Prepared for

Massachusetts Department of Conservation and Recreation (MA DCR)

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EFFECTIVENESS OF ENVIRONMENTALLY SENSITIVE SITE DESIGN AND LOW-IMPACT DEVELOPMENT ON STORM WATER RUNOFF PATTERNS AT PARTRIDGEBERRY PLACE LID SUBDIVISION IN IPSWICH, MA

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LIST OF ACRONYMS

BMP	Best Management Practice
CN	Curve Number
EPA	U. S. Environmental Protection Agency
HSG	Hydrologic Soil Group
LID	Low Impact Development
MA DCR	Massachusetts Department of Conservation and Recreation
MSL	Mean Sea Level
NCDC	National Climate Data Center
NRCS	Natural Resource Conservation Service
OSRD	Open Space Residential Design
SWMM	Storm Water Management Model
SCS	Soil Conservation Service
USGS	United States Geological Survey

EXECUTIVE SUMMARY

The Massachusetts Department of Conservation and Recreation (DCR), under a cooperative agreement with the U.S. Environmental Protection Agency (EPA), contracted with a developer, the Martins Companies, to install and demonstrate a variety of LID site design and storm water management techniques at Partridgeberry Place, a new residential subdivision development, designed by Meridian Associates, located in the Ipswich River Watershed in Ipswich, Massachusetts. The project's goals were to help improve groundwater base flow, reduce site runoff, and demonstrate a range of LID practices to local and regional developers, engineers, and water resource managers. Geosyntec was retained to evaluate the impacts on storm water flow that resulted from using LID site design and storm water management techniques at this subdivision.

This report summarizes the storm water analyses that were conducted by Geosyntec from data collected at the Partridgeberry Place Subdivision (LID Subdivision). The purpose of the study was to compare the storm water runoff patterns, rates, and volumes of this real-world application of environmentally sensitive site design and Low-Impact Development (LID) principles to both the pre-development condition and conventional storm water management practices.

The study compared the LID Subdivision, as built, and three theoretical alternatives: 1) a subdivision that is clustered but that contains no additional LID storm water features, 2) a conventionally developed subdivision, and 3) the pre-development (forested) condition. This state-of-the-practice comparison will help communities and developers understand how LID designs function hydraulically compared to both the pre-development condition and conventional development. Careful lot-by-lot delineation of drainage areas and a complete understanding of the flow paths during rainfall events were critical for the success of this project.

The LID Subdivision incorporates an environmentally sensitive site design that includes a cluster house layout and a variety of LID storm water management features. The compact site design, approved under the Town of Ipswich's Open Space Residential Design (OSRD) ordinance clusters 20 single family homes on residential lots less than 0.20-acres in size, preserving 74% (28-acres) of the 38-acre site as undeveloped open space. LID storm water techniques include dry wells for roof runoff, vegetated swales, grass pavers, bioretention, as well as three raingardens on individual residential lots, and native drought-resistant vegetation. Using an OSRD approach, the amount of open space was maximized and the amount of impervious area was reduced.

To understand the storm water runoff dynamics at the LID Subdivision, Geosyntec conducted on-site monitoring to estimate storm water runoff volumes and discharge rates. We collected monitoring data at the LID Subdivision from June 27, 2008 through September 30, 2008. During this time, we captured forty-four (44) storm events (ranging from 0.01 to 2.45 inches), and collected approximately twenty (20) inches of precipitation. We used the monitoring data to evaluate the performance of the LID Subdivision Raingarden and storm water management basin (Pond One) during different size storm events and intensities using a water balance approach. Geosyntec collected monitoring data for the Pre-development Watershed from July 30, 2008 through September 30, 2008. We used these monitoring data to evaluate the storm water runoff volume from a forested condition.

Results show that the Raingarden reduces storm water runoff volumes entering Pond One, infiltrating, and evaporating most small events fully. However, overflow occurs into Pond One during storm events slightly smaller than those the Raingarden was designed to fully retain. This appears to be the result of soil infiltration rates in the Raingarden that are lower than the design specifications. In turn, Pond One fully infiltrates and evaporates storms almost up to its design capacity, but discharges into Pond Two during events slightly smaller than this volume, possibly as a result of the premature overflow from the Raingarden.

Geosyntec's Pre-development Watershed monitoring indicated that for storms greater than 0.25 inches in size runoff is generated from the Pre-development Watershed. For storms less than 0.25 inches, all the rainfall is either infiltrated or evaporated. Monitoring data at the LID Subdivision showed that runoff occurs for storms greater than 0.04 inches. During the monitoring period, we observed approximately 29 storm events that generated runoff in the LID Subdivision but would not have generated runoff in the Pre-development Watershed, according to our modeling. This study underscored the complexity and challenges of monitoring and modeling a forested condition, especially the difficulty of accurately representing the effect of the plant litter layer on infiltration and evaporation rates.

Geosyntec developed models for the LID Subdivision and Pre-development Watershed, which were calibrated using the monitoring data. During calibration, Geosyntec altered the soil types and infiltration parameters to allow for less infiltration and more runoff. Both models were calibrated to within 10 percent of the observed storm water runoff volume. Geosyntec then adjusted these calibrated models to represent two additional theoretical land use conditions (a Cluster Only Subdivision and a Conventional Subdivision) for a total of four land use scenarios on the same 38-acre site.

The LID Subdivision (the as-built condition) includes LID storm water management features, a cluster site design, and preservation of open space. The Cluster Only Subdivision retains the LID Subdivision layout (cluster site design and the preservation of open space), but uses conventional storm water management techniques (i.e., curb and gutter, no roof drywells, no raingardens). The Conventional Subdivision includes twenty 1.0-acre house lots, curb and gutter storm water management and minimal preservation of open space. The Pre-development Watershed is the forested condition before development of the Subdivision.

The LID Subdivision, Cluster Only Subdivision, Conventional Subdivision, and Pre-development Watershed models were used to predict and compare storm water runoff dynamics over the entire 38-acre parcel for a variety of design storm events (2-year, 10-year, 25-year, 50-year, and 100-year, 24-hour). Based on the model results, the LID Subdivision generates the smallest volume of storm water runoff among the three development scenarios. For the 2-year design storm, the Cluster Only Subdivision reduced runoff volume relative to the Conventional scenario by 35 percent. The LID scenario, which enhances the cluster design with additional LID storm water features, reduced runoff volume relative to the Conventional scenario by an additional 3 percent, for a total 38 percent reduction.

A comparison of the of three development scenarios to the Pre-development Watershed showed that runoff volumes from the LID Subdivision most closely resembled those of the pre-development condition. For the 2-year design storm, the LID Subdivision generated 11 percent more runoff volume than the Pre-development Watershed, while the Cluster only generated 16 percent more, and the Conventional Subdivision generated 45 percent more.

The preservation of open space and the reduction of impervious area appear to play the most significant role in minimizing increased storm water runoff volume resulting from development. Implementing LID storm water management features in the site design also plays an important role in further reducing storm water runoff volume; however, the number of LID features installed governs the quantity of reduction.

Historically, studies have produced little data and few benchmarks related to pre-development storm water runoff. Thus, predicting pre-development storm water runoff remains a great challenge. This study is among few in the nation that use actual field measurements from two land-use types in the same watershed to compare pre-development and post-development storm water conditions. Results reveal that pre-development hydrology is hard to fully replicate even with the incorporation of LID storm water management features and the preservation of open space. Implementing LID features in conjunction with an Open Space Residential Design approach, however, allows us to significantly minimize storm water runoff and more closely approximate the pre-development conditions.

CHAPTER 1

INTRODUCTION

This report was prepared by Geosyntec Consultants, Inc. (Geosyntec) on behalf of Massachusetts Department of Conservation and Recreation (MA DCR), with funding from the U.S. Environmental Protection Agency (EPA), to evaluate the effectiveness of environmentally sensitive site design and low-impact development (LID) on storm water runoff dynamics at the Partridgeberry Place Subdivision, located in Ipswich, Massachusetts (LID Subdivision). This subdivision is one of nine demonstration projects funded by EPA and implemented by DCR through the Ipswich River Targeted Watershed Grant Project. The demonstrations all highlight and research LID or water conservation strategies designed to help address the severe low flow conditions in the Ipswich River.

Figure 1-1: Partridgeberry Place LID Subdivision Storm Water Management Features

This study provides an understanding of how incorporation of a cluster subdivision with LID site design reduces storm water runoff volume and peak flow for various design storms.

Geosyntec conducted hydraulic and hydrologic monitoring and modeling to evaluate the effectiveness of the LID Subdivision, including the Open Space Residential Design (OSRD) (i.e., cluster layout) and the LID storm water management features. Effectiveness was evaluated by comparing storm water runoff dynamics for the following conditions: "LID Subdivision," "Cluster Only Subdivision," "Conventional Subdivision" and the "Pre-development watershed." Brief descriptions of these four conditions are provided on the following page.

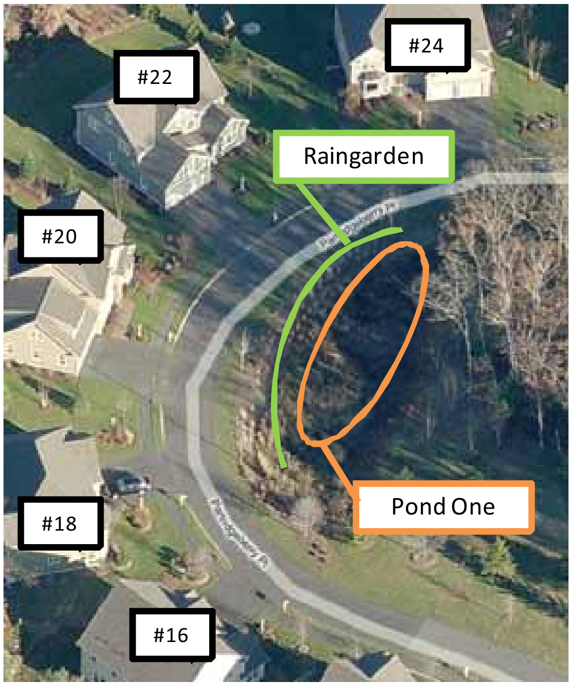

Figure 1-2: Raingarden and Pond One Locations

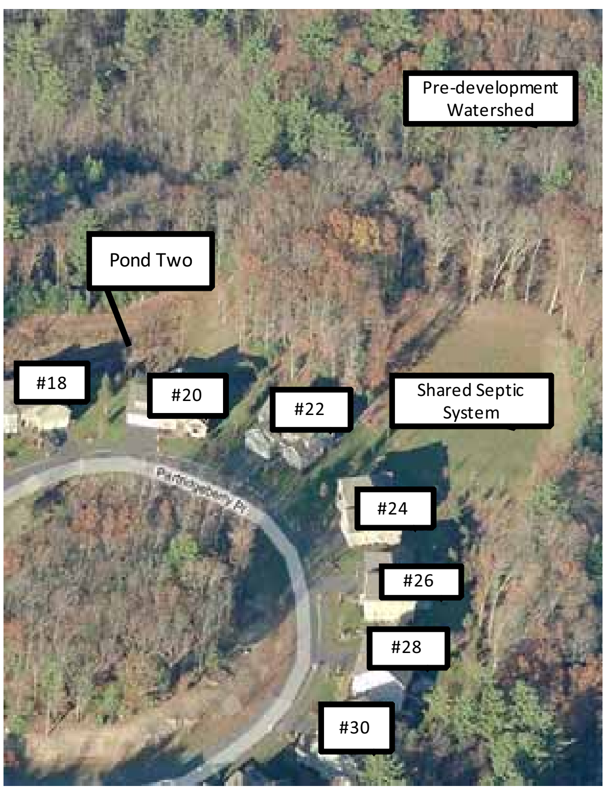

Figure 1-3: Pre-development Watershed Locations

- The LID Subdivision (Figure 1-1) condition is the constructed configuration of the Partridgeberry Place Subdivision incorporating OSRD (cluster layout) and LID design. This condition includes LID storm water management (i.e., open grass lined swales, drywells and raingardens) with a clustered house layout, which includes reduced house lot size (0.20 acres), reduced driveway length and width and reduced street width. The design and construction of the LID Subdivision was done prior to any hydraulic and hydrologic monitoring.
- The Cluster Only Subdivision condition is the modeled configuration of Partridgeberry Place with conventional storm water management (i.e., curb and gutter). The condition includes reduced house lot size (0.20 acres), reduced driveway length and width and reduced street width.
- The Conventional Subdivision was modeled using a preliminary, non-clustered design previously submitted, but not approved, for this site. The Conventional Subdivision contains road widths of 24 feet (compared to 18 feet in the LID Subdivision and Cluster Only Subdivision condition); lot sizes of 1.0 acre (compared to 0.20-acres in the LID Subdivision and Cluster Only Subdivision condition); rooftops that drain via a gutter system to downspouts that discharge onto the lawn (compared to drywells in the LID Subdivision condition), setbacks of 50 feet, which increases lawns and driveway length (compared to 20 feet setbacks in the LID Subdivision and Cluster Only Subdivision condition); and storm water management consisting of curb and gutter drainage to a central on-site storm water management basin (compared to several features in the LID Subdivision condition that decentralize storm water treatment).
- The Pre-development Watershed condition is an undeveloped forested parcel located in the protected open space area adjacent to the LID Subdivision. The monitored area of the Pre-development Watershed is approximately 0.08-acres and represents the condition of the LID Subdivision prior to land development.

Monitoring was conducted at the LID Subdivision and in the Pre-development Watershed. Data were collected from June 27, 2008 through September 30, 2008 in the LID Subdivision and from July 24, 2008 through September 30, 2008 in the Pre-development Watershed.

The monitoring program was designed to address the following five questions:

- How does runoff from individual catchments draining to catch basins, swales, etc. respond hydraulically to storm events?
- What is the water balance of the LID Subdivision central raingarden located at the north end of the cul-de-sac (Raingarden) and how does it perform during different storm sizes and intensities?
- What is the water balance of the storm water management basin located at the north end of the loop road (Pond One) and how does it perform during different storm sizes and intensities?
- What is the cumulative impact of the LID features on the hydrology of the site, as captured at the inflow points of the storm water management features at the LID Subdivision?
- What are the Pre-development (i.e., forested) Watershed runoff characteristics?

Models were developed for the LID Subdivision, Cluster Only Subdivision, Conventional Subdivision, and the Pre-development Watershed. The LID Subdivision and Pre-development models were calibrated using hydraulic and hydrologic monitoring data.

The models were used to predict storm water runoff dynamics for storm events with magnitudes outside of those captured during the period of study (i.e., 10-, 25-, 50- and 100-year, 24-hour design storm events). The modeling was set up to address the following three questions:

- What are the volumes of storm water runoff discharged from the LID Subdivision condition for different design storms?
- How do the runoff patterns at the LID Subdivision condition differ from those of a Cluster Only Subdivision and Conventional Subdivision for the same design storms?
- How do runoff patterns at the LID Subdivision, Cluster Only Subdivision, and Conventional Subdivision differ from those of a Pre-development Watershed for the same design storms?

Report Organization

This report is organized into 8 chapters, with accompanying tables, figures, and attachments:

- Chapter 2 provides project background information;
- Chapter 3 discusses the monitoring methodology, including equipment installed and field maintenance of equipment;
- Chapter 4 discusses the modeling methodology, hydrologic and hydraulic assumptions, and precipitation;
- Chapter 5 discusses the model analysis, including calibration of the models;

- Chapter 6 discusses results including precipitation analysis, monitoring results and modeling results;
- Chapter 7 describes report conclusions and future work; and
- Chapter 8 provides document references.

CHAPTER 2

PROJECT BACKGROUND

Photo Provided by Martin's Company

Figure 2-1: OSRD Site Design for Partridgeberry Place LID Subdivision

Figure 2-2: Partridgeberry Place LID Subdivision

The MA DCR under an agreement from the EPA contracted with a developer to install and demonstrate a variety of LID site design techniques in a residential subdivision development. The project's goals were to minimize overland runoff, provide a wide range of LID examples to expose local and regional developers, engineers, and water resource managers to LID practices, and characterize the impact of the LID design on runoff patters. The LID Subdivision is omprised of 20 home lots built on 38-acres and is designed as a cluster of single-family homes, on lots of approximately 0.20 acres (8,000 to 11,000 square feet).

Partridgeberry Place was originally designed as a Conventional Subdivision in 1997. Partridgeberry Place was never constructed as a Conventional Subdivision, which consisted of 1.0-acre lots sizes and minimal preservation of open space. The Town of Ipswich adopted an Open Space Residential Design (OSRD) ordinance, which provides developers incentives such as density bonuses to preserve valuable open space on site, based on environmental and cultural priorities, and cause minimal disturbance to the natural terrain.

The OSRD approach identifies conservation areas as "open space" and includes wetlands, floodplains, buffers to streams, wildlife habitats, and historic features. The site is evaluated to determine which features should be preserved and designated as conservation land. The benefits of the OSRD approach are reduced economic costs from reduced infrastructure and increased property value. Local and state officials are increasingly turning to OSRD as an alternative to standard "cluster zoning" provisions, as an improved resource-based approach (www.greenneighborhoods.org).

When Partridgeberry Place Subdivision was re-designed, OSRD and LID storm water management features were incorporated to have post-development storm water mimic pre-development hydrology. Two OSRD approaches were incorporated into the design: (1) cluster design, which includes single-family homes on 0.20-acre lots with small yards, and (2) the reduction of impervious area, such as reduced road width and driveway lengths.

The LID storm water features at Partridgeberry Place include grass pavers for overflow parking; two open grass-lined swales that drain to the Raingarden; installation of small raingardens on three house lots to manage driveway runoff; management of roof runoff through drywells; and use of native, drought-resistant vegetation throughout the site. A shared septic system facilitates smaller lot sizes while still allowing for on-site treatment and recharge of wastewater.

Table 2.1: LID Features at Partridgeberry Place

LID Feature (Number at LID Subdivision)	Purpose
Grass Pavers	Overflow parking around loop road
Open Grass-lined Swale (Two)	Manage loop road runoff and route it to central raingarden
Small Raingarden (Four)	Manage driveway runoff at Houses #20, #22 and #24 and manage overland flow near shared septic system
Central Raingarden (One)	Manage runoff from half of the loop road
Drywell (Twenty)	Manage roof runoff
Native, Drought-Resistant Vegetation	Reduce introduction of non-native species

Relevant Studies

A study by Dietz and Clausen (2007) compares the storm water runoff of two residential subdivisions in Waterford, Connecticut. One of the subdivisions is an LID layout and the other a traditional layout. Both of the subdivisions drain to a small estuary called Jordan Cove, which discharges to Long Island Sound. The traditional site contained 17 lots on 4.9 acres and was built under current Connecticut regulations and construction practices. The traditional storm water management consisted of curb and gutter that collect runoff and drain to catch basins and a storm drain system. The total impervious area of the traditional subdivision after construction was 32 percent.

The LID subdivision layout contained 12 lots on 4.2 acres and was built to incorporate several pollution prevention measures as part of its design. The LID features at the development include the replacement of asphalt road and associated curb and gutter storm water collection system with an Ecostone® porous paver road and grass swales. A bioretention cul-de-sac and additional individual raingardens were incorporated into each lot to collect roof and lot runoff. Shared driveways were incorporated into the design (Figure 2-3), which used Ecostone®. Houses were design in a clustered layout, similar to that at Partridgeberry Place Subdivision. After completion of construction, the total impervious area was 21 percent of the total development compared to 32 percent in the traditional subdivision.

Figure 2-3: LID Subdivision in Waterford, CT, shared driveway

Comparisons in the annual storm water volume from the two subdivisions were made and the study found that as total impervious area increased in the traditional subdivision from 1 to 32 percent, runoff volume increased by 49,000 percent, from 0.1 to 50 cubic meters. In contrast, annual storm water runoff in the LID subdivision did not change as watershed impervious coverage increased. Dietz and Clausen (2007) concluded that this lack of change was due to the LID storm water management techniques used through the watershed.

Dietz and Clausen (2007) also state that the overall goal of LID is to mimic the pre-development hydrology of an area, including the runoff volumes that existed prior to development. These volumes were not stated in the report for the pre-development conditions at the LID subdivision, but Dietz and Clausen (2007) conclude that storm water runoff from the LID subdivision remain unchanged from pre-development levels.

Figure 2-4: LID Subdivision in Cross Plains, WI, grassed swale

An additional study completed by the United States Geological Survey (USGS) and United States Department of Interior (Selbig and Bannerman, 2008), compares storm water discharge from two watersheds in Cross Plains, Wisconsin, one a traditional subdivision and another a LID subdivision. The study was designed to compare runoff quantity and quality at the outlet of each watershed. The traditional subdivision consisted of curb and gutter, with 40-foot street widths and a connected storm drain system. The LID subdivision consisted of grassed swales, a reduced road width of 32-feet, street inlets which drain to grassed swales, a detention pond and an infiltration basin.

Selbig and Bannerman (2008) found that only six events with precipitation depths less than or equal to 0.40 inches produced measurable discharge from the LID basin. Five of the six events occurred during the winter months, when underlying soils may be frozen, causing reduced infiltration rates. For the Conventional Subdivision basin, the number of measureable discharge events for precipitation depths less than or equal to 0.40 inches, increased from six (6) in the LID to one-hundred and eighty (180). Approximately half of these events were from precipitation events less than 0.20 inches. When Selbig and Bannerman (2008) looked at total annual discharge volume from the two basins, the traditional basin discharge volume was 1.3 to 9.2 times greater than that in the LID basin.

Selbig and Bannerman (2008) concluded that the quantity of storm water discharge leaving a residential basin can be reduced by incorporating LID practices. The study shows that precipitation from smaller, more frequent events produces storm water discharge from the traditional basin and not the LID basin. Of the total volume of storm water discharged from the LID basin, approximately fifty percent (50%) was associated with precipitation events greater than 3 inches compared to eighteen percent (18%) in the traditional basin (i.e., the traditional basin has proportionally greater runoff from smaller storm events).

Both the Dietz and Clausen (2007) and Selbig and Bannerman (2008) studies demonstrate the effectiveness of LID design practices in residential design. The studies both show the reduction of storm water volume and peak discharge when compared to Conventional Subdivision design. Neither one of these studies compared the effectiveness of LID development to the pre-development condition, which is one of the main objectives of this report.

CHAPTER 3

MONITORING METHODOLOGY

Monitoring equipment was installed in the LID Subdivision and the Pre-development Watershed to understand routing of storm water runoff during storm events. The monitoring data show how OSRD and LID features respond during different storm intensities and sizes. Water balances of the Raingarden and Pond One (central storm water management basin) provides data on the performance of the design in different sizes and intensities of storms. A description of the monitoring equipment, equipment maintenance, Pre-development Watershed site selection and infiltration tests conducted on the Raingarden are described in the following subsections.

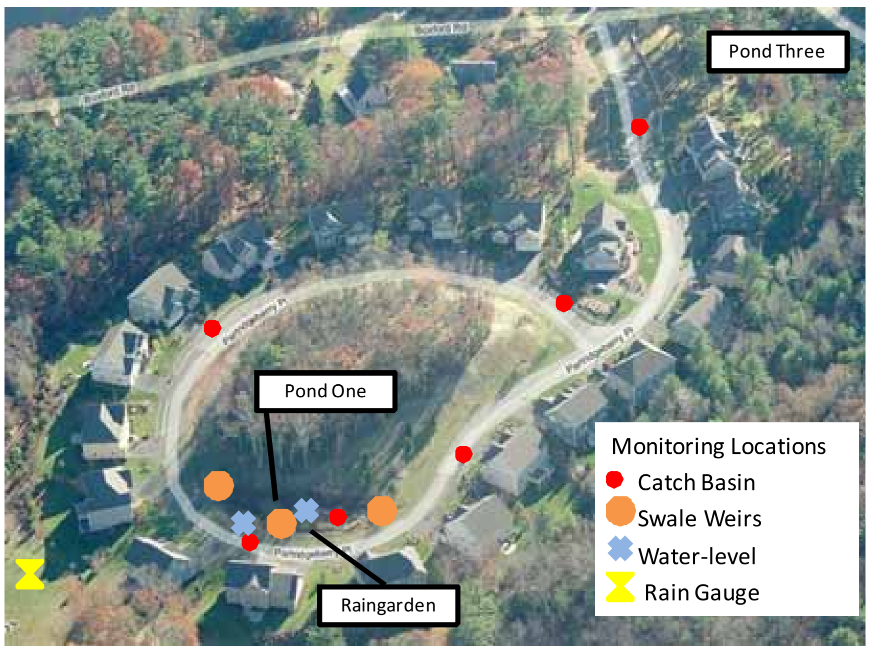

Figure 3-1: Monitoring Locations at Partridgeberry Place.

Monitoring Instrumentation Installation

Monitoring of the LID Subdivision was performed using the guidelines described in the Quality Assurance Plan Addendum A2 (QAPP) dated April 29, 2008 (Geosyntec, 2008). The hydrology and hydraulics at the LID Subdivision were evaluated at thirteen monitoring points, which were selected based on monitoring objectives and the storm water infrastructure at the site.

Figure 3-2: Thel-Mar Volumetric Weir installed in Pond Two Inflow.

Monitoring instrumentation installed consisted of a rain gauge, V-notch and volumetric weirs with associated pressure transducers, and a storm water collection trench. Figure 3-1 and Attachment 1 shows the locations of the instrumentation installed at the LID Subdivision (Note: Undisturbed area monitoring point not included in Figure 3-1). A brief summary of the monitoring instrumentation is described in the following subsections and for a more detailed description, refer to the QAPP (Geosyntec, 2008).

Volumetric Weirs

Volumetric weirs were installed at three inflow points to Pond One and the outflow of Pond One. The weirs were installed in catch basin structures on the inlet end of the pipes to Pond One as follows: (1) sediment and debris, if present, was removed from the culvert; (2) the weir was placed in the pipe one inch from the pipe end in accordance with the manufacture's installation instructions; and (3) the weir was secured in-place using the weir's thumb-wheel tensioning bolt.

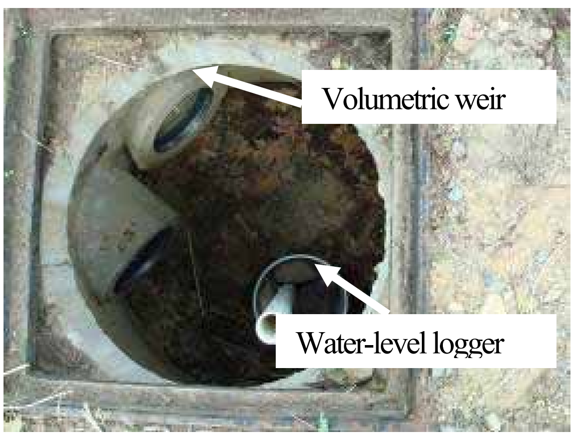

Figure 3-3: Water-level logger in bucket in catch basin.

A water-level logger (pressure transducer) (further described below) was installed in each catch basin sump to measure the water level in the catch basin (Figure 3-3). The pressure transducer was installed in a 2 inch diameter, 0.010 inch slotted, PVC pipe, capped at the bottom and top, secured in a 5 gallon bucket, filled with 2 inch crushed gravel, and secured in the catch basin sump. The slotted screen was used to limit the amount of sediment that was introduced to the pipe to ensure that the pressure transducer was not exposed to silt. The pressure transducer was tied to a string that was secured to the cap on the PVC pipe so the transducer could be reinstalled at the same elevation after each download (described below). The pressure transducer was set up to log water surface elevations at 5 minute increments.

The water-level data collected from the pressure transducer were used to calculate the flow of water over the volumetric weir using Equation 1 described in the Weir Structures section below.

Figure 3-4: V-Notch Weir Structure in Grass-lined Swale

Weir Structures

Weir structures were installed at the two grass-lined swale inflow points to the Raingarden (Figure 3-4), at the Raingarden overflow to Pond One (Figure 3-5) and in the Pre-development Watershed. The weir structures, which consisted of a sharp crested triangular or V-notch weir were used for low flow conditions and have an opening (θ˚) of 90 degrees. The water surface elevation above the V-notch (H, in feet) can be used to generate discharge (Q, in cubic feet per second (cfs)) by the following empirical Equation 1:

$$Q = 2.5 * H^{\frac{5}{2}} \qquad (1)$$

Discharge measured using a triangular or V-notch weir is accurate to ± 1.5% (Henderson, 1966).

A water-level logger was installed on the upstream weir face to measure water-level. The water-level data from the pressure transducer was used to calculate the flow of water using Equation 1.

Figure 3-5: Raingarden Overflow Weir Structure.

Figure 3-6: HOBO ® RG3 Tipping Bucket Rain Gauge.

Figure 3-7: HOBO® Water Level Data Logger

Rain Gauge

Precipitation was monitored using an Onset HOBO® RG3 tipping bucket rain gauge (Figure 3-6) and an Onset HOBO® Micro Station Data Logger. The rain gauge was deployed at the south side of the septic field area at the northeast corner of the LID Subdivision. Accumulated precipitation was collected in 5 minute intervals from June 27, 2008 through July 30, 2008. Once monitoring equipment was installed in the Pre-development Watershed (described below), collection interval decreased to 60 seconds from July 31, 2008 through September 30, 2008.

Water-Level Data Loggers

Water-level data loggers are pressure transducers that measure absolute pressure and have logging capabilities to store data at intervals established by the user. Absolute pressure represents the pressure exerted on the sensor due to atmospheric pressure plus the hydrostatic pressure exerted by the water column above the sensor. In the event there is no hydrostatic pressure or water above the sensor, the pressure represents the barometric pressure. Onset HOBO® water-level data loggers (Figure 3-7) were used to measure water depth in all the locations in the LID Subdivision and in the Pre-development Watershed. The loggers were set to record absolute pressure at 5 minute increments, except for the logger installed in the Pre-development Watershed, which was set to record in 60 second increments.

Onset HOBO® water-level data loggers are calibrated at the factory and therefore, calibration in the field was not necessary.

Figure 3-8: Storm Water Collection Trench

Storm Water Collection Trench

A storm water collection trench was installed to collect sheet flow storm water runoff from the portion of the loop road immediately north of the Raingarden. The storm water collection trench (Figure 3-8) was constructed by excavating an 8-inch by 8-inch trench, placing a 4-inch diameter perforated pipe in the bottom and backfilling the trench with 2-inch diameter round stone. The storm water collection trench intercepts runoff that would otherwise flow over the mulch to the Raingarden, and so it was designed to allow for some infiltration through the perforated pipe. The perforated pipe drains to a central collection point (Figure 3-9) used to monitor flow. The collection point consists of a 35 gallon drum cut in half with a 90 degree sharp crested weir structure on one face of the drum and a water-level data logger.

Figure 3-9: Storm Water Collection Trench Monitoring Point

The water-level data in the collection point and the weir equation (Equation 1) was used to determine the sheet flow into the Raingarden from the loop road.

Pre-development (forested) Monitoring

The Pre-development Watershed (Figure 1-3) was monitored to evaluate the hydrologic response during storm events from an undeveloped forested watershed. Geosyntec, DCR, and EPA conducted a field investigation on May 30, 2008 to confirm that the forested location (Figure 3-10) met the expectations of all parties prior to implementing the monitoring instrumentation.

Figure 3-10: Pre-development Watershed

The location of the area was selected based on the following criteria:

- The area did not exhibit signs of recent past disturbance;
- The watershed was well-defined with either natural ridges or boundaries or artificial boundaries;
- The watershed did not include vernal pools or wetlands that would capture and store runoff;
- The watershed area was manageable from a monitoring perspective; and
- Access to the location was granted by DCR (property owner).

The location selected for the Pre-development Watershed is part of the "open space" portion of the LID Subdivision layout deeded to DCR. The Pre-development monitoring area is located off of a walking trail to the northeast of the LID Subdivision and has an area of 0.08 acres (3,370 square feet). The estimated forest coverage of the trees is 30 percent in the canopy, 60 percent in the middle layer, and 25 percent at 10 feet above ground surface. The shrub density at ground level is approximately 25 percent. The litter and duff layer throughout the site ranges from one to four inches deep.

The Pre-development Watershed boundaries were established by installing silt fence with an impermeable liner (Figure 3-11) that consists of a 6 mil polyurethane membrane. The

Figure 3-11: Section of the Impermeable Structural Boundary in the Pre-development Watershed.

Figure 3-12: Pre-development watershed monitoring point.

Figure 3-13: Double Ring Infiltrometer.

structural boundary did not allow storm water run-on into the monitoring area. The site sloped toward the monitoring point (Figure 3-12), allowing all runoff to be monitored for volume and rate at a central location. The average slope of the undisturbed area is approximately 9 percent. The undisturbed area did not contain discrete drainage paths; it drained via overland flow or shallow subsurface flow through the litter and duff layer.

The monitoring point consists of a half 35 gallon HDPE drum placed horizontally with a 90 degree V-notch weir and a water-level data logger. Using the water level data, storm volume was estimated by using a stage-storage relationship to estimate the volume in the drum and the weir equation for the volume that discharged over the weir.

Maintenance of Field instrumentation

Bi-weekly routine site visits were conducted by Geosyntec field personnel to inspect the monitoring instrumentation and download the data loggers. In addition to routine site visits, Geosyntec also conducted site visits after rainfall events of 0.5 inch or greater. Maintenance consisted of clearing accumulated debris or sediment that might have collected on the instruments and inspecting instrumentation for damage.

Raingarden Infiltration Test

An infiltration test of the soil in the Raingarden was conducted using a double ring infiltrometer (Figure 3-13). The infiltration test was conducted to determine the soil infiltration rate, for use in the LID Subdivision model. The study used the infiltration test methodology in American Standard Testing of Materials (ASTM) D3385-03 (http://www.astm.org/Standards/D3385.htm).

A double ring infiltrometer set-up includes two 16 gauge galvanized steel rings with adjustable level floats and two graduated cylinders used to contribute flow to each of the rings. The inner ring had a diameter of 12 inches and the outer ring had a diameter of 24 inches. Locations at each test site were selected based on suitability for the infiltration test (i.e., level ground surface and area representative of entire BMP). When the selections were made, the outer ring of the double ring infiltrometer was driven into the soil to approximately 6 inches in depth. This depth is chosen to prevent water from migrating horizontally. The inner ring is placed in the center of the outer ring and driven into the soil to a depth of approximately 2 to 4 inches. Water was added to each of the rings to ensure a constant head of approximately 2 inches above the soil surface. The soils were then saturated in the area between both rings for approximately 5 to 10 minutes and the test was conducted.

Each test was run to ensure a sufficient number of points (approximately 10-20 readings) were achieved. Using the ASTM standard, the infiltration rate was calculated for each location and the results are presented in Chapter 6.

CHAPTER 4

MODELING METHODOLOGY

The storm water management systems (e.g., pipes, swales, raingardens, etc…) for the scenarios described in Chapter 1 were modeled using EPA Storm Water Management Model (SWMM) (US EPA, 2005), version 5.0 hydrologic and hydraulic model. SWMM is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality. The runoff component of SWMM operates on a collection of subcatchment areas that receive precipitation and generate runoff. The routing portion of SWMM transports this runoff through a system of pipes, channels, storage/treatment devices, and other conveyances and storm water management features. SWMM has the capability to track the quantity of runoff generated within a subcatchment, and the flow rate and flow depth of water in each conveyance during a simulation period. The routing dynamics of SWMM, including input parameters are presented in Figure 4-1. Input parameters related to runoff and routing components of the model are described in the following subsections.

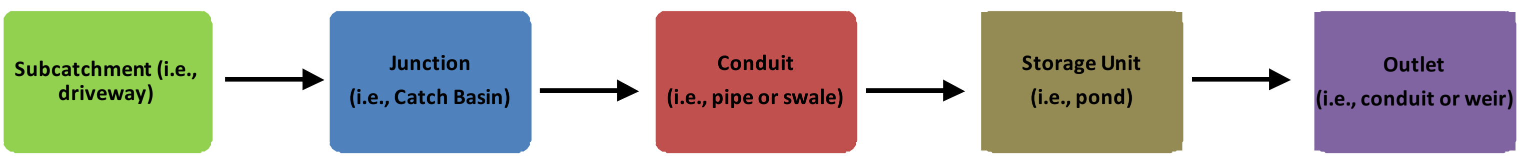

Figure 4-1: Flow schematic used in SWMM.

Project Models

To accurately and effectively evaluate the hydrologic and hydraulic conditions of the LID Subdivision, Cluster Only Subdivision, Conventional Subdivision and the Pre-development Watershed, Geosyntec developed a site hydrology model for each condition, as follows:

- **LID Subdivision:** This condition demonstrates the as-built conditions at the Partridgeberry Place Subdivision, which includes the incorporation of LID storm water management features and cluster site design;
- **Cluster Only Subdivision:** This condition demonstrates the Partridgeberry Place Subdivision with a cluster site design layout and conventional curb and gutter storm water management features;
- **Conventional Subdivision:** This condition demonstrates the design of the Subdivision under traditional layout (non-clustered and no LID features). The condition represents the same lot numbers (twenty) in the LID Subdivision; however, the lot size increases from 0.20 to 1.0 acres; and
- **Pre-development (forested) Watershed:** This condition demonstrates the pre-development hydrology at Partridgeberry Place, prior to construction at the site.

The input parameters used in SWMM are discussed in further detail in the following subsections.

Figure 4-2: Dye test

Figure 4-3: Visible dye through storm water trench monitoring device.

Subcatchment Delineation

Subcatchments are defined in SWMM through inputs generated by the user that represent the subcatchment physical characteristics. Subcatchments were delineated for the LID Subdivision and Pre-development Watershed conditions by reviewing topographic data presented in detailed as-built conditions plans, conducting field topographic surveys as well as monitoring actual runoff flow patterns in the field.

Partridgeberry Place LID Subdivision

The LID Subdivision subcatchments were delineated using as-built condition plans, field topographic survey, and field monitoring and dye tests. An as-built conditions plan entitled "Record Conditions Plan of Land Located in Ipswich, Massachusetts" prepared by Meridian Associates, Inc. dated March 5, 2007 of Beverly, Massachusetts (Attachment 2), included as-built conditions of the Subdivision such as the storm drain system, the extent of loop road paving and associated driveways and final topography.

Subcatchment delineations were verified in the field during three rain events on April 29, 2008, July 24, 2008, and August 6, 2008; the field verification helped identify runoff patterns from vegetated and impervious areas. A dye-test was also conducted on August 6, 2008 along the loop road to visually identify runoff patterns at the LID Subdivision. Field observations (Figures 4-2 and 4-3) show water draining from the loop road along the grass paver strip to the stone collection trench monitoring device. The observation of the dye in the monitoring device helped assure that the device was collecting sheet flow runoff from the loop road adjacent to the Raingarden.

Based on all the field observations, as-built condition plans and additional survey, Geosyntec determined that subcatchments at the LID Subdivision generally drain to the Raingarden, Pond One or Pond Three (Figure 4-4). Approximately half of the loop road, as well as the open space it encloses, drain directly to the Raingarden via sheet flow to the storm water collection trench or via the grass-lined swales located along the interior edge of the loop road. Driveways around the loop road, lawns, and the remaining portion of the loop road drain to Pond One, via drop inlets to the storm water drain system. The driveways for Houses #20, #22 and #24, drain to small isolated raingardens located on the lots and driveways for Houses #32, 34, and 36, drain to trench drains at the edge of the garages. Pond One ultimately overflows to Pond Two, which is located along the northwest side of the LID Subdivision. A small area of the LID Subdivision drains to Pond Three, which is located on the southwest corner of the development. The area that drains to Pond Three includes all the houses, driveways, lawns, and road up to where the loop road begins.

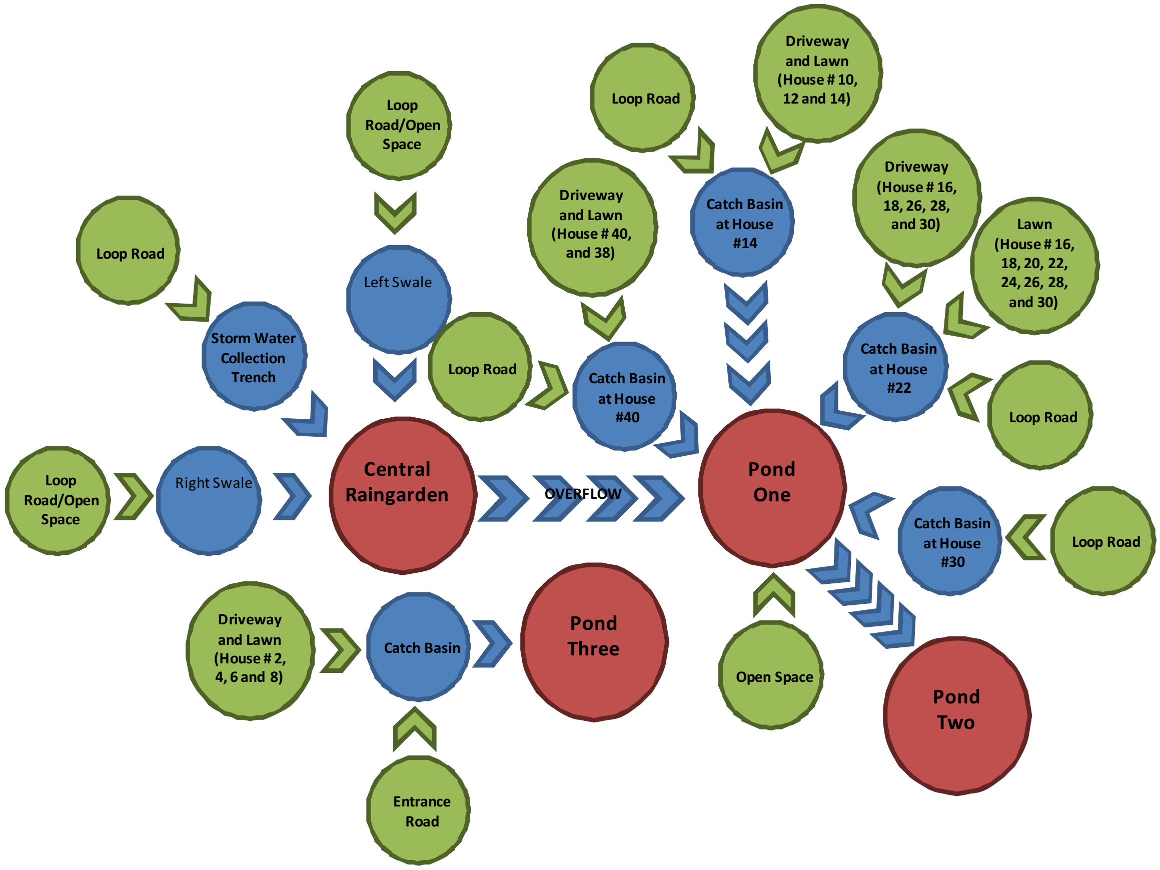

Figure 4-4: LID Subdivision Model Flow Chart

In SWMM, each roof, driveway, lawn, and roadway has a unique subcatchment. Subcatchment drainage area maps for the LID Subdivision can be found on the site maps located in Attachment 3. SWMM subcatchment inputs can be found in Attachment 4.

Cluster Only Subdivision

The Cluster Only Subdivision subcatchment layout is similar to that of the LID Subdivision, but the LID features of the LID Subdivision model, including roof top disconnect to dry wells, the grass-lined swales and the raingardens, were eliminated from the Cluster Only Subdivision model.

The following storm water management routing changes were made, when compared to the LID Subdivision:

- Rooftop runoff was routed (via modeling) to the front portion of the lawn which drains to the driveway and ultimately to the roadway adjacent to the house; and
- Subcatchments that previously were routed to the Raingarden were routed to Pond One via the catch basins along the loop road. The runoff from the portion of the loop road that previously drained to the swales was routed to the same catch basins that existed in the LID Subdivision, as if the entire loop road were pitched toward the curb.

Conventional Subdivision

The Conventional Subdivision subcatchments were delineated based on a preliminary subdivision design plan entitled "Preliminary Subdivision Plan," dated May 15, 1997 and prepared by Demetriou Property of Ipswich, Massachusetts (Attachment 5). The plan includes the profile of a conventional layout of the Partridgeberry Place Subdivision.

The Conventional Subdivision condition is a non-LID, non-clustered layout with lot areas of approximately 1.0 acre, a 24-foot road width, rooftops that drain to the front portion of the vegetated lawn on the lot, minimum lot widths of 175 feet and minimum building set back of 50 feet, causing an increased driveway length.

The drainage features (i.e., storm water infrastructure and location of storm water management features) were not present on the preliminary design plans, nor was topography included in the preliminary design, therefore the following assumptions were made to delineate the subcatchments for the Conventional Subdivision condition:

- Subcatchments in the Conventional Subdivision condition include the same number of lots (twenty) as in the LID Subdivision condition; however, the lot size increases from 0.2 to 1.0 acres;
- Subcatchments were routed via drop inlets and culverts to one of two storm water management basins (Pond One or Pond Three);
- The subcatchments to each of the storm water management basins (Pond One or Pond Three) were the same as in the LID Subdivision layout; however, the area of the subcatchments increased due to an increase in lot size and driveway length;
- Subcatchments that previously were routed to the Raingarden were routed to Pond One via the drop inlets along the road. The runoff from the portion of the road that previously drained to the swales, was routed to drop inlets that existed in the LID Subdivision, as if the entire road was pitched toward the curb; and
- Rooftop runoff was routed to the front lawns which drain onto driveways and ultimately to the roadway adjacent each house.

Drainage area maps for the Conventional Subdivision can be found on the site maps located in Attachment 6. SWMM subcatchment inputs can be found in Attachment 4.

Pre-development Watershed

The Pre-development Watershed was delineated by Geosyntec during a detailed site survey conducted on August 1, 2008 to determine the watershed area and topography. The Pre-development Watershed is located off of a walking trail to the northwest of the LID Subdivision and has an area of 0.08 acres (3,370 square feet). The estimated forest coverage of the trees is 30% in the canopy, 60% in the middle layer, and 25% at 10 feet above ground surface. The shrub density at ground level is approximately 25%. The litter and duff layer throughout the site ranges from one to four inches deep. A drainage map for the Pre-development Watershed can be found in Attachment 7.

Table 4.1: Land Use Based on Model Scenario

Characteristic	LID Subdivision	Cluster Only Subdivision	Conventional Subdivision	Pre-development Watershed
Drainage Area (acres)	38	38	38	38
Land Use (acres)				
Driveway	0.23	0.23	0.46	0
Lawns	3.06	3.06	27.72	0
Roofs	0.92	0.92	0.92	0
Sidewalks	0.25	0.25	0.25	0
Streets	0.61	0.61	1.75	0
Open Space	30.89	30.89	6.90	38
Other (i.e., septic field)	2.04	2.04	0	0
Impervious Area (percent)	5%	5%	9%	0%

Table 4.1 provides a breakdown of the land use area in each of the model scenarios. This shows that the LID Subdivision and Cluster Only Subdivision have the same land use areas and that the Conventional Subdivision has an increase in lawn area, driveways, streets and a decrease in the amount of open space. Open space or conservation areas include wetlands, buffers to streams, wildlife habitats, and historic features.

Subcatchment Characterization

EPA SWMM Version 5.0 requires physical parameters for each subcatchment:

- **Area:** The areas of each subcatchment were calculated from the delineations shown in Attachments 3, 6, and 7.
- **Width**: Subcatchment width is the physical width of overland flow that is anticipated to occur within the subcatchment. Overland flow on the subcatchment is assumed to derive from an idealized rectangular subcatchment. In practice, the subcatchment will not be rectangular with properties of symmetry and uniformity (James, 2005). In order to systematically estimate the width of the subcatchment, the measured area of the subcatchment is divided by the length of the flow path. Due to the high uncertainty of fixing the length of the flow path from upstream to downstream, uncertainty of estimating length is ±15 percent (James, 2005). When the physical conditions of the subcatchments could not be identified in the field, as-built plans were imported into AutoCAD and the dimensions were calculated.
- **Slope:** Subcatchment slope is the average slope along the pathway of overland flow to the inlet. The slope for each subcatchment was calculated based on estimating the length of the anticipated flow path and difference in elevation along the flow path. The elevations along the flow path were estimated from as-built plans imported into AutoCAD. The error associated with the change in elevation of the subcatchment is assumed to be ±10 percent.
- **Percent impervious area**: Imperviousness is defined as the percentage of area which is impervious and hydraulically directly connected to the outlet, such as driveways and

rooftops with downspouts (James, 2005). In reality, runoff that flows over the driveway and rooftops will not completely drain into the storm drain system, due to the depression storage of water on the road surfaces and rooftops. As a result, an error of 12 percent is appropriate (James, 2005). Impervious area was estimated based on the actual area of imperviousness presented on the plans and drawings.

- **Impervious area depression storage:** Impervious area depression storage is defined as water stored in depressions on impervious areas and is depleted only by evaporation (James, 2005). Depression storage varies according to soil type, subcatchment slope and pavement.
- **Pervious area depression storage:** Pervious area depression storage is defined as water stored in depressions on pervious area and is subject to infiltration and evaporation (James, 2005). Pervious area depression storage has the same properties as impervious area depression storage, which is mainly dependent on soil type and slope.
- **Manning's Roughness Coefficient (n-value):** Manning's roughness coefficient, n, is one of the parameters used to calculate overland flow characteristics. Due to the high variability in the values for Manning's roughness coefficient, it is very difficult to estimate this value model-wide (James, 2005).

Assumed model subcatchment parameter values are listed in Table 4.2. The Manning's n impervious value of 0.011 corresponds to smooth asphalt, whereas the pervious value of 0.24 corresponds to dense grass. The percent (%) zero impervious represents the percent of the impervious area with no depression storage, which was assumed to be 75 percent, since the paved area appeared to be properly graded and in good condition and little ponding was observed on site during rain events. Subarea routing refers to the internal routing of runoff between pervious and impervious areas. For this model, Outlet routing was chosen, which routes runoff from both pervious and impervious directly to the outlet. The percent routing represents the percentage of area in each subcatchment which is routed to the outlet.

Table 4.2: Subcatchment Model Assumptions by Parameter

Subcatchment Parameter	Assumed Value
Manning's n-impervious	0.011
Manning's n-pervious	0.24
D-store impervious	0.05
D-store pervious	0.15
% Zero impervious	75
Subarea Routing	Outlet
% Routed	100

Additional subcatchment parameters that are important inputs to SWMM are evapotranspiration and infiltration, which are described in the following subsections.

Evapotranspiration

Under natural conditions, a portion of surface water and moisture in the upper soil (i.e., vadose) zone may circulate back to the atmosphere via evapotranspiration processes (Thornthwaite, 1948). Water removed via evapotranspiration in the model is subtracted from the available water balance. Monthly evapotranspiration rates input to the model were taken from the National Climate Data Center (NCDC) Station No. 770, at Boston WSFO Airport, located in Suffolk County, approximately 30 miles south of the LID Subdivision. NCDC evapotranspiration data was available from 1948 through 2006 (NCDC, 2006) and are included in Table 4.3. Evapotranspiration rates were listed for months where monitoring data were collected at the LID Subdivision. Of the four months of monitoring, it appears that monthly evapotranspiration rates are highest in the month of July.

Table 4.3: Monthly Evapotranspiration Rates for Massachusetts

Month	Average Temperature (°F)	Evapotranspiration Rate (in/month)
June	64.87	4.49
July	70.30	6.27
Aug	68.22	5.55
Sept	61.05	3.42

Watershed Infiltration

Infiltration was estimated for the models using the Green-Ampt infiltration equation. EPA SWMM Version 5.0 performs these calculations with three input parameters: (i) average capillary suction at the wetting front (SUCT), (ii) initial moisture deficit (IMD), and (iii) saturated hydraulic conductivity of the soil (K_s).

Based on a test pit dug by Geosyntec in the Pre-development Watershed, the underlying soils were determined to be light to moderate medium brown fine sandy loam with some clay and stones. According to the United States Department of Agriculture Natural Resource Conservation Service (NRCS) web soil survey (Attachment 8), the soils present at the LID Subdivision include Walpole fine sandy loam, Canton fine sandy loam, Pits gravel, Hinkley gravely fine sandy loam, Freetown Muck, Swansea Muck and Merrimac fine sandy loam. Based on the web soil survey, approximately 72% of the soil at the site is comprised of sandy loam.

NRCS also categorizes soils into four groups: A, B, C or D and the classification is based on hydrologic soil properties such as conductivity. According to the observations made by Geosyntec and the web soil survey, the soils at the site appear to be "B" soils. A "B" soil is described as having moderate infiltration rates when thoroughly wetted and consisting mostly of moderately deep to deep, moderately well to well-drained soils with moderately fine to moderately coarse textures (e.g., shallow loess, sandy loam). The conductivity of "B" soils ranges from 0.13 to 0.43 inches per hour (Attachment 9).

Depression storage is another infiltration parameter which is the ability of an area to retain water in its pits or depressions. This value accounts for storm water runoff in the system that is stored in topographical depressions (i.e., puddles), and is represented as a percent of the total area of the subcatchment. Table 4.4 includes the assumed values of the infiltration parameters for the models.

Table 4.4: Assumed Infiltration Parameter Values

Infiltration Parameter	Assumed Value
Suction Head	4.33
Conductivity (in/hr)	0.43
Initial Deficit	0.263
Depression Storage (percent)	75%

Hydraulics

SWMM simulates hydraulics by routing runoff through a drainage system network of pipes, channels, storage/treatment units, and diversions that are defined by the user. The model translates the runoff generated from each subcatchment into flow directed to junctions (e.g., drop inlets, curb inlets, or manholes) that define the drainage system network. The junctions are connected by links, or conduits, (e.g., drainage swales or culverts). The outlet of the drainage network for each watershed drains to a storage unit (i.e., raingarden, detention basin, etc).

Junction Characterization

Junctions are nodes where runoff enters the drainage system network and where conduits join together. Physically they can represent the confluence of natural surface water channels or pipe connection fittings (US EPA, 2005). Junctions were used at several locations in the models with the following purposes:

- As the outlets of subcatchments, to allow for the runoff generated from the subcatchment to be collected and subsequently routed through the storm drain network;
- As connection points for swales; and
- In locations where inlets/ manholes/ and catch basins are.

The three principal input parameters for a junction are: (1) invert elevation, (2) maximum depth (i.e., depth from the ground surface to the invert), and (3) ponded surface area when flooded. The data for each of these parameters were determined from as-built condition plans or field investigations and can be found in Attachment 4. For the Cluster Only and Conventional Subdivision models, the junction input parameters used in the LID Subdivision were replicated for these scenarios.

Conduit Characterization

Conduits are linear features, such as pipes or channels that convey flow from one junction to another in the drainage system network. SWMM uses the Manning equation to express the relationship between flow rate, cross-sectional area, hydraulic radius, and slope in open channels and partially full closed conduits (US EPA, 2005). The parameters described below were easily defined for the LID Subdivision. The parameters were not available for the Clustered and Conventional Subdivision, and therefore, the LID Subdivision values were assumed to apply for these scenarios.

The principal input parameters for a conduit and the information source for this report are as follows:

- **Inlet and Outlet Node Identifiers**: The identifiers of the inlet and outlet junctions for each conduit;
- **Cross-sectional Geometry Shape**: The cross-sectional geometry of the conduits is generally trapezoidal for swales, and circular or elliptical for pipes and culverts;
- **Conduit Length**: The length of each conduit in plan view was calculated based on the as-built plans and field measurements;
- **Conduit Depth**: The depth of the conduit was entered as the diameter of the culvert or the depth of the swale;
- **Manning's Roughness**: The Manning's roughness coefficients used were based on the material of the culvert or the cover type in the swale. The culvert material was generally obtained from the as-built condition plans and included reinforced concrete pipe (RCP) with a Manning's n of 0.011. Swales were evaluated in the field and a grass lining with a Manning's n of 0.24 was modeled;
- **Offset Heights of the Conduit above the Inlet and Outlet Node Inverts:** The offset height was calculated as the difference between the conduit invert elevation and the junction invert elevation; and
- **Entrance, Exit, and Average Pipe Losses**: The entrance, exit, and average pipe losses are the loss coefficients associated with energy losses at the entrance, exit and along the length of the conduit, respectively. Entrance and exit losses for all circular pipes modeled were determined to be 0.5 and 1.0, respectively, from *Fluid Mechanics* (White, 1986).

SWMM inputs for conduits can be found in the SWMM Input Parameters in Attachment 4.

Storage Unit Characterization

Storage units are drainage system nodes that provide storage volume. Physically they represent storage facilities as small as a catch basin or as large as a lake. The volumetric properties of a storage unit are described by a stage-storage relationship. All storm water management basins (Pond One and Pond Three) and the Raingarden were represented as storage units in the models. The principal input parameters (Attachment 4) for storage units include: (1) invert elevation, (2) maximum depth, (3) initial depth, (4) stage-area relationship, (5) evaporation potential, (6) ponded surface area when flooded, and (7) external inflow data (US EPA, 2005).

Dynamic Routing

Flow routing within a conduit link in SWMM is governed by the conservation of mass and momentum equations for gradually varied, unsteady flow. The three routing options are: (i)

Steady Flow Routing, (ii) Kinematic Wave Routing, and (iii) Dynamic Wave Routing. Dynamic Wave Routing was chosen as the routing methodology for modeling the three conditions. Dynamic Wave Routing solves the complete one-dimensional Saint Venant flow equations. These equations consist of continuity and momentum in conduits and volume continuity at nodes. With this form of routing, it is also possible to represent pressurized flow (i.e., when a closed conduit becomes full) in which the full-flow Manning's equation value can exceed the actual flow. Flooding occurs when the water depth at a node exceeds the maximum available depth. The excess volume/flow then ponds atop the node based on the allowable ponding area until the water depth decreases and the volume/flow re-enters the drainage system network. Water is lost from the drainage system network if the volume/flow exceeds the allowable ponding area.

In addition to pressurized flow, Dynamic Wave Routing can account for channel storage, backwater effects, entrance/exit losses, and flow reversal. It combines the solution for water levels in nodes and flows in conduits; it can be applied to any general network layout (US EPA, 2005).

Precipitation

Precipitation is a primary hydrologic input parameter in SWMM. Precipitation data were collected locally at the site as part of the site monitoring program using a tipping bucket rain gauge installed at the site, described in detail in Chapter 3. To ensure that the short-term collection of precipitation at the site is representative of historic precipitation, the site precipitation data were compiled and compared to regional historic rainfall sources.

The historic precipitation gauge data were obtained from the National Climate Data Center (NCDC) Station No. 770 and precipitation data were available for the Station for 1948 through 2006 in 60 minute increments (NCDC, 2006).

A statistical frequency analysis of the historic precipitation data was performed using the Statistics tool within SWMM. A SWMM Statistics Report was generated for the precipitation data using the following steps:

- Segregate the simulation period into a sequence of non-overlapping events, either by day, month, or by flow (or volume) above some minimum threshold value;
- Compute a statistical value that characterizes each event, such as the mean; maximum, or sum of the variable over the period of analysis; and
- Perform a frequency analysis on the set of precipitation data.

CHAPTER 5

MODEL ANALYSIS

The SWMM hydraulic and hydrologic models were analyzed, after compiling the input parameters, to determine if they were accurately predicting the monitored condition data. The rainfall data for the entire monitoring period were input into the LID Subdivision and Pre-development Watershed models. Continuous simulation model runs were used to compare the storm event peak discharge and storm event volume, to determine if calibration of the models was necessary. Based on these initial runs, described below in more detail, the peak discharge and storm event volume were being over-estimated by the uncalibrated model.

Therefore, model simulations were performed to calibrate the data in order to mimic monitoring results, such that the watershed response could be predicted under potential future rainfall scenarios. A description of the calibration process and results are presented in the following subsections.

Calibration

Calibration is the comparison of a model to field measurements, other known estimates of output, or another model known to be accurate, and the subsequent adjustment of the model parameters to best fit those measurements.

Model input variables or "parameters" can be categorized into four groups, based on the act of choosing values for them, parameter estimation or parameterization. The four groups include (James, 2005):

- **Parameters that can be measured with almost total certainty.** Examples are subcatchment areas, culvert diameter, swale geometry, and other conduit geometries, conduit slopes and elevations, conduit lengths, storage areas, spillway geometry, and others. These are not good candidates for calibration, since uncertainty is small, between 5 and 10 percent.
- **Parameters that can be estimated with a high degree of certainty in the field, design office, or laboratory.** These include percent imperviousness, Manning's n for pipes, flow and others. These parameters may be modified during calibration, and typically have an uncertainty between 10 and 25 percent.
- **Parameters that cannot be easily measured in the field or laboratory.** These include infiltration rates and pollutant build-up or wash-off. These are good candidates for calibration, due to the level of uncertainty between 25 and 50 percent.
- **Parameters with high uncertainty**. Examples are mean ground slope, catchment widths, and recovery of infiltration capacities. These parameters are considered significantly adjustable for calibration, and have an uncertainty of 50 to 100 percent.

During model calibration, the high uncertainty parameters were focused on; a standard practice for model calibration. During calibration, typically three response hydrographs are analyzed: volume, peak discharge and time-to-peak (James, 2005).

Due to the data collection time of 5-minutes, the focus of the model calibration was placed on total storm volume, since the odds of capturing the peak discharge at the exact moment it occurred was unlikely. James (2005) states that the accuracy level for calibration is typically:

Dry weather: ± 5 percent of volume and ±10 percent of peak; and

Wet weather: ± 10 percent of volume and ± 15 percent of peak.

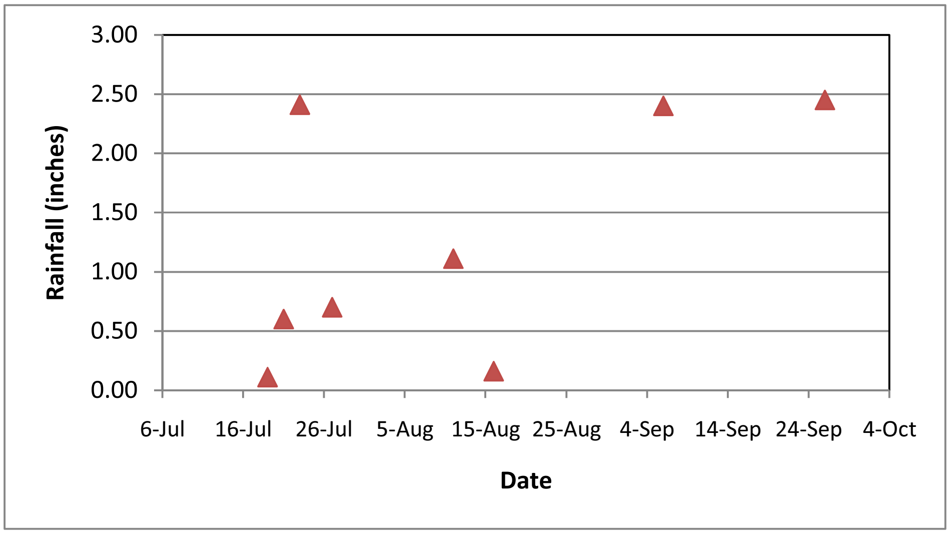

Figure 5-1: Storm Events used for Model Calibration of Raingarden and Pond One

Only reliable events were considered for calibration, which is typically determined to be the top 5 percent of the total number of events (James, 2005). Therefore, 4 storms (top 10 percent) with the largest accumulated precipitation and 4 storms (top 10 percent) with the largest event intensity were used to adjust model parameters and the remaining events in the continuous simulation period were used to verify the selection of parameters. Figure 5-1 presents the eight storm events with their corresponding rainfall accumulation used during model calibration of the Raingarden and Pond One.

LID Subdivision Model

The LID Subdivision model was calibrated to mimic the observed response of the inflow hydrograph and storm volume for the Raingarden, Pond One, and Pond Three. The continuous rainfall for the duration of the monitoring period was evaluated using SWMM to ensure the storm volume from the model was representative of the observed data. Calibration of parameters and results are explained in the following subsections and in Attachment 10.

Raingarden

The Raingarden receives inflow from three monitoring points: storm water collection trench and two open grass-lined swales. The drainage area to the storm water management feature is comprised of the loop road and open space area surrounding the grass-lined swales.

Figure 5-2 presents the observed storm volume verses the computed model storm volume prior to calibration. For the data to perfectly mimic observed conditions (0 percent uncertainty), all the data points would fall on a straight line. Based on Figure 5-2 it appears that

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the uncalibrated model was over-predicting the storm volume for one storm and under-predicting for five additional storms. The storms that produce a smaller storm volume (i.e., less than 1000 cubic feet) appear to be predicted well by the uncalibrated model. Therefore, adjustments to the model, as shown in Table 5.1, were made to provide a more accurate representation of the observed conditions.

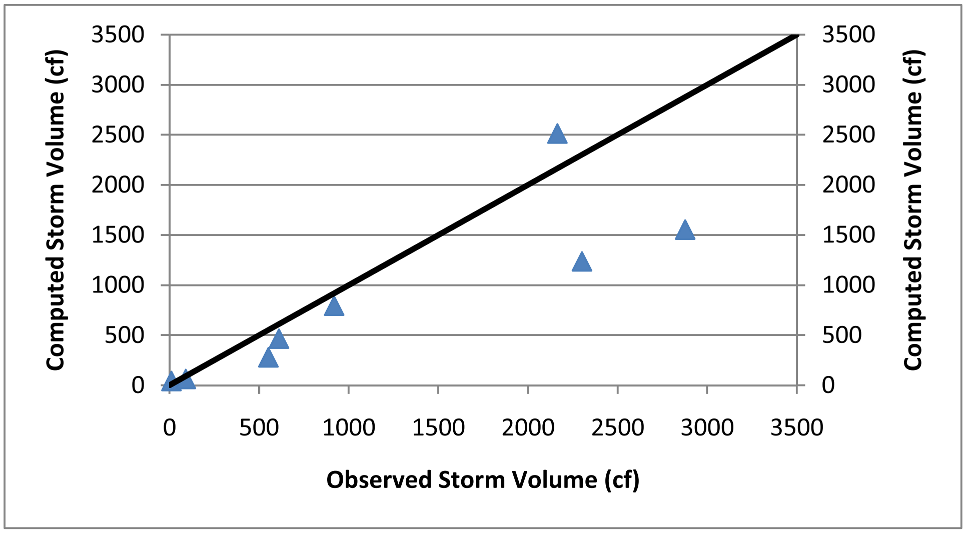

Figure 5-2: Observed verses Computed Storm Volume Prior to Calibration for Raingarden

The model subcatchment parameters that were altered during model calibration were the soil type, infiltration and Manning's n-values. The assumed soil type for the LID Subdivision in the uncalibrated model was sandy loam, which has an average hydraulic conductivity of 0.43 inches per hour. The modeled soil type was changed to silt loam during calibration, which represents an infiltration rate of 0.26 inches per hour. The decreased infiltration rate increases the storm water runoff volume from vegetated subcatchments, which are mostly comprised of the open space area encompassed by the loop road. The Manning's n-values for overland flow were decreased to decrease hydraulic travel time and increase peak discharge from the subcatchments. The Manning's n-values for channelized flow were increased during calibration to increase the hydraulic travel times through the vegetated swales thus reducing the peak discharge rates into the Raingarden.

Table 5.1: Raingarden Model Parameter Changes during Calibration

Parameter	Pre-Calibrated Model	Calibrated Model
Soil Type	Sandy Loam	Silt Loam
Infiltration		
SUCT	4.33	6.69
Conductivity (K)	0.43	0.26
Initial Deficit	0.263	0.217
Vegetated Subcatchments		
Pervious N-value	0.24	0.15
Swales		
Pervious N-value	0.24	0.41

Figure 5-3 presents the observed storm volume verses the computed storm volume after calibration of the model. For the eight storms used to calibrate the model, computed storm volumes mimic observed conditions within 10 percent.

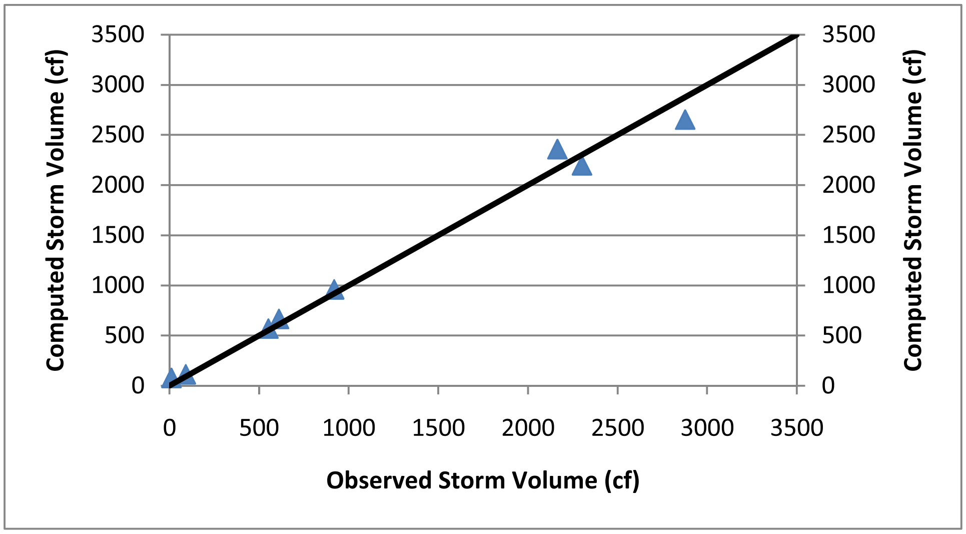

Figure 5-3: Observed verses Computed Storm Volume after Calibration, for Raingarden

To ensure that the shape of the hydrograph in the calibrated model was similar to the observed conditions, the storm events were plotted as line graphs. Figure 5-4 presents the storm that occurred on 9/6/2008 through 9/7/2008 and produced 2.40 inches. The calibrated model hydrograph appears to have a similar shape when compared to the observed conditions and therefore, is a good representation of the observed conditions.

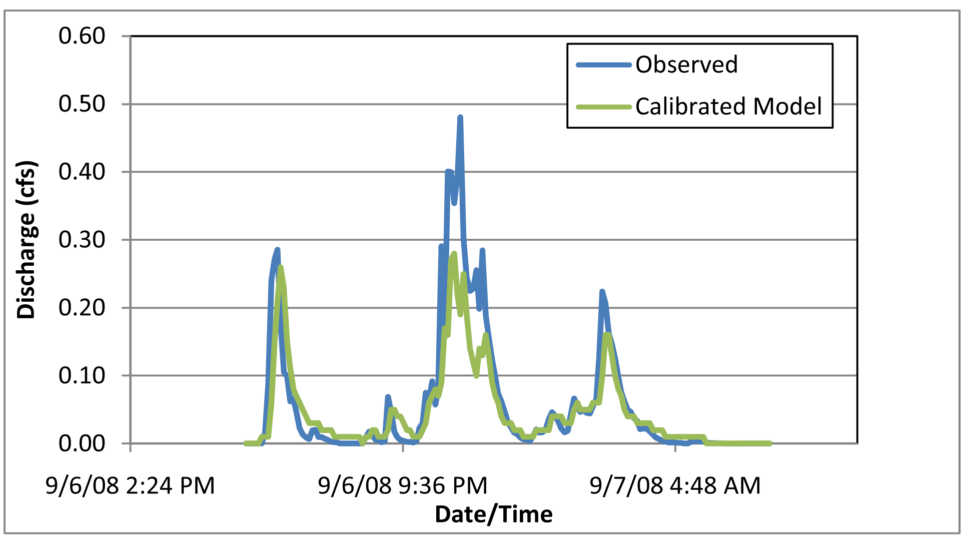

Figure 5-4: Observed verses Calibrated Discharge into Raingarden

Pond One

Pond One receives inflow from four monitoring points, three storm water pipes leading from roadside catch basins and the Raingarden overflow weir. The drainage area to Pond One is primarily comprised of the loop road, lawns, driveways and Raingarden overflow.

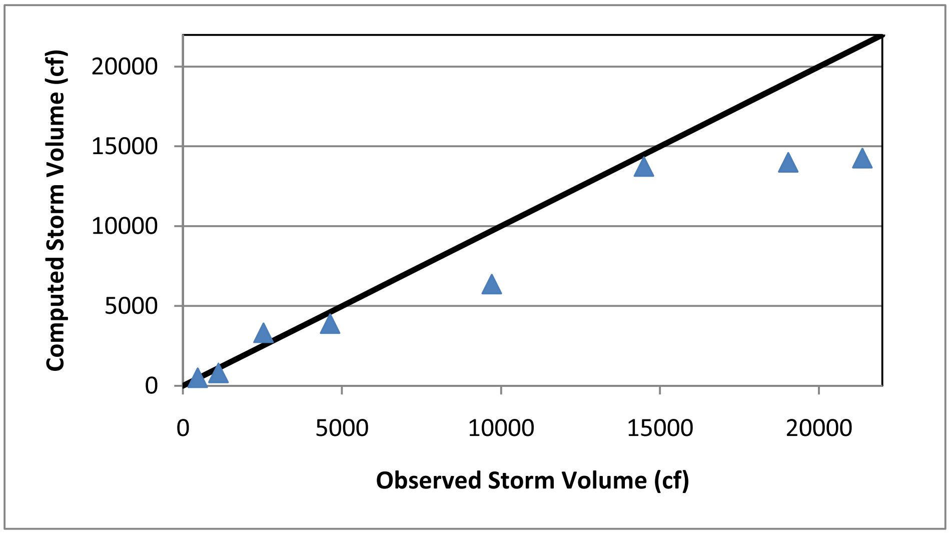

Figure 5-5: Observed verses Computed Storm Volume Prior to Calibration, for Pond One

Figure 5-5 presents the observed storm volume verses the computed model storm volume prior to calibration. Based on Figure 5-5 it appears that the uncalibrated model predicted the small volume storms (i.e., less than 5,000 cubic feet) well and under-predicts the larger volume storms. Therefore, adjustments to the model parameters, included in Table 5.2, were made to provide a more accurate representation of the observed conditions.

Table 5.2: Pond One and Pond Three Model Parameter Changes during Calibration

Parameter	Pre-Calibrated Model	Calibrated Model
Soil Type	Sandy Loam	Clay
Infiltration		
SUCT	4.33	12.60
Conductivity (K)	0.43	0.01
Initial Deficit	0.263	0.097
Vegetated Subcatchments		
Pervious N-value	0.24	0.15
Impervious Cover	3.0%	7.0%

The model parameters that were altered during calibration were the soil type, infiltration Manning's n-value and impervious cover. The assumed soil type (i.e., sandy loam) was changed to clay during calibration, which represents an infiltration rate of 0.01 inches per hour.

The decreased infiltration rate results in an increase in storm water runoff volume from vegetated subcatchments. The infiltration parameters representative of a clay soil, were chose to mimic compacted sandy loam soils. Compaction of soils typically can occur during construction of the development. The Manning's n-values for overland flow in the subcatchment were decreased to decrease hydraulic travel time and increase peak discharge from the subcatchments. The impervious cover for the vegetated subcatchment was increased from 3 to 7 percent, resulting in an increase in storm water runoff volume.

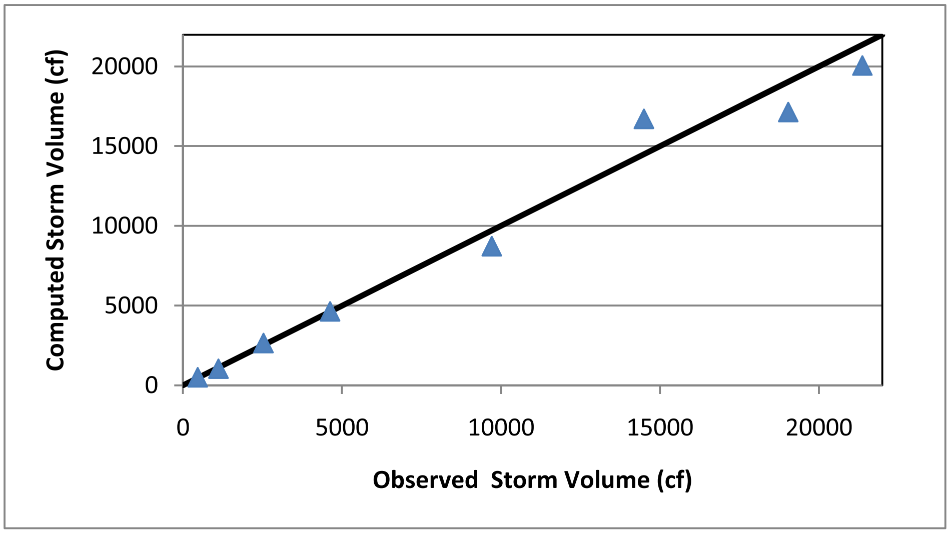

Figure 5-6: Observed verses Computed Storm Volume after Calibration, for Pond One

Figure 5-6 presents the observed storm volume verses the calibrated model storm volume. For the eight storms used to calibrate the model, computed storm volumes mimic observed conditions within 10 percent. Six of the eight computed storm volumes are within 5 percent of the observed storm volume.

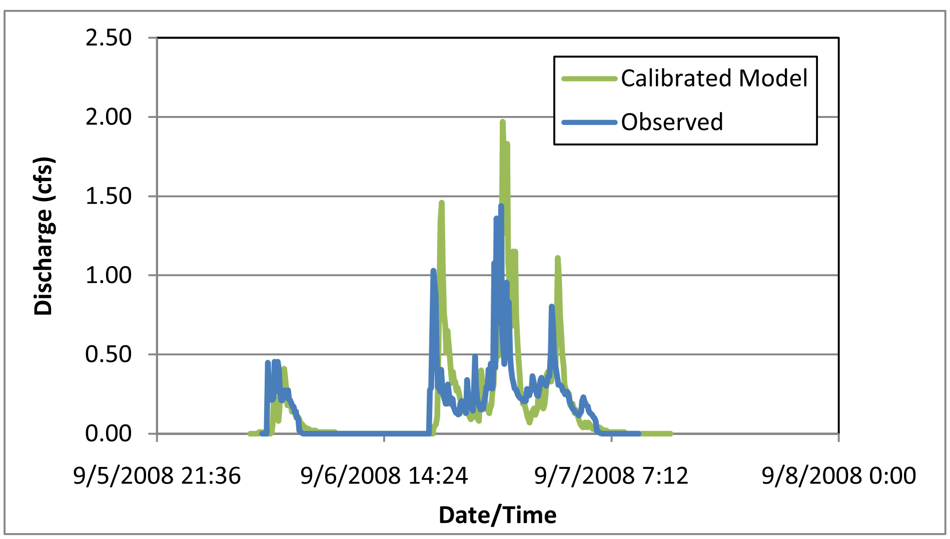

Figure 5-7: Observed verses Calibrated Discharge into Pond One

To ensure that the shape of the hydrograph in the calibrated model was similar to the observed conditions, the storm events were plotted as line graphs. Figure 5-7 presents the storm that occurred on 9/6/2008 through 9/7/2008 and produced 2.40 inches. The calibrated model hydrograph in Pond One appears to have a similar shape when compared to the observed conditions and therefore is a good representation of the observed conditions.

Pond Three

Pond Three receives inflow from one monitoring point which is located at a catch basin along the entrance to the LID Subdivision. The drainage area to Pond Three is primarily comprised of the entrance road, lawns and driveways.

Five storms were chosen to calibrate Pond Three. Different storm events were used for Pond Three calibration because of missing data points from July 24th through August 13th in the Pond Three monitoring data. The missing data was the result of a water level logger malfunction apparently caused by accumulated sediment over the probe. The five storm events, presented in Figure 5-8, were used to adjust model parameters and the remaining events in the continuous simulation period were used to verify the selection of parameters.

Figure 5-9 presents the observed storm volume verses the computed model storm volume prior to calibration. Based on Figure 5-9 it appears that the pre-calibrated model under-predicts the storm volume. Therefore, adjustments to the model parameters, included in Table 5.2, were made to provide a more accurate representation of the observed conditions.

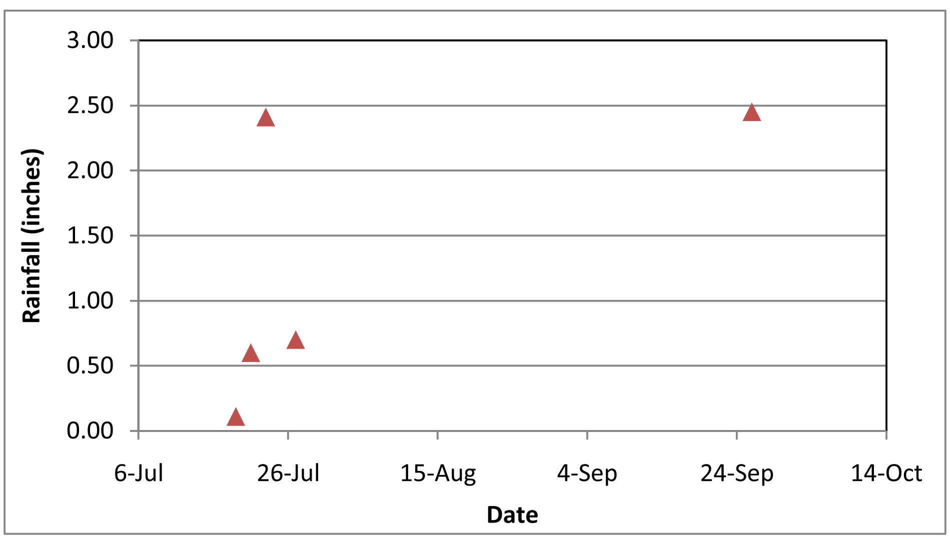

Figure 5-8: Storm Events used for Model Calibration of Pond Three

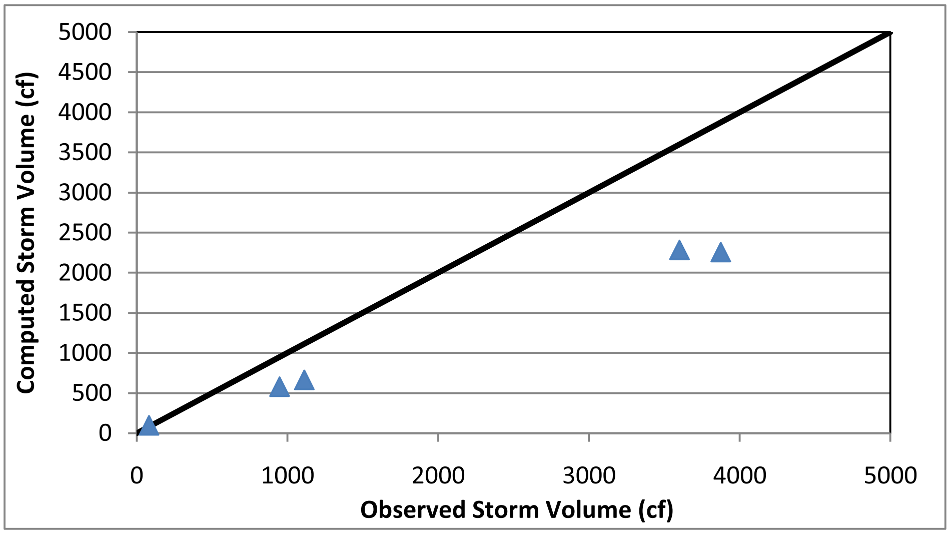

Figure 5-9: Observed verses Computed Storm Volume Prior to Calibration, for Pond Three

The model parameters that were altered during calibration were the soil type, infiltration Manning's n-value and impervious cover. The assumed soil type (i.e., sandy loam) was changed to clay during calibration, which represents an infiltration rate of 0.01 inches per hour. The decreased infiltration rate results in increased storm water runoff volume from vegetated subcatchments. The Manning's n-values for overland flow in the subcatchment were decreased to decrease hydraulic travel time and increase peak discharge from the subcatchments. The impervious cover for the vegetated subcatchment was increased from 3 to 7 percent, resulting in increased storm water runoff volume.

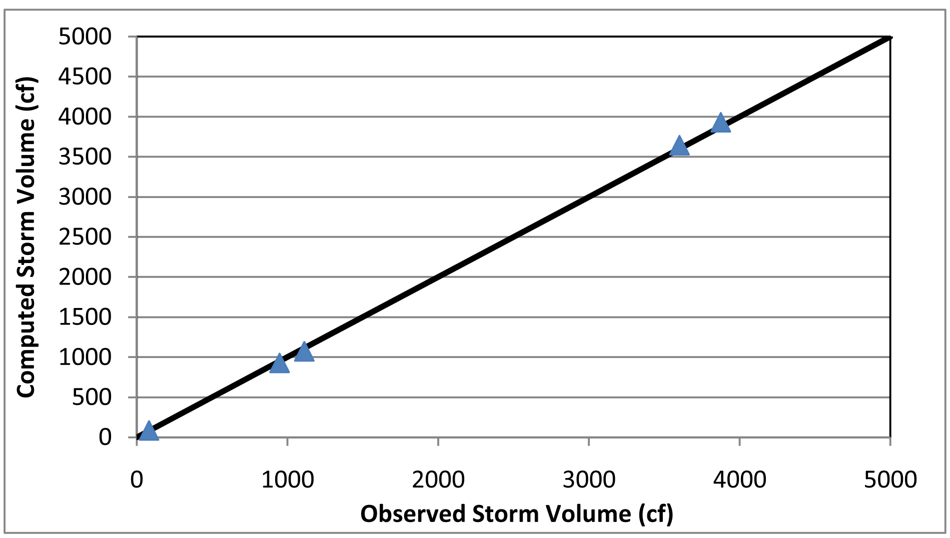

Figure 5-10: Observed verses Computed Storm Volume after Calibration, for Pond Three

Figure 5-10 presents the observed storm volume verses the calibrated model storm volume. For the five storms used to calibrate the model, computed storm volumes mimic observed conditions within 8 percent.

Pre-development Watershed Model

The Pre-development Watershed receives runoff from the 0.08 acre forested area. The SWMM for the Pre-development Watershed is comprised of a single catchment which drains to an outlet.

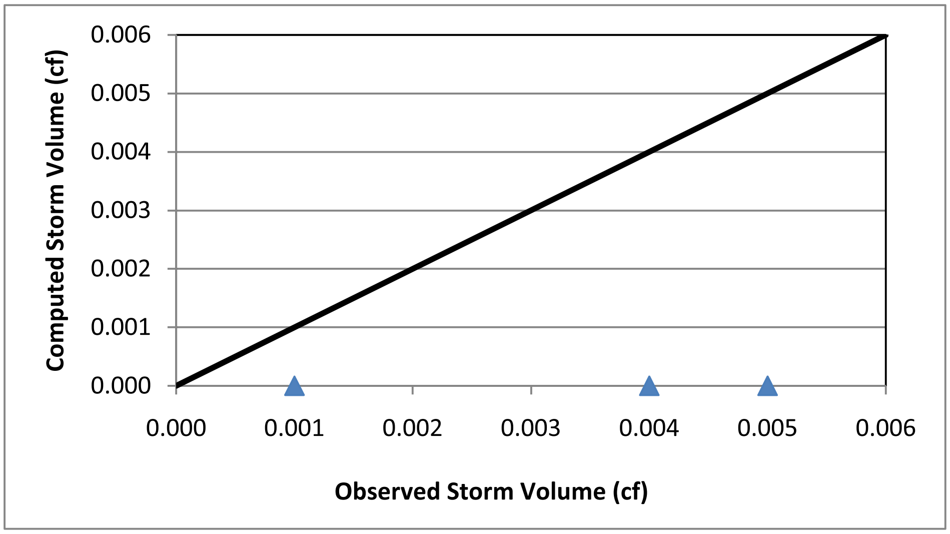

Figure 5-11: Observed verses Computed Storm Volume Prior to Calibration, for Pre-development Watershed

Figure 5-11 presents the observed storm volume verses the computed model storm volume prior to calibration, for the Pre-development model. Based on Figure 5-11 it appears that the uncalibrated model predicts zero runoff for the storms being used for calibration. The three storms being analyzed for calibration are shown in Figure 5-12. Due to the lack of accurate prediction of the observed flows, adjustments to the model parameters, included in Table 5.3, were made during model calibration

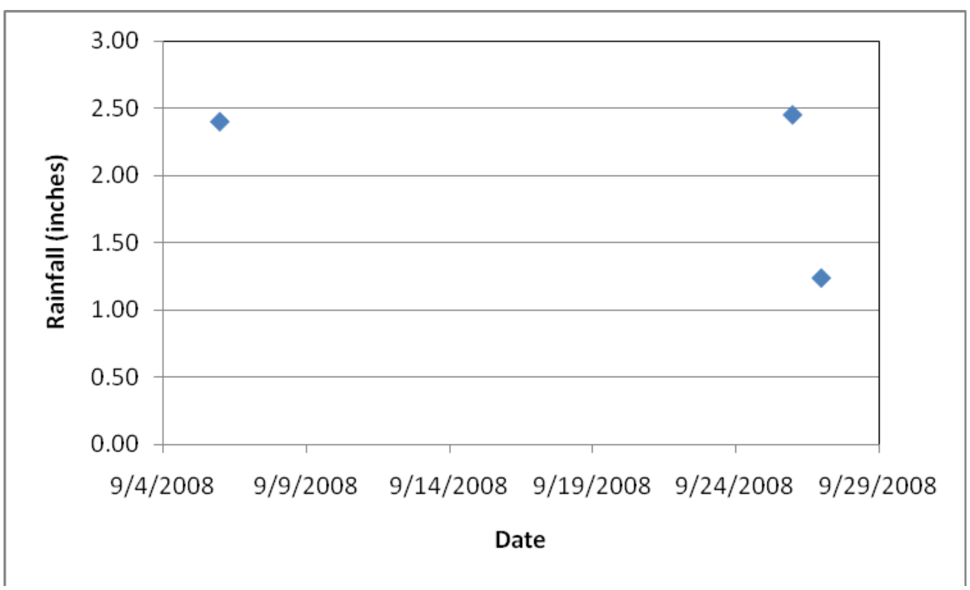

Figure 5-12: Storm Events used for Model Calibration of Pre-development Watershed

The model parameters that were altered during calibration were the soil type, infiltration and impervious cover. The assumed soil for the Pre-development Watershed was sandy loam, which has a hydraulic conductivity of 0.43 inches per hour. The soil type was changed during calibration to sandy/silty loam, which represents an infiltration rate of 0.17 inches per hour. The decreased infiltration rate results in greater storm water runoff volume from the forested subcatchment. The impervious cover for the forested subcatchment was assumed to be 0 and increased to 0.12 percent, resulting in additional storm water runoff from the area.

Table 5.3: Pre-development Watershed Model Parameter Changes during Calibration

Parameter	Pre-Calibrated Model	Calibrated Model
Soil Type	Sandy Loam	Sandy/Silt Loam
Infiltration		
SUCT	4.33	3.71
Conductivity (K)	0.43	0.17
Initial Deficit	0.263	0.239
Impervious Cover	0%	0.12%

Figure 5-13 presents the observed storm volume verses the calibrated model storm volume. For the three storms used to calibrate the model, computed storm volumes mimic observed conditions within 2 percent. The calibrated Pre-development Watershed parameters were used in four model scenarios for the area designated as "open space".

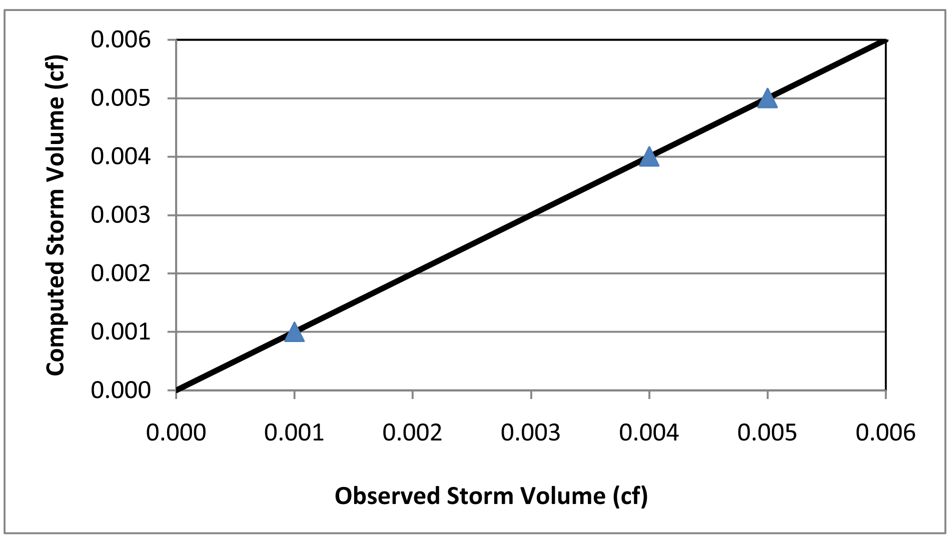

Figure 5-13: Observed verses Computed Storm Volume after Calibration, for Pre-development Watershed

CHAPTER 6

RESULTS AND DISCUSSION

Results were drawn for the precipitation data, monitoring instrumentation data and the modeling analysis. The instrumentation data and modeling analysis were analyzed to determine if the data met the project goals and objectives described in Chapter 1 of this report. The results and discussion are presented in the following subsections.

Precipitation Results

Precipitation data were analyzed to determine how representative the data collected at the LID Subdivision were compared to historic rainfall in the Boston, MA area. Precipitation data were collected at the LID Subdivision from June 27, 2008 through September 30, 2008. Figure 6-1 shows a histogram of storm event sizes from the LID Subdivision rain gauge. A storm event is defined by precipitation that accumulates with a dry inter-event period greater than or equal to 6 hours. A total of 44 storm events were observed over the period of study, of which 33 (75 percent) were less than or equal to 0.35 inches in accumulation. Approximately 20 inches of precipitation fell during the period of monitoring, which is less than half of the average annual rainfall for the Boston, MA area (47 inches).

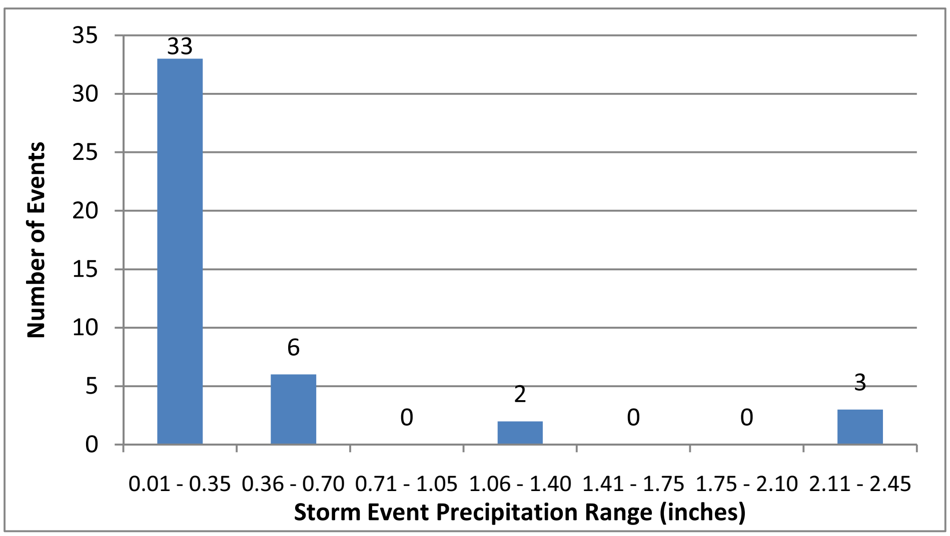

Figure 6-1: LID Subdivision Storm Events

Historic Precipitation Data

To ensure that site specific precipitation collected at the LID Subdivision was representative of historic rainfall for the area, the data were statistically analyzed to determine how closely the LID Subdivision rainfall data distribution mimicked the historic rainfall distribution.

Historical precipitation data from the NCDC Station No. 770, Boston WSFO Airport were analyzed from 1948 through 2006 (Historic Rain Gauge). Based on the statistical analysis, Table 6.1 shows the mean, median, maximum and minimum rainfall values for both the LID

Subdivision and Historic Rain Gauges. These results indicate that for all statistical measures the values are almost equal, except for the maximum rainfall amount for the records. The difference in the maximum rainfall accumulation is due to the length of the historic precipitation record, which includes precipitation events with magnitudes equivalent to the 60-year event.

Conversely, the precipitation monitoring data collected at the LID Subdivision spanned a small period of study and includes events equal to the mean, median and minimum historic events.

Table 6.1: Statistics for LID Subdivision and Historic Rain Gauges

Statistic	Rain Gauge Location	
	LID Subdivision (June - Sept. 2008)	Historic (1948-2006)
Rainfall (inches)		
Mean	0.37	0.34
Median	0.14	0.15
Maximum	2.45	7.06
Minimum	0.01	0.01

A statistical frequency analysis was also performed on the historic precipitation record to determine the return periods associated with the precipitation events. An inter-event time of 6 hours was used and a SWMM Statistics Report was run, which organized the historic precipitation data into independent rainfall events with a total rainfall that occurred over the duration of the event.

The return period calculation is dependent on the gauge period of record. The design return periods for the historic precipitation record are as follows:

- For the 2-year return period: the rainfall is 2.47 inches (SCS rainfall is 3.00 inches);
- For the 10-year return period: the rainfall is 3.88 inches (SCS rainfall is 4.50 inches);
- For the 25-year return period: the rainfall is 4.91 inches (SCS rainfall is 5.50 inches); and
- For the 50-year return period: the rainfall is 6.62 inches (SCS rainfall is 6.00 inches).

The Historic Rain Gauge data statistical results for the design storms were compared to those typically found on the SCS (Soil Conservation Service) Synthetic Rainfall Maps, as shown above in parenthesis. The results for the design storms that could be calculated from the historic precipitation record are relatively equal to SCS design storms.

The historic record has less than 100 years of recorded data; therefore, a 100-year design storm could not be estimated for the historic record and the SCS Synthetic Rainfall Map Design Storm was used for 100-year event. The 100-year SCS return period rainfall amount is equal to 7.25 inches.

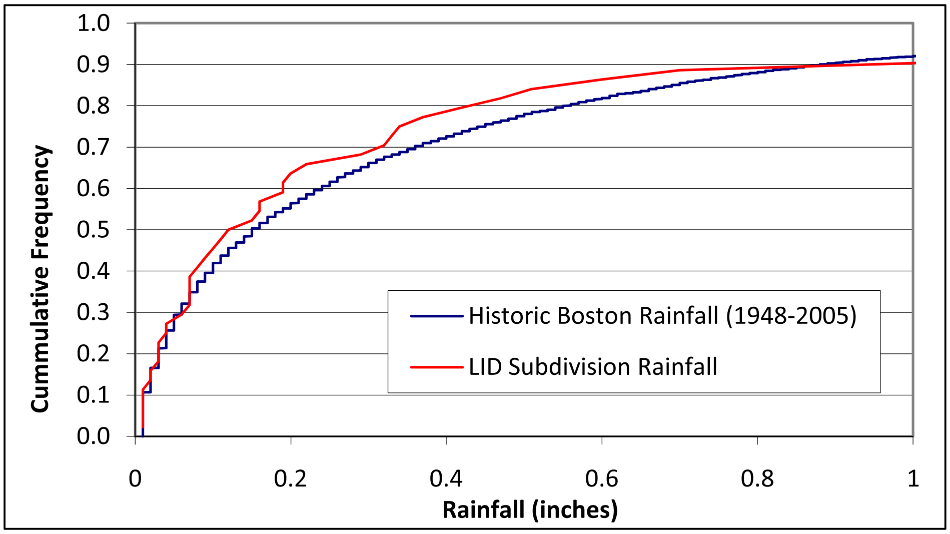

Figure 6-2: Cumulative Frequency Distribution of Rainfall at the LID Subdivision and Historic Rain Gauge for Events Less than 1-inch.

The cumulative frequency distributions for the Historic and LID Subdivision Rain Gauge data sets were analyzed to determine how closely the monitoring data collected at the LID Subdivision represents the historic rainfall for the area. Figure 6-2 is a plot of cumulative frequency distributions for storms less than 1.0 inch in accumulation. This plot shows that the cumulative frequency of the LID Subdivision precipitation data closely mimics the historic data.

For storms with accumulation of 1.0 inch or greater, the number of storms included in the Historic data set were much greater than the number of storms observed at the LID Subdivision; therefore, the cumulative frequency distribution plots are more variable and the historic precipitation data are more accurate than the monitoring data.

Based on the precipitation analysis, the number of storm events and accumulation of these events appeared to be sufficient to provide an understanding of how the modeled scenarios perform hydraulically and hydrologically when compared to historic rainfall records.

Monitoring Results and discussion

Hydraulic and hydrologic data were collected at thirteen monitoring points in the LID Subdivision during the period of study. The monitoring data were analyzed to meet the objectives stated in Chapter 1.

The individual data collected at each of the monitoring points, helped provide an understanding of the amount of runoff volume being contributed to each of the storm water management features (i.e., Raingarden, Pond One and Pond Three). These data played an important role in the calibration of the models, as described in Chapter 5. A summary of the monitoring data at each location is included in Attachment 11.

The results and discussion of the monitoring objectives are described in the following subsections.

Raingarden Water Balance

The Raingarden collects runoff from two grass-lined swales and the storm water collection trench, which conveys overland flow from the loop road. According to the as-built condition plans for the LID Subdivision, the Raingarden was designed to capture and retain the volume of a 1-inch precipitation event (storm runoff volume equal to 800 cubic feet), without overflowing into Pond One. When water enters the Raingarden it either infiltrates or fills and eventually overflows to Pond One via a separation berm between the two features. The overflow point from the Raingarden to Pond One was monitored through a weir, as described in Chapter 3.

A water balance of the Raingarden was established using the monitoring results to evaluate how the LID feature functions under different size precipitation events. The water balance uses the following equation:

$$V_{OUTFLOW} = \sum V_{INFLOW} - V_{INFILTRATION} - V_{ET}$$

where V is volume in cubic feet (cf); and ET is evapotranspiration.

Table 6.2 includes a summary of the water balance for the Raingarden during events when overflow occurred into Pond One. The water balance indicates that the Raingarden overflowed for the monitored storms greater than 0.60 inches in accumulated precipitation. Even when overflow occurs it appears that of the total storm volume entering the Raingarden, approximately 68 to 99 percent of that total volume is infiltrating or evaporating, indicating that the Raingarden is performing well as an infiltration BMP. For storms where the Raingarden does not overflow into Pond One, 100% of the total rainfall volume is captured in the Raingarden.

Table 6.2: Raingarden Water Balance When Overflow Occurs

Storm Start Date/Time	Volume In (cf)	Infiltration/ET Volume Out (cf)	Overflow Volume Out (cf)	Percent of Rainfall Volume Infiltrating/ET (%)	Precipitation Event (in)
7/21/2008	630	612	18	97%	0.60
7/23/2008	2616	2213	403	85%	2.41
7/27/2008	701	661	40	94%	0.70
8/11/2008	1063	902	161	85%	1.11
9/6/2008	3190	2413	777	76%	2.40
9/26/2008	2485	1679	806	68%	2.45
9/27/2008	700	694	6	99%	1.24

Figure 6-3 presents the storm water volume entering the Raingarden and overflowing via the weir into Pond One. The horizontal black line represents 800 cubic feet, the design volume to be retained before overflow. Figure 6-3 and Table 6.2 show that the Raingarden overflowed into Pond One for three precipitation events which produced a volume less than 800 cubic feet (represented by red circles in Figure 6-3). It is difficult to make comparisons from these observations, as the distribution of rainfall during these monitored events is very different from the distribution typically used in design storm events.

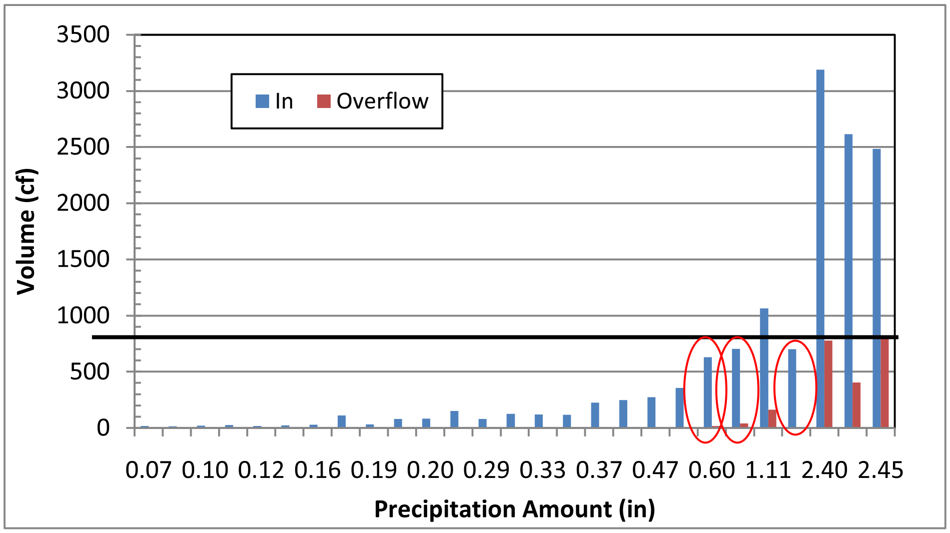

Figure 6-3: Storm Volume In and Out of the Raingarden Based on Precipitation Amount.

Figure 6-4 presents the storm water volume into the Raingarden and out via the overflow weir into Pone One, based on precipitation intensity. The horizontal black line indicates the volume above which the Raingarden is designed to overflow into Pond One. Storms with a high intensity that produce a small volume of runoff, appear to cause overflow into Pond One, which is likely because the high intensity storms exceed the Raingarden's infiltration capacity. Reduced moisture in the surface soils can cause water to pond instead of initially infiltrating through the soil.

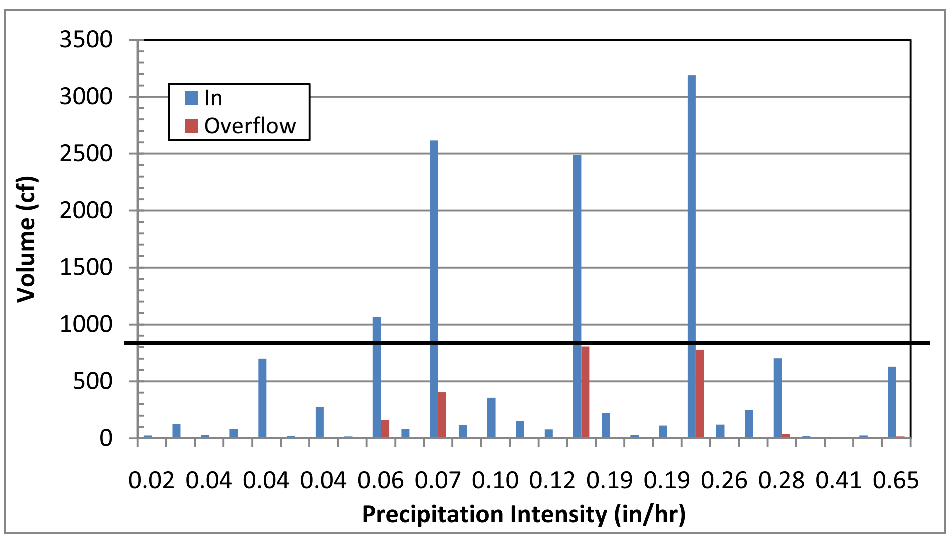

Figure 6-4: Storm Volume In and Out of the Raingarden Based on Precipitation Intensity

Infiltration plays an important role in the ability of the Raingarden to meet its design standards; therefore, infiltration tests were conducted on June 20, 2008 (Location A) and August 13, 2008 (Locations A and B). Two infiltration locations were selected, Location A which is along the east end of the Raingarden, where the water-level data logger was installed and Location B along the west end of the Raingarden (Figure 6-5). Three infiltration tests were conducted, two at Location A and one at Location B. Location A was chosen as a location for the infiltration rate test, since it was close to the water-level data logger and therefore, two data sets could be compared. A second test point, Location B was chosen due to grading work in the Raingarden that removed approximately 6 inches of material from the surface in the western end of the Raingarden where fines had accumulated. On August 13, 2008, a test at both Location A and B were conducted to show the effects of maintenance and removal of accumulated sediment, on the infiltration rates of the soil.

Figure 6-5: Raingarden Infiltration Test Locations

Table 6.3 presents the infiltration test results and shows that Location A has a lower infiltration rate than Location B. The variation in infiltration rates is thought to be primarily due to the removal of sediment fines in Location B. Sediment fines typically clog the pore space of the bioretention soil and can reduce the infiltration rate. The variation between the infiltration rates in Location A for the two tests is likely due to a large precipitation event (1.11 inches) on August 12, 2008, which may have saturated the underlying soils, causing a reduction in the infiltration rate.

Table 6.3: Raingarden Infiltration Tests Results

Date	Location	Infiltration Rate (in/hr)
6/20/2008	A	0.63
8/13/2008	A	0.30
8/13/2008	B	1.47

Infiltration rates were also calculated using the water-level data logger deployed in the Raingarden. The average infiltration rates were calculated based on different depths of water in the Raingarden. Data were excluded for periods where the Raingarden discharged via the overflow to Pond One. Table 6.4 shows the average infiltration rate as a function of the depth of water. As the depth of water increases in the Raingarden, the infiltration rate of the underlying soils increases. The infiltration rates from the water-level data logger are greater than the on-site field infiltration test. This could be due to the water-level data based infiltration rates being estimated when the underlying soil was unsaturated prior to the monitored storm event. The double ring infiltrometer tests were conducted in the field after saturation of the underlying soil prior to running the test and therefore, may be a more conservative estimate of the infiltration rates.

Table 6.4: Raingarden Average Infiltration Rates Based on Depth of Water

Depth of Water in Raingarden (in)	Average Infiltration Rate (in/hr)
2 to 4	0.84
4 to 6	0.88
6 to 8	1.07
8 to 10	1.10
10 to 12	1.15
12 to 14	1.78

The infiltration rates of the soil in the Raingarden, on average approximately 1.48 inches per hour, do not appear to be characteristic of the bioretention soil specified in the LID Subdivision design. The bioretention soil specified for the Raingarden is engineered to have a higher hydraulic conductivity (20 to 50 in/hr) than conventional planting soil and has a significantly higher sand content and significantly lower silt, clay and organic content (50-85% Sand, 0-50% Silt, 5-10% Clay and 1.5-10% Organic Matter) when compared to conventional planting soil.

Geosyntec collected two soil samples from the Raingarden on August 13, 2008, one in Location A and another in Location B, to determine if the soil composition was that of the specified bioretention soil. Based on two soil samples collected by Geosyntec, the particle distribution in Location A consisted of 6.9% Gravel, 61.4% Sand, and 31.7% Silt and Clay. The particle distribution at Location B consisted of 8.8% Gravel, 68.5% Sand, and 22.7% Silt and Clay. Based on these particle distributions, the sampled soil in the Raingarden appears to have a high percentage of silt and clay and is within the lower range for the sand content when compared to the engineered soil specification. The lower sand content and higher clay content could be responsible for the reduced infiltration rates in the Raingarden.

Additional modeling was completed to determine whether the performance of the Raingarden would be affected by a change in the soil infiltration rate (i.e., from the average infiltration rate of 1.48 inches per hour to 3 inches per hour). The storms that produced overflow into Pond One during observed conditions with a runoff volume of less than 800 cubic feet in volume were used in the model. The modeling concluded that overflow will not occur during storms that produce a volume less than 800 cubic feet, with the increased infiltration rate of the soils.

During site observations, it appeared that minimal to no maintenance of the Raingarden had occurred since installation. Providing maintenance, such as removal of accumulated sediment or tilling the soil, helps restore and maximize infiltration rates in the soils. The proper use and installation of the specified materials (i.e., bioretention soil) ensure that LID features perform and infiltrate as designed. The site observations also help show the importance of construction oversight in the successful performance of LID features, from design to installation.

Pond One Water Balance

Pond One is a storm water management basin in the LID Subdivision, which receives flow from four catch basins along the loop road and overflow from the Raingarden. Pond One has a low-flow, 4-inch diameter orifice and a primary outlet control structure that drains to Pond Two (Figure 1-1). The design of Pond One was intended to act as an infiltrating basin prior to discharging into Pond Two.

A water balance of Pond One was established using the monitoring results to evaluate the effectiveness of Pond One in the reduction of storm water runoff volume prior to discharging to Pond Two. Table 6.5 includes a summary of the water balance of Pond One for storm events greater than 0.60 inches in accumulation. The monitoring results indicate that Pond One discharges into Pond Two for storms greater than or equal to 2.40 inches, which is slightly less than the historic precipitation record 2-year event accumulation.

Table 6.5 Pond One Water Balance Results

Storm Date	Inflow (cf)	Infiltration and ET (cf)	Outflow (cf)	Rainfall (in)
7/21/2008	2,577	2,577	0	0.60
7/23/2008	21,325	20,079	1,246	2.41
7/27/2008	4,545	4,545	0	0.70
8/11/2008	9,715	9,715	0	1.11
9/6/2008	14,499	12,381	2,118	2.40
9/26/2008	19,036	17,281	1,756	2.45
9/27/2008	28,392	28,392	0	1.24

Pond One is consistent with traditional storm water management practices. In a conventional subdivision it would be the primary storm water management practice. Based on Table 6.5, Pond One discharges to Pond Two through the 4-inch orifice when water reaches a depth of approximately 1.15 feet or greater. When the water depth is less than 1.15 feet (13.8 inches), below the low-flow orifice, Pond One infiltrates. The low flow orifice in Pond One was designed to discharge during a 2-year, 24-hour design storm (3.00 inches). Although it appears that Pond One is discharging to Pond Two for storms less than the design storm, the distribution of rainfall and intensity for the monitored storms is likely much different than the design storm. Although from these observations it appears that Pond One is not functioning as designed, it is difficult to make comparisons, as the distribution of rainfall during these monitored events is likely different from the distribution typically used in design storm events.

Pond One infiltration rates were calculated using the water-level data from the water-level data logger installed in the center of Pond One. Rates were calculated based on 15 storm events where water was retained in Pond One but did not discharge through the low-flow orifice. Table 6.6 summarizes the average infiltration rate based on the depth of water in Pond One. The infiltration rates range from 0.22 in/hr for depths between 12 and 13.8 inches to 0.89 for depths between 8 and 10 inches. The average infiltration rates appear to be erratic and unrelated to pond depth. The fluctuations in infiltration rates could reflect the variable extent to which the underlying soil was saturated from a prior rain event.

Table 6.6: Pond One Average Infiltration Rate Based on Water Depth

Depth in Pond One (inches)	Average Infiltration Rate (in/hr)
2 to 4	0.82
4 to 6	0.60
6 to 8	0.34
8 to 10	0.89
10 to 12	0.36
12 to 13.8	0.22

Not surprisingly, the rates of infiltration in Pond One are less than those in the Raingarden, as Pond One is comprised of native soil and the Raingarden has engineered bioretention soil. This difference may also explain why Pond One infiltration rates appear to be more subject to antecedent soil moisture conditions.

Pond Three

Pond Three is a storm water management basin located in an adjacent subdivision and shared by the LID subdivision. It receives flow from the adjacent subdivision and from one catch basin along the entrance road to Partridgeberry Place. The drainage area to this catch basin is primarily comprised of the entrance road and lawns and driveways from the Partridgeberry Place lots up to where the loop road begins.

Monitoring data points were missing from July 28th through August 13th in the Pond Three monitoring data. The missing data was the result of a water level logger malfunction apparently caused by accumulated sediment over the probe. Therefore, during this time period, reliable data was not collected.

Table 6.7 presents monitoring data results for five storms during the data collection period with the corresponding rainfall and storm volume.

Table 6.7: Pond Three Monitoring Results

Date	Rainfall (in)	Observed Storm Volume (cf)
7/19/2008	0.11	82
7/21/2008	0.60	948
7/27/2008	0.70	1112
7/23/2008	2.41	3601
9/26/2008	2.45	3875

Pre-development Watershed

The Pre-development Watershed monitoring point receives flow from a 0.08 acre forested area. Runoff from nine storms was collected from this area between July 20, 2008 and

September 30, 2008. To calculate the total runoff volume for a storm event, the volume accumulated in the drum and the volume of runoff discharged through the weir were taken into account.

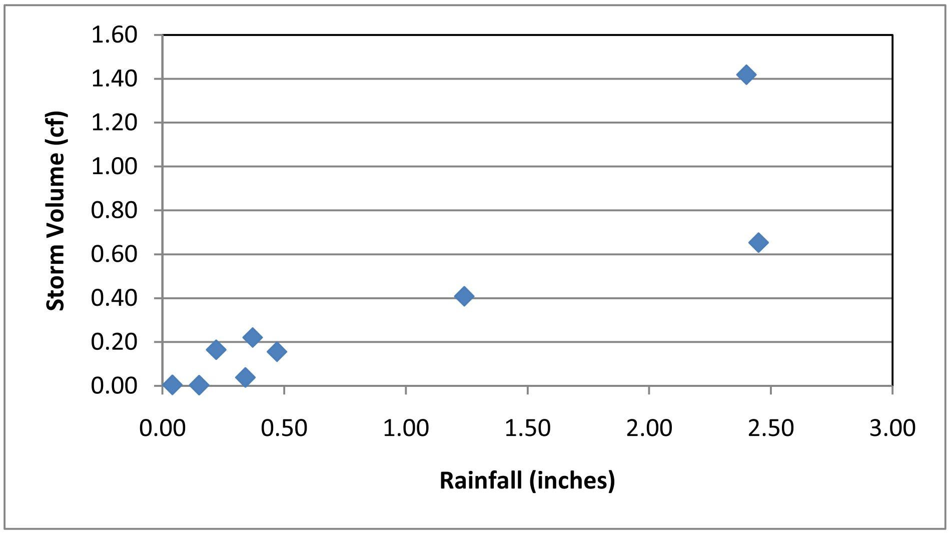

Figure 6-6: Pre-development Watershed Runoff Volume Based on Rainfall

Figure 6-6 presents the runoff volume generated in the Pre-development Watershed and the corresponding precipitation event. The trend shows that as the rainfall amount increases, the runoff volume generally increases. From the data collected, for storms greater than 0.25 inches in size runoff is generated from the Pre-development Watershed. For storms less than 0.25 inches, all the rainfall is either infiltrated or evaporated. This can be compared to the LID Subdivision, for which runoff occurs for storms greater than 0.04 inches. For the duration of the monitoring period, approximately 29 of the 44 storm events would not have produced runoff in the Pre-development Watershed, when runoff was generated in the LID Subdivision.

Although the data tend to show increased volume with an increase in storm size and intensity, there were uncertainties with the data collection and analysis. Variability between the barometric pressure gauge located at the LID Subdivision and the water-level data logger in the drum caused the data to appear as if water was retained in the drum during periods of no rain. In these instances, field observations proved that the drum was empty. The variability is thought to potentially be due to the precision of the pressure transducer and the lack of synchronization of the barometric pressure transducer to the water-level data logger.

Another level of uncertainty with the Pre-development Watershed data was introduced when estimating the volume discharged through the V-notch weir, due to the very small amount of runoff that drains from the forested area. Only a small volume of water was captured in the drum during the one minute data collection interval. The water-level data logger, which has an accuracy of approximately ±0.033 feet of water, likely, could not detect the change in water level over the weir during any one minute data collection interval. Therefore, for the events when water was believed to be flowing over the weir, data were analyzed over 5-minute increments to determine the additional volume.

In undisturbed forested areas, forest plant litter on the surface and decomposed plant material, often found below the plant litter, can influence infiltration (Brooks et. al, 1997). The upper layer protects the soil surface from the energy of the raindrop and also slows or detains surface runoff. The decomposed plant material can have a substantial impact on the water storage capacity. Therefore, plant litter is important as both a storage component and a protective cover that maintains open soils surface conditions favorable for high infiltration rates (Brooks et. al, 1997). Modeling and understanding the infiltration of the forest litter layer is difficult and limited by the infiltration parameters.

Modeling Results and discussion

After compiling the hydrologic and hydraulic parameters for the models the data were input into SWMM (i.e., EPA SWMM Version 5.0). Model simulations were run for the following return period design storm events:

- 2-Year: 3.00 inches;
- 10-Year: 4.50 inches;
- 25-Year: 5.50 inches;
- 50-year: 6.00 inches; and
- 100-Year: 7.25 inches.

The results from the model simulations were used to compare the inflow volumes and peak discharge for each of the storm water management features. Due to the lack of monitored storms greater than the 2-year, 24 hour design storm, model confidence in estimation beyond this design storm is significantly reduced. Each model condition was evaluated for the total storm water runoff generated over the whole 38-acre parcel. The results are discussed in the following subsections. SWMM Status Reports for the five rainfall event simulations for all modeling scenarios described below can be found in Attachments 12 through 15.

LID Subdivision Model

The LID Subdivision model results for total storm volume into the Raingarden, Pond One and Pond Three, presented in Figure 6-7, show that approximately 70 percent of the storm water runoff volume generated from the developed portion of the subdivision during the 2-year storm is being captured by Pond One, which includes Raingarden overflow during all modeled storm events. The drainage area to Pond One is comprised of half of the loop road and all the lawn and driveway runoff to catch basins along the loop road. Since Pond One and Pond Three are not LID storm water management features, approximately 15 percent of the runoff volumes generated by the developed portion of the Subdivision during the 2-year storm event are being mitigated through LID techniques via the swales and central Raingarden.

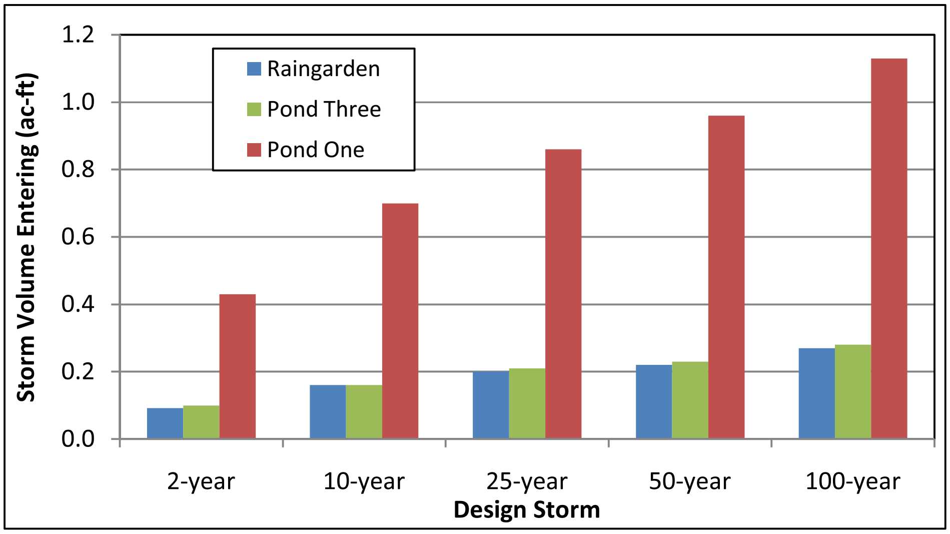

Figure 6-7: LID Subdivision Model Design Storm Volume Results

Cluster Only Subdivision Model

In the Cluster Only Subdivision model, no LID storm water management features were present. Rooftop runoff was routed (via modeling) to adjacent lawns, which drain to driveways and ultimately to curbed roadways in the Subdivision with catch basins. The results, presented in Figure 6-8, indicate that storm water runoff volume over the entire 38-acre site increases by 6 and 7 percent for the 2-year and 10-year design storms, respectively, when compared to the LID Subdivision. The increase in storm water runoff volume is due to the conventional storm water management features.

Conventional Subdivision Model

The Conventional Subdivision model results, presented in Figure 6-8, indicate that this scenario produces the most storm runoff volume of the four scenarios. Storm water runoff volume from the Conventional Subdivision ranges from 11 to 38 percent greater than from the LID Subdivision across all design storms, and from 10 to 38 percent greater than from the Cluster Only Subdivision. The increased storm water runoff volume is due to the increase of impervious area and the decrease of open forested space.

When comparing the three development scenario models, the trend appears to show that the preservation of open space is important in reduction of storm water runoff volume. The greatest reduction in storm water runoff volume relative to conventional development occurs when LID storm water management and a clustered design approach are incorporated, representative of the LID Subdivision. The clustering design effect plays a key role in reduction of impervious cover, which greatly reduces the storm water runoff from both the LID Subdivision and the Cluster Only Subdivision.

Pre-development Watershed Model

Results for the Pre-development Watershed model, presented in Figure 6-8, indicate that this scenario produces the least amount of runoff when compared to the three other scenarios. The volume of runoff generated from the LID Subdivision appears to most closely replicate the Pre-development Watershed when compared to the other scenarios, which is primarily due to the reduced impervious cover, incorporation of LID storm water management techniques and preservation of open space.

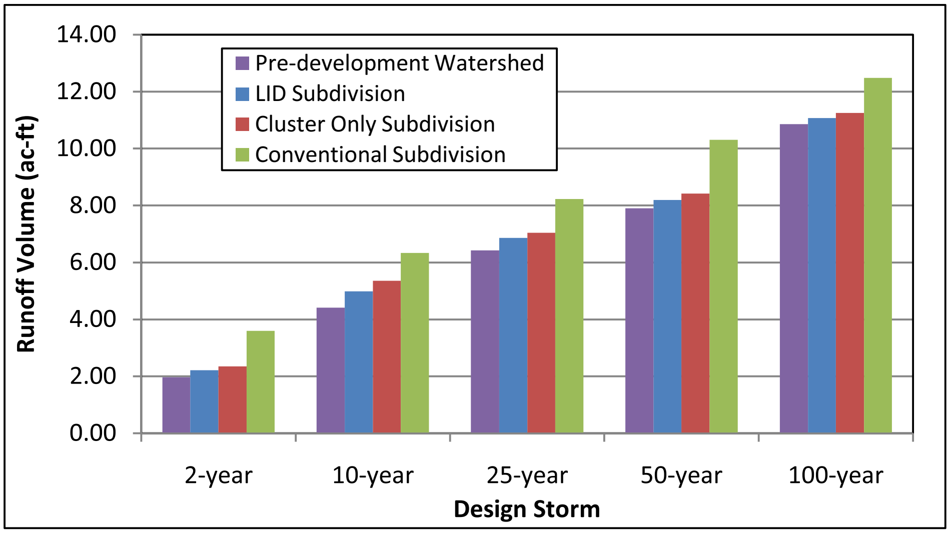

Figure 6-8: Model Design Storm Volume Runoff Results for entire 38-acre parcel

For the 2-year design storm, the LID Subdivision generates 11 percent more, the Cluster Only generates 16 percent more, and the Conventional Subdivision generates 45 percent more storm water runoff volume than the Pre-development Watershed.

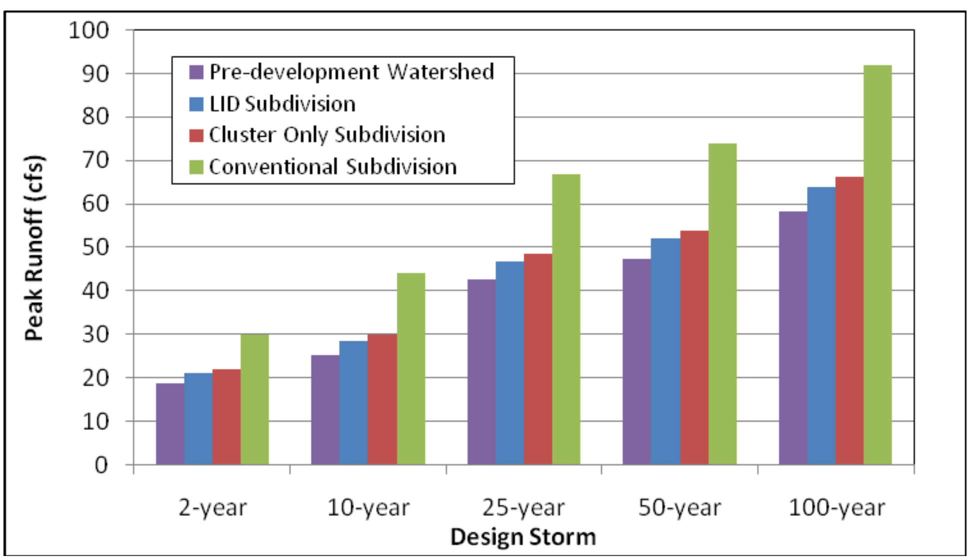

Figure 6-9: Model Design Storm Peak Discharge Results

Results for the peak discharge runoff for the four model scenarios, presented in Figure 6-9, indicates that the Pre-development Watershed has the smallest peak discharge when compared to the three other scenarios. For the 2-year design storm, the peak discharge at the LID

Subdivision is 11 percent more, the Cluster Only 17 percent more, and the Conventional Subdivision 58 percent more than the Pre-development Watershed.

A comparison of runoff results among the four scenarios highlights the fact that a cluster site design is the most important contributing factor of low impact development in reducing runoff relative to conventional development. For example, during the 2-year storm the Cluster Only scenario reduced runoff volume by 35% relative to the Conventional scenario. The LID scenario, which enhances the cluster design with additional LID storm water features, reduced runoff volume by 38% relative to the Conventional scenario, contributing an additional 3% reduction in runoff volume.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

Geosyntec Consultants, Inc. (Geosyntec) evaluated the hydrologic and hydraulic performance of environmentally sensitive site design and low-impact development (LID) on storm water runoff dynamics at the Partridgeberry Place Subdivision (LID Subdivision), located in the Ipswich River Watershed in Ipswich, Massachusetts.

Our study compared the storm water runoff patterns, rates, and volumes of an environmentally sensitive site design with LID features to pre-development and conventional developments with storm water management, and thus determined the degree to which LID can reduce the increases in runoff caused by development. Geosyntec characterized the storm water runoff dynamics at the LID Subdivision and in the adjacent forested area through on-site monitoring. The comparison of the LID Subdivision to the Pre-development (i.e., forested) Watershed allowed us to understand how closely LID design mimics the pre-development condition. Through this study we estimated, via modeling, the storm water runoff effects of both the Partridgeberry Place Subdivision as-built and the Pre-development Watershed as well as two theoretical versions of Partridgeberry Place: 1) as a clustered subdivision that contains no additional LID storm water features ("Cluster Only") and 2) as a conventionally developed subdivision ("Conventional").

Geosyntec conducted on-site monitoring and collected data from June 27, 2008 through September 30, 2008 to estimate storm water runoff dynamics at the LID Subdivision. During this time, we captured forty-four (44) storm events (ranging from 0.01 to 2.45 inches), and collected approximately twenty (20) inches of precipitation.

Based on the data we collected we developed a water balance of the LID Subdivision Raingarden to evaluate its performance. Geosyntec evaluated the Raingarden's performance based on the design criteria of no overflow occurring for the 1-inch storm event, equivalent to 800 cubic feet of water. The water balance showed that the Raingarden overflows into Pond One during storms greater than 0.60 inches, and for three events where the storm event volume is less than the 800 cubic feet. We then conducted additional soil testing, monitoring and modeling of the Raingarden bioretention soil to understand why the Raingarden is not performing up to its design potential. Geosyntec used in-situ infiltration tests to determine that the average infiltration rate of the soils is 1.48 inches per hour. In the model, the infiltration rate of the soil was increased from 1.48 to 3.0 inches per hour to determine if increasing the infiltration rate of the soil would enhance the performance of the Raingarden. The modeling results confirm that with a 3.0 inches per hour infiltration rate, overflows would not occur during storms that produce a volume less than 800 cubic feet.

Geosyntec collected soil samples from the Raingarden to determine if the soil matched the design specifications for bioretention soil. Our analysis of the soil sample showed higher silt and clay contents (22 - 31 percent) when compared to the design specification for bioretention soil (5 -10 percent). We determined that the soil content differences could be a result of lack of construction oversight during installation, to ensure that the specified materials were installed. During field observations, Geosyntec also noticed that the top two to three inches of soil contained a large amount of fine sediments, primarily from sediment laden inflow to the Raingarden and lack of maintenance. Our field analysis and observations of the Raingarden helped demonstrate the importance of construction oversight and maintenance in the performance of low-impact development features.

Geosyntec used the monitoring data to develop a water balance of the LID Subdivision Pond One to evaluate its performance. We evaluated the performance of Pond One based on the design criteria of no overflow occurring for the 2-year design storm event - equivalent to a 3.0 inch storm. The water balance of Pond One indicated that overflow occurs for events greater than 2.40 inches, slightly less than the 2-year design storm. Pond One receives overflow from the Raingarden, and the Raingarden is under-performing when compared to its design standard. Therefore, we concluded the overflow is likely the primary reason Pond One is discharging during events smaller than the 2-year design storm.

Geosyntec collected monitoring data for the Pre-development Watershed from July 30, 2008 through September 30, 2008. We used these monitoring data to evaluate the storm water runoff volume from a forested condition. The data showed that for storms greater than 0.25 inches in size, runoff is generated from the Pre-development Watershed. For storms less than 0.25 inches, all the rainfall is either infiltrated or evaporated. Monitoring data at the LID Subdivision showed that runoff occurs for storms greater than 0.04 inches. During the monitoring period, we observed that approximately 29 of the 44 storm events would not have produced runoff in the Pre-development Watershed, when runoff was generated in the LID Subdivision. Geosyntec's Pre-development Watershed monitoring provided insight on the complexity and challenges of monitoring and modeling a forested condition – it is difficult to estimate, via modeling, the effect of the plant litter layer in the forest on infiltration and evaporation rates. Based on the data collected and our observations, Geosyntec believes that the effect on infiltration and evaporation of the plant litter layer will be better understood with continued monitoring.

Geosyntec modeled the LID Subdivision, a Cluster Only Subdivision, a Conventional Subdivision, and the Pre-development Watershed, to predict storm water runoff dynamics for design storm events. The LID Subdivision includes LID storm water management features, a cluster site design, and preservation of open space. The Cluster Only Subdivision is a hypothetical design of the LID Subdivision layout with conventional storm water management techniques (i.e., curb and gutter), a cluster site design, and preservation of open space. The Conventional Subdivision is a hypothetical development with twenty (20) 1.0-acre house lots, curb and gutter storm water management and minimal preservation of open space. The Pre-development Watershed is the forested condition before development of the Subdivision. All four model scenarios were 38-acres in size, to ensure accurate comparison of the results.

We evaluated the models for five design storms: 2-year, 10-year, 25-year, 50-year, and 100-year, 24-hour. Based on the model results, Geosyntec determined that the LID Subdivision had the smallest volume of storm water runoff when compared to the Cluster Only Subdivision and Conventional Subdivision. For the 2-year design storm, the LID Subdivision generated 11 percent more, the Cluster Only generated 16 percent more, and the Conventional Subdivision generated 45 percent more storm water runoff volume than the Pre-development Watershed.

Geosyntec's comparison of runoff results among the four scenarios highlighted the fact that a cluster site design is the most important contributing factor of low impact development in reducing runoff relative to conventional development. For the 2-year storm, for example, the Cluster Only scenario reduced runoff volume by 35 percent relative to the Conventional scenario. The LID scenario, which enhances the cluster design with additional LID storm water features, reduced runoff volume by 38 percent relative to the Conventional scenario, contributing an additional 3 percent reduction in runoff volume.

When Geosyntec compared the LID Subdivision, Cluster Only Subdivision, and Conventional Subdivision runoff volumes to the Pre-development Watershed model, the LID Subdivision most closely resembles the pre-development condition. **Our evaluation results show that LID design most closely replicates Pre-development Watershed conditions due to reduced impervious cover, preservation of open space, and incorporation of LID techniques, when compared to developments using conventional storm water management techniques**.

The preservation of open space and the reduction of impervious area appear to play the most significant role in minimizing increases in storm water runoff volume that would occur under more conventional development storm water management. Implementing LID storm water management features in site design and development also plays an important role in reduction of storm water volume; however, the number of LID features installed governs the quantity of reduction.

Predicting pre-development storm water runoff remains a great challenge. This study is one of the first to use actual field measurements in the same watershed to compare pre-development and post-development storm water conditions. Even with the incorporation of LID storm water management features and preservation of open space, the pre-development hydrology is still difficult to mimic both in modeling and design. However, **implementing LID principles with an Open Space Residential Design approach allows us to significantly minimize storm water runoff and more closely approximate the pre-development conditions**.

Lessons learned

During the course of this study, Geosyntec's data collection and analysis, monitoring results, and observations led to several "lessons learned" regarding evaluating LID storm water management features and design. Geosyntec compared the average infiltration rate (1.48 inches) in the LID Subdivision Raingarden to others with comparable service life in Massachusetts, which ranged from 5 to 20 inches per hour. This comparison let to the following points about maintenance and construction oversight.

- **Maintenance** of LID features is important in maintaining the infiltration capacity of the feature and its overall function. Lack of maintenance can decrease infiltration rates of bioretention soil, due to accumulated sediment clogging the pore space. Our observations of grass-pavers along the loop road indicated that lack of maintenance to this feature resulted in almost zero infiltration, due to lack of vegetated growth and build up of fine sediment. During rainfall events, sediment was observed washing into the Raingarden.
- **Construction** oversight by the design engineer or a knowledgeable professional is key to ensuring that design specifications of the LID features are implemented in the field. This applies to both the method of construction (i.e., staging of equipment to avoid compaction of soils) and the use of specified materials during construction. Our soil composition tests in the LID Subdivision Raingarden suggested that during construction, contractors may install soil materials that do not meet the engineer specification.

RECOMMENDATIONS

Geosyntec's monitoring and modeling conclusions allowed us to identify and develop recommendations that could be implemented to build upon and refine the results presented in this study, help improve groundwater base flow, and develop a scientifically-based, reliable storm water model to aid in other future LID designs within the Ipswich River Watershed. Our recommendations include:

- Change the monitoring apparatus in the Pre-development Watershed area to include a vented pressure transducer, which would reduce the variability between absolute pressure and barometric pressure and install a collection point consisting of a drum without a weir, to retain the total volume during storm events;
- Provide funding for additional monitoring in the LID Subdivision and Pre-development Watershed. The additional monitoring data would help refine the model calibration and allow for more accurate predictions of larger storm events;
- Develop construction oversight standards to provide to planning boards to ensure what is specified by the engineer is actually installed onsite. Planning board members or other trained professionals could serve as inspectors, for quality control; and
- Incorporate quality assurance and operation and maintenance plans into all LID design projects and require a reporting system to ensure that they are being implemented.

CHAPTER 8

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ATTACHMENT SECTION

Table of Contents

LIST OF ATTACHMENTS

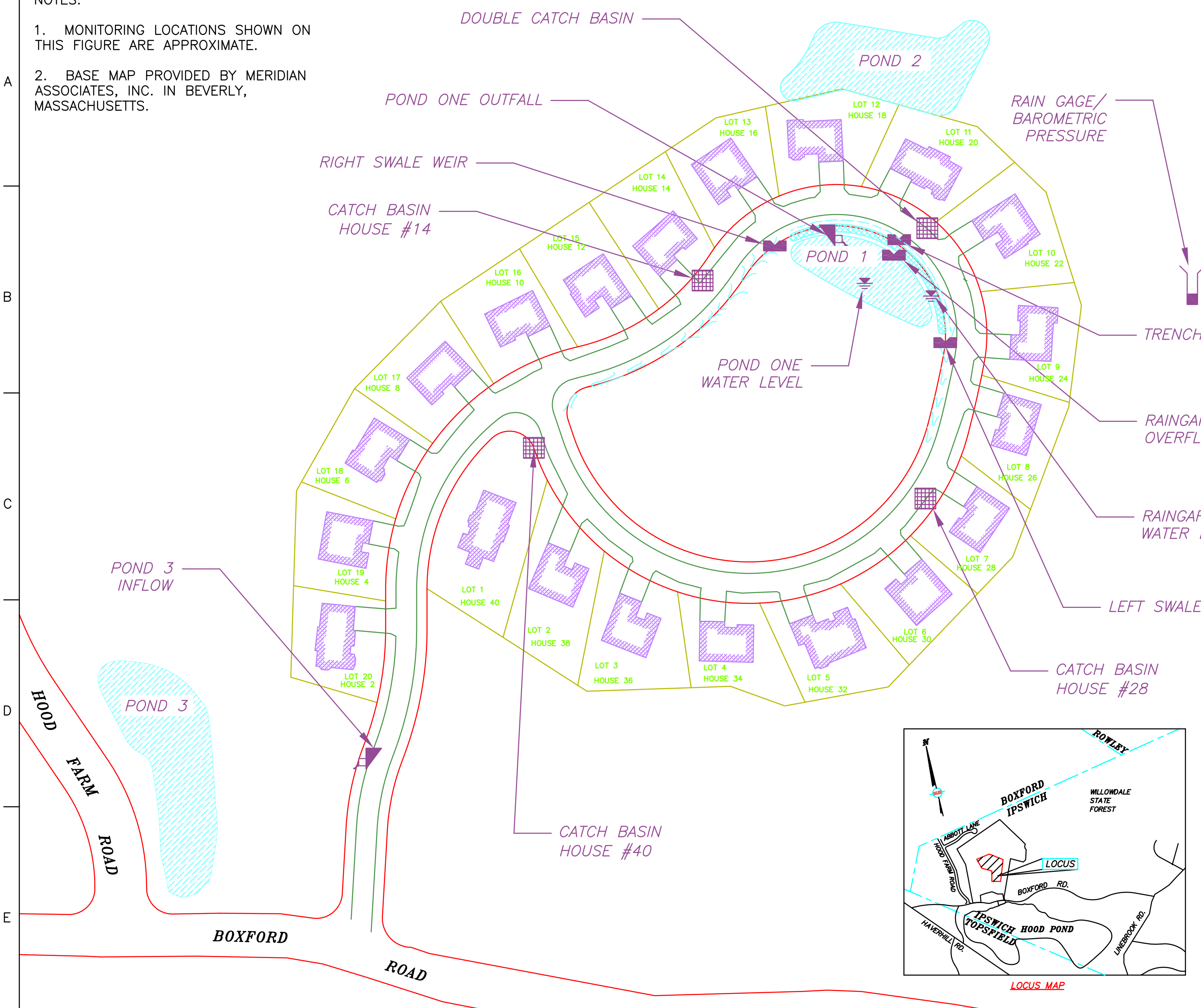
ATTACHMENT 1

LID Subdivision Monitoring Location Map

NOTES:

1. MONITORING LOCATIONS SHOWN ON THIS FIGURE ARE APPROXIMATE.

2. BASE MAP PROVIDED BY MERIDIAN ASSOCIATES, INC. IN BEVERLY, MASSACHUSETTS.



NORTH

100 50 0 100 200

SCALE IN FEET

LEGEND

- WEIR MONITORING LOCATION
- RAIN GAGE / PRESSURE MONITORING
- POND INLET MONITORING LOCATION
- WATER LEVEL MONITORING LOCATION
- CATCH BASIN MONITORING LOCATION
- DETENTION POND
- RAINGARDEN
- HOUSE FOOTPRINT
- PROPERTY LINE
- EDGE OF PAVEMENT
- STORM WATER COLLECTION TRENCH

REV. NO	DATE	DESCRIPTION	DES. BY	DR. BY	CHK. BY	RVW. BY	APP. BY

PROJECT:

PARTRIDGEBERRY PLACE

TITLE:

SUBDIVISION MONITORING LOCATION MAP

DATE: 10/9/2008
SCALE: 1"=100'
PROJECT NO: JR0058
FILE NO: MONITORING LOCATIONS.DWG

CONSULTANT/ENGINEER

Geosyntec consultants

289 GREAT ROAD, SUITE 105
ACTON, MASSACHUSETTS, 01720 USA
PHONE: 978.263.9588

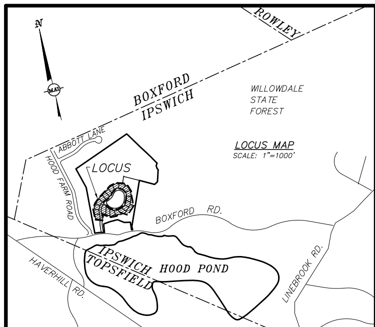
ATTACHMENT

1

1 INCH AT FULL SCALE PLOT

ATTACHMENT 2

LID Subdivision As-Built Plan



LOCUS MAP
SCALE: 1"=1000'

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N.T.S.

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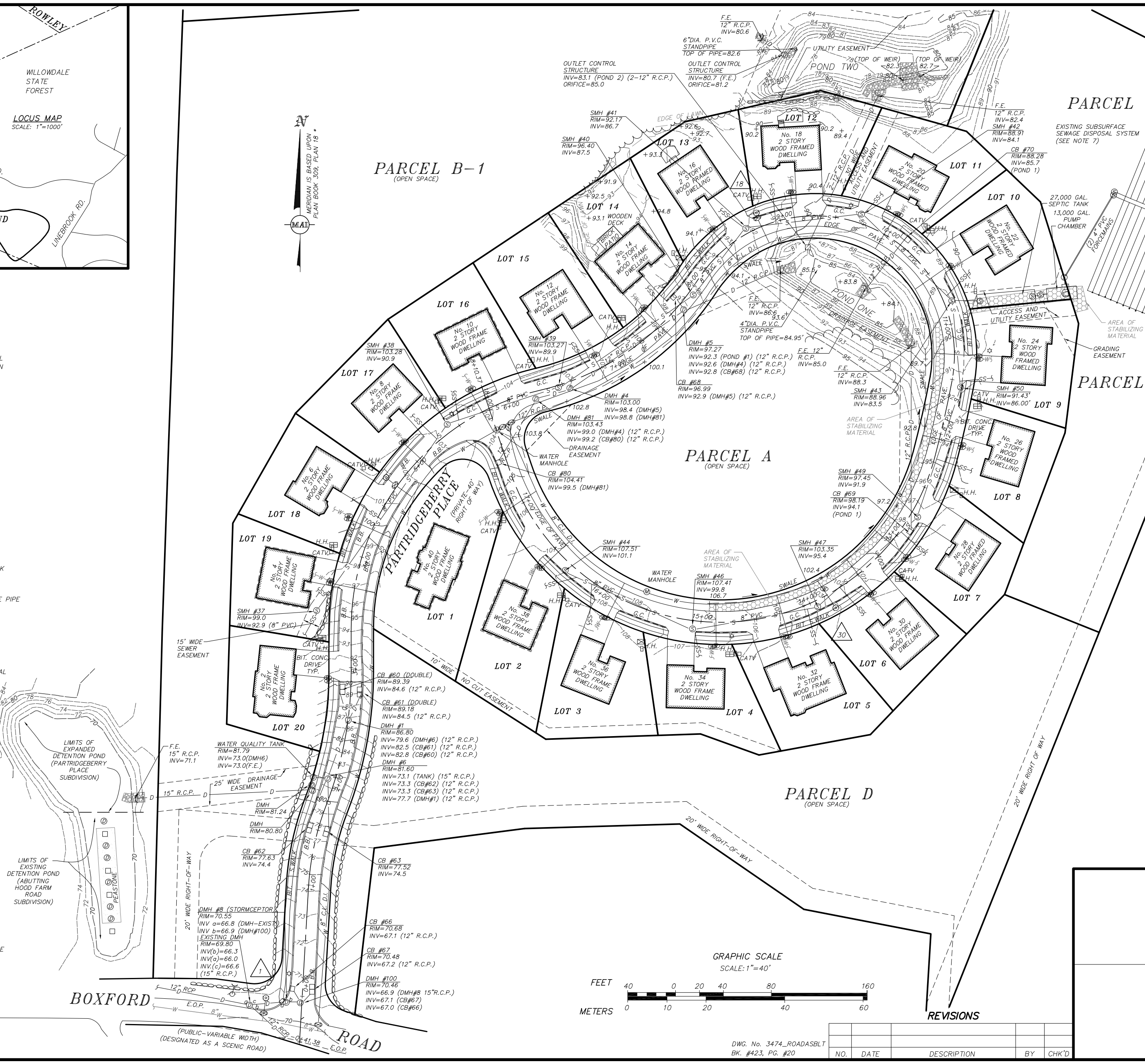
	BITUMINOUS BERM
	RETAINING STONE WALL
	SWALE FLOW DIRECTION
	CATCHBASIN
	DRAIN MANHOLE
	SEWER MANHOLE
	WATER MANHOLE
	LIGHT POLE
	HYDRANT
H.H.	HAND HOLE
CATV	CABLE T.V.
	TELEPHONE BOX
	ELECTRIC BOX
---D---	DRAIN LINE
---S---	SEWER LINE
---W---	WATER LINE
	HYDRANT
	WATER SERVICE
	WATER GATE
	FLARED END
	TERMINOUS UNKNOWN
	TEMPORARY BENCHMARK
F.E.	FLARED END PIPE
R.C.P.	REINFORCED CONCRETE PIPE
P.V.C.	POLYVINYL CHLORIDE
DIA.	DIAMETER
RIM	RIM ELEVATION
INV.	INVERT
TYP.	TYPICAL
	RIP-RAP AREA
	STABILIZATION MATERIAL



RECORD OWNER:
PARTRIDGEBERRY, LLC
130 SYLVAN STREET
DANVERS, MASSACHUSETTS 01923
DEED BOOK 18810, PAGE 13 *

REFERENCES:
PLAN BOOK 358, PAGE 52 *
PLAN BOOK 375, PAGE 18 *
DEED BOOK 18810, PAGE 13 *
DEED BOOK 18657, PAGE 233 *

* DENOTES DOCUMENTS RECORDED AT THE ESSEX SOUTH REGISTRY OF DEEDS

TEMPORARY BENCHMARK CHART:

1	X-CUT IN FRONT CAP BOLT OF HYDRANT	71.98
18	FRONT CAP BOLT OF HYDRANT	93.74
30	FRONT CAP BOLT OF HYDRANT	104.52

(SEE NOTE #6)

NOTES:

1. THE SOLE PURPOSE OF THIS ASBUILT/RECORD PLAN IS TO DEPICT THE TOPOGRAPHY, SITE DETAIL AND SURFACE IMPROVEMENTS FOR EXISTING ROADWAY, UTILITIES, PONDS AND GRADING OF DEFINITIVE SUBDIVISION "PARTRIDGEBERRY PLACE" ("FORMERLY WINCHESTER COMMONS"). ADDITIONALLY TO DEPICT THE IMPROVEMENTS MADE TO PORTIONS OF LOTS 12, 13 & 14 AS PROPOSED IN PERMIT SITE PLANS FILED WITH THE TOWN OF IPSWICH IN 2004.
2. THE TOPOGRAPHY, SITE DETAIL & SURFACE IMPROVEMENTS DEPICTED HEREON ARE BASED UPON AN ON THE GROUND FIELD SURVEY PERFORMED BETWEEN SEPTEMBER 19, 2002 AND JANUARY 22, 2007 BY MERIDIAN ASSOCIATES, INC.
3. THE LOCUS PROPERTY DEPICTED IS LOCATED IN ZONING DISTRICT RRA.
4. THE LOCUS PROPERTY IS DEPICTED AS LOT 43-62 ON TOWN OF IPSWICH ASSESSOR'S MAP 36.
5. THIS PLAN DOES NOT SHOW ANY UNRECORDED OR UNWRITTEN EASEMENTS WHICH MAY EXIST.
6. THE ELEVATIONS REFER TO NATIONAL GEODETIC VERTICAL DATUM OF 1929 (N.G.V.D 29). STARTING BENCHMARK: AS BRASS DISK STAMPED 302, ELEVATION=89.10 SET IN CAST IRON SQUARE POST WITH COVER LOCATED ON ROUTE 97 IN TOPSFIELD NEAR THE "SUNOCO" GAS STATION 0.6 MILES WESTERLY FROM BOWERY ROAD. REFERENCE IS MADE TO CONTROL SUMMARY, TOPSFIELD, MASSACHUSETTS, DATED: NOVEMBER 4, 1997. ON FILE AT THE TOWN OF TOPSFIELD ENGINEERING DEPARTMENT.
7. REFERENCE IS MADE TO PLANS TITLED: "RECORD CONDITIONS SUBSURFACE SEWAGE DISPOSAL SYSTEM," PREPARED FOR MARTINS CONSTRUCTION, REVISION DATE 3-29-04 BY MERIDIAN ASSOCIATES, INC.
8. EXISTING WATER AND SEWER SERVICES DEPICTED HEREON BASED UPON FIELD OBSERVATIONS AND INFORMATION PROVIDED BY THE MARTINS COMPANIES.
9. REFERENCE IS MADE TO PLAN SET TITLED: "DEFINITIVE SUBDIVISION PLAN OF LAND OPEN SPACE PRESERVATION CLUSTER FOR WINCHESTER COMMONS LOCATED IN IPSWICH, MASSACHUSETTS," REVISED MAY 24, 2001, PREPARED BY MERIDIAN ENGINEERING, INC. RECORDED AS PLAN BOOK 358, PLAN 52*.

GRAPHIC SCALE
SCALE: 1"=40'
FEET 40 0 20 40 80 160
METERS 0 10 20 40 60

DWG. No. 3474_ROADASBLT
BK. #423, PG. #20

REVISIONS

NO.	DATE	DESCRIPTION	BY	CHK'D

PARTRIDGEBERRY PLACE

RECORD CONDITIONS PLAN OF LAND
LOCATED IN
IPSWICH, MASSACHUSETTS
(ESSEX COUNTY)

PREPARED FOR
PARTRIDGEBERRY, LLC

SCALE: 1"= 40' DATE: MARCH 5, 2007

MERIDIAN
ASSOCIATES, INC.
152 CONANT STREET, BEVERLY, MASSACHUSETTS 01915, TELEPHONE: (978) 299-0447
69 MILK STREET, SUITE 302, WESTBOROUGH, MASSACHUSETTS 01581, TELEPHONE: (508) 871-7030
WWW.MERIDIANASSOC.COM

SHEET No. 1 OF 3 PROJECT No. 3474

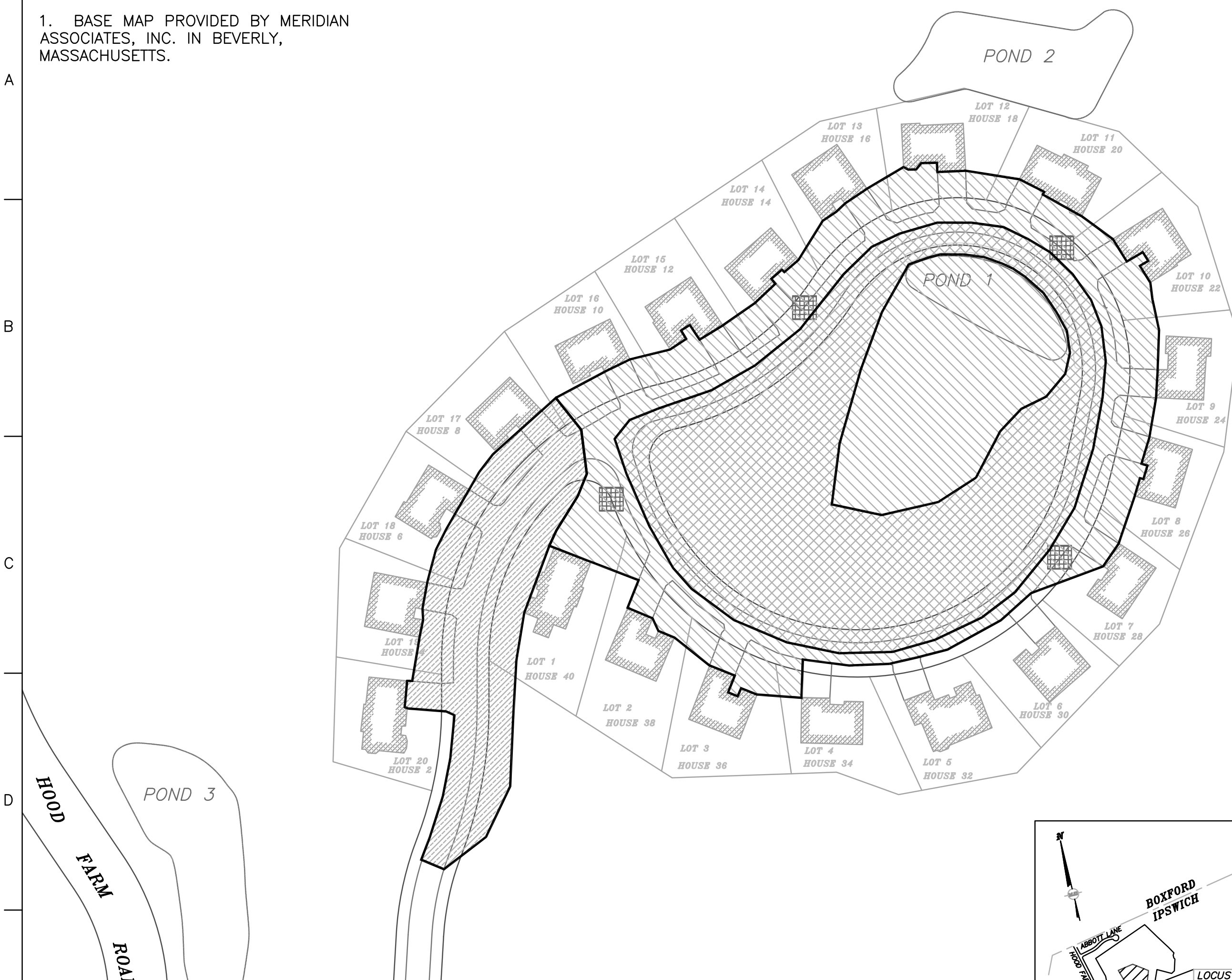
ATTACHMENT 3

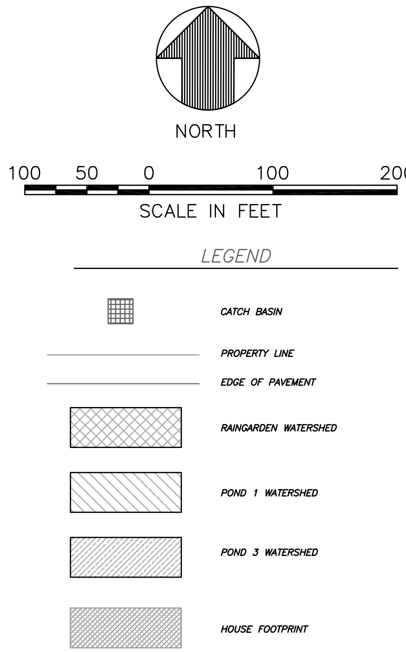
LID Subdivision Drainage Area Map

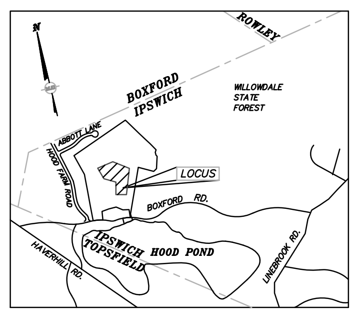
1 INCH AT FULL SCALE PLOT

NOTE:

1. BASE MAP PROVIDED BY MERIDIAN ASSOCIATES, INC. IN BEVERLY, MASSACHUSETTS.







LOCUS MAP

REV. NO	DATE	DESCRIPTION	DES. BY	DR. BY	CHK. BY	RVW. BY	APP. BY

PROJECT:

PARTRIDGEBERRY PLACE

TITLE:

SUBDIVISION DRAINAGE AREA MAP

DATE:	10/9/2008
SCALE:	1"=100'
PROJECT NO:	JR0058
FILE NO:	MONITORING LOCATIONS.DWG

CONSULTANT/ENGINEER

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ATTACHMENT

3

ATTACHMENT 4

SWMM Model Input Parameter Tables

LID Subdivision

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LID Subdivision
Inputs

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 DRY_DAYS               0
 REPORT_STEP            00:05:00
 WET_STEP               00:15:00
 DRY_STEP               01:00:00
 ROUTING_STEP           0:00:30
 ALLOW_PONDING          NO
 INERTIAL_DAMPING       PARTIAL
 VARIABLE_STEP          0.75
 LENGTHENING_STEP       0
 MIN_SURFAREA           0
 NORMAL_FLOW_LIMITED    NO
 SKIP_STEADY_STATE      NO
 IGNORE_RAINFALL        NO

[EVAPORATION]
;;Type         Parameters
;;-----------------------
  MONTHLY      0.031  0      0      0      0      0.15   0.20   0.18   0.114  0      0      0

[RAINGAGES]
;;                 Rain      Recd.  Snow   Data       Source           Station    Rain
;;Name             Type      Freq.  Catch  Source     Name             ID         Units
;;--------------------------------------------------------------------------------------
  100-yr           CUMULATIVE 1:00   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW Mon\Data and Analysis\Model\R
  10-yr            CUMULATIVE 1:00   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW Mon\Data and Analysis\Model\R
  25-yr            CUMULATIVE 1:00   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW Mon\Data and Analysis\Model\R
  2-yr             CUMULATIVE 1:00   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW Mon\Data and Analysis\Model\R
  50-yr            CUMULATIVE 1:00   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW Mon\Data and Analysis\Model\R
  1                VOLUME    0:05   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW Mon\Data and Analysis\Model\Ra

[SUBCATCHMENTS]
;;                                                Total    Pcnt.             Pcnt.    Curb     Snow
;;Name             Raingage         Outlet           Area     Imperv   Width    Slope    Length   Pack
;;----------------------------------------------------------------------------------------------------
```

```
  Drive1           100-yr           Pond_3           0.01     100      20       5        0
  Drive13          100-yr           CB#70            0.01     100      20       3        0
  Drive14          100-yr           CB#68            0.01     100      20       5        0
  Drive15          100-yr           CB#68            0.01     100      20       3        0
  Drive16          100-yr           CB#68            0.01     100      20       3        0
  Drive17          100-yr           Pond_3           0.01     100      20       3        0
  Drive18          100-yr           Pond_3           0.01     100      20       3        0
  Drive19          100-yr           Pond_3           0.01     100      20       3        0
  Drive2           100-yr           CB#40            0.01     100      20       3        0
  Drive20          100-yr           Pond_3           0.01     100      20       3        0
  Drive3           100-yr           CB#40            0.01     100      20       3        0
  Drive7           100-yr           CB#70            0.01     100      20       3        0
  Drive8           100-yr           CB#70            0.01     100      20       5        0
  LeftWeirVeg      100-yr           24               0.30     0        100      5        0
  Lot10On          100-yr           CB#70            0.04     7        20       5        0
  Lot11On          100-yr           CB#70            0.06     7        20       5        0
  Lot12On          100-yr           CB#70            0.05     7        20       5        0
  Lot13On          100-yr           CB#70            0.06     7        20       5        0
  Lot14On          100-yr           CB#68            0.068    7        20       5        0
  Lot15On          100-yr           CB#68            0.063    7        20       5        0
  Lot16On          100-yr           CB#68            0.028    7        20       5        0
  Lot17On          100-yr           Pond_3           0.06     7        20       5        0
  Lot18On          100-yr           Pond_3           0.06     7        20       5        0
  Lot19On          100-yr           Pond_3           0.05     7        20       5        0
  Lot1On           100-yr           Pond_3           0.06     7        20       5        0
  Lot20On          100-yr           Pond_3           0.055    7        20       5        0
  Lot2On           100-yr           CB#40            0.034    7        20       5        0
  Lot3On           100-yr           CB#40            0.031    7        20       5        0
  Lot7On           100-yr           CB#70            0.06     7        20       5        0
  Lot8On           100-yr           CB#70            0.04     7        20       3        0
  Lot9On           100-yr           CB#70            0.03     7        20       3        0
  LWPave           100-yr           24               0.08     100      9        5        0
  R1               100-yr           Pond_3           0.18     100      18       5        0
  R2               100-yr           CB#68            0.06     100      9        8        0
  R3               100-yr           CB#69            0.09     100      9        8        0
  RightWeirVeg     100-yr           23               0.30     0        100      5        0
  RWPave           100-yr           23               0.093    100      9        5        0
  TrenchPave       100-yr           33               0.10     100      10       6        0
  R4               100-yr           CB#40            0.08     100      9        5        0
  R5               100-yr           CB#70            1        100      10       8        0

[SUBAREAS]
;;Subcatchment     N-Imperv   N-Perv     S-Imperv   S-Perv     PctZero    RouteTo    PctRouted
;;-------------------------------------------------------------------------------------------
  Drive1           0.011      0.24       0.05       0.15       75         OUTLET
  Drive13          0.011      0.24       0.05       0.15       75         OUTLET
  Drive14          0.011      0.24       0.05       0.15       75         OUTLET
  Drive15          0.011      0.24       0.05       0.15       75         OUTLET
  Drive16          0.011      0.24       0.05       0.15       75         OUTLET
  Drive17          0.011      0.24       0.05       0.15       75         OUTLET
```

```
  Drive18          0.011      0.24       0.05       0.15       75         OUTLET
  Drive19          0.011      0.24       0.05       0.15       75         OUTLET
  Drive2           0.011      0.24       0.05       0.15       75         OUTLET
  Drive20          0.011      0.24       0.05       0.15       75         OUTLET
  Drive3           0.011      0.24       0.05       0.15       75         OUTLET
  Drive7           0.011      0.24       0.05       0.15       75         OUTLET
  Drive8           0.011      0.24       0.05       0.15       75         OUTLET
  LeftWeirVeg      0.011      0.15       0.05       0.15       75         OUTLET
  Lot10On          0.01       0.15       0.05       0.15       75         OUTLET
  Lot11On          0.01       0.15       0.05       0.15       75         OUTLET
  Lot12On          0.01       0.15       0.05       0.15       75         OUTLET
  Lot13On          0.01       0.15       0.05       0.15       75         OUTLET
  Lot14On          0.01       0.15       0.05       0.15       75         OUTLET
  Lot15On          0.01       0.15       0.05       0.15       75         OUTLET
  Lot16On          0.01       0.15       0.05       0.15       75         OUTLET
  Lot17On          0.01       0.15       0.05       0.15       75         OUTLET
  Lot18On          0.01       0.15       0.05       0.15       75         OUTLET
  Lot19On          0.01       0.15       0.05       0.15       75         OUTLET
  Lot1On           0.01       0.15       0.05       0.15       75         OUTLET
  Lot20On          0.01       0.15       0.05       0.15       75         OUTLET
  Lot2On           0.011      0.15       0.05       0.15       75         OUTLET
  Lot3On           0.01       0.15       0.05       0.15       75         OUTLET
  Lot7On           0.01       0.15       0.05       0.15       75         OUTLET
  Lot8On           0.01       0.15       0.05       0.15       75         OUTLET
  Lot9On           0.01       0.15       0.05       0.15       75         OUTLET
  LWPave           0.011      0.24       0.05       0.15       75         OUTLET
  R1               0.011      0.24       0.05       0.15       75         OUTLET
  R2               0.011      0.24       0.05       0.15       75         OUTLET
  R3               0.011      0.24       0.05       0.15       75         OUTLET
  RightWeirVeg     0.011      0.15       0.05       0.15       75         OUTLET
  RWPave           0.011      0.20       0.05       0.15       75         OUTLET
  TrenchPave       0.011      0.24       0.05       0.15       75         OUTLET
  R4               0.011      0.24       0.05       0.15       75         OUTLET
  R5               0.011      0.24       0.05       0.15       75         OUTLET

[INFILTRATION]
;;Subcatchment    Suction    HydCon     IMDmax
;;--------------------------------------------------
  Drive1           12.60      0.01       0.097
  Drive13          12.60      0.01       0.097
  Drive14          12.60      0.01       0.097
  Drive15          12.60      0.01       0.097
  Drive16          12.60      0.01       0.097
  Drive17          12.60      0.01       0.097
  Drive18          12.60      0.01       0.097
  Drive19          12.60      0.01       0.097
  Drive2           12.60      0.01       0.097
  Drive20          12.60      0.01       0.097
  Drive3           12.60      0.01       0.097
  Drive7           12.60      0.01       0.097
```

```
  Drive8           12.60      0.01       0.097
  LeftWeirVeg      4.33       0.43       0.263
  Lot10On          12.60      0.01       0.097
  Lot11On          12.60      0.01       0.097
  Lot12On          12.60      0.01       0.097
  Lot13On          12.60      0.01       0.097
  Lot14On          12.60      0.01       0.097
  Lot15On          12.60      0.01       0.097
  Lot16On          12.60      0.01       0.097
  Lot17On          12.60      0.01       0.097
  Lot18On          12.60      0.01       0.097
  Lot19On          12.60      0.01       0.097
  Lot1On           12.60      0.01       0.097
  Lot20On          12.60      0.01       0.097
  Lot2On           12.60      0.01       0.097
  Lot3On           12.60      0.01       0.097
  Lot7On           12.60      0.01       0.097
  Lot8On           12.60      0.01       0.097
  Lot9On           12.60      0.01       0.097
  LWPave           4.33       0.43       0.263
  R1               12.60      0.01       0.097
  R2               12.60      0.01       0.097
  R3               12.60      0.01       0.097
  RightWeirVeg     4.33       0.43       0.263
  RWPave           4.33       0.43       0.263
  TrenchPave       4.33       0.43       0.263
  R4               12.60      0.01       0.097
  R5               12.60      0.01       0.097

[JUNCTIONS]
;;                 Invert     Max.       Init.      Surcharge  Ponded
;;Name             Elev.      Depth      Depth      Depth      Area
;;--------------------------------------------------------------------------
  CB#69            85         1          0          0          0
  CB#70            88         1          0          0          0
  CB#68            90         8          0          0          0
  CB#40            98         0          0          0          0
  23               104        1          0          0          0
  24               95         0          0          1000       0
  33               90         8          0          1000       0

[OUTFALLS]
;;                 Invert     Outfall    Stage/Table      Tide
;;Name             Elev.      Type       Time Series      Gate
;;------------------------------------------------------------
  36               0          FREE                        NO
  37               0          FREE                        NO

[STORAGE]
;;                 Invert   Max.     Init.    Shape      Shape                      Ponded   Evap.
```

```
;;Name              Elev.    Depth    Depth    Curve      Parameters                  Area     Frac.
;;------------------------------------------------------------------------------------------------
  PondOne           78.8     10       0        TABULAR    PondOne                     10000    1
  Raingarden        86.5     1.5      0        TABULAR    Raingarden                  1567.5   1
  Pond_3            70       6        0        TABULAR    P3                          19319.25 1

[CONDUITS]
;;                  Inlet            Outlet                          Manning    Inlet      Outlet     Init.      Maximum
;;Name              Node             Node             Length         N          Height     Height     Flow       Flow
;;------------------------------------------------------------------------------------------------------------------------
  3                 CB#70            PondOne          48             0.013      1          0          0          0
  10                CB#69            PondOne          150            0.013      6          1          0          0
  11                CB#68            PondOne          20             0.013      3.91       0          0          0
  RightSwale        23               Raingarden       243            0.41       0          0.25       0          0
  LeftSwale         24               Raingarden       312            0.41       0          0          0          0
  TrenchPipe        33               Raingarden       150            0.013      0          0          0          0
  18                CB#40            PondOne          400            0.01       0          0          0          0

[WEIRS]
;;                  Inlet            Outlet                            Crest      Disch.     Flap End          End
;;Name              Node             Node             Type             Height     Coeff.     Gate Coeff.       Con.
;;---------------------------------------------------------------------------------------------------------
  9                 Raingarden       PondOne          V-NOTCH          1.0        1.45       NO   0            0

[OUTLETS]
;;                  Inlet            Outlet           Outflow    Discharge  Qcoeff/               Flap
;;Name              Node             Node             Height     Curve      Qtable     Qexpon     Gate
;;---------------------------------------------------------------------------------------------------
  15                Raingarden       37               0.10       TABULAR    Inf                   NO

[XSECTIONS]
;;Link              Type         Geom1      Geom2      Geom3      Geom4      Barrels
;;-----------------------------------------------------------------------------------
  3                 CIRCULAR     1          0          0          0          1
  10                CIRCULAR     1          0          0          0          1
  11                CIRCULAR     1          0          0          0          1
  RightSwale        TRAPEZOIDAL  0.50       1          1          1          1
  LeftSwale         TRAPEZOIDAL  0.75       1          1          1          1
  TrenchPipe        CIRCULAR     1          0          0          0          1
  18                CIRCULAR     1          0          0          0          1
  9                 TRIANGULAR   .67        1.34       0.943      0.943

[LOSSES]
;;Link              Inlet      Outlet     Average    Flap Gate
;;-------------------------------------------------------------
  3                 0.50       1.0        1.50       NO
  10                0.50       1.0        1.50       NO
  11                0.50       1.0        1.50       NO
  RightSwale        0.5        1          1.50       NO
  LeftSwale         0.50       1.0        1.50       NO
```

```
  TrenchPipe       0.50       1.0        1.50       NO
  18               0.5        1.0        0          NO

[CURVES]
;;Name             Type       X-Value    Y-Value
;;-------------------------------------------------
  PondOne          Storage    0          0
  PondOne                     0.20       1000
  PondOne                     1.2        2000
  PondOne                     2.2        2600
  PondOne                     10         100000

  Raingarden       Storage    0          0
  Raingarden                  0.5        301
  Raingarden                  1.5        1567.5

  P3               Storage    0          0
  P3                          1          7325
  P3                          2          14472
  P3                          4          17644
  P3                          6          19319

  Forebay          Storage    0          718.78
  Forebay                     1          1197.15
  Forebay                     1.5        1680.06

  Pond_2           Storage    0          0
  Pond_2                      1          1417.23
  Pond_2                      2          3383.52
  Pond_2                      4          5901.52
  Pond_2                      6          10725.21

  INFILT           Storage    0          15000
  INFILT                      1          30000

  Infil            Diversion  0.090      0.090

  RG2              Rating     0          0.11
  RG2                         1.50       0.11

  Pond1            Rating     0          0
  Pond1                       3.2        0

  Inf              Rating     0          0
  Inf                         0.5        0.03
  Inf                         1          0.03
  Inf                         1.5        0.03

[REPORT]
 INPUT     NO
```

Cluster Only Subdivision

```
[TITLE]
Cluster Only Subdivision
Inputs

[OPTIONS]
 FLOW_UNITS             CFS
 INFILTRATION           GREEN_AMPT
 FLOW_ROUTING           DYNWAVE
 START_DATE             01/01/2008
 START_TIME             00:00:00
 REPORT_START_DATE      01/01/2008
 REPORT_START_TIME      00:00:00
 END_DATE               01/02/2008
 END_TIME               00:00:00
 SWEEP_START            01/01
 SWEEP_END              12/31
 DRY_DAYS               0
 REPORT_STEP            00:05:00
 WET_STEP               00:15:00
 DRY_STEP               01:00:00
 ROUTING_STEP           0:00:30
 ALLOW_PONDING          NO
 INERTIAL_DAMPING       PARTIAL
 VARIABLE_STEP          0.75
 LENGTHENING_STEP       0
 MIN_SURFAREA           0
 NORMAL_FLOW_LIMITED    NO
 SKIP_STEADY_STATE      NO
 IGNORE_RAINFALL        NO

[EVAPORATION]
;;Type         Parameters
;;-----------------------
  MONTHLY      0.031  0.0    0.0    0.0    0.0    0.023  0.031  0.028  0.018  0.0    0.0    0.0

[RAINGAGES]
;;                Rain      Recd.  Snow   Data       Source           Station    Rain
;;Name            Type      Freq.  Catch  Source     Name             ID         Units
;;--------------------------------------------------------------------------------------
  2-yr            CUMULATIVE 1:00   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW Mon\Data and Analysis\Model\R
  10-yr           CUMULATIVE 1:00   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW Mon\Data and Analysis\Model\R
  25-yr           CUMULATIVE 1:00   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW Mon\Data and Analysis\Model\R
  50-yr           CUMULATIVE 1:00   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW Mon\Data and Analysis\Model\R
  100-yr          CUMULATIVE 1:00   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW Mon\Data and Analysis\Model\R
  1               CUMULATIVE 1:00   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW Mon\Data and Analysis\Model\R

[SUBCATCHMENTS]
;;                                                 Total    Pcnt.             Pcnt.    Curb     Snow
;;Name            Raingage         Outlet           Area     Imperv   Width    Slope    Length   Pack
;;----------------------------------------------------------------------------------------------------
```

Cluster Only Subdivision

Drive1	100-yr	Pond_Three	0.01	100	20	5	0
Drive10	100-yr	CB#70	0.01	100	20	3	0
Drive11	100-yr	CB#70	0.01	100	20	3	0
Drive12	100-yr	CB#70	0.01	100	20	3	0
Drive13	100-yr	CB#70	0.01	100	20	3	0
Drive14	100-yr	CB#68	0.01	100	20	5	0
Drive15	100-yr	CB#68	0.01	100	20	3	0
Drive16	100-yr	CB#68	0.01	100	20	3	0
Drive17	100-yr	Pond_Three	0.01	100	20	3	0
Drive18	100-yr	Pond_Three	0.01	100	20	3	0
Drive19	100-yr	Pond_Three	0.01	100	20	3	0
Drive2	100-yr	CB#40	0.01	100	20	3	0
Drive20	100-yr	Pond_Three	0.01	100	20	3	0
Drive3	100-yr	CB#40	0.01	100	20	3	0
Drive4	100-yr	CB#69	0.01	100	20	3	0
Drive5	100-yr	CB#69	0.01	100	20	3	0
Drive6	100-yr	CB#69	0.01	100	20	3	0
Drive7	100-yr	CB#70	0.01	100	20	3	0
Drive8	100-yr	CB#70	0.01	100	20	5	0
Drive9	100-yr	CB#70	0.01	100	20	5	0
LeftWeirVeg	100-yr	CB#69	0.30	0	21	3	0
Lot10On	100-yr	CB#70	0.03	38	20	3	0
Lot11On	100-yr	CB#70	0.05	38	20	3	0
Lot12On	100-yr	CB#70	0.033	38	20	5	0
Lot13On	100-yr	CB#70	0.036	38	20	5	0
Lot14On	100-yr	CB#68	0.068	38	20	5	0
Lot15On	100-yr	CB#68	0.063	38	20	5	0
Lot16On	100-yr	CB#68	0.028	38	20	5	0
Lot17On	100-yr	Pond_Three	0.03	38	20	5	0
Lot18On	100-yr	Pond_Three	0.039	38	20	5	0
Lot19On	100-yr	Pond_Three	0.05	38	20	5	0
Lot1On	100-yr	Pond_Three	0.04	38	20	6	0
Lot20On	100-yr	Pond_Three	0.045	38	20	5	0
Lot2On	100-yr	CB#40	0.034	38	20	5	0
Lot3On	100-yr	CB#40	0.031	38	20	5	0
Lot7On	100-yr	CB#70	0.05	38	20	3	0
Lot8On	100-yr	CB#70	0.03	38	20	3	0
Lot9On	100-yr	CB#70	0.02	38	20	3	0
LWPave	100-yr	CB#69	0.12	100	12	5	0
R1	100-yr	Pond_Three	0.18	100	24	5	0
R2	100-yr	CB#68	0.06	100	12	5	0
R3	100-yr	CB#69	0.078	100	12	5	0
RightWeirVeg	100-yr	DMH#4	0.26	0	23	5	0
Roof1	100-yr	Drive1	0.046	100	45	66	0
Roof10	100-yr	Drive10	0.046	100	45	66	0
Roof11	100-yr	Drive11	0.046	100	45	66	0
Roof12	100-yr	Drive12	0.046	100	45	66	0
Roof13	100-yr	Drive13	0.046	100	45	66	0
Roof14	100-yr	Drive14	0.046	100	45	66	0
Roof15	100-yr	Drive15	0.046	100	45	66	0

```
  Roof16           100-yr           Drive16          0.046    100      45       66       0
  Roof17           100-yr           Drive17          0.046    100      45       66       0
  Roof18           100-yr           Drive18          0.046    100      45       66       0
  Roof19           100-yr           Drive19          0.046    100      45       66       0
  Roof2            100-yr           Drive2           0.046    100      45       66       0
  Roof20           100-yr           Drive20          0.046    100      45       66       0
  Roof3            100-yr           Drive3           0.046    100      45       66       0
  Roof4            100-yr           Drive4           0.046    100      45       66       0
  Roof5            100-yr           Drive5           0.046    100      45       66       0
  Roof6            100-yr           Drive6           0.046    100      45       66       0
  Roof7            100-yr           Drive7           0.046    100      45       66       0
  Roof8            100-yr           Drive8           0.046    100      45       66       0
  Roof9            100-yr           Drive9           0.046    100      45       66       0
  RWPave           100-yr           DMH#4            0.014    100      12       5        0
  TrenchPave       100-yr           CB#70            0.24     100      12       6        0
  R4               100-yr           CB#40            0.08     100      9        5        0
  R5               100-yr           CB#70            0.24     100      12       6        0

[SUBAREAS]
;;Subcatchment    N-Imperv   N-Perv     S-Imperv   S-Perv     PctZero    RouteTo    PctRouted
;;--------------------------------------------------------------------------------------------
  Drive1           0.011      0.24       0.075      0.15       75         OUTLET
  Drive10          0.011      0.24       0.075      0.15       75         OUTLET
  Drive11          0.01       0.24       0.075      0.15       75         OUTLET
  Drive12          0.011      0.24       0.075      0.15       75         OUTLET
  Drive13          0.011      0.24       0.075      0.15       75         OUTLET
  Drive14          0.011      0.24       0.075      0.15       75         OUTLET
  Drive15          0.011      0.24       0.075      0.15       75         OUTLET
  Drive16          0.011      0.24       0.075      0.15       75         OUTLET
  Drive17          0.011      0.24       0.075      0.15       75         OUTLET
  Drive18          0.011      0.24       0.075      0.15       75         OUTLET
  Drive19          0.011      0.24       0.075      0.15       75         OUTLET
  Drive2           0.011      0.24       0.075      0.15       75         OUTLET
  Drive20          0.011      0.24       0.075      0.15       75         OUTLET
  Drive3           0.011      0.24       0.075      0.15       75         OUTLET
  Drive4           0.011      0.24       0.075      0.15       75         OUTLET
  Drive5           0.011      0.24       0.075      0.15       75         OUTLET
  Drive6           0.011      0.24       0.075      0.15       75         OUTLET
  Drive7           0.011      0.24       0.075      0.15       75         OUTLET
  Drive8           0.011      0.24       0.075      0.15       75         OUTLET
  Drive9           0.011      0.24       0.075      0.15       75         OUTLET
  LeftWeirVeg      0.01       0.24       0.075      0.15       75         OUTLET
  Lot10On          0.01       0.24       0.075      0.15       75         OUTLET
  Lot11On          0.01       0.24       0.075      0.15       75         OUTLET
  Lot12On          0.01       0.24       0.075      0.15       75         OUTLET
  Lot13On          0.01       0.24       0.075      0.15       75         OUTLET
  Lot14On          0.01       0.24       0.075      0.15       75         OUTLET
  Lot15On          0.01       0.24       0.075      0.15       75         OUTLET
  Lot16On          0.01       0.24       0.075      0.15       75         OUTLET
  Lot17On          0.01       0.24       0.075      0.15       75         OUTLET
```

```
  Lot18On          0.01       0.24       0.075      0.15       75         OUTLET
  Lot19On          0.01       0.24       0.075      0.15       75         OUTLET
  Lot1On           0.01       0.24       0.075      0.15       75         OUTLET
  Lot20On          0.01       0.24       0.075      0.15       75         OUTLET
  Lot2On           0.011      0.24       0.075      0.15       75         OUTLET
  Lot3On           0.01       0.24       0.075      0.15       75         OUTLET
  Lot7On           0.01       0.24       0.075      0.15       75         OUTLET
  Lot8On           0.01       0.24       0.075      0.15       75         OUTLET
  Lot9On           0.01       0.24       0.075      0.15       75         OUTLET
  LWPave           0.011      0.24       0.075      0.15       75         OUTLET
  R1               0.011      0.24       0.075      0.15       75         OUTLET
  R2               0.011      0.24       0.075      0.15       75         OUTLET
  R3               0.011      0.24       0.075      0.15       75         OUTLET
  RightWeirVeg     0.01       0.24       0.075      0.15       75         OUTLET
  Roof1            0.011      0.24       0.075      0.15       75         OUTLET
  Roof10           0.011      0.24       0.075      0.15       75         OUTLET
  Roof11           0.011      0.24       0.075      0.15       75         OUTLET
  Roof12           0.011      0.24       0.075      0.15       75         OUTLET
  Roof13           0.011      0.24       0.075      0.15       75         OUTLET
  Roof14           0.011      0.24       0.075      0.15       75         OUTLET
  Roof15           0.011      0.24       0.075      0.15       75         OUTLET
  Roof16           0.011      0.24       0.075      0.15       75         OUTLET
  Roof17           0.011      0.24       0.075      0.15       75         OUTLET
  Roof18           0.011      0.24       0.075      0.15       75         OUTLET
  Roof19           0.011      0.24       0.075      0.15       75         OUTLET
  Roof2            0.011      0.24       0.075      0.15       75         OUTLET
  Roof20           0.011      0.24       0.075      0.15       75         OUTLET
  Roof3            0.011      0.24       0.075      0.15       75         OUTLET
  Roof4            0.011      0.24       0.075      0.15       75         OUTLET
  Roof5            0.011      0.24       0.075      0.15       75         OUTLET
  Roof6            0.011      0.24       0.075      0.15       75         OUTLET
  Roof7            0.011      0.24       0.075      0.15       75         OUTLET
  Roof8            0.011      0.24       0.075      0.15       75         OUTLET
  Roof9            0.011      0.24       0.075      0.15       75         OUTLET
  RWPave           0.011      0.24       0.075      0.15       75         OUTLET
  TrenchPave       0.011      0.24       0.075      0.15       75         OUTLET
  R4               0.011      0.24       0.075      0.15       75         OUTLET
  R5               0.01       0.24       0.075      0.15       75         OUTLET

[INFILTRATION]
;;Subcatchment    Suction    HydCon     IMDmax
;;--------------------------------------------------
  Drive1           12.60      0.01       0.097
  Drive10          12.60      0.01       0.097
  Drive11          12.60      0.01       0.097
  Drive12          12.60      0.01       0.097
  Drive13          12.60      0.01       0.097
  Drive14          12.60      0.01       0.097
  Drive15          12.60      0.01       0.097
  Drive16          12.60      0.01       0.097
```

Drive17	12.60	0.01	0.097
Drive18	12.60	0.01	0.097
Drive19	12.60	0.01	0.097
Drive2	12.60	0.01	0.097
Drive20	12.60	0.01	0.097
Drive3	12.60	0.01	0.097
Drive4	12.60	0.01	0.097
Drive5	12.60	0.01	0.097
Drive6	12.60	0.01	0.097
Drive7	12.60	0.01	0.097
Drive8	12.60	0.01	0.097
Drive9	12.60	0.01	0.097
LeftWeirVeg	12.60	0.01	0.097
Lot10On	12.60	0.01	0.097
Lot11On	12.60	0.01	0.097
Lot12On	12.60	0.01	0.097
Lot13On	12.60	0.01	0.097
Lot14On	12.60	0.01	0.097
Lot15On	12.60	0.01	0.097
Lot16On	12.60	0.01	0.097
Lot17On	12.60	0.01	0.097
Lot18On	12.60	0.01	0.097
Lot19On	12.60	0.01	0.097
Lot1On	12.60	0.01	0.097
Lot20On	12.60	0.01	0.097
Lot2On	12.60	0.01	0.097
Lot3On	12.60	0.01	0.097
Lot7On	12.60	0.01	0.097
Lot8On	12.60	0.01	0.097
Lot9On	12.60	0.01	0.097
LWPave	12.60	0.01	0.097
R1	12.60	0.01	0.097
R2	12.60	0.01	0.097
R3	12.60	0.01	0.097
RightWeirVeg	12.60	0.01	0.097
Roof1	12.60	0.01	0.097
Roof10	12.60	0.01	0.097
Roof11	12.60	0.01	0.097
Roof12	12.60	0.01	0.097
Roof13	12.60	0.01	0.097
Roof14	12.60	0.01	0.097
Roof15	12.60	0.01	0.097
Roof16	12.60	0.01	0.097
Roof17	12.60	0.01	0.097
Roof18	12.60	0.01	0.097
Roof19	12.60	0.01	0.097
Roof2	12.60	0.01	0.097
Roof20	12.60	0.01	0.097
Roof3	12.60	0.01	0.097
Roof4	12.60	0.01	0.097

```
  Roof5            12.60      0.01       0.097
  Roof6            12.60      0.01       0.097
  Roof7            12.60      0.01       0.097
  Roof8            12.60      0.01       0.097
  Roof9            12.60      0.01       0.097
  RWPave           12.60      0.01       0.097
  TrenchPave       12.60      0.01       0.097
  R4               12.60      0.01       0.097
  R5               12.60      0.01       0.097

[JUNCTIONS]
;;                 Invert     Max.       Init.      Surcharge  Ponded
;;Name             Elev.      Depth      Depth      Depth      Area
;;----------------------------------------------------------------------
  CB#69            77         8          0          0          0
  CB#70            78         1          0          1000       0
  CB#68            88.99      8          0          0          0
  CB#40            96.41      8          0          0          0
  DMH#81           99.20      0          0          0          0
  DMH#4            98.4       0          0          0          0

[OUTFALLS]
;;                 Invert     Outfall    Stage/Table      Tide
;;Name             Elev.      Type       Time Series      Gate
;;-------------------------------------------------------------
  27               0          FREE                        NO

[STORAGE]
;;                 Invert   Max.     Init.    Shape      Shape                      Ponded   Evap.
;;Name             Elev.    Depth    Depth    Curve      Parameters                 Area     Frac.
;;-----------------------------------------------------------------------------------------------
  1                73.8     10       0        TABULAR    PondOne                    4485     1
  Pond_Three       70       6        0        TABULAR    P3                         19319.25 1

[CONDUITS]
;;                 Inlet            Outlet                      Manning    Inlet      Outlet     Init.      Maximum
;;Name             Node             Node             Length     N          Height     Height     Flow       Flow
;;-----------------------------------------------------------------------------------------------------------------------
  3                CB#70            1                120        0.013      0          1.2        0          0
  6                CB#40            DMH#81           56         0.013      3.09       0          0          0
  7                DMH#4            1                120        0.013      0          0.3        0          0
  8                DMH#81           DMH#4            24         0.013      0          0.4        0          0
  9                DMH#81           DMH#4            400        0.01       0          0          0          0
  10               CB#69            1                150        0.013      4          4.5        0          0
  11               CB#68            1                400        0.01       0          0          0          0

[XSECTIONS]
;;Link             Type         Geom1      Geom2      Geom3      Geom4      Barrels
;;--------------------------------------------------------------------------------
  3                CIRCULAR     1          0          0          0          1
```

```
  6               CIRCULAR    1          0          0          0          1
  7               DUMMY       0          0          0          0          1
  8               CIRCULAR    1          0          0          0          1
  9               CIRCULAR    1          0          0          0          1
  10              CIRCULAR    1          0          0          0          1
  11              DUMMY       0          0          0          0          1

[LOSSES]
;;Link           Inlet      Outlet     Average    Flap Gate
;;----------------------------------------------------------
  3               0.5        1.0        0          NO
  6               0.5        1.0        0          NO
  7               0.5        1.0        0          NO
  8               0.5        1.0        0          NO
  9               0          1.0        0          NO
  10              0.5        1.0        0          NO
  11              0          1.0        0          NO

[CURVES]
;;Name           Type       X-Value    Y-Value
;;----------------------------------------------
  PondOne         Storage    0          0
  PondOne                    0.20       760
  PondOne                    1.2        2640
  PondOne                    2.2        3500
  PondOne                    3.2        4485
  PondOne                    10         50000

  Raingarden      Storage    0          301
  Raingarden                 1.5        1567.5

  P3              Storage    0          0
  P3                         1          7325
  P3                         2          14472
  P3                         4          17644
  P3                         6          19319.25

  P2              Storage    0          0
  P2                         1          1417.23
  P2                         2          3383.52
  P2                         4          5901.52
  P2                         10         50000

  RGI             Rating     0          0.038
  RGI                        0.5        0.038
  RGI                        1          0.038
  RGI                        1.5        0.038

[REPORT]
 INPUT     NO
```

Conventional Subdivison

```
[TITLE]
Conventional Subdivison
Inputs

[OPTIONS]
FLOW_UNITS           CFS
INFILTRATION         GREEN_AMPT
FLOW_ROUTING         DYNWAVE
START_DATE           01/01/2008
START_TIME           00:00:00
REPORT_START_DATE    01/01/2008
REPORT_START_TIME    00:00:00
END_DATE             01/02/2008
END_TIME             00:00:00
SWEEP_START          01/01
SWEEP_END            12/31
DRY_DAYS             0
REPORT_STEP          00:05:00
WET_STEP             00:15:00
DRY_STEP             01:00:00
ROUTING_STEP         0:00:30
ALLOW_PONDING        NO
INERTIAL_DAMPING     PARTIAL
VARIABLE_STEP        0.75
LENGTHENING_STEP     0
MIN_SURFAREA         0
NORMAL_FLOW_LIMITED  SLOPE
SKIP_STEADY_STATE    NO
FORCE_MAIN_EQUATION  H-W
LINK_OFFSETS         DEPTH
MIN_SLOPE            0

[EVAPORATION]
;;Type       Parameters
;;---------- ----------
CONSTANT     0.031

[RAINGAGES]
;;               Rain      Time   Snow   Data
;;Name           Type      Intrvl Catch  Source
;;-------------- --------- ------ ------ ----------
2-yr             CUMULATIVE 1:00   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW Mon\Data and Analysis\Model\Rai
10-yr            CUMULATIVE 1:00   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW Mon\Data and Analysis\Model\Rai
25-yr            CUMULATIVE 1:00   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW Mon\Data and Analysis\Model\Rai
50-yr            CUMULATIVE 1:00   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW Mon\Data and Analysis\Model\Rai
100-yr           CUMULATIVE 1:00   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW Mon\Data and Analysis\Model\Rai
1                CUMULATIVE 1:00   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW Mon\Data and Analysis\Model\Rai

[SUBCATCHMENTS]
;;                                                   Total    Pcnt.             Pcnt.    Curb     Snow
```

Conventional Subdivison

;;Name	Raingage	Outlet	Area	Imperv	Width	Slope	Length	Pack
Drive1	2-yr	25	0.022	100	20	5	0	
Drive10	2-yr	Roof10	0.022	100	20	3	0	
Drive11	2-yr	Roof11	0.022	100	20	3	0	
Drive12	2-yr	CB#70	0.022	100	20	3	0	
Drive13	2-yr	CB#70	0.022	100	20	3	0	
Drive14	2-yr	1	0.022	100	20	5	0	
Drive15	2-yr	CB#68	0.022	100	20	3	0	
Drive16	2-yr	CB#68	0.022	100	20	3	0	
Drive17	2-yr	25	0.022	100	20	3	0	
Drive18	2-yr	25	0.022	100	20	3	0	
Drive19	2-yr	25	0.022	100	20	3	0	
Drive2	2-yr	CB#40	0.022	100	20	3	0	
Drive20	2-yr	25	0.022	100	20	3	0	
Drive3	2-yr	CB#40	0.022	100	20	3	0	
Drive4	2-yr	DMH#4	0.022	100	20	3	0	
Drive5	2-yr	DMH#4	0.022	100	20	3	0	
Drive6	2-yr	DMH#4	0.022	100	20	3	0	
Drive7	2-yr	CB#70	0.022	100	20	3	0	
Drive8	2-yr	CB#70	0.022	100	20	5	0	
Drive9	2-yr	Roof9	0.022	100	20	5	0	
LeftWeirVeg	2-yr	1	0.30	38	21	3	0	
Lot10On	2-yr	CB#70	1	5	20	3	0	
Lot11On	2-yr	CB#70	1	5	20	3	0	
Lot12On	2-yr	CB#70	1	5	20	5	0	
Lot13On	2-yr	CB#70	1	5	20	5	0	
Lot14On	2-yr	CB#68	1	5	20	5	0	
Lot15On	2-yr	CB#68	1	5	20	5	0	
Lot16On	2-yr	CB#68	1	5	20	5	0	
Lot17On	2-yr	25	1	5	20	5	0	
Lot18On	2-yr	25	1	5	20	5	0	
Lot19On	2-yr	25	1	5	20	5	0	
Lot1On	2-yr	25	1	5	20	6	0	
Lot20On	2-yr	25	1	5	20	5	0	
Lot2On	2-yr	CB#40	1	5	20	5	0	
Lot3On	2-yr	CB#40	1	5	20	5	0	
Lot7On	2-yr	CB#70	1	5	20	3	0	
Lot8On	2-yr	CB#70	1	5	20	3	0	
Lot9On	2-yr	CB#70	1	5	20	3	0	
LWPave	2-yr	1	0.08	100	9	5	0	
R1	2-yr	25	0.18	100	18	5	0	
R2	2-yr	CB#68	0.04	100	9	5	0	
R3	2-yr	1	0.062	100	9	5	0	
RightWeirVeg	2-yr	DMH#4	0.26	38	23	5	0	
Roof1	2-yr	Lot1On	0.046	100	45	66	0	
Roof10	2-yr	Lot10On	0.046	100	45	66	0	
Roof11	2-yr	Lot11On	0.046	100	45	66	0	
Roof12	2-yr	Lot12On	0.046	100	45	66	0	
Roof13	2-yr	Lot13On	0.046	100	45	66	0	

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Roof14           2-yr             Lot14On          0.046    100      45       66       0
Roof15           2-yr             Lot15On          0.046    100      45       66       0
Roof16           2-yr             Lot16On          0.046    100      45       66       0
Roof17           2-yr             Lot17On          0.046    100      45       66       0
Roof18           2-yr             Lot18On          0.046    100      45       66       0
Roof19           2-yr             Lot19On          0.046    100      45       66       0
Roof2            2-yr             Lot2On           0.046    100      45       66       0
Roof20           2-yr             Lot20On          0.046    100      45       66       0
Roof3            2-yr             Lot3On           0.046    100      45       66       0
Roof4            2-yr             Drive4           0.046    100      45       66       0
Roof5            2-yr             Drive5           0.046    100      45       66       0
Roof6            2-yr             Drive6           0.046    100      45       66       0
Roof7            2-yr             Lot7On           0.046    100      45       66       0
Roof8            2-yr             Lot8On           0.046    100      45       66       0
Roof9            2-yr             Lot9On           0.046    100      45       66       0
RWPave           2-yr             DMH#4            0.093    100      9        5        0
R4               2-yr             CB#40            0.08     100      9        5        0

[SUBAREAS]
;;Subcatchment   N-Imperv   N-Perv     S-Imperv   S-Perv     PctZero    RouteTo    PctRouted
;;-------------- ---------- ---------- ---------- ---------- ---------- ---------- ----------
Drive1           0.011      0.24       0.075      0.15       75         IMPERVIOUS 100
Drive10          0.011      0.24       0.075      0.15       75         OUTLET
Drive11          0.01       0.24       0.075      0.15       75         OUTLET
Drive12          0.011      0.24       0.075      0.15       75         OUTLET
Drive13          0.011      0.24       0.075      0.15       75         OUTLET
Drive14          0.011      0.24       0.075      0.15       75         OUTLET
Drive15          0.011      0.24       0.075      0.15       75         OUTLET
Drive16          0.011      0.24       0.075      0.15       75         OUTLET
Drive17          0.011      0.24       0.075      0.15       75         OUTLET
Drive18          0.011      0.24       0.075      0.15       75         OUTLET
Drive19          0.011      0.24       0.075      0.15       75         OUTLET
Drive2           0.011      0.24       0.075      0.15       75         OUTLET
Drive20          0.011      0.24       0.075      0.15       75         OUTLET
Drive3           0.011      0.24       0.075      0.15       75         OUTLET
Drive4           0.011      0.24       0.075      0.15       75         OUTLET
Drive5           0.011      0.24       0.075      0.15       75         OUTLET
Drive6           0.011      0.24       0.075      0.15       75         OUTLET
Drive7           0.011      0.24       0.075      0.15       75         OUTLET
Drive8           0.011      0.24       0.075      0.15       75         OUTLET
Drive9           0.011      0.24       0.075      0.15       75         OUTLET
LeftWeirVeg      0.011      0.41       0.075      0.15       75         OUTLET
Lot10On          0.01       0.24       0.075      0.15       75         OUTLET
Lot11On          0.01       .24        0.075      0.15       75         OUTLET
Lot12On          0.01       .24        0.075      0.15       75         OUTLET
Lot13On          0.01       .24        0.075      0.15       75         OUTLET
Lot14On          0.01       .24        0.075      0.15       75         OUTLET
Lot15On          0.01       .24        0.075      0.15       75         OUTLET
Lot16On          0.01       .24        0.075      0.15       75         OUTLET
Lot17On          0.01       .24        0.075      0.15       75         OUTLET
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Lot18On          0.01       .24        0.075      0.15       75         OUTLET
Lot19On          0.01       .24        0.075      0.15       75         OUTLET
Lot1On           0.01       .24        0.075      0.15       75         OUTLET
Lot20On          0.01       .24        0.075      0.15       75         OUTLET
Lot2On           0.011      .24        0.075      0.15       75         OUTLET
Lot3On           0.01       .24        0.075      0.15       75         OUTLET
Lot7On           0.01       .24        0.075      0.15       75         OUTLET
Lot8On           0.01       .24        0.075      0.15       75         OUTLET
Lot9On           0.01       .24        0.075      0.15       75         OUTLET
LWPave           0.011      0.24       0.075      0.15       75         OUTLET
R1               0.011      0.24       0.075      0.15       75         OUTLET
R2               0.011      0.24       0.075      0.15       75         OUTLET
R3               0.011      0.24       0.075      0.15       75         OUTLET
RightWeirVeg     0.011      0.41       0.075      0.15       75         OUTLET
Roof1            0.011      0.24       0.075      0.15       75         OUTLET
Roof10           0.011      0.24       0.075      0.15       75         OUTLET
Roof11           0.011      0.24       0.075      0.15       75         OUTLET
Roof12           0.011      0.24       0.075      0.15       75         OUTLET
Roof13           0.011      0.24       0.075      0.15       75         OUTLET
Roof14           0.011      0.24       0.075      0.15       75         OUTLET
Roof15           0.011      0.24       0.075      0.15       75         OUTLET
Roof16           0.011      0.24       0.075      0.15       75         OUTLET
Roof17           0.011      0.24       0.075      0.15       75         OUTLET
Roof18           0.011      0.24       0.075      0.15       75         OUTLET
Roof19           0.011      0.24       0.075      0.15       75         OUTLET
Roof2            0.011      0.24       0.075      0.15       75         OUTLET
Roof20           0.011      0.24       0.075      0.15       75         IMPERVIOUS 100
Roof3            0.011      0.24       0.075      0.15       75         OUTLET
Roof4            0.011      0.24       0.075      0.15       75         OUTLET
Roof5            0.011      0.24       0.075      0.15       75         OUTLET
Roof6            0.011      0.24       0.075      0.15       75         OUTLET
Roof7            0.011      0.24       0.075      0.15       75         OUTLET
Roof8            0.011      0.24       0.075      0.15       75         OUTLET
Roof9            0.011      0.24       0.075      0.15       75         OUTLET
RWPave           0.011      0.24       0.075      0.15       75         OUTLET
R4               0.011      0.24       0.075      0.15       75         OUTLET

[INFILTRATION]
;;Subcatchment   Suction    HydCon     IMDmax
;;-------------- ---------- ---------- ----------
Drive1           12.60      0.01       0.097
Drive10          12.60      0.01       0.097
Drive11          12.60      0.01       0.097
Drive12          12.60      0.01       0.097
Drive13          12.60      0.01       0.097
Drive14          12.60      0.01       0.097
Drive15          12.60      0.01       0.097
Drive16          12.60      0.01       0.097
Drive17          12.60      0.01       0.097
Drive18          12.60      0.01       0.097
```

Drive19	12.60	0.01	0.097
Drive2	12.60	0.01	0.097
Drive20	12.60	0.01	0.097
Drive3	12.60	0.01	0.097
Drive4	12.60	0.01	0.097
Drive5	12.60	0.01	0.097
Drive6	12.60	0.01	0.097
Drive7	12.60	0.01	0.097
Drive8	12.60	0.01	0.097
Drive9	12.60	0.01	0.097
LeftWeirVeg	12.60	0.01	0.097
Lot10On	12.60	0.01	0.097
Lot11On	12.60	0.01	0.097
Lot12On	12.60	0.01	0.097
Lot13On	12.60	0.01	0.097
Lot14On	12.60	0.01	0.097
Lot15On	12.60	0.01	0.097
Lot16On	12.60	0.01	0.097
Lot17On	12.60	0.01	0.097
Lot18On	12.60	0.01	0.097
Lot19On	12.60	0.01	0.097
Lot1On	12.60	0.01	0.097
Lot20On	12.60	0.01	0.097
Lot2On	12.60	0.01	0.097
Lot3On	12.60	0.01	0.097
Lot7On	12.60	0.01	0.097
Lot8On	12.60	0.01	0.097
Lot9On	12.60	0.01	0.097
LWPave	12.60	0.01	0.097
R1	12.60	0.01	0.097
R2	12.60	0.01	0.097
R3	12.60	0.01	0.097
RightWeirVeg	12.60	0.01	0.097
Roof1	12.60	0.01	0.097
Roof10	12.60	0.01	0.097
Roof11	12.60	0.01	0.097
Roof12	12.60	0.01	0.097
Roof13	12.60	0.01	0.097
Roof14	12.60	0.01	0.097
Roof15	12.60	0.01	0.097
Roof16	12.60	0.01	0.097
Roof17	12.60	0.01	0.097
Roof18	12.60	0.01	0.097
Roof19	12.60	0.01	0.097
Roof2	12.60	0.01	0.097
Roof20	12.60	0.01	0.097
Roof3	12.60	0.01	0.097
Roof4	12.60	0.01	0.097
Roof5	12.60	0.01	0.097
Roof6	12.60	0.01	0.097

Conventional Subdivison

```
Roof7            12.60      0.01       0.097
Roof8            12.60      0.01       0.097
Roof9            12.60      0.01       0.097
RWPave           12.60      0.01       0.097
R4               12.60      0.01       0.097

[JUNCTIONS]
;;               Invert     Max.       Init.      Surcharge  Ponded
;;Name           Elev.      Depth      Depth      Depth      Area
;;-------------- ---------- ---------- ---------- ---------- ----------
CB#70            82.28      8          0          1000       0
CB#68            88.99      8          0          1000       0
CB#40            96.41      8          0          0          0
DMH#81           99.20      0          0          0          0
DMH#4            98.4       0          0          0          0
25               72         0          0          0          0

[OUTFALLS]
;;               Invert     Outfall    Stage/Table      Tide
;;Name           Elev.      Type       Time Series      Gate
;;-------------- ---------- ---------- ---------------- ----
32               0          FREE                        NO
33               0          FREE                        NO

[STORAGE]
;;               Invert   Max.     Init.    Shape      Shape                      Ponded   Evap.
;;Name           Elev.    Depth    Depth    Curve      Params                     Area     Frac.    Infiltration Parameters
;;-------------- -------- -------- -------- ---------- -------- -------- -------- -------- -------- -----------------------
1                84       10       0        TABULAR    PondOne                    0        1
Pond3            70       8        0        TABULAR    Pond_3                     19319.25 0

[CONDUITS]
;;               Inlet            Outlet                      Manning    Inlet      Outlet     Init.      Max.
;;Name           Node             Node             Length     N          Offset     Offset     Flow       Flow
;;-------------- ---------------- ---------------- ---------- ---------- ---------- ---------- ---------- ----------
3                CB#70            1                48         0.013      4.42       1.2        0          0
6                CB#40            DMH#81           56         0.013      3.09       0          0          0
7                DMH#4            1                120        0.013      0          0.3        0          0
8                DMH#81           DMH#4            24         0.013      0          0.4        0          0
ToPond3          25               Pond3            25         0.013      0          1          0          0
15               CB#68            1                400        0.01       0          0          0          0

[XSECTIONS]
;;Link           Shape        Geom1            Geom2      Geom3      Geom4      Barrels
;;-------------- ------------ ---------------- ---------- ---------- ---------- ----------
3                CIRCULAR     1                0          0          0          1
6                CIRCULAR     1                0          0          0          1
7                DUMMY        0                0          0          0          1
8                CIRCULAR     1                0          0          0          1
ToPond3          DUMMY        0                0          0          0          1
```

```
15               DUMMY        0                0          0          0          1

[LOSSES]
;;Link           Inlet      Outlet     Average    Flap Gate
;;-------------- ---------- ---------- ---------- ----------
3                0.5        1          0          NO
6                0.5        1          0          NO
7                0.5        1          0          NO
8                0.5        1          0          NO
ToPond3          0.5        1          0          NO

[CURVES]
;;Name           Type       X-Value    Y-Value
;;-------------- ---------- ---------- ----------
PondOne          Storage    0          1962
PondOne                     2          4354
PondOne                     4          7448
PondOne                     10         100000

Raingarden       Storage    0          301
Raingarden                  1.5        1567.5

Pond_3           Storage    0          7325
Pond_3                      2          14472
Pond_3                      4          17644
Pond_3                      6          19319
Pond_3                      8          70000

Forebay          Storage    0          718.78
Forebay                     1          1197.15
Forebay                     1.5        1680.06

Pond2            Storage    0          1417
Pond2                       2          3383
Pond2                       4          5901
Pond2                       6          10725

[REPORT]
INPUT      NO
CONTROLS   NO
SUBCATCHMENTS ALL
NODES ALL
LINKS ALL
```

Pre-Development Watershed Model

```
[TITLE]
Pre-Development Watershed Model
Input Parameters

[OPTIONS]
 FLOW_UNITS            CFS
 INFILTRATION          GREEN_AMPT
 FLOW_ROUTING          DYNWAVE
 START_DATE            01/01/2008
 START_TIME            00:00:00
 REPORT_START_DATE     01/01/2008
 REPORT_START_TIME     00:00:00
 END_DATE              01/02/2008
 END_TIME              00:00:00
 SWEEP_START           01/01
 SWEEP_END             12/31
 DRY_DAYS              0
 REPORT_STEP           00:01:00
 WET_STEP              00:15:00
 DRY_STEP              01:00:00
 ROUTING_STEP          0:00:30
 ALLOW_PONDING         NO
 INERTIAL_DAMPING      PARTIAL
 VARIABLE_STEP         0.75
 LENGTHENING_STEP      0
 MIN_SURFAREA          0
 NORMAL_FLOW_LIMITED   NO
 SKIP_STEADY_STATE     NO
 IGNORE_RAINFALL       NO

[EVAPORATION]
;;Type         Parameters
;;-----------------------
  MONTHLY      0.018  0.0    0.0    0.0    0.0    0.15   0.20   0.18   0.114  0.0    0.0    0.0

[RAINGAGES]
;;                 Rain      Recd.  Snow   Data       Source           Station    Rain
;;Name             Type      Freq.  Catch  Source     Name             ID         Units
;;--------------------------------------------------------------------------------------
  100-yr           CUMULATIVE 1:00   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW
  10-yr            CUMULATIVE 1:00   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW
  25-yr            CUMULATIVE 1:00   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW
  2-yr             CUMULATIVE 1:00   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW
  50-yr            CUMULATIVE 1:00   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW
  Event_1          VOLUME    0:05   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW
  Event_2          VOLUME    0:05   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW
  Event_3          VOLUME    0:05   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW
  Event_4          VOLUME    0:05   1.0    FILE       "T:\Projects\1940 - Water Resources\BW0122 - Partridgeberry PL SW

[SUBCATCHMENTS]
;;                                                 Total    Pcnt.             Pcnt.    Curb     Snow
;;Name             Raingage         Outlet           Area     Imperv   Width    Slope    Length   Pack
;;-----------------------------------------------------------------------------------------------------
  Cal_Forest       100-yr           2                0.077    0.175    60       18       0

[SUBAREAS]
;;Subcatchment     N-Imperv   N-Perv     S-Imperv   S-Perv     PctZero    RouteTo    PctRouted
;;-----------------------------------------------------------------------------------------------
  Cal_Forest       0.38       0.40       0.40       0.30       90         OUTLET

[INFILTRATION]
;;Subcatchment     Suction    HydCon     IMDmax
;;--------------------------------------------------
  Cal_Forest       3.71       0.165      0.239

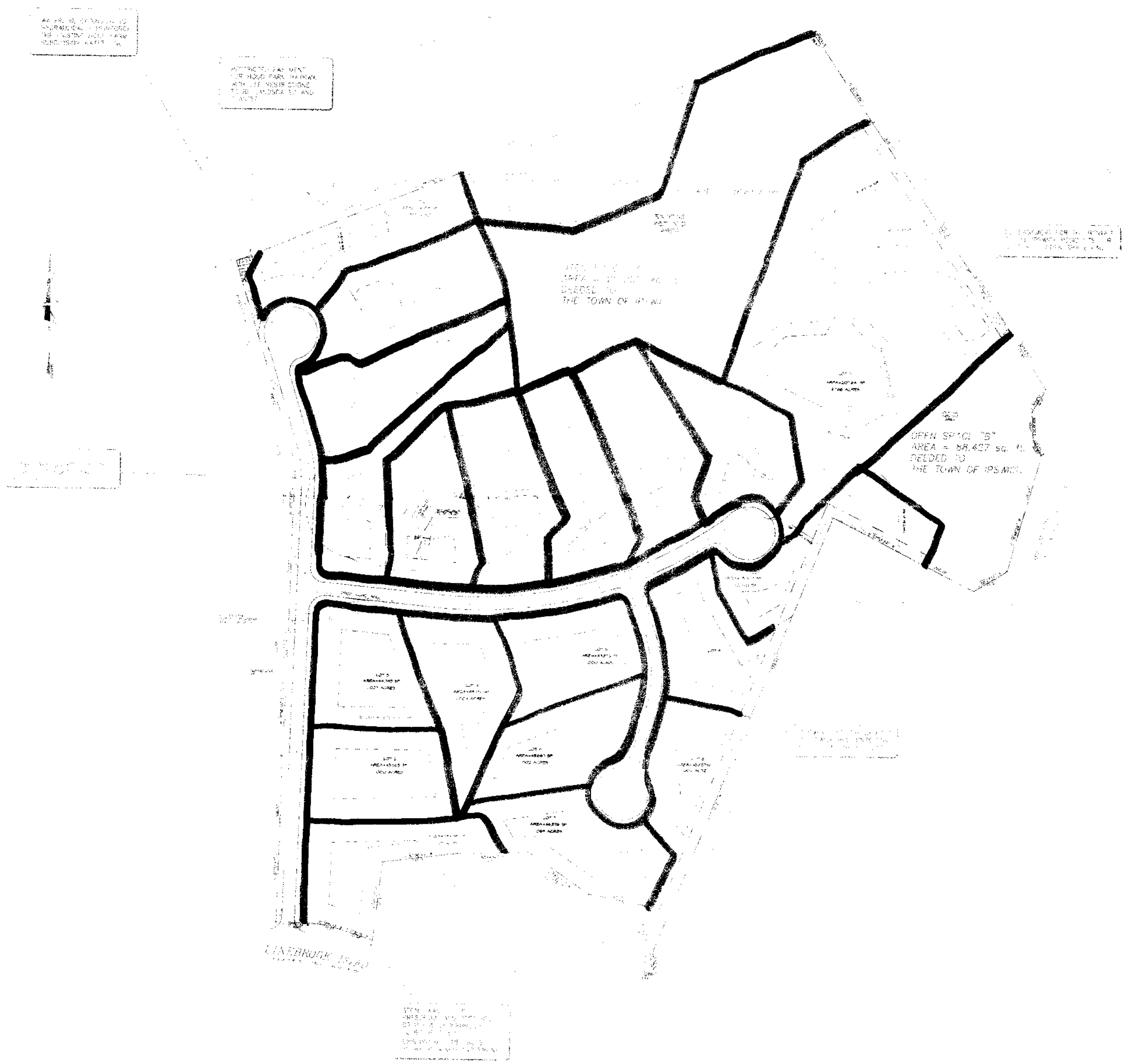
[OUTFALLS]
;;                 Invert     Outfall    Stage/Table      Tide
;;Name             Elev.      Type       Time Series      Gate
;;--------------------------------------------------------------
  1                0          FREE                        NO
  2                0          FREE                        NO
  4                0          FREE                        NO

[REPORT]
 INPUT      NO
 CONTROLS   NO

[OPTIONS]
 TEMPDIR    "C:\DOCUME~1\rfitsik\LOCALS~1\Temp\"
```

ATTACHMENT 5

Conventional Subdivision Design Plan



DEMETRIOU PROPERTY
IPSWICH, MASSACHUSETTS

PRELIMINARY
SUBDIVISION PLAN

OPEN SPACE PROTECTION PLAN

S

DRAWING NUMBER
CC 1.1

ATTACHMENT 6

Conventional Subdivision Drainage Area Map

NOTE:

1. BASE MAP WAS TAKEN FROM PLAN ENTITLED "PRELIMINARY SUBDIVISION PLAN," DATED 15 MAY 1997 AND PREPARED BY DEMETRIOUS PROPERTY OF IPSWICH, MASSACHUSETTS

LOCUS MAP

NORTH

100 50 0 100 200

SCALE IN FEET

LEGEND

PROPERTY LINE

EDGE OF PAVEMENT

POND 1 WATERSHED

POND 3 WATERSHED

REV. NO.	DATE	DESCRIPTION	DES. BY	DR. BY	CHK. BY	RVW. BY	APP. BY

PROJECT: PARTRIDGEBERRY PLACE

TITLE: CONVENTIONAL SUBDIVISION DRAINAGE AREA MAP

CONSULTANT/ENGINEER

Geosyntec consultants

289 GREAT ROAD, SUITE 105
ACTON, MASSACHUSETTS, 01720 USA
PHONE: 978.263.9588

DATE:	10/9/2008
SCALE:	1"=100'
PROJECT NO:	JR0058
FILE NO:	MONITORING LOCATIONS.DWG

ATTACHMENT 6

1 INCH AT FULL SCALE PLOT

ATTACHMENT 7

Pre-development Watershed Drainage Area Map

LEGEND

—100—	MAJOR CONTOUR
- - -	MINOR CONTOUR
— SF —	IMPERMEABLE RIGID BOUNDARY
(symbol)	EVERGREEN TREE
(symbol)	DECIDUOUS TREE

REV. NO	DATE	DESCRIPTION	DES. BY	DR. BY	CHK. BY	RVW. BY	APP. BY

PROJECT:

PARTRIDGEBERRY PLACE

TITLE:

PRE-DEVELOPMENT CONDITION WATERSHED

DATE:	10/9/2008
SCALE:	1"=12'
PROJECT NO:	BW0122
FILE NO:	UNDISTURBED AREA1.DWG

CONSULTANT/ENGINEER

Geosyntec consultants
engineers | scientists | innovators
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ACTON, MASSACHUSETTS, 01720 USA
PHONE: 978.263.9588

ATTACHMENT
7

1 INCH AT FULL SCALE PLOT

ATTACHMENT 8

NRCS Soil Survey for Essex County, MA

Attachment 8 – NRCS Soil Survey for Partridgeberry Place Subdivision

Source: United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) web soil survey (http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx)

Map Unit Symbol	Map Unit Name	Percent of AOI
1	Water	2.7%
31A	Walpole fine sandy loam, 0 to 3 percent slopes	9.2%
51A	Swansea muck, 0 to 1 percent slopes	0.9%
52A	Freetown muck, 0 to 1 percent slopes	9.7%
242C	Hinckley gravelly fine sandy loam, 8 to 15 percent slopes	40.4%
254B	Merrimac fine sandy loam, 3 to 8 percent slopes	4.5%
421C	Canton fine sandy loam, 8 to 15 percent slopes, very stony	0.2%
421D	Canton fine sandy loam, 15 to 25 percent slopes, very stony	18.0%
600	Pits, gravel	10.1%
602	Urban land	4.3%

ATTACHMENT 9

SWMM Manual Soil Characteristics Table

Attachment 9: SWMM Manual Soil Characteristics Table

Characteristics of Various Soils

Soil Texture Class	**K**	**Ψ**	**ϕ**	**FC**	**WP**
Sand	4.74	1.93	0.437	0.062	0.024
Loamy Sand	1.18	2.40	0.437	0.105	0.047
Sandy Loam	0.43	4.33	0.453	0.190	0.085
Loam	0.13	3.50	0.463	0.232	0.116
Silt Loam	0.26	6.69	0.501	0.284	0.135
Sandy Clay Loam	0.06	8.66	0.398	0.244	0.136
Clay Loam	0.04	8.27	0.464	0.310	0.187
Silty Clay Loam	0.04	10.63	0.471	0.342	0.210
Sandy Clay	0.02	9.45	0.430	0.321	0.221
Silty Clay	0.02	11.42	0.479	0.371	0.251
Clay	0.01	12.60	0.475	0.378	0.265

K = hydraulic conductivity, in/hr
Ψ = suction head, in.
ϕ = porosity, fraction
FC = field capacity, fraction
WP= wilting point, fraction

Source: Rawls, W.J. et al., (1983). *J. Hyd. Engr.*, 109:1316.

NRCS Hydrologic Soil Group Definitions

Group	Meaning	Saturated Conductivity (in/hr)
A	Low runoff potential. Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels.	$\geq$ 0.45
B	Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well-drained soils with moderately fine to moderately coarse textures. E.g., shallow loess, sandy loam.	0.30 - 0.15
C	Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine textures. E.g., clay loams, shallow sandy loam.	0.15 - 0.05
D	High runoff potential. Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a clay-pan or clay layer at or near the surface, and shallow soils over nearly impervious material.	0.05 - 0.00

ATTACHMENT 10

Model Calibration Results

Raingarden Model Calibration Results

Date	Rainfall (in)	Pre-Calibrated (cf)	Observed Volume (cf)	Calibrated Model Volume (cf)	Percent Change (%)
7/19/2008	0.11	42	11	12	109%
8/16/2008	0.16	63	91	114	125%
7/21/2008	0.60	279	552	570	103%
7/27/2008	0.70	465	611	666	109%
8/11/2008	1.11	794	919	960	104%
9/6/2008	2.40	1554	2878	2652	92%
7/23/2008	2.41	1237	2302	2196	95%
9/26/2008	2.45	2514	2165	2358	109%

Pond One Model Calibration Results

Date	Rainfall (in)	Pre-Calibrated (cf)	Observed Volume (cf)	Calibrated Model Volume (cf)	Percent Change (%)
7/19/2008	0.11	516	465	498	107%
8/16/2008	0.16	816	1117	1038	93%
7/21/2008	0.60	3330	2533	2648	105%
7/27/2008	0.70	3903	4629	4632	100%
8/11/2008	1.11	6384	9714	8723	90%
7/23/2008	2.41	14274	21369	20058	94%
9/26/2008	2.45	14010	19036	17141	90%
9/6/2008	2.40	13746	14498	16713	115%

Pond Three Model Calibration Results

Date	Rainfall (in)	Pre-Calibrated (cf)	Observed Volume (cf)	Calibrated Model Volume (cf)	Percent Change (%)
7/19/2008	0.11	99	82	87	106%
7/21/2008	0.60	582	948	930	98%
7/27/2008	0.70	666	1112	1074	97%
7/23/2008	2.41	2286	3601	3645	101%
9/26/2008	2.45	2259	3875	3930	101%

ATTACHMENT 11

Monitoring Data Summary Tables

Appendix Table 11.1 Hydrologic and precipitation characteristics for discharge events for discharge into Pond One from Catch Basin 14

Start Date (mm/dd/yyyy)	Start Time (hh:mm)	End Date (mm/dd/yyyy)	End Time (hh:mm)	Duration (hours)	Precipitation Depth (inches)	Event Precipitation Intensity (in/h)	Total Event Volume (ft^3)	Peak Flow (ft^3/s)
6/29/2008	17:58	6/29/2008	17:58	0.083	0.16	0.19	30.01	0.100
7/1/2008	21:03	7/1/2008	21:28	0.420	0.33	0.26	42.69	0.140
7/3/2008	18:58	7/3/2008	19:18	0.330	0.29	0.12	0.01	<0.001
7/9/2008	23:13	7/10/2008	1:03	1.830	0.51	0.10	0.45	0.001
7/18/2008	20:58	7/18/2008	20:58	0.083	0.07	0.17	<0.01	<0.001
7/19/2008	20:13	7/19/2008	20:13	0.083	0.11	0.65	0.96	0.003
7/20/2008	6:43	7/20/2008	6:43	0.083	0.07	0.41	0.03	<0.001
7/21/2008	2:58	7/21/2008	2:58	0.083	0.32	0.03	6.18	0.021
7/21/2008	16:08	7/24/2008	21:08	5.000	0.60	0.65	132.90	0.151
7/27/2008	17:18	7/27/2008	18:53	1.583	0.70	0.28	65.71	0.207
8/3/2008	13:08	8/3/2008	14:58	1.830	0.37	0.19	36.90	0.104
8/6/2008	12:03	8/6/2008	14:43	2.670	0.47	0.04	6.17	0.014
8/8/2008	1:28	8/8/2008	2:03	0.583	0.07	0.03	1.44	0.002
8/8/2008	16:08	8/9/2008	11:13	19.083	0.22	0.04	613.76	0.106
8/10/2008	17:53	8/11/2008	1:18	7.420	0.20	0.01	117.65	0.094
8/11/2008	9:03	8/11/2008	9:13	0.170	0.03	0.06	0.41	0.001
8/11/2008	17:53	8/12/2008	8:53	15.000	1.11	0.04	125.97	0.104
8/15/2008	21:53	8/15/2008	23:18	1.420	0.19	0.28	0.60	0.001
8/16/2008	15:38	8/16/2008	16:13	0.580	0.16	0.24	3.78	0.005
8/19/2008	10:13	8/19/2008	10:13	0.083	0.04	0.09	<0.01	<0.001
9/6/2008	5:43	9/7/2008	2:53	21.170	2.74	0.16	50.08	0.110
9/9/2008	13:08	9/9/2008	13:08	0.083	0.42	0.13	41.80	0.139
9/26/2008	17:48	9/26/2008	19:48	2.000	2.45	0.04	12.84	0.119
9/27/2008	16:23	9/28/2008	22:28	30.083	1.24	0.04	35.90	<0.001

Appendix Table 11.2 Hydrologic and precipitation characteristics for discharge events for discharge into Pond One from Catch Basin 28

Start Date (mm/dd/yyyy)	Start Time (hh:mm)	End Date (mm/dd/yyyy)	End Time (hh:mm)	Duration (hours)	Precipitation Depth (inches)	Event Precipitation Intensity (in/h)	Total Event Volume (ft^3)	Peak Flow (ft^3/s)
6/27/2008	14:47	6/27/2008	14:47	0.08	0.12	0.05	<0.01	<0.001
6/29/2008	18:02	6/29/2008	18:47	0.75	0.16	0.19	0.71	0.002
7/1/2008	21:02	7/1/2008	21:37	0.58	0.33	0.26	40.12	0.092
7/3/2008	18:57	7/3/2008	20:02	1.08	0.29	0.12	50.50	0.139
7/4/2008	4:42	7/4/2008	9:47	5.08	0.19	0.04	1.27	0.001
7/9/2008	23:17	7/10/2008	1:42	2.42	0.51	0.10	93.40	0.115
7/19/2008	20:17	7/19/2008	20:22	0.08	0.11	0.65	2.08	0.007
7/20/2008	6:47	7/20/2008	6:52	0.08	0.07	0.41	1.82	0.006
7/20/2008	17:47	7/21/2008	3:07	9.33	0.32	0.03	3.86	0.008
7/21/2008	16:12	7/21/2008	16:52	0.67	0.60	0.65	194.50	0.227
7/23/2008	14:37	7/24/2008	21:17	30.67	2.41	0.07	421.61	0.285
7/27/2008	6:32	7/27/2008	19:07	12.58	0.80	0.28	189.78	0.407
8/3/2008	13:12	8/3/2008	15:02	1.83	0.37	0.19	69.93	0.188
8/6/2008	12:02	8/6/2008	15:02	3.00	0.47	0.04	71.59	0.182
8/8/2008	19:22	8/8/2008	21:12	1.83	0.22	0.04	4.95	0.003
8/10/2008	18:27	8/10/2008	20:57	2.50	0.20	0.06	4.77	0.006
8/11/2008	17:52	8/12/2008	9:12	15.33	1.11	0.06	114.62	0.110
8/15/2008	22:37	8/15/2008	23:37	1.00	0.19	0.04	1.97	0.002
8/16/2008	15:42	8/16/2008	16:22	0.67	0.16	0.28	9.08	0.011
9/6/2008	6:22	9/6/2008	7:17	0.92	0.34	0.09	8.33	0.015
9/6/2008	17:47	9/7/2008	4:02	10.25	2.40	0.20	553.49	0.194
9/9/2008	13:07	9/9/2008	15:37	2.50	0.42	0.16	115.32	0.284
9/26/2008	12:32	9/27/2008	2:12	13.67	2.45	0.13	157.60	0.149
9/27/2008	15:17	9/27/2008	17:47	2.50	1.24	0.04	63.48	0.202
9/28/2008	0:27	9/28/2008	1:12	0.75	0.03	0.03	0.21	<0.001
9/28/2008	17:37	9/28/2008	17:37	0.08	0.01	0.12	0.09	<0.001

Appendix Table 11.3 Hydrologic and precipitation characteristics for discharge events for discharge into Pond One from Catch Basin 40

Start Date (mm/dd/yyyy)	Start Time (hh:mm)	End Date (mm/dd/yyyy)	End Time (hh:mm)	Duration (hours)	Precipitation Depth (inches)	Event Precipitation Intensity (in/h)	Total Event Volume (ft^3)	Peak Flow (ft^3/s)
7/1/2008	21:27	7/1/2008	21:32	0.08	0.33	0.26	6.85	0.020
7/3/2008	19:02	7/3/2008	19:02	0.08	0.29	0.12	1.14	0.004
7/10/2008	0:37	7/10/2008	1:02	0.42	0.51	0.10	3.27	0.006
7/21/2008	16:12	7/21/2008	16:27	0.25	0.60	0.65	38.79	0.094
7/23/2008	17:12	7/24/2008	13:27	20.25	2.41	0.07	32.30	0.095
8/3/2008	13:12	8/3/2008	15:02	1.83	0.37	0.19	6.16	0.018
8/6/2008	13:12	8/6/2008	13:12	0.08	0.47	0.04	0.40	0.001
8/16/2008	15:42	8/16/2008	15:57	0.25	0.16	0.28	0.26	0.001
9/6/2008	6:17	9/6/2008	6:32	0.25	0.34	0.09	4.50	0.014
9/6/2008	17:57	9/6/2008	23:27	5.50	2.40	0.20	12.29	0.011
9/9/2008	13:07	9/9/2008	13:07	0.08	0.42	0.16	6.38	0.021
9/26/2008	18:42	9/26/2008	18:42	0.08	2.45	0.13	<0.01	0.001
9/27/2008	16:22	9/27/2008	16:22	0.08	1.24	0.04	0.91	0.003

Appendix Table 11.4 Hydrologic and precipitation characteristics for discharge events for discharge into Pond One from Double Catch Basin

Start Date	Start Time	End Date	End Time	Duration	Precipitation Depth	Event Precipitation Intensity	Total Event Volume	Peak Flow
(mm/dd/yyyy)	(hh:mm)	(mm/dd/yyyy)	(hh:mm)	(hours)	(inches)	(in/h)	(ft^3)	(ft^3/s)
6/27/2008	14:37	6/27/2008	17:22	2.75	0.12	0.50	599	0.384
6/29/2008	18:02	6/29/2008	19:07	1.08	0.16	1.17	549	0.509
7/1/2008	21:02	7/1/2008	22:02	1.00	0.33	2.91	1,266	0.841
7/3/2008	18:57	7/3/2008	20:32	1.58	0.29	2.65	1,823	0.715
7/4/2008	4:42	7/4/2008	10:17	5.58	0.19	0.68	1,640	0.361
7/9/2008	23:17	7/10/2008	2:07	2.83	0.51	2.79	3,437	0.752
7/18/2008	21:02	7/18/2008	21:17	0.25	0.07	2.67	291	0.520
7/19/2008	20:12	7/19/2008	20:32	0.33	0.11	3.23	464	0.585
7/20/2008	6:47	7/21/2008	3:37	20.83	0.07	0.41	3,739	0.568
7/21/2008	16:12	7/21/2008	17:27	1.25	0.6	4.03	2,192	1.204
7/22/2008	21:42	7/22/2008	22:22	0.67	0.07	1.45	423	0.283
7/23/2008	14:37	7/25/2008	0:32	9.92	2.41	4.74	20,468	1.094
7/27/2008	5:12	7/27/2008	7:22	2.17	0.1	1.39	1,309	0.328
7/27/2008	17:22	7/27/2008	20:17	2.92	0.7	3.34	4,249	2.265
7/31/2008	17:37	7/31/2008	17:47	0.17	0.06	1.90	141	0.280
8/2/2008	17:37	8/2/2008	18:57	1.33	0.08	1.41	818	0.251
8/3/2008	13:12	8/3/2008	15:32	2.33	0.37	1.23	1,251	0.777
8/6/2008	5:12	8/6/2008	16:12	11.00	0.47	0.77	3,687	0.961
8/8/2008	1:37	8/8/2008	2:32	0.92	0.07	1.41	564	0.259
8/8/2008	19:22	8/8/2008	22:02	2.67	0.22	2.09	2,435	0.413
8/10/2008	18:12	8/10/2008	21:32	3.33	0.2	0.89	1,294	0.409
8/11/2008	17:37	8/12/2008	11:07	17.50	1.11	1.22	9,313	0.732
8/15/2008	21:57	8/16/2008	0:12	2.25	0.19	1.84	1,807	0.324
8/16/2008	15:42	8/16/2008	16:52	1.17	0.16	2.17	1,104	0.503
8/19/2008	10:17	8/19/2008	10:37	0.33	0.04	1.20	173	0.252
9/6/2008	5:47	9/6/2008	8:27	2.67	0.34	1.79	2,083	0.447
9/6/2008	17:47	9/7/2008	6:37	12.83	2.4	2.35	13,106	1.134
9/9/2008	13:07	9/9/2008	16:52	3.75	0.42	1.36	2,221	1.353
9/14/2008	7:17	9/14/2008	12:47	5.50	0.15	0.71	1,703	0.194
9/21/2008	18:42	9/21/2008	21:57	3.25	0.09	0.37	530	0.264
9/26/2008	8:32	9/27/2008	4:57	20.42	2.45	2.03	18,059	1.173
9/27/2008	14:57	9/29/2008	12:37	45.67	1.24	1.42	28,285	0.944

Appendix Table 11.5 Hydrologic and precipitation characteristics for discharge events for discharge into Raingarden from Left Swale

Start Date (mm/dd/yyyy)	Start Time (hh:mm)	End Date (mm/dd/yyyy)	End Time (hh:mm)	Duration (hours)	Precipitation Depth (inches)	Event Precipitation Intensity (in/h)	Total Event Volume (ft^3)	Peak Flow (ft^3/s)
7/1/2008	21:29	7/1/2008	22:04	0.58	0.33	0.26	12.26	0.016
7/3/2008	19:14	7/3/2008	19:59	0.75	0.29	0.12	1.03	0.001
7/10/2008	0:49	7/10/2008	1:59	1.17	0.51	0.10	3.81	0.003
7/21/2008	16:14	7/21/2008	17:09	0.92	0.60	0.65	66.65	0.060
7/23/2008	17:09	7/24/2008	21:49	28.67	2.41	0.07	153.11	0.025
7/27/2008	17:29	7/27/2008	19:29	2.00	0.70	0.28	66.96	0.051
8/3/2008	14:59	8/3/2008	15:29	0.50	0.37	0.19	3.46	0.004
8/6/2008	13:14	8/6/2008	15:14	2.00	0.47	0.04	5.88	0.005
8/8/2008	19:59	8/8/2008	20:39	0.67	0.22	0.04	0.10	<0.001
8/11/2008	19:09	8/12/2008	9:44	14.58	1.11	0.06	67.05	0.022
8/16/2008	16:09	8/16/2008	16:29	0.33	0.16	0.28	0.73	0.001
9/6/2008	18:04	9/7/2008	4:04	10.00	2.40	0.20	288.23	0.068
9/9/2008	13:09	9/9/2008	14:14	1.08	0.42	0.16	10.03	0.007
9/26/2008	14:24	9/27/2008	0:29	10.08	2.45	0.13	275.08	0.065
9/27/2008	16:24	9/28/2008	12:54	20.50	1.24	0.04	49.98	0.019

Appendix Table 11.6 Hydrologic and precipitation characteristics for discharge events for discharge into Raingarden from Right Swale

Start Date	Start Time	End Date	End Time	Duration	Precipitation Depth	Event Precipitation Intensity	Total Event Volume	Peak Flow
(mm/dd/yyyy)	(hh:mm)	(mm/dd/yyyy)	(hh:mm)	(hours)	(inches)	(in/h)	(ft^3)	(ft^3/s)
7/1/2008	21:29	7/1/2008	22:19	0.83	0.33	0.65	14.52	0.011
7/3/2008	19:09	7/3/2008	20:39	1.50	0.29	0.28	6.23	0.007
7/4/2008	5:19	7/4/2008	5:39	0.33	0.19	0.28	0.20	0.000
7/10/2008	0:44	7/10/2008	2:14	1.50	0.51	0.26	18.37	0.010
7/21/2008	16:19	7/21/2008	17:29	1.17	0.60	0.20	141.19	0.090
7/23/2008	17:09	7/24/2008	22:04	28.92	2.41	0.19	315.51	0.052
7/27/2008	17:29	7/27/2008	19:54	2.42	0.70	0.16	136.65	0.073
8/3/2008	15:01	8/3/2008	15:51	0.83	0.37	0.13	6.43	0.003
8/6/2008	13:16	8/6/2008	15:36	2.33	0.47	0.12	12.07	0.011
8/8/2008	19:56	8/8/2008	21:31	1.58	0.22	0.10	1.72	0.001
8/11/2008	19:11	8/12/2008	10:11	15.00	1.11	0.07	138.32	0.048
8/16/2008	16:06	8/16/2008	16:46	0.67	0.16	0.06	3.42	0.003
9/6/2008	18:06	9/7/2008	4:11	10.08	2.40	0.04	373.66	0.076
9/9/2008	13:11	9/9/2008	14:16	1.08	0.42	0.04	11.44	0.007
9/26/2008	14:01	9/27/2008	0:16	10.25	2.45	0.13	305.64	0.061
9/27/2008	16:26	9/28/2008	2:11	9.75	1.24	0.04	47.83	0.016

Appendix Table 11.7 Hydrologic and precipitation characteristics for discharge events for discharge from Storm Water Collection Trench

Start Date (mm/dd/yyyy)	Start Time (hh:mm)	End Date (mm/dd/yyyy)	End Time (hh:mm)	Duration (hours)	Precipitation Depth (inches)	Event Precipitation Intensity (in/h)	Total Event Volume (ft^3)	Peak Flow (ft^3/s)
6/27/2008	14:43	6/27/2008	17:13	2.50	0.12	<0.01	1.18	0.002
6/29/2008	18:03	6/29/2008	18:58	0.92	0.16	0.02	7.06	0.020
7/1/2008	21:08	7/1/2008	21:48	0.67	0.33	0.17	49.43	0.093
7/3/2008	19:03	7/3/2008	20:13	1.17	0.29	0.07	34.60	0.058
7/4/2008	4:48	7/4/2008	10:03	5.25	0.19	0.00	6.86	0.004
7/9/2008	23:18	7/10/2008	2:23	3.08	0.51	0.20	268.16	0.133
7/19/2008	20:18	7/19/2008	20:23	0.08	0.11	0.30	10.85	0.030
7/20/2008	6:48	7/20/2008	7:03	0.25	0.07	0.09	9.31	0.018
7/21/2008	0:03	7/21/2008	3:38	3.58	0.32	0.05	82.44	0.064
7/21/2008	16:13	7/21/2008	17:58	1.75	0.60	0.45	343.53	0.224
7/23/2008	14:48	7/24/2008	23:18	32.50	2.41	0.13	1,832.32	0.225
7/27/2008	6:38	7/27/2008	7:13	0.58	0.10	0.02	5.67	0.004
7/27/2008	17:28	7/27/2008	20:18	2.83	0.70	0.33	406.43	0.245
8/3/2008	13:13	8/3/2008	15:38	2.42	0.37	0.16	165.29	0.155
8/6/2008	5:23	8/6/2008	16:03	10.67	0.47	0.04	195.09	0.002
8/8/2008	1:48	8/8/2008	2:33	0.75	0.07	0.02	5.18	0.149
8/8/2008	19:28	8/8/2008	22:03	2.58	0.22	0.11	121.54	0.033
8/10/2008	18:23	8/10/2008	21:33	3.17	0.20	0.04	57.67	0.037
8/11/2008	17:58	8/12/2008	11:23	17.42	1.11	0.09	712.94	0.152
8/15/2008	22:18	8/16/2008	0:13	1.92	0.19	0.07	55.61	0.015
8/16/2008	15:43	8/16/2008	16:53	1.17	0.16	0.17	86.68	0.055
9/6/2008	5:53	9/6/2008	7:38	1.75	0.34	0.10	73.29	0.052
9/6/2008	17:53	9/7/2008	5:53	12.00	2.40	0.42	2,214.39	0.338
9/9/2008	13:08	9/9/2008	14:33	1.42	0.42	0.28	172.33	0.229
9/14/2008	8:28	9/14/2008	9:18	0.83	0.15	0.01	4.38	0.003
9/26/2008	11:18	9/27/2008	3:08	15.83	2.45	0.23	1,584.66	0.243
9/27/2008	15:23	9/28/2008	18:33	27.17	1.24	0.04	440.49	1.468

Appendix Table 11.8 Hydrologic and precipitation characteristics for discharge events for discharge into Pond One from Raingarden Overflow Weir

Start Date	Start Time	End Date	End Time	Duration	Precipitation Depth	Event Precipitation Intensity	Total Event Volume	Peak Flow
(mm/dd/yyyy)	(hh:mm)	(mm/dd/yyyy)	(hh:mm)	(hours)	(inches)	(in/h)	(ft^3)	(ft^3/s)
7/21/2008	16:37	7/21/2008	17:27	0.83	0.60	0.65	18.22	0.014
7/24/2008	5:27	7/24/2008	22:47	17.33	2.41	0.07	403.07	0.065
7/27/2008	17:47	7/27/2008	19:52	2.08	0.70	0.28	40.37	0.018
8/12/2008	8:27	8/12/2008	10:37	2.17	1.11	0.06	161.34	0.066
9/6/2008	22:42	9/7/2008	4:47	6.08	2.40	0.20	776.73	0.170
9/26/2008	15:47	9/26/2008	21:17	5.50	2.45	0.13	806.42	0.002
9/27/2008	17:47	9/28/2008	2:27	8.67	1.24	0.04	6.15	0.151

Appendix Table 11.9 Hydrologic and precipitation characteristics for discharge events for discharge into Pond Two from Pond One Outflow

Start Date	**Start Time**	**End Date**	**End Time**	**Duration**	**Precipitation Depth**	**Event Precipitation Intensity**	**Total Event Volume**	**Peak Flow**
(mm/dd/yyyy)	**(hh:mm)**	**(mm/dd/yyyy)**	**(hh:mm)**	**(hours)**	**(inches)**	**(in/h)**	**(ft^3)**	**(ft^3/s)**
7/24/2008	7:01	7/25/2008	0:26	17.42	2.41	0.07	1,246	0.258
9/6/2008	23:01	9/7/2008	6:11	7.17	2.40	0.20	2,118	0.330
9/26/2008	17:51	9/27/2008	0:36	6.75	2.45	0.13	1,756	0.277
9/28/2008	0:21	9/28/2008	3:06	2.75	1.24	0.04	5	0.002

Appendix Table 11.10 Hydrologic and precipitation characteristics for discharge events for discharge into Pond Three

Start Date	Start Time	End Date	End Time	Duration	Precipitation Depth	Event Precipitation Intensity	Total Event Volume	Peak Flow
(mm/dd/yyyy)	(hh:mm)	(mm/dd/yyyy)	(hh:mm)	(hours)	(inches)	(in/h)	(ft^3)	(ft^3/s)
6/27/2008	14:32	6/27/2008	18:57	4.42	0.12	0.05	578	1.50
6/29/2008	17:57	6/29/2008	18:47	0.83	0.16	0.19	634	2.20
7/1/2008	20:52	7/1/2008	23:57	3.08	0.33	0.26	886	2.59
7/3/2008	18:57	7/3/2008	22:47	3.83	0.29	0.12	758	2.06
7/4/2008	4:37	7/4/2008	9:57	5.33	0.19	0.04	361	1.53
7/9/2008	23:12	7/10/2008	5:57	6.75	0.51	0.10	993	1.89
7/18/2008	20:57	7/18/2008	21:12	0.25	0.07	0.17	471	1.59
7/19/2008	20:12	7/19/2008	20:22	0.17	0.11	0.65	526	1.87
7/20/2008	6:42	7/20/2008	6:57	0.25	0.07	0.41	400	1.51
7/20/2008	16:07	7/21/2008	3:17	11.17	0.32	0.03	1005	2.06
7/21/2008	16:07	7/21/2008	17:07	1.00	0.60	0.65	823	2.88
7/22/2008	20:52	7/23/2008	6:02	9.17	0.07	0.01	260	0.77
7/23/2008	14:32	7/24/2008	22:42	32.17	2.41	0.07	3972	2.52
9/6/2008	3:30	9/6/2008	7:30	4.00	0.34	0.09	745	2.61
9/6/2008	17:35	9/7/2008	5:45	12.16	2.40	0.20	3166	3.29
9/9/2008	12:50	9/9/2008	15:30	2.67	0.42	0.16	839	2.24
9/14/2008	5:55	9/14/2008	15:55	10.00	0.15	0.02	522	1.58
9/21/2008	18:37	9/21/2008	22:57	4.33	0.09	0.02	210	0.51
9/26/2008	7:37	9/27/2008	2:47	19.17	2.45	0.13	2414	2.72
9/27/2008	13:32	9/28/2008	22:52	33.33	1.24	0.04	1855	2.12

Table 11.11 - Pre-development Watershed Monitoring Summary

Start Date (mm/dd/yyyy)	Start Time (hh:mm)	End Date (mm/dd/yyyy)	End Time (hh:mm)	Duration (hours)	Precipitation Depth (inches)	Event Precipitation Intensity (in/h)	Event Volume Bucket (ft^3)	Event Volume Weir (ft^3)	Total Event Volume (ft^3)
8/3/2008	13:05	8/3/2008	16:02	2.95	0.37	0.19	0.144	0.076	0.220
8/6/2008	4:45	8/6/2008	15:43	10.96	0.47	0.04	0.051	0.104	0.155
8/8/2008	15:25	8/9/2008	23:19	7.90	0.22	0.04	0.000	0.164	0.164
9/6/2008	17:35	9/7/2008	4:20	10.75	2.40	0.20	0.477	0.942	1.419
9/26/2008	7:35	9/26/2008	20:07	12.53	2.45	0.13	0.051	0.602	0.653
9/27/2008	13:10	9/28/2008	1:51	12.68	1.24	0.04	0.000	0.408	0.408
9/14/2008	5:55	9/14/2008	6:38	0.72	0.15	0.02	0.003	0.000	0.003
9/12/2008	18:50	9/12/2008	19:05	0.25	0.04	0.02	0.004	0.000	0.004
9/6/2008	3:30	9/6/2008	12:00	8.50	0.34	0.09	0.038	0.000	0.038

ATTACHMENT 12

SWMM LID Subdivision Model Results

LID Subdivision

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.009)
--------------------------------------------------------------

LID Subdivision
2-year, 24-hour design storm

****************
Analysis Options
****************
Flow Units ............... CFS
Infiltration Method ...... GREEN_AMPT
Flow Routing Method ...... DYNWAVE
Starting Date ............ JAN-01-2008 00:00:00
Ending Date .............. JAN-02-2008 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:05:00
Wet Time Step ............ 00:15:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 30.00 sec


*********************
Rainfall File Summary
*********************
Station    First        Last         Recording   Periods    Periods    Periods
ID         Date         Date         Frequency    w/Rain    Missing    Malfunc.
-------------------------------------------------------------------------------
STA100     JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA10      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA25      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA02      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA50      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA01      JUN-27-2008  SEP-29-2008      5 min       802          0          0


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         0.816         3.000
Evaporation Loss .........         0.008         0.031
Infiltration Loss ........         0.183         0.674
Surface Runoff ...........         0.610         2.243
Final Surface Storage ....         0.015         0.055
Continuity Error (%) .....        -0.090


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      Mgallons
**************************     ---------     ---------
```

```
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.594         0.194
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.042         0.014
Surface Flooding .........         0.000         0.000
Evaporation Loss .........         0.001         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.537         0.175
Continuity Error (%) .....         2.247
```

****
Subcatchment Runoff Summary
****

Subcatchment	Total Precip in	Total Runon in	Total Evap in	Total Infil in	Total Runoff in	Peak Runoff CFS	Runoff Coeff
Drive1	3.000	0.000	0.031	0.000	2.956	0.01	0.985
Drive13	3.000	0.000	0.031	0.000	2.956	0.01	0.985
Drive14	3.000	0.000	0.031	0.000	2.956	0.01	0.985
Drive15	3.000	0.000	0.031	0.000	2.956	0.01	0.985
Drive16	3.000	0.000	0.031	0.000	2.956	0.01	0.985
Drive17	3.000	0.000	0.031	0.000	2.956	0.01	0.985
Drive18	3.000	0.000	0.031	0.000	2.956	0.01	0.985
Drive19	3.000	0.000	0.031	0.000	2.956	0.01	0.985
Drive2	3.000	0.000	0.031	0.000	2.956	0.01	0.985
Drive20	3.000	0.000	0.031	0.000	2.956	0.01	0.985
Drive3	3.000	0.000	0.031	0.000	2.956	0.01	0.985
Drive7	3.000	0.000	0.031	0.000	2.956	0.01	0.985
Drive8	3.000	0.000	0.031	0.000	2.956	0.01	0.985
LeftWeirVeg	3.000	0.000	0.031	2.565	0.415	0.10	0.138
Lot10On	3.000	0.000	0.031	0.775	2.027	0.03	0.676
Lot11On	3.000	0.000	0.031	0.775	2.051	0.04	0.684
Lot12On	3.000	0.000	0.031	0.775	2.040	0.04	0.680
Lot13On	3.000	0.000	0.031	0.775	2.051	0.04	0.684
Lot14On	3.000	0.000	0.031	0.775	2.051	0.05	0.684
Lot15On	3.000	0.000	0.031	0.775	2.051	0.05	0.684
Lot16On	3.000	0.000	0.031	0.775	2.019	0.02	0.673
Lot17On	3.000	0.000	0.031	0.775	2.051	0.04	0.684
Lot18On	3.000	0.000	0.031	0.775	2.051	0.04	0.684
Lot19On	3.000	0.000	0.031	0.775	2.040	0.04	0.680
Lot1On	3.000	0.000	0.031	0.775	2.051	0.04	0.684
Lot20On	3.000	0.000	0.031	0.775	2.052	0.04	0.684
Lot2On	3.000	0.000	0.031	0.775	2.028	0.02	0.676
Lot3On	3.000	0.000	0.031	0.775	2.028	0.02	0.676

Lot7On	3.000	0.000	0.031	0.775	2.051	0.04	0.684
Lot8On	3.000	0.000	0.031	0.775	2.039	0.03	0.680
Lot9On	3.000	0.000	0.031	0.775	2.027	0.02	0.676
LWPave	3.000	0.000	0.031	0.000	2.955	0.06	0.985
R1	3.000	0.000	0.031	0.000	2.955	0.14	0.985
R2	3.000	0.000	0.031	0.000	2.956	0.05	0.985
R3	3.000	0.000	0.031	0.000	2.955	0.07	0.985
RightWeirVeg	3.000	0.000	0.031	2.565	0.415	0.10	0.138
RWPave	3.000	0.000	0.031	0.000	2.955	0.07	0.985
TrenchPave	3.000	0.000	0.031	0.000	2.955	0.08	0.985
R4	3.000	0.000	0.031	0.000	2.955	0.06	0.985
R5	3.000	0.000	0.031	0.000	2.927	0.75	0.976
System	3.000	0.000	0.031	0.674	2.243	2.17	0.748

****
Node Depth Summary
****

Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum HGL Feet	Time of Max Occurrence days	Time of Max Occurrence hr:min	Total Flooding acre-in	Total Minutes Flooded
CB#69	JUNCTION	5.22	6.06	91.06	0	12:25	0	0
CB#70	JUNCTION	1.05	1.27	89.27	0	14:11	0	0
CB#68	JUNCTION	3.40	3.97	93.97	0	11:22	0	0
CB#40	JUNCTION	0.04	0.08	98.08	0	12:59	0	0
23	JUNCTION	0.13	0.34	104.34	0	12:59	0	0
24	JUNCTION	0.15	0.43	95.43	0	13:00	0	0
33	JUNCTION	0.04	0.08	90.08	0	12:02	0	0
36	OUTFALL	0.00	0.00	0.00	0	00:00	0	0
37	OUTFALL	0.00	0.00	0.00	0	00:00	0	0
PondOne	STORAGE	2.22	3.52	82.32	1	00:00	0	0
Raingarden	STORAGE	0.82	1.50	88.00	0	13:03	0	0
Pond_3	STORAGE	0.65	1.09	71.09	1	00:00	0	0

****
Node Flow Summary
****

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days	Time of Max Occurrence hr:min	Maximum Flooding Overflow CFS	Time of Max Occurrence days hr:min
CB#69	JUNCTION	0.07	0.07	0	12:29	0.00	

```
CB#70                JUNCTION      1.02     1.02     0  12:59     0.00
CB#68                JUNCTION      0.18     0.18     0  12:59     0.00
CB#40                JUNCTION      0.12     0.12     0  12:59     0.00
23                   JUNCTION      0.17     0.17     0  12:59     0.00
24                   JUNCTION      0.16     0.16     0  12:59     0.00
33                   JUNCTION      0.08     0.08     0  11:45     0.00
36                   OUTFALL       0.00     0.00     0  00:00     0.00
37                   OUTFALL       0.00     0.03     0  11:16     0.00
PondOne              STORAGE       0.00     1.64     0  12:59     0.00
Raingarden           STORAGE       0.00     0.40     0  13:00     0.08      0  13:03
Pond_3               STORAGE       0.38     0.38     0  12:59     0.00


**********************
Storage Volume Summary
**********************

--------------------------------------------------------------------------------------
                       Average     Avg       Maximum     Max    Time of Max    Maximum
                        Volume    Pcnt        Volume    Pcnt     Occurrence    Outflow
Storage Unit          1000 ft3    Full      1000 ft3    Full    days hr:min        CFS
--------------------------------------------------------------------------------------
PondOne                  8.324       2        18.251       5       1  00:00       0.00
Raingarden               0.350      35         1.009     100       0  13:03       0.29
Pond_3                   2.092       3         4.343       5       1  00:00       0.00


***********************
Outfall Loading Summary
***********************

-----------------------------------------------
                      Flow       Avg.      Max.
                      Freq.      Flow      Flow
Outfall Node          Pcnt.      CFS       CFS
-----------------------------------------------
36                     0.00      0.00      0.00
37                    96.67      0.02      0.03
-----------------------------------------------
System                48.33      0.02      0.03


********************
Link Flow Summary
********************

-----------------------------------------------------------------------------------------
                                Maximum  Time of Max   Maximum    Max/     Max/       Total
                                   Flow   Occurrence  Velocity    Full     Full     Minutes
Link                 Type           CFS  days hr:min    ft/sec    Flow    Depth  Surcharged
```

```
------------------------------------------------------------------------------------------
3                    CONDUIT      1.26      0  14:11       3.17     0.08     0.63          0
10                   CONDUIT      0.07      0  11:33       3.29     0.01     0.53          0
11                   CONDUIT      0.19      0  11:20       0.46     0.01     0.54          0
RightSwale           CONDUIT      0.17      0  13:00       1.48     0.50     0.84          0
LeftSwale            CONDUIT      0.16      0  13:00       0.17     0.35     0.79          0
TrenchPipe           CONDUIT      0.08      0  11:45       0.31     0.01     0.54          0
18                   CONDUIT      0.12      0  12:47       0.93     0.01     0.54          0
9                    WEIR         0.26      0  13:03                         0.75          0
15                   DUMMY        0.03      0  11:16


***************************
Flow Classification Summary
***************************

-----------------------------------------------------------------------------------------
                    Adjusted    --- Fraction of Time in Flow Class ----   Avg.     Avg.
                    /Actual         Up    Down  Sub   Sup   Up    Down    Froude   Flow
Conduit              Length    Dry  Dry   Dry   Crit  Crit  Crit  Crit    Number   Change
-----------------------------------------------------------------------------------------
3                      1.00   0.03  0.01  0.00  0.95  0.01  0.00  0.00      0.23   0.0005
10                     1.00   0.22  0.00  0.00  0.71  0.00  0.00  0.07      0.13   0.0000
11                     1.00   0.03  0.19  0.00  0.78  0.00  0.00  0.00      0.04   0.0001
RightSwale             1.00   0.03  0.00  0.00  0.83  0.00  0.00  0.14      0.06   0.0053
LeftSwale              1.00   0.02  0.01  0.00  0.98  0.00  0.00  0.00      0.02   0.0002
TrenchPipe             1.00   0.02  0.00  0.00  0.98  0.00  0.00  0.00      0.03   0.0000
18                     1.00   0.02  0.00  0.00  0.98  0.00  0.00  0.00      0.04   0.0000


*************************
Highest Continuity Errors
*************************
Node Raingarden (9.98%)


***************************
Time-Step Critical Elements
***************************
Link 3 (30.88%)
Node CB#70 (0.03%)


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     0.53 sec
Average Time Step           :    22.31 sec
Maximum Time Step           :    30.00 sec
Percent in Steady State     :     0.00
```

LID Subdivision

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.009)
--------------------------------------------------------------

LID Subdivision
10-year, 24-hour design storm

****************
Analysis Options
****************
Flow Units ............... CFS
Infiltration Method ...... GREEN_AMPT
Flow Routing Method ...... DYNWAVE
Starting Date ............ JAN-01-2008 00:00:00
Ending Date .............. JAN-02-2008 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:05:00
Wet Time Step ............ 00:15:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 30.00 sec


*********************
Rainfall File Summary
*********************
Station    First        Last          Recording   Periods    Periods    Periods
ID         Date         Date          Frequency    w/Rain    Missing    Malfunc.
-------------------------------------------------------------------------------
STA100     JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA10      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA25      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA02      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA50      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA01      JUN-27-2008  SEP-29-2008      5 min       802          0          0


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         1.223         4.500
Evaporation Loss .........         0.008         0.031
Infiltration Loss ........         0.224         0.825
Surface Runoff ...........         0.977         3.592
Final Surface Storage ....         0.016         0.060
Continuity Error (%) .....        -0.190


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      Mgallons
**************************     ---------     ---------
```

Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	0.961	0.313
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.000	0.000
External Outflow	0.046	0.015
Surface Flooding	0.041	0.013
Evaporation Loss	0.001	0.000
Initial Stored Volume	0.000	0.000
Final Stored Volume	0.858	0.280
Continuity Error (%)	1.537	

****
Subcatchment Runoff Summary
****

Subcatchment	Total Precip in	Total Runon in	Total Evap in	Total Infil in	Total Runoff in	Peak Runoff CFS	Runoff Coeff
Drive1	4.500	0.000	0.031	0.000	4.456	0.01	0.990
Drive13	4.500	0.000	0.031	0.000	4.456	0.01	0.990
Drive14	4.500	0.000	0.031	0.000	4.456	0.01	0.990
Drive15	4.500	0.000	0.031	0.000	4.456	0.01	0.990
Drive16	4.500	0.000	0.031	0.000	4.456	0.01	0.990
Drive17	4.500	0.000	0.031	0.000	4.456	0.01	0.990
Drive18	4.500	0.000	0.031	0.000	4.456	0.01	0.990
Drive19	4.500	0.000	0.031	0.000	4.456	0.01	0.990
Drive2	4.500	0.000	0.031	0.000	4.456	0.01	0.990
Drive20	4.500	0.000	0.031	0.000	4.456	0.01	0.990
Drive3	4.500	0.000	0.031	0.000	4.456	0.01	0.990
Drive7	4.500	0.000	0.031	0.000	4.456	0.01	0.990
Drive8	4.500	0.000	0.031	0.000	4.456	0.01	0.990
LeftWeirVeg	4.500	0.000	0.031	3.331	1.157	0.21	0.257
Lot10On	4.500	0.000	0.031	0.817	3.496	0.04	0.777
Lot11On	4.500	0.000	0.031	0.817	3.514	0.07	0.781
Lot12On	4.500	0.000	0.031	0.817	3.508	0.05	0.780
Lot13On	4.500	0.000	0.031	0.817	3.514	0.07	0.781
Lot14On	4.500	0.000	0.031	0.817	3.512	0.07	0.780
Lot15On	4.500	0.000	0.031	0.817	3.513	0.07	0.781
Lot16On	4.500	0.000	0.031	0.817	3.476	0.03	0.772
Lot17On	4.500	0.000	0.031	0.817	3.514	0.07	0.781
Lot18On	4.500	0.000	0.031	0.817	3.514	0.07	0.781
Lot19On	4.500	0.000	0.031	0.817	3.508	0.05	0.780
Lot1On	4.500	0.000	0.031	0.817	3.514	0.07	0.781
Lot20On	4.500	0.000	0.031	0.817	3.515	0.06	0.781
Lot2On	4.500	0.000	0.031	0.817	3.497	0.04	0.777
Lot3On	4.500	0.000	0.031	0.817	3.486	0.03	0.775

Lot7On	4.500	0.000	0.031	0.817	3.514	0.07	0.781
Lot8On	4.500	0.000	0.031	0.817	3.508	0.04	0.780
Lot9On	4.500	0.000	0.031	0.817	3.497	0.03	0.777
LWPave	4.500	0.000	0.031	0.000	4.455	0.09	0.990
R1	4.500	0.000	0.031	0.000	4.455	0.20	0.990
R2	4.500	0.000	0.031	0.000	4.455	0.07	0.990
R3	4.500	0.000	0.031	0.000	4.455	0.10	0.990
RightWeirVeg	4.500	0.000	0.031	3.331	1.157	0.21	0.257
RWPave	4.500	0.000	0.031	0.000	4.455	0.10	0.990
TrenchPave	4.500	0.000	0.031	0.000	4.455	0.11	0.990
R4	4.500	0.000	0.031	0.000	4.455	0.09	0.990
R5	4.500	0.000	0.031	0.000	4.424	1.13	0.983
System	4.500	0.000	0.031	0.825	3.592	3.39	0.798

****
Node Depth Summary
****

Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum HGL Feet	Time of Max Occurrence days hr:min	Total Flooding acre-in	Total Minutes Flooded
CB#69	JUNCTION	5.52	6.07	91.07	0 11:30	0	0
CB#70	JUNCTION	1.09	1.29	89.29	0 09:50	0	0
CB#68	JUNCTION	3.62	3.98	93.98	0 12:59	0	0
CB#40	JUNCTION	0.05	0.09	98.09	0 12:59	0	0
23	JUNCTION	0.20	0.48	104.48	0 12:59	0	0
24	JUNCTION	0.25	0.61	95.61	0 12:59	0	0
33	JUNCTION	0.06	0.10	90.10	0 12:13	0	0
36	OUTFALL	0.00	0.00	0.00	0 00:00	0	0
37	OUTFALL	0.00	0.00	0.00	0 00:00	0	0
PondOne	STORAGE	2.66	4.02	82.82	1 00:00	0	0
Raingarden	STORAGE	0.97	1.50	88.00	0 12:01	0	0
Pond_3	STORAGE	0.84	1.39	71.39	1 00:00	0	0

****
Node Flow Summary
****

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days hr:min	Maximum Flooding Overflow CFS	Time of Max Occurrence days hr:min
CB#69	JUNCTION	0.10	0.10	0 12:30	0.00	

```
CB#70                JUNCTION      1.54     1.54     0  12:59     0.00
CB#68                JUNCTION      0.28     0.28     0  12:59     0.00
CB#40                JUNCTION      0.18     0.18     0  12:59     0.00
23                   JUNCTION      0.31     0.31     0  12:59     0.00
24                   JUNCTION      0.30     0.30     0  12:59     0.00
33                   JUNCTION      0.11     0.11     0  12:15     0.00
36                   OUTFALL       0.00     0.00     0  00:00     0.00
37                   OUTFALL       0.00     0.03     0  10:12     0.00
PondOne              STORAGE       0.00     2.35     0  12:59     0.00
Raingarden           STORAGE       0.00     0.72     0  12:59     0.44     0  12:59
Pond_3               STORAGE       0.57     0.57     0  12:59     0.00


**********************
Storage Volume Summary
**********************

--------------------------------------------------------------------------------------
                       Average     Avg       Maximum     Max    Time of Max    Maximum
                        Volume    Pcnt        Volume    Pcnt     Occurrence    Outflow
Storage Unit          1000 ft3    Full      1000 ft3    Full    days hr:min        CFS
--------------------------------------------------------------------------------------
PondOne                 13.428       3        29.370       7       1  00:00       0.00
Raingarden               0.486      48         1.009     100       0  12:01       0.29
Pond_3                   3.386       4         7.109       8       1  00:00       0.00


***********************
Outfall Loading Summary
***********************

-----------------------------------------------
                      Flow       Avg.      Max.
                      Freq.      Flow      Flow
Outfall Node          Pcnt.      CFS       CFS
-----------------------------------------------
36                     0.00      0.00      0.00
37                    98.60      0.03      0.03
-----------------------------------------------
System                49.30      0.03      0.03


********************
Link Flow Summary
********************

-----------------------------------------------------------------------------------------
                                Maximum  Time of Max   Maximum    Max/     Max/       Total
                                   Flow   Occurrence  Velocity    Full     Full     Minutes
Link                 Type           CFS  days hr:min    ft/sec    Flow    Depth  Surcharged
```

```
-----------------------------------------------------------------------------------------
3                    CONDUIT      1.77      0  10:09       4.52     0.11     0.66           0
10                   CONDUIT      0.10      0  11:30       3.48     0.01     0.54           0
11                   CONDUIT      0.28      0  12:51       0.65     0.01     0.54           0
RightSwale           CONDUIT      0.31      0  12:59       1.50     0.94     0.98           0
LeftSwale            CONDUIT      0.30      0  12:59       0.26     0.68     0.91           0
TrenchPipe           CONDUIT      0.11      0  12:09       0.32     0.02     0.55           0
18                   CONDUIT      0.18      0  12:58       1.30     0.02     0.55           0
9                    WEIR         0.26      0  12:01                         0.75           0
15                   DUMMY        0.03      0  10:12


***************************
Flow Classification Summary
***************************

-----------------------------------------------------------------------------------------
                      Adjusted    --- Fraction of Time in Flow Class ----   Avg.     Avg.
                      /Actual          Up    Down  Sub   Sup   Up    Down   Froude   Flow
Conduit                Length    Dry   Dry   Dry   Crit  Crit  Crit  Crit   Number   Change
-----------------------------------------------------------------------------------------
3                        1.00   0.00  0.02  0.00  0.97  0.01  0.00  0.00     0.34   0.0014
10                       1.00   0.15  0.00  0.00  0.79  0.00  0.00  0.06     0.14   0.0000
11                       1.00   0.00  0.14  0.00  0.86  0.00  0.00  0.00     0.07   0.0002
RightSwale               1.00   0.01  0.00  0.00  0.92  0.00  0.00  0.07     0.08   0.0047
LeftSwale                1.00   0.00  0.00  0.00  1.00  0.00  0.00  0.00     0.03   0.0003
TrenchPipe               1.00   0.00  0.00  0.00  1.00  0.00  0.00  0.00     0.04   0.0000
18                       1.00   0.00  0.00  0.00  1.00  0.00  0.00  0.00     0.06   0.0000


*************************
Highest Continuity Errors
*************************
Node Raingarden (6.59%)


***************************
Time-Step Critical Elements
***************************
Link 3 (38.71%)
Node CB#70 (0.16%)


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     0.50 sec
Average Time Step           :    20.11 sec
Maximum Time Step           :    30.00 sec
Percent in Steady State     :     0.00
```

LID Subdivision

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.009)
--------------------------------------------------------------

LID Subdivision
25-year, 24-hour design storm

****************
Analysis Options
****************
Flow Units ............... CFS
Infiltration Method ...... GREEN_AMPT
Flow Routing Method ...... DYNWAVE
Starting Date ............ JAN-01-2008 00:00:00
Ending Date .............. JAN-02-2008 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:05:00
Wet Time Step ............ 00:15:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 30.00 sec


*********************
Rainfall File Summary
*********************
Station    First        Last         Recording   Periods    Periods    Periods
ID         Date         Date         Frequency    w/Rain    Missing    Malfunc.
-------------------------------------------------------------------------------
STA100     JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA10      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA25      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA02      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA50      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA01      JUN-27-2008  SEP-29-2008      5 min       802          0          0


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         1.495         5.500
Evaporation Loss .........         0.008         0.031
Infiltration Loss ........         0.249         0.917
Surface Runoff ...........         1.223         4.501
Final Surface Storage ....         0.017         0.062
Continuity Error (%) .....        -0.208


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      Mgallons
**************************     ---------     ---------
```

```
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         1.209         0.394
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.048         0.016
Surface Flooding .........         0.077         0.025
Evaporation Loss .........         0.001         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         1.066         0.347
Continuity Error (%) .....         1.400


***************************
Subcatchment Runoff Summary
***************************
```

Subcatchment	Total Precip in	Total Runon in	Total Evap in	Total Infil in	Total Runoff in	Peak Runoff CFS	Runoff Coeff
Drive1	5.500	0.000	0.031	0.000	5.457	0.01	0.992
Drive13	5.500	0.000	0.031	0.000	5.457	0.01	0.992
Drive14	5.500	0.000	0.031	0.000	5.457	0.01	0.992
Drive15	5.500	0.000	0.031	0.000	5.457	0.01	0.992
Drive16	5.500	0.000	0.031	0.000	5.457	0.01	0.992
Drive17	5.500	0.000	0.031	0.000	5.457	0.01	0.992
Drive18	5.500	0.000	0.031	0.000	5.457	0.01	0.992
Drive19	5.500	0.000	0.031	0.000	5.457	0.01	0.992
Drive2	5.500	0.000	0.031	0.000	5.457	0.01	0.992
Drive20	5.500	0.000	0.031	0.000	5.457	0.01	0.992
Drive3	5.500	0.000	0.031	0.000	5.457	0.01	0.992
Drive7	5.500	0.000	0.031	0.000	5.457	0.01	0.992
Drive8	5.500	0.000	0.031	0.000	5.457	0.01	0.992
LeftWeirVeg	5.500	0.000	0.031	3.808	1.681	0.29	0.306
Lot10On	5.500	0.000	0.031	0.833	4.494	0.05	0.817
Lot11On	5.500	0.000	0.031	0.833	4.496	0.08	0.817
Lot12On	5.500	0.000	0.031	0.833	4.498	0.07	0.818
Lot13On	5.500	0.000	0.031	0.833	4.496	0.08	0.817
Lot14On	5.500	0.000	0.031	0.833	4.494	0.09	0.817
Lot15On	5.500	0.000	0.031	0.833	4.495	0.09	0.817
Lot16On	5.500	0.000	0.031	0.833	4.461	0.04	0.811
Lot17On	5.500	0.000	0.031	0.833	4.496	0.08	0.817
Lot18On	5.500	0.000	0.031	0.833	4.496	0.08	0.817
Lot19On	5.500	0.000	0.031	0.833	4.498	0.07	0.818
Lot1On	5.500	0.000	0.031	0.833	4.496	0.08	0.817
Lot20On	5.500	0.000	0.031	0.833	4.497	0.07	0.818
Lot2On	5.500	0.000	0.031	0.833	4.495	0.05	0.817
Lot3On	5.500	0.000	0.031	0.833	4.480	0.04	0.814

Lot7On	5.500	0.000	0.031	0.833	4.496	0.08	0.817
Lot8On	5.500	0.000	0.031	0.833	4.498	0.05	0.818
Lot9On	5.500	0.000	0.031	0.833	4.494	0.04	0.817
LWPave	5.500	0.000	0.031	0.000	5.456	0.11	0.992
R1	5.500	0.000	0.031	0.000	5.455	0.25	0.992
R2	5.500	0.000	0.031	0.000	5.455	0.08	0.992
R3	5.500	0.000	0.031	0.000	5.455	0.13	0.992
RightWeirVeg	5.500	0.000	0.031	3.808	1.681	0.29	0.306
RWPave	5.500	0.000	0.031	0.000	5.455	0.13	0.992
TrenchPave	5.500	0.000	0.031	0.000	5.456	0.14	0.992
R4	5.500	0.000	0.031	0.000	5.456	0.11	0.992
R5	5.500	0.000	0.031	0.000	5.421	1.38	0.986
System	5.500	0.000	0.031	0.917	4.501	4.24	0.818

****
Node Depth Summary
****

Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum HGL Feet	Time of Max Occurrence days	Time of Max Occurrence hr:min	Total Flooding acre-in	Total Minutes Flooded
CB#69	JUNCTION	5.64	6.08	91.08	0	11:30	0	0
CB#70	JUNCTION	1.11	1.29	89.29	0	15:24	0	0
CB#68	JUNCTION	3.70	4.01	94.01	0	11:05	0	0
CB#40	JUNCTION	0.06	0.10	98.10	0	11:59	0	0
23	JUNCTION	0.38	1.00	105.00	0	11:34	0.11	89
24	JUNCTION	0.31	0.71	95.71	0	12:13	0	0
33	JUNCTION	0.06	0.11	90.11	0	12:00	0	0
36	OUTFALL	0.00	0.00	0.00	0	00:00	0	0
37	OUTFALL	0.00	0.00	0.00	0	00:00	0	0
PondOne	STORAGE	2.90	4.29	83.09	1	00:00	0	0
Raingarden	STORAGE	1.03	1.50	88.00	0	11:46	0	0
Pond_3	STORAGE	0.96	1.57	71.57	1	00:00	0	0

****
Node Flow Summary
****

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days	Time of Max Occurrence hr:min	Maximum Flooding Overflow CFS	Time of Max Occurrence days hr:min
CB#69	JUNCTION	0.13	0.13	0	11:59	0.00	

CB#70	JUNCTION	1.89	1.89	0	12:00	0.00		
CB#68	JUNCTION	0.34	0.34	0	11:59	0.00		
CB#40	JUNCTION	0.23	0.23	0	11:59	0.00		
23	JUNCTION	0.41	0.41	0	12:00	0.08	0	12:00
24	JUNCTION	0.40	0.40	0	12:00	0.00		
33	JUNCTION	0.14	0.14	0	11:59	0.00		
36	OUTFALL	0.00	0.00	0	00:00	0.00		
37	OUTFALL	0.00	0.03	0	09:27	0.00		
PondOne	STORAGE	0.00	2.84	0	12:00	0.00		
Raingarden	STORAGE	0.00	0.86	0	12:11	0.58	0	12:10
Pond_3	STORAGE	0.71	0.71	0	11:59	0.00		

****
Storage Volume Summary
****

Storage Unit	Average Volume 1000 ft3	Avg Pcnt Full	Maximum Volume 1000 ft3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CFS
PondOne	16.824	4	36.515	9	1 00:00	0.00
Raingarden	0.542	54	1.009	100	0 11:46	0.29
Pond_3	4.285	5	8.965	11	1 00:00	0.00

****
Outfall Loading Summary
****

Outfall Node	Flow Freq. Pcnt.	Avg. Flow CFS	Max. Flow CFS
36	0.00	0.00	0.00
37	98.96	0.03	0.03
System	49.48	0.03	0.03

****
Link Flow Summary
****

Link	Type	Maximum Flow CFS	Time of Max Occurrence days hr:min	Maximum Velocity ft/sec	Max/ Full Flow	Max/ Full Depth	Total Minutes Surcharged

```
-----------------------------------------------------------------------------------------
3                    CONDUIT      2.59      0  10:29       4.45     0.16     0.69          0
10                   CONDUIT      0.13      0  11:30       1.91     0.01     0.54          0
11                   CONDUIT      0.37      0  11:05       0.86     0.01     0.55          0
RightSwale           CONDUIT      0.33      0  11:34       1.71     1.00     1.00         96
LeftSwale            CONDUIT      0.39      0  12:12       0.31     0.90     0.97          0
TrenchPipe           CONDUIT      0.14      0  11:30       0.33     0.03     0.55          0
18                   CONDUIT      0.23      0  11:58       1.49     0.02     0.55          0
9                    WEIR         0.26      0  11:46                         0.75          0
15                   DUMMY        0.03      0  09:27


***************************
Flow Classification Summary
***************************

-----------------------------------------------------------------------------------------
                    Adjusted    --- Fraction of Time in Flow Class ----   Avg.     Avg.
                    /Actual          Up    Down  Sub   Sup   Up    Down   Froude   Flow
Conduit              Length    Dry  Dry   Dry   Crit  Crit  Crit  Crit   Number   Change
-----------------------------------------------------------------------------------------
3                      1.00   0.00  0.02  0.00  0.97  0.01  0.00  0.00     0.41   0.0014
10                     1.00   0.12  0.00  0.00  0.82  0.00  0.00  0.06     0.13   0.0000
11                     1.00   0.00  0.12  0.00  0.88  0.00  0.00  0.00     0.08   0.0002
RightSwale             1.00   0.01  0.00  0.00  0.95  0.00  0.00  0.04     0.08   0.0041
LeftSwale              1.00   0.00  0.00  0.00  1.00  0.00  0.00  0.00     0.03   0.0004
TrenchPipe             1.00   0.00  0.00  0.00  1.00  0.00  0.00  0.00     0.04   0.0000
18                     1.00   0.00  0.00  0.00  0.99  0.01  0.00  0.00     0.07   0.0000


*************************
Highest Continuity Errors
*************************
Node Raingarden (5.59%)


***************************
Time-Step Critical Elements
***************************
Link 3 (41.73%)
Node CB#70 (0.13%)


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     0.50 sec
Average Time Step           :    19.20 sec
Maximum Time Step           :    30.00 sec
Percent in Steady State     :     0.00
```

LID Subdivision

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.009)
--------------------------------------------------------------

LID Subdivision
50-year, 24-hour design storm

****************
Analysis Options
****************
Flow Units ............... CFS
Infiltration Method ...... GREEN_AMPT
Flow Routing Method ...... DYNWAVE
Starting Date ............ JAN-01-2008 00:00:00
Ending Date .............. JAN-02-2008 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:05:00
Wet Time Step ............ 00:15:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 30.00 sec


********************
Rainfall File Summary
********************
Station    First        Last          Recording   Periods    Periods    Periods
ID         Date         Date          Frequency    w/Rain    Missing    Malfunc.
-------------------------------------------------------------------------------
STA100     JAN-01-2008  JAN-01-2008     60 min         24          0          0
STA10      JAN-01-2008  JAN-01-2008     60 min         24          0          0
STA25      JAN-01-2008  JAN-01-2008     60 min         24          0          0
STA02      JAN-01-2008  JAN-01-2008     60 min         24          0          0
STA50      JAN-01-2008  JAN-01-2008     60 min         24          0          0
STA01      JUN-27-2008  SEP-29-2008      5 min        802          0          0


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         1.631         6.000
Evaporation Loss .........         0.008         0.031
Infiltration Loss ........         0.262         0.962
Surface Runoff ...........         1.347         4.957
Final Surface Storage ....         0.017         0.063
Continuity Error (%) .....        -0.210


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      Mgallons
**************************     ---------     ---------
```

```
Dry Weather Inflow .......        0.000         0.000
Wet Weather Inflow .......        1.335         0.435
Groundwater Inflow .......        0.000         0.000
RDII Inflow ..............        0.000         0.000
External Inflow ..........        0.000         0.000
External Outflow .........        0.049         0.016
Surface Flooding .........        0.096         0.031
Evaporation Loss .........        0.001         0.000
Initial Stored Volume ....        0.000         0.000
Final Stored Volume ......        1.172         0.382
Continuity Error (%) .....        1.259


***************************
Subcatchment Runoff Summary
***************************
```

Subcatchment	Total Precip in	Total Runon in	Total Evap in	Total Infil in	Total Runoff in	Peak Runoff CFS	Runoff Coeff
Drive1	6.000	0.000	0.031	0.000	5.957	0.02	0.993
Drive13	6.000	0.000	0.031	0.000	5.957	0.02	0.993
Drive14	6.000	0.000	0.031	0.000	5.957	0.02	0.993
Drive15	6.000	0.000	0.031	0.000	5.957	0.02	0.993
Drive16	6.000	0.000	0.031	0.000	5.957	0.02	0.993
Drive17	6.000	0.000	0.031	0.000	5.957	0.02	0.993
Drive18	6.000	0.000	0.031	0.000	5.957	0.02	0.993
Drive19	6.000	0.000	0.031	0.000	5.957	0.02	0.993
Drive2	6.000	0.000	0.031	0.000	5.957	0.02	0.993
Drive20	6.000	0.000	0.031	0.000	5.957	0.02	0.993
Drive3	6.000	0.000	0.031	0.000	5.957	0.02	0.993
Drive7	6.000	0.000	0.031	0.000	5.957	0.02	0.993
Drive8	6.000	0.000	0.031	0.000	5.957	0.02	0.993
LeftWeirVeg	6.000	0.000	0.031	4.046	1.945	0.32	0.324
Lot10On	6.000	0.000	0.031	0.837	4.993	0.06	0.832
Lot11On	6.000	0.000	0.031	0.837	4.992	0.09	0.832
Lot12On	6.000	0.000	0.031	0.837	4.994	0.07	0.832
Lot13On	6.000	0.000	0.031	0.837	4.992	0.09	0.832
Lot14On	6.000	0.000	0.031	0.837	4.990	0.10	0.832
Lot15On	6.000	0.000	0.031	0.837	4.991	0.09	0.832
Lot16On	6.000	0.000	0.031	0.837	4.974	0.04	0.829
Lot17On	6.000	0.000	0.031	0.837	4.992	0.09	0.832
Lot18On	6.000	0.000	0.031	0.837	4.992	0.09	0.832
Lot19On	6.000	0.000	0.031	0.837	4.994	0.07	0.832
Lot1On	6.000	0.000	0.031	0.837	4.992	0.09	0.832
Lot20On	6.000	0.000	0.031	0.837	4.993	0.08	0.832
Lot2On	6.000	0.000	0.031	0.837	4.994	0.05	0.832
Lot3On	6.000	0.000	0.031	0.837	4.979	0.05	0.830

Lot7On	6.000	0.000	0.031	0.837	4.992	0.09	0.832
Lot8On	6.000	0.000	0.031	0.837	4.994	0.06	0.832
Lot9On	6.000	0.000	0.031	0.837	4.993	0.04	0.832
LWPave	6.000	0.000	0.031	0.000	5.955	0.12	0.993
R1	6.000	0.000	0.031	0.000	5.955	0.27	0.993
R2	6.000	0.000	0.031	0.000	5.955	0.09	0.992
R3	6.000	0.000	0.031	0.000	5.955	0.14	0.993
RightWeirVeg	6.000	0.000	0.031	4.046	1.945	0.32	0.324
RWPave	6.000	0.000	0.031	0.000	5.955	0.14	0.993
TrenchPave	6.000	0.000	0.031	0.000	5.955	0.15	0.993
R4	6.000	0.000	0.031	0.000	5.955	0.12	0.993
R5	6.000	0.000	0.031	0.000	5.922	1.51	0.987
System	6.000	0.000	0.031	0.962	4.957	4.65	0.826

****
Node Depth Summary
****

Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum HGL Feet	Time of Max Occurrence days hr:min	Total Flooding acre-in	Total Minutes Flooded
CB#69	JUNCTION	5.67	6.08	91.08	0 11:30	0	0
CB#70	JUNCTION	1.12	1.28	89.28	0 16:05	0	0
CB#68	JUNCTION	3.72	4.04	94.04	0 13:46	0	0
CB#40	JUNCTION	0.06	0.11	98.11	0 12:58	0	0
23	JUNCTION	0.41	1.00	105.00	0 11:29	0.20	96
24	JUNCTION	0.50	1.64	96.64	0 12:59	0	0
33	JUNCTION	0.07	0.11	90.11	0 12:28	0	0
36	OUTFALL	0.00	0.00	0.00	0 00:00	0	0
37	OUTFALL	0.00	0.00	0.00	0 00:00	0	0
PondOne	STORAGE	3.01	4.41	83.21	1 00:00	0	0
Raingarden	STORAGE	1.06	1.50	88.00	0 11:41	0	0
Pond_3	STORAGE	1.01	1.65	71.65	1 00:00	0	0

****
Node Flow Summary
****

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days hr:min	Maximum Flooding Overflow CFS	Time of Max Occurrence days hr:min
CB#69	JUNCTION	0.14	0.14	0 12:59	0.00	

```
CB#70                JUNCTION      2.06      2.06     0  12:59      0.00
CB#68                JUNCTION      0.37      0.37     0  12:59      0.00
CB#40                JUNCTION      0.25      0.25     0  12:59      0.00
23                   JUNCTION      0.46      0.46     0  12:45      0.13      0  12:45
24                   JUNCTION      0.44      0.44     0  12:59      0.00
33                   JUNCTION      0.15      0.15     0  12:59      0.00
36                   OUTFALL       0.00      0.00     0  00:00      0.00
37                   OUTFALL       0.00      0.03     0  09:08      0.00
PondOne              STORAGE       0.00      3.07     0  12:59      0.00
Raingarden           STORAGE       0.00      0.93     0  12:59      0.64      0  12:59
Pond_3               STORAGE       0.77      0.77     0  12:59      0.00


**********************
Storage Volume Summary
**********************

--------------------------------------------------------------------------------------
                       Average     Avg       Maximum     Max    Time of Max    Maximum
                        Volume    Pcnt        Volume    Pcnt     Occurrence    Outflow
Storage Unit          1000 ft3    Full      1000 ft3    Full    days hr:min        CFS
--------------------------------------------------------------------------------------
PondOne                 18.606       5        40.159      10       1  00:00       0.00
Raingarden               0.569      56         1.009     100       0  11:41       0.29
Pond_3                   4.775       6         9.917      12       1  00:00       0.00


***********************
Outfall Loading Summary
***********************

-----------------------------------------------
                      Flow       Avg.      Max.
                      Freq.      Flow      Flow
Outfall Node          Pcnt.      CFS       CFS
-----------------------------------------------
36                     0.00      0.00      0.00
37                    98.98      0.03      0.03
-----------------------------------------------
System                49.49      0.03      0.03


********************
Link Flow Summary
********************

-----------------------------------------------------------------------------------------
                                Maximum  Time of Max   Maximum    Max/     Max/      Total
                                   Flow   Occurrence  Velocity    Full     Full    Minutes
Link                 Type           CFS  days hr:min    ft/sec    Flow    Depth Surcharged
```

```
-----------------------------------------------------------------------------------------
3                    CONDUIT      2.06     0  12:53      4.03     0.13     0.66          0
10                   CONDUIT      0.14     0  11:30      3.84     0.01     0.54          0
11                   CONDUIT      0.81     0  13:42      1.73     0.03     0.58          0
RightSwale           CONDUIT      0.33     0  11:29      1.71     1.00     1.00        101
LeftSwale            CONDUIT      0.44     0  12:59      0.34     1.01     1.00         73
TrenchPipe           CONDUIT      0.15     0  11:30      0.34     0.03     0.56          0
18                   CONDUIT      0.25     0  12:55      1.49     0.02     0.55          0
9                    WEIR         0.26     0  11:41                        0.75          0
15                   DUMMY        0.03     0  09:08


***************************
Flow Classification Summary
***************************

-----------------------------------------------------------------------------------------
                   Adjusted    --- Fraction of Time in Flow Class ----   Avg.     Avg.  
                   /Actual         Up    Down  Sub   Sup   Up    Down    Froude   Flow  
Conduit             Length    Dry  Dry   Dry   Crit  Crit  Crit  Crit    Number   Change
-----------------------------------------------------------------------------------------
3                     1.00   0.00  0.02  0.00  0.97  0.01  0.00  0.00     0.45    0.0016
10                    1.00   0.13  0.00  0.00  0.84  0.00  0.00  0.03     0.21    0.0001
11                    1.00   0.00  0.11  0.00  0.89  0.00  0.00  0.00     0.09    0.0002
RightSwale            1.00   0.01  0.00  0.00  0.96  0.00  0.00  0.03     0.08    0.0040
LeftSwale             1.00   0.00  0.00  0.00  1.00  0.00  0.00  0.00     0.03    0.0004
TrenchPipe            1.00   0.00  0.00  0.00  1.00  0.00  0.00  0.00     0.04    0.0000
18                    1.00   0.00  0.00  0.00  0.99  0.01  0.00  0.00     0.08    0.0000


*************************
Highest Continuity Errors
*************************
Node Raingarden (5.26%)


***************************
Time-Step Critical Elements
***************************
Link 3 (43.38%)
Node CB#70 (0.15%)


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     0.50 sec
Average Time Step           :    18.72 sec
Maximum Time Step           :    30.00 sec
Percent in Steady State     :     0.00
```

LID Subdivision

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.009)
--------------------------------------------------------------

LID Subdivision
100-year, 24-hour design storm

****************
Analysis Options
****************
Flow Units ............... CFS
Infiltration Method ...... GREEN_AMPT
Flow Routing Method ...... DYNWAVE
Starting Date ............ JAN-01-2008 00:00:00
Ending Date .............. JAN-02-2008 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:05:00
Wet Time Step ............ 00:15:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 30.00 sec


*********************
Rainfall File Summary
*********************
Station    First        Last         Recording   Periods    Periods    Periods
ID         Date         Date         Frequency    w/Rain    Missing    Malfunc.
-------------------------------------------------------------------------------
STA100     JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA10      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA25      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA02      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA50      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA01      JUN-27-2008  SEP-29-2008      5 min       802          0          0


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         1.971         7.250
Evaporation Loss .........         0.008         0.031
Infiltration Loss ........         0.291         1.070
Surface Runoff ...........         1.659         6.102
Final Surface Storage ....         0.018         0.066
Continuity Error (%) .....        -0.263


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      Mgallons
**************************     ---------     ---------
```

```
Dry Weather Inflow .......         0.000          0.000
Wet Weather Inflow .......         1.648          0.537
Groundwater Inflow .......         0.000          0.000
RDII Inflow ..............         0.000          0.000
External Inflow ..........         0.000          0.000
External Outflow .........         0.051          0.016
Surface Flooding .........         0.145          0.047
Evaporation Loss .........         0.002          0.001
Initial Stored Volume ....         0.000          0.000
Final Stored Volume ......         1.436          0.468
Continuity Error (%) .....         0.923
```

```
***************************
Subcatchment Runoff Summary
***************************
```

Subcatchment	Total Precip in	Total Runon in	Total Evap in	Total Infil in	Total Runoff in	Peak Runoff CFS	Runoff Coeff
Drive1	7.250	0.000	0.031	0.000	7.208	0.02	0.994
Drive13	7.250	0.000	0.031	0.000	7.207	0.02	0.994
Drive14	7.250	0.000	0.031	0.000	7.208	0.02	0.994
Drive15	7.250	0.000	0.031	0.000	7.207	0.02	0.994
Drive16	7.250	0.000	0.031	0.000	7.207	0.02	0.994
Drive17	7.250	0.000	0.031	0.000	7.207	0.02	0.994
Drive18	7.250	0.000	0.031	0.000	7.207	0.02	0.994
Drive19	7.250	0.000	0.031	0.000	7.207	0.02	0.994
Drive2	7.250	0.000	0.031	0.000	7.207	0.02	0.994
Drive20	7.250	0.000	0.031	0.000	7.207	0.02	0.994
Drive3	7.250	0.000	0.031	0.000	7.207	0.02	0.994
Drive7	7.250	0.000	0.031	0.000	7.207	0.02	0.994
Drive8	7.250	0.000	0.031	0.000	7.208	0.02	0.994
LeftWeirVeg	7.250	0.000	0.030	4.616	2.639	0.42	0.364
Lot10On	7.250	0.000	0.031	0.848	6.254	0.07	0.863
Lot11On	7.250	0.000	0.031	0.848	6.231	0.11	0.859
Lot12On	7.250	0.000	0.031	0.848	6.234	0.09	0.860
Lot13On	7.250	0.000	0.031	0.848	6.231	0.11	0.859
Lot14On	7.250	0.000	0.031	0.848	6.228	0.12	0.859
Lot15On	7.250	0.000	0.031	0.848	6.230	0.11	0.859
Lot16On	7.250	0.000	0.031	0.848	6.220	0.05	0.858
Lot17On	7.250	0.000	0.031	0.848	6.231	0.11	0.859
Lot18On	7.250	0.000	0.031	0.848	6.231	0.11	0.859
Lot19On	7.250	0.000	0.031	0.848	6.234	0.09	0.860
Lot1On	7.250	0.000	0.031	0.848	6.231	0.11	0.859
Lot20On	7.250	0.000	0.031	0.848	6.233	0.10	0.860
Lot2On	7.250	0.000	0.031	0.848	6.238	0.06	0.860
Lot3On	7.250	0.000	0.031	0.848	6.238	0.06	0.860

Lot7On	7.250	0.000	0.031	0.848	6.231	0.11	0.859
Lot8On	7.250	0.000	0.031	0.848	6.234	0.07	0.860
Lot9On	7.250	0.000	0.031	0.848	6.236	0.05	0.860
LWPave	7.250	0.000	0.031	0.000	7.209	0.15	0.994
R1	7.250	0.000	0.031	0.000	7.209	0.33	0.994
R2	7.250	0.000	0.031	0.000	7.209	0.11	0.994
R3	7.250	0.000	0.031	0.000	7.209	0.17	0.994
RightWeirVeg	7.250	0.000	0.030	4.616	2.639	0.42	0.364
RWPave	7.250	0.000	0.031	0.000	7.209	0.17	0.994
TrenchPave	7.250	0.000	0.031	0.000	7.209	0.18	0.994
R4	7.250	0.000	0.031	0.000	7.209	0.15	0.994
R5	7.250	0.000	0.031	0.000	7.169	1.83	0.989
System	7.250	0.000	0.031	1.070	6.102	5.70	0.842

****
Node Depth Summary
****

Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum HGL Feet	Time of Max Occurrence days	Time of Max Occurrence hr:min	Total Flooding acre-in	Total Minutes Flooded
CB#69	JUNCTION	5.75	6.09	91.09	0	12:15	0	0
CB#70	JUNCTION	1.14	1.26	89.26	0	12:59	0	0
CB#68	JUNCTION	3.76	4.03	94.03	0	10:22	0	0
CB#40	JUNCTION	0.07	0.12	98.12	0	12:47	0	0
23	JUNCTION	0.45	1.00	105.00	0	11:19	0.42	109
24	JUNCTION	2.27	7.07	102.07	0	12:45	0	0
33	JUNCTION	0.07	0.13	90.13	0	12:46	0	0
36	OUTFALL	0.00	0.00	0.00	0	00:00	0	0
37	OUTFALL	0.00	0.00	0.00	0	00:00	0	0
PondOne	STORAGE	3.26	4.69	83.49	1	00:00	0	0
Raingarden	STORAGE	1.12	1.50	88.00	0	11:31	0	0
Pond_3	STORAGE	1.14	1.84	71.84	1	00:00	0	0

****
Node Flow Summary
****

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days	Time of Max Occurrence hr:min	Maximum Flooding Overflow CFS	Time of Max Occurrence days hr:min
CB#69	JUNCTION	0.17	0.17	0	12:44	0.00	

CB#70	JUNCTION	2.50	2.50	0	12:59	0.00		
CB#68	JUNCTION	0.45	0.45	0	12:59	0.00		
CB#40	JUNCTION	0.30	0.30	0	12:45	0.00		
23	JUNCTION	0.59	0.59	0	12:45	0.26	0	12:45
24	JUNCTION	0.57	0.57	0	12:45	0.00		
33	JUNCTION	0.18	0.18	0	12:45	0.00		
36	OUTFALL	0.00	0.00	0	00:00	0.00		
37	OUTFALL	0.00	0.03	0	08:14	0.00		
PondOne	STORAGE	0.00	3.68	0	12:58	0.00		
Raingarden	STORAGE	0.00	1.08	0	12:45	0.79	0	12:45
Pond_3	STORAGE	0.94	0.94	0	12:59	0.00		

****
Storage Volume Summary
****

Storage Unit	Average Volume 1000 ft3	Avg Pcnt Full	Maximum Volume 1000 ft3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CFS
PondOne	23.060	6	49.227	12	1 00:00	0.00
Raingarden	0.622	62	1.009	100	0 11:31	0.29
Pond_3	5.950	7	12.279	15	1 00:00	0.00

****
Outfall Loading Summary
****

Outfall Node	Flow Freq. Pcnt.	Avg. Flow CFS	Max. Flow CFS
36	0.00	0.00	0.00
37	99.10	0.03	0.03
System	49.55	0.03	0.03

****
Link Flow Summary
****

Link	Type	Maximum Flow CFS	Time of Max Occurrence days hr:min	Maximum Velocity ft/sec	Max/ Full Flow	Max/ Full Depth	Total Minutes Surcharged

3	CONDUIT	2.58	0	10:01	4.79	0.16	0.69	0
10	CONDUIT	0.17	0	12:44	4.12	0.02	0.55	0
11	CONDUIT	1.04	0	10:22	2.16	0.03	0.59	0
RightSwale	CONDUIT	0.33	0	11:20	1.78	1.00	1.00	113
LeftSwale	CONDUIT	0.57	0	12:45	0.43	1.29	1.00	99
TrenchPipe	CONDUIT	0.18	0	12:15	0.40	0.03	0.56	0
18	CONDUIT	0.30	0	12:35	1.55	0.03	0.56	0
9	WEIR	0.26	0	11:31			0.75	0
15	DUMMY	0.03	0	08:14				

****
Flow Classification Summary
****

Conduit	Adjusted /Actual Length	--- Fraction of Time in Flow Class ---- Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Avg. Froude Number	Avg. Flow Change
3	1.00	0.00	0.02	0.00	0.65	0.33	0.00	0.00	0.54	0.0019
10	1.00	0.11	0.00	0.00	0.87	0.00	0.00	0.02	0.20	0.0001
11	1.00	0.00	0.11	0.00	0.89	0.00	0.00	0.00	0.12	0.0004
RightSwale	1.00	0.01	0.00	0.00	0.98	0.00	0.00	0.02	0.08	0.0037
LeftSwale	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.04	0.0005
TrenchPipe	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.05	0.0000
18	1.00	0.00	0.00	0.00	0.99	0.01	0.00	0.00	0.09	0.0000

****
Highest Continuity Errors
****
Node Raingarden (4.58%)

****
Time-Step Critical Elements
****
Link 3 (46.84%)
Node CB#70 (0.20%)

****
Routing Time Step Summary
****

```
Minimum Time Step          :     3.31 sec
Average Time Step          :    17.70 sec
Maximum Time Step          :    30.00 sec
Percent in Steady State    :     0.00
```

ATTACHMENT 13

SWMM Cluster Only Subdivision Model Results

Cluster Only Subdivision

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.009)
--------------------------------------------------------------

Cluster Only Subdivision
2-year, 24-hour Design Storm Results

****************
Analysis Options
****************
Flow Units ............... CFS
Infiltration Method ...... GREEN_AMPT
Flow Routing Method ...... DYNWAVE
Starting Date ............ JAN-01-2008 00:00:00
Ending Date .............. JAN-02-2008 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:05:00
Wet Time Step ............ 00:15:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 30.00 sec


*********************
Rainfall File Summary
*********************
Station    First        Last         Recording   Periods    Periods    Periods
ID         Date         Date         Frequency    w/Rain    Missing    Malfunc.
-------------------------------------------------------------------------------
STA02      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA10      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA25      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA50      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA100     JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA08      JAN-01-2008  JAN-01-2008     60 min        24          0          0


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         0.842         3.000
Evaporation Loss .........         0.009         0.031
Infiltration Loss ........         0.068         0.242
Surface Runoff ...........         0.746         2.657
Final Surface Storage ....         0.019         0.066
Continuity Error (%) .....         0.118


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      Mgallons
**************************     ---------     ---------
```

Cluster Only Subdivision

Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	0.734	0.239
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.000	0.000
External Outflow	0.000	0.000
Surface Flooding	0.000	0.000
Evaporation Loss	0.001	0.000
Initial Stored Volume	0.000	0.000
Final Stored Volume	0.728	0.237
Continuity Error (%)	0.652	

****
Subcatchment Runoff Summary
****

Subcatchment	Total Precip in	Total Runon in	Total Evap in	Total Infil in	Total Runoff in	Peak Runoff CFS	Runoff Coeff
Drive1	3.000	13.460	0.031	0.000	16.392	0.04	0.996
Drive10	3.000	13.460	0.031	0.000	16.394	0.04	0.996
Drive11	3.000	13.460	0.031	0.000	16.393	0.04	0.996
Drive12	3.000	13.460	0.031	0.000	16.394	0.04	0.996
Drive13	3.000	13.460	0.031	0.000	16.394	0.04	0.996
Drive14	3.000	13.460	0.031	0.000	16.392	0.04	0.996
Drive15	3.000	13.460	0.031	0.000	16.394	0.04	0.996
Drive16	3.000	13.460	0.031	0.000	16.394	0.04	0.996
Drive17	3.000	13.460	0.031	0.000	16.394	0.04	0.996
Drive18	3.000	13.460	0.031	0.000	16.394	0.04	0.996
Drive19	3.000	13.460	0.031	0.000	16.394	0.04	0.996
Drive2	3.000	13.460	0.031	0.000	16.394	0.04	0.996
Drive20	3.000	13.460	0.031	0.000	16.394	0.04	0.996
Drive3	3.000	13.460	0.031	0.000	16.394	0.04	0.996
Drive4	3.000	13.460	0.031	0.000	16.394	0.04	0.996
Drive5	3.000	13.460	0.031	0.000	16.394	0.04	0.996
Drive6	3.000	13.460	0.031	0.000	16.394	0.04	0.996
Drive7	3.000	13.460	0.031	0.000	16.394	0.04	0.996
Drive8	3.000	13.460	0.031	0.000	16.392	0.04	0.996
Drive9	3.000	13.460	0.031	0.000	16.392	0.04	0.996
LeftWeirVeg	3.000	0.000	0.031	0.833	1.940	0.20	0.647
Lot10On	3.000	0.000	0.031	0.517	2.358	0.02	0.786
Lot11On	3.000	0.000	0.031	0.517	2.356	0.04	0.785
Lot12On	3.000	0.000	0.031	0.517	2.359	0.02	0.786
Lot13On	3.000	0.000	0.031	0.517	2.358	0.03	0.786
Lot14On	3.000	0.000	0.031	0.517	2.356	0.05	0.785
Lot15On	3.000	0.000	0.031	0.517	2.356	0.05	0.785
Lot16On	3.000	0.000	0.031	0.517	2.359	0.02	0.786

Lot17On	3.000	0.000	0.031	0.517	2.359	0.02	0.786
Lot18On	3.000	0.000	0.031	0.517	2.358	0.03	0.786
Lot19On	3.000	0.000	0.031	0.517	2.357	0.04	0.786
Lot1On	3.000	0.000	0.031	0.517	2.358	0.03	0.786
Lot20On	3.000	0.000	0.031	0.517	2.358	0.03	0.786
Lot2On	3.000	0.000	0.031	0.517	2.359	0.02	0.786
Lot3On	3.000	0.000	0.031	0.517	2.359	0.02	0.786
Lot7On	3.000	0.000	0.031	0.517	2.356	0.04	0.785
Lot8On	3.000	0.000	0.031	0.517	2.358	0.02	0.786
Lot9On	3.000	0.000	0.031	0.517	2.359	0.01	0.786
LWPave	3.000	0.000	0.031	0.000	2.949	0.09	0.983
R1	3.000	0.000	0.031	0.000	2.949	0.14	0.983
R2	3.000	0.000	0.031	0.000	2.949	0.05	0.983
R3	3.000	0.000	0.031	0.000	2.949	0.06	0.983
RightWeirVeg	3.000	0.000	0.031	0.833	1.962	0.18	0.654
Roof1	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof10	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof11	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof12	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof13	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof14	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof15	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof16	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof17	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof18	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof19	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof2	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof20	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof3	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof4	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof5	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof6	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof7	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof8	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof9	3.000	0.000	0.031	0.000	2.936	0.03	0.979
RWPave	3.000	0.000	0.031	0.000	2.950	0.01	0.983
TrenchPave	3.000	0.000	0.031	0.000	2.946	0.18	0.982
R4	3.000	0.000	0.031	0.000	2.949	0.06	0.983
R5	3.000	0.000	0.031	0.000	2.947	0.18	0.982
System	3.000	0.799	0.031	0.242	3.458	3.18	0.910

****
Node Depth Summary
****

	Average Depth	Maximum Depth	Maximum HGL	Time of Max Occurrence	Total Flooding	Total Minutes

Node	Type	Feet	Feet	Feet	days	hr:min	acre-in	Flooded
CB#69	JUNCTION	3.84	4.23	81.23	0	12:59	0	0
CB#70	JUNCTION	0.27	0.64	78.64	1	00:00	0	0
CB#68	JUNCTION	0.00	0.00	88.99	0	00:00	0	0
CB#40	JUNCTION	2.92	3.32	99.73	0	11:30	0	0
DMH#81	JUNCTION	0.06	0.17	99.37	0	12:59	0	0
DMH#4	JUNCTION	0.00	0.01	98.41	0	12:12	0	0
27	OUTFALL	0.00	0.00	0.00	0	00:00	0	0
1	STORAGE	2.88	4.84	78.64	1	00:00	0	0
Pond_Three	STORAGE	0.80	1.33	71.33	1	00:00	0	0

****
Node Flow Summary
****

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days hr:min	Maximum Flooding Overflow CFS	Time of Max Occurrence days hr:min
CB#69	JUNCTION	0.48	0.48	0 12:59	0.00	
CB#70	JUNCTION	0.84	0.84	0 12:59	0.00	
CB#68	JUNCTION	0.29	0.29	0 12:59	0.00	
CB#40	JUNCTION	0.19	0.19	0 12:59	0.00	
DMH#81	JUNCTION	0.00	0.19	0 11:31	0.00	
DMH#4	JUNCTION	0.19	0.39	0 12:59	0.00	
27	OUTFALL	0.00	0.00	0 00:00	0.00	
1	STORAGE	0.00	1.99	0 12:59	0.00	
Pond_Three	STORAGE	0.50	0.50	0 12:59	0.00	

****
Storage Volume Summary
****

Storage Unit	Average Volume 1000 ft3	Avg Pcnt Full	Maximum Volume 1000 ft3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CFS
1	11.770	6	25.124	13	1 00:00	0.00
Pond_Three	3.134	4	6.493	8	1 00:00	0.00

****
Outfall Loading Summary
****

Cluster Only Subdivision

Outfall Node	Flow Freq. Pcnt.	Avg. Flow CFS	Max. Flow CFS
27	0.00	0.00	0.00
System	0.00	0.00	0.00

****
Link Flow Summary
****

Link	Type	Maximum Flow CFS	Time of Max Occurrence days hr:min	Maximum Velocity ft/sec	Max/ Full Flow	Max/ Full Depth	Total Minutes Surcharged
3	CONDUIT	0.84	0 12:58	2.64	0.15	0.82	0
6	CONDUIT	0.19	0 11:31	1.79	0.07	0.19	0
7	DUMMY	0.39	0 12:59				
8	CONDUIT	0.19	0 12:48	2.48	0.04	0.15	0
9	CONDUIT	0.01	0 12:46	0.71	0.00	0.09	0
10	CONDUIT	0.48	0 13:00	3.72	0.10	0.22	0
11	DUMMY	0.29	0 12:59				

****
Flow Classification Summary
****

Conduit	Adjusted /Actual Length	--- Fraction of Time in Flow Class ---- Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Avg. Froude Number	Avg. Flow Change
3	1.00	0.01	0.00	0.00	0.68	0.01	0.00	0.30	0.53	0.0001
6	1.00	0.12	0.00	0.00	0.88	0.00	0.00	0.00	0.58	0.0000
8	1.00	0.12	0.00	0.00	0.00	0.00	0.00	0.88	0.90	0.0000
9	1.00	0.12	0.00	0.00	0.88	0.00	0.00	0.00	0.20	0.0000
10	1.00	0.09	0.00	0.00	0.30	0.01	0.00	0.60	0.85	0.0001

****
Highest Continuity Errors
****

Node DMH#81 (0.14%)
Node DMH#4 (-0.00%)

Cluster Only Subdivision

```
***************************
Time-Step Critical Elements
***************************
Link 6 (20.65%)
Link 3 (2.83%)


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     9.84 sec
Average Time Step           :    25.46 sec
Maximum Time Step           :    30.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00


Analysis begun on:  Wed Feb 25 18:01:55 2009
Total elapsed time: 00:00:01
```

Cluster Only Subdivision

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.009)
--------------------------------------------------------------

Cluster Only Subdivision
10-year, 24-hour Design Storm Results

****************
Analysis Options
****************
Flow Units ............... CFS
Infiltration Method ...... GREEN_AMPT
Flow Routing Method ...... DYNWAVE
Starting Date ............ JAN-01-2008 00:00:00
Ending Date .............. JAN-02-2008 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:05:00
Wet Time Step ............ 00:15:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 30.00 sec


*********************
Rainfall File Summary
*********************
Station    First        Last         Recording   Periods    Periods    Periods
ID         Date         Date         Frequency    w/Rain    Missing    Malfunc.
-------------------------------------------------------------------------------
STA02      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA10      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA25      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA50      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA100     JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA08      JAN-01-2008  JAN-01-2008     60 min        24          0          0


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         1.263         4.500
Evaporation Loss .........         0.009         0.031
Infiltration Loss ........         0.072         0.255
Surface Runoff ...........         1.164         4.144
Final Surface Storage ....         0.021         0.073
Continuity Error (%) .....        -0.091


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      Mgallons
**************************     ---------     ---------
```

Cluster Only Subdivision

```
Dry Weather Inflow .......         0.000          0.000
Wet Weather Inflow .......         1.156          0.377
Groundwater Inflow .......         0.000          0.000
RDII Inflow ..............         0.000          0.000
External Inflow ..........         0.000          0.000
External Outflow .........         0.000          0.000
Surface Flooding .........         0.000          0.000
Evaporation Loss .........         0.001          0.000
Initial Stored Volume ....         0.000          0.000
Final Stored Volume ......         1.148          0.374
Continuity Error (%) .....         0.590


***************************
Subcatchment Runoff Summary
***************************
```

Subcatchment	Total Precip in	Total Runon in	Total Evap in	Total Infil in	Total Runoff in	Peak Runoff CFS	Runoff Coeff
Drive1	4.500	20.475	0.031	0.000	24.904	0.06	0.997
Drive10	4.500	20.475	0.031	0.000	24.904	0.06	0.997
Drive11	4.500	20.475	0.031	0.000	24.905	0.06	0.997
Drive12	4.500	20.475	0.031	0.000	24.904	0.06	0.997
Drive13	4.500	20.475	0.031	0.000	24.904	0.06	0.997
Drive14	4.500	20.475	0.031	0.000	24.904	0.06	0.997
Drive15	4.500	20.475	0.031	0.000	24.904	0.06	0.997
Drive16	4.500	20.475	0.031	0.000	24.904	0.06	0.997
Drive17	4.500	20.475	0.031	0.000	24.904	0.06	0.997
Drive18	4.500	20.475	0.031	0.000	24.904	0.06	0.997
Drive19	4.500	20.475	0.031	0.000	24.904	0.06	0.997
Drive2	4.500	20.475	0.031	0.000	24.904	0.06	0.997
Drive20	4.500	20.475	0.031	0.000	24.904	0.06	0.997
Drive3	4.500	20.475	0.031	0.000	24.904	0.06	0.997
Drive4	4.500	20.475	0.031	0.000	24.904	0.06	0.997
Drive5	4.500	20.475	0.031	0.000	24.904	0.06	0.997
Drive6	4.500	20.475	0.031	0.000	24.904	0.06	0.997
Drive7	4.500	20.475	0.031	0.000	24.904	0.06	0.997
Drive8	4.500	20.475	0.031	0.000	24.904	0.06	0.997
Drive9	4.500	20.475	0.031	0.000	24.904	0.06	0.997
LeftWeirVeg	4.500	0.000	0.031	0.878	3.360	0.32	0.747
Lot10On	4.500	0.000	0.031	0.544	3.828	0.03	0.851
Lot11On	4.500	0.000	0.031	0.544	3.824	0.06	0.850
Lot12On	4.500	0.000	0.031	0.544	3.829	0.04	0.851
Lot13On	4.500	0.000	0.031	0.544	3.828	0.04	0.851
Lot14On	4.500	0.000	0.031	0.544	3.824	0.08	0.850
Lot15On	4.500	0.000	0.031	0.544	3.824	0.07	0.850
Lot16On	4.500	0.000	0.031	0.544	3.829	0.03	0.851

Lot17On	4.500	0.000	0.031	0.544	3.829	0.03	0.851
Lot18On	4.500	0.000	0.031	0.544	3.828	0.04	0.851
Lot19On	4.500	0.000	0.031	0.544	3.826	0.06	0.850
Lot1On	4.500	0.000	0.031	0.544	3.828	0.04	0.851
Lot20On	4.500	0.000	0.031	0.544	3.827	0.05	0.850
Lot2On	4.500	0.000	0.031	0.544	3.828	0.04	0.851
Lot3On	4.500	0.000	0.031	0.544	3.829	0.03	0.851
Lot7On	4.500	0.000	0.031	0.544	3.824	0.06	0.850
Lot8On	4.500	0.000	0.031	0.544	3.828	0.03	0.851
Lot9On	4.500	0.000	0.031	0.544	3.829	0.02	0.851
LWPave	4.500	0.000	0.031	0.000	4.449	0.14	0.989
R1	4.500	0.000	0.031	0.000	4.449	0.20	0.989
R2	4.500	0.000	0.031	0.000	4.449	0.07	0.989
R3	4.500	0.000	0.031	0.000	4.449	0.09	0.989
RightWeirVeg	4.500	0.000	0.031	0.878	3.390	0.28	0.753
Roof1	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof10	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof11	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof12	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof13	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof14	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof15	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof16	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof17	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof18	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof19	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof2	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof20	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof3	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof4	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof5	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof6	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof7	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof8	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof9	4.500	0.000	0.031	0.000	4.450	0.05	0.989
RWPave	4.500	0.000	0.031	0.000	4.450	0.02	0.989
TrenchPave	4.500	0.000	0.031	0.000	4.447	0.27	0.988
R4	4.500	0.000	0.031	0.000	4.449	0.09	0.989
R5	4.500	0.000	0.031	0.000	4.447	0.27	0.988
System	4.500	1.215	0.031	0.255	5.360	4.79	0.938

****
Node Depth Summary
****

	Average Depth	Maximum Depth	Maximum HGL	Time of Max Occurrence	Total Flooding	Total Minutes

Node	Type	Feet	Feet	Feet	days	hr:min	acre-in	Flooded
CB#69	JUNCTION	4.05	4.29	81.29	0	12:47	0	0
CB#70	JUNCTION	0.60	1.44	79.44	1	00:00	0	0
CB#68	JUNCTION	0.00	0.00	88.99	0	00:00	0	0
CB#40	JUNCTION	3.14	3.36	99.77	0	11:30	0	0
DMH#81	JUNCTION	0.11	0.21	99.41	0	13:00	0	0
DMH#4	JUNCTION	0.00	0.01	98.41	0	11:45	0	0
27	OUTFALL	0.00	0.00	0.00	0	00:00	0	0
1	STORAGE	3.71	5.64	79.44	1	00:00	0	0
Pond_Three	STORAGE	1.05	1.67	71.67	1	00:00	0	0

****
Node Flow Summary
****

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days hr:min	Maximum Flooding Overflow CFS	Time of Max Occurrence days hr:min
CB#69	JUNCTION	0.73	0.73	0 13:00	0.00	
CB#70	JUNCTION	1.26	1.26	0 12:59	0.00	
CB#68	JUNCTION	0.43	0.43	0 12:59	0.00	
CB#40	JUNCTION	0.29	0.29	0 12:59	0.00	
DMH#81	JUNCTION	0.00	0.29	0 11:31	0.00	
DMH#4	JUNCTION	0.30	0.59	0 13:00	0.00	
27	OUTFALL	0.00	0.00	0 00:00	0.00	
1	STORAGE	0.00	3.01	0 12:49	0.00	
Pond_Three	STORAGE	0.74	0.74	0 12:59	0.00	

****
Storage Volume Summary
****

Storage Unit	Average Volume 1000 ft3	Avg Pcnt Full	Maximum Volume 1000 ft3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CFS
1	18.687	10	39.677	20	1 00:00	0.00
Pond_Three	4.965	6	10.173	12	1 00:00	0.00

****
Outfall Loading Summary
****

Cluster Only Subdivision

Outfall Node	Flow Freq. Pcnt.	Avg. Flow CFS	Max. Flow CFS
27	0.00	0.00	0.00
System	0.00	0.00	0.00

****
Link Flow Summary
****

Link	Type	Maximum Flow CFS	Time of Max Occurrence days	Time of Max Occurrence hr:min	Maximum Velocity ft/sec	Max/ Full Flow	Max/ Full Depth	Total Minutes Surcharged
3	CONDUIT	1.26	0	12:01	2.57	0.22	1.00	605
6	CONDUIT	0.29	0	11:31	1.98	0.11	0.24	0
7	DUMMY	0.59	0	13:00				
8	CONDUIT	0.28	0	12:56	2.71	0.06	0.19	0
9	CONDUIT	0.01	0	12:54	0.38	0.00	0.11	0
10	CONDUIT	0.74	0	12:49	4.17	0.15	0.54	0
11	DUMMY	0.43	0	12:59				

****
Flow Classification Summary
****

Conduit	Adjusted /Actual Length	--- Fraction of Time in Flow Class ---- Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Avg. Froude Number	Avg. Flow Change
3	1.00	0.00	0.00	0.00	0.82	0.01	0.00	0.17	0.45	0.0001
6	1.00	0.06	0.00	0.00	0.94	0.00	0.00	0.00	0.65	0.0000
8	1.00	0.06	0.00	0.00	0.00	0.00	0.00	0.94	1.03	0.0000
9	1.00	0.06	0.00	0.00	0.94	0.00	0.00	0.00	0.15	0.0000
10	1.00	0.04	0.00	0.00	0.34	0.04	0.00	0.58	0.88	0.0001

****
Highest Continuity Errors
****

Node DMH#81 (0.09%)
Node DMH#4 (0.00%)

Cluster Only Subdivision

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***************************
Time-Step Critical Elements
***************************
Link 8 (37.83%)
Link 3 (7.53%)
Link 6 (3.53%)


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     3.49 sec
Average Time Step           :    18.18 sec
Maximum Time Step           :    30.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00


Analysis begun on:  Wed Feb 25 18:03:07 2009
Total elapsed time: < 1 sec
```

Cluster Only Subdivision

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EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.009)
--------------------------------------------------------------

Cluster Only Subdivision
25-year, 24-hour Design Storm Results

****************
Analysis Options
****************
Flow Units ............... CFS
Infiltration Method ...... GREEN_AMPT
Flow Routing Method ...... DYNWAVE
Starting Date ............ JAN-01-2008 00:00:00
Ending Date .............. JAN-02-2008 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:05:00
Wet Time Step ............ 00:15:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 30.00 sec


*********************
Rainfall File Summary
*********************
Station    First        Last         Recording   Periods    Periods    Periods
ID         Date         Date         Frequency    w/Rain    Missing    Malfunc.
-------------------------------------------------------------------------------
STA02      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA10      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA25      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA50      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA100     JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA08      JAN-01-2008  JAN-01-2008     60 min        24          0          0


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         1.544         5.500
Evaporation Loss .........         0.009         0.031
Infiltration Loss ........         0.073         0.260
Surface Runoff ...........         1.442         5.137
Final Surface Storage ....         0.022         0.077
Continuity Error (%) .....        -0.092


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      Mgallons
**************************     ---------     ---------
```

```
Dry Weather Inflow .......         0.000          0.000
Wet Weather Inflow .......         1.435          0.468
Groundwater Inflow .......         0.000          0.000
RDII Inflow ..............         0.000          0.000
External Inflow ..........         0.000          0.000
External Outflow .........         0.000          0.000
Surface Flooding .........         0.000          0.000
Evaporation Loss .........         0.001          0.000
Initial Stored Volume ....         0.000          0.000
Final Stored Volume ......         1.426          0.465
Continuity Error (%) .....         0.540
```

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***************************
Subcatchment Runoff Summary
***************************
```

Subcatchment	Total Precip in	Total Runon in	Total Evap in	Total Infil in	Total Runoff in	Peak Runoff CFS	Runoff Coeff
Drive1	5.500	25.077	0.031	0.000	30.502	0.08	0.998
Drive10	5.500	25.077	0.031	0.000	30.501	0.08	0.998
Drive11	5.500	25.077	0.031	0.000	30.502	0.08	0.998
Drive12	5.500	25.077	0.031	0.000	30.501	0.08	0.998
Drive13	5.500	25.077	0.031	0.000	30.501	0.08	0.998
Drive14	5.500	25.077	0.031	0.000	30.502	0.08	0.998
Drive15	5.500	25.077	0.031	0.000	30.501	0.08	0.998
Drive16	5.500	25.077	0.031	0.000	30.501	0.08	0.998
Drive17	5.500	25.077	0.031	0.000	30.501	0.08	0.998
Drive18	5.500	25.077	0.031	0.000	30.501	0.08	0.998
Drive19	5.500	25.077	0.031	0.000	30.501	0.08	0.998
Drive2	5.500	25.077	0.031	0.000	30.501	0.08	0.998
Drive20	5.500	25.077	0.031	0.000	30.501	0.08	0.998
Drive3	5.500	25.077	0.031	0.000	30.501	0.08	0.998
Drive4	5.500	25.077	0.031	0.000	30.501	0.08	0.998
Drive5	5.500	25.077	0.031	0.000	30.501	0.08	0.998
Drive6	5.500	25.077	0.031	0.000	30.501	0.08	0.998
Drive7	5.500	25.077	0.031	0.000	30.501	0.08	0.998
Drive8	5.500	25.077	0.031	0.000	30.502	0.08	0.998
Drive9	5.500	25.077	0.031	0.000	30.502	0.08	0.998
LeftWeirVeg	5.500	0.000	0.031	0.895	4.324	0.40	0.786
Lot10On	5.500	0.000	0.031	0.555	4.817	0.04	0.876
Lot11On	5.500	0.000	0.031	0.555	4.812	0.07	0.875
Lot12On	5.500	0.000	0.031	0.555	4.818	0.05	0.876
Lot13On	5.500	0.000	0.031	0.555	4.817	0.05	0.876
Lot14On	5.500	0.000	0.031	0.555	4.812	0.09	0.875
Lot15On	5.500	0.000	0.031	0.555	4.813	0.09	0.875
Lot16On	5.500	0.000	0.031	0.555	4.818	0.04	0.876

Lot17On	5.500	0.000	0.031	0.555	4.818	0.04	0.876
Lot18On	5.500	0.000	0.031	0.555	4.817	0.05	0.876
Lot19On	5.500	0.000	0.031	0.555	4.815	0.07	0.875
Lot1On	5.500	0.000	0.031	0.555	4.817	0.05	0.876
Lot20On	5.500	0.000	0.031	0.555	4.816	0.06	0.876
Lot2On	5.500	0.000	0.031	0.555	4.817	0.05	0.876
Lot3On	5.500	0.000	0.031	0.555	4.827	0.04	0.878
Lot7On	5.500	0.000	0.031	0.555	4.812	0.07	0.875
Lot8On	5.500	0.000	0.031	0.555	4.817	0.04	0.876
Lot9On	5.500	0.000	0.031	0.555	4.818	0.03	0.876
LWPave	5.500	0.000	0.031	0.000	5.449	0.17	0.991
R1	5.500	0.000	0.031	0.000	5.449	0.25	0.991
R2	5.500	0.000	0.031	0.000	5.449	0.08	0.991
R3	5.500	0.000	0.031	0.000	5.449	0.11	0.991
RightWeirVeg	5.500	0.000	0.031	0.895	4.359	0.35	0.793
Roof1	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof10	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof11	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof12	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof13	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof14	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof15	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof16	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof17	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof18	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof19	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof2	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof20	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof3	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof4	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof5	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof6	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof7	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof8	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof9	5.500	0.000	0.031	0.000	5.451	0.06	0.991
RWPave	5.500	0.000	0.031	0.000	5.450	0.02	0.991
TrenchPave	5.500	0.000	0.031	0.000	5.447	0.33	0.990
R4	5.500	0.000	0.031	0.000	5.449	0.11	0.991
R5	5.500	0.000	0.031	0.000	5.448	0.33	0.991
System	5.500	1.489	0.031	0.260	6.625	5.88	0.948

****
Node Depth Summary
****

	Average Depth	Maximum Depth	Maximum HGL	Time of Max Occurrence	Total Flooding	Total Minutes

Node	Type	Feet	Feet	Feet	days	hr:min	acre-in	Flooded
CB#69	JUNCTION	4.10	4.32	81.32	0	12:21	0	0
CB#70	JUNCTION	0.85	1.87	79.87	1	00:00	0	0
CB#68	JUNCTION	0.00	0.00	88.99	0	00:00	0	0
CB#40	JUNCTION	3.20	3.39	99.80	0	11:30	0	0
DMH#81	JUNCTION	0.13	0.24	99.44	0	11:58	0	0
DMH#4	JUNCTION	0.00	0.01	98.41	0	11:43	0	0
27	OUTFALL	0.00	0.00	0.00	0	00:00	0	0
1	STORAGE	4.07	6.07	79.87	1	00:00	0	0
Pond_Three	STORAGE	1.18	1.86	71.86	1	00:00	0	0

****
Node Flow Summary
****

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days hr:min	Maximum Flooding Overflow CFS	Time of Max Occurrence days hr:min
CB#69	JUNCTION	0.90	0.90	0 12:59	0.00	
CB#70	JUNCTION	1.55	1.55	0 12:00	0.00	
CB#68	JUNCTION	0.53	0.53	0 12:00	0.00	
CB#40	JUNCTION	0.36	0.36	0 12:00	0.00	
DMH#81	JUNCTION	0.00	0.36	0 11:30	0.00	
DMH#4	JUNCTION	0.37	0.72	0 12:59	0.00	
27	OUTFALL	0.00	0.00	0 00:00	0.00	
1	STORAGE	0.00	3.70	0 12:59	0.00	
Pond_Three	STORAGE	0.92	0.92	0 12:00	0.00	

****
Storage Volume Summary
****

Storage Unit	Average Volume 1000 ft3	Avg Pcnt Full	Maximum Volume 1000 ft3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CFS
1	23.340	12	49.382	25	1 00:00	0.00
Pond_Three	6.153	7	12.583	15	1 00:00	0.00

****
Outfall Loading Summary
****

Cluster Only Subdivision

Outfall Node	Flow Freq. Pcnt.	Avg. Flow CFS	Max. Flow CFS
27	0.00	0.00	0.00
System	0.00	0.00	0.00

****
Link Flow Summary
****

Link	Type	Maximum Flow CFS	Time of Max Occurrence days	Time of Max Occurrence hr:min	Maximum Velocity ft/sec	Max/ Full Flow	Max/ Full Depth	Total Minutes Surcharged
3	CONDUIT	1.55	0	11:37	2.73	0.28	1.00	692
6	CONDUIT	0.36	0	11:30	2.07	0.14	0.27	0
7	DUMMY	0.72	0	12:59				
8	CONDUIT	0.35	0	11:58	2.82	0.08	0.21	0
9	CONDUIT	0.01	0	11:54	0.37	0.00	0.12	0
10	CONDUIT	0.90	0	12:59	4.37	0.19	0.59	0
11	DUMMY	0.53	0	12:00				

****
Flow Classification Summary
****

Conduit	Adjusted /Actual Length	--- Fraction of Time in Flow Class ---- Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Avg. Froude Number	Avg. Flow Change
3	1.00	0.00	0.00	0.00	0.86	0.00	0.00	0.14	0.43	0.0001
6	1.00	0.04	0.00	0.00	0.96	0.00	0.00	0.00	0.66	0.0001
8	1.00	0.04	0.00	0.00	0.00	0.00	0.00	0.96	1.05	0.0000
9	1.00	0.04	0.00	0.00	0.96	0.00	0.00	0.00	0.14	0.0000
10	1.00	0.03	0.00	0.00	0.43	0.04	0.00	0.50	0.82	0.0001

****
Highest Continuity Errors
****

Node DMH#81 (0.09%)
Node DMH#4 (0.00%)

```
***************************
Time-Step Critical Elements
***************************
Link 8 (41.41%)
Link 3 (9.30%)
Link 6 (2.65%)


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     3.32 sec
Average Time Step           :    17.07 sec
Maximum Time Step           :    30.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00


Analysis begun on:  Wed Feb 25 18:04:48 2009
Total elapsed time: < 1 sec
```

Cluster Only Subdivision

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.009)
--------------------------------------------------------------

Cluster Only Subdivision
50-year, 24-hour Design Storm Results

****************
Analysis Options
****************
Flow Units ............... CFS
Infiltration Method ...... GREEN_AMPT
Flow Routing Method ...... DYNWAVE
Starting Date ............ JAN-01-2008 00:00:00
Ending Date .............. JAN-02-2008 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:05:00
Wet Time Step ............ 00:15:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 30.00 sec


*********************
Rainfall File Summary
*********************
Station    First        Last          Recording   Periods    Periods    Periods
ID         Date         Date          Frequency    w/Rain    Missing    Malfunc.
-------------------------------------------------------------------------------
STA02      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA10      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA25      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA50      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA100     JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA08      JAN-01-2008  JAN-01-2008     60 min        24          0          0


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         1.684         6.000
Evaporation Loss .........         0.009         0.031
Infiltration Loss ........         0.073         0.262
Surface Runoff ...........         1.582         5.634
Final Surface Storage ....         0.022         0.078
Continuity Error (%) .....        -0.078


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      Mgallons
**************************     ---------     ---------
```

Cluster Only Subdivision

```
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         1.575         0.513
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.000         0.000
Surface Flooding .........         0.000         0.000
Evaporation Loss .........         0.001         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         1.566         0.510
Continuity Error (%) .....         0.504
```

```
***************************
Subcatchment Runoff Summary
***************************
```

Subcatchment	Total Precip in	Total Runon in	Total Evap in	Total Infil in	Total Runoff in	Peak Runoff CFS	Runoff Coeff
Drive1	6.000	27.369	0.031	0.000	33.293	0.08	0.998
Drive10	6.000	27.369	0.031	0.000	33.293	0.08	0.998
Drive11	6.000	27.369	0.031	0.000	33.293	0.08	0.998
Drive12	6.000	27.369	0.031	0.000	33.293	0.08	0.998
Drive13	6.000	27.369	0.031	0.000	33.293	0.08	0.998
Drive14	6.000	27.369	0.031	0.000	33.293	0.08	0.998
Drive15	6.000	27.369	0.031	0.000	33.293	0.08	0.998
Drive16	6.000	27.369	0.031	0.000	33.293	0.08	0.998
Drive17	6.000	27.369	0.031	0.000	33.293	0.08	0.998
Drive18	6.000	27.369	0.031	0.000	33.293	0.08	0.998
Drive19	6.000	27.369	0.031	0.000	33.293	0.08	0.998
Drive2	6.000	27.369	0.031	0.000	33.293	0.08	0.998
Drive20	6.000	27.369	0.031	0.000	33.293	0.08	0.998
Drive3	6.000	27.369	0.031	0.000	33.293	0.08	0.998
Drive4	6.000	27.369	0.031	0.000	33.293	0.08	0.998
Drive5	6.000	27.369	0.031	0.000	33.293	0.08	0.998
Drive6	6.000	27.369	0.031	0.000	33.293	0.08	0.998
Drive7	6.000	27.369	0.031	0.000	33.293	0.08	0.998
Drive8	6.000	27.369	0.031	0.000	33.293	0.08	0.998
Drive9	6.000	27.369	0.031	0.000	33.293	0.08	0.998
LeftWeirVeg	6.000	0.000	0.031	0.900	4.813	0.44	0.802
Lot10On	6.000	0.000	0.031	0.558	5.314	0.04	0.886
Lot11On	6.000	0.000	0.031	0.558	5.309	0.07	0.885
Lot12On	6.000	0.000	0.031	0.558	5.324	0.05	0.887
Lot13On	6.000	0.000	0.031	0.558	5.314	0.05	0.886
Lot14On	6.000	0.000	0.031	0.558	5.309	0.10	0.885
Lot15On	6.000	0.000	0.031	0.558	5.310	0.09	0.885
Lot16On	6.000	0.000	0.031	0.558	5.316	0.04	0.886

Lot17On	6.000	0.000	0.031	0.558	5.315	0.04	0.886
Lot18On	6.000	0.000	0.031	0.558	5.314	0.06	0.886
Lot19On	6.000	0.000	0.031	0.558	5.312	0.07	0.885
Lot1On	6.000	0.000	0.031	0.558	5.314	0.06	0.886
Lot20On	6.000	0.000	0.031	0.558	5.313	0.07	0.885
Lot2On	6.000	0.000	0.031	0.558	5.314	0.05	0.886
Lot3On	6.000	0.000	0.031	0.558	5.315	0.05	0.886
Lot7On	6.000	0.000	0.031	0.558	5.309	0.07	0.885
Lot8On	6.000	0.000	0.031	0.558	5.314	0.04	0.886
Lot9On	6.000	0.000	0.031	0.558	5.315	0.03	0.886
LWPave	6.000	0.000	0.031	0.000	5.949	0.18	0.992
R1	6.000	0.000	0.031	0.000	5.949	0.27	0.991
R2	6.000	0.000	0.031	0.000	5.949	0.09	0.991
R3	6.000	0.000	0.031	0.000	5.949	0.12	0.992
RightWeirVeg	6.000	0.000	0.031	0.900	4.851	0.38	0.808
Roof1	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof10	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof11	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof12	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof13	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof14	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof15	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof16	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof17	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof18	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof19	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof2	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof20	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof3	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof4	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof5	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof6	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof7	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof8	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof9	6.000	0.000	0.031	0.000	5.950	0.07	0.992
RWPave	6.000	0.000	0.031	0.000	5.950	0.02	0.992
TrenchPave	6.000	0.000	0.031	0.000	5.948	0.36	0.991
R4	6.000	0.000	0.031	0.000	5.949	0.12	0.992
R5	6.000	0.000	0.031	0.000	5.948	0.36	0.991
System	6.000	1.625	0.031	0.262	7.259	6.44	0.952

****
Node Depth Summary
****

	Average Depth	Maximum Depth	Maximum HGL	Time of Max Occurrence	Total Flooding	Total Minutes

Node	Type	Feet	Feet	Feet	days	hr:min	acre-in	Flooded
CB#69	JUNCTION	4.11	4.33	81.33	0	12:11	0	0
CB#70	JUNCTION	0.98	2.08	80.08	1	00:00	0	0
CB#68	JUNCTION	0.00	0.00	88.99	0	00:00	0	0
CB#40	JUNCTION	3.21	3.41	99.82	0	11:30	0	0
DMH#81	JUNCTION	0.14	0.26	99.46	0	13:00	0	0
DMH#4	JUNCTION	0.00	0.01	98.41	0	12:29	0	0
27	OUTFALL	0.00	0.00	0.00	0	00:00	0	0
1	STORAGE	4.24	6.28	80.08	1	00:00	0	0
Pond_Three	STORAGE	1.24	1.95	71.95	1	00:00	0	0

****
Node Flow Summary
****

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days hr:min	Maximum Flooding Overflow CFS	Time of Max Occurrence days hr:min
CB#69	JUNCTION	0.99	0.99	0 12:59	0.00	
CB#70	JUNCTION	1.69	1.69	0 12:59	0.00	
CB#68	JUNCTION	0.58	0.58	0 12:59	0.00	
CB#40	JUNCTION	0.39	0.39	0 12:59	0.00	
DMH#81	JUNCTION	0.00	0.39	0 11:31	0.00	
DMH#4	JUNCTION	0.40	0.79	0 12:59	0.00	
27	OUTFALL	0.00	0.00	0 00:00	0.00	
1	STORAGE	0.00	4.05	0 12:59	0.00	
Pond_Three	STORAGE	1.00	1.00	0 12:59	0.00	

****
Storage Volume Summary
****

Storage Unit	Average Volume 1000 ft3	Avg Pcnt Full	Maximum Volume 1000 ft3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CFS
1	25.810	13	54.284	28	1 00:00	0.00
Pond_Three	6.772	8	13.785	16	1 00:00	0.00

****
Outfall Loading Summary
****

Outfall Node	Flow Freq. Pcnt.	Avg. Flow CFS	Max. Flow CFS
27	0.00	0.00	0.00
System	0.00	0.00	0.00

****
Link Flow Summary
****

Link	Type	Maximum Flow CFS	Time of Max Occurrence days	Time of Max Occurrence hr:min	Maximum Velocity ft/sec	Max/ Full Flow	Max/ Full Depth	Total Minutes Surcharged
3	CONDUIT	1.69	0	12:59	2.87	0.30	1.00	707
6	CONDUIT	0.39	0	11:31	2.11	0.15	0.28	0
7	DUMMY	0.79	0	12:59				
8	CONDUIT	0.38	0	12:30	2.87	0.08	0.22	0
9	CONDUIT	0.01	0	12:29	0.42	0.00	0.13	0
10	CONDUIT	0.99	0	12:59	4.46	0.21	0.65	0
11	DUMMY	0.58	0	12:59				

****
Flow Classification Summary
****

Conduit	Adjusted /Actual Length	--- Fraction of Time in Flow Class ---- Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Avg. Froude Number	Avg. Flow Change
3	1.00	0.00	0.00	0.00	0.87	0.00	0.00	0.12	0.41	0.0001
6	1.00	0.04	0.00	0.00	0.96	0.00	0.00	0.00	0.67	0.0001
8	1.00	0.04	0.00	0.00	0.00	0.00	0.00	0.96	1.05	0.0000
9	1.00	0.04	0.00	0.00	0.96	0.00	0.00	0.00	0.14	0.0000
10	1.00	0.03	0.00	0.00	0.47	0.04	0.00	0.46	0.78	0.0001

****
Highest Continuity Errors
****
Node DMH#81 (0.08%)
Node DMH#4 (0.00%)

```
***************************
Time-Step Critical Elements
***************************
Link 8 (41.61%)
Link 3 (14.05%)
Link 6 (2.42%)


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     3.25 sec
Average Time Step           :    16.35 sec
Maximum Time Step           :    30.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00


Analysis begun on:  Wed Feb 25 18:06:30 2009
Total elapsed time: < 1 sec
```

Cluster Only Subdivision

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.009)
--------------------------------------------------------------

Cluster Only Subdivision
100-year, 24-hour Design Storm Results

****************
Analysis Options
****************
Flow Units ............... CFS
Infiltration Method ...... GREEN_AMPT
Flow Routing Method ...... DYNWAVE
Starting Date ............ JAN-01-2008 00:00:00
Ending Date .............. JAN-02-2008 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:05:00
Wet Time Step ............ 00:15:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 30.00 sec


*********************
Rainfall File Summary
*********************
Station    First        Last          Recording   Periods    Periods    Periods
ID         Date         Date          Frequency    w/Rain    Missing    Malfunc.
-------------------------------------------------------------------------------
STA02      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA10      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA25      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA50      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA100     JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA08      JAN-01-2008  JAN-01-2008     60 min        24          0          0


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         2.035         7.250
Evaporation Loss .........         0.009         0.031
Infiltration Loss ........         0.074         0.265
Surface Runoff ...........         1.931         6.878
Final Surface Storage ....         0.023         0.083
Continuity Error (%) .....        -0.102


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      Mgallons
**************************     ---------     ---------
```

```
Dry Weather Inflow .......         0.000          0.000
Wet Weather Inflow .......         1.925          0.627
Groundwater Inflow .......         0.000          0.000
RDII Inflow ..............         0.000          0.000
External Inflow ..........         0.000          0.000
External Outflow .........         0.000          0.000
Surface Flooding .........         0.000          0.000
Evaporation Loss .........         0.001          0.000
Initial Stored Volume ....         0.000          0.000
Final Stored Volume ......         1.915          0.624
Continuity Error (%) .....         0.452
```

****
Subcatchment Runoff Summary
****

Subcatchment	Total Precip in	Total Runon in	Total Evap in	Total Infil in	Total Runoff in	Peak Runoff CFS	Runoff Coeff
Drive1	7.250	33.131	0.031	0.000	40.299	0.10	0.998
Drive10	7.250	33.131	0.031	0.000	40.299	0.10	0.998
Drive11	7.250	33.131	0.031	0.000	40.298	0.10	0.998
Drive12	7.250	33.131	0.031	0.000	40.299	0.10	0.998
Drive13	7.250	33.131	0.031	0.000	40.299	0.10	0.998
Drive14	7.250	33.131	0.031	0.000	40.299	0.10	0.998
Drive15	7.250	33.131	0.031	0.000	40.299	0.10	0.998
Drive16	7.250	33.131	0.031	0.000	40.299	0.10	0.998
Drive17	7.250	33.131	0.031	0.000	40.299	0.10	0.998
Drive18	7.250	33.131	0.031	0.000	40.299	0.10	0.998
Drive19	7.250	33.131	0.031	0.000	40.299	0.10	0.998
Drive2	7.250	33.131	0.031	0.000	40.299	0.10	0.998
Drive20	7.250	33.131	0.031	0.000	40.299	0.10	0.998
Drive3	7.250	33.131	0.031	0.000	40.299	0.10	0.998
Drive4	7.250	33.131	0.031	0.000	40.299	0.10	0.998
Drive5	7.250	33.131	0.031	0.000	40.299	0.10	0.998
Drive6	7.250	33.131	0.031	0.000	40.299	0.10	0.998
Drive7	7.250	33.131	0.031	0.000	40.299	0.10	0.998
Drive8	7.250	33.131	0.031	0.000	40.299	0.10	0.998
Drive9	7.250	33.131	0.031	0.000	40.299	0.10	0.998
LeftWeirVeg	7.250	0.000	0.031	0.912	6.026	0.53	0.831
Lot10On	7.250	0.000	0.031	0.565	6.558	0.05	0.904
Lot11On	7.250	0.000	0.031	0.565	6.552	0.09	0.904
Lot12On	7.250	0.000	0.031	0.565	6.558	0.06	0.905
Lot13On	7.250	0.000	0.031	0.565	6.558	0.07	0.905
Lot14On	7.250	0.000	0.031	0.565	6.551	0.12	0.904
Lot15On	7.250	0.000	0.031	0.565	6.553	0.11	0.904
Lot16On	7.250	0.000	0.031	0.565	6.559	0.05	0.905

Lot17On	7.250	0.000	0.031	0.565	6.559	0.05	0.905
Lot18On	7.250	0.000	0.031	0.565	6.557	0.07	0.904
Lot19On	7.250	0.000	0.031	0.565	6.556	0.09	0.904
Lot1On	7.250	0.000	0.031	0.565	6.558	0.07	0.905
Lot20On	7.250	0.000	0.031	0.565	6.557	0.08	0.904
Lot2On	7.250	0.000	0.031	0.565	6.558	0.06	0.905
Lot3On	7.250	0.000	0.031	0.565	6.559	0.06	0.905
Lot7On	7.250	0.000	0.031	0.565	6.552	0.09	0.904
Lot8On	7.250	0.000	0.031	0.565	6.558	0.05	0.904
Lot9On	7.250	0.000	0.031	0.565	6.559	0.04	0.905
LWPave	7.250	0.000	0.031	0.000	7.203	0.22	0.993
R1	7.250	0.000	0.031	0.000	7.203	0.33	0.994
R2	7.250	0.000	0.031	0.000	7.203	0.11	0.994
R3	7.250	0.000	0.031	0.000	7.203	0.14	0.994
RightWeirVeg	7.250	0.000	0.031	0.912	6.072	0.47	0.838
Roof1	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof10	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof11	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof12	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof13	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof14	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof15	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof16	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof17	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof18	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof19	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof2	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof20	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof3	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof4	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof5	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof6	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof7	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof8	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof9	7.250	0.000	0.031	0.000	7.202	0.08	0.993
RWPave	7.250	0.000	0.031	0.000	7.201	0.03	0.993
TrenchPave	7.250	0.000	0.031	0.000	7.200	0.44	0.993
R4	7.250	0.000	0.031	0.000	7.203	0.15	0.993
R5	7.250	0.000	0.031	0.000	7.201	0.44	0.993
System	7.250	1.967	0.031	0.265	8.845	7.83	0.960

****
Node Depth Summary
****

	Average Depth	Maximum Depth	Maximum HGL	Time of Max Occurrence	Total Flooding	Total Minutes

Node	Type	Feet	Feet	Feet	days	hr:min	acre-in	Flooded
CB#69	JUNCTION	4.15	4.36	81.36	0	11:52	0	0
CB#70	JUNCTION	1.31	2.53	80.53	1	00:00	0	0
CB#68	JUNCTION	0.00	0.00	88.99	0	00:00	0	0
CB#40	JUNCTION	3.24	3.44	99.85	0	11:30	0	0
DMH#81	JUNCTION	0.16	0.29	99.49	0	12:40	0	0
DMH#4	JUNCTION	0.00	0.01	98.41	0	12:37	0	0
27	OUTFALL	0.00	0.00	0.00	0	00:00	0	0
1	STORAGE	4.61	6.73	80.53	1	00:00	0	0
Pond_Three	STORAGE	1.38	2.15	72.15	1	00:00	0	0

****
Node Flow Summary
****

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days hr:min	Maximum Flooding Overflow CFS	Time of Max Occurrence days hr:min
CB#69	JUNCTION	1.21	1.21	0 13:00	0.00	
CB#70	JUNCTION	2.05	2.05	0 13:00	0.00	
CB#68	JUNCTION	0.71	0.71	0 13:00	0.00	
CB#40	JUNCTION	0.47	0.47	0 12:44	0.00	
DMH#81	JUNCTION	0.00	0.47	0 12:46	0.00	
DMH#4	JUNCTION	0.49	0.96	0 13:00	0.00	
27	OUTFALL	0.00	0.00	0 00:00	0.00	
1	STORAGE	0.00	4.93	0 13:00	0.00	
Pond_Three	STORAGE	1.21	1.21	0 12:42	0.00	

****
Storage Volume Summary
****

Storage Unit	Average Volume 1000 ft3	Avg Pcnt Full	Maximum Volume 1000 ft3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CFS
1	31.756	16	66.445	34	1 00:00	0.00
Pond_Three	8.277	10	16.799	20	1 00:00	0.00

****
Outfall Loading Summary
****

Outfall Node	Flow Freq. Pcnt.	Avg. Flow CFS	Max. Flow CFS
27	0.00	0.00	0.00
System	0.00	0.00	0.00

****
Link Flow Summary
****

Link	Type	Maximum Flow CFS	Time of Max Occurrence days	hr:min	Maximum Velocity ft/sec	Max/ Full Flow	Max/ Full Depth	Total Minutes Surcharged
3	CONDUIT	2.05	0	12:59	2.86	0.36	1.00	735
6	CONDUIT	0.47	0	12:46	2.20	0.18	0.32	0
7	DUMMY	0.96	0	13:00				
8	CONDUIT	0.46	0	12:36	2.98	0.10	0.25	0
9	CONDUIT	0.01	0	12:39	0.57	0.00	0.15	0
10	CONDUIT	1.20	0	13:00	4.64	0.25	0.67	0
11	DUMMY	0.71	0	13:00				

****
Flow Classification Summary
****

Conduit	Adjusted /Actual Length	--- Fraction of Time in Flow Class ---- Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Avg. Froude Number	Avg. Flow Change
3	1.00	0.00	0.00	0.00	0.89	0.00	0.00	0.10	0.41	0.0001
6	1.00	0.03	0.00	0.00	0.97	0.00	0.00	0.00	0.66	0.0001
8	1.00	0.03	0.00	0.00	0.00	0.00	0.00	0.97	1.05	0.0000
9	1.00	0.03	0.00	0.00	0.97	0.00	0.00	0.00	0.12	0.0000
10	1.00	0.02	0.00	0.00	0.54	0.03	0.00	0.40	0.74	0.0001

****
Highest Continuity Errors
****

Node DMH#81 (0.08%)
Node DMH#4 (0.00%)

Cluster Only Subdivision

```
***************************
Time-Step Critical Elements
***************************
Link 8 (43.59%)
Link 3 (15.87%)
Link 6 (2.03%)


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     3.10 sec
Average Time Step           :    15.54 sec
Maximum Time Step           :    30.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00


Analysis begun on:  Wed Feb 25 18:17:27 2009
Total elapsed time: 00:00:01
```

ATTACHMENT 14

SWMM Conventional Subdivision Model Results

Conventional Subdivison

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.009)
--------------------------------------------------------------

Conventional Subdivison
2-year, 24-hour Design Storm

****************
Analysis Options
****************
Flow Units ............... CFS
Infiltration Method ...... GREEN_AMPT
Flow Routing Method ...... DYNWAVE
Starting Date ............ JAN-01-2008 00:00:00
Ending Date .............. JAN-02-2008 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:05:00
Wet Time Step ............ 00:15:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 30.00 sec


*********************
Rainfall File Summary
*********************
Station    First        Last         Recording   Periods    Periods    Periods
ID         Date         Date         Frequency    w/Rain    Missing    Malfunc.
-------------------------------------------------------------------------------
STA02      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA10      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA25      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA50      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA100     JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA08      JAN-01-2008  JAN-01-2008     60 min        24          0          0


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         4.864         3.000
Evaporation Loss .........         0.051         0.031
Infiltration Loss ........         1.152         0.710
Surface Runoff ...........         3.231         1.993
Final Surface Storage ....         0.430         0.265
Continuity Error (%) .....         0.005


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      Mgallons
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         3.214         1.047
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.000         0.000
Surface Flooding .........         0.000         0.000
Evaporation Loss .........         0.001         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         3.208         1.045
Continuity Error (%) .....         0.126


***************************
Subcatchment Runoff Summary
***************************

--------------------------------------------------------------------------------------
                         Total      Total      Total      Total      Total       Peak     Runoff
                        Precip      Runon       Evap      Infil     Runoff     Runoff      Coeff
Subcatchment                in         in         in         in         in        CFS
```

Conventional Subdivison

Drive1	3.000	0.000	0.031	0.000	2.950	0.02	0.983
Drive10	3.000	0.000	0.031	0.000	2.949	0.02	0.983
Drive11	3.000	0.000	0.031	0.000	2.950	0.02	0.983
Drive12	3.000	0.000	0.031	0.000	2.949	0.02	0.983
Drive13	3.000	0.000	0.031	0.000	2.949	0.02	0.983
Drive14	3.000	0.000	0.031	0.000	2.950	0.02	0.983
Drive15	3.000	0.000	0.031	0.000	2.949	0.02	0.983
Drive16	3.000	0.000	0.031	0.000	2.949	0.02	0.983
Drive17	3.000	0.000	0.031	0.000	2.949	0.02	0.983
Drive18	3.000	0.000	0.031	0.000	2.949	0.02	0.983
Drive19	3.000	0.000	0.031	0.000	2.949	0.02	0.983
Drive2	3.000	0.000	0.031	0.000	2.949	0.02	0.983
Drive20	3.000	0.000	0.031	0.000	2.949	0.02	0.983
Drive3	3.000	0.000	0.031	0.000	2.949	0.02	0.983
Drive4	3.000	6.118	0.031	0.000	9.060	0.05	0.994
Drive5	3.000	6.118	0.031	0.000	9.060	0.05	0.994
Drive6	3.000	6.118	0.031	0.000	9.060	0.05	0.994
Drive7	3.000	0.000	0.031	0.000	2.949	0.02	0.983
Drive8	3.000	0.000	0.031	0.000	2.950	0.02	0.983
Drive9	3.000	0.000	0.031	0.000	2.950	0.02	0.983
LeftWeirVeg	3.000	0.000	0.031	0.517	2.321	0.21	0.774
Lot10On	3.000	0.193	0.031	0.796	2.036	0.50	0.638
Lot11On	3.000	0.193	0.031	0.796	2.036	0.50	0.638
Lot12On	3.000	0.135	0.031	0.796	2.025	0.55	0.646
Lot13On	3.000	0.135	0.031	0.796	2.025	0.55	0.646
Lot14On	3.000	0.135	0.031	0.796	2.025	0.55	0.646
Lot15On	3.000	0.135	0.031	0.796	2.025	0.55	0.646
Lot16On	3.000	0.135	0.031	0.796	2.025	0.55	0.646
Lot17On	3.000	0.135	0.031	0.796	2.025	0.55	0.646
Lot18On	3.000	0.135	0.031	0.796	2.025	0.55	0.646
Lot19On	3.000	0.135	0.031	0.796	2.025	0.55	0.646
Lot1On	3.000	0.135	0.031	0.796	2.039	0.57	0.650
Lot20On	3.000	0.135	0.031	0.796	2.025	0.55	0.646
Lot2On	3.000	0.135	0.031	0.796	2.025	0.55	0.646
Lot3On	3.000	0.135	0.031	0.796	2.025	0.55	0.646
Lot7On	3.000	0.135	0.031	0.796	1.980	0.49	0.632
Lot8On	3.000	0.135	0.031	0.796	1.980	0.49	0.632
Lot9On	3.000	0.193	0.031	0.796	2.036	0.50	0.638
LWPave	3.000	0.000	0.031	0.000	2.949	0.06	0.983
R1	3.000	0.000	0.031	0.000	2.949	0.14	0.983
R2	3.000	0.000	0.031	0.000	2.949	0.03	0.983
R3	3.000	0.000	0.031	0.000	2.949	0.05	0.983
RightWeirVeg	3.000	0.000	0.031	0.517	2.336	0.19	0.779
Roof1	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof10	3.000	1.263	0.031	0.000	4.200	0.05	0.985
Roof11	3.000	1.263	0.031	0.000	4.200	0.05	0.985
Roof12	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof13	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof14	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof15	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof16	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof17	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof18	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof19	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof2	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof20	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof3	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof4	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof5	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof6	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof7	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof8	3.000	0.000	0.031	0.000	2.936	0.03	0.979
Roof9	3.000	1.264	0.031	0.000	4.200	0.05	0.985
RWPave	3.000	0.000	0.031	0.000	2.949	0.07	0.983
R4	3.000	0.000	0.031	0.000	2.949	0.06	0.983
System	3.000	0.156	0.031	0.710	2.151	11.01	0.681

****

Conventional Subdivison

Node Depth Summary
****

Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum HGL Feet	Time of Max Occurrence days hr:min	Total Flooding acre-in	Total Minutes Flooded
CB#70	JUNCTION	7.15	8.53	90.81	1 00:00	0	0
CB#68	JUNCTION	0.00	0.00	88.99	0 00:00	0	0
CB#40	JUNCTION	3.32	3.67	100.08	0 13:00	0	0
DMH#81	JUNCTION	0.26	0.57	99.77	0 13:00	0	0
DMH#4	JUNCTION	0.04	0.07	98.47	0 13:00	0	0
25	JUNCTION	0.00	0.00	72.00	0 00:00	0	0
32	OUTFALL	0.00	0.00	0.00	0 00:00	0	0
33	OUTFALL	0.00	0.00	0.00	0 00:00	0	0
1	STORAGE	4.98	6.81	90.81	1 00:00	0	0
Pond3	STORAGE	1.86	3.16	73.16	1 00:00	0	0

****
Node Flow Summary
****

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days hr:min	Maximum Flooding Overflow CFS	Time of Max Occurrence days hr:min
CB#70	JUNCTION	3.63	3.63	0 12:59	0.00	
CB#68	JUNCTION	1.70	1.70	0 12:59	0.00	
CB#40	JUNCTION	1.18	1.18	0 12:59	0.00	
DMH#81	JUNCTION	0.00	1.18	0 13:00	0.00	
DMH#4	JUNCTION	0.41	1.59	0 12:59	0.00	
25	JUNCTION	2.96	2.96	0 12:59	0.00	
32	OUTFALL	0.00	0.00	0 00:00	0.00	
33	OUTFALL	0.00	0.00	0 00:00	0.00	
1	STORAGE	0.33	7.25	0 12:59	0.00	
Pond3	STORAGE	0.00	2.96	0 12:59	0.00	

****
Storage Volume Summary
****

Storage Unit	Average Volume 1000 ft3	Avg Pcnt Full	Maximum Volume 1000 ft3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CFS
1	53.488	16	100.029	29	1 00:00	0.00
Pond3	21.403	12	39.682	22	1 00:00	0.00

****
Outfall Loading Summary
****

Outfall Node	Flow Freq. Pcnt.	Avg. Flow CFS	Max. Flow CFS
32	0.00	0.00	0.00
33	0.00	0.00	0.00
System	0.00	0.00	0.00

****

Conventional Subdivison

Link Flow Summary
****

Link	Type	Maximum Flow CFS	Time of Max Occurrence days hr:min	Maximum Velocity ft/sec	Max/ Full Flow	Max/ Full Depth	Total Minutes Surcharged
3	CONDUIT	3.63	0 13:00	4.62	0.58	1.00	720
6	CONDUIT	1.18	0 13:00	2.54	0.45	0.57	0
7	DUMMY	1.59	0 12:59				
8	CONDUIT	1.18	0 13:00	3.38	0.26	0.46	0
ToPond3	DUMMY	2.96	0 12:59				
15	DUMMY	1.70	0 12:59				

****
Flow Classification Summary
****

Conduit	Adjusted /Actual Length	--- Fraction of Time in Flow Class ---- Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Avg. Froude Number	Avg. Flow Change
3	1.00	0.03	0.00	0.00	0.89	0.00	0.00	0.08	0.47	0.0001
6	1.00	0.03	0.00	0.00	0.97	0.00	0.00	0.00	0.66	0.0001
8	1.00	0.03	0.00	0.00	0.00	0.00	0.00	0.97	1.01	0.0000

****
Highest Continuity Errors
****
Node DMH#81 (0.02%)
Node DMH#4 (0.00%)

****
Time-Step Critical Elements
****
Link 8 (62.67%)
Link 3 (22.71%)

****
Routing Time Step Summary
****
```
Minimum Time Step           :     2.50 sec
Average Time Step           :     7.56 sec
Maximum Time Step           :    30.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00
```

Analysis begun on: Mon May 11 11:09:05 2009
Total elapsed time: < 1 sec

Conventional Subdivison

EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.009)

Conventional Subdivison
10-year, 24-hour Design Storm

```
****************
Analysis Options
****************
Flow Units ............... CFS
Infiltration Method ...... GREEN_AMPT
Flow Routing Method ...... DYNWAVE
Starting Date ............ JAN-01-2008 00:00:00
Ending Date .............. JAN-02-2008 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:05:00
Wet Time Step ............ 00:15:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 30.00 sec
```

```
*********************
Rainfall File Summary
*********************
```

Station ID	First Date	Last Date	Recording Frequency	Periods w/Rain	Periods Missing	Periods Malfunc.
STA02	JAN-01-2008	JAN-01-2008	60 min	24	0	0
STA10	JAN-01-2008	JAN-01-2008	60 min	24	0	0
STA25	JAN-01-2008	JAN-01-2008	60 min	24	0	0
STA50	JAN-01-2008	JAN-01-2008	60 min	24	0	0
STA100	JAN-01-2008	JAN-01-2008	60 min	24	0	0
STA08	JAN-01-2008	JAN-01-2008	60 min	24	0	0

Runoff Quantity Continuity	Volume acre-feet	Depth inches
Total Precipitation	7.296	4.500
Evaporation Loss	0.051	0.031
Infiltration Loss	1.211	0.747
Surface Runoff	5.520	3.405
Final Surface Storage	0.518	0.320
Continuity Error (%)	-0.060	

Flow Routing Continuity	Volume acre-feet	Volume Mgallons
Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	5.504	1.794
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.000	0.000
External Outflow	0.000	0.000
Surface Flooding	0.000	0.000
Evaporation Loss	0.002	0.001
Initial Stored Volume	0.000	0.000
Final Stored Volume	5.499	1.792
Continuity Error (%)	0.069	

```
***************************
Subcatchment Runoff Summary
***************************
```

Subcatchment	Total Precip in	Total Runon in	Total Evap in	Total Infil in	Total Runoff in	Peak Runoff CFS	Runoff Coeff

Conventional Subdivison

Drive1	4.500	0.000	0.031	0.000	4.450	0.02	0.989
Drive10	4.500	0.000	0.031	0.000	4.450	0.02	0.989
Drive11	4.500	0.000	0.031	0.000	4.450	0.02	0.989
Drive12	4.500	0.000	0.031	0.000	4.450	0.02	0.989
Drive13	4.500	0.000	0.031	0.000	4.450	0.02	0.989
Drive14	4.500	0.000	0.031	0.000	4.450	0.02	0.989
Drive15	4.500	0.000	0.031	0.000	4.450	0.02	0.989
Drive16	4.500	0.000	0.031	0.000	4.450	0.02	0.989
Drive17	4.500	0.000	0.031	0.000	4.450	0.02	0.989
Drive18	4.500	0.000	0.031	0.000	4.450	0.02	0.989
Drive19	4.500	0.000	0.031	0.000	4.450	0.02	0.989
Drive2	4.500	0.000	0.031	0.000	4.450	0.02	0.989
Drive20	4.500	0.000	0.031	0.000	4.450	0.02	0.989
Drive3	4.500	0.000	0.031	0.000	4.450	0.02	0.989
Drive4	4.500	9.307	0.031	0.000	13.747	0.08	0.996
Drive5	4.500	9.307	0.031	0.000	13.747	0.08	0.996
Drive6	4.500	9.307	0.031	0.000	13.747	0.08	0.996
Drive7	4.500	0.000	0.031	0.000	4.450	0.02	0.989
Drive8	4.500	0.000	0.031	0.000	4.450	0.02	0.989
Drive9	4.500	0.000	0.031	0.000	4.450	0.02	0.989
LeftWeirVeg	4.500	0.000	0.031	0.544	3.771	0.32	0.838
Lot10On	4.500	0.301	0.031	0.837	3.534	0.90	0.736
Lot11On	4.500	0.301	0.031	0.837	3.534	0.90	0.736
Lot12On	4.500	0.205	0.031	0.837	3.497	0.95	0.743
Lot13On	4.500	0.205	0.031	0.837	3.497	0.95	0.743
Lot14On	4.500	0.205	0.031	0.837	3.497	0.95	0.743
Lot15On	4.500	0.205	0.031	0.837	3.497	0.95	0.743
Lot16On	4.500	0.205	0.031	0.837	3.497	0.95	0.743
Lot17On	4.500	0.205	0.031	0.837	3.497	0.95	0.743
Lot18On	4.500	0.205	0.031	0.837	3.497	0.95	0.743
Lot19On	4.500	0.205	0.031	0.837	3.497	0.95	0.743
Lot1On	4.500	0.205	0.031	0.837	3.514	0.98	0.747
Lot20On	4.500	0.205	0.031	0.837	3.497	0.95	0.743
Lot2On	4.500	0.205	0.031	0.837	3.497	0.95	0.743
Lot3On	4.500	0.205	0.031	0.837	3.497	0.95	0.743
Lot7On	4.500	0.205	0.031	0.837	3.442	0.88	0.732
Lot8On	4.500	0.205	0.031	0.837	3.442	0.88	0.732
Lot9On	4.500	0.301	0.031	0.837	3.534	0.90	0.736
LWPave	4.500	0.000	0.031	0.000	4.449	0.09	0.989
R1	4.500	0.000	0.031	0.000	4.449	0.20	0.989
R2	4.500	0.000	0.031	0.000	4.449	0.05	0.989
R3	4.500	0.000	0.031	0.000	4.449	0.07	0.989
RightWeirVeg	4.500	0.000	0.031	0.544	3.791	0.29	0.842
Roof1	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof10	4.500	2.082	0.031	0.000	6.532	0.08	0.992
Roof11	4.500	2.082	0.031	0.000	6.532	0.08	0.992
Roof12	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof13	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof14	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof15	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof16	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof17	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof18	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof19	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof2	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof20	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof3	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof4	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof5	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof6	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof7	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof8	4.500	0.000	0.031	0.000	4.450	0.05	0.989
Roof9	4.500	2.082	0.031	0.000	6.532	0.08	0.993
RWPave	4.500	0.000	0.031	0.000	4.449	0.10	0.989
R4	4.500	0.000	0.031	0.000	4.449	0.09	0.989
System	4.500	0.240	0.031	0.747	3.645	18.90	0.769

****

Conventional Subdivison

Node Depth Summary
****

Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum HGL Feet	Time of Max Occurrence days hr:min	Total Flooding acre-in	Total Minutes Flooded
CB#70	JUNCTION	8.62	11.01	93.29	0 13:00	0	0
CB#68	JUNCTION	0.00	0.00	88.99	0 00:00	0	0
CB#40	JUNCTION	3.45	4.01	100.42	0 13:00	0	0
DMH#81	JUNCTION	0.35	0.87	100.07	0 13:00	0	0
DMH#4	JUNCTION	0.05	0.08	98.48	0 13:00	0	0
25	JUNCTION	0.00	0.00	72.00	0 00:00	0	0
32	OUTFALL	0.00	0.00	0.00	0 00:00	0	0
33	OUTFALL	0.00	0.00	0.00	0 00:00	0	0
1	STORAGE	6.12	8.00	92.00	1 00:00	0	0
Pond3	STORAGE	3.01	4.79	74.79	1 00:00	0	0

****
Node Flow Summary
****

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days hr:min	Maximum Flooding Overflow CFS	Time of Max Occurrence days hr:min
CB#70	JUNCTION	6.46	6.46	0 13:00	0.00	
CB#68	JUNCTION	2.95	2.95	0 13:00	0.00	
CB#40	JUNCTION	2.05	2.05	0 13:00	0.00	
DMH#81	JUNCTION	0.00	2.04	0 13:00	0.00	
DMH#4	JUNCTION	0.62	2.66	0 13:00	0.00	
25	JUNCTION	5.12	5.12	0 13:00	0.00	
32	OUTFALL	0.00	0.00	0 00:00	0.00	
33	OUTFALL	0.00	0.00	0 00:00	0.00	
1	STORAGE	0.51	12.59	0 13:00	0.00	
Pond3	STORAGE	0.00	5.12	0 13:00	0.00	

****
Storage Volume Summary
****

Storage Unit	Average Volume 1000 ft3	Avg Pcnt Full	Maximum Volume 1000 ft3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CFS
1	99.311	29	171.466	50	1 00:00	0.00
Pond3	39.703	22	68.022	38	1 00:00	0.00

****
Outfall Loading Summary
****

Outfall Node	Flow Freq. Pcnt.	Avg. Flow CFS	Max. Flow CFS
32	0.00	0.00	0.00
33	0.00	0.00	0.00
System	0.00	0.00	0.00

****

Conventional Subdivison

Link Flow Summary
****

Link	Type	Maximum Flow CFS	Time of Max Occurrence days hr:min	Maximum Velocity ft/sec	Max/ Full Flow	Max/ Full Depth	Total Minutes Surcharged
3	CONDUIT	6.46	0 13:00	8.23	1.03	1.00	760
6	CONDUIT	2.04	0 13:00	2.75	0.78	0.90	0
7	DUMMY	2.66	0 13:00				
8	CONDUIT	2.04	0 13:00	3.66	0.44	0.67	0
ToPond3	DUMMY	5.12	0 13:00				
15	DUMMY	2.95	0 13:00				

****
Flow Classification Summary
****

Conduit	Adjusted /Actual Length	--- Fraction of Time in Flow Class ---- Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Avg. Froude Number	Avg. Flow Change
3	1.00	0.01	0.00	0.00	0.76	0.17	0.00	0.06	0.59	0.0001
6	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.64	0.0001
8	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.99	0.0001

****
Highest Continuity Errors
****
Node DMH#81 (0.02%)
Node DMH#4 (0.00%)

****
Time-Step Critical Elements
****
Link 8 (66.72%)
Link 3 (24.93%)

****
Routing Time Step Summary
****
Minimum Time Step : 2.11 sec
Average Time Step : 5.81 sec
Maximum Time Step : 30.00 sec
Percent in Steady State : 0.00
Average Iterations per Step : 2.00

Analysis begun on: Tue Mar 10 16:24:15 2009
Total elapsed time: 00:00:01

Conventional Subdivison

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.009)
--------------------------------------------------------------

Conventional Subdivison
25-year, 24-hour Design Storm

****************
Analysis Options
****************
Flow Units ............... CFS
Infiltration Method ...... GREEN_AMPT
Flow Routing Method ...... DYNWAVE
Starting Date ............ JAN-01-2008 00:00:00
Ending Date .............. JAN-02-2008 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:05:00
Wet Time Step ............ 00:15:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 30.00 sec


*********************
Rainfall File Summary
*********************
Station    First        Last         Recording   Periods    Periods    Periods
ID         Date         Date         Frequency    w/Rain    Missing    Malfunc.
-------------------------------------------------------------------------------
STA02      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA10      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA25      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA50      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA100     JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA08      JAN-01-2008  JAN-01-2008     60 min        24          0          0


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         8.917         5.500
Evaporation Loss .........         0.051         0.031
Infiltration Loss ........         1.235         0.762
Surface Runoff ...........         7.070         4.361
Final Surface Storage ....         0.567         0.350
Continuity Error (%) .....        -0.066


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      Mgallons
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         7.051         2.298
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.000         0.000
Surface Flooding .........         0.003         0.001
Evaporation Loss .........         0.002         0.001
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         7.044         2.295
Continuity Error (%) .....         0.034


***************************
Subcatchment Runoff Summary
***************************

--------------------------------------------------------------------------------------
                        Total      Total      Total      Total      Total       Peak     Runoff
                       Precip      Runon       Evap      Infil     Runoff     Runoff      Coeff
Subcatchment               in         in         in         in         in        CFS
```

Conventional Subdivison

Drive1	5.500	0.000	0.031	0.000	5.450	0.03	0.991
Drive10	5.500	0.000	0.031	0.000	5.450	0.03	0.991
Drive11	5.500	0.000	0.031	0.000	5.450	0.03	0.991
Drive12	5.500	0.000	0.031	0.000	5.450	0.03	0.991
Drive13	5.500	0.000	0.031	0.000	5.450	0.03	0.991
Drive14	5.500	0.000	0.031	0.000	5.450	0.03	0.991
Drive15	5.500	0.000	0.031	0.000	5.450	0.03	0.991
Drive16	5.500	0.000	0.031	0.000	5.450	0.03	0.991
Drive17	5.500	0.000	0.031	0.000	5.450	0.03	0.991
Drive18	5.500	0.000	0.031	0.000	5.450	0.03	0.991
Drive19	5.500	0.000	0.031	0.000	5.450	0.03	0.991
Drive2	5.500	0.000	0.031	0.000	5.450	0.03	0.991
Drive20	5.500	0.000	0.031	0.000	5.450	0.03	0.991
Drive3	5.500	0.000	0.031	0.000	5.450	0.03	0.991
Drive4	5.500	11.399	0.031	0.000	16.838	0.09	0.996
Drive5	5.500	11.399	0.031	0.000	16.838	0.09	0.996
Drive6	5.500	11.399	0.031	0.000	16.838	0.09	0.996
Drive7	5.500	0.000	0.031	0.000	5.450	0.03	0.991
Drive8	5.500	0.000	0.031	0.000	5.450	0.03	0.991
Drive9	5.500	0.000	0.031	0.000	5.450	0.03	0.991
LeftWeirVeg	5.500	0.000	0.031	0.555	4.748	0.40	0.863
Lot10On	5.500	0.369	0.031	0.854	4.548	1.17	0.775
Lot11On	5.500	0.369	0.031	0.854	4.548	1.17	0.775
Lot12On	5.500	0.251	0.031	0.853	4.495	1.23	0.782
Lot13On	5.500	0.251	0.031	0.853	4.495	1.23	0.782
Lot14On	5.500	0.251	0.031	0.853	4.495	1.23	0.782
Lot15On	5.500	0.251	0.031	0.853	4.495	1.23	0.782
Lot16On	5.500	0.251	0.031	0.853	4.495	1.23	0.782
Lot17On	5.500	0.251	0.031	0.853	4.495	1.23	0.782
Lot18On	5.500	0.251	0.031	0.853	4.495	1.23	0.782
Lot19On	5.500	0.251	0.031	0.853	4.495	1.23	0.782
Lot1On	5.500	0.251	0.031	0.853	4.513	1.25	0.785
Lot20On	5.500	0.251	0.031	0.853	4.495	1.23	0.782
Lot2On	5.500	0.251	0.031	0.853	4.495	1.23	0.782
Lot3On	5.500	0.251	0.031	0.853	4.495	1.23	0.782
Lot7On	5.500	0.251	0.031	0.853	4.435	1.15	0.771
Lot8On	5.500	0.251	0.031	0.853	4.435	1.15	0.771
Lot9On	5.500	0.369	0.031	0.854	4.548	1.17	0.775
LWPave	5.500	0.000	0.031	0.000	5.449	0.11	0.991
R1	5.500	0.000	0.031	0.000	5.449	0.25	0.991
R2	5.500	0.000	0.031	0.000	5.449	0.06	0.991
R3	5.500	0.000	0.031	0.000	5.454	0.09	0.992
RightWeirVeg	5.500	0.000	0.031	0.555	4.771	0.35	0.868
Roof1	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof10	5.500	2.582	0.031	0.000	8.027	0.09	0.993
Roof11	5.500	2.582	0.031	0.000	8.027	0.09	0.993
Roof12	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof13	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof14	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof15	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof16	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof17	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof18	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof19	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof2	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof20	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof3	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof4	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof5	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof6	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof7	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof8	5.500	0.000	0.031	0.000	5.451	0.06	0.991
Roof9	5.500	2.582	0.031	0.000	8.027	0.09	0.993
RWPave	5.500	0.000	0.031	0.000	5.449	0.13	0.991
R4	5.500	0.000	0.031	0.000	5.449	0.11	0.991
System	5.500	0.294	0.031	0.762	4.655	24.22	0.803

****

Conventional Subdivison

Node Depth Summary
****

Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum HGL Feet	Time of Max Occurrence days hr:min	Total Flooding acre-in	Total Minutes Flooded
CB#70	JUNCTION	9.45	13.73	96.01	0 12:59	0	0
CB#68	JUNCTION	0.00	0.00	88.99	0 00:00	0	0
CB#40	JUNCTION	3.53	4.35	100.76	0 12:59	0	0
DMH#81	JUNCTION	0.41	1.00	100.20	0 12:41	0.03	23
DMH#4	JUNCTION	0.06	0.09	98.49	0 12:41	0	0
25	JUNCTION	0.00	0.00	72.00	0 00:00	0	0
32	OUTFALL	0.00	0.00	0.00	0 00:00	0	0
33	OUTFALL	0.00	0.00	0.00	0 00:00	0	0
1	STORAGE	6.59	8.65	92.65	1 00:00	0	0
Pond3	STORAGE	3.61	5.81	75.81	1 00:00	0	0

****
Node Flow Summary
****

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days hr:min	Maximum Flooding Overflow CFS	Time of Max Occurrence days hr:min
CB#70	JUNCTION	8.39	8.39	0 12:59	0.00	
CB#68	JUNCTION	3.80	3.80	0 12:59	0.00	
CB#40	JUNCTION	2.63	2.63	0 12:59	0.00	
DMH#81	JUNCTION	0.00	2.63	0 13:00	0.16	0 13:00
DMH#4	JUNCTION	0.76	3.22	0 12:59	0.00	
25	JUNCTION	6.56	6.56	0 12:59	0.00	
32	OUTFALL	0.00	0.00	0 00:00	0.00	
33	OUTFALL	0.00	0.00	0 00:00	0.00	
1	STORAGE	0.63	16.04	0 12:59	0.00	
Pond3	STORAGE	0.00	6.56	0 12:59	0.00	

****
Storage Volume Summary
****

Storage Unit	Average Volume 1000 ft3	Avg Pcnt Full	Maximum Volume 1000 ft3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CFS
1	126.053	37	219.631	65	1 00:00	0.00
Pond3	50.405	28	87.153	48	1 00:00	0.00

****
Outfall Loading Summary
****

Outfall Node	Flow Freq. Pcnt.	Avg. Flow CFS	Max. Flow CFS
32	0.00	0.00	0.00
33	0.00	0.00	0.00
System	0.00	0.00	0.00

****

Conventional Subdivison

Link Flow Summary
****

Link	Type	Maximum Flow CFS	Time of Max Occurrence days hr:min	Maximum Velocity ft/sec	Max/ Full Flow	Max/ Full Depth	Total Minutes Surcharged
3	CONDUIT	8.39	0 13:00	10.68	1.33	1.00	779
6	CONDUIT	2.63	0 13:00	3.34	1.01	1.00	23
7	DUMMY	3.22	0 12:59				
8	CONDUIT	2.46	0 12:41	3.84	0.54	0.76	0
ToPond3	DUMMY	6.56	0 12:59				
15	DUMMY	3.80	0 12:59				

****
Flow Classification Summary
****

Conduit	Adjusted /Actual Length	--- Fraction of Time in Flow Class ---- Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Avg. Froude Number	Avg. Flow Change
3	1.00	0.01	0.00	0.00	0.69	0.25	0.00	0.05	0.70	0.0002
6	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.64	0.0001
8	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.98	0.0001

****
Highest Continuity Errors
****

Node DMH#81 (0.02%)
Node DMH#4 (0.00%)

****
Time-Step Critical Elements
****

Link 8 (72.46%)
Link 3 (20.96%)

****
Routing Time Step Summary
****

```
Minimum Time Step           :     1.91 sec
Average Time Step           :     5.16 sec
Maximum Time Step           :    30.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00
```

Analysis begun on: Tue Mar 10 16:24:42 2009
Total elapsed time: < 1 sec

Conventional Subdivison

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.009)
--------------------------------------------------------------

Conventional Subdivison
50-year, 24-hour Design Storm

****************
Analysis Options
****************
Flow Units ............... CFS
Infiltration Method ...... GREEN_AMPT
Flow Routing Method ...... DYNWAVE
Starting Date ............ JAN-01-2008 00:00:00
Ending Date .............. JAN-02-2008 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:05:00
Wet Time Step ............ 00:15:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 30.00 sec


*********************
Rainfall File Summary
*********************
Station    First        Last         Recording   Periods    Periods    Periods
ID         Date         Date         Frequency    w/Rain    Missing    Malfunc.
-------------------------------------------------------------------------------
STA02      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA10      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA25      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA50      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA100     JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA08      JAN-01-2008  JAN-01-2008     60 min        24          0          0


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         9.728         6.000
Evaporation Loss .........         0.051         0.031
Infiltration Loss ........         1.240         0.765
Surface Runoff ...........         7.857         4.846
Final Surface Storage ....         0.586         0.361
Continuity Error (%) .....        -0.064


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      Mgallons
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         7.836         2.554
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.000         0.000
Surface Flooding .........         0.018         0.006
Evaporation Loss .........         0.002         0.001
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         7.814         2.546
Continuity Error (%) .....         0.030


***************************
Subcatchment Runoff Summary
***************************

--------------------------------------------------------------------------------------
                        Total      Total      Total      Total      Total       Peak     Runoff
                       Precip      Runon       Evap      Infil     Runoff     Runoff      Coeff
Subcatchment               in         in         in         in         in        CFS
```

Conventional Subdivison

Drive1	6.000	0.000	0.031	0.000	5.950	0.03	0.992
Drive10	6.000	0.000	0.031	0.000	5.950	0.03	0.992
Drive11	6.000	0.000	0.031	0.000	5.950	0.03	0.992
Drive12	6.000	0.000	0.031	0.000	5.950	0.03	0.992
Drive13	6.000	0.000	0.031	0.000	5.950	0.03	0.992
Drive14	6.000	0.000	0.031	0.000	5.950	0.03	0.992
Drive15	6.000	0.000	0.031	0.000	5.950	0.03	0.992
Drive16	6.000	0.000	0.031	0.000	5.950	0.03	0.992
Drive17	6.000	0.000	0.031	0.000	5.950	0.03	0.992
Drive18	6.000	0.000	0.031	0.000	5.950	0.03	0.992
Drive19	6.000	0.000	0.031	0.000	5.950	0.03	0.992
Drive2	6.000	0.000	0.031	0.000	5.950	0.03	0.992
Drive20	6.000	0.000	0.031	0.000	5.950	0.03	0.992
Drive3	6.000	0.000	0.031	0.000	5.950	0.03	0.992
Drive4	6.000	12.441	0.031	0.000	18.379	0.10	0.997
Drive5	6.000	12.441	0.031	0.000	18.379	0.10	0.997
Drive6	6.000	12.441	0.031	0.000	18.379	0.10	0.997
Drive7	6.000	0.000	0.031	0.000	5.950	0.03	0.992
Drive8	6.000	0.000	0.031	0.000	5.950	0.03	0.992
Drive9	6.000	0.000	0.031	0.000	5.950	0.03	0.992
LeftWeirVeg	6.000	0.000	0.031	0.558	5.241	0.44	0.874
Lot10On	6.000	0.403	0.031	0.857	5.064	1.31	0.791
Lot11On	6.000	0.403	0.031	0.857	5.064	1.31	0.791
Lot12On	6.000	0.274	0.031	0.857	5.002	1.37	0.797
Lot13On	6.000	0.274	0.031	0.857	5.002	1.37	0.797
Lot14On	6.000	0.274	0.031	0.857	5.002	1.37	0.797
Lot15On	6.000	0.274	0.031	0.857	5.002	1.37	0.797
Lot16On	6.000	0.274	0.031	0.857	5.002	1.37	0.797
Lot17On	6.000	0.274	0.031	0.857	5.002	1.37	0.797
Lot18On	6.000	0.274	0.031	0.857	5.002	1.37	0.797
Lot19On	6.000	0.274	0.031	0.857	5.002	1.37	0.797
Lot1On	6.000	0.274	0.031	0.857	5.021	1.39	0.800
Lot20On	6.000	0.274	0.031	0.857	5.002	1.37	0.797
Lot2On	6.000	0.274	0.031	0.857	5.002	1.37	0.797
Lot3On	6.000	0.274	0.031	0.857	5.002	1.37	0.797
Lot7On	6.000	0.274	0.031	0.857	4.940	1.28	0.787
Lot8On	6.000	0.274	0.031	0.857	4.940	1.28	0.787
Lot9On	6.000	0.403	0.031	0.857	5.064	1.31	0.791
LWPave	6.000	0.000	0.031	0.000	5.949	0.12	0.992
R1	6.000	0.000	0.031	0.000	5.949	0.27	0.992
R2	6.000	0.000	0.031	0.000	5.949	0.06	0.992
R3	6.000	0.000	0.031	0.000	5.949	0.09	0.992
RightWeirVeg	6.000	0.000	0.031	0.558	5.266	0.39	0.878
Roof1	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof10	6.000	2.819	0.031	0.000	8.763	0.10	0.994
Roof11	6.000	2.820	0.031	0.000	8.763	0.10	0.994
Roof12	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof13	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof14	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof15	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof16	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof17	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof18	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof19	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof2	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof20	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof3	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof4	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof5	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof6	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof7	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof8	6.000	0.000	0.031	0.000	5.950	0.07	0.992
Roof9	6.000	2.819	0.031	0.000	8.763	0.10	0.994
RWPave	6.000	0.000	0.031	0.000	5.949	0.14	0.992
R4	6.000	0.000	0.031	0.000	5.949	0.12	0.992
System	6.000	0.321	0.031	0.765	5.168	26.93	0.818

****

Conventional Subdivison

Node Depth Summary
****

Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum HGL Feet	Time of Max Occurrence days hr:min	Total Flooding acre-in	Total Minutes Flooded
CB#70	JUNCTION	9.87	15.30	97.58	0 13:00	0	0
CB#68	JUNCTION	0.00	0.00	88.99	0 00:00	0	0
CB#40	JUNCTION	3.57	4.49	100.90	0 13:00	0	0
DMH#81	JUNCTION	0.43	1.00	100.20	0 12:18	0.21	52
DMH#4	JUNCTION	0.06	0.10	98.50	0 12:18	0	0
25	JUNCTION	0.00	0.00	72.00	0 00:00	0	0
32	OUTFALL	0.00	0.00	0.00	0 00:00	0	0
33	OUTFALL	0.00	0.00	0.00	0 00:00	0	0
1	STORAGE	6.79	8.94	92.94	1 00:00	0	0
Pond3	STORAGE	3.90	6.26	76.26	1 00:00	0	0

****
Node Flow Summary
****

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days hr:min	Maximum Flooding Overflow CFS	Time of Max Occurrence days hr:min
CB#70	JUNCTION	9.37	9.37	0 13:00	0.00	
CB#68	JUNCTION	4.23	4.23	0 13:00	0.00	
CB#40	JUNCTION	2.92	2.92	0 13:00	0.00	
DMH#81	JUNCTION	0.00	2.92	0 13:00	0.46	0 13:00
DMH#4	JUNCTION	0.84	3.30	0 13:00	0.00	
25	JUNCTION	7.30	7.30	0 13:00	0.00	
32	OUTFALL	0.00	0.00	0 00:00	0.00	
33	OUTFALL	0.00	0.00	0 00:00	0.00	
1	STORAGE	0.69	17.58	0 13:00	0.00	
Pond3	STORAGE	0.00	7.30	0 13:00	0.00	

****
Storage Volume Summary
****

Storage Unit	Average Volume 1000 ft3	Avg Pcnt Full	Maximum Volume 1000 ft3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CFS
1	138.968	41	243.473	72	1 00:00	0.00
Pond3	55.736	31	96.870	54	1 00:00	0.00

****
Outfall Loading Summary
****

Outfall Node	Flow Freq. Pcnt.	Avg. Flow CFS	Max. Flow CFS
32	0.00	0.00	0.00
33	0.00	0.00	0.00
System	0.00	0.00	0.00

****

Conventional Subdivison

Link Flow Summary
****

Link	Type	Maximum Flow CFS	Time of Max Occurrence days hr:min	Maximum Velocity ft/sec	Max/ Full Flow	Max/ Full Depth	Total Minutes Surcharged
3	CONDUIT	9.37	0 13:00	11.93	1.49	1.00	800
6	CONDUIT	2.92	0 13:00	3.72	1.12	1.00	52
7	DUMMY	3.30	0 13:00				
8	CONDUIT	2.46	0 12:18	3.84	0.54	0.76	0
ToPond3	DUMMY	7.30	0 13:00				
15	DUMMY	4.23	0 13:00				

****
Flow Classification Summary
****

Conduit	Adjusted /Actual Length	--- Fraction of Time in Flow Class ---- Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Avg. Froude Number	Avg. Flow Change
3	1.00	0.01	0.00	0.00	0.68	0.27	0.00	0.05	0.75	0.0002
6	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.64	0.0001
8	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.97	0.0001

****
Highest Continuity Errors
****
Node DMH#81 (0.01%)
Node DMH#4 (0.00%)

****
Time-Step Critical Elements
****
Link 8 (74.91%)
Link 3 (18.99%)

****
Routing Time Step Summary
****
Minimum Time Step : 1.91 sec
Average Time Step : 4.95 sec
Maximum Time Step : 30.00 sec
Percent in Steady State : 0.00
Average Iterations per Step : 2.00

Analysis begun on: Tue Mar 10 16:25:09 2009
Total elapsed time: < 1 sec

Conventional Subdivison

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.009)
--------------------------------------------------------------

Conventional Subdivison
100-year, 24-hour Design Storm

****************
Analysis Options
****************
Flow Units ............... CFS
Infiltration Method ...... GREEN_AMPT
Flow Routing Method ...... DYNWAVE
Starting Date ............ JAN-01-2008 00:00:00
Ending Date .............. JAN-02-2008 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:05:00
Wet Time Step ............ 00:15:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 30.00 sec


*********************
Rainfall File Summary
*********************
Station    First        Last         Recording   Periods    Periods    Periods
ID         Date         Date         Frequency    w/Rain    Missing    Malfunc.
-------------------------------------------------------------------------------
STA02      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA10      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA25      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA50      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA100     JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA08      JAN-01-2008  JAN-01-2008     60 min        24          0          0


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......        11.754         7.250
Evaporation Loss .........         0.051         0.031
Infiltration Loss ........         1.257         0.775
Surface Runoff ...........         9.805         6.048
Final Surface Storage ....         0.651         0.401
Continuity Error (%) .....        -0.076


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      Mgallons
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         9.780         3.187
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.000         0.000
Surface Flooding .........         0.087         0.028
Evaporation Loss .........         0.003         0.001
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         9.688         3.157
Continuity Error (%) .....         0.023


***************************
Subcatchment Runoff Summary
***************************

--------------------------------------------------------------------------------------
                        Total      Total      Total      Total      Total       Peak    Runoff
                       Precip      Runon       Evap      Infil     Runoff     Runoff     Coeff
Subcatchment               in         in         in         in         in        CFS
```

Conventional Subdivison

Drive1	7.250	0.000	0.031	0.000	7.202	0.04	0.993
Drive10	7.250	0.000	0.031	0.000	7.203	0.04	0.993
Drive11	7.250	0.000	0.031	0.000	7.201	0.04	0.993
Drive12	7.250	0.000	0.031	0.000	7.203	0.04	0.993
Drive13	7.250	0.000	0.031	0.000	7.203	0.04	0.993
Drive14	7.250	0.000	0.031	0.000	7.202	0.04	0.993
Drive15	7.250	0.000	0.031	0.000	7.203	0.04	0.993
Drive16	7.250	0.000	0.031	0.000	7.203	0.04	0.993
Drive17	7.250	0.000	0.031	0.000	7.203	0.04	0.993
Drive18	7.250	0.000	0.031	0.000	7.203	0.04	0.993
Drive19	7.250	0.000	0.031	0.000	7.203	0.04	0.993
Drive2	7.250	0.000	0.031	0.000	7.203	0.04	0.993
Drive20	7.250	0.000	0.031	0.000	7.203	0.04	0.993
Drive3	7.250	0.000	0.031	0.000	7.203	0.04	0.993
Drive4	7.250	15.060	0.031	0.000	22.245	0.12	0.997
Drive5	7.250	15.060	0.031	0.000	22.245	0.12	0.997
Drive6	7.250	15.060	0.031	0.000	22.245	0.12	0.997
Drive7	7.250	0.000	0.031	0.000	7.203	0.04	0.993
Drive8	7.250	0.000	0.031	0.000	7.202	0.04	0.993
Drive9	7.250	0.000	0.031	0.000	7.202	0.04	0.993
LeftWeirVeg	7.250	0.000	0.031	0.565	6.469	0.54	0.892
Lot10On	7.250	0.489	0.031	0.869	6.340	1.66	0.819
Lot11On	7.250	0.489	0.031	0.869	6.340	1.66	0.819
Lot12On	7.250	0.331	0.031	0.868	6.256	1.71	0.825
Lot13On	7.250	0.331	0.031	0.868	6.256	1.71	0.825
Lot14On	7.250	0.331	0.031	0.868	6.256	1.71	0.825
Lot15On	7.250	0.331	0.031	0.868	6.256	1.71	0.825
Lot16On	7.250	0.331	0.031	0.868	6.256	1.71	0.825
Lot17On	7.250	0.331	0.031	0.868	6.256	1.71	0.825
Lot18On	7.250	0.331	0.031	0.868	6.256	1.71	0.825
Lot19On	7.250	0.331	0.031	0.868	6.256	1.71	0.825
Lot1On	7.250	0.331	0.031	0.868	6.277	1.74	0.828
Lot20On	7.250	0.331	0.031	0.868	6.256	1.71	0.825
Lot2On	7.250	0.331	0.031	0.868	6.256	1.71	0.825
Lot3On	7.250	0.331	0.031	0.868	6.256	1.71	0.825
Lot7On	7.250	0.331	0.031	0.868	6.188	1.62	0.816
Lot8On	7.250	0.331	0.031	0.868	6.188	1.62	0.816
Lot9On	7.250	0.489	0.031	0.869	6.340	1.66	0.819
LWPave	7.250	0.000	0.031	0.000	7.203	0.15	0.993
R1	7.250	0.000	0.031	0.000	7.203	0.33	0.993
R2	7.250	0.000	0.031	0.000	7.203	0.07	0.994
R3	7.250	0.000	0.031	0.000	7.203	0.11	0.994
RightWeirVeg	7.250	0.000	0.031	0.565	6.499	0.47	0.896
Roof1	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof10	7.250	3.444	0.031	0.000	10.642	0.12	0.995
Roof11	7.250	3.445	0.031	0.000	10.642	0.12	0.995
Roof12	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof13	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof14	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof15	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof16	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof17	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof18	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof19	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof2	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof20	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof3	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof4	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof5	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof6	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof7	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof8	7.250	0.000	0.031	0.000	7.202	0.08	0.993
Roof9	7.250	3.445	0.031	0.000	10.642	0.12	0.995
RWPave	7.250	0.000	0.031	0.000	7.202	0.17	0.993
R4	7.250	0.000	0.031	0.000	7.203	0.15	0.993
System	7.250	0.389	0.031	0.775	6.437	33.61	0.843

****

Conventional Subdivison

Node Depth Summary
****

Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum HGL Feet	Time of Max Occurrence days hr:min	Total Flooding acre-in	Total Minutes Flooded
CB#70	JUNCTION	10.92	19.73	102.01	0 12:59	0	0
CB#68	JUNCTION	0.00	0.00	88.99	0 00:00	0	0
CB#40	JUNCTION	3.66	4.88	101.29	0 12:59	0	0
DMH#81	JUNCTION	0.47	1.00	100.20	0 11:48	1.04	96
DMH#4	JUNCTION	0.06	0.09	98.49	0 12:26	0	0
25	JUNCTION	0.00	0.00	72.00	0 00:00	0	0
32	OUTFALL	0.00	0.00	0.00	0 00:00	0	0
33	OUTFALL	0.00	0.00	0.00	0 00:00	0	0
1	STORAGE	7.24	9.59	93.59	1 00:00	0	0
Pond3	STORAGE	4.46	6.96	76.96	1 00:00	0	0

****
Node Flow Summary
****

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days hr:min	Maximum Flooding Overflow CFS	Time of Max Occurrence days hr:min
CB#70	JUNCTION	11.80	11.80	0 12:59	0.00	
CB#68	JUNCTION	5.28	5.28	0 12:59	0.00	
CB#40	JUNCTION	3.65	3.65	0 12:59	0.00	
DMH#81	JUNCTION	0.00	3.65	0 13:00	1.18	0 13:00
DMH#4	JUNCTION	1.02	3.48	0 12:59	0.00	
25	JUNCTION	9.10	9.10	0 12:59	0.00	
32	OUTFALL	0.00	0.00	0 00:00	0.00	
33	OUTFALL	0.00	0.00	0 00:00	0.00	
1	STORAGE	0.84	21.40	0 12:59	0.00	
Pond3	STORAGE	0.00	9.10	0 12:59	0.00	

****
Storage Volume Summary
****

Storage Unit	Average Volume 1000 ft3	Avg Pcnt Full	Maximum Volume 1000 ft3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CFS
1	169.436	50	301.063	88	1 00:00	0.00
Pond3	68.672	38	120.907	67	1 00:00	0.00

****
Outfall Loading Summary
****

Outfall Node	Flow Freq. Pcnt.	Avg. Flow CFS	Max. Flow CFS
32	0.00	0.00	0.00
33	0.00	0.00	0.00
System	0.00	0.00	0.00

****

Conventional Subdivison

Link Flow Summary
****

Link	Type	Maximum Flow CFS	Time of Max Occurrence days hr:min	Maximum Velocity ft/sec	Max/ Full Flow	Max/ Full Depth	Total Minutes Surcharged
3	CONDUIT	11.80	0 13:00	15.02	1.87	1.00	845
6	CONDUIT	3.65	0 13:00	4.64	1.40	1.00	96
7	DUMMY	3.48	0 12:59				
8	CONDUIT	2.46	0 12:26	3.84	0.54	0.76	0
ToPond3	DUMMY	9.10	0 12:59				
15	DUMMY	5.28	0 12:59				

****
Flow Classification Summary
****

Conduit	Adjusted /Actual Length	--- Fraction of Time in Flow Class ---- Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Avg. Froude Number	Avg. Flow Change
3	1.00	0.01	0.00	0.00	0.65	0.31	0.00	0.04	0.88	0.0002
6	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.66	0.0001
8	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.97	0.0001

****
Highest Continuity Errors
****
Node DMH#81 (0.01%)
Node DMH#4 (0.00%)

****
Time-Step Critical Elements
****
Link 8 (72.50%)
Link 3 (22.47%)

****
Routing Time Step Summary
****

```
Minimum Time Step           :     1.74 sec
Average Time Step           :     4.50 sec
Maximum Time Step           :    30.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00
```

Analysis begun on: Tue Mar 10 16:26:00 2009
Total elapsed time: < 1 sec

ATTACHMENT 15

SWMM Pre-development Watershed Model Results

Pre-Development Watershed Model

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.009)
--------------------------------------------------------------

Pre-Development Watershed Model
2-Year, 24-Hour Design Storm

****************
Analysis Options
****************
Flow Units ............... CFS
Infiltration Method ...... GREEN_AMPT
Starting Date ............ JAN-01-2008 00:00:00
Ending Date .............. JAN-02-2008 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:01:00
Wet Time Step ............ 00:15:00
Dry Time Step ............ 01:00:00


*********************
Rainfall File Summary
*********************
Station    First        Last         Recording   Periods    Periods    Periods
ID         Date         Date         Frequency    w/Rain    Missing    Malfunc.
-------------------------------------------------------------------------------
STA100     JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA10      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA25      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA02      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA50      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA40      SEP-26-2008  SEP-27-2008      5 min       121          0          0
STA05      AUG-11-2008  AUG-12-2008      5 min        53          0          0
STA06      SEP-06-2008  SEP-07-2008      5 min        87          0          0
STA01      SEP-27-2008  SEP-28-2008      5 min       100          0          0


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         0.019         3.000
Evaporation Loss .........         0.000         0.018
Infiltration Loss ........         0.016         2.446
Surface Runoff ...........         0.004         0.547
Final Surface Storage ....         0.000         0.000
Continuity Error (%) .....        -0.367


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      Mgallons
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.003         0.001
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.003         0.001
Surface Flooding .........         0.000         0.000
Evaporation Loss .........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.000
Continuity Error (%) .....         0.000


***************************
Subcatchment Runoff Summary
***************************

--------------------------------------------------------------------------------------
                     Total      Total      Total      Total      Total       Peak     Runoff
                    Precip      Runon       Evap      Infil     Runoff     Runoff      Coeff
```

Pre-Development Watershed Model

Subcatchment	in	in	in	in	in	CFS	
Cal_Forest	3.000	0.000	0.018	2.446	0.547	0.04	0.182
System	3.000	0.000	0.018	2.446	0.547	0.04	0.182

Analysis begun on: Tue Mar 10 16:31:24 2009
Total elapsed time: 00:00:01

Pre-Development Watershed Model

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.009)
--------------------------------------------------------------

Pre-Development Watershed Model
10-Year, 24-Hour Design Storm

****************
Analysis Options
****************
Flow Units ............... CFS
Infiltration Method ...... GREEN_AMPT
Starting Date ............ JAN-01-2008 00:00:00
Ending Date .............. JAN-02-2008 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:01:00
Wet Time Step ............ 00:15:00
Dry Time Step ............ 01:00:00


*********************
Rainfall File Summary
*********************
Station    First        Last         Recording   Periods    Periods    Periods
ID         Date         Date         Frequency    w/Rain    Missing    Malfunc.
-------------------------------------------------------------------------------
STA100     JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA10      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA25      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA02      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA50      JAN-01-2008  JAN-01-2008     60 min        24          0          0
STA40      SEP-26-2008  SEP-27-2008      5 min       121          0          0
STA05      AUG-11-2008  AUG-12-2008      5 min        53          0          0
STA06      SEP-06-2008  SEP-07-2008      5 min        87          0          0
STA01      SEP-27-2008  SEP-28-2008      5 min       100          0          0


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......         0.029         4.500
Evaporation Loss .........         0.000         0.018
Infiltration Loss ........         0.020         3.075
Surface Runoff ...........         0.009         1.427
Final Surface Storage ....         0.000         0.000
Continuity Error (%) .....        -0.435


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      Mgallons
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.009         0.003
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.009         0.003
Surface Flooding .........         0.000         0.000
Evaporation Loss .........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.000
Continuity Error (%) .....         0.000


***************************
Subcatchment Runoff Summary
***************************

--------------------------------------------------------------------------------------
                     Total      Total      Total      Total      Total       Peak    Runoff
                    Precip      Runon       Evap      Infil     Runoff     Runoff     Coeff
```

Pre-Development Watershed Model

Subcatchment	in	in	in	in	in	CFS	
Cal_Forest	4.500	0.000	0.018	3.075	1.427	0.07	0.317
System	4.500	0.000	0.018	3.075	1.427	0.07	0.317

Analysis begun on: Tue Mar 10 16:31:59 2009
Total elapsed time: < 1 sec

Pre-Development Watershed Model

EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.009)

Pre-Development Watershed Model
25-Year, 24-Hour Design Storm

****
Analysis Options
****

Flow Units	CFS
Infiltration Method	GREEN_AMPT
Starting Date	JAN-01-2008 00:00:00
Ending Date	JAN-02-2008 00:00:00
Antecedent Dry Days	0.0
Report Time Step	00:01:00
Wet Time Step	00:15:00
Dry Time Step	01:00:00

****
Rainfall File Summary
****

Station ID	First Date	Last Date	Recording Frequency	Periods w/Rain	Periods Missing	Periods Malfunc.
STA100	JAN-01-2008	JAN-01-2008	60 min	24	0	0
STA10	JAN-01-2008	JAN-01-2008	60 min	24	0	0
STA25	JAN-01-2008	JAN-01-2008	60 min	24	0	0
STA02	JAN-01-2008	JAN-01-2008	60 min	24	0	0
STA50	JAN-01-2008	JAN-01-2008	60 min	24	0	0
STA40	SEP-26-2008	SEP-27-2008	5 min	121	0	0
STA05	AUG-11-2008	AUG-12-2008	5 min	53	0	0
STA06	SEP-06-2008	SEP-07-2008	5 min	87	0	0
STA01	SEP-27-2008	SEP-28-2008	5 min	100	0	0

Runoff Quantity Continuity	Volume acre-feet	Depth inches
Total Precipitation	0.035	5.500
Evaporation Loss	0.000	0.018
Infiltration Loss	0.022	3.419
Surface Runoff	0.013	2.090
Final Surface Storage	0.000	0.000
Continuity Error (%)	-0.490	

Flow Routing Continuity	Volume acre-feet	Volume Mgallons
Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	0.013	0.004
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.000	0.000
External Outflow	0.013	0.004
Surface Flooding	0.000	0.000
Evaporation Loss	0.000	0.000
Initial Stored Volume	0.000	0.000
Final Stored Volume	0.000	0.000
Continuity Error (%)	0.000	

****
Subcatchment Runoff Summary
****

	Total Precip	Total Runon	Total Evap	Total Infil	Total Runoff	Peak Runoff	Runoff Coeff

Pre-Development Watershed Model

Subcatchment	in	in	in	in	in	CFS	
Cal_Forest	5.500	0.000	0.018	3.419	2.090	0.09	0.380
System	5.500	0.000	0.018	3.419	2.090	0.09	0.380

Analysis begun on: Tue Mar 10 16:32:24 2009
Total elapsed time: < 1 sec

Pre-Development Watershed Model

EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.009)

Pre-Development Watershed Model
50-Year, 24-Hour Design Storm

****
Analysis Options
****

Flow Units .... CFS
Infiltration Method ...... GREEN_AMPT
Starting Date JAN-01-2008 00:00:00
Ending Date JAN-02-2008 00:00:00
Antecedent Dry Days 0.0
Report Time Step 00:01:00
Wet Time Step 00:15:00
Dry Time Step 01:00:00

****
Rainfall File Summary
****

Station ID	First Date	Last Date	Recording Frequency	Periods w/Rain	Periods Missing	Periods Malfunc.
STA100	JAN-01-2008	JAN-01-2008	60 min	24	0	0
STA10	JAN-01-2008	JAN-01-2008	60 min	24	0	0
STA25	JAN-01-2008	JAN-01-2008	60 min	24	0	0
STA02	JAN-01-2008	JAN-01-2008	60 min	24	0	0
STA50	JAN-01-2008	JAN-01-2008	60 min	24	0	0
STA40	SEP-26-2008	SEP-27-2008	5 min	121	0	0
STA05	AUG-11-2008	AUG-12-2008	5 min	53	0	0
STA06	SEP-06-2008	SEP-07-2008	5 min	87	0	0
STA01	SEP-27-2008	SEP-28-2008	5 min	100	0	0

Runoff Quantity Continuity	Volume acre-feet	Depth inches
Total Precipitation	0.038	6.000
Evaporation Loss	0.000	0.018
Infiltration Loss	0.023	3.560
Surface Runoff	0.016	2.443
Final Surface Storage	0.000	0.000
Continuity Error (%)	-0.358	

Flow Routing Continuity	Volume acre-feet	Volume Mgallons
Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	0.016	0.005
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.000	0.000
External Outflow	0.016	0.005
Surface Flooding	0.000	0.000
Evaporation Loss	0.000	0.000
Initial Stored Volume	0.000	0.000
Final Stored Volume	0.000	0.000
Continuity Error (%)	0.000	

****
Subcatchment Runoff Summary
****

	Total Precip	Total Runon	Total Evap	Total Infil	Total Runoff	Peak Runoff	Runoff Coeff

Pre-Development Watershed Model

Subcatchment	in	in	in	in	in	CFS	
Cal_Forest	6.000	0.000	0.018	3.560	2.443	0.10	0.407
System	6.000	0.000	0.018	3.560	2.443	0.10	0.407

Analysis begun on: Tue Mar 10 16:32:50 2009
Total elapsed time: < 1 sec

Pre-Development Watershed Model

EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.009)

Pre-Development Watershed Model
100-Year, 24-Hour Design Storm

****
Analysis Options
****

Flow Units .... CFS
Infiltration Method ...... GREEN_AMPT
Starting Date JAN-01-2008 00:00:00
Ending Date JAN-02-2008 00:00:00
Antecedent Dry Days 0.0
Report Time Step 00:01:00
Wet Time Step 00:15:00
Dry Time Step 01:00:00

****
Rainfall File Summary
****

Station ID	First Date	Last Date	Recording Frequency	Periods w/Rain	Periods Missing	Periods Malfunc.
STA100	JAN-01-2008	JAN-01-2008	60 min	24	0	0
STA10	JAN-01-2008	JAN-01-2008	60 min	24	0	0
STA25	JAN-01-2008	JAN-01-2008	60 min	24	0	0
STA02	JAN-01-2008	JAN-01-2008	60 min	24	0	0
STA50	JAN-01-2008	JAN-01-2008	60 min	24	0	0
STA40	SEP-26-2008	SEP-27-2008	5 min	121	0	0
STA05	AUG-11-2008	AUG-12-2008	5 min	53	0	0
STA06	SEP-06-2008	SEP-07-2008	5 min	87	0	0
STA01	SEP-27-2008	SEP-28-2008	5 min	100	0	0

Runoff Quantity Continuity	Volume acre-feet	Depth inches
Total Precipitation	0.047	7.250
Evaporation Loss	0.000	0.018
Infiltration Loss	0.025	3.910
Surface Runoff	0.022	3.373
Final Surface Storage	0.000	0.000
Continuity Error (%)	-0.693	

Flow Routing Continuity	Volume acre-feet	Volume Mgallons
Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	0.022	0.007
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.000	0.000
External Outflow	0.022	0.007
Surface Flooding	0.000	0.000
Evaporation Loss	0.000	0.000
Initial Stored Volume	0.000	0.000
Final Stored Volume	0.000	0.000
Continuity Error (%)	0.000	

****
Subcatchment Runoff Summary
****

	Total Precip	Total Runon	Total Evap	Total Infil	Total Runoff	Peak Runoff	Runoff Coeff

Pre-Development Watershed Model

Subcatchment	in	in	in	in	in	CFS	
Cal_Forest	7.250	0.000	0.018	3.910	3.373	0.12	0.465
System	7.250	0.000	0.018	3.910	3.373	0.12	0.465

Analysis begun on: Tue Mar 10 16:33:17 2009
Total elapsed time: 00:00:01