STORMWATER RUNOFF TREATMENT by a FILTRATION SYSTEM and WET POND in TAMPA, FLORIDA

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Southwest Florida
Water Management District

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Cover Photographs

The cover shows four views of the Street Pond underdrains and wet pond system. See Figures 1 and 2 for the site plan.

Top picture: A mid-construction view of the inflow looking west. The shaft encoder, sedimentation basin, and housing unit for the sampler and datalogger are in the mid view. The construction activity for the trolley line and the completed parking garage are in the background.

Middle right picture: A view of a Thel-Mar™ volumetric weir measuring flow in an underdrain. The sampler and bubbler line are also shown.

Middle left picture: A post-construction view of the treatment basin of the Street Pond with the underdrains (looking northwest). In the foreground are the sampling equipment (samplers, bubbler flow meters, dataloggers, and shaft encoder) and the outflow weir. The equalizer pipe connecting the sections of the pond is in the mid view. The Florida Aquarium Parking lot is in the background.

Bottom picture: A pre-construction view of the treatment basin of the Street Pond before redesign and addition of second underdrain (looking east). The intake to the underdrain is in the right mid view. The shaft encoder and outflow weir are in the background.

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Executive Summary

Filtration systems are often used to treat stormwater runoff, especially in the Southwest Florida Water Management District; however, little research has been done on these systems under field conditions. This study, conducted at The Florida Aquarium in Tampa, Florida, documents stormwater runoff treatment by a wet pond with a filtration system (referred to as underdrains). This project characterizes an urban stormwater treatment system by: 1) analyzing processes taking place in the stormwater system, 2) measuring the reduction (or increase) of pollutants in storm runoff treated by a wet pond and filtration system, 3) tracking patterns in field parameters monthly for the entire pond, and 4) comparing sediment samples for different years to determine migration of pollutants in the soil. Data collection occurred during two years. Year 1 began in November of 2000 and concluded in August of 2001. Year 2 began in June of 2002 and concluded in October of 2003. Construction of a cruise terminal, building of a trolley line, and dredging and reshaping of the filtration pond occurred between the sampling years.

Hydrology

Rain characteristics varied between Years 1 and 2. Drought conditions prevailed during Year 1, and the site consequently received considerably less rainfall than the long-term average. As a result, the inter-event dry periods were longer during Year 1. El Nino conditions increased rainfall during Year 2, and the site received higher amounts of rain than the long-term average. Consequently, storms produced more rainfall, on average, and lasted for longer durations than in Year 1.

A complete water budget for storm events revealed that most of the outflow occurred through the underdrains. However, the flow from the underdrains may have been affected by groundwater seepage. The outflow weir was raised in Year 2, which reduced the amount of flow by-passing the underdrains to 35% instead of the 54% measured in Year 1. When the level of the pond was high enough for water to go over the outflow weir, the time lag between the inflow and outflow weir was short enough to suggest that the water going over the weir was treated stormwater from the pond being pushed out by the new stormwater from the inflow.

Water Quality

For rain events large enough to produce enough flow to collect water quality samples (> 0.23 inches), flow-weighted samples were collected at the inflow, at the outflow weir, and in the underdrains to determine the efficiency of the pond at removing pollutants. Additionally, samples were collected at the underdrains in between storms as they flowed continuously. Nitrogen levels were reduced from the inflow to the outflow, with reduction increasing in Year 2. Ambient criteria for water bodies in pristine condition have been recommended by the U.S. Environmental Protection Agency as guidelines for lakes and reservoirs and rivers and streams. For water discharged from the pond, nitrogen levels were above the guidelines for lakes and reservoirs in Year 1, but Year 2 levels met the guidelines, and both years were well under guidelines for the river and stream criteria. Phosphorous levels were also reduced from the inflow to the outflow, but levels of phosphorous exceeded criteria for lakes and reservoirs during both years. Year 2 levels met the criteria for rivers and streams. The underdrains showed high

levels of nutrients. While exceeding the recommended criteria for nutrients in both years, the concentrations at the underdrains were still lower than the inflow overall.

The pond was successful in reducing total suspended solids and metals, with the largest reduction occurring at the underdrains. Metal and hardness were measured and compared to the State Surface Water Quality Standards published by the Florida Department of Environmental Protection (FDEP). During this study, the pond discharge waters failed to meet fresh water Class III standards 7 times for copper, 8 times for lead, one time for zinc, and one time for iron in the 42 samples collected from water discharged over the outflow weir. Also outflow water concentrations measured in the underdrain pipes were compared to the Class III standards and did not exceed the criteria recommendations for metals. Considering the underdrains accounted for the majority of the flow exiting the pond (see previous sections for discussion), the overall quality of the water was better than this analysis presents. Due to the increase in rain during Year 2, the pond had lower hardness, which could increase the toxicity of metals.

As mentioned, the underdrains flowed continuously; therefore, flow from the underdrains was compared to pond level. When the pond level was below the level of the bottom of the underdrain pipe (6 ft. NGVD), the flow was considered baseflow and the source was assumed to be local groundwater. Storm events were also considered separately as flow increased dramatically during storm events. The baseflow had higher levels of nutrients. Hardness was also higher during baseflow conditions, suggesting the local groundwater was harder than the stormwater. Metal concentrations in underdrain flow were low during all pond levels.

Pollutant Loads

Load efficiency, calculated on a monthly basis, indicated that the stormwater system is not effective for removing dissolved nutrients and may be dewatering the ground water. Ammonia loads increased by 84 percent and ortho-phosphorus by 64 percent from the inflow to the outflow. Other nutrient loads were only moderately reduced (14 to 17 percent). In contrast, the system removed total suspended solids and most metals by a significant amount (79 to 89 percent).

Field Parameters

Temperature, pH, dissolved oxygen (DO), and conductivity were measured monthly at the inflow and outflow. Fluctuations in pH and DO follow a diurnal pattern and are the result of algal photosynthetic processes that peak during daylight hours. These fluctuations are very small at the inflow, where water enters the pond through underground pipes into a concrete lined basin. In contrast, the fluctuations at the outflow are dramatic, indicative of a eutrophic system. Rainfall disrupts these patterns, which return in a few days. The state of Florida Class III Water Quality Standards permit a pH range between 5 and 8 standard units. This range was sometimes exceeded at the outflow during daylight hours during summer months. Florida state standards require that DO shall not fall below 5.0 mg/L, and normal daily and seasonal fluctuations above these levels should be maintained. While the inflow was often below 5 mg/L during interevent conditions, the outflow was above 5 mg/L during daytime. Conductivity was constant at the inflow and outflow until rain diluted the system and caused a decrease.

Sediment Samples

Sediment samples were taken for the analysis of nutrients, metals, and pesticides in the pond to study the vertical and spatial migration of pollutants. Sediment samples were taken in October 1997, November 2000, and December 2003. Between the 2000 and 2003 sampling events, many construction activities occurred which affected the quality of the pond sediments, including a dredging of the pond and construction of the cruise ship terminal. Particle sizes were predominately sand in the 0.125-2 mm size range. Total Kjeldahl Nitrogen increased through the years and increased from the inflow to the outflow. The presence of floating algal mats in Year 2 likely affected the high concentrations in the 2003 sampling event. Total phosphorous levels were also highest in 2003. Along with the increased vegetation, the low levels of DO measured probably led to the higher phosphorous levels.

Metals were, overall, below toxic levels. The stations where metals were consistently measured highest were the outflow, where the organic matter was also highest, and the sedimentation basin, which was designed to collect heavier particles before they entered the pond. Copper levels in 2000 were one major exception; these high levels were a result of algaecide applications that have since ceased. Pesticides and PAH's were also found in the sediments. Pesticides were most often below toxic recommendations. Diazinon was found at the inflow in 2003, but was reduced to below detection limit at the outflow. Chlordane was also found in the sedimentation basin in 2000 and at the inflow in 2003. These, too, were reduced to below detection limit at the outflow. While PAH's were measured in greater concentrations in Year 2, they were well below the levels where probable effects occur. The high measurements of metals in the sedimentation basin indicate the importance of regular maintenance and removal of sediments from the basin

Statistical Analysis

Statistical analysis confirmed some of the processes taking place in the system. Metals, suspended solids and total phosphorus often occur together explaining 85 to 95 percent of their variation at the inflow. The older south under drain discharged soluble nutrients at significantly higher concentrations than the more recently constructed north under drain. Both under drains reduced metals and suspended solids to low levels. Significant differences between years showed rainfall characteristics with no differences, but some of the water quality concentrations were significantly higher or lower. The construction activity explains some of the discrepancies; and processes taking place in the system caused other differences. The data show that, if conditions remain constant, stormwater professionals can probably feel confident in using short-term studies with 15 to 20 rain events in other applications such as models.

Introduction

Stormwater runoff is rainwater traveling across land and paved surfaces, through ditches, pipes, and swales, and ending up in rivers, lakes, and streams. In urban areas, instead of seeping into the ground, stormwater flows rapidly across hard surfaces, picking up pollutants such as oil, grease, heavy metals, sediment, pesticides, fertilizers, and trash. As stormwater ultimately ends up in natural water bodies, it is classified as a major source for non-point pollution. Urban runoff and storm sewer discharges are ranked the second most prevalent source of water quality impairment to the nation's estuaries and the fourth most prevalent source of impairment to the nation's lakes (APHA 1985). Although rainfall is an important natural process that saturates soils, replenishes aquifers, and provides water for biological processes, the resulting runoff combined with anthropogenic activity is a serious pollution source.

Several stormwater research projects have been conducted at The Florida Aquarium, and this report presents the results of one of these studies. The pond studied was part of The Florida Aquarium construction in downtown Tampa. Given the problems associated with stormwater runoff and the amount of effort expended to improve Tampa Bay, staff at the Southwest Florida Water Management District (SWFWMD) initiated a research project to study the effectiveness of the filtration pond systems in treating storm runoff. Tampa Bay is identified as an estuary of national significance in the National Estuary Program and as a water body in need of attention. Matching funds from the Florida Department of Environmental Protection (FDEP) provided by Section 319 of the Clean Water Act provided the support needed to monitor the effectiveness of the pond to reduce pollutant loads before stormwater reached Tampa Bay. The pond provided opportunities to educate the public about stormwater issues, to investigate some problems associated with pond maintenance, and to study various aspects of stormwater management including evaluation of the efficiency of effluent filtration systems to treat stormwater pollution. A companion report is also available that compares three different types of stormwater ponds.

The pond evaluated in this study incorporates side bank filters to treat stormwater while also reducing the size of the pond needed. Filtration systems are one method approved by the SWFWMD to treat stormwater runoff. However, little research has been conducted on the efficiency of this treatment method, especially under field conditions. Indeed, we could find only three research reports of similar systems. Though none of these was studied for extended periods, most of the measured concentrations of constituents in the filtration systems were found to be lower than those in the pond surface water. The exceptions to this were nitrogen and ortho-phosphorous, which were measured at higher concentrations in the filtration effluent than in the pond water. These outcomes are explained by Harper and Herr (1993), who found evidence in their study that trapped particles in the filtration media were undergoing decomposition processes, affecting the measured concentrations of these species. Additionally, in two of the three studies, the filtration systems clogged rather quickly after installation, adversely affecting the performance of the filters (Harper and Herr 1993).

The research effort at The Florida Aquarium evaluated the entire effluent filtration pond system including rain, inflow, outflow over the weir, and discharge water from the two underdrain filters. The pond has been labeled *Street Pond* to describe the area of the watershed that it drains. While several stormwater ponds were actually studied at the site, for purposes of this paper, only one pond is discussed. This project was designed to characterize an urban stormwater treatment system by: 1) analyzing processes taking place in the stormwater system, 2) measuring the reduction (or increase) of pollutants in storm runoff treated by a wet pond and filtration system, 3) tracking patterns in field parameters monthly for the entire pond, and 4) comparing sediment samples for different years to determine migration of pollutants in the soil.

This paper presents the results from two years of data collection. Sampling began in November of 2000 and concluded in October of 2003. Sampling was halted from August 2001 to June 2002 during construction of the cruise ship terminal. This break in sampling splits the data into Years 1 and 2.

Study Site

The study site is located at The Florida Aquarium, 701 Channelside Drive, Tampa, Florida (Section 19, Township 29, Range 19). The stormwater pond is situated between Cumberland Street and the parking lot for The Florida Aquarium. It discharges to Ybor Channel, which leads directly into Tampa Bay.

The Street Pond collects runoff from a well-traveled downtown thoroughfare and a large parking garage. The pond treats 10.4 acres of street and urban stormwater runoff. It is an effluent filtration system, which incorporates artificial side bank filters packed in aggregate. According to the SWFWMD's Environmental Resource Permit Manual: Rules and Basis of Review (2002), detention ponds with effluent filtration systems must treat one-half inch of rain for drainage areas less than 100 acres. The filter medium of such systems must meet the Florida Department of Transportation road and bridge specifications, be of effective grain size, and be contained in a way that they do not move. Stormwater must pass through at least two feet of filter before entering the underdrain and held no longer than 36 hours in the filtrations system. One disadvantage of filter systems is that they must be properly maintained and replaced if they become clogged. Inspections are required on effluent filtration systems every 18 months. The complete rule on filtration systems is included as Appendix A.

The Street Pond actually consists of two ponds connected in the middle by an equalizer pipe. The first pond was designed to act as a sedimentation basin, and the second pond includes the sidebank filtration system. Between the summers of 2001 and 2002, monitoring of the pond was halted during the construction of a cruise ship terminal between the ponds and Ybor Channel. During this construction, the north underdrain was added to the pond system, and the existing south underdrain was cleaned out. As part of the construction activity of the cruise terminal, the pond was dredged and the shape of the treatment basin was changed. The weir at the outflow was also altered to increase the accuracy of measuring flow and volume. Additionally, prior to the construction of the terminal building and alterations to the pond, the parking garage across the street from the pond inflow (Channelside drive) was built. See Figures 1a and 1b for before and after designs.

During Year 1 of the study, a filter system directed low flows through the filtration media to underdrain pipes, which discharge to a drop box at the outflow. A second, independent filter system was added for Year 2. High flows are discharged over the outfall weir to prevent flooding upstream. Figure 2 is a diagram that shows the components of the pond system. Figure 3 is a cross section of the side bank filter (effluent filtration) system referred to as underdrain pipes in this study.

Methods

Hydrology

The hydrology of the pond was characterized by recording rainfall at 15-minute intervals and measuring surface levels. Rainfall amount was calculated using a tipping-bucket rain gauge and surface water was recorded with shaft encoders (float and pulley). Sensors at both the inflow and outflow sampling stations were connected to Campbell Scientific data loggers (CR10™ at the inflow and CR500™ at the outflow) that stored the data and averaged the measurements at 15-minute intervals. These measurements allowed interpretation of the hydrological interaction between various elements of the watershed.

Rainfall was characterized by calculating total rainfall, duration, inter-event dry period, rainfall intensity, and runoff coefficient using the following criteria:

Rainfall (in.)	rainfall amounts for each event >0.23 in.,
Inter-event dry period (hr.)	period since previous rain event (>6 hours separates events,
Duration (hr.)	periods of active rainfall,
Intensity (in./hr.)	total event rainfall / duration,
Maximum intensity	15-minute period during the storm with the highest average maximum intensity (in./ hr.),
Runoff coefficient	inflow (ft^3 / rain amount (ft) * basin area (ft^2).

Rainfall amounts less than 0.23 in. were not included in the calculations because these smaller events did not produce enough runoff to collect water quality samples. Also, storms of at least 0.23 in. resulted in a perceptible change in pond water levels.

To measure inflow hydrology, a Sontek™ velocity meter was suspended within the inflow pipe about ten feet before the submerged pipe discharged into the pond. The Sontek™ measured velocity, which was later converted to flow using the area of the pipe, 1.2 m^2 (7.07 ft^2). A CR10™ data logger was connected to The Sontek™ to record data at fifteen-minute intervals. Outflow hydrology was measured using a CR500™ data logger connected to a float and shaft encoder. The data logger recorded water level from the outflow; this data was used to estimate the amount of flow exiting the pond over the outflow weir. The flow data for the weir structure at the outflow were estimated using the standard formula for a rectangular weir with end contractions:

$$(3.33 * (9.89 - (0.2 * H)) * (H^{1.5})) + (2 * (3.33 * (4.41 - (0.2 * H)) * (H^{1.5})))$$

where H is the head (depth of water over the weir). Each side of the outfall box was then treated as a separate rectangular weir. Appendix B includes all calculations involved with flow.

Figure 1a. Site plan showing the stormwater pond (Street Pond) and the layout of the whole basin stormwater system before the cruise ship terminal construction.

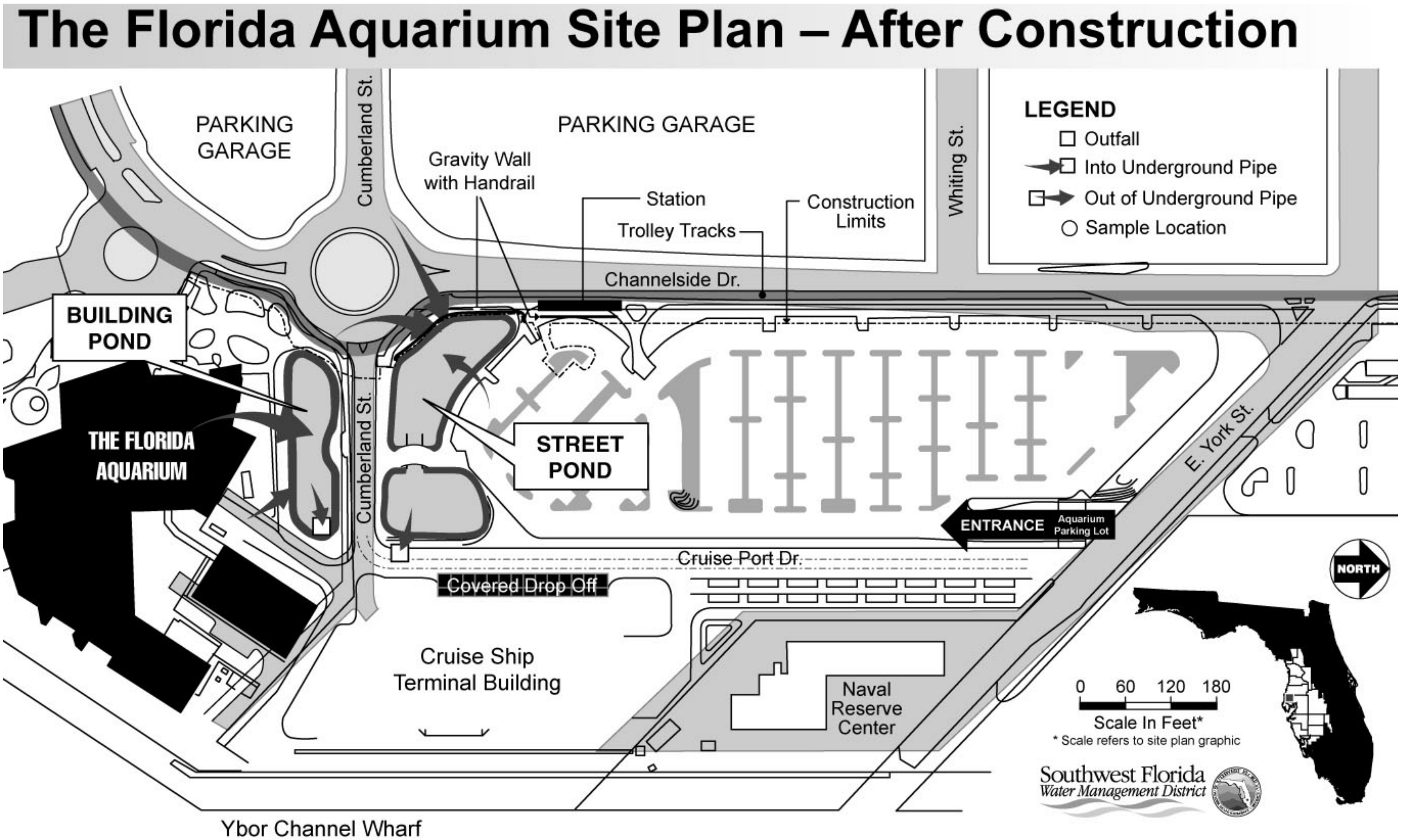


Figure 1b. Site plan showing the stormwater pond (Street Pond) and the layout of the whole basin stormwater system after the cruise ship terminal construction.

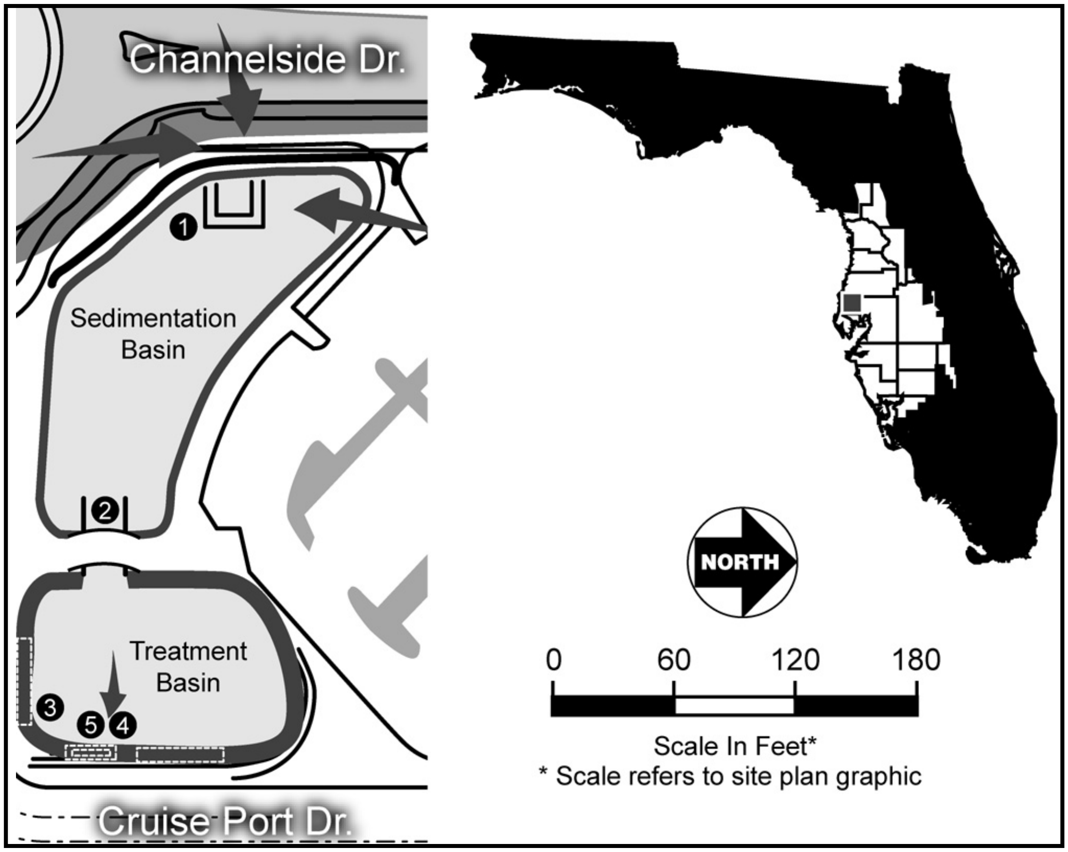


Figure 2. Site map showing the pond system: Station 1088- inflow and sedimentation basin (1), Station 1089- equalizer pipe (2), Station 1085- South underdrain (3), Station 3904- North underdrain (4), and Station 638- weir overflow (5). Arrows denote runoff direction.

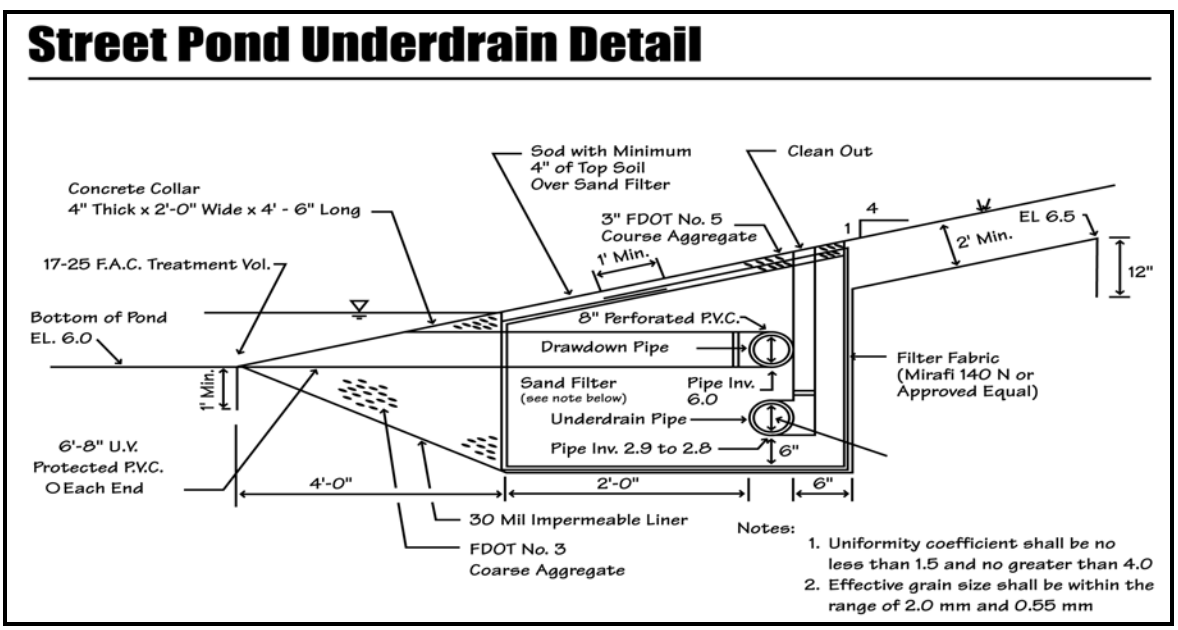


Figure 3. Cross section of the south side bank filter (effluent filtration) system used to treat stormwater.

Flow

To measure the flow out of the pond through the underdrains, Thel-Mar™ volumetric weirs were installed in the eight-inch pipes; the weirs were connected to ISCO™ bubbler flow meters to measure flow. The side bank filtration system and the outflow structure were taken into consideration when computing water budget and flow. It should be mentioned that flow measurements from the underdrains is not without a degree of error. Small pipes and erratic flow made flow measurements difficult. Baseflow issuing from the pipes when the pond level was below the intake for the filter added to this error. During summer months, there was a problem of algae growing in the bubbler tube, which affected the flow measurements until the tube was manually cleaned. Additionally, unmeasured flow from a pipe draining 10% of the watershed was estimated as 10% of the inflow measured by the Sontek™ velocity meter.

As a further check on the flow measurements, a monthly water budget evaluated inputs and outputs. The Water Budget Method includes:

(*Precipitation + Inflow – Outflow – Evapotranspiration +/- Seepage = Change in Storage*),

where:

- *Precipitation* is the amount of rain falling directly on the pond converted to m^3 or ft^3,
- *Inflow* and *Outflow* is measured using the methods described above,
- *Evapotranspiration* is estimated from evaporation pan data using a coefficient of 0.7,
- *Seepage* is the error term plus seepage. High negative seepage values probably correlate with a consistent seepage of groundwater into the underdrains, and
- *Change in Storage* is difference in water levels in the pond at the beginning and end of the month, m^3 or ft^3.

Water Quality

Stormwater was monitored throughout a two-year period. Year 1 includes data from November 2000 through August 2001. Stormwater monitoring was discontinued during the construction of the cruise ship terminal. Year 2 includes data from June 2002 through October 2003. Flow-weighted composite water quality samples were collected during rain events using ISCO™ automatic portable samplers. The samples were preserved with ice until retrieved, then preserved according to SWFWMD standard procedures for collecting samples (SWFWMD 2001). The storms with water quality data were numbered for easy cross-reference with other data.

The Street Pond was sampled at the inflow, outflow, and underdrain structures to quantify the flow and water quality entering and exiting the system. A rainfall collector sampled water quality concentrations for rainfall input directly to the pond. Rainfall of 0.15 in. within 15 minutes was required to trigger the sampler to begin flow-weighted sample collection at the inflow. The erratic nature of velocity measurements during low flow made rainfall a better predictor of rain events. Flow-weighted samples taken when the level of the pond was high enough that water flowed over the outflow weir characterized overflow discharge. In the underdrains, flow-weighted composite samples collected at regular intervals compared discharge through the filters. Additionally, baseflow samples were taken from the underdrain pipes in-between storms for comparison to flow resulting from storms.

The SWFWMD chemistry laboratory analyzed water quality samples. Laboratory analyses were performed according to either Standard Methods (A.P.H.A. 1989) or Methods for Chemical Analysis of Water and Wastes (U.S. EPA 1983) (Table 1). Water quality samples for the analysis of total nitrogen, ammonia, nitrate-nitrite, total phosphorus, ortho-phosphorus, were stored in 500 ml polyethylene bottles and preserved with the addition of sulfuric acid to lower the pH below 2.0. Samples for metal analysis (copper, lead, zinc, iron, and cadmium) were stored in 250 ml EPA-approved pre-washed bottles and preserved with the addition of nitric acid to lower the pH below 2.0. Samples for the analysis of total suspended solids and hardness (as a product of calcium and magnesium) were collected in 1000 ml. and 500 ml. bottles. The samples were placed on ice in coolers and transported to the SWFWMD laboratory for analysis using standard methods.

Table 1. Description of laboratory analyses for parameters measured in stormwater study. References refer to sections in Standard Methods (APHA 1992) or (US EPA 1983) where descriptions that are more detailed can be found. When values were below the laboratory detection limit, one-half the detection limit was substituted for statistical analysis.

Parameter	Method	Det. Limit	Reference.
Total Suspended Solids	Total filterable residue dried at 103-105^{o} C	0.05 mg/l	SM 2540
Total lead	Electrothermal atomic absorption spectrometry	0.001 mg/l	SM 3113B
Total copper	Electrothermal atomic absorption spectrometry	0.001 mg/l	SM 3113B
Total cadmium	Electrothermal atomic absorption spectrometry	0.0003 mg/l	SM 3113B
Total zinc	Direct aspiration into air-acetylene flame	0.015 mg/l	SM 3111B
Total iron	Direct aspiration into air-acetylene flame	0.025 mg/l	SM 3111B
Ammonia-N	Automated phenate	0.1 mg/l	SM4500
Organic nitrogen	Semi Automatic Block Digester	0.01 mg/l	EPA 351.2
Nitrate-nitrite-N	Cadmium reduction	0.01 mg/l	EPA 353.2
Total Phosphorus	Colorimetric automated block digester	0.01 mg/l	EPA 365.1
Ortho-phosphorus		0.01 mg/l	SM 4500-P

When analyzing the water quality data, there were some measurements below the laboratory detection limit. When a value was listed below the detection limit (D.L.), one-half the detection limit was substituted for calculating summary statistics. Starting in December 2002, new equipment for analyzing metals increased the detection limit making most of the samples for lead and cadmium reported as below detection.

Water quality data were compared to regional and federal standards to determine toxicity. Nutrients were compared to ambient water quality criteria recommendations set by the U.S. EPA for Ecoregion XII (Table 2). For metals, the standards are based on water hardness, and a unique standard has to be calculated for each water sample. These standards are listed in Table 3.

Table 2. Ambient Water Quality Criteria Recommendations for Nutrients in Ecoregion XII (U.S. EPA 2000).

Parameter	Lakes & Reservoirs	Rivers & Streams
Nitrate + Nitrite (mg/L)	n/a	0.02 annual average median
Total Nitrogen (mg/L)	0.52 annual average median	0.90 annual average median
Total Phosphorus (mg/L)	0.01 annual average median	0.04 annual average median

Table 3. A comparison of State Surface Water Quality Standards (FDEP 1992). Standards are exceeded when pollutant concentrations are $\geq$ the values given below. Units in ug/l unless indicated.

Constituent	Class II & III Standards - Marine	Class III Standards - Fresh
Cadmium	≤ 9.3	$\leq e^{(0.7852[\ln H]-3.49)}$
Copper	≤ 2.9	$\leq e^{(0.8545[\ln H]-1.465)}$
Iron	≤ 300	≤ 1000
Lead	≤ 5.6	$\leq e^{(1.273[\ln H]-4.705)}$; 50 max
Manganese	≤ 100	≤ 100 (mg/l) (Class II)
Zinc	≤ 86	$\leq e^{(0.8473[\ln H]+0.7614)}$; $\geq$ 1000
Dissolved oxygen (DO)	5000; Normal daily and seasonal fluctuations above these levels shall be maintained (see rules).	5000; Normal daily and seasonal fluctuations above these levels shall be maintained (see rules).
pH	6.0 min. 8.0 max; ± 1.0 NB (standard units)	6.0 min 8.0 max; ± 1.0 NB (standard units)
lnH = natural logarithm of total hardness expressed as mg/l of $CaCO_3$. NB = Natural background. If hardness is less than 25 mg/L then use 25 mg/L or greater than 400 mg/L then use 400 mg/L		

For quality assurance, de-ionized water (D.I.) samples were taken in the same manner as stormwater samples to determine if the method of collection led to any contamination (Appendix C). Quality assurance samples were taken when sampler tubing was changed and when sample collection bottles were cleaned. The fact that a few levels were above the detection limit may indicate that some residual pollutant stayed on the instruments after the tubing was changed. None of the detections was high enough to affect the overall results of this study.

Field Parameters

Field parameters were recorded using submersible automated Hydrolab™ Datasonde III units. They were deployed about once a month to record data at one-hour intervals for 10 days at a time. These units were deployed at both the inflow and the outflow at an average depth of 6 in. below the surface. The parameters measured were temperature, pH, dissolved oxygen (DO), and specific conductivity.

Sediment Samples

Sediment samples were taken for the analysis of nutrients, metals, and pesticides in the pond to study the vertical and spatial migration of pollutants. As part of another research project prior to this study, sediment samples were taken at four locations in the pond during September 1997- the inflow, both sides of the equalizer pipe, and the outflow. During Year 1 (November 2000), sediment samples were taken at the inflow, sedimentation basin at the inflow, side bank of sedimentation pond, and outflow. During Year 2 (December 2003), samples were taken at the inflow, sedimentation basin at the inflow, equalizer pipe, and outflow. Samples were extracted intact from the sediments with a two-inch diameter stainless steel, hand-driven corer. At each location, a sample was taken at a depth of 1-2 inches and again at 4-5 inches to determine migration of constituents vertically in the soil. In order to gather a sufficient amount of sediment for analysis, four to six replicate cores were collected in close proximity for each sample. These cores were composited using the four-corner mixing method. For quality assurance, one random duplicate sample was taken during each sampling event at one of the locations to determine how closely samples from the same location matched. Samples were placed in EPA approved glass jars supplied by the FDEP laboratory, preserved with ice in insulated coolers, and sent by overnight mail to the FDEP laboratory for analysis using the FDEP approved quality assurance protocol (FDEP 1996). In addition, grab samples for ambient water quality analysis were taken at a depth of 4-6 in. before sediment sampling at each station. These samples were sent to the SWFWMD laboratory for analysis as described in previous sections. Field parameters were also taken at each sampling site using a Hydrolab™ Minisonde/Surveyor 4 unit.

When analyzing sediment concentrations, it is helpful to know what levels may affect the environment. Sediment quality guidelines have been developed for the National Status and Trends Program (NOAA 1999) (Table 4, column a). These guidelines are for comparison purposes only and provide a basis to compare toxicity of the sediments. The guidelines have a range of values. The low end of the range, "Effects Range-Low" (ERL), indicates concentrations below which adverse effects rarely occur. The 50^{th} percentile range, "Effects Range-Median" (ERM), represents concentrations above which adverse effects likely occur. Other standards that have been developed from lab studies are also listed in Table 4. Since possible biological effects on aquatic animals need more stringent requirements, two levels have been set for aquatic sediment – the possible effect level and the probable effect level. Informal sediment contamination guidelines have been published for freshwater sediments in Canada that identify potentially adverse biological effects (Persuad et al. 1990). Possible effects listed in Table 4 represent the boundary between the level at which no toxic effects have been observed and the lowest level showing the concentration that can be tolerated by the majority of benthic organisms. The probable effect indicates the level at which a pronounced disturbance to the benthic community occurs. Along these lines, guidelines for estuarine sediments have been established for Florida (column c) (MacDonald et al 1993).

Sediment criteria have not been enforced to date; Table 4 contains guidelines for comparison purposes only. Any exceedance should indicate further tests. This conclusion was

Table 4. Sediment quality criteria giving threshold concentrations where constituents have the possible effect level (Low) and the limit of tolerance level (Prob). See text for a more complete explanation.

Constituent		Sediment Quality Guidelines (a)		Freshwater (b)		Estuarine (c)	
		ERL	ERM	Low	Prob	Low	Prob
TKN	mg/kg	na	na	545	4800	na	na
Total Phosphorous	mg/kg	na	na	600	2050	na	na
Cadmium	mg/kg	1.2	9.6	1	10	1	8
Chromium	mg/kg	81	370	31	111	33	240
Copper	mg/kg	34	270	25	114	28	170
Lead	mg/kg	46.7	218	31	250	21	160
Mercury	mg/kg	0.15	0.71	na	na	na	na
Zinc	mg/kg	150	410	110	800	68	300
DDE	ug/kg	2.2	27	na	na	na	na
DDT	ug/kg	1.58	46.1	na	na	na	na
Total PAH's	ug/kg	4022	44792	na	na	na	na

(a) Sediment Guidelines (NOAA 1999)
(b) Development of Sediment Quality Guidelines (Persuad et al. 1990)
(c) Sediment Quality in Florida Coastal Waters (MacDonald 1993)
(d) Magnitude and Extent of Sediment Toxicity in Tampa Bay, FL (Long et al. 1995)

the result of a study by O'Connor et al. (1998). They looked at the guidelines provided by NOAA (1999) and compared them to an amphipod survival test to verify the claims of sediment toxicity to biological activity. Sediments were considered toxic if fewer than 80 percent of the amphipods relative to controls survived the exposure. Of the 481 samples below the probable exceedance level, only five percent were toxic and agreed with the prediction. On the other hand, of the 239 samples that had at least one concentration greater than the probably toxic level, only 38 percent were actually toxic (O'Connor et al. 1998). Thus, results greater than the ERM do not necessarily indicate toxicity, but they do render cause for further investigation.

Statistical Analysis

Statistical computations were performed using the SAS system, version 8.1, to determine significant differences and to analyze relationships between variables. Most statistical tests assume the variables are from an independent and normally distributed population and that the variances are homogeneous. This is rarely the case for water quality data and tests for skewness, kurtosis and the Shapiro-Wilk statistic showed that most variables rarely exhibited a normal distribution. Log transformations did not improve the distribution enough to produce the desired results; therefore, the data were tested with non-parametric procedures. The Wilcoxon Rank Sum method tested for statistical differences and the Spearman method computed correlation coefficients.

Results and Discussion

The Street Pond, a wet pond with sidebank filters, evaluated the dynamics of the pond system and the effectiveness of the pond in removing pollutants from stormwater before the runoff reached Tampa Bay. Water quality data was collected in the pond from November 2000 through October 2003. Sampling was halted from August 2001 to June 2002 during construction of the cruise ship terminal. This break in sampling splits the data into Years 1 and 2.

Hydrology

Amount of Rain

During Year 1, which covered a 10-month period, the site was undergoing drought conditions. The amount of rain measured was 26 inches, which is considerably less than the long-term average of 44 inches. El Niño conditions affected the site during Year 2 (17 month period); the site received 113 inches, noticeably more than the long-term average of 88 inches. Figure 4 shows average monthly rainfall compared to the long-term average. The record includes several large rain events as well as one hurricane (Hurricane Cristobal on August 7, 2002). In contrast, it also includes several months with essentially no rain. Florida normally has wet and dry seasons, and about sixty percent of all rainfall occurs from June to October when convective activity often produces afternoon thunderstorms. Hurricanes and tropical depressions also often occur during this season. During the winter, frontal storms from the north bring rain. Since frontal storms rarely make it this far south in spring and fall months (April – May and October- November), these are usually dry months.

Rainfall Characteristics

The intensity and duration of rainfall events are relevant not only to water quantity issues, where they affect flooding and peak discharge, but also to water pollution, where they influence constituent concentrations and removal efficiency. Rainfall influences pollutant concentrations and removal efficiencies in several ways. Antecedent conditions (inter-event dry period) increase pollutant concentrations by allowing time for accumulation of pollution on land surfaces. High rainfall intensity following these dry periods dislodges pollutants from the drainage basin. In addition, wet and dry years affect input and output concentrations by changing subsurface flow and evapotranspiration. A few large rain events also have the ability

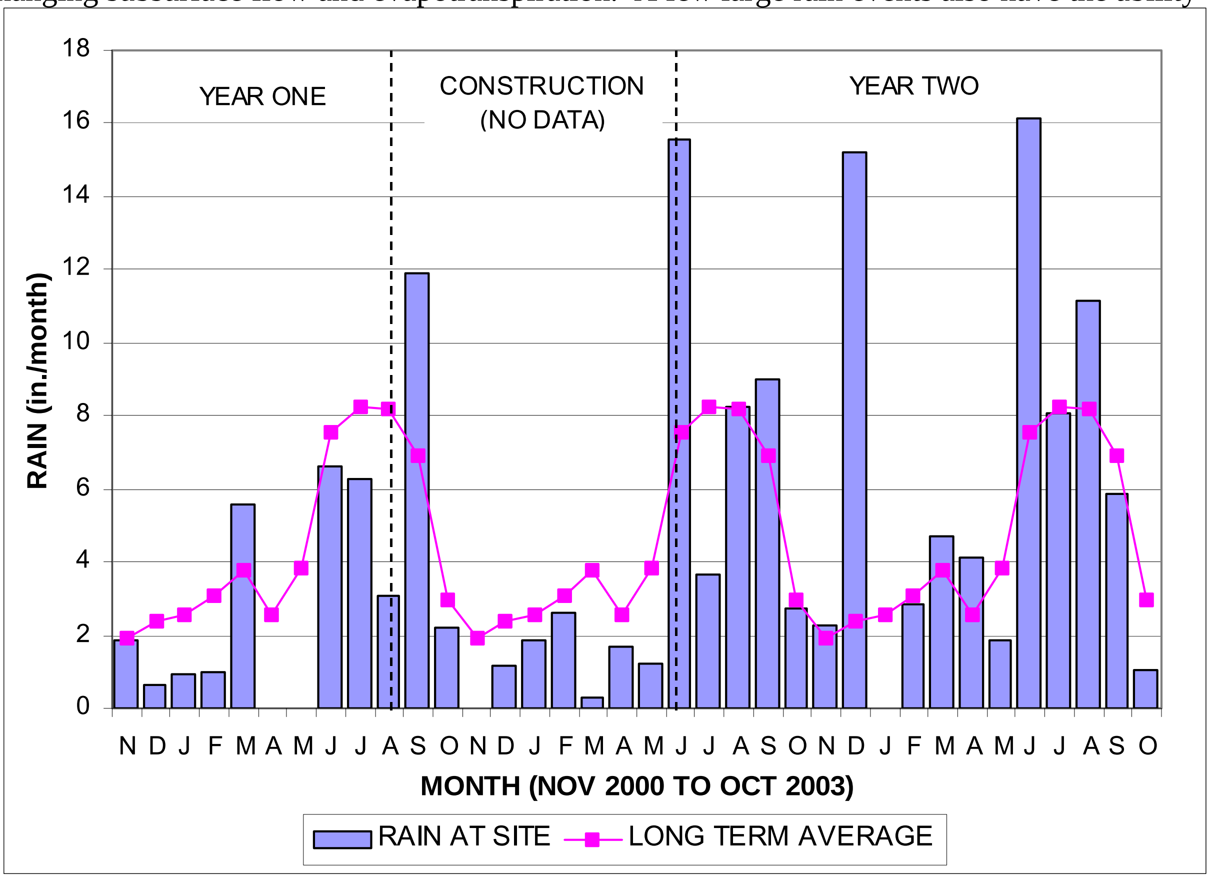


Figure 4. Amount of rain measured each month during the study compared to the long-term rainfall average for the region.

to flush out the system; this is especially true for reducing floating algal mats, phytoplankton, and other organic matter in stormwater pond.

Rainfall characteristics for most storms during this study with enough flow to produce runoff (> 0.23 inches) are presented in Appendix D, and a summary for each year is shown in Table 5. The most obvious differences are the longer inter-event dry periods in Year 1 and the higher average rainfall amounts and longer average storm durations for Year 2. These results reflect the drought conditions during Year 1 and the El Nino conditions during Year 2.

Surface Flow

Flow data were analyzed to provide a better understanding of how water quality loads affected the entire pond system. Flow was considered in terms of rainfall and water entering the pond through the inflow pipe and exiting over the outflow weir. Table 6 lists flow entering and exiting the pond for storms where water quality was sampled. Appendix E contains plots of rainfall, outflow, and inflow for all storms. There was about a fifteen-minute lag between the beginning of a storm and flow coming into the pond. Thus, the highly impervious drainage basin is a flashy system where rain has an immediate impact on the pond. Likewise, there also occurred a 15-minute lag between the inflow and the outflow. Not only is the entire drainage basin flashy, the pond system also quickly responds to rainfall.

Table 5. A summary of rainfall characteristics for most rain events that produced flow (>0.23 inches).

SUMMARY STATISITCS	TOTAL RAIN (in.)	INTER-EVENT (hrs.)	DURA-TION (hrs.)	MAX. INT. (in./15 min.)	AVG. INT. (in./hr.)
YEAR ONE (NOVEMBER 2000 THROUGH AUGUST 2001)					
# Observations	31	31	31	31	31
Average	0.84	218.47	3.08	0.48	0.45
Median	0.60	97.50	2.50	0.40	0.21
Maximum	3.29	1525.50	11.75	1.40	2.40
Minimum	0.23	14.25	0.25	0.03	0.02
Std Deviation	0.67	315.76	2.95	0.38	0.61
Coefficient of Variation	0.79	1.45	0.96	0.79	1.35
CONSTRUCTION YEAR (SEPTEMBER 2001 THROUGH JUNE 2002)					
# Observations	28	27	27	27	26
Average	1.34	286.50	5.14	0.48	0.47
Median	1.03	182.00	2.75	0.41	0.31
Maximum	6.10	1053.25	36.75	1.28	1.71
Minimum	0.30	9.25	0.75	0.07	0.04
Std Deviation	1.17	290.57	7.07	0.34	0.45
Coefficient of Variation	0.87	1.01	1.38	0.71	0.96
YEAR TWO (JULY 2002 THROUGH OCTOBER 2003)					
# Observations	92	92	92	92	92
Average	0.93	125.97	5.08	0.31	0.34
Median	0.63	75.48	3.75	0.22	0.18
Maximum	4.64	1120.25	29.50	1.00	2.92
Minimum	0.22	6.25	0.25	0.04	0.04
Std Deviation	0.90	156.10	4.62	0.22	0.43
Coefficient of Variation	0.97	1.24	0.91	0.73	1.27

An effluent filtration pond is designed to slowly drain storm flow through the filters and only discharge over the outflow weir for large events. For monitored storms, 54% of the inflow was discharged over the weir in Year 1, but only 35 % in Year 2. Since Year 2 had higher average rainfall and more storm events, the lower percentage going over the weir indicates that the additional sidebank filter and storage capacity of the pond in Year 2 provided conditions for

Table 6. Flow for storms where water quality was sampled. Underdrain flow is not included.

	Date	Storm #	Rain (in.)	Inflow (c.f.)	Outflow (c.f.)	Runoff Coeff.
Year 1	03/19/01	5	0.89	11,219	0	0.37
	03/29/01	6	3.56	55,745	31,084	0.46
	06/06/01	7	1.97	29,166	10,581	0.43
	06/19/01	8	0.64	7,852	0	0.36
	06/23/01	9	0.52	4,501	1,202	0.25
	06/28/01	10	2.15	34,034	22,064	0.46
	07/11/01	11	0.83	12,204	6,367	0.43
	07/13/01	12	0.95	12,696	5,063	0.39
	07/21/01	13	1.07	15,237	7,256	0.42
	07/23/01	14	1.41	26,784	16,980	0.56
	07/27/01	15	0.48	6,499	2,743	0.40
	08/05/01	16	0.5	8,590	12,428	0.50
	08/07/01	17	1.05	12,764	13,490	0.36
	TOTAL*		**16.02**	**237,291**	**129,258**	**0.41**
Year 2	06/12/02	1	0.84	12,599	0	0.44
	06/18/02	2	2.67	45,262	24,110	0.50
	06/24/02	3	3.26	58,484	30,135	0.53
	06/28/02	4	2.73	46,709	13,828	0.50
	06/29/02	5	1.21	20,798	4,115	0.50
	07/01/02	6	0.91	14,809	207	0.48
	07/25/02	7	0.41	5,264	0	0.38
	08/02/02	8	0.27	3,327	0	0.36
	08/07/02	9	1.48	30,772	1,521	0.61
	08/14/02	10	2.93	47,612	20,010	0.48
	08/17/02	11	0.74	10,609	0	0.42
	08/30/02	12	1.18	16,994	0	0.42
	09/02/02	13	1.1	17,804	332	0.47
	09/11/02	14	1.55	27,879	11,342	0.53
	09/12/02	15	0.72	11,195	5,949	0.46
	09/17/02	16	1.34	21,690	8,818	0.47
	09/26/02	17	0.41	7,351	0	0.53
	10/12/02	18	0.92	12,977	0	0.41
	10/15/02	19	0.54	7,025	0	0.38
	10/30/02	20	0.51	7,003	0	0.40
	11/12/02	21	0.89	10,732	0	0.35
	12/09/02	22	3.69	62,485	28,259	0.50
	12/12/02	23	4.65	89,057	57,644	0.56
	02/22/03	24	0.57	6,478	0	0.33
	02/28/03	25	1	18,092	382	0.53
	03/16/03	26	0.69	12,446	0	0.53
	03/21/03	27	1.64	35,773	20,024	0.64
	03/23/03	28	1.45	20,425	7,144	0.41
	04/25/03	29	3.5	53,644	16,912	0.45
	05/22/03	30	0.77	9,328	0	0.36
	06/08/03	31a	0.26	4,123	0	0.46
	06/09/03	31b	0.74	10,478	0	0.41
	06/11/03	32	1.65	28,082	6,103	0.50
	06/16/03	33	0.92	11,093	0	0.35
	06/18/03	34	1.52	32,413	12,951	0.62
	06/19/03	35	1.5	23,097	19,320	0.45
	06/29/03	36				
	07/11/03	37	0.71	13,014	7,929	0.54
	08/27/03	38	0.96	14,206	5,193	0.43
	09/19/03	39	2.31	30,572	15,078	0.39
	TOTAL*		**55.14**	**911,701**	**317,306**	**0.45**

*Runoff Coefficient is average of all storms, not total.

more water to go through the filters. As mentioned earlier, between Years 1 and 2, a second sidebank filter was added to the pond and the overflow weir was raised, which effectively retained water in the pond and allowed for filtration treatment. It is estimated that an even greater percentage was treated by the filters because of some unmeasured flow that entered the pond through a pipe draining one acre of the parking lot.

Water Budget

A complete water budget was estimated for one storm event that took place on July 13, 2003 (Figure 5). Inflow to the pond increased with rain intensity. The pond was then balanced by a volume of outflow over the weir that was close to the volume of inflow. The outflow was *most likely due to pre-existing water in the pond, which was discharged as stormwater entered the system. Evidence of this can be seen by comparing the immediate increase in outflow following the increase in inflow (Appendix E) and the substantially lower concentrations of constituents and differences in field parameters between the outflow and inflow (to be discussed in later sections). Although the flow volume was very low compared to the inflow and outflow over the weir, the underdrains flowed continuously. This was probably due to groundwater seepage. However, the flow from the underdrains did increase during rain events, about an hour after the increase in inflow in Figure 6. One important note is that the underdrains flowed continuously, though Figure 6 only represents an 8-hour storm, indicating that they were effective for slowly releasing storm flow over several days, especially for most storms that did not exit over the outflow weir.

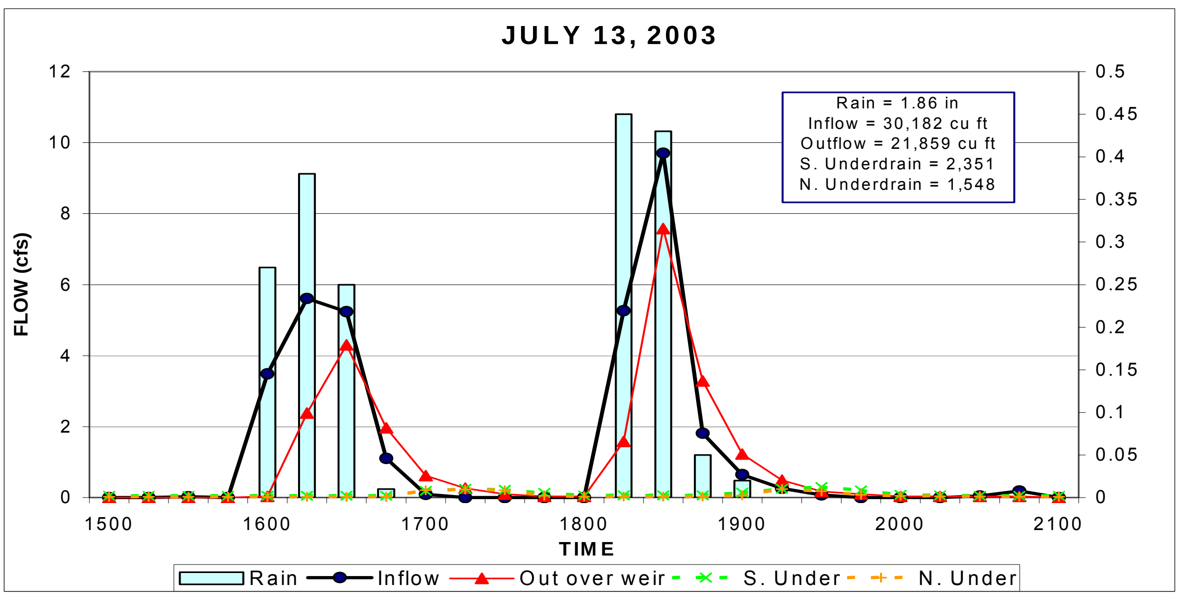


Figure 6. Inflow and outflow relative to the rain event of July 13, 2003. Underdrain data is included to illustrate that the pond level increased enough to flow into the filtration system.

The water budget was calculated monthly for Year 2 (Table 7). The effects of seepage from groundwater into the underdrains complicated calculating the water budget, which is evident in the high error values. Appendix F includes hydrographs that further illustrate the effect of groundwater in the underdrains. It is evident from the hydrographs that the flow from the underdrains followed the fluctuations in the pond level. However, there was flow issuing from the underdrains at times when the pond level was below the elevation of the underdrain intake pipes. At first, this phenomenon was thought to be due to the fact that the underdrain system was cleaned out during the construction, but further research revealed substantial baseflow before this event; see Appendix F. Thus, the water table at the site was high enough that groundwater was likely continuously seeping into the underdrains. This discharge, although small on a daily basis, was considerable when calculated as a monthly discharge as was demonstrated in the water budget calculations (Table 7). The high error values in the water budget also result from low baseflows coming in the inflow in between storms. The higher inflows during some summer months were probably caused by baseflow coming into the pond. Although velocity meters are known for not being very accurate for measuring low flows, measurable flows into the pond were detected even when there was no rain. On a monthly basis, this flow could have an impact on volume. However, the Sontek™ velocity meter does not give as accurate readings in low flow situations.

Table 7. Water budget for Year 2 (July 2002-October 2003). Red values in parentheses denote flow out of the system or a decrease in level.

MONTH	RAIN in.	RAIN ON POND cu. ft.	INFLOW cu. ft.	10% EST. N.PIPE cu. ft.	OVER WEIR cu. ft.	UNDER DRAIN SOUTH cu. ft.	UNDER DRAIN NORTH cu. ft.	ET (est) cu. ft.	CHANGE IN STORAGE cu. ft.	GROUND WATER & error
July '02*	3.68	4,408	52,061	5,206	(207)	(19,894)	(19,894)	(7,047)	(11,788)	26,421
Aug. '02	8.23	9,859	123,485	12,349	(36,761)	(56,913)	(69,263)	(6,305)	10,063	(33,612)
Sept. '02	8.99	10,769	162,943	16,294	(57,183)	(107,786)	(109,962)	(5,031)	(3,738)	(86,218)
Oct. '02	2.75	3,294	21,422	2,142	0	(32,810)	(35,341)	(4,451)	1,150	(46,893)
Nov. '02	2.29	2,743	27,620	2,762	(2,857)	(61,540)	(50,289)	(3,953)	(7,188)	(78,326)
Dec. '02	11.28	13,513	207,757	20,776	(160,944)	(61,360)	(73,318)	(2,225)	6,038	(61,840)
Jan. '03	3.87	4,636	69,870	6,987	(49,737)	(24,846)	(28,298)	(1,484)	(12,219)	(10,653)
Feb. '03	2.85	3,414	104,151	10,415	(382)	(54,294)	(48,497)	(2,010)	23,000	(10,202)
March '03	4.68	5,606	117,491	11,749	(27,167)	(73,791)	(74,146)	(3,709)	(12,219)	(31,748)
April '03	4.10	4,911	144,169	14,417	(16,912)	(44,951)	(59,500)	(5,031)	(2,731)	39,834
May '03	1.84	2,204	140,381	14,038	0	(29,535)	(47,527)	(5,934)	(9,056)	82,684
June '03**	10.62	12,722	189,380	18,938	(63,863)	(57,135)	(82,807)	(6,469)	18,688	(7,921)
July '03	8.07	9,667	207,011	20,701	(44,209)	(146,024)	(103,540)	(7,047)	(6,181)	(57,259)
Aug. '03	11.16	13,369	340,951	34,095	(96,530)	(128,479)	(137,179)	(6,305)	1,150	18,772
Sept. '03	5.89	7,056	127,718	12,772	(20,344)	(104,012)	(80,818)	(5,031)	2,731	(65,391)
Oct. '03	1.06	1,270	289,279	28,928	0	(94,398)	(154,184)	(4,451)	(11,500)	77,944
TOTAL	91.36	109,442	2,325,689	232,569	(577,096)	(1,097,768)	(1,174,563)	(76,481)	(13,800)	(244,408)

*Underdrain data were caculated from pond level and are likewise underestimated.
**Two days of data were omitted due to equipment malfunction. Also, for three days, the velocity meter was not recording data and inflow values were estimated.

Appendix G shows the relationship between rain, inflow, and outflow (over the weir and through the underdrains) on a monthly basis. The inflow and outflow respond to increases in rain. Increases in inflow without significant increases in outflow over the weir or through the underdrains represent the pond being recharged after low levels.

Water Quality

Flow-weighted water quality samples were collected for surface water during storm events and for the underdrains on a regular schedule to determine the ability of the pond system to remove pollutants. Water quality concentrations for the inflow, outfall, and rainfall are included in Appendix H; concentrations for underdrains are included in Appendix I. Figure 7 reflects concentrations for most major constituents.

Nitrogen

Nitrogen is an important nutrient for plants. However, too much nitrogen can lead to noxious plant growth and blue-green algae blooms (Fox and Absher 2002). Nitrogen sources include fertilizers, atmospheric fallout, discharges from automobiles, mineralization of soil organic matter, and decomposition of plant material (Rushton, et al. 2002). A major pathway for both the ammonia and nitrate found in rainfall comes from the transformation of nitrogen oxides discharged from power plants and automobile exhausts. Nitrogen levels are a major concern in the region because nitrogen has been identified as the limiting factor in Tampa Bay.

The pond reduced the median total nitrogen concentrations by about 0.20 mg/L (22%) in Year 1 when levels are compared between the inflow and the outflow weir. Nitrogen reduction increased for Year 2 as median levels show a 0.25 mg/L (35%) reduction when measured at the outflow weir.

Nitrogen reduction is important because the impact of nitrogen on the environment is of great interest. Nutrient levels have been recommended by the U.S. Environmental Protection Agency (U.S. EPA) to protect against adverse effects of over-enrichment from nutrients. See Table 2. These levels are ambient criteria for water bodies in pristine conditions. While they serve as a measurement to compare to and a goal to aim for, the stormwater measured in this study will have, by nature, higher values. The criterion for median total nitrogen for lakes and reservoirs is 0.52 mg/L and for rivers and streams is 0.90 mg/L. Median levels of total nitrogen at the outflow weir exceeded the value for lakes and reservoirs during Year 1 (0.67 mg/L). By Year 2, median nitrogen levels were below the criteria recommendation (0.47 mg/L). It is likely the construction activity occurring during Year 1 (discussed later) affected these levels. The median values for the underdrain discharges, however, exceeded the criteria recommendations in both years (0.64 mg/L and 0.61 mg/L). Values were below the criterion for rivers and streams at all stations for both years.

Considering the pond discharges into Tampa Bay, it is also relevant to look at the criteria recommendations for rivers and streams. (Actually, criteria specific to estuaries would be most appropriate, but the U.S. Environmental Protection Agency has not published criteria for this ecoregion at the time of this writing.) During both years, median levels of nitrogen were below criteria recommendations for rivers and streams at both the outflow weir and the underdrains. For nitrate + nitrite levels, median level at the outflow weir for Year 1 (0.02 mg/L) met criteria recommendations for rivers and streams. The median levels at the underdrains exceeded recommendations (0.09 mg/L). The median levels for nitrate + nitrite increased at both the outflow weir and the underdrains in Year 2, and the levels exceeded criteria recommendations (0.07 mg/L at the outflow weir and 0.09 mg/L at the underdrains).

For both years, the concentrations of nitrogen and phosphorous measured at the underdrains were greater than those at the outflow weir (Figure 7). Other studies have also found higher levels of inorganic nitrogen and phosphorus in the underdrain pipes of effluent filtration systems (Harper and Herr 1993). Trapped organic particles of nitrogen and phosphorous on the filter media were listed as probable causes.

Even though nitrogen levels at the outflow weir (0.47 mg/L in Year 2) did not exceed levels thought to produce nuisance algal blooms, the Street Pond was highly eutrophic as measured by the amount of nuisance plant growth and by the response of dissolved oxygen and pH (to be discussed later). This indicates that the level of total nitrogen should be kept much lower than 0.52 mg/L (Table 2) to maintain ecosystem integrity.

Phosphorus

Phosphorus concentrations are a concern in stormwater ponds because algae require only small amounts of this nutrient to thrive; excess amounts can lead to extensive algal blooms (Fox and Absher 2002). Rainfall is not a significant source for phosphorous; phosphorous is introduced into stormwater through activities including soil erosion, construction activities, fertilizers, and vegetation cycling. The pond reduced the total phosphorous concentrations by about 0.24 mg/L (75 %) in Year 1 when median levels at the inflow are compared to those at the outflow weir. A 0.12 mg/L (67%) reduction in total phosphorous levels was measured for Year 2. Although it appears the pond was less effective in treating the phosphorous load in Year 2, as mentioned in previous sections, El Nino conditions were in effect in Year 2, and the levels of phosphorous were lower, overall, during Year 2 (see Appendix H). It is reasonable to assume that the increased volume of rain in Year 2 compared to Year 1 resulted in the pond system not accumulating as much pollutants between storm events.

The water quality criteria recommendation for total phosphorous for ambient conditions in pristine lakes and reservoirs is 0.01 mg/L (Table 2). Median levels of total phosphorous exceeded this value during Year 1 (0.08 mg/L) and Year 2 (0.02 mg/L). The median values for the underdrain discharges were also in exceedance in both years (0.12 mg/L and 0.09 mg/L). The criterion is 0.04 mg/L for streams and rivers. While both the outflow weir in Year 1 and the underdrains in both years did not meet this criterion, the outflow weir was below the criteria in Year 2. As mentioned earlier, it is likely the increased volume of rain and number of storm events which resulted in diluting the pollutant concentrations coming into the pond. Since the criteria are for ambient conditions in pristine water bodies, the pond was reasonably effective in reducing nutrients. The underdrains were not as effective. Indeed, for both years, the levels measured at the underdrains were significantly greater than those at the outflow weir (Figure 7). As mentioned in the previous section, other studies have also found higher levels of nutrients in the underdrain pipes of effluent filtration systems. Harper and Herr (1993) found increases of over 200% for outflow concentrations of ortho-phosphorus through the filter media. Still, the concentrations for total nitrogen and phosphorous species at the underdrains were measured lower than at the inflow (Figure 7). This is significant as underdrains contribute greatly to the overall water budget of the pond.

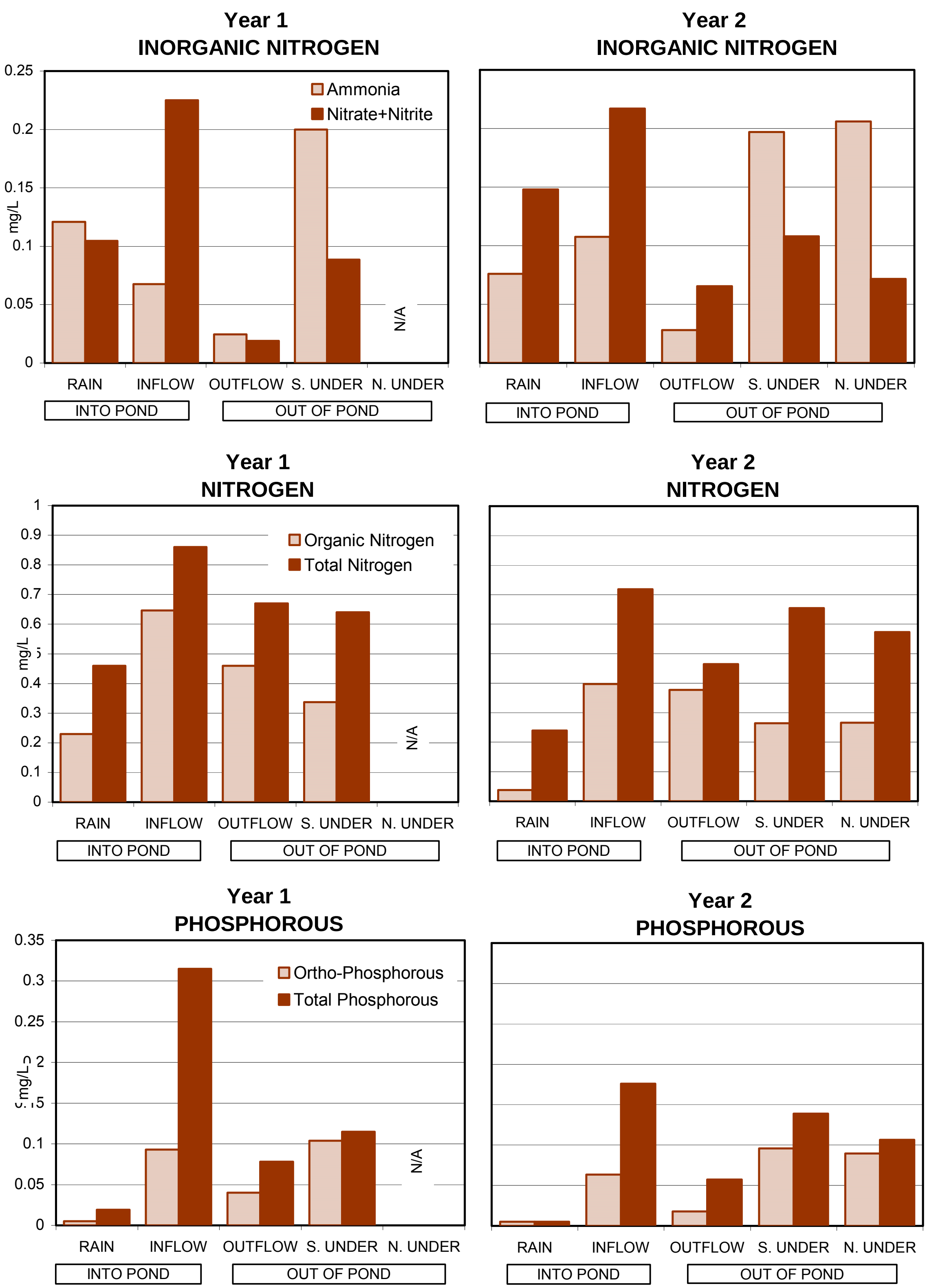


Figure 7. Comparison of water quality concentrations measured in rainfall, surface discharge, and underdrain discharge. Cadmium was not included as it was usually below lab detection limit.

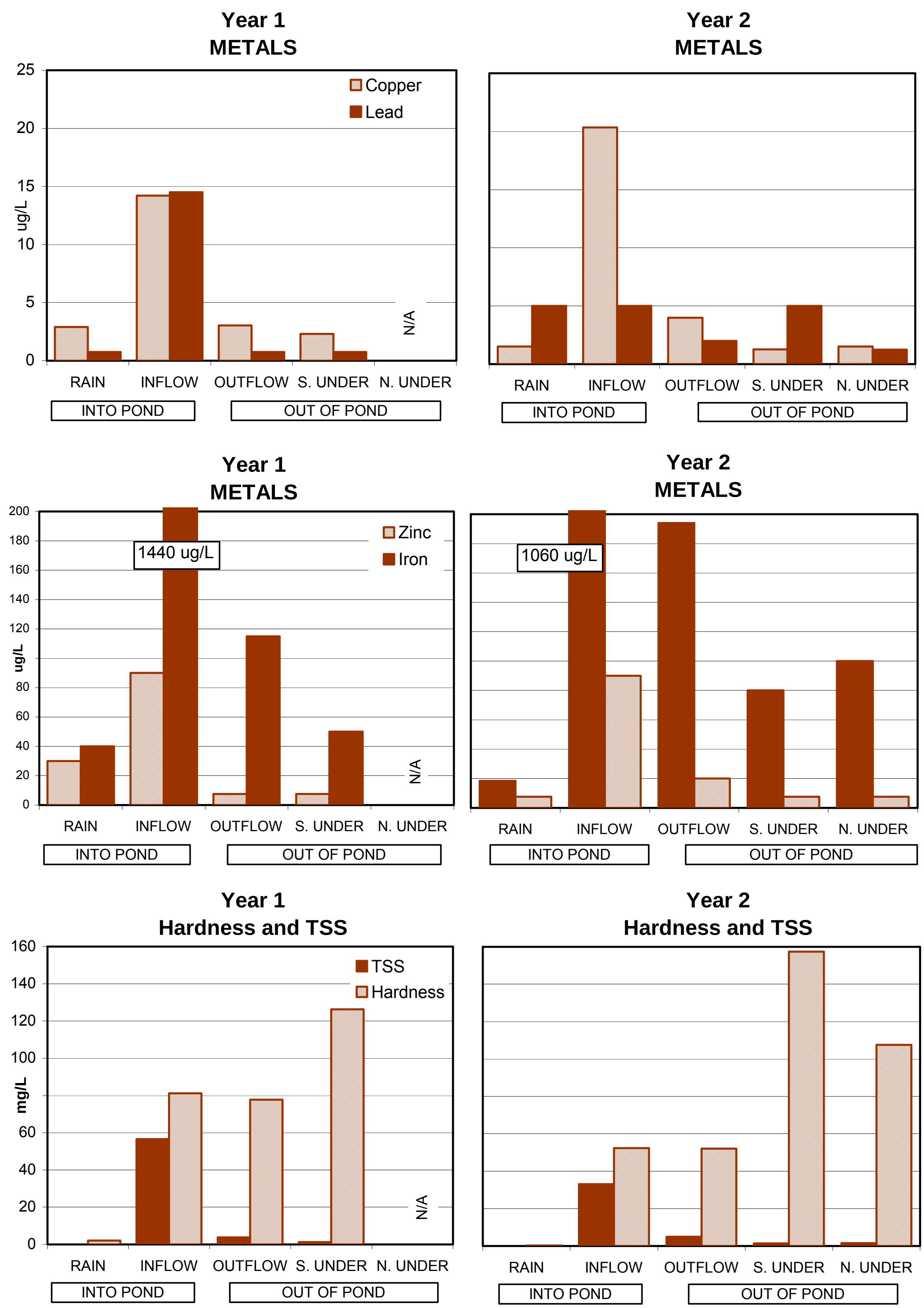


Figure 7 *continued.*

Total Suspended Solids

"Suspended solids" is descriptive of the organic and inorganic particulate matter which is of a size and type that allows the particles to stay suspended in water. Total suspended solids affect the water clarity, reduce the amount of sunlight available to aquatic life, cover fish spawning areas, and contribute to anaerobic conditions. Except for a few outliers, median levels of total suspended solids (TSS) were usually measured at low concentrations at the outflow during both years (3.7 mg/L in Year 1 and 4.95 mg/L in Year 2) (see Appendix H). Additionally, median TSS concentrations measured at the underdrains were also low (1.2 mg/L in Year 1 and 1.5 mg/L in Year 2). Indeed, the pond was successful in reducing TSS loads. TSS was reduced by about 52.8 mg/L (93 %) in Year 1 and 28.1 mg/L (85%) in Year 2 when median levels at the inflow are compared to those at the outflow These findings are consistent with other research results, which have shown that stormwater systems, both ponds and underdrains, are effective at removing suspended solids (Harper and Herr, 1993).

Metals

Metals are a concern in urban runoff with loads 10 to 100 times greater than the concentration of sanitary sewage (U.S. EPA 1983). Heavy metal sources are largely associated with the operation of motor vehicles, atmospheric fallout, and road surface material. Cadmium levels at The Florida Aquarium site were often measured below the laboratory detection limit; however, copper, lead, zinc, and iron were measured at concentrations high enough to be of concern (Figure 7). Copper, lead, and zinc were reported by The National Urban Runoff Program (U.S. EPA 1983) to be the most abundant and most frequently detected in stormwater. The pond was effective in treating these toxic metals. Copper was reduced by 11.16 ug/L (79%) in Year 1 and 16.37 ug/L (80%) in Year 2 when values were compared between the inflow and outflow weir. Lead was reduced by 13.75 ug/L (95%) in Year 1 and 3.0 ug/L (60%) in Year 2. Zinc was reduced by 82.50 ug/L (92%) in Year 1 and 70.00 ug/L (78%) in Year 2. Finally, iron was reduced by 1325.0 ug/L (92%) in Year 1 and 866.0 ug/L (82%) in Year 2. for all metals except copper, it would appear the efficiency of the pond for removing metals diminished somewhat by Year 2. It is likely the increased frequency of storms and flow through the pond resulted in more water going over the weir and less time for metals to settle out of the water. Also, higher concentrations are more easily reduced to lower levels than lower concentrations. However, in all cases, metal concentrations were still greatly reduced compared to the concentrations coming into the pond system from this highly impervious urban drainage basin.

The Florida Aquarium site is adjacent to the city incinerator and a marine dry dock; consequently, it had significantly higher loads of metals measured in atmospheric deposition than other sites in the Tampa Bay region (Dixon, et al. 1998). Metals were compared to the criteria for surface water quality. See Table 3. During this study, the pond discharge waters only exceeded fresh water Class III standards 7 times for copper, 8 times for lead, one time for zinc, and one time for iron in the 42 samples collected from water discharged over the outflow weir (Table 6). Averaged outflow from the underdrains was also compared to the Class III standards and was never found to exceed the criteria recommendations. Considering the underdrains accounted for the majority of the flow exiting the pond (see previous sections for discussion), the overall quality of the water was better than this analysis presents. The toxicity of metals for fresh water Class III standards is related to water hardness; concentrations in soft water are more harmful to fish and wildlife than concentrations in hard water. It is likely non-compliance of the standards increased in Year 2 due to the decrease in hardness (described in next section). The calculated fresh water Class III standards for each sample were compared to the actual sample concentration in Appendix J; the summary data for each year are presented in Table 8.

Table 8. Summary data comparing metal concentrations measured at the outflow (Station 638) to metal class III standards. All values are in ug/L. Exceedance (%) represents percent of samples in non-compliance with state standards

YEAR 1	TOTAL COPPER	STD. COPPER	TOTAL LEAD	STD. LEAD	TOTAL ZINC	STD. ZINC
Number	16	16	16	16	15	16
Average	4.0	9.9	1.4	2.5	12.6	89.0
Median	3.0	9.5	0.8	2.3	7.5	85.5
Exceedance (%)	0.0%		12.5%		0.0%	
YEAR 2						
Number	26	26	26	26	26	26
Average	8.4	7.2	4.0	1.5	28.9	64.4
Median	4.0	6.8	2.0	1.4	20.0	61.0
Exceedance (%)	26.9%		23.1%		3.8%	

Hardness

Hardness was measured as a product of calcium and magnesium levels. Hardness was consistently above the laboratory detection limit of 20 mg/L. The concentrations of hardness were slightly higher at the inflow than the outflow. Conversely, the concentrations of hardness measured at the underdrains were much higher than both the inflow and outflow. See Figure 7. This is likely due to interaction of the water with the alkaline substrate used as filter material in the underdrain structure . In addition, the quality of the surficial groundwater seepage into the underdrains could affect the hardness depending on the soil type in the area. Hardness is not a pollutant of concern in stormwater, and, in fact, hard water renders pollutants less toxic to organisms. A decrease in hardness was found between Years 1 and 2. This trend is likely due to the greater amount of rainfall in Year 2, which would increase water softness as is evident in Figure 7.

Underdrains

For Year 2, the underdrains were compared based on pond level. When the pond level was below the bottom of the underdrain intake (6 ft. NGVD), the flow was considered baseflow. When the pond level was above the bottom of the underdrain intake, the flow was considered treated stormwater. Finally, storm events resulted in a substantial increase in flow (see Appendix F) and were looked at separately. The box-plots from this analysis are included in Figure 9 and Appendix K. Nutrient species, ammonia, total nitrogen, ortho-phosphorous, and total phosphorous, were considerably higher when the pond level was below the bottom of the underdrain intake (Figure 9); this supports statements from earlier sections that water in the underdrains generally have higher nutrient concentrations. As the groundwater would migrate through the filter material at a slower rate, the water would have time to pick up more nutrients.

The hardness from the baseflow was also slightly higher, suggesting that the local groundwater was, indeed, more hard than the pond water. The metal concentrations were consistent for all three categories. The one major difference is the baseflow, which had less variation in metal concentrations. This could be expected as stormwater would vary between storms and seasons.

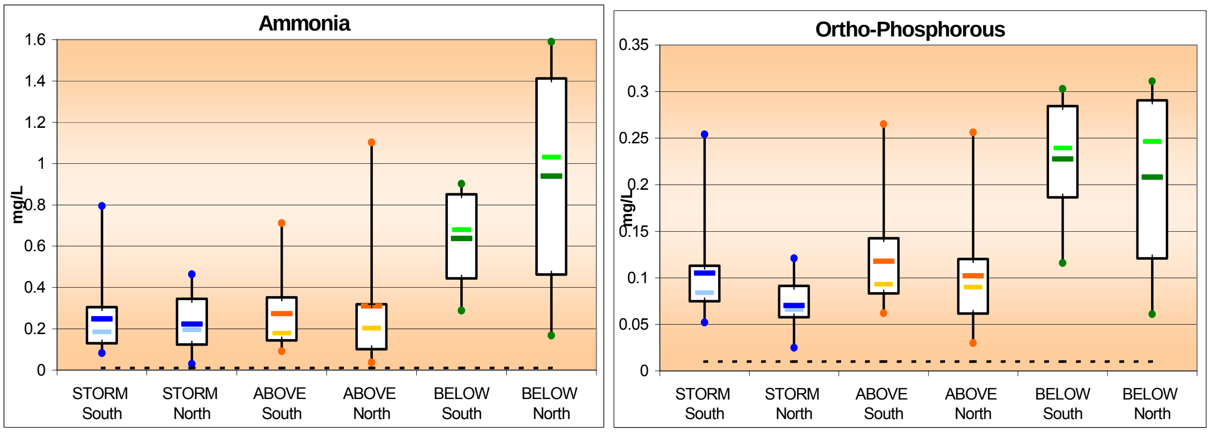


Figure 9. Box plots of underdrain flow for ammonia and ortho-phosphorous during different pond levels: storm event--STORM (blue), above the bottom of the underdrain pipe (6 ft. NGVD)--ABOVE (orange), and below the bottom of the underdrain pipe--BELOW (green). STORM and ABOVE are considered treated stormwater, and BELOW is considered baseflow. Graphs show maximum and minimum values (dots), 25th and 75th percentiles (box), means (dark lines), medians (light lines), and minimum detection level (dashed line).

Pollutant Loads

Pollutant loads estimated for one 12-month period during Year 2, depended on some uncertain under drain data (see Appendix F). Load calculations were difficult to make for several reasons. 1) The under drains flowed continuously and much of this was believed to be groundwater since the level of the pond was below the intake pipes. 2) The small eight-inch diameter under drain pipes were equipped with weir structures, but the results depended on measurements of an inch or two while the accuracy of the level measuring instrument was less than half an inch. In addition, these level measurements drifted and required constant adjustments. 3) The bubbler tubing for the level measurements in the under drains often became clogged with algae and other debris, which interfered with correct measurements.

The load calculations were made on a monthly basis since the rain, inflow and weir outflow occurred only during rain events, but the under drains flowed continuously. The under drains were not necessarily sampled during rain events, but were sampled twice a month with composite samples covering several days. The results indicate that the stormwater system is not effective for removing dissolved nutrients and may be dewatering the ground water (Table 9). Estimates showed 10 percent more water left the system compared to storm event flows into the pond. Dissolved nutrient loads increased considerable in the system. For example, ammonia increased by 84 percent and ortho-phosphorus by 64 percent; and only a moderate reduction occurred for other nutrient species (14 to 17 percent). In contrast, total suspended solids and most metals showed a significant load reduction (79 to 89 percent).

Table 9. Monthly loads measured entering and leaving the pond (Eff% positive=reduction and negative=increase loads).

	HYDROLOGY cubic feet					AMMONIA grams					NITRATE + NITRITE grams					ORGANIC NITROGEN grams				
	RAIN	INFLOW	OUTFLOW	S.UNDER	N.UNDER	RAIN	INFLOW	OUTFLOW	S.UNDER	N.UNDER	RAIN	INFLOW	OUTFLOW	S.UNDER	N.UNDER	RAIN	INFLOW	OUTFLOW	S.UNDER	N.UNDER
Jul-02	4,408	57,267	-207	-19,894	-19,894	29	1,346	-1	-685	-415	17	623	0	-78	-62	4	573	-5	-131	-198
Aug-02	9,859	135,834	-36,761	-56,913	-69,263	237	373	-22	-666	-382	68	1,092	-75	-329	-365	0	1,400	-255	-354	-391
Sep-02	10,769	179,237	-57,183	-107,786	-109,962	39	254	-14	-521	-634	29	609	-18	-299	-207	11	1,167	-551	-736	-1,186
Oct-02	3,294	23,564	0	-32,810	-35,341	60	115	0	-240	-450	15	200	0	-162	-87	3	338	0	-216	-294
Nov-02	2,743	30,382	-2,857	-61,540	-50,289	24	287	0	-717	-758	14	243	0	-284	-184	0	305	0	-407	-471
Dec-02	13,513	228,533	-160,944	-61,360	-73,318	50	637	-109	-237	-326	24	764	-330	-683	-536	22	1,349	-1,452	-392	-488
Jan-03	4,636	76,857	-49,737	-24,846	-28,298	0	0	0	-474	-849	0	0	0	-61	-70	0	0	0	-218	-139
Feb-03	3,414	114,566	-382	-54,294	-48,497	16	19	0	-291	-406	10	509	0	-232	-46	2	1,807	-5	-262	-363
Mar-03	5,606	129,240	-27,167	-73,791	-74,146	146	325	-22	-584	-874	17	576	-52	-324	-119	24	2,074	-285	-413	-499
Apr-03	4,911	158,586	-16,912	-44,951	-59,500	296	1,945	-64	-494	-1,044	34	1,563	-144	-322	-265	8	2,645	-314	-332	-502
May-03	2,204	154,419	0	-29,535	-47,527	3	708	0	-464	-772	5	761	0	-206	-117	5	1,662	0	-238	-458
Jun-03	12,722	208,318	-63,863	-57,135	-82,807	133	439	-41	-540	-683	70	1,250	-123	-215	-133	16	2,902	-863	-466	-721
TOTAL	78,080	1,496,803	-416,013	-624,855	-698,842	1,033	6,449	-272	-5,913	-7,593	303	8,190	-743	-3,195	-2,191	96	16,223	-3,729	-4,165	-5,708
IN/OUT		1,574,883			-1,739,710		7,482			-13,778		8,492			-6,129		16,319			-13,602
EFF%					-10%					-84%					28%					17%

	TOTAL NITROGEN grams					ORTHO- PHOSPHATE grams					TOTAL - PHOSPHATE grams					TOTAL COPPER milligrams				
	RAIN	INFLOW	OUTFLOW	S.UNDER	N.UNDER	RAIN	INFLOW	OUTFLOW	S.UNDER	N.UNDER	RAIN	INFLOW	OUTFLOW	S.UNDER	N.UNDER	RAIN	INFLOW	OUTFLOW	S.UNDER	N.UNDER
Jul-02	33	1,654	-6	-442	-401	1	190	0	-89	-54	1	367	0	-200	-81	187	28,138	-7	-1,149	-710
Aug-02	136	3,262	-314	-1,348	-1,139	1	269	-16	-253	-135	1	769	-64	-279	-172	2,178	82,322	-3,904	-2,788	-2,984
Sep-02	52	2,975	-605	-1,556	-2,028	2	294	-19	-251	-270	2	873	-84	-310	-366	351	81,724	-5,101	-4,317	-4,226
Oct-02	42	654	0	-618	-831	0	32	0	-82	-79	2	181	0	-119	-145	233	21,688	0	-1,696	-1,827
Nov-02	16	835	0	-1,407	-1,414	0	101	0	-234	-171	0	296	0	-260	-212	89	29,426	0	-2,004	-2,848
Dec-02	63	2,751	-1,892	-1,312	-1,350	2	307	-123	-126	-135	2	492	-255	-149	-178	440	116,173	-47,403	-6,951	-7,579
Jan-03	0	0	0	-753	-1,058	0	0	0	-186	-205	0	0	0	-201	-224	0	0	0	-809	-1,843
Feb-03	18	2,336	-5	-786	-814	1	113	0	-155	-130	0	243	-1	-186	-165	128	65,539	-42	-1,874	-4,052
Mar-03	91	2,974	-358	-1,322	-1,657	1	105	-9	-272	-266	4	534	-47	-306	-330	238	91,136	-2,851	-2,763	-3,150
Apr-03	142	6,153	-522	-1,149	-1,810	1	328	-10	-195	-236	1	1,073	-52	-224	-294	209	180,095	-5,556	-2,549	-5,521
May-03	11	3,131	0	-907	-1,347	0	559	0	-167	-185	0	800	0	-183	-221	94	89,650	0	-1,074	-2,750
Jun-03	131	4,590	-1,026	-1,221	-1,537	2	407	-16	-214	-186	2	1,202	-103	-246	-248	540	151,983	-7,506	-2,368	-3,518
TOTAL	735	31,314	-4,728	-12,821	-15,385	11	2,706	-192	-2,223	-2,052	15	6,831	-606	-2,662	-2,635	4,687	937,874	-72,368	-30,342	-41,008
IN/OUT		32,050			-32,933		2,717			-4,467		6,847			-5,903		942,561			-143,718
EFF%					-3%					-64%					14%					85%

	TOTAL IRON milligrams					TOTAL ZINC milligrams					TSS grams			
	RAIN	INFLOW	OUTFLOW	S.UNDER	N.UNDER	RAIN	INFLOW	OUTFLOW	S.UNDER	N.UNDER	INFLOW	OUTFLOW	S.UNDER	N.UNDER
Jul-02	2,200	1,524,496	-410	-10,299	-12,023	936	103,390	-44	-10,536	-3,718	16,218	-47	-890	-1,042
Aug-02	8,376	5,193,186	-176,982	-106,377	-162,527	2,094	384,680	-26,027	-23,371	-25,220	146,179	-4,685	-1,805	-3,082
Sep-02	4,575	4,517,640	-259,108	-274,725	-462,670	2,287	456,840	-40,486	-33,796	-44,487	119,286	-6,883	-3,619	-5,143
Oct-02	6,531	1,134,475	0	-134,731	-350,300	1,866	80,081	0	-12,776	-20,017	25,959	0	-2,769	-3,218
Nov-02	1,165	1,445,503	0	-143,782	-245,672	2,331	137,667	0	-51,195	-25,813	48,958	0	-1,988	-2,731
Dec-02	5,740	2,621,179	-1,162,273	-156,394	-259,546	2,870	194,161	-91,159	-13,033	-15,573	81,839	-23,542	-3,015	-3,748
Jan-03	0	0	0	-63,327	-88,154	0	0	0	-5,277	-6,010	0	0	-739	-994
Feb-03	1,624	901,974	-2,748	-65,733	-86,938	658	144,705	-280	-17,767	-10,040	15,866	0	-1,462	-2,568
Mar-03	2,929	3,578,338	-160,029	-113,108	-227,410	1,866	295,856	-18,119	-34,434	-13,243	101,994	-2,908	-2,176	-4,315
Apr-03	5,091	7,006,198	-129,316	-101,883	-189,342	516	529,956	-16,811	-5,512	-10,784	171,562	-2,993	-2,364	-6,358
May-03	390	2,772,576	0	-51,580	-93,679	594	238,337	0	-11,562	-36,072	61,224	0	-1,072	-2,019
Jun-03	11,697	8,680,228	-405,579	-128,564	-280,786	2,396	659,965	-29,571	-7,610	-16,528	286,522	-9,929	-2,909	-3,518
TOTAL	50,319	39,375,793	-2,296,444	-1,350,504	-2,459,047	18,414	3,225,638	-222,496	-226,869	-227,506	1,075,607	-50,987	-24,808	-38,736
IN/OUT		39,426,112			-6,105,996		3,244,052			-676,870	1,075,607			-114,531
EFF%					85%					79%				89%

KEY:

RAIN-Rain on the pond

INFLOW = Runoff into pond thru storm drains

OUTFLOW= Discharge over outflow weir

S.UNDER=South under drain discharge*

N. UNDER= North under drain discharge*

*It should be remembered that the under drains discharge all the time and much of this is ground water.

EFF%= Load efficiency. Reduction or increase of pollutant loads from the inflow to the outflow. A negative % = increase load

IN/OUT= total in/total out (1,574,803 cubic feet in to 1,739,710 cubic feet out) For example, 10% more water was measured leaving the pond than entered.

Field Parameters

Physical water quality parameters are important in understanding the processes that influence constituent cycling in natural waters. During this study, temperature, pH, DO, and conductivity were periodically measured hourly at the inflow and outflow for a week each month. At the inflow, the unit was suspended and hung over the opening of the inflow pipe where water entered the pond. The unit was anchored to the shaft encoder at the outflow and allowed to rest on the pond bottom. Measurements were summarized in graphs for each of the weekly measurements, and averages of each week were calculated to compare field parameter characteristics between the inflow and outflow. The results are included in Appendix L, and an example is shown in Figure 10

Temperature

As is evident from the graphs in Appendix L, the overall temperature of the pond is warmer in summer and cooler in winter. Also, temperatures at the outflow showed a diurnal cycle with warmer temperatures during the day and cooler temperatures at night. Rainfall disrupted this pattern by lowering temperatures (Figure 10 and Appendix L). This diurnal cycle was not evident at the inflow where measurements were taken in water flowing through an urban storm drain system.

pH

Fluctuations in pH and DO are the result of algal photosynthetic processes that peak during daylight hours. pH reaches a low at night when algal respiration dominates, producing carbon dioxide, and using oxygen. These diurnal patterns are small at the inflow except after rain evens. Conditions soon return to previous levels at the inflow within three to five days. Except during rain events, the pH maintains a level of about 7.5 at the inflow (Figure 10). In contrast to the inflow, the outflow had widely fluctuating diurnal levels indicating eutrophic conditions and considerable biologic activity.

pH is an important parameter since it affects the water chemistry and biology in stormwater ponds. For example, denitrifying bacteria operate best in the range $6.5 < pH < 7.5$, while nitrifiers prefer $pH > 7.2$ (Kadlec and Knight 1996). This target range for denitrification was seldom reached in the Street Pond. Some chemical reactions also require pH at lower levels than found in the Street Pond. For example, aluminum phosphate precipitates best at a theoretical pH of 6.3 and iron phosphate at a pH of 5.3 (Kadlec and Knight 1996). The state of Florida Class III Water Quality Standards permit a pH range between 5 and 8 standard units. This range was sometimes exceeded at the outflow during daylight hours during summer months.

Dissolved Oxygen

Dissolved oxygen (DO) was measured at low levels (usually below 4 mg/L) as it entered the pond at the inflow. It should be noted that the inflow sensors were measuring water in a concrete lined basin where water collects after being conveyed though underground pipes and

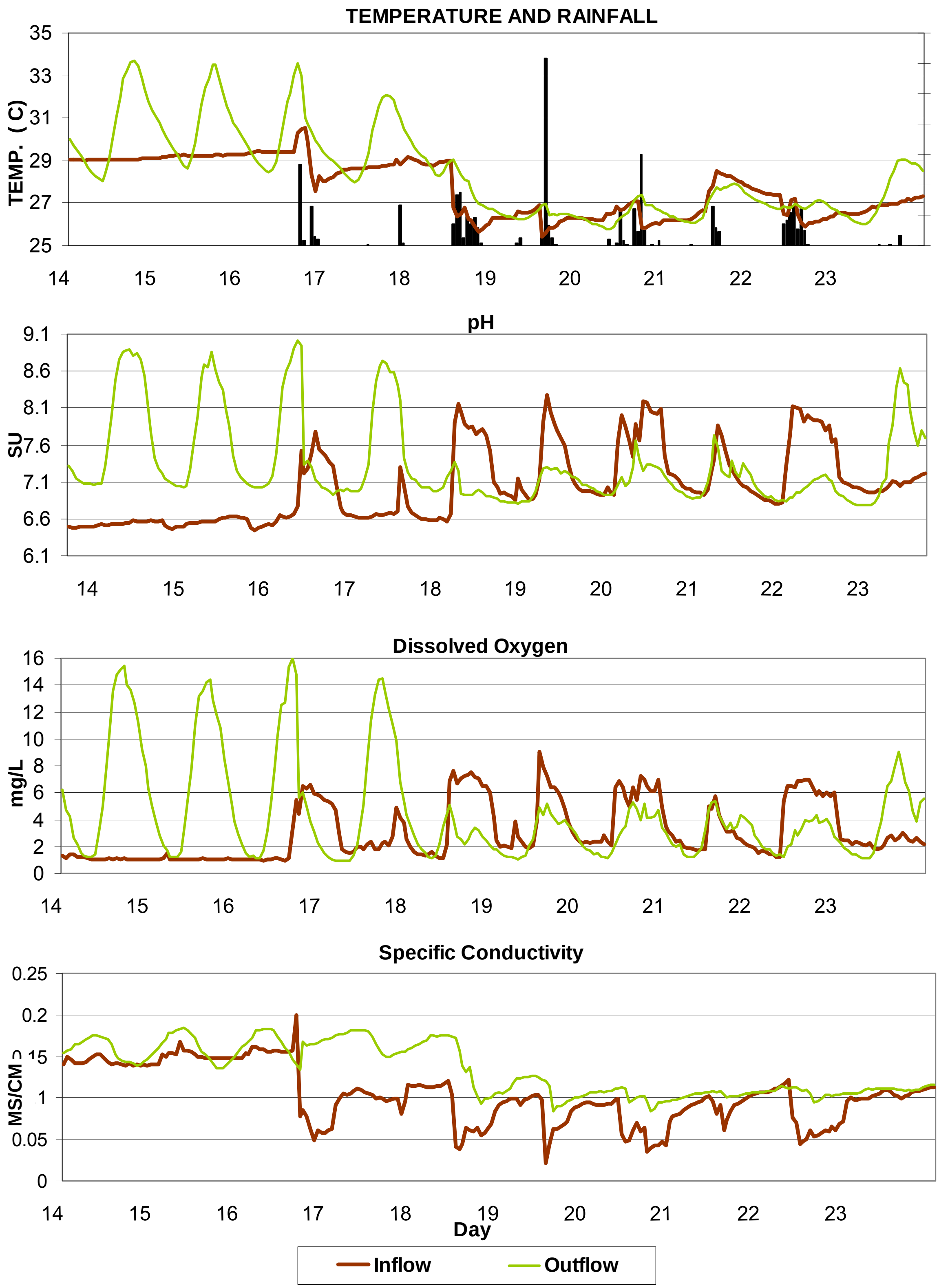


Figure 10. Field inflow and outflow parameters measured during June 2003.

where little biological activity takes place. The graph for the inflow indicates little fluctuation between storm events, supporting the fact that the inflow comes from a dark, underground pipe with no sunlight or photosynthesis. The measurements of DO at the inflow showed that rainfall raised DO levels due to surface-air interaction.

The DO at the outflow exhibited the wide fluctuations typical of a highly productive (eutrophic), emergent vegetation-dominated system (Figure 10). A diurnal cycle was created due to photosynthesis during the day and algal respiration at night. Photosynthesis utilizes carbon dioxide and produces oxygen during the day; during nighttime hours, algal respiration uses oxygen and expels carbon dioxide. The release of metals and phosphorus from the sediments when DO is low (reduced conditions) is one reason state standards require that DO shall not fall below 5.0 mg/L, and normal daily and seasonal fluctuations above these levels should be maintained (FDEP 1992). While the inflow was often below 5 mg/L during interevent conditions, the outflow was above 5 mg/L during daytime.

Conductivity

The graph for conductivity demonstrates the response of the pond to rainfall. During dry periods, conductivity rose as evaporation occurred and ions became more concentrated. Figure 10 and all the graphs in Appendix L show a sharp drop in the conductivity curve at the inflow, which reflects dilution by rain (soft water with low conductivity). As evaporation occurred between rainstorms, conductivity began to increase again until the next event. The outflow conductivity exhibits a relatively unchanging pattern, showing that the pond is well mixed and was effective in keeping the discharge conductivity steady. However, after several days of afternoon thunderstorms, the outflow also showed a drop in conductivity. A comparison of the conductivity measurements may indicate the slow mixing of inflow water with outflow water.

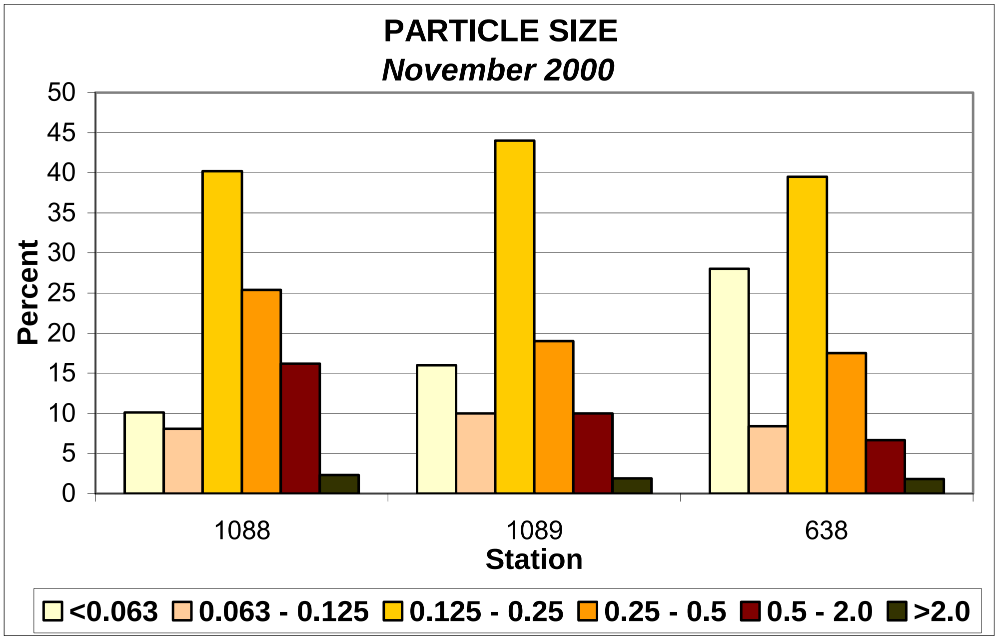
Sediment Samples

Sediment samples were taken in October 1997, November 2000, and December 2003. Between the 2000 and 2003 sampling events, many disturbances occurred which affected the quality of the pond sediments. The parking garage across the street from the pond inflow (Channelside drive) was built. In addition, the cruise ship terminal was constructed and a trolley line was built next to the inflow. During this interval, the North Underdrain was added to the pond, and the west side of the pond (filtration side) was dredged and reconstructed. Therefore, not only was the entire pond system altered, the existing sediment column was disturbed. Sediment sampling data, including water quality and field parameters, are in Appendix M, and Appendix N includes graphs comparing metals at each sampling event.

Particle Size Analysis

The size of sediment particles affects the removal of pollutants in stormwater runoff by sedimentation. Usually, the smaller the particle size, the greater the attachment of metal ions to the soil particle, and the longer it takes for the soil particle to settle out of suspension in the water column. Results from both the 2000 and 2003 sampling events show that fine sand size particles (0.125-0.25 mm) predominated, averaging 39% of the sample (Figure 11 and Appendix M). The only exception was at the inflow (1088) during 2003; the predominate size was medium sand (0.25-0.5 mm) at 42%. Indeed, the majority of the samples were of sand size. Silt size particles (<0.063 mm) were also well represented at the outflow in 2000. Otherwise, gravel, silt, and clay size particles were minor at all stations.

The Florida Aquarium is built on altered land that has been redeveloped several times. The soils are, therefore, a conglomeration of spoil or other fill material. The sediments were likely clean sand laid down when the effluent filtration system was constructed.



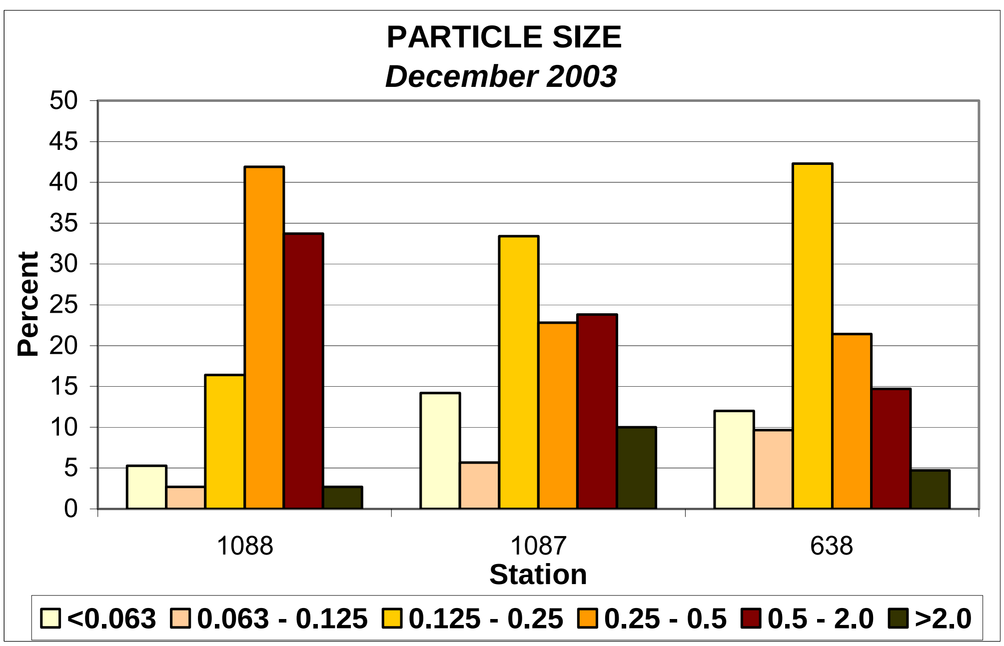


Figure 11. Comparison of particle sizes from the sampling events in 2000 and 2003. Size in is millimeters (mm). The x-axis is aligned geographically from inflow (1088) to outflow (638).

Percent Organic Matter

Organic matter improves soil structure and provides conditions conducive to healthy soil microbes. These microbes are important for transformation and degradation processes that remove pollutants. Also, the behavior of metals in aquatic systems is connected to the role of organic matter in processes such as adsorption and /or chelation/complexation. Once metals bind with organic and inorganic compounds, they can settle out of the water column. In 1997, organic matter was less than one percent (Figure 12 and Appendix M). Over the years, the organic matter increased, and by 2003, it was over one percent. Percent organic matter was measured highest at the outflow during 2000 (2.5%). The decrease by almost 1.5% in 2003 reflects the recontouring of the pond and exposing deeper bottom sediments.

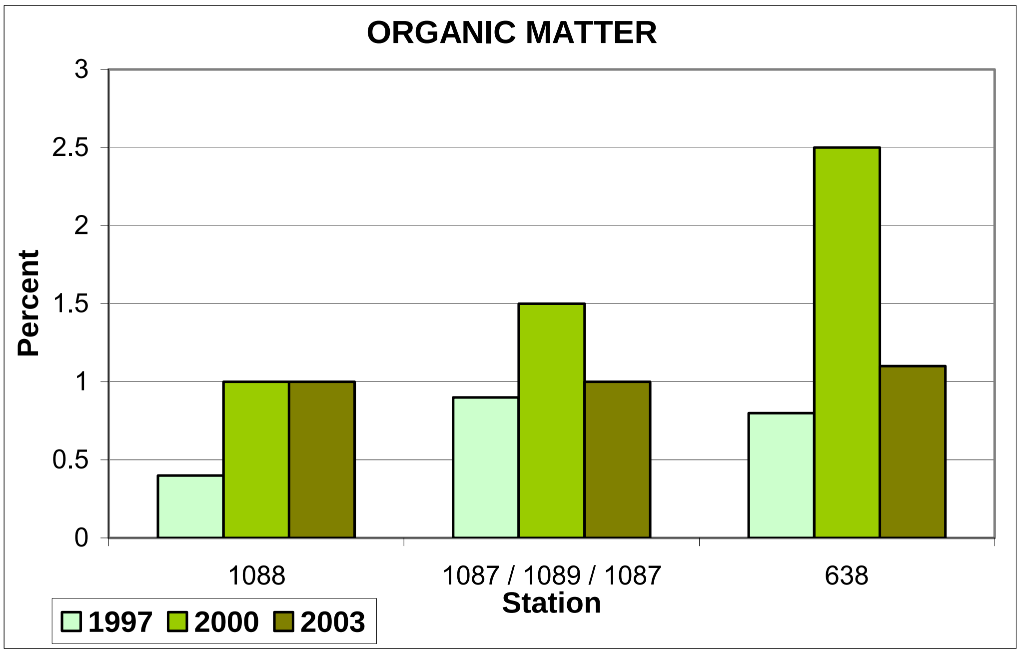


Figure 12. Comparison of percent organic matter from all three sampling events (1997, 2000, and 2003). The x-axis is aligned geographically from inflow (Station 1088) to outflow (Station 638).

Total Kjeldahl Nitrogen (TKN)

TKN is a combination of organic nitrogen and ammonia. As would be expected, TKN concentrations were higher in the first inch of soil as opposed to 4-5 inches below the surface. As evident from Figure 13, TKN concentrations in sediments were much higher in 2003 than in either of the previous sediment samplings. It is likely that all the disturbances altered the pond system. Also, the increase in vegetation and time by 2003 increased TKN in the sediments. Floating vegetation mats were observed often during 2003; these occasionally died and sank to the pond bottom, which would affect TKN in the sediments. All sediment sampling events showed the TKN concentrations to be significantly higher at the outflow than the rest of the pond. At all sites in 2003, the levels were well above problem levels. See Table 4. There also appeared to be an increase in TKN in the water column as the water moved through the pond.

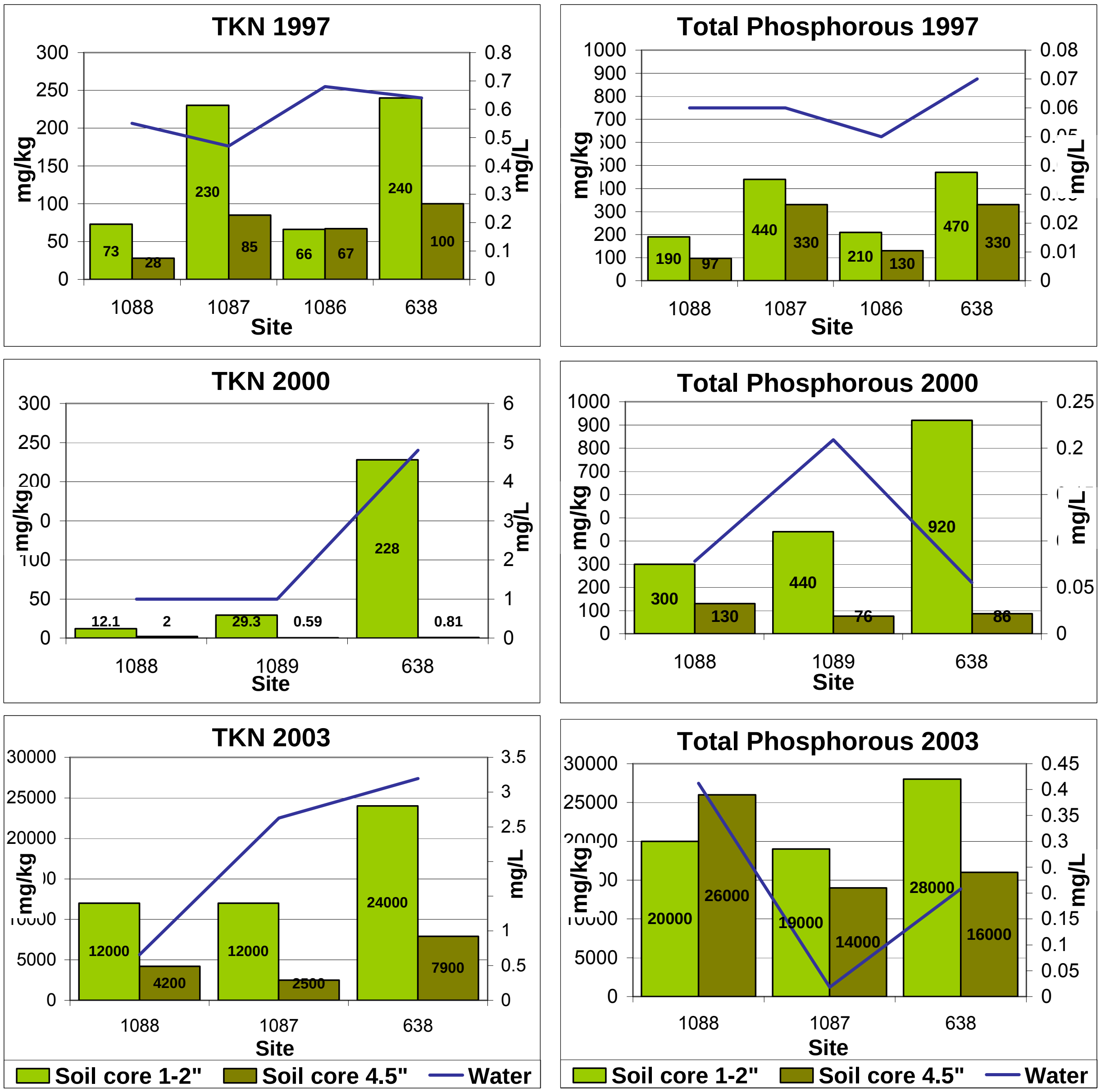


Figure 13. Total Kjeldahl Nitrogen and Total Phosphorous (left y-axis) measured at two depths in the sediments compared to grab samples from the water column (right y-axis). The x-axis is aligned geographically from inflow (Station 1088) to outflow (Station 638) (See Figure 2). Note the differences in scale among different years.

Total Phosphorous

As with TKN, total phosphorous concentrations were much higher at the 2003 sampling event. In fact, total phosphorous concentrations showed similar patterns to those of TKN for all sampling events (Figure 13). The exception was at the inflow in 2003, where total phosphorus was measured at higher concentrations 4-5 inches below the surface than at the surface. Along with all the disturbances that affect sediment quality (discussed in previous sections), higher phosphorus concentrations result from low dissolved oxygen (below 2 mg/L). The average dissolved oxygen during the sampling 2003 event was 2.4 mg/L, much lower than the two previous events. According to Table 4, the phosphorous readings were not high enough to cause problems except in the results from the 2003 sampling event.

Metals

As seen with the nutrients, significant differences were measured in metal concentrations as a result of various construction activities in the ponds. However, in many cases, the differences were not as drastic as with nutrients. Chromium and cadmium concentrations were consistent and always well below toxic levels listed in Table 4. Manganese and nickel concentrations were consistent throughout the sampling periods. Copper was below toxic levels except at two stations from the 2000 sampling event (the sedimentation basin and the outflow). The sedimentation value, 46 mg/kg, was within the range where it might possibly affect benthic organisms. The high concentration of copper at the outflow during the 2000 event, and at all stations compared to other years, was probably the result of algaecide applications that have since ceased. Finally, lead and zinc concentrations were below toxic guidelines except for the sedimentation basin and the outflow during the 2000 sampling event. However, these were well below the guidelines for both the possible and probable effect levels. For all three sampling events, metal concentrations were usually highest at the sedimentation basin and/or the outflow. One reason for this is that organic matter is effective in attracting metal ions before sinking to the bottom and becoming part of the sediments. Organic matter percentage was higher at these stations.

The sedimentation basin, overall, was effective in removing metals before they reached the pond. In many cases, metal concentrations were highest in the sedimentation basin. This was especially true for manganese, copper, iron, and zinc. As the basin is concrete lined, only the 1-2 inch sample was taken since there was not a depth of 5 inches of sediment in the basin. The high measurements of metals in the basin indicate the importance of regular maintenance and removal of sediments from the basin.

Pesticides

The pesticides found in the sediments were the same ones often measured in other studies, diazinon and chlordane. Diazinon is one of the leading causes of acute insecticide poisoning for humans and wildlife (EPA 2000), and it was only found once during the three sampling events- the inflow in 2003. Chlordane was found in sediment at each sampling event: the outflow in 1997, the sedimentation box in 2000, and the inflow in 2003 (Appendix M).

Other pesticides found in the ponds include the daughter compounds of DDT- DDD and DDE. DDD was measured at the equalizer pipe and the outflow in 1997 and in the sedimentation basin in 2003. DDE was measured at the equalizer pipe and the outflow in 1997, at the outflow in 2000, and at the outflow and in the sedimentation basin in 2003. All of these were well below toxicity guidelines (see Table 4) except at the outflow in 1997 and 2000. Additionally, endosulfan sulfate was measured in 2000 at the second inflow (Station 1089).

Polycyclic Aromatic Hydrocarbons (PAH's)

The increasing dependence of today's society on technology derived from organic chemicals has led to widespread hydrocarbon pollution in stormwater runoff. Some of the pathways available for PAH's to enter the environment include air pollution, vehicle exhaust, and runoff from asphalt paving material (ATSDR 2001). PAH's were sampled in 2000 and 2003 and were found in both years (Appendix M). Results from the 2003 sampling event show a great increase in PAH concentrations at most stations in the pond. As mentioned in previous sections, this is very likely related to the construction activities between 2000 and 2003. In both years, the PAH concentrations were above the 4,022 ug/kg toxic guideline (11,727 ug/kg in 2000 and 33,428 ug/kg in 2003). See Table 4. However, both were well below the level at which adverse effects could occur (44,792 ug/kg).

Statistical Analysis

Our conclusions were further verified with statistical analyses for the entire data set and also for individual stations. The stations analyzed included rainfall on the pond, inflow into the pond, outflow over the weir and outflow through the under drains. The SAS system (SAS 8.2) tested for normality, significant differences between stations, and correlations. Some of the stronger correlations were further investigated with regressions. All the data used for analysis are listed in Appendix P-2 and a list of abbreviations used for the calculations are in Appendix P-1.

Tests for Normality

A summary of all the data with descriptive statistics is presented in Appendix P-3 and the descriptive statistics were further divided into two comparable years in Appendix P-4. Hydrology data include the amount of rainfall for each event, the inter-event dry period, and the average intensity of the storm event. The remaining parameters describe the water quality data for rainfall on the pond, inflow into the pond, outflow over the weir and outfall through the under drains. All water quality data represent storm events except for the under drain concentrations, since they discharged continuously and were collected on a regular schedule. Descriptive statistics for skewness and kurtosis were used to analyze for normality. Kurtosis, as calculated in SAS, has a value near zero for a normal distribution and describes the "heaviness of the tails" of a distribution. Extremely non-normal distributions have high positive or negative kurtosis values, while nearly normal distribution will have kurtosis values close to zero. When kurtosis is positive then the tails are heavier than for a normal distribution and negative if the tails are lighter than for a normal distribution (Lchlotzhauer and Littell 1997). Most of the results of the tests on the data in this report showed a strong log normal distribution with one or two outliers on the positive side and most of the values close to the y-axis. The exceptions usually represented data with low concentrations or large numbers of values below the detection limit. Skewness measures how symmetrical the distribution is and whether it is more spread out on one side than the other. For a normal distribution skewness is zero. The Shapiro-Wilk statistic was also used to evaluation the shape of the data, but the results are not included. The Univariate procedure in SAS provides a wealth of information for analyzing the pattern of data and it indicated the data were strongly right skewed. Taking the log of the data did not improve the distribution much, especially those with values near the detection limit, therefore non-parametric tests were used for statistical analysis.

Correlation Analysis

Chemical and physical processes in surface waters influence the concentration of pollutants in stormwater systems causing some constituents to vary together. In addition, rainfall characteristics such as storm intensity and antecedent conditions (inter-event dry period) often affect pollutant concentrations. To better identify and understand relationships between the variables measured for storm events the nonparametric Spearman correlation coefficient was calculated. It is important to remember that almost all correlations are significant for large data sets such as this one and that correlations indicate only the strength of a relationship – it does not imply causality (Cody and Smith 1997). One of the best ways to interpret a correlation coefficient (r) is to look at the square of the coefficient (R^2) and report the results as a percentage (Cody and Smith 1997).

Inflow relationships – The best ten matches for the inflow data, as calculated by the Spearman Correlation Analysis, show some of the stronger relationships (Appendix P-5). Once the results told us that the relationship was different from zero, we looked further in interpreting the importance of that correlation. We used regression analysis to investigate the relationships of some of the stronger correlations (Figure 14). Rainfall and stormwater inflow showed a strong relationship as expected (R^2=0.97) or described another way rainfall explains 97 percent of the variation in storm flow. In this central city drainage basin with little chance for infiltration, stormwater travels rapidly through storm sewers into the pond producing almost a one-to-one response. The results also gave us confidence that the inflow measurements are accurate. Since rainfall is soft water and the biological activity in ponds increases water hardness, an inverse relationship occured with increasing rainfall amounts.

Metals, suspended solids and total phosphorus often vary together. The interaction of iron with other agents partially explains many of these relationships. Most iron is present as colloidal particles of ferric hydroxide, which occurs here, in part, as suspended solids. Metals, represented in this example as lead, can be adsorbed by and co-precipitated with the ferric hydroxide precipitate (Wetzel 1975). Ferric hydroxide is an efficient scavenger that can sorb large amounts of a variety of contaminants. Although iron's effect on chronic toxicity is unknown, iron readily sorbs many toxic metals, thereby reducing their adverse effect on acute toxicity. Even though iron is not toxic in most water, but when the iron redox cycle is broken, as happens with low dissolved oxygen conditions, significant environmental effects can become a problem caused by the release of other pollutants (Moore 1991). Besides lead (r=87), other constituents that exhibited a strong correlation with iron were zinc (r=0.86), total phosphorus (r=0.82), copper (r=0.68), hardness (r=0.54) and cadmium (r=0.48)(Appendix P-5). A single outlier probably improved the correlation coefficient for some of the parameters.

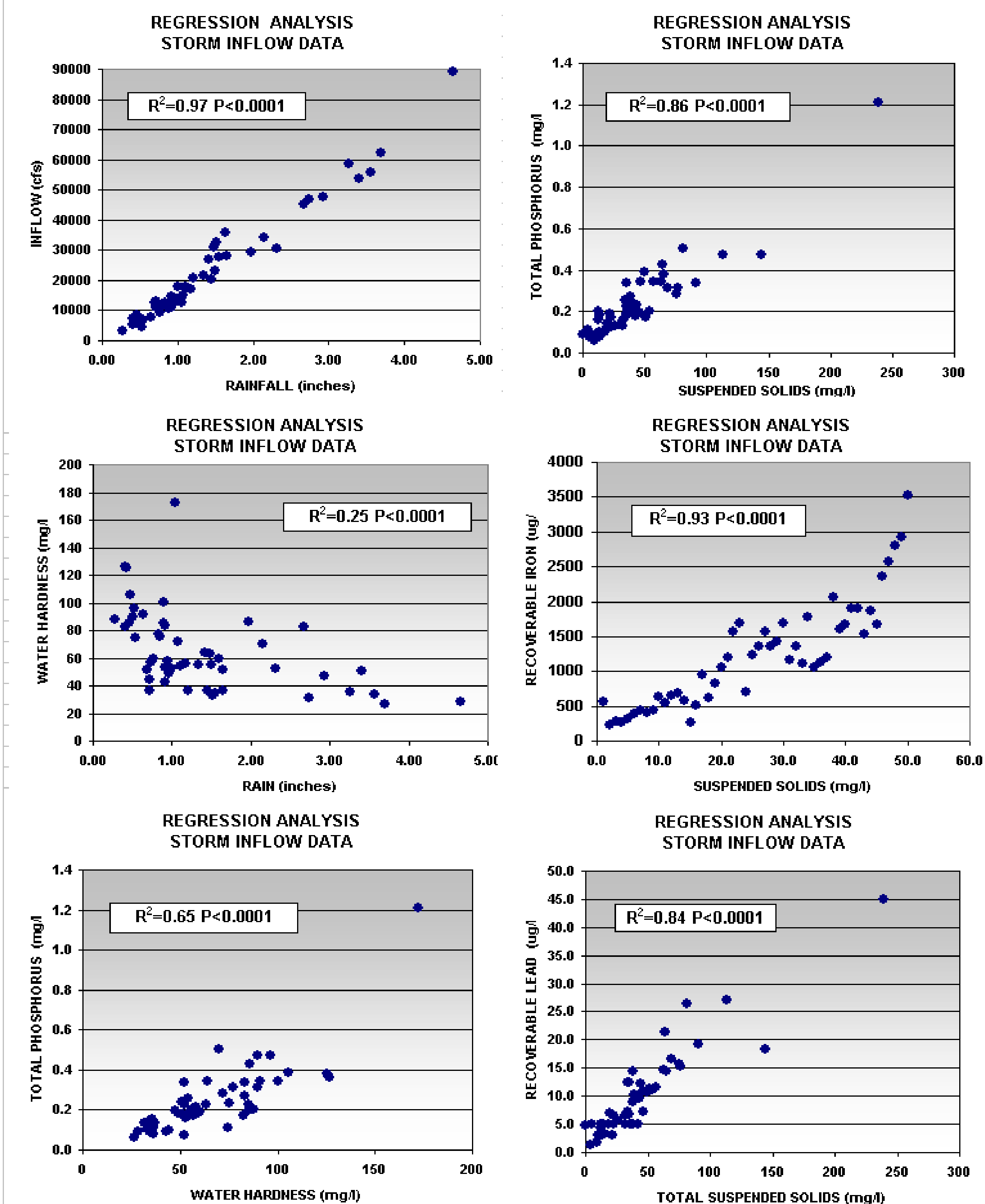


Figure 14. Relationship between variables measured at the inflow of the pond.

Total suspended solids (TSS) are the finer sediments measured in stormwater and are important mechanisms for transport of pollutants since many contaminants are readily adsorbed to them. The ability of TSS to adsorb relates to their surface chemical properties and the coatings on certain particles such as iron and manganese oxides as discussed above as well as organic material. The surfaces of algae provide various types of surface groups, on which metal ions may be adsorbed; these complexing surface groups include carboxyl, amino groups and sulfide groups in proteins at the cell surface (Sigg 1998). Total suspended solids measured at the inflow exhibited some strong correlations with other constituents that included: iron (r=91), lead (r=0.89), total phosphorus (r=0.87), zinc (r=0.81), cadmium (r=0.46) and total nitrogen (r=0.41)(Appendix P-5).

Outflow Relationships - When the highest ten correlations for each constituent at the overflow weir were calculated by the Spearman method, relationships were much weaker than at the inflow (Appendix P-6). Several conditions lead to these results: 1) fewer samples were collected at the overflow weir since it only discharged during the larger rain events (80% of the outflow exited through the underground filter systems) and also 2) concentrations were much lower after flow through the pond, especially for metals and suspended solids (see Figure 7). Some of the stronger correlations were investigated with regression analysis and showed some of the same patterns existed as for the inflow data (Figure 15). Seventy-two percent of the flow discharged over the overflow weir resulted from rainfall while rainfall only explains 37 percent of the reduction in water hardness. Rainfall, which has high nitrate concentrations, also increases nitrate concentrations in the pond (R^2=0.42).

Comparison of the Under Drains - The two under drains treat stormwater from the same pond (see Figure 2) and one would expect that their water quality concentrations would be similar. The flow through the under drains is almost the same or only slightly higher in the north under drain (see Table 7 and Appendix F), but water quality concentrations are significantly higher in the south under drain (Figure 16). It should be remembered that the south under drain was installed in 1995 when the pond was first constructed and the north under drain was installed during the reshaping of the treatment basin during the port construction in 2002. Although both systems are similar in size, pond water enters the south system through drawdown pipes and in the north system water infiltrates through a rock media into filter pipes. In addition, the south system is much older than the north system. If the two filters treated the discharge equally, one would expect the paired samples in Figure 16 to fall along the diagonal line. Several conclusions can be drawn from this analysis, either the south filter has deteriorated over time or the design is not as effective as the north filter.

Only nutrients and water hardness were evaluated since most metals and total suspended solids were discharged at low concentrations with many measured below the laboratory limit of detection. In contrast, dissolved nutrients, especially ammonia and ortho-phosphorus were measured at the highest concentrations measured at the site in discharge water from the under drains (see Figure 7). Water hardness was also elevated. Other researchers have also found higher concentrations of dissolved nutrients in under drain systems. One theory suggests that the trapped particulate organic nutrients are undergoing conversion to the dissolved inorganic forms, possibly by microbial activity inside the filter bed (Harper and Herr 1993).

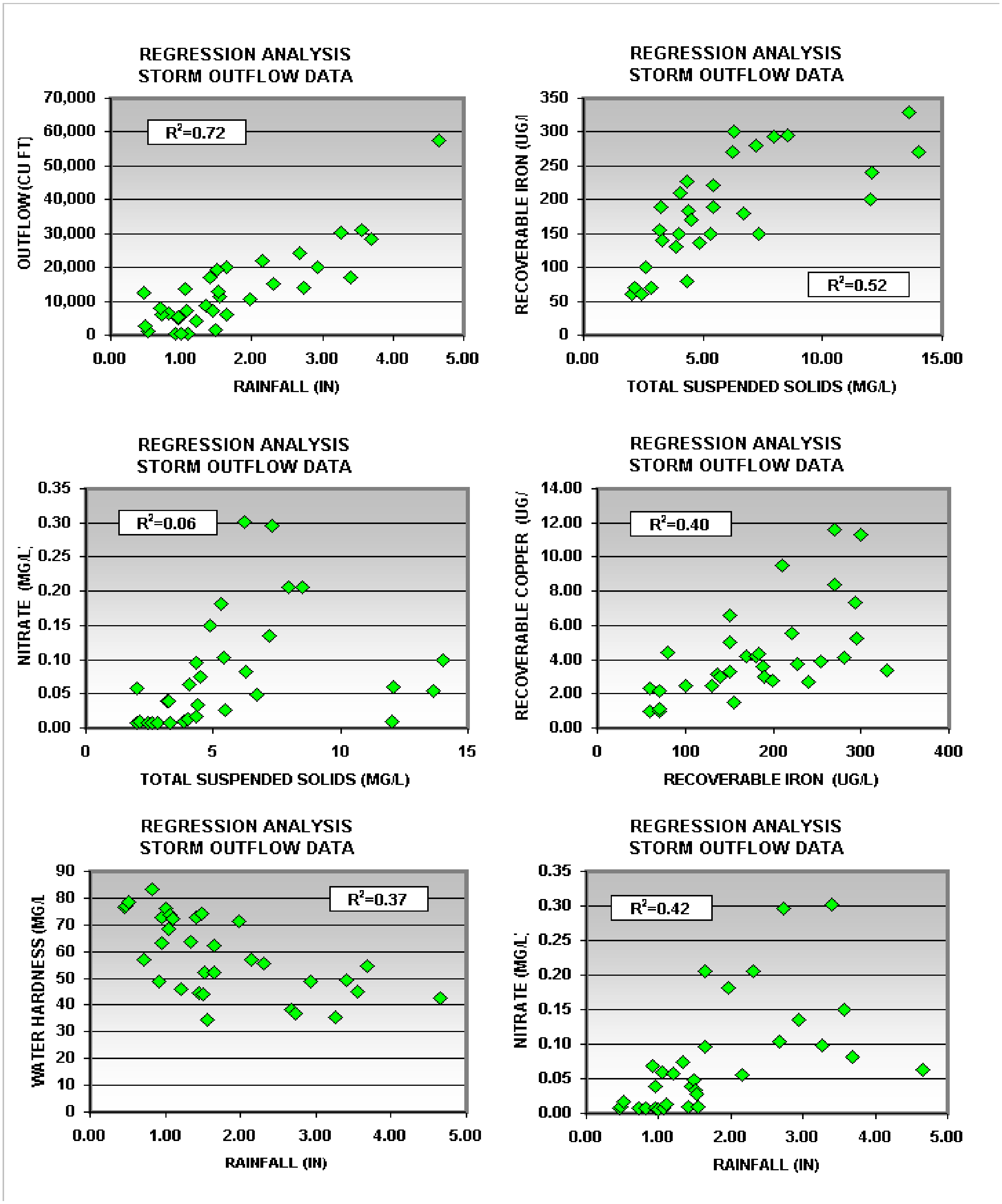


Figure 15. Relationships between variables measured at the outflow overflow weir.

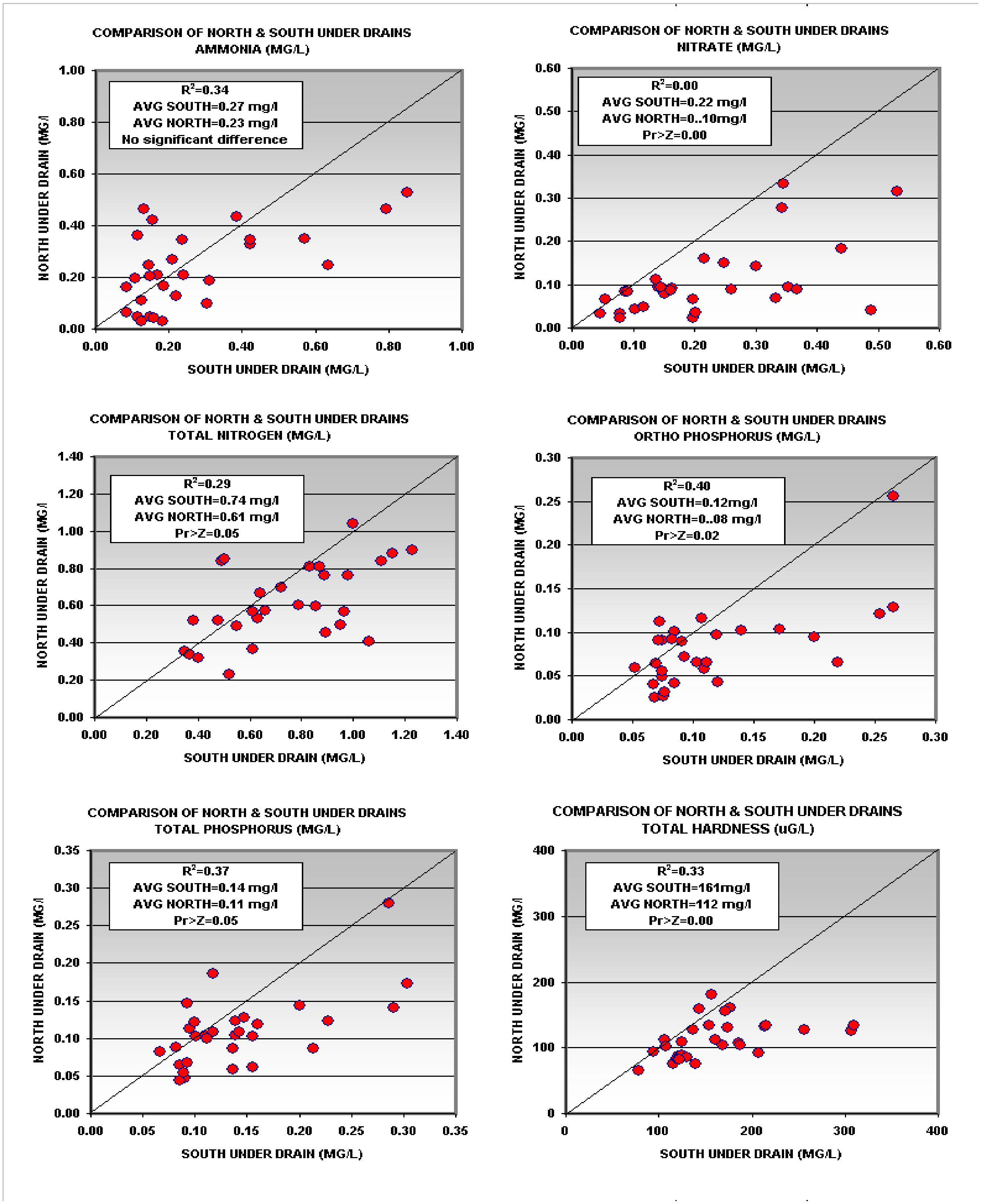


Figure 16. Comparison of paired water quality samples collected from the two under drains. Significant differences measured with the Wilcoxon Two-Sample Test.

Comparison between Years

Since models and comparison studies often use data from short-term research projects, it is of interest to know if values are significantly different between years. The nonparametric Wilcoxon Rank Sum Test in the SAS Npar1way Procedure analyzed the data for significant differences between two comparable nine-month periods (Table 10). Rainfall characteristics showed no differences, but some of the water quality concentrations were significantly higher or lower between years. The construction activity explains some of the differences and processes taking place in the system caused others. For example, significantly higher concentrations in rainfall of organic nitrogen, phosphorus and some metals in year one was probably caused by the location of the rainfall collector in the construction yard during that year, which had bare soils, heavy traffic and lots of dust. The higher concentration of metals at the outflow of the pond in year 3 may be the result of reshaping the treatment basin and releasing metals to the water column. Nitrate and organic nitrogen were increased in the south under drains in year 3, which may be the result of more trapped organic particles on the filter media and more dissolved nitrogen being discharged. This difference was also noted when the older south under drain was compared to the north under drain and found to have significantly higher concentrations of nitrate and total nitrogen (See Figure 16). The north under drain was not compared in this comparison study between years since it was not built until after the port construction. Trapped particles on the filter material may also explain the higher water hardness in year 3. Water hardness in the pond was significantly lower in year 3 caused by increased rainfall amounts. Phosphorus was significantly lower at the inflow during year 3.

Table 10. Wilcoxon Rank Sum Tests analyzed for significant differences between two comparable nine-month periods (Nov. 2000 to Sep. 2001 and Nov. 2002 to Sept. 2003). Parameters with more than 50% of samples below the lab detection limit were omitted.

LABEL MEANING	LABEL	UNITS	YEAR ONE		YEAR THREE		Sig.Dif.
			mean	median	mean	median	
Rainfall for rain event	RAIN	inches	1.2	0.95	1.61	1.23	no
Average intensity of rain	AVGI	in/hr	0.48	0.21	0.3	0.21	no
Interevent period	ANTE	hours	189	121	123	69	no
Rain on pond	RNPD	cubic ft.	1440	1138	1932	1467	no
Inflow	INFL	cubic ft.	18253	12696	27166	19259	no
Outflow	OUFL	cubic ft.	9934	7256	10871	5648	no
Ammonia in rain	NHRN	mg/L	0.650	0.121	0.155	0.073	no
Ammonia in inflow	NHIN	mg/L	0.105	0.068	0.117	0.092	no
Ammonia in outlfow	NHOU	mg/L	0.034	0.021	0.032	0.016	no
Ammonia in south underdrain	NHSUD	mg/L	0.183	0.150	0.211	0.146	no
Nitrate + Nitrite in rain	NXRN	mg/L	0.204	0.105	0.148	0.099	no
Nitrate + Nitrite in inflow	NXIN	mg/L	0.259	0.232	0.197	0.158	no
Nitrate + Nitrite in outflow	NXOU	mg/L	0.054	0.019	0.081	0.039	no
Nitrate + Nitrite in south underdrain	NXSUD	mg/L	0.143	0.102	0.239	0.201	0.036
Organic nitrogen in rain	ONRN	mg/L	0.617	0.230	0.057	0.045	0.002
Organic nitrogen in inflow	ONIN	mg/L	0.540	0.552	0.459	0.410	no
Organic nitrogen in outflow	ONOU	mg/L	0.633	0.548	0.430	0.392	no
Organic nitrogen in south underdrain	ONSUD	mg/L	0.405	0.404	0.263	0.264	0.006
Total nitrogen in rain	TNRN	mg/L	0.946	0.460	0.354	0.207	0.004
Total nitrogen in inflow	TNIN	mg/L	0.908	0.890	0.774	0.718	no
Total nitrogen in outflow	TNOU	mg/L	0.762	0.670	0.543	0.480	no
Total nitrogen in south underdrain	TNSUD	mg/L	0.731	0.620	0.713	0.681	no
Ortho-phosphorus in inflow	OPIN	mg/L	0.111	0.092	0.064	0.065	0.001
Ortho-phosorus in outflow	OPOU	mg/L	0.042	0.040	0.017	0.018	0.012
Ortho-phosphorus in south underdrain	OPSUD	mg/L	0.098	0.084	0.109	0.080	no
Total phosphorus in rain	TPRN	mg/L	0.030	0.029	0.008	0.005	0.000
Total phos in inflow	TPIN	mg/L	0.363	0.331	0.178	0.167	0.001
Total phosphorus in outflow	TPOU	mg/L	0.087	0.078	0.065	0.060	no
Total phosphorus in south underdrain	TPSUD	mg/L	0.122	0.105	0.136	0.106	no
Suspended solids in inflow	SSIN	mg/L	65.5	56.5	34.4	28.0	0.005
Suspended solids in outflow	SSOU	mg/L	4.8	3.7	4.9	4.3	no
Suspended solids in south underdrain	SSSUD	mg/L	1.1	1.1	3.4	1.1	no
Copper in inflow	CUIN	ug/L	19.2	14.2	24.9	21.9	0.070
Copper in outflow	CUOU	ug/L	4.0	3.0	5.6	4.3	0.080
Copper in south underdrain	CUSUD	ug/L	3.3	2.5	1.9	1.5	0.035
Zinc in rain	ZNRN	ug/L	29.8	30.0	8.5	7.5	0.001
Zinc in inflow	ZNIN	ug/L	101.1	90.0	89.5	68.3	no
Zinc in outflow	ZNOU	ug/L	12.6	7.5	20.8	20.0	0.003
Zinc in south underdrain	ZNSUD	ug/L	7.5	7.5	11.8	5.9	no
Iron in rain	FERN	ug/L	66.2	40.0	22.9	18.5	0.003
Iron in inflow	FEIN	ug/L	1722.0	1440.0	1122.0	933.0	no
Iron in outflow	FEOU	ug/L	128.0	115.0	227.0	221.0	0.001
Iron in south underdrain	FESUD	ug/L	64.8	60.0	104.0	63.0	no
Hardness in inflow	HDIN	mg/L	83.4	81.1	51.0	51.1	0.001
Hardness in outflow	HDOU	mg/L	76.4	76.7	55.9	52.2	0.007
Hardness in south underdrain	HDSUD	mg/L	127.2	117.2	152.3	134.9	0.060

Conclusions

Summary of Results

The volume of inflow to the pond was nearly equal to the outflow of the system for most large rain events when the under drain flow is considered. From further study of smaller storms, it was shown that inflow volumes were greater than overflow weir volumes, suggesting the pond was being recharged during smaller storms and at the beginning of big storms after a significant inter-storm time period (Appendix E). This theory is supported by the success of the under drains in allowing storm flow to slowly drain through the filters. According to the flow calculations (Figure 6, Appendix E), it appears that the overflow weir discharge consisted of water treated in the pond before the rain event since the flow over the weir contained much lower concentrations even though inflow and outflow occurred almost simultaneously.

Since the majority of the outflow went through the under drains (65% in Year 2), the water had prolonged time in the pond for pollutants to settle out of the water column and biological processes to take place. The inflow to the Street Pond measured high levels of metals, total nitrogen and total phosphorus; and these concentrations were reduced when measured discharging at the overflow weir and in the under drains (Figure 7). However, the under drains measured high concentrations of soluble nutrients. This remains a common problem for filtration systems and increases pollutant loads for dissolved constituents.

Pollutant load calculations indicate that the stormwater system is not effective for removing dissolved nutrients and may be dewatering the ground water (Table 9). Estimates showed 10 percent more water left the system compared to storm event flows into the pond and dissolved nutrient loads increased considerable in the system. For example, ammonia increased by 84 percent and ortho-phosphorus by 64 percent; while only a moderate reduction occurred for other nutrient species (14 to 17 percent). In contrast, total suspended solids and most metals showed a significant load reduction (79 to 89 percent).

The field parameter measurements indicated improved conditions from the inflow to the outflow. Except for rain events, fluctuations were nearly flat when the water entered the pond system via an anaerobic underground pipe system but showed wide variations at the outflow. Photosynthesis and algal processes caused the wide diurnal fluctuation after water passed through the pond. As is evident from the conductivity data, the pond also showed a dramatic response to rainfall, which affected all parameters at both the inflow and outflow. After a few days, the pond returned to pre-storm patterns (see Figure 10). Rainfall is soft water with low conductivity, while pond algal productivity increases conductivity.

The construction of the port terminal building affected the analyses of sediment samples by disturbing the soils in the treatment basin between 2000 and 2003. Nutrients were higher in 2003, especially in the top inch of soil (Figure 13). This is likely a result of the increase in algal mats observed in the pond. Metals were below toxic levels. The stations where metals were consistently measured highest were the outflow, where the organic matter was also highest, and also in the sedimentation basin, which was designed to collect particles so that they can be removed before being washed into the treatment pond (Appendix N). Pesticides and PAH's were also found in the sediments. Pesticides were most often below toxic recommendations. While PAH's were found in greater concentrations in 2003, they were still well below the guideline levels where probable effects occur (Table 4 and Appendix M).

Statistical analysis confirmed some of the processes taking place in the system. Metals, suspended solids and total phosphorus often occur together explaining 85 to 95 percent of their variation at the inflow (Figure 14). The older south under drain discharged soluble nutrients at significantly higher concentrations than the more recently constructed north under drain (Figure 16). Both under drains reduced metals and suspended solids to low levels. Significant differences between years showed rainfall characteristics with no differences, but some of the water quality concentrations were significantly higher or lower (Table 10). The construction activity explains some of the discrepancies and processes taking place in the system caused others. The data show that, if conditions remain constant, stormwater professionals can probably feel confident in using short-term studies with 15 to 20 rain events in other applications such as models.

Recommendations

- Provide some pre-treatment to reduce metals, oils, and greases.
- Clean out the concrete lined sedimentation basin at least once a year to remove pollutants.
- Reuse the water in the pond to irrigate garden areas near the pond.
- Stock the pond with appropriate fish and other aquatic animals to determine if it can be maintained as a healthy aquatic habitat.
- Vacuum out underdrain pipes.
- Remove exotic vegetation.
- Remove floating vegetation (duckweed).
- Restrict mowing too close to littoral zone vegetation.
- Use material in the filter system designed to remove nutrients.

Final Remarks

The effluent filtration system is effective in reducing metal and suspended solid loads, but is not successful in reducing soluble nutrients. The pond system detained water so that the majority of the outflow (65% to 70%) went through the under drains. Concentrations of metals and suspended solids were much lower from the under drains and the outflow weir than at the inflow, but during year two 25 percent of some metals exceeded state standards in the discharge water at the overflow weir. The south under drain was still operational seven years after construction, but improvements are necessary if they are going to reduce nutrient loads. Maintenance is also an issue since the older south under drain was not as effective as the more recently constructed one.

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Appendix A

SWFWMD ERP Manual

Chapter 2.6.3. Administrative criteria: Future operation and maintenance

Chapter 5.2.b. Water quality: Detention with effluent filtration

Appendix A SWFWMD ERP Manual: Part B - District Basis of Review for 40D Rules.

2.6.3 Future Operation and Maintenance - The operation and maintenance entity is required to provide for the inspection of the surface water management system by a Florida registered Professional Engineer to assure that the system is properly operated and maintained. Inspection schedules will be specifically stated in the permit. For those systems utilizing effluent filtration or exfiltration, the inspections shall be performed 18 months after operation is authorized and every 18 months thereafter. A written report of the findings of the inspection shall be filed with the District within 30 days of the date of the inspection. The permit shall be subject to additional reasonable conditions as are necessary, including performance bonds, to ensure future operation and maintenance of the surface water management system.

5.2 Retention, detention criteria - The volume of runoff to be treated from a site shall be determined by the type of treatment system, i.e., wet detention, detention with effluent filtration, on-line treatment system, or off-line treatment system. If off-site run-off is not prevented from combining with on-site runoff prior to treatment, then treatment must be provided for the combined off-site/project runoff.

b. Detention with effluent filtration system (manmade underdrains).

1. A detention with effluent filtration system shall treat the runoff from the first one inch of rainfall; or as an option for projects or project subunits with drainage areas less than 100 acres, the first one-half inch of runoff. In determining the runoff from one inch of rainfall, the applicant must provide calculations determining runoff from the directly connected impervious areas separately from any other contributing area.
2. Filtration systems shall have a minimum of 0.5 feet of vertical head between the center line of the perforated pipe and the normal water elevation or the pond bottom of the system. The seasonal high water level must be at least one foot below the center line of the perforated pipe (measured from the lowest point of the perforated pipe), or separated by structural means from the hydraulic contribution of the surrounding water table. The storm water must pass through a minimum of two feet of the filter material before entering the perforated pipe.
3. Filtration systems shall have pore spaces large enough to provide sufficient flow capacity so that the permeability of the filter is equal to or greater than the surrounding soil. The design shall ensure that the filter medium particles do not move. The filter material shall be of a quality sufficient to satisfy the requirements listed below, but these requirements are not intended to preclude the use of multilayered filters nor the use of materials to increase ion exchange, precipitation, or pollutant absorption capacity of the filter. The requirements are:

   (a) Washed material meeting FDOT road and bridge specifications for silica sand and quartz gravels, or mixtures thereof (less than 1 percent silt, clay and organic matter), unless filter cloth is used which is suitable to retain the silt, clay and organic matter within the filter; calcium carbonate aggregate is not an acceptable substitute;

(b) Uniformity coefficient 1.5 or greater; and

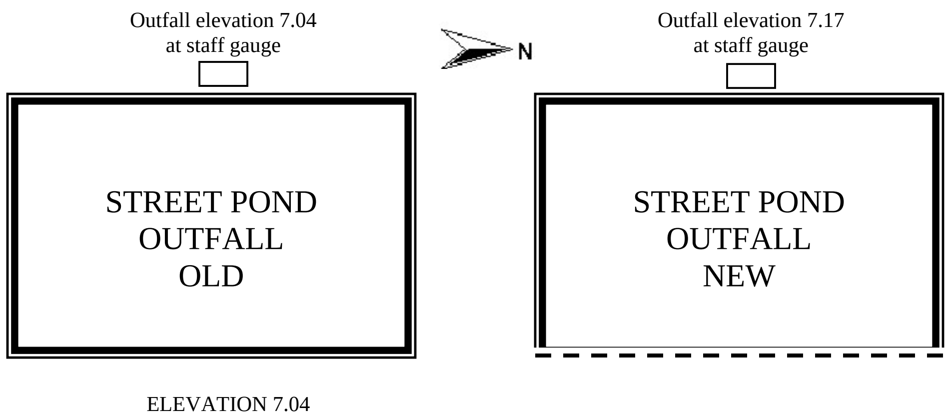
(c) Effective grain size of 0.20 to 0.55 millimeters in diameter.

4. The total detention volume shall again be available within 36 hours.
5. The treatment volume can be counted as part of the storage required for water quantity storage in Chapter 4.
6. Maintenance of filter includes proper disposal of spent filter material.
7. The design of the system must be such that the water velocities and associated flow path through the storage pond do not cause the accumulated pollutants to be flushed out of the treatment pond up to the 25-year, 24-hour design storm.

Appendix B

Flow Calculation

FLOW CALCULATION SET UP FOR THE STREET POND AT THE FLORIDA AQUARIUM



Standard formula for rectangular weir with end contractions:

Q=K(L-(0.2 * H))(H^1.5)

Q = flow in cubic feet per second (cfs)
K = constant of 3.33
L = length of weir
H = head (depth of water over weir)

INFLOW STREET POND DISCHARGE:
Q=AV=flow in cubic feet per second (cfs)
A = area of pipe (7.07 ft^2)
V = average velocity
Q=7.07V

OLD STREET POND ELEVATION vs. FLOW:

Flow calculations begin at 7.04 NGVD. At pond level 7.04, head is 0.0. Between pond levels 7.04 and 7.06, flow calculations should be done utilizing only one long side of the outfall box
3.33 (8.50 – (0.2 * H))(H^1.5)

Between pond levels above 7.06 thru 7.49 (head 0.07 ft. thru 0.50 ft.), flow calculations should be done utilizing all four sides of the outfall box:
2 * (3.33 * (8.50 – (0.2 * H)) * (H^1.5) + 2 * (3.33 * (3.04 – (0.2 * H)) * (H^1.5))

NEW STREET POND ELEVATION vs. FLOW (went into effect September, 2002, after cruise ship terminal construction):

Flow calculations begin at 7.17 NGVD. Calculations should be done utilizing only three sides of the outfall box:

(3.33 * (9.89 – (0.2 * H)) * (H^1.5)) +(2 * (3.33 * (4.41 – (0.2 * H)) * (H^1.5)))

Appendix C

Quality Assurance

Appendix C. Samples taken for quality assurance. Samples were taken using deionized water (D.I.) in the same manner (i.e. through equipment tubing) as regular samples. Samples were also analyzed using the D.I. water directly from the old and new bottles.

	D.I. Water	Old Bottle	Clean Bottle	D.I. Water	Tubing	Tubing	Old Bottle	Clean Bottle	D.I. Water	Tubing	Tubing	Tubing
DATE	07/02/01	07/02/01	07/02/01	10/09/02	10/09/02	10/09/02	10/09/02	10/09/02	07/07/03	07/07/03	07/07/03	07/07/03
Station		S. UNDER	S. UNDER		S. UNDER	N. UNDER	N. UNDER	N. UNDER		S. UNDER	N. UNDER	Inflow
AMMONIA	BD	BD	0.021	0.029	BD	0.017	0.023	0.012	BD	BD	BD	BD
NITRATE + NITRITE	BD	BD	BD	0.019	0.019	0.012	0.013	0.015	BD	BD	BD	BD
TOTAL NITROGEN	0.220	0.14	BD	0.190	0.12	0.180	BD	BD	BD	BD	BD	BD
ORTHO-PHOSPHATE	BD	BD	BD	BD	BD	BD	BD	BD	BD	BD	BD	BD
TOTAL - PHOSPHATE	BD	BD	BD	0.012	0.019	0.034	0.016	0.011	BD	BD	BD	BD
TOTAL CADMIUM	BD	BD	BD	0.360	BD	BD	BD	BD	BD	BD	BD	BD
TOTAL COPPER	BD	BD	11.9	4.500	BD	BD	BD	BD	BD	BD	BD	BD
TOTAL IRON	BD	BD	BD	BD	BD	BD	BD	BD	21.8	100	48.8	37.4
TOTAL LEAD	BD	BD	BD	BD	BD	BD	BD	0.4	BD	BD	BD	BD
MANGANESE	BD	BD	BD	BD	BD	0.800	1.6	BD	NA	NA	NA	NA
TOTAL ZINC	BD	BD	BD	BD	BD	BD	BD	BD	2.49	4.5	4.31	8.18
HARDNESS	BD	BD	BD	BD	BD	BD	BD	BD	BD	BD	BD	BD
CALCIUM	BD	BD	BD	BD	BD	BD	BD	BD	BD	1.85	0.8	1.24
CHLORIDE	BD	BD	BD	BD	BD	0.120	0.210	1.25	NA	NA	NA	NA
POTASSIUM	BD	BD	BD	BD	BD	BD	BD	BD	NA	NA	NA	NA
SODIUM	BD	BD	BD	BD	BD	BD	BD	BD	NA	NA	NA	NA
SULFATE	BD	BD	BD	BD	BD	BD	0.19	BD	NA	NA	NA	NA
MAGNESIUM	BD	BD	BD	BD	BD	BD	BD	BD	BD	BD	BD	BD

Appendix D

Rainfall Characteristics

Appendix D. Rainfall characteristics for most of the larger rain events (> 0.23 inches).

START DATE	END DATE	YEAR	DAY Julian	START TIME	END TIME	TOTAL RAIN (in.)	INTER-EVENT (hrs.)	DURA-TION (hrs.)	MAX. INT. (in./15 min.)	AVG. INT. (in./hr.)
YEAR ONE										
11/25/00	11/25/00	2000	330	2015	2115	1.50	168.00	1.00	0.20	0.20
11/26/00	11/26/00	2000	331	915	1245	0.36	24.50	3.50	0.05	0.02
12/17/00	12/17/00	2000	353	245	300	0.43	530.00	0.50	0.43	0.11
12/28/00	12/28/00	2000	363	830	1045	0.23	763.75	2.25	0.05	0.03
01/08/01	01/08/01	2001	8	1145	1415	0.94	241.00	2.50	0.15	0.06
02/01/01	02/01/01	2001	32	430	930	0.57	563.00	5.00	0.20	0.03
02/03/01	02/03/01	2001	34	1315	1715	0.39	51.75	4.00	0.03	0.02
03/04/01	03/04/01	2001	63	915	1430	1.59	688.00	5.25	0.19	0.07
03/19/01	03/19/01	2001	78	1145	1500	0.89	357.25	3.25	0.11	0.05
03/29/01	03/29/01	2001	88	1045	2230	3.29	237.75	11.75	1.16	0.07
06/01/01	06/01/01	2001	152	1300	1330	0.32	1525.50	0.50	0.32	0.64
06/06/01	06/06/01	2001	157	1745	2015	1.97	124.25	2.50	1.40	0.79
06/19/01	06/19/01	2001	170	1645	1915	0.64	308.50	2.50	0.52	0.26
06/22/01	06/22/01	2001	173	1045	1315	1.00	77.50	2.50	0.91	0.40
06/23/01	06/23/01	2001	174	830	1630	0.52	19.25	8.00	0.20	0.07
06/28/01	06/28/01	2001	179	1545	2030	2.15	121.25	4.75	1.40	0.45
07/01/01	07/01/01	2001	182	15	300	0.46	51.75	2.75	0.41	0.17
07/07/01	07/07/01	2001	188	1430	1500	0.31	155.50	0.50	0.31	0.62
07/10/01	07/10/01	2001	191	1030	1045	0.60	67.50	0.25	0.60	2.40
07/11/01	07/11/01	2001	192	630	1145	0.82	19.75	5.25	0.60	0.16
07/13/01	07/13/01	2001	194	1100	1300	0.64	47.25	2.00	0.61	0.32
07/17/01	07/17/01	2001	198	1430	1615	0.42	97.50	1.75	0.40	0.24
07/21/01	07/21/01	2001	202	1345	1500	0.98	97.75	1.25	0.94	0.78
07/23/01	07/23/01	2001	204	900	1430	1.18	42.00	5.50	0.72	0.21
07/27/01	07/27/01	2001	208	1515	1600	0.48	96.75	0.75	0.48	0.64
07/31/01	07/31/01	2001	212	1915	2130	0.40	99.25	2.25	0.21	0.18
08/02/01	08/02/01	2001	214	1100	2215	0.98	37.50	11.25	0.28	0.09
08/05/01	08/05/01	2001	217	2215	2230	0.46	72.00	0.25	0.46	1.84
08/07/01	08/07/01	2001	219	1645	1715	1.05	42.25	0.50	1.05	2.10
08/08/01	08/08/01	2001	220	2330	2400	0.29	30.25	0.50	0.29	0.58
08/09/01	08/09/01	2001	221	1315	1415	0.31	14.25	1.00	0.30	0.31
CONSTRUCTION YEAR										
09/03/01	09/03/01	2001	246	15	130	1.01	585.75	1.25	1.00	0.81
09/06/01	09/06/01	2001	249	1845	2115	0.83	17.25	2.50	0.68	0.33
09/08/01	09/08/01	2001	251	1745	1830	1.28	44.50	0.75	1.28	1.71
09/13/01	09/14/01	2001	257	1630	1415	6.10	118.00	21.75		0.28
09/14/01	09/15/01	2001	258	2330	630	1.46	9.25	7.00	0.43	0.21
09/22/01	09/22/01	2001	265	2030	2130	1.23	182.00	1.00	1.22	1.23
10/21/01	10/21/01	2001	294	1715	1930	1.32	691.75	2.25	0.49	0.59
10/24/01	10/25/01	2001	298	2245	315	0.87	75.25	4.50	0.26	0.19
12/08/01	12/08/01	2001	342	30	245	0.73	1053.25	2.25	0.22	0.32
12/18/01	12/18/01	2001	352	415	500	0.43	241.50	0.75	0.28	0.57
01/02/02	01/02/02	2002	2	1200	1445	0.83	367.00	2.75	0.41	0.30
01/14/02	01/15/02	2002	15	1045	15	1.05	284.00	13.50	0.11	0.08

Appendix D. *Continued*

START DATE	END DATE	YEAR	DAY Julian	START TIME	END TIME	TOTAL RAIN (in.)	INTER-EVENT (hrs.)	DURA-TION (hrs.)	MAX. INT. (in./15 min.)	AVG. INT. (in./hr.)
02/07/02	02/07/02	2002	38	945	1500	1.07	561.50	5.25	0.27	0.20
02/22/02	02/23/02	2002	54	800	2045	1.54	473.00	36.75	0.07	0.04
03/03/02	03/03/02	2002	62	2000	2115	0.31	215.25	1.25	0.11	0.25
04/03/02	04/03/02	2002	93	1230	2045	1.38	735.25	8.25	0.44	0.17
04/15/02	04/15/02	2002	105	1630	1815	0.30	283.75	1.75	0.11	0.17
05/16/02	05/16/02	2002	136	1830	1930	0.32	744.25	2.00	0.27	0.16
05/18/02	05/19/02	2002	139	2345	1000	0.91	52.25	10.25	0.21	0.09
06/12/02	06/12/02	2002	163	1715	1815	0.84	583.25	1.00	0.36	0.84
06/15/02	06/15/02	2002	166	700	1045	0.60	60.75	3.75	0.32	0.16
06/17/02	06/17/02	2002	168	1515	2115	0.81	52.50	6.00	0.13	0.14
06/18/02	06/18/02	2002	169	645	1130	2.67	9.50	4.75	0.56	0.56
06/24/02	06/24/02	2002	175	1600	2300	3.26	148.50	7.00	0.87	0.47
06/25/02	06/25/02	2002	176	1430	1900	1.64	175.50	4.50	0.69	0.36
06/27/02	06/27/02	2002	178	1730	1915	0.84	46.50	1.75	0.51	0.48
06/28/02	06/28/02	2002	179	1630	2145	2.72	21.25	5.25	0.97	0.52
06/29/02	06/29/02	2002	180	1845	1930	1.21	21.00	0.75	0.74	1.61
YEAR TWO										
07/01/02	07/01/02	2002	182	1500	2030	0.91	43.50	5.50	0.36	0.17
07/09/02	07/09/02	2002	190	1215	1545	0.33	183.75	3.50	0.12	0.09
07/12/02	07/12/02	2002	193	945	1215	0.39	66.00	2.50	0.12	0.16
07/13/02	07/13/02	2002	194	700	1515	0.64	18.75	8.25	0.17	0.08
07/25/02	07/25/02	2002	206	1700	1815	0.39	289.75	1.25	0.31	0.31
07/29/02	07/29/02	2002	210	1745	1845	0.27	95.50	1.00	0.11	0.27
08/02/02	08/02/02	2002	214	900	1015	0.29	86.25	1.25	0.17	0.23
08/02/02	08/02/02	2002	214	2230	2330	0.27	6.25	1.00	0.11	0.27
08/07/02	08/07/02	2002	219	1200	1630	1.48	132.50	4.50	0.16	0.33
08/09/02	08/09/02	2002	221	2100	2200	0.33	52.50	1.00	0.16	0.33
08/14/02	08/15/02	2002	226	1700	200	2.93	139.00	9.00	0.89	0.33
08/17/02	08/17/02	2002	229	1715	2015	0.74	187.25	3.00	0.39	0.25
08/27/02	08/27/02	2002	239	645	945	0.47	226.50	3.00	0.07	0.16
08/30/02	08/30/02	2002	242	1430	1930	1.17	76.75	5.00	0.53	0.23
09/02/02	09/02/02	2002	245	1515	1600	1.10	67.75	0.75	0.85	1.47
09/05/02	09/05/02	2002	248	1300	2000	2.51	69.00	7.00	0.78	0.36
09/08/02	09/08/02	2002	251	2015	2030	0.29	72.25	0.50	0.28	0.58
09/11/02	09/11/02	2002	254	845	1815	1.53	60.25	9.50	0.76	0.16
09/12/02	09/12/02	2002	255	1330	1500	0.71	19.25	1.50	0.17	0.47
09/17/02	09/17/02	2002	260	1900	2045	1.39	124.00	1.75	0.53	0.79
09/24/02	09/24/02	2002	267	1500	1930	0.31	162.25	4.50	0.15	0.07
09/26/02	09/26/02	2002	269	1645	2245	0.39	45.25	6.00	0.25	0.07
10/12/02	10/12/02	2002	285	1715	2245	0.92	378.50	5.50	0.54	0.17
10/15/02	10/15/02	2002	288	1345	1730	0.53	63.00	3.75	0.23	0.14
10/23/02	10/23/02	2002	296	1845	1900	0.27	193.25	0.50	0.22	0.54
10/30/02	10/30/02	2002	303	1245	1330	0.51	161.75	0.75	0.33	0.68
11/12/02	11/13/02	2002	317	1845	500	0.88	317.25	10.25	0.33	0.09
11/16/02	11/16/02	2002	320	945	1630	0.70	76.45	6.75	0.13	0.10
11/17/02	11/17/02	2002	321	230	845	0.56	10.00	7.25	0.06	0.08

Appendix D. ***Continued***

START DATE	END DATE	YEAR	DAY Julian	START TIME	END TIME	TOTAL RAIN (in.)	INTER-EVENT (hrs.)	DURA-TION (hrs.)	MAX. INT. (in./15 min.)	AVG. INT. (in./hr.)
12/05/02	12/06/02	2002	340	2130	600	1.04	444.75	8.50	0.46	0.12
12/09/02	12/10/02	2002	344	330	900	3.68	69.50	29.50	0.19	0.12
12/12/02	12/13/02	2002	347	1500	915	4.64	54.00	18.25	0.42	0.25
12/20/02	12/20/02	2002	354	600	800	0.54	164.75	2.00	0.26	0.27
12/24/02	12/25/02	2002	359	1915	200	1.30	114.00	8.75	0.18	0.15
12/31/02	12/31/02	2002	365	1800	2400	3.87	142.75	6.00	0.64	0.65
02/16/03	02/16/03	2003	047	16:15	22:30	0.70	1120.25	6.25	0.19	0.11
02/22/03	02/22/03	2003	053	16:45	19:15	0.57	138.25	2.50	0.15	0.23
02/28/03	02/28/03	2003	059	11:45	23:45	1.00	136.50	12.00	0.58	0.08
03/16/03	03/17/03	2003	075	23:30	1:00	0.69	383.75	1.50	0.19	0.46
03/21/03	03/21/03	2003	080	10:00	13:45	1.64	105.00	3.75	0.28	0.44
03/23/03	03/23/03	2003	082	5:45	20:45	1.45	41.00	14.00	0.19	0.10
03/27/03	03/27/03	2003	086	13:00	18:45	0.34	88.25	5.75	0.16	0.06
04/09/03	04/09/03	2003	099	1:45	4:15	0.25	295.00	2.50	0.06	0.10
04/09/03	04/09/03	2003	099	16:15	16:45	0.37	12.00	0.50	0.21	0.74
04/25/03	04/26/03	2003	115	19:00	4:00	3.40	386.25	9.00	0.76	0.38
05/18/03	05/18/03	2003	138	20:30	21:15	0.35	544.50	0.75	0.18	0.47
05/19/03	05/19/03	2003	139	15:15	23:00	0.32	18.00	7.75	0.15	0.04
05/22/03	05/22/03	2003	142	19:45	22:30	0.77	68.75	2.75	0.17	0.28
06/05/03	06/05/03	2003	156	5:45	7:45	0.36	318.25	2.00	0.08	0.18
06/08/03	06/08/03	2003	159	10:15	12:15	0.26	74.50	2.00	0.09	0.13
06/09/03	06/09/03	2003	160	10:00	13:45	0.74	21.75	3.75	0.38	0.20
06/11/03	06/11/03	2003	162	16:00	17:15	1.65	50.25	1.25	0.66	1.32
06/16/03	06/16/03	2003	167	16:30	21:30	0.92	119.25	5.00	0.26	0.18
06/17/03	06/17/03	2003	168	20:30	21:15	0.29	23.00	0.75	0.19	0.39
06/18/03	06/18/03	2003	169	11:15	19:45	1.52	14.00	8.50	0.26	0.18
06/19/03	06/19/03	2003	170	6:00	16:30	1.50	10.25	10.50	0.81	0.15
06/20/03	06/20/03	2003	171	7:30	21:45	1.40	15.00	14.25	0.39	0.10
06/21/03	06/21/03	2003	172	6:30	14:15	0.48	8.75	7.75	0.15	0.06
06/22/03	06/22/03	2003	173	8:30	15:45	1.25	18.25	7.25	0.18	0.17
07/03/03	07/03/03	2003	184	5:15	12:15	0.36	253.50	7.00	0.24	0.05
07/04/03	07/04/03	2003	185	18:00	19:00	0.44	29.75	1.00	0.39	0.44
07/08/03	07/08/03	2003	189	16:30	18:30	0.93	93.50	2.00	0.30	0.47
07/09/03	07/09/03	2003	190	16:45	17:00	0.73	22.25	0.25	0.49	2.92
07/11/03	07/11/03	2003	192	1:15	1:30	0.25	32.25	0.25	0.22	1.00
07/11/03	07/11/03	2003	192	14:30	15:15	0.71	13.00	0.75	0.41	0.95
07/12/03	07/12/03	2003	193	18:15	22:00	0.59	243.00	3.75	0.23	0.16
07/13/03	07/13/03	2003	194	16:00	19:00	1.86	18.00	3.00	0.45	0.62
07/16/03	07/16/03	2003	197	14:30	17:30	0.31	67.50	3.00	0.20	0.10
07/18/03	07/18/03	2003	199	19:00	20:15	0.81	50.75	1.25	0.49	0.65
07/22/03	07/22/03	2003	203	12:30	15:00	0.22	88.25	2.50	0.13	0.09
07/27/03	07/27/03	2003	208	14:30	14:45	0.47	119.50	0.25	0.37	1.88
08/02/03	08/02/03	2003	214	16:00	20:15	3.90	145.25	4.25	1.00	0.92
08/07/03	08/07/03	2003	219	10:45	20:45	0.46	110.50	10.00	0.29	0.05
08/08/03	08/08/03	2003	220	8:30	21:45	0.48	25.00	13.25	0.22	0.04
08/09/03	08/09/03	2003	221	9:00	16:00	1.24	11.25	7.00	0.34	0.18

Appendix D. ***Continued***

START DATE	END DATE	YEAR	DAY Julian	START TIME	END TIME	TOTAL RAIN (in.)	INTER-EVENT (hrs.)	DURA-TION (hrs.)	MAX. INT. (in./15 min.)	AVG. INT. (in./hr.)
08/10/03	08/10/03	2003	222	0:30	10:45	0.84	8.50	10.25	0.19	0.08
08/16/03	08/16/03	2003	228	18:00	20:00	0.28	151.25	2.00	0.12	0.14
08/20/03	08/20/03	2003	232	15:30	21:00	0.62	91.50	5.50	0.21	0.11
08/21/03	08/21/03	2003	233	15:15	19:00	1.54	18.25	3.75	0.79	0.41
08/25/03	08/25/03	2003	237	15:30	19:15	0.28	92.50	3.75	0.05	0.07
08/26/03	08/26/03	2003	238	18:00	19:15	0.26	22.75	1.25	0.20	0.21
08/27/03	08/27/03	2003	239	16:00	19:00	0.96	20.75	3.00	0.62	0.32
09/02/03	09/02/03	2003	245	16:15	22:15	0.52	141.25	6.00	0.32	0.09
09/03/03	09/03/03	2003	246	15:45	20:15	0.27	17.50	4.50	0.21	0.06
09/05/03	09/05/03	2003	248	4:00	16:45	0.83	31.75	12.75	0.13	0.07
09/06/03	09/06/03	2003	249	3:15	5:15	0.33	10.50	2.00	0.17	0.17
09/19/03	09/19/03	2003	262	18:00	22:45	2.31	324.75	4.75	0.80	0.49
09/25/03	09/25/03	2003	268	13:15	23:45	0.79	134.50	10.50	0.06	0.08
09/28/03	09/28/03	2003	271	14:30	18:15	0.26	62.75	3.75	0.08	0.07
09/29/03	09/29/03	2003	272	4:30	10:00	0.24	10.25	5.50	0.04	0.04
10/14/03	10/14/03	2003	287	8:15	8:30	0.25	358.25	0.25	0.25	1.00
10/28/03	10/28/03	2003	301	16:15	23:15	0.61	343.75	7.00	0.13	0.09

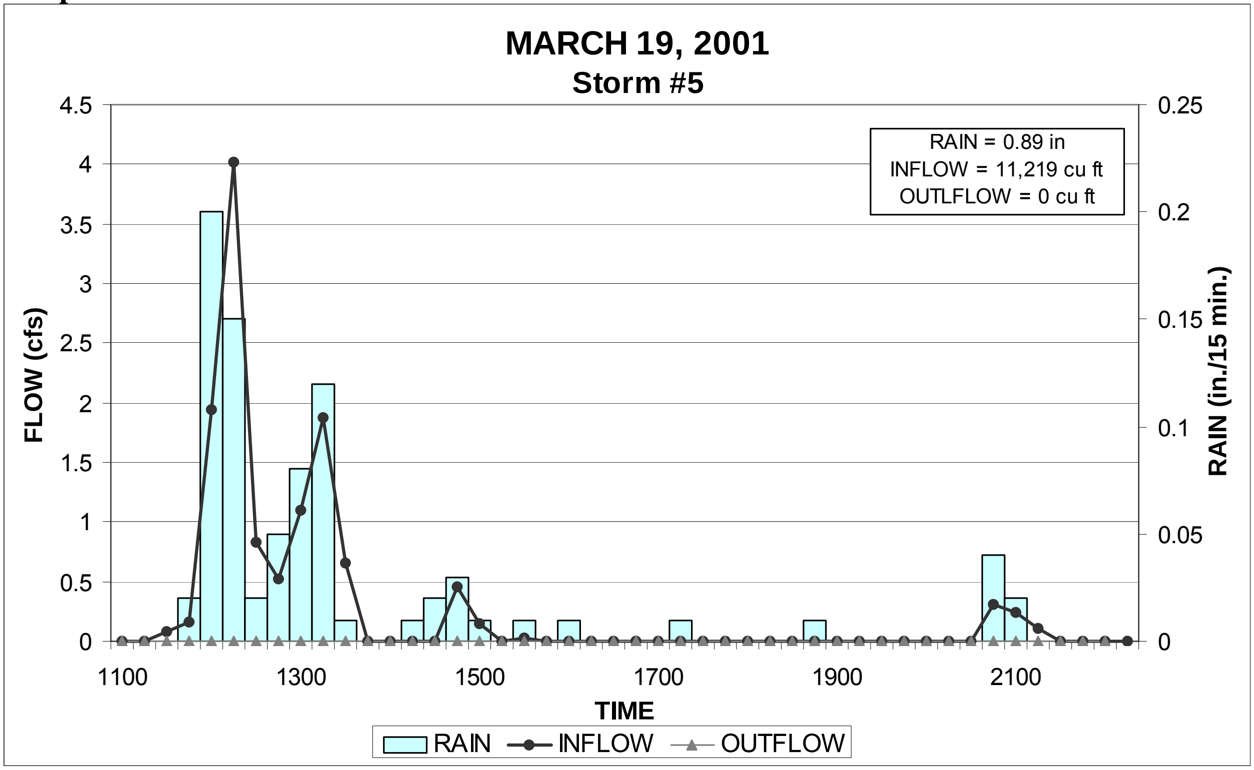
SUMMARY STATISITCS	TOTAL RAIN (in.)	INTER-EVENT (hrs.)	DURA-TION (hrs.)	MAX. INT. (in./15 min.)	AVG. INT. (in./hr.)
YEAR ONE (NOVEMBER 2000 THROUGH AUGUST 2001)					
# Observations	31	31	31	31	31
Average	0.84	218.47	3.08	0.48	0.45
Median	0.60	97.50	2.50	0.40	0.21
Maximum	3.29	1525.50	11.75	1.40	2.40
Minimum	0.23	14.25	0.25	0.03	0.02
Std Deviation	0.67	315.76	2.95	0.38	0.61
Coefficient of Variation	0.79	1.45	0.96	0.79	1.35
CONSTRUCTION YEAR (SEPTEMBER 2001 THROUGH JUNE 2002)					
# Observations	28	28	28	27	26
Average	1.34	280.48	5.73	0.48	0.47
Median	1.03	178.75	3.25	0.41	0.31
Maximum	6.10	1053.25	36.75	1.28	1.71
Minimum	0.30	9.25	0.75	0.07	0.04
Std Deviation	1.17	286.91	7.62	0.34	0.45
Coefficient of Variation	0.87	1.02	1.33	0.71	0.96
YEAR TWO (JULY 2002 THROUGH OCTOBER 2003)					
# Observations	92	92	92	92	92
Average	0.93	125.97	5.08	0.31	0.34
Median	0.63	75.48	3.75	0.22	0.18
Maximum	4.64	1120.25	29.50	1.00	2.92
Minimum	0.22	6.25	0.25	0.04	0.04
Std Deviation	0.90	156.10	4.62	0.22	0.43
Coefficient of Variation	0.97	1.24	0.91	0.73	1.27

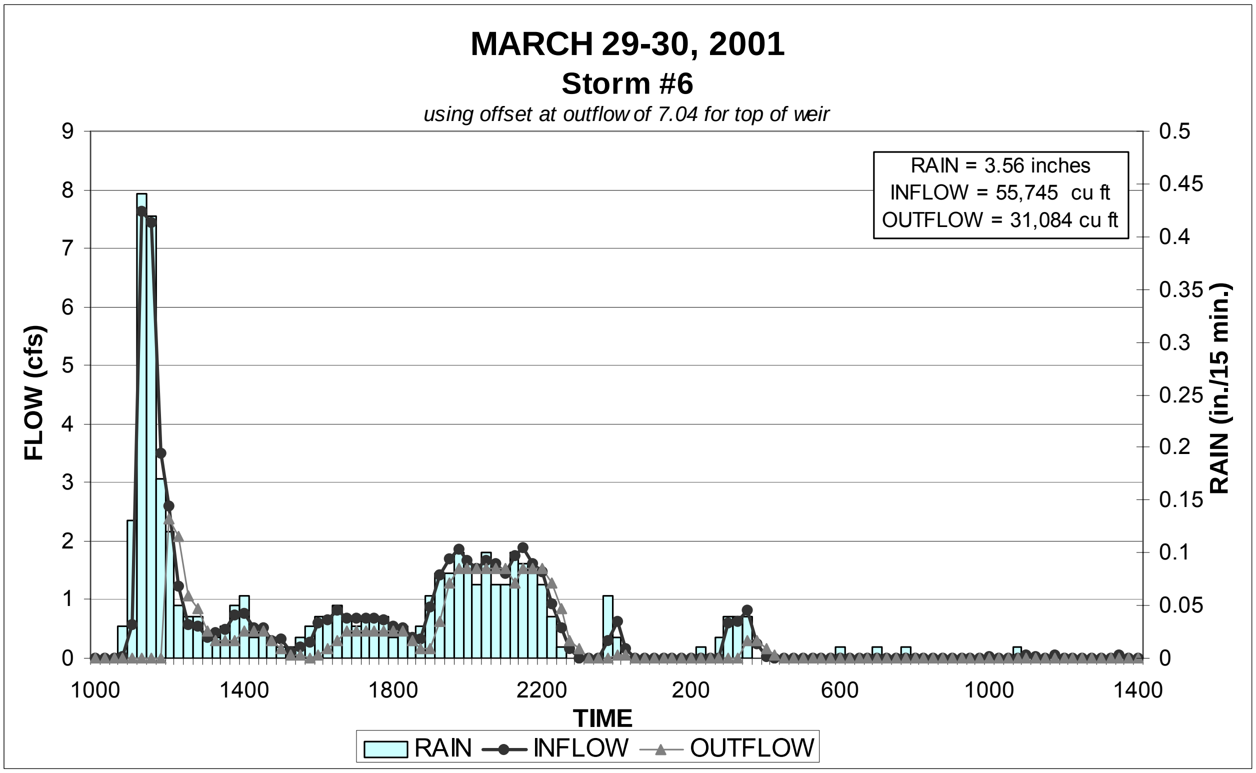
Appendix E

Flow Data for Major Rainfall Events

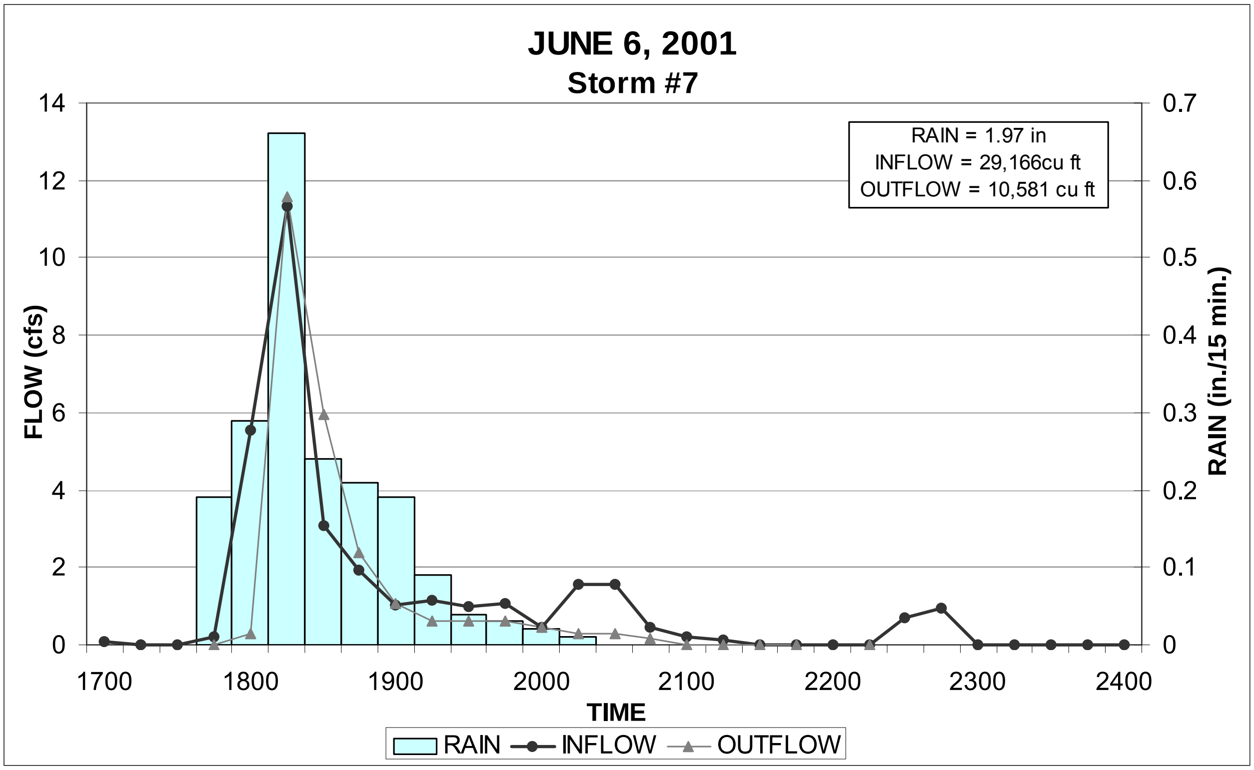
Compares inflow to outflow weir and does not include underdrain outflow.

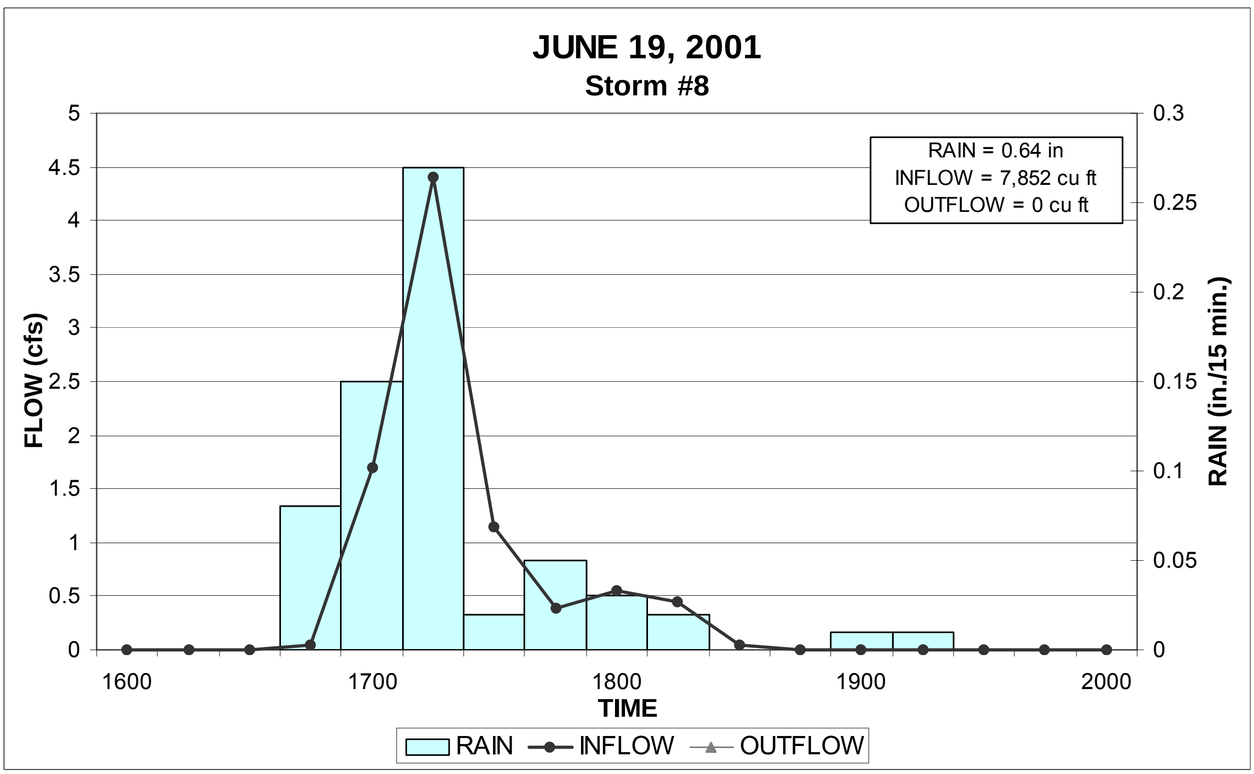
Appendix E-1. Year 1 flow for major rain events. Storms are numbered if water quality samples were taken. Underdrain flow not included.



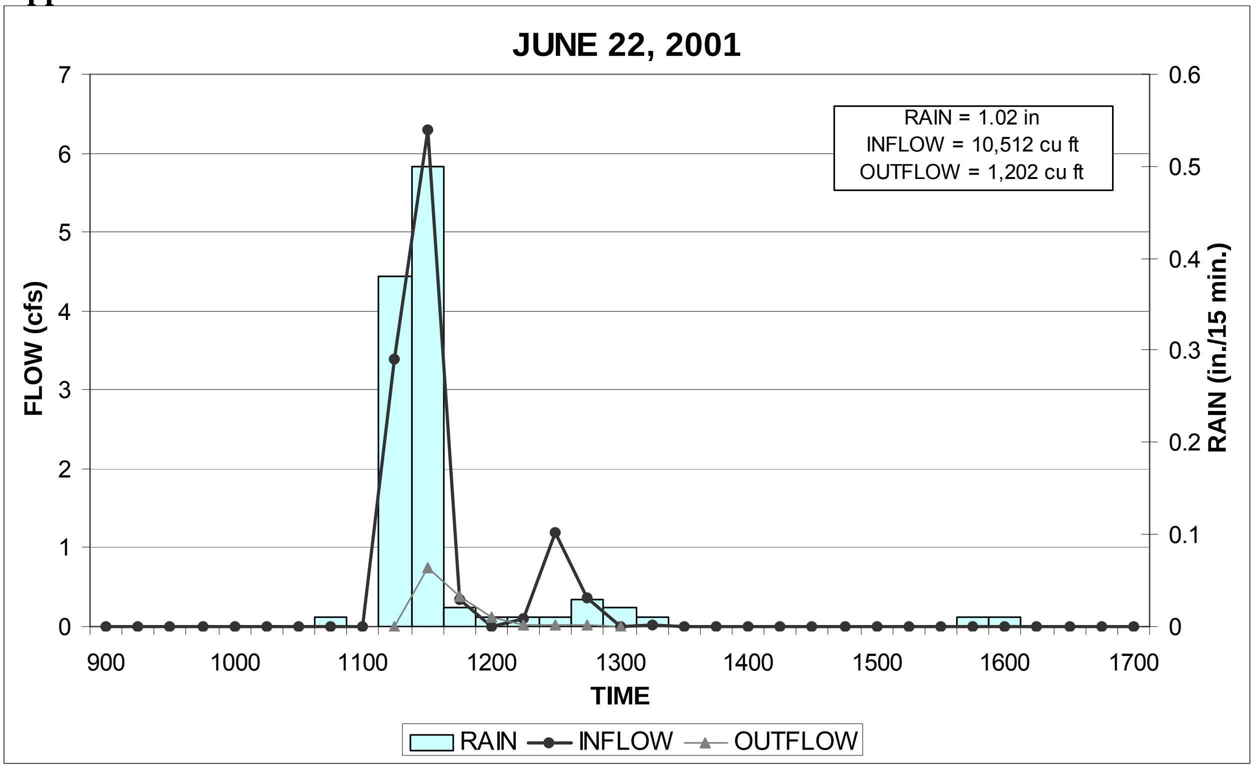


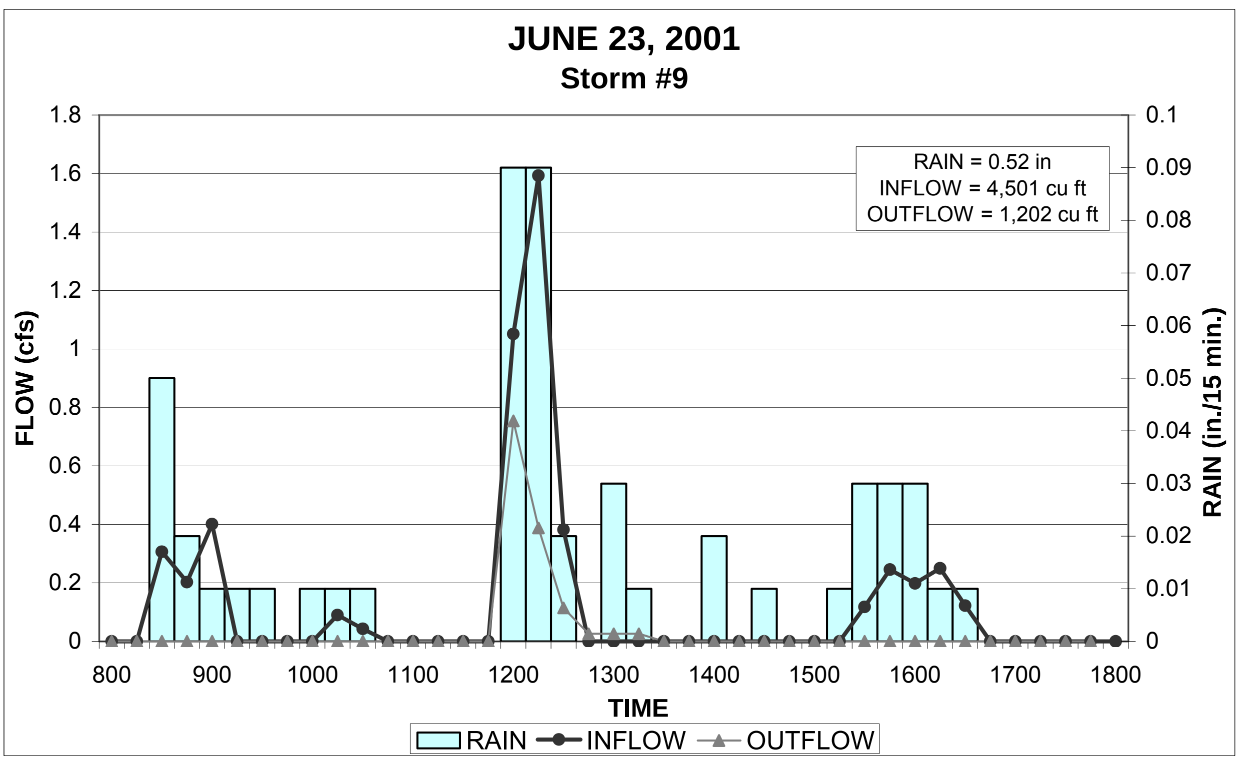
Appendix E-1. *Continued*


JUNE 6, 2001
Storm #7
RAIN = 1.97 in
INFLOW = 29,166cu ft
OUTFLOW = 10,581 cu ft
FLOW (cfs)
RAIN (in./15 min.)
TIME
0
2
4
6
8
10
12
14
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
1700
1800
1900
2000
2100
2200
2300
2400
RAIN
INFLOW
OUTFLOW

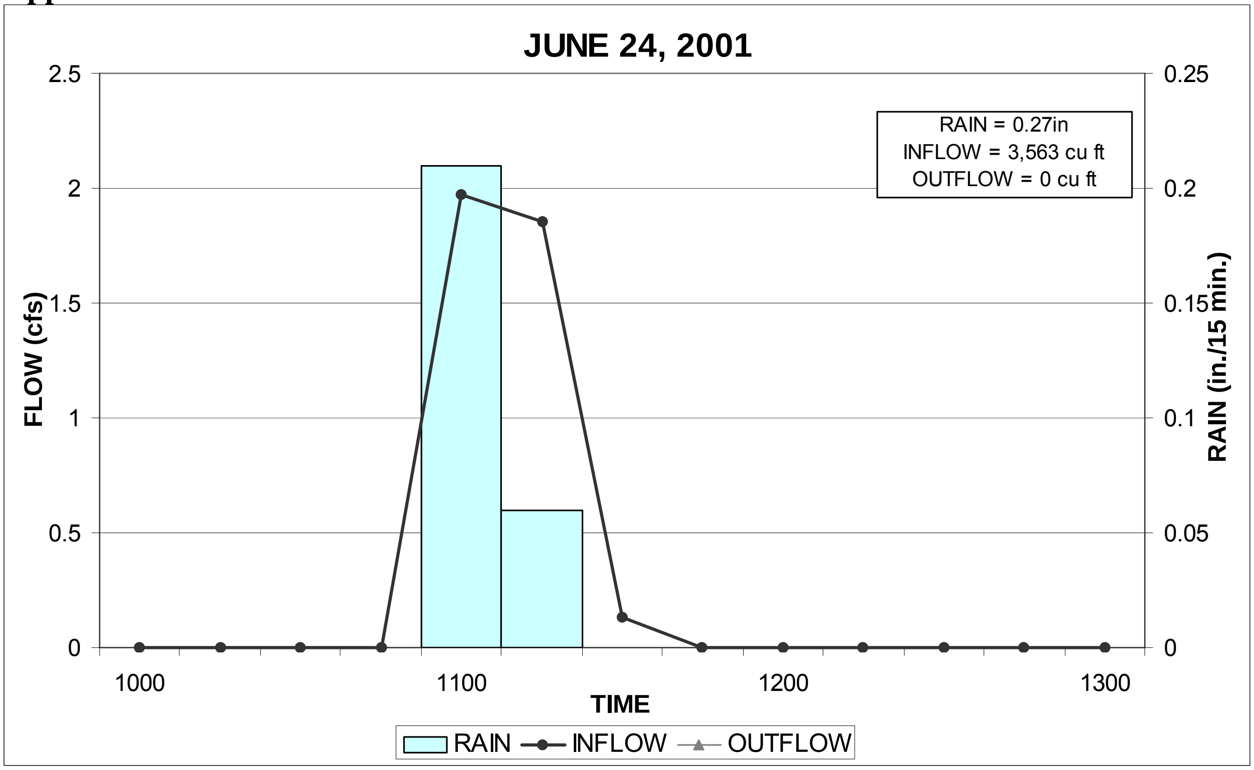

JUNE 19, 2001
Storm #8
RAIN = 0.64 in
INFLOW = 7,852 cu ft
OUTFLOW = 0 cu ft
FLOW (cfs)
RAIN (in./15 min.)
TIME
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
0.05
0.1
0.15
0.2
0.25
0.3
1600
1700
1800
1900
2000
RAIN
INFLOW
OUTFLOW

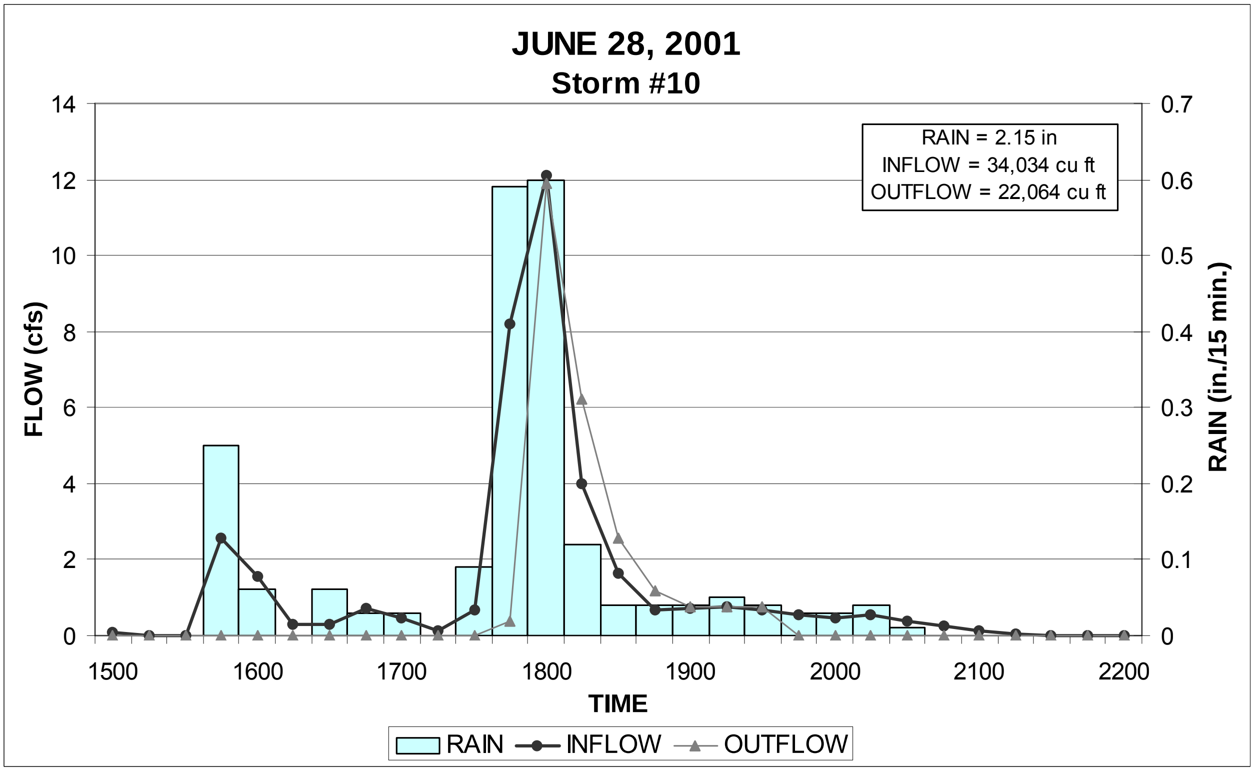
Appendix E-1. ***Continued***



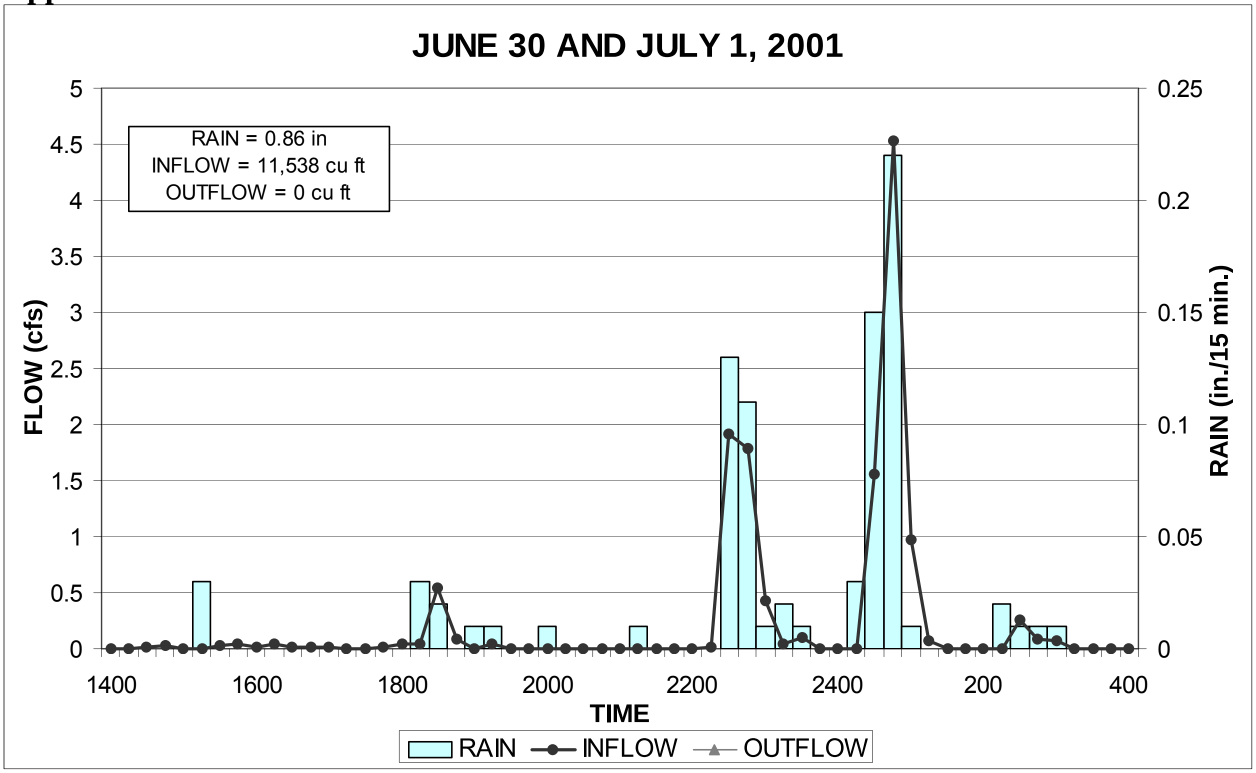


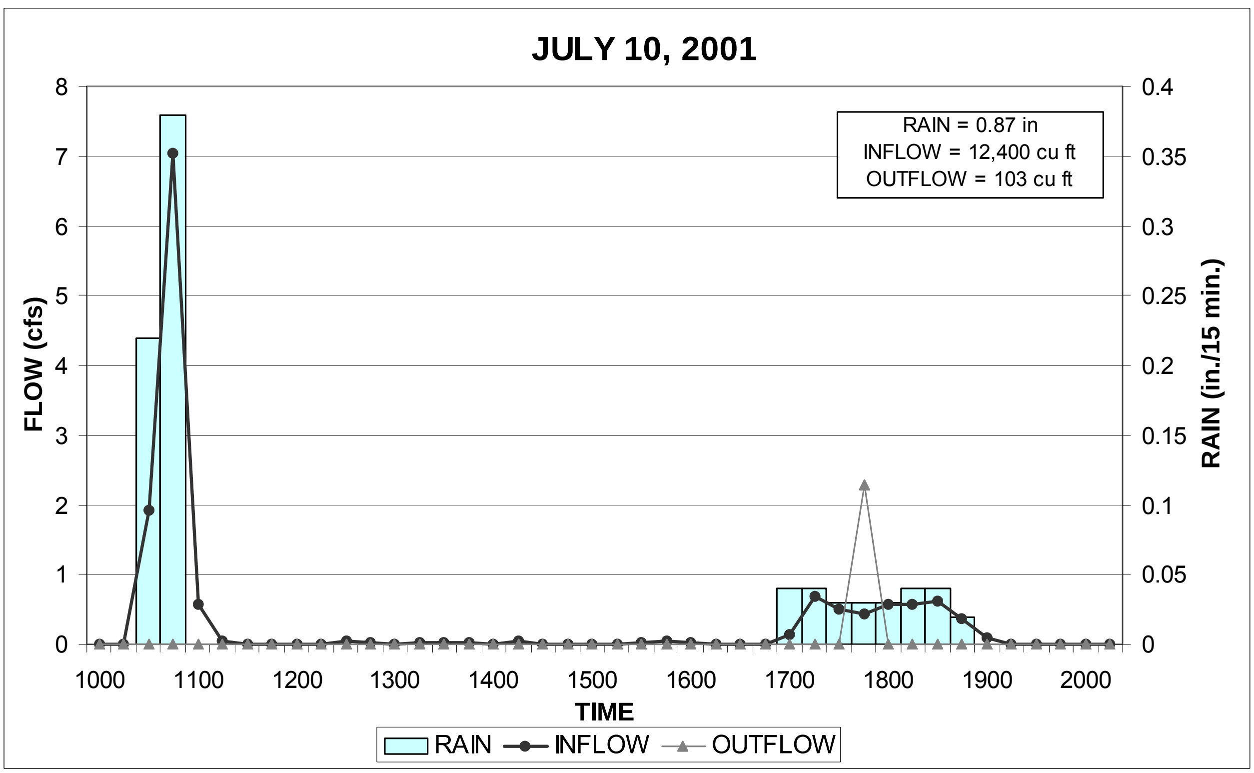
Appendix E-1. ***Continued***



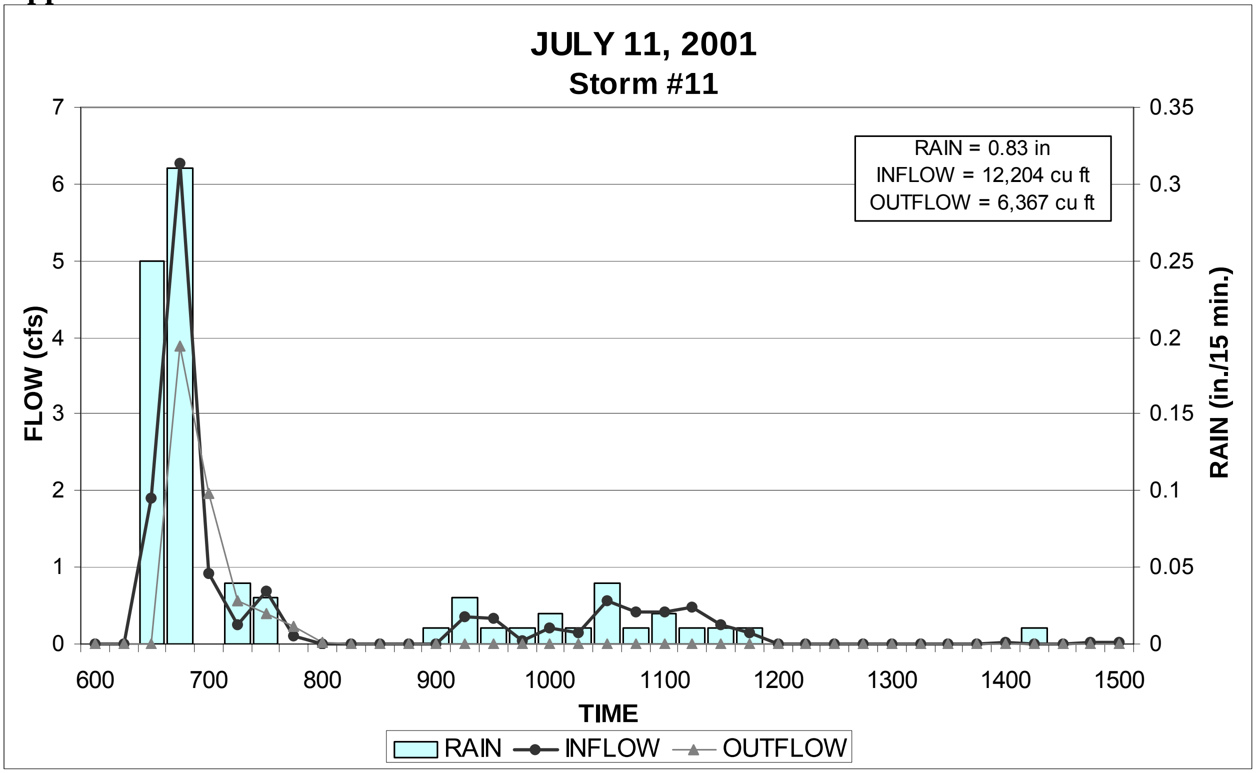


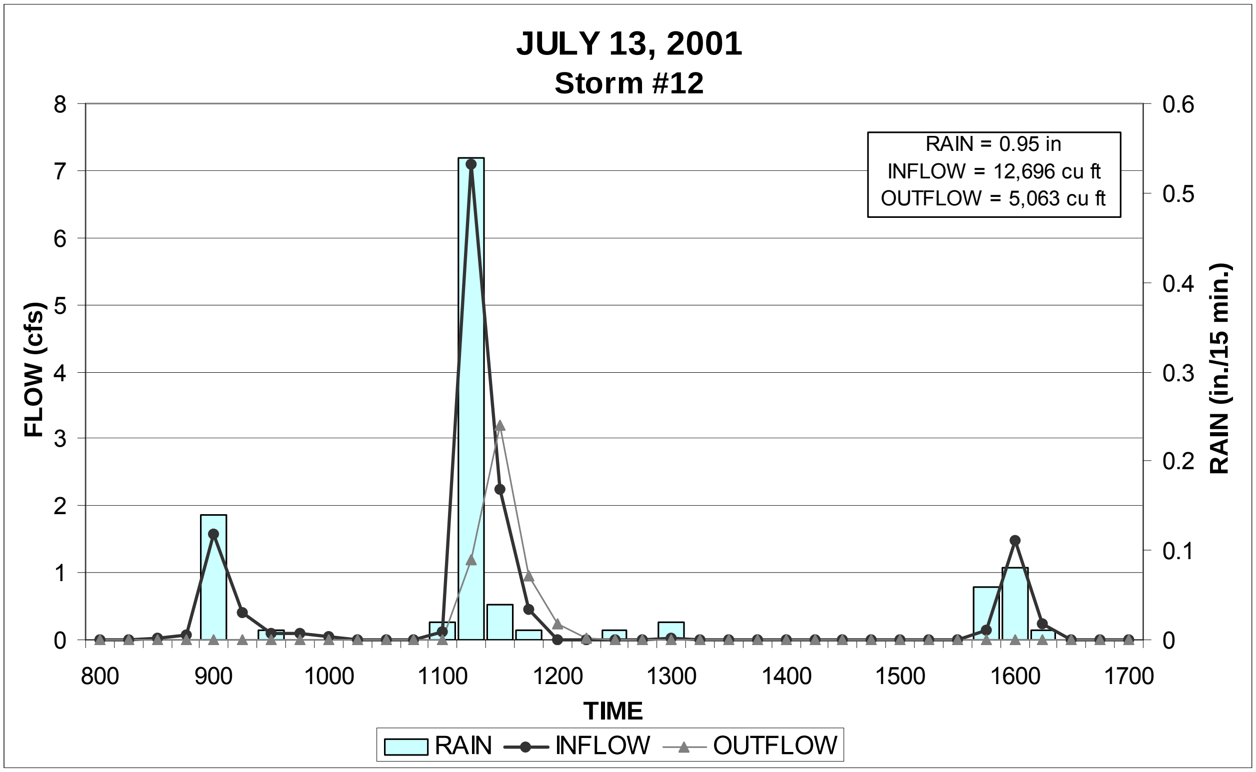
Appendix E-1. *Continued*



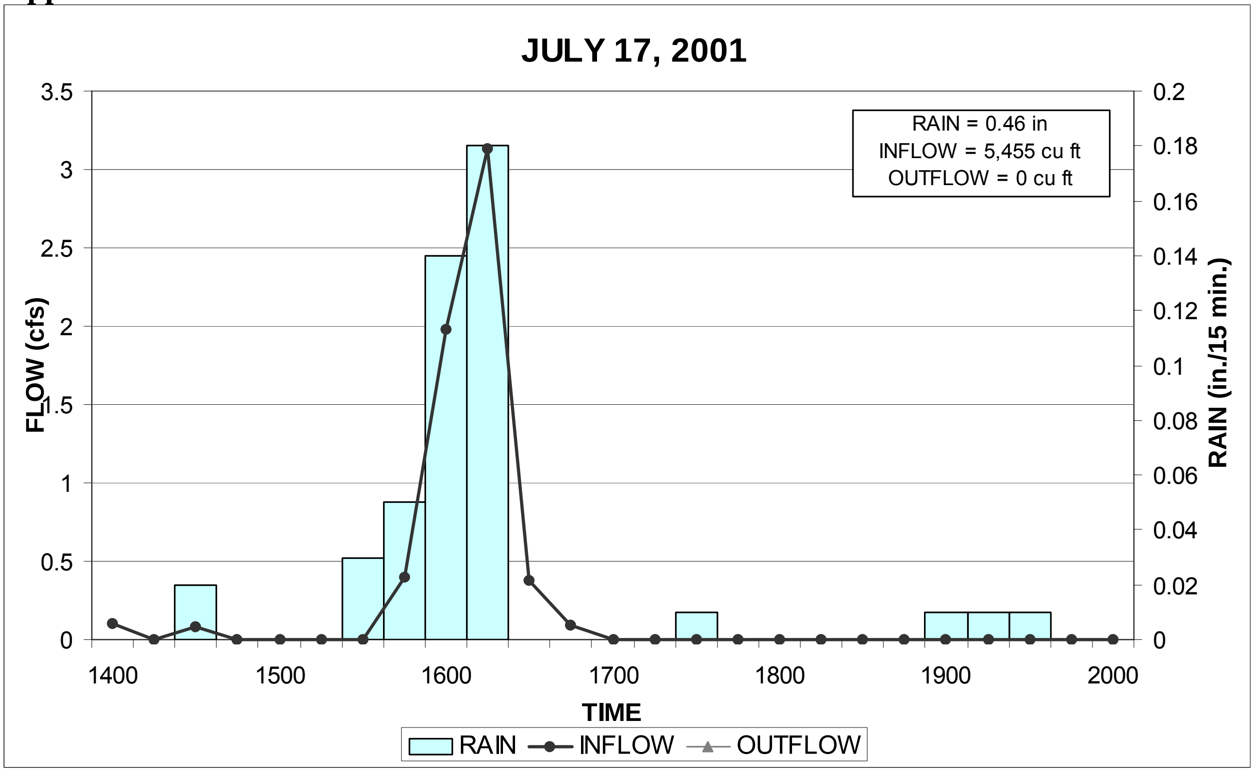


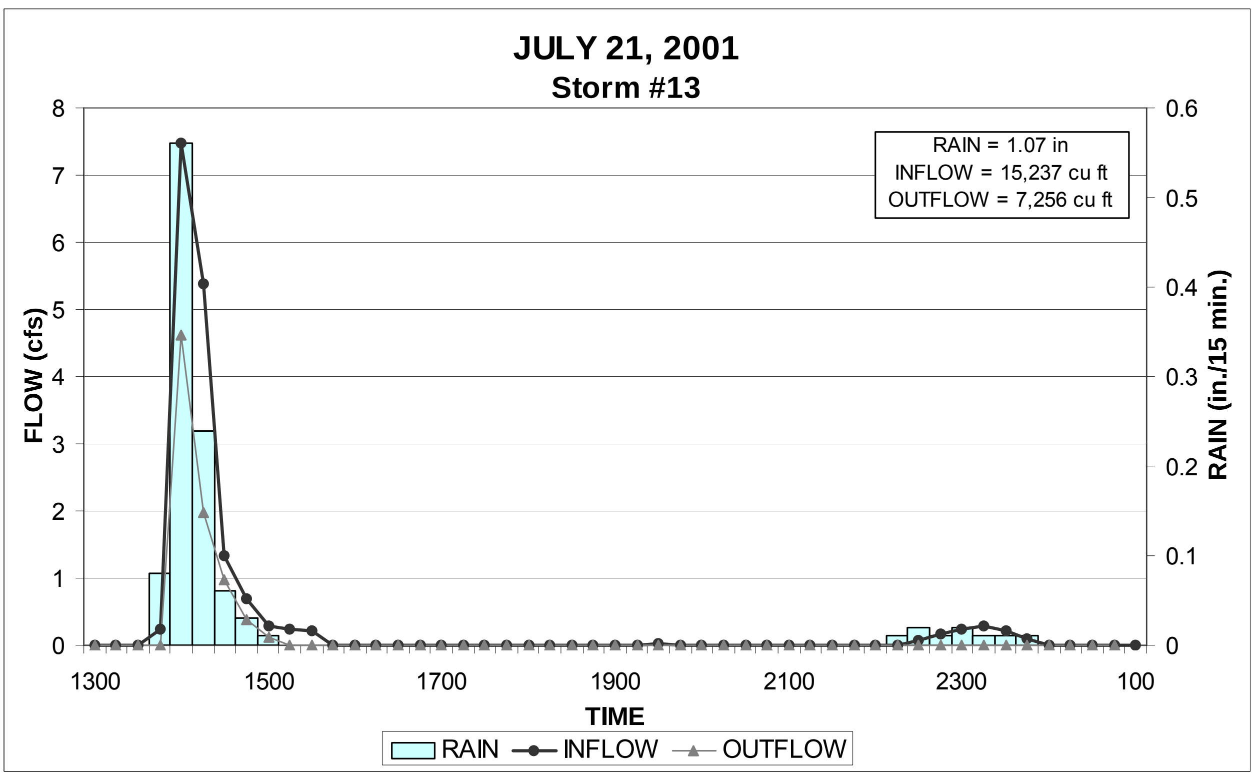
Appendix E-1. *Continued*



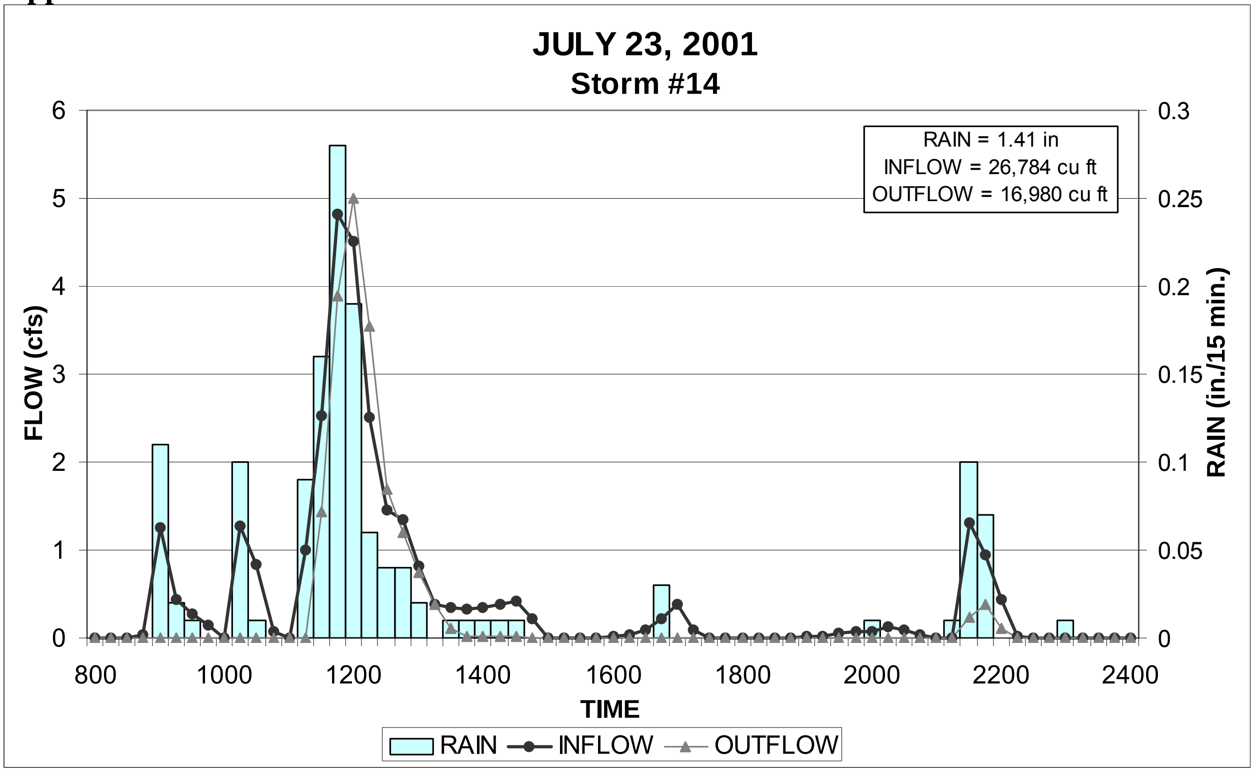


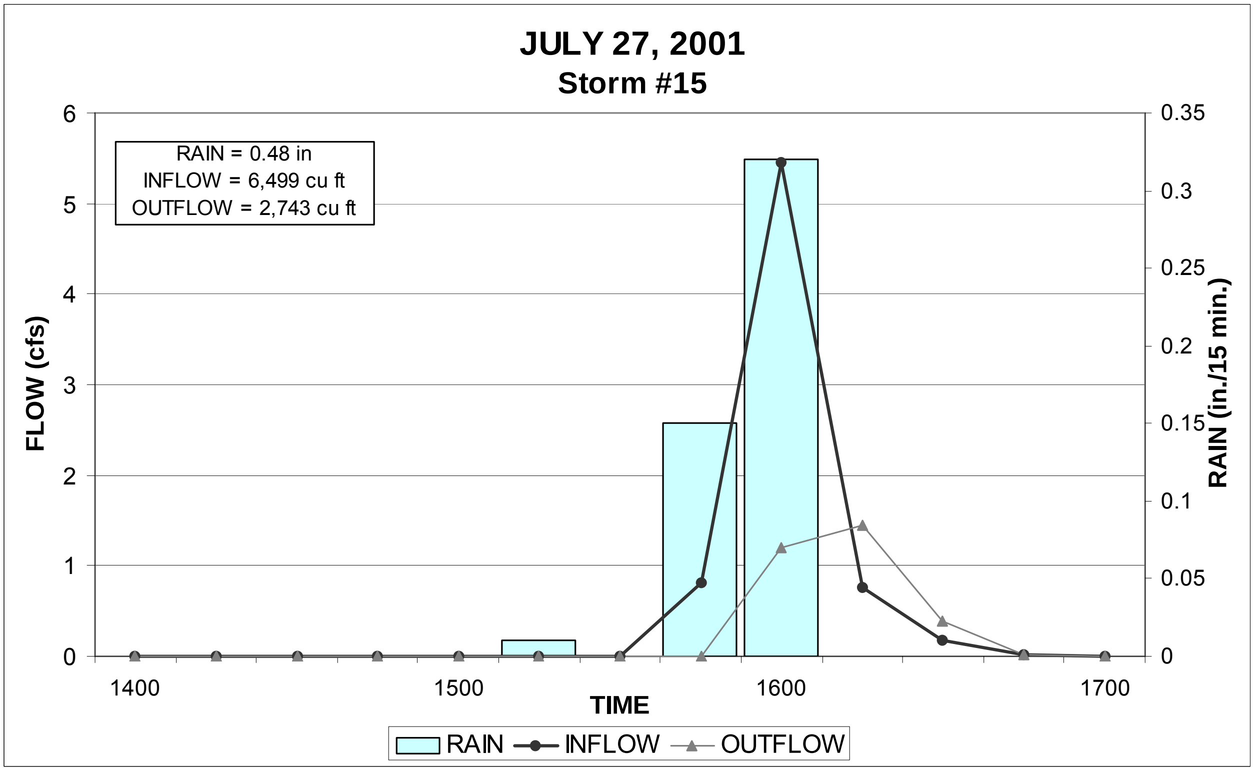
Appendix E-1. ***Continued***



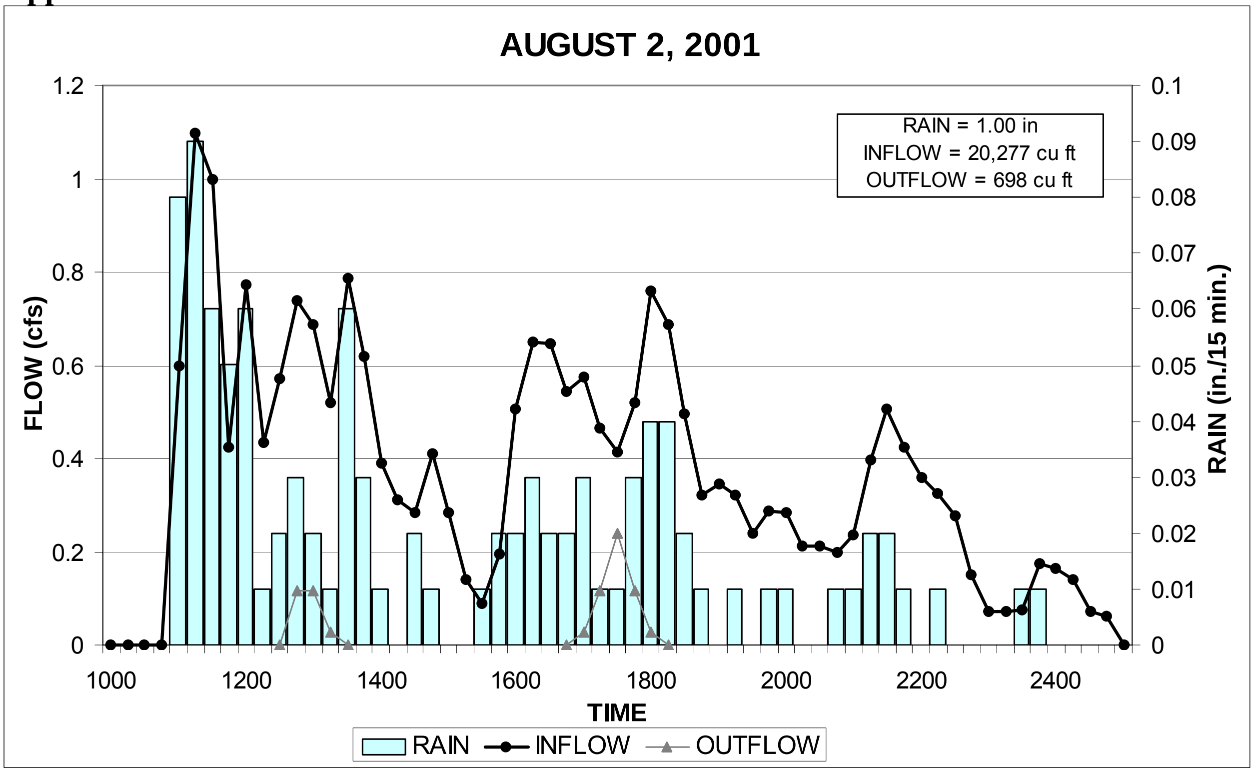


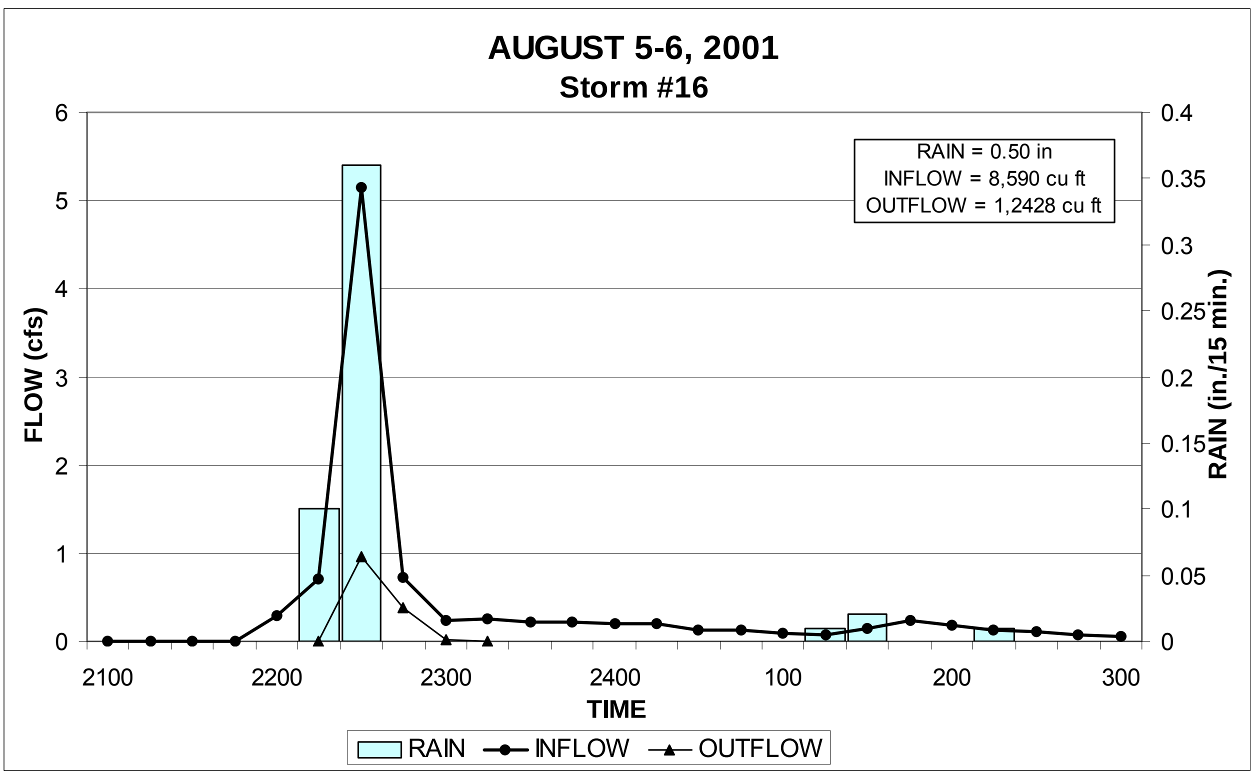
Appendix E-1. ***Continued***



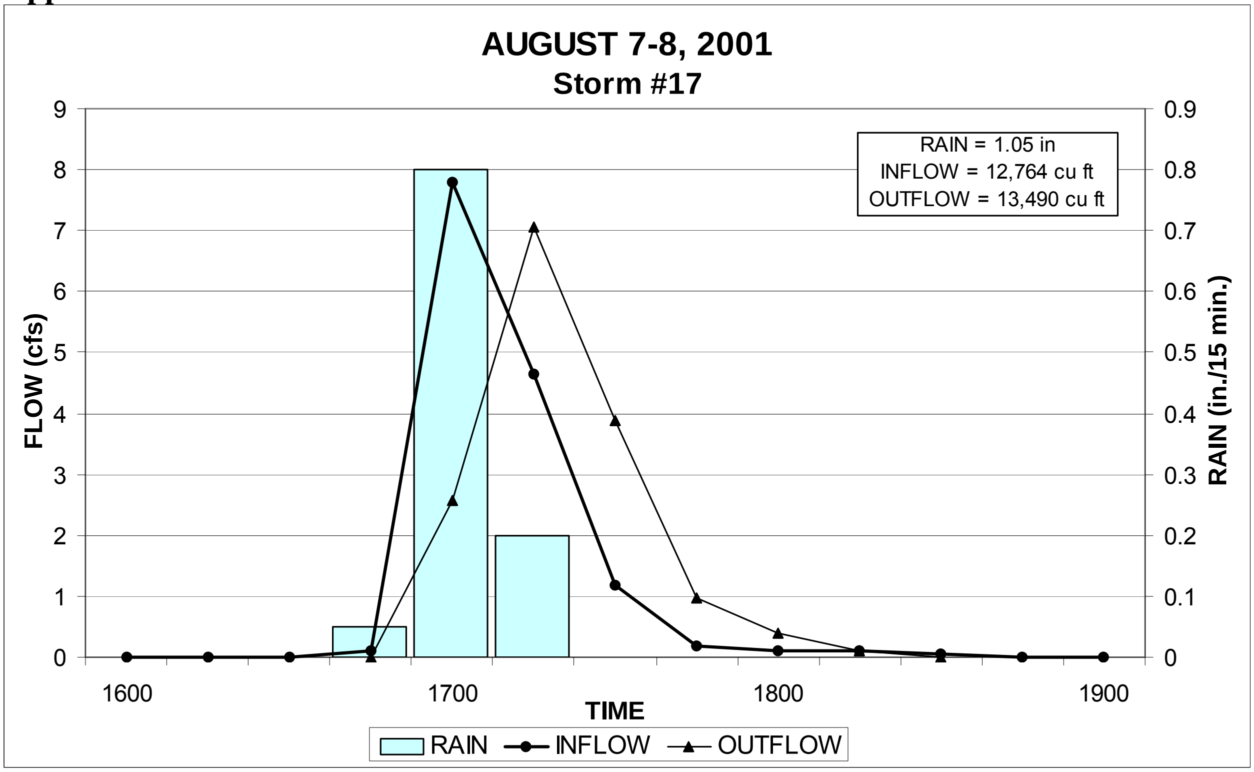


Appendix E-1. *Continued*

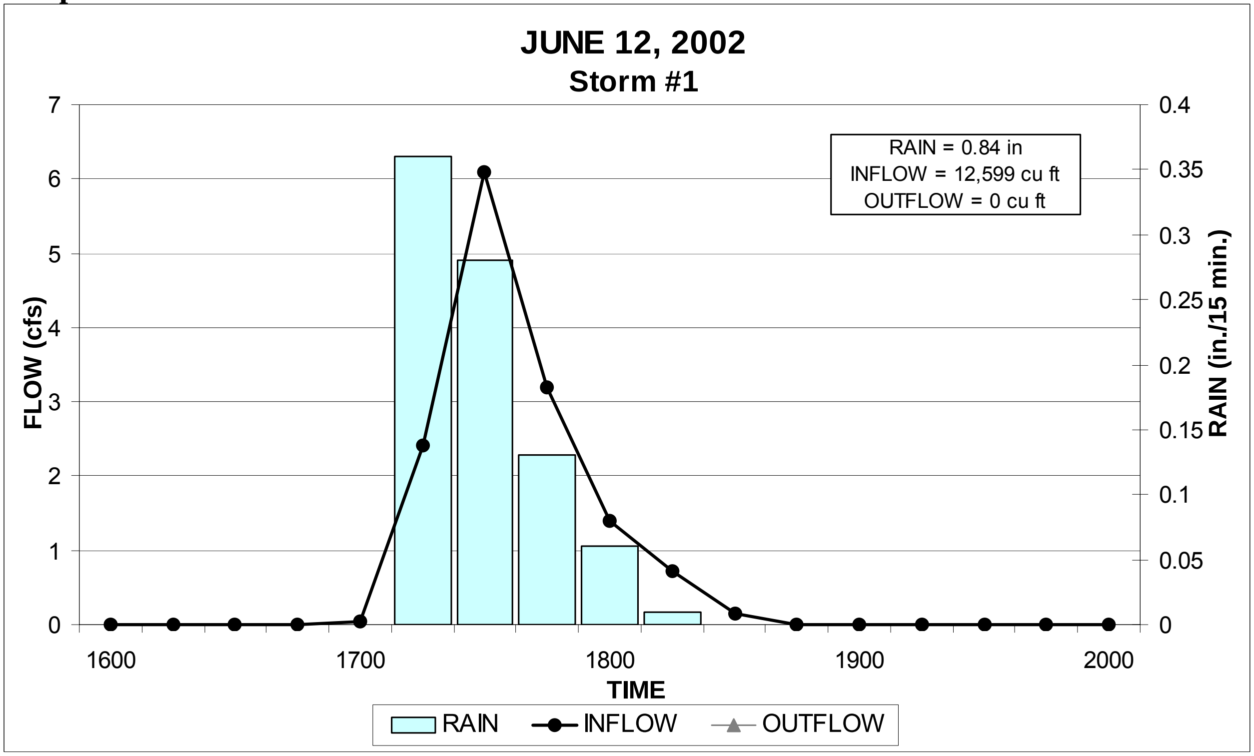


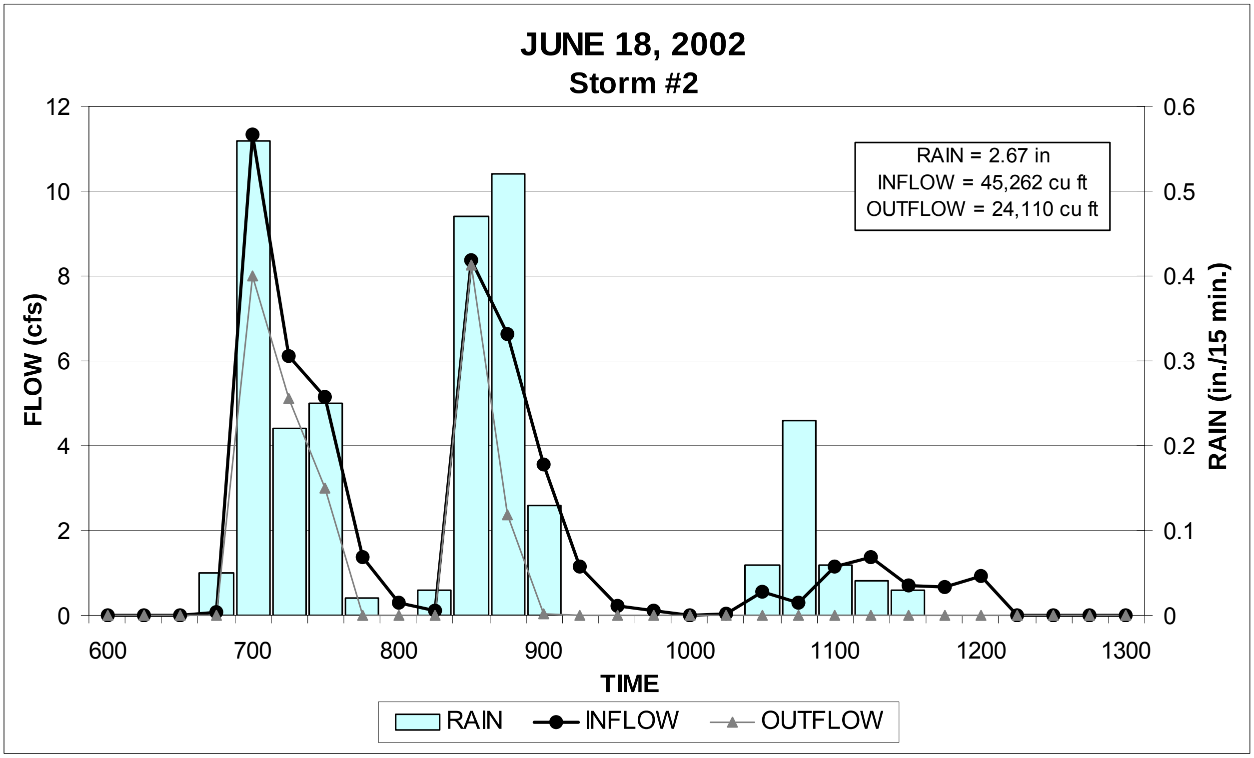


Appendix E-1. *Continued*

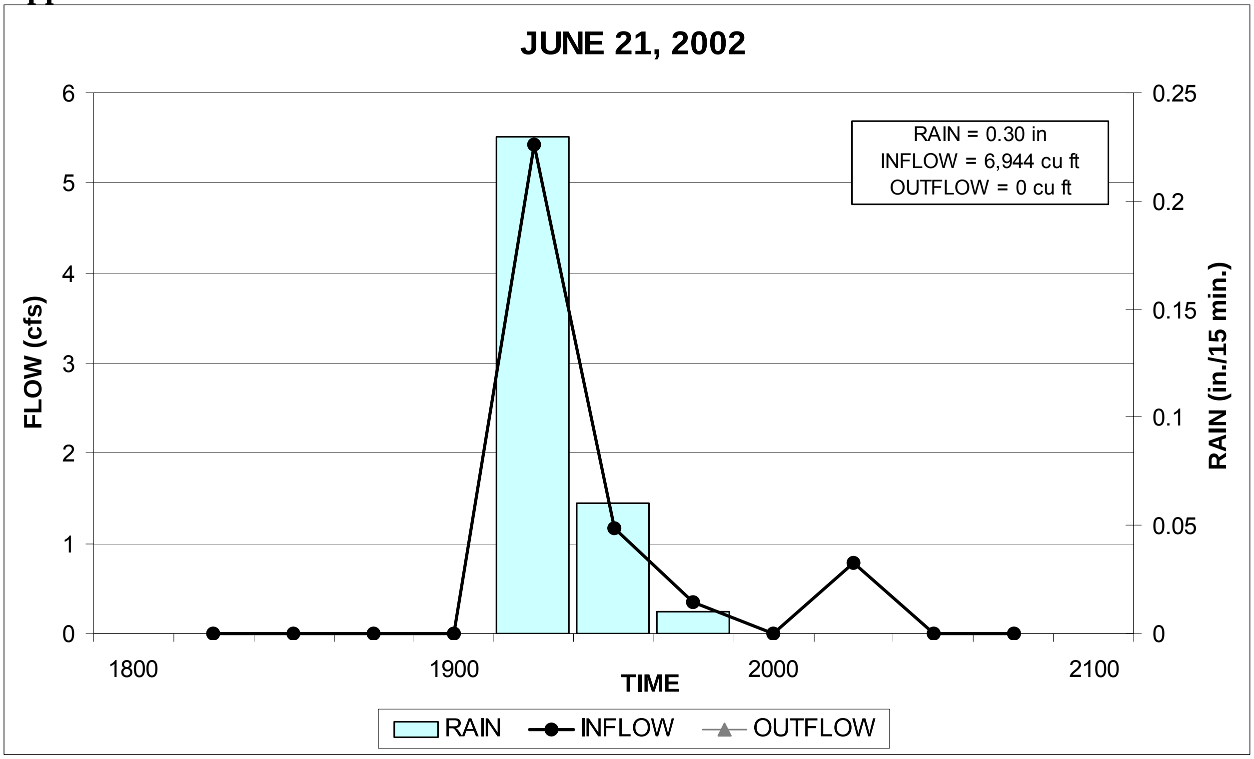


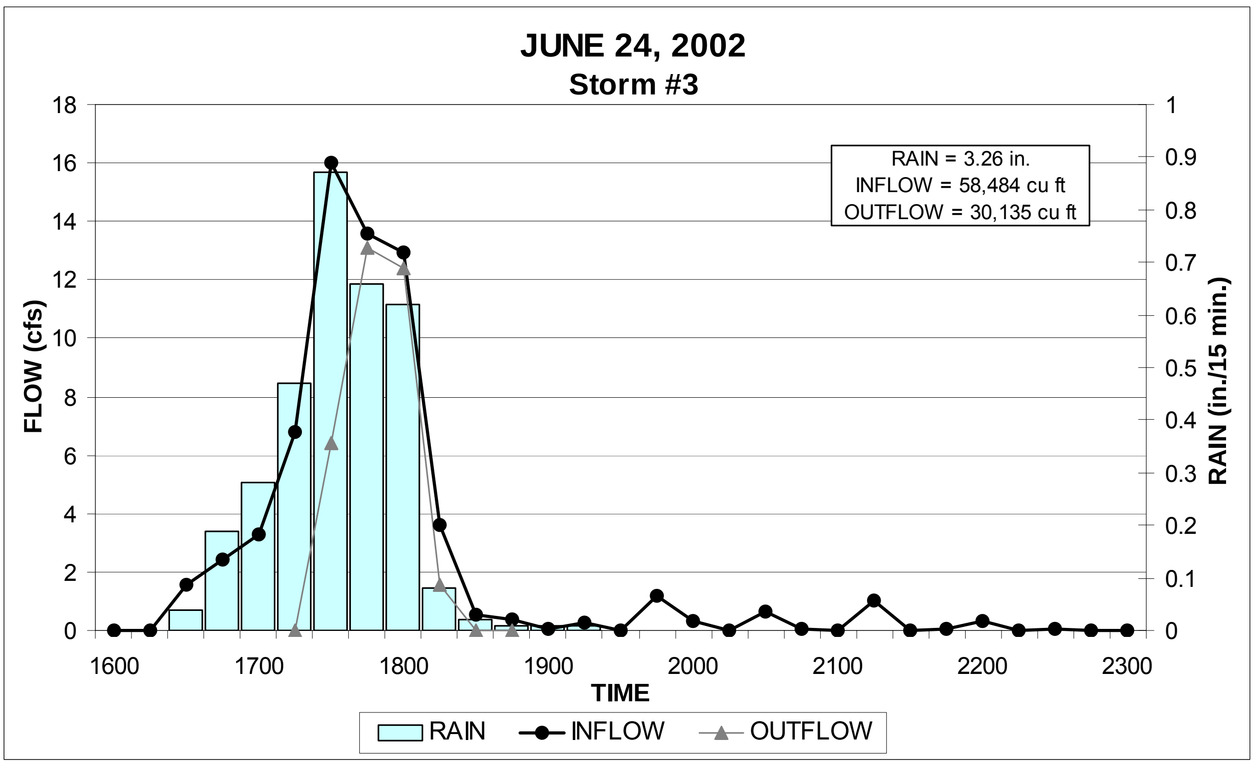
Appendix E-2. Year 2 flow for major rain events. Storms are numbered if water quality samples were taken. Underdrain flow not included.



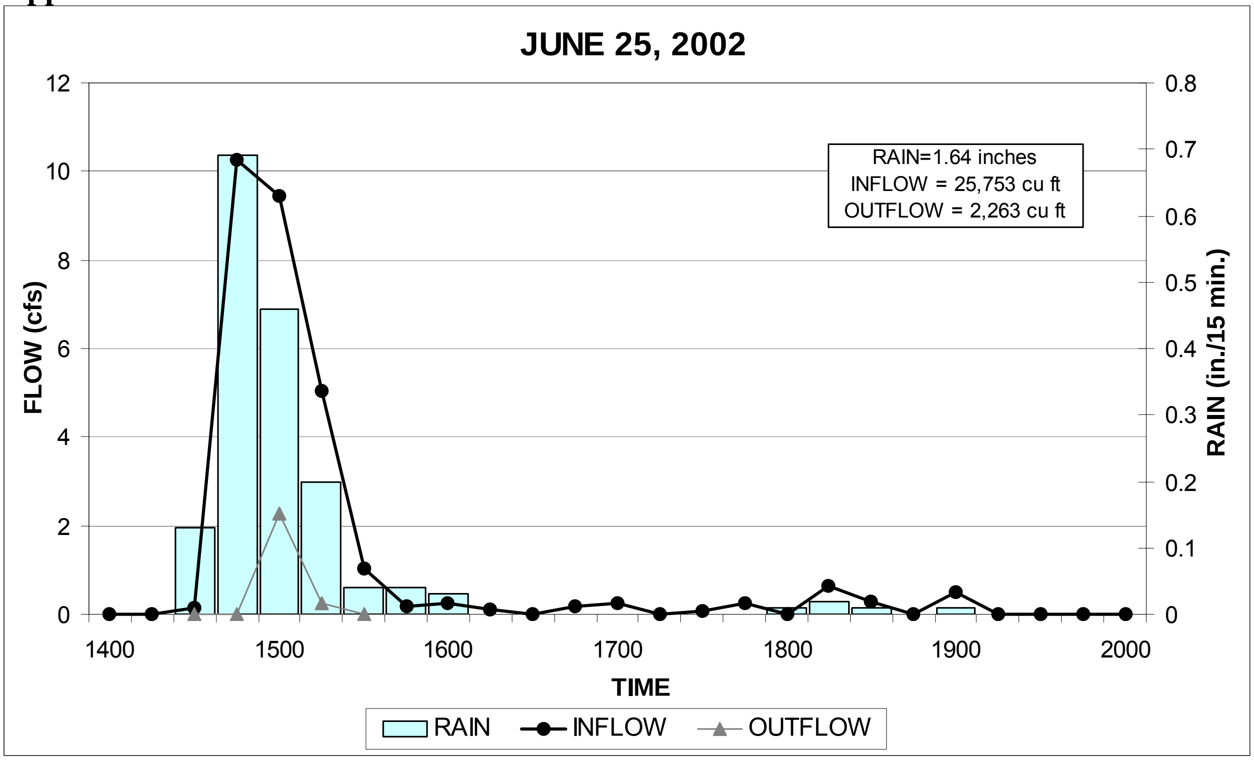


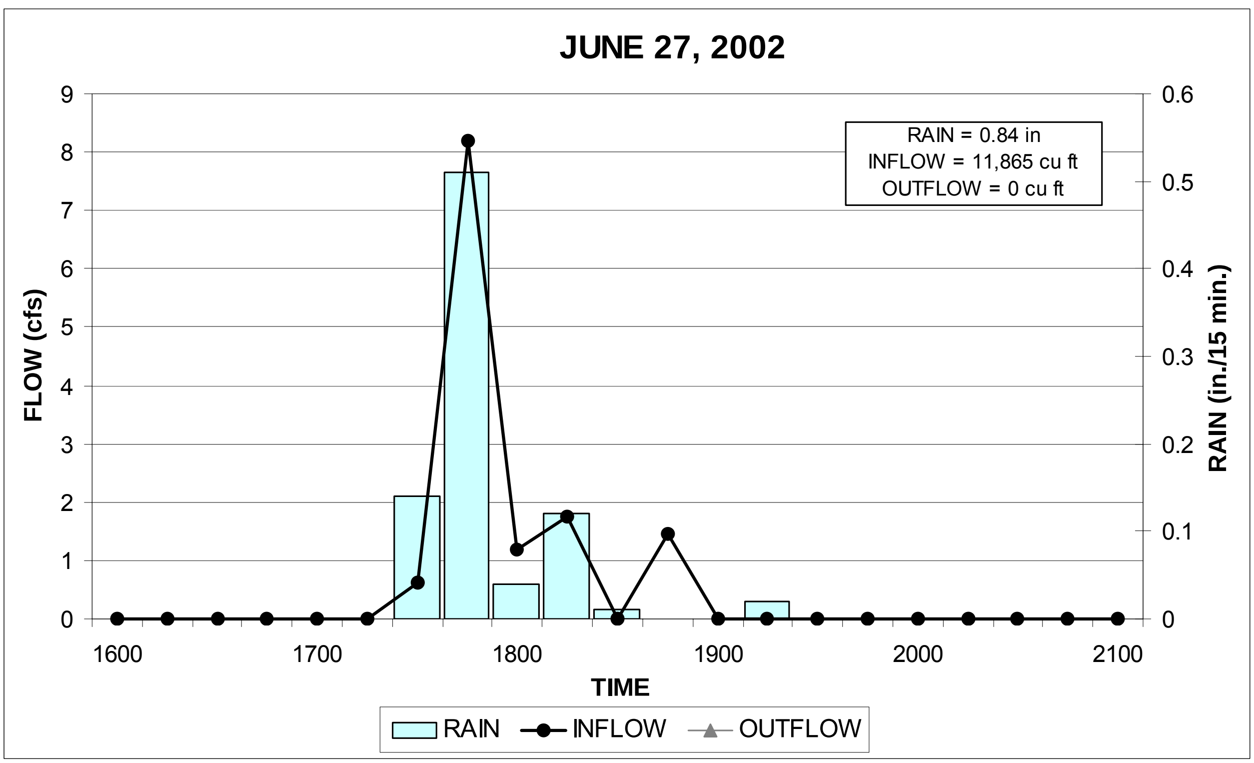
Appendix E-2. *Continued*



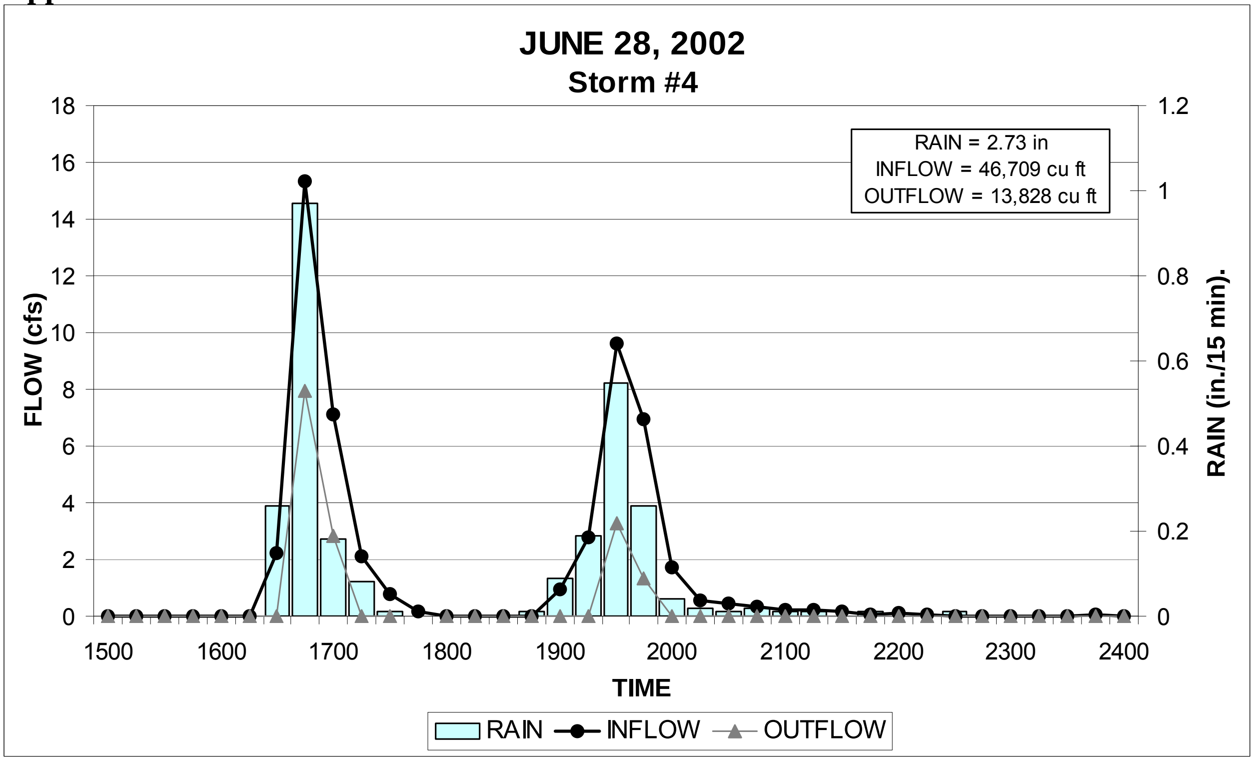


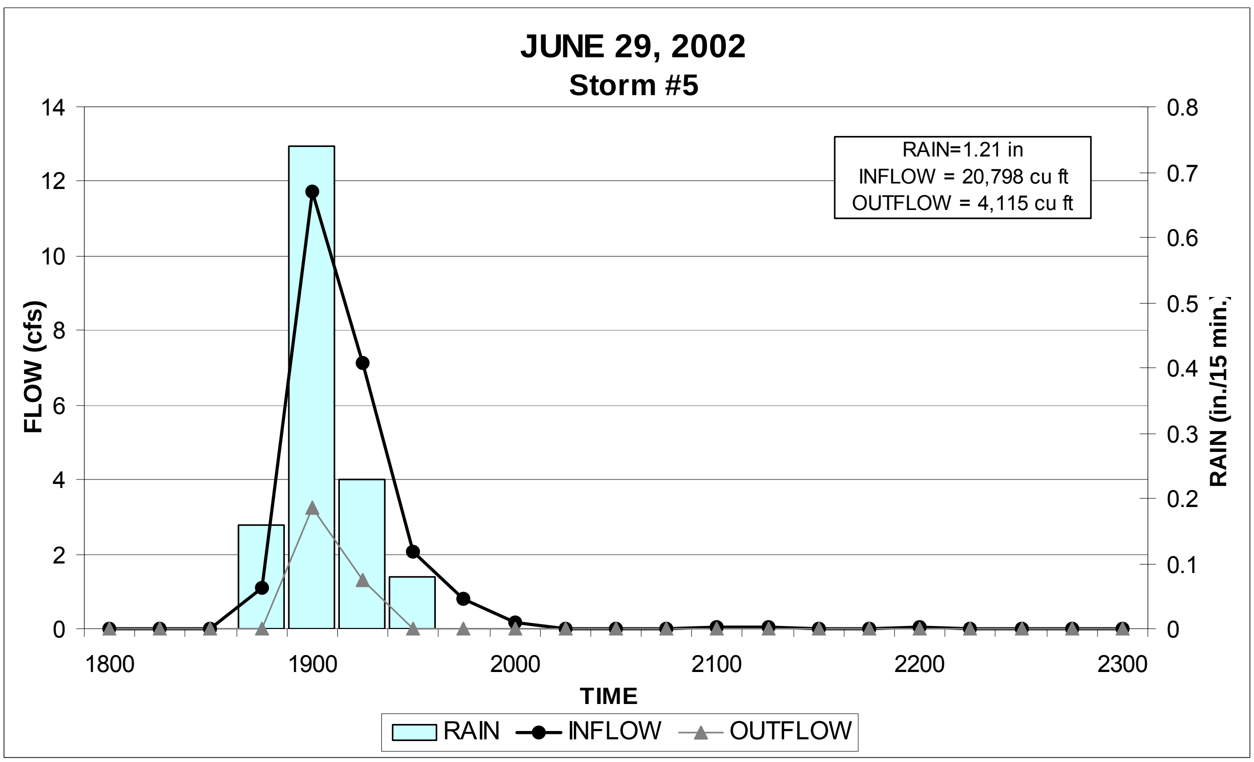
Appendix E-2. *Continued*



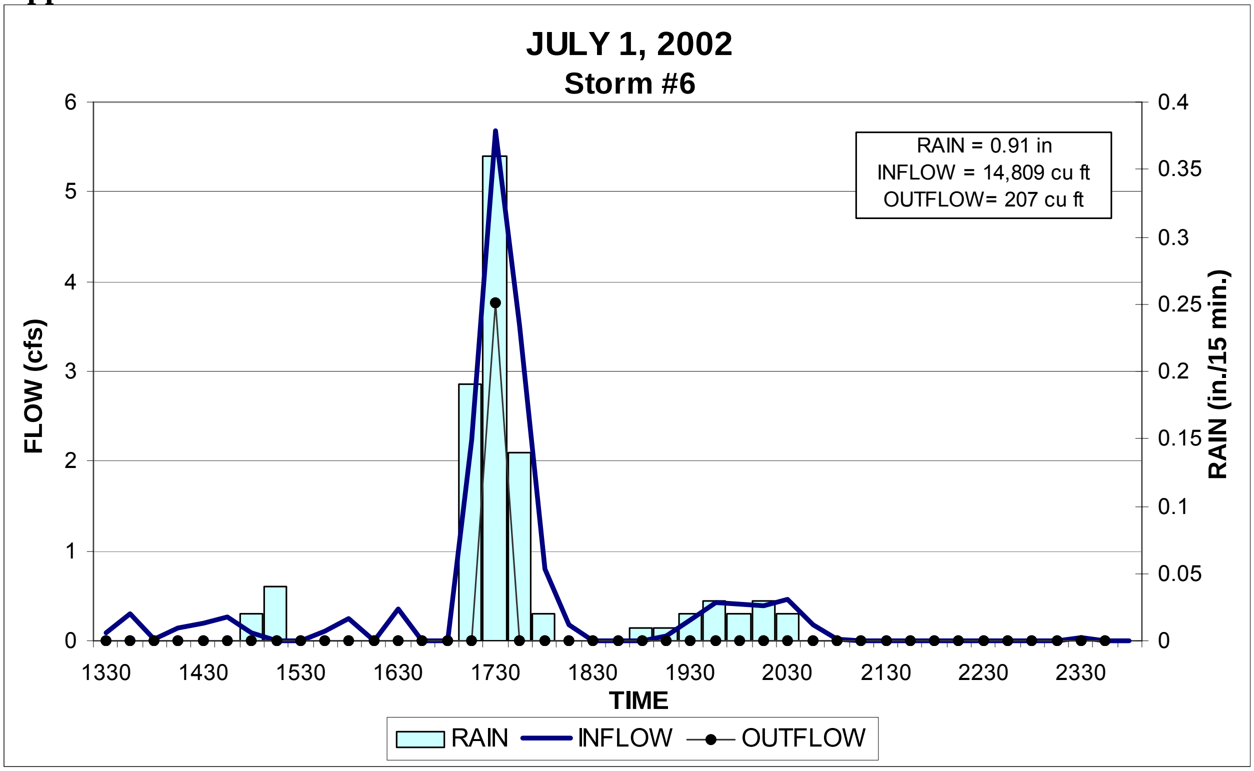


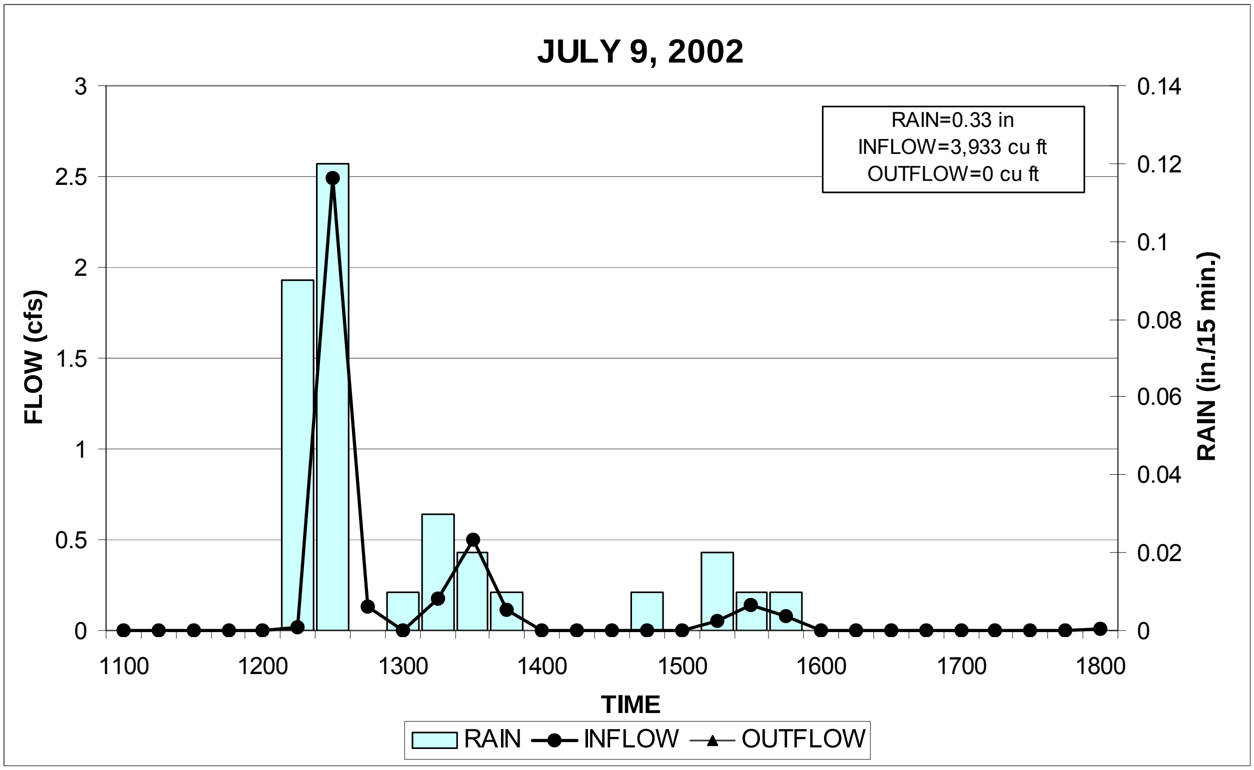
Appendix E-2. ***Continued***





Appendix E-2. *Continued*





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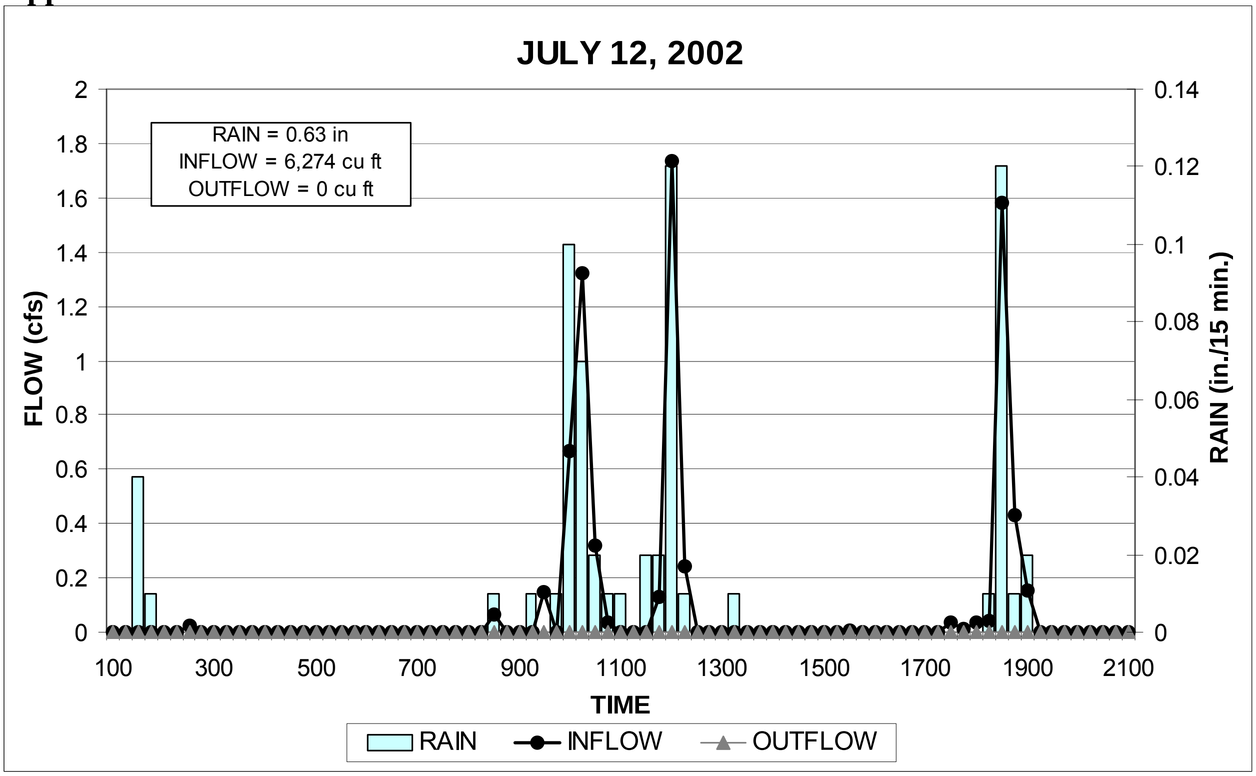
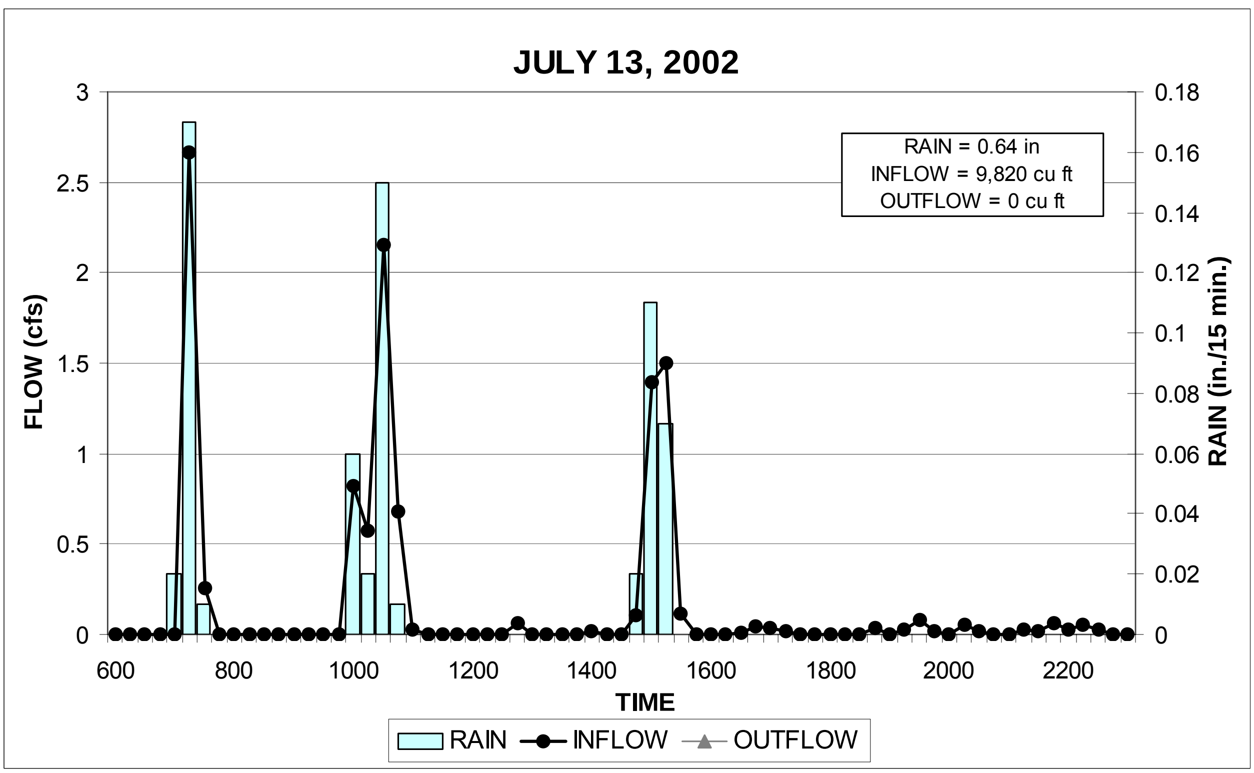
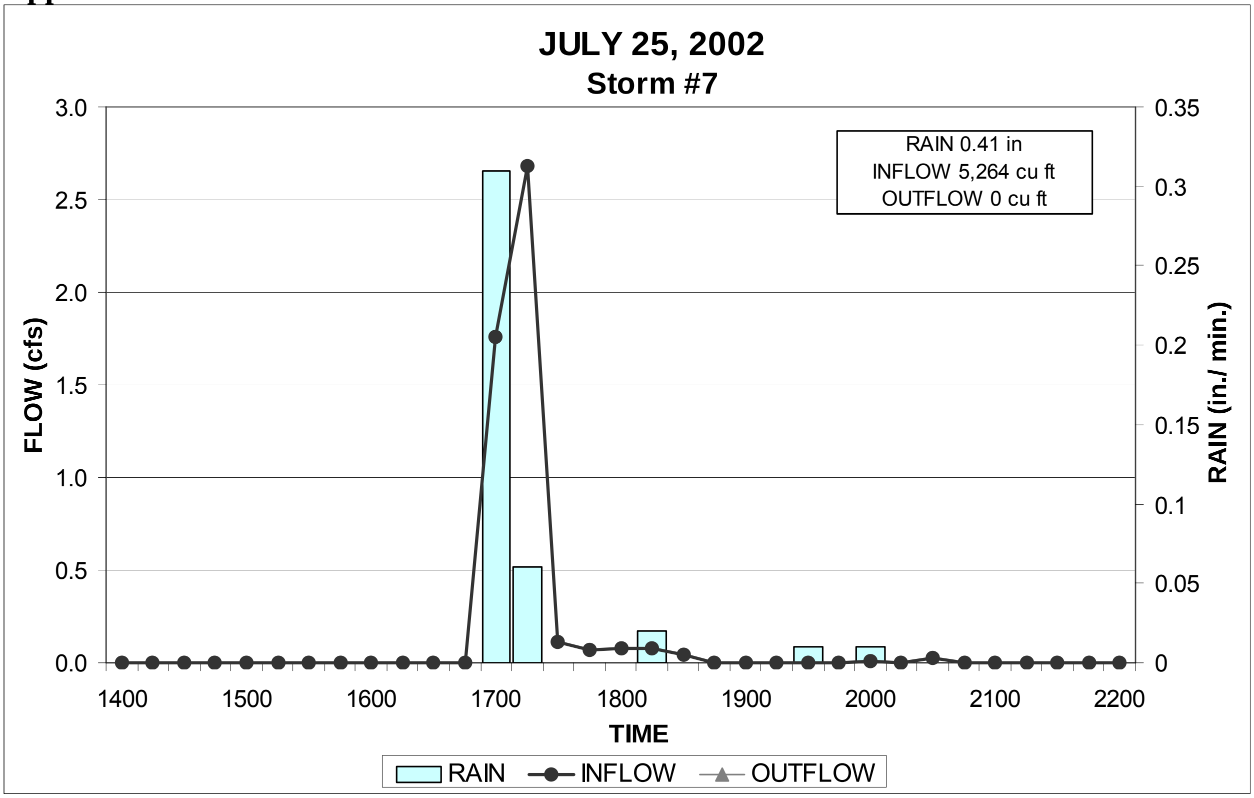
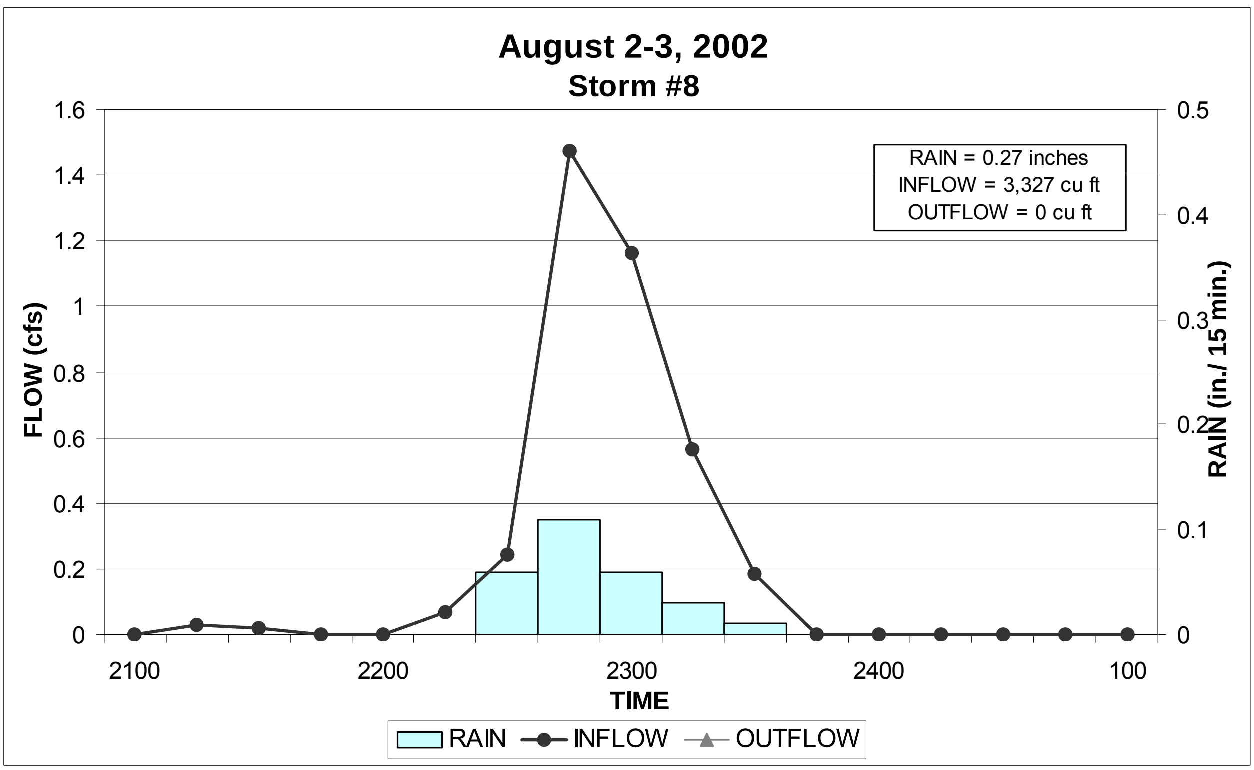


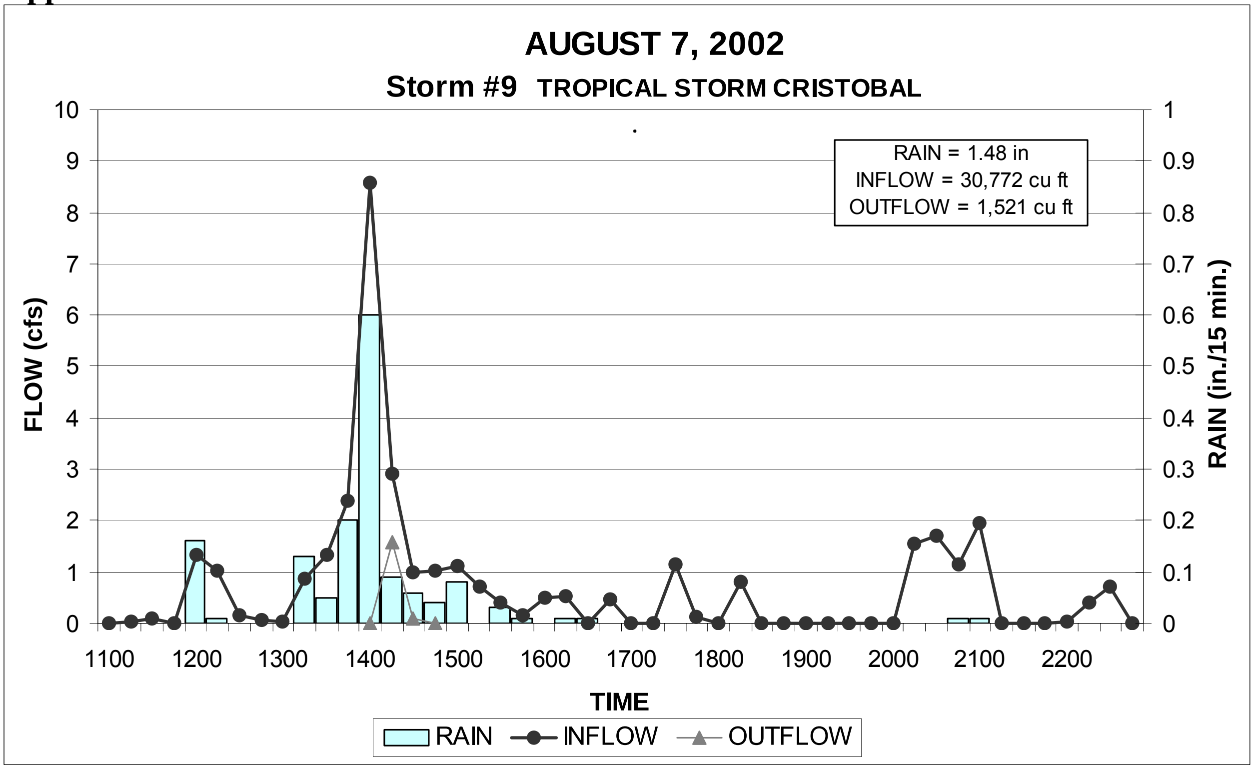


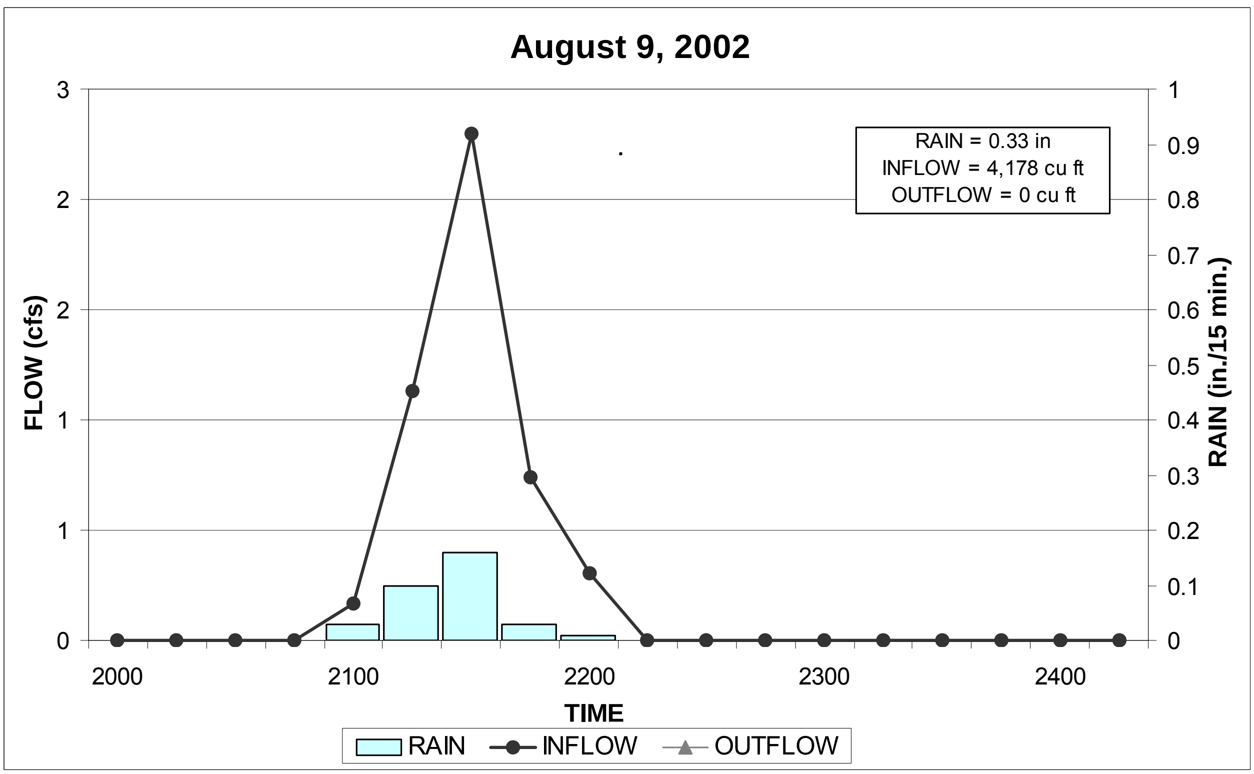
Appendix E-2. *Continued*





Appendix E-2. ***Continued***





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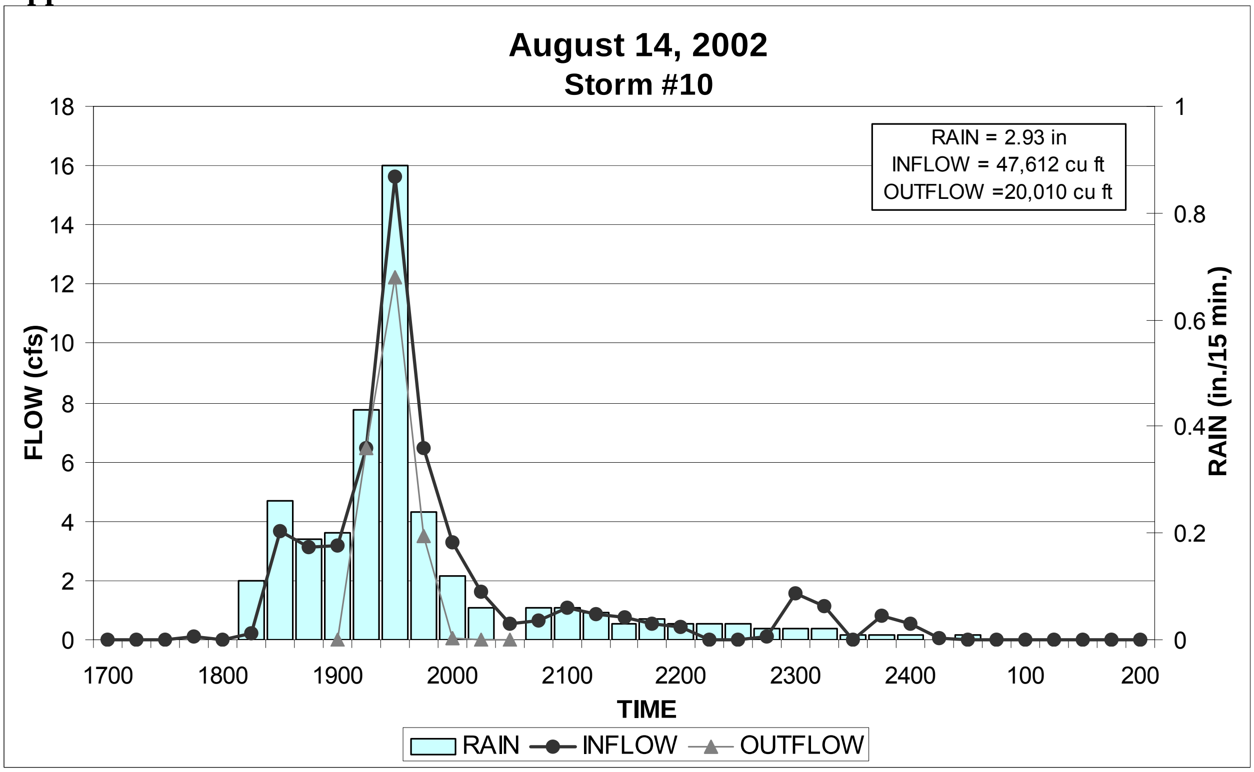

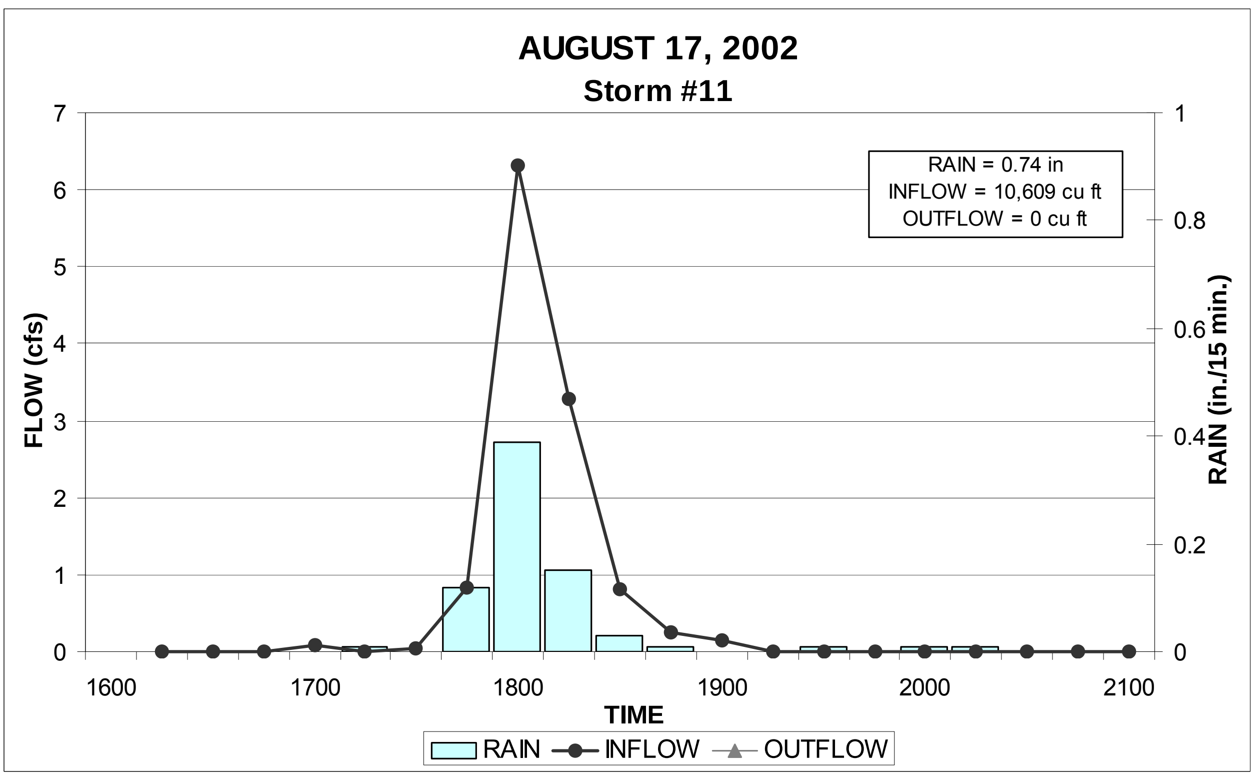

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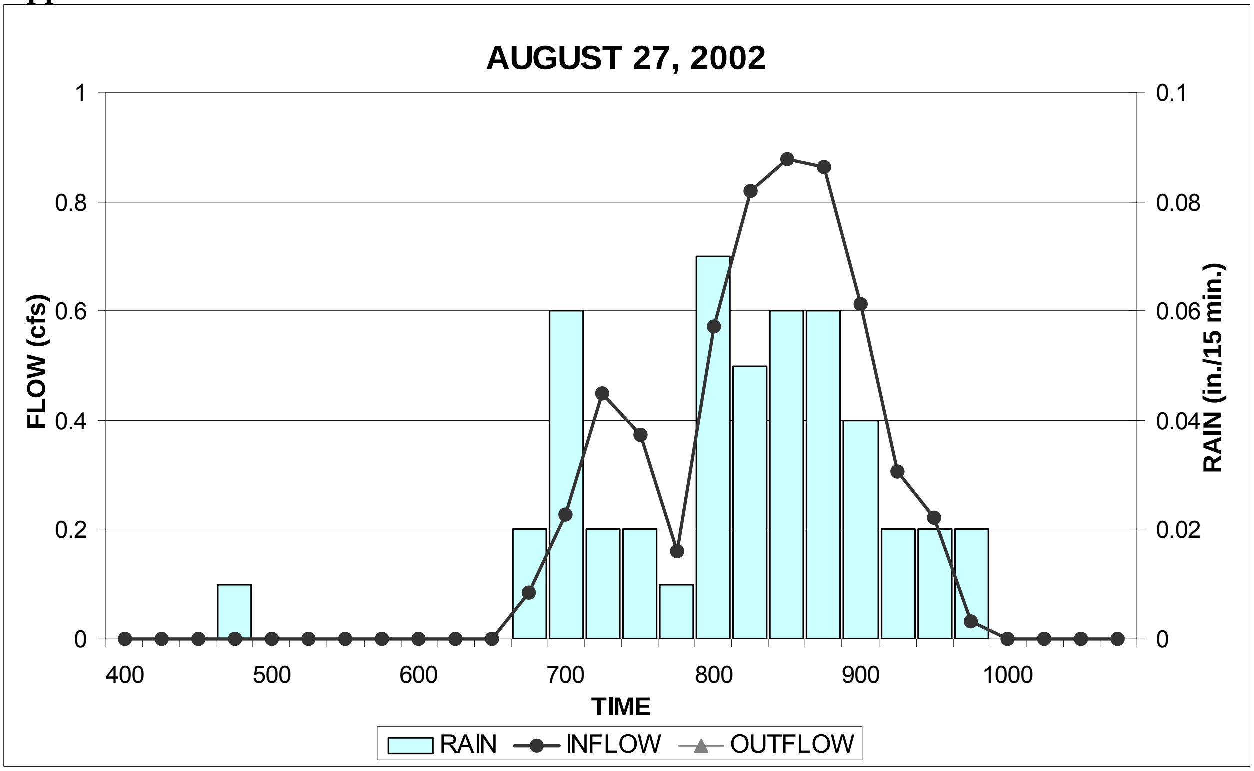
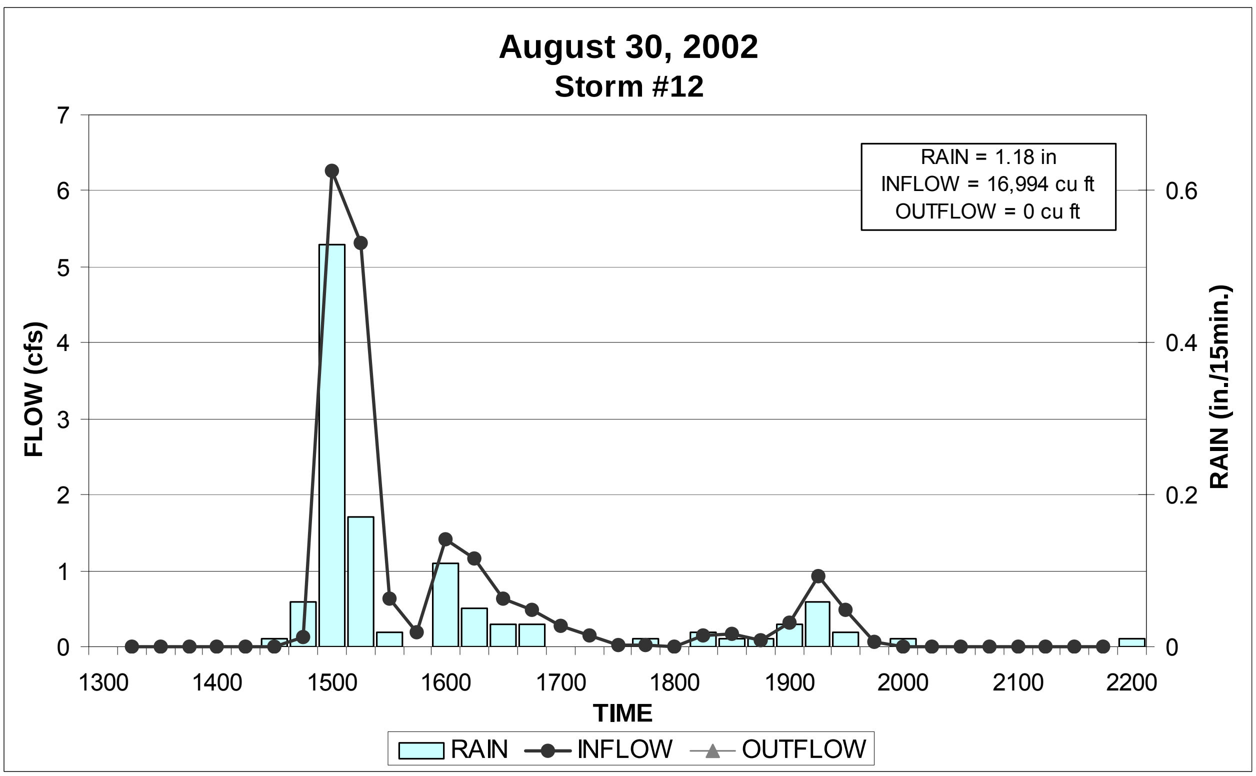
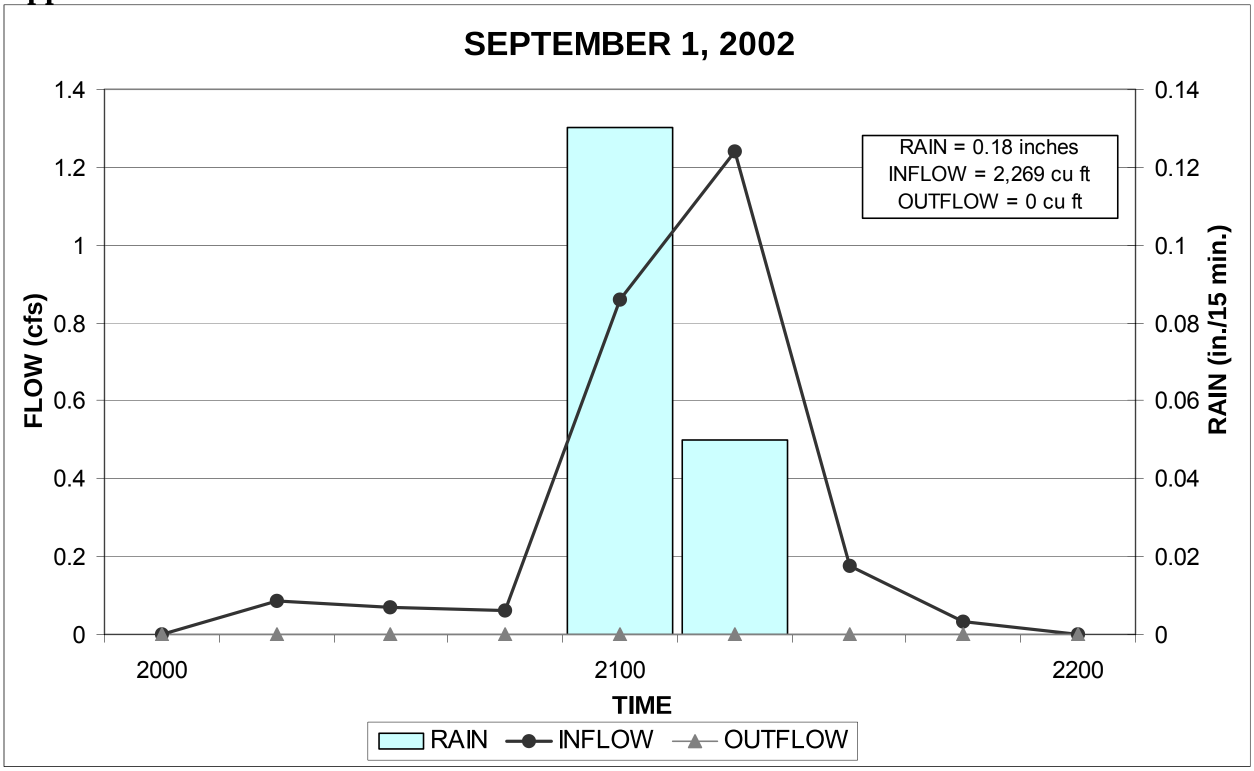
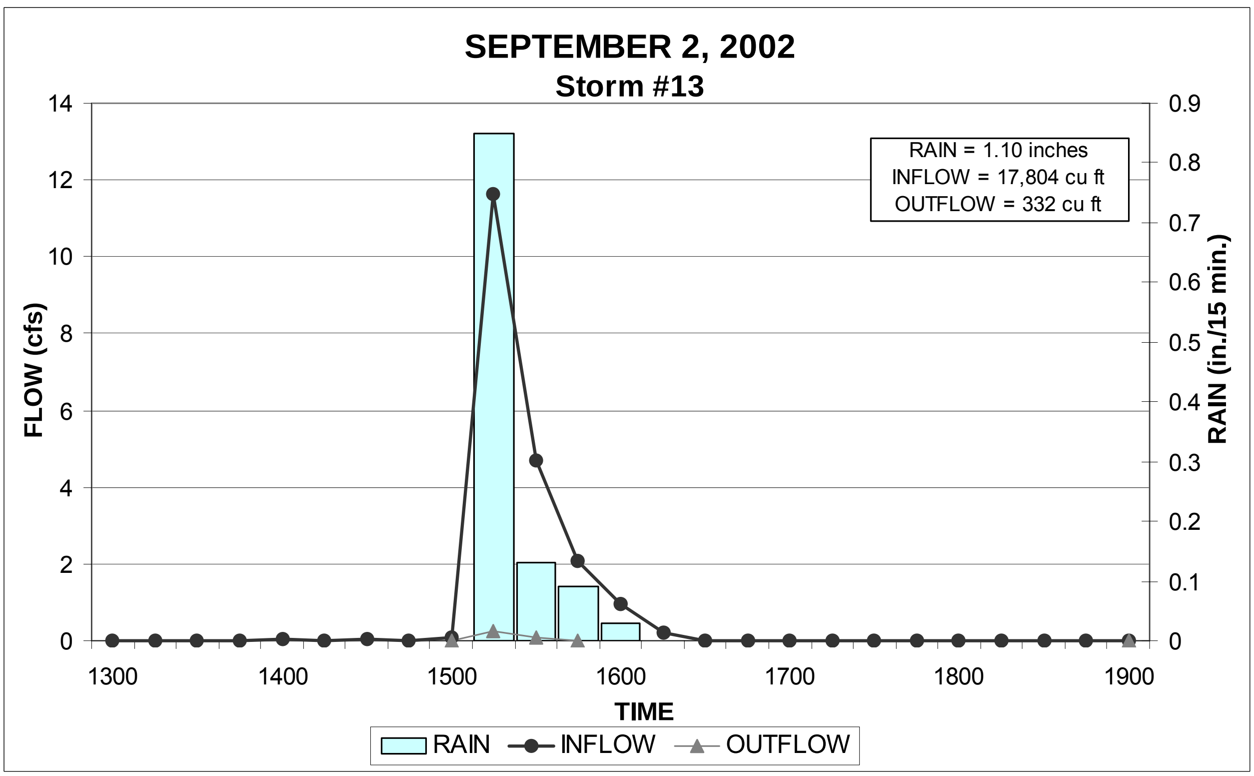


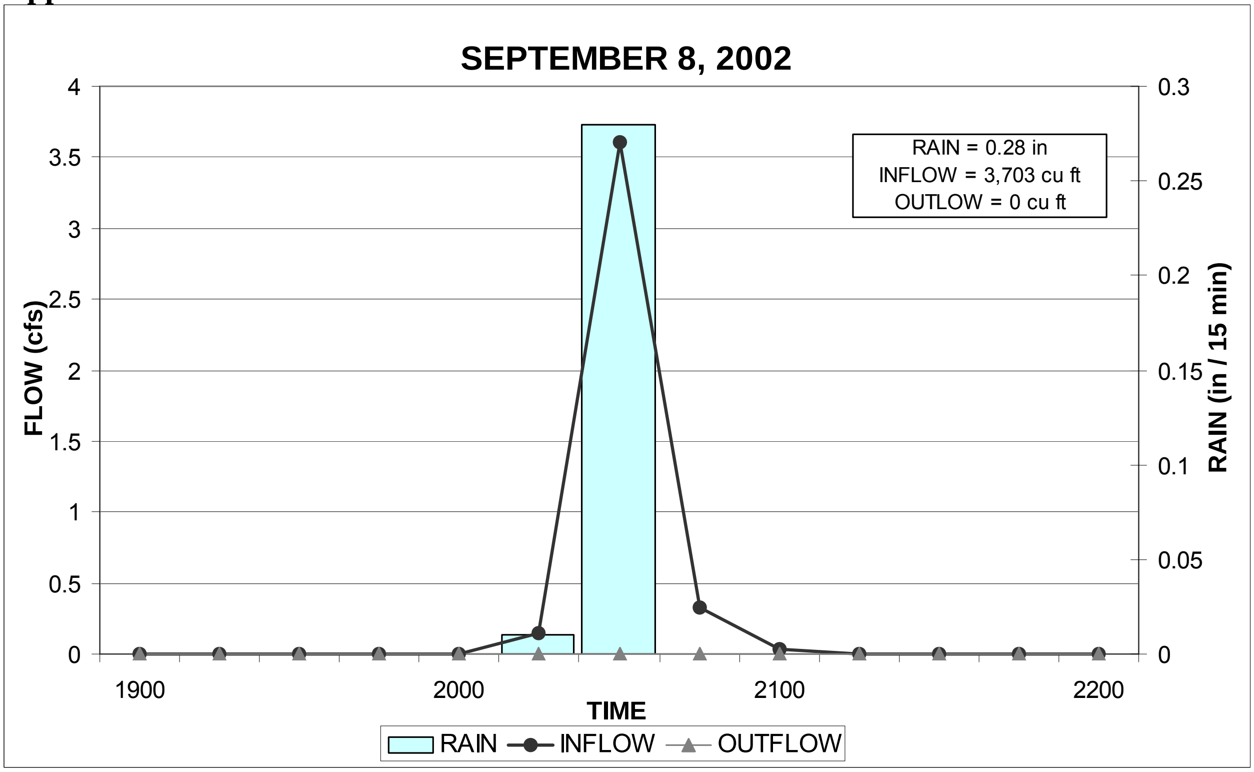


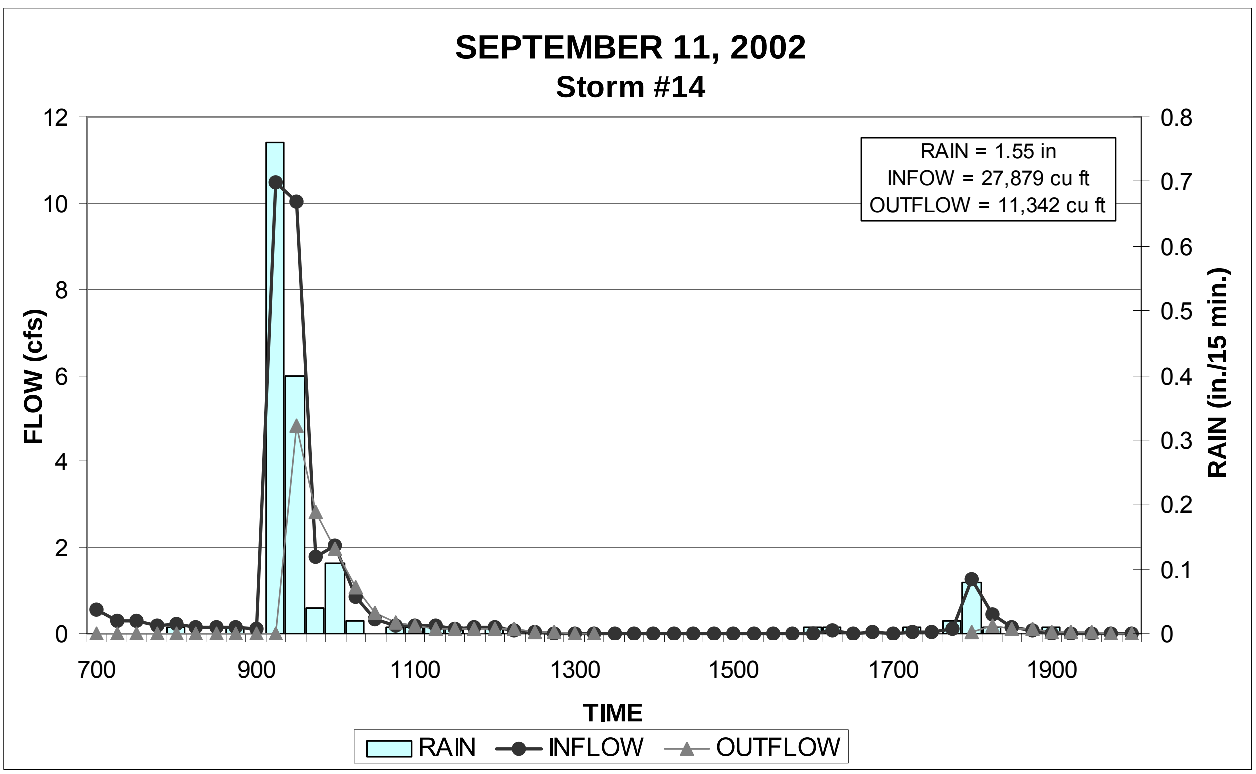
Appendix E-2. ***Continued***



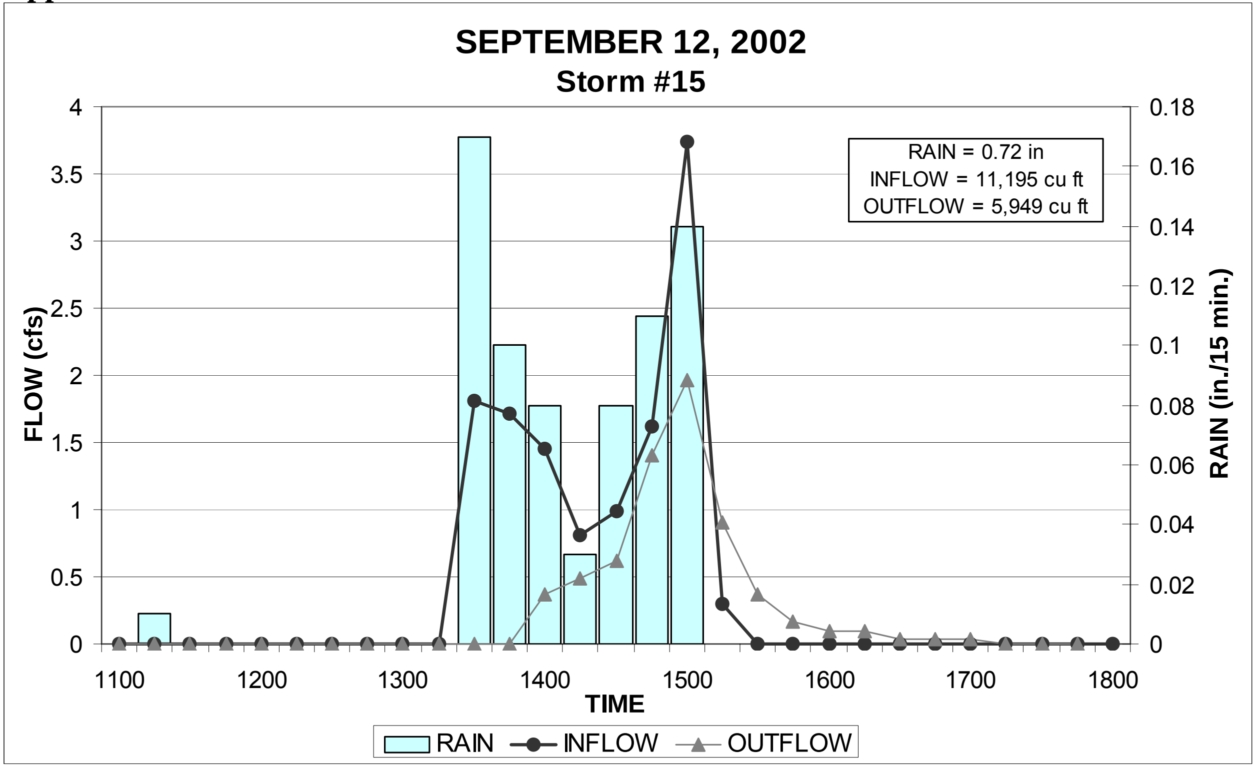


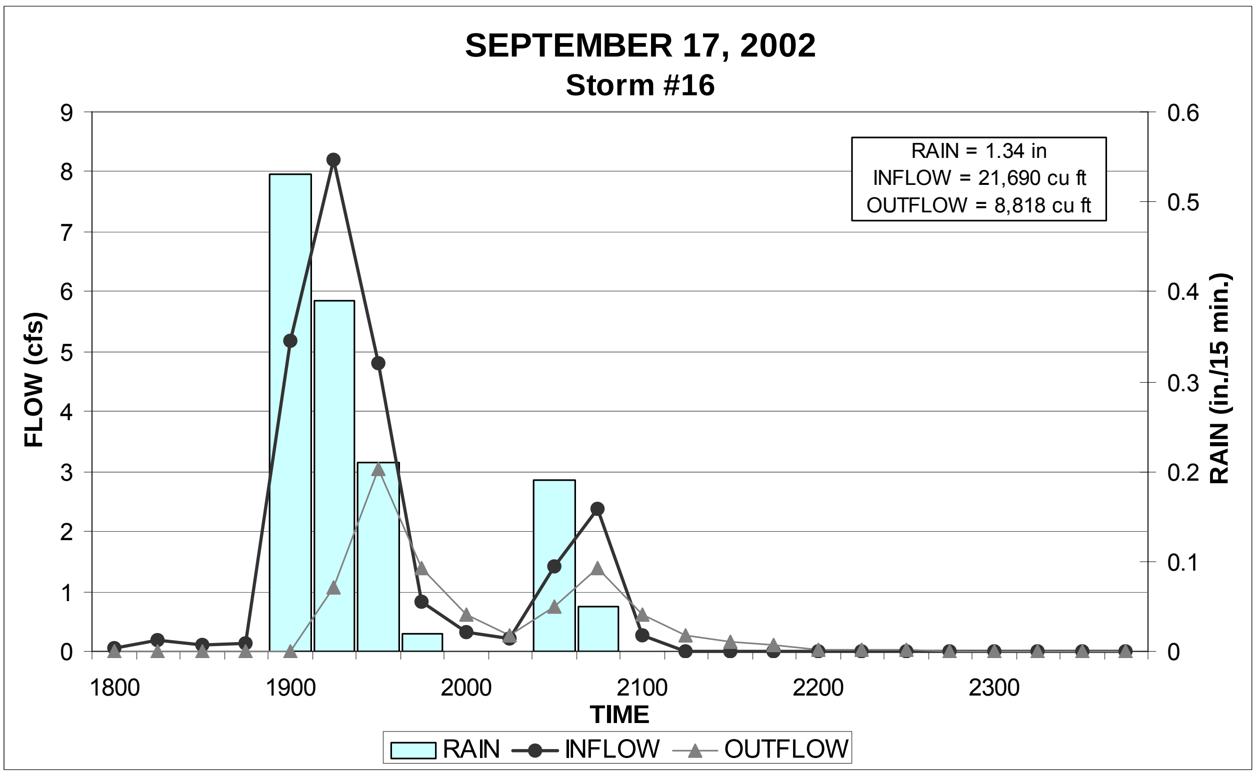
Appendix E-2. *Continued*



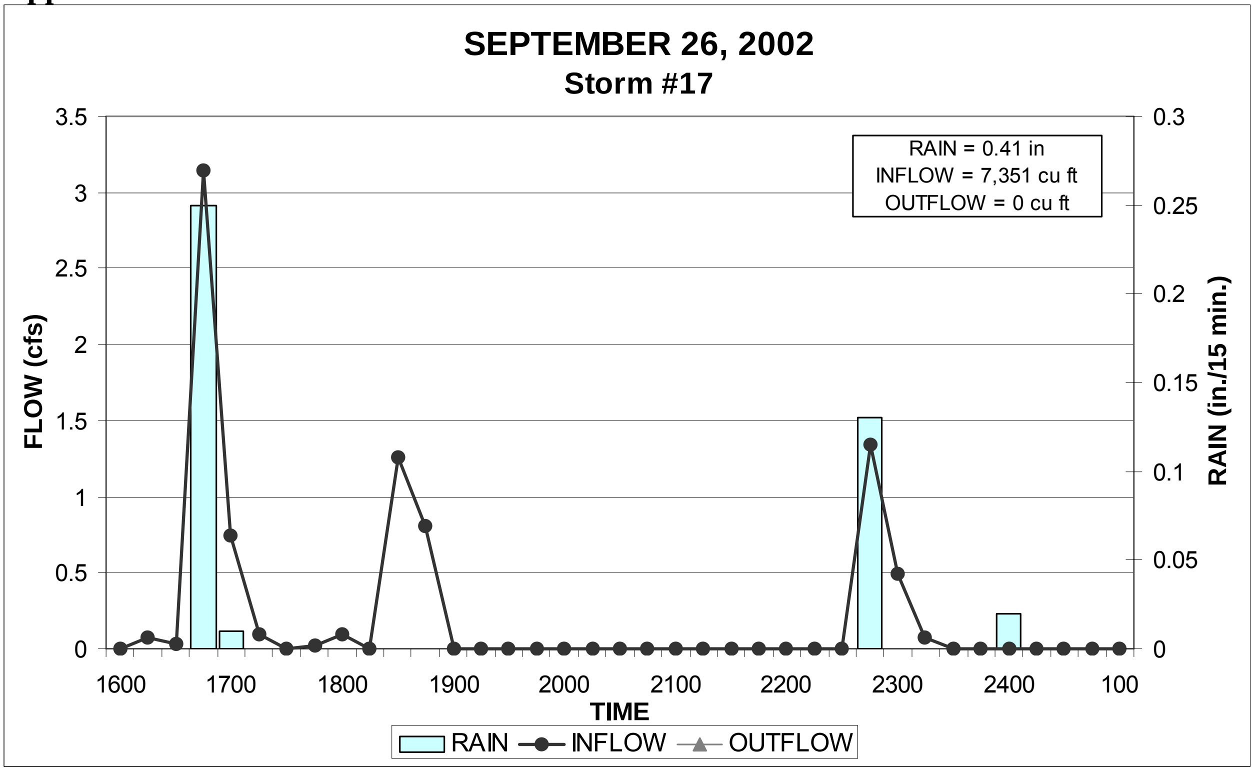


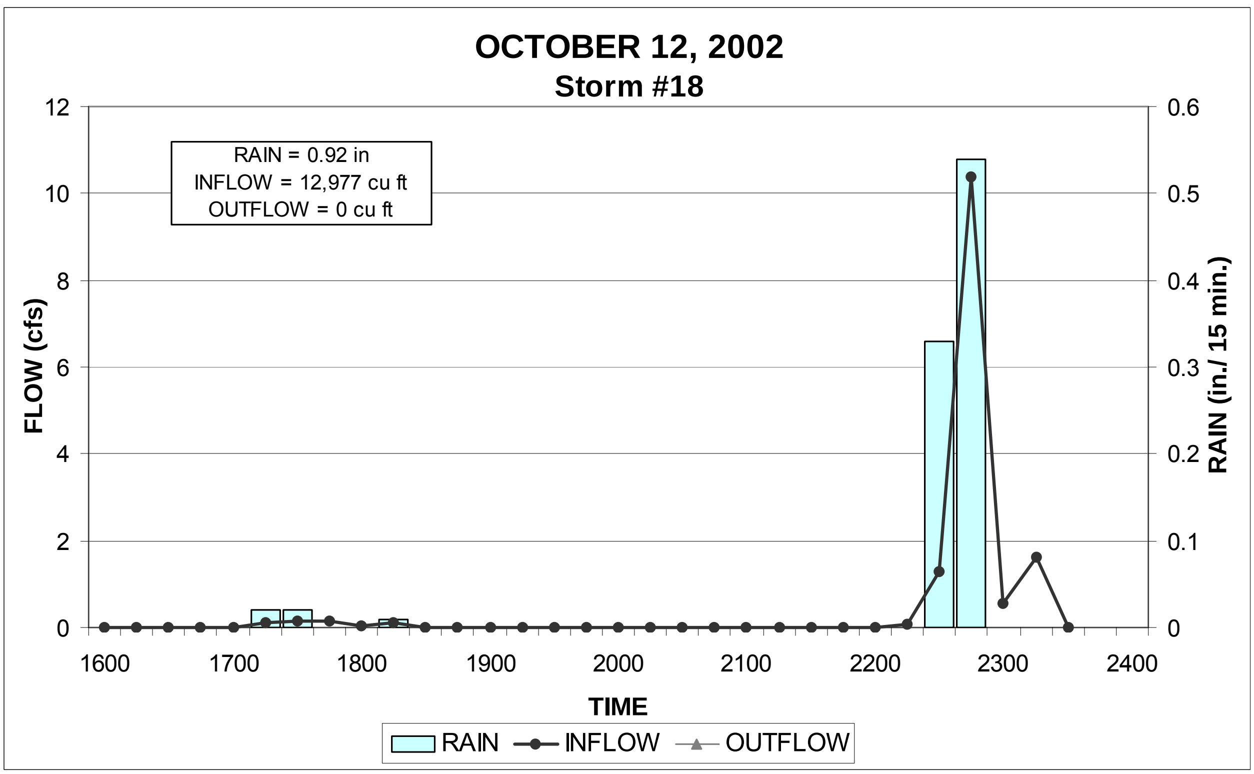
Appendix E-2. *Continued*



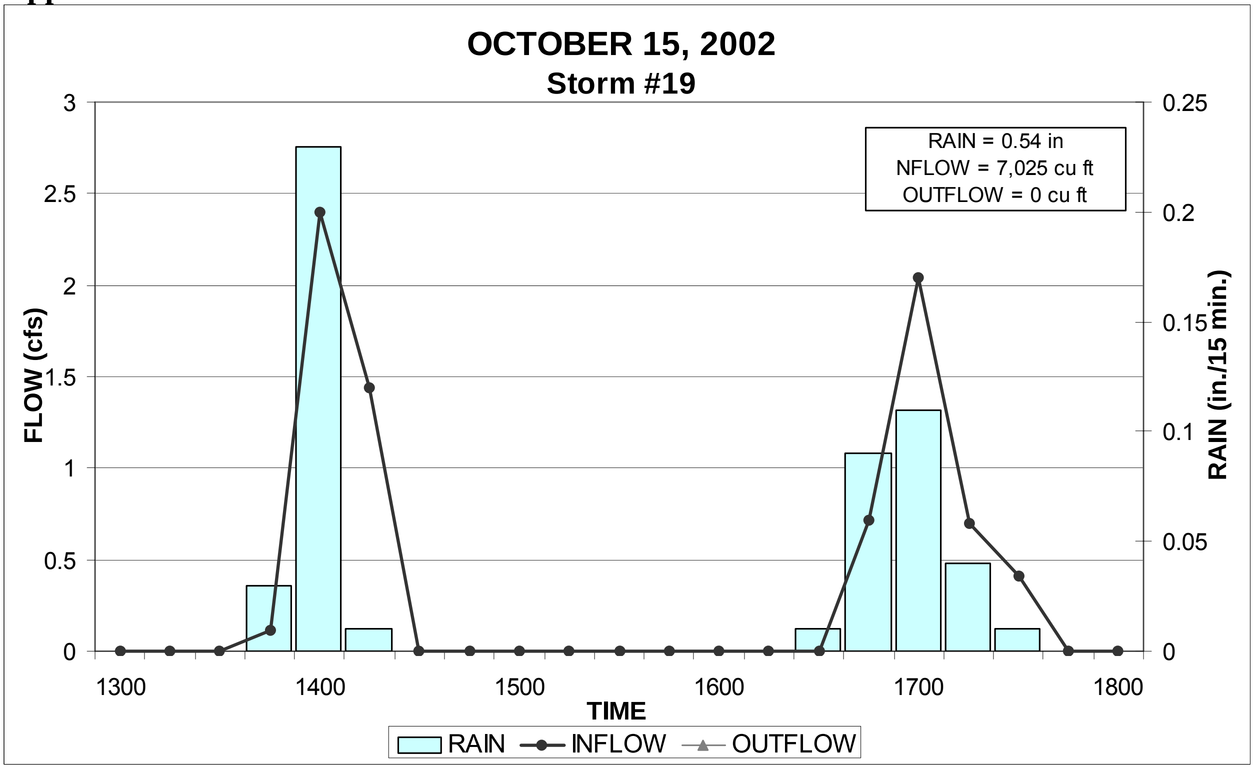


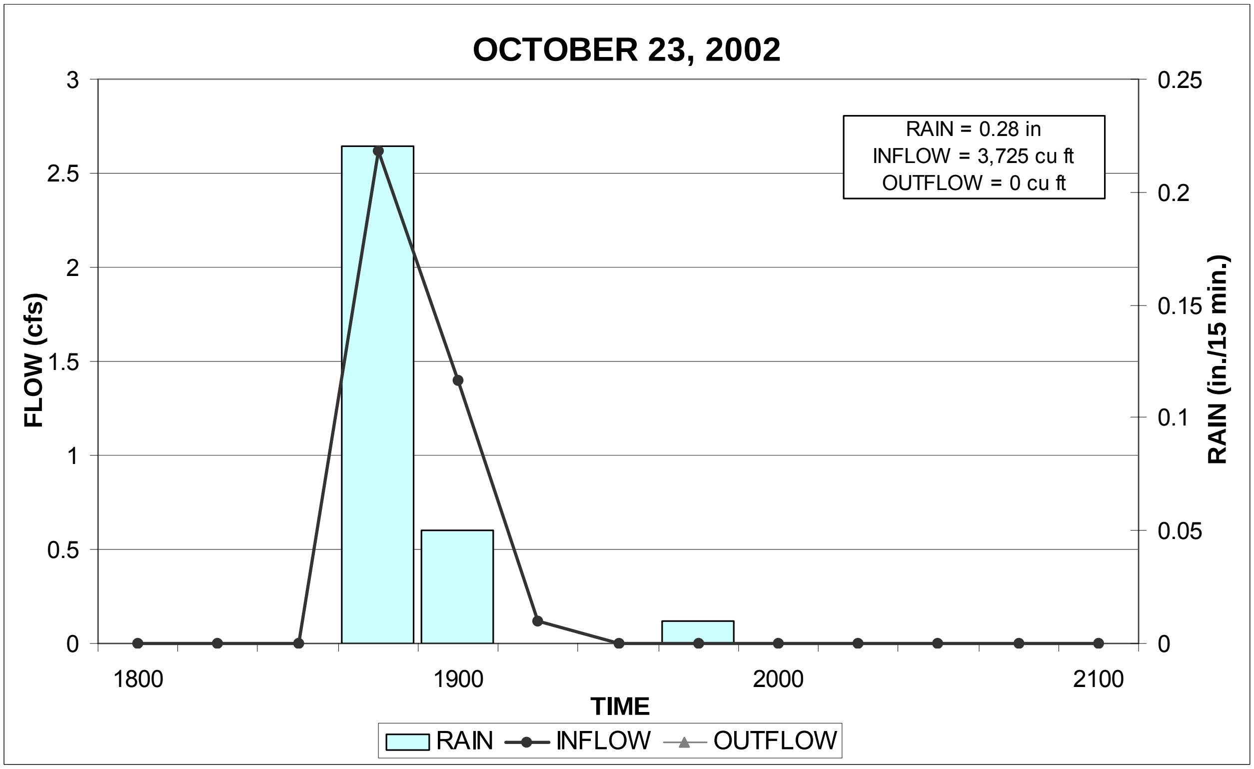
Appendix E-2. ***Continued***



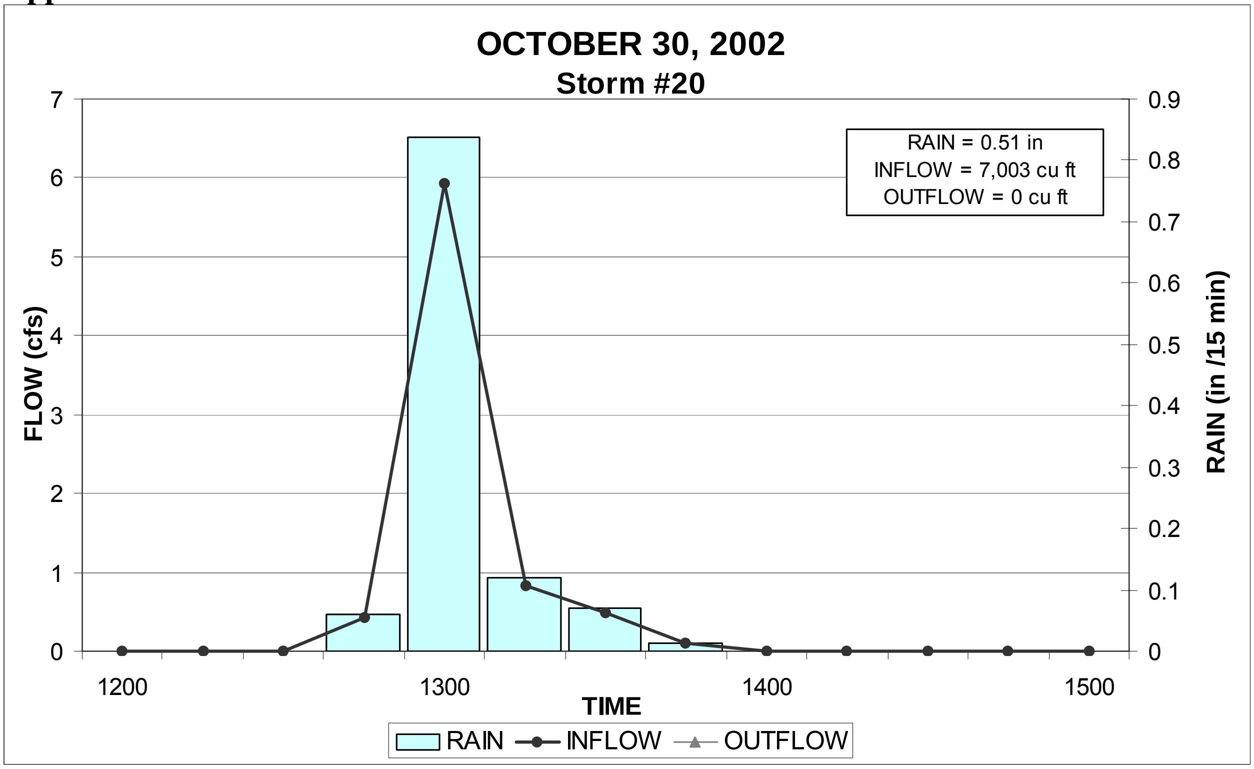


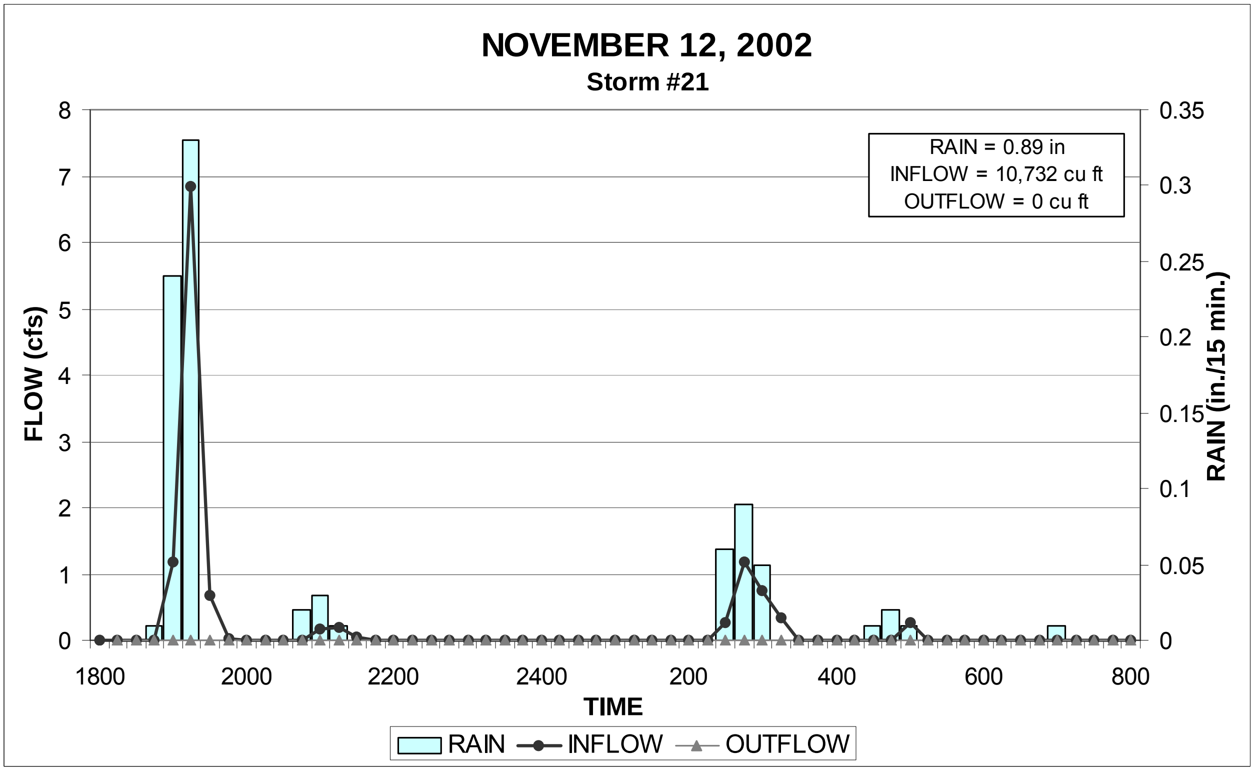
Appendix E-2. ***Continued***



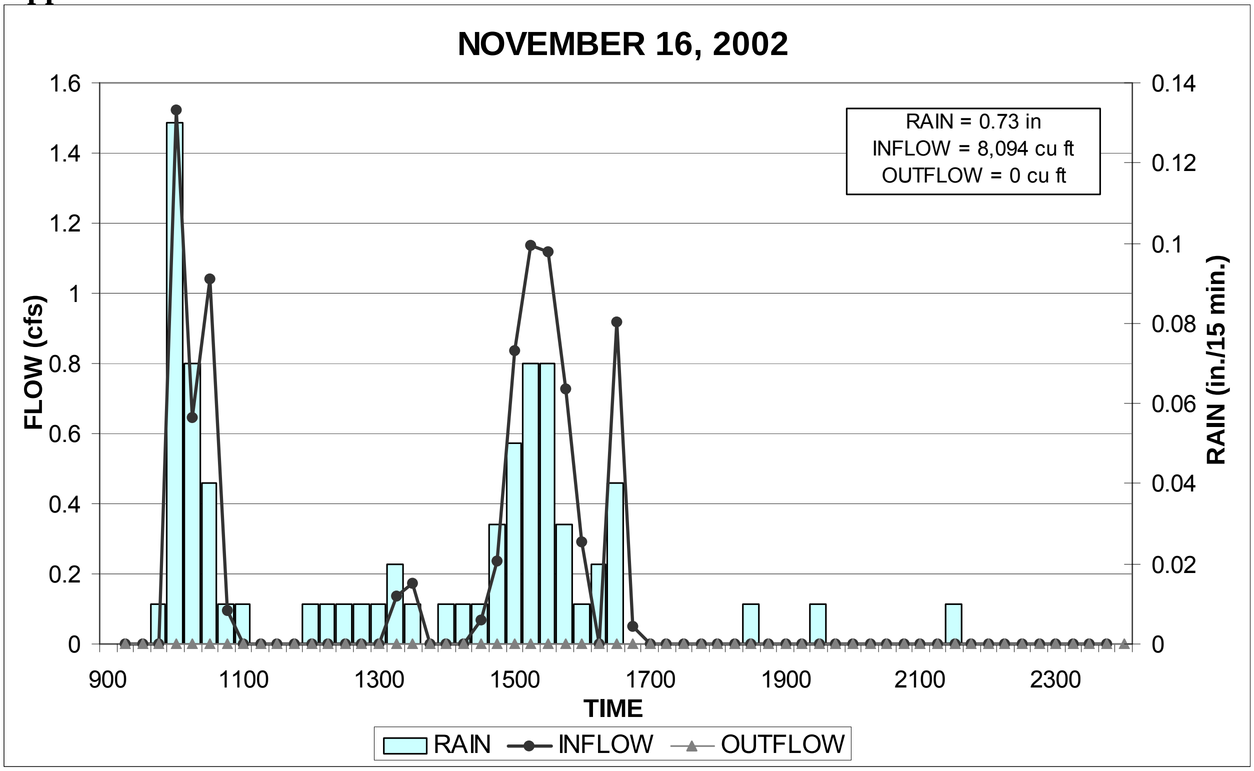


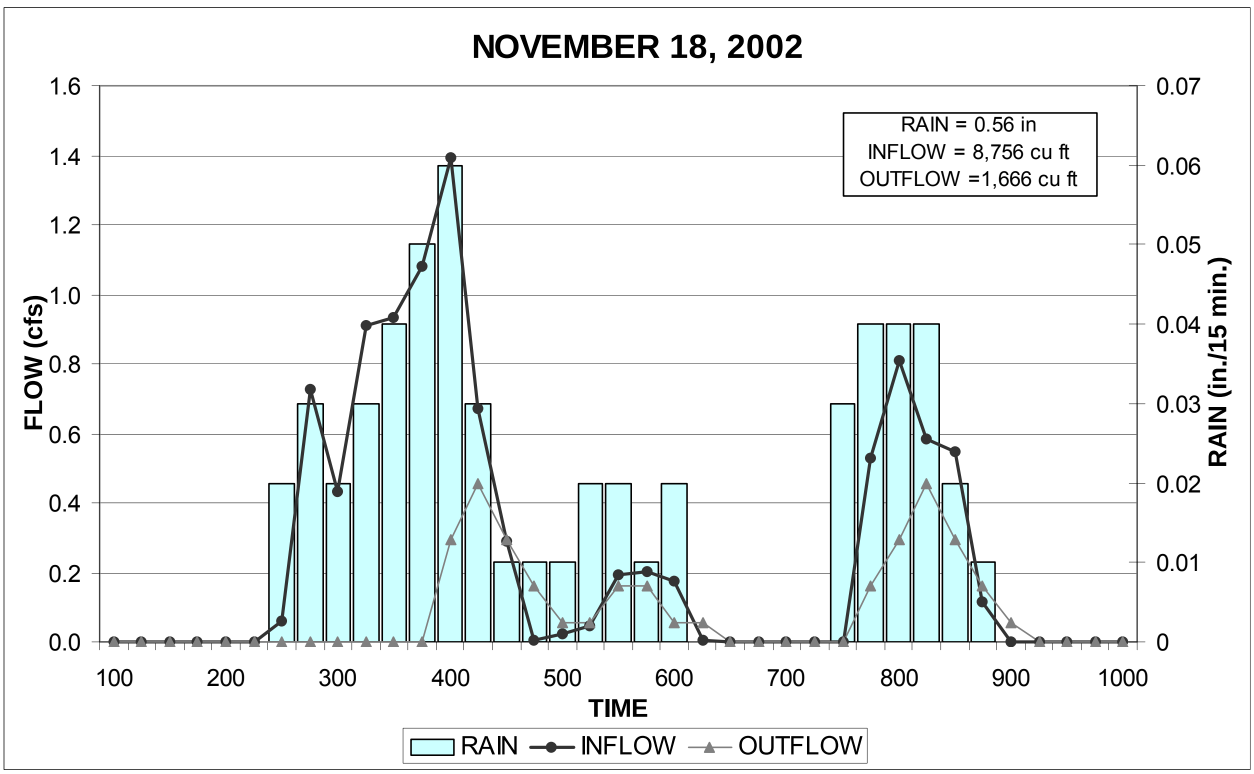
Appendix E-2. *Continued*



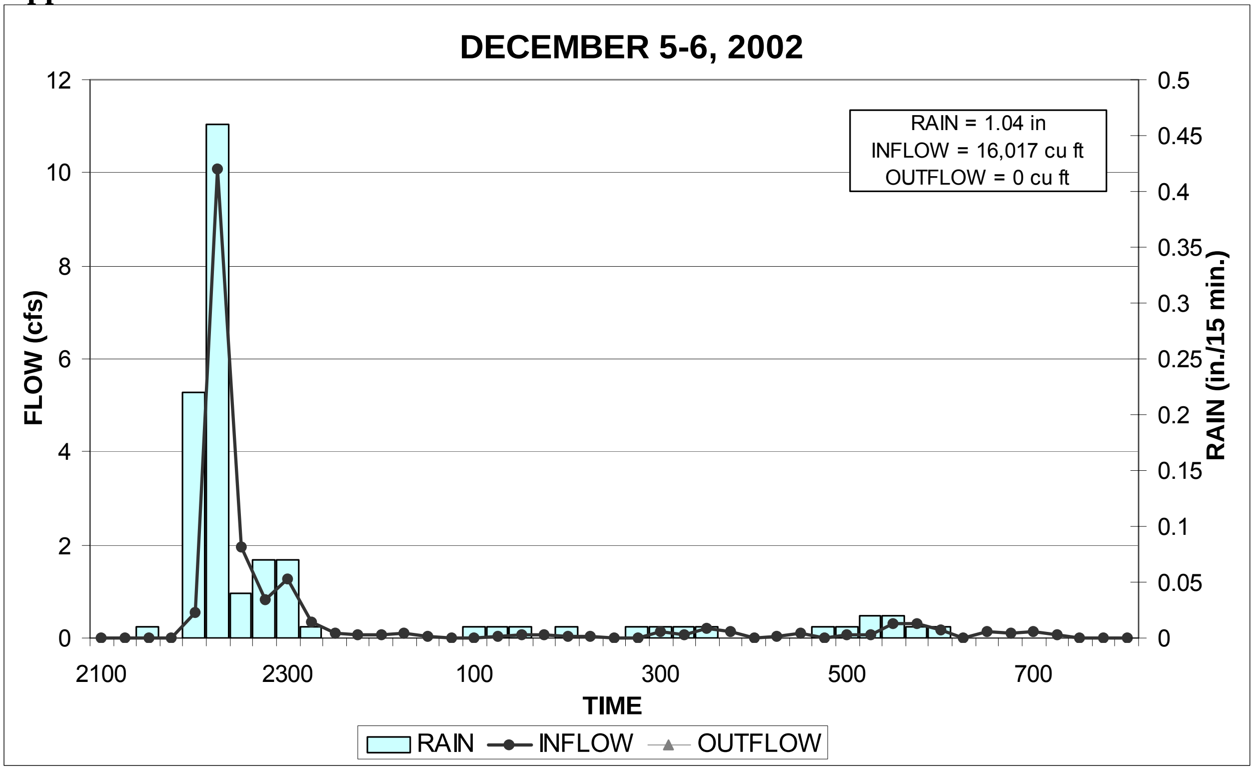


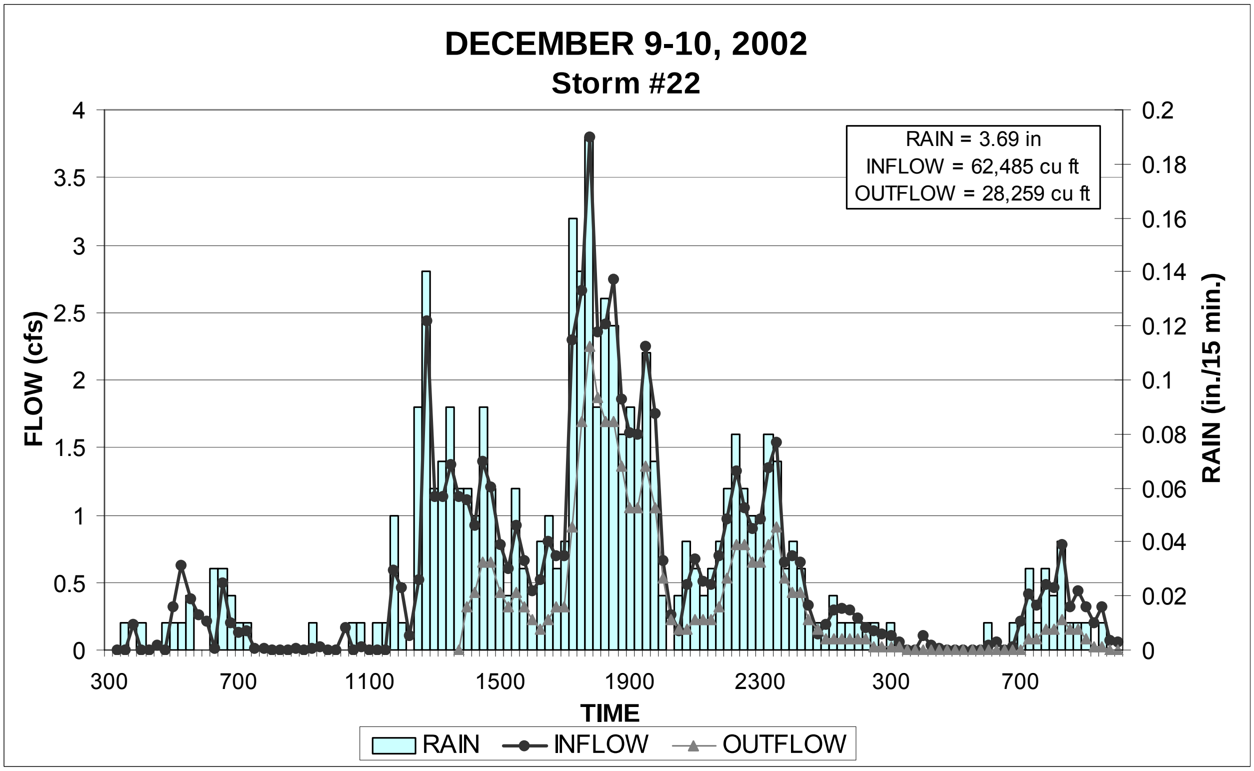
Appendix E-2. *Continued*





Appendix E-2. ***Continued***





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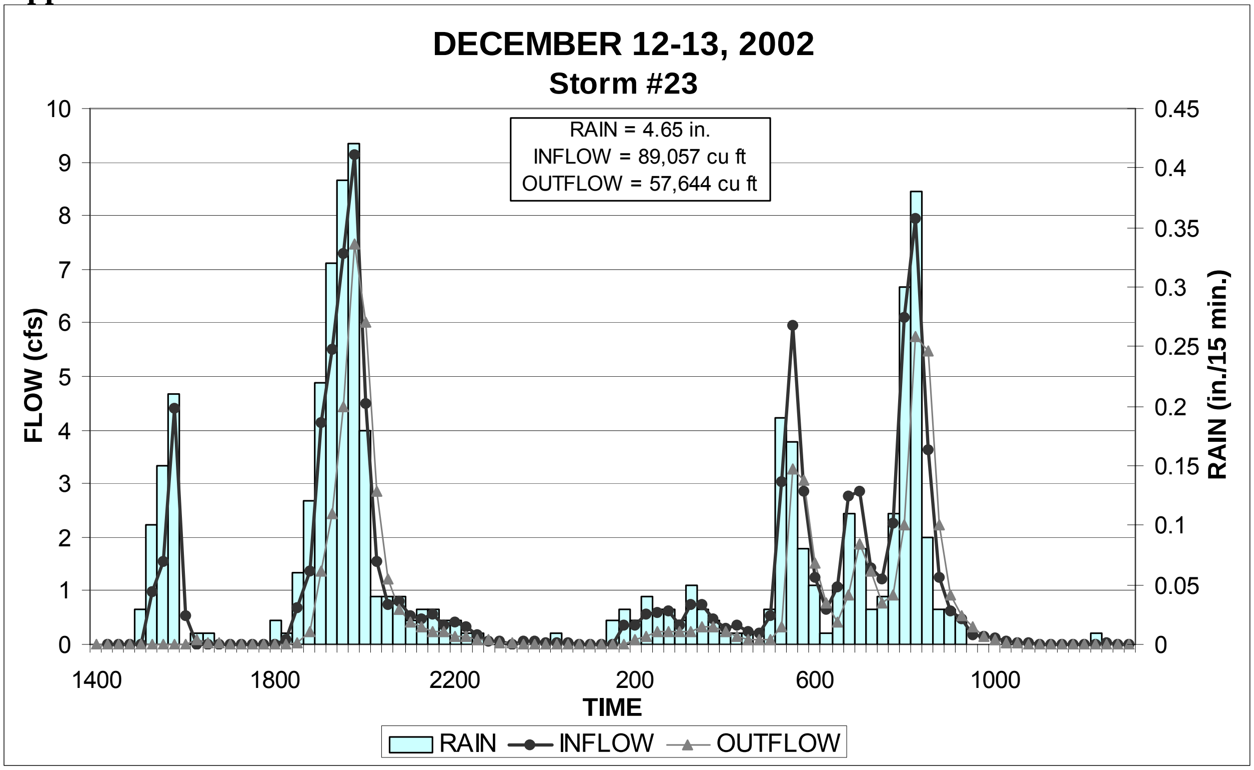
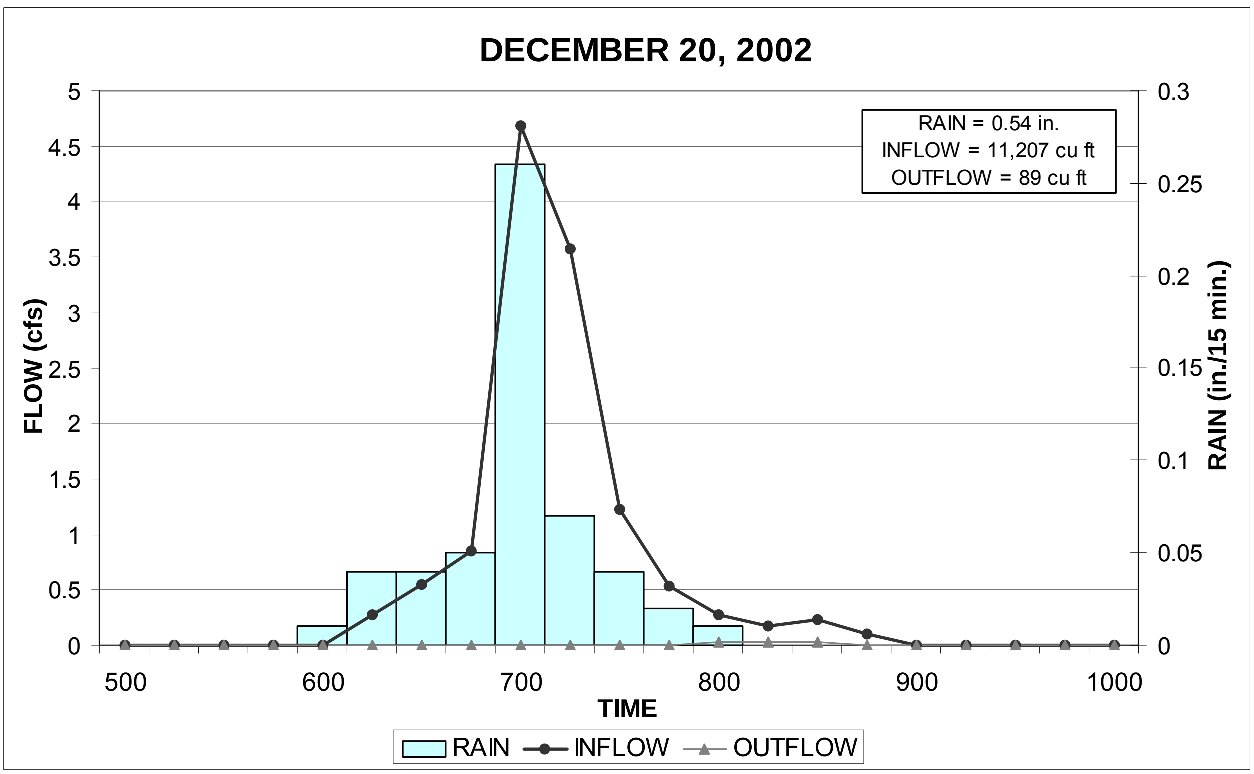
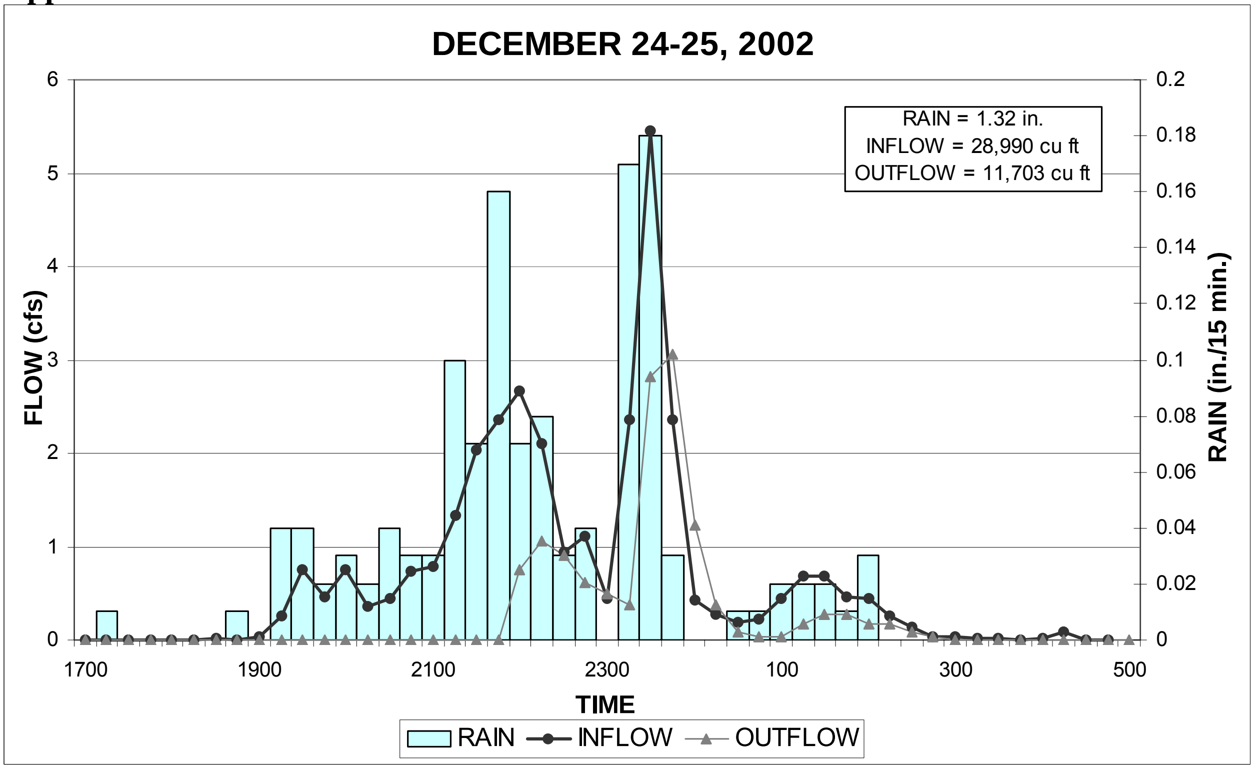
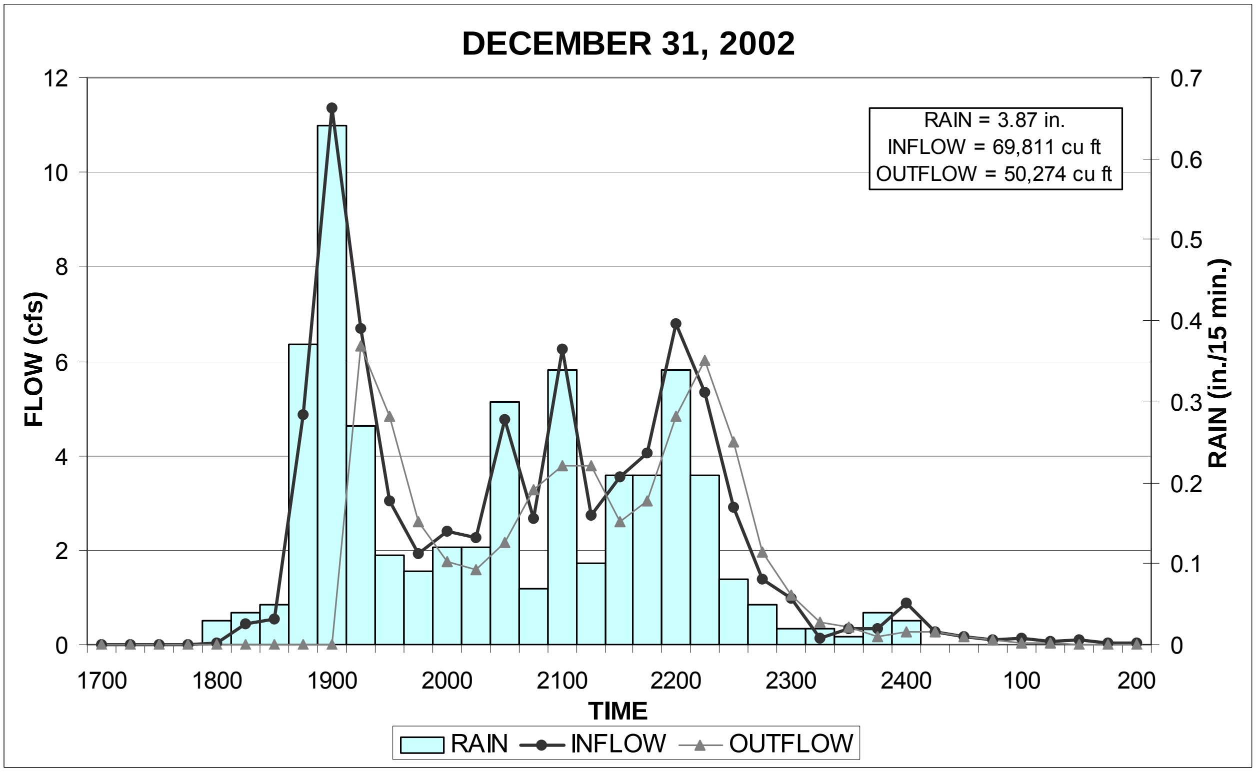


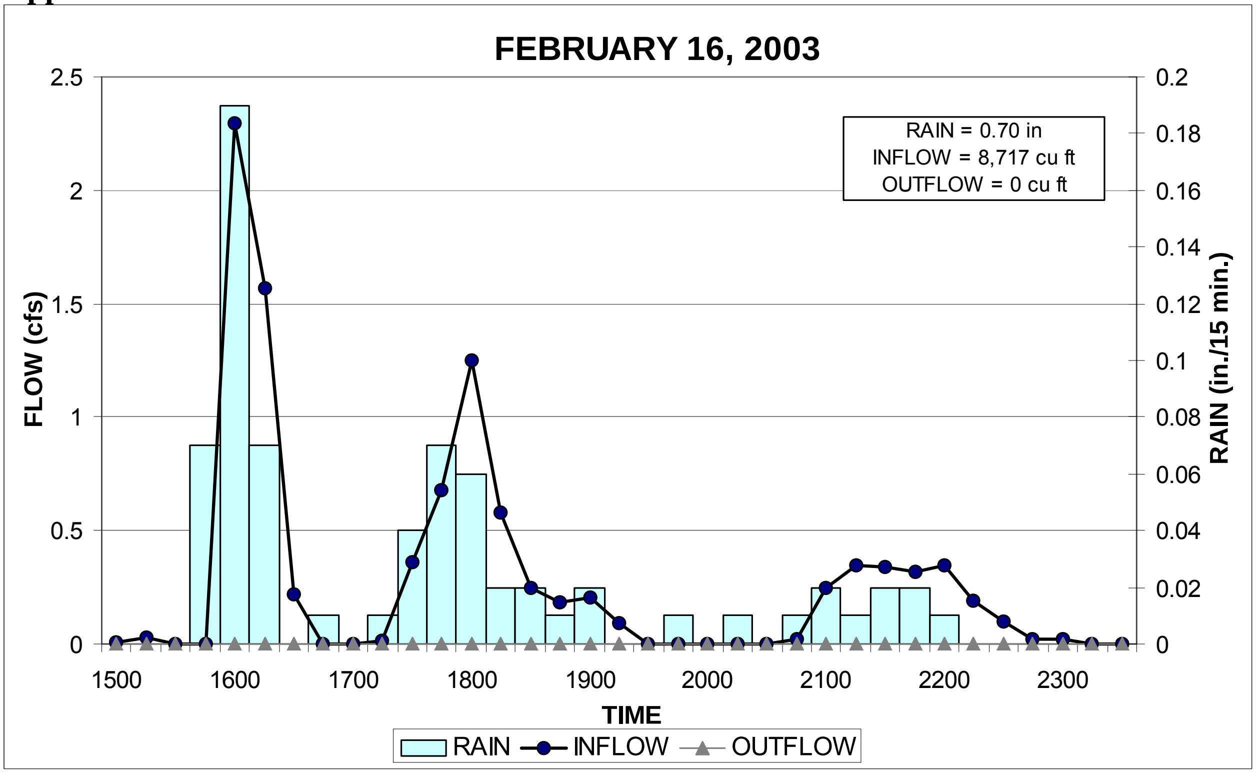


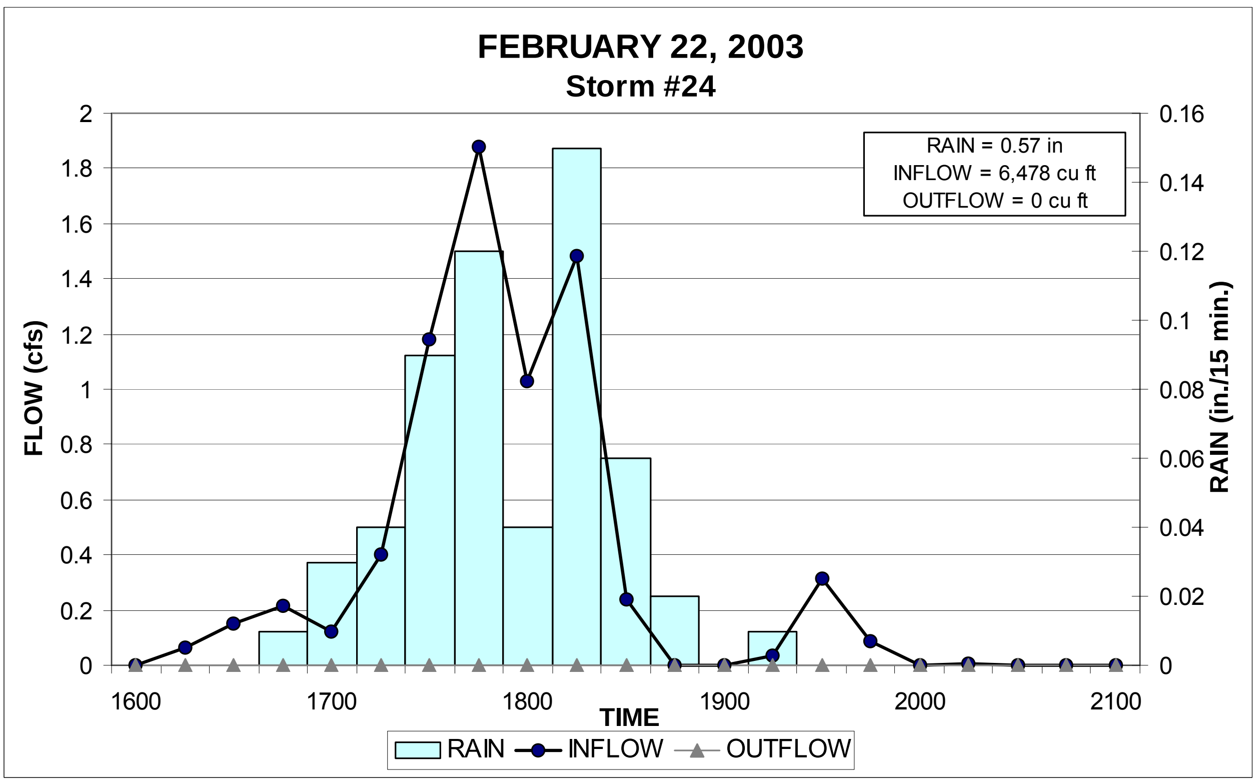
Appendix E-2. *Continued*





Appendix E-2. *Continued*





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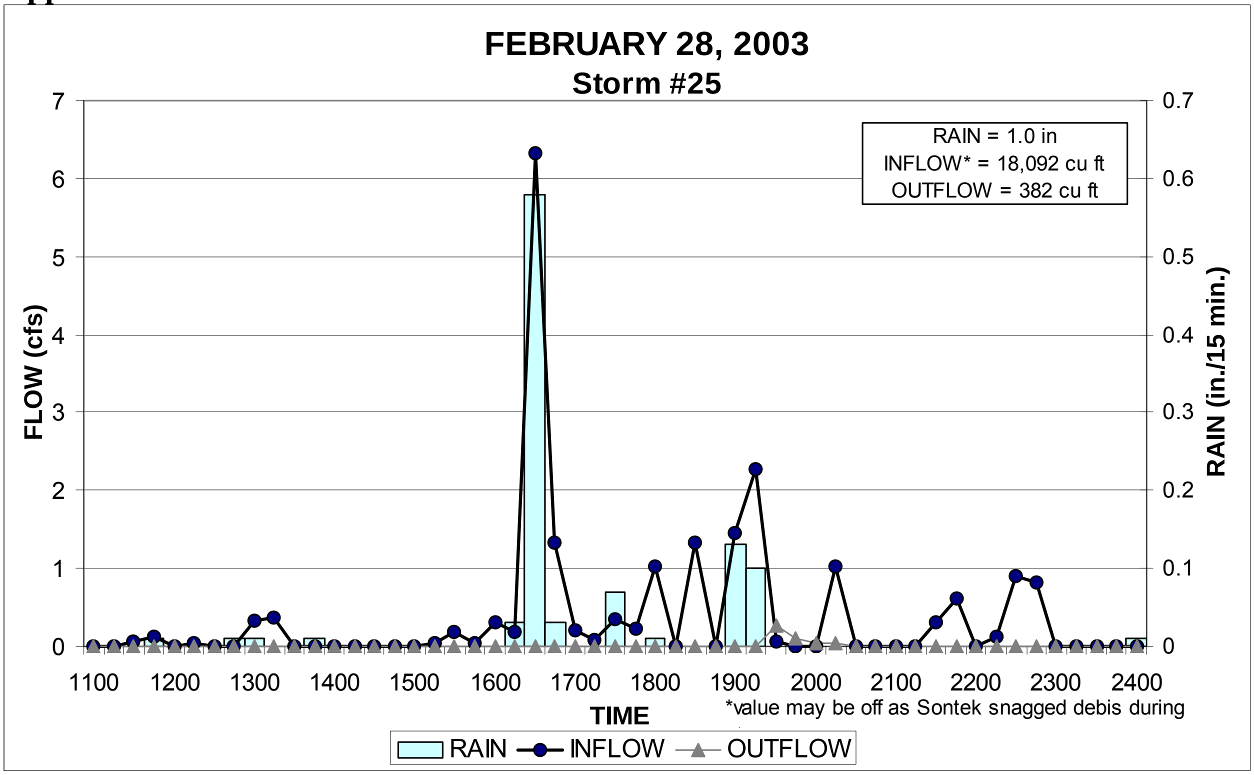

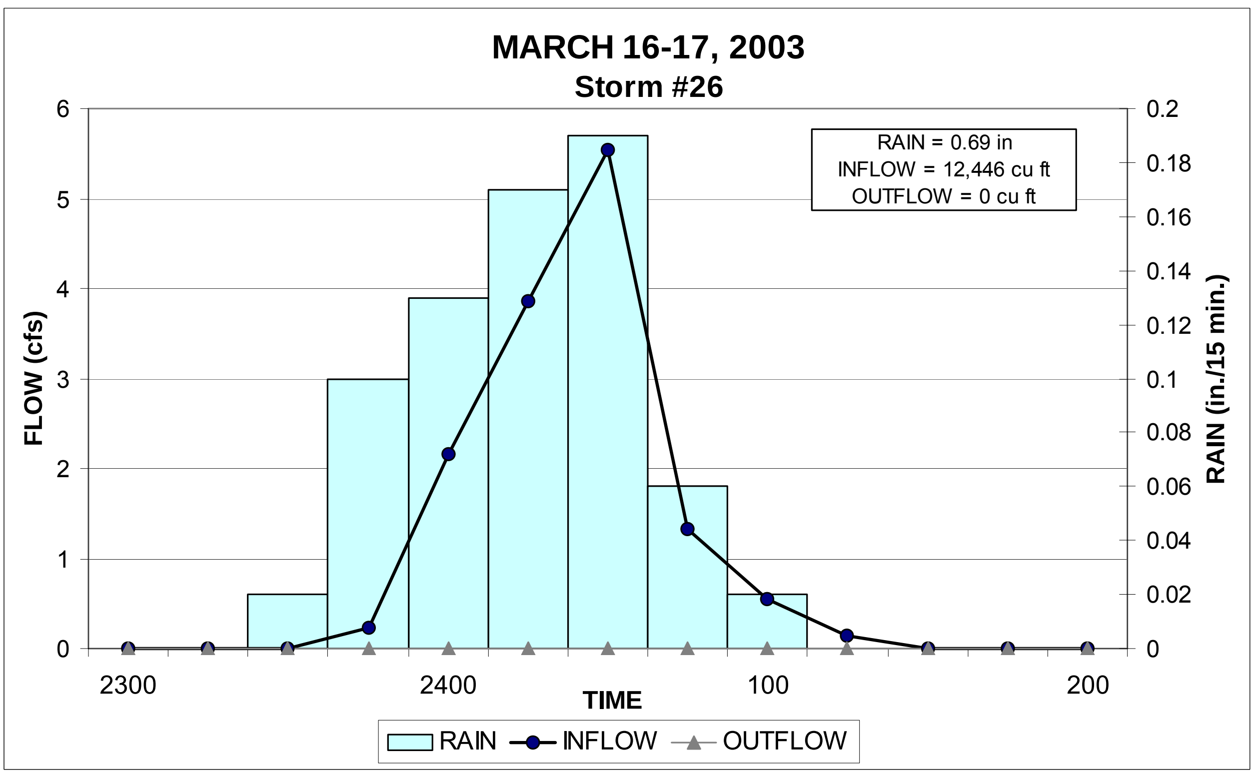

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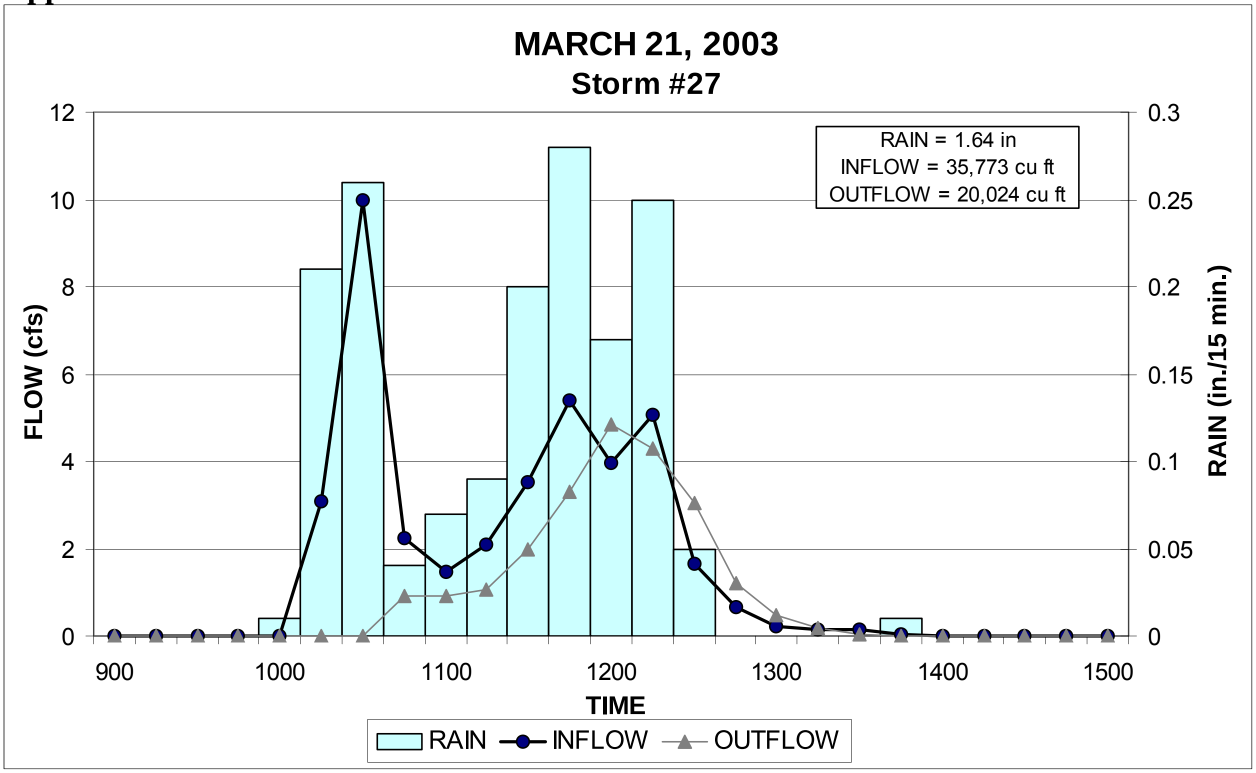

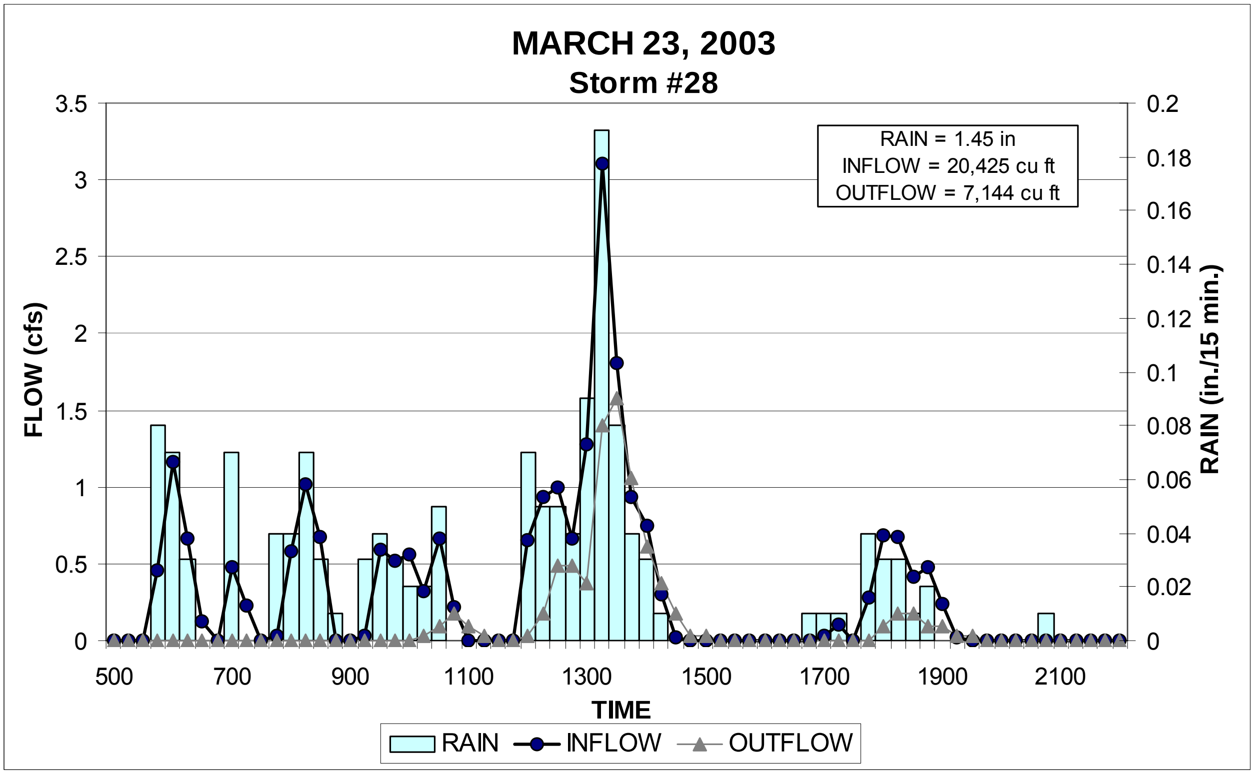

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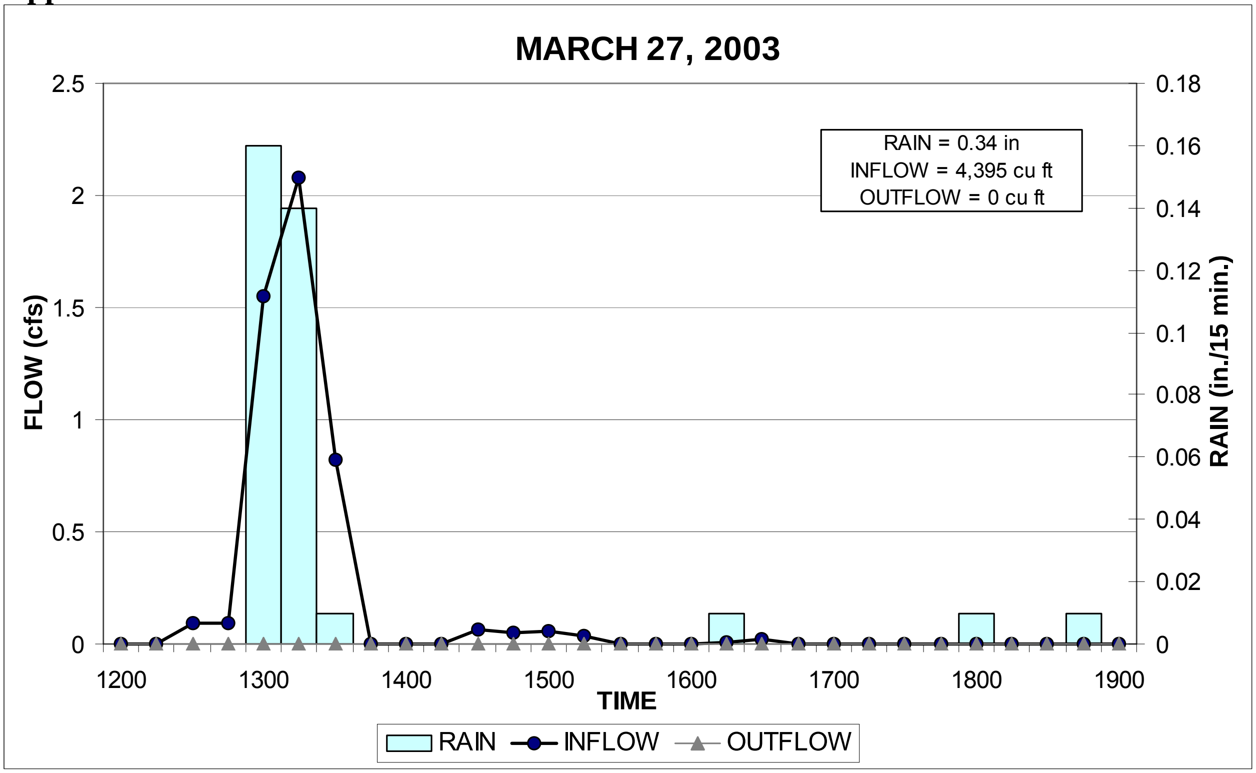

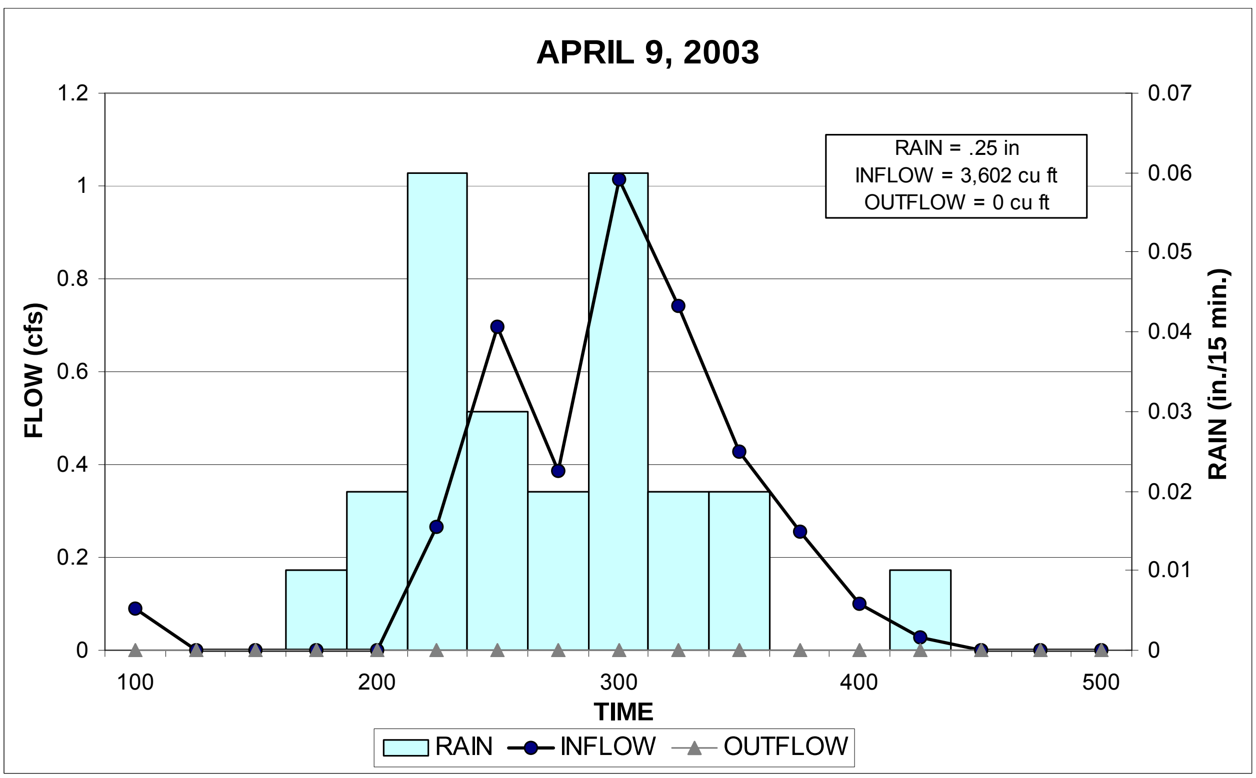

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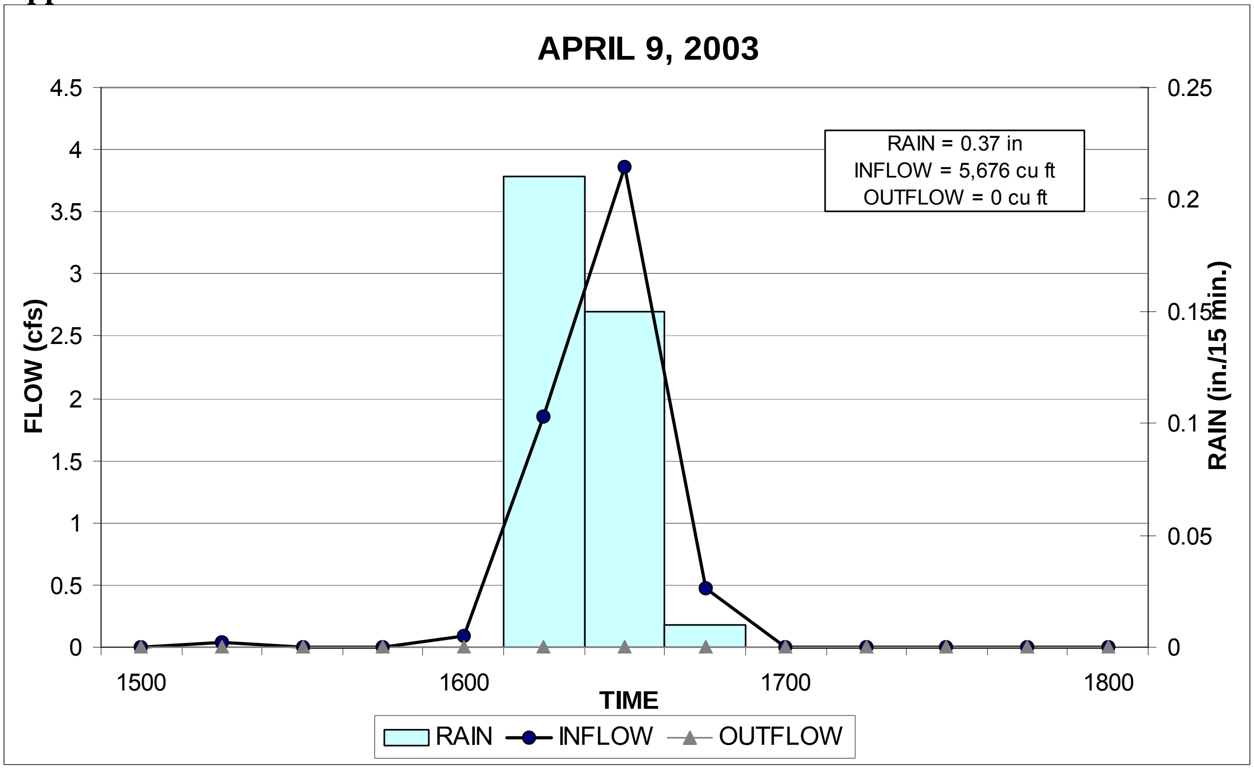

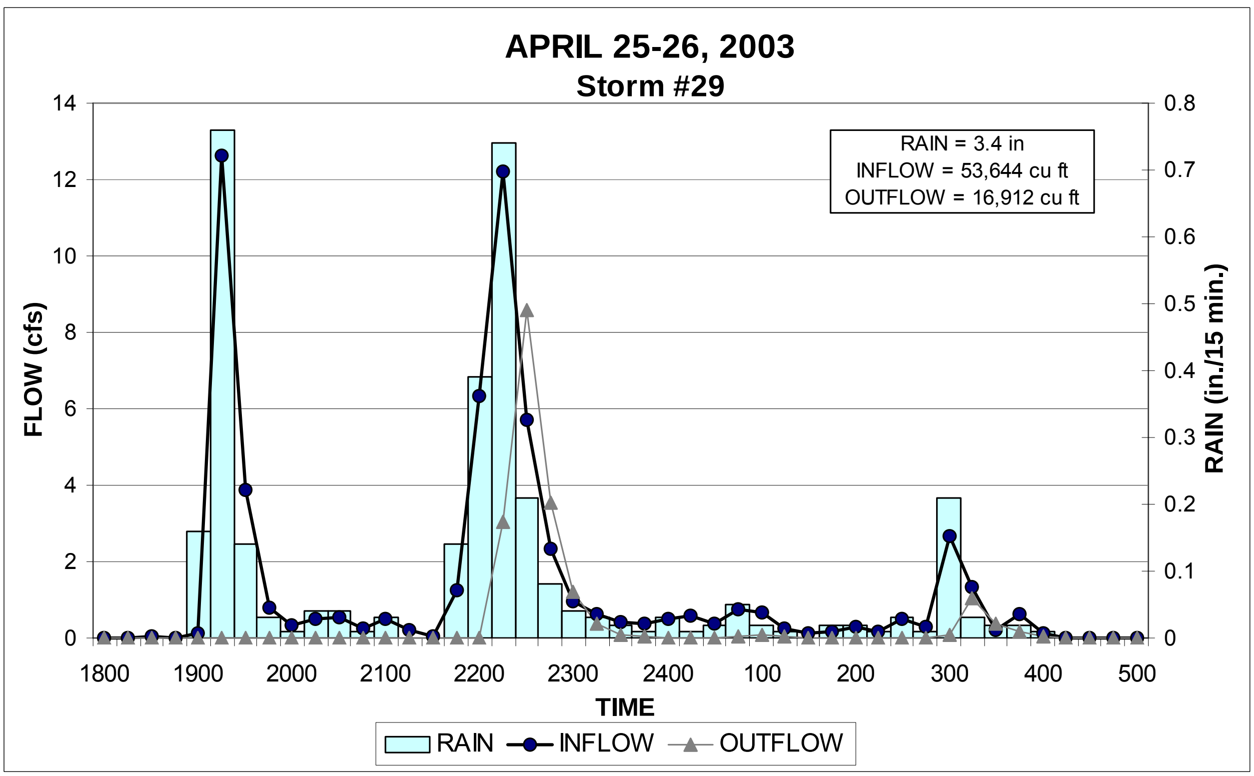

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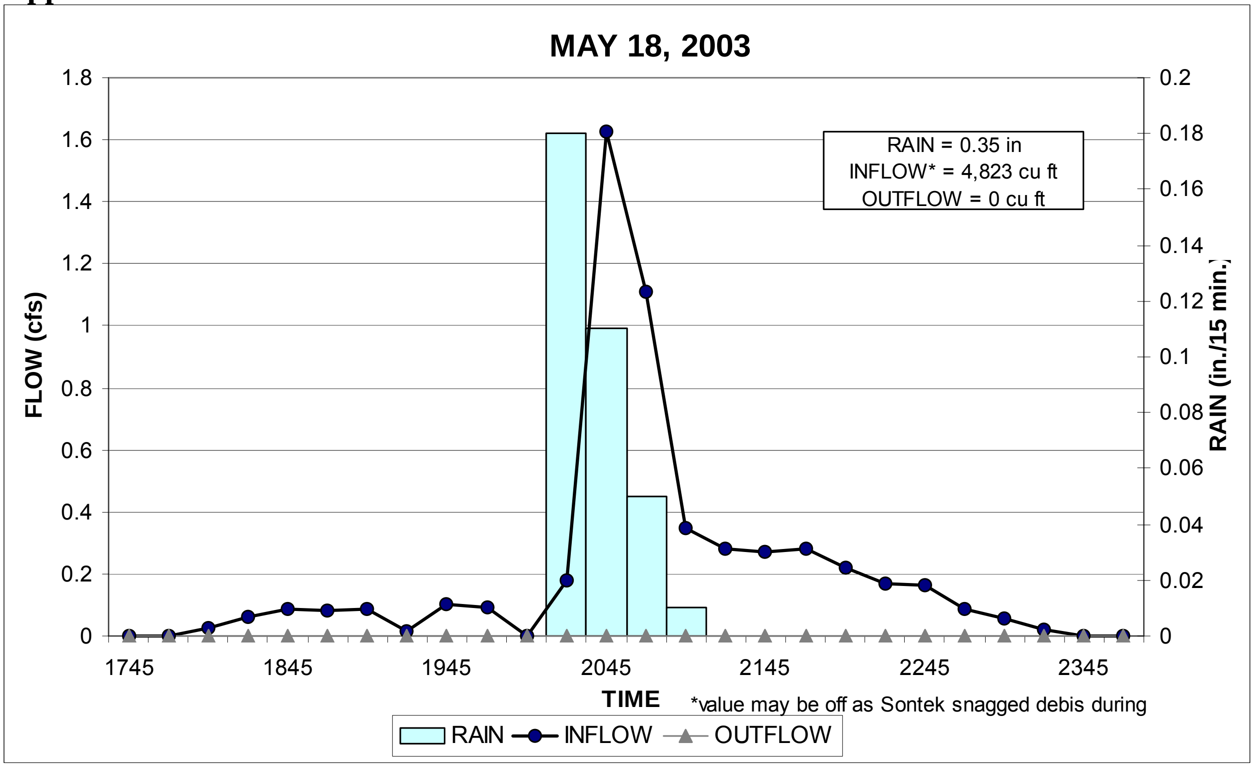

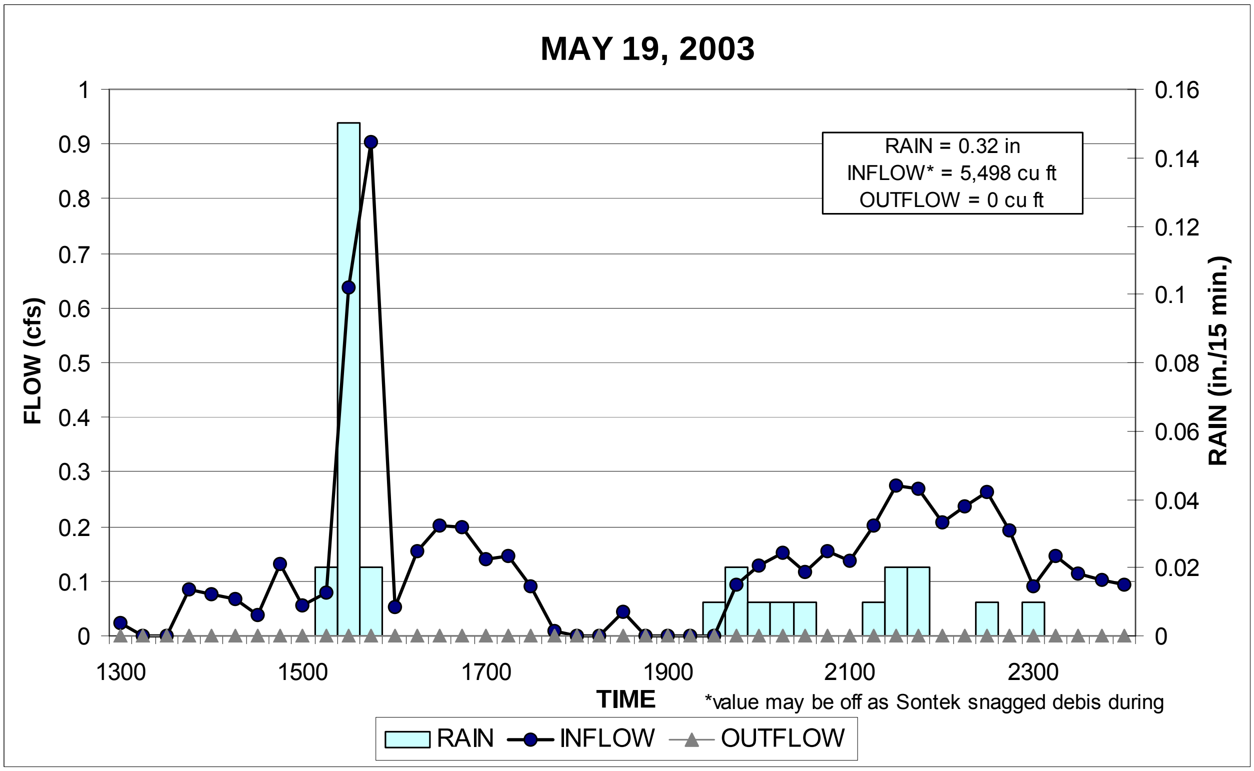

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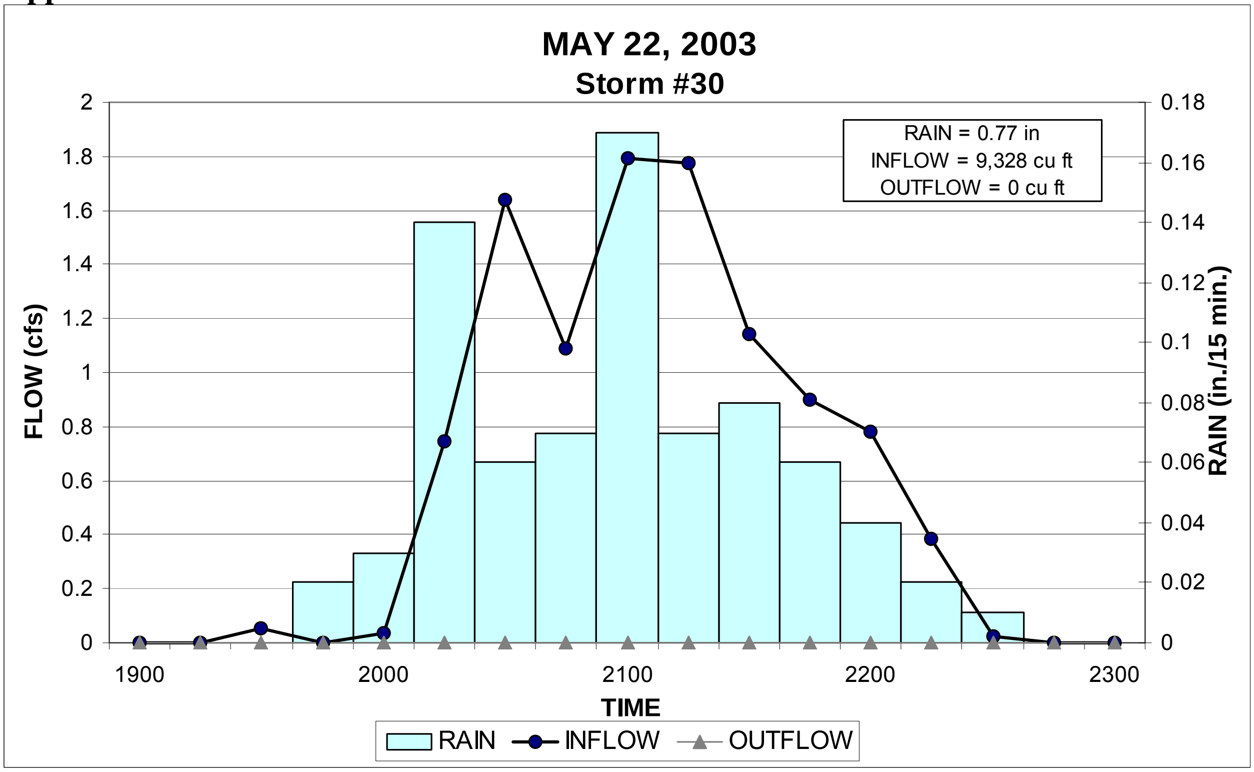

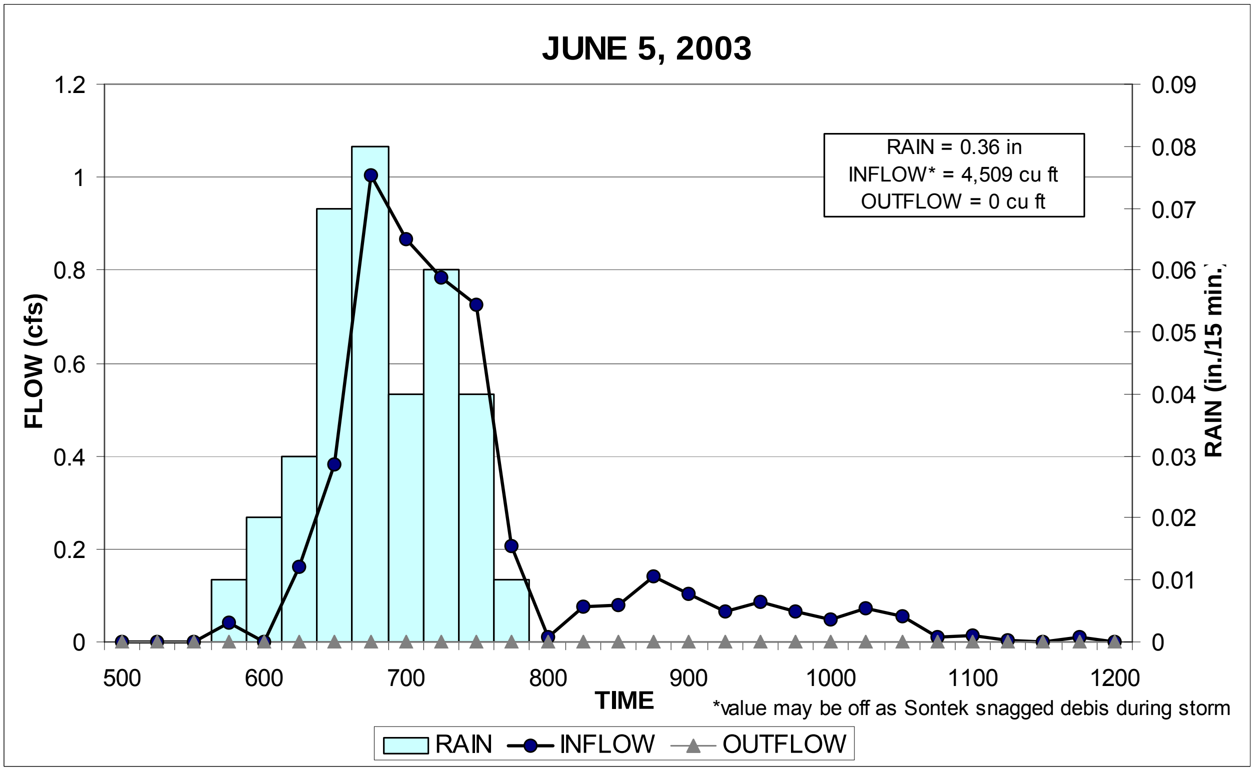

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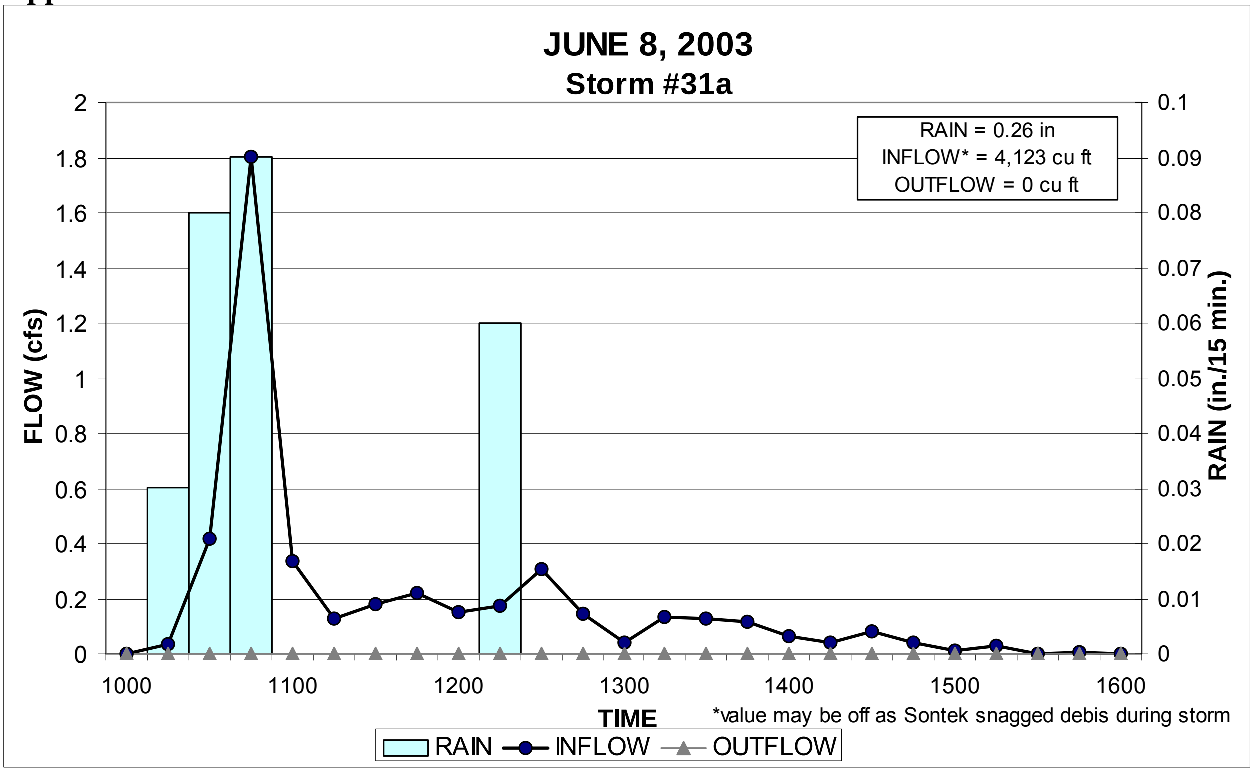

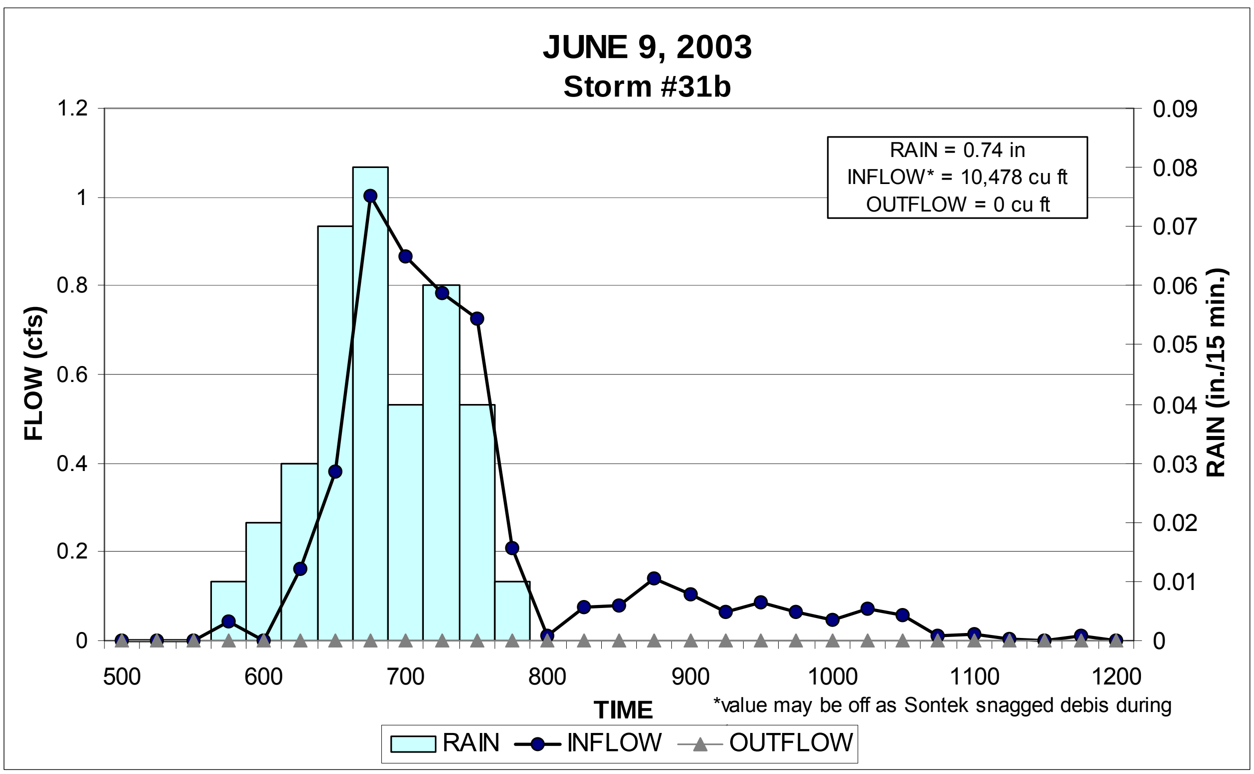

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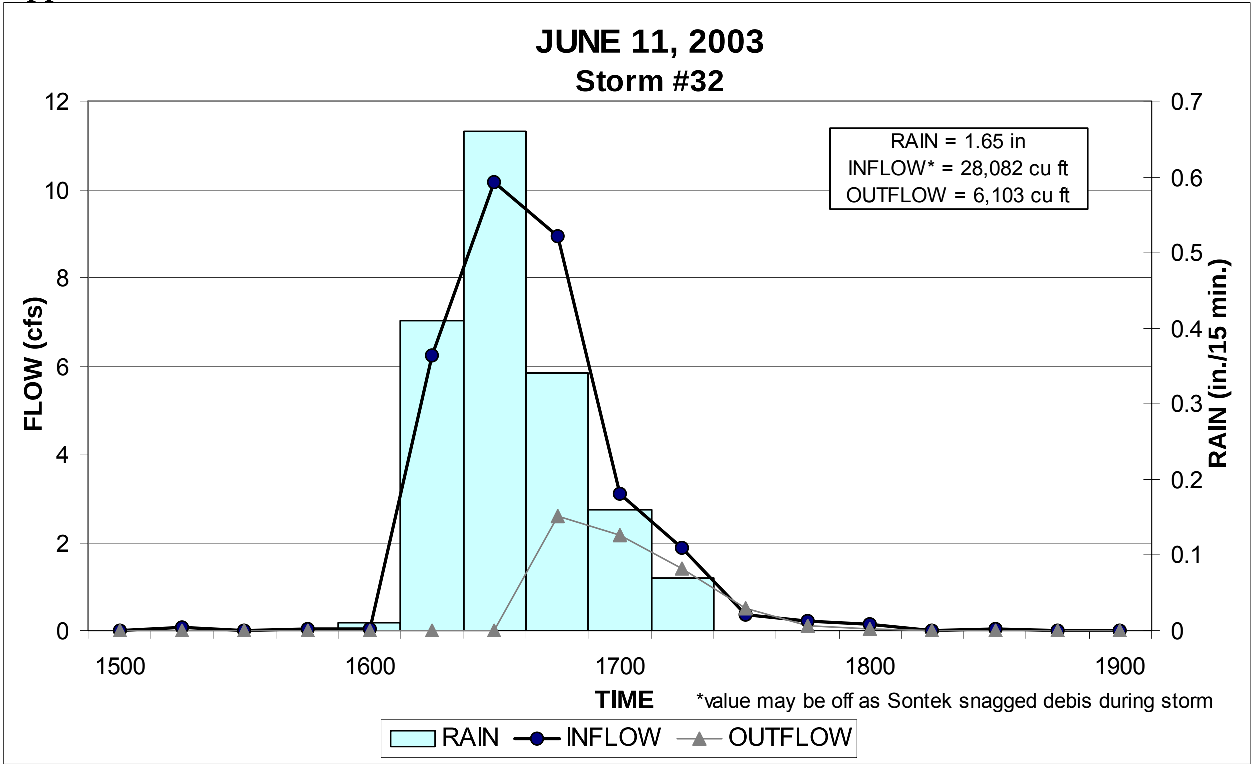

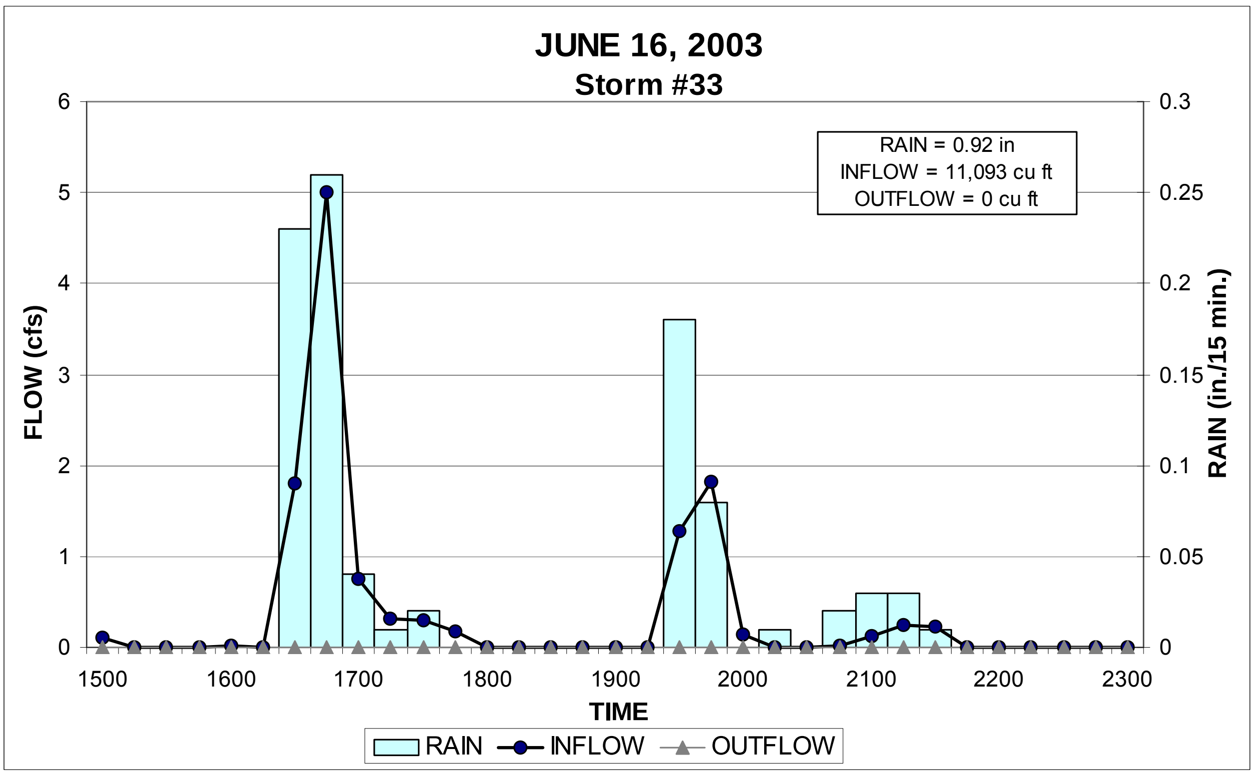

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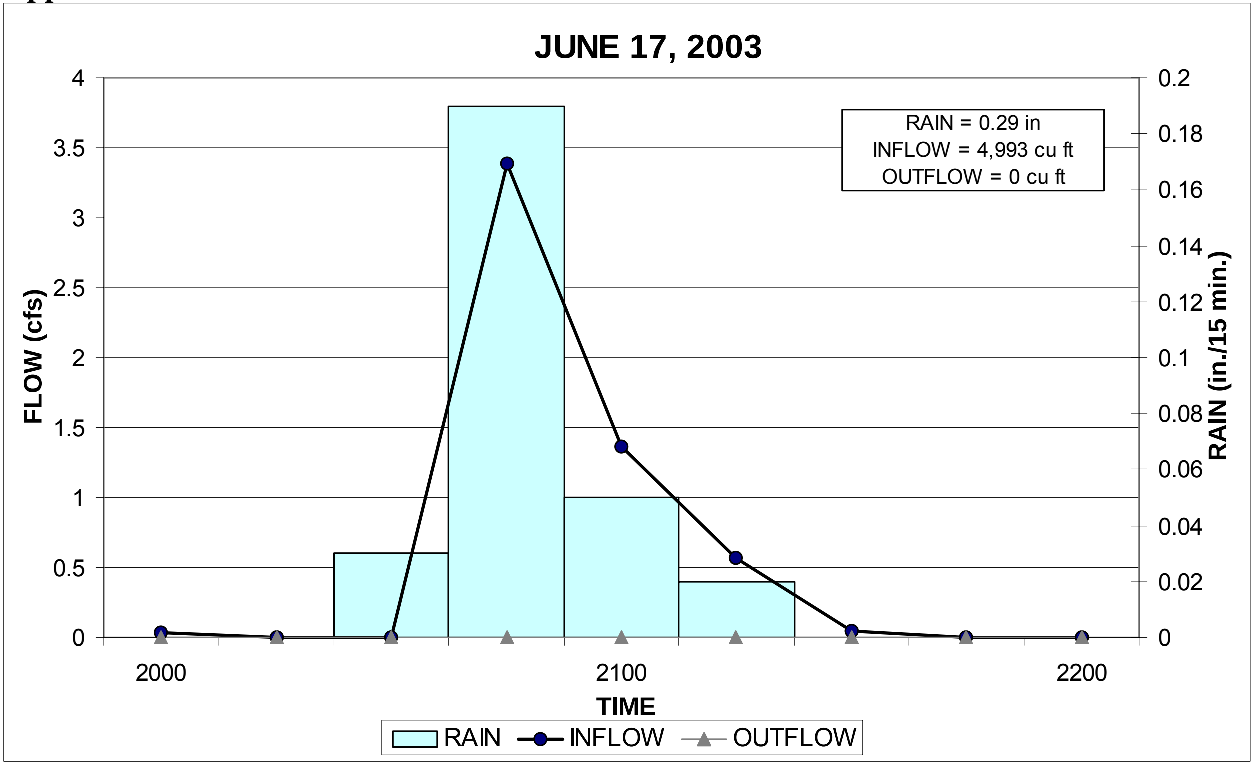

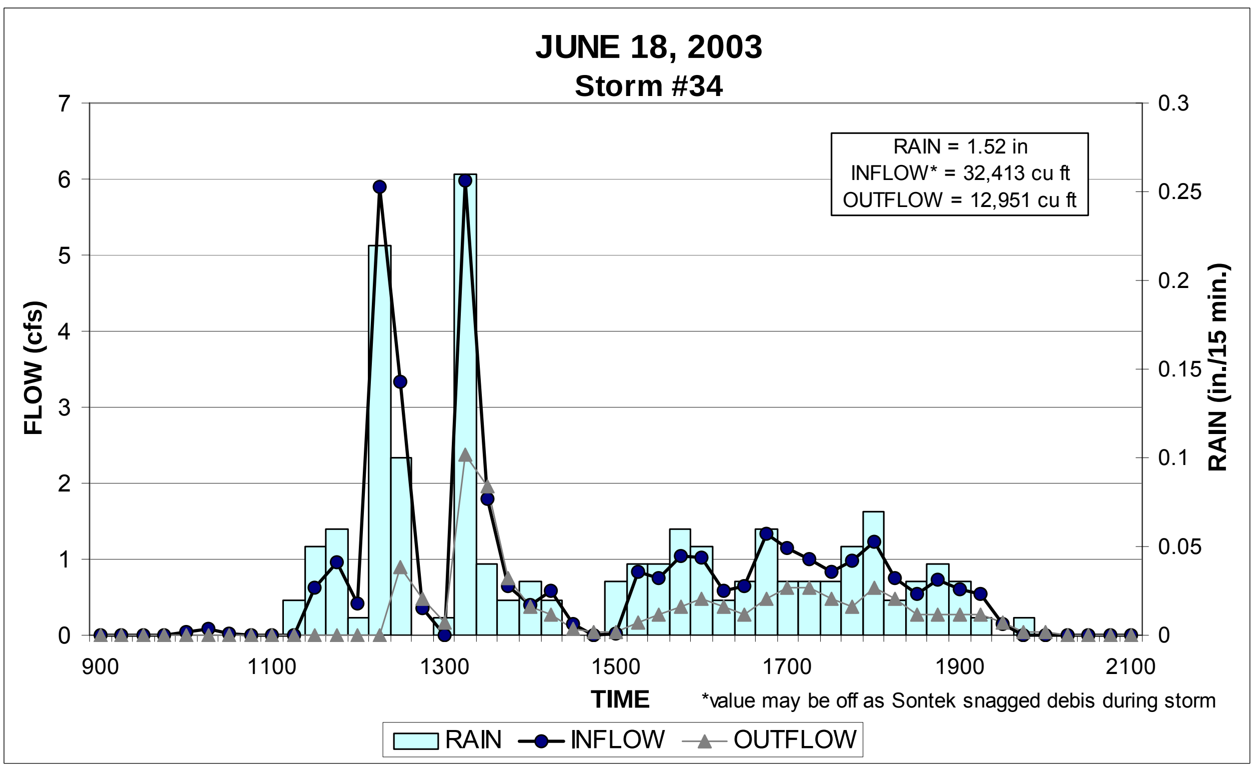

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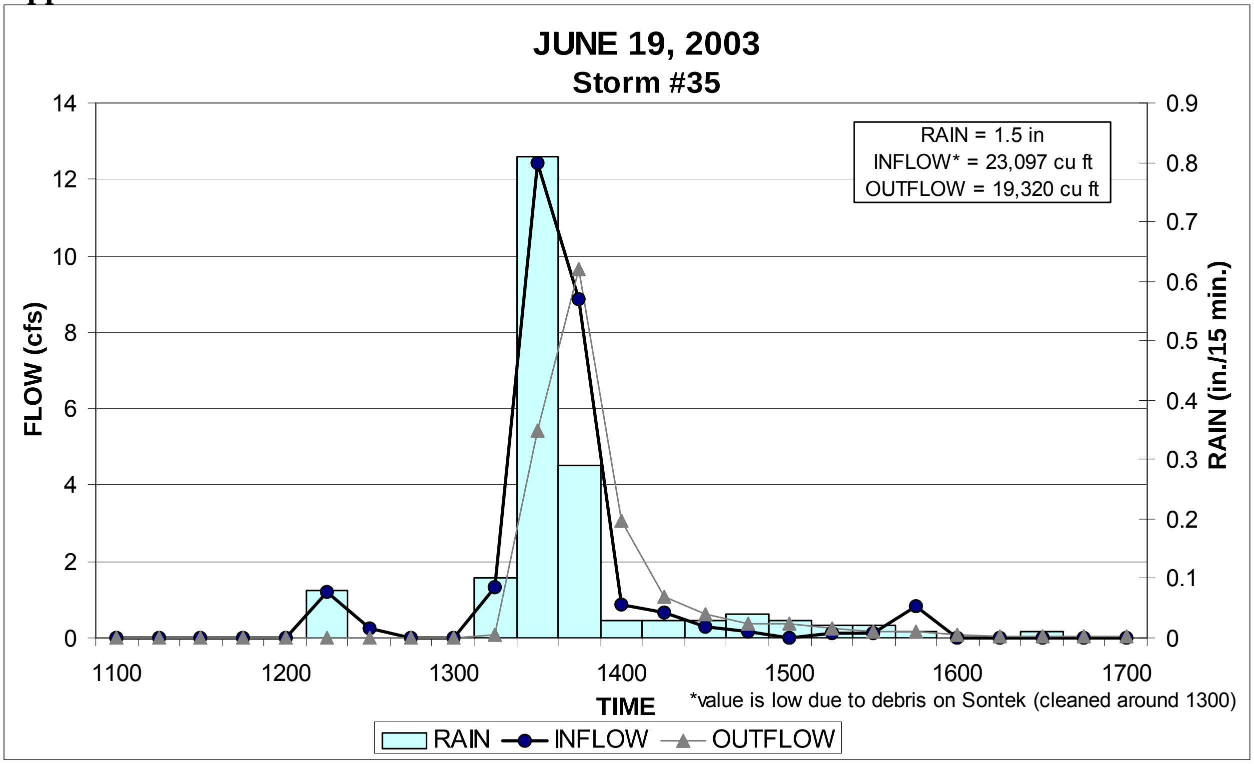

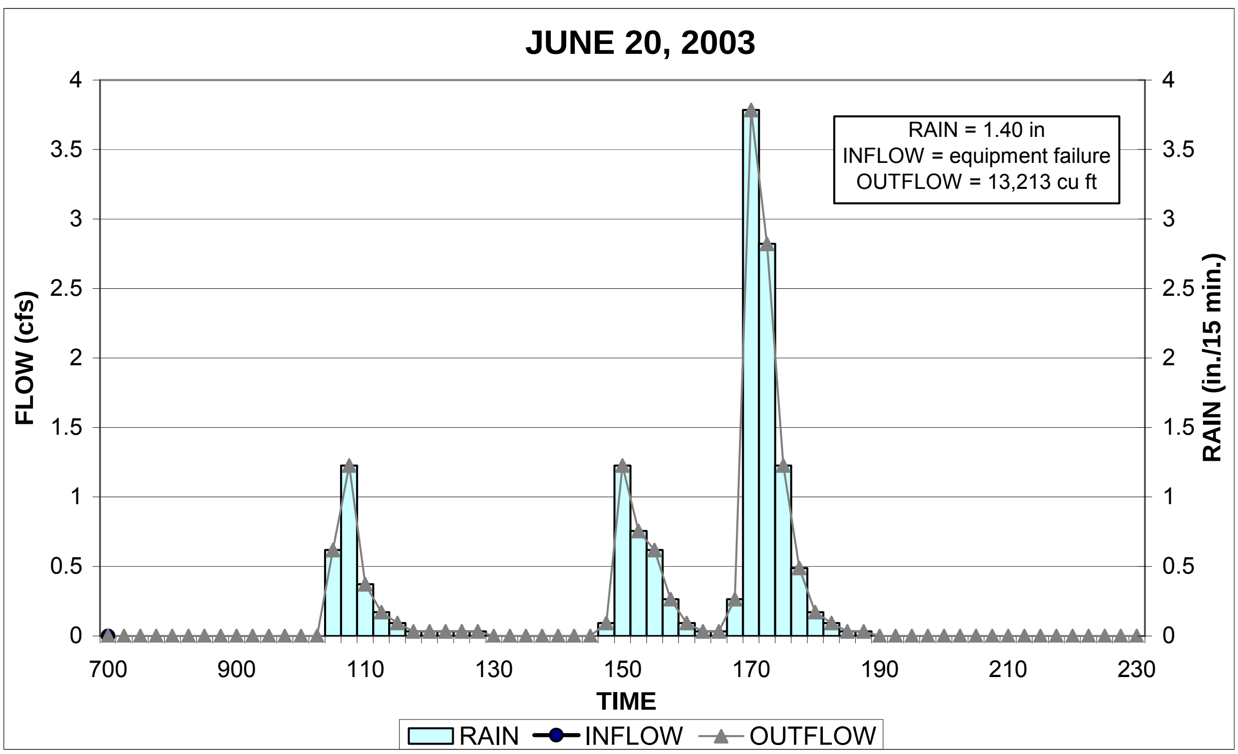

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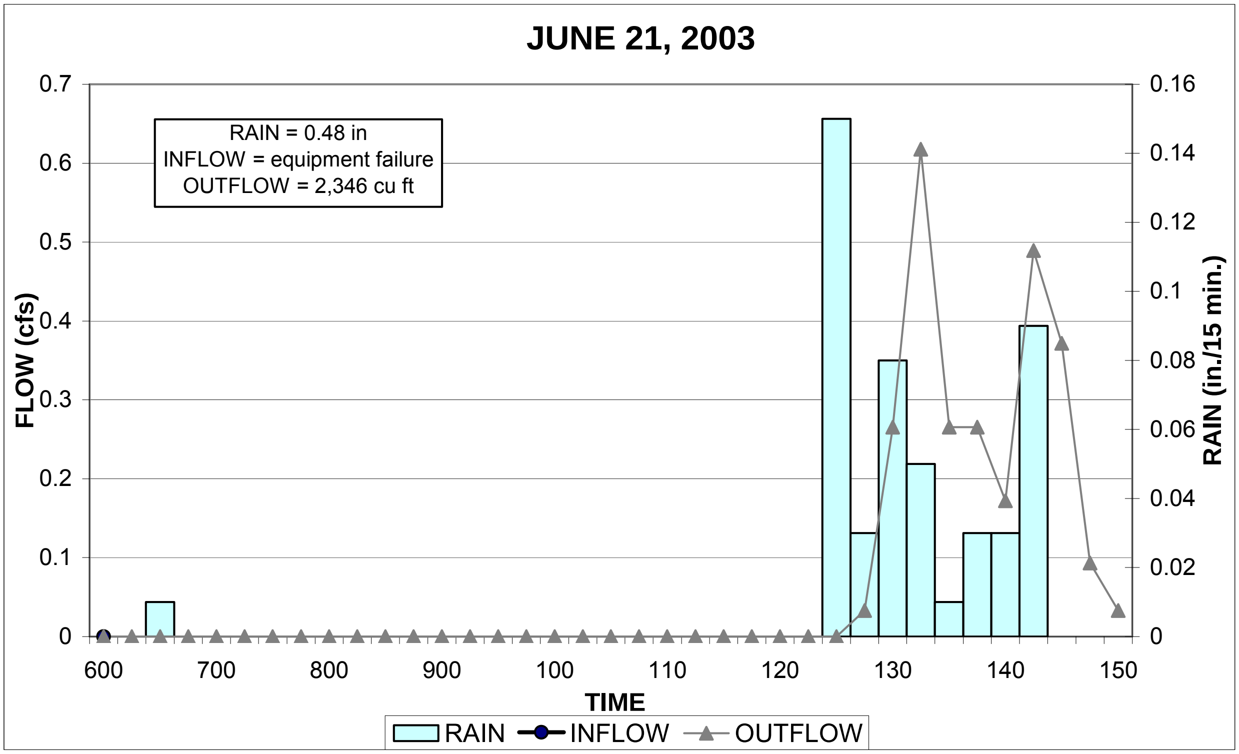

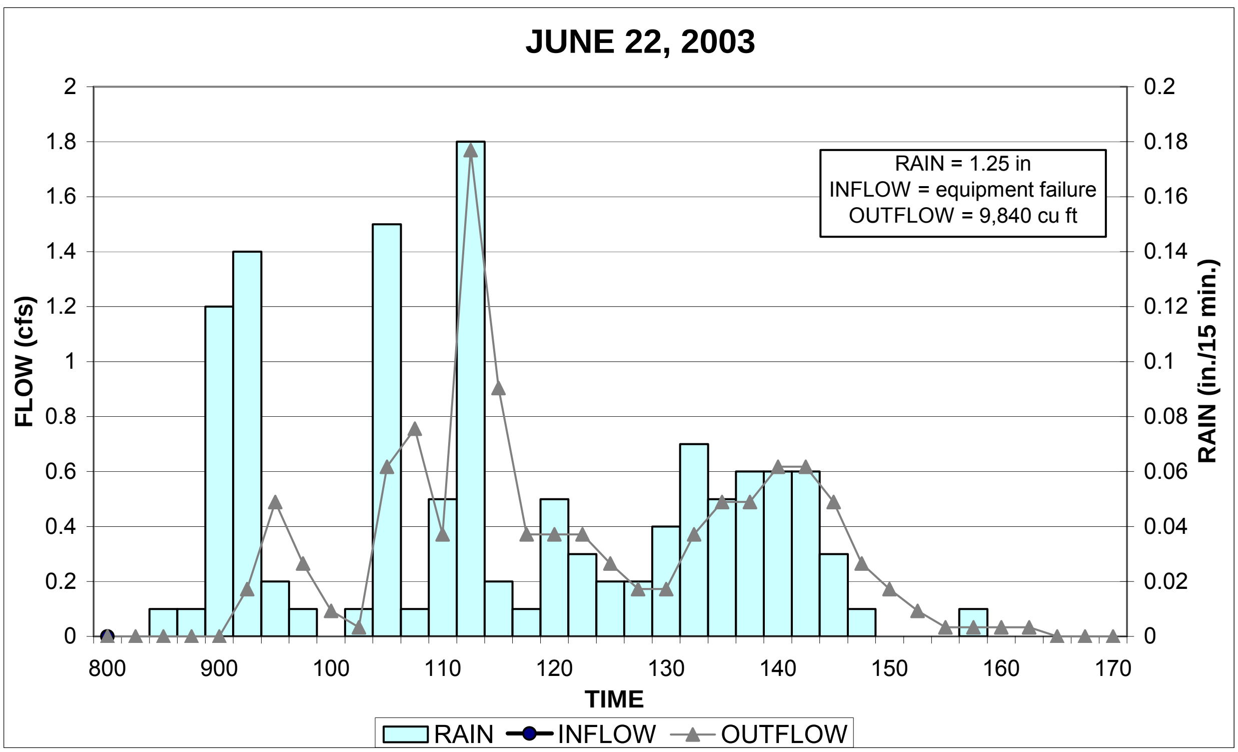

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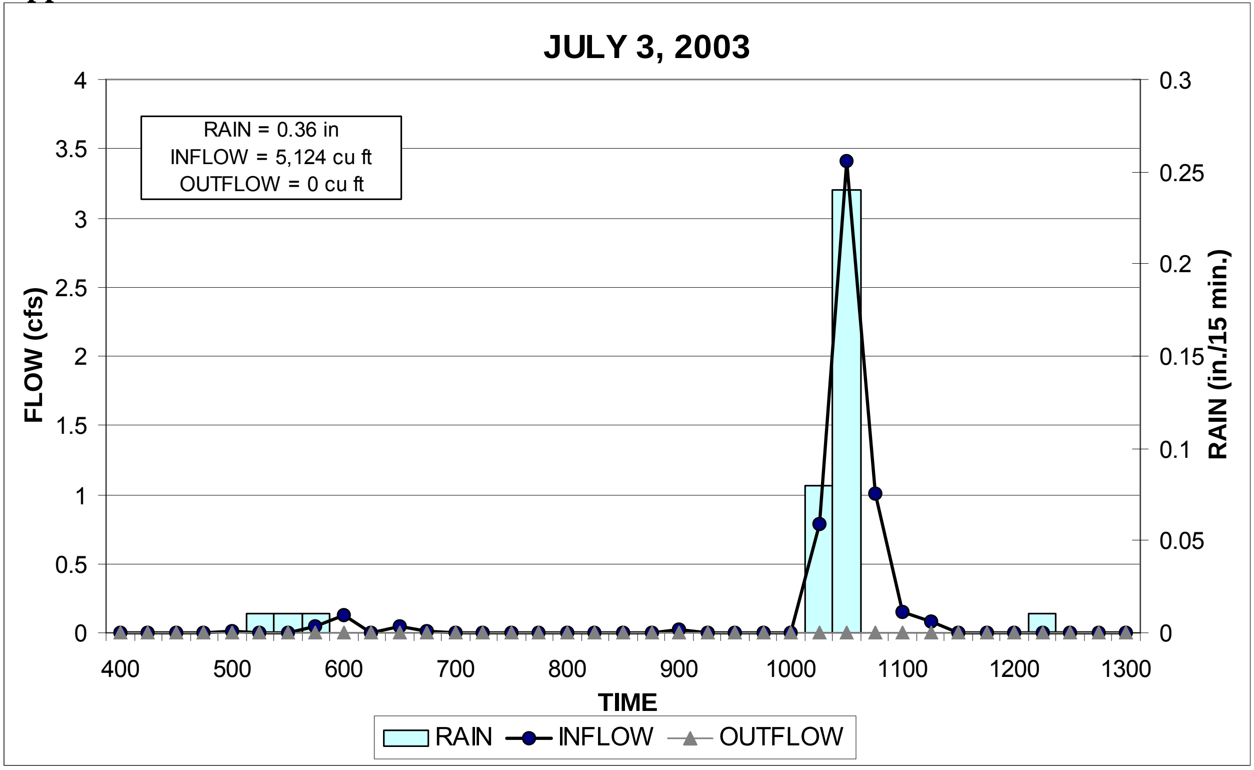

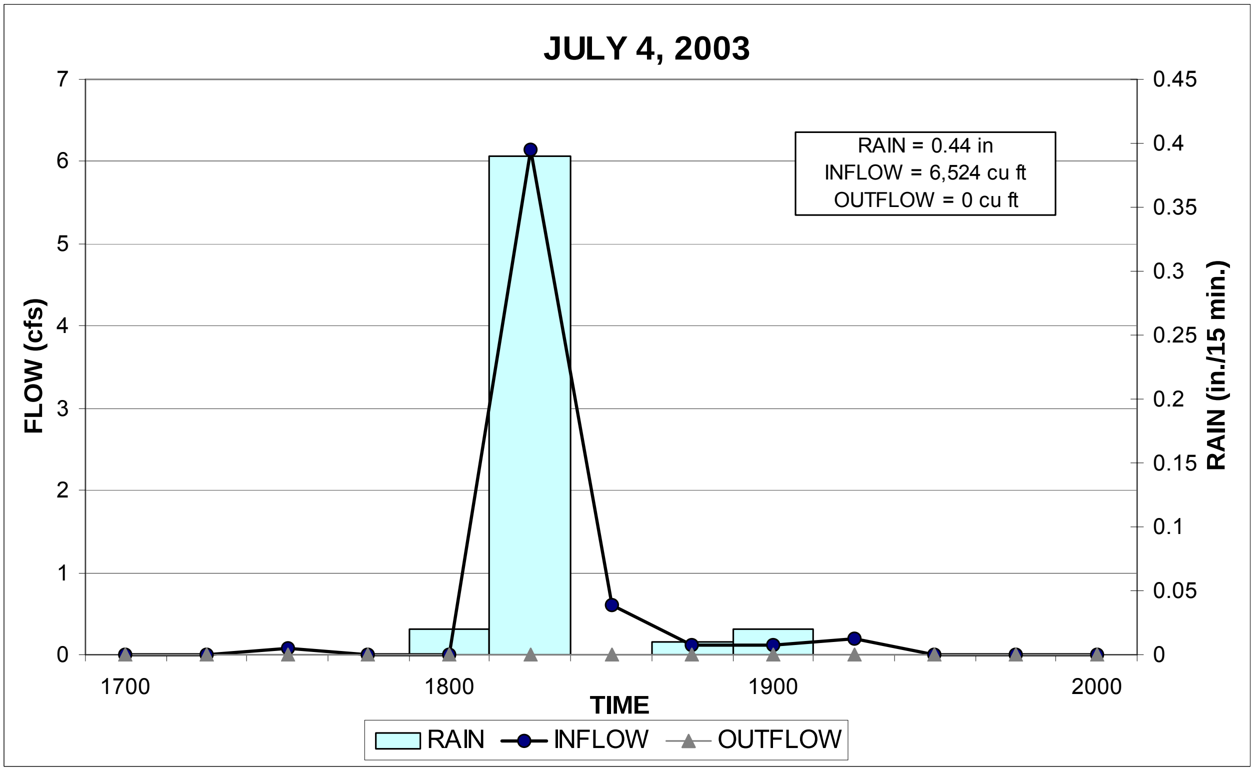

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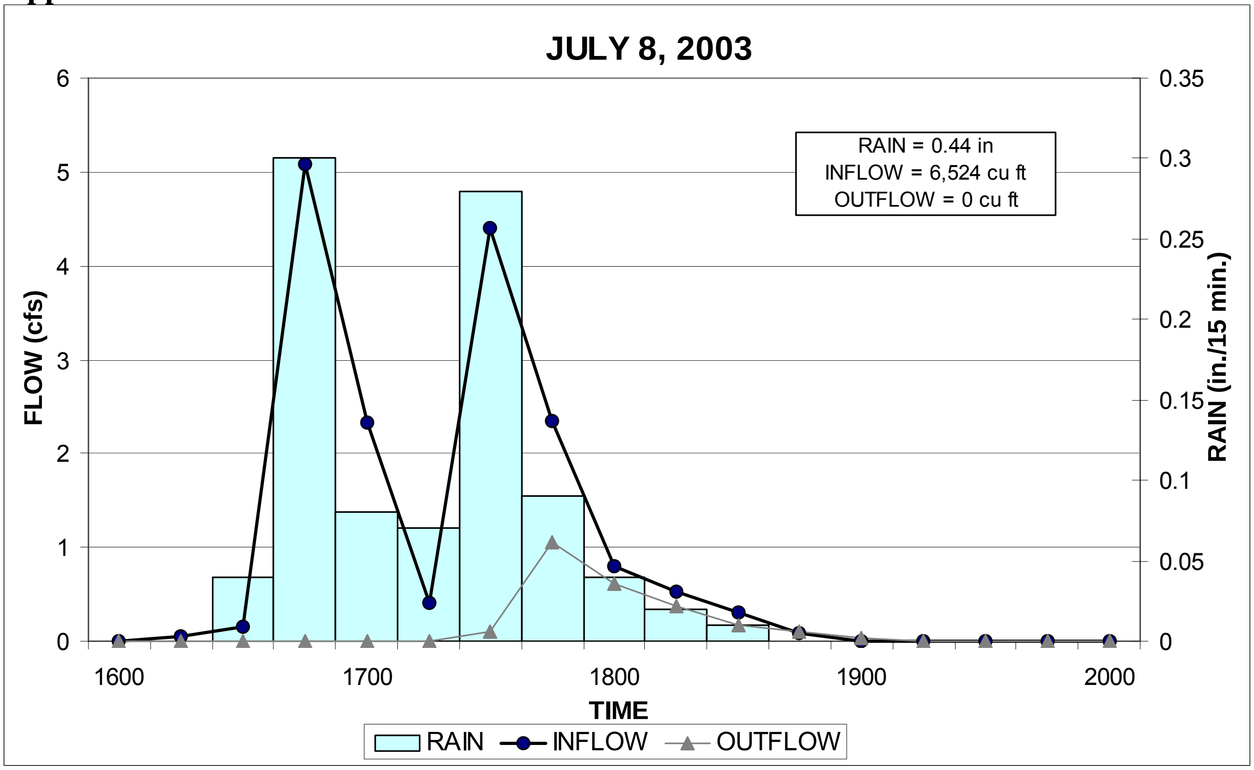

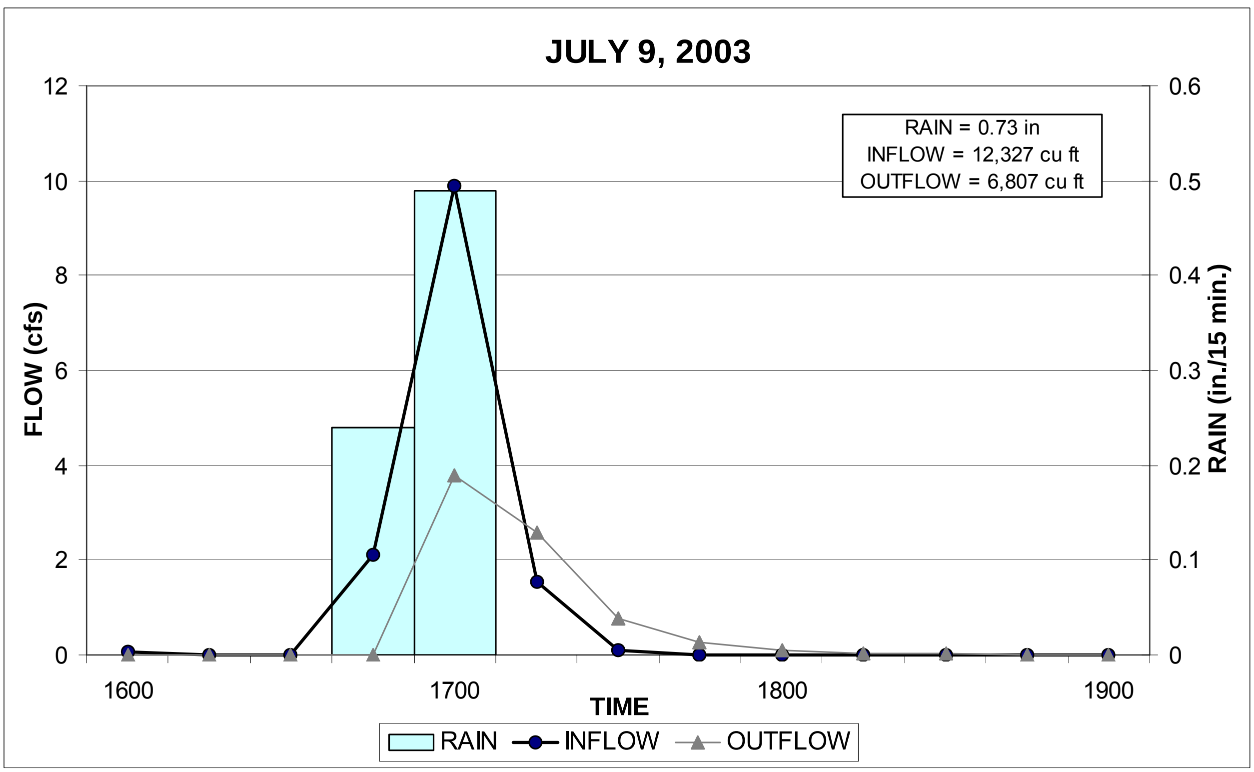

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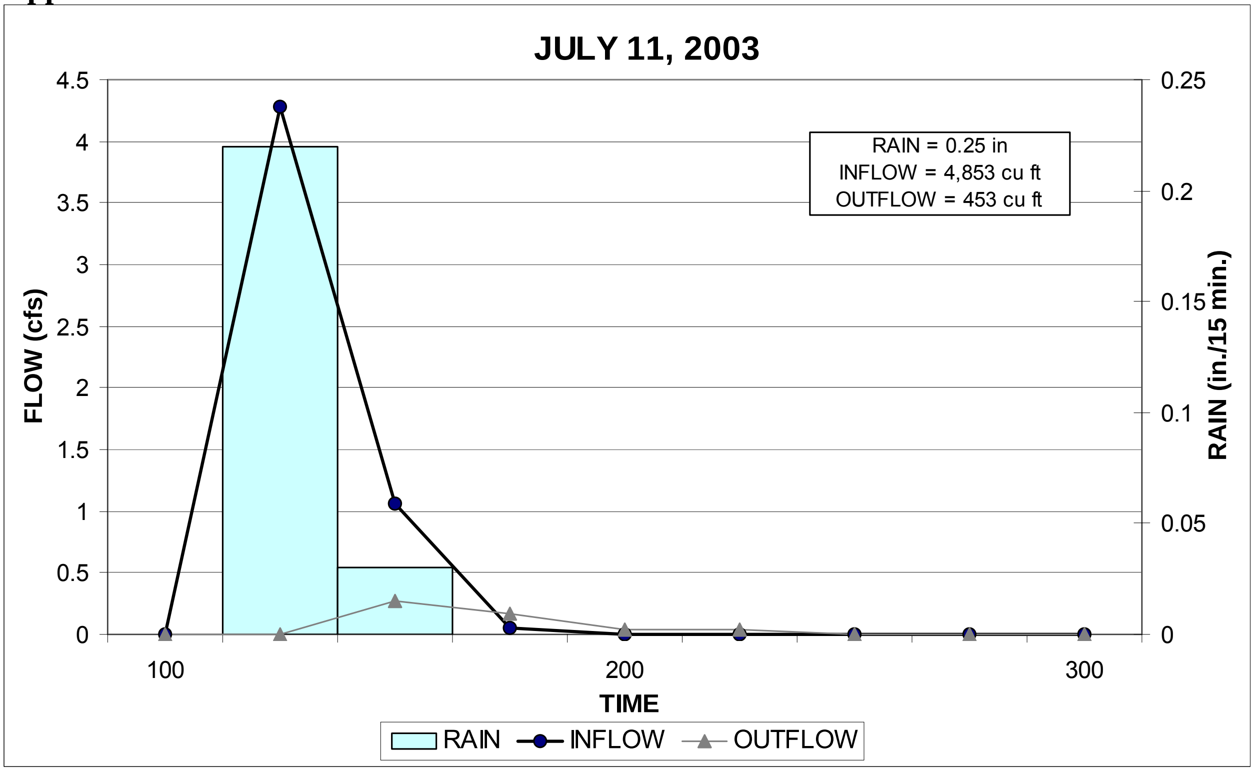

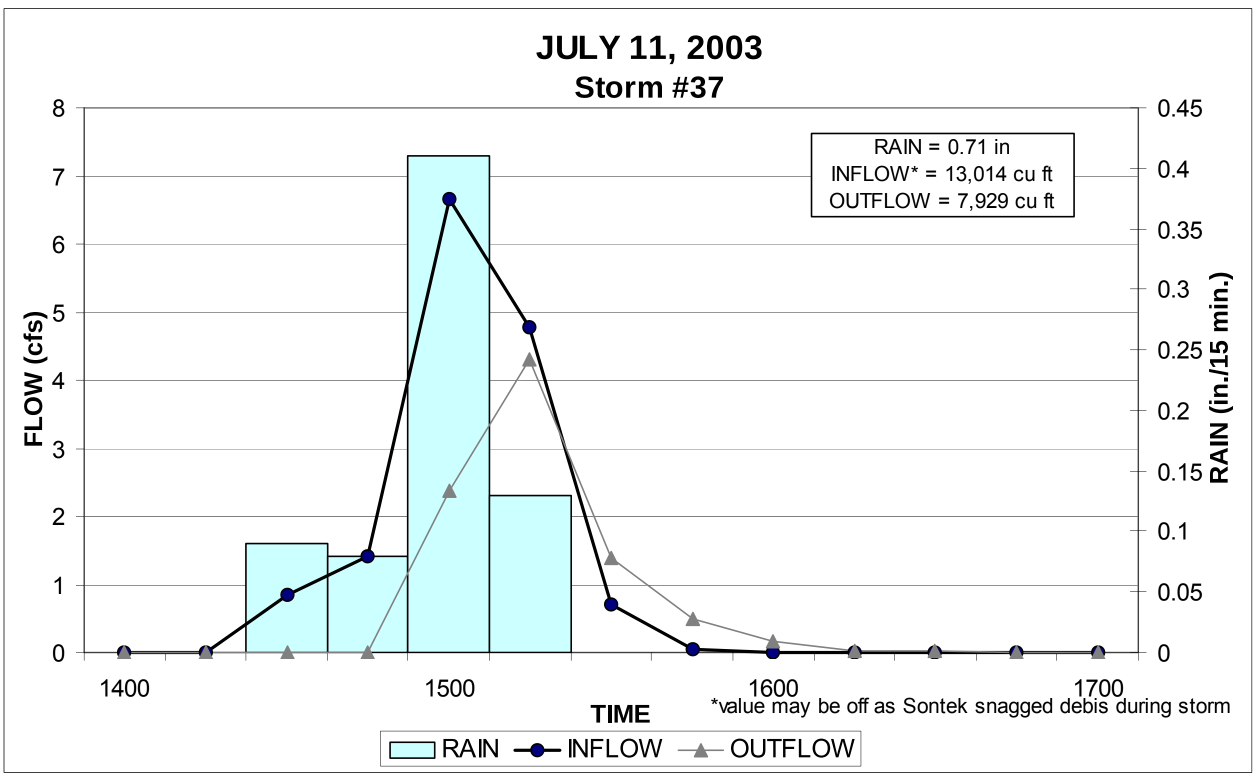

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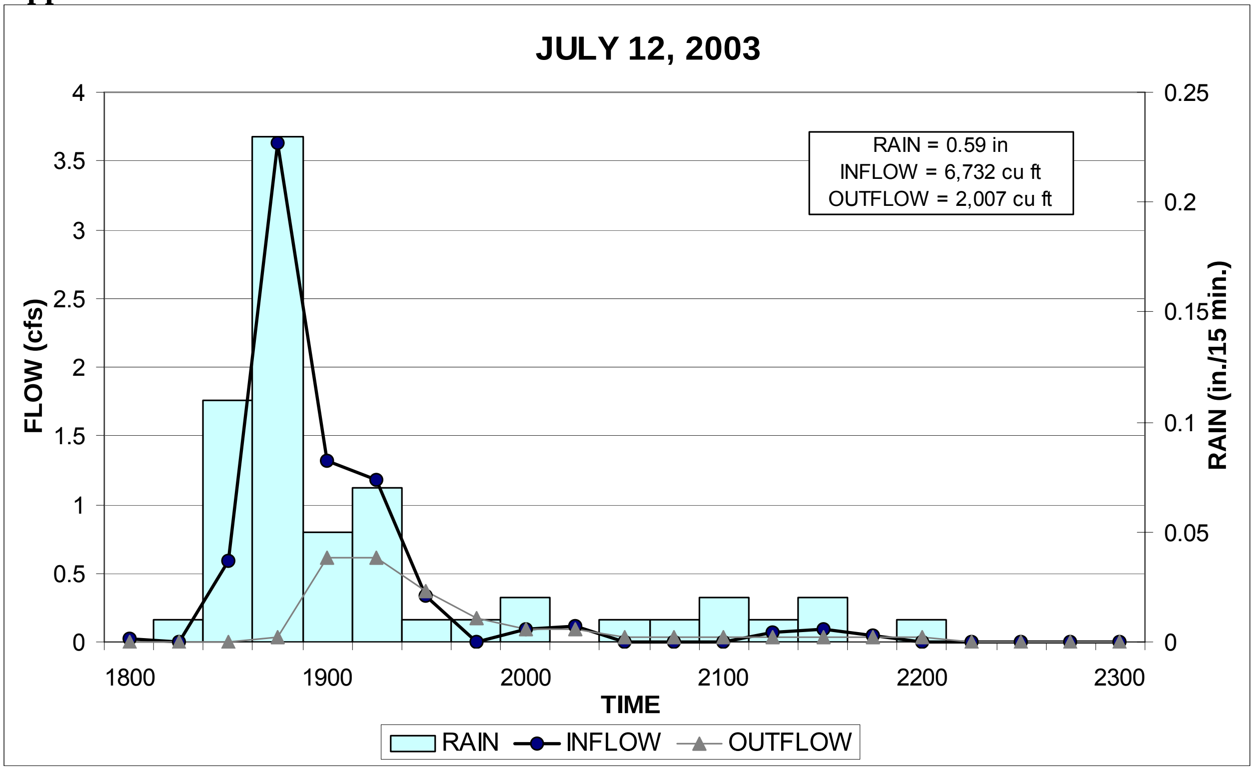

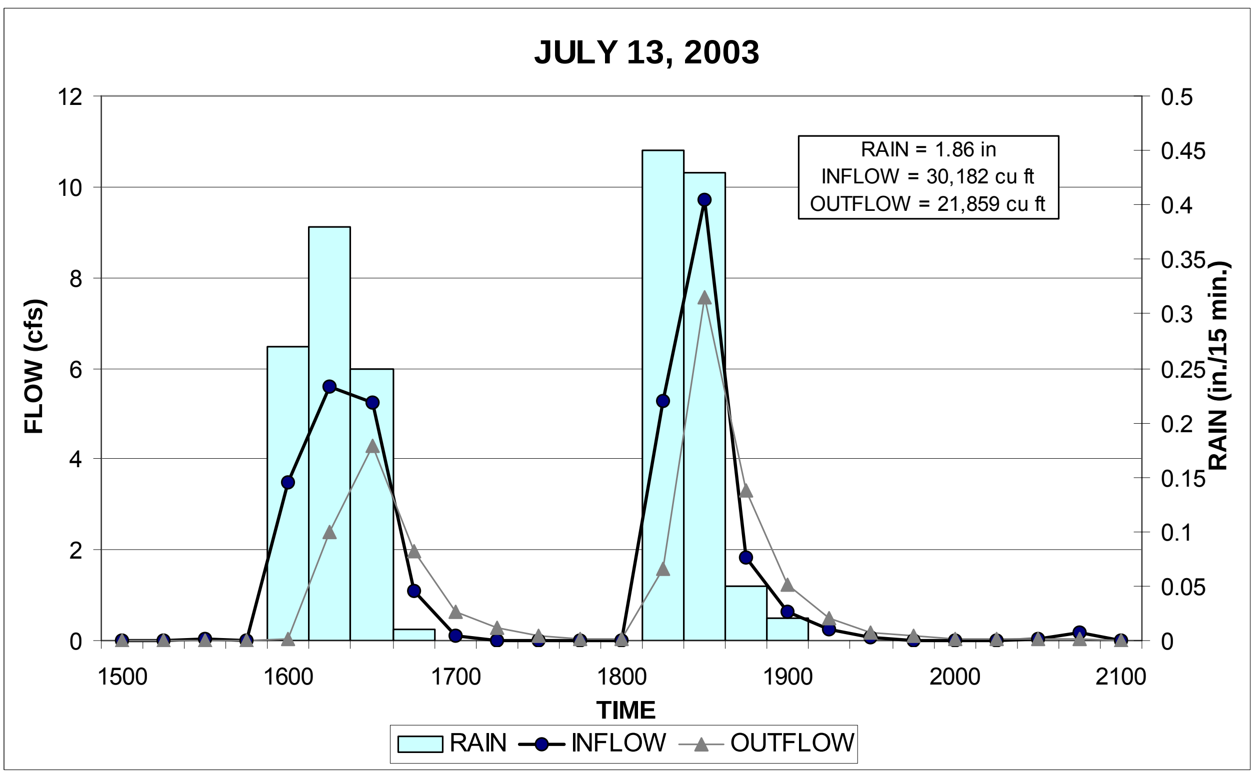

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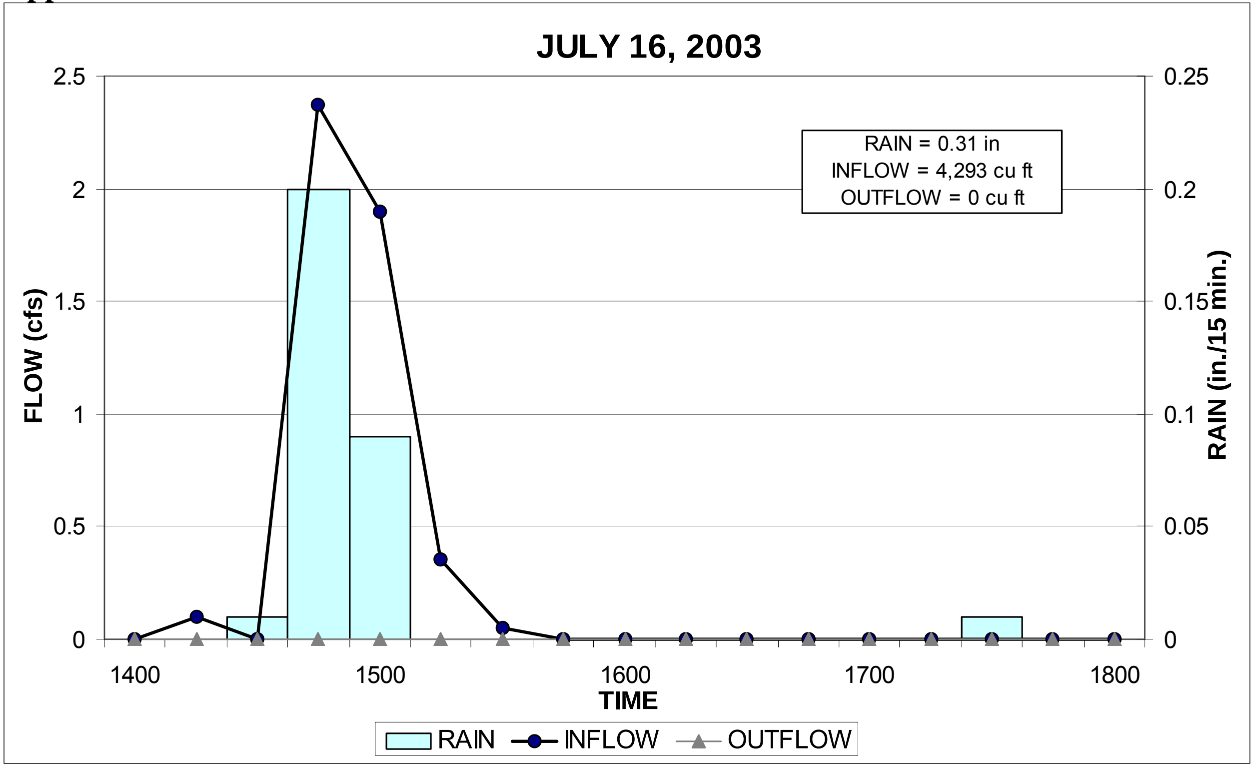

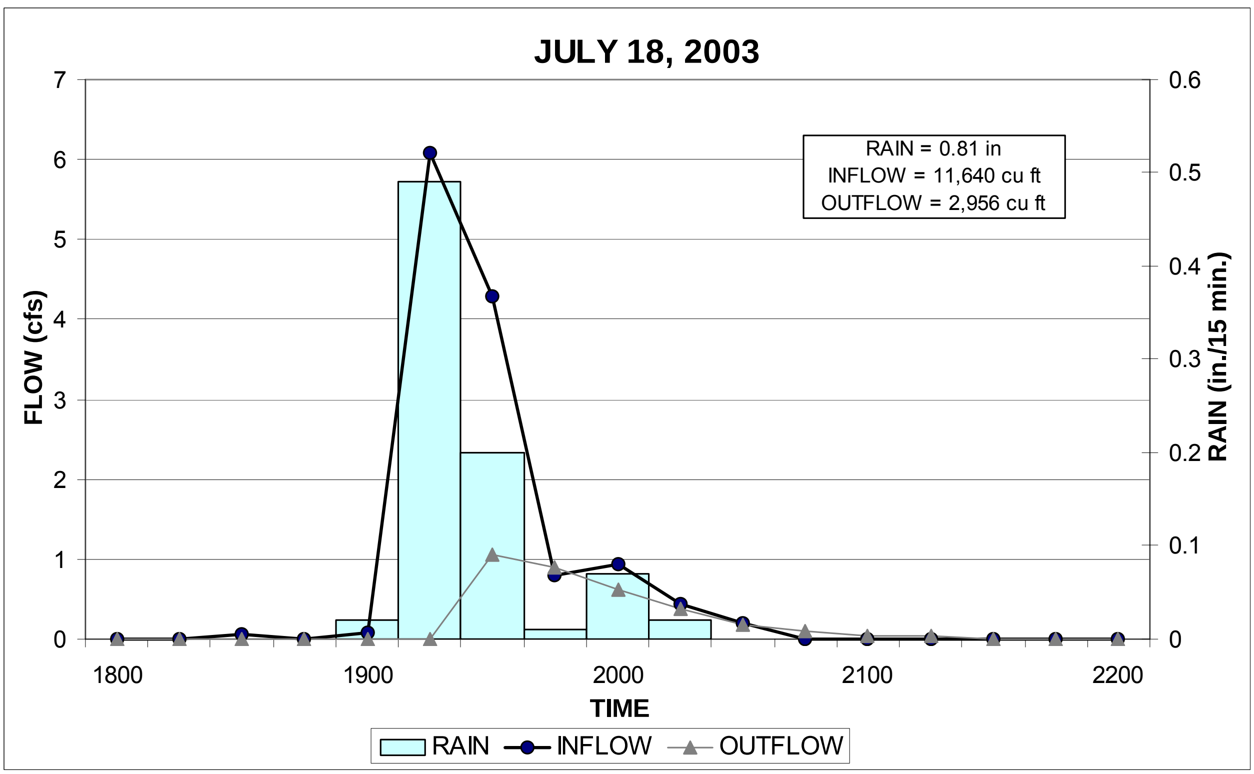

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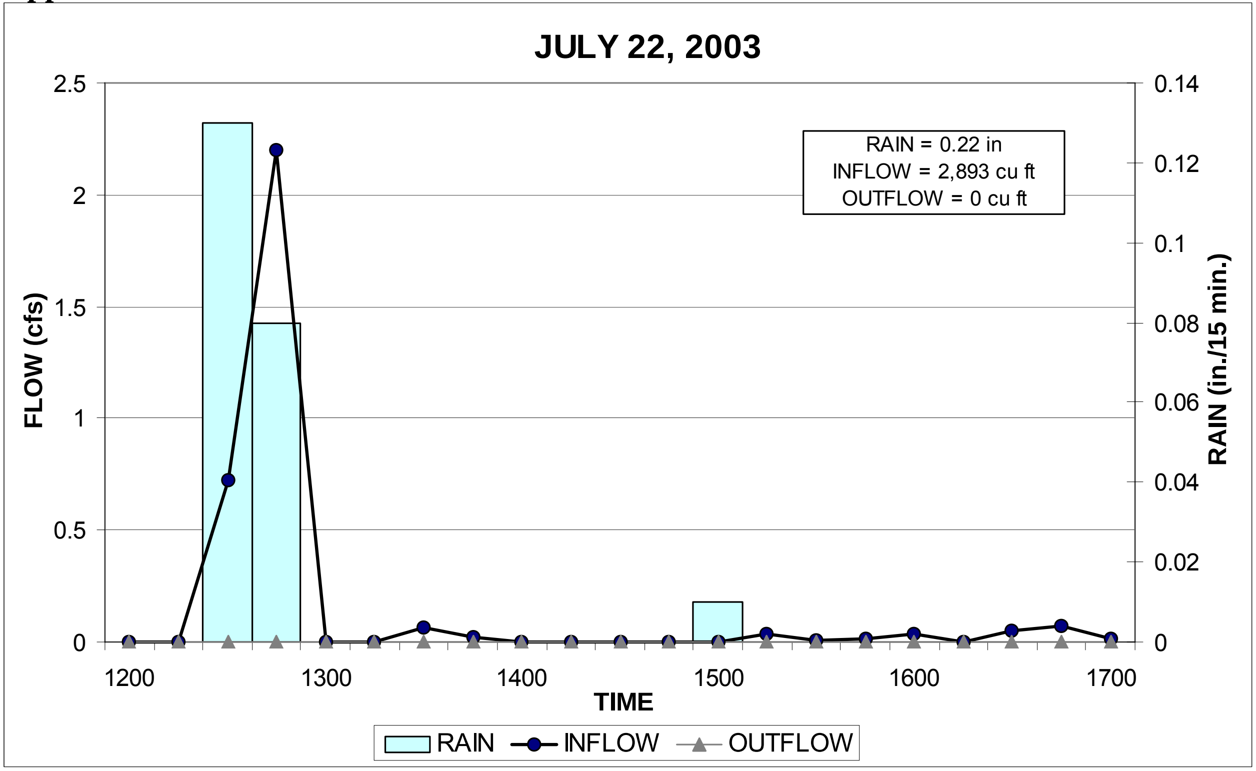

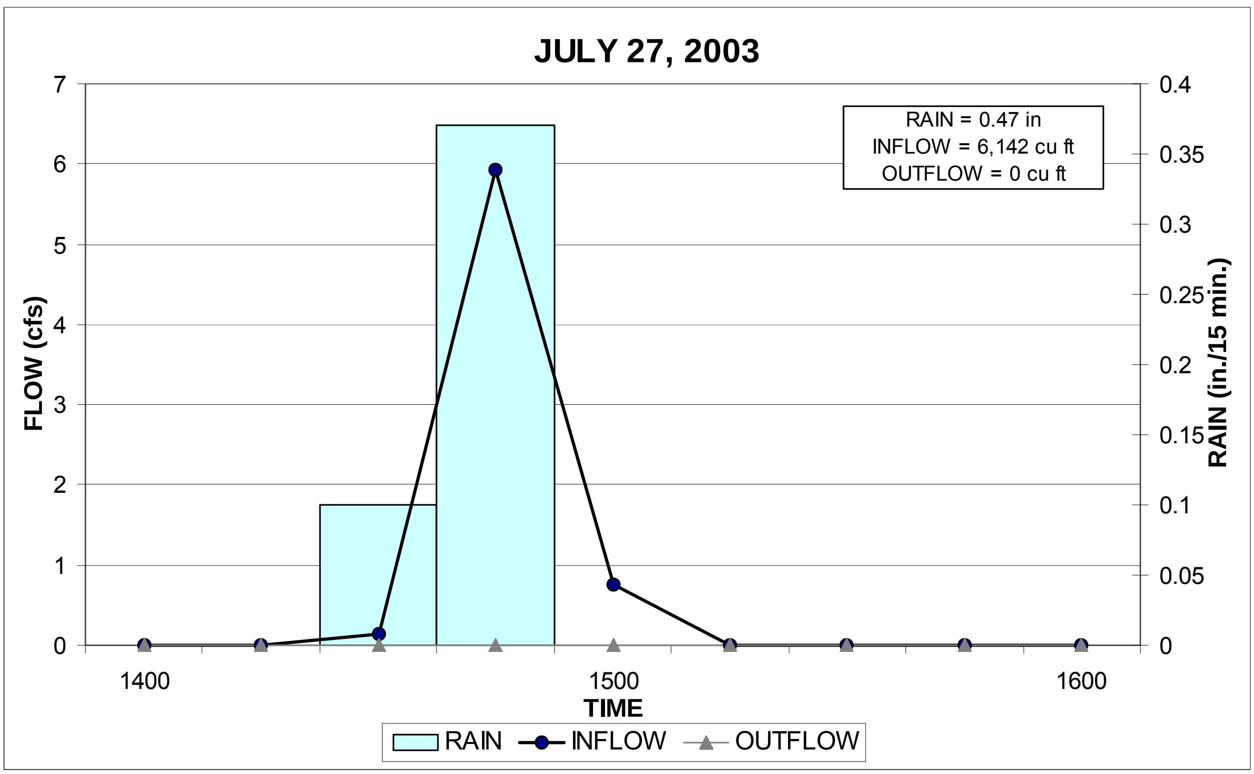

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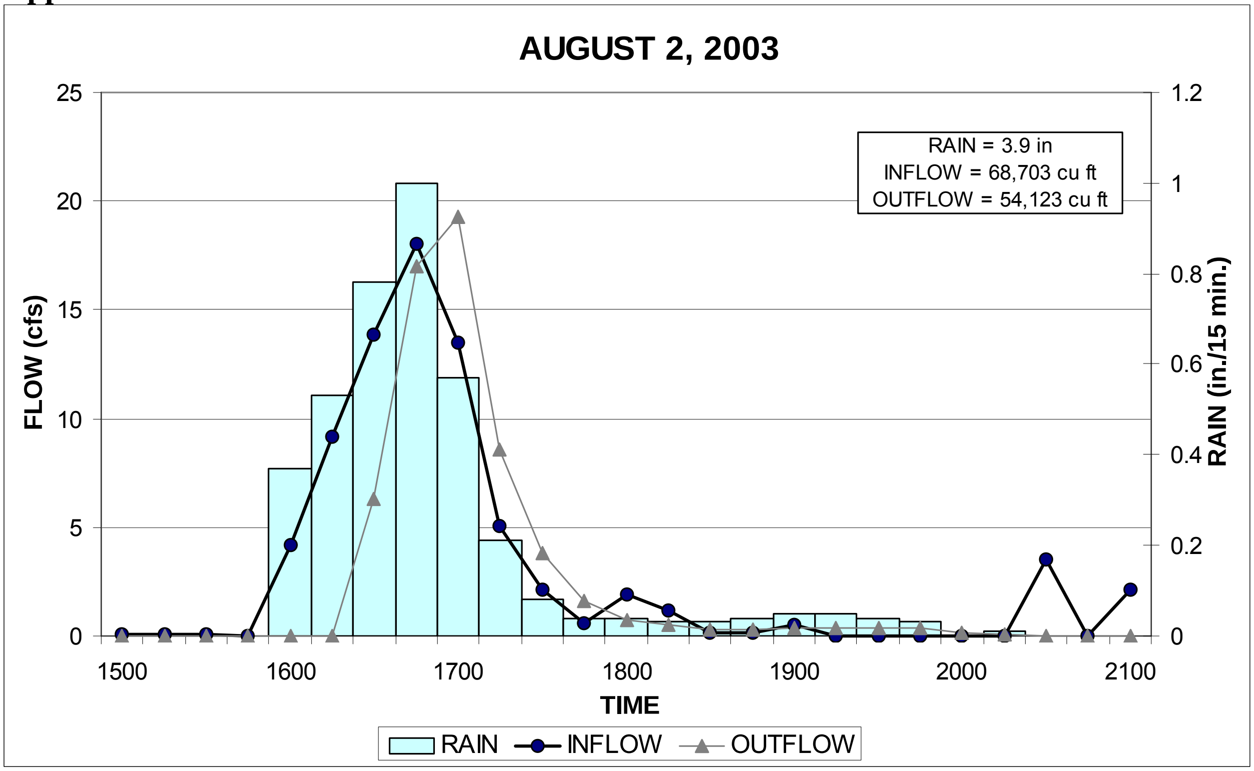

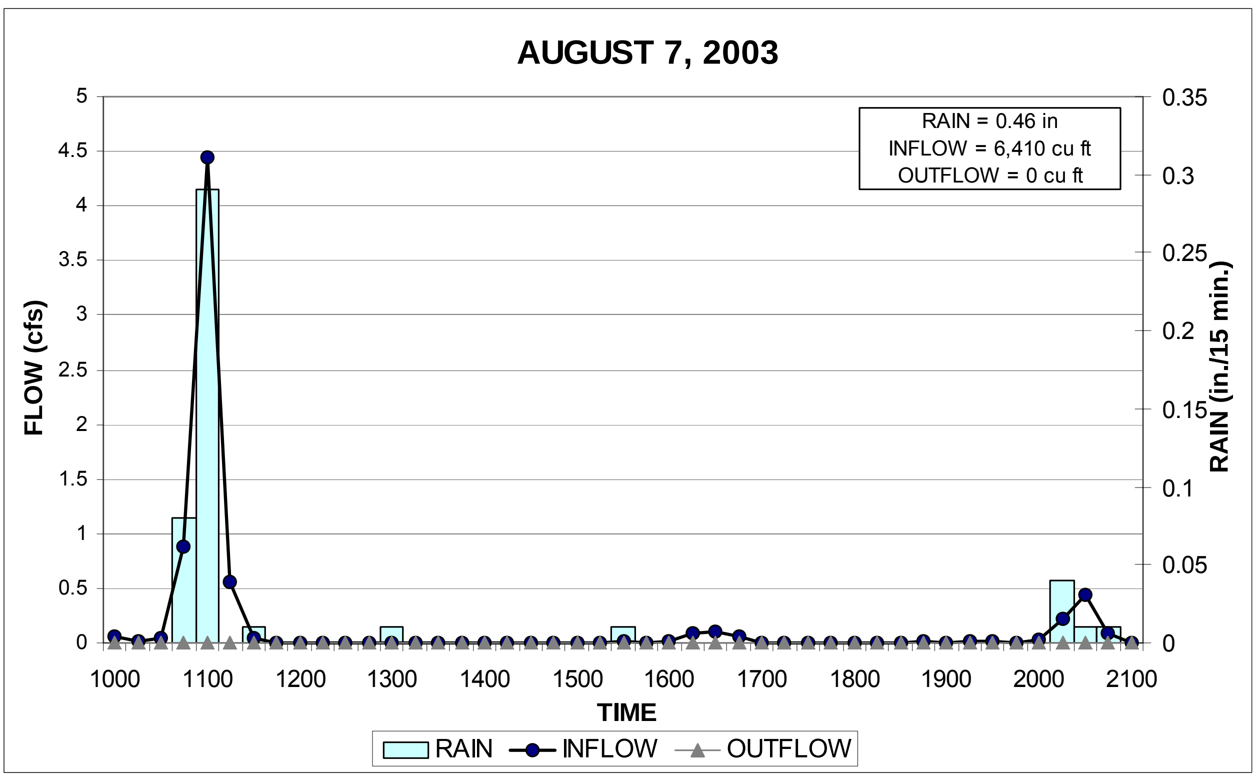

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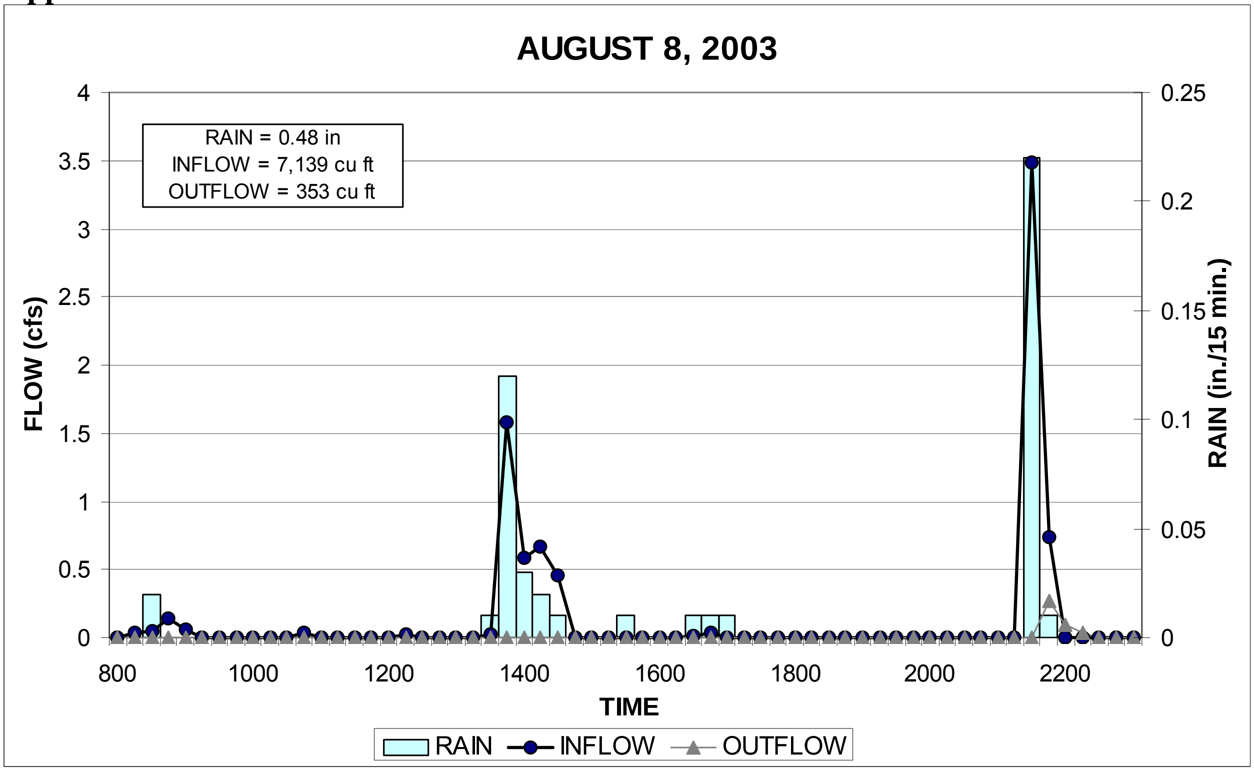

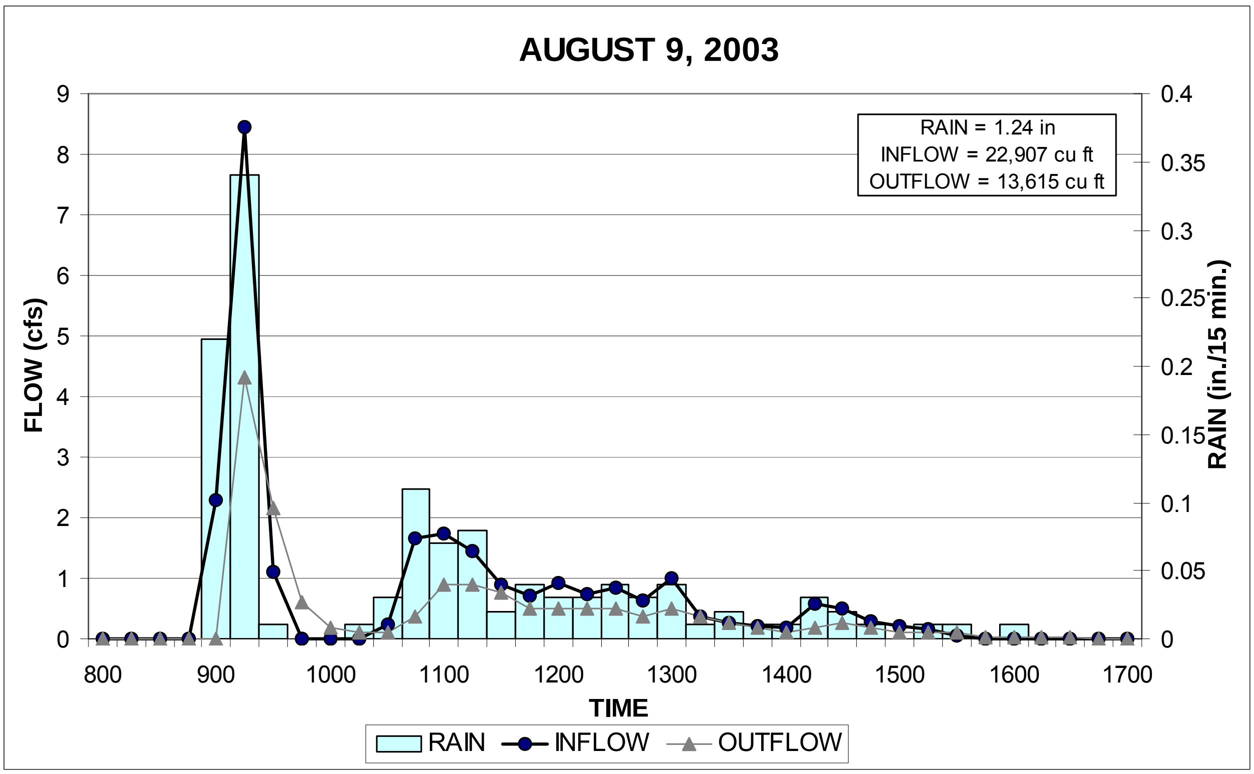

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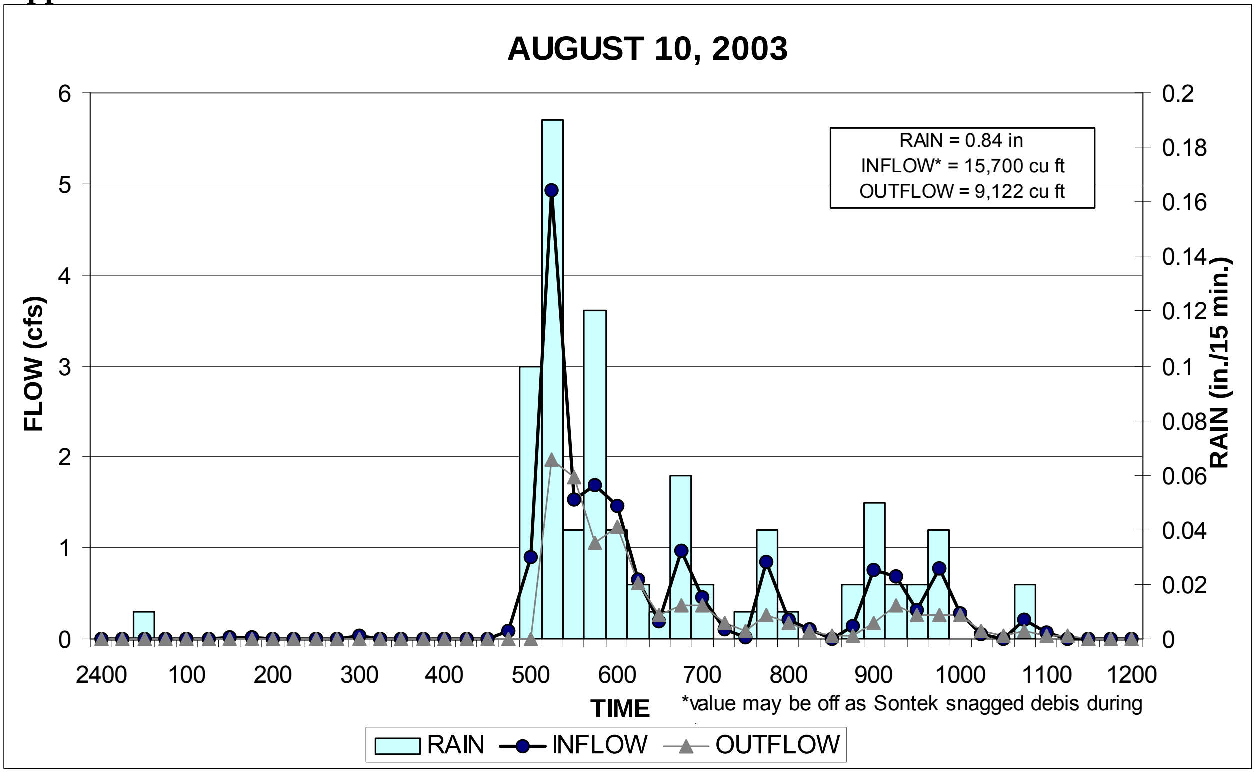

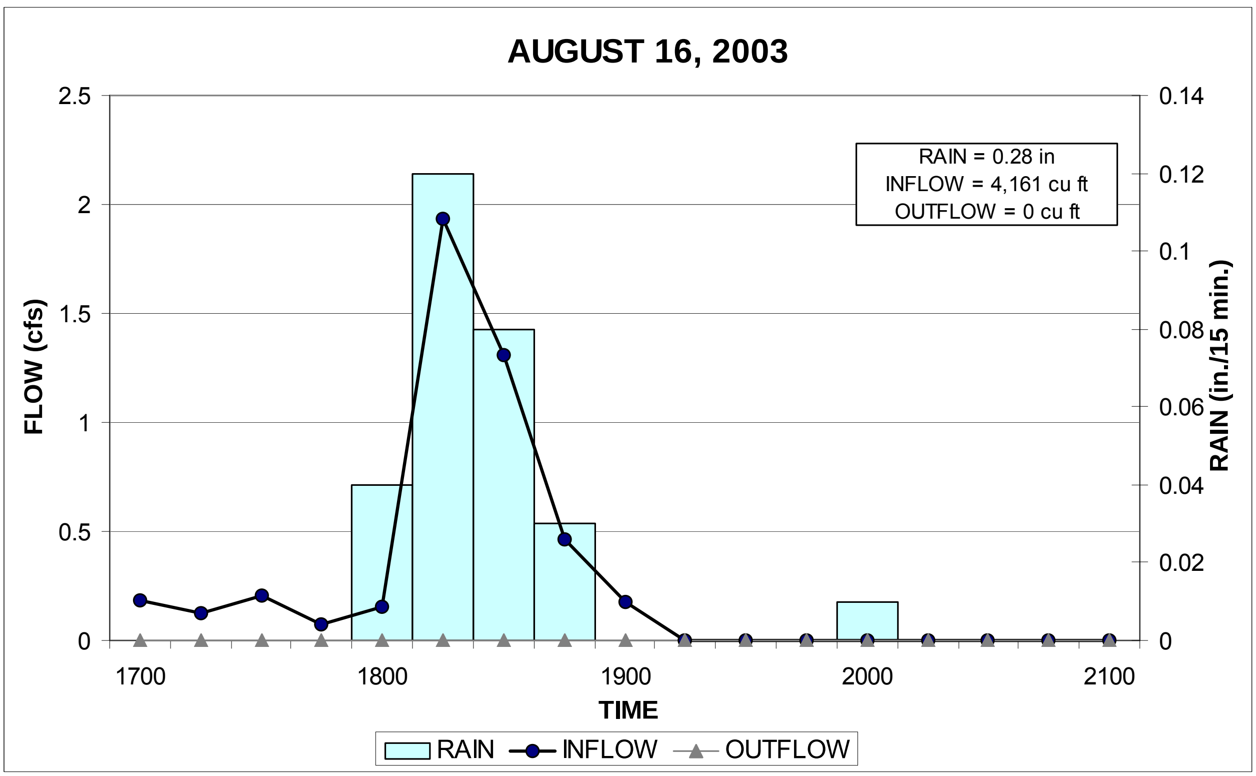

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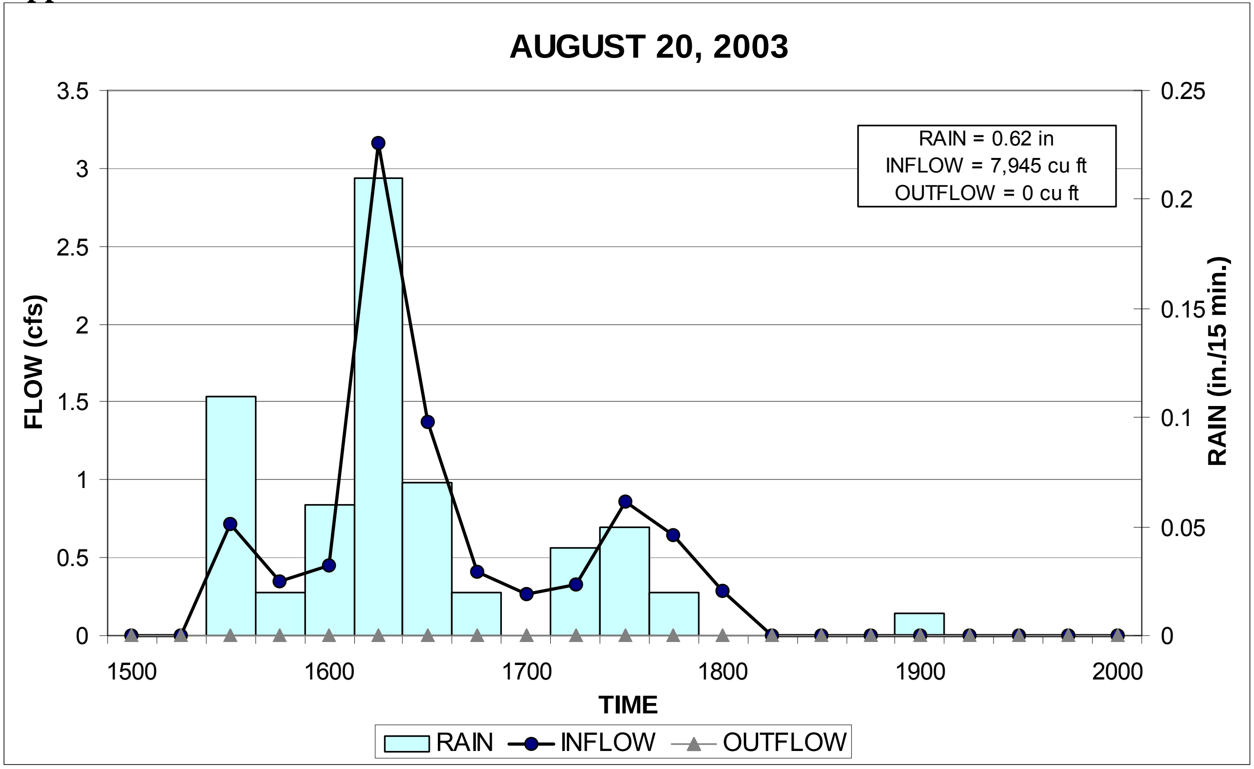

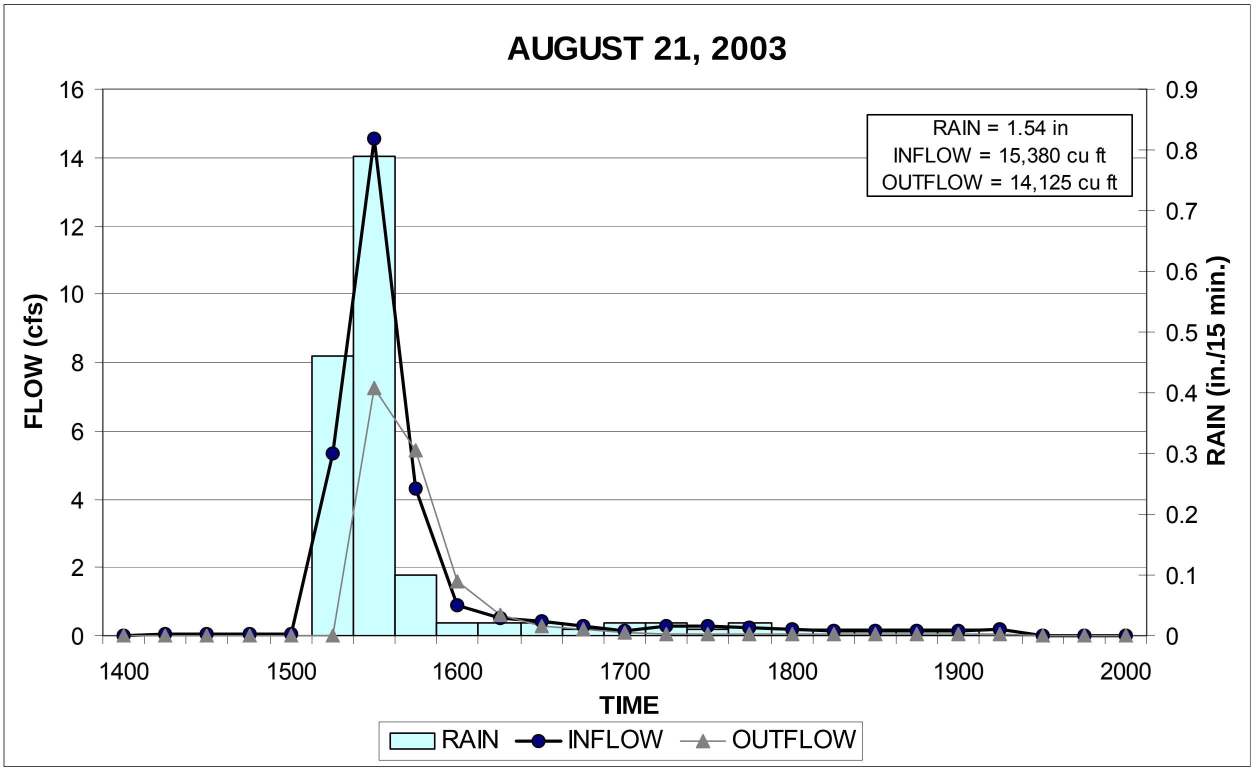

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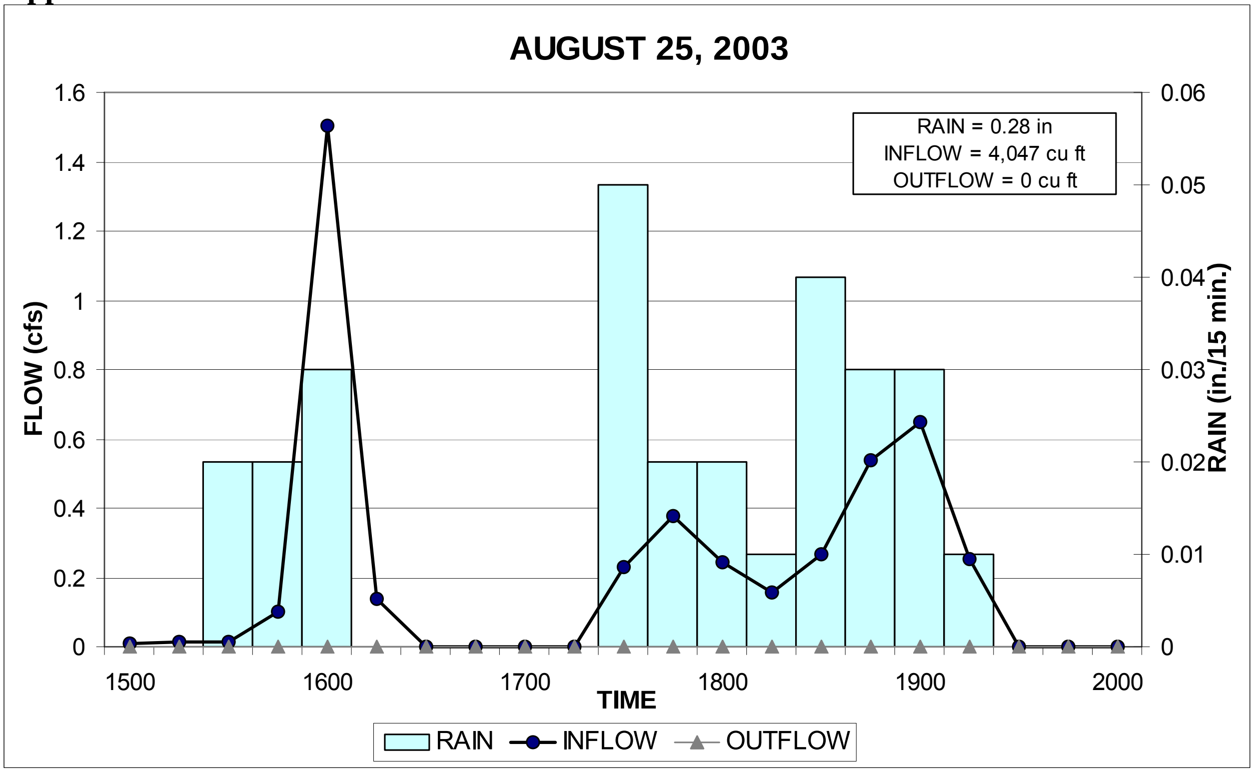

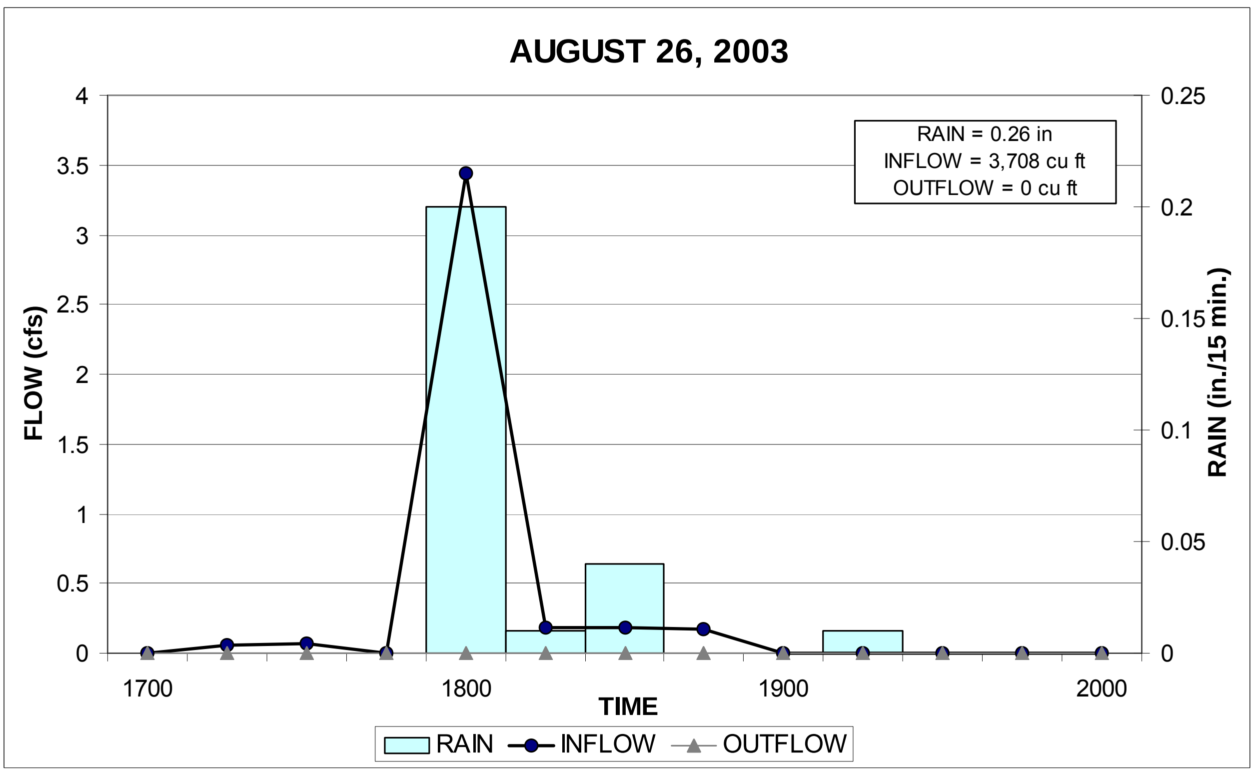

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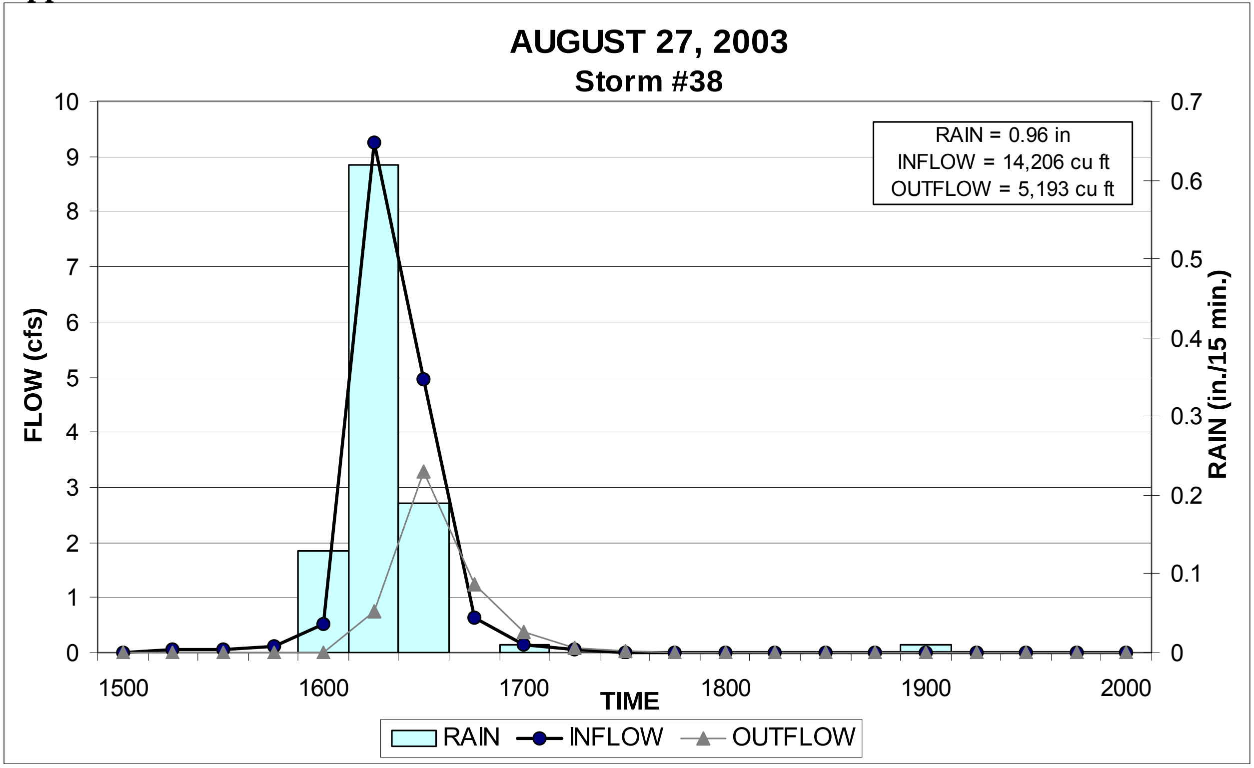

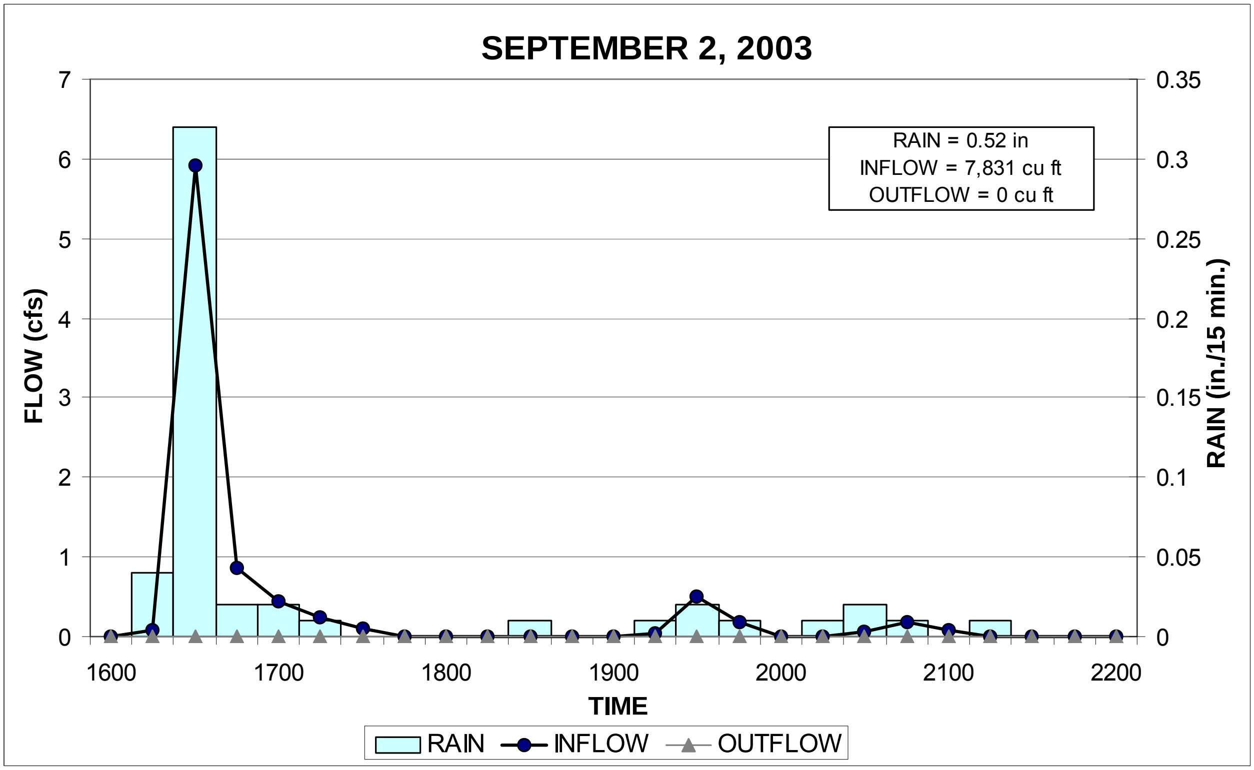

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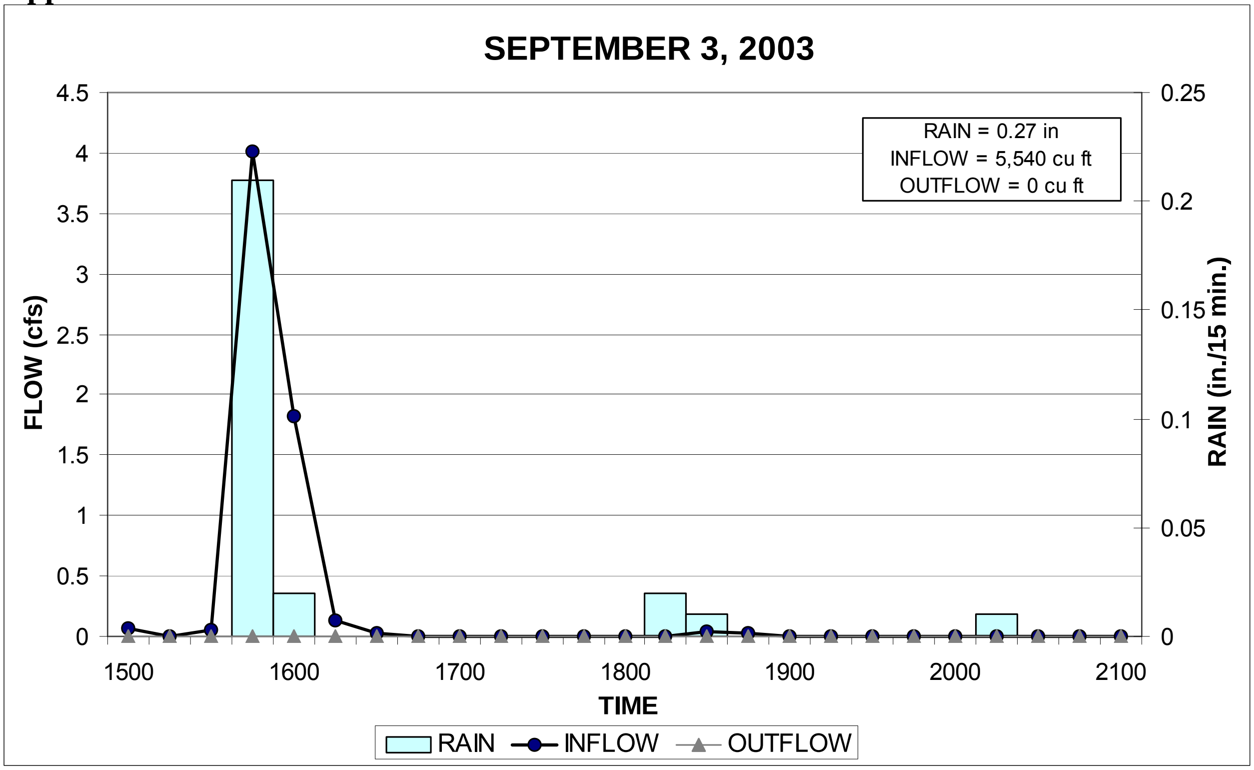

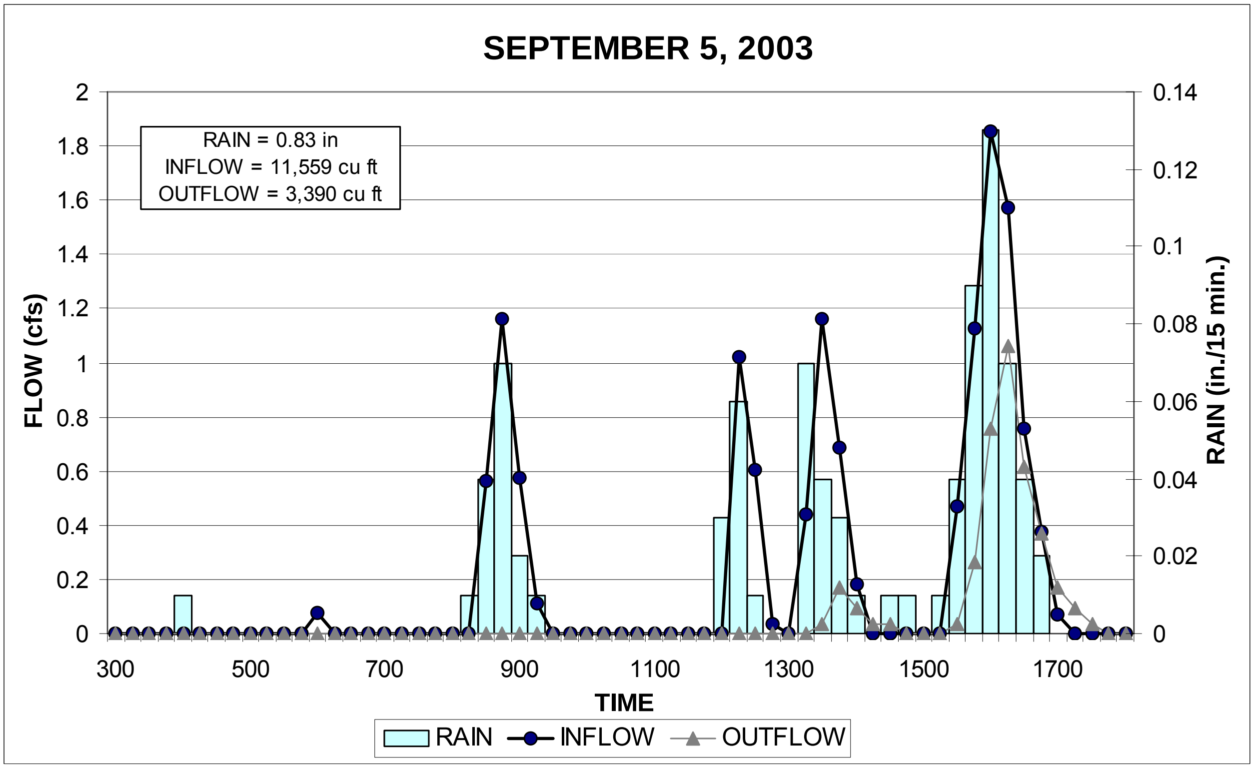

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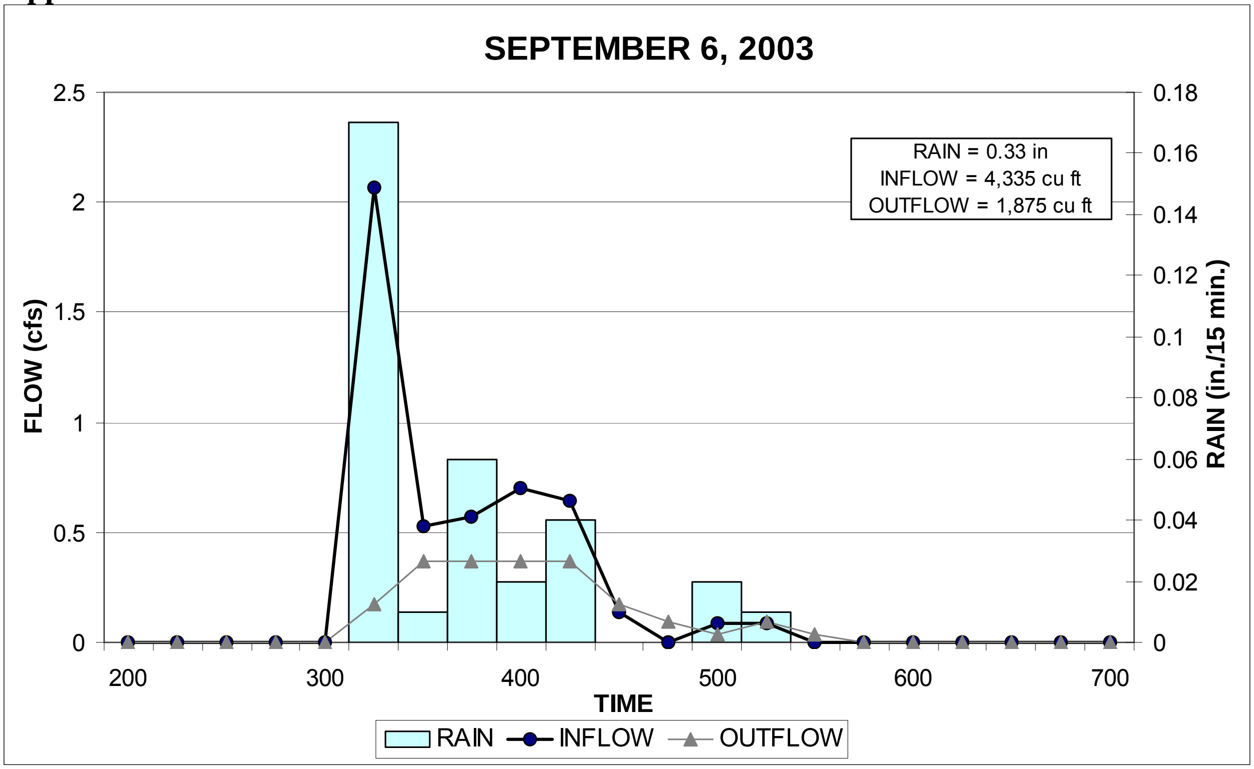

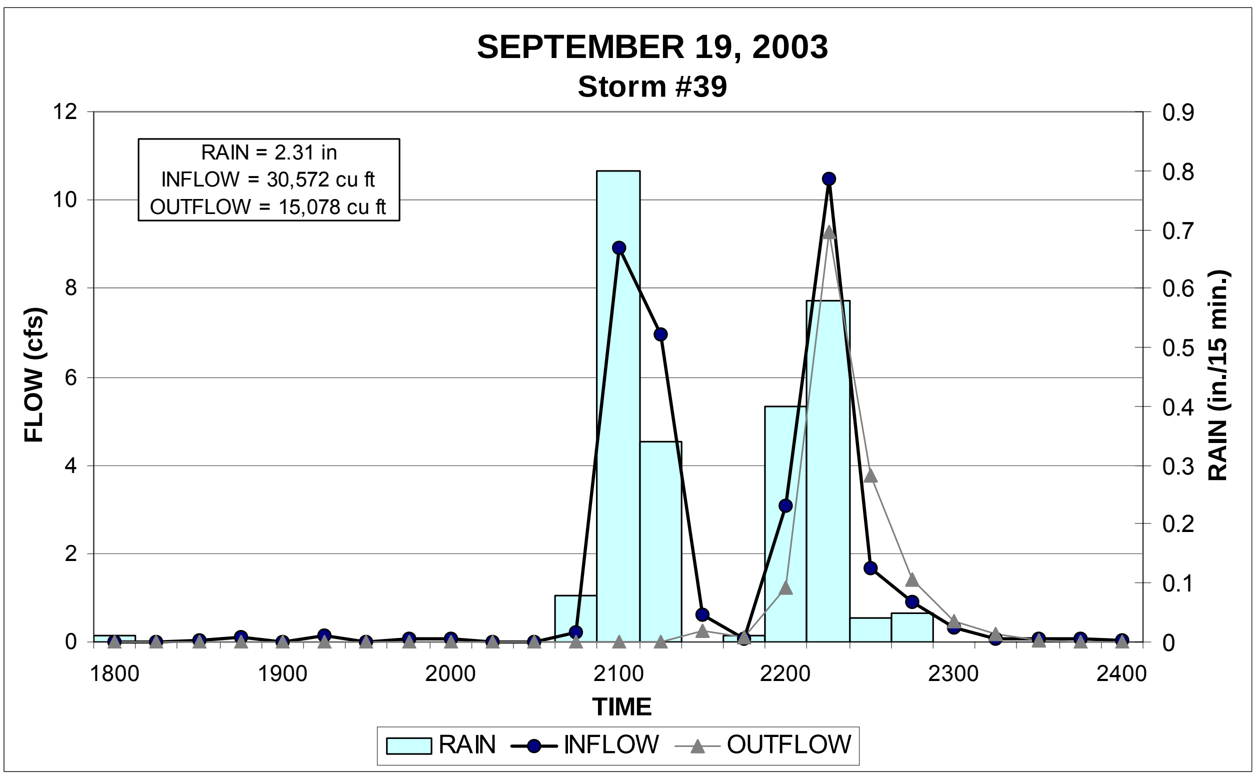

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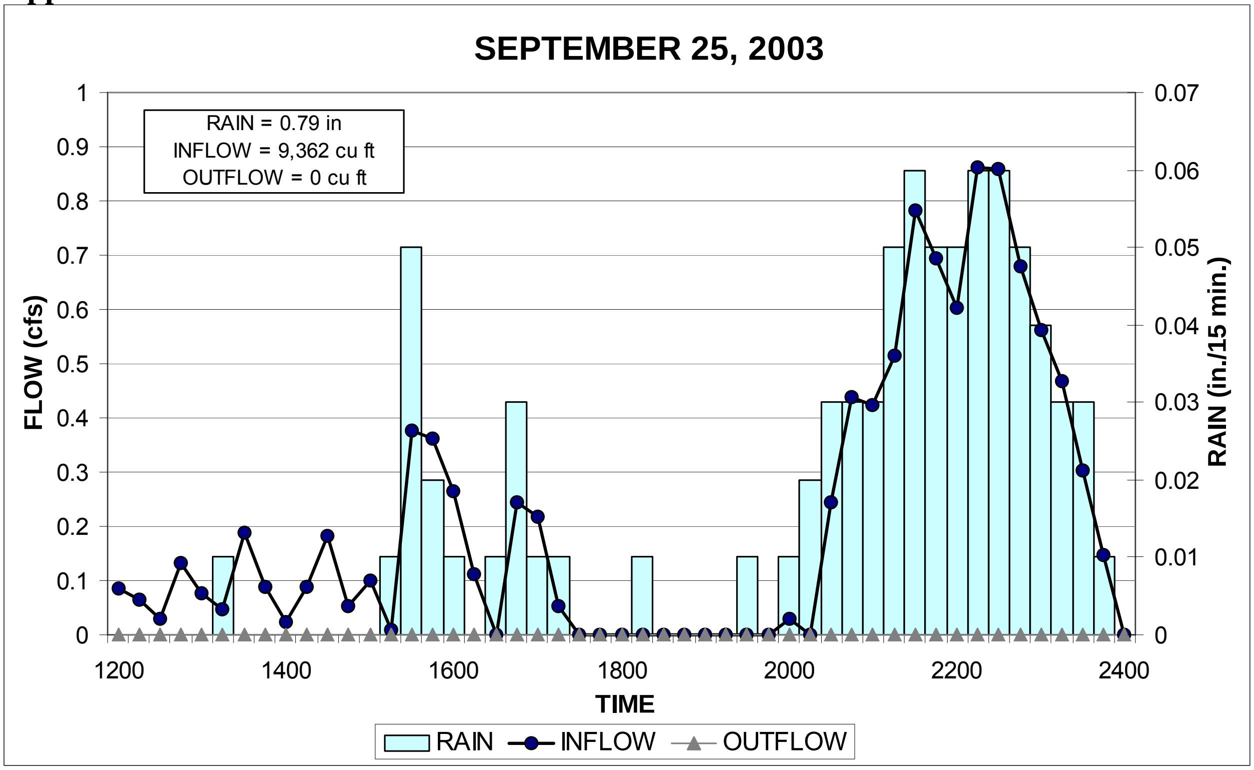

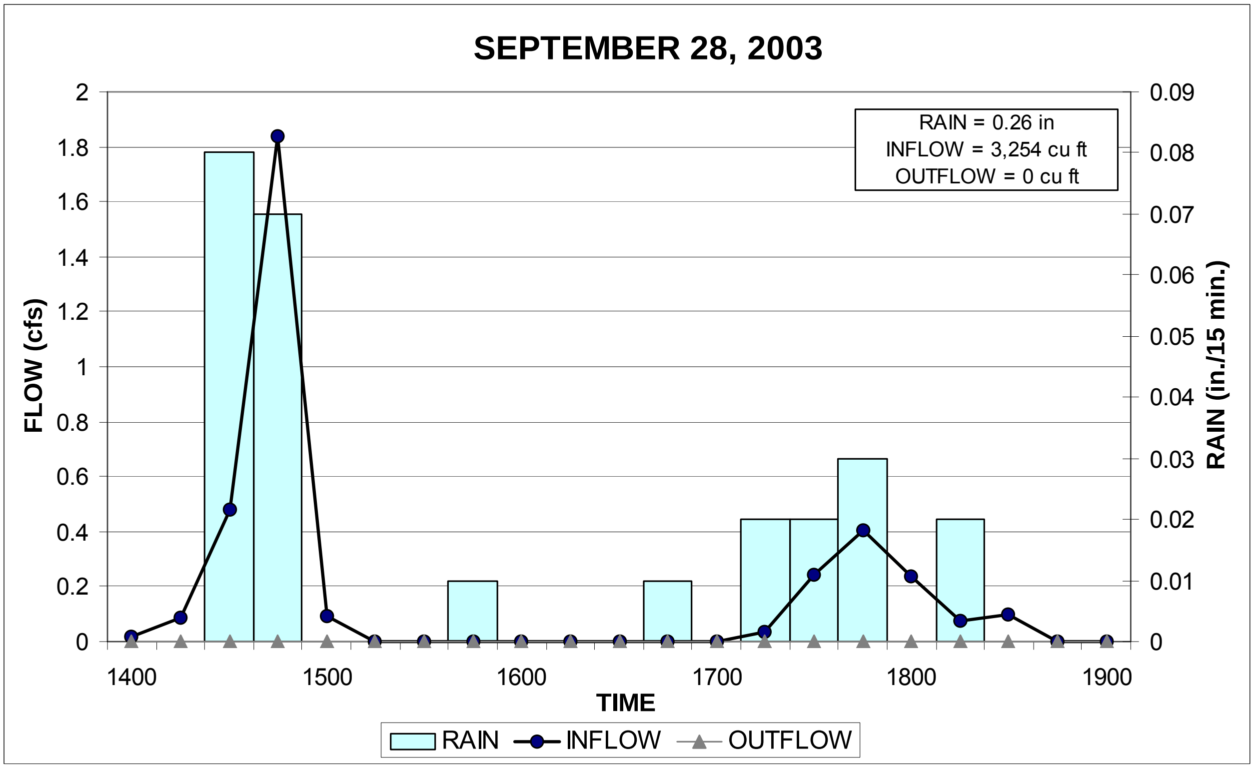

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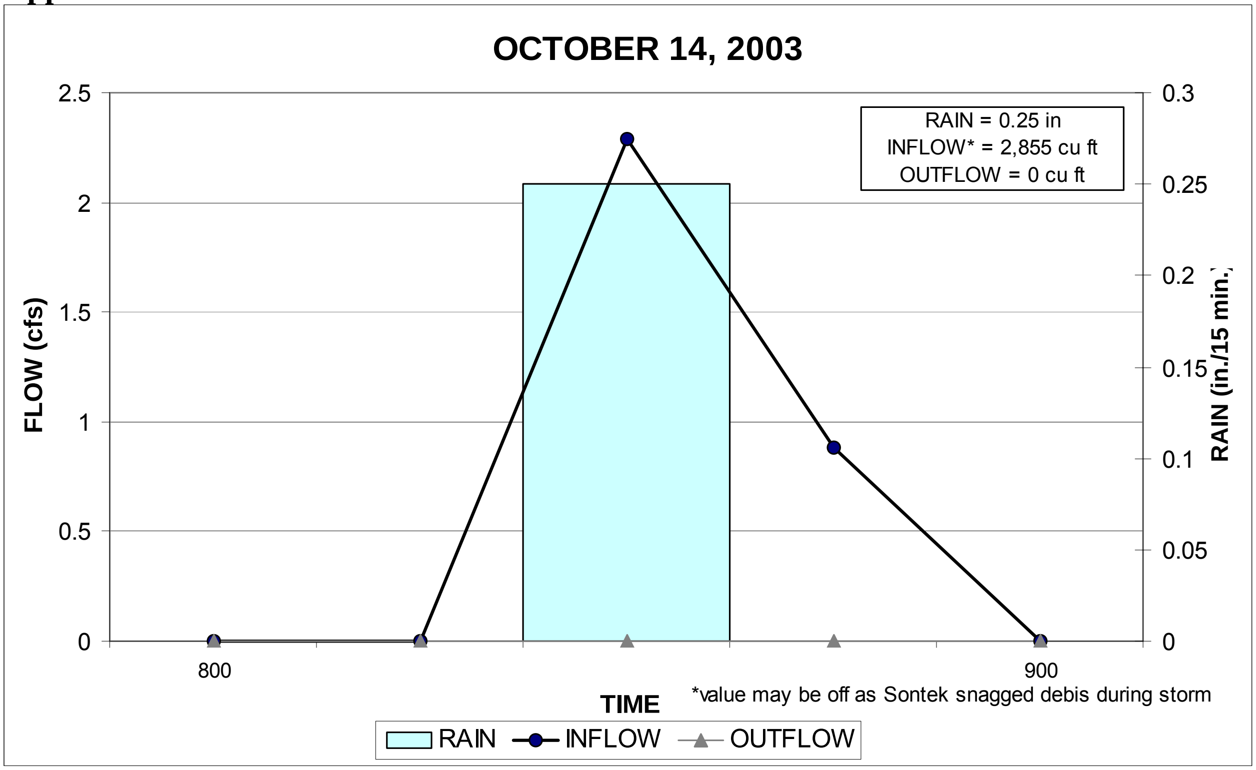
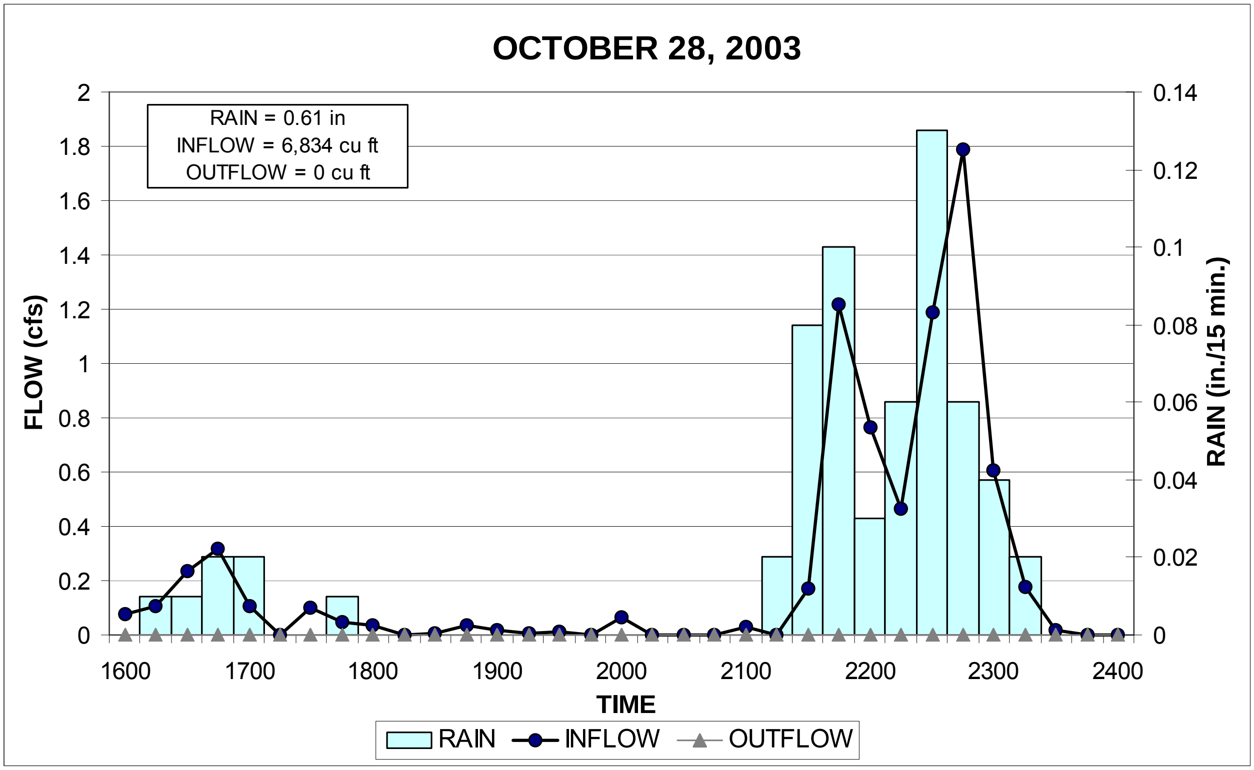


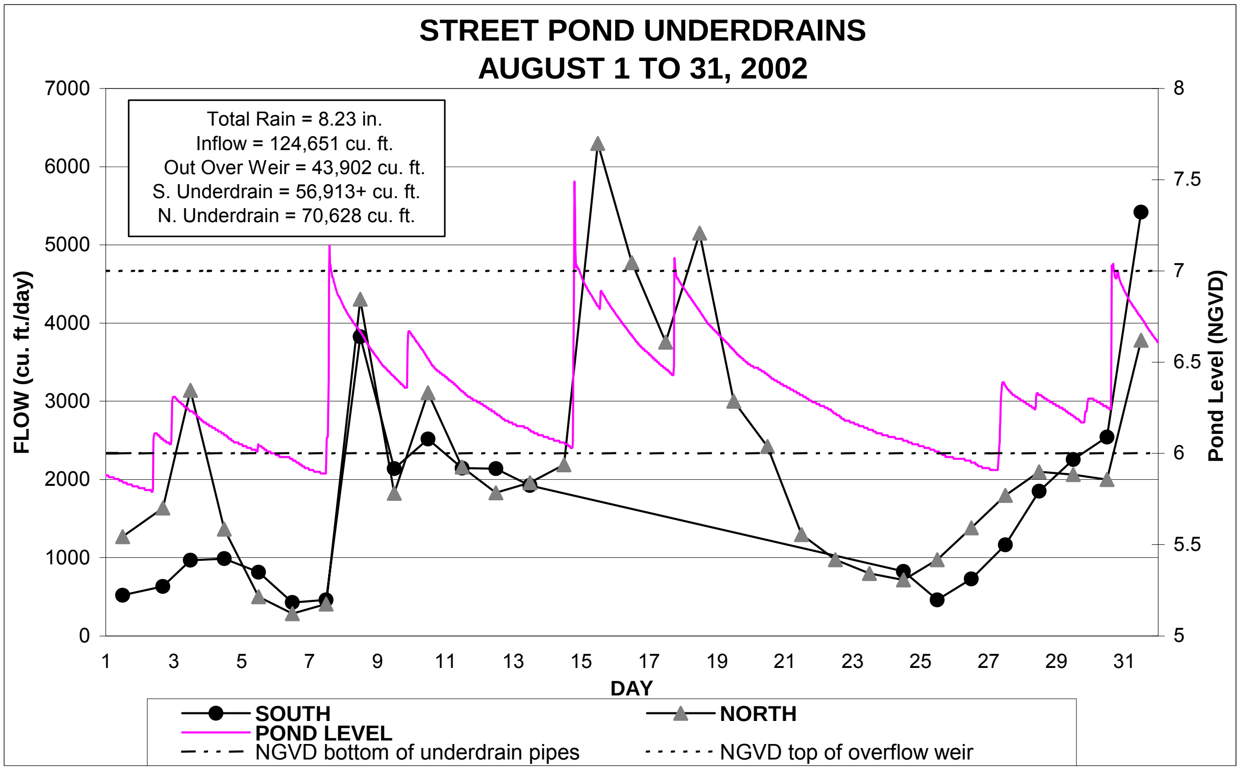


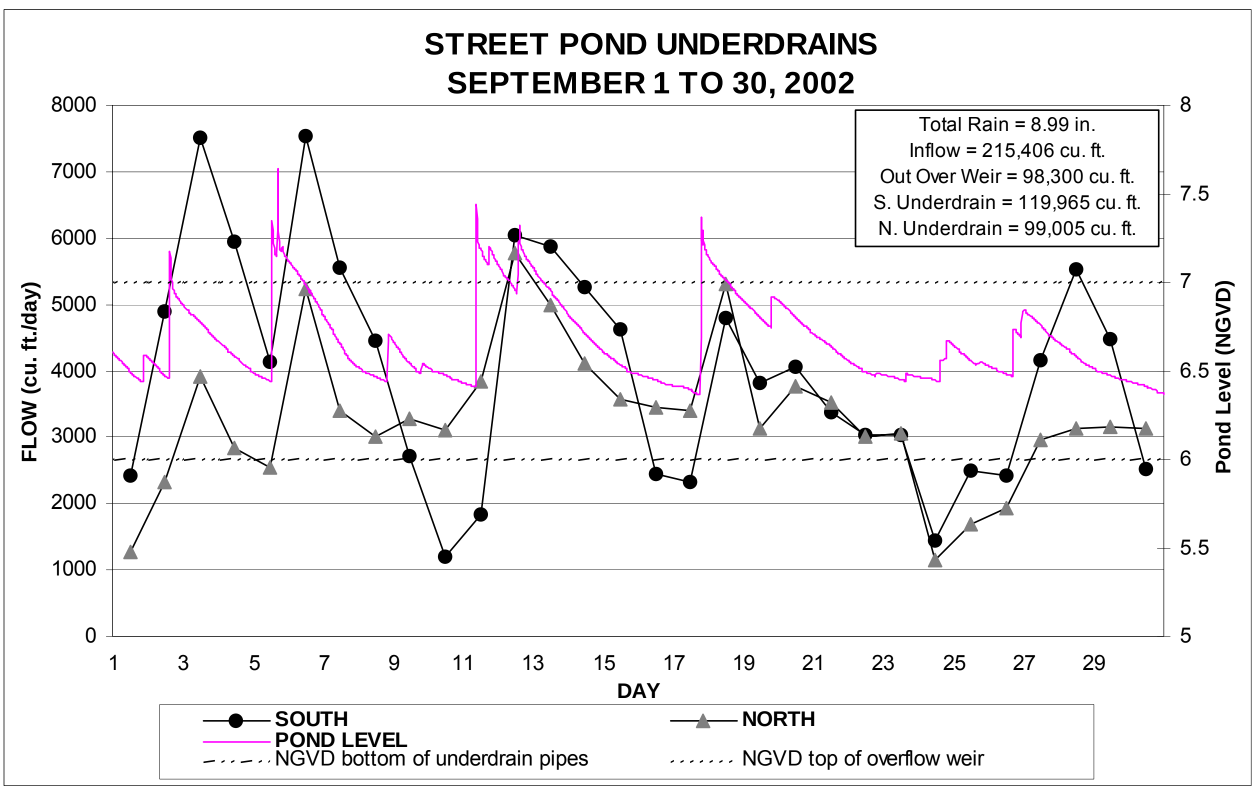
Appendix F

Year 2 Underdrain Flow compared to Pond Level

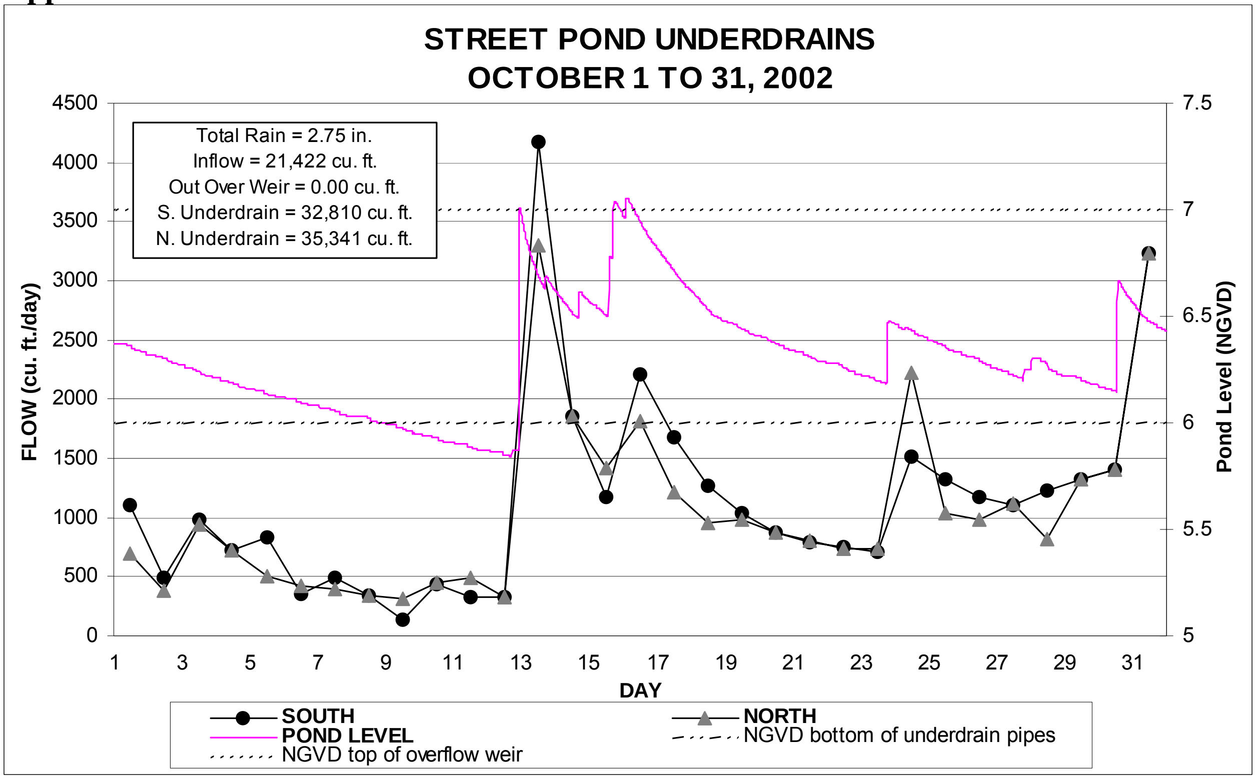
Underdrain flow is a best estimate from data. It was difficult to accurately measure the low flows discharging from the small 8 inch underdrain pipes.

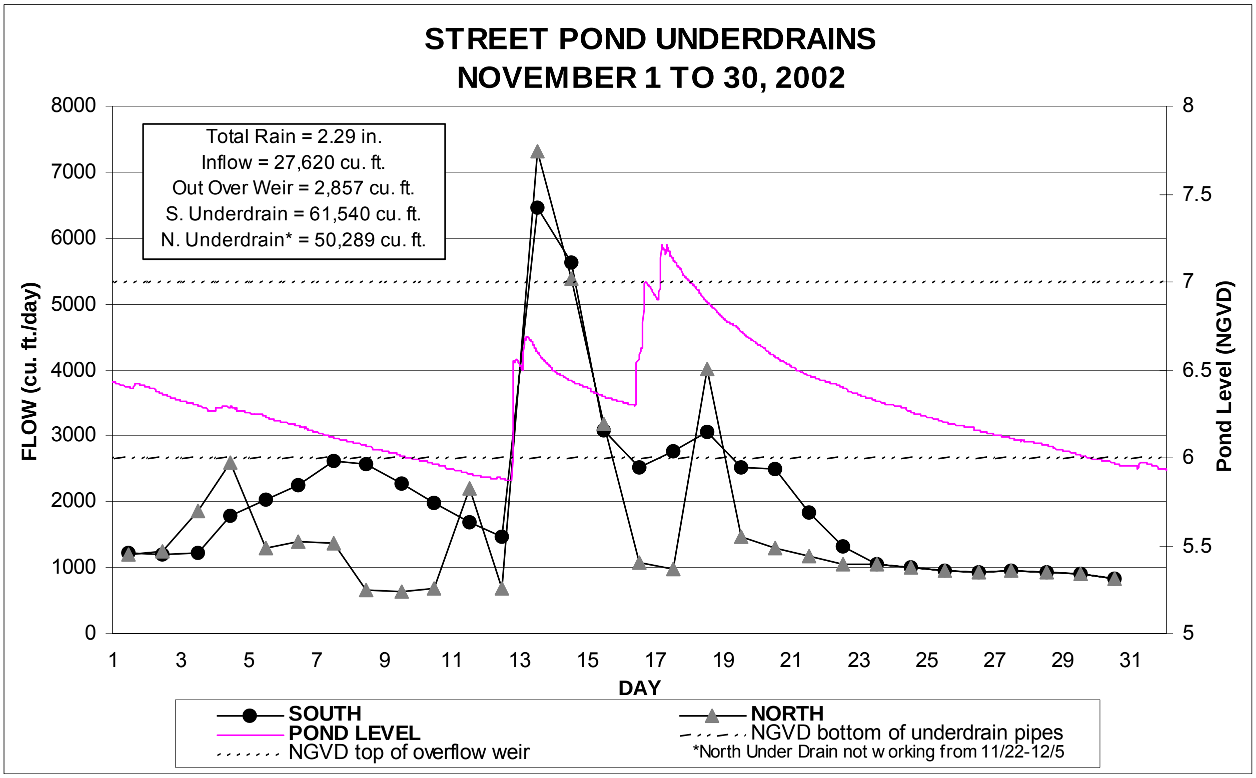
Appendix F. Monthly flow from the underdrains (north and south) compared to the pond level for Year 2.



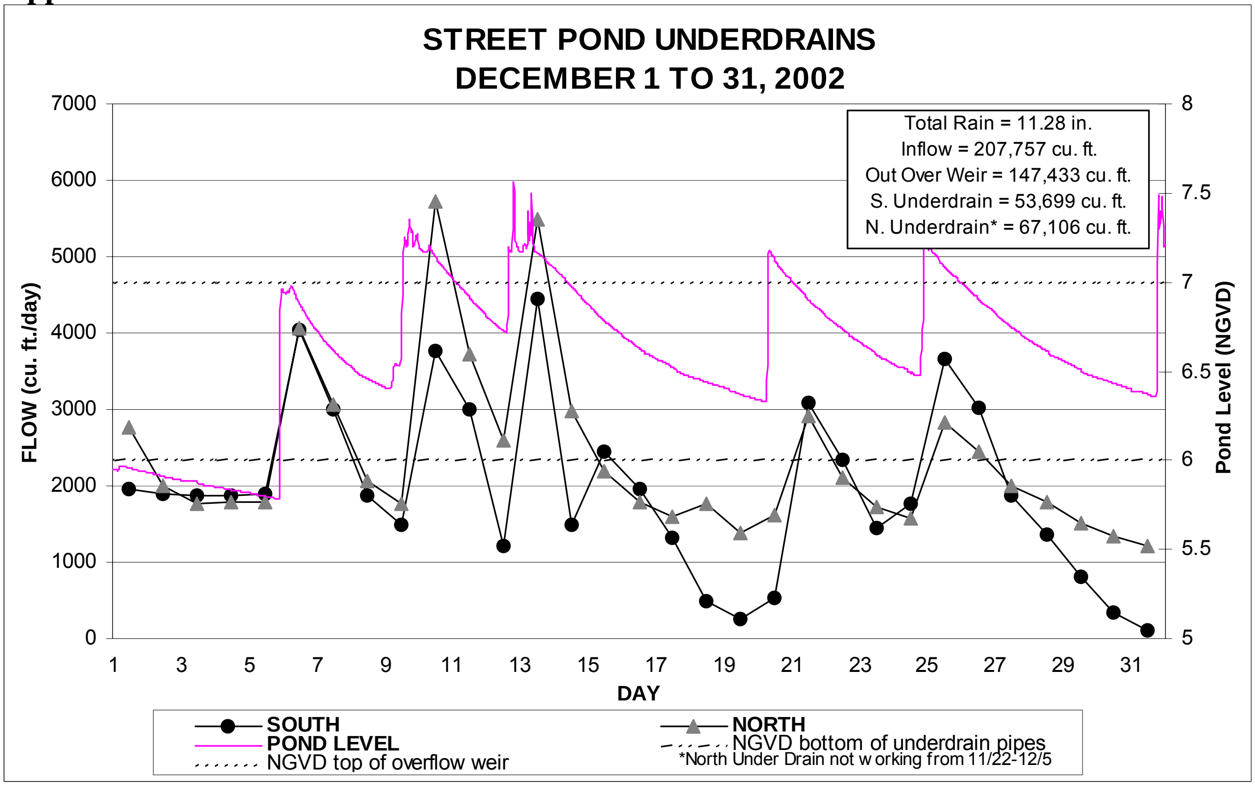


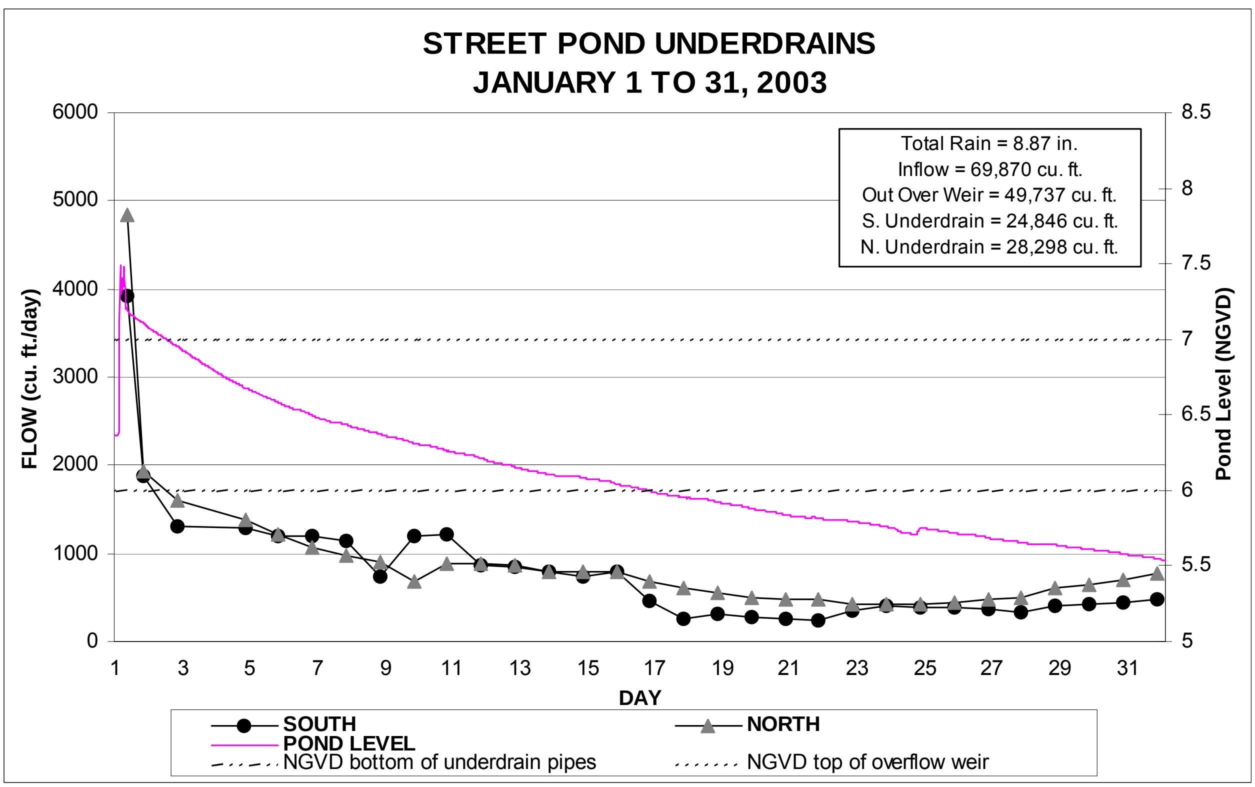
Appendix F. ***Continued***





Appendix F. ***Continued***





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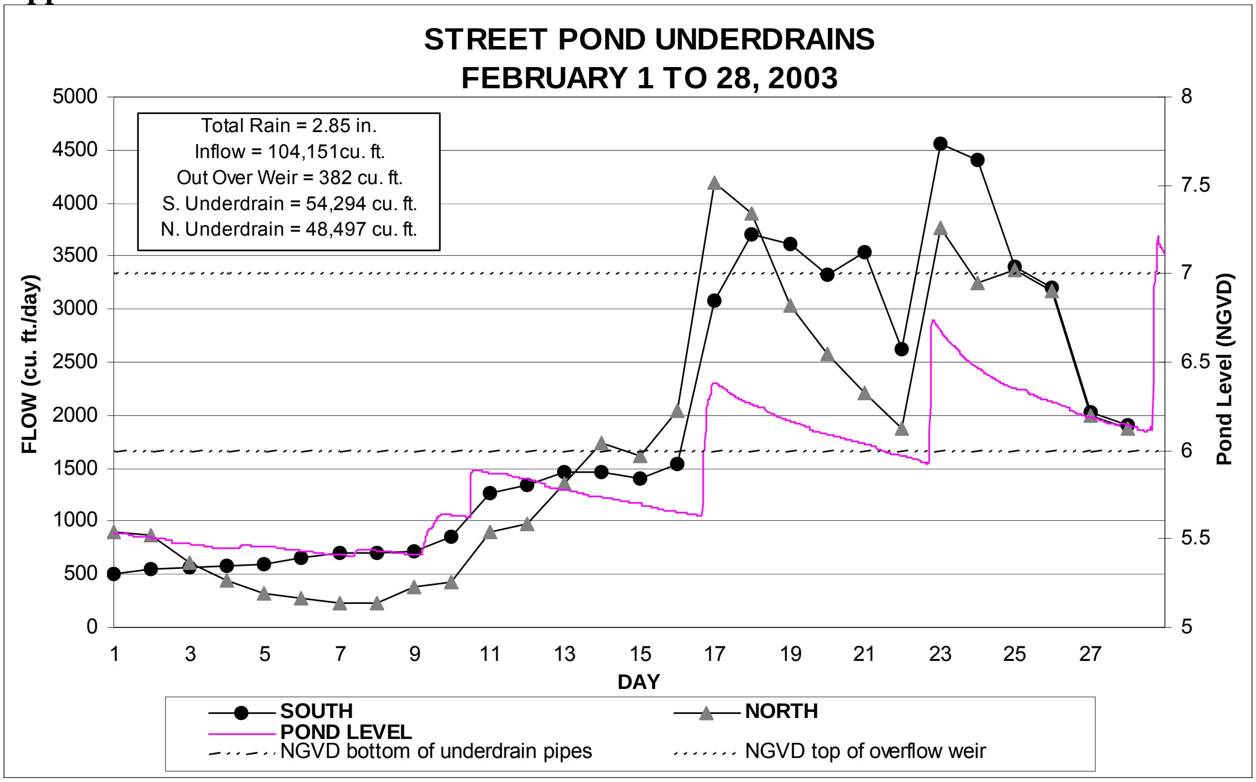

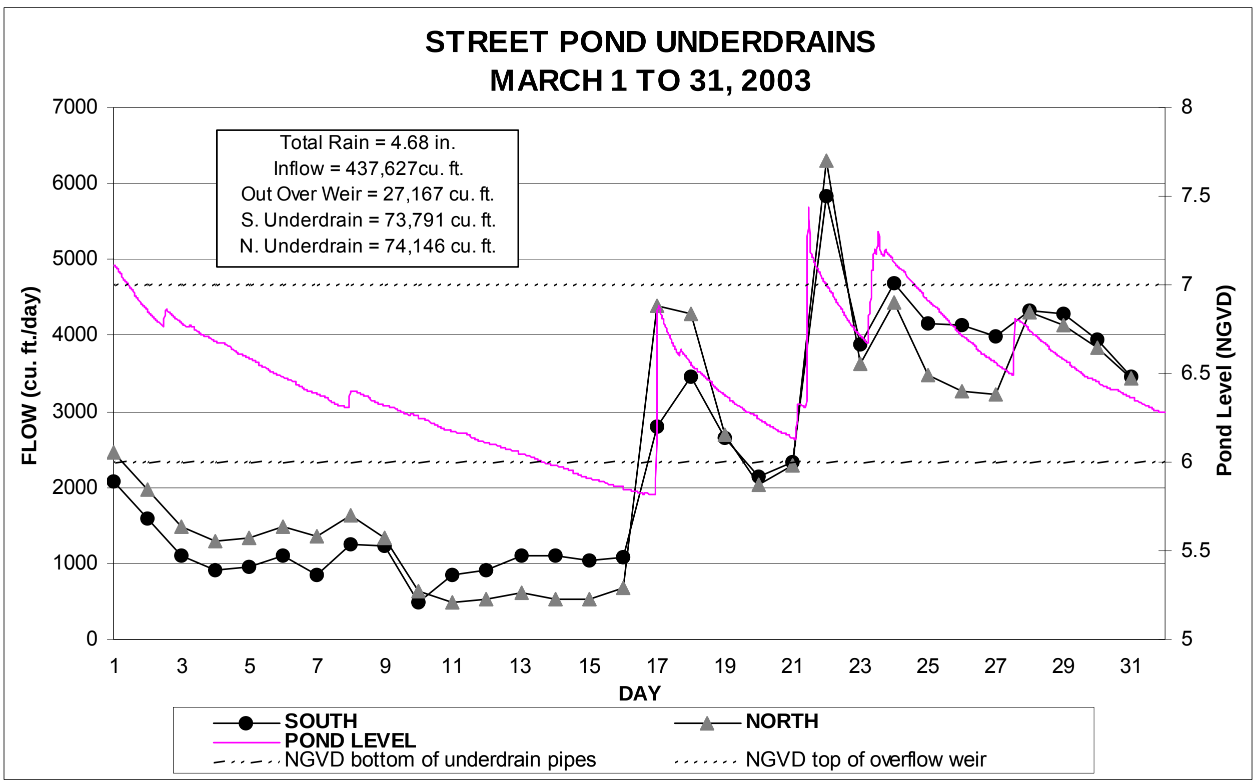

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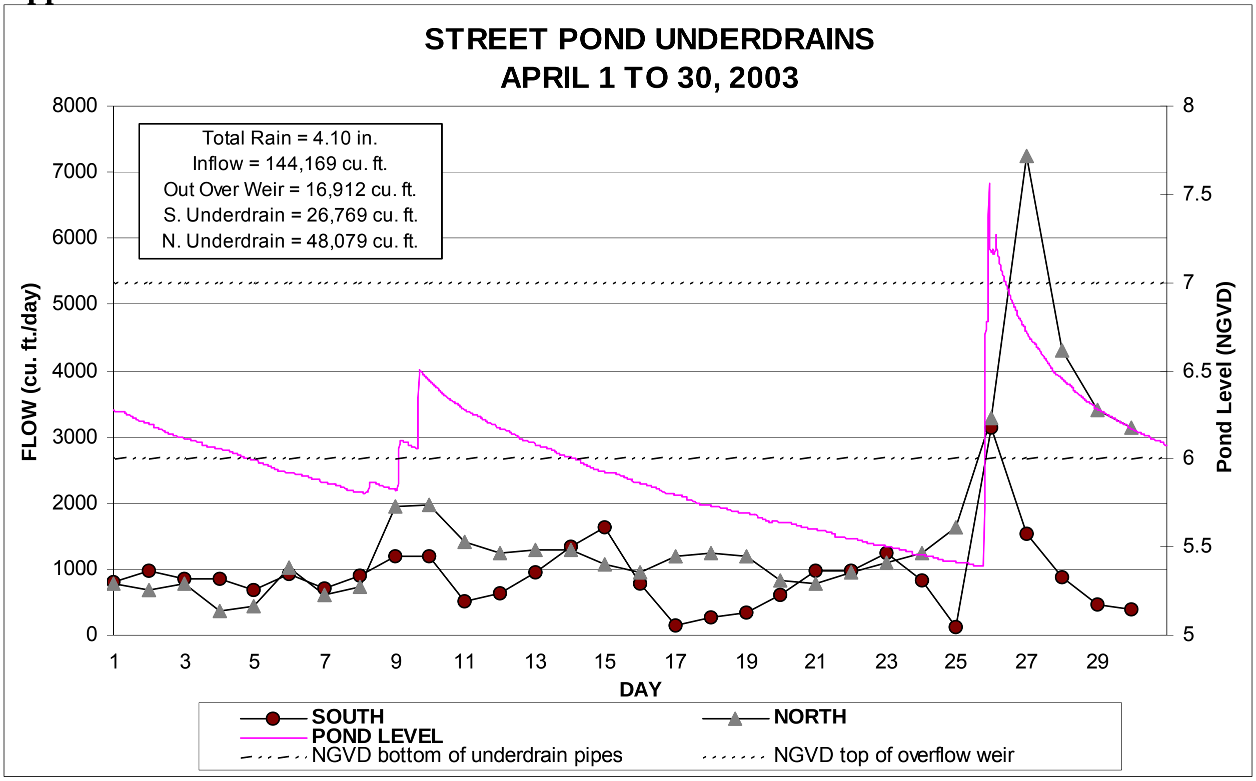
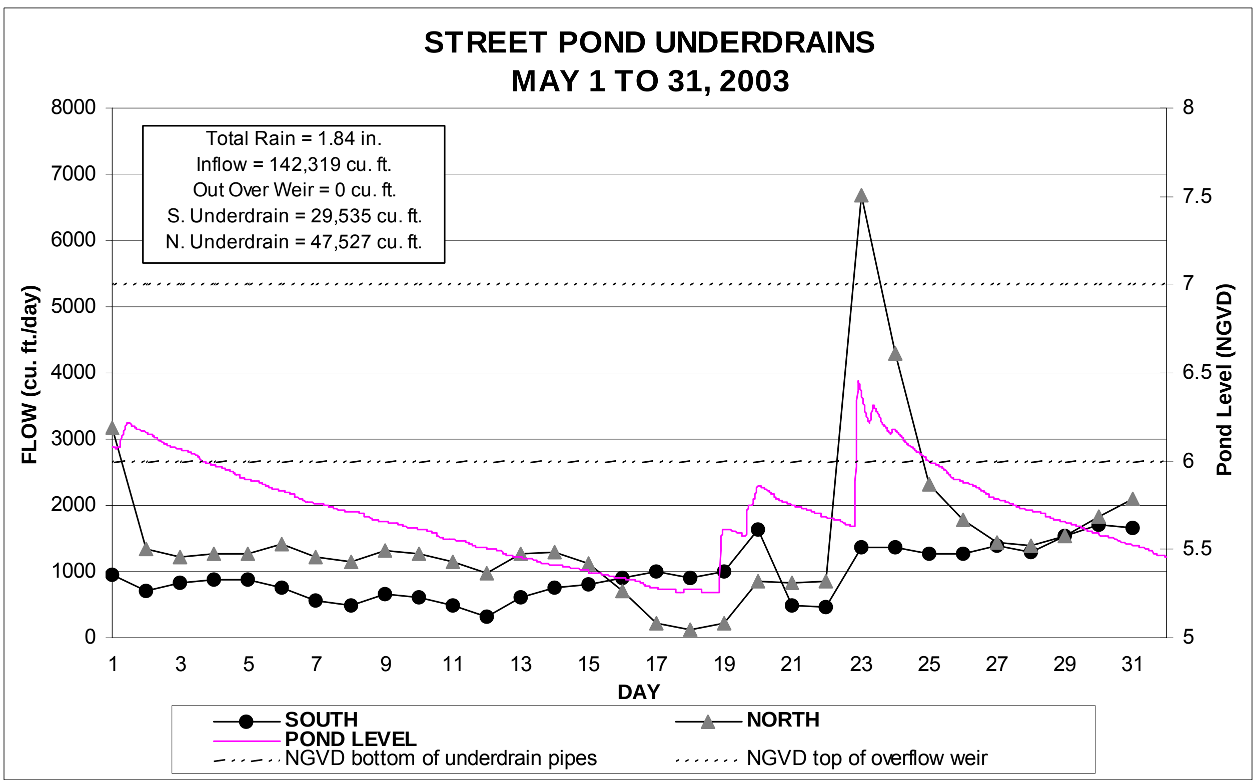
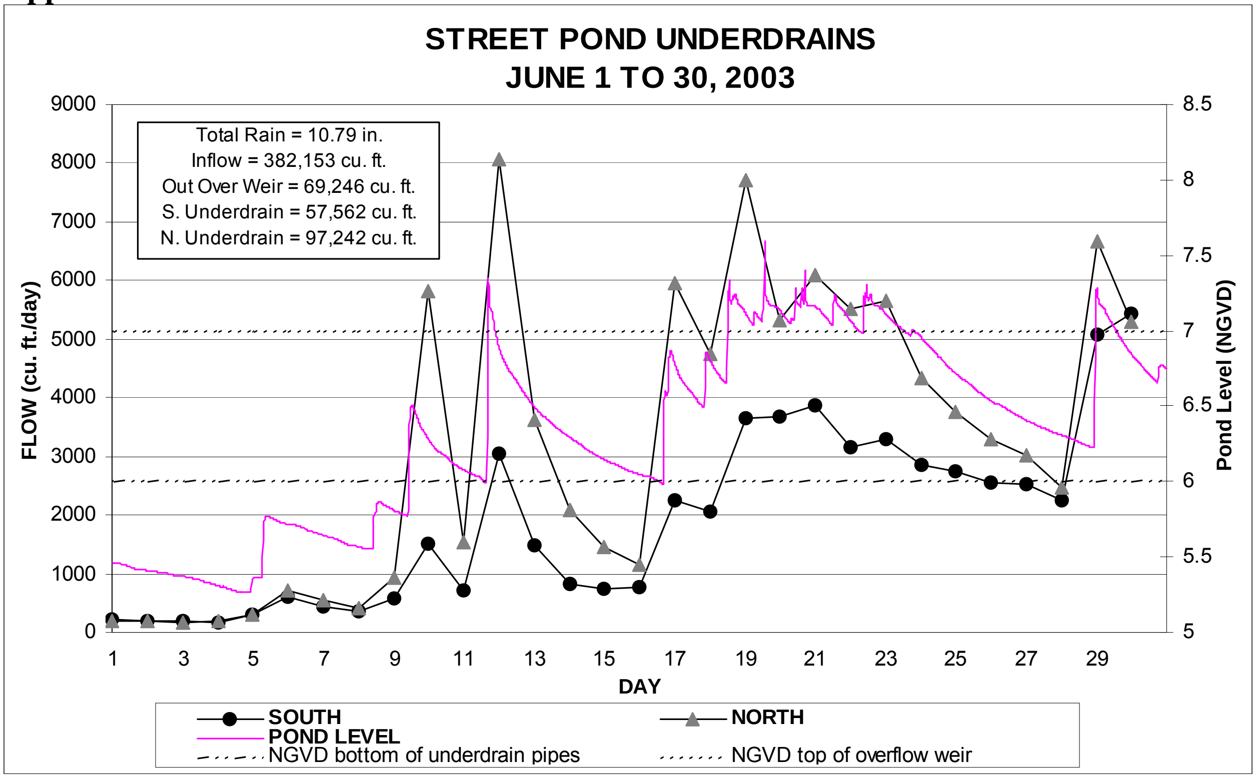
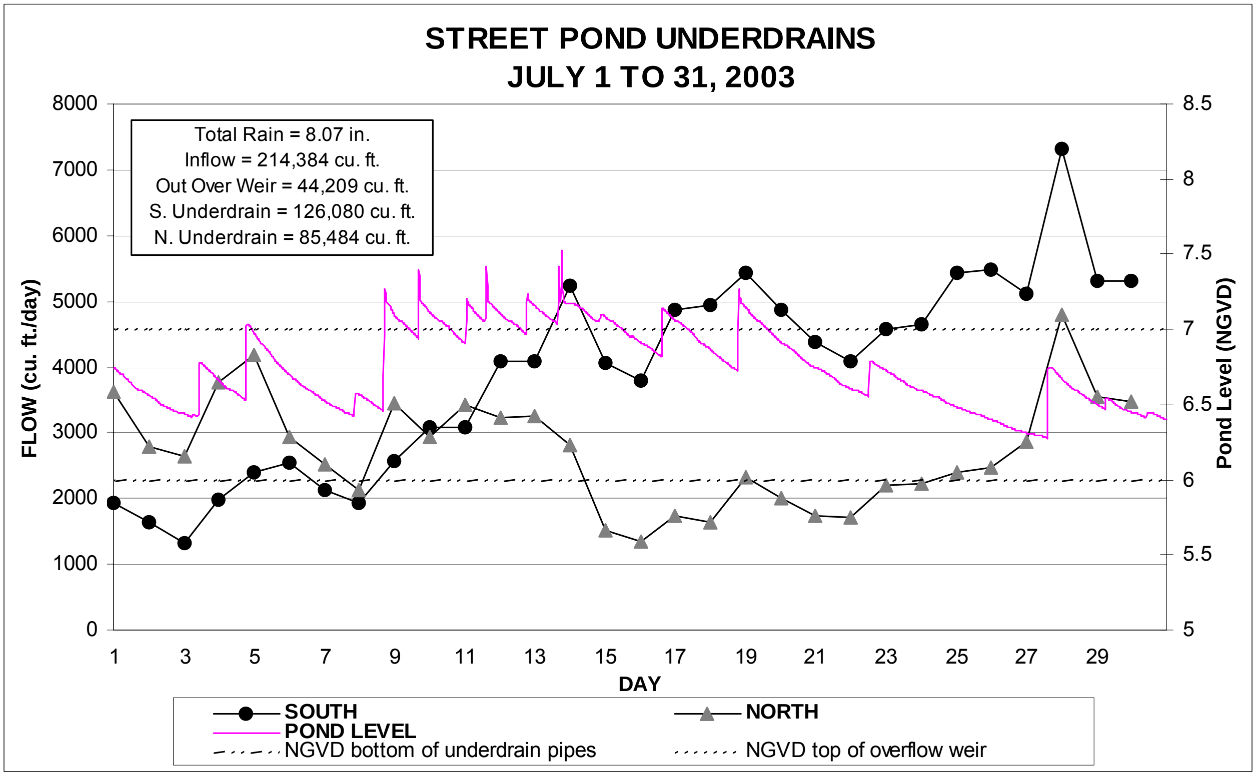


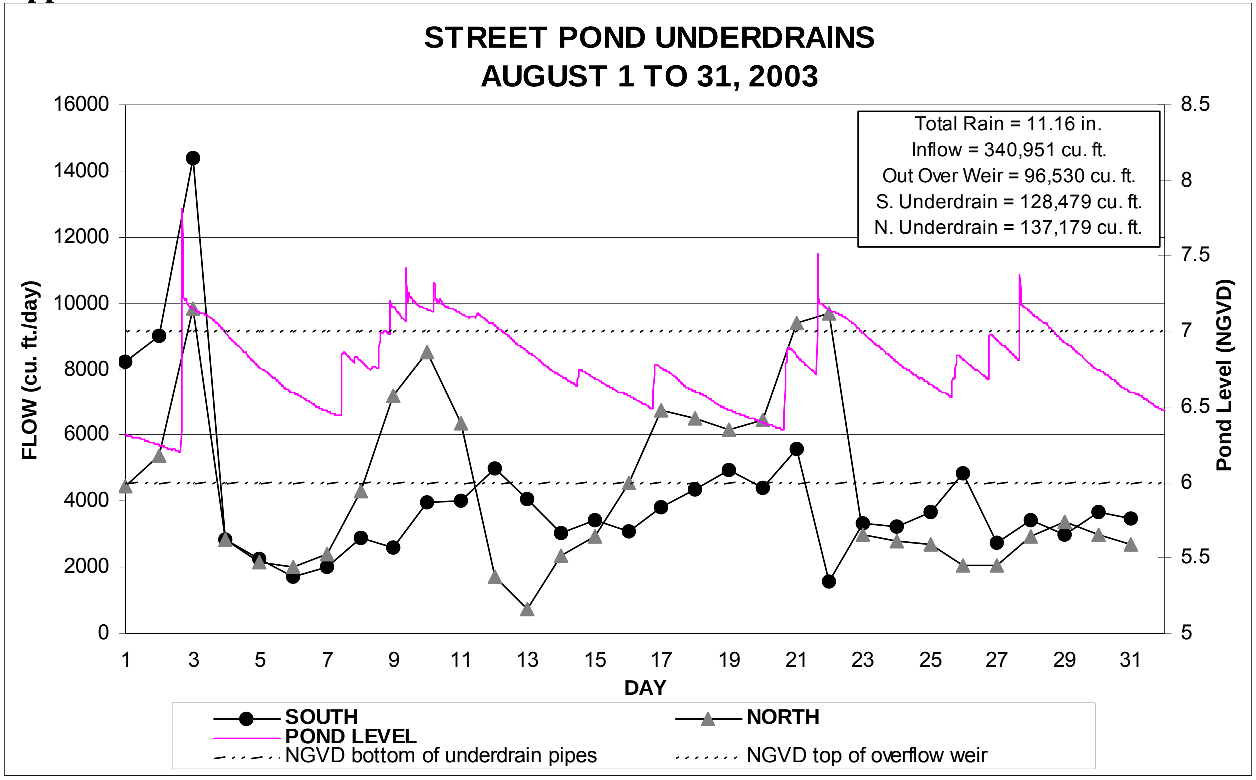


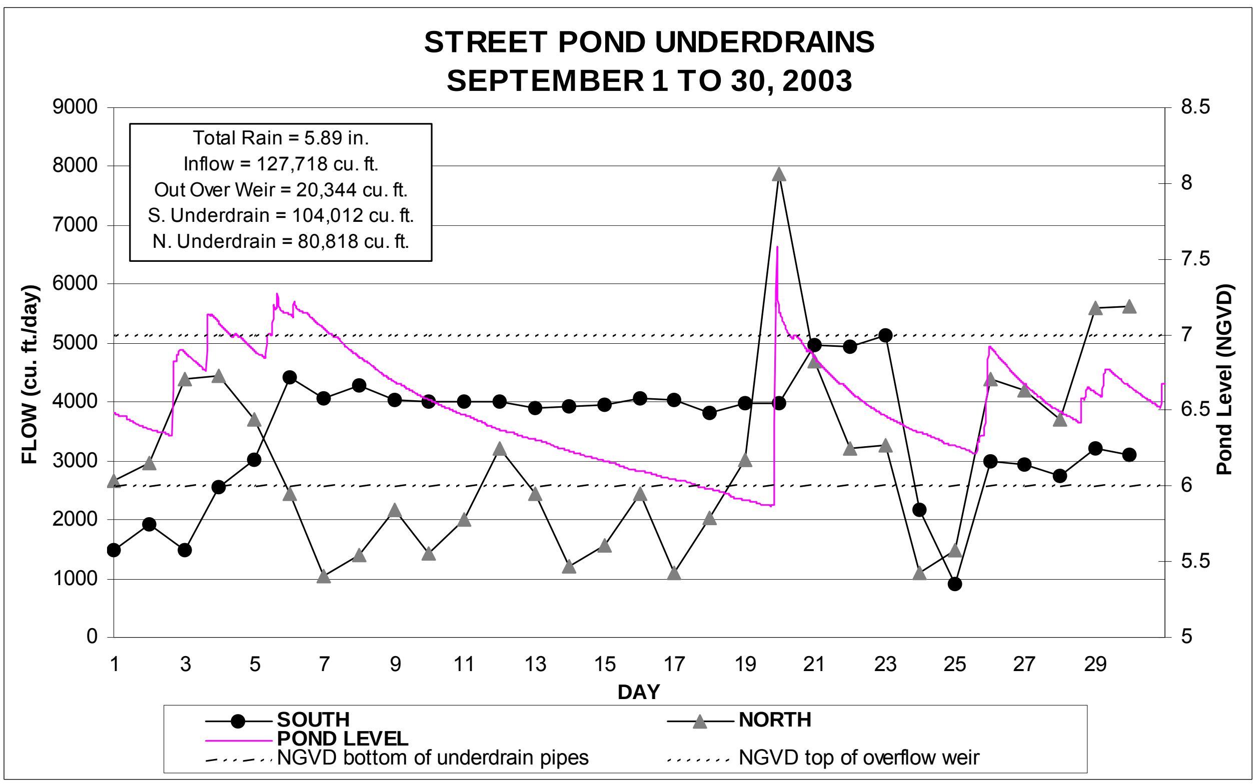
Appendix F. ***Continued***



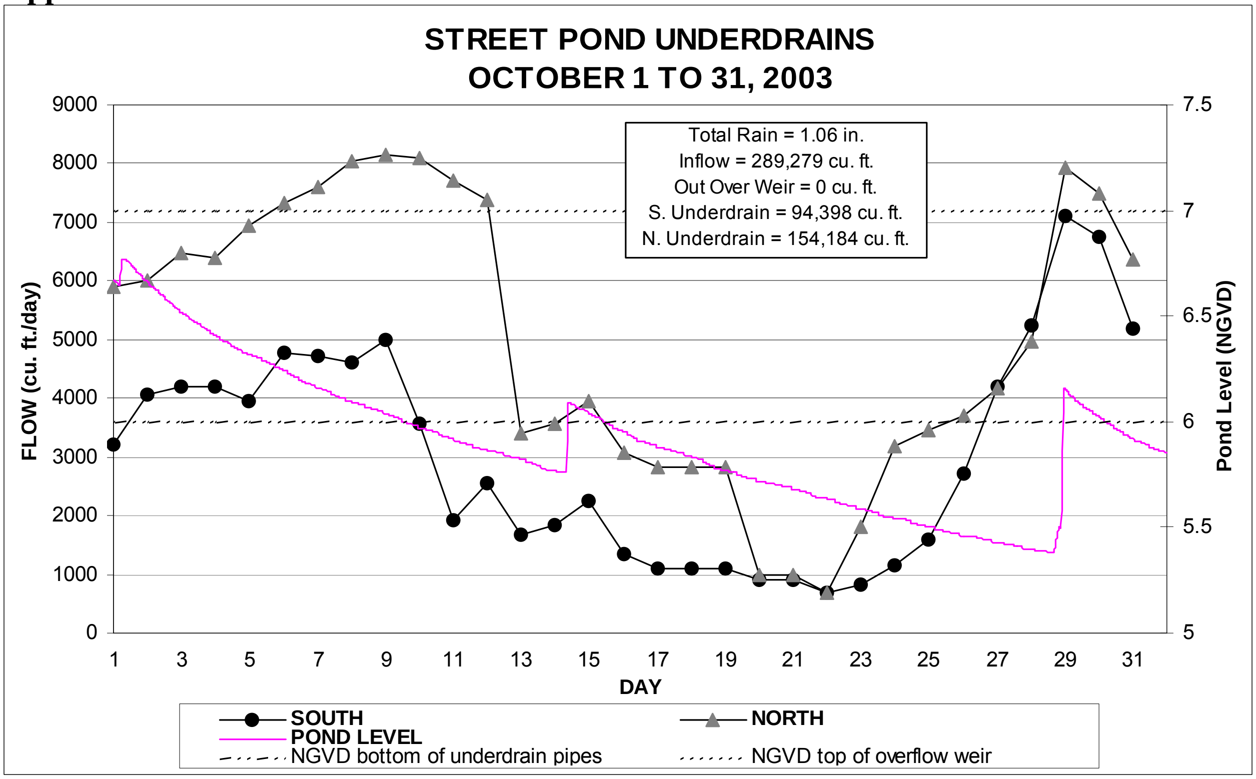


Appendix F. ***Continued***





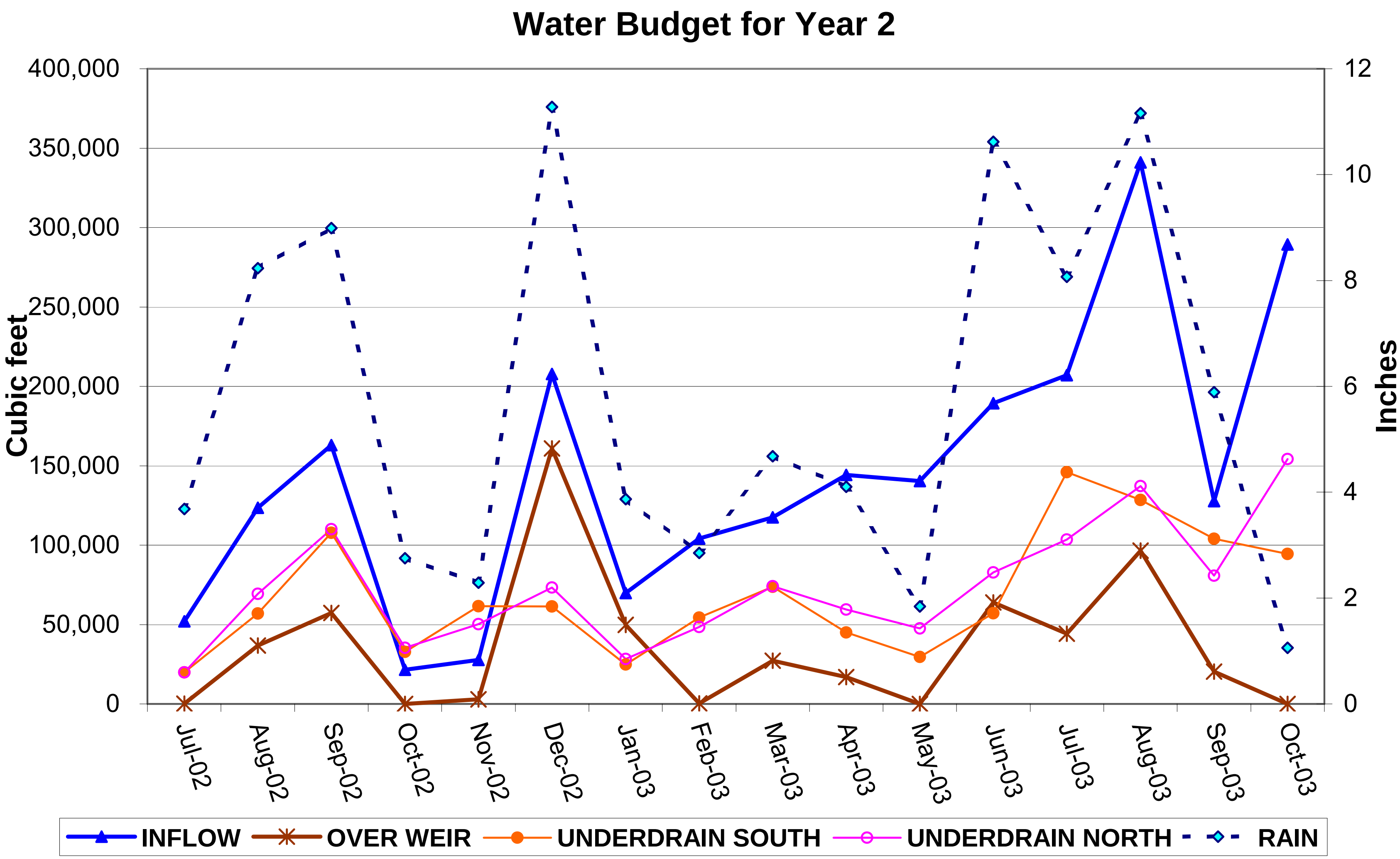
Appendix F. ***Continued***



Appendix G

Water Budget for Year 2

Appendix G. Relationship between rain, inflow, outflow over weir, and underdrain flow for Year 2. *July 2002 underdrain data were caculated from pond level and are likewise underestimated. **Two days of data were omitted from June 2003 data due to equipment malfunction. Also, for three days, the velocity meter was not recording data; inflow values were estimated for these days.



Appendix H

Water Quality for Inflow, Outfall, and Rainfall

Appendix H-1. Constituent concentrations measured in composite samples collected in Year 1 in rainfall (RAIN), at the inflow (INFL), outflow (OUFL), and underdrains (UNDER). **Numbers in italics are below the lab D.L., and 1/2 the D.L. was used in the calculations. *C.V. = Coefficient of Variation (Standard Deviation/Mean). Negative Organic Nitrogen values were changed to zero for calculations.

STORM #		AMMONIA mg/L				NITRATE + NITRITE mg/L				ORGANIC NITROGEN mg/L				TOTAL NITROGEN mg/L			
	L.O.Q.**	0.01				0.01				0.06				0.05			
	DATE	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER
1	11/25/00	0.121	0.041	0.075		0.084	-----	0.169		0.14	-----	0.64		0.34	-----	0.88	
2	12/18/00	0.068	0.059	*0.005*		0.054	0.267	0.019		0.31	0.77	0.75		0.43	1.10	0.77	
3	01/08/01	0.092	0.066	0.019		*0.085*	*0.221*	*0.113*		0.20	0.16	0.38		0.38	0.45	0.51	
4	03/04/01	0.192	0.005	0.011		0.105	0.247	0.073		0.90	0.67	0.91		1.20	0.92	0.99	
5	03/19/01	0.229	0.182	0.044		0.238	0.282	0.026		0.43	0.74	0.70		0.90	1.20	0.77	
6	03/29/01	0.212	0.150	0.049	See "Appendix F"	0.211	0.239	0.149	See "Appendix F"	0.19	0.28	0.44	See "Appendix F"	0.61	0.67	0.63	See "Appendix F"
7	06/06/01	0.156	0.028	0.031		0.287	0.316	0.181		0.00	0.65	0.46		0.40	0.99	0.67	
8	06/19/01	0.510	0.420	0.182		*0.869*	*0.748*	*0.000*		----	0.83	----		1.60	2.00	----	
9	06/23/01	0.088	0.144	0.028		*0.202*	*0.178*	*0.018*		0.12	0.65	*-0.05*		0.41	0.97	----	
10	06/28/01	0.086	0.088	*0.005*		*0.085*	*0.131*	*0.055*		0.23	0.23	0.46		0.40	0.45	0.52	
11	07/11/01	0.109	0.068	*0.005*		*0.440*	*0.291*	*0.008*		0.24	0.44	0.73		0.79	0.80	0.74	
12	07/13/01	----	0.047	0.021		*0.000*	*0.176*	*0.008*		----	0.31	0.42		----	0.53	0.45	
13	07/21/01	----	0.067	*0.005*		*0.000*	*0.063*	*0.008*		----	1.37	0.66		----	1.50	0.67	
14	07/23/01	0.029	0.005	0.018		*0.008*	*0.072*	*0.010*		0.00	0.16	0.25		0.03	0.24	0.28	
15	07/27/01	0.132	0.190	0.042		0.263	0.225	0.010		----	0.27	0.34		0.46	0.68	0.39	
16	08/05/01	0.071	0.072	0.035		0.051	0.139	0.008		4.73	0.65	2.38		4.85	0.86	2.42	
17	08/07/01	0.381	0.158	*0.005*		0.485	0.555	0.059		0.52	0.46	0.68		1.39	1.17	0.74	
	Count	14	16	16	29	14	15	15	29	12	15	15	29	14	15	14	29
	Average	0.169	0.106	0.038	0.257	0.204	0.259	0.054	0.111	0.58	0.53	0.59	0.39	0.93	0.88	0.70	0.76
	Median	0.121	0.068	0.025	0.200	0.105	0.225	0.019	0.089	0.23	0.65	0.46	0.34	0.46	0.86	0.67	0.64
	Max.	0.510	0.420	0.182	0.741	0.869	0.748	0.181	0.551	4.73	1.37	2.38	0.92	4.85	2.00	2.42	1.60
	Min.	0.029	0.005	0.005	0.044	0.000	0.063	0.000	0.008	0.00	0.16	-0.05	0.13	0.03	0.24	0.28	0.43
	Std. Dev.	0.129	0.102	0.044	0.199	0.225	0.174	0.062	0.111	1.26	0.33	0.54	0.19	1.16	0.45	0.51	0.31
	C.V.***	0.765	0.966	1.155	0.775	1.104	0.670	1.153	1.000	2.16	0.62	0.91	0.50	1.26	0.51	0.74	0.41

Appendix H-1. *Continued*

STORM #		ORTHO- PHOSPHATE mg/L				TOTAL - PHOSPHATE mg/L				TSS mg/L			TOTAL COPPER ug/L			
	L.O.Q.**	0.01				0.01							2.0			
	DATE	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER
1	11/25/00	0.016	----	0.105	See "Appendix F"	0.032	----	0.174	See "Appendix F"	----	6.4	See "Appendix F"	3.7	-----	9.5	See "Appendix F"
2	12/18/00	0.011	0.167	0.017		0.019	0.378	0.070		65.4	3.5		3.8	40.2	7.4	
3	01/08/01	0.005	0.090	0.052		0.030	0.171	0.095		22.7	4.5		4.2	12.9	5.5	
4	03/04/01	0.154	0.093	0.051		0.180	0.190	0.109		21.7	3.0		21.7	8.9	9.2	
5	03/19/01	0.005	0.124	0.033		0.036	0.228	0.080		35.2	2.8		4.4	11.4	2.9	
6	03/29/01	0.013	0.069	0.039		0.024	0.144	0.073		20.0	4.9		4.7	12.2	3.2	
7	06/06/01	0.014	0.094	0.067		0.013	0.428	0.161		64.2	5.3		*1.0*	30.1	5.0	
8	06/20/01	0.024	0.207	----		0.031	0.346	----		46.7	----		7.4	19.2	----	
9	06/22/01	0.005	0.081	0.019		0.017	0.472	0.064		113.2	4.3		2.9	35.0	4.4	
10	06/28/01	0.005	0.161	0.057		0.012	0.504	0.131		81.0	13.6		*1.0*	19.0	3.4	
11	07/11/01	0.005	0.091	0.040		*0.005*	0.315	0.059		68.9	2.6		2.2	13.8	2.5	
12	07/13/01	----	0.060	0.043		----	0.215	0.078		38.3	2.8		----	16.8	1.0	
13	07/22/01	----	0.088	0.010		----	0.282	0.078		75.7	2.4		----	14.6	1.0	
14	07/23/01	0.005	0.193	0.049		0.012	0.346	0.083		63.1	3.9		2.1	9.5	2.5	
15	07/27/01	0.005	0.132	0.039		0.015	0.389	0.060		49.9	2.1		*1.0*	12.7	2.2	
17	08/05/01	0.005	0.073	0.016		*0.005*	0.196	0.025		43.0	2.0		*1.0*	9.4	1.0	
18	08/07/01	0.012	0.050	0.032		0.023	1.210	0.047		239.0	12.1		2.3	40.8	2.7	
	Count	14	15	15	29	14	15	15	29	15	15	14	15	16	16	29
	Average	0.019	0.112	0.040	0.127	0.030	0.298	0.080	0.148	63.0	4.1	1.1	4.2	19.2	4.0	3.0
	Median	0.005	0.093	0.040	0.104	0.019	0.315	0.078	0.115	56.5	3.7	1.2	2.9	14.2	3.0	2.3
	Max.	0.154	0.207	0.105	0.331	0.180	0.504	0.174	0.359	239.0	13.6	2.2	21.7	40.8	9.5	8.1
	Min.	0.005	0.060	0.010	0.055	0.005	0.144	0.025	0.072	20.0	2.0	0.1	1.0	8.9	1.0	1.0
	Std. Dev.	0.038	0.047	0.024	0.072	0.043	0.114	0.040	0.082	52.5	3.4	0.5	5.0	10.7	2.6	2.0
	C.V.***	2.022	0.417	0.597	0.565	1.415	0.382	0.499	0.551	0.8	0.8	0.5	1.2	0.6	0.7	0.7

Appendix H-1. ***Continued***

STORM #	L.O.Q.**	TOTAL LEAD ug/L 1.50				TOTAL ZINC ug/L 15.0				MANGANESE ug/L 1.0				TOTAL IRON ug/L 25.0			
	DATE	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER
1	11/25/00	*0.75*	----	1.50		30.0	-----	------		1.40	-----	11.30		40.0	----	200.0	
2	12/18/00	*0.75*	14.50	0.75		60.0	140.0	7.5		2.70	38.30	6.50		160.0	1530.0	80.0	
3	01/08/01	*0.75*	6.60	2.20		20.0	50.0	20.0		2.00	12.10	8.80		50.0	510.0	130.0	
4	03/04/01	*0.75*	3.10	2.00		60.0	40.0	20.0		2.50	9.30	8.50		130.0	260.0	140.0	
5	03/19/01	*0.75*	6.70	0.75		40.0	70.0	7.5		2.60	20.40	7.10		40.0	700.0	70.0	
6	03/29/01	1.79	6.93	1.83		39.2	77.2	21.2		3.77	12.21	5.87		168.2	586.9	136.2	
7	06/06/01	*0.75*	21.40	2.00		20.0	130.0	20.0		1.40	28.00	11.50		40.0	1910.0	150.0	
8	06/20/01	1.70	11.00	----		30.0	100.0	----		4.60	27.00	----		80.0	1120.0	----	
9	06/22/01	*0.75*	27.10	0.75	See "Appendix F"	*7.5*	200.0	7.5	See "Appendix F"	1.30	37.10	10.70	See "Appendix F"	40.0	2920.0	80.0	See "Appendix F"
10	06/28/01	*0.75*	26.40	3.40		*7.5*	100.0	7.5		1.40	28.30	8.90		30.0	2580.0	330.0	
11	07/11/01	*0.75*	16.70	0.75		*7.5*	100.0	7.5		1.80	24.90	9.50		*12.5*	1860.0	100.0	
12	07/13/01	----	14.50	0.75		----	90.0	7.5		----	20.30	6.90		----	1350.0	70.0	
13	07/22/01	----	15.70	0.75		----	80.0	20.0		----	29.10	17.10		----	1680.0	60.0	
14	07/23/01	*0.75*	14.70	0.75		*7.5*	60.0	20.0		*0.50*	15.00	11.40		*12.5*	1910.0	130.0	
15	07/27/01	*0.75*	10.70	0.75		70.0	90.0	7.5		1.40	21.30	12.90		60.0	1200.0	70.0	
16	08/05/01	*0.75*	9.60	0.75		*7.5*	70.0	7.5		1.30	20.20	4.50		40.0	1110.0	60.0	
17	08/07/01	1.50	45.00	2.20		40.0	220.0	7.5		1.90	65.60	9.10		90.0	6320.0	240.0	
	Count	15	16	16	29	15	16	15	29	15	16	16	29	15	16	16	29
	Average	0.93	15.66	1.37	0.99	29.8	101.1	12.6	10.6	2.04	25.57	9.41	7.17	66.2	1721.7	127.9	75.0
	Median	0.75	14.50	0.75	0.75	30.0	90.0	7.5	7.5	1.80	23.10	9.00	6.20	40.0	1440.0	115.0	50.0
	Max.	1.79	45.00	3.40	4.30	70.0	220.0	21.2	40.0	4.60	65.60	17.10	16.20	168.2	6320.0	330.0	430.0
	Min.	0.75	3.10	0.75	0.75	7.5	40.0	7.5	7.5	0.50	9.30	4.50	1.80	12.5	260.0	60.0	12.5
	Std. Dev.	0.37	10.08	0.79	0.89	20.7	48.4	6.2	8.8	1.02	13.14	2.99	3.93	48.2	1381.3	72.4	84.2
	C.V.***	0.40	0.64	0.58	0.90	0.7	0.5	0.5	0.8	0.50	0.51	0.32	0.55	0.7	0.8	0.6	1.1

Appendix H-1. ***Continued***

STORM #	L.O.Q.**	TOTAL CADMIUM ug/L 0.3				HARDNESS mg/L as CaCO3 20.0				CALCIUM (mg/l) 0.25				MAGNESIUM mg/L			
	DATE	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER
1	11/25/00	0.15	----	0.15	See "Appendix F"	0.6	----	82.4	See "Appendix F"	*0.15*	----	27.40	See "Appendix F"	0.05	----	3.39	See "Appendix F"
2	12/18/00	0.15	1.10	0.15		0.6	125.6	109.2		*0.15*	44.10	37.00		0.06	3.75	4.08	
3	01/08/01	0.15	0.15	0.15		0.8	52.6	83.0		*0.15*	19.10	28.70		0.11	1.18	2.76	
4	03/04/01	0.15	0.15	0.15		1.6	60.0	91.6		*0.15*	21.40	31.90		0.30	1.59	2.91	
5	03/19/01	0.15	0.60	0.15		1.0	85.0	80.2		*0.15*	30.60	28.40		0.15	2.09	2.25	
6	03/29/01	0.15	0.21	0.15		0.8	33.6	44.9		*0.15*	12.62	15.84		0.10	0.50	1.30	
7	06/06/01	0.15	0.40	0.15		0.6	86.1	71.2		*0.15*	32.60	26.10		0.06	1.14	1.46	
8	06/19/01	0.15	0.30	----		0.8	91.3	----		*0.15*	33.40	----		*0.10*	1.92	----	
9	06/23/01	0.15	0.50	0.15		0.8	96.0	78.3		*0.15*	36.80	28.50		*0.10*	1.01	1.74	
10	06/28/01	0.15	0.50	0.15		0.8	70.1	56.8		*0.15*	26.90	20.90		*0.10*	0.71	1.11	
11	07/11/01	0.15	0.40	0.15		0.8	77.2	83.2		*0.15*	29.20	30.30		*0.10*	1.05	1.82	
12	07/13/01	----	0.30	0.15		----	58.0	72.6		----	22.20	26.70		----	0.63	1.44	
13	07/21/01	----	0.30	0.15		----	72.0	73.8		----	27.50	27.10		----	0.82	1.48	
14	07/23/01	0.15	0.15	0.15		0.8	64.2	72.9		*0.15*	24.50	27.40		*0.10*	0.73	1.09	
15	07/27/01	0.15	0.15	0.15		0.8	105.4	77.0		*0.15*	38.70	28.50		*0.10*	2.14	1.41	
16	08/05/01	0.15	0.15	0.15		0.8	85.5	76.5		*0.15*	31.90	28.10		*0.10*	1.41	1.54	
17	08/07/01	0.15	0.80	0.15		0.8	172.4	68.4		*0.15*	66.80	25.00		*0.10*	1.35	1.44	
	Count	15	16	16	29	15	16	16	29	15	16	16	29	15	16	16	29
	Average	0.15	0.39	0.15	0.16	0.8	83.4	76.4	138.1	0.15	31.15	27.37	45.45	0.11	1.38	1.95	6.98
	Median	0.15	0.30	0.15	0.15	0.8	81.1	76.7	126.3	0.15	29.90	27.75	41.20	0.10	1.16	1.51	5.66
	Max.	0.15	1.10	0.15	0.40	1.6	172.4	109.2	299.5	0.15	66.80	37.00	82.00	0.30	3.75	4.08	23.00
	Min.	0.15	0.15	0.15	0.15	0.6	33.6	44.9	53.2	0.15	12.62	15.84	18.20	0.05	0.50	1.09	1.89
	Std. Dev.	0.00	0.26	0.00	0.05	0.2	31.4	13.6	51.2	0.00	11.93	4.40	14.35	0.06	0.79	0.85	4.87
	C.V.***	0.00	0.68	0.00	0.33	0.3	0.4	0.2	0.4	0.00	0.38	0.16	0.32	0.52	0.57	0.44	0.70

Appendix H-1. *Continued*

STORM #	L.O.Q.**	CHLORIDE mg/L 0.4				POTASSIUM mg/L 0.04				SODIUM mg/L 0.06				SULFATE mg/L			
	DATE	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER
1	11/25/00	1.1	----	27.7		0.10	----	8.86		0.38	----	24.50		1.25	----	39.20	
2	12/18/00	1.4	27.8	29.5		0.07	8.06	9.44		0.63	22.60	26.00		1.21	40.30	40.70	
3	1/8/01	2.2	9.6	20.7		0.02	4.58	6.90		1.13	8.03	17.80		2.26	12.30	27.70	
4	3/4/01	2.7	12.6	24.3		0.52	5.21	6.78		1.66	11.70	21.20		2.22	16.70	31.30	
5	3/19/01	1.8	14.2	17.8		0.15	5.77	6.07		0.88	12.60	15.60		2.46	20.40	24.50	
6	3/29/01	1.6	3.5	10.2	See "Appendix F"	0.02	2.51	4.30	See "Appendix F"	0.60	3.30	9.40	See "Appendix F"	2.40	6.60	15.40	See "Appendix F"
7	6/6/01	1.1	7.0	12.4		0.04	3.30	5.17		0.20	6.14	11.00		3.25	15.30	23.90	
8	6/20/01	1.2	15.9	----		0.05	5.32	----		0.61	13.10	----		5.64	24.40	----	
9	6/22/01	0.5	4.7	12.9		0.02	3.42	4.98		0.20	4.06	11.50		1.70	10.60	20.60	
10	6/28/01	0.5	2.9	6.2		0.18	2.25	3.77		1.40	2.67	5.50		1.83	5.99	10.90	
11	7/11/01	0.7	6.4	8.8		0.14	3.18	4.68		0.30	5.85	8.99		3.21	10.30	13.20	
12	7/13/01	----	4.0	6.8		----	3.26	3.82		----	3.38	7.08		----	5.41	10.90	
13	7/22/01	----	5.5	8.5		----	3.03	4.11		----	4.73	7.65		----	7.36	10.80	
14	7/23/01	2.7	6.0	7.9		0.02	3.55	3.60		1.35	4.73	6.46		1.57	8.64	11.60	
15	7/27/01	1.8	14.9	10.4		0.02	5.46	4.35		0.86	13.70	9.18		3.04	17.90	13.10	
16	8/5/01	1.2	9.2	10.1		0.02	3.94	4.32		0.14	9.54	9.30		2.30	23.00	15.70	
17	8/7/01	0.9	3.9	8.2		0.02	3.06	4.19		0.11	3.31	8.18		3.41	11.10	16.20	
	Count	15	16	16	29	15	16	16	29	15	16	16	29	15	16	16	29
	Average	1.4	9.2	13.9	81.8	0.09	4.12	5.33	8.40	0.70	8.09	12.46	52.51	2.52	14.77	20.36	32.76
	Median	1.2	6.7	10.3	56.0	0.04	3.49	4.52	7.01	0.61	6.00	9.35	40.80	2.30	11.70	15.95	26.90
	Max.	2.7	27.8	29.5	302.0	0.52	8.06	9.44	19.40	1.66	22.60	26.00	189.00	5.64	40.30	40.70	80.70
	Min.	0.5	2.9	6.2	17.2	0.02	2.25	3.60	4.02	0.11	2.67	5.50	13.00	1.21	5.41	10.80	13.90
	Std. Dev.	0.7	6.4	7.4	68.4	0.13	1.47	1.74	3.57	0.48	5.29	6.34	41.36	1.08	8.80	9.64	16.82
	C.V.***	0.5	0.7	0.5	0.8	1.38	0.36	0.33	0.42	0.70	0.65	0.51	0.79	0.43	0.60	0.47	0.51

Appendix H-2. Constituent concentrations measured from composite samples collected in Year 2 for rainfall (RAIN), inflow (INFL), outflow (OUFL), and underdrains (UNDER). *Sampling event covers two independant storms. **Numbers in italics were below the lab detection limit, and 1/2 the detection limit was used in the calculations. ***C.V. = Coefficient of Variation (Standard Deviation/Mean). Negative Organic Nitrogen values were changed to zero for calculations.

STORM #		AMMONIA mg/L				NITRATE + NITRITE mg/L				ORGANIC NITROGEN mg/L			
	L.O.Q.**	0.01				0.01				0.06			
	DATE	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER
1	06/13/02	-----	0.281	-----	See "Appendix F"	-----	0.801	-----	See "Appendix F"	-----	0.168	-----	See "Appendix F"
2	06/18/02	-----	0.098	0.054		-----	0.156	0.103		-----	0.406	0.293	
3	06/24/02	-----	0.169	0.053		-----	0.116	0.099		-----	0.185	0.598	
4	06/28/02	-----	0.130	0.027		-----	0.370	0.296		-----	0.260	0.677	
5	06/29/02	-----	0.097	0.036		-----	0.703	0.058		-----	0.200	0.646	
6	07/01/02	-----	0.134	0.049		-----	0.355	0.068		-----	0.161	0.883	
7	07/25/02	-----	0.431	-----		-----	0.413	-----		-----	0.546	-----	
8	08/02/02	-----	0.247	-----		-----	0.159	-----		-----	0.584	-----	
9	08/07/02	-----	0.023	0.037		-----	0.297	0.048		-----	0.620	0.485	
10	08/14/02	-----	0.127	0.040		-----	0.226	0.135		-----	0.195	0.000	
11	08/17/02	-----	0.062	*0.005*		-----	0.422	0.008		-----	0.364	0.227	
12	08/30/02	0.289	0.097	*0.005*		0.245	0.284	0.096		0.000	0.291	0.263	
13	09/02/02	0.161	*0.005*	*0.005*		0.354	0.337	0.013		0.000	0.284	0.330	
14	09/11/02	0.040	0.033	0.012		0.095	0.081	0.010		0.038	0.168	0.362	
15	09/12/02	0.043	0.050	*0.005*		0.064	0.120	0.008		0.062	0.187	0.351	
16	09/17/02	-----	0.109	0.029		-----	0.391	0.075		-----	0.230	0.321	
17	09/27/02	-----	0.106	-----		-----	0.059	-----		-----	*0.421*	-----	
18	10/12/02	0.324	0.173	-----		0.387	0.300	-----		0.030	0.507	-----	
19	10/15/02	0.080	0.040	-----		0.160	0.061	-----		0.000	0.459	-----	
20	10/30/02	0.220	0.248	-----		0.114	0.319	-----		0.117	0.743	-----	
21	11/12/02	0.104	0.334	-----		0.175	0.282	-----		0.000	0.354	-----	
22	12/09/02	0.021	0.016	0.016		0.052	0.095	0.082		0.107	0.299	0.332	
23	12/12/02	0.068	0.181	0.032		0.073	0.141	0.063		0.009	0.118	0.305	
24	02/22/03	0.036	-----	-----		0.063	-----	-----		0.004	-----	-----	
25	02/28/03	0.077	*0.006*	0.018		0.148	0.157	*0.005*		0.045	0.557	0.467	
26	03/16/03	0.073	0.038	-----		0.056	0.146	-----		0.085	0.836	-----	
27	03/21/03	-----	0.116	0.050		-----	0.139	0.096		-----	0.399	0.348	
28	03/23/03	0.554	0.112	*0.006*		0.162	0.187	0.039		0.220	0.465	0.392	
29	04/25/03	0.724	0.433	0.133		0.241	0.348	0.301		0.055	0.589	0.656	
30	05/22/03	0.016	0.162	-----		0.078	0.174	-----		0.084	0.380	-----	
31*	06/09/03	0.067	0.048	-----		0.112	0.158	-----		0.000	0.894	-----	
32	06/11/03	0.284	0.117	0.064		0.694	0.579	0.206		0.082	0.534	0.640	
33	06/16/03	0.072	0.045	-----		0.164	0.215	-----		0.005	0.463	-----	
34	06/18/03	0.217	0.071	0.014		0.085	0.113	0.027		0.108	0.396	0.439	
35	06/19/03	0.038	0.047	*0.006*		0.038	0.076	0.033		0.044	0.417	0.251	
36	06/29/03	0.076	0.118	*0.006*		0.079	0.130	*0.005*		0.030	0.247	0.578	
37	07/11/03	0.050	0.050	0.329		0.273	0.328	0.247		0.007	0.319	1.074	
38	08/27/03	0.051	0.028	*0.003*		0.152	0.219	0.039		0.037	0.403	0.319	
39	09/19/03	0.138	0.166	0.077		0.187	0.259	0.206		0.039	0.437	0.430	
	Count	25	38	26	64	25	38	26	64	25	38	26	64
	Average	0.153	0.125	0.043	0.320	0.170	0.256	0.091	0.125	0.048	0.397	0.449	0.278
	Median	0.076	0.108	0.028	0.202	0.148	0.217	0.066	0.090	0.038	0.398	0.377	0.265
	Max.	0.724	0.433	0.329	1.635	0.694	0.801	0.301	0.470	0.220	0.894	1.074	1.458
	Min.	0.016	0.005	0.003	0.021	0.038	0.059	0.005	0.018	0.000	0.118	0.000	0.030
	Std. Dev.	0.173	0.107	0.065	0.311	0.143	0.169	0.089	0.097	0.052	0.187	0.224	0.181
	C.V.***	1.130	0.853	1.533	0.972	0.841	0.661	0.979	0.781	1.078	0.471	0.499	0.650

Appendix H-2. ***Continuted***

STORM #	L.O.Q.**	TOTAL NITROGEN mg/L 0.05				ORTHO- PHOSPHATE mg/L 0.01				TOTAL - PHOSPHATE mg/L 0.01			
	DATE	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER
1	06/13/02	-----	1.250	-----	See "Appendix F"	-----	0.090	-----	See "Appendix F"	-----	0.236	-----	See "Appendix F"
2	06/18/02	-----	0.660	0.450		-----	0.063	0.043		-----	0.340	0.076	
3	06/24/02	-----	0.470	0.750		-----	0.062	0.035		-----	0.154	0.098	
4	06/28/02	-----	0.760	1.000		-----	0.060	0.036		-----	0.133	0.079	
5	06/29/02	-----	1.000	0.740		-----	0.032	0.024		-----	0.110	0.034	
6	07/01/02	-----	0.650	1.000		-----	0.064	0.024		-----	0.091	0.043	
7	07/25/02	-----	1.390	-----		-----	0.171	-----		-----	0.362	-----	
8	08/02/02	-----	0.990	-----		-----	0.135	-----		-----	0.203	-----	
9	08/07/02	-----	0.940	0.570		-----	0.050	0.015		-----	0.230	0.079	
10	08/14/02	-----	0.548	0.009		-----	0.070	0.027		-----	0.194	0.074	
11	08/17/02	-----	0.848	0.239		-----	0.064	0.005		-----	0.172	0.028	
12	08/30/02	0.487	0.672	0.364		0.005	0.082	0.015		0.005	0.200	0.049	
13	09/02/02	0.445	0.626	0.347		0.005	0.035	0.010		0.005	0.258	0.051	
14	09/11/02	0.172	0.282	0.384		0.005	0.032	0.013		0.005	0.090	0.053	
15	09/12/02	0.168	0.357	0.363		0.005	0.058	0.005		0.005	0.099	0.046	
16	09/17/02	-----	0.730	0.425		-----	0.067	0.016		-----	0.195	0.055	
17	09/27/02	-----	0.586	-----		-----	0.086	-----		-----	0.172	-----	
18	10/12/02	0.740	0.980	-----		0.016	0.080	-----		0.034	0.271	-----	
19	10/15/02	0.220	0.560	-----		0.005	0.047	-----		0.021	0.113	-----	
20	10/30/02	0.450	1.310	-----		0.005	0.048	-----		0.005	0.316	-----	
21	11/12/02	0.200	0.970	-----		0.005	0.117	-----		0.005	0.344	-----	
22	12/09/02	0.180	0.410	0.430		0.005	0.041	0.027		0.005	0.060	0.060	
23	12/12/02	0.150	0.440	0.400		0.005	0.054	0.027		0.005	0.092	0.052	
24	02/22/03	0.103	-----	-----		0.005	-----	-----		0.005	-----	-----	
25	02/28/03	0.270	0.720	0.490		0.010	0.035	0.018		0.005	0.075	0.069	
26	03/16/03	0.214	1.020	-----		0.013	0.050	-----		0.050	0.226	-----	
27	03/21/03	-----	0.654	0.494		-----	0.031	0.018		-----	0.133	0.072	
28	03/23/03	0.936	0.764	0.437		0.005	0.005	0.005		0.005	0.079	0.050	
29	04/25/03	1.020	1.370	1.090		0.005	0.073	0.020		0.005	0.239	0.108	
30	05/22/03	0.178	0.716	-----		0.005	0.128	-----		0.005	0.183	-----	
31*	06/09/03	0.160	1.100	-----		0.005	0.086	-----		0.005	0.475	-----	
32	06/11/03	1.060	1.230	0.910		0.005	0.074	0.005		0.005	0.177	0.086	
33	06/16/03	0.241	0.723	-----		0.005	0.078	-----		0.005	0.158	-----	
34	06/18/03	0.410	0.580	0.480		0.005	0.060	0.013		0.005	0.103	0.051	
35	06/19/03	0.120	0.540	0.290		0.005	0.047	0.013		0.005	0.175	0.041	
36	06/29/03	0.185	0.495	0.589		0.005	0.069	0.005		0.005	0.134	0.049	
37	07/11/03	0.330	0.697	1.650		0.005	0.031	0.073		0.005	0.122	0.471	
38	08/27/03	0.240	0.65	0.360		0.005	0.069	0.039		0.005	0.187	0.072	
39	09/19/03	0.364	0.862	0.713		0.005	0.135	0.12		0.005	0.339	0.207	
	Count	25	38	26	64	25	38	26	64	25	38	26	64
	Average	0.362	0.778	0.576	0.726	0.006	0.068	0.025	0.115	0.009	0.191	0.083	0.153
	Median	0.240	0.718	0.465	0.614	0.005	0.064	0.018	0.093	0.005	0.176	0.058	0.123
	Max.	1.060	1.390	1.650	1.935	0.016	0.171	0.120	0.322	0.050	0.475	0.471	0.663
	Min.	0.103	0.282	0.009	0.289	0.005	0.005	0.005	0.039	0.005	0.060	0.028	0.055
	Std. Dev.	0.283	0.285	0.337	0.343	0.003	0.034	0.025	0.070	0.011	0.095	0.086	0.102
	C.V.***	0.781	0.366	0.585	0.474	0.468	0.496	0.983	0.610	1.256	0.497	1.042	0.650

Appendix H-2. *Continuted*

STORM #	L.O.Q.**	TSS mg/L			TOTAL COPPER ug/L 2.0				TOTAL LEAD ug/L 1.50			
	DATE	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER
1	06/13/02	42.0	-----		-----	24.50	-----		-----	10.00	-----	
2	06/18/02	91.0	5.4		-----	23.80	3.00		-----	19.20	1.30	
3	06/24/02	32.0	14.0		-----	11.90	8.40		-----	6.50	2.40	
4	06/28/02	26.0	7.3		-----	8.10	6.60		-----	5.70	1.60	
5	06/29/02	19.0	2.0		-----	8.30	2.30		-----	5.10	*1.00*	
6	07/01/02	10.0	-----		-----	6.20	*1.15*		-----	3.10	*1.00*	
7	07/25/02	-----	-----		-----	28.50	-----		-----	14.20	-----	
8	08/02/02	12.0	-----		-----	*1.15*	-----		-----	4.30	-----	
9	08/07/02	44.0	6.7		-----	21.80	4.20		-----	12.20	1.40	
10	08/14/02	38.0	7.2		-----	21.40	4.10		-----	9.00	2.00	
11	08/17/02	34.0	2.3		-----	15.50	*1.15*		-----	7.20	*1.00*	
12	08/30/02	54.0	2.2		7.80	23.70	3.40		*1.00*	11.20	*1.00*	
13	09/02/02	34.0	4.0		*1.15*	18.90	3.30		*1.00*	12.50	*1.00*	
14	09/11/02	*0.3*	12.0		*1.15*	9.50	2.80		*1.00*	4.80	*1.00*	
15	09/12/02	13.0	3.3		*1.15*	10.30	3.00		*1.00*	3.10	*1.00*	
16	09/17/02	46.0	4.5		-----	16.10	4.20		-----	7.20	2.00	
17	09/27/02	-----	-----		-----	24.40	-----		-----	5.00	-----	
18	10/12/02	38.9	-----		2.50	32.50	-----		1.20	10.20	-----	
19	10/15/02	4.1	-----		3.10	4.00	-----		1.20	1.30	-----	
20	10/30/02	76.7	-----	See "Appendix F"	*1.15*	51.40	-----	See "Appendix F"	*1.00*	15.20	-----	See "Appendix F"
21	11/12/02	56.9	-----		*1.15*	34.20	-----		*1.00*	11.50	-----	
22	12/09/02	9.7	6.3		*1.15*	17.80	11.30		*1.00*	1.80	1.70	
23	12/12/02	15.6	4.1		*1.15*	18.10	9.50		*1.00*	3.30	*1.00*	
24	02/22/03	-----	-----		*1.15*	-----	-----		*5.00*	-----	-----	
25	02/28/03	4.89	-----		*1.50*	20.20	3.87		*5.00*	*5.00*	*5.00*	
26	03/16/03	38.40	-----		*1.50*	28.10	-----		*5.00*	*5.00*	-----	
27	03/21/03	32.00	4.32		-----	23.30	3.78		-----	*5.00*	*5.00*	
28	03/23/03	13.20	3.24		*1.50*	23.30	3.63		*5.00*	*5.00*	*5.00*	
29	04/25/03	38.20	6.25		*1.50*	40.10	11.60		*5.00*	*5.00*	*5.00*	
30	05/22/03	14.00	-----		*1.50*	20.50	-----		*5.00*	*5.00*	-----	
31*	06/09/03	144.00	-----		*1.50*	55.80	-----		*5.00*	18.40	-----	
32	06/11/03	42.10	8.51		*1.50*	23.40	5.23		*5.00*	*5.00*	*5.00*	
33	06/16/03	12.10	-----		*1.50*	9.87	-----		*5.00*	*5.00*	-----	
34	06/18/03	18.10	5.45		*1.50*	15.80	5.53		*5.00*	*5.00*	*5.00*	
35	06/19/03	51.10	4.36		*1.50*	33.90	4.34		*5.00*	11.40	*5.00*	
36	06/29/03	24.00	3.64		*1.50*	15.80	*1.50*		*5.00*	*5.00*	*5.00*	
37	07/11/03	23.00	73.90		*1.50*	14.20	102.00		*5.00*	*5.00*	32.70	
38	08/27/03	35.60	3.17		*1.50*	18.20	*1.50*		*5.00*	*5.00*	*5.00*	
39	09/19/03	35.2	7.94		*1.50*	38.7	7.35		*5.00*	12.5	*5.00*	
	Count	36	24	64	25	38	26	63	25	38	26	64
	Average	33.97	8.42	3.68	1.74	21.40	8.41	1.74	3.42	7.52	3.97	3.06
	Median	33.00	4.95	1.45	1.50	20.35	3.99	1.38	5.00	5.00	2.00	3.13
	Max.	144.00	73.90	44.55	7.80	55.80	102.00	4.59	5.00	19.20	32.70	8.80
	Min.	0.25	2.00	0.25	1.15	1.15	1.15	0.80	1.00	1.30	1.00	0.35
	Std. Dev.	27.38	14.25	7.11	1.33	11.98	19.30	0.90	1.98	4.44	6.14	2.17
	C.V.***	0.81	1.69	1.67	0.77	0.56	2.29	0.52	0.58	0.59	1.55	0.71

* In February 2002 the laboratory bought new equipment and this raised the minimum detection limit for copper from 2ug/l to 3ug/l and lead from 1.5 ug/l to 10ug/l. (1/2 detection limit in table).

Appendix H-2. *Continuted*

STORM #	L.O.Q.**	TOTAL ZINC ug/L 15.0				MANGANESE ug/L 1.0				TOTAL IRON ug/L 25.0			
	DATE	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER
1	06/13/02	-----	100.0	-----		-----	23.70	-----		-----	1170.0	-----	
2	06/18/02	-----	160.0	20.0		-----	32.00	5.40		-----	2810.0	190.0	
3	06/24/02	-----	30.0	20.0		-----	11.60	7.20		-----	820.0	270.0	
4	06/28/02	-----	70.0	7.5		-----	8.80	4.50		-----	610.0	150.0	
5	06/29/02	-----	40.0	7.5		-----	10.10	3.20		-----	690.0	60.0	
6	07/01/02	-----	7.5	7.5		-----	8.00	2.90		-----	320.0	70.0	
7	07/25/02	-----	120.0	-----		-----	45.70	-----		-----	1560.0	-----	
8	08/02/02	-----	90.0	-----		-----	17.90	-----		-----	390.0	-----	
9	08/07/02	-----	150.0	40.0		-----	25.70	18.50		-----	1780.0	180.0	
10	08/14/02	-----	90.0	20.0		-----	19.90	10.50		-----	1350.0	280.0	
11	08/17/02	-----	100.0	7.5		-----	18.40	2.50		-----	1190.0	40.0	
12	08/30/02	7.5	130.0	30.0		1.10	26.90	10.80		30.0	1610.0	160.0	
13	09/02/02	7.5	110.0	20.0		0.50	22.10	17.60		30.0	1560.0	150.0	
14	09/11/02	7.5	60.0	30.0		0.50	8.50	16.60		15.0	560.0	200.0	
15	09/12/02	7.5	60.0	20.0		0.50	7.00	8.00		15.0	410.0	140.0	
16	09/17/02	-----	100.0	30.0		-----	16.50	9.90		-----	1060.0	170.0	
17	09/27/02	-----	90.0	-----		-----	20.50	-----		-----	890.0	-----	
18	10/12/02	20.0	120.0	-----		1.20	36.10	-----		80.0	1700.0	-----	
19	10/15/02	20.0	20.0	-----		1.00	19.50	-----		70.0	230.0	-----	
20	10/30/02	7.5	170.0	-----	See "Appendix F"	1.50	41.20	-----	See "Appendix F"	15.0	2370.0	-----	See "Appendix F"
21	11/12/02	30.0	160.0	-----						15.0	1680.0	-----	
22	12/09/02	7.5	20.0	20.0						15.0	270.0	300.0	
23	12/12/02	7.5	40.0	20.0						15.0	540.0	210.0	
24	02/22/03	5.76	-----	-----						13.7	-----	-----	
25	02/28/03	7.86	45	25.9						19.9	278.0	254.0	
26	03/16/03	16.90	118	-----						18.4	1430.0	-----	
27	03/21/03	-----	82	21.9						-----	1060.0	227.0	
28	03/23/03	6.60	43	25.2						18.5	443.0	189.0	
29	04/25/03	3.71	118	35.1						36.6	1560.0	270.0	
30	05/22/03	9.51	55	-----			Changed Lab Constituents			6.3	634.0	-----	
31*	06/09/03	11.10	299	-----						21.1	3520.0	-----	
32	06/11/03	8.73	94	27.8						35.3	1350.0	295.0	
33	06/16/03	7.84	55	-----						19.8	432.0	-----	
34	06/18/03	3.36	45	15.2						13.9	650.0	221.0	
35	06/19/03	6.39	126	12.9						29.0	2070.0	183.0	
36	06/29/03	2.48	52	9.5						75.7	806.0	198.0	
37	07/11/03	4.75	65	236.0						70.5	955.0	2060.0	
38	08/27/03	1.00	82	15.7						12.5	1240.0	155.0	
39	09/19/03	2.95	122	26						15.9	1690.0	293.0	
	Count	25	38	26	64	7	20	13	26	25	38	26	64
	Average	8.9	90.4	28.9	11.4	0.90	21.01	9.05	27.95	28.3	1149.7	266.0	140.6
	Median	7.5	90.0	20.0	7.5	1.00	19.70	8.00	15.85	18.5	1060.0	194.0	90.0
	Max.	30.0	299.0	236.0	60.0	1.50	45.70	18.50	83.70	80.0	3520.0	2060.0	899.0
	Min.	1.0	7.5	7.5	1.0	0.50	7.00	2.50	7.80	6.3	230.0	40.0	37.5
	Std. Dev.	6.5	54.5	43.1	10.6	0.40	11.12	5.62	21.59	21.7	738.2	372.6	170.9
	C.V.***	0.7	0.6	1.5	0.9	0.45	0.53	0.62	0.72	0.8	0.6	1.4	1.2

- In February 2002 the laboratory bought new equipment and this lowered the minimum detection limit for zinc from 15ug/l to 2ug/l and iron from 25 ug/l to 30ug/l. (1/2 detection limit in table).

Appendix H-2. ***Continuted***

STORM #	L.O.Q.**	TOTAL CADMIUM ug/L 0.3				HARDNESS mg/L as CaCO3 20.0				CALCIUM (mg/l) 0.25			
	DATE	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER
1	06/13/02	-----	0.23	-----	See "Appendix F"	-----	75.45	-----	See "Appendix F"	-----	28.60	-----	See "Appendix F"
2	06/18/02	-----	0.32	0.06		-----	83.08	38.14		-----	32.10	14.40	
3	06/24/02	-----	*0.10*	0.28		-----	35.57	35.19		-----	13.70	13.30	
4	06/28/02	-----	*0.10*	*0.10*		-----	31.37	37.06		-----	12.10	14.00	
5	06/29/02	-----	*0.10*	*0.10*		-----	36.11	45.96		-----	13.80	17.40	
6	07/01/02	-----	*0.10*	*0.10*		-----	42.79	48.87		-----	16.00	18.50	
7	07/25/02	-----	0.34	-----		-----	126.49	-----		-----	46.40	-----	
8	08/02/02	-----	*0.10*	-----		-----	87.77	-----		-----	32.10	-----	
9	08/07/02	-----	0.24	*0.10*		-----	63.10	74.39		-----	24.10	27.50	
10	08/14/02	-----	*0.10*	*0.10*		-----	47.25	48.91		-----	18.10	18.40	
11	08/17/02	-----	*0.10*	*0.10*		-----	57.03	47.13		-----	21.70	17.90	
12	08/30/02	0.41	0.26	*0.10*		0.32	56.24	59.92		*0.13*	21.40	22.20	
13	09/02/02	*0.10*	0.21	*0.10*		0.32	54.45	72.29		*0.13*	21.00	27.30	
14	09/11/02	*0.10*	*0.10*	*0.10*		0.32	34.38	34.38		*0.13*	12.30	12.30	
15	09/12/02	*0.10*	*0.10*	*0.10*		0.32	44.12	56.86		*0.13*	16.50	21.60	
16	09/17/02	-----	0.22	*0.10*		-----	55.48	63.72		-----	20.80	24.10	
17	09/27/02	-----	*0.10*	-----		-----	82.40	-----		-----	33.00	-----	
18	10/12/02	0.23	0.20	-----		0.32	83.44	-----		*0.13*	30.20	-----	
19	10/15/02	0.27	*0.10*	-----		1.64	74.75	-----		0.65	27.20	-----	
20	10/30/02	*0.10*	0.30	-----		0.32	89.98	-----		*0.13*	33.00	-----	
21	11/12/02	0.20	0.20	-----		-----	100.60	-----		-----	37.50	-----	
22	12/09/02	*0.10*	*0.10*	*0.10*		-----	26.23	54.57		-----	10.50	20.90	
23	12/12/02	*0.10*	*0.10*	*0.10*		-----	28.09	42.57		-----	11.00	16.30	
24	02/22/03	-----	-----	-----		-----	-----	-----		-----	-----	-----	
25	02/28/03	-----	*0.05*	-----		-----	52.16	75.96		-----	19.7	27.8	
26	03/16/03	-----	*0.05*	-----		-----	51.94	-----		-----	19.4	-----	
27	03/21/03	-----	*0.50*	*0.50*		-----	36.73	52.23		-----	14	19.4	
28	03/23/03	-----	*0.50*	*0.50*		-----	36.36	44.34		-----	14.1	16.8	
29	04/25/03	-----	0.50	*0.50*		-----	50.95	49.53		-----	19.4	18.5	
30	05/22/03	-----	*0.50*	-----		-----	59.60	-----		-----	22.3	-----	
31*	06/09/03	-----	*0.50*	-----		-----	89.64	-----		-----	34.3	-----	
32	06/11/03	-----	*0.50*	*0.50*		-----	51.25	62.39		-----	19.7	23.7	
33	06/16/03	-----	*0.50*	-----		-----	53.11	-----		-----	20	-----	
34	06/18/03	-----	*0.50*	*0.50*		-----	33.11	52.00		-----	12.8	20	
35	06/19/03	-----	0.50	*0.50*		-----	54.70	44.18		-----	21.1	17	
36	06/29/03	-----	0.50	*0.50*		-----	43.17	73.28		-----	16.1	27.6	
37	07/11/03	-----	*0.50*	1.14		-----	36.61	121.61		-----	14.1	29.9	
38	08/27/03	-----	*0.50*	*0.50*		-----	48.92	63.34		-----	18.7	23.7	
39	09/19/03	-----	*0.50*	*0.50*		-----	52.45	55.52		-----	19.9	20.6	
	Count	10	38	25	63	7	38	26	64	7	38	26	64
	Average	0.17	0.27	0.29	0.32	0.51	57.02	55.94	149.17	0.20	21.54	20.43	51.59
	Median	0.10	0.23	0.10	0.50	0.32	52.30	52.11	132.42	0.13	19.80	19.70	47.23
	Max.	0.41	0.50	1.14	0.85	1.64	126.49	121.61	287.00	0.65	46.40	29.90	89.25
	Min.	0.10	0.05	0.06	0.06	0.32	26.23	34.38	71.74	0.13	10.50	12.30	26.10
	Std. Dev.	0.11	0.18	0.26	0.21	0.50	22.73	18.07	54.32	0.20	8.36	4.89	16.14
	C.V.***	0.62	0.65	0.90	0.67	0.97	0.40	0.32	0.36	0.99	0.39	0.24	0.31

* In February 2002 the laboratory bought new equipment and raised the minimum detection limit for cadmium from 0.3ug/l to 1ug/l. (1/2 detection limit in table).

Appendix H-2. *Continuted*

STORM #	L.O.Q.**	MAGNESIUM mg/L				CHLORIDE mg/L 0.4				POTASSIUM mg/L 0.04					
	DATE	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER		
1	06/13/02	-----	0.98	-----	See "Appendix F"	-----	6.9	-----	See "Appendix F"	-----	3.78	-----	See "Appendix F"		
2	06/18/02	-----	0.71	0.53		-----	1.7	3.5		-----	1.70	2.07			
3	06/24/02	-----	0.33	0.48		-----	1.3	2.7		-----	1.41	1.89			
4	06/28/02	-----	0.28	0.51		-----	1.5	3.0		-----	1.89	2.09			
5	06/29/02	-----	0.40	0.61		-----	2.0	3.3		-----	2.05	2.13			
6	07/01/02	-----	0.69	0.65		-----	4.3	3.0		-----	2.65	2.20			
7	07/25/02	-----	2.58	-----		-----	19.0	-----		-----	6.35	-----			
8	08/02/02	-----	1.85	-----		-----	12.9	-----		-----	5.33	-----			
9	08/07/02	-----	0.71	1.39		-----	3.6	1.4		-----	2.49	3.61			
10	08/14/02	-----	0.50	0.72		-----	2.5	4.6		-----	1.70	2.37			
11	08/17/02	-----	0.69	0.59		-----	4.3	3.2		-----	2.47	1.97			
12	08/30/02	*0.00*	0.68	1.09		1.7	4.7	7.6		*0.04*	2.49	2.73			
13	09/02/02	*0.00*	0.49	1.00		0.2	1.6	6.2		*0.04*	2.49	3.38			
14	09/11/02	*0.00*	0.34	0.89		0.3	1.7	5.2		*0.04*	1.42	2.49			
15	09/12/02	*0.00*	0.44	0.71		0.7	2.8	3.9		*0.04*	2.28	2.13			
16	09/17/02	-----	0.63	0.86		-----	3.3	4.9		-----	2.36	2.52			
17	09/27/02	-----	1.24	-----		-----	9.2	-----		-----	4.11	-----			
18	10/12/02	*0.00*	1.45	-----		0.5	8.8	-----		*0.04*	3.84	-----			
19	10/15/02	*0.00*	1.25	-----		0.9	9.0	-----		*0.04*	3.98	-----			
20	10/30/02	*0.00*	1.48	-----		0.9	9.4	-----		*0.04*	2.68	-----			
21	11/12/02	-----	1.69	-----		Changed Lab Constituents									
22	12/09/02	-----	*0.00*	0.58											
23	12/12/02	-----	0.15	0.45											
24	02/22/03	-----	-----	-----											
25	02/28/03	-----	0.72	1.59											
26	03/16/03	-----	0.85	-----											
27	03/21/03	-----	0.43	0.92											
28	03/23/03	-----	0.28	0.58											
29	04/25/03	-----	0.61	0.81											
30	05/22/03	-----	0.95	-----											
31*	06/09/03	-----	0.97	-----											
32	06/11/03	-----	0.5	0.78											
33	06/16/03	-----	0.77	-----											
34	06/18/03	-----	0.28	0.5											
35	06/19/03	-----	0.49	0.42											
36	06/29/03	-----	0.72	1.06											
37	07/11/03	-----	0.34	11.4											
38	08/27/03	-----	0.54	1.01											
39	09/19/03	-----	0.67	0.99											
	Count	7	38	26	64	7	20	13	26	7	20	13	26		
	Average	0.00	0.75	1.20	4.96	0.7	5.527	4.0	53.1	0.04	2.87	2.43	7.44		
	Median	0.00	0.68	0.75	3.48	0.7	3.930	3.5	31.9	0.04	2.49	2.20	5.27		
	Max.	0.00	2.58	11.40	16.45	1.7	19.000	7.6	228.3	0.04	6.35	3.61	22.91		
	Min.	0.00	0.00	0.42	1.48	0.2	1.340	1.4	4.2	0.04	1.41	1.89	3.26		
	Std. Dev.	0.00	0.52	2.10	3.66	0.5	4.644	1.6	55.4	0.00	1.31	0.53	4.80		
	C.V.***	0.00	0.68	1.76	0.71	0.7	0.840	0.4	0.8	0.00	0.46	0.22	0.55		

Appendix H-2. *Continuted*

STORM #	L.O.Q.**	SODIUM mg/L 0.06				SULFATE mg/L			
	DATE	RAIN	INFL	OUFL	UNDER	RAIN	INFL	OUFL	UNDER
1	06/13/02	-----	6.23	-----	See "Appendix F"	-----	13.50	-----	See "Appendix F"
2	06/18/02	-----	1.59	3.28		-----	3.80	6.35	
3	06/24/02	-----	1.39	2.63		-----	3.84	5.78	
4	06/28/02	-----	1.45	2.65		-----	5.00	7.87	
5	06/29/02	-----	2.02	2.30		-----	6.64	7.70	
6	07/01/02	-----	4.23	2.87		-----	9.57	8.28	
7	07/25/02	-----	17.10	-----		-----	34.70	-----	
8	08/02/02	-----	12.40	-----		-----	24.10	-----	
9	08/07/02	-----	3.98	10.40		-----	10.20	18.30	
10	08/14/02	-----	2.16	4.35		-----	5.81	9.38	
11	08/17/02	-----	3.66	2.96		-----	9.88	7.23	
12	08/30/02	0.52	3.89	7.98		2.95	9.71	13.90	
13	09/02/02	*0.03*	1.87	6.18		1.85	6.64	11.50	
14	09/11/02	*0.03*	1.71	4.79		0.98	4.67	9.01	
15	09/12/02	0.25	2.45	3.61		1.69	8.68	8.45	
16	09/17/02	-----	3.25	4.52		-----	9.31	10.40	
17	09/27/02	-----	7.55	-----		-----	0.51	-----	
18	10/12/02	0.28	7.21	-----		2.17	14.00	-----	
19	10/15/02	0.54	7.37	-----		0.91	12.50	-----	
20	10/30/02	0.57	7.36	-----		1.69	16.10	-----	
21	11/12/02	Changed Lab Constituents							
22	12/09/02								
23	12/12/02								
24	02/22/03								
25	02/28/03								
26	03/16/03								
27	03/21/03								
28	03/23/03								
29	04/25/03								
30	05/22/03								
31*	06/09/03								
32	06/11/03								
33	06/16/03								
34	06/18/03								
35	06/19/03								
36	06/29/03								
37	07/11/03								
38	08/27/03								
39	09/19/03								
	Count	7	20	13	26	7	20	13	25
	Average	0.32	4.94	4.50	42.07	1.75	10.46	9.55	50.26
	Median	0.28	3.78	3.61	25.95	1.69	9.44	8.45	31.90
	Max.	0.57	17.10	10.40	139.05	2.95	34.70	18.30	135.00
	Min.	0.03	1.39	2.30	10.73	0.91	0.51	5.78	18.40
	Std. Dev.	0.23	4.07	2.40	38.12	0.70	7.74	3.41	36.38
	C.V.***	0.73	0.82	0.53	0.70	0.40	0.74	0.36	0.72

Appendix I

Water Quality for Underdrains

Appendix I-1. Constituent concentrations measured in composite samples collected in Year 1 at the South underdrain. The North underdrain was installed during construction and is included in Year 2. **Numbers in italics are below the lab D.L., and 1/2 the D.L. was used in the calculations. *C.V. = Coefficient of Variation (Standard Deviation/Mean).

STORM #		AMMONIA mg/L		NITRATE + NITRITE mg/L		ORGANIC NITROGEN mg/L		TOTAL NITROGEN mg/L		ORTHO-PHOSPHATE mg/L		TOTAL - PHOSPHATE mg/L		TSS mg/L		TOTAL COPPER ug/L	
	L.O.Q**	0.01		0.01		0.05		0.05		0.01		0.01		0.05		2.0	
	DATE	South		South		South		South		South		South		South		South	
	11/17/00	0.673	-----	*0.008*	-----	0.920	-----	1.600	-----	0.331	-----	0.359	-----	-----	-----	4.7	-----
1	11/25/00	0.099	-----	0.195	-----	0.416	-----	0.710	-----	0.113	-----	0.158	-----	-----	-----	4.1	-----
3	01/08/01	0.108	-----	0.117	-----	0.336	-----	0.560	-----	0.085	-----	0.110	-----	-----	-----	5.4	-----
4	03/04/01	0.143	-----	0.061	-----	0.557	-----	0.760	-----	0.084	-----	0.107	-----	-----	-----	5.8	-----
6	03/29/01	0.078	-----	0.187	-----	0.246	-----	0.510	-----	0.061	-----	0.079	-----	-----	-----	2.1	-----
	03/30/01	0.080	-----	0.133	-----	0.217	-----	0.430	-----	0.063	-----	0.072	-----	-----	-----	8.1	-----
	04/02/01	0.194	-----	0.024	-----	0.343	-----	0.560	-----	0.095	-----	0.101	-----	-----	-----	*1.0*	-----
	04/06/01	0.305	-----	0.054	-----	0.262	-----	0.620	-----	0.146	-----	0.157	-----	-----	-----	*1.0*	-----
	04/09/01	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	04/30/01	0.741	-----	*0.008*	-----	0.352	-----	1.100	-----	0.282	-----	0.313	-----	-----	-----	2.3	-----
	05/25/01	0.695	-----	0.019	-----	0.287	-----	1.000	-----	0.280	-----	0.353	-----	-----	-----	*1.0*	-----
7	06/06/01	0.335	-----	0.551	-----	0.514	-----	1.400	-----	0.157	-----	0.229	-----	-----	-----	6.5	-----
	06/11/01	0.094	-----	0.230	-----	0.177	-----	0.500	-----	0.088	-----	0.122	-----	-----	-----	5.4	-----
	06/18/01	0.635	-----	*0.008*	-----	0.338	-----	0.980	-----	0.234	-----	0.273	-----	-----	-----	3.0	-----
8	06/20/01	0.499	-----	0.285	-----	0.416	-----	1.200	-----	0.189	-----	0.223	-----	-----	-----	4.2	-----
9	06/22/01	0.044	-----	0.046	-----	0.531	-----	0.620	-----	0.055	-----	0.096	-----	2.2	-----	5.2	-----
	06/25/01	0.078	-----	0.051	-----	0.331	-----	0.460	-----	0.055	-----	0.076	-----	1.3	-----	2.1	-----
	06/27/01	0.182	-----	0.082	-----	0.437	-----	0.700	-----	0.101	-----	0.115	-----	-----	-----	2.3	-----
10	06/28/01	0.151	-----	0.102	-----	0.297	-----	0.550	-----	0.084	-----	0.105	-----	1.6	-----	*1.0*	-----
	07/03/01	0.290	-----	0.169	-----	0.191	-----	0.650	-----	0.135	-----	0.151	-----	0.9	-----	2.8	-----
	07/06/01	0.316	-----	0.192	-----	0.892	-----	1.400	-----	0.147	-----	0.144	-----	1.3	-----	*1.0*	-----
	07/09/01	0.209	-----	0.101	-----	0.231	-----	0.540	-----	0.119	-----	0.104	-----	1.5	-----	*1.0*	-----
11	07/11/01	0.150	-----	0.037	-----	0.404	-----	0.590	-----	0.084	-----	0.098	-----	1.4	-----	2.1	-----
12	07/13/01	0.200	-----	0.078	-----	0.333	-----	0.610	-----	0.109	-----	0.118	-----	0.3	-----	*1.0*	-----
	07/16/01	0.166	-----	0.114	-----	0.401	-----	0.680	-----	0.104	-----	0.115	-----	1.3	-----	5.6	-----
	07/18/01	0.202	-----	0.090	-----	0.389	-----	0.680	-----	0.116	-----	0.139	-----	1.0	-----	2.4	-----
	07/20/01	0.212	-----	0.089	-----	0.280	-----	0.580	-----	0.104	-----	0.125	-----	1.2	-----	*1.0*	-----
13	07/22/01	0.130	-----	*0.008*	-----	0.783	-----	0.920	-----	0.072	-----	0.084	-----	0.1	-----	2.0	-----
14	07/23/01	0.231	-----	0.066	-----	0.134	-----	0.430	-----	0.084	-----	0.090	-----	0.6	-----	*1.0*	-----
15	07/27/01	0.213	-----	0.125	-----	0.303	-----	0.640	-----	0.092	-----	0.087	-----	1.1	-----	2.5	-----
	Count	29	-----	29	-----	29	-----	29	-----	29	-----	29	-----	14.0	-----	29.0	-----
	Average	0.257	-----	0.111	-----	0.390	-----	0.758	-----	0.127	-----	0.148	-----	1.1	-----	3.0	-----
	Median	0.200	-----	0.089	-----	0.338	-----	0.640	-----	0.104	-----	0.115	-----	1.2	-----	2.3	-----
	Max.	0.741	-----	0.551	-----	0.920	-----	1.600	-----	0.331	-----	0.359	-----	2.2	-----	8.1	-----
	Min.	0.044	-----	0.008	-----	0.134	-----	0.430	-----	0.055	-----	0.072	-----	0.1	-----	1.0	-----
	Std. Dev.	0.199	-----	0.111	-----	0.194	-----	0.313	-----	0.072	-----	0.082	-----	0.5	-----	2.0	-----
	C.V.***	0.775	-----	1.000	-----	0.497	-----	0.413	-----	0.565	-----	0.551	-----	0.5	-----	0.7	-----

Appendix I-1. ***Continued***

STORM #		TOTAL LEAD		TOTAL ZINC		MANGANESE		TOTAL IRON		TOTAL CADMIUM		HARDNESS		CALCIUM		MAGNESIUM	
		ug/L		ug/L		ug/L		ug/L		ug/L		mg/L as CaCO3		mg/l		mg/L	
	L.O.Q**	1.50		15.0		1.0		25.0		0.3		20.0					
	DATE	South		South		South		South		South		South		South		South	
	11/17/00	*0.75*	-----	20.0	-----	12.80	-----	70.0	-----	0.30	-----	240.8	-----	68.90	-----	16.70	-----
1	11/26/00	*0.75*	-----	*7.5*	-----	3.60	-----	80.0	-----	*0.15*	-----	166.0	-----	56.40	-----	6.11	-----
3	01/09/01	*0.75*	-----	*7.5*	-----	3.20	-----	80.0	-----	*0.15*	-----	103.0	-----	35.00	-----	3.78	-----
4	03/05/01	*0.75*	-----	*7.5*	-----	3.70	-----	100.0	-----	*0.15*	-----	117.2	-----	39.50	-----	4.52	-----
6	03/29/01	*0.75*	-----	*7.5*	-----	2.40	-----	70.0	-----	*0.15*	-----	70.1	-----	23.90	-----	2.52	-----
	03/30/01	4.10	-----	40.0	-----	4.30	-----	250.0	-----	*0.15*	-----	53.2	-----	18.20	-----	1.89	-----
	04/02/01	4.30	-----	40.0	-----	13.90	-----	430.0	-----	0.40	-----	118.8	-----	41.00	-----	4.00	-----
	04/06/01	*0.75*	-----	*7.5*	-----	7.20	-----	70.0	-----	*0.15*	-----	129.4	-----	41.20	-----	6.45	-----
	04/09/01	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	04/30/01	*0.75*	-----	*7.5*	-----	13.80	-----	40.0	-----	*0.15*	-----	238.1	-----	68.80	-----	16.10	-----
	05/25/01	*0.75*	-----	20.0	-----	13.70	-----	40.0	-----	*0.15*	-----	299.5	-----	82.00	-----	23.00	-----
7	06/07/01	*0.75*	-----	*7.5*	-----	6.40	-----	190.0	-----	*0.15*	-----	173.1	-----	54.00	-----	9.30	-----
	06/11/01	*0.75*	-----	*7.5*	-----	1.80	-----	*12.5*	-----	*0.15*	-----	110.9	-----	38.10	-----	3.83	-----
	06/18/01	*0.75*	-----	*7.5*	-----	16.20	-----	60.0	-----	*0.15*	-----	127.9	-----	75.30	-----	14.60	-----
8	06/20/01	*0.75*	-----	*7.5*	-----	10.80	-----	60.0	-----	*0.15*	-----	192.5	-----	59.60	-----	10.60	-----
9	06/23/01	*0.75*	-----	*7.5*	-----	3.40	-----	70.0	-----	*0.15*	-----	95.1	-----	33.50	-----	2.79	-----
	06/25/01	*0.75*	-----	*7.5*	-----	3.50	-----	30.0	-----	*0.15*	-----	101.5	-----	35.60	-----	3.06	-----
	06/27/01	*0.75*	-----	*7.5*	-----	5.90	-----	50.0	-----	*0.15*	-----	126.3	-----	41.70	-----	5.39	-----
10	06/29/01	*0.75*	-----	*7.5*	-----	4.00	-----	50.0	-----	*0.15*	-----	101.6	-----	33.90	-----	4.11	-----
	07/03/01	*0.75*	-----	*7.5*	-----	8.70	-----	80.0	-----	*0.15*	-----	143.5	-----	47.40	-----	6.10	-----
	07/06/01	*0.75*	-----	*7.5*	-----	8.70	-----	50.0	-----	*0.15*	-----	154.7	-----	50.10	-----	7.18	-----
	07/09/01	*0.75*	-----	*7.5*	-----	5.80	-----	40.0	-----	*0.15*	-----	121.8	-----	40.50	-----	5.02	-----
11	07/11/01	*0.75*	-----	*7.5*	-----	4.80	-----	*12.5*	-----	*0.15*	-----	112.4	-----	38.30	-----	4.06	-----
12	07/13/01	*0.75*	-----	*7.5*	-----	6.20	-----	30.0	-----	*0.15*	-----	121.0	-----	40.80	-----	4.64	-----
	07/16/01	*0.75*	-----	*7.5*	-----	5.80	-----	30.0	-----	*0.15*	-----	130.7	-----	43.00	-----	5.66	-----
	07/18/01	*0.75*	-----	*7.5*	-----	6.60	-----	40.0	-----	*0.15*	-----	123.1	-----	39.60	-----	5.89	-----
	07/20/01	*0.75*	-----	*7.5*	-----	6.30	-----	40.0	-----	*0.15*	-----	131.3	-----	41.70	-----	6.61	-----
13	07/22/01	*0.75*	-----	*7.5*	-----	7.10	-----	30.0	-----	*0.15*	-----	116.7	-----	39.10	-----	4.63	-----
14	07/24/01	*0.75*	-----	*7.5*	-----	11.30	-----	30.0	-----	*0.15*	-----	143.8	-----	46.50	-----	6.72	-----
15	07/27/01	*0.75*	-----	*7.5*	-----	5.90	-----	40.0	-----	*0.15*	-----	140.6	-----	44.50	-----	7.15	-----
	Count	29	-----	29.0	-----	29	-----	29.0	-----	29	-----	29.0	-----	29	-----	29	-----
	Average	0.99	-----	10.6	-----	7.17	-----	75.0	-----	0.16	-----	138.1	-----	45.45	-----	6.98	-----
	Median	0.75	-----	7.5	-----	6.20	-----	50.0	-----	0.15	-----	126.3	-----	41.20	-----	5.66	-----
	Max.	4.30	-----	40.0	-----	16.20	-----	430.0	-----	0.40	-----	299.5	-----	82.00	-----	23.00	-----
	Min.	0.75	-----	7.5	-----	1.80	-----	12.5	-----	0.15	-----	53.2	-----	18.20	-----	1.89	-----
	Std. Dev.	0.89	-----	8.8	-----	3.93	-----	84.2	-----	0.05	-----	51.2	-----	14.35	-----	4.87	-----
	C.V.***	0.90	-----	0.8	-----	0.55	-----	1.1	-----	0.33	-----	0.4	-----	0.32	-----	0.70	-----

Appendix I-1. *Continued*

STORM #	L.O.Q**	CHLORIDE mg/L 0.4		POTASSIUM mg/L 0.04		SODIUM mg/L 0.06		SULFATE mg/L	
	DATE	South		South		South		South	
	11/17/00	235.0	-----	15.10	-----	142.00	-----	55.40	-----
1	11/26/00	38.6	-----	10.10	-----	48.00	-----	41.50	-----
3	01/09/01	33.6	-----	7.48	-----	27.60	-----	30.50	-----
4	03/05/01	41.6	-----	7.74	-----	31.50	-----	33.80	-----
6	03/29/01	22.1	-----	5.65	-----	17.90	-----	21.60	-----
	03/30/01	17.2	-----	4.02	-----	13.00	-----	13.90	-----
	04/02/01	44.2	-----	5.48	-----	29.40	-----	19.70	-----
	04/06/01	78.7	-----	7.67	-----	50.90	-----	31.00	-----
	04/09/01	-----	-----	-----	-----	-----	-----	-----	-----
	04/30/01	209.0	-----	14.80	-----	134.00	-----	61.00	-----
	05/25/01	302.0	-----	19.40	-----	189.00	-----	80.70	-----
7	06/07/01	126.0	-----	11.90	-----	78.60	-----	58.40	-----
	06/11/01	41.9	-----	6.96	-----	28.30	-----	32.10	-----
	06/18/01	174.0	-----	14.60	-----	106.00	-----	67.40	-----
8	06/20/01	125.0	-----	11.20	-----	76.40	-----	49.40	-----
9	06/23/01	24.4	-----	5.78	-----	17.80	-----	24.00	-----
	06/25/01	28.2	-----	5.69	-----	19.60	-----	21.40	-----
	06/27/01	56.0	-----	7.29	-----	35.70	-----	26.90	-----
10	06/29/01	41.8	-----	6.31	-----	26.20	-----	20.90	-----
	07/03/01	72.0	-----	7.76	-----	43.20	-----	26.60	-----
	07/06/01	88.8	-----	8.72	-----	54.60	-----	30.40	-----
	07/09/01	55.8	-----	7.00	-----	35.70	-----	21.40	-----
11	07/11/01	36.7	-----	6.20	-----	26.80	-----	18.90	-----
12	07/13/01	50.2	-----	6.39	-----	32.40	-----	20.00	-----
	07/16/01	66.3	-----	6.97	-----	40.80	-----	23.40	-----
	07/18/01	69.3	-----	7.01	-----	41.80	-----	22.30	-----
	07/20/01	75.1	-----	7.26	-----	45.50	-----	24.50	-----
13	07/22/01	48.9	-----	5.98	-----	30.20	-----	18.20	-----
14	07/24/01	82.5	-----	6.51	-----	46.20	-----	27.40	-----
15	07/27/01	88.7	-----	6.76	-----	53.80	-----	27.20	-----
	Count	29.0	-----	29	-----	29	-----	29	-----
	Average	81.8	-----	8.40	-----	52.51	-----	32.76	-----
	Median	56.0	-----	7.01	-----	40.80	-----	26.90	-----
	Max.	302.0	-----	19.40	-----	189.00	-----	80.70	-----
	Min.	17.2	-----	4.02	-----	13.00	-----	13.90	-----
	Std. Dev.	68.4	-----	3.57	-----	41.36	-----	16.82	-----
	C.V.***	0.8	-----	0.42	-----	0.79	-----	0.51	-----

Appendix I-2. Constituent concentrations measured in composite samples collected in Year 1 at the South and North Underdrains. ***Sampling event covers two storms. **Numbers in italics were below the lab detection limit, and 1/2 the detection limit was used in the calculations. ***C.V. = Coefficient of Variation (Standard Deviation/Mean).**

STORM #	L.O.Q**	AMMONIA mg/L 0.01		NITRATE + NITRITE mg/L 0.01		ORGANIC NITROGEN mg/L 0.05		TOTAL NITROGEN mg/L 0.05		ORTHO-PHOSPHATE mg/L 0.01		TOTAL - PHOSPHATE mg/L 0.01		TSS mg/L 0.05	
	DATE	South	North	South	North	South	North	South	North	South	North	South	North	South	North
	06/10/02	0.012	0.418	0.035	0.011	1.733	0.051	1.780	0.480	0.322	0.182	0.353	0.201	6.62	*0.25*
	06/12/02	1.680	0.334	0.026	0.014	0.255	0.133	1.960	0.480	0.333	0.175	0.353	0.204	*0.25*	1.30
2	06/18/02	0.181	0.031	0.488	0.040	0.391	0.340	1.060	0.410	0.067	0.040	0.156	0.062	2.60	2.60
3	06/24/02	0.109	0.195	0.142	0.093	0.229	0.232	0.480	0.520	0.107	0.116	0.139	0.123	9.10	3.70
5	06/29/02	0.170	0.208	0.249	0.149	0.211	0.173	0.630	0.530	0.085	0.101	0.101	0.102	5.00	2.40
6	07/01/02	0.185	0.166	0.216	0.160	0.209	0.244	0.610	0.570	0.091	0.090	0.110	0.104	2.90	1.60
	07/02/02	0.163	0.191	0.094	0.083	0.323	0.276	0.580	0.550	0.093	0.094	0.970	0.099	1.70	1.10
	07/10/02	0.688	0.246	0.135	0.074	0.337	0.310	1.160	0.630	0.238	0.096	0.259	0.230	0.80	2.00
	07/16/02	0.180	0.125	0.112	0.125	0.129	0.682	0.421	0.932	0.105	0.070	0.134	0.111	0.90	-----
7	07/25/02	0.852	0.526	0.137	0.112	0.161	0.242	1.150	0.880	0.265	0.128	0.304	0.173	1.60	2.70
8	08/02/02	0.795	0.462	0.086	0.083	0.349	0.355	1.230	0.900	0.254	0.121	0.291	0.141	2.10	1.20
9	08/07/02	0.220	0.127	0.343	0.278	0.327	0.355	0.890	0.760	0.109	0.058	0.136	0.086	1.40	2.70
	08/12/02	0.288	0.168	0.130	0.188	0.182	0.154	0.600	0.510	0.116	0.061	0.133	0.071	1.60	1.30
10	08/14/02	-----	0.163	-----	0.408	-----	0.147	-----	0.718	-----	0.069	-----	0.080	-----	2.20
	08/19/02	-----	0.085	-----	0.211	-----	0.064	-----	0.360	-----	0.060	-----	0.074	-----	1.10
12	08/30/02	0.634	0.246	0.198	0.066	0.060	0.141	0.892	0.453	0.219	0.066	0.214	0.086	*0.25*	1.10
	08/31/02	0.128	0.114	0.263	0.069	0.179	0.179	0.570	0.362	0.086	0.047	0.090	0.076	*0.25*	1.40
13	09/02/02	0.083	0.064	0.091	0.083	0.174	0.210	0.348	0.357	0.075	0.049	0.086	0.065	0.90	1.10
14	09/11/02	0.240	0.210	0.151	0.079	0.266	0.282	0.657	0.571	0.093	0.072	0.118	0.109	1.80	1.30
15	09/12/02	0.083	0.161	0.079	0.033	0.205	0.142	0.367	0.336	0.052	0.059	0.066	0.082	0.60	1.80
	09/16/02	0.091	0.204	0.095	0.049	0.189	0.322	0.375	0.575	0.062	0.094	0.081	0.132	0.90	2.20
16	09/17/02	0.421	0.327	0.164	0.092	0.272	0.178	0.857	0.597	0.140	0.102	0.160	0.119	1.30	0.60
17	09/27/02	0.154	0.420	0.054	0.066	0.284	0.350	0.492	0.836	0.072	0.112	0.093	0.146	1.12	1.30
	09/30/02	0.122	0.039	0.052	0.064	0.299	1.183	0.472	1.286	0.081	0.120	0.106	0.170	1.68	3.26
18	10/12/02	0.386	0.435	0.301	0.142	0.143	0.233	0.830	0.810	0.103	0.066	0.139	0.104	4.09	2.65
19	10/15/02	0.131	0.464	0.047	0.032	0.322	0.354	0.500	0.850	0.074	0.091	0.117	0.186	1.87	3.78
	11/04/02	0.711	1.102	0.124	0.096	0.085	0.272	0.920	1.470	0.206	0.211	0.206	0.235	0.40	1.86
21	11/12/02	0.211	0.266	0.354	0.093	0.305	0.451	0.870	0.810	0.075	0.056	0.111	0.099	2.33	2.49
	11/18/02	0.140	0.217	0.109	0.128	0.281	0.295	0.530	0.640	0.069	0.063	0.077	0.087	1.15	1.58
	11/25/02	0.583	0.545	0.064	0.201	0.263	0.304	0.910	1.050	0.187	0.152	0.202	0.175	0.69	1.74
22	12/09/02	0.125	0.110	0.345	0.333	0.250	0.257	0.720	0.700	0.069	0.064	0.082	0.088	1.12	2.08
23	12/12/02	0.148	0.204	0.441	0.183	0.201	0.213	0.790	0.600	0.076	0.066	0.089	0.083	2.35	1.53
	01/14/03	0.674	1.060	0.086	0.087	0.310	0.173	1.070	1.320	0.265	0.256	0.286	0.279	1.05	1.24
24	02/22/03	0.235	0.345	0.198	0.023	0.209	0.298	0.642	0.666	0.119	0.097	0.147	0.128	1.31	2.24
25	02/28/03	0.144	0.246	0.104	0.044	0.132	0.230	0.380	0.520	0.083	0.092	0.095	0.113	0.59	*1.50*
	03/10/03	0.409	0.797	0.086	0.042	0.159	0.231	0.654	1.070	0.178	0.216	0.191	0.241	0.70	3.72

Appendix I-2. *Continued*

STORM #	L.O.Q**	AMMONIA mg/L 0.01		NITRATE + NITRITE mg/L 0.01		ORGANIC NITROGEN mg/L 0.05		TOTAL NITROGEN mg/L 0.05		ORTHO-PHOSPHATE mg/L 0.01		TOTAL - PHOSPHATE mg/L 0.01		TSS mg/L 0.05	
	DATE	South	North	South	North	South	North	South	North	South	North	South	North	South	North
26	03/16/03	0.422	0.345	0.333	0.068	0.223	0.351	0.978	0.764	0.171	0.103	0.201	0.144	1.58	1.50
28	03/23/03	0.108		0.101		0.212	0.000	0.421		0.074		0.089		1.09	*1.50*
	03/27/03	0.179	0.106	0.101	0.060	0.197	0.368	0.477	0.534	0.098	0.062	0.105	0.087	0.80	*1.50*
	04/21/03	0.902	1.460	0.067	0.057	0.281	0.323	1.250	1.840	0.303	0.294	0.334	0.355	2.04	3.50
29	04/25/03	0.116	0.361	0.532	0.314	0.350	0.365	0.998	1.040	0.071	0.091	0.100	0.121	3.11	4.57
	04/28/03	0.146	0.037	0.161	0.100	0.152	0.206	0.459	0.343	0.085	0.036	0.094	0.047	0.42	3.25
	05/12/03	0.799	1.270	0.071	0.042	0.360	0.338	1.230	1.650	0.277	0.280	0.295	0.323	1.01	*1.50*
	05/21/03	0.561	0.353	0.299	0.129	0.200	0.301	1.060	0.783	0.202	0.090	0.227	0.110	1.96	*1.50*
30	05/22/03	0.303	0.098	0.368	0.090	0.293	0.381	0.964	0.569	0.120	0.043	0.136	0.059	0.88	*1.50*
	06/02/03	0.869	1.590	0.046	0.040	0.285	0.280	1.200	1.910	0.287	0.311	0.302	0.343	0.51	*1.50*
31*	06/09/03	0.572	0.349	0.261	0.090	0.277	0.401	1.110	0.840	0.200	0.094	0.228	0.123	0.77	*1.50*
	06/11/03	0.296	0.066	0.107	0.025	0.227	0.379	0.630	0.470	0.122	0.030	0.149	0.058	0.61	*1.50*
32	06/11/03	0.114	0.045	0.145	0.095	0.291	0.350	0.550	0.490	0.068	0.025	0.092	0.067	1.01	*1.50*
	06/16/03	0.409	0.264	0.076	0.067	0.338	0.446	0.823	0.777	0.163	0.089	0.175	0.112	0.75	*1.50*
33	06/16/03	0.148	0.045	0.117	0.048	0.346	0.272	0.611	0.365	0.076	0.026	0.090	0.047	0.49	*1.50*
34	06/18/03	0.125	0.030	0.079	0.024	0.196	0.266	0.400	0.320	0.077	0.031	0.086	0.044	2.81	*1.50*
35	06/19/03	0.160	0.044	0.203	0.036	0.157	0.150	0.520	0.230	0.085	0.042	0.089	0.054	0.58	*1.50*
36	06/29/03	0.312	0.187	0.162	0.086	0.475	0.223	0.949	0.496	0.111	0.065	0.156	0.102	8.66	*1.50*
	07/01/03	0.163	0.068	0.098	0.069	0.549	0.213	0.810	0.350	0.093	0.048	0.309	0.064	37.60	14.50
37	07/11/03	0.217	0.176	0.079	0.040	0.334	0.227	0.630	0.443	0.096	0.075	0.333	0.116	47.00	6.84
	07/23/03	0.282	0.397	0.087	0.062	0.264	0.132	0.633	0.591	0.117	0.121	0.398	0.138	74.60	10.40
	08/12/03	0.213	0.202	0.108	0.052	0.277	0.189	0.598	0.443	0.094	0.091	0.113	0.095	3.70	*1.50*
	08/18/03	0.128	0.226	0.085	0.085	0.155	0.153	0.368	0.464	0.079	0.100	0.097	0.109	5.46	*1.50*
38	08/27/03	0.135	0.139	0.077	0.058	0.288	0.263	0.500	0.460	0.075	0.064	0.181	0.073	27.10	4.95
	09/05/03	0.164	0.172	0.048	0.037	0.263	0.286	0.475	0.495	0.077	0.066	0.103	0.082	3.45	*1.50*
	09/10/03	0.197	0.293	0.092	0.055	0.396	0.277	0.685	0.625	0.089	0.099	0.157	0.121	8.58	*1.50*
39	09/19/03	0.212	0.163	0.199	0.118	0.300	0.260	0.711	0.541	0.106	0.068	0.168	0.089	11.80	5.51
	10/03/03	0.164	0.193	0.064	0.056	0.198	0.175	0.426	0.424	0.087	0.084	0.102	0.091	1.66	*1.50*
	10/13/03	0.404	0.792	0.069	0.012	0.283	0.356	0.756	1.160	0.181	0.213	0.196	0.238	1.13	*1.50*
	Count	64	64	64	64	64	65	64	64	64	64	64	64	64	64
	Average	0.316	0.320	0.154	0.094	0.276	0.277	0.745	0.696	0.129	0.099	0.177	0.126	4.91	2.37
	Median	0.191	0.206	0.108	0.072	0.264	0.266	0.648	0.573	0.095	0.090	0.138	0.107	1.36	1.50
	Max.	1.680	1.590	0.532	0.408	1.733	1.183	1.960	1.910	0.333	0.311	0.970	0.355	74.60	14.50
	Min.	0.010	0.030	0.010	0.011	0.050	0.000	0.050	0.230	0.010	0.025	0.010	0.044	0.05	0.25
	Std. Dev.	0.289	0.334	0.116	0.078	0.206	0.156	0.337	0.358	0.075	0.065	0.133	0.071	11.95	2.20
	C.V.***	0.915	1.043	0.755	0.821	0.747	0.564	0.452	0.515	0.584	0.651	0.753	0.562	2.43	0.93

* Backflow from Ybor channel into south under drains in July 2003 caused high

Appendix I-2. *Continued*

STORM #		TOTAL COPPER ug/L		TOTAL LEAD ug/L		TOTAL ZINC ug/L		MANGANESE ug/L		TOTAL IRON ug/L		TOTAL CADMIUM ug/L		HARDNESS mg/L as CaCO3	
	L.O.Q**	2.0		1.50		15.0		1.0		25.0		0.3		20.0	
	DATE	South	North	South	North	South	North	South	North	South	North	South	North	South	North
	06/10/02	2.50	1.15	0.40	1.00	30.0	6.0	39.4	41.9	90.0	130.0	0.28	0.10	344.40	116.31
	06/12/02	3.30	1.15	0.20	1.00	6.0	6.0	37.0	38.7	80.0	100.0	0.10	0.10	341.94	111.48
2	06/18/02	3.20	2.60	2.40	0.50	20.0	20.0	15.7	10.0	460.0	160.0	0.08	0.04	116.14	75.11
3	06/25/02	2.80	2.70	2.20	1.30	6.0	6.0	10.4	11.6	320.0	190.0	0.10	0.10	78.45	65.03
5	06/29/02	3.10	1.15	1.00	1.00	50.0	6.0	10.8	11.1	110.0	110.0	0.10	0.10	94.32	93.53
6	07/01/02	2.60	1.15	1.00	1.00	30.0	6.0	12.7	8.6	110.0	90.0	0.10	0.10	120.74	87.68
	07/02/02	2.80	1.15	1.00	1.00	6.0	6.0	12.1	10.2	110.0	70.0	0.10	0.10	107.28	84.82
	07/10/02	1.15	1.15	1.00	1.00	30.0	6.0	29.0	13.4	110.0	90.0	0.10	0.10	279.74	87.24
	07/16/02	2.50	1.70	1.00	1.00	20.0	7.5	7.3	14.8	80.0	100.0	0.07	0.05	128.60	80.24
7	07/26/02	1.15	1.15	1.00	1.00	7.5	7.5	30.3	59.7	70.0	100.0	1.09	0.10	306.93	125.33
8	08/02/02	1.15	1.15	1.60	1.00	30.0	20.0	22.1	31.0	80.0	90.0	0.10	0.10	309.22	133.27
9	08/08/02	1.15	1.15	1.00	1.00	20.0	20.0	12.1	15.7	80.0	100.0	0.10	0.10	169.32	103.14
	08/12/02	1.15	2.40	1.00	1.00	7.5	7.5	9.3	10.9	70.0	80.0	0.10	0.10	162.21	99.90
10	08/15/02	-----	1.15	-----	1.00	-----	7.5	-----	14.9	-----	130.0	-----	0.10	-----	88.72
	08/19/02	-----	1.15	-----	1.00	-----	7.5	-----	11.4	-----	60.0	-----	0.10	-----	83.90
12	08/30/02	2.60	2.50	1.00	1.00	7.5	20.0	16.2	12.1	30.0	60.0	0.10	0.60	207.52	91.86
	08/31/02	2.60	1.15	1.00	1.00	7.5	7.5	8.9	11.6	70.0	60.0	0.10	0.10	113.64	88.51
13	09/03/02	1.15	1.15	1.00	1.00	7.5	7.5	7.0	14.3	40.0	60.0	0.41	0.10	125.46	108.10
14	09/11/02	1.15	1.15	1.00	1.00	7.5	30.0	25.5	37.5	100.0	110.0	0.10	0.10	154.49	133.46
15	09/13/02	1.15	2.60	1.00	1.20	20.0	20.0	9.6	32.2	60.0	100.0	0.10	0.10	106.27	111.48
	09/16/02	1.15	1.15	1.00	1.00	7.5	7.5	7.7	71.6	60.0	140.0	0.10	0.10	121.47	144.45
16	09/18/02	1.15	1.15	1.00	1.00	20.0	20.0	29.1	61.4	100.0	130.0	0.10	0.10	214.60	132.45
17	09/27/02	3.00	1.15	1.00	1.00	7.5	7.5	20.7	50.7	160.0	220.0	0.10	0.10	157.35	180.89
	09/30/02	1.15	1.15	1.00	1.00	7.5	7.5	16.0	91.1	110.0	280.0	0.10	0.10	175.09	205.28
18	10/14/02	2.50	2.50	1.00	1.00	7.5	20.0	26.0	102.0	110.0	190.0	0.33	0.10	176.84	159.83
19	10/16/02	1.15	1.15	1.00	1.00	20.0	20.0	32.9	128.0	180.0	510.0	0.10	0.10	143.90	159.19
	11/04/02	1.15	2.40	1.00	1.00	20.0	50.0	33.6	73.2	110.0	240.0	0.10	0.10	246.81	223.32
21	11/14/02	1.15	1.15	1.00	1.00	70.0	7.5	Changed Lab Constituents		80.0	160.0	-----	-----	171.95	156.31
	11/18/02	1.15	1.15	1.00	1.00	20.0	7.5			70.0	110.0	0.10	0.10	143.97	139.75
	11/25/02	1.15	3.30	1.00	1.00	7.5	7.5			70.0	180.0	0.10	0.10	225.36	176.75
22	12/10/02	3.80	3.80	1.00	1.00	7.5	7.5			60.0	130.0	0.10	0.10	120.08	84.20
23	12/13/02	4.20	3.50	1.00	1.00	7.5	7.5			120.0	120.0	0.10	0.10	125.08	89.15
	01/14/03	1.15	2.30	1.00	1.00	7.5	7.5			90.0	110.0	0.10	0.10	275.63	160.16
24	02/24/03	1.50	1.50	5.00	5.00	4.3	5.4			44.9	47.3	0.50	0.50	173.58	129.93
25	02/28/03	0.94	4.40	5.00	5.00	18.8	9.2			40.6	79.3	0.50	0.50	136.63	126.62
	03/10/03	1.54	1.50	5.00	5.00	9.0	5.4			78.5	88.9	0.50	0.50	222.84	191.89

Appendix I-2. ***Continued***

STORM #	L.O.Q**	TOTAL COPPER ug/L 2.0		TOTAL LEAD ug/L 1.50		TOTAL ZINC ug/L 15.0		MANGANESE ug/L 1.0		TOTAL IRON ug/L 25.0		TOTAL CADMIUM ug/L 0.3		HARDNESS mg/L as CaCO3 20.0	
	DATE	South	North	South	North	South	North	South	North	South	North	South	North	South	North
26	03/16/03	1.77	1.50	5.00	5.00	16.8	7.7			66.7	113.0	0.50	0.50	215.03	134.69
28	03/23/03			5.00		13.8				31.6		0.50		109.71	
	03/27/03	0.66	1.50	5.00	5.00	26.3	5.8			39.7	123.0	0.50	0.50	135.18	93.60
	04/21/03	1.71	1.50	5.00	5.00	4.4	8.7			69.4	99.2	0.50	0.50	318.18	220.09
29	04/25/03	3.73	4.66	5.00	5.00	5.6	5.6			130.0	193.0	0.50	0.50	108.21	101.54
	04/28/03	0.57	3.67	5.00	5.00	2.9	4.9			40.7	44.9	0.50	0.50	111.77	65.96
	05/12/03	2.22	1.50	5.00	5.00	18.6	35.6			51.2	81.1	0.50	0.50	303.78	213.78
	05/21/03	0.45	1.50	5.00	5.00	16.7	30.4			69.8	64.2	0.50	0.50	234.91	131.11
30	05/22/03	1.18	3.13	5.00	5.00	6.2	14.4			64.0	63.5	0.50	0.50	185.61	106.86
	06/02/03	1.57	1.50	5.00	5.00	6.3	3.4			50.6	86.5	0.50	0.50	313.75	229.60
31*	06/09/03	1.46	1.50	5.00	5.00	3.9	3.2			47.4	66.3	0.50	0.50	256.26	126.94
	06/11/03	1.22	1.50	5.00	5.00	5.2	2.1			64.3	57.6	0.50	0.50	177.60	98.88
32	06/11/03	1.89	1.50	5.00	5.00	4.3	22.8			62.3	91.3	0.50	0.50	121.10	82.26
	06/16/03	1.47	1.50	5.00	5.00	3.2	8.8	Changed Lab Constituents		70.8	151.0	0.50	0.50	211.14	120.26
33	06/16/03	1.38	1.50	5.00	5.00	3.1	12.2			41.6	86.1	0.50	0.50	130.49	85.02
34	06/18/03	2.00	1.50	5.00	5.00	5.1	2.3			102.0	74.5	0.50	0.50	122.73	81.57
35	06/19/03	0.72	1.50	5.00	5.00	5.6	5.0			53.1	95.3	0.50	0.50	139.79	75.86
36	06/29/03		1.50	5.00	5.00	5.7	3.6			223.0	369.0	0.50	0.50	187.87	103.67
	07/01/03	0.60	1.50	5.00	5.00	25.9	2.5			1140.0	72.1	0.50	0.50	162.01	84.95
37	07/11/03	4.51	1.50	5.00	5.00	20.2	5.4			1160.0	518.0	0.50	0.50	176.67	98.34
	07/23/03	0.98	1.50	12.60	5.00	24.2	3.9			1280.0	215.0	0.50	0.50	208.66	130.52
	08/12/03	0.74	1.50	5.00	5.00	3.5	3.3			87.7	109.0	0.50	0.50	139.19	103.24
	08/18/03	1.26	1.50	5.00	5.00	4.6	1.0			78.9	105.0	0.50	0.50	142.64	125.04
38	08/27/03	0.68	1.50	5.00	5.00	10.2	3.9			503.0	69.2	0.50	0.50	133.24	92.51
	09/05/03	0.59	1.50	5.00	5.00	2.6	1.0			89.8	59.3	0.50	0.50	125.70	97.45
	09/10/03	0.97	1.50	5.00	5.00	4.8	1.0			199.0	104.0	0.50	0.50	150.16	123.58
39	09/19/03	2.20	1.50	5.00	5.00	7.4	3.1			296.0	66.9	0.50	0.50	148.09	86.51
	10/03/03	1.34	1.50	5.00	5.00	2.3	1.0			49.7	102.0	0.50	0.50	124.26	97.59
	10/13/03	2.34	1.50	5.00	5.00	1.0	1.0			51.2	74.3	0.50	0.50	206.47	176.74
	Count	62	64	64	64	64	64	26	27	64	64	63	63	64	64
	Average	1.73	1.76	3.15	2.94	13.0	9.8	18.6	36.7	153.0	126.2	0.33	0.30	175.28	120.59
	Median	1.30	1.50	3.70	1.25	7.5	7.5	15.9	15.7	79.5	100.0	0.50	0.50	155.92	107.48
	Max.	4.51	4.66	12.60	5.00	70.0	50.0	39.4	128.0	1280.0	518.0	1.09	0.60	344.40	229.60
	Min.	0.45	1.15	0.20	0.50	1.0	1.0	1.0	8.6	25.0	44.9	0.07	0.04	20.00	65.03
	Std. Dev.	0.96	0.84	2.32	2.02	11.9	9.2	10.8	32.8	249.0	91.3	0.22	0.21	69.92	41.03
	C.V.***	0.56	0.48	0.73	0.69	0.9	0.9	0.6	0.9	1.6	0.7	0.65	0.68	0.40	0.34

Appendix I-2. ***Continued***

STORM #	L.O.Q**	CALCIUM mg/l		MAGNESIUM mg/L		CHLORIDE mg/L 0.4		POTASSIUM mg/L 0.04		SODIUM mg/L 0.06		SULFATE mg/L	
	DATE	South	North	South	North	South	North	South	North	South	North	South	North
	06/10/02	99.50	43.00	23.30	2.17	0.3	13.9	23.00	7.52	247.00	14.80	109.00	18.70
	06/12/02	100.00	41.20	22.40	2.09	413.0	13.3	21.10	7.00	239.00	14.30	106.00	18.30
2	06/18/02	41.40	28.10	3.10	1.20	31.6	8.1	4.88	3.15	22.30	8.17	24.20	15.20
3	06/25/02	28.20	24.00	1.95	1.24	18.9	8.7	3.61	2.90	13.70	7.76	18.40	10.80
5	06/29/02	33.80	33.50	2.41	2.40	30.0	19.6	4.46	4.41	20.20	20.20	27.00	18.80
6	07/01/02	42.60	31.70	3.49	2.07	43.8	18.0	5.66	3.83	29.20	13.30	33.90	18.20
	07/02/02	38.10	31.10	2.95	1.74	36.5	13.0	5.11	3.60	23.90	9.92	27.00	15.20
	07/10/02	89.60	32.10	13.60	1.72	206.0	8.8	15.00	3.56	134.00	8.43	89.60	13.40
	07/16/02	44.00	29.20	7.30	1.78	54.6	12.8	38.30	2.92	38.30	11.20	35.20	17.90
7	07/26/02	90.10	44.70	19.90	3.33	294.0	29.7	19.10	4.27	185.00	24.10	135.00	24.20
8	08/02/02	89.70	47.50	20.70	3.56	277.0	31.6	18.80	4.42	174.00	25.30	127.00	27.00
9	08/08/02	56.30	37.10	6.98	2.55	81.9	19.9	7.96	3.96	56.10	18.20	53.70	26.70
	08/12/02	55.20	36.00	5.92	2.43	73.3	19.6	7.82	4.10	51.90	16.80	47.60	23.40
10	08/15/02	-----	32.00	-----	2.14	-----	12.3	-----	3.77	-----	11.00	-----	19.90
	08/19/02	-----	30.30	-----	2.00	-----	14.3	-----	3.23	-----	11.90	-----	17.30
12	08/30/02	68.20	32.70	9.04	2.48	133.0	17.7	12.20	3.29	92.50	16.00	92.20	21.30
	08/31/02	40.10	32.10	3.28	2.03	33.8	13.2	5.29	3.20	25.90	12.50	29.50	19.60
13	09/03/02	44.80	39.30	3.30	2.42	38.1	16.7	5.73	4.10	28.30	14.80	30.40	21.50
14	09/11/02	54.50	48.40	4.47	3.06	51.0	19.8	6.34	4.07	35.90	16.00	31.90	19.40
15	09/13/02	38.80	41.00	2.28	2.21	21.2	11.4	3.71	3.25	15.50	9.69	19.50	14.90
	09/16/02	43.40	51.50	3.18	3.85	32.8	26.5	4.63	4.76	22.80	19.60	25.80	22.70
16	09/18/02	72.60	47.60	8.09	3.30	102.0	20.7	10.10	4.22	66.10	16.00	57.80	19.90
17	09/27/02	56.70	65.30	3.83	4.33	35.6	27.5	6.00	5.88	25.80	20.70	26.70	21.10
	09/30/02	62.70	73.70	4.50	5.16	45.8	35.1	6.43	6.45	31.80	26.00	31.40	25.70
18	10/14/02	61.70	58.70	5.53	3.22	49.3	20.2	7.91	6.33	36.20	16.50	33.20	20.00
19	10/16/02	52.40	57.80	3.17	3.61	24.6	21.4	5.86	6.01	19.30	17.00	20.60	17.20
	11/04/02	82.40	78.50	9.97	6.63	49.3	43.5	10.30	7.50	69.70	31.10	23.80	29.10
21	11/13/03	62.30	57.90	3.98	2.85								
	11/18/02	52.20	51.30	3.31	2.83								
	11/25/02	74.80	63.10	9.37	4.66								
22	12/10/02	43.80	31.10	2.60	1.59								
23	12/13/02	44.80	32.80	3.21	1.76	Changed Lab Constituents							
	01/14/03	86.80	53.90	14.30	6.21								
24	02/24/03	59.80	46.00	5.89	3.66								
25	02/28/03	48.60	45.40	3.71	3.22								
	03/10/03	77.60	65.80	7.06	6.70								

Appendix I-2. ***Continued***

STORM #		CALCIUM mg/l		MAGNESIUM mg/L		CHLORIDE mg/L		POTASSIUM mg/L		SODIUM mg/L		SULFATE mg/L	
	L.O.Q**					0.4		0.04		0.06			
	DATE	South	North	South	North	South	North	South	North	South	North	South	North
26	03/16/03	73.40	48.40	7.71	3.36								
28	03/23/03	39.40		2.75									
	03/27/03	48.20	34.60	3.60	1.75								
	04/21/03	98.40	73.20	17.60	9.06								
29	04/25/03	38.90	35.80	2.69	2.95								
	04/28/03	39.70	24.70	3.07	1.04								
	05/12/03	95.60	69.80	15.80	9.59								
	05/21/03	77.80	47.00	9.87	3.34								
30	05/22/03	63.20	39.20	6.75	2.18								
	06/02/03	95.80	76.20	18.10	9.55								
31*	06/09/03	83.00	45.00	11.90	3.54								
	06/11/03	62.40	36.60	5.29	1.82								
32	06/11/03	43.80	30.90	2.85	1.24								
	06/16/03	72.70	43.10	7.19	3.07								
33	06/16/03	46.80	32.20	3.31	1.12	Changed Lab Constituents							
34	06/18/03	44.40	31.00	2.88	1.01								
35	06/19/03	49.50	28.60	3.93	1.08								
36	06/29/03	63.00	37.10	7.42	2.68								
	07/01/03	56.80	31.40	4.90	1.59								
37	07/11/03	63.30	36.20	4.52	1.93								
	07/23/03	72.30	46.20	6.83	3.68								
	08/12/03	48.80	37.70	4.21	2.21								
	08/18/03	49.90	44.50	4.38	3.38								
38	08/27/03	48.00	33.80	3.25	1.97								
	09/05/03	44.90	35.40	3.30	2.20								
	09/10/03	52.70	43.80	4.51	3.45								
39	09/19/03	52.20	31.10	4.31	2.15								
	10/03/03	44.80	35.80	3.01	1.99								
	10/13/03	71.90	59.50	6.54	6.84								
	Count	63	64	63	64	26	27	26	27	26	27	25	27
	Average	59.99	43.19	6.83	3.09	83.8	19.2	9.97	4.51	65.56	15.97	50.26	19.90
	Median	55.20	39.25	4.50	2.46	44.8	18.0	6.39	4.10	33.85	16.00	31.90	19.60
	Max.	100.00	78.50	23.30	9.59	413.0	43.5	38.30	7.52	247.00	31.10	135.00	29.10
	Min.	28.20	24.00	1.95	1.01	0.3	8.1	0.04	2.90	0.06	7.76	18.40	10.80
	Std. Dev.	18.74	13.53	5.37	1.94	101.6	8.5	8.26	1.42	70.24	5.86	36.38	4.30
	C.V.***	0.31	0.31	0.79	0.63	1.2	0.4	0.83	0.32	1.07	0.37	0.72	0.22

Appendix J

Metal Concentrations at the Outflow Weir compared to Class III Standards

Appendix J. Comparison of metal concentrations measured at the outflow to metal class III standards. Bolded values exceed Class III Water Quality Standards. Exceedance (%) represents the percent of samples in non-compliance with standards. Numbers in italics indicate values that were below laboratory level of quantification (LOQ) and ½ the LOQ was substituted.

DATE	TOTAL COPPER	STD. COPPER	TOTAL LEAD	STD. LEAD	TOTAL ZINC	STD. ZINC	Hardness
	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	
LOQ==>	2		1.5		15		
YEAR 1							
11/25/00	9.5	10.02	1.50	2.49	------	89.94	82.4
12/18/00	7.4	12.75	0.75	3.56	7.5	114.20	109.2
01/08/01	5.5	10.09	2.20	2.51	20.0	90.54	83.0
03/04/01	9.2	10.97	2.00	2.85	20.0	98.43	91.6
03/19/01	2.9	9.79	0.75	2.40	7.5	87.90	80.2
03/29/01	3.2	5.97	**1.83**	1.15	21.2	53.80	44.9
06/06/01	5.0	8.84	2.00	2.06	20.0	79.47	71.2
06/22/01	4.4	9.60	0.75	2.33	7.5	86.18	78.3
06/28/01	3.4	7.29	**3.40**	1.55	7.5	65.60	56.8
07/11/01	2.5	10.10	0.75	2.52	7.5	90.65	83.2
07/13/01	*1.0*	8.99	0.75	2.12	7.5	80.80	72.6
07/22/01	*1.0*	9.12	0.75	2.16	20.0	81.90	73.8
07/23/01	2.5	9.03	0.75	2.13	20.0	81.09	72.9
07/27/01	2.2	9.45	0.75	2.28	7.5	84.91	77.0
08/05/01	*1.0*	9.41	0.75	2.26	7.5	84.48	76.5
08/07/01	2.7	17.23	2.20	5.57	7.5	153.95	155.4
Number	16	16	16	16	15	16	16
Average	4.0	9.9	1.4	2.5	12.6	89.0	81.8
Median	3.0	9.5	0.8	2.3	7.5	85.5	77.7
Exceedance (%)	0.0		0.1		0.0		

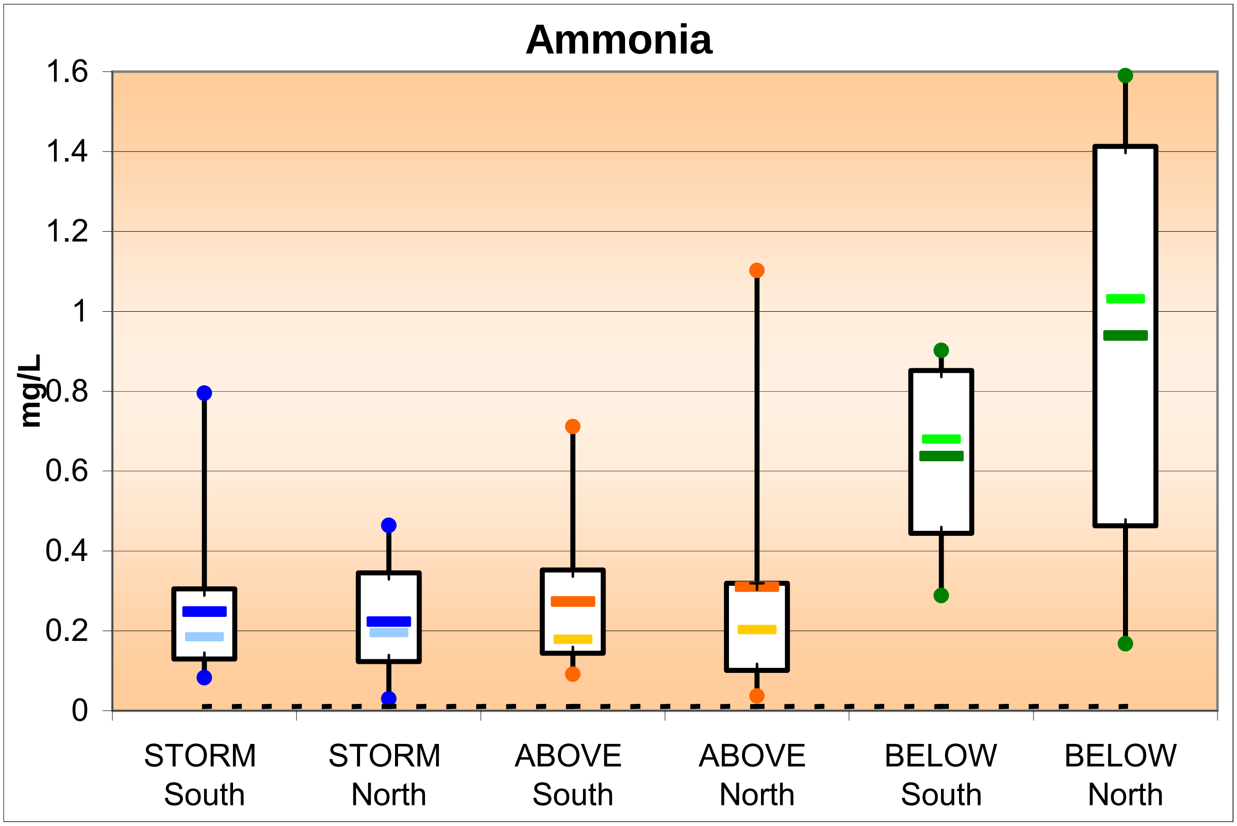
Appendix J. ***Continued***

DATE	TOTAL COPPER	STD. COPPER	TOTAL LEAD	STD. LEAD	TOTAL ZINC	STD. ZINC	Hardness
	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	
LOQ==>	2		1.5		15		
YEAR 2							
06/18/02	3.00	5.19	**1.30**	0.93	20.0	46.84	38.14
06/24/02	**8.40**	4.84	**2.40**	0.84	20.0	43.74	35.19
06/28/02	**6.60**	5.06	**1.60**	0.90	*7.5*	45.71	37.06
06/29/02	2.30	6.09	*1.00*	1.18	*7.5*	54.85	45.96
07/01/02	*1.15*	6.41	*1.00*	1.28	*7.5*	57.78	48.87
08/07/02	4.20	9.18	1.40	2.18	40.0	82.49	74.39
08/14/02	4.10	6.42	**2.00**	1.28	20.0	57.82	48.91
08/17/02	*1.15*	6.22	*1.00*	1.22	*7.5*	56.03	47.13
08/30/02	3.40	7.63	*1.00*	1.66	30.0	68.68	59.92
09/02/02	3.30	8.96	*1.00*	2.10	20.0	80.51	72.29
09/11/02	2.80	4.75	*1.00*	0.82	30.0	42.89	34.38
09/12/02	3.00	7.30	*1.00*	1.55	20.0	65.69	56.86
09/17/02	4.20	8.04	**2.00**	1.79	30.0	72.35	63.72
12/09/02	**11.30**	7.05	**1.70**	1.47	20.0	63.45	54.57
12/12/02	**9.50**	5.70	*1.00*	1.07	20.0	51.41	42.57
02/28/03	3.87	9.35	*5.00*	2.24	25.9	83.96	75.96
03/21/03	3.78	6.79	*5.00*	1.39	21.9	61.13	52.23
03/23/03	3.63	5.90	*5.00*	1.13	25.2	53.21	44.34
04/25/03	**11.60**	6.49	*5.00*	1.30	35.1	58.44	49.53
06/11/03	5.23	7.90	*5.00*	1.75	27.8	71.07	62.39
06/18/03	5.53	6.76	*5.00*	1.38	15.2	60.90	52.00
06/19/03	4.34	5.88	*5.00*	1.12	12.9	53.05	44.18
06/29/03	*1.50*	9.07	*5.00*	2.14	9.5	81.45	73.28
07/11/03	**102.00**	13.97	**32.70**	4.08	**236.0**	125.10	121.61
08/27/03	*1.50*	8.00	*5.00*	1.78	15.7	71.98	63.34
09/19/03	**7.35**	7.15	*5.00*	1.50	26	64.37	55.52
Number	26	26	26	26	26	26	26
Average	8.4	7.2	4.0	1.5	28.9	64.4	55.9
Median	4.0	6.8	2.0	1.4	20.0	61.0	52.1
Exceedance (%)	26.9%		26.9%		3.8%		

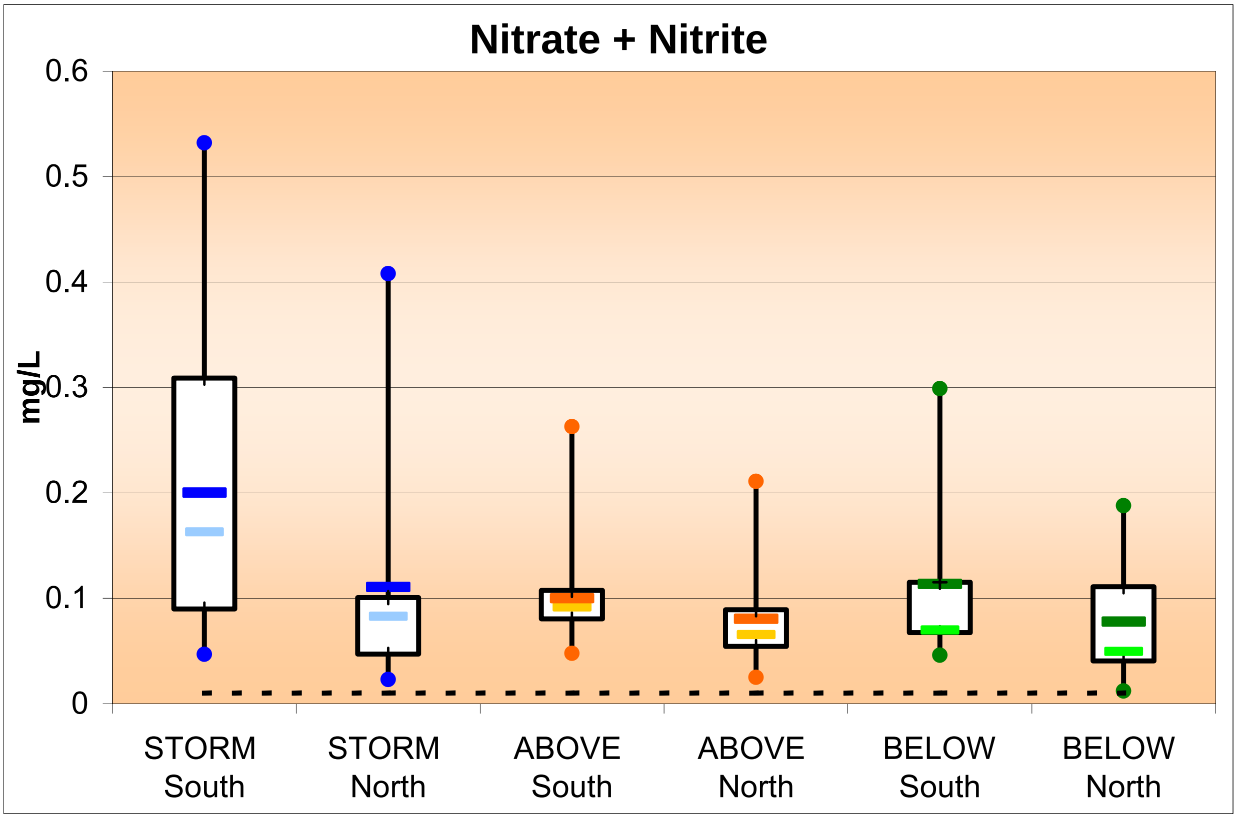
Appendix K

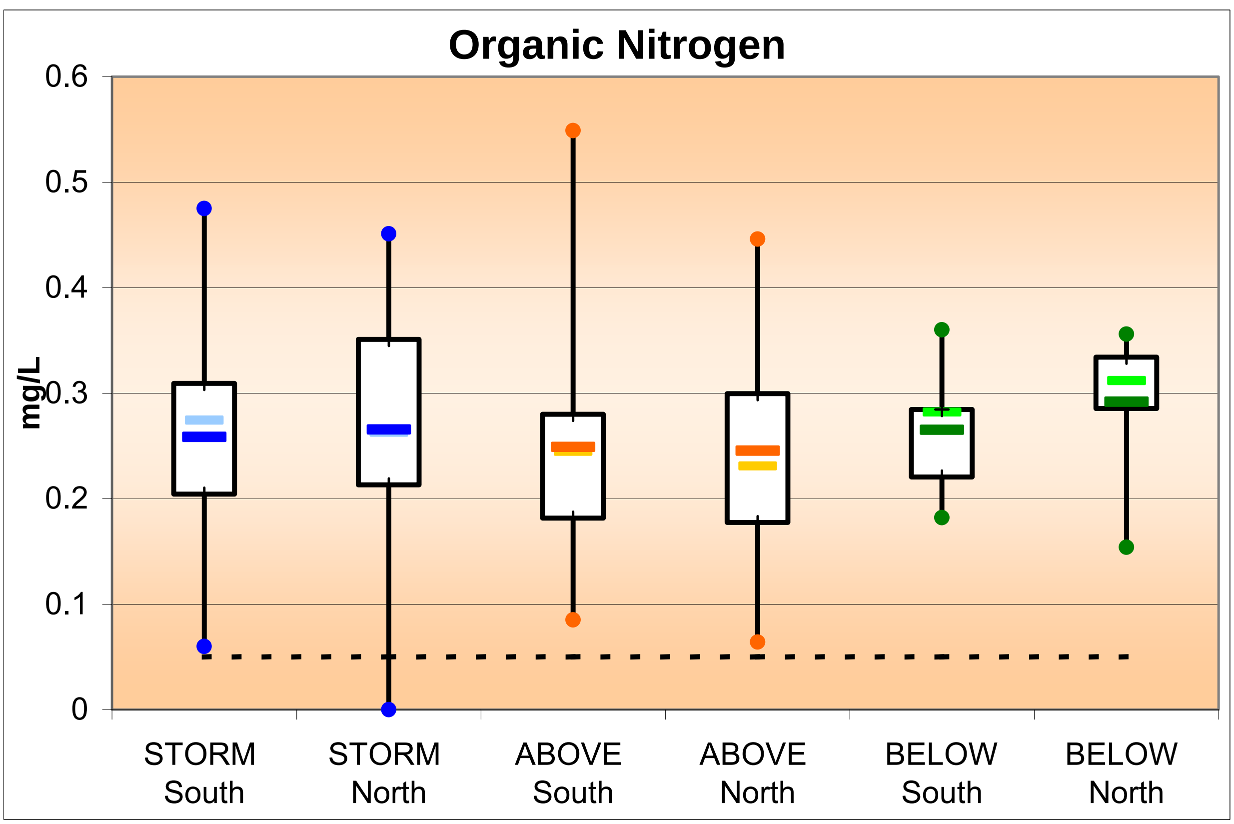
Box Plot Comparisons of Underdrains

Appendix K. Box plot comparisons of underdrain flow during different pond levels: storm event --STORM (blue), above the bottom of the underdrain pipe (6 ft. NGVD)--ABOVE (orange), and below the bottom of the underdrain pipe--BELOW (green). STORM and ABOVE are considered treated stormwater; BELOW is considered baseflow. Graphs show maximum and minimum values (dots), 25th and 75th percentiles (box), means (dark lines), medians (light lines), and minimum detection level (dashed line).

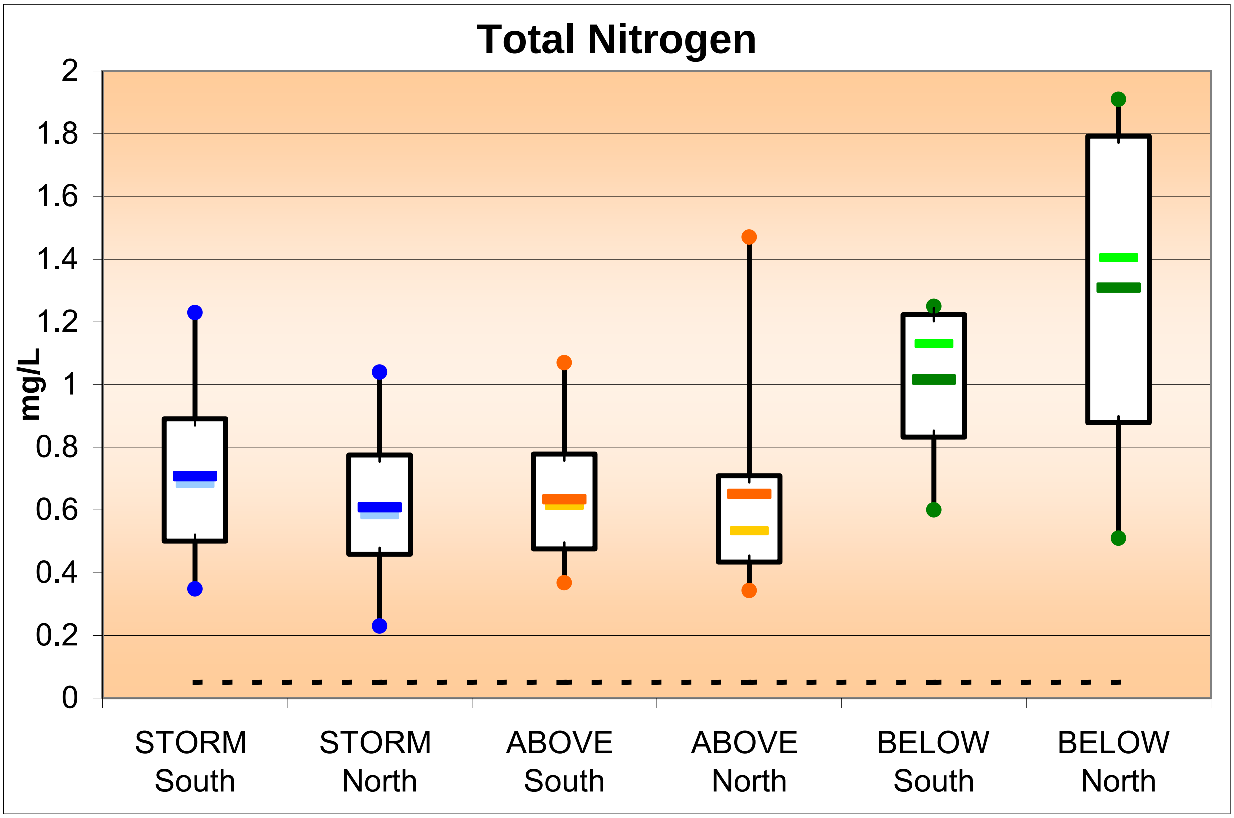


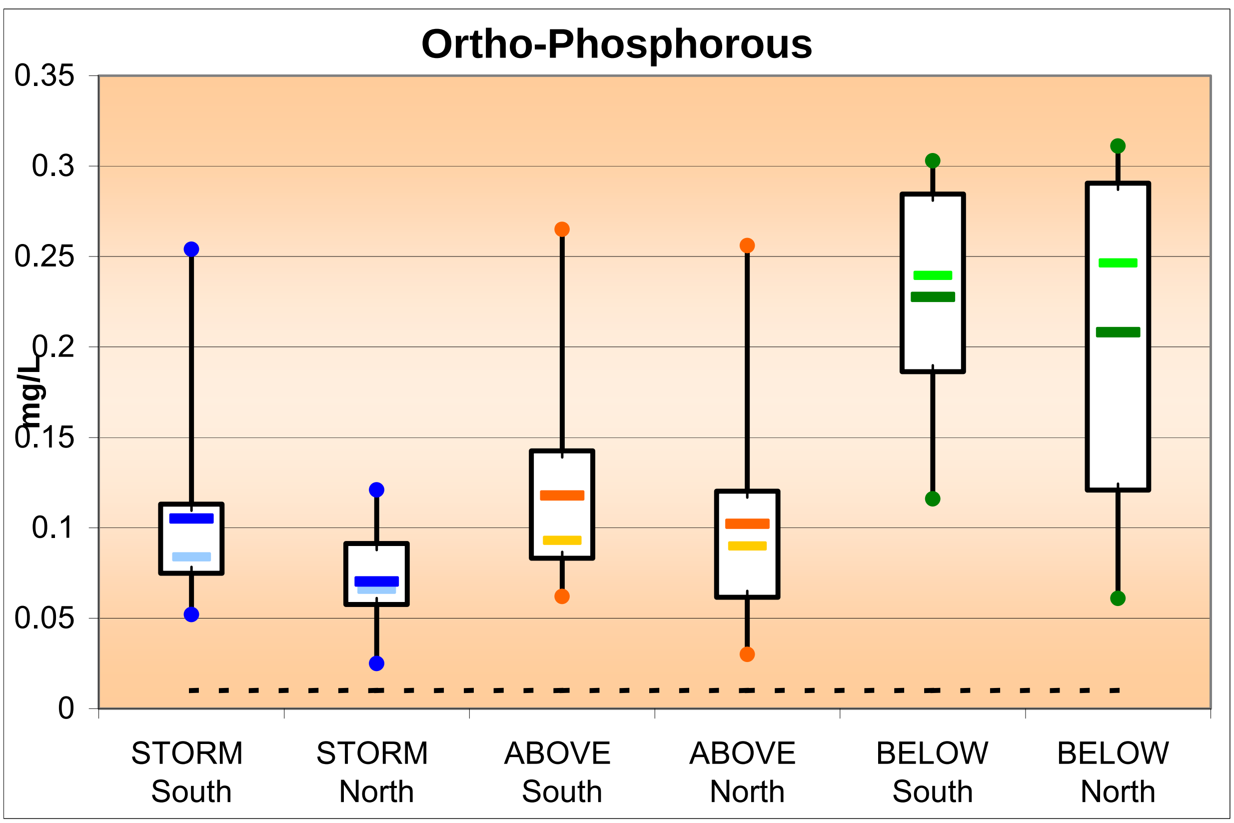
Appendix K. ***Continued***



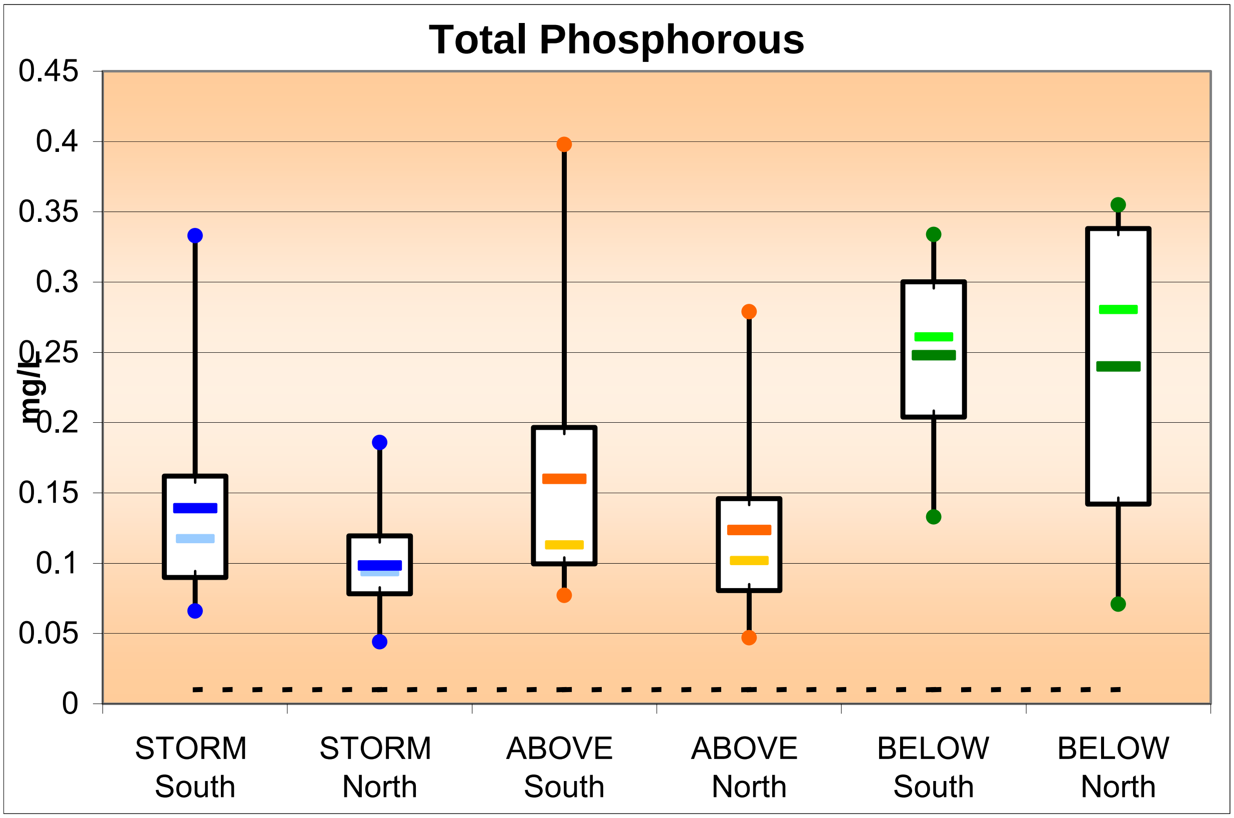


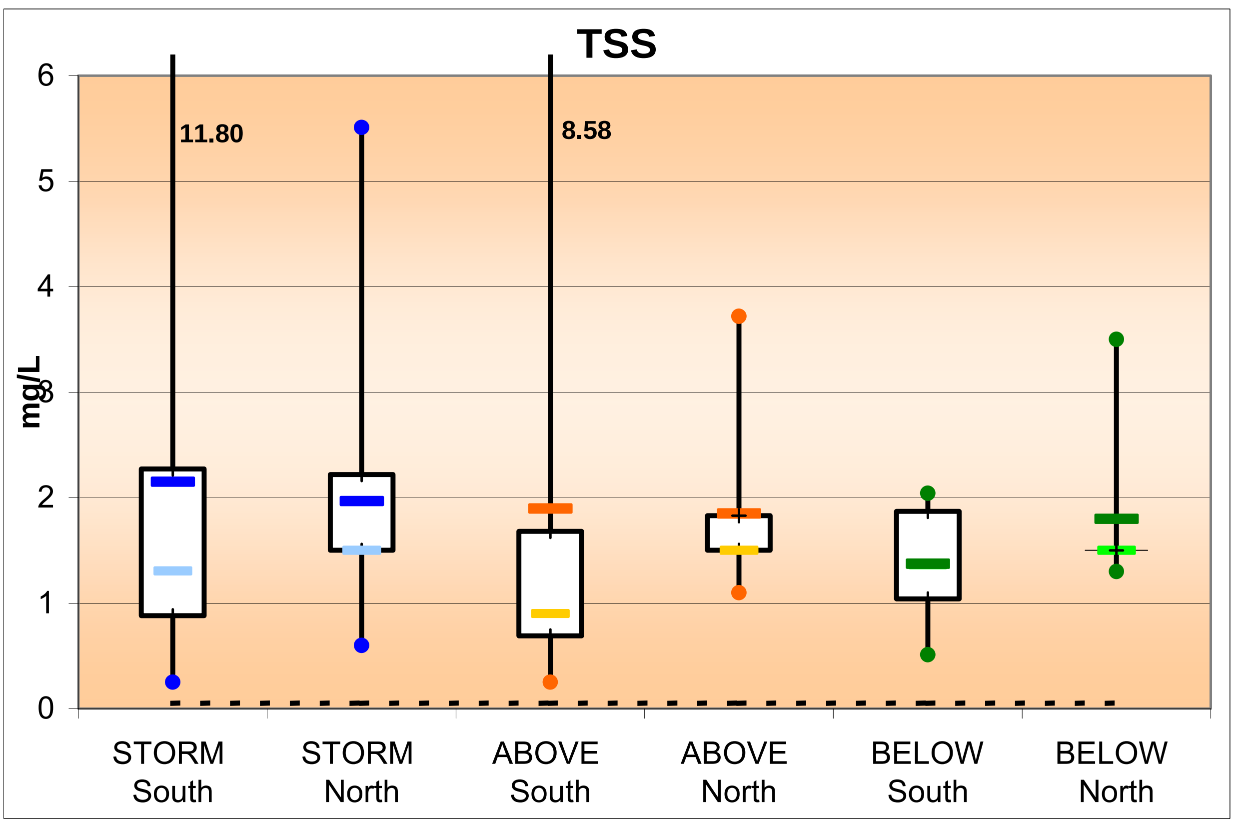
Appendix K. ***Continued***



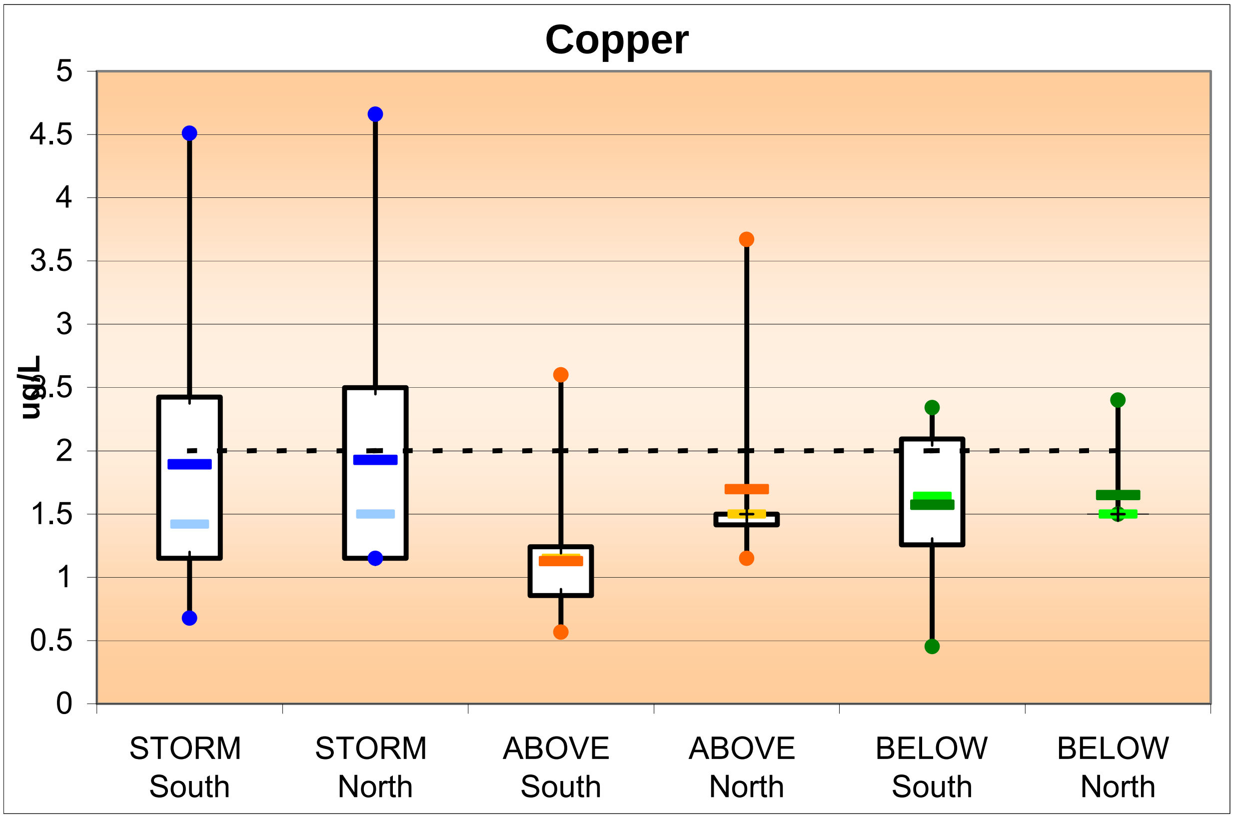


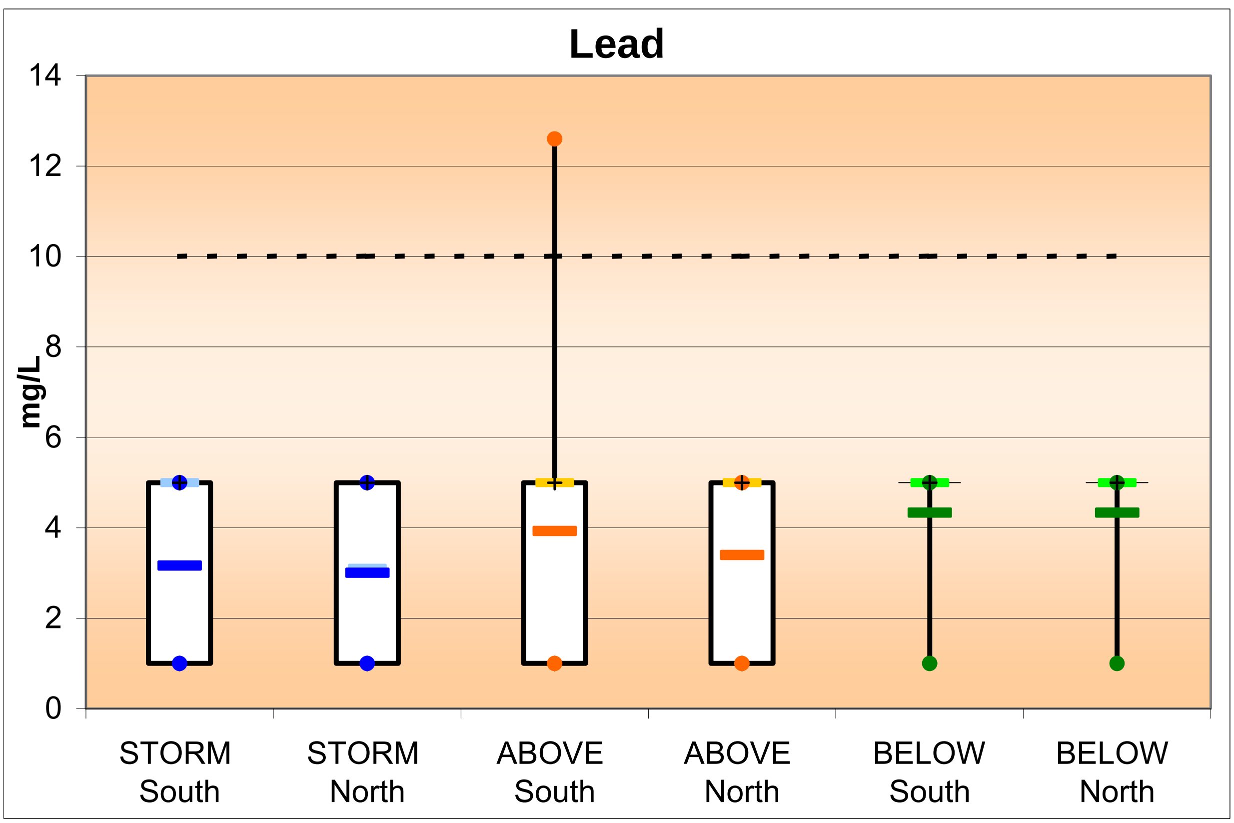
Appendix K. ***Continued***



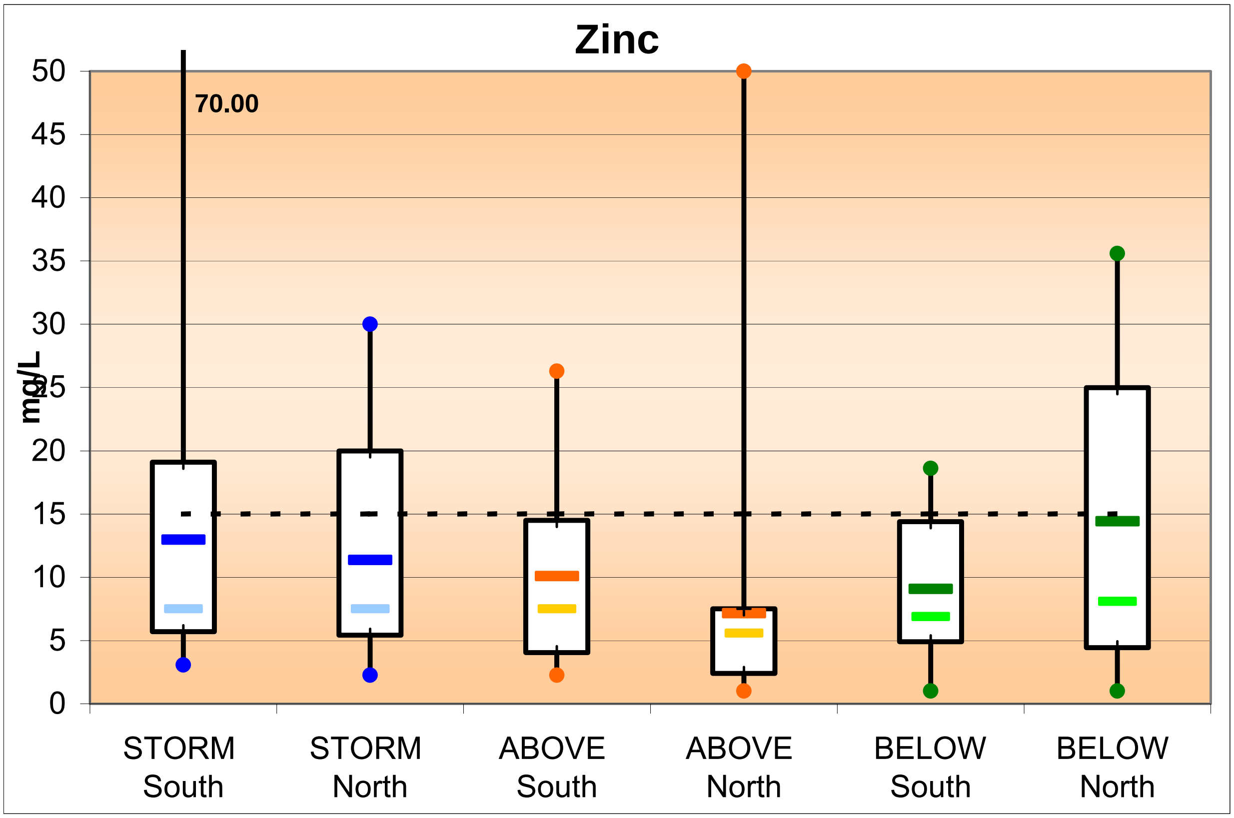


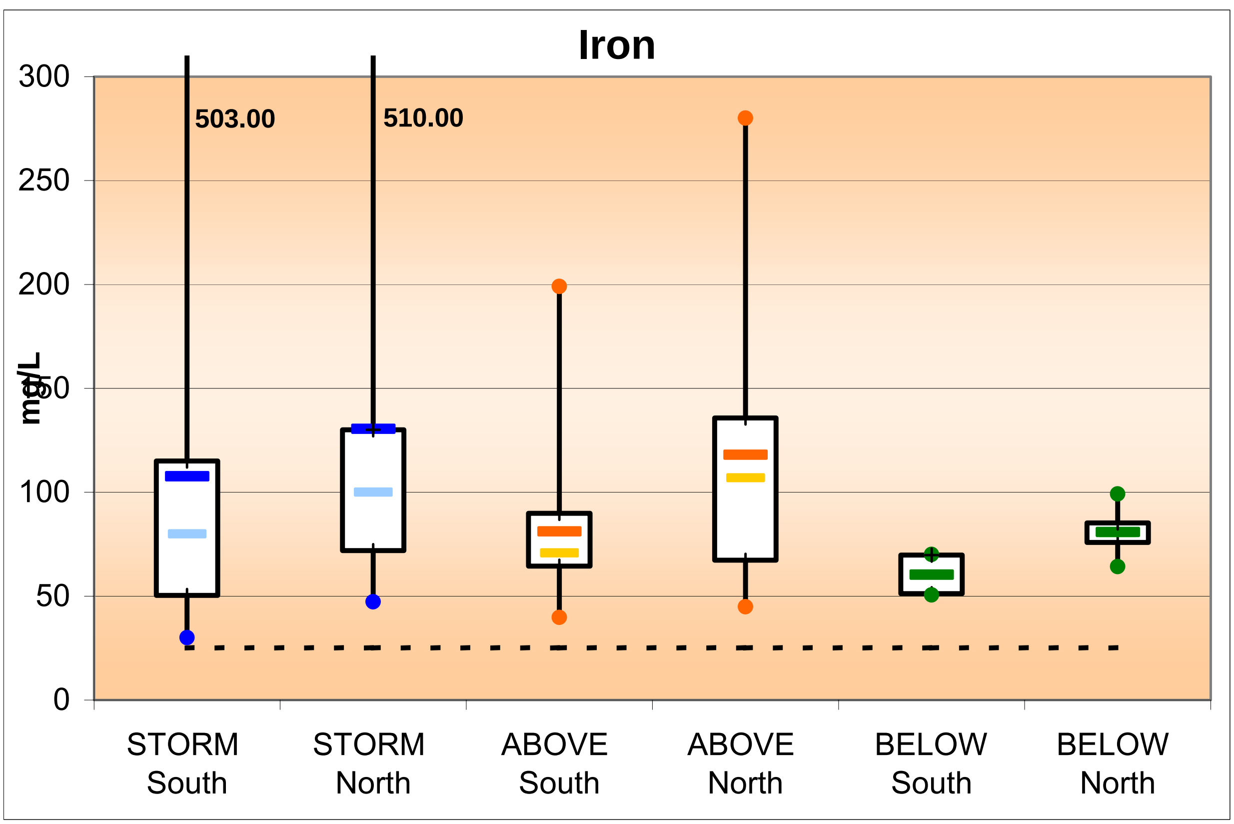
Appendix K. ***Continued***



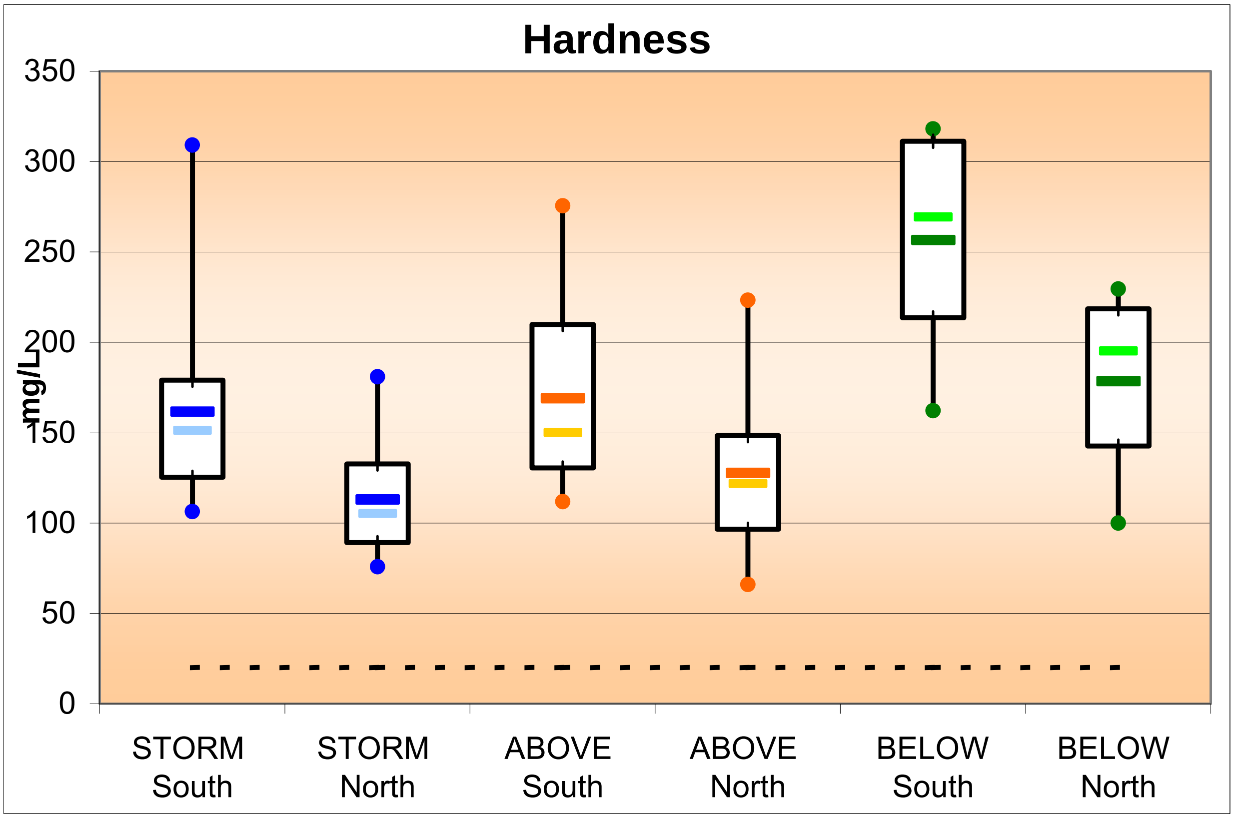


Appendix K. ***Continued***





Appendix K. ***Continued***

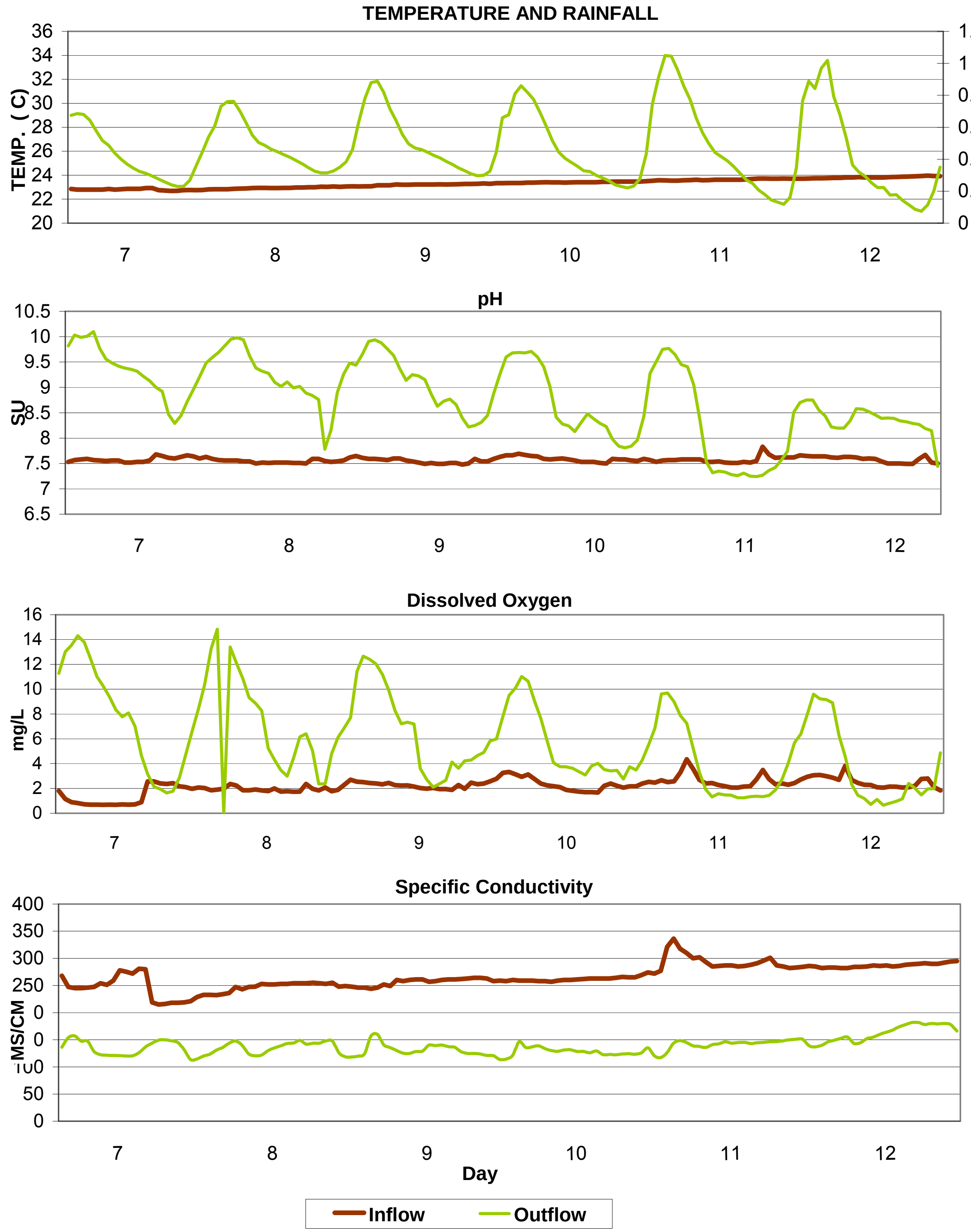


Appendix L

Field Parameter Data

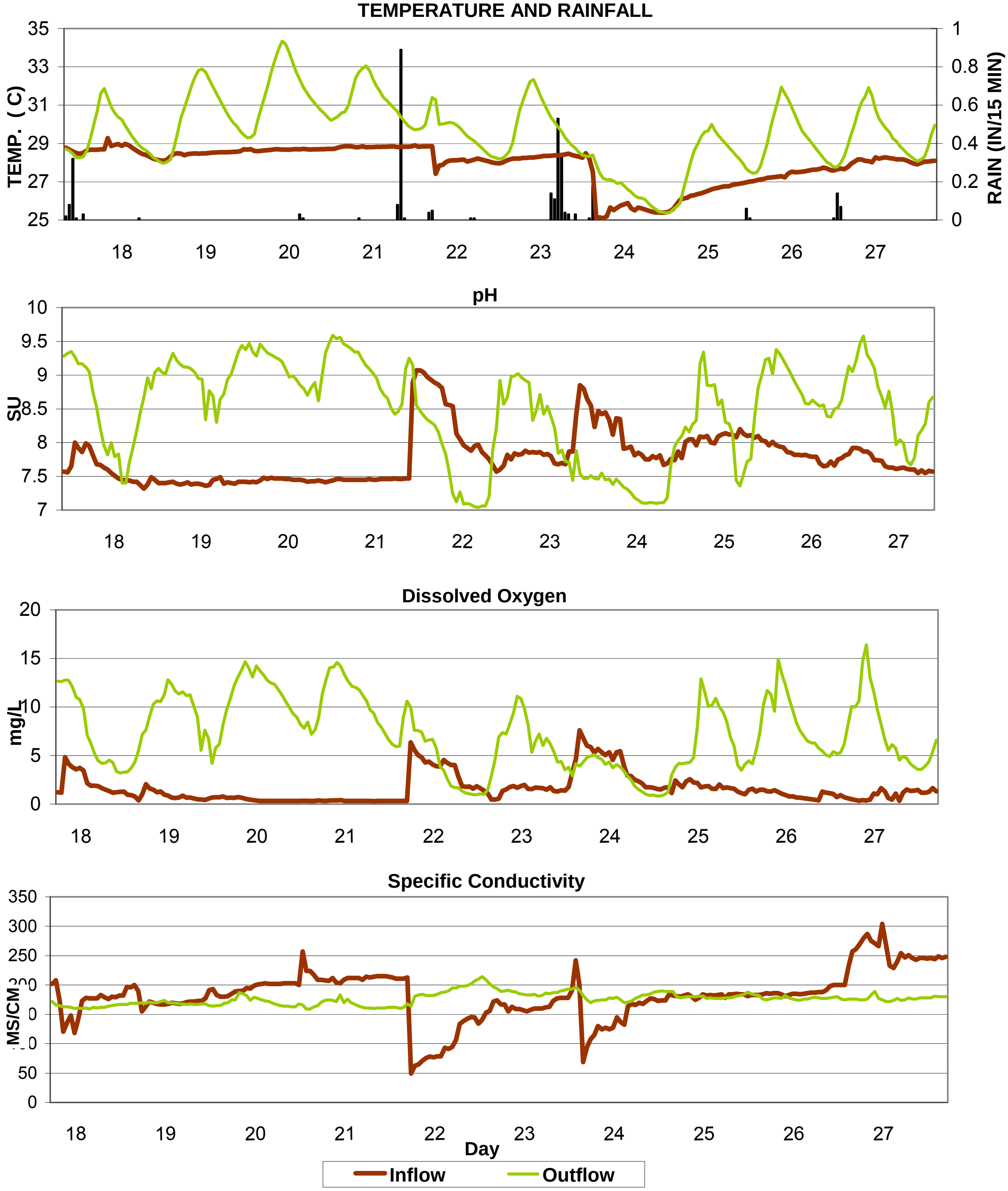
Appendix L. Field parameter data for the inflow and outflow.

April 2001



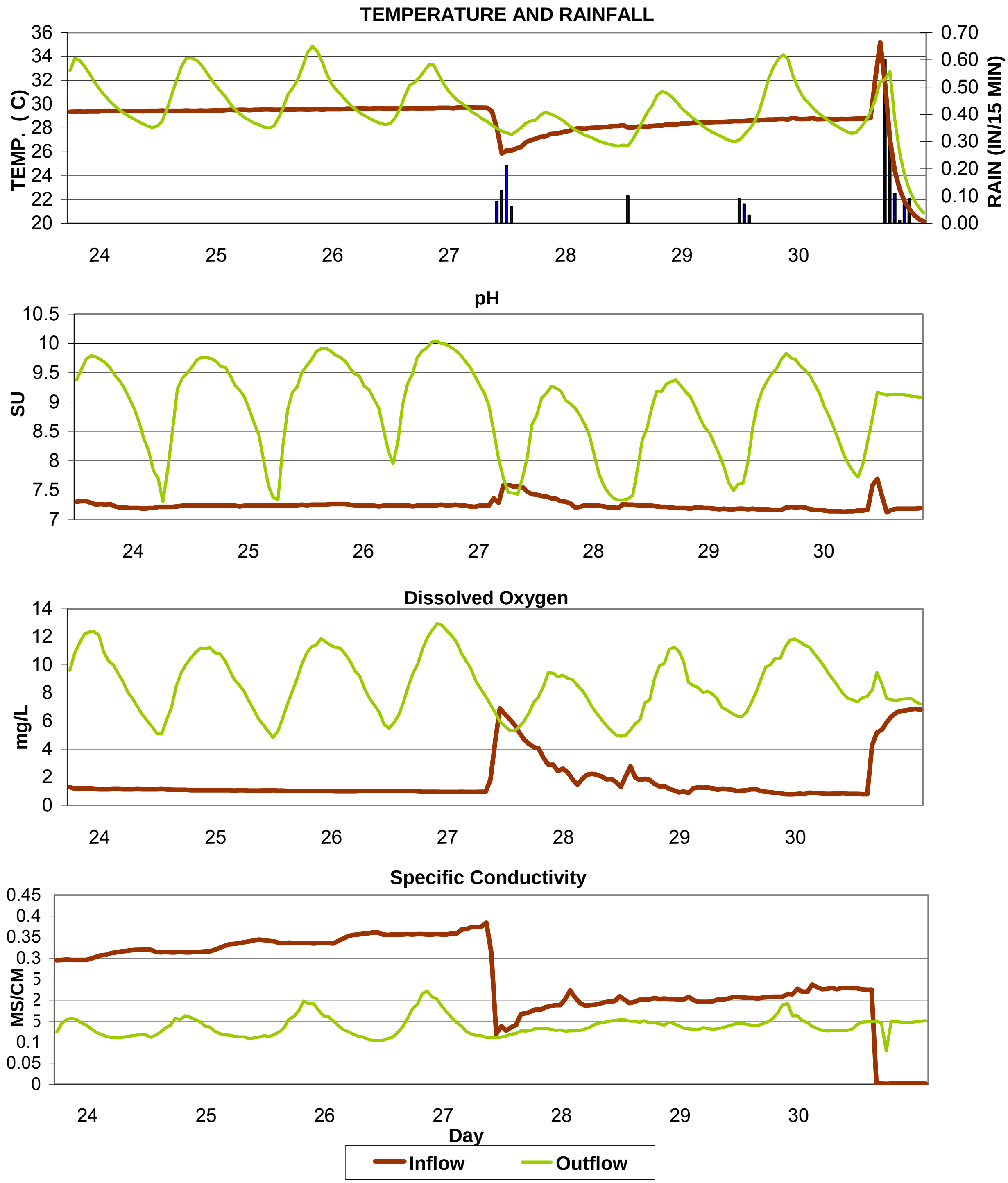
Appendix L. ***Continued***

July 2001



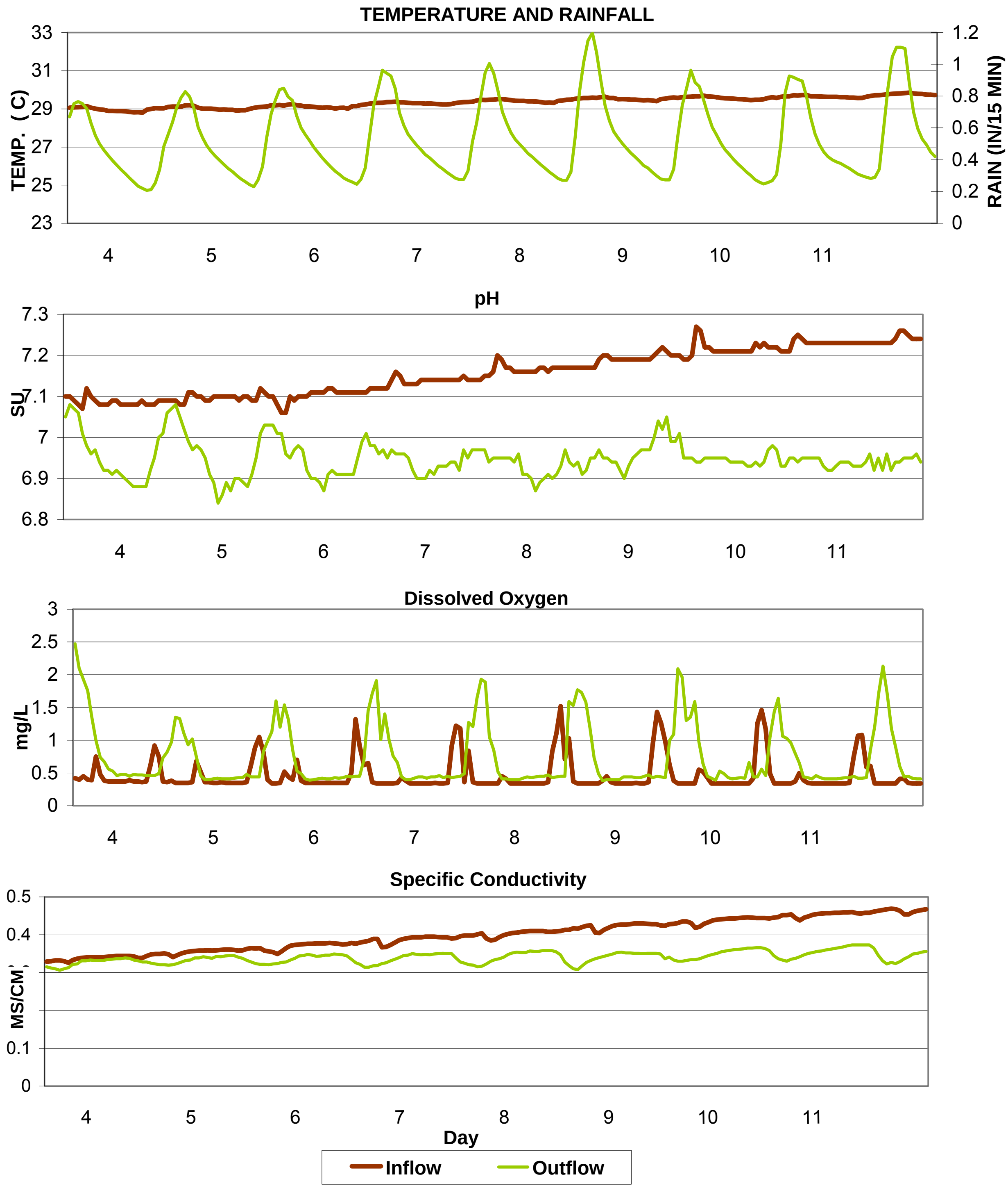
Appendix L. ***Continued***

August 2002



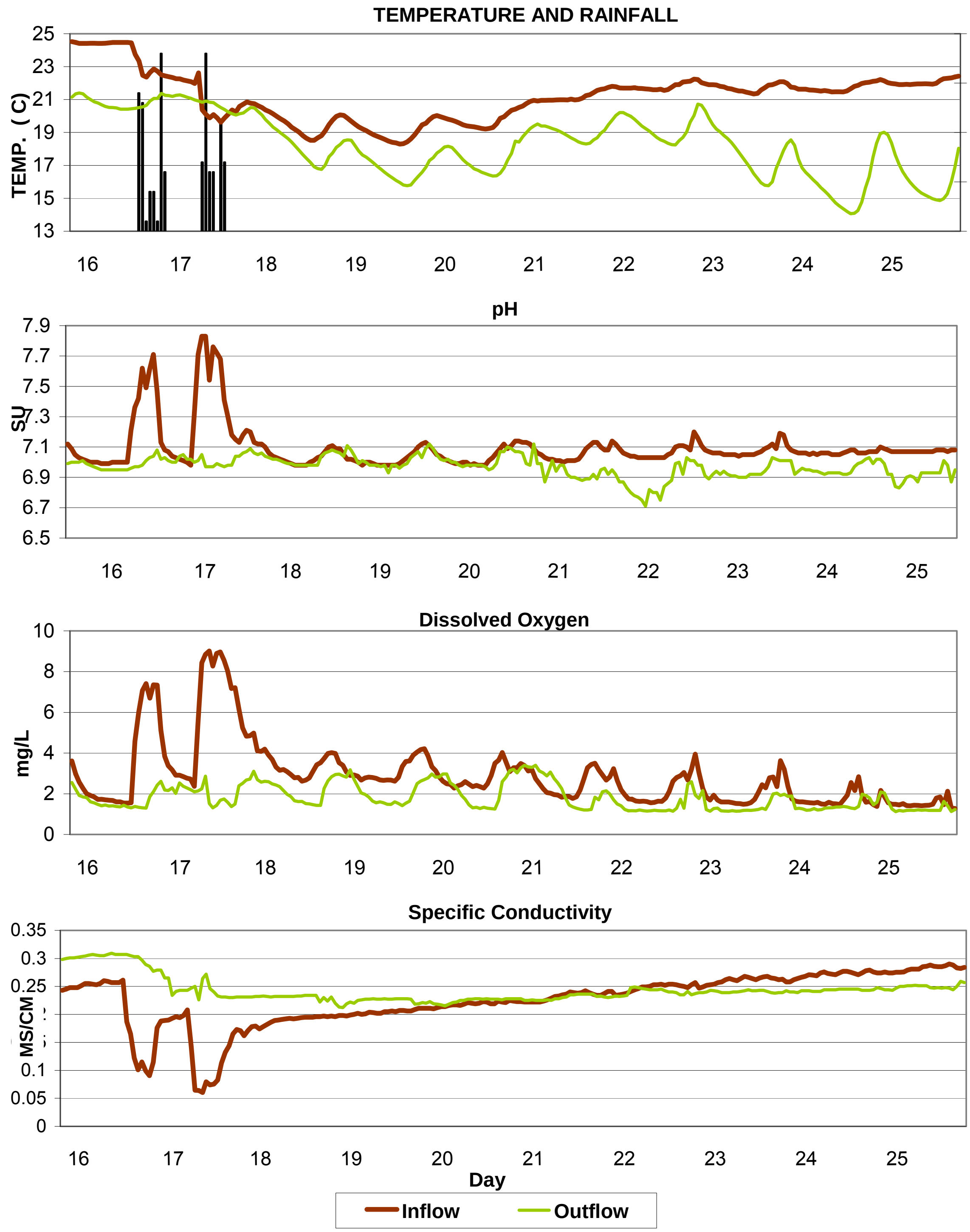
Appendix L. *Continued*

October 2002



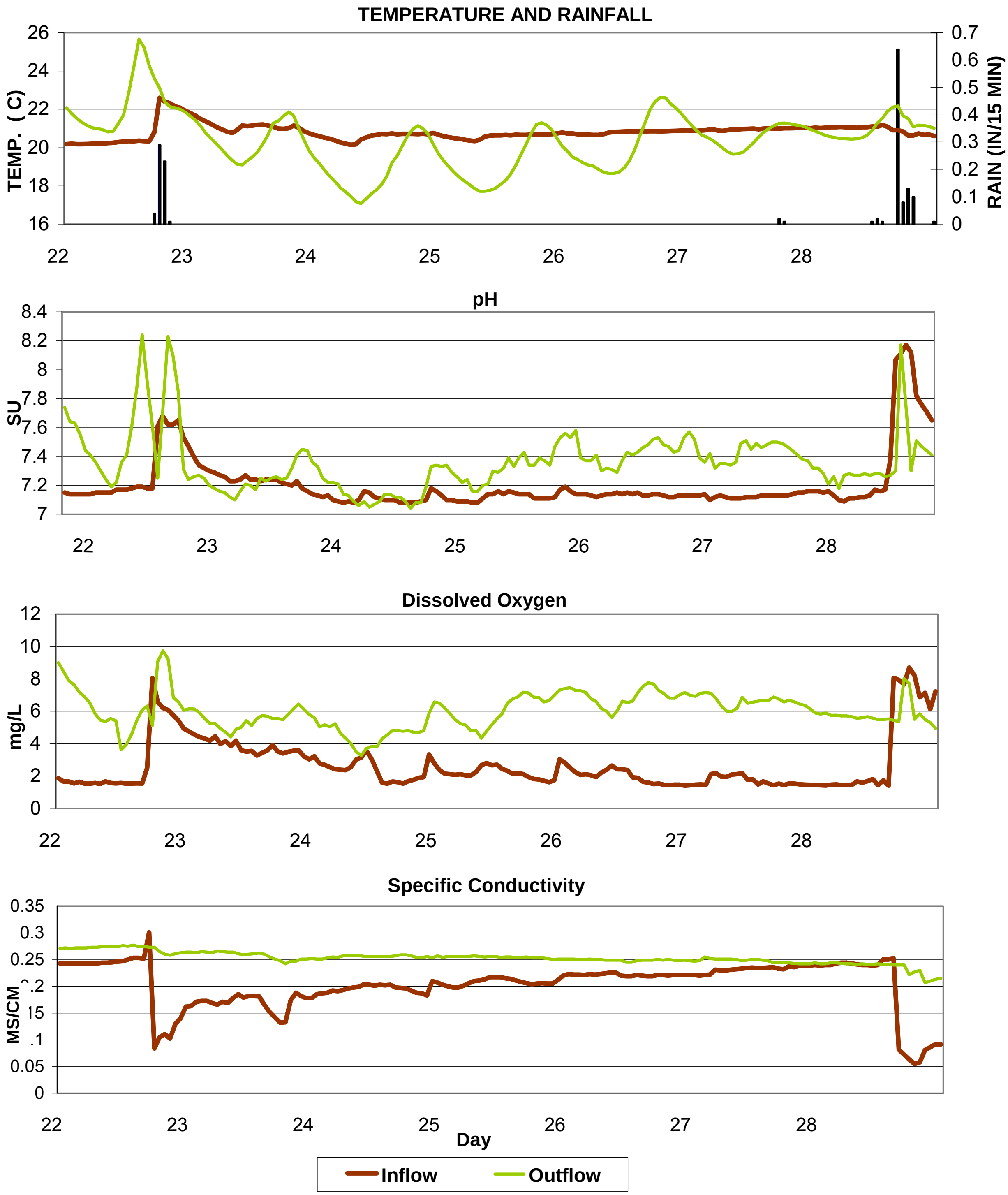
Appendix L. ***Continued***

November 2002



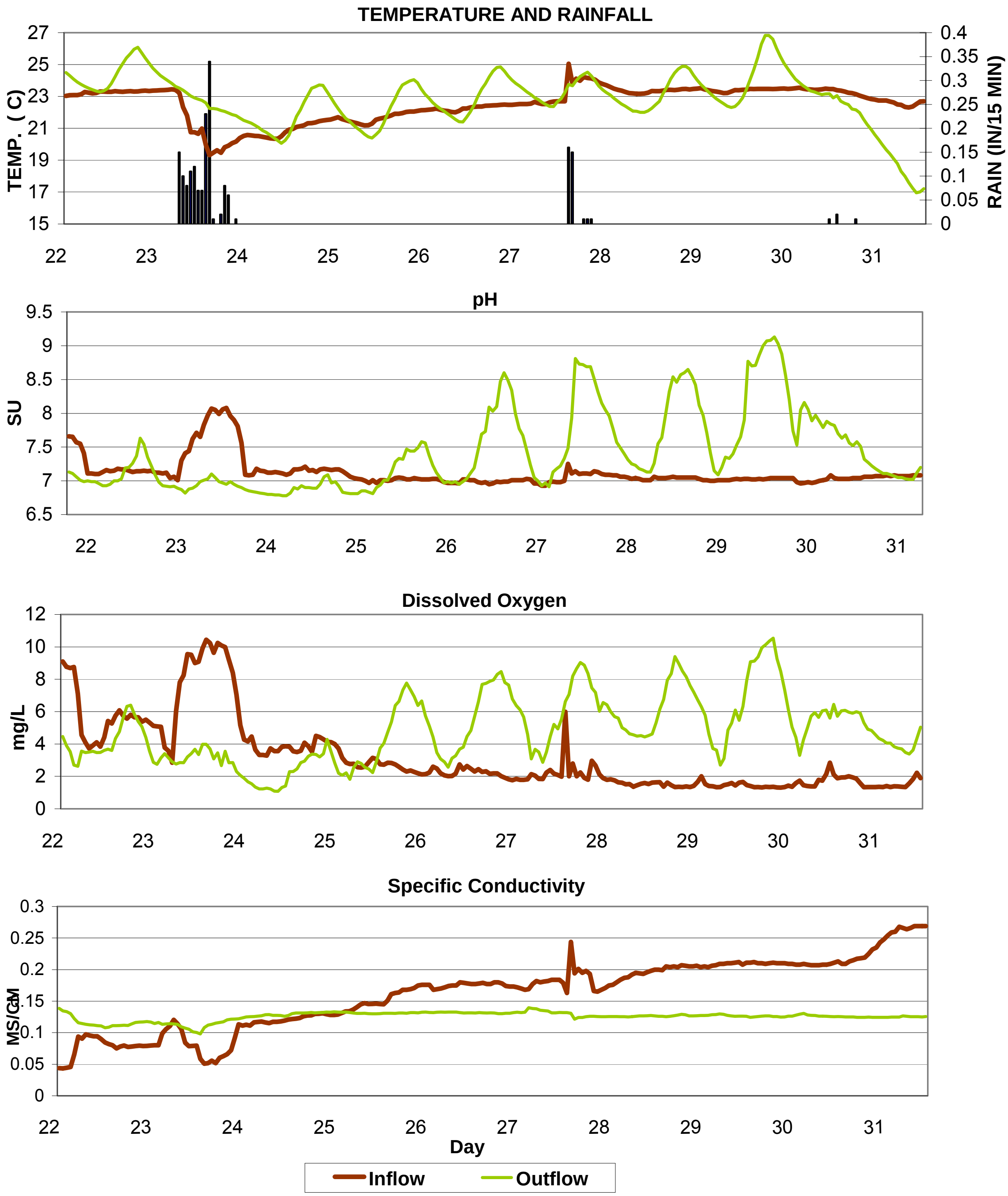
Appendix L. ***Continued***

February 2003



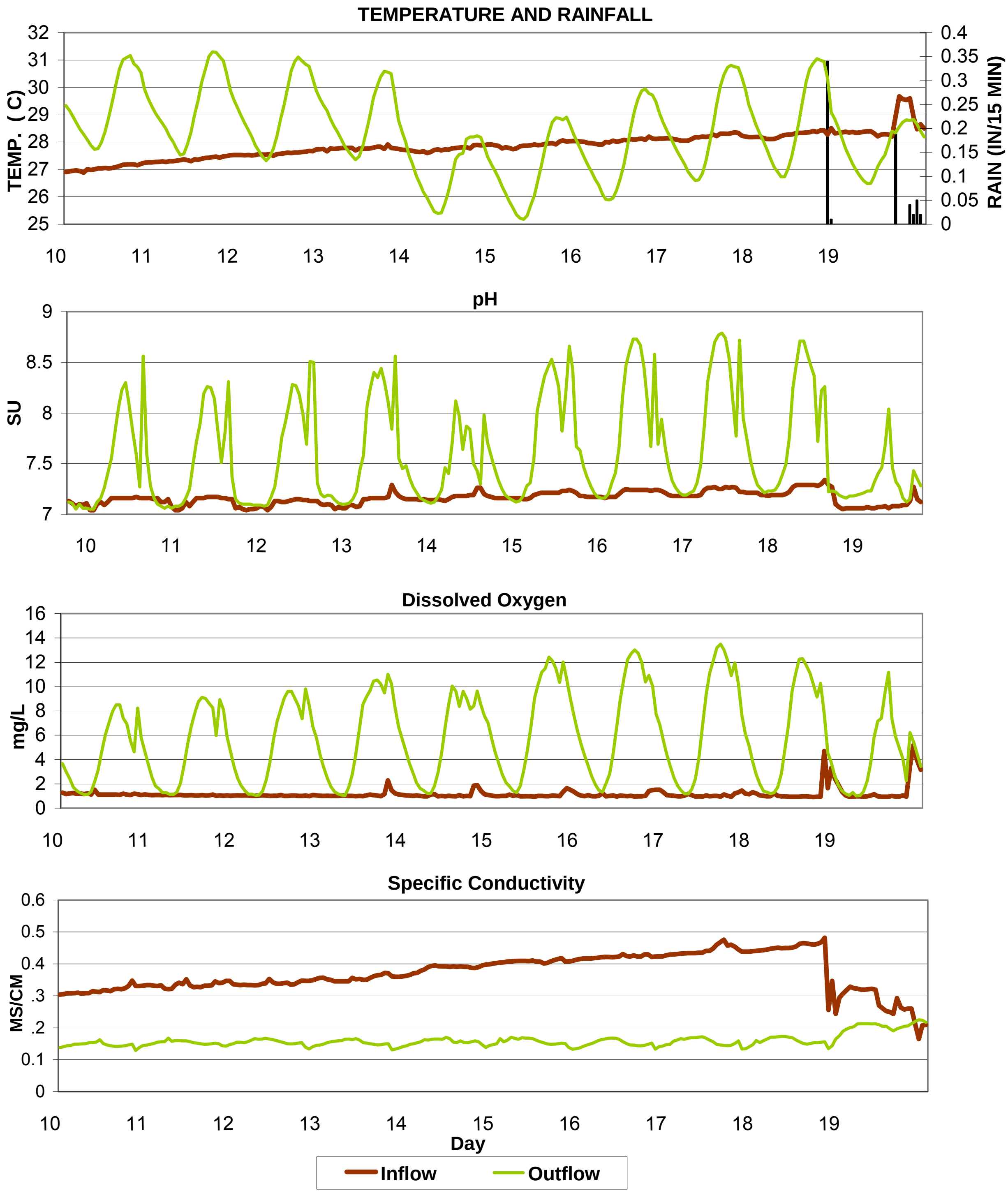
Appendix L. ***Continued***

March 2003



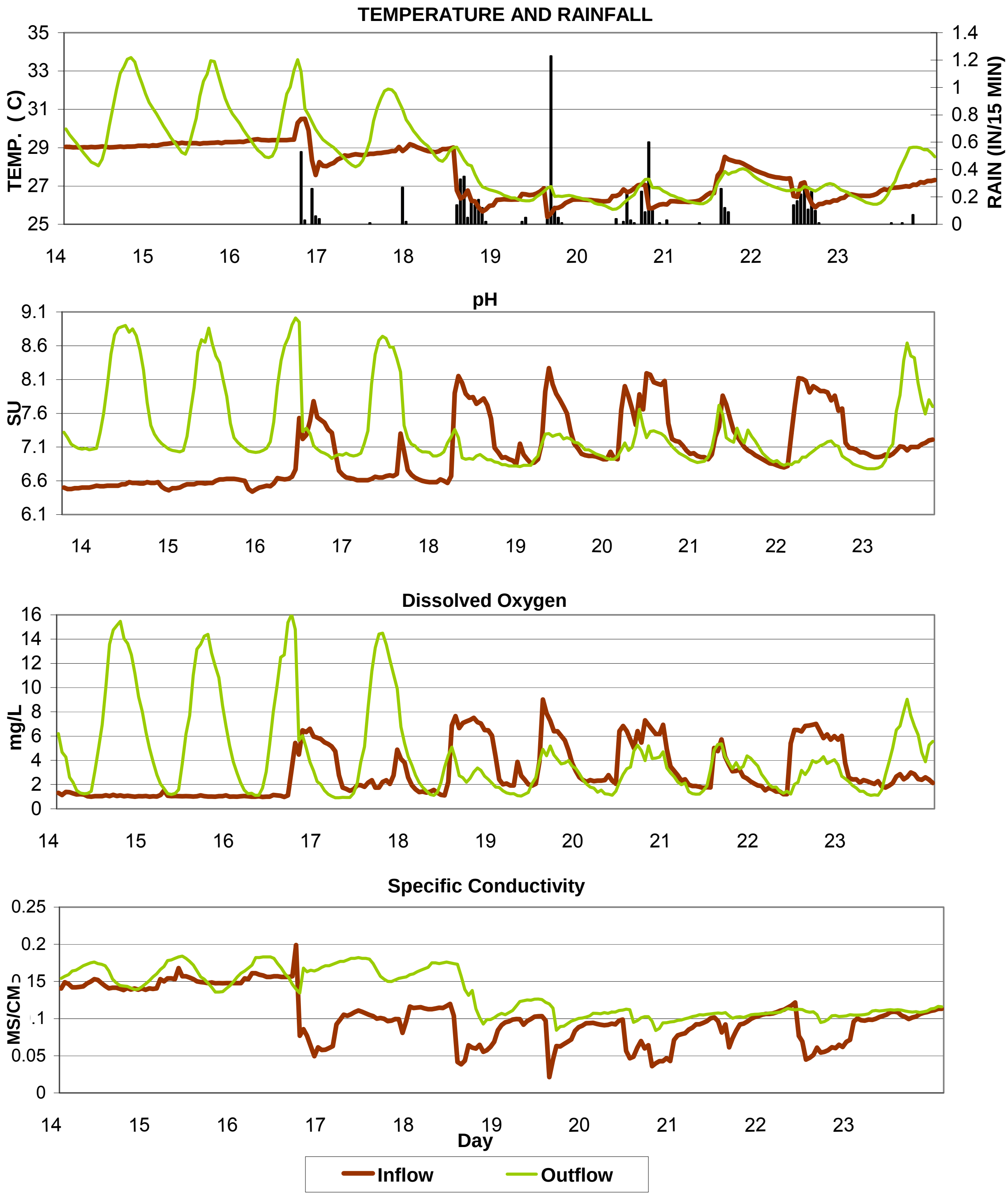
Appendix L. ***Continued***

May 2003



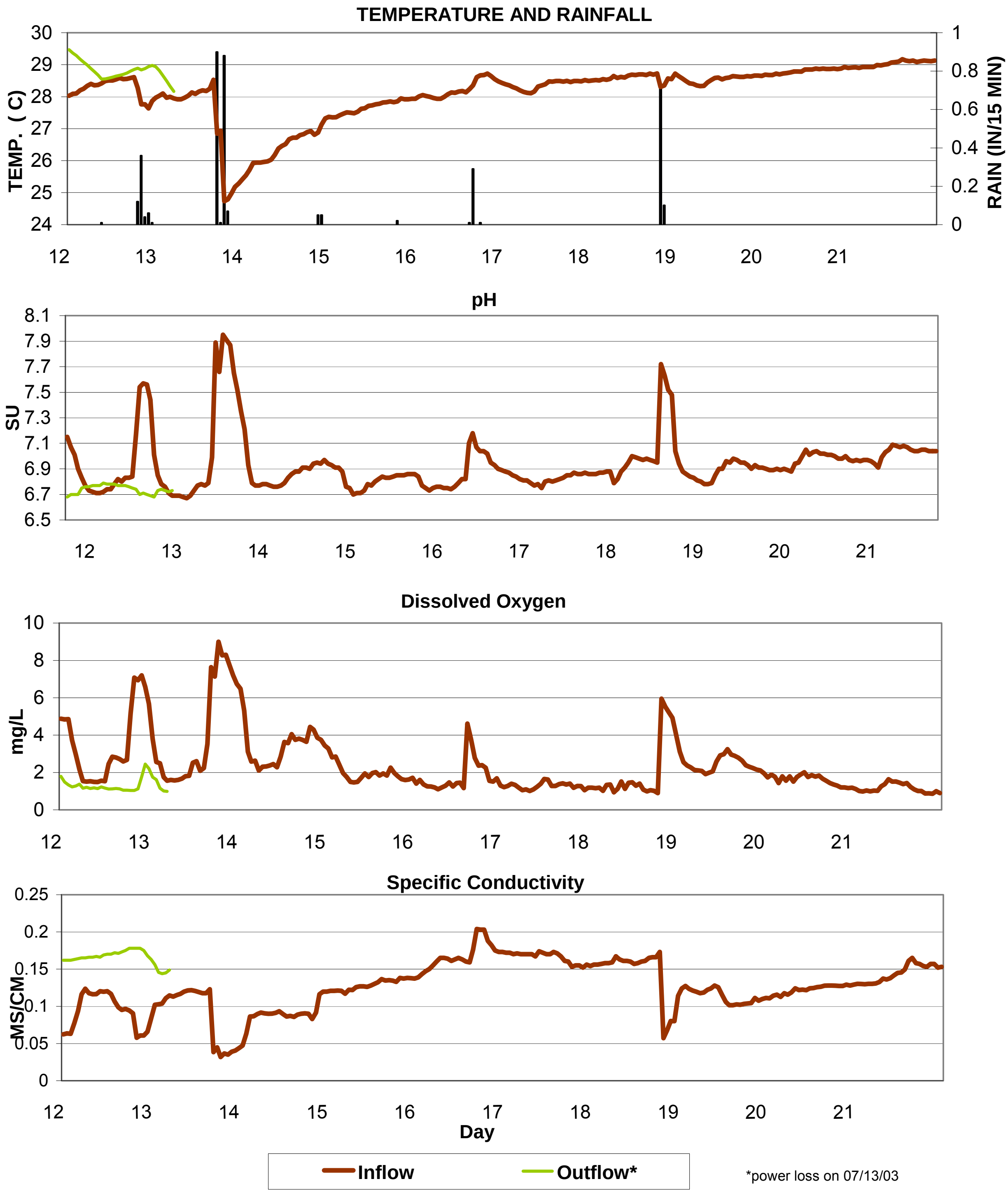
Appendix L. ***Continued***

June 2003



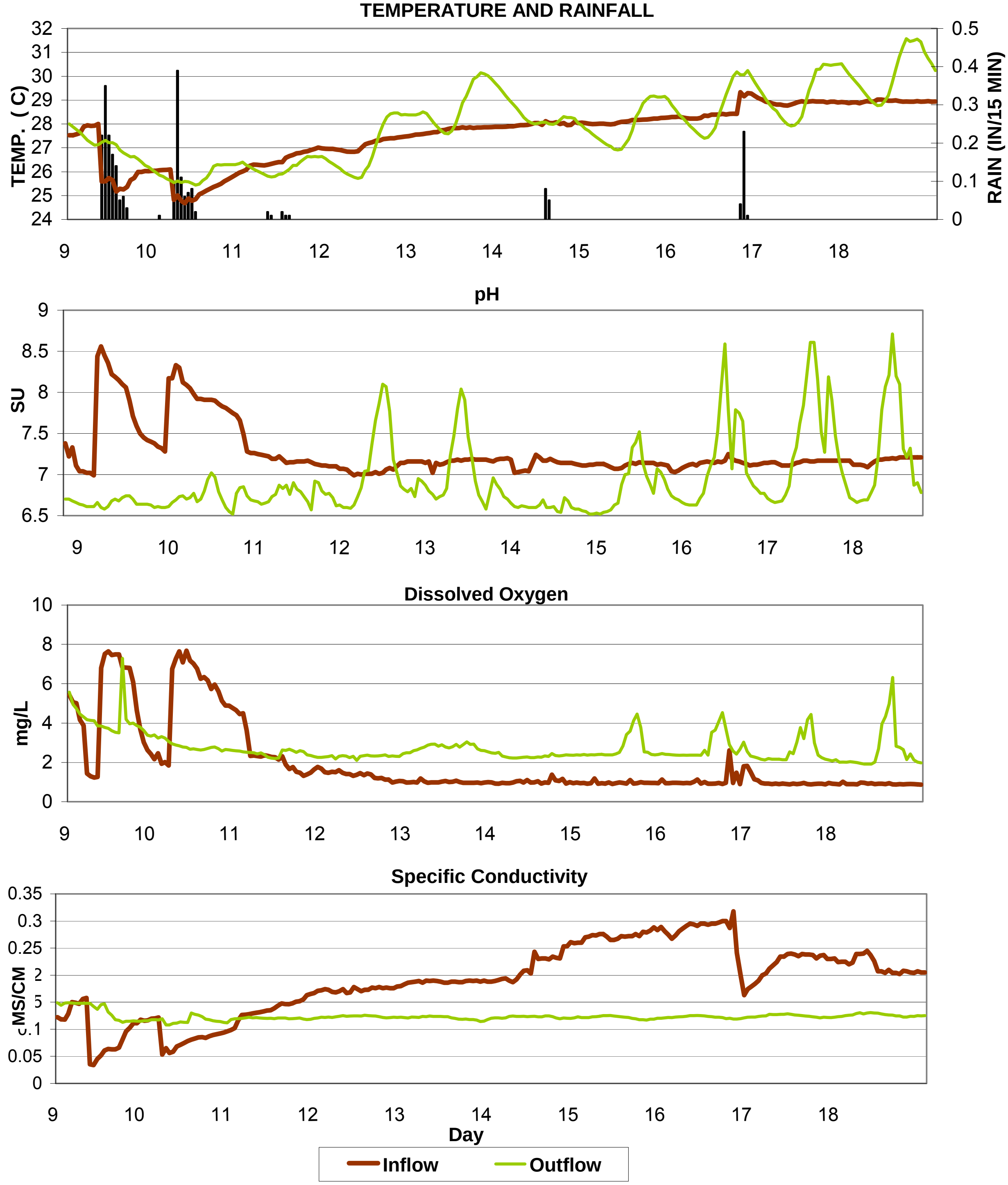
Appendix L. ***Continued***

July 2003



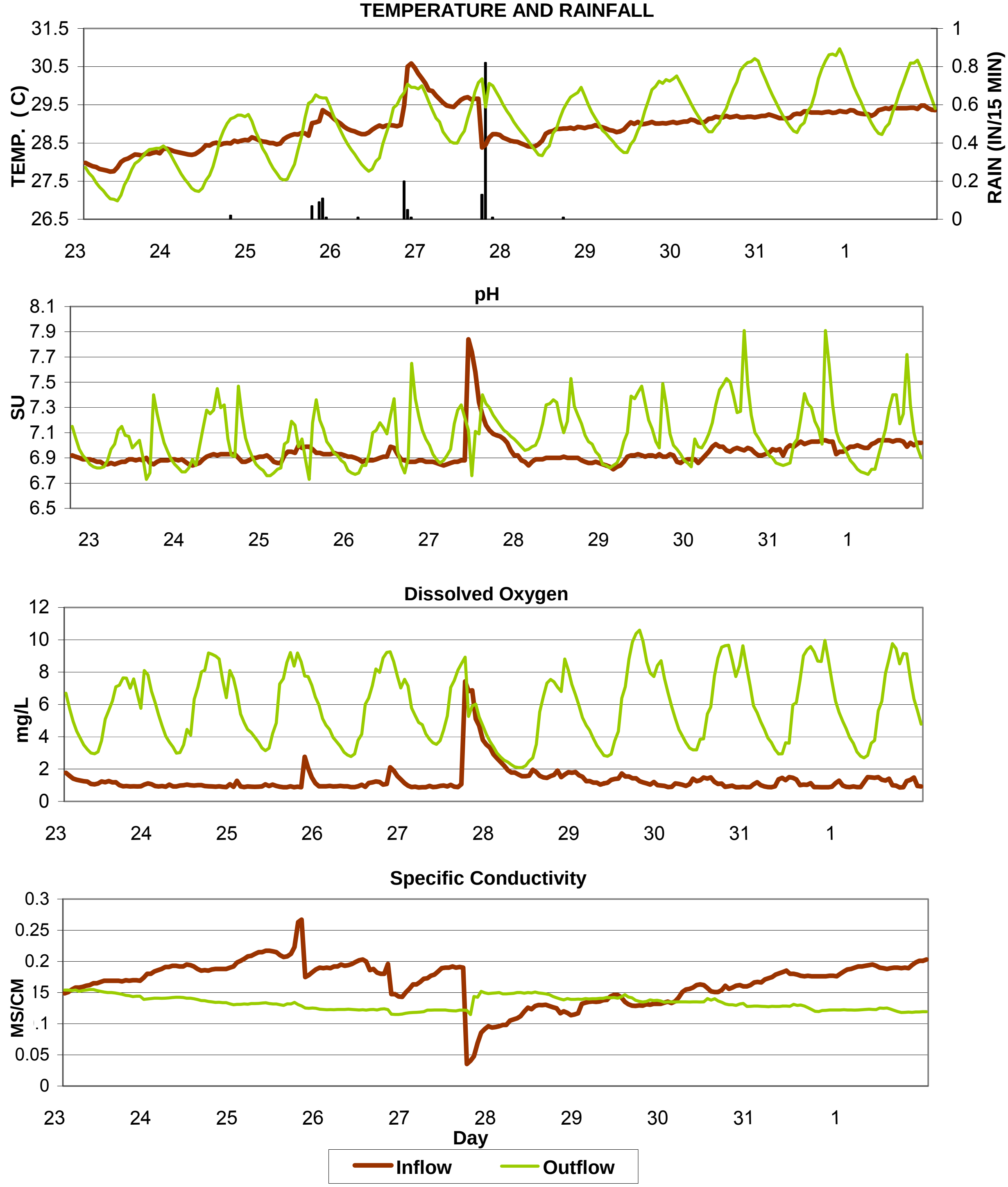
Appendix L. ***Continued***

August 2003

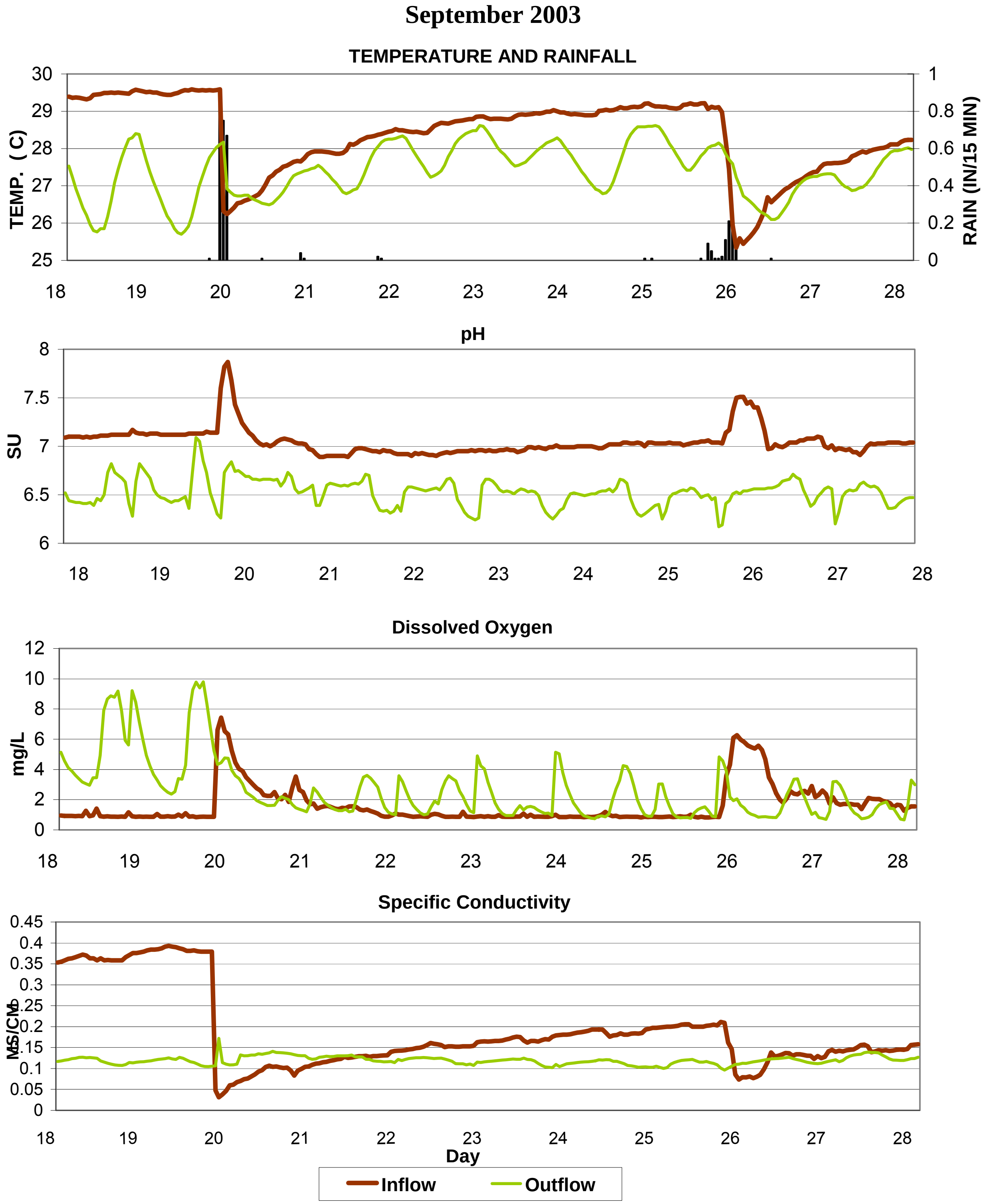


Appendix L. ***Continued***

August-September 2003

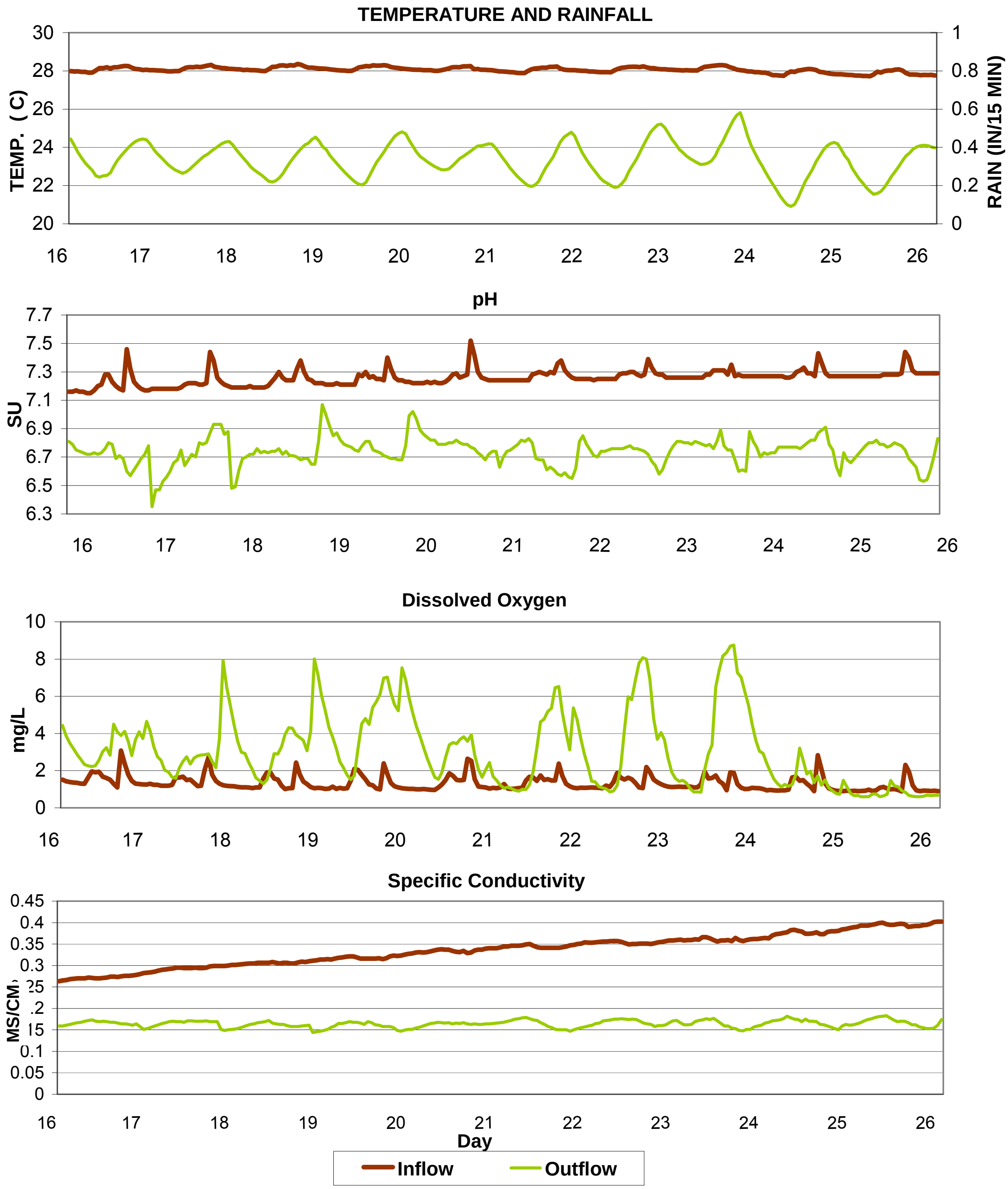


Appendix L. ***Continued***



Appendix L. ***Continued***

October 2003



Appendix M

Sediment Data

Appendix M-1. Concentrations measured n sediment cores taken at two depths (1-2 in. and 4-5 in. below the surface for sampling event in October 1997. Data only includes constituents that were detected during one of the three sampling events. Also included are water quality data from the overlying water column and field parameters for each site.

CONSTITUENT		1088-1 Inflow		1088-4 Inflow		1087-1 Eq.Pipe		1087-4 Eq.Pipe		1086-1 Eq.Pipe		1086-4 Eq.Pipe		638-1 Outfall		638-4 Outfall	
SEDIMENT PARTICLE SIZE																	
Gravel	%	2.6		-		13.6		-		10.3		-		8.6		-	
Sand	%	96.2		-		71.1		-		78.3		-		81.3		-	
Silt	%	0.7		-		12.4		-		9		-		9.3		-	
Clay	%	0.5		-		2.9		-		2.4		-		0.9		-	
% Organic	%	0.4		-		0.9		-		0		-		0.8		-	
SEMI-VOLATILE ORGANIC POLLUTANTS																	
Acenaphthylene	ug/Kg	-		-		-		-		-		-		-		-	
Anthracene	ug/kg	-		-		-		-		-		-		-		-	
Benzo(a)anthracene	ug/kg	-		-		-		-		-		-		-		-	
Benzo(a)pyrene	ug/kg	-		-		-		-		-		-		-		-	
Benzo(b)fluoranthene	ug/kg	-		-		-		-		-		-		-		-	
Benzo(k)fluoranthene	ug/kg	-		-		-		-		-		-		-		-	
Benzo(g,h,i)perylene	ug/kg	-		-		-		-		-		-		-		-	
Bis(2-ethylhexyl)phthalate	ug/kg	-		-		-		-		-		-		-		-	
Butyl benzyl phthalate	ug/kg	-		-		-		-		-		-		-		-	
Chrysene	ug/kg	-		-		-		-		-		-		-		-	
Di-n-octyl phthalate	ug/kg	-		-		-		-		-		-		-		-	
Dibenzo(a,h)anthracene	ug/kg	-		-		-		-		-		-		-		-	
Endrin aldehyde	ug/kg	-		-		-		-		-		-		-		-	
Fluoranthene	ug/kg	-		-		-		-		-		-		-		-	
Hexachlorocyclopentadiene	ug/kg	-		-		-		-		-		-		-		-	
Indeno(1,2,3-cd)pyrene	ug/kg	-		-		-		-		-		-		-		-	
Isophorone	ug/kg	-		-		-		-		-		-		-		-	
2-Methylnaphthalene	ug/Kg	-		-		-		-		-		-		-		-	
Phenanthrene	ug/kg	-		-		-		-		-		-		-		-	
Pyrene	ug/kg	-		-		-		-		-		-		-		-	
METALS, TOTAL RECOVERABLE																	
Aluminum	mg/kg	1970		1560		4240	J	4650	J	1740	J	1190	J	2450	J	6850	J
Cadmium	mg/kg	U		U		U		U		U		U		U		1.7	I
Chromium	mg/kg	2.5	I	2.4	I	15	J	21	J	11	J	5.4	J	9.9	J	21.8	J
Copper	mg/kg	4.2		U		8.4		U		2.9	I	1.8	I	19		3.2	I
Iron	mg/kg	842	J	504	J	3140	J	1780	J	1030	J	406	J	2650	J	3410	J
Lead	mg/kg	U		U		U		U		U		U		15		8.7	
Manganese	mg/kg	6.8	J	2.9	J	20.3	J	7.9	J	8	J	3.6	J	29.2	J	15	J
Nickel	mg/kg	1.2	I	0.8	I	4.2	J	4.5	J	2	J	1	J	3.4	J	6.4	J
Zinc	mg/kg	13.3	I	U		24.7		11	I	8.3	I	9.7		41.7		17.3	
NUTRIENTS																	
TKN	mg/kg	73		28		230		85		66		67		240		100	
Total - P	mg/kg	190		97		440		330		210		130		470		330	

A – Value reported is the mean of two or more determinations.
I - Value reported is less than the laboratory method detection limit and the practical quantification limit.
J - Estimated Value
U - Material was analyzed but not detected; value reported is the minimum detection limit for the sample.

Appendix M-1. *Continued*

CONSTITUENT		1088-1 Inflow		1088-4 Inflow		1087-1 Eq.Pipe		1087-4 Eq.Pipe		1086-1 Eq.Pipe		1086-4 Eq.Pipe		638-1 Outfall		638-4 Outfall	
ORGANONITROGEN & PHOSPHORUS PESTICIDES																	
Bromacil	ug/kg	U		U		U		U		U		U		U		U	
Chlorpyrifos Ethyl	ug/kg	U		-		U		-		U		-		U		-	
Diazinon	ug/kg	U		-		U		-		U		-		U		-	
ORGANOCHLORINE PESTICIDES																	
Chlordane	ug/kg	U		-		U		-		U		-		8.8	I	-	
DDD-p,p'	ug/kg	U		-		1.3	I	-		U		-		1.9	I	-	
DDE-p,p'	ug/kg	U		-		1.5	I	-		U		-		5.8		-	
Endosulfan Sulfate	ug/kg	U		-		U		-		U		-		U		-	
PCB																	
PCB-1260	ug/kg	U		-		U		-		U		-		22	I	-	
WATER QUALITY																	
Cadmium	ug/L	-		-		-		-		-		-		-		-	
Copper	ug/L	11.0		-		2.1		-		2.7		-		4.9		-	
Iron	ug/L	79.0		-		112.0		-		73.0		-		122.0		-	
Lead	ug/L	U		-		U		-		U		-		U		-	
Manganese	ug/L	8.0		-		8.7		-		7.2		-		7.4		-	
Zinc	mg/L	U		-		U		-		U		-		U		-	
TSS	mg/L	-		-		-		-		-		-		-		-	
Phosphorous, Total	mg/L	0.06		-		0.06		-		0.05		-		0.07		-	
Phosphorous, Ortho	mg/L	-		-		-		-		-		-		-		-	
Nitrogen, Total	mg/L	-		-		-		-		-		-		-		-	
Ammonia	mg/L	-		-		-		-		-		-		-		-	
Nitrate + Nitrite	mg/L	-		-		-		-		-		-		-		-	
Organic Nitrogen	mg/L	-		-		-		-		-		-		-		-	
TKN	mg/L	0.55		-		0.47		-		0.68		-		0.64		-	
Chloride	mg/L	-		-		-		-		-		-		-		-	
Potassium	mg/L	-		-		-		-		-		-		-		-	
Sodium	mg/L	-		-		-		-		-		-		-		-	
Sulfate	mg/L	-		-		-		-		-		-		-		-	
Calcium	mg/L	-		-		-		-		-		-		-		-	
Magnesium	mg/L	-		-		-		-		-		-		-		-	
Hardness	mg/L	-		-		-		-		-		-		-		-	
FIELD PARAMETERS																	
Depth	cm	28		-		41		-		4.6		-		37		-	
D.O.	mg/L	9.5		-		6.5		-		6.8		-		7.7		-	
pH	SU	8.8		-		8.5		-		8.4		-		8.6		-	
Salinity	PPth	0.1		-		0.1		-		0.1		-		0.1		-	
Specific Conductivity	umho/cm	0.2		-		0.2		-		0.2		-		0.2		-	
Temperature	C	29.5		-		30.6		-		29.5		-		30.8		-	
Time		11:30		-		2:00		-		12:00		-		13:30		-	

A – Value reported is the mean of two or more determinations.
I - Value reported is less than the laboratory method detection limit and the practical quantification limit.
J - Estimated Value
U - Material was analyzed but not detected; value reported is the minimum detection limit for the sample.

Appendix M-2. Concentrations measured n sediment cores taken at two depths (1-2 in. and 4-5 in. below the surface for sampling event in November 2000. Data only includes constituents that were detected during one of the three sampling events. Also included are water quality data from the overlying water column and field parameters for each site.

CONSTITUENT		1088-1 Inflow		1088-4 Inflow		1088-1 Dup		1088-4 Dup		1088-B Box		1089-1 2nd Inflow		1089-4 2nd Inflow		638-1 Outfall		638-4 Outfall	
SEDIMENT PARTICLE SIZE																			
>2.0	mm	2.3		-		3.3		-		-		1.9	*	-		1.8		-	
0.5 - 2.0	mm	16.2		-		13.6		-		-		10	*	-		6.67		-	
0.25 - 0.5	mm	25.4		-		25.6		-		-		19	*	-		17.5		-	
0.125 - 0.25	mm	40.2		-		41.3		-		-		44	*	-		39.5		-	
0.063 - 0.125	mm	8.07		-		8.51		-		-		10	*	-		8.38		-	
<0.063	mm	10.1		-		11		-		-		16	*	-		28		-	
% Organic		1		-		1.1		-		-		1.5	*	-		2.5		-	
SEMI-VOLATILE ORGANIC POLLUTANTS																			
Acenaphthylene	ug/kg	U		U		U		U		U		U		U		U		U	
Anthracene	ug/kg	U		U		U		U		U		U		U		U		U	
Benzo(a)anthracene	ug/kg	370	I	U		530	I	U		U		U		U		U		U	
Benzo(a)pyrene	ug/kg	340	I	U		470	I	U		U		U		U		U		U	
Benzo(b)fluoranthene	ug/kg	660	I	U		900	I	U		U		U		U		U		U	
Benzo(k)fluoranthene	ug/kg	U		U		270	I	U		U		U		U		U		U	
Benzo(g,h,i)perylene	ug/kg	300	I	U		350	I	U		U		U		U		U		U	
Bis(2-ethylhexyl)phthalate	ug/kg	U		U		U		U		U		U		U		U		U	
Butyl benzyl phthalate	ug/kg	U		U		U		U		U		U		U		U		U	
Chrysene	ug/kg	620	I	U		860	I	U		U		U		U		U		U	
Di-n-octyl phthalate	ug/kg	250	I	U		240	I	U		U		U		U		U		U	
Dibenzo(a,h)anthracene	ug/kg	U		U		U		U		U		U		U		U		U	
Endrin aldehyde	ug/kg	U		U		U		U		U		U		U		U		U	
Fluoranthene	ug/kg	630	I	U		1200	J	U		U		U		U		U		U	
Hexachlorocyclopentadiene	ug/kg	U		U		U		U		U		U		U		U		U	
Indeno(1,2,3-cd)pyrene	ug/kg	350	I	U		450	I	U		U		U		U		U		U	
Isophorone	ug/kg	U		U		U		U		U		U		U		U		U	
2-Methylnaphthalene	ug/kg	U		U		U		U		U		U		U		U		U	
Phenanthrene	ug/kg	310	I	U		480	I	U		U		U		U		U		U	
Pyrene	ug/kg	770	I	77	I	1300	J	U		U		U		U		U		U	
METALS, TOTAL RECOVERABLE																			
Aluminum	mg/kg	1040	AJ	1050	J	1070	J	408	J	1870	J	1660	J	250	A	2480		719	
Cadmium	mg/kg	0.31	I	0.24	I	0.34	I	0.19	I	0.69		0.71		0.18	I	0.95		0.16	I
Chromium	mg/kg	7	AJ	1.8	J	6.8	J	1.9	J	20.5	J	11.1	J	1.3	A	13.7		1.9	
Copper	mg/kg	12.1	A	2		13.6		2.5		45.5		29.3		0.59	I	228		0.81	I
Iron	mg/kg	1030	A	462		1100		292		2570		1370		153	A	1740		224	
Lead	mg/kg	8.6	A	1.9	I	8.4		2.6	I	28.6		15.4		U		36.6		1.2	I
Manganese	mg/kg	10.1	A	4.3		9		3.7		27.2		10.6		2.2	AJ	22.7	J	2.3	J
Nickel	mg/kg	U		U		U		U		5.8	I	2	I	U		6.4	I	U	
Zinc	mg/kg	48	A	9.9	I	56		U		180		79		U		125		U	
PCB																			
PCB-1260	ug/kg	U		U		U		U		U		U		U		U		U	
NUTRIENTS																			
TKN	mg/kg	380		56		460		52		2100		1200		30	A	1600		28	
Total - P	mg/kg	300		130		370		180		750		440		76	A	920		86	

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I - Value reported is less than the laboratory method detection limit and the practical quantification limit.
J - Estimated Value
U - Material was analyzed but not detected; value reported is the minimum detection limit for the sample.

Appendix M-2. *Continued*

CONSTITUENT		1088-1 Inflow	1088-4 Inflow	1088-1 Dup	1088-4 Dup	1088-B Box	1089-1 2nd Inflow	1089-4 2nd Inflow	638-1 Outfall	638-4 Outfall
ORGANONITROGEN & PHOSPHORUS PESTICIDES										
Bromacil	ug/kg	U	U	U	U	U	U	U	U	U
Chlorpyrifos Ethyl	ug/kg	U	U	U	U	U	U	U	U	U
Diazinon	ug/kg	U	U	U	U	U	U	U	U	U
ORGANOCHLORINE PESTICIDES										
Chlordane	ug/kg	U	U	U	U	24 I	21 I	U	U	U
DDD-p,p'	ug/kg	U	U	U	U	U	U	U	U	U
DDE-p,p'	ug/kg	U	U	U	U	U	U	U	6.1	U
Endosulfan Sulfate	ug/kg	U	U	U	U	U	U	4.6 N	U	U
WATER QUALITY										
Cadmium	ug/L	U	-	U	-	-	U	-	U	-
Copper	ug/L	1.0	-	1.0	-	-	1.0	-	4.8	-
Iron	ug/L	220.0	-	200.0	-	-	170.0	-	100.0	-
Lead	ug/L	0.75		1.50	-	-	0.75	-	1.60	-
Manganese	ug/L	17.20	-	13.10	-	-	42.00	-	4.70	-
Zinc	mg/L	20.0 I	-	7.5	-	-	7.5	-	20.0	-
TSS	mg/L	17.9	-	13.1	-	-	3.5	-	2.9	-
Phosphorous, Total	mg/L	0.078	-	0.068	-	-	0.209	-	0.055	-
Phosphorous, Ortho	mg/L	0.024 I	-	0.014 I	-	-	0.129	-	0.005	-
Nitrogen, Total	mg/L	0.79 Q	-	0.78 Q	-	-	1.10 Q	-	0.99 Q	-
Ammonia	mg/L	0.060	-	0.044	-	-	0.057	-	0.031 I	-
Nitrate + Nitrite	mg/L	0.010	-	0.011 I	-	-	0.008	-	0.008	-
Organic Nitrogen	mg/L	0.72	-	0.73	-	-	1.04	-	0.95	-
TKN	mg/L	0.780 J		0.769 J	-	-	1.092 J	-	0.982 J	-
Chloride	mg/L	43.3	-	40.8	-	-	43.0	-	26.8	-
Potassium	mg/L	11.00	-	10.60	-	-	14.70	-	8.29	-
Sodium	mg/L	40.10	-	36.10	-	-	44.60	-	24.50	-
Sulfate	mg/L	40.80	-	37.10	-	-	28.70	-	25.50	-
Calcium	mg/L	43.30	-	39.30	-	-	51.10	-	23.40	-
Magnesium	mg/L	5.38	-	4.90	-	-	6.86	-	0.05	-
Hardness	mg/L	130.3	-	118.3	-	-	155.9	-	58.6	-
FIELD PARAMETERS										
Depth	cm	-	-	-	-	0.53	-	-	-	-
D.O.	mg/L	5.54	-	-	-	1.54	1.51	-	12.04	-
pH	SU	7.63	-	-	-	7.39	7.13	-	9.1	-
Salinity	PPth	0.32	-	-	-	0.45	0.28	-	0.14	-
Specific Conductivity	umho/cm	0.631	-	-	-	0.863	0.549	-	0.828	-
Temperature	C	23.67	-	-	-	26.13	24.27	-	27.79	-
Time		10:30	-	-	-	14:30	11:30	-	12:25	-

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I - Value reported is less than the laboratory method detection limit and the practical quantification limit.
J - Estimated Value
U - Material was analyzed but not detected; value reported is the minimum detection limit for the sample.
DUP=duplicate sample.

Appendix M-3. Concentrations measured n sediment cores taken at two depths (1-2 in. and 4-5 in. below the surface) for sampling event in December 2003. Table only includes constituents that were detected during one of the three sampling events. Also included are water quality data from the overlying water column and field parameters for each site.

CONSTITUENT		1088-1 Inflow		1088-4 Inflow		1088B-1 Box		1087-1 Eq.Pipe		1087-4 Eq.Pipe		638-1 Outfall		638-4 Outfall		638-1 Dup		638-4 Dup	
SEDIMENT PARTICLE SIZE																			
>2.0	mm	2.7		-		18		10		-		4.7	*	-		3.3		-	
0.5 - 2.0	mm	33.7		-		72.1		23.8		-		14.7	*	-		14.3		-	
0.25 - 0.5	mm	41.9		-		18.2		22.8		-		21.4	*	-		21.3		-	
0.125 - 0.25	mm	16.4		-		4.31		33.4		-		42.3	*	-		41.7		-	
0.063 - 0.125	mm	2.69		-		1.16		5.66		-		9.66	*	-		9.18		-	
<0.063	mm	5.3		-		4.32		14.2		-		12	*	-		13.6		-	
% Organic		1		-		3.1		1		-		1.1	*	-		1.4		-	
SEMI-VOLATILE ORGANIC POLLUTANTS																			
Acenaphthylene	ug/kg	U		U		U		U		U		U		U		160	I	U	
Anthracene	ug/kg	U		U		U		U		U		U		U		240	I	U	
Benzo(a)anthracene	ug/kg	400		U		390		88	I	U		160	I	78	I	460		91	I
Benzo(a)pyrene	ug/kg	480		U		480		130	I	U		200	I	85	I	430		110	I
Benzo(b)fluoranthene	ug/kg	950		U		1100		240	I	86	I	280	I	120	I	500		150	I
Benzo(k)fluoranthene	ug/kg	300	I	U		380		U		U		U		U		130	I	U	
Benzo(g,h,i)perylene	ug/kg	190	I	U		170	I	87	I	U		180	I	78	I	190	I	U	
Bis(2-ethylhexyl)phthalate	ug/kg	8700	I	U		2100		U		U		710	I	U		U		U	
Butyl benzyl phthalate	ug/kg	U		U		U		U		U		U		U		U		U	
Chrysene	ug/kg	650		U		660		160	I	U		180	I	86	I	460		91	I
Di-n-octyl phthalate	ug/kg	U	I	U		U		U		U		U		U		U		U	
Dibenzo(a,h)anthracene	ug/kg	U		U		U		U		U		U		U		U		U	
Endrin aldehyde	ug/kg	U		U		U		200	I	U		U		U		U		U	
Fluoranthene	ug/kg	1000		U		1000		U		U		290	I	150	I	900		160	I
Hexachlorocyclopentadiene	ug/kg	76		U		U		U		U		U		U		U		U	
Indeno(1,2,3-cd)pyrene	ug/kg	200	I	U		180	I	83	I	U		130	I	U		160	I	U	
Isophorone	ug/kg	U		U		240	I	U		U		U		U		U		U	
2-Methylnaphthalene	ug/kg	U		U		200	I	U		U		U		U		U		U	
Phenanthrene	ug/kg	410		U		300	I	U		U		130	I	U		900		81	I
Pyrene	ug/kg	920		U		990		200	I	78	I	260	I	140	I	1000		140	I
METALS, TOTAL RECOVERABLE																			
Aluminum	mg/kg	2530	J	4360	J	1630	J	1760	J	5400	J	2510	J	1280	J	2860	J	1530	J
Cadmium	mg/kg	0.075	I	0.073	U	0.26	I	0.12	I	0.42		0.22	I	0.13	I	0.25	I	0.096	I
Chromium	mg/kg	6.83		4.84		9.78		8.68		22.8		8.69		6.9		11.3		8.22	
Copper	mg/kg	10.7		2.3	I	13.7		9.6		2	I	8		2.8	I	11		2.2	I
Iron	mg/kg	2230	J	2330	J	2490	J	1120	J	2230	J	1780	J	922	J	1920	J	1010	J
Lead	mg/kg	7.3		4		9.7		7.3		5.5		27.3		6.9		26.6		7.1	
Manganese	mg/kg	11		25.9		38.7		8.2		10.1		15.6		10.8		17.3		9.9	
Nickel	mg/kg	3.3		2.1		2.5		2.6		6		2.3		2		3.9		2.9	
Zinc	mg/kg	44.7		7.3	I	64.7		25.9		8.7	I	24.1		12.4		36		10.5	
PCB																			
PCB-1260	ug/kg	U		U		U		U		U		U		U		U		U	
NUTRIENTS																			
TKN	mg/kg	12000	J	4200	J	14000	J	12000	J	2500	J	24000	JQ	7900	AJQ	19000	JQ	5300	JQ
Total - P	mg/kg	20000		26000		57000		19000		14000		28000	Q	16000	AQ	22000	Q	19000	Q

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J - Estimated Value
U - Material was analyzed but not detected; value reported is the minimum detection limit for the sample.
DUP=duplicate sample

Appendix M-3. *Continued*

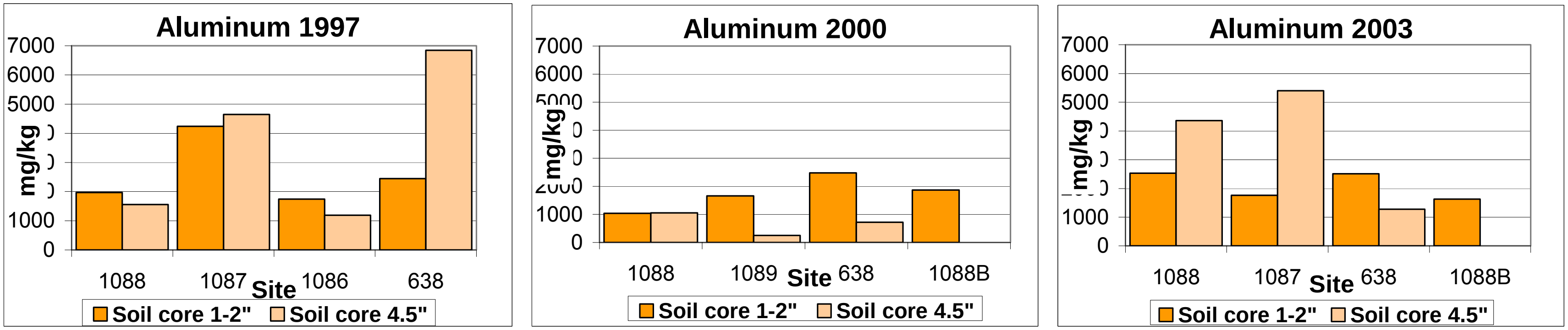
CONSTITUENT		1088-1 Inflow	1088-4 Inflow	1088B-1 Box	1087-1 Eq.Pipe	1087-4 Eq.Pipe	638-1 Outfall	638-4 Outfall	638-1 Dup	638-4 Dup
ORGANONITROGEN & PHOSPHORUS PESTICIDES										
Bromacil	ug/kg	U	U	U	U	U	U	U	U	U
Chlorpyrifos Ethyl	ug/kg	U	U	U	U	U	U	U	U	U
Diazinon	ug/kg	35	U	10 I	U	U	U	U	U	U
ORGANOCHLORINE PESTICIDES										
Chlordane	ug/kg	7.1 I	U	12 I	U	U	U	U	7 I	U
DDD-p,p'	ug/kg	U	U	1.2 I	U	U	U	U	U	U
DDE-p,p'	ug/kg	U	U	1.5 I	U	U	1.4 I	U	1.5 I	0.91 I
Endosulfan Sulfate	ug/kg	U	U	U	U	U	U	U	U	U
WATER QUALITY										
Cadmium	ug/L	*U*	-	*U*	2.77	-	*U*	-	-	-
Copper	ug/L	5.39	-	*1.50*	193.00	-	14.40	-	-	-
Iron	ug/L	583.0	-	161.0	12700.0	-	1300.0	-	-	-
Lead	ug/L	*U*	-	*U*	75.70	-	12.40	-	-	-
Manganese	ug/L	-	-	-	-	-	-	-	-	-
Zinc	mg/L	23.7	-	16.3	395.0	-	61.3	-	-	-
TSS	mg/L	15.7	-	2.0	395.0	-	134.0	-	-	-
Phosphorous, Total	mg/L	0.412	-	0.352	0.018	-	0.208	-	-	-
Phosphorous, Ortho	mg/L	0.209	-	0.303	*0.005*	-	0.014	-	-	-
Nitrogen, Total	mg/L	0.78	-	0.94	2.63	-	3.20	-	-	-
Ammonia	mg/L	0.288	-	0.514	0.081	-	0.152	-	-	-
Nitrate + Nitrite	mg/L	0.124	-	0.043	0.005	-	0.006	-	-	-
Organic Nitrogen	mg/L	0.37 J	-	0.38 J	2.54 J	-	3.04 J	-	-	-
TKN	mg/L	0.657 J	-	0.897 J	2.625 J	-	3.194 J	-	-	-
Chloride	mg/L	-	-	-	-	-	-	-	-	-
Potassium	mg/L	-	-	-	-	-	-	-	-	-
Sodium	mg/L	-	-	-	-	-	-	-	-	-
Sulfate	mg/L	-	-	-	-	-	-	-	-	-
Calcium	mg/L	49.10	-	49.20	70.10	-	36.20	-	-	-
Magnesium	mg/L	3.37	-	3.45	4.40	-	2.42	-	-	-
Hardness	mg/L	136.5	-	137.1	193.2	-	100.4	-	-	-
FIELD PARAMETERS										
Depth	cm	6.5	-	31.75	4.5	-	8.75	-	-	-
D.O.	mg/L	1.76	-	0.97	3.28	-	3.5	-	-	-
pH	SU	7.36	-	7.47	7.44	-	7.53	-	-	-
Salinity	PPth	0.22	-	0.22	0.18	-	0.14	-	-	-
Specific Conductivity	umho/cm	446	-	445.9	376.8	-	294	-	-	-
Temperature	C	19.8	-	23.06	13.77	-	14.77	-	-	-
Time		10:00	-	10:45	9:00	-	13:30	-	-	-

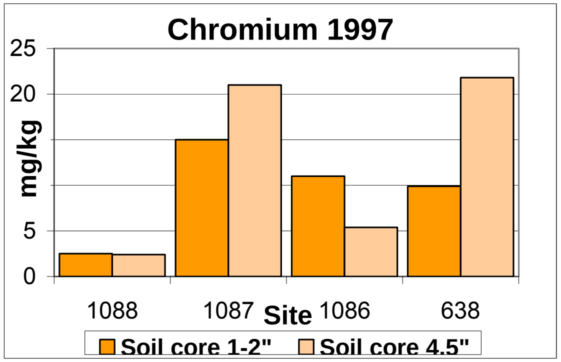
A – Value reported is the mean of two or more determinations.
I - Value reported is less than the laboratory method detection limit and the practical quantification limit.
J - Estimated Value
U - Material was analyzed but not detected; value reported is the minimum detection limit for the sample.

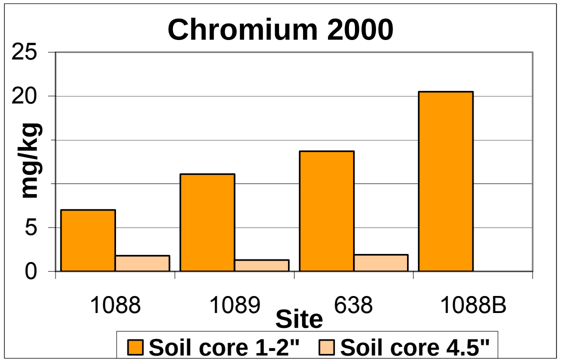
Appendix N

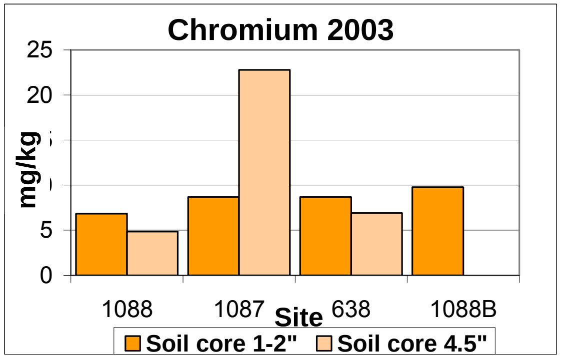
Graphs of Metals from Sediment Sampling

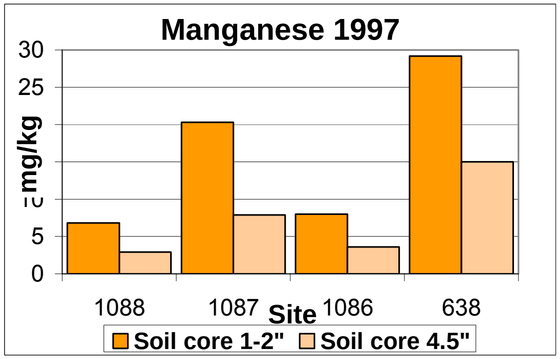
Appendix N. Metal concentrations for two depths in the sediments compared to concentrations in the overlying water column (when applicable) for all three sampling events (October 1997, November 2000, and December 2003). The x-axis is aligned geographically from inflow (Station 1088) to outflow (Station 638) (See Figure 2). Station 1088B refers to samples taken from the sedimentation basin.

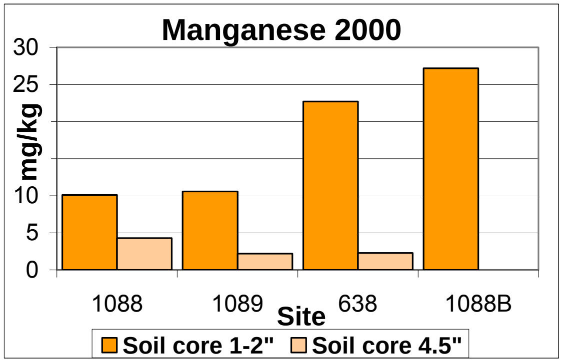


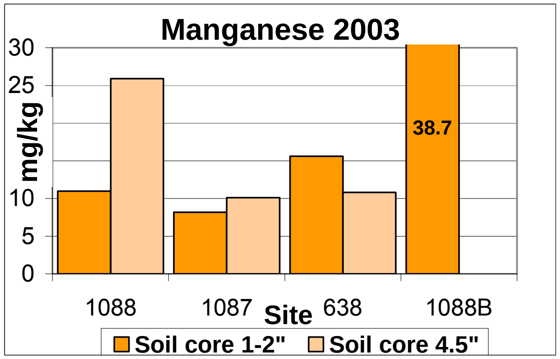

Chromium 1997
mg/kg
Site
1088
1087
1086
638
Soil core 1-2"
Soil core 4.5"


Chromium 2000
mg/kg
Site
1088
1089
638
1088B
Soil core 1-2"
Soil core 4.5"

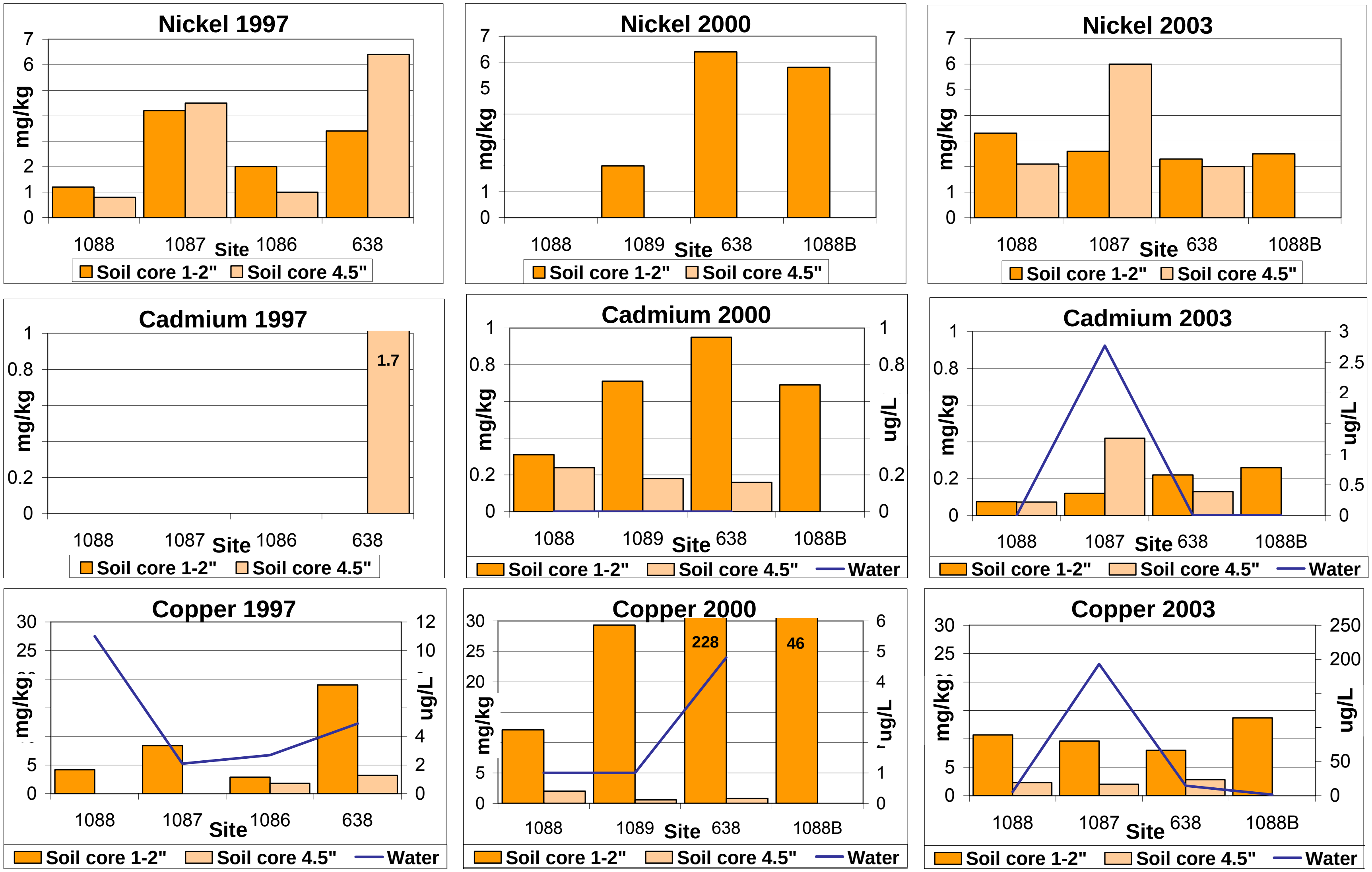

Chromium 2003
mg/kg
Site
1088
1087
638
1088B
Soil core 1-2"
Soil core 4.5"


Manganese 1997
mg/kg
Site
1088
1087
1086
638
Soil core 1-2"
Soil core 4.5"

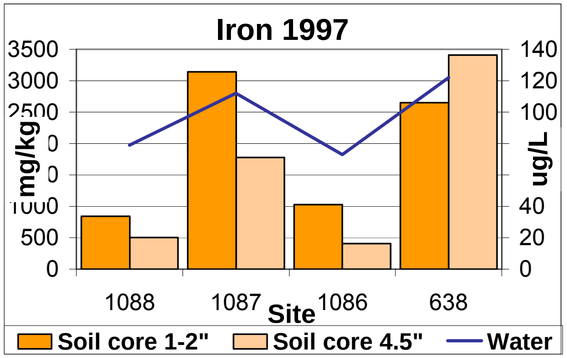

Manganese 2000
mg/kg
Site
1088
1089
638
1088B
Soil core 1-2"
Soil core 4.5"

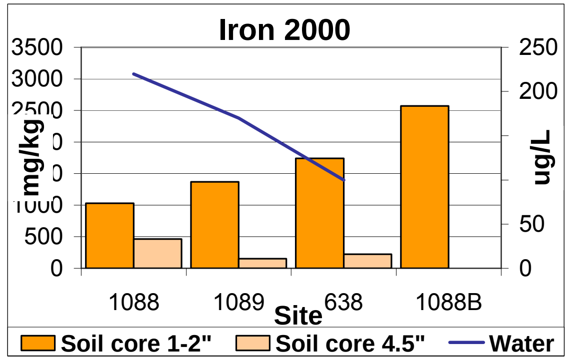

Manganese 2003
mg/kg
38.7
Site
1088
1087
638
1088B
Soil core 1-2"
Soil core 4.5"

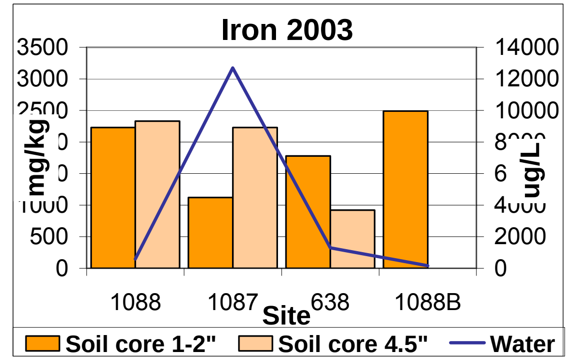
Appendix N. ***Continued***

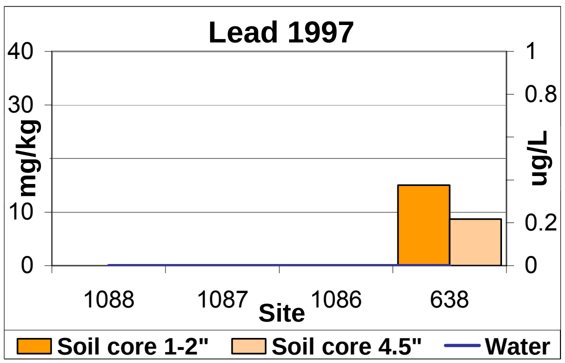


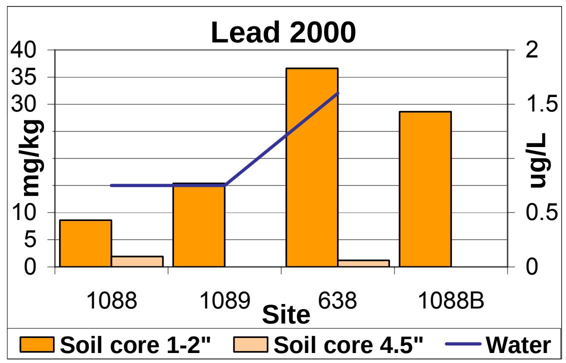
Appendix N. ***Continued***

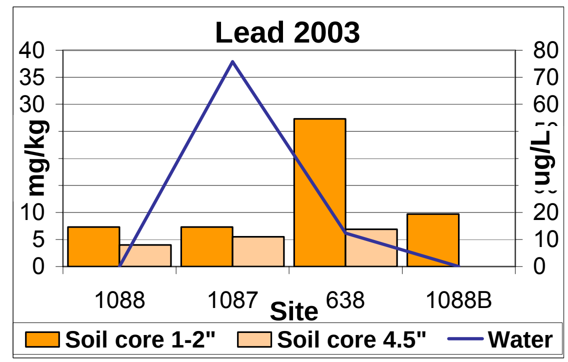


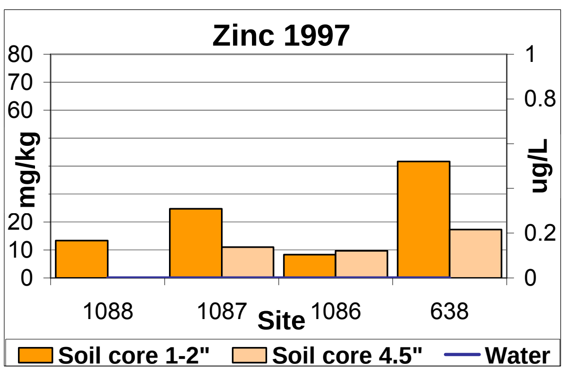


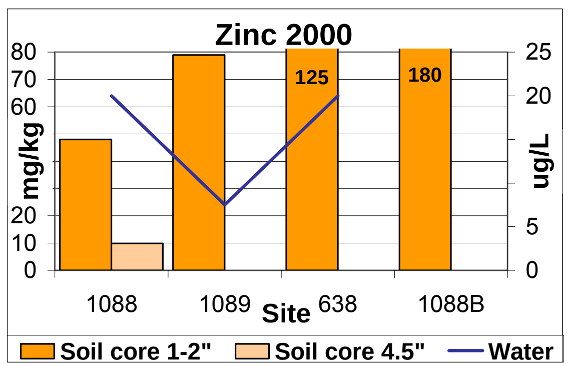


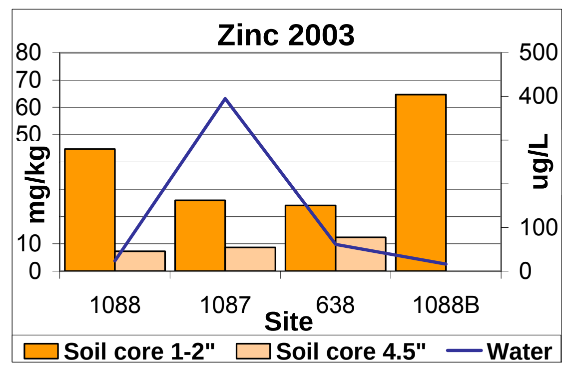












Appendix O

Statistical Analysis

ABBREVIATIONS USED IN STATISTICAL ANALYSIS

LABEL	UNITS	LABEL MEANING		LABEL	UNITS	LABEL MEANING
C YR		Comparable year (same months)		SSRN	mg/L	Suspended solids in rain
S YR		Sampling year		SSIN	mg/L	Suspended solids in inflow
NO		Storm number		SSOU	mg/L	Suspended solids in outlfow
MO		Month		SSSUD	mg/L	Suspended solids in south underdrain
DA		Day		SSNUD	mg/L	Suspended solids in north underdrain
YR		Year		CURN	ug/L	Copper in rain
RAIN	inches	Rainfall		CUIN	ug/L	Copper in inflow
AVGI	inches	Average intensity of rain		CUOU	ug/L	Copper in outlfow
ANTE	hours	Interevent period		CUSUD	ug/L	Copper in south underdrain
RNPD	cubic ft.	Rain on pond		CUNUD	ug/L	Copper in north underdrain
INFL	cubic ft.	Inflow		PBRN	ug/L	Lead in rain
OUFL	cubic ft.	Outflow		PBIN	ug/L	Lead in inflow
NHRN	mg/L	Ammonia in rain		PBOU	ug/L	Lead in outlfow
NHIN	mg/L	Ammonia in inflow		PBSUD	ug/L	Lead in south underdrain
NHOU	mg/L	Ammonia in outlfow		PBNUD	ug/L	Lead in north underdrain
NHSUD	mg/L	Ammonia in south underdrain		ZNRN	ug/L	Zinc in rain
NHNUD	mg/L	Ammonia in north underdrain		ZNIN	ug/L	Zinc in inflow
NXRN	mg/L	Nitrate + Nitrite in rain		ZNOU	ug/L	Zinc in outlfow
NXIN	mg/L	Nitrate + Nitrite in inflow		ZNSUD	ug/L	Zinc in south underdrain
NXOU	mg/L	Nitrate + Nitrite in outlfow		ZNNUD	ug/L	Zinc in north underdrain
NXSUD	mg/L	Nitrate + Nitrite in south underdrain		MNRN	ug/L	Manganese in rain
NXNUD	mg/L	Nitrate + Nitrite in north underdrain		MNIN	ug/L	Manganese in inflow
ONRN	mg/L	Organic nitrogen in rain		MNOU	ug/L	Manganese in outlfow
ONIN	mg/L	Organic nitrogen in inflow		MNSUD	ug/L	Manganese in south underdrain
ONOU	mg/L	Organic nitrogen in outlfow		MNNUD	ug/L	Manganese in north underdrain
ONSUD	mg/L	Organic nitrogen in south underdrain		FERN	ug/L	Iron in rain
ONNUD	mg/L	Organic nitrogen in north underdrain		FEIN	ug/L	Iron in inflow
TNRN	mg/L	Total nitrogen in rain		FEOU	ug/L	Iron in outlfow
TNIN	mg/L	Total nitrogen in inflow		FESUD	ug/L	Iron in south underdrain
TNOU	mg/L	Total nitrogen in outlfow		FENUD	ug/L	Iron in north underdrain
TNSUD	mg/L	Total nitrogen in south underdrain		CDRN	ug/L	Cadmium in rain
TNNUD	mg/L	Total nitrogen in north underdrain		CDIN	ug/L	Cadmium in inflow
OPRN	mg/L	Ortho-phos in rain		CDOU	ug/L	Cadmium in outlfow
OPIN	mg/L	Ortho-phos in inflow		CDSUD	ug/L	Cadmium in south underdrain
OPOU	mg/L	Ortho-phos in outlfow		CDNUD	ug/L	Cadmium in north underdrain
OPSUD	mg/L	Ortho-phos in south underdrain		HDRN	mg/L	Hardness in rain
OPNUD	mg/L	Ortho-phos in north underdrain		HDIN	mg/L	Hardness in inflow
TPRN	mg/L	Total phos in rain		HDOU	mg/L	Hardness in outlfow
TPIN	mg/L	Total phos in inflow		HDSUD	mg/L	Hardness in south underdrain
TPOU	mg/L	Total phos in outlfow		HDNUD	mg/L	Hardness in north underdrain
TPSUD	mg/L	Total phos in south underdrain				
TPNUD	mg/L	Total phos in north underdrain				

SAS DATA SET USED FOR STATISTICAL ANALYSIS (PAGE 1)

OBS	WABUD	C YR	S YR	NO	MO	DA	YR	RAIN	AVGI	ANTE	RNPD	INFL	OUFL	NHRN	NHIN
1	NB	1	1	1	11	25	00	1.5	0.2	168.00	1797	.	.	0.121	0.041
2	NB	1	1	2	12	18	00	0.43	0.11	530.00	515	.	.	0.068	0.059
3	NB	1	1	3	01	08	01	0.94	0.06	241.00	1126	.	.	0.092	0.066
4	NB	1	1	4	03	04	01	1.59	0.07	688.00	1905	.	.	0.192	0.005
5	NB	1	1	5	03	19	01	0.89	0.05	357.25	1066	11219	0	0.229	0.182
6	NB	1	1	6	03	29	01	3.56	0.07	237.75	4265	55745	31084	0.212	0.150
7	NB	1	1	7	06	06	01	1.97	0.79	124.25	2360	29166	10581	0.156	0.028
8	NB	1	1	8	06	20	01	0.64	0.26	308.50	767	7852	0	0.510	0.420
9	NB	1	1	9	06	23	01	0.52	0.07	19.25	623	4501	1202	0.088	0.144
10	NB	1	1	10	06	28	01	2.15	0.45	121.25	2576	34034	22064	0.086	0.088
11	NB	1	1	11	07	11	01	0.83	0.16	19.75	994	12204	6367	0.109	0.068
12	NB	1	1	12	07	13	01	0.95	0.32	47.25	1138	12696	5063	.	0.047
13	NB	1	1	13	07	22	01	1.07	0.78	97.75	1282	15237	7256	.	0.067
14	NB	1	1	14	07	23	01	1.41	0.21	42.00	1689	26784	16980	0.029	0.005
15	NB	1	1	15	07	27	01	0.48	0.64	96.75	575	6499	2743	0.132	0.190
16	NB	1	1	16	08	05	01	0.46	1.84	72.00	551	8590	12428	0.071	0.072
17	NB	1	1	17	08	07	01	1.05	2.1	42.25	1258	12764	13490	0.381	0.158
18	NB	0	2	1	06	13	02	0.84	0.84	583.25	1006	12599	0	.	0.281
19	NB	0	2	2	06	18	02	2.67	0.56	9.50	3198	45262	24110	.	0.098
20	NB	0	2	3	06	24	02	3.26	0.47	148.50	3905	58484	30135	.	0.169
21	NB	0	2	4	06	28	02	2.73	0.52	21.25	3270	46709	13828	.	0.130
22	NB	0	2	5	06	29	02	1.21	1.61	21.00	1449	20798	4115	.	0.097
23	WB	0	2	6	07	01	02	0.91	0.17	43.50	1090	14809	207	.	0.134
24	WB	0	2	7	07	25	02	0.41	0.31	289.75	491	5264	0	.	0.431
25	WB	0	2	8	08	02	02	0.27	0.27	6.25	323	3327	0	.	0.247
26	WB	0	2	9	08	07	02	1.48	0.33	132.50	1773	30772	1521	.	0.023
27	WB	0	2	10	08	14	02	2.93	0.33	139.00	3510	47612	20010	.	0.127
28	WB	0	2	11	08	17	02	0.74	0.25	187.25	886	10609	0	.	0.062
29	WB	0	2	12	08	30	02	1.18	0.23	76.75	1414	16994	0	0.289	0.097
30	WB	0	2	13	09	02	02	1.1	1.47	67.75	1318	17804	332	0.161	*0.005*
31	WB	0	2	14	09	11	02	1.55	0.16	60.25	1857	27879	11342	0.040	0.033
32	WB	0	2	15	09	12	02	0.72	0.47	19.25	863	11195	5949	0.043	0.050
33	WB	0	2	16	09	17	02	1.34	0.79	124.00	1605	21690	8818	.	0.109
34	WB	0	2	17	09	27	02	0.41	0.07	45.25	491	7351	0	.	0.106
35	WB	0	2	18	10	12	02	0.92	0.17	378.50	1102	12977	0	0.324	0.173
36	WB	0	2	19	10	15	02	0.54	0.14	63.00	647	7025	0	0.080	0.040
37	WB	0	2	20	10	30	02	0.51	0.68	161.75	611	7003	0	0.220	0.248
38	WB	3	2	21	11	12	02	0.89	0.09	317.25	1066	10732	0	0.104	0.334
39	WB	3	2	22	12	09	02	3.69	0.12	69.50	4420	62485	28259	0.021	0.016
40	WB	3	2	23	12	12	02	4.65	0.25	54.00	5570	89057	57644	0.068	0.181
41	WB	3	2	24	02	22	03	0.57	0.23	138.25	683	6478	0	0.036	.
42	WB	3	2	25	02	28	03	1	0.08	136.50	1198	18092	382	0.077	*0.006*
43	WB	3	2	26	03	16	03	0.69	0.46	383.75	827	12446	0	0.073	0.038
44	WB	3	2	27	03	21	03	1.64	0.44	105.00	1965	35773	20024	.	0.116
45	WB	3	2	28	03	23	03	1.45	0.1	41.00	1737	20425	7144	0.554	0.112
46	WB	3	2	29	04	25	03	3.4	0.38	386.25	4073	53644	16912	0.724	0.433
47	WB	3	2	30	05	22	03	0.77	0.28	68.75	922	9328	0	0.016	0.162
48	WB	3	2	31	06	09	03	0.5	0.165	48.13	599	7300.5	0	0.067	0.048
49	WB	3	2	32	06	11	03	1.65	1.32	50.25	1977	28082	6103	0.284	0.117
50	WB	3	2	33	06	16	03	0.92	0.18	119.25	1102	11093	0	0.072	0.045
51	WB	3	2	34	06	18	03	1.52	0.18	14.00	1821	32413	12951	0.217	0.071
52	WB	3	2	35	06	19	03	1.5	0.15	10.25	1797	23097	19320	0.038	0.047
53	WB	3	2	36	06	29	03	.	.	.	0	.	.	0.076	0.118
54	NB	3	2	37	07	11	03	0.71	0.95	13.00	851	13014	7929	0.050	0.050
55	NB	3	2	38	08	27	03	0.96	0.32	20.75	1150	14206	5193	0.051	0.028
56	NB	0	2	39	09	19	03	2.31	0.49	324.75	2767	30572	15078	0.138	0.166

SAS DATA SET USED FOR STATISTICAL ANALYSIS (PAGE 2)

OBS	NHOU	NHSUD	NHNUD	NXRN	NXIN	NXOU	NXSUD	NXNUD	ONRN	ONIN	ONOU
1	0.075	0.099	.	0.084	.	0.169	0.195	.	0.14	.	0.64
2	0.005	.	.	0.054	0.267	0.019	.	.	0.31	0.77	0.75
3	0.019	0.108	.	0.085	0.221	0.113	0.117	.	0.20	0.16	0.38
4	0.011	0.143	.	0.105	0.247	0.073	0.061	.	0.90	0.67	0.91
5	0.044	.	.	0.238	0.282	0.026	.	.	0.43	0.74	0.70
6	0.049	0.078	.	0.211	0.239	0.149	0.187	.	0.19	0.28	0.44
7	0.031	0.335	.	0.287	0.316	0.181	0.551	.	0.00	0.65	0.46
8	0.182	0.499	.	0.869	0.748	0.000	0.285	.	.	0.83	.
9	0.028	0.044	.	0.202	0.178	0.018	0.046	.	0.12	0.65	-0.05
10	0.005	0.151	.	0.085	0.131	0.055	0.102	.	0.23	0.23	0.46
11	0.005	0.150	.	0.440	0.291	0.008	0.037	.	0.24	0.44	0.73
12	0.021	0.200	.	0.000	0.176	0.008	0.078	.	.	0.31	0.42
13	0.005	.	.	0.000	0.063	0.008	0.008	.	.	1.37	0.66
14	0.018	.	.	0.008	0.072	0.010	0.066	.	0.00	0.16	0.25
15	0.042	0.130	.	0.263	0.225	0.010	0.125	.	.	0.27	0.34
16	0.035	0.231	.	0.051	0.139	0.008	.	.	4.73	0.65	2.38
17	0.005	0.213	.	0.485	0.555	0.059	.	.	0.52	0.46	0.68
18	.	.	.	.	0.801	.	.	.	.	0.168	.
19	0.054	0.181	0.031	.	0.156	0.103	0.488	0.040	.	0.406	0.293
20	0.053	0.109	0.195	.	0.116	0.099	0.142	0.093	.	0.185	0.598
21	0.027	.	.	.	0.370	0.296	.	.	.	0.260	0.677
22	0.036	0.170	0.208	.	0.703	0.058	0.249	0.149	.	0.200	0.646
23	0.049	0.185	0.166	.	0.355	0.068	0.216	0.160	.	0.161	0.883
24	.	0.852	0.526	.	0.413	.	0.137	0.112	.	0.546	.
25	.	0.795	0.462	.	0.159	.	0.086	0.083	.	0.584	.
26	0.037	0.220	0.127	.	0.297	0.048	0.343	0.278	.	0.620	0.485
27	0.040	.	0.163	.	0.226	0.135	.	0.408	.	0.195	0.000
28	0.005	.	.	.	0.422	0.008	.	.	.	0.364	0.227
29	0.005	0.634	0.246	0.245	0.284	0.096	0.198	0.066	0.000	0.291	0.263
30	0.005	0.083	0.064	0.354	0.337	0.013	0.091	0.083	0.000	0.284	0.330
31	0.012	0.240	0.210	0.095	0.081	0.010	0.151	0.079	0.038	0.168	0.362
32	0.005	0.083	0.161	0.064	0.120	0.008	0.079	0.033	0.062	0.187	0.351
33	0.029	0.421	0.327	.	0.391	0.075	0.164	0.092	.	0.230	0.321
34	.	0.154	0.420	.	0.059	.	0.054	0.066	.	0.421	.
35	.	0.386	0.435	0.387	0.300	.	0.301	0.142	0.030	0.507	.
36	.	0.131	0.464	0.160	0.061	.	0.047	0.032	0.000	0.459	.
37	.	.	.	0.114	0.319	.	.	.	0.117	0.743	.
38	.	0.211	0.266	0.175	0.282	.	0.354	0.093	0.000	0.354	.
39	0.016	0.125	0.110	0.052	0.095	0.082	0.345	0.333	0.107	0.299	0.332
40	0.032	0.148	0.204	0.073	0.141	0.063	0.441	0.183	0.009	0.118	0.305
41	.	0.235	0.345	0.063	.	.	0.198	0.023	0.004	.	.
42	0.018	0.144	0.246	0.148	0.157	0.005	0.104	0.044	0.045	0.557	0.467
43	.	0.422	0.345	0.056	0.146	.	0.333	0.068	0.085	0.836	.
44	0.050	.	.	.	0.139	0.096	.	.	.	0.399	0.348
45	0.006	0.108	.	0.162	0.187	0.039	0.101	.	0.220	0.465	0.392
46	0.133	0.116	0.361	0.241	0.348	0.301	0.532	0.314	0.055	0.589	0.656
47	.	0.303	0.098	0.078	0.174	.	0.368	0.090	0.084	0.380	.
48	.	0.572	0.349	0.112	0.158	.	0.261	0.090	0.000	0.894	.
49	0.064	0.114	0.045	0.694	0.579	0.206	0.145	0.095	0.082	0.534	0.640
50	.	0.148	0.045	0.164	0.215	.	0.117	0.048	0.005	0.463	.
51	0.014	0.125	0.030	0.085	0.113	0.027	0.079	0.024	0.108	0.396	0.439
52	0.006	0.160	0.044	0.038	0.076	0.033	0.203	0.036	0.044	0.417	0.251
53	0.006	0.312	0.187	0.079	0.130	0.005	0.162	0.086	0.030	0.247	0.578
54	0.329	0.217	0.176	0.273	0.328	0.247	0.079	0.040	0.007	0.319	1.074
55	0.003	0.135	0.139	0.152	0.219	0.039	0.077	0.058	0.037	0.403	0.319
56	0.077	0.212	0.163	0.187	0.259	0.206	0.199	0.118	0.039	0.437	0.430

SAS DATA SET USED FOR STATISTICAL ANALYSIS (PAGE 3)

OBS	ONSUD	ONNUD	TNRN	TNIN	TNOU	TNSUD	TNNUD	OPRN	OPIN	OPOU	OPSUD	OPNUD
1	0.416	.	0.34	.	0.88	0.710	.	0.016	.	0.105	0.113	.
2	.	.	0.43	1.10	0.77	.	.	0.011	0.167	0.017	.	.
3	0.336	.	0.38	0.45	0.51	0.560	.	0.005	0.090	0.052	0.085	.
4	0.557	.	1.20	0.92	0.99	0.760	.	0.154	0.093	0.051	0.084	.
5	.	.	0.90	1.20	0.77	.	.	0.005	0.124	0.033	.	.
6	0.246	.	0.61	0.67	0.63	0.510	.	0.013	0.069	0.039	0.061	.
7	0.514	.	0.40	0.99	0.67	1.400	.	0.014	0.094	0.067	0.157	.
8	0.416	.	1.60	2.00	.	1.200	.	0.024	0.207	.	0.189	.
9	0.531	.	0.41	0.97	.	0.620	.	0.005	0.081	0.019	0.055	.
10	0.297	.	0.40	0.45	0.52	0.550	.	0.005	0.161	0.057	0.084	.
11	0.404	.	0.79	0.80	0.74	0.590	.	0.005	0.091	0.040	0.084	.
12	0.333	.	.	0.53	0.45	0.610	.	.	0.060	0.043	0.109	.
13	0.783	.	.	1.50	0.67	0.920	.	.	0.088	0.010	0.072	.
14	0.134	.	0.03	0.24	0.28	0.430	.	0.005	0.193	0.049	0.084	.
15	0.303	.	0.46	0.68	0.39	0.640	.	0.005	0.132	0.039	0.092	.
16	.	.	4.85	0.86	2.42	.	.	0.005	0.073	0.016	.	.
17	.	.	1.39	1.17	0.74	.	.	0.012	0.050	0.032	.	.
18	.	.	.	1.250	.	.	.	.	0.090	.	.	.
19	0.391	0.340	.	0.660	0.450	1.060	0.410	.	0.063	0.043	0.067	0.040
20	0.229	0.232	.	0.470	0.750	0.480	0.520	.	0.062	0.035	0.107	0.116
21	.	.	.	0.760	1.000	.	.	.	0.060	0.036	.	.
22	0.211	0.173	.	1.000	0.740	0.630	0.530	.	0.032	0.024	0.085	0.101
23	0.209	0.244	.	0.650	1.000	0.610	0.570	.	0.064	0.024	0.091	0.090
24	0.161	0.242	.	1.390	.	1.150	0.880	.	0.171	.	0.265	0.128
25	0.349	0.355	.	0.990	.	1.230	0.900	.	0.135	.	0.254	0.121
26	0.327	0.355	.	0.940	0.570	0.890	0.760	.	0.050	0.015	0.109	0.058
27	.	0.147	.	0.548	0.009	.	0.718	.	0.070	0.027	.	0.069
28	.	.	.	0.848	0.239	.	.	.	0.064	*0.005*	.	.
29	0.060	0.141	0.487	0.672	0.364	0.892	0.453	*0.005*	0.082	0.015	0.219	0.066
30	0.174	0.210	0.445	0.626	0.347	0.348	0.357	*0.005*	0.035	0.010	0.075	0.049
31	0.266	0.282	0.172	0.282	0.384	0.657	0.571	*0.005*	0.032	0.013	0.093	0.072
32	0.205	0.142	0.168	0.357	0.363	0.367	0.336	*0.005*	0.058	*0.005*	0.052	0.059
33	0.272	0.178	.	0.730	0.425	0.857	0.597	.	0.067	0.016	0.140	0.102
34	0.284	0.350	.	0.586	.	0.492	0.836	.	0.086	.	0.072	0.112
35	0.143	0.233	0.740	0.980	.	0.830	0.810	0.016	0.080	.	0.103	0.066
36	0.322	0.354	0.220	0.560	.	0.500	0.850	*0.005*	0.047	.	0.074	0.091
37	.	.	0.450	1.310	.	.	.	*0.005*	0.048	.	.	.
38	0.305	0.451	0.200	0.970	.	0.870	0.810	*0.005*	0.117	.	0.075	0.056
39	0.250	0.257	0.180	0.410	0.430	0.720	0.700	*0.005*	0.041	0.027	0.069	0.064
40	0.201	0.213	0.150	0.440	0.400	0.790	0.600	*0.005*	0.054	0.027	0.265	0.256
41	0.209	0.298	0.103	.	.	0.642	0.666	*0.005*	.	.	0.119	0.097
42	0.132	0.230	0.270	0.720	0.490	0.380	0.520	0.010	0.035	0.018	0.083	0.092
43	0.223	0.351	0.214	1.020	.	0.978	0.764	0.013	0.050	.	0.171	0.103
44	.	.	.	0.654	0.494	.	.	.	0.031	0.018	.	.
45	0.212	0.000	0.936	0.764	0.437	0.421	.	*0.005*	*0.005*	*0.005*	0.074	.
46	0.350	0.365	1.020	1.370	1.090	0.998	1.040	*0.005*	0.073	0.020	0.071	0.091
47	0.293	0.381	0.178	0.716	.	0.964	0.569	*0.005*	0.128	.	0.120	0.043
48	0.277	0.401	0.160	1.100	.	1.110	0.840	*0.005*	0.086	.	0.200	0.094
49	0.291	0.350	1.060	1.230	0.910	0.550	0.490	*0.005*	0.074	*0.005*	0.068	0.025
50	0.346	0.272	0.241	0.723	.	0.611	0.365	*0.005*	0.078	.	0.076	0.026
51	0.196	0.266	0.410	0.580	0.480	0.400	0.320	*0.005*	0.060	0.013	0.077	0.031
52	0.157	0.150	0.120	0.540	0.290	0.520	0.230	*0.005*	0.047	0.013	0.085	0.042
53	0.475	0.223	0.185	0.495	0.589	0.949	0.496	*0.005*	0.069	*0.005*	0.111	0.065
54	0.334	0.227	0.330	0.697	1.650	0.630	0.443	*0.005*	0.031	0.073	0.096	0.075
55	0.288	0.263	0.240	0.65	0.360	0.500	0.460	*0.005*	0.069	0.039	0.075	0.064
56	0.300	0.260	0.364	0.862	0.713	0.711	0.541	*0.005*	0.135	0.12	0.106	0.068

SAS DATA SET USED FOR STATISTICAL ANALYSIS (PAGE 4)

OBS	TPRN	TPIN	TPOU	TPSUD	TPNUD	SSIN	SSOU	SSSUD	SSNUD	CURN	CUIN	CUOU	CUSUD
1	0.032	.	0.174	0.158	.	.	6.4	.	.	3.7	.	9.5	4.1
2	0.019	0.378	0.070	.	.	65.4	3.5	.	.	3.8	40.2	7.4	.
3	0.030	0.171	0.095	0.110	.	22.7	4.5	.	.	4.2	12.9	5.5	5.4
4	0.180	0.190	0.109	0.107	.	21.7	3.0	.	.	21.7	8.9	9.2	5.8
5	0.036	0.228	0.080	.	.	35.2	2.8	.	.	4.4	11.4	2.9	.
6	0.024	0.144	0.073	0.079	.	20.0	4.9	.	.	4.7	12.2	3.2	2.1
7	0.013	0.428	0.161	0.229	.	64.2	5.3	.	.	*1.0*	30.1	5.0	6.5
8	0.031	0.346	.	0.223	.	46.7	.	.	.	7.4	19.2	.	4.2
9	0.017	0.472	0.064	0.096	.	113.2	4.3	2.2	.	2.9	35.0	4.4	5.2
10	0.012	0.504	0.131	0.105	.	81.0	13.6	1.6	.	*1.0*	19.0	3.4	*1.0*
11	*0.005*	0.315	0.059	0.098	.	68.9	2.6	1.4	.	2.2	13.8	2.5	2.1
12	.	0.215	0.078	0.118	.	38.3	2.8	0.3	.	.	16.8	1.0	*1.0*
13	.	0.282	0.078	0.084	.	75.7	2.4	0.1	.	.	14.6	1.0	2.0
14	0.012	0.346	0.083	0.090	.	63.1	3.9	0.6	.	2.1	9.5	2.5	*1.0*
15	0.015	0.389	0.060	0.087	.	49.9	2.1	1.1	.	*1.0*	12.7	2.2	2.5
16	*0.005*	0.196	0.025	.	.	43.0	2.0	.	.	*1.0*	9.4	1.0	.
17	0.023	1.210	0.047	.	.	239.0	12.1	.	.	2.3	40.8	2.7	.
18	.	0.236	.	.	.	42.0	.	.	.	.	24.50	.	.
19	.	0.340	0.076	0.156	0.062	91.0	5.4	2.60	2.60	.	23.80	3.00	3.20
20	.	0.154	0.098	0.139	0.123	32.0	14.0	9.10	3.70	.	11.90	8.40	2.80
21	.	0.133	0.079	.	.	26.0	7.3	.	.	.	8.10	6.60	.
22	.	0.110	0.034	0.101	0.102	19.0	2.0	5.00	2.40	.	8.30	2.30	3.10
23	.	0.091	0.043	0.110	0.104	10.0	.	2.90	1.60	.	6.20	*1.15*	2.60
24	.	0.362	.	0.304	0.173	.	.	1.60	2.70	.	28.50	.	*1.15*
25	.	0.203	.	0.291	0.141	12.0	.	2.10	1.20	.	*1.15*	.	*1.15*
26	.	0.230	0.079	0.136	0.086	44.0	6.7	1.40	2.70	.	21.80	4.20	*1.15*
27	.	0.194	0.074	.	0.080	38.0	7.2	.	2.20	.	21.40	4.10	.
28	.	0.172	0.028	.	.	34.0	2.3	.	.	.	15.50	*1.15*	.
29	*0.005*	0.200	0.049	0.214	0.086	54.0	2.2	*0.25*	1.10	7.80	23.70	3.40	2.60
30	*0.005*	0.258	0.051	0.086	0.065	34.0	4.0	0.90	1.10	*1.15*	18.90	3.30	*1.15*
31	*0.005*	0.090	0.053	0.118	0.109	*0.3*	12.0	1.80	1.30	*1.15*	9.50	2.80	*1.15*
32	*0.005*	0.099	0.046	0.066	0.082	13.0	3.3	0.60	1.80	*1.15*	10.30	3.00	*1.15*
33	.	0.195	0.055	0.160	0.119	46.0	4.5	1.30	0.60	.	16.10	4.20	*1.15*
34	.	0.172	.	0.093	0.146	.	.	1.12	1.30	.	24.40	.	3.00
35	0.034	0.271	.	0.139	0.104	38.9	.	4.09	2.65	2.50	32.50	.	2.50
36	0.021	0.113	.	0.117	0.186	4.1	.	1.87	3.78	3.10	4.00	.	*1.15*
37	*0.005*	0.316	.	.	.	76.7	.	.	.	*1.15*	51.40	.	.
38	*0.005*	0.344	.	0.111	0.099	56.9	.	2.33	2.49	*1.15*	34.20	.	*1.15*
39	*0.005*	0.060	0.060	0.082	0.088	9.7	6.3	1.12	2.08	*1.15*	17.80	11.30	3.80
40	*0.005*	0.092	0.052	0.286	0.279	15.6	4.1	1.05	1.24	*1.15*	18.10	9.50	4.20
41	*0.005*	.	.	0.147	0.128	.	.	1.31	2.24	*1.15*	.	.	*1.50*
42	*0.005*	0.075	0.069	0.095	0.113	4.89	.	0.59	*1.50*	*1.50*	20.20	3.87	0.94
43	*0.050*	0.226	.	0.201	0.144	38.40	.	1.58	1.50	*1.50*	28.10	.	1.77
44	.	0.133	0.072	.	.	32.00	4.32	.	.	.	23.30	3.78	.
45	*0.005*	0.079	0.050	0.089	.	13.20	3.24	1.09	*1.50*	*1.50*	23.30	3.63	.
46	*0.005*	0.239	0.108	0.100	0.121	38.20	6.25	3.11	4.57	*1.50*	40.10	11.60	3.73
47	*0.005*	0.183	.	0.136	0.059	14.00	.	0.88	*1.50*	*1.50*	20.50	.	1.18
48	*0.005*	0.475	.	0.228	0.123	144.00	.	0.77	*1.50*	*1.50*	55.80	.	1.46
49	*0.005*	0.177	0.086	0.092	0.067	42.10	8.51	1.01	*1.50*	*1.50*	23.40	5.23	1.89
50	*0.005*	0.158	.	0.090	0.047	12.10	.	0.49	*1.50*	*1.50*	9.87	.	1.38
51	*0.005*	0.103	0.051	0.086	0.044	18.10	5.45	2.81	*1.50*	*1.50*	15.80	5.53	2.00
52	*0.005*	0.175	0.041	0.089	0.054	51.10	4.36	0.58	*1.50*	*1.50*	33.90	4.34	0.72
53	*0.005*	0.134	0.049	0.156	0.102	24.00	3.64	8.66	*1.50*	*1.50*	15.80	*1.50*	.
54	*0.005*	0.122	0.471	0.333	0.116	23.00	73.90	47.00	6.84	*1.50*	14.20	102.00	4.51
55	*0.005*	0.187	0.072	0.181	0.073	35.60	3.17	27.10	4.95	*1.50*	18.20	*1.50*	0.68
56	*0.005*	0.339	0.207	0.168	0.089	35.2	7.94	11.80	5.51	*1.50*	38.7	7.35	2.20

SAS DATA SET USED FOR STATISTICAL ANALYSIS (PAGE 5)

OBS	CUNUD	PBRN	PBIN	PBOU	PBSUD	PBNUD	ZNRN	ZNIN	ZNOU	ZNSUD	ZNNUD	FERN	FEIN	FEOU
1	.	0.75	.	1.50	0.75	.	30.0	.	.-	7.5	.	40.0	.	200.0
2	.	0.75	14.50	0.75	.	.	60.0	140.0	7.5	.	.	160.0	1530.0	80.0
3	.	0.75	6.60	2.20	0.75	.	20.0	50.0	20.0	7.5	.	50.0	510.0	130.0
4	.	0.75	3.10	2.00	0.75	.	60.0	40.0	20.0	7.5	.	130.0	260.0	140.0
5	.	0.75	6.70	0.75	.	.	40.0	70.0	7.5	.	.	40.0	700.0	70.0
6	.	1.79	6.93	1.83	0.75	.	39.2	77.2	21.2	7.5	.	168.2	586.9	136.2
7	.	0.75	21.40	2.00	0.75	.	20.0	130.0	20.0	7.5	.	40.0	1910.0	150.0
8	.	1.70	11.00	.	0.75	.	30.0	100.0	.	7.5	.	80.0	1120.0	.
9	.	0.75	27.10	0.75	0.75	.	7.5	200.0	7.5	7.5	.	40.0	2920.0	80.0
10	.	0.75	26.40	3.40	0.75	.	7.5	100.0	7.5	7.5	.	30.0	2580.0	330.0
11	.	0.75	16.70	0.75	0.75	.	7.5	100.0	7.5	7.5	.	12.5	1860.0	100.0
12	.	.	14.50	0.75	0.75	.	.	90.0	7.5	7.5	.	.	1350.0	70.0
13	.	.	15.70	0.75	0.75	.	.	80.0	20.0	7.5	.	.	1680.0	60.0
14	.	0.75	14.70	0.75	0.75	.	7.5	60.0	20.0	7.5	.	12.5	1910.0	130.0
15	.	0.75	10.70	0.75	0.75	.	70.0	90.0	7.5	7.5	.	60.0	1200.0	70.0
16	.	0.75	9.60	0.75	.	.	7.5	70.0	7.5	.	.	40.0	1110.0	60.0
17	.	1.50	45.00	2.20	.	.	40.0	220.0	7.5	.	.	90.0	6320.0	240.0
18	.	.	10.00	.	.	.	.	100.0	.	.	.	.	1170.0	.
19	2.60	.	19.20	1.30	2.40	0.50	.	160.0	20.0	20.0	20.0	.	2810.0	190.0
20	2.70	.	6.50	2.40	2.20	1.30	.	30.0	20.0	6.0	6.0	.	820.0	270.0
21	.	.	5.70	1.60	.	.	.	70.0	7.5	.	.	.	610.0	150.0
22	1.15	.	5.10	1.00	1.00	1.00	.	40.0	7.5	50.0	6.0	.	690.0	60.0
23	1.15	.	3.10	1.00	1.00	1.00	.	7.5	7.5	30.0	6.0	.	320.0	70.0
24	1.15	.	14.20	.	1.00	1.00	.	120.0	.	7.5	7.5	.	1560.0	.
25	1.15	.	4.30	.	1.60	1.00	.	90.0	.	30.0	20.0	.	390.0	.
26	1.15	.	12.20	1.40	1.00	1.00	.	150.0	40.0	20.0	20.0	.	1780.0	180.0
27	1.15	.	9.00	2.00	.	1.00	.	90.0	20.0	.	7.5	.	1350.0	280.0
28	.	.	7.20	1.00	.	.	.	100.0	7.5	.	.	.	1190.0	40.0
29	2.50	1.00	11.20	1.00	1.00	1.00	7.5	130.0	30.0	7.5	20.0	30.0	1610.0	160.0
30	1.15	1.00	12.50	1.00	1.00	1.00	7.5	110.0	20.0	7.5	7.5	30.0	1560.0	150.0
31	1.15	1.00	4.80	1.00	1.00	1.00	7.5	60.0	30.0	7.5	30.0	15.0	560.0	200.0
32	2.60	1.00	3.10	1.00	1.00	1.20	7.5	60.0	20.0	20.0	20.0	15.0	410.0	140.0
33	1.15	.	7.20	2.00	1.00	1.00	.	100.0	30.0	20.0	20.0	.	1060.0	170.0
34	1.15	.	5.00	.	1.00	1.00	.	90.0	.	7.5	7.5	.	890.0	.
35	2.50	1.20	10.20	.	1.00	1.00	20.0	120.0	.	7.5	20.0	80.0	1700.0	.
36	1.15	1.20	1.30	.	1.00	1.00	20.0	20.0	.	20.0	20.0	70.0	230.0	.
37	.	1.00	15.20	.	.	.	7.5	170.0	.	.	.	15.0	2370.0	.
38	1.15	1.00	11.50	.	1.00	1.00	30.0	160.0	.	70.0	7.5	15.0	1680.0	.
39	3.80	1.00	1.80	1.70	1.00	1.00	7.5	20.0	20.0	7.5	7.5	15.0	270.0	300.0
40	3.50	1.00	3.30	1.00	1.00	1.00	7.5	40.0	20.0	7.5	7.5	15.0	540.0	210.0
41	1.50	5.00	.	.	5.00	5.00	5.76	.	.	4.3	5.4	13.7	.	.
42	4.40	5.00	5.00	5.00	5.00	5.00	7.86	45	25.9	18.8	9.2	19.9	278.0	254.0
43	1.50	5.00	5.00	.	5.00	5.00	16.90	118	.	16.8	7.7	18.4	1430.0	.
44	.	.	5.00	5.00	.	.	.	82	21.9	.	.	.	1060.0	227.0
45	.	5.00	5.00	5.00	5.00	.	6.60	43	25.2	13.8	.	18.5	443.0	189.0
46	4.66	5.00	5.00	5.00	5.00	5.00	3.71	118	35.1	5.6	5.6	36.6	1560.0	270.0
47	3.13	5.00	5.00	.	5.00	5.00	9.51	55	.	6.2	14.4	6.3	634.0	.
48	1.50	5.00	18.40	.	5.00	5.00	11.10	299	.	3.9	3.2	21.1	3520.0	.
49	1.50	5.00	5.00	5.00	5.00	5.00	8.73	94	27.8	4.3	22.8	35.3	1350.0	295.0
50	1.50	5.00	5.00	.	5.00	5.00	7.84	55	.	3.1	12.2	19.8	432.0	.
51	1.50	5.00	5.00	5.00	5.00	5.00	3.36	45	15.2	5.1	2.3	13.9	650.0	221.0
52	1.50	5.00	11.40	5.00	5.00	5.00	6.39	126	12.9	5.6	5.0	29.0	2070.0	183.0
53	1.50	5.00	5.00	5.00	5.00	5.00	2.48	52	9.5	5.7	3.6	75.7	806.0	198.0
54	1.50	5.00	5.00	32.70	5.00	5.00	4.75	65	236.0	20.2	5.4	70.5	955.0	2060.0
55	1.50	5.00	5.00	5.00	5.00	5.00	1.00	82	15.7	10.2	3.9	12.5	1240.0	155.0
56	1.50	5.00	12.5	5.00	5.00	5.00	2.95	122	26	7.4	3.1	15.9	1690.0	293.0

SAS DATA USED FOR STATISTICAL ANALYSIS (PAGE 6)

OBS	FESUD	FENUD	CDRN	CDIN	CDOU	CDSUD	CDNUD	HDRN	HDIN	HDOU	HDSUD	HDNUD
1	80.0	.	0.15	.	0.15	0.15	.	0.58	.	82.38	165.99	.
2	.	.	0.15	1.10	0.15	.	.	0.62	125.56	109.19	.	.
3	80.0	.	0.15	0.15	0.15	0.15	.	0.83	52.55	83.03	102.96	.
4	100.0	.	0.15	0.15	0.15	0.15	.	1.61	59.98	91.64	117.24	.
5	.	.	0.15	0.60	0.15	.	.	0.99	85.01	80.18	.	.
6	70.0	.	0.15	0.21	0.15	0.15	.	0.79	33.57	44.91	70.06	.
7	190.0	.	0.15	0.40	0.15	0.15	.	0.62	86.10	71.18	173.14	.
8	60.0	.	0.15	0.30	.	0.15	.	0.79	91.31	.	192.47	.
9	70.0	.	0.15	0.50	0.15	0.15	.	0.79	96.05	78.33	95.14	.
10	50.0	.	0.15	0.50	0.15	0.15	.	0.79	70.09	56.76	101.57	.
11	12.5	.	0.15	0.40	0.15	0.15	.	0.79	77.24	83.15	112.35	.
12	30.0	.	.	0.30	0.15	0.15	.	.	58.03	72.60	120.99	.
13	30.0	.	.	0.30	0.15	0.15	.	.	72.04	73.76	116.70	.
14	30.0	.	0.15	0.15	0.15	0.15	.	0.79	64.18	72.91	143.78	.
15	40.0	.	0.15	0.15	0.15	0.15	.	0.79	105.45	76.97	140.56	.
16	.	.	0.15	0.15	0.15	.	.	0.79	85.46	76.51	.	.
17	.	.	0.15	0.80	0.15	.	.	0.79	172.36	68.35	.	.
18	.	.	.	0.23	.	.	.	.	75.45	.	.	.
19	460.0	160.0	.	0.32	0.06	0.08	0.04	.	83.08	38.14	116.14	75.11
20	320.0	190.0	.	0.10	0.28	0.10	0.10	.	35.57	35.19	78.45	65.03
21	.	.	.	0.10	0.10	.	.	.	31.37	37.06	.	.
22	110.0	110.0	.	0.10	0.10	0.10	0.10	.	36.11	45.96	94.32	93.53
23	110.0	90.0	.	0.10	0.10	0.10	0.10	.	42.79	48.87	120.74	87.68
24	70.0	100.0	.	0.34	.	1.09	0.10	.	126.49	.	306.93	125.33
25	80.0	90.0	.	0.10	.	0.10	0.10	.	87.77	.	309.22	133.27
26	80.0	100.0	.	0.24	0.10	0.10	0.10	.	63.10	74.39	169.32	103.14
27	.	130.0	.	0.10	0.10	.	0.10	.	47.25	48.91	.	88.72
28	.	.	.	0.10	0.10	.	.	.	57.03	47.13	.	.
29	30.0	60.0	0.41	0.26	0.10	0.10	0.60	0.32	56.24	59.92	207.52	91.86
30	40.0	60.0	0.10	0.21	0.10	0.41	0.10	0.32	54.45	72.29	125.46	108.10
31	100.0	110.0	0.10	0.10	0.10	0.10	0.10	0.32	34.38	34.38	154.49	133.46
32	60.0	100.0	0.10	0.10	0.10	0.10	0.10	0.32	44.12	56.86	106.27	111.48
33	100.0	130.0	.	0.22	0.10	0.10	0.10	.	55.48	63.72	214.60	132.45
34	160.0	220.0	.	0.10	.	0.10	0.10	.	82.40	.	157.35	180.89
35	110.0	190.0	0.23	0.20	.	0.33	0.10	0.32	83.44	.	176.84	159.83
36	180.0	510.0	0.27	0.10	.	0.10	0.10	1.64	74.75	.	143.90	159.19
37	.	.	0.10	0.30	.	.	.	0.32	89.98	.	.	.
38	80.0	160.0	0.20	0.20	.	.	.	.	100.60	.	171.95	156.31
39	60.0	130.0	0.10	0.10	0.10	0.10	0.10	.	26.23	54.57	120.08	84.20
40	120.0	120.0	0.10	0.10	0.10	0.10	0.10	.	28.09	42.57	125.08	89.15
41	44.9	47.3	.	.	.	0.50	0.50	.	.	.	173.58	129.93
42	40.6	79.3	.	0.05	.	0.50	0.50	.	52.16	75.96	136.63	126.62
43	66.7	113.0	.	0.05	.	0.50	0.50	.	51.94	.	215.03	134.69
44	.	.	.	0.50	0.50	.	.	.	36.73	52.23	.	.
45	31.6	.	.	0.50	0.50	0.50	.	.	36.36	44.34	109.71	.
46	130.0	193.0	.	0.50	0.50	0.50	0.50	.	50.95	49.53	108.21	101.54
47	64.0	63.5	.	0.50	.	0.50	0.50	.	59.60	.	185.61	106.86
48	47.4	66.3	.	0.50	.	0.50	0.50	.	89.64	.	256.26	126.94
49	62.3	91.3	.	0.50	0.50	0.50	0.50	.	51.25	62.39	121.10	82.26
50	41.6	86.1	.	0.50	.	0.50	0.50	.	53.11	.	130.49	85.02
51	102.0	74.5	.	0.50	0.50	0.50	0.50	.	33.11	52.00	122.73	81.57
52	53.1	95.3	.	0.50	0.50	0.50	0.50	.	54.70	44.18	139.79	75.86
53	223.0	369.0	.	0.50	0.50	0.50	0.50	.	43.17	73.28	187.87	103.67
54	1160.0	518.0	.	0.50	1.14	0.50	0.50	.	36.61	121.61	176.67	98.34
55	503.0	69.2	.	0.50	0.50	0.50	0.50	.	48.92	63.34	133.24	92.51
56	296.0	66.9	.	0.50	0.50	0.50	0.50	.	52.45	55.52	148.09	86.51

DESCRIPTIVE STATISTICS - ALL DATA

The MEANS Procedure

Variable	N	Mean	Std Error	C.V.	Skewness	Kurtosis
RAIN	55	1.36	0.13	71.37	1.53	1.96
AVGI	55	0.44	0.06	104.25	2.04	4.03
ANTE	55	147.13	20.94	105.54	1.68	2.60
RNPD	56	1603.92	157.06	73.28	1.49	1.93
INFL	51	22386.11	2537.74	80.96	1.61	2.72
OUFL	51	8756.16	1597.12	130.26	2.00	5.58
NHRN	40	0.16	0.02	99.17	2.02	4.28
NHIN	55	0.12	0.01	87.55	1.60	2.52
NHOU	43	0.04	0.01	145.42	3.68	16.20
NHSUD	46	0.24	0.03	77.01	1.97	3.70
NXRN	42	0.18	0.03	97.39	2.12	5.33
NXIN	54	0.26	0.02	65.73	1.53	2.49
NXOU	43	0.08	0.01	105.92	1.37	1.23
NXSUD	46	0.19	0.02	72.12	1.10	0.55
ONRN	38	0.24	0.12	316.52	5.68	33.71
ONIN	54	0.44	0.03	54.46	1.31	2.92
ONOU	42	0.52	0.06	71.47	3.15	15.13
ONSUD	46	0.30	0.02	43.63	1.32	3.28
TNRN	40	0.58	0.12	135.37	4.37	22.94
TNIN	54	0.82	0.05	41.46	0.97	1.56
TNOU	41	0.64	0.06	63.12	2.45	8.82
TNSUD	46	0.72	0.04	35.40	0.69	-0.17
OPRN	40	0.01	0.00	218.10	6.00	37.10
OPIN	54	0.08	0.01	53.16	1.15	1.15
OPOU	42	0.03	0.00	80.18	1.75	3.76
OPSUD	46	0.11	0.01	50.33	1.74	2.25
TPRN	40	0.02	0.00	172.70	4.90	27.41
TPIN	54	0.24	0.02	72.20	3.41	17.29
TPOU	42	0.08	0.01	84.93	4.18	21.24
TPSUD	46	0.14	0.01	47.07	1.39	1.22
SSIN	52	43.67	5.44	89.88	2.88	11.76
SSOU	40	6.96	1.79	162.37	5.61	33.71
SSSUD	40	3.93	1.33	213.36	4.22	19.32
CURN	40	2.68	0.55	130.09	4.53	23.72
CUIN	54	20.74	1.58	56.16	0.99	0.88
CUOU	42	6.72	2.36	228.10	6.15	39.02
CUSUD	44	2.39	0.23	63.20	1.06	0.31
PBRN	40	2.48	0.31	79.98	0.49	-1.80
PBIN	54	9.94	1.04	76.96	2.28	7.56
PBOU	42	2.98	0.77	167.47	5.41	32.54
PBSUD	46	2.30	0.28	83.50	0.69	-1.52
ZNRN	40	16.70	2.72	102.94	1.73	2.36
ZNIN	54	93.59	7.21	56.59	1.38	3.40
ZNOU	41	22.92	5.50	153.69	5.79	35.68
ZNSUD	46	12.49	1.82	98.86	3.08	11.20

CONTINUED

DESCRIPTIVE STATISTICS - ALL DATA (Continued)
The MEANS Procedure

Variable	N	Mean	Std Error	C.V.	Skewness	Kurtosis
FERN	40	42.51	6.18	92.01	1.89	3.42
FEIN	54	1319.16	137.84	76.78	2.55	10.40
FEOU	42	213.36	46.63	141.62	5.81	36.17
FESUD	46	129.97	27.50	143.52	4.22	21.12
CDRN	25	0.16	0.01	41.59	2.62	8.70
CDIN	54	0.31	0.03	69.41	1.17	2.13
CDOU	41	0.24	0.03	90.75	2.29	6.65
CDSUD	45	0.28	0.03	77.33	1.32	2.39
HDRN	22	0.72	0.08	49.87	1.22	2.02
HDIN	54	64.85	3.86	43.78	1.32	2.74
HDOU	42	63.72	2.98	30.27	0.75	0.86
HDSUD	46	149.93	7.61	34.43	1.37	2.33

DESCRIPTIVE STATISTICS OF THE DATA BY COMPARABLE YEARS

--------------------------Eight Months (Nov 2000 through July 2001) -------------------

Variable	Label	N	Mean	Std Dev	Std Error	C.V.
NHRN	NHRN	15	0.17	0.13	0.03	78.19
NHIN	NHIN	17	0.11	0.10	0.02	94.96
NHOU	NHOU	17	0.03	0.04	0.01	125.63
NHSUD	NHSUD	13	0.18	0.12	0.03	66.12
NXRN	NXRN	17	0.20	0.22	0.05	110.39
NXIN	NXIN	16	0.26	0.17	0.04	66.96
NXOU	NXOU	17	0.05	0.06	0.01	115.30
NXSUD	NXSUD	13	0.14	0.14	0.04	101.29
ONRN	ONRN	13	0.62	1.26	0.35	204.08
ONIN	ONIN	16	0.54	0.32	0.08	58.79
ONOU	ONOU	16	0.63	0.52	0.13	82.11
ONSUD	ONSUD	13	0.41	0.16	0.05	40.61
TNRN	TNRN	15	0.95	1.16	0.30	123.13
TNIN	TNIN	16	0.91	0.44	0.11	48.19
TNOU	TNOU	15	0.76	0.50	0.13	65.03
TNSUD	TNSUD	13	0.73	0.28	0.08	38.73
OPRN	OPRN	15	0.02	0.04	0.01	199.42
OPIN	OPIN	16	0.11	0.05	0.01	43.37
OPOU	OPOU	16	0.04	0.02	0.01	55.59
OPSUD	OPSUD	13	0.10	0.04	0.01	38.55
TPRN	TPRN	15	0.03	0.04	0.01	140.58
TPIN	TPIN	16	0.36	0.25	0.06	69.12
TPOU	TPOU	16	0.09	0.04	0.01	45.89
TPSUD	TPSUD	13	0.12	0.05	0.01	41.32

Variable	Label	Minimum	Maximum	Skewness	Kurtosis
NHRN	NHRN	0.03	0.51	1.75	2.96
NHIN	NHIN	0.01	0.42	2.07	5.63
NHOU	NHOU	0.01	0.18	2.84	9.42
NHSUD	NHSUD	0.04	0.50	1.66	3.18
NXRN	NXRN	0.00	0.87	1.83	3.90
NXIN	NXIN	0.06	0.75	1.80	3.74
NXOU	NXOU	0.00	0.18	1.16	-0.07
NXSUD	NXSUD	0.01	0.55	2.14	5.23
ONRN	ONRN	0.00	4.73	3.39	11.81
ONIN	ONIN	0.16	1.37	1.04	1.70
ONOU	ONOU	-0.05	2.38	2.66	9.31
ONSUD	ONSUD	0.13	0.78	0.74	1.27
TNRN	TNRN	0.03	4.85	3.02	10.20
TNIN	TNIN	0.24	2.00	0.90	1.37
TNOU	TNOU	0.28	2.42	2.94	10.15
TNSUD	TNSUD	0.43	1.40	1.54	1.74
OPRN	OPRN	0.01	0.15	3.73	14.16
OPIN	OPIN	0.05	0.21	0.83	-0.44
OPOU	OPOU	0.01	0.11	1.19	2.62
OPSUD	OPSUD	0.06	0.19	1.52	2.12
TPRN	TPRN	0.01	0.18	3.53	13.15
TPIN	TPIN	0.14	1.21	2.77	9.32
TPOU	TPOU	0.03	0.17	0.99	0.72
TPSUD	TPSUD	0.08	0.23	1.59	1.38

DESCRIPTIVE STATISTICS OF DATA BY COMPARABLE YEARS

------------------ Eight Months (November 2002 through July 2003) ----------------

Variable	Label	N	Mean	Std Dev	Std Error	C.V.
NHRN	NHRN	17	0.15	0.20	0.05	133.82
NHIN	NHIN	17	0.11	0.11	0.03	101.56
NHOU	NHOU	12	0.06	0.09	0.03	165.97
NHSUD	NHSUD	17	0.21	0.13	0.03	60.14
NXRN	NXRN	17	0.16	0.15	0.04	99.07
NXIN	NXIN	17	0.21	0.12	0.03	59.99
NXOU	NXOU	12	0.10	0.10	0.03	104.98
NXSUD	NXSUD	17	0.23	0.14	0.03	61.93
ONRN	ONRN	17	0.05	0.06	0.01	105.05
ONIN	ONIN	17	0.45	0.19	0.05	42.87
ONOU	ONOU	12	0.48	0.23	0.07	47.38
ONSUD	ONSUD	17	0.27	0.08	0.02	31.40
TNRN	TNRN	17	0.35	0.32	0.08	90.96
TNIN	TNIN	17	0.77	0.28	0.07	35.99
TNOU	TNOU	12	0.64	0.39	0.11	62.11
TNSUD	TNSUD	17	0.71	0.23	0.06	33.20
OPRN	OPRN	17	0.01	0.00	0.00	38.56
OPIN	OPIN	17	0.06	0.03	0.01	50.25
OPOU	OPOU	12	0.02	0.02	0.01	87.06
OPSUD	OPSUD	17	0.11	0.06	0.01	50.99
TPRN	TPRN	17	0.01	0.01	0.00	142.72
TPIN	TPIN	17	0.17	0.11	0.03	60.28
TPOU	TPOU	12	0.10	0.12	0.03	120.73
TPSUD	TPSUD	17	0.15	0.08	0.02	51.50

Variable	Label	Minimum	Maximum	Skewness	Kurtosis
NHRN	NHRN	0.02	0.72	2.23	4.37
NHIN	NHIN	0.01	0.43	1.85	3.29
NHOU	NHOU	0.00	0.33	2.66	7.47
NHSUD	NHSUD	0.11	0.57	1.80	3.14
NXRN	NXRN	0.04	0.69	2.94	10.04
NXIN	NXIN	0.08	0.58	1.97	4.61
NXOU	NXOU	0.01	0.30	1.22	0.16
NXSUD	NXSUD	0.08	0.53	0.68	-0.61
ONRN	ONRN	0.00	0.22	1.59	3.37
ONIN	ONIN	0.12	0.89	0.93	1.28
ONOU	ONOU	0.25	1.07	1.69	3.35
ONSUD	ONSUD	0.13	0.48	0.67	1.00
TNRN	TNRN	0.10	1.06	1.67	1.31
TNIN	TNIN	0.41	1.37	0.83	-0.08
TNOU	TNOU	0.29	1.65	1.88	3.38
TNSUD	TNSUD	0.38	1.11	0.19	-1.32
OPRN	OPRN	0.01	0.01	2.89	7.78
OPIN	OPIN	0.01	0.13	0.51	0.50
OPOU	OPOU	0.01	0.07	1.92	4.47
OPSUD	OPSUD	0.07	0.27	1.93	3.38
TPRN	TPRN	0.01	0.05	4.12	17.00
TPIN	TPIN	0.06	0.48	1.71	3.43
TPOU	TPOU	0.04	0.47	3.32	11.23
TPSUD	TPSUD	0.08	0.33	1.34	1.05

EFFLUENT FILTRATION WET POND - INFLOW DATA

28

The CORR Procedure

17 Variables: RAIN AVGI ANTE INFL NHIN NXIN ONIN TNIN OPIN TPIN SSIN CUIN PBIN ZNIN FEIN CDIN HDIN

Simple Statistics

Variable	N	Mean	Std Dev	Median	Minimum	Maximum	Label
RAIN	53	1.37566	0.98512	1.00000	0.27000	4.65000	RAIN
AVGI	53	0.44858	0.46534	0.28000	0.05000	2.10000	AVGI
ANTE	53	146.89858	158.19970	76.75000	6.25000	688.00000	ANTE
INFL	50	22704	18163	15023	3327	89057	INFL
NHIN	53	0.12036	0.10549	0.09700	0.00500	0.43300	NHIN
NXIN	53	0.25916	0.16946	0.22500	0.05900	0.80100	NXIN
ONIN	53	0.44291	0.24002	0.40600	0.11800	1.37000	ONIN
TNIN	53	0.82243	0.33871	0.73000	0.24000	2.00000	TNIN
OPIN	53	0.08080	0.04322	0.07000	0.00500	0.20700	OPIN
TPIN	53	0.24378	0.17556	0.19600	0.06000	1.21000	TPIN
SSIN	51	44.05707	39.54356	38.00000	0.25000	239.00000	SSIN
CUIN	53	20.82943	11.73727	18.90000	1.15000	55.80000	CUIN
PBIN	53	10.02883	7.68904	7.20000	1.30000	45.00000	PBIN
ZNIN	53	94.37736	53.15248	90.00000	7.50000	299.00000	ZNIN
FEIN	53	1329	1020	1190	230.00000	6320	FEIN
CDIN	53	0.30348	0.21352	0.24000	0.05000	1.10000	CDIN
HDIN	53	65.25827	28.50152	57.02632	26.23085	172.35890	HDIN

Spearman Correlation Coefficients ╥ Inflow Data

Prob > |r| under H0: Rho=0

Number of Observations

RAIN	RAIN	INFL	HDIN	ONIN	TNIN	OPIN	TPIN	ZNIN	SSIN	NHIN
RAIN	1.00000	0.97068	-0.63865	-0.37264	-0.34720	-0.28904	-0.27924	-0.20756	-0.15829	-0.10896
		<.0001	<.0001	0.0060	0.0109	0.0358	0.0429	0.1359	0.2672	0.4374
	53	50	53	53	53	53	53	53	51	53

AVGI	AVGI	NXIN	FEIN	SSIN	PBIN	TNIN	TPIN	ZNIN	OPIN	INFL
AVGI	1.00000	0.32777	0.29916	0.26370	0.22730	0.21668	0.21550	0.20427	-0.15565	0.12277
		0.0166	0.0295	0.0615	0.1017	0.1191	0.1212	0.1423	0.2657	0.3957
	53	53	53	51	53	53	53	53	53	50

ANTE	ANTE	TNIN	OPIN	NXIN	CUIN	TPIN	ONIN	NHIN	HDIN	ZNIN
ANTE	1.00000	0.39194	0.34838	0.30093	0.26030	0.25099	0.22973	0.22611	0.19969	0.16530
		0.0037	0.0106	0.0286	0.0598	0.0699	0.0980	0.1035	0.1517	0.2369
	53	53	53	53	53	53	53	53	53	53

INFL	INFL	RAIN	HDIN	ONIN	TNIN	OPIN	TPIN	ZNIN	NHIN	SSIN
INFL	1.00000	0.97068	-0.70411	-0.41840	-0.38913	-0.33708	-0.32454	-0.22106	-0.16881	-0.16013
		<.0001	<.0001	0.0025	0.0052	0.0167	0.0215	0.1229	0.2412	0.2770
	50	50	50	50	50	50	50	50	50	48

NHIN	NHIN	TNIN	NXIN	OPIN	HDIN	TPIN	CUIN	ANTE	ZNIN	INFL
NHIN	1.00000	0.41407	0.37625	0.32481	0.23609	0.23538	0.23469	0.22611	0.20635	-0.16881
		0.0021	0.0055	0.0176	0.0888	0.0898	0.0907	0.1035	0.1382	0.2412
	53	53	53	53	53	53	53	53	53	50

NXIN	NXIN	TNIN	NHIN	ZNIN	AVGI	ANTE	TPIN	PBIN	SSIN	CUIN
NXIN	1.00000	0.59428	0.37625	0.33709	0.32777	0.30093	0.25485	0.21187	0.19055	0.18917
		<.0001	0.0055	0.0136	0.0166	0.0286	0.0655	0.1278	0.1804	0.1749
	53	53	53	53	53	53	53	53	51	53

ONIN	ONIN	TNIN	HDIN	INFL	ZNIN	TPIN	CUIN	CDIN	RAIN	SSIN
ONIN	1.00000	0.71545	0.52490	-0.41840	0.41517	0.40931	0.38872	0.38366	-0.37264	0.34492
		<.0001	<.0001	0.0025	0.0020	0.0023	0.0040	0.0046	0.0060	0.0132
	53	53	53	50	53	53	53	53	53	51

Spearman Correlation Coefficients – Inflow Data

TNIN	TNIN	ONIN	NXIN	HDIN	TPIN	ZNIN	NHIN	SSIN	CUIN	ANTE
TNIN	1.00000	0.71545	0.59428	0.52743	0.50012	0.49292	0.41407	0.41310	0.40181	0.39194
		<.0001	<.0001	<.0001	0.0001	0.0002	0.0021	0.0026	0.0029	0.0037
	53	53	53	53	53	53	53	51	53	53

OPIN	OPIN	TPIN	HDIN	SSIN	PBIN	ANTE	INFL	NHIN	TNIN	RAIN
OPIN	1.00000	0.63461	0.59660	0.40693	0.36915	0.34838	-0.33708	0.32481	0.31610	-0.28904
		<.0001	<.0001	0.0030	0.0065	0.0106	0.0167	0.0176	0.0211	0.0358
	53	53	53	51	53	53	50	53	53	53

TPIN	TPIN	SSIN	PBIN	FEIN	HDIN	ZNIN	OPIN	CUIN	TNIN	CDIN
TPIN	1.00000	0.86933	0.83626	0.81994	0.81572	0.78881	0.63461	0.52134	0.50012	0.43840
		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0001	0.0010
	53	51	53	53	53	53	53	53	53	53

SSIN	SSIN	FEIN	PBIN	TPIN	ZNIN	HDIN	CUIN	CDIN	TNIN	OPIN
SSIN	1.00000	0.91211	0.88541	0.86933	0.80801	0.68284	0.58677	0.45993	0.41310	0.40693
		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0007	0.0026	0.0030
	51	51	51	51	51	51	51	51	51	51

CUIN	CUIN	ZNIN	FEIN	SSIN	TPIN	PBIN	CDIN	TNIN	ONIN	HDIN
CUIN	1.00000	0.77058	0.67898	0.58677	0.52134	0.50462	0.48512	0.40181	0.38872	0.37189
		<.0001	<.0001	<.0001	<.0001	0.0001	0.0002	0.0029	0.0040	0.0061
	53	53	53	51	53	53	53	53	53	53

PBIN	PBIN	SSIN	FEIN	TPIN	ZNIN	HDIN	CUIN	CDIN	OPIN	TNIN
PBIN	1.00000	0.88541	0.87905	0.83626	0.75037	0.62789	0.50462	0.43329	0.36915	0.31682
		<.0001	<.0001	<.0001	<.0001	<.0001	0.0001	0.0012	0.0065	0.0208
	53	51	53	53	53	53	53	53	53	53

ZNIN	ZNIN	FEIN	SSIN	TPIN	CUIN	PBIN	HDIN	TNIN	CDIN	ONIN
ZNIN	1.00000	0.85850	0.80801	0.78881	0.77058	0.75037	0.62823	0.49292	0.42824	0.41517
		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0002	0.0014	0.0020
	53	53	51	53	53	53	53	53	53	53

FEIN	FEIN	SSIN	PBIN	ZNIN	TPIN	CUIN	HDIN	CDIN	TNIN	AVGI
FEIN	1.00000	0.91211	0.87905	0.85850	0.81994	0.67898	0.53729	0.47622	0.32715	0.29916
		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0003	0.0168	0.0295
	53	51	53	53	53	53	53	53	53	53

EFFLUENT FILTRATION WET POND - INFLOW DATA

29

The CORR Procedure

Spearman Correlation Coefficients

Prob > |r| under H0: Rho=0
Number of Observations

CDIN	CDIN	CUIN	FEIN	SSIN	TPIN	PBIN	ZNIN	ONIN	TNIN	HDIN
CDIN	1.00000	0.48512	0.47622	0.45993	0.43840	0.43329	0.42824	0.38366	0.34002	0.28719
		0.0002	0.0003	0.0007	0.0010	0.0012	0.0014	0.0046	0.0127	0.0371
	53	53	53	51	53	53	53	53	53	53

HDIN	HDIN	TPIN	INFL	SSIN	RAIN	ZNIN	PBIN	OPIN	FEIN	TNIN
HDIN	1.00000	0.81572	-0.70411	0.68284	-0.63865	0.62823	0.62789	0.59660	0.53729	0.52743
		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
	53	53	50	51	53	53	53	53	53	53

D:/sasdata/corr infl

EFFLUENT FILTRATION - STORM OUTFLOW DATA

The CORR Procedure

17 Variables: RAIN AVGI ANTE OUFL NHOU NXOU ONOU TNOU OPOU TPOU SSOU CUOU PBOU ZNOU FEOU CDOU HDOU

Simple Statistics

Variable	N	Mean	Std Dev	Median	Minimum	Maximum	Label
RAIN	34	1.73029	1.05546	1.46500	0.46000	4.65000	RAIN
AVGI	34	0.56147	0.52951	0.41000	0.07000	2.10000	AVGI
ANTE	34	86.23529	86.58465	57.12500	9.50000	386.25000	ANTE
OUFL	34	13134	11741	10962	207.00000	57644	OUFL
NHOU	34	0.03937	0.05768	0.02850	0.00250	0.32900	NHOU
NXOU	34	0.08139	0.08542	0.05650	0.00500	0.30100	NXOU
ONOU	33	0.52731	0.39103	0.43508	0	2.37750	ONOU
TNOU	33	0.64532	0.43806	0.49400	0.00900	2.42000	TNOU
OPOU	34	0.03050	0.02330	0.02550	0.00500	0.12000	OPOU
TPOU	34	0.08487	0.07694	0.07050	0.02500	0.47100	TPOU
SSOU	32	7.80693	12.50122	4.68515	2.00000	73.90000	SSOU
CUOU	34	7.10447	16.98399	3.70500	1.00000	102.00000	CUOU
PBOU	34	3.25818	5.47693	1.76400	0.75000	32.70000	PBOU
ZNOU	34	24.63824	38.36364	20.00000	7.50000	236.00000	ZNOU
FEOU	34	233.62471	332.37070	181.50000	60.00000	2060	FEOU
CDOU	33	0.24939	0.22958	0.15000	0.06000	1.14000	CDOU
HDOU	34	60.27709	17.94764	56.80863	34.37812	121.60550	HDOU

EFFLUENT FILTRATION - STORM OUTFLOW DATA
Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

RAIN	RAIN	OUFL	HDOU	NXOU	CUOU	FEOU	SSOU	ANTE	TPOU	PBOU
RAIN	1.00000	0.76043	-0.70451	0.65095	0.58152	0.54630	0.52846	0.40996	0.37264	0.36059
		<.0001	<.0001	<.0001	0.0003	0.0008	0.0019	0.0160	0.0300	0.0362
	34	34	34	34	34	34	32	34	34	34

AVGI	AVGI	TNOU	ONOU	NXOU	HDOU	NHOU	RAIN	TPOU	CUOU	OUFL
AVGI	1.00000	0.35882	0.29524	0.22127	0.19123	0.18978	-0.15209	0.11018	-0.08962	-0.08346
		0.0403	0.0953	0.2085	0.2786	0.2824	0.3905	0.5351	0.6142	0.6389
	34	33	33	34	34	34	34	34	34	34

ANTE	ANTE	RAIN	TPOU	ZNOU	NHOU	NXOU	FEOU	SSOU	OUFL	CUOU
ANTE	1.00000	0.40996	0.39575	0.39157	0.33627	0.24552	0.22820	0.22640	0.20827	0.17314
		0.0160	0.0205	0.0220	0.0518	0.1616	0.1943	0.2128	0.2372	0.3275
	34	34	34	34	34	34	34	32	34	34

OUFL	OUFL	RAIN	HDOU	NXOU	FEOU	SSOU	CUOU	OPOU	ONOU	PBOU
OUFL	1.00000	0.76043	-0.54286	0.46897	0.46784	0.43149	0.39486	0.31365	-0.28175	0.25495
		<.0001	0.0009	0.0051	0.0053	0.0137	0.0208	0.0709	0.1122	0.1456
	34	34	34	34	34	32	34	34	33	34

NHOU	NHOU	NXOU	TNOU	TPOU	CUOU	ZNOU	ANTE	SSOU	RAIN	OPOU
NHOU	1.00000	0.65127	0.44910	0.41738	0.39284	0.37575	0.33627	0.31596	0.29526	0.26168
		<.0001	0.0087	0.0141	0.0215	0.0285	0.0518	0.0781	0.0900	0.1349
	34	34	33	34	34	34	34	32	34	34

NXOU	NXOU	SSOU	NHOU	RAIN	CUOU	PBOU	FEOU	TPOU	OUFL	HDOU
NXOU	1.00000	0.66275	0.65127	0.65095	0.64280	0.54013	0.53271	0.50138	0.46897	-0.43254
		<.0001	<.0001	<.0001	<.0001	0.0010	0.0012	0.0025	0.0051	0.0106
	34	32	34	34	34	34	34	34	34	34

ONOU	ONOU	TNOU	AVGI	RAIN	OUFL	HDOU	CDOU	NHOU	SSOU	ZNOU
ONOU	1.00000	0.91782	0.29524	-0.28977	-0.28175	0.26070	0.20072	0.16176	0.14578	-0.13135
		<.0001	0.0953	0.1019	0.1122	0.1428	0.2707	0.3685	0.4339	0.4662
	33	33	33	33	33	33	32	33	31	33

EFFLUENT FILTRATION - STORM OUTFLOW DATA
Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

TNOU	TNOU	ONOU	NHOU	NXOU	AVGI	CDOU	TPOU	SSOU	OPOU	ANTE
TNOU	1.00000	0.91782	0.44910	0.38432	0.35882	0.25101	0.25017	0.24574	0.16679	0.13695
		<.0001	0.0087	0.0272	0.0403	0.1658	0.1603	0.1827	0.3535	0.4473
	33	33	33	33	33	32	33	31	33	33
OPOU	OPOU	TPOU	NXOU	OUFL	NHOU	ZNOU	SSOU	TNOU	RAIN	HDOU
OPOU	1.00000	0.54550	0.33068	0.31365	0.26168	-0.21284	0.20018	0.16679	0.13846	0.11001
		0.0008	0.0561	0.0709	0.1349	0.2268	0.2720	0.3535	0.4348	0.5357
	34	34	34	34	34	34	32	33	34	34
TPOU	TPOU	OPOU	SSOU	NXOU	FEOU	NHOU	CUOU	ANTE	ZNOU	RAIN
TPOU	1.00000	0.54550	0.51495	0.50138	0.41845	0.41738	0.40610	0.39575	0.38824	0.37264
		0.0008	0.0026	0.0025	0.0138	0.0141	0.0172	0.0205	0.0233	0.0300
	34	34	32	34	34	34	34	34	34	34
SSOU	SSOU	FEOU	NXOU	CUOU	PBOU	RAIN	TPOU	OUFL	ZNOU	HDOU
SSOU	1.00000	0.82983	0.66275	0.65591	0.58069	0.52846	0.51495	0.43149	0.40109	-0.32169
		<.0001	<.0001	<.0001	0.0005	0.0019	0.0026	0.0137	0.0229	0.0726
	32	32	32	32	32	32	32	32	32	32
CUOU	CUOU	FEOU	SSOU	NXOU	PBOU	RAIN	ZNOU	TPOU	OUFL	NHOU
CUOU	1.00000	0.71048	0.65591	0.64280	0.58424	0.58152	0.47624	0.40610	0.39486	0.39284
		<.0001	<.0001	<.0001	0.0003	0.0003	0.0044	0.0172	0.0208	0.0215
	34	34	32	34	34	34	34	34	34	34
PBOU	PBOU	FEOU	CDOU	CUOU	SSOU	NXOU	ZNOU	RAIN	TPOU	HDOU
PBOU	1.00000	0.76685	0.60002	0.58424	0.58069	0.54013	0.48599	0.36059	0.28978	-0.25852
		<.0001	0.0002	0.0003	0.0005	0.0010	0.0036	0.0362	0.0964	0.1399
	34	34	33	34	32	34	34	34	34	34

EFFLUENT FILTRATION - STORM OUTFLOW DATA
Spearman Correlation Coefficients

The CORR Procedure
Prob > |r| under H0: Rho=0
Number of Observations

ZNOU	ZNOU	FEOU	PBOU	CUOU	SSOU	ANTE	TPOU	NHOU	NXOU	RAIN
ZNOU	1.00000	0.51256	0.48599	0.47624	0.40109	0.39157	0.38824	0.37575	0.34762	0.34042
		0.0019	0.0036	0.0044	0.0229	0.0220	0.0233	0.0285	0.0440	0.0488
	34	34	34	34	32	34	34	34	34	34

FEOU	FEOU	SSOU	PBOU	CUOU	RAIN	NXOU	ZNOU	OUFL	TPOU	CDOU
FEOU	1.00000	0.82983	0.76685	0.71048	0.54630	0.53271	0.51256	0.46784	0.41845	0.29537
		<.0001	<.0001	<.0001	0.0008	0.0012	0.0019	0.0053	0.0138	0.0952
	34	32	34	34	34	34	34	34	34	33

CDOU	CDOU	PBOU	TPOU	FEOU	TNOU	CUOU	ONOU	HDOU	ZNOU	NHOU
CDOU	1.00000	0.60002	0.29990	0.29537	0.25101	0.23159	0.20072	0.18492	0.16884	0.13775
		0.0002	0.0900	0.0952	0.1658	0.1947	0.2707	0.3029	0.3476	0.4446
	33	33	33	33	32	33	32	33	33	33

HDOU	HDOU	RAIN	OUFL	NXOU	SSOU	ONOU	PBOU	FEOU	CUOU	AVGI
HDOU	1.00000	-0.70451	-0.54286	-0.43254	-0.32169	0.26070	-0.25852	-0.25312	-0.24199	0.19123
		<.0001	0.0009	0.0106	0.0726	0.1428	0.1399	0.1486	0.1679	0.2786
	34	34	34	34	32	33	34	34	34	34

Appendix P

Pictures

Appendix Q. Pictures during different stages of project.

Picture 1 – Inflow (west view of pond) during Year 1 with new parking garage in background and before the littoral zone was planted.

Appendix O. *Continued*

Picture 2 – Inflow and sedimentations basin during trolley construction and pond reconfiguration. Finished parking garage is in background.

Picture 3 – Outflow (east view of pond) during Year 1. Note the cruise ship terminal has not been built.

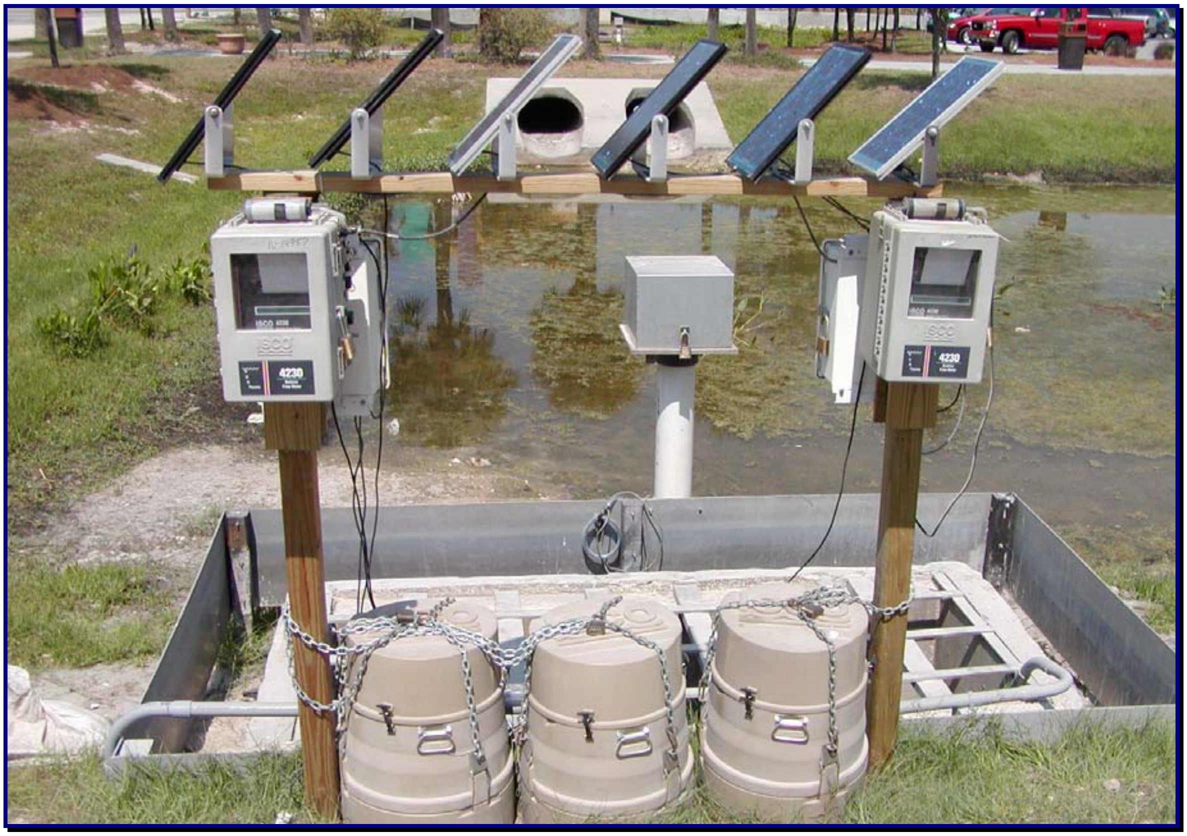
Appendix O. *Continued*

Picture 4 – Underdrain intake and cleanout.

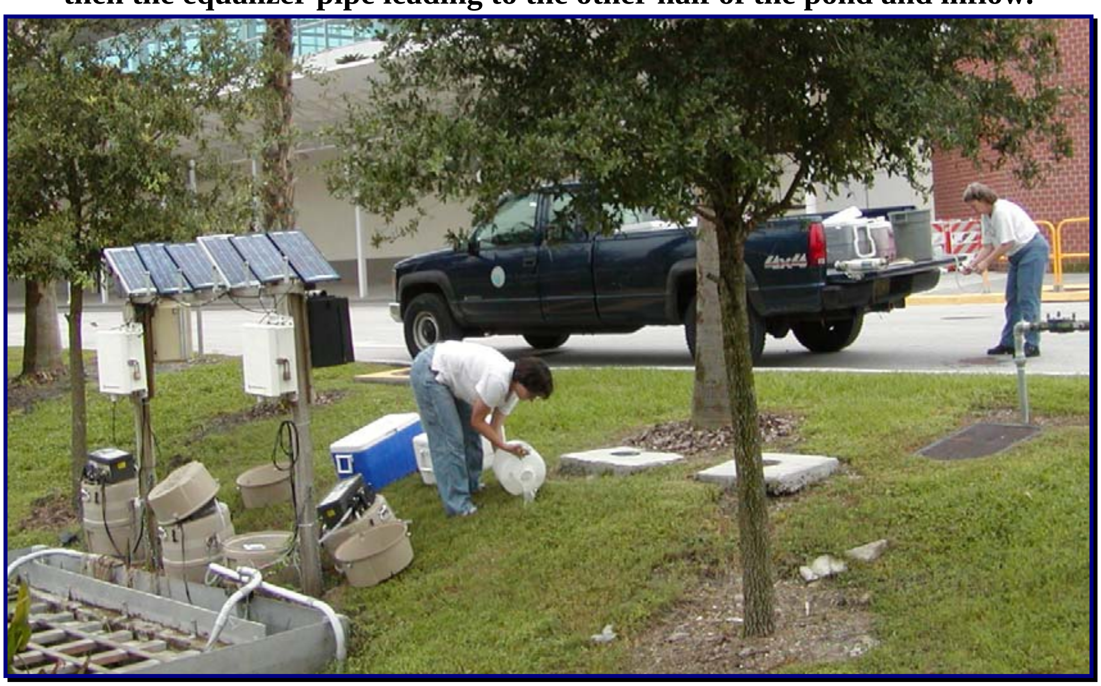
Picture 5 – Underdrain weir with sampling and bubbler tubing. Picture taken during low flow.

Picture 6 – Outflow weir and underdrains.

Appendix O. ***Continued***



Picture 7 – West view of pond from outflow. In foreground are the flowmeters and samplers for the outflow weir and underdrains. In the background is the shaft encoder, then the equalizer pipe leading to the other half of the pond and inflow.



Picture 8 – Routine sampling of the outflow weir and underdrains after an event. The new cruise ship terminal is pictured in background.

Appendix O. ***Continued***

Picture 9 – Preparing to take a sediment sample with corer.

Picture 10 – Resultant core from sediment samplng.

Appendix O. ***Continued***

Picture 11 – Northwest view of pond after sampling equipment removed from outflow.