0.00	0.00
125	1.56	13546.08	167261.63	0.00	60000.00	0.00	0.00	13546.08	0.00
126	1.43	12417.81	179679.45	0.00	60000.00	0.00	0.00	12417.81	0.00
127	0.28	2430.91	182110.35	0.00	60000.00	0.00	0.00	2430.91	0.00
128	0.00	0.00	182110.35	0.00	60000.00	0.00	0.00	0.00	0.00
129	0.00	0.00	182110.35	0.00	60000.00	0.00	0.00	0.00	0.00
130	0.00	0.00	182110.35	0.00	60000.00	0.00	0.00	0.00	0.00
131	0.13	1128.95	183239.31	0.00	60000.00	0.00	0.00	1128.95	0.00
132	0.00	0.00	183239.31	0.00	60000.00	0.00	0.00	0.00	0.00
133	0.00	0.00	183239.31	0.00	60000.00	0.00	0.00	0.00	0.00
134	0.00	0.00	183239.31	0.00	60000.00	0.00	0.00	0.00	0.00
135	0.65	5644.77	188884.08	0.00	60000.00	0.00	0.00	5644.77	0.00
136	0.13	1128.95	190013.03	0.00	60000.00	0.00	0.00	1128.95	0.00
137	0.00	0.00	190013.03	0.00	60000.00	0.00	0.00	0.00	0.00
138	0.65	5644.77	195657.80	0.00	60000.00	0.00	0.00	5644.77	0.00
139	0.01	86.84	195744.65	0.00	60000.00	0.00	0.00	86.84	0.00
140	0.20	1736.85	197481.50	0.00	60000.00	0.00	0.00	1736.85	0.00
141	0.42	3648.07	201129.57	0.00	60000.00	0.00	0.00	3648.07	0.00
142	2.13	18496.80	219626.37	0.00	60000.00	0.00	0.00	18496.80	0.00
143	0.00	0.00	219626.37	0.00	60000.00	0.00	0.00	0.00	0.00

2003 c.e. Day	P	Q_{HARV} (gals)	Cum. Q_{HARV} (gals)	(KL = .55) TWA (gals)	Storage at end of prior day (gals)	Change in Storage (gals)	Harvested water used for irgn(gals)	Overflow (gals)	Suppl.Water req'd (gals)
144	0.00	0.00	219626.37	0.00	60000.00	0.00	0.00	0.00	0.00
145	0.00	0.00	219626.37	0.00	60000.00	0.00	0.00	0.00	0.00
146	0.07	607.90	220234.27	0.00	60000.00	0.00	0.00	607.90	0.00
147	0.00	0.00	220234.27	0.00	60000.00	0.00	0.00	0.00	0.00
148	0.00	0.00	220234.27	0.00	60000.00	0.00	0.00	0.00	0.00
149	0.00	0.00	220234.27	0.00	60000.00	0.00	0.00	0.00	0.00
150	0.00	0.00	220234.27	0.00	60000.00	0.00	0.00	0.00	0.00
151	0.00	0.00	220234.27	0.00	60000.00	0.00	0.00	0.00	0.00
152	0.00	0.00	220234.27	0.00	60000.00	0.00	0.00	0.00	0.00
153	0.00	0.00	220234.27	0.00	60000.00	0.00	0.00	0.00	0.00
154	0.85	7381.62	227615.89	0.00	60000.00	0.00	0.00	7381.62	0.00
155	0.07	607.90	228223.79	0.00	60000.00	0.00	0.00	607.90	0.00
156	0.00	0.00	228223.79	0.00	60000.00	0.00	0.00	0.00	0.00
157	0.84	7296.15	235519.94	0.00	60000.00	0.00	0.00	7296.15	0.00
158	1.16	10072.38	245592.31	0.00	60000.00	0.00	0.00	10072.38	0.00
159	0.00	0.00	245592.31	0.00	60000.00	0.00	0.00	0.00	0.00
160	0.00	0.00	245592.31	0.00	60000.00	0.00	0.00	0.00	0.00
161	0.00	0.00	245592.31	0.00	60000.00	0.00	0.00	0.00	0.00
162	0.04	347.37	245939.69	0.00	60000.00	0.00	0.00	347.37	0.00
163	0.15	1302.64	247242.32	0.00	60000.00	0.00	0.00	1302.64	0.00
164	0.91	7901.31	255143.64	0.00	60000.00	0.00	0.00	7901.31	0.00
165	0.83	7207.25	262350.89	0.00	60000.00	0.00	0.00	7207.25	0.00
166	0.00	0.00	262350.89	0.00	60000.00	0.00	0.00	0.00	0.00
167	1.58	13720.45	276071.34	0.00	60000.00	0.00	0.00	13720.45	0.00
168	0.16	1389.48	277460.82	0.00	60000.00	0.00	0.00	1389.48	0.00
169	0.10	868.43	278329.25	0.00	60000.00	0.00	0.00	868.43	0.00
170	0.00	0.00	278329.25	0.00	60000.00	0.00	0.00	0.00	0.00
171	0.00	0.00	278329.25	0.00	60000.00	0.00	0.00	0.00	0.00
172	0.00	0.00	278329.25	0.00	60000.00	0.00	0.00	0.00	0.00
173	0.00	0.00	278329.25	0.00	60000.00	0.00	0.00	0.00	0.00
174	0.00	0.00	278329.25	0.00	60000.00	0.00	0.00	0.00	0.00
175	0.00	0.00	278329.25	0.00	60000.00	0.00	0.00	0.00	0.00
176	0.00	0.00	278329.25	0.00	60000.00	0.00	0.00	0.00	0.00
177	0.00	0.00	278329.25	0.00	60000.00	0.00	0.00	0.00	0.00
178	0.04	347.37	278676.62	0.00	60000.00	0.00	0.00	347.37	0.00
179	0.44	3822.44	282499.06	0.00	60000.00	0.00	0.00	3822.44	0.00
180	0.00	0.00	282499.06	0.00	60000.00	0.00	0.00	0.00	0.00

2003 c.e. Day	P	Q_{HARV} (gals)	Cum. Q_{HARV} (gals)	(KL = .55) TWA (gals)	Storage at end of prior day (gals)	Change in Storage (gals)	Harvested water used for irgn(gals)	Overflow (gals)	Suppl.Water req'd (gals)
181	1.25	10855.33	293354.39	0.00	60000.00	0.00	0.00	10855.33	0.00
182	4.73	41062.20	334416.59	0.00	60000.00	0.00	0.00	41062.20	0.00
183	0.00	0.00	334416.59	0.00	60000.00	0.00	0.00	0.00	0.00
184	0.00	0.00	334416.59	0.00	60000.00	0.00	0.00	0.00	0.00
185	0.00	0.00	334416.59	0.00	60000.00	0.00	0.00	0.00	0.00
186	2.17	18845.53	353262.13	0.00	60000.00	0.00	0.00	18845.53	0.00
187	0.01	86.84	353348.97	0.00	60000.00	0.00	0.00	86.84	0.00
188	0.00	0.00	353348.97	0.00	60000.00	0.00	0.00	0.00	0.00
189	0.00	0.00	353348.97	0.00	60000.00	0.00	0.00	0.00	0.00
190	0.00	0.00	353348.97	0.00	60000.00	0.00	0.00	0.00	0.00
191	0.59	5125.08	358474.05	0.00	60000.00	0.00	0.00	5125.08	0.00
192	0.20	1736.85	360210.91	0.00	60000.00	0.00	0.00	1736.85	0.00
193	0.00	0.00	360210.91	0.00	60000.00	0.00	0.00	0.00	0.00
194	0.17	1476.32	361687.23	0.00	60000.00	0.00	0.00	1476.32	0.00
195	0.00	0.00	361687.23	0.00	60000.00	0.00	0.00	0.00	0.00
196	0.00	0.00	361687.23	0.00	60000.00	0.00	0.00	0.00	0.00
197	0.00	0.00	361687.23	0.00	60000.00	0.00	0.00	0.00	0.00
198	0.00	0.00	361687.23	0.00	60000.00	0.00	0.00	0.00	0.00
199	0.96	8335.52	370022.75	0.00	60000.00	0.00	0.00	8335.52	0.00
200	0.00	0.00	370022.75	0.00	60000.00	0.00	0.00	0.00	0.00
201	0.85	7381.62	377404.38	0.00	60000.00	0.00	0.00	7381.62	0.00
202	0.61	5296.03	382700.41	0.00	60000.00	0.00	0.00	5296.03	0.00
203	0.72	6253.35	388953.76	0.00	60000.00	0.00	0.00	6253.35	0.00
204	0.97	8424.42	397378.18	0.00	60000.00	0.00	0.00	8424.42	0.00
205	0.01	86.84	397465.02	0.00	60000.00	0.00	0.00	86.84	0.00
206	0.00	0.00	397465.02	0.00	60000.00	0.00	0.00	0.00	0.00
207	0.07	607.90	398072.92	0.00	60000.00	0.00	0.00	607.90	0.00
208	0.00	0.00	398072.92	0.00	60000.00	0.00	0.00	0.00	0.00
209	0.00	0.00	398072.92	0.00	60000.00	0.00	0.00	0.00	0.00
210	0.00	0.00	398072.92	0.00	60000.00	0.00	0.00	0.00	0.00
211	0.13	1128.95	399201.88	0.00	60000.00	0.00	0.00	1128.95	0.00
212	1.58	13720.45	412922.33	0.00	60000.00	0.00	0.00	13720.45	0.00
213	0.01	86.84	413009.17	0.00	60000.00	0.00	0.00	86.84	0.00
214	0.01	86.84	413096.01	0.00	60000.00	0.00	0.00	86.84	0.00
215	0.42	3648.07	416744.09	0.00	60000.00	0.00	0.00	3648.07	0.00
216	0.50	4342.13	421086.22	0.00	60000.00	0.00	0.00	4342.13	0.00
217	0.00	0.00	421086.22	0.00	60000.00	0.00	0.00	0.00	0.00

2003 c.e. Day	P	Q_{HARV} (gals)	Cum. Q_{HARV} (gals)	(KL = .55) TWA (gals)	Storage at end of prior day (gals)	Change in Storage (gals)	Harvested water used for irgn(gals)	Overflow (gals)	Suppl.Water req'd (gals)
218	0.02	173.69	421259.90	0.00	60000.00	0.00	0.00	173.69	0.00
219	0.24	2084.22	423344.13	0.00	60000.00	0.00	0.00	2084.22	0.00
220	0.00	0.00	423344.13	0.00	60000.00	0.00	0.00	0.00	0.00
221	0.13	1128.95	424473.08	0.00	60000.00	0.00	0.00	1128.95	0.00
222	0.04	347.37	424820.45	0.00	60000.00	0.00	0.00	347.37	0.00
223	0.00	0.00	424820.45	0.00	60000.00	0.00	0.00	0.00	0.00
224	0.27	2344.75	427165.20	0.00	60000.00	0.00	0.00	2344.75	0.00
225	0.01	86.84	427252.05	0.00	60000.00	0.00	0.00	86.84	0.00
226	0.00	0.00	427252.05	0.00	60000.00	0.00	0.00	0.00	0.00
227	0.00	0.00	427252.05	0.00	60000.00	0.00	0.00	0.00	0.00
228	0.18	1563.17	428815.21	0.00	60000.00	0.00	0.00	1563.17	0.00
229	0.00	0.00	428815.21	0.00	60000.00	0.00	0.00	0.00	0.00
230	0.00	0.00	428815.21	0.00	60000.00	0.00	0.00	0.00	0.00
231	0.00	0.00	428815.21	0.00	60000.00	0.00	0.00	0.00	0.00
232	0.00	0.00	428815.21	0.00	60000.00	0.00	0.00	0.00	0.00
233	0.00	0.00	428815.21	0.00	60000.00	0.00	0.00	0.00	0.00
234	0.00	0.00	428815.21	0.00	60000.00	0.00	0.00	0.00	0.00
235	0.00	0.00	428815.21	0.00	60000.00	0.00	0.00	0.00	0.00
236	0.00	0.00	428815.21	0.00	60000.00	0.00	0.00	0.00	0.00
237	0.00	0.00	428815.21	0.00	60000.00	0.00	0.00	0.00	0.00
238	0.00	0.00	428815.21	0.00	60000.00	0.00	0.00	0.00	0.00
239	0.00	0.00	428815.21	0.00	60000.00	0.00	0.00	0.00	0.00
240	0.00	0.00	428815.21	0.00	60000.00	0.00	0.00	0.00	0.00
241	0.00	0.00	428815.21	0.00	60000.00	0.00	0.00	0.00	0.00
242	0.00	0.00	428815.21	0.00	60000.00	0.00	0.00	0.00	0.00
243	0.07	607.90	429423.11	0.00	60000.00	0.00	0.00	607.90	0.00
244	0.00	0.00	429423.11	0.00	60000.00	0.00	0.00	0.00	0.00
245	0.01	86.84	429509.95	0.00	60000.00	0.00	0.00	86.84	0.00
246	0.00	0.00	429509.95	0.00	60000.00	0.00	0.00	0.00	0.00
247	0.06	521.06	430031.01	0.00	60000.00	0.00	0.00	521.06	0.00
248	0.00	0.00	430031.01	0.00	60000.00	0.00	0.00	0.00	0.00
249	0.00	0.00	430031.01	0.00	60000.00	0.00	0.00	0.00	0.00
250	0.00	0.00	430031.01	0.00	60000.00	0.00	0.00	0.00	0.00
251	0.00	0.00	430031.01	0.00	60000.00	0.00	0.00	0.00	0.00
252	0.00	0.00	430031.01	0.00	60000.00	0.00	0.00	0.00	0.00
253	0.00	0.00	430031.01	0.00	60000.00	0.00	0.00	0.00	0.00
254	0.00	0.00	430031.01	0.00	60000.00	0.00	0.00	0.00	0.00

2003 c.e.			Cum. Q_{HARV}	(KL = .55)	Storage at end	Change in	Harvested water	Overflow	Suppl.Water
Day	P	Q_{HARV} (gals)	(gals)	TWA (gals)	of prior day (gals)	Storage (gals)	used for irgn(gals)	(gals)	req'd (gals)
255	0.00	0.00	430031.01	0.00	60000.00	0.00	0.00	0.00	0.00
256	0.00	0.00	430031.01	0.00	60000.00	0.00	0.00	0.00	0.00
257	0.00	0.00	430031.01	0.00	60000.00	0.00	0.00	0.00	0.00
258	0.00	0.00	430031.01	0.00	60000.00	0.00	0.00	0.00	0.00
259	0.00	0.00	430031.01	0.00	60000.00	0.00	0.00	0.00	0.00
260	0.00	0.00	430031.01	0.00	60000.00	0.00	0.00	0.00	0.00
261	0.00	0.00	430031.01	0.00	60000.00	0.00	0.00	0.00	0.00
262	0.00	0.00	430031.01	0.00	60000.00	0.00	0.00	0.00	0.00
263	0.00	0.00	430031.01	0.00	60000.00	0.00	0.00	0.00	0.00
264	0.01	86.84	430117.85	0.00	60000.00	0.00	0.00	86.84	0.00
265	2.14	18585.69	448703.54	0.00	60000.00	0.00	0.00	18585.69	0.00
266	0.01	86.84	448790.38	0.00	60000.00	0.00	0.00	86.84	0.00
267	0.00	0.00	448790.38	0.00	60000.00	0.00	0.00	0.00	0.00
268	0.00	0.00	448790.38	0.00	60000.00	0.00	0.00	0.00	0.00
269	0.00	0.00	448790.38	0.00	60000.00	0.00	0.00	0.00	0.00
270	1.25	10855.33	459645.71	0.00	60000.00	0.00	0.00	10855.33	0.00
271	0.00	0.00	459645.71	0.00	60000.00	0.00	0.00	0.00	0.00
272	0.00	0.00	459645.71	0.00	60000.00	0.00	0.00	0.00	0.00
273	0.00	0.00	459645.71	0.00	60000.00	0.00	0.00	0.00	0.00
274	0.00	0.00	459645.71	0.00	60000.00	0.00	0.00	0.00	0.00
275	0.00	0.00	459645.71	0.00	60000.00	0.00	0.00	0.00	0.00
276	0.00	0.00	459645.71	0.00	60000.00	0.00	0.00	0.00	0.00
277	0.00	0.00	459645.71	0.00	60000.00	0.00	0.00	0.00	0.00
278	0.00	0.00	459645.71	0.00	60000.00	0.00	0.00	0.00	0.00
279	0.02	173.69	459819.40	0.00	60000.00	0.00	0.00	173.69	0.00
280	0.04	347.37	460166.77	0.00	60000.00	0.00	0.00	347.37	0.00
281	0.11	955.27	461122.04	0.00	60000.00	0.00	0.00	955.27	0.00
282	0.00	0.00	461122.04	0.00	60000.00	0.00	0.00	0.00	0.00
283	0.00	0.00	461122.04	0.00	60000.00	0.00	0.00	0.00	0.00
284	0.04	347.37	461469.41	0.00	60000.00	0.00	0.00	347.37	0.00
285	0.00	0.00	461469.41	0.00	60000.00	0.00	0.00	0.00	0.00
286	0.00	0.00	461469.41	0.00	60000.00	0.00	0.00	0.00	0.00
287	0.00	0.00	461469.41	0.00	60000.00	0.00	0.00	0.00	0.00
288	0.00	0.00	461469.41	0.00	60000.00	0.00	0.00	0.00	0.00
289	0.00	0.00	461469.41	0.00	60000.00	0.00	0.00	0.00	0.00
290	0.04	347.37	461816.78	0.00	60000.00	0.00	0.00	347.37	0.00
291	0.00	0.00	461816.78	0.00	60000.00	0.00	0.00	0.00	0.00

2003 c.e.			Cum. Q_{HARV}	(KL = .55)	Storage at end	Change in	Harvested water	Overflow	Suppl.Water
Day	P	Q_{HARV} (gals)	(gals)	TWA (gals)	of prior day (gals)	Storage (gals)	used for irgn(gals)	(gals)	req'd (gals)
292	0.00	0.00	461816.78	0.00	60000.00	0.00	0.00	0.00	0.00
293	0.00	0.00	461816.78	0.00	60000.00	0.00	0.00	0.00	0.00
294	0.00	0.00	461816.78	0.00	60000.00	0.00	0.00	0.00	0.00
295	0.00	0.00	461816.78	0.00	60000.00	0.00	0.00	0.00	0.00
296	0.00	0.00	461816.78	0.00	60000.00	0.00	0.00	0.00	0.00
297	0.00	0.00	461816.78	0.00	60000.00	0.00	0.00	0.00	0.00
298	0.00	0.00	461816.78	0.00	60000.00	0.00	0.00	0.00	0.00
299	1.69	14677.77	476494.55	0.00	60000.00	0.00	0.00	14677.77	0.00
300	0.02	173.69	476668.24	0.00	60000.00	0.00	0.00	173.69	0.00
301	0.01	86.84	476755.08	0.00	60000.00	0.00	0.00	86.84	0.00
302	0.00	0.00	476755.08	0.00	60000.00	0.00	0.00	0.00	0.00
303	0.00	0.00	476755.08	0.00	60000.00	0.00	0.00	0.00	0.00
304	0.00	0.00	476755.08	0.00	60000.00	0.00	0.00	0.00	0.00
305	0.00	0.00	476755.08	0.00	60000.00	0.00	0.00	0.00	0.00
306	0.00	0.00	476755.08	0.00	60000.00	0.00	0.00	0.00	0.00
307	0.00	0.00	476755.08	0.00	60000.00	0.00	0.00	0.00	0.00
308	0.00	0.00	476755.08	0.00	60000.00	0.00	0.00	0.00	0.00
309	1.11	9638.16	486393.24	0.00	60000.00	0.00	0.00	9638.16	0.00
310	0.01	86.84	486480.08	0.00	60000.00	0.00	0.00	86.84	0.00
311	0.00	0.00	486480.08	0.00	60000.00	0.00	0.00	0.00	0.00
312	0.01	86.84	486566.93	0.00	60000.00	0.00	0.00	86.84	0.00
313	0.00	0.00	486566.93	0.00	60000.00	0.00	0.00	0.00	0.00
314	0.00	0.00	486566.93	0.00	60000.00	0.00	0.00	0.00	0.00
315	0.00	0.00	486566.93	0.00	60000.00	0.00	0.00	0.00	0.00
316	0.00	0.00	486566.93	0.00	60000.00	0.00	0.00	0.00	0.00
317	0.00	0.00	486566.93	0.00	60000.00	0.00	0.00	0.00	0.00
318	0.00	0.00	486566.93	0.00	60000.00	0.00	0.00	0.00	0.00
319	0.00	0.00	486566.93	0.00	60000.00	0.00	0.00	0.00	0.00
320	0.00	0.00	486566.93	0.00	60000.00	0.00	0.00	0.00	0.00
321	0.00	0.00	486566.93	0.00	60000.00	0.00	0.00	0.00	0.00
322	0.71	6164.46	492731.39	0.00	60000.00	0.00	0.00	6164.46	0.00
323	1.02	8858.63	501590.02	0.00	60000.00	0.00	0.00	8858.63	0.00
324	0.00	0.00	501590.02	0.00	60000.00	0.00	0.00	0.00	0.00
325	0.00	0.00	501590.02	0.00	60000.00	0.00	0.00	0.00	0.00
326	0.00	0.00	501590.02	0.00	60000.00	0.00	0.00	0.00	0.00
327	0.00	0.00	501590.02	0.00	60000.00	0.00	0.00	0.00	0.00
328	0.14	1215.80	502805.81	0.00	60000.00	0.00	0.00	1215.80	0.00

2003 c.e. Day	P	Q_{HARV} (gals)	Cum. Q_{HARV} (gals)	(KL = .55) TWA (gals)	Storage at end of prior day (gals)	Change in Storage (gals)	Harvested water used for irgn(gals)	Overflow (gals)	Suppl.Water req'd (gals)
329	0.00	0.00	502805.81	0.00	60000.00	0.00	0.00	0.00	0.00
330	0.00	0.00	502805.81	0.00	60000.00	0.00	0.00	0.00	0.00
331	0.19	1650.01	504455.82	0.00	60000.00	0.00	0.00	1650.01	0.00
332	0.31	2690.75	507146.58	0.00	60000.00	0.00	0.00	2690.75	0.00
333	0.00	0.00	507146.58	0.00	60000.00	0.00	0.00	0.00	0.00
334	0.00	0.00	507146.58	0.00	60000.00	0.00	0.00	0.00	0.00
335	0.00	0.00	507146.58	0.00	60000.00	0.00	0.00	0.00	0.00
336	0.00	0.00	507146.58	0.00	60000.00	0.00	0.00	0.00	0.00
337	0.03	260.53	507407.11	0.00	60000.00	0.00	0.00	260.53	0.00
338	0.56	4861.82	512268.93	0.00	60000.00	0.00	0.00	4861.82	0.00
339	0.01	86.84	512355.77	0.00	60000.00	0.00	0.00	86.84	0.00
340	0.00	0.00	512355.77	0.00	60000.00	0.00	0.00	0.00	0.00
341	0.00	0.00	512355.77	0.00	60000.00	0.00	0.00	0.00	0.00
342	0.00	0.00	512355.77	0.00	60000.00	0.00	0.00	0.00	0.00
343	0.00	0.00	512355.77	0.00	60000.00	0.00	0.00	0.00	0.00
344	0.99	8598.79	520954.56	0.00	60000.00	0.00	0.00	8598.79	0.00
345	0.00	0.00	520954.56	0.00	60000.00	0.00	0.00	0.00	0.00
346	0.00	0.00	520954.56	0.00	60000.00	0.00	0.00	0.00	0.00
347	0.24	2084.22	523038.78	0.00	60000.00	0.00	0.00	2084.22	0.00
348	0.23	1997.38	525036.16	0.00	60000.00	0.00	0.00	1997.38	0.00
349	0.00	0.00	525036.16	0.00	60000.00	0.00	0.00	0.00	0.00
350	0.00	0.00	525036.16	0.00	60000.00	0.00	0.00	0.00	0.00
351	0.14	1215.80	526251.96	0.00	60000.00	0.00	0.00	1215.80	0.00
352	0.01	86.84	526338.80	0.00	60000.00	0.00	0.00	86.84	0.00
353	0.00	0.00	526338.80	0.00	60000.00	0.00	0.00	0.00	0.00
354	0.00	0.00	526338.80	0.00	60000.00	0.00	0.00	0.00	0.00
355	0.00	0.00	526338.80	0.00	60000.00	0.00	0.00	0.00	0.00
356	0.00	0.00	526338.80	0.00	60000.00	0.00	0.00	0.00	0.00
357	0.25	2171.07	528509.86	0.00	60000.00	0.00	0.00	2171.07	0.00
358	0.02	173.69	528683.55	0.00	60000.00	0.00	0.00	173.69	0.00
359	0.00	0.00	528683.55	0.00	60000.00	0.00	0.00	0.00	0.00
360	0.00	0.00	528683.55	0.00	60000.00	0.00	0.00	0.00	0.00
361	0.00	0.00	528683.55	0.00	60000.00	0.00	0.00	0.00	0.00
362	0.00	0.00	528683.55	0.00	60000.00	0.00	0.00	0.00	0.00
363	0.02	173.69	528857.23	0.00	60000.00	0.00	0.00	173.69	0.00
364	0.03	260.53	529117.76	0.00	60000.00	0.00	0.00	260.53	0.00
365	0.00	0.00	529117.76	0.00	60000.00	0.00	0.00	0.00	0.00

2003 c.e. Day	P	Q_{HARV} (gals)	Cum. Q_{HARV} (gals)	(KL = .55) TWA (gals)	Storage at end of prior day (gals)	Change in Storage (gals)	Harvested water used for irgn(gals)	Overflow (gals)	Suppl.Water req'd (gals)
Total	60.928	529117.76		1479.88			1479.88	467637.88	0.00

APPENDIX E

LEED WATER EFFICIENT LANDSCAPE IRRIGATION

Powerpoint Presentation by Fred Hall
Hydro-Environmental, Inc.

LEED
Water Efficient Landscape Irrigation

LEED Credits

- Credit 1.1 – 1 point

  use of high efficiency irrigation technology

  OR use captured rain water or

  recycled site water to

  reduce potable water consumption by 50%

LEED Credits

- Credit 1.2 – 1 point

  use only captured rain water or
  recycled site water for and additional
  50% reduction(100% total)
  of potable water for site irrigation

LEED Definitions

- High efficiency irrigation technology
  - Micro-irrigation
  - Moisture sensors
  - Weather database controllers
- Captured rain water
  - Storm water shed collected & stored
- Recycled site water
  - Graywater recovery and storage
    - Wastewater-lavatories,showers,bathtubs, & sinks not used in food preparation or disposal of hazardous, toxic or organic waste
- Potable water
  - Suitable for drinking from municipal source OR wells

LEED Calculations

- Calculate irrigation volume requirements for baseline
- Calculate irrigation volume requirements designed system
- Resulting water savings is the difference between the two

LEED Calculations

- Three step process
  - KL = landscape coefficient must be determined
  - Apply landscape coefficient to reference evapotranspiration rate ETr
  - Volume of irrigation water determined by factoring system efficiency

LEED Calculations

- KL - landscape coefficient
  - Volume of water lost via evapotranspiration based on species, planting density and microclimate
- KL = ks * kd * kmc

LEED Calculations

- KL = ks * kd * kmc
  - **ks = species factor (water needs for particular species)**
    - **three categories – high, average, and low**
      - **high = requires irrigation**
      - **average = can be maintained at 50% of ETr**
      - **Low = requires water only in drought**
  - **kd = density factor (number of plants & total leaf area)**
    - **three categories – high, average, and low**
      - **high = mixed landscape tree cover under story plantings**
      - **average = ground shading from trees 60-100%**
      - **low = ground shading >60% from trees or >90% plant material**
  - **kmc = microclimate factor (specific site areas)**
    - **Three categories – high, average, and low**
      - **high = parking lots, west & south exposures, wind tunnel**
      - **average = areas unaffected by blgs, slopes, reflective surfaces**
      - **low = shaded & protected areas, north & east exposures**

LEED Calculations
Factor Values

Vegetation Type	Species Factor ks			Density Factor kd			Microclimate Factor kmc		
	low	avg	high	low	avg	high	low	avg	high
Trees	0.2	0.5	0.9	0.5	1.0	1.3	0.5	1.0	1.4
Shrubs	0.2	0.5	0.7	0.5	1.0	1.1	0.5	1.0	1.3
Groundcover	0.2	0.5	0.7	0.5	1.0	1.1	0.5	1.0	1.2
Mixed planting	0.2	0.5	0.9	0.6	1.1	1.3	0.5	1.0	1.4
Turfgrass	0.6	0.7	0.8	0.6	1.0	1.0	0.8	1.0	1.2

KL = ks *kd *kmc

LEED Calculations
Landscape Coefficient

Mixed plantings - average conditions

(ks) 0.5 * (kd) 1.1 * (kmc) 1.0 = (KL) .55

Mixed plantings - low conditions

(ks) 0.2 * (kd) 1.1 * (kmc) 1.0 = (KL) .22

Turfgrass - average

(ks) 0.7 * (kd) 1.0 * (kmc) 1.0 = (KL) 0.7

Turfgrass - high

(ks) 0.9 * (kd) 1.0 * (kmc) 1.0 = (KL) 0.9

Once the KL is determined, the evapotranspiration rate of the specific landscape (ETL) can be calculated. KL is multiplied by the reference evapotranspiration data (Etr) to get ETL

ETL = KL * ETr

ETr values are available for all regions throughout the U.S.
to determine annual requirement this must be done for each month

LEED Calculations

Procedure

To determine the water savings the above calculations must be performed for the designed landscape irrigation system as well as a baseline irrigation system

First, calculate a baseline system. This is done using conventional plant species and plant densities using the landscape factors.

Next, calculate the designed system with lower requirement plant material and higher efficiency irrigation

Plans should use the identical microclimate factors and reference evapotranspiration rates

The difference between the two is the projected water savings.

A 50% reduction in potable usage = 1 point

LEED Calculations

Project Conditions worksheet 1

- Site data: Landscape: 1.71 acres Location: Atlanta, GA
- Calculated Landscape Coefficient (KL)
- Mixed planting average = .55 Mixed planting low = .22 Turfgrass = .7

ETL = KL * ETr

Reference Evapotranspiration data (Etr)

Month	average rainfall	(Etr)	LEED calculations (ETL) turf/avg	turf/high	plants low	avg
Mar	5.57	1.78	1.25	1.60	.39	.98
Apr	4.65	3.27	2.29	2.94	.72	1.80
May	3.66	5.27	3.69	4.74	1.15	2.90
Jun	3.75	6.77	4.74	6.09	1.49	3.72
Jul	5.10	7.33	5.13	6.59	1.61	4.03
Aug	4.00	6.68	4.68	6.01	1.47	3.67
Sep	3.23	4.88	3.42	4.39	1.07	2.68
Oct	2.99	2.96	2.07	2.66	.65	1.63

LEED Calculations
Plan Comparison

- Baseline Plan 1
  - .25 acres turfgrass , 1.46 acres plant material using conventional irrigation
- Plan 2
  - .25 ac turfgrass conven. Irrig., 1.46 ac plant material using micro irrigation
- Plan 3
  - .25 ac turf grass conven. Irrig., .46 ac “green” planting, 1.00 ac hardier plant material
- Plan 4
  - 1.71 ac hardy plant material (no turf)

LEED Calculations
Irrigation efficiencies

To calculate irrigation volumes, irrigation efficiency (IE) must be applied.

Irrigation Efficiencies

sprinklers .625

drip .90

The Total Potable Water Applied (TPWA) to a given area (A) can be calculated as follows

TPWA = A * ETL / IE

LEED Calculations

Baseline Plan 1

worksheet 2

TPWA = A * ETL / IE

•.25 acres turf 1.46 acres planted - conventional irrigation

Month	Area		ETL		IE		TPWA	
	turf	Inds	turf	Inds	turf	Inds	turf	Inds
Mar	6,788	39,644	1.60	.98	.625	.625	17,377	62,161
Apr			2.94	1.80	"	"	31,930	114,174
May			4.74	2.90	"	"	51,480	183,948
Jun			6.09	3.72	"	"	66,142	235,961
Jul			6.59	4.03	"	"	71,572	255,624
Aug			6.01	3.67	"	"	65,273	232,789
Sep			4.39	2.68	"	"	47,678	106,245
Oct			2.66	1.63	"	"	28,889	103,391
							380,341	1,294,293

Combined annual usage 1,674,634 gallons

LEED Calculations

Plan 2

worksheet 3a

• Plan 2

TPWA = A * ETL / IE

•.25 acres turf bermuda vs fescue

•Month	Area		ETL		IE		TPWA	
	turf 1	turf 2	turf 1	turf 2	turf 1	turf 2	turf 1	turf 2
Mar	6,788	39,644	1.25	1.60	.625	.625	13,576	17,377
Apr			2.29	2.94	"	"	24,871	31,930
May			3.69	4.74	"	"	40,076	51,480
Jun			4.74	6.09	"	"	51,480	66,142
Jul			5.13	6.59	"	"	55,715	71,572
Aug			4.68	6.01	"	"	50,828	65,273
Sep			3.42	4.39	"	"	37,143	47,678
Oct			2.07	2.66	"	"	22,481	28,889
							296,170	380,341

turf 1 bermuda grass 296,170 gallons

turf 2 fescue grass 380,341 gallons

84,171 gallons more for fescue

LEED Calculations

Plan 2

worksheet 3b

• Plan 2

TPWA = A * ETL / IE

•.25 acres turf   1.46 acres planted – micro irrigation

Month	Area	ETL	IE	TPWA landscape	TWPA turf from 3a turf 1	turf 2
Mar	39,644	.98	.90	43,167	13,576	17,377
Apr		1.80	"	79,288	24,871	31,930
May		2.90	"	127,741	40,076	51,480
Jun		3.72	"	163,861	51,480	66,142
Jul		4.03	"	177,517	55,715	71,572
Aug		3.67	"	161,659	50,828	65,273
Sep		2.68	"	118,051	37,143	47,678
Oct		1.63	"	71,799	22,481	28,889
				943,083	296,170	380,341

Combined annual usage   1,239,253 gallons (turf 1 - bermuda grass)

Combined annual usage   1,323,424 gallons (turf 2 - fescue grass)

LEED Calculations

Plan 3

worksheet 4

• Plan 3

TPWA = A * ETL / IE

•<u>Turf remains as in Plan 2 (bermuda grass)</u>

•.46 acres landscape <u>average (Inds 1)</u> ,   1.00 acres landscape <u>hardy (Inds 2)</u> micro irrigation

Month	Area Inds 1	Area Inds 2	ETL Inds 1	ETL Inds 2	IE Inds 1	IE Inds 2	TPWA Inds 1	TPWA Inds 2
Mar	12,490	27,154	.98	.39	.90	.90	13,600	11,766
Apr			1.80	.72	"	"	24,980	21,723
May			2.90	1.15	"	"	40,245	34,696
Jun			3.72	1.49	"	"	51,625	44,954
Jul			4.03	1.61	"	"	55,927	48,575
Aug			3.67	1.47	"	"	50,931	44,351
Sep			2.68	1.07	"	"	37,192	32,283
Oct			1.63	.65	"	"	22,620	18,706
							297,120	257,054

Combined <u>landscape</u> area usage of   554,174 gallons

LEED Calculations

Plan 4

worksheet 5

- Plan 4

TPWA = A * ETL / IE

- Turf removed and replaced with mondo grass
- 1.71 acres landscape hardy micro irrigation

Month	Area		IE	TPWA
Mar	46,433	.49	.90	25,280
Apr		.90		46,433
May		1.44		74,292
Jun		1.86		95,961
Jul		2.01		103,700
Aug		1.84		94,929
Sep		1.34		69,133
Oct		.81		41,789
				551,517

Combined landscape area usage of 551,517 gallons

LEED Calculations

Plan Comparison Final

worksheet 6

Month	Plan 1	Plan 4	Plan 4 vs Plan 1 water savings
Mar	79,538	25,280	54,258
Apr	146,104	46,433	99,671
May	235,428	74,292	161,136
Jun	302,103	95,961	206,142
Jul	327,196	103,700	223,496
Aug	298,062	94,929	203,133
Sep	153,923	69,133	84,790
Oct	132,280	41,789	90,491
TPWA	1,674,634	551,517	1,123,117

Savings in gallons 1,123,117

Percent of baseline 67%

LEED Calculations
Plan Comparison

now what ?

Only 67%

Can we save even more ?

either change landscape material and recalculate the numbers

or

investigate recycled site water

LEED Calculations

recycled site water

Runoff=watershed area x runoff coefficient x rainfall amount

Site watershed = 2.5 acres **runoff coefficient = .7**

Month runoff	rainfall	runoff gallonage	available gallonage	excess
Jan	5.57	264,684	40,000	224,684
Feb	4.65	220,966	0	220,966
Mar	3.66	173,921	120,000	53,921
Apr	3.75	178,198	120,000	58,198
May	5.10	242,349	120,000	122,349
Jun	4.00	190,078	120,000	70,078
Jul	3.23	153,488	120,000	33,488
Aug	2.99	142,083	120,000	22,083
Sep	3.26	154,914	120,000	34,914
Oct	4.96	235,697	120,000	155,697
Nov	3.26	154,913	0	154,913
Dec	4.96	235,696	0	235,696
gallons		2,346,987	1,000,000	1,386,987

Usable gallonage - assuming .8" rain falling every ten days

LEED Calculations
Plan Comparison
worksheet 6a

Month	Plan 1 TPWA	Plan 4 TWPA	Recycled site water	TPWA	TWPA Savings
Feb			40,000	0	0
Mar	79,538	25,280	40,000	0	79,538
Apr	146,104	46,433	80,000	0	146,104
May	235,428	74,292	120,000	0	235,428
Jun	302,103	95,961	120,000	0	302,103
Jul	327,196	103,700	120,000	0	327,196
Aug	298,062	94,929	120,000	0	298,062
Sep	153,923	69,133	120,000	0	153,923
Oct	132,280	41,789	80,000	0	132,280
	1,674,634	551,517	840,000	0	1,674,634

Plan 4 with recycled site water total savings 1,674,634 gallons

now 6% of original estimates 100% reduction

LEED Calculations
Plan Comparison
tell me more

Using these worksheets we have reduced the TPWA by 100%

This comes with a price.

In irrigation equipment

conventional spray irrigation equipment

spacing 15'x 15' square 225 sq ft = 4 spray heads

drip irrigation equipment cost less, yet more equipment is required along with additional filtration

spacing 12" oc 225 sq ft = 225 drip emitters

spacing 12" oc 225 sq ft = 150 drip emitters

et based control package, ect…

Recycled site water

site development cost (drainage, retention facility, particulate and hydrocarbon separator, pump stations)

space

40,000 gallon = 5,347 cu ft 10 ft x 10 ft box culvert 53+ feet long

55,000 gallon = 7,352 cu ft 10 ft x 10 ft box culvert 73+ feet long ask us

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