Retrofitted Green Infrastructure Stormwater Controls at Cincinnati State College, the Cincinnati Zoo, and the Clark Montessori High School: An Evaluation using Monitoring Data and WinSLAMM

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1. Introduction

The main objective of this project is to examine the effectiveness of retrofitted green infrastructure stormwater controls in small- and large-scale developed urban watersheds at five monitoring locations at three areas: the Cincinnati State College, the Cincinnati Zoo, and the Clark Montessori High School sites. These areas are served either by separate or combined sewer systems. These study areas in Cincinnati have about three years of high-resolution (5-minute) flow measurements from in-system flow monitors located in combined and separate sewers on or adjacent to several green infrastructure installations which are being evaluated. The flow data are available from before, during, and after stormwater controls construction for three monitoring locations and after control construction at two locations at the three study areas. This report describes watershed analyses and statistical methods that are applied to evaluate these data. Also, this report provides flow analyses results at the monitoring locations.

Analyses were conducted for all combined and separate flow monitors in these areas to determine the benefits of green infrastructure-based stormwater controls. The preliminary analyses are indicating that some monitoring approaches are better than others. In addition, some of the flow monitoring results appear to be faulty and since the monitoring period has concluded and the equipment removed, it is not possible to verify the calibrations or investigate other potential equipment issues. Therefore, an important part of this project is to recommend effective monitoring strategies and QA/QC processes. Table 1 summarizes the availability of flow monitoring data for the different construction phases at each monitoring location.

Table 1. Availability of flow data for different construction phases at each monitoring location

Location	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12
Cincinnati State College Combined Sewer (above & below site monitoring)																																			
Cincinnati State College Separate Sewer (single monitoring location)																																			
Cincinnati Zoo - Main Entrance (separate sewer)																																			
Cincinnati Zoo - African Savannah (combined sewer)																																			
Clark Montessori High School (combined sewer)																																			

Note: Before Construction (pink), During Construction (yellow), and After Construction (green)

2. Geographical Locations and Description of Case Studies

2.1 Cincinnati State Technical and Community College

The Cincinnati State College occupies about 40-acres located east of I-75, bounded by Central Parkway to the North, and West, and Ludlow to the east. Three monitoring locations measured

the flows from this study area (Figure 1). On the northeast side of the campus hill, a large 72'' combined sewer had a flow monitoring location above and below the confluence of several separate stormwater lines coming from Cincinnati State College areas. On the southwest side of the campus hill, a single monitoring location measured the separate stormwater from a 24'' line from the campus. Therefore, this site provided two typical scenarios for measuring the effects of watershed controls: above and below the discharge location, and monitoring the runoff directly.

Figure 1. Flow monitoring locations (red circles) at Cincinnati State Technical and Community College

2.2 Cincinnati Zoo

The Cincinnati Zoo is located at the northeast corner of Vine Street and Erkenbrecher Avenue. Two monitoring locations are located at the zoo, one at the African Savannah exhibit area (still under construction) and another at the main zoo entry area. The predevelopment conditions at the African Savannah area were comprised of a large paved parking lot and small landscaped areas. A flow monitoring station measured the flows in a 36" combined sewer pipe coming from the African Savannah area currently undergoing conversion to new exhibit spaces and includes the construction of large storage tanks and numerous smaller controls (porous pavement walkways and bioretention areas). The main entry monitoring location measured separate stormwater flows in a 24'' pipe draining an area where large amounts of paver blocks replaced prior pavement controls at the zoo entrance (Figure 2).

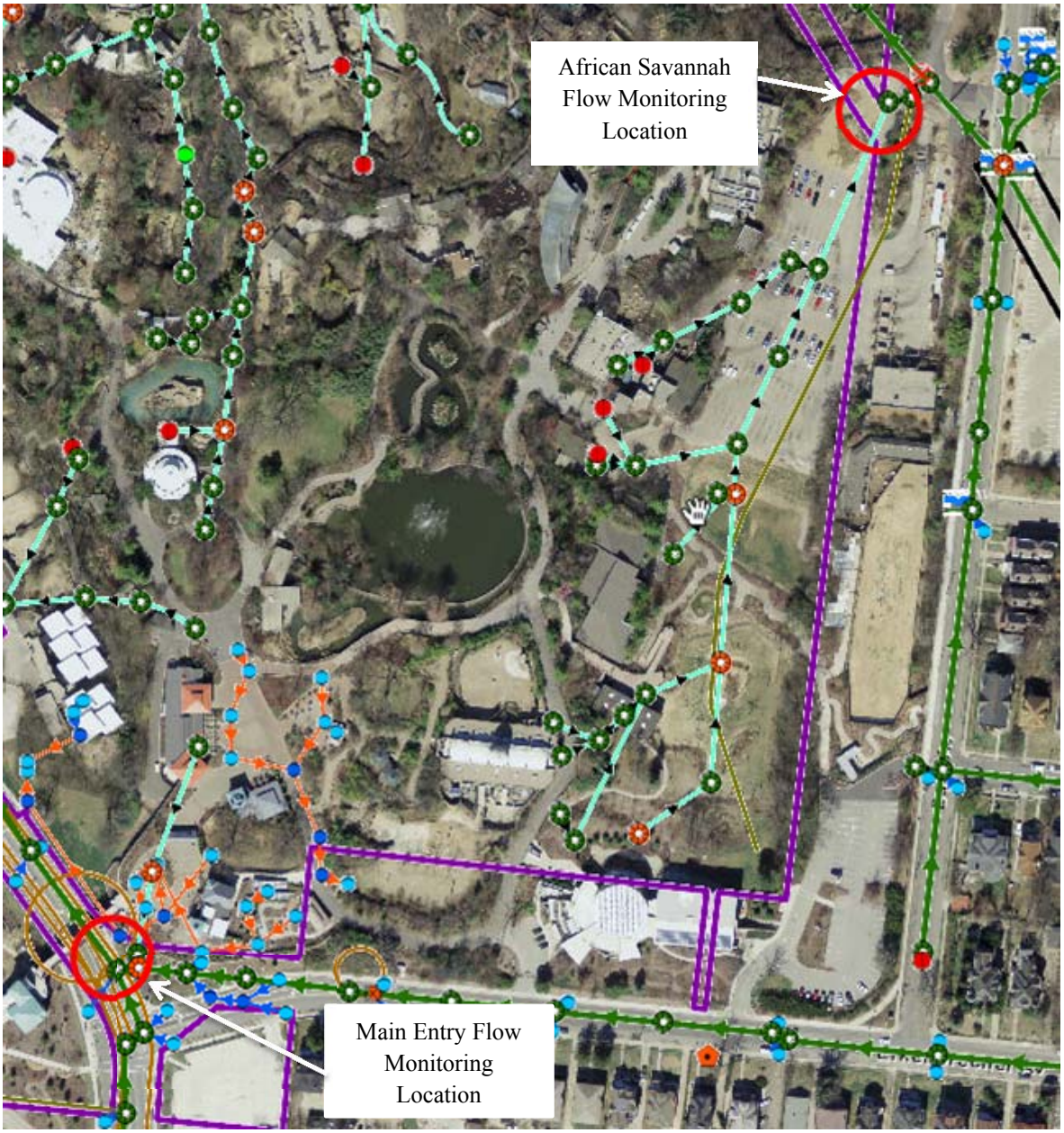

Figure 2. Flow monitoring locations (red circles) at Cincinnati Zoo

2.3 Clark Montessori High School

This project area is surrounded by a residential district and is located on Erie Avenue, east of downtown Hyde Park in Cincinnati, Ohio. There is one monitoring location that measures the separate stormwater flows in a 20'' pipe from this newly constructed area before it is discharged into the adjacent combined sewer system (Figure 3).

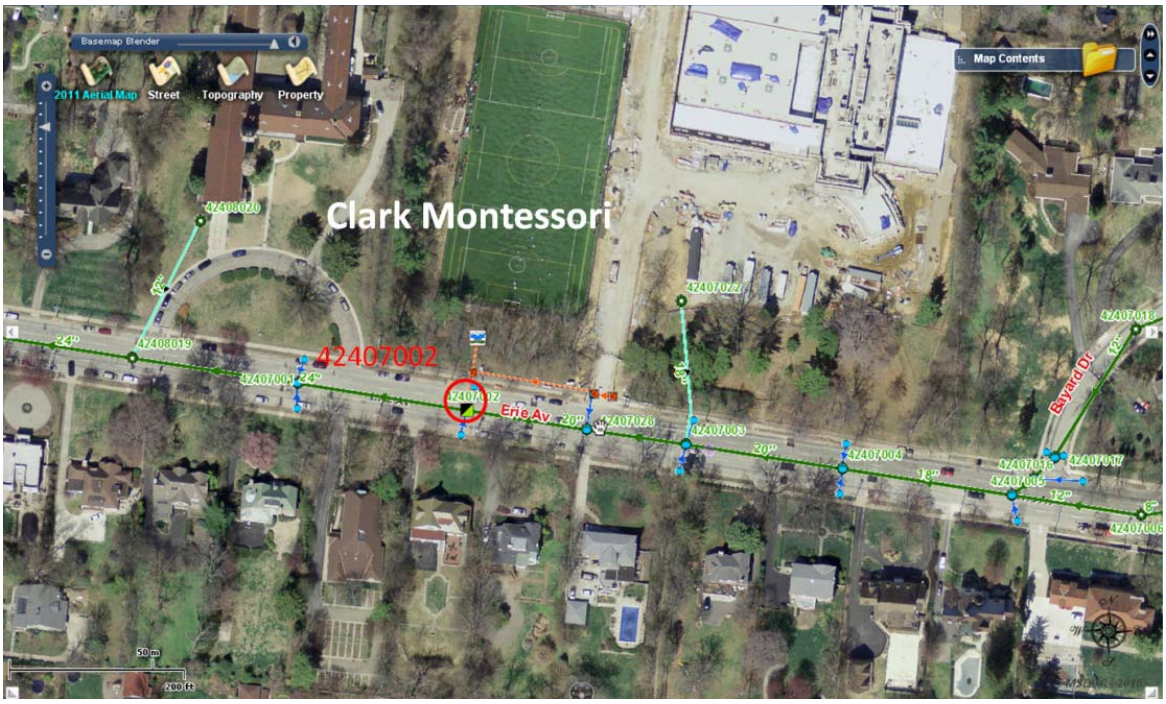

Figure 3. Flow monitoring location (red circle) at Clark Montessori High School

3. Green Infrastructure Features

3.1 Cincinnati State Technical and Community College

The Cincinnati State College (Cincy State) campus is located on the top of a hill. Therefore, runoff from the southern portion of the campus flows south into the Bates Run Regulator combined sewer system, while runoff from the northern part of the campus flows north into the Streng Street Diversion Dam combined sewer system. The Cincinnati State College campus has several green infrastructure stormwater control facilities including; pervious pavement, rain gardens, cisterns, infiltration trenches, bioretention trenches (with level spreaders), ponds, and a green retaining wall. Table 2 summarizes the green infrastructure features at Cincy State. The schematic drawings of stormwater controls are also cross-referenced in Table 2, which can be found in Appendix A. Figure 4 shows a map of the location of the GI stormwater controls, along with the flow monitoring locations and the watershed boundaries.

Table 2. Summary of green infrastructure features at Cincinnati State College

GI Feature	Size	Comments	Figure Reference
Pervious Asphalt Pavement	2,002 ft^2	All have underdrains and located in various locations, mostly at parking lot "C" located in northeastern part of the campus	Figure A-1
Pervious Concrete Pavement	1,645 ft^2		
Pervious Concrete Pavers	40,038 ft^2		
Rain Gardens	56,222 ft^2	Ten rain gardens installed in various locations, mostly in southwestern part of the campus	Figure A-2
Cisterns for Rainwater Harvesting	24,000 gallon	Two 10,000 gallon in-ground storage tanks connected to irrigation systems, and one 4,000 gallon above-ground cistern for greenhouse	N/A
Infiltration trench	1,540 ft^2	Located in southwestern part of the campus	Figure A-3
Bioretention (level spreader)	420 ft^2	Located in southwestern part of the campus	Figure A-4
Pond	6,900 ft^2	Located in northeastern part of the campus, close to the greenhouse	N/A
Green retaining wall	140 ft	Planted with sedum	Figure A-5

(Source of data: Enabled Impact Program, Interim Summary Report, December 2011)

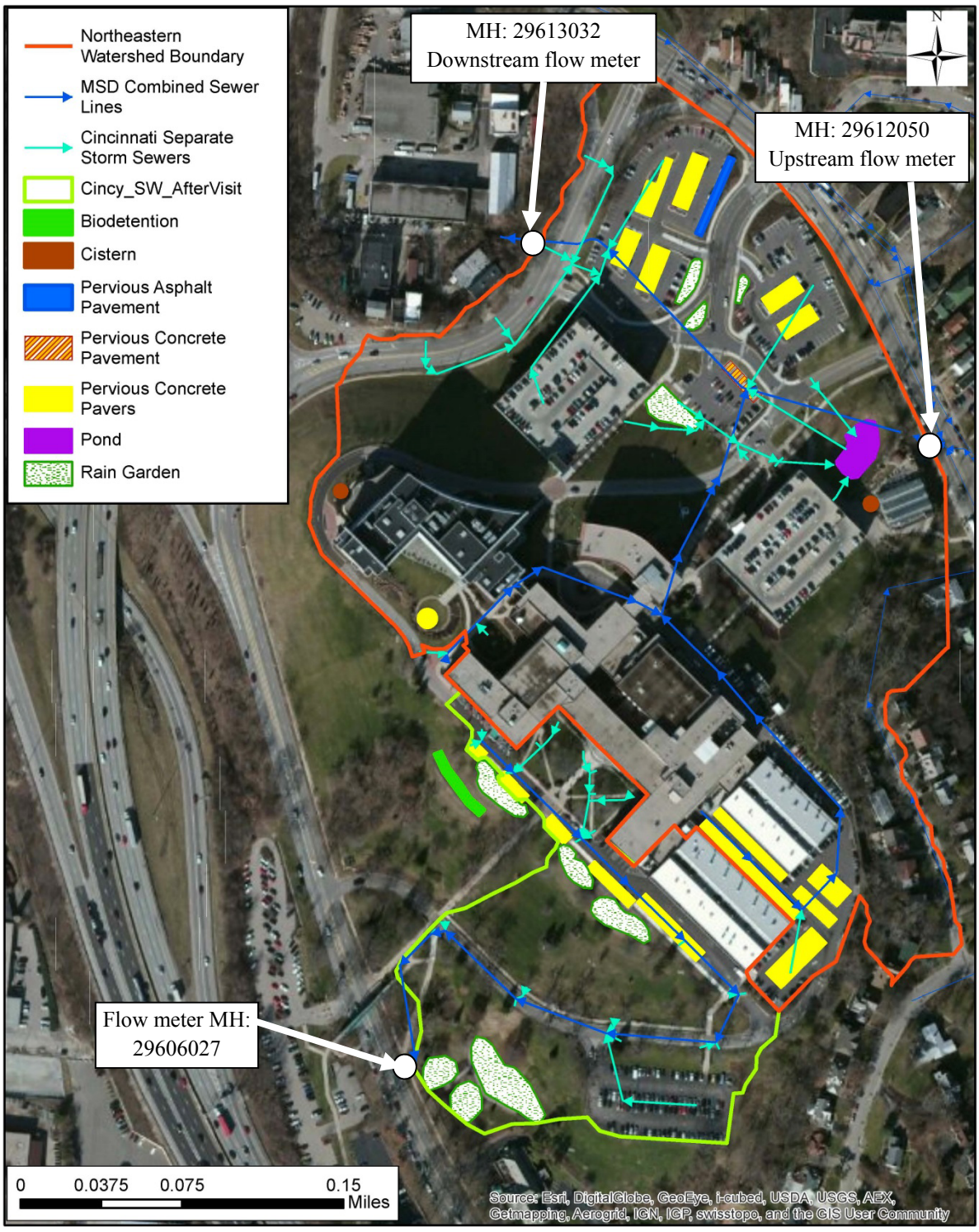

Figure 4. Location of GI stormwater controls at Cincinnati State College

3.2 Cincinnati Zoo

The Cincinnati Zoo's stormwater management objective is to have no site runoff for all rains up to the 50-year storm event at the African Savannah and main entry areas. To meet this objective, the African Savannah has different types of coordinated green infrastructure controls, including enhanced turf/vegetation, permeable pavers, and an underground rainwater harvesting storage system. One of the components of the stormwater control project in the African Savannah area was to disconnect the existing storm sewer and roof leader system which currently discharges into the combined sewer. Stormwater and roof runoff are being collected and redirected to the rainwater harvesting system (RHS). Approximately 180,000 ft^2 of enhanced turf grass and permeable walkways will replace the existing impervious parking lot. The RHS has a storage capacity of about 16,000 ft^3 and the collected water will eventually be reused for on-site irrigation of the outdoor zoo water features.

The zoo main entry area has 30,760 ft^2 of pervious paver blocks, and a 10,000 gallon storage tank. The storage tank collects runoff from 11,700 ft^2 of rooftop for reuse for irrigation of landscaped areas. Figure 5 illustrates the location of these GI stormwater controls at the Cincinnati Zoo. (Source of data: Enabled Impact Program, Interim Summary Report, December 2011)

3.3 Clark Montessori High School

This site has various green infrastructure stormwater controls, including: green roofs, permeable pavement, and bioretention facilities (bioswales, stormwater planters, and a rain garden). Green roofs comprise 9,200 ft^2 of intensive green roofs which have a permanent subsurface irrigation system, and 5,500 ft^2 of extensive green roof. In addition, the site has 13,000 ft^2 of pervious concrete pavement and 2,000 ft^2 of permeable pavers with no underdrains. Bioretention facilities include three stormwater planters, two bioswales, and one rain garden. Figure 6 is a map of the location of these GI stormwater controls located at Clark Montessori High School. (Source of data: Enabled Impact Program, Interim Summary Report, December 2011)

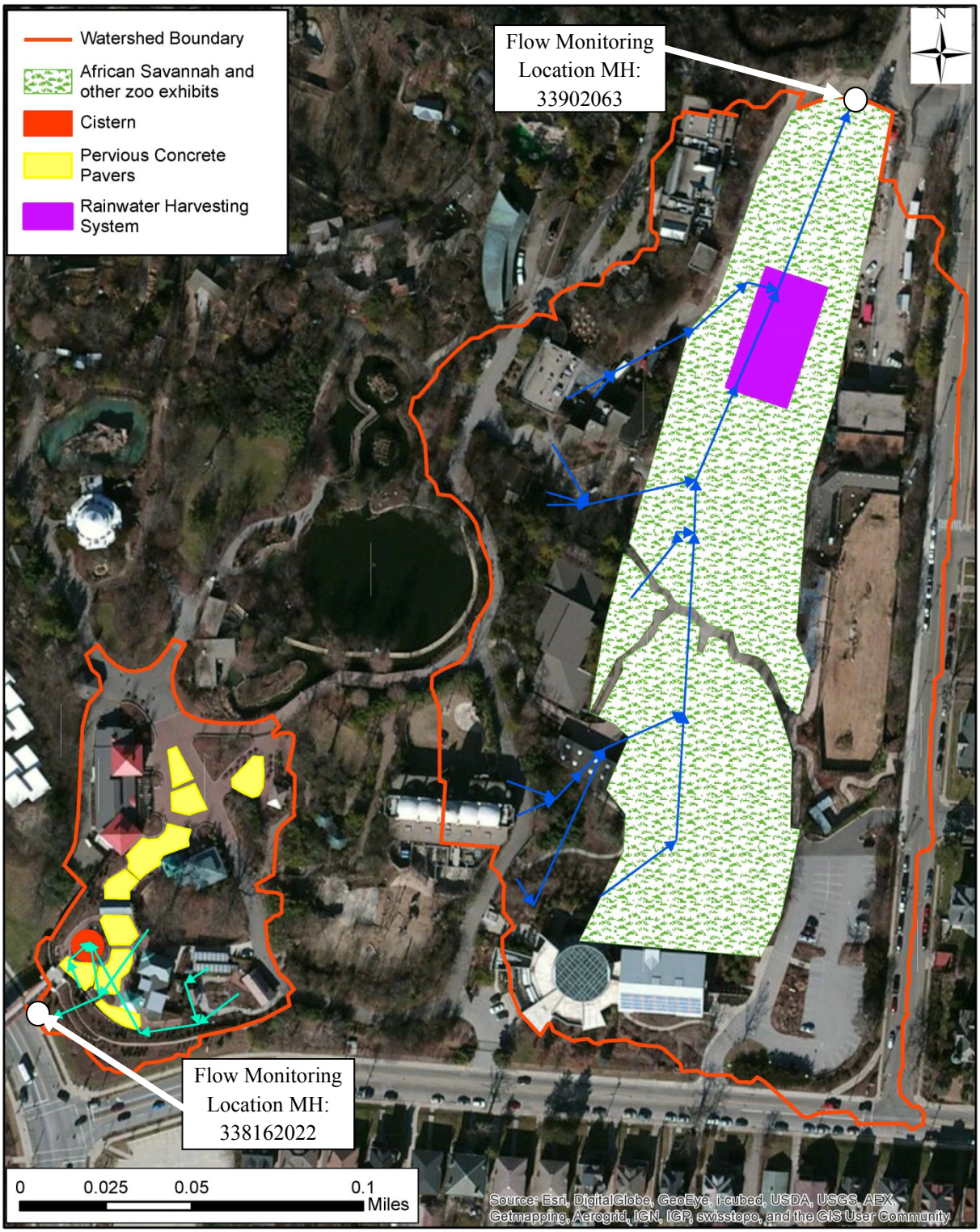

Figure 5. Location of GI stormwater controls at Cincinnati Zoo (Note: Enhanced vegetation area is still under construction)

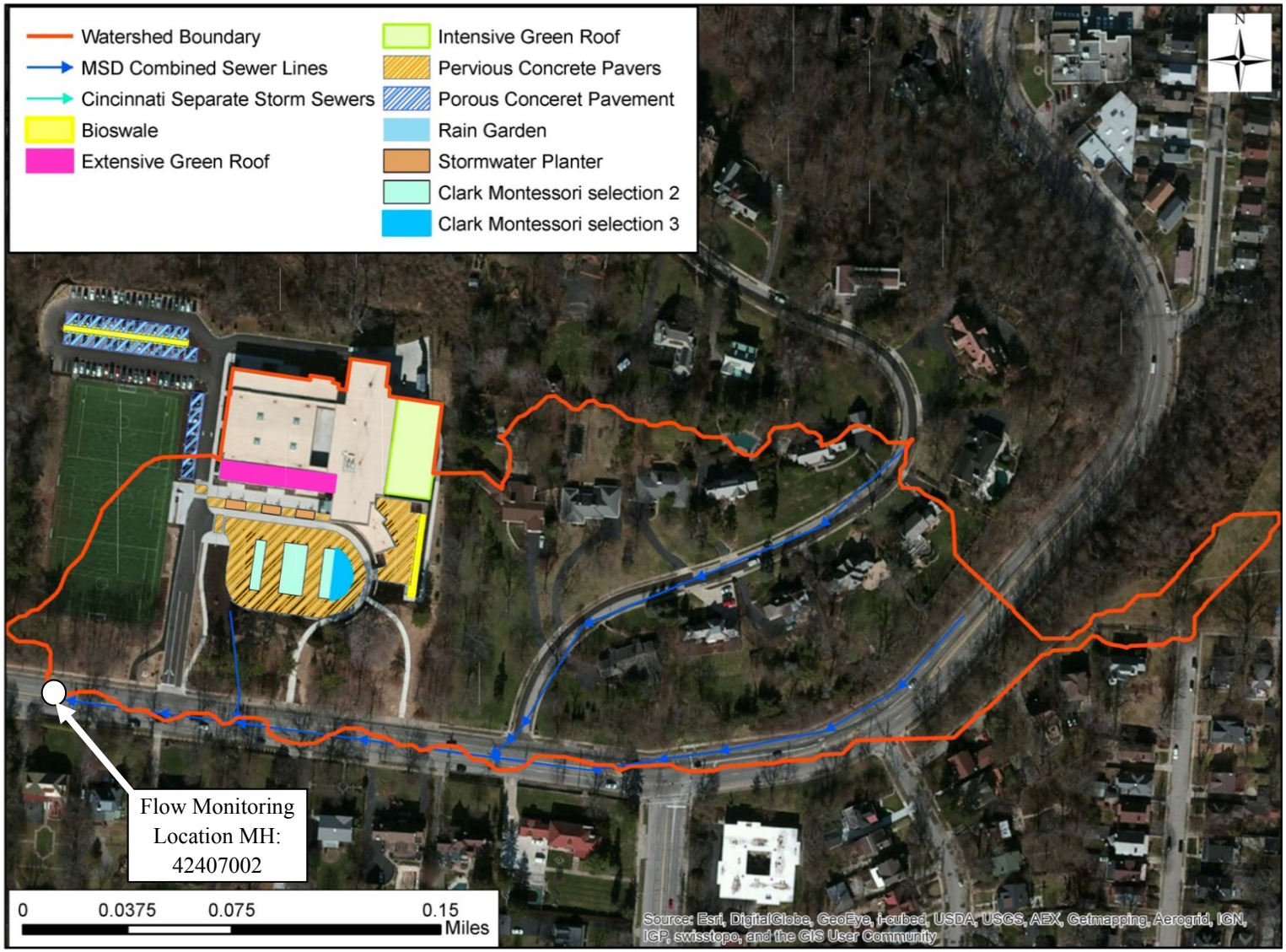

Figure 6. Location of GI stormwater controls at Clark Montessori High School

4. Watershed Analyses and Land Cover Descriptions

One of the important steps in urban stormwater quantity and quality modeling is to quantify the drainage area characteristics. High resolution aerial photos available in the ArcMap 10 base map dataset were used to measure the watershed areas of the study areas, as well as to determinge the different land cover categories (such as roofs, streets, parking lots, driveways, landscaped areas, etc.).

The GIS dataset of 1 ft topographic contours (shapefile) provided by the MSD was used to create a digital elevation model (DEM) for each of the study areas in Cincinnati. The Hydrology tool of ArcMap 10 consisted of fill, flow direction, flow accumulation, snap pour point, and watershed, and was used to create the DEM to delineate the watershed and to calculate drainage areas and the areas of the land cover characteristics.

4.1 Cincinnati State Technical and Community College

The Cincinnati State college study area includes three drainage areas. As shown in Figure 7, the largest sub-watershed (in purple) is 335.5 acres which drains towards the Upstream Flow Meter with manhole number 29612050. An additional drainage area of 28 acres from the campus enters the Downstream Flow Meter (manhole number 29613032) (shown in pink, on Figure 7). Therefore, the drainage area between the Downstream Flow Meter and the Upstream Flow Meter is about 8% of the drainage area flowing into the Upstream Flow Meter. The southern portion of the campus has a drainage area of about 8.71 acres and flows towards the south into the manhole number 29606027 (watershed boundary is shown in blue on Figure 7). No other areas affected the flows at this southern area of the campus.

Aerial photography, available in ArcMap 10.0, was used to estimate the land coverage for each watershed. Table 3 summarizes different source areas for the Cincinnati State College study area. As shown in Table 3, a large portion of the study area is comprised of landscaped areas. Figure 8 high-lights the land cover characteristics of the Cincinnati State College study area, along with MSD combined sewer lines, and watershed boundaries.

Table 3. Summary of land cover characteristics for the Cincinnati State college study area

Land Cover type	Northern part of campus Areas drain into *Downstream Flow Meter* with manhole number 29613032		Southern part of campus Areas drain into manhole number 29606027	
	Area (ft^2)	Area (%)	Area (ft^2)	Area (%)
Landscaped area	486,835	39.7	227,411	59.9
Parking lot	270,558	22.1	48,556	12.8
Paved area	2,687	0.2	0	0
Roof	241,644	19.7	35,539	9.3
Street	156,707	12.8	43,050	11.3
Walkway	68,532	5.6	25,101	6.7
Total	1,226,962	100.0	379,657	100

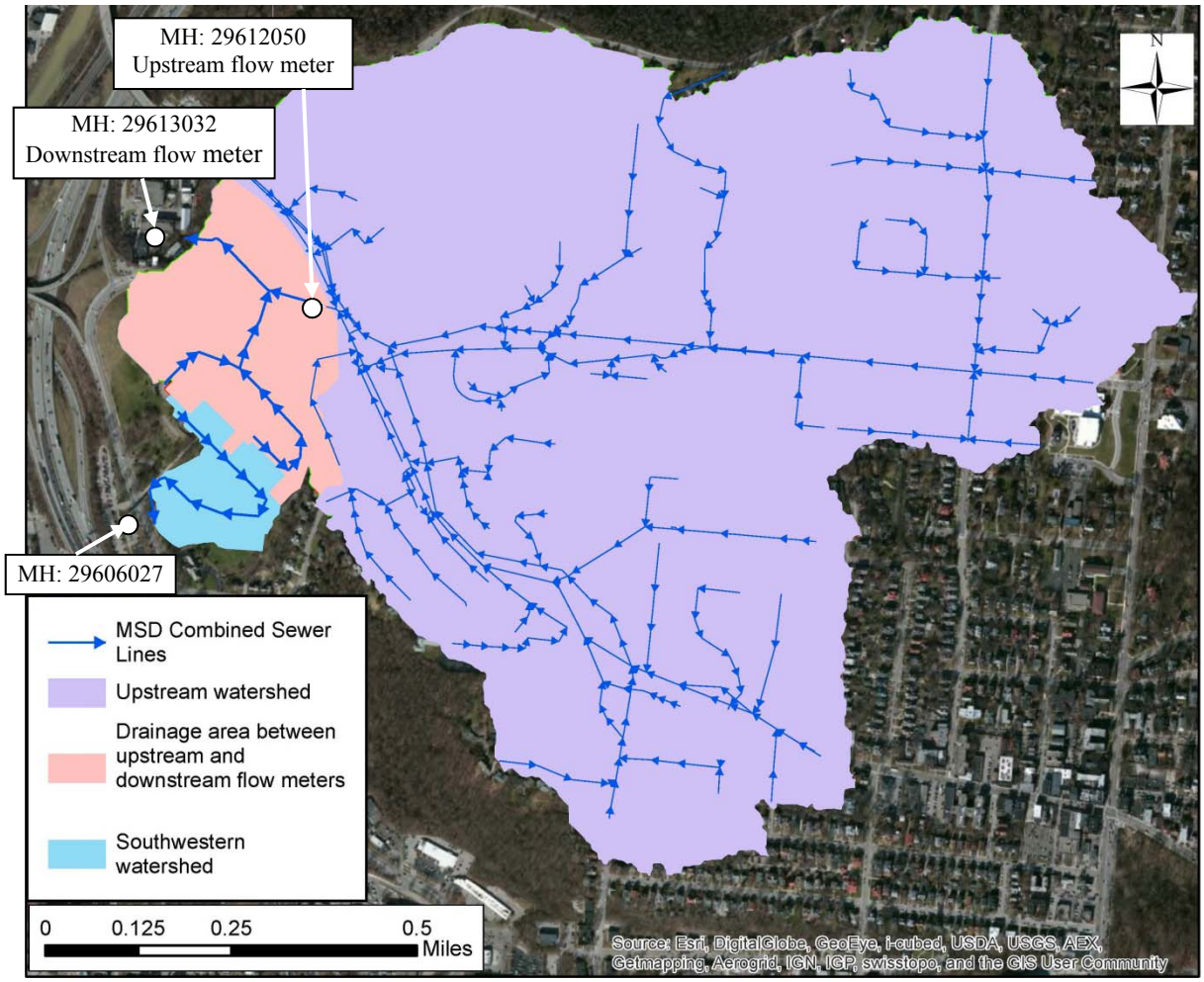

Figure 7. Watershed areas of Cincinnati State College

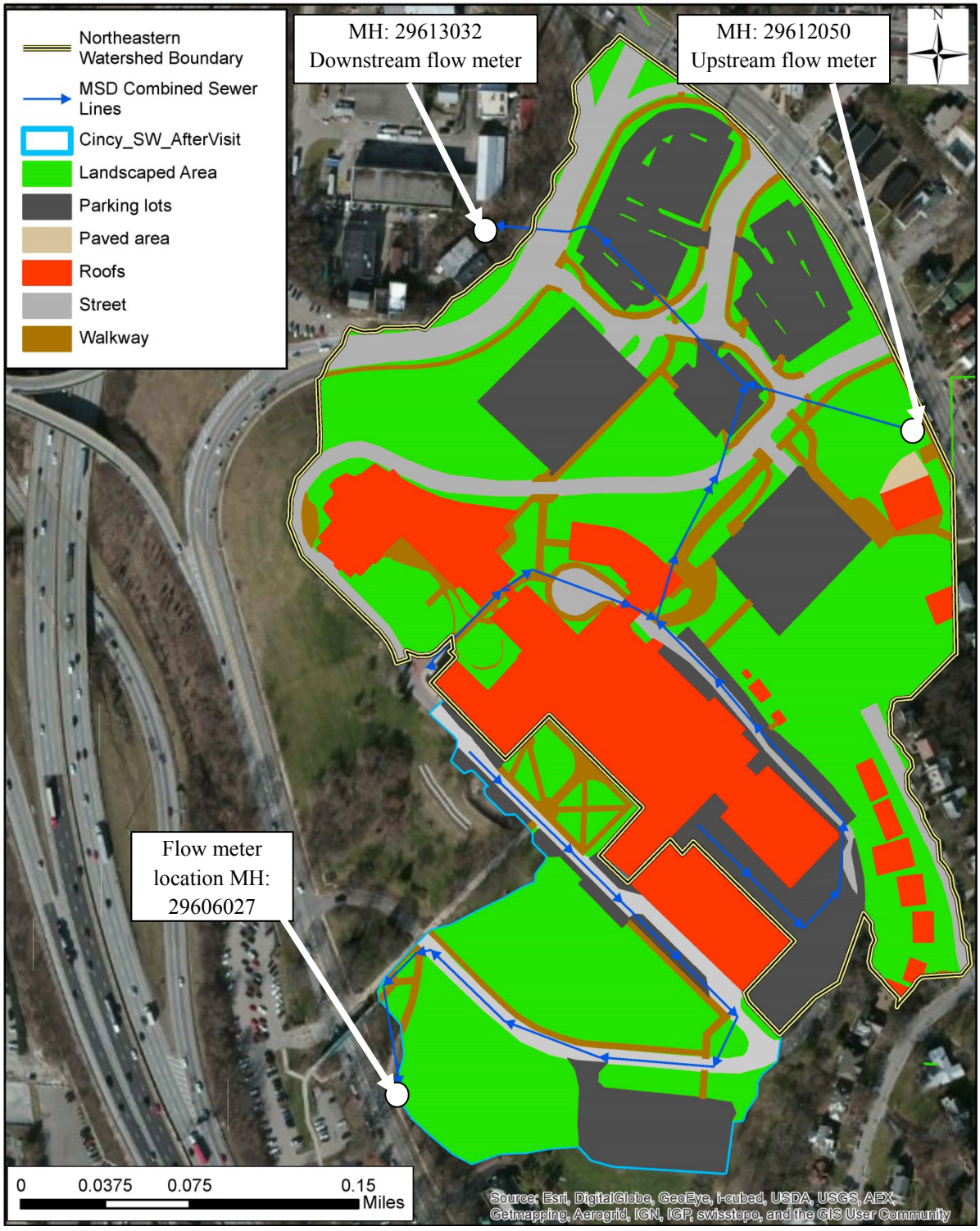

Figure 8. Map of Cincinnati State College area showing main surface characteristics.

4.2 Cincinnati Zoo

The African Savannah area, located in the northeastern part of the Zoo, has a drainage area of about 13.4 acres and flows towards the northeast to the flow monitor with manhole number 33902063 (Figure 9). The main Zoo entrance area, located in the southwestern part of the Zoo, has a drainage area of about 2.5 acres, and is comprised of landscaped areas, paved areas, and roofs (Figure 9). Figure 9 is a map of Cincinnati Zoo area showing these main land cover areas.

Tables 4 and 5 summarize the breakdown of land cover characteristics for the African Savannah, and main entrance areas, respectively. About 40% of both watersheds are covered by landscaping. Twenty six percent of the African Savannah area is under construction for new zoo exhibits and will be covered by enhanced vegetation and the exhibits in the near future.

Table 4. Summary of land cover characteristics for African Savannah area at Cincinnati Zoo

Land Cover type	Area (ft^2)	Area (%)
Landscaped area	228,614	39.2
Active Construction	152,923	26.2
Parking lot	30,521	5.2
Paved area	10,058	1.7
Roof	76,676	13.1
Street	24,907	4.3
Walkway	59,466	10.2
Total	583,166	100

Table 5. Summary of land cover characteristics for main entrance of Cincinnati Zoo area

Land Cover type	Area (ft^2)	Area (%)
Landscaped area	43,060	40.2
Paved area	47,996	44.8
Roof	16,150	15.1
Total	107,206	100

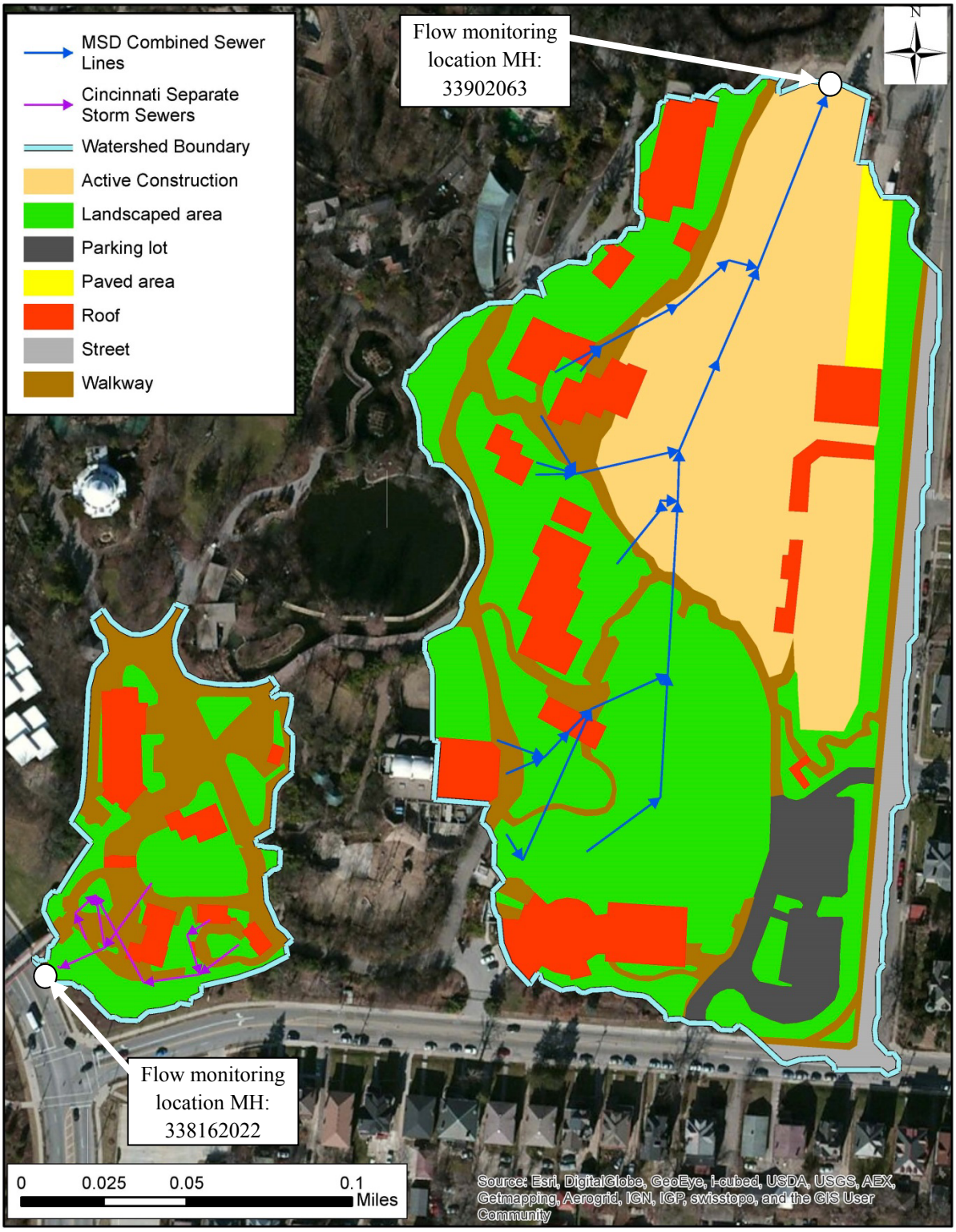

Figure 9. Map of Cincinnati Zoo area showing main surface characteristics.

4.3 Clark Montessori High School:

The drainage area for the Clark Montessori High School above the monitoring location is approximately 14.8 acres, and mostly consists of landscaped areas (58%), roofs (13.5%), and streets (13.4%) (Table 6, and Figure 10). The watershed is mostly upstream residential areas comprising of ten large and well maintained homes.

Table 6. Summary of land cover characteristics for Clark Montessori High School

Land Cover type	Area (ft^2)	Area (%)
Driveway	22,842	3.6
Landscaped area	369,455	57.5
Parking lot	22,082	3.4
Paved area	15,026	2.3
Roof	86,624	13.5
Soccer Field	25,867	4.0
Street	86,134	13.4
Walkway	14,956	2.3
Total	642,986	100.0

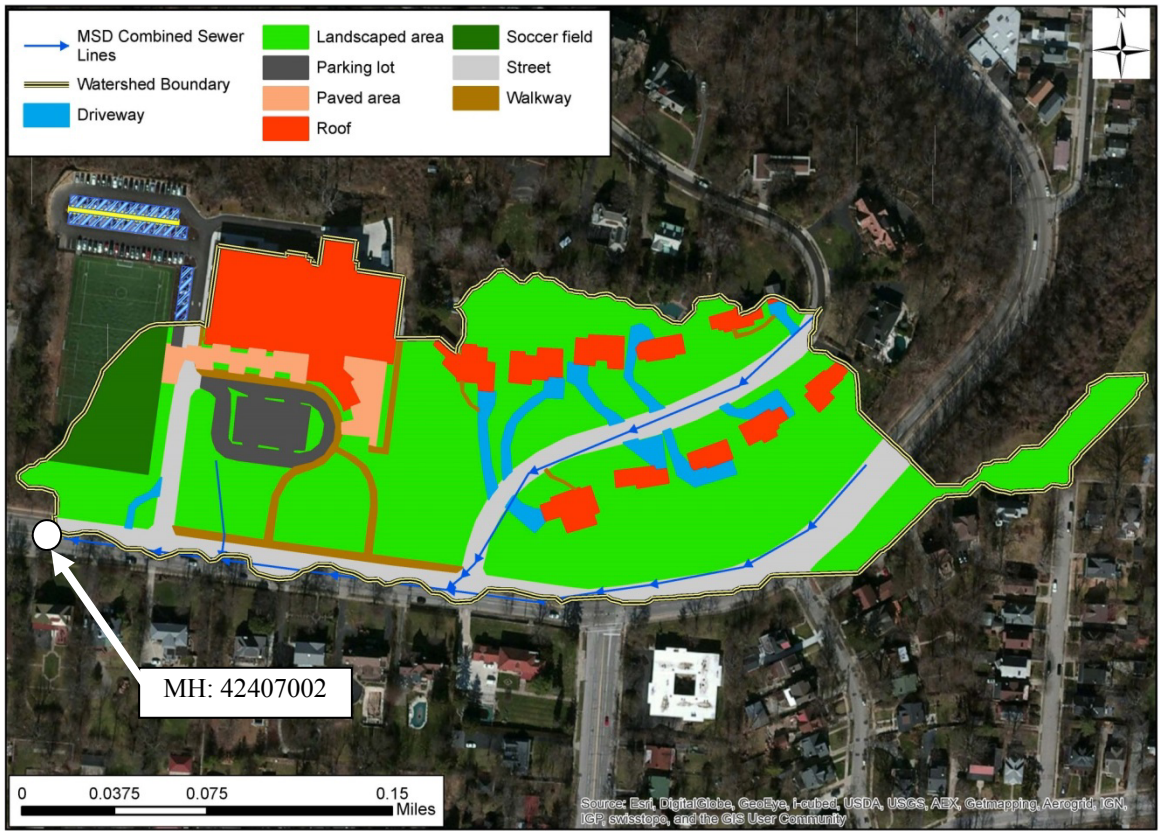

Figure 10. Map of Clark Montessori High School area showing main surface characteristics.

5. Soil Characteristics

The study areas in Cincinnati, OH (Cincinnati State Technical and Community, Cincinnati Zoo, and Clark Montessori High School) have soils listed as UrUXC—Urban land-Udorthents complex, with 0 to 12 percent slopes (Figures 11 to 13). Soils in this group have high to very high runoff potential when thoroughly wet. Drainage class and other properties of this soil type have not been rated.

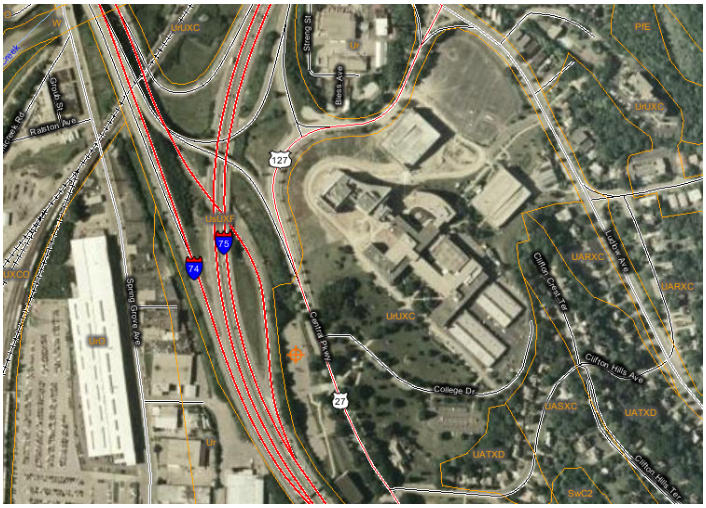

Figure 11. Soil Group Index for the Cincinnati State College area (http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx)

Figure 12. Soil Group Index for the Cincinnati Zoo area (http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx)

Figure 13. Soil Group Index for the Clark Montessori High School area (http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx)

6. WinSLAMM Stormwater Management Model

WinSLAMM (Source Loading and Management Model) was developed to identify sources of problem stormwater pollutants and flows in urban areas and to identify and evaluate cost-effective stormwater management and development strategies. It accomplishes this by calculating stormwater runoff volumes and pollutant loadings for different land uses using continuous small storm hydrology calculations, in contrast to single event hydrology methods that have been traditionally used for much larger single storm models used for drainage design (Pitt and Voorhees, 1995). Using the local rain records, WinSLAMM evaluates the runoff volume as well as pollutant loadings from each individual source area (such as roofs, streets, small and large landscaped areas, sidewalks, and parking lots) within each land use category (including residential, institutional, industrial, and commercial areas) for each rain. Detailed results considering source area, drainage system, and outfall stormwater controls are then used to help stormwater managers evaluate alternative management programs. The model does a complete mass balance and routing of water volume and particulate mass, considering the combined effects of all controls. Hydraulic and particle size routing occurs for each device individually, and serial effects of multiple devices (in series and/or parallel) are used in version 10.

In this project, WinSLAMM is being used to calculate the effectiveness of GI stormwater controls, based upon long series of rainfalls, the source area characteristics, and the characteristics of stormwater control (such as size and location). WinSLAMM also calculates the

stormwater contributions to the combined sewer system during wet weather before and after construction, by providing a time series of flows for various types of upland controls.

7. Statistical Analyses of the Flow Data

This section provides description of some selected statistical tests and their data requirements being used for data evaluations during this project.

7.1 Basic Data Plots

Several basic data plots including scatterplots, time series, and box-and-whisker plots are used for demonstrating overall data trends, along with QA/QC analyses (such as finding data gaps and meter errors). Time series plots are used to show flows in combined and separate sewer lines over time, for monthly and daily periods. These time series help define trends, patterns, and possible clustering of data.

Box and whisker plots are used to graphically depict the distribution of a dataset, and to indicate possible groupings of the data. This type of plot provides many important characteristics of datasets including median, first and third quartiles, skewness, and outliers. Box and whisker plots also help to examine the differences between the significant groupings of the data by comparing the range and major percentile locations of the data. As an example, for small data sets, if the lower and upper quartile lines of two boxes do not overlap, the medians of the two groups are likely significantly different. In this project, box plots are used to compare the data of observed flows to the modeled (using WinSLAMM) flows, as well as comparing runoff volumes for different study periods (before and after construction).

7.2 Analysis of Variance (ANOVA)

An Analysis of Variance (ANOVA) test is used to analyze the differences between two or more groups of data (within vs. between data groups). The null hypothesis in an ANOVA test is that the means of several sets of data are equal. ANOVA is a parametric test, which requires data to be independent, and normally distributed. In addition, the variance of data in groups should be equal. To interpret the ANOVA result, if the p-value is less than or equal to the selected α-level (confidence level), the null hypothesis will be rejected in favor of the alternative hypothesis, which indicates that at least one subset is statistically different from at least one other subset. However, ANOVA is not able to identify which group is different from the others. In this project, a traditional value "α" of 0.05 is being used to test the hypotheses.

If the data did not meet the assumptions of normality and equal variance, the Kruskal-Wallis test was used to determine if there is a statistically significant difference between two or more subsets of data. The Kruskal-Wallis test is a non-parametric test that requires data to be independent from continuous distributions, with the distributions having the same shape. Similar to the ANOVA test, Kruskal-Wallis does not identify which subset of data is different from other

subsets, or how many different sets exist among all sets. Supporting statistical tests (the post-hoc test below) and data plots assist in identifying the data groupings, if these ANOVA tests indicate that data groupings exist.

In this project, one-way ANOVA (when data are normally distributed) or Kruskal-Wallis (when data are not normally distributed) are used to indicate any significant differences between before, during, and after stormwater controls construction periods. In addition, one-way ANOVA or Kruskal-Wallis tests are used to examine infiltration data to determine whether the data can be grouped based on soil characteristics.

7.3 Post-hoc Tests

While ANOVA or Kruskal-Wallis tests do not determine which groups of the data are different from other groups, post-hoc tests are applied to identify whether any two sets of data are similar or different. Post-hoc tests are used when a significant F-value is obtained from an ANOVA or Kruskal-Wallis test. The post hoc tests provide pairwise comparisons that help to determine if particular pairs of data are significantly different from each other. There are several post-hoc tests with different assumptions about group sizes and equality of variance including; Bonferroni t-test, Tukey's test, and Mann-Whitney test. Grouped box and whisker plots and grouped probability plots were also used to identify likely groupings of the individual data sets.

7.4 Trend analysis

In this project, trend analysis were conducted on the flow monitoring data. Flow trends for dry days (individually for each day of the week) were analyzed for evidence of diurnal patterns within each month. In hydrographs from sewer flow monitors, differences between weekdays, weekends, and holidays/special events are usually apparent. Therefore, within each month, dry weekdays, as well as dry weekends were examined using trend analysis with "run chart" tests (using Minitab), along with trends, and clustering tests.

The run chart is a simple representation of process data over time which plots individual flow observations chronically, and draws a horizontal reference line at the mean of the data. Run charts provide information on non-random variations due to trends, oscillation, mixtures, and clustering. This information includes numbers of runs about the median, numbers of runs up or down, expected numbers of runs, p-values for clustering, trends, mixtures, and oscillations. The null hypothesis of run charts is that the data have a random sequence. "Run Chart converts the observed number of runs into a test statistic that is approximately standard normal, then uses the normal distribution to obtain p-values" (Minitab 16). Therefore, if the calculated p-value is less than the chosen α-level, the hypothesis of randomness is rejected. These tests are conducted to examine weekday base flow and weekend base flow for each month at each monitoring location.

8. Flow Monitoring Analyses Results

Direct measurements of flows by the in-system flow monitors in the combined or separate sewers on or adjacent to several of green infrastructures were used to directly measure system performance. The small-scale infiltration results above each area are used to calibrate the model and then the system measurements are used to verify the larger-scale predictions, for example.

Real time rainfall and runoff data from combined and separate sewer systems that are affected by GI stormwater controls in upstream areas were analyzed before, during and after the construction of the stormwater controls. Then, runoff characteristics of pre- and post-construction conditions were compared to measure the benefits of integrated GI stormwater controls at large scales. The hypothesis is that the flows being discharged from study areas are much less than would occur if the GI stormwater controls were not present. The linearity between the small-scale measurements and the scaled-up large scale measured flows verifies the system benefits by using distributed small GI controls, a rare confirmation in the literature.

8.1 Cincinnati State College Combined Sewer Flow Analyses (above and below site monitoring)

The first step in analyzing flow characteristics in combined stormwater/sanitary sewer systems is to determine the base flow and the dry and wet weather flow components from the flow time series in sewer lines. Figure 14 shows an example of the diurnal flow time series for dry Tuesdays in August 2012, for the Cincinnati State College combined sewer system at manhole number 29613032 (also known as the downstream flow meter in this report). Since time series analyses for all dry weekdays within this month seem to have similar trends, all dry weekdays were combined and statistically analyzed to identify whether the data have a random sequence.

Figures 15 is an example of a run chart test for all dry weekdays in August 2012, for the Cincinnati State College combined sewer system at manhole number 29613032 (Minitab, 16). In this figure, fewer runs about the median are observed than expected, which indicates clustering of data. In addition, fewer numbers of runs up or down were observed than expected, which indicates trending of data. Therefore, the run chart results supports combining of all dry weekdays as one data set. In this project, the statistical tests indicated that for most of the months, there were two base flow patterns; one for all dry weekdays, and another for all dry weekends.

The preceding dry weather period (showing the diurnal flow fluctuations that vary by day of the week and time of day) were subtracted from the combined flows during wet weather to result in the separate rainfall-runoff contributions (direct runoff from rain events). Figures 16 and 17 are examples of subtracting base flows from combined flows after a storm event in August 2012 for the Cincinnati State College combined sewer system at manhole number 29613032.

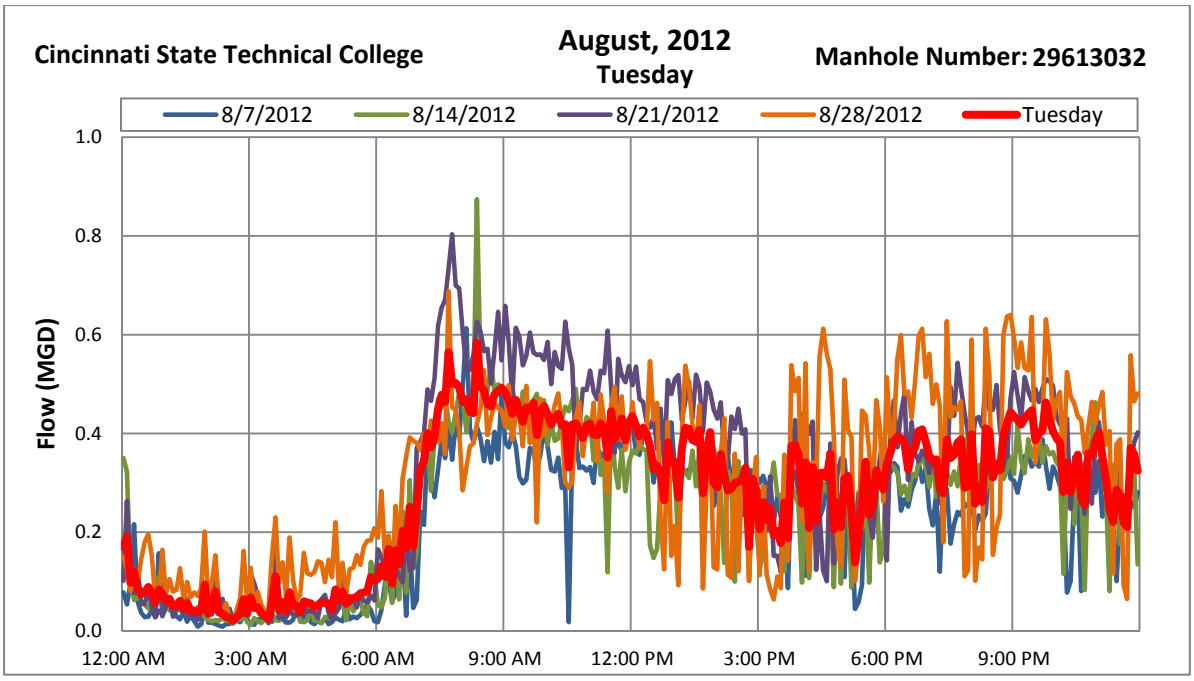

Figure 14. Example of diurnal flow time series for dry Tuesdays in August 2012, for Cincinnati State College combined sewer system at manhole number 29613032

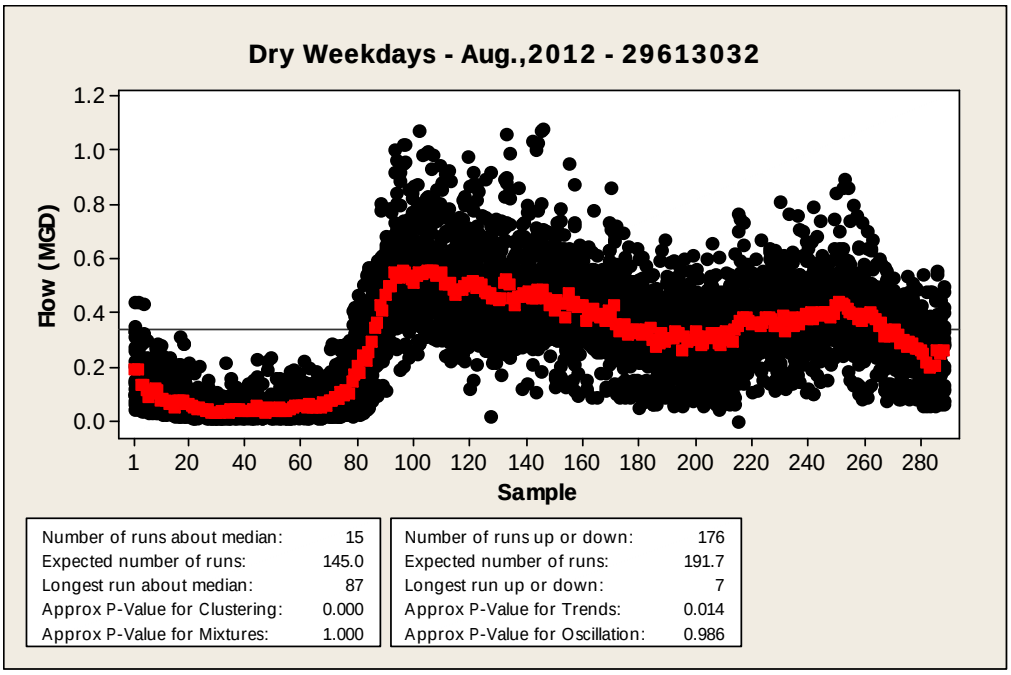

Figure 15. Example of diurnal flow time series for all dry weekdays combined in August 2012, for Cincinnati State College combined sewer system at manhole number 29613032

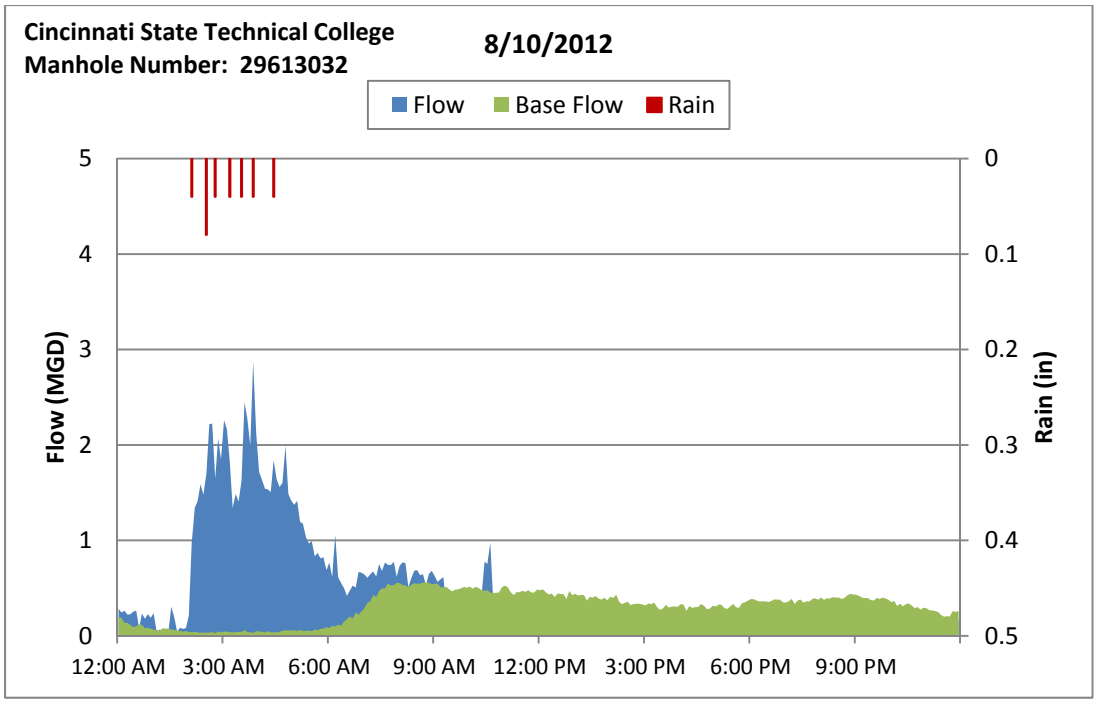

Figure 16. Example of monitored flows after a storm event in August 2012, for Cincinnati State College combined sewer system at manhole number 29613032

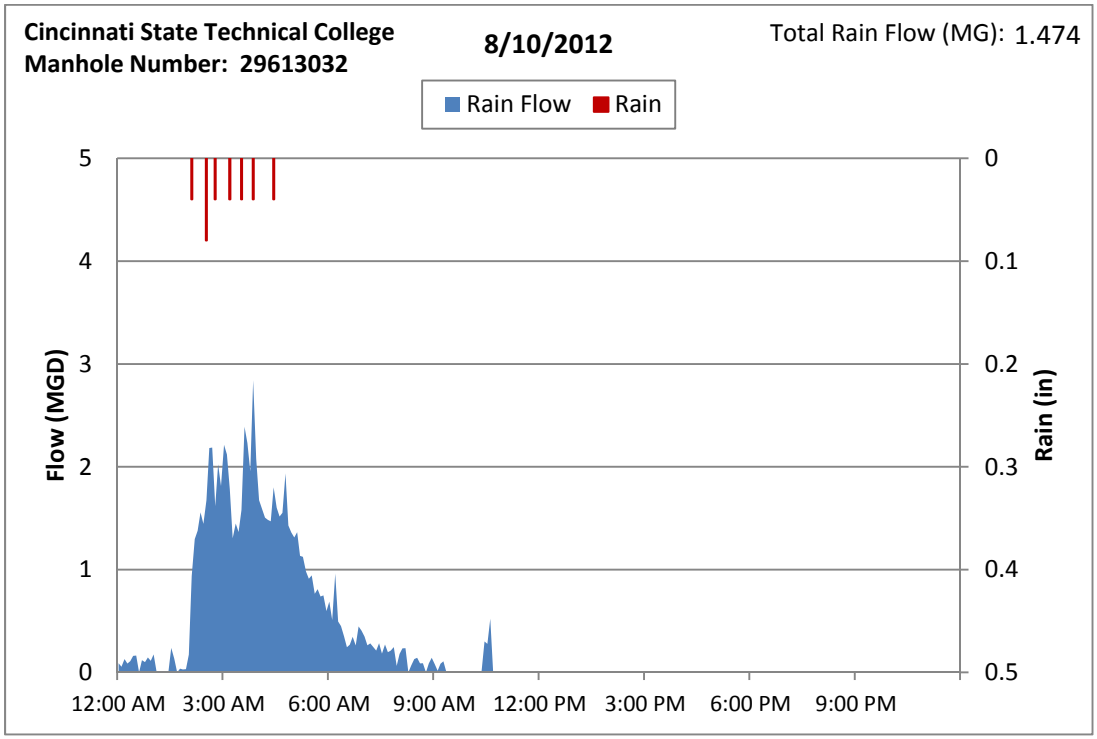

Figure 17. Example of wet weather separate stormwater flows after a storm event in August 2012, for Cincinnati State College combined sewer system at manhole number

The next step in the flow analyses at the large scales was to summarize the event flows and rainfall characteristics for all events at each monitoring location (after separating the base flows), using land development characteristics and watershed analyses. Also, upstream flows are subtracted from downstream flows to isolate direct runoff from the site, as appropriate.

Due to questionable flows (upstream flows generally larger than downstream flows for example) during the early monitoring period for Cincinnati State College combined sewer lines (manhole 29612050 at upstream, and manhole 29612032 at downstream), the flow and hydrological analyses have only been conducted for the period from the beginning of August, 2012, through December, 2012 (the after construction period). During this period of time, about 21 rain events have increasing flows downstream and are therefore suitable for the statistical and hydrological analyses. Tables 7 and 8 summarize flow and runoff characteristics for Cincinnati State College combined sewer lines at downstream and upstream locations. The detailed tables are attached in Appendix B, including rainfall and runoff characteristics for about 21events. Figures 18 and 19 summarize the total discharge depth versus the rain depth for 21 "after construction" events for upstream and downstream locations at Cincinnati State College.

Table 7. Rainfall characteristics for downstream and upstream flow monitoring locations at Cincinnati State College combined sewer system (Manholes 29612032, and 29612050)

	Antecedent dry days	Rain duration (hrs)	Total rain (in)	5-minute peak rain intensity (in/hr)	Avg. rain int. (in/hr)
number	21	21	21	21	21
average	5.02	7.81	0.43	0.63	0.12
median	4.41	4.75	0.32	0.48	0.07
st dev	3.51	9.27	0.38	0.65	0.13
COV	0.70	1.19	0.88	1.02	1.13
min	0.54	0.08	0.01	0.05	0.01
max	14.38	40.92	1.38	2.64	0.48

Note: Data for September, 2012 are not included

Table 8. Runoff characteristics for downstream and upstream flow monitoring locations at Cincinnati State College combined sewer system

	Pipe flow duration (hrs)	Total pipe flow discharge volume (ft^3)	Total discharge (in)	Peak pipe flow discharge rate (cfs)	Avg. pipe flow discharge rate (cfs)	Peak/avg. pipe flow rate ratio	R_v	Pipe flow/rain duration ratio
Manhole 29612032 at downstream location								
number	21	21	21	21	21	21	21	21
average	19.9	126,660	0.10	9.16	1.51	5.23	0.19	5.32
median	11.8	56,994	0.04	4.97	1.47	3.30	0.16	2.81
st dev	19.6	164,353	0.13	15.01	0.48	5.92	0.11	7.78
COV	0.98	1.30	1.30	1.64	0.32	1.13	0.58	1.46
min	1.4	0.00	0.00	2.64	0.79	2.25	0.05	0.72
max	64.2	587,551	0.45	71.21	2.54	29.30	0.45	34.00
Manhole 29612050 at upstream location								
number	21	21	21	21	21	21	21	21
average	14.9	36,948	0.03	3.70	0.69	5.01	0.06	4.50
median	8.4	19,238	0.02	2.80	0.66	4.06	0.06	1.94
st dev	14.7	41,628	0.03	3.92	0.38	2.93	0.03	7.93
COV	0.99	1.13	1.13	1.06	0.55	0.58	0.56	1.76
min	1.0	0.00	0.00	0.43	0.17	2.08	0.01	0.38
max	47.8	143,887	0.12	18.70	1.49	13.75	0.14	34.00

Note: Data for September, 2012 are not included

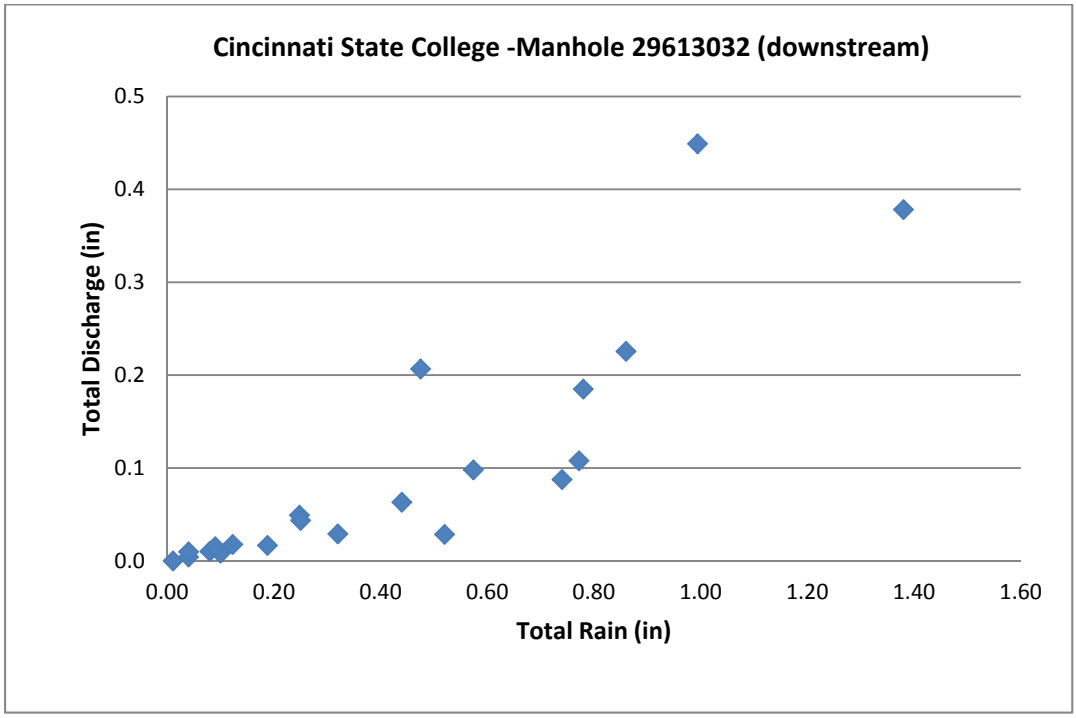

Figure 18. Runoff depth vs. rain depth at Cincinnati State College – Manhole 29613021 (downstream) (Note: Data for September, 2012 are not included)

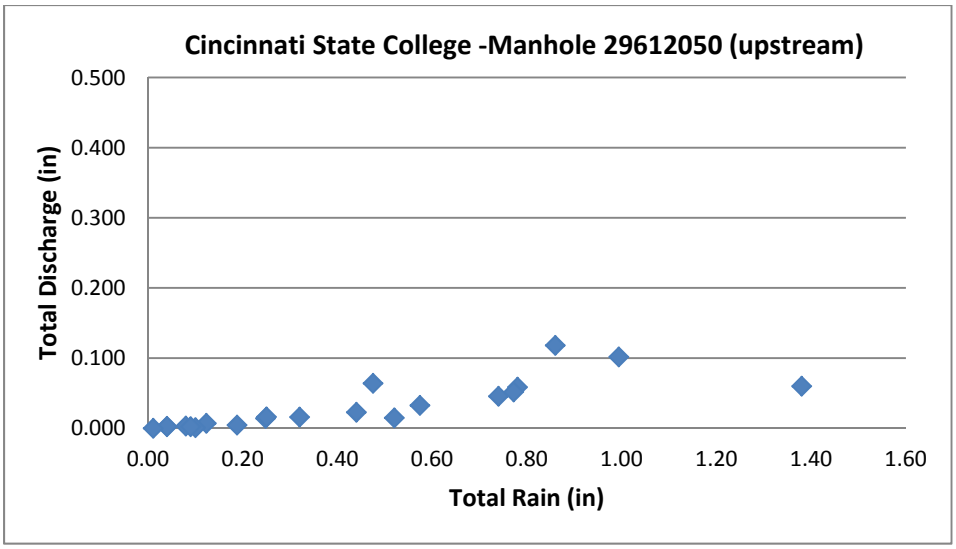

Figure 19. Runoff depth vs. rain depth at Cincinnati State College – Manhole 29612050 (upstream) (Note: Data for September, 2012 are not included)

Figure 20 is a box and whisker plot that shows the R_v values (ratio of runoff depth to rain depth) for upstream and downstream flows, showing that the downstream unit area runoff depths were much larger than the upstream runoff depths. Considering that the drainage area above the upstream location is more than 90% of the drainage area above the downstream location, and the area between upstream and downstream is served by several green infrastructures, the recorded flows are questionable. In addition, Mann-Whitney test result indicates that the upstream runoff depths are significantly different from the downstream runoff depths (p-value < 0.05).

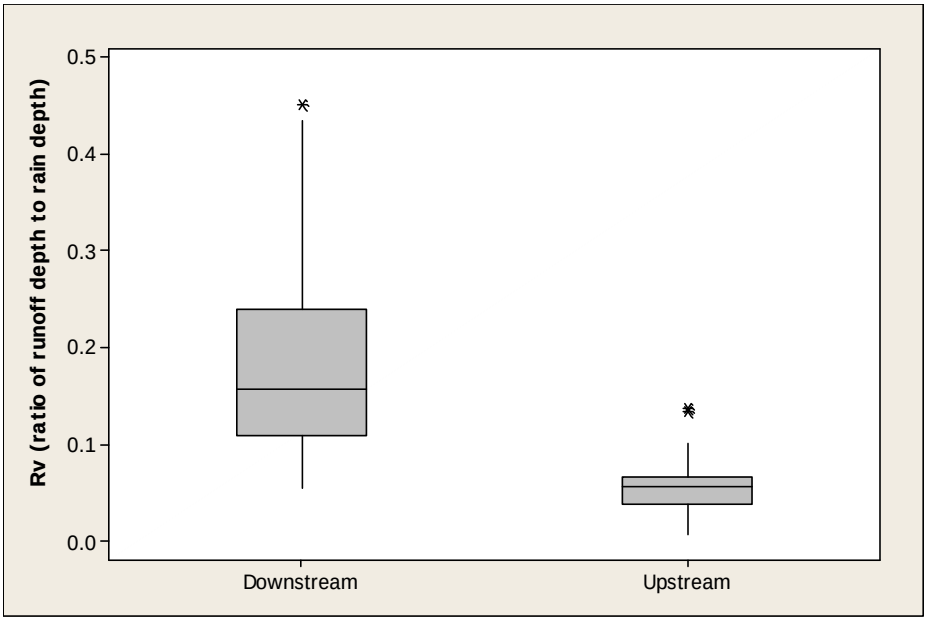

Figure 20. Box and whisker plot of R_v for upstream and downstream locations at Cincinnati State College. (Note: Data for September, 2012 are not included)

Mann-Whitney Test and CI: Downstream, Upstream

	N	Median
Downstream	20	0.15678
Upstream	20	0.05644

Point estimate for ETA1-ETA2 is 0.10307
95.0 Percent CI for ETA1-ETA2 is (0.06569, 0.14577)
W = 584.0
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.0000

Therefore, further analyses at this drainage area is not deemed worthwhile as the flow data cannot resolve the effects of the relatively small portion of the watershed affected by the control practices compared to the very large up-gradient watershed area that is also being monitored at the flow monitoring locations. Basically, subtracting two very large numbers having substantial variability (and uncertainty) does not result in confident results of the difference. We evaluated these data many ways to reduce the variability in the larger flows, but the results were still not clear. The desired outcome would be to show that there were significant differences between the upstream and downstream flow results. Unfortunately, in most cases, the downstream flow values were much smaller than the upstream flow values, an impossible outcome for the drainage system (as illustrated in Figure 20). It is thought that the flow monitoring at one or both of the locations was hindered by poor flow conditions, or faulty sensors (especially considering that the flow depths were very low, a challenging situation).

8.2 Cincinnati State College Separate Storm Sewer Analyses (single monitoring location)

This portion of the Cincy State study area includes a single separate stormwater drainage system that serves a portion of the hilltop campus, having a small impervious area (access roads and roofs) along with a large turf grass hillside). A number of controls are located in the flow path above the single flow monitoring location that is located before this separate stormwater drainage enters the larger combined sewer.

Tables 9 and 10 summarize the rainfall and runoff characteristics for this Cincinnati State College separate storm sewer line (manhole number 29606027). The detailed tables are attached in Appendix B, including rainfall and runoff characteristics for about 169 events. Tables 9, and 10 contain the observed values and the calculated rain and flow parameters based on the observed data. The raw flow data represent both the dry and wet weather flows together in the monitored combined sewers. These data are also being used in the model calibration efforts.

Tables 9 and 10 are divided into three sections: before construction, during construction, and after construction. Table 9 describes the rain conditions, while Table 10 describes the observed runoff conditions for each of the three mentioned periods.

Figure 21 is a box and whisker plot that shows the R_v values (ratio of runoff depth to rain depth) for before, during, and after construction periods for the Cincinnati State College separate sewer system (manhole number 29606027). The Kruskal-Wallis One Way Analysis of Variance on Ranks test was used to indicate if any significant differences between these categories occurred. This test indicated that at least one category was significantly different from the others ($p < 0.001$).

Table 9. Rainfall characteristics during different flow monitoring periods for Cincinnati State College separate sewer system (manhole number 29606027)

	Antecedent dry days	Rain duration (hrs)	Total rain (in)	5-minute peak rain intensity (in/hr)	Avg. rain int. (in/hr)
Before Construction					
number	41	41	41	41	41
average	6.43	3.96	0.62	1.48	0.33
median	3.61	2.50	0.40	0.96	0.16
st dev	7.28	4.35	0.64	1.12	0.47
COV	1.13	1.10	1.03	0.76	1.41
min	0.27	0.08	0.04	0.48	0.02
max	27.52	18.42	2.84	5.78	2.88
During Construction					
number	52	52	52	52	52
average	4.83	6.15	0.92	1.91	0.24
median	2.92	4.75	0.68	1.45	0.17
st dev	6.38	5.96	0.87	2.70	0.24
COV	1.32	0.97	0.95	1.42	1.03
min	0.24	0.50	0.12	0.48	0.02
max	31.89	27.50	5.16	19.76	1.33
After Construction					
number	76	76	76	76	76
average	5.40	6.90	0.70	1.16	0.22
median	4.27	5.25	0.56	0.96	0.10
st dev	4.58	6.97	0.63	1.03	0.33
COV	0.85	1.01	0.89	0.89	1.55
min	0.28	0.25	0.09	0.05	0.01
max	19.91	40.92	3.36	6.27	2.08

Note: Data for August, 2012 and September, 2012 are not included

Table 10. Flow characteristics during different flow monitoring periods for Cincinnati State College separate sewer system (manhole number 29606027)

	Pipe flow duration (hrs)	Total pipe flow discharge volume (ft^3)	Total discharge (in)	Peak pipe flow discharge rate (cfs)	Avg. pipe flow discharge rate (cfs)	Peak/avg. pipe flow rate ratio	R_v	Pipe flow/rain duration ratio
Before Construction								
number	41	41	41	41	41	41	41	41
average	7.42	7,497	0.15	1.88	0.28	10.19	0.23	6.21
median	5.92	3,973	0.08	1.70	0.20	7.36	0.23	2.22
st dev	5.47	9,274	0.18	1.19	0.26	6.70	0.10	9.93
COV	0.74	1.24	1.24	0.63	0.95	0.66	0.43	1.60
min	0.75	824	0.02	0.54	0.03	1.72	0.04	0.15
max	24.75	42,160	0.82	6.12	1.20	26.33	0.47	41.00
During Construction								
number	52	52	52	52	52	52	52	52
average	12.88	10,270	0.20	1.68	0.21	10.21	0.22	3.18
median	10.17	6,913	0.13	1.43	0.18	8.40	0.21	2.24
st dev	8.97	11,059	0.21	1.03	0.12	7.38	0.13	2.77
COV	0.70	1.08	1.08	0.61	0.58	0.72	0.60	0.87
min	1.50	211	0.00	0.13	0.02	2.29	0.01	0.58
max	34.08	47,914	0.93	4.93	0.49	39.50	0.73	13.33
After Construction								
number	76	76	76	76	76	76	76	76
average	12.01	1,914	0.04	0.63	0.06	11.78	0.04	2.60
median	7.33	785	0.02	0.48	0.03	9.14	0.03	1.24
st dev	13.14	2,905	0.06	0.71	0.08	10.64	0.04	5.85
COV	1.09	1.52	1.52	1.12	1.33	0.90	0.98	2.25
min	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
max	67.50	14,794	0.29	2.80	0.52	43.00	0.24	44.67

Note: Data for August, 2012 and September, 2012 are not included

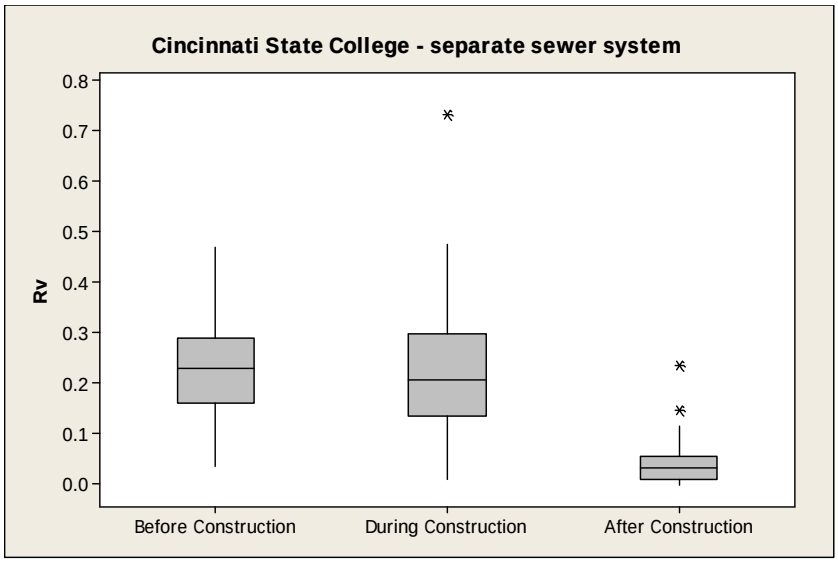

Figure 21. R_v values for different study periods for Cincinnati State College separate sewer system (manhole number 29606027) (Note: Data for August, 2012 and September, 2012 are not included)

The Kruskal-Wallis One Way Analysis of Variance on Ranks test was conducted to identify any significant differences between these categories. This test indicated that at least one category was significantly different from the others ($p < 0.001$).

Group	N	Missing	Median	25%	75%
Before Construction	41	0	0.230	0.160	0.290
During Construction	52	0	0.205	0.135	0.297
After Construction	76	0	0.0300	0.01000	0.0600

H = 99.041 with 2 degrees of freedom. (P = <0.001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001). In this case, it is obvious that the "after" construction period is significantly different from the other two periods. A statistical post-hoc comparison test (Dunn's test) was conducted to verify these groupings.

Comparison	Diff of Ranks	Q	P<0.05
Before Constr vs After Constru	78.663	8.297	Yes
Before Constr vs During Constr	6.431	0.629	No
During Constr vs After Constru	72.232	8.203	Yes

Figure 22 is a box and whisker plot that shows the R_v values for before and during construction periods (combined), and the after construction period for the Cincinnati State College separate sewer system (manhole number 29606027). The Mann-Whitney Rank Sum Test was used to statistically identify the differences between these two categories. This test indicated that the R_v values for the after construction period is significantly different from the before plus during construction periods.

Mann-Whitney Rank Sum Test

Group	N	Missing	Median	25%	75%
Before and During Construction	93	0	0.220	0.155	0.295
After Construction	76	0	0.0300	0.01000	0.0600

Mann-Whitney U Statistic= 394.500

T = 3320.500 n(small)= 76 n(big)= 93 (P = <0.001)

The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

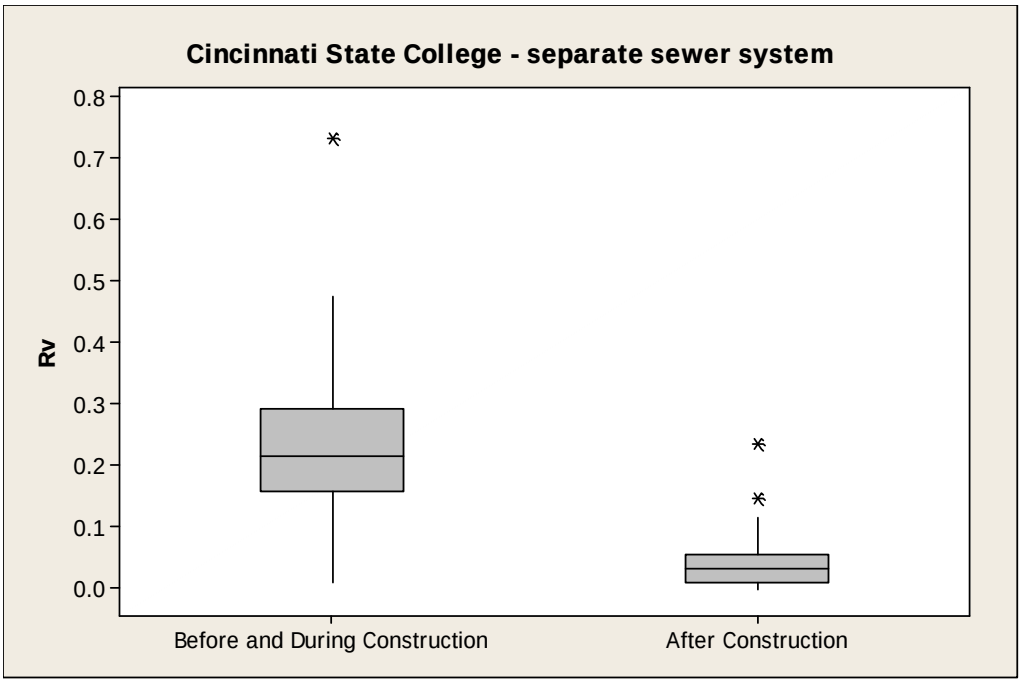

Figure 22. R_v values for before and during construction periods (combined) compared to before construction period at Cincinnati State College separate sewer system

At this study area, the statistical tests indicate that the "after" construction flows are much less than the "before" and "during" construction flows. This supports the hypothesis that the flows being discharged from areas with GI stormwater controls are much less than would occur if the GI stormwater controls were not present. Since a monitored area with "no stormwater controls" is not available for this study area, the "before" construction runoff and rainfall data are being used to calibrate WinSLAMM. The calibrated WinSLAMM is used to model GI stormwater controls in order to predict performance of control options for varying conditions. Then the observed event summary statistics have been compared with the predicted runoff responses from WinSLAMM model to account for varying rain conditions during the different monitoring periods.

8.3 Cincinnati Zoo Main Entrance Area

The main entrance of the Cincinnati Zoo is about 2.5 ac served by a separate sewer system. More than 60% of the paved area has been replaced by porous paver blocks. There is also a cistern with a capacity of 10,000 gallon to collect runoff from rooftops and reuse it for irrigation of landscaped areas. For the main entrance of the Cincinnati Zoo area, all the available recorded flows belong to "after construction" period. Tables 11 and 12 summarize the rainfall and runoff characteristics of about 176 events for the main entrance of the Cincinnati Zoo (The detailed tables are provided in Appendix B). Figure 23 shows total discharge depth versus the rain depth for 176 after construction events at the main entrance of the Cincinnati Zoo. The average R_v

values for after GI construction is about 0.1 (compared to about 0.8 for conventional pavement in the area)

Table 11. Rainfall characteristics for main entrance of the Cincinnati zoo separate sewer line

	Antecedent dry days	Rain duration (hrs)	Total rain (in)	5-minute peak rain intensity (in/hr)	Avg. rain int. (in/hr)
number	176	176	176	176	176
average	5.39	7.31	0.67	1.01	0.20
median	3.82	5.04	0.48	0.72	0.10
st dev	5.10	8.62	0.63	0.90	0.29
COV	0.95	1.18	0.95	0.89	1.48
min	0.12	0.08	0.07	0.05	0.01
max	31.45	61.25	3.38	5.90	2.33

Note: Data for August, 2012 and September, 2012 are not included

Table 12. Runoff characteristics for main entrance of the Cincinnati zoo separate sewer line

	Pipe flow duration (hrs)	Total pipe flow discharge volume (ft^3)	Total discharge (in)	Peak pipe flow discharge rate (cfs)	Avg. pipe flow discharge rate (cfs)	Peak/avg. pipe flow rate ratio	R_v	Pipe flow/rain duration ratio
number	176	176	176	176	176	176	176	176
average	9.09	733	0.08	0.17	0.03	7.18	0.08	1.34
median	5.92	151	0.02	0.04	0.01	5.56	0.04	0.84
st dev	11.02	3,391	0.38	0.77	0.10	6.06	0.20	2.51
COV	1.21	4.63	4.63	4.53	3.92	0.84	2.60	1.86
min	0.00	0.00	0.00	0.00	0.00	0.90	0.00	0.00
max	56.75	43,925	4.92	9.88	1.07	49.55	1.92	25.00

Note: Data for August, 2012 and September, 2012 are not included

At the main entrance area of the Cincinnati zoo, all available monitored flows are for the "after" construction condition. Therefore, WinSLAMM is being applied to predict the "before" construction condition. The predicted "no control" flows from WinSLAMM are statistically compared to the measured flows to compare the "before" and "after" construction conditions to determine the benefits of the porous paved areas and rainwater harvesting system at this study area.

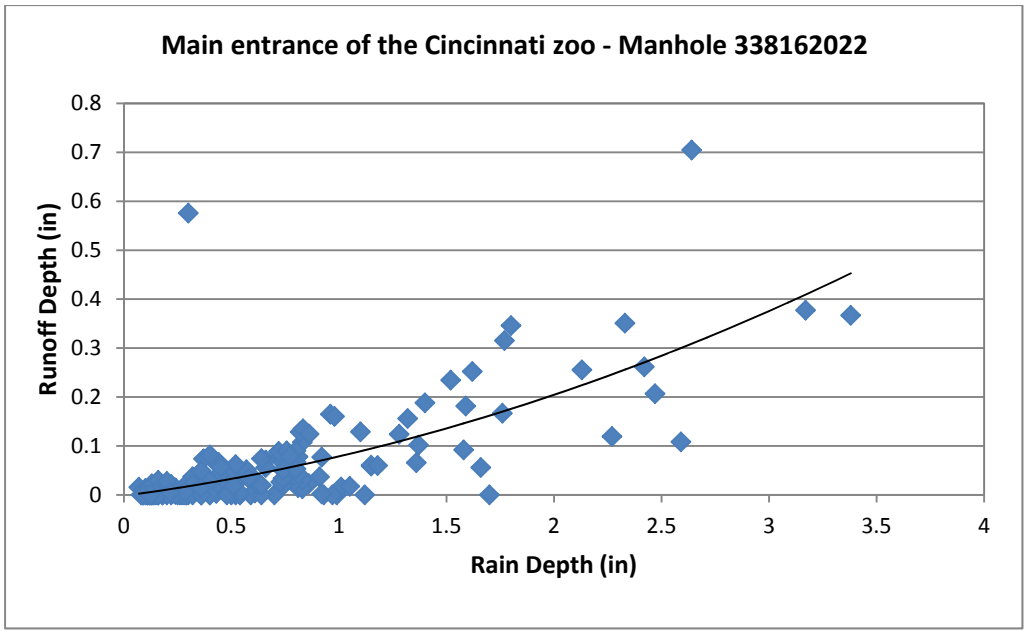

Figure 23. Runoff depth versus the rain depth for 176 after construction events at the main entrance of the Cincinnati zoo. (Note: Data for August, 2012 and September, 2012 are not included)

8.4 Cincinnati Zoo African Savannah Combined Stormwater Monitoring Location

The African Savannah is served by a combined sewer system. This study area has different types of green infrastructure controls, including permeable pavers, and an underground rainwater harvesting storage system. In addition, the African Savannah area will have enhanced turf/vegetation, which is currently under construction. Construction of the African Savannah project started in October, 2011, and the underground storage component was completed in January, 2012. Therefore, the available flow monitoring data are mostly for "before" and "during" construction conditions.

Since the African Savannah area is served by a combined sewer system, the first step in analyzing flow characteristics is to determine the base flow and to separate the dry weather flows from the wet weather flow components. The flow data analyses and statistical tests for this study site is similar to the steps that were described for the Cincinnati State College combined sewer system (above and below site monitoring) under section 8.1.

Tables 13 and 14 are summaries of the rainfall and runoff characteristics of 167 events for the main entrance of African Savannah zoo (The detailed tables are provided in Appendix B). 107, 15, and 41 events have been recorded for before construction, during construction, and after construction periods, respectively. Figure 24 shows total discharge depths versus the rain depths for different construction periods at African Savannah zoo. As shown in Figure 24, the slope of the rainfall vs. runoff decreases for after construction period compared to the before construction period.

Figure 25 is a box and whisker plot that shows the R_v values for before, during, and after construction periods for the African Savannah Zoo combined sewer system. The Kruskal-Wallis One Way Analysis of Variance on Ranks test was used to indicate if any significant differences between these categories occurred. This test indicated that at least one category was significantly different from the others ($p < 0.001$). A statistical post-hoc comparison test (Dunn's test) was conducted to verify these groupings. The results show that the "after construction" period was statistically different from the "before construction" and "during construction" periods.

Table 13. Rainfall characteristics for African Savannah zoo combined sewer line

	Antecedent dry days	Rain duration (hrs)	Total rain (in)	5-minute peak rain intensity (in/hr)	Avg. rain int. (in/hr)
Before Construction					
number	107	107	107	107	107
average	5.79	7.67	0.71	1.05	0.19
median	3.58	5.42	0.53	0.72	0.11
st dev	6.48	8.20	0.68	0.90	0.29
COV	1.12	1.07	0.95	0.86	1.50
min	0.21	0.17	0.08	0.12	0.01
max	31.45	44.42	3.38	5.90	2.33
During Construction					
number	15	15	15	15	15
average	4.92	13.69	0.99	0.75	0.08
median	4.44	9.08	0.66	0.48	0.07
st dev	4.17	12.86	0.88	0.71	0.04
COV	0.85	0.94	0.89	0.95	0.53
min	0.24	2.92	0.16	0.24	0.02
max	14.60	50.92	3.17	2.41	0.16
After Construction					
number	41	41	41	41	41
average	5.99	5.30	0.53	1.20	0.25
median	4.43	5.00	0.40	0.96	0.09
st dev	4.72	4.37	0.37	1.00	0.36
COV	0.79	0.82	0.70	0.83	1.47
min	0.27	0.08	0.10	0.05	0.02
max	19.78	17.67	1.52	5.30	1.92

Note: Data for August, 2012 and September, 2012 are not included

Table 14. Runoff characteristics for African Savannah zoo combined sewer line

	Pipe flow duration (hrs)	Total pipe flow discharge volume (ft^3)	Total discharge (in)	Peak pipe flow discharge rate (cfs)	Avg. pipe flow discharge rate (cfs)	Peak/avg. pipe flow rate ratio	R_v	Pipe flow/rain duration ratio
Before Construction								
number	107	107	107	107	107	107	107	107
average	12.15	24469.89	0.39	2.85	0.59	7.19	0.45	2.79
median	9.08	12146.20	0.19	2.58	0.42	5.90	0.41	1.53
st dev	12.03	31945.07	0.51	2.10	0.63	5.17	0.27	3.88
COV	0.99	1.31	1.31	0.74	1.06	0.72	0.60	1.39
min	0.58	22.28	0.00	0.03	0.00	0.71	0.00	0.41
max	90.33	157096.58	2.52	12.13	3.59	27.40	1.28	30.33
During Construction								
number	15	15	15	15	15	15	15	15
average	13.61	46776.33	0.75	2.46	0.89	4.30	0.56	0.98
median	10.33	17639.00	0.28	2.54	0.70	3.55	0.52	0.99
st dev	12.84	64334.36	1.03	1.41	0.82	2.38	0.39	0.18
COV	0.94	1.38	1.38	0.57	0.93	0.55	0.70	0.18
min	3.00	2314.09	0.04	0.85	0.11	0.98	0.10	0.71
max	52.17	222056.45	3.56	5.51	2.93	8.49	1.26	1.32
After Construction								
number	41	41	41	41	41	41	41	41
average	7.36	6281.80	0.10	1.41	0.28	6.96	0.16	3.87
median	5.96	3474.53	0.06	1.01	0.14	5.15	0.13	1.38
st dev	5.12	8511.85	0.14	1.26	0.34	5.88	0.14	8.87
COV	0.70	1.36	1.36	0.90	1.22	0.84	0.86	2.29
min	2.17	0.00	0.00	0.06	0.01	1.73	0.00	0.44
max	24.25	36631.59	0.59	4.47	1.51	28.65	0.61	52.00

Note: Data for August, 2012 and September, 2012 are not included

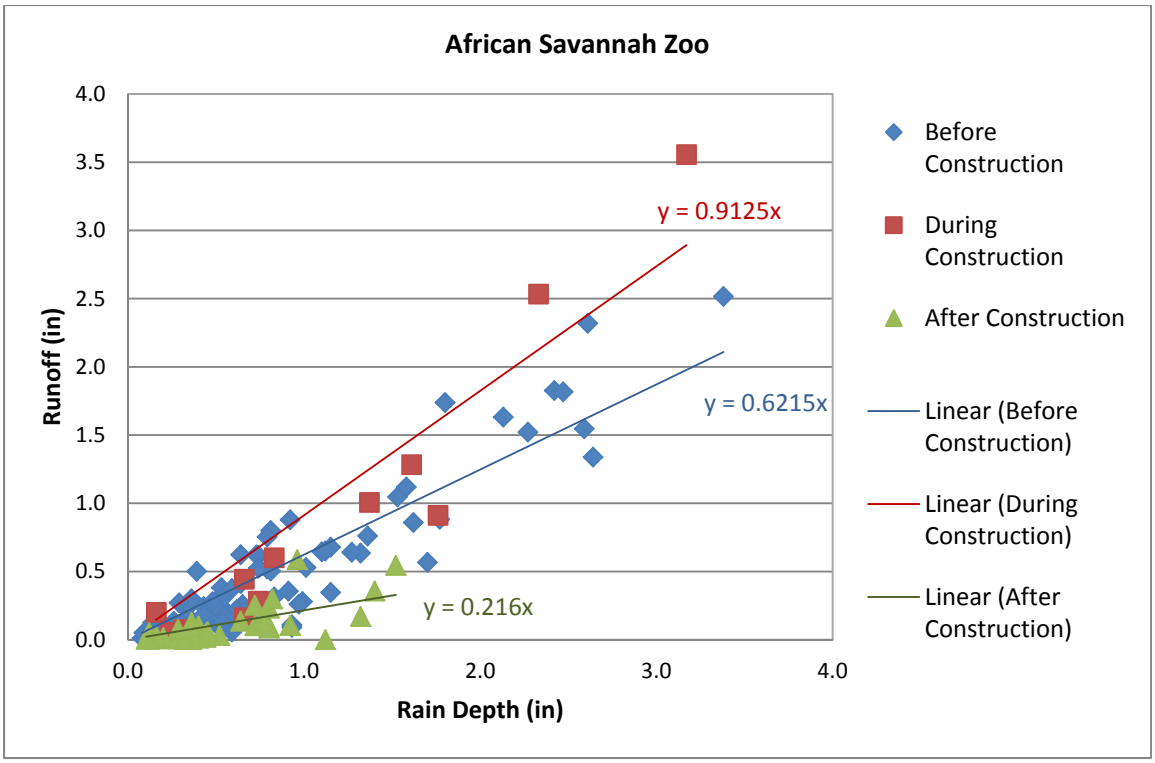

Figure 24. Runoff depth versus the rain depth for different study periods at African Savannah Zoo.

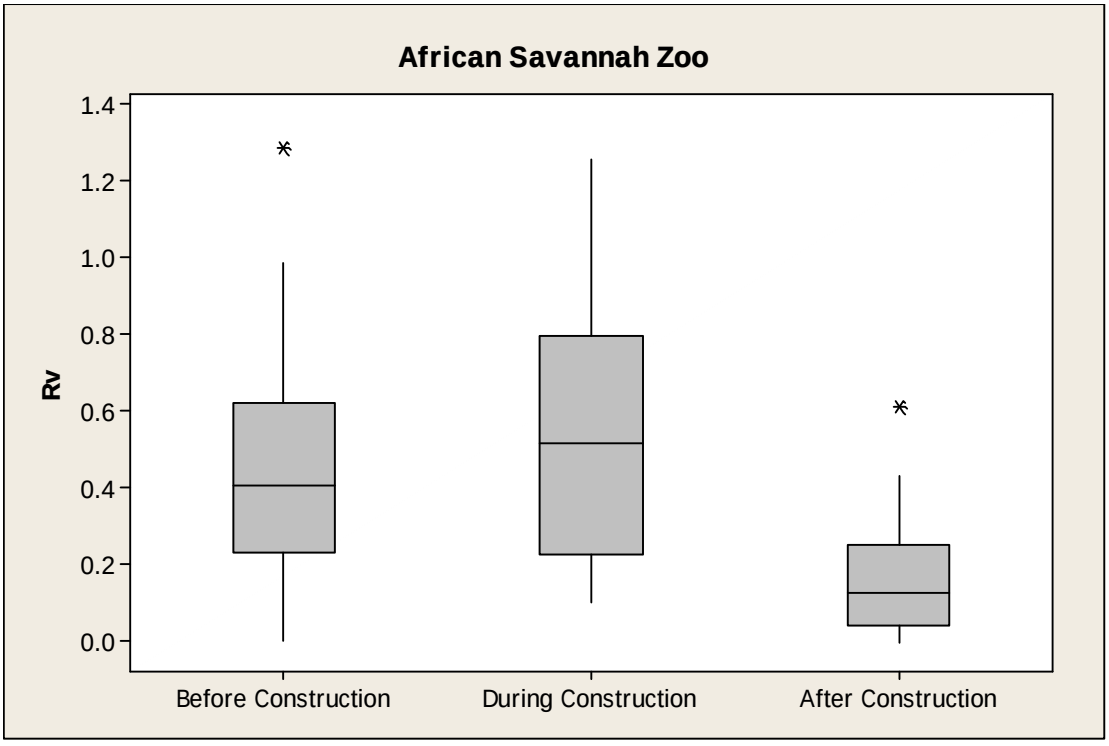

Figure 25. Rv values for different study periods at African Savannah Zoo.

Group	N	Missing	Median	25%	75%
Before Construction	107	0	0.410	0.232	0.621
During Construction	15	0	0.518	0.228	0.797
After Construction	41	0	0.126	0.0409	0.254

H = 42.053 with 2 degrees of freedom. (P = <0.001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

All Pairwise Multiple Comparison Procedures (Dunn's Method):

Comparison	Diff of Ranks	Q	P<0.05
During Construction vs After Construction	61.971	4.351	Yes
During Construction vs Before Construction	7.940	0.610	No
Before Construction vs After Construction	54.031	6.233	Yes

Figure 26 is a box and whisker plot that shows the R_v values for before and during construction (combined), and after construction periods. The R_v values for the after construction period were significantly less than the before and during construction periods (combined).

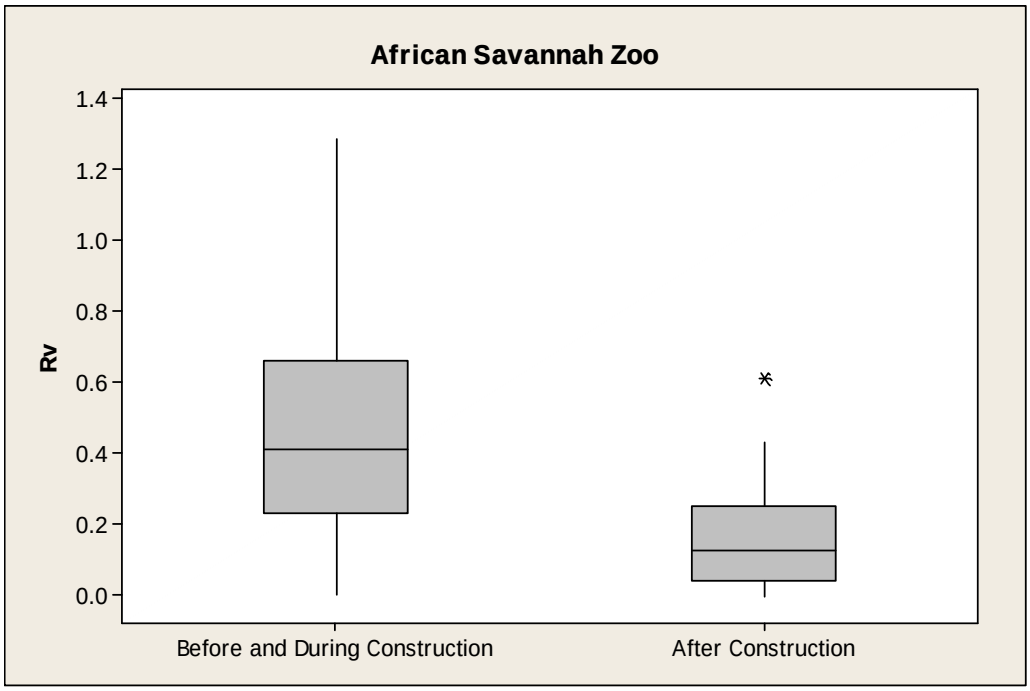

Figure 26. R_v values for before and during construction periods (combined) compared to before construction period at African Savannah Zoo.

Mann-Whitney Rank Sum Test

Group	N	Missing	Median	25%	75%
Before and During Construction	122	0	0.412	0.230	0.660
After Construction	41	0	0.126	0.0409	0.254

Mann-Whitney U Statistic= 813.000

T = 1674.000 n (small)= 41 n (big) = 122 (P = <0.001)

The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

At the African Savannah study area, the statistical tests indicate that the "after" construction flows are significantly less than the "before" and "during" construction flows. This supports the hypothesis that the flows being discharged from areas with GI stormwater controls are much less than would occur if the GI stormwater controls were not present. The "before" construction runoff and rainfall data are being used to calibrate the WinSLAMM model.

8.5 Clark Montessori High School Combined Stormwater Monitoring Location

The Clark Montessori High School study area has various green stormwater controls including green roofs, permeable pavements, and bioretention facilities. The construction of GI stormwater controls at this site started in April/May of 2011 and ended in April/May 2012. Therefore for this site, flow monitoring data are available for three construction phases including; before, during, and after construction periods. This presents the opportunity to compare runoff characteristics for all phases.

Since the data were collected from a combined sewer system, the base dry weather flows were subtracted from the recorded wet weather flows to separate the wet weather components to obtain direct runoff data. Summaries of flow and runoff characteristics are shown in Tables 15 and 16 for the three construction phases, including the recorded values and the calculated rain and flow parameters based on the observed data. These data are also being used in the model calibration efforts. Box and whisker plots of R_v values (ratio of runoff depth to rain depth) for before, during, and after construction periods are shown on Figure 27. The Kruskal-Wallis One Way Analysis of Variance on Ranks test were used to determine if there were any statistically significant differences between different construction phases. A post-hoc test was also used to identify which data group(s) were different from the others. Figure 28 is a box and whisker plot that shows the R_v values for before and during construction (combined), and after construction periods. The statistical tests showed that the R_v values for the after construction period were significantly different from the before and during construction periods (combined).

The "before" construction rainfall and runoff characteristics are being used to calibrate WinSLAMM. The calibrated model is used to examine GI stormwater controls and to predict performance of control options for varying conditions, especially to account for varying rains

during the different monitoring periods. The recorded event characteristics are being statistically compared with the expected runoff responses from the WinSLAMM model.

Table 15. Rainfall characteristics for Clark Montessori High School combined sewer line

	Antecedent dry days	Rain duration (hrs)	Total rain (in)	5-minute peak rain intensity (in/hr)	Avg. rain int. (in/hr)
Before Construction					
number	47	47	47	47	47
average	6.46	7.09	0.59	1.31	0.29
median	3.34	4.17	0.36	0.96	0.08
st dev	9.47	7.19	0.57	1.14	0.68
COV	1.47	1.01	0.97	0.87	2.32
min	0.23	0.08	0.08	0.48	0.01
max	57.04	32.33	2.56	5.78	3.84
During Construction					
number	80	80	80	80	80
average	4.60	7.66	0.79	1.38	0.20
median	3.40	5.17	0.54	0.96	0.12
st dev	4.81	8.63	0.69	1.16	0.25
COV	1.05	1.13	0.87	0.84	1.22
min	0.25	0.08	0.12	0.16	0.01
max	21.34	48.33	3.16	7.23	1.44
After Construction					
number	39	39	39	39	39
average	5.69	5.82	0.52	1.25	0.17
median	3.97	5.17	0.40	0.69	0.08
st dev	5.04	3.99	0.41	1.66	0.32
COV	0.88	0.68	0.78	1.33	1.82
min	0.39	0.33	0.08	0.05	0.01
max	17.94	15.67	1.96	8.19	1.80

Note: Data for August, 2012 and September, 2012 are not included

Table 16. Runoff characteristics for Clark Montessori High School combined sewer line

	Pipe flow duration (hrs)	Total pipe flow discharge volume (ft^3)	Total discharge (in)	Peak pipe flow discharge rate (cfs)	Avg. pipe flow discharge rate (cfs)	Peak/avg. pipe flow rate ratio	R_v	Pipe flow/rain duration ratio
Before Construction								
number	47	47	47	47	47	47	47	47
average	13.40	10,698	0.20	1.97	0.20	11.86	0.27	5.30
median	10.75	4,058	0.08	1.52	0.15	9.63	0.27	1.99
st dev	9.09	13,827	0.26	1.86	0.20	7.99	0.17	9.68
COV	0.68	1.29	1.29	0.94	0.97	0.67	0.63	1.83
min	1.83	68	0.00	0.03	0.00	2.42	0.01	1.04
max	36.75	48,686	0.91	8.09	0.76	41.21	0.76	55.00
During Construction								
number	80	80	80	80	80	80	80	80
average	13.80	14,512	0.27	2.59	0.31	10.43	0.30	3.63
median	11.79	8,435	0.16	1.84	0.22	7.97	0.29	2.10
st dev	10.48	16,450	0.31	2.25	0.31	7.68	0.13	7.35
COV	0.76	1.13	1.13	0.87	1.01	0.74	0.42	2.03
min	1.67	252	0.00	0.08	0.01	0.38	0.03	1.06
max	56.33	97,119	1.81	9.06	2.50	39.80	0.70	65.00
After Construction								
number	39	39	39	39	39	39	39	39
average	10.08	7,065	0.13	1.49	0.18	8.79	0.23	3.11
median	8.08	4,583	0.09	1.06	0.15	8.77	0.23	1.62
st dev	6.83	7,343	0.14	1.58	0.17	4.35	0.16	4.90
COV	0.68	1.04	1.04	1.06	0.95	0.49	0.71	1.58
min	0.92	32	0.00	0.01	0.00	2.62	0.00	0.22
max	31.83	25,177	0.47	6.68	0.86	20.00	0.62	28.50

Note: Data for August, 2012 and September, 2012 are not included

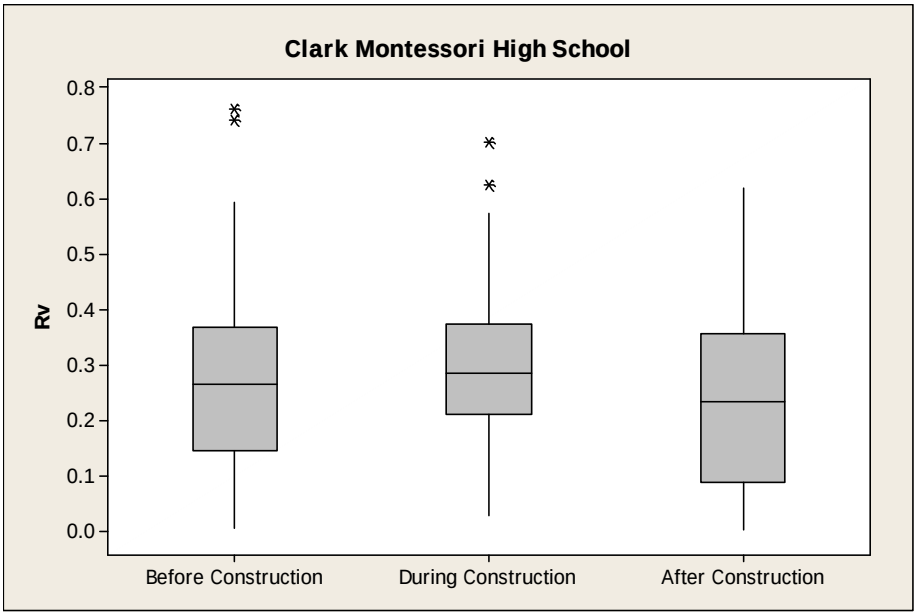

Figure 27. R_v values for different study periods at Clark Montessori High School.

Kruskal-Wallis One Way Analysis of Variance on Ranks

Group	N	Missing	Median	25%	75%
Before	47	0	0.270	0.150	0.370
During	80	0	0.285	0.210	0.370
After	39	0	0.230	0.0900	0.360

H = 6.705 with 2 degrees of freedom. (P = 0.035)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.035)

All Pairwise Multiple Comparison Procedures (Dunn's Method) :

Comparison	Diff of Ranks	Q	P<0.05
During vs After	23.873	2.543	Yes
During vs Before	11.801	1.336	No
Before vs After	12.072	1.160	No

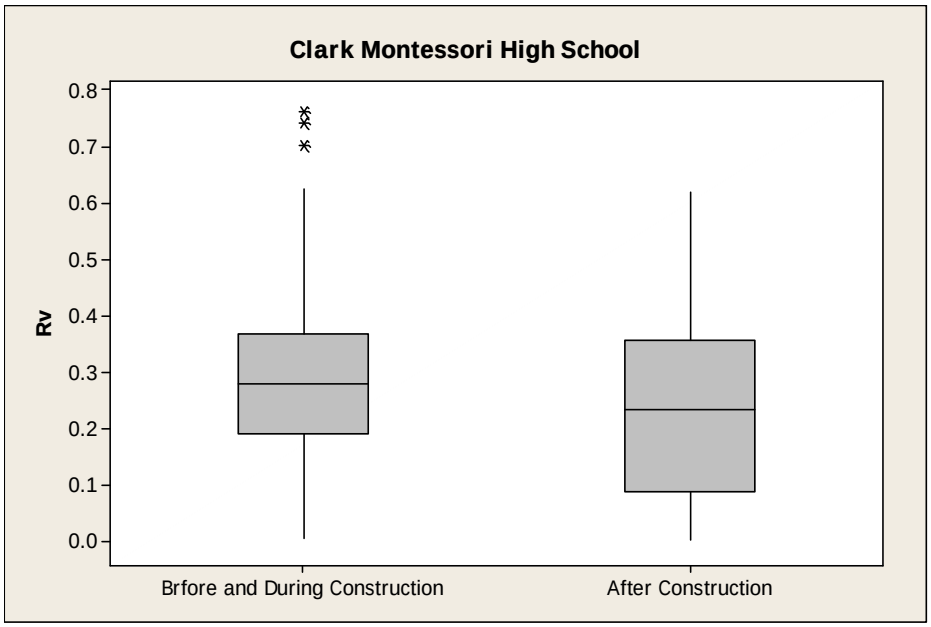

Figure 28. R_v values for before and during construction periods (combined) compared to before construction period at Clark Montessori High School.

Kruskal-Wallis One Way Analysis of Variance on Ranks

Group	N	Missing	Median	25%	75%
Before and During	127	0	0.280	0.190	0.370
After	39	0	0.230	0.0900	0.360

H = 4.918 with 1 degrees of freedom. (P = 0.027)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.027)

All Pairwise Multiple Comparison Procedures (Dunn's Method) :

Comparison	Diff of Ranks	Q	P<0.05
Before and During vs After	19.506	2.217	Yes

9. WinSLAMM Model

9.1. Model Calibration using Site Monitoring Data

Figures 29, 30, and 31 are scatterplots showing the observed versus the modeled total flows for each of the studied areas in Cincinnati. As shown, these are all close to the line of equivalent values.

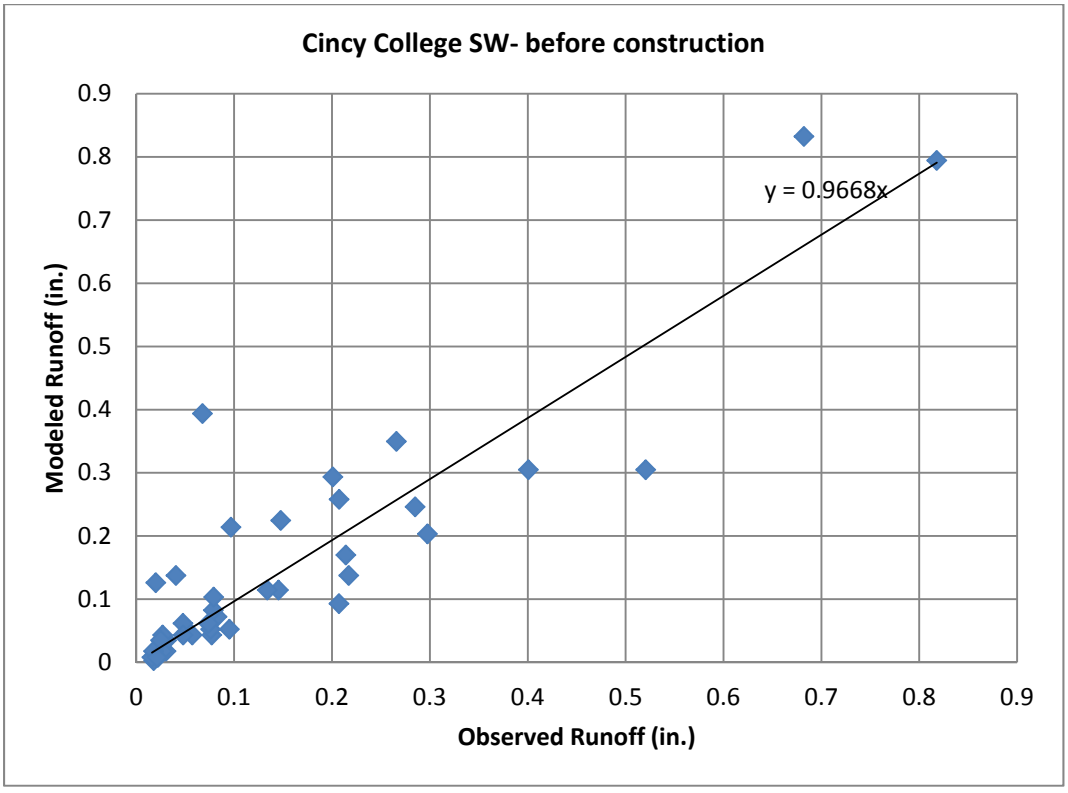

Figure 29. Observed versus modeled flows for Cincinnati State College Separate Sewer System

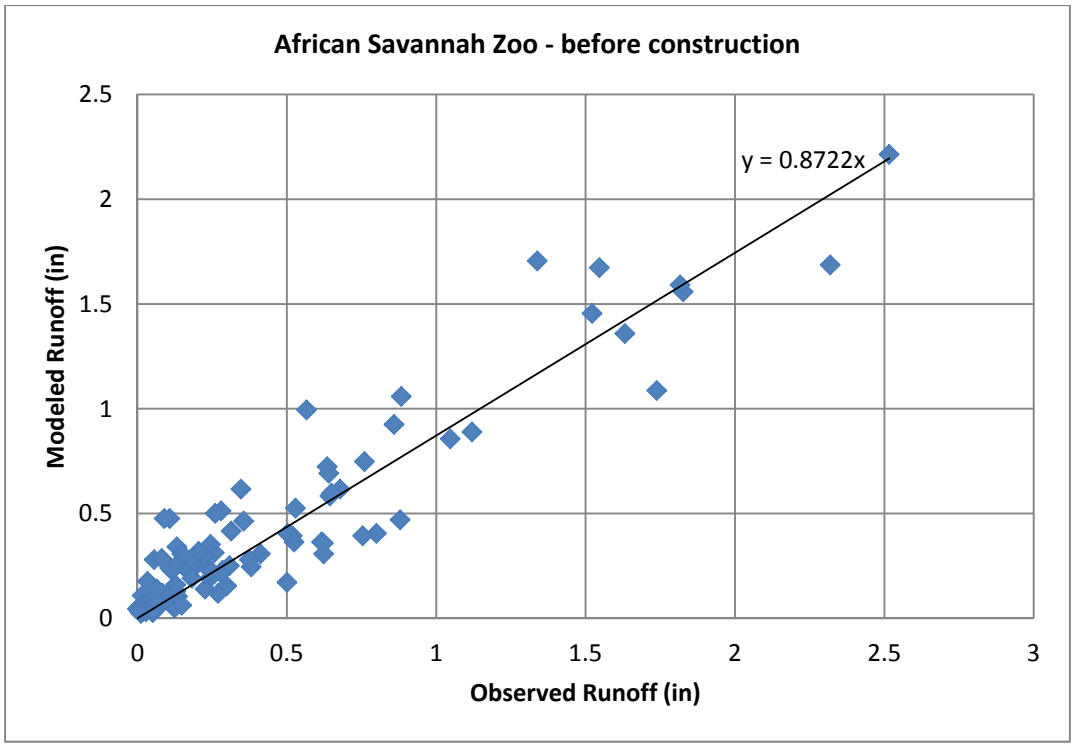

Figure 30. Observed versus modeled flows for African Savannah Zoo

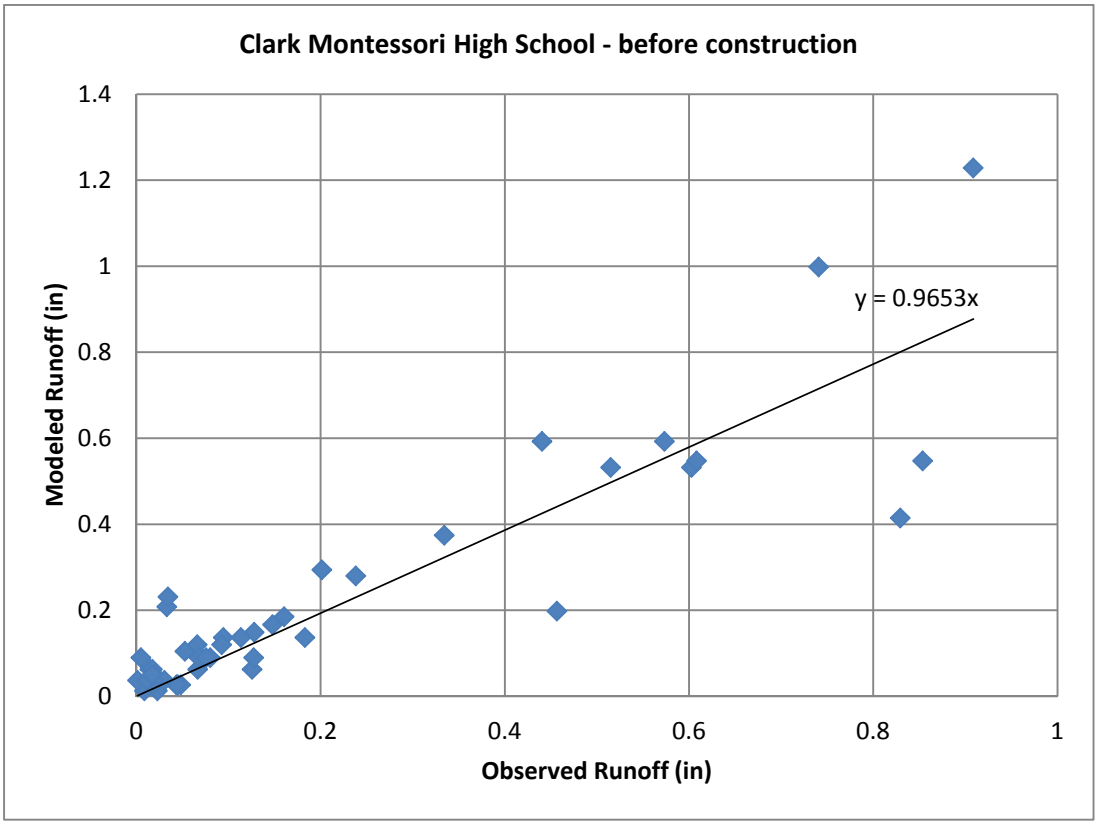

Figure 31. Observed versus modeled flows for Clark Montessori High School

Figures 32, 33, and 34 are box plots (using Minitab 16) that compare the single event observed flows to the modeled flows for Cincinnati State College separate sewer system, African Savannah Zoo, and Clark Montessori High School. For all three sites the modeled and observed boxes significantly overlap.

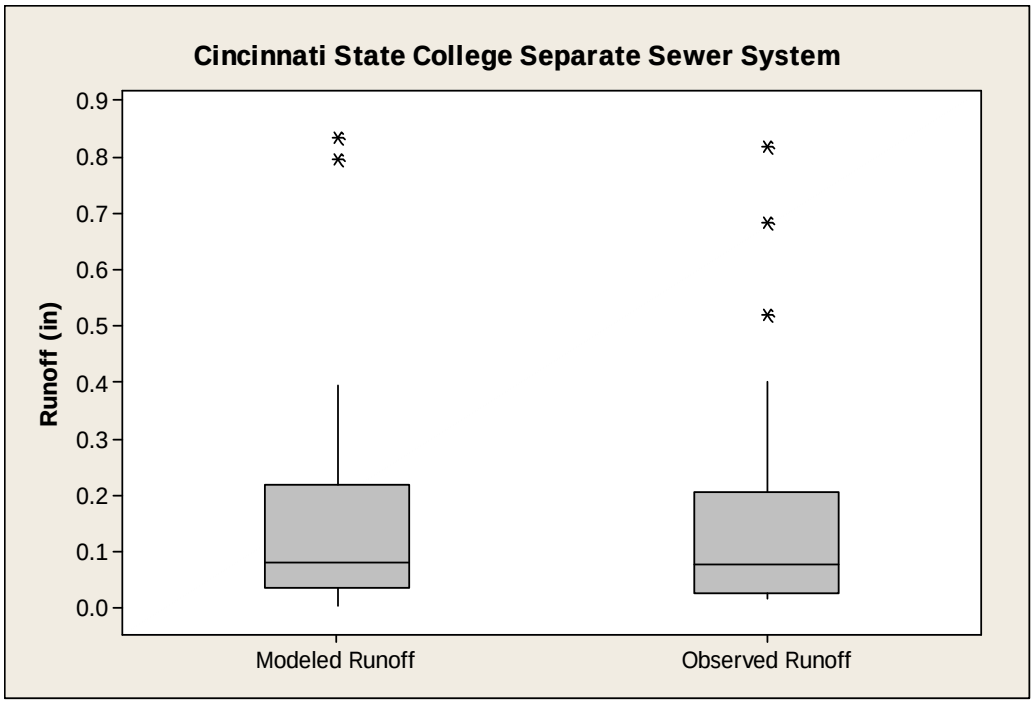

Figure 32. Variabilities of runoff volumes observed and modeled at Cincinnati State College Separate Sewer System.

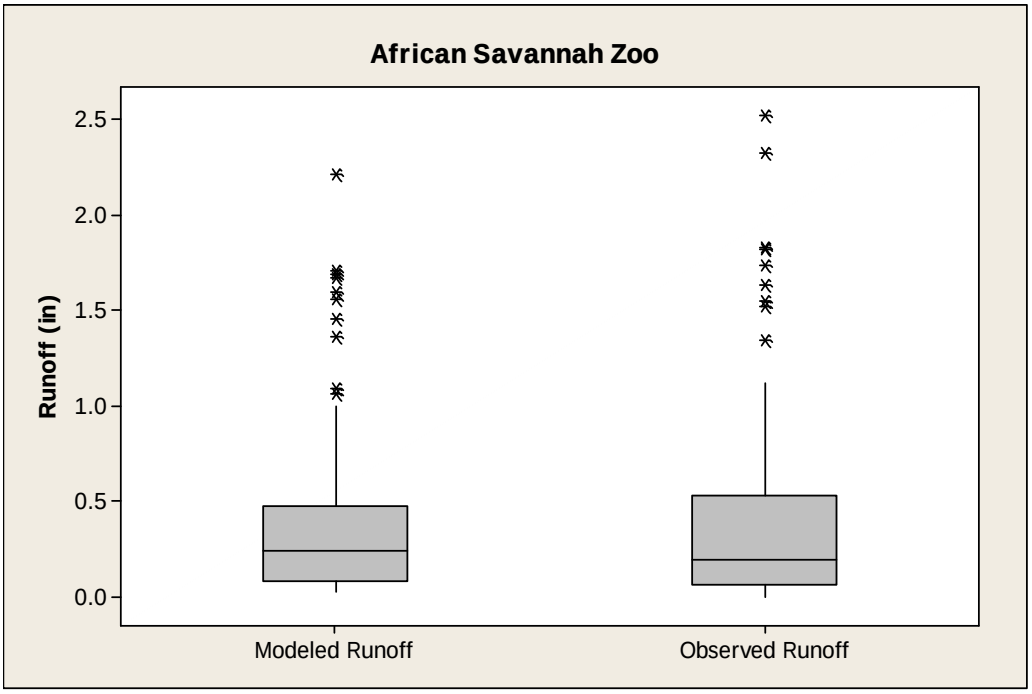

Figure 32. Variabilities of runoff volumes observed and modeled at African Savannah Zoo.

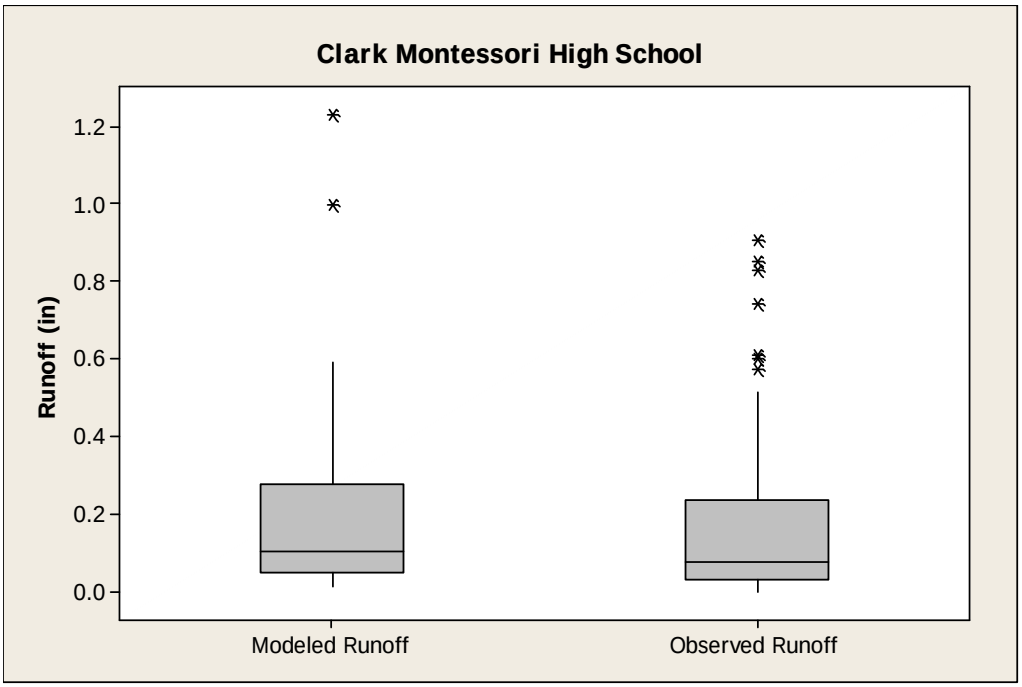

Figure 33. Variabilities of runoff volumes observed and modeled at Clark Montessori High School.

The Mann-Whitney Rank Sum Test (using Minitab 16) was used to compare the observed with the modeled runoff volumes for all three study areas.

- Cincinnati State College Separate Sewer System

Group	N	Missing	Median	25%	75%
Modeled flows	41	0	0.0824	0.0346	0.219
Observed flows	41	0	0.0771	0.0266	0.207

Mann-Whitney U Statistic= 839.000
T = 1700.000 n(small)= 41 n(big)= 41 (P = 0.993)

The difference in the median values between the observed and modeled runoff groups at Cincinnati State College (separate sewer system) is not great enough to exclude the possibility that the difference is because of random sampling variability; there is not a statistically significant difference (p = 0.993).

- African Savannah Zoo

Group	N	Missing	Median	25%	75%
Modeled flows	107	0	0.246	0.0858	0.470
Observed flows	107	0	0.195	0.0640	0.529

Mann-Whitney U Statistic= 5301.000
T = 11926.000 n(small)= 107 n(big)= 107 (P = 0.350)

The difference in the median values between the observed and modeled runoff groups at African Savannah Zoo is not great enough to exclude the possibility that the difference is because of random sampling variability; there is not a statistically significant difference (p = 0.350).

- Clark Montessori High School:

Group	N	Missing	Median	25%	75%
Modeled flows	47	0	0.104	0.0500	0.280
Observed flows	47	0	0.0757	0.0305	0.238

Mann-Whitney U Statistic= 965.000
T = 2372.000 n(small)= 47 n(big)= 47 (P = 0.293)

The difference in the median values between the observed and modeled runoff groups at Clark Montessori High School is not great enough to exclude the possibility that the difference is

because of random sampling variability; there is not a statistically significant difference (p = 0.293).

9.2. WinSLAMM modeling results

Figure 34 compares the modeled with the measured runoff volumes for the Cincinnati State College site (separate sewer system) for 75 events after GI construction. Figure 35 shows the box plot of measured vs. modeled flows for the after construction period. Figure 36 shows residual plots for the Cincinnati State College observed vs. calculated flows, while Figures 37 to 45 show similar graphs for the other study areas examined in Cincinnati, OH.

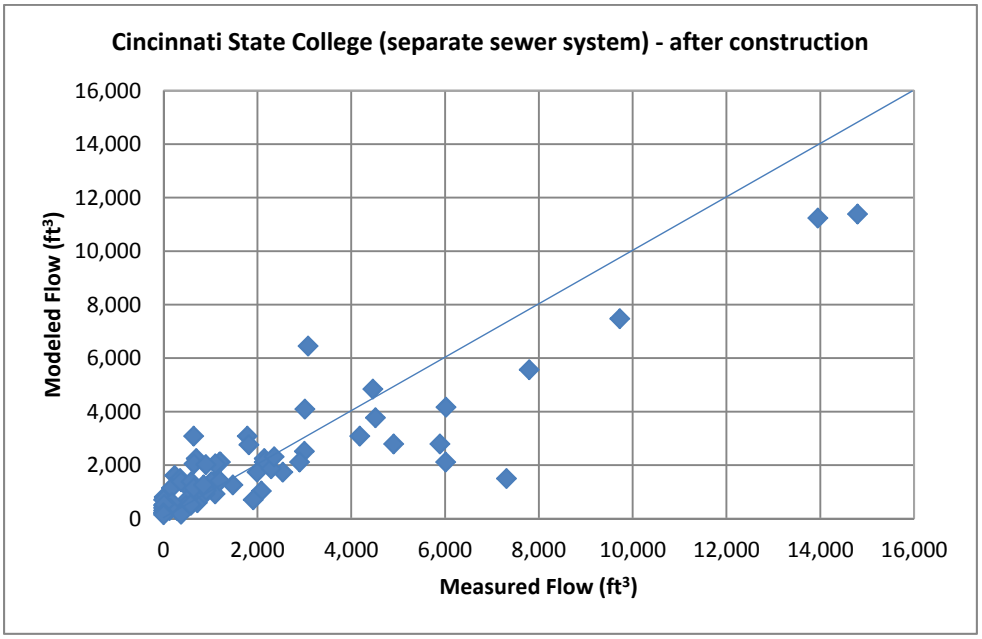

Figure 34. Observed and modeled flows for Cincinnati State College, after GI construction.

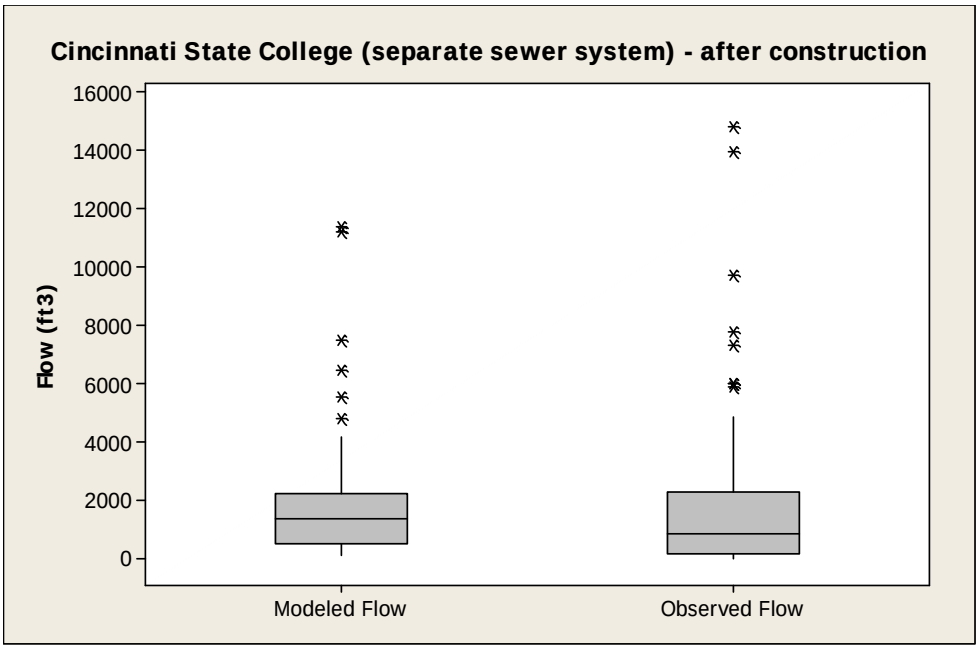

Figure 35. Box plot of modeled and observed flows for Cincinnati State College, after GI construction.

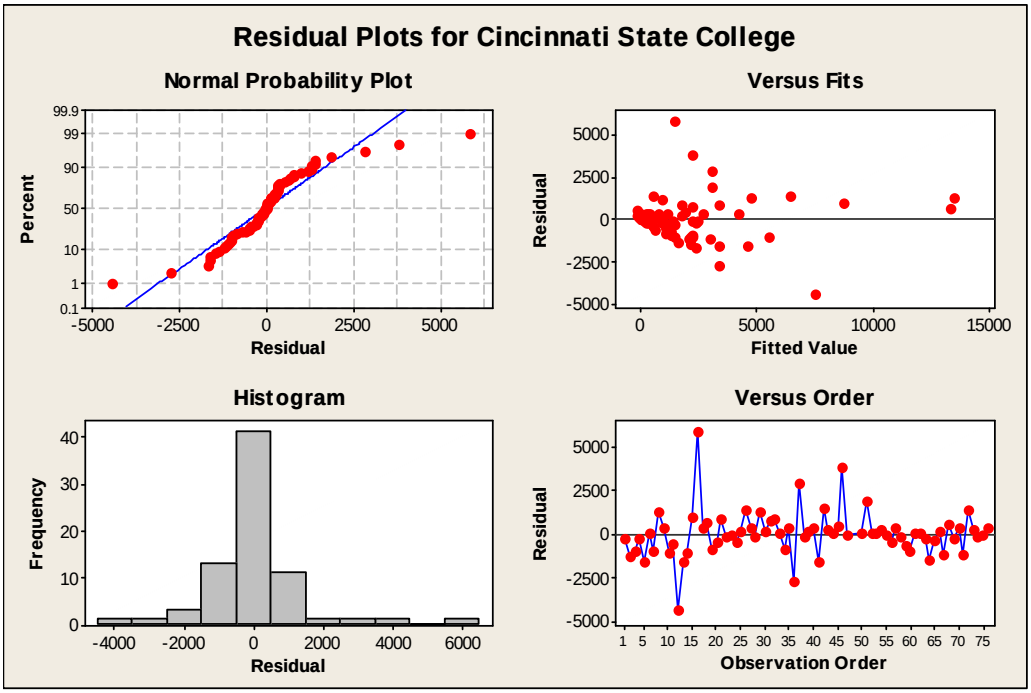

Figure 36. Residual plots for Cincinnati State College for observed vs. calculated flows, after GI construction.

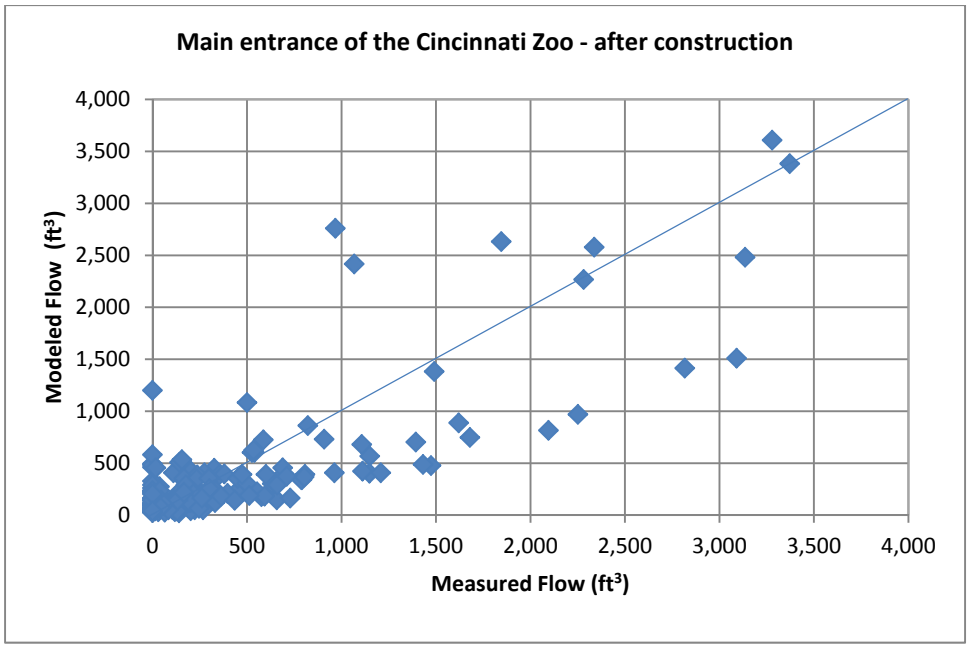

Figure 37. Observed and modeled flows for main entrance of the Cincinnati Zoo, after GI construction.

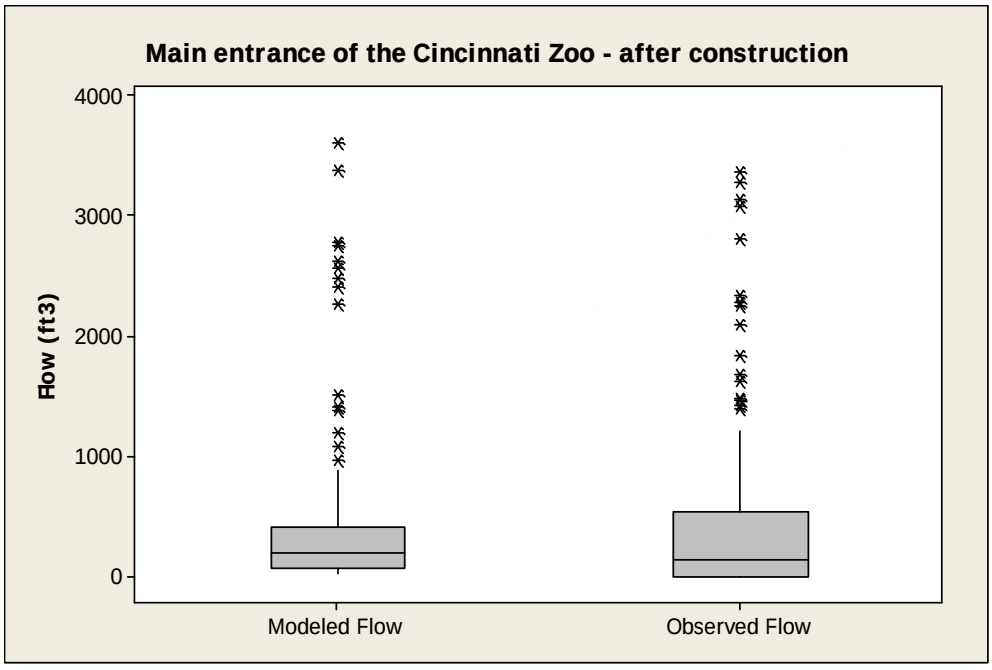

Figure 38. Box plot of modeled and observed flows for main entrance of the Cincinnati Zoo, after GI construction.

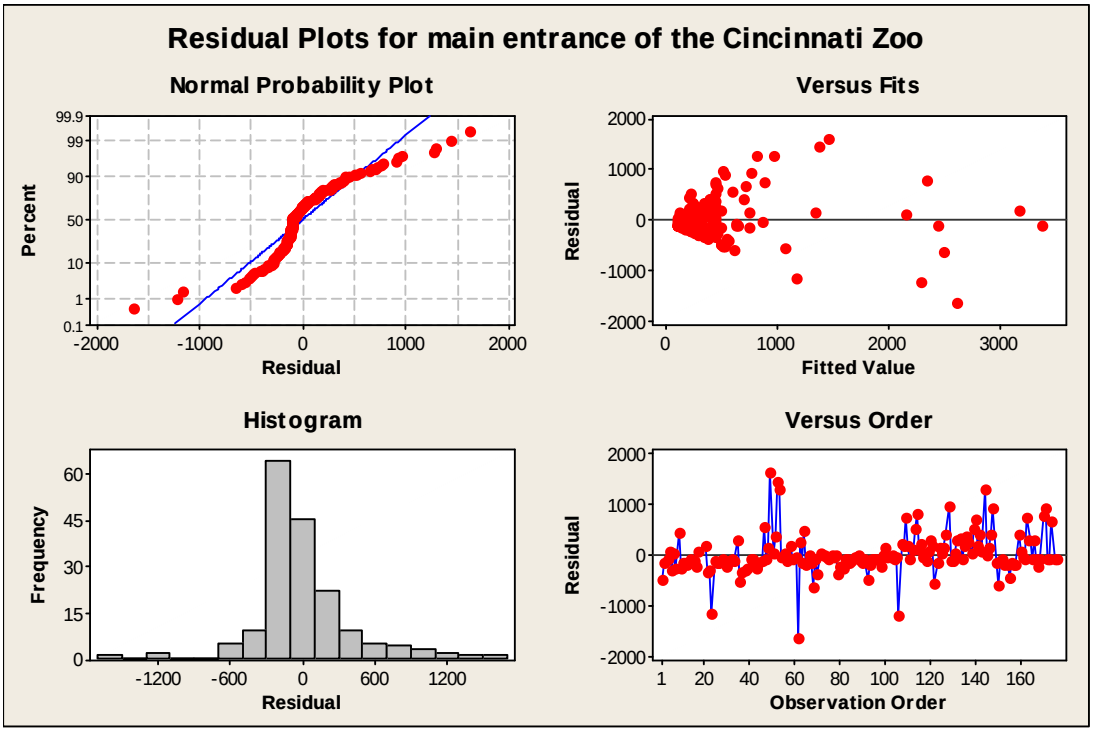

Figure 39. Residual plots for main entrance of the Cincinnati Zoo, after GI construction.

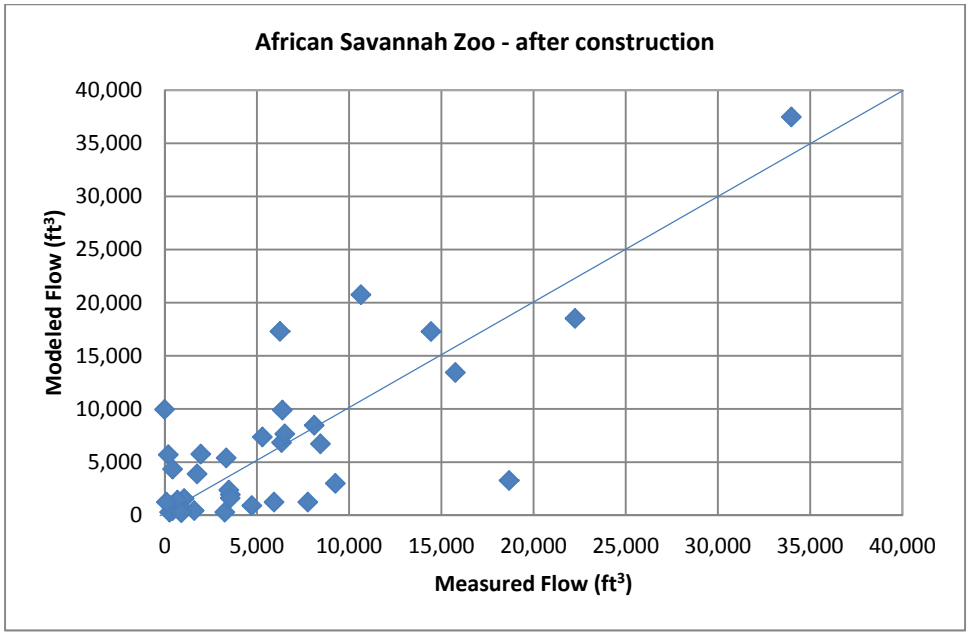

Figure 40. Observed and modeled flows for African Savannah Zoo, after GI construction.

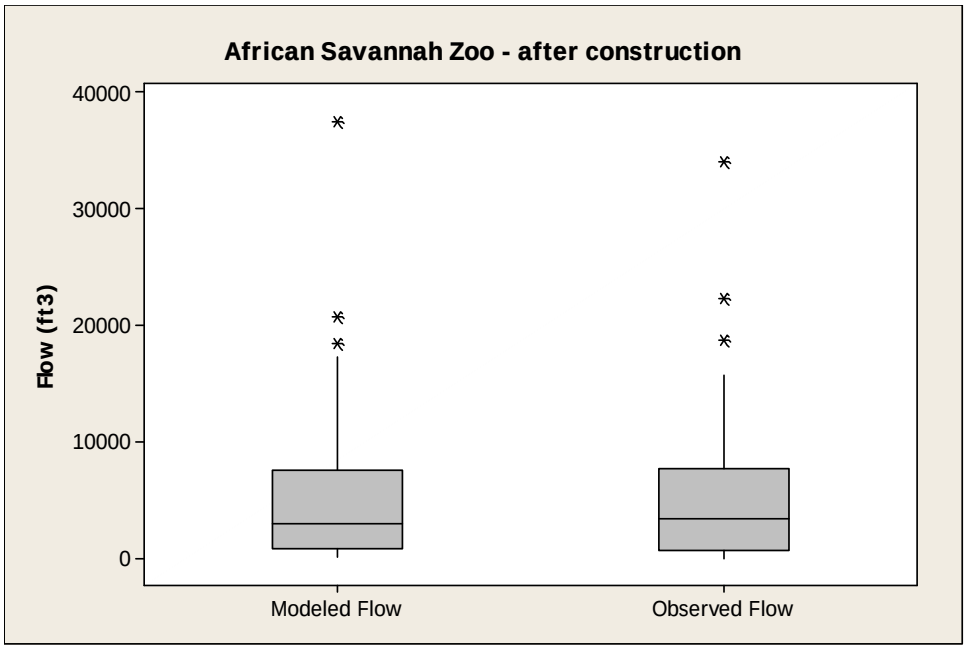

Figure 41. Box plot of modeled and observed flows for African Savannah Zoo, after GI construction.

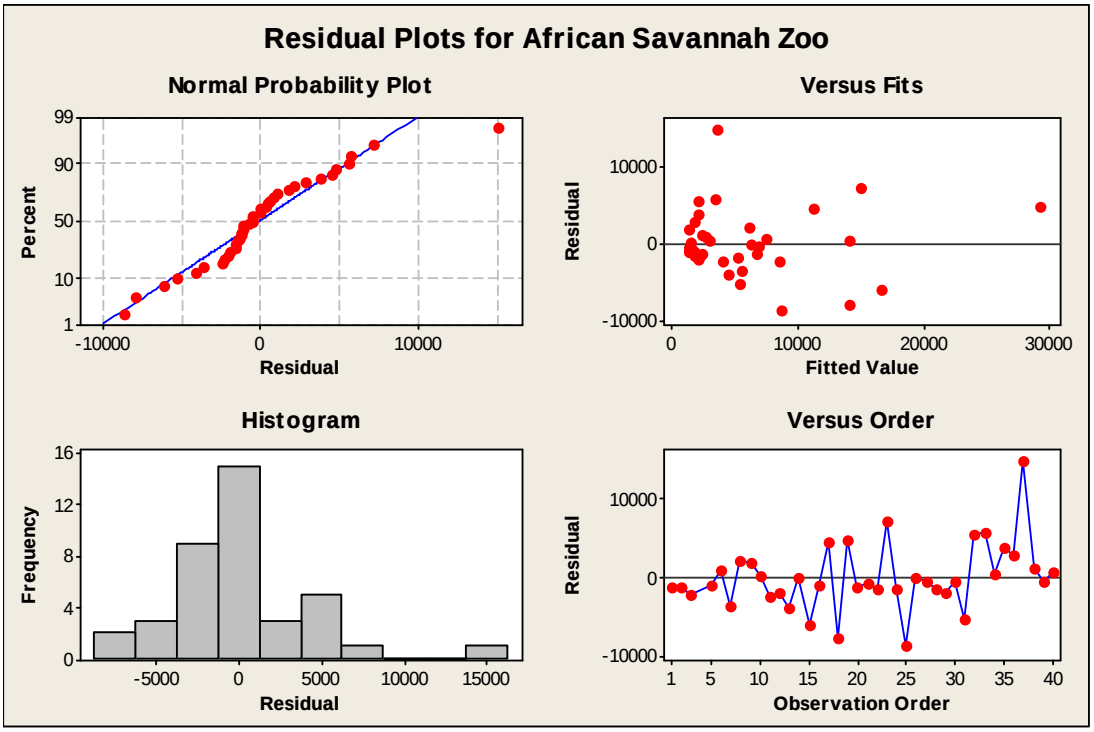

Figure 42. Residual plots for African Savannah Zoo, after GI construction.

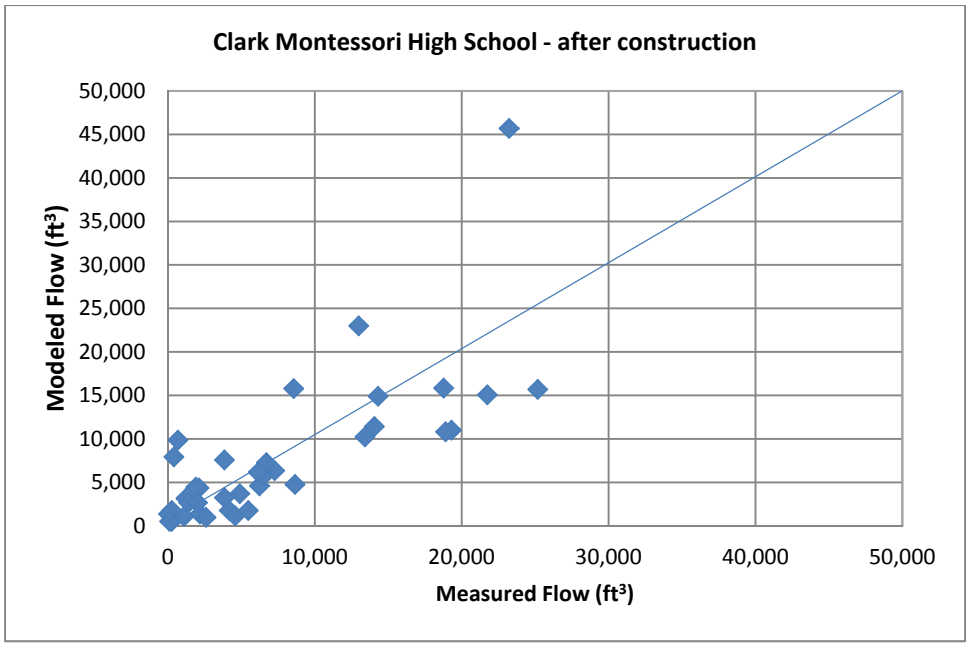

Figure 43. Observed and modeled flows for Clark Montessori High School, after GI construction.

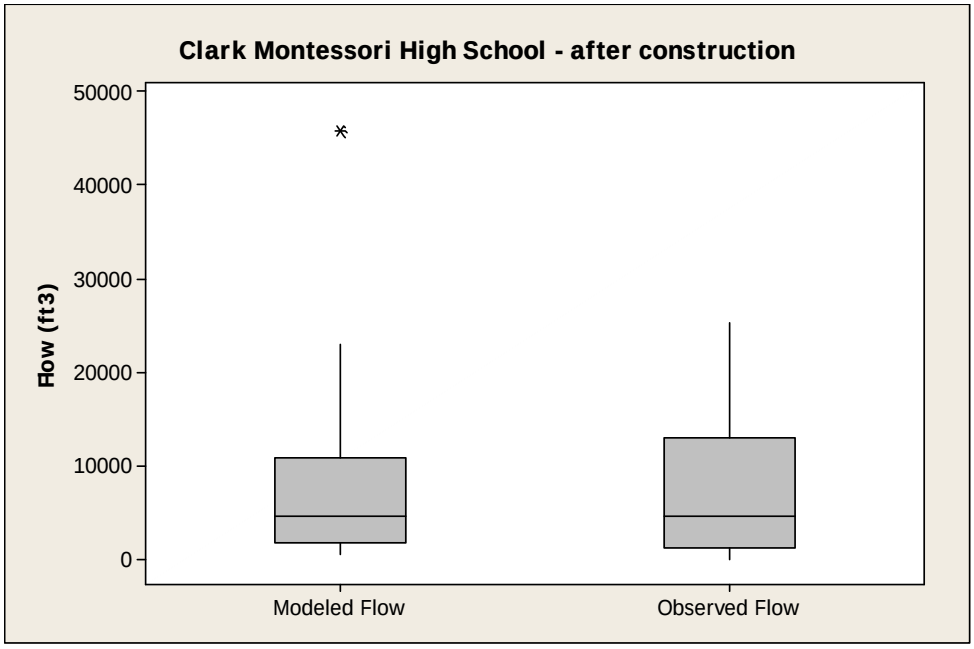

Figure 44. Box plot of modeled and observed flows for Clark Montessori High School, after GI construction.

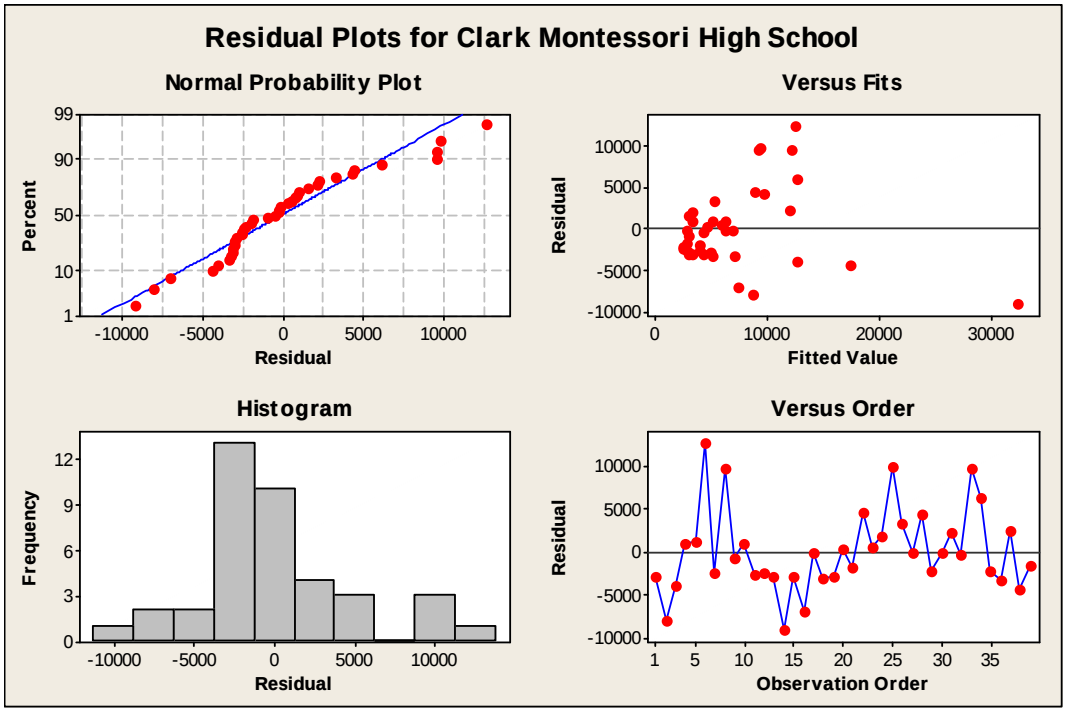

Figure 45. Residual plots for Clark Montessori High School for observed vs. modeled flows, after GI construction.

Table 17 summarizes the Rank Sum Test analysis results for all the study areas (using Minitab 16). As shown, the p-values for most of the areas are greater than 0.05, indicating that observed flows and modeled flows are not significantly different. For the main entrance of the Cincinnati Zoo the p-value is 0.031, which indicates that the difference in the median values between the two groups (observed flows vs. modeled flows) is greater than would be expected by chance, therefore there is a statistically significant difference between the two groups. One possible reason for differences in modeled and observed flows is that the before construction data were not available at the main entrance of the Cincinnati Zoo to calibrate the model. With a power analysis (alpha = 0.05, and beta = 0.2), the number of samples available and the monitored flow variations would allow differences of about 15% to 30%, or larger, to be detected.

Table 17. Summary of Rank Sum Test results for study areas in Cincinnati

Study area	Group	N	Median	25%	75%	Mann-Whitney U Statistic	T value	P-value	Significant difference between modeled and measures flow?
Cincinnati State College	Modeled flow (ft^3)	76	1378	523	2247	2251	6000	0.062	No
	Observed flow (ft^3)	76	865	176	2307				
Main entrance of the Cincinnati Zoo	Modeled flow (ft^3)	176	196	74	401	12802	31660	0.031	Yes
	Observed flow (ft^3)	176	146	0	550				
African Savannah Zoo	Modeled flow (ft^3)	40	2992	900	7649	740	1561	0.84	No
	Observed flow (ft^3)	40	3475	777	7765				
Clark Montessori High School	Modeled flow (ft^3)	39	4616	1775	10816	716	1585	0.66	No
	Observed flow (ft^3)	39	4583	1225	12990				

10. Summary and Conclusions

This report evaluated the effectiveness of green infrastructure stormwater controls in combined and separate sewer systems at three locations including Cincinnati State College, the Cincinnati Zoo, and the Clark Montessori High School sites. High-resolution flow measurements from in-system flow sensors were evaluated to measure the runoff volume reductions after GI facility construction at each study site. The flow data are available from before, during, and after stormwater controls construction for most of the study areas, and after construction for all.

Cincinnati State College southwest drainage area (separate sewer system) is approximately 8.7 acres and was monitored for about 170 events (including 76 post-construction events). This area contains four rain gardens and several pervious parking areas. The statistical analyses indicated about 85% reductions in runoff volume for this study area ($p < 0.001$). This supports the hypothesis that the flows being discharged from areas with GI stormwater controls are much less than would occur if the GI stormwater controls were not present. Since a monitored area with "no stormwater controls" was not available for this study area, the "before" construction runoff and rainfall data were used to calibrate WinSLAMM.

The main entrance of the Cincinnati Zoo has a 2.5 acre drainage area and is served by a separate sewer system. More than 60% of the area has been replaced by porous paver blocks. This area has been monitored for 176 events (all being in the post-construction period). The average Rv values after GI controls is about 0.1 (compared to about 0.8 for conventional pavement in the area, using calibrated WinSLAMM to predict pre-construction conditions).

The African Savannah area of the Cincinnati Zoo is served by a combined sewer system. This study area has different types of green infrastructure controls, including permeable pavers, and an underground rainwater harvesting storage system. In addition, the African Savannah area will have enhanced turf/vegetation, which is currently under construction. 107, 15, and 40 events were recorded during the before construction, during construction, and after construction periods, respectively. At the African Savannah study area, the statistical tests indicate that the "after" construction flows were significantly less than the "before" and "during" construction flows (about 70% reductions in runoff volume).

The Clark Montessori High School study area has various green stormwater controls including green roofs, permeable pavements, and bioretention facilities, but only a small portion of the whole drainage area is served by GI stormwater control practices. This area has been monitored during about 166 events, with 39 events during the post-construction period. The statistical analysis indicated 20% reductions in runoff volume and showed that the Rv values for the after construction period were significantly different from the before and during construction periods ($p < 0.05$). For this area, the runoff volume directed to the green infrastructure stormwater controls was estimated using WinSLAMM to be about 20% to 25% of the total watershed area

runoff. Therefore, the maximum level of flow reductions that could have been associated with the stormwater controls was estimated to be 20% to 25%, close to the reductions observed.

WinSLAMM was calibrated using before construction period data, if available. The as-built stormwater control designs were then included in the model and the calculated flows were then compared to the monitored flows after construction. In all cases, the agreement between the modeled and observed flows were very good, indicating the ability to expand results from small-scale monitoring to larger systems, as long as critical site characteristics are known.

Analyses indicate that for most of the study watersheds, the post-construction pipe flow data are significantly less than the pre-construction pipe flow data. Table 18 summarizes the runoff volume reductions (percentages) compared to pre-construction period for each monitoring location.

Table 18. Summary of runoff volume reduction

Location	**Runoff Volume Reduction (%) Compared to Pre-Construction Data**
Cincinnati State College – Southern Area (bioinfiltration and rain gardens)	85 ($p<0.001$)
Cincinnati Zoo – Main Entrance (extensive paver blocks)	>80 (Average R_v values after construction are about 0.1 ,compared to about 0.8 for conventional pavement)
Cincinnati Zoo – African Savannah (rainwater harvesting system and pavement removal)	70 ($p<0.001$)
Clark Montessori High School (green roofs and parking lot biofilters on small portion of watershed)	20 ($p = 0.027$)

10.1 Recommendations for Flow Monitoring for Green Infrastructure Performance Evaluations

- Soil surveys at pilot-scales are needed to identify site selection of GI stormwater controls in order to maximize their benefits.
- It is essential to have adequate rain gauges (at least several) near the flow sensors in the study area.
- Monitor as many rain events as practical, due to high variability in data. This also helps analyze GI benefits for different ranges of rain events. The experimental design of the

monitoring plan must quantify the likely expected detectable level of performance through a power analysis.

- Monitor adjacent test and control areas during before and after construction of stormwater controls for the greatest reliability (to account for typical year-to-year rainfall variations and to detect sensor problems early).
- Test areas should have most of their flows treated by the control practices to maximize measurable reductions.
    - Any untreated up-gradient areas should be very small in comparison to the test areas. Difficult to subtract two large numbers (each having measurement errors and other sources of variability), such as above- and down-gradient monitoring stations, and have confidence on the targeted flows.
- Most monitored flows from common rains may only result in shallow depths in the sewerage, a flow condition that is difficult to accurately monitor.
- Flow sensors may fail more often than expected.
- Costs of flow monitoring are small compared to green infrastructure investment.
    - Use redundant sensors, such as an area-velocity sensor (or bubbler) in addition to an acoustic depth sensor mounted on the crown.
    - Calibrate the flow sensors at the beginning and periodically throughout the project period.
    - Review flow data frequently and completely to identify sensor failures or other issues.
    - Supplement the flow sensors with adequate numbers and placement of rain gages in the watersheds.
    - Use hydraulic control sections to obtain the most accurate flow data. Normally, these are not used in combined sewers due to issues associated with head loss or clogging. However, if placed on the downgradient side of large manholes, pooled wastewater can flow through a v-notch weir after some partial settling and the large area reduces head loss issues. Again, use redundant depth sensors to optimize both shallow and deep flow depths.

Appendix A

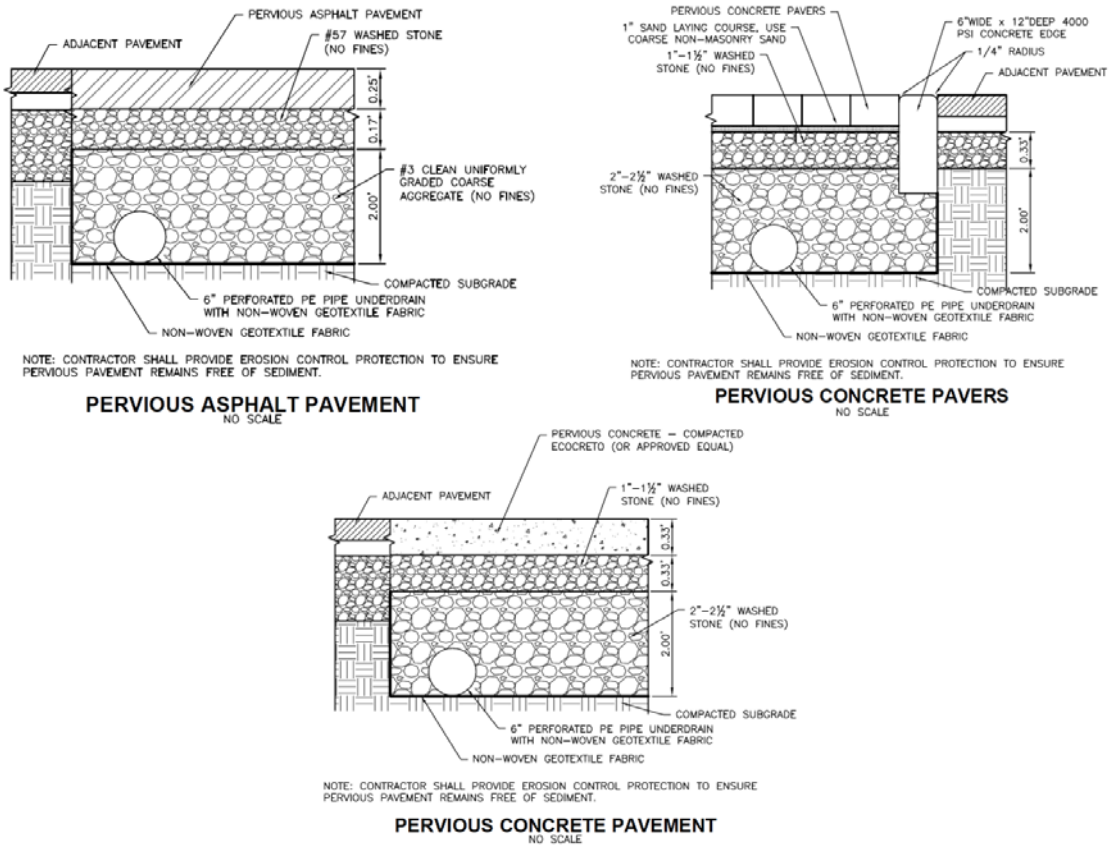

Figure A-1 Permeable pavement/pavers typical details

(Source: MSDGC Green Demonstration Project, Part 1, Appendix A, Sheet NO. C500, April 19, 2010.)

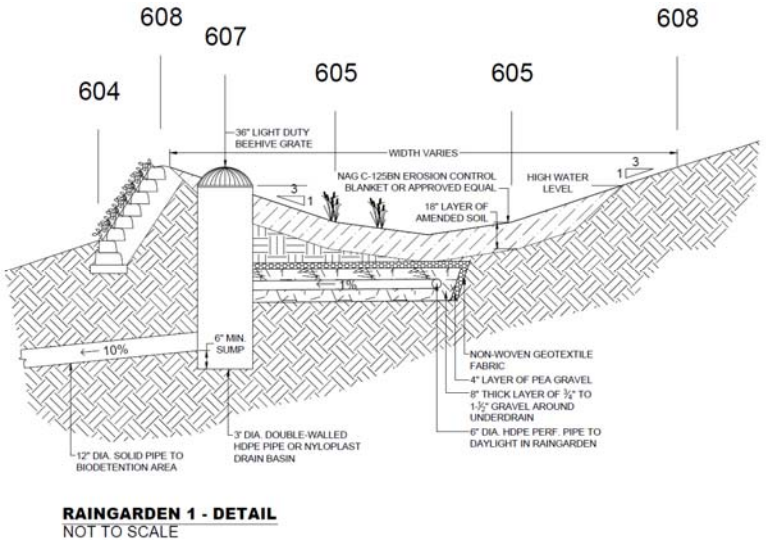

Figure A-2 Rain garden typical details

(Source: MSDGC Green Demonstration Project, Part 1, Appendix A, Sheet NO. C500, April 19, 2010.)

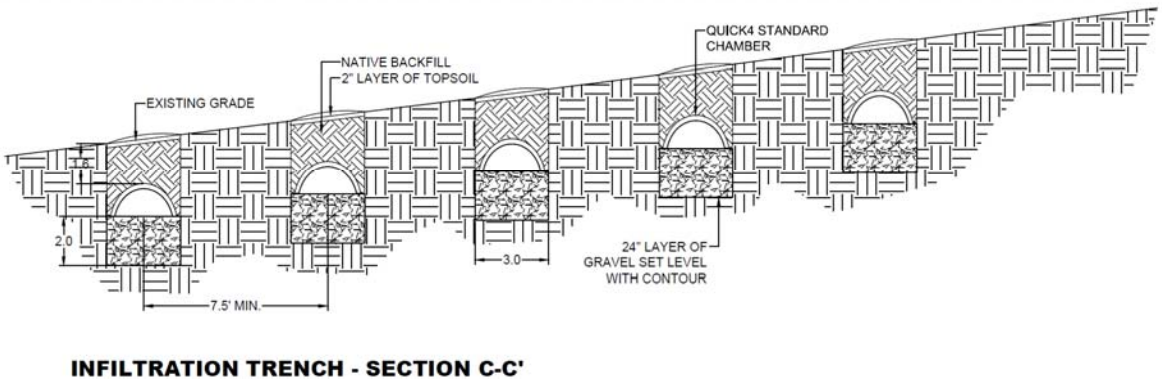

Figure A-3 Infiltration trench typical details

(Source: MSDGC Green Demonstration Project, Part 1, Appendix A, Sheet NO. C500, April 19, 2010.)

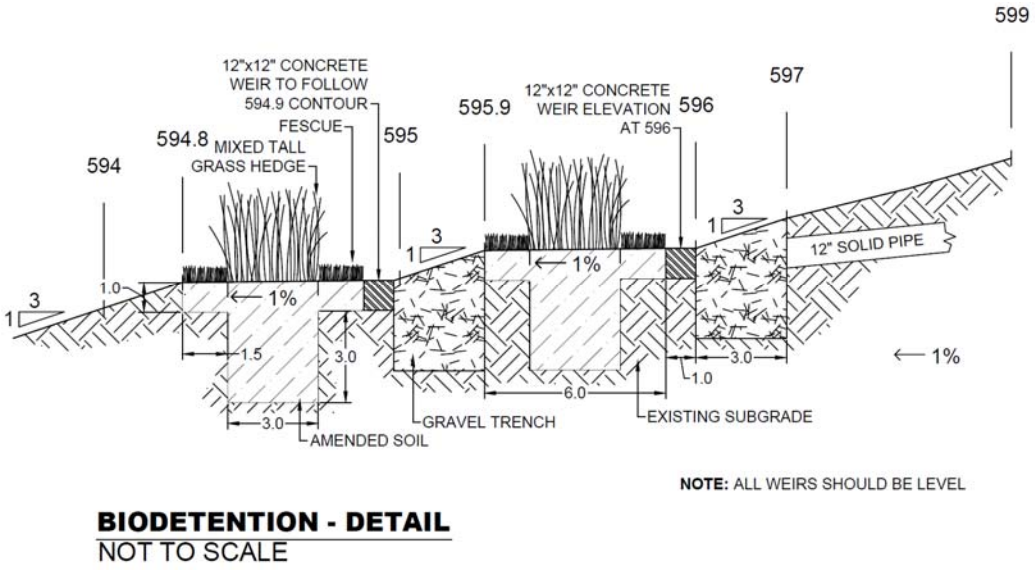

Figure A-4 Biodetention typical details

(Source: MSDGC Green Demonstration Project, Part 1, Appendix A, Sheet NO. C500, April 19, 2010.)

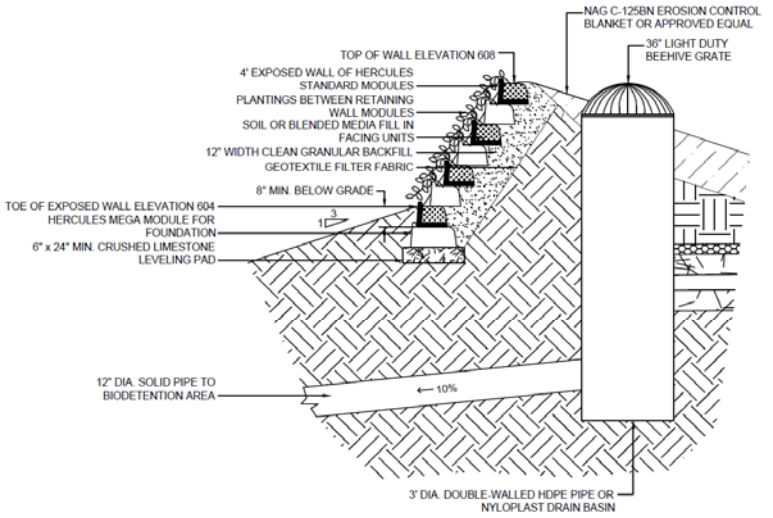

Figure A-5 Retaining wall details

(Source: MSDGC Green Demonstration Project, Part 1, Appendix A, Sheet NO. C500, April 19, 2010.)

Appendix B

Rainfall characteristics for downstream flow monitoring location at Cincinnati State College combined sewer system (Manhole 29612032)

Event #	Rain start date	Rain start time	Rain end date	Rain end time	Antecedent dry days	Rain dur. (hrs)	Total rain (in)	5-minute peak rain intensity (in/hr)	Avg rain int. (in/hr)
1	8/5/2012	16:10	8/5/2012	16:15		0.08	0.04	0.48	0.48
2	8/10/2012	2:05	8/10/2012	4:30	4.41	2.42	0.32	0.96	0.13
3	8/17/2012	7:50	8/17/2012	7:55	7.14	0.08	0.04	0.48	0.48
4	8/27/2012	16:50	8/27/2012	17:10	10.37	0.33	0.08	0.48	0.24
5	10/1/2012	16:15	10/1/2012	21:05		4.83	0.74	1.43	0.15
6	10/5/2012	19:45	10/6/2012	0:30	3.94	4.75	0.44	0.66	0.09
7	10/14/2012	16:50	10/14/2012	19:20	8.68	2.50	0.19	0.52	0.08
8	10/19/2012	13:25	10/20/2012	0:20	4.75	10.92	0.25	0.23	0.02
9	10/20/2012	13:15	10/20/2012	13:30	0.54	0.25	0.01	0.06	0.04
10	10/26/2012	12:00	10/27/2012	0:55	5.94	12.92	0.78	0.32	0.06
11	10/30/2012	0:55	10/31/2012	17:50	3.00	40.92	0.48	0.11	0.01
12	11/3/2012	10:45	11/3/2012	16:10	2.70	5.42	0.12	0.13	0.02
13	11/12/2012	3:50	11/12/2012	13:45	8.49	9.92	0.77	0.32	0.08
14	11/26/2012	22:55	11/27/2012	2:15	14.38	3.33	0.10	0.05	0.03
15	12/2/2012	7:25	12/2/2012	11:30	5.22	4.08	0.52	0.77	0.13
16	12/4/2012	15:35	12/4/2012	19:25	2.17	3.83	0.25	0.70	0.07
17	12/7/2012	0:15	12/7/2012	18:20	2.20	18.08	0.99	0.39	0.05
18	12/9/2012	16:50	12/10/2012	0:25	1.94	7.58	1.38	2.64	0.18
19	12/15/2012	11:55	12/15/2012	15:00	5.48	3.08	0.09	0.17	0.03
20	12/17/2012	12:35	12/18/2012	4:40	1.90	16.08	0.57	1.90	0.04
21	12/20/2012	7:15	12/20/2012	19:55	2.11	12.67	0.86	0.47	0.07

Runoff characteristics for downstream flow monitoring location at Cincinnati State College combined sewer system (Manhole 29612032)

Event #	Pipeflow start date	Pipeflow start time	Pipeflow end date	Flow end time	Flow dur. (hrs)	Total pipeflow discharge volume (ft3)	Total disch. (in)	5-minute Peak flow disch. rate (CFS)	5-minute Avg flow disch. rate (CFS)	Peak/avgpipeflow rate ratio	Rv (Runoff Depth/Rain Depth)	flow/ rain dur. ratio
1	8/5/2012	14:55	8/5/2012	16:20	1.42	5,580	0.004	3.51	1.09	3.22	0.11	17.00
2	8/10/2012	2:05	8/10/2012	9:20	7.25	37,919	0.029	4.4	1.45	3.03	0.09	3.00
3	8/17/2012	8:00	8/17/2012	10:50	2.83	12,666	0.010	2.96	1.21	2.45	0.24	34.00
4	8/27/2012	15:30	8/27/2012	18:50	3.33	13,314	0.010	2.64	1.11	2.38	0.13	10.00
5	10/1/2012	17:45	10/2/2012	20:35	26.83	114,691	0.088	6.33	1.19	5.32	0.12	5.55
6	10/5/2012	21:00	10/6/2012	12:30	15.50	82,501	0.063	6.31	1.48	4.26	0.14	3.26
7	10/14/2012	18:00	10/15/2012	0:40	6.67	21,651	0.017	4.29	0.9	4.77	0.09	2.67
8	10/19/2012	15:20	10/20/2012	7:15	15.92	64,368	0.049	3.79	1.12	3.38	0.20	1.46
9						0	0.000					
10	10/26/2012	12:25	10/28/2012	2:30	38.08	241,875	0.185	4.76	1.76	2.70	0.24	2.95
11	10/30/2012	4:30	10/31/2012	23:55	43.42	270,276	0.207	5.17	1.73	2.99	0.43	1.06
12	11/3/2012	15:20	11/3/2012	23:25	8.08	23,054	0.018	3.5	0.79	4.43	0.14	1.49
13	11/12/2012	4:15	11/12/2012	23:40	19.42	141,016	0.108	5.29	2.02	2.62	0.14	1.96
14	11/27/2012	0:50	11/27/2012	3:15	2.42	10,919	0.008	2.72	1.21	2.25	0.08	0.72
15	12/2/2012	8:10	12/2/2012	14:30	6.33	37,313	0.029	6.33	1.64	3.86	0.05	1.55
16	12/4/2012	16:20	12/5/2012	0:20	8.00	56,994	0.044	14.25	1.94	7.35	0.17	2.09
17	12/7/2012	0:30	12/9/2012	16:40	64.17	587,551	0.449	7.88	2.54	3.10	0.45	3.55
18	12/9/2012	16:45	12/12/2012	1:20	56.58	494,906	0.378	71.21	2.43	29.30	0.27	7.46
19	12/15/2012	12:25	12/15/2012	16:55	4.50	20,043	0.015	3.52	1.21	2.91	0.17	1.46
20	12/17/2012	13:35	12/18/2012	10:45	21.17	128,178	0.098	14.98	1.68	8.92	0.17	1.32
21	12/20/2012	7:40	12/22/2012	7:35	47.92	295,040	0.226	9.26	1.71	5.42	0.26	3.78

Rainfall characteristics for upstream flow monitoring location at Cincinnati State College combined sewer system (Manhole 29612050)

Event #	Rain start date	Rain start time	Rain end date	Rain end time	Antecedent dry days	Rain dur. (hrs)	Total rain (in)	5-minute peak rain intensity (in/hr)	Avg rain int. (in/hr)
1	8/5/2012	16:10	8/5/2012	16:15		0.08	0.04	0.48	0.48
2	8/10/2012	2:05	8/10/2012	4:30	4.41	2.42	0.32	0.96	0.13
3	8/17/2012	7:50	8/17/2012	7:55	7.14	0.08	0.04	0.48	0.48
4	8/27/2012	16:50	8/27/2012	17:10	10.37	0.33	0.08	0.48	0.24
5	10/1/2012	16:15	10/1/2012	21:05		4.83	0.74	1.43	0.15
6	10/5/2012	19:45	10/6/2012	0:30	3.94	4.75	0.44	0.66	0.09
7	10/14/2012	16:50	10/14/2012	19:20	8.68	2.50	0.19	0.52	0.08
8	10/19/2012	13:25	10/20/2012	0:20	4.75	10.92	0.25	0.23	0.02
9	10/20/2012	13:15	10/20/2012	13:30	0.54	0.25	0.01	0.06	0.04
10	10/26/2012	12:00	10/27/2012	0:55	5.94	12.92	0.78	0.32	0.06
11	10/30/2012	0:55	10/31/2012	17:50	3.00	40.92	0.48	0.11	0.01
12	11/3/2012	10:45	11/3/2012	16:10	2.70	5.42	0.12	0.13	0.02
13	11/12/2012	3:50	11/12/2012	13:45	8.49	9.92	0.77	0.32	0.08
14	11/26/2012	22:55	11/27/2012	2:15	14.38	3.33	0.10	0.05	0.03
15	12/2/2012	7:25	12/2/2012	11:30	5.22	4.08	0.52	0.77	0.13
16	12/4/2012	15:35	12/4/2012	19:25	2.17	3.83	0.25	0.70	0.07
17	12/7/2012	0:15	12/7/2012	18:20	2.20	18.08	0.99	0.39	0.05
18	12/9/2012	16:50	12/10/2012	0:25	1.94	7.58	1.38	2.64	0.18
19	12/15/2012	11:55	12/15/2012	15:00	5.48	3.08	0.09	0.17	0.03
20	12/17/2012	12:35	12/18/2012	4:40	1.90	16.08	0.57	1.90	0.04
21	12/20/2012	7:15	12/20/2012	19:55	2.11	12.67	0.86	0.47	0.07

Runoff characteristics for upstream flow monitoring location at Cincinnati State College combined sewer system (Manhole 29612050)

Event #	Pipeflow start date	Pipeflow start time	Pipeflow end date	Flow end time	Flow dur. (hrs)	Total pipeflow discharge volume (ft3)	Total disch. (in)	5-minute Peak flow disch. rate (CFS)	5-minute Avg flow disch. rate (CFS)	Peak/avgpipeflow rate ratio	Rv (Runoff Depth/Rain Depth)	flow/ rain dur. ratio
1	8/5/2012	14:55	8/5/2012	16:25	1.50	2,658	0.002	2.12	0.49	4.33	0.05	18.00
2	8/10/2012	1:55	8/10/2012	9:30	7.58	19,238	0.016	2.58	0.7	3.69	0.05	3.14
3	8/17/2012	8:00	8/17/2012	10:50	2.83	3,196	0.003	1.14	0.3	3.80	0.07	34.00
4	8/27/2012	16:50	8/27/2012	18:50	2.00	3,715	0.003	1.33	0.50	2.66	0.04	6.00
5	10/1/2012	17:45	10/2/2012	18:45	25.00	55,455	0.046	5.67	0.61	9.30	0.06	5.17
6	10/5/2012	22:50	10/6/2012	7:55	9.08	27,531	0.023	4.21	0.84	5.01	0.05	1.91
7	10/14/2012	18:00	10/14/2012	19:00	1.00	5,352	0.004	3.16	1.49	2.12	0.02	0.40
8	10/19/2012	15:20	10/20/2012	7:10	15.83	17,044	0.014	1.12	0.3	3.73	0.06	1.45
9						0	0.000					
10	10/26/2012	12:45	10/27/2012	8:30	19.75	71,266	0.059	2.08	1	2.08	0.08	1.53
11	10/30/2012	4:30	10/31/2012	23:55	43.42	77,841	0.064	2.00	0.5	4.00	0.13	1.06
12	11/3/2012	15:40	11/3/2012	23:25	7.75	8,454	0.007	1.26	0.3	4.20	0.06	1.43
13	11/12/2012	4:15	11/12/2012	23:40	19.42	62,831	0.052	3.02	0.9	3.36	0.07	1.96
14	11/27/2012	1:10	11/27/2012	2:25	1.25	945	0.001	0.43	0.2	2.15	0.01	0.38
15	12/2/2012	8:15	12/2/2012	12:00	3.75	17,841	0.015	4.8	1.29	3.72	0.03	0.92
16	12/4/2012	16:20	12/4/2012	23:55	7.58	19,736	0.016	4.86	0.71	6.85	0.06	1.98
17	12/7/2012	0:35	12/8/2012	18:45	42.17	123,758	0.102	4.27	0.81	5.27	0.10	2.33
18	12/9/2012	17:40	12/10/2012	8:35	14.92	72,882	0.060	18.7	1.36	13.75	0.04	1.97
19	12/15/2012	12:35	12/15/2012	16:55	4.33	2,682	0.002	0.7	0.17	4.12	0.02	1.41
20	12/17/2012	13:55	12/18/2012	10:45	20.83	39,588	0.033	4.97	0.53	9.38	0.06	1.30
21	12/20/2012	7:45	12/22/2012	7:35	47.83	143,887	0.118	5.59	0.84	6.65	0.14	3.78

Rainfall characteristics during different flow monitoring periods for Cincinnati State College separate sewer system (manhole number 29606027)

Event #	Rain start date	Rain start time	Rain end date	Rain end time	Antecedent dry days	Rain dur. (hrs)	Total rain [a] (in)	5-minute peak rain intensity (in/hr)	Avg rain int. (in/hr)
1	3/11/2010	9:00	3/11/2010	9:10		0.17	0.08	0.48	0.48
2	3/11/2010	16:00	3/11/2010	16:05	0.28	0.08	0.04	0.48	0.48
3	3/12/2010	17:40	3/12/2010	20:55	1.07	3.25	0.84	2.89	0.26
4	3/13/2010	9:15	3/13/2010	19:25	0.51	10.17	0.44	0.48	0.04
5	3/21/2010	23:25	3/22/2010	5:05	8.17	5.67	0.60	0.48	0.11
6	3/25/2010	15:10	3/26/2010	1:10	3.42	10.00	1.20	0.96	0.12
7	3/28/2010	14:15	3/28/2010	14:35	2.55	0.33	0.08	0.48	0.24
8	4/8/2010	0:55	4/8/2010	8:20	10.43	7.42	0.52	0.96	0.07
9	4/23/2010	10:50	4/23/2010	14:10	15.10	3.33	0.28	0.96	0.08
10	4/24/2010	17:00	4/24/2010	22:25	1.12	5.42	0.72	1.45	0.13
11	4/25/2010	15:00	4/25/2010	18:00	0.69	3.00	0.12	0.48	0.04
12	5/2/2010	3:20	5/2/2010	21:45	6.39	18.42	1.36	1.45	0.07
13	5/11/2010	4:40	5/11/2010	8:30	8.29	3.83	0.32	1.45	0.08
14	5/12/2010	7:40	5/12/2010	13:15	0.97	5.58	0.88	1.45	0.16
15	5/16/2010	20:40	5/16/2010	22:50	4.31	2.17	0.12	0.48	0.06
16	5/17/2010	5:25	5/17/2010	6:55	0.27	1.50	0.20	0.48	0.13
17	5/21/2010	2:00	5/21/2010	3:20	3.80	1.33	0.12	0.48	0.09
18	5/21/2010	16:20	5/21/2010	17:45	0.54	1.42	0.36	0.96	0.25
19	6/6/2010	8:25	6/6/2010	8:50	15.61	0.42	0.24	1.45	0.58
20	6/9/2010	5:50	6/9/2010	6:10	2.88	0.33	0.24	0.96	0.72
21	6/12/2010	7:40	6/12/2010	12:25	3.06	4.75	2.84	3.37	0.60
22	6/13/2010	3:20	6/13/2010	3:30	0.62	0.17	0.12	0.96	0.72
23	6/14/2010	22:30	6/14/2010	23:50	1.79	1.33	0.40	2.41	0.30
24	6/15/2010	20:40	6/15/2010	22:10	0.87	1.50	0.56	1.93	0.37
25	6/19/2010	7:15	6/19/2010	8:55	3.38	1.67	0.52	1.45	0.31
26	6/21/2010	12:30	6/21/2010	14:20	2.15	1.83	0.28	1.93	0.15
27	6/27/2010	23:30	6/28/2010	4:20	6.38	4.83	1.20	3.86	0.25
28	7/9/2010	11:05	7/9/2010	12:40	11.28	1.58	0.48	1.93	0.30
29	7/17/2010	17:20	7/17/2010	17:55	8.19	0.58	0.60	2.89	1.03
30	7/20/2010	20:00	7/20/2010	22:10	3.09	2.17	0.32	0.96	0.15
31	8/11/2010	15:05	8/11/2010	15:10	21.70	0.08	0.24	2.88	2.88
32	8/15/2010	16:55	8/15/2010	17:25	4.07	0.50	0.24	0.96	0.48
33	9/11/2010	10:25	9/11/2010	10:40	26.71	0.25	0.12	0.96	0.48
34	9/16/2010	3:00	9/16/2010	6:20	4.68	3.33	0.20	0.96	0.06
35	10/13/2010	18:55	10/13/2010	22:15	27.52	3.33	0.08	0.48	0.02
36	10/26/2010	12:30	10/26/2010	16:50	12.59	4.33	1.52	5.78	0.35
37	11/16/2010	11:10	11/16/2010	21:45	20.76	10.58	1.16	1.45	0.11
38	11/23/2010	1:35	11/23/2010	4:05	6.16	2.50	0.92	2.89	0.37
39	11/24/2010	13:20	11/24/2010	23:00	1.39	9.67	1.04	0.96	0.11
40	11/25/2010	6:10	11/25/2010	23:25	0.30	17.25	2.72	1.45	0.16
41	11/29/2010	22:00	11/30/2010	4:10	3.94	6.17	1.00	0.96	0.16
42	1/1/2011	1:25	1/1/2011	8:40	31.89	7.25	0.48	0.48	0.07

Event #	Rain start date	Rain start time	Rain end date	Rain end time	Antecedent dry days	Rain dur. (hrs)	Total rain [a] (in)	5-minute peak rain intensity (in/hr)	Avg rain int. (in/hr)
43	1/18/2011	8:55	1/18/2011	15:55	17.01	7.00	0.32	0.48	0.05
44	1/24/2011	19:35	1/25/2011	9:40	6.15	14.08	0.28	0.48	0.02
45	2/1/2011	5:10	2/2/2011	0:10	6.81	19.00	1.24	0.96	0.07
46	2/5/2011	5:55	2/5/2011	11:50	3.24	5.92	0.24	0.48	0.04
47	2/21/2011	9:05	2/21/2011	18:50	15.89	9.75	2.08	0.96	0.21
48	2/24/2011	17:40	2/25/2011	4:25	2.95	10.75	1.96	1.45	0.18
49	2/27/2011	18:55	2/27/2011	20:45	2.60	1.83	0.36	1.45	0.20
50	2/28/2011	5:20	2/28/2011	8:40	0.36	3.33	0.40	1.45	0.12
51	3/4/2011	6:25	3/5/2011	9:55	3.91	27.50	1.64	0.96	0.06
52	3/5/2011	16:30	3/5/2011	20:30	0.27	4.00	0.24	0.48	0.06
53	3/8/2011	21:55	3/9/2011	19:55	3.06	22.00	1.64	1.45	0.07
54	3/18/2011	17:35	3/18/2011	18:50	8.90	1.25	0.32	0.96	0.26
55	4/1/2011	20:45	4/1/2011	21:15	14.08	0.50	0.20	0.96	0.40
56	4/4/2011	14:15	4/4/2011	17:50	2.71	3.58	1.08	1.45	0.30
57	4/9/2011	11:40	4/9/2011	15:00	4.74	3.33	0.76	1.45	0.23
58	4/11/2011	8:10	4/12/2011	6:30	1.72	22.33	2.28	0.96	0.10
59	4/15/2011	22:15	4/16/2011	3:55	3.66	5.67	1.84	1.93	0.32
60	4/19/2011	1:15	4/19/2011	11:40	2.89	10.42	2.72	3.37	0.26
61	4/20/2011	1:30	4/20/2011	8:05	0.58	6.58	1.08	1.45	0.16
62	4/22/2011	17:20	4/22/2011	19:40	2.39	2.33	0.60	2.89	0.26
63	4/23/2011	1:30	4/23/2011	6:50	0.24	5.33	0.68	0.96	0.13
64	4/23/2011	14:20	4/23/2011	19:00	0.31	4.67	1.48	2.89	0.32
65	4/24/2011	18:20	4/24/2011	22:10	0.97	3.83	0.24	0.48	0.06
66	4/25/2011	4:00	4/25/2011	8:55	0.24	4.92	0.56	1.45	0.11
67	4/27/2011	4:50	4/27/2011	10:45	1.83	5.92	0.92	2.41	0.16
68	4/28/2011	18:50	4/28/2011	19:50	1.34	1.00	0.20	0.96	0.20
69	5/2/2011	1:30	5/2/2011	8:50	3.24	7.33	0.88	0.96	0.12
70	5/2/2011	16:35	5/3/2011	10:10	0.32	17.58	1.76	0.96	0.10
71	5/7/2011	23:50	5/8/2011	0:25	4.57	0.58	0.32	0.96	0.55
72	5/13/2011	15:50	5/13/2011	16:35	5.64	0.75	1.00	4.34	1.33
73	5/15/2011	20:45	5/15/2011	22:25	2.17	1.67	0.20	0.96	0.12
74	5/17/2011	20:30	5/18/2011	4:45	1.92	8.25	0.20	0.96	0.02
75	5/23/2011	5:40	5/23/2011	7:25	5.04	1.75	0.48	0.96	0.27
76	5/23/2011	19:20	5/23/2011	23:40	0.50	4.33	0.68	2.41	0.16
77	5/26/2011	0:30	5/26/2011	3:25	2.03	2.92	0.60	1.45	0.21
78	5/26/2011	14:10	5/26/2011	14:45	0.45	0.58	0.40	1.93	0.69
79	6/10/2011	12:55	6/10/2011	20:15	14.92	7.33	5.16	19.76	0.70
80	6/11/2011	3:55	6/11/2011	7:25	0.32	3.50	1.08	3.37	0.31
81	6/15/2011	11:15	6/15/2011	16:05	4.16	4.83	0.64	0.96	0.13
82	6/19/2011	9:50	6/19/2011	15:55	3.74	6.08	0.24	0.48	0.04
83	6/20/2011	10:10	6/20/2011	12:35	0.76	2.42	2.04	4.34	0.84
84	6/21/2011	15:15	6/21/2011	17:10	1.11	1.92	0.80	1.93	0.42
85	6/22/2011	22:35	6/23/2011	4:20	1.23	5.75	0.76	2.89	0.13
86	6/26/2011	5:10	6/26/2011	10:30	3.03	5.33	0.92	1.45	0.17

Event #	Rain start date	Rain start time	Rain end date	Rain end time	Antecedent dry days	Rain dur. (hrs)	Total rain [a] (in)	5-minute peak rain intensity (in/hr)	Avg rain int. (in/hr)
87	6/27/2011	10:05	6/27/2011	11:10	0.98	1.08	0.24	1.45	0.22
88	7/8/2011	2:40	7/8/2011	7:40	10.65	5.00	0.76	1.45	0.15
89	8/3/2011	5:10	8/3/2011	11:55	25.90	6.75	0.32	0.96	0.05
90	8/7/2011	5:40	8/7/2011	7:30	3.74	1.83	1.28	3.37	0.70
91	8/8/2011	19:25	8/8/2011	23:25	1.50	4.00	0.72	1.93	0.18
92	8/14/2011	2:25	8/14/2011	4:10	5.13	1.75	0.12	0.96	0.07
93	8/21/2011	15:20	8/21/2011	17:55	7.47	2.58	0.52	2.41	0.20
94	9/4/2011	1:05	9/4/2011	2:20	13.30	1.25	0.60	2.89	0.48
95	9/4/2011	20:20	9/4/2011	22:55	0.75	2.58	0.64	1.93	0.25
96	9/7/2011	7:40	9/7/2011	23:10	2.36	15.50	0.80	0.48	0.05
97	9/14/2011	22:25	9/15/2011	2:15	6.97	3.83	0.56	0.96	0.15
98	9/19/2011	9:05	9/19/2011	15:55	4.28	6.83	0.84	1.45	0.12
99	9/21/2011	9:50	9/21/2011	13:50	1.75	4.00	0.16	0.48	0.04
100	9/23/2011	2:25	9/23/2011	9:50	1.52	7.42	0.80	0.96	0.11
101	9/26/2011	0:00	9/26/2011	8:35	2.59	8.58	3.36	2.41	0.39
102	9/29/2011	19:30	9/29/2011	22:15	3.45	2.75	0.28	0.96	0.10
103	10/13/2011	9:40	10/13/2011	15:20	13.48	5.67	0.60	1.45	0.11
104	10/19/2011	0:00	10/19/2011	4:10	5.36	4.17	0.36	0.48	0.09
105	10/19/2011	11:00	10/20/2011	11:35	0.28	24.58	2.00	0.96	0.08
106	10/26/2011	20:35	10/27/2011	3:55	6.38	7.33	1.36	0.96	0.19
107	11/3/2011	12:45	11/4/2011	2:15	7.37	13.50	1.56	0.48	0.12
108	11/14/2011	20:25	11/15/2011	6:40	10.76	10.25	2.28	6.27	0.22
109	11/16/2011	6:00	11/16/2011	10:55	0.97	4.92	0.60	0.48	0.12
110	11/21/2011	6:40	11/21/2011	12:00	4.82	5.33	0.92	0.96	0.17
111	12/4/2011	14:50	12/6/2011	0:05	13.12	33.25	3.32	0.96	0.10
112	12/15/2011	3:05	12/15/2011	12:00	9.13	8.92	0.48	0.48	0.05
113	12/19/2011	19:05	12/20/2011	0:25	4.30	5.33	0.32	0.96	0.06
114	12/21/2011	3:25	12/21/2011	7:50	1.13	4.42	0.68	0.96	0.15
115	12/22/2011	12:10	12/22/2011	19:55	1.18	7.75	0.84	0.96	0.11
116	12/27/2011	2:25	12/27/2011	15:35	4.27	13.17	0.80	0.96	0.06
117	1/11/2012	7:30	1/11/2012	13:00	14.66	5.50	0.48	0.48	0.09
118	1/12/2012	13:40	1/12/2012	15:45	1.03	2.08	0.16	0.48	0.08
119	1/17/2012	3:15	1/17/2012	14:40	4.48	11.42	1.76	2.41	0.15
120	1/20/2012	23:20	1/21/2012	0:35	3.36	1.25	0.16	0.96	0.13
121	1/22/2012	12:05	1/22/2012	15:10	1.48	3.08	0.24	0.48	0.08
122	1/22/2012	23:50	1/23/2012	5:25	0.36	5.58	0.44	0.96	0.08
123	1/25/2012	17:55	1/25/2012	19:15	2.52	1.33	0.12	0.48	0.09
124	1/26/2012	4:00	1/26/2012	10:35	0.36	6.58	0.80	0.96	0.12
125	1/26/2012	17:25	1/27/2012	5:40	0.28	12.25	1.08	0.96	0.09
126	2/16/2012	3:35	2/16/2012	7:10	19.91	3.58	0.20	0.48	0.06
127	2/29/2012	3:15	2/29/2012	9:10	12.84	5.92	0.56	0.48	0.09
128	3/2/2012	9:35	3/2/2012	16:50	2.02	7.25	0.40	0.96	0.06
129	3/8/2012	7:40	3/8/2012	17:25	5.62	9.75	1.08	0.96	0.11
130	3/15/2012	10:15	3/15/2012	12:05	6.70	1.83	1.00	4.50	0.55

Event #	Rain start date	Rain start time	Rain end date	Rain end time	Antecedent dry days	Rain dur. (hrs)	Total rain [a] (in)	5-minute peak rain intensity (in/hr)	Avg rain int. (in/hr)
131	3/23/2012	11:05	3/23/2012	17:50	7.96	6.75	0.44	0.48	0.07
132	3/24/2012	0:50	3/24/2012	1:50	0.29	1.00	0.40	1.45	0.40
133	4/1/2012	23:45	4/2/2012	0:50	8.91	1.08	0.24	0.96	0.22
134	4/14/2012	9:40	4/14/2012	17:40	12.37	8.00	1.08	0.96	0.14
135	4/25/2012	23:45	4/26/2012	0:00	11.25	0.25	0.32	2.89	1.28
136	4/28/2012	12:25	4/28/2012	13:15	2.52	0.83	0.68	1.93	0.82
137	4/28/2012	20:20	4/28/2012	22:20	0.30	2.00	0.16	0.48	0.08
138	4/30/2012	20:30	4/30/2012	23:15	1.92	2.75	0.72	1.93	0.26
139	5/1/2012	17:35	5/1/2012	22:45	0.76	5.17	0.80	2.41	0.15
140	5/5/2012	1:05	5/5/2012	3:30	3.10	2.42	0.20	0.96	0.08
141	5/8/2012	0:05	5/8/2012	8:35	2.86	8.50	0.48	0.48	0.06
142	5/13/2012	3:50	5/13/2012	16:00	4.80	12.17	1.36	0.48	0.11
143	5/29/2012	8:50	5/29/2012	10:50	15.70	2.00	0.20	0.48	0.10
144	6/1/2012	0:35	6/1/2012	7:55	2.57	7.33	1.00	1.45	0.14
145	6/11/2012	7:30	6/11/2012	10:15	9.98	2.75	0.20	0.48	0.07
146	6/18/2012	6:35	6/18/2012	6:50	6.85	0.25	0.32	2.41	1.28
147	6/29/2012	17:50	6/29/2012	18:05	11.46	0.25	0.24	1.45	0.96
148	7/1/2012	19:25	7/1/2012	19:40	2.06	0.25	0.20	0.96	0.80
149	7/15/2012	13:20	7/15/2012	13:55	13.74	0.58	0.32	0.96	0.55
150	7/18/2012	16:45	7/18/2012	17:00	3.12	0.25	0.52	3.37	2.08
151	7/26/2012	15:25	7/26/2012	18:55	7.93	3.50	0.28	1.93	0.08
152	7/27/2012	17:15	7/27/2012	18:45	0.93	1.50	0.56	2.41	0.37
154	10/5/2012	19:45	10/6/2012	0:30	3.94	4.75	0.45	0.66	0.09
155	10/14/2012	16:50	10/14/2012	19:20	8.68	2.50	0.19	0.52	0.08
156	10/19/2012	13:25	10/20/2012	0:20	4.75	10.92	0.25	0.23	0.02
157	10/26/2012	12:00	10/27/2012	0:55	6.49	12.92	0.78	0.32	0.06
158	10/30/2012	0:55	10/31/2012	17:50	3.00	40.92	0.48	0.11	0.01
159	11/3/2012	10:45	11/3/2012	16:10	2.70	5.42	0.12	0.13	0.02
160	11/12/2012	3:50	11/12/2012	13:45	8.49	9.92	0.77	0.32	0.08
161	11/26/2012	22:55	11/27/2012	2:15	14.38	3.33	0.10	0.05	0.03
162	12/2/2012	7:25	12/2/2012	11:30	5.22	4.08	0.52	0.77	0.13
163	12/4/2012	15:35	12/4/2012	19:25	2.17	3.83	0.25	0.70	0.07
164	12/7/2012	0:15	12/7/2012	18:20	2.20	18.08	0.99	0.39	0.05
165	12/9/2012	16:50	12/10/2012	0:25	1.94	7.58	1.38	2.64	0.18
166	12/15/2012	11:55	12/15/2012	15:00	5.48	3.08	0.09	0.17	0.03
167	12/17/2012	12:35	12/18/2012	4:40	1.90	16.08	0.57	1.90	0.04
168	12/20/2012	7:15	12/20/2012	19:55	2.11	12.67	0.86	0.47	0.07
169	12/26/2012	3:15	12/26/2012	18:45	5.31	15.50	1.27	0.47	0.08

Runoff characteristics during different flow monitoring periods for Cincinnati State College separate sewer system (manhole number 29606027)

Event #	Pipeflow start date	Pipeflow start time	Pipeflow end date	Flow end time	Flow dur. (hrs)	Total pipeflow discharge volume (ft3)	Total disch. (in)	5-minute Peak flow disch. rate (CFS)	5-minute Avg flow disch. rate (CFS)	Peak/avg pipeflow rate ratio	Rv (Runoff Depth/Rain Depth)	flow/ rain dur. ratio
1	3/11/2010	9:10	3/11/2010	14:05	4.92	1,143	0.022	1.32	0.06	22.00	0.28	29.50
2	3/11/2010	14:30	3/11/2010	17:25	2.92	918	0.018	1.66	0.09	18.44	0.45	35.00
3	3/12/2010	17:35	3/13/2010	1:40	8.08	15,336	0.298	2.39	0.52	4.60	0.35	2.49
4	3/13/2010	9:15	3/14/2010	3:10	17.92	10,672	0.207	0.84	0.16	5.25	0.47	1.76
5	3/21/2010	21:00	3/22/2010	9:05	12.08	11,191	0.217	2.12	0.26	8.15	0.36	2.13
6	3/25/2010	14:00	3/26/2010	14:45	24.75	26,828	0.520	2.06	0.31	6.65	0.43	2.48
7	3/28/2010	14:25	3/28/2010	20:55	6.50	824	0.016	0.65	0.03	21.67	0.20	19.50
8	4/8/2010	0:55	4/8/2010	11:30	10.58	7,489	0.145	1.25	0.20	6.41	0.28	1.43
9	4/23/2010	9:40	4/23/2010	15:35	5.92	4,900	0.095	1.07	0.23	4.72	0.34	1.77
10	4/24/2010	17:00	4/25/2010	2:50	9.83	11,038	0.214	1.90	0.31	6.15	0.30	1.82
11	4/25/2010	14:45	4/25/2010	19:00	4.25	1,565	0.030	0.74	0.10	7.36	0.25	1.42
12	5/2/2010	3:05	5/2/2010	5:50	2.75	13,699	0.266	1.15	0.15	7.64	0.20	0.15
13	5/11/2010	4:35	5/11/2010	18:35	14.00	2,459	0.048	1.16	0.05	23.18	0.15	3.65
14	5/12/2010	7:40	5/12/2010	18:40	11.00	4,986	0.097	1.53	0.13	12.24	0.11	1.97
15	5/16/2010	21:05	5/17/2010	3:20	6.25	1,192	0.023	0.59	0.05	11.28	0.19	2.88
16	5/17/2010	4:50	5/17/2010	14:50	10.00	1,596	0.031	0.75	0.04	16.95	0.15	6.67
17	5/21/2010	2:10	5/21/2010	6:35	4.42	1,231	0.024	0.54	0.08	7.14	0.20	3.31
18	5/21/2010	16:20	5/22/2010	0:35	8.25	4,251	0.082	2.35	0.14	16.56	0.23	5.82
19	6/6/2010	8:15	6/6/2010	10:50	2.58	3,973	0.077	4.20	0.41	10.24	0.32	6.20
20	6/9/2010	5:20	6/9/2010	9:05	3.75	2,946	0.057	2.07	0.21	9.73	0.24	11.25
21	6/12/2010	7:35	6/12/2010	15:55	8.33	35,166	0.682	4.74	1.16	4.09	0.24	1.75
22	6/13/2010	3:25	6/13/2010	8:30	5.08	1,359	0.026	1.84	0.07	26.33	0.22	30.50
23	6/14/2010	22:35	6/15/2010	5:10	6.58	4,061	0.079	4.18	0.17	24.74	0.20	4.94
24	6/15/2010	20:30	6/15/2010	23:50	3.33	1,025	0.020	1.44	0.08	18.05	0.04	2.22
25	6/19/2010	7:20	6/19/2010	11:00	3.67	6,900	0.134	3.38	0.51	6.61	0.26	2.20
26	6/21/2010	11:30	6/21/2010	15:30	4.00	3,919	0.076	2.06	1.20	1.72	0.27	2.18
27	6/27/2010	23:15	6/28/2010	11:15	12.00	20,649	0.401	6.12	0.47	12.91	0.33	2.48
28	7/9/2010	11:00	7/9/2010	18:25	7.42	4,077	0.079	1.89	0.15	12.60	0.16	4.68
29	7/17/2010	17:25	7/17/2010	18:55	1.50	2,089	0.041	2.17	0.37	5.87	0.07	2.57
30	7/20/2010	21:35	7/20/2010	23:00	1.42	3,797	0.074	1.91	0.70	2.72	0.23	0.65
31	8/11/2010	14:50	8/11/2010	18:15	3.42	1,385	0.027	2.03	0.11	18.45	0.11	41.00
32	8/15/2010	16:45	8/15/2010	19:10	2.42	2,464	0.048	1.09	0.27	4.04	0.20	4.83
33	9/11/2010	10:15	9/11/2010	11:00	0.75	904	0.018	0.80	0.30	2.67	0.15	3.00
34	9/16/2010	2:55	9/16/2010	5:05	2.17	1,283	0.025	1.20	0.16	7.50	0.12	0.65
35	10/13/2010	18:05	10/13/2010	21:40	3.58	1,092	0.021	0.54	0.08	6.75	0.26	1.08
36	10/26/2010	12:20	10/26/2010	17:55	5.58	3,485	0.068	1.29	0.17	7.59	0.04	1.29
37	11/16/2010	11:25	11/16/2010	23:45	12.33	10,358	0.201	1.66	0.24	6.92	0.17	1.17
38	11/23/2010	1:25	11/23/2010	6:10	4.75	7,603	0.148	2.29	0.44	5.20	0.16	1.90
39	11/24/2010	13:40	11/25/2010	1:40	12.00	10,681	0.207	1.70	0.25	6.80	0.20	1.24
40	11/25/2010	6:15	11/26/2010	5:15	23.00	42,160	0.818	2.65	0.51	5.20	0.30	1.33
41	11/29/2010	22:00	11/30/2010	8:00	10.00	14,689	0.285	1.80	0.40	4.50	0.28	1.62

Event #	Pipeflow start date	Pipeflow start time	Pipeflow end date	Flow end time	Flow dur. (hrs)	Total pipeflow discharge volume (ft3)	Total disch. (in)	5-minute Peak flow disch. rate (CFS)	5-minute Avg flow disch. rate (CFS)	Peak/avg pipeflow rate ratio	Rv (Runoff Depth/Rain Depth)	flow/ rain dur. ratio
42	1/1/2011	1:25	1/1/2011	10:55	9.50	5,213	0.101	0.93	0.15	6.20	0.21	1.31
43	1/18/2011	9:30	1/18/2011	16:30	7.00	2,115	0.041	0.71	0.08	8.88	0.13	1.00
44	1/24/2011	14:15	1/25/2011	18:05	27.83	2,859	0.055	1.18	0.03	39.33	0.20	1.98
45	2/1/2011	5:05	2/2/2011	15:00	33.92	19,968	0.387	1.45	0.16	9.06	0.31	1.79
46	2/5/2011	4:00	2/5/2011	17:35	13.58	2,037	0.040	0.63	0.04	15.75	0.16	2.30
47	2/21/2011	8:15	2/22/2011	11:30	27.25	39,235	0.761	2.39	0.40	5.98	0.37	2.79
48	2/24/2011	17:55	2/25/2011	23:05	29.17	47,914	0.930	2.68	0.46	5.83	0.47	2.71
49	2/27/2011	19:10	2/27/2011	21:35	2.42	3,087	0.060	1.68	0.34	4.94	0.17	1.32
50	2/28/2011	5:20	2/28/2011	12:45	7.42	8,045	0.156	4.40	0.30	14.67	0.39	2.22
51	3/4/2011	8:55	3/5/2011	11:05	26.17	29,592	0.574	1.49	0.31	4.81	0.35	0.95
52	3/5/2011	16:25	3/6/2011	5:45	13.33	9,062	0.176	1.12	0.49	2.29	0.73	3.33
53	3/8/2011	22:05	3/10/2011	1:25	27.33	37,339	0.724	1.28	0.38	3.37	0.44	1.24
54	3/18/2011	16:25	3/19/2011	0:05	7.67	4,446	0.086	1.85	0.16	11.56	0.27	6.13
55	4/1/2011	20:45	4/2/2011	1:55	5.17	1,595	0.031	1.26	0.08	15.75	0.15	10.33
56	4/4/2011	12:00	4/5/2011	9:30	21.50	11,123	0.216	1.38	0.14	9.86	0.20	6.00
57	4/9/2011	11:50	4/10/2011	0:20	12.50	7,948	0.154	2.16	0.18	12.00	0.20	3.75
58	4/11/2011	7:00	4/12/2011	17:05	34.08	37,686	0.731	1.03	0.31	3.32	0.32	1.53
59	4/15/2011	22:20	4/16/2011	9:30	11.17	17,364	0.337	1.60	0.43	3.72	0.18	1.97
60	4/19/2011	1:35	4/19/2011	23:55	22.33	22,398	0.435	4.93	0.28	17.61	0.16	2.14
61	4/20/2011	1:30	4/21/2011	9:50	32.33	19,611	0.380	1.88	0.17	11.06	0.35	4.91
62	4/22/2011	17:10	4/23/2011	0:05	6.92	7,107	0.138	2.29	0.28	8.18	0.23	2.96
63	4/23/2011	1:35	4/23/2011	14:00	12.42	12,478	0.242	2.21	0.28	7.89	0.36	2.33
64	4/23/2011	14:20	4/24/2011	0:40	10.33	13,068	0.254	2.58	0.35	7.37	0.17	2.21
65	4/24/2011	18:20	4/25/2011	3:00	8.67	4,015	0.078	0.84	0.13	6.46	0.32	2.26
66	4/25/2011	4:00	4/25/2011	21:20	17.33	3,421	0.066	0.78	0.05	15.60	0.12	3.53
67	4/27/2011	3:30	4/27/2011	17:00	13.50	10,343	0.201	1.85	0.21	8.81	0.22	2.28
68	4/28/2011	17:30	4/29/2011	4:30	11.00	2,930	0.057	0.99	0.07	14.14	0.28	11.00
69	5/2/2011	1:25	5/2/2011	12:50	11.42	9,778	0.190	1.10	0.24	4.58	0.22	1.56
70	5/2/2011	15:40	5/3/2011	19:55	28.25	25,776	0.500	1.41	0.25	5.64	0.28	1.61
71	5/7/2011	23:20	5/8/2011	1:55	2.58	2,871	0.056	1.09	0.30	3.63	0.17	4.43
72	5/13/2011	15:55	5/14/2011	1:55	10.00	8,402	0.163	4.77	0.23	20.74	0.16	13.33
73	5/15/2011	19:25	5/16/2011	2:20	6.92	2,989	0.058	1.73	0.12	14.42	0.29	4.15
74	5/17/2011	20:25	5/18/2011	12:20	15.92	4,702	0.091	0.78	0.08	9.75	0.46	1.93
75	5/23/2011	5:50	5/23/2011	12:45	6.92	5,949	0.115	1.45	0.24	6.04	0.24	3.95
76	5/23/2011	19:20	5/24/2011	0:45	5.42	6,720	0.130	2.18	0.34	6.41	0.19	1.25
77	5/26/2011	0:30	5/26/2011	10:00	9.50	8,056	0.156	1.07	0.23	4.65	0.26	3.26
78	5/26/2011	14:15	5/26/2011	21:05	6.83	4,160	0.081	1.31	0.17	7.71	0.20	11.71
79	6/10/2011	13:20	6/11/2011	1:35	12.25	11,864	0.230	2.47	0.27	9.15	0.04	1.67
80	6/11/2011	4:05	6/11/2011	17:45	13.67	14,709	0.285	4.29	0.30	14.30	0.26	3.90
81	6/15/2011	11:10	6/15/2011	18:00	6.83	7,177	0.139	1.23	0.29	4.24	0.22	1.41
82	6/19/2011	10:40	6/19/2011	18:00	7.33	3,084	0.060	1.02	0.12	8.50	0.25	1.21
83	6/20/2011	10:05	6/20/2011	15:30	5.42	7,667	0.149	2.33	0.39	5.97	0.07	2.24
84	6/21/2011	14:40	6/21/2011	20:40	6.00	4,226	0.082	1.62	0.15	10.80	0.10	3.13

Event #	Pipeflow start date	Pipeflow start time	Pipeflow end date	Flow end time	Flow dur. (hrs)	Total pipeflow discharge volume (ft3)	Total disch. (in)	5-minute Peak flow disch. rate (CFS)	5-minute Avg flow disch. rate (CFS)	Peak/avg pipeflow rate ratio	Rv (Runoff Depth/Rain Depth)	flow/ rain dur. ratio
85	6/22/2011	21:50	6/23/2011	5:40	7.83	3,073	0.060	2.17	0.18	12.06	0.08	1.36
86	6/26/2011	5:05	6/26/2011	11:10	6.08	2,801	0.054	0.66	0.13	5.08	0.06	1.14
87	6/27/2011	9:40	6/27/2011	13:55	4.25	1,500	0.029	1.20	0.10	12.00	0.12	3.92
88	7/8/2011	5:50	7/8/2011	17:00	11.17	2,262	0.044	1.20	0.06	20.00	0.06	2.23
89	8/3/2011	8:05	8/3/2011	15:40	7.58	1,060	0.021	1.58	0.04	39.50	0.06	1.12
90	8/7/2011	5:45	8/7/2011	9:00	3.25	1,548	0.030	1.08	0.13	8.31	0.02	1.77
91	8/8/2011	20:00	8/9/2011	14:00	18.00	11,198	0.217	1.90	0.17	11.18	0.30	4.50
92	8/14/2011	2:25	8/14/2011	5:40	3.25	211	0.004	0.13	0.02	6.50	0.03	1.86
93	8/21/2011	17:45	8/21/2011	19:15	1.50	282	0.005	0.26	0.05	5.20	0.01	0.58
94	9/4/2011	1:15	9/4/2011	5:40	4.42	1,137	0.022	0.82	0.07	11.71	0.04	3.53
95	9/4/2011	20:15	9/4/2011	22:45	2.50	234	0.005	0.20	0.03	6.67	0.01	0.97
96	9/7/2011	1:50	9/8/2011	5:30	27.67	1,211	0.023	0.26	0.01	26.00	0.03	1.78
97	9/14/2011	23:50	9/15/2011	7:10	7.33	1,013	0.020	0.43	0.04	10.75	0.04	1.91
98	9/19/2011	8:40	9/19/2011	21:35	12.92	696	0.013	0.43	0.01	43.00	0.02	1.89
99						0	0.000	0.00	0.00	0.00	0.00	0.00
100	9/23/2011	2:30	9/23/2011	20:45	18.25	1,192	0.023	0.31	0.02	15.50	0.03	2.46
101	9/26/2011	1:05	9/26/2011	21:25	20.33	14,794	0.287	2.39	0.20	11.95	0.09	2.37
102	9/29/2011	19:25	9/30/2011	1:45	6.33	718	0.014	0.43	0.03	14.33	0.05	2.30
103	10/13/2011	9:50	10/13/2011	14:35	4.75	351	0.007	0.19	0.02	9.50	0.01	0.84
104	10/19/2011	5:25	10/19/2011	5:55	0.50	11	0.000	0.01	0.01	1.00	0.00	0.12
105	10/19/2011	11:40	10/20/2011	15:30	27.83	3,077	0.060	0.48	0.03	16.00	0.03	1.13
106	10/26/2011	20:45	10/27/2011	18:30	21.75	3,009	0.058	0.54	0.04	13.50	0.04	2.97
107	11/3/2011	12:30	11/4/2011	22:20	33.83	4,461	0.087	0.51	0.04	12.75	0.06	2.51
108	11/14/2011	21:25	11/15/2011	10:50	13.42	9,723	0.189	2.74	0.20	13.70	0.08	1.31
109	11/16/2011	6:00	11/17/2011	11:40	29.67	7,309	0.142	2.80	0.07	40.00	0.24	6.03
110	11/21/2011	7:10	11/21/2011	22:35	15.42	3,001	0.058	2.74	0.20	13.70	0.06	2.89
111	12/4/2011	20:05	12/6/2011	0:20	28.25	13,948	0.271	0.69	0.14	4.93	0.08	0.85
112	12/15/2011	4:55	12/15/2011	16:50	11.92	167	0.003	0.05	0.01	5.00	0.01	1.34
113	12/19/2011	23:25	12/19/2011	23:30	0.08	14	0.000	0.02	0.02	1.00	0.00	0.02
114	12/21/2011	6:15	12/21/2011	17:15	11.00	2,539	0.049	0.52	0.06	8.67	0.07	2.49
115	12/22/2011	13:45	12/23/2011	3:35	13.83	2,145	0.042	0.24	0.04	6.00	0.05	1.78
116	12/27/2011	4:45	12/27/2011	21:30	16.75	2,143	0.042	0.59	0.04	14.75	0.05	1.27
117	1/11/2012	8:35	1/11/2012	14:55	6.33	528	0.010	0.25	0.02	12.50	0.02	1.15
118	1/12/2012	14:05	1/12/2012	16:40	2.58	124	0.002	0.02	0.01	2.00	0.02	1.24
119	1/17/2012	3:55	1/18/2012	15:50	35.92	7,792	0.151	1.47	0.06	24.50	0.09	3.15
120	1/20/2012	23:20	1/21/2012	4:45	5.42	286	0.006	0.05	0.01	5.00	0.03	4.33
121						0	0.000	0.00	0.00	0.00	0.00	0.00
122	1/22/2012	0:30	1/23/2012	20:45	44.25	2,083	0.040	0.67	0.03	22.33	0.09	7.93
123						0	0.000	0.00	0.00	0.00	0.00	
124	1/26/2012	5:00	1/26/2012	17:20	12.33	2,897	0.056	0.99	0.06	16.50	0.07	1.87
125	1/26/2012	17:25	1/27/2012	11:25	18.00	4,179	0.081	0.26	0.03	8.67	0.08	1.47
126	2/16/2012	3:55	2/16/2012	8:55	5.00	110	0.002	0.03	0.01	3.00	0.01	1.40
127	2/29/2012	3:15	2/29/2012	12:30	9.25	369	0.007	0.13	0.01	13.00	0.01	1.56

Event #	Pipeflow start date	Pipeflow start time	Pipeflow end date	Flow end time	Flow dur. (hrs)	Total pipeflow discharge volume (ft3)	Total disch. (in)	5-minute Peak flow disch. rate (CFS)	5-minute Avg flow disch. rate (CFS)	Peak/avg pipeflow rate ratio	Rv (Runoff Depth/Rain Depth)	flow/ rain dur. ratio
128	3/2/2012	12:10	3/2/2012	20:45	8.58	1,096	0.021	0.75	0.04	18.75	0.05	1.18
129	3/8/2012	8:30	3/8/2012	18:30	10.00	640	0.012	0.19	0.02	9.50	0.01	1.03
130	3/15/2012	9:20	3/15/2012	18:00	8.67	5,891	0.114	1.16	0.19	6.11	0.11	4.73
131	3/23/2012	12:00	3/23/2012	18:25	6.42	670	0.013	1.02	0.03	34.00	0.03	0.95
132	3/24/2012	1:00	3/24/2012	5:35	4.58	879	0.017	0.44	0.05	8.80	0.04	4.58
133	4/1/2012	23:55	4/2/2012	1:40	1.75	583	0.011	0.68	0.09	7.56	0.05	1.62
134	4/14/2012	9:55	4/15/2012	7:25	21.50	1,783	0.035	0.66	0.02	33.00	0.03	2.69
135	4/25/2012	23:45	4/26/2012	5:50	6.08	1,907	0.037	1.94	0.09	21.56	0.12	24.33
136	4/28/2012	12:20	4/28/2012	14:30	2.17	1,991	0.039	0.87	0.25	3.48	0.06	2.60
137	4/29/2012	21:10	4/29/2012	22:05	0.92	32	0.001	0.01	0.01	1.00	0.00	0.46
138	4/30/2012	20:40	4/30/2012	23:55	3.25	2,291	0.044	0.81	0.19	4.26	0.06	1.18
139	5/1/2012	17:40	5/2/2012	17:50	24.17	6,011	0.117	1.95	0.07	27.86	0.15	4.68
140	5/5/2012	1:40	5/5/2012	2:20	0.67	35	0.001	0.02	0.01	2.00	0.00	0.28
141						0	0.000	0.00	0.00	0.00	0.00	0.00
142						0	0.000	0.00	0.00	0.00	0.00	0.00
143	5/29/2012	8:55	5/29/2012	10:20	1.42	97	0.002	0.04	0.02	2.00	0.01	0.71
144	6/1/2012	0:40	6/1/2012	12:55	12.25	4,904	0.095	1.49	0.11	13.55	0.10	1.67
145	6/11/2012	12:45	6/11/2012	12:55	0.17	156	0.003	0.52	0.52	1.00	0.02	0.06
146	6/18/2012	6:15	6/18/2012	8:40	2.42	496	0.010	0.71	0.06	11.83	0.03	9.67
147	6/29/2012	17:50	6/29/2012	18:25	0.58	474	0.009	0.68	0.20	3.40	0.04	2.33
148						0	0.000	0.00	0.00	0.00	0.00	0.00
149						0	0.000	0.00	0.00	0.00	0.00	0.00
150	7/18/2012	16:40	7/19/2012	3:50	11.17	1,477	0.029	0.84	0.04	21.00	0.06	44.67
151	7/26/2012	15:30	7/26/2012	19:10	3.67	179	0.003	0.28	0.01	28.00	0.01	1.05
152	7/27/2012	17:20	7/27/2012	18:45	1.42	585	0.011	0.69	0.11	6.27	0.02	0.94
153	10/1/2012	18:25	10/1/2012	23:00	4.58	1,102	0.021	0.64	0.07	9.14	0.03	0.95
154	10/5/2012	23:45	10/6/2012	2:20	2.58	906	0.018	0.45	0.09	5.00	0.04	0.54
155	10/14/2012	18:00	10/14/2012	18:40	0.67	142	0.003	0.14	0.05	2.80	0.01	0.27
156	10/19/2012	21:50	10/19/2012	22:10	0.33	8	0.000	0.02	0.01	2.00	0.00	0.03
157	10/26/2012	14:30	10/27/2012	4:40	14.17	645	0.013	0.05	0.01	5.00	0.02	1.10
158	10/30/2012	6:05	10/30/2012	18:35	12.50	641	0.012	0.06	0.01	6.00	0.03	0.31
159						0	0.000	0	0	0.00	0.00	0.00
160	11/12/2012	7:35	11/12/2012	14:55	7.33	899	0.017	0.8	0.03	26.67	0.02	0.74
161	11/27/2012	6:20	11/27/2012	9:30	3.17	371	0.007	0.65	0.03	21.67	0.07	0.95
162	12/2/2012	8:10	12/2/2012	10:55	2.75	852	0.017	0.85	0.08	10.63	0.03	0.67
163	12/4/2012	16:25	12/4/2012	18:20	1.92	575	0.011	0.69	0.08	8.63	0.04	0.50
164	12/7/2012	0:50	12/9/2012	20:20	67.50	1,817	0.035	0.95	0.03	31.67	0.04	3.73
165	12/9/2012	20:25	12/10/2012	16:05	19.67	6,020	0.117	2.76	0.08	34.50	0.08	2.59
166						0	0.000	0	0	0.00	0.00	0.00
167	12/17/2012	14:00	12/17/2012	18:25	4.42	1,198	0.023	0.9	0.07	12.86	0.04	0.27
168	12/20/2012	7:55	12/20/2012	17:45	9.83	2,357	0.046	0.36	0.07	5.14	0.05	0.78
169	12/26/2012	5:30	12/28/2012	11:05	53.58	4,515	0.088	1.17	0.04	29.25	0.07	3.46

Rainfall characteristics for main entrance of the Cincinnati zoo separate sewer line (manhole number 338162022)

Event #	Rain start date	Rain start time	Rain end date	Rain end time	Antecedent dry days	Rain dur. (hrs)	Total rain [a] (in)	5-minute peak rain intensity (in/hr)	Avg rain int. (in/hr)
1	2/5/2010	9:50	2/6/2010	4:35		18.75	0.93	0.60	0.05
2	2/12/2010	10:10	2/12/2010	16:55	6.23	6.75	0.27	0.24	0.04
3	2/18/2010	14:55	2/18/2010	18:30	5.92	3.58	0.13	0.36	0.04
4	2/22/2010	3:05	2/22/2010	9:55	3.36	6.83	0.07	0.24	0.01
5	3/12/2010	17:45	3/12/2010	22:10	18.33	4.42	0.81	1.08	0.18
6	3/13/2010	7:05	3/13/2010	20:40	0.37	13.58	0.45	0.12	0.03
7	3/21/2010	22:05	3/22/2010	5:10	8.06	7.08	0.61	0.48	0.09
8	3/25/2010	11:35	3/26/2010	1:15	3.27	13.67	1.28	0.48	0.09
9	4/8/2010	0:55	4/8/2010	8:10	12.99	7.25	0.54	0.96	0.07
10	4/24/2010	16:55	4/25/2010	3:25	16.36	10.50	0.91	0.60	0.09
11	5/2/2010	3:00	5/2/2010	20:15	6.98	17.25	1.36	0.72	0.08
12	5/11/2010	4:35	5/11/2010	10:15	8.35	5.67	0.40	0.96	0.07
13	5/16/2010	21:20	5/16/2010	23:55	5.46	2.58	0.13	0.12	0.05
14	5/17/2010	5:00	5/17/2010	8:05	0.21	3.08	0.16	0.12	0.05
15	5/21/2010	2:10	5/21/2010	3:50	3.75	1.67	0.16	0.24	0.10
16	5/21/2010	16:20	5/21/2010	18:35	0.52	2.25	0.86	2.29	0.38
17	6/5/2010	14:45	6/5/2010	15:05	14.84	0.33	0.22	1.33	0.66
18	6/6/2010	8:15	6/6/2010	8:50	0.72	0.58	0.30	1.33	0.51
19	6/12/2010	3:10	6/12/2010	11:25	5.76	8.25	2.64	2.05	0.32
20	6/14/2010	22:35	6/14/2010	23:20	2.47	0.75	0.50	2.65	0.67
21	6/19/2010	7:15	6/19/2010	9:20	4.33	2.08	0.70	1.81	0.34
22	6/21/2010	11:55	6/21/2010	14:45	2.11	2.83	0.59	2.17	0.21
23	6/27/2010	23:10	6/28/2010	5:50	6.35	6.67	1.70	3.37	0.26
24	7/9/2010	11:00	7/9/2010	12:50	11.22	1.83	0.22	0.48	0.12
25	7/13/2010	9:00	7/13/2010	16:25	3.84	7.42	0.25	0.72	0.03
26	7/17/2010	17:35	7/17/2010	18:05	4.05	0.50	0.29	1.20	0.58
27	7/20/2010	20:05	7/20/2010	22:45	3.08	2.67	0.48	1.33	0.18
28	8/11/2010	14:55	8/11/2010	15:10	21.67	0.25	0.11	0.96	0.44
29	8/14/2010	17:25	8/14/2010	18:55	3.09	1.50	0.50	1.20	0.33
30	8/15/2010	16:50	8/15/2010	17:25	0.91	0.58	0.18	0.60	0.31
31	9/16/2010	4:10	9/16/2010	6:40	31.45	2.50	0.15	0.72	0.06
32	9/27/2010	12:45	9/27/2010	16:50	11.25	4.08	0.09	0.12	0.02
33	10/13/2010	18:10	10/13/2010	19:40	16.06	1.50	0.14	0.36	0.09
34	10/26/2010	12:30	10/26/2010	17:25	12.70	4.92	0.72	2.05	0.15
35	11/16/2010	11:10	11/16/2010	22:05	20.74	10.92	0.99	0.84	0.09

Event #	Rain start date	Rain start time	Rain end date	Rain end time	Antecedent dry days	Rain dur. (hrs)	Total rain [a] (in)	5-minute peak rain intensity (in/hr)	Avg rain int. (in/hr)
36	11/23/2010	1:30	11/23/2010	5:00	6.14	3.50	0.64	0.96	0.18
37	11/25/2010	6:05	11/26/2010	1:05	2.05	19.00	2.61	1.08	0.14
38	11/30/2010	9:20	11/30/2010	20:40	4.34	11.33	0.83	0.60	0.07
39	12/11/2010	16:55	12/12/2010	4:55	10.84	12.00	0.52	0.24	0.04
40	12/18/2010	13:25	12/18/2010	15:30	6.35	2.08	0.09	0.12	0.04
41	12/20/2010	12:30	12/20/2010	14:25	1.88	1.92	0.08	0.24	0.04
42	12/30/2010	0:55	12/30/2010	12:35	9.44	11.67	0.30	0.24	0.03
43	1/1/2011	1:20	1/1/2011	9:50	1.53	8.50	0.50	0.36	0.06
44	1/18/2011	3:25	1/18/2011	11:50	16.73	8.42	0.29	0.24	0.03
45	1/24/2011	22:25	1/25/2011	10:10	6.44	11.75	0.20	0.24	0.02
46	2/1/2011	1:45	2/2/2011	0:40	6.65	22.92	1.10	0.36	0.05
47	2/5/2011	5:20	2/5/2011	12:05	3.19	6.75	0.23	0.24	0.03
48	2/21/2011	8:10	2/21/2011	19:15	15.84	11.08	2.13	1.20	0.19
49	2/24/2011	17:45	2/25/2011	5:05	2.94	11.33	1.80	0.60	0.16
50	2/27/2011	19:05	2/27/2011	20:50	2.58	1.75	0.19	0.48	0.11
51	2/28/2011	5:15	2/28/2011	11:45	0.35	6.50	0.43	1.33	0.07
52	3/4/2011	6:35	3/5/2011	21:55	3.78	39.33	1.77	0.48	0.04
53	3/8/2011	21:55	3/9/2011	19:55	3.00	22.00	1.62	0.48	0.07
54	3/15/2011	10:40	3/15/2011	18:20	5.61	7.67	0.11	0.36	0.01
55	3/18/2011	16:00	3/18/2011	18:55	2.90	2.92	0.60	1.33	0.21
56	4/1/2011	20:40	4/2/2011	4:00	14.07	7.33	0.14	0.48	0.02
57	4/4/2011	13:30	4/4/2011	18:00	2.40	4.50	1.15	2.65	0.26
58	4/9/2011	11:45	4/9/2011	15:25	4.74	3.67	0.57	1.45	0.16
59	4/11/2011	8:00	4/12/2011	7:00	1.69	23.00	2.42	1.45	0.11
60	4/15/2011	22:15	4/16/2011	10:25	3.64	12.17	1.58	0.96	0.13
61	4/19/2011	1:35	4/19/2011	12:00	2.63	10.42	2.59	2.53	0.25
62	4/20/2011	1:35	4/20/2011	8:10	0.57	6.58	0.81	1.08	0.12
63	4/22/2011	16:45	4/22/2011	19:55	2.36	3.17	0.83	2.53	0.26
64	4/24/2011	19:30	4/25/2011	9:35	1.98	14.08	0.37	0.24	0.03
65	4/27/2011	4:00	4/27/2011	11:45	1.77	7.75	0.79	2.17	0.10
66	4/27/2011	17:00	4/28/2011	2:50	0.22	9.83	0.24	0.24	0.02
67	4/28/2011	17:45	4/28/2011	19:55	0.62	2.17	0.26	0.72	0.12
68	5/1/2011	20:30	5/3/2011	11:35	3.02	39.08	2.47	0.60	0.06
69	5/7/2011	23:25	5/8/2011	2:05	4.49	2.67	0.31	0.48	0.12
70	5/13/2011	15:55	5/13/2011	16:55	5.58	1.00	1.01	3.73	1.01
71	5/15/2011	12:00	5/15/2011	14:10	1.80	2.17	0.10	0.12	0.05
72	5/15/2011	19:50	5/16/2011	2:05	0.24	6.25	0.18	0.60	0.03
73	5/17/2011	13:30	5/18/2011	7:00	1.48	17.50	0.33	0.24	0.02
74	5/22/2011	17:45	5/22/2011	17:55	4.45	0.17	0.10	0.84	0.60

Event #	Rain start date	Rain start time	Rain end date	Rain end time	Antecedent dry days	Rain dur. (hrs)	Total rain [a] (in)	5-minute peak rain intensity (in/hr)	Avg rain int. (in/hr)
75	5/23/2011	5:45	5/23/2011	7:50	0.49	2.08	0.32	0.48	0.15
76	5/23/2011	19:20	5/24/2011	0:25	0.48	5.08	0.53	1.08	0.10
77	5/26/2011	0:30	5/26/2011	18:20	2.00	17.83	0.79	1.45	0.04
78	6/4/2011	22:25	6/4/2011	22:35	9.17	0.17	0.09	0.72	0.54
79	6/10/2011	17:15	6/10/2011	21:15	5.78	4.00	1.05	1.08	0.26
80	6/11/2011	4:05	6/11/2011	8:45	0.28	4.67	0.74	1.57	0.16
81	6/15/2011	11:10	6/15/2011	15:35	4.10	4.42	0.54	0.48	0.12
82	6/18/2011	8:15	6/18/2011	13:05	2.69	4.83	0.10	0.12	0.02
83	6/19/2011	10:35	6/19/2011	11:35	0.90	1.00	0.13	0.24	0.13
84	6/20/2011	9:10	6/20/2011	12:35	0.90	3.42	0.73	1.45	0.21
85	6/21/2011	14:35	6/21/2011	17:00	1.08	2.42	0.62	1.57	0.26
86	6/22/2011	22:30	6/23/2011	4:25	1.23	5.92	0.36	1.08	0.06
87	6/26/2011	4:25	6/26/2011	10:40	3.00	6.25	0.81	0.36	0.13
88	6/27/2011	10:10	6/27/2011	11:15	0.98	1.08	0.17	1.08	0.16
89	7/4/2011	8:50	7/4/2011	9:10	6.90	0.33	0.18	0.36	0.54
90	7/8/2011	2:35	7/8/2011	8:05	3.73	5.50	0.64	1.81	0.12
91	7/13/2011	14:00	7/13/2011	14:10	5.25	0.17	0.11	0.84	0.66
92	7/23/2011	13:05	7/23/2011	13:30	9.95	0.42	0.97	5.90	2.33
93	8/3/2011	8:05	8/3/2011	8:35	10.77	0.50	0.43	2.53	0.86
94	8/7/2011	5:40	8/7/2011	7:30	3.88	1.83	0.74	2.29	0.40
95	8/8/2011	20:00	8/8/2011	21:40	1.52	1.67	1.15	2.17	0.69
96	8/14/2011	2:20	8/14/2011	4:15	5.19	1.92	0.12	0.36	0.06
97	8/21/2011	17:40	8/21/2011	17:55	7.56	0.25	0.20	1.69	0.80
98	9/4/2011	1:10	9/4/2011	3:30	13.30	2.33	0.54	2.05	0.23
99	9/4/2011	20:10	9/4/2011	21:55	0.69	1.75	0.28	0.84	0.16
100	9/7/2011	10:40	9/8/2011	3:05	2.53	16.42	0.49	0.36	0.03
101	9/14/2011	22:30	9/15/2011	2:10	6.81	3.67	0.43	0.36	0.12
102	9/19/2011	9:25	9/19/2011	16:30	4.30	7.08	0.48	0.36	0.07
103	9/23/2011	5:10	9/23/2011	10:00	3.53	4.83	0.58	0.36	0.12
104	9/25/2011	23:25	9/26/2011	9:00	2.56	9.58	3.38	1.69	0.35
105	9/29/2011	19:20	9/29/2011	21:30	3.43	2.17	0.37	1.45	0.17
106	10/18/2011	2:10	10/20/2011	15:25	18.19	61.25	2.27	0.96	0.04
107	10/26/2011	20:35	10/27/2011	4:10	6.22	7.58	0.92	0.60	0.12
108	11/3/2011	12:55	11/4/2011	2:50	7.36	13.92	1.37	0.48	0.10
109	11/14/2011	20:20	11/15/2011	7:10	10.73	10.83	1.59	1.69	0.15
110	11/16/2011	5:45	11/16/2011	11:05	0.94	5.33	0.32	0.24	0.06
111	11/21/2011	6:30	11/21/2011	9:25	4.81	2.92	0.36	2.05	0.12
112	11/21/2011	15:10	11/21/2011	23:30	0.24	8.33	0.16	0.24	0.02
113	11/22/2011	6:50	11/22/2011	15:30	0.31	8.67	0.83	0.60	0.10

Event #	Rain start date	Rain start time	Rain end date	Rain end time	Antecedent dry days	Rain dur. (hrs)	Total rain [a] (in)	5-minute peak rain intensity (in/hr)	Avg rain int. (in/hr)
114	11/27/2011	2:05	11/29/2011	5:00	4.44	50.92	2.33	0.36	0.05
115	11/29/2011	17:35	11/29/2011	21:55	0.52	4.33	0.13	0.12	0.03
116	12/4/2011	14:20	12/6/2011	2:15	4.68	35.92	3.17	0.60	0.09
117	12/15/2011	3:10	12/15/2011	12:15	9.04	9.08	0.32	0.36	0.04
118	12/19/2011	19:20	12/20/2011	1:35	4.30	6.25	0.24	0.24	0.04
119	12/20/2011	18:25	12/21/2011	7:55	0.70	13.50	0.74	0.84	0.05
120	12/22/2011	12:00	12/22/2011	20:10	1.17	8.17	0.66	0.24	0.08
121	12/27/2011	2:20	12/27/2011	17:25	4.26	15.08	0.66	0.36	0.04
122	12/28/2011	3:20	12/28/2011	18:25	0.41	15.08	1.66	0.36	0.11
123	1/11/2012	7:45	1/11/2012	12:55	13.56	5.17	0.36	0.48	0.07
124	1/17/2012	3:00	1/17/2012	14:20	5.59	11.33	1.76	2.41	0.16
125	1/20/2012	23:40	1/21/2012	0:35	3.39	0.92	0.12	0.48	0.13
126	1/23/2012	0:35	1/23/2012	5:55	2.00	5.33	0.44	0.96	0.08
127	1/26/2012	4:50	1/26/2012	9:50	2.95	5.00	0.72	0.96	0.14
128	1/26/2012	17:25	1/27/2012	5:40	0.32	12.25	0.96	0.96	0.08
129	2/16/2012	0:20	2/16/2012	7:10	19.78	6.83	0.28	0.48	0.04
130	2/29/2012	3:20	2/29/2012	5:40	12.84	2.33	0.24	0.48	0.10
131	2/29/2012	8:30	2/29/2012	9:15	0.12	0.75	0.12	0.48	0.16
132	3/2/2012	11:15	3/2/2012	17:05	2.08	5.83	0.52	1.45	0.09
133	3/8/2012	8:25	3/8/2012	17:00	5.64	8.58	0.64	0.48	0.07
134	3/12/2012	7:20	3/12/2012	11:55	3.60	4.58	0.12	0.48	0.03
135	3/15/2012	10:25	3/15/2012	12:10	2.94	1.75	0.80	1.93	0.46
136	3/23/2012	12:00	3/23/2012	18:30	7.99	6.50	0.44	0.96	0.07
137	3/24/2012	1:00	3/24/2012	2:00	0.27	1.00	0.36	1.93	0.36
138	3/30/2012	20:20	3/30/2012	22:20	6.76	2.00	0.32	1.45	0.16
139	4/1/2012	23:40	4/2/2012	0:35	2.06	0.92	0.40	0.96	0.44
140	4/14/2012	9:50	4/14/2012	17:35	12.39	7.75	1.32	1.45	0.17
141	4/20/2012	20:35	4/21/2012	3:20	6.13	6.75	0.16	0.48	0.02
142	4/25/2012	22:55	4/25/2012	23:55	4.82	1.00	0.72	3.37	0.72
143	4/28/2012	11:55	4/28/2012	14:20	2.50	2.42	0.80	1.93	0.33
144	5/1/2012	17:35	5/1/2012	20:00	3.14	2.42	1.52	5.30	0.63
145	5/4/2012	16:35	5/4/2012	16:40	2.86	0.08	0.16	1.93	1.92
146	5/5/2012	1:10	5/5/2012	3:05	0.35	1.92	0.20	0.48	0.10
147	5/7/2012	20:25	5/8/2012	8:30	2.72	12.08	0.80	2.89	0.07
148	5/13/2012	5:15	5/13/2012	21:30	4.86	16.25	1.40	0.96	0.09
149	5/29/2012	8:55	5/29/2012	10:00	15.48	1.08	0.28	0.96	0.26
150	6/1/2012	0:40	6/1/2012	8:10	2.61	7.50	1.12	1.93	0.15
151	6/11/2012	7:40	6/11/2012	10:30	9.98	2.83	0.16	0.48	0.06
152	6/17/2012	13:40	6/17/2012	14:05	6.13	0.42	0.12	0.96	0.29

Event #	Rain start date	Rain start time	Rain end date	Rain end time	Antecedent dry days	Rain dur. (hrs)	Total rain [a] (in)	5-minute peak rain intensity (in/hr)	Avg rain int. (in/hr)
153	6/29/2012	17:45	6/29/2012	18:05	12.15	0.33	0.40	1.45	1.20
154	7/14/2012	9:00	7/14/2012	10:30	14.62	1.50	0.36	1.45	0.24
155	7/18/2012	16:40	7/18/2012	17:55	4.26	1.25	0.92	1.93	0.74
156	7/19/2012	11:50	7/19/2012	12:35	0.75	0.75	0.32	1.93	0.43
157	7/23/2012	15:30	7/23/2012	21:45	4.12	6.25	0.36	1.93	0.06
158	7/27/2012	14:00	7/27/2012	18:50	3.68	4.83	0.36	1.45	0.07
159	10/1/2012	18:50	10/1/2012	23:25		4.58	0.76	1.23	0.17
160	10/5/2012	18:25	10/6/2012	0:40	3.79	6.25	0.40	0.58	0.06
161	10/14/2012	13:15	10/14/2012	22:45	8.52	9.50	0.36	1.02	0.04
162	10/19/2012	13:25	10/20/2012	0:30	4.61	11.08	0.28	0.17	0.03
163	10/26/2012	9:50	10/27/2012	3:30	6.39	17.67	0.82	0.36	0.05
164	10/30/2012	2:10	10/30/2012	10:30	2.94	8.33	0.45	0.11	0.05
165	11/3/2012	10:50	11/3/2012	16:10	4.01	5.33	0.11	0.12	0.02
166	11/12/2012	3:50	11/12/2012	13:55	8.49	10.08	0.77	0.35	0.08
167	11/26/2012	22:55	11/27/2012	2:20	14.38	3.42	0.10	0.05	0.03
168	12/2/2012	7:35	12/2/2012	11:30	5.22	3.92	0.48	0.59	0.12
169	12/4/2012	15:35	12/4/2012	19:30	2.17	3.92	0.22	0.27	0.06
170	12/7/2012	7:55	12/7/2012	18:20	2.52	10.42	0.83	0.28	0.08
171	12/9/2012	20:05	12/10/2012	0:25	2.07	4.33	0.98	1.59	0.23
172	12/15/2012	11:55	12/15/2012	15:00	5.48	3.08	0.09	0.14	0.03
173	12/17/2012	12:30	12/17/2012	16:20	1.90	3.83	0.51	1.54	0.13
174	12/20/2012	7:20	12/20/2012	16:20	2.63	9.00	0.86	0.51	0.10
175	12/26/2012	3:10	12/26/2012	15:15	5.45	12.08	1.18	0.37	0.10
176	12/28/2012	21:00	12/29/2012	6:10	2.24	9.17	0.12	0.08	0.01

Runoff characteristics for main entrance of the Cincinnati Zoo separate sewer line (manhole number 338162022)

Event #	Pipeflow start date	Pipeflow start time	Pipeflow end date	Flow end time	Flow dur. (hrs)	Total pipeflow discharge volume (ft3)	Total disch. (in)	5-minute Peak flow disch. rate (CFS)	5-minute Avg flow disch. rate (CFS)	Peak/avg pipeflow rate ratio	Rv (Runoff Depth/Rain Depth)	flow/ rain dur. ratio
1						0	0.000	0.00	0.00		0.00	0.00
2						0	0.000	0.00	0.00		0.00	0.00
3						0	0.000	0.00	0.00		0.00	0.00
4	2/22/2010	14:45	2/22/2010	23:35	8.83	140	0.016	0.02	0.00	5.00	0.22	1.29
5	3/12/2010	19:00	3/12/2010	20:15	1.25	132	0.015	0.11	0.03	3.67	0.02	0.28
6	3/13/2010	14:00	3/14/2010	0:35	10.58	261	0.029	0.04	0.01	5.71	0.06	0.78
7	3/22/2010	2:10	3/22/2010	2:35	24.42	37	0.004	0.08	0.02	3.33	0.01	3.45
8	3/25/2010	17:55	3/26/2010	8:50	14.92	1,107	0.124	0.11	0.02	5.24	0.10	1.09
9					0.00	0	0.000	0.00	0.00		0.00	0.00
10	4/24/2010	20:05	4/24/2010	21:30	1.42	327	0.037	0.19	0.07	2.79	0.04	0.13
11	5/2/2010	4:55	5/3/2010	1:15	20.33	586	0.066	0.09	0.01	9.00	0.05	1.18
12						0	0.000	0.00	0.00		0.00	0.00
13						0	0.000	0.00	0.00		0.00	0.00
14						0	0.000	0.00	0.00		0.00	0.00
15						0	0.000	0.00	0.00		0.00	0.00
16	5/21/2010	15:50	5/21/2010	16:40	0.83	203	0.023	0.20	0.06	3.23	0.03	0.37
17	6/5/2010	13:55	6/5/2010	14:40	0.75	189	0.021	0.19	0.07	2.71	0.10	2.25
18	6/6/2010	7:20	6/6/2010	8:40	1.33	5,144	0.576	4.34	1.072	1.25	1.92	2.29
19	6/12/2010	7:00	6/12/2010	19:15	12.25	6,295	0.705	0.74	0.143	5.17	0.27	1.48
20	6/14/2010	21:45	6/14/2010	23:00	1.25	449	0.050	0.63	0.1	6.30	0.10	1.67
21						0	0.000	0.00	0.00		0.00	0.00
22						0	0.000	0.00	0.00		0.00	0.00
23						0	0.000	0.00	0.00		0.00	0.00
24						0	0.000	0.00	0.00		0.00	0.00
25						0	0.000	0.00	0.00		0.00	0.00
26						0	0.000	0.00	0.00		0.00	0.00
27	7/20/2010	20:45	7/20/2010	21:05	0.33	130	0.015	0.43	0.108	3.98	0.03	0.12
28						0	0.000	0.00	0.00		0.00	0.00
29	8/14/2010	17:55	8/14/2010	18:05	0.17	9	0.001	0.02	0.015	1.33	0.00	0.11
30						0	0.000	0	0		0.00	0.00
31						0	0.000	0	0		0.00	0.00
32						0	0.000	0	0		0.00	0.00
33						0	0.000	0	0		0.00	0.00
34	10/26/2010	11:35	10/26/2010	15:30	3.92	668	0.075	0.4	0.047	8.51	0.10	0.80
35						0	0.000	0.00	0.00		0.00	0.00
36						0	0.000	0.00	0.00		0.00	0.00

Event #	Pipeflow start date	Pipeflow start time	Pipeflow end date	Flow end time	Flow dur. (hrs)	Total pipeflow discharge volume (ft3)	Total disch. (in)	5-minute Peak flow disch. rate (CFS)	5-minute Avg flow disch. rate (CFS)	Peak/avg pipeflow rate ratio	Rv (Runoff Depth/Rain Depth)	flow/ rain dur. ratio
37	11/25/2010	12:15	11/26/2010	3:10	14.92	43,925		9.88	0.818	12.08	0.00	0.79
38	11/30/2010	16:15	11/30/2010	20:55	4.67	110	0.012	0.19	0.01	19.00	0.01	0.41
39						0	0.000	0	0		0.00	0.00
40						0	0.000	0	0		0.00	0.00
41						0	0.000	0	0		0.00	0.00
42						0	0.000	0	0		0.00	0.00
43						0	0.000	0	0		0.00	0.00
44						0	0.000	0	0		0.00	0.00
45						0	0.000	0	0		0.00	0.00
46	2/1/2011	17:55	2/2/2011	9:45	15.83	1,150	0.129	0.23	0.02	11.50	0.12	0.69
47	2/5/2011	12:00	2/6/2011	2:35	14.58	32	0.004	0.01	0.001	10.00	0.02	2.16
48	2/21/2011	11:20	2/22/2011	10:30	23.17	2,282	0.255	0.25	0.027	9.26	0.12	2.09
49	2/24/2011	21:00	2/26/2011	6:40	33.67	3,091	0.346	0.24	0.025	9.60	0.19	2.97
50	2/27/2011	20:15	2/27/2011	21:25	1.17	143	0.016	0.17	0.034	5.00	0.08	0.67
51	2/28/2011	5:20	2/28/2011	17:55	12.58	577	0.065	0.37	0.013	28.46	0.15	1.94
52	3/4/2011	11:10	3/6/2011	12:10	49.00	2,817	0.315	0.16	0.016	10.00	0.18	1.25
53	3/8/2011	23:05	3/10/2011	2:20	27.25	2,251	0.252	0.2	0.023	8.70	0.16	1.24
54	3/15/2011	11:35	3/15/2011	19:10	7.58	31	0.003	0.02	0.002	10.00	0.03	0.99
55	3/18/2011	17:35	3/18/2011	21:45	4.17	316	0.035	0.25	0.021	11.90	0.06	1.43
56						0	0.000	0	0		0.00	0.00
57	4/4/2011	14:35	4/4/2011	22:35	8.00	526	0.059	0.41	0.018	22.78	0.05	1.78
58	4/9/2011	12:40	4/9/2011	20:10	7.50	458	0.051	0.18	0.017	10.59	0.09	2.05
59	4/11/2011	8:40	4/13/2011	5:00	44.33	2,337	0.262	0.06	0.015	4.00	0.11	1.93
60	4/15/2011	23:05	4/17/2011	4:30	29.42	822	0.092	0.05	0.008	6.25	0.06	2.42
61	4/19/2011	1:55	4/19/2011	16:50	14.92	968	0.108	0.06	0.018	3.33	0.04	1.43
62	4/20/2011	2:00	4/21/2011	12:00	34.00	694	0.078	0.05	0.006	8.33	0.10	5.16
63	4/22/2011	16:55	4/23/2011	1:50	8.92	275	0.031	0.04	0.009	4.44	0.04	2.82
64	4/24/2011	19:45	4/25/2011	9:40	13.92	657	0.074	0.04	0.013	3.08	0.20	0.99
65	4/27/2011	4:00	4/27/2011	15:30	11.50	237	0.026	0.04	0.006	6.67	0.03	1.48
66	4/27/2011	18:20	4/28/2011	4:55	10.58	127	0.014	0.04	0.003	13.33	0.06	1.08
67						0	0.000	0	0		0.00	0.00
68	5/2/2011	18:25	5/4/2011	9:00	38.58	1,846	0.207	0.12	0.013	9.23	0.08	0.99
69	5/8/2011	0:15	5/8/2011	2:05	1.83	66	0.007	0.03	0.01	3.00	0.02	0.69
70	5/13/2011	16:50	5/14/2011	0:55	8.08	143	0.016	0.03	0.005	6.00	0.02	8.08
71	5/15/2011	11:45	5/15/2011	16:55	5.17	118	0.013	0.03	0.006	5.00	0.13	2.38
72	5/15/2011	19:35	5/16/2011	4:55	9.33	106	0.012	0.03	0.003	10.00	0.07	1.49
73	5/17/2011	13:50	5/18/2011	12:05	22.25	182	0.020	0.02	0.002	10.00	0.06	1.27
74	5/22/2011	17:55	5/22/2011	20:15	2.33	30	0.003	0.02	0.004	5.00	0.03	14.00

Event #	Pipeflow start date	Pipeflow start time	Pipeflow end date	Flow end time	Flow dur. (hrs)	Total pipeflow discharge volume (ft3)	Total disch. (in)	5-minute Peak flow disch. rate (CFS)	5-minute Avg flow disch. rate (CFS)	Peak/avg pipeflow rate ratio	Rv (Runoff Depth/Rain Depth)	flow/ rain dur. ratio
75	5/23/2011	7:05	5/23/2011	9:20	2.25	70	0.008	0.04	0.009	4.44	0.02	1.08
76	5/23/2011	20:55	5/24/2011	9:35	12.67	247	0.028	0.03	0.005	6.00	0.05	2.49
77	5/26/2011	0:50	5/27/2011	0:40	23.83	353	0.039	0.04	0.004	10.00	0.05	1.34
78	6/4/2011	22:50	6/4/2011	23:45	0.92	65	0.007	0.14	0.018	7.78	0.08	5.50
79	6/10/2011	18:25	6/10/2011	23:30	5.08	155	0.017	0.04	0.008	5.00	0.02	1.27
80	6/11/2011	4:15	6/11/2011	13:15	9.00	166	0.019	0.13	0.005	26.00	0.03	1.93
81						0	0.000	0	0		0.00	0.00
82						0	0.000	0	0		0.00	0.00
83						0	0.000	0	0		0.00	0.00
84	6/20/2011	10:35	6/20/2011	18:15	7.67	234	0.026	0.04	0.008	5.00	0.04	2.24
85	6/21/2011	15:45	6/21/2011	21:20	5.58	185	0.021	0.05	0.009	5.56	0.03	2.31
86	6/22/2011	23:05	6/23/2011	8:15	9.17	148	0.017	0.05	0.004	12.50	0.05	1.55
87	6/26/2011	6:05	6/26/2011	14:30	8.42	380	0.043	0.05	0.013	3.85	0.05	1.35
88	6/27/2011	10:30	6/27/2011	16:20	5.83	105	0.012	0.04	0.005	8.00	0.07	5.38
89						0	0.000	0	0		0.00	0.00
90	7/8/2011	6:00	7/8/2011	8:30	2.50	176	0.020	0.05	0.02	2.50	0.03	0.45
91						0	0.000	0	0		0.00	0.00
92						0	0.000	0	0		0.00	0.00
93	8/3/2011	8:30	8/3/2011	8:50	0.33	25	0.003	0.03	0.021	1.43	0.01	0.67
94	8/7/2011	5:55	8/7/2011	7:55	2.00	298	0.033	0.25	0.041	6.10	0.05	1.09
95	8/8/2011	20:10	8/9/2011	0:05	3.92	539	0.060	0.32	0.038	8.42	0.05	2.35
96						0	0.000	0	0		0.00	0.00
97	8/21/2011	18:00	8/21/2011	18:35	0.58	17	0.002	0.03	0.008	3.75	0.01	2.33
98	9/4/2011	2:25	9/4/2011	3:20	0.92	38	0.004	0.05	0.012	4.17	0.01	0.39
99	9/4/2011	20:25	9/4/2011	21:55	1.50	156	0.017	0.11	0.029	3.79	0.06	0.86
100	9/7/2011	12:55	9/8/2011	23:25	34.50	396	0.044	0.04	0.01	4.00	0.09	2.10
101	9/15/2011	0:00	9/15/2011	2:30	2.50	185	0.021	0.04	0.021	1.90	0.05	0.68
102	9/19/2011	14:55	9/19/2011	16:20	1.42	215	0.024	0.07	0.009	7.78	0.05	0.20
103	9/23/2011	5:55	9/23/2011	10:10	4.25	301	0.034	0.09	0.02	4.50	0.06	0.88
104	9/26/2011	1:20	9/26/2011	7:15	5.92	3,279	0.367	0.45	0.031	14.52	0.11	0.62
105	9/29/2011	19:35	9/29/2011	22:20	2.75	141	0.016	0.08	0.014	5.71	0.04	1.27
106	10/19/2011	5:30	10/20/2011	9:30	28.00	1,067	0.119	0.06	0.011	5.45	0.05	0.46
107	10/26/2011	21:20	10/27/2011	5:25	8.08	689	0.077	0.09	0.024	3.75	0.08	1.07
108	11/3/2011	16:45	11/4/2011	3:40	10.92	908	0.102	0.06	0.023	2.61	0.07	0.78
109	11/14/2011	20:30	11/15/2011	15:20	18.83	1,621	0.181	0.2	0.024	8.33	0.11	1.74
110	11/16/2011	6:05	11/16/2011	15:55	9.83	331	0.037	0.06	0.009	6.67	0.12	1.84
111	11/21/2011	6:40	11/21/2011	10:20	3.67	113	0.013	0.07	0.009	7.78	0.04	1.26
112	11/21/2011	14:30	11/22/2011	0:50	10.33	223	0.025	0.04	0.006	6.67	0.16	1.24

Event #	Pipeflow start date	Pipeflow start time	Pipeflow end date	Flow end time	Flow dur. (hrs)	Total pipeflow discharge volume (ft3)	Total disch. (in)	5-minute Peak flow disch. rate (CFS)	5-minute Avg flow disch. rate (CFS)	Peak/avg pipeflow rate ratio	Rv (Runoff Depth/Rain Depth)	flow/ rain dur. ratio
113	11/22/2011	6:45	11/22/2011	22:15	15.50	962	0.108	0.14	0.017	8.24	0.13	1.79
114	11/27/2011	5:20	11/29/2011	14:05	56.75	3,136	0.351	0.05	0.015	3.33	0.15	1.11
115	11/29/2011	17:35	11/30/2011	2:35	9.00	202	0.023	0.04	0.006	6.67	0.17	2.08
116	12/4/2011	16:20	12/7/2011	0:45	56.42	3,372	0.377	0.14	0.017	8.24	0.12	1.57
117	12/15/2011	5:45	12/15/2011	12:55	7.17	114	0.013	0.03	0.004	7.50	0.04	0.79
118	12/19/2011	23:45	12/20/2011	1:20	1.58	9	0.001	0.003	0.001	3.00	0.00	0.25
119	12/21/2011	4:00	12/21/2011	12:25	8.42	451	0.050	0.082	0.015	5.47	0.07	0.62
120	12/22/2011	13:00	12/23/2011	2:00	13.00	634	0.071	0.045	0.014	3.21	0.11	1.59
121	12/27/2011	4:45	12/27/2011	17:25	12.67	499	0.056	0.043	0.011	3.91	0.08	0.84
122	12/28/2011	5:45	12/28/2011	18:25	12.67	500	0.056	0.043	0.011	3.91	0.03	0.84
123	1/11/2012	11:15	1/11/2012	14:10	2.92	47	0.005	0.028	0.004	7.00	0.01	0.56
124	1/17/2012	7:55	1/17/2012	21:25	13.50	1,491	0.167	0.285	0.025	11.40	0.09	1.19
125	1/20/2012	23:45	1/21/2012	2:55	3.17	143	0.016	0.032	0.012	2.67	0.13	3.45
126	1/23/2012	0:45	1/23/2012	10:25	9.67	363	0.041	0.155	0.01	15.50	0.09	1.81
127	1/26/2012	4:55	1/26/2012	15:30	10.58	791	0.089	0.152	0.021	7.24	0.12	2.12
128	1/26/2012	17:25	1/27/2012	21:30	28.08	1,474	0.165	0.204	0.015	13.60	0.17	2.29
129	2/16/2012	7:05	2/16/2012	7:40	0.58	38	0.004	0.043	0.018	2.39	0.02	0.09
130	2/29/2012	6:00	2/29/2012	6:15	0.25	17	0.002	0.032	0.019	1.68	0.01	0.11
131	2/29/2012	8:50	2/29/2012	10:25	1.58	130	0.015	0.105	0.023	4.57	0.12	2.11
132	3/2/2012	12:20	3/2/2012	19:35	7.25	554	0.062	0.223	0.021	10.62	0.12	1.24
133	3/8/2012	8:55	3/8/2012	18:55	10.00	659	0.074	0.085	0.018	4.72	0.12	1.17
134	3/12/2012	9:30	3/12/2012	10:35	1.08	12	0.001	0.008	0.003	2.67	0.01	0.24
135	3/15/2012	9:35	3/15/2012	15:05	5.50	600	0.067	0.19	0.03	6.33	0.08	3.14
136	3/23/2012	12:05	3/23/2012	19:10	7.08	593	0.066	0.118	0.023	5.13	0.15	1.09
137	3/24/2012	1:00	3/24/2012	5:15	4.25	434	0.049	0.303	0.028	10.82	0.14	4.25
138	3/30/2012	20:40	3/30/2012	23:50	3.17	199	0.022	0.067	0.017	3.94	0.07	1.58
139	4/2/2012	0:00	4/2/2012	2:00	2.00	729	0.082	1.343	0.097	13.85	0.20	2.18
140	4/14/2012	10:20	4/14/2012	22:45	12.42	1,393	0.156	0.215	0.031	6.94	0.12	1.60
141	4/20/2012	22:45	4/21/2012	12:20	13.58	267	0.030	0.036	0.005	7.20	0.19	2.01
142	4/25/2012	23:45	4/26/2012	6:45	7.00	787	0.088	1.536	0.031	49.55	0.12	7.00
143	4/28/2012	12:25	4/28/2012	18:10	5.75	473	0.053	0.204	0.023	8.87	0.07	2.38
144	5/1/2012	17:45	5/2/2012	5:55	12.17	2,095	0.235	1.038	0.048	21.63	0.15	5.03
145	5/4/2012	16:40	5/4/2012	18:45	2.08	84	0.009	0.056	0.011	5.09	0.06	25.00
146	5/5/2012	1:10	5/5/2012	19:45	18.58	246	0.028	0.051	0.009	5.67	0.14	9.70
147	5/7/2012	20:40	5/8/2012	12:00	15.33	807	0.090	0.152	0.015	10.13	0.11	1.27
148	5/13/2012	7:50	5/13/2012	23:10	15.33	1,680	0.188	0.149	0.03	4.97	0.13	0.94
149						0	0.000	0	0		0.00	0.00
150						0	0.000	0	0		0.00	0.00

Event #	Pipeflow start date	Pipeflow start time	Pipeflow end date	Flow end time	Flow dur. (hrs)	Total pipeflow discharge volume (ft3)	Total disch. (in)	5-minute Peak flow disch. rate (CFS)	5-minute Avg flow disch. rate (CFS)	Peak/avg pipeflow rate ratio	Rv (Runoff Depth/Rain Depth)	flow/ rain dur. ratio
151						0	0.000	0	0		0.00	0.00
152						0	0.000	0	0		0.00	0.00
153						0	0.000	0	0		0.00	0.00
154						0	0.000	0	0		0.00	0.00
155	7/18/2012	17:30	7/18/2012	18:40	1.17	17	0.002	0.036	0.04	0.90	0.00	0.93
156						0	0.000	0	0		0.00	0.00
157						0	0.000	0	0		0.00	0.00
158						0	0.000	0	0		0.00	0.00
159	10/1/2012	18:50	10/1/2012	23:25	4.58	802	0.090	0.234	0.049	4.78	0.12	1.00
160	10/6/2012	1:05	10/6/2012	2:35	1.50	261	0.029	0.139	0.048	2.90	0.07	0.24
161	10/14/2012	18:25	10/14/2012	19:25	1.00	133	0.015	0.176	0.037	4.76	0.04	0.11
162	10/20/2012	1:05	10/20/2012	2:15	1.17	60	0.007	0.039	0.014	2.79	0.02	0.11
163	10/26/2012	14:45	10/27/2012	3:35	12.83	1,148	0.128	0.08	0.025	3.20	0.16	0.73
164	10/30/2012	7:15	10/30/2012	11:35	4.33	512	0.057	0.063	0.032	1.97	0.13	0.52
165						0	0.000	0	0		0.00	0.00
166	11/12/2012	8:30	11/12/2012	14:25	5.92	710	0.079	0.139	0.033	4.21	0.10	0.59
167						0	0.000	0	0		0.00	0.00
168						0	0.000	0	0		0.00	0.00
169	12/4/2012	18:00	12/4/2012	18:45	0.75	43	0.005	0.019	0.007	2.71	0.02	0.19
170	12/7/2012	9:55	12/7/2012	19:50	9.92	1,208	0.135	0.13	0.034	3.82	0.16	0.95
171	12/9/2012	20:40	12/10/2012	5:20	8.67	1,431	0.160	0.339	0.046	7.37	0.16	2.00
172						0	0.000	0	0		0.00	0.00
173	12/17/2012	15:40	12/17/2012	16:50	1.17	166	0.019	0.128	0.039	3.28	0.04	0.30
174	12/20/2012	9:05	12/20/2012	17:05	8.00	1,112	0.124	0.122	0.039	3.13	0.14	0.89
175	12/26/2012	6:50	12/26/2012	15:05	8.25	535	0.060	0.104	0.018	5.78	0.05	0.68
176						0	0.000	0	0		0.00	0.00

Rainfall characteristics for African Savannah zoo combined sewer line

Event #	Rain start date	Rain start time	Rain end date	Rain end time	Antecedent dry days	Rain dur. (hrs)	Total rain [a] (in)	5-minute peak rain intensity (in/hr)	Avg rain int. (in/hr)
1	1/17/2010	10:30	1/17/2010	17:15		6.75	0.13	0.12	0.02
2	1/21/2010	4:15	1/22/2010	0:15	3.46	20.00	0.65	0.36	0.03
3	1/24/2010	4:35	1/24/2010	14:50	2.18	10.25	0.54	0.60	0.05
4	2/5/2010	9:50	2/6/2010	4:40	11.79	18.83	0.93	0.60	0.05
5	2/12/2010	10:10	2/12/2010	17:00	6.23	6.83	0.27	0.24	0.04
6	2/18/2010	14:05	2/18/2010	18:35	5.88	4.50	0.13	0.36	0.03
7	3/12/2010	17:45	3/13/2010	20:40	21.97	26.92	1.32	1.08	0.05
8	3/21/2010	22:05	3/22/2010	5:10	8.06	7.08	0.61	0.48	0.09
9	3/25/2010	13:55	3/26/2010	1:15	3.36	11.33	1.27	0.48	0.11
10	3/29/2010	6:15	3/29/2010	9:35	3.21	3.33	0.08	0.12	0.02
11	4/5/2010	19:30	4/5/2010	20:55	7.41	1.42	0.11	0.48	0.08
12	4/8/2010	0:55	4/8/2010	8:05	2.17	7.17	0.54	0.96	0.08
13	4/23/2010	11:00	4/23/2010	15:10	15.12	4.17	0.14	0.24	0.03
14	4/24/2010	16:55	4/25/2010	3:20	1.07	10.42	0.91	0.60	0.09
15	4/25/2010	14:35	4/25/2010	19:25	0.47	4.83	0.16	0.36	0.03
16	5/2/2010	3:00	5/2/2010	20:15	6.32	17.25	1.36	0.72	0.08
17	5/11/2010	4:35	5/11/2010	10:15	8.35	5.67	0.40	0.96	0.07
18	5/12/2010	7:45	5/12/2010	13:40	0.90	5.92	0.50	1.20	0.08
19	5/16/2010	20:00	5/16/2010	23:55	4.26	3.92	0.14	0.12	0.04
20	5/17/2010	5:00	5/17/2010	8:05	0.21	3.08	0.16	0.12	0.05
21	5/21/2010	2:10	5/21/2010	3:55	3.75	1.75	0.16	0.36	0.09
22	5/21/2010	12:45	5/21/2010	18:35	0.37	5.83	0.93	2.41	0.16
23	6/5/2010	14:45	6/5/2010	15:05	14.84	0.33	0.22	1.33	0.66
24	6/6/2010	8:15	6/6/2010	8:50	0.72	0.58	0.30	1.33	0.51
25	6/12/2010	7:30	6/12/2010	12:20	5.94	4.83	2.64	2.05	0.55
26	6/14/2010	22:35	6/14/2010	23:20	2.43	0.75	0.50	2.65	0.67
27	6/19/2010	7:15	6/19/2010	9:20	4.33	2.08	0.70	1.81	0.34
28	6/21/2010	11:55	6/21/2010	14:45	2.11	2.83	0.59	2.17	0.21
29	6/27/2010	23:10	6/28/2010	5:50	6.35	6.67	1.70	3.37	0.26
30	7/9/2010	11:00	7/9/2010	12:50	11.22	1.83	0.22	0.48	0.12
31	7/13/2010	9:00	7/13/2010	16:25	3.84	7.42	0.25	0.72	0.03
32	7/17/2010	17:35	7/17/2010	18:05	4.05	0.50	0.29	1.20	0.58
33	7/20/2010	18:05	7/20/2010	22:45	3.00	4.67	0.52	1.33	0.11
34	8/11/2010	14:55	8/11/2010	15:10	21.67	0.25	0.20	1.20	0.80
35	8/14/2010	17:25	8/14/2010	18:55	3.09	1.50	0.50	1.20	0.33
36	8/15/2010	16:50	8/15/2010	17:25	0.91	0.58	0.18	0.60	0.31
37	9/16/2010	4:10	9/16/2010	6:40	31.45	2.50	0.15	0.72	0.06

Event #	Rain start date	Rain start time	Rain end date	Rain end time	Antecedent dry days	Rain dur. (hrs)	Total rain [a] (in)	5-minute peak rain intensity (in/hr)	Avg rain int. (in/hr)
38	10/13/2010	18:10	10/13/2010	19:40	27.48	1.50	0.14	0.36	0.09
39	10/26/2010	12:30	10/26/2010	17:25	12.70	4.92	0.72	2.05	0.15
40	11/16/2010	11:10	11/16/2010	22:05	20.74	10.92	0.99	0.84	0.09
41	11/23/2010	1:30	11/23/2010	5:00	6.14	3.50	0.64	0.96	0.18
42	11/25/2010	6:05	11/26/2010	1:05	2.05	19.00	2.61	1.08	0.14
43	11/30/2010	0:00	11/30/2010	20:40	3.95	20.67	1.53	0.60	0.07
44	1/1/2011	1:20	1/1/2011	9:50	31.19	8.50	0.50	0.36	0.06
45	1/18/2011	3:25	1/18/2011	18:10	16.73	14.75	0.29	0.24	0.02
46	1/24/2011	22:25	1/25/2011	10:10	6.18	11.75	0.20	0.24	0.02
47	2/1/2011	1:45	2/2/2011	0:40	6.65	22.92	1.10	0.36	0.05
48	2/5/2011	5:20	2/5/2011	12:05	3.19	6.75	0.23	0.24	0.03
49	2/21/2011	8:10	2/21/2011	19:15	15.84	11.08	2.13	1.20	0.19
50	2/24/2011	17:45	2/25/2011	5:05	2.94	11.33	1.80	0.60	0.16
51	2/27/2011	19:05	2/27/2011	20:50	2.58	1.75	0.19	0.48	0.11
52	2/28/2011	5:15	2/28/2011	11:45	0.35	6.50	0.43	1.33	0.07
53	3/4/2011	6:35	3/5/2011	21:55	3.78	39.33	1.77	0.48	0.04
54	3/8/2011	21:55	3/9/2011	19:55	3.00	22.00	1.62	0.48	0.07
55	3/15/2011	10:40	3/15/2011	18:20	5.61	7.67	0.11	0.36	0.01
56	3/18/2011	16:00	3/18/2011	18:55	2.90	2.92	0.60	1.33	0.21
57	4/1/2011	20:40	4/2/2011	4:00	14.07	7.33	0.14	0.48	0.02
58	4/4/2011	13:30	4/4/2011	18:00	2.40	4.50	1.15	2.65	0.26
59	4/9/2011	11:45	4/9/2011	15:25	4.74	3.67	0.57	1.45	0.16
60	4/11/2011	8:00	4/12/2011	7:00	1.69	23.00	2.42	1.45	0.11
61	4/15/2011	22:15	4/16/2011	10:25	3.64	12.17	1.58	0.96	0.13
62	4/19/2011	1:35	4/19/2011	12:00	2.63	10.42	2.59	2.53	0.25
63	4/20/2011	1:35	4/20/2011	8:10	0.57	6.58	0.81	1.08	0.12
64	4/22/2011	16:45	4/22/2011	19:55	2.36	3.17	0.83	2.53	0.26
65	4/24/2011	18:35	4/25/2011	9:35	1.94	15.00	0.39	0.24	0.03
66	4/27/2011	4:00	4/27/2011	11:45	1.77	7.75	0.79	2.17	0.10
67	4/27/2011	17:00	4/28/2011	2:50	0.22	9.83	0.24	0.24	0.02
68	4/28/2011	17:45	4/28/2011	19:55	0.62	2.17	0.26	0.72	0.12
69	5/1/2011	20:30	5/3/2011	11:35	3.02	39.08	2.47	0.60	0.06
70	5/7/2011	23:25	5/8/2011	2:05	4.49	2.67	0.31	0.48	0.12
71	5/13/2011	15:55	5/13/2011	16:55	5.58	1.00	1.01	3.73	1.01
72	5/15/2011	12:00	5/15/2011	14:10	1.80	2.17	0.10	0.12	0.05
73	5/15/2011	19:50	5/16/2011	2:05	0.24	6.25	0.18	0.60	0.03
74	5/17/2011	13:30	5/18/2011	7:00	1.48	17.50	0.33	0.24	0.02
75	5/22/2011	17:45	5/22/2011	17:55	4.45	0.17	0.10	0.84	0.60
76	5/23/2011	5:45	5/23/2011	7:50	0.49	2.08	0.33	0.48	0.16

Event #	Rain start date	Rain start time	Rain end date	Rain end time	Antecedent dry days	Rain dur. (hrs)	Total rain [a] (in)	5-minute peak rain intensity (in/hr)	Avg rain int. (in/hr)
77	5/23/2011	19:20	5/24/2011	0:25	0.48	5.08	0.53	1.08	0.10
78	5/26/2011	0:30	5/26/2011	18:20	2.00	17.83	0.79	1.45	0.04
79	6/4/2011	22:25	6/4/2011	22:35	9.17	0.17	0.09	0.72	0.54
80	6/10/2011	13:15	6/10/2011	21:15	5.61	8.00	1.12	1.08	0.14
81	6/11/2011	4:05	6/11/2011	8:45	0.28	4.67	0.74	1.57	0.16
82	6/15/2011	11:10	6/15/2011	15:35	4.10	4.42	0.54	0.48	0.12
83	6/18/2011	8:15	6/18/2011	13:05	2.69	4.83	0.10	0.12	0.02
84	6/19/2011	10:35	6/19/2011	11:35	0.90	1.00	0.13	0.24	0.13
85	6/20/2011	9:10	6/20/2011	12:35	0.90	3.42	0.73	1.45	0.21
86	6/21/2011	14:35	6/21/2011	17:00	1.08	2.42	0.62	1.57	0.26
87	6/22/2011	22:30	6/23/2011	4:25	1.23	5.92	0.36	1.08	0.06
88	6/26/2011	4:25	6/26/2011	10:40	3.00	6.25	0.81	0.36	0.13
89	6/27/2011	10:10	6/27/2011	11:15	0.98	1.08	0.17	1.08	0.16
90	7/4/2011	2:35	7/4/2011	8:00	6.64	5.42	0.64	1.81	0.12
91	7/8/2011	2:35	7/8/2011	8:05	3.77	5.50	0.64	1.81	0.12
92	7/23/2011	13:05	7/23/2011	13:30	15.21	0.42	0.97	5.90	2.33
93	8/3/2011	5:10	8/3/2011	11:40	10.65	6.50	0.66	2.53	0.10
94	8/7/2011	5:40	8/7/2011	7:30	3.75	1.83	0.74	2.29	0.40
95	8/8/2011	20:00	8/8/2011	21:40	1.52	1.67	1.15	2.17	0.69
96	8/14/2011	2:20	8/14/2011	4:15	5.19	1.92	0.12	0.36	0.06
97	8/21/2011	17:40	8/21/2011	17:55	7.56	0.25	0.20	1.69	0.80
98	9/4/2011	1:10	9/4/2011	3:30	13.30	2.33	0.54	2.05	0.23
99	9/4/2011	20:10	9/4/2011	23:25	0.69	3.25	0.29	0.84	0.09
100	9/7/2011	10:40	9/8/2011	3:05	2.47	16.42	0.49	0.36	0.03
101	9/14/2011	22:30	9/15/2011	2:10	6.81	3.67	0.43	0.36	0.12
102	9/19/2011	9:25	9/19/2011	16:30	4.30	7.08	0.48	0.36	0.07
103	9/23/2011	5:10	9/23/2011	12:15	3.53	7.08	0.59	0.36	0.08
104	9/25/2011	23:25	9/26/2011	9:00	2.47	9.58	3.38	1.69	0.35
105	9/29/2011	19:20	9/29/2011	21:30	3.43	2.17	0.37	1.45	0.17
106	10/18/2011	19:00	10/20/2011	15:25	18.90	44.42	2.27	0.96	0.05
107	10/26/2011	20:35	10/27/2011	4:10	6.22	7.58	0.92	0.60	0.12
108	11/3/2011	12:55	11/4/2011	2:50	7.36	13.92	1.37	0.48	0.10
109	11/14/2011	20:20	11/15/2011	7:10	10.73	10.83	1.61	1.69	0.15
110	11/16/2011	5:45	11/16/2011	11:05	0.94	5.33	0.32	0.24	0.06
111	11/21/2011	6:30	11/21/2011	9:25	4.81	2.92	0.36	2.05	0.12
112	11/21/2011	15:10	11/21/2011	23:30	0.24	8.33	0.16	0.24	0.02
113	11/22/2011	6:50	11/22/2011	15:30	0.31	8.67	0.83	0.60	0.10
114	11/27/2011	2:05	11/29/2011	5:00	4.44	50.92	2.33	0.36	0.05
115	12/4/2011	14:20	12/6/2011	2:15	5.39	35.92	3.17	0.60	0.09

Event #	Rain start date	Rain start time	Rain end date	Rain end time	Antecedent dry days	Rain dur. (hrs)	Total rain [a] (in)	5-minute peak rain intensity (in/hr)	Avg rain int. (in/hr)
116	12/15/2011	3:10	12/15/2011	12:15	9.04	9.08	0.32	0.36	0.04
117	12/19/2011	19:20	12/20/2011	1:35	4.30	6.25	0.24	0.24	0.04
118	12/20/2011	18:25	12/21/2011	7:55	0.70	13.50	0.74	0.84	0.05
119	12/22/2011	12:00	12/22/2011	20:10	1.17	8.17	0.66	0.24	0.08
120	12/27/2011	2:20	12/27/2011	17:25	4.26	15.08	0.66	0.36	0.04
121	1/11/2012	7:45	1/11/2012	12:55	14.60	5.17	0.36	0.48	0.07
122	1/17/2012	3:00	1/17/2012	14:20	5.59	11.33	1.76	2.41	0.16
123	1/20/2012	23:40	1/21/2012	0:35	3.39	0.92	0.12	0.48	0.13
124	1/23/2012	0:35	1/23/2012	5:55	2.00	5.33	0.44	0.96	0.08
125	1/26/2012	4:50	1/26/2012	9:50	2.95	5.00	0.72	0.96	0.14
126	1/26/2012	17:25	1/27/2012	5:40	0.32	12.25	0.96	0.96	0.08
127	2/16/2012	0:20	2/16/2012	7:10	19.78	6.83	0.28	0.48	0.04
128	2/29/2012	3:20	2/29/2012	9:15	12.84	5.92	0.36	0.48	0.06
129	3/2/2012	11:15	3/2/2012	17:05	2.08	5.83	0.52	1.45	0.09
130	3/8/2012	8:25	3/8/2012	17:00	5.64	8.58	0.64	0.48	0.07
131	3/12/2012	7:20	3/12/2012	11:55	3.60	4.58	0.12	0.48	0.03
132	3/15/2012	10:25	3/15/2012	12:10	2.94	1.75	0.80	1.93	0.46
133	3/23/2012	12:00	3/23/2012	18:30	7.99	6.50	0.44	0.96	0.07
134	3/24/2012	1:00	3/24/2012	2:00	0.27	1.00	0.36	1.93	0.36
135	3/30/2012	20:20	3/30/2012	22:20	6.76	2.00	0.32	1.45	0.16
136	4/1/2012	23:40	4/2/2012	0:35	2.06	0.92	0.40	0.96	0.44
137	4/14/2012	9:50	4/14/2012	17:35	12.39	7.75	1.32	1.45	0.17
138	4/20/2012	20:35	4/21/2012	3:20	6.13	6.75	0.16	0.48	0.02
139	4/25/2012	22:55	4/25/2012	23:55	4.82	1.00	0.72	3.37	0.72
140	4/28/2012	11:55	4/28/2012	14:20	2.50	2.42	0.80	1.93	0.33
141	5/1/2012	17:35	5/1/2012	20:00	3.14	2.42	1.52	5.30	0.63
142	5/4/2012	16:35	5/4/2012	16:40	2.86	0.08	0.16	1.93	1.92
143	5/5/2012	1:10	5/5/2012	3:05	0.35	1.92	0.20	0.48	0.10
144	5/7/2012	20:25	5/8/2012	8:30	2.72	12.08	0.80	2.89	0.07
145	5/13/2012	5:15	5/13/2012	21:30	4.86	16.25	1.40	0.96	0.09
146	5/29/2012	8:55	5/29/2012	10:00	15.48	1.08	0.28	0.96	0.26
147	6/1/2012	0:40	6/1/2012	8:10	2.61	7.50	1.12	1.93	0.15
148	6/11/2012	7:40	6/11/2012	10:30	9.98	2.83	0.16	0.48	0.06
149	6/17/2012	13:40	6/17/2012	14:05	6.13	0.42	0.12	0.96	0.29
150	6/29/2012	17:45	6/29/2012	18:05	12.15	0.33	0.40	1.45	1.20
151	7/14/2012	9:00	7/14/2012	10:30	14.62	1.50	0.36	1.45	0.24
152	7/18/2012	16:40	7/18/2012	17:55	4.26	1.25	0.92	1.93	0.74
153	7/19/2012	11:50	7/19/2012	12:35	0.75	0.75	0.32	1.93	0.43
154	7/27/2012	14:00	7/27/2012	18:50	8.06	4.83	0.36	1.45	0.07

Event #	Rain start date	Rain start time	Rain end date	Rain end time	Antecedent dry days	Rain dur. (hrs)	Total rain [a] (in)	5-minute peak rain intensity (in/hr)	Avg rain int. (in/hr)
155	10/1/2012	16:15	10/1/2012	23:25		7.17	0.76	1.23	0.11
156	10/5/2012	18:25	10/6/2012	0:40	3.79	6.25	0.40	0.58	0.06
157	10/14/2012	13:15	10/14/2012	22:45	8.52	9.50	0.36	1.02	0.04
158	10/19/2012	13:25	10/20/2012	0:30	4.61	11.08	0.28	0.17	0.03
159	10/26/2012	9:50	10/27/2012	3:30	6.39	17.67	0.82	0.36	0.05
160	10/30/2012	2:10	10/30/2012	10:30	2.94	8.33	0.45	0.11	0.05
161	11/3/2012	10:50	11/3/2012	16:10	4.01	5.33	0.11	0.12	0.02
162	11/12/2012	3:50	11/12/2012	13:55	8.49	10.08	0.77	0.35	0.08
163	11/26/2012	22:55	11/27/2012	2:20	14.38	3.42	0.10	0.05	0.03

Runoff characteristics for African Savannah zoo combined sewer line

Event #	Pipeflow start date	Pipeflow start time	Pipeflow end date	Flow end time	Flow dur. (hrs)	Total pipeflow discharge volume (ft3)	Total disch. (in)	5-minute Peak flow disch. rate (CFS)	5-minute Avg flow disch. rate (CFS)	Peak/avg pipeflow rate ratio	Rv (Runoff Depth/Rain Depth)	flow/ rain dur. ratio
1	1/17/2010	10:15	1/17/2010	19:05	8.83	1,050	0.017	0.10	0.05	2.00	0.13	1.31
2	1/21/2010	14:25	1/22/2010	8:45	90.33	16,066	0.257	2.81	0.24	11.71	0.40	4.52
3	1/24/2010	5:30	1/24/2010	16:40	11.17	12,146	0.195	3.91	0.27	14.48	0.36	1.09
4	2/5/2010	12:40	2/6/2010	10:15	21.58	6,768	0.108	0.21	0.09	2.33	0.12	1.15
5	2/12/2010	11:10	2/12/2010	19:40	8.50	1,023	0.016	0.22	0.03	7.33	0.06	1.24
6	2/18/2010	16:20	2/18/2010	19:10	2.83	22	0.000	0.03	0.00	15.00	0.00	0.63
7	3/12/2010	17:50	3/14/2010	4:15	34.42	39,670	0.635	2.78	0.32	8.69	0.48	1.28
8	3/21/2010	22:20	3/22/2010	11:30	13.17	13,052	0.209	2.07	0.28	7.39	0.34	1.86
9	3/25/2010	14:15	3/26/2010	7:05	16.83	39,993	0.641	3.10	0.74	4.19	0.50	1.49
10	3/29/2010	6:25	3/29/2010	10:10	3.75	756	0.012	0.16	0.06	2.67	0.15	1.12
11	4/5/2010	19:40	4/5/2010	20:15	0.58	442	0.007	0.59	0.21	2.81	0.06	0.41
12	4/8/2010	1:00	4/8/2010	10:05	9.08	9,497	0.152	1.71	0.29	5.90	0.28	1.27
13	4/23/2010	11:30	4/23/2010	16:40	5.17	7,779	0.125	2.93	0.42	6.98	0.89	1.24
14	4/24/2010	17:05	4/25/2010	4:10	11.08	22,198	0.356	2.35	0.56	4.20	0.39	1.06
15	4/25/2010	14:45	4/25/2010	20:50	6.08	1,153	0.018	0.40	0.05	8.00	0.12	1.26
16	5/2/2010	3:00	5/3/2010	8:20	29.33	47,466	0.760	1.96	0.45	4.36	0.56	1.70
17	5/11/2010	4:45	5/11/2010	12:30	7.75	2,122	0.034	1.59	0.08	19.88	0.08	1.37
18	5/12/2010	8:00	5/12/2010	16:40	8.67	7,229	0.116	1.05	0.23	4.57	0.23	1.46
19	5/16/2010	21:10	5/17/2010	0:55	3.75	1,386	0.022	0.36	0.05	7.20	0.16	0.96
20	5/17/2010	5:20	5/18/2010	8:35	27.25	1,760	0.028	0.45	0.15	3.00	0.18	8.84
21	5/21/2010	2:10	5/21/2010	4:55	2.75	545	0.009	0.29	0.06	4.83	0.05	1.57
22	5/21/2010	12:10	5/21/2010	22:35	10.42	5,636	0.090	2.16	0.15	14.40	0.10	1.79
23	6/5/2010	14:50	6/5/2010	16:45	1.92	3,993	0.064	4.38	0.58	7.55	0.29	5.75
24	6/6/2010	8:15	6/6/2010	10:30	2.25	3,417	0.055	2.58	0.42	6.14	0.18	3.86
25	6/12/2010	7:40	6/12/2010	21:30	13.83	83,555	1.338	7.36	1.67	4.41	0.51	2.86
26	6/14/2010	21:45	6/15/2010	5:45	8.00	10,908	0.175	7.12	0.42	16.84	0.35	10.67
27	6/19/2010	7:15	6/19/2010	12:55	5.67	8,284	0.133	2.19	0.41	5.40	0.19	2.72
28	6/21/2010	12:10	6/21/2010	22:40	10.50	3,530	0.057	1.97	0.09	21.05	0.10	3.71
29	6/27/2010	21:50	6/28/2010	11:35	13.75	35,363	0.566	4.61	0.71	6.46	0.33	2.06
30	7/9/2010	10:45	7/9/2010	14:05	3.33	5,198	0.083	3.51	0.43	8.11	0.38	1.82
31	7/13/2010	7:00	7/13/2010	17:40	10.67	6,511	0.104	2.14	0.17	12.65	0.42	1.44
32	7/17/2010	16:40	7/17/2010	23:05	6.42	5,242	0.084	3.02	0.22	13.49	0.29	12.83
33	7/20/2010	17:40	7/21/2010	5:30	11.83	6,781	0.109	2.49	0.21	11.62	0.21	2.54
34	8/11/2010	13:25	8/11/2010	21:00	7.58	2,770	0.044	2.37	0.10	23.37	0.22	30.33
35	8/14/2010	15:40	8/15/2010	6:30	14.83	17,790	0.285	2.83	0.33	8.54	0.57	9.89
36	8/15/2010	16:50	8/15/2010	23:55	7.08	2,877	0.046	1.10	0.11	9.91	0.26	12.14

Event #	Pipeflow start date	Pipeflow start time	Pipeflow end date	Flow end time	Flow dur. (hrs)	Total pipeflow discharge volume (ft3)	Total disch. (in)	5-minute Peak flow disch. rate (CFS)	5-minute Avg flow disch. rate (CFS)	Peak/avg pipeflow rate ratio	Rv (Runoff Depth/Rain Depth)	flow/ rain dur. ratio
37	9/16/2010	4:10	9/16/2010	12:00	7.83	1,551	0.025	1.37	0.05	27.40	0.17	3.13
38	10/13/2010	15:20	10/13/2010	23:25	8.08	885	0.014	0.39	0.03	13.00	0.10	5.39
39	10/26/2010	12:10	10/26/2010	20:05	7.92	15,278	0.245	4.51	0.53	8.51	0.34	1.61
40	11/16/2010	12:20	11/17/2010	5:00	16.67	17,488	0.280	1.97	0.29	6.79	0.28	1.53
41	11/23/2010	1:30	11/23/2010	14:15	12.75	25,732	0.412	4.44	0.56	7.93	0.64	3.64
42	11/25/2010	15:10	11/26/2010	23:05	31.92	144,779	2.319	4.11	1.03	3.99	0.89	1.68
43	11/30/2010	0:00	11/30/2010	23:55	23.92	65,363	1.047	2.62	0.38	6.89	0.68	1.16
44	1/1/2011	0:00	1/1/2011	14:10	14.17	15,176	0.243	1.19	0.30	4.00	0.49	1.67
45	1/18/2011	3:25	1/18/2011	19:30	16.08	6,472	0.104	0.46	0.11	4.18	0.36	1.09
46	1/24/2011	22:25	1/25/2011	8:00	9.58	1,778	0.028	0.14	0.05	2.75	0.14	0.82
47	2/1/2011	1:40	2/2/2011	9:30	31.83	40,229	0.644	1.75	0.35	4.99	0.59	1.39
48	2/5/2011	5:45	2/5/2011	18:25	12.67	2,701	0.043	0.31	0.06	5.20	0.19	1.88
49	2/21/2011	7:00	2/21/2011	23:55	16.92	101,883	1.632	4.29	1.66	2.58	0.77	1.53
50	2/24/2011	19:45	2/25/2011	15:00	19.25	108,532	1.738	4.59	1.56	2.94	0.97	1.70
51	2/27/2011	19:05	2/27/2011	22:40	3.58	3,995	0.064	2.12	0.30	7.01	0.34	2.05
52	2/28/2011	5:20	2/28/2011	12:00	6.67	15,148	0.243	5.11	0.35	14.55	0.56	1.03
53	3/4/2011	6:35	3/5/2011	23:00	40.42	55,126	0.883	2.32	0.38	6.13	0.50	1.03
54	3/8/2011	23:20	3/9/2011	23:55	24.58	53,640	0.859	2.77	0.37	7.53	0.53	1.12
55	3/15/2011	9:30	3/15/2011	17:05	7.58	974	0.016	0.44	0.04	12.39	0.14	0.99
56	3/18/2011	17:25	3/18/2011	20:25	3.00	5,075	0.081	2.72	0.46	5.94	0.14	1.03
57	4/1/2011	20:00	4/2/2011	5:20	9.33	4,166	0.067	1.25	0.05	23.27	0.48	1.27
58	4/4/2011	14:20	4/4/2011	23:55	9.58	42,351	0.678	2.88	1.22	2.36	0.59	2.13
59	4/9/2011	11:50	4/9/2011	17:20	5.50	11,909	0.191	2.66	0.60	4.43	0.33	1.50
60	4/11/2011	7:35	4/12/2011	15:50	32.25	114,039	1.826	2.94	0.98	3.00	0.75	1.40
61	4/15/2011	23:00	4/16/2011	17:00	18.00	69,906	1.120	4.75	1.08	4.40	0.71	1.48
62	4/19/2011	1:35	4/19/2011	21:15	19.67	96,529	1.546	2.72	0.46	5.94	0.60	1.89
63	4/20/2011	1:35	4/20/2011	11:40	10.08	49,954	0.800	3.19	1.51	2.11	0.99	1.53
64	4/22/2011	16:45	4/22/2011	23:45	7.00	19,591	0.314	5.49	0.77	7.15	0.38	2.21
65	4/24/2011	18:40	4/25/2011	12:00	17.33	31,262	0.501	5.22	0.50	10.47	1.28	1.16
66	4/27/2011	4:05	4/27/2011	15:55	11.83	32,382	0.519	7.19	0.76	9.46	0.66	1.53
67	4/27/2011	17:20	4/28/2011	4:40	11.33	6,271	0.100	0.95	0.15	6.18	0.42	1.15
68	4/28/2011	17:15	4/28/2011	21:20	4.08	8,413	0.135	2.30	0.56	4.10	0.52	1.88
69	5/1/2011	21:15	5/3/2011	17:25	44.17	113,436	1.817	2.30	3.29	0.71	0.74	1.13
70	5/7/2011	23:25	5/8/2011	2:15	2.83	8,020	0.128	2.42	0.76	3.17	0.41	1.06
71	5/13/2011	15:55	5/13/2011	23:00	7.08	33,037	0.529	8.93	1.30	6.89	0.52	7.08
72	5/15/2011	12:25	5/15/2011	15:00	2.58	1,819	0.029	0.51	0.20	2.62	0.29	1.19
73	5/15/2011	20:30	5/16/2011	2:20	29.83	4,719	0.076	2.43	0.22	10.81	0.42	4.77
74	5/17/2011	13:40	5/18/2011	7:15	17.58	4,082	0.065	0.59	0.06	9.23	0.20	1.00

Event #	Pipeflow start date	Pipeflow start time	Pipeflow end date	Flow end time	Flow dur. (hrs)	Total pipeflow discharge volume (ft3)	Total disch. (in)	5-minute Peak flow disch. rate (CFS)	5-minute Avg flow disch. rate (CFS)	Peak/avg pipeflow rate ratio	Rv (Runoff Depth/Rain Depth)	flow/ rain dur. ratio
75	5/22/2011	17:50	5/22/2011	18:25	0.58	1,153	0.018	2.38	0.55	4.33	0.18	3.50
76	5/23/2011	5:45	5/23/2011	9:10	3.42	14,137	0.226	2.87	1.15	2.49	0.69	1.64
77	5/23/2011	19:25	5/24/2011	1:15	5.83	23,787	0.381	3.15	1.12	2.82	0.72	1.15
78	5/26/2011	0:35	5/26/2011	23:10	22.58	47,071	0.754	3.13	0.58	5.41	0.95	1.27
79	6/4/2011	22:30	6/4/2011	23:55	1.42	3,209	0.051	2.23	0.12	18.58	0.57	8.50
80	6/10/2011	13:30	6/11/2011	0:50	11.33	40,568	0.650	6.64	0.99	6.73	0.58	1.42
81	6/11/2011	4:05	6/11/2011	10:55	6.83	38,479	0.616	7.43	1.56	4.76	0.83	1.46
82	6/15/2011	11:15	6/15/2011	18:25	7.17	19,238	0.308	2.77	0.75	3.69	0.57	1.62
83	6/18/2011	8:35	6/18/2011	14:05	5.50	476	0.008	0.39	0.02	19.50	0.08	1.14
84	6/19/2011	10:10	6/19/2011	12:55	2.75	3,324	0.053	1.01	0.34	2.97	0.41	2.75
85	6/20/2011	9:50	6/20/2011	19:10	9.33	38,870	0.623	4.69	1.15	4.08	0.85	2.73
86	6/21/2011	15:20	6/21/2011	19:45	4.42	13,962	0.224	4.98	0.88	5.66	0.36	1.83
87	6/22/2011	22:30	6/23/2011	5:20	6.83	18,675	0.299	4.38	0.76	5.76	0.83	1.15
88	6/26/2011	5:10	6/26/2011	14:25	9.25	31,408	0.503	2.74	0.94	2.91	0.62	1.48
89	6/27/2011	10:10	6/27/2011	14:30	4.33	9,269	0.148	3.74	0.59	6.34	0.87	4.00
90	7/4/2011	2:45	7/4/2011	11:05	8.33	38,931	0.624	3.94	1.28	3.08	0.97	1.54
91	7/8/2011	12:10	7/8/2011	16:30	4.33	9,271	0.148	3.74	0.59	6.34	0.23	0.79
92	7/23/2011	10:40	7/23/2011	18:05	7.42	16,264	0.260	1.96	0.61	3.21	0.27	17.80
93	8/3/2011	5:10	8/3/2011	14:45	9.58	12,774	0.205	3.54	0.37	9.57	0.31	1.47
94	8/7/2011	5:40	8/7/2011	15:45	10.08	32,743	0.524	4.32	0.89	4.85	0.71	5.50
95	8/8/2011	20:25	8/8/2011	22:00	1.58	21,648	0.347	9.08	3.14	2.89	0.30	0.95
96	8/14/2011	2:20	8/14/2011	5:50	3.50	3,535	0.057	1.58	0.28	5.64	0.47	1.83
97	8/21/2011	17:45	8/21/2011	19:25	1.67	4,168	0.067	2.31	0.69	3.35	0.33	6.67
98	9/4/2011	1:15	9/4/2011	6:10	4.92	8,088	0.130	2.55	0.46	5.54	0.24	2.11
99	9/4/2011	20:15	9/4/2011	23:55	3.67	16,852	0.270	2.97	1.25	2.38	0.93	1.13
100	9/7/2011	10:25	9/8/2011	3:40	17.25	15,452	0.247	1.77	0.25	7.08	0.51	1.05
101	9/14/2011	22:10	9/15/2011	4:10	6.00	11,396	0.183	1.46	0.53	2.75	0.42	1.64
102	9/19/2011	9:45	9/19/2011	20:00	10.25	17,407	0.279	2.86	0.47	6.09	0.58	1.45
103	9/23/2011	4:55	9/23/2011	15:40	10.75	23,411	0.375	4.79	0.60	7.98	0.64	1.52
104	9/25/2011	22:55	9/26/2011	13:00	14.08	157,097	2.516	12.13	3.59	3.38	0.74	1.47
105	9/29/2011	19:25	9/29/2011	22:00	2.58	8,002	0.128	2.41	0.69	3.49	0.35	1.19
106	10/18/2011	19:05	10/20/2011	15:25	44.33	95,034	1.522	3.06	0.60	5.13	0.67	1.00
107	10/26/2011	20:35	10/27/2011	8:10	11.58	54,908	0.879	3.05	1.32	2.32	0.96	1.53
108	11/3/2011	13:10	11/4/2011	7:00	17.83	62,888	1.007	3.05	2.93	0.98	0.74	1.28
109	11/14/2011	20:25	11/15/2011	10:40	14.25	80,137	1.284	3.93	1.56	2.51	0.80	1.32
110	11/16/2011	6:15	11/16/2011	11:35	5.33	4,613	0.074	0.85	0.24	3.55	0.23	1.00
111	11/21/2011	6:50	11/21/2011	9:50	3.00	2,314	0.037	1.73	0.21	8.06	0.10	1.03
112	11/21/2011	16:05	11/21/2011	23:55	7.83	12,553	0.201	2.54	0.70	3.64	1.26	0.94

Event #	Pipeflow start date	Pipeflow start time	Pipeflow end date	Flow end time	Flow dur. (hrs)	Total pipeflow discharge volume (ft3)	Total disch. (in)	5-minute Peak flow disch. rate (CFS)	5-minute Avg flow disch. rate (CFS)	Peak/avg pipeflow rate ratio	Rv (Runoff Depth/Rain Depth)	flow/ rain dur. ratio
113	11/22/2011	6:55	11/22/2011	17:15	10.33	37,521	0.601	3.05	1.32	2.32	0.72	1.19
114	11/27/2011	3:00	11/29/2011	7:10	52.17	158,234	2.534	2.84	0.84	3.37	1.09	1.02
115	12/4/2011	18:45	12/6/2011	2:10	31.42	222,056	3.557	5.51	1.96	2.81	1.12	0.87
116	12/15/2011	4:55	12/15/2011	12:50	7.92	3,065	0.049	0.91	0.11	8.49	0.15	0.87
117	12/19/2011	21:30	12/20/2011	2:00	4.50	3,418	0.055	0.87	0.21	4.12	0.23	0.72
118	12/20/2011	21:35	12/21/2011	11:50	14.25	17,639	0.283	2.60	0.34	7.59	0.38	1.06
119	12/22/2011	15:30	12/22/2011	22:40	7.17	27,696	0.444	2.23	1.07	2.08	0.67	0.88
120	12/27/2011	4:45	12/27/2011	18:00	13.25	10,032	0.161	1.49	0.21	7.11	0.24	0.88
121	1/11/2012	10:25	1/11/2012	14:05	3.67	2,533	0.041	0.88	0.19	4.60	0.11	0.71
122	1/17/2012	4:10	1/17/2012	15:25	11.25	56,945	0.912	4.49	1.41	3.19	0.52	0.99
123	1/20/2012	23:40	1/21/2012	23:55	24.25	269	0.004	0.55	0.30	1.84	0.04	26.45
124	1/23/2012	3:50	1/23/2012	6:10	2.33	1,056	0.017	0.62	0.12	5.13	0.04	0.44
125	1/26/2012	5:05	1/26/2012	12:00	6.92	6,383	0.102	1.33	0.26	5.17	0.14	1.38
126	1/26/2012	19:35	1/27/2012	3:50	8.25	36,632	0.587	3.61	1.23	2.93	0.61	0.67
127	2/16/2012	0:30	2/16/2012	7:25	6.92	777	0.012	0.24	0.03	7.53	0.04	1.01
128	2/29/2012	3:20	2/29/2012	10:05	6.75	3,562	0.057	0.95	0.15	6.49	0.16	1.14
129	3/2/2012	12:15	3/2/2012	17:30	5.25	1,954	0.031	1.48	0.10	14.28	0.06	0.90
130	3/8/2012	5:20	3/8/2012	21:00	15.67	8,445	0.135	0.54	0.17	3.15	0.21	1.83
131	3/12/2012	7:50	3/12/2012	11:20	3.50	3,255	0.052	0.48	0.28	1.73	0.43	0.76
132	3/15/2012	9:30	3/15/2012	14:05	4.58	14,443	0.231	2.91	0.86	3.39	0.29	2.62
133	3/23/2012	12:10	3/23/2012	18:40	6.50	1,754	0.028	0.36	0.07	4.78	0.06	1.00
134	3/24/2012	1:00	3/24/2012	4:15	3.25	3,336	0.053	2.75	0.29	9.65	0.15	3.25
135	3/30/2012	20:20	3/30/2012	23:20	3.00	426	0.007	0.17	0.04	4.31	0.02	1.50
136	4/1/2012	23:55	4/2/2012	3:35	3.67	6,340	0.102	2.79	0.48	5.81	0.25	4.00
137	4/14/2012	10:20	4/14/2012	20:25	10.08	10,640	0.170	2.67	0.29	9.10	0.13	1.30
138	4/20/2012	20:30	4/21/2012	4:00	7.50	433	0.007	0.18	0.02	11.38	0.04	1.11
139	4/25/2012	23:45	4/26/2012	3:45	4.00	15,764	0.252	4.47	1.07	4.17	0.35	4.00
140	4/28/2012	13:00	4/28/2012	17:20	4.33	6,250	0.100	1.33	0.40	3.31	0.13	1.79
141	5/1/2012	17:45	5/1/2012	23:45	6.00	33,981	0.544	3.92	1.51	2.60	0.36	2.48
142	5/4/2012	15:00	5/4/2012	19:20	4.33	371	0.006	0.35	0.14	2.55	0.04	52.00
143	5/5/2012	1:25	5/5/2012	3:35	2.17	949	0.015	0.27	0.12	2.19	0.08	1.13
144	5/7/2012	20:30	5/8/2012	10:35	14.08	5,296	0.085	0.69	0.10	6.62	0.11	1.17
145	5/13/2012	5:40	5/13/2012	23:55	18.25	22,251	0.356	1.33	0.40	3.31	0.25	1.12
146	5/29/2012	19:00	5/29/2012	23:20	4.33	353	0.006	0.23	0.04	6.19	0.02	4.00
147						0	0.000				0.00	
148	6/11/2012	7:25	6/11/2012	11:35	4.17	1,601	0.026	3.06	0.11	28.65	0.16	1.47
149	6/17/2012	13:40	6/17/2012	15:50	2.17	915	0.015	1.50	0.12	12.80	0.12	5.20
150	6/29/2012	16:55	6/29/2012	20:05	3.17	687	0.011	0.14	0.06	2.39	0.03	9.50

Event #	Pipeflow start date	Pipeflow start time	Pipeflow end date	Flow end time	Flow dur. (hrs)	Total pipeflow discharge volume (ft3)	Total disch. (in)	5-minute Peak flow disch. rate (CFS)	5-minute Avg flow disch. rate (CFS)	Peak/avg pipeflow rate ratio	Rv (Runoff Depth/Rain Depth)	flow/ rain dur. ratio
151	7/14/2012	17:55	7/14/2012	21:05	3.17	96	0.002	0.11	0.02	6.01	0.00	2.11
152	7/18/2012	16:45	7/18/2012	20:30	3.75	6,511	0.104	1.76	0.48	3.64	0.11	3.00
153	7/19/2012	19:55	7/19/2012	23:05	3.17	196	0.003	0.44	0.08	5.37	0.01	4.22
154	7/27/2012	14:20	7/27/2012	21:10	6.83	7,765	0.124	2.80	0.32	8.88	0.35	1.41
155	10/1/2012	16:40	10/1/2012	23:40	7.00	9,251	0.148	2.73	0.37	7.45	0.20	0.98
156	10/5/2012	18:35	10/6/2012	2:35	8.00	3,475	0.056	1.11	0.12	9.33	0.14	1.28
157	10/14/2012	13:10	10/14/2012	23:00	9.83	5,935	0.095	2.85	0.17	17.00	0.27	1.04
158	10/19/2012	12:55	10/20/2012	0:35	11.67	4,724	0.076	3.11	0.12	26.01	0.27	1.05
159	10/26/2012	9:40	10/27/2012	4:45	19.08	18,679	0.299	0.65	0.27	2.38	0.36	1.08
160	10/30/2012	2:20	10/30/2012	13:45	11.42	3,553	0.057	0.40	0.09	4.65	0.13	1.37
161	11/3/2012	10:50	11/3/2012	16:45	5.92	897	0.014	0.20	0.04	4.74	0.13	1.11
162	11/12/2012	3:50	11/12/2012	17:25	13.58	8,107	0.130	1.07	0.17	6.46	0.17	1.35
163	11/26/2012	23:10	11/27/2012	4:35	5.42	242	0.004	0.06	0.01	5.01	0.04	1.59

Rainfall characteristics for Clark Montessori High School combined sewer line

Event #	Rain start date	Rain start time	Rain end date	Rain end time	Antecedent dry days	Rain dur. (hrs)	Total rain [a] (in)	5-minute peak rain intensity (in/hr)	Avg rain int. (in/hr)
1	3/10/2010	3:05	3/10/2010	11:50		8.75	0.12	0.96	0.01
2	3/11/2010	9:35	3/11/2010	11:00	0.91	1.42	0.08	0.48	0.06
3	3/12/2010	17:35	3/13/2010	19:40	1.27	26.08	1.56	1.45	0.06
4	3/14/2010	6:50	3/14/2010	8:30	0.47	1.67	0.12	0.48	0.07
5	3/21/2010	22:00	3/22/2010	5:00	7.56	7.00	0.60	0.48	0.09
6	3/25/2010	13:40	3/26/2010	1:20	3.36	11.67	1.12	0.96	0.10
7	3/28/2010	11:15	3/28/2010	23:10	2.41	11.92	0.24	0.48	0.02
8	3/29/2010	7:20	3/29/2010	7:50	0.34	0.50	0.08	0.48	0.16
9	4/5/2010	19:40	4/5/2010	19:50	7.49	0.17	0.36	3.86	2.16
10	4/8/2010	1:10	4/8/2010	7:55	2.22	6.75	0.40	0.96	0.06
11	4/23/2010	11:00	4/23/2010	13:55	15.13	2.92	0.24	0.48	0.08
12	4/24/2010	16:45	4/24/2010	22:40	1.12	5.92	1.04	1.45	0.18
13	4/25/2010	15:50	4/25/2010	18:15	0.72	2.42	0.12	0.48	0.05
14	5/16/2010	19:35	5/16/2010	23:30		3.92	0.20	0.48	0.05
15	5/17/2010	5:05	5/17/2010	7:35	0.23	2.50	0.24	0.48	0.10
16	5/21/2010	12:45	5/21/2010	18:35	4.22	5.83	0.36	2.41	0.06
17	5/31/2010	21:05	5/31/2010	23:25	10.10	2.33	0.12	0.48	0.05
18	6/14/2010	22:45	6/14/2010	23:10		0.42	0.44	2.89	1.06
19	6/15/2010	20:55	6/15/2010	23:55	0.91	3.00	0.44	1.45	0.15
20	6/19/2010	7:20	6/19/2010	10:00	3.31	2.67	0.52	0.96	0.20
21	6/21/2010	12:35	6/21/2010	14:45	2.11	2.17	0.24	0.96	0.11
22	6/27/2010	23:45	6/28/2010	4:10	6.38	4.42	1.56	5.78	0.35
23	7/20/2010	18:20	7/20/2010	22:10		3.83	0.32	0.48	0.08
24	8/11/2010	15:00	8/11/2010	15:20	21.70	0.33	0.63	3.82	1.90
25	8/14/2010	17:50	8/14/2010	18:00	3.10	0.17	0.12	0.95	0.71
26	9/16/2010	4:20	9/16/2010	6:30		2.17	0.16	0.96	0.07
27	9/20/2010	10:00	9/20/2010	10:05	4.15	0.08	0.32	3.86	3.84
28	11/16/2010	11:05	11/17/2010	0:10	57.04	13.08	0.84	0.96	0.06
29	11/23/2010	1:45	11/23/2010	5:25	6.07	3.67	0.56	2.41	0.15
30	11/24/2010	13:50	11/24/2010	23:00	1.35	9.17	0.80	0.48	0.09
31	11/25/2010	6:15	11/25/2010	23:45	2.03	17.50	2.56	2.41	0.15
32	11/29/2010	22:00	11/30/2010	20:00	3.93	22.00	1.40	0.96	0.06
33	12/11/2010	17:15	12/12/2010	5:35	10.89	12.33	0.48	0.48	0.04
34	12/18/2010	11:55	12/18/2010	15:15	6.26	3.33	0.16	0.96	0.05
35	12/30/2010	2:00	12/30/2010	11:35	11.45	9.58	0.32	0.96	0.03
36	1/1/2011	1:50	1/1/2011	9:00	1.59	7.17	0.44	0.96	0.06
37	1/18/2011	9:40	1/18/2011	18:35	17.03	8.92	0.32	0.48	0.04

Event #	Rain start date	Rain start time	Rain end date	Rain end time	Antecedent dry days	Rain dur. (hrs)	Total rain [a] (in)	5-minute peak rain intensity (in/hr)	Avg rain int. (in/hr)
38	1/24/2011	15:30	1/24/2011	22:50	5.87	7.33	0.16	0.48	0.02
39	2/5/2011	7:50	2/5/2011	12:00	11.38	4.17	0.16	0.48	0.04
40	2/21/2011	8:55	2/21/2011	19:00	15.87	10.08	2.08	1.45	0.21
41	2/24/2011	17:30	2/25/2011	5:25	2.94	11.92	1.44	0.96	0.12
42	2/27/2011	17:20	2/27/2011	20:50	2.50	3.50	0.68	1.45	0.19
43	2/28/2011	5:25	2/28/2011	7:05	0.36	1.67	0.32	0.96	0.19
44	3/4/2011	11:05	3/5/2011	19:25	4.17	32.33	1.40	1.45	0.04
45	3/8/2011	22:05	3/9/2011	20:05	3.11	22.00	1.44	1.45	0.07
46	3/15/2011	4:55	3/15/2011	16:20	5.37	11.42	0.20	0.48	0.02
47	3/18/2011	17:45	3/18/2011	18:55	3.06	1.17	0.40	2.41	0.34
48	4/1/2011	20:55	4/1/2011	21:20	14.08	0.42	0.16	0.96	0.38
49	4/4/2011	14:20	4/4/2011	17:45	2.71	3.42	1.08	1.45	0.32
50	4/9/2011	11:55	4/9/2011	15:30	4.76	3.58	0.48	0.96	0.13
51	4/11/2011	8:20	4/12/2011	8:05	1.70	23.75	1.92	1.93	0.08
52	4/15/2011	23:10	4/16/2011	10:15	3.63	11.08	0.92	0.96	0.08
53	4/19/2011	1:30	4/19/2011	11:35	2.64	10.08	2.04	0.16	0.20
54	4/20/2011	1:35	4/20/2011	8:15	0.58	6.67	1.08	2.41	0.16
55	4/22/2011	17:30	4/22/2011	19:50	2.39	2.33	0.64	2.89	0.27
56	4/23/2011	1:45	4/23/2011	6:40	0.25	4.92	0.56	0.96	0.11
57	4/23/2011	13:15	4/23/2011	20:15	0.27	7.00	1.16	2.89	0.17
58	4/24/2011	8:10	4/24/2011	10:45	0.50	2.58	0.20	0.48	0.08
59	4/27/2011	5:45	4/27/2011	9:55	3.40	4.17	0.56	1.45	0.13
60	4/27/2011	17:30	4/27/2011	20:55	0.32	3.42	0.16	0.48	0.05
61	4/28/2011	18:55	4/28/2011	20:00	0.92	1.08	0.16	0.96	0.15
62	5/1/2011	20:25	5/2/2011	7:50	3.02	11.42	0.76	0.96	0.07
63	5/2/2011	16:50	5/3/2011	10:35	0.38	17.75	1.48	0.96	0.08
64	5/7/2011	23:25	5/8/2011	0:40	4.53	1.25	0.32	0.96	0.26
65	5/13/2011	16:00	5/13/2011	16:15	5.64	0.25	0.12	0.48	0.48
66	5/14/2011	7:40	5/14/2011	15:50	0.64	8.17	0.16	0.48	0.02
67	5/15/2011	20:15	5/15/2011	21:10	1.18	0.92	0.16	0.96	0.17
68	5/17/2011	12:45	5/18/2011	4:35	1.65	15.83	0.33	0.24	0.02
69	5/22/2011	18:10	5/22/2011	18:15	4.57	0.08	0.12	1.45	1.44
70	5/23/2011	1:00	5/23/2011	6:55	0.28	5.92	1.08	4.34	0.18
71	5/23/2011	19:30	5/24/2011	0:35	0.52	5.08	0.72	1.45	0.14
72	5/26/2011	0:35	5/26/2011	18:40	2.00	18.08	1.12	1.45	0.06
73	6/10/2011	18:20	6/10/2011	20:50	14.99	2.50	2.72	7.23	1.09
74	6/11/2011	4:05	6/11/2011	8:05	0.30	4.00	1.20	1.45	0.30
75	6/15/2011	11:25	6/15/2011	16:05	4.14	4.67	0.52	0.96	0.11
76	6/19/2011	10:40	6/19/2011	16:25	3.77	5.75	0.16	0.48	0.03

Event #	Rain start date	Rain start time	Rain end date	Rain end time	Antecedent dry days	Rain dur. (hrs)	Total rain [a] (in)	5-minute peak rain intensity (in/hr)	Avg rain int. (in/hr)
77	6/20/2011	10:30	6/20/2011	12:35	0.75	2.08	0.84	1.93	0.40
78	6/21/2011	11:35	6/21/2011	19:25	0.96	7.83	1.76	3.86	0.22
79	6/22/2011	22:50	6/23/2011	4:30	1.14	5.67	0.64	1.93	0.11
80	6/26/2011	5:15	6/26/2011	10:35	3.03	5.33	0.60	0.96	0.11
81	7/4/2011	9:20	7/4/2011	9:40	7.95	0.33	0.24	0.96	0.72
82	7/8/2011	3:25	7/8/2011	7:50	3.74	4.42	1.20	1.93	0.27
83	7/23/2011	12:15	7/23/2011	13:30	15.18	1.25	0.28	2.41	0.22
84	8/3/2011	5:15	8/3/2011	8:35	10.66	3.33	0.68	1.93	0.20
85	8/7/2011	5:55	8/7/2011	7:30	3.89	1.58	0.84	2.41	0.53
86	8/8/2011	19:55	8/8/2011	20:30	1.52	0.58	0.36	1.45	0.62
87	8/21/2011	17:50	8/21/2011	18:05	12.89	0.25	0.24	1.45	0.96
88	9/4/2011	1:10	9/4/2011	2:30	13.30	1.33	0.48	1.45	0.36
89	9/4/2011	20:35	9/4/2011	22:50	0.75	2.25	0.40	1.45	0.18
90	9/7/2011	9:30	9/8/2011	22:05	2.44	36.58	0.44	0.96	0.01
91	9/14/2011	23:45	9/15/2011	1:35	6.07	1.83	0.44	0.96	0.24
92	9/19/2011	9:55	9/19/2011	15:05	4.35	5.17	0.36	0.48	0.07
93	9/23/2011	2:50	9/23/2011	10:20	3.49	7.50	0.52	0.96	0.07
94	9/25/2011	23:55	9/26/2011	9:55	2.57	10.00	2.76	3.37	0.28
95	9/29/2011	19:35	9/29/2011	21:20	3.40	1.75	0.32	1.45	0.18
96	10/13/2011	9:50	10/13/2011	14:45	13.52	4.92	0.32	0.48	0.07
97	10/19/2011	0:45	10/20/2011	12:15	5.42	35.50	2.28	1.45	0.06
98	10/26/2011	20:40	10/27/2011	3:35	6.35	6.92	1.36	0.96	0.20
99	11/3/2011	13:05	11/4/2011	1:00	7.40	11.92	0.96	0.96	0.08
100	11/14/2011	20:30	11/15/2011	7:10	10.81	10.67	1.96	0.96	0.18
101	11/16/2011	5:40	11/16/2011	10:25	0.94	4.75	0.40	0.48	0.08
102	11/20/2011	15:50	11/20/2011	20:40	4.23	4.83	0.20	0.48	0.04
103	11/21/2011	6:50	11/21/2011	7:20	0.42	0.50	0.40	2.89	0.80
104	11/21/2011	16:20	11/21/2011	21:10	0.38	4.83	0.20	0.48	0.04
105	11/22/2011	6:45	11/22/2011	11:55	0.40	5.17	0.80	0.96	0.15
106	11/27/2011	4:10	11/29/2011	4:30	4.68	48.33	2.24	0.96	0.05
107	11/29/2011	17:55	11/29/2011	21:35	0.56	3.67	0.24	0.96	0.07
108	12/4/2011	15:00	12/6/2011	0:40	4.73	33.67	3.16	0.96	0.09
109	12/15/2011	3:55	12/15/2011	11:50	9.14	7.92	0.40	0.48	0.05
110	12/19/2011	18:40	12/20/2011	0:30	4.28	5.83	0.32	0.48	0.05
111	12/21/2011	1:55	12/21/2011	12:10	1.06	10.25	0.52	0.48	0.05
112	12/22/2011	12:10	12/22/2011	20:15	1.00	8.08	0.76	0.96	0.09
113	12/27/2011	2:35	12/27/2011	15:30	4.26	12.92	0.76	0.96	0.06
114	1/11/2012	7:35	1/11/2012	11:30	14.67	3.92	0.36	0.96	0.09
115	1/12/2012	14:05	1/12/2012	16:10	1.11	2.08	0.20	0.48	0.10

Event #	Rain start date	Rain start time	Rain end date	Rain end time	Antecedent dry days	Rain dur. (hrs)	Total rain [a] (in)	5-minute peak rain intensity (in/hr)	Avg rain int. (in/hr)
116	1/17/2012	3:10	1/17/2012	12:15	4.46	9.08	1.68	3.37	0.18
117	1/22/2012	23:25	1/23/2012	5:40	5.47	6.25	0.44	0.96	0.07
118	1/26/2012	4:20	1/26/2012	23:30	2.94	19.17	1.64	0.96	0.09
119	2/16/2012	0:00	2/16/2012	11:20	20.02	11.33	0.28	0.48	0.02
120	2/29/2012	3:25	2/29/2012	12:55	12.67	9.50	0.56	0.48	0.06
121	3/2/2012	13:10	3/2/2012	17:15	2.01	4.08	0.24	0.96	0.06
122	3/8/2012	7:50	3/8/2012	16:50	5.61	9.00	0.60	0.48	0.07
123	3/12/2012	7:05	3/12/2012	13:45	3.59	6.67	0.12	0.48	0.02
124	3/15/2012	10:25	3/15/2012	20:50	2.86	10.42	1.64	5.30	0.16
125	3/23/2012	12:15	3/23/2012	19:00	7.64	6.75	1.16	1.45	0.17
126	3/24/2012	1:05	3/24/2012	2:15	0.25	1.17	0.28	1.45	0.24
127	4/14/2012	10:20	4/14/2012	17:40	21.34	7.33	0.92	0.96	0.13
128	4/20/2012	23:55	4/21/2012	5:05	6.26	5.17	0.32	0.96	0.06
129	4/25/2012	20:00	4/26/2012	0:10	4.62	4.17	0.76	6.27	0.18
130	4/28/2012	5:05	4/28/2012	13:25	2.20	8.33	1.00	2.89	0.12
131	5/4/2012	21:20	5/5/2012	7:25	6.33	10.08	0.52	0.96	0.05
132	5/8/2012	0:35	5/8/2012	9:20	2.72	8.75	0.40	0.48	0.05
133	5/13/2012	3:40	5/13/2012	18:55	4.76	15.25	1.04	0.96	0.07
134	5/29/2012	8:55	5/29/2012	10:00	15.58	1.08	0.28	0.96	0.26
135	6/1/2012	1:50	6/1/2012	9:10	2.66	7.33	1.04	2.89	0.14
136	6/11/2012	7:35	6/11/2012	10:35	9.93	3.00	0.16	0.48	0.05
137	6/29/2012	9:15	6/29/2012	11:00	17.94	1.75	0.20	0.48	0.11
138	7/1/2012	6:40	7/1/2012	7:50	1.82	1.17	0.16	0.48	0.14
139	7/1/2012	19:35	7/1/2012	21:55	0.49	2.33	0.12	0.48	0.05
140	7/15/2012	13:55	7/15/2012	14:15	13.67	0.33	0.20	0.96	0.60
141	7/18/2012	16:00	7/18/2012	18:05	3.07	2.08	1.96	8.19	0.94
142	7/19/2012	9:45	7/19/2012	12:30	0.65	2.75	0.36	1.93	0.13
143	7/20/2012	12:35	7/20/2012	12:55	1.00	0.33	0.60	3.86	1.80
144	7/26/2012	15:40	7/26/2012	22:00	6.11	6.33	0.60	2.41	0.09
145	7/27/2012	17:30	7/27/2012	20:55	0.81	3.42	0.40	1.45	0.12
146	8/9/2012	16:45	8/9/2012	17:20	12.83	0.58	0.16	0.96	0.27
147	8/10/2012	2:35	8/10/2012	4:25	0.39	1.83	0.36	0.96	0.20
148	8/27/2012	10:10	8/27/2012	17:20	17.24	7.17	0.28	1.45	0.04
149	10/1/2012	16:00	10/1/2012	21:45		5.75	0.79	1.07	0.14
150	10/5/2012	18:20	10/6/2012	1:30	3.86	7.17	0.50	0.60	0.07
151	10/19/2012	13:25	10/19/2012	21:00	13.50	7.58	0.14	0.17	0.02
152	10/26/2012	9:55	10/27/2012	1:35	6.54	15.67	0.85	0.33	0.05
153	10/30/2012	2:10	10/30/2012	10:00	3.02	7.83	0.41	0.11	0.05
154	11/3/2012	12:00	11/3/2012	16:25	4.08	4.42	0.12	0.16	0.03

Event #	Rain start date	Rain start time	Rain end date	Rain end time	Antecedent dry days	Rain dur. (hrs)	Total rain [a] (in)	5-minute peak rain intensity (in/hr)	Avg rain int. (in/hr)
155	11/12/2012	3:50	11/12/2012	13:50	8.48	10.00	0.78	0.35	0.08
156	11/26/2012	22:55	11/27/2012	2:10	14.38	3.25	0.08	0.05	0.02
157	12/2/2012	7:20	12/2/2012	11:25	5.22	4.08	0.49	0.69	0.12
158	12/4/2012	15:40	12/4/2012	18:45	2.18	3.08	0.18	0.41	0.06
159	12/6/2012	19:00	12/7/2012	1:40	2.01	6.67	0.29	0.37	0.04
160	12/7/2012	7:55	12/7/2012	18:20	2.55	10.42	0.71	0.28	0.07
161	12/9/2012	19:50	12/10/2012	3:50	2.06	8.00	0.98	1.59	0.12
162	12/15/2012	12:00	12/15/2012	16:05	5.34	4.08	0.08	0.14	0.02
163	12/17/2012	12:45	12/17/2012	16:05	1.86	3.33	0.54	0.96	0.16
164	12/20/2012	7:15	12/20/2012	20:00	2.63	12.75	0.94	0.48	0.07
165	12/26/2012	3:50	12/26/2012	14:35	5.33	10.75	1.33	0.47	0.12
166	12/28/2012	21:00	12/29/2012	6:05	2.27	9.08	0.12	0.08	0.01

Runoff characteristics for Clark Montessori High School combined sewer line

Event #	Pipeflow start date	Pipeflow start time	Pipeflow end date	Flow end time	Flow dur. (hrs)	Total pipeflow discharge volume (ft3)	Total disch. (in)	5-minute Peak flow disch. rate (CFS)	5-minute Avg flow disch. rate (CFS)	Peak/avg pipeflow rate ratio	Rv (Runoff Depth/Rain Depth)	flow/ rain dur. ratio
1	3/10/2010	3:45	3/10/2010	15:10	11.42	2,417	0.045	0.83	0.06	13.83	0.38	1.30
2	3/11/2010	7:00	3/11/2010	18:25	11.42	1,227	0.023	0.46	0.03	15.33	0.29	8.06
3	3/12/2010	17:50	3/14/2010	3:30	33.67	30,726	0.573	2.21	0.25	8.84	0.37	1.29
4	3/14/2010	3:40	3/14/2010	23:55	20.25	2,367	0.044	0.24	0.03	8.00	0.37	12.15
5	3/21/2010	17:50	3/22/2010	9:10	15.33	24,469	0.457	1.88	0.44	4.27	0.76	2.19
6	3/25/2010	13:55	3/26/2010	11:40	21.75	44,445	0.829	4.22	0.57	7.40	0.74	1.86
7	3/28/2010	2:45	3/29/2010	2:25	23.67	791	0.015	0.27	0.01	27.00	0.06	1.99
8	3/29/2010	6:15	3/29/2010	9:15	3.00	475	0.009	0.16	0.04	4.00	0.11	6.00
9	4/5/2010	18:30	4/6/2010	1:10	6.67	3,407	0.064	5.77	0.14	41.21	0.18	40.00
10	4/8/2010	0:55	4/8/2010	12:45	11.83	3,540	0.066	0.77	0.08	9.63	0.17	1.75
11	4/23/2010	11:20	4/23/2010	16:20	5.00	934.01	0.017	0.27	0.05	5.40	0.07	1.71
12	4/24/2010	16:50	4/25/2010	1:40	8.83	17,913	0.334	2.64	0.56	4.71	0.32	1.49
13	4/25/2010	15:10	4/25/2010	23:30	8.33	965	0.018	0.51	0.04	12.75	0.15	3.45
14	5/16/2010	18:15	5/17/2010	2:45	8.50	1,050	0.020	0.23	0.03	7.67	0.10	2.17
15	5/17/2010	5:10	5/18/2010	17:35	36.42	3,570	0.067	1.18	0.08	14.75	0.28	14.57
16	5/21/2010	12:30	5/21/2010	23:55	11.42	2,825	0.053	1.52	0.07	21.71	0.15	1.96
17	5/31/2010	14:50	5/31/2010	23:55	9.08	2,582	0.048	1.46	0.08	18.25	0.40	3.89
18	6/14/2010	22:50	6/15/2010	2:40	3.83	5,061	0.094	7.07	0.37	19.11	0.21	9.20
19	6/15/2010	20:55	6/16/2010	5:20	8.42	6,089	0.114	2.6	0.2	13.00	0.26	2.81
20	6/19/2010	6:00	6/19/2010	14:30	8.50	7,932	0.148	2.77	0.26	10.65	0.28	3.19
21	6/21/2010	12:20	6/21/2010	23:05	10.75	6,739	0.126	3.88	0.17	22.82	0.52	4.96
22	6/27/2010	22:40	6/28/2010	8:35	9.92	23,602	0.440	8.09	0.66	12.26	0.28	2.25
23	7/20/2010	18:35	7/21/2010	2:40	8.08	4,300	0.080	2.55	0.15	17.00	0.25	2.11
24	8/11/2010	14:05	8/11/2010	17:00	2.92	1,772	0.033	1.44	0.17	8.47	0.05	8.75
25	8/14/2010	17:40	8/14/2010	19:30	1.83	2,332	0.044	2.3	0.34	6.76	0.37	11.00
26	9/16/2010	4:25	9/16/2010	9:50	5.42	1,635	0.031	1.63	0.08	20.38	0.19	2.50
27	9/20/2010	9:45	9/20/2010	14:20	4.58	267	0.005	0.1	0.02	5.00	0.02	55.00
28	11/16/2010	11:05	11/17/2010	1:40	14.58	10,791	0.201	1.84	0.21	8.76	0.24	1.11
29	11/23/2010	1:40	11/23/2010	9:00	7.33	8,600	0.161	3.32	0.33	10.06	0.29	2.00
30	11/24/2010	13:20	11/25/2010	1:40	12.33	12,770	0.238	1.05	0.29	3.62	0.30	1.35
31	11/25/2010	6:15	11/26/2010	6:30	24.25	48,686	0.909	3.39	0.76	4.46	0.35	1.39
32	11/29/2010	22:05	11/30/2010	23:55	25.83	32,292	0.603	1.74	0.35	4.97	0.43	1.17
33	12/11/2010	16:55	12/12/2010	12:20	19.42	6,855	0.128	0.36	0.1	3.60	0.27	1.57
34	12/18/2010	11:35	12/18/2010	17:35	6.00	68	0.001	0.03	0.00	10.72	0.01	1.80
35	12/30/2010	1:00	12/30/2010	16:35	15.58	3,644	0.068	0.26	0.06	3.96	0.21	1.63
36	1/1/2011	1:10	1/1/2011	12:45	11.58	9,803	0.183	1.21	0.25	4.84	0.42	1.62

Event #	Pipeflow start date	Pipeflow start time	Pipeflow end date	Flow end time	Flow dur. (hrs)	Total pipeflow discharge volume (ft3)	Total disch. (in)	5-minute Peak flow disch. rate (CFS)	5-minute Avg flow disch. rate (CFS)	Peak/avg pipeflow rate ratio	Rv (Runoff Depth/Rain Depth)	flow/ rain dur. ratio
37	1/18/2011	9:20	1/18/2011	18:35	9.25	4,058	0.076	0.29	0.12	2.42	0.24	1.04
38	1/24/2011	14:25	1/25/2011	4:15	13.83	990	0.018	0.18	0.02	9.00	0.12	1.89
39	2/5/2011	5:20	2/5/2011	13:20	8.00	617	0.012	0.28	0.02	14.00	0.07	1.92
40	2/21/2011	8:15	2/21/2011	23:55	15.67	39,691	0.741	3.2	0.7	4.57	0.36	1.55
41	2/24/2011	17:45	2/25/2011	21:25	27.67	45,743	0.854	4.43	0.46	9.63	0.59	2.32
42	2/27/2011	19:00	2/27/2011	23:20	4.33	1,837	0.034	0.99	0.12	8.25	0.05	1.24
43	2/28/2011	5:20	2/28/2011	15:40	10.33	6,830	0.127	4.6	0.18	25.56	0.40	6.20
44	3/4/2011	11:10	3/5/2011	23:55	36.75	27,595	0.515	1.88	0.2	9.40	0.37	1.14
45	3/8/2011	22:15	3/10/2011	7:55	33.67	32,593	0.608	3.4	0.27	12.59	0.42	1.53
46	3/15/2011	4:10	3/15/2011	17:30	13.33	923	0.017	0.57	0.02	28.50	0.09	1.17
47	3/18/2011	13:55	3/18/2011	23:10	9.25	4,967	0.093	2.73	0.15	18.20	0.23	7.93
48	4/1/2011	21:00	4/1/2011	23:35	2.58	1,198	0.022	0.81	0.12	6.75	0.14	6.20
49	4/4/2011	13:05	4/4/2011	20:30	7.42	13,370	0.250	2.18	0.5	4.36	0.23	2.17
50	4/9/2011	11:10	4/9/2011	16:35	5.42	6,363	0.119	1.03	0.33	3.12	0.25	1.51
51	4/11/2011	8:15	4/12/2011	18:35	34.33	44,225	0.825	2.76	0.36	7.67	0.43	1.45
52	4/15/2011	23:00	4/17/2011	13:20	38.33	17,157	0.320	2.5	0.33	7.58	0.35	3.46
53	4/19/2011	0:00	4/19/2011	21:00	21.00	51,250	0.956	8.05	0.51	15.78	0.47	2.08
54	4/20/2011	1:30	4/20/2011	20:45	19.25	28,646	0.535	3.83	0.41	9.34	0.50	2.89
55	4/22/2011	17:00	4/23/2011	23:45	30.75	12,045	0.225	5.94	0.5	11.88	0.35	13.18
56	4/23/2011	1:40	4/23/2011	11:50	10.17	21,031	0.393	4.78	0.57	8.39	0.70	2.07
57	4/23/2011	13:45	4/24/2011	6:15	16.50	31,109	0.581	6.61	0.52	12.71	0.50	2.36
58	4/24/2011	8:00	4/24/2011	15:15	7.25	2,910	0.054	0.73	0.11	6.64	0.27	2.81
59	4/27/2011	2:30	4/27/2011	15:10	12.67	8,524	0.159	3.87	0.19	20.37	0.28	3.04
60	4/27/2011	16:30	4/27/2011	23:20	6.83	3,152	0.059	0.97	0.13	7.46	0.37	2.00
61	4/28/2011	18:00	4/28/2011	21:20	3.33	2,397	0.045	1.78	0.2	8.90	0.28	3.08
62	5/1/2011	19:50	5/2/2011	13:40	17.83	11,663	0.218	2.08	0.18	11.56	0.29	1.56
63	5/2/2011	15:20	5/3/2011	20:00	28.67	41,510	0.775	2.01	0.4	5.03	0.52	1.62
64	5/7/2011	23:25	5/8/2011	4:10	4.75	6,303	0.118	2.32	0.37	6.27	0.37	3.80
65	5/13/2011	16:05	5/13/2011	18:15	2.17	1,148	0.021	1.45	0.15	9.67	0.18	8.67
66	5/14/2011	7:05	5/14/2011	17:20	10.25	905	0.017	0.4	0.02	20.00	0.11	1.26
67	5/15/2011	18:00	5/15/2011	23:55	5.92	1,760	0.033	1.04	0.03	34.67	0.21	6.45
68	5/17/2011	10:00	5/18/2011	10:45	24.75	3,792	0.071	0.51	0.04	12.75	0.21	1.56
69	5/22/2011	18:00	5/22/2011	23:25	5.42	1,240	0.023	1.99	0.05	39.80	0.19	65.00
70	5/23/2011	1:10	5/23/2011	13:20	12.17	14,576	0.272	8.32	0.33	25.21	0.25	2.06
71	5/23/2011	19:30	5/24/2011	7:20	11.83	8,333	0.156	1.78	0.19	9.37	0.22	2.33
72	5/26/2011	0:35	5/26/2011	22:50	22.25	14,658	0.274	2.83	0.18	15.72	0.24	1.23
73	6/10/2011	18:25	6/11/2011	2:55	8.50	24,064	0.449	9.06	0.7	12.94	0.17	3.40
74	6/11/2011	4:05	6/11/2011	13:00	8.92	24,074	0.449	8.43	0.74	11.39	0.37	2.23

Event #	Pipeflow start date	Pipeflow start time	Pipeflow end date	Flow end time	Flow dur. (hrs)	Total pipeflow discharge volume (ft3)	Total disch. (in)	5-minute Peak flow disch. rate (CFS)	5-minute Avg flow disch. rate (CFS)	Peak/avg pipeflow rate ratio	Rv (Runoff Depth/Rain Depth)	flow/ rain dur. ratio
75	6/15/2011	11:25	6/15/2011	20:45	9.33	4,722	0.088	1.1	0.14	7.86	0.17	2.00
76	6/19/2011	10:50	6/19/2011	17:55	7.08	252	0.005	0.08	0.01	8.00	0.03	1.23
77	6/20/2011	10:25	6/20/2011	17:45	7.33	17,360	0.324	4.54	0.66	6.88	0.39	3.52
78	6/21/2011	11:45	6/22/2011	7:30	19.75	25,995	0.485	8.86	0.37	23.95	0.28	2.52
79	6/22/2011	22:40	6/23/2011	11:45	13.08	9,473	0.177	7.89	0.2	39.45	0.28	2.31
80	6/26/2011	4:40	6/26/2011	16:20	11.67	10,131	0.189	0.99	0.24	4.13	0.32	2.19
81	7/4/2011	9:15	7/4/2011	10:55	1.67	2,312	0.043	2.26	0.39	5.79	0.18	5.00
82	7/8/2011	2:45	7/8/2011	12:25	9.67	11,740	0.219	1.96	0.34	5.76	0.18	2.19
83	7/23/2011	8:40	7/23/2011	15:20	6.67	2,434	0.045	3.38	0.1	33.80	0.16	5.33
84	8/3/2011	3:00	8/3/2011	11:10	8.17	4,594	0.086	1.67	0.16	10.44	0.13	2.45
85	8/7/2011	5:50	8/7/2011	10:05	4.25	10,575	0.197	4.7	0.69	6.81	0.23	2.68
86	8/8/2011	20:15	8/8/2011	23:55	3.67	7,498	0.140	2.81	0.22	12.77	0.39	6.29
87	8/21/2011	16:55	8/21/2011	20:20	3.42	1,910	0.036	2.14	0.16	13.38	0.15	13.67
88	9/4/2011	1:15	9/4/2011	6:10	4.92	8,629	0.161	5.78	0.48	12.04	0.34	3.69
89	9/4/2011	20:25	9/4/2011	23:55	3.50	6,519	0.122	2.22	0.25	8.88	0.30	1.56
90	9/7/2011	9:05	9/8/2011	23:50	38.75	6,807	0.127	0.61	0.13	4.69	0.29	1.06
91	9/14/2011	23:25	9/15/2011	5:50	6.42	5,369	0.100	1.35	0.24	5.63	0.23	3.50
92	9/19/2011	9:55	9/19/2011	20:20	10.42	7,349	0.137	0.96	0.2	4.80	0.38	2.02
93	9/23/2011	3:05	9/23/2011	16:10	13.08	8,345	0.156	1.36	0.18	7.56	0.30	1.74
94	9/26/2011	0:00	9/26/2011	15:20	15.33	39,920	0.745	5.72	0.72	7.94	0.27	1.53
95	9/29/2011	19:30	9/29/2011	23:50	4.33	2,366	0.044	1.2	0.15	8.00	0.14	2.48
96	10/13/2011	9:50	10/13/2011	17:55	8.08	4,986	0.093	1.62	0.17	9.53	0.29	1.64
97	10/19/2011	0:00	10/20/2011	16:35	40.58	38,659	0.721	1.85	0.22	8.41	0.32	1.14
98	10/26/2011	20:40	10/27/2011	9:55	13.25	21,346	0.398	1.79	0.45	3.98	0.29	1.92
99	11/3/2011	13:10	11/4/2011	8:45	19.58	17,529	0.327	1.43	0.25	5.72	0.34	1.64
100	11/14/2011	21:25	11/15/2011	13:20	15.92	31,730	0.592	3.06	0.55	5.56	0.30	1.49
101	11/16/2011	6:55	11/16/2011	16:20	9.42	8,757	0.163	1.14	0.26	4.38	0.41	1.98
102	11/20/2011	14:40	11/20/2011	23:20	8.67	2,806	0.052	0.32	0.09	3.56	0.26	1.79
103	11/21/2011	6:25	11/21/2011	12:10	5.75	3,612	0.067	1.82	0.17	10.71	0.17	11.50
104	11/21/2011	14:35	11/22/2011	2:35	12.00	5,181	0.097	1.39	0.12	11.58	0.48	2.48
105	11/22/2011	5:15	11/22/2011	21:40	16.42	24,224	0.452	2.67	0.41	6.51	0.57	3.18
106	11/27/2011	3:40	11/29/2011	12:00	56.33	57,151	1.067	0.93	0.28	3.32	0.48	1.17
107	11/29/2011	17:35	11/30/2011	9:00	15.42	3,584	0.067	0.33	0.06	5.50	0.28	4.20
108	12/4/2011	14:45	12/6/2011	12:05	45.33	97,119	1.813	3.2	0.6	5.33	0.57	1.35
109	12/15/2011	3:40	12/15/2011	16:45	13.08	8,867	0.165	1.15	0.19	6.05	0.41	1.65
110	12/19/2011	18:15	12/20/2011	9:55	15.67	6,065	0.113	0.91	0.11	8.27	0.35	2.69
111	12/21/2011	1:35	12/21/2011	14:15	12.67	13,419	0.250	2.25	0.29	7.76	0.48	1.24
112	12/22/2011	12:10	12/22/2011	23:55	11.75	19,099	0.356	1.19	0.45	2.64	0.47	1.45

Event #	Pipeflow start date	Pipeflow start time	Pipeflow end date	Flow end time	Flow dur. (hrs)	Total pipeflow discharge volume (ft3)	Total disch. (in)	5-minute Peak flow disch. rate (CFS)	5-minute Avg flow disch. rate (CFS)	Peak/avg pipeflow rate ratio	Rv (Runoff Depth/Rain Depth)	flow/ rain dur. ratio
113	12/27/2011	2:25	12/27/2011	20:25	18.00	11,894	0.222	1.26	0.19	6.63	0.29	1.39
114	1/11/2012	7:20	1/11/2012	14:45	7.42	3,348	0.062	0.85	0.13	6.54	0.17	1.89
115	1/12/2012	12:40	1/12/2012	18:50	6.17	1,305	0.024	0.44	0.06	7.33	0.12	2.96
116	1/17/2012	1:40	1/17/2012	20:55	19.25	41,980	0.783	4.56	0.61	7.48	0.47	2.12
117	1/22/2012	23:50	1/23/2012	15:30	15.67	7,091	0.132	1.77	0.13	13.62	0.30	2.51
118	1/26/2012	3:45	1/27/2012	11:20	31.58	54,795	1.023	2.93	0.48	6.10	0.62	1.65
119	2/16/2012	0:10	2/16/2012	14:25	14.25	3,137	0.059	0.52	0.06	8.67	0.21	1.26
120	2/29/2012	3:30	2/29/2012	17:20	13.83	6,658	0.124	2.02	0.13	15.54	0.22	1.46
121	3/2/2012	11:35	3/2/2012	20:55	9.33	3,534	0.066	2.02	0.11	18.36	0.27	2.29
122	3/8/2012	6:05	3/8/2012	19:15	13.17	8,094	0.151	1.07	0.17	6.29	0.25	1.46
123	3/12/2012	6:00	3/12/2012	17:00	11.00	1,101	0.021	0.43	0.03	14.33	0.17	1.65
124	3/15/2012	10:30	3/15/2012	23:15	12.75	17,451	0.326	4.66	0.4	11.65	0.20	1.22
125	3/23/2012	11:35	3/23/2012	23:55	12.33	22,756	0.425	6.1	0.51	11.96	0.37	1.83
126	3/24/2012	1:05	3/24/2012	5:45	4.67	4,140	0.077	1.48	0.23	6.43	0.28	4.00
127	4/14/2012	10:00	4/14/2012	23:05	13.08	17,820	0.333	0.215	2.5	0.38	0.36	1.78
128	4/20/2012	23:45	4/21/2012	4:35	4.83	1,225	0.023	0.39	0.03	13.00	0.07	0.94
129	4/25/2012	23:55	4/26/2012	0:50	0.92	681	0.013	2.05	0.21	9.76	0.02	0.22
130	4/28/2012	4:50	4/28/2012	18:20	13.50	8,561	0.160	2.19	0.18	12.17	0.16	1.62
131	5/4/2012	21:15	5/5/2012	9:40	12.42	7,265	0.136	2.42	0.16	15.13	0.26	1.23
132	5/8/2012	0:35	5/8/2012	12:45	12.17	6,231	0.116	1.43	0.14	10.21	0.29	1.39
133	5/13/2012	5:15	5/13/2012	23:55	18.67	25,177	0.470	2.19	0.37	5.92	0.45	1.22
134	5/29/2012	9:15	5/29/2012	12:00	2.75	1,408	0.026	0.65	0.14	4.64	0.09	2.54
135	6/1/2012	0:45	6/1/2012	15:05	14.33	21,744	0.406	6.49	0.42	15.45	0.39	1.95
136	6/11/2012	6:40	6/11/2012	14:05	7.42	2,186	0.041	0.28	0.08	3.50	0.25	2.47
137	6/29/2012	17:35	6/29/2012	20:35	3.00	4,175	0.078	2.28	0.39	5.85	0.39	1.71
138	7/1/2012	5:20	7/1/2012	7:50	2.50	200	0.004	0.12	0.02	6.00	0.02	2.14
139	7/1/2012	15:20	7/1/2012	23:05	7.75	277	0.005	0.2	0.01	20.00	0.04	3.32
140	7/15/2012	11:20	7/15/2012	20:50	9.50	261	0.005	0.11	0.01	11.00	0.02	28.50
141	7/18/2012	16:00	7/18/2012	23:30	7.50	23,232	0.434	6.68	0.86	7.77	0.22	3.60
142	7/19/2012	9:40	7/19/2012	15:35	5.92	2,116	0.039	1.24	0.1	12.40	0.11	2.15
143	7/20/2012	12:35	7/20/2012	16:30	3.92	400	0.007	0.36	0.03	12.00	0.01	11.75
144	7/26/2012	15:25	7/26/2012	23:50	8.42	6,704	0.125	3.93	0.22	17.86	0.21	1.33
145	7/27/2012	17:30	7/27/2012	22:25	4.92	1,899	0.035	1.61	0.11	14.64	0.09	1.44
146	8/9/2012	17:05	8/9/2012	23:50	6.75	32	0.001	0.01	0.00	11.35	0.00	11.57
147	8/10/2012	1:50	8/10/2012	6:30	4.67	4,892	0.091	0.76	0.29	2.62	0.25	2.55
148	8/27/2012	10:15	8/27/2012	18:15	8.00	2,016	0.038	0.92	0.07	13.14	0.13	1.12
149	10/1/2012	18:05	10/1/2012	23:55	5.83	13,418	0.250	0.234	0.049	4.78	0.32	1.01
150	10/5/2012	21:25	10/6/2012	7:30	10.08	6,509	0.121	1.79	0.18	9.94	0.24	1.41

Event #	Pipeflow start date	Pipeflow start time	Pipeflow end date	Flow end time	Flow dur. (hrs)	Total pipeflow discharge volume (ft3)	Total disch. (in)	5-minute Peak flow disch. rate (CFS)	5-minute Avg flow disch. rate (CFS)	Peak/avg pipeflow rate ratio	Rv (Runoff Depth/Rain Depth)	flow/ rain dur. ratio
151	10/19/2012	14:35	10/19/2012	23:20	8.75	4,583	0.086	0.6	0.15	4.00	0.62	1.15
152	10/26/2012	10:40	10/27/2012	9:20	22.67	19,307	0.360	1.06	0.24	4.42	0.43	1.45
153	10/30/2012	4:30	10/30/2012	14:55	10.42	8,647	0.161	0.63	0.23	2.74	0.39	1.33
154	11/3/2012	12:20	11/3/2012	20:25	8.08	2,596	0.048	0.57	0.09	6.33	0.40	1.83
155	11/12/2012	4:30	11/12/2012	16:35	12.08	14,058	0.262	1.46	0.32	4.56	0.34	1.21
156	11/26/2012	0:50	11/27/2012	5:00	28.17	254	0.005	0.08	0.02	4.00	0.06	8.67
157	12/2/2012	8:05	12/2/2012	14:15	6.17	6,148	0.115	2.15	0.23	9.35	0.23	1.51
158	12/4/2012	16:05	12/4/2012	23:20	7.25	5,472	0.102	1.9	0.19	10.00	0.57	2.35
159	12/6/2012	17:05	12/7/2012	0:55	31.83	3,850	0.072	0.92	0.1	9.20	0.25	4.77
160	12/7/2012	7:15	12/7/2012	23:55	16.67	18,898	0.353	1.14	0.13	8.77	0.50	1.60
161	12/9/2012	20:35	12/10/2012	6:10	9.58	18,773	0.350	4.49	0.54	8.31	0.36	1.20
162	12/15/2012	12:25	12/15/2012	14:30	2.08	115	0.002	0.07	0.02	3.50	0.03	0.51
163	12/17/2012	14:05	12/17/2012	20:35	6.50	3,845	0.072	1.49	0.16	9.31	0.13	1.95
164	12/20/2012	7:55	12/20/2012	21:15	13.33	14,302	0.267	2.1	0.3	7.00	0.28	1.05
165	12/26/2012	4:50	12/26/2012	23:30	18.67	12,990	0.242	0.87	0.19	4.58	0.18	1.74
166	12/28/2012	21:05	12/29/2012	12:05	15.00	1,091	0.020	0.15	0.02	7.50	0.17	1.65