

CONCEPTUAL DESIGN OF A BEST
MANAGEMENT PRACTICE RETROFIT
PROJECT IN A SMALL URBAN WATERSHED

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**CONCEPTUAL DESIGN OF A BEST MANAGEMENT PRACTICE RETROFIT
PROJECT IN A SMALL URBAN WATERSHED**

By

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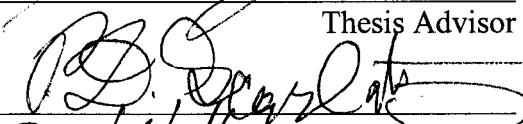
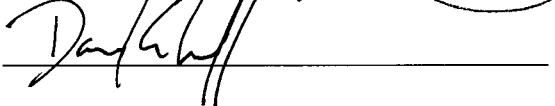
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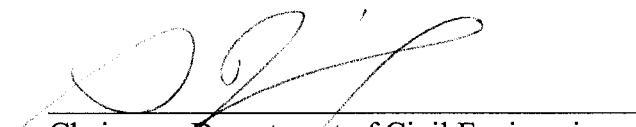
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This thesis was prepared under the direction of the candidate's thesis advisor, Dr. Stephan Nix, Department of Civil Engineering, and has been approved by the members of his supervisory committee. It was submitted to the faculty of the College of Engineering and was accepted in partial fulfillment of the requirements for the degree of Master of Science.

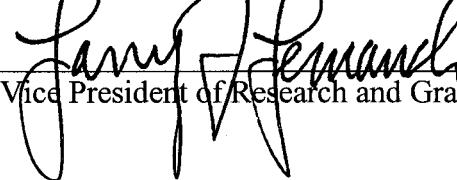
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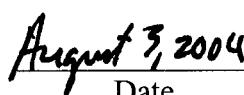
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ABSTRACT

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Across the state of Florida, stormwater retrofit projects have been gaining increasingly more attention in recent years, mainly due to the effects stormwater and non-point source pollution have shown to have on the environment. Many retrofit projects focus mainly on “end-of-pipe” solutions with little regard for watershed behavior and the nature of the drainage system’s deficiencies. This report focuses on an intimate understanding of watershed behavior and how the knowledge gained by such an understanding can be a valuable tool in designing an effective stormwater management system. A case study is presented involving a small urban watershed in the Town of Davie, Florida. An intense site investigation was performed followed by a modeling procedure using the Environmental Protection Agency’s Stormwater Management Model. The knowledge gained was applied to building an understanding of the drainage system and its deficiencies, and developing a tailored set of solutions for both quality and quantity.

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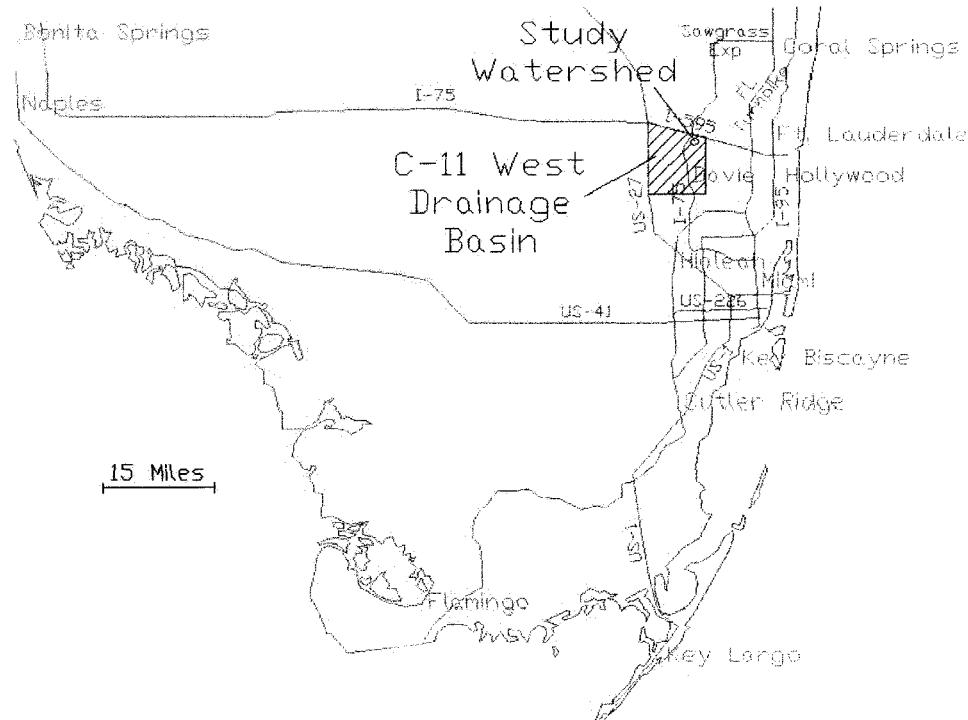
1 INTRODUCTION

1.1 URBANIZATION AND DEVELOPMENT IN SOUTH FLORIDA

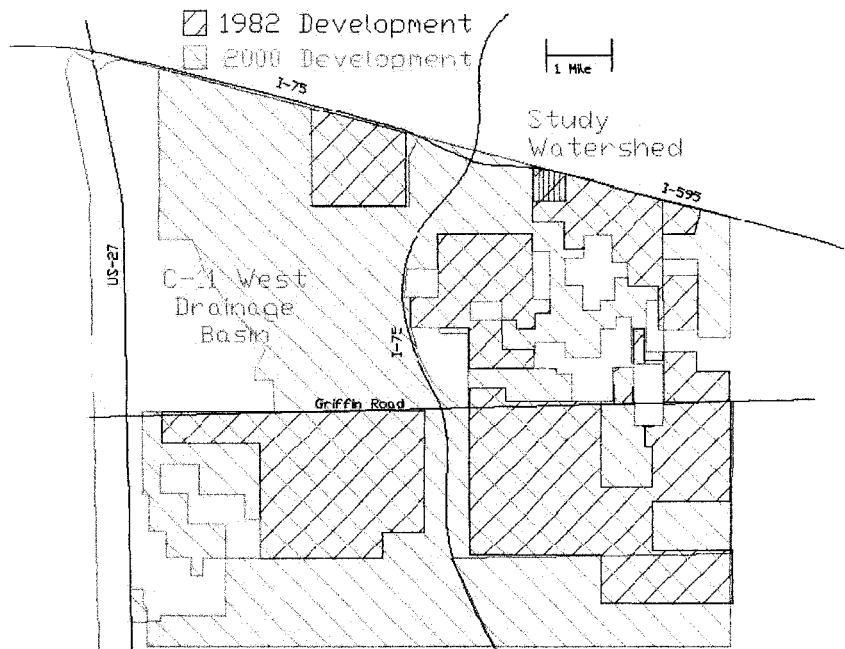
Urbanization in this country and around the world is occurring at a phenomenal rate. As our dependencies on modern transportation highways, mini-malls and single-family homes continue to grow so does the alteration to our environment. As a result, non-point source (NPS) pollution from urbanized areas has become an increasingly important issue. Many studies have clearly shown the effects urbanization can have on the quantity and quality of the stormwater runoff, and ultimately the impact it has on the receiving waterways, specifically changes to the physical, chemical and biological processes otherwise naturally present (Urbonas, 2001).

Florida is particularly susceptible to NPS pollution caused by urbanization. As of the 2000 census almost 16 million people resided in the state of Florida, up from 9.7 million in 1980 (Purdum, 2002). The subject of this study, the C-11 west drainage basin,

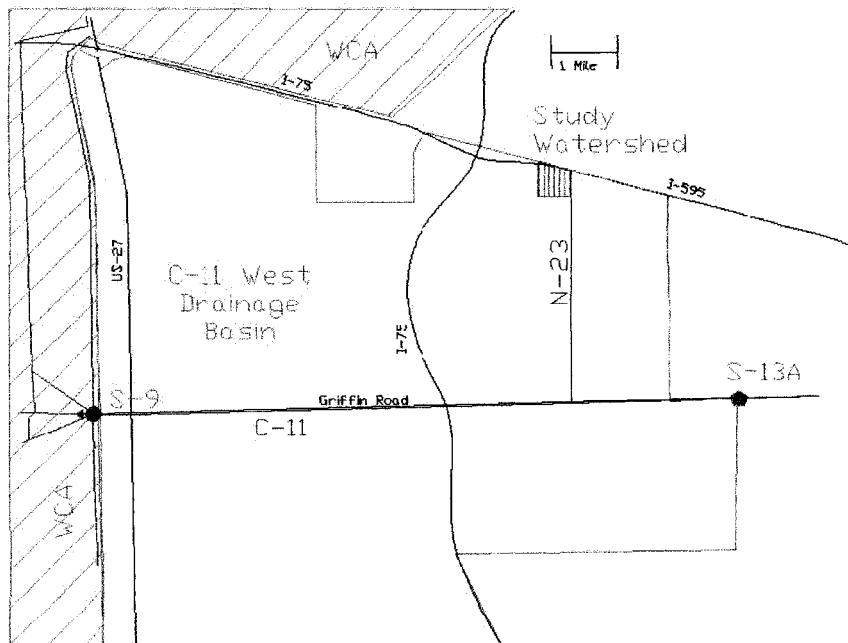
in Broward County (see Map 1), was about 86% urbanized by the year 2000 where it was only 32% before 1982 (see Map 2). The first Stormwater permitting program was established in Florida in that year. Before 1982 little attention was given towards the effects of urbanization and NPS pollution. Stormwater management consisted mainly of flood control measures, and drainage systems were designed to convey water as efficiently and as quickly as possible away from the developed areas (FDEP, 1997). However, the C-11 west drainage basin, as well as a large percentage of western Broward County, drains directly into the Everglades and the Water Conservation Areas (WCA's) via a series of canals and pumps (see Map 3). As a consequence, major eutrophication and degradation has occurred in the Florida Everglades.



Map 1. Location of C-11 west drainage basin and the study watershed.



Map 2: Development in the C-11 West Drainage Basin.



Map 3: Watershed connection to the WCA and Florida Everglades

1.2 NPS POLLUTION AND STORMWATER LEGISLATION

In response to the eutrophication and erosion cause by NPS pollution, much legislation has been enacted over the last 30 years at the national, state and local levels. The first, the Federal Clean Water Act (FCWA) of 1972, addressed the reduction of pollutant loads entering the Florida Everglades as well as all surface water bodies across the nation. Section 319 of the 1987 FCWA amendments established a national program that requires states to assess sources of NPS pollution within that state. It further provides funding for implementation of EPA approved NPS management programs designed to minimize the impacts of NPS and restore impaired water bodies (FDEP, 1999). In the past several years, agencies across the state of Florida have recognized poorly designed drainage systems servicing older, urbanized watersheds as a major cause of impaired water bodies. As a result, many projects have been proposed requesting funding under the section 319 rule. A few will be presented in this report, one of which will be used as a case study in the conceptual design of a Best Management Practice (BMP) retrofit project.

1.3 STORMWATER MANAGEMENT IN SMALL URBAN WATERSHEDS

Because of the vast urbanization preceding any regulatory requirements regarding stormwater drainage, and the recognized fact that urban stormwater runoff is a major contributor to surface water degradation, system retrofit projects of older and poorly designed systems are of particular concern (England, 2001). England (2001) suggests

that focusing stormwater management at the smaller watershed scale, rather than undertaking major area-wide projects has several financial and political benefits. For instance, high priced consultant firms are not required for small stormwater management projects. In addition, immediate results are obtained and easily observed, which help validate the project and increases public support.

1.4 STUDY OBJECTIVES AND METHODOLOGY

This report develops a conceptual design of BMP's and a stormwater management plan for a small urban watershed located in Davie, Florida on the northern edge of the C-11 West Drainage Basin (Map 1). This site was chosen for its susceptibility to surface flooding, its lack of NPS pollution control devices, and its connection to the WCA's and the Florida Everglades. Final design considerations will address the issues of surface flooding, catchbasin overflow, discharge volume and pollutant loads. The objective of this study is to develop and illustrate an easily and economically applicable design process, which can be used as a template for other small urban watershed, stormwater management retrofit projects in South Florida; one which will provide a comprehensive design process at the watershed level, be easily adaptable to small watersheds with minimal resources, and will focus attention on watershed behavior and BMP interactions. The design process will include an intense site investigation, watershed analyses and problem characterizations, and design development based on the knowledge gained. Appendix H includes an overview of the design process outlined in this report.

2 STORMWATER PRACTICES AND BMP USE IN SOUTH FLORIDA

Florida regularly receives between 50 and 65 inches of rain a year. Because of the phenomenal growth rate and urbanization, the runoff from that rainfall has had drastic effects on the biological diversity and chemical composition of Florida's surface water. The FDEP (1997) explains the impacts that stormwater runoff has on Florida waters: stormwater generates almost all of the sediments found in receiving waters, contributes nine times more biological oxygen demand (BOD) than point sources, flushes nutrients at a rate comparable to waste water treatment plants, deposits 80-95% of the heavy metals, and it carries viruses, bacteria, and disease causing organisms. The use of BMP's has been developed to cope with these issues and to help return Florida's water back to its natural state. Focus for BMP design should be given to both the prevention/reduction of pollutants and the total volume of runoff entering the receiving waters (SFWMDb, 2002).

2.1 FCWA SECTION 319 AND OTHER STORMWATER RETROFIT PROJECTS IN SOUTH FLORIDA

There are several ongoing studies requesting section 319 funding across the state of Florida dealing with urban stormwater retrofit projects. Many of which are in highly urbanized areas with little space available for additional BMP construction and low impact development (LID) without major disruption to daily residential life. Three such projects are described below as presented by the Section 319 Non-Point Source Management Implementation Grant Abstracts (FDEP, 2003), each utilizing a various BMP combination.

2.1.1 City of Stuart Public Works Department

The City of Stuart Public Works Department has begun retrofitting several drainage outfall pipes in basins that are 100% built out. To date, 26 baffle boxes have been or are planned for construction in the City of Stuart. Nutrient separating baffle boxes can be an efficient BMP for controlling total suspended solids (TSS) and preventing nutrient release from organic debris by providing dry storage of organic matter. England (1988) has shown baffle boxes to have solid removal efficiencies as high as 90% for sand and sandy clay size particles, decreasing to 28% for fly ash. They can be an effective choice in areas where space is not available for traditional surface detention systems.

2.1.2 City of Cocoa Beach Stormwater Utility

The City of Coca Beach Stormwater Utility, as part of the Indian River Lagoon restoration project, proposed a 0.75-acre detention area for the treatment of stormwater runoff. The project has been designed to treat the runoff from an 83-acre urbanized watershed discharging into the Banana River, a tributary to the Indian River Lagoon. It will include an alum injection system to help in the removal of dissolved nutrients. Coagulants, such as alum ($\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$), can be used in situations where the detention time necessary for sedimentation can not be achieved for adequate removal of suspended partials. The alum causes the colloid size particles, associated with water color and turbidity, to aggregate, thereby increasing the effective particle size and corresponding settling rate (Escobar, 1998).

2.1.3 Sarasota County Utilities Department

A project initiated by the Sarasota County Utilities Department proposes the use of a BMP treatment train system. The system will incorporate the installation of inlet traps, exfiltration trenches and baffle boxes. Inlet traps are used to collect organic debris that is then kept in dry storage to minimize nutrient leaching. Exfiltration trenches are commonly used in developed areas to capture the first flush of runoff, which is then allowed to percolate through the trench gravel and into the surrounding soil via perforations in the pipe (Branscome, 1987). The treatment train system of stormwater management can be an effective means for NPS pollution control. No one BMP can be

totally effective for a particular situation. They have been shown to be most effective when working in unison (SFWMD, 2002a).

2.2 GENERALIZATIONS OF STORMWATER MANAGEMENT PRACTICES

Stormwater management programs are often developed based on expert advice, familiarity and availability of management practices, or by selecting the lowest cost option (Kalman, 2000). As a result, designers tend towards standard, “end-of-pipe” solutions with little regard for the dynamics of the watershed in question, or for the true nature of the stormwater issues. With an emphasis applied to understanding the watershed, stormwater practices can be tailored for more optimal control, and a more efficient and cost effective solution can be devised. Unfortunately, little information exists regarding techniques and procedures for making appropriate management decisions. Hence, engineers often rely on the successes and failures of others without regard for site-specific conditions.

3 CASE STUDY: SUNSHINE VILLAGE AND WESTERN HILLS

The case study presented in this report is an example of an ongoing retrofit project located in the Town of Davie, Florida. Funding was provided under section 319 of the FCWA and was distributed by FDEP to the Town of Davie. In conjunction with the engineering firm Chen and Associates, the Florida Atlantic University Civil Engineering and Environmental Science Departments were charged with the responsibilities of site analysis and conceptual design of the stormwater management system.

3.1 WATERSHED DESCRIPTION

3.1.1 Study Site Description and Delineation

The neighborhoods of Sunshine Village and Western Hills are two adjacent, single-family communities located on the northern edge of the town of Davie, Florida (see Map 1). The communities are a mix of single and doublewide mobile homes on

approximately 1/10-ac lots. The actual age of the communities and drainage system is unknown but do pre-date (circa 1982) any significant water quantity/quality regulations.

Sunshine Village and Western Hills together comprise two watersheds extending over 90 acres total. They are bounded by SW 134th Avenue and SW 130th Avenue on the east and west and by SW 3rd Court and SW 6th Court on the North and South. The watersheds discharge into the N-23 canal at two separate outfalls (see Map A-1). The first, referred to throughout this report as the northern watershed, extends over about 67 acres and drains all of Sunshine Village and the northern portion of Western Hills north of SW 5th Court. The second, referred to throughout this report as the southern watershed, extends over the remaining 23 acres of Western Hills south of SW 5th Court.

3.1.2 Storm Water Issues

This area has been chosen for in-depth study due to its unfortunate history of continual flooding, specifically after hurricane Irene in 1999. Even storms of short duration and moderate intensity result in prolonged water retention in residential use areas such as driveways and roadways. The development in the area pre-dates any significant stormwater regulations and, after years of neglect, has left the existing stormwater management system grossly inadequate in terms of water removal and pollution control.

3.1.3 The Drainage System

The communities of Sunshine Village and Western Hills have a surface drainage system consisting of roadside swales for collection, infiltration and conveyance to one of 52 widely spaced catchbasins. The catchbasins are connected to each other and to five partially submerged outfalls by a system of corrugated steel storm sewers. Discharge is routed through two connected ponds and ultimately to the N-23 canal via a 3-ft diameter, 1400-ft long storm sewer with no access point. The N-23 canal conveys flow to the C-11 South New River, located at Griffin Road, which flows west to the Everglades and east to the Atlantic Ocean (see Map 3). The normal variation in water surface elevation throughout the system is 3 to 4 ft mean sea level (MSL), more during intense storms. Any change in the water surface elevation propagates system wide. This generates some uncertainty when evaluating the watershed's response to given rainfall due to the influence of the unpredictable downstream effects.

3.2 SITE INVESTIGATION

3.2.1 Use of Geographical Information Systems

To assist in deciphering and the visualization of the drainage system for subsequent modeling and planning, all the data collected, detailed in the following sections, were plotted on the Geographical Information System (GIS) computer program AutoCAD, and to a limited extent ArcMAP. Locations were plotted relative to an aerial photograph of the region. From the GIS data, storm sewer lengths, areas, and a multitude

of additional information was easily attainable that otherwise would have been very difficult to accurately estimate.

3.2.2 Observational Analysis

Before any significant analysis of a watershed can be done, it is necessary to understand its characteristics, much of which can be deduced by observation. Observational analysis plays a vital role in recognizing specific stormwater management issues, as well as uncovering subtle clues and gaining general information needed for an efficient, more intense investigation. Several conclusions were based on observational analysis during dry and wet weather about the Sunshine Village and Western Hills watersheds.

3.2.2.1 Watershed response

Basic flow characteristics were observed, including the watersheds' response to varying degrees of rain intensity. It was found that the swale system very effectively deals with the short duration and light to moderate intensity rainstorms that occur almost daily during the summer months. No significant runoff was observed during these events. The watersheds require at least 1- to 2-in/hr rain intensity over a minimum 10-minute interval for significant runoff to occur.

3.2.2.2 Surface flooding

Observations have revealed several problematic areas within the drainage system, including the location of areas prone to frequent flooding. These areas are not only an inconvenience for the residents, but also provide a haven for a likely source of nutrient loading (i.e. phosphorous) – a dense population of Muscovy Ducks. In addition, after speaking with residents and detecting evidence catchbasin surcharge, it was found that many problems stemmed from clogging and improper maintenance. A major cause of surface flooding also appeared to be the lack of maintenance of the swale system. SFWMD requires the centerline elevation of the swale be no higher than the lowest upstream driveway (SFWMD, 2003). For 90% of the watershed, this is not the case.

3.2.3 Pre-Existing Catchbasin and Storm Sewer Systems

Since no accurate as-built information exists, a complete picture of the current conveyance system was to be constructed. Each catchbasin was located and plotted on an aerial photograph of the site, and the structural dimensions were measured. The measurements recorded for each catchbasin and storm sewer are shown in Figure 1. Map A-2 depicts the layout of the system and Tables B-1 and B-2 are a compilation of the data shown in Figure 1.

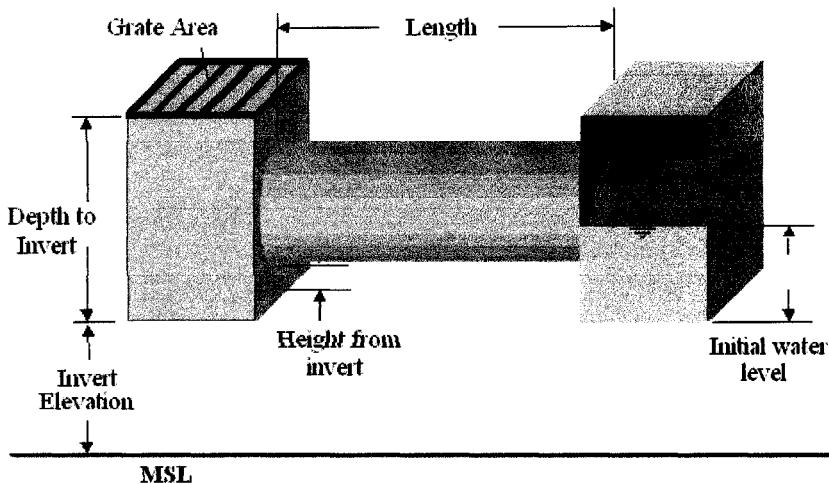


Figure 1. Catchbasin and storm sewer dimensions

3.2.4 Swale Elevation Analysis

Important information concerning the stormwater flow patterns within the watersheds can be deduced from Map A-3. It was constructed by interpolating surface elevations that were measured recorded and plotted at each of 204 locations throughout the communities within the swale system. No points mid-block or on the road surfaces were taken to help expedite the process. It provides for a quick visual examination of elevation peaks, depressions, and land slope, which are all important factors in determining runoff direction, subwatershed delineation, and locating areas prone to flooding.

3.2.5 Flow Assumptions

In order to completely understand flow behavior and how it relates to the topography shown in Map A-3, two assumptions must be made. The actual watershed

topography was assumed to be configured such that any runoff resulting from rainfall occurring within a subwatershed is first conveyed perpendicular to, and towards, the respective collecting swale. Once in the swale system, the channel slope, depicted in Map A-3, dictates the flow direction. It was further assumed, except in one location where it has been observed, that no flow can occur over the road crest. Both these concepts are illustrated in Figure 2.

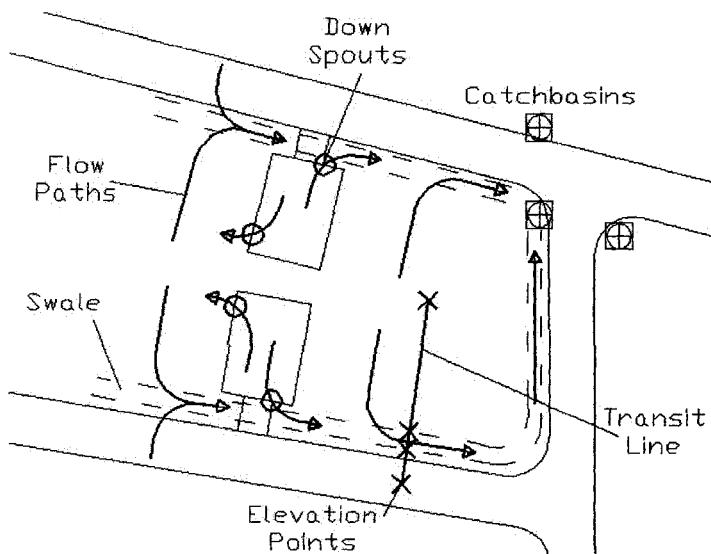


Figure 2. Surface flow path

3.2.6 Watershed Slope Analysis

To verify the flow assumptions, a slope analysis was performed in five selected areas along a transit line perpendicular to the road surface. The elevation was determined at intermediate points along that line as shown in Figure 2. It was found that, on average, each yard tends towards the corresponding swale at a slope of 0.014 (vertical/ horizontal) and each road with a slope of 0.020 (v/h). The supporting measurements and calculations are shown in Table 1. Moreover, each swale has on average a slope one order of

magnitude lower at 0.003 (v/h) calculated from data shown in Map 3. It is therefore reasonable to assume that there is no longitudinal flow down a block except within the swale system.

Table 1. Subwatershed Slope Data

	Impervious (Road)	Pervious (Yard)		Impervious (Road)	Pervious (Yard)
Crown Elevation	7.24	8.16	Crown Elevation	7.15	7.81
Edge Elevation	7.01	7.01	Edge Elevation	6.92	6.92
Length	11.7	66.5	Length	11	73
Slope	0.020	0.017	Slope	0.021	0.012
Crown Elevation	7.19	7.64	Crown Elevation	7.15	8
Edge Elevation	6.97	6.87	Edge Elevation	6.92	6.92
Length	10.9	72	Length	11	73.5
Slope	0.020	0.011	Slope	0.021	0.015
Crown Elevation	7.19	8.02	Average Slope	0.020	0.014
Edge Elevation	6.96	6.86			
Length	10.9	75.5			
Slope	0.021	0.015			

3.2.7 Swale Cross-Section

To assist in later investigations, it was necessary to generate a plot of the average swale cross-sectional dimensions. Elevations were measured at 15 stations in 1-ft intervals across the swale at the same five locations used for the watershed slope analysis. The data is listed in Table 2. The resulting data was normalized such that each location would have a comparable reference point, the road surface. Figure 3 depicts the average channel cross-section constructed using the normalized data. This average swale

configuration will be used rather than determining the configuration of each swale individually.

Table 2. Swale Cross-Section Data

Station (ft)	Actual Elevations					Shifted Elevations					Average	
	Location					Location						
	1	2	3	4	5	1	2	3	4	5		
0	6.92	6.92	6.97	6.96	6.99	6.92	6.92	6.92	6.92	6.92	6.92	
1	6.93	6.92	6.93	6.90	6.97	6.93	6.92	6.88	6.86	6.90	6.90	
2	6.86	6.78	6.91	6.88	6.86	6.86	6.78	6.86	6.84	6.79	6.83	
3	6.80	6.80	6.88	6.85	6.73	6.80	6.80	6.83	6.81	6.66	6.78	
4	6.75	6.72	6.85	6.81	6.75	6.75	6.72	6.80	6.77	6.68	6.74	
5	6.71	6.69	6.84	6.75	6.69	6.71	6.69	6.79	6.71	6.62	6.70	
6	6.68	6.69	6.84	6.74	6.68	6.68	6.69	6.79	6.70	6.61	6.69	
7	6.70	6.70	6.82	6.75	6.66	6.70	6.70	6.77	6.71	6.59	6.69	
8	6.68	6.77	6.84	6.75	6.63	6.68	6.77	6.79	6.71	6.56	6.70	
9	6.76	6.84	6.91	6.77	6.70	6.76	6.84	6.86	6.73	6.63	6.76	
10	6.80	6.88	6.95	6.81	6.77	6.80	6.88	6.90	6.77	6.70	6.81	
11	6.81	6.91	7.01	6.85	6.90	6.81	6.91	6.96	6.81	6.83	6.86	
12	6.91	6.99	7.02	6.81	7.00	6.91	6.99	6.97	6.77	6.93	6.91	
13	6.93	7.01	7.09	6.88	7.03	6.93	7.01	7.04	6.84	6.96	6.96	
14	6.93	7.06	7.18	6.90	7.14	6.93	7.06	7.13	6.86	7.07	7.01	
15	6.93	7.06	7.25	7.04	7.18	6.93	7.06	7.20	7.00	7.11	7.06	

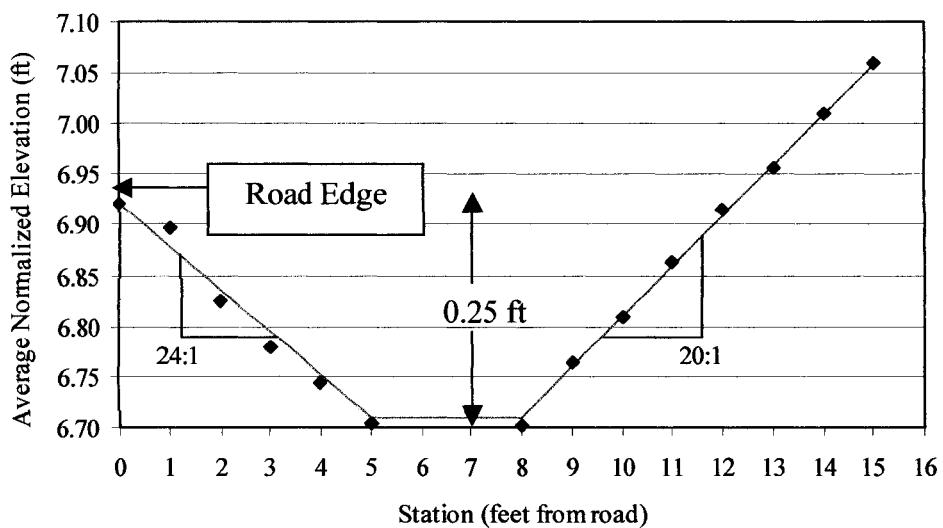


Figure 3. Typical swale cross-section

3.2.8 Other Considerations

Besides taking an in depth look into the topography, geography and current drainage status of any site, ASCE (1994) also recommends careful consideration of the water table, soil characteristics, environmental factors and physical constraints of the system. Ideally these characteristics should be evaluated with in situ tests or some other means. However, for this study, a few assumptions or generalizations from other published sources will be applied to these areas, such as a constant water table at about 3 ft MSL, and soil properties consistent with Hallandale Fine Sand.

3.3 STORMWATER MONITORING

3.3.1 Flow Measurement

For each storm event, flow velocity and flow depth at the outfall to the northern watershed were recorded at 5-minute intervals. Velocity was measured using a Marsh-McBirney Flo-Mate Model 2000 flow meter and taken at the three depth locations of 0.2, 0.4 and 0.8 times the total depth from the invert. The average velocity was calculated based on the weighted average of the three measurements as shown in Equation 1. The flow rate was further calculated using Equation 2 (Marsh-McBirney, 1989).

$$\bar{U} = \frac{1}{4}(U_{0.2} + 2U_{0.4} + U_{0.8}) \quad (1)$$

$$Q = KD^2\bar{U} \quad (2)$$

where

U = velocity

D = pipe Diameter

K = flow unit multiplier, based on depth/diameter ratio (0.8 to 1.0)

Flow measurements and calculations are listed in Tables C-1 through C-5 for five storm events and the hydrographs for two of those are plotted in Figures C-1 and C-2.

3.3.2 Water Sampling

At 5-minute time intervals during each storm event, samples for water quality were also taken. A procedure for sampling was taken from FDEP (2002). Samples were collected in sterile containers after triple rinsing, immediately stabilized with sulfuric acid and set on ice. Analysis for total phosphorous (TP) and total solids (TS) was performed at the Florida Atlantic University Environmental Science laboratory using procedures adopted from the SFWMD.

3.3.3 Rainfall Data

A RainWise REGL Tipping Bucket Recording rain gage was located on site and set to record rain depth readings at one-minute intervals with an accuracy of 0.01 inches during all rain events. Rain data was collected for the storm events on 9/17/03 and 9/27/03. The hyetographs for those two storms are shown in Figures C-1 and C-2 respectively and are compared to the resulting runoff hydrographs.

3.3.4 Data Uncertainties

It should be noted that some concerns exist about the validity of the data collected. Several problems were encountered while obtaining it. The velocity meter employed was suspected to contain significant error at the low velocities present in the outfall. Flows were perceived (using floating debris and a stop watch) to be much greater than those actually obtained. In addition, the unpredictable effect of the head variation at the outfalls has also contributed to some uncertainty about the flow data, including the effects of back flow and surcharge. While, quantitatively the data collected is suspect, much can still be inferred about the watersheds based on the information collected from a qualitative point of view.

4 HYDROLOGIC AND HYDRAULIC MODELING

4.1 USEPA STORMWATER MANAGEMENT MODEL

Engineers have been using computer models to evaluate complex situations for almost 50 years. Among the first to use them were water resources engineers. The advent of high-speed computers has allowed progressively more sophisticated and complex hydrologic models to be developed. After a history of 33 years of continual maintenance and upgrades, the most well known and perhaps the most widely accepted of the runoff quantity/quality models is the EPA Stormwater Management Model, also known as SWMM (Huber and Dickinson, 1992).

The SWMM software package is a comprehensive mathematical model capable of simulating real storm events. It can predict the outcome of quantity and quality on the basis of precipitation and watershed characterizations. Runoff collection, translation and attenuation are modeled through networks of pipes, channels, storage, and treatment systems for ultimate discharge into the receiving waters (Nix, 1994).

The main structure of the SWMM software package includes several components or “blocks” each designed for a particular task. That task is either a computational function, performing hydrologic and hydraulic calculations, or is a service function, performing data processing and program management duties. Figure 4 illustrates the flow of information between the computational blocks. The functions of the two blocks used in this project are further described in the proceeding sections. Most agree that the SWMM package is a rather large and daunting program. However, if the fundamentals are understood and the unused portions are discarded, using it can be a rather streamlined process (Nix, 1994).

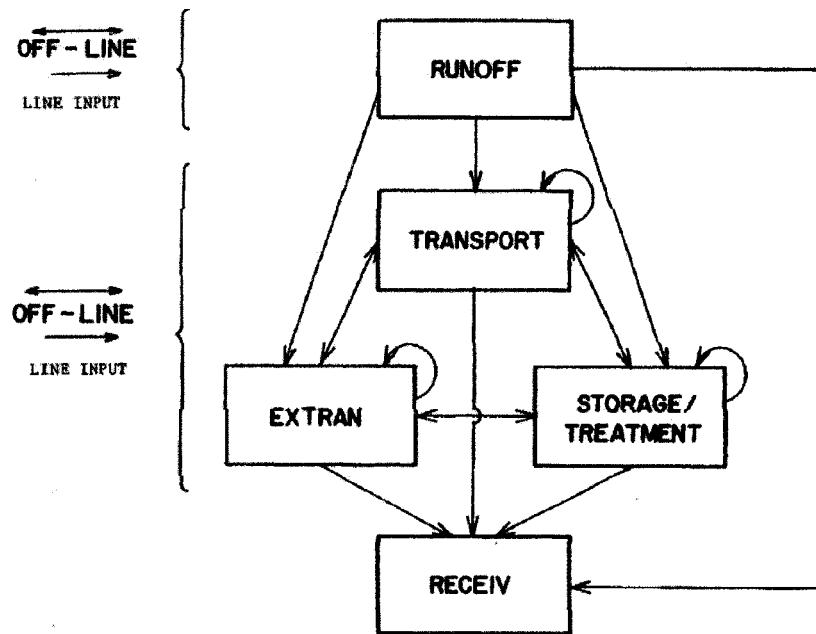


Figure 4. Overview of SWMM model structure, indicating linkages among the computational blocks (from Huber and Dickinson, 1992)

4.1.1 RUNOFF Block

The RUNOFF Block acts as the main water input source of the system. Precipitation information is provided in the form of hyetographs. Surface flow and pollutant loads are generated based on the antecedent conditions, land use, and topography of a series of subwatersheds. Characterized in Figure 5, overland flow in the subwatersheds acts as a nonlinear reservoir. It is modeled using Manning's equation and lumped continuity of net inflow, including precipitation (rain and snow melt), evaporation, infiltration and runoff (Huber and Dickinson, 1992). The capacity of the reservoir is equivalent to the depression storage of the subwatershed provided by ponding, surface wetting, and interception. Runoff occurs only when the water depth in the reservoir exceeds the maximum depression storage (Nix, 1994). The runoff rate is calculated for each subwatershed as the depth varies with time.

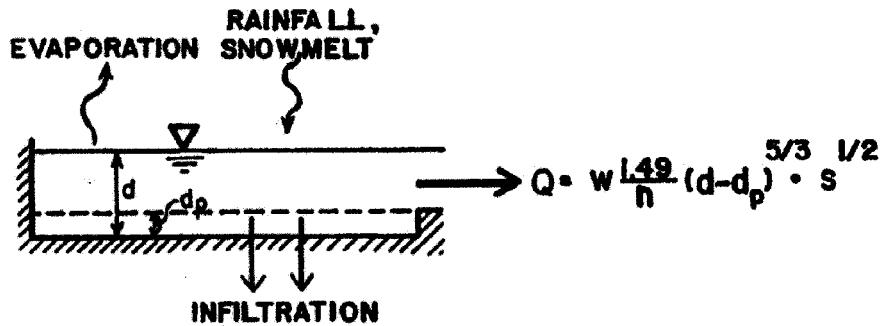


Figure 5. Nonlinear reservoir representation of a subwatershed, RUNOFF Block, SWMM (from Huber and Dickinson, 1992)

4.1.1.1 Computations

The equation in Figure 5 is nothing more than a derivation of Manning's equation, which can be stated as

$$Q = A_c \frac{\beta}{n} R^{2/3} S_0^{1/2} \quad (3)$$

where Q = runoff flow rate from subwatershed (cfs or m^3/sec)

A_c = cross-sectional area of flow over subwatershed (ft^2 or m^2)

n = Manning's roughness coefficient

R = hydraulic radius of flow over subwatershed (ft or m)

S_0 = slope of the subwatershed (ft/ft or m/m)

β = 1.49 for U.S. customary units (1.0 for metric units)

The hydraulic radius is the ratio of the cross-sectional area and the wetted parameter and is defined as follows based on the dimensions shown in Figure 5.

$$R = \frac{W(d - d_p)}{W + 2d} \approx d - d_p \quad (4)$$

where W = width of overland flow on subwatershed (ft or m)

d = depth water on the subwatershed (ft or m)

d_p = depth of maximum depression storage (ft or m)

Substituting Equation 4 into 3 yields

$$Q = W \frac{\beta}{n} (d - d_p)^{5/3} S_0^{1/2} \quad (5)$$

The time dependency of the depth, and hence the flow Q , is governed by the continuity equation.

water volume change on subwatershed	net inflow to subwatershed	runoff from subwatershed
$\frac{dV}{dt} = \frac{d(A \cdot d)}{dt}$	= $(A \cdot i_e)$	- Q

where V = volume of water on the subwatershed (ft^3 or m^3)

A = Area of the subwatershed (ft^2 or m^2)

t = time (sec)

i_e = excess rainfall, rainfall intensity less the evaporation and infiltration rates (ft/sec or m/sec)

Combining Equations 5 and 6 yields

$$\frac{d(d)}{dt} = i_e - \frac{W\beta}{An} (d - d_p)^{5/3} S_0^{1/2} \quad (7)$$

Equations 5 and 7 form the core of the RUNOFF Block. For each time step, both can be easily solved with a simple finite difference method (Nix, 1994).

4.1.1.2 Routing options

A relatively new aspect of the RUNOFF Block is its ability to allow the user to route flow within the subwatershed. The user has the option to route the flow of runoff from the impervious onto the pervious surface or visa versa. This method provides for the situations such as flow off a rooftop onto a grassed lawn.

Once the runoff is generated as discharge from a subwatershed, several routing options exist to further increase the functionality of the RUNOFF Block. The technique most often employed is routing the runoff from a subwatershed directly into a single point or node. The TRANSPORT and EXTRAN Blocks can then be used to model the more sophisticated flows through the channels and pipes where the RUNOFF Block is somewhat limited. In this situation the subwatershed width is used as a computational tool only since the runoff is concentrated at a point and not distributed over the length of the width (Nix, 1994).

Two additional routing options exist for runoff exiting a subwatershed. The runoff can either be routed into a channel or gutter, or it can be routed into another subwatershed. In the first option, the runoff is distributed along the length of the channel, such as in roadside and rooftop gutters. In the second, the runoff is evenly distributed over the entire receiving subwatershed. This method can be a powerful tool for simulating physical processes that have been until now very limited. An example is the ability to model infiltration in a channel. This method will be shown in more detail later as part of this report.

4.1.2 EXTRAN Block

The Extended Transport, or EXTRAN, Block is normally employed once flows become more complex. Unlike the other blocks, this block is able to simulate the sophisticated flows associated with branched and looped networks, surcharge, backflow and a number of other situations (Roesner, et al., 1992). This versatility is provided by the conceptual representation of the drainage system as a network of nodes and links. The links represent transport structures such as channels, pipes, weirs, orifices, and pumps. The nodes represent the ends, or the point of intersection of one or more links. Nodes include structures such as catchbasin, outfalls and other junctions.

System inflows occurring at nodal locations are in the form of hydrographs, which can be either user defined or read from an interface file created in an upstream block. The EXTRAN Block applies the complete Saint-Venant equations to model flow through the system. The Saint-Venant equations include momentum and continuity.

momentum:

pressure and gravity force	convective acceleration	local acceleration	friction force
-------------------------------	----------------------------	-----------------------	-------------------

$$g \cdot A \cdot \frac{\partial H}{\partial x} + \frac{\delta(Q^2/A)}{\delta t} + \frac{\delta Q}{\delta t} + gAS_f = 0 \quad (8)$$

continuity:

net inflow to control volume	change in amount of water in control volume
---------------------------------	------------------------------------------------

$$\frac{\delta Q}{\delta x} + \frac{\delta A}{\delta t} = 0 \quad (9)$$

where H = hydraulic head (ft or m)
 x = distance along the conduit (ft or m)
 t = time (sec)
 g = gravitational acceleration (32.2 ft/sec² or 9.81 m/sec²)
 S_f = friction or energy slope (ft/ft or m/m)
 Q = flow rate (cfs)
 A = cross-sectional area of flow (ft² or m²)

The friction or energy slope (S_f) is estimated using a form of the Manning's equation:

$$S_f = \frac{Q}{(\beta/n)^2 A^2 R^{4/3}} \quad (10)$$

Combining Equations 8, 9 and 10 with a few algebraic manipulations and rearrangements yields the basic flow equation used in the EXTRAN Block:

$$gA \frac{\partial H}{\partial x} - 2v \frac{\partial A}{\partial t} - v^2 \frac{\partial A}{\partial x} + gAS_f = 0 \quad (11)$$

where v = average flow velocity (ft/sec or m/sec)

Using Equations 9 and 11 with a finite difference solution, the variables Q and H are determined for each time step. Unfortunately, the process is somewhat unstable and care must be taken in choosing an appropriate time step and link lengths (Nix, 1994).

Given the link lengths associated with the actual storm sewer lengths, a time step of 1 sec was adequate.

4.1.3 Other Computational and Service Blocks

There are several additional blocks included in the SWMM software package used to simulate various processes including flow and pollutant transport, treatment and storage. This report does not go into great depth concerning these blocks since they are not part of the final analysis.

4.1.3.1 TRANSPORT Block

The TRANSPORT Block accepts flow and pollutant loads from the RUNOFF Block. It uses the same technique as the EXTRAN Block of representing the system as a collection of links and nodes. It also uses the Saint-Venant equations but with a somewhat simplified solution (Nix, 1994). In consequence, it is unable to handle the more complex flow regimes such as backflow and surcharge. It is, however, more stable and more desirable for use in most situations as compared to the EXTRAN Block (Roesner, et al, 1992).

4.1.3.2 STORAGE/TREATMENT Block

The STORAGE/TREATMENT Block simulates the routing of flow and pollutants in both dry- and wet-weather through a series of up to five storage/treatment

units. The units can be modeled as either detention or non-detention processes, and can handle up to three pollutants in addition to the flow (Huber and Dickinson, 1992).

4.1.3.3 Service blocks

The service blocks in the SWMM software package provide various management and user interfacing options. Some functions administered by the service blocks include block interfacing, input data processing, and output manipulation and analysis. For further information on these or any of the SWMM blocks refer to Huber and Dickinson (1992).

4.2 WATERSHED CHARACTERIZATION

The generation of runoff from a watershed, through the drainage system and into a receiving waterway can be divided into a series of processes relating to the collection, abstraction, conveyance or treatment of the runoff. Figure 6 depicts the routing of flow through a sequence of “objects”, each containing one or more process. Once these processes are defined and the associated parameters established, the objects can be included into the SWMM model for further analysis.

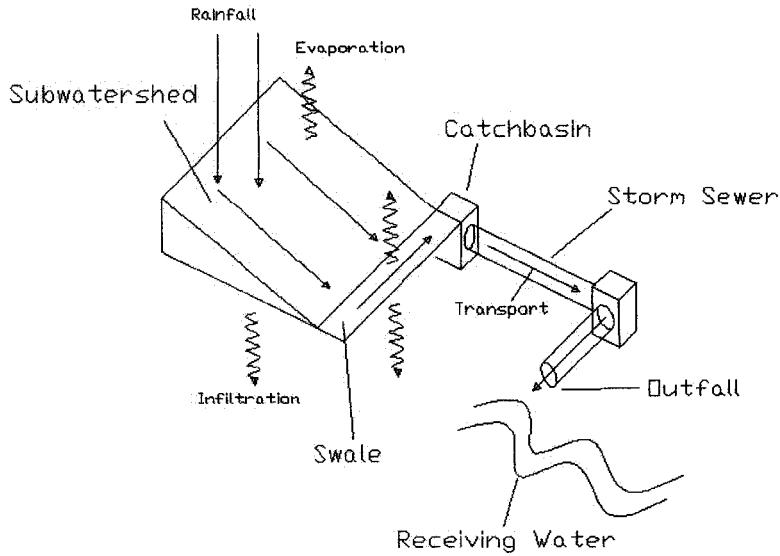


Figure 6. Flow routing in the drainage system through a series of objects.

4.2.1 Subwatersheds

The subwatershed is the main rainfall receiving object where a number of processes occur governing the volume, attenuation, and pollutant load of the resultant runoff. Infiltration, evaporation and other abstractions limit the volume of effective rainfall. The land roughness controls the attenuation effects, and pollutant loads increase due to erosion and surface washoff.

4.2.1.1 Subwatershed delineation and geometry

Map A-4 shows the boundaries of the subwatersheds and Table B-3 the physical parameters of each. The physical parameters of the subwatershed are considered separately for the roadways and yards. A boundary between the two is assumed at the road edge. Boundaries between subwatersheds were also assumed at the road crest and

mid-block property line parallel to the road. Figure 7 shows an example of typical boundaries. Additional boundaries perpendicular to the road were assumed at the high points in the swale system identified in the elevation analysis. The dimensions of the subwatersheds are identified in Figure 8, where the width is the distance of the edge parallel to the receiving swale and the length is the distance perpendicular. The total area is the length times the width.

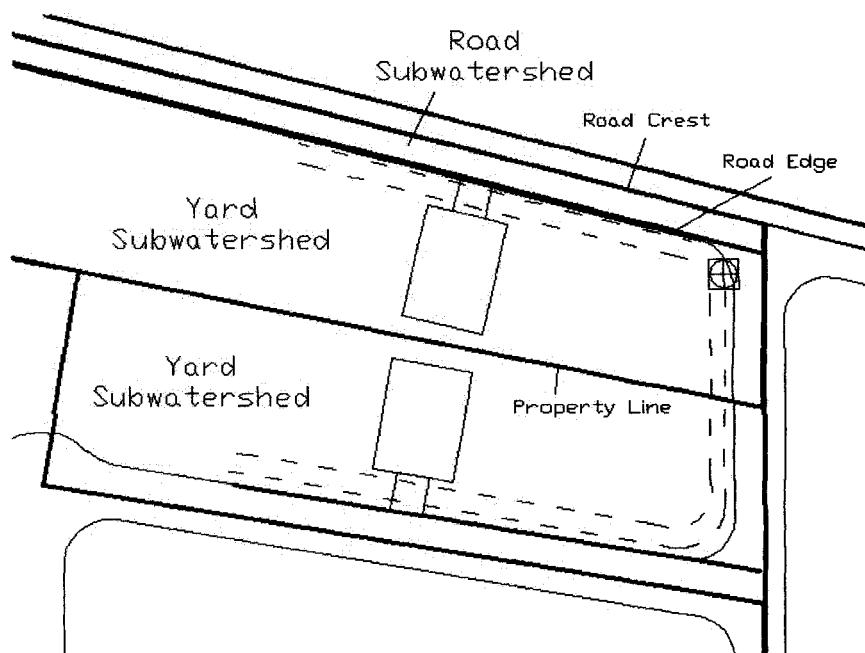


Figure 7. Location of typical subwatershed boundaries

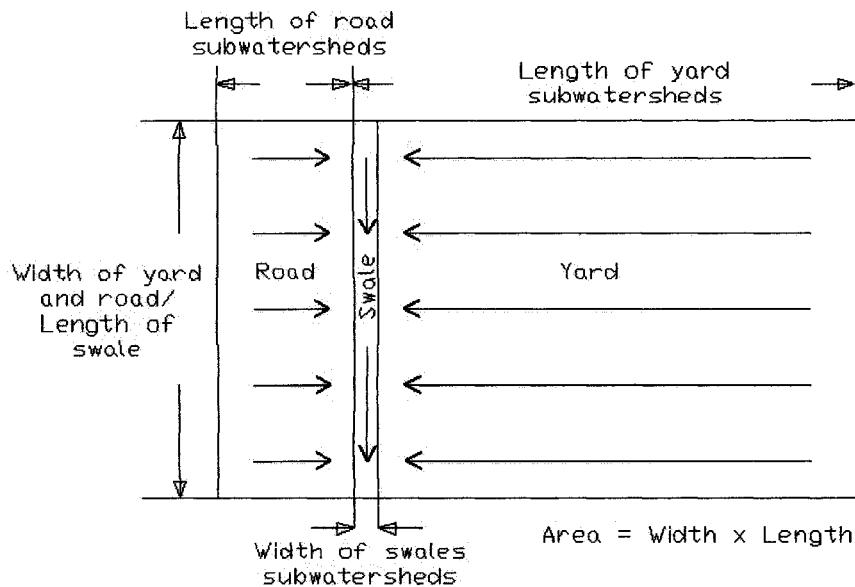


Figure 8. Dimensions of a typical subwatershed

4.2.1.1 Infiltration and evaporation

The effective rainfall on a subwatershed includes input from rainfall and losses mainly from infiltration, and evaporation. Losses from evaporation and other abstractions (surface wetting, interception, and evapo-transpiration) are relatively small compared to infiltration and are largely ignored for single event flood analyses. In many situations it is acceptable to assume general averages for the losses. For this study a loss of 0.1 in/day was assumed for all non-infiltration abstractions.

Several methods can be used for estimating infiltration; most consider the physical properties and antecedent conditions of the soil. The method chosen for use in the SWMM RUNOFF Block is the Green-Ampt Model. It considers the hydraulic conductivity, the wetting front suction head, and the initial volumetric water content of

the soil. The main governing equation for the cumulative infiltration as a function of time for $t > t_p$ is given as

$$K_s(t - t_p + t'_p) = F - (n - \theta_i)\Phi_f \ln \left[1 + \frac{F}{(n - \theta_i)\Phi_f} \right] \quad (12)$$

where K_s = hydraulic conductivity

t = time

t_p = time to ponding

t'_p = equivalent time to infiltrate F_p under conditions of surface ponding

F_p = total infiltrated volume at time ponding is initiated

F = total infiltrated volume at time t

n = porosity of the soil

θ_i = initial volumetric water content

Φ_f = wetting front suction head

A soil survey completed by the National Resource Conservation Service (NRCS, 1996) and the Broward County Department of Planning and Environmental Protection (BCDPEP, 2000) has classified the soil in the study watersheds as Hallandale fine sand. This soil type corresponds to a hydraulic conductivity of about 13 in/hr (SFWMD, 2002b), a suction head of 4 in (Chin, 2000) and a soil deficit of 0.34 (void ratio – water content) under dry antecedent conditions (Huber and Dickinson, 1992).

4.2.1.2 Percent imperviousness

The total imperviousness of the yard subwatersheds was estimated from an aerial photograph to be 55%. This includes driveways and rooftops. The roadways, considered separately, are assumed to be 100% impervious.

While runoff drains directly from the driveways and roadways, the rooftop runoff is first routed through downspouts. The downspouts discharge both onto the pervious grass and the impervious driveways. This idea is better visualized in Figure 2. Huber and Dickinson (1992) suggest that an impervious area discharging to a pervious surface be considered a pervious surface itself. Because of the near impossibility of an accurate determination, the rooftop runoff is assumed divided equally between pervious and impervious discharge. Ultimately, the effective percent imperviousness for the yards is calculated as the addition of the driveways and one half the rooftop area for a resultant 32% effective imperviousness.

4.2.1.3 Surface Roughness and Slope

The parameters associated with the ground condition affecting the velocity of flow include roughness (Manning's coefficient) and slope. Estimations for subwatershed slope were made based on the slope analysis described in more detail in section 3.2.6. The slope for the road subwatersheds is estimated at 0.021 (v/h) and that for the yard subwatersheds is estimated at 0.014 (v/h).

The Manning's coefficient is more complicated to directly estimate. Generalized values were taken from Chin (2000) who suggests a value of 0.011 for overland flow on

asphalt (impervious surfaces) and 0.35 for overland flow on a dense turf (pervious surfaces) in this case Saint Augustine grass.

4.2.2 Swales

A roadside swale system is the main conveyance component of runoff from the subwatersheds to the catchbasins. It acts as both a retention device, and a transport mechanism. It is considered a retention device in the sense that a well-designed swale will accept a large amount of water as surface storage for subsequent infiltration. It is a transport mechanism in the sense that once the retention capacity is exceeded, the excess runoff is transported to a nearby catchbasin.

As a retention device, it is subject to the same processes of infiltration, evaporation and runoff as the subwatersheds. It also includes the same pollutant loading mechanisms of erosion and washoff. Because the same processes occur within the swale system as the subwatersheds, it can be characterized much the same way. However, some differences do exist.

Based on the elevation analysis of the swale system, the longitudinal slope of each was taken individually, generally on the order of magnitude of 0.003 (v/h). The land cover includes intermittent areas of driveway and grassed swale, estimated to be about 50% each. The land cover of the swale system is similar to that of the subwatersheds, but because of the differences in flow regimes between the overland and channel flows, Manning's coefficient will be slightly different. The SFWMD (2003) stipulates that a Manning's roughness coefficient of 0.20 be used for swale design purposes. This value is a composite roughness for both surface types.

The determination of the typical swale cross-section, shown in Figure 3, is described in more detail in the site investigation, section 3.2.7. It is estimated to be a trapezoid with side slopes of 20 (v/h) and 24 (v/h). The base width was found to be 3.0 ft and the maximum depth, located at the height of the road surface, was found to be 0.25 ft

Map A-5 illustrates the layout of the swale system and Table B-4 includes the physical parameters for each. Individual swales were identified, and the connections to each other and the catchbasins were established according to the topography shown in Map A-3. One swale is defined for every road and yard subwatershed pair. In addition, a few non-runoff receiving swales, designated as mainly transport devices, are also included.

4.2.3 Catchbasins and Storm Sewers

A system of catchbasins and storm sewers are used for the collection and conveyance of runoff from the ground surface to the receiving water. Map A-2 illustrates the location of each catchbasin and storm sewer and Tables B-1 and B-2 list the physical parameters for the catchbasins and storm sewers respectively.

The process of conveyance in the storm sewer system is similar to that of the swale channels. Flow rates are for the most part related to pipe roughness and energy slope. Manning's coefficient values were assumed to range between 0.011 and 0.018, based on pipe diameters of 12 to 36 in for corrugated steel piping. These values were taken from a document prepared by the American Iron and Steel Institute (AISI, 1995). Elevation and pipe length data were gathered in the site investigation and estimated with the GIS information.

4.2.4 Central Ponds

When the northern watershed is considered in its entirety to be a single drainage system, the central ponds act as a conveyance mechanism, and to a limited degree, a storage device. Manning's coefficient for a straight, uniform, earthen channel is about 0.025 (Chin, 2000). The two channels have on average a width of about 60 ft and a length of 525 ft each. A relatively steep side slope, about 2.0 (v/h), exists at least in the region of the water surface. Figure 9 depicts a qualitative view of the cross-sectional area, although the exact depth and bottom shape is irregular.

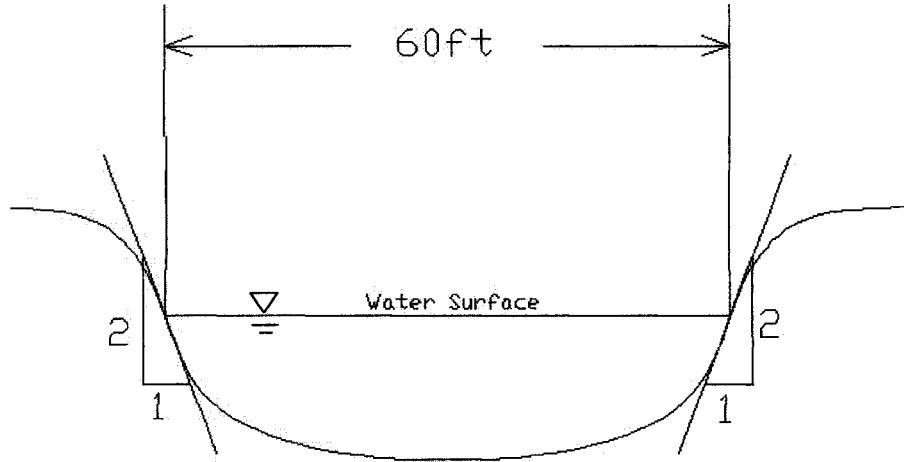


Figure 9. Qualitative cross-sectional view of the central ponds

4.2.5 Orifices

A series of catchbasins in the eastern portion of the northern watershed are connected to the main draining storm sewer via 15-inch diameter orifices, rather than direct inline connections. The locations of the orifices are shown in Map A-6.

4.2.6 Outfalls

Seven outfalls exist on site. Map A-2 shows their locations. All the outfalls located on the study site are partially submerged. Depending on the rainfall intensity basin wide, the total head at the outfalls can vary by as much as a foot, more during large, widespread rain events. If the head at the outfall rises above the head further upstream, back flow occurs. This creates a very complex system that is difficult to model accurately.

4.3 MODEL CONSTRUCTION

The two study watersheds were modeled with USEPA's SWMM version 4.4h, specifically the RUNOFF and EXTRAN Blocks. Rain input and surface flows were modeled in the RUNOFF Block, including runoff generation in the subwatersheds and transport through the swale system (see Figure 10). Flows through the catchbasin and storm sewer systems were modeled in the EXTRAN Block (see Figure 11). The EXTRAN Block was chosen due to the presence of surcharge, backflow and adverse slope conditions.

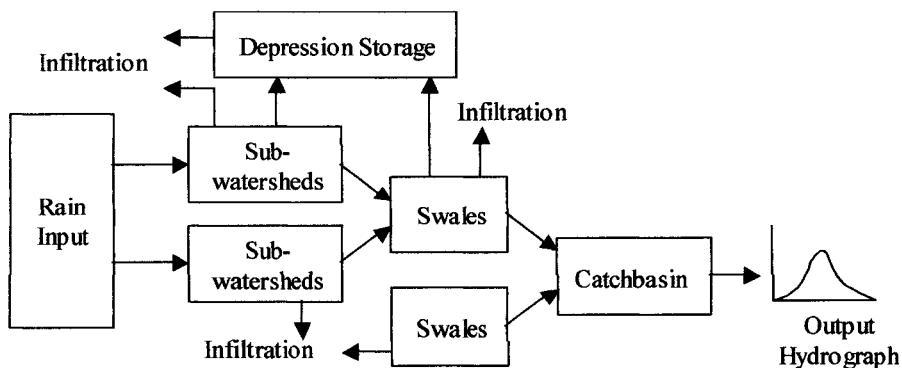


Figure 10. Flow routing in RUNOFF Block

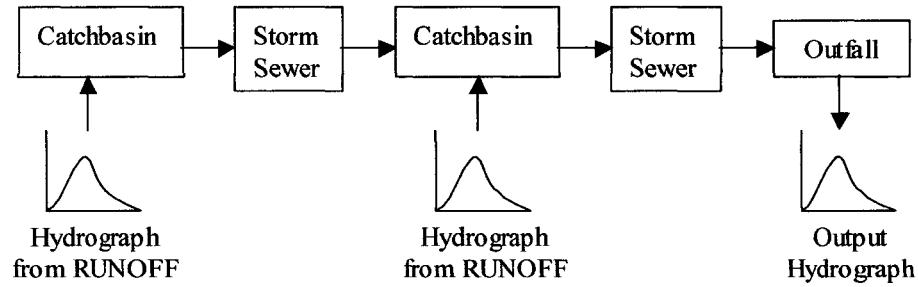


Figure 11. Flow routing in EXTRAN Block

A sample input file for a storm event on 9/17/03 can be found in Appendix D and the corresponding output file can be found in Appendix E. Each line of input represents either a program control option or a specific object in the flow route. The first entry on each line informs the program of the function or the associated object type for that input line as designated by the letters shown in Table 3.

Table 3. SWMM Input Line Designations

<u>RUNOFF Block</u>		<u>EXTRAN Block</u>	
First entry on line	Program Function	First entry on line	Program Function
A	Title	A	Title
B	Program control options	B	Program control options
C	Snow input	C	Conduit link data
D	Rainfall control options	D	Junction data
E	Rainfall input	E	Storage junction data
F	Evaporation data	F	Orifice data
G	Channel/pipe data	G	Weir data
H	Subwatershed data	H	Pump data
I	Snow input data	I	Outfall junction data
J	General quality control	J	Boundary condition data
K	Erosion data	K	User input hydrographs
M	Print control		

4.3.1 Design Storm Events

Because this study is concerned with stormwater quality and quantity, a variety of storm types will be addressed. Pitt and Voorhees (2000) indicate that moderate storms ranging between 0.5 to 1.5 inches in depth contribute about 75% of the NPS pollution from runoff. Smaller, more frequent storms generally have a relatively low impact on receiving systems since that runoff is easily retained and infiltrated, and larger storms occur much more seldomly. It is therefore vital to consider the moderate storm when determining the effectiveness of any BMP in pollution removal. However, the system also needs to be evaluated for flood control, and as a result, larger storms will also be considered. The system will be evaluated for the 24-hour storm with return periods of 5-, 10- and 25-years.

For the design storm events, the NRCS 24-hour type III distribution was employed. The type III hyetograph is the most appropriate for the South Florida area (Chin, 2000). Depths for the 24-hour, 5-, 10- and 25-year return period storms are 6.5, 7.5 and 9.0 in respectively (SFWMD, 2004). The design hyetographs are found in Figures F-1 and F-2 and F-3.

4.3.2 RUNOFF Block

The RUNOFF Block was used to model the surface flow of the system through the subwatersheds and the swales. The input parameters for the subwatersheds are based on the physical parameters listed in Table B-3 and the swales listed in B-4.

4.3.2.1 Subwatershed modeling technique

Modeling the subwatersheds was a somewhat direct procedure. The subwatersheds were distinguished between two types, roads and yards, each with its own parameter values. The boundaries between a road and yard subwatershed pair were assumed adjacent and located at the road edge (see Figure 7).

4.3.2.2 Swale modeling technique

Creating an accurate model of a swale within the SWMM program can be a more difficult process. One of the disadvantages of the SWMM program is its inability to simulate channel infiltration within the RUNOFF Block. In order to account for infiltration, each swale was modeled using a narrow but long subwatershed rather than a channel. Two disadvantages to this process exist. Using a subwatershed as a channel limits the cross-sectional shape to a rectangle. As it was shown previously, the swales in the study watersheds are trapezoidal. In addition, while infiltration is taken into account, it does not take into consideration the increase in potential infiltration due to both a build up of head and the increase in the wetted perimeter with depth. Despite these disadvantages, modeling the swale system as subwatersheds was still found to be the most accurate method available.

4.3.2.3 Determination of the swale subwatershed width

The amount of infiltration in a subwatershed is partially dependent on the area of the pervious surface. For a subwatershed, equivalent to a rectangular channel, that area

does not change as the water depth rises with an increase in rain input. Therefore, the width of the subwatershed can be considered its wetted perimeter ($W \approx P_w$, when $P_w \gg d$) as is shown in Figure 12, which is constant. However, in a trapezoidal channel with very mild side slopes, a change in depth can cause a considerable change in the width, wetted perimeter and the area available for infiltration. The wetted parameter of the trapezoidal channel shown in Figure 12 is defined as

$$P_w \approx W = b + d(z_1 + z_2) = 3 + d(44) \quad (13)$$

where P_w = wetted parameter

W = channel width at the water surface

b = channel base width (3 ft)

d = depth of water from base

z = left and right side slopes (24, 20 v/h)

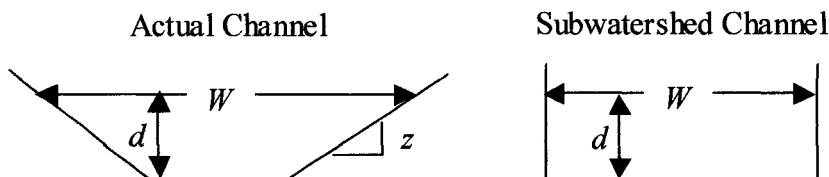


Figure 12. Comparison of the trapezoidal and rectangular channels

Because the channel width is dependent on the depth of water, it was necessary to iteratively determine the width of the swale subwatersheds corresponding to the resultant channel depths for each design storm event. Assuming first a value for the width of 10 ft, the peak flow rates through the swale subcatchments were determined from the SWMM

model. Using Manning's equation to determine the depth with equation 13, the corresponding widths were calculated for the resultant flow rates. The new widths were then applied to the model. This process was repeated until two subsequent widths were within a 1-ft difference.

4.3.2.4 Swale depression storage

The swale surface consists of intermittent areas of driveway and grass. It has been observed that in the majority of the site, the driveway surfaces are much lower than the grassed areas. During moderate storms, excessive ponding on the impervious surface forms due to the elevation difference between the two surfaces types. To account for this, impervious depression storage of 0.5 in was included in the SWMM model for all swales.

4.3.3 EXTRAN Block

The EXTRAN Block was used to simulate flows from entry into the catchbasins, transport through the storm sewers, and discharge into the N-23 canal. The EXTRAN Block, as described previously, represents the drainage system as network of links and nodes. The storm sewers are modeled as links, and the catchbasins as nodes. In addition to the storm sewers other links include the orifices and ponds, and in addition to the catchbasins, other nodes include the outfalls and several non-storage junctions. The physical parameters for the storm sewers and ponds (links) are shown in Table B-2; those

for the orifices are shown in Table B-5. The physical parameters for the catchbasins, outfalls and non-storage junctions (nodes) are shown in Table B-1.

4.3.4 Outfall Head Variation

Due to the submerged condition of the watershed outfalls, it was necessary to take into account the variation of head due to the rise in depth of the receiving water with time. For preliminary analysis, it was adequate to create a water stage time series based on measured elevations during the storm events. Unfortunately, actual stage series are dependent on the temporal and spatial distribution of rainfall outside the study watersheds and are unpredictable when considering theoretical design storms. In those situations the water stage elevation was estimated to gradually increase from a dry weather level of 3.34 ft MSL to a maximum 4.1 ft over the first 12 hours of the 24-hour storm and remain constant there afterwards.

4.4 MODEL CALIBRATION AND VALIDATION

Given good input data, it can be assumed that the model is sufficiently accurate. However, it is important to recognize that urban runoff models are imperfect representations of urban watershed behavior (Nix, 1994). Several factors can influence the accuracy of the model including structural misrepresentations, and errors in the input parameters. It is therefore necessary to calibrate the model by characterizing the uncertainty in the input data, adjusting it accordingly, and verifying the performance of the model by comparing it to known outcomes.

4.4.1 Uncertainties and Sensitivity Analysis

In an effort to simplify the model construction, several estimations and assumptions were necessary. Most are believed to be reasonably accurate, but are nonetheless based on generalized conditions rather than site-specific specifications, and thus contain a degree of uncertainty. While this is sufficient for conceptual and preliminary analyses, a more in depth, site-specific approach should be used for making detailed design decisions for parameters such as hydraulic conductivity and roughness.

A sensitivity analysis can be a useful tool to help characterize the effects uncertainty has on a model. This process systematically varies model factors to determine the impact each has on the model (Nix, 1994). Seven parameters were chosen for an in depth look at model sensitivity, swale width, hydraulic conductivity, swale percent impervious, yard percent impervious, pervious Manning's coefficient, impervious Manning's coefficient and the storm sewer Manning's coefficient. Figures 13 and 14 were constructed by varying each parameter in turn by $\pm 10\%$ while leaving the remaining parameters constant. These figures illustrate the change in runoff volume and peak flow rate through storm sewer 214 (see Map A-2) for a given a variance in each of the seven parameters. Storm sewer 214 was chosen for the sensitivity analysis rather than the final outfall so the unpredictability of the variation of the receiving water elevation would not be a contributing factor. The center point in both figures represents the parameter values as outlined in this report and presented in Appendix B.

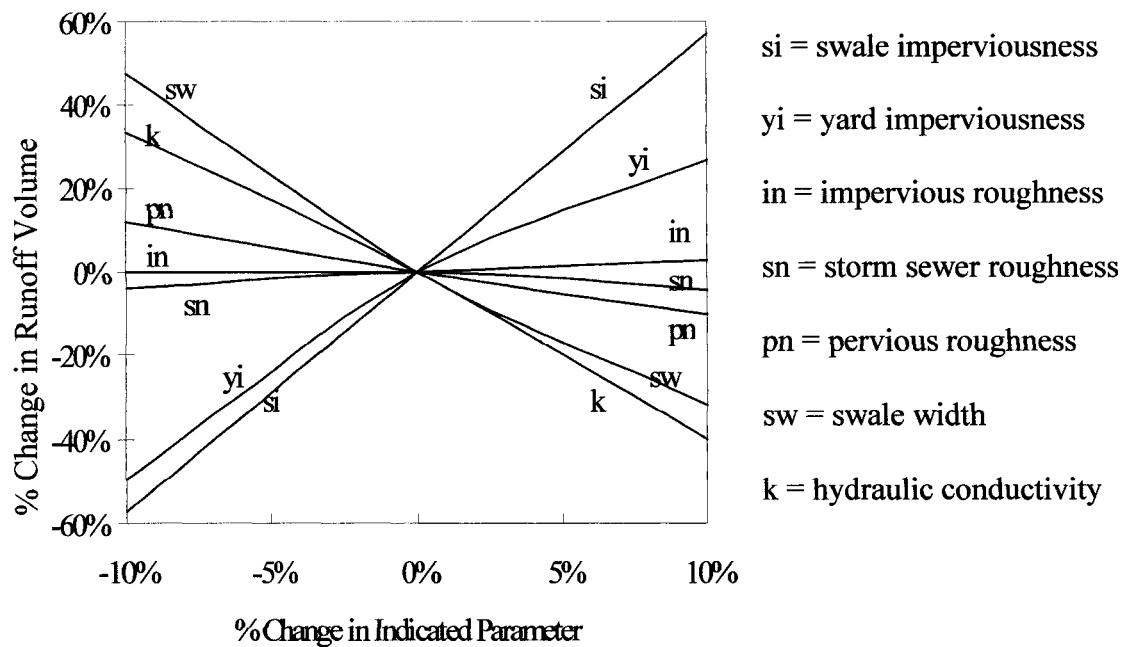


Figure 13. Sensitivity analysis, runoff volume

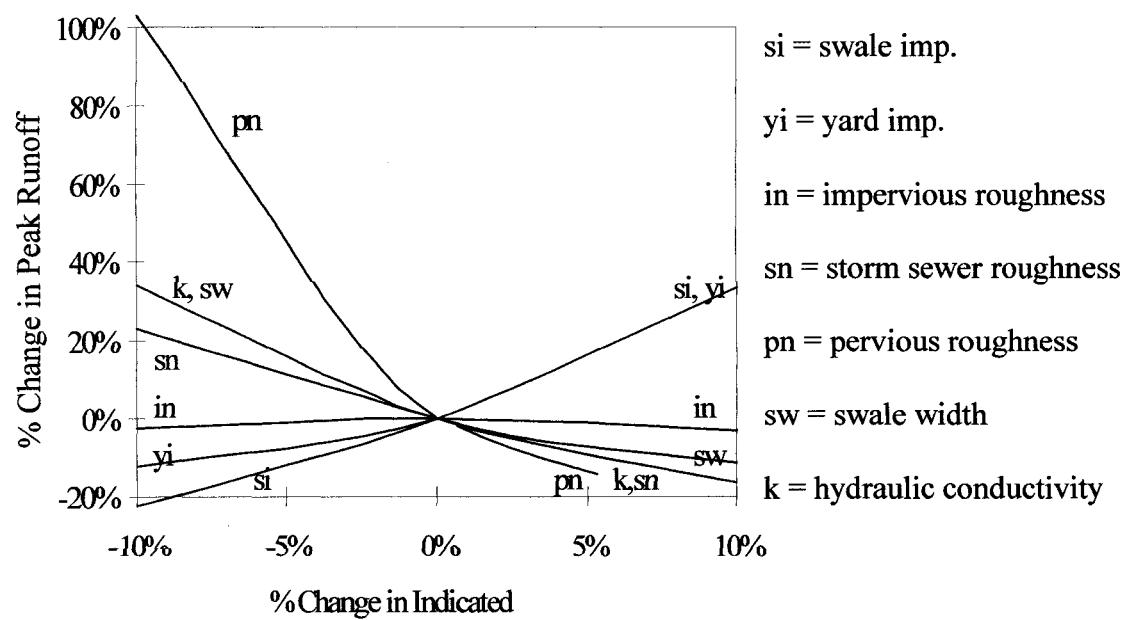


Figure 14. Sensitivity analysis, peak runoff rate

Figure 13 illustrates the importance of the swale width in determining the total volume of runoff. Unfortunately, it is also the most conceptual and most difficult to quantify. Also of great importance is the imperviousness of both the swales and the yard subwatersheds. Of lesser importance for total volume but of great importance for the peak runoff rate are the roughness coefficients, which deal more with runoff attenuation rather than volume.

It can be seen in Figure 14 that the most influential parameter for peak runoff are the pervious roughness coefficient. The peak runoff was found to double with only a 10% decrease from the original value, whereas the imperviousness, while still important, is not as influential when considering peak runoff rate as it is for volume.

4.4.2 Calibration and Verification

The calibration and verification of a hydraulic model involves adjusting the model parameters based on their uncertainty and model sensitivity so that the model agrees with a set of field data, and then further verifying it with additional data (Nix, 1994). As was mentioned previously, the field runoff data collected is not believed to be completely accurate. As a result, the calibration and verification process is somewhat limited. Nevertheless, a qualitative comparison can still be made to both the 9/17/03 and 9/27/03 storm events.

Figures 15 and 16 illustrate the observed hydrographs at the outfall of the northern watershed during the two storm events and are compared to those predicted by the model. It can be seen in Figures 15 and 16 that little quantitative correlation exists

between the observed and modeled hydrographs. To allow a clearer qualitative comparison the axis for the observed data was expanded. There is some consistency in the flow rate on a relative scale, which does add credibility to the model. If the construction techniques of the model are considered, the differences that exist between the model and the observed data can be better understood.

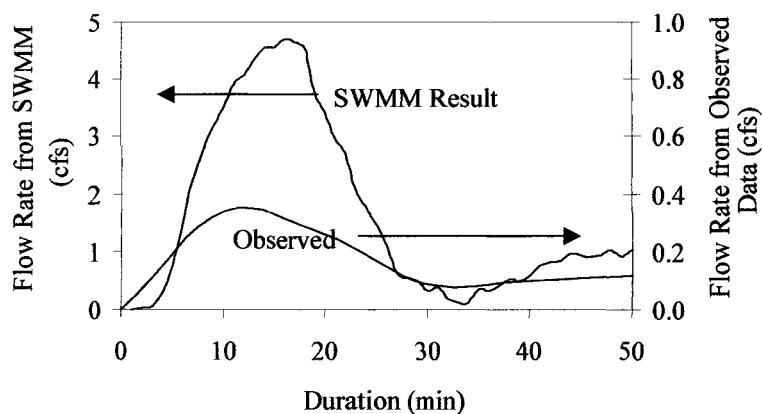


Figure 15. Observed and modeled hydrographs for the 9/17/03 storm event

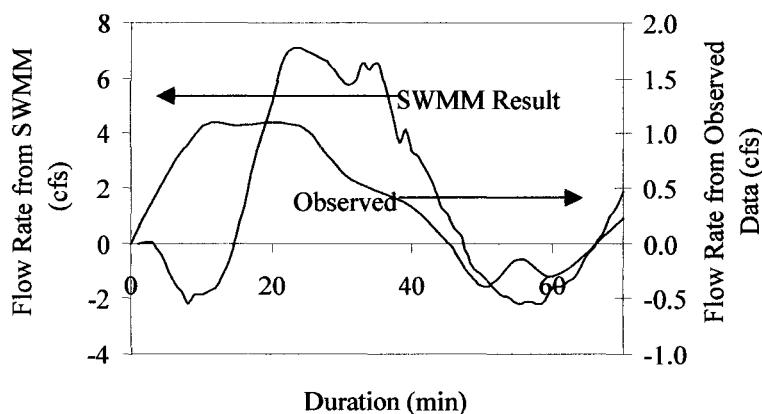


Figure 16. Observed and modeled hydrographs for the 9/27/03 storm event

The swale width is the most conceptual and difficult parameter to understand. It also has great influence on the model. Unfortunately, no exact value for the width exists because it continually varies with depth as is shown in equation 13. Only an average value can be found. As a result, during periods of low intensity rainfall, the width and therefore the infiltration are overestimated, and oppositely during periods of high intensity rainfall, the width and infiltration are underestimated. This results in the situations seen in Figures 15 and 16. Initially the SWMM result is shown to drop dramatically below the observed rates when the infiltration is overestimated. It then quickly rebounds as the rain intensity increases and the infiltration is underestimated. This is not a major concern for flood analysis since the resultant peak flows are on the conservative side.

5 DEVELOPMENT OF A MANAGEMENT PLAN

The retrofit plan developed in this chapter is based on a three-part analysis as described in the list below. The knowledge of the physical conditions and an understanding of the watershed mechanisms are emphasized and are essential to developing successful solutions.

- **Watershed Analysis** examines the watershed drainage under specific criteria to identify in what manner the drainage system performs inadequately.
- **Problem Characterization** is an in-depth examination of the physical processes and inadequacies of the watershed.
- **Solution Development** occurs only after a complete picture of the situation is understood.

5.1 WATERSHED ANALYSES AND PROBLEM CHARACTERIZATION

The two watersheds were analyzed under design storm conditions. Debo and Reese (2003) suggest that swale systems be designed to handle a 2- to 5-year storm, while storm sewer systems generally are designed for the 10- to 25-year storm. The SWMM model was executed for the 5-, 10- and 25-year storms. The Results are found in Appendix G. Swale peak flows are shown in Tables G-1 for the 5-year storm and G-2 for the 10-year storm. Maximum catchbasin depths are shown in Tables G-3 for the 10-year storm and G-4 for the 25-year storm.

5.1.1 Surface Ponding

The most apparent stormwater management concern is the large amount of surface ponding occurring on the impervious surfaces. Effects are seen even after small storms and remain well afterwards. This is due to the large differences in elevation between the higher grassed areas and the lower driveways within the swale system. In some areas it can be as much as a few inches. Some areas appear to have been filled with sedimentation over the years, while others appear to have been intentionally filled. Unfortunately, the areas most likely to have ponding are those of residential activity including the driveways and front porches.

5.1.2 Swale Overflow

Channel overflow rarely occurs under mild rainfall conditions. However, it can still be shown to exist for more intense rainfall given an accurate model. The peak swale flow rates were taken from the 5-year storm model (see Table G-1). The Manning's equation was then used to calculate the runoff depths in each swale assuming the channel cross-section shown in Figure 3 and a Manning's coefficient of 0.2. The swale channels predicted to reach depths greater than a maximum of 0.25 ft are listed in Table 4 below. The locations are shown in Map A-7.

Table 4. Predicted Swale Overflow for 5-Year Storm,
Pre-Existing System

I.D	Peak Depth (ft)	%Over 0.25ft	I.D	Peak Depth (ft)	%Over 0.25ft
301	0.27	8	334	0.26	4
306	0.29	16	327	0.27	9
307	0.33	31	328	0.28	12
308	0.33	33	339	0.28	10
310	0.30	18	340	0.33	33
311	0.31	26	346	0.35	40
312	0.26	6	347	0.39	58
323	0.27	8	352	0.27	10
325	0.26	3	335	0.29	14
365	0.26	4	376	0.26	3
393	0.30	20	377	0.33	34
394	0.29	16	388	0.27	7
398	0.39	55			

Under the 10-year rainfall, the maximum depths predicted by the model are still within reason. The highest occurrence was found to be only 0.41ft, which is less than 2 in above the maximum depth of 0.25 ft. Not until the 25-year storm is considered does an unreasonable situation develop. The highest depth for the 25-year storm is predicted to be 0.5 ft.

5.1.3 Canal overflow

For moderate storms, it is adequate to assume a maximum water surface elevation slightly above 4 feet MSL within the canal system. All preceding analyses were based on this assumption. However, for more intense storms, it is possible for the canal water level to rise dangerously high. During hurricane Irene in 1999 for example, water levels crested over the canal banks flooding streets and homes. Naturally, no on-site improvement could have prevented this. It does suggest however, that some basin-wide management improvement may be needed.

5.1.4 Catchbasin Overflow

The catchbasins and storm sewers, unlike that on the surface, must be able to handle larger flows given a finite capacity. Predicted by the model for the 10-year storm, Table G-3 shows the water surface level relative to the ground for each basin at its highest point. No catchbasins are shown to overflow. Several are expected to increase in depth to within 1 foot from the ground elevation however. The seven furthest upstream catchbasins in the southern watershed (numbers 118, 119 and 131-135 in Map A-2) are

expected to rise to between 0.99 and 0.53 feet from the ground elevation. When considering the 25-year storm, results shown in Table G-4, the model has predicted only one catchbasin (number 131) to overflow, but only by 0.4 in. It can be concluded that as long as the system remains clear, catchbasin overflow is not a major concern.

5.1.5 Adverse Slope

The pre-existing storm sewer system does appear to be reasonably acceptable under a design storm situation, although, the large number of conduits having an adverse slope is of some concern. Adverse slopes are found in 17 of the storm sewers. Looking at the longitudinal profile of the southern watershed's storm sewer system (see Figure 17), more than half have either adverse or zero slopes. Under intense flows this could cause flooding. It is not surprising that catchbasin 131 would be the first to overflow given the orientation of the connecting storm sewers (240 and 223)

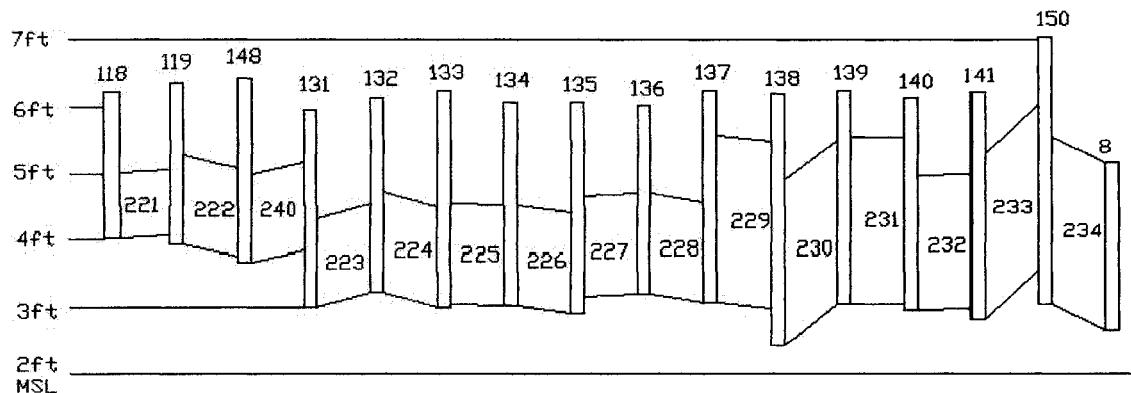


Figure 17. Longitudinal cross-sectional view of storm sewer system

5.1.6 Pollutant Loads

The pollutant data obtained, shown in Table C-6, is not was not conclusive in showing a temporal nor spatial distribution. However, some conclusions can still be made on the basis of average concentrations per weather event and treatment train location (i.e. surface or pond). Table 5 lists average TP concentrations under various dry and wet weather events. TS concentration was also included in the original sampling protocol. However, due to time and lab availability, it was not included in the final study. During both wet and dry weather, the average ambient TP concentration in the canals and ponds are on the order of magnitude of 30 ppb. Whereas the TP concentration of the surface runoff entering the storm sewer system is on the order of magnitude of 600 ppb with a maximum concentration as high as 2400 ppb. This suggests that the wet retention of the ponds have significant phosphorous uptake capability. However, the Everglades Forever Act has enacted a 10 ppb TP standard for all parts of the everglades including the WCA's (Florida, 2003). Because the surface runoff does eventually reach the WCA's, it can be concluded that surface runoff can indeed have a dramatic impact on achieving compliance of the Everglades Forever Act.

Table 5. Average TP Concentrations

Weather condition/Location	Date Sampled	Average Concentration (ppb)	Minimum Concentration (ppb)	Maximum Concentration (ppb)	Number of Samples
Rain event, surface runoff	various	602	48	2438	21
Dry weather, ambient pond	9/26/2003	33	22	85	12
Rain event, outfall 7	9/6/2003	32	20	40	12
Rain event, outfall 7	9/17/2003	22	20	31	6
Rain event, outfall 7	9/27/2003	21	3	54	24
Rain event, outfall 7	11/2/2003	31	26	42	13

5.1.7 Pollutant Sources

5.1.7.1 Phosphorous Sources

SFWMD (2002a) has identified phosphorous and nitrogen as major components to urban stormwater runoff, which is contributing to the eutrophication of Florida's receiving waters. Most likely the largest source of nutrients in the study watersheds is the permanent population of Muscovy Ducks attracted by the large amount of retained surface water. Many other wild and domestic animals are also present, such as stray cats, dogs, and a various other birds. It seems obvious enough, if the surface water is removed, the wildlife will move on.

Another major contribution to phosphorous pollution probably comes from fertilizers and yard debris. The majority of the catchbasins have shown to contain large amounts of leaves, grass clippings, branches and other plant debris. England (2001) has found that the majority of nutrients are leached out of the plant debris after 1 to 22 days of being submerged, 31% after the first day. This is of some concern since nearly all the catchbasins contain standing water most of the year.

5.1.7.2 Sources of Solids

Solids are another significant pollutant of concern within the watersheds. Excessive sedimentation is suspected to have caused clogging within various areas of the storm sewer system. Major blockages were found in the main discharging conduit in the northern watershed. It has since been cleared, but unfortunately a lack of access to the

rest of the storm sewer has prevented any confirmation of additional blockage. However, it is likely to exist.

Identifying any one source of solids may be difficult. According to SFWMD (2002a), solids are mainly the result of erosion and the accumulation of organic material. A likely culprit in the study site is bank erosion. Several locations along the bank of the central ponds do appear highly eroded. Plant debris and trash has also been observed in large quantities in and around the catchbasins and in the sewer system. Other sources include road debris (tire and emission particles), and possible surface erosion.

5.1.7.3 Other Pollutants

Many of the residents appear to own older, high mileage vehicles that are park over the swales, many of which can be expected to be leaking oil and various other pollutants. During subsequent storm events, the pollutants collecting in the swale water from the automobiles are easily and swiftly sent into the drainage system.

5.1.8 Runoff Volume

Except for the infiltration capacity of the swale system, flows are routed directly to the receiving water. For the storm event on 9/17/03, the total discharge predicted by the model was $1.74 \times 10^4 \text{ ft}^3$, or 0.07 in of the 0.67 in of rainfall. For the 9/27/03 storm event, the total discharge was predicted to be $5.84 \times 10^4 \text{ ft}^3$, or 0.24 in of the 1.38 in of rainfall. This suggests an average runoff coefficient of about 0.14. It will be shown later

that both these storms under Florida Administrative Code (FAC) should be completely retained.

5.2 DESIGN SOLUTIONS

5.2.1 Design Criteria

The study watersheds are located in the C-11 West Drainage Basin, which is adjacent to the WCA as illustrated in Map 3. As a result, it falls under FAC Chapter 40E-41, Part IV. State regulations require that the greater of the first inch of runoff or 2.5 times the percentage of impervious surface must be contained within the watershed system (SFWMD, 2003). The total percent impervious was found to be about 60%.

$$2.5 \text{ in} \times 0.60 = 1.5 \text{ in} \quad (14)$$

Therefore, 1.5 in must be retained in the drainage system. The solutions proposed in the following sections are based on reaching that criterion, while also achieving surface flood relief for the residents. To reach maximum stormwater management efficiency, no single technique is adequate. It is important to have effective control measures established throughout the treatment train (SFWMD, 2002a). The following proposed solutions consider all components of the existing treatment train and how each can be improved.

5.2.2 Downspout Relocation

The current rooftop discharge from each home is directed through downspouts both onto the pervious grass and the impervious driveways as is shown in Figure 3. Given the high conductivity of the soil, the water discharging onto the grass surface has a significant potential for infiltration. It is shown by the model to be fully abstracted even during the 25-year storm. Hence, it would be very beneficial to remove the downspouts discharging onto the driveways and redirect the runoff to completely discharge into the grassed areas. Homes cover about 42% of the watershed, half of which contributes runoff directly into the swale system without experiencing any infiltration losses. Hence, by relocating the discharge to solely pervious surfaces, the total runoff volume can potentially be cut by 21%.

5.2.3 Swale Reconfiguration

Surface retention is a proven and effective method of storm attenuation and water treatment when it occurs in the proper place. The SFWMD (2002a) claims an effective retention system can help facilitate the preservation or restoration of the predevelopment hydrology. Whalen and Cullum (1988) have found that retention systems, including swales, can have nutrient and solid removal rates as high as 90%. Even though little excess land is available in the study watersheds for fully functioning retention areas, there are still many places with pervious cover that can be easily and cheaply adapted for that purpose. The most effective approach would be to excavate a few inches of the existing swales to the point that the invert of the grassed portion is below that of the driveways.

SFWMD (2003) suggests that the centerline elevation of the swale be maintained no higher than the lowest upstream driveway. The resulting effects would be the diversion of the depression storage away from the impervious surfaces and residential activities, and a significant increasing in the volume of runoff abstracted as a result of the depression storage being exposed to infiltration as well as evaporation as is seen in Figure 18.

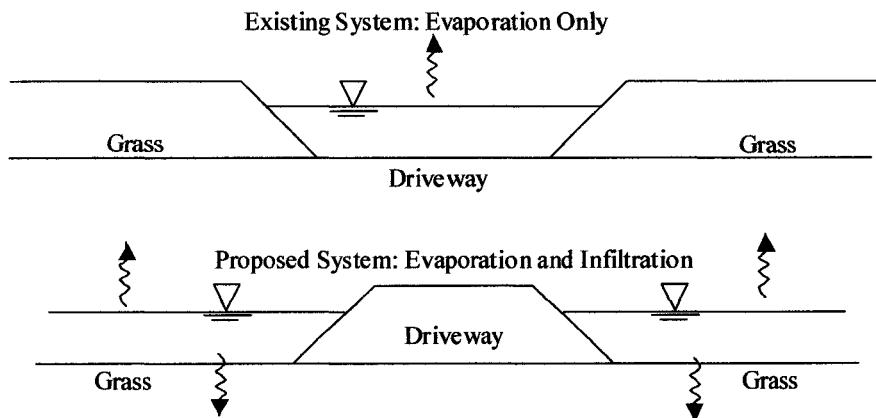


Figure 18. Result of proposed swale reconfiguration

5.2.4 Additional Catchbasins and Exfiltration Trenches

Additional catchbasins and connecting exfiltration trenches are recommended for 30 locations (13 have been constructed to date). Sites for the catchbasins have been selected based on the locations of excessive ponding, locations of mild slope and minimal flow capacity, and locations topographically isolated from the existing system. Connections to the existing storm sewer system were based on identifying the areas that can best handle the increased flows and allow for easy storm sewer instillation. Exfiltration trenches are a common stormwater management BMP utilized in Florida. Retained water is allowed to percolate into the surrounding gravel as a means of

improving water quality (Branscome and Tomasello, 1987). They are effective at increasing the systems total infiltration capacity and will greatly assist in reaching the 1.5 in of required retention. Map A-8 depicts the locations for the recommended additional structures.

5.2.5 Weir Boxes

An effective weir system is needed to maximize the treatment efficiencies of the stormwater management system. Weirs are recommended for installation in six locations as shown in Map A-9, which also identifies the regions affected by each weir. Weir box placements were chosen based on the ability to increase the residence time in the ponds, maximize the pressure head in the new exfiltration trenches, and to force sedimentation in more isolated and accessible locations. If designed properly, the storms resulting in the greatest pollutant loads, (Pitt and Voorhees, 2000) those ranging in depth between 0.5 and 1.5 inches, can be nearly retained by the weir system resulting in minimal discharge to the N-23 canal.

5.2.6 Grate Inlet Baskets

England (1998) noted great success using inlet baskets in Brevard County. Grate inlet baskets are fiberglass inserts that effectively trap dirt, trash, and debris in dry storage. The water is still able to flow in without a significant loss of hydraulic capacity. Installing an inlet basket in every catchbasin would be preferred; however, they would be most effective in the catchbasins located in the Western Hills community. This area has a

greater density of trees and appears to have a larger amount of ground debris as a result as compared to Sunshine Village. Furthermore, that region of the storm sewer system is more susceptible to sedimentation and clogging do to the lack of accessibility of any normal maintenance devices.

5.2.7 Maintenance

Maintenance is a vital component to the longevity of any stormwater management system. The watersheds' drainage infrastructure appears to have been mostly neglected over the years. The first improvement recommendation, already complete at the time of this report, was a thorough cleaning of the catchbasins in the northern portion of Western Hills. A crew from the Town of Davie pulled out several melon-sized boulders from the catchbasins, which were effectively blocking the connecting orifices. The remainder of the catchbasins in both communities now needs the same treatment.

Regular street sweeping should be performed to prevent the build up of surface pollutants on the roadways. The large amount of garbage needs to be removed from the ponds and storm sewer system and continue to be removed on a regular schedule.

5.2.8 Public Education

The best pollution control is source reduction. Residents should be made aware of the impacts of stormwater runoff and NPS pollution on surface water, and how everyday activities of yard and home care can impact the quality.

5.3 ANALYSIS OF PROPOSED IMPROVEMENTS

The above improvements were tested under the same criteria as the pre-existing system. This was done to confirm that the flood control measures are effective and do not negatively impact pollution control. Similarly, it is important that any additional pollution control devices do not result in additional flooding.

5.3.1 Model Additions

5.3.1.1 Recommended catchbasins and storm sewers

The following SWMM analysis is based on the addition of 30 catchbasins and 4100 ft of exfiltration trenching. The locations and dimensions of the 13 catchbasins and exfiltration trenches already installed were obtained with the same procedure outlined in the site investigation. The results are shown in tables B-5 and B-6. Those proposed, but not yet installed, were assumed to have similar dimensions, a 4-ft depth from the grate elevation to the invert, and a grate area of 6.14 ft².

SWMM is not capable of modeling infiltration in the EXTRAN Block; therefore, simple storm sewer links were used to model the exfiltration trenches instead. As a result, a final analysis of flow volume will be overestimated resulting in a conservative design. The retention capacity of the system will be evaluated using another means in section 5.3.3.

5.3.1.2 Reevaluation of subwatershed and swale configuration

The surface drainage patterns were reevaluated based on the locations of the recommended catchbasins according to the same procedure used in the watershed characterization. Maps A-10 and A-11 depict the layouts, and Tables B-7 and B-8 include the physical parameters of the new subwatersheds and swales respectively.

In addition, the 0.5-in impervious depression storage originally included in each swale was removed and replaced by 0.5-in pervious depression storage. This was done to account for the excavation of the swale system to a depth of 0.5 inches below the driveway surfaces.

5.3.1.3 Weir box design

The weir boxes to be installed are 6-ft x 6-ft structures separated into two chambers by a rectangular, broad crested weir. A schematic of a typical weir is shown in Figure 19. The equation normally used for calculating discharge over a broad crested weir is

$$Q = CLH^{1/2} \quad (14)$$

where Q = discharge (cfs)

C = weir coefficient (3.13 in)

L = weir length (ft)

H = head on weir (ft)

The weir coefficient is almost always equal to 3.13 in stormwater management systems (SFWMD, 2004).

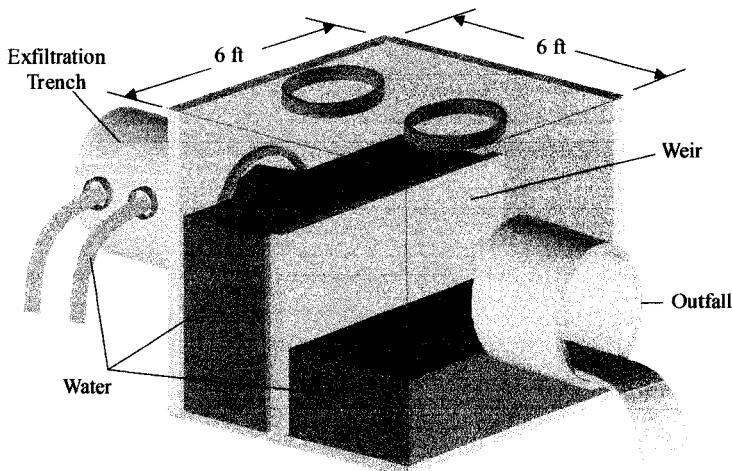


Figure 19. Weir schematic

5.3.2 Model Analysis

The model was again executed for the 5-, 10-, and 25-year storm events. The results are tabularized in Appendix G. The results shown include maximum predicted swale flows and maximum predicted catchbasin depths.

5.3.2.1 Swale overflow

Using Manning's equation, the peak depths in each swale were calculated from the peak flows predicted by the model for the 5-year storm, shown in Table G-5. Those with resultant depths greater than the maximum (0.25 ft) are shown in Table 6 and are located in Map A-12. Comparing Map A-12 to A-7, it can be seen that several areas

have decreased in potential depth. Some locations did have an increase in depth, but mostly in short lengths and relatively near a catchbasin where the effects are minimal.

Table 6. Predicted Swale Overflow for 5-Year Storm,
After Improvement

ID	Peak Depth (ft)	% Over 0.25 ft	ID	Peak Depth (ft)	% Over 0.25 ft
3022	0.37	46	3351	0.35	42
3231	0.31	22	311	0.31	23
340	0.33	32	315	0.33	34
346	0.35	38	393	0.30	20
347	0.37	48	3081	0.27	7
348	0.46	84	334	0.26	4
352	0.27	9	335	0.29	14
365	0.26	3	376	0.26	3
398	0.39	54	377	0.33	34
3282	0.39	56	388	0.27	7

5.3.2.2 Weir Heights

To maximize the efficiency of the exfiltration trench system, the weirs should be set at least to the same elevation as the conduit crest (SFWMD, 2003). The higher the hydraulic head is within the trench, the greater the potential for infiltration. The maximum height should be such that no catchbasin overflows during the 25-year storm. The maximum weir heights were determined through a trial and error process using the 25-year storm event in the SWMM model. Weir heights were varied until the maximum elevation without catchbasin overflow was achieved. The final recommended elevation ranges for the six weirs are shown in Table 7. The affected region for each weir is identified in Map A-9.

Table 7. Maximum and Minimum Weir Elevations

Affected Region	Minimum Weir Elevation (ft MSL)	Maximum Weir Elevation (ft MSL)	Depth Below Ground at Deepest Catchbasin (ft)
A	5.3	5.5	0.37
B	4.5	5.5	0.21
C	4.9	5.5	0.59
D	4.1	5.2	0.01
G	4.0	4.5	0.23
H	4.0	4.2	0*

*Note: Catchbasin experiencing overflow before weir instillation

The peak water elevation predicted in region H was found to rise above the ground elevation. That location (catchbasin 131) did however experience overflow even before the weirs were included in the model. Given an expected rise in the receiving water to 4.1 ft MSL, the weir elevation was chosen to extend just above that at 4.2 ft MSL. This was done to allow for the retention of normal storms, but also to prevent any additional flooding for large widespread storms.

The overflow predicted in catchbasin 131 does suggest that the storm sewers down stream of catchbasin 131 should be replaced with larger piping. Unfortunately, this would be a politically sensitive operation since these structures are located between homes on private property where stormwater management structures are not generally accepted. It would not be particularly beneficial since the predicted catchbasin head for the 25-year storm is only about 0.4 in above the ground elevation.

5.3.3 Retention Analysis

The SFWMD (2003) illustrates a standard for calculating the retention capacity of an exfiltration trench system based on the configuration shown in Figure 20. The length of exfiltration trench required to retain a given volume of runoff is given by

$$L = \frac{V}{K(H_2 W + 2H_2 D_u - D_u^2 + 2H_2 D_s) + (1.39 \times 10^{-4} W D_u)} \quad (15)$$

where, L = required length of infiltration trench (ft)

V = volume required for retention (ac-in)

K = hydraulic conductivity (cfs/ft²·ft head)

W = trench width (4 ft)

H_2 = depth to water table (4 ft)

D_u = non-saturated trench depth (2.5 ft)

D_s = saturated trench depth (1.5 ft)

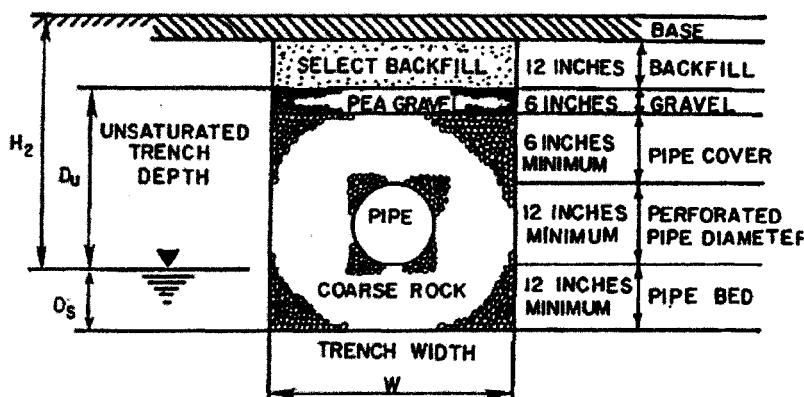


Figure 20. Typical exfiltration trench cross-section
(from SFWMD, 2003)

It was stated earlier that retention of 1.5 in of runoff is required to obtain the pollution control standard set by the FAC. A total area of 90 ac for the two watersheds requires a volume of 135 ac·in be retained. The two ponds extend over 1.68 ac and have a potential depth increase of about 12 in (change in depth from 3.5 ft MSL to 4.5 ft MSL), which results in a retention capacity of 20 ac·in. Therefore, the exfiltration trenches must be designed to retain the remaining 115 ac·in of runoff. The hydraulic conductivity was given earlier as 13 in/hr. This is equivalent to 3×10^{-4} cfs/ft²·ft head. The other parameters are design conditions, which at this point are unknown. The values shown are based on a typical design used in the area (SFWMD, 2003). Equation 15 results in a required length of exfiltration trenching of 9500 ft. About 4100 ft are included in the design shown in map A-8. Of the remaining 5400 ft, half should be installed in the southern watershed and half in the Western Hills portion of the northern watershed (Regions G and H on Map A-9). The exact locations are arbitrary but should be evenly spaced.

Given an average runoff coefficient (volume of runoff / volume of rainfall) for the watersheds of about 0.14 and a retention capacity of the exfiltration trenches of 1.5 in, a rain event up to a depth of 11 in can potentially be fully retained. That is greater than the 24-hour, 5-year storm event, which is 9 in.

6 IMPLEMENTATION AND CONCLUSIONS

6.1 IMPLEMENTATION

Final design considerations for drainage improvement focus on alleviating surface flooding while also achieving regulatory standards for water quality. The design proposed involves all aspects of the treatment train from controlling volume input to maximizing collection, conveyance and retention efficiency, including the following target areas.

- Relocating the roof downspouts to discharge onto grass surfaces can reduce the runoff volume
- The swale system needs restructuring to eliminate impervious ponding and maximize its retention capabilities.
- Additional catchbasins are recommended in 30 locations identified as having inadequate flow capacity and excessive surface ponding.

- To help achieve the required retention and connect the additional basins to the existing system, 9500 ft of exfiltration trenching are recommended.
- A series of weirs are recommended in key locations to help maximize the performance of the exfiltration trench system.
- Grate inlet baskets should be installed in the catchbasins to help retain organics and solid debris in a dry state.
- A regular maintenance schedule should be set in place for maximum system performance and longevity.

Figure 21 illustrates the timeline since project initiation in August of 2003.

During phase one construction, completed in February of 2004, several improvements were implemented including 13 catchbasins and 1500 ft of exfiltration trenching. Also included in phase one construction, 13 catchbasins were thoroughly cleaned. Phase two, planned for August and September 2004, will include 17 additional catchbasins and 2000 ft of exfiltration trenching; although, 9400 ft total is required to achieve water quality standards for the entire study area. Weir installation is in the final design process; however, only four of the six weirs suggested will be constructed. Implementation will focus only on the Sunshine Village community because of the minimal need for surface drainage improvements in the Western hills community. Of course, the final extent of the recommended improvements implemented in phase two will be subject to other criteria as the Town of Davie sees fit. For instance, funding, cost/benefit, feasibility and space constraints will all be considered.

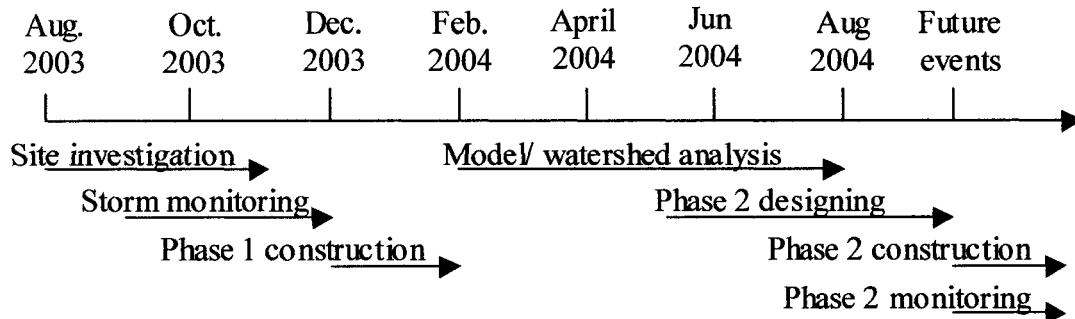


Figure 21. Project timeline

After complete implementation, surface ponding should be minimized and occur only on pervious surfaces where the water can quickly be infiltrated. The entire system will have a potential retention greater than the 24-hour, 25-year storm event, thereby preventing the release of the high pollutant loads contained in the surface runoff. In addition, the weir system will allow for increased sedimentation to occur in areas that are easily maintained. Monitoring activities will continue throughout the remainder of the project, through construction and beyond complete implementation. This will be done to confirm the results predicted in this report.

6.2 CONCLUSIONS

Stormwater management retrofit projects have gained attention in recent years. Mainly due to NPS pollution and the effects it has shown to have on Florida's receiving waterways. The FCWA, as well as many other state and local regulations enacted since the 1970's, have done much to prevent new pollution sources. Only recently have retrofit projects of older, poorly designed stormwater management systems been a priority. As a result, little documentation exists on the processes of analysis and design, and most

projects focus on “end-of-pipe” solutions with little regard for watershed behavior or the nature of the systems deficiencies. This report has addressed the issue of watershed behavior and has illustrated a viable method for retrofit design

6.2.1 Design Summary

This report has presented a design process with attention to understanding the behavior of a small urban watershed located in the Town of Davie. A great deal of knowledge was gained through an intense site investigation, including a land survey of elevation, ground cover, and existing structures, coupled with GIS applications. A stormwater monitoring program was established to collect valuable data on watershed response, and was used as a calibration tool for the modeling process. The watershed behavior was analyzed under the criteria of surface flooding and pollutant loads using EPA’s SWMM for design storm simulations. The knowledge gained by these analyses was applied to building an understanding of the drainage system and its deficiencies, and developing a set of solutions specific to the situation at hand. Gaining an understanding of the design process and the issues of stormwater management for small urban watersheds is paramount in protecting the environment from NPS pollution. This project has addressed the issues regarding stormwater management in such a way that is comprehensive, inexpensive and is easily adaptable to most situations.

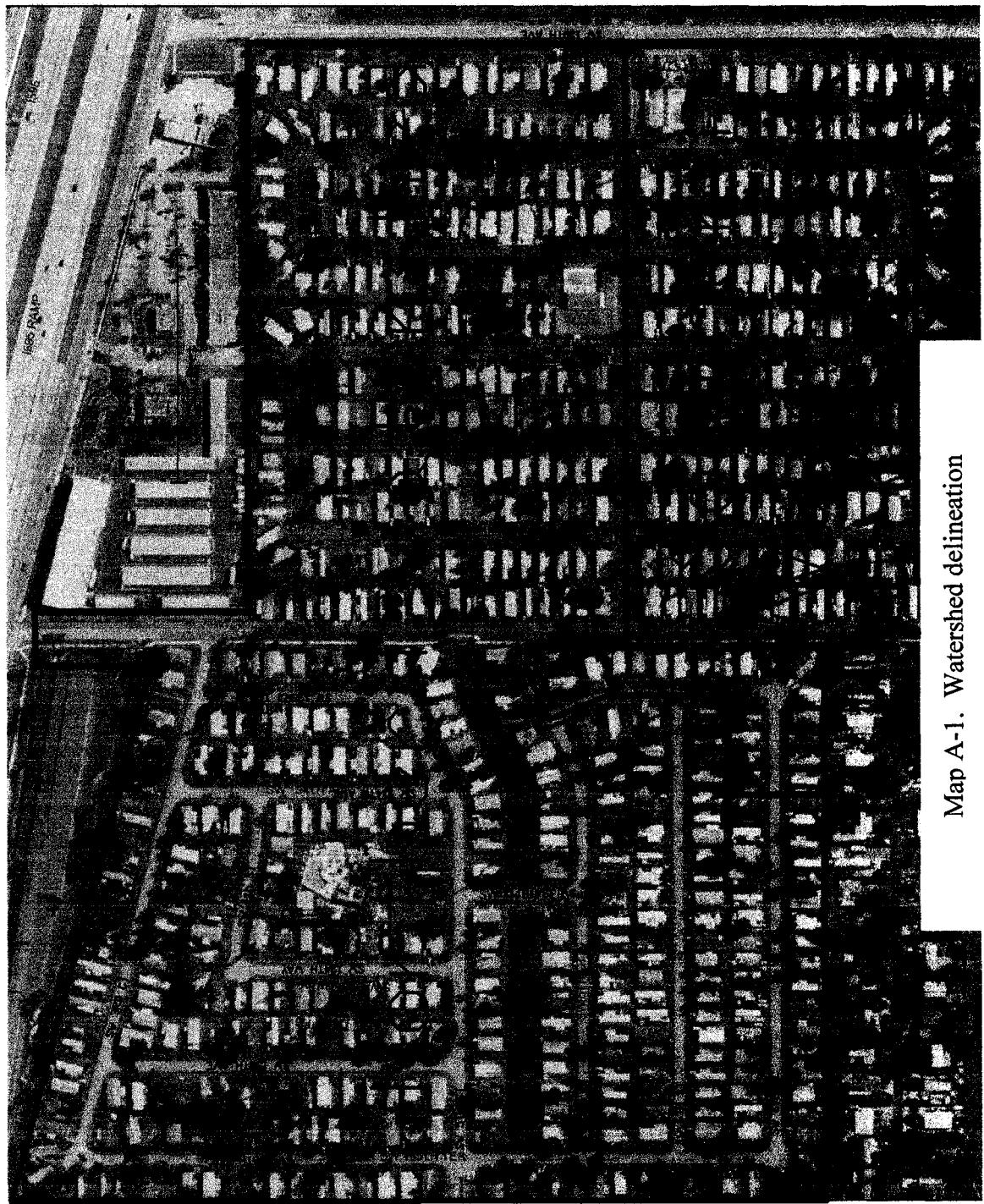
6.2.2 Future Recommendations

Unfortunately, this project was somewhat financially limited, resulting in a shortage of adequate equipment and labor. This shortage has mainly impacted the quantity and quality of the storm monitoring data obtained. Complete weather, flow and pollution data was only collected for two storm events, with limited data collected for three additional storm events. Because of the limited data, coupled with the inaccuracies in the flow measurements, very few conclusions can actually be deduced from the storm monitoring data. It is recommended that in future studies of this type more resources are dedicated to storm monitoring. Sufficient monitoring would include complete and accurate data for at least five storm events. If that is not possible, special care must be taken in determining the watershed characteristics so a reasonably accurate analysis can be made. This may necessitate performing in situ hydraulic conductivity tests, a roughness analysis, and performing a more thorough inspection of the existing structures (identifying clogs resulting from sedimentation and other debris).

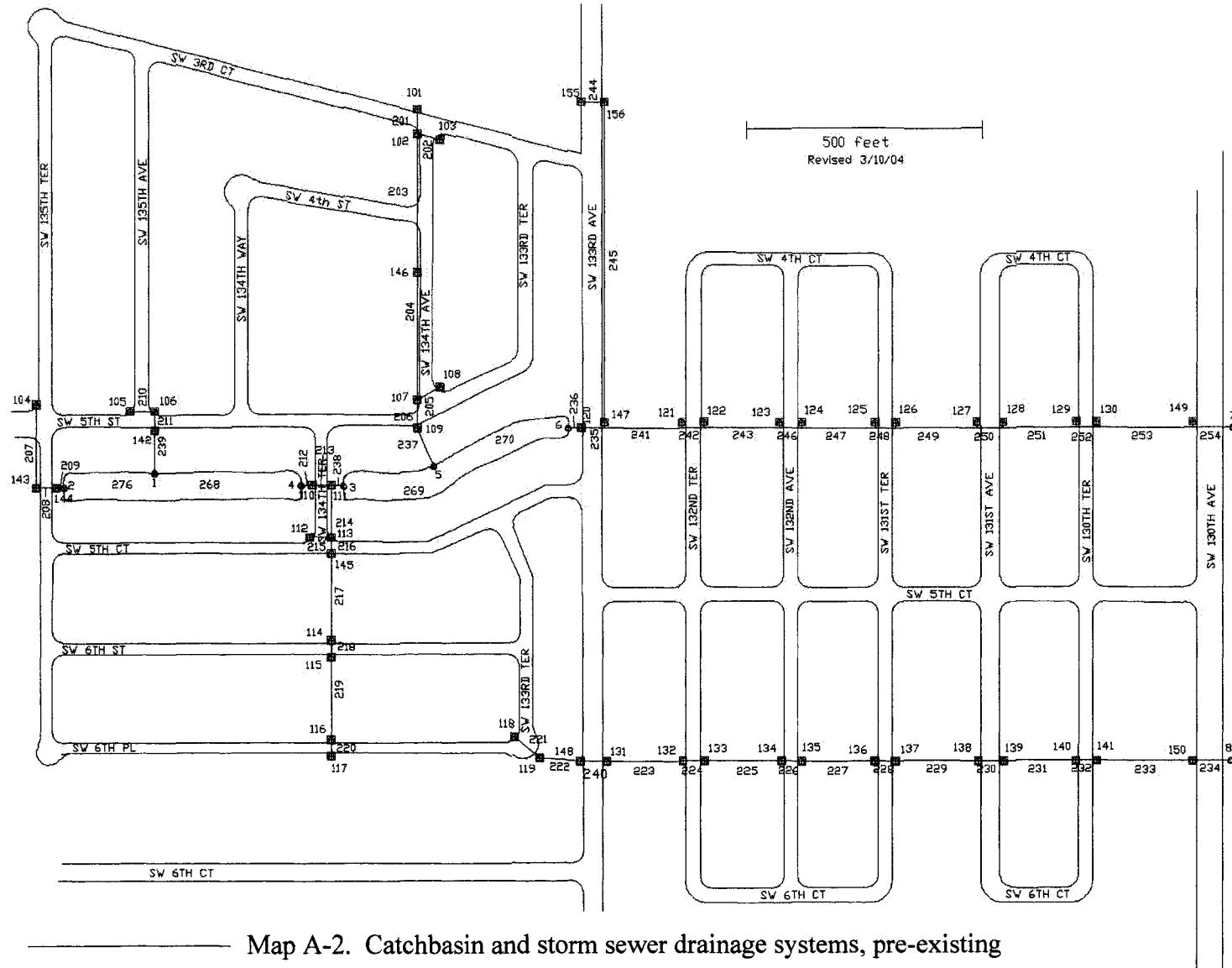
Initially, a component of this project was a nutrient budget of the area. Due to time and budget constraints this was not completed at the time of this report. However, it may prove to be enlightening given the apparent TP assimilation capability of the ponds and canals. It may also be beneficial to quantify the assimilation of other pollutants such as nitrogen and solids.

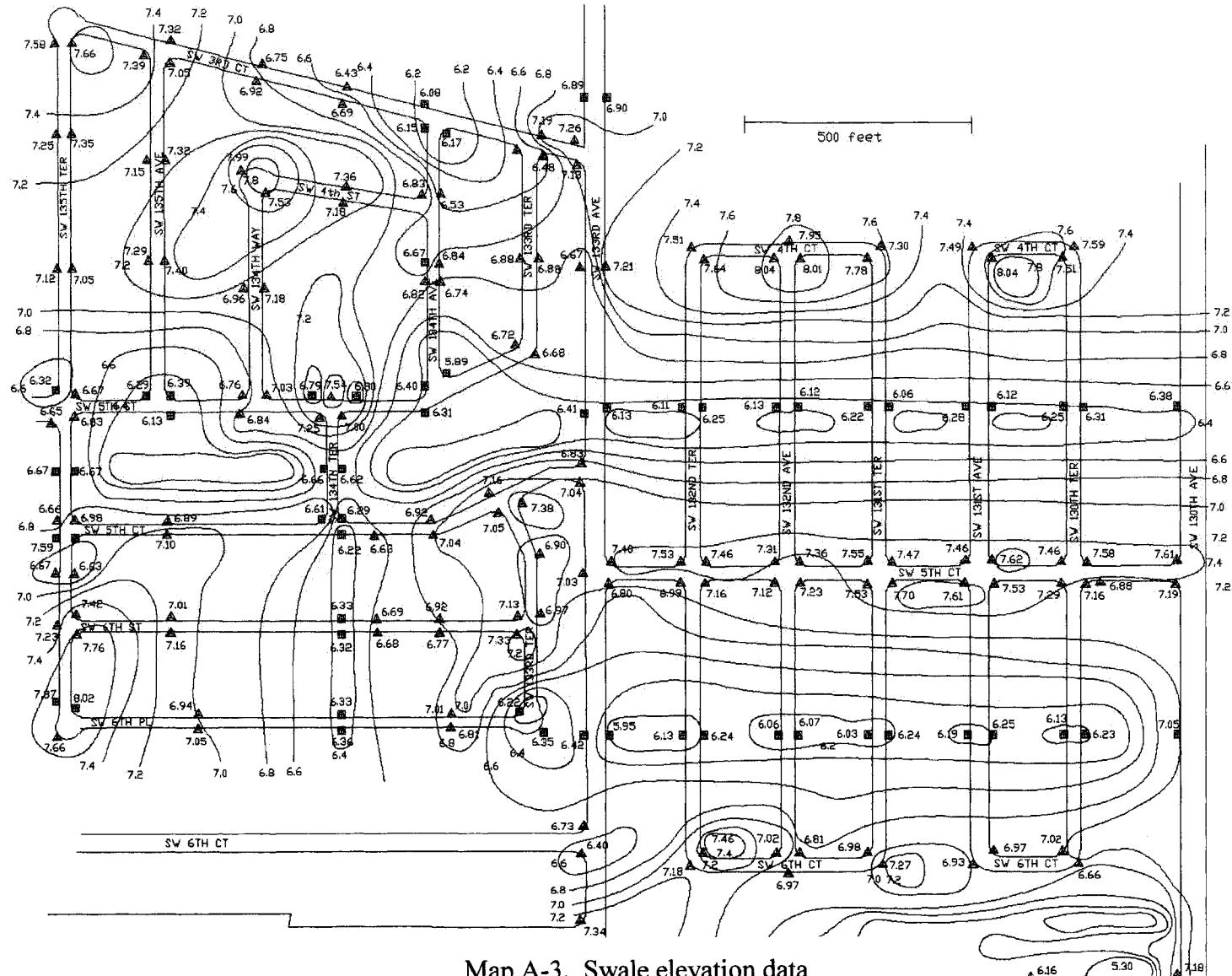
APPENDIX A

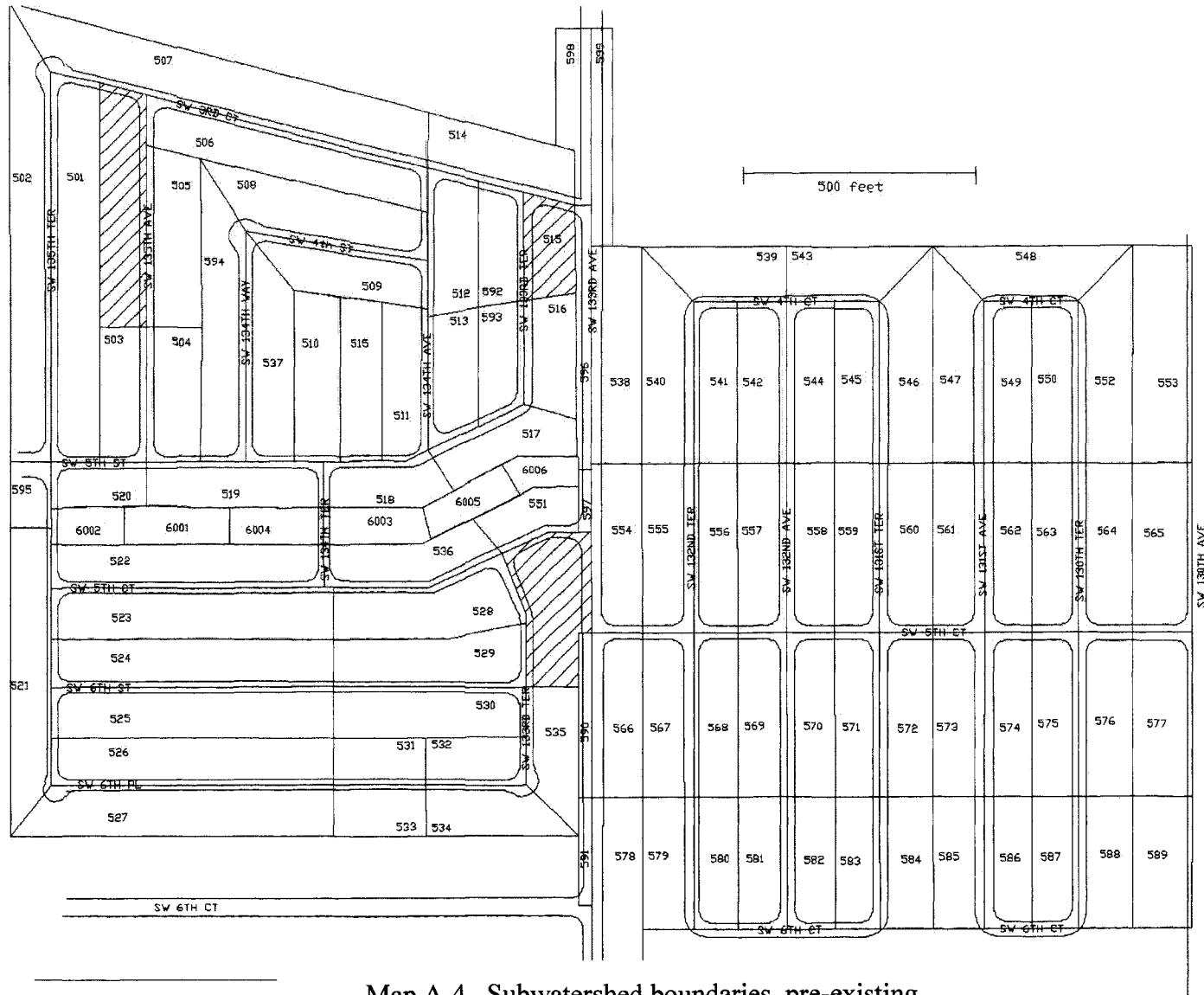
Project Maps



Map A-1. Watershed delineation

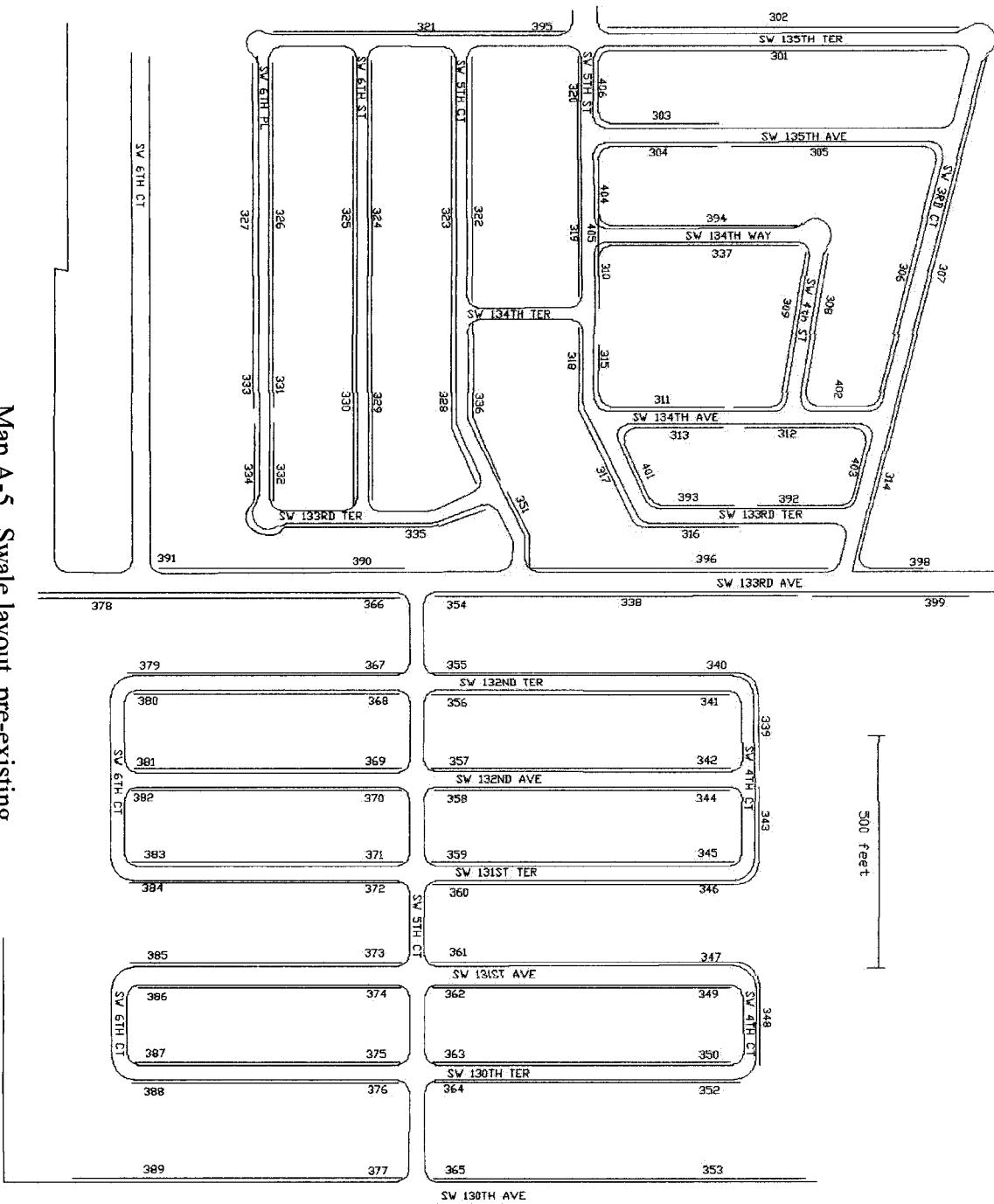






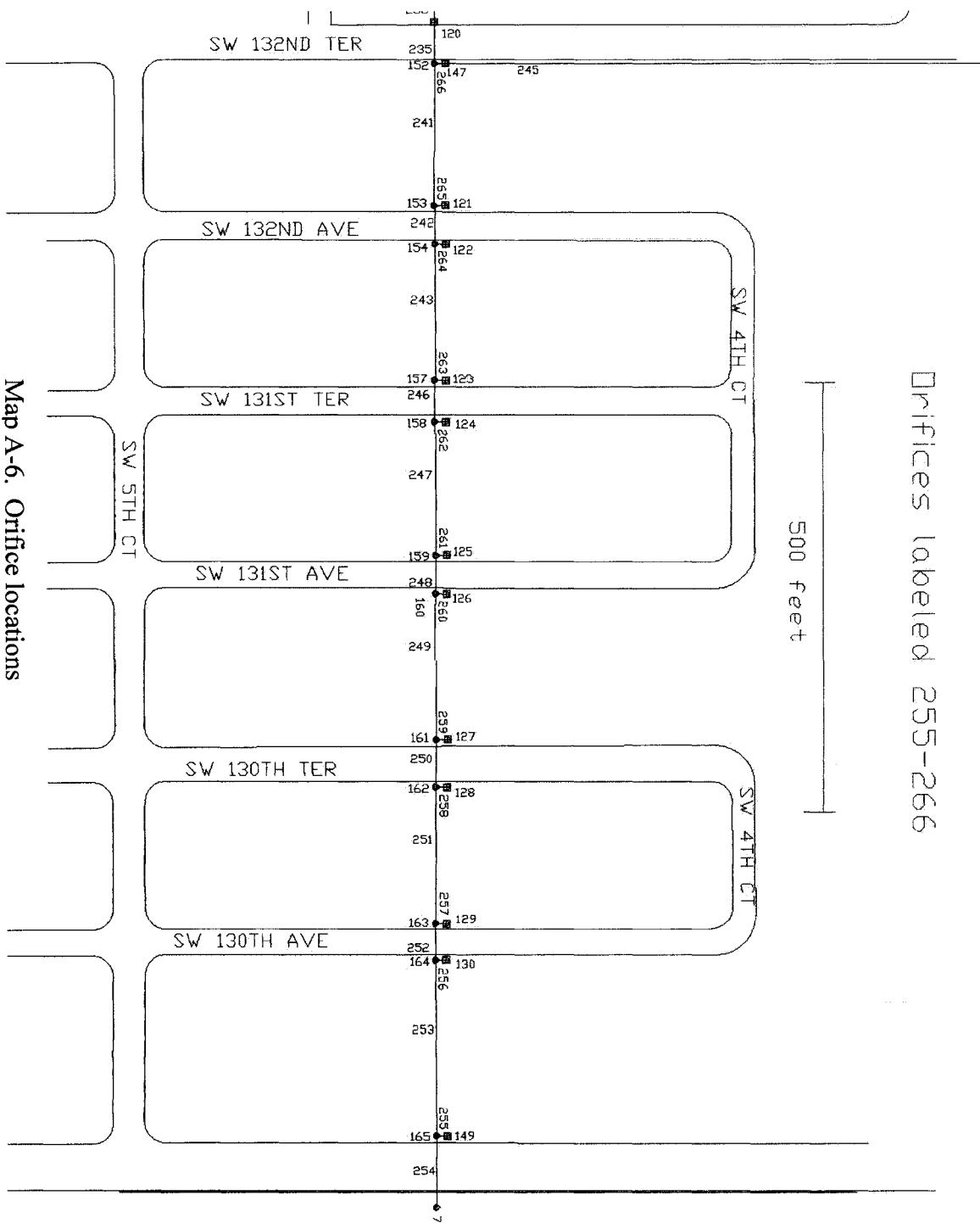
Map A-4. Subwatershed boundaries, pre-existing

Map A-5. Swale layout, pre-existing



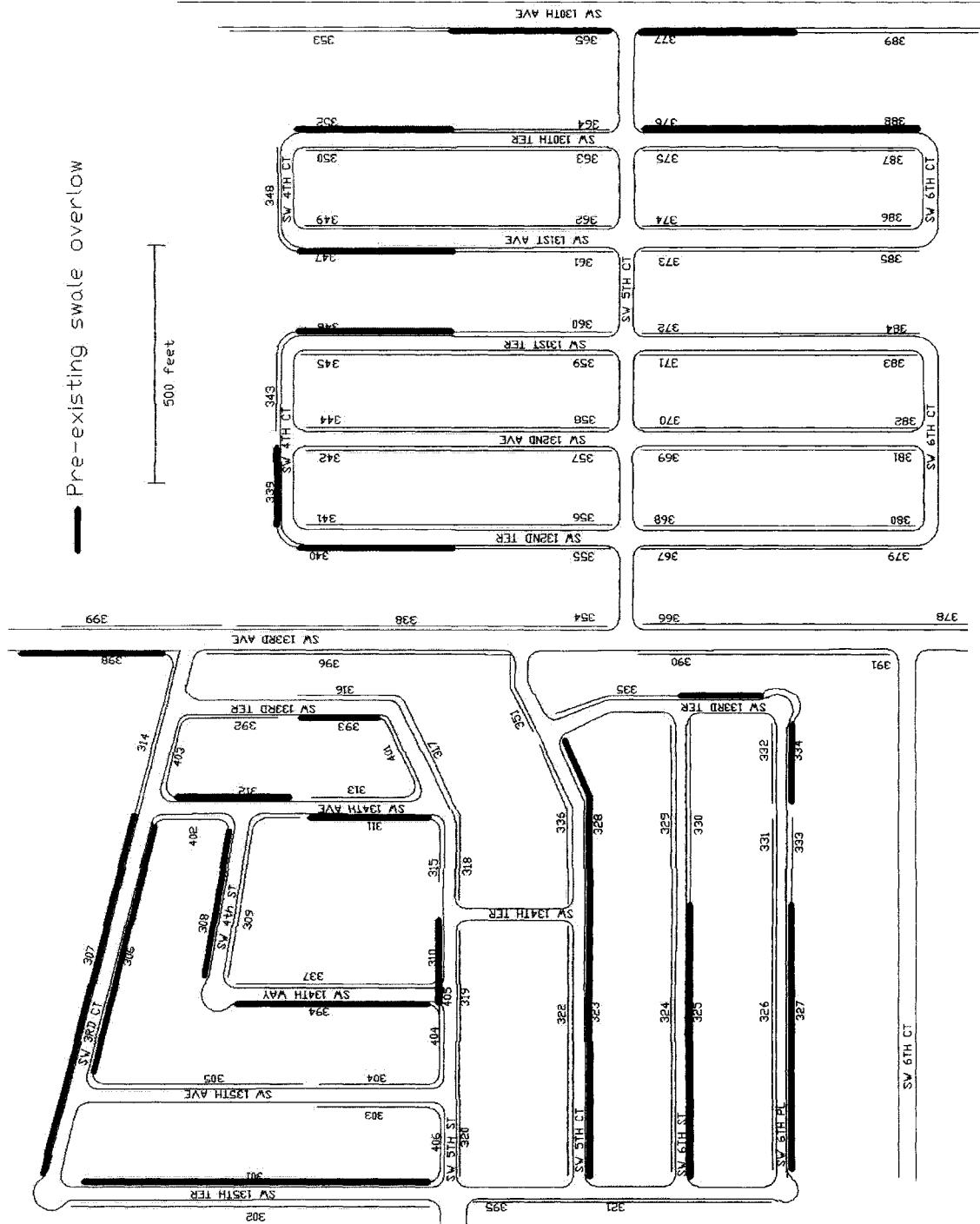
Orifices labelled 255-266

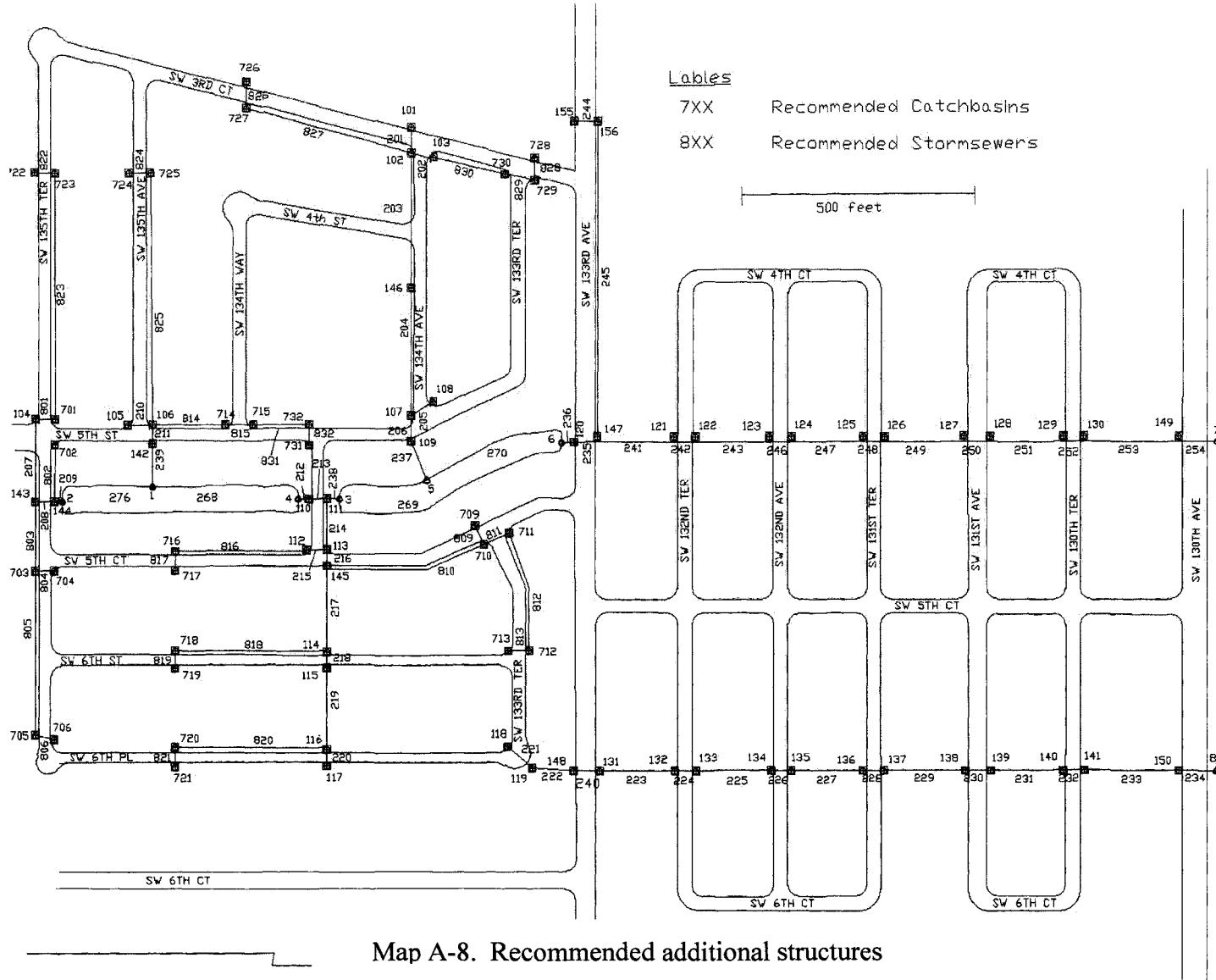
500 feet

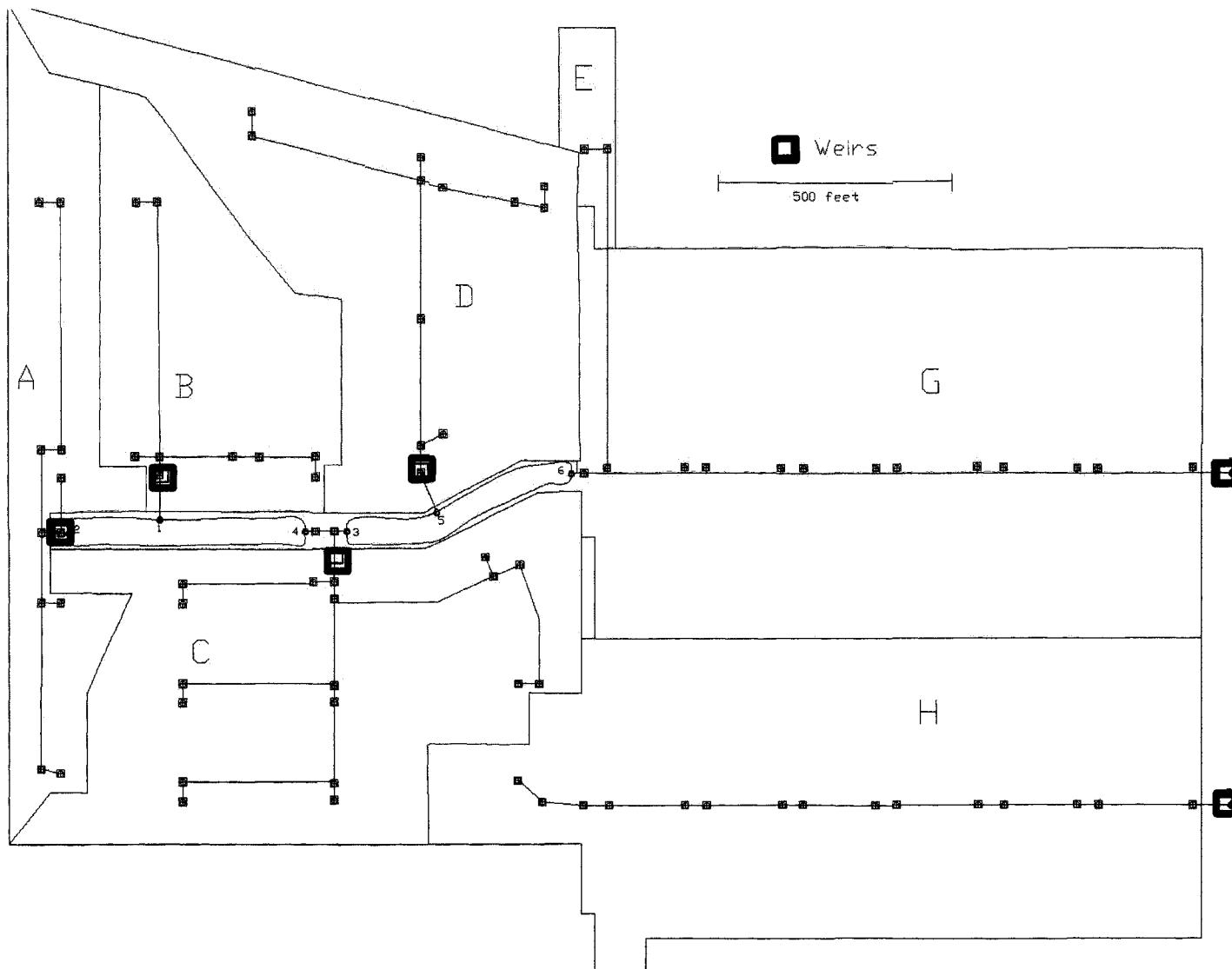


Map A-6. Orifice locations

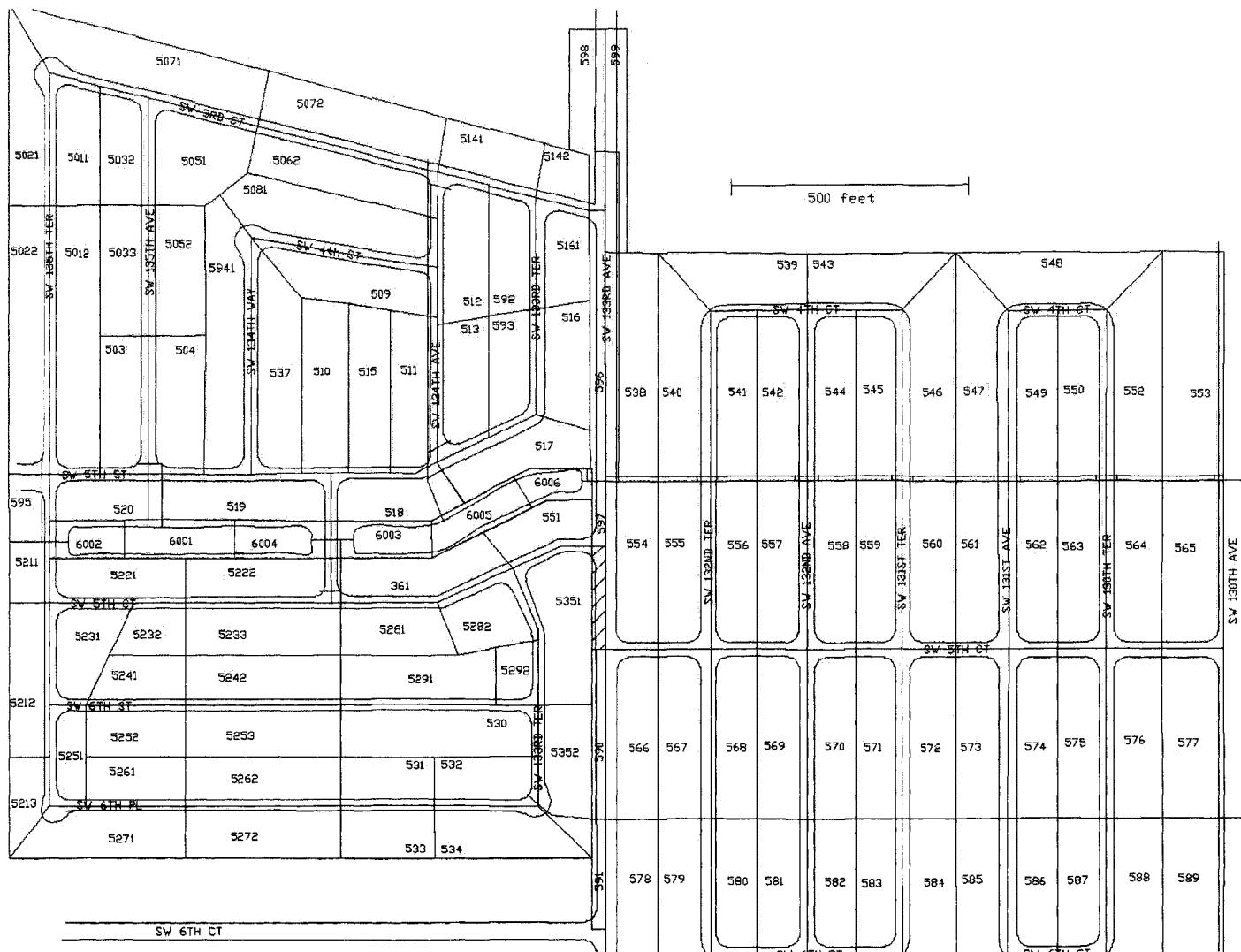
Map A-7. Swales with predicted overflow for the 5-year storm, pre-existing





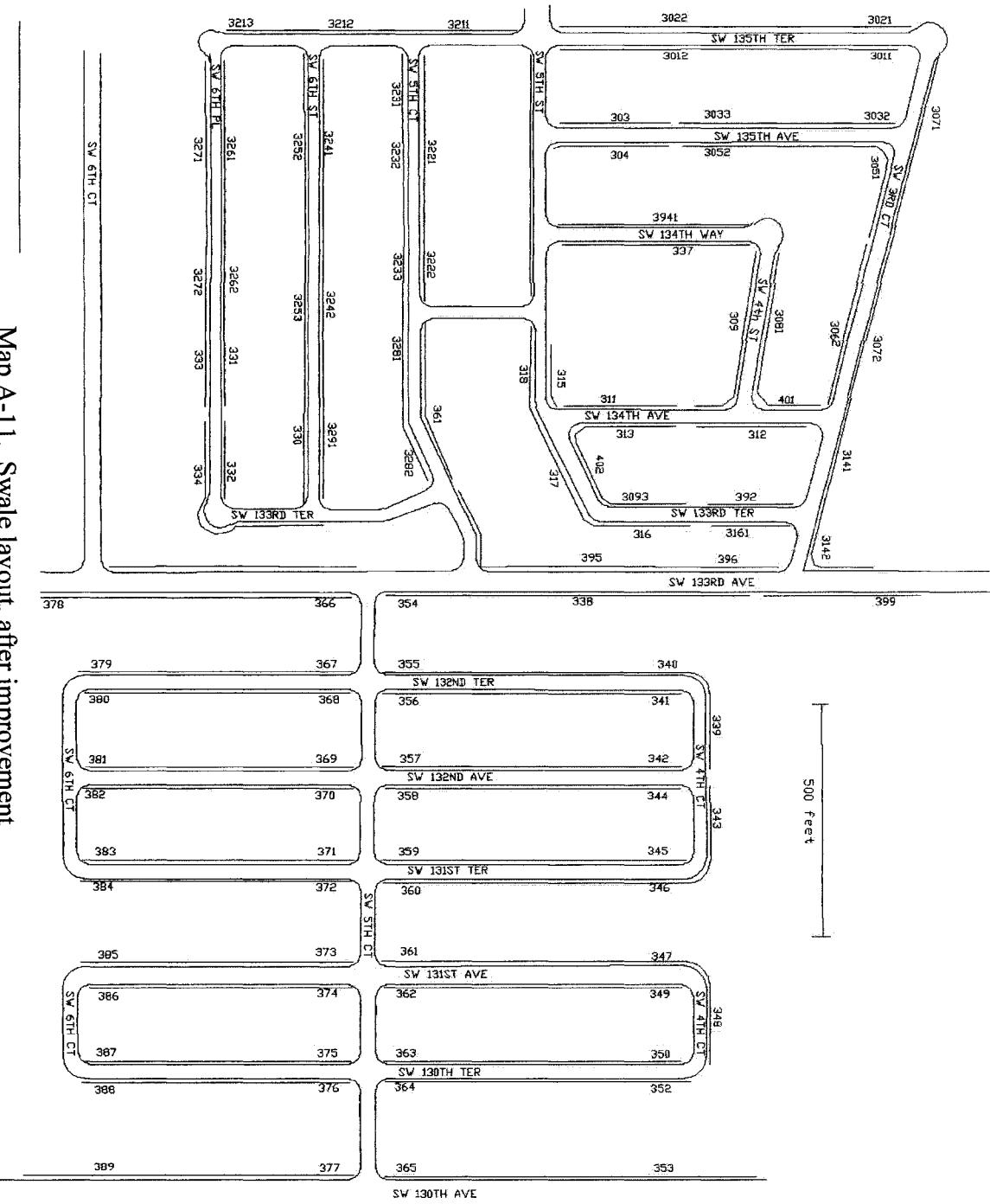


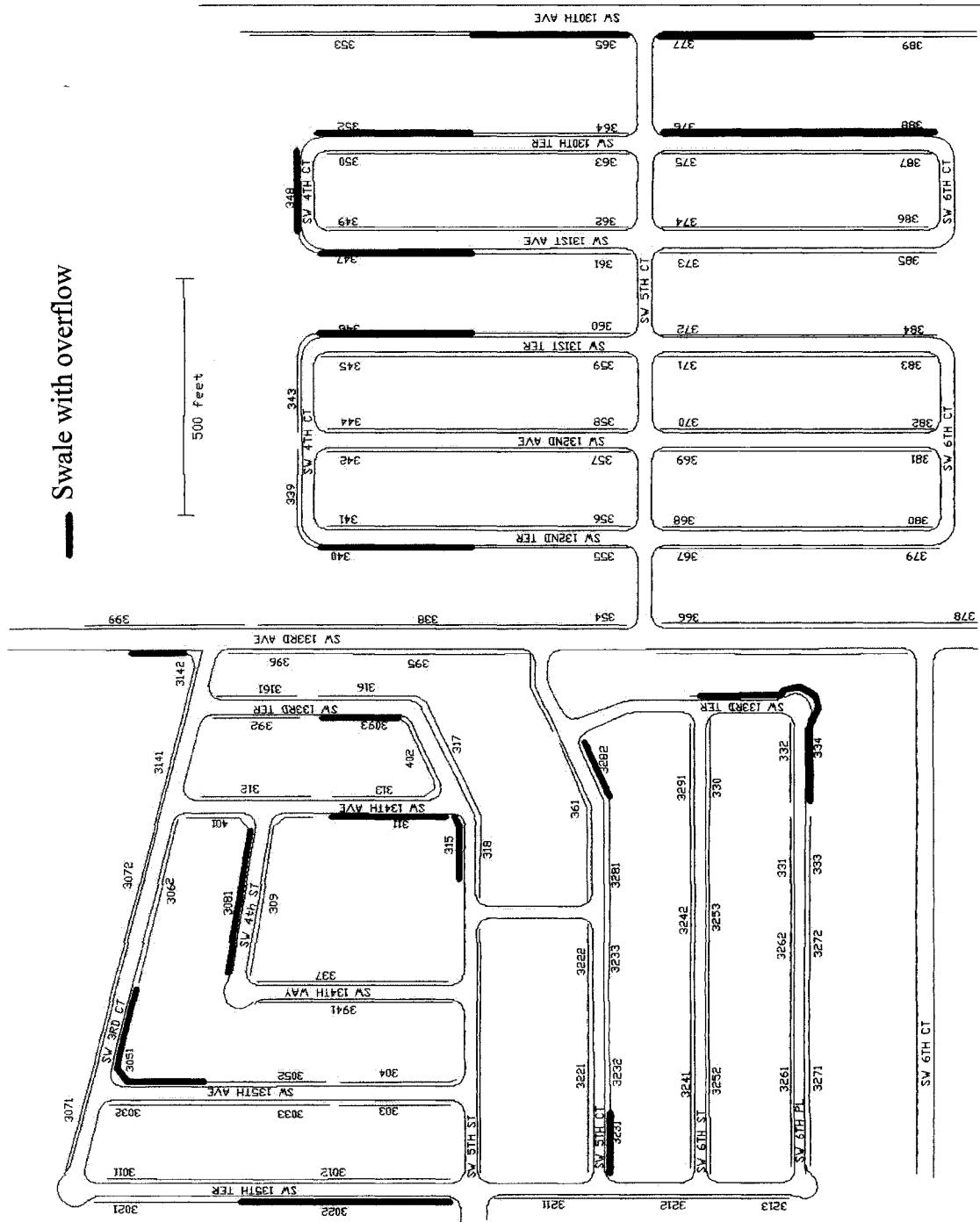
Map A-9. Weir placements and the affected regions



Map A-10. Subwatershed boundaries, after improvement

Map A-11. Swale layout, after improvement





Map A-12. Swales with predicted overflow for the 5-year storm, after improvement

APPENDIX B

Object Parameters

Table B-1. Catchbasin and Junction Parameters

ID	Group	Surface Elev. (ft MSL)	Invert Elev. (ft MSL)	Initial Depth (ft)	Grate Area (ft ²)	ID	Group	Grate Elev. (ft MSL)	Invert Elev. (ft MSL)	Initial Depth (ft)	Grate Area (ft ²)
104	A	6.32	3.99	0.00	6.14	129	G	6.25	0.00	3.34	6.14
143	A	6.22	3.85	0.00	6.14	130	G	6.31	0.06	3.28	6.14
144	A	6.24	3.15	0.19	6.14	147	G	6.13	1.13	2.21	6.14
2	G	6.00	3.20	0.14	‡	149	G	6.38	1.96	1.38	6.14
105	B	6.29	3.98	0.00	6.14	152	G	6.50	1.90	1.44	6.14
106	B	6.39	3.14	0.20	6.14	153	G	6.50	1.75	1.59	6.14
142	B	6.13	3.09	0.25	6.14	154	G	6.50	1.75	1.59	*
1	G	6.00	2.18	1.16	‡	155	G	6.89	3.89	0.00	*
110	C	6.66	2.37	0.97	6.14	156	G	6.90	3.70	0.00	*
111	C	6.62	2.46	0.88	6.14	157	G	6.50	1.60	1.74	*
112	C	6.86	4.44	0.00	6.14	158	G	6.50	1.60	1.74	*
113	C	6.45	2.70	0.64	6.14	159	G	6.50	1.45	1.89	*
114	C	6.33	3.08	0.26	6.14	160	G	6.50	1.45	1.89	*
115	C	6.32	3.23	0.11	6.14	161	G	6.50	1.30	2.04	*
116	C	6.33	3.83	0.00	6.14	162	G	6.50	1.30	2.04	*
117	C	6.36	4.15	0.00	6.14	163	G	6.50	1.15	2.19	*
145	C	6.22	2.43	0.91	6.14	164	G	6.50	1.14	2.20	*
3	G	6.00	1.75	1.59	‡	165	G	6.50	1.00	2.34	*
4	G	6.00	2.28	1.06	‡	6	G	6.00	0.00	3.34	‡
101	D	6.08	4.08	0.00	6.14	7	G	6.00	0.93	2.41	‡
102	D	6.15	3.40	0.00	6.14	118	G	6.22	4.02	0.00	6.14
103	D	6.17	4.51	0.00	6.14	119	G	6.35	3.94	0.00	6.14
107	D	6.40	3.32	0.02	6.14	131	G	5.95	2.99	0.35	6.14
108	D	5.89	3.32	0.02	6.14	132	G	6.13	3.21	0.13	6.14
109	D	6.31	2.73	0.61	6.14	133	G	6.24	3.00	0.34	6.14
146	D	6.58	3.54	0.00	6.14	134	G	6.06	3.02	0.32	6.14
5	G	6.00	2.28	1.06	‡	135	G	6.07	2.90	0.44	6.14
120	G	6.41	1.91	1.43	6.14	136	G	6.03	3.20	0.14	6.14
121	G	6.11	0.24	3.10	6.14	137	G	6.24	3.07	0.27	6.14
122	G	6.25	0.63	2.71	6.14	138	G	6.19	2.44	0.90	6.14
123	G	6.13	0.05	3.29	6.14	139	G	6.25	3.04	0.30	6.14
124	G	6.12	2.60	0.74	6.14	140	G	6.13	2.96	0.38	6.14
125	G	6.22	0.80	2.54	6.14	141	G	6.23	2.81	0.53	6.14
126	G	6.06	2.54	0.80	6.14	148	G	6.42	3.67	0.00	6.14
127	G	6.28	-0.22	3.56	6.14	150	G	7.05	3.05	0.29	6.14
128	G	6.12	2.30	1.04	6.14	8	G	6.00	2.66	0.68	‡

* non-storage junctions; ‡ outfall

Table B-2. Storm Sewer Parameters

I.D.	Upstream Junction	Down Junction	Diameter (ft)	Length (ft)	Inlet ht (ft)	Outlet ht (ft)	n
207	104	143	1.33	175	0.00	0.00	0.012
208	143	144	1.67	46	0.00	0.00	0.014
209	144	2	1.67	23	0.00	3.20	0.014
210	105	106	1.50	46	0.00	0.58	0.013
211	106	142	2.00	46	0.00	0.08	0.015
239	142	1	1.00	91	0.00	2.18	0.011
212	4	110	2.50	23	2.28	0.17	0.016
213	110	111	2.50	46	0.00	0.00	0.016
214	113	111	2.50	108	0.00	0.08	0.016
215	112	113	1.00	46	0.00	1.08	0.011
216	145	113	2.50	65	0.00	0.00	0.016
217	114	145	2.00	180	0.00	0.92	0.015
218	115	114	2.00	46	0.00	1.00	0.015
219	116	115	1.50	180	0.08	1.00	0.013
220	117	116	1.33	46	0.00	0.00	0.012
238	111	3	2.50	23	0.00	1.75	0.016
201	101	102	1.50	46	0.00	0.00	0.013
202	103	102	1.33	46	0.00	0.83	0.012
203	102	146	2.00	292	0.25	0.08	0.015
204	146	107	2.00	270	0.00	0.00	0.015
205	108	107	2.00	54	0.00	0.00	0.015
206	107	109	2.50	60	0.00	0.00	0.016
237	109	5	2.50	89	0.00	2.28	0.016
235	120	152	3.00	46	0.00	0.00	0.018
236	6	120	3.00	23	1.36	0.08	0.018
241	152	153	3.00	127	0.00	0.00	0.018
242	153	154	3.00	46	0.00	0.00	0.018
243	154	157	3.00	127	0.00	0.00	0.018
244	155	156	1.17	46	0.00	0.00	0.012
245	156	147	1.25	670	0.12	0.00	0.012
246	157	158	3.00	46	0.00	0.00	0.018
247	158	159	3.00	127	0.00	0.00	0.018
248	159	160	3.00	46	0.00	0.00	0.018
249	160	161	3.00	127	0.00	0.00	0.018
250	161	162	3.00	46	0.00	0.00	0.018
251	162	163	3.00	127	0.00	0.00	0.018
252	163	164	3.00	46	0.00	0.00	0.018
253	164	165	3.00	127	0.00	0.00	0.018
254	165	7	3.00	81	0.00	0.00	0.018
221	118	119	1.00	69	0.00	0.12	0.011
222	119	148	1.33	86	0.00	0.08	0.012
223	131	132	1.33	127	0.00	0.00	0.012
224	132	133	1.50	46	0.00	0.00	0.013
225	133	134	1.50	127	0.04	0.00	0.013
226	134	135	1.50	46	0.00	0.00	0.013
227	135	136	1.50	127	0.25	0.00	0.013
228	136	137	1.50	46	0.00	0.00	0.013
229	137	138	2.50	127	0.00	0.54	0.016
230	138	139	2.50	46	0.00	0.00	0.016
231	139	140	2.50	127	0.00	0.08	0.016
232	140	141	2.00	46	0.00	0.17	0.015
233	141	150	2.50	127	0.00	0.50	0.015
234	150	8	2.50	81	0.00	0.00	0.015
240	148	131	1.33	46	0.00	0.83	0.012

Table B-3. Subwatershed Parameters, Pre-Existing

I.D.	Drains to	Width (ft)	Area (ac)	Imperv (%)	Slope	I.D.	Drains to	Width (ft)	Area (ac)	Imperv (%)	Slope	I.D.	Drains to	Width (ft)	Area (ac)	Imperv (%)	Slope
502	302	892	1.61	32	0.014	612	312	293	0.07	100	0.021	696	396	561	0.40	100	0.021
521	321	599	1.06	32	0.014	613	313	263	0.07	100	0.021	697	397	133	0.08	100	0.021
595	395	139	0.24	32	0.014	614	314	320	0.08	100	0.021	698	398	374	0.09	100	0.021
602	302	892	0.23	100	0.021	615	315	92	0.02	100	0.021	699	399	464	0.12	100	0.021
621	321	599	0.15	100	0.021	616	316	244	0.06	100	0.021	532	332	213	0.45	32	0.014
695	395	139	0.04	100	0.021	617	317	284	0.07	100	0.021	534	334	269	0.60	32	0.014
501	301	810	1.79	32	0.014	618	318	266	0.07	100	0.021	535	335	387	0.73	32	0.014
503	303	285	0.59	32	0.014	692	392	250	0.06	100	0.021	566	366	349	0.78	32	0.014
504	304	285	0.69	32	0.014	693	393	236	0.06	100	0.021	567	367	349	0.81	32	0.014
510	310	92	0.73	32	0.014	538	338	461	1.06	32	0.014	568	368	349	0.67	32	0.014
519	319	374	0.75	32	0.014	539	339	250	0.63	32	0.014	569	369	349	0.76	32	0.014
520	320	206	0.41	32	0.014	540	340	402	0.93	32	0.014	570	370	349	0.73	32	0.014
537	337	415	0.92	32	0.014	541	341	344	0.66	32	0.014	571	371	349	0.69	32	0.014
594	394	549	1.14	32	0.014	542	342	344	0.75	32	0.014	572	372	349	0.96	32	0.014
601	301	810	0.20	100	0.021	543	343	252	0.63	32	0.014	573	373	349	0.79	32	0.014
603	303	285	0.07	100	0.021	544	344	344	0.71	32	0.014	574	374	349	0.73	32	0.014
604	304	285	0.07	100	0.021	545	345	344	0.68	32	0.014	575	375	349	0.72	32	0.014
610	310	92	0.02	100	0.021	546	346	402	0.96	32	0.014	576	376	349	0.84	32	0.014
619	319	374	0.09	100	0.021	547	347	402	0.91	32	0.014	577	377	349	0.94	32	0.014
620	320	206	0.05	100	0.021	548	348	304	0.78	32	0.014	578	378	433	0.97	32	0.014
637	337	415	0.10	100	0.021	549	349	344	0.72	32	0.014	579	379	279	0.65	32	0.014
694	394	549	0.14	100	0.021	550	350	344	0.71	32	0.014	580	380	279	0.54	32	0.014
522	322	583	1.10	32	0.014	551	351	196	0.40	32	0.014	581	381	279	0.61	32	0.014
523	323	602	1.38	32	0.014	552	352	402	0.99	32	0.014	582	382	279	0.59	32	0.014
524	324	602	1.26	32	0.014	553	353	461	1.24	32	0.014	583	383	279	0.55	32	0.014
525	325	602	1.38	32	0.014	554	354	357	0.80	32	0.014	584	384	279	0.67	32	0.014
526	326	602	1.26	32	0.014	555	355	357	0.82	32	0.014	585	385	279	0.62	32	0.014
527	327	643	1.47	32	0.014	556	356	357	0.69	32	0.014	586	386	279	0.59	32	0.014
528	328	382	1.02	32	0.014	557	357	357	0.78	32	0.014	587	387	279	0.58	32	0.014
529	329	408	0.92	32	0.014	558	358	357	0.75	32	0.014	588	388	279	0.69	32	0.014
530	330	408	0.94	32	0.014	559	359	357	0.70	32	0.014	589	389	279	0.75	32	0.014
531	331	194	0.41	32	0.014	560	360	357	0.84	32	0.014	632	332	213	0.05	100	0.021
533	333	194	0.44	32	0.014	561	361	357	0.81	32	0.014	634	334	269	0.07	100	0.021
536	336	347	0.67	32	0.014	562	362	357	0.74	32	0.014	635	335	387	0.08	100	0.021
622	322	583	0.15	100	0.021	563	363	357	0.74	32	0.014	666	366	349	0.09	100	0.021
623	323	602	0.15	100	0.021	564	364	357	0.87	32	0.014	667	367	349	0.09	100	0.021
624	324	602	0.15	100	0.021	565	365	357	0.97	32	0.014	668	368	349	0.09	100	0.021
625	325	602	0.15	100	0.021	598	398	374	0.44	32	0.014	669	369	349	0.09	100	0.021
626	326	602	0.15	100	0.021	599	399	464	0.36	32	0.014	670	370	349	0.09	100	0.021
627	327	643	0.16	100	0.021	638	338	461	0.12	100	0.021	671	371	349	0.09	100	0.021
628	328	382	0.10	100	0.021	639	339	250	0.06	100	0.021	672	372	349	0.09	100	0.021
629	329	408	0.10	100	0.021	640	340	402	0.10	100	0.021	673	373	349	0.09	100	0.021
630	330	408	0.10	100	0.021	641	341	344	0.09	100	0.021	674	374	349	0.09	100	0.021
631	331	194	0.05	100	0.021	642	342	344	0.09	100	0.021	675	375	349	0.09	100	0.021
633	333	194	0.05	100	0.021	643	343	252	0.06	100	0.021	676	376	349	0.09	100	0.021
636	336	347	0.09	100	0.021	644	344	344	0.09	100	0.021	677	377	349	0.09	100	0.021
505	305	385	0.89	32	0.014	645	345	344	0.09	100	0.021	678	378	433	0.11	100	0.021
506	306	616	1.24	32	0.014	646	346	402	0.10	100	0.021	679	379	279	0.07	100	0.021
507	307	869	2.15	32	0.014	647	347	402	0.10	100	0.021	680	380	279	0.07	100	0.021
508	308	431	1.10	32	0.014	648	348	304	0.08	100	0.021	681	381	279	0.07	100	0.021
509	309	326	0.73	32	0.014	649	349	344	0.09	100	0.021	682	382	279	0.07	100	0.021
511	311	314	0.67	32	0.014	650	350	344	0.09	100	0.021	683	383	279	0.07	100	0.021
512	312	293	0.66	32	0.014	651	351	196	0.05	100	0.021	684	384	279	0.07	100	0.021
513	313	263	0.60	32	0.014	652	352	402	0.10	100	0.021	685	385	279	0.07	100	0.021
514	314	320	0.76	32	0.014	653	353	461	0.12	100	0.021	686	386	279	0.07	100	0.021
515	315	92	0.72	32	0.014	654	354	357	0.09	100	0.021	687	387	279	0.07	100	0.021
516	316	244	0.56	32	0.014	655	355	357	0.09	100	0.021	688	388	279	0.07	100	0.021
517	317	284	0.61	32	0.014	656	356	357	0.09	100	0.021	689	389	279	0.07	100	0.021
518	318	266	0.51	32	0.014	657	357	357	0.09	100	0.021	690	390	563	0.22	100	0.021
592	392	250	0.50	32	0.014	658	358	357	0.09	100	0.021	691	391	227	0.14	100	0.021
593	393	236	0.47	32	0.014	659	359	357	0.09	100	0.021	6001	1	10000	0.34	100	1
605	305	385	0.10	100	0.021	660	360	357	0.09	100	0.021	6002	2	10000	0.34	100	1
606	306	616	0.16	100	0.021	661	361	357	0.09	100	0.021	6003	3	10000	0.34	100	1
607	307	869	0.22	100	0.021	662	362	357	0.09	100	0.021	6004	4	10000	0.34	100	1
608	308	431	0.11	100	0.021	663	363	357	0.09	100	0.021	6005	5	10000	0.34	100	1
609	309	326	0.08	100	0.021	664	364	357	0.09	100	0.021	6006	6	10000	0.34	100	1
611	311	314	0.08	100	0.021	665	365	357	0.09	100	0.021						

Table B-4. Swale Parameters, Pre-Existing

I.D.	Drains to	Width (ft)	Area (ac)	Slope	I.D.	Drains to	Width (ft)	Area (ac)	Slope
302	104	13	0.22	0.0017	347	127	13	0.09	0.0038
321	143	13	0.16	0.0028	348	347	13	0.05	0.0006
395	143	13	0.03	0.0046	349	128	13	0.09	0.0063
301	406	13	0.21	0.0014	350	129	13	0.09	0.0041
303	105	13	0.07	0.0044	351	397	13	0.05	0.0041
304	106	13	0.07	0.0045	352	130	13	0.09	0.0040
310	405	13	0.04	0.0038	353	149	13	0.14	0.0022
319	142	13	0.09	0.0036	354	147	13	0.10	0.0039
320	142	13	0.06	0.0036	355	121	13	0.10	0.0044
337	310	13	0.13	0.0009	356	122	13	0.10	0.0037
394	404	13	0.12	0.0029	357	123	13	0.10	0.0036
404	106	13	0.05	0.0022	358	124	13	0.10	0.0038
405	404	13	0.01	0.0064	359	125	13	0.10	0.0041
406	105	13	0.05	0.0024	360	126	13	0.10	0.0043
322	112	13	0.16	0.0002	361	127	13	0.10	0.0036
323	145	13	0.17	0.0015	362	128	13	0.10	0.0046
324	114	13	0.17	0.0019	363	129	13	0.10	0.0037
325	115	13	0.17	0.0026	364	130	13	0.10	0.0039
326	116	13	0.17	0.0025	365	149	13	0.10	0.0038
327	117	13	0.17	0.0023	396	120	13	0.16	0.0014
328	145	13	0.10	0.0024	397	120	13	0.03	0.0039
329	114	13	0.11	0.0021	398	155	13	0.03	0.0008
330	115	13	0.11	0.0027	399	156	13	0.10	0.0008
331	116	13	0.05	0.0039	332	118	13	0.05	0.0048
333	117	13	0.05	0.0026	334	119	13	0.07	0.0020
336	113	13	0.10	0.0032	335	119	13	0.07	0.0022
305	306	13	0.12	0.0008	366	131	13	0.09	0.0027
306	102	13	0.15	0.0017	367	132	13	0.09	0.0027
307	101	13	0.23	0.0019	368	133	13	0.09	0.0029
308	402	13	0.09	0.0039	369	134	13	0.09	0.0033
309	146	13	0.09	0.0030	370	135	13	0.09	0.0037
311	107	13	0.07	0.0007	371	136	13	0.09	0.0047
312	103	13	0.07	0.0029	372	137	13	0.09	0.0046
313	108	13	0.06	0.0050	373	138	13	0.09	0.0045
314	101	13	0.09	0.0038	374	139	13	0.09	0.0040
315	107	13	0.04	0.0038	375	140	13	0.09	0.0037
316	317	13	0.06	0.0010	376	141	13	0.09	0.0029
317	109	13	0.08	0.0014	377	150	13	0.09	0.0004
318	109	13	0.05	0.0040	378	131	13	0.15	0.0026
392	403	13	0.05	0.0027	379	132	13	0.08	0.0038
393	401	13	0.05	0.0010	380	133	13	0.07	0.0049
401	108	13	0.05	0.0055	381	134	13	0.07	0.0039
402	102	13	0.03	0.0061	382	135	13	0.07	0.0030
403	103	13	0.04	0.0017	383	136	13	0.07	0.0038
338	147	13	0.13	0.0025	384	137	13	0.08	0.0040
339	340	13	0.05	0.0027	385	138	13	0.08	0.0029
340	121	13	0.09	0.0044	386	139	13	0.07	0.0029
341	122	13	0.09	0.0046	387	140	13	0.07	0.0036
342	123	13	0.09	0.0063	388	141	13	0.08	0.0017
343	346	13	0.05	0.0040	389	150	13	0.11	0.0001
344	124	13	0.09	0.0062	390	148	13	0.10	0.0018
345	125	13	0.09	0.0051	391	148	13	0.06	0.0016
346	126	13	0.09	0.0039					

Table B-5. Additional Catchbasins

I.D.	Group	Elev. (ft MSL)	Elev. (ft MSL)	Depth (ft)	Area (ft ²)
701	A	6.67	2.67	0.67	6.14
702	A	7.19	3.19	0.15	6.14
703	A	7.59	3.59	0.00	6.14
704	A	7.59	3.59	0.00	6.14
705	A	7.87	3.87	0.00	6.14
706	A	8.02	4.02	0.00	6.14
722	A	7.23	3.23	0.11	6.14
723	A	7.22	3.22	0.12	6.14
144*	A	6.240	3.15	0.19	18
1441*	A	6.24	3.15	0.19	18
714	B	6.76	2.76	0.58	6.14
715	B	7.03	3.03	0.31	6.14
724	B	7.21	3.21	0.13	6.14
725	B	7.20	3.20	0.14	6.14
731	B	7.20	3.20	0.14	6.14
732	B	7.21	3.21	0.00	6.14
142*	B	6.13	3.09	0.25	18
1421*	B	6.13	3.09	0.25	18
709	C	7.16	3.16	0.00	6.14
710	C	7.17	3.17	0.17	6.14
711	C	7.61	3.61	0.00	6.14
712	C	7.09	3.09	0.25	6.14
713	C	7.19	3.19	0.00	6.14
716	C	6.89	2.89	0.45	6.14
717	C	7.00	3.00	0.00	6.14
718	C	7.00	3.00	0.34	6.14
719	C	7.10	3.10	0.00	6.14
720	C	6.90	2.90	0.44	6.14
721	C	7.00	3.00	0.00	6.14
1111*	C	6.45	2.50	0.84	18
1131*	C	6.45	2.50	0.84	18
726	D	6.75	2.75	0.59	6.14
727	D	6.92	2.92	0.00	6.14
728	D	7.19	3.19	0.15	6.14
729	D	6.48	2.48	0.00	6.14
730	D	6.47	2.47	0.87	6.14
109*	D	6.310	2.73	0.61	18
1091*	D	6.31	2.73	0.61	18
71*	G	6.30	0.93	2.41	18
1201*	G	6.41	1.91	1.43	18

*weir box

Table B-6. Exfiltration Trench Parameters

I.D.	Upstream Junction	Down Junction	Diameter (ft)	Length (ft)	Inlet ht (ft)	Outlet ht (ft)	n
801	701	104	1.25	43	0.85	0.62	0.013
802	702	144	1.25	120	0.52	0.80	0.013
803	703	143	1.25	151	0.63	0.72	0.013
804	704	703	1.25	42	1.00	0.58	0.013
805	705	703	1.25	356	0.88	0.69	0.013
806	706	705	1.25	43	0.33	0.85	0.013
822	722	723	1.25	45	0.00	0.00	0.013
823	722	104	1.25	164	0.00	0.00	0.013
2091*	1441	2	1.67	23	0.00	3.20	0.014
824	724	725	1.25	46	0.00	0.00	0.013
825	725	106	1.25	555	0.00	0.00	0.013
814	714	106	1.25	156	0.00	0.00	0.013
815	715	714	1.25	59	0.00	0.00	0.013
831	732	715	1.25	115	0.00	0.00	0.013
832	732	731	1.25	45	0.00	0.00	0.013
2391*	1421	1	2.00	91	0.00	2.18	0.011
809	709	710	1.25	46	0.00	0.00	0.013
810	710	145	1.25	352	0.00	0.00	0.013
811	711	710	1.25	60	0.00	0.00	0.013
812	712	711	1.25	261	0.00	0.00	0.013
813	713	712	1.25	44	0.00	0.00	0.013
816	716	112	1.25	282	0.00	0.00	0.013
817	717	716	1.25	40	0.00	0.00	0.013
818	718	114	1.25	327	0.00	0.00	0.013
819	719	718	1.25	38	0.00	0.00	0.013
820	720	116	1.25	327	0.00	0.00	0.013
821	721	720	1.25	42	0.00	0.00	0.013
2142*	113	1131	2.50	54	0.00	0.00	0.016
2141*	1111	111	2.50	54	0.00	0.00	0.016
826	726	727	1.25	54	0.00	0.00	0.013
827	727	102	1.25	372	0.00	0.00	0.013
828	728	729	1.25	47	0.00	0.00	0.013
829	729	730	1.25	65	0.00	0.00	0.013
830	730	103	1.25	158	0.00	0.00	0.013
2371	1091	5	2.50	89	0.00	2.28	0.016
2361*	6	1201	3.00	23	1.36	0.00	0.018
2541*	165	71	3.00	81	0.00	0.00	0.018

* storm sewers altered due to addition of weirs

Table B-7. Subwatershed Parameters, After Improvement

I.D.	Drains to	Width (ft)	Area (ac)	Imperv (%)	Slope	I.D.	Drains to	Width (ft)	Area (ac)	Imperv (%)	Slope	I.D.	Drains to	Width (ft)	Area (ac)	Imperv (%)	Slope
5012	3012	566	1.27	32	0.014	5292	3292	88	0.23	32	0.014	542	342	344	0.75	32	0.014
5022	3022	566	1.01	32	0.014	5351	3351	318	0.86	32	0.014	543	343	252	0.63	32	0.014
5011	3011	266	0.60	32	0.014	630	330	408	0.10	100	0.0206	544	344	344	0.71	32	0.014
5021	3021	350	0.63	32	0.014	631	331	194	0.05	100	0.0206	545	345	344	0.68	32	0.014
5211	3211	130	0.23	32	0.014	633	333	194	0.05	100	0.0206	546	346	402	0.96	32	0.014
5212	3212	325	0.57	32	0.014	636	336	347	0.09	100	0.0206	547	347	402	0.91	32	0.014
5213	3213	159	0.28	32	0.014	6221	3221	287	0.07	100	0.0206	548	348	304	0.78	32	0.014
5231	3231	178	0.59	32	0.014	6222	3222	306	0.08	100	0.0206	549	349	344	0.72	32	0.014
5251	3251	214	0.34	32	0.014	6232	3232	135	0.03	100	0.0206	550	350	344	0.71	32	0.014
595	395	139	0.25	32	0.014	6233	3233	327	0.08	100	0.0206	551	351	196	0.40	32	0.014
6012	3012	566	0.14	100	0.0206	6241	3241	187	0.05	100	0.0206	552	352	402	0.99	32	0.014
6022	3022	566	0.14	100	0.0206	6242	3242	327	0.08	100	0.0206	553	353	461	1.24	32	0.014
6011	3011	266	0.07	100	0.0206	6252	3252	208	0.05	100	0.0206	554	354	357	0.80	32	0.014
6021	3021	350	0.09	100	0.0206	6253	3253	327	0.08	100	0.0206	555	355	357	0.82	32	0.014
6211	3211	130	0.03	100	0.0206	6261	3261	208	0.05	100	0.0206	556	356	357	0.69	32	0.014
6212	3212	325	0.08	100	0.0206	6262	3262	327	0.08	100	0.0206	557	357	357	0.78	32	0.014
6213	3213	159	0.04	100	0.0206	6271	3271	331	0.08	100	0.0206	558	358	357	0.75	32	0.014
6231	3231	178	0.04	100	0.0206	6272	3272	327	0.08	100	0.0206	559	359	357	0.70	32	0.014
6251	3251	214	0.05	100	0.0206	6281	3281	228	0.06	100	0.0206	560	360	357	0.84	32	0.014
695	395	139	0.04	100	0.0206	6282	3282	174	0.04	100	0.0206	561	361	357	0.81	32	0.014
503	303	285	0.59	32	0.014	6291	3291	327	0.08	100	0.0206	562	362	357	0.74	32	0.014
504	304	285	0.69	32	0.014	6292	3292	88	0.02	100	0.0206	563	363	357	0.74	32	0.014
510	732	99	0.80	50	0.014	6351	3351	318	0.08	100	0.0206	564	364	357	0.87	32	0.014
519	319	374	0.75	32	0.014	509	309	326	0.73	32	0.014	565	365	357	0.97	32	0.014
520	320	206	0.41	32	0.014	511	311	314	0.67	32	0.014	598	398	374	0.44	32	0.014
537	337	415	0.92	32	0.014	515	315	177	0.67	50	0.014	599	399	464	0.36	32	0.014
5032	3032	238	0.50	32	0.014	516	316	244	0.56	32	0.014	638	338	461	0.12	100	0.0206
5033	3033	275	0.57	32	0.014	517	317	284	0.61	32	0.014	639	339	250	0.06	100	0.0206
5052	3052	275	0.68	32	0.014	518	318	266	0.51	32	0.014	640	340	402	0.10	100	0.0206
5941	3941	554	1.11	32	0.014	592	392	250	0.50	32	0.014	641	341	344	0.09	100	0.0206
603	303	285	0.07	100	0.0206	593	393	236	0.47	32	0.014	642	342	344	0.09	100	0.0206
604	304	285	0.07	100	0.0206	5051	3051	367	0.82	32	0.014	643	343	252	0.06	100	0.0206
610	732	99	0.03	100	0.0206	5062	3062	403	0.80	32	0.014	644	344	344	0.09	100	0.0206
619	319	374	0.09	100	0.0206	5071	3071	513	1.27	32	0.014	645	345	344	0.09	100	0.0206
620	320	206	0.05	100	0.0206	5072	3072	393	0.93	32	0.014	646	346	402	0.10	100	0.0206
637	337	415	0.10	100	0.0206	5081	3081	426	1.09	32	0.014	647	347	402	0.10	100	0.0206
6032	3032	238	0.06	100	0.0206	5141	3141	212	0.50	32	0.014	648	348	304	0.08	100	0.0206
6033	3033	275	0.07	100	0.0206	5142	3142	102	0.25	32	0.014	649	349	344	0.09	100	0.0206
6052	3052	275	0.07	100	0.0206	5161	3161	205	0.39	32	0.014	650	350	344	0.09	100	0.0206
6941	3941	554	0.14	100	0.0206	611	309	326	0.08	100	0.0206	651	351	196	0.05	100	0.0206
530	330	408	0.94	32	0.014	615	311	314	0.08	100	0.0206	652	352	402	0.10	100	0.0206
531	331	194	0.41	32	0.014	615	315	177	0.04	100	0.0206	653	353	461	0.12	100	0.0206
533	333	194	0.44	32	0.014	616	316	244	0.06	100	0.0206	654	354	357	0.09	100	0.0206
536	336	347	0.67	32	0.014	617	317	284	0.07	100	0.0206	655	355	357	0.09	100	0.0206
5221	3221	287	0.54	32	0.014	618	318	266	0.07	100	0.0206	656	356	357	0.09	100	0.0206
5222	3222	306	0.58	32	0.014	692	392	250	0.06	100	0.0206	657	357	357	0.09	100	0.0206
5232	3232	135	0.31	32	0.014	693	393	236	0.06	100	0.0206	658	358	357	0.09	100	0.0206
5233	3233	327	0.75	32	0.014	6051	3051	367	0.07	100	0.0206	659	359	357	0.09	100	0.0206
5241	3241	187	0.39	32	0.014	6062	3062	403	0.10	100	0.0206	660	360	357	0.09	100	0.0206
5242	3242	327	0.69	32	0.014	6071	3071	513	0.13	100	0.0206	661	361	357	0.09	100	0.0206
5252	3252	208	0.48	32	0.014	6072	3072	393	0.10	100	0.0206	662	362	357	0.09	100	0.0206
5253	3253	327	0.75	32	0.014	6081	3081	426	0.11	100	0.0206	663	363	357	0.09	100	0.0206
5261	3261	208	0.44	32	0.014	6141	3141	212	0.05	100	0.0206	664	364	357	0.09	100	0.0206
5262	3262	327	0.69	32	0.014	6142	3142	102	0.03	100	0.0206	665	365	357	0.09	100	0.0206
5271	3271	331	0.75	32	0.014	6161	3161	205	0.05	100	0.0206	696	396	561	0.40	100	0.0206
5272	3272	327	0.74	32	0.014	538	338	461	1.06	32	0.014	697	397	133	0.08	100	0.0206
5281	3281	228	0.52	32	0.014	539	339	250	0.63	32	0.014	698	398	374	0.09	100	0.0206
5282	3282	174	0.52	32	0.014	540	340	402	0.93	32	0.014	699	399	464	0.12	100	0.0206
5291	3291	327	0.70	32	0.014	541	341	344	0.66	32	0.014						

Table B-8. Swale Parameters, After Improvement

I.D.	Drains to	Width (ft)	Area (ac)	Imperv (%)	Slope	I.D.	Drains to	Width (ft)	Area (ac)	Imperv (%)	Slope
3012	701	15.0	0.19	50	0.0010	318	109	15.0	0.06	50	0.0040
3022	104	15.0	0.09	50	0.0033	392	730	15.0	0.06	50	0.0027
3011	723	15.0	0.09	50	0.0017	393	401	15.0	0.05	50	0.0010
3021	722	15.0	0.12	50	0.0010	3051	727	15.0	0.13	50	0.0002
3211	143	12.0	0.04	50	0.0022	3062	102	15.0	0.14	50	0.0020
3212	703	14.3	0.11	50	0.0017	3071	726	15.0	0.15	50	0.0019
3213	705	15.0	0.04	50	0.0016	3072	101	15.0	0.14	50	0.0017
3231	704	15.0	0.06	50	0.0006	3081	402	15.0	0.13	50	0.0030
3251	706	12.3	0.06	50	0.0037	3141	101	14.0	0.07	50	0.0052
395	143	12.5	0.04	50	0.0046	3142	728	15.0	0.04	50	0.0006
303	105	15.0	0.08	50	0.0044	3161	729	13.4	0.07	50	0.0018
304	106	15.0	0.08	50	0.0045	401	108	5.4	0.02	0	0.0061
319	142	15.0	0.11	50	0.0036	402	102	14.2	0.04	0	0.0017
320	142	14.1	0.06	50	0.0036	338	147	15.0	0.15	50	0.0025
337	715	13.0	0.14	50	0.0155	339	340	15.0	0.06	50	0.0027
3032	724	15.0	0.08	50	0.0008	340	121	15.0	0.11	50	0.0044
3033	724	15.0	0.09	50	0.0003	341	122	15.0	0.10	50	0.0046
3052	725	15.0	0.09	50	0.0007	342	123	15.0	0.10	50	0.0063
3941	714	15.0	0.19	50	0.0022	343	346	15.0	0.06	50	0.0040
330	115	15.0	0.13	50	0.0027	344	124	15.0	0.10	50	0.0062
331	116	14.1	0.06	50	0.0039	345	125	15.0	0.10	50	0.0051
333	117	15.0	0.06	50	0.0026	346	126	11.2	0.08	50	0.0039
336	113	15.0	0.12	50	0.0032	347	127	15.0	0.11	50	0.0038
3221	716	15.0	0.10	50	0.0003	348	347	15.0	0.06	50	0.0006
3222	112	15.0	0.11	50	0.0001	349	128	15.0	0.10	50	0.0063
3232	717	15.0	0.04	50	0.0014	350	129	15.0	0.10	50	0.0041
3233	145	15.0	0.11	50	0.0024	351	397	13.8	0.05	50	0.0041
3241	718	13.4	0.06	50	0.0024	352	130	15.0	0.11	50	0.0040
3242	114	15.0	0.11	50	0.0020	353	149	15.0	0.16	50	0.0022
3252	719	15.0	0.07	50	0.0024	354	147	15.0	0.11	50	0.0039
3253	115	15.0	0.11	50	0.0024	355	121	15.0	0.11	50	0.0044
3261	720	13.7	0.07	50	0.0034	356	122	15.0	0.11	50	0.0037
3262	116	15.0	0.11	50	0.0017	357	123	15.0	0.11	50	0.0036
3271	721	15.0	0.10	50	0.0023	358	124	15.0	0.11	50	0.0038
3272	117	15.0	0.11	50	0.0020	359	125	15.0	0.11	50	0.0041
3281	145	15.0	0.07	50	0.0040	360	126	15.0	0.11	50	0.0043
3282	710	15.0	0.05	50	0.0002	361	127	15.0	0.11	50	0.0036
3291	114	15.0	0.11	50	0.0020	362	128	15.0	0.11	50	0.0046
3292	713	13.2	0.03	50	0.0016	363	129	15.0	0.11	50	0.0037
3351	712	15.0	0.06	50	0.0029	364	130	15.0	0.11	50	0.0039
309	146	15.0	0.11	50	0.0030	365	149	15.0	0.11	50	0.0038
311	107	15.0	0.08	50	0.0007	396	120	14.3	0.17	50	0.0014
315	107	15.0	0.06	50	0.0045	397	120	14.4	0.04	50	0.0039
316	317	15.0	0.07	50	0.0010	398	155	15.0	0.04	50	0.0008
317	109	15.0	0.09	50	0.0014	399	156	13.6	0.10	50	0.0008

APPENDIX C

Monitoring Data

Table C-1. Flow Calculations, 9/17/03 Storm Event

Time (pm)	Culvert		Velocity	Velocity	Velocity	Velocity	K	Flow Rate ft3/sec
	Duration (min)	Depth (ft)	0.2d (ft/sec)	0.4d (ft/sec)	0.8d (ft/sec)	Avg (ft/sec)		
12:25	3	2.58	0.09	0.04	0.04	0.05	0.72	0.34
12:35	13	2.58	0.03	0.04	0.05	0.04	0.72	0.26
12:45	23	2.75	0.02	0.01	0.01	0.01	0.75	0.08
12:55	33	2.75	0.03	0.01	0.01	0.02	0.75	0.10
1:05	43	2.75	0.02	0.02	0.01	0.02	0.75	0.12

Table C-2. Flow Calculations, 9/27/03 Storm Event

Time (pm)	Duration (min)	Culvert		Velocity	Velocity	Velocity	Velocity	K	Flow Rate ft3/sec
		Depth (ft)	0.2 (ft/sec)	0.4 (ft/sec)	0.8 (ft/sec)	Avg (ft/sec)			
4:12	2	2.41	0.00	0.00	0.00	0.00	0.67	0.00	
4:15	5	2.41	0.11	0.13	0.04	0.10	0.67	0.62	
4:20	10	2.52	0.15	0.19	0.14	0.17	0.70	1.06	
4:25	15	2.52	0.14	0.19	0.15	0.17	0.70	1.06	
4:30	20	2.58	0.16	0.16	0.20	0.17	0.72	1.10	
4:35	25	2.67	0.12	0.16	0.17	0.15	0.74	1.01	
4:40	30	2.74	0.10	0.10	0.08	0.10	0.75	0.64	
4:45	35	2.83	0.07	0.09	0.02	0.07	0.77	0.47	
4:50	40	2.96	0.05	0.07	0.00	0.05	0.78	0.34	
4:55	45	3.00	0.00	0.01	-0.01	0.00	0.79	0.02	
5:00	50	3.00	-0.05	-0.06	-0.05	-0.06	0.79	-0.39	
5:05	55	3.00	-0.01	-0.03	-0.01	-0.02	0.79	-0.14	
5:10	60	3.00	-0.06	-0.03	-0.05	-0.04	0.79	-0.30	
5:15	65	3.00	-0.01	-0.02	0.00	-0.01	0.79	-0.09	
5:20	70	3.00	0.02	0.04	0.03	0.03	0.79	0.23	

Table C-3. Flow Calculations, 11/02/03 Storm Event

Time (pm)	Duration (min)	Culvert Depth (ft)	Velocity				K	Flow Rate ft ³ /sec
			0.2 (ft/sec)	0.4 (ft/sec)	0.8 (ft/sec)	Avg (ft/sec)		
7:52	0	2.58	0.02	0.05	0.04	0.06	0.72	0.36
7:57	5	2.58	0.05	0.05	0.10	0.15	0.72	0.94
8:02	10	2.58	0.30	0.34	0.43	0.26	0.72	1.68
8:07	15	2.58	0.04	0.03	0.06	0.06	0.72	0.36
8:12	20	2.58	0.09	0.10	0.12	0.10	0.72	0.66
8:17	25	2.58	0.06	0.09	0.12	0.10	0.72	0.63
8:22	30	2.58	0.11	0.13	0.15	0.10	0.72	0.66
8:27	35	2.58	0.04	0.05	0.04	0.05	0.72	0.31
8:32	40	2.58	0.04	0.05	0.05	0.04	0.72	0.23

Table C-4. Flow Calculations, 11/04/03 Storm Event

Time (pm)	Duration (min)	Culvert Depth (ft)	Velocity				K	Flow Rate ft ³ /sec
			0.2 (ft/sec)	0.4 (ft/sec)	0.8 (ft/sec)	Avg (ft/sec)		
1:23	0	2.75	-0.05	-0.04	-0.03	-0.04	0.75	-0.24
1:28	5	2.75	-0.04	-0.02	-0.01	-0.01	0.75	-0.05
1:33	10	2.75	0.04	0.04	0.05	0.03	0.75	0.20
1:38	15	2.75	-0.04	0.00	0.00	0.01	0.75	0.07
1:43	20	2.75	0.06	0.05	0.08	0.05	0.75	0.34
1:48	25	2.75	0.03	0.02	0.04	0.02	0.75	0.15
1:53	30	2.75	0.03	0.02	0.02	0.03	0.75	0.17
1:58	35	2.75	0.01	0.02	0.03	0.02	0.75	0.14
2:03	40	2.75	0.02	0.03	0.03	0.03	0.75	0.17
2:08	45	2.75	0.00	0.01	0.02	0.02	0.75	0.14
2:13	50	2.75	0.04	0.05	0.06	0.04	0.75	0.29
2:18	55	2.75	0.03	0.03	0.03	0.04	0.75	0.24
2:23	60	2.75	0.05	0.05	0.05	0.04	0.75	0.25

Table C-5. Flow Calculations, 11/05/03 Storm Event

Time (pm)	Duration (min)	Culvert Depth (ft)	Velocity				K	Flow Rate ft ³ /sec
			0.2 (ft/sec)	0.4 (ft/sec)	0.8 (ft/sec)	Avg (ft/sec)		
2:04	0	0.09	0.03	0.04	0.06	0.04	0.77	0.42
2:14	10	0.09	0.00	0.00	0.00	0.00	0.77	0.00
2:19	15	0.10	-0.03	0.02	0.04	0.01	0.77	0.28
2:24	20	0.10	0.01	0.04	0.04	0.03	0.78	0.28
2:29	25	0.10	0.02	0.02	0.05	0.03	0.77	0.35
2:34	30	0.11	-0.02	0.00	0.01	0.00	0.77	0.07
2:39	35	0.11	-0.02	0.01	0.02	0.01	0.77	0.14
2:44	40	0.11	0.02	0.04	0.05	0.04	0.77	0.35
2:49	45	0.12	0.00	0.00	0.01	0.00	0.77	0.07

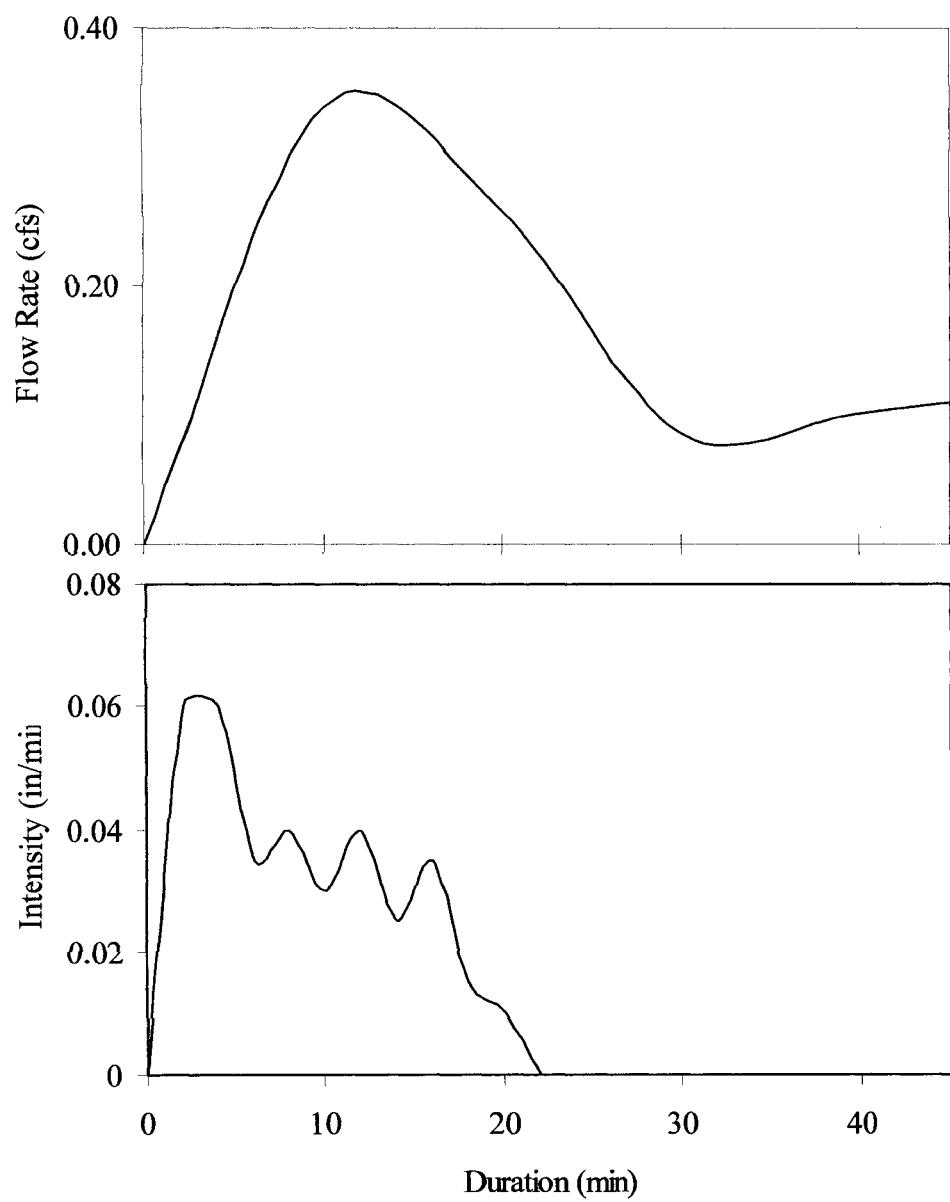


Figure C-1. Hydrograph and hyetograph from 9/17/03 storm event

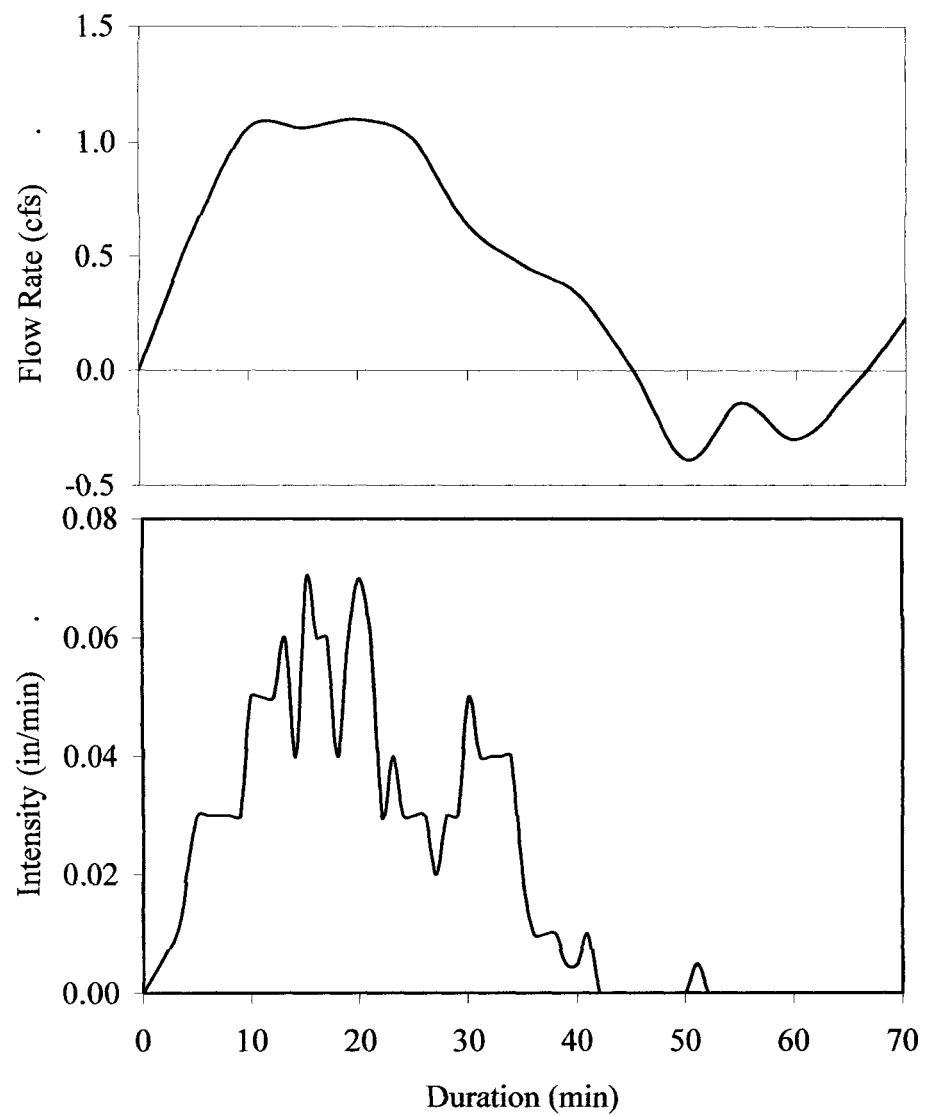


Figure C-2. Hydrograph and hyetograph from 9/27/03 storm event

Table C-6. Total Phosphorous Concentrations

Site	Date Collected	Time	Weather	Concentration (ppb)	Site	Date Collected	Time	Weather	Concentration (ppb)
7	9/6/02	5:10 PM	Rain	27	7	9/27/03	4:45 PM	Rain	54
7	9/6/03	5:10 PM	Rain	28	7	9/27/03	4:55 PM	Rain	43
7	9/6/03	5:10 PM	Rain	20	7	9/27/03	4:55 PM	Rain	30
7	9/6/03	5:20 PM	Rain	36	7	9/27/03	4:55 PM	Rain	25
7	9/6/03	5:20 PM	Rain	55	7	9/27/03	5:05 PM	Rain	18
7	9/6/03	5:20 PM	Rain	23	7	9/27/03	5:05 PM	Rain	25
7	9/6/03	5:30 PM	Rain	40	7	9/27/03	5:20 PM	Rain	32
7	9/6/03	5:30 PM	Rain	26	110	9/28/03		Rain	168
7	9/6/03	5:30 PM	Rain	34	110	9/28/03		Rain	541
110	9/6/03	5:50 PM	Rain	20	110	9/28/03		Rain	499
110	9/6/03	5:50 PM	Rain	20	119	9/28/03		Rain	747
110	9/6/03	5:50 PM	Rain	22	119	9/28/03		Rain	687
116	9/7/03	3:00 PM	Rain	189	119	9/28/03		Rain	923
116	9/7/03	3:00 PM	Rain	96	7	9/29/03	11:46 AM	Rain	30
116	9/7/03	3:00 PM	Rain	175	7	9/29/03	11:46 AM	Rain	34
7	9/17/03	12:35 PM	Rain	20	7	9/29/03	11:46 AM	Rain	31
7	9/17/03	12:45 PM	Rain	31	4	9/29/03	12:40 PM	Rain	184
7	9/17/03	12:45 PM	Rain	22	4	9/29/03	12:40 PM	Rain	201
7	9/17/03	12:45 PM	Rain	21	4	9/29/03	12:40 PM	Rain	437
7	9/17/03	12:55 PM	Rain	20	6	9/29/03	1:02 PM	Rain	34
7	9/17/03	12:55 PM	Rain	23	6	9/29/03	1:02 PM	Rain	27
6	9/26/03		Dry	27	6	9/29/03	1:02 PM	Rain	43
6	9/26/03		Dry	23	2	9/29/03	1:10 PM	Rain	57
6	9/26/03		Dry	22	2	9/29/03	1:10 PM	Rain	50
4	9/26/03		Dry	36	2	9/29/03	1:10 PM	Rain	19
4	9/26/03		Dry	26	116	9/29/03	1:06 PM	Rain	60
4	9/26/03		Dry	50	116	9/29/03	1:06 PM	Rain	48
2	9/26/03		Dry	37	116	9/29/03	1:06 PM	Rain	61
2	9/26/03		Dry	20	119	9/29/03	12:47 PM	Rain	928
2	9/26/03		Dry	23	119	9/29/03	12:47 PM	Rain	1044
7	9/26/03		Dry	27	119	9/29/03	12:47 PM	Rain	1401
7	9/26/03		Dry	85	110	9/29/03	1:00 PM	Rain	2242
7	9/26/03		Dry	22	110	9/29/03	1:00 PM	Rain	2334
7	9/27/03	4:15 PM	Rain	12	110	9/29/03	1:00 PM	Rain	2438
7	9/27/03	4:15 PM	Rain	23	7	11/2/03	7:52 PM	Rain	42
7	9/27/03	4:15 PM	Rain	0	7	11/2/03	7:52 PM	Rain	29
7	9/27/03	4:20 PM	Rain	13	7	11/2/03	7:52 PM	Rain	30
7	9/27/03	4:20 PM	Rain	12	7	11/2/03	7:57 PM	Rain	31
7	9/27/03	4:25 PM	Rain	8	7	11/2/03	7:57 PM	Rain	37
7	9/27/03	4:25 PM	Rain	3	7	11/2/03	8:02 PM	Rain	28
7	9/27/03	4:30 PM	Rain	17	7	11/2/03	8:02 PM	Rain	26
7	9/27/03	4:30 PM	Rain	30	7	11/2/03	8:02 PM	Rain	28
7	9/27/03	4:35 PM	Rain	16	7	11/2/03	8:07 PM	Rain	29
7	9/27/03	4:35 PM	Rain	3	7	11/2/03	8:07 PM	Rain	31
7	9/27/03	4:35 PM	Rain	3	7	11/2/03	8:07 PM	Rain	26
7	9/27/03	4:40 PM	Rain	22	7	11/2/03	8:12 PM	Rain	28
7	9/27/03	4:40 PM	Rain	44	7	11/2/03	8:12 PM	Rain	36
7	9/27/03	4:40 PM	Rain	11	7	11/21/03	3:44 PM	Rain	34
7	9/27/03	4:45 PM	Rain	38	7	11/21/03	3:44 PM	Rain	41
7	9/27/03	4:45 PM	Rain	26	7	11/21/03	3:44 PM	Rain	42

APPENDIX D

Example SWMM Input File

```

* EXAMPLE SWMM INPUT FILE FOR 9-17-03 STORM EVENT
*
* Built 5-18-04
* Group A swale type b
=====
*File set up
* NBLOCK JIN(1) JOUT(1) JIN(2) JOUT(2)
SW 2 0 9 9 0
=====
* NITCH NSCRAT(1) NSCRAT(2) NSCRAT(3) NSCRAT(4) NSCRAT(5) NSCRAT(6) NSCRAT(7)
MM 8 1 2 3 10 11 12 13
* NSCRAT(8)
14
=====
* creates interface file that will be used by extran block
@ 9 'RUNOFF.DNT'
=====
* Begin Runoff Block
*
$RUNOFF Call the RUNOFF block with a '$' in first column.
=====
*Title
A1 'RUNOFF DATA Group N catchment, RAIN DATA FROM 9/17/03 yr storm'
A1 'Swale type b'
=====
* METRIC ISNOW NRGAG INFILM KWALTY IVAP NHR NMN NDAY MONTH IYRSTR
B1 0 0 2 1 0 0 0 0 27 9 2003
=====
* IPRN(1) IPRN(2) IPRN(3) IRPNWG
B2 0 0 1
=====
* WET WET/DRY DRY LUNIT LONG
B3 3. 3.0 5. 2 2
=====
* ROPT
D1 0
=====
*Rain input for 9/17/03 storm event
* KTYPE KINC KPRINT KTHIS KTIME KPREP NHISTO THISTO TZRAIN
E1 1 1 0 0 0 1 13 2.0 0.
=====
* RAIN DATA FROM 9/17/03
* REIN(1) REIN(2)
E1 0 0
E1 2 0.12
E1 4 0.12
E1 6 0.07
E1 8 0.08
E1 10 0.06
E1 12 0.08
E1 14 0.05
E1 16 0.07
E1 18 0.03
E1 20 0.02
E1 22 0
=====
*Used for zero rain input into swale subcatchments
E1 0 0
E1 2 0
E1 4 0
E1 6 0
E1 8 0
E1 10 0
E1 12 0
E1 14 0
E1 16 0
E1 18 0
E1 20 0
E1 22 0

```

*Swale Data																		
*	Gage	I.D.	Drains	Width	Area	%imp	Slope	n	n	TDS	PDS	Suct	Hyd	Sat	Max	Flow	Path	
*			to					imp	perv				Con		Inf			
***	Group A	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	
H1	2	302	104	4.7	0.08	50	0.0017	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	321	143	4.7	0.06	50	0.0028	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	395	143	4.7	0.01	50	0.0046	0.011	0.35	0.5	0	4	13	0.34	0	1		
***	Group B	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	
H1	2	301	406	4.7	0.08	50	0.0014	0.011	0.35	0.5	0	4	13	0.34	0	4		
H1	2	303	105	4.7	0.02	50	0.0044	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	304	106	4.7	0.02	50	0.0045	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	310	405	4.7	0.01	50	0.0038	0.011	0.35	2	2	4	13	0.34	0	4		
H1	2	319	142	4.7	0.03	50	0.0036	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	320	142	4.7	0.02	50	0.0036	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	337	310	4.7	0.05	50	0.0009	0.011	0.35	0.5	0	4	13	0.34	0	4		
H1	2	394	404	4.7	0.05	50	0.0029	0.011	0.35	0.5	0	4	13	0.34	0	4		
H1	2	404	106	4.7	0.02	0	0.0022	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	405	404	4.7	0.01	100	0.0064	0.011	0.35	2	0	4	13	0.34	0	4		
H1	2	406	105	4.7	0.02	0	0.0024	0.011	0.35	0.5	0	4	13	0.34	0	1		
***	Group C	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	
H1	2	322	112	4.7	0.06	50	0.0002	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	323	145	4.7	0.06	50	0.0015	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	324	114	4.7	0.06	50	0.0019	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	325	115	4.7	0.06	50	0.0026	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	326	116	4.7	0.06	50	0.0025	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	327	117	4.7	0.06	50	0.0023	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	328	145	4.7	0.04	50	0.0024	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	329	114	4.7	0.04	50	0.0021	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	330	115	4.7	0.04	50	0.0027	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	331	116	4.7	0.02	50	0.0039	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	333	117	4.7	0.02	50	0.0026	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	336	113	4.7	0.04	50	0.0032	0.011	0.35	0.5	0	4	13	0.34	0	1		
***	Group D	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	
H1	2	305	306	4.7	0.04	50	0.0008	0.011	0.35	0.5	0	4	13	0.34	0	4		
H1	2	306	102	4.7	0.06	50	0.0017	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	307	101	4.7	0.08	50	0.0019	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	308	402	4.7	0.03	50	0.0039	0.011	0.35	0.5	0	4	13	0.34	0	4		
H1	2	309	146	4.7	0.03	50	0.0030	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	311	107	4.7	0.03	50	0.0007	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	312	103	4.7	0.02	50	0.0029	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	313	108	4.7	0.02	50	0.0050	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	314	101	4.7	0.03	50	0.0038	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	315	107	4.7	0.01	0	0.0038	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	316	317	4.7	0.02	50	0.0010	0.011	0.35	0.5	0	4	13	0.34	0	4		
H1	2	317	109	4.7	0.03	50	0.0014	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	318	109	4.7	0.02	50	0.0040	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	392	403	4.7	0.02	50	0.0027	0.011	0.35	0.5	0	4	13	0.34	0	4		
H1	2	393	401	4.7	0.02	50	0.0010	0.011	0.35	0.5	0	4	13	0.34	0	4		
H1	2	401	108	4.7	0.02	0	0.0055	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	402	102	4.7	0.01	0	0.0061	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	403	103	4.7	0.01	0	0.0017	0.011	0.35	0.5	0	4	13	0.34	0	1		
***	Group EFG	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	
H1	2	338	147	4.7	0.05	50	0.0025	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	339	340	4.7	0.02	50	0.0027	0.011	0.35	0.5	0	4	13	0.34	0	4		
H1	2	340	121	4.7	0.03	50	0.0044	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	341	122	4.7	0.03	50	0.0046	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	342	123	4.7	0.03	50	0.0063	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	343	346	4.7	0.02	50	0.0040	0.011	0.35	0.5	0	4	13	0.34	0	4		
H1	2	344	124	4.7	0.03	50	0.0062	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	345	125	4.7	0.03	50	0.0051	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	346	126	4.7	0.03	50	0.0039	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	347	127	4.7	0.03	50	0.0038	0.011	0.35	0.5	0	4	13	0.34	0	1		
H1	2	348	347	4.7	0.02	50	0.0006	0.011	0.35	0.5	0	4	13	0.34	0	4		

H1	2	349	128	4.7	0.03	50	0.0063	0.011	0.35	0.5	0	4	13	0.34	0	1
H1	2	350	129	4.7	0.03	50	0.0041	0.011	0.35	0.5	0	4	13	0.34	0	1
H1	2	351	397	4.7	0.02	50	0.0041	0.011	0.35	0.5	0	4	13	0.34	0	4
H1	2	352	130	4.7	0.03	50	0.0040	0.011	0.35	0.5	0	4	13	0.34	0	1
H1	2	353	149	4.7	0.05	50	0.0022	0.011	0.35	0.5	0	4	13	0.34	0	1
H1	2	354	147	4.7	0.04	50	0.0039	0.011	0.35	0.5	0	4	13	0.34	0	1
H1	2	355	121	4.7	0.04	50	0.0044	0.011	0.35	0.5	0	4	13	0.34	0	1
H1	2	356	122	4.7	0.04	50	0.0037	0.011	0.35	0.5	0	4	13	0.34	0	1
H1	2	357	123	4.7	0.04	50	0.0036	0.011	0.35	0.5	0	4	13	0.34	0	1
H1	2	358	124	4.7	0.04	50	0.0038	0.011	0.35	0.5	0	4	13	0.34	0	1
H1	2	359	125	4.7	0.04	50	0.0041	0.011	0.35	0.5	0	4	13	0.34	0	1
H1	2	360	126	4.7	0.04	50	0.0043	0.011	0.35	0.5	0	4	13	0.34	0	1
H1	2	361	127	4.7	0.04	50	0.0036	0.011	0.35	0.5	0	4	13	0.34	0	1
H1	2	362	128	4.7	0.04	50	0.0046	0.011	0.35	0.5	0	4	13	0.34	0	1
H1	2	363	129	4.7	0.04	50	0.0037	0.011	0.35	0.5	0	4	13	0.34	0	1
H1	2	364	130	4.7	0.04	50	0.0039	0.011	0.35	0.5	0	4	13	0.34	0	1
H1	2	365	149	4.7	0.04	50	0.0038	0.011	0.35	0.5	0	4	13	0.34	0	1
H1	2	396	120	4.7	0.06	50	0.0014	0.011	0.35	0.5	0	4	13	0.34	0	1
H1	2	397	120	4.7	0.01	50	0.0039	0.011	0.35	0.5	0	4	13	0.34	0	1
H1	2	398	155	4.7	0.01	50	0.0008	0.011	0.35	0.5	0	4	13	0.34	0	1
H1	2	399	156	4.7	0.04	50	0.0008	0.011	0.35	0.5	0	4	13	0.34	0	1
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*Subwatershed Data																
*	Gage	I.D.	Drains	Width	Area	%imp	Slope	n imp	n perv	IDS	PDS	Suct	Hyd Con	Sat	Max Inf	Flow Path
*			to													
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*A*****																
***	Yards	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
H1	1	502	302	892	1.61	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	521	321	599	1.06	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	595	395	139	0.24	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
***	Roads	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
H1	1	602	302	892	0.23	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	621	321	599	0.15	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	695	395	139	0.04	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
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*B*****																
***	Yards	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
H1	1	501	301	810	1.79	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	503	303	285	0.59	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	504	304	285	0.69	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	510	310	92	0.73	32	0.014	0.011	0.35	0	0	4	13	0.34	0	5
H1	1	519	319	374	0.75	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	520	320	206	0.41	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	537	337	415	0.92	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	594	394	549	1.14	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
***	Roads	***	***	***	***	***	*****	***	***	***	***	***	***	***	***	***
H1	1	601	301	810	0.20	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	603	303	285	0.07	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	604	304	285	0.07	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	610	310	92	0.02	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	619	319	374	0.09	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	620	320	206	0.05	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	637	337	415	0.10	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	694	394	549	0.14	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
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*C*****																
***	Yards	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
H1	1	522	322	583	1.10	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	523	323	602	1.38	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	524	324	602	1.26	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	525	325	602	1.38	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	526	326	602	1.26	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	527	327	643	1.47	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	528	328	382	1.02	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	529	329	408	0.92	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3

H1	1	530	330	408	0.94	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	531	331	194	0.41	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	533	333	194	0.44	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	536	336	347	0.67	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
***	Roads	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
H1	1	622	322	583	0.15	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	623	323	602	0.15	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	624	324	602	0.15	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	625	325	602	0.15	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	626	326	602	0.15	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	627	327	643	0.16	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	628	328	382	0.10	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	629	329	408	0.10	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	630	330	408	0.10	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	631	331	194	0.05	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	633	333	194	0.05	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	636	336	347	0.09	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
*D*****	Yards	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
H1	1	505	305	385	0.89	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	506	306	616	1.24	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	507	307	869	2.15	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	508	308	431	1.10	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	509	309	326	0.73	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	511	311	314	0.67	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	512	312	293	0.66	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	513	313	263	0.60	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	514	314	320	0.76	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	515	315	92	0.72	32	0.014	0.011	0.35	0	0	4	13	0.34	0	5
H1	1	516	316	244	0.56	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	517	317	284	0.61	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	518	318	266	0.51	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	592	392	250	0.50	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	593	393	236	0.47	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
***	Roads	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
H1	1	605	305	385	0.10	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	606	306	616	0.16	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	607	307	869	0.22	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	608	308	431	0.11	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	609	309	326	0.08	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	611	311	314	0.08	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	612	312	293	0.07	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	613	313	263	0.07	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	614	314	320	0.08	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	615	315	92	0.02	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	5
H1	1	616	316	244	0.06	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	617	317	284	0.07	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	618	318	266	0.07	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	692	392	250	0.06	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	693	393	236	0.06	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
*EFG*****	Lake	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
H1	1	6001	1	10000	0.34	100	1	0.001	0.3	0	0	4	13	0.34	0	0
H1	1	6002	2	10000	0.34	100	1	0.001	0.3	0	0	4	13	0.34	0	0
H1	1	6003	3	10000	0.34	100	1	0.001	0.3	0	0	4	13	0.34	0	0
H1	1	6004	4	10000	0.34	100	1	0.001	0.3	0	0	4	13	0.34	0	0
H1	1	6005	5	10000	0.34	100	1	0.001	0.3	0	0	4	13	0.34	0	0
H1	1	6006	6	10000	0.34	100	1	0.001	0.3	0	0	4	13	0.34	0	0
***	Yard	***	***	***	***	***	***	***	***	***	***	***	13	***	***	***
H1	1	538	338	461	1.06	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	539	339	250	0.63	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	540	340	402	0.93	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	541	341	344	0.66	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3

H1	1	542	342	344	0.75	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	543	343	252	0.63	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	544	344	344	0.71	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	545	345	344	0.68	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	546	346	402	0.96	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	547	347	402	0.91	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	548	348	304	0.78	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	549	349	344	0.72	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	550	350	344	0.71	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	551	351	196	0.40	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	552	352	402	0.99	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	553	353	461	1.24	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	554	354	357	0.80	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	555	355	357	0.82	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	556	356	357	0.69	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	557	357	357	0.78	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	558	358	357	0.75	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	559	359	357	0.70	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	560	360	357	0.84	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	561	361	357	0.81	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	562	362	357	0.74	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	563	363	357	0.74	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	564	364	357	0.87	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	565	365	357	0.97	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	598	398	374	0.44	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	599	399	464	0.36	32	0.014	0.011	0.35	0	0	4	13	0.34	0	3
***	Roads	***	***	***	***	***	***	***	***	***	***	***	13	***	***	***
H1	1	638	338	461	0.12	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	639	339	250	0.06	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	640	340	402	0.10	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	641	341	344	0.09	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	642	342	344	0.09	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	643	343	252	0.06	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	644	344	344	0.09	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	645	345	344	0.09	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	646	346	402	0.10	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	647	347	402	0.10	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	648	348	304	0.08	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	649	349	344	0.09	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	650	350	344	0.09	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	651	351	196	0.05	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	652	352	402	0.10	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	653	353	461	0.12	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	654	354	357	0.09	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	655	355	357	0.09	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	656	356	357	0.09	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	657	357	357	0.09	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	658	358	357	0.09	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	659	359	357	0.09	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	660	360	357	0.09	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	661	361	357	0.09	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	662	362	357	0.09	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	663	363	357	0.09	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	664	364	357	0.09	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	665	365	357	0.09	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	696	396	561	0.40	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	697	397	133	0.08	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	698	398	374	0.09	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3
H1	1	699	399	464	0.12	100	0.0206	0.011	0.35	0	0	4	13	0.34	0	3

*Print Control
 * NPRNT INTERV
 M1 0 0

```

=====
*      <<<<< SWMM 4.4H EXTRAN DATA FILE >>>>>
*
$EXTRAN      Call the Extran Block with a '$' in first column.
=====
A1 'NORTH BASIN RUN'
A1 'INITIAL CONDITIONS CORRISOND TO 3.36FT GWT'
=====
*Time Step Assignment
* NTCYC      DELT  TZERO      NSTART     INTER    JINTER    JREDO    IDATZ
* 30 hr run - 30 min records
B1 108000      1.0      0      0      0      1800      0      20030927
=====
* METRIC NEQUAL AMEN ITMAX SURTOL
B2 0      0      0.0      30      0.05
=====
*Print Comands
*      NHPRNT NQPRNT      NPLT      LPLT NJSW
B3 0      1      1      1      0
=====
* JPRT1 JPRT2 etc.
B4 7
* CPRT1 CPRT2 etc.
B5 254
* JPLT1 JPLT2 etc.
B6 7
* KPLT1 KPLT2 etc.
B7 254
=====
* JHEAD JP10 IWLEN
BA 1      0      2
=====
*Conduit Data
*      ID      Upstn      Down      QO      Type      na      Diam      Width      LEN      ZP1      ZP2      ROUGH      Left      Right
*A*****
C1 207      104      143      0      1      0      1.33      0      175      0.00      0.00      0.012      0      0
C1 208      143      144      0      1      0      1.67      0      46      0.00      0.00      0.014      0      0
C1 209      144      2      0      1      0      1.67      0      23      0.00      3.20      0.014      0      0
*B*****
C1 210      105      106      0      1      0      1.50      0      46      0.00      0.58      0.013      0      0
C1 211      106      142      0      1      0      2.00      0      46      0.00      0.08      0.015      0      0
C1 239      142      1      0      1      0      2.00      0      91      0.00      2.18      0.011      0      0
*C*****
C1 212      4      110      0      1      0      2.50      0      23      2.28      0.17      0.016      0      0
C1 213      110      111      0      1      0      2.50      0      46      0.00      0.00      0.016      0      0
C1 214      113      111      0      1      0      2.50      0      108      0.00      0.08      0.016      0      0
C1 215      112      113      0      1      0      1.00      0      46      0.00      1.08      0.011      0      0
C1 216      145      113      0      1      0      2.50      0      64.5      0.00      0.00      0.016      0      0
C1 217      114      145      0      1      0      2.00      0      180      0.00      0.92      0.015      0      0
C1 218      115      114      0      1      0      2.00      0      46      0.00      1.00      0.015      0      0
C1 219      116      115      0      1      0      1.50      0      180      0.08      1.00      0.013      0      0
C1 220      117      116      0      1      0      1.33      0      46      0.00      0.00      0.012      0      0
C1 238      111      3      0      1      0      2.50      0      23      0.00      1.75      0.016      0      0
*D*****
C1 201      101      102      0      1      0      1.50      0      46      0.00      0.00      0.013      0      0
C1 202      103      102      0      1      0      1.33      0      46      0.00      0.83      0.012      0      0
C1 203      102      146      0      1      0      2.00      0      292      0.25      0.08      0.015      0      0
C1 204      146      107      0      1      0      2.00      0      270      0.00      0.00      0.015      0      0
C1 205      108      107      0      1      0      2.00      0      54      0.00      0.00      0.015      0      0
C1 206      107      109      0      1      0      2.50      0      60.3      0.00      0.00      0.016      0      0
C1 237      109      5      0      1      0      2.50      0      89      0.00      2.28      0.016      0      0
*EFG*****
C1 235      120      152      0      1      0      3.00      0      46      0.00      0.00      0.018      0      0

```

C1	236	6	120	0	1	0	3.00	0	23	1.36	0.08	0.018	0	0	
C1	241	152	153	0	1	0	3.00	0	127	0.00	0.00	0.018	0	0	
C1	242	153	154	0	1	0	3.00	0	46	0.00	0.00	0.018	0	0	
C1	243	154	157	0	1	0	3.00	0	127	0.00	0.00	0.018	0	0	
C1	244	155	156	0	1	0	1.17	0	46	0.00	0.00	0.012	0	0	
C1	245	156	147	0	1	0	1.25	0	670	0.12	0.00	0.012	0	0	
C1	246	157	158	0	1	0	3.00	0	46	0.00	0.00	0.018	0	0	
C1	247	158	159	0	1	0	3.00	0	127	0.00	0.00	0.018	0	0	
C1	248	159	160	0	1	0	3.00	0	46	0.00	0.00	0.018	0	0	
C1	249	160	161	0	1	0	3.00	0	127	0.00	0.00	0.018	0	0	
C1	250	161	162	0	1	0	3.00	0	46	0.00	0.00	0.018	0	0	
C1	251	162	163	0	1	0	3.00	0	127	0.00	0.00	0.018	0	0	
C1	252	163	164	0	1	0	3.00	0	46	0.00	0.00	0.018	0	0	
C1	253	164	165	0	1	0	3.00	0	127	0.00	0.00	0.018	0	0	
C1	254	165	7	0	1	0	3.00	0	81	0.00	0.00	0.018	0	0	
C1	267	2	1	0	6	0	6.00	60	195	0.00	0.00	0.025	2	2	
C1	268	1	4	0	6	0	6.00	60	307	0.00	0.00	0.025	2	2	
C1	269	3	5	0	6	0	6.00	60	196	0.00	0.00	0.025	2	2	
C1	270	5	6	0	6	0	6.00	60	290	0.00	0.00	0.025	2	2	
=====															
*Junction Data															
*	JUN	GRELLEV	Z	QINST	YO		[XLOC YLOC IWHICH SURELEV]								
*A*****															
D1	104	6.32	3.99	0	0.00										
D1	143	6.22	3.85	0	0.00										
D1	144	6.24	3.15	0	0.19										
*D1	2	6.00	3.20	0	0.14										
D1	2	6.004	0.004	0	3.34										
*B*****															
D1	105	6.29	3.98	0	0.00										
D1	106	6.39	3.14	0	0.20										
D1	142	6.13	3.09	0	0.25										
*D1	1	6.00	2.18	0	1.16										
D1	1	6.003	0.003	0	3.34										
*C*****															
D1	110	6.66	2.37	0	0.97										
D1	111	6.62	2.46	0	0.88										
D1	112	6.86	4.44	0	0.00										
D1	113	6.45	2.70	0	0.64										
D1	114	6.33	3.08	0	0.26										
D1	115	6.32	3.23	0	0.11										
D1	116	6.33	3.83	0	0.00										
D1	117	6.36	4.15	0	0.00										
D1	145	6.22	2.43	0	0.91										
*D1	3	6.00	1.75	0	1.59										
D1	3	6.002	0.002	0	3.34										
*D1	4	6.00	2.28	0	1.06										
D1	4	6.002	0.002	0	3.34										
*D*****															
D1	101	6.08	4.08	0	0.00										
D1	102	6.15	3.40	0	0.00										
D1	103	6.17	4.51	0	0.00										
D1	107	6.40	3.319	0	0.02										
D1	108	5.89	3.32	0	0.02										
D1	109	6.31	2.73	0	0.61										
D1	146	6.58	3.54	0	0.00										
*D1	5	6.00	2.28	0	1.06										
D1	5	6.001	0.001	0	3.34										
*EFG*****															
D1	120	6.41	1.91	0	1.43										
D1	121	6.11	0.24	0	3.10										

```

D1    122    6.25    0.63    0    2.71
D1    123    6.13    0.05    0    3.29
D1    124    6.12    2.60    0    0.74
D1    125    6.22    0.80    0    2.54
D1    126    6.06    2.54    0    0.80
D1    127    6.28    -0.22    0    3.56
D1    128    6.12    2.30    0    1.04
D1    129    6.25    0.00    0    3.34
D1    130    6.31    0.06    0    3.28
D1    147    6.13    1.13    0    2.21
D1    149    6.38    1.96    0    1.38
D1    152    6.50    1.90    0    1.44
D1    153    6.50    1.75    0    1.59
D1    154    6.50    1.75    0    1.59
D1    155    6.89    3.89    0    0.00
D1    156    6.90    3.70    0    0.00
D1    157    6.50    1.60    0    1.74
D1    158    6.50    1.60    0    1.74
D1    159    6.50    1.45    0    1.89
D1    160    6.50    1.45    0    1.89
D1    161    6.50    1.30    0    2.04
D1    162    6.50    1.30    0    2.04
D1    163    6.50    1.15    0    2.19
D1    164    6.50    1.14    0    2.20
D1    165    6.50    1.00    0    2.34
D1    6     6.00    0.00    0    3.34
D1    7     6.00    0.93    0    2.41
=====
* Junction Storage Data
*      JSTORE   ZTOP    ASTORE   NUMST
*A***** ***** ***** ***** ***** *****
E1    104    6.32    6.14    0
E1    143    6.22    6.14    0
E1    144    6.24    6.14    0
*B***** ***** ***** ***** ***** *****
E1    105    6.29    6.14    0
E1    106    6.39    6.14    0
E1    142    6.13    6.14    0
*C***** ***** ***** ***** ***** *****
E1    110    6.66    6.14    0
E1    111    6.62    6.14    0
E1    112    6.86    6.14    0
E1    113    6.45    6.14    0
E1    114    6.33    6.14    0
E1    115    6.32    6.14    0
E1    116    6.33    6.14    0
E1    117    6.36    6.14    0
E1    145    6.22    6.14    0
*D***** ***** ***** ***** ***** *****
E1    101    6.08    6.14    0
E1    102    6.15    6.14    0
E1    103    6.17    6.14    0
E1    107    6.40    6.14    0
E1    108    5.89    6.14    0
E1    109    6.31    6.14    0
E1    146    6.58    6.14    0
*EFG***** ***** ***** ***** *****
E1    120    6.41    6.14    0
E1    121    6.11    6.14    0
E1    122    6.25    6.14    0
E1    123    6.13    6.14    0
E1    124    6.12    6.14    0
E1    125    6.22    6.14    0
E1    126    6.06    6.14    0
E1    127    6.28    6.14    0
E1    128    6.12    6.14    0
E1    129    6.25    6.14    0
E1    130    6.31    6.14    0
E1    147    6.13    6.14    0
E1    149    6.38    6.14    0
E1    155    6.89    6.14    0
E1    156    6.90    6.14    0
=====
* Orifice Data
F1    149    165    1    1    0.6    0.04    0    0
F1    130    164    1    1    0.6    2.09    0    0
F1    129    163    1    1    0.6    2.15    0    0
F1    128    162    1    1    0.6    0    0    0
F1    127    161    1    1    0.6    2.52    0    0
F1    126    160    1    1    0.6    0    0    0
F1    125    159    1    1    0.6    1.65    0    0
F1    124    158    1    1    0.6    0    0    0
F1    123    157    1    1    0.6    2.55    0    0
F1    122    154    1    1    0.6    2.12    0    0
F1    121    153    1    1    0.6    2.51    0    0
F1    147    152    1    1    0.6    1.77    0    0
=====
* OUTFALL TO BOUNDARY CONDITION SPECIFIED IN J1
*      JFREE    NBCF
I1    7     1
=====
* NTIDE *5=STAGE HISTORY BOUNDARY, 2=constant head boundary
J1    5
=====
*J2    3.34    *Use for constant stage boundary

```

```

=====
*STAGE HISTORY SETUP
*      KO      NI      NCHTID    DELTA
J3      0       3       1       0
=====
*Stage History
*      TT      YY      TT      YY      TT      YY      TT      YY
J4     0.000   3.34    0.150   3.34    0.233   3.45    0.317   3.45
J4     0.483   3.60    0.567   3.67    0.650   3.76    0.733   3.89
J4     0.900   4.06    0.983   4.07    1.067   4.08    1.150   4.06
J4    12.000   3.34
=====
*      End your input data set with a $ENDPROGRAM and a <CR> (carriage return)
$ENDPROGRAM
□

```

APPENDIX E

Example SWMM Output File

```

#####
#      File names by SWMM Block      #
#      JIN  -> Input to a Block    #
#      JOUT -> Output from a Block   #
#####

JIN for Block #     1 File #    0 JIN.UF
JOUT for Block #    1 File #    9 RUNOFF.DNT
JIN for Block #    2 File #    9 RUNOFF.DNT
JOUT for Block #    2 File #    0 JOT.UF

#####
# Scratch file names for this simulation. #
#####

NSCRAT #     1 File #    1 SCRT1.UF
NSCRAT #     2 File #    2 SCRT2.UF
NSCRAT #     3 File #    3 SCRT3.UF
NSCRAT #     4 File #   10 SCRT4.UF
NSCRAT #     5 File #   11 SCRT5.UF
NSCRAT #     6 File #   12 SCRT6.UF
NSCRAT #     7 File #   13 SCRT7.UF
NSCRAT #     8 File #   14 SCRT8.UF

*****
* Parameter Values on the Tapes Common Block *
*****
```

Number of Subcatchments in the Runoff Block (NW)..... 2000
Number of Channel/Pipes in the Runoff Block (NG)..... 2000
Number of Connections to Runoff Channels/Inlets (NCP)..... 6
Number of Water Quality Constituents (MQUAL)..... 20
Number of Runoff Land Uses per Subcatchment (NLU)..... 20
Number of Groundwater Plot/prints in Runoff (NGW)..... 100
Number of Interface Locations for all Blocks (NIE)..... 2000
Number of Elements in the Transport Block (NET)..... 1000
Number of Storage Junctions in Transport (NTSE)..... 100
Number of Transport interface input locations (NTHI)..... 500
Number of Transport interface output locations (NTHO)..... 500
Number of Transport input locations on R lines (NTHR)..... 80
Number of Transport printed output locations (NTOA)..... 80
Number of Tabular Flow Splitters in Transport (NTSP)..... 50
Number of Elements in the Extran Block (NEE)..... 2000
Number of Pumps in Extran (NEP)..... 500
Number of Orifices in Extran (NEO)..... 200
Number of Tide Gates/Free Outfalls in Extran (NTG)..... 500
Number of Extran Weirs (NEW)..... 400
Number of Extran Printout Locations (NPO)..... 150
Number of Tide Elements in Extran (NTE)..... 50
Number of Natural Channels (NNC)..... 1200
Number of Storage Junctions in Extran (NVSE)..... 2000
Number of Time History Data Points in Extran (NTVAL)..... 500
Number of Data Points for Variable Storage Elements
 in the Extran Block (NVST)..... 200
Number of Input Hydrographs in Extran (NEH)..... 500
Number of Allowable Channel Connections to
 Junctions in the Extran Block (NCHN)..... 15
Number Rain Gages in Rain and Runoff (MAXRG)..... 200
Number PRATE/VRATE Points for Extran Pump
 Input (MAXPRA)..... 10
Number of Variable Orifices in Extran (NVORP)..... 50
Number of Variable Orifice Data Points (NVOTIM)..... 50
Number of Allowable Precip. Values/yr in Rain (LIMRN)..... 5000
Number of Storm Events for Rain Analysis (LSTORM)..... 20000
Number of Plugs for Plug-flow in S/T (NPPLUG)..... 3000
Number Conduits for Extran Results to ASCII
 File (MXFLOW)..... 400

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#####
# Entry made to the Runoff Block, last updated by #
# Oregon State University, and Camp, Dresser and #
# McKee, Inc., July 2003. #
#####
# "And wherever water goes, amoebae go along for #
# the ride"                                     Tom Robbins #
#####

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RUNOFF DATA Group N catchment, RAIN DATA FROM 9/17/03 yr storm

Swale type b

Snowmelt parameter - ISNOW..... 0
Number of rain gages - NRGAG..... 2
Green-Ampt infiltration equation used - INFILM.. 1
Quality is not simulated - KWALTY..... 0
Default evaporation rate used - IVAP..... 0
Hour of day at start of storm - NHR..... 0
Minute of hour at start of storm - NMN..... 0
Time TZERO at start of storm (hours)..... 0.000
Use U.S. Customary units for most I/O - METRIC.. 0
Runoff input print control.... 0
Runoff graph plot control.... 0
Runoff output print control.. 1

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Print headers every 50 lines - NOHEAD (0=yes, 1=no)          0
Print land use load percentages -LANDUPR (0=no, 1=yes)      0
Limit number of groundwater convergence messages to 10000 (if simulated)
Month, day, year of start of storm is:                   9/27/2003
Wet time step length (seconds).....                      3.
Dry time step length (seconds).....                      5.
Wet/Dry time step length (seconds)...                   3.
Simulation length is.....                            2.0 Hours
Percent of impervious area with zero detention depth    25.0
Rainfall from E3 Data Group

KTYPE - Rainfall input type.....                         1
NHISTO - Total number of rainfall values..            12
KINC - Rainfall values (pairs) per line.               1
KPRINT - Print rainfall (0=Yes,1=No).....             0
KTIME - Precipitation time units
  0 --> Minutes 1 --> Hours.....                  0
KPREP - Precipitation unit type
  0 --> Intensity 1 --> Volume.....                1
KTHIS - Variable rainfall intervals
  0 --> No, > 1 --> Yes.....                        0
THISTO - Rainfall time interval.....                 2.00
TZRAIN - Starting time (KTIME units).....            0.00

Rainfall printout for gage number....                  1
Time(mn)/ Rain(in) Time(mn)/ Rain(in) Time(mn)/ Rain(in) Time(mn)/ Rain(in) Time(mn) Rain(in)
0.00/   0.0000   2.00/   0.1200   4.00/   0.1200   6.00/   0.0700   8.00/   0.0800 10.00/   0.0600
12.00/  0.0800  14.00/   0.0500  16.00/   0.0700  18.00/   0.0300
20.00/  0.0200  22.00/   0.0000

Rainfall printout for gage number....                  2
Time(mn)/ Rain(in) Time(mn)/ Rain(in) Time(mn)/ Rain(in) Time(mn)/ Rain(in) Time(mn) Rain(in)
0.00/   0.0000   2.00/   0.0000   4.00/   0.0000   6.00/   0.0000   8.00/   0.0000 10.00/   0.0000
12.00/  0.0000  14.00/   0.0000  16.00/   0.0000  18.00/   0.0000
20.00/  0.0000  22.00/   0.0000

*****
* Rainfall input summary from Runoff *
*****
Total rainfall for gage # 1 is 0.7000 inches
Total rainfall for gage # 2 is 0.0000 inches

#####
# Data Group F1 #
# Evaporation Rate (in/day) #

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NOTE. SEE LATER TABLE FOR OPTIONAL SUBCATCHMENT PARAMETERS

	SUBCATCH-MENT NO.	CHANNEL OR INLET	WIDTH (FT)	AREA (AC)	PERCENT IMPERV.	SLOPE (FT/FT)	RESISTANCE IMPERV.	FACTOR PERV.	DEPRES. IMPERV.	STORAGE (IN) PERV.	GREEN-AMPT SUCTION (IN)	INFIL HYD.CON	PARAMS IMD	GAGE NO. (IN/HR)
1	302	104	4.70	0.08	50.00	0.0017	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
2	321	143	4.70	0.06	50.00	0.0028	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
3	395	143	4.70	0.01	50.00	0.0046	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
4	301	406	4.70	0.08	50.00	0.0014	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
5	303	105	4.70	0.02	50.00	0.0044	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
6	304	106	4.70	0.02	50.00	0.0045	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
7	310	405	4.70	0.01	50.00	0.0038	0.011	0.350	2.000	2.000	4.00	13.000	0.340	2
8	319	142	4.70	0.03	50.00	0.0036	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
9	320	142	4.70	0.02	50.00	0.0036	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
10	337	310	4.70	0.05	50.00	0.0009	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
11	394	404	4.70	0.05	50.00	0.0029	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
12	404	106	4.70	0.02	0.00	0.0022	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
13	405	404	4.70	0.01	100.00	0.0064	0.011	0.350	2.000	0.000	4.00	13.000	0.340	2
14	406	105	4.70	0.02	0.00	0.0024	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
15	322	112	4.70	0.06	50.00	0.0002	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
16	323	145	4.70	0.06	50.00	0.0015	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
17	324	114	4.70	0.06	50.00	0.0019	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
18	325	115	4.70	0.06	50.00	0.0026	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
19	326	116	4.70	0.06	50.00	0.0025	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
20	327	117	4.70	0.06	50.00	0.0023	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
21	328	145	4.70	0.04	50.00	0.0024	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
22	329	114	4.70	0.04	50.00	0.0021	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
23	330	115	4.70	0.04	50.00	0.0027	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
24	331	116	4.70	0.02	50.00	0.0039	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
25	333	117	4.70	0.02	50.00	0.0026	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
26	336	113	4.70	0.04	50.00	0.0032	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
27	305	306	4.70	0.04	50.00	0.0008	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
28	306	102	4.70	0.06	50.00	0.0017	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
29	307	101	4.70	0.08	50.00	0.0019	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
30	308	402	4.70	0.03	50.00	0.0039	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
31	309	146	4.70	0.03	50.00	0.0030	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
32	311	107	4.70	0.03	50.00	0.0007	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
33	312	103	4.70	0.02	50.00	0.0029	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
34	313	108	4.70	0.02	50.00	0.0050	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
35	314	101	4.70	0.03	50.00	0.0038	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
36	315	107	4.70	0.01	0.00	0.0038	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
37	316	317	4.70	0.02	50.00	0.0010	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
38	317	109	4.70	0.03	50.00	0.0014	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
39	318	109	4.70	0.02	50.00	0.0040	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
40	392	403	4.70	0.02	50.00	0.0027	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
41	393	401	4.70	0.02	50.00	0.0010	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
42	401	108	4.70	0.02	0.00	0.0055	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
43	402	102	4.70	0.01	0.00	0.0061	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
44	403	103	4.70	0.01	0.00	0.0017	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
45	338	147	4.70	0.05	50.00	0.0025	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
46	339	340	4.70	0.02	50.00	0.0027	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
47	340	121	4.70	0.03	50.00	0.0044	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
48	341	122	4.70	0.03	50.00	0.0046	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
49	342	123	4.70	0.03	50.00	0.0063	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
50	343	346	4.70	0.02	50.00	0.0040	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
51	344	124	4.70	0.03	50.00	0.0062	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
52	345	125	4.70	0.03	50.00	0.0051	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
53	346	126	4.70	0.03	50.00	0.0039	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
54	347	127	4.70	0.03	50.00	0.0038	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
55	348	347	4.70	0.02	50.00	0.0006	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
56	349	128	4.70	0.03	50.00	0.0063	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
57	350	129	4.70	0.03	50.00	0.0041	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
58	351	397	4.70	0.02	50.00	0.0041	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2

59	352	130	4.70	0.03	50.00	0.0040	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
60	353	149	4.70	0.05	50.00	0.0022	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
61	354	147	4.70	0.04	50.00	0.0039	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
62	355	121	4.70	0.04	50.00	0.0044	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
63	356	122	4.70	0.04	50.00	0.0037	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
64	357	123	4.70	0.04	50.00	0.0036	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
65	358	124	4.70	0.04	50.00	0.0038	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
66	359	125	4.70	0.04	50.00	0.0041	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
67	360	126	4.70	0.04	50.00	0.0043	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
68	361	127	4.70	0.04	50.00	0.0036	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
69	362	128	4.70	0.04	50.00	0.0046	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
70	363	129	4.70	0.04	50.00	0.0037	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
71	364	130	4.70	0.04	50.00	0.0039	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
72	365	149	4.70	0.04	50.00	0.0038	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
73	396	120	4.70	0.06	50.00	0.0014	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
74	397	120	4.70	0.01	50.00	0.0039	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
75	398	155	4.70	0.01	50.00	0.0008	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
76	399	156	4.70	0.04	50.00	0.0008	0.011	0.350	0.500	0.000	4.00	13.000	0.340	2
77	502	302	392.00	1.61	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
78	521	321	599.00	1.06	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
79	595	395	139.00	0.24	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
80	602	302	392.00	0.23	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
81	621	321	599.00	0.15	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
82	695	395	139.00	0.04	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
83	501	301	810.00	1.79	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
84	503	303	285.00	0.59	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
85	504	304	285.00	0.69	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
86	510	310	92.00	0.73	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
87	519	319	374.00	0.75	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
88	520	320	206.00	0.41	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
89	537	337	415.00	0.92	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
90	594	394	549.00	1.14	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
91	601	301	810.00	0.20	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
92	603	303	285.00	0.07	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
93	604	304	285.00	0.07	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
94	610	310	92.00	0.02	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
95	619	319	374.00	0.09	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
96	620	320	206.00	0.05	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
97	637	337	415.00	0.10	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
98	694	394	549.00	0.14	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
99	522	322	583.00	1.10	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
100	523	323	602.00	1.38	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
101	524	324	602.00	1.26	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
102	525	325	602.00	1.38	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
103	526	326	602.00	1.26	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
104	527	327	643.00	1.47	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
105	528	328	382.00	1.02	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
106	529	329	408.00	0.92	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
107	530	330	408.00	0.94	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
108	531	331	194.00	0.41	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
109	533	333	194.00	0.44	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
110	536	336	347.00	0.67	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
111	622	322	583.00	0.15	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1 112
0.15	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1	112	623	323	602.00
113	624	324	602.00	0.15	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
114	625	325	602.00	0.15	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
115	626	326	602.00	0.15	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
116	627	327	643.00	0.16	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1 117
0.10	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1	117	628	328	382.00
118	629	329	408.00	0.10	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
119	630	330	408.00	0.10	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
120	631	331	194.00	0.05	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
121	633	333	194.00	0.05	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1

122	636	336	347.00	0.09	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
123	505	305	385.00	0.89	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
124	506	306	616.00	1.24	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
125	507	307	869.00	2.15	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
126	508	308	431.00	1.10	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
127	509	309	326.00	0.73	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
128	511	311	314.00	0.67	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
129	512	312	293.00	0.66	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
130	513	313	263.00	0.60	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
131	514	314	320.00	0.76	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
132	515	315	92.00	0.72	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
133	516	316	244.00	0.56	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
134	517	317	284.00	0.61	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
135	518	318	266.00	0.51	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
136	592	392	250.00	0.50	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
137	593	393	236.00	0.47	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
138	605	305	385.00	0.10	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
139	606	306	616.00	0.16	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
140	607	307	869.00	0.22	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
141	608	308	431.00	0.11	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
142	609	309	326.00	0.08	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
143	611	311	314.00	0.08	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
144	612	312	293.00	0.07	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
145	613	313	263.00	0.07	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
146	614	314	320.00	0.08	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
147	615	315	92.00	0.02	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
148	616	316	244.00	0.06	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
149	617	317	284.00	0.07	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
150	618	318	266.00	0.07	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
151	692	392	250.00	0.06	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
152	693	393	236.00	0.06	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
153	6001	1	10000.00	0.34	100.00	1.0000	0.001	0.300	0.000	0.000	4.00	13.000	0.340	1
154	6002	2	10000.00	0.34	100.00	1.0000	0.001	0.300	0.000	0.000	4.00	13.000	0.340	1
155	6003	3	10000.00	0.34	100.00	1.0000	0.001	0.300	0.000	0.000	4.00	13.000	0.340	1
156	6004	4	10000.00	0.34	100.00	1.0000	0.001	0.300	0.000	0.000	4.00	13.000	0.340	1
157	6005	5	10000.00	0.34	100.00	1.0000	0.001	0.300	0.000	0.000	4.00	13.000	0.340	1
158	6006	6	10000.00	0.34	100.00	1.0000	0.001	0.300	0.000	0.000	4.00	13.000	0.340	1
159	538	338	461.00	1.06	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
160	539	339	250.00	0.63	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
161	540	340	402.00	0.93	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
162	541	341	344.00	0.66	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
163	542	342	344.00	0.75	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
164	543	343	252.00	0.63	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
165	544	344	344.00	0.71	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
166	545	345	344.00	0.68	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
167	546	346	402.00	0.96	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
168	547	347	402.00	0.91	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
169	548	348	304.00	0.78	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
170	549	349	344.00	0.72	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
171	550	350	344.00	0.71	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
172	551	351	196.00	0.40	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
173	552	352	402.00	0.99	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
174	553	353	461.00	1.24	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
175	554	354	357.00	0.80	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
176	555	355	357.00	0.82	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
177	556	356	357.00	0.69	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
178	557	357	357.00	0.78	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
179	558	358	357.00	0.75	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
180	559	359	357.00	0.70	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
181	560	360	357.00	0.84	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
182	561	361	357.00	0.81	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
183	562	362	357.00	0.74	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
184	563	363	357.00	0.74	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1

185	564	364	357.00	0.87	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
186	565	365	357.00	0.97	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
187	598	398	374.00	0.44	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
188	599	399	464.00	0.36	32.00	0.0140	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
189	638	338	461.00	0.12	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
190	639	339	250.00	0.06	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
191	640	340	402.00	0.10	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
192	641	341	344.00	0.09	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
193	642	342	344.00	0.09	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
194	643	343	252.00	0.06	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
195	644	344	344.00	0.09	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
196	645	345	344.00	0.09	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
197	646	346	402.00	0.10	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
198	647	347	402.00	0.10	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
199	648	348	304.00	0.08	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
200	649	349	344.00	0.09	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
201	650	350	344.00	0.09	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
202	651	351	196.00	0.05	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
203	652	352	402.00	0.10	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
204	653	353	461.00	0.12	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
205	654	354	357.00	0.09	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
206	655	355	357.00	0.09	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
207	656	356	357.00	0.09	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
208	657	357	357.00	0.09	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
209	658	358	357.00	0.09	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
210	659	359	357.00	0.09	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
211	660	360	357.00	0.09	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
212	661	361	357.00	0.09	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
213	662	362	357.00	0.09	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
214	663	363	357.00	0.09	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
215	664	364	357.00	0.09	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
216	665	365	357.00	0.09	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
217	696	396	561.00	0.40	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
218	697	397	133.00	0.08	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
219	698	398	374.00	0.09	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1
220	699	399	464.00	0.12	100.00	0.0206	0.011	0.350	0.000	0.000	4.00	13.000	0.340	1

TOTAL NUMBER OF SUBCATCHMENTS... 220
 TOTAL TRIBUTARY AREA (ACRES)... 69.15
 IMPERVIOUS AREA (ACRES)..... 28.75
 PERVERS AREA (ACRES)..... 40.40
 TOTAL WIDTH (FEET)..... 113291.20
 PERCENT IMPERVIOUSNESS..... 41.58

 * ADDITIONAL SUBCATCHMENT INPUT DATA *

 * IF OVERLAND FLOW REROUTING OCCURS, *
 * PARAMETER IFLOW MEANS: *
 * 0 - NO REROUTING *
 * 1 - REROUTE SUBCAT. IMPERV TO PERV *
 * 2 - REROUTE SUBCAT. PERV TO IMPERV *
 * 3,4,5 - ABOVE, BUT ROUTE SUBCAT *
 * OUTFLOW TO ANOTHER SUBCATCHMENT *

SUBCAT	VARIABLE	REDIRECTED	TO	
NAME	PCT	ZERO	OVLND FLOW	SUBCAT
	#		(IFLOWP)	
302		1		
321		1		

395	1	
301	4	406
303	1	
304	1	
310	4	405
319	1	
320	1	
337	4	310
394	4	404
404	1	
405	4	404
406	1	
322	1	
323	1	
324	1	
325	1	
326		
327	1	
328	1	
329	1	
330	1	
331	1	
333	1	
336	1	
305	4	306
306	1	
307	1	
308	4	402
309	1	
311	1	
312	1	
313	1	
314	1	
315	1	
316	4	317
317	1	
318	1	
392	4	403
393	4	401
401	1	
402	1	
403	1	
338	1	
339	4	340
340	1	
341	1	
342	1	
343	4	346
344	1	
345	1	
346	1	
347	1	
348	4	347
349	1	
350	1	
351	4	397
352	1	
353	1	
354	1	
355	1	
356	1	
357	1	
358	1	
359	1	
360	1	
361	1	
362	1	
363	1	
364	1	
365	1	
396	1	
397	1	
398	1	
399	1	
502	3	302
521	3	321
595	3	395
602	3	302
621	3	321
695	3	395
501	3	301
503	3	303
504	3	304
510	5	310
519	3	319
520	3	320
537	3	337
594	3	394
601	3	301
603	3	303
604	3	304
610	3	310
619	3	319
620	3	320
637	3	337

694	3	394
522	3	322
523	3	323
524	3	324
525	3	325
526	3	326
527	3	327
528	3	328
529	3	329
530	3	330
531	3	331
533	3	333
536	3	336
622	3	322
623	3	323
624	3	324
625	3	325
626	3	326
627	3	327
628	3	328
629	3	329
630	3	330
631	3	331
633	3	333
636	3	336
505	3	305
506	3	306
507	3	307
508	3	308
509	3	309
511	3	311
512	3	312
513	3	313
514	3	314
515	5	315
516	3	316
517	3	317
518	3	318
592	3	392
593	3	393
605	3	305
606	3	306
607	3	307
608	3	308
609	3	309
611	3	311
612	3	312
613	3	313
614	3	314
615	5	315
616	3	316
617	3	317
618	3	318
692	3	392
693	3	393
6001	0	
6002	0	
6003	0	
6004	0	
6005	0	
6006	0	
538	3	338
539	3	339
540	3	340
541	3	341
542	3	342
543	3	343
544	3	344
545	3	345
546	3	346
547	3	347
548	3	348
549	3	349
550	3	350
551	3	351
552	3	352
553	3	353
554	3	354
555	3	355
556	3	356
557	3	357
558	3	358
559	3	359
560	3	360
561	3	361
562	3	362
563	3	363
564	3	364
565	3	365
598	3	398
599	3	399
638	3	338
639	3	339
640	3	340
641	3	341

642	3	342
643	3	343
644	3	344
645	3	345
646	3	346
647	3	347
648	3	348
649	3	349
650	3	350
651	3	351
652	3	352
653	3	353
654	3	354
655	3	355
656	3	356
657	3	357
658	3	358
659	3	359
660	3	360
661	3	361
662	3	362
663	3	363
664	3	364
665	3	365
696	3	396
697	3	397
698	3	398
699	3	399

* Arrangement of Subcatchments and Channel/Pipes *

* See second subcatchment output table for connectivity *
* of subcatchment to subcatchment flows. *

INLET		
104	No Tributary Channel/Pipes	
	Tributary Subareas.....	302
143	No Tributary Channel/Pipes	
	Tributary Subareas.....	321
105	No Tributary Channel/Pipes	
	Tributary Subareas.....	303
106	No Tributary Channel/Pipes	
	Tributary Subareas.....	304
142	No Tributary Channel/Pipes	
	Tributary Subareas.....	319
112	No Tributary Channel/Pipes	
	Tributary Subareas.....	322
145	No Tributary Channel/Pipes	
	Tributary Subareas.....	323
114	No Tributary Channel/Pipes	
	Tributary Subareas.....	324
115	No Tributary Channel/Pipes	
	Tributary Subareas.....	325
116	No Tributary Channel/Pipes	
	Tributary Subareas.....	326
117	No Tributary Channel/Pipes	
	Tributary Subareas.....	327
113	No Tributary Channel/Pipes	
	Tributary Subareas.....	336
102	No Tributary Channel/Pipes	
	Tributary Subareas.....	306
101	No Tributary Channel/Pipes	
	Tributary Subareas.....	307
146	No Tributary Channel/Pipes	
	Tributary Subareas.....	309
107	No Tributary Channel/Pipes	
	Tributary Subareas.....	311
103	No Tributary Channel/Pipes	
	Tributary Subareas.....	312
108	No Tributary Channel/Pipes	
	Tributary Subareas.....	313
109	No Tributary Channel/Pipes	
	Tributary Subareas.....	317
147	No Tributary Channel/Pipes	
	Tributary Subareas.....	338
121	No Tributary Channel/Pipes	
	Tributary Subareas.....	340
122	No Tributary Channel/Pipes	
	Tributary Subareas.....	341
123	No Tributary Channel/Pipes	
	Tributary Subareas.....	342
124	No Tributary Channel/Pipes	
	Tributary Subareas.....	344
125	No Tributary Channel/Pipes	
	Tributary Subareas.....	345
126	No Tributary Channel/Pipes	
	Tributary Subareas.....	346
127	No Tributary Channel/Pipes	
	Tributary Subareas.....	347
128	No Tributary Channel/Pipes	
	Tributary Subareas.....	349
129	No Tributary Channel/Pipes	
	Tributary Subareas.....	350
130	No Tributary Channel/Pipes	

	Tributary Subareas.....	352	364
149	No Tributary Channel/Pipes		
	Tributary Subareas.....	353	365
120	No Tributary Channel/Pipes		
	Tributary Subareas.....	396	397
155	No Tributary Channel/Pipes		
	Tributary Subareas.....	398	
156	No Tributary Channel/Pipes		
	Tributary Subareas.....	399	
1	No Tributary Channel/Pipes		
	Tributary Subareas.....	6001	
2	No Tributary Channel/Pipes		
	Tributary Subareas.....	6002	
3	No Tributary Channel/Pipes		
	Tributary Subareas.....	6003	
4	No Tributary Channel/Pipes		
	Tributary Subareas.....	6004	
5	No Tributary Channel/Pipes		
	Tributary Subareas.....	6005	
6	No Tributary Channel/Pipes		
	Tributary Subareas.....	6006	

* Hydrographs will be stored for the following 40 INLETS *

104	143	105	106	142	112
145	114	115	116	117	113
102	101	146	107	103	108
109	147	121	122	123	124
125	126	127	128	129	130
149	120	155	156	1	2
3	4	5	6		

* Quality simulation not included in this run *

End of preliminary input data and data echo.

* Precipitation Interface File Summary *
* Number of precipitation station... 2 *

Location Station Number

1.	1
2.	2

* Summary of Quantity and Quality results for *
* 2003 *

Month	Inlet	Rain Inch	Flow Inch
September	104	0.70000	0.6010E-03
Year	104	0.70000	0.6010E-03
September	143	0.70000	0.9369E-03
Year	143	0.70000	0.9369E-03
September	105	0.70000	0.1133E-02
Year	105	0.70000	0.1133E-02
September	106	0.70000	0.1511E-02
Year	106	0.70000	0.1511E-02
September	142	0.70000	0.1448E-02
Year	142	0.70000	0.1448E-02
September	112	0.70000	0.9090E-04
Year	112	0.70000	0.9090E-04
September	145	0.70000	0.1648E-02
Year	145	0.70000	0.1648E-02
September	114	0.70000	0.1303E-02
Year	114	0.70000	0.1303E-02
September	115	0.70000	0.1681E-02
Year	115	0.70000	0.1681E-02
September	116	0.70000	0.1121E-02
Year	116	0.70000	0.1121E-02
September	117	0.70000	0.1535E-02
Year	117	0.70000	0.1535E-02
September	113	0.70000	0.2902E-03
Year	113	0.70000	0.2902E-03
September	102	0.70000	0.1424E-02
Year	102	0.70000	0.1424E-02
September	101	0.70000	0.2314E-02
Year	101	0.70000	0.2314E-02
September	146	0.70000	0.8291E-03
Year	146	0.70000	0.8291E-03
September	107	0.70000	0.1477E-02
Year	107	0.70000	0.1477E-02
September	103	0.70000	0.1272E-02
Year	103	0.70000	0.1272E-02
September	108	0.70000	0.1176E-02
Year	108	0.70000	0.1176E-02
September	109	0.70000	0.1643E-02
Year	109	0.70000	0.1643E-02
September	147	0.70000	0.1165E-02
Year	147	0.70000	0.1165E-02

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September    121  0.70000  0.3053E-02
Year        121  0.70000  0.3053E-02
September   122  0.70000  0.1157E-02
Year        122  0.70000  0.1157E-02
September   123  0.70000  0.1593E-02
Year        123  0.70000  0.1593E-02
September   124  0.70000  0.1441E-02
Year        124  0.70000  0.1441E-02
September   125  0.70000  0.1255E-02
Year        125  0.70000  0.1255E-02
September   126  0.70000  0.3208E-02
Year        126  0.70000  0.3208E-02
September   127  0.70000  0.3057E-02
Year        127  0.70000  0.3057E-02
September   128  0.70000  0.1482E-02
Year        128  0.70000  0.1482E-02
September   129  0.70000  0.1343E-02
Year        129  0.70000  0.1343E-02
September   130  0.70000  0.2421E-02
Year        130  0.70000  0.2421E-02
September   149  0.70000  0.1796E-02
Year        149  0.70000  0.1796E-02
September   120  0.70000  0.6105E-03
Year        120  0.70000  0.6105E-03
September   155  0.70000  0.1502E-02
Year        155  0.70000  0.1502E-02
September   156  0.70000  0.1699E-04
Year        156  0.70000  0.1699E-04
September   1   0.70000  0.3435E-02
Year        1   0.70000  0.3435E-02
September   2   0.70000  0.3435E-02
Year        2   0.70000  0.3435E-02
September   3   0.70000  0.3435E-02
Year        3   0.70000  0.3435E-02
September   4   0.70000  0.3435E-02
Year        4   0.70000  0.3435E-02
September   5   0.70000  0.3435E-02
Year        5   0.70000  0.3435E-02
September   6   0.70000  0.3435E-02
Year        6   0.70000  0.3435E-02

```

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*****
*      End of time step DO-loop in Runoff      *
*****

```

```

Final Date (Mo/Day/Year) =          9/27/2003
Total number of time steps =       2400
Final Julian Date =              2003270
Final time of day =             7200. seconds.
Final time of day =             2.00  hours.
Final running time =            2.0000  hours.
Final running time =            0.0833  days.

```

```

*****
*      Extrapolation Summary for Watersheds      *
* # Steps ==> Total Number of Extrapolated Steps *
* # Calls ==> Total Number of OVERLND Calls   *
*****

```

Subcatch	# Steps	# Calls	Subcatch	# Steps	# Calls	Subcatch	# Steps	# Calls
302	19097	6355	321	18834	6266	395	13212	4288
301	19282	6414	303	17388	5780	304	17598	5858
310	17679	5141	319	18781	6251	320	17804	5920
337	18922	6306	394	18923	6289	404	1576	524
405	11928	3964	406	117	39	322	18727	6229
323	19037	6339	324	18945	6307	325	18928	6296
326	18980	6316	327	19069	6347	328	18787	6253
329	18860	6272	330	18777	6251	331	17600	5860
333	18715	6229	336	18593	6187	305	19102	6358
306	19162	6382	307	19339	6437	308	18937	6307
309	18762	6250	311	19065	6331	312	18772	6252
313	17129	5695	314	18791	6253	315	2376	792
316	18845	6271	317	19136	6368	318	17668	5868
392	18759	6249	393	18802	6254	401	93	31
402	1852	616	403	177	59	338	18829	6267
339	18834	6266	340	18926	6306	341	18840	6272
342	18741	6239	343	18080	6008	344	18800	6256
345	18831	6269	346	19106	6362	347	19182	6386
348	19079	6345	349	18729	6239	350	18730	6234
351	17297	5759	352	18875	6273	353	19032	6328
354	18719	6225	355	18688	6216	356	18628	6204
357	18701	6227	358	18712	6228	359	18706	6230
360	18616	6188	361	18667	6213	362	18615	6193
363	18698	6222	364	18816	6260	365	18806	6258
396	18627	6205	397	13644	4536	398	18673	6215
399	18587	6185	502	5470	1818	521	5434	1806
595	5392	1792	602	6454	1346	621	6408	1336
695	6248	1384	501	5844	1948	503	5718	1906
504	6042	2014	510	9906	3278	519	5652	1884
520	5640	1880	537	5864	1952	594	5724	1908
601	6364	1332	603	6494	1330	604	6494	1330
610	6444	1292	619	6420	1324	620	6442	1326
637	6380	1324	694	6426	1342	522	5554	1846
523	5922	1974	524	5744	1912	525	5922	1974

526	5744	1912	527	5916	1972	528	6258	2086
529	5886	1962	530	5934	1978	531	5754	1918
533	5898	1966	536	5588	1860	622	6422	1346
623	6426	1334	624	6426	1334	625	6426	1334
626	6426	1334	627	6410	1334	628	6330	1350
629	6414	1330	630	6414	1330	631	6430	1346
633	6430	1346	636	6404	1348	505	5940	1980
506	5658	1886	507	6090	2030	508	6156	2052
509	5882	1958	511	5778	1926	512	5886	1962
513	5910	1970	514	6000	2000	515	9830	3258
516	5928	1976	517	5798	1930	518	5568	1856
592	5646	1882	593	5640	1880	605	6500	1348
606	6436	1348	607	6444	1340	608	6434	1342
609	6398	1330	611	6466	1342	612	6390	1322
613	6436	1356	614	6376	1336	615	6444	1292
616	6510	1330	617	6324	1332	618	6448	1352
692	6438	1322	693	6370	1342	6001	5820	812
6002	5820	812	6003	5820	812	6004	5820	812
6005	5820	812	6006	5820	812	538	5928	1976
539	6126	2042	540	5940	1980	541	5584	1856
542	5820	1940	543	6108	2036	544	5712	1904
545	5644	1876	546	6012	2004	547	5898	1966
548	6168	2056	549	5744	1912	550	5712	1904
551	5688	1896	552	6078	2026	553	6276	2092
554	5874	1958	555	5928	1976	556	5580	1860
557	5834	1942	558	5750	1914	559	5610	1870
560	5976	1992	561	5904	1968	562	5718	1906
563	5718	1906	564	6054	2018	565	6300	2100
598	5018	1590	599	6188	1420	638	6436	1348
639	6438	1322	640	6466	1334	641	6426	1350
642	6426	1350	643	6440	1320	644	6426	1350
645	6426	1350	646	6466	1334	647	6466	1334
648	6448	1352	649	6426	1350	650	6426	1350
651	6426	1342	652	6466	1334	653	6436	1348
654	6342	1338	655	6342	1338	656	6342	1338
657	6342	1338	658	6342	1338	659	6342	1338
660	6342	1338	661	6342	1338	662	6342	1338
663	6342	1338	664	6342	1338	665	6342	1338
696	5454	1810	697	5178	1710	698	6420	1324
699	6438	1346						

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* Continuity Check for Surface Water *

	Inches over cubic feet	Total Basin
Total Precipitation (Rain plus Snow)	1.690527E+05	0.673
Total Infiltration	1.493004E+05	0.595
Total Evaporation	5.692549E+02	0.002
Surface Runoff from Watersheds	1.735679E+04	0.069
Total Water remaining in Surface Storage	1.829261E+03	0.007
Infiltation over the Pervious Area...	1.493004E+05	1.018

Infiltration + Evaporation +		
Surface Runoff + Snow removal +		
Water remaining in Surface Storage +		
Water remaining in Snow Cover.....	1.690557E+05	0.673
Total Precipitation + Initial Storage.	1.690527E+05	0.673

The error in continuity is calculated as

* Precipitation + Initial Snow Cover *
* - Infiltration - *
*Evaporation - Snow removal - *
*Surface Runoff from Watersheds - *
*Water in Surface Storage - *
*Water remaining in Snow Cover *

* Precipitation + Initial Snow Cover *

Error..... -0.002 Percent

* Continuity Check for Channel/Pipes *

	Inches over cubic feet	Total Basin
Initial Channel/Pipe Storage.....	0.000000E+00	0.000
Final Channel/Pipe Storage.....	0.000000E+00	0.000
Surface Runoff from Watersheds.....	1.735679E+04	0.069
Groundwater Subsurface Inflow.....	0.000000E+00	0.000
Evaporation Loss from Channels.....	0.000000E+00	0.000
Channel/Pipe/Inlet Outflow.....	1.735679E+04	0.069
Initial Storage + Inflow.....	1.735679E+04	0.069
Final Storage + Outflow.....	1.735679E+04	0.069

* Final Storage + Outflow + Evaporation - *		
* Watershed Runoff - Groundwater Inflow - *		
* Initial Channel/Pipe Storage *		
* ----- *		
* Final Storage + Outflow + Evaporation *		

Error.....	0.000 Percent	

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SUMMARY STATISTICS FOR SUBCATCHMENTS

SUBCATCH- MENT NO.	GUTTER NO.	OR INLET AREA (AC)	PERVIOUS AREA			IMPERVIOUS AREA			TOTAL SUBCATCHMENT AREA			
			TOTAL SIMULATED RAINFALL (IN)	TOTAL DEPTH (IN)	PEAK LOSSSES (IN)	TOTAL RUNOFF (IN)	PEAK RATE (CFS)	RUNOFF (IN)	PEAK DEPTH (IN)	PEAK RATE (CFS)	PEAK RUNOFF (IN/Hr)	
			PERCENT IMPER. (%)									
302	104	0.08	50.0	0.00	1.039	11.544	0.152	6.089	0.817	0.519	0.152	1.898
321	143	0.06	50.0	0.00	0.933	10.044	0.119	5.292	0.574	0.466	0.119	1.983
395	143	0.01	50.0	0.00	7.361	8.544	0.151	7.763	0.210	3.681	0.151	15.123
301	406	0.08	50.0	0.00	1.100	11.956	0.154	6.324	0.839	0.550	0.154	1.931
303	105	0.02	50.0	0.00	7.832	9.824	0.302	8.637	0.447	3.916	0.302	15.109
304	106	0.02	50.0	0.00	9.830	10.051	0.369	9.749	0.503	4.915	0.369	18.446
310	405	0.01	50.0	0.00	23.477	12.817	0.452	17.393	0.364	11.738	0.452	45.248
319	142	0.03	50.0	0.00	4.590	10.361	0.270	7.283	0.514	2.295	0.270	8.993
320	142	0.02	50.0	0.00	3.128	9.120	0.136	5.933	0.293	1.564	0.136	6.783
337	310	0.05	50.0	0.00	0.514	10.081	0.056	5.097	0.432	0.257	0.056	1.118
394	404	0.05	50.0	0.00	2.577	11.107	0.241	6.647	0.639	1.289	0.241	4.827
404	106	0.02	0.0	0.00	0.309	8.028	0.035	0.000	0.000	0.309	0.035	1.734
405	404	0.01	100.0	0.00	0.000	0.000	0.000	10.231	0.448	0.000	0.000	0.000
406	105	0.02	0.0	0.00	0.000	2.200	0.000	0.000	0.000	0.000	0.000	0.000
322	112	0.06	50.0	0.00	0.210	11.002	0.026	5.380	0.477	0.105	0.026	0.431
323	145	0.06	50.0	0.00	1.610	11.734	0.172	6.473	0.669	0.805	0.172	2.870
324	114	0.06	50.0	0.00	1.359	11.098	0.155	6.031	0.635	0.679	0.155	2.575
325	115	0.06	50.0	0.00	2.003	11.347	0.221	6.478	0.704	1.001	0.221	3.688
326	116	0.06	50.0	0.00	1.525	10.934	0.176	6.033	0.652	0.763	0.176	2.929
327	117	0.06	50.0	0.00	2.407	11.843	0.254	6.928	0.750	1.203	0.254	4.240
328	145	0.04	50.0	0.00	3.282	11.184	0.244	7.039	0.559	1.641	0.244	6.094
329	114	0.04	50.0	0.00	2.466	10.888	0.188	6.483	0.502	1.233	0.188	4.709
330	115	0.04	50.0	0.00	2.809	10.769	0.216	6.595	0.532	1.405	0.216	5.406
331	116	0.02	50.0	0.00	3.175	9.072	0.138	5.932	0.294	1.587	0.138	6.893
333	117	0.02	50.0	0.00	3.396	9.518	0.143	6.265	0.299	1.698	0.143	7.146
336	113	0.04	50.0	0.00	1.003	9.220	0.093	4.918	0.382	0.502	0.093	2.314
305	306	0.04	50.0	0.00	1.575	11.437	0.115	6.308	0.441	0.787	0.115	2.885
306	102	0.06	50.0	0.00	1.649	11.940	0.172	6.596	0.642	0.824	0.172	2.867
307	101	0.08	50.0	0.00	2.362	13.052	0.301	7.505	1.019	1.181	0.301	3.762
308	402	0.03	50.0	0.00	9.837	11.239	0.535	10.346	0.756	4.919	0.535	17.838
309	146	0.03	50.0	0.00	3.822	10.363	0.226	6.900	0.466	1.911	0.226	7.540
311	107	0.03	50.0	0.00	2.031	11.256	0.113	6.447	0.353	1.015	0.113	3.768
312	103	0.02	50.0	0.00	8.793	10.421	0.331	9.415	0.476	4.397	0.331	16.540
313	108	0.02	50.0	0.00	8.131	9.746	0.313	8.747	0.453	4.065	0.313	15.644
314	101	0.03	50.0	0.00	4.366	10.265	0.259	7.123	0.496	2.183	0.259	8.630
315	107	0.01	0.0	0.00	7.168	10.226	0.277	0.000	0.000	7.168	0.277	27.740
316	317	0.02	50.0	0.00	5.153	11.131	0.191	7.949	0.355	2.576	0.191	9.557
317	109	0.03	50.0	0.00	3.443	11.926	0.181	7.490	0.364	1.721	0.181	6.038
318	109	0.02	50.0	0.00	6.195	9.679	0.246	7.745	0.398	3.097	0.246	12.287
392	403	0.02	50.0	0.00	5.064	9.888	0.203	7.284	0.361	2.532	0.203	10.141
393	401	0.02	50.0	0.00	3.651	10.629	0.141	6.947	0.305	1.825	0.141	7.068
401	108	0.02	0.0	0.00	0.000	1.825	0.000	0.000	0.000	0.000	0.000	0.000
402	102	0.01	0.0	0.00	4.901	9.854	0.221	0.000	0.000	4.901	0.221	22.082
403	103	0.01	0.0	0.00	0.000	5.064	0.000	0.000	0.000	0.000	0.000	0.000
338	147	0.05	50.0	0.00	1.726	10.684	0.169	6.010	0.556	0.863	0.169	3.382
339	340	0.02	50.0	0.00	7.488	10.357	0.286	8.731	0.433	3.744	0.286	14.300
340	121	0.03	50.0	0.00	11.298	11.782	0.608	11.348	0.658	5.649	0.608	20.254
341	122	0.03	50.0	0.00	3.768	9.846	0.231	6.615	0.473	1.884	0.231	7.706
342	123	0.03	50.0	0.00	5.084	9.865	0.306	7.283	0.539	2.542	0.306	10.192
343	346	0.02	50.0	0.00	7.875	9.970	0.303	8.731	0.444	3.938	0.303	15.160
344	124	0.03	50.0	0.00	4.592	9.764	0.280	6.986	0.516	2.296	0.280	9.319
345	125	0.03	50.0	0.00	4.080	9.831	0.249	6.764	0.489	2.040	0.249	8.312
346	126	0.03	50.0	0.00	11.850	11.932	0.635	11.699	0.671	5.925	0.635	21.176
347	127	0.03	50.0	0.00	11.574	12.661	0.582	11.925	0.637	5.787	0.582	19.387
348	347	0.02	50.0	0.00	9.667	12.910	0.321	11.094	0.490	4.834	0.321	16.034
349	128	0.03	50.0	0.00	4.725	9.780	0.287	7.061	0.522	2.362	0.287	9.560
350	129	0.03	50.0	0.00	4.238	10.117	0.254	6.986	0.495	2.119	0.254	8.464
351	397	0.02	50.0	0.00	3.040	8.984	0.133	5.821	0.290	1.520	0.133	6.658
352	130	0.03	50.0	0.00	8.029	10.949	0.446	9.297	0.675	4.014	0.446	14.874
353	149	0.05	50.0	0.00	2.522	11.489	0.229	6.810	0.625	1.261	0.229	4.576
354	147	0.04	50.0	0.00	1.872	9.799	0.159	5.642	0.464	0.936	0.159	3.968
355	121	0.04	50.0	0.00	2.082	9.812	0.176	5.754	0.483	1.041	0.176	4.391
356	122	0.04	50.0	0.00	1.175	9.271	0.107	5.030	0.402	0.588	0.107	2.675
357	123	0.04	50.0	0.00	1.696	9.752	0.145	5.531	0.448	0.848	0.145	3.624
358	124	0.04	50.0	0.00	1.540	9.575	0.134	5.364	0.436	0.770	0.134	3.359
359	125	0.04	50.0	0.00	1.280	9.278	0.116	5.086	0.414	0.640	0.116	2.899
360	126	0.04	50.0	0.00	2.205	9.911	0.184	5.865	0.492	1.103	0.184	4.600
361	127	0.04	50.0	0.00	1.888	9.894	0.159	5.698	0.463	0.944	0.159	3.966
362	128	0.04	50.0	0.00	1.581	9.423	0.140	5.309	0.443	0.790	0.140	3.496
363	129	0.04	50.0	0.00	1.465	9.538	0.129	5.308	0.429	0.732	0.129	3.214
364	130	0.04	50.0	0.00	2.348	10.102	0.192	6.032	0.500	1.174	0.192	4.807
365	149	0.04	50.0	0.00	3.058	10.504	0.240	6.588	0.549	1.529	0.240	6.008
396	120	0.06	50.0	0.00	0.163	8.730	0.027	4.247	0.432	0.082	0.027	0.452
397	120	0.01	50.0	0.00	7.466	9.387	0.166	8.236	0.146	3.733	0.166	16.583
398	155	0.01	50.0	0.00	20.777	11.036	0.369	15.715	0.414	10.388	0.369	36.866
399	156	0.04	50.0	0.00	0.059	7.750	0.008	3.706	0.258	0.029	0.008	0.209
502	302	1.61	32.0	0.70	0.000	0.700	0.000	0.697	1.864	0.223	1.864	1.158
521	321	1.06	32.0	0.70	0.000	0.700	0.000	0.697	1.227	0.223	1.227	1.158
595	395	0.24	32.0	0.70	0.000	0.700	0.000	0.697	0.278	0.223	0.278	1.158
602	302	0.23	100.0	0.70	0.000	0.000	0.000	0.698	0.834	0.698	0.834	3.626
621	321	0.15	100.0	0.70	0.000	0.000	0.000	0.698	0.544	0.698	0.544	3.626
695	395											

510	310	0.73	32.0	0.70	0.000	0.700	0.000	0.694	0.734	0.222	0.734	1.006
519	319	0.75	32.0	0.70	0.000	0.700	0.000	0.697	0.867	0.223	0.867	1.156
520	320	0.41	32.0	0.70	0.000	0.700	0.000	0.697	0.474	0.223	0.474	1.157
537	337	0.92	32.0	0.70	0.000	0.700	0.000	0.697	1.062	0.223	1.062	1.155
594	394	1.14	32.0	0.70	0.000	0.700	0.000	0.697	1.318	0.223	1.318	1.156
601	301	0.20	100.0	0.70	0.000	0.000	0.000	0.698	0.725	0.698	0.725	3.626
603	303	0.07	100.0	0.70	0.000	0.000	0.000	0.698	0.254	0.698	0.254	3.626
604	304	0.07	100.0	0.70	0.000	0.000	0.000	0.698	0.254	0.698	0.254	3.626
610	310	0.02	100.0	0.70	0.000	0.000	0.000	0.698	0.073	0.698	0.073	3.626
619	319	0.09	100.0	0.70	0.000	0.000	0.000	0.698	0.326	0.698	0.326	3.626
620	320	0.05	100.0	0.70	0.000	0.000	0.000	0.698	0.181	0.698	0.181	3.626
637	337	0.10	100.0	0.70	0.000	0.000	0.000	0.698	0.363	0.698	0.363	3.626
694	394	0.14	100.0	0.70	0.000	0.000	0.000	0.698	0.508	0.698	0.508	3.626
522	322	1.10	32.0	0.70	0.000	0.700	0.000	0.697	1.273	0.223	1.273	1.157
523	323	1.38	32.0	0.70	0.000	0.700	0.000	0.697	1.592	0.223	1.592	1.154
524	324	1.26	32.0	0.70	0.000	0.700	0.000	0.697	1.456	0.223	1.456	1.156
525	325	1.38	32.0	0.70	0.000	0.700	0.000	0.697	1.592	0.223	1.592	1.154
526	326	1.26	32.0	0.70	0.000	0.700	0.000	0.697	1.456	0.223	1.456	1.156
527	327	1.47	32.0	0.70	0.000	0.700	0.000	0.697	1.696	0.223	1.696	1.154
528	328	1.02	32.0	0.70	0.000	0.700	0.000	0.696	1.172	0.223	1.172	1.149
529	329	0.92	32.0	0.70	0.000	0.700	0.000	0.697	1.062	0.223	1.062	1.154
530	330	0.94	32.0	0.70	0.000	0.700	0.000	0.697	1.085	0.223	1.085	1.154
531	331	0.41	32.0	0.70	0.000	0.700	0.000	0.697	0.474	0.223	0.474	1.156
533	333	0.44	32.0	0.70	0.000	0.700	0.000	0.697	0.508	0.223	0.508	1.154
536	336	0.67	32.0	0.70	0.000	0.700	0.000	0.697	0.775	0.223	0.775	1.157
622	322	0.15	100.0	0.70	0.000	0.000	0.000	0.698	0.544	0.698	0.544	3.626
623	323	0.15	100.0	0.70	0.000	0.000	0.000	0.698	0.544	0.698	0.544	3.626
624	324	0.15	100.0	0.70	0.000	0.000	0.000	0.698	0.544	0.698	0.544	3.626
625	325	0.15	100.0	0.70	0.000	0.000	0.000	0.698	0.544	0.698	0.544	3.626
626	326	0.15	100.0	0.70	0.000	0.000	0.000	0.698	0.544	0.698	0.544	3.626
627	327	0.16	100.0	0.70	0.000	0.000	0.000	0.698	0.580	0.698	0.580	3.626
628	328	0.10	100.0	0.70	0.000	0.000	0.000	0.698	0.363	0.698	0.363	3.626
629	329	0.10	100.0	0.70	0.000	0.000	0.000	0.698	0.363	0.698	0.363	3.626
630	330	0.10	100.0	0.70	0.000	0.000	0.000	0.698	0.363	0.698	0.363	3.626
631	331	0.05	100.0	0.70	0.000	0.000	0.000	0.698	0.181	0.698	0.181	3.626
633	333	0.05	100.0	0.70	0.000	0.000	0.000	0.698	0.181	0.698	0.181	3.626
636	336	0.09	100.0	0.70	0.000	0.000	0.000	0.698	0.326	0.698	0.326	3.626
505	305	0.89	32.0	0.70	0.000	0.700	0.000	0.697	1.027	0.223	1.027	1.154
506	306	1.24	32.0	0.70	0.000	0.700	0.000	0.697	1.434	0.223	1.434	1.156
507	307	2.15	32.0	0.70	0.000	0.700	0.000	0.697	2.476	0.223	2.476	1.152
508	308	1.10	32.0	0.70	0.000	0.700	0.000	0.696	1.266	0.223	1.266	1.151
509	309	0.73	32.0	0.70	0.000	0.700	0.000	0.697	0.843	0.223	0.843	1.154
511	311	0.67	32.0	0.70	0.000	0.700	0.000	0.697	0.774	0.223	0.774	1.155
512	312	0.66	32.0	0.70	0.000	0.700	0.000	0.697	0.762	0.223	0.762	1.154
513	313	0.60	32.0	0.70	0.000	0.700	0.000	0.697	0.692	0.223	0.692	1.154
514	314	0.76	32.0	0.70	0.000	0.700	0.000	0.697	0.876	0.223	0.876	1.153
515	315	0.72	32.0	0.70	0.000	0.700	0.000	0.694	0.727	0.222	0.727	1.009
516	316	0.56	32.0	0.70	0.000	0.700	0.000	0.697	0.646	0.223	0.646	1.154
517	317	0.61	32.0	0.70	0.000	0.700	0.000	0.697	0.705	0.223	0.705	1.155
518	318	0.51	32.0	0.70	0.000	0.700	0.000	0.697	0.590	0.223	0.590	1.157
592	392	0.50	32.0	0.70	0.000	0.700	0.000	0.697	0.578	0.223	0.578	1.156
593	393	0.47	32.0	0.70	0.000	0.700	0.000	0.697	0.544	0.223	0.544	1.157
605	305	0.10	100.0	0.70	0.000	0.000	0.000	0.698	0.363	0.698	0.363	3.626
606	306	0.16	100.0	0.70	0.000	0.000	0.000	0.698	0.580	0.698	0.580	3.626
607	307	0.22	100.0	0.70	0.000	0.000	0.000	0.698	0.798	0.698	0.798	3.626
608	308	0.11	100.0	0.70	0.000	0.000	0.000	0.698	0.399	0.698	0.399	3.626
609	309	0.08	100.0	0.70	0.000	0.000	0.000	0.698	0.290	0.698	0.290	3.626
611	311	0.08	100.0	0.70	0.000	0.000	0.000	0.698	0.290	0.698	0.290	3.626
612	312	0.07	100.0	0.70	0.000	0.000	0.000	0.698	0.254	0.698	0.254	3.626
613	313	0.07	100.0	0.70	0.000	0.000	0.000	0.698	0.254	0.698	0.254	3.626
614	314	0.08	100.0	0.70	0.000	0.000	0.000	0.698	0.290	0.698	0.290	3.626
615	315	0.02	100.0	0.70	0.000	0.000	0.000	0.698	0.073	0.698	0.073	3.626
616	316	0.06	100.0	0.70	0.000	0.000	0.000	0.698	0.218	0.698	0.218	3.626
617	317	0.07	100.0	0.70	0.000	0.000	0.000	0.698	0.254	0.698	0.254	3.626
618	318	0.07	100.0	0.70	0.000	0.000	0.000	0.698	0.254	0.698	0.254	3.626
692	392	0.06	100.0	0.70	0.000	0.000	0.000	0.698	0.218	0.698	0.218	3.626
693	393	0.06	100.0	0.70	0.000	0.000	0.000	0.698	0.218	0.698	0.218	3.626
6001	1	0.34	100.0	0.70	0.000	0.000	0.000	0.699	1.233	0.699	1.233	3.626
6002	2	0.34	100.0	0.70	0.000	0.000	0.000	0.699	1.233	0.699	1.233	3.626
6003	3	0.34	100.0	0.70	0.000	0.000	0.000	0.699	1.233	0.699	1.233	3.626
6004	4	0.34	100.0	0.70	0.000	0.000	0.000	0.699	1.233	0.699	1.233	3.626
6005	5	0.34	100.0	0.70	0.000	0.000	0.000	0.699	1.233	0.699	1.233	3.626
6006	6	0.34	100.0	0.70	0.000	0.000	0.000	0.699	1.233	0.699	1.233	3.626
538	338	1.06	32.0	0.70	0.000	0.700	0.000	0.697	1.223	0.223	1.223	1.154
539	339	0.63	32.0	0.70	0.000	0.700	0.000	0.697	0.725	0.223	0.725	1.151
540	340	0.93	32.0	0.70	0.000	0.700	0.000	0.697	1.073	0.223	1.073	1.154
541	341	0.66	32.0	0.70	0.000	0.700	0.000	0.697	0.764	0.223	0.764	1.157
542	342	0.75	32.0	0.70	0.000	0.700	0.000	0.697	0.866	0.223	0.866	1.155
543	343	0.63	32.0	0.70	0.000	0.700	0.000	0.697	0.725	0.223	0.725	1.152
544	344	0.71	32.0	0.70	0.000	0.700	0.000	0.697	0.821	0.223	0.821	1.156
545	345	0.68	32.0	0.70	0.000	0.700	0.000	0.697	0.787	0.223	0.787	1.157
546	346	0.96	32.0	0.70	0.000	0.700	0.000	0.697	1.107	0.223	1.107	1.153
547	347	0.91	32.0	0.70	0.000	0.700	0.000	0.697	1.050	0.223	1.050	1.154
548	348	0.78	32.0	0.70	0.000	0.700	0.000	0.696	0.898	0.223	0.898	1.151
549	349	0.72	32.0	0.70	0.000	0.700	0.000	0.697	0.832	0.223	0.832	1.156
550	350	0.71	32.0	0.70	0.000	0.700	0.000	0.697	0.821	0.223	0.821	1.156
551	351	0.40	32.0	0.70	0.000	0.700	0.000	0.697</td				

560	360	0.84	32.0	0.70	0.000	0.700	0.000	0.697	0.969	0.223	0.969	1.153
561	361	0.81	32.0	0.70	0.000	0.700	0.000	0.697	0.935	0.223	0.935	1.154
562	362	0.74	32.0	0.70	0.000	0.700	0.000	0.697	0.855	0.223	0.855	1.156
563	363	0.74	32.0	0.70	0.000	0.700	0.000	0.697	0.855	0.223	0.855	1.156
564	364	0.87	32.0	0.70	0.000	0.700	0.000	0.697	1.002	0.223	1.002	1.152
565	365	0.97	32.0	0.70	0.000	0.700	0.000	0.696	1.114	0.223	1.114	1.149
598	398	0.44	32.0	0.70	0.000	0.700	0.000	0.697	0.510	0.223	0.510	1.160
599	399	0.36	32.0	0.70	0.000	0.700	0.000	0.698	0.418	0.223	0.418	1.160
638	338	0.12	100.0	0.70	0.000	0.000	0.000	0.698	0.435	0.698	0.435	3.626
639	339	0.06	100.0	0.70	0.000	0.000	0.000	0.698	0.218	0.698	0.218	3.626
640	340	0.10	100.0	0.70	0.000	0.000	0.000	0.698	0.363	0.698	0.363	3.626
641	341	0.09	100.0	0.70	0.000	0.000	0.000	0.698	0.326	0.698	0.326	3.626
642	342	0.09	100.0	0.70	0.000	0.000	0.000	0.698	0.326	0.698	0.326	3.626
643	343	0.06	100.0	0.70	0.000	0.000	0.000	0.698	0.218	0.698	0.218	3.626
644	344	0.09	100.0	0.70	0.000	0.000	0.000	0.698	0.326	0.698	0.326	3.626
645	345	0.09	100.0	0.70	0.000	0.000	0.000	0.698	0.326	0.698	0.326	3.626
646	346	0.10	100.0	0.70	0.000	0.000	0.000	0.698	0.363	0.698	0.363	3.626
647	347	0.10	100.0	0.70	0.000	0.000	0.000	0.698	0.363	0.698	0.363	3.626
648	348	0.08	100.0	0.70	0.000	0.000	0.000	0.698	0.290	0.698	0.290	3.626
649	349	0.09	100.0	0.70	0.000	0.000	0.000	0.698	0.326	0.698	0.326	3.626
650	350	0.09	100.0	0.70	0.000	0.000	0.000	0.698	0.326	0.698	0.326	3.626
651	351	0.05	100.0	0.70	0.000	0.000	0.000	0.698	0.181	0.698	0.181	3.626
652	352	0.10	100.0	0.70	0.000	0.000	0.000	0.698	0.363	0.698	0.363	3.626
653	353	0.12	100.0	0.70	0.000	0.000	0.000	0.698	0.435	0.698	0.435	3.626
654	354	0.09	100.0	0.70	0.000	0.000	0.000	0.698	0.326	0.698	0.326	3.626
655	355	0.09	100.0	0.70	0.000	0.000	0.000	0.698	0.326	0.698	0.326	3.626
656	356	0.09	100.0	0.70	0.000	0.000	0.000	0.698	0.326	0.698	0.326	3.626
657	357	0.09	100.0	0.70	0.000	0.000	0.000	0.698	0.326	0.698	0.326	3.626
658	358	0.09	100.0	0.70	0.000	0.000	0.000	0.698	0.326	0.698	0.326	3.626
659	359	0.09	100.0	0.70	0.000	0.000	0.000	0.698	0.326	0.698	0.326	3.626
660	360	0.09	100.0	0.70	0.000	0.000	0.000	0.698	0.326	0.698	0.326	3.626
661	361	0.09	100.0	0.70	0.000	0.000	0.000	0.698	0.326	0.698	0.326	3.626
662	362	0.09	100.0	0.70	0.000	0.000	0.000	0.698	0.326	0.698	0.326	3.626
663	363	0.09	100.0	0.70	0.000	0.000	0.000	0.698	0.326	0.698	0.326	3.626
664	364	0.09	100.0	0.70	0.000	0.000	0.000	0.698	0.326	0.698	0.326	3.626
665	365	0.09	100.0	0.70	0.000	0.000	0.000	0.698	0.326	0.698	0.326	3.626
696	396	0.40	100.0	0.70	0.000	0.000	0.000	0.697	1.447	0.697	1.447	3.617
697	397	0.08	100.0	0.70	0.000	0.000	0.000	0.697	0.290	0.697	0.290	3.622
698	398	0.09	100.0	0.70	0.000	0.000	0.000	0.698	0.326	0.698	0.326	3.626
699	399	0.12	100.0	0.70	0.000	0.000	0.000	0.698	0.435	0.698	0.435	3.626

*** NOTE *** IMPERVIOUS AREA STATISTICS AGGREGATE IMPERVIOUS AREAS WITH AND WITHOUT DEPRESSION STORAGE

SUMMARY STATISTICS FOR CHANNEL/PIPES

RATIO OF FULL TO MAX. CHANNEL FLOW TO FULL NUMBER	FULL DEPTH	FULL VELOCITY	FULL DEPTH	COMPUTED INFLOW	COMPUTED OUTFLOW	COMPUTED DEPTH	COMPUTED VELOCITY	TIME OCCURRENCE	LENGTH SURCHARGE	MAX. VOLUME	FULL FLOW
6				1.23				9/27/2003 0.04			
5				1.23				9/27/2003 0.04			
4				1.23				9/27/2003 0.04			
3				1.23				9/27/2003 0.04			
2				1.23				9/27/2003 0.04			
1				1.23				9/27/2003 0.04			
156				0.01				9/27/2003 0.32			
155				0.37				9/27/2003 0.24			
120				0.19				9/27/2003 0.32			
149				0.47				9/27/2003 0.33			
130				0.64				9/27/2003 0.31			
129				0.38				9/27/2003 0.31			
128				0.43				9/27/2003 0.31			
127				0.74				9/27/2003 0.32			
126				0.82				9/27/2003 0.32			
125				0.36				9/27/2003 0.31			
124				0.41				9/27/2003 0.31			
123				0.45				9/27/2003 0.31			

122	0.34	9/27/2003 0.31
121	0.78	9/27/2003 0.32
147	0.33	9/27/2003 0.33
109	0.41	9/27/2003 0.32
108	0.31	9/27/2003 0.31
103	0.33	9/27/2003 0.31
107	0.39	9/27/2003 0.31
146	0.23	9/27/2003 0.31
101	0.55	9/27/2003 0.33
102	0.39	9/27/2003 0.38
113	0.09	9/27/2003 0.32
117	0.39	9/27/2003 0.32
116	0.31	9/27/2003 0.32
115	0.44	9/27/2003 0.33
114	0.34	9/27/2003 0.34
145	0.41	9/27/2003 0.34
112	0.03	9/27/2003 0.37
142	0.41	9/27/2003 0.31
106	0.37	9/27/2003 0.31
105	0.30	9/27/2003 0.31
143	0.25	9/27/2003 0.31
104	0.15	9/27/2003 0.35

TOTAL NUMBER OF CHANNELS/PIPES = 40

*** NOTE *** THE MAXIMUM FLOWS AND DEPTHS ARE CALCULATED AT THE END OF THE TIME INTERVAL

(Rainfall hyetograph and runoff hydrograph removed for space considerations and illegibility)

====> Runoff simulation ended normally.

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*****
* Entry made to the EXTENDED TRANSPORT MODEL (EXTRAN) *
* developed 1973 by Camp, Dresser and McKee (CDM) with *
* modifications 1977-1991 by the University of Florida. *
*
* Most recent update: March 2002 by CDM and Oregon *
* State University *
*
* "Smooth runs the water where the brook is deep." *
* Shakespeare, Henry VI, II, III, 1 *
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ENVIRONMENTAL PROTECTION AGENCY**** EXTENDED TRANSPORT PROGRAM ****WATER RESOURCES DIVISION
WASHINGTON, D.C. **** **** CAMP DRESSER & MCKEE INC.
**** ANALYSIS MODULE **** ANNANDALE, VIRGINIA

NORTH BASIN RUN
INITIAL CONDITIONS CORRISPOND TO 3.36FT GWT

Control information for simulation

Integration cycles..... 7200
Length of integration step is..... 1.00 seconds
Simulation length..... 2.00 hours

Do not create equiv. pipes(NEQUAL)... 0

Use U.S. customary units for I/O... 0

Printing starts in cycle..... 1

Intermediate printout intervals of 999999999 cycles
Intermediate printout intervals of ***** minutes

Summary printout intervals of..... 60 cycles
Summary printout time interval of.. 1.00 minutes

Hot start file parameter (JRDO)... 0

Initial time (TZERO)..... 0.00 hours
This is time displacement from JIN interface file starting date/time when
interface file is used.

This also describes starting hour in K3 line hydrograph input when K3
lines are used.

Initial date (IDATZ)..... 20030927 (yr/mo/day)
NOTE: Initial date from JIN interface file will be used, if accessed,
unless IDATZ is negative.

Iteration variables: ITMAX..... 30
SURTOL..... 0.0500

Default surface area of junctions.... 12.57 square feet.

EXTRAN VERSION 3.3 SOLUTION. (ISOL = 0).
Sum of junction flow is zero during surcharge.

NORMAL FLOW OPTION WHEN THE WATER
SURFACE SLOPE IS LESS THAN THE

GROUND SURFACE SLOPE (KSUPER=0)....

NJSW INPUT HYDROGRAPH JUNCTIONS.... 0

Printed output for the following 1 Conduits

254

Water surface elevations will be plotted for the following 1 Junctions

7

Flow rate will be plotted for the following 1 Conduits

254

INTERMEDIATE HEADER LINES ARE EXCLUDED FROM JUNCTION AND CONDUIT INPUT AND OUTPUT SUMMARY TABLES
IDS ARE WRITTEN AS IN ORIGINAL PROGRAM
PROGRAM USES IRREGULAR SECTION LENGTHS SPECIFIED ON THE C1 LINES (IWLEN = 2)
JELEV = 0 (DEFAULT). STANDARD INPUTS ARE DEPTHS NOT ELEVATIONS
JDOWN = 0 - Minimum of normal or critical depth will be used at free outfalls (II).
Characteristic depth for M2 and S2 water surface profiles will be computed as in previous versions of EXTRAN (IM2 = 0).

SEDIMENT DEPTHS WILL NOT BE READ FROM C1 LINES
Intermediate continuity output will not be created
NORTH BASIN RUN
INITIAL CONDITIONS CORRISPOND TO 3.36FT GWT

INP TRAPEZOID NUM SIDE SLOPES	CONDUIT NUMBER	LENGTH (FT)	CONDUIT CLASS	AREA (SQ FT)	MANNING COEF.	MAX WIDTH (FT)	DEPTH (FT)	JUNCTIONS		INVERT HEIGHT ABOVE JUNCTIONS
								AT THE ENDS	---	
1	207	175.	CIRCULAR	1.39	0.01200	1.33	1.33	104	143	
2	208	46.	CIRCULAR	2.19	0.01400	1.67	1.67	143	144	
3	209	23.	CIRCULAR	2.19	0.01400	1.67	1.67	144	2	0.00 3.20
4	210	46.	CIRCULAR	1.77	0.01300	1.50	1.50	105	106	0.00 0.58
5	211	46.	CIRCULAR	3.14	0.01500	2.00	2.00	106	142	0.00 0.08
6	239	91.	CIRCULAR	3.14	0.01100	2.00	2.00	142	1	0.00 2.18
7	212	23.	CIRCULAR	4.91	0.01600	2.50	2.50	4	110	2.28 0.17
8	213	46.	CIRCULAR	4.91	0.01600	2.50	2.50	110	111	
9	214	108.	CIRCULAR	4.91	0.01600	2.50	2.50	113	111	0.00 0.08
10	215	46.	CIRCULAR	0.79	0.01100	1.00	1.00	112	113	0.00 1.08
11	216	64.	CIRCULAR	4.91	0.01600	2.50	2.50	145	113	
12	217	180.	CIRCULAR	3.14	0.01500	2.00	2.00	114	145	0.00 0.92
13	218	46.	CIRCULAR	3.14	0.01500	2.00	2.00	115	114	0.00 1.00
14	219	180.	CIRCULAR	1.77	0.01300	1.50	1.50	116	115	0.08 1.00
15	220	46.	CIRCULAR	1.39	0.01200	1.33	1.33	117	116	
16	238	23.	CIRCULAR	4.91	0.01600	2.50	2.50	111	3	0.00 1.75
17	201	46.	CIRCULAR	1.77	0.01300	1.50	1.50	101	102	
18	202	46.	CIRCULAR	1.39	0.01200	1.33	1.33	103	102	0.00 0.83
19	203	292.	CIRCULAR	3.14	0.01500	2.00	2.00	102	146	0.25 0.08
20	204	270.	CIRCULAR	3.14	0.01500	2.00	2.00	146	107	
21	205	54.	CIRCULAR	3.14	0.01500	2.00	2.00	108	107	
22	206	60.	CIRCULAR	4.91	0.01600	2.50	2.50	107	109	
23	237	89.	CIRCULAR	4.91	0.01600	2.50	2.50	109	5	0.00 2.28
24	235	46.	CIRCULAR	7.07	0.01800	3.00	3.00	120	152	
25	236	23.	CIRCULAR	7.07	0.01800	3.00	3.00	6	120	1.36 0.08
26	241	127.	CIRCULAR	7.07	0.01800	3.00	3.00	152	153	
27	242	46.	CIRCULAR	7.07	0.01800	3.00	3.00	153	154	
28	243	127.	CIRCULAR	7.07	0.01800	3.00	3.00	154	157	
29	244	46.	CIRCULAR	1.08	0.01200	1.17	1.17	155	156	
30	245	670.	CIRCULAR	1.23	0.01200	1.25	1.25	156	147	0.12 0.00
31	246	46.	CIRCULAR	7.07	0.01800	3.00	3.00	157	158	
32	247	127.	CIRCULAR	7.07	0.01800	3.00	3.00	158	159	
33	248	46.	CIRCULAR	7.07	0.01800	3.00	3.00	159	160	
34	249	127.	CIRCULAR	7.07	0.01800	3.00	3.00	160	161	
35	250	46.	CIRCULAR	7.07	0.01800	3.00	3.00	161	162	
36	251	127.	CIRCULAR	7.07	0.01800	3.00	3.00	162	163	
37	252	46.	CIRCULAR	7.07	0.01800	3.00	3.00	163	164	
38	253	127.	CIRCULAR	7.07	0.01800	3.00	3.00	164	165	
39	254	81.	CIRCULAR	7.07	0.01800	3.00	3.00	165	7	
40	267	195.	TRAPEZOID	378.00	0.02500	60.00	6.00	2	1	
0.50	0.50									
41	268	307.	TRAPEZOID	378.00	0.02500	60.00	6.00	1	4	
0.50	0.50									
42	269	196.	TRAPEZOID	378.00	0.02500	60.00	6.00	3	5	
0.50	0.50									
43	270	290.	TRAPEZOID	378.00	0.02500	60.00	6.00	5	6	
0.50	0.50									

* Conduit Volume *

Input full depth volume..... 3.8855E+05 cubic feet

==> Warning !! The upstream and downstream junctions for the following conduits have been reversed to correspond to the positive flow and decreasing slope EXTRAN convention. A negative flow in the output thus means

the flow was from your original upstream junction to your original downstream junction. Any initial flow has been multiplied by -1.

1. Conduit #... 209 has been changed.
 2. Conduit #... 211 has been changed.
 3. Conduit #... 212 has been changed.
 4. Conduit #... 213 has been changed.
 5. Conduit #... 216 has been changed.
 6. Conduit #... 217 has been changed.
 7. Conduit #... 218 has been changed.
 8. Conduit #... 219 has been changed.
 9. Conduit #... 236 has been changed.
 Conduit #... 242 has zero slope. 0.001 feet added to upstream invert.
 Conduit #... 246 has zero slope. 0.001 feet added to upstream invert.
 Conduit #... 248 has zero slope. 0.001 feet added to upstream invert.
 Conduit #... 250 has zero slope. 0.001 feet added to upstream invert.

1

 * Junction Data *

INP NUM	JUNCTION NUMBER	GROUND ELEV.	CROWN ELEV.	INVERT ELEV.	QINST CFS	INITIAL DEPTH(FT)	CONNECTING CONDUITS
1	104	6.32	5.32	3.99	0.00	0.00	207
2	143	6.22	5.52	3.85	0.00	0.00	207 208
3	144	6.24	4.82	3.15	0.00	0.19	208 209
4	2	6.00	6.00	0.00	0.00	3.34	209 267
5	105	6.29	5.48	3.98	0.00	0.00	210
6	106	6.39	5.22	3.14	0.00	0.20	210 211
7	142	6.13	5.17	3.09	0.00	0.25	211 239
8	1	6.00	6.00	0.00	0.00	3.34	239 267 268
9	110	6.66	5.04	2.37	0.00	0.97	212 213
10	111	6.62	5.04	2.46	0.00	0.88	213 214 238
11	112	6.86	5.44	4.44	0.00	0.00	215
12	113	6.45	5.20	2.70	0.00	0.64	214 215 216
13	114	6.33	6.08	3.08	0.00	0.26	217 218
14	115	6.32	5.73	3.23	0.00	0.11	218 219
15	116	6.33	5.41	3.83	0.00	0.00	219 220
16	117	6.36	5.48	4.15	0.00	0.00	220
17	145	6.22	5.35	2.43	0.00	0.91	216 217
18	3	6.00	6.00	0.00	0.00	3.34	238 269
19	4	6.00	6.00	0.00	0.00	3.34	212 268
20	101	6.08	5.58	4.08	0.00	0.00	201
21	102	6.15	5.65	3.40	0.00	0.00	201 202 203
22	103	6.17	5.84	4.51	0.00	0.00	202
23	107	6.40	5.82	3.32	0.00	0.02	204 205 206
24	108	5.89	5.32	3.32	0.00	0.02	205
25	109	6.31	5.23	2.73	0.00	0.61	206 237
26	146	6.58	5.62	3.54	0.00	0.00	203 204
27	5	6.00	6.00	0.00	0.00	3.34	237 269 270
28	120	6.41	4.99	1.91	0.00	1.43	235 236
29	121	6.11	0.24	0.24	0.00	3.10	
30	122	6.25	0.63	0.63	0.00	2.71	
31	123	6.13	0.05	0.05	0.00	3.29	
32	124	6.12	2.60	2.60	0.00	0.74	
33	125	6.22	0.80	0.80	0.00	2.54	
34	126	6.06	2.54	2.54	0.00	0.80	
35	127	6.28	-0.22	-0.22	0.00	3.56	
36	128	6.12	2.30	2.30	0.00	1.04	
37	129	6.25	0.00	0.00	0.00	3.34	
38	130	6.31	0.06	0.06	0.00	3.28	
39	147	6.13	2.38	1.13	0.00	2.21	245
40	149	6.38	1.96	1.96	0.00	1.38	
41	152	6.50	4.90	1.90	0.00	1.44	235 241
42	153	6.50	4.75	1.75	0.00	1.59	241 242
43	154	6.50	4.75	1.75	0.00	1.59	242 243
44	155	6.89	5.06	3.89	0.00	0.00	244
45	156	6.90	5.07	3.70	0.00	0.00	244 245
46	157	6.50	4.60	1.60	0.00	1.74	243 246
47	158	6.50	4.60	1.60	0.00	1.74	246 247 248 249 159 6.50
4.45	1.45	0.00	1.89	247	248		
49	160	6.50	4.45	1.45	0.00	1.89	248 249
50	161	6.50	4.30	1.30	0.00	2.04	249 250
51	162	6.50	4.30	1.30	0.00	2.04	250 251
52	163	6.50	4.15	1.15	0.00	2.19	251 252
53	164	6.50	4.14	1.14	0.00	2.20	252 253
54	165	6.50	4.00	1.00	0.00	2.34	253 254
55	6	6.00	6.00	0.00	0.00	3.34	236 270
56	7	6.00	3.93	0.93	0.00	2.41	254

 * STORAGE JUNCTION DATA SUMMARY *

STORAGE JUNCTION NUMBER OR NAME	JUNCTION TYPE	CONSTANT AREA (FT2)	MAXIMUM OR SURFACE	PEAK OR VOLUME (CUBIC FEET)	CROWN ELEVATION (FT)
104	CONSTANT		6.14	14.31	6.320
143	CONSTANT		6.14	14.55	6.220
144	CONSTANT		6.14	18.97	6.240
105	CONSTANT		6.14	14.18	6.290
106	CONSTANT		6.14	19.95	6.390

142	CONSTANT	6.14	18.67	6.130
110	CONSTANT	6.14	26.34	6.660
111	CONSTANT	6.14	25.54	6.620
112	CONSTANT	6.14	14.86	6.860
113	CONSTANT	6.14	23.02	6.450
114	CONSTANT	6.14	19.95	6.330
115	CONSTANT	6.14	18.97	6.320
116	CONSTANT	6.14	15.35	6.330
117	CONSTANT	6.14	13.57	6.360
145	CONSTANT	6.14	23.27	6.220
101	CONSTANT	6.14	12.28	6.080
102	CONSTANT	6.14	16.89	6.150
103	CONSTANT	6.14	10.19	6.170
107	CONSTANT	6.14	18.92	6.400
108	CONSTANT	6.14	15.78	5.890
109	CONSTANT	6.14	21.98	6.310
146	CONSTANT	6.14	18.67	6.580
120	CONSTANT	6.14	27.63	6.410
121	CONSTANT	6.14	36.04	6.110
122	CONSTANT	6.14	34.51	6.250
123	CONSTANT	6.14	37.33	6.130
124	CONSTANT	6.14	21.61	6.120
125	CONSTANT	6.14	33.28	6.220
126	CONSTANT	6.14	21.61	6.060
127	CONSTANT	6.14	39.91	6.280
128	CONSTANT	6.14	23.45	6.120
129	CONSTANT	6.14	38.38	6.250
130	CONSTANT	6.14	38.38	6.310
147	CONSTANT	6.14	30.70	6.130
149	CONSTANT	6.14	27.14	6.380
155	CONSTANT	6.14	18.42	6.890
156	CONSTANT	6.14	19.65	6.900

* ORIFICE DATA *

FROM JUNCTION	TO JUNCTION	TYPE	AREA (FT ²)	DISCHARGE COEFFICIENT	HEIGHT ABOVE JUNCTION (FT)
149	165	1	1.00	0.600	0.040
130	164	1	1.00	0.600	2.090
129	163	1	1.00	0.600	2.150
128	162	1	1.00	0.600	0.000
127	161	1	1.00	0.600	2.520
126	160	1	1.00	0.600	0.000
125	159	1	1.00	0.600	1.650
124	158	1	1.00	0.600	0.000
123	157	1	1.00	0.600	2.550
122	154	1	1.00	0.600	2.120
121	153	1	1.00	0.600	2.510
147	152	1	1.00	0.600	1.770

====> EQUIVALENT CIRCULAR PIPE INFORMATION FOR ORIFICE # 1

CONDUIT NUMBER.....	90044
PIPE DIAMETER.....	1.13
PIPE LENGTH.....	200.00
MANNINGS ROUGHNESS.....	0.00939
INVERT ELEVATION AT UPSTREAM END....	2.0000
INVERT ELEVATION AT DOWNSTREAM END...	1.9900

====> EQUIVALENT CIRCULAR PIPE INFORMATION FOR ORIFICE # 2

CONDUIT NUMBER.....	90045
PIPE DIAMETER.....	1.13
PIPE LENGTH.....	200.00
MANNINGS ROUGHNESS.....	0.00939
INVERT ELEVATION AT UPSTREAM END....	2.1500
INVERT ELEVATION AT DOWNSTREAM END...	2.1400

====> EQUIVALENT CIRCULAR PIPE INFORMATION FOR ORIFICE # 3

CONDUIT NUMBER.....	90046
PIPE DIAMETER.....	1.13
PIPE LENGTH.....	200.00
MANNINGS ROUGHNESS.....	0.00939
INVERT ELEVATION AT UPSTREAM END....	2.1500
INVERT ELEVATION AT DOWNSTREAM END...	2.1400

====> EQUIVALENT CIRCULAR PIPE INFORMATION FOR ORIFICE # 4

CONDUIT NUMBER.....	90047
PIPE DIAMETER.....	1.13
PIPE LENGTH.....	200.00
MANNINGS ROUGHNESS.....	0.00939
INVERT ELEVATION AT UPSTREAM END....	2.3000
INVERT ELEVATION AT DOWNSTREAM END...	2.2900

====> EQUIVALENT CIRCULAR PIPE INFORMATION FOR ORIFICE # 5

CONDUIT NUMBER.....	90048
PIPE DIAMETER.....	1.13
PIPE LENGTH.....	200.00
MANNINGS ROUGHNESS.....	0.00939
INVERT ELEVATION AT UPSTREAM END....	2.3000
INVERT ELEVATION AT DOWNSTREAM END...	2.2900

====> EQUIVALENT CIRCULAR PIPE INFORMATION FOR ORIFICE # 6

CONDUIT NUMBER.....	90049
PIPE DIAMETER.....	1.13
PIPE LENGTH.....	200.00
MANNINGS ROUGHNESS.....	0.00939
INVERT ELEVATION AT UPSTREAM END....	2.5400
INVERT ELEVATION AT DOWNSTREAM END...	2.5300
=====> EQUIVALENT CIRCULAR PIPE INFORMATION FOR ORIFICE # 7	
CONDUIT NUMBER.....	90050
PIPE DIAMETER.....	1.13
PIPE LENGTH.....	200.00
MANNINGS ROUGHNESS.....	0.00939
INVERT ELEVATION AT UPSTREAM END....	2.4500
INVERT ELEVATION AT DOWNSTREAM END...	2.4400
=====> EQUIVALENT CIRCULAR PIPE INFORMATION FOR ORIFICE # 8	
CONDUIT NUMBER.....	90051
PIPE DIAMETER.....	1.13
PIPE LENGTH.....	200.00
MANNINGS ROUGHNESS.....	0.00939
INVERT ELEVATION AT UPSTREAM END....	2.6000
INVERT ELEVATION AT DOWNSTREAM END...	2.5900
=====> EQUIVALENT CIRCULAR PIPE INFORMATION FOR ORIFICE # 9	
CONDUIT NUMBER.....	90052
PIPE DIAMETER.....	1.13
PIPE LENGTH.....	200.00
MANNINGS ROUGHNESS.....	0.00939
INVERT ELEVATION AT UPSTREAM END....	2.6000
INVERT ELEVATION AT DOWNSTREAM END...	2.5900
=====> EQUIVALENT CIRCULAR PIPE INFORMATION FOR ORIFICE # 10	
CONDUIT NUMBER.....	90053
PIPE DIAMETER.....	1.13
PIPE LENGTH.....	200.00
MANNINGS ROUGHNESS.....	0.00939
INVERT ELEVATION AT UPSTREAM END....	2.7500
INVERT ELEVATION AT DOWNSTREAM END...	2.7400
=====> EQUIVALENT CIRCULAR PIPE INFORMATION FOR ORIFICE # 11	
CONDUIT NUMBER.....	90054
PIPE DIAMETER.....	1.13
PIPE LENGTH.....	200.00
MANNINGS ROUGHNESS.....	0.00939
INVERT ELEVATION AT UPSTREAM END....	2.7500
INVERT ELEVATION AT DOWNSTREAM END...	2.7400
=====> EQUIVALENT CIRCULAR PIPE INFORMATION FOR ORIFICE # 12	
CONDUIT NUMBER.....	90055
PIPE DIAMETER.....	1.13
PIPE LENGTH.....	200.00
MANNINGS ROUGHNESS.....	0.00939
INVERT ELEVATION AT UPSTREAM END....	2.9000
INVERT ELEVATION AT DOWNSTREAM END...	2.8900

* FREE OUTFALL DATA (DATA GROUP II) *
* BOUNDARY CONDITION ON DATA GROUP J1 *

OUTFALL AT JUNCTION.... 7 HAS BOUNDARY CONDITION NUMBER... 1

* INTERNAL CONNECTIVITY INFORMATION *

CONDUIT	JUNCTION	JUNCTION
90044	149	165
90045	130	164
90046	129	163
90047	128	162
90048	127	161
90049	126	160
90050	125	159
90051	124	158
90052	123	157
90053	122	154
90054	121	153
90055	147	152
90056	7	0

1

* BOUNDARY CONDITON INFORMATION *
* DATA GROUPS J1-J4 *

* DOWNSTREAM BOUNDARY STAGE INFORMATION *
* FOR BOUNDARY CONDITION # 1. *

NO.	TIME (HR)	STAGE (FT)	NO.	TIME (HR)	STAGE (FT)	NO.	TIME (HR)	STAGE (FT)
-----	-----------	------------	-----	-----------	------------	-----	-----------	------------

1 0.00 3.340 2 0.22 3.340 3 0.38 3.510

#####
Header information from interface file:
#####

Title from first computational block:
RUNOFF DATA Group N catchment, RAIN DATA FROM 9/17/03 yr storm
Swale type b

Title from immediately preceding computational block:
RUNOFF DATA Group N catchment, RAIN DATA FROM 9/17/03 yr storm
Swale type b

Name of preceding block:.....Runoff Block
Initial Julian date (IDATEZ)..... 2003270
Initial time of day in seconds (TZERO)..... 0.0
No. transferred input locations..... 40
No. transferred pollutants..... 0
Size of total catchment area (acres)..... 69.15
ID numbers (JCE=0) or alphanumeric (JCE=1)..... 0

#####
Element numbers of interface inlet locations:
#####

104	143	105	106	142	112	145	114	115
116	117	113	102	101	146	107	103	108
109	147	121	122	123	124	125	126	127
128	129	130	149	120	155	156	1	2
3	4	5	6					

Conversion factor to cfs for flow units
on interface file. Multiply by: 1.00000

>>> STARTING DATE AND TIME OF EXTRAN RUN ARE:
JULIAN DATE: 2003270
YR/MO/DA: 2003/ 9/27
TIME OF DAY: 0.000 HRS
THIS IS 0.000 HOURS BEYOND INTERFACE FILE STARTING TIME
AS PROVIDED BY TZERO ON LINE B1.
TZERO = 2003270 0.000000E+00

* INITIAL MODEL CONDITION *
* INITIAL TIME = 0.00 HOURS *

JUNCTION / DEPTH / ELEVATION	==> ** JUNCTION IS SURCHARGED.	
104/ 0.00 / 3.99	143/ 0.00 / 3.85	144/ 0.19 / 3.34
2/ 3.34 / 3.34	105/ 0.00 / 3.98	106/ 0.20 / 3.34
142/ 0.25 / 3.34	1/ 3.34 / 3.34	110/ 0.97 / 3.34
111/ 0.88 / 3.34	112/ 0.00 / 4.44	113/ 0.64 / 3.34
114/ 0.26 / 3.34	115/ 0.11 / 3.34	116/ 0.00 / 3.83
117/ 0.00 / 4.15	145/ 0.91 / 3.34	3/ 3.34 / 3.34
4/ 3.34 / 3.34	101/ 0.00 / 4.08	102/ 0.00 / 3.40
103/ 0.00 / 4.51	107/ 0.02 / 3.34	108/ 0.02 / 3.34
109/ 0.61 / 3.34	146/ 0.00 / 3.54	5/ 3.34 / 3.34
120/ 1.43 / 3.34	121/ 3.10 / 3.34	122/ 2.71 / 3.34
123/ 3.29 / 3.34	124/ 0.74 / 3.34	125/ 2.54 / 3.34
126/ 0.80 / 3.34	127/ 3.56 / 3.34	128/ 1.04 / 3.34
129/ 3.34 / 3.34	130/ 3.28 / 3.34	147/ 2.21 / 3.34
149/ 1.38 / 3.34	152/ 1.44 / 3.34	153/ 1.59 / 3.34
154/ 1.59 / 3.34	155/ 0.00 / 3.89	156/ 0.00 / 3.70
157/ 1.74 / 3.34	158/ 1.74 / 3.34	159/ 1.89 / 3.34
160/ 1.89 / 3.34	161/ 2.04 / 3.34	162/ 2.04 / 3.34
163/ 2.19 / 3.34	164/ 2.20 / 3.34	165/ 2.34 / 3.34
6/ 3.34 / 3.34	7/ 2.41 / 3.34	

CONDUIT/ FLOW ==> ** CONDUIT USES THE NORMAL FLOW OPTION.

207/ 0.00	208/ 0.00	209/ 0.00	210/ 0.00
211/ 0.00	239/ 0.00	212/ 0.00	213/ 0.00
214/ 0.00	215/ 0.00	216/ 0.00	217/ 0.00
218/ 0.00	219/ 0.00	220/ 0.00	238/ 0.00
201/ 0.00	202/ 0.00	203/ 0.00	204/ 0.00
205/ 0.00	206/ 0.00	237/ 0.00	235/ 0.00
236/ 0.00	241/ 0.00	242/ 0.00	243/ 0.00
244/ 0.00	245/ 0.00	246/ 0.00	247/ 0.00
248/ 0.00	249/ 0.00	250/ 0.00	251/ 0.00
252/ 0.00	253/ 0.00	254/ 0.00	267/ 0.00
268/ 0.00	269/ 0.00	270/ 0.00	90044/ 0.00
90045/ 0.00	90046/ 0.00	90047/ 0.00	90048/ 0.00
90049/ 0.00	90050/ 0.00	90051/ 0.00	90052/ 0.00
90053/ 0.00	90054/ 0.00	90055/ 0.00	90056/ 0.00

CONDUIT/ VELOCITY

207/ 0.00	208/ 0.00	209/ 0.00	210/ 0.00
211/ 0.00	239/ 0.00	212/ 0.00	213/ 0.00
214/ 0.00	215/ 0.00	216/ 0.00	217/ 0.00
218/ 0.00	219/ 0.00	220/ 0.00	238/ 0.00
201/ 0.00	202/ 0.00	203/ 0.00	204/ 0.00
205/ 0.00	206/ 0.00	237/ 0.00	235/ 0.00
236/ 0.00	241/ 0.00	242/ 0.00	243/ 0.00
244/ 0.00	245/ 0.00	246/ 0.00	247/ 0.00
248/ 0.00	249/ 0.00	250/ 0.00	251/ 0.00

252/	0.00	253/	0.00	254/	0.00	267/	0.00
268/	0.00	269/	0.00	270/	0.00	90044/	0.00
90045/	0.00	90046/	0.00	90047/	0.00	90048/	0.00
90049/	0.00	90050/	0.00	90051/	0.00	90052/	0.00
90053/	0.00	90054/	0.00	90055/	0.00		

CONDUIT/ CROSS SECTIONAL AREA

207/	0.00	208/	0.00	209/	0.11	210/	0.00
211/	0.15	239/	0.99	212/	1.66	213/	1.65
214/	1.17	215/	0.00	216/	1.30	217/	0.00
218/	0.00	219/	0.00	220/	0.00	238/	2.42
201/	0.00	202/	0.00	203/	0.00	204/	0.00
205/	0.01	206/	0.36	237/	1.44	235/	3.34
236/	4.03	241/	3.58	242/	3.80	243/	4.03
244/	0.00	245/	0.00	246/	4.25	247/	4.47
248/	4.69	249/	4.90	250/	5.12	251/	5.32
252/	5.54	253/	5.74	254/	6.00	267/	205.98
268/	205.98	269/	205.98	270/	205.98	90044/	1.00
90045/	1.00	90046/	1.00	90047/	0.97	90048/	0.97
90049/	0.76	90050/	0.85	90051/	0.70	90052/	0.70
90053/	0.53	90054/	0.53	90055/	0.37		

CONDUIT/ HYDRAULIC RADIUS

207/	0.00	208/	0.12	209/	0.10	210/	0.00
211/	0.12	239/	0.39	212/	0.51	213/	0.50
214/	0.41	215/	0.00	216/	0.44	217/	0.16
218/	0.07	219/	0.00	220/	0.00	238/	0.62
201/	0.00	202/	0.00	203/	0.00	204/	0.02
205/	0.02	206/	0.20	237/	0.47	235/	0.73
236/	0.80	241/	0.75	242/	0.78	243/	0.80
244/	0.00	245/	0.31	246/	0.82	247/	0.84
248/	0.85	249/	0.87	250/	0.88	251/	0.89
252/	0.90	253/	0.91	254/	0.91	267/	3.05
268/	3.05	269/	3.05	270/	3.05	90044/	0.28
90045/	0.28	90046/	0.28	90047/	0.33	90048/	0.33
90049/	0.34	90050/	0.34	90051/	0.33	90052/	0.33
90053/	0.29	90054/	0.29	90055/	0.24		

CONDUIT/ UPSTREAM/ DOWNSTREAM ELEVATION

207/	3.99/	3.85	208/	3.85/	3.34	209/	3.34/	3.34
210/	3.98/	3.72	211/	3.34/	3.34	239/	3.34/	3.34
212/	3.34/	3.34	213/	3.34/	3.34	214/	3.34/	3.34
215/	4.44/	3.78	216/	3.34/	3.34	217/	3.35/	3.34
218/	4.08/	3.34	219/	4.23/	3.91	220/	4.15/	3.83
238/	3.34/	3.34	201/	4.08/	3.40	202/	4.51/	4.23
203/	3.65/	3.62	204/	3.54/	3.34	205/	3.34/	3.34
206/	3.34/	3.34	237/	3.34/	3.34	235/	3.34/	3.34
236/	3.34/	3.34	241/	3.34/	3.34	242/	3.34/	3.34
243/	3.34/	3.34	244/	3.89/	3.70	245/	3.82/	3.34
246/	3.34/	3.34	247/	3.34/	3.34	248/	3.34/	3.34
249/	3.34/	3.34	250/	3.34/	3.34	251/	3.34/	3.34
252/	3.34/	3.34	253/	3.34/	3.34	254/	3.34/	3.34
267/	3.34/	3.34	268/	3.34/	3.34	269/	3.34/	3.34
270/	3.34/	3.34	90044/	3.34/	3.34	90045/	3.34/	3.34
90046/	3.34/	3.34	90047/	3.34/	3.34	90048/	3.34/	3.34
90049/	3.34/	3.34	90050/	3.34/	3.34	90051/	3.34/	3.34
90052/	3.34/	3.34	90053/	3.34/	3.34	90054/	3.34/	3.34
90055/	3.34/	3.34						

WARNING !! SIMULATION CONTINUES AFTER THE TIME HISTORY STAGE ENDS FOR TIDAL BOUNDARY CONDITION
PROGRAM DEFAULTS TO THE LAST STAGE VALUE.

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*****
* FINAL MODEL CONDITION *
* FINAL TIME = 2.00 HOURS *
*****
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>>> ENDING DATE AND TIME OF EXTRAN RUN ARE:
JULIAN DATE: 2003270
YR/MO/DA: 2003/ 9/27
TIME OF DAY: 2.000 HRS

JUNCTION / DEPTH / ELEVATION	====> ** JUNCTION IS SURCHARGED.	
104/ 0.01 / 4.00	143/ 0.00 / 3.85	144/ 0.36 / 3.51
2/ 3.51 / 3.51	105/ 0.00 / 3.98	106/ 0.37 / 3.51
142/ 0.42 / 3.51	1/ 3.51 / 3.51	110/ 1.14 / 3.51
111/ 1.05 / 3.51	112/ 0.00 / 4.44	113/ 0.81 / 3.51
114/ 0.43 / 3.51	115/ 0.85 / 4.08	116/ 0.40 / 4.23
117/ 0.08 / 4.23	145/ 1.08 / 3.51	3/ 3.51 / 3.51
4/ 3.51 / 3.51	101/ 0.00 / 4.08	102/ 0.30 / 3.70
103/ 0.00 / 4.51	107/ 0.20 / 3.51	108/ 0.19 / 3.51
109/ 0.78 / 3.51	146/ 0.02 / 3.56	5/ 3.51 / 3.51
120/ 1.60 / 3.51	121/ 3.27 / 3.51	122/ 2.88 / 3.51
123/ 3.46 / 3.51	124/ 0.91 / 3.51	125/ 2.71 / 3.51
126/ 0.97 / 3.51	127/ 3.73 / 3.51	128/ 1.21 / 3.51
129/ 3.50 / 3.50	130/ 3.44 / 3.50	147/ 2.38 / 3.51
149/ 1.55 / 3.51	152/ 1.61 / 3.51	153/ 1.76 / 3.51
154/ 1.76 / 3.51	155/ 0.00 / 3.89	156/ 0.13 / 3.83
157/ 1.91 / 3.51	158/ 1.91 / 3.51	159/ 2.06 / 3.51
160/ 2.06 / 3.51	161/ 2.21 / 3.51	162/ 2.21 / 3.51
163/ 2.36 / 3.51	164/ 2.37 / 3.51	165/ 2.51 / 3.51
6/ 3.51 / 3.51	7/ 2.58 / 3.51	

CONDUIT/ FLOW ==> ** CONDUIT USES THE NORMAL FLOW OPTION.

207/	0.00	208/	0.00*	209/	0.01	210/	0.00
211/	0.01	239/	0.01	212/	-0.06	213/	-0.07
214/	-0.01	215/	0.00	216/	0.00	217/	0.00
218/	0.00	219/	0.00	220/	0.00	238/	0.06
201/	0.00*	202/	0.00	203/	0.00	204/	0.00*
205/	0.00	206/	-0.02	237/	0.01	235/	0.11
236/	-0.11	241/	0.10	242/	0.12	243/	0.13
244/	0.00*	245/	0.00*	246/	0.12	247/	0.11
248/	0.10	249/	0.11	250/	0.08	251/	0.11
252/	0.14	253/	0.14	254/	0.15	267/	0.00
268/	-0.26	269/	0.16	270/	0.01	90044/	0.00
90045/	0.00	90046/	0.00	90047/	-0.01	90048/	-0.01
90049/	0.01	90050/	0.02	90051/	0.01	90052/	0.00
90053/	0.00	90054/	0.01	90055/	0.00	90056/	0.15
CONDUIT/ VELOCITY							
207/	0.10	208/	0.00	209/	0.02	210/	0.00
211/	0.03	239/	0.01	212/	-0.03	213/	-0.03
214/	-0.01	215/	0.00	216/	0.00	217/	0.00
218/	0.00	219/	0.00	220/	-0.02	238/	0.02
201/	0.00	202/	0.00	203/	0.12	204/	0.03
205/	-0.01	206/	-0.03	237/	0.01	235/	0.03
236/	-0.02	241/	0.02	242/	0.03	243/	0.03
244/	0.00	245/	0.00	246/	0.03	247/	0.02
248/	0.02	249/	0.02	250/	0.01	251/	0.02
252/	0.02	253/	0.02	254/	0.02	267/	0.00
268/	0.00	269/	0.00	270/	0.00	90044/	0.00
90045/	0.00	90046/	0.00	90047/	-0.01	90048/	-0.01
90049/	0.01	90050/	0.02	90051/	0.01	90052/	0.01
90053/	0.00	90054/	0.01	90055/	0.00		
CONDUIT/ CROSS SECTIONAL AREA							
207/	0.00	208/	0.13	209/	0.31	210/	0.00
211/	0.38	239/	1.33	212/	2.09	213/	2.08
214/	1.58	215/	0.00	216/	1.71	217/	0.29
218/	0.49	219/	0.00	220/	0.17	238/	2.85
201/	0.00	202/	0.00	203/	0.01	204/	0.07
205/	0.16	206/	0.68	237/	1.85	235/	3.86
236/	4.54	241/	4.10	242/	4.32	243/	4.54
244/	0.00	245/	0.62	246/	4.75	247/	4.97
248/	5.18	249/	5.38	250/	5.58	251/	5.78
252/	5.97	253/	6.15	254/	6.39	267/	216.74
268/	216.81	269/	216.86	270/	216.92	90044/	1.00
90045/	1.00	90046/	1.00	90047/	1.00	90048/	1.00
90049/	0.92	90050/	0.98	90051/	0.87	90052/	0.87
90053/	0.72	90054/	0.73	90055/	0.56		
CONDUIT/ FINAL VOLUME							
207/	0.18	208/	5.96	209/	7.21	210/	0.00
211/	17.66	239/	120.63	212/	47.98	213/	95.49
214/	170.14	215/	0.00	216/	110.15	217/	52.88
218/	22.49	219/	0.30	220/	7.87	238/	65.47
201/	0.07	202/	0.00	203/	3.94	204/	18.76
205/	8.64	206/	40.83	237/	164.73	235/	177.52
236/	104.38	241/	520.37	242/	198.51	243/	576.14
244/	0.04	245/	414.03	246/	218.67	247/	630.93
248/	238.09	249/	683.55	250/	256.70	251/	733.63
252/	274.83	253/	781.55	254/	517.62	267/	42264.73
268/	66560.39	269/	42505.06	270/	62906.82	90044/	200.00
90045/	200.00	90046/	200.00	90047/	200.00	90048/	200.00
90049/	183.67	90050/	195.45	90051/	173.94	90052/	173.86
90053/	144.50	90054/	145.04	90055/	112.16		
CONDUIT/ HYDRAULIC RADIUS							
207/	0.01	208/	0.11	209/	0.20	210/	0.00
211/	0.22	239/	0.46	212/	0.57	213/	0.57
214/	0.49	215/	0.00	216/	0.51	217/	0.18
218/	0.25	219/	0.19	220/	0.15	238/	0.67
201/	0.18	202/	0.00	203/	0.02	204/	0.07
205/	0.12	206/	0.30	237/	0.54	235/	0.78
236/	0.84	241/	0.80	242/	0.82	243/	0.84
244/	0.08	245/	0.31	246/	0.86	247/	0.87
248/	0.88	249/	0.89	250/	0.90	251/	0.91
252/	0.91	253/	0.91	254/	0.91	267/	3.19
268/	3.20	269/	3.20	270/	3.20	90044/	0.28
90045/	0.28	90046/	0.28	90047/	0.28	90048/	0.28
90049/	0.34	90050/	0.32	90051/	0.34	90052/	0.34
90053/	0.33	90054/	0.33	90055/	0.30		
CONDUIT/ UPSTREAM/ DOWNSTREAM ELEVATION							
207/	4.00/	3.85	208/	3.85/	3.51	209/	3.51/
210/	3.98/	3.72	211/	3.51/	3.51	239/	3.51/
212/	3.51/	3.51	213/	3.51/	3.51	214/	3.51/
215/	4.44/	3.78	216/	3.51/	3.51	217/	3.51/
218/	4.08/	4.08	219/	4.23/	4.23	220/	4.23/
238/	3.51/	3.51	201/	4.08/	3.70	202/	4.51/
203/	3.70/	3.62	204/	3.56/	3.51	205/	3.51/
206/	3.51/	3.51	237/	3.51/	3.51	235/	3.51
236/	3.51/	3.51	241/	3.51/	3.51	242/	3.51/
243/	3.51/	3.51	244/	3.89/	3.83	245/	3.83/
246/	3.51/	3.51	247/	3.51/	3.51	248/	3.51/
249/	3.51/	3.51	250/	3.51/	3.51	251/	3.51/
252/	3.51/	3.51	253/	3.51/	3.51	254/	3.51/
267/	3.51/	3.51	268/	3.51/	3.51	269/	3.51/
270/	3.51/	3.51	90044/	3.51/	3.51	90045/	3.50/

90046/	3.50/	3.51	90047/	3.51/	3.51	90048/	3.51/	3.51
90049/	3.51/	3.51	90050/	3.51/	3.51	90051/	3.51/	3.51
90052/	3.51/	3.51	90053/	3.51/	3.51	90054/	3.51/	3.51
90055/	3.51/	3.51						

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#####
# Surcharge Iteration Summary #
#####


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Maximum number of iterations in a time step.... 1
 Total number of iterations in the simulation... 14400
 Average number of iterations per time step.... 2.00
 Surcharge iterations during the simulation.... 0
 Maximum surcharge flow error during simulation.. 0.00E+00 cfs
 Total number of time steps during simulation.. 7200

1

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*****
* CONDUIT COURANT CONDITION SUMMARY *
* TIME IN MINUTES DELT > COURANT TIME STEP *
*****
* SEE BELOW FOR EXPLANATION OF COURANT TIME STEP. *
*****
```

CONDUIT #	TIME(MN)						
207	0.00	208	0.00	209	0.00	210	0.00
211	0.00	239	0.00	212	0.00	213	0.00
214	0.00	215	0.00	216	0.00	217	0.00
218	0.00	219	0.00	220	0.00	238	0.00
201	0.00	202	0.00	203	0.00	204	0.00
205	0.00	206	0.00	237	0.00	235	0.00
236	0.00	241	0.00	242	0.00	243	0.00
244	0.00	245	0.00	246	0.00	247	0.00
248	0.00	249	0.00	250	0.00	251	0.00
252	0.00	253	0.00	254	0.00	267	0.00
268	0.00	269	0.00	270	0.00	90044	0.00
90045	0.00	90046	0.00	90047	0.00	90048	0.00
90049	0.00	90050	0.00	90051	0.00	90052	0.00
90053	0.00	90054	0.00	90055	0.00		

1

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*****
* CONDUIT COURANT CONDITION SUMMARY *
*****
* COURANT = CONDUIT LENGTH *
* TIME STEP = -----
* VELOCITY + SQRT(GRVT*AREA/WIDTH) *
*****
* AVERAGE COURANT CONDITION TIME STEP(SECONDS) *
*****
```

CONDUIT #	TIME(SEC)						
207	165.03	208	12.42	209	6.55	210	69.38
211	12.69	239	13.78	212	3.57	213	7.41
214	19.05	215	45.49	216	10.79	217	43.38
218	7.44	219	41.81	220	12.61	238	3.03
201	7.76	202	66.55	203	121.01	204	88.12
205	21.31	206	11.43	237	13.85	235	6.32
236	2.74	241	16.71	242	6.05	243	16.02
244	15.66	245	72.12	246	5.80	247	15.41
248	5.59	249	14.94	250	5.39	251	14.43
252	5.21	253	13.98	254	8.79	267	18.66
268	29.37	269	18.75	270	27.73	90044	28.57
90045	29.99	90046	30.16	90047	31.87	90048	31.57
90049	35.22	90050	34.14	90051	36.77	90052	36.72
90053	40.08	90054	39.49	90055	43.91		

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*****
* EXTRAN CONTINUITY BALANCE AT THE LAST TIME STEP *
*****
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*****
* JUNCTION INFLOW, OUTFLOW OR STREET FLOODING *
*****
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JUNCTION	INFLOW, FT3
104	1.5085E+02
143	2.3518E+02
2	8.6232E+02
105	2.8431E+02
106	3.7929E+02
142	3.6345E+02
1	8.6232E+02
112	2.2817E+01
113	7.2834E+01
114	3.2701E+02
115	4.2206E+02
116	2.8136E+02

117	3.8539E+02
145	4.1360E+02
3	8.6232E+02
4	8.6232E+02
101	5.8074E+02
102	3.5746E+02
103	3.1920E+02
107	3.7076E+02
108	2.9515E+02
109	4.1233E+02
146	2.0811E+02
5	8.6232E+02
120	1.5325E+02
121	7.6633E+02
122	2.9049E+02
123	3.9994E+02
124	3.6181E+02
125	3.1506E+02
126	8.0535E+02
127	7.6724E+02
128	3.7203E+02
129	3.3708E+02
130	6.0761E+02
147	2.9255E+02
149	4.5082E+02
155	3.7710E+02
156	4.2636E+00
6	8.6232E+02

JUNCTION	OUTFLOW, FT3
-----	-----
7	5.2610E+03

```
*****
* INITIAL SYSTEM VOLUME      = 2.1205E+05 CU FT *
* TOTAL SYSTEM INFLOW VOLUME = 1.7357E+04 CU FT *
* INFLOW + INITIAL VOLUME   = 2.2940E+05 CU FT *
*****
* TOTAL SYSTEM OUTFLOW       = 5.2610E+03 CU FT *
* VOLUME LEFT IN SYSTEM     = 2.2395E+05 CU FT *
* OUTFLOW + FINAL VOLUME    = 2.2921E+05 CU FT *
*****
* ERROR IN CONTINUITY, PERCENT = 0.08 *
*****
```

TEST WRITE OF ALTERNATIVE CONTINUITY ERROR CALCULATION
VOLUME LEFT IN SYSTEM = 2.2390E+05 CU. FT.
ERROR IN CONTINUITY PERCENT = 1.07

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1
*****
* JUNCTION SUMMARY STATISTICS *
*****
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UPPERMOST JUNCTION NUMBER	MEAN GROUND ELEVATION (FT)	PIPE CROWN ELEVATION (FT)	TIME OF JUNCTION ELEVATION (FT)	FEET OF AVERAGE ELEV. (%)	FEET MAX. OCCURRENCE (HR. MIN.)	LENGTH AT MAX. SURCHARGE ELEVATION	LENGTH BELOW GROUND ELEVATION	MAXIMUM OF SURCHARGE (MIN.)	OF FLOODING (MIN.)	JUNCTION AREA (SQ. FT)
104	6.32	6.32	4.05	0.0029	4.24	0 23	0.00	2.08	0.0	0.0 1.099E+02
143	6.22	6.22	3.89	0.0020	4.02	0 19	0.00	2.20	0.0	0.0 1.267E+02
144	6.24	6.24	3.50	0.0051	3.53	0 38	0.00	2.71	0.0	0.0 8.131E+01
2	6.00	6.00	3.49	0.0010	3.53	0 37	0.00	2.48	0.0	0.0 6.221E+03
105	6.29	6.29	4.02	0.0024	4.18	0 18	0.00	2.11	0.0	0.0 4.210E+01
106	6.39	6.39	3.51	0.0053	3.60	0 18	0.00	2.79	0.0	0.0 9.323E+01
142	6.13	6.13	3.49	0.0048	3.53	0 37	0.00	2.60	0.0	0.0 1.369E+02
1	6.00	6.00	3.49	0.0007	3.53	0 38	0.00	2.48	0.0	0.0 1.604E+04
110	6.66	6.66	3.49	0.0050	3.52	0 38	0.00	3.14	0.0	0.0 1.042E+02
111	6.62	6.62	3.49	0.0066	3.52	0 41	0.00	3.10	0.0	0.0 2.349E+02
112	6.86	6.86	4.45	0.0006	4.49	0 22	0.00	2.37	0.0	0.0 2.875E+01
113	6.45	6.45	3.49	0.0028	3.52	0 42	0.00	2.93	0.0	0.0 2.240E+02
114	6.33	6.33	3.56	0.0049	3.98	0 23	0.00	2.35	0.0	0.0 3.661E+02
115	6.32	6.32	4.08	0.0069	4.48	0 21	0.00	1.84	0.0	0.0 1.096E+02
116	6.33	6.33	4.28	0.0072	4.67	0 22	0.00	1.66	0.0	0.0 3.124E+02
117	6.36	6.36	4.30	0.0078	4.67	0 21	0.00	1.69	0.0	0.0 4.890E+01
145	6.22	6.22	3.49	0.0026	3.54	0 22	0.00	2.68	0.0	0.0 2.162E+02
3	6.00	6.00	3.49	0.0007	3.53	0 41	0.00	2.48	0.0	0.0 6.265E+03
4	6.00	6.00	3.49	0.0007	3.53	0 38	0.00	2.48	0.0	0.0 9.792E+03
101	6.08	6.08	4.13	0.0140	4.42	0 23	0.00	1.66	0.0	0.0 5.029E+01
102	6.15	6.15	3.85	0.0091	4.41	0 21	0.00	1.74	0.0	0.0 3.446E+02
103	6.17	6.17	4.35	0.0034	4.72	0 18	0.00	1.45	0.0	0.0 4.075E+01
107	6.40	6.40	3.53	0.0052	3.72	0 21	0.00	2.68	0.0	0.0 3.510E+02
108	5.89	5.89	3.53	0.0074	3.73	0 21	0.00	2.16	0.0	0.0 6.230E+01
109	6.31	6.31	3.49	0.0055	3.53	0 44	0.00	2.78	0.0	0.0 1.908E+02
146	6.58	6.58	3.72	0.0064	4.25	0 23	0.00	2.33	0.0	0.0 2.685E+02
5	6.00	6.00	3.49	0.0006	3.52	0 41	0.00	2.48	0.0	0.0 1.556E+04
120	6.41	6.41	3.49	0.0017	3.53	0 40	0.00	2.88	0.0	0.0 1.219E+02
121	6.11	6.11	3.49	0.0015	3.54	0 24	0.00	2.57	0.0	0.0 1.314E+02
122	6.25	6.25	3.49	0.0014	3.52	0 43	0.00	2.73	0.0	0.0 1.314E+02
123	6.13	6.13	3.49	0.0013	3.53	0 43	0.00	2.60	0.0	0.0 1.257E+02
124	6.12	6.12	3.49	0.0021	3.52	0 43	0.00	2.60	0.0	0.0 1.257E+02
125	6.22	6.22	3.49	0.0025	3.53	0 42	0.00	2.69	0.0	0.0 1.104E+02
126	6.06	6.06	3.49	0.0030	3.56	0 22	0.00	2.50	0.0	0.0 1.209E+02
127	6.28	6.28	3.49	0.0074	3.63	0 21	0.00	2.65	0.0	0.0 7.829E+01
128	6.12	6.12	3.49	0.0092	3.53	0 43	0.00	2.59	0.0	0.0 7.828E+01
129	6.25	6.25	3.49	0.0040	3.52	0 44	0.00	2.73	0.0	0.0 1.871E+01
130	6.31	6.31	3.49	0.0052	3.54	0 20	0.00	2.77	0.0	0.0 1.871E+01
147	6.13	6.13	3.50	0.0010	3.53	0 21	0.00	2.60	0.0	0.0 3.404E+02
149	6.38	6.38	3.49	0.0048	3.52	0 25	0.00	2.86	0.0	0.0 1.871E+01
152	6.50	4.90	3.49	0.0033	3.53	0 40	0.00	2.97	0.0	0.0 3.840E+02
153	6.50	4.75	3.49	0.0028	3.52	0 42	0.00	2.98	0.0	0.0 3.842E+02
154	6.50	4.75	3.49	0.0028	3.52	0 43	0.00	2.98	0.0	0.0 3.836E+02
155	6.89	6.89	3.94	0.0023	4.14	0 14	0.00	2.75	0.0	0.0 4.134E+01
156	6.90	6.90	3.87	0.0026	4.06	0 19	0.00	2.84	0.0	0.0 4.124E+02
157	6.50	4.60	3.49	0.0034	3.52	0 42	0.00	2.98	0.0	0.0 3.758E+02
158	6.50	4.60	3.49	0.0034	3.52	0 38	0.00	2.98	0.0	0.0 3.743E+02
159	6.50	4.45	3.49	0.0039	3.52	0 42	0.00	2.98	0.0	0.0 3.551E+02
160	6.50	4.45	3.49	0.0042	3.52	0 41	0.00	2.98	0.0	0.0 3.633E+02
161	6.50	4.30	3.49	0.0099	3.52	0 36	0.00	2.98	0.0	0.0 3.140E+02
162	6.50	4.30	3.49	0.0096	3.52	0 43	0.00	2.98	0.0	0.0 3.103E+02
163	6.50	4.15	3.49	0.0040	3.52	0 43	0.00	2.98	0.0	0.0 2.450E+02
164	6.50	4.14	3.49	0.0058	3.52	0 23	0.00	2.98	0.0	0.0 2.395E+02
165	6.50	4.00	3.49	0.0029	3.51	0 23	0.00	2.99	0.0	0.0 2.726E+02
6	6.00	6.00	3.49	0.0007	3.53	0 42	0.00	2.47	0.0	0.0 9.256E+03
7	6.00	3.93	3.48	0.0008	3.51	0 22	0.00	2.49	0.0	0.0 2.077E+02

```

1
#####
# Time History of Flow and Velocity #
# Q(cfs), Vel(ft/s), Total(cubic feet) #
#####

```

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*****
* C O N D U I T S U M M A R Y S T A T I S T I C S *
*****

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CONDUIT CONDUIT NUMBER	MAXIMUM DESIGN FLOW (CFS)	TIME DESIGN VELOCITY (FPS)	MAXIMUM VERTICAL DEPTH (IN)	TIME COMPUTED FLOW (CFS)	RATIO OF COMPUTED TO MAX. TO MAX. OCCURRENCE (FPS)	MAXIMUM DEPTH ABOVE CONDUIT ENDS	LENGTH OF CONDUIT FLOW (FT)	OF NORM FLOW (MIN)	SLOPE (FT/FT)
				HR. MIN.	HR. MIN.	UPSTREAM FLOW (FT)	DOWNTREAM (FT)		
207	2.34E+00	1.68	15.960	1.44E-01	0 22	1.05	0 23	0.06	0.25
208	1.60E+01	7.31	20.040	3.71E-01	0 19	1.63	0 19	0.02	0.17
209	6.29E+00	2.87	20.040	3.70E-01	0 20	-1.36	0 19	-0.06	0.32
210	7.90E+00	4.47	18.000	3.01E-01	0 18	2.14	0 18	0.04	0.20
211	5.01E+00	1.59	24.000	-6.72E-01	0 18	-1.67	0 18	-0.13	0.36
239	2.67E+01	8.50	24.000	1.12E+00	0 19	0.97	0 19	0.04	0.44
212	3.53E+01	7.19	30.000	2.91E+00	0 24	1.47	0 24	0.08	0.98
213	1.47E+01	3.00	30.000	2.83E+00	0 25	1.43	0 25	0.19	1.06
214	1.28E+01	2.61	30.000	1.86E+00	0 22	1.21	0 22	0.15	0.82
215	5.04E+00	6.42	12.000	2.58E-02	0 22	1.65	0 22	0.01	0.05
216	2.16E+01	4.39	30.000	-1.73E+00	0 22	-0.99	0 22	-0.08	0.82
217	7.59E+00	2.42	24.000	-1.32E+00	0 23	-1.50	0 23	-0.17	0.40
218	2.67E+01	8.48	24.000	-1.05E+00	0 21	-0.89	0 21	-0.04	0.35
219	4.43E+00	2.51	18.000	-6.33E-01	0 22	-1.15	0 22	-0.14	0.29
220	6.89E+00	4.96	15.960	4.21E-01	0 19	1.16	0 8	0.06	0.52
238	5.85E+01	11.91	30.000	-1.37E+00	0 25	-0.49	0 25	-0.02	1.06
201	1.28E+01	7.23	18.000	6.56E-01	0 22	1.02	0 27	0.05	0.34
202	6.44E+00	4.64	15.960	3.30E-01	0 18	2.43	0 18	0.05	0.21
203	1.99E+00	0.63	24.000	1.18E+00	0 21	1.61	0 21	0.59	0.76
204	5.61E+00	1.79	24.000	1.33E+00	0 23	1.87	0 23	0.24	0.71
205	8.44E-01	0.27	24.000	2.98E-01	0 18	1.06	0 11	0.35	0.41
206	3.29E+01	6.71	30.000	1.88E+00	0 21	2.20	0 21	0.06	0.41
237	2.37E+01	4.82	30.000	2.25E+00	0 21	1.28	0 21	0.10	0.80
235	7.10E+00	1.00	36.000	-1.93E+00	0 23	-0.52	0 22	-0.27	1.62
236	7.97E+01	11.28	36.000	2.10E+00	0 21	0.47	0 22	0.03	1.54
241	1.66E+01	2.34	36.000	-1.45E+00	0 25	-0.36	0 25	-0.09	1.63
242	2.25E+00	0.32	36.000	1.34E+00	0 14	0.33	0 14	0.60	1.77
243	1.66E+01	2.34	36.000	1.53E+00	0 14	0.36	0 14	0.09	1.77
244	3.77E+00	3.51	14.040	3.68E-01	0 14	2.05	0 8	0.10	0.25
245	4.43E+00	3.61	15.000	3.52E-01	0 19	0.46	0 19	0.08	0.24
246	2.25E+00	0.32	36.000	1.93E+00	0 15	0.43	0 15	0.86	1.92
247	1.66E+01	2.34	36.000	2.03E+00	0 14	0.43	0 14	0.12	1.92
248	2.25E+00	0.32	36.000	2.37E+00	0 15	0.48	0 15	1.05	2.07
249	1.66E+01	2.34	36.000	2.67E+00	0 15	0.53	0 14	0.16	2.07
250	2.25E+00	0.32	36.000	3.42E+00	0 19	0.62	0 20	1.52	2.22
251	1.66E+01	2.34	36.000	3.51E+00	0 17	0.63	0 15	0.21	2.22
252	7.10E+00	1.00	36.000	3.77E+00	0 17	0.65	0 17	0.53	2.37
253	1.60E+01	2.26	36.000	4.33E+00	0 18	0.72	0 18	0.27	2.38
254	1.42E+01	2.00	36.000	4.71E+00	0 17	0.76	0 17	0.33	2.51
267	1.52E+02	0.40	72.000	-1.62E+00	0 26	-0.01	0 26	-0.01	3.52
268	1.21E+02	0.32	72.000	-2.40E+00	0 24	-0.01	0 24	-0.02	3.52
269	1.51E+02	0.40	72.000	-2.30E+00	0 24	-0.01	0 25	-0.02	3.52
270	1.24E+02	0.33	72.000	1.49E+00	0 41	0.01	0 41	0.01	3.52
90044	5.11E+00	0.48	13.541	4.74E-01	0 20	0.47	0 20	0.09	1.52
90045	5.11E+00	0.48	13.541	6.76E-01	0 20	0.68	0 20	0.13	1.39
90046	5.11E+00	0.48	13.541	3.82E-01	0 19	0.38	0 19	0.07	1.37
90047	5.11E+00	0.48	13.541	4.39E-01	0 19	0.44	0 19	0.09	1.23

90048	5.11E+00	0.48	13.541	9.08E-01	0	21	0.91	0	21	0.18	1.33	1.23	0.2	0.00005
90049	5.11E+00	0.48	13.541	8.12E-01	0	19	0.90	0	19	0.16	1.02	0.99	0.1	0.00005
90050	5.11E+00	0.48	13.541	3.59E-01	0	19	0.38	0	19	0.07	1.08	1.08	0.0	0.00005
90051	5.11E+00	0.48	13.541	4.16E-01	0	18	0.50	0	18	0.08	0.92	0.93	0.0	0.00005
90052	5.11E+00	0.48	13.541	4.39E-01	0	18	0.53	0	18	0.09	0.93	0.93	0.0	0.00005
90053	5.11E+00	0.48	13.541	3.28E-01	0	19	0.49	0	18	0.06	0.77	0.78	0.0	0.00005
90054	5.11E+00	0.48	13.541	7.81E-01	0	19	1.12	0	19	0.15	0.79	0.78	0.1	0.00005
90055	5.11E+00	0.48	13.541	6.53E-01	0	20	1.20	0	20	0.13	0.63	0.64	0.2	0.00005
90056	UNDEF	UNDEF	4.71E+00	0	17									

* SUBLITICAL AND CRITICAL FLOW ASSUMPTIONS FROM *
* SUBROUTINE HEAD. SEE FIGURE 5-4 IN THE EXTRAN *
* MANUAL FOR FURTHER INFORMATION. *

CONDUIT NUMBER	LENGTH OF DRY FLOW(MIN)	LENGTH OF SUBCRITICAL FLOW(MIN)	LENGTH OF UPSTR. CRITICAL FLOW(MIN)	LENGTH OF DOWNSTR. CRITICAL FLOW(MIN)	MEAN FLOW (CFS)	AVERAGE % CHANGE	TOTAL FLOW CUBIC FT	MAXIMUM HYDRAULIC RADIUS (FT)	MAXIMUM CROSS SECT AREA(FT2)
207	4.92	115.08	0.00	0.00	0.02	0.0017	1.4948E+02	0.1270	0.1369
208	3.85	116.15	0.00	0.00	0.05	0.0006	3.8581E+02	0.1658	0.2289
209	0.00	120.00	0.00	0.00	-0.05	0.0133	-3.7534E+02	0.2101	0.3347
210	3.78	0.00	0.00	116.22	0.04	0.0011	2.8430E+02	0.1245	0.1406
211	0.00	107.75	12.25	0.00	-0.09	0.0151	-6.5267E+02	0.2256	0.4035
239	0.00	120.00	0.00	0.00	0.14	0.0036	9.9529E+02	0.4622	1.3505
212	0.00	120.00	0.00	0.00	0.21	0.0118	1.4954E+03	0.5784	2.1151
213	0.00	120.00	0.00	0.00	0.21	0.0103	1.5133E+03	0.5767	2.1026
214	0.00	120.00	0.00	0.00	0.23	0.0105	1.6803E+03	0.4959	1.6000
215	5.43	0.00	0.00	114.57	0.00	0.0001	2.2815E+01	0.0330	0.0156
216	0.00	120.00	0.00	0.00	-0.23	0.0077	-1.6223E+03	0.5207	1.7464
217	3.68	87.50	28.82	0.00	-0.17	0.0052	-1.2272E+03	0.3638	0.8821
218	14.07	0.00	105.93	0.00	-0.13	0.0011	-9.5058E+02	0.4472	1.1729
219	17.65	0.00	102.35	0.00	-0.08	0.0040	-5.9766E+02	0.2903	0.5524
220	4.38	115.62	0.00	0.00	0.05	0.0059	3.8306E+02	0.3358	0.7104
238	0.00	120.00	0.00	0.00	0.02	0.0129	1.2701E+02	0.6734	2.8747
201	48.38	71.62	0.00	0.00	0.08	0.0101	5.8135E+02	0.3480	0.7654
202	3.75	0.88	0.00	115.37	0.04	0.0015	3.1918E+02	0.1263	0.1358
203	7.43	0.00	0.00	112.57	0.17	0.0197	1.2423E+03	0.3256	0.7312
204	4.53	115.47	0.00	0.00	0.20	0.0066	1.4468E+03	0.3201	0.7103
205	0.00	120.00	0.00	0.00	0.04	0.0295	2.8795E+02	0.2459	0.4619
206	0.00	120.00	0.00	0.00	0.29	0.0048	2.0686E+03	0.3435	0.8643
237	0.00	120.00	0.00	0.00	0.34	0.0069	2.4491E+03	0.5440	1.8890
235	0.00	120.00	0.00	0.00	-0.01	0.0334	-4.7161E+01	0.7857	3.8986
236	0.00	120.00	0.00	0.00	0.02	0.0036	1.7933E+02	0.8432	4.5741
241	0.00	120.00	0.00	0.00	0.07	0.0099	5.1018E+02	0.8072	4.1291
242	0.00	120.00	0.00	0.00	0.17	0.0926	1.1950E+03	0.8257	4.3475
243	0.00	120.00	0.00	0.00	0.19	0.0130	1.3984E+03	0.8425	4.5651
244	23.72	96.28	0.00	0.00	0.05	0.0028	3.7775E+02	0.1751	0.2179
245	6.17	113.83	0.00	0.00	0.05	0.0022	3.7563E+02	0.3454	0.7613
246	0.00	120.00	0.00	0.00	0.24	0.1361	1.7154E+03	0.8581	4.7787
247	0.00	120.00	0.00	0.00	0.28	0.0121	1.9945E+03	0.8721	4.9913
248	0.00	120.00	0.00	0.00	0.31	0.1769	2.2364E+03	0.8841	5.1975
249	0.00	120.00	0.00	0.00	0.41	0.0193	2.9664E+03	0.8936	5.4071
250	0.00	120.00	0.00	0.00	0.51	0.5166	3.6795E+03	0.9012	5.5983
251	0.00	120.00	0.00	0.00	0.56	0.0161	3.9983E+03	0.9081	5.7970
252	0.00	120.00	0.00	0.00	0.60	0.0715	4.2921E+03	0.9115	5.9917
253	0.00	120.00	0.00	0.00	0.67	0.0157	4.8575E+03	0.9127	6.1662
254	0.00	120.00	0.00	0.00	0.73	0.0184	5.2610E+03	0.9127	6.3947
267	0.00	120.00	0.00	0.00	0.03	0.0197	1.8506E+02	3.2046	217.5106
268	0.00	120.00	0.00	0.00	-0.09	0.0110	-6.8009E+02	3.2051	217.5523
269	0.00	120.00	0.00	0.00	-0.01	0.0107	-8.1176E+01	3.2055	217.5788

270	0.00	120.00	0.00	0.00	0.08	0.0112	5.5638E+02	3.2060	217.6226	
90044	0.00	120.00	0.00	0.00	0.06	0.0077	4.4765E+02	0.2821	1.0000	
90045	0.00	120.00	0.00	0.00	0.08	0.0139	6.0453E+02	0.2821	1.0000	
90046	0.00	120.00	0.00	0.00	0.05	0.0090	3.3400E+02	0.2821	1.0000	
90047	0.00	120.00	0.00	0.00	0.05	0.0131	3.6461E+02	0.3303	1.0000	
90048	0.00	120.00	0.00	0.00	0.11	0.0242	7.5947E+02	0.3303	1.0000	
90049	0.00	120.00	0.00	0.00	0.11	0.0113	7.8646E+02	0.3433	0.9320	
90050	0.00	120.00	0.00	0.00	0.04	0.0103	2.9911E+02	0.3433	0.9826	
90051	0.00	120.00	0.00	0.00	0.05	0.0070	3.4169E+02	0.3433	0.8789	
90052	0.00	120.00	0.00	0.00	0.05	0.0072	3.7990E+02	0.3433	0.8791	
90053	0.00	120.00	0.00	0.00	0.04	0.0063	2.6867E+02	0.3326	0.7359	
90054	0.00	120.00	0.00	0.00	0.10	0.0097	7.4388E+02	0.3324	0.7345	
90055	0.00	120.00	0.00	0.00	0.09	0.0060	6.1641E+02	0.3013	0.5743	
90056	UNDEFINED	UNDEFINED	UNDEFINED	UNDEFINED	0.73		5.2610E+03			

```
*****
* AVERAGE % CHANGE IN JUNCTION OR CONDUIT IS DEFINED AS: *
* CONDUIT % CHANGE ==> 100.0 ( Q(n+1) - Q(n) ) / Qfull   *
* JUNCTION % CHANGE ==> 100.0 ( Y(n+1) - Y(n) ) / Yfull   *
*****
```

The Conduit with the largest average change... 250 had 0.517 percent
The Junction with the largest average change... 101 had 0.014 percent

====> Extended Transport model simulation ended normally.

====> SWMM 4.4H simulation ended normally.
Always check output file for possible warning messages.

====> Your input file was named : in.n1.txt
====> Your output file was named: 17g.txt

```
*****
*      SWMM 4.4H Simulation Date and Time Summary *
*****
* Starting Date... July      5, 2004          *
* Time...        10:54; 2,322           *
* Ending Date... July      5, 2004          *
* Time...        10:54:24.494          *
* Elapsed Time...    0.370 minutes.       *
* Elapsed Time...    22,170 seconds.       *
*****
```

APPENDIX F

Design Storm Hyetographs

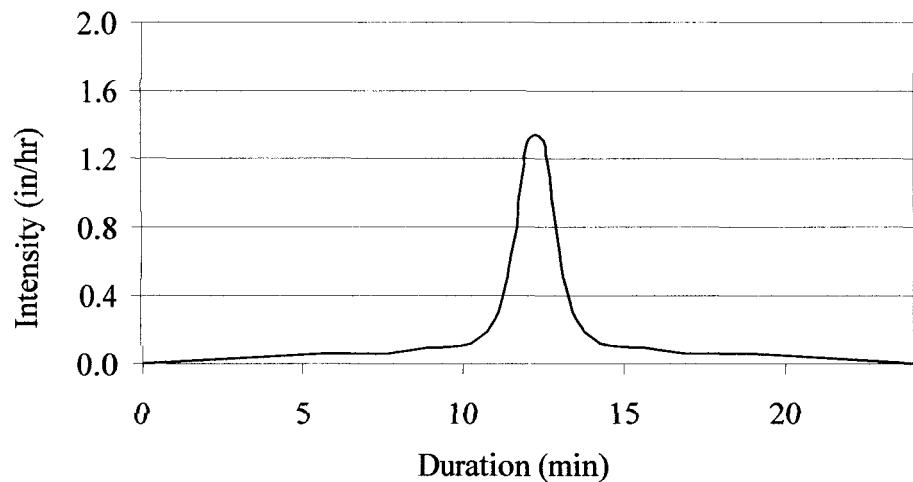


Figure F-1. 5-year design storm hyetograph

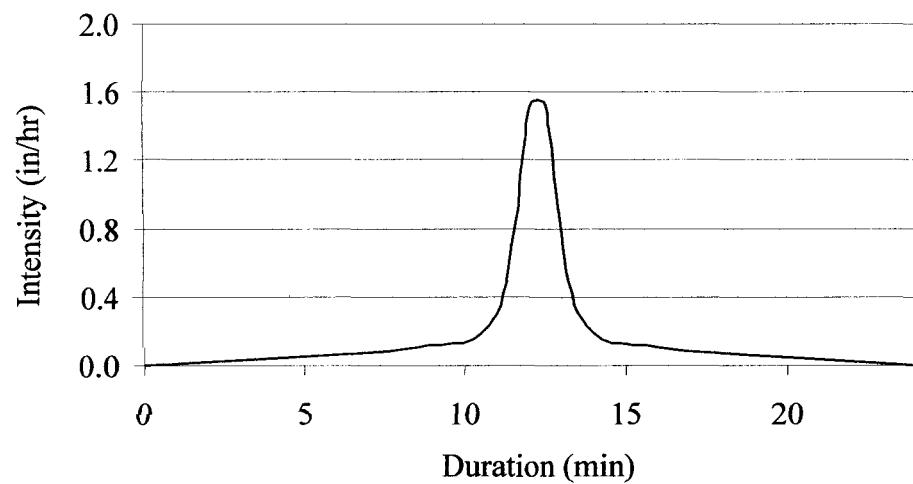


Figure F-2. 10-year design storm hyetograph

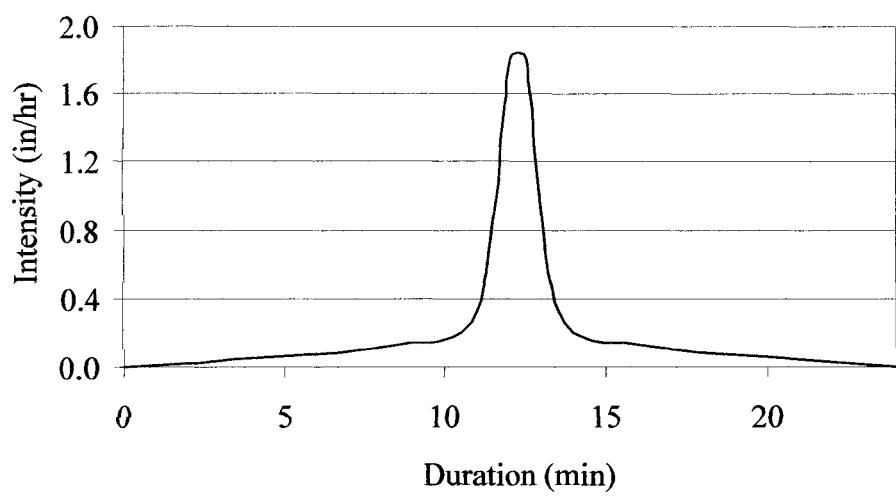


Figure F-3. 25-year design storm hyetograph

APPENDIX G

SWMM Results

Table G-1. Predicted Swale Peak Flows for the 5-Year Storm Event,
Pre-Existing System

	Peak Flow	Peak Depth	Wetted Perimeter	Peak Velocity		Peak Flow	Peak Depth	Wetted Perimeter	Peak Velocity
I.D	(cfs)	(ft)	(ft)	(ft/sec)	I.D	(cfs)	(ft)	(ft)	(ft/sec)
301	0.20	0.27	15.0	0.08	327	0.26	0.27	15.0	0.11
302	0.16	0.23	14.0	0.08	328	0.28	0.28	15.0	0.11
303	0.22	0.22	12.7	0.13	329	0.19	0.24	13.7	0.09
304	0.30	0.25	14.2	0.14	330	0.21	0.24	13.8	0.11
305	0.12	0.24	12.9	0.06	331	0.15	0.18	11.4	0.11
306	0.26	0.29	14.7	0.10	333	0.17	0.22	12.9	0.10
307	0.37	0.33	15.0	0.12	336	0.18	0.21	11.9	0.11
308	0.55	0.33	15.0	0.17	337	0.09	0.20	13.2	0.05
309	0.21	0.23	13.0	0.11	338	0.21	0.24	13.9	0.10
310	0.41	0.30	15.0	0.15	339	0.29	0.28	15.0	0.12
311	0.20	0.31	15.0	0.07	340	0.58	0.33	15.0	0.18
312	0.28	0.26	14.2	0.12	341	0.18	0.20	12.3	0.12
313	0.30	0.24	13.9	0.15	342	0.27	0.22	12.9	0.15
314	0.24	0.24	13.2	0.13	343	0.3	0.25	14.7	0.13
315	0.12	0.17	11.8	0.09	344	0.23	0.21	12.3	0.15
316	0.14	0.25	14.4	0.07	345	0.2	0.20	12.4	0.13
317	0.16	0.24	14.4	0.08	346	0.61	0.35	15.0	0.18
318	0.29	0.25	13.8	0.14	347	0.79	0.39	15.0	0.20
319	0.19	0.21	13.2	0.11	348	0.53	0.17	13.3	0.04
320	0.15	0.19	11.4	0.11	349	0.24	0.21	12.4	0.15
321	0.21	0.24	12.8	0.11	350	0.23	0.22	13.1	0.13
322	0.06	0.23	12.7	0.03	351	0.14	0.18	11.4	0.11
323	0.21	0.27	14.4	0.09	352	0.35	0.27	15.0	0.14
324	0.20	0.25	13.5	0.10	353	0.21	0.25	14.7	0.09
325	0.25	0.26	14.2	0.11	354	0.23	0.23	13.3	0.12
326	0.22	0.25	13.6	0.11	355	0.25	0.23	13.4	0.13

Table G-1. Continued

	Peak Flow	Peak Depth	Wetted Perimeter	Peak Velocity		Peak Flow	Peak Depth	Wetted Perimeter	Peak Velocity
I.D.	(cfs)	(ft)	(ft)	(ft/sec)	I.D.	(cfs)	(ft)	(ft)	(ft/sec)
356	0.21	0.22	12.4	0.12	335	0.29	0.29	15.0	0.11
357	0.21	0.22	13.1	0.12	366	0.20	0.24	13.6	0.11
358	0.19	0.21	12.9	0.11	367	0.23	0.25	14.2	0.11
359	0.22	0.22	12.5	0.13	368	0.19	0.22	12.9	0.11
360	0.27	0.24	13.8	0.13	369	0.19	0.22	13.3	0.11
361	0.24	0.24	13.6	0.12	370	0.24	0.24	12.7	0.13
362	0.26	0.23	12.7	0.14	371	0.21	0.21	12.4	0.13
363	0.18	0.20	12.8	0.11	372	0.30	0.25	14.6	0.14
364	0.29	0.25	13.9	0.14	373	0.23	0.22	13.3	0.13
365	0.31	0.26	14.7	0.13	374	0.24	0.23	12.9	0.13
392	0.18	0.22	13.4	0.10	375	0.23	0.23	12.9	0.13
393	0.22	0.30	15.0	0.08	376	0.26	0.26	14.2	0.12
394	0.35	0.29	15.0	0.13	377	0.18	0.33	15.0	0.06
395	0.18	0.19	11.7	0.12	378	0.11	0.17	11.9	0.08
396	0.10	0.19	10.8	0.07	379	0.19	0.21	13.0	0.11
397	0.15	0.18	11.7	0.11	380	0.17	0.19	11.7	0.12
398	0.35	0.39	15.0	0.09	381	0.23	0.23	13.0	0.13
399	0.05	0.15	10.3	0.04	382	0.21	0.23	13.2	0.11
401	0.00	0.06	4.5	0.09	383	0.18	0.20	12.2	0.11
402	0.05	0.10	9.7	0.08	384	0.21	0.22	12.8	0.12
403	0.00	0.06	4.7	0.05	385	0.16	0.21	13.0	0.10
404	0.13	0.20	9.5	0.10	386	0.21	0.24	12.9	0.11
405	0.00	0.06	3.4	0.11	387	0.21	0.22	12.9	0.12
406	0.01	0.07	4.1	0.07	388	0.22	0.27	14.3	0.09
332	0.18	0.19	12.2	0.12	389	0.01	0.13	12.5	0.01
334	0.22	0.26	14.3	0.10	390	0.09	0.17	9.7	0.08
					391	0.10	0.19	9.4	0.08

**Table G-2. Predicted Swale Peak Flows for the 10-Year Storm Event,
Pre-Existing System**

	Peak Flow	Peak Depth	Wetted Perimeter	Peak Velocity		Peak Flow	Peak Depth	Wetted Perimeter	Peak Velocity
ID	(cfs)	(ft)	(ft)	(ft/sec)	ID	(cfs)	(ft)	(ft)	(ft/sec)
301	0.45	0.38	15.0	0.10	327	0.51	0.36	15.0	0.13
302	0.34	0.32	15.0	0.10	328	0.47	0.35	15.0	0.13
303	0.33	0.26	14.5	0.14	329	0.28	0.29	15.0	0.10
304	0.36	0.27	14.9	0.15	330	0.31	0.28	15.0	0.12
305	0.13	0.25	14.1	0.06	331	0.23	0.23	13.0	0.13
306	0.41	0.35	15.0	0.11	333	0.18	0.23	12.9	0.10
307	0.69	0.41	15.0	0.12	336	0.25	0.25	13.8	0.12
308	0.75	0.38	15.0	0.17	337	0.16	0.27	14.9	0.07
309	0.28	0.26	14.6	0.12	338	0.33	0.29	15.0	0.12
310	0.59	0.35	15.0	0.16	339	0.41	0.32	15.0	0.13
311	0.33	0.39	15.0	0.07	340	0.88	0.40	15.0	0.18
312	0.33	0.28	15.0	0.12	341	0.25	0.23	12.9	0.14
313	0.41	0.28	15.0	0.16	342	0.34	0.25	13.8	0.17
314	0.31	0.26	14.6	0.13	343	0.41	0.29	15.0	0.15
315	0.23	0.23	13.1	0.12	344	0.30	0.23	13.2	0.16
316	0.25	0.32	15.0	0.08	345	0.27	0.23	13.1	0.14
317	0.38	0.35	15.0	0.10	346	0.91	0.41	15.0	0.18
318	0.32	0.26	14.6	0.14	347	1.02	0.44	15.0	0.18
319	0.26	0.24	13.8	0.13	348	0.60	0.52	15.0	0.08
320	0.16	0.19	11.5	0.11	349	0.31	0.24	13.3	0.16
321	0.27	0.26	14.6	0.12	350	0.30	0.25	14.1	0.14
322	0.08	0.28	15.0	0.03	351	0.22	0.22	12.6	0.13
323	0.36	0.34	15.0	0.10	352	0.54	0.33	15.0	0.16
324	0.28	0.29	15.0	0.10	353	0.42	0.33	15.0	0.12
325	0.41	0.32	15.0	0.12	354	0.31	0.26	14.5	0.14
326	0.30	0.28	15.0	0.11	355	0.34	0.26	14.6	0.14

Table G-2. Continued

	Peak Flow	Peak Depth	Wetted Perimeter	Peak Velocity		Peak Flow	Peak Depth	Wetted Perimeter	Peak Velocity
I.D	(cfs)	(ft)	(ft)	(ft/sec)	I.D	(cfs)	(ft)	(ft)	(ft/sec)
356	0.27	0.25	14.0	0.13	335	0.42	0.34	15.0	0.12
357	0.29	0.26	14.3	0.13	366	0.28	0.27	14.9	0.12
358	0.26	0.24	13.6	0.13	367	0.31	0.28	15.0	0.12
359	0.28	0.25	13.9	0.14	368	0.25	0.25	14.1	0.11
360	0.36	0.27	14.9	0.15	369	0.26	0.25	14.1	0.12
361	0.32	0.27	14.8	0.13	370	0.31	0.26	14.6	0.13
362	0.33	0.26	14.3	0.15	371	0.28	0.24	13.5	0.14
363	0.25	0.24	13.5	0.13	372	0.48	0.30	15.0	0.16
364	0.38	0.29	15.0	0.14	373	0.38	0.28	15.0	0.15
365	0.48	0.32	15.0	0.15	374	0.32	0.26	14.5	0.14
392	0.28	0.27	14.8	0.11	375	0.30	0.26	14.5	0.13
393	0.31	0.35	15.0	0.08	376	0.34	0.29	15.0	0.12
394	0.57	0.36	15.0	0.14	377	0.33	0.43	15.0	0.06
395	0.16	0.18	11.1	0.12	378	0.14	0.20	11.6	0.09
396	0.12	0.21	12.3	0.07	379	0.32	0.27	14.7	0.14
397	0.26	0.24	13.7	0.13	380	0.28	0.24	13.4	0.14
398	0.44	0.43	15.0	0.08	381	0.28	0.25	13.9	0.13
399	0.07	0.18	11.0	0.05	382	0.25	0.25	14.1	0.12
401	0.15	0.17	10.6	0.13	383	0.29	0.25	14.2	0.13
402	0.27	0.22	12.8	0.16	384	0.34	0.27	14.9	0.14
403	0.00	0.06	5.8	0.04	385	0.21	0.23	13.3	0.11
404	0.14	0.20	12.0	0.09	386	0.25	0.26	14.2	0.12
405	0.00	0.06	5.8	0.08	387	0.25	0.24	13.5	0.12
406	0.04	0.11	7.7	0.06	388	0.27	0.29	15.0	0.10
332	0.27	0.23	13.2	0.14	389	0.03	0.20	11.6	0.02
334	0.26	0.28	15.0	0.10	390	0.11	0.19	11.6	0.08
					391	0.09	0.18	10.8	0.07

Table G-3. Maximum Catchbasin Depths for 10-Year Storm,
Pre-Existing System

Group	ID	Depth below ground at maximum depth	Group	ID	Depth below ground at maximum depth
A	104	1.7 ft	F	123	1.5 ft
A	143	1.6	F	124	1.5
A	144	1.4	F	125	1.5
F	2	1.4	F	126	1.5
B	105	1.6	F	127	1.7
B	106	1.7	F	128	1.5
B	142	1.4	F	129	1.8
F	1	1.4	F	130	1.9
C	110	2.0	F	147	1.5
C	111	2.0	F	149	2.1
C	112	2.2	F	155	2.2
C	113	1.8	F	156	2.2
C	114	1.7	F	6	1.4
C	115	1.6	F	7	1.9
C	116	1.5	H	118	0.8
C	117	1.5	H	119	0.9
C	145	1.6	H	131	0.6
F	3	1.4	H	132	0.8
F	4	1.3	H	133	0.9
D	101	1.3	H	134	0.8
D	102	1.4	H	135	0.9
D	103	1.4	H	136	1.0
D	107	1.8	H	137	1.3
D	108	1.2	H	138	1.3
D	109	1.7	H	139	1.4
D	146	1.9	H	140	1.3
F	5	1.4	H	141	1.5
F	120	1.7	H	148	1.0
F	121	1.3	H	150	2.9
F	122	1.6	H	8	1.9

Table G-4. Maximum Catchbasin Depths for 25-Year Storm,
Pre-Existing System

Group	ID	Depth below ground at maximum depth	Group	ID	Depth below ground at maximum depth
A	104	1.34 ft	E	123	0.80 ft
A	143	1.23	E	124	0.74
A	144	1.03	E	125	0.98
E	2	1.03	E	126	0.73
B	105	1.15	E	127	0.87
B	106	1.25	E	128	0.90
B	142	0.99	E	129	1.35
E	1	1.04	E	130	1.56
C	110	1.69	E	147	1.05
C	111	1.65	E	149	1.87
C	112	1.85	E	155	0.00
C	113	1.46	E	156	1.82
C	114	1.28	E	6	1.03
C	115	1.21	E	7	1.90
C	116	1.12	H	118	0.22
C	117	1.14	H	119	0.36
C	145	1.23	H	131	0*
E	3	1.04	H	132	0.23
E	4	1.03	H	133	0.36
D	101	0.94	H	134	0.31
D	102	1.01	H	135	0.39
D	103	1.03	H	136	0.62
D	107	1.44	H	137	0.96
D	108	0.93	H	138	0.96
D	109	1.35	H	139	1.05
D	146	1.55	H	140	1.01
E	5	1.05	H	141	1.21
E	120	1.04	H	148	0.45
E	121	0.77	H	150	2.83
E	122	0.88	H	8	1.90

*note: Catchbasin with overflow

Table G-5. Predicted Swale Peak Flows for the 5-Year Storm Event,
After Improvement

I.D.	Peak	Peak	Wetted	Peak	I.D.	Peak	Peak	Wetted	Peak
	Flow	Depth	Perimeter	Velocity		(ft3/sec)	Flow	Depth	Velocity
	(ft3/sec)	(ft)	(ft)	(ft/sec)		(ft3/sec)	(ft)	(ft)	(ft/sec)
3012	0.12	0.24	13.6	0.06	339	0.29	0.28	15.0	0.12
3022	0.62	0.37	15.0	0.18	340	0.57	0.33	15.0	0.18
3011	0.12	0.21	13.0	0.07	341	0.18	0.19	12.4	0.12
3021	0.10	0.21	11.5	0.06	342	0.27	0.22	12.9	0.15
3211	0.07	0.15	9.9	0.07	343	0.29	0.25	14.7	0.13
3212	0.12	0.20	11.0	0.08	344	0.23	0.20	12.5	0.14
3213	0.14	0.23	13.0	0.08	345	0.20	0.20	12.4	0.13
3231	0.18	0.31	15.0	0.06	346	0.60	0.35	15.0	0.18
3251	0.08	0.14	10.0	0.09	347	0.68	0.37	15.0	0.19
395	0.12	0.16	10.4	0.11	348	0.46	0.46	15.0	0.10
303	0.21	0.21	12.9	0.13	349	0.24	0.21	12.7	0.15
304	0.30	0.25	13.9	0.14	350	0.22	0.22	12.8	0.13
319	0.25	0.24	13.1	0.13	351	0.14	0.18	11.5	0.11
320	0.14	0.19	11.4	0.11	352	0.35	0.27	14.9	0.14
337	0.30	0.19	10.3	0.24	353	0.25	0.27	14.5	0.11
3032	0.07	0.19	12.8	0.05	354	0.22	0.22	13.3	0.12
3033	0.05	0.20	12.3	0.03	355	0.24	0.23	13.2	0.13
3052	0.09	0.22	13.9	0.05	356	0.20	0.22	12.5	0.12
3941	0.11	0.19	12.4	0.08	357	0.20	0.22	12.8	0.12
330	0.20	0.23	13.7	0.10	358	0.25	0.24	12.7	0.13
331	0.15	0.18	11.4	0.11	359	0.21	0.22	12.6	0.12
333	0.17	0.22	12.5	0.10	360	0.26	0.24	13.5	0.13
336	0.17	0.21	11.6	0.11	361	0.23	0.23	13.3	0.12
3221	0.04	0.17	12.3	0.03	362	0.25	0.23	12.6	0.14
3222	0.01	0.14	12.3	0.01	363	0.16	0.20	12.8	0.10
3232	0.14	0.23	13.5	0.07	364	0.29	0.25	13.9	0.13
3233	0.13	0.19	12.7	0.08	365	0.30	0.26	14.5	0.13
3241	0.12	0.19	11.1	0.09	396	0.08	0.17	11.1	0.06
3242	0.15	0.22	12.6	0.09	397	0.14	0.18	12.1	0.10
3252	0.13	0.19	11.7	0.09	398	0.34	0.39	15.0	0.09

Table 5. Continued

I.D.	Peak Flow (ft ³ /sec)	Peak Depth (ft)	Wetted Perimeter (ft)	Peak Velocity (ft/sec)	I.D.	Peak Flow (ft ³ /sec)	Peak Depth (ft)	Wetted Perimeter (ft)	Peak Velocity (ft/sec)
3253	0.13	0.19	12.7	0.08	399	0.03	0.13	10.7	0.04
3261	0.17	0.20	11.3	0.11	332	0.18	0.19	12.2	0.12
3262	0.15	0.22	12.5	0.08	334	0.22	0.26	14.3	0.10
3271	0.22	0.25	14.2	0.10	335	0.29	0.29	15.0	0.11
3272	0.20	0.25	12.6	0.10	366	0.20	0.24	13.6	0.11
3281	0.20	0.21	12.6	0.12	367	0.23	0.25	14.2	0.11
3282	0.17	0.39	15.0	0.05	368	0.19	0.22	12.9	0.11
3291	0.16	0.22	11.9	0.09	369	0.19	0.22	13.3	0.11
3292	0.12	0.20	12.0	0.08	370	0.24	0.24	12.7	0.13
3351	0.54	0.35	15.0	0.16	371	0.21	0.21	12.4	0.13
309	0.20	0.23	13.0	0.11	372	0.30	0.25	14.6	0.14
311	0.19	0.31	15.0	0.07	373	0.23	0.22	13.3	0.13
315	0.60	0.33	15.0	0.19	374	0.24	0.23	12.9	0.13
316	0.13	0.24	14.1	0.06	375	0.23	0.23	12.9	0.13
317	0.13	0.22	14.6	0.07	376	0.26	0.26	14.2	0.12
318	0.29	0.25	13.7	0.14	377	0.18	0.33	15.0	0.06
392	0.18	0.22	13.6	0.10	378	0.11	0.17	11.9	0.08
393	0.22	0.30	15.0	0.08	379	0.19	0.21	13.0	0.11
3051	0.07	0.25	12.3	0.03	380	0.17	0.19	11.7	0.12
3062	0.13	0.21	11.9	0.09	381	0.23	0.23	13.0	0.13
3071	0.30	0.30	15.0	0.11	382	0.21	0.23	13.2	0.11
3072	0.17	0.24	13.6	0.08	383	0.18	0.20	12.2	0.11
3081	0.29	0.27	15.0	0.12	384	0.21	0.22	12.8	0.12
3141	0.15	0.17	11.4	0.12	385	0.16	0.21	13.0	0.10
3142	0.09	0.22	12.2	0.05	386	0.21	0.24	12.9	0.11
3161	0.12	0.20	9.9	0.09	387	0.21	0.22	12.9	0.12
401	0.00	0.00	4.7	0.00	388	0.22	0.27	14.3	0.09
402	0.00	0.00	6.1	0.00	389	0.01	0.13	12.5	0.01
338	0.19	0.23	13.5	0.10	390	0.09	0.17	9.7	0.08
					391	0.10	0.19	9.4	0.08

Table G-6. Maximum Catchbasin Depths for 25-year storm,
After Improvement

Group	ID	Depth below ground	Group	ID	Depth below ground	Group	ID	Depth below ground
A	104	0.37 ft	C	145	0.16 ft	F	122	1.17 ft
A	143	0.37	C	709	0.92	F	123	0.91
A	701	0.71	C	710	0.93	F	124	0.94
A	702	1.37	C	711	1.33	F	125	1.02
A	703	1.71	C	712	0.74	F	126	0.23
A	704	1.71	C	713	0.84	F	127	0.44
A	705	1.95	C	716	0.84	F	128	0.85
A	706	2.10	C	717	0.94	F	129	1.02
A	722	1.26	C	718	0.84	F	130	0.89
A	723	1.25	C	719	0.93	F	147	0.61
F	2	0.99	C	720	0.62	F	149	0.99
B	1441	1.23	C	721	0.71	F	155	1.50
B	144	0.42	F	3	0.99	F	156	1.53
B	105	0.36	F	4	0.99	F	6	0.99
B	106	0.46	D	1111	1.44	F	7	1.90
B	714	0.60	D	1131	0.43	F	71	1.32
B	715	0.81	D	101	0.01	F	118	0.22
B	724	1.18	D	102	0.11	F	119	0.36
B	725	1.17	D	103	0.11	F	131	0*
F	1	0.99	D	107	0.73	F	132	0.22
C	731	0.91	D	108	0.19	F	133	0.35
C	732	0.92	D	146	0.67	F	134	0.28
C	142	0.22	D	726	0.65	F	135	0.36
C	1421	1.12	D	727	0.83	F	136	0.58
C	110	1.65	D	728	1.17	F	137	0.91
C	111	1.61	D	729	0.46	F	138	0.91
C	112	0.57	D	730	0.45	F	139	0.99
C	113	0.25	F	5	0.99	F	140	0.95
C	114	0.19	F	109	0.65	F	141	1.15
C	115	0.17	F	1091	1.30	F	148	0.45
C	116	0.11	F	120	0.51	F	8	1.90
C	117	0.14	F	121	0.54	F	1501	2.83
						F	150	2.26

APPENDIX H

Design Overview

SITE INVESTIGATION

The pre-existing condition of the study watersheds was thoroughly described by means of an intense site investigation. Each structure was identified, located and plotted on the GIS software with an accuracy of 5 to 10 ft, which is sufficiently accurate for preliminary analysis. The internal dimensions of each catchbasin and storm sewer taken with a standard tape measure and recorded for subsequent analyses (the data collected is described in more detail in section 3.2.3). Elevation data was collected with the aid of a level and Philadelphia rod. Measurements were recorded, relative to two (United States Geological Service) USGS benchmarks located on site. In addition to the physical data, much was learned regarding the watershed behavior by watching the flow patterns and recording occurrence of surface ponding, flow, and various other stormwater processes

WATERSHED ANALYSIS/ PROBLEM CHARACTERIZATION

The watershed was analyzed for its performance under design storm situations. This was mainly accomplished with help of EPA's SWMM. The data collected from the site investigation was incorporated in the model, which was then executed under 5-, 10-, and 15-year storm events. Occurrences of swale overflow and catchbasin surcharge were identified. The watersheds were also analyzed for their water retaining and pollutant uptake capability. Retention was analyzed base on a procedure suggested by the SFWMD (2003) and pollution loads were analyzed by testing water samples for total phosphorus at various locations and during various weather events.

DESIGN DEVELOPMENT

The knowledge gained by the preceding analyses was applied to building a full understanding of the watershed behavior and the interaction between the BMP devices employed. Solutions were developed based on maximizing the positive aspects of the watershed such as swale infiltration, and addressing the cause of the negative aspects such as nutrient sources. As a result a full solution set was developed addressing all aspects of the treatment train from volume input and abstractions to treatment and retention.

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